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Cover Images:

Front: Gladesville Bridge, photographed in May 2016. Photo: John Muirhead.

Back: On the Beirut to Tripoli Railway – the first 98 foot (about 30m) high pier of the Nahr el Djadz (No.1) bridge has been completed. A group of men on the top are installing the "piece de resistance" of the pier – a carved stone AIF rising sun badge – to be seen by passers by from the road bridge to the east, where the photographer is probably standing. To the west is the dry river bed and the Mediterranean Sea beyond. Photo: ARHSnsw.

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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.

CONTENTS

"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 here:

https://www.eabooks.com.au/Engineers-Australia-Centenary-Book-Wonders-Never-Cease

Editorial & Connections

This issue, I left myself without enough space for a Connections page at the end of the Magazine, but a few items have turned up, or (in one case) have re-emerged from the mists of time, and are worth a mention, so here they are. And here is a warning – because this is the editorial page, I have let some of my opinions loose on the following subjects.

Maybe I am in danger of repeating myself here, but it seems a long time ago that I came across a NSW State Library web site announcing a new feature called *The Bridge* – purporting to be all about the Sydney Harbour Bridge – at a NSW State Library site on https://thebridge.sl.nsw.gov.au/ There wasn't much on it at the time, and what there was was barely intelligible, but it looked as though they just hadn't got their act together yet. I had another look recently, and it has turned into *A five-part series starring Australia's favourite icon*. You can *Listen to the Podcast* or *Read the Story*. I don't have the patience or the time to listen to podcasts (showing my age?), so I thought I would read it. But no – two minutes in and I was totally confused. It's very pretty, but the text is all over the place and the often beautiful images are not tied to the text and are not explained without a painful search for captions, which don't appear to exist in many cases. Have a look and see what you think. I think it would be fantastic if it could be better organised and able to be downloaded as five PDFs, or one PDF with the five episodes forming chapters in a book.

Our colleague Ken McInnes has been on a crusade to get all the early Institution of Engineers Australia Transactions digitised and online and available to all, and as well, the Transactions (or Proceedings) of all the State Institutions (or Institutes) of Engineers which preceded their amalgamation with IEAust in 1919. As Ken tells us, the IEAust Transactions *used to be available on the EA website for free, but not anymore. However, the old EA website has been archived by the National Library Australia, through Pandora, so they are still able to be found and downloaded for free as follows* :

All 9 sets of Transactions, from 1920 to 1928, can be downloaded one-by-one, starting with Volume 1, 1920 at: http://pandora.nla.gov.au/pan/128542/20161003-0002/www.engineersaustralia.org.au/sites/default/files/shado/Member+Services/Library/I_E_A+Transactions+vol_1+1920.pdf
To save taking up the space to print all 9 links, just change the 1+1920 to whichever volume you want, eg. 2+1921 or 9+1928. It worked for me! Ken also tells us the West Australian Engineers Proceedings can now be downloaded from links to the Battye library on: https://portal.engineersaustralia.org.au/news/saving-western-australias-engineering-history This seems to me an incredibly tedious process, even after you work out how to download the volumes, but it's worth the effort. The South Australian Institute of Engineers Proceedings have been digitised by Ken, and have now been put on line by the South Australian State library at: https://www.catalog.slsa.sa.gov.au:443/record=b1476070~S1

The Timber Truss Bridge Book, edited by Lenore Coltheart and Amie Nicholas, has been published as a digital release by the NSW Roads & Maritime Services Department as a sort of commemoration of the 420 timber truss bridges that once dotted the whole of NSW. The RMS tells us they are *committed to conserving 27 of these remaining bridges as part of the state's road network under its Timber Truss Bridge Strategy*. If 27 are all that are left, I hope they really mean it. I spent a lot of time during the years I worked for the NSW Department of Planning Heritage Branch (for the NSW Heritage Council) trying to save a number of such bridges – some large and spectacular – some small and modest – but all stunning in their structural and material coherence and design. Sadly, I failed, and those bridges are all deceased. It seemed then that all the rest were destined for oblivion, so I am relieved that they called a halt at 27.

I suspect the new book is intended as a memorial to bridges past. I hope it is widely enough distributed to act as a call to arms, persuading the heritage fraternity to never let any more timber truss bridges disappear off the map. To see an intro to the sequence of web pages that RMS calls a "Book", go to:

https://www.rms.nsw.gov.au/about/environment/protecting-heritage/timber-truss-bridges.html

At the end of that page is a link to the start of the book, with a box to click on (Get Started) that leads to the Foreword, and so on through 16 sections, all of which take an age to open if you are not on high speed broadband – an exercise in tedium.

The Killawarra Bridge over the Manning River near Wingham NSW.
One of my sad failures, demolished circa 1986 Photo: MJ Doring, 1985..

And then what about keeping it to read later, like a real book? All can be read on screen, or saved as html – but that leaves the same opening problem next time around. Of course you can print it to PDF, if you have the software that allows this, but that method loses a great deal of atmosphere, and some terrific images don't get through. I find it hard to understand why this "book" cannot be downloaded as a series of PDFs – or even better, as one large PDF. I, for one, will probably never get to read it, because I will never have time to open (not download) each section, one at a time. One of the joys of a real book, whether in print or online, is the ability to dip into it, wherever your fancy takes you. With this one? Not a hope.

From the Editor

Electrification of Melbourne's Suburban Railway Network

Summing up for the Centenary – 1919 to 2019 *By Miles Pierce*

In May 1919, the first regular passenger electric train services commenced on the Sandringham and Essendon suburban railway lines. By 1923, this ambitious project for electrification of the suburban railway lines was effectively completed. Then, it was claimed to be the largest suburban railway network in the world to be successfully converted from steam locomotive to electric traction. It was an immediate success in terms of increasing rail patronage & reducing operating costs.

Image Source: "The Engineer", 1920.

The electrification of Melbourne's suburban railway lines was first mooted in the closing years of the nineteenth century, however, the first detailed assessment was made in 1908 by UK consultant Charles Merz, under a commission from the Victorian Government. In his detailed 1908 report, Merz demonstrated the financial viability of the proposal for Melbourne with its relatively low population density – compared to large UK and European cities – and thus significant use, and potential increased use, of suburban rail transportation. The then Railway Commissioners conservatively opted not to proceed immediately, but to keep the option under review.

Following the deliberations of a Royal Commission into Melbourne's railway and tramway systems in 1910-11, Merz was re-appointed to review and update the original report. The revised report, submitted in July 1912, included costings based on actual tender prices for major plant and equipment, with alternatives for high voltage single-phase AC and medium-voltage DC traction.

IMAGE at RIGHT: Charles Merz (1874 to 1940). Electrical engineer and pioneer of high-voltage AC power distribution in the UK. Merz studied at Armstrong College in Newcastle UK before joining the Newcastle Electric Supply Company (UK) as an apprentice. He later became Chief Engineer at the Cork Electric Tramways and Lighting Company before setting up a consultancy firm with William McLellan in 1898 – this company would become Merz & McLellan. Merz set up the UK's first three-phase power supply and advised Parliament on setting up a national electrical network, which led to the 1919 Electricity Supply Act. He was killed in an air raid in 1940. Image: Institution of Engineering & Technology.

Electrification of Melbourne's Suburban Railway Network

The high voltage single-phase AC and medium-voltage DC traction was shown to be the more cost effective for Melbourne and a 1500volt DC traction system with an overhead contact wire was recommended. This differed from the 1908 proposal for an 800volt DC system with a protected contact rail (third rail system). After further parliamentary committee investigations, the electrification scheme was approved in December 1912.

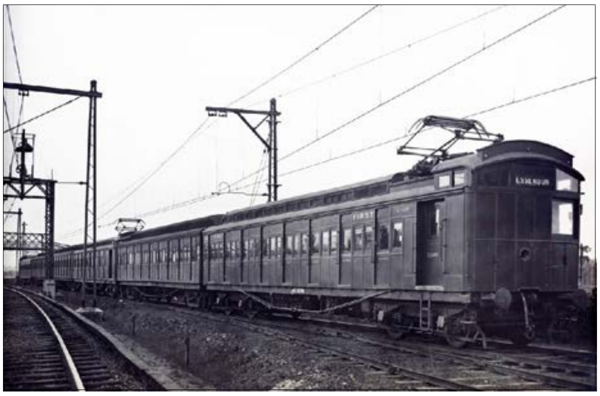
The first Newport Power Station, photographed from across the Yarra River. Photo: Public Records Office of Victoria (PROV).

In accordance with the consultant's proposal, the scheme was constructed in three stages. It included the building of a dedicated 78 MW coal-fired power station at Newport that was claimed to be the then largest electricity generating plant in the southern hemisphere.

Victorian Railways two track curve construction on the Brighton line between Prahran and Windsor stations. Photo: April 1929, from PROV.

IMAGE at LEFT: The Lygon St. North Carlton level crossing on the former Inner Circle Railway Line – illustrating the intersection of Railway 1500V DC traction lines with Tramway 600V DC lines. Note the signal box at right.. Photo: PROV.

IMAGE BELOW: A six-car standard Tait train - the first electrified trains used on the Melbourne electrified rail system - standard until 1952. Photo: PROV.



The overall implementation of the scheme was protracted by onset of the First World War, but work continued throughout with much equipment and services being locally sourced. Although the consulting firm of Merz & McLellan was retained to undertake the detail design and to overview construction, Australian professional engineers and technologists, employed by the Victorian Railways and by local contractors, contributed in many ways to the ultimate successful completion of this major enhancement to Victoria's public transport infrastructure.

With some extensions to the area of coverage, the successive introduction of newer technology rolling stock and upgrades to the substation AC to DC conversion plant, the electrified suburban railway network has served metropolitan Melbourne for a century and it continues to do so with ever more people using the service.

IMAGE at RIGHT: Tait train at Newport Railway Workshops in March 2019. Photo: Miles Pierce.
Tait trains were introduced in 1910 by the Victorian Railways as steam locomotive hauled cars, and converted to electric traction from 1919 for the Melbourne electrification system. The trains were named for Sir Thomas James Tait, Chairman of Commissioners of Victorian Railways from 1903 to 1910. The first cars were built during 1909 with the last entering service in 1952. They were the workhorse of the system, known as the Red Rattlers in later life – Wikipedia.

Further reading:

Doran & Henderson, *Electric Railways of Victoria*, Australian Electric Traction Association, 1979.
Electrification of Melbourne Suburban Railways, The Engineer, 9 Jan 1920 pp44-47.
The Electrification of the Metropolitan Railway System of Melbourne, The Industrial Australian and mining standard, 1919.

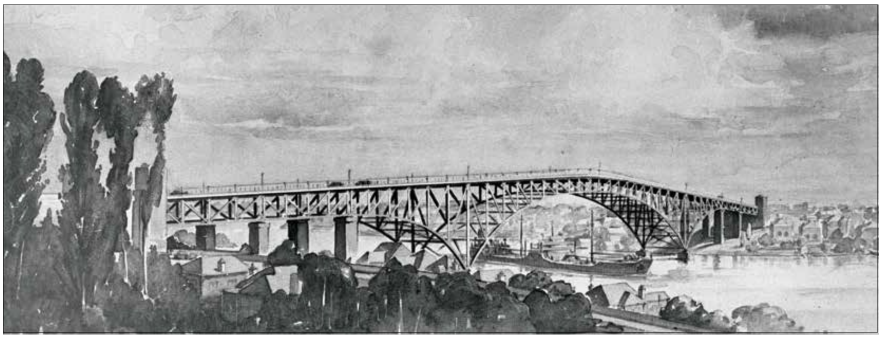
Gladesville Bridge, Sydney, NSW.

A brief account of the building of a pioneering concrete arch bridge.

by John Muirhead, FIEAust, CPEng(R'td), LFIAMA.

The Gladesville Bridge, viewed from the north-east. Photo 2016, by John Muirhead.

When it was opened in 1964 the Gladesville Bridge in Sydney Australia was the longest span concrete bridge in the world. In 1957 the Department of Main Roads of New South Wales (DMR) called tenders for the construction of a trussed steel cantilever bridge of conventional design and 225.5 m span between the main piers. However, at the suggestion of Mr Guy Maunsell, Consulting Engineer from London, Mr Howard Sherrard, the Commissioner for Main Roads, agreed to accept tenders based on alternative designs.

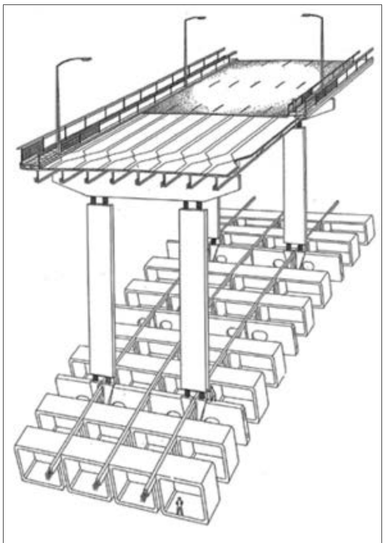


Artist's impression of the DMR's originally proposed 740-foot span steel cantilever truss bridge over the Parramatta River at Gladesville. Image: from the Main Roads Journal of June 1957..

