

Notable Australian contributions to the management of ventilatory failure of acute poliomyelitis

With special reference to the Both respirator and Dr John A Forbes

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In reading about poliomyelitis ("polio") in the 20th century, I have been surprised that some Australian contributions to treatment seem not to have been adequately recognised, considering their importance in the history of both polio and intensive care medicine. They comprise, first, the 1937 inventions by Edward Both^{1,2} and the less well known Aubrey Burstall^{3,4} of their eponymous, wooden-cabinet (or "tank") respirators for treating acute ventilatory failure from paralytic polio; and secondly, the clinical success achieved in the 1950s by Dr John Forbes^{5,6} and his team in using the Both tank to treat that complication of polio. This was in the Acute Respiratory Unit at the Queen's Memorial Hospital for Infectious Diseases at Fairfield, Victoria. (The hospital — hereafter referred to as Fairfield Hospital — was founded in October 1904⁷ and closed on 30 June 1996.) My account draws especially on articles in the March and December 2003 issues of *The HaMMer*¹⁻³ (the Australian Health and Medicine Museums newsletter).

Acute infectious poliomyelitis, or Heine–Medin disease, was first systematically described in Europe in 1840 by Jakob Heine,⁸ although the withered leg portrayed on an ancient Egyptian relief suggests that the disease existed in antiquity (Figure 1). Karl Oskar Medin's study, completed in 1891, was the first documentation of an epidemic of polio (in Stockholm in 1887),⁸ while Australia's first epidemic recorded as polio¹ was at Port Lincoln, South Australia, in 1895 (Megan Hicks, Powerhouse Museum, Sydney, New South Wales, personal communication, 2006). During the first six decades of the 20th century, successive epidemics swept through populations that lacked acquired immunity, with the most severe later epidemics in the years 1937–38, 1947–48 and 1952–53.¹ Children were affected more often than adults, and "infantile paralysis" became, in the commonly used newspaper phrase, "every parent's greatest dread". Before 1928, available methods were inadequate for supporting those with the paralytic breathing failure that can complicate polio, thereby putting those afflicted at high risk of death.

The Drinker respirator

Then, at the Harvard School of Public Health in Boston in the United States, Phillip Drinker (1894–1972) and Louis

ABSTRACT

When Australia's 1937 epidemic of poliomyelitis created an urgent need for extra ventilating machines to compensate for respiratory paralysis, Edward Both, an innovative Adelaide biomedical engineer, invented a wooden-cabinet respirator capable of being made relatively quickly in sufficient quantity. His device, here called "the Both", alleviated the problem at Adelaide's Northfield Infectious Diseases Hospital and others, and in late 1938 was introduced into England when Both was visiting there. Appreciating its merits, Lord Nuffield financed assembly-line production at the Morris motor works in Cowley, Oxford. Then, through the Nuffield Department of Anaesthetics in Oxford's Radcliffe Infirmary, he had the Both distributed Commonwealth-wide, as a gift for treating ventilatory failure in polio — especially in children.

For the 1937 epidemic in Victoria, and to the design of Melbourne University's Professor of Engineering, Aubrey Burstall, nearly 200 of another wooden-cabinet respirator were ultimately built. Some were installed at the Acute Respiratory Unit of the Infectious Diseases Hospital at Fairfield, then others "all over Australia". However, by the early 1950s, the Both had replaced Fairfield Hospital's "Burstall", which had functioned as Victoria's favoured respirator since 1937. Dr John Forbes at Fairfield became the foremost Australian clinician for expertise with the Both.

Before the advent of intermittent positive pressure ventilation, the Both's usefulness had seen it tried for ventilatory failure in some non-polio conditions, but uptake of that application was limited. Nonetheless, Nuffield's philanthropy with the (Nuffield-)Both ultimately furthered progress along the 20th century pathway to intensive care medicine.

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Shaw,⁹ with help from Cecil Drinker,¹⁰ designed and built a truly effective ventilating machine: their "artificial respiration tank" was a body-enclosing sheet-iron cabinet (with the patient's head and neck protruding and sealed off from the cabinet), powered by an electric motor, which provided



Figure 1. The “Polio Stela” or “Stela of The Doorkeeper Roma to the (Syrian) Goddess Astarte”, from her sanctuary at Memphis, Egypt. The stela, considered to be from the XVIII Dynasty reign of Amenophis III, circa 1403–1365 BC, is now in the Ny Carlsbad Glyptotek, København (inventory # AEIN 134). The withered right leg is generally regarded as resulting from polio. (Photographed by Ole Haupt, reproduced with permission of the Glyptotek.)

external, intermittent “negative” (subatmospheric) pressure ventilation (INPV).⁹ The initial use (14–19 October 1928) of this first-ever practical^{10,11} INPV machine prolonged the life of a dying child for 122 hours.⁹ Warren E Collins Inc, Boston, undertook full production of the Drinker(–Collins) respirator (they were not called “ventilators” then), and an unknown reporter dubbed it the “iron lung”.¹⁰ Although effective and life-saving, it was large, heavy (about 102 kg¹⁰), cumbersome and expensive: in the US, an adult machine cost about US\$2000 in 1930^{12[p.1253]} (and £2000 to land in Melbourne in 1936,^{13[p.6]}) while the cost in Europe in the mid-1950s was around £1500 sterling.^{14[p.57]} Apparently the Emerson iron lung (from May 1931 and) subject of an acrimonious lawsuit over patent, was about half the Drinker’s price. Infant-sized machines were also made,¹² although adult machines were used on children. The 1937 polio epidemic reaching Australia brought a dire need for respirators. There were only “a few” Drinkers in the country then, and they had to be sent to the US for servicing!¹ One had been imported to the Fairfield Hospital in 1936 to treat a patient with post-diphtheritic, bulbar-type paralysis.³

Respirators in Australia

A notable, eminently practical invention from Adelaide, South Australia, in 1937 provided a realistic alternative. This

article attempts to pay tribute to the designers and manufacturers, Edward Both (died 1987) and his brother Donald (died 2005),^{1,2} and to the later but probably foremost clinical user of their invention in Australia, Dr John Forbes (1920–1989) of Fairfield Hospital, Victoria.^{5,6} William Morris, Lord Nuffield (1877–1963), made an important contribution^{15–17} by ensuring manufacture and widespread availability of the Both respirator, free of charge, throughout “the Empire” (United Kingdom and Dominions). The independent contributions of Aubrey Burstall³ (1902–1984) must also be recognised, although his cabinet respirator did not achieve the Commonwealth-wide ubiquity of the Both.

