quite low levels of supplementary heating. The voluntary tolerance time for a man in shallow water in a wet suit can be measured or even calculated with reasonable accuracy if the amount of muscular activity is known. At a water temperature of 11.5°C for instance, a person doing light work will become fairly cold in 100-110 minutes without any supplementary heating. If the diver is equipped with local heating pads that deliver, say, 50W, the time required to become cold increases to 230 minutes. This is a substantial improvement in tolerance to cold, but the amount of heating required is only about one quarter of the amount required to keep a person warm. For most of the dive, however, the person would consider himself reasonably comfortable. In an ideal situation it would be desirable to install 200W of heating to keep the subject warm indefinitely. However it is very much more cost effective to reduce the supplementary heating to a low level and to accept a tolerance time that is reasonable.

The high effectiveness of the low level supplementary heating system is related to the way the body protects itself when it starts to become cool. The skin temperature in the extremities and limbs of a cooling person drops as a result of decreased blood flow to the skin. This markedly reduces the rate of heat loss to the environment as the exposure progresses. If the rate of heat loss is not too high it may take a very long time to accumulate a substantial heat debt and reach a tolerance limit. Small changes to the heat supply can therefore have large effects on tolerance time.

ADDENDUM

Cost

Based on the high cost of analytical grade imported magnesium, the 'materials only' costs are $0.15 per sachet. This would be much reduced with appropriate sources.

Availability

Availability is not good because we have been unable to offer patent protection to potential licensees. However Mr Crawford Grier of Croft Cottage, Croft Road, Oban, Scotland, has expressed an interest in manufacture. The Antarctic Division at Channel Highway, Kingston, Tasmania 7150, have been manufacturing in house. Their contact is the officer-in-charge of R & D, Mr Atilla Vrana.

Safety

Local heating pads must not be placed on the skin because local temperature may rise above the burn threshold of about 45 C. However, we have found that pads may be safely placed between overlapping areas of wet suit. A Farmer John pattern of suit without modifications allows placement of heating pads over most of the torso area. We have been interested in possible toxic effects on skin, of metals such Chromium, Manganese and Nickel which are present in cast iron. X-ray fluorescence analysis shows these metals to be present in trace amounts in samples of water taken from the vicinity of the skin during heated dives. However their concentration does not significantly exceed the levels to be found in clean sea water. One cause for concern is that such water samples tend to be slightly alkaline, a pH value of 9.6 was found for water squeezed from active local heating pads. For some people not tolerant to alkalinity this may be a problem, but application of a barrier cream prior to diving should give effective protection. No evidence concerning skin problems has been reported to date, the total exposure probably being a hundred hours or so and about 50 subjects.

O_2 BE ALIVE

Gavin Dawson

Oxygen is a gas, lethal at low concentrations, poisonous at high concentrations and extremely dangerous at pressure. 2,000 pounds per square inch in a cylinder of medical oxygen can cause a lot of damage! It is considerably more than you would put in your motor car tyres! Today I intend to concentrate on hyperbaric oxygen. I am not going to go into any statistics or complicated tables. We have been running the chamber at Prince Henry's Hospital for 11 and a half years and have not treated all that many patients, but we do have a lot of clinical impressions and good results in certain directions.

Before starting on hyperbaric oxygen let us take a quick tour around the field of oxygen; its role in life, industry, aviation, rocketry, combustion, steel manufacture, mountaineering and diving. We will not spend too much time on diving. This already has been very well covered in the previous paper.

Here we are on planet earth and for some reason breathe 20.98% oxygen. Oxygen was discovered in 1774 by Joseph Priestly and independently by a Swedish chemist, Scheele, at the same time. Both produced oxygen by heating mercuric oxide. Its uses are vast.

