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### Professor Sir Robert Macintosh 1897-1989

An appreciation by Dr T B Boulton | 97 |

### MEMBERSHIP OF THE SOCIETY - June 1990

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It was at a course at Oxford in 1951 that I met Professor Macintosh and was inspired by his teaching of the principles of anaesthesia and by the excellent collection of historical apparatus to try and assemble a teaching collection at St Thomas's. I knew that there were a number of old bits and pieces in cupboards around the hospital and I was allowed space for them in the crowded anaesthetic department.

The collection has two functions, firstly the original one of helping juniors to understand the working of the apparatus on which they and their patients depend for safety and, secondly, the preservation of objects that had belonged to particular anaesthetists. I had written to anaesthetists whose inventions had been described in journals but were not in the makers' catalogues and was amazed at the marvellous response I had. The crowning event was when Sir Ivan Magill gave his apparatus, much of which he had personally made, to the collection, together with other items such as the lead that he used to protect the front teeth when he intubated which still bears the imprint of many of his patients' teeth, and his own personal laryngeal spray. These objects are too precious to be handled by all and sundry, in fact they need never be touched by anyone and they should be locked away so that access to them is strictly limited.

The collection is now housed in a lecture theatre in glass-doored cupboards on one wall and in 'pictures' on the wall; the larger items such as complete anaesthetic apparatus and ventilators are housed in a long cupboard outside the department in a corridor. When visiting the department after my retirement I found the collection in disorder and some things missing. Fortunately they had been loaned and were being safely kept at the Association of Anaesthetists' Museum at 9 Bedford Square.

The reasons for the disorder were that the lecturers have no time to put things back and, anyway, they probably could not remember from where they had taken things and no one else, particularly a non-anaesthetist, could possibly put things away in their proper places. I thought that my solution might possibly be useful to other collectors.

One problem I have not solved and that is how to ensure that the marks on each article are irremovable, but I believe that Dr Eccles (the Association's Curator/Archivist) may have a solution to that. The marks are a key, without the list or card index they will tell the reader nothing. The collection can still, therefore, be used for tests and competitions. The marks, however, do give the exact shelf where the piece belongs so that anyone who knows the system can replace a piece correctly.

Each cupboard or picture is given a letter and each shelf a number; thus J5 means a particular shelf in cupboard J. Each item on that shelf is given a number, this is written before the shelf letter; thus 4J5 tells the finder that it goes on the 5th shelf of cupboard J, and by looking
at the list of shelf contents he finds that it is a Cardiff Inhaler for Penthrane. Near it will be an item with the mark 4aJ5; this is the keyed filler for Penthrane for filling the inhaler. By using a lower case letter there can be no ambiguity and up to 26 small objects can be kept under one heading. Thus even very small things can be given an individual number for identification, checking purposes and to enable them to be replaced in their proper places.

Any marks must be reasonably permanent, not too large and preferably not give a clue as to what the object is, so that they can be used to test people's knowledge. I have been using a small sticky label, but I believe there are special pens available.

It is also possible to find the whereabouts of anything from the card index or alphabetical list if the name is known, and the name of an unknown object, from the shelf lists of the collection. By this means the curator will also have been forced to do what I for so long did not do, and that was to make a proper list of the contents, partly because whenever I started I had no means of being sure where I had got to because things were never in the proper place for very long. It will be easier to keep the catalogue up to date because you will have a list and a card index or possibly another list alphabetically arranged, so that additions will be simple to deal with.

A code for the institution can easily be added, if you are often asked to lend things. The use of a word processor has made this whole task so much easier.

Before you start allotting letters and numbers you should count the number of shelves and cupboards etc. because you might find that it would be better in your case to reverse the letter and the last figure; fortunately I have only had to use A-M.

I hope that this idea will help other collectors to make their collections better for the users and easier to manage for themselves.
In the last quarter of the eighteenth century, after the identification of oxygen and Lavoisier's explanation of the nature of the gas exchange taking place during respiration, physicians here and on the continent latched on to the idea that ailing lungs might be directly medicated using air breathed in the ordinary way as the vehicle. Among the first to try this was the Plymouth scientist and physician John Mudge FRS. As a scientist he was interested in improving the lenses of telescopes; as a physician he devised an inhaler for treating not only the patient's lungs but also his skin with warm moist air. In the late 1770's Mudge described his inhaler in a short book entitled 'A Radical and Expeditious Cure for a Recent Catarrhous Cough'. His starting point was the widely held belief that, as he put it, 'catarrhous coughs are really dangerous, and often lay the foundations of a pulmonary phthisis'.

Mudge's inhaler

The illustration of his inhaler showed a handsome pint-sized pewter tankard, its sturdy handle curving down from the rim of the mug to within an inch or so of the base. What made the tankard into an inhaler was a closely fitting lid with two holes through it. One hole was surmounted by a short inhaling tube of coiled brass, wire bound round and round with a strip of oiled silk, and tipped with a wooden nozzle. The other hole, opened and closed by a perforated guard, was the outlet for an expiratory ball-and-socket valve beneath. The socket was thimble-shaped; the ball was of very lightweight cork. There was no inspiratory valve.

According to Mudge's strategy: when the patient breathed in, air was drawn into the tankard's handle (which was hollow) through three holes punched in the shoulder, and at the lower end it passed through another hole into the belly of the mug and up to the inhaling tube. In use the tankard was two-thirds filled with hot water, and the patient was instructed to breathe both in and out into it. The expired air, mixing with the steam from the water, then lifted the cork ball from its seating and escaped. That was only part of the routine to be followed. An hour before bedtime on the day the cough started, the patient took three teaspoonfuls of 'paragoric elixir', each containing a quarter of a grain of opium (a young child took only one teaspoonful). When bedtime came the patient got into bed and someone brought him the inhaler swathed in a napkin and containing water as nearly boiling as possible. This was securely lodged in the curve of his ampit and, taking the nozzle of the inhaling tube in his lips, he pulled the bedclothes over the inhaler and up to his chin - being careful not to obstruct the air inlets. For the next half hour he would lie with his body bathed in a soothing mixture of steamy exhalations and sweat and, since the inhaler was under the blankets, he breathed the same mixture. Next morning the cough would be gone.
One might, of course, inhale sitting at a table, and medicines could be added to the hot water; but it was water vapour alone that Mudge advocated. Even a five-year-old child could use this machine without effort, Mudge said, explaining - rather oddly, one might think - that the various openings 'were of such dimensions as to equal the size of both nostrils together .... so as not to obstruct respiration'. A rather different assessment of Mudge's inhaler was made by Priestly's friend, the Birmingham botanist and physician William Withering. Writing on Christmas Eve 1793 to Thomas Beddoes about arrangements for the proposed Pneumatic Institution at Clifton, Withering said: 'In constructing the apparatus I have no doubt but you will contrive to balance the air vessel inverted in water, so that the patient may breathe with perfect ease. The resistance given to inspiration by the column of water, low as it is, in Mudge's inhaler, is so great that even a healthy person cannot persevere in breathing through it, and I have never seen a patient use it so as to draw the air through the water as its author intended should be done.'

Since patients were allowed the free use of their nostrils, and since Mudge assured them that breathing through the inhaler needed no effort on their part, it is not surprising they simply puffed to and fro across the surface of the water as though the tankard were some kind of hookah pipe.

Mudge, in his book which reached a second edition in 1779, advertised the fact that his inhaler could be bought from a London pewterer in Fleet Street. The inhaler evidently sold well and by 1793, when Withering referred to it, its use was firmly established and it was a household name. And so it remained for the next 65 years at least.

The Pneumatic Institution

From the mid-1770's onward attempts were occasionally made at treating the lungs with carbon dioxide or oxygen diluted with atmospheric air. But the new specialty, Pneumatic Medicine, was created by Thomas Beddoes and his associates James Watt and young Humphry Davy, at the Pneumatic Institution which opened in 1796. Beddoes was the front man, Watt designed the apparatus, and in 1798 Davy took over the running of the research laboratory.

The work done at the Institution is very well known as are the gases investigated - carbon dioxide, oxygen, hydrogen, and Davy's particular interest, nitrous oxide. There were however a few significant changes in the way they were administered. The mouthpiece Watt initially attached to the oiled silk inhaling bags was simply a wooden tap opened and closed by a spigot and tapered to form a nozzle. The patient was told to breathe from the bag through his mouth and then out into the room through his nose. Watt soon saw that many people found that difficult, and he redesigned the mouthpiece to include inspiratory and expiratory valves made of oiled silk, so that to and fro breathing could go on in the ordinary way. Nobody thought of closing the patient's nostrils.
Beddoes disliked the oiled silk bags; they smelt, they were expensive and soon deteriorated, and it was nearly impossible to free them completely from residual gas between one administration and the next. He wanted patients to inhale directly from a gasholder containing a known volume of an accurately proportioned mixture of gas and atmospheric air. For this, Watt provided long inhaling tubes made either of indiarubber or the newly patented thin waterproof leather for boots and shoes. The tubes plugged into a pipe at the bottom of the gasholders. For patients too weak to use a mouthpiece Watt designed a beehive-shaped hood to envelop the head and neck. The nozzle of a gasbag was held inside the hood and gently pressed. Those three innovations - the valved mouthpiece, the reservoir-container for inhaling a known volume of a ready-prepared inhalant, and the hood within which the patient breathed whatever inhalant was introduced - each found a place in the anaesthetic repertory.

The gas-generating apparatus for the Pneumatic Institution, made at Watt’s engineering works in Birmingham, could be bought by the public. Interlinked by tubing, it comprised a coke-fired iron pot for the chemical reaction, a washing and cooling unit, and a gas reservoir that delivered measured amounts. Atmospheric air was added from a small separate bellows.

Watt, writing on January 1 1795, before the Institution was in operation, recorded that several generators were ‘already in the hands of able practitioners’. Dr Richard Pearson, physician to the Birmingham General Hospital, announced that one had been installed there. ‘In process of time’, he said, ‘we may expect that the apparatus will be found in the laboratories of most of the apothecaries. Physicians will then have opportunities of prescribing the pneumatic treatment in all cases judged to be proper for it’.

Ether treatment

Beddoes asserted that ‘to prepare a dose of factitious air by means of Mr Watt’s apparatus will, I think, be found more easy than to dress a joint of meat. In several instances under my eye, a servant of plain understanding (in one case a maid servant) has managed the apparatus perfectly’. Nevertheless, the generators could not be set up just anywhere, and Richard Pearson was one of those who turned to the inhalation of sulphuric ether vapour because of its simplicity. Writing to Beddoes on February 2 1795, Pearson said: ‘As the number of consumptive cases in this large manufacturing town is deplorably great I have had frequent opportunities of trying the inhalation of ether in such cases; and have found it very beneficial’. But he warned of the danger of addiction: ‘Patients ... find it so grateful to their feelings that they are disposed to have recourse to it too often and cannot readily be prevailed upon to lay it aside when it is no longer necessary’.

Pearson gave ether in a cup under an upturned funnel to confine the vapour, the patient inhaling through the tail. In cold weather the cup was put in a basin of warm water, with a large funnel over all, its rim raised on a folded slip of paper to let in some air.”
physician, R.J. Thornton, used a teapot, holding it near - but not too near - a lighted candle to vaporise the ether. The patient inhaled through the tip of the spout. Compared with the ease of buying ether from an apothecary and improvising an inhaler from some handy receptacle off the kitchen dresser, making and administering any kind of gas was troublesome.

Beddoes and Davy had shown that gases, even quite inimical ones, could be safely inhaled mixed with about twenty times as much ordinary air. But they had not been able to show much positive evidence of benefit to the patient. When Davy left Bristol for a lectureship at the newly established Royal Institution in London, Beddoes reckoned he could do no more and closed the Pneumatic Institution. The strange outcome of their researches was the subsequent popularity of inhaling laughing gas - and occasionally ether - for fun, leading eventually to the recognition of an anaesthetic state sufficient for more than minor surgery.

During the first two decades of the nineteenth century interest in how to benefit ailing lungs turned away from attempts at direct medication and back to the old belief in the importance of the interaction between climate and health. This trend both encouraged and was encouraged by the current enthusiasm for sea-bathing and family holidays at one or other of the new watering places being developed around the coasts of Britain and France. The eminent Parisian chest physician, R.T.H. Laennec, developer of the stethoscope and the skills of auscultation, was a great believer in the healing effects of sea air on consumptive lungs and when, in 1823, he became Professor of Clinical Medicine with beds at La Charite Hospital, he tried an experiment. He set aside a small ward for twelve patients with advanced pulmonary phthisis, and regularly imported cartloads of fresh seaweed which he strewed over the ward floor creating, as he believed, an artificial maritime climate. The experiment lasted for four months in the winter of 1823-1824, ending when the supply of seaweed failed. By that time nine of the patients, thinking themselves cured, had left hospital; the state of the remaining three, Laennec said, rapidly deteriorated.