The Both team and their portable cabinet respirator²

Biomedical engineer Edward (Ted) Both developed a medical equipment laboratory at Adelaide University in the 1930s. Together with his wife Eileen and brother Donald (Figure 2), he formed Both Equipment Limited. During the 1937 polio epidemic, in response to requests from South Australian health authorities for an alternative to the Drinker, the brothers designed and constructed their cabinet respirator within a few weeks¹⁸ (Figure 3). Although its cabinet was made of plywood, the Both respirator could not shake off the “iron lung” nickname, which it seems the Both brothers themselves used.²

The Both tank worked in much the same way as the Drinker, but the incorporation of a bivalved design allowed temporary access to the patient’s body, by hinging upwards the top section of the tank. “Working non-stop with the help of several other enthusiastic young men, the brothers



Figure 2. Edward Both (left) with his wife Eileen and younger brother Donald, photographed at his home in 1987 by Dr Richard Bailey, FANZCA. (Reproduced with the kind permission of Dr Bailey.)

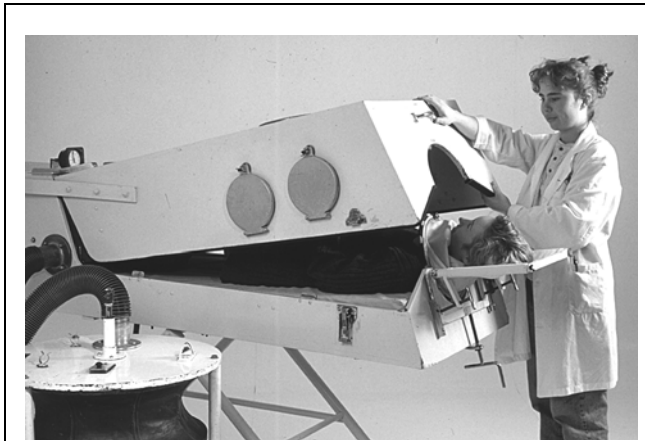


Figure 3. The “alligator” design of the Both Portable Cabinet Respirator, in Auckland Hospital. (Courtesy of Alex Fraser and the Department of Medical Photography.)

produced sufficient machines to cope with the polio epidemic in South Australia.² The GEC electrical motor which provided pressure changes was external to the cabinet, together with the compressor and bellows, and connected to it by a large flexible hose-pipe. This wooden “Both portable cabinet respirator”, as it was named,² was considerably lighter than the Drinker, and its wheels made it mobile. It was quickly put into life-saving use at Adelaide’s Northfield Infectious Diseases Hospital (with a few also at the Royal Adelaide Hospital [Stephen Hagley, FJFICM, Royal Adelaide Hospital, retired, personal communication, 2001]), and then was taken up in multiple hospitals and respiration units in other States (such as the Royal Alexandra Hospital

for Children at Camperdown in NSW,¹⁹ and in Western Australia and New Zealand).

Megan Hicks informs us that the Both was the commonest of the various respirators based on the Drinker, but able to be made quickly and inexpensively.¹ The original Both, costing around £100,¹³ was made only in Adelaide, but Both agencies were established later in Sydney and Melbourne (Richard Bailey, FANZCA, personal communication, 2006). The respirator underwent various improvements and was also “copied in the workshops of several Australian hospitals; as was a ‘Nuffield–Both’ at Prince Henry [‘Coast’] Hospital, NSW, in the 1940s”.¹ In consequence, the Boths and facsimiles in Australian museums are not necessarily identical, as they could have been manufactured in different places at different times.¹ Even today in Australia and New Zealand, a few individuals with residual ventilatory incapacity use their own Both at home, unwilling to exchange a trusted long-time friend for a modern machine (eg, in 2003, there were five in Victoria² and one in NSW²⁰). Such individuals are still partially dependent on it, for instance during sleep²⁰ or respiratory infections.

Professor Aubrey Frederick Burstall

For the 1937 polio epidemic in Victoria, a different wooden cabinet respirator^{3,21} (Figure 4) was used at the Acute Respiratory Unit of Fairfield Hospital, under the direction of the unit’s 1932 founder, Dr Henry (Sandy) McLorinan.⁶ This was purpose-designed locally by Aubrey Burstall, and six respirators could be coupled to a Burstall pulsator unit (35 of which were eventually made) (Footnote 1). Burstall cabinets were installed “for use all over Australia”.²¹ Burstall himself implies a total of nearly 200 at the end of 1937,^{21,22} but Bryan Speed’s count³ (Footnote 2) does not indicate so many.

FN1. Biographical Note. [See Carolyn Rasmussen’s Increasing momentum — engineering at the University of Melbourne²³. Aubrey Frederick Burstall (PhD, Cambridge), newly arrived from England to the Chair of Engineering at Melbourne University, rapidly developed his solutions for treating the ventilatory failure of polio in 1937 — the year the University of Melbourne conferred on him a DSc, *honoris causa*. Burstall also designed gas producers for motor vehicles. His other medical devices included “a tiny heat-regulated respirator” for neonates at Royal Women’s Hospital, Melbourne, and an aspirator, while his Faculty supplied a “Crash Team” for beach rescues.²³ After difficulties over challenging “the dominance of civil engineering”,²⁴ Dean Burstall returned to the United Kingdom in 1946 to the chair of Mechanical and Marine Engineering at the University of Durham. His books include the highly rated 1963 *History of mechanical engineering* and the 1968 *Simple working models of historic engines*.

