A being breathing thoughtful breath

The history of the British Iron Lung 1832 - 1995

by

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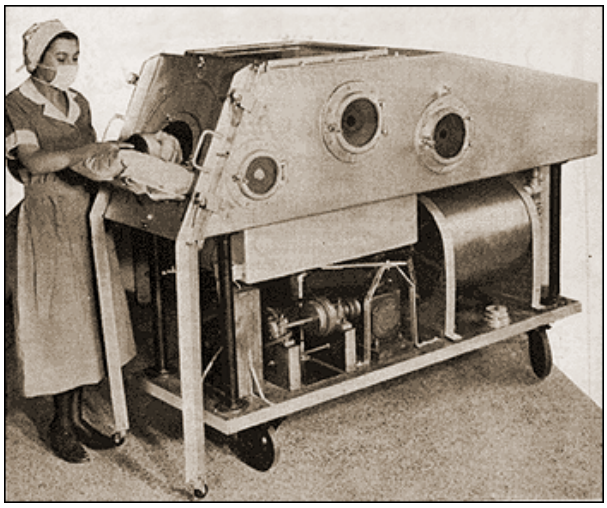
(Winner of the 1995 Lord Brock Memorial Historical Essay Prize - Guy's Hospital., London)

Most people under the age of 40 are unlikely ever to have seen an iron lung, yet forty years ago, these medical mechanical monsters would have been a common sight in most hospitals throughout the country. Through the late 1920's and into the 50's, the iron lung was considered to be state of the art, high tech, life support technology. Indeed medical students of the time would have learnt about such devices as a recommended treatment for respiratory paralysis, used to maintain life for those whose breathing capabilities had been impaired or destroyed by poliomyelitis. They were non-invasive in the sense that no part of the device penetrated the patient.

Below: A Drinker Iron Lung in use in 1937.



In truth, it was the patient who was invasive to the machine. The whole body was enclosed within the air tight chamber of the device, apart from the head which protruded through a tight seal around the neck.

For each inspiration, a large set of leather bellows mounted in a separate pump unit would expand causing the pressure within the cabinet to be lowered to below that of the surrounding atmosphere. This sub-atmospheric pressure in turn acted upon the chest, causing it to expand, thereby drawing fresh air into the lungs through the patients' mouth.

During expiration, the pressure equalised to atmospheric, and the patient exhaled passively. This method of artificial respiration became known as External Negative Pressure Ventilation (ENPV), but the idea was not new.

The first scientist to appreciate the 'mechanics' of respiration was John Mayow (1641-1679) who, in 1670, demonstrated that air is drawn into the lungs by enlarging the thoracic cavity. He built a model consisting of a bellows inside which was inserted a bladder. The mouth of the bladder was sealed to the opening in the bellows so that air could pass into the bladder, but no additional air could enter the cavity between the bladder and the bellows. Expanding the bellows caused air to rush into the bladder and conversely compressing the bellows caused the

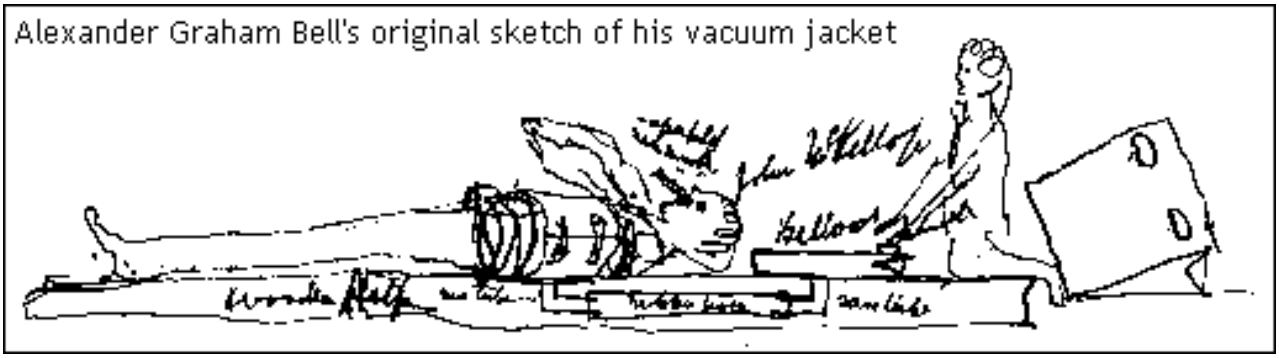
bladder within to expel air. It was this very principle that would lead to the development of ENPV devices over a century and a half later.

