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 2 1/4 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,

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; also Great Exhibition, *Reports by* the *Juries on the Subjects in the Thirty Classes into which the Exhibition was divided* (London 1852), p 15.

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

but a local smelter was now being constructed by Graham & Hallett.[5] By 1850 some 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] In 1890 Wunderlichs installed a copper roof on the spire of St James's Church, Sydney, the appearance of which was criticised. When it began to acquire a more desirable patina they were criticised for inducing this artificially, though all they had done, according to Ernest Wunderrlich, was to sponge it with seawater from Coogee.[9] 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,[10] a fate which may well have been shared by other examples.

Roofing lead would generally have been rolled sheets, which had first begun to replace cast lead in England in the 1670s, because they were lighter and easier to work, though regarded as inferior.[11] The Melbourne Hospital of 1846 had 'a curious cupola formed of lead-covered wood', something which the architect, Samuel Jackson, seems to have used elsewhere as well.[12] In the latter part of the nineteenth century the rise of the Second Empire Style caused a demand for more ornamental lead elements, until they were superseded by the lighter, cheaper and more convenient zinc products. In 1876 it required a specific resolution of the Hotham Town Council, in Melbourne, to invest in a lead cable moulding for the hips of the new town hall roof. [13]

Lead was mined in South Australia from the 1840s.[14], and in New South Wales by 1870,[15] but the local products rarely found their way directly into

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5 Great Exhibition, *Catalogue*, II p 991; *Reports by* the *Juries,* p 15.

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 Ernest Wunderlich, *All My Yesterdays: a Mosaic of Music and Manufacturing* (Angus & Robertson, Sydney 1945), p 37.

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

11 When the first lead rolling mill was established in Paris in 1729 it was a matter of some controversy, resulting in the publication of Pierre Remond de Saint-Albine's *Mémoire sur le Laminage du Plomb* in 1731: Hugh Pagan Limited, *Catalogue 54 Architecture* (London 2006), p 36.

12 'Garryowen' [Edmund Finn], *The Chronicles of Early Melbourne 1835 to 1852* (2 vols, Fergusson & Mitchell, Melbourne 1888), I, p 239.

13 Bill Hannan, *Pride of Hotham* (North Mebourne 2006), p 105.

14 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*

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.

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.[16] 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[17] patented in England in 1832, apparently by George Frederick Muntz, although others had previously developed similar combinations of copper and zinc,[18] 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,[19] 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.[20] Other references wich follow, such as one in 1853 to 'Muntz's metal sheeting and felt'[21] do not seem to be related solely to

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Little Cornwall (Adelaide 1969 [1962]), pp 18-20; Douglas Pike, *Paradise of Dissent* (Melbourne 1967 [1957]), pp 301-2.

15 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.

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

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

18 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.

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

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

21 *Argus,* 20 July 12853, p 7.

sheathing of ships', but there is no clear evidence of irs architectural use at this stage. .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.[22] In 1880 P H Muntz & Co of London showed what was described simply as 'Muntz Metal' at the Melbourne International Exhibition.[23]

Sheets of muntz metal were used to clad the dome of Barnet's Goulburn Court House, completed in 1887,[24] and nails were imported in the 1881,[25] 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,[26] 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.[27] The sheeting, together with 'naval brass' sheeting, was advertised by Austral Bronze in 1931.[28] 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.[29] As made by ICI in Britain in the twentieth century, it was 60% copper, up to 6% lead, and the balance zinc.[30] Composition roofing nails were somewhat similar, with a ratio of copper to zinc of 7:4.[31]

An American text of 1861 gives the composition of various brasses, bronzes and other alloys, of which the following are a selection:[32]

	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

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

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

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

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

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

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

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

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

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

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

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

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[33] 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.[34] The Austral Bronze Co Ltd was established in 1915[35] and by the 1930s, in addition to muntz metal, produced copper and brass sheets, phosphor copper, manganese bronze, and phosphor bronze.[36] 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.[37] By the 1950s they were also advertisding their 'copper strip' dampcourse, discussed below. 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 for roofing,[38] 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.[39]

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.[40] The metal was little used until the discovery of electroplating in 1840, after which it

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

34 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.

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

36 *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.

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

38 It was exhibited in 1862: London, International Exhibition of 1862, *The International Exhibition of 1862. Illustrated Catalogue of the Industrial Department. British Division* (2 vols, Her Majesty's Commissioners, London 1862), class I, p 14; Robert Mallet, *The Record of the 1862 International Exhibition* (Glasgow 1862), p 82. 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.

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

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

rapidly rose to prominence. Even so it was some time before it had much impact in Australia. 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.[41]

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.'[42] 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.[43] 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.[44] 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.[45]

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.[46] 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.[47] 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 International Nickel Company.[48] It was used for sinks until superseded by stainless steel, as well as for grilles, reliefs, and architectural details.[49] In Australia it was used for the carving table and bain marie at the Government Savings Bank, Sydney, or 1926-8.[50] Later it was advertised by Ferrier & Dickinson for domestic kitchen sinks, commercial kitchen equipment generally, and hospital uses,[51] and its use for 'Metalite' glazing bars will be referred to

41 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.

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

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

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

45 *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.

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

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

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

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

50 *Building,* 21 December 1928, p 75.