FN2. Bryan Speed has determined³ that, at Fairfield Hospital’s Acute Respiratory Unit, “The initial six respirators increased to 23, with up to 47 patients having to ‘time share’. A further 36 ‘Burstall’ respirators were distributed to regional centres in Victoria. A total of 1,275 patients were treated. Most were less than 14 years old, 140 had respiratory paralysis, 106 required respirator treatment and 37 of these died.” (Mortality rate was thus 35% among those ventilated.)

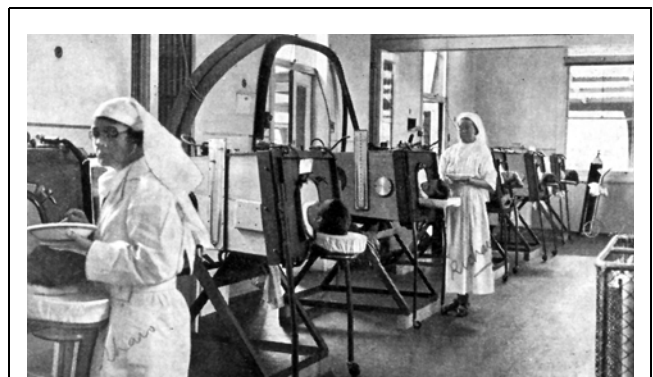


Figure 4. A rare photograph of Burstall respirators at Fairfield Hospital, 1937. (Courtesy of Dr Bryan Speed, FANZCA, and the Fairfield Hospital Historical Collection.)



Figure 5. Aubrey Burstall's cuirass jacket respirator, from his original 1938 article.⁴ (Reproduced with kind permission of the British Medical Journal.)

Later, towards the end of the epidemic (Christmas 1937), Burstall developed a simpler, neck-to-waistline "jacket respirator",^{21,22} a hammered-out, 6 lb (2.7 kg), aluminium, thoracic cuirass for respiratory support at the convalescent stage of polio ventilatory paralysis (Figure 5). This jacket had its initial clinical use in the first week of February 1938 at Melbourne's Children's Hospital, and then soon at Fairfield.²¹ One Burstall cuirass could be connected to a pulsator, or many cuirasses to a cabinet respirator. The inventor documented his jacket's "merits and demerits".²¹

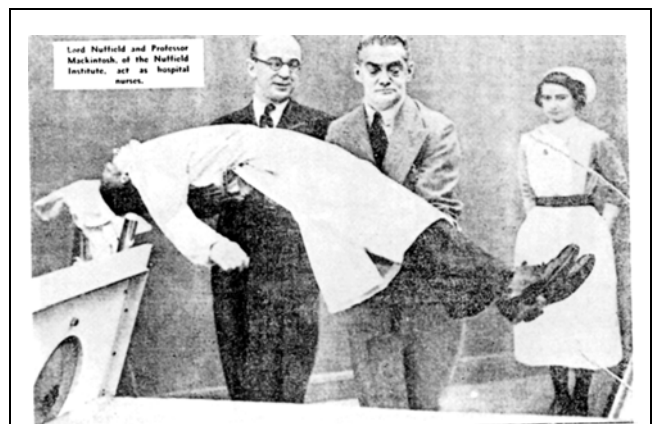
Burstall apparatus provided sterling service for Victoria,³ but unfortunately no examples appear to remain today. Despite this local success, it was the Both that, through its ubiquity, became the Commonwealth's regular cabinet respirator, as discussed below.

Lord Nuffield and the Nuffield Department of Anaesthetics¹⁵⁻¹⁷

Eileen Both² recollected how Edward Both "heard an SOS on the BBC radio for an 'iron lung' needed by a poliomyelitis patient", when he was in London in 1938 to promote the Both direct-writing portable electrocardiogram (probably the world's first). Both offered his services, rapidly putting together an example of his own respirator, which gained standards approval from the London County Council. Another Both unit, "lent" (Eileen Both²) to the Nuffield Department of Anaesthetics at the Radcliffe Infirmary, Oxford, was featured in a departmental film (Dr C L G Pratt, director) about mechanical ventilators for artificial respiration (Figure 6).

In October 1938,¹⁶ the Professor of the Nuffield Department, New Zealander Sir Robert Macintosh (1897–1989), ensured Lord Nuffield saw the film, which featured a "child whose life was saved in one of the newly invented 'lungs'".¹⁶ Eileen Both described Nuffield as impressed with the Both's "simplicity of operation and its design".² Accordingly, Robert Jackson's biography of Nuffield¹⁷ has him, directly after viewing the film, wanting to know why more hospitals were not equipped with tanks. "Money" was Macintosh's simple answer. Commenting "it seems a dreadful state of affairs that children are dying because hospitals cannot get hold of iron lungs in time", Nuffield then asked: "If every hospital throughout the Empire had a 'lung', is there a reasonable prospect of three lives being saved?" To Macintosh's reply, "Undoubtedly they would", Nuffield responded: "Well, I will give instructions immediately for a thousand to be made".¹⁷

Jennifer Beinart (now Stanton) states in her careful account^{16(p.43)} that, after viewing the film, Lord Nuffield chanced a "few days later" upon a newspaper headline "Iron Lung Arrives Too Late" for a young patient who might have been saved. The accompanying article stated (possibly incorrectly¹⁵) that there were only five iron lungs in all England. This led to Nuffield offering on 24 November 1938 "to make 5000 of them if necessary, at a cost of something like £500 000".^{16(p.43)} Other doctors wanted Nuffield to be aware that further improvements could still be possible, but Nuffield was dismissive:



LORD NUFFIELD believes in trying out for himself everything his factory produces. A week after his decision to build 5,000 iron lungs, costing £98 each, Lord Nuffield personally took part in a test of the first unit.

3. Lord Nuffield and Professor Macintosh lift a volunteer into an 'iron lung'. Macintosh is on the left, Nuffield on the right, Sister looking on — the volunteer is R. Salt. (From a cutting in the NDA museum, 1938.)

