WITH ENTHUSIASM BURNING

by

PAUL C. SAVAGE

The story of welding and associated industries in Australia

Tell me, tell me, learned Elder,
How can I become a Welder?
Let me be an honest Toiler,
Let me only weld a Boiler . . .
I am eager for my learning,
With enthusiasm burning,
Like my flame, the Oxidising,
Flame Reducing, Flame Surprising,
Flame Protected, Argon-Shielded,
Flame by Willing Welder Wielded.
Welding Skilful, Welding Painless,
Welding Mild and Welding Stainless,
Welding Struts and Welding Collars,
Welding Exports, earning Dollars,
Welding Forging, Welding Casting,
Welding, Welding everlasting!
Lead me to it learned Elder—
Let me only be a Welder!

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FOREWORD

The story of welding in Australia is the story of people battling against prejudice, of their failures, of their ignorance and of their considerable achievements.

When the Australian welding industry began, few people elsewhere knew very much about the process. Largely self-taught, the industry developed its own techniques which often were a guide to welders in other countries.

For a time, the world's largest welded structure was located in Melbourne. Half a century later it is still in use. Australian development of coated electrodes was several years in advance of the United States. An Australian was invited to Britain to show a major manufacturer how to make better electrodes at a cheaper price. Two engineers at the N.S.W. State Dockyard in Newcastle secured world patents for a portable automatic arc welder they developed in 1922.

Although CIG did not come into existence until after much of the groundwork in the welding and associated industries had been laid, the company can trace its origin back to the very start of those industries.

The story of welding in Australia is indeed very much the story of CIG.

K. O. HUMPHREYS
Chairman
The Commonwealth Industrial Gases Limited
46 Kippax Street, Surry Hills, N.S.W.
Australia, 2010

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CHAPTER

I

THE FIRST FIRESTICKS

The brightly-hued Rainbow Bird, which migrates to Australia from New Guinea and surrounding islands every spring, has two feathers, like thin sticks, projecting beyond the rest of its tail. These, according to an Aboriginal legend, are the firesticks which the Rainbow Bird stole from the Crocodile in the Dreamtime and gave to the Aborigines so that they could have the secret of fire.

Captain Arthur Phillip, commander of the First Fleet which introduced European settlement to Australia, wrote from Sydney Cove in May, 1788, that the natives "are seldom seen without a fire, or a piece of wood on fire, which they carry with them from place to place, and in their canoes, so that I apprehend they find some difficulty in procuring fire by any other means with which they are acquainted."

Like the newcomers, however, Aborigines in some parts of Australia produced fire from flint, but generally they used the friction method of the firesticks. A missionary was to record that one man using firesticks took less than 28 seconds to produce a flame.

The Aborigines carried their entire possessions with them on their continuous trek in search of food. Though the firesticks did not add substantially to the burden, the Aborigines found it more convenient to have their women or children carry a few embers from their last camp fire or a smouldering piece of fungus in one of the family's few utensils.

The Dreamtime was the Aborigines' equivalent to the events chronicled in the Book of Genesis. But where Genesis was able to describe Tubal Cain as "the instructor of all artificers of brass and iron," the Australian Aborigines roamed a mineral-rich continent for countless centuries without becoming aware of metals and metalworking. They selected and shaped stones into weapons and they dug oxidised ores only for the ochres they needed for cave art and body decoration. The Macassans brought knives to the north Australian coast some hundreds of years before the Europeans arrived, but most Aborigines remained ignorant of metal until after the First Fleet.

They were skilled, however, in heat treatment techniques which they applied to wood. They flame-hardened the tips of their digging sticks and spears. They used heat to straighten saplings for spear shafts and to bend pieces of wood into the boomerang shape. They also heated green branches of certain trees to induce the sap to flow. They collected this gum, reheated it and used it to join pieces of wood together.

Rainbow bird with firesticks projecting beyond its tail. One of the first Australian electrodes was called the Firestick.

Forge welding was brought to Australia with the First Fleet. This scene in a blacksmith's shop of that era was featured on a C I G Christmas card.

The first means of manufacturing metal objects in Australia—"Iron Forges, Anvils and Hammers 10 @ £3" and "Bar Iron Flat and Square 10 tons @ £17"—arrived in the convict ships of the First Fleet along with samples of what could be manufactured—chains, manacles and leg irons, some of which had seen previous service on African slaves.

The new community of soldiers, convicts, farmers and merchants around Sydney Cove concentrated its early efforts on food production. However, by 1821, saltworks, glassworks, tanneries and brickyards had been established, together with small factories making hats, cloth and blankets.

Steam was being used in 1828 to grind corn and by 1837 Sydney had grown sufficiently for a company to be incorporated with the object of lighting the town with coal gas. The gas lights were first lit on the Queen's Birthday in 1841.

Iron ore was found at Mittagong, south of Sydney, in 1833 and in 1848 the Sydney Morning Herald commented that "the public has witnessed the success of the mine by the specimens of manufactured articles (a stove and spades) in Sydney." The colony of New South Wales then had 223 flourmills, two distilleries, 51 breweries, 30 soap and candleworks, eight potteries, two sugar refineries, seven rope works, five salt works, four hat manufacturers and 27 foundries.

Agricultural equipment was the chief product of the foundries, but they were also the source of much of the cast and wrought iron lace adornment on buildings—despite estate agents' claims more than a century later that the lace was brought out as ballast in sailing ships. The ballast was the pig iron from which the lace and other articles were made.

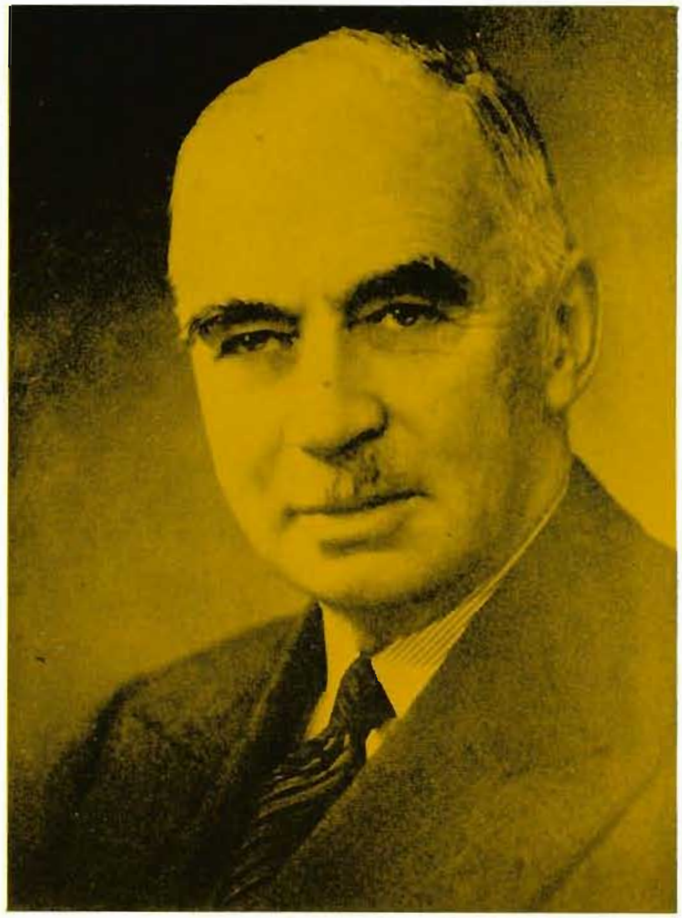
The dynamo for the growth of the Australian colonies in the last half of the 19th century in terms of money, people and manufacturing capability was the discovery of gold at Ophir, near Bathurst, 132 miles west of Sydney, in 1851 and the subsequent opening up of immense gold and silver fields in other parts of the continent.

An Aboriginal prospector found the rich silver chloride deposit which proved to be the best initial access to the enormous silver lode, which Charles Rasp had discovered, at Broken Hill and the shaft that resulted gave Broken Hill Proprietary its first income. Aborigines guided European prospectors into the hinterland and probably found numerous deposits without gaining credit for their finds. In northern Australia, the tribes still lived their ancient ways, uninterested in gold, but concerned at the intrusion of miners into their hunting grounds.

Clashes occurred and wooden spears were usually of little consequence against the miners' Martini-Henry and Snider rifles. The notorious Merkin tribe along the Palmer River in North Queensland enlisted the aid of metal to drive the gold seekers out. The Merkins, who had a reputation for cannibalism, killed the miners' horses to get the animals' shoes. These they broke and sharpened into knives. Ambushed miners' waggons were later recovered with every piece of metal, including the tyres, removed. Wire was stolen from telegraph lines and used for spear tips. But the white man's rifles maintained their superiority.

The Australian colonies' pastoral and manufacturing industries progressed with the mineral boom and by 1891 the manufacturers were employing 200,000 people. Victoria had 91,000 factory workers and N.S.W. 74,000, but N.S.W. forged ahead after Victoria was stricken by financial crisis in 1893. Federation of the colonies brought a uniform national tariff protection against overseas competition and a new national market ushered the Australian industrialists into the 20th century.

Among them were F. S. Grimwade and Alfred Felton, who had established a business as wholesale druggists in Melbourne in 1867. Felton, Grimwade and Company already carried the foundations from which Australian Consolidated Industries Ltd., Drug Houses of Australia Ltd. and Adelaide and Wallaroo Fertilisers Ltd. were later to evolve.



Russell Grimwade, one of the pioneers of the industrial gases and welding industries in Australia.

Russell Grimwade, one of F. S. Grimwade's four sons, graduated in science at the University of Melbourne in 1901. He joined Felton, Grimwade's in 1903 to begin a career which would significantly contribute to the development of welding and industrial gas production in Australia and to the establishment of The Commonwealth Industrial Gases Limited as a major enterprise.

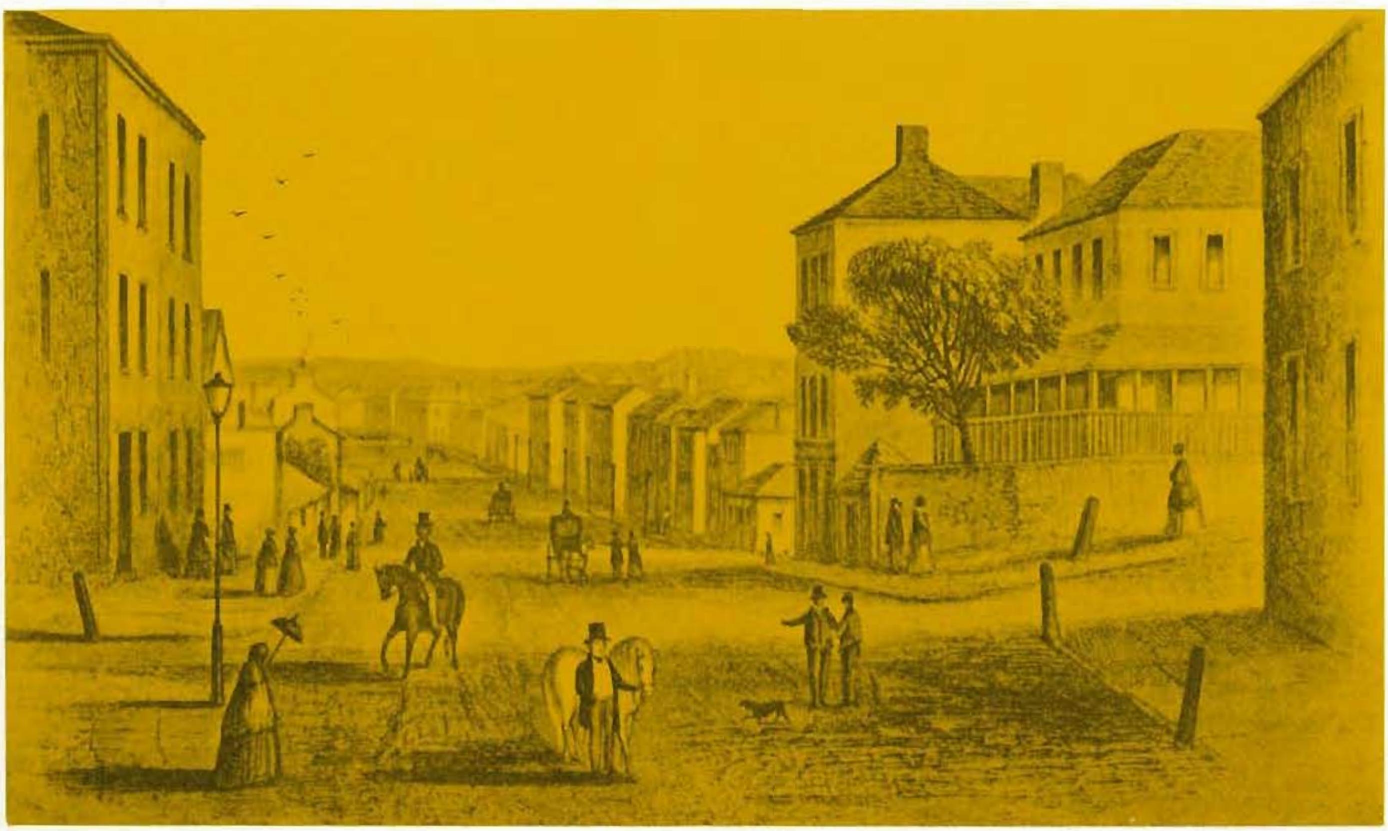
Young Grimwade was by no means the sole contributor. Among the many people also substantially involved were Phillip Schemnitz, a German-born amateur wrestler; J. D. Waern, the Swedish Consul in Melbourne; Corrie Gardner, who was Australia's entire team at the 1904 Olympic Games in St. Louis, U.S.A.; John F. Clack, company secretary and accountant; the Scottish-born engineering partners, William Fyvie and Alexander Stewart; mechanical engineer, John B. Arnold; BHP's Essington Lewis, and Steven Hardie, the man who became chairman of The British Oxygen Company Ltd. and later chairman of Britain's nationalised steel industry.

And there were the welders themselves—the blacksmiths, the boilermakers, the garage men and the engineers, whose enthusiasm in the face of widespread scepticism took Australia to the forefront of world welding knowledge. They were people like Harry Grove, of the Melbourne Metropolitan Gas Company; Albert Longoni, the Swiss-born consulting engineer; Joe Hunter, of Gardner Constructions; W. D. Chapman a future president of the Institution of Engineers Australia; Bill Featonby, of the Victorian Railways; Daniel Evans, of Evans Deakin and Co.; Archie Campbell, of Charles Ruwolt Pty. Ltd., and the Ogdens, father and son, of Welded Products Ltd.—to name only a few.

Phillip Schemnitz, who installed Australian Oxygen's first plant in Melbourne in 1910, with his wife, Margaret, and son, Hugo.

John Clack was a leading figure in the development of Commonwealth Oxygen in Sydney and later was a key C I G executive.

A view of Sydney from Woolloomooloo in 1849



King Street looking west in the early 1850s

Left: Limelight apparatus from the Museum of Applied Arts and Sciences in Sydney recreates late 19th Century stage illumination.

CHAPTER II
OXYGEN IN THE LIMELIGHT

Russell Grimwade visited England in 1902 and took a deep interest there in Dewar's experiments with the storage of liquids at low temperature in vacuum flasks and in Hampson's apparatus for liquefying air.

Felton, Grimwade's had been producing small quantities of oxygen for some years before the turn of the century by heating potassium chlorate and manganese dioxide. Doctors used the oxygen for resuscitation and theatre owners needed it for their limelight projectors. In the latter application, the oxygen was combined with hydrogen gas to produce a hot flame. Impinging on a block of lime near the burner tip, the flame heated the lime to incandescence, producing an intense light which was projected on to the theatre stage.

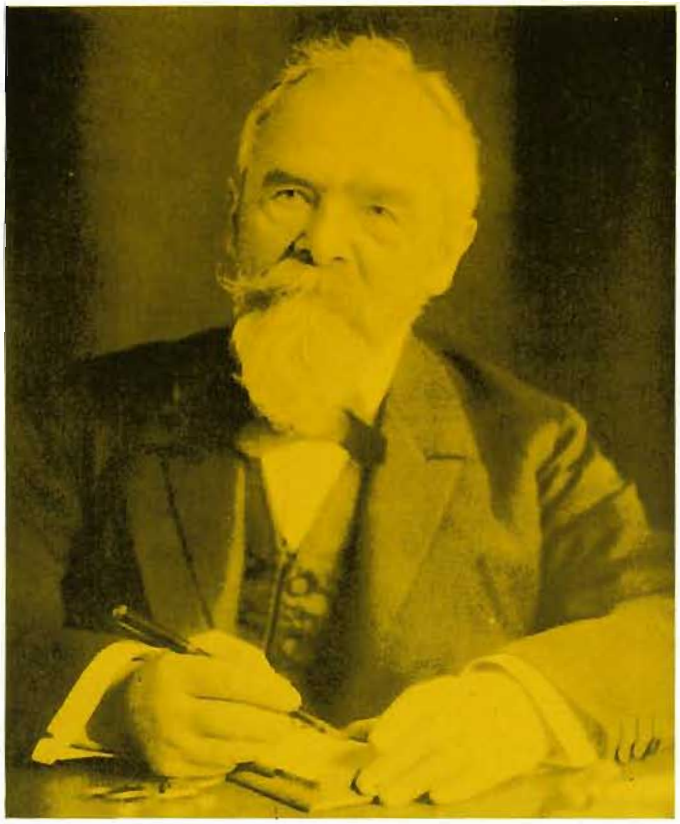
"In the limelight" was a phrase which was to endure long after electricity had banished the system from city theatres. Even with limelight, the market for oxygen in Australia had been meagre.

