8.11 Non-Ferrous Metals

a. sources & uses
b. alloys
c. the zinc market
d. zinc sheeting
e. zinc tiles
f. other zinc products
g. tin
h. local production
i. aluminium

a. sources & uses

The uses of non-ferrous metals in building are pervasive, but generally inconspicuous. They have a traditional role in roofing, especially for flat areas and irregular shapes, while in the twentieth century bronze and aluminium have been prominent in window frames and curtain walls. But otherwise these materials are mainly ancillary or invisible, as in the galvanising of iron elements, in pipes, wires and electrical components, and as constituents in paints. Lead was probably the most extensively used, for roofing and general plumbing. One country house in the 1860s used 2¼ tonnes of the metal.[1]

These goods were nearly all imported, and even the first hospital in Sydney, imported from Britain in 1790, was roofed in copper.[2] However copper was mined in South Australia and New South Wales from the 1840s. Copper ore from the Kanmantoo mines; Lyndoch Valley; the Burra Burra Mines (where over a thousand people were employed); and Baker's lode at Tangkillo Reedy Creek, was shown at the Great Exhibition of 1851 by, respectively, the South Australian Company, the Barossa Range Mining Company of Coode, Browne & Co; Graham & Hallett; and J A Joseph of Bayswater, London.[3] Both ore and copper products were exhibited by Hatmel & Ellis of Manchester.[4] Nearly all the ore so far had been smelted at Swansea, Wales, but a local smelter was now being constructed.[5] By 1850 some

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1 J H Stanton, 'Diary kept by J H Stanton, Clerk of Works for the Erection of Mansion, Out Houses and Woolshed, Daniel Toomey Esqe Proprietor, Messrs Reed & Barnes Architects, Site of Building Mount Rouse, Penshurst' (Mount Rouse [Victoria] 1867-9), State Library of Victoria, MS 7057, box 397/2, copy of letter, Broadbent & Co to Reed & Barnes, 25 November 1868.

2 Robert Irving, 'The First Australian Architecture' (MArch, University of New South Wales, Sydney 1975), p 487, and Peter Bridges, *Foundations of Identity* (Sydney 1995), p 16, quoting Colonial Office 201/4, f 60 (meaning Colonial Office series 201 at the Public Record Office, London: despatches from New South Wales, book or box 1, folio or page 60).

3 Great Exhibition of the Works of Industry of all Nations, 1851, *Official Descriptive and Illustrated Catalogue* (3 vols, London 1851), II, pp 991-2.

4 Great Exhibition, *Catalogue*, I, p 187.

5 Great Exhibition, *Catalogue*, II p 991.

copper had been obtained in New Zealand,[6] and James Smith discovered copper in Tasmania,[7] though it was not exploited. The major local use of copper continued to be in roofing, as in the dome of the Custom House, Brisbane, of 1886-9.[8] H D Annear's Macgeorge house at Alphington, Melbourne, had a roof of copper when built in 1910, but it was donated to the war effort during World War I,[9] a fate which may well have been shared by other examples. There was a revival of copper roofing in 1950s, led by the great dome of Roy Grounds's Academy of Science building in Canberra. In Melbourne the roof of the Shrine of Remembrance was sheathed in copper on Grounds's advice, with disastrous aesthetic effect, and the State Library dome was similarly sealed, skylights and all - an offence which was to be reversed some decades later. By this time copper was also being used as a dampcourse, as discussed elsewhere.

Lead was mined in South Australia from the 1840s.[10], and in New South Wales by 1870,[11] but the local products rarely found their way directly into local buildings, and most were in any case used in the form of alloys. By the early twentieth century Australia was exporting substantial quantities of lead to Britain, and importing quantities of processed lead products in return. So far as white lead for paints was concerned, this cycle was broken by the establishment of BALM Paints in 1916, as will be discussed below. Tin was mined briefly in Victoria in the later 1850. Only zinc was really prominent as a building material in the nineteenth century, and this was not extracted in Australia at all. In the twentieth century aluminium began to become important before World War II, and was similarly imported, but local production was initiated at a later date.

A variety of non-ferrous metals and alloys - including zinc, aluminium, brass, copper, lead, iron, and bronze - could be applied as coatings in the form of a molten spray, using the Schoop process. Its most common application was in the coating of iron with zinc, which is a form of galvanizing, and it will be discussed in that context.

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6 This was on the island of Kawau, where it was reported that 105 tonnes of copper ore had been shipped for Sydney on the *Sussex*, from Whitaker & Heales's mine, and 160 tonnes on the *Joseph*, from the Kawau Company: *Hobart Town Gazette*, 3 November 1849, p 4.

7 James Fenton, *Bush Life in Tasmania Fifty Years Ago* (London 1891), pp 167-8.

8 Harriet Edquist, *Harold Desbrowe-Annear: a Life in Architecture* (Melbourne 2004), p 74, ref Bryce Raworth, 'The Macgeorge House: 25 Riversdale Road Ivanhoe, report prepared for the Heritage Committee' (Melbourne 1988), p 6.

9 Australian Heritage Commission, *The Heritage of Australia* (Melbourne 1981), p 4/16.

10 Galena, a silver-lead ore, was discovered at Glen Osmond in 1839, mined there from 1841 at what became Wheal Gawler, and smelted by the Messrs Penny on adjoining land. Then an outstanding deposit of galena was discovered at Wheal Watkins and mined from 1844. Copper was discovered at Kapunda in 1842 and mined from 1844, and at Burra from 1845. J W Bull, *Early Experiences of Life in South Australia, and an Extended Colonial History* (London 1884), pp, pp 139-140; Oswald Pryor, *Australia's Little Cornwall* (Adelaide 1969 [1962]), pp 18-20; Douglas Pike, *Paradise of Dissent* (Melbourne 1967 [1957]), pp 301-2.

11 The Wolgarlo Lead Mining Company exhibited in 1870 what was claimed to be the first lead produced in the colony, from Wolgarlo, near Yass, but by this time B H Dods was also able to exhibit samples from Bombala. *The Industrial Progress of New South Wales* (Sydney 1871), p 78.

b. alloys

The role of alloys generally is little recorded. By 1908 various alloys were used to encase timber sections used in the construction of shop windows - bronze, brass, nickel, and copper itself, as well as 'brass metal boards' for the foot of these windows.[12] But alloys had been used for roofing, sheathing and ornamental purposes long before this.

In the case of muntz metal, an alloy of 60% copper and 40% zinc[13] patented in England in 1832, apparently by George Frederick Muntz, although others had previously developed similar combinations of copper and zinc,[14] broadly described as 'yellow metal', and had applied them to similar purposes. The first evidence in Australia is an advertisement for the sale of eight cases of the metal in Hobart on 1849,[15] and this was followed by an advertisement by Lane & Co of Sydney in 1850, where reference was made to its use for metal sheathing and bolts.[16] At the Sydney Exhibition of 1879, Muntz's Metal Company, through the London joint agents Charles Moss & Co and Young, Dawson & Co, showed metal sheathing, bolts, nails and castings.[17] In 1880 P H Muntz & Co of London showed what was described simply as 'Muntz Metal' at the Melbourne International Exhibition.[18]

Sheets of muntz metal were used to clad the dome of Barnet's Goulburn Court House, completed in 1887,[19] and nails were imported in the 1881,[20] presumably for roofing, but we do not know whether either the sheeting or the nails were widely used in this country. Sheets, bolts and straps of muntz metal are listed in Mayes's price book of 1908,[21] and he also gives the cost of sheathing piles in muntz metal, which could be done by divers at the rate of fourteen sheets per day.[22] The sheeting, together with 'naval brass' sheeting, was advertised by Austral Bronze in 1931.[23] Muntz metal is also said to have been used by Wunderlichs in the 1890s for stamped metal ceilings. It still consisted of 60% copper and 40% zinc, and was also known as alpha beta brass, in distinction from alpha brass, which was not so strong.[24] As made by ICI in Britain in the twentieth century, it was 60% copper, up to 6% lead, and the balance

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12 C E Mayes, *The Australian Builders and Contractors' Price-Book* (7th ed, Sydney 1908), p 205.

13 Arthur Street & William Alexander, *Metals in the Service of Man* (Harmondsworth [Middlesex] 1954 [1944]), p 164.

14 W C Aitken, 'Brass and Brass Manufactures' in Samuel Timmins [ed], *The Resources, Products and Industrial History of the Birmingham and Midland Hardware District* (London 1866), p 313.

15 *Hobart Town Courier*, 4 July 1849, p 1.

16 *Sydney Morning Herald*, 2 February 1850, p 1.

17 Sydney International Exhibition 1879, *Official Catalogue of the British Section* (London 1879), p 59.

18 Melbourne International Exhibition, 1880-1881, *Official Record* (Melbourne 1882), p 611.

19 *Australasian Builder & Contractor's News*, 15 October 1887, p 365.

20 *Australian Engineering and Building News*, 1 May 1881, p 216.

21 Mayes, *Australian Builders Price-Book* (1908), p 205.

22 Mayes, *Australian Builders Price-Book* (1908), p 206.

23 *Journal of the Royal Victorian Institute of Architects*, XXXI, 7 (July 1933), advertisement p xi.