In 1832 in an essay entitled 'On Sleep, and an Apparatus for Promoting Artificial Respiration', a Scottish physician John Dalziel described a device that in cases of respiratory depression or failure, the patient might gain relief by having a sub-atmospheric pressure applied to the body rhythmically in phase with inspiration.

Alexander Graham Bell, the inventor of the telephone, also turned his thoughts to artificial ventilation, prompted perhaps by the death of his one day old son Edward on 15th August 1881. He invented a 'vacuum jacket' while on a visit to England the following year.

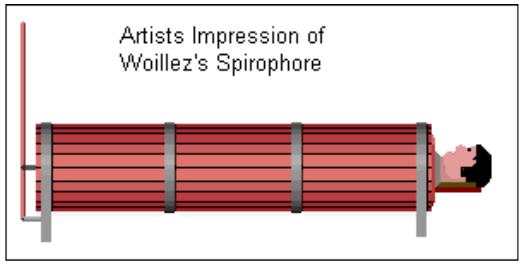
It consisted of a rigid shell in two halves with a soft lining, which was strapped around the chest and a bellows provided the negative pressure. He lent it to 'some gentleman connected with the University College in London' who promised to experiment with the jacket, but apparently did not do so. The jacket was eventually recovered and in 1892 Bell improved on the design. The following extract is taken from a facsimile of a note written in Bell's own hand; the original includes a sketch of the device:

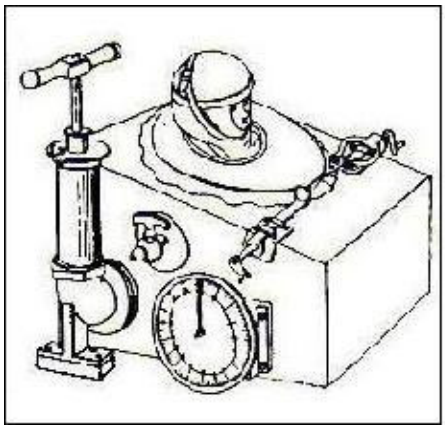
1892 Aug 14 - Wed. Old vacuum jacket made in England for me - many years ago - and recovered by W.McCurdy from Prof Yeo at King's College - London - has been put in order for trial. Brass pipe attached seemed to have too small diameter so it has been removed and larger tube fabricated - 1 1/2" diam. John McKillop submitted to experiment - seems to work perfectly. W.Ellis worked bellows. John McKillop stated that he made no effort to breathe - yet a piece of paper was moved to and fro when held in front of...

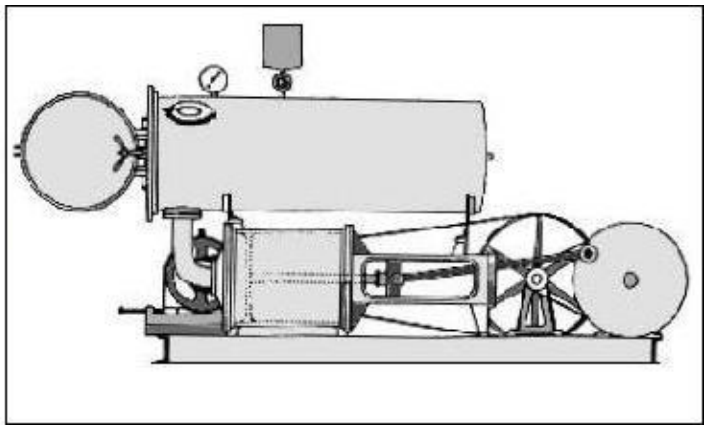


Throughout the nineteenth century, physicians and engineers world-wide experimented with, and developed ENPV devices. Dr Alfred F Jones (USA) 1864, Ignez von Hauke (Austria) 1874, Eugene Joseph Woillez (France) 1875 , Charles Breuillard (France) 1887 were a few who constructed and demonstrated such machines.