A partnership of Reed & Mallik Limited, of Salisbury, UK and Stuart Bros Pty Ltd of Sydney under the name of Stuart Bros & Partner, submitted an alternative tender for a concrete arch bridge. The alternative, the lowest bid received, was based on a design very similar to the bridge as it exists today but with a span of only 900 feet (274m).

In view of the fact that the span of the bridge was over 15% greater than any previous arch, the DMR commissioned independent design checks by Professor Roderick of Sydney University, Professor Pippard of London University and Yves Guyon of Freyssinet in Paris. These proved the design to be satisfactory.

A model of the alternative design was assembled in the tender opening room at the DMR Head Office in Sydney. The Commissioner asked Mr Reed about other concrete bridges worldwide, existing and planned, and it was decided to increase the span to 1000 feet (305 m) to make it then the longest span concrete bridge in the world.



Schematic diagram of the four arch ribs, the columns and roadway. Image: Roads & Maritime Services (RMS).

Mr Reed then instructed Maunsells to proceed with documentation. The bridge arch was to be comprised of four individual parallel ribs, tied together by prestressed concrete diaphragms which support the columns. The central 61m of roadway was to be supported directly on the crown of the arch. The remaining lengths of roadway consist of 16 spans of 100 ft, eight on each side, including approaches, and consisting of 30.5m long prestressed concrete T-girders.

The DMR modified the road system at the Gladesville end of the bridge, causing a substantial widening of those approaches.

The increase in the span of the arch had the beneficial effect of moving the springings closer to the shore lines and this produced economies in the size of the temporary cofferdams for the abutments. The foundation material is hard, massively bedded Hawkesbury sandstone.

The precast arch segments (box sections) are all 6.1m wide and vary in depth from 7.0m to 4.27m. The thickness of their tops and bottoms is 381 mm and the vertical sides are 254 mm thick. The segments are in various lengths to fit between the diaphragms, with 76 mm wide gaps for insitu concrete joints. To be within the lifting capacity of the crane, most segments were about 2.7 m long.

Gladesville Bridge, Sydney, NSW.

The diaphragm units contain ducts for transverse stressing cables which tie together the four arch ribs and are at 15.25m horizontal intervals. Alternate diaphragms support the columns and their pre-cast headstocks, and thus support the 30.5 m span deck girders.

The precast concrete units were cast in a yard set up by the Contractor at Woolwich, about 2.5 km downstream of the bridge site. They were transported to the site on pontoons. The specified concrete strength for the arch segments was 40 MPa.

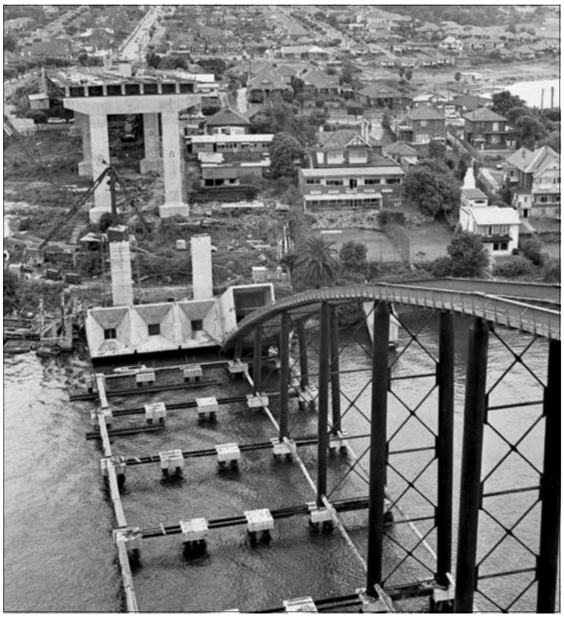
The headstocks were placed on the columns by the steam powered floating crane "Titan", which was hired from Vickers Cockatoo Dockyard. They were post tensioned to the columns by Macalloy bars coupled to the column bars.

Box units in the casting yard at Woolwich. Photo: RMS January 1962.

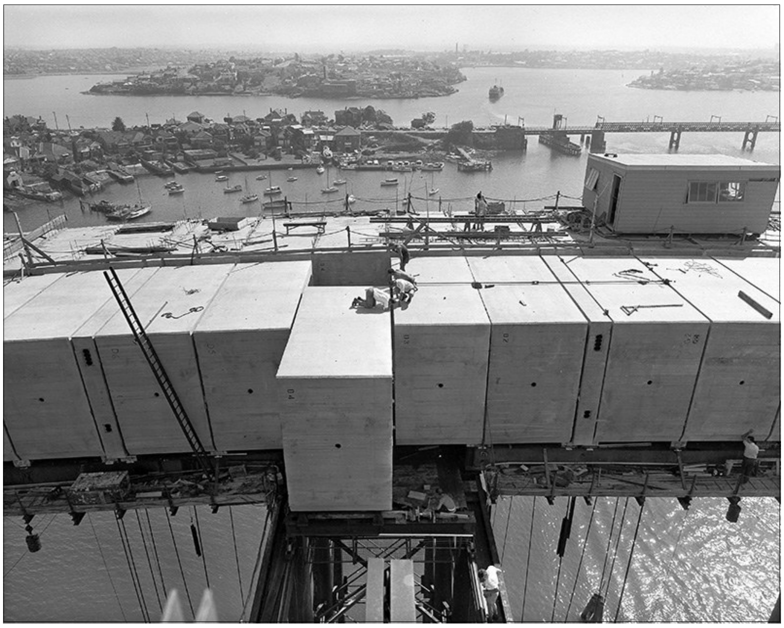
A box unit has been lifted to the crown of the falsework arch and is being slid down the arch to its seat. Photo: RMS January 1963.

The columns were post-tensioned by 27 mm diameter Macalloy bars, wrapped in two layers of Denso tape so that they could move within the hardened concrete when tensioned from the top of the headstocks. There was no loss of load due to friction.

The arch segments were packed up to the arch profile off the falsework girders, with 75 mm wide gaps between them; these gaps were then filled with concrete. When all concrete joints had reached the design strength; Freyssinet Flat Jacks at two points 76.2 m each side of the apex of the arch were inflated to compress the arch and lift it off the falsework.



Several box units are in place at the base of the 1st falsework rib. Note the land side columns & headstocks for building the road way are already in place. Photo: RMS March 1963.

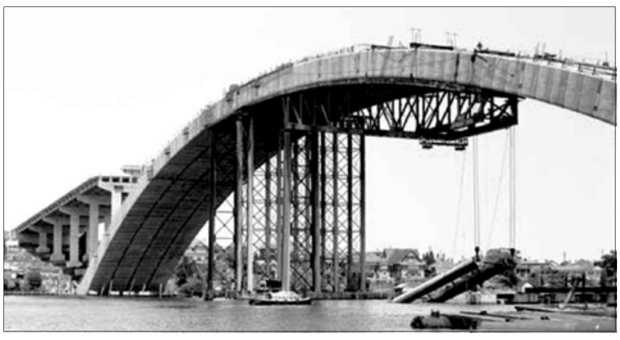


The last concrete box unit on the 2nd rib is slid into place. Note the narrow diaphragm units either side of the last box unit, also the original Gladesville Bridge in the background. Photo: RTA neg14526 taken 13 July 1962.

The jacks were pre-assembled in banks of four and encased in concrete blocks respectively 380 mm and 305 mm square and then assembled between pairs of special diaphragm segments. The jacks were inflated with hydraulic oil to apply a force concentric with the thrust line of the arch and lift it off the falsework; making it self-supporting from its springings. After the conclusion of jacking of each bank, the oil in the jacks was sequentially drained and replaced with cement grout as the permanent filling.

The performance of the ribs during jacking was monitored continuously by theodolite observations from the abutments and by "Talyvel" instruments at the crown. The hydraulic circuits allowed for the jacks in the banks in the vertical walls of the arch to be isolated so that any deviation of the arch rib from the centre line could be corrected.

IMAGE at RIGHT: All 4 arch ribs are complete, the arch is jacked up to be self supporting and the falsework is being removed. Note the land side decking & columns are already in place. Photo: RTA neg17418 taken November 1963.



A precast concrete deck column lifted into place on the arch by the Titan crane. Photo: RTA neg16700 Aug 1963.

The falsework was then moved down stream, to the position of the next arch rib and the process was repeated until all four ribs were completed. The diaphragms were then stressed in preparation for the construction of the columns to support the bridge deck structure. The deck girders were constructed on the bridge approaches and placed by a launching girder.

The concept for the construction method was devised by Mr Z.A. Lester MSc, Chief Engineer of Reed & Mallik Ltd. He also prepared the tender. All other construction methods were devised by the Contractor's engineering staff on the site in Sydney.

A pair of columns is in place on the arch, ready for installing a pre-cast headstock. Photo: RTA - no date or number.

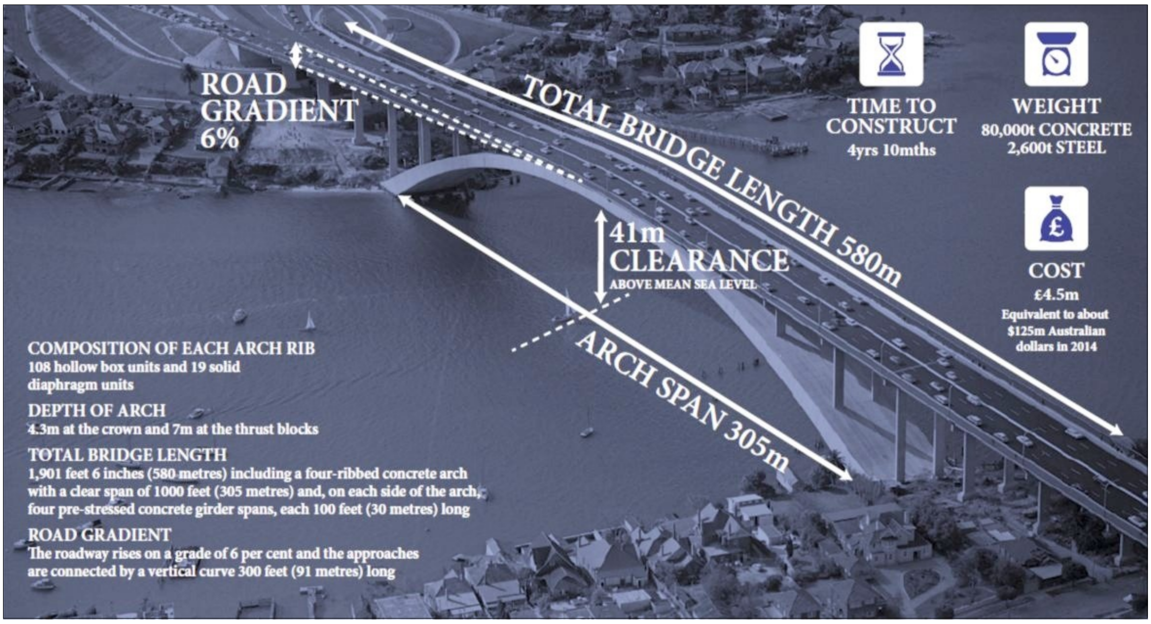
The increase in span required the tender falsework to be changed and Maunsells were engaged for the redesign and documentation. Their design consisted of a pair of segmented steel arches comprised of 36 inch x16½ inch x 260 lb/ft high tensile steel girders braced together at 5.49m centres and designed to support all the precast concrete units for one complete arch rib at a time. The steel girders were supported on a structure comprised of raked steel tube columns braced together in pairs. The girders were specially rolled for the project by Dorman Long, the British firm that built the Sydney Harbour Bridge.

IMAGE at RIGHT: The Titan floating crane is prepared for lifting a pre-cast headstock up to the two short columns on the bridge arch. Another headstock is already in place on columns at left, and supports a set of concrete T-girders to carry the roadway. Photo: RTA neg17489 circa 1963.

The foundation structure for the falsework consisted of steel beams supported by concrete pile caps. The piles were raked at 1:5 in each direction and were driven to bed rock. This foundation structure was built to the full width of the bridge so that the falsework could be traversed from the position of one arched rib to the next, working from upstream to downstream. The 61 m navigation opening in the falsework was spanned by two steel lattice girders braced together at 5.49m centres between waybeams, each on a row of steel tube columns 1524 mm ID x 22mm thick. The falsework structures on each side of the navigation channel were traversed downstream for each successive arch rib by Lift Slab synchronised jacks.

At one end of the navigation opening at the apex of the arch there was a steel tower across the full width of the falsework with plate girder cantilever beams which supported a fixed crane at the downstream end. This lifted the arch rib segments weighing up to 50 tons from barges and placed them on to a trolley for transport to the centre of the arch rib under construction. The trolley then transported the arch segments down to their final positions along rails fixed to the top of the falsework girders.