In aviation, pilots of high flying aircraft wear oxygen masks. You may not think oxygen was vital for the flight of Gossamer Albatross but if you ask Brian Allen he will tell you that it was! He did not have any extra oxygen apart from fresh air and his lowest recorded altitude on the Channel crossing was six inches. He did need oxygen to produce the energy and horsepower for his leg muscles that were peddling that man-powered machine 22.5 miles across the Channel. Oxygen was used as a rocket propellant in the doodle-bug V2 designed by Von Braun which pestered London towards the end of the Second World War. Liquid oxygen and 75% ethyl alcohol were the propellants. America's first man into space, Alan B Shepherd, in 1961 ascended in Mercury Redstone. Then came Atlas and Friendship 7 and John Glenn's first orbit. Titan 3C launched the Gemini space capsule and Ed White was the first American to walk in space. He naturally depended on oxygen for his life support system and the rocket depended on oxygen for its propellant. Finally in

the rocket era we come to that gigantic piece of technology, the Saturn V, which uses liquid oxygen in all 3 stages with RPI kerosene in the first and liquid hydrogen in the second and third stage. By using this third stage it was able to escape from the earth's atmosphere and progress onwards to land Armstrong on the moon. Later on, there were more missions involving lunar Rovers. It enabled man to leave the moon which had never even been done before. In the Lunar Module a different sort of propellant with oxygen was used in a hypergollic propellant solution. Nitrogen tetroxide and oxygen combined and spontaneously combusted lifting the lunar module off and returning to earth. We then found that human beings can survive in space for many months and they require appropriate concentrations of oxygen. There was a time when the Americans and Russians were talking to each other and found they could dock in space even though the Soyuz had an air environment and the Apollo had an oxygen 0.3 atmosphere environment.

Oxygen is used in the Bessemer converter for the manufacture of steel from iron, a very important use. It was used in the conquest of Everest, although Everest has been climbed without oxygen. You would be pretty grateful in this situation to find that on what has been called the highest rubbish tip in the world, there were two full oxygen cylinders left by a previous expedition. The oxygen bottles lay at 26,000 feet and Everest is 29,000 feet to the summit.

So on to hyperbaric oxygen. This is the inhalation of oxygen at a partial pressure greater than one atmosphere. In Prince Henry's Hospital (Ward 3 South) we have a Vickers mono-place chamber. It is a radiotherapy model 7 feet long. It is made of perspex, a similar material to aircraft windows. It has double layers, one cylinder inside another, so you have a pressure tested cylinder centrally and an outside cylinder. If your pressure tested cylinder blew you would not kill the patient and everybody else around you. The outer cylinder, (although it will not hold the original pressure) would allow the gas to gradually leak away. In 1967, the William Buckland Foundation gave a donation of $15,000. At that time a chamber was $14,000 and the price now is $45,275.

The chamber has a big oxygen inlet and an exhaust line. There is no recirculation. We use very high flows of gas, between 200 and 400 litres a minute. The oxygen is dumped out into the environment above the balcony in Ward 3 South. High above the balcony because we do not want it too low down in case somebody lights a cigarette nearby. It is a fairly simple piece of equipment. There is a normal supply pressure of about 65 psi. The chamber pressure is graded in pounds per square inch or atmospheres absolute.

The pressure is selected by a dial on the side of the chamber. There is a compression rate knob, and an intercom on the side which causes a few problems with communication. I find that the density alters the tone of your voice. But more important is the fact that you have got between 200 and 400 litres of oxygen blowing through the head end of the chamber. That is where there is a microphone and two loud speakers, so there is a lot of feed-back which is a problem. The simple way to overcome it is to switch the oxygen off while you talk. You can do that because it is a portable model. It should not be done for longer than 4 minutes, but if you switch the oxygen off all your problems are solved. At the door there are electrical and pneumatic connections to cater for an ECG, give intravenous fluids, take blood pressure, etc. All we have monitored is ECG but we have had a fluid logic ventilator inside which is a very, very risky business. The Vickers Company do supply a support unit (and many times we have had need of this) at $4440 and that will provide information on blood pressure, information through a stethoscope, administration of intravenous fluids and positive pressure ventilation. The reason that hospitals use liquid oxygen is that you get 840 volumes of gas for 1 volume of liquid. I will give you a little more information on oxygen. We use at Prince Henry's Hospital 104,400 cubic metres of gas a year. We pay 9.6 cents per cubic metre. The cost to the hospital is $10,022 per year for oxygen for which CIG charges 25% delivery fees. Prince Henry's Hospital now has a larger liquid oxygen than they used to have. The old one was 30,000 cubic feet and the present one is 70,000 cubic feet which means that it will produce two million litres of gaseous oxygen.