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

below. 'Metalite' brass-mounted metal light fitting were also imported.[52] 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.[53]

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.[54] 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',[55] and in 1597 Andreas Libavius described the metal as a 'peculiar kind of tin' from India.[56] The word 'zinc' first appears in the writings of Paracelsus (d 1541).[57] 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,[58] and in either 1738 or 1742 Antonius Van Swab extracted the metal from its ores.[59] It is claimed that one Dr Lane succeeded in smelting zinc ore at his copper works at Swansea in 1720,[60] and it has been more securely said that by 1730 zinc had been smelted in England.[61] In 1740 it was produced on a commercial scale by William Champion of Bristol,[62] and it is reported that the secret of the process had been bought from Van Swab whilst he was on a visit to Britain.[63] At the Great Exhibition of 1851 T B & J Lawrence of London, manufacturers, showed 'British zinc ores' and a variety of products including ingots, rolled sheets, plates, perforated sheets and nails.[64]

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

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

54 *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.

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

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

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

58 Chambers, 'Zinc'; Rees, 'Zinc'.

59 Chambers, 'Zinc'.

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

61 Dittmar, 'Zinc', p 784.

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

63 Chambers, 'Zinc'.

64 Great Exhibition, *Catalogue,* II, p 598.

In 1789 the Abbé Dony of Liège developed a means of distilling calamine ore and charcoal, and depositing metallic zinc in a retort.[65] But it was only in about 1807 that this was developed to an industrial scale and the first Continental zinc works were established at Liège.[66] This came about when the chemist J J Dony – presumably the Abbé, but conceivably a relation - claimed to have mastered the refining of zinc, and in 1806 was given a concession to mine the ore.[67] The first good sheet of rolled zinc is said to have been produced by Dony in 1808, and he went on to roof the Church of Barthelemy in that town with the new material.[68] In 1809 the State Engineer, Mathieu, attested that industrial production had been achieved, and in 1810 Napoleon issued a permit for the establishment of a full scale furnace. However Dony experienced great difficulties, and in 1813 his factory was acquired by Dominique Mosselman.[69] It was Mosselman's heirs who created the Vieille Montagne Zinc Company in 1837.[70] The company first overcame the difficulties involved in rolling thin sheet zinc, and then went on to develop stamped products, drawn zinc mouldings, nails, spikes and wire, and large ornamental castings. By 1850 it was producing 11,500 tonnes of zinc annually, and newer companies had sprung up in competition.[71]

At the Great Exhibition the Societé des Mines at Fonderies de Zinc de la Vieille Montagne, of Liége, exhibited zinc ore in various forms, raw zinc, sheet zinc for roofing &c, bars for ships' nails, and a range of zinc compounds.[72] 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.[73] 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.[74] By 1855 the company had works in Belgium,. Prussia, and France, was purchasing zinc from other works for further manufacture, and

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65 E-O Lami, *Dictionnaire Encyclopédique et Biographique de l'Industrie et des Arts Industriels* (7 volumes & Supplément, Paris 1881-1891), VII, p 1133.

66 Dittmar, 'Zinc', p 784.

67 *Société des Mines et Fonderies de Zinc de la Vieille Montagne Société Anonyme Liége* (Liége 1937), pp 15-16.

68 James McCawley, *Roofing* (New York 1938), p 150. Mc Cawley refers to him as the Abbé Dony of Liège.

69 *Société Vieille Montagne* [1937], pp 15-16.

70 *Société Anonyme des Mines et Fonderies de Zinc de la Vieille-Montagne* (Paris 1933), no page.See also Susan Becker, *'Multinationalität hat Verschiedene Gesichter', Formen internationaler Unternehmenstätigkeit der Société Anonyme des Mines et Fonderies de la Vieille Montagne und der Metallgesellschaft vor 1914* (Franz Steiner, Stuttgart 2002).

71 London, Great Exhibition of the Works of Industry of all Nations, 1851, *Reports by the Juries on the Subjects in the Thirty Classes into which the Exhibition was divided* (London 1852), p 4.

72 Great Exhibition, *Catalogue,* III, p 1152.

73 *Illustrated Exhibitor,* 2 (14 June 1851), pp 35-6; Great Exhibition, *Catalogue,* I, p 161.

74 Great Exhibition, *Catalogue,* III, p 1227.

produced annually 25,000 tonnes of sheet zinc, and 5,000 tonnes of zinc white for paint.[75]

An upstart Societé de la Nouvelle Montagne (ie the new mountain as opposed to the old) of Verviers showed its own ores, sheet zinc, roofing tiles,[76] and two models of zinc roofs,[77] 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.[78] 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.[79] This was apparently the red oxide ore which was especially characteristic of the United States.[80]

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.[81] According to Ure this patent was rendered ineffective by the low price and 'superior tenacity' of copper for the same purposes.[82] 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.[83]

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 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.[84] By 1834 there was said to be an abundance of zinc available for roofing purposes at Cape Colony (South Africa),[85] no doubt as a

75 Warington Smyth, 'On Class I. Mining and Metallurgical Products', in United Kingdom, Parliament, *Reports on the Paris Universal Exhibition* (2 vols, HMSO, London 1856), II, p 55..

76 Great Exhibition, *Catalogue,* III, p 1151.

77 Great Exhibition, *Reports by Juries*, p 23.

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

79 Great Exhibition, *Catalogue,* III, p 1447. See also Great Exhibition, *Reports by Juries*, p 18.

80 D S Price, 'Metallurgical Operations', in Robert Mallet [ed], *The Record of the 1862* International *Exhibition* (Glasgow 1862), p 134.

81 *Repertory of Arts,* IX, 52 (September 1806), pp 251-2. Channing, 'Zinc', p 81, says that Hobson & Sylvester obtained a patent in 1805 for manufacturing zinc wire and vessels.