The revised tender submitted by Reed and Mallik on 8th February 1960 was in the sum of £2,560,031 ($6,400,078) and this was accepted by DMR letter dated 27th June 1960. The Contractor submitted claims for extras. An independent arbitrator awarded a further $57,832. The contract period was 156 weeks. Time extensions were granted to 21st October 1964 and the work was completed within time.



These Key Statistics for the Gladesville Bridge appear on page 5 of the RMS Gladesville Bridge 50 Year Anniversary booklet.

The bridge was formally opened in 1964 by Princes Marina of Kent in a big ceremony for which a stand was set up on the crown of the bridge. It is commemorated by plaques at each end of the footpath that read:

This bridge was opened by Her Royal Highness Princess Marina Duchess of Kent, 2nd October, 1964.

At Huntleys Point a further plaque was erected which reads: *The overall length of the bridge is 1901 feet 6 inches. The arch spans 1000 feet and rises 134 feet. The height above water at this point is 150 feet. Period of construction from 2nd December, 1959 to 2nd October, 1964.*

No representatives of the Contractor, Stuart Bros & Partner or Consulting Engineers G. Maunsell and Partners were included in the official opening ceremony nor were their achievements and contributions acknowledged in any form on the bridge. This omission is the more curious having regard for the fact that they had both, between them, designed and built what was then the largest span concrete bridge in the world. There is no acknowledgement of the contributions of Mr Howard Sherrard, who was the Commissioner for Main Roads until April 1962. Without his approval to the submission of alternative designs, we would now have an unexceptional steel bridge requiring regular painting. It was also he who accepted the recommendation to increase the span of the arch from 277 m to 305 m to ensure it was the longest concrete span in the world. Mr Sherrard retired on 20th April 1962.

In 2015 The Institution of Engineers, Australia and The American Society of Civil Engineers presented a bronze plaque which recognises the standing of the bridge. On 4th October 2015 the fiftieth anniversary of the opening of the bridge was commemorated.[1]

These notes were compiled from the records of Stuart Bros Pty Ltd, Braithwaite Foundation & Construction Co Ltd and of Reed and Mallik Ltd. They contain essential contributions from Mr Tony Gee.

John Muirhead, FIEAust, CPEng, LFIAMA, was a director of Reed and Mallik Ltd from 1968 to 1981. He assisted in tender preparation and the stressing of the first arch rib of the bridge. John has been involved with IEAust Engineering Heritage committee work for more than 40 years, and in 2005 he received the Award of Merit for Engineering Heritage.

1 For the nomination document and other information see: https://portal.engineersaustralia.org.au/heritage/gladesville-bridge-sydney-1964
For more information about Tony Gee, the (then) 22year-old designer of the bridge, and something of his later career, see: http://www.eng.cam.ac.uk/news/alumni-news-tony-gee-designer-gladesville-bridge

Lighting the Streets with Electricity

Introduction

The first practical application of electricity was the telegraph, introduced in the late 1830s. About 1802, Sir Humphrey Davy had shown that electricity could produce light when he struck an arc between two electrodes, and this was a primitive arc lamp. However, the successful introduction of such electric lighting required a continuous supply of electric current. This had to await Michael Faraday's 1831 discovery of the principle of electricity generation and then the development of the engine-driven dynamo.

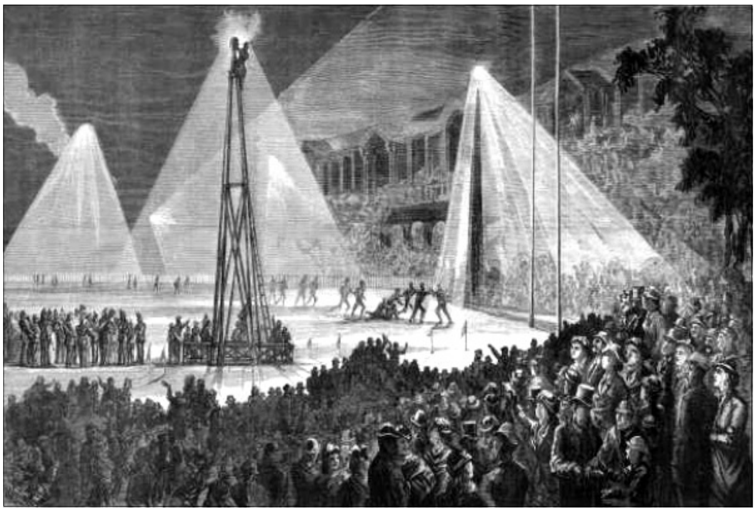
Early developments were widely reported in the Australian colonies as news of them arrived from the far side of the world. Amateur scientists or professional showmen acquired apparatus and delivered lectures which were attended by hundreds of fascinated people in smoky gas-lit halls.

From Concept to Engineered Demonstrations

In Launceston, Dr James Kenworthy first demonstrated electric light in 1845. He continued regular lectures until 1856 when he returned to England. However, it was the telegraph experts who were the first electrical engineers – they understood batteries and circuits. In 1855 Charles Todd, newly-appointed Superintendent of Telegraphs in South Australia said he would carry out some experiments, but it wasn't until October 1860 that he demonstrated an arc lamp that he had made, to an audience of 800 people. Todd took his light outside in 1867 and lit up King William Street on the occasion of the visit of the Duke of York.

Edward Cracknell, Todd's former assistant and now Superintendent of Telegraphs in New South Wales, had displayed arc lighting from the Sydney Observatory to celebrate the marriage of the Prince of Wales in 1863. One light was tinted red with strontium.

A searchlight scans the water – testing a Siemens arc light on Sydney Harbour in 1878. Source: Internet, via Richard Venus.



Night football at the Melbourne Cricket Ground in 1879. Source: State Library of Victoria.

Electricity became important in coastal defence - electrical circuits could detonate mines (then called "torpedoes") while powerful electric lights could reveal an approaching enemy. Consequently, in 1878 Cracknell tested a Siemens arc lamp on Sydney Harbour. He then demonstrated the light from the General Post Office (GPO) tower in Martin Place, Sydney. It was said that over on the North Shore a newspaper could be read by its light.

In Melbourne, electric light had been used in concerts on the Melbourne Cricket Ground in 1878, and – not entirely successfully – for night football in 1879.

In Brisbane in 1882, an attempt was made to float the Queensland Electric Light and Power Co. with a demonstration of 8 Brush arc street lights in Queen Street. However, the float was unsuccessful, and the progress of electric lighting gradually continued with private indoor commercial lighting schemes including shop fronts.

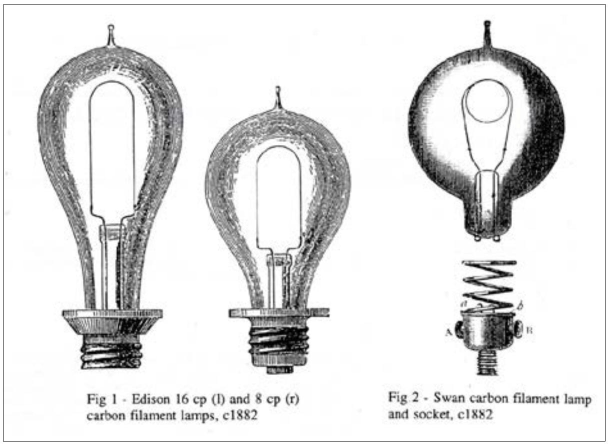
A Sydney-based company was responsible for Adelaide's first installations - in flour mills at Port Adelaide and Gawler where the new light reduced the risk of fire and explosion. Their engineer – L. Maurice Grant – operated the lighting plant at Adelaide's Jubilee International Exhibition in 1887, which set record attendances in Australia because it was the first to open at night.

From Demonstration to Permanent Street Lighting.

To move from lighting demonstrations to a reticulated system in buildings or streets, not only required dynamos to continuously generate the electricity, but a means to distribute the power. By the late 19th century, "cable" systems such as Edison Tubes and overhead wiring with weatherproof insulation were being developed. These, together with the invention and development of the incandescent lamp, became the catalyst for a wider use of electric lighting.

Lighting the Streets with Electricity

The first electric lighting using arc lamps was not suitable for universal use due to arc lighting's properties of intense uncontrolled light only suitable for outdoor areas, complicated and expensive mechanisms to feed the carbon electrodes as they burnt away, frequent electrode replacement, flickering light, odour, noise, and heat. Development of the first practical incandescent filament lamps by Swan (UK) and Edison (USA) in 1879 using filaments in a vacuum, together with the engine-driven dynamo, led to the rapid growth of electricity supply systems.



The first carbon filament incandescent light bulbs, invented by Edison (left) and Swan (right) Source: EHA Qld.

Incandescent lamps, by contrast with arc lamps, were clean and quiet, maintenance free, with a long life, and could be more easily controlled. They started a revolution in electric lighting, and made commercial and domestic lighting practicable. Incandescent lamps remained in use for street lighting well into the 20th century, although the 1930s saw the adoption of the more efficient, sodium and mercury vapour lamps, then of fluorescent lamps and recently of halogen and light emitting diode (LED) lighting.

Sydney

After the Sydney GPO tower demonstration in 1878, Cracknell and Professor Richard Threlfall of Sydney University prepared plans for the Sydney City Council to light the streets and parks. However, the council first had to secure the necessary legislative power and this took until 1896. Meanwhile lighting plants had been installed in many major buildings including the Council's own Town Hall.

In 1882, a private company installed 16 arc lamps at Circular Quay, supplied from a small generating plant at Fort Macquarie (now the site of the Opera House). Cracknell also installed arc lamps at the Redfern Railway Station and ten years later the Redfern Council lit their streets.

Early in 1900 Major Philip Cardew from Preece & Cardew, the leading English consulting electrical engineers, visited Sydney to plan a lighting system and call tenders on the Council's behalf. Work started on a power station at Pyrmont in 1902 and the station was opened on 8 July 1904.

By the turn of the century there emerged a three-way approach to generation and distribution of electricity in Sydney:

- Private power stations at Redfern and Newtown (later Balmain) supplied the general needs of private consumers and some isolated street lighting.
- Tramways/Railways power stations at Ultimo and later White Bay supplied the electric trams, workshops and offices, and later the electric trains.
- Sydney Municipal Council's system from Pyrmont and later Bunnerong Power stations, converted the city's street lighting from gas to electricity, and supplied industrial and domestic needs.

Tamworth

Smaller municipalities in NSW could respond more quickly. The first was Tamworth which started its town electric lighting scheme in November 1888. Sydney electrical engineers, Harrison & Whiffen, representing Crompton of England, installed a power station and distribution wiring to supply 3 Crompton arc lights and Swan incandescent lights on 52 existing gas light posts. It was the first municipally-organised scheme in Australia. Young followed Tamworth in 1889. For the centenary in 1988 of Australia's first city of electric street lighting, the Peel Cunningham County Council opened a full replica power station and arc lights as part of their new Tamworth Power Station Museum, which still runs monthly demonstrations.

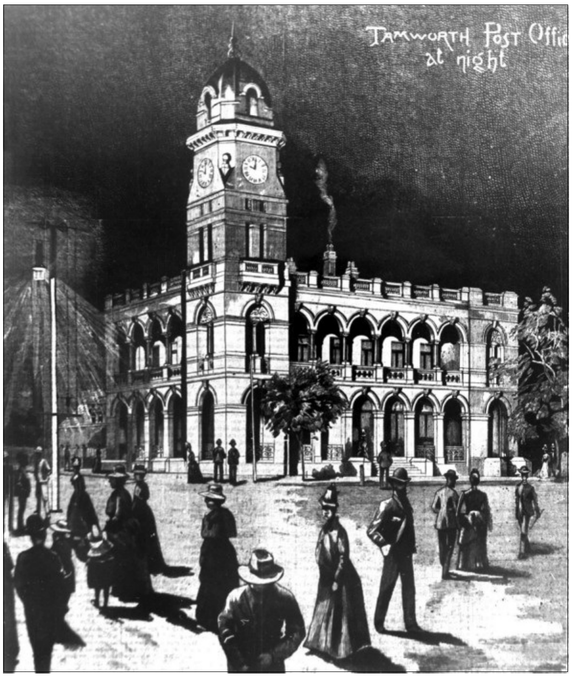


IMAGE at RIGHT: Street lighting in Tamworth – the Post Office at night in 1888.
Image: Courtesy of the Tamworth Power House Museum.

Lighting the Streets with Electricity

Melbourne

In September 1880, clockmaker Robert Joseph saw the potential of the new technology and set up the Victorian Electric Company. An arc lamp installed outside their office in Swanston Street was a powerful advertisement. The company lit the Eastern Market with six arc lamps each powered by its own portable dynamo. The company then began to build the first central power station in Australia – and only the third in the world – in Russell Place, off Bourke Street. Joseph also set up a factory to make dynamos, lights and other appliances for customers rather than ordering and shipping them from overseas.

The Melbourne City Council opened its Spencer Street Power Station in 1894 and the dynamos were driven by locally made steam engines.

An arc lamp displayed outside the Victorian Electricity Company office in 1880. Source: Illustrated News.