The advantages and disadvantages of the monoplace or one man chamber compared to the large multi-man chamber which can accommodate medical attendants, nurses, etc, are as follows:

Advantages: cheaper, low running costs, total body immersion in oxygen which means that the patient does not have the inconvenience of having a tight fitting mask on his face. There is some evidence that oxygen has a therapeutic effect on open mucous membranes to increase the rate of wound healing. There are no decompression dangers to patients or attendants because pure oxygen is used.

Disadvantages: are that there is a high fire risk because it is 100% oxygen. I will go into fire a little bit later. It has limited pressure capability. However, three atmospheres is quite enough pure oxygen if you wish to avoid the CNS effects of oxygen toxicity.

There is minimal environmental control. Another model has a recirculating system whereby you can control humidity and temperature and monitor CO_2. There are isolation problems of therapy. By isolation I do not mean claustrophobia. I mean you just cannot get at the patient. You cannot monitor them properly. You cannot support them. You really have not got much control apart from psychological persuasion.

Problems: Apprehension, boredom and claustrophobia can occur. Some patients do get claustrophobic and some are frightened. We rarely have to sedate patients and often the best way of sedating them is to talk and explain what it is all about.

Really when you are lying in the chamber and relax it is quite comfortable. Oxygen is a pleasant gas. To avoid aural barotrauma, we tell them how to fix their ears, we take them up slowly and watch them. We have little tricks of pressure dropping with which we can equilibrate to the outside pressure. I will go into oxygen toxicity and fire risk later. My personal experience with equilibrating ears is that swallowing opens my own Eustachian tubes. For others the Valsalva manoeuvre works better. At Milwaukee they have a very nice idea. A baby's bottle and you just swallow a little water each time you want to equilibrate your ears.

On the subject of problems let me give you a few cases involving litigation in hyperbaric oxygen. This is quite important.

In 1971 a 42 year old man was being treated for a scrotal Clostridial infection. He became permanently blind. He lost his vision during his last hyperbaric session. There was no clinical justification for that session. He had complained at one stage that his sight was going off. During the three week trial they found there was no record of any blood pressure. In 1978 he was awarded $65,000.

In the second case a 21 year old footballer suffered a compound fracture of tibia and fibula. The bone was pinned and on the fourth post operative day he developed gas gangrene. He was given, despite a history of allergy, intramuscular penicillin and anti-gas gangrene serum. Most of us in the intensive care unit here do not agree with this, certainly not intramuscular penicillin. On the fifth day the gas gangrene was spreading alarmingly. He was referred to another hospital for hyperbaric oxygen, but even so had to undergo a below knee amputation. Negligence was proved. It was said that gas gangrene should have been diagnosed earlier and that he should have been referred earlier for treatment of hyperbaric oxygen. The settlement was £28,000.

The final case, in the United States (and this case could only be in the USA), was carbon monoxide poisoning. A 26 year old male was found in his car with the garage doors closed and the motor running. Doctors referred him to the hyperbaric oxygen unit at Wayne County, Michigan Hospital. The hospital did not follow the referring doctor's advice and the patient suffered severe permanent brain damage. His parents filed suit against the hospital and the jury awarded them over $3,000,000.

The effect of hyperbaric oxygen on vision appears at 3 atmospheres. If you have 3 atmospheres for 3 hours there is a definite contraction of your visual fields from the normal cone of between 60 and 80 degrees. Your visual field contracts to a tunnel becoming as narrow as 10 degrees, which lasts about an hour. After returning to atmospheric pressure you are back to normal. In my personal experience of 3 atmospheres of oxygen I found vision incredibly clear. I could read very small print and noticed this with patients. They look at all the small instructions in small typewriting on the notice board near the hyperbaric chamber. This may just be an impression but there seems to be something that improves the visual acuity. Somebody asked me whether the shape of the chamber acts as a magnifying glass for those inside. It did not seem to when I had a look at it in air.

Just briefly to discuss pressure. We talk in terms of 1 atmosphere absolute (ATA) at sea level so that we can go up into the air or down into the ocean. Fortunately 1 atmosphere is 10 metres or 33 feet of sea water. As you go down 10 metres or another 33 feet in the sea you add another atmosphere. When you go up, the pressure starts reducing. If you are in a pressurized civilian aircraft with a cabin pressure of 8,000 feet, or around the altitude of Mexico City, you are at 0.75 ATA. On the top of Mount Everest (29,000 feet) the pressure is one third of an atmosphere.