82 Andrew Ure, *Dictionary of Arts, Manufactures and Mines* (London 1839), p 1330.

83 *Repertory of Arts,* IX, 52 (September 1806), pp 251-2.

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

85 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.

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.[86]

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.[87] 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.[88]

d. zinc sheeting

Late in the 1840s the desirability of zinc roofing was being questioned in Britain, but the Vieille Montagne Company's agent attempted to rebut the criticisms by citing its use in large shed roofs at Amsterdam and Rotterdam, the prison at Cherbourg, and other buildings.[89] In 1854 Morewood, Rogers & Co's Melbourne agency was selling what they called plumbic zinc,[90] which was zinc coated on one or both sides wirh lead, so as to combine the

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

87 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.

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

89 *Builder,* 18 July 1849, p 353, quoted in Channing, 'Zinc', p 81.

90 *Argus,* 9 February 1854, p 7.

lightmerss of zinc with the slow oxidation of lead,[91] the main use of which would have been for roofing. In fact in April that year two substantial houses and six cottages offered in sale in what is now Fitzroy were described as having plumbic zinc roofing and spouting.[92] Later in the year Morewqood & Rogers;s patent plumbic zinc was being sold at W Parker's Collingwood Store (as distinct from their local agency).[93]

Zinc was used on a small minority of buildings in Melbourne,[94] and one must assume that it was generally laid in the traditional method 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 side joints over upstanding timber rolls to ensure watertightness.[95] However examples of zinc roofing have rarely been reported in Australia,[96] 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.[97] 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.[98]

By 1851 the more elaborate forms usually associated with the Second Empire style were beginning to appear, and Mme Deydier of Vaugirard, Paris, exhibited a dormer window and roofng for a belfry, both in zinc.[99] In the 1870s Jacob Hilgers of Rheinbrohl, whose galvanized iron has been referred to above, was also advertising flat and corrugated zinc sheets, and even illusdtrated an arched corrugated zinc roof.[100]

Corrugated zinc sheets, plate II.

Arched roof, plate V.

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91 Robert Hunt [ed], *Hunt's Hand-Book to the Official Catalogue of the Great Exhibition: an Explanatory Guide to the Natural Products and Manufactures of the Great Exhibition of the Industry of all Nations, 1851* (2 vols, Cambridge UP 2011 [1851]), I, p 53.

92 *Argus,* 7 April 1854, p 9.

93 *Argus,* 24 May 1854, p 8.

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

95 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.

96 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

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

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

99 Great Exhibition, *Catalogue,* III, p 1919.

100 Jacob Hilgers, Rheinbrohl [Rheinprovinz], loose sheet marked as Tafel V, no date {Miles Lewis collection]..

In 1854 not only zinc roofing tiles, but spouts, pipes, heads and brackets, were being advertised in Melbourne for supply on contract.[101] 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,'[102] and in Western Australia G D C Lefroy made his own zinc gutter in 1852 for his house at 'Walebing', the roofing of which was an early use of galvanised iron.[103] Charles Laing, in 1849, specified: 'The whole of the eaves throughout to have zinc trough spouts 20 inchesin girt and neatly turned over the spout to form a roll moulding.[104] 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.[105]

Zinc was not used merely for roofing. Complete zinc buildings were being made in London by 1839 and advertised for the use of emigrants to Australia,[106] and in the early 1850s such buildings were imported in significant numbers. I have touched upon this topic elsewhere,[107] 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,[108] 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 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.[109]

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

101 *Argus,* 27 January 1854, p 10. In 1859 Edmund Westby advertised, from stock, zinc (as opposed to galvanized or cast iron) water pipes, and Thomas Warburton advertised zinc (as opposed to galvanized iron) spouting. C Mayes, *The Victorian Contractors' and Builders' Price-Book* (C Mayes, Melbourne 1859), advertisements pp A, xxii.

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

103 Ingrid van Bremen, 'Earth Structures: Rammed Earth and Mud Brick', *Architect* (Spring 2004), p 8.

104 Charles Laing, 'Specification of work to be performed and materials to be provided in the erection and completion of a Villa intended to be built at Coryule Indented Head for Mesdames Drysdale and Newcomb' (1849) State Library of Victoria, p 10.

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

106 Hewetson's advertisement, loc cit.

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

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

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

building at Guildford, the walls of which are more or less completely clad in flat zinc sheets.[110] 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.[111]

Frederick Braby & Co's 'Italian-forned' zinc roof sheting.

For some time from the 1850s onwards Frederick Braby & Co of London were 'sole manufacturing agents' for the Vieille Montagne company for Great Britain, India and the colonies.[112] They showed their Vieille Montagne 'Italian-formed' zinc at the London Exhibition of 1862. It appears to have been in sheets like modern metal tray roofing, wtih either two or three rfbs to the width.[113] In 1887-8 they supplied the Vieille Montagne roof for the proposed Toowoomba Railway Station[114] (which was not in fact used, but sent elsewhere) and apparently for other stations on the line. In 1883 their catalogue explained that the the Vieille Montagne Company made a special quality if zinc sheeting for them, stamped: [115]

"ROOFING ZINC"
"F. BRABY"
& CO.

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.[116] J W Tyler of Westminster sold and laid Devaux Vieille Montagne Thick Roofing Zinc, which was

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110 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.

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

112 They are so described in their catalogue *Frederick Braby & Co. (Limited), Sole Manufacturing Agents for the Vieille Montagne Company in Great Britain, India, and the Colonies. Instructions for the application of Zinc for covering Houses, Railway Stations, Platforms, Sheds, Farm Buildings, Verandahs, Conservatories and other Structures ... Architects and Engineers to the Company. J & R Fisher, Great George Street, Westminster, S. W.* (London 1869), cited in [Guedes] 'Queensland's Imported Railway Stations', np According to their 1883 catalogue, *infra,* they have been manufacturing agents for thirty years.