Chlorine and iodine treatment

Laennec's somewhat unusual attempt at producing sea air in a Paris hospital ward naturally attracted reports in newspapers. At about the same time it was announced that purified chlorine was now readily available. Gay-Lussac in France and Davy in England had recently produced it from the crude chlorine long used as a bleaching agent in industry, and in medicine as a disinfectant for ulcers and other lesions. These two news items together reminded a Parisian chemist and pharmacologist, J.N. Gannet, of an observation he had made a year or two previously, while attached to a calico-printing factory. He noticed that employees showing phthisical symptoms soon lost them in the chlorine-laden air of the works. In 1823 he suggested to Laennec that the cautious inhalation of chlorine vapour from drops of the pure liquid diluted in an ample quantity of warm distilled water might bring about similar improvements in his consumptive patients. Laennec not only sprinkled lime on the seaweed, he persuaded his brother and some other
medical men to try the inhalation of chlorine in water in an inhaler. Gannal had put together form laboratory glassware. Their considered opinion was that inhaled chlorine vapour did have some beneficial action, though not very much. But in a few cases it had proved positively harmful.

This lack of enthusiasm disappointed Gannal, who hoped to establish a monopoly in supplying pure liquid chlorine for inhaling. He next wrote to several journals, drawing attention to his observation in the calico factory and setting out proposals for clinical trials. That brought him invitations from hospital doctors in Paris to demonstrate - under their supervision - on some of their patients. The trials were successful, but instead of the recognition Gannal felt he should receive, he found his formula for the solution and the design of his inhaler were being freely used without any acknowledgment at all. Finally, during 1828, Gannal presented two 'Memoirs' on chlorine inhalation, supported by case histories, at meetings of the Académie Royale des Sciences, and he published these 'Memoirs' in 1830. They were at once picked up by a London chemist, W.H. Potter, who translated and published them, mentioning that the all-glass inhaler, made exactly to Gannal's specification, and the pure liquid chlorine, could be bought from his chemical laboratory in Old Compton Street, Soho.

In Potter's translation the inhaler was described as a half-litre, wide-mouthed jar closed by a bung with two holes through it. One hole was for an air inlet: a half inch calibre glass tube long enough to dip well below the surface of liquid in the bottom of the jar. The other hole was for the inhaling tube, similar to the air inlet but bent to a right angle, providing a short arm inside the flask and a long arm outside, flattened at the end to form a mouthpiece. There were no valves. Just before use, four ounces of distilled water heated to 32°C were poured into the jar, ten drops of liquid chlorine were added and the jar gently shaken. The amount of chlorine vapour released lasted for about six minutes, when the dose was repeated - and so on, according to the patient's tolerance.

Chlorine inhalation

Chlorine inhalation had already been tried in England soon after 1823, by Charles Scudamore, a general physician with a fashionable London practice. He had been told about chlorine by Laennec himself. In 1828 Scudamore changed from chlorine (of which, like Laennec, he didn't think much) to another new inhalant - iodine. Besides water and a little alcohol he added some conium - an extract of dried hemlock leaves. In 1830 he published a detailed account of successful cases, but did not describe the inhaler he used beyond saying it was made of glass and well adapted for the purpose. Nor did he give the formula for his iodine and conium mixture, because he was afraid patients might attempt their own treatment; but physicians, he said, could get it by asking for it.

Potter's translation of Gannal's 'Memoirs' and Scudamore's case histories seem to have started a widespread revival of interest in therapeutic inhalation in this country. On January 31 1831, John Elliotson in a clinical lecture delivered at St Thomas's Hospital,
casually remarked that he was trying the inhalation of both chlorine and iodine for some of his phthisical patients. In a further lecture, at the end of March, he returned to the subject, saying: 'I think that as medical men we have all been much to blame for neglecting the inhalation of various substances, though proposed and practiced thirty or forty years ago. ...Nothing is easier to inhale ... by means of warm water. Inhalation is a more difficult thing if you employ gases. It cannot be done, unless you have a large receptacle with the gas at the exact strength that can be borne; but by causing the patient to inhale through impregnated water ... you can employ any quantity ... you think proper. It is the simplest thing in the world and can be employed without any expense.'

The inhaler described by Elliotson was clearly based directly on Gannal's, and so were most of those subsequently used for various aqueous solutions during the 1830's and early 40's. A few, but not very many, had a valved mouthpiece and required the patient's nostrils to be closed during administration. So much appears in a letter to the 'Lancet' in October 1831. It was from G.R. Mart, a general practitioner - like Snow - with an address in Frith Street, Soho. One of his patients, a delicate young lady suffering from phthisis, had lately been distressed during inhaling sessions by having her nose roughly pinched between the forefinger and thumb of a clumsy assistant. To spare her, Mart designed a self-supporting nose clip shaped like a pair of sugar-tongs with adjustable nippers padded with several layers of velvet. The device was welcomed also by other of his patients.

Sir Charles Scudamore (for so he had become) remained faithful to his iodine-conium mixture, though he sometimes used other herbal additives, and occasionally gave sulphuric ether in water. But some other people were more venturesome and although iodine, and less often chlorine, held the field, pungent substances such as creosote, ammonia, naphtha, and camphor were tried.

Steam diffusion

Using an inhaler was not the only way of medicating the lungs directly. There was also diffusion, whereby the liquid chemical, whatever it might be, was carried to the patient in a cloud of steam. The method appears to have been more common on the continent than in this country, and indeed the two chief exponents of the method were based in Belfast and Dublin. Sir James Murray, in Belfast, where he was resident physician to the Lord Lieutenant of Ireland, published his first account of iodine diffusion in 1830, while Scudamore's case histories were still in press. He generated the steam in an iron boiler with a very long spout, set on the hob of a moderately hot fire in the grate of the patient's room. The jet of steam picked up the iodine from a small pot dangling in it from a wire gibbet at the tip of the spout.

Dr Dominic Corrigan read a paper on diffusion and his way of doing it, at a meeting of the Dublin College of Physicians on February 18 1839. He had rigged up a cylindrical metal frame about 18 inches high and 12 inches in diameter, to support three pieces of equipment, one below the other: at the top was a dropper for the liquid chemical, beneath it was
an evaporating dish of boiling water to receive the drops, and on the floor of the frame there was a spirit lamp to keep the water steaming briskly. The dropper was an inverted flask with a narrow neck plugged with a twist of cotton wick. The rate of drip was regulated by adding or pulling out strands of wick. This contraption, looking rather like a birdcage, was hung up near the patient. Corrigan so far had been using iodine and he blandly remarked that so perfect was the diffusion that it had tinted the curtains blue. Had he been using chlorine he would no doubt have noticed, as other users did, that whatever colour the curtains had been they were now bleached.

In Sir Charles Scudamore's opinion diffusion was far less satisfactory than the use of an inhaler. Corrigan could not have disagreed more. 'Gannal', he said, 'invented the glass inhaler which is the one now ordinarily in use. ... It is only requisite to see a patient attempting to use this inhaler, to be convinced of its total inefficiency for the end proposed. Its employment is fatiguing and most disagreeable; many patients can never be taught to use it; with all their exertions they never draw a particle of vapour into the lungs, but suck it into the mouth, and puff it out through the nostrils, without its ever passing beyond the throat,' just what Withering wrote about Mudge's inhaler on Christmas Eve 1793. And in 1842 Dr Julius Jefferys endorsed what both Withering and Corrigan had said. In describing his own inhaler for warm moist air, Jefferys said: 'The drawing of the air through the body of the water has always appeared to me to be objectionable. The temperature of the air is liable to be too hot at first and rapidly cools. Also I cannot think it desirable to subject weak lungs to the labour of inhaling against the pressure of a column of several inches of water.'

In Jeffrey's opinion the proper arrangement was for the air to be drawn over the surface of the water and this, he said, was achieved in Mudge's inhaler as it was commonly used, though not as Mudge intended: 'But as the course the air takes is equal only to the radius of the circular vessel it becomes necessary to make the aperture very small, that no more air shall enter than can be rendered warm and moist during the short transit. To obviate this defect, I constructed for an invalid friend six years ago (in 1836) an inhaler of a very simple kind.' That of course, was the famous circular metal drum nearly filled by a spirally coiled baffle-plate that John Snow took as the basic model for his ether inhaler.

Development of inhalers for anaesthesia

An unusually elaborate medicinal inhaler was devised by James Startin MRCS, LSA, in the summer of 1846, and displayed at a meeting of the Royal Society of Arts on June 3. He called it the Pneumatic Inhaler, for use with the usual range of aqueous chemical solutions. It was an ordinary, largish Gannal's inhaler with some special features. When being used, the base of the jar rested in a hollow metal stand containing water at a temperature of 200°F, kept topped up. An inhaling tube not less than the human windpipe in diameter linked the jar to an 'Inspirator' - a metal cylinder about three inches long. One end was flanged to cup the lips closely; at the opposite end a vulcanised-
rubber expiratory valve opened outwards. Midway along the cylinder the
inhaling tube connected with the interior through an inspiratory valve.
The patient's nostrils were closed by a brass clip.

Besides the air-inlet tube and the outlet for the inhaling tube, the
stopper of the jar carried a conical metal container for liquid
chemical, the 'Injector'. Its mouth was closed by a very thin metal
diaphragm drawn down each time the patient breathed in, the partial
vacuum sending a jet of chemical into water in the bottom of the jar.
The 'Injector' was interchangeable with a 'Purigator' - another conical
metal container to support a pre-heated, red-hot dish for burning
mercury or a pellet of opium to fill the jar with medicinal fumes.

After the successful use of Squire's inhaler for Liston's first
operation on an anaesthetised patient, on December 21 1846, Startin
saw that his Pneumatic Inhaler would do very well for etherising. The
apparatus was written up in the 'Medical Times' of January 30, and a
week later there was an unexpected opportunity to use it. At King's
College Hospital on February 6, Professor William Fergusson was about to
begin a major operation - the excision of a scapula and one half of the
clavicle - when it became evident that Hooper's inhaler was not going to
succeed in anaesthetising the patient. According to the 'Lancet',
'Sartin's inhaler was then tried and in a few minutes a quiet slumber
was induced'. The operation lasted fifteen minutes, and it is clear
from the 'Lancet's report that no more than a precarious state of
analgesia was achieved. Nevertheless, 'when the patient recovered his
senses he declared he was scarcely conscious of anything having been
done'.

No-one explained how a Startin's inhaler came to be in the theatre at
KCH, or who then applied it. My guess is that Startin himself was one
of the crowd of people gathered to watch Fergusson operate. I guess,
moreover, that Startin had brought along his inhaler to show it off;
and in the emergency he offered to use it.

When Fergusson operated there had always to be plentiful supplies of hot
water and cold water for mopping up, so Startin - or whoever it was -
could put really hot water into the metal stand of the vaporising jar,
and renew it as often as necessary. That, and the close fitting, valved
'Inspirator' probably enabled same ether to go on reaching the patient's
lungs throughout those tense fifteen minutes.

After February 6 not much more was heard of Startin's inhaler in either
of its roles. And, in general, interest in medicinal inhalation was
displaced by the excitements of etherising. But by 1851 John Snow and
others were busy with the further investigation of its usefulness.
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That John Snow based his ether vaporiser on the humidifier designed by Julius Jeffreys is a footnote in the history of anaesthesia. But that Jeffreys himself is now totally forgotten is surprising, because for several decades during the mid-nineteenth century his name must have been a household word. He was a pioneer in the treatment of respiratory ailments, and in the physiology of lung volumes, anticipating the work of John Hutchinson. He was thought to be sufficiently eminent to merit an entry in the Dictionary of National Biography, and there is where this investigation started.

According to the DNB, Julius was the son of the Reverend Richard Jeffreys, Rector of Throckington, Hertfordshire, and he was born at Hall Place, Kent, in 1801. A careful search of the guide books failed to reveal anywhere called Throckington, but found Throcking, a tiny hamlet about one mile west of Buntingford, which is on the A10, the road from London to Cambridge. Going there on the off chance, I was rewarded by the sight of the largely C13 church of the Holy Trinity, built of flint, with a brick tower dating from 1660. Inside, the list of Rectors confirmed that Richard Jeffreys had been the incumbent from 1786 to 1830, and also revealed that he had succeeded his father, Edward, who had been Rector from 1745 to 1786; Richard Jeffreys' 46 years in office is commemorated by a white marble tablet.