To remind you of the pressure-volume relationship. If you double the pressure, you halve the volume of gas. If you triple the pressure, you reduce the volume to one third. Quadruple the pressure and you quarter the volume. So at five times the pressure and if the volume was 10 litres before you increased the pressure you are down to two litres. What happens to a bubble? I have told you about reduction in volume. But reduction in the diameter of the sphere is a very different matter. A bubble present at 1 atmosphere absolute at sea level will expand as you go up in a civil aircraft pressurized to about 8,O00 feet. If we give 2 atmospheres absolute of pressure, the bubble compresses. With 3 atmospheres absolute of pressure it gets smaller. The reduction in diameter gradually gets less and less, so there is really not much point in producing more and more pressure. Because of this slowing in the reduction of bubble size you often get the best mileage in the treatment of decompression sickness by treating it with 3 atmospheres absolute of oxygen. This therapy produces a high oxygen gradient going into the plasma and displaces the nitrogen from the bubble with reasonable bubble compression.

A partial pressure of 1 ATA of oxygen (100% at sea level) fully saturates haemoglobin and from there on any more oxygen is dissolved in the plasma. When the oxygen partial pressure is just under 3 atmospheres you have 6 ml of oxygen dissolved in the plasma and that is enough to support life without haemoglobin. The experiment was done on pigs with no red cells and they survived. The experiment has also been confirmed on Jehovah's Witnesses after surgery where they have been put into oxygen chambers, fed spinach every two hours and then put back again while their haemoglobin built up.

At Prince Henry's we have treated 163 patients in 11 years. Hyperbaric medicine here is a part-time job. We use hyperbaric oxygen therapy for emergencies, an important medical tool. There was a great burst of interest in the late 60s and early 70s, not knowing anything about it! We were treating all sorts of funny infections, etc. Then we got to know more and more about the indications. Our enthusiasm has kept going. We have treated about 16 to 18 patients a year.

A quick run through the patients. We have treated too many ischaemic limb disease for infections, because we have a lot of vascular surgeons at Prince Henry's. Operations go wrong and Clostridial infections have been treated. It was not really worth it as they were not gas gangrene. I will say a little more on decompression sickness, gas gangrene and carbon monoxide poisoning. They are the main points of interest.

On carbon monoxide I will give you a record of what we have treated. Being on natural gas it is not as many as Ian Unsworth in Sydney, who seems to receive a large number of cases. Over the years we have treated at Prince Henry's five people for carbon monoxide poisoning. Four males and one female and only one of those five was a simple carbon monoxide poisoning. By simple I mean he had not combined his carbon monoxide with drugs such as sedatives, hypnotics, tranquillisers or alcohol. They were all deliberate. There were several pathetic suicide letters in the cars. All piped their exhaust gases in through the back window with the engine running and just sat there. Three combined their gas poisonings with sedatives and one combined it with a whole bottle of whisky.

I feel that the treatment of carbon monoxide poisoning with hyperbaric oxygen is important but it must be started early. If you have been on 100% oxygen for an hour your have already got rid of half of the carbon monoxide in the body. This is due to the half-life times. If you are in air it would take you about five hours to recover from carbon monoxide. In 100% oxygen it is about 80 minutes. And with 3 atmospheres of oxygen it is about 20 minutes.

In some areas of medical practice hyperbaric oxygen is used to overcome certain types of hypoxia. The Peter McCallum Clinic use it in radiotherapy because certain rumours are resistant to treatment and are made more sensitive to treatment if they are well oxygenated They are resistant to treatment while the cells are hypoxic, and hyperbaric oxygen gets oxygen to these cells, that is the theory. Hyperbaric oxygen is essential in gas gangrene. It is a primary mode of therapy in decompression sickness. Over the years there has been a lot said about hyperbaric oxygen. Its reputation has been affected by certain anecdotal references by various people on rejuvenation and so forth, which very readily catches the attention of the lay press. The Americans (the Undersea Medical Society) formed a committee to classify the role of hyperbaric oxygen. This committee decided that there should be four categories of indications in which category one is fully reimbursed by their Blue Cross insurance. Category two, which shows good evidence, perhaps should be reimbursed in the future but would be re-looked at. Categories three and four are for things like turning your grey hair dark again, sexual rejuvenation, etc.