113 London, International Exhibition of 1862, *The International Exhibition of 1862. Illustrated Catalogue of the Industrial Department. British Division* (2 vols, Her Majesty's Commissioners, London 1862), class 10, p 38.

114 *Builder,* XXV, 1269 (1 June 1867), p 393..

115 F W Braby & Co, *F. W. Braby & Co. No. 9* (London 1883), p 3.

116 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.

presumably the sort approved by Mayes, and claimed to lay it according to the principle established by the architect James Edmeston.[117] 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*.[118]

The only one substantial example of early zinc roofing is known to survive in Australia is the stables at 'Bontharambo', Victoria, probably of the later 1850s. The sheets are nearly three feet [900 mm] on the slope and perhaps eight feet [2.4 m] across. Each has the lower edge turned under and the upper edge turned out, so that they lock together. The lowest sheet has been placed first, and fixed with tingles which hook into the turnover of the top edge and are then fixed to the rafters just above the top of the sheet. Then the next sheet is fitted in and fixed the same way, andf so on.[119] The roof of Charles Tiffin's Parliament House, Brisbane, of 1865-6, was of more substantial, architecturally formed, Vieille Montagne zinc, not sent direct from Belgium, but 'prepared and fitted' in London under James Edmeston's supervision,[120] which is consistent with Tyler's advertisement. It arrived in '33 large cases', but was found to have manufacturing defects.[121] At the Paris Exposition of 1867 the Veille Montagne Company of Paris showed a system of ribbed zinc sheeting secured to the purlins by hook bolts.[122]

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[123] - a new development, of which more below. In the 1930s the Vieille Montagne company illustrated sheet zinc roofing in trays which were laid over boarding, lapped at the side over trapezoidal timber rolls, and fixed at the upper edge with tingles.[124] They had also introduced of form of zinc decking, and were still manufacturing corrugated sheet. In 1957 a pavilion was built at the

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

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

119 Inspected 2007. The tingles are bent-over straps, similar to the tingles or bale hooks used to fix the overlapping pieces of glass in greenhouse roofs. See A C Passmore, *Handbook of Technical Terms Used in Architecture and Building, &c* (London 1904), sv Tingles.

120 *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.

121 Guedes, 'Queensland's Imported Railway Stations, p 111, note 4, cites Bruce Buchanan & Associates Architects, 'The History of Partliament House, Queensland: a Report prepared for the State Works Department (Ipswich [Queensland] 1983), especially §7.6.

122 R S Burn, *Modern Building and Architecture: a Series of Working Drawings and Practical Designs, &c* (A Fullarton & Co, Edinburgh, no date [c 1870]), p 198.

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

124 *Société Vieille Montagne* [1933], no page: 'Partie Haute en Basse d'une Couverture à Tasseaux et Agrafures'.

Launceston Showground to display the products of the Electrolytic Zinc Co, with a curved and ribbed zinc roof, and zinc gutters downpipes and trimmings.[125] 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.[126] 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,[127] 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.

England, patent no 399 to L A C St P de Sinçay. 9 February 1869, for metallic roofing tiles.

Tiling of exactly the Woodlands sort was shown by the Vieille Montagne company at the Paris Exposition of 1867,[128] and similar tiles illustrated by Barberot are also said to be made by the Vieille Montagne Zinc Company.[129] An English pattern of 1869[130] seems to describe this system, but it was possibly 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.[131]

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.[132] Mme Deydier's factory at Vaugirard, already mentioned, seems to have produced individual zinc tiles on a fishscale pattern, and individual

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

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

127 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).

128 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.

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

130 England, patent no 399 to L A C St P de Sinçay. 9 February 1869, for metallic roofing tiles.

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

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

ridge tiles, as well as larger elenents such as finials.[133] Others manufactured corrugated or ribbed ('Italian') zinc sheets, which seem have regularly been used over battens without any layer of boarding.[134] 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.[135] Whether any such roofing was used in Australia is unclear, because of the perennial 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.[136] 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.[137] They are probably the same as the interlocking zinc tiles which, together with fishscale tiles, were being advertised early in the twentieth century.[138] The diamond shape appears at the former fuse factory, Bendigo, Victoria, on tower roofs which were probably added in 1892 to the design of William Beebe.[139] The Vieille Montagne company was still marketing both the square and the diamond patterns in the 1930s.[140] 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

Zinc had a great variety of applicatons other than roof sheeting and tiles. In the 1850s zinc roof ridging and spouting were regukarly advertised.[141] It is not entirely clear how a soft metal would be used for these purposes, but another advertisement for 'Zinc Spouting (double beaded)' perhaps suggests that it gained strength from the complexity of the cross-section.

Folded zinc was regularly used for glazing bars in Britain, and Tarbuck illustrates nine sections, all apparently quite small and used for purposes

133 London, Great Exhibition *Art Journal Illustrated Catalogue,* p 147.

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

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

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

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

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

139 Mike Butcher entertains the possibility that they date from the 1880s, but this seems improbable: Mike Butcher, 'Safety Fuse and Powder Manufacture in Bendigo', in Mike Butcher & Yolande Collins [eds], *Bendigo at Work: an Industrial History* (National Trust, Bendigo [Victoria] 2005), p 55 & illustration, p 57

140 *Société Vieille Montagne* [1933], no page.