24 Susan Bures, *The House of Wunderlich* (Kenthurst [New South Wales] 1987), p 45.

zinc.[25] Composition roofing nails were somewhat similar, with a ratio of copper to zinc of 7:4.[26]

An American text of 1861 gives the composition of varies brasses, bronzes and other alloys, of which the following are a selection:[27]

	Cu	Zn	Pb	An	Bi	Sn
1. yellow brass for turning	320	160	1-5			
2. red brass for turning	24	5	8			
3. red brass, free, for turning	240	75	15	4		
4. another brass for turning	32	10	1			
5. best red brass for fine castings	384	80			1	
6. bronze metal	7	3				2
7. bronze metal	1	12				8
8. bell metal	100					20-25
12. good britannia metal	3			10		150
13. britannia metal, 2nd quality	3			9		140
14. britannia metal, for casting	4			12		210
15. britannia metal, for spinning	2			4		100
19. best britannia, for handles	2			5		110
20. best britannia, for lamps, pillars, &c	4			15		300
37. rivet metal	32	1				2

Phosphor bronze was produced in Britain only by the Phosphor Bronze Company of London, which exhibited its products at the Sydney Exhibition of 1879[28] and in Melbourne in 1880, most of them for specialised engineering and other purposes, but including cast sculpture such as may well have found its way into Australian buildings.[29] The Austral Bronze Co Ltd was established in 1915[30] and by the 1930s, in addition to muntz metal, produced copper and brass sheets, phosphor copper, manganese bronze, and phosphor bronze.[31] A prominent example was the multi-storey Railway Building, Sydney, where all the windows of the tall façade were in Austral Extruded Architectural Bronze and related products.[32] The Wunderlich system of glazing, set in copper strips, 'electro-copper glazing', or 'Wunderglaze', will be referred to below. Wetterstedt's Patent Marine Metal, though available in Britain

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25 William Kinniburgh, *Dictionary of Building Materials* (London 1966), p 171.

26 J T Rea, *How to Estimate: being the Analysis of Builders' Prices* (London 1904 [1902]), p 186.

27 I R Butts, *The Tinman's Manual and Builder's and Mechanic's Handbook, &c* (Boston 1861), pp 91-2.

28 Sydney Exhibition 1879, *Catalogue of British Section*, p 62.

29 Melbourne International Exhibition, 1880, *Official Catalogue of the Exhibits* (2 vols, Melbourne 1880), I, pp 341-2; Melbourne International Exhibition, 1880-1881, *Official Record* (Melbourne 1882), pp 6 ff.

30 *Journal of the Royal Victorian Institute of Architects*, XXXIV, 4 (September 1936, p ix.

31 *Journal of the Royal Victorian Institute of Architects*, XXXI, 7 (July 1933), advertisement p xi. Copper itself, in forms including window sash line, was listed by Mayes in 1908: Mayes, *Australian Builders Price-Book* (1908), p 201.

32 *Journal of the Royal Victorian Institute of Architects*, XXXIV, 4 (September 1936, p ix.

for roofing,[33] has not been reported in Australia at all. Gunmetal, an alloy of copper and tin, was listed by Mayes in 1908 solely for use in the railings and balusters of lighthouses, casements (apparently also for lighthouses), and sluice valves for sewer pipes.[34]

At the mid-nineteenth century metallic nickel was being produced by the Royal Saxon Cobalt and Nickel Works at Schneeberg, Saxony, which claimed to be the oldest establishment of the kind in the world.[35] At this stage it the metal seems to have been little used in Anglophone countries, especially in the building industry. However, at the National Mutual Life headquarters in Melbourne in 1890 the stair handrails were specified to be nickel-plated brass pipe, fixed to the wall with nickel-plated cast iron brackets.[36] Nickel steel was exhibited at Sydney in 1879 by Thomas Webb & Sons of Stourbridge, Staffordshire, and described as 'a soft steel, which welds and forges perfectly, polishing to densely white and silvery surface, and possessing great tensile and torsional strength.'[37] It is nor apparent whether it had any architectural applications, still less whether it found any market in Australia. Nickel silver was used in 1891 for handrails in the Mutual Store, Melbourne.[38] The material does not contain silver, but is an alloy of copper, nickel and zinc, which had in fact been known for about two thousand years, long before nickel itself was isolated.[39] Nickel, nickel silver and monel metal appear to have been produced, under the Inco Monel Metal trademark, by a cartel of British, United States and Canadian companies: Henry Wiggin & Co Ltd, the International Nickel Co Inc, and the Mond Nickel Co Ltd. In 1933 they reorganised their Australian distribution to be through Wright and Company of Sydney and Hawtin Richardson & Co of Melbourne.[40]

Monel metal is an alloy of about one third nickel to two thirds copper, containing 1.5 to 2.5 % of iron, 0.5 to 1 % of manganese, and very small amounts of silicon, sulphur and carbon.[41] The Australian distributors were Ferrier & Dickinson of Sydney, with agents in the other states, and they described the alloy as consisting of 67% nickel, 28% copper, and 5% of other metals.[42] It was made by the direct smelting of a nickel-copper-iron ore mined near Sudbury in Canada, as had been first proposed in 1905 by the quasi-eponymous Ambrose Monell, the then President of the

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33 It was available in weights of two or three pounds per square foot [10 k or 15 k per square metre] and sheets of nine feet by three [2.7 x 0.9 m] from W W & R Johnson & Sons of the White Lead Works, Limehouse, London: F W Laxton, *Laxton's Builder's Price Book for 1863* (43rd ed, London 1863), advertisements, no page; G R Burnell [reviser], *The Builder's and Contractor's Price-Book for 1865* (London 1865), advertisements, no page.

34 Mayes, *Australian Builders Price-Book* (1908), p 206.

35 Great Exhibition, *Catalogue*, III, p 1105.

36 Wright, Reed & Beaver, 'Specification for Erection of Premises for the National Mutual Life Association of Australasia. Corner of Collins & Queen Streets Melbourne' (Melbourne 1890), p 30.

37 Sydney Exhibition 1879, *Catalogue of British Section*, pp 25-6.

38 *Building and Engineering Journal*, 5 September 1891, p 113.

39 Street & Alexander, *Metals in the Service of Man*, p 181.

40 *Journal of the Royal Victorian Institute of Architects*, XXXI, 7 (July 1933), advertisement p xxx. Henry Wiggin & Co Ltd of Hereford were the English makers: Kinniburgh, *Dictionary of Building Materials*, p 169.

41 S G B Stubbs, *The Building Encyclopedia* (4 vols, London, no date [c 1955]), III, p 1029.

42 W L Richardson [ed], *Ramsay's Architectural Catalogue* (Melbourne 1931), p 134.

International Nickel Company.[43] It was used for sinks until superseded by stainless steel, as well as for grilles, reliefs, and architectural details.[44] In Australia it was advertised by Ferrier & Dickinson for domestic kitchen sinks, commercial kitchen equipment generally, and hospital uses,[45] and its use for 'Metalite' glazing bars will be referred to below. 'Metalite' brass-mounted metal light fitting were also imported.[46] In 1932-3 cupro-nickel - presumably monel metal or something very similar - was used by Brooks Robinson Pty Ltd of Melbourne in the fabrication of entrance gates and window grilles for A & K Henderson's Shell Building in Melbourne.[47]

c. the zinc market

Zinc was a rare and expensive material until the eighteenth century, when the Chinese method (or perhaps more correctly the Indian method) of extracting it was introduced to Europe.[48] Zinc ore had long been used in the production of brass, but the existence of the metal itself was not understood, and when the metal did reach Europe from China and India the connection was not at first recognised. Albertus Magnus (d 1280) called it 'golden marcasite',[49] and in 1597 Andreas Libavius described the metal as a 'peculiar kind of tin' from India.[50] The word 'zinc' first appears in the writings of Paracelsus (d 1541).[51] The *Shorter Oxford Dictionary* dates the use of the word in English to 1651. In about 1720 Henckel succeeded in extracting the metal experimentally from lapis calaminaris, but kept his method secret,[52] and in either 1738 or 1742 Antonius Van Swab extracted the metal from its ores.[53] It is claimed that one Dr Lane succeeded in smelting zinc ore at his copper works at Swansea in 1720,[54] and it has been more securely said that by 1730 zinc had been smelted in England.[55] In 1740 it was produced on a commercial scale by William Champion of Bristol,[56] and it is reported that the secret of the process had been bought from Van Swab whilst he was on a visit to Britain.[57] At the Great Exhibition of 1851 T B & J Lawrence of London, manufacturers, showed 'British

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43 Street & Alexander, *Metals in the Service of Man*, p 180.

44 D H Trelstad, 'Monel' in T C Jester [ed], *Twentieth-Century Building Materials* (Washington [DC] 1995), pp 52-7

45 *Ramsay's Catalogue* [1931], pp 134-6.

46 Carol Hardwick, 'The Influence of Art Deco on Architecture in Victoria' (2 vols, MArch, University of Melbourne, 1980), I, p 112.

47 *Journal of the Royal Victorian Institute of Architects*, XXXI, 7 (July 1933), advertisement p ii.

48 *Revue Générale de l'Architecture et des Travaux Publiques*, II (1841), p 300 & note. According to this account it was the Chinese method which reached Europe in 1770.

49 E Chambers, 'Zinc', *Encyclopædia* (5 vols, London 1788), V, sv.

50 William Dittmar, 'Zinc', *Encyclopædia Britannica* (9th ed, 25 vols, Edinburgh 1875-9), XXIV, p 784.

51 Abraham Rees, *The Cyclopædia, or Universal Dictionary of Arts, Sciences and Literature* (39 + 6 vols, London 1819), XXXIX, sv 'Zinc'.

52 Chambers, 'Zinc'; Rees, 'Zinc'.

53 Chambers, 'Zinc'.

54 Information from Colin Allen, who cites J M Dawkins, *Zinc and Spelter - notes on Early History of Zinc* (ZDA, London 1956).