Woillez's machine, earned a silver medal at an exhibition of life saving devices at Le Havre in 1876. His device known as the 'Spirophore' is largely regarded as the forerunner of the iron lung as we now know it. But it was some years later before the iron lung would have such a widespread use.







Above: Other early forms of ‘Iron Lungs’

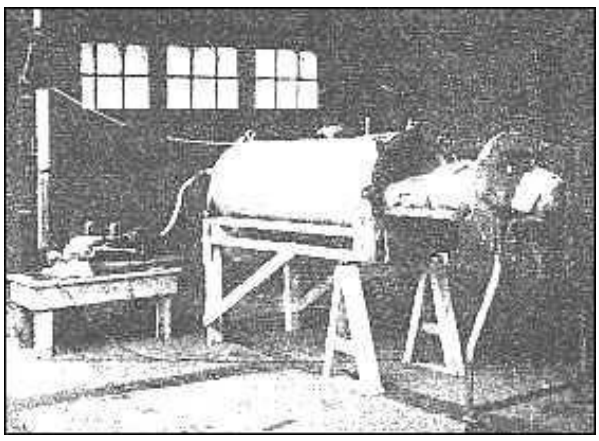
Polio in the 1920's affected mostly children. Patients who had "anterior" polio involving the cervical and thoracic spinal cord were unable to breathe at all. Usually only a few hours elapsed from the first signs of respiratory distress to death, and those involved in the care of such patients reported that it was very painful to watch these children as they smothered or drowned in their own secretions.

In 1926, an American, Philip Drinker was appointed to a commission at the Rockefeller Institute formed to develop improved methods of resuscitation.

At the time Philip's brother Cecil and a young physiologist Lois A. Shaw were studying various aspects of respiratory physiology in cats. They found that if they placed an anaesthetised cat in a sealed box, with only the head exposed, they could accurately measure the amount of air the cat breathed. When the cat inhaled, its’ chest expanded and the pressure within the box rose because the cat was now taking up more of the volume. When the cat exhaled, the pressure fell.

After watching these experiments, Drinker reasoned that the opposite should also be true. He injected the cat with curare, a deadly American arrow poison, which acts as a very powerful muscle relaxant, to a degree where breathing stops. He then, having already modified the box to include a syringe to increase and lower the pressure inside, placed the cat in the device and successfully ventilated the animal for a few hours until the effects of the drug wore off.

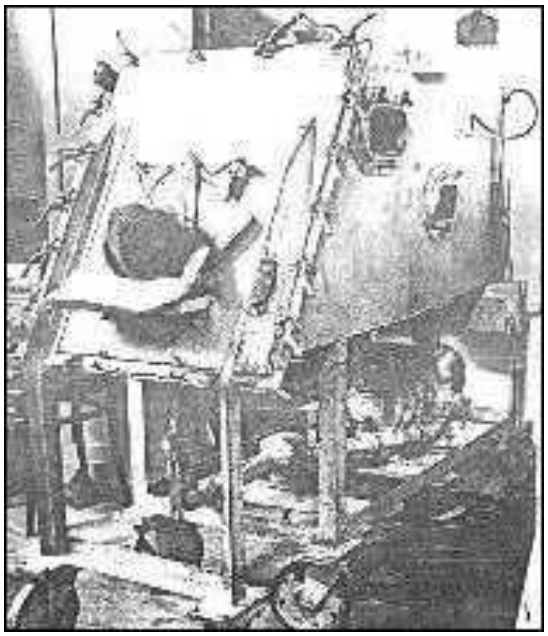
Drinker concluded that if it worked for a cat, that it would also work for a human, which prompted him to construct an adult sized respirator, (similar perhaps to his prototype pictured right), using a local tinsmith for the cabinet construction and a vacuum cleaner blower to provide the suction. The patient would be slid into the respirator on a garage mechanics 'creeper', after which the end plate was secured and a rubber collar slipped over the patients head.