Figure 6. Lord Nuffield and Professor R.R. Macintosh with the first Both respirator at Oxford. (Reproduced with kind permission of the Nuffield Department of Anaesthetics, courtesy of Professor Clive Hahn, from Jennifer Beinart's *The history of the Nuffield Department of Anaesthetics, Oxford, 1937–1987*.)

Table 1. Patients treated by negative pressure respirators in the eastern United States

Indication	28 October 1928 to June 1930 ¹²	"After 2 years" ²⁹
Neonatal asphyxia	Limited success	> 30
Polio respiratory failure	2 of 7 survived	100
Coal gas/carbon monoxide poisoning	9 of 17 recovered	50
Overdose	3 of 5 recovered	
After scoliosis surgery	1 of 1 successful	
Drowning	1 of 1 recovered	7
Alcoholic coma	3 of 8 recovered	10
Postdiphtheritic paralysis	–	1
Total	80 (46 adults, 6 children, 28 infants)	> 198

If I had waited for the perfect car, I should be bankrupt now. We must get on with the best possible model available now and improve on it as we go along. It seems a pity to think that some of these respirators will be used as coal scuttles, but it is more tragic still to think of the possibility of a life being lost through the failure on my part to spend £25 or £30.¹⁷

A London County Council medical officer called Nuffield's providing iron lungs for "all and sundry"²⁵ the height of folly.¹⁷ But, trusting the advice of his friend Sir Robert, Nuffield himself laid out the line for mass production of the Boths in a corner of his Morris motor works in Cowley, Oxford.¹⁷ Until stopped by the war, production continued to supply every hospital still asking for Boths¹⁵ — and Jackson says "several thousands did so".¹⁷ Jackson repeats the above cost (sterling) of a Both–Nuffield at "about £25 each"¹⁷ (versus £100 each, should 5000 respirators cost £500 000,^{16(p.43)} compare the £98 cited in the caption to Figure 6).

The Nuffield Department of Anaesthetics was to distribute the Both–Nuffield respirator.¹⁵ Alex Crampton Smith records "in 1939 he [Nuffield] made the gift of a Both type 'iron-lung' to every hospital in the Commonwealth which asked for one ... The Nuffield Department helped to distribute the respirators and by demonstrations and films gave instructions in their use".¹⁵ One initial, sharp criticism complained of "a wanton waste of private benevolence".²⁵

FN3. The Pioneer Park Museum in Griffith, NSW has pointed out that the museum's "Both Bros ... 'alligator' style respirator [purchased by the Griffith community], unlike the one donated by Lord Nuffield, which patients had to be slid in and out of, ... has a lid that works on a counterweight. This system is said to be a lot more user-friendly."¹³

By RE Smith's later precise count,²⁶ "at the end of March, 1939, there were in the British Isles, including the Services ... 965 Both machines". (Smith also noted 30 Drinker machines and 43 Bragg–Paul respirators.) At the end of 1939, the Nuffield Department could report that "just over 1600 respirators" had been allocated throughout the Empire and "about 800 delivered"¹⁶ (versus "just on 1800", as Professor Peter Morris of the John Radcliffe Hospital Oxford asserts^{2(p.4)}). Although Beinart stated in 1987^{16(p.44)} that, because the later Nuffield Department of Anaesthetics records of the total number of Both–Nuffield respirators supplied have not survived, uncertainty existed over that number, earlier in 1947 the *Lancet* reported (anonymously) definitively on the numbers distributed (see Appendix). Sometimes Boths in Australia, a proportion of them coming from Cowley,¹⁶ were called "Nuffields" (Footnote 3).

Importantly in the history of intensive care medicine, "at one stroke" Nuffield's foresight with "this equipment ... forced physicians to treat actively patients developing respiratory failure".^{27[A.p.199]} Ted Both, Professor Macintosh, Lord Nuffield, you earned our thanks indeed! As William Mushin contended, the Both respirator functioned well to compensate for polio-paralysed respiratory muscles and did "an enormous amount of good".^{16(p.44)} Mushin et al saw the anaesthetists whom Nuffield caused to be involved^{27[A.p.199]} as the natural operators for tank respirators:

At one stroke a large section of the population working in British hospitals became familiar with this [Both] apparatus and, perhaps as importantly, Departments of Anaesthetics became recognised as the experts in its use and in the care of patients with acute respiratory difficulties.^{27[B.p.210]}

The excellent results obtained in these units stimulated major hospitals in many centres to establish 'respiratory units'.^{27[A.p.215]}

None of the reliable positive pressure (PP) machines developed in Sweden since 1934 for artificial ventilation during anaesthesia had received a trial for the long-term artificial ventilation which polio victims might require. (And of course, intermittent positive-pressure ventilation [IPPV] would also require satisfactory, cuffed intratracheal tubes.)

Non-polio use of negative pressure ventilation and the Both respirator

The 1928 Drinker iron lung represented a distinct advance over any existing machine providing respiratory assistance.¹¹ Not surprisingly, "the application of the respirator to a wide range of conditions other than polio started almost as soon as the Drinker machine was invented".²⁸ Philip Drinker and colleagues listed its application in 80 patients by June

1930^{12,29} (Table 1). In 1934, this machine enabled the survival of five out of eight diphtheria patients with diaphragmatic paralysis.³⁰ In the 1930s–1940s, innovators continued trying out mechanical NPV for numerous life-threatening disorders other than polio (Table 2).