55 Dittmar, 'Zinc', p 784.

56 Allen, citing Dawkins, *Zinc and Spelter*.

57 Chambers, 'Zinc'.

zinc ores' and a variety of products including ingots, rolled sheets, plates, perforated sheets and nails.[58]

The first Continental zinc works (presumably those of the Vieille Montagne Company) were established at Liège in 1807.[59] At the great Exhibition the Societé des Mines at Fonderies de Zinc de la Vieille Montagne, of Liege, exhibited zinc ore in various forms, raw zinc, sheet zinc for roofing &c, bars for ships' nails, and a range of zinc compounds.[60] Through its London agent H F Schmoll, the company also showed zinc paints, zinc bolts, a colossal statue of Queen Victoria in zinc which had been made to look like bronze, and other castings in the same material.[61] However, there was also a Vieille Montagne Joint Stock Company in Paris, the precise relationship of which is not apparent, but which was more involved in building products, including mouldings, roofing (plain, Italian and corrugated) gutters, pipes, balconies, nails, statues and church ornaments.[62] An upstart Societé de la Nouvelle Montagne (ie the new mountain as opposed to the old) of Verviers showed its own ores, sheet zinc and roofing tiles,[63] but it seems to have soon disappeared. Belgian expertise was also transmitted to the United States, where in 1838 Belgian workmen smelted the first ores at the Arsenal in Washington.[64] Zinc was now mined in that country as well, and at some time around 1850 the New Jersey Exploring and Mining Company accidentally discovered a massive piece of zinc ore weighing about 7.3 tonnes, at their Sterling Hill Zinc Mine, and managed to extract it and transport it to the Great Exhibition.[65]

Zinc was used for building purposes in Britain only after 1805, when Hobson, Sylvester & Moorhouse patented the use of zinc for sheathing ships, roofing houses and lining waterspouts, all of which (it appears) was entirely new.[66] According to Ure this patent was rendered ineffective by the low price and 'superior tenacity' of copper for the same purposes.[67] Hobson and his partners had specified a system of rolling the metal initially while hot to prevent it cracking, after which it could be further rolled down to the required thickness. The sheets that resulted were then very hard, and had to be annealed to make them workable.[68] The first good sheet of rolled zinc is said to have been produced in 1808 by the Abbé Dony of Liège, Belgium, who went on to roof the Church of Barthelemy in that town with the new material,[69] but it does not appear that anything of the sort was used in Australia before about 1840.

The duty charged on zinc in Britain was at first so high as to make it prohibitively expensive for building purposes, but it was reduced in 1832 to £2 per ton, and in

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58 Great Exhibition, *Catalogue*, II, p 598.
59 Dittmar, 'Zinc', p 784.
60 Great Exhibition, *Catalogue*, III, p 1152.
61 Great Exhibition, *Catalogue*, I, p 161.
62 Great Exhibition, *Catalogue*, III, p 1227.
63 Great Exhibition, *Catalogue*, III, p 1151.
64 Allen, citing Dawkins, *Zinc and Spelter*.
65 Great Exhibition, *Catalogue*, III, p 1447.
66 *Repertory of Arts*, IX, 52 (September 1806), pp 251-2.
67 Andrew Ure, *Dictionary of Arts, Manufactures and Mines* (London 1839), p 1330.
68 *Repertory of Arts*, IX, 52 (September 1806), pp 251-2.
69 James McCawley, *Roofing* (New York 1938), p 150.

1842 to one shilling, and then in 1845 it was abolished. Britain, which imported the raw material from Upper Silesia through the Baltic ports, now developed a substantial re-export trade to India (where direct German exports had already undermined the traditional supply from China) and elsewhere.[70] By 1834 there was said to be an abundance of zinc available for roofing purposes at Cape Colony (South Africa),[71] no doubt as a result of the first reduction in duty, and it is likely that the first significant use of zinc in Australia dates from about the same period. Indeed, by 1839 Australian colonists were being told that:

> In consequence of the great improvement recently introduced in the manufacture of Zink it is at this time in very extensive use, and in many instances most advantageously employed, and is particularly recommended to Emigrants to South Australia, Sydney, and other British Colonies, combining the important requisites of economy, efficiency, and durability.[72]

The Vieille Montagne Company was to become the pre-eminent supplier of zinc to Europe and its dependencies, including Australia. The method of manufacture at its works near Liège differed from the English process in various ways. The ore consisted of compact crystalline zinc carbonate and silicate with cavities containing clay or gangue. It was exposed to the weather for some months, which softened the clay so that it could be easily removed. The ore was then washed, calcined in kilns resembling continuous or 'running' lime kilns, sifted, reduced to powder by an edge runner, and transferred to the reducing furnace. From this, which was actually four furnaces in one, ingots were produced. The greater proportion of the ingots were reheated, divided into suitably sized portions and rolled into sheets while hot. Apart from these sheets, which could be stamped in various designs, the company produced zinc mouldings, spikes, nails and flexible wire.[73] Some of these products will be referred to below.

In the mid-twentieth century the Electrolytic Zinc Company began local production in Tasmania, taking advantage that state's cheap hydro-electric power.[74]

d. zinc sheeting

During the 1840s zinc roofing was used on a small minority of buildings in Melbourne,[75] and one must assume that it was generally laid in the traditional method

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70 J R McCulloch [ed H G Reid], *A Dictionary of Commerce* (new ed, London 1871), p 1151.

71 J E Alexander, in *Graham's Town Journal*, 20 August 1835, supplement reproduced in Ronald Lewcock, *Early Nineteenth Century Architecture in South Africa* (Cape Town 1963), p 169.

72 Henry Hewetson's advertisement in John Stephens, *The Land of Promise* (London 1839), advertising sheet, no page.

73 Charles Tomlinson [ed], *Cyclopaedia of Useful Arts & Manufactures*(2 vols, London, no date [c 1855]), II, pp 1046-7. see also George Gladstone, 'Mining and Quarrying. - XXIII. Zinc', in *The Technical Educator* (London, no date, published in parts [?c1880]), III, pp 321-2.

74 *Cross-Section*, no 58 (August 1957), p 2.

75 C J Griffith, *The Present State and Prospects of the Port Phillip District of New South Wales* (Dublin 1845), pp 4-5.

for sheet metal roofing, which was to sark the roof surface completely with timber boarding, to run the metal down the slope from ridge to eave, either as a continuous strip, or in a series of overlapping sheets, and to make lapped edge joints over upstanding timber rolls to ensure watertightness.[76] However examples of zinc roofing have rarely been reported in Australia,[77] partly, no doubt, because zinc was a material with a very high re-sale value - about half the original price - and could be salvaged from older buildings.[78] It also because it can be difficult to distinguish from other materials such as tin, and even galvanized iron (according to how discoloured it is, and whether one can actually handle it). The notable exception is the roof of Parliament House, Brisbane, which will be referred to below.[79]

In 1854 not only zinc roofing tiles, but spouts, pipes, heads and brackets, were being advertised in Melbourne for supply on contract.[80] It would seem, however, that zinc spouting might equally be formed on the spot rather than bought in, for R S Burn described a 'gutter, formed by bending thin iron or zinc into the shape required, and nailing it to the end of the rafter.'[81] Charles Heley, who reached Melbourne late in 1852, employed men at twenty to thirty shillings a day making tinware and fixing zinc roofs and spouting.[82]

Zinc was not used merely for roofing. At the Great Exhibition Charles Jack of London showed perforated zinc, mouldings, sash bars and other articles, all of zinc supplied by the Vieille Montagne company,[83] and the use of such items in Australia is discussed below. Complete zinc buildings were being made in London by 1839 and advertised for the use of emigrants to Australia,[84] and in the early 1850s such buildings were imported in significant numbers. I have touched upon this topic elsewhere,[85] and I need merely say that these buildings were made in a number of European countries, but that those reaching Australia probably came mainly from James Middlemass and William Kirkwood, both of Edinburgh, and from Boydell & Glasier of Smethwick and Camden Town. A major structure, probably not prefabricated, was built of 'wood covered with zinc' in Spring Street, Melbourne by Thomas Mooney,[86] and was soon to be well known as Astley's Amphitheatre. Zinc was also a common lining of packing cases for dry goods, and hence recycled to line

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76 Good later references for zinc roofing methods, and for the practices recommended by the Vieille Montagne Company are W P Buchan, *Plumbing* (London 1899), chapter 10, and R S Burn, *Building Construction* (London 1877), pp 178-182.

77 For example, Clive Lucas, *Conservation and Restoration of Buildings: conservation of roofs* (Canberra 1984), p 13, names only what he calls 'rolled zinc roof' as being almost exclusive to Queensland, where it was much used on public buildings, such as Parliament House, Brisbane

78 C B Mayes, *The Australian Builders' Price-Book* (Melbourne 1862), p 94, quoting the pamphlet of the Vieille Montagne Zinc Company.

79 *Builder*, XXIV, 1243 (1 December 1866), p 885.

80 *Argus*, 27 January 1854, p 10.

81 R S Burn, *The Colonist's and Emigrant's Handbook of the Mechanical Arts* (London 1854), p 69.

82 Charles Heley, in *Records of the Castlemaine Pioneers* (Adelaide 1972), p 90.

83 Great Exhibition, *Catalogue*, I, p 162.

84 Hewetson's advertisement, loc cit.

85 Miles Lewis, 'The Portable House', in Robert Irving [ed], *The History and Design of the Australian House* (Melbourne 1985), pp 280-281.

