Port Waratah, on the Hunter River, Newcastle, was selected as the site for the works. The area of land acquired for the commencement comprised 24 acres of freehold, purchased by the company in 1896, 110 acres acquired by purchase in 1912, and 96 acres granted by the New South Wales Government; also 17 acres reclaimed on 50 years leasehold, and 17 acres to be reclaimed. The New South Wales Government had undertaken to dredge and maintain a channel from the works to the Pacific Ocean, 500 feet wide and 25 feet deep at low water.

The construction of the steel works proceeded with remarkable speed. A large portion of the ground for the blast furnaces had to be reclaimed, and solid foundations put in by driving piles to a depth of over 30 feet to carry the concrete beds for the furnaces and heavy machinery; but, notwithstanding these difficulties, by June, 1914, the great blast furnace was nearing completion, and foundations were being put in for the open-hearth plant, rolling mills, etc. A number of the boilers were in place, and coke ovens in course of construction, and before the declaration of war in August, 1914, practically all the machinery for the original plant was on the ground and in course of erection.

The first shipment of ore from the Company's quarries at Iron Knob, in South Australia, arrived at Newcastle in January, 1915. Bins and machinery had been installed at Hummock Hill—the foreshore for the quarries—and by means of conveyor belts, the vessel was loaded with 2,800 tons at the rate of 800 tons per hour.

The first blast furnace was put into commission on the 8th March, 1915, and, when a sufficient stock of pig iron was available, the steel furnaces were started, and the first rail rolled on the 24th April of that year.

The present blast furnace plant consists of three furnaces, two with a nominal daily capacity of 450 tons, and a third of 100 tons capacity per day, used for the production of foundry iron. The approximate annual output of pig iron is about 240,000 tons.

The steel plant consists of seven 65-ton open-hearth furnaces, for each of which the charge consists of 40,000 lbs. of steel scrap, 80,000 lbs. of pig iron, 20,000 lbs. of limestone, and 12,000 lbs. of ore. The annual output of steel ingots is approximately 245,000 tons.

The steel ingots are passed on to the 28-inch blooming and rolling mill, which is a 35-inch geared mill of massive construction, driven by a twin reversing engine of high power, with cylinders 42-inch by 60-inch. Some idea of the power of

the engine may be formed by the fact that there are seven pieces of metal in it, each weighing forty-two (42) tons, besides many smaller parts.

When the ingot goes to the approach table it is about 20 inches square by about 5 feet long, and in 15 passes through the rolls the ingot of steel is reduced to a bloom 4 or 6 inches square. This mill has sufficient capacity and power to deal with up to about 500 tons of finished rails per day, and it is calculated that a parcel of ore taken from the pile on the wharf can be converted into a finished rail and placed in the track within 48 hours. This mill has been producing 2,500 to 3,000 tons of blooms, billets, rails, etc., per week—equal to 130,000 tons per year.

The additional mills are 18-inch, 12-inch, and 8-inch for merchant steel, and a rod-mill, for the production of rods for wire-drawing, capable of an output of 350 to 400 tons of rods per week, down to size No. 5—.212 of an inch.

The 18-inch merchant mill is a continuous running mill, served by four tilting tables, which permit of rolling two bars at a time, and can deal in a year with over 40,000 tons. The finished products consist of light rails, fishplate bars, structural steel, and billets for the smaller 12-inch and 8-inch merchant mills.

The 12-inch mill, which produces light rails, splice bars, angles, squares, billets, and flats, deals with over 20,000 tons in a year, while the 8-inch mill, for smaller sizes of squares, flats, angles and rounds, produces in a year approximately 5,000 tons.

The fishplate mill produces fishplates as required, the usual annual production totalling over 4,000 tons.

STEEL AND IRON FOUNDRY.

This plant is equipped with an acid open-hearth steel furnace of 25 tons capacity, and castings up to 40 tons in weight have been made.

The coke required for the blast furnaces is produced by the company's own coke-ovens, which are the Semet-Solvay recuperative by-product type. The present coking plant consists of 131 ovens, while further ovens are in course of erection.

The gas from the ovens is passed through the condensers to the by-product house, where tar and ammonia are extracted. The ammonia is subsequently used in the manufacture of sulphate of ammonia for agricultural purposes.

