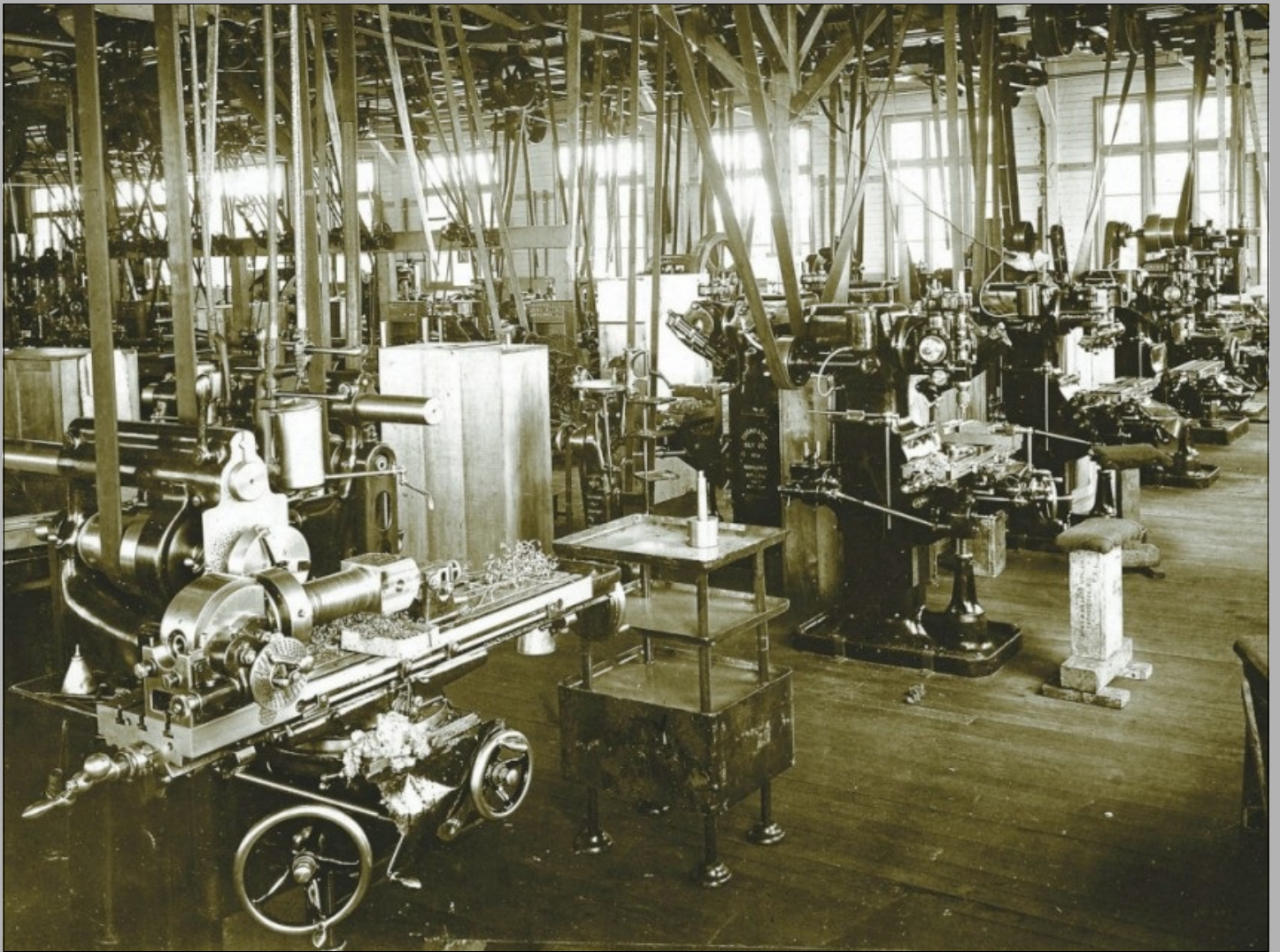




ENGINEERS
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EHA MAGAZINE



Engineering Heritage Australia Magazine

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Cover Images:

Front: The Tool Room of the Lithgow Small Arms Factory in 1914.

Photo: From the SAF Museum Archives.

Back: Two paintings by "Brendorah", The "Nom de Brush" of a Sydney artist who worked at the Lithgow Small Arms Factory in WW2. See page 27 for details.

Top: Woman's Night Shift.

Bottom: Morning After Night Shift.

This is a free magazine covering stories and news items about industrial and engineering heritage in Australia and elsewhere. It is published online as a down-loadable PDF document for readers to view on screen or print their own copies. EA members and non-members on the EHA mailing lists will receive emails notifying them of new issues, with a link to the relevant Engineers Australia website page.

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"Wonders Never Cease"

"100 Australian Engineering Achievements."

Engineers Australia (EA) is celebrating its centenary year in 2019. To mark this occasion, Engineering Heritage Australia has produced a book of 100 significant Australian engineering achievements, from the Stump Jump Plough, to the Sydney Harbour Bridge, to the Snowy Mountains Scheme. A celebration of our rich engineering heritage, these stories will appeal to engineers and non-engineers alike, and are accompanied by an array of remarkable images. Engineers have taken often visionary ideas and turned them into practical realities, and the pages of this book highlight the combination of toil and genius which has shaped the Australia we live in today.



For the price of the book, to EA members & non-members, and how to buy it, see a link to EA Books on the next page.

Editorial

For some years now, the Engineering Heritage Committee of the South Australia Division of Engineers Australia, has been running, very successfully, engineering history half day conferences, timed to coincide with South Australia's History Festival. I was never able to attend, but I admired their enterprise greatly, and when I could find the conference papers online, I thought many were interesting, and a few turned out to be very useful in my research for this magazine.

I was prompted recently to go back to look for some of the earlier papers that I hadn't got round to downloading the first time I looked them up. I found the programmes for the 2017 and 2018 conferences, but none of the papers from any of the conferences. They are (or were) an extremely valuable source of knowledge about South Australia's engineering history, which should be easily available for students, engineers and historians to consult. If anyone can tell me where to find them, I will be very grateful.

The reason I was prompted to make that search was that the Engineering Heritage Victoria (EHV) Committee had decided to conduct a similar style half day (mini) conference in July or August this year. At their last meeting the Committee was putting together a program and looking for a suitable venue. By the 10th of May the programme had been sorted out, the date was established (15th August) and the Committee had found the absolutely perfect venue – the Royal Historical Society of Victoria (RHSV) rooms in History House at 239 A'Beckett Street Melbourne.

Here is the "Advance Notice"

Celebrating Engineering History

An afternoon mini-conference "**Celebrating Engineering History**" is planned for Thursday 15 August 2019, 1pm – 5pm, at the Royal Historical Society of Victoria, being organised by Engineering Heritage Victoria in conjunction with the RHSV.

Engineering has been defined as being "a vital art, working with the great sources of power in nature for the wealth and well-being of the whole of society". We often just think of engineering as being something that started when engineers became a separate profession, but engineering dates back many thousands of years.

Victoria has many outstanding world leading engineering works, but many of these achievements are not well documented, or have been forgotten, and need to be celebrated.

Four papers will be presented focussing on the history of some of the significant engineering works in Victoria. This year is the 150th anniversary of the Great Melbourne Telescope; the 100th anniversary of the Electrification of Melbourne's suburban railways; and the 100th anniversary of the formation of the Institution of Engineers, Australia, and as many notable indigenous engineering works survive in Australia, we hope to include a paper on this topic as well.

Put the date in your diary, and look out for more information soon on the RHSV website at:

<https://www.historyvictoria.org.au/date-claimer-engineering-heritage-mini-conference/>

Three cheers for our volunteers!

In the *Insight* page of the May issue of Engineers Australia's *Create Magazine*, EA's National President, Trish White, and CEO Peter McIntyre, recognise National Volunteers Week with some well deserved praise and *Three Cheers* for EA's volunteers. They were referring to all the volunteers, in the Colleges, the Technical Societies and, I hope, Regional Groups.

With National Volunteer Week in May, it's timely to highlight the sheer variety and scope of the work our thousands of volunteers do and to thank them for their contributions. Throughout 2019, our centenary year, we're holding events to acknowledge our volunteers for their role in making our centenary theme of 'Anything is possible' true. Engineers Australia could not do the work we do without our more than 2500 volunteers. . . .

Here's what they had to say about Engineering Heritage Australia (EHA), which is ALL volunteers!

Engineering Heritage Australia volunteers work to record and celebrate our engineering achievements, providing a window on the past that can inform the future. The Engineering Heritage Recognition Program encourages the conservation of engineering heritage and raises community awareness. More than 220 sites have been recognised under the program with markers or interpretive panels. The National Engineering Oral History Program records history as it was, not a sanitised version from files and history books.

Engineering Heritage volunteers in every EA Division around Australia also organise occasional seminars, conferences, and regular speaker nights on engineering heritage topics. And the EHA volunteers are the majority of contributors who provide the interesting stories to be found in EHA Magazine. Three Cheers from me too! And check this out – the content is from EHA Volunteers: <https://www.eabooks.com.au/Engineers-Australia-Centenary-Book-Wonders-Never-Cease>

See the previous page for information about this new EHA Book.

Towrang Bridge & Culverts

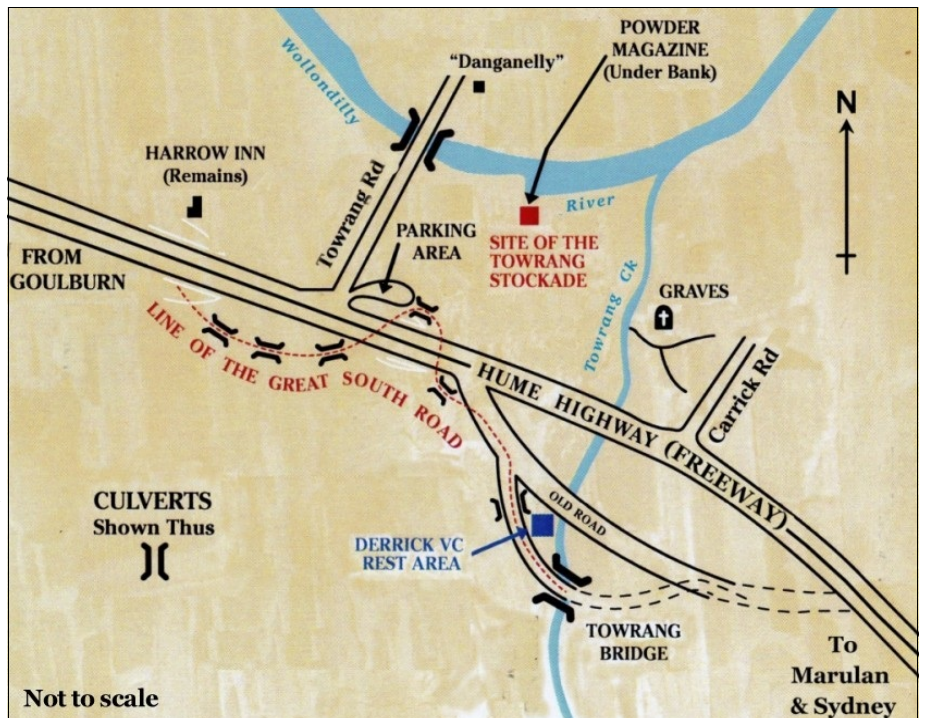
& some notes on their designer/builder.

By Frank Johnson

Introduction

Motoring down the Hume Highway (or Freeway) through the Southern Highlands one might assume that it is all 20th and 21st Century engineering as far as the eye can see. However, some 20 kilometres south of Marulan near the Derrick VC Rest Area at Towrang (off the south-bound lane of the Freeway) lie some remarkably well preserved examples of 19th Century civil engineering.

Towrang is well known, especially locally, for its Convict Stockade, but the purpose of the stockade was to house the convict labour force building the Great South Road, one of three major routes out of Sydney planned by Surveyor-General Major Thomas Mitchell in the 1830s. And, of course, roads inevitably need bridges and culverts, and those at Towrang are some of the few original examples remaining in NSW.



Map adapted from one published by Goulburn Council. The "north bound lane" to Sydney is here going from NW to SE over this short section of the road.

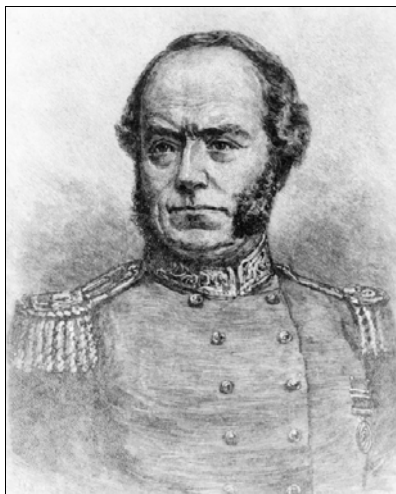
Derrick VC

Before exploring the engineering of the bridge and culverts, the naming of the rest area should be given due recognition. The route between Sydney and Canberra on the Hume and Federal Highways contains the Remembrance Driveway, initiated in 1954 in memory of those who served in the Australian forces in World War II and subsequent wars or conflicts. Each of the rest areas along this route is named after a recipient of the Victoria Cross, the highest decoration for gallantry "in the face of the enemy" awarded to members of the British and Commonwealth armed forces.