86 Melbourne City Council building permit application no 843, 29 April 1854 [Burchett Index].

chimneys and wet areas. At Warwick in Queensland, for example, zinc sheeting of this character was said to be the standard lining of fireplaces in the 1830s.[87]

In the past I have been able to report what may have been a zinc or tin roof subsequently covered in bark, on T B Pearse's hut at 'Angahook', Airey's Inlet, Victoria, of the 1850s. This was destroyed by bushfire in 1983. A number of other examples of surviving zinc sheeting have turned up in Victoria in recent years, of which one is a prefabricated timber-framed building at Guildford, the walls of which are more or less completely clad in flat zinc sheets.[88] At the second homestead at 'Boondarra' on the Lower Darling, of about 1868-70, zinc sheeting was laid over cane grass roofing: this apparently proved unsatisfactory and was covered with another layer of cane grass, and ultimately with corrugated iron.[89]

J W Tyler of Westminster sold and laid Devaux Vieille Montagne Thick Roofing Zinc, which was presumably the sort approved by Mayes, and claimed to lay it according to the principle established by the architect James Edmeston.[90] In England, Thomas Hardy made a note in his sketchbook to the effect that only Devaux's Vieille Montagne zinc sheets should be used. They measured eight feet by three [2.4 x 0.9 m] and in 16, 15, 14 or a minimum 13 gauge thicknesses. Hardy seems to have transcribed this information from Tyler's advertisement in the *Builder* .[91]

In 1862 Mayes's *Australian Builders' Price-Book* listed prices for Vieille Montagne zinc sheets generally of 7 by 3 feet [2.1 x 0.9 m], both plain and corrugated, as well as for zinc gutters and pipes. He explained that London-made zinc was also imported, but was less ductile and durable, variable in thickness, and sometimes incorrectly stamped.[92] The roof of Charles Tiffin's Parliament House, Brisbane, of 1865-6, was of Vieille Montagne zinc, not sent direct from Belgium, but 'prepared and fitted' in London under James Edmeston's supervision,[93] which is consistent with Tyler's advertisement. In 1881 the current prices listed in the *Australian Engineering and Building News* included rolled zinc sheeting in a range of weights (3 to 8 and upwards), corrugated sheeting, and fish scale roofing[94] - a new development, of which more below. In 1957 a pavilion was built at the Launceston Showground to display the products of the Electrolytic Zinc Co, with a curved and ribbed zinc roof,

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87 Thomas Hill, *The Early History of the Warwick District and Pioneers of the Darling Downs* (Toowoomba [Queensland] 1988 [Toowoomba, no date (?1920s)]), p 91.

88 The building has been bought from unsympathetic owners by Mr Ian Huxley, for removal. Although I inspected it some twenty years ago, I have no notes on file, and my current information is from Mr Huxley by phone, 20 February 1990. The timber frame is lined with packing case boards, the roof trusses have numbers cut in, and the roof is of corrugated iron.

89 Peter Freeman, *The Homestead: a Riverina Anthology* (Melbourne 1982), p 154.

90 Laxton, *Price Book for 1863*, advertisements, no page.

91 Thomas Hardy [introduced C J P Beatty] *The Architectural Notebook of Thomas Hardy* (Dorchester [Dorset] 1966), p 69.

92 Mayes, *Price-Book* (1862), p 94. In 1883 and 1886 Mayes's *Australian Builder's Price Book* listed sheet zinc in a variety of sizes: Charles Mayes, *The Australian Builders' Price-Book* (4th ed, Melbourne 1883), pp 82, 111; ibid (5th ed, Melbourne 1886), pp 124-5.

93 *Builder*, XXIV, 1243 (1 December 1866), p 885. In about 1866 James Polworth, a temporary foreman in the Colonial Architect's office, was required to report on this roof: Donald Watson & Judith McKay, *Queensland Architects of the 19th Century* (Brisbane 1994), p 144.

94 *Australian Engineering and Building News*, II, 11 (1 May 1881), p 216.

and zinc gutters downpipes and trimmings.[95] However there is nothing to suggest that such products were then in general currency.

e. zinc tiles

Diagonally laid tinplate tiles were used in Canada in the eighteenth century, and were very strong in Québec and Montreal in the first half of the nineteenth century.[96] Nothing exactly comparable has been reported in Australia, but square zinc tiles laid on the diagonal, with ingenious cuts and folds at the edge, have been found on the prefabricated timber house 'Woodlands' at Tullamarine, Victoria. The two adjoining lower edges are folded under the face, and the upper edges over it, so that each course locks over the one below, ensuring a watertight junction. The house was made by Peter Thompson of London and put up on the present site in 1843,[97] and has a boarded roof with a layer of oilcloth, itself an unusual survival. The zinc tiles were laid over this, probably after the oilcloth had begun to fail.

Tiling of exactly the Woodlands sort was shown by the Vieille Montagne company at the Paris Exposition of 1867,[98] and similar tiles illustrated by Barberot are also said to be made by the Vieille Montagne Zinc Company.[99] But it was probably a well established pattern, for we have seen that the company was making zinc tiles by 1851. Nor were they alone, for at the Great Exhibition Ruffer & Co of Breslau, Prussia, showed zinc tiles measuring 14 x 28 inches [356 x 712 mm], and S B Renner of the same city showed a zinc roof consisting of 'plates' which could be laid at a very low slope.[100]

Whereas these were essentially flat zinc plates designed to be laid over boarding, various forms of pre-formed zinc sheets or tiles were also produced.[101] including corrugated or ribbed ('Italian') zinc sheets which seem have regularly been used over battens without any layer of boarding.[102] They are probably be the same as the self-supporting ribbed zinc roofing displayed by the Vieille Montagne Company in 1867 as 'the Italian Undulated System'. The sheets were ribbed upwards at intervals, and were designed to be fixed to transverse battens of either wrought iron or timber.[103] Whether any such roofing was used in Australia is unclear, because of the perennial

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95 *Cross-Section,* no 58 (August 1957), p 2.

96 A J Richardson, 'Guide to the Buildings in the Old City of Quebec', *APT Bulletin,* II, 3 & 4 (1970), p 49.

97 The original study (preceding the discovery of either the oilcloth or the zinc tiles referred to below) is Peter Lovell, 'Woodlands Homestead Complex: an Historic Structure Report: the Building Fabric' (mimeograph report, Melbourne 1981).

98 R S Burn, *Modern Building and Architecture* (London, no date [c 1870]), p 195, pl XLIII fig 38; see also R S Burn, *Building Construction* (London 1877), p 182.

99 E Barberot, *Constructions Civiles* (2nd ed, Paris 1900), pp 459-460.

100 Great Exhibition, *Catalogue,* III, pp 1048, 1052.

101 For example the 'Italian roofing' illustrated in [J L Tarbuck], *The Builder's Practical Director* (Leipzig, no date [c 1858]), p 133.

102 P B Eassie, *Wood and its Uses* (Gloucester 1878), pp 46-7.

103 R S Burn, *The New Guide to Carpentry, General Framing and Joinery* (Glasgow, no date [c 1870]), pp 349-351.

problem that the high resale value of zinc has tended to ensure the destruction of any evidence.

In 1888 zinc tiles, both square and diamond-shaped, were described as being an invention of quite recent date, now becoming known in Sydney, and they had been used on several houses.[104] Zinc tiles like those of 'Woodlands', but longer in proportion, were used to roof the tower of George Hoskins's house, 'St Cloud', in the Sydney suburb of Burwood, completed in 1893.[105] They are probably the same as the interlocking zinc tiles which, together with fishscale tiles, were being advertised early in the twentieth century.[106] By now, however, similar effects were being gained with sheets embossed in patterns representing a number of tiles per sheet, and these will be discussed separately below.

f. other zinc products

Folded zinc was regularly used for glazing bars in Britain, and Tarbuck illustrates nine sections, all apparently quite small and used for purposes such as diamond glazing, rather in the manner of lead cames.[107] Glazing bars of this character, and probably of zinc, are found in La Trobe's Cottage, a prefabricated house by Manning of London, erected in Melbourne in 1839, and it seems possible that similar windows by Manning survive at 'Moorlands', near Bunbury, Western Australia.[108]

Caroline Drysdale and Anne Newcomb had 'zink cottage windows' in their cottage at the Boronggoop run in the Port Phillip District, of 1841.[109] Most of the present windows, however, are recreations. Zinc glazing bars are also identifiable in two South Australian buildings, the Rosaville Methodist Chapel at Mount Gambier, of 1869,[110] and the school/chapel building of the Destitute Asylum, Kintore Avenue, Adelaide. In the latter they are in a diagonal or diaper pattern and are said to have been folded to create a cruciform section.[111] By 1908 zinc glazing bars 'fitted with capping' were listed in Mayes's price book,[112] but these must have been a different thing altogether.

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104 *Australasian Builder & Contractor's' News*, 22 December 1888, p 560.

105 Robert Irving & John Kinstler, *Fine Houses of Sydney* (Sydney 1982), p 81.

106 Mayes, *Australian Builders Price-Book* (1908), p 203.

107 Tarbuck, *Builder's Practical Director (*Leipzig, no date [c 1858]), pp 117-2.

108 This is the house to which Marshall Clifton's widow retired, and is reported by Ian Molyneux to have leadlight windows in imitation of the original windows (possibly by Manning), which Molyneux has assumed to be of iron. However he has also assumed that the windows of La Trobe's cottage are of iron. If those at Moorlands had the slender zinc glazing bars, he might reasonably have taken them for leadlighting. Ian Molyneux, '"Leschenault Homestead" Conservation Plan' (Fremantle [Western Australia] 1996), p 138.

109 Anne Drysdale's diary, 14 August 1841, quoted in P L Brown [ed], *Clyde Company Papers, III, 1841-5* (London 1958), p 79.