The question then arose, if Richard Jeffreys was a Rector in north Hertfordshire, why was his son born at Hall Place, somewhere in Kent? Several possibilities came to mind: a family connection, or the unexpected onset of labour. Hall Place is now the local history museum, and headquarters of the Libraries Department of the London Borough of Bexley. Part of the house dates back to 1540. Enquiries of the Curator revealed that on 30th December 1795 the Reverend Richard Jeffreys, while Rector of Throcking, had taken a 21 year lease on Hall Place from the owner, the notorious Sir Francis Dashwood. The parish register revealed that Julius Jeffreys was born there not in 1801 but on 14th September 1800. With two errors in two lines, so much for the accuracy of the DNB which did, however, supply sufficient information to keep me going in the right direction.

Subsequent research in the India Office Library revealed that the Reverend Jeffreys, while still Rector of Throcking, served as Chaplain to the East India Company in India from 1803 to 1810. The whole family, including Julius, accompanied him. Several other children were born there, and his eldest daughter, who plays an important role in this story, later married there. I would propose the Reverend Jeffreys as a pretty good example of clerical pluralism and absenteeism, although by the standards of the times he doesn't seem to have been doing anything very much out of the ordinary.

Of Julius's early life, apart from his stay in India, we know very little. Like his brothers he was educated mainly by his father, whom his eldest son described as a profound mathematician and classicist.
Julius studied medicine at Edinburgh and London, and became a Member of the Royal College of Surgeons of London on 1st March 1822. He then applied for a post as assistant surgeon in the Bengal Presidency of the East India Company. His application, along with many dozens of others, is preserved in the India Office Library. His Membership was accepted as adequate training in surgery, but for medicine the Company's regulations required a six-month attachment to a recognised physician, followed by an examination. Candidates were also required to attend a course of lectures on Hindoostanee, and to produce a certificate of attendance.

Jeffreys' file contains certificates that he had passed the exam and attended the course, together with a certified copy of the record of his birth in the parish register.

India - a pioneer in public health

Jeffreys sailed to India, and on landing at Calcutta was first attached to the General Hospital, where there was a cholera epidemic raging. He was thrown into this head first, and at one time had more than two hundred patients under his care.

He had already published two papers which revealed an interest in the application of physics to medicine, and his intention was to continue with research along those lines, but the carelessness of the shipping agents caused the destruction of all his scientific instruments, so he turned his interests into a different direction. He set himself to study the effects of the Indian climate on health. The British had made no concessions to climatic differences. Regiments drilled during the hottest time of the day; anything less was considered effeminate, with the result that one third to one half of the troops were in hospital with heat stroke at any one time, and there were many deaths. There was also the belief that it was dangerous to live at an altitude above 4000 feet, because of the rarefaction of the atmosphere. Jeffreys set himself to study the physics of heat and solar radiation. After a year he went on a tour of the Himalayas. He found that in the hill country the climate was superior even to that of England. He stayed at Simla, about 8000 feet above sea level, where there was at that time only one house, and that only occupied during part of the year. On his return he wrote a report strongly advocating the establishment of convalescent stations at places such as Simla, where those exhausted by the heat of the plains could be sent to recuperate. This led to a commission of enquiry, then action, so that one could say that the subsequent modus operandi of the British in India, the establishment of hill stations, and the annual move from the plains to the hills and back again, stemmed at least indirectly from Jeffreys' report.

Jeffreys served most of his time in what is now Uttar Pradesh, mainly in Cawnpore (Kanpur) and Fatehguhr. He married in 1826, and during the next six years three sons and twin daughters were born. Arising from his climatic studies, he designed installations and apparatus for the cooling of dwelling places and barracks. One of these consisted of a series of water-filled pits, over which air was drawn and cooled by evaporation, and then pumped into the dwelling by a pendulum action quadrantic pump of his own design, which he called The Refrigerator, an early use of the word. He studied air flow through the solar topee,
insisting that it should not be hermetically sealed to the head. He 
allowed his faith in the application of scientific principles to 
overake commonsense on more than one occasion, as in his design of a 
flounced heat-resisting military costume for the tropics, of distinctly 
unmilitary appearance.

In about 1830 he transferred from the military to the civilian 
establishment, and then starting interesting himself in developing the 
natural resources of India. He established factories for the 
manufacture of pottery, brickware, saltpetre, soda water and the 
stoneware jars to contain it, designed furnaces and kilns, and provided 
employment for a thousand Indians. He was commended for his enterprise 
by the reforming Governor General, Lord William Bentinck.

Jeffreys' health began to fail, and he resolved to give up medical 
practice. He was offered the superintendenship of the East India 
Company's main opium factory, but turned it down on moral and religious 
grounds, and he and his family returned to England in 1835. En route he 
invented a method of converting the rolling and pitching motion of 
becalmed ships into a useful if slow forward movement. In October of 
that year he published in the 'Asiatic Journal' a long article on the 
Resources and Industrial State of India, strongly advocating that much 
of the wealth that was being drained out of the country by the East 
India Company should instead be reinvested there for the development of 
agriculture and industry.

Return to England - a sister's cough

At home he found that his eldest sister, now a widow, was suffering from 
advanced pulmonary disease, manifested especially by a troublesome 
cough. He was struck, as he went about, by the prevalence of lung 
disease. As he later wrote: 'In every quarter of a congregation, in 
church or other assembly, the stifled cough was to be heard during the 
colder months'. He was particularly struck by the irritating effect of 
cold air, and especially by change of temperature, as when going out of 
doors, or from a warm room to a cold passage or bedroom. This 
observation turned his mind to the devising of a means of warming the 
inspired air. At first he thought of using a portable source of heat, 
such as a lamp, but he discarded that idea as impractical. He considered 
the humidifiers already available, but ruled them out also; their output 
was inconstant, they cooled rapidly, and they could not be used during 
sleep, which was when they would be of greatest value.

He designed his volute humidifier as an improvement on Mudge's, and he 
appears to have been the first to use this method of lengthening the 
path over a fluid surface so as to increase the vapour uptake. As we 
know, John Snow based his ether vaporiser on this design, but as far as 
Jeffreys was concerned, this humidifier was virtually a throwaway. It 
was not the answer to the problem that he had set himself, which was to 
devis a means of constantly warming, and humidifying the inspired air, 
which could also be used during sleep.
The 'Respirator'

He described how the idea suddenly came to him, that exhaled air itself could be used as the source of both heat and moisture. What was needed was a means of trapping both, and transferring them to the next inspiration. Quickly he worked out the scientific principles involved. The medium must be a good conductor, which meant a metal. It must not obstruct the breath, nor affect the transmission of the voice. Since heat passes down a temperature gradient, some sort of cascade mechanism was required. All these considerations led him to the idea of a series of metal grids, or lattices, insulated from one another, through which the breath would pass. During exhalation warmth would pass from the breath to the lattices, and moisture would condense on them. During inspiration the cold air would be warmed, and humidified.

He made a crude model, and was so encouraged by its effect that he continued with his experiments on heat transfer, gradually refining the design. He then looked for a craftsman to make it, but the requirements were such that he was forced to design his own machinery. To the device he gave the name 'Respirator'. He claims to have invented the word, and the Oxford English Dictionary credits him with it.

When I started this investigation, Jeffreys, to me, was just a name attached to an apparatus of interest only tangential to the history of anaesthesia, so you may imagine my feelings when I realised that I had stumbled on the inventor of what we now call the condenser humidifier.

The Respirator, as finally designed, consisted of two parts: a packet of metal lattices, called a plate, and a frame in which the plate was mounted. The lattices were of different gradations of silver wire. Those nearest the mouth were 1/300 inch thick and 1/300 inch apart. The intermediate layers were 1/600 inch thick and 1/600 inch apart, and the outer even finer and closer together. Each lattice was insulated from the next by a similar lattice of a waterproof material. The silver lattices were overlaid by a gold lattice both inside and out. A complete plate consisted of from eight to twelve lattices and their insulating layers, and was curved to suit the curvature of the mouth. Attached to the frame was a silk cover and tapes.

This design required the construction techniques of the age of microelectronics, and Jeffreys' machine must have been a marvel. It was able to solder 40,000 to 50,000 minute points accurately in each respirator, and after 20 years it was still in use, having made over one million lattices during this time. Unfortunately, we have no information about its design.

Because of the intricacy of the manufacture, and to protect the accuracy of its construction, Jeffreys took a step that was to put him at loggerheads with some members of the medical profession for the next twenty years. He decided to patent the design. He sought advice from Messrs Poole and Carmoel of the Government Patent Office on the likelihood that his invention might be acceptable to the public, and they advised him to consult Dr Neil Arnott, one of London's most fashionable physicians, and the inventor of the water-bed. This he did,
but the meetings later gave rise to a lengthy dispute about originality and priority. It is evident that at the time Arnott had no idea about the Respirator; he did not understand the principle on which it worked, nor did he appreciate its purpose until Jeffreys was able to persuade him to try it.

The patent was taken out in January 1836. On 11th March 1836, Arnott, during a lecture on heating and ventilation at the Royal Institution, during which he attempted to promote a stove of his own invention, damned the Respirator with faint praise. It was a useful device, he said, but not original in conception. Any coachman who wound a scarf round his mouth during the cold weather and breathed through it would achieve the same result. He also commented adversely on the patent, and on the cost of the device. This attack incensed Jeffreys greatly. He had confided in Arnott, and he was very proud both of the original idea, and of the mental processes whereby he had applied scientific principles to achieve the final design.

Later in 1836 Jeffreys published a brochure, addressed to the medical profession, explaining the construction and purpose of the Respirator. He claimed that no exhaled air was retained, since the whole of the internal space was only 3/4 cubic inch, about 12 ml. He mentioned an unexpected side effect; since little body heat was lost in the exhaled air, it was retained in the circulation, and it was found that the whole of the body, and especially the extremities, became much warmer after using the Respirator for a little while.

When I made enquiries at the Science Museum, at first it was thought, because of cataloguing uncertainties, that there were no Respirators in the collection, but with more information the search was very helpfully resumed, and one was found (Figure), and later two more.

Purchasers were supplied with a leaflet giving instructions on how to apply the device to the face, and how to clean it.

Jeffreys' Respirator (courtesy of the Trustees, the Science Museum)
Compliments and brickbats

On Saturday 7th January 1837, the Respirator was demonstrated before a medical audience at a meeting of the Westminster Medical Society. It would be very interesting to know whether John Snow, who was then a student at the Great Windmill Street School where the Society met, was present, but although the Medical Society of London have some of the Westminster Society's attendance books, the one for that period could not be found.

A complimentary annotation appeared in the 'Lancet' the following week, and the quality of the workmanship was endorsed in a letter to Jeffreys from Charles Babbage. Jane Carlyle (wife of Thomas, the historian and philosopher), who suffered from a weak chest, bought one, and described it as a most wonderful acquisition: 'It is a thing made of black silk with a quarter of a mile of brass wire in it, which I clasp on the under part of my face when I go out, and which is precisely like the muzzle on a mad dog; but has the property of making all the air that goes down one's throat as warm as summer air. They call it a respirator.'

The Respirator was again under attack, and Jeffreys said that it was now being sold for 28/- and, far from making a large profit, he claimed to have lost £200 on the first batch of 700. During the current season, sales had been very large and consequently, at last remunerating, but the total profit on each instrument, which had to be shared with the retailers, was not more than 4/-.

Discussing Arnott's proposal to modify the Respirator by substituting a counter-current system of thin-walled valved metal tubes, he supposed sarcastically, that it might work: 'If we had two windpipes - one, for instance, from the right lung, going to the nose, and the other from the left lung to the mouth, and had the power of expanding the right side of the chest while we contracted the left, and vice versa...'