Adelaide

Following the lighting of the Adelaide Exhibition in 1887 with both arc lamps and incandescent lamps, L. Maurice Grant was also responsible for the running the electric lighting in Melbourne's Exhibition Building the following year. He then returned to Adelaide as the agent for the Brush Company and, among other things, installed the electric light plant at the Theatre Royal which later supplied power to Adelaide's first single electric street light in October 1895. The first full public electric street lighting scheme in South Australia was at Port Adelaide in February 1899, supplied from the Nile Street Power Station, using dynamos and lamps by Johnson & Phillips. This scheme was installed by a company founded by L.M. Grant in 1895 – the South Australian Electric Light and Motive Power Company.

That company, which eventually became the Adelaide Electric Supply Co., and much later the Electricity Trust of South Australia, secured the contract for the first public electric street lighting scheme in Adelaide, supplied initially from a temporary plant. The installation of 31 arc lamps along King William and O'Connell streets was switched on in January 1900 and handed over to the Adelaide City Council. Pioneering electrical engineer L.M. Grant, who also went on to establish new electricity systems in Geelong, Victoria and Northern New South Wales regional towns, can thus be credited with laying the foundations for the electricity supply industry in South Australia.

Brisbane

In April 1888, the local partnership of Barton, White and Co made an unsuccessful offer to the Brisbane Municipal Council to replace gas lighting in Queen Street with electric lighting. However, it was not until the 17th of July 1917 that Brisbane's first permanent electric street lighting was switched on with supply from the City Electric Light Co Ltd, successors to Barton and White.

In August 1888, the first commercial public supply in Brisbane commenced when the Brisbane GPO accepted Barton and White's offer to supply its premises. The 110 Volt DC supply was to replace hot gas lights with "cool" electric light and fans at the GPO, but was soon extended to nearby premises. This company continued to prosper under pioneering electrical engineer Edward Barton through many reorganisations, and laid the foundations for the Queensland interconnected supply system that exists today.

As in other colonies, there were several private lighting schemes in Brisbane before public supply became available, including: Sutton's Foundry, Jan 1883; The Queensland Government Printery, April 1883; The Brisbane Courier, March 1884; Roma Street Station & railway yards, April 1884; and Queensland Parliament House, July 1886.

Arc lamp at the Adelaide Jubilee Exhibition. in 1887. Similar lamps were demonstrated in Brisbane in 1882. Source: Richard Venus.

Thargomindah

The town of Thargomindah in South-west Queensland was well ahead of Brisbane. In January 1893 an electric lighting scheme, including street lighting, commenced from a steam driven plant owned by a local storekeeper. This was the first permanent public lighting scheme operating in Queensland. In late 1897, the Bulloo Divisional Board acquired the scheme and in March 1898, supply was transferred to a new hydro plant using water from an artesian bore. All of the equipment, including the Pelton-type waterwheel, dynamos, and switchboards was designed and manufactured in Queensland. A 3 wire 440/220 V DC system, the first in the colony, was adopted to overcome the voltage drop in the 1 mile long, overhead line from the hydro power station. This town was the first in Queensland with electric lighting supplied by hydroelectric power. The hydro plant ran continuously until 1951, and is still run regularly as a demonstration plant for the public.

Lighting the Streets with Electricity

Perth

In 1891, Charles Otte floated a company in Perth, similar to the Adelaide venture, and established a temporary "Central Electric Lighting Station" in Howick [Hay] Street. The Legislative Assembly was the first building to be supplied, while the first electric light in a Perth street was a lamp on a hitching post outside the Station. This prompted the Western Australian Gas Company to also undertake to supply electric light, and their power station opened early in 1894.

Launceston & Hobart

Not surprisingly, Tasmania harnessed water power rather than burn coal or wood. First suggested in 1881, the Duck Reach Power Station opened in 1895 to supply street lighting in Launceston – the first major publicly owned Hydro-Electric Power Scheme and Electricity Network in the Southern Hemisphere. Interestingly, Duck Reach produced both DC for arc lights and AC for incandescent lights and motors.

Hobart's first electric light was supplied to private consumers by the Gas Company's power station – driven by gas engines, of course – that opened in November 1898. The Gas Company also provided street lighting with a mixture of gas and electric lights.

Engineering

Development of arc lighting into a viable street lighting apparatus, followed by a similar development of the more suitable incandescent lighting, was a significant advance. Combining this with electricity generating plant and a means of reticulation led to the development of an electricity system where the merits of centralised generation were soon realised. All the very early lighting schemes used DC, nominally 110 V for incandescent lighting, and up to 300 V for series connected arc lighting. Establishment of a vacuum globe enabled the carbon filaments in incandescent lights to become a commercial product, but later, carbon was superseded by tungsten. The advent of AC systems in the early 1900s essentially made no difference to the incandescent light, which operates equally well on both systems.

The development of electric lighting to replace gas, oils and candles in the late 19th century certainly changed the world, and Australia, despite its remoteness, was at the forefront of taking up this technology. Engineers Australia recognised these life changing projects by including them in their 100-year 2019 publication *Wonders Never Cease*, released to mark *100 Australian Engineering Achievements.*

Community benefits

Street lights made the streets safer at night. In comparison with gas lighting, electric street lighting provided a higher standard of lighting over a wider area at a reduced cost. Safety was also enhanced in comparison with gas lighting systems as the attendant smoke and potential fire hazards were removed – all with the flick of a switch.

Abbreviations: DC- Direct Current, AC-Alternating Current, V-Volt (unit of electrical pressure)

References:

Prentice S A, *Edward Barton-1858-1942 – Pioneer Electrical Engineer*, in *Memoirs of the Queensland Museum*, Vol.27 Pt.1, Brisbane, 1988

Becconsall B J & Simmers J M, *Electric Lighting in Brisbane- The First Decade 1882-1892*, Qld Division Technical Papers, Vol.33, April 1992. The Institution of Engineers, Australia, Qld Division.

Dunstan D, *From Settlement to City: An Engineering History of Sydney*, Chap.14 – *Electricity Supply in the Sydney Region.* The Institution of Engineers, Australia, Sydney Division. 1989.

Venus, R., *Edward Maurice Grant – The Forgotten Electrical Pioneer*, in Second South Australian Engineering Heritage Conference, Engineers Australia, Adelaide, 10 May 2013.

This article has been developed from a research paper prepared for the EA Centenary book *Wonders Never Cease.*

The authors of this article are:
Richard Venus of EH South Australia, with
Jim Simmers, Stuart Wallace & Brian Becconsall,
all of EH Qld.

Addendum to Lighting the Streets with Electricity — From the Editor

For more about pioneering electrical works mentioned here, see *Edward Barton & the Barton White & Co. Power Station – 125 years since the first commercial electricity supply happened in Queensland* in EHA Magazine, Vol.1, No.1, Dec. 2013, and *The Recovery of 134-year-old "Edison Street Tubes" from William Street, Brisbane* in EHA Magazine, Vol.2, No.9, Sept. 2018.

There is a wealth of information about the fascinating Duck Reach Hydro Power Station in the EA Heritage Register at: https://portal.engineersaustralia.org.au/heritage/duck-reach-power-scheme-south-esk-river-1895-1955

Miles Pierce wrote a paper – *An Australian Hydroelectric Milestone - the 1895 Duck Reach Power Scheme* – in the Australian Journal of Electrical & Electronics Engineering Vol.3 No.3. This is available via Informit at: https://search.informit.com.au/documentSummary;dn=852141081298764;res=IELENG

Honeysuckle Creek & the Moon Landings

50th Anniversary of the Apollo 11 Lunar Landing

By Keith Baker,
incorporating an extract from his book
"A Century of Canberra Engineering".

John Saxon (at rear) and Mike Dinn working on the Honeysuckle Creek operations console.
Photo: Hamish Lindsay, 1969.

For the 50th anniversary of the Apollo 11 Lunar Landing, Engineering Heritage Canberra engaged in the widespread celebrations of the occasion. John Saxon and Mike Dinn were the engineer duty operators in direct contact with the astronauts via the Honeysuckle Creek operations console, and both are now retired in Canberra. Mike Dinn gave an informative and entertaining talk to an audience of Canberra Retired Engineers and Engineering Heritage, and John Saxon was interviewed for EH Canberra Oral History Program through a cooperative program with the Australian National University.

Honeysuckle Creek was opened in 1967 as a tracking Station designed specially to support the lunar phase of NASA's Apollo project for manned exploration of the moon.

Like its sister station Orroral[1], Honeysuckle Creek had a 26m antenna installed by Collins Radio from Texas. The main requirement at Honeysuckle was reliability coupled with sufficient sensitivity to handle communications with astronauts at the Moon to receive their television, backpack[2], biomedical, voice and other transmissions.

The Honeysuckle Creek Tracking Station played an integral role in all the eleven manned Apollo missions and particularly the Apollo 11 mission, providing the first historic pictures of man walking on the Moon on Monday, 21st July 1969. Apart from the telecast for television, Honeysuckle Creek had voice and telemetry contact with the command module in orbit around the moon, and particularly with the Lunar module on the lunar surface. Tidbinbilla[3] station also played a significant role in Apollo, as an extension to Honeysuckle.

Honeysuckle Creek Tracking Station with the Antenna and the Operations Building. Note the US and Australian flags outside the building. Photo: Courtesy Hamish Lindsay. Date not known.

During the Manned Spaceflight missions, Honeysuckle had the ability to watch many critical spacecraft details, to send commands and speak to the Astronauts if the communication lines to Houston had problems. Several voice contacts were made during Apollo with perhaps the most notable being with Apollo 16 Astronauts John Young and Charlie Duke on the Lunar Surface in 1972, where the Astronauts insisted on talking about a particular Australian beer! (see transcript next page)

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1 Orroral Valley Tracking Station is situated about 50km south of Canberra in the Australian Capital Territory (ACT) and not far from Honeysuckle Creek. It closed in 1985.

2 The astronaut's backpacks were their life support system, worn on the back of their spacesuits, and needing to be monitored by NASA while the astronauts were outside the space vehicle.

3 The Canberra Deep Space Communication Complex near Tidbinbilla in the ACT is about 20km from Canberra City.

50th Anniversary of the Apollo 11 Lunar Landing

In 1974 at the conclusion of the Apollo and Skylab and Manned Space Flight activities, Honeysuckle Creek was converted to become a part of NASA's deep space network using equipment from a station at Woomera which had been closed. When Honeysuckle closed in December 1981, the 26-metre antenna was relocated to the Canberra Deep Space Communications Complex, Tidbinbilla and renamed Deep Space Station 46 where it was used for high altitude Earth orbiting spacecraft.

Engineers Australia recognised the DSS46 antenna at Tidbinbilla, with a National Engineering Heritage Landmark Award on 20th July 2009, 40 years after the moon landing, jointly with CSIRO and NASA. See: https://portal.engineersaustralia.org.au/heritage/antenna-dss-46-1965

Doug Hargreaves of EA & Miriam Baltuck unveil the EA marker at Antenna DSS46 in its changed location, Tidbinbilla. Photo: Keith Baker.

CSIRO manages the Deep Space Complex under contract to NASA. Since the early 1960s NASA has also contracted the CSIRO radio telescopes to augment its network of tracking stations for particular missions. The first such occasion occurred in 1962, when CSIRO's 64 metre, telescope at Parkes, NSW was used to receive signals from the Mariner II spacecraft. Parkes' most prominent contribution to NASA's missions came in 1969, when it was used in conjunction with Honeysuckle Creek to receive television signals from the Apollo 11 Moon landing and relay them to a worldwide audience of 600 million.

Conversation between Apollo 16 Astronauts John Young and Charlie Duke on the Moon, and John Saxon at Honeysuckle Creek:

Saxon: "Orion, this is Honeysuckle. We have a [communications] outage with Houston at this time. Stand by one, please."

Young: "Okay, Honeysuckle - nice to talk to you. How are ya'll all doin' down there?"

Saxon: "We are doing great. Nice to talk to you. We will be with you shortly, we are just getting some lines configured for you."

Young: "Have a Swan for us."

Saxon: "Say, again, Orion. You are pretty poor quality on this back up."

Duke: "Honeysuckle, what John was saying was have a Swan for us."

Saxon: "Oh, Roger. We should get the lines restored very shortly for you. Sorry about the delay."

Young: "Okay - you guys are nice to talk to. We do not care about the delay."

Saxon: "Thanks very much. Certainly appreciate it. It's a pleasure working on this mission."

Young: "Roger. We would like to come down there and see you folks at Honeysuckle."

Saxon: "Right - you've got a permanent invite, anytime you like."

Young: "That's very kind."

Saxon: "We will keep the beer cool for you".[4]

Duke: "You have just got a couple of fellows ready to show up on your lawn. That's the best idea I've heard for a long time."

Saxon: "I think that's a pretty good one down here too."

Duke: "You see in my terminology that's certainly 48 packs. Right now that's how I feel - really love one."