110 Information from Duncan Ross-Watt and John Hoysted, 1991.

111 Information from Ron Danvers, 1991.

112 Mayes, *Price-Book* (1908), p 203.

The introduction of perforated zinc for uses such as ventilators and meat safes is not very well documented, but in 1839 Henry Hewetson of the Zink Warehouse, London, was advertising, to an Australian audience, perforated zinc for meat safes,[113] and in 1850 a cask of perforated zinc in assorted sizes was offered for sale in Hobart.[114] At the Great Exhibition perforated zinc was shown by a number of firms, including T B & J Lawrence.[115] By the 1850s the use of perforated zinc for food or meat safes had become well established in Australia, as is indicated by Joseph Elliott's description in 1860 of one which he made for his own cottage:

> not a fly or anything whatever can get to the inside unless through the perforated zinc when the door is open. It has a zinc front and two sides & all the corners of the wood are closely joined, & covered with tin.[116]

Vieille Montage zinc for safes, larders and ventilators is listed by Mayes in 1862 and later, in 9 or 10 gauge.[117]

Henry Hewetson's advertisement of 1839 also listed perforated zinc for dairy windows, and 'perforated metallic window blinds'[ie perforated screens],[118] which were probably also of sheet zinc. In 1851 H & W Treggon exhibited zinc window blinds 'perforated on one piece of metal, with varied designs',[119] and Harcourt Quincey of Birmingham and Sheffield (better known as a shutter manufacturer) advertised 'Corrugated Window-Blinds, in perforated Metal.'[120] In 1879 perforated zinc doors were reported among other measures to minimise the heat at 'Czar Lodge' in Hay, New South Wales.[121] In 1883 Frederick Braby & Co, one of the largest British manufacturers, advertised a wide range of perforated patterns, including a number or ornamental designs intended to be used for blinds.[122] Braby also offered a wide range of perforated zinc 'friezes and frets'.[123]

Cast zinc products tend to be later. In 1850 it was reported that M Geiss of Berlin had developed the use of cast zinc for architectural ornaments. It had been used in Berlin for seventeen years and had been praised by Schinkel, but not so far used in England.[124] At the Great Exhibition Geiss showed a number of statues, as well as capitals, columns and tiles of cast zinc,[125] and castings were also shown by a number of other German makers, many in imitation of bronze like those of the Vieille Montagne Company, mentioned above. The AMP Society Building in Sydney, of 1863-4, carried a cast zinc sculptural group on the parapet, depicting the goddess

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113 Hewetson's advertisement in Stephens, *Land of Promise*.
114 *Hobart Town Courier*, 3 January 1850, p 3
115 Great Exhibition, *Catalogue*, II, p 598
116 Joseph Elliott, *Our Home in Australia* (Sydney 1984), p 61.
117 Mayes, *Price-Book* (1862), p 94.
118 Hewetson's advertisement in Stephens, *Land of Promise*.
119 Great Exhibition, *Catalogue*, II, p 598
120 Great Exhibition, *Catalogue*, I, advertisement p 44
121 M A Gardam, *The Bishop's Lodge* (Hay [NSW] 1993), p 10, quoting *Riverine Grazier*, 2 April 1879, p 2.
122 *Frederick Braby & Co. No 9* [catalogue] (London 1883), pp 5-19.
123 *Frederick Braby & Co*, pp 20-29.
124 John Timbs [ed], *The Year-Book of Facts* (London 1850), pp 86-7.
125 Great Exhibition, *Catalogue*, III, p 1063.

Tyche next to a cornucopia, and three other figures. This had been modelled by Charles Summers and cast in Melbourne.[126]

In 1883 and 1886 Mayes listed Corinthian capitals for three inch [77 mm] wood or iron columns.[127] He does not list the even smaller capitals sometimes found on colonettes in window and other joinery, nor the strips of guilloche and other relief ornament. In fact most references to such elements are vague, as in a specification of 1889 for a domestic front door 'to have a small metal enrichment planted on the transom'.[128] However, it appears that all these were normally of zinc, and a specification of 1891 refers to a deal door frame with a 'zinc enriched frieze', a rail with 'e[n]riched zinc moulding', and a main entrance door with 'bolection moulding outside with zinc enrichments'.[129] Even quite large capitals for hall columns were cast in zinc.[130] In 1908 C E Mayes listed stamped and cast zinc ventilators, half round letters for signs, glazing bars, sash bars, and even bronzed zinc statues.[131] Zinc hollow ware, pressed zinc ceilings, friezes and ornaments will be moire conveniently discussed in the context of pressed metal, below.

g. tin

References to metal or tin 'tiles' in Australia usually mean galvanised iron, and tinplate seems to have been little used for roofing in earlier years. This stands in unexplained contrast to the United States, where tinplate was widely used from about 1808 onwards, and zinc was not. The tinplate sheets were mainly imported from Wales, the leading producer of tin.[132] The sizes were 10 x 14 inches [254 x 356 mm], 12^1/$_2$ x 17 [315 x 433], 12 x 12 [300 x 300], 11 x 15 [279 x 381], and 14 x 20 inches [356 x 508 mm],[133] the latter giving a finished surface of 13 x 17^3/$_4$ inches [330 x 451 mm].[134] Quebec imported tin from France, and it was used at first in churches and public buildings, then later, as the price fell, became common in ordinary houses.[135] One of the Welsh tinplate manufacturers was Phillips Smith & Co of Llanelly, who described the process in 1851:

> ... sheets of iron are very carefully cleaned from all oxidation and from every trace of organic matter: then being dipped into a saline solution,

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126 Geoffrey Blainey, *A History of the AMP 1848-1998* (St Leonards [New South Wales] 1999), pp 30-32, quoted by George Tibbits in a draft chapter for the history of Bates Smart, 2002, p 16.

127 Charles Mayes, *The Australian Builders' Price-Book* (4th ed, Melbourne 1883), pp 82, 111; ibid (5th ed, Melbourne 1886), pp 124-5.

128 Beswicke & Hutchins, 'Specification of Works to be done in painting "Altyre" Barkers Road Kew for James E Cumming Esq.' (Melbourne 1889), single page.

129 W S Law, 'Specifications of Residence Drummond St. Carlton for Mrs. L. Abrahams' (Melbourne 1891), pp 14-15.

130 Law, 'Specifications for Mrs. L. Abrahams', p 20.

131 Mayes, *Australian Builders Price-Book* (1908), p 203.

132 The Exchange Coffee House in Boston is reported to be one of the first examples of tin roofing, and was completed in 1808: D S Waite, 'Roofing Early America', in C E Peterson [ed], *Building Early America* (Radnor [Pennsylvania] 1976), p 141.

133 Butts, *Tinman's Manual*, p 30.

134 Michael Lynch, in an email on the Vernacular Architecture Forum web site, 14 August 2003, cites D S Waite, *Nineteenth Century Truss Roofing and its use at Hyde Hall* (New York 1974).

135 P H Simpson, *Cheap, Quick, & Easy* (Knoxville [Tennessee] 1999), pp 32-3.

> which serves as a flux, they are dipped into melted tin, which is diffused by heat over the surface, and the tin plates completed.[136]

Small household or other items of tinplate, often japanned, were probably more common in Australia than sheet tinplate for building purposes such as roofing.[137] Nonetheless Simon Zöllner, Louis Heitz and Henry Lippman are claimed to have set up in Sydney as tinplate manufacturers (as distinct from tinsmiths) during the 1850s.[138]

A related material, used overseas but not apparently in Australia, was 'tern plate' in which the coating contained more lead than tin, making it much cheaper but with a duller finish.[139] Tern plate was also made in Wales, and was one of the products advertised in 1851 by the Cwm Avon Iron, Copper & Tinplate Works of Taibach, Glamorganshire.[140] By 1870 tern plate was exported from Britain to Canada on a large scale, for roofing purposes.[141] A tinsmith's guide of 1879 cites it in the larger of the tin sizes, 14 x 20 inches, and one size larger again, 20 x 28 inches [505 x 212 mm] giving a finished size of 12$^{3}/_{4}$ x 27 inches [452 x 686 mm]. In the United States tinplate and ternplate were hardly manufactured at all before 1890, but by 1906 that country was the world's largest producer.[142]

Although tin was regularly imported into Australia in the nineteenth century, most of it seems to have been destined for small products such as canisters, rather than for the building industry. Tin valued at £25,770 was imported to Victoria in 1858 (in addition to manufactured tinware, tinfoil &c) while £19,600-worth of black tin was exported.[143] This was a material containing the tin ore cassiterite,[144] which was obtained in the Ovens Valley.[145] By early 1860 it was being smelted by the Victoria Tin Smelting Company of William Street, Melbourne,[146] but this enterprise must have failed, for nothing is heard of it later.

In Melbourne 'tin' roofing tiles were advertised for sale in 1853,[147] and E A Rippingille, who had migrated from Adelaide to Melbourne in the 1850s, made 'metallic shingles' from imported tinplate, and did sufficiently well to return to England in 1861 as a wealthy man.[148] There can hardly be any doubt about the

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136 Great Exhibition, *Catalogue,* I, p 174.

137 See Butts, *Tinman's Manual,* pp 49 ff, for the techniques of japanning, varnishing &c.

138 G P Walsh, 'Simon Zöllner (1821-1880)', in Christopher Cunneen [ed], *Australian Dictionary of Biography Supplement 1580-1980* (Melbourne 2005), p 418.

139 Simpson, *Cheap, Quick, & Easy,* p 33.

140 Great Exhibition, *Catalogue,* I, advertisement p 47

141 Gladstone, George, 'Mining and Quarrying - XVIII Tin', *Technical Educator,* III (no date [c 1870]), p 175.

142 *'Sweet's' Indexed Catalogue of Building Construction* (New York 1906), p 176.