In this case, we have Sgt Thomas Currie "Diver" Derrick VC, DCM. (20 March 1914 – 24 May 1945), who was awarded the Victoria Cross in November 1943 for his assault on a heavily defended Japanese position at Sattelberg, New Guinea. During the engagement, he scaled a cliff face while under heavy fire and silenced seven machine gun posts, before leading his platoon in a charge that destroyed a further three. Derrick VC was commissioned Lieutenant in November 1944 and rejoined his former company as a platoon commander. Sadly, he was killed in action at Tarakan about 6 months later.¹



Photo of Derrick VC, taken around the time he won the VC. Image from Wikipedia.



Major Mitchell. Image from Wikipedia.

History of the route

The Hume Highway is inextricably linked with the early history of the colony of New South Wales, the opening up of the countryside south of Sydney, and the linking of Sydney and Melbourne. Together with this sit the names of a number of famous people in the colony, including Surveyor-General Major Thomas Mitchell, the explorers Hamilton Hume and William Hovell, and the bridge "engineer" David Lennox.

Hamilton Hume was born in the NSW colony in 1797, and in 1814 on one of his expeditions he discovered a tract of land north of Goulburn, that became the County of Argyle. This led to the progressive opening up of the country between Sydney and Goulburn, and the establishment of settlements, such as Moss Vale and Berrima, along the way.

In 1827, Surveyor-General Mitchell began a detailed survey of the colony and recommended extending and improving the existing road system from Sydney to the Hunter River, Bathurst and Goulburn.

¹ https://en.wikipedia.org/wiki/Tom_Derrick

Towrang Bridge & Culverts

Mitchell surveyed the routes for the new highways: the Great North Road; the Great Western Road; and the Great South Road respectively. In 1832, approval was given for the construction of the Great South Road, along the alignment surveyed by Mitchell.

Work in the area north of Goulburn was largely by convict labour, with a stockade at Towrang in use from 1836 to 1842. In 1928, the Great South Road was proclaimed as a State Highway, giving it the name *Hume or Great Southern Highway*. Until about 1940, Hume Highway traffic used the Towrang Bridge, and then it was bypassed. After that, local sources indicate that the road over the bridge was used as part of a tourist circuit until 1980, when it was closed to all traffic.

Towrang Stockade

At the time the Towrang Bridge and Culverts were constructed, NSW was still very much dependent on the convict workforce, even 50 years on from the first white penal settlement in 1788. For construction projects like the Great South Road, stockades were established, to hold the convicts, and the Towrang Stockade is a prime example.

The workforce comprised road parties, bridge gangs and iron gangs. The iron gangs were the most heavily supervised and had the most incorrigible felons, many serving 14 years to life sentences, and these men were usually kept in leg-irons. They wore a black and yellow uniform, and marched in files to their worksites. A guard of soldiers with fixed bayonets escorted the men and stood over them at work – from dawn to five in the afternoon. Members of the iron gang were quartered in wooden stockades with their irons still on, sleeping on bare boards, with just a blanket apiece – unimaginable in a Goulburn winter!

These then were the workers that built the Great South Road, and the Towrang Bridge and Culverts, relying mainly on their sheer physical strength. This is a far cry from today's workforce and construction techniques, which makes recognition and preservation of these pieces of infrastructure even more notable and important.

Sadly, all that remains of the Towrang Stockade now are three gravestones and the Powder Magazine. These relics of the Towrang Stockade are to be found close to the Derrick VC Rest Area, but off the opposite, northbound lane side of the Hume Freeway, close to the Wollondilly River. They are on private property, but are able to be visited.

The Towrang Bridge.

So far as engineers are concerned, the pièce de résistance of the site must surely be the Towrang Bridge, a magnificent stone arch spanning Towrang Creek. Certainly, it is small by any standard, spanning just 4.60m and 5.50m high at the arch, but its history and preservation really set it apart.

The bridge spans Towrang Creek, which seems placid enough but after heavy rains, great torrents of water surge down from Mt Towrang (aka Mt Toongabiya), at 2849 feet or 947 metres and into the Wollondilly River. That the low-level road crossing of the Wollondilly River on the Towrang Stockade side of the Hume Freeway can be flooded to depth of 5m, is a clear indication of the torrential water flow that can occur in this area. The fact that the Towrang Bridge has survived in such great condition after 180 years is surely a testament to the skills and endeavours of its builders.



The Towrang Bridge across Towrang Creek.

Photo: Frank Johnson, 2019.



A relic of the Towrang Stockade – the Powder magazine under the bank of the Wollondilly River. Photo: N. Secomb for NSW OEH.

Construction of the bridge involved the cutting, dressing and placing of nine quoins (the horizontal blocks which line the sides of the arch) on each side. These are topped by 19 voussoirs forming the arch, including the two springers, which are lowest voussoirs on each side, and the keystone at the top which locks the arch in position.

Towrang Bridge & Culverts

Some of the stonework has been fixed with lime mortar, probably using local materials. Lime mortar used in Sydney construction at the time had remnants of sea shells, pointing to the coastal origin of the limestone. However, there are no traces of sea shells in the Towrang Bridge, indicating that the limestone was probably sourced from the newly discovered deposits at nearby Marulan South. 180 years on, the Marulan South limestone is still being used in the manufacture of cement and steel. Sadly, the Towrang Bridge has been vandalised over the years, with the 1839 inscription on the top of the arch obliterated and some of the sandstone coping stones stolen.

David Lennox

It is worth briefly reflecting on David Lennox, to whom the Towrang Bridge is attributed, although not proven, as he had a significant role in bridge building in the early days of the Colony of New South Wales.

David Lennox was born in Ayr, Scotland in 1788. He became a master mason and for some 20 years held responsible positions in Britain, working on many bridges. These included Telford's magnificent suspension bridge over the Menai Straits and the 46m span stone-arch bridge over the Severn River at Gloucester.²

Some four years after the death of his wife, Lennox: *took passage to Australia in the "Florentia", arriving in Sydney in August 1832. . . . In Sydney he was at first employed on day wages, cutting the coping stone for the hospital wall in Macquarie Street.* There he attracted the attention of the Surveyor-General (Sir) Thomas Mitchell.³

In his book *Spanning Two Centuries - Historic Bridges of Australia*, Colin O'Connor provides an interesting version of Mitchell's account of their meeting when Mitchell invited Lennox to his office: *Mr David Lennox, who left his stone wall at my request, and with his sleeves still tucked up, came with me to my office, and undertook to plan the stone bridges we required. . . . Thus originated all the bridges this Colony possesses worthy of his name.*⁴

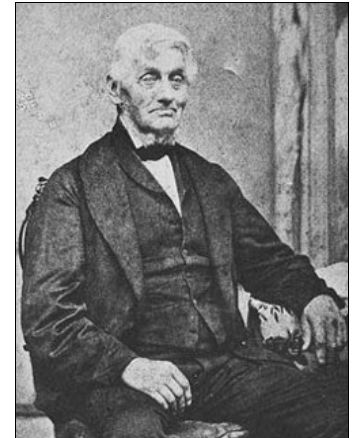
Mitchell was evidently quite impressed with Lennox and recommended him to the Governor, Sir Richard Bourke, as a person experienced in the construction of arches of the greatest magnitude in England. This secured Lennox's appointment, first as sub-inspector of roads on 1 October 1832 and then superintendent of bridges in June 1833, the position he held until 1843. Thus, Lennox would have been in charge of bridge construction in NSW when the Towrang Bridge was being commissioned and constructed.



The 1833 Lennox Bridge at Lapstone Hill.
Photo by Maudlingothic, 2006 – from Wikipedia

Lennox's first bridge was on the Great Western Road out of Sydney, at the foot of the Blue Mountains at Lapstone Hill. This was a graceful single arch of 6.2m span, a road width of 9m and stood 9m above the water level. In keeping with the times, it was constructed by convict labour, using stone quarried near the site. It was named the Lennox Bridge by order of the governor, and the keystones bear the name of Lennox and the construction date of 1833. This is the oldest bridge still standing on the mainland of Australia and carried traffic on the Great Western Highway until 1926. The significance of Lennox Bridge was recognised by the placing of an Historic Engineering Marker by the Institution of Engineers, Australia and the Blue Mountains City Council in 2002.

Closer to Sydney, one of Lennox's other notable bridges was over the Georges River at Lansdowne, a single span masonry arch of 34m span, 9m road width and 9m above water level. After a difficult construction period with labour shortages and flooding of the river, this bridge was opened by the governor with due ceremony on 26 January 1836 and Lennox received a special bonus of £200 and his salary increased to £250 per annum. This bridge still carries Hume Highway traffic more than 180 years on.



David Lennox – from a portrait in State Library of NSW.
Photographer unknown.

2 Antill, J.M., Lennox, David (1788–1873), Australian Dictionary of Biography, National Centre of Biography, Australian National University, <http://adb.anu.edu.au/biography/lennox-david-2350/text3071>

3 *ibid.*

4 O'Connor, *Spanning Two Centuries - Historic Bridges of Australia*, pub. UQ Press, 1985. Unfortunately, O'Connor gives no provenance nor a reference for this supposed direct quote. (Ed.)

Towrang Bridge & Culverts

Bridges on the Great South Road out of Sydney towards Goulburn also came under Lennox. An early one was a two span timber structure supported on masonry piers over the Medway Rivulet, about five kilometres south of Berrima. This was completed in 1835 but was destroyed by flood in about 1860. A similar fate befell Lennox's 15m masonry arch over the Wingecarribee River at Berrima, completed in 1836 but also destroyed by floods in 1860. Thus the Towrang Bridge is significant, as it is the only surviving Lennox bridge in the Southern Highlands of NSW.

In November 1843, Lennox was appointed district surveyor to the Parramatta Council. This was a short lived appointment, as Governor Sir George Gipps appointed him to the position of superintendent of bridges in the Port Phillip District in October 1844. He held this position until 1853, when he retired from public life and returned to New South Wales to live in Parramatta. He passed away in 1873 and, strangely enough for a master mason, is buried in an unmarked grave in the old St James Cemetery in Parramatta.

Lennox was described as: *a shy and retiring man, kindly but capable of firmness when required, a master craftsman and a splendid manager of men.*⁵ It was also noted that he was a kindly taskmaster and he sought mitigation of the sentences of convicts who gave good service and he seldom had any trouble with the hundreds of prisoners working on his projects.

In his entry on Lennox in the *Australian Dictionary of Biography*, J. M. Antill notes: *There is no doubt that, just as his arrival in New South Wales opened a new chapter in the bridge building history of the colony, so did his departure close it. He was a pioneer of great skill and a master craftsman whose solution to the many technical problems brought him well deserved and lasting fame.*

Overall, Lennox sounds like the type of 'engineer' or foreman/superintendent that I would have been quite pleased to have working for me on civil design and construction works.

The Culverts

The Towrang Bridge site also included seven culverts which, while not as imposing as the Bridge, were ornately designed and quite impressive. Only six still exist. They can be found by walking south along the old road alignment, but access can be a little difficult in places.

Five of the existing culverts are on the same side of the Freeway as the Rest Area, while the other is on the Stockade side. The alignment of the Great South Road seems somewhat tortuous in this area but this is probably due to finding a suitable location to cross Towrang Creek. Just beyond the final culvert and on the other side of the Hume Freeway sit the remains of the old Harrow Inn. No doubt this was a welcome stop for those making their way down to Goulburn – by foot or with the original horse-power only.



One of the surviving culverts near the Towrang Bridge. Photo: Frank Johnson.



Another culvert near the Towrang Bridge.

Photo: Frank Johnson.

The six remaining culverts range in span from 580mm to 1600mm, and in height from 1.80m to 4.40m. While these would not seem significant in terms of major engineering works of the same vintage elsewhere, due recognition should be given to their remote location, style of construction, and their lasting for 180 years, despite the many changes to the alignment of the adjacent Hume Freeway.

In addition, the attention to detail in the construction is of interest, with the decorative effects on the sandstone quoins and voussoirs. This would surely indicate a designer whose vision for the bridge and culverts extended beyond the simply utilitarian. Further, the skills of the convict workforce are also evident in the stonework and one could wonder what they went on to, once they had served their terms in the iron gangs.

⁵ Another unattributed quote from O'Connor in *Spanning Two Centuries*. (Ed.)

Towrang Bridge & Culverts

Old South Road

Particularly north of the Towrang Bridge, one can still trace remnants of the Great South Road and earlier alignments of the Hume Highway. In some areas there are still patches of the old bitumen paving, which looks very thin compared to modern day paving design. Indeed, looking along the old alignment, the contrasts in width, gradient and curvature between the Great South Road and the current Hume Highway are starkly evident. Road design has progressed remarkably in 180 years!

Image at right: A short section of the original Great South Road near Towrang Bridge. Photo: Frank Johnson.



The Site

The Derrick VC Rest Area is quite popular, especially in holiday times, and has the usual rest area facilities. There are information boards with details of the Towrang Stockade, the bridge and culverts, and Thomas Derrick VC. I would encourage all to consider stopping at the Derrick VC Rest Area when heading southbound along the Hume Freeway towards Goulburn and then spend a few minutes exploring the site and marvelling at these incredibly preserved examples of early 19th Century civil engineering. The rest area is only accessible from the southbound lanes of the Hume Highway, and motorists travelling northbound are advised to turn into Tiyces Lane, about 1.5 km past Carrick Road, and then join the southbound lanes.

NSW State Heritage Register

The Towrang Stockade, Bridges and Culverts are listed in the NSW State Heritage Register, which is available on-line. See: <https://www.environment.nsw.gov.au/heritageapp/ViewHeritageItemDetails.aspx?ID=5001346> In assessing the significance of the site, it was determined that the following criteria were met: Historical significance; Aesthetic significance; Research potential; Rarity; Representativeness; and Integrity /Intactness. The rarity is certainly applicable, for there are no other known examples of such stockade and bridge works on the Hume Highway.