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4 He kept the beer cool for some time! John Young attended the 25th anniversary of Apollo 11 celebrations at Canberra in 1994. See a photo at: https://www.hq.nasa.gov/alsj/a16/a16swan2.jpg

Honeysuckle Creek & the Moon Landings

It is Fifty Years since the Moon Landing and EHA has commemorated this momentous event and Australia's engineering and technical contribution to it. *by Judy Lindsay*
EHA Oral History

The 85 foot antenna at Honeysuckle Creek in operation during the lunar landing on 21st July 1969. Photo: supplied by Hamish Lindsay - see www.honeysucklecreek.net

There is little physical evidence left at Honeysuckle Creek near Canberra to remind us of the few minutes when it became the connection between the world and Neil Armstrong as he stepped onto the moon's surface. As the tangible evidence is further obscured by time and the elements, the intangible evidence of what occurred becomes even more important. In recognition of Honeysuckle Creek's role in receiving the first images of the 1969 lunar landing, EHA Canberra Division proposed an Engineering Heritage Marker for the antenna, as physical evidence of the engineering works, and it was granted in 2009.

To protect the memories of those involved in this event that stopped the world, EHA Canberra, with support from Australian National University (ANU) and their Masters Course in Oral History, have started the recording of oral histories as part of an ongoing program.

Mr John Saxon, Maintenance and Operations Supervisor at Honeysuckle Creek was interviewed by Susannah Churchill (ANU Masters student). I read the essay written about the interview and asked Ms Churchill if she would consider condensing it for our EHA magazine, to promote access to this important and very interesting piece of oral engineering history or intangible heritage. The interview, itself, and other EA Canberra Division oral history recordings can be accessed through the ACT Heritage Library – contact it via: http://www.library.act.gov.au/find/history/library

IMAGE at RIGHT: No dish stands at HSK today. The 85-foot antenna was moved to Tidbinbilla and has now been retired from active duty. Photo: Susannah Churchill 3/8/2019. Photo 50 years on, cleverly taken looking between the same rocks and trees and in the same direction as the one of the antenna above.

Making an Oral History of the Moon Landing *by Susannah Churchill*

2019 marks the fiftieth anniversary of the first manned lunar landing, with which Australia has a direct connection. Honeysuckle Creek Tracking Station (HSK) in the ACT's southern ranges was built by NASA especially for the Apollo missions, as it was close to Tidbinbilla, an established deep space tracking station.

When Neil Armstrong stepped out of the Lunar Module Honeysuckle's picture was much better than Goldstone's in California, which was upside-down. All the monitors were switched to Honeysuckle Creek's feed. It was therefore Honeysuckle Creek that relayed Armstrong's words,

"That's one small step for (a) man, one giant leap for Mankind."

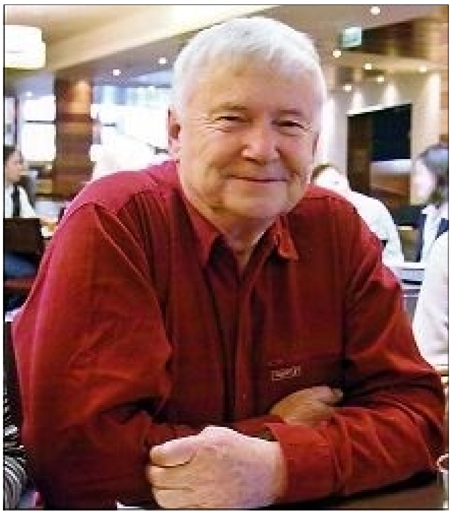
Commemoration of the site and the event has increased in the last decade. Although abandoned in 1981 and demolished in 1992 the concrete slabs and horticultural plantings remain. Commemorative plaques now explain the site and in 2016 the HSK site was inscribed onto the ACT Heritage Register. Engineers Australia is creating an Oral History archive of engineering involvement in the lunar landing, for which the author interviewed John Saxon, Maintenance and Operations Supervisor at HSK.

Making an Oral History of the Moon Landing

John Saxon at the Honeysuckle Creek Operations Console. No date is given, but it was probably during the Apollo missions around 1969. Photo: See https://www.honeysucklecreek.net/people/saxon.html

Oral History's strength is its immediacy. Vocal timbre and emotional reaction can bring an event closer. As following one instrument in an orchestral score makes it possible to appreciate the parts that other instruments are playing, hearing one person's role can help us to appreciate the wider scope of an event. One can feel the excitement in John's sentence: "Armstrong and Aldrin weren't going to have a snooze when they landed on the moon!"

Surprisingly, none of the workers at HSK knew then that it was their footage of the moon landing that the world saw for the first eight minutes. The movie *The Dish*, fosters the misconception that all the action was at Parkes. When John Saxon protested that "half of Australia thinks this is what happened now" the producers responded that it was a work of fiction, not a documentary. HSK staff have been diligently countering the misconceptions but it is an uphill battle. Hearing the disappointment in John Saxon's voice brings that home clearly.



John Saxon in Canberra in 1983.
Photo: source as the earlier photo above. .

An interesting tension has emerged regarding the value of a place and the collection of oral history – authenticity is easily attached to sites which are obviously 'old' yet oral history exists in much closer chronological proximity to an event or place. Perhaps the emerging field of intangible heritage accommodates Oral History more easily. West and Ansell note that Intangible Heritage reflects: *a holistic approach to heritage as something that is meaningful because of what people think and do* (2010:42.) Stewart and Kirby state that: *Space becomes place when a physical setting is enriched with human meanings.* (1998:40)

The Apollo 11 Moon Landing is a significant achievement, yet millions have been born since who haven't experienced the event first-hand, and the original structures of HSK no longer exist. Oral History has a critical part to play. The site can bring us so much in the way of history and imagination – Oral History adds experience, personal dimension and social value.

I wish to acknowledge here, John Saxon's generosity in granting me the interview, and the space to do, it in his very busy schedule. Susannah Churchill

References:

- Australia ICOMOS. 2000 *The Burra Charter: the Australia ICOMOS charter for places of cultural significance: with associated guidelinesand code on the ethics of co-existence*. Australia ICOMOS, Burwood.
- Saxon, John and Churchill, Susannah 2019 Oral History Interview, Canberra Australia.
- McHugh, Siobhan 2015 *The Affective Power of Sound: Oral History on Radio*. In Alistair Thomson and Robert Perks (eds), *The Oral History Reader*, Third Edition. Routledge Milton Park, Abingdon.
- Stewart, Emma & Kirby, Val, 1998 *Interpretive evaluation: Towards a place approach*, International Journal of Heritage Studies, Vol 4 No 1, pp 30-44.
- West, Susie & Ansell, Jacqueline, 2010, *A History of Heritage* in Susie West *Understanding Heritage in Practice*, Manchester University Press. Manchester UK: Chapter 1 pp7-41.
- Honeysuckle Creek tribute website www.honeysucklecreek.net
- ACT Gov't 2016 Heritage Listing for Honeysuckle Creek Tracking Station, see: https://www.legislation.act.gov.au/ni/2016-75

IMAGE at RIGHT: Decommissioned Deep Space Station 46 at Tidbinbilla.
Photo: 17 September 2014 by Mitch Ames on Wikimedia.

Wikimedia Caption: Originally built as 26 metre DSS-44 in 1967 and located at Honeysuckle Creek, it was moved in 1984 and reassigned DSS-46. It was decommissioned in late 2009. In May 2010 the American Institute of Aeronautics and Astronautics declared the antenna a Historical Aerospace Site, and the antenna remains in place.

Beirut to Tripoli Railway

By Bill Phippen, Australian Railway Historical Society NSW (ARHSnsw).

The Beirut (in Lebanon) to Tripoli (in Syria) Railway may seem an unusual topic for an Australian heritage magazine. The connection is however that it was built by a unit of the Australian Army, the Australian Railway Construction and Maintenance Group, (ARC&MG), led by an extraordinary engineer, Lieutenant Colonel Keith Fraser.

The Commanding Officer: Keith Aird Fraser.

The ARC&MG was led by a competent military officer with the rank of lieutenant-colonel, but he was also a man of great engineering skill with significant achievements behind him in Australia. Keith Fraser had served as a young lieutenant in the Great War in Europe, returning to Australia to become Resident Engineer on the construction of the Sydney City Railway for ten years from 1922.

Fraser held other engineering roles in the New South Wales Government Railways (NSWGR) until he was briefly responsible for the work of replacing the Hawkesbury River Bridge before war intervened in his career again. In 1943 he was demobilised to return to the bridge which was finally opened in July 1946. Fraser was sent on a study tour to the United Kingdom and America, clearly being groomed for greater roles in the NSWGR. In 1950 he became Chief Civil Engineer on the death of Albert Fewtrell, and in early 1952 Fraser became NSW Commissioner for Railways. His time in this role was brief for he died suddenly in August of the same year.

Keith Aird Fraser at his desk in Sydney c1950.
Source - ARHSnsw

The Need for a Railway

The Middle East was a bitterly fought theatre of the Second World War. Australians well know the place names Tobruk and El Alamein and of the battle against Erwin Rommel's Afrika Korps fought by Australian divisions. The important supply base for these operations was Egypt.

Syria and Lebanon (then part of French Syria) were French mandated territories between the Great Wars, and the fall of France in 1940 led Syria to ally itself with the Petain (Vichy French) government, which had made peace with Germany after it invaded France. To the north of Syria, Turkey remained neutral. The Vichy French Syrian government co-operated with Germany by opening its airfields to German forces, and allowing the passage of supplies. The Germans took advantage of this opportunity by attacking British troops in Iraq. Churchill, aware of the threat, and influenced by Free French leaders who wanted their army to invade Syria, *insisted that Wavell, then C-in-C Middle East, send a force to accompany the Free French into Syria . . . The largest formation Wavell had available for new operations was the 7th Australian Division.*[1]

The invasion of Syria started on the 8th of June. It was led by the 7th Division (complete except for its 18th Brigade which stayed in Egypt) accompanied by six battalions of Free French and part of the British Cavalry Division. The 7th Div. 21st Brigade drove up the coast, the 25th Brigade took an inland route towards Merdjayoun and Damour, and the Free French moved on the right flank, further inland towards Damascus. The fighting was memorably hard, and fast, and it was all over by the 12th July after the Vichy French sought an armistice.

The 7th Division continued its march north, up the coast, setting up garrisons along the way as far as Tripoli, where many of the 7th Div. men stayed until January 1942. With Syria occupied by Allied troops, the British wished to encourage Turkey to join the war on the Allied side, and thus needed a capability to supply them. An existing railway of differing gauges with very steep rack sections was inadequate to the task.

IMAGE at LEFT:
12th June 1941 – Near Khiam on the way to Merdjayoun in the Lebanon.
Members of C Company 2/33rd Battalion (part of 25th Brigade) loading up a donkey with rations and ammunition. The donkey will take the load up the mountain to the rest of the company who were occupying a strategic position overlooking one of the mountain roads to Merdjayoun. Source: AWM 008205 – Photo by Damien Parer.

1 Mark Johnston, *The Silent 7th, An illustrated History of the 7th Australian Division 1940-46*. Pub. Allen & Unwin, 2005.

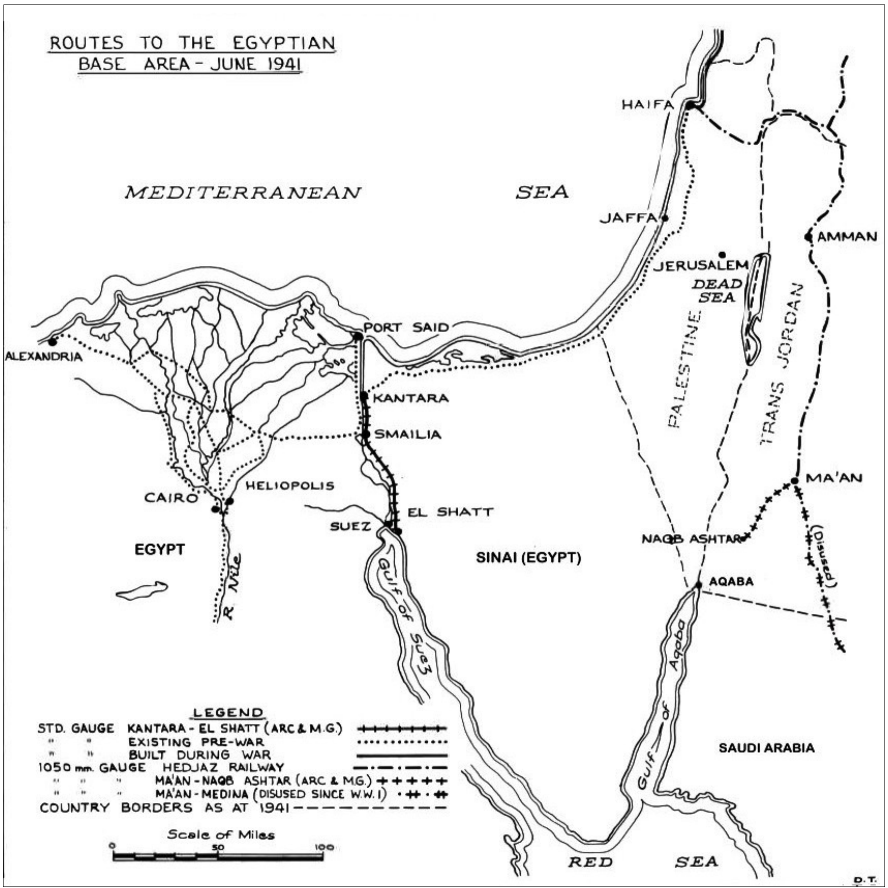
Beirut to Tripoli Railway

The decision was made to build a 213 km long, high quality, standard-gauge railway along the Mediterranean coast connecting the cities of Haifa, in Palestine and Tripoli, in Lebanon, and a significant section was allocated to the Australian Railway Construction and Maintenance Group. (ARC&MG). This unit had been formed in Australia in April 1940, with a view to operating railways behind the front in France, as had been done by Australian companies in the Great War. Before the ARC&MG could reach Europe, France had capitulated and there was no front. The unit spent some months in the United Kingdom building sidings and so on at depots and other places. The ARC&MG arrived in the Middle East in early 1941 where they built several important rail links – relatively easy tasks compared to their later work.