141 *Argus,* 18 June 1853, p 10.

such as diamond glazing, rather in the manner of lead cames.[142] 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. Most of the present windows are re-creations. It seems possible that similar windows by Manning survive at 'Moorlands', near Bunbury, Western Australia.[143] 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.[144]

Caroline Drysdale and Elizabeth Newcomb had 'zink cottage windows' in their cottage at the Boronggoop run in the Port Phillip District, of 1841.[145] Their later house, 'Coryule' at Drysdale, has diamond paned casement sashes, and the bars are of what appears to be solid cast zinc rather than folded sheet. In 1833 'zinc glazed windows' wwere on sale in Melbourne.[146] Zinc glazing bars are identifiable in two South Australian buildings, the Rosaville Methodist Chapel at Mount Gambier, of 1869,[147] 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.[148] By 1908 zinc glazing bars 'fitted with capping' were listed in Mayes's price book,[149] but these must have been a different thing altogether.

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,[150] and in 1850 a cask of perforated zinc in assorted sizes was offered for sale in Hobart.[151] At the Great Exhibition perforated zinc was shown by a number of firms, including T B & J Lawrence.[152] 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

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

143 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.

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

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

146 *Argus,* 5 August 1853, p 7; 24 May 1854, p 8.

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

148 Information from Ron Danvers, 1991.

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

150 Hewetson's advertisement in Stephens, *Land of Promise*.

151 *Hobart Town Courier,* 3 January 1850, p 3

152 Great Exhibition, *Catalogue,* II, p 598

> front and two sides & all the corners of the wood are closely joined, & covered with tin.[153]

Vieille Montage zinc for safes, larders and ventilators is listed by Mayes in 1862 and later, in 9 or 10 gauge.[154]

Henry Hewetson's advertisement of 1839 also listed perforated zinc for dairy windows, and 'perforated metallic window blinds'[ie perforated screens],[155] 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',[156] and Harcourt Quincey of Birmingham and Sheffield (better known as a shutter manufacturer) advertised 'Corrugated Window-Blinds, in perforated Metal.'[157] In 1879 perforated zinc doors were reported among other measures to minimise the heat at 'Czar Lodge' in Hay, New South Wales.[158] 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.[159] Braby also offered a wide range of perforated zinc 'friezes and frets'.[160]

Cast zinc products tend to be later. Cast zinc came into use in Berlin in about 1832. In 1850 it was reported that M Geiss of Berlin had developed the use of cast zinc for architectural ornaments, and it had been praised by Schinkel, but not so far used in England.[161] At the Great Exhibition Geiss showed a number of statues, as well as capitals, columns and tiles of cast zinc,[162] and castings were also shown by a number of other German makers and one French one,[163] many in imitation of bronze like those of the Vieille Montagne Company, mentioned above. It was reported that almost every modern building in Prussia used some zinc work, whereas it was fairly rare in England.[164] It was of course still later in Australia, but the The AMP Society Building in Sydney, of 1863-4, carried a cast zinc sculptural group on the parapet, depicting the goddess Tyche next to a cornucopia, and three other figures. This had been modelled by Charles Summers and cast in Melbourne.[165] In 1890 it was reported that the roof of the Commercial Bank

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153 Joseph Elliott, *Our Home in Australia* (Sydney 1984), p 61.

154 Mayes, *Price-Book* (1862), p 94.

155 Hewetson's advertisement in Stephens, *Land of Promise*.

156 Great Exhibition, *Catalogue,* II, p 598

157 Great Exhibition, *Catalogue,* I, advertisement p 44

158 M A Gardam, *The Bishop's Lodge* (Hay [NSW] 1993), p 10, quoting *Riverine Grazier,* 2 April 1879, p 2.

159 *Frederick Braby & Co. No 9* [catalogue] (London 1883), pp 5-19.

160 *Frederick Braby & Co,* pp 20-29.

161 *Builder* [London], 28 July 1849, p 353, quoted in Channing, 'Zinc', p 82. See also John Timbs [ed], *The Year-Book of Facts* (London 1850), pp 86-7.

162 *Illustrated Exhibitor,* 23 (8 November 1851), p 415; Great Exhibition, *Catalogue,* III, p 1063.

163 De Braux, D'Anglure, of Paris: Great Exhibition, *Catalogue,* III, p 1218.

164 John Timbs [ed], *The Year-Book of Facts* (London 1850), pp 86-7.

165 London, Great Exhibition, *Art Journal Illustrated Catalogue,* p 37.

in Melbourne was to be of cast zinc,[166] but this was probably an erronwis reference to the pressed zinc thn being introduced by Wunderlichs, as dscussed above.

Zinc came to replace lead for elements of mansard roofs such as ridging, cable mouldings, lucarnes and finials, one French example being Victor Laloux's Gare d'Orsay, Paris, of 1900.[167] In Australia in 1883 and 1886 Mayes listed Corinthian capitals for three inch [77 mm] wood or iron columns.[168] 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'.[169] 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'.[170] Even quite large capitals for hall columns were cast in zinc.[171] 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.[172] 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.[173] 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],[174] the latter giving a finished surface of 13 x 17$^{3}/_{4}$ inches [330 x 451 mm].[175] For 'Hyde Hall', New York, tinplates of the 10 x 14 inch size are thought to have been used i 1829-

166 *Buuilding, Engineering and Mining Journal,* 26 July 1890, p 256.

167 Patrick Drevet & Douglas McGuige, *Vieille Montagne Zinc Cu-Ti Nf A* (Liège 1993), p 39.

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

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

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

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

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

173 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.