Conclusion

This story was inspired by my attendance at the 2019 Goulburn History Weekend, which was supported by Goulburn and District Historical Society. The Towrang Bridge and Culverts featured over the weekend, with a talk by Phil Leighton-Daly and a site inspection led by Tom Bryant, both notable local authors and historians. Both the talk and site inspection were well attended, showing the interest in engineering heritage that exists in the general community.

The Goulburn Visitor Information Centre at 201 Sloane Street, Goulburn (just north of the Railway Station) has an excellent leaflet on the Towrang Stockade, and it includes information on the historic bridge and culverts. The Visitor Information Centre can be contacted on (02) 4823 4492 or visitor@goulburn.nsw.gov.au

References:

O'Connor, Colin, *Spanning Two Centuries – Historic Bridges of Australia*, pub. University of Queensland Press, 1985.

NSW Roads & Maritime Services, *The Old Hume Highway – History begins with a road*, NSW, 2014. See:

<https://www.rms.nsw.gov.au/documents/projects/south-western/hume-highway/history-begins-with-a-road.pdf>

Hume Highway, in *Main Roads*, *Journal of the NSW Department of Main Roads*, pub. June 1948 in *Historical Roads of NSW* series.

Leighton-Daly, Phil, *The Towrang Stockade*, 2019.

NSW State Heritage Register, *Towrang Convict Stockade, Associated Sites and Road Formations*.

Connections – Big Stuff

from Alison Wain

From 11-13 September, 2019, lovers of big industrial machinery will gather at Katowice in Poland for the sixth Big Stuff conference. With the theme "Preserving large industrial objects in a changing environment", the conference will address the future of large scale industrial heritage in the face of a rapidly changing environment, where social relations, architectural and urban design, landscape environments, mobility infrastructures, spatial functions are all being transformed, and where climate change adds another unknown to the preservation of historic buildings and machinery.

The conference welcomes heritage professionals and academics, private machinery owners, heritage volunteers and students. Registration is €200 per person. To register please go to the conference website at:

<https://www.muzeatechniki.pl/bigstuff/>

The Avalon Australian International Air Show

By Owen Peake



Royal Australian Air Force F-35 fighter – not quite engineering heritage but give it time!

Photo: Owen Peake.

This year we saw one of Australia's brand new F-35 Joint Strike Fighters in the flesh for the first time (above). The RAAF will acquire 72 of these very sophisticated multi-role fighters over the next four years.

The United States Air Force (USAF) brought one of its B-1 heavy bombers as well as an example of the massive B-52 bomber, always a crowd favourite, from the Cold War Era. They also brought a pair of F-22 Raptor fighters, perhaps the most powerful fighter flying today, operated only by the United States.

Every type of aircraft type was represented from the lightest private aircraft to the largest airliners and small airliners. The RAAF was well represented with examples of many types from the nimble Pilatus PC-21 advanced trainer to the C-130 Hercules and C17A Globemaster heavy airlifters.

There were many heritage aircraft both on display and flying – from aerobatic Tiger Moths to the B-52, still in service with the USAF since 1955. The outside display of aircraft is backed up by indoors exhibits of aircraft manufacturers, parts, engine suppliers and aircraft services. These exhibits were thinner this year as many exhibition spaces had been converted to small entertainment rooms for serious customers. This trend is less attractive to the general public who mostly come to see aircraft rather than write cheques to buy aircraft.



Douglas DC3 airliner from the 1930s – still flying but very much engineering heritage.

Photo: Owen Peake.



Image left: Australian owned Lockheed C-121C Super Constellation (L-1049F) VH-EAG "Southern Preservation", nicknamed "Connie".

Photo: from Wikimedia Commons, by Robert Frola at Avalon Air Show 14 March 2009.

Connie was built in 1955 and delivered to the US Air Force in October 1955. She had a varied career in US Government service until placed in storage in Tucson Arizona in 1972. On the scrap heap for years, she was discovered by the Australian Historic Aircraft Restoration Society (HARS) in 1990, restored by HARS in Tucson, and flown to Australia in 1996.

Connie's fascinating story is recorded at <https://hars.org.au/lockheed-c-121c-super-constellation/> and at [http://www.aussieairliners.org/1-1049/vh-eag\(2\)/vheaghars.html](http://www.aussieairliners.org/1-1049/vh-eag(2)/vheaghars.html)

Peter Behrendt

Australia's most prominent quasi-engineer

By Miles Lewis

The self-styled engineer Peter Behrendt had a career of less than a decade in Melbourne, but during that time his reputation and influence were unparalleled. His background is a little mysterious. He claimed to have a BA from the University of Königsberg, Bauführer Polytechnic, Berlin,¹ presumably some sort of master builder's qualification. He served in the Franco-Prussian War (1870-1), and it seems likely that he had worked in Germany either for or in association with Hein Lehmann & Co, manufacturers of Traegerwellblech iron.²

We first hear of Behrendt in Melbourne in 1882, when the partnership of Seitz & Behrendt, engineers, gave its address as 16 Market Buildings, Flinders Lane.³ Germans were prominent in both Melbourne and Sydney in the 1880s, though from the 1890s they were under increasing pressure to become more British, and during the Great War they might even be interned. But in the 1880s it was Russia, not Germany, which threatened the colonies, and the Germans were happy to help us.

In 1885 there was a move to establish a German volunteer military corps to help defend the colony if this should be necessary. Behrendt, who had apparently been naturalised as a British citizen in 1883,⁴ supported the proposal, saying that he 'had as much love for this country as any native could have for it' – which seems surprising after about three years in the colony. Behrendt was appointed chairman of a committee to advance the matter,⁵ though ultimately the government responded that the Germans should join their local corps rather than form a separate body.

Shortly after this Behrendt was elected librarian of the Deutscher Turn Verein.⁶ The Turn Verein was in principle an athletics club, but in practice it was the main social centre for Germans in Melbourne. And while Behrendt was thus embedded in the local German culture he was also professionally active in promoting things German in the colony at large.



A social evening at the Melbourne Turn Verein: Australasian Sketcher, 23 October 1880

1 *Argus* (Melbourne), 19 January 1884, p 6.

2 See EHA Magazine January 2019 at: <https://www.engineersaustralia.org.au/Communities-And-Groups/Special-Interest-Groups/Engineering-Heritage-Australia/Previous-Magazines>

3 *Age* (Melbourne), 4 April 1882, p 4.

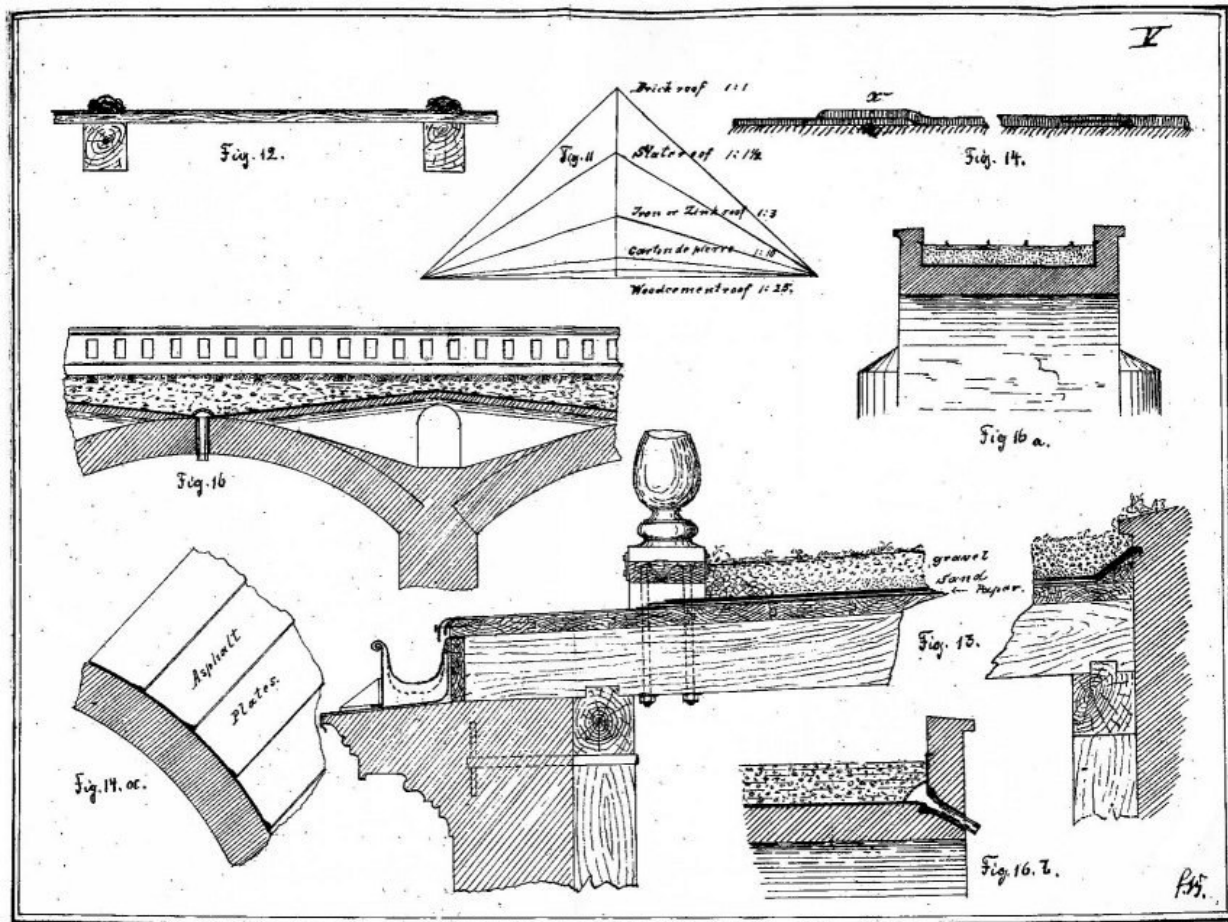
4 Ken McInnes 'Behrendt, Peter (c 1851-1908)', Encyclopedia of Australian Science <http://www.eoas.info/>, 7 August 2018.

5 *Age* (Melbourne), 18 April 1889, p 19.

6 *Age* (Melbourne), 13 May 1885, p 5.

Peter Behrendt – Australia’s most prominent quasi-engineer

He delivered a paper to the Royal Society of Victoria, in which he dealt with Traegerwellblech iron and with waterproofing materials manufactured by Büsscher & Hoffmann of Berlin. In 1884 he exhibited to the Royal Society and to the Institute of Surveyors a new type of telemeter, a surveying instrument imported from Germany, which had been invented by Professor Cerebotani of Berlin, and which measured up to 1000 yards [900 m].⁷



Application of an asphalt damp-proof course above the foundations: Peter Behrendt, *Modern Fireproof and Watertight Building Materials: Traegerwellblech and Asphalt*, Royal Society of Victoria, Transactions and Proceedings, vol xx (Royal Society, Melbourne 1884), plate 6.

He seems to have joined every possible body and to have pontificated on almost every possible topic. He first represented himself as a railway expert, and he delivered papers to the Royal Society on *Description and Estimate of an Electric Railway for Melbourne* and *A New System of Second and Third Class Railways*.⁸ He donated to the Bendigo School of Mines ‘two angle steel rails and double flanged truck wheels’ of the latter, which was a light rail system suitable for use in mines.⁹

When a competition was held in 1882 for the design of the Falls Bridge over the Yarra, Behrendt was one of the entrants. He did not win but he wrote a letter to the *Argus* criticising all the other entries.¹⁰ A number of the authors responded,¹¹ and Behrendt in turn responded to them.¹² It would seem that he had succeeded shortly after his arrival in Melbourne in alienating a good portion of the engineering profession. In 1884 he was listed as engineer to the newly floated Houghton Park Brick Company, of which he was also a director,¹³ and in this capacity, rather unusually, he presented a paper on ‘Ceramics’ in a room at Scott’s Hotel.¹⁴ Then in his new role as an apostle of clay Behrendt published an article in the *Victorian Review* calling for a new style of Australian brick architecture.¹⁵

7 *Argus* (Melbourne), 17 April 1884, pp 5, 10; 18 April 1884, p 3.

8 *Argus* (Melbourne), 12 October 1882, p 5; 28 September 1883, p 8.

9 *Bendigo Advertiser* (Victoria), 20 June 1883, p 2.

10 *Argus* (Melbourne), 24 March 1882, p 10.

11 *Argus* (Melbourne), 28 March 1882, p 10; 3 April 1882, p 9.

12 *Argus* (Melbourne), 8 April 1882, p 11.

13 *Argus* (Melbourne), 19 January 1884, p 6.

14 *Argus* (Melbourne), 1 March 1884, p 9; 4 March 1884, p 1.