Within a few months in 1928 the first clinical trial was under way. An 8 year old girl, comatose from lack of oxygen was placed in the machine. Within a minute or two she regained consciousness and a little later asked for ice cream. Although this little girl died a few days later of pneumonia, the principle of External Negative Pressure Ventilation was firmly established.

Dubbed by an unknown American journalist as the 'iron lung', Drinker's machine was continually improved and publicised. It finally went into commercial production and by 1931 seventy Drinker Respirators were in use throughout the USA.

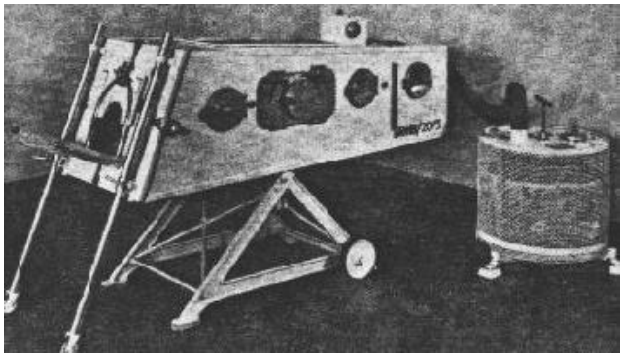
Shortly afterwards, Drinker's iron lung crossed the Atlantic to be marketed in the United Kingdom by licensees Siebe, Gorman and Company Ltd. This company had for many years led the development of deep diving and submarine techniques and equipment. The firm's activities had widened to embrace all aspects of breathing under abnormal conditions.



Under the chairmanship of Sir Robert Davis, the company made the first iron lung available in the UK from their headquarters at 187 Westminster Bridge Road. a remarkable coincidence perhaps, being so close to St.Thomas' Hospital, one of the only hospitals in the country still to use iron lungs in the 1990's as will be described later.

The Drinker Iron Lung on the left is thought to be that same first iron lung supplied by Siebe-Gorman in the UK. The patient is believed to be a young Fred Naylor and his presence in the iron lung was widely reported in the national press. In later years, Fred became a patient at the Phipps Respiratory Unit. Fred also wrote the book *'After Fortune Green'*.

In 1937 The London County Council commissioned an Australian Engineer called Both to design a cheaper alternative to the Drinker iron lung. In Oxford, Lord Nuffield, who founded the Morris Motor Car Company, had been shown a film that featured a Both iron lung, and the same evening, by coincidence, he read a newspaper headline about an iron lung arriving too late to save a life. Lord Nuffield became immediately interested in the iron lung project and, at a cost of £97 each, manufactured in his Cowley factory 800 'Both' Iron lungs which he donated to hospitals throughout the commonwealth (pictured right). Suprisingly, this generous donation did not entirely please the doctors of the time. The device was still only experimental and Lord Nuffield was bitterly attacked by the



medical press for jumping the gun and imposing the 'Both' iron lung on the profession, even to the extent of branding it "a wanton waste of private benevolence". A Pathe' Newsreel in December 1938 demonstrated the 'Both' iron lung to the cinema-goers of the time. In it Lord Nuffield commented *"I sincerely hope that my gift will be the means of saving many valuable lives."*

By March 1939 there were 965 of these iron lungs in use in the UK and beyond. In his diary following a visit to a hospital in Malta in August 1943, Noel Coward recorded:

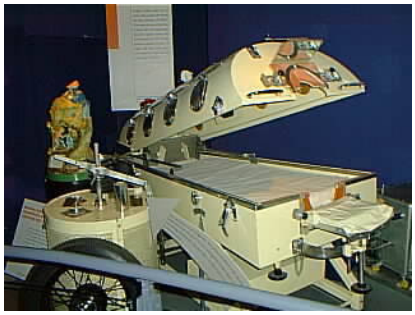
"One poor man with some sort of rheumatic paralysis had been in an iron lung for eight months. He was wonderfully cheerful and he had a photograph of his wife stuck on the ceiling so that he could smile at her quite easily."

Although a small number of 'Both' iron lungs were in use until relatively recently the Both had a number of limitations. Not least of these limitations was its' space requirement. The patient had to be slid into and out of the cabinet for nursing purposes, like a filing cabinet drawer. This effectively doubled the length of the iron lung, and as space in hospitals was at a premium at the time due to the severe polio epidemic, an alternative had to be found.

The man behind the Alvis Motor Car Company, Captain G T Smith-Clarke (left) was commissioned in 1952 by the Birmingham Regional Hospital Board to design modifications to the Both iron lung. Following some success in modifying the Both, Smith-Clarke suggested that a further advantage would be if the whole cabinet could be split as to open like the jaws of an alligator, with the lid hinged at the foot end. This meant that means for withdrawing the patient would become unnecessary, and that the patient would become immediately accessible for nursing purposes.

This technique demanded an entirely new design and in the autumn of 1952, a scale model had been built to demonstrate the feasibility of the principle. Local interest was awakened and in 1953, during the coronation procession in Coventry, about £800 was raised which was added to what became known as the Coventry iron lung fund.

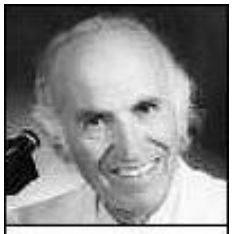
In June 1953, the Ministry of Health, announced this entirely new type of iron lung and on 3rd April 1954, it was described in the Lancet by J.F.Galpine, Consultant in Infectious Diseases in Coventry.



This iron lung (pictured left) became known as the Smith-Clarke Coventry Alligator Cabinet Respirator. The prototype respirator had a glass fibre lid, but the first production model, manufactured and sold by Cape Engineering of Warwick in November 1954 was made entirely of aluminium, wood and steel. Today, this first Alligator iron lung, originally sold to the Wheatly Military Hospital in Coventry remains part of the collection of iron lungs still in use at the Lane-Fox Respiratory Unit at St. Thomas' Hospital.

In all Cape Engineering manufactured around 150 of these iron lungs between 1954 and 1967, and they were sold as far afield as Malaya, Kenya, Uganda, Nigeria and in the USSR. The first recorded use of the 'Alligator' Iron lung at St.Thomas' was in August 1967.

In 1954, the American microbiologist Jonas Edward Salk developed the first successful vaccine against polio, and it was widely used from around 1956, but for many who had already contracted the disease, it came too late. There were still those who required prolonged artificial ventilation, and many who didn't, who were to find that in later life, the late effects of polio would cause them to once again to need the nocturnal support of iron lungs or other such devices.


Jonas Edward Salk

A Consultant Physician, Dr W Howlett Kelleher, at the Artificial Respiration Unit in the Western Hospital, Fulham had much experience in the prevention and treatment of airway complications in paralytic disease such as polio. He became convinced of the need for an iron lung in which postural drainage would be facilitated with little effort for the staff, and least disturbance to the patients. Previously, to aid patients who were too weak or too paralysed to cough up their own secretions, it had been necessary for the iron lung to be opened, the patient turned face down, the Iron lung reclosed and tilted head down by as much as 25 degrees. Physiotherapy on the patients back could then be performed by opening the porthole seals on the side of the machine allowing the Physiotherapist to insert his or her arms through the airtight seal and push on the patients' back in phase with the pump. This had many disadvantages and risks, particularly for patients with complete paralysis.