First ARC&MG Works in the Middle East

The Suez Canal, with its southern terminus at Suez was vital to the supply of material and men to the war, but the canal was blocked by German marine mines dropped from aircraft. Supplies came from the UK via the Cape of Good Hope and from Australia, South Africa and India through the Red Sea to Suez. To circumvent the blocked canal a standard-gauge railway was built from El Shatt, close to Suez, along the east bank to a junction with the Trans-Sinai Railway at Kantara. A railway already existed on the west bank, so this new railway was amplification and insurance. This work was relatively simple, the topography being flat, the ground sand and the 70-miles were completed in three months. One surprising design constraint was that the route could not be straight, as it could easily have been, but rather meandered unnecessarily from an engineering standpoint, to avoid the possibility of enemy aircraft flying along it to strafe and bomb.

Eighteen men who worked on the Trans Jordan Railway with the ARC&MG. The sign reads 'Ma'an to Naqb Ashtar Railway, Trans Jordan, 1st Nov 1941'.
Source - AWM P03459.003

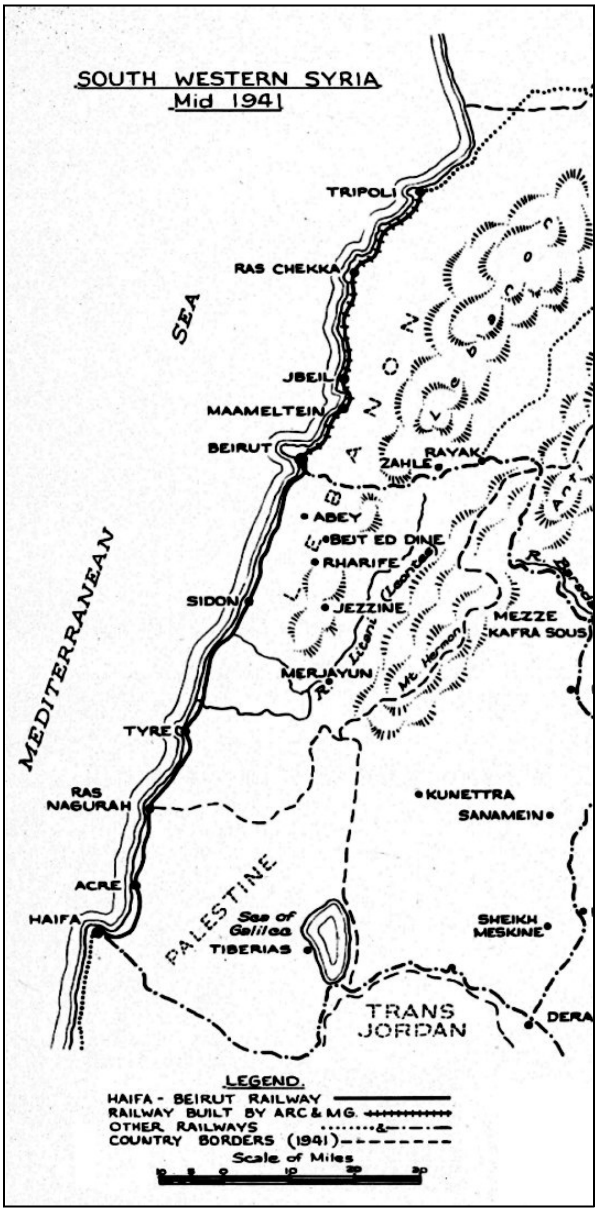


A more difficult but short line was built from Ma'an on the Hedjaz Railway, the famed target of Lawrence of Arabia in the Great War, to Naqb Ashtar in Trans-Jordan. The aim was to connect the Hedjaz railway to the port of Aqaba and thus create a second supply route to Syria. Ma'an is at an elevation of 1050m, but between there and Aqaba, only 50 km away, is the 1600m Ras en Naqb Range with a steep scarp on the Aqaba side. Building a railway down this scarp was deemed impossible in the time frame envisaged, so the Australians were asked to build a line to Naqb Ashtar above the scarp, while the steep mountain road from there to Aqaba was improved. This was no re-run of the Suez line as the ground was rugged, earthworks heavy and the rock hard.

Rail was recovered from the Hedjaz railway south of Ma'an, never restored since the destructive efforts of Lawrence. The railway was completed by February 1942, though by that stage nearly all the Australians had been withdrawn to work on the Beirut to Tripoli route.

IMAGE ABOVE: This map shows the first two railways built by the ARC&MG unit in the Middle East in 1941. These railways were the Kantara to El Shatt railway built along the Suez Canal and the Ma'an to Naqb Ashtar railway, built to improve access from the Hejaz railway to Aqaba on the Gulf of Aqaba. Haifa in Palestine at the top of the map is the starting point of the railway from Haifa north to Tripoli, via Beirut.
Source - John Knowles in the ARHSnsw Bulletin, 1978. Map drawn by David Taylor

The Haifa to Tripoli Railway – Maps

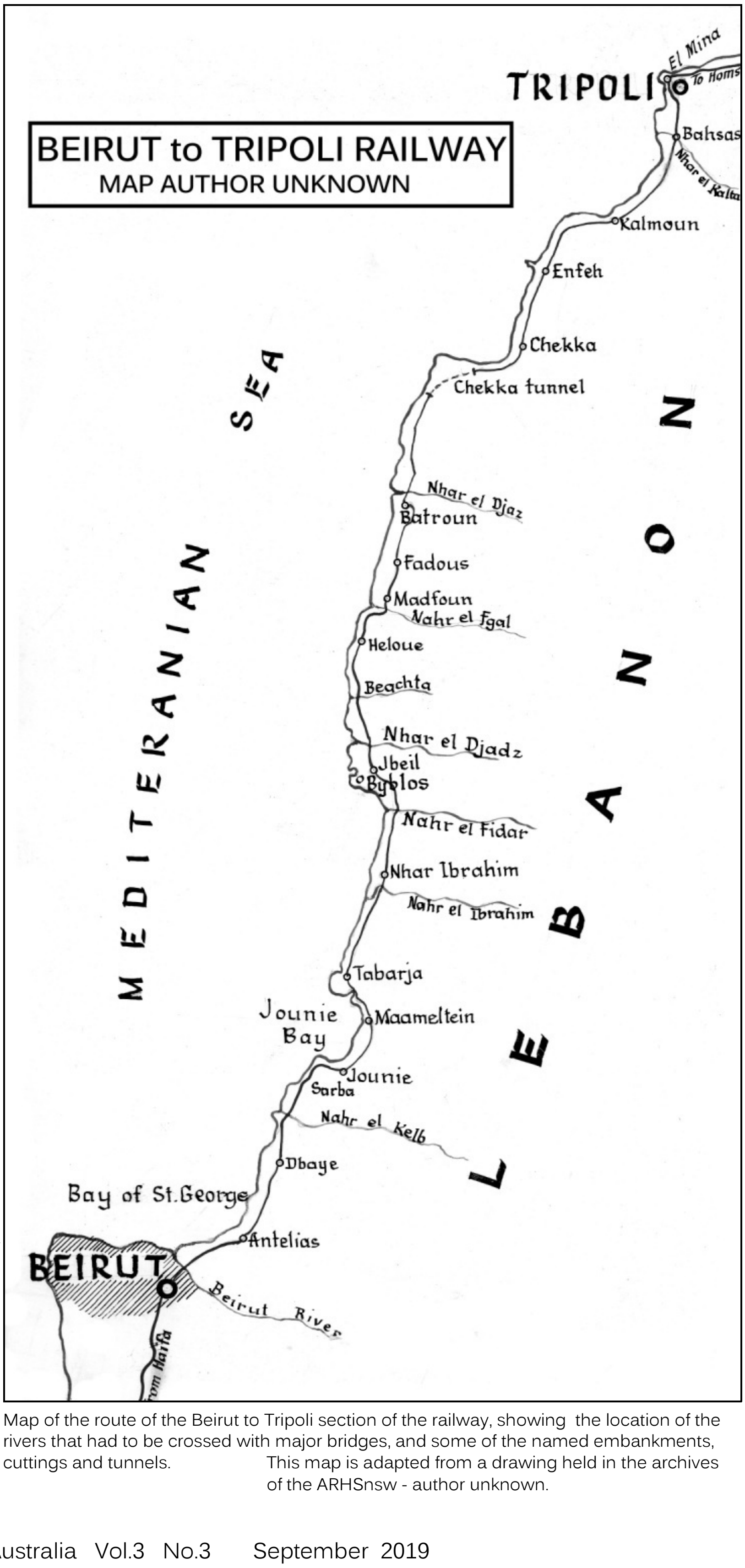


Map shows the coastal route of the Haifa to Tripoli Railway, with the Beirut to Tripoli section built by the ARC&MG unit shown with a crossed line. Extract from a map drawn by David Taylor.

Several routes were considered for the connection between the Egyptian and Syrian standard-gauge networks. The shortest of these, via the Jordan Valley to Rayak, was through hard basalt country with deep canyons, and required a descent to 700 feet (210m) below sea level and a climb to 3,300 feet (1000m) above sea level. There was little road access to the area for construction purposes and the conclusion reached was that it could never be completed in time to meet the strategic objectives driving the project.

A second route following the Litani Valley was surveyed, but only after the Vichy French government of Syria capitulated. It also could not be built in the time available because of the heavy earthworks in the valley, many bridges and the lack of road access.

The coastal route chosen, though longer and certainly not easy to construct, was through limestone country and had an existing road generally parallel with it. There was also some preliminary planning of the route by the French. This line would also serve Beirut, and pass the cement works at Chekka and that was a distinct advantage as much concrete was used in foundations, retaining walls and bridge piers.



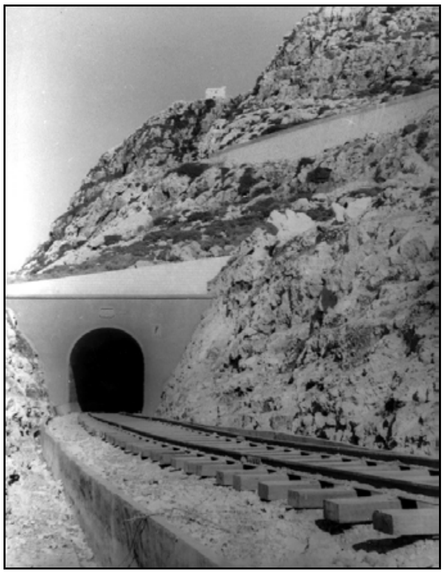
Map of the route of the Beirut to Tripoli section of the railway, showing the location of the rivers that had to be crossed with major bridges, and some of the named embankments, cuttings and tunnels. This map is adapted from a drawing held in the archives of the ARHSnsw - author unknown.

Beirut to Tripoli Railway

The Lebanese mountains come down to the sea in many places, and the streams flowing down from those mountains are substantial, especially in the wetter winter period. There would have to be large cuttings, embankments, long tunnels and high bridges.

The section of the line from Acre to chainage 137.6km, just south of Beirut, was allocated to the South African Engineering Corps and from that point to Tripoli, at 229.4km, was the allotted task of the ARC&MG. The expected duration of the project set by the British War Office was 18 months. Perhaps the major constraint was the Lebanon Range where it met the sea at Chekka headland. Even though the existing road used a tunnel, the Australian Survey Section tried for a surface route, but could not create one, so a tunnel was accepted.

Personnel for the construction, apart from the 1,000 men of ARC&MG itself, consisted of 2100 men in South African labour battalions and up to 8,000 locals – men, women and children. The South Africans were Swazis, Basutos and Bechuanas who were proud warriors, joining the army to fight, not move dirt. They liked military drill more than earthmoving, so at one stage when Fraser needed an embankment compacted he had them march at the double back and forth, achieving quite acceptable results.