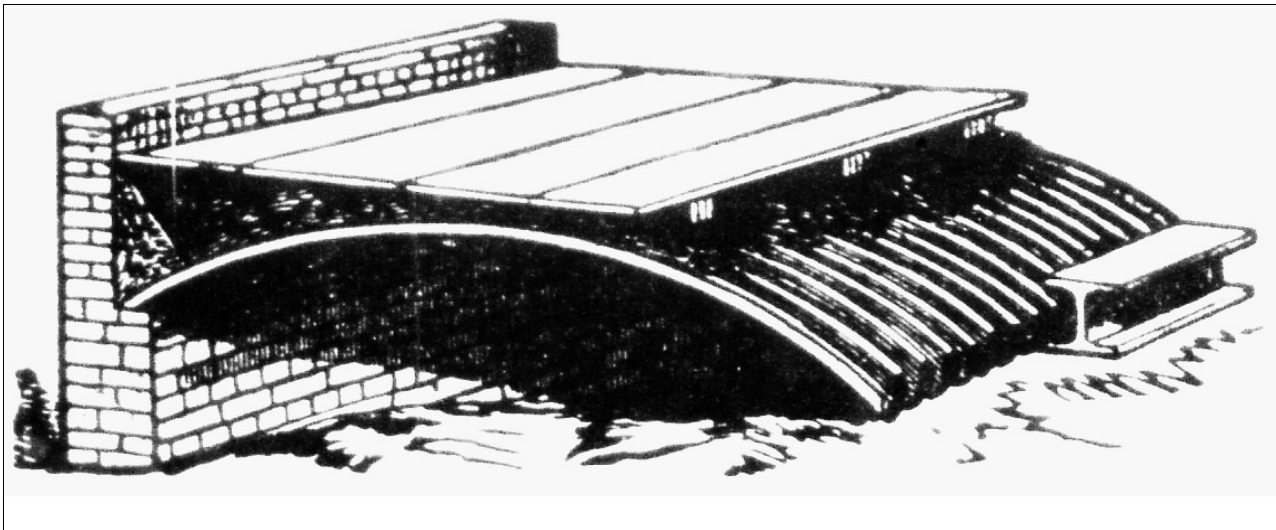
15 *Argus* (Melbourne), 15 May 1884, p 6, citing the *Victorian Review*, no 55.

Peter Behrendt – Australia’s most prominent quasi-engineer

Behrendt already had architectural pretensions. In 1883 he put his name forward as a candidate for the design of new market buildings for the City Council,¹⁶ but was unsuccessful. By 1884 he was a partner in the short-lived firm of Cutler & Behrendt, architects.¹⁷ In 1885 he was still calling himself an architect, but calling tenders in his own name only.¹⁸ In 1888 he was nominated for associateship of the Victorian Institute of Architects,¹⁹ but it is not clear whether he was successful. When he called tenders for additions to a house in Brighton, he described himself only as C.E.,²⁰ possibly to avoid offending Institute members while his candidacy was before them.

In 1889 he read a paper to the Architectural & Engineering Association on *Architectural Styles*.²¹ From this we can perhaps infer two things: firstly that he had been forced to settle for membership of the second-ranking body, normally for employees rather than principals, and secondly that in his topic he was making a defiant statement of his architectural expertise. He similarly addressed the Victorian Engineers’ Association (not the Institution of Civil Engineers), this time on the topic of *Sanitation and Drainage of Large Cities*.²² He resumed the practice of calling himself an architect when it suited him.

Behrendt’s connection with the Melbourne engineering firm of Palmer, Scott & Co was important, but how it developed is not clear. Behrendt spoke approvingly of Traegerwellblech when it was shown in the winning entry in the Falls Bridge competition of 1882, though he did not think it suitable for bridge purposes.²³ In 1884 Palmer Scott & Co were agents for Traegerwellblech, and Behrendt was advocating the material, but there is no evidence that he had any particular connection with it at this stage. Palmer Scott & Co had other German interests, and in 1885 were advertising Westphalian rolled H girders, from 4 to 22 inches [100-450 mm] deep, in lengths from 10 to 40 feet [3-12 m]²⁴ (the term H girders implies that they were being rolled in one of the new universal mills). It is really not clear whether it was Behrendt or Palmer Scott & Co who had the initiative in these matters.



Traegerwellblech iron flooring.; Australasian Builder & Contractors’ News, 9 July 1887, p 139.

Built-up wrought iron beams carried on cast iron columns were still being used in Australia, as they had been for decades, up until the time when steel began to be introduced, in the 1890s. Thus there was little call for wrought iron frames, though they can be regarded as transitional to all-steel construction. The first completely wrought iron framed building in Australia (other than the smaller prefabricated examples of the 1850s) was to be the 5-storey Melbourne Storage Company building, Lonsdale Street, designed in 1887 by the architect in George Jobbins and the engineer Peter Behrendt ‘of Palmer, Scott & Co’. Palmer Scott were to supply all the iron, including Westphalian joists, columns of built-up angle and flat iron, and 8030 m² of arched Traegerwellblech plates for the fireproof flooring. The outside walls were to be of conventional masonry construction.²⁵

16 *Argus* (Melbourne), 31 August 1883, p 5; 4 September 1883, 4.

17 *Age* (Melbourne), 16 October 1884, p 3.

18 *Argus* (Melbourne), 19 August 1885, p 3.

19 *Argus* (Melbourne), 17 April 1888, p 8.

20 *Oakleigh Leader* (Melbourne), 29 September 1888, p 6.

21 *Oakleigh Leader* (Melbourne), 29 September 1888, p 6.

22 *Argus* (Melbourne), 5 July 1889, p 5; 9 August 1889, p 8.

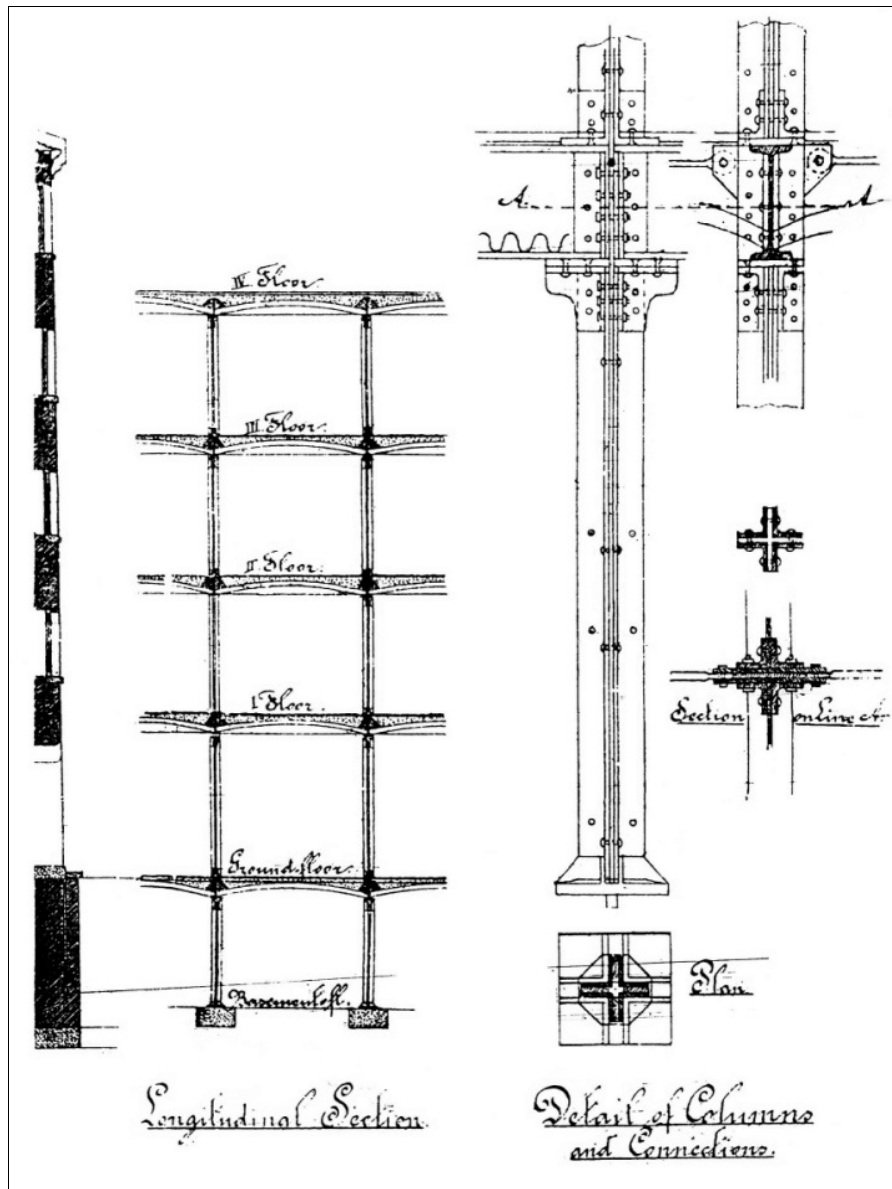
23 *Argus* (Melbourne), 24 March 1882, p 10.

24 *Argus* (Melbourne), 7 February 1885, p 12.

25 *Australasian Builder & Contractors’ News*, 26 November 1887, p 464.

Peter Behrendt – Australia’s most prominent quasi-engineer

But it is doubtful whether the Jobbins / Behrendt building was ever constructed. On 16 November 1889 tenders were called for an eight storey warehouse in Lonsdale Street for Melbourne Storage Company Ltd, which sounds like the same project – but the architects were now Twentyman & Askew jointly with F. G. Green, and there was no mention of Jobbins or Behrendt. This building can be identified from a photograph in D. C. Askew’s records, though only six storeys are visible. A Mahlstedt fire insurance plan shows it to have been at 541-551 Lonsdale Street, to have consisted of six storeys plus basement, and to have been constructed with steel girders.²⁶



Frame of the Melbourne Storage Company building, 565 Lonsdale Street, Melbourne, by the architect George Jobbins and the engineer P. Behrendt of Palmer, Scott & Co, 1887.
Image: Australasian Builder & Contractors' News, 26 November 1887, p 46.

In 1887, when they were proposing the Melbourne Storage Company warehouse, Behrendt appeared to be a member of the firm of Palmer Scott and Co, though whether as a principal or an employee is not apparent. In 1888 his office was 'above' that of Palmer Scott in Collins Street West.²⁷ By 1889 he was associated with Palmer Scott in the agency for the Liernur sewerage system, of Belgian origin. But in 1890 he seems to have designed a warehouse in his own right as an architect,²⁸ and he was he was also advertising as a landscape architect, offering to prepare plans for parks and gardens.²⁹

26 G Mahlstedt & Son [fire insurance plans] (Melbourne 1924, and cumulative), block 19. The building had by 1924 become Spicers & Detmold [printers], and an annotation indicates that it was subsequently Omnibus Insurance Brokers.

27 *Oakleigh Leader* (Melbourne), 29 September 1888, p 6.

28 *Argus* (Melbourne), 23 April 1890, p 5.

29 *Argus* (Melbourne), 6 March 1890, p 5.



Melbourne Storage Company, 565 Lonsdale Street, Melbourne, architects Twentyman & Askew, with F G Green, 1889. Image: State Library of Victoria H12223.

By 1889 Behrendt was becoming more and more involved in the affairs of the Roman Catholic Church, giving a lecture on the sanitation of cities, in aid of St Joseph’s Home,³⁰ and another at St Patrick’s College on *Sacred Architecture*.³¹ He also excelled himself at a meeting of tailors who were forming an association to resist sweated labour: Behrendt not only attended, but contributed the most asinine observations.³² Nothing is heard of him in Melbourne after 1890, when he probably emigrated, like so many architects and others who were victims of the economic depression. There is evidence of his being in Adelaide that year.³³

But he is probably the same man as the P Behrendt of Sydney who in partnership with two others patented a new form of insulation in 1895.³⁴ In 1897 Mr & Mrs P Behrendt were passengers on the *Darmstadt*, bound for Genoa,³⁵ but if this was the same man, he returned to Australia, for he was manager of the Eskbank Ironworks at Lithgow, New South Wales, in 1900-1. He was then briefly a drawing instructor at Sydney Technical College, but before the end of 1901 was gold prospecting in New Guinea. From 1902 to 1906 he was employed by the German New Guinea Government in surveying land for selection. He died in 1908.³⁶

30 *Argus* (Melbourne), 1 October 1889, p 1.

31 *Argus* (Melbourne), 18 April 1890, p 4.

32 *Age* (Melbourne), 31 July 1890, p 8.

33 Ken McInnes ‘Behrendt, Peter (c 1851-1908)’, Encyclopedia of Australian Science <http://www.eoas.info/>, 7 August 2018.

34 *Age* (Melbourne), 12 July 1895, p 9.

35 *Argus* (Melbourne), 7 January 1897, p 4.

36 Ken McInnes ‘Behrendt, Peter (c 1851-1908)’, Encyclopedia of Australian Science <http://www.eoas.info/>, 7 August 2018.

A Melbourne Docklands Cargo Crane

Restoration of Berth No. 5 North Wharf semi-portal cargo crane.

By Miles Pierce.



The Malcolm Moore semi-portal crane photographed in 2011 at the west end of the North Wharf Cargo Shed.

Photo: Owen Peake.

As part of a commercial and residential redevelopment project by Riverlee P/L of the Seafarers Place precinct on the Yarra River adjacent to the Melbourne CBD, the semi-portal crane at Berth No. 5 was recently externally cleaned and its exposed steelwork repainted.

The former Port of Melbourne Berth No. 5 on the Yarra River, comprising its section of riverside wharf, its cargo shed and its semi-portal type cargo crane is listed on the Victorian Heritage Register (VHR) as number H1798. The statement of significance in the VHR listing asserts in part: *Berth No.5 North Wharf consists of a shipping berth, a concrete and timber wharf apron, a steel framed cargo shed and an electric travelling crane. The area has been a wharf since 1855 dealing mainly with domestic cargo. The current built fabric dates from the immediate post war era but there appears to be earlier bluestone paving under later bitumen. The 1948 crane was locally designed and built by Malcolm Moore Limited. The berth was made redundant by the closure of the river below the Charles Grimes Bridge in 1975.*

Riverlee are in the process of reworking the wharf section and adjoining land into a \$450,000,000 multi-use redevelopment that will retain and repurpose the heritage listed cargo shed, refurbish the No. 5 berth and preserve the cargo crane. The heritage related work, and that for the crane in particular, is a collaborative effort between Riverlee, Architects and Heritage Consultants Lovell Chen, and maritime contractor Freyssinet. In the process, the crane has been moved from the west end to the east end of the cargo shed, and its wharf leg partially enclosed. It is not known to what extent, if any, internal restoration work, including to the crane's electrical system, has been undertaken or is yet planned.

