8.09 Steel & Welding

the introduction of steel
local production
spans and frames
welding
stainless steel

the introduction of steel

Modern writers have been lax or ignorant in distinguishing uses of wrought iron and steel, and so one must treat with scepticism most claims of the early use of steel. Crucible steel is of little relevance to us, for the steel used in building was produced directly from iron by the Bessemer process, not in the original form of 1856-8, but as later improved by Mushet, and then by Siemens's open hearth process. It took a long time to have any impact on the building industry generally, especially in so remote a region as Australia. One reason was cost. In the early 1870s steel was about twice as strong as wrought iron and twice as expensive, and therefore offered little or no cost benefit (unless perhaps in extreme spans where self-weight became a significant issue).

Until late in the century the range of sizes rolled in steel was much smaller than in wrought iron,[1] which was a further disadvantage, and its physical properties were less than ideal. Although steel was better for bending and shaping, it lacked the fibrous quality of wrought iron, until in the 1880s a fibrous steel was developed and patented by Dorman, Long & Co in association with R Harrison of Middlesborough-on-Tees. Under this patent the new material was manufactured at a number of locations in the 'black country' of England, by the granulating and 'balling-up' of Siemens-Martin steel.[2] In consequence Dorman Long themselves were the major British exporters of steel to Australia.

The first Australian building to use conventional steel seems to have been the shearing shed at 'Afton Downs', Queensland, of 1887. The roof is of branded Dorman Long steel, and is thought that the building was brought from Melbourne.[3] An analysis has shown the material to be cast steel 'but of a rather inferior form being rich in inclusions which were not graphite (as observed in cast iron) or normal silicate slag.[4] This therefore sounds as if it preceded the fibrous steel which was soon to become Dorman Long's speciality. It was contemporary with the completion of

1 Ewing Matheson, *Works in Iron* (London 1873), pp 14-19.
2 *Australasian Builder and Contractor's News*, 10 September 1887, p 295.
3 Information from Geoff Morton of Cairns, 1998. The roof is described as consisting 'of arched steel trusses formed from angle iron top chords and forged steel rods for the remainder'. Morton has not described the framing below, but it seems that it is not of steel. The tradition was that the building, or at least the roof frame, came from an exhibition hall in Melbourne. However the date seems to render this proposition almost impossible.
4 D R Tilbrooke [of MEC Services Pty Ltd, South Australia], 'Report on Analysis: Sample of Iron/Steel from Afton Downs Wool Shed, 2 September 1999', kindly provided by Geoff Morton.

William le Baron Jenney's Home Insurance Building, Chicago, which used steel for the first time in a conventional building, in combination with iron, and it preceded the first steel frame in California, reputed to be the Hotel de Coronado in San Diego, by the architects Reid Brothers, of 1888.[5]

In 1888 Dorman Long showed their rolled steel joists at the Centennial Exhibition, Melbourne, and were awarded a silver medal.[6] They were alone in showing steel joists, and it seems likely that these were of the company's new form of the material. Other exhibitors displayed such steel products as plates, angles, bars, cast steel, and sheet steel. D Colville & Sons of the Dalzell Steel and Iron Works at Motherwell, Scotland, who were soon to be rivals of Dorman Long, exhibited 'Dalzell mild steel', not further specified.[7] In 1888-9 built-up steel beams were used in the ground to the sixth floors of the Australian Building in Elizabeth Street, and steel girders were used throughout the flooring of the National Mutual Building in Collins Street.[8] A steel frame was used in the extension of the Dennys Lascelles building at Geelong in 1889. In 1891-3 steel was used extensively in the Australian Club building in William Street, Melbourne, as will appear below.[9] The steel supporting the dome is branded in relief with the name of Dorman long, and stencilled with that of the fabricators, 'AUSTRAL OTIS C^{O} LTD.[10] Exposed steel trusses are said to have been used in G H M Addison's Exhibition Building, Brisbane, of 1891,[11] and steel girders were first used in Sydney at the CML Building of 1892, at the corner of Pitt Street and Martin Place. The F L Barker Wool Store in Sydney, of 1893, had cast iron girders and wrought iron beams, according to one report, but steel girders, according to another.[12]

By late 1891 R L Scruton & Co of Pitt Street, Sydney, were advertising as importers and manufacturers of rolled iron and steel girders[13] (and were obviously 'manufacturers' only in the sense of fabricating the materials, which were themselves imported). From this time onwards a considerable amount of steel was used, but all of it was imported from Britain, Belgium or Germany, until the Broken Hill Proprietary Co [B.H.P.] achieved significant local production at about the end of World War I. Johns' Hydraulic and Engineering Co were major Melbourne fabricators of imported steel, who acquired the Waygood lift company in 1893 and became Johns and Waygood. They imported Belgian and German Steel in competition with Dorman Long, and then from 1904 brought in rapidly increasing quantities from the Carnegie Steel Co. of Pittsburgh, acquired the agency, and began to advertise only this brand.[14]

---

5 Information from Peter Barrett, 2001, apparently citing the *Architect and Engineer of California*, XXIII. 3 (November 1910), pp 36-7.