The south portal of the Chekka Headland Tunnel. The tunnel was cut by South African army engineers and their men, and completed in August 1942.

photo: ARHSnsw

Beirut to Tripoli Railway – the Bridges

In the section built by the Australians there are ten bridges, all of steel girders or trusses supported on stone faced concrete piers. Foundations are on exposed rock or below scour level in gravel, placed by open caisson methods.

Because timber for formwork and scaffolding was in scarce supply, the retaining walls of abutments and the bridge piers were built with limestone blocks carefully laid as a face and this contained the concrete as it was poured. The concrete then formed the working platform for the next flight of stone facing. The local masons who did the work were skilled and committed to their trade and often incorporated different coloured stones architecturally. Of particular note is the carving into stones high on bridge piers of the Australian military insignia.

Nahr El Beirut Bridge:

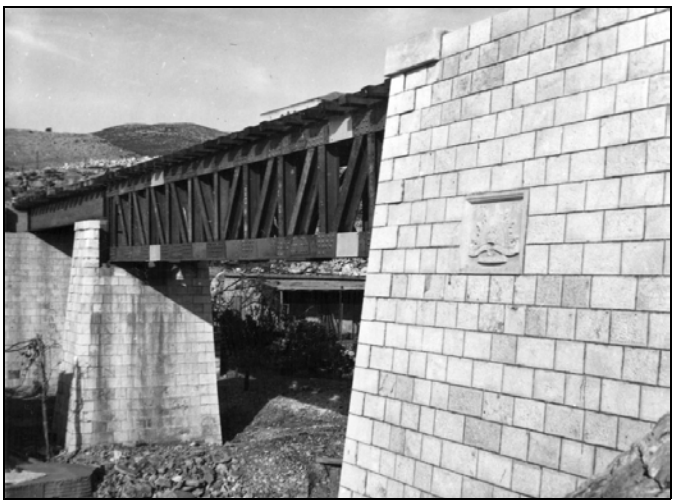
3 x 100ft (30m) lattice girders, sourced from South Africa. The superstructure, with relatively low height concrete piers, was erected on falsework.

The Beirut River Bridge – photo - J.W. Knowles, 1965. The photo has been trimmed for this Magazine and a caption by Ross Gordon removed.

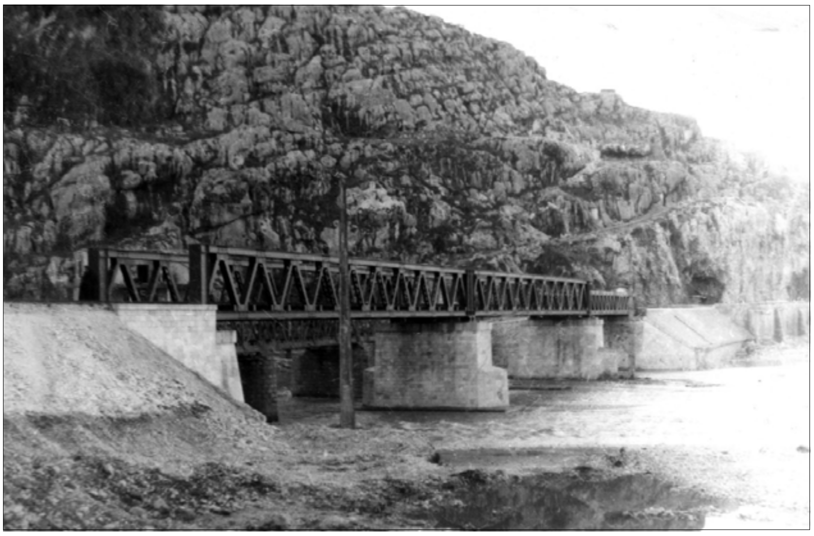
Maameltein Creek Bridge: IMAGE at RIGHT

Descriptions of this bridge specify a 1 x 60ft (18m) Unit Construction Railway Bridge (UCRB) and a 1 x 36ft (11m) concrete slab, but this and other photographs suggest the smaller span is a plate web girder. A UCRB is a rivetted Pratt truss designed for ready assembly in the field to varying spans.

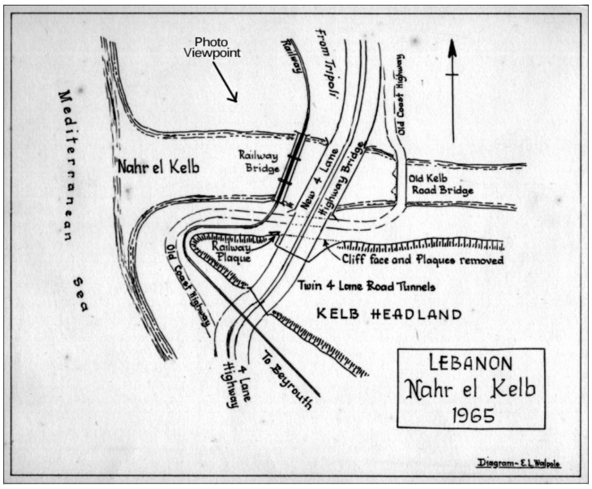
Note the high-quality masonry of the abutment and the elegantly carved rising sun badge of the Australian Army. The lettering on the WW2 badge says "Australian Commonwealth Military Forces".



Nahr El Kelb – the Dog River Bridge: 2 x 100ft (30m) Warren Trusses, 1 x 70ft (21m) UCRB erected on falsework.



Nahr El Kelb (Dog River) Bridge shown soon after its completion. Photo E.L. Walpole.



This 1965 diagram by E.L.Walpole was drawn to show the location of the twin tunnel, 4-lane highway driven through the El Kelb headland years after the Nahr El Kelb bridge was built. The drawing has been adapted to show the viewpoint of the original photo (at left). The December 1942 opening ceremony for the railway took place close to the cliff face beyond the bridge (see later photos).

Nahr El Ibrahim Bridge:

This was intended to be 1 x 100ft (30m) lattice girder and 1 x 70ft (21m) lattice girder supplied from South Africa. The shorter span was lost at sea and a UCRB substituted. Thus, the two girders at the site do not match. Interesting also is that the bridge was assembled on falsework, which was swept away in a flood the day after the bridge became self-supporting.

IMAGE at RIGHT:
This photo came from the Australian War Memorial, with the caption: The Lebanon. 1942-12-19. The Bridge At Nahr El Ibrahim built by the Australian Railway Construction and Maintenance Group when constructing the railway line between Beirut and Tripoli.

Nahr El Fidar Bridge:

The piers on this bridge are 62ft (19m) high, so all four spans were launched from the north approach embankment, falsework being impractical. As this was one of the later-constructed bridges on the route, all the spans were tied end to end and launched together, after the learning experience at Nahr El Djadz noted below (see next page). The bridge is comprised of 4 x 75ft (22.5m) UCRBs. It is also one of the best documented constructions in terms of photographs.

Nahr El Fidar Bridge under construction. The four spans of the bridge have reached the third pier. At the front the light launching nose extends to reach the next support (the south abutment) before too much of the weight of the girder proper has cantilevered beyond the last support. When all the spans are in place, they will be lowered to their seats on the piers and abutments, one by one.. Photo: ARHSnsw.

Nahr El Djadz (No. 1) Bridge:

This was also a high bridge comprised of 3 x 80ft (24m) UCRB and was the first erected by launching from the approach. A single span was placed, but the difficulty arose that the launching nose, projecting beyond the pier had to be dismantled in mid-air, using a flying fox. The second and third spans were launched together and thus the launching nose was on the other approach embankment when it needed to be dismantled. Subsequent bridges built by this method had all spans launched together, Like Nahr El Fidar, above.

Nahr El Djadz - Image 1: The first span on wheeled trucks is ready for pulling forward. Note the light weight launching nose and the ballast, of spare rail, at the rear to ensure that the nose reaches the next pier before the whole lot tips over. Photo: ARHSnsw

Nahr El Djadz - Image 2: The limitation of launching a single span was that the launching nose then extended out of reach. It had to be dismantled for the next use, piece by piece, high in the air using a block and tackle extending from the lowering gantry. Photo: ARHSnsw.

IMAGE at RIGHT
Nahr El Djadz Image 3:
Each section of the nose was lowered before the whole assembly could be moved forward again. Note the use of the tackle on the cantilever from the lowering gantry and another tackle on a flying fox. The pier has a carved panel with the AIF badge on the east side, facing the old roadway. Photo: ARHSnsw.

Nahr El Djadz - Image 4: The nose has gone, the cribs have been removed and the first (south) span has been lowered into its final position. Photo: ARHSnsw.

Nahr El Djadz - Image 5: The second and third spans, rigidly connected as one, are launched together, wheeled across the first span and hauled by a cable attached to the launching nose. Photo: ARHSnsw. .

IMAGE at LEFT
Nahr El Djadz - Image 6: The bridge completed, and carrying traffic – 3 x 80 feet spans of UCRBs. The height of the rails above ground over one of the piers was 98 feet (about 30m). The bridge is photographed from the west looking inland, with the road bridge in the background. Photo: E.L.Walpole in Eakins IEAust 1951 text.

Nahr El Djadz (No. 2) Bridge:

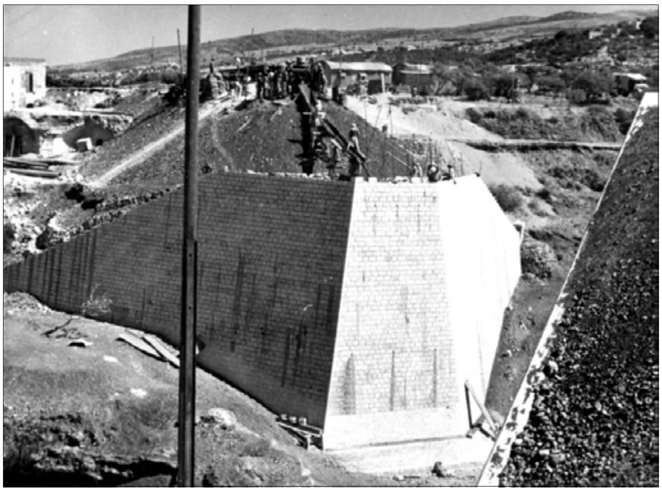
This bridge, further comprises 2 x 44ft (13m) deck girders, sourced from India. Knowles description of this bridge suggests that it was 'launched across trestles', but no photographs have been located to clarify what this means.

Beirut to Tripoli Railway – the Bridges

Nahr El Fgal Bridge: This high bridge, 69 ft (21m) is a single 80ft (24m) UCRB span.

IMAGES: Although this bridge is much shorter than others shown here, there is a series of photos showing the sequence of construction of typical abutments.

Nahr El Fgal - Image 1: The massive retaining walls of the high abutments. The stone facing acts as formwork for 2,000 tons of reinforced concrete behind. The abutment at left is almost completed. Across the ravine, two mixers feed wet concrete into chutes, filling up behind the masonry.. Photo: ARHSnsw.

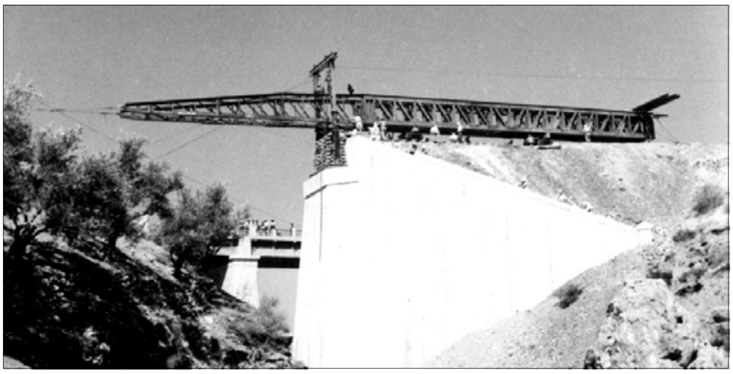


Nahr El Fgal - Image 2: The high abutment rises. Engineering design may have been Australian, but the wonderful masonry was Lebanese. One chute has been dismantled - the other is still operating. Photo: ARHSnsw

Nhar El Fgal - Image 3: The ARC&MG was well equipped - eventually. Here a bulldozer backfills behind the abutment. Photo: ARHSnsw.

Nhar El Fgal - Image 4: The stone and concrete abutments are complete. The lowering gantries and the cribs are in place. The truss is assembled on the track bed, with its launching nose, ready to launch. Photo: ARHSnsw.

Nhar El Fgal - Image 5: A mobile crane places steel rail as ballast to balance the span until the nose reaches the other abutment. Photo: ARHSnsw



Nhar El Fgal - Image 6: The launch under way. Note the towing cable to the left. Local Lebanese watch from the adjacent road bridge. Photo: ARHSnsw.

IMAGE at LEFT
Nhar El Fgal - Image 7: The UCRB has been towed across, the launching nose removed and the truss lowered into its final position. A mobile crane is removing the gantries used for lowering the truss. Photo: ARHSnsw.

There were no photographs for the other two bridges listed:

Nahr El Asfour: 1 x 40ft (12m) Plate web girder.