Jeffreys' series of articles was followed by the publication in the 'Lancet' of a most unpleasant anonymous personal attack, by someone who signed himself 'Medicus.' I wondered what could have caused all the animosity that was being directed against Jeffreys, and after some thought it struck me that probably the worst thing that he could have done in the eyes of the profession was to advertise to the public. Acting on this suspicion, I searched 'The Times' and 'Morning Post', and eventually found an advert that seems first to have appeared in both papers on Friday 12th October 1838. It read as follows: 'THE BREATH-WARMING INSTRUMENT. - Mr. JEFFREYS' RESPIRATOR, for the use of all persons to whom the breathing of cold air is distressing and injurious, and for affording rest at night where it is interrupted by cough. It renders warm and genial the most cold and foggy air. From the numerous communications the Inventor has been favoured with, describing in strong terms the relief afforded by the Respirator, he need not hesitate to refer inquiries to any of the invalids in the different parts of the kingdom, wearing the instrument, whose number amounts to many thousands, and these will confer an obligation upon many a person meeting its use if they will make known to the neighbouring agents the result of their
own experience of the effects of the Respirator during whatever period they may have used it. London depots are 82, Cheapside, and 148, Regent Street; wholesale office, Cheapside. In London and the larger towns certain respectable houses are also agents for the Respirator.'

This advertisement, which could learn little from modern advertising practices, since it managed, for example, to repeat the name of the instrument four times, reappeared in a shortened form the following week, but with the addition of a list of suppliers, among whom are several familiar names, notably Mr P. Squire, chemist to the Queen, Messrs Savory and Moore, Mr John Read, inventor of the syringe-pump, Messrs Weiss, and Mr S. Maw, who later seems to have become the main distributor. The advert reappeared sporadically during that winter.

In 1840 Jeffreys was campaigning against the increasing importation and use of opium in this country. In 1841 he was elected Fellow of the Royal Society. In his application he gave Bath as his usual place of residence. Among his sponsors were the celebrated historian and philosopher of science, William Whewell, and the Presidents of both Royal Colleges.

Humidifiers and the respiratory tract

In 1842 he published a very long series of articles in the 'London Medical Gazette', entitled: 'On artificial Climates and the Restoration and Preservation of Health'. There is an indication that these may have been prepared at the invitation of the Editor, and that they were originally intended to be the first part of the book that Jeffreys published the following year. In these papers he set out his ideas about the pathology of diseases of the respiratory tract, and their treatment.

We cannot see the lining of the trachea, he said, but we can see a analogous membrane, the surface of the eye. From the appearance of the eye when irritated or inflamed, we can infer the appearance of the trachea - the swelling, the redness, and especially the dryness. He went on to conceptualise the idea that both the skin and the respiratory membrane are external surfaces of the body; so both are open to the actions of the atmosphere, but they meet only at the nose and the mouth. Hence it is possible to put the lungs and the skin under the influence of different climates, an idea that had previously commanded little attention. So one can supply warm, moist air to the lungs, while keeping the skin cool and dry.

He went on to consider the workings and effects of humidifiers, Mudge's and others, and gave a long account of the physical principles on which the function of the Respirator was based, and of its construction. He discussed the importance of clean air, and the need to filter the atmosphere in large cities, because it was heavily charged not only with dust, but with acrimonious particles of all kinds, mainly composed, as his investigations with the microscope had shown, of dried horse droppings. He found it surprising that healthy lungs could endure unstrained city air, and a marvel that affected lungs could sometimes recover while breathing it. To employ drugs to suppress cough before
removing the chief atmospheric cause of it, '...may be compared to the act of a native surgeon in India, whom I found applying a plaister of opium and herbs to the foot of a person in great pain, in which there proved to be a very large thorn, which he had overlooked'.

As regards warming, a person in a cold room lost heat in two ways - by conduction and by radiation; many people entirely overlooked the second. So, Jeffreys continued, not only should the air be heated, but there should also be a source of radiant heat, so that too much atmospheric warming would be unnecessary. He himself had designed a stove exactly for that purpose.

He went on to stress his conviction, arrived at after lengthy study, that ventilation should be adequate in volume and, contrary to current practice, should be from above downwards. This would avoid draughts, avoid raising and dispersing dust, and would bring the freshest air first to the mouth and nostrils. He advocated such a system for the ventilation of the new House of Commons, but his views had been disregarded. Air had been brought in at floor level, and extracted near the ceiling, but within a short time the volume of complaints from members was such that the whole system had had to be reversed. In his view, the application of scientific principles to the many domestic wants concerned with comfort, health, and even life, was of the greatest importance, and not only one science was concerned, but several.

In the next year, 1843, Jeffreys published a book of some 230 pages, entitled: 'On the Statics of the Human Chest'. The first two-thirds of this book, which deals with the physiology of lung volumes, and theories of metabolism, is most interesting and important; the last third is totally cranky. Jeffreys made at least two important contributions concerning lung volumes and their measurement, that were then absorbed into the work of Hutchinson. He was also one of the first to make some cogent criticisms of some of the metabolic hypotheses of Liebig, published in his 'Animal Chemistry' of 1842, for which others were later given the credit.

In 1844 Jeffreys modified the Respirator patent to include a nasal model, and also to allow for the addition of detachable packets of plates, so as to increase the power of the device when necessary. In 1850 he modified it again, providing a louvred front. Also, there was a model which attached to the handle of an umbrella.

There can be little doubt that the Respirator was an effective device. Many tens of thousands were sold, and the design was widely copied. Purchasers were invited to write to the suppliers, who collected bookfuls of testimonials. People who had been housebound during the winter reported that they were able to continue at work. Those who had been forced to winter abroad found that they were able to remain in this country. People slept better, with no cough, and warm feet. It was in use on the Continent, and was being produced also in Germany. But an unforeseen complication was the effect on the general practitioner. Patients could buy a Respirator from the chemist, and no longer needed to visit the doctor regularly and pay for his bottle of linctus; and the adverse effect on their incomes seems to have accounted for much of
Jeffreys' unpopularity with some members of the profession. But
Jeffreys, for his part, stoutly defended his patent. Apart from all
other considerations, he declared that he would rather live on the
returns from his intellectual property, which was bringing great benefit
to the public, than on the income gained by prescribing ineffective
rubbish. Because it was, in a sense, a form of 'alternative' medicine,
not being prescribed by the doctors, the Respirator received no mention
in the textbooks; but with so many having been sold, it is surprising
that it has faded so completely from memory, not appearing even in books
or collections of Victorians.

More inventions - more troubles

In 1851 Jeffreys invented a much improved method of launching ships'
lifeboats, greatly reducing the tendency to capsize. After successful
trials it was fitted to a number of vessels, and it substantially
increased the rate of survival from shipwreck.

Then in 1854 the Respirator came under fire again, on this occasion in a
letter to 'The Times' from a lecturer on chemistry at St Bartholomew's
Hospital, John Stenhouse. Stenhouse was pioneering the use of
charcoal as an adsorbent of unpleasant odours. He wrote drawing
attention to this innovation, and he followed up his letter with a
lecture at the Royal Institution in March 1855. Among his proposals
was that charcoal be incorporated into a breathing device, sandwiched
between two layers of metal gauze, and this led him to attack Jeffreys'
instrument, and to repeat the allegations made by Arnott almost twenty
years earlier, but with additions, implying that Jeffreys had stolen the
idea from Arnott.

In the Red House Museum at Christchurch near Bournemouth, I came across
what seems to answer the description of Stenhouse's device; it was made
by Bourne & Taylor, and the retail price was 4/-.

Stenhouse's attack had the beneficial effect of stimulating Jeffreys' older brother,
Colonel Edward Jeffreys, to write a booklet, a confutative biography, in
which he set the record straight, and provided some useful information
about both Jeffreys and the family.

During the Crimean war, Jeffreys invented a projectile intended to
demolish the Russian fortifications that sounds very much like the
modern armour-piercing shell, but he was unable to interest the War
Office in it. He also, with much foresight, strongly advocated the
fire-proofing of battleships.

Then in 1858 Jeffreys published his last work, 'The British Army in
India', into which he distilled all his experience and his thoughts. It
deals with the topics we have mentioned, life in a hot climate, and the
preservation of health. It received a very long and most laudatory
review in the 'British Medical Journal'. At last Jeffreys' quarrel
with the profession was over. The Respirator was exhibited at the
1862 International Exhibition, and was featured in a full page
description in the catalogue. (I am grateful to Richard Ellis for
drawing my attention to this.)
Jeffreys died at Richmond on 13th May 1877, and is buried in the cemetery there. With the help of the old-boy network of cemetery superintendents I was able to discover both the cemetery and the location of his grave. In his will he refers to a different wife from the one he married in India, and to only two of his five children, one of whom had emigrated to New Zealand. He had retained an interest in the Respirator, but his whole estate was valued at less than £2,000.

The Respirator remained a stock item available from pharmacists, being strongly promoted during the winter months, as can be seen from advertisements in the 'Chemist and Druggist'. It was, for example, the subject of whole-page advertisements during 1879, and pharmacists were being offered mahogany display cabinets free. It appeared in Arnold's catalogues for 1885 and 1895, and it continued to appear in Maw's catalogue for the next fifteen years or so, but then it gradually dropped out of use; but the principle was reintroduced, unknowingly, by Walley in 1956, as an auto-humidifier for use with mechanical ventilators, and it soon appeared in a more elegant form. The physical principles on which it was based were explored by Mapleson and his colleagues in 1963, and in a most interesting piece of research they, again unwittingly, provided justification both for Jeffreys' design, and for everything that he had claimed.

Summing up, Julius Jeffreys could claim credit for some remarkable innovations in India. Also, he invented the Respirator, made important contributions to respiratory physiology, and to the science and practice of heating and ventilation; and he was one of the earliest environmentalists. He embodied all the qualities that characterise our idea of the typical Victorian, he was inventive, enterprising, entrepreneurial, and philanthropic. He had a simple religious faith that was strongly combined with a belief in progress and in the ability of science to solve all problems - to the extent that the single-minded application of scientific principles, unaccompanied by common sense, took him into the ridiculous on more than one occasion.

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16. Stenhouse J. Charcoal as a disinfectant. The Times 1854; Nov.22:8(Col3).
Within a matter of days of anaesthesia's introduction into Britain, Dr John Snow, capitalising on his earlier scientific training and knowledge, designed an efficient inhaler for giving ether. Subsequently, improved versions of this, and other inhalers designed by Snow, helped to ensure his (and others') success in the administration of anaesthetic agents. He also developed various methods for giving medicated inhalations. This paper will review some of the features of the twenty inhaling devices invented or used by Snow, and of the agents which he administered with them.

The devices can be classified as follows:

I. 'ACCURATE' ANAESTHETIC DEVICES
   a. Ether Inhalers:
      1. Mark I
      2. Mark II
      3. Mark III
      4. Mark IV

II. 'INACCURATE' ANAESTHETIC DEVICES
   11. 'The Small' Chloroform Inhaler
   12. Sponge
   13. Simple cloths
      - Towel
   14. Handkerchief
      - Napkin
   15. Bottles

III. MEDICINAL INHALERS
   17. The 'Larger'
      - Heated
      - Unheated
      The 'Smaller'
   18. Woulfe's Bottle
   19. Simple Straw

Dr. Ellis did not wish to publish a full paper in this Proceedings but consented to the use of this brief abstract. Ed.
Diethyl ether was first reported to induce epileptiform seizures in 1922 by Patch, a Liverpool anaesthetist who described two non-fatal cases in young men having limb surgery. In one, a 30-year-old having a finger amputation, the convolution began after seven minutes of anaesthesia and the generalised fit which started in the facial muscles lasted 40 seconds. The second patient had a similar attack but was a known epileptic. Although these seem to be the first reported cases of 'ether convulsions' the clinical descriptions differ from the classical case.

It is fascinating to realise that the first two major papers on ether convolution were published on the same day, May 28, 1927, they were both written by Manchester anaesthetists and neither referred to the other's work. Pinson published in the 'British Medical Journal' and Wilson in the 'Lancet'.

Wilson, describing himself as the First Anaesthetist at Manchester Royal Infirmary recorded four fatal cases of ether convulsions, all occurring within a year of publication. He believed the ether to be impure as it contained 'a conspicuous amount of aldehyde ... [and] ... definite test as regards peroxide.'

Pinson, quoting from a personal experience of nine years' anaesthesia, during which time he had anaesthetised 11,000 persons, recalled 15 cases of ether convulsions, five of which were fatal. In none of his cases was there a history of epilepsy or chorea. Interestingly, Pinson described the muscle activity to be more a spasm than a convolution. The other important difference is his observation that the first sign in his cases was a breathing problem which he attributed to an excess of carbon dioxide.

These two papers triggered others to report their own experiences and to express their own opinions as to the aetiology. These included Langton Hewer (who not only dispelled Pinson's CO₂ theory but recommended CO₂ to treat the condition); Hornabrook, who suggested atropine overdosage to be the cause; Boyle, who supported the impurity theory advanced by Wilson; Fairlee Dickson and others.