Overseas, however, several scientists had been experimenting with ways of producing oxygen on a large scale. The French chemist Boussingault had shown in 1851 that barium monoxide when heated to 538°Celsius would absorb oxygen from the atmosphere and when heated further to 871°Celsius it would discharge this oxygen.

The French brothers, Arthur and Leon Brin, former laboratory assistants of Boussingault, demonstrated a patented adaptation of this method at the Inventions Exhibition in London in 1885.

Drummoyne garage in 1916 offered gas welding and oxygen decarbonising of cylinder heads. *Museum of Applied Arts & Sciences picture.*

Carl von Linde was one of the first to produce oxygen by distilling liquified air.



The following year a family named Sharp formed Brin's Oxygen Co. Ltd. to operate the patent with the Brin brothers and commercial production of oxygen began in England at Westminster.

Brin's oxygen was of poor quality and its purity never reached more than 94 per cent. Other scientists were producing oxygen of high quality by the electrolysis of water, but the most significant work on new processes for the production of oxygen by the fractional distillation of liquefied air was being carried out by Carl von Linde in Germany, C. E. Tripler in America, Hampson in England and Georges Claude in France.

Brin's Oxygen Company acquired three Hampson patents relating to the liquefaction and separation of air in 1905, and in the following year, when it changed its name to The British Oxygen Company Ltd., it also acquired the rights to Linde patents in the United Kingdom.

In 1895 a French scientist, Le Chatelier, read a paper before the Academie des Sciences which stated that acetylene gas, discovered by Edmund Davy in 1836, when burnt with an equal volume of oxygen gave a flame with a temperature of 3130°C which was 470°C higher than the oxy-hydrogen flame.

Commercial production of acetylene gas from calcium carbide began in 1895 after Thomas L. Willson, a Canadian living in North Carolina, had used an electric furnace to try to produce metal calcium by reducing lime and carbon. The experiment produced calcium carbide instead.

Acetylene was widely used for lighting, but attempts to compress it into cylinders, in the same manner as oxygen, failed because of its explosive nature. Claude and M. A. Hess in 1897 noted that acetylene dissolved in acetone and Edmond Fouche succeeded in compressing it into cylinders containing an acetone-saturated porous filling.

Until the early 1900s the metal industries depended on the blacksmith's forge when they wanted to join pieces of metal without using rivets or other mechanical means. Forge welding had been practised for more than 3000 years, but it could be applied to only relatively small components because of the difficulty of raising large metal masses to forging temperatures and then manipulating them for mechanical forging.

Adapting the limelight apparatus method o mixing the gases in a chamber before they reachec the burner nozzle, Fouche in 1900 produced the firs high pressure oxy-acetylene torch. He also devised a low pressure torch which could be used by the many firms who were producing their own supplies o acetylene in low pressure generators.

Cutting torches appeared in 1901 and thieves used one to open a safe in a London post office tha year. However, the first cutting torch patent in th United Kingdom was granted to Felix Jottrand c Brussels, in 1904. Jottrand used two separate nozzles one for delivering an oxy-acetylene or oxy-hydroge mixture for preheating the metal to be cut, and th other for delivering an oxygen stream for cutting.

The British Oxygen Company acquired th Jottrand patent in 1906 and improved on the inventio by combining the two nozzles into a single nozzl having a central delivery passage for the cuttin oxygen.

Cutting required high purity oxygen. This wa now available in the liquefied air production methoc which had supplanted the Brin's system.

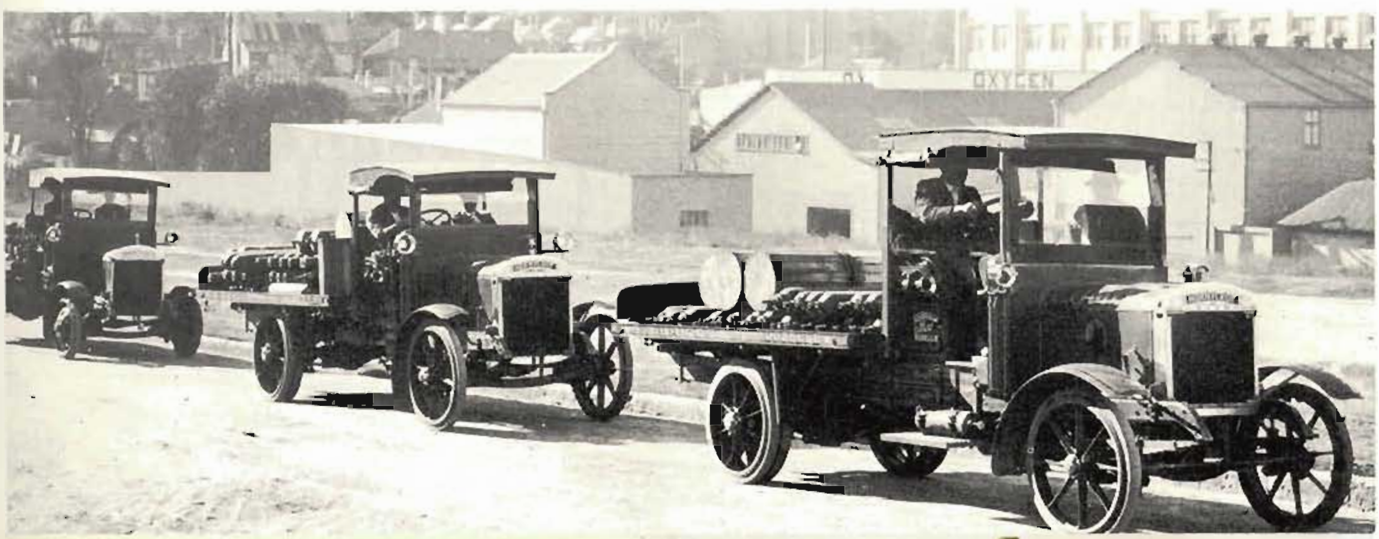
Although melting of metals by electricity ha been known as far back as the 18th century, it largel remained a laboratory process until suitable electr generators were developed. Electric welding fir came into prominence when Bernados, a Russian, patented a carbon arc welding process in 1887. Another Russian, Slavianoff, introduced a method of electric welding ferrous metals with a bare metal electrode in 1888. Neither process made much progress over the next 20 years but in the following decade metal arc welding developed considerably.

The thermit process of welding, originated by a metallurgist, C. Vautin, in 1894, and patented by a German chemist, Dr. Hans Goldschmidt, in 1897, was used to butt weld 10,000 joints in Adelaide's tramway track in 1910.

In the thermit process, a mixture of iron oxide and aluminium powder is ignited with magnesium and the iron oxide is reduced to iron as its oxygen combines with the aluminium. The intense heat evolved melts the iron and alloy additives produce steel of the required chemistry. The molten steel pours from a crucible in which the reaction takes place into a mould around the parts to be joined.

Although portable and requiring little equipment, thermit did not develop to the extent of the other welding processes because it was not adaptable to automation, but it did become an important repair and fabrication technique where heavy sections had to be joined *in situ*. Large, expensive components of heavy steelmaking plant for instance, have been repaired by thermit which enables tons of weld metal to be deposited instantaneously without extensive preheating or distorting the component. Thermit is also still extensively used for joining rail tracks *in situ*.

Loaded with oxygen cylinders, solid-tyred Thornycrofts parade near the Comox plant at Balmain about 1919.



Modern oxygen transport requires the variety of vehicles shown at C I G 's Melbourne Branch, Bell St., Preston.

HEAD OFFICE:
PERMANENT TRUSTEE BUILDING
25 O'CONNELL STREET
SYDNEY

TELEPHONES { WORKS: REDFERN 641
HEAD OFFICE: CITY 940 }

THE Commonwealth Oxygen Co. Ltd.

WORKS:
PARK STREET
ALEXANDRIA

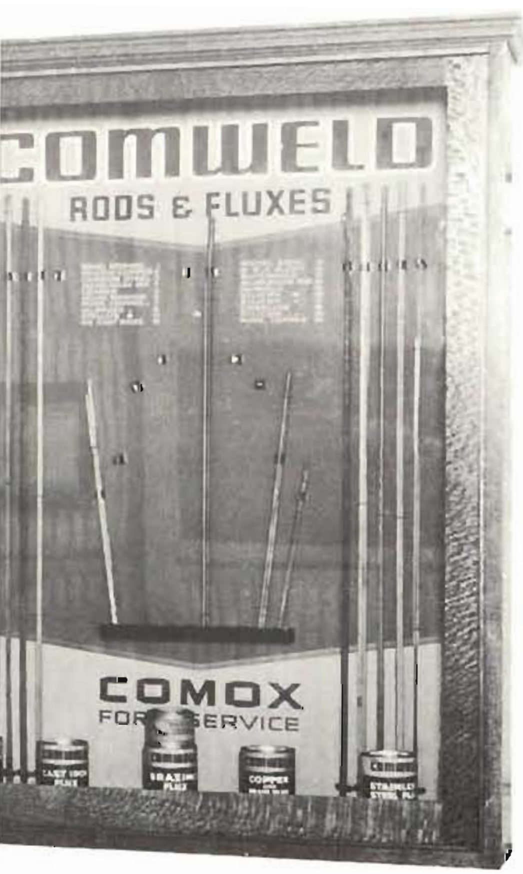
SYDNEY N.S.W. ______________ 191

Murex, which in 1948 bought the Oerlikon electrode factory in Tasmania. Warren-Smith returned to Australia in 1949 and was N.S.W. manager for Murex until he switched his career to the insurance industry in 1953.

Moon was replaced at EMF by W. D. Chapman and this appointment further helped the company to extend its welding crusade throughout the engineering profession. Chapman stayed with EMF until 1936 when he became a research and development engineer with Australian Paper Manufacturers Ltd. A year later he joined Malcolm Moore as chief engineer under Longoni, who was technical director.

Meanwhile, Whiting and Holland had developed a new machine which mass-produced electrodes from coil wire. Called the "Gawrah" (a name formed from their initials), the machine produced up to 6000 ft of electrodes a day with only two operators.

Display board for Comox and Arnold products at Queensland Oxygen, Newstead.



It enabled EMF to reduce its prices and dominate the electrode market. Robert Bryce soon complained to EMF that electrode prices were ridiculous.

H. S. B. Wight, the Robert Bryce managing director, told Holland: "You've cut the price till we're both losing money. You'd better come over here and talk some sense and let us fix a price".

Holland replied: "Mr. Wight, I don't know where you get your information about EMF losing money. I'm just about to recommend to my board that we again reduce the price of our electrodes because I think that we are taking too much from the public".

The board approved the reduction and the company's profits were still considered to be very satisfactory.

When Carr and Terry closed their business in Melbourne, Carr returned to Sydney where R. W. Cameron's asked him to rejoin them. He accepted and took his U.K. agencies into Cameron's. Soon after, Cameron's came into contact with John B. Arnold. Carr had noted the similarity in the plant needed to manufacture spray painting handpieces and oxy-cutting and welding torches. Both processes required somewhat similar accessories, such as pressure regulating valves. An arrangement followed between the Aerograph Company, Cameron's and Arnold for Arnold to assemble Aerograph parts in Melbourne. It soon became apparent that Arnold's manufacturing methods were much superior to those of Aerograph and furthermore an advanced new type of spray painting handpieces of American design had been introduced to the Australian market. Arnold dispensed with Aerograph and designed a new handpiece, marketing it successfully under his own name.

In 1931 R. W. Cameron decided to curtail part of its business and Carr left with his U.K. agencies to form EMF Welding Distributors in Sydney. Holland gave him a commission of 50 per cent and very liberal credit.

EMF had established a welding school after it moved into the old cable tram shed in Rathdown Street, North Carlton, Melbourne, in 1928. This school had the full support of firms like Gardner Constructions and of Trades Hall officials who appreciated that many unemployed men could, free of charge, become boilermaker-welders through the EMF instruction.

CHAPTER
III
FROZEN AIR AND MOLTEN STEEL

On May 5, 1909, 85 members of the Victorian Institute of Engineers at a meeting in Melbourne saw "air frozen to a fluid and steel melting like wax before the blowpipe flame". The occasion was a lecture by Russell Grimwade on "Oxygen and its Manufacture" and a demonstration of oxy-acetylene welding and cutting by an institute member, William Fyvie.

Fyvie had resigned from his position of chief engineer of Colonial Sugar Refinery Ltd's Yarraville refinery in December, 1902, to become a consulting engineer. Two years later, Alexander Stewart, chief engineer of the Aberdeen line vessel *Aberdeen*, settled in Melbourne and later became Fyvie's partner in the firm of Fyvie and Stewart. Stewart married into the Cuming family and he was to become one of Australia's great industrialists.

Grimwade told the institute meeting that working of refractory metals by the oxy-hydrogen blowpipe was not new, but until quite recently the price of oxygen precluded the free use of the method commercially. Now oxygen could, under favourable conditions, be manufactured at a cost that brought it well within the range of economic use in the workshop. That "and the coming into common use of acetylene had placed in engineers' hands a tool of power that would have been thought impossible a few years ago".

Grimwade used a Hampson laboratory unit made by British Oxygen Company to distil about a quart of liquid air and he showed how Dewar flasks conserved the liquid.

Fyvie had an oxy-acetylene plant consisting of Fouche blowpipes and a Sirius acetylene generator which he had brought back from the Franco-British Exhibition in Paris. He demonstrated cutting and then welded two pieces of $\frac{1}{4}$-inch thick mild steel plates. The proceedings noted that he used soft iron wire as a "solder".

Fyvie told the meeting that before very long this blowpipe would be one of the most important tools in the mechanical engineer's outfit. He said welding by the gas process did not supersede forge welding, but it was a very portable system and it compared favourably with brazing and riveting. It also enabled difficult work to be done *in situ*.

He suggested oxy-welding could be used for repairs to steam boilers, in the jointing of tubing, in storage tanks and to fix plates to boats. To a questioner, he agreed that the welder needed skill to finish a weld without setting up "internal strains" in the metal. He said that unless the welder had some

Comox began oxygen production in 1912 in this building in Park St. (now Power Avenue), Alexandria.

experience "and a good many failures" he is not to be thoroughly depended upon.

Later in 1909 Russell Grimwade and two of his brothers ordered a German liquid air plant capable of producing 175 cubic feet of oxygen an hour.

The plant was a Volant made by Maschinenfabrik Suerth which was later absorbed by Linde A.G. It was imported by Noyes Bros. who were also agents for Krupp. A Krupp engineer visited Noyes Bros. regularly and when he heard that Russell Grimwade wanted somebody to install the plant the Krupp man recommended Phillip Schemnitz, a fellow member of the German Club in Melbourne.

Schemnitz had been born in 1884 in Hungary, which was part of the Austro-Hungarian empire at the time. He had left home at the age of eight to make it easier for his widowed mother to bring up the rest of the family. For a time he survived by doing odd jobs in small factories. Then he was made a ward of the State and placed in an institution where the main feature of the inmates' lives was the beatings they received from pitiless overseers.

At the age of 18, Schemnitz went to England where he worked briefly in an engineering establishment run by his uncle. At the docks one day he noticed that a small steamer had a vacancy for a cook. Schemnitz got the job and at the first meal he served he was relieved to find that the crew liked his curry—even though he had put a tin of Colman's mustard powder in it in mistake for curry powder!

In April, 1905, Schemnitz was a trimmer in a German steamer which called at Melbourne. He decided to stay in Australia and after some difficulty he was paid off. The engineers, Kelly and Lewis, gave him a job.

Schemnitz had built up his physique with weightlifting and wrestling to the extent that he had an 18 inch neck. He took part in wrestling bouts at the old Cyclorama stadium in Melbourne and in 1907 he won both the middleweight and heavyweight gold medals in championship bouts staged by the City of Ballarat.

Schemnitz was naturalised in 1908 and in the following year he read an article in a German scientific journal about oxygen production. He went to Germany to learn about the process, returned to Melbourne late in 1909 and installed the oxygen plant for the Grimwades at the back of the Felton, Grimwade

Gas cutting—particularly underwater—was a strong drawcard at Melbourne Shows in the 1920s.

premises in West Melbourne. Schemnitz recalled in his 87th year when he was "mentally and physically equal to men 20 and 30 years my junior" that the plant began production on May 10, 1910. The Grimwades registered the Australian Oxygen Company as a partnership in the following month.

Schemnitz stayed to operate the plant, but his volatile personality clashed with Russell Grimwade's and they were in dispute, for instance, over Grimwade's charge of 6d. a cubic foot for oxygen supplied to hospitals. Schemnitz considered the price was exorbitant. On October 23, 1911, Grimwade hired Harry Thomson, an engineer from the famous but then declining Long Tunnel gold mine at Walhalla in the Gippsland mountains. Soon after Schemnitz was dismissed. It was not to be his last clash with Grimwade, nor was it the end of his association with the Australian industrial gas and welding industry.