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

175 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).

30.[176] 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.[177] In 1827 Basil Hall reported that about a quarter of the houses in Quebec were roofed in sheet tin, and some had their walls clad in the material.[178]

The art of tinning iron had first been developed in Bohemia, but introduced into Saxony in 1630, and into Britain in 1670 when works were established at Pontypool in Wales.[179] Wales was henceforward a leading source, and the main supplier of tinplate to the United States. One of leading 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, which serves as a flux, they are dipped into melted tin, which is diffused by heat over the surface, and the tin plates completed.[180]

In 1873 two tinplate works were established in the United States, and another two years later, but all three ceased in 1878. This was blamed upon the inadequate duty charged on imported tinplate, and American manufacture resumed only after 1891 when the duty was doubled.[181] In 1892 N & G Taylor of Philadelphia advertised 'American bright tin plate', 'American roofing tin'. the 'Taylor Old Style', the 'Taylor Roofing', and Taylor's Columbia'. They claimed to have been founded in 1810 and to be the originators of 'stamped and guaranteed roofing tin'.[182] It is unclear whjether this means that they had revived a business dating from before the 1870s, and nor is it clear how the Taylor products related to the others.

In 1853 Morewood, Rogers & Co were selling, through their Melbourne agent David Cannan 'Patent tin plate' and 'Tin plates IX and IXX', apparently for architectural purposes.[183] But in Australia tinplate was probably used less for roofing than for small household or other items of tinplate, often japanned.[184] 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.[185]

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176 Diana S Waite, *19th Century Tin Roofing and its Use at Hyde Hall* (New York State Historic Trust, New York 1971), pp 27-9.

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

178 Basil Hall, *Travels in North America in the years 1827 and 1828* (3 vols, Edinburgh 1830), I, p 390.

179 J S Swank, *History of the Manufacture of Iron in all Ages, &c* (2nd ed, Philadelphia 1892 [1884]), pp 49-50.

180 Great Exhibition, *Catalogue,* I, p 174. See also *Reports by the Juries,* p 13.

181 Swank, *Manufacture of Iron,* p 459.

182 *Scientific American* [Architects and Builders Edition], XIII, 1, January 1892, p xviii.

183 *Argus,* 9 February 1854, p 7.

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

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

A related material, used overseas but not apparently in Australia, was 'terneplate' in which the coating contained more lead than tin, making it much cheaper but with a duller finish.[186] Terneplate 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.[187] It was manufactured in smaller quantities than tinplate, and more for the American than the British market.[188] By 1870 it was being exported from Britain to Canada on a large scale, for roofing purposes.[189] 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.[190]

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.[191] This was a material containing the tin ore cassiterite,[192] which was obtained in the Ovens Valley.[193] By early 1860 it was being smelted by the Victoria Tin Smelting Company of William Street, Melbourne,[194] but this enterprise must have failed, for nothing is heard of it later. Other miners continued, and in one period of three months in 1886 New South Wales alone exported 400 tonnes.[195]

In Melbourne tin roofing tiles were advertised for sale in 1853 by John Stirling[196] and by Ferguson & Urie, who also advertised tin roofing,[197] doubtless the same 'improved tin roofing' which they displayed at the Melbourne Exhibition of 1854.[198] 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.[199] A 'tinsmith' would work not only in tin but in other metals: thus, for

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

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

188 Diana S Waite, *19th Century Tin Roofing and its Use at Hyde Hall* (New York State Historic Trust, New York 1971), p 5.

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

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

191 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.

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

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

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

195 *Australasian Ironmonger,* 1 November 1886, p 178.

196 Of Smith Street, Collingwood: *Argus,* 11 August 1853.

197 *Argus,* 4 October 1853, p 8.

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

199 *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 1859), for Rippingille's address at La Trobe Street East, also C B Mayes, *The Victorian Contractors' and Builders' Price-Book,* p xl.

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.[200] There was even a local Operative Society of Tinsmiths.[201] 'Rolled tin' was used on the roof of the Treasury Building, Brisbane, of 1886-9.[202]

Tin packing case lining was often recycled for building purposes, a practice specifically recommednded in the *Settler's Hand Book* of 1861.[203] Examples included the old bark hut at Airey's Inlet, Victoria, where it weas used as the bottom layer beneath the bark roof (the building was destroyed by fire in 1983). In Albert and May Wright's house at 'Nulalbin', New South Wales, of 1871, the sitting room was reportedly lined with tin and painted,[204] though this may be an erroneous reference to some other metal lining

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,[205] 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.[206]

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200 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.

201 *Argus,* 24 May 1854, p 8.

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

203 *Australian Settler's Hand Book: the Farm, being Practical Hints, &c* (Sydney 1861), p 7.

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

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

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

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 interests, and in doing so faced the probable collapse of the local metal mining industry.[207] 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.[208] 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.[209]

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.[210] 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.[211] 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.[212]

The Colonial Ammunition Company had by 1921 begun producing brass sheet and strop for commercial purposes, before giving up in again 1924 due

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

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

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

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

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

212 *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.

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.[213] By the 1950s Noyes Bros were acting as distributors for another manufacturer of extruded brass rods and sections. Metalex Pty Ltd of South Oakleigh. Melbourne.[214] 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.[215] 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.[216]

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.[217] Brooks Robinson made a range of architectural metalwork in stainless steel, bronze, copper, aluminium and nickel.[218] 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.[219] 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.[220]

By the 1950s there was quite a fad for roofing or re-roofing public buildings in sheet copper. The domed Academy of Science building in Canberra, by Roy Grounds, was of concrete clad in copper.[221] In Melbourne the roof of the Shrine of Remembrance was sheathed in copper on Grounds's advice, with disastrous aesthetic effect. By this time copper was also being used as a dampcourse, as discussed elsewhere. The great glazed dome of the

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

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

215 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.