The crane is one of two 3-ton, semi-portal electric cranes built and erected by Malcolm Moore Limited under a contract let by the then Melbourne Harbour Trust Commissioners in 1946. The crane was used for loading and unloading goods into and out of ship hulls. As a semi-portal crane, its northern (landward) side was supported off a rail mounted above the top edge of the wharf-side wall of the cargo shed whilst the outer (river-side) structure rested on a rail set along the wharf edge. Flanged wheels running along the respective rails allowed the crane to traverse up and down the berth in front of the cargo shed. The crane was electrically powered with wound rotor induction motors used for traverse, slew and raise/lower operations. Drum type controllers in the crane driver's cabin controlled the respective motors and affected speed regulation by inserting or cutting out resistance elements connected to the respective motor rotor windings via slip rings.

The 1991 Docklands Heritage Study asserted that Berth No 5, including its extant cargo crane and cargo shed, was: *important at State level as the most complete of all the traditional (non-containerised) river berths on the north side of the Yarra River.* The Study's recommendation that it be placed on the Victorian Heritage Register was duly effected, as mentioned above. This semi-portal cargo crane is believed to be the only surviving one of its type left in Victoria.

Image right: The crane photographed in 2019 at the east end of the wharf shed. Note how the semi-portal structure allows the inboard side of the crane to run on a rail at roof level, thus freeing up the width of the wharf deck. Photo: Owen Peake 2019.



The Black Box Flight Recorder

by Owen Peake

Introduction

In September 1949, David Warren (1925-2010), a young Australian PhD student studying industrial chemistry at the Imperial College in London, visited the Farnborough Air Show and was awestruck by the prototype Havilland DH 106 turbojet-powered Comet airliner.

Airlines rushed to order the new airliner. In May 1952, the British Overseas Airways Corporation (BOAC) inaugurated the world's first jet airliner service with the introduction of Comets on their London-Johannesburg route, and by October 1952 they were also operating on the London-Singapore route. By 1953, Qantas and two other airlines were making plans to begin flying Comets on international routes out of Sydney.

It was 1953 when (now) Dr Dave Warren spotted the world's first pocket sound recorder, the Minifon, at a trade fair. "I was attracted because it meant I could go to a jazz concert with the recorder in my pocket and not have to spend money on records," Dr Warren said.¹

Tragically, during 1953 and 1954 four Comets were lost in fatal crashes. While investigators quickly established 'pilot error' on take-off as the cause of the first accident and attributed the second to structural failure after flying into a severe monsoonal thunderstorm, the primary cause of the next two accidents was far more mysterious. Both planes had disintegrated while flying at high altitude in clear air over the Mediterranean, with widely scattered debris falling into the sea. After months trawling the seafloor for debris and extensive research and testing, it was finally concluded that the cause was metal fatigue in the fuselage structure.

The 28-year-old jazz fan worked as a chemist specialising in fuel and combustion problems at the Aeronautical Research Laboratory (now the Aeronautical and Maritime Research Laboratory) at Fishermans Bend. . . . Dr Warren was testing how aeroplane fuel tanks exploded in a bid to explain a Comet jet crash. And one of aviation's greatest ideas started to form. "The Comet had crashed without explanation, without survivors and without witnesses," he said. During a meeting to determine the cause of the crash, Dr Warren 's mind wandered to the Minifon recorder. "The thought occurred to me, 'Why don't we have one of these in the cockpit to record what the pilots are saying?' " His thought expanded to include recording instrument readings and developed into the black box flight recorder.²

Between 1954 and 1964 the Australian government-owned Aeronautical Research Laboratories in Port Melbourne developed an invention by one of the organisation's senior research scientists, Dr David Warren, into a working prototype of the world's first integrated Cockpit Voice Recorder (CVR) and Flight Data Recorder (FDR). The device, was designed to withstand both high impact forces and intense fire that could be experienced in a catastrophic aircraft accident. A decoding or playback unit enabled the wire recording to be subsequently reprocessed. In 1961, Australia became the first country in the world to make mandatory the use of Flight Data Recorders in all large commercial aircraft, effective from 1963.



Type 1190, 'Red Egg' Recycling Wire Flight Recorder, developed by S. Davall & Sons Ltd, Greenford, London, England, from the 'ARL Flight Memory' prototype, c1967. Photo: Matthew Churchward, Museums Victoria.

AT PYROX STAND No. 7
OFFICE MANAGEMENT EXHIBITION
PYROX
Magictape Recorder
Giving you 2 hrs high fidelity recording on one tape. Fast forward and rewind.

MINIFON
Pocket dictating machine. Weighs only 2 1/2 lbs. 2 hrs. recording on one spool.

PYROX LTD.
14-36 Queensberry Street, Melbourne, FJ9121
"The Pioneers of Magnetic Recording in Australia"

Pyrox Ltd advertise a display of their Minifon miniature wire recorders at an exhibition in Melbourne in 1954. The Argus, 21 Sept 1954, p.14, from Trove.

In 1964, the British firm S. Davall & Sons Ltd began development of a commercial version of flight data recorder. By 1968, Davall Flight Recorders were in use with over 15 airlines worldwide and had accumulated over one million flying hours, successfully recording flight data associated with 84 'incidents', including several fatal crashes. 'Black Box' Flight Recorders continue to play a vital role in air accident investigations worldwide and have made a major contribution to improvements in the safety of air travel.

1 From a story about Dr Warren, pub. in *The Age, News*, p.18, 27th March 1999.

2 *ibid.*

The Black Box Flight Recorder

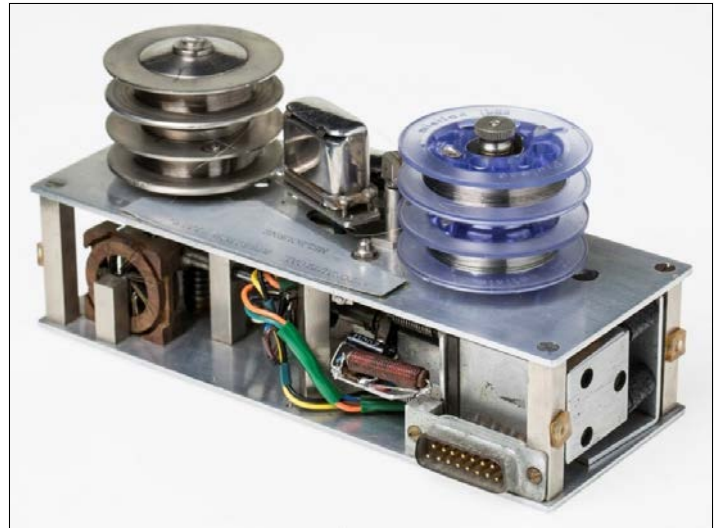
Design and Development

Following the third Comet crash in January 1954, David Warren was invited to attend a meeting of experts in Melbourne to discuss possible causes of the accidents and it was during this event that he was inspired by the idea of using a miniature magnetic wire recorder to provide a “permanent memory” of the conversation and noises in an aircraft cockpit as a tool to investigate the circumstances leading up to a crash.

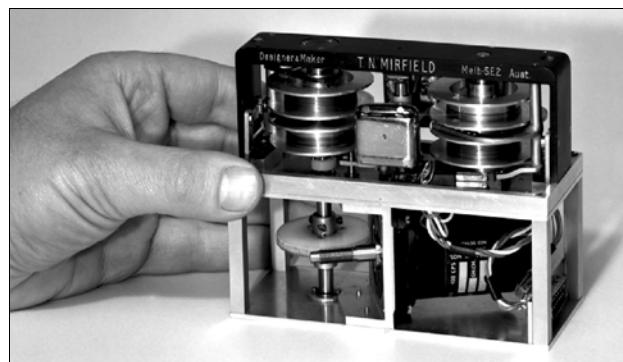
Warren documented his ideas in April 1954 but initially struggled against demoralising bureaucratic apathy. Finally in November 1955 Warren’s boss, Tom Keeble, managed to obtain funds to purchase an imported Minifon Type 54 wire recorder for Warren to undertake some trial recordings in the cockpit of a DC3 aircraft owned by the Department of Civil Aviation (DCA).

In late 1955 Warren had his second inspiration, conceiving the idea of overlaying data from flight instrument readings onto the cockpit voice recording, by using a form of Morse code to record the instrument levels as a series of ‘dots’ at higher or lower frequencies than the human voice.

Tom Keeble arranged through the DCA for further testing to be carried out in the cockpits of Vickers Viscount and Douglas DC-6B aircraft that had recently been introduced by Australian domestic airlines, TAA and ANA. A variety of different microphone types and filters were trialled before satisfactory results were obtained.



Mk 1 prototype wire cockpit voice & flight data recorder that formed the basis of the “ARL Flight Memory” invention. Photo: Museums Victoria.



Miniature wire recorder with detachable spool magazine, built by T.N. Mirfield for the Mk.2 prototype of the “ARL Flight Memory” development, 1961. Photo source: Museums Victoria.

In April 1958, Warren produced a detailed technical specification for a combined voice and data aircraft crash data recorder. The Melbourne instrument maker T. N. Mirfield was commissioned to build a miniature recording unit that could store up to four hours of audio combined with readings from eight instruments onto two miles (3.2 km) of fine stainless steel wire no larger than a human hair. The design represented the world’s first fully automatic ‘fit and forget’ flight recorder with the recording wire being continuously recycled. The working prototype, which is today held in the collections of Museums Victoria was completed by June 1958. It was fireproof-tested in an asbestos-lined steel box, being subjected to the heat of an intense fire for the requisite period of half an hour. After cooling, the case was opened, and the wire, which was the only part of the equipment that needed to survive, was found to be in perfect condition with its magnetic record unimpaired.

Again there was bureaucratic disinterest from Australian authorities. Then, by good fortune, Robert Hardingham, Secretary of the UK Air Registration Board was given a demonstration of the prototype during an informal visit to the Aeronautical Research Laboratories (ARL), and immediately recognised its potential. Warren and an assistant were soon dispatched to the UK to demonstrate the prototype. To their great surprise, the Australians were ‘treated like heroes’ in Britain. Warren gave interviews on BBC radio and television and in August 1958, presented a public lecture in London. It was at this event that Eric Newton, Chief Investigating Officer of the Accidents Investigation Branch (AIB) made the earliest recorded reference to the device as a ‘little black box’.

The principal outcome of the UK trip was an agreement of Electric Music Industries (EMI) to undertake commercial development of the ARL instrument through an Australian subsidiary. The arrangement lasted only six months, but EMI technical staff added value to Warren’s work by coming up with a better method of coding the instrument readings onto the magnetic wire.

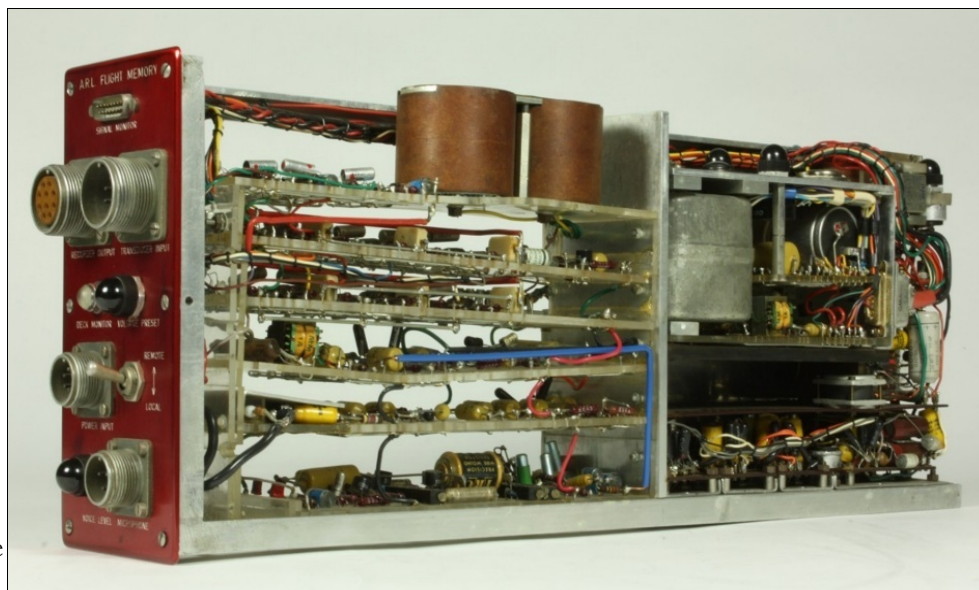


Fireproof case used in the fire testing of the Mk.1 “ARL Flight Memory” prototype “Black Box” flight recorder, circa 1958. Photo source: Museums Victoria.

The Black Box Flight Recorder

Australian interest in the 'black box' flight recorder was rekindled by the mysterious loss of a Trans Australian Airlines (TAA) F27 Fokker Friendship that crashed into the sea off Mackay in north Queensland on 10 June 1960, killing all 29 people on board. The subsequent inquiry headed by Justice John Spicer 'found it impossible to reach any firm conclusion on the cause of the air disaster'. Spicer described the circumstances leading to the accident as 'well-nigh inexplicable', but was interested to hear submissions from the DCA on the work that had been undertaken in Australia to develop a crash recorder.