The arrival of the Both provided a respirator which was, although at times inconvenient and for some perhaps claustrophobic,³¹ less complicated than the Drinker for nursing procedures, and much cheaper (Mini versus Rolls-Royce comparisons have been heard). A year after the “Both–Nuffield” was introduced to Oxford, Robert Macintosh was trying it to prevent postoperative respiratory complications,³¹ then, William Mushin and Nancy Faux³² successfully used it in a trial with 24 patients “to reduce post-operative morbidity”. However, contemplating his attempts at postoperative, prophylactic negative pressure ventilation, Professor Macintosh commented ruefully: “The sound of iron lung was pretty sinister ... The surgeons’ reputation could not stand for it” (personal communication, 1987).³² Still, the Both machine had sufficient, continuing, non-conventional use in the UK that a 1944 issue of the *Lancet*³³ could have it that “in a little over five years the Both respirator, once described as a ‘white elephant’, has produced persuasive reports of its use both as a life-saver and as a valuable adjunct to physical medicine”, and also that “use of the [Both] respirator to combat respiratory depression of barbiturate poisoning may now be said to be routine”. But does the literature support such a claim? It appears hardly quite that.

“The Nuffield model [of the Both] was modified and improved in various ways over the years”,² and infant models were devised — Nuffield’s original intention was “a gift primarily for children”.¹⁷ In the 1950s, various adaptations made to the Both were documented: for instance, in the UK the valuable modifications of RE Smith,²⁶ the Ministry of Health especially,³⁴ and others,^{35,36} and in Australia of John Forbes.⁶ At the Royal Adelaide Hospital, October 1938, Boths were also used, albeit rarely, for acute respiratory failure from (unspecified) causes other than polio, the last time probably in the early 1950s with the attempted resuscitation of a drowned person (Dr Stephen Hagley, personal communication, 2006).

Demise of intermittent negative pressure ventilation

Anaesthetist Bjørn Ibsen and colleagues, with H C A Lassen, demonstrated at Copenhagen’s Blegdamhospitalet, 1952–53, that manual IPPV was effective, safe and successful on a large scale and for long-term use.^{14,37,38} That led to the rapid development of multiple models of PP ventilators in Europe and the UK.^{27[B]} However, in Australasia the Both had

Table 2. Further applications of negative pressure ventilation to 1945*

Year	Indication	Author	Reference
1930–1940s	Poliomyelitis	Gilbertson A ²⁸	<i>J Roy Soc Med</i> 88: 459P-63P
1934	Diphtheritic paralysis diaphragm	Mitman M, Begg N ³⁰	<i>Lancet</i> i: 1438-40
1939	Paraldehyde poisoning	Macintosh RR ²⁸	<i>BMJ</i> i: 827
1941	Snake-bite poisoning	Linton R, Sarker N	<i>Indian Med Gaz</i> 76: 92(-3)
1940	Poor risk abdominal surgery (2 patients)	Macintosh RR ³¹	<i>Lancet</i> ii: 745-6
1944	Ditto (24 patients)	Mushin WW, Faux N ³²	<i>Lancet</i> ii: 685-6
1942	Diphtheritic palsy diaphragm	Todesco J	<i>Lancet</i> ii: 261
1944	Myasthenia gravis	Bates J	<i>Lancet</i> ii: 770
1944	Crush injury	Marshall DV	<i>Lancet</i> ii: 562-3
1945	Crush injury of the chest	Hagen K	<i>J Bone Joint Surg Am</i> 27: 330-4

* Mostly of the Both. Based on Gilbertson.²⁸

continuing use during the 1950s (much in the same way that the Drinker was being retained in the US), and its successful 1950s use at one Melbourne hospital in Victoria is examined below. By 1960 in the British Commonwealth, IPPV was supplanting INPV (per the Both) for any intensive care-type application, if not necessarily for patients with chronic polio. But, until then, the Both machine had made a valuable life-saving contribution for nearly a quarter of a century in Australasia, the UK and elsewhere. Although several other inexpensive, quickly manufactured substitutes for the Drinker tank had been devised for INPV outside the US (or at least in the Commonwealth), it was the respirator invented by Edward Both, OBE, which predominated.

Afterthoughts

Certainly, Lord Nuffield’s benevolence saved many lives. Ultimately, it also furthered progress along the pathway to intensive care medicine, a benefit he hardly envisaged. But the thought does come, could the very availability of the Both respirator have inadvertently delayed both the introduction of positive pressure ventilation (PPV) into Australasia and the earlier promotion of intensive care medicine? Australia and New Zealand received their supply of Boths just before the outbreak of World War II, and they were distributed to widely separated units or stored centrally, for instance in Wellington. Later, into the 1940s, exploratory attempts were made at Oxford to introduce the Both for

some specific clinical applications, but were abandoned.^{31,32} Although the Copenhagen demonstration of the efficacy of manual IPPV in the Danish epidemic was reported in the medical literature just 4 months into its use,³⁸ it was not taken up seriously in Australasia for half a dozen years, apart from a few isolated instances. Possibly the stores of available Boths, such a godsend when there were exceedingly few mechanical ventilators in Australasia, inhibited a more aggressive swing to developing PPV. Perhaps not.

Meantime, in 1950s Europe, especially Scandinavia and the UK, innovative designers, motivated initially by fears of further polio epidemics (until 1961, when the Salk and then Sabin vaccines brought the disease under control in the Western world), pressed ahead with invention of various PPV machines.^{27[A]} That venture had great spin-off in its application to non-polio conditions, especially tetanus. When the last polio epidemic arrived in Australasia in 1961 (Footnote 4), the very limited number of PPV machines here meant that the Boths, whatever their drawbacks, were undoubtedly saving lives. Jennifer Beinart discusses these issues, and questions whether the Both was outdated in 1939.^{16[p.45]} But the way ahead was not shown until 1952–53, when Bjørn Ibsen did precisely that (despite Anthony Gilbertson's brave claim that "'Intensive Care' did not start in 1952, it changed gear"²⁸).