Throughout the works the latest mechanical appliances have been installed. The ore is discharged from the ironstone

steamers by means of electrically-operated grabs; the furnaces are mechanically charged, and the handling of the metal from the time it leaves the blast furnaces until it emerges as finished steel is by mechanical means. Large 5-ton magnets are employed for the handling of rails and other steel in placing into stack or on trucks.

The works have been laid out with a view to extensions to all departments, and already subsidiary industries for the manufacture of wire nails, galvanised iron, and other commodities are being established adjacent to the Broken Hill Proprietary Company's works.

COKE MANUFACTURE.

The progress of manufactures in this State can be fairly gauged by the statistics relating to the coke industry.

Up to the end of 1897, the total output of coke in New South Wales was 239,806 tons.

The following table shows the rapid expansion of this industry since the year 1902.

TABLE NO. 3.

COKE PRODUCTION IN NEW SOUTH WALES

Year	Total production Tons	Total Value £	Value per ton £
			£: s: d
1902	126,872	89,605	0:14: 2
1905	162,961	100,306	0:12: 4
1910	282,337	189,069	0:13: 5
1915	417,753	313,241	0:14:11
1918	608,492	647,798	1: 1: 4

It will be seen that in 1918 the price of coke increased exactly 50 per cent. over the price ruling in 1902. Prior to the war a considerable amount of coke was imported from abroad. In 1917-18, however, the imports were negligible. A small quantity of coke is made in Queensland—13,400 tons for 1917—but the bulk of that used in ore reduction is imported, mainly from New South Wales. These imports from New South Wales in 1917 amounted to 60,000 tons.

The other States have not engaged in the coke-making industry.

MANUFACTURE OF FIREBRICKS.

With the introduction of the iron and steel industry into Australia came a large demand for firebricks for furnace linings. Prior to the war, large quantities of firebricks were imported, but several companies were manufacturing certain grades in Australia. Since the war the production of Australian firebricks has increased about fourfold.

TABLE NO. 4.

Firebrick Manufacture

	1913	1919
Number of Brickworks	3	6
Value of Plant	£13,200	£58,849
Value of Land & Buildings ...	£9,615	£58,923
Production of Firebricks	1,649,000	6,258,000
Value	£11,132	£52,888
Production of Fireclay Blocks	147,140	551,590
Value	£2,854	£13,914
Production of Fireclay (tons)	790	2,935
Value	£790	£2,997

The Newbold Silica Firebrick Co., Ltd., was formed about eight years ago, and manufactured silica-bricks at works established at Marrangaroo, near Lithgow, from silica obtained locally.

About two years ago the company acquired several mining leases in the Ulladulla (South Coast) district, and erected modern brickworks at Waratah, near Newcastle, where the Ulladulla silica is used in the manufacture of special firebricks required in the steel and other furnaces of the Broken Hill Proprietary Company's Works. These bricks are stated to be equal, if not superior to any imported silica brick.

The silica quarry of the company is practically a mountain of silica, and, if necessary, a vertical face of over 400 feet could be obtained, giving an almost inexhaustible supply of suitable raw material for firebrick manufacture.

Since the outbreak of the war, only small quantities of firebricks could be imported, and then only at enormous cost. The development of the Newbold Company's works during the war period is shown by the following table:—

TABLE NO. 5.

Newbold Silica Firebrick Co., Ltd.

Year	Annual Turnover	Year	Annual Turnover
1913	£4,831	1917	£15,126
1914	8,568	1918	26,259
1915	11,594	1919	40,858
1916	13,745		

THE MANUFACTURE OF GALVANISED IRON, WIRE-NETTING, WIRE NAILS, &c.

Another important industry which is likely to reach considerable dimensions now that iron and steel-making is firmly established in this country, is the manufacture of galvanised iron, wire-netting, etc. It was not until 1854, when steam-power was first used for corrugating, that galvanised iron came into general use. Since that date the industry has reached enormous dimensions, and is now making good progress in Australia, where the vast deposits of iron ores have scarcely been disturbed. Thousands of tons of wire-netting are used annually in Australia, and prior to the introduction of rod-rolling mills in this State, all netting manufactured in this country was made from imported material.

At the present time the necessary material is produced in Australia.