Gas gangrene is any condition of necrotic muscle associated with the production of gas. We diagnose it, not so much on crepitus but on wound, blackness and straw fluid blebs. The first thing that has to be done is for the wound to be opened. There often is crepitus and the patient is frequently very toxaemic and for some reason the pulse rate is much higher comparatively than the temperature elevation. Unless they are moribund, the conscious state is usually reasonable. Our last case was a schizophrenic who jumped off Puffing Billy while it was crossing an 80 foot bridge. He did not land on his head. If he had we would have had no problems. But he did manage to fracture his sternum, bilateral tibia and fibula, one was compound, radius and ulna at the wrist. He had a pin through his wrist and got gas gangrene of the arm. That was the least of our problems because at the time he had a shock lung and other multiple problems. He would have benefited greatly from a large chamber.

How does hyperbaric oxygen work? It is the alpha toxin, the Lecithinase C, that does all the damage. If we can stop that toxin being produced then the systemic toxaemia is very much improved. I have seen patients come in one day virtually moribund and the next day, after treatment, sitting up in bed reading the paper. The alpha toxin seems to destroy everything, muscle cell, red blood cells, and it advances very, very rapidly. There are several Clostridial organisms, mainly welchii (perfringens). Perfringens destroy membranes and produces haemolysis. When you have got haemolysis the situation is quite serious. This is how I think hyperbaric oxygen works. I believe it stops the production of the toxin. It reduces the systemic toxaemia by inhibiting the production of alpha toxin and sustains by oxygenation the viability of damaged tissues. It also reduces pain because as the patient goes under pressure the gas is compressed. Also the penicillin given intravenously gets a better chance to get to the muscles. By doing this we have reduced the need for early and radical surgery.

In one of the first cases we treated the surgeons were going to do a disarticulation of the hip, and I said, "Let's give him a go with hyperbaric oxygen." He had already had an above knee amputation and he finished up having nothing further done. So hyperbaric oxygen is an adjuvant. You need everything. First of all surgery to clean up the wound, open it and remove the debris. You need very high doses of penicillin. We have given up to 40,000,000 units a day intravenously. In fact, we give so much penicillin that there is enough sodium for the whole body in the penicillin alone without giving any other form of sodium. And we give hyperbaric oxygen and tremendous supportive care from the intensive care unit with fluid therapy, etc. One finds that you get a demarcation. The spread of infection stops, and the pulse comes down along with the temperature. Haemolysis also stops, the mental state improves, and pain is diminished. As I said before, the pain diminishes because we decrease the volume of tissue gas by pressure and improve the oxygenation of the tissues.

Some people today still give antitoxin, we do not. For the reasons that it is not necessary if hyperbaric oxygen is available. It does not always work. Ten percent of patients have a reaction to it. It has also been abandoned by all other hyperbaric centres that know anything about gas gangrene. It has been banned by the US forces.

Abalone divers have been one of our problems. That wise old gentleman Albert Behnke made a very important, clear

and simple statement. "It is useful to remember that time, air and oxygen is cheaper than nervous tissue and bone". If there is any doubt about the diagnosis of decompression sickness we will treat them because to date we have done no harm to anyone in our hyperbaric chamber. We have treated 11 cases of joint bends with or without symptoms. They were not neurological symptoms, they were pains in the stomach and minor type 1 signs.

In 1977 the Institute of Aviation Medicine at Point Cook sent us three cases in fairly rapid succession. Were they cases though? Now let me elaborate for the benefit of the RAAF. They might be interested in the case histories. Between March and October 1977 we had three cases from their altitude chamber. One had an A run which is 24,000 feet and they were worried because he had skin tingling, paraesthesia and not much else. The second was a C run following half an hour of pre-oxygenation and a brief exposure at 43,000 feet. He had complained of left shoulder and back pain but was asymptomatic on arrival. The third was an A run to 24.000 feet. He had knee pain which was relieved on oxygen. They all recovered on 100% oxygen at two atmospheres. As they had no symptoms at two atmospheres I really did not see any need to go to a higher pressure and they were decompressed over a two hour period. As far as I know, the lowest recorded case occurred at 18,500 feet.

Cases have occurred at 5,000 feet after diving and there is a rule that scuba divers should not fly for 24 hours following a dive which involves decompression stops. The only difference between decompression sickness from diving and decompression sickness from sudden exposure to altitude is that there is less spinal involvement in altitude decompression sickness.