Dissolved acetylene had been available in Australia soon after 1904 when Melbourne athlete Corrie Gardner visited Stockholm after the Olympic Games and returned to Melbourne with an agency for AGA dissolved acetylene. Gardner had run unplaced in the 110-metre hurdles at the Games as Australia's sole representative.

At the Engineering Exhibition in Melbourne in 1973 C I G highlighted its top status in 1970s technology.

In Stockholm, he had arranged for AGA cylinders of acetylene to be exported to Australia and returned to Sweden for refilling. AGA's specialty was lighthouse equipment, and Gardner Waern & Company, owned by Corrie's father and the Swedish Consul in Melbourne, J. D. Waern, entered this market in Australia. In 1908, Gardner Waern ordered an AGA plant to manufacture acetylene in Australia and they were the sole suppliers of high pressure dissolved acetylene until 1919. Several large industrial concerns installed generators to produce their own acetylene at low pressure.

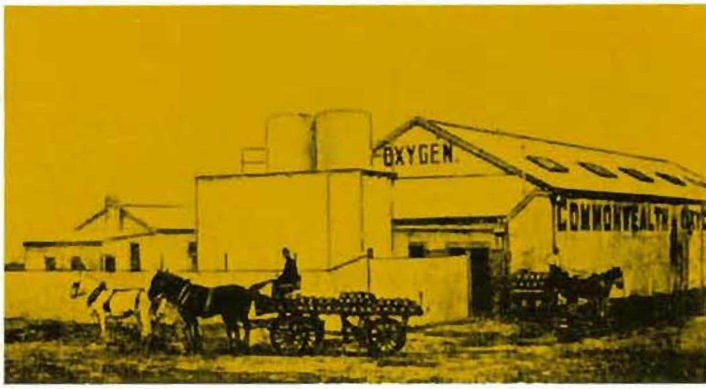
Meanwhile, in 1910, Fyvie and Stewart had secured an agency for British Oxygen Company oxygen and in the following year BOC decided to erect an oxygen plant in Sydney. BOC sent out Ernest Mayston to erect the 750 cubic feet/hour Linde plant on a site in Park Street (now Power Avenue), Alexandria. BOC also gave a Scottish marine engineer, Herbert Bremner, instruction in the plant operation and he joined Fyvie and Stewart in Melbourne as an engineer-draughtsman until the plant was ready. When the plant began production in July, 1912, Bremner was appointed works manager.

The first year's sales were made by Fyvie and Stewart trading as Commonwealth Oxygen Company. John F. Clack, an accountant newly-arrived from Britain, was introduced to Fyvie and Stewart by Melbourne technical publisher Peter Tait and he was given a job in September, 1912, in Fyvie and Stewart's Melbourne office. His first duties were to establish the cost of the Alexandria plant from bank pass book, cheque butts, invoices and receipts. Two months later Clack was transferred to Sydney.

The Commonwealth Oxygen Company Ltd. was incorporated in July, 1913, with an authorised capital of £25,000. Russell Sinclair, a principal in the firm of Wildridge & Sinclair, agents for Linde refrigeration equipment, was appointed one of three local managers. The others were Fyvie and Stewart. Fyvie was also appointed a director of the London board of Commonwealth Oxygen.

In 1915 BOC arranged with Lever Bros. at Port Sunlight in England to buy the oxygen by-product from the electrolytic hydrogen plants which Lever Bros. were operating in various parts of the world. In Sydney, the surplus oxygen from the Lever Bros. plant at Balmain exceeded Commonwealth's Oxygen's total sales at that time. In 1916 Lever Bros. took up 5000 shares in Commonwealth Oxygen and J. L. Buchanan, of Lever Bros., was appointed to the London

Horse and dray coped with the distribution of the Comox plant production at Alexandria in 1912. Output was only 70 cylinders a day.



board. J. Meek, of Lever Bros., was appointed a local manager of Commonwealth Oxygen in 1917 when the gas company's operations were transferred from Alexandria to a site in Foy Street, Balmain, alongside the Lever Bros. plant.

British Oxygen then held 16,000 shares in Commonwealth Oxygen and Fyvie and Stewart had 1000. The local managers were appointed local directors in 1918 and in 1920 the company changed its name to Commonwealth Oxygen & Accessories Ltd. In the same year a 50 cubic metre oxygen plant was installed at Balmain.

Australian Oxygen Company had been growing steadily in Melbourne and in 1914 it moved to a new site in Latrobe Street where additional plant was installed. By 1917 the company was also producing hydrogen, nitrous oxide and carbon dioxide.

Corrie Gardner had married Lilian Arnold in 1916 and at the end of World War I her brother, John Bowman Arnold, joined Gardner Waern. Arnold, then aged 19, had studied engineering through an International Correspondence School course during the war while he was a naval wireless operator. Gardner Waern sent him to Sweden to look at the latest procedures for the production of acetylene.

A grateful Australian Government allowed AIF men in France three months leave in England at the end of the war and encouraged them to seek training in jobs or to make business connections which would help them to re-enter civilian life back in Australia. Two of the men, Major T. G. ("Tommy") Millner and Edgar H. Wickham, were offered an agency by Allen-Liversidge Ltd., which had a close relationship with BOC, to manufacture dissolved acetylene and sell it in "A-L" cylinders which contained a patented kapok mass.

They accepted and Millner immediately began to look for Harold C. Morgan, an NCO in his company who had completed his apprenticeship with the Bendigo Motor & Engineering Company and School of Mines before enlisting.

Morgan was traced to New York where he and 10 other Diggers had been given a fortnight's leave to participate in a victory march with New York's own 27th U.S. Division with whom the Australians had served.

John Barrymore, the actor, was among the many Americans who lavished hospitality on the Australians and he put them up at the Vanderbilt Hotel. They were having such a good time that the fortnight lengthened into three months before the Australian Army caught up with them and sent them back to London.

Millner took it all in good spirit and instead of being punished for being A.W.L., Morgan was taken to Allen-Liversidge and British Oxygen works to learn about acetylene and oxygen production under the A.I.F. rehabilitation scheme. An acetylene plant was eventually shipped to Australia and when Morgan reached Sydney, Millner gave him the job of erecting it at Annandale in 1919. Allen-Liversidge (Australia) began manufacturing and marketing dissolved acetylene in cylinders in January, 1920.

Gardner Waern had established an acetylene plant in Sydney about 1912 and it had built up a useful business refilling cylinders for the Commonwealth Lighthouse Service and port and harbour authorities. There was also good business in refilling the "Prest-o-Lite" acetylene cylinders used for lighting purposes on motor vehicles.

Staffed by returned servicemen at a time when patriotism was running high, Allen-Liversidge (Australia) was able to make inroads into the market. Industry was expanding and oxy-acetylene welding was starting to develop, increasing the demand for dissolved acetylene in cylinders. The A-L cylinders were much easier to handle than the heavy AGA cylinders of Gardner Waern which could not be stood upright because of their convex bottoms.

In 1920 Harold Morgan had discussions with Russell Grimwade on the establishment of an A-L factory in Melbourne. Grimwade encouraged the idea and persuaded the board of Australian Oxygen to buy shares in the company and to market its acetylene. A-L began operations in Melbourne in 1921.

Calcium carbide, from which acetylene gas is produced, was not manufactured in Australia until 1917. Overseas, carbide was obtained by smelting lime and carbon at high temperature in an electric arc furnace. Because of the war, the cost of imported carbide in Australia had soared to £80 a ton.

In 1909 James H. Gillies was a sponsor of Complex Ores Limited which aimed at harnessing the waters of the Great Lake in central Tasmania to produce cheap electricity. This, he believed, could be used for a variety of purposes, including the treatment of zinciferous ores and manufacture of calcium carbide. The company was under-capitalised and was soon in financial difficulties. Gillies then promoted Hydro-Electric Power and Metallurgical Company Limited into which Complex Ores Limited was merged.

The new company had constructed a dam at Miena on the Great Lake for a hydro-electric power station when the Tasmanian Government established a Hydro-Electric Department and built two hydro-power stations. Instead of proceeding with its power station, the company became the Government's first customer for bulk hydro-electric power, contracting to buy 3500 h.p. at £3 per h.p. with an option to obtain more.

The company owned 200 acres of land, including limestone deposits, at Electrona, along the foreshores of North-West Bay, about 20 miles from Hobart. Chief electrical engineer George Graham was given the task of establishing the carbide works there. Electrodes for the electric furnace and a works manager were obtained from Sweden.

Carbide production began in 1916-17 and although the plant's initial output was offered at £24 a ton, it took two-three years to achieve a satisfactory product and quality even then was not as good as the imported material.

Confusion caused by the similarity of the company's name to that of the Government's power department prompted the company to change its name in 1919 to Carbide and Electro Products Limited. While it was battling to improve its product quality, the company was subjected to fierce competition from overseas carbide dumped on the Australian market. Soon it had accumulated losses of about £100,000 and large stocks of unsaleable carbide. It had announced cessation of production when the Tasmanian Government came to the rescue with a substantial loan secured by first mortgage. At the same time the Federal Government imposed an embargo on imported carbide.

By 1923, however, the company was unable to pay its electricity bills and the State Government appointed a receiver. Later the Government made the foreclosure absolute and it took over the whole operation.

Under Government ownership plant improvements costing £40,000 were introduced and new Soderberg self-baking electrodes were installed in the furnace. The remodelled plant was officially opened by Tasmania's Premier, the Hon. J. A. Lyons, who was later to become Prime Minister of the Commonwealth. Realising the need for a more vigorous sales policy, the State Government also appointed the well-known "IXL" brand canners and merchants, Henry Jones & Co. Pty Ltd, as distributors for the carbide.

Carbide production did not remain a state enterprise for very long, however. In 1927 the Government sold the plant to the Australian Commonwealth Carbide Company Limited which had been incorporated in England that year. ACC had a lean first seven years, but it was to have more than 40 years as Australia's sole carbide producer before it encountered serious crises.

Victory figure atop World War I memorial in Leichhardt, Sydney, was cast in about 30 pieces and welded together with oxy-acetylene.

Ted Raymond . . . a few obscure disciples of science crying aloud in the wilderness . . .

CHAPTER

IV

THE RULE OF THUMB

The welders had to battle from the start for acceptance of their new craft. A notion that the heat of welding "took the life out of steel" was widespread. The author of a leading mechanical engineering handbook wrote that "no welding should be allowed on any steel that enters into structures". Engineers generally were suspicious not only of the weld itself, but also of stresses which they said were set up in the metal around it. Prejudices against the welding process persisted for more than half a century.

Unlike most new processes which are adopted through progress in scientific knowledge, the art preceded the science in welding. Australia was to make many notable contributions to the advancement of welding knowledge, but the oxy-acetylene welders of the World War I era were severely handicapped by the fact that they knew very little about the process which they were enthusiastically introducing. Few appreciated that welding was a metallurgical joint which was vastly different from the mechanical joint formed by the familiar rivet.

E. J. (Ted) Raymond, who joined Australian Oxygen in 1913 and later became chief technical officer of CIG, told a Sydney conference in 1939: "Considering the limits of our knowledge in the early stages, it is somewhat surprising that welding has advanced to the position that it occupies today".

He said the old-timers had a lot of superstitions and beliefs regarding the value of patent and mysterious fluxes.

"If the flux could be given a foreign sounding name, the mystery became even deeper", he went on.

"There was only one quality of rod for welding steel and the ambition of the average welder was to puddle his weld, with continuous oscillating movements, in an endeavour to eliminate all surface traces on a half-inch mild steel plate.

"After this display of blowpipe acrobatics, the weld would often be two inches wide and would naturally be very course-grained and brittle".

Metallographic study of welds was not even dreamt of in those early days, Raymond said, yet in spite of difficulties and poor materials, some surprisingly good welds were made.

"The fundamental principles, however, were not appreciated, nor was any real attempt made to understand them", Raymond added. "There were a few obscure disciples of science crying aloud in the wilderness, but their cries were not heard and the rule of thumb prevailed".

It was, perhaps, a question of priorities. Until the welders could demonstrate that their craft had a significant role to play in industry, few scientists would bother about trying to improve it. The welder, meanwhile, had to get under his belt the "good many failures" which William Fyvie regarded as vital.

After leaving Grimwade in 1911, Schemnitz helped the McCann family to modernise the cement plant it had established in 1890 at Fyansford, near Geelong, and then had gone to Germany to learn oxy-acetylene welding and cutting. He returned to Melbourne after nine months with about a dozen Messer automatic acetylene generators and torches and made his first sale of a welding plant to his previous employers, Kelly and Lewis.

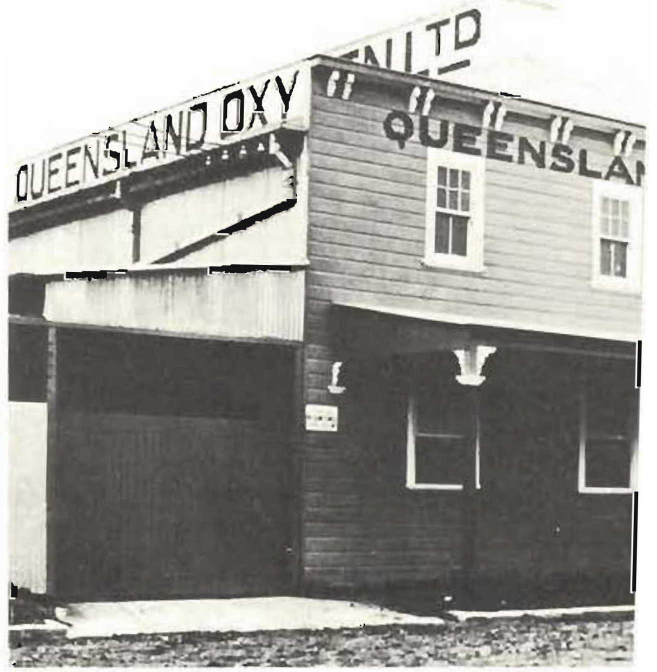
In 1914 he joined the Newport workshops of the Victorian Railways as a "supernumerary oxy-acetylene operator" at a salary of £325 a year. The workshops had an order for 375 bogies which were being turned out on presses and milling machines at the rate of half a bogey in eight days. Schemnitz used the cutting torch to do the same job in half an hour. He was told to slow down.

As a naturalised British subject, Schemnitz volunteered for the army after the outbreak of World War I, but was rejected because of varicose veins. In February, 1916, he was dismissed from the railways. It was three days after he had knocked down another railway employee who goaded him about his German ancestry in a train on his way home. However, Schemnitz was given a certificate of service usually reserved for employees leaving with a clean slate. In the "cause of leaving" section the head of the Rolling Stock Branch, W. M. Shannon, wrote: "Is an enemy subject—but for this I should have been glad to retain his services".

Later in 1916 Schemnitz was in Adelaide demonstrating oxy-acetylene welding of body panels at Holden's motor works and showing how welding and cutting could be applied at the Gawler locomotive workshops which Samuel Perry had acquired from James Martin & Co. Over the next four years he operated agencies from Melbourne and manufactured a few blowpipes, drilling the fine nozzle holes by hand.

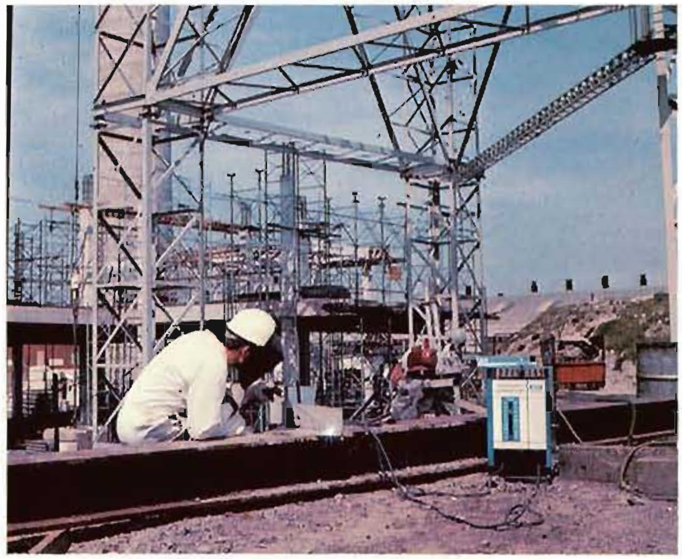
Welding had been given a big boost in Sydney before World War I by the arrival of the brothers, George and Alfred Kennedy, who formed a company called Autogenous Welders of Australia Ltd. Georg was a first class welder and had been a demonstrato for British Oxygen at the Paris Exhibition. Boil repairs were his specialty, but his charges were n related to the size or difficulty of the repair. He simp estimated how much it would cost his client to repla the boiler and his price was a substantial percentag of that cost.