216 *Herald,* 24 October 1939.

217 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.

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

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

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

221 *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.

Melbourne Public Library, which had leaked in recent rains, was subjected to what were described as repairs, in copper and aluminium.[222] 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.[223] This was laid over resin-bonded marine plywood underlined with aluminium, both metals being hot resin-bonded to the plywood sheet.

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.[224] 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.[225]

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.[226] 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,[227] and in London by W Gerhard[228] (this latter lasting for

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

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

224 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.

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

226 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.

227 Richards, *Aluminium,* p 24.

only four years).[229] It is unclear whether it is connected with an English patent taken out in 1857, on behalf of a foreigner, claiming to enable aluminium production on a practical and commercial basis. This involved replacing the clay vessels witrh ones of cast or wrought iron, and adding calcium fluoride rather than sodium chloride.[230] From 1860 to 1874 Bell Brothers, under Deville's supervision, manufactured the metal at Washington, near Newcastle,[231] and in 1874 J F Wirtz and Co established works at Berlin.[232] In 1884 Colonel William Frismuth obtained a patent for the sodium reduction process[233] and began operations at Philadelphia, with little success, and then began to experiment with electrolytic methods.[234]

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 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.[235] The Aluminium Crown Metal Co, now of London, mounted an exhibit at the Centennial Exhibition, Melbourne, illustrating the Castner production process, and obtained a first order of merit.[236] 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.[237]

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.[238] 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.[239] In 1886-7 Charles Martin Hall of the United States, and Paul Héroult of France, discovered simultaneously

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

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

230 *Builder,* XV, 739 (4 June 1857). p 196.

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

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

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

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

235 Richards, *Aluminium,* p 31; Ristori, 'Aluminium', p 341. They exhibited in 1862: Mallet, *Record of the 1862 Exhibition,* p 82.

236 Centennial International Exhibition 1888-1889, *Official Record* (Melbourne 1890), pp 466, 898, 984.

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

238 Richards, *Aluminium,* p 32.

239 Richards, *Aluminium,* p 35.

an improved electrolytic process for the electrical reduction of alumina to metallic aluminium in a warmed bath.[240] 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).[241] Hall was granted a United States patent in 1889,[242] and Héroult obtained French and other European patents in 18878-8 and began manufacture with the Societé Metallurgique Suisse, near Schaffhausen, in 1888.[243] Between 1885 and 1892 the price of aluminium in the United States dropped from $11.33 a pound [454 g] to fifty-seven cents.[244] 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.[245]

Aluminium was first used more or less architecturally in 1884 for the tip of the Washington Monument, weighing about three kilograms.[246] Then in 1893 aluminium elements were used in the Venetian, Isabella and Monadnock buildings in Chicago,[247] and in Britain the 'Eros' statue in Piccadilly Circus, a memorial to Lord Shaftesbury, was cast in aluminium in the same year.[248] Its use increased steadily from this point on. It was used to sheathe the cupolas of the Church of Gioacchino in Rome and the cornice of the Canada Life Building Montreal, both in 1897.[249] In about 1912 over nine hundred sand cast aluminium spandrels were used in the Koppers Building, Pittsburgh.[250] It was then used for the spire of the German Evangelical Church, Pittsburgh, in 1927,[251] and in 1930 the A.O. Smith Corporation Research and Engineering Building in Milwaukee, by Holabird & Root, was clad entirely in aluminium.[252] Then in 1931 cast aluminium spandrels were used at the Rockefeller Center, New York[253]

240 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.
241 Kelley, 'Aluminum', p 47.
242 Richards, *Aluminium,* p 33.
243 Richards, *Aluminium,* p 36.
244 Paul Weidlinger, *Aluminium in Modern Architecture, Volume 2: Engineering Designs and Details* (Louisville 1956), p 15.
245 Ristori, 'Aluminium', pp 341 -2.
246 Weidlinger, *Aluminum in Modern Architecture,* p 14.
247 Kelley, 'Aluminum', p 48.
248 Ashby, 'The Aluminium Legacy', p 82, citing Hobbs, *Aluminium,* p 367.
249 John Peter, *Aluminium in Modern Architecture* (2 vols, Reynolds Metals Company, Louisville [Kentucky] 1956), I, pp 9-10.
250 Kelley, 'Aluminum', p 49.
251 Peter, *Aluminium in Modern Architecture* I, p 10.
252 Kelley, 'Aluminum', p 49.
253 Peter, *Aluminium in Modern Architecture* I, p 10.

The use of aluminium for cladding, in the form of spandrels, panels and pier casings soon spread to Britain.[254] 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,[255] using heat-treatable high strength alloys, together with the anodic treatment which protected, and if necessary tinted the surface of the metal.[256] In the 1930s aluminium alloy glazing bars gained rapid acceptance in prestige buildings, up to the outbreak of World War II.[257]

The Aluminaire house, designed by AL Kocher & Albert Frey, 1931. John Burchard, 'Survey of Efforts to Modernize Housing Structure', in A F Bemis, *The Evolving House,* vol III, *Rational Design* (Cambridge [Massachusetts] 1936), p 336.