The United States was the first country to introduce regulations governing the use of 'crash-protected' flight recorders, issuing a directive that 'all air carrier airplanes over 12,500 pounds (5670 kg) that operate above 25,000 feet (7,600 m)' were required to be fitted with a flight data (but not voice) recorder by 1 July 1958. This requirement was extended to all 'turbine-powered' aircraft operating in the United States, from August 1960. France introduced similar regulations from January 1959. The United Kingdom Air Ministry issued an order for flight data recorders to be in service on all large commercial aircraft by the end of 1961.



Airborne signal encoding unit, part of the Mk.2 "ARL Flight Memory" prototype "Black Box" flight recorder, developed in 1961 - 1962. Photo: David Thompson, Museums Victoria.

In March 1961, the Australian DCA became the first authority in the world to issue a directive for the installation of both flight data recorders and 'flight station voice recorders' initially applying to all 'turbine powered' aircraft only (as in the US), effective from January 1963, although due to problems with the reliability of early CVRs, the compliance date was eventually extended to November 1966. The United States' first CVR rules were passed in 1964, requiring all large turbine and piston powered aircraft with four or more engines to have CVRs installed by 1 March 1967, while in the UK similar requirements did not finally come into force until 1975.



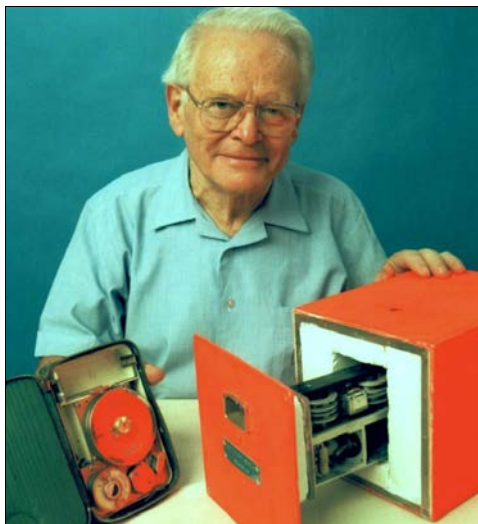
Ground Playback or Decoding Unit for separating audio & instrument data from the recorded signal. Part of the Mk.2 "ARL Flight Memory" prototype "Black Box" flight recorder, developed in 1961 - 1962.

Photo: David Thompson, Museums Victoria.

Encouraged by interest in the 'flight memory' development at the Mackay Inquiry, ARL decided 'to press on again with making a full airborne prototype' in August 1960, appointing a team of electronics experts - Lane Sear, Dr Walter Boswell and Ken Fraser - to work on the design and construction of improved encoding and decoding units. In May 1961, T. N. Mirfield was awarded a contract to construct a new memory unit with the recording wire spools in a detachable magazine. By early 1962, a full working version of the ARL Flight Memory Mk 2 prototype was completed comprising an airborne signal encoding unit with independent battery power supply, the miniature wire recorder with an insulated crash-proof case and the ground station playback or decoding unit that could be used to recover the separate recordings of the voice and instrument data readings. (See photos above & left)

The 'one and only' flight test of the Mk 2 system took place on Friday 23 March 1962, on a DCA Fokker F27 Friendship flying from Essendon Airport to Avalon. Ken Fraser, who was involved in the test flight, remembers it as a 'critical' moment, with the team being pleasantly surprised to find that everything worked the first time - 'we recovered everything.' With the completion of a fully functional working prototype, ARL began a campaign to more actively promote its Flight Memory technology for commercialisation. A large public display was presented at the International Trade Fair held in Melbourne, in early 1963, and a 9-minute promotional film was produced. Around this time ARL was approached by the British clock and scientific instrument maker S. Davall & Sons Limited who expressed interest in commercialising the ARL Flight Memory technology for worldwide markets.

The Black Box Flight Recorder



David Warren with his original "Minifon" wire recorder and the Mk.2 prototype of the "Black Box" flight recorder. Photo: from DSTO, 2002.

Negotiations were conducted through the Australian embassy in London and an information team consisting of David Warren and Donald Cocks arrived in London in June 1963, meeting with industry representatives and officials over the next six weeks. Unfortunately progress towards a final licencing agreement was suddenly derailed by the Department of Supply, which insisted on taking over all communications relating to the commercial negotiations. The Department was reluctant to grant worldwide rights, failing to appreciate the complexity of the devices. Finally in frustration, given the lack of any effective patent protection, Davall announced that it would simply proceed on its own – effectively daring the Australians to take legal action. Thus Australia got nothing for the contribution of its scientists and engineers.

Davall worked with British European Airways to develop their first Type 1050 Series Long-Duration Flight Data Recorder, which was released in February 1965. It used a cassette with two reels holding up to 10 miles (16,000 m) of fine wire on which data from six cockpit instruments could be recorded for up to 200 flying hours, before being removed and replaced with a new cassette.

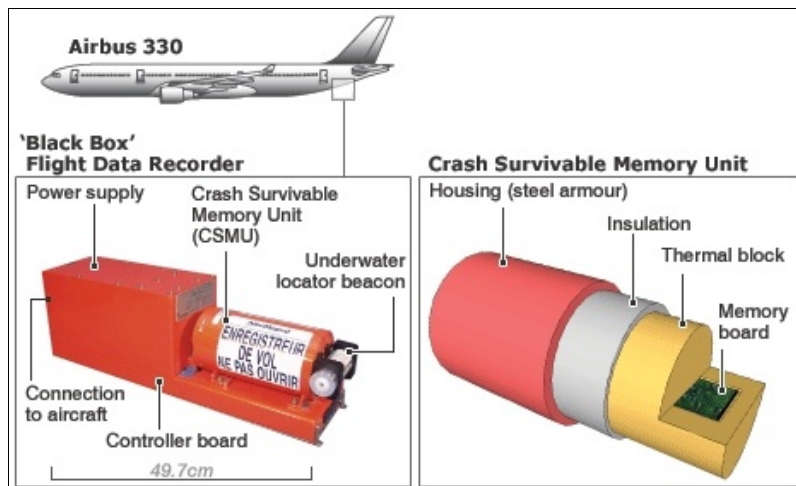
Less than 12 months later, on 26 October 1965, a BEA Vickers Vanguard turbo-prop airliner carrying a Davall recorder crash landed at London's Heathrow Airport in heavy fog, killing all 36 passengers and crew. The recorder was recovered from the burnt out wreckage and yielded valuable data that assisted in the accident investigation. The experience enabled Davall to make the claim that their equipment was 'Crash Proven' in subsequent marketing of their flight recorders.

Davall's second generation of flight recorders, the 1100 Series, was introduced in 1967. They quickly became known as the 'Red Egg', because the recording unit was protected from fire and impact by a small insulated cylinder with domed ends, painted in a bright fluorescent orange so that it could be easily located amongst crash wreckage. The 1100 Series flight recorders were the world's first commercially available equipment to both incorporate a recycling wire recorder and allow the simultaneous recording of voice and data – key features of David Warren's original design. They were tested to withstand sudden deceleration of up to 1,000 g (one thousand times gravity), to resist a crush loading of 2.25 tonnes and survive a fire of up to 1,100°C for 30 minutes, without any loss of data. By 1969, Davall magnetic wire recorders were also finding widespread application as a reliable cost-effective and lightweight data storage device in the rapidly developing technology of aircraft integrated data systems.

Fifty years later all airliners and many military and light aircraft are equipped with Black Box Flight Recorders which, since the mid-1960s have become an indispensable tool of aviation safety authorities worldwide in the examination of the causes of major aircraft accidents. The information



Dr David Warren (left) and Ken Fraser, at the Aeronautical Research Laboratories, Melbourne. Photo: from DSTO, 2001.



Diagrams of a modern flight data recorder. Note that the recording wire has been replaced by a solid-state memory board. Image from BBC News, 12th June, 2009.

recovered from these devices by air accident investigators following hundreds of aircraft accidents and serious inflight incidents has enabled the safety of air travel throughout the world to be significantly improved over the past 50 years, saving thousands of lives that might otherwise have been lost and making air travel today some eight times safer per billion kilometres travelled than any other mode of transport, including walking. The fate of many crashed aircraft has been determined from the data on their Flight Recorders, allowing faults to be corrected, procedures refined, and the training of pilots and flight crews improved from the lessons learnt.

For more information see:

<https://portal.engineersaustralia.org.au/heritage/black-box-flight-recorder-1962>

Lithgow Small Arms Factory & Museum *a microcosm of Australian values, ingenuity and history.*

by Renzo Benedet, President & Secretary of the SAF Museum.

Introduction

It was the 7th April 1908 when the Commonwealth Department of Home Affairs placed an advertisement in the Commonwealth Gazette advising of the purchase of lands for defence purposes at Lithgow, NSW for a sum of £2776-17s-6d (valued at A\$602,000 in 2019 dollars). That land purchase subsequently led to the design and construction of the Lithgow Small Arms Factory (the Factory), an industrial icon of massive proportions in Australia's history.

Lithgow became the birthplace for precision manufacturing in defence applications in Australia. It introduced mass production with world class production techniques. It developed and sustained the Lithgow region for 70 years, economically and socially. In 1942 it was leading the way in equality of working conditions and pay for women and men. It gave Australian troops firearms suited to varying operating conditions in various war zones. At its opening in 1912, the Factory was a smallish complex but it 'grew and grew' with production facilities being added in short bursts over a 20 year period.

This story traces some of the essential features of the Factory: the decision for choosing Lithgow; the engineering challenges and triumphs experienced in WW1 and WW2; the key figures in the making of the Factory; and the rising of the Lithgow Small Arms Factory Museum (the Museum) and its development.

Choosing Lithgow

Lithgow is located 140km west of Sydney and is on the fringe of the Blue Mountains. In the early 1900s, Lithgow was primarily farmland, co-existing with the coal mines, railway works and the iron and steel industry.

Federation was a mere 6 years old when the Australian Government began to seriously think about self-reliance in terms of military effort. It had 113 years of English rule prior to 1901 – its customs and traditions were very much geared to the 'mother country'. It seemed 'the colonies' were just that, an offshoot of England that would never cease. The experience of Australians in the Boer War planted a seed in the minds of the first Australian Parliament and Defence hierarchy that 'self-reliance' should be considered. In fact, the concept of Australia having its own 'central arsenal' was first raised in 1881 but was not acted on until 1907, when Prime Minister Deakin resolved to make Australia's defence supply independent of Britain.

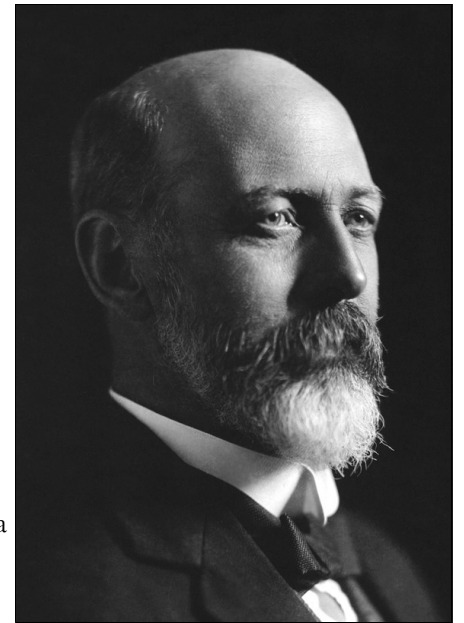
But Australia had no expertise in defence production. Its secondary industry was embryonic. Despite this, it was the local Member of Parliament, Joseph Cook, and the Lithgow Progress Association which, in the years preceding 1908, lobbied hard for Lithgow as the site for a possible small arms factory. At the time, Lithgow was an industrial (iron & steel making), railway and coal mining district with ample farmland. But the Lithgow site had a strong rival in the Victorian based Colonial Ammunition Company (the nation's first modern ammunition factory), located in Footscray, a suburb of Melbourne. Joseph Cook and Lithgow industrialists prevailed over Victoria because of Lithgow's industry, its railway access and plenty of available land.

On November 11, 1908, the Department of Defence called tenders for supply of a plant for manufacture of small arms, bayonets and scabbards, to be built at Lithgow.

The 1908 decision without the prospect of war

The question that is often asked is why the Australian Government made plans for a small arms factory in 1908, when there were no obvious threats of war – World War 1 was six years away. Well, it wasn't just about war, although some threats were emerging. In fact, it all began with the plans of Prime Minister Deakin to create an Australian defence force by overhauling the collective forces of the States. He was adamant that Australia needed a defence force that could stand on its 'own two feet'. But behind the scenes and from British intelligence, military mobilisation was beginning in some parts of the world. In 1906, Deakin had warned that 'leading nations are arming themselves with feverish haste'. He felt it was incumbent on Australia to take greater responsibility for its defence and to play its part in the defence of the Empire, 'to be a source of strength and not of weakness'.

At that time, Britain was concerned about Germany's naval build up and Australia was concerned by Japan's rise and quick defeat of the Russian navy in 1905. Australia had always been conscious of its geographic isolation from Britain. The increasing international tensions were a concern but not at a level that impacted the proposed Factory. The expectation of war was not on the horizon. Developments in Europe were distant to Australia and any needed support to the 'mother country' would be honoured perhaps in a similar vein to that during the Boer War.



Sir Joseph Cook, 6th Prime Minister of Australia.
Crown Studios, 1914 - from Wikipedia.