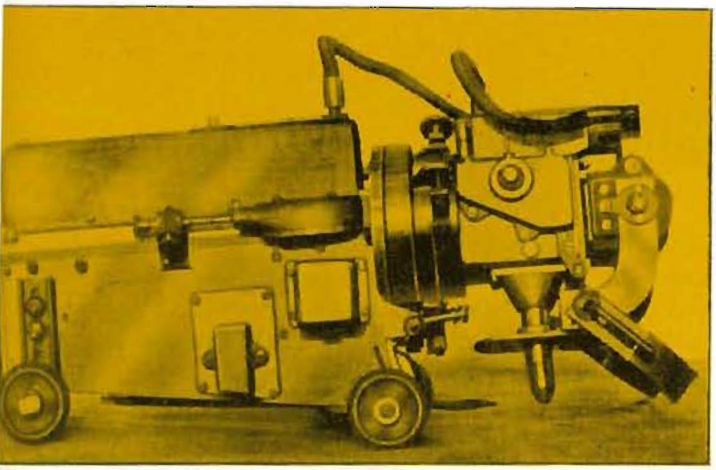
The N.S.W. Railways invited tenders for th welding of illuminating gas containers which we fitted under railway carriages. A Sydney firm whic had no experience in welding won the contract. It boug an oxy-welding plant from Commonwealth Oxyge and after elementary instruction in its use, the fir began supplying the containers. When one of th containers exploded because of welding faults, weldir was banned from Eveleigh workshops. John Cla began a lengthy correspondence with the railway protesting that the welding system had been unjust blamed when an inexperienced welding operator, wh was nothing more than a "metal plasterer", was fault. The Railway Commissioners demanded th Clack desist from writing to them on the subjec Clack eventually got the oxy plant into the railways demonstrating oxy cutting at Eveleigh in competiti with band saws.



C I G 's Transarc Junior portable welder enables the farmer to carry out on-the-spot repairs or to build new plant and buildings.

Transarc Tradesman has won wide acceptance for heavy duty work on construction sites and at other industrial locations.





Portable automatic arc welder for pipe welding was patented in 1922 by Cutler and Marsden, engineers at Walsh Island State Dockyard, N.S.W.

Oxygen production in Queensland began at this plant at Newstead in 1922. Evans Deakin had been Comox distributors from 1912.

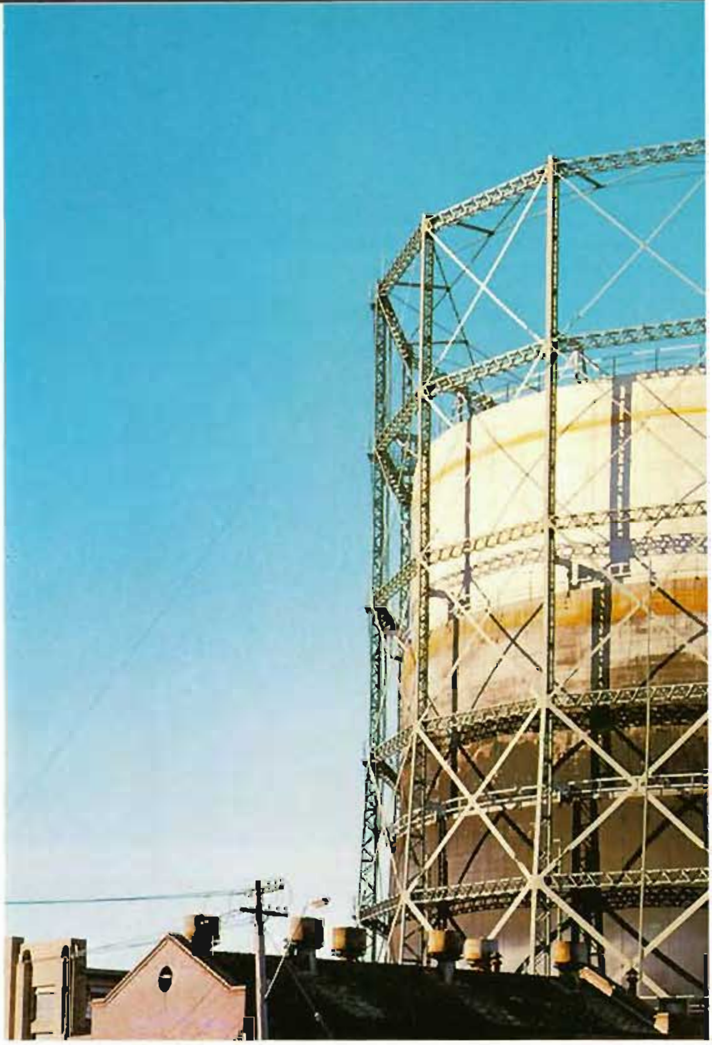
Fred Sims, who had just completed a seven-year apprenticeship as a blacksmith in Toowoomba, Queensland, joined Lever Bros. at Balmain in 1915 and he was taught to gas weld by an instructor who had been sent from Port Sunlight.

As welding developed, the boilermakers' union in N.S.W. endeavoured to have the welding torch classified as the specific tool of boilermaking. Few boilermakers, however, knew how to weld and when a welder who was not a member of the union was brought in to do a job, the union insisted that a boilermaker had to stand alongside the welder while he worked. Disputes arose over the issue and in the industrial court John Clack claimed that the welding torch was as common to a variety of trades as the hammer.

Welding later caused a demarcation dispute between the sheet metal workers' union and the boilermakers. It was resolved by the sheet metal workers agreeing to confine their welding to metal plates below a certain thickness. The boilermakers took over responsibility for welding heavier gauge plates.

The oxy torch was appearing more frequently in other parts of the continent. In 1911, Daniel Evans, former chief engineer of an Adelaide Steamship Company vessel, and Arthur Deakin, who had been working with Schweppes in Sydney, set up a business as suppliers of engineering equipment in Brisbane. Evans had worked for four years at Bundaberg Foundry in his youth and he recognised the important role welding could achieve in industry.

Gas-holder at North Fitzroy was world's largest all-welded structure when completed in 1923. It's still in use.



Among the first products offered by Evans, Deakin & Co. were gas welding plants and oxygen imported from abroad by Fyvie & Stewart, in 100 cubic feet cylinders. The oxygen cost 3d. a cubic foot.

Evans toured Queensland in a truck demonstrating welding and teaching it to anybody who was interested. Among his first pupils were the boilermaker apprentices at W. S. Binnie & Sons Ltd., including W. S. Coates who was president of the Australian Welding Institute in 1955–56 and again in 1961–62. Evans, Deakin were agents for Commonwealth Oxygen until Queensland Oxygen Ltd. was established by Commonwealth Oxygen in 1922.

Electric welding was introduced at Randwick Tramway Workshops in Sydney in 1915 by workshops' manager, Frank Bowman Shenstone. Initially it was used for repairs to rolling stock, but in 1918 the workshops built two welded trucks and put them into the heaviest service available. In two years they completed 42,000 miles without problems and it was then decided to use electric welding wherever possible throughout the workshops. Welding enabled lightweight trams to be designed and built to replace the cumbersome vehicles then in service in Sydney.

At the Walsh Island (Newcastle) workshops of the State Dockyards, two engineers, Cutler and Marsden, had been experimenting with the welding of pipes for water supply authorities and in 1922 they were granted a patent for a portable automatic arc welding machine. Thompsons Engineering and Pipe Co. Ltd. —later to be known as Thompsons (Castlemaine) Ltd. —bought the Victorian rights and manufactured a number of the machines to carry out a contract they had for the supply of 24 miles of 46-inch and 54-inch steel pipes for the Melbourne and Metropolitan Board of Works.

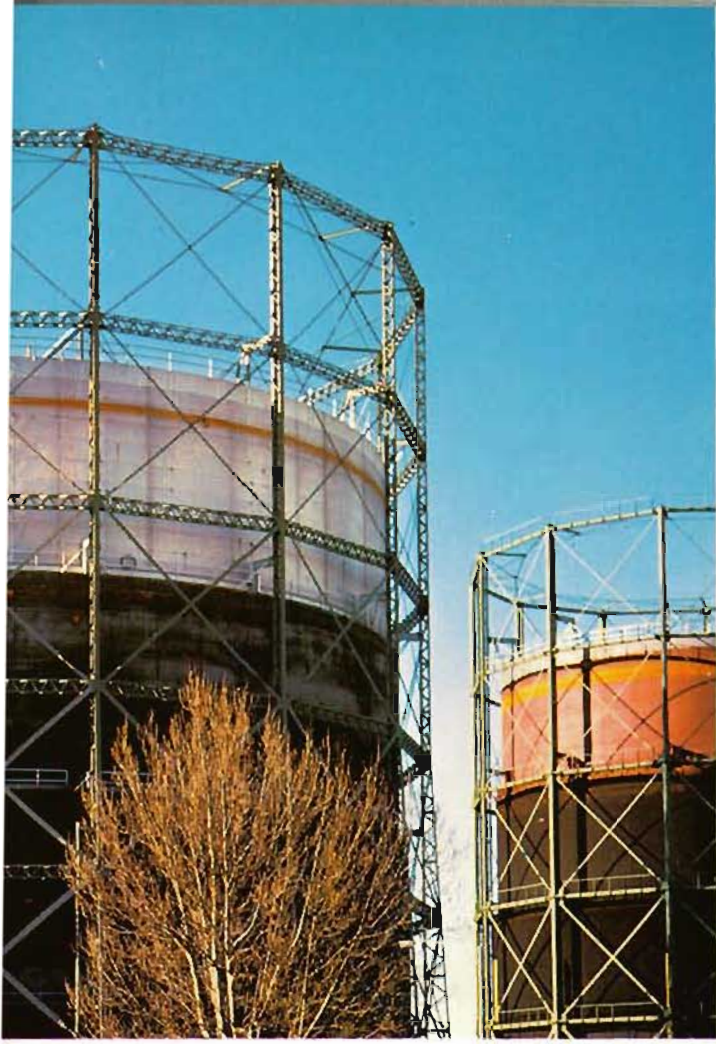
Early electric welding was carried out with direct-current equipment employing high voltages to produce the arc which melted the electrode. The latter was usually a piece of bare fencing wire. As the wire melted it absorbed oxygen and nitrogen from the air and a brittle weld resulted. By lowering the voltage and shortening the arc, it was found that exposure of the melted metal to the air was reduced and the quality of the weld improved, but the welder required more skill to lay the metal. It was also found that some types of bare wire protected the weld surface from air contamination.

Welders at the Brisbane workshops of W. S. Binnie & Sons who switched to electric welding after their company was acquired by Evans Deakin, discovered that they produced better welds if they rubbed their bare wire electrode with carbide sludge from a low pressure acetylene plant. Evans Deakin had become more interested in electric welding after they lost their oxygen franchise following the establishment of Queensland Oxygen.

In Sweden in 1907, Oscar Kjellberg had produced an electrode with a complex mineral coating. As it melted, the coating vaporised into a gas which shielded the molten metal from the air. Coated electrodes—a great variety of materials was used in the coatings—eventually supplanted bare wire electrodes, but acceptance of them was slow at first because of their cost. Australian welders switched to coated electrodes, however, many years before their counterparts in the United States.

Coated electrodes were introduced to Australia by E. J. Rigby of Melbourne, who gained the Australian agency for Quasi-Arc towards the end of 1913. Rigby joined Robert Bryce to form Robert Bryce & Co. Pty. Ltd.

Quasi-Arc had been formed in England in 1911 by A. Strohmenger, a South African, who had coated



Brigadier W. D. Chapman helped establish acceptance of welding by Australia's engineering profession.

an electrode wire with asbestos impregnated with sodium silicate. A friend of Strohmenger, Professor Sylvanus P. Thomson, said he had never seen an electric arc enclosed by vaporised flux. Thomson described it as an electrical condition similar to the normal metallic arc, but not identical. He named it a "quasi-arc".

Strohmenger registered the name and his mild steel electrode gained world markets because it represented a significant breakthrough in "out-of-position" welding. Bare wire or lightly dipped electrodes were only useable in down-hand positions, but Quasi-Arc electrodes made vertical and overhead welding relatively easy.

Robert Bryce's first plant consisted of a 20 kVA single phase transformer with an output of 100 volts at 200 amps. Output was regulated by a series of cast iron grid resistors to suit the different gauges of electrodes.

World War I prevented experienced operators from being imported from Britain and the Robert Bryce technical salesmen taught themselves to weld on this machine which was known at first as a "putting on tool". In 1920 an AIF man who had been trained by Quasi-Arc returned to Melbourne and the standard of instruction provided by Robert Bryce immediately improved.

Robert Bryce helped establish electric welding in Melbourne's Metropolitan Gas Company where the construction department started welding in 1920. In the next two years, working on limited information from Quasi-Arc in England, the gas company's chief engineer, J. M. Reeson and his assistant, Harry E. Grove, planned the construction of the world's largest all-welded gas-holder at North Fitzroy. Completed in 1923, the $2\frac{3}{4}$-million cubic feet capacity structure involved more than 5000 steel plates and sheets and 15 miles of welded seams.

"This was a colossal and magnificent undertaking, after so little experience in welding", a gas reticulation expert told a world symposium on welding in London in 1935. W. T. B. McCormack, chairman of the Country Roads Board of Victoria, told the same symposium: "Most engineers at the time were very distrustful of the new process and it appeared to me that a few rivets through the joints—which had the appearance of very poor soldering—would relieve anxiety concerning what sort of unforeseen stresses would cause the crazy-looking work to fail".

The 750 ft. long Mackillop Bridge over the Snowy River in 1932 had world's second longest welded spans. Floods washed it away soon after it was opened.

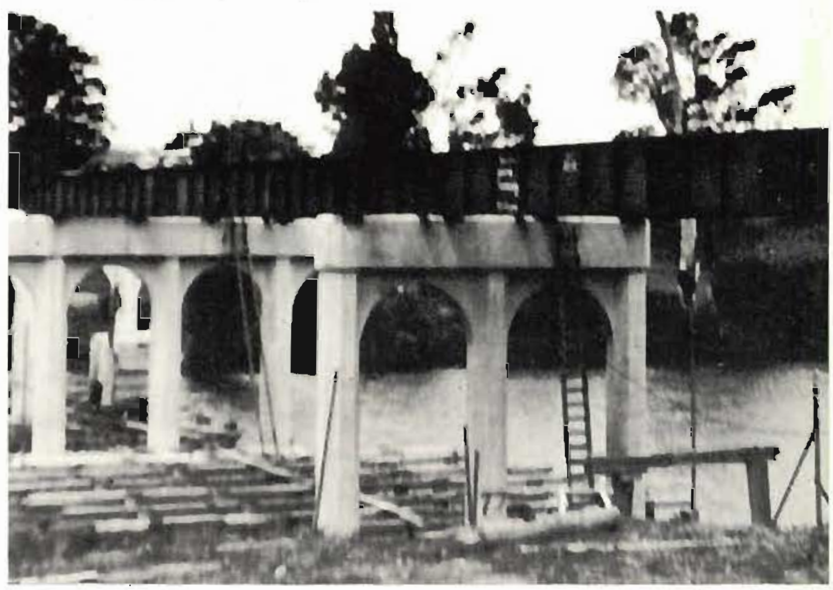
Among the engineers who clambered over th scaffolding of the gasholder to watch Grove and hi men at work was Wilfred Dinsey Chapman, of th railways construction branch of the Board of Land an Works. Although frequently employed on railwa construction work, "Chappie of the Railways", wh was to become a leading figure in Australian weldin and engineering, was never on the railways staf Chapman was awarded a Master of Civil Engineerin degree by the University of Melbourne in 1925.

Grove developed the first system of specifyin details of welded joints using a "length run" formula t express the number of inches of weld for an 18 inc electrode of specified gauge.

Welding had been introduced at the Sunshir plant of H. V. McKay after World War I by Arthu H. Collins and in the early 1920s he was the doyen Melbourne's welding fraternity. By the mid-twentie Joseph Hunter had half a dozen d.c. plants at Broke Hill Associated Smelters in Port Pirie. Hunter's fath

Mackillop Bridge wreckage (left) showed that all welded joints had stayed intact.