Dr John A Forbes and Fairfield Hospital, Victoria

John Alan Forbes (1920–1989; Figure 7), one of the wartime "Rats of Tobruk", qualified in medicine after demobilisation and, after a spell as a patient at Fairfield Hospital^{41[A]} from 1950,⁴² took up duties as senior medical officer and registrar in February 1953. He became deputy medical superintendent the following year and, by January 1955, was reporting on the recent polio experience of Fairfield's respiratory unit, which had been under the overall supervision of Dr Henry (Sandy) McLorinan.⁶ In 1956–57, the unit was extensively refurbished and upgraded "to be used as a modern respirator ward"^{41[D]} to "provide excellent facilities for all types of respirator patients".^{41[E]} When Dr McLorinan retired in 1961, Dr Forbes became medical superintendent. The tribute for the Royal Australasian College of Physicians (RACP) by Mr Ian McDonald (FRACS)⁴² states that Dr Forbes "literally transformed Fairfield Hospital from a receiving centre for communicable diseases to a

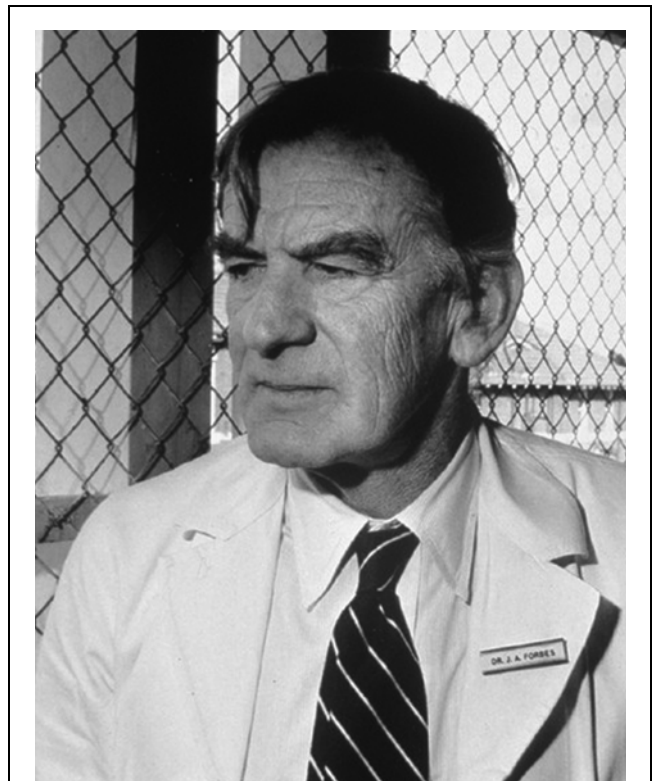


Figure 7. Dr John Forbes (FRACP, AM). (From the Fairfield Hospital Historical Collection, courtesy of Dr Bryan Speed, FANZCA.)

major university teaching and research establishment with an international reputation".

Despite the successful outcomes achieved by Dr Forbes and his team in treating polio respiratory insufficiency by INPV, and his two 1950s publications describing this treatment,^{5,6} it is not mentioned in the RACP tribute.⁴² Possibly this was because his heavy involvement in treating acute polio lasted only a few years, compared with his time dealing with other infectious diseases. The RACP's measure of this outstanding man lies with his notable achievements in the following decades. After his earlier years treating polio and other infectious diseases, he developed immunology and further research, later undertaking extensive philanthropic relief ventures in Ambon in Indonesia, and Vietnam.⁴² OldMedline lists about 35 articles with Forbes as sole or conjoint author. The clinical and research titles are spread widely, principally over infectious diseases, but also research and epidemiology.

Treatment of polio at Fairfield, with mortality data^{5,6}

Forbes' success between 1953 and 1956 in treating breathing inadequacy in polio by artificial respiration (accompanied by tracheostomy in 28 of 71 patients) is certainly impressive. For the 30 months from July 1954 to December 1956, 85 of the 295 patients with paralytic polio had

FN4. In New Zealand during the 1961 poliomyelitis epidemic, of the 304 cases admitted to Auckland Hospital, 85 went to its infectious diseases unit and associated respiratory unit. Sixteen of 17 bulbar and/or respiratory cases received intermittent positive pressure ventilation (with a tracheostomy) when intermittent negative pressure ventilation was not appropriate or was inadequate. A single death gave a 6.25% mortality rate for this group.^{39,40}

respiratory or pharyngeal paralysis (including adults and children of both sexes). Of these 85, 39 were artificially ventilated by tank respirator, a third of them with a tracheostomy (17 others with pharyngeal paralysis were not ventilated). Mortality rate among the 39 patients receiving artificial respiration was 20.5% (whereas, for the 32 artificial respiration patients during the previous 12 months, the 11 deaths gave a rate of 34.4%). Of the eight deaths in 1954–56, four occurred rapidly in the acute stage (as also happened in Copenhagen, 1952^{14,37,38}) and four others were from severe, non-polio causes.⁶ This rate compares favourably with other NPV series, such as HCA Lassen's 87.1% in a devastating first month of the 1952–53 Danish epidemic.^{14,37,38} R Bergman's poor 1948 results of 70% mortality among 827 cases may reflect use of the Sahlin–Stille cuirass alone.⁴³ In the 1952 New Zealand epidemic, the death rate of "respiratory cases" was 36 out of 46, or 78.3%.⁴⁴ (But how many who died did not receive negative pressure ventilation? Compare Southland, New Zealand: deaths in bulbar and/or respiratory cases were 11 of 57, giving a 19.3% mortality.³⁹)

Forbes introduced many changes to his Boths, but that of a "mechanical cough" was followed by a "dramatic fall in mortality rate of acute cases"⁶ (this had been noted earlier in the Medical Superintendent's Report, 1955^{41[C]}) (Footnote 5). Forbes placed considerable emphasis on this facility (previously described in the US by John Affeldt, 1954⁴⁵), and on two further ventilatory improvements: bellows of higher volume, and "a larger intratank positive-pressure phase" for thoracic and abdominal compression during expiration. In Forbes' opinion, his multiple measures all helped to reduce the mortality rate from the 34.4% of the previous 12 months (1953–54). Apart from respiratory care and tracheostomy, other general measures, such as nutritional needs, fluid balance, infection control, nursing care and physiotherapy, also received careful attention. Forbes considered that "chemotherapy" (antibiotics) had an important role in his unit, but one not to be abused.