Pain only bends are treated on a two hour table. We did not use the long table because we only had oxygen. Now we have designed an air breathing system where we can use air breaks. We have made up an air break system. It is an ordinary anaesthetic face mask supplied with compressed air from a cylinder between the patient's legs. It is pretty narrow in the Vicker's chamber, only two feet in diameter. The system works but there is too much resistance on the expiratory valve. We may change to a T-piece or something else. We have only had to treat pain only bends. I would not care to, and I am sure I would not treat anything more complicated than pain only or minor neurological bends. If you have a serious neurological problem you must have a multiman unit as you ought to have someone in the chamber who can care for the patient. They can assess the improvement and look after the airway. We just cannot do that in a single man chamber.

Let me tell you a very interesting story about what happened to a chap in the States. A 24 year old male was cleaning the interior of a 6 x 6 foot cylindrical vacuum chamber which was used for coating metal. His mate, as a result of a prank, closed the lid and started to decompress him thinking he could turn it off at any time. However, he suddenly realised he could not and panicked. He went to look for the supervisor in a hurry. In about three minutes the victim had gone to almost three times the height of Mount Everest (your blood is supposed to vaporise at 63,O00 feet) and he was held there for four minutes. The supervisor arrived. The victim was recompressed over a one minute period back to ground level. On opening the lid the patient was deeply unconscious, cyanotic, frothing from the lips and blood was coming up from his lungs. He was taken to a hospital ten miles away where he was intubated, given 100% oxygen and his colour improved but he was still unresponsive to painful stimuli. There was a consultation with the Physician of the USAF School of Aerospace Medicine of San Antonio and he was transferred in a pressurized jet to St Luke's Hospital, Milwaukee. There was, of course, a mixed diagnosis, of massive aviation decompression sickness, burst lungs, possible cerebral air embolism, post-hypoxic state and status post-embolism (vaporisation of blood).

He was pressurized to 6 atmospheres absolute on 50%-50% nitrogen and oxygen. He was there for a few minutes and then was brought back to 60 feet and placed on oxygen. He was treated on an extended table 6A. He had five and a half hours of hyperbaric treatment and then went to intensive care where he was put on a respirator and gradually became more alert. A series of psychological tests were performed because he wanted to get as much money out of the business as possible. Three months later they found there was a 15% decrement on what his psychological testing should have been.

Oxygen convulsions occur. Oxygen is toxic to the lungs after a while and is acutely toxic to the brain. Three or four weeks ago when I was enjoying the first quarter of a football match at the MCG between Richmond and St Kilda I was summoned over the loud speakers. I had to go to Prince Henry's Hospital to attend a patient who had gas gangrene. We took him to three atmospheres in the Vickers Chamber. Until then I had not seen an oxygen convulsion in our Chamber. This fellow convulsed after about 30 minutes at 3ATA. He said he felt banging in the ears and that is one of the warning signs. The convulsions lasted for two minutes and, of course, if a person convulses there is nothing you can do. The worst thing you can do is to suddenly decompress him. If you suddenly decompress him it is like bouncing up with a full lung of air from 66 feet. Because of the decreasing pressure there is a threefold expansion of the gas in the lungs and this usually results in a burst lung. A burst lung can give you a pneumothorax, or if you are very unlucky you can get an air embolism or surgical emphysema. It is completely illogical to decompress a patient during oxygen convulsions because they are so full of oxygen in their blood and body fluids that they would stay for 10 minutes or more completely pink. The convulsions only last for about three minutes just like an epileptic convulsion.

Anyway having done that, the next day I did it again. Not by intention but because I thought the first convulsion could have been due to the Ethane anaesthetic he had recently had. Ethrane produces an epileptiform ECG tracing during anaesthesia. We took him to three atmospheres again the next day and he vomited, he got

banging in the ears, echoing, apprehensive and he had time to say "Oh no, not again" and then off he went into a full clonic convulsion lasting three minutes. We then reduced the pressure a bit and completed treatment. Following that episode, and with advice from a colleague of mine in Sydney the next day he was treated at a slightly lower pressure. Dr Unsworth has been using 5% Ethrane on goats at 3 atmospheres and has had no convulsions. He has also used Ethane on patients in the chamber. His is a multi-man chamber. He was certain that Ethane was not to blame. You do need to get to 3 ATA to get the oxygen gradient for gas gangrene. This time we used dilantin and we reduced the pressure to about 2.6 - 2.7 atmospheres and he was fine.