143 C B Mayes, 'Essay on the Manufactures more immediately required for the Economical Development of the Resources of the Colony', in *Victorian Government Prize Essays 1860* (Melbourne 1861), p 368.

144 R B Smyth, *The Gold Fields and Mineral Districts of Victoria* (Melbourne 1869), p 412.

145 Smyth, *Gold Fields and Mineral Districts,* p 83.

146 Mayes, 'Essay on the Manufactures', p 368.

147 By John Stirling of Smith Street, Collingwood: *Argus,* 11 August 1853.

148 *Australasian Ironmonger,* 1 June 1894, obituary, cited in E & R Jensen, *Colonial Architecture in South Australia* (Adelaide 1980), p 91. See *Tanner's Melbourne Directory* (Melbourne

'improved tin roofing' which Ferguson & Urie displayed at the Melbourne Exhibition of 1854.[149] In Albert and May Wright's house at 'Nulalbin' of 1871 the sitting room was reportedly lined with tin and painted,[150] though this may be an erroneous reference to some other metal lining. A 'tinsmith' would work not only in tin but in other metals: thus, for example, the tinsmith Archibald Allan emigrated from Glasgow in 1853, and after visiting the goldfields settled in Fitzroy, where he made 'metal' tiles, called his business the Collingwood Zinc and Galvanized Iron Works, and described the trade as being in galvanized iron and hardware.[151] 'Rolled tin' was used on the roof of the Treasury Building, Brisbane, of 1886-9.[152]

Though tin is less common than zinc, and far less well documented, in the twentieth century at least it was produced in the same one inch [25 mm] corrugated profile as zinc and galvanised iron ['ripple iron']. An example thought to date from about 1930 is a hut on the Bennison High Plains,[153] where the material must have been used because it was relatively light and portable, for a site accessible only on horseback. The sheets are variously stamped:

TIN MADE
IN
AUSTRALIA

and

TIN MADE
IN
WESTERN
AUSTRALIA

The identity of any Western Australian manufacturer (or, more probably, recycler) is not known, but one supplier of tin in the 1930s - probably imported - was Austral Bronze.[154]

h. local production

The local production of non-ferrous metals was virtually all exported prior to World War I, and even in copper, mined locally since the 1840s, Australia's share in world production was very small. But by about 1910 the demand for copper was escalating due to developments in the world armaments, electrical and telecommunications industries, and Germany made a subtle attempt to capture a world monopoly. Upon the outbreak of war Australia repudiated its contracts with German controlled

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1859), for Rippingille's address at La Trobe Street East, also C B Mayes, *The Victorian Contractors' and Builders' Price-Book*, p xl.

149 *Official Catalogue of the Melbourne Exhibition, 1854* (Melbourne 1854), p 13.

150 Judith Wright, *The Generations of Men* (Melbourne 1953), p 73.

151 James Smith [ed], *The Cyclopedia of Victoria* (3 vols, Melbourne, 1903, 1904, 1905), I, pp 578-9; II, pp 138-40; C B Mayes, *The Victorian Contractors' and Builders' Price-Book* (Melbourne 1859), p xviii.

152 Allom Lovell Marquis-Kyle, *The Treasury Buildings Group Conservation Study* (3 vols, Brisbane 1992), I, p 85.

153 Information and photographs supplied by Linda Barraclough of Briagolong, 1994.

154 *Journal of the Royal Victorian Institute of Architects*, XXXI, 7 (July 1933), advertisement p xi.

interests, and in doing so faced the probable collapse of the local metal mining industry.[155] In 1912 the Colonial Ammunition Company in the Melbourne suburb of Footscray installed a rolling mill and a brass foundry for the production of .303 cartridge cases, but not at this stage for general commercial production. Now W L Baillieu of the Collins House group, backed by the government, set about establishing a local processing industry, and in 1915-16 Metal Manufacturers Ltd was established and acquired a factory site at Port Kembla. On 22 May 1918 the first copper was rolled.[156] Wire, bars, rods and strip were produced, one of the first major orders being from the Post Office for telephone cable. Tubes and brasswork were sold through the established Melbourne form of Knox, Schlapp & Co.[157]

Meanwhile the firm of Noyes Brothers entered the field. Edward and Henry Noyes, immigrants from England, established themselves in Melbourne in 1888 as merchants, importers, shipping agents and manufacturers' representatives, becoming a proprietary company in 1907 and a public company in 1936. They handled general hardware, and also developed interests in pig iron, scrap iron, coke, cement, corrugated iron, barbed wire and wire netting then developed a specialisation in importing electrical equipment and associated products.[158] As an outgrowth of their trading interests in copper, lead and zinc, members of the firm in 1914 established the Austral Bronze Company of Sydney, which was sold to Metal Manufactures in 1929. During the 1920s Austral Bronze had begun making high quality extruded rods and bars, as well as sheets, for ornamental doors, windows and grilles, which were to become prominent in Australian commercial and public buildings, for this business was continued under the new ownership.[159] By the 1930s the company dealt in a considerable range on non-ferrous metals, which have been mentioned above. But bronze was always a niche market, and by 1954 even the Bronze Window Frame Co was manufacturing only in aluminium.[160]

The Colonial Ammunition Company had by 1921 begun producing brass sheet and strop for commercial purposes, before giving up in again 1924 due to lack of profitability. By the late 1920s the government that munitions factories should enter the commercial trade and the Colonial factory, which had been taken over by the government, entered into a contract with Noyes Brothers on a substantial scale. The competition, Austral Bronze, did not have a plant 'with the power and versatility of the Department's plant'. Austral Bronze protested against the new arrangement, but a deal was struck in which they would supply the New South Wales and Queensland markets, while the Footscray factory supplied Victoria, South Australia and Tasmania.[161] By the 1950s Noyes Bros were acting as distributors for another manufacturer of extruded brass rods and sections. Metalex Pty Ltd of South

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155 M H Ellis, *Metal Manufactures Ltd* (Sydney 1966), p 8.

156 Ellis, *Metal Manufactures Ltd*, pp 8-14.

157 Ellis, *Metal Manufactures*, pp 18-21.

158 *Commonwealth Engineer*, 1 July 1948, p 492.

159 Ellis, *Metal Manufactures*, pp 28-9.

160 *Ramsay's Catalogue* [1954], § 21/1. However J Connolly Ltd still made bronze windows, though probably on a small scale in relation to its extensive range of steel windows and its new aluminium types: ibid, §2 1/5.

161 Allom Lovell [report on Colonial Munition factory - check], p 38.

Oakleigh. Melbourne.[162] Despite all this activity importation from overseas continued, and Anaconda Architectural Bronze Extruded Shapes, produced by the American Brass Company, seem to have been used in Australia during the 1920s.[163] In 1939 St Patrick's Cathedral, Melbourne, was supplied with a grille and gates constituting the largest piece of architectural bronze work in the southern hemisphere.[164]

After World War II Extruded Metals Pty Ltd of Maidstone, near Melbourne, was dealing in brass and bronze alloys 'in association with' the Brass Company of Australia. They advertised a range of balustrades, architectural mouldings, lift doors and cars, stair components, partitions, shopfronts, ventilators, ducts and door hardware.[165] Brooks Robinson made a range of architectural metalwork in stainless steel, bronze, copper, aluminium and nickel.[166] The Wunderlich company made a similar range of products, apparently using a wider selection of metals - not just bronze, copper and brass, but also stainless steel, aluminium, zinc and galvanized steel.[167] A lesser rival was Chubb's Australian Co Ltd of Sydney, which had expanded from the field of safe manufacture into architectural metalwork in steel, bronze and aluminium.[168]

By the 1950s there was quite a fad for roofing or re-roofing public buildings in sheet copper. The great glazed dome of the Melbourne Public Library, which had leaked in recent rains, was subjected to what were described as repairs, in copper and aluminium.[169] In fact the whole of the glazing was sealed off in copper, and it was almost half a century before a more enlightened regime re-opened the glazed lights. The historically important St Matthews Church, Windsor, New South Wales, had had its shingle roof repaired three times already, and in 1955 it was decided to roof it in copper.[170] This was laid over resin-bonded marine plywood underlined with aluminium, both metals being hot resin-bonded to the plywood sheet. The domed Academy of Science building in Canberra, by Roy Grounds, was of concrete clad in copper.[171]

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162 F W Ware & W L Richardson [eds], *Ramsay's Architectural and Engineering Catalogue* (3rd ed, Melbourne 1954), § 19/6.

163 American Brass Company, *Anaconda Architectural Bronze Extruded Shapes* (Waterbury [Connecticut] 1926. The writer holds a copy of this catalogue, together with a typescript letter addressed by the company to Charles Foster of Prahran, advising of corrections and amendments.

164 *Herald*, 24 October 1939.

165 F W Ware & W L Richardson [eds], *Ramsay's Architectural and Engineering Catalogue* (2nd ed, Melbourne 1949), § 19/2; *Ramsay's Catalogue* [1954], § 19/1.

166 *Ramsay's Catalogue* [1954], § 19/2.

167 *Ramsay's Catalogue*[1949], § 19/5; *Ramsay's Catalogue* [1954], § 19/8.

168 *Ramsay's Catalogue* [1954], § 19/7.

169 *Cross-Section*, no 29 (1 March 1955), p 2 .

170 *Cross-Section*, no 34 (1 August 1955), p 3 .