6 Centennial International Exhibition 1888-1889, *Official Record* (Melbourne 1890), pp 467, 985.

7 Centennial International Exhibition, *Official Record*, p 985.

8 Robert Haddon, 'Australian Planning and Construction', in G A T Middleton [ed] *Modern Buildings* (6 vols, London, no date [c 1910]), V, p 152.

9 *Building & Engineering Journal*, 19 December 1891, p 275.

10 Inspection November 1998, courtesy of Janet Beeston.

11 Robert Riddel, 'Sheeted in Iron', in Trevor Howells [ed], *Towards the Dawn* (Sydney 1989), p 109.

12 Andrew Wilson, *F.L. Barker Wool Store Conservation Plan* (Sydney 1990), pp 15-16, ref *Building and Engineering Journal of Australia*, March 1893, p 107.

13 *Australasian Builder and Contractor's News*, advertisement plate, unpaginated but bound between issues of 31 October and 14 November 1891.

14 J M, M E & J M Coane, *Australasian Roads* (Melbourne 1908), advertisements p ii.

Dorman Long & Co of Middlesborough were major suppliers, with a Melbourne agency, and later with their own branch in South Melbourne.[15] Early Dorman Long steel carries not only the company's name, but also the city, first as 'Middlesboro', and later in full as 'Middlesborough', a change which Lawrence Hurst claims to date between 1896 and 1901, on the basis of dateable English examples,[16] and certainly one local example thought to date from about 1920 bears the full name.[17] Local experience is that the shorter version continues to appear well after the turn of the century (perhaps attributable to sluggish movement of stock in the 1890s). After 1931 an additional label 'BRITISH STEEL' is added in response to a 'buy British' campaign which followed the Depression.[18] Dorman Long were responsible for major works such as the extension of the Swanston Street railway bridge in 1908.[19]

Generally the other imported brands (if they appear at all) are also rolled into the web in relief, while fabricators' brands, like those of Johns and Austral Otis, are painted on, and in themselves give no indication of the source of the material. Common English brands, or 'rolling marks', are 'CARGO-FLEET', 'FRODINGHAM IRON & STEEL - CO. LTD' and 'DALZELL [crown] STEEL [year].[20] But as the beams and columns in a city building are normally fire protected these brands are not seen. The steel in the basement of the Australian Club extension, Melbourne, of about 1892 (as distinct from the Dorman long steel of the dome), is branded in relief with the Dalzell crown brand, but no year, and the core building of the Windorah Store, in Western Queensland, thought to have been built in about 1920, reportedly has a steel frame branded only 'DALZELL'.[21] The label 'LANARKSHIRE STEEL' can still be seen on the framing in the basement of the Dalgety Wool Store at Geelong on the Victoria Terrace frontage, which dates from 1901, and the stables of 'Dahwilly', southern New South Wales (probably early twentieth century).

An unidentified brand found in the water tower at 12 Millard Street, Wangaratta, Victoria, of 1902-3,[22] is

[mark like a small and a large 'L' in reverse] A. H. A. V. [mirror image of same mark]

The conservatory in Central Park, in the Melbourne suburb of Malvern, is said to date from about 1927 and is an epitome of the cutthroat international competition in the steel market during the Depression, with seven different brands, reportedly: BV & Co Ltd; Cargo Fleet; Fordingham [actually Frodingham]; Lanarckshire Steel Co Ltd Scotland [actually Lanarkshire]; Dorman and Long Co [actually Dorman Long &

15 Helen Hughes, *The Australian Iron and Steel Industry 1848-1962* (Melbourne 1960), p 28; Coane, *Australasian Roads*, advertisements p viii.
16 Lawrence Hurst, 'Date-It. Rolling Marks on Steel and Iron', *CHS Newsletter*, 54 (July 1999).
17 Outbuilding at 'Holey Plain', Victoria, inspected 2001.
18 Hurst, 'Date-It', p 1.
19 *Building*, 19 May 1908, pp 36-40.
20 Hurst, 'Date-It', p 1.
21 Letter from Mrs Dot Gordon, Windorah, 14 March 1994.
22 Inspection 1999, based upon information from Carl Doring and from the Victorian Heritage Register. The tank was designed by the Euroa engineer W C Howitt, and fabricated by A Challingsworth of East Richmond, Melbourne.