Messrs. John Lysaght and Sons have extensive wire works at Five Dock Bay, Parramatta River. These works and warehouses cover about 5 acres, and have a monthly output capacity of approximately 2,000 tons of wire. It has been estimated that a six or seven months capacity output from these works would put a wire-netting fence round the entire coast line of Australia (11,310 miles). The monthly output capacity at present is:—

1,600 miles of wire netting.
400 tons of barbed wire.
300 tons of wire nails.
100 tons of zinc white.

STEEL MAKING IN THE ELECTRIC FURNACE.

After the establishment of the iron and steel industry in New South Wales, the development of subsidiary industries followed as a natural corollary.

One of these industries of great engineering importance is the manufacture of steel ingots for special locomotive axle-forgings, and high-grade alloy steel castings.

As in the copper industry, electricity has provided a means for removing impurities in steel not possible by fire reduction, and the introduction of the electric furnace about 10 years ago has enabled alloy steel of very high grade to be produced.

The electric manufacture of these high-grade products has been successfully introduced into Australia, and the engineering workshops which, prior to the war, were dependent upon imports for their supplies, can now to a large extent meet requirements locally.

The Australian Electric Steel Co., Ltd., has established a plant at Alexandria, Sydney, the installation consisting of two-ton electric furnaces of the electro-metals, two-phase type. Electric current is supplied by the Sydney Municipal Council at 5,000 volts, which is transformed and delivered to the furnace as two-phase, low-tension current.

The steel is made in basic-lined tilting furnaces, the process being similar to the ordinary open-hearth method; but the charge is reduced by electric arcs instead of gas. The removal of oxide from the metal is much more complete in the electric than in any other type of steel-making furnace, the reason being that, although cleansing additions of deoxidising alloys are made in the ordinary processes, the metal is always in contact with a slag containing considerable amounts of oxide of iron. In the electric furnace the slag itself as well as the metal is thoroughly freed from the oxide. This freedom from oxygen prevents segregation, blow-holes and surface defects, and the steel has generally a high elastic ratio with good ductility for a given tensile strength.

Since the Australian Electric Steel, Ltd., introduced electric steel-melting methods into this country, they have produced large quantities of first quality steels, including slow moving parts for mining and general machinery, subject to heavy gritty wear, forging ingots for crank shafts, battery cam-shafts, boring tools, also locomotive axle and tyres to the New South Wales Government Railway specifications. Ingots are being made in sizes ranging from 4 in. x 4 in. to 24 in. x 24 in., the latter weighing two tons.

Recently the company supplied vanadium cast-steel bar-frames for locomotives, the first material of this kind made in Australia. Other products include high percentage silicon-steels used in electrical work, chrome-vanadium tool steels, nickel steel, and special acid-resisting ferro-alloys for chemical works practice.

Similar electric furnaces are operating in Melbourne, and New Zealand is also following on similar lines.

THE COPPER INDUSTRY, PORT KEMBLA, 1902-1919.

The war in Europe focussed the attention of the mining world on the production and refining of copper.

In Australia, for some years prior to the war period, the Mount Morgan Gold Mining Co., Ltd., found that its rich gold ore was giving place to copper in payable quantities. Smelting was introduced, the product being known as "blister copper," which was sent to America, where the gold was extracted and the copper refined.

With the primary object of encouraging Australian industry, and for reasons of economy, the company decided upon the construction of an electrolytic copper refinery at Port Kembla. The electrolytic method of refining copper has superseded the fire-refining method, as the former permits of more effective separation of the precious metals and the elimination of certain impurities not possible with the latter.

The works at Port Kembla are considered to rank with the most modern copper refining plants in the world. The company will treat small parcels of crude ore sent in by miners or the blister copper sent forward by the mining companies.

When coffer ore reaches the works it is treated in a blast furnace, from which a copper "matte" is obtained. This copper matte, in a molten state, is run into a silica-lined converter, with the object of fluxing the iron contained in the matte, and burning-off the sulphur content. The product, known as "blister," assays approximately 99 per cent. copper, but the remaining unit is made up of gold, silver and impurities. In the early days large quantities of copper matte from our lead and silver mines were sent to Germany, and great losses to the companies resulted, as in every case adequate payment was not made for the gold contents, the buyers purchasing on a copper content only.

The blister copper produced contains, in addition to the mineral contents, certain impurities which, for electrical or war purposes, must be entirely eliminated; and it is at this point that the Port Kembla works excel in the effective electrolytic plant installed for this purpose.