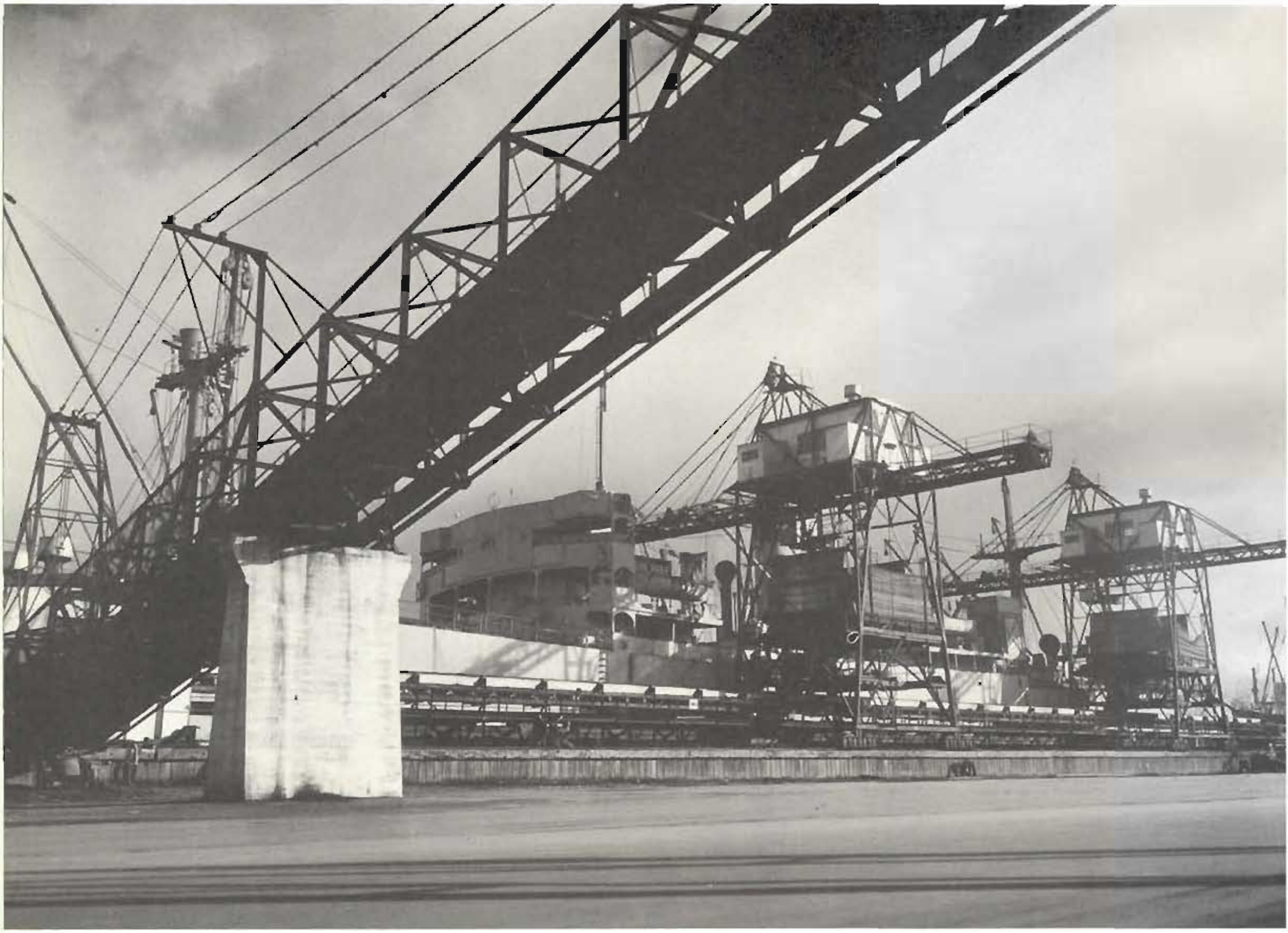
Welded plate girders were used for Tambo River Bridge (below) in Gippsland about 1930.



had been manager of the Wattle Gully mine in northern New South Wales and as a youngster Joe had learnt how to run the colours on the blacksmith's forge at the age of five. He was using a blowpipe at the age of nine.

A Swiss engineer, Albert Longoni, who was another of the Australian welding pioneers, arrived in Melbourne in 1919. He established himself as a consulting engineer and worked closely with Quasi-Arc and Grove. Spurred by Grove's work in welding gasholders, other engineers began applying welding to various types of structures. The Railways Construction Branch carried out tests on welding in 1924 and as a result permitted the welding of certain non-structural parts of bridges then being designed. In March, 1925, Chapman used welding to repair and strengthen the wrought iron Echuca road-railway bridge over the Murray River. The engineer in charge was C. A. (Gerry) Masterton, who was later to become Engineer for Bridges for the Country Roads Board.

In 1926, about the time Johns & Waygood put on their first welder, a Commonwealth Oil Refineries Ltd. engineer, D. E. Baldwin, welded an oil storage tank and welding became the accepted construction method at the refineries. It was even used for a 125 ft. dumb oil barge, the Comor, which Thompsons Engineering & Pipe Co. Ltd. built using welding specifications supplied by Longoni. Comor had been designed for rivet construction to secure a Lloyd's classification, but Baldwin claimed welding reduced its cost by 15 per cent. Although Britain had built an all-welded ship, the Fullagar, and Sweden, the ESAB-IV, in 1920, the Comor demonstrated the potential of Australian welding in shipbuilding. Baldwin's company, Commonwealth Oil Refineries, was later absorbed into British Petroleum, formerly the Anglo-Iranian Oil Co., which had its origins in the huge dividends which Rockhampton solicitor, William Knox D'Arcy, received from his shares in Mount Morgan gold mine in Queensland. Some of the Mount Morgan ore assayed at 3700 ounces to the ton—or nearly 10 per cent gold.



Welded 100-ton grab bucket unloaders were designed and built by Malcolm Moore for gas companies in Melbourne and Sydney in early 1930s.

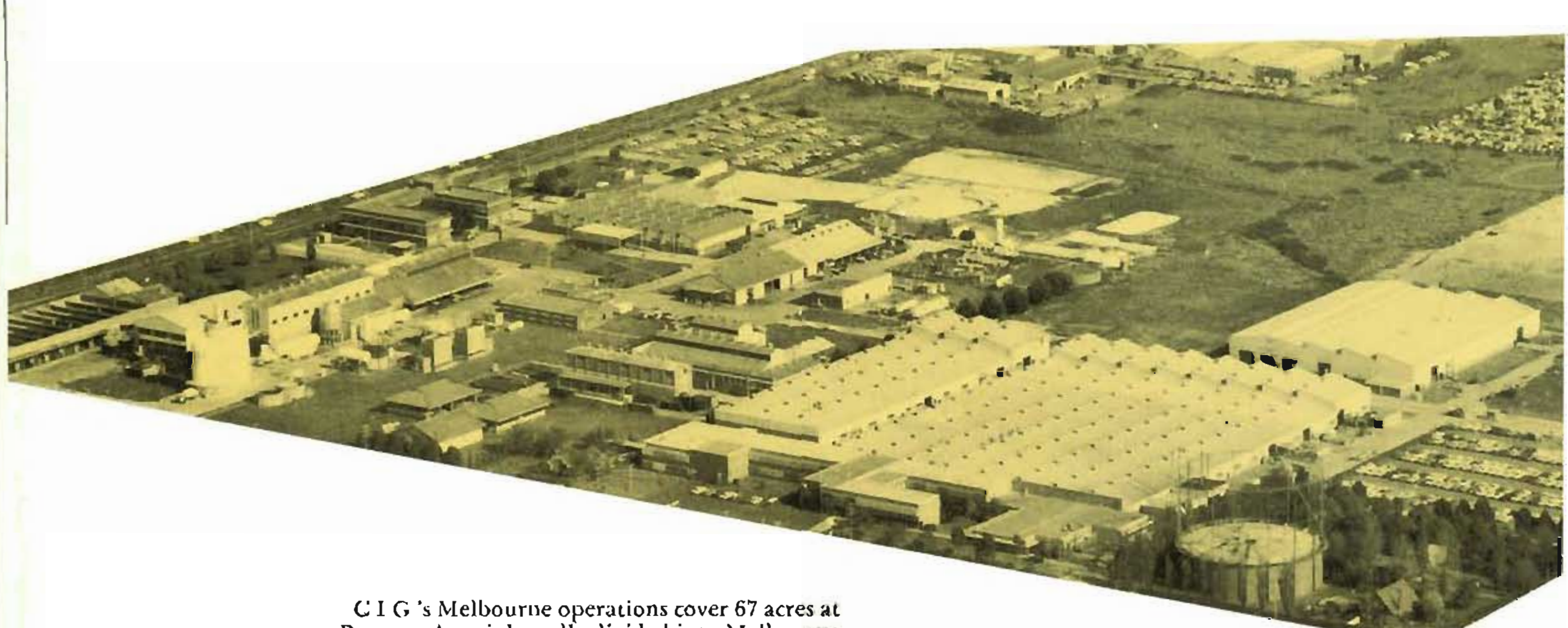
Welding was widely used on new bridges built by the Railways Construction Branch up to 1929, but the main girders, trusses and viaduct towers were still designed as riveted construction because few contractors were sufficiently experienced or equipped to undertake heavy welded fabrication. The branch reconstructed the Hawthorn Bridge over the River Yarra in Melbourne by welding in 1930–31 and in 1932 similarly reconditioned the Yarra River Bridge at Victoria Street. In 1934, the branch built its first all-welded bridge over the Yarra River at Grange Road in the city.

Welding was first used by the Country Roads Board for structural work on bridges in 1928 when a reinforced concrete deck was built on top of welded trusses of a bridge over Pykes Creek Reservoir at Ballan. Welded plate girders were used in the Tambo River Bridge at Swan Reach. The welding on both bridges was carried out by Gardner Constructions Pty. Ltd., a company sponsored by Corrie Gardner. D. E. Baldwin was a director and "The Two Joes"—E. L. (Joe) Hambridge and Joe Hunter—were general manager and works manager respectively. Several Metropolitan Gas Company employees joined Gardner Constructions during the depression.

The gas company in 1927 had completed a large welded coke handling plant at West Melbourne which had been designed by Longoni and included a 164 ft. long travelling conveyor bridge with 110 ft. clear span between the tracks. Longoni in 1929 joined Malcolm Moore Industries which designed and built two 100 ton grab bucket unloaders for the gas company at West Melbourne. Every connection in these structures was electrically welded. The units were ordered in 1931 and placed in commercial operation in 1933. They were sold for scrap in 1955–60 when the whole of the West Melbourne plant was declared obsolete.

In 1931–32, the Country Roads Board constructed a 750 ft. welded superstructure on concrete piers and abutments across the upper Snowy River at Mackillop's Crossing, near the N.S.W. border. Above this point the Snowy had a catchment of 4000 square miles of mountainous country and the bridge was designed to have a clearance of 10 ft. above the highest flood in the area in the previous 60 years. The bridge had been barely completed when a flood 16 ft. above the previous highest level dumped masses of debris into the trusses and swept the superstructure in a twisted mass 1000 ft. downstream. Engineers gained greater confidence in welding through the disaster, however. Examination of the wreckage showed that the welded joints had resisted "forces which twisted and bent the adjacent steel sections as if they had been so much brown paper", board chairman, W. T. B. McCormack, stated. Gardner Constructions won the contract to build a higher bridge at the site.

Tasmania's Public Works Department had its first experience with welding in 1930 when alternative tenders were called for riveting or welding cover plates to rolled steel beams. The amounts of the tenders were £2400 and £998 respectively. This made departmental officers consider welding very seriously, according to the Director of Public Works, G. D. Balsille. Tests were carried out at the University of Tasmania to demonstrate the strength of welds. Satisfied with the strength and economy of welding, the department designed a welded road bridge. This was a 220 ft. structure containing 56 tons of steelwork which was supplied, fabricated and erected at White Rock, Kimberley, at a cost of £41/10/0 a ton.



C I G 's Melbourne operations cover 67 acres at Preston. Area is broadly divided into Melbourne Branch (at left along Bell St.), Equipment (right foreground) and Consumables (top right) Front of Equipment building is shown opposite.

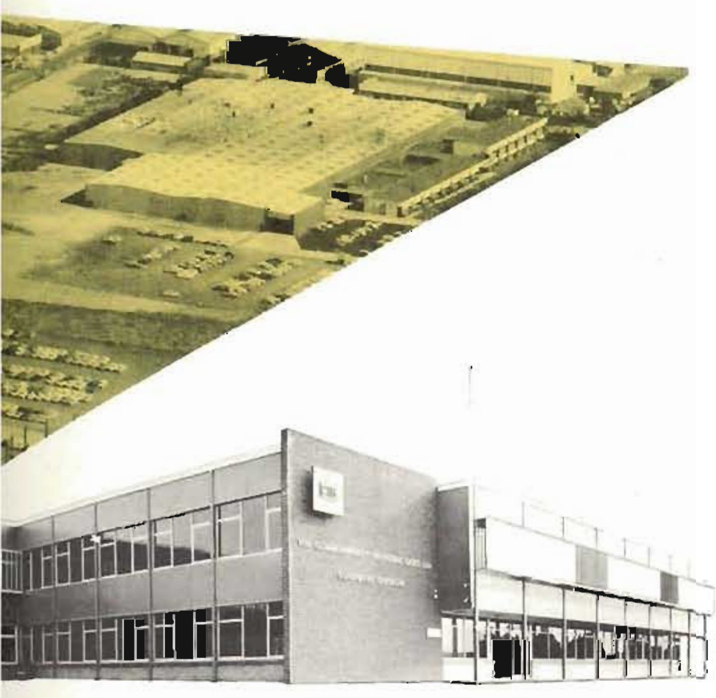
CHAPTER V
ARNOLD WINS A MEDAL

John B. Arnold left Gardner Waern in 1922 because he believed that Waern was neglecting the welding side of the business. Gardner Waern marketed AGA oxy-acetylene equipment, but did not try to exploit it. The company had some choice Swedish agencies like SKF ball bearings and ASEA motors, but Waern was an ambitious man, always wanting to do something new. According to Arnold, Waern would spend money like water on things that did not matter—such as hiring a train for himself when he went home to Sweden. He poured money into a company to make prefabricated building components and he invested in anything he thought would make him a million. He did not rate dissolved acetylene very highly. The cylinders were very expensive and they did not return much for the outlay.

Arnold decided to start manufacturing welding equipment on his own account and a fitter and turner from Gardner Waern, Knut Oscar Grunden, joined him to set up a small city workshop. They had two turret lathes, two drilling machines, a pedestal grinder and a polishing machine. Many years later Arnold was to wonder why he had ever bought so many machines because he did not have enough business to keep them going.

By the 1960's however, Arnold's workshop had grown into the multi-million dollar CIG Equipment Division, one of the largest light engineering plants in Australia, occupying a substantial part of a 67-acre site at Preston, Melbourne.

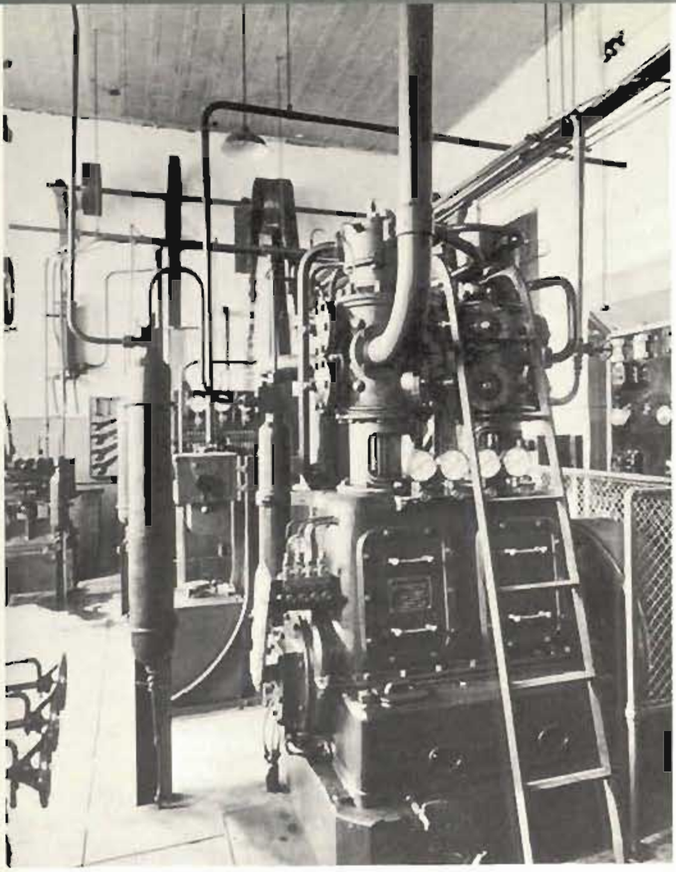
Arnold had had no previous contact with Russell Grimwade, but the new workshop soon came to Grimwade's attention. Grimwade, who had been granted a patent for the oxy-acetylene piercing of metal rails and plates in 1919, started calling on Grunden. Grimwade encouraged Arnold to form John B. Arnold Pty. Ltd. in 1924. Australian Oxygen invested in the venture and undertook to distribute the company's output.



Arnold torches and cutting equipment quickly gained a reputation that they were as good as, and often better than, imported equipment. Arnold was awarded a medal for equipment he exhibited at the Wembley Exhibition in London in 1924. Arnold also had considerable success with an acetylene flare he produced after learning that imported flares were giving a lot of trouble. The Victorian Railways used many of the flares on night maintenance work.

Western Oxygen acquired this plant at Subiaco, Perth, in 1926 from Westralian Chemicals.

Westox plant established in Adelaide in 1922 was joint venture of Austox and Comox.



Equipment in the Subiaco plant of Westox in late 1920s included this BOC air compressor.

Schemnitz, meanwhile, was back in the oxygen business. He had obtained permission from the Government to import a Linde or Claude plant and he suggested to the railway and civil engineering contractor, Henry Teesdale Smith, that he sponsor an oxygen manufacturing venture. They first met at Menzies Hotel in Melbourne in 1920 and within half an hour Schemnitz was told to book his passage to Europe to obtain the plant.