This led Dr Howlett Kelleher to design a new pattern of iron lung which he described in the Lancet on November 18th 1961. Essentially based on the 'Alligator', it permitted the chamber to be rotated 'chicken spit' fashion by up to 180 degrees in either direction. Portholes on the underside of the device allowed access for physiotherapy once rotated. In all, eleven of these 'Rotating iron lungs' were manufactured 10 of which remain in use at St. Thomas' Hospital.

For those who contracted polio and whose lives depended on artificial ventilation such as the iron lung, life was confined to an existence within a hospital or similar institution. The decrease in the numbers requiring artificial ventilation led to the closure of many specialist units until hardly any remained. One of the last to close was the Artificial Respiration Unit in the Western Hospital mentioned earlier. As a result of the closures, many patients found themselves relegated to the general or intensive care wards of local hospitals, who often had little experience in tending to the needs of such patients. After several years experience running London's first general intensive care unit at St. Thomas' Hospital, consultant anaesthetist Dr Geoffrey Spencer became increasingly concerned by the lack of rehabilitation facilities for patients who remained dependant on prolonged artificial ventilation. In an attempt to meet this need he created the Phipps Respiratory Unit at South Western Hospital, part of the St. Thomas' group of hospitals.


Dr Geoffrey Spencer OBE


Phipps Respiratory Unit - South Western Hospital - London

He formed a group of nurses, nursing officer and senior social worker together with a team of three technicians to provide the support necessary if these patients were to be successfully rehabilitated to a home life. The patients called themselves 'Responauts', for they, like astronauts, were venturing into the unknown. The success of the Phipps unit was soon to become evident. 18 respirator dependant patients were able to leave hospital and the unit began to accept referrals from a wide area of South-East England.

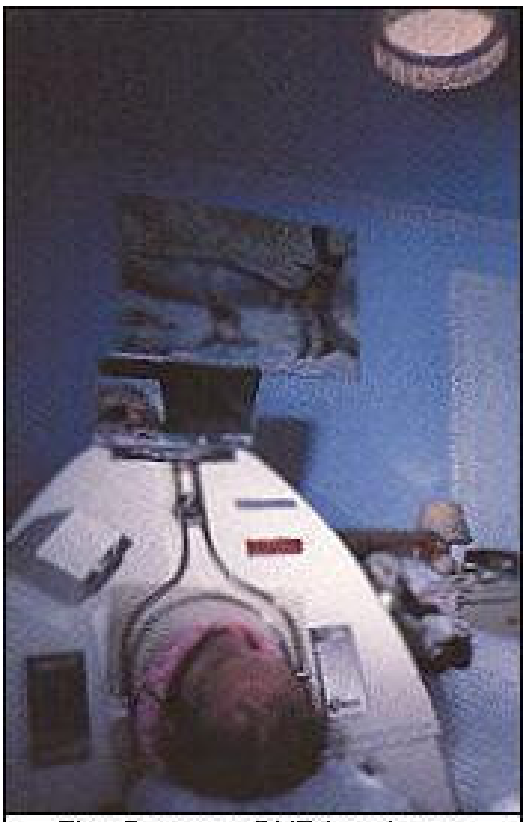
The unit gained knowledge and expertise in the new field of home ventilation. Soon its' reputation spread and attracted other patients from all parts of the UK and beyond. Iron lungs and other forms of ventilators were installed by the technicians in patients' homes throughout the UK. Regular home visits were, and are still carried out to keep these 1950's machines in their peak condition of performance and reliability.