In 1936 an attempt was made to promote aluminium for the upper end of the housing market by the creation of the 'Aluminaire House'. Prefabrication in aluminium was also developed for emergency housing by the Tennessee Valley Authority before World War II,[258] 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'.[259] 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.[260]

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 shipbuilding and heavy construction business) bought into the industry. The three companies then worked to expand the peacetime market by promoting

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

255 Kelley, 'Aluminum', p 48.

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

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

258 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.

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

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

innovations in aluminium and supporting new developments,[261] 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.[262]

The first impact of aluminium in Australia occurred in the 1880s. As early as 1884-5 'the best aluminium metal' was used for the taps and other bathroom fittings of the 'Villa Alba' in the Melbourne suburb of Kew,[263] and in 1886 Gibbs, Bright & Co showed plates and ingots by Webster's Patent Aluminium Crown Metal Co at the Sydney Scientific and Mechanical Exhibition.[264] The Aluminium Crown Metal Co's exhibit in 1888-9 probably made it much better known, and it has been claimed to have been used in the 1890s for stamped metal ceilings.[265] 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.[266] More certainly, the giant aluminium screen of the 'photo-play theatre' or cinema of the Crystal Palace, Sydney, was completed in 1912.[267]

Rather surprisingly, Mayes's price book of 1908 lists the prices of aluminium ingots, sheets, round bars, flat bars and wire,[268] just as if these components were regularly used in the local building industry, which they certainly were not. However, by 1923 a nickel aluminium sink and draining board ('can't get dirty') was advertised by R J Ball of Melbourne.[269] In 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',[270] while later in the 1930s Wunderlichs advertised aluminium alloys in architectural metalwork.[271] By this time an aluminium alloy manufactured in Britain as 'Birmabright' was in use especially for strips and beadings in glass

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261 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).

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

263 *Table Talk,* 26 June 1885, p 4.

264 *Australasian Ironmonger,* 1 October 1886, p 164.

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

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

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

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

269 V C Marshall, *The 'Herald' Ideal Homes Exhibition, Wirth's Park, Melbourne* [catalogue] ([Herald, Melbourne] 1923), p 113.

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

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

walling, but had not so far been much used for cladding in general.[272] 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.[273]

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.[274] 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.[275] 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.[276] In 1953 an American eagle almost twelve metres high was installed on the American War Memorial in Canberra.[277]

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.[278] Nothing seems to have come of the high grade bauxite fields in the Wessel Islands, off the Northern Territory, which were reported in 1954.[279] Production was due to begin at Bell Bay in 1951,[280] 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.[281] In 1955-6 the Commission achieved an output of 5520 tonnes, and substantial sales to Japan and India.[282] A proposal was also under discussion for the Reynolds Metal Co of New York to establish a local prefabrication plant at Bell Bay,

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272 Percy Thomas, *Modern Building Practice* (4 vols, London, no date [c 1935]), advertisement p 1. In 1950 J Starkie Gardner Ltd of London were specialist suppliers of Birmabright: Evelyn Drury et al, *Architects', Builders' and Civil Engineers' Reference Book* (London 1950), p 790.

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

274 *Australian Aluminium Data,* p i.

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

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

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

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

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

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

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

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

which would absorb some of the aluminium production.[283] 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.[284] Australian investigators had reported in 1949 on the use of aluminium alloys in the United States for roofing shingles and wall siding,[285] and by 1950, as will appear below, Wunderlichs were making pressed aluminium ceilings and wall linings. By 1954 Econo-steel was making an aluminium cladding sheet in the same profile which it used in zincanneal steel, as well as in a weatherboard profile,[286] as discussed below. In about 1971 an aluminium house was built at Geelong.[287]

Kynalok corrugated aluminium alloy wall cladding (KSF, marketed by ICI) with secret fixing and an almost continuous two inch [50 mm] air space between the aluminium and the insulating board, giving a U value of 0.171, much lower than a cavity wall: view and diagram. Eric de Maré [ed], *New Ways of Building* (3rd ed, Architectural Press, London 1958 [1948]), p 220

Three examples of single lap aluminium alloy roofing sheet. Eric de Maré [ed], *New Ways of Building* (3rd ed, Architectural Press, London 1958 [1948]), p 220.

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.[288] In 1954 Australuco Aluminium was advertising aluminium for roofing in both flat sheet and corrugated form.[289] 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.[290] Another aluminium roofing, Fural, described as 'zip-on', was used in 1957 on the Beaurepaire Sports Centre at Melbourne University.[291]

283 *Commonwealth Engineer,* 1 June 1948, p 449.
284 Ellis, *Metal Manufactures,* pp 49-52.
285 D V Isaacs & J W Drysdale, *Building Technique and Building Research* (Sydney 1949), p 40.
286 *Ramsay's Catalogue* [1954], § 16/11.
287 *Australian Home Beautiful,* March 1972, p 73.
288 *Ramsay's Catalogue* [1954], § 12/1.
289 *Ramsay's Catalogue* [1954], § 19/3.
290 *Cross-Section,* no 51 (1 January 1957), p 2.
291 *Cross-Section,* no 54 (1 April 1957), p 1.

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.[292] 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.[293]

Aparet from the curtain wall, which is discussed elsewhere, 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',[294] and Australuco Aluminium.[295] 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.[296] Locally, steel was largely superseded for domestic windows by 1960.

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292 *Cross-Section,* no 59 (September 1957), p 2.
293 *Cross-Section,* no 75 (1 January 1959), p 3.
294 *Cross-Section,* no 75 (1 January 1959), p 3.
295 *Ramsay's Catalogue* [1954], §§ 21/2, 21/21/4, 21/5. 21/10.
296 *Cross-Section,* no 79 (1 May 1959), p 2.