Co]; Australian Steel Industries [probably Australian Iron & Steel Ltd, though they were not in production until 1928]; and BHP.[23]

In Western Australia Saunders & Stuart of Perth, Fremantle and Kalgoorlie were 'resident representatives and attorneys' of the Frodingham Iron & Steel Co of Frodingham, near Doncaster, England, and the handbook they issued in 1905 gives a very good idea of the sections available. There were billets, blooms, slabs, rounds, squares, spring bars, nub bars, flats, keel bars, equal and unequal angles, bulb angles, zeds, channels, tees, various special sections, and no less than thirty-two I-sections, from 3 x 1$^1/_2$ inches [76 x 38 mm] to 16 x 6 [400 x 150 mm].[24] This was a little old-fashioned, compared with the range offered by H J Skelton & Co of London in the following year, which included broad flange beams,[25] but still more retardataire were Redpath, Brown & Co Ltd of Edinburgh, who were offering only the old British standard beams even in 1920. They were represented in Australia by James Hurll & Co Ltd of Sydney, with branches in Melbourne and Brisbane.[26]

The traditional way of rolling a joist was between two rollers which contained grooves corresponding to the flanges. The steel was squeezed into the grooves, but tended to be spongy and of poorer quality in this portion, so that the practicable depth of the grooves was quite small, and therefore the breadth of the flange was limited. Henry Grey, an Englishman who had migrated to America, developed the 'Grey Mill' while he was manager of the Carnegie Company's works at Homestead. This used main rollers shaped to fit the side of the beam, and other rollers at right angles to form the flanges. There were no rollers at right angles *within* the section, and the mill still could not produce the 'universal' section of more recent times, because a substantial taper was still required in the flanges. Nevertheless the effect was to make much broader flanges possible, and to reduce the need for sections built up by means of 'plating'.[27] How soon and to what extent Grey Mill sections were introduced in Australia has yet to be established. Little Carnegie steel has been identified in Australia, but one example is a tank stand at 'Elderslie', north-west of Winton in Queensland, the members of which are branded.[28]

After World War II cold-rolled steel strip became significant for building purposes, in the form of structural sections in 20 to 14 gauge [1-2 mm] thicknesses. The strip had to be imported to Australia, for although BHP were preparing to manufacture it, it was reported in 1949 that production was still some years away. Nevertheless a Scottish-made rolling machine was reported to be already in Melbourne.[29]

local production

23 Roger Beeston, 'Central Park Conservatory', *Architect* [Melbourne], October 1997, p 10.
24 *Frodingham Iron and Steel (Foreign and Colonial) Co. Ltd* (Perth 1905), passim.
25 H J Skelton & Co, *Structural Steel* (London 1905), pp 223-5.
26 Redpath, Brown & Co Ltd, *British Standard Beams* (Edinburgh 1920), passim.
27 Skelton, *Structural Steel*, pp 223-5.
28 Information from Richard Allom, Brisbane, 1991.
29 D V Isaacs & J W Drysdale, *Building Technique and Building Research* (Sydney 1949), p 51,

William Sandford had come to Australia in 1883 as an employee of Lysaghts, to establish their wire netting works on the Parramatta River. In 1886 he obtained a lease of the Fitz Roy Iron Works at Mittagong from the new owners, the Mittagong Land Company. Then, finding the works unsuited to his purpose, he visited Lithgow and was impressed by the Eskbank works, which he tried, unsuccessfully, to persuade Lysaghts to acquire. A cooperative of workmen, which was keeping the operation afloat, engaged Sandford as manager in 1886, and a few months later granted him a seven year lease with an option to purchase, which he exercised in 1892. He rolled scrap iron bars and sheets, installed a galvanising plant, and in 1899 ordered a Siemens-Martin steel plant from England. With this furnace, uneconomical though it proved to be, Sandford made steel for the first time in Australia.[30] Sandford was bought out by G & C Hoskins of Sydney, effective from 1 January 1908, when Charles Hoskins assumed control of the plant, at first expanding wrought iron production, before he recognised the expanding market for steel.[31] Between 1908 and 1913 the annual production of steel averaged only 3,736 tonnes, but in 1914-17, stimulated by a system of government bounties and by wartime demand, it averaged 22,030 tonnes.[32]