The blister copper resulting from the smelting of ore parcels from the small mines, together with the large quantities of blister copper sent forward from the large mines, such as Mount Morgan, Mount Lyall, Hampden Cloncurry, etc., is, after assay, sent to the anode furnace, where it is melted and cast into anodes, which are slabs of copper, cast with lugs at one end, by which they are suspended in the tanks where electrolysis is conducted.

In a large tank-house the anodes are suspended in lead-lined tanks, through which circulates an acid solution, to which is applied the current supplied by the power station. Opposite each anode is placed a thin copper cathode, which grows as the anode disappears under the action of the current, passing through the surrounding solution. The gold, silver, and other impurities gravitate to the bottom of the tanks. The cathodes, when sufficiently grown, are removed from the tanks, sent to the refinery, melted, and cast into wire bars or ingots, as may be required for either wire-drawing or subsequent conversion into sheets.

During the war the whole of the refined copper, amounting to approximately 24,000 tons per annum, was sent home for use by Great Britain and her Allies for war purposes.

THE MANUFACTURE OF COPPER SULPHATE.

Copper sulphate is made on these works from white metal, an intermediate product in the converter process, containing approximately 75 per cent. copper, 1.5 per cent. iron, and 23 per cent. sulphur.

The white metal is crushed and well worked in a reverberatory furnace. The roasted material, which will consist of a mixture of copper oxide, sulphate, metallic copper, and two or three per cent. of undecomposed white metal, is charged into agitators containing "mother" liquor, from the crystallising tanks, to which is added sufficient sulphuric acid to dissolve the copper oxide. The contents of the agitators are heated by steam until the whole of the soluble copper is in solution, when it is discharged into launders, elevated to settling boxes, and the clear sulphate of copper solution siphoned off and run into the crystallising tanks and allowed to stand for from 7 to 9 days, when the copper sulphate crystals have grown to a suitable size for trade purposes.

The following table gives the production of refined metals at these works from 1909 to 1919 :—

TABLE NO. 6.

ELECTROLYTIC REFINING AND SMELTING CO., OF AUSTRALIA LTD.,

Production of Refined Metals from 1909 to 1919

	Gold ozs.	Silver ozs.	Copper tons
Febry. - Nov. 1909	37,461	24,595	6,049
Dec.1909 - Nov. 1910	113,651	73,333	9,693
Dec.1910 - Oct. 1911	82,291	149,809	11,557
Nov.1911 - Oct. 1912	109,036	479,525	16,277
Nov.1912 - Oct. 1913	127,536	357,393	13,979
Nov.1913 - Oct. 1914	121,639	529,286	16,955
Nov.1914 - Oct. 1915	129,395	548,294	19,497
Nov.1915 - Oct. 1916	137,864	492,863	24,741
Nov.1916 - Oct. 1917	177,702	563,611	27,035
Nov.1917 - Oct. 1918	170,626	471,227	30,200
Nov.1918 - Oct. 1919	134,848	490,983	15,401
Total production	1,342,049	-,181,119	191,384

METAL MANUFACTURE WORKS, PORT KEMBLA.

With the large supplies of refined copper going forward from Australia to Great Britain, and a general shortage of copper wire during the war period, this country was faced with a serious problem in meeting demands for manufactured copper.

To a large extent this problem was solved by the formation of the Metal Manufactures Co., and the establishment of works at Port Kambla by the chief copper producing companies in Australia, jointly with the British Insulated and Helsby Cables, Ltd.

The works of the new company are conveniently situated alongside the Electrolytic Refining and Smelting Company's Works, and at present cover an area of 6,450 square yards.

The wire bars from the Electrolytic Works are brought into the rolling mills on an electrically operated track. The wire bars, the average weight of which is 140 lbs., are first heated to the necessary rolling temperature in a furnace of the reverberatory type. The rolling mill is of the continuous or looping type. The wire bar is first reduced by passing through the breaking-down mill; then further by a series of passes through an intermediate train, then finally rolled to "rod" form in the finishing train—the "rod" being coiled up by means of a power-driven coiling machine.

These coiled "rods," thoroughly freed from surface oxide, are now in a convenient form for passing through the wire-drawing mills, the dies for which are made in the company's own machine shops.