171 *Cross-Section*, no 51 (1 January 1957), p 1; no 54 (1 April 1957), p 1; no 59 (September 1957), p 1; no 81 (1 July 1959), p 1.

i. aluminium

Sir Humphry Davy had in 1807 suspected the presence of aluminium in clay, but was unable to extract it. In 1833, however, Beauxite [bauxite] ore was discovered near the eponymous village of Les Beaux in the south of France, and after this H C Oersted of Copenhagen University succeeded in producing what he believed to be aluminium. Shortly after this the German Friedrich Wöhler produced aluminium in powder form, and then in 1845 he succeeded in transforming it into very small particles. In 1854 both the Frenchman Henri Sainte-Claire Deville and the German Robert Von Bunsen succeeded in isolating aluminium by the use of sodium rather than potassium, achieving 96-97% purity.[172] Deville had experimented both with the reduction of aluminium chloride using potassium, and with an electrolytic method, but the first was impractical because of the cost of potassium and the danger of handling it, the second because of the limited capacity of the electric batteries then available. Deville then turned to a sodium production method and developed it so successfully that it remained largely unchanged for thirty years.[173]

Deville had designed a process and plant for the production of aluminium on a scale which, though still very small, far exceeded the grains of metal produced by earlier means. As a result the metal became available, though there was little technical information about it other than that in French or German.[174] Bars of aluminium were shown at the Paris Exposition of 1855, and by about 1857 full scale production was established at Nanterre by Deville and Morin,[175] and in London by W Gerhard[176] (this latter lasting for only four years). From 1860 to 1874 Bell Brothers, under Deville's supervision, manufactured the metal at Washington, near Newcastle,[177] and in 1874 J F Wirtz and Co established works at Berlin.[178] In 1884 Colonel William Frismuth obtained a patent for the sodium reduction process[179] and began operations at Philadelphia, with little success, and then began to experiment with electrolytic methods.[180]

The first impact of aluminium in Australia was that of the Aluminium Crown Metal Co of Hollywood, near Birmingham. In 1881 Webster patented an improved process for making alumina, and in the following year the Aluminium Crown Metal Co was established at Hollywood to exploit it, in conjunction with the Deville method of

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172 J W Richards, *Aluminium: its History, Occurrence, Properties, &c* (2nd ed, Philadelphia 1890 [1886]), pp 17-21; Paul Weidlinger, *Aluminum in Modern Architecture,* volume II (Louisville [Kentucky] 1956), pp 13-14. For details of the Les Beaux and other deposits see Richards, p 47.

173 E J Ristori, 'Aluminium', *Encyclopædia Britannica* (10th ed, new volumes) XXV (London 1902), p 339.

174 Elton Engineering Books, *Catalogue Number 13* (London 1998), p 110, note on J W Richards, *Aluminum: its History, Occurrence, Properties, Metallurgy, &c* (Philadelphia 1887); S J Kelley, 'Aluminum', in T C Jester [ed], *Twentieth-Century Building Materials* (Washington [DC] 1995), p 47.

175 Richards, *Aluminium,* p 24.

176 James Ashby, 'The Aluminium Legacy: the History of the Metal and its Role in Architecture', *Construction History,* XV (1999), p 80.

177 Richards, *Aluminium,* pp 17-18; Ristori, 'Aluminium', p 340.

178 Richards, *Aluminium,* pp 39-41.

179 Ashby, 'The Aluminium Legacy', p 80.

180 Richards, *Aluminium,* pp 40-41.

production. In 1886 new patents on the sodium process, representing the first significant improvements to the Deville method, were taken out by H Y Castner of New York. Castner had realised that sodium was the only practicable reducing agent, and had set out to reduce its cost, with such success that by 1887 it could be produced at less than a quarter of the former price. The Aluminium Co of Oldbury was then formed to combine the advantages of Webster's alumina and Castner's sodium, beginning manufacture in 1888.[181] The Aluminium Crown Metal Co, now of London, mounted an exhibit at the Centennial Exhibition, Melbourne, illustrating the Castner production process.[182] In the same year, the new works to produce aluminium by Castner's process was opened at Oldbury, near Birmingham, and Castner expected to be able to reduce the price from forty to fifteen shillings a pound.[183]

However, the Castner process was not the revolution it seemed, for electrical reduction had now become viable, and was soon to sweep the field. In 1883 the Gräteels process, using electrolytes, was patented in Germany, and this was then exploited commercially by the Aluminium und Magnezium Fabrik, Patent Gräteel, near Bremen.[184] In 1885 E H & A H Cowles patented a viable method, which they brought into production at Lockport, New York State, and then at Stoke-on-Trent, England.[185] In 1886-7 Charles Martin Hall of the United States, and Paul Héroult of France, discovered simultaneously an improved electrolytic process for the electrical reduction of alumina to metallic aluminium in a warmed bath.[186] The metal suddenly became much more viable for commercial purposes, and by 1888 Hall's process was put into commercial production by the Pittsburgh Reduction Company, which later became the Aluminum Company of America (Alcoa).[187] Hall was granted a United States patent in 1889,[188] and Héroult obtained French and other European patents in 18878-8 and began manufacture with the Societé Metallurgique Suisse, near Schaffhausen, in 1888.[189] Between 1885 and 1892 the price of aluminium in the United States dropped from $11.33 a pound [454 g] to fifty-seven cents.[190] In 1890 the Hall process was in operation at Patricroft, Lancashire, though this continued only until 1894, and other works followed in Europe. In 1895 the British Aluminium Company was established to mine bauxite and manufacture alumina in Ireland, prepare the electrodes at Greenock, reduce the aluminium at Foyers, and refine and work up the metal at the Milton factory of the old Cowles syndicate.[191]

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181 Richards, *Aluminium,* p 31; Ristori, 'Aluminium', p 341.

182 Centennial International Exhibition 1888-1889, *Official Record* (Melbourne 1890), pp 466, 984.

183 *Australasian Builder & Contractor's News,* 12 January 1889, p 31.

184 Richards, *Aluminium,* p 32.

185 Richards, *Aluminium,* p 35.

186 Ristori, 'Aluminium', p 341. See also *Australian Aluminium Data* (Sydney, no date [c 1956], p ii; Marian Bowley, *Innovations in Building Materials* (London 1960), p 308.

187 Kelley, 'Aluminum', p 47.

188 Richards, *Aluminium,* p 33.

189 Richards, *Aluminium,* p 36.

190 Paul Weidlinger, *Aluminium in Modern Architecture, Volume 2: Engineering Designs and Details* (Louisville 1956), p 15.

191 Ristori, 'Aluminium', pp 341 -2.

Aluminium was first used more or less architecturally in 1884 for the tip of the Washington Monument, weighing about three kilograms.[192] Then in 1893 aluminium elements were used in the Venetian, Isabella and Monadnock buildings in Chicago,[193] and in Britain the 'Eros' statue in Piccadilly Circus, a memorial to Lord Shaftesbury, was cast in aluminium in the same year.[194] Its use increased steadily from this point on. In about 1912 over nine hundred sand cast aluminium spandrels were used in the Koppers Building, Pittsburgh, and in 1930 the A.O. Smith Corporation Research and Engineering Building in Milwaukee, by Holabird & Root, was clad entirely in aluminium.[195] The use of aluminium for cladding, in the form of spandrels, panels and pier casings soon spread to Britain.[196] In the United States G A Dick had extruded both brass and aluminium in the 1890s, and by the 1920s aluminium extrusions were manufactured extensively,[197] using heat-treatable high strength alloys, together with the anodic treatment which protected, and if necessary tinted the surface of the metal.[198] In the 1930s aluminium alloy glazing bars gained rapid acceptance in prestige buildings, up to the outbreak of World War II.[199]

Prefabrication in aluminium seems to have been pioneered for emergency housing by the Tennessee Valley Authority before World War II,[200] and then developed after the war largely because of the capacity in this field developed by wartime aircraft factories. In Britain in 1943 the privately organised Committee for the Industrial and Scientific Provision of Housing proposed to produce a two storey house of light alloy. This proposal as set aside, however, when the Bristol Aeroplane Co began instead to cooperate with the government in its scheme for the 'Aluminium Bungalow'.[201] It was only after World War II that the full potential of the material became apparent. In 1947 the American architect Pietro Belluschi designed an office building for *Architectural Forum* which was to have aluminium structural members, and aluminium sheet cladding with air space within it. The building did not proceed, but the concept was realised in the Equitable Building, of 1948.[202]

Until 1940 Alcoa had remained the sole American producer, but to meet wartime demand the United States Government invested in and subsidised the industry, so that production increased 600% between 1939 and 1943. Following the *Surplus Property Act* of 1944 the government began to divest itself of factories built with public money during the war, but anti-trust legislation initiated by the Justice Department, prevented Alcoa from acquiring the factories and hence from maintaining its regional monopoly. Instead the R J Reynolds Tobacco Company and the Kaiser Company (a

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192 Weidlinger, *Aluminum in Modern Architecture*, p 14.

193 Kelley, 'Aluminum', p 48.

194 Ashby, 'The Aluminium Legacy', p 82, citing Hobbs, *Aluminium*, p 367.

195 Kelley, 'Aluminum', p 49.

196 E G West, 'Aluminium and its Alloys', in John Madge [ed], *Tomorrow's Houses: New Building Methods Structures and Materials* (London 1946), p 31.

197 Kelley, 'Aluminum', p 48.

198 Ashby, 'The Aluminium Legacy', pp 83-4.

199 West, 'Aluminium', pp 27-8.

200 J H Markham, 'Prefabrication as an Aid to Building', in F E Drury et al [eds], *Architects', Builders' and Civil Engineers' Technical Catalogue* (London 1946), p 363.