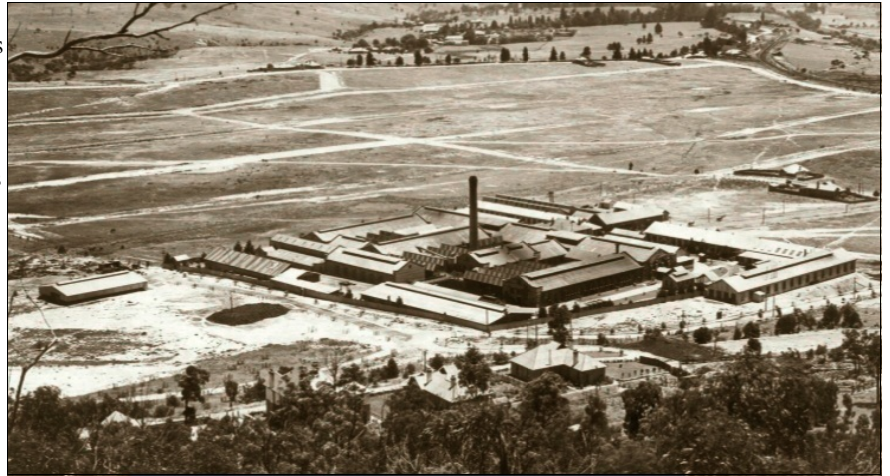
Lithgow Small Arms Factory & Museum

The tender for the Factory issued in 1908 was responded to by four overseas groups. But the choice was really between two companies – Pratt & Whitney (US) and Greenwood & Batley (UK). The tender prices were almost identical (between £68,000 and £69,000 – equivalent to A\$15million in 2019 dollars purchasing power). In 1909, the decision was taken to award the design and build of the facilities and production management to Pratt & Whitney. It was announced by the Minister for Defence, Joseph Cook, who as the Commonwealth Member of Parliament representing Lithgow, had been the architect behind the Lithgow site selection a year earlier.

A Factory triumphant in overcoming engineering & operational challenges

The decision to go with Pratt & Whitney met with expected British criticism and there was considerable consternation as to how could 'a colony' do this to England. The 'writing was already on the wall' after an exhaustive international tour by Australian Defence officials of military industrial plants in the US and UK revealed the superiority of US production techniques, with a lesser need for skilled personnel.

The Pratt & Whitney decision suited Australia's primitive manufacturing base and its lack of skilled people. Pratt & Whitney had perfected a production regime which not only involved precision mass production and the interchangeability of parts, its workforce needs were less, with lesser skills as the machines did the 'repetitive work'. In contrast, the British model required a much greater workforce with higher skills.



The Lithgow Small Arms Factory in 1919.

From the SAF Museum Archives.

The challenges facing the Factory were intense, starting from a 'blank sheet of paper'. The fact that Pratt & Whitney had never built and supplied an entire factory complex anywhere outside the US and that they had no experience whatsoever in their machines 'punching out' parts to comply with British War Office specifications, didn't go unnoticed in both political circles and the media. The Lithgow plant was to be Pratt & Whitney's showpiece internationally – and it was to be, at the time, Australia's largest arms factory. Construction got underway in late 1909. Usual construction-related issues emerged in terms of insufficient labour, material supply issues and the Lithgow weather conditions.

The Factory was designed for a one-shift 48-hour working week, producing 15,000 rifles and bayonets a year. Pratt & Whitney supplied the various machine tools (340 in number plus 11 forge hammers and 22 oil furnaces), the jigs and fixtures for making, measuring and maintaining the cutting tools and gauges to check sizes after each machining operation (6370 gauges were ordered). 6500 tools and 9000 spares were ordered, including 2250 cutting tools – the remainder being tools used for making, measuring and maintaining the cutting tools.

Optimistically, full factory production was originally expected to be achieved in late 1910 – this pushed out to early 1911, then to late 1911. The Factory finally opened on June 8th, 1912.

When is an Inch not an Inch?

To retain operational and supply compatibility between the UK and Australian armies, the US-designed Lithgow plant was going to make rifles to the UK SMLE 303 design, ie the then British standard Short Magazine Lee-Enfield .303 inch bore, bolt action rifle, soon to be widely used by Britain and British-allied armies (like Australia) in WW1, and used again later in WW2.

The first major hurdle became evident during the production trialling phase at Pratt & Whitney, prior to the machinery being sent to Lithgow from the US. The issue was that, unbeknown to anybody outside of the Enfield Factory in England, the British were using two different measurement standards. Anything below 2 inches was measured against a local Enfield standard that was 'four tenths of a thou' (0.0004 of an inch) shorter than the true Standard Imperial Inch that was used for dimensions over 2 inches. (More details on this can be found in the book titled *The Enfield Inch & The Lithgow .303*, copies of which reside in the Lithgow Small Arms Factory Museum.)

The UK designed SMLE 303 required over 2250 special cutting and forming operations to make the 173 separate parts of the rifle. It soon became evident that due to the two different "standard" inches, and poorly chosen British manufacturing tolerances, interchangeability and compatibility of parts just couldn't 'come together'.

Lithgow Small Arms Factory & Museum

To overcome the problem, Pratt & Whitney designed and manufactured a perfectly toleranced version of the SMLE 303 rifle and used it to develop a whole new set of drawings, tolerances and specifications. The batch of compromise-design rifles which P&W along with Clarkson¹ developed in 1911, after knowing of the sloppy British specifications, were taken to the UK for inspection and approval. The P&W rifles had been modified to allow interchangeability of parts, and following approval, the P&W design was used subsequently. This 'blew out' the time it took to design and perfect the equipment to build truly interchangeable rifles at Lithgow. The Enfield Inch was never used after that and was abolished in 1924.

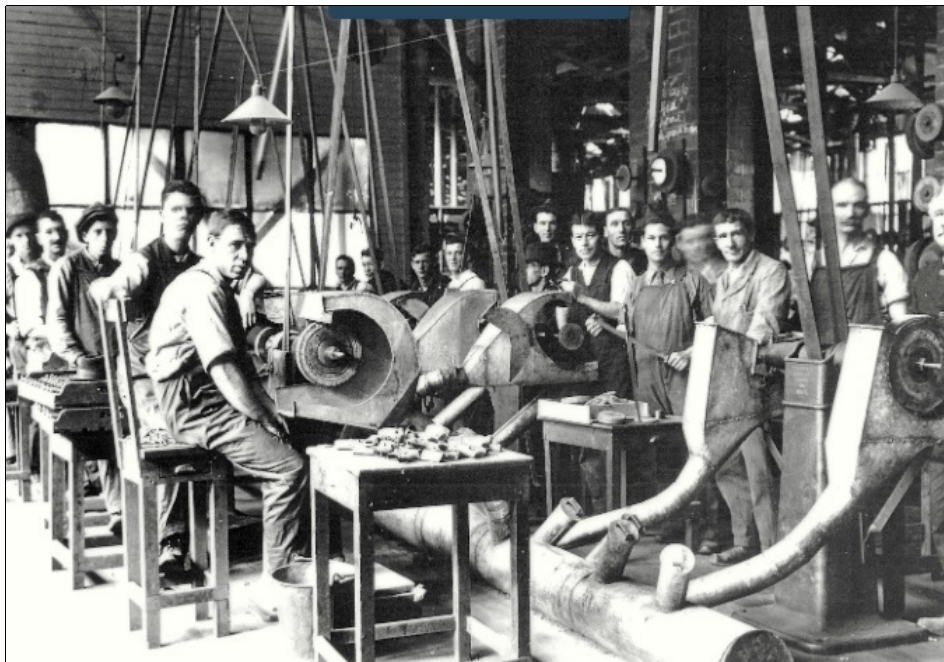


Lithgow SAF Machine Shop, Boring & Rifle Barrels Section in 1914. From the SAF Museum Archives. As was typical at the time, machines did not have individual electric motors, but were powered by flat leather belts run from overhead pulleys on lineshafts.

Time in making a rifle

Under the British Enfield manufacturing methods, between 48 and 72 man-hours per rifle were required, with virtually all of the time requiring skilled tradesmen. Such men were widely available in Britain – but not so in Australia.

With the more mechanised Pratt & Whitney production practices, 23.5 man-hours per rifle were needed to build an SMLE 303 rifle, of which only 10 minutes required a skilled tradesman (for barrel straightening). However, it should be noted that the practices used by Pratt & Whitney required skilled labour in terms of toolmakers and millwrights for making tools, jigs, gauges and undertaking machinery modifications. The Drawing Office also required skills. In fact, the Lithgow Factory had to supply a lot of its own production equipment beyond that supplied with the original contract. Much of the production equipment was managed by the Factory but supplied and installed by local and UK contractors, such as the major power plant – this being in 1910 to 1912.



The Lithgow SAF Polishing Shop in 1914.

From the SAF Museum Archives.

At the time and subsequently, the machinery-based production methods of the US proved their value. The initial annual volume of 15,000 rifles and bayonets was soon increased in 1913 to 20,000. This was further increased to 35,000 in 1914. The working week increased from 48 hours per week to 68 hours. Initially, this move was on a one shift basis – people were asked to work extended hours from September 1914 to July 1915. It soon became apparent that this was harming worker health and it was in July 1915 that a two-shift production process was introduced. Employee numbers soared from 120 in 1912 to 1300 in 1918.

At the end of WW1 and after, rifle production was ongoing but at a significantly reduced rate of 3000 per year. One-off defence requirements were in play such as producing spare

parts and converting rifle barrels for the new Mk VII ammunition. In the lead up to WW1 and during most of the WW1 period, the SMLE used Mark VI ammunition. As the war progressed, so did ammunition technology and in 1917, the new ammunition – Mark VII – with aerodynamically superior projectiles gave the rifle bullets a 24% higher muzzle velocity than the Mk VI version. And so, there were many rifles which needed to be updated to take the Mk VII ammunition.

¹ Wm Clarkson - see Movers & Shakers below.

Lithgow Small Arms Factory & Museum

Kicking in commercial production

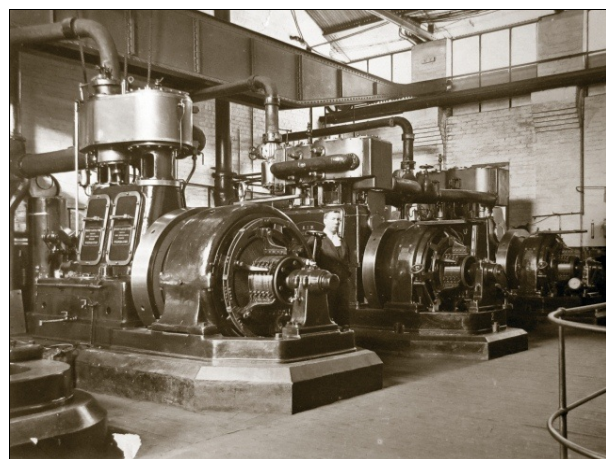
Commercial manufacture began in 1920 and continued through to 1986. In the 1920s, commercial works made up about 3% of total production, rising to 31% in 1930, to 80% in 1932, and falling to 7% in 1939. Commercial work was less than 1% in 1942 but gradually rose to 6% 1945, and flourished in the 1950s and 1960s.

With WW1 behind them, the Defence hierarchy had not been too keen on the Factory taking on commercial work. They didn't want a Government run establishment competing against private industry. But keeping the Factory open was a necessity to preserve valuable skills and keep the machinery ready for when it would be needed again. It transpired that commercial work could be done as long as it related to products which otherwise were not or could not be made in Australia. And so began the transition. There was uncomplicated commercial work including toasting forks, washers, air brake parts for trains, artificial limbs, aircraft parts and hand tools. The workforce numbers slipped to around 300 to 350 during the 1920s.

As the Depression hit, the Government changed its position and encouraged the Factory to seek more commercial work. This resulted in profitable and long-lasting work on shearing handsets, combs and cutters, parts for cinema projectors, sewing machines, golf clubs, spanners and sophisticated handcuffs. This commercial work flourished and was the mainstay of the Factory until WW2 started.



The first Pinnock Sewing Machine, made in the Factory in 1949. From the SAF Museum Archives.



Bellis & Morcom steam engines and power generators in the SAF Powerhouse, 1920. Photo from the SAF Museum Archives.

Both the Vickers and Bren machine guns were complex firearms (compared to the simple bolt-action SMLE rifles) as they had many more complex parts, with closer dimensional tolerances. The Bren gun alone required 4074 different types of tools. As a result, the degree of skill required from the workforce was higher, particularly in assembly where the machine guns were put together. However, semi-skilled labour continued to be used in doing fine tolerance machining work. Production philosophies in the mid-1930s were vastly different to those 20 years earlier.

Production volume during 1914-1918 was 133,600 rifles. This increased to 439,000 for 1939 to 1945. As a result, higher capacity required more machinery, more buildings and more power. WW2 weapons required many orders of accuracy and complexity compared to that of weapons used in WW1. Production philosophy was not only about volume but more so about productivity. The issue was that as the weapons were more engineered, the calibre of staff was not always adequate to the task and so techniques were implemented to minimise long or expensive machining operations and simplifying or deleting complex parts, thus requiring modifications to tooling.

New weapons

The late 1930s saw a rise in military aggression in Europe. The Factory was 'humming along'. Building works on the site continued to accommodate the planned manufacture of the Vickers machine gun and the Bren light machine gun. But the dimensions and layout of the various Factory facilities, designed for a much earlier era, were not well suited to Bren gun production. A new building, specifically designed for Bren gun manufacture was built between 1941 and 1942 and new machinery brought in. The Bren gun building was large and square in layout as it accommodated a series of machines with individual small electric motors, unlike the earlier machines. Those were driven by flat belts and overhead line-shafts, which dictated a longitudinal layout and which derived their power from a few centralised large electric motors, or from steam engines in the earliest times.