They agreed to form a partnership with Frank Benson, of the engineering firm of Benson Bros., to manufacture and sell oxygen in Melbourne under the name of Oxygen Supply Company. Teesdale Smith was to supply the capital of £8500. Schemnitz was to get £500 a year plus 30/- a day travelling expenses while abroad. Benson Bros. would distribute the oxygen for five per cent commission.

At first the P & O Company refused to give Schemnitz a passage because they said he was a German and the crew would go on strike when they found out. The official who issued him with a passport solved the problem by stating on the passport that Schemnitz was a naturalised British subject of Serbian origin—a status acceptable to the British seamen.

Low-pressure acetylene generator at right of the picture below was part of a Westox exhibit at a Perth show in the early 1920s.

Schemnitz had been abroad for three of the six months he had been allocated when he received a cable telling him Teesdale Smith had died.

Returning to Australia, Schemnitz signed a new agreement with William Abel Gray who represented a Sydney syndicate which included Teesdale Smith's son, Basil; Scruttons, the machinery suppliers; representatives of Gibson Battle in Sydney and London; an engineer named van Gelder and soft goods retailer Sydney Snow.

A Linde plant, which had been made under licence in Holland, was installed by Schemnitz in Sydney and it began operating early in 1922. The Oxygen Supply Company Ltd. was incorporated in the same year with Sydney Snow as chairman.

Schemnitz received 5000 shares in the new company, but he was disappointed he was not made a director or even manager of the new plant as he had expected. Selling the shares back to the other participants for £2000, he returned to Melbourne. In 1924 he went to Germany and with £3000 credit granted to him by Dr. Linde had an oxygen plant shipped to Australia. He offered it first to Walter Crabtree, manager of Australian Oxygen in Melbourne, on condition that he was given "a position of some standing" in the firm. Crabtree said he would consider the offer, but Schemnitz did not get a reply.

Austox and Allen-Liversidge staff picnic at Warrandyte in 1924. Ted Raymond is 7th from left in the third row, next to Walter Crabtree and Harold Morgan. Lawrie Martin is third from left in the front row.

Company promoter D. C. Jenkins helped him to organise the formation of the Oxygen Service and Manufacturing Company in 1925. Other participants included Jeremiah Carrigan, Leslie William Woolcott and George Dance. Schemnitz made certain he would have "a position of some standing" in the new company. He had it stipulated in the articles of association that he was to be permanent director as long as he held 1000 shares in the new company.

In June of the same year Oxygen Service tendered for the Railways Contract—the supply of 3,000,000 cubic feet of oxygen which the Victorian Railways required over the next 12 months. The new company offered 99.5 per cent purity for 1¼d. a cubic foot and 98 per cent purity for 1d. Oxygen Service was awarded the business but before the contract could be finalised, Russell Grimwade, upset over the loss of Australian Oxygen's biggest account, complained to the Railways. Fresh tenders were called. This time Oxygen Service was awarded the contract for high purity oxygen and Australian Oxygen got the low purity business—at 1d. a cubic foot. It was small consolation to Grimwade. Most of the railway's requirements were for high purity oxygen for cutting. The low purity oxygen was used in welding which had not yet been adopted to any large extent by the railway workshops. Schemnitz then offered the hospitals oxygen of 99.5 per cent purity for 2d. a cubic foot compared with the 6d. a cubic foot they were still paying Australian Oxygen. At first the hospitals turned down the offer, but then it was reconsidered and the business was given to Schemnitz. Australian Oxygen decided to counter-attack and their prices were cut even below cost to retain customers. This price war was to continue for several years.

Australian Oxygen and Commonwealth Oxygen had established a joint venture for the manufacture of oxygen in Adelaide in 1922. This company was incorporated as Western Oxygen Company Ltd. in 1923. It began trading in Western Australia in September, 1926 and in the same month it secured an option over a Heylandt oxygen plant which Westralian Chemicals Ltd. had established in the Perth suburb of Subiaco. This option was subsequently exercised for £6500. In 1929 Western Oxygen, Subiaco, was incorporated as a West Australian company. H. B. (Harry) Coburn, who had been manager at Adelaide, was appointed general manager of the two Western Oxygen companies and W. P. Bridge was appointed manager in Perth.

Allen-Liversidge, meanwhile, had quickly made inroads into Gardner Waern's Melbourne market despite the crude conditions at A–L's North Fitzroy plant. Lawrie Martin began work there as a shorthand typist in 1922 at the age of 14. When he retired as company secretary of CIG after 49 years' service, Martin recalled that his parents were not impressed with his new job.

The rough environment was totally unsuitable for female clerical staff and that was why Martin had been taken on. The office was an old cottage which had seen better days and the factory was an ancient timber structure sheeted with corrugated iron. The inner walls were covered with a whitewash made from carbide sludge.

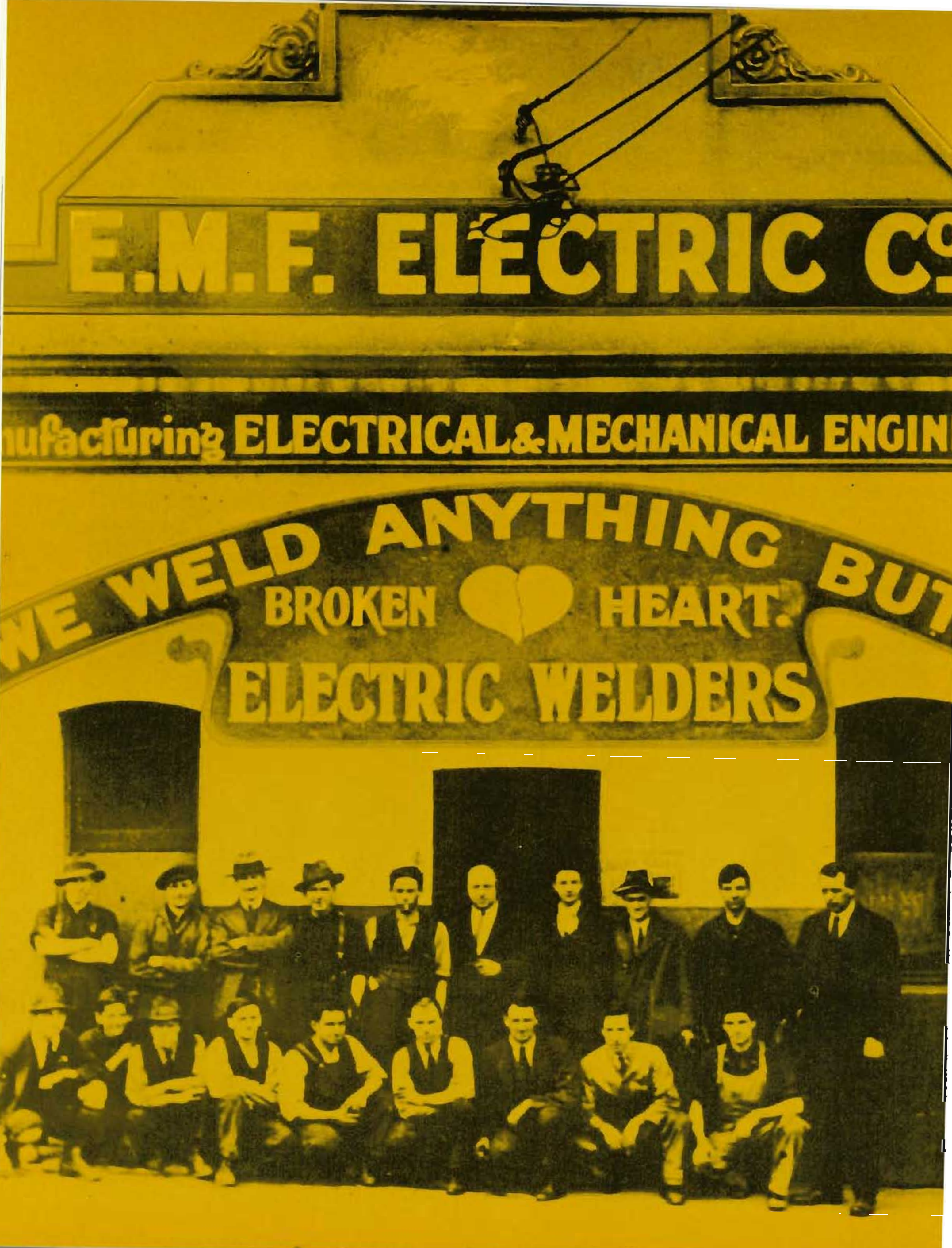
Allen-Liversidge had installed a 15 hp electric motor designed for three-phase electric current which was gradually being adopted, but supply to the plant was still single-phase. The motor had to be started in the early hours of the morning when power demand in the neighbourhood was low. It was also prone to overheating and a young electrical engineer, Raymond Garrett, was constantly being summoned.

Garrett, who drove a "Le Zebre" sportscar—usually at hair-raising speed—was to become an R.A.A.F. group captain and President of Victoria's Legislative Council. Founder of the Gliding Club of Victoria, he held the British Empire glider duration record in 1931. He was knighted in 1973.

While the electric motor at Allen-Liversidge was out of commission, the plant used a standby coal gas engine. This drew so heavily on the gas main that neighbouring households complained to Harold Morgan that they could not get enough gas for their domestic needs.

Rain was also likely to bring complaints, not only from the neighbours, but also from the local council. The carbide sludge pit frequently would overflow and block drains in the street.

There was commotion one weekend when a man with a wooden leg had to be rescued from a perilous position on the plant roof. Jack Messenger, honorary caretaker of the premises, had climbed on to the roof to repair damage caused by high winds. He slipped on the steeply pitched sheeting, but was saved from a heavy fall when his wooden leg jammed in the gutter.


E.M.F. ELECTRIC Co
ufacturing ELECTRICAL & MECHANICAL ENGIN
WE WELD ANYTHING BUT
BROKEN HEART.
ELECTRIC WELDERS

CHAPTER

VI

ANYTHING BUT A BROKEN HEART

EMF's staff pose under their famous slogan at their factory in Toorak Rd. in 1922. Standing at right is George Whiting. Third from right in same row is Ted Geere and 5th from right is Jack Frost.

Reginald Carr, an AIF veteran, was one of the Diggers who took advantage of the Australian Army's non-military employment scheme in Britain at the end of World War I for men awaiting return to Australia. He obtained a job in the Birmingham office of T. Lea Elliott & Co. Elliott had a business arrangement with a relative of Carr's in Sydney who operated as Carr & Elliott, manufacturers' representatives.

While in Birmingham, Carr arranged with several U.K. firms to act as their Australian representative. One of these was the Aerograph Company, of London, manufacturers of spray painting equipment. Before he had enlised in the AIF in 1915, Carr had been working with an American firm of indent agents, R. W. Cameron & Co., who had promised to re-employ him on his return from the war. Before Carr got back, Cameron's general manager, C. M. Terry, left the company and started on his own account. Cameron's did not have a job for Carr as promised and he joined Terry in Melbourne in 1920 and they traded under the name of Terry & Carr.

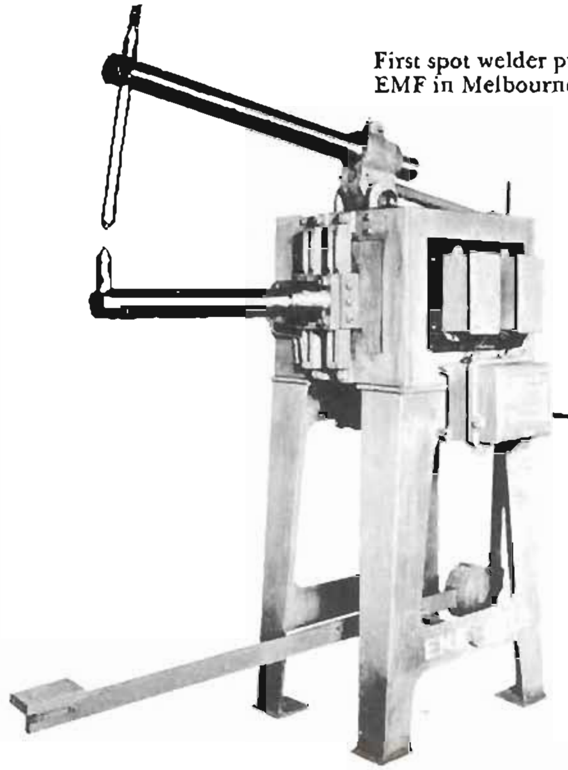
The business was not a success, due partly to Carr's inexperience and partly to the recession which followed the war. A few months before the business closed, Terry and Carr won a large contract from the Victorian Railways for mild steel plates and soon after a town traveller for a Melbourne electrical supply house, Edward Geere, suggested to Carr that he call on George Whiting who might want to buy transformer iron. Whiting had served an apprenticeship at Wonthaggi State coalmine in Victoria and had then started on his own account, doing household electrical repairs and manufacturing electric transformer-type water heaters. The plates could be used in his transformers.

Carr reported that he found Whiting "with his shirt tail hanging out of his disreputable-looking overalls in an equally untidy workshop which had been half the stable of a South Yarra doctor. I did not press for an order as it struck me as being too much of a financial risk for us."

Soon after, Geere was shown a picture of an electric spot welder in an overseas journal by one of his firm's clients who asked where one could be obtained. Geere went to Whiting at Dr. E. Keogh's stable at 209 Toorak Road and announced: "George, we are going to make a spot welder".

Cream can being seam welded and bucket spot welded in Melbourne workshop in early 1920s.

First spot welder produced by EMF in Melbourne in 1921.

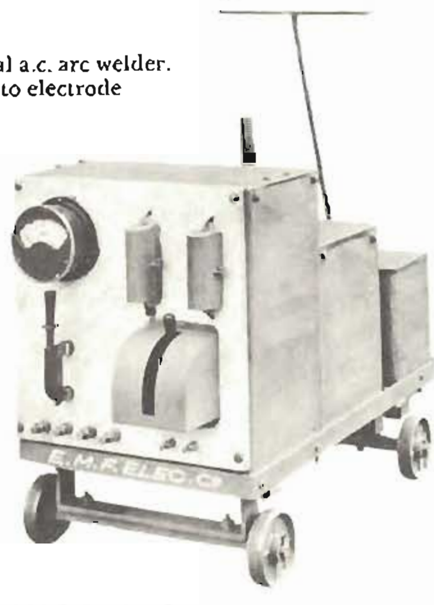


With Whiting's friend, an electrical engineer named R. J. Frost, they went to the State Library in Melbourne and read all the literature they could find on resistance welding. Then they produced sketches and a quote for manufacture. Mayne and Holberry, a metal-working firm, ordered the machine in 1921 and, finding it satisfactory soon ordered another.

Dr. Keogh, Frost, Whiting and Geere had by then formed a partnership, trading under the name of EMF Electric Company. Geere borrowed money for the venture from his mother-in-law. There was to be conjecture in later decades as to whether the letters EMF stood for the electrical term "electro-motive force" or were derived from the name of Frost's wife, Ellen Mary. According to the company's first metallurgist, Roy A. Holland, some people said the letters stood for "Eat More Fruit"—a well-known slogan at the time. In any case it turned out to be an unfortunate choice when the company later tried to copyright the EMF brand on products it was marketing in Britain. The abbreviation was in common electrical usage and the authorities refused to register it until an artist produced a logotype design in which the letters were joined into a single unit.

Encouraged by the success of the spot welder and already active in transformer manufacture, Whiting and Frost decided to make an alternating current transformer type of arc welder which was much cheaper than the direct current arc welders then being used.

EMF's original a.c. arc welder. It led EMF into electrode manufacture.



The a.c. machines required covered electrodes. Quasi-Arc and AWP electrodes were available.

In 1922 EMF moved from the stable to a factory at 269 Toorak Road which had been occupied by the Booty Croaker Air Gas Machine Company. A large sign across the front of the building soon proclaimed: "We Weld Anything But A Broken Heart".

The EMF a.c. arc welders were a success and the company began manufacturing electrodes. Over the years it became accepted that EMF was forced into electrode manufacture when Robert Bryce refused to supply Quasi-Arc electrodes to EMF a.c. welding machine customers. Robert Bryce, however, later emphatically denied this allegation. The company said its engineering department in the early 1920s welcomed the arrival of suitable plants because these extended the electrode market.

Although the reasons for EMF's new venture might be obscure, Geere, a wartime pilot who had been shot down and shell-shocked, scraped the coverings off some electrodes, crushed the material into powder and took it to Roy Holland for analysis. Holland had joined the Victoria Iron Rolling Company Pty. Ltd. in 1919 from BHP's Newcastle steelworks to install a seven ton Heroult electric steel furnace under the chief engineer, J. E. Edgerton, son of the main shareholder and managing director. Holland's brother and W. D. Chapman were attending Melbourne University at the time and Roy Holland for a period stayed at their boarding house. Roy Holland had been engaged at BHP in finding substitutes for paint chemicals and ferrochromium, supplies of which had been cut off by the German raider Emden. He was able to help his brother and Chapman with their university chemistry work.