John Forbes and negative versus positive pressure ventilation

John Forbes implied his firm belief that he had demonstrated INPV with his Both "tank respirator" to be prefera-

ble not only to use of cuirasses (this was indisputably so, as a cuirass had only 47%–61% of a tank's efficiency⁴⁵), but also to use of PPV, and that it was easier for nurses than managing IPPV!⁶ He quotes the Lassen–Ibsen polio mortality at Copenhagen during the 1952–53 Danish epidemic as 51.3% of 232 "ITPP" (intra-tracheal positive pressure) cases (but I cannot find such figures in the reference that Forbes supplies), all of them with a tracheostomy, he says (but it was actually not so: 26⁴⁶ among 262^{47[p.167]} [or 277^{14[p.13]}] artificially ventilated patients did not have tracheostomies). But the Fairfield mortality rate has to be considered in the light of the severity of the disease, and Lassen described the Danish epidemic as "by far the worst ever recorded in Europe".^{47[p.158]}

Lassen does not supply virus typing (apart from the 20 patients studied, who all had type 1^{14[p.41]}), but Forbes points out that in his own cases the cerebral lesions were worse when the causative polio virus was type 3 rather than type 1 or 2.⁶ Lassen did further classify the Danish cases into six anatomico-clinical groups of differing severity.^{14,46} Recently, the Copenhagen mortality has been re-estimated⁴⁶ as showing a rate of 11% among the last 18 patients, within a 41.7% overall epidemic mortality in patients whom Lassen classified as meeting his criteria for "life-threatening poliomyelitis".^{14,47} Reassessing their Blegdam cases after the epidemic, Lassen referred to improving results "despite the constant severity of the cases throughout the whole epidemic period",^{47[p.158]} so presumably such an assessment applied to the last 18 patients too.

The Medical Superintendent's 1956 Fairfield Report claimed "this hospital with experience of all methods of artificial respiration considers that the tank type of respirator or iron lung is still the most efficient machine".^{41[D]} It would seem from the critical remarks John Forbes made about PPV that he distrusted it.⁶ If using PPV, he would expect a higher mortality rate, the employment of a higher tracheostomy rate with the consequent "inevitable tracheobronchitis", and "unopposed intratracheal positive pressure", producing problems of cuff trauma to the trachea and circulatory impairment. (In the early 1950s, there was widespread unease that IPPV decreased venous return unduly.) As Forbes quoted⁶ a 1954 textbook of Albert Bower on treating acute polio at Los Angeles, he presumably knew thereby about V Ray Bennett's IPP respirator attachment for their INPV machines,⁴⁸ although he never adopted it. But he did "maintain" his patients "when out of the respirator" by intratracheal PP oxygen.⁶ The Bennett attachment did bring significantly better results for Albert Bower's team at Los Angeles (in 1949, the mortality rate among 130 "respirator cases" was 17%,

FN5. The 19(54-)55 Fairfield Annual Report^{41[C]} mentions the use of "new chest respirators" (presumably Boths to replace longstanding Burstalls, but just when the changeover happened before 30 June 1955, I cannot find stated); and Forbes' application, obviously to his Boths, of a "mechanical cough" mechanism (a phrase also used by Forbes himself). Forbes described the mechanism in detail⁶ and eulogised it, after 2½ to 3 years experience of the "cough type [Both] iron lung"^{41[F]} (again, a Fairfield Report expression).

compared with 62% in 1946 — but see Footnote 6⁴⁸ regarding Bower's superior resources); and was helpful for William O'Brien and associates⁵¹ at Reno, Nevada (mortality rate of "23.5%" over 3 years in a critical group of 51 ventilated patients). John Affeldt⁴⁵ at Hondo, California, invoking Bower, used a PP "attachment to the mouth or tracheostomy" which "greatly facilitated nursing care".

FN6. *A comparison of resources: during the 1948–49 polio epidemic, the resources available to Bower's unit enabled simultaneous treatment of patients with 42 Drinker–Collins mechanical ventilating units, each with a Bennett positive pressure attachment, while 25 had physiological cams installed. The 42 units were "in almost constant use",⁴⁷ providing intermittent positive pressure ventilation. Compare Copenhagen: the epidemic started with HCA Lassen having no Drinkers, only one Emerson tank and five cuirass respirators.¹⁴ The number of Boths available to Forbes would certainly be below Bower's total number of Drinkers. In his 1961 visit to Fairfield, M Spence noted Forbes' unit "equipped for the operation of 14 Tank (or Cabinet) respirators".⁴⁹ These numbers conflict with those he later gave at an address to the Australian and New Zealand Intensive Care Society (NSW) in 1986.⁵⁰ "25–30 Boths with 20 occupied by chronic polio patients".*

FN7. *Fairfield Annual Reports: the year's table of "total number and principal diseases treated", among which polio is prominent, has a large group (eg, 2156 of 4405 admitted for "1953") labelled "miscellaneous — including admission for General Division". Tetanus is not separated out from this group until 1957, with seven cases,^{41[E]} and "acute infective polyneuritis" not until 1958, with 15 cases.^{41[F]} Fresh polio admissions taper off, 1955–60. Not until 1958 — and for that year alone — do the reports provide data on the total of polio paralytic cases (168), cases with respiratory or pharyngeal paralysis (53), cases requiring artificial respiration (22), and mortality of paralytic cases (4 patients, 2.3%).*