Wilson in his 'Lancet' paper, mentioned that he had written to 24 anaesthetists in various parts of the country, and had received comments from several of them. One respondent was Hadfield from St Bartholomew's who had written on behalf of the Joint Anaesthetists Committee of the Royal Society of Medicine and Medical Research Council. It is not surprising, therefore, that on May 4th 1928 Hadfield addressed the Section of Anaesthetics of the RSM entitling his paper 'Later Ether Convulsions'. He reported the St Bartholomew's cases which had occurred in 1926, several of whom had died on the operating table or post-operatively. The discussants included Shipway, who blamed Pinson's Bomb, Ashley Daly, who described five cases occurring between 1913 and 1925, Mennell, who reported eight cases from St Thomas's, Boyle, Featherstone and McDonald.
The cardinal features of ether convulsions at that time were: deep ether anaesthesia (though not only ether, as convulsions had been described with chloroform) muscle spasms; excess CO\textsubscript{2} and acidic breathing; raised body temperature due to infection and toxaemia, atropine, hot anaesthetic vapours or hot environments and cyanosis. The condition usually occurred in young persons and males were more commonly affected than females. An incidence of 1:5000 was recorded with a mortality of 25%. Lee summarised ether convulsions as a triad of deep anaesthesia, hyperthermia and hypercapnoea.

Thus the clinical syndrome bears some remarkable similarities to the only other major hypermetabolic syndrome occurring during anaesthesia - malignant hyperthermia - which was first described in association with ether anaesthesia 38 years after ether convulsions. The cardinal features of malignant hyperthermia are (in similar order): deep inhalation anaesthesia, muscle rigidity, excessive CO\textsubscript{2} production and hyperpnoea, raised body temperature and cyanosis. It also usually occurs in young persons and males are more commonly affected than females, while there is an incidence of 1:6,000 to 1:200,000 depending on the source, and a mortality rate of 24%. The main clinical difference is in the type of abnormal muscle contraction, with clonic activity in ether convulsions and spasm or rigidity with malignant hyperthermia. Also, I am unaware of any genetic predisposition to ether convulsions whereas malignant hyperthermia predisposition is inherited as a Mendelian dominant characteristic.

Even if the two conditions are fundamentally different, the patho-aetiology may be common to both. Convulsions cause an increase in heat production due to muscle activity and an increase in CO\textsubscript{2} production which further increases heat production by a concomitant release of endogenous catecholamines. Therefore the dominant feature of the ether convulsion could be hypermetabolic and its secondary manifestations such as cyanosis. The hypermetabolic effects of the convulsions would be compounded if the body was already hypermetabolic with infection, atropine overdosage or in a hot environment.

I do retain a belief that some cases of 'ether convulsions' could be cases of malignant hyperthermia, but this is hard to prove after 60 years.

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My interest in this small episode in Sir Humphry Davy's life came about through his connection with Henry Hill Hickman. It is well recognised that Dennis Smith is the uncrowned king of Hickman research and what follows is in no sense an attempt to usurp him - indeed, all my source material was obtained from Dr Smith's work, and I would like to pay my tribute at the outset to his industry and scholarship.

Some years ago, I anaesthetised the husband of Hickman's great, great grand-daughter. He was an interesting man. He had an Oxford degree in PPE and had spent some time in Africa studying anthropology before drifting into teaching, and becoming headmaster of Steyning Grammar School, about 10 miles from Brighton. His wife Jean was descended form Hickman by the female line in every generation. I became interested in Hickman through her, and during a recent pilgrimage to Hickman country, I happened upon several interesting facts.

Hickman had completed his first series of seven experiments in which he had performed apparently painless surgery on small animals anaesthetised with carbon dioxide, but he needed to get his results presented before an influential scientific audience for criticism and publicity. He chose to describe his work in a letter to Thomas Knight FRs, a local squire and expert horticulturist who lived at Downton Castle, two or three miles from Hickman's birthplace, and he must have hoped that Knight would show his letter to Sir Humphry Davy. Davy was a regular visitor to Downton Castle, where he valued the peace and quiet and enjoyed the scientific company of his host; but Davy was a keen fisherman and perhaps the greatest attraction was the River Teme which flowed through the castle grounds and contained a plentiful supply of grayling.

Thomas Knight's daughter has left some reminiscences of one of these visits: '....I in the Autumn of 1811 a visit from Sir Humphry Davy caused some amusement. To his surprise my father heard that D and party had established themselves at a little Inn at Leintwardine instead of coming to the Castle as usual.... and a messenger was at once dispatched to learn the cause of so unusual a proceeding. The next morning Sir H appeared in person and after some hesitation said that 'a lady was of the party'. It soon appeared that the lady was a Mrs A.Preece, a blue stocking widow, to whose literary soirees Sir H had taken my father in the preceding Spring. An invitation was then sent to the whole party.'

'The Widow appears'

'Mrs P explained that she was on the way to Herefordshire and that she had been induced to linger a few days by the beauty of the country.'

Thomas Knight's daughter continues: 'She was showy in person and conversation, handsomely dressed and highly rouged. Her admiration for H's talents was very evident and no other conclusion could be come to but that she intended to bestow herself and her fortune on him and we
suspected the latter was the more attractive to him. ... They were married in the following Spring.'

Downton Castle is now owned by a Greek and unless personally invited, it is impossible to get into the grounds or see the castle. Certainly the response of the gatekeeper when I told him of my interest, and asked him for special dispensation to take photographs was straight and to the point: 'I'm paid to keep people like you out'.

However, I had a stroke of luck at a nearby pub that night when I got talking to the worthies in the bar, one of whom worked on the castle estate and clearly had no love for the management there. He gave me directions, drawn on the back of a paper napkin, for getting on to the estate at an unmanned crossing point without getting my backside peppered with buckshot. The next morning I got a view of the castle and the actual section of the Teme which Davy used to fish - under the bridge is a weir and the water is too rough to fish downstream of it.

And what about the pub where I had stayed the night before? It was the only place for miles around with any vacant accommodation that night, and quite by chance it was in Leintwardine. There are two pubs in Leintwardine today, but the second was built in the 1930's when a council estate was put up.

My pub, the Lion, has been there since 1640, so it has to be the one in which Davy stayed with his blue stocking widow. It is by the river - and a place of obvious attraction to a fisherman like Davy.

I will let Thomas Knight's daughter have the last word on Davy. 'We looked forward to his arrival with considerable awe, but to our surprise came a shy man who blushed and held his head down when he was spoken to and was very soon running races with us on the lawn. He was said to have been spoiled by the way he was courted by great people, but to us he was always unaffected and affectionate and there was a combination of poetry with science in his conversation that was particularly attractive and which I have never met in any person.'

Reference

I should like to start by explaining how I, as a non-medical man, came to present this paper to the Society.

It all began some two years ago when Dr Ward and I sat opposite each other at a professional dinner in this very hotel. On seeing my surname, Dr Ward asked if I was aware of Sir Humphry Davy. 'Of course,' I replied, 'he was my great-great-grandfather, indeed my brother has Humphrey as his middle name.' 'Well', he said, 'that is interesting. We are having a conference in Huddersfield in a couple of years, perhaps you would like to come along and say a few words?' 'Delighted to', I said, and promptly forgot all about it.

When, a few weeks ago I received the letter outlining the programme, it tended to crystallise my thinking (a bit like being hung tomorrow). So I got down to some serious research. Unfortunately, I soon came across a bit of a snag. As far as I have been able to discover, and despite their best efforts, Sir Humphry Davy and the Blue Stockinged Widow didn't have any children. As I am sure you can appreciate, for someone who has spent 48 years assuming he was a great-great-grandson of Sir Humphry Davy, this was a somewhat disconcerting discovery, and when it is also only a couple of weeks before one has to give a talk on the subject, it's downright petrifying.

Happily, I can now become much more positive, because it seems likely that we actually are related to Humphry's younger brother John, who was not only very close to Humphry, but was also a distinguished physician, surgeon and writer of his times. Indeed, it was Dr John Davy who looked after Humphry during his convalescence at Ravenna in 1827, and again, early in 1829, when he was so ill in Rome. Shortly after completing 'Consolations in Travel or the Last Days of a Philosopher', Humphry wrote to Dr John with the words: 'My Dear John, I am dying, come as quickly as you can'. Dr Davy arrived in Rome on 16th March and Sir Humphry rallied somewhat, leaving Rome on 20th April and reaching Geneva on 28th May. The following day he died with Dr John Davy at his bedside.

John Davy was 12 years younger than Humphry, having been born on 24th May 1793, the second son of Robert Davy. Determined to become a surgeon, which had been his original ambition, he studied medicine in Edinburgh, taking his degree in 1814. It is interesting to note that when some of Humphry's advanced theories were under attack, John strongly supported his brother and made experiments in the laboratory of Edinburgh University before many learned men of the time and obtained results which entirely confirmed his brother's theories.

* See Dr Armitage's paper. Ed.
Dr John Davy then entered the army as a surgeon and served extensively overseas, becoming ultimately, Inspector General of army hospitals.

Encouraged by his elder brother, John wrote many books and papers both on his travels and also his work. After Humphry's death, he edited 'Memoirs of Sir Humphry Davy' published in 1836, and in 1839 edited his brother's collected works. In the same year he published another of his own works entitled 'Researches, Physiological and Anatomical'. A later work was entitled 'The West Indies Before and Since Slave Emancipation, Comprising the Windward and Leeward Islands Military Command'.

**Piscatorial Soliloquies**

I believe that talking today about Dr John Davy is very fitting, because in 1834, 'After Humphry', John was himself elected a Fellow of the Royal Society. Like Humphry, he was also a great lover of fishing. Indeed, in 1855 he published a book entitled 'The Angler and His Friends', or 'Piscatorial Soliloquies and Fishing Excursions', in which he pleasantly described the deep delight he took in angling over the Lake Districts of Westmorland and Cumberland. By 1863, he had published 152 books, memoirs and medical papers.

I mentioned earlier that John and Humphry were very close. When Sir Humphry died, he made several bequests to his brother, including the Service of Plate presented to him for the discovery of the Miners' Safety Lamp, and expressed the wish that it should be sold to endow a prize medal if John should not be in a position to use it.

On his own death, almost thirty years later, on 24 January 1868, John Davy made a bequest in accordance with this wish and an annual prize for the Best Chemical Discovery in Europe or America was founded by the Royal Society. Something which could be truly said to be 'After Humphry'.

Whilst my researches have not as yet thrown up a continuing dynasty of doctors and scientists, I can confirm that much of the very early work of Humphry Davy in the field of anaesthetics has been resolutely carried on by the family. It is well known how Humphry and his friends, Coleridge, the Earl of Durham, Roget, Watt Wedgwood and others would gather for convivial evenings inhaling nitrous oxide. Much of this valuable work was carried on because in the late 1800's his great nephews founded a brewery and winery in Greenwich, London. Still family owned, it has expanded and now includes over 60 notorious London Wine Bars, going under such names as The Boot and Flogger, The Crusting Pipe, Skinker and Jingle Boy.

So, one may be confident that after Humphry, the Davy family still plays a leading role in anaesthetising the senses of the population of London and in particular, City folk between the hours of 12.00 and 3.00.
The use of convulsive therapy in attempts to alleviate mental illness was introduced by Paracelsus in the sixteenth century. He contributed substantially to the rise of modern medicine. He introduced the treatment of syphilis with mercury, outlined the theory of homeopathy and made use of oral camphor as a convulsant in the treatment of mental illness.

In 1785, Oliver treated a depressed patient with a large dose of oral camphor, apparently with good results. The patient became depressed again two years later but this time the camphor treatment did not work. In 1930, Muller reported two cases of catatonic schizophrenia who developed epilepsy and were cured. Dietelm reported a deeply depressed patient whose depression improved after developing epileptic seizures. In 1934, Mehuina used camphor in oil by intramuscular injection, but it sometimes took two hours for the convulsion to occur, and sometimes led to multiple fits, so he changed to intravenous Cardiazol and suggested combining it with insulin coma. Like a number of others, he was a firm believer in the antagonism between schizophrenia and epilepsy.

In 1745, with the introduction of the Leyden Jar Condenser, electricity was used as a convulsant. John Franklin and John Wesley were enthusiasts. In 1799, with Volta's introduction of the battery, galvanic stimulation was used. Charcot used electrical convulsions in the treatment of melancholia. In the late 1830s, faradic, or alternating current, was used but rarely produced convulsions, as it was not of sufficient strength. In 1938, Carlotti and Bini, after some horrifying and usually fatal animal experiments, used electrodes applied bilaterally to patients' temples. The results, particularly in the elderly, were confusion, memory loss, and often fractures.