Nahr El Kalta: 1 x 40ft (12m) Plate web girder.

The Ras el Chekka and Ras Bayada tunnels

The Chekka Tunnel, is 4,800 feet (1.5km) long. For its construction miners were recruited, as the 61st South African Tunnelling Company, from the deep hard-rock mines of the Rand. The choice of the coastal route over the inland ones had been partly based on the rock conditions and the limestone at Chekka was perhaps close to an ideal material to work. The tunnel, which was generally self-supporting, was only concrete lined in parts, and although the South Africans mined the tunnel, the Australians lined it where required. Track through the tunnel was also part of the work of the ARC&MG. The tunnel was completed in eight months, working around-the-clock from five faces, using two adits driven in from the cliff facing the Mediterranean Sea. Excellent film (by Frank Hurley) of the tunnel work may be seen in the Australian War Memorial Archives at:
https://www.awm.gov.au/collection/C188825

A second tunnel, shorter at 900ft (270m) was also built near Chekka by the South Africans once they had finished the longer tunnel. They then returned to the Haifa – Beirut section to build a 1,000 ft (300m) tunnel to improve the route at Ras Bayada.

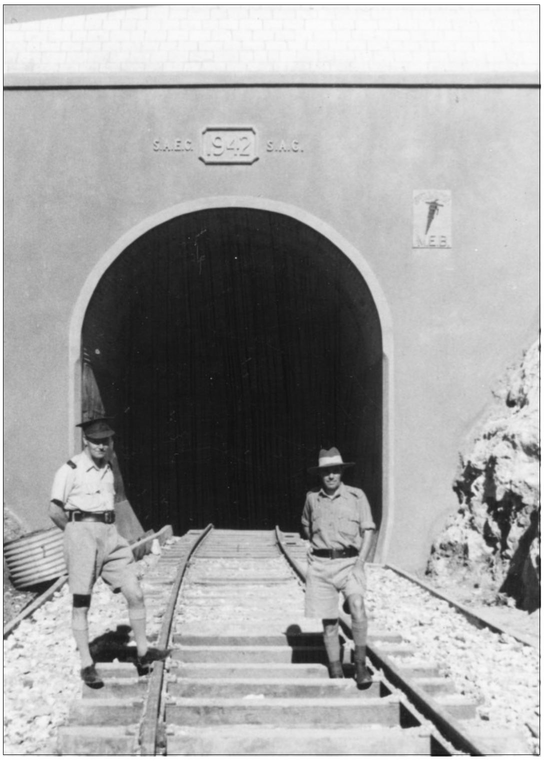


IMAGE at RIGHT
Ras El Chekka Tunnel: An Australian and a South African officer stand at the south portal of the Chekka tunnel. Photo: ARHSnsw.

Beirut to Tripoli Railway – Earthworks

Obviously, in the rugged terrain, crossing headland after headland separated by rivers in deep valleys, the earthworks were considerable. Nearly a million cubic yards (¾ million m³) were excavated, of which about two-thirds were sand and soil and one-third rock. 40,000 cubic yards (30,000m³) of concrete were used and 21,000 square yards (19,000m²) of masonry walls. The largest cutting is at Maameltein where 35,000 cubic yards (27,000m³) were moved into the adjacent fill for both the railway and a deviated road. This embankment occupied around-the-clock shifts for six months.

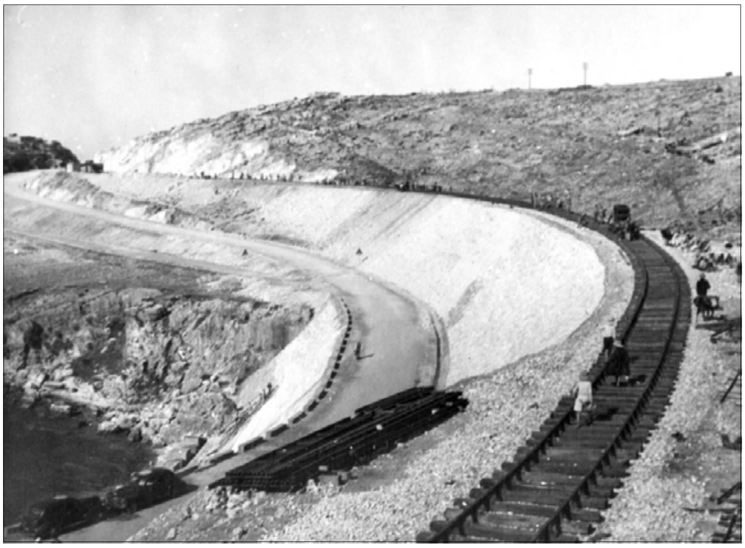


IMAGE ABOVE: The embankment at Maameltein viewed from track level. The task was made greater by the need to deviate the road. Photo: ARHSnsw.

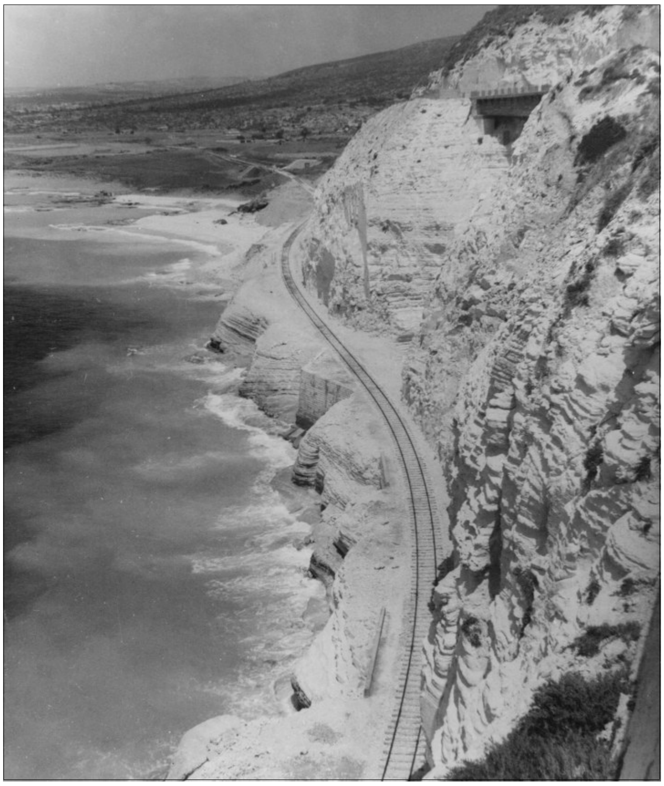


IMAGE at RIGHT: The line occupied a narrow shelf as it traversed some headlands. The road can be seen high above the railway at right. Looking from south to north, the railway extends into a valley beyond the headland, with a small bridge, seemingly under construction in the distance. Photo: ARHSnsw.

Some images of the People who built the Railway.

IMAGE ABOVE: The soldiers of the ARC&MG surveyed and managed the work. No indication of where these men are, but they are possibly above the adit to a tunnel. Photo: ARHSnsw.

IMAGE at RIGHT: A group on an abutment watching a truss of a Nahr El Fidar Bridge span being lowered with chain blocks to its final position. Photo: ARHSnsw.

2,100 South African soldiers in labour battalions worked with the Australians. Photo: ARHSnsw.

South Africans laying tracks north of Maameltein. Photo: ARHSnsw.

South Africans loading the concrete mixer with coarse aggregate supplied in baskets. This is probably the Nahr El Fgal bridge. Photo: ARHSnsw.

Carving Australian Rising Sun Plaques for bridge piers.
At right is Brother Natamuk an altar sculptor from the Maronite church at Byblos and two assistants.
Bro. Natamuk selected the stone from the nearby mountains, and our railway draughtsmen made templates for the sculptors' guidance.
The accuracy and gleaming finish of the plaques is a trubute to these Lebanese craftsmen.
The largest plaques were approx. 4 ft. x 3 ft.

Track ballast was obtained by our machines, and local piece-work. Here, gang of Bedouin women also assist in gathering and carrying stone from adjacent olive groves, while an Arab Rias (ganger) supervises.

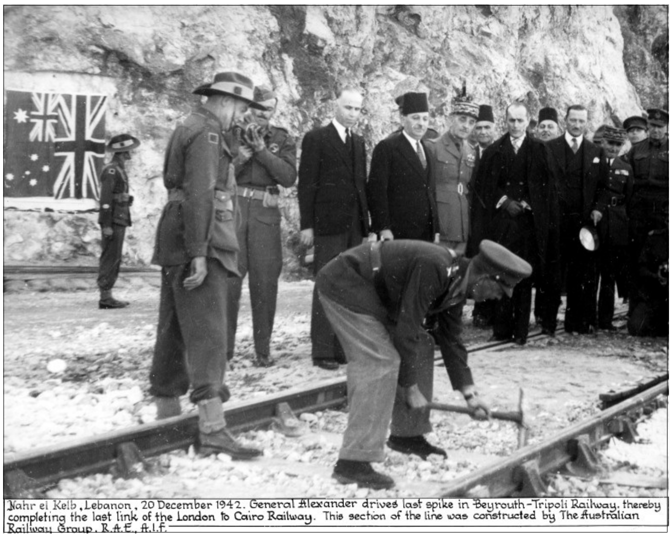
IMAGES - LEFT & ABOVE: The captions to these two ARHSnsw photographs were written by Ross Gordon, later Chief Civil Engineer of the NSW Railways.

Beirut to Tripoli Railway – The Opening Ceremony

With Lt.Col.K.A.Fraser, Gen. Alexander inspects guard

The line was completed six months ahead of the 18-month schedule requested by the British War Office. A large ceremony was arranged at Nahr El Kelb headland on 20 December 1942 when General Harold Alexander, the British Commander in the Middle East, drove the last spike and unveiled a plaque. This place was chosen probably because of the presence of other inscriptions nearby, including one left by Pharaoh Rameses II in 1300 BC! Other noteworthy sites on the route are St Georges Bay, the place where St George slew the dragon, and the Nahr El Ibrahim, the river which each February runs red with the blood of Adonis, though others say the colouration is from minerals in the grotto which is its source. The town of Byblos, through which the line passes has been occupied for 50 centuries. Film of the opening may be seen at:

https://www.awm.gov.au/collection/C190145



Nahr el Kelb, Lebanon, 20 December 1942. General Alexander drives last spike in Beyrouth-Tripoli Railway, thereby completing the last link of the London to Cairo Railway. This section of the line was constructed by The Australian Railway Group, R.A.E., A.I.F.

These three photographs (LEFT & ABOVE) show aspects of the formal opening ceremony on 20th December 1942. At top, General Alexander inspects the guard with Fraser behind him. With Fraser looking on, at left Alexander drives the last spike and above he questions an Australian sapper. All photos from ARHSnsw.

Recognition for Keith Fraser

For his efforts on the railways, Fraser was first Mentioned in Despatches and then in 1943 awarded an OBE (Order of the British Empire). The citation for that decoration (partly quoted below) best summarises his role.

> *During the period under review his unit has been specially employed on the Haifa-Tripoli railway project. Col. Fraser was almost solely responsible for the survey, layout and supervision of construction. His expert knowledge, initiative, resource and drive have succeeded in overcoming the inherent difficulties of the task. His handling of equipment problems, and of labour (native and civilian in addition to his own unit) has been so capably performed that he has succeeded in bringing his section of the work almost to a stage of completion in a remarkably short period. He is an officer of outstanding merit, who has carried out his duties at all times with exceptional ability and whose quiet confidence impresses all members of his own and other units.*

The railway still exists but has fallen victim to the troubles in that part of the world. There are proposals from time to time to rehabilitate and re-open it.

References:

Those wishing to know more about the railway construction can access a 1951 paper by DH Eakins, re-published in the Royal Engineers Jnl in 1952, see:
https://arhsnsw.com.au/wp-content/uploads/2019/06/Royal-Engineers-Journal-June-1952.pdf
and an article by John Knowles in an ARHS Bulletin in 1978 at:
https://arhsnsw.com.au/wp-content/uploads/2019/06/Knowles-Beirut-to-Tripoli.pdf
A much more extensive album of photos than is included in either of these documents was assembled by E.R. (Ross) Gordon, who also worked on the construction, and who later went on to a career in the NSW Railways, ultimately as Chief Civil Engineer. This album, now held by ARHSnsw, is the basis of this article.

IMAGE at RIGHT: The plaque that was unveiled in 1942, photographed circa 1965.
In the lettering on the plaque, Beirut is spelled in the French manner. The Carving above the text is the ARC&MG badge of a howling dingo standing on a boomerang. Photo: ARHSnsw.

On the Beirut to Tripoli Railway – the first 98 foot (about 30m) high pier of the Nahr el Djadz (No.1) bridge has been completed. A group of men on the top are installing the "piece de resistance" of the pier – a carved stone AIF rising sun badge – to be seen by passers by from the road bridge to the east, where the photographer is probably standing. To the west is the dry river bed and the Mediterranean Sea beyond. Photo: Australian Railway Historical Society NSW.