Meanwhile the Broken Hill Proprietary Company established works at Newcastle in 1913-15,[33] and in 1916-21 produced between 140,000 and 180,000 tonnes of iron and steel annually.[34] In effect, therefore, from the end of the Great War very substantial quantities of local steel were available to the building industry. None of this development meant that importation ceased. In the early years of the century it cost more to ship iron to Melbourne from Sydney than from Middlesborough, and given that the Australian iron had to be got to the coast in the first place, it remained at a severe disadvantage.[35] In the 1920s Cecil Hoskins, son of C H Hoskins, found himself unable to resource the replacement of the Lithgow works with a modern steel making plant, and therefore entered arrangements with two of the British steel exporters, Dorman Long and Baldwins, together with the local shipper and coal miner Howard Smith Ltd, to establish Australian Iron and Steel Ltd. The company got into production at Port Kembla in 1928.[36] It did not last long. The world entered the Depression, the Port Kembla plant was designed upon outdated British principles, the rates of pay were high, and BHP was able to use its size and capital reserves to outflank AIS at every point, finally acquiring it in 1935 and establishing a national monopoly in the steel industry

spans and frames

30 Hughes, *Australian Iron and Steel Industry*, pp 26-30, 37; also A W Jose & H V Carter [eds], *The Illustrated Australian Encyclopaedia* (2 vols, Sydney 1925), I, pp 669-70.
31 Hughes, *Australian Iron and Steel Industry*, pp 48 ff.
32 Jose & Carter, *Illustrated Australian Encyclopaedia*, I, pp 669-70.
33 Hughes, *Australian Iron and Steel Industry*, p 69.
34 Hughes, *Australian Iron and Steel Industry*, p 73.
35 Hughes, *Australian Iron and Steel Industry*, p 72.
36 Hughes, *Australian Iron and Steel Industry*, pp 106-7.

In 1891 an innovative steel frame was used in the Australian Club building in William Street, in which the first floor was suspended from steel lattice girders above, so that the ground floor could be kept clear of columns.[37] It appears that the girders have been raised above door height of the first floor, but the manner of suspending the beams below is not apparent from inspection. The trusses are filled (according to report) with terra cotta lumber, and it seems likely that the whole of the walls above, rising for another two floors, are of this material, so as to minimise the load.

Surprisingly, however, something very like this had been done in an imported iron building of 1853, though it is unlikely that Charlesworth, the Australian Club's architect, would have been aware of it. The Brown Brothers building at Geelong, imported from Robertson & Lister of Glasgow, is of two storeys, framed in wrought and cast iron, and clad in corrugated iron, with an arched roof. In the front part of the roof space are two timber queen post trusses, which have no function in relation to the arched corrugated iron roof (which is self-supporting). Three quarter inch [19 mm] rods hang from the panel points, two to each truss, to carry the first floor beams, thus allowing a clear span in the front part of the ground floor. The upper floor is divided into rooms as living quarters, and the rods are artfully concealed within the partitioning, which is only one board thick.

In 1908 Russell, Robson & Russell's warehouse in Bourke Street, Melbourne, incorporated the largest steel girder in Australia, measuring 16.8 metres long, 1.35 m deep and 0.6 m wide.[38] By 1919 the Sydney Steel Co claimed to have made Australia's largest steel girder for G & C Hoskins Ltd (predecessors of BHP). It was a parallel chorded open web girder 25.8 metres long, probably for an engineering rather than a regular building use.[39]

The Ritz Hotel in London, often claimed to be the first steel frame in Britain, was constructed only 1904 (in fact, though it was the most prominent, it was far from being the first). In 1906 the San Francisco earthquake and the subsequent fires had dramatically demonstrated the superiority of the steel frame over other forms of construction. The American-born Sydney architect, J B Clamp, wrote of these events as a baptism of fire for steel construction, and referred especially to the giant Call newspaper building, entirely consumed but for its steel frame, which was in due course re-clad in brick and concrete.[40] By 1908 amendments to the *Melbourne Building Act* were under consideration, designed to allow framed construction in either steel or reinforced concrete, clad in a non-structural curtain wall.[41] Meanwhile in 1908 Hooper & Co's Brunswick Stores was built (outside the area controlled by the Act), and claimed as 'the first example of the American style of steel construction'. There were steel piers set in behind its long expanse of display window, and other huge piers carried girders to support the second floor, so that the interior could be

37 *Building & Engineering Journal*, 19 December 1891, p 275.
38 *Building*, 18 February 1908, p 31.
39 *Building*, XXIV, 145 (12 September 1919), p 34.
40 J B Clamp, 'The Steel Age. Impressions of a Tour Abroad', *Building*, 12 September 1913, p 54, quoted by Peter Barrett in thesis notes, 2001, p 77.
41 *Building*, 19 May 1908, pp 72 ff.

partition-free.[42] The architects, H W & F B Tompkins, were to continue as the leading Melbourne innovators in steel.