In the 1950s, with the introduction of short acting muscle relaxants and the use of intravenous anaesthesia, sinusoidal current was replaced by pulsed current, and bilateral application of the electrodes was replaced by unilateral application to the non-dominant side, with a view to causing less confusion and memory loss. There is a slight problem here, as many left-handed people are left side dominant. Confusion and memory loss are thought to be much reduced in unilateral ECT, but this may be due to the fact that less current reaches the brain for a shorter time. The effect of a course of ECT is related to the sum of the convulsion-time totals. There is no doubt that elderly patients, and those with mania, respond better to bilateral ECT.

In the 1960s, there was a vogue for regressive ECT in the treatment of schizophrenia. Patients were given a series of ECTs, usually three in rapid succession, no time being wasted on reoxygenation between fits. The treatment was accompanied by very heavy sedation, and the patient was reduced to the state of a zombie. He was then put into a very rigid programme of activities to build up a new personality in place of the one destroyed. This method of treating schizophrenia was still being used in this area in the 1970s.
Efficacy of ECT

The success rates of drug treatments compared with ECT are usually given as: monoaminoxidase inhibitors, 50%; tricyclic agents, 40%; and placebo, 25%. The effect of placebo treatment is shortlived.

Many studies have been carried out to compare the effectiveness of:
   - ECT with anaesthesia, muscle relaxant and convulsion;
   - ECT with subconvulsive dose;
   - anaesthesia alone without ECT and anaesthesia plus a muscle relaxant without ECT.
There is no doubt that the most effective treatment is ECT with anaesthesia and a muscle relaxant. There is no justification for the use of 'straight' ECT. Patients who have been subjected to it say it is like being kicked in the head.

I have only one success story of a patient who was given anaesthesia alone. He was unable to destroy suxamethonium or any other relaxant. He was put to sleep once a week for ten weeks and did extremely well. He was even able to return to work.

When our Unit opened in 1965, very few patients were given any drug treatment to accompany the course of ECT. The numbers of patients were very much higher. More than a third of the patients came for treatment as out-patients. This required very careful supervision; making sure they attended when they should, that they were fasting, and that they did not drive themselves to hospital or back home after an anaesthetic and ECT. In 1965, from April to December, we carried out 9,500 treatments at St Luke's Hospital. In 1989 the number of treatments was 1,020. I imagine this is due to the advances in the use of antidepressants. One of the most striking advances has been the use of the depot drugs in the treatment of schizophrenia. This has been a great blessing since ECT is not very helpful in this disease.

Whether the drop in the number of treatments will continue, I very much doubt. The number of elderly depressed patients is rising steadily, as people live longer and lose a partner. It is no longer possible to transfer such patients to long-stay psychogeriatric hospitals. The accommodation no longer exists. And these old people do very well on ECT.

I have reservations about the use of 'maintenance' ECT. It may simply be the effect of a bit of care and a bit of company. ECT is thought to work by the release of neurotransmitters in the brain, the most likely being noradrenaline which is found in the limbic area and the brainstem. Reserpine reduces the brain concentration of noradrenaline and certainly produces depression.

The improvement that follows ECT persists long after treatment ceases. Ideally, treatment should be carried out three times a week. If it is only given twice a week, patients can be seen to slip back before the next treatment.
For ethical reasons, it is very important to follow the rules of consent to treatment or 'Sectioning' of patients unable to give informed consent. It is equally important to have proper accommodation and equipment, and to consider the training of nursing and junior medical staff. Many nurses start out with an ignorant and hostile attitude to ECT, which can easily be overcome by explaining the problems of the anaesthetist, the importance of pre-treatment tests, the possibility of undesirable drug interactions and the complications that can be caused by the patient's physical condition. I have always found it easy and rewarding to get them interested in learning.

Junior medical staff can be a problem. They tend to think of ECT as a disagreeable chore which is beneath them. Several of them have informed me that the anaesthetist is there to carry out their orders and not vice versa. We now have a steady supply of GP trainees whose attitude is much more professional.

I have kept my own detailed records for twenty-five years, and have found them invaluable. Psychiatric hospital notes are so often scrappy and disorganised and are frequently illegible. For instance, I had a run of twelve patients on Clopixol, all of whom showed marked delay in starting breathing after treatment. My records showed that they had all received suxamethonium from one batch, suggesting a reaction between that agent and that batch of Clopixol. I waited hopefully for one or two of the twelve to return for another course of ECT, but alas, none of them did.

In Huddersfield we have a substantial 'ethnic' population who present rather different problems. The West Indians are mainly second generation immigrants, speaking good English but with poor educational attainments, very much bound to their own culture and intensely superstitious. They have high incidence of schizophrenia and an incidence of mania three times higher than the native population in the case of men, and six times higher in the case of women. Many of the younger men use cannabis and always revert to its use when they leave hospital. There has been a foolish campaign recently for the legalisation of cannabis by people who state that it is harmless and are apparently unaware of the close link between the use of cannabis and schizophrenia.

Sickle cell anaemia is something we have to think about. There are a number of families in this area who are fully sickle cell positive. Many West Indian women are diabetics and it is quite impossible to get them to keep to a sensible diet. The Indians are mainly Gujaratis, who are well educated and speak good English. They have a higher than average incidence of depression and schizophrenia. It may be that they come with higher expectations. The women certainly react badly to crowded living conditions. The Pakistanis are Muslim, mainly illiterate and claim to speak little English, but in fact, understand a great deal. The incidence of depression and schizophrenia is lower than in the Indian population, but they all seem to have 'psychiatric' relatives at home, whom they frequently bring over here for treatment. They have tendency to transfer their psychiatric problems to physical ailments. Tuberculosis was a real problem in the 1960's but is now rarely seen and much more easily dealt with.
I have not had much to do with Sikhs as patients, but had an unfortunate experience with a Sikh doctor who suddenly went off his head in the middle of a treatment session and started screaming at me that I was putting the evil eye on him. Before anyone could stop him he clamped the electrodes on my arm and pressed the button. He was sacked, but not, to my annoyance, for giving me unauthorised ECT but for going off to Blackpool when he should have been on duty. I last saw him driving the wrong way round Shawhead roundabout, pursued by the police.

I feel very strongly that ECT is a lifesaving procedure in endogenous depression. The misery of the patients is indescribable. If the condition is not quickly resolved, their physical health, their jobs and often their marriages are at risk. It is important the person in overall charge of anaesthesia for ECT should have seniority. Psychiatrists, like ophthalmologists, know depressingly little about physical illness, and feel that these problems belong purely to the anaesthetist. It is important to be able to stand up to them, where the safety of the patient is concerned, and no junior can be expected to do so.

I remember the patient with an enlarged prostate, urinary retention, hydronephrosis, hydroureter and a blood urea of 132mg/100ml. The sole contribution of the psychiatrist was to put the unfortunate lady patient on imipramine. Or the lady with a recently broken neck; I was assured she had been seen by a consultant orthopaedic surgeon, who had authorised treatment, but had been in too much of a hurry to write anything in the notes. Not surprisingly, since he was on holiday in Scotland. Or the lady who had just been operated on for a detached retina - ECT would have been ideal postoperative treatment!

But my all time favourite is the girl we battled for a week to get out of status epilepticus only to find her down for ECT on Monday morning.
**THE DEVELOPMENT OF NITROUS OXIDE-OXYGEN APPARATUS**

Professor L. Rendell-Baker

This is the story of how three American dentists - S.S. White, Charles K. Teter and Jay A. Heidbrink became interested in nitrous oxide and oxygen anaesthesia, designed their own apparatus and became major manufacturers of anaesthetic equipment. They were ably supported by two physicians - one, Elmer I. McKesson, became an important manufacturer who also practised and taught anaesthesia, and ran a pioneer anaesthetic group practice for all the hospitals in Toledo, Ohio. The other physician, James T. Gwathmey of New York, probably one of the first Americans who specialised in anaesthesia, designed his own machine which gave birth to the British Boyle apparatus. He also helped to found the American Society of Anesthesiologists.

Dentists were always interested in anaesthesia for much of their practice inflicted pain on their patients. Since 1863, when Gardner Q. Colton popularised the use of nitrous oxide, many dentists prepared this gas and administered it to their patients from a gasometer. However, it was not until compressed gases from cylinders became available - nitrous oxide from Coxeter in London in 1869 and from Johnston Bros in New York in 1871, and oxygen in 1888 - that apparatus providing variable percentage mixtures became feasible.

**Frederick Hewitt**

In London, Frederick Hewitt commenced experiments with various mixtures of gas and oxygen in 1886 using a gasometer. He first reported success with 12% oxygen and 88% nitrous oxide in 1889. This encouraged him to design a portable apparatus with separate bags for each gas. The nitrous oxide came up a central passageway in the apparatus, and up to 10% oxygen was added from small holes around the periphery. An outside quadrant control opened the holes.

In 1897, when his book 'Nitrous Oxide/Oxygen Anaesthesia for Dental Operations' was published, Hewitt advised starting anaesthesia with 2-4% oxygen in nitrous oxide, gradually increasing to 8-9% oxygen before removing the mask for the dentist to extract the teeth. This hypoxic mixture, though tolerated for short dental procedures, became hazardous when used for more prolonged general surgical operations.

**S.S. White**

The Philadelphia dentist and manufacturer, S.S. White, was greatly impressed with Hewitt's publications and in 1900 produced an apparatus based on his design. It had cylinders of nitrous oxide and oxygen which filled individual bags. When a control lever was opened nitrous oxide flowed to a mixing chamber, and from there to the patient. Oxygen was added by opening a control which was calibrated, like Hewitt's, from 0-10% oxygen. This machine had no reducing valves or flow meters and was equipped with a non-rebreathing system. Like Hewitt's, it was designed for short dental procedures only. Purchasers of White's
machine were strongly advised to buy and read Hewitt's book on dental anaesthesia (which was on sale for $1.25) and to follow his advice.

Charles K. Teter

In 1903, Charles K. Teter, a Cleveland, Ohio dentist, introduced his apparatus with which he popularised nitrous oxide-oxygen anaesthesia for general surgery. He convinced George Crile, the famous surgeon and founder of the Cleveland Clinic, of the superiority of the mixture. Later, in 1914, Crile and Lower, with their nurse-anaesthetist, Miss Agatha Hodgins (who was to become the first President of the Association of Nurse Anesthetists), introduced the concept of 'balanced anaesthesia'. They termed their combination of narcotic premedication, nitrous oxide-oxygen with a local anaesthetic field block, 'Anoci-Association'.

Teter's machine also had separate bags for nitrous oxide-oxygen. It had two reducing valves with taps to control the flow of nitrous oxide and oxygen. It is said that each Teter machine came with instructions on how it should be used to produce anaesthesia. Later reports blamed Teter for spreading the idea that 5-10% oxygen in the mixture was adequate, cyanosis could be disregarded and that a state of hypoxia was essential to 'gas' anaesthesia. High consumption of gases was a problem with Teter's machine. Its originator reported in 'Dental Cosmos' in 1907 that, for his longest case of 2 hours and 48 minutes (anaesthesia for laparotomy with division of adhesions) nearly 600 gallons of nitrous oxide were used - approximately one and a half E cylinders, and 80 gallons of oxygen - approximately half of an E cylinder.

Willis D. Gatch

As an economy measure, Willis D. Gatch of Johns Hopkins Hospital, introduced in 1910, the rebreathing principle. His apparatus had an 8 litres capacity breathing bag which was filled with nitrous oxide from a cylinder. The face mask contained valves which provided either non-rebreathing or total rebreathing of the gas in the bag. For induction, the valves were set to non-rebreathing and the patient took in 100% nitrous oxide from the bag. Once anaesthesia had been achieved, a small puff of oxygen was added to somewhat restore the patient's colour and then the valves were set to rebreathing. The patient rebreathed 16 times from the bag before the mixture was removed.

Gatch calculated that the carbon dioxide in the bag would not rise above 4%, which the physiologist Haldane had said was the limit that could be tolerated. Gatch noted that the patient's respiration was vigorous and the pulse was full and bounding. The American physiologist, Yandell Henderson had stated that conserving carbon dioxide prevented surgical shock. After Gatch's publication in 1910, and its support by Henderson, most apparatus included a rebreathing bag.