Former cable tram shed in Rathdown St., North Carlton, became EMF headquarters in 1928.

With Jim Edgerton's approval, Roy Holland told Geere and Whiting what the powder they had given him for analysis contained. The EMF men bought quantities of the materials, mixed a batch, dipped 18 inch lengths of wire in it, dried them and tried them out on their a.c. arc welders with fair success. EMF began manufacturing electrodes in 1923.

Their customers certainly received a package deal—a bundle of 18 inch pieces of wire, a tin of "Ovo" egg preservative (a silicate of soda), and a 10 lb bag of red oxide. The kit enabled the welding operator to manufacture the electrodes on the spot, dipping the wire first into the egg preservative and then into the oxide.

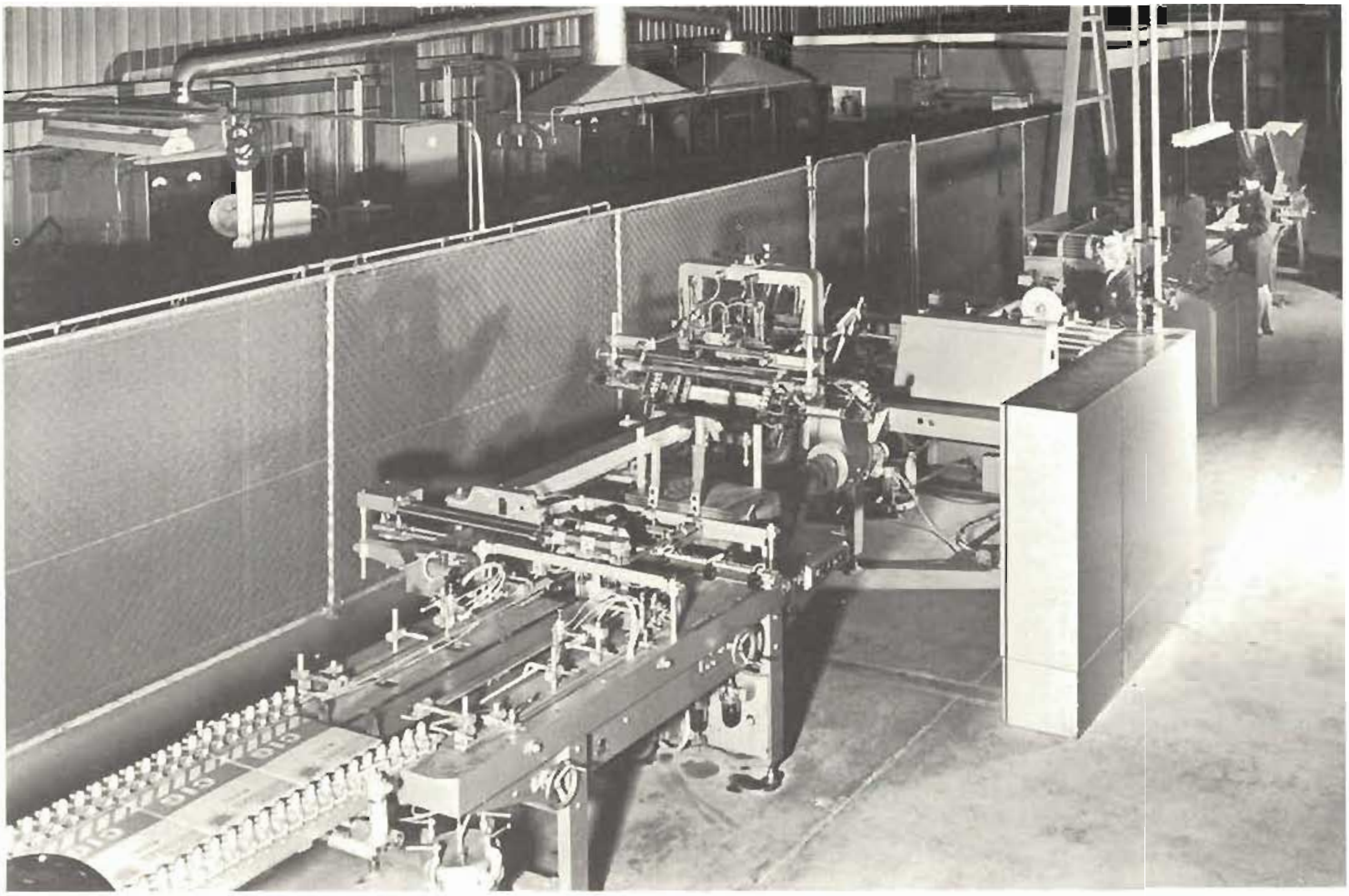
The electrodes, however, were little better than bare wire. Extra flux could not be held on the wire unless it was bound with some material like the asbestos fibre which Quasi-Arc used. The welder usually bent the electrode to suit the curvature of his arm and the unreinforced flux broke and fell off.

Whiting came up with the idea of covering the wire with a cotton sheaf and dipping it into the flux paste. He found that lacing used on women's corsets and stays made an ideal sheaf and girls in a printing works partly-owned by Whiting's elder brother were given the job of threading the lace on to the core wire lengths in their spare time. The new electrode was called the "Firestick".

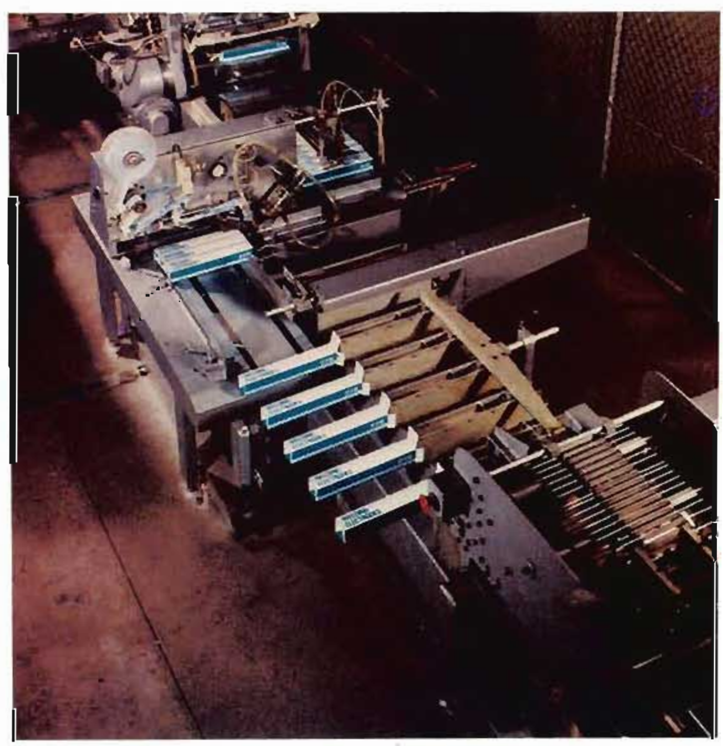
Whiting took out a patent for the cotton sheaf, stating that as the cellulose cotton burnt in the heat of the arc, it generated hydrogen, carbon dioxide and carbon monoxide gases which formed an inert atmosphere around the arc and fused metal.

Whiting began to realise that electrode development would require specialist metallurgical knowledge. The Firestick had become popular, but the production rate of 500 per day was too slow and the cotton "stocking" gave off fumes which welders working in confined spaces found distressing.

Whiting induced Roy Holland to join EMF in 1925, offering a salary arrangement which included a bonus of five per cent on the first £100 worth of electrodes sold, four per cent on the next £400 worth and 2½ per cent on the remainder. It was not long



Electrode packaging line at C I G 's Consumables Division at Preston.



Filling table where electrodes are weighed and boxed. Packs are sealed in polyethylene.

before Holland was earning more in bonuses than anybody else in the company. He voluntarily gave Whiting half of what he received.

The commission arrangement did not last long because EMF got heavily into debt through making and supplying petrol tanks and bowsers to another company which went out of business when each oil company began supplying tanks and bowsers free to garages selling its brand of petrol exclusively. The EMF board persuaded Holland to give up his commission and take instead 2000 of the 12,000 £1 shares in the company, plus a directorship. Holland agreed after Geere retired. Edmunds Bros. took over the overdraft guarantee at the E. S. & A. Bank which was necessary to pay off Geere and cover EMF's debts. Edmunds Bros. also were given wholesale distribution rights for EMF electrodes and machines throughout Victoria. This agreement later prevented Russell Grimwade acquiring EMF products for Australian Oxygen to market.

An unwritten part of Holland's agreement to take shares and a directorship instead of commission was that he would run the business and that he could not be over-ruled by Whiting. Later, Whiting privately gave Holland a power of attorney over Whiting's affairs and this was lodged with EMF's acting secretary, Miss Ada Wyatt, for safekeeping.

In 1926 Holland developed a manufacturing line operated by two labourers which produced wire-bound, cut length core electrodes at the rate of about 3000 ft per eight-hour day. These wire-bound electrodes offered the welder a considerable saving because they deposited up to 25 per cent more metal than equivalent gauge electrodes. Holland was also able to produce electrodes for specific purposes by changing the alloy in the wire strands. In one type he ran a copper strand and these electrodes were ordered by welders in England to weld steel with a high copper content used in marine installations.

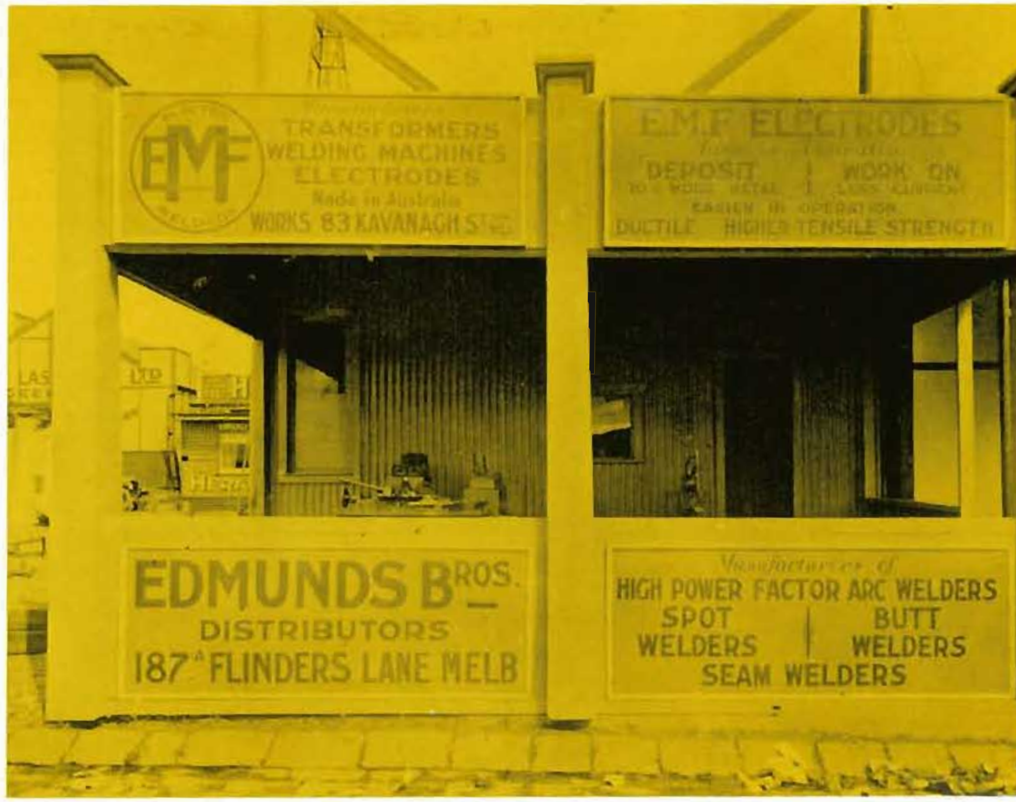
The EMF Electric Company Pty. Ltd. was incorporated in May, 1923, and the company began expanding its market area by appointing interstate agents—R. W. Cameron & Co. in Sydney, Evans Deakin & Co. in Queensland, and Atkins (W.A.) Ltd. in Western Australia and South Australia. EMF's Melbourne distributors were Edmunds Bros. who in 1933 joined in the establishment of EMF Welding Processes Pty. Ltd. in South Africa.

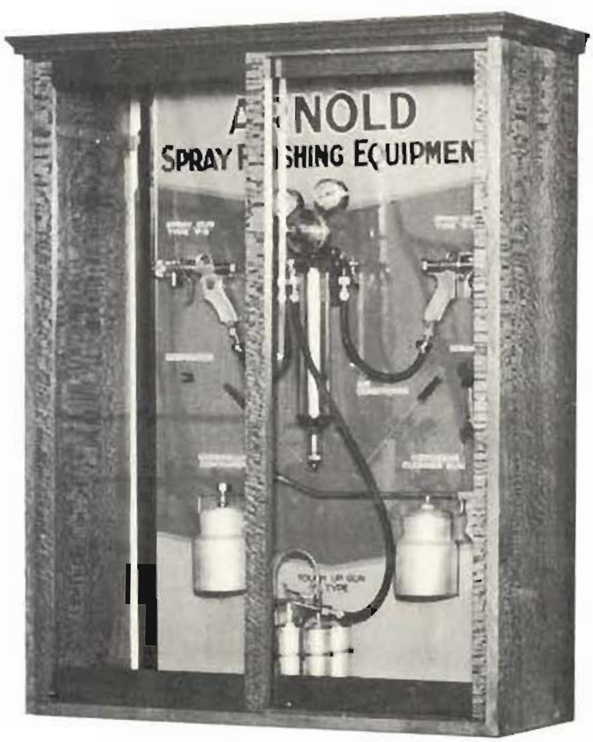
In 1928 EMF appointed a sales engineer from Robert Bryce, A. Ramsay Moon, to advise customers on design for welded fabrication. Moon had built up a reputation for his technical papers on Quasi-Arc electrodes. He participated in a long series of tests at Melbourne University from which the "throat thickness" system which could be checked by simple gauges was evolved. The booklet on the system which was published by Robert Bryce became a standard textbook. Moon went to England in 1931 and there he resigned from EMF.

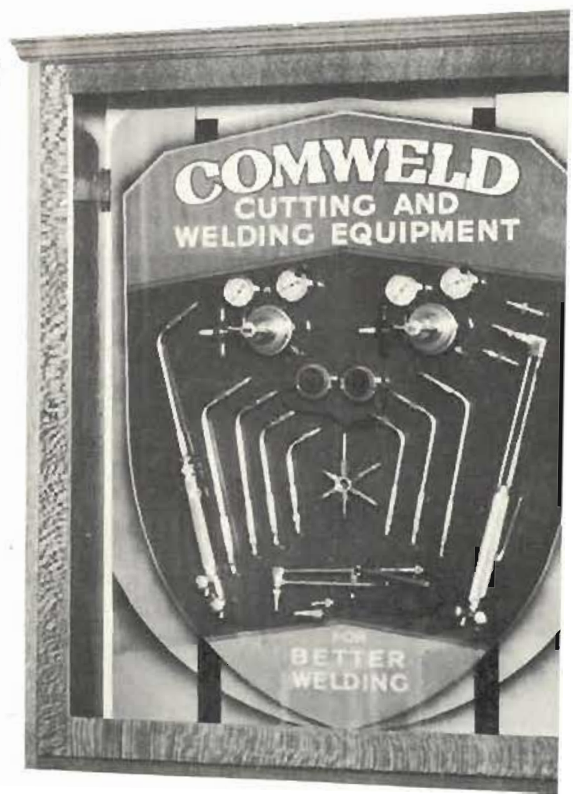
Later Moon became a world authority on welded structural design and a director of the British Welding Research Association. Austin L. Warren-Smith, an Australian who became the first articled apprentice welder in Britain while employed by Alloy Welding Processes Ltd., recalled seeing Moon supervising the welding in the Bank of England extensions in London while Mrs. Moon, an artist, climbed the girders to sketch the operations. Alloy Welding Processes became

Keith Winsor, EMF's test engineer, corrected the Army's mathematicians.

Flinders Lane premises of Edmund Bros., Melbourne, distributors for EMF in 1920s.





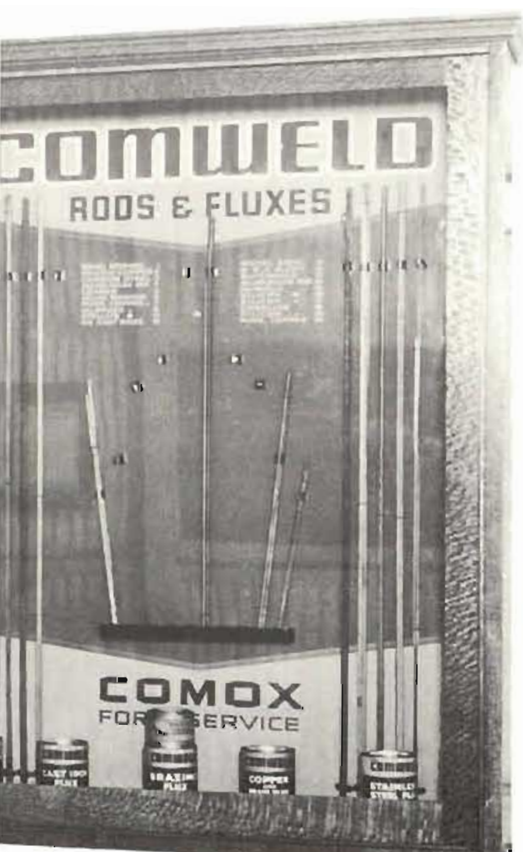


Murex, which in 1948 bought the Oerlikon electrode factory in Tasmania. Warren-Smith returned to Australia in 1949 and was N.S.W. manager for Murex until he switched his career to the insurance industry in 1953.