Subsequent Melbourne examples of steel framing included the Centreway Building, Collins Street, of 1911; Collins House, Collins Street, of 1911;[43] the Methodist Book Depot, Little Collins Street, of 1912;[44] the Leviathan Store of 1912-13; the Commercial Travellers Association building in Flinders Street, of 1912-13 (fabricated by Johns & Waygood[45]), and the first Myers building of 1913-14 (the steel fabrication drawings for which survive).[46] All these were designed by H W & F B Tompkins. The Tompkinses did not have a total monopoly of steel construction in Melbourne, for Purchas and Teague's Australian Estates and Mortgage Company building in Flinders Lane, of 1912-13, was reportedly 50% greater in size than any other steel framed building in the country.

The first fully framed steel building in Sydney was Nelson house in Clarence Street, of 1910, nine storeys high and clad in a thin curtain of brickwork,[47] followed in 1911 by the Grace Brothers store in Broadway (demolished), which was reportedly of Dorman Long steel, in the form of a complete frame with non-load-bearing walls.[48] However Burcham Clamp criticised the *Sydney Building Act* as being 'legislatively ignorant of the constructional properties of the steel frame'.[49] Which was the first full steel frame in Brisbane is not clear, but Ascot Chambers in Queen Street, of 1923-5, is amongst the most important. It was designed by Hall & Prentice and was the first to reach the city's height limit of 132 feet [40.2 m].[50]

Within a few years pressed steel sections were being marketed locally by Gardner Constructions, for use especially for small structures such as garages, where the greater depth to weight ratio was useful.[51] More innovative was the Manufacturers' Pavilion, or 150th Anniversary Commemorative Pavilion, at the Royal Agricultural Society Showgrounds in Sydney, by the architects Trenchard, Smith & Maisey of 1937-8. Inside a brick outer carcase is a series of what appear to be two-hinged arches springing from near ground level. They are of openwork framing - apparently of steel with bolted joints - divided into thirty-two braced panels, and are deepest at the centre,

---

42 *Footscray Advertiser*, March 1908, quoted in *Footscray's First Fifty Years*, extract kindly supplied by Robert Green.

43 Minutes of the Royal Victorian Institute of Architects (La Trobe Manuscript Collection, SLV), 27 February 1912.

44 *Herald*, 12 March 1936.

45 *Journal of the Royal Victorian Institute of Architect*s, March 1918, p ix.

46 The bulk of the drawings are held by Tompkins Shaw & Evans, but for the amended contract signed on 1 December 1913 there are linen drawings of structural steelwork numbered 10A, 11A, 12A, 13A, 14A, 15A, 16A, 16B, 17A, 18A, 19A and 20A, discovered recently by Ms Stella Barber, Coles-Myer archivist.

47 Allom Lovell Marquis-Kyle, *Ascot Chambers, 225 Queen Street* (Brisbane 1992), p 29.

48 Information, 1997, from Janine Nicholson of Godden Mackay Pty Ltd, Sydney, who saw the demolition under way.

49 Clamp, 'The Steel Age' quoted by Barrett, p 78.

50 Allom Lovell, *Ascot Chambers*, passim, especially pp 7-10.

51 D W Tulloch, *Details of Australian Building Construction* (Melbourne, no date [c 1933]), p 84.

tapering off towards the supports, in the form of a more than semicircular crescent. Externally the arched form is concealed by a stepped up roof profile.[52]

In about 1936 W D Chapman wrote of the potential use of rigid welded joints for Vierendeel trusses, and one gathers that there were as yet no examples in Australia. Indeed Vierendeel's own bridges over the Albert Canal in Belgium had been built only from 1933 onwards, and the International Agricultural Co at Chicago Heights, a prominent American example of the Vierendeel frame used architecturally, would not be built until 1938.[53] Chapman does not even mention the portal frame, but in 1940 it was used for the Canberra Bus Depot in Wentworth Avenue, Kingston, ACT, to the design of the Government Engineer.[54] Open web joists became increasingly common after World War II, and began to be produced in standard sizes for uses such as industrial buildings and garages. The first tall city building in Melbourne was one at the corner of Lonsdale and Queen Streets, built in about 1958.[55]

welding

Welding is almost more confusing than the introduction of steel. Traditional welding, going back to Egyptian times, involved hammering or pressing together two pieces of heated metal, which is of no distinctive interest in Australian terms. Modern welding involves the actual melting of the metal to produce a more or less homogeneous joint. It is heated either by the use of an electric current to melt and fuse the two components, or with an oxy-acetylene or oxy-hydrogen flame, with the addition of weldmetal. A Victorian patent was granted in 1864 for 'an economical method of fastening the plates of girders, etc., by means of melted metal', of which no more is known,[56] but it is inconceivable that a sufficient temperature was achieved for this to be welding in the modern sense.