201 R B White, *Prefabrication*, (London 1965), p 130.

202 M L Clauscen, 'Belluschi and the Equitable Building', *Journal of the Society of Architectural Historians*, L, 2 (June 1991), pp 109-129.

shipbuilding and heavy construction business) bought into the industry. The three companies then worked to expand the peacetime market by promoting innovations in aluminium and supporting new developments,[203] the most relevant to Australia being the R J Reynolds Co. One of the fields which the new companies were able to exploit was that of aluminium siding, especially that in a weatherboard or clapboard profile.[204]

One of the earliest impacts of the metal in Australia, apart from the Aluminium Crown Metal Co's exhibit in 1888-9, may have been its use in the 1890s for stamped metal ceilings - if we can believe Susan Bures on this point.[205] It is also reported that the 'Secretariat Buildings' of the New South Wales Government in Sydney were roofed in corrugated sheet aluminium in 1900. After forty years the underside was still bright, the upper face pitted to a depth of only 0.13 mm, and the strength little below that of new sheet.[206] More certainly, the giant aluminium screen of the 'photo-play theatre' or cinema of the Crystal Palace, Sydney, was completed in 1912.[207]

Rather surprisingly, Mayes's price book of 1908 lists the prices of aluminium ingots, sheets, round bars, flat bars and wire,[208] just as if these components were regularly used in the local building industry, which they certainly were not. However, by 1930 the Intercolonial Boring Co of Brisbane was advertising aluminium for a range of industrial products, including 'fluted matting', 'step edging', 'gutterplate' and 'door plate',[209] while later in the 1930s Wunderlichs advertised aluminium alloys in architectural metalwork.[210] By this time an aluminium alloy manufactured in Britain as 'Birmabright' was in use especially for strips and beadings in glass walling, but had not so far been much used for cladding in general.[211] In 1938, according to Roy Lumby, the David Jones building at the corner of Elizabeth and Castlereagh Streets, Sydney, by Partridge & Mackeller (diagonally opposite the 1928 building of Budden & Mackellar) had aluminium framed windows and a fluted aluminium fascia.[212]

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203 Dennis Doordan, 'Promoting Aluminum: Design and the American Aluminum Industry', in Dennis Doordan [ed] *Design History: an Anthology* (Cambridge [Massachusetts] 1995), pp 158-164, ref especially Sterling Brubacher, *Trends in the World Aluminum Industry* (Baltimore [Maryland] 1967); Charles Corr, *Alcoa, an American Enterprise* (New York 1952); M J Peck, *Competition in the Aluminum Industry 1945-1959* (Cambridge [Massachusetts] 1961).

204 John Lauber, 'And it never needs Painting: the Development of Residential Aluminium Siding', *APT Bulletin*, XXXI, 2-3 (2000), passim.

205 Susan Bures, *The House of Wunderlich* (Kenthurst [NSW] 1987), p 45.

206 Brian Grant, 'Light Metals'. in Eric de Maré [ed] *New Ways of Building* (London 1958 [1948]), p 204.

207 *Sydney Herald*, 11 June 1912, extract forwarded by John Sellwood, who is compiling material on James Baxter, builder.

208 Mayes, *Australian Builders Price Book* (1908), p 189.

209 *Architect and Builder's Journal of Queensland*, 10 April 1930, p 53 [reference supplied by Michael Kennedy].

210 C E Mayes, *The Australian Builders' and Contractors' Price Book* (10th ed, Sydney 1938), advertisement p 1.

211 Percy Thomas, *Modern Building Practice* (4 vols, London, no date [c 1935]), advertisement p 1.

212 Patrick Van Daele & Roy Lumby, *A Spirit of Progress: Art Deco Architecture in Australia* (Sydney 1999), p 42.

It was not until 1941 that the Australian Aluminium Company Pty Ltd began production of a wide range of semi-fabricated aluminium and aluminium alloy commodities at Granville, New South Wales. During the first four years the total output was diverted into the war effort, principally for aircraft construction, but from 1945 aluminium was supplied to industry in rapidly increasing quantities.[213] By 1948 a range of alloys was being produced for food processing equipment, the ribs and panels of road transport vehicles, aircraft construction, beer barrels and milk cans, and, finally, window frames and gutters.[214] In 1949 the company was advertising a range of much more specifically architectural products, including grilles, windows, staircases, roofing, awnings, furniture, lifts, doors, spandrels and cast figures.[215] In 1953 an American eagle almost twelve metres high was installed on the American War Memorial in Canberra.[216]

In 1948 it was reported that an aluminium production plant was to be established at Bell Bay near George Town, as the result of a contract between the Tasmanian Hydro-Electric Commission and the Aluminium Production Commission, and of a guarantee by the premier to maintain an adequate water supply.[217] Nothing seems to have come of the high grade bauxite fields in the Wessel Islands, off the Northern Territory, which were reported in 1954.[218] Production was due to begin at Bell Bay in 1951,[219] but the first ingots did not appear until 1955, and even then in the face of severe criticism of Commission, which was unable to account for £1,200,000 of its expenditure between November 1949 and October 1952.[220] In 1955-6 the Commission achieved an output of 5520 tonnes, and substantial sales to Japan and India.[221] A proposal was also under discussion for the Reynolds Metal Co of New York to establish a local prefabrication plant at Bell Bay, which would absorb some of the aluminium production.[222] This does not seem to have eventuated.

Meanwhile Metal Manufactures Ltd had been using imported aluminium in some of its products from the first years, and Austral Bronze engaged in aluminium rolling in the early 1950s and then, in about 1957, set up a substantial aluminium fabrication plant. As a result of a policy shift dictated by shareholders, however, this plant was soon sold off to other interests.[223] Australian investigators had reported in 1949 on the use of aluminium alloys in the United States for roofing shingles and wall siding,[224] and by 1950, as will appear below, Wunderlichs were making pressed aluminium ceilings and wall linings. By 1954 Econo-steel was making an aluminium

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213 *Australian Aluminium Data*, p i.

214 *Commonwealth Engineer*, 1 January 1948, p 248.

215 F Wentworth & W L Richardson [eds], *Ramsay's Architectural and Engineering Catalogue* (Melbourne 1949), § 19.2.

216 *Cross-Section*, no 12 (1 October 1953), p 2.

217 *Commonwealth Engineer*, 1 June 1948, p 449. The location is erroneously given as Native Point

218 *Cross-Section*, no 19 (1 May 1954), p 2.

219 *Commonwealth Engineer*, 1 June 1948, p 449.

220 *Cross-Section*, no 26 (1 October 1953), p 2.

221 *Cross-Section*, no 19 (1 May 1954), p 2.

222 *Commonwealth Engineer*, 1 June 1948, p 449.

223 Ellis, *Metal Manufactures*, pp 49-52.

224 D V Isaacs & J W Drysdale, *Building Technique and Building Research* (Sydney 1949), p 40.

cladding sheet in the same profile which it used in zincanneal steel, as well as in a weatherboard profile,[225] as discussed below.

By the 1950s sheet aluminium was being used for roofing in various composite forms. A lightweight type consisted of a layer of bituminous felt or similar material, and then two layers of 42 gauge aluminium, with each of these layers set in hot bitumen and the top one finished with Alcote Liquid Aluminium. For a more heavily trafficked surface one layer of felt, one of aluminium and another of felt were used. For a permanently trafficked location on a concrete slab it was one of felt, two of aluminium and one of felt, on top of which were placed precast InsulTiles set in hot bitumen, or cast in situ granolithic paving.[226] In 1954 Australuco Aluminium was advertising aluminium for roofing in both flat sheet and corrugated form.[227] In 1956 an aluminium sheet roofing requiring no nails, Noral Snaprib, was demonstrated by the New Zealand Loan & Mercantile Agency Co as agents for the British manufacturers. It came in 22 inch [559 mm] widths up to 30 feet [9 m] long, and each strip fitted over the rib of the previous sheet, on the one side, and clips fixed to the roof framing, on the other.[228] Another aluminium roofing, Fural, described as 'zip-on', was used in 1957 on the Beaurepaire Sports Centre at Melbourne University.[229]

Aluminium foil insulation, as discussed elsewhere, came to Australia in the early 1950s. The use of marine plywood with an aluminium surface, at the Myer Music Bowl, has been discussed above. Another hybrid material was asbestos cement sandwiched between aluminium sheets, and this was used for a standardised bus shelter design introduced in Perth in 1957.[230] In about 1958 the Lincoln Electric Co factory at Padstow, New South Wales, was built with 1226 square metres of 'curtain walling' consisting of square panels with 25 mm of rock wool sandwiched between aluminium sheets, all clipped and bolted in a welded steel frame.[231]

The most enduring market for aluminium was probably doors and windows, especially in domestic applications. By 1954 makers included the Bronze Window Frame Co, Chubb's Australian Co, J Connolly Ltd, Australian Metal Products [Dowell] 'Alwintite',[232] and Australuco Aluminium.[233] In May 1959 H M Cowderoy's factory at Balgowlah, New South Wales, was enlarged to 15,000 square feet [1400 m^2], for not only had the local demand for its sliding aluminium windows increased, but they had been exported for use in a luxury villa in France and 250 flats in Coventry, England. They were also being manufactured under licence in the United States.[234] Locally, steel was largely superseded for domestic windows by 1960.

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225 *Ramsay's Catalogue* [1954], § 16/11.
226 *Ramsay's Catalogue* [1954], § 12/1.
227 *Ramsay's Catalogue* [1954], § 19/3.
228 *Cross-Section*, no 51 (1 January 1957), p 2.
229 *Cross-Section*, no 54 (1 April 1957), p 1.
230 *Cross-Section*, no 59 (September 1957), p 2.
231 *Cross-Section*, no 75 (1 January 1959), p 3.
232 *Cross-Section*, no 75 (1 January 1959), p 3.
233 *Ramsay's Catalogue* [1954], §§ 21/2, 21/21/4, 21/5. 21/10.
234 *Cross-Section*, no 79 (1 May 1959), p 2.