We have also had two penicillin convulsions, one of which occurred before the patient even got into the chamber. If the patient goes into renal failure then the penicillin builds up and they can easily convulse.

At the time we started using hyperbaric oxygen we were terribly frightened, and we still are, about fire after the Apollo One tragedy. The spacecraft was pressurized with pure oxygen slightly above normal atmospheric pressure and some wiring overheated. There were certain materials in the capsule that should not have been there, Velcro and Nylon, which were inflammable and burnt. The fire flashed through and blew the spacecraft to pieces. We make absolutely certain that matches, cigarette lighters, etc., are not in the chamber. Incidentally, there was a President of the Royal College of Surgeons of England who wanted to try out a hyperbaric chamber. He had never seen one before. He was put in wearing his ordinary suit and they closed the door. Looking through the perspex the onlookers suddenly realised that his pipe was glowing brightly, in his breast pocket. Professor Sir Hedley Arkins was very quickly removed from the chamber! To keep down the risk of static sparking we try to keep the relative humidity to 60% and use pure cotton, 100% cotton material and no synthetic fibres. The machine is earthed. You can play music, tapes or radio over the intercom but that is all part of the Vicker's design. We do not allow any modification of the intercom. We avoid oils, grease, ointments, etc. We keep it clean.

It is interesting that at the RAF base at Wroughton in England, they use air in the Vickers Chamber to pressurize it and the patient breathes oxygen. The reason I went there was that I wanted to do it the other way around to give air breaks in oxygen. The reason they did it was because they were very frightened about the fire risk to patients in pure oxygen from the flash fire experiments from the Institute of Aviation Medicine at Farnborough.

In conclusion Priestly said some very true words in 1774 when he discovered oxygen. He said "From the greater strength and vivacity of the flame of the candle in this pure air it may be conjectured that it might be peculiarly sound treatment for the lungs in certain morbid cases. But perhaps we may also infer from these experiments that though pure dephlogisticated air might be very useful in medicine, it might not be so proper for us in the usual healthy state of the body. For as the candle burns out much faster in dephlogisticated than in common air, so we might, as may be said, live out too fast and the animal powers be too soon exhausted in this pure kind of air. But I fancied that my breast felt peculiarly light and easy for some time afterwards. Who can tell but in time that this pure air might become a fashionable article of luxury. Hitherto only two mice and myself have had the privilege of breathing it. And a moralist may say that the air which nature has provided for us is as good as we deserve."

This paper was presented by Wing Commander Gavin Dawson, RAAF, at the Tri-Service Medical Officers Meeting held at Prince Henry's Hospital, Melbourne, on 7 June 1980.

MEASUREMENT OF EUSTACHIAN TUBE FUNCTION USING ELECTRO-ACOUSTIC TECHNIQUES

WD McNicholl

A variety of procedures have been designed to assess Eustachian function in subjects with intact tympanic membranes; no single test has proved entirely satisfactory.

The finding of a negative middle ear pressure after a Toynbee test indicates excellent tubal function, since the Eustachian tube has to actively open. The production of a positive middle ear after performing the Valsalva manoeuvre does not indicate that there is positive Eustachian function but that the tube is distensible.(1) Elner et al (2) found that 74 out of 94 subjects had a positive Toynbee manoeuvre while 86 out of 100 subjects had a positive Valsalva manoeuvre.

The purpose of this paper is to present a test of Eustachian tube function that can be performed using an electro-acoustic instrument which has the added facility for testing Eustachian function. This test is performed in conjunction with tympanometry, inflation-deflation test and Toynbee's and Valsalva's tests. This test provides confirmation of positive or negative Eustachian function in ears with intact tympanic membranes.

Two hundred and twenty-one male subjects were assessed; they were divided into two groups:

Group 1: One hundred and seventy-one subjects who had an unsuspected Eustachian dysfunction, who were volunteers to the Submarine Branch of the Royal Navy.

Group 2: Fifty subjects who had an unsuspected Eustachian dysfunction, who were non-volunteers to the Submarine Branch of the Royal Navy.

The subjects in both groups had intact, normal tympanic membranes that were immobile on otoscopy when the