Oxy-acetylene welding had been introduced in Victoria by 1911. The leading suppliers were Commonwealth Oxygen & Acetylene Limited [Comox], who dealt in both the low pressure and the high pressure systems. In the high pressure system both the oxygen and the acetylene were supplied under pressure, the latter in a patent cylinder containing a porous mass charged with acetone. The proper mixture could be obtained by adjusting the regulators on each supply. In the low pressure system the acetylene was drawn direct from an acetylene generator, and the correct mixture depended upon a blowpipe action designed to draw the required amount of acetylene in when the oxygen was at the prescribed pressure. The high pressure system was recommended where first cost had to be minimised; where the use was intermittent, as in garages; where portability was important; and for use in confined spaces. The low pressure system was preferred in country districts remote from acetylene charging

52 Illustrated internally and externally in *Wunderlich Deep Corrugated Durabestos* (Sydney 1938), pp 4-5. Also Wunderlich Limited files in the Wunderlich Collection, Powerhouse Museum, Sydney, A7437 - 9 / 141, 145.

53 D J Wickersheimer, 'The Vierendeel', *Journal of the Society of Architectural Historians,* XXXV, 1 (March 1976), pp 55-9.

54 Information from Graham Trickett of Canberra, 2001.

55 *Cross-Section,* March 1958, n p.

56 No 681 to George Bate, 21 January 1864.

stations; for shops where the regular gas consumption was large, and for circumstances in which the working costs had to be minimised.[57]

Arc welding, developed from the electric arc lamp, had been introduced overseas in about 1885, at first using carbon rods, later replaced with metal wires.[58] In 1913 E J Rigby obtained the Australian agency for the English Quasi Arc Company,[59] and the company he formed with Robert Bryce under the style of Robert Bryce & Company Pty Ltd[60] did much to establish electric welding in Australia. It is said to have been first used in Victoria for tram tracks laid by the Prahran and Malvern Tramway Trust,[61] and it was used in Sydney for the manufacture of tramway rolling stock. In Victoria welding was also used from 1919 by the Metropolitan Gas Company, which made the world's first fully electrically welded gasholder at South Melbourne in 1922.[62] Only gradually did electric welding come into use for conventional buildings,[63] beginning in 1924 when the Metropolitan Gas Company built the first substantial example, an 800 tonne retort house at West Melbourne. This was followed by many thousands of tonnes of steel buildings and other work for the company.[64]

From 1927 to 1932 many welded buildings, amounting to more than 10,000 tonnes of steelwork, were built in Australia and New Zealand,[65] and in the latter year Eric Lang could speak of 'the almost wholesale adoption of the process by the engineering profession in recent years'.[66] In 1933 the Standards Association of Australia published its code for welded construction.[67] Gardner Constructions had been the pioneering independent contractors in the field, beginning with ten or more welded

---

57 N W Smith, *The Comox Welder's Manual* (Balmain [New South Wales]), pp 5-7.

58 C D Elliott, *Technics and Architecture* (Cambridge [Massachusetts] 1992), p 104.

59 George Weickhardt, 'The Development of Welding in Steel Construction', *Trust News,* XVIII, 9 (April 1990), pp 22-3, ref C A Masterton 'The Development of Electric Welding', *Journal of the Institution of Engineers, Australia,* XXXIII, 6; H Symons, 'Evolution of Welding in Australia', *Seminar, Australian Welding Institute,* 1987.

60 Robert Bryce & Co. Pty. Ltd., *Notes on the "Quasi-Arc" Process of Electric Welding for Iron and Steel* (Melbourne, no date). The parent company's *Particulars of the Quasi-Arc System of Electric Welding* (London, no date [?c 1915]), lists Melbourne amongst its branch locations, though the copy in the writer's possession bears the stamp 'Sole Agents / Robert Bryce & Co. Pty. Ltd. / 166 Clarence St., / Sydney'.

61 Peter Milner, 'Made in Victoria', *Historic Environment,* VIII, 3 & 4 (1991), p 11.

62 Weickhardt, 'Development of Welding in Steel Construction', pp 22-3. Milner, loc cit, refers to the Metropolitan Gas Company's holders at Melbourne and Fitzroy as being amongst the earliest examples.