In the mid-seventies the work of the Phipps unit had expanded to such an extent that the 'Alligator' iron lungs that it had so far inherited were almost all in use. It became evident that there was an urgent need for more. At first the Department of Health was reluctant to approve the £50,000 investment needed to commission the manufacture of Cape Engineering's minimum quantity of ten, and suggested that perhaps the unit should trawl the country for unused iron lungs. Using Cape Engineering's original sale ledger an attempt was made by Dr Spencer to trace as many 'Alligators' as possible. A few were traced, a small number found to be in use, many had been scrapped, and a third of those manufactured had been exported to other parts of the world, many in use by the military, their hospitals having since been donated complete as a 'going concern' to local inhabitants. Only a small number were eventually made available on loan to Phipps. The crisis continued even prompting parliamentary questions in the house, involving Jack Ashley MP and the then Secretary of State for Social Services Mr Alfred Morris MP who himself visited Phipps in April 1977. Eventually the Department of Health agreed funding for the ten iron lungs, but allowed only five to go to Phipps, insisting that the remaining five should be placed in storage until they were needed, one each to the Regional Health Authorities who had none.

In the early 1980's the iron lung took another step forward. There were concerns among the team at the Phipps Unit about the safety of patients using iron lungs in their homes. Many users were perfectly capable of entering and leaving iron lungs for themselves, but they had to be 'locked-in' by an assistant on the outside of the device. Some patients were trapped in the iron lung all night until a carer or partner, summoned perhaps by a patient operated bell, came to release them from their 'prison' . What might happen if there were a fire, or the carer or partner were taken ill, and at the very least what could be done to improve independence for Iron lung users to get into and out of the machine as and when they pleased without relying on others ? Thus it was, that in the early 1980's, in conjunction with The Royal Brompton Hospital and Cape Engineering, the team at Phipps began examining ways of overcoming these and other difficulties associated with the 'Alligator iron lung'. The objective was to design an iron lung that

was more 'user friendly'. It should contain the pump unit within the main body of the device. The mattress should be at the same height as a domestic bed to allow a user to lie alongside a partner if necessary. It should also be possible to transfer to and from the Iron lung easily from a wheelchair. For those users who were physically able, it should be possible to install oneself into, but more importantly get out of the device without assistance.

It should be shorter, but allow more freedom of movement within the chamber. All these objectives were met and in the mid-eighties twenty of these Portable iron lungs were manufactured by Cape Warwick (formerly Cape Engineering) and very soon most were installed into patients homes (pictured right). In the mid-1980's, Cape Warwick became a subsidiary of, and was subsequently closed down by British Tyre and Rubber Industries (BTR).



The Spencer-DHB Iron Lung home bedroom installation

Shortly after moving to St. Thomas' Hospital in 1989, the newly named Lane-Fox Respiratory Unit (formerly Phipps), saw a need for more Portable iron lungs, and although a survey revealed an international marketing potential, BTR under the chairmanship of Sir Owen Green believed that the profit margins were not substantial enough to justify the manufacture of any further iron lungs.

Through another subsidiary however, BTR continued to hold the patents, drawings and manufacturing rights to the Portable iron lung, effectively preventing any other company from manufacturing the device.

Following much pressure from Dr Geoffrey Spencer, the Lane-Fox Patients Association, and perhaps more importantly the reporting of the difficulties in the national press, BTR finally agreed to offer the manufacturing rights for sale. A number of companies were interested, among them a small engineering company in Leamington Spa, DHB Tools. Fortunately, DHB had previously worked with Cape Warwick and even employed some of the old workforce, including the consultant designer of the Portable iron lung, John Wines. DHB subsequently purchased the manufacturing rights and, in 1992 manufactured five improved Portable iron lungs called the Spencer-DHB iron lung.