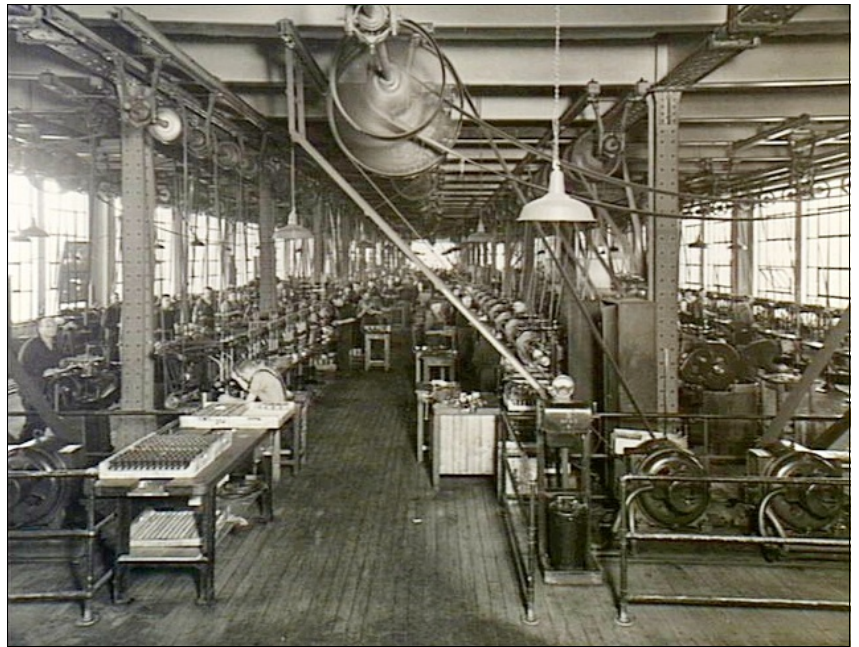
Making Bren Guns, SAF, May 1940. This early production line in the drilling section was driven by flat belts from overhead lineshafts. Photo No. 001759 from AWM.

Lithgow Small Arms Factory & Museum

The looming war

The Factory was soon to discover what it meant to be overwhelmed. As WW2 broke out and gathered pace, demands on the Factory went 'sky-high'. The WW1-style SMLE rifles were still in production, and were now peaking at 200,000 units a year (in WW1 it had reached 35,000 per year). The Vickers machine guns and Bren light machine guns were being churned out at peak, in 1942 and 1943, of 2,900 and 6,900 units per year, respectively. Bren gun production first started in 1939, with 1942 through to 1945 being the period where production was ramped up. In those years 1942 to 1945, there were 17,110 Bren guns produced at the Factory. Correspondingly, Vickers gun production for the 1942 to 1945 period was 10,130.

The Factory could not cope with the extreme volume. It just didn't have the capacity nor the people.



The Vickers Machine Gun department at SAF in May 1940.

Photo No. 001763 from AWM.



Bren Gun Dept., Turret Lathe section, SAF May 1940.

Photo No. 001760 from AWM.

New manufacturing facilities were needed. It fell on the Lithgow Factory management to establish a series of eleven feeder factories within 3 hours drive of Lithgow, recruit and train the workforce, and achieve the exacting quality required for armaments. The feeder factories were in the Central West of NSW, at Forbes, Orange, Wellington, Mudgee, Cowra, Young, Dubbo, Parkes and Portland.

It was a horrendously arduous task given the demanding war effort requirements. In all, during peak production in 1942, there were 5,700 employees at the Lithgow Factory with a further 6,000 across the feeder factories. But the pleasing fact was that as the men 'went to war', many women took their places and did a resoundingly good job – in fact, 40% of the workforce at the time was female. A case in point in support of female labour was that women barrel setters in Orange were found to be more skilled than many of the men, rightly earning them an increase in wages.

Movers & Shakers

The early days of the Factory were crucial to its longevity. The 'eyes of the world' were on Lithgow to either perform or perish – the British said it was not possible to do what Pratt & Whitney proposed. But there was a handful of people who 'went out on a limb' to make it all happen. They were the entrepreneurs. They were the risk-takers. They were the true movers and shakers. While there were many involved, four individuals stand out.

William Clarkson was associated with the factory from 1908 to 1911. It was on his recommendation that US technology was used, alienating his British masters no end. Despite some fundamental reservations, Clarkson's technical instincts (although he was a Navy man) foresaw the benefits of the US technology in terms of production philosophies and work practices. He was proven right.

John Jensen – a Cost Accountant by training, Jensen was more than just a 'bean counter'. He was one of the longest serving senior managers and was the 'go to man' since his remit was extensive, covering industrial relations, employment, production planning and control, stock control and office administration. He by-passed Government procedures where he could. He took on the unions. He revolutionised work practices with resultant high productivity. He was the innovator of the Factory and made the US mass production process work for Lithgow.

Lithgow Small Arms Factory & Museum

John Jensen was directly involved with the Factory from mid-1911 through to late 1914. But he remained close to the Factory and its operations in his various roles within the Department of Defence overseeing ordnance production. He became the Secretary of the Department of Supply and Development from 1942 to 1948.

Frederick Ratcliffe worked at the factory from 1909 through 1927. It was 1916 when Ratcliffe was appointed Factory Manager after serving his 'apprenticeship' under Clarkson. He was an Engineer who had worked at Pratt & Whitney in the US, where he specialised in planning arms factories. It was his efforts to commence non-defence work that stamped his mark on the Factory,



The Rifle section at SAF in one of the new buildings, long after WW2. Note these machines have individual electric motors - no lineshafting. Note also the women operators. Photo details - see top right.



One of 12 female apprentices in 1975. From SAF Museum Archives.

together with his unflinching desire to overcome a dreadful housing shortage in Lithgow which had worked against the recruiting of people. On both counts, his legacy was profound.

Jack Findlay was connected with the factory from 1909 to 1947. He was the Factory's specialist (senior Foreman) on heat treatment and steel properties, a role which became ever so important as WW2 hit. His technical nous was instrumental in ensuring the stringent quality control across the SMLE 303 rifles and Bren and Vickers machine guns of both the Factory and feeder factories during WW2 when production was at its highest. He became General Manager of the Factory post WW2 and served the Factory for over 40 years.

From Government owned to private ownership.

After a rather lengthy period in Government control, the Office of Defence Production (capturing all Defence production facilities across Australia, including the Lithgow Factory) was corporatised under the Australian Defence Industries Pty Ltd (ADI) banner which took effect in April 1989. The decision had its detractors and those impacted by it did not fully realise the impending consequences. At the time, the Factory was embarking on trialing and manufacturing the F88 Steyr rifle, while its workforce was around 600 people.

The Small Arms Factory name disappeared and in its place ADI emerged. In late 1999, ADI was sold to the commercial interests of Transfield and Thompson-CSF. Ownership changed again when in 2006, the French based Thales Group acquired the facilities and assets, which remain in their hands to this day. The Thales Group at the Lithgow site continues to manufacture the F90 Steyr rifle (an upgraded version of the F88), and almost 200 people are employed there by Thales.



A 1986 aerial photo of Lithgow SAF.

From Trip Advisor website.

Lithgow Small Arms Factory & Museum

Birth of the Museum.

The birth of the Lithgow Small Arms Factory Museum was the brainchild of a few ex-employees and local community members. In the early 1990s, ADI was downsizing and/or rationalising its production facilities, including Lithgow. Its intention was to sell off assets and the like, without any regard to leaving a legacy for the people of Lithgow.

From 1990 through to 1995 was when many of the Australian munitions factories were rationalised. During the latter part of this period ex-employees in particular voiced their concerns to ADI not to dispense with the various machines. ADI management did not take any notice initially and its 'fire sale' mentality continued.

Lithgow Council bought into the act in 1994 and along with the ex-employees, persuaded ADI to leave a legacy. In 1995 ADI gifted the Administration building (the current Museum facility) along with many artefacts to the City of Lithgow. A special committee was formed to decide how the history of the Factory could be preserved. Council did not want any direct involvement in this. It happened that a group of ex-employees and some locals would establish the museum.



Main rifle room of the Museum.

Source: SAF Museum.



A display of small guns in the SAF Museum.

Source: SAF Museum.

The current Factory operates alongside the Museum, which is associated with the Factory, and occupies the former Factory Administration Building, and soon, the former General Machine Shop.

The Museum has an extensive and significant archival collection that documents the history of the Small Arms Factory and its role in pioneering precision manufacturing in Australia. The conservation of such industrial archives is so rare, it is worth providing some detail about the collection. It contains an extensive run of the American Machinist magazine, dating back to the early years of the twentieth century; plans and blueprints for machines in the original Pratt & Whitney 1910 contract; building plans; and specifications for munitions manufactured at the Small Arms Factory. It also holds records relating to executives and employees of the SAF; wartime posters; publications on industrial safety; an in-house newspaper produced in the Orange feeder factory during WW2; and an extensive photographic collection that documents not only the SAF, its employees and industrial processes, but also the SAF sporting teams, and de facto community facilities such as the Factory Dam. The archive collection is the only collection of its kind providing a glimpse of history from the early 1900s through to the 1980s at Australia's primary ordnance/weapons production facility in the lead up to and during both World Wars.

Over the past 22 years, the Museum has amassed an array of historical, educational, research and scientific objects and artefacts that make it the largest Museum of its kind in Australia. It is renowned internationally for its collection. The Museum collection was recognised in February 2019 by UNESCO and now forms part of the Memory of Australia World Register. We are the first organisation in Lithgow to be awarded this prestigious accolade and the first in Australia for the type of collection we have. The UNESCO award is significant as it demonstrates the value of history held by the Museum depicting a time in Australia's past where a community was forged and grown on the back of what would become the start of precision manufacturing in Australia.

The rationale for having a Museum was to preserve the history of the Factory and tell the story of ingenuity, adversity and community mateship to current and future generations. The Factory meant so much to Lithgow. It was the mainstay of the township for many years. Generations of families were indebted to the Factory. Skills learned were of world class. Trades were inspired. Unionism evolved. Serving one's country during the wars through precision manufacturing was an honour. The bold step into commercial production showed the fortitude and innovation of management and workers.

But the most telling fact is that the Factory, on the same site, continues to manufacture high precision firearms, some 107 years after it all started - an unique situation in Australia.



The Ron Hayes room in the Museum. In 2006, Mr Ron Hayes donated a large collection of handguns to the Museum. Source: SAF Museum.

Lithgow Small Arms Factory & Museum

Staffed by volunteers, the Museum has today some 35,000 archived records, almost 3000 firearms and over 50 precision metal working machines dating back to the early 1900s and formerly used by the Factory. The metal working machines are located in the General Machine Shop building, having been brought in from other parts of the site. The oldest machine dates to the early 1900s – being the Pratt & Whitney rifling machine. The vast majority of the machines were used at the Factory – many imported (from the US and UK), some made by the Factory and others made in Sydney. We also have one of the first Computer Numerical Control (CNC) machines which the Factory used. We are in the process of ‘cleaning the machines up’. Some have electric motors but many no longer have any power source, having formerly been operated by lineshafting.

Our aim is to convert the General Machine Shop building (which measures 60m by 25m) into a precision engineering display area plus a workshop and presentation area. We plan to include other machines (not used at the Factory) depicting machinery technology, such as typewriters and possibly the early computer age.

We are in the process of spending some \$200,000 on improving the Museum and adjoining General Machine Shop. Museum improvements cover rust proofing and painting the external windows, placing a metal mesh cover across the front of the building and installing a series of internal panels to ‘dress up’ the building and use as painted murals. Monies on the General Machine Shop are going towards rust proofing the roof, fixing the many skylights, fixing the guttering and downpipes, painting all exterior windows, fixing the wooden floor and putting reinforced glass surrounds around the rifling machine at the entrance of the building.

Over 105,000 people have visited the Museum since its opening. Looking ahead, the Museum will become a prized precinct hosting an international precision engineering and firearms collection in honour of the Factory and its resilient people.



This “Rising Sun” display appears to have become the de facto emblem of the SAF Museum.

The Brendorah Paintings at the Lithgow SAF Museum

From the Editor

From <https://www.lithgowsafmuseum.org.au/collection.html> the Brendorah Paintings :

*During World War II when men heeded the call to war many women were employed at the Small Arms Factory. An eccentric but talented artist **Heliodore (Dore) Hawthorne**, worked at the Small Arms Factory in the Bren [Gun] Section from 1942 to 1945. During her time at the factory Dore drew many sketches of scenes from the Factory and was later encouraged to produce a series of paintings from those sketches. These paintings, under the pseudonym "**Brendorah**", depicted the daily incidents of factory life and reflected her deeply felt commitment to social justice. The paintings were shown and sold in Lithgow and Sydney in two exhibitions entitled "Factory Folk".*

There is much more to be found on various websites about Brendorah. I have reproduced here three of her paintings from the Museum collection. I just loved these ones!

At right is *The Verticals*, depicting men and women workers in the Bren Gun section.

On the next page, the top one is *Woman's Night Shift*, showing the weariness of those long all-nighters at the lathes.

Underneath is *Morning after Night Shift*, with the girls, shattered after a long night's work, hiding from the strong morning light and trying to sleep on the train trip home to Sydney.