63 See, for example, Clayton-Joel & Co., *Arc Welding Plants* (Melbourne, no date): the company's products are said to be used for bridge building, boiler work, oil tanks, steel pipes, railway stock and permanent way, structural steel work and all classes of repairs.

64 W D Chapman, *The Application of Welding to Buildings* (Melbourne, no date [c 1935]), p [3], states that it is eighteen years since electric welding was first used [overseas] in buildings, and twelve years in Australia, and on p [9] identifies a building of the Lincoln Electric Co in the United States as the first overseas example, of 1916, and the West Melbourne retort house of 1924 as the first local one of any magnitude. The dates are inconsistent, and would suggest a date for Chapman's paper of either 1934 or 1936.

65 Chapman, *Application of Welding,* p [9].

66 Eric Lang, *Engineering Aspects of Welding* [Melbourne 1932: reprint from the *Mechanical and Welding Engineer,* 20 September 1932], p 2.

67 Standards Association of Australia, *Code for Metallic Arc Welding in Buildings,* No. C.A.8, 1933.

roofs and single storey mill buildings in 1928-9.[68] By 1930 they were advertising their patented steel frame construction as being suitable for halls, stores, factories, woolsheds and other station buildings, and even illustrated a small church.[69] They claimed, in 1931:[70]

> Gardner Constructions are indisputably the leading Structural Welding Engineers in Australia. We are convinced that electric welding is better in every way than riveting. ... The design of electrically welded structures has now been developed on a rational scientific basis.

In 1929 Melbourne's first all-welded city building, that of Oxygen & Industrial Gases Pty Ltd, was built at 327 Spencer Street to the design of Arthur and Hugh Peck. The company was obviously one interested in promoting the new technology, and the building was advertised in the *Journal* of the Royal Victorian Institute of Architects.[71] Meanwhile welding was used in the later 1920s for the strengthening of existing railway bridges, and in 1933-4 a 228 metre welded steel bridge was thrown over the Upper Snowy River at McKillop's Crossing. This was very soon swept from its site in a flood.[72]

In 1934 the Grange Road bridge over the Yarra was built, and although electric welding had now become fully accepted, the details of the welding were still of sufficient interest to be published:[73]

> Main members are made up of two channels connected by batten plates, with the addition of cover plates and plates welded to the channel webs where additional area is required. The maximum chord section is composed of two channels 10 in, by 3 1/2 in. by 24.46 lb., one cover plate 14 in. by 3/4 in. and two web plates 10 in. by 3/4 in., total area 36.9 sq. in., carrying a calculated load of 530,000 lb. The largest web member is made up of two channels 12 in. by 3 1/2 in. by 29.23 lb., and two flats 6 in. by 3/8 in., carrying a calculated load of 290,000 lb. Sub-verticals are of two angles, battened, and sub-diagonals, subject to tension only, are of two flats. Batten plates are a simpler and cheaper form of column bracing than latticing. Gusset plates are avoided except at the joints at the pier bearings, resulting in a saving as compared with rivetted work. Butt splices, reinforced 10 per cent, are used throughout. Continuous welding is used around chord plates where there is any possibility of moisture getting in between the plate and channel.
>
> The channels of the top and bottom chords are spaced 12 in. back to back with flanges turned out. Tension diagonals are placed between the chord members with flanges of channel turned in, and with webs in contact with webs of chord members. Compression diagonals are placed outside chord members with

68 Chapman, *Application of Welding,* p [9].
69 *Australian Home Beautiful,* 1 October 1930, p 45.
70 W L Richardson [ed], *Ramsay's Architectural Catalogue* (Melbourne 1931), p 116.
71 *Journal of the Royal Victorian Institute of Architects,* September 1929, p xxxiii.
72 Weickhardt, 'Development of Welding in Steel Construction', pp 22-3.
73 R W McCall & A S Atkinson, *Design and Construction of the Grange Road Bridge Melbourne* (Melbourne 1935: reprint from the *Commonwealth Engineer,* February 1935).

> flanges turned out and with webs in contact with chord channels. To achieve this, portion of one flange of each chord channel was cut away to allow the diagonal compression member to be placed. Steel plate and butt welding was supplied at each weakened section to restore the full strength of the portion of chord channel flange cut out. ..... The flanges of the deeper channel were separated from the web by torch cuts for a distance of about 2 ft. back from the joint to be made. The flanges were then bent in until the distance back to back of flanges at the joint end was the same as that of the smaller channel. The severed portion of the flanges was then welded to the web with a run each side, and the superfluous triangular portions of web cut away by torch. The ends of the channels were then bevel-cut and butt-welded. Rocker bearings are connected to trusses by mild steel pins 4 in. diameter at abutments and 8 in. diameter at piers.