Elmer I. McKesson

In 1911, Elmer McKesson of Toledo, Ohio produced a new apparatus which provided accurate percentage flows of both gases by means of a single
control; as the oxygen percentage was increased the nitrous oxide percentage decreased. For economy, intermittent flows of gases and fractional rebreathing were provided, using what we would now call a Mapleson A breathing system. McKesson illustrated the first description of his apparatus in 1911 with five of his anaesthetic records. These charted pulse, blood pressure, respiratory rate and the 10% oxygen given for appendectomy, oophorectomy etc! Unfortunately, McKesson’s advocacy of ‘secondary saturation’, during which hypoxia – to the point of respiratory arrest or arrhythmia before oxygen was given, set a poor example and gave rise to many cases of hypoxic cerebral damage in the years that followed.

McKesson designed a large aneroid BP manometer and brachial stethoscope to enable readings to be made easily during anaesthesia. In 1930 he introduced the first automatic recording anaesthesia apparatus, the ‘Recording Nargraf’. This set down the patient’s tidal exchange and the percentage of oxygen given while the blood pressure could also be noted by a simple manual control.

**Jay A. Heidbrink**

Dissatisfied with the Teter apparatus, Jay Heidbrink introduced his own machine in 1912. This had no flow meters but did possess reducing valves. One control adjusted the nitrous oxide pressure and a further control set the desired oxygen percentage between 0 and 25%. The total flow of gas mixture, in gallons per minute, could be regulated. A 6½ litres capacity reservoir bag was provided, with a Mapleson A type system to permit partial rebreathing. The apparatus also had a stop watch attached.

In his papers Heidbrink instructed the user to administer 93% nitrous oxide with 7% oxygen at a rate of 3 gallons per minute for one minute by the watch. At the end of this time the oxygen was to be shut off and nitrous oxide alone given for 40 seconds or until the degree of anaesthesia desired for dental operations was reached. The anaesthetist should then turn on 7% oxygen with 93% nitrous oxide. In the average case anaesthesia would have been maintained without changing the proportions of gases.

When Dr Heidbrink retired in 1938 he sold his company to the Ohio Chemical Company of Cleveland and the combined organisation moved its operations to Madison, Wisconsin at that time. In the 1970’s, the British Oxygen Company bought Ohio and changed its name to Ohmeda and Anaquest.

**Accurate flow meters**

In 1910, the German physician Neu had Karl Kupper’s Rotameter flow-meters modified for nitrous oxide and oxygen anaesthesia. Unfortunately, the high cost of the Rotameters and of imported nitrous oxide in Germany, prevented wide acceptance of this apparatus. A pity, for these were the first accurate flow meters. They didn’t come into widespread use in Britain until 1937.
In 1912, Boothby and Cotton introduced the bubble flow meter which was adopted for Gwathmey's machine in New York and later by Boyle for his version of the Gwathmey apparatus.

James T. Gwathmey

The apparatus devised by Gwathmey in 1912 (with the improved version of the bubble flow meter) mixed expired and fresh gases. In 1913, Gwathmey, Teter and Crile took part in an International Symposium in London on nitrous oxide-oxygen anaesthesia and did much to popularise the method in Britain.

First World War

On the outbreak of war, George Crile took an American Red Cross hospital unit, which included Agatha Hodgins, his anaesthetist, to Paris. Colonel Berkeley Moynihan, a British Army Consultant Surgeon, was 'sold' on Miss Hodgins' nitrous oxide-oxygen anaesthesia and Anoci Association method for the wounded. For her demonstration Miss Hodgins used the Ohio Monovalve machine - the company's first anaesthesia apparatus, produced in Cleveland, Ohio in 1912. Like others, it had separate bags for nitrous oxide and oxygen and also two-stage reducing valves which filled the bags to a pre-set pressure. In the centre it had a control valve with three positions. The first gave 100% nitrous oxide, the second gave a variable mixture of oxygen and nitrous oxide and the third gave pure oxygen. A further control varied the flow of nitrous oxide.

Boyle attended the London symposium in 1913 and was greatly impressed with Gwathmey's apparatus, so much so that he imported one in 1914 and adapted it for British cylinders, retaining Gwathmey's inefficient breathing system. Thereafter all such machines made in Britain were called after Boyle even though he, in one of his papers in 1917 said: 'the machine I use is Gwathmey's'.

While serving from 1915 in a British military hospital in France, Geoffrey Marshall (later Sir Geoffrey) built an apparatus with bubble flow meters to give nitrous oxide-oxygen-ether anaesthesia to war casualties. More compact than Boyle's, it became the standard model in British army practice after 1916. It had the same breathing system as the Boyle apparatus, with the bag attached to the face mask.

Sir Ivan Magill

Towards the end of the war, Ivan Magill and Stanley Rowbotham were sent by the British army to a maxillo-facial trauma unit near London. As general duties medical officers with no surgical expertise, they were assigned the duty of giving anaesthesia to these most difficult problem cases. Initially they used insufflation of ether and oxygen through narrow bore catheters, and then they introduced the present-day wide-bore tubes for spontaneous respiration with nitrous oxide, oxygen and ether. Between 1919 and 1932, they developed the repertoire of techniques and equipment for endotracheal and endobronchial anaesthesia for maxillo-facial and thoracic surgery that we use today. Magill introduced the 'blind' nasal intubation method in 1928 and the breathing
system, now known as the Mapleson A system in 1932. Not bad for two
delayed, unskilled, general practitioner anaesthetists!

As it was not possible to have the Boyle apparatus breathing bag near
the surgical field—usually the patient's face in these cases—Magill re-attached the bag to the machine once more. The tubing
separates the fresh gas from the expired gas permitting efficient carbon
dioxide removal. Examination of American equipment—McKesson's of 1911
and Heidbrink's of 1920—shows that they, in fact, had the Mapleson A
system before Magill reintroduced it in 1932 in Britain.

Closed circuit anaesthesia

In 1915, the American pharmacologist Dennis Jackson introduced an in-
circuit carbon dioxide absorption apparatus. An electrically driven
pump circulated the gases around the system and through the absorbent.
The patient breathed to and fro from a large mechanically ventilated
bag. Although the inventor demonstrated his apparatus at several
anaesthesia meetings, anaesthetists ignored it and so Jackson used it on
the dogs in his laboratory. In 1918, he offered a prototype military
circle carbon dioxide absorption apparatus to the US army. Consultant
surgeons felt it would be too complicated for their anaesthetists to
manage.

It remained for Ralph Waters, in Sioux City, Iowa, to introduce carbon
dioxide absorption into every day anaesthesia. Waters' patients
breathed to and fro from the bag, through the absorbent. Many
anaesthetists found the absorber rather clumsy and it was only widely
used after Waters introduced cyclopropane, which was both expensive and
explosive, in 1930. As a result, Brian Sword's more convenient circle
absorption apparatus was rapidly adopted as a standard breathing system
in the USA to facilitate the use of cyclopropane.

Studies on carbon dioxide absorbers led James Elam and colleagues of
Roswell Park, New York, to complete this saga by introducing the present
day large capacity absorber which has been universally adopted. The
absorber has two compartments, each of which is more than adequate to
accommodate a patient's 500ml tidal volume. Elam reported that with
minute volume fresh gas flow, each chamber of the apparatus had capacity
to absorb for 60-90 hours. This resulted from the components of the
system being correctly arranged so that expired carbon dioxide was
preferentially eliminated and fresh gas was conserved to be delivered to
the patient.
Professor Sir Robert Macintosh, 1897-1989

An appreciation

Dr Thomas B. Boulton

Professor Sir Robert Macintosh died on 28 August 1989. He was appointed as the first Nuffield Professor of Anaesthetics in the University of Oxford in 1937. He thus became the first professor of anaesthesia to be appointed to a university chair outside the United States of America, (his friend and mentor, Ralph Waters having become a full professor of anaesthesia at Madison, Wisconsin just three years earlier).

Robert Macintosh exerted a very considerable influence on the technical and political development of anaesthesia for over half a century. It is true that, apart from his presidency of the Section of Anaesthetics of the Royal Society of Medicine in 1953, he held himself aloof from high office in national and international bodies, but the world-wide prestige of the Nuffield Department of Anaesthetics which he established and developed, his services to anaesthesia in the British armed forces in the Second World War of 1939-1945 and his ambassadorial post-war pilgrimages abroad to developed and developing countries were unrivalled in promoting the interests and status of anaesthesia throughout the world.

Sir Robert's death resulted from a head injury following a fall while exercising his dog after which he never regained consciousness. This was probably fortunate as he made no secret of the fact that, when the inevitable end of his life came, he would prefer sudden oblivion to an existence of geriatric incapacity.

The honours which were showered on Robert Macintosh read like an international gazetteer (Appendix 1) but, though a positive leader and a firm disciplinarian in his Department, he was essentially a modest and sympathetic man with the ability to listen to his juniors as well as his contemporaries - a characteristic which is not always typical of professors. Mac had a well-developed but generous sense of humour and the manners of a perfect gentleman. The writer recollects that, on one occasion when he was about to be admitted to honorary membership of a certain foreign anaesthetic society, he whispered that, actually, his hosts were unknowingly bestowing the honour for the third time; needless to say, he accepted their gesture of good will with grace and dignity.

The Editors of the Silver Jubilee volume of the Nuffield Department of Anaesthetics quote Sir William Osler as writing that the perfect, but very rare professor must be able to think and talk as well as be expert in his subject. Mac certainly had all three of these characteristics, but he also had in addition a number of other important virtues; specifically these were courage and determination and a desire for adventure.
Robert Reynolds Macintosh was born at Timaru, New Zealand on 17 October 1897. He was the son of one of the members of the original All Blacks rugby team. He spent a considerable part of his childhood in Argentina, where his father had business interests, and there learnt to speak fluent Spanish. He returned to New Zealand in his teens and went to school in Watiki where he was a formidable boxer and rugby player.

The First World War - 1914-1918

It was characteristic of the young Macintosh that, after the outbreak of the First World war, he took passage to England, enlisted while under age, was commissioned in the Royal Scots Greys in 1915, and then transferred to the Royal Flying Corps. His exploits earned him a Mention in Dispatches before he was shot down over the enemy lines in France and was made a prisoner of war in Germany.

Mac's companions in captivity included Lieutenant H.E. (Tim) Hervey (a pioneer aviator in peace and war) and Lieutenant Brian Horrocks (General Sir Brian of the Second World War 1939-1945). All three were inveterate escapers and Hervey wrote the book 'Cage Birds' about their exploits. Mac learnt fluent German while in captivity, but despite this, his attempts at escaping, though often successful as break-outs, resulted in recapture on each occasion.

Early medical career.

Robert Macintosh stayed on in the United Kingdom after demobilisation. He entered Guy's Medical School and continued to play rugby actively both before and after qualification in 1924. His first publication was a description of apparatus for blood transfusion which was written during one of his earlier house appointments as Assistant Medical Officer to the Venereal Disease Department at Guy's Hospital.

Mac's sights were set on a surgical career. He passed the examination for the Edinburgh Fellowship in Surgery in 1927, but started to give anaesthetics in private to earn money while looking for an opening to further his surgical career. He became fascinated by anaesthesia and joined the efficient and well-organized practice, sometimes irreverently known as the Mayfair Gas Company, whose members administered anaesthetics in the fashionable dental surgeries and surgical clinics in the West End of London. Robert Macintosh was one of the first to make use of the then recently introduced intravenous barbiturates for the induction of anaesthesia. This technique was at first condemned by some of the more established senior members of the profession, but Mac vigorously defended the practice both in print and at meetings of the Anaesthetics Section of the Royal Society of Medicine.

The establishment of the Nuffield Chair of Anaesthetics at Oxford

Macintosh became friendly with Sir William Morris (later Lord Nuffield), the motor manufacturer and philanthropist, through both social and professional relationships with him. Nuffield had had unfortunate
experiences of dental anaesthesia as a young man. He had suffered the discomforts of inhalation induction with nitrous oxide which contrasted unfavourably with the smooth transition to unconsciousness which Mac was able to provide with the aid of the intravenous barbiturates.

These experiences, and Mac's suggestions, prompted Lord Nuffield to insist on the endowment of a Chair of Anaesthetics at Oxford as a condition of financing those of more well established disciplines which he was donating to the University, and further, much to the astonishment of both the University and the anaesthetic establishment of the day, he went on to recommend the then comparatively unknown Robert Macintosh for the appointment.

Mac was to need all his talents, including courage and determination, to establish the Department in the face of considerable adverse prejudice on the part of the University and the difficulties of superimposing an academic department as part of a postgraduate medical school on what had hitherto been primarily a provincial general hospital.