This brings us up to date with the development of the iron lung. At the time of writing (August 1995) 17 iron lungs are still in use around the UK by patients of The Lane-Fox Respiratory Unit. But what of the future?. Throughout the 70's and early 80's the work of the Phipps Respiratory Unit was becoming well known, and was studied by overseas healthcare institutions examining the feasibility of setting up similar projects. As Phipps was expanding the use of iron lungs in the home, research was also going on at the Unit, and in other institutions around the world, into another aspect of non-invasive ventilation for nocturnal use. This was nasal intermittent positive pressure ventilation (nIPPV), and it was to revolutionise the lives of many people who previously had

depended on iron lungs for their night- time ventilatory support. The discovery in 1981 that positive pressure applied nasally relieved the obstruction to breathing in sleep apnoea, led to the creation of nasal masks, a prerequisite for nIPPV. The principle of nIPPV is reasonable straightforward. A small ventilator, about the size of a vanity case, delivers air to the patient through a small mask placed over the nose. The ventilator can be set so that each breath is triggered by any residual ability that the patient has to inspire spontaneously. Thus each patient is ventilated at their normal breathing rate. If however, the patient fails to take a breath within a set time, as occurs during sleep apnoea, the ventilator will automatically take over respiration at a preset rate.

Many patients have been successfully weaned onto this form of ventilation, leaving them free to lead lives not formerly possible using an iron lung. The ability to take the ventilator anywhere they please, to travel the world, and to sleep in an ordinary bed are all 'firsts' for many of these patients. This has finally led to the inevitable decline in the use of the iron lung. For the first time since it's creation in 1968 the Respiratory Unit at St.Thomas' Hospital has offered it's redundant iron lungs for sale.

The Lane-Fox Respiratory Unit, now led by Dr A J Williams, remains one of the UK's leading centres of respiratory support and investigation of sleep disorders. Perhaps also this is where the iron lung will finally retire after years of dedicated service.

At the turn of the century, the American inventor Thomas Alva Edison said; "Genius is one per cent inspiration, ninety-nine per cent perspiration." This brief history illustrates "inspiration" in many senses of the word. This technology supports life in the form of physical and active inspiration of air into human lungs, and also the inspiration of the brain, the breathtaking genius of those who brought artificial ventilation from Dr Dalziel's 1832 apparatus through 160 years of research and development to the micro-processor based ventilators of the 1990's, tracing not only the history of the iron lung but perhaps witnessing the birth of Biomedical Engineering. Finally, there is of course, artistic inspiration. Iron lungs have been featured in fiction: Dick Francis, 'Forfeit'; in autobiography: Mimi Rudulph, 'Inside the iron lung'; in newspaper headlines: The Times, 'Baby born to patient in iron lung'; and perhaps most astonishingly in rock n' roll: Big Pig, 'Iron Lung'.

The last word should go to those 'Responauts' for whom life was not only enhanced, but even made possible by this technology :

> *'Very soon several doctors and nurses came in and wheeled my bed into another room, a big one. Quickly I was lifted onto a narrow trolley type bed, and the entire thing with me on it was pushed into a huge long white box, rather like a coffin on legs. I was completely encased except for my head. Then my neck was fastened into a kind of rubber collar and the whole machine was closed up. At that moment there was a tremendous feeling of pressure inside the box. It was breathing for me, but I didn't understand at all.'*
>
> Phyll Western* 1955 aged 15

> *'I know that I'm lucky to be alive. I'm also very aware that, if it hadn't been for the Respiratory Unit in London, I probably wouldn't be.'*
>
> Phyll Western* 1992

or perhaps the last word should go to William Wordsworth:

'And now I see with eye serene, The very pulse of the machine;
A being breathing thoughtful breath; A traveller betwixt life and death.'

DEDICATIONS

The 1996 version of *'A being breathing thoughtful breath'* is dedicated to the memory of two of my friends, Phyll Western who died in 1996, and Tom Bagshaw who died in 1997. Both conquered and lived with polio, but lost their final battle with cancer.

This illustrated 'Online' version is dedicated to my very good friend, John Prestwich MBE. John contracted polio on his 17th birthday in November 1955 and spent over 50 years totally dependent on artificial ventilation for his very survival. Sadly John passed away in the spring of 2006. The various types of 'iron lung' devices that kept John alive gave him an estimated 400 million breaths throughout his lifetime with polio.

Below: John and Maggie Prestwich