Just after this Gardner Constructions were responsible for the steelwork of the Richmond Baths in Victoria, which is similar in character to that of the Grange Road Bridge. Whilst the arches at the baths differ from this account in many respects, the description gives a good impression of the state of welded framing technique at the time, and is directly comparable in some points of detail, such as the pins, which were of 3½ inch [89 mm] diameter at the baths as compared with 4 inches [102 mm] at the bridge abutments. One distinctive feature at the baths is the use of angles welded edge to edge to create square sections, a technique illustrated in a contemporary paper by W D Chapman.[74] Another feature is the omission of bracing in one panel where the walkway of the upper gallery level passes through the truss: this panel is filled instead with a solid web with an opening through it. More detail about the actual process of welding at this time is available in a paper published by W D Chapman in 1935.[75]

In another paper published by Chapman at about the time the Richmond Baths were being built, illustrated two other welded steel buildings, a pavilion at the Flemington Racecourse and the totalisator building at Caulfield.[76] He also showed welded girders at Swan Hill Town Hall and a picture theatre at Oakleigh with welded roof trusses.[77] None of these was nearly so striking as the baths. The two fully steel-framed buildings at the racetracks were of modest dimensions and conventional design, while the picture theatre had conventional brick walls, and a simple pitched truss form with a curved bottom chord, over a considerably smaller span than at Richmond.

stainless steel

The term 'stainless steel' embraces a range of alloys containing iron and 11% or more of chromium, which were investigated early in the nineteenth century. So far as architectural purposes are concerned its use developed from the work of Edward Maurer of Germany in 1909-12 on austenitic stainless steel, which contains 18% of

74 Chapman, *Application of Welding,* p [5], fig 3.
75 W D Chapman, *Notes on the Electric Arc Welding of Structures* (Melbourne 1935).
76 Chapman, *Application of Welding,* p [7], figs 7 & 8.
77 Chapman, *Application of Welding,* p [6], figs 5 & 6.

chromium and 8% of nickel. This was one of various white metals used for ornamental purposes in the Art Deco style, and one of the earliest major applications of it was in the Chrysler Building, New York, of 1930.[78]

It was in the 1930s that stainless steel rose to general prominence in Australia, as elsewhere. In 1931 R H Mytton & Co of South Melbourne were advertising a range of sinks and similar products in monel metal, white metal and silveroid. By 1933 they were making monel metal and stainless steel domestic and restaurant equipment,[79] but the 'Silva' brand of their stainless steel sinks, suggests that they had opted for silveroid for this purpose.[80] By 1938 Malleys of Sydney could cite some major hotel and hospital contracts for stainless steel installations, and had introduced Ludlite Silichrome 'Stainless Steel', imported from the manufacturers and patentees, the Ludlum Steel Co of America. It was made with an inner surface of tough waterproof rag felt material, and an outer of light stainless steel, and it could be used to clad plaster, wood and other surfaces.[81]

Commonwealth Steel Products Limited had begun operations at Waratah, New South Wales, in 1917, producing railway requirements such as wheels, tyres and axles, and using a Héroult-type electric arc steel making furnace. In 1924 an association was formed with Vickers Limited of England, creating Vickers-Commonwealth Steel Products Limited, after which the plant was extended and the work force rose to six hundred. During the 1930s another close association was developed with the neighbouring Newcastle Iron and Steel Works of the Broken Hill Company, and in 1935 they formed the Commonwealth Steel Company. At this time the company began its first tentative production of stainless steel - the first time the material had been made in Australia - and two years later it began tooling up for the production of alloy and special steels. Even before the outbreak of World War II the company was commissioned to produce quantities of shells, gun barrels and steel helmets, and at the height of the war there were 3,600 employees producing 140 grades of special steel, a figure which rose even higher in the immediate post-war period. It was now that the locally produced stainless steel came into use for domestic fittings such sinks.[82]

78 Robert Score & I J Cohen, 'Stainless Steel', in T C Jester [ed], *Twentieth-Century Building Materials* (Washington [DC] 1995), pp 64-71.

79 *Royal Victorian Institute of Architects Journal*, XXXI, 3 (July 1933), advertisement p xxix.

80 D W Tulloch, *Details of Australian Building Construction* (Melbourne, no date [c 1933]), p 91.

81 C E Mayes, *The Australian Builders and Contractors' Price Book* (10th ed, Sydney 1938), pp 278-9.

82 Comsteel, *Commonwealth Steel Company Limited: Plant, Processes and Products at Waratah, N.S.W. together with a Brief History of the Company since 1918* (Waratah [New South Wales], no date [c 1947]), passim.