Professor Macintosh wisely took leave of absence at an early stage to visit the principal teaching hospital departments of anaesthesia both in the United Kingdom and in the United States. He was particularly impressed by the well-organised teaching department of Ralph Waters at Madison, Wisconsin, but much less so with the oxygen limiting techniques of McKesson at Toledo, Ohio. Mac led a discussion on 'Anaesthesia in the USA and Canada' at the Royal Society of Medicine on his return.

Another development in these early prewar years was the collaboration between Macintosh and his nascent department and Nuffield's Morris Motor Works at Cowley which led to the manufacture of five thousand negative pressure respirators (iron-lungs), for use in treating poliomyelitis and other respiratorily paralysing diseases, for distribution to any hospital in the British Empire which asked to have one.

Anaesthesia in the Spanish Civil War

The brief years before the beginning of the Second World War in 1939 included an adventurous humanitarian expedition to administer anaesthesia to casualties of the Spanish Civil War at the request of the American plastic surgeon Eastman Shehan. Shehan's main problem was the difficulty of operating upon maxillofacial patients when the only anaesthetic available was by means of a face mask. Mac had brought a laryngoscope and tracheal tubes with him, but he had to improvise an inhaler for ether in air from a Lyle's Golden Syrup tin on the lines of the principle demonstrated to him by his American friend Paul Flagg some years before. This experience furnished the germ of an idea which led to the design of sophisticated apparatus for the British Armed Services for use during the Second World War. Dr Kenneth Boston, who had been appointed early in 1938 as the first whole-time Junior Assistant of the Nuffield Department, continued the work in Spain after his chief returned to the United Kingdom.
The Second World War 1939-1945

The Second World War brought new responsibilities. Air Commodore Macintosh became the Adviser in Anaesthetics to the Royal Air Force, and vicariously to the other British Armed Services, while continuing to administer the Department at Oxford. This was an excellent arrangement. The Nuffield Department played a prominent part in training the many anaesthetists required for the Services and in developing and evaluating the special apparatus required for anaesthesia and life-saving equipment needed during the conflict.9,15

Many young medical practitioners, who had their initial training in anaesthesia on short courses at Oxford, subsequently became leading civilian consultant anaesthetists in the postwar period when the British National Health Service was introduced in 1948. The Oxford Vaporisers for ether and chloroform were the forerunners of the EMO (Epstein-Macintosh-Oxford) ether vaporiser and the OMV (Oxford Miniature Vaporiser) which were developed for newer volatile agents and have become important in developing countries and military anaesthesia in the postwar period. Twenty seven thousand of the original Oxford Vaporisers were manufactured, distributed, and largely financed by Nuffield's Morris Motor Works during the war.9,14

A number of those appointed to the staff of the Nuffield Department during the prewar and war periods have subsequently become nationally and internationally wellknown. Their names bear testimony to the ability of Professor Macintosh to choose his collaborators, and his desire to include members of other disciplines, both medical and non-medical, who could contribute to his team. They include Professors Pask and Mushin, Chief Technician Richard Salt, who had been his technical assistant in the London practice, Epstein the physicist and Barbara Duncum, the historian.

It was common for members of the Department to join the medical branches of the armed services after varying periods in the Department - particularly, of course, the Royal Air Force. Edgar Pask joined the Royal Air force, but his collaboration with Macintosh continued through the RAF Research Institute at Farnborough. Squadron Leader Pask was subjected to low concentrations of oxygen in his research into high altitude flying, and was anaesthetised by the Professor to the point of apnoea to assess various methods of artificial respiration, and again anaesthetised and flung into a swimming pool to test life jackets. The superlative bravery of Pask is unquestionable as is the heavy burden of responsibility for his safety imposed upon Macintosh.15

The vintage years

The coming of peace in 1945 heralded the period in which the reputation of the Nuffield Department of Anaesthetics was consolidated and its research potential expanded. Many of those who had served in the Department have gone on to lead British and international anaesthesia. The Department became, and remains, an international centre for the initial and advanced training of physician anaesthetists from many
countries, and especially of those who, like Macintosh himself, originate in the antipodes.

Interest in the development of respiratory and intensive care continued ahead of general acceptance in the United Kingdom of the predominant role which British anaesthetists now play in this field. The development of the positive pressure Radcliffe ventilators to replace negative pressure respirators after the Copenhagen poliomyelitis epidemic of 1952, in collaboration with the Oxford firm of H.G.East, was particularly important. Dr Alex Crampton Smith, who ultimately succeeded Macintosh as Nuffield Professor played the leading role in this work.

Professor Macintosh himself became a tireless and peripatetic leader of international clinical anaesthesia. He dedicated himself to supporting and succouring the emergent specialty in many lands, both developed and developing. There must be very few countries in the world in which anaesthetists do not remember his visits and demonstrations with gratitude and affection. He demonstrated that it was possible to practise the principles of modern anaesthesia using simple yet effective appropriate technology such as is provided by the EMO and OMV vaporisers, both of which had been developed in collaboration with the Longworth Scientific Instrument Company (later Penlon Ltd). His paper 'A plea for simplicity', read before a joint meeting of the British, Canadian and Ontario Medical Associations in 1955 and published in 'The British Medical Journal' is a classic. Professor Macintosh recognised the need for, and the needs of, occasional medical, nurse and technician anaesthetists in countries where there were medical manpower problems. Robert Macintosh was honoured with a well deserved knighthood in 1955.

Publications

Sir Robert's publications (Appendix 2) were always apposite and usually clinically practical, and invariably expressed in clear and readable prose. His early communications, before he became a professor, have already been mentioned. His first book, 'Essentials of General Anaesthesia' was written in conjunction with Freda B.Pratt (later Bannister) who joined the Department in 1938 as a Junior Assistant. It appeared in 1940 and was published by Blackwell Scientific Publications. It reflects the vast experience of Robert Macintosh as a dental anaesthetist; it has been criticised as devoting an undue amount of space to that particular specialty, but it ran to five editions - the last being published in 1952.

The wartime publications include a description of Mac's most famous eponymous items of equipment, the Macintosh laryngoscope, which has been adopted as standard for intubation by anaesthetists worldwide. The design originated with the observation that an excellent view of the glottis could be obtained with the Boyle-Davies tonsillectomy gag. There are also descriptions of the series of ether and air and chloroform and air inhalers, which have already been mentioned, and a series of brief communications promoting useful ideas and cautioning against dangerous practices; the latter must have been most helpful to inexperienced anaesthetists in the military medical services.
'Physics for the Anaesthetist' appeared in 1947. The first edition was written in collaboration with Doctor (later Professor) W.W. Mushin, then First Assistant to the Department. Epstein, who was a physicist to the Department from 1940 to 1976 has told us that: 'Sir Robert was not enamoured of abstract theoretical physics'. This is fortunate as the work can be readily understood even by those who are not mathematically minded. Epstein was co-author of the second and third editions and the fourth appeared in 1987 edited by Professor Mushin and Dr Peter F. Jones.

The first editions of the well-known Local anaesthesia series were written in cooperation with various members of the Department between 1944 and 1955. They are beautifully illustrated by Miss M. McClarty. The most successful volume in the series is undoubtedly 'Lumbar puncture and Spinal Anaesthesia'; this has run to four editions - the third and fourth being in collaboration with Dr J. Alfred Lee and Dr Lee and Dr R. S. Atkinson respectively.

Valute

Sir Robert retired in 1965 but he continued to be an active participant at meetings of the Nuffield Department of Anaesthesia, the Royal Society of Medicine and elsewhere, and to lecture and publish on occasion. He described his lecture of 1970 in honour of his old friend Ralph Waters as his 'swan song' but he continued to delight audiences and publish until almost the end of his life.

Three major events occurred in 1987. The first was the fiftieth anniversary of the Nuffield Department of Anaesthetics. This was commemorated by the publication of a definitive history of the Department by Jennifer Beinart, a professional historian. She succeeded in producing a very perceptive and readable account after careful and painstaking research and many hours spent in conversation with Sir Robert and other members of the Department.

The second event was a memorable presentation by Sir Robert on his experiences during the Spanish Civil War during the Second International Symposium on the History of Anaesthesia held in London at the Royal College of Surgeons of England.

Mac also celebrated his ninetieth birthday in October 1987. This important event was celebrated by a meeting hosted jointly by the Royal Society of Medicine, the Association of Anaesthetists of Great Britain and Ireland, and the Faculty of Anaesthetists of the Royal College of Surgeons of England.

Conclusion

Sir Robert Macintosh's life spanned almost the whole of the twentieth century - a period of great sociological and political change. His professional life covered the period which saw the establishment of anaesthesia as a leading specialty. He was a pioneer who appreciated the importance and potential of new attitudes and discoveries before others did so, and developed them on the solid basis of tradition. He became an academic anaesthetist before the need for such appointments
were recognised; he foresaw and promoted the value of anaesthetists participating in respiratory and intensive care; he publicised the importance of local anaesthesia at a time when it was not considered to be a viable alternative to general anaesthesia, and he led the movement for the adoption of modern anaesthetic practice for use in military medicine and developing countries.

Sir Robert was married twice; since the death of his first wife thirty years ago he enjoyed the support and companionship of Lady Ann. Mac did not have any children of his own but countless specialist anaesthetists practising today looked upon him as their professional father-figure, and through them their own trainees benefit in turn from his wisdom, expertise and teaching.

REFERENCES

Author's note on the appendices

The two appendices have been made as complete as possible with the assistance of Mrs. U.G. Spanner, formerly Librarian at the Royal Berkshire Hospital, Reading, but the writer would be pleased to learn of any omissions with dates and, in particular, of any eponymous lectures (other than the Clover and the Waters which are already included), which Sir Robert may have delivered, and details of honorary membership of organisations other than those mentioned in Appendix 1. Correspondence to Dr. T.B. Boulton, Townsend Farm, Streatley, Berkshire, RG8 9JX, England, please.


Professor Emeritus Nuffield Department of Anaesthetics, University of Oxford
Air Commodore Royal Air Force Volunteer Reserve (Retired).

Honours

1955 Knight Bachelor.
1917 Mentioned in Dispatches.
1938 Spanish Order of Military Merit.
1945 Norwegian Order of Liberty.

Medals of Learned Societies

1947 Henry Hill Hickman Medal of the Royal Society of Medicine.

Professional Qualifications

1924 Member of the Royal College of Surgeons and Licentiate of the Royal College of Physicians of London.
1927 Fellow of the Royal College of Surgeons of Edinburgh.
1937 Master of Arts and Doctor of Medicine, University of Oxford.
1948 Fellow of the Faculty of Anaesthetists of the Royal College of Surgeons of England.
1988 Fellow of the College of Anaesthetists.

Honorary Doctorates of Medicine


Honorary Doctorates of Science

1962 Wales; 1977 Ohio.
Honorary Fellowships and Memberships

1950 Faculty of Anaesthetists of the Royal Australasian College of Surgeons.
1959 Association of Anaesthetists of Great Britain and Ireland.
1964 Faculty of Anaesthetists Royal College of Surgeons of Ireland.
1965 Pembroke College University of Oxford.
1966 Royal Society of Medicine.
1968 Faculty of Anaesthetists Royal College of Surgeons of England.
1973 Royal College of Obstetricians and Gynaecologists.
1986 History of Anaesthesia Society.
Honorary Membership of a number of other national societies.


Papers and Lectures

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Dr C K Adam
Dr A K Adams CBE
Dr C N Adams
Dr J D Alderson
Dr J I Alexander
Dr P Amoroso
Dr E N Ammitage
Dr L Allan
Dr J C Allen
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Dr J F Cahill
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Dr T N Calvey
Dr W Campbell
Dr W D J Cantrell
Dr S J Catling
Dr G D Chack
Dr A Chaffe

Dr J E Charlton
Dr G S Clark
Prof R S J Clarke
Dr W B Clarkson
Mr A D Clover
Dr D P Coates
Dr P A Coe
Dr B B Collier
Dr I D Conacher
Prof J L Couper
Dr M G Cooper
Dr I M Corall
Dr G C Corser
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Dr G M J White
Dr M J Whitehead
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Dr J A W Wildsmith
Dr D J Wilkinson
Dr S Willatts
Dr J Wilson
Dr S Wilson
Dr D P Winder
Dr C M Wiseley
Dr M J Wolfe
Dr C H M Woolham
Dr D Wright
Mr P Wright
Mr S R Wyndham-Crickmore
Dr E Young
Dr T M Young
Dr G L Zeitlin
Dr J S M Zorab
Dr D Zuck
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