FN8. *Re Forbes' Acute Respiratory Unit: a first-hand assessment lies within Matt Spence's extended and locally famous 1961 Report to the Department of Health in New Zealand,⁴⁹ written following his close scrutiny of the world's top 42 [English-speaking] ICUs during a 5 month overseas study tour. Fairfield's unit was the first Spence saw, over a 6-day visit. Apart from some milder criticisms, Spence declares "He [Forbes] has accumulated a vast experience in the management of respiratory inadequacy using tank respirators with a cough mechanism incorporated ... The respiratory unit at Fairfield Hospital receives mainly poliomyelitis, polyneuritis and tetanus patients. Respiratory inadequacy due to neurological lesions and respiratory disease has been treated. They do not receive surgical cases. The Unit operates very efficiently and all concerned are proficient at their duties. This is primarily due to organisation and close supervision by Dr Forbes and Dr Bennett, the permanency of the nursing staff and physiotherapy staff and the enthusiastic assistance of the hospital engineer in maintaining and effecting improvements to equipment." Spence later added myasthenia gravis to the above list of conditions treated at Fairfield — and more. In his notoriously opinionated address at the ANZICS 6th Continuing Education Meeting, Newcastle, March 1986⁵⁰ (see also James Judson^{55[p.84]}), he asserted, "Concentration of paralyzing and convulsive diseases at Fairfield delayed the organisation of Intensive Care facilities in Melbourne Teaching and Acute Hospitals until the middle of 60's era of traffic accidents", etc.*

In New Zealand around this time, ventilatory support from "tank respirators, cuirass respirators and positive pressure equipment" was being advocated for respiratory centres which were to be established in the main hospitals, as well as stored in a central pool at Wellington.⁵² Yet Christopher Woollams has pointed out²² that, as early as 1938, the Medical Research Council Committee in Britain had recommended respirators be loaned out, as required, from depots best sited at regional centres,⁵³ as "Both respirators were bulky and difficult to store".²² But how well could such a system function to meet an immediate need — surely it would fall short?

Early intensive care medicine in Australia: John Forbes and others

The unit probably regarded as Australia's first *formal* ICU — which is generally taken to be one using (at least) IPPV — was the one Victor Hercus had refurbished at Prince Henry Hospital, Sydney, 1961–62.⁵⁴ Claims could be made that before that renaissance, Forbes' NPV respiratory unit at Fairfield came close. Thus, the Fairfield 195(5–)6 Report^{41[D]} (note that Fairfield Hospital Annual Reports for a specified year were dated only to 30 June, but ran from 1 July of the previous year) states that "several severe tetanus patients have been successfully treated with relaxants and artificial respiration" in a "'cough type' iron lung";^{41[F]} while the report of 1957 states that "in the last 15 cases of tetanus, there have been only 3 deaths".^{41[E]} Forbes' 1958 article⁶ on his management of polio patients with ventilatory failure also specifies treating patients with "infective polyneuritis" (see also Footnote 7). Tracheostomy — but not endotracheal intubation — was readily performed by Dr John Forbes and his full-time assistant Dr Noel Bennett.⁴⁹

For all these reasons, it has been written that Forbes' unit "must be credited as probably the first official ICU in Australia"⁵⁵ (see also Footnote 8). Properly however, such a term is reserved for PPV units. Before "true" ICUs became established in Australasia around 1960, there were occasional intensive care medicine activities. Thus, for treating tetanus: over July–October 1957, at the Royal Adelaide Hospital without a formalised ICU, nine patients of Maurice Sando and Graeme Marshall received curarisation and IPPV for controlling their tetanus, with five surviving.⁵⁶ The same treatment had been provided earlier: by Patricia Wilson (now Mackay) in Melbourne in 1954 (personal communication, 2001), and later by others⁵⁷ there; by Dr I Schalit at the Royal Newcastle Hospital 1954–55;⁵⁸ and Brian Dwyer in Sydney, 1956.⁵⁹ It can be noted that Dr Mackay's ANZCA Citation, 2000, mentions she also treated head injuries, myasthenia gravis and polyneuritis.⁶⁰

In conclusion

Concerning success in treating paralytic polio in the 1940s to 1960s, it seems that, with the limited information available, one can hardly make valid comparisons between polio respiration units in different countries. However, it is not unknown in intensive care medicine for a unit such as John Forbes', with a team superbly led by an inspiring leader and with organised, enthusiastic, experienced staff (especially nursing staff) and ready medical back-up (Forbes lived on site) to achieve results not to be expected with more limited or inferior facilities and resources (Footnote 6). Forbes was "imaginative, quickly responding to new ideas and advances in medical science".⁴² It comes as no surprise then to be informed that "he treated patients with a wonderfully high and compassionate standard" (Barbara Rossall-Wynne, Curator, Fairfield Hospital Historical Collection, Austin Health, Melbourne, personal communication, 2006).

Appendix

Since this article was written, Professor Sir Keith Sykes has kindly drawn my attention to a *Notes and News* report in the *Lancet* (2 August 1947; 250: 193), concerning where the Nuffield–Both respirators "were distributed approximately": United Kingdom and the Services, 750; Canada, 347; Australia, 198; India and Burma, 183; South Africa, 46; Eire, 40; New Zealand, 33; Newfoundland, 14; British hospitals abroad, 10; and elsewhere in the British Empire, 134; total, 1755.

In addition, Jenny Jolley, Library Assistant, Australian and New Zealand College of Anaesthetists, has pointed out further historical information for me, about modification to the Both–Nuffield respirator by UK medical (and automobile) engineer G T Smith-Clarke (1884–1960). An entry initiated by Dr Adrian Padfield, FRCA, in the Oxford Dictionary of National Biography, states:

Upset at the distress caused to a patient taken out of an iron lung for nursing care, he [Smith-Clarke] redesigned all aspects of the existing Nuffield/Both ... widely used to treat patients with respiratory paralysis caused by poliomyelitis. ... Kits to modify 500 Both machines were manufactured by a new company, Cape Engineering, set up with Smith-Clarke's support by several ex-Alvis employees. He then designed and helped to produce a much superior (and less coffin like) model called the 'Alligator' ... Apart from the new iron lung, Smith-Clarke's paper describes junior and baby versions.

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It is also a delight to be able to acknowledge the important roles played with the Both respirator by Lord Nuffield, my patron to Oxford and the Nuffield Department of Anaesthetics, and my teachers there, "Prof Mac" and Alex Crampton Smith. (Macintosh's own life story is detailed in the short biography by Professor Sir Keith Sykes in volume IX of the series *Careers in anesthesiology* from the Wood-Library Museum, 2005.)

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