Moon was replaced at EMF by W. D. Chapman and this appointment further helped the company to extend its welding crusade throughout the engineering profession. Chapman stayed with EMF until 1936 when he became a research and development engineer with Australian Paper Manufacturers Ltd. A year later he joined Malcolm Moore as chief engineer under Longoni, who was technical director.

Meanwhile, Whiting and Holland had developed a new machine which mass-produced electrodes from coil wire. Called the "Gawrah" (a name formed from their initials), the machine produced up to 6000 ft of electrodes a day with only two operators.

Display board for Comox and Arnold products at Queensland Oxygen, Newstead.



It enabled EMF to reduce its prices and dominate the electrode market. Robert Bryce soon complained to EMF that electrode prices were ridiculous.

H. S. B. Wight, the Robert Bryce managing director, told Holland: "You've cut the price till we're both losing money. You'd better come over here and talk some sense and let us fix a price".

Holland replied: "Mr. Wight, I don't know where you get your information about EMF losing money. I'm just about to recommend to my board that we again reduce the price of our electrodes because I think that we are taking too much from the public".

The board approved the reduction and the company's profits were still considered to be very satisfactory.

When Carr and Terry closed their business in Melbourne, Carr returned to Sydney where R. W. Cameron's asked him to rejoin them. He accepted and took his U.K. agencies into Cameron's. Soon after, Cameron's came into contact with John B. Arnold. Carr had noted the similarity in the plant needed to manufacture spray painting handpieces and oxy-cutting and welding torches. Both processes required somewhat similar accessories, such as pressure regulating valves. An arrangement followed between the Aerograph Company, Cameron's and Arnold for Arnold to assemble Aerograph parts in Melbourne. It soon became apparent that Arnold's manufacturing methods were much superior to those of Aerograph and furthermore an advanced new type of spray painting handpieces of American design had been introduced to the Australian market. Arnold dispensed with Aerograph and designed a new handpiece, marketing it successfully under his own name.

In 1931 R. W. Cameron decided to curtail part of its business and Carr left with his U.K. agencies to form EMF Welding Distributors in Sydney. Holland gave him a commission of 50 per cent and very liberal credit.

EMF had established a welding school after it moved into the old cable tram shed in Rathdown Street, North Carlton, Melbourne, in 1928. This school had the full support of firms like Gardner Constructions and of Trades Hall officials who appreciated that many unemployed men could, free of charge, become boilermaker-welders through the EMF instruction.

OPERATING

Gases Division	R. T. Hardwick	Chief Executive
	J. P. Best	Administration Manager
	A. W. Butler	General Manager—New South Wales
	D. L. Bryant	General Manager—Victoria
	G. C. Plenty	General Manager—South Queensland
	J. G. Shumack	General Manager—North Australia
	B. F. Dalby	General Manager—South Australia
	R. L. Rogerson	General Manager—Western Australia
	B. M. Schmitzer	General Manager—Tasmania
Equipment Division	D. K. Allston	Chief Executive
	G. Cooke	Controller
	W. J. Dawson	Divisional Personnel Manager
	A. R. Morris	General Manager—Gas Equipment
	R. B. A. Noack	General Manager—Equipment Subsidiaries
	D. J. Daffey	General Manager—Welding Consumables
	R. A. Stringer	General Manager—Electric Welding Equipment
	R. H. Millar	Manager—Safety Products
	D. H. Kenneally	Manager—Murex
	G. T. McPherson	Export Manager
	R. F. Pfeil	Manager—Spray Equipment
Subsidiaries Division	B. A. Rathborne	Chief Executive
	J. Magno	Manager—Business Development
	G. Mealing	Commercial Manager—Subsidiaries
	B. M. Quin-Conroy	General Manager—P.T. Industrial Gases Indonesia
	P. T. Ford	Manager—Thai Industrial Gases Ltd.
	J. E. Barter	Manager—C.I.G. New Guinea Pty. Ltd.
	A. Pfeiffer	Manager—C.I.G. Fiji Ltd.
	R. T. C. Macarthur	General Manager—Cutting Edges Pty. Ltd.
	V. J. Gwynne	Manager—Gas Cylinders

Among the early pupils at the school was Archie Campbell who was later to become managing director of Vickers-Ruwolt. A naval architect, Campbell had joined an Australian emigration office in Britain when his shipyard closed. Soon he began to believe the migration propaganda: "A Million Farms Await a Million Farmers" and "1000 Hens Give You £1000 A Year". He migrated, but a year on a farm in a Gippsland swamp at £1 a week convinced him there were better ways of earning a living. He spent the following year with Johns and Waygood and then became one of Chapman's assistants in the railways construction branch. Campbell had been working on the Spencer Street bridge when Chapman asked him to help Charles Ruwolt to estimate the cost of the nine-span Bethanga bridge, a large riveted structure to be built over the Hume Weir. Ruwolt won the contract, but he quickly got into difficulties because he had no structural engineering and only minor bridge-building experience. He appealed to Chapman again for help and Campbell was assigned to him for six

One of the retail shops which C I G has established.

months. At the end of that period Chapman told Campbell he would be sacked if he returned to the railways construction branch. It was 1929 and the depression had begun. Campbell stayed with Ruwolt as structural manager.

Ruwolt had one welder and, according to Campbell, he was "a little tin god—the beginning and end of the world" in the eyes of other employees. Although Campbell had been designing for welding, he had never laid an electrode and he decided it was time to learn.

The EMF instructors made him a very efficient welder and when a new electrode was developed—EMF were marketing 25 types by 1933—Campbell was among the first to try it out in the Ruwolt workshop.

When Chapman joined EMF he sold a property in Kooyong Road, Elsternwick, to Roy Holland for EMF shares. Later Chapman sold the shares at a substantial profit and he offered to pay Holland a four-figure sum in £s to square the account. Holland refused, pointing out that he would have got Chapman's property for nothing if EMF had failed.

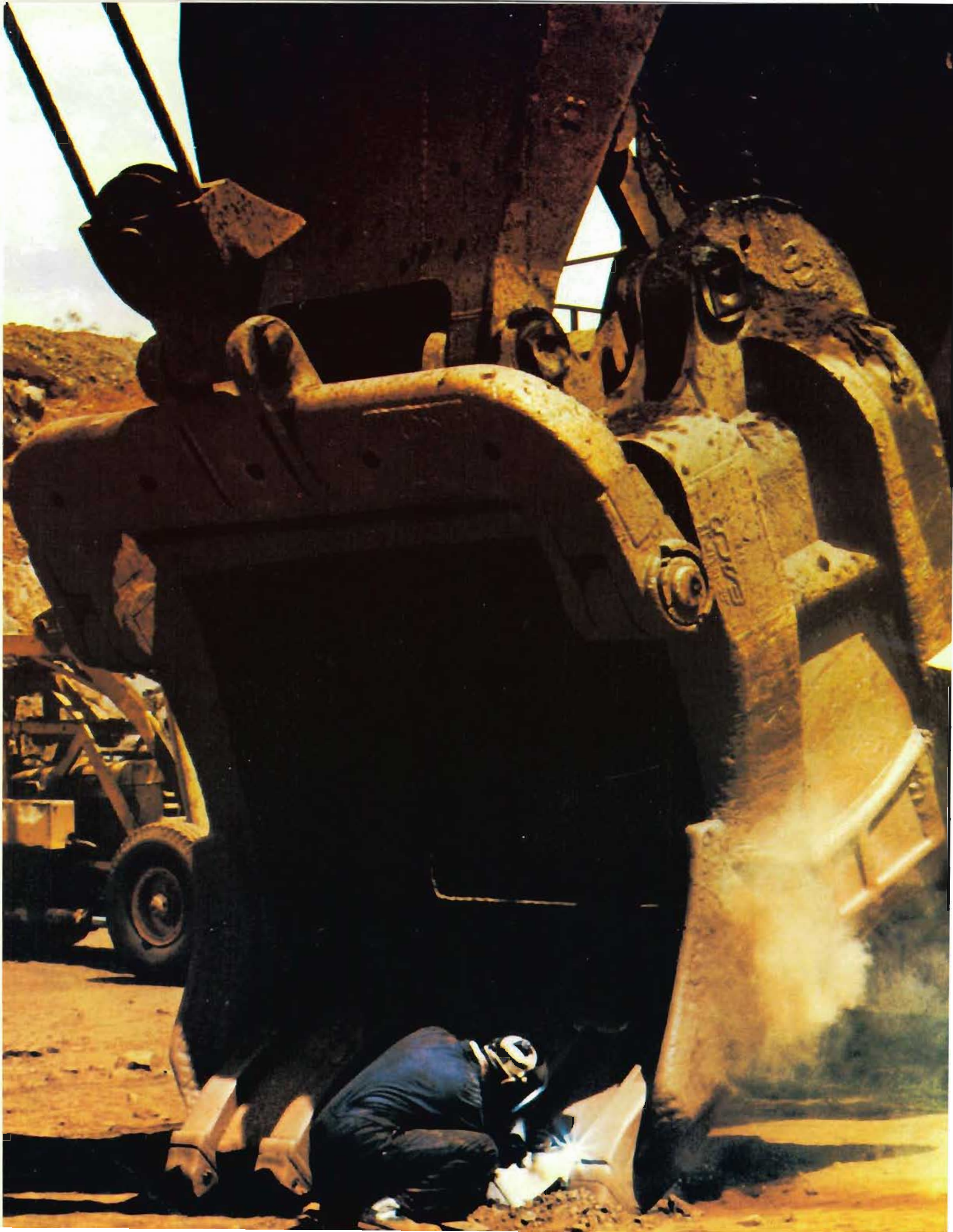
Soon after Chapman joined EMF, Holland produced a "forging electrode" which would readily stand hot working and at the same time had exceptional resistance to cold shock tests. Izod impact test pieces at Ruwolt's often remained unbroken by the 100 ft/lb testing machine. Structural steel specifications called for a 30 ft/lb minimum test.

These electrodes had other unusual properties. They were able, for instance, to make good repairs to cast iron. It was these new properties which prompted Chapman to say that the electrodes set a new era in welding. The name New Era was adopted and the electrode achieved wide market acceptance. EMF paid Rylands £1 a ton more for the core wire which was drawn to a close tolerance from steel which Holland's friends at the Newcastle steelworks had specially treated. New Era electrodes were still a major CIG line 40 years after they were introduced.

According to Holland, however, the man who did by far the most to improve EMF electrode quality was EMF's test engineer and record keeper, Keith Winsor. An exceptionally good mathematician, Winsor was the first to successfully use a 21-inch dispersion spectrograph in Australia. The Victorian Railways had a similar machine, but lacked people who could do the calculations necessary to produce proper results.

Winsor appointed two women graduates of Melbourne University to EMF staff. One was a statistician and the other a science graduate who replaced C. P. Keogh when he retired from EMF. Winsor kept in calibrated cabinets all the broken test pieces from every batch of every grade of electrode EMF produced. He personally conducted the spectrographic analyses at every point of breakage and the statistician made histograms to tabulate the reasons for the breakages and the physical properties at the actual points of failure.

Before joining the army at the outbreak of World War II, Winsor had 10,000 broken test pieces filed away in cabinets. He upset army mathematics instructors by correcting their calculations and Alexander Stewart arranged for him to be discharged and sent back to EMF. Winsor later did special spectrographic work for Sir Macfarlan Burnett. He was on a visit to America and Europe for CIG in 1950 when he died of a heart attack in London.



CHAPTER
VII
THE PHAR LAP ERA

C I G welding equipment being used for on-site maintenance of Marion 12 cu. yd. shovel at Mt. Tom Price.

The depression helped the Australian welding industry to enhance its status, although the industrial gas producers suffered from the general decline in oxygen requirements for cutting purposes. Geoff Scott, who was working in Australian Oxygen's despatch department at that time, recalled in 1971 in his 50th year of service with CIG companies, that spider webs accumulated on cylinders in the warehouse during the depression years. This was a remarkable situation because shortage of cylinders was a problem that the industrial gas industry until the 1960s was not able to solve.

A prime cause of Australian Oxygen's predicament was the price war it was involved in with Oxygen Service Company and its profits did not recover until after the two companies reached a sales and price agreement in 1932.

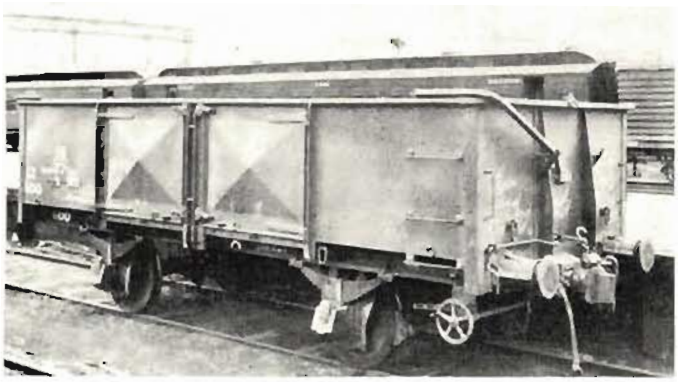
Individualists saw in welding an opportunity to beat the depression. A welding plant which did not require a major outlay could be obtained on a promissory note. With a vehicle a man could travel around the country, mending household and farm equipment. Blacksmiths and garagemen bought welding equipment to extend their capabilities. Commonwealth Oxygen sold a record number of regulators in 1929 and its blowpipe sales that year were the second highest yet achieved. By 1931, however, the market had collapsed.

Commonwealth Oxygen's net profit fell from £18,199 in 1929 to £8356 in 1931, but it recovered sharply to reach £30,345 in 1934. Allen-Liversidge (Australia) continued to pay a 10 per cent dividend with a five per cent bonus throughout the depression although its profit fell from £20,314 in 1929 to £11,599 in 1930.

With greater emphasis on cost savings, engineers were more inclined to listen when a case was put for welded construction. Riveting had offered them a line of least resistance because its constants and variables were known, but the lower cost of welding had assumed a powerful appeal. Archie Campbell at Ruwolt's submitted alternative tenders for jobs which almost invariably showed that welded construction was 20 per cent cheaper than riveting.

At first he had been unable to get money from Charles Ruwolt, a rivet disciple, to buy welding plant so he arranged with Roy Holland to rent four EMF units without Ruwolt's knowledge. By the time Ruwolt discovered them, welding was responsible for much of the firm's business and Ruwolt became a welding convert.

Gas control regulators dating from around the 1920s to the present CIG Monitor which has built-in gauges to prevent damage.



Victorian Railways' welded truck in 1931 was nicknamed after the champion racehorse "Phar Lap".

Oxy-acetylene welding was used to deposit new metal on worn rails in the 1920s. The method spread to the repair of other worn equipment.

Campbell created business by redesigning riveted and cast structures for welded construction. He offered the Victorian Railways a welded design for lighting towers in marshalling yards which eliminated the heavy members, huge gussets and masses of rivets of the old towers. The design was adopted throughout Australia.

Ruwolt's entered the structural field, building city offices and factories, which up until then were almost entirely of rivet design. Campbell developed a batch of standard welded designs for roof trusses, main girders and other components and published them in a book which was sent to every architect. It brought in a substantial amount of work.

New buildings for Caulfield racecourse were designed for rivets, but Campbell showed the designers how welded design would save them 20 per cent of the cost. Ruwolt's got the job despite complaints from rivet fabricators that his tactics were unethical.

Mining equipment, such as ball mills, had plenty of scope for the welder. Campbell's designs did away with the heavy riveted seams, massive angles and enormous steel castings.

The Victorian Railways rolling stock branch did not begin to adopt welding on a large scale until the late 1920s. The railways' first welding apprentice, E. G. Quilliam, was appointed in 1923, but in 1930 Wilfred (Bill) Featonby found only about half a dozen oxy-acetylene sets and one arc welding machine in use at Newport workshops.

Featonby had started with the railways as an apprentice in 1915 and had rejoined them after a period with private industry when assistant chief mechanical engineer, N. C. Harris, asked him to extend the use of welding at Newport.

Featonby found he had to improvise to enable his budget to be allocated to as many new arc machines as possible. He started buying EMF choke coils, but when finances dwindled he induced EMF to give him the plans for the coils so that he could make them at the workshops. In return he gave EMF a verbal promise that the workshops would use EMF electrodes while he was in charge. As EMF were already on the purchasing schedule this was not a difficult promise to keep.

The workshops had scores of riveted two-ton trailers which were hauled by Fordson tractors and used for carrying heavy components. The trailers quickly failed under severe service conditions. Featonby turned out welded trailers which cost 40 per cent less and gave a better performance because there was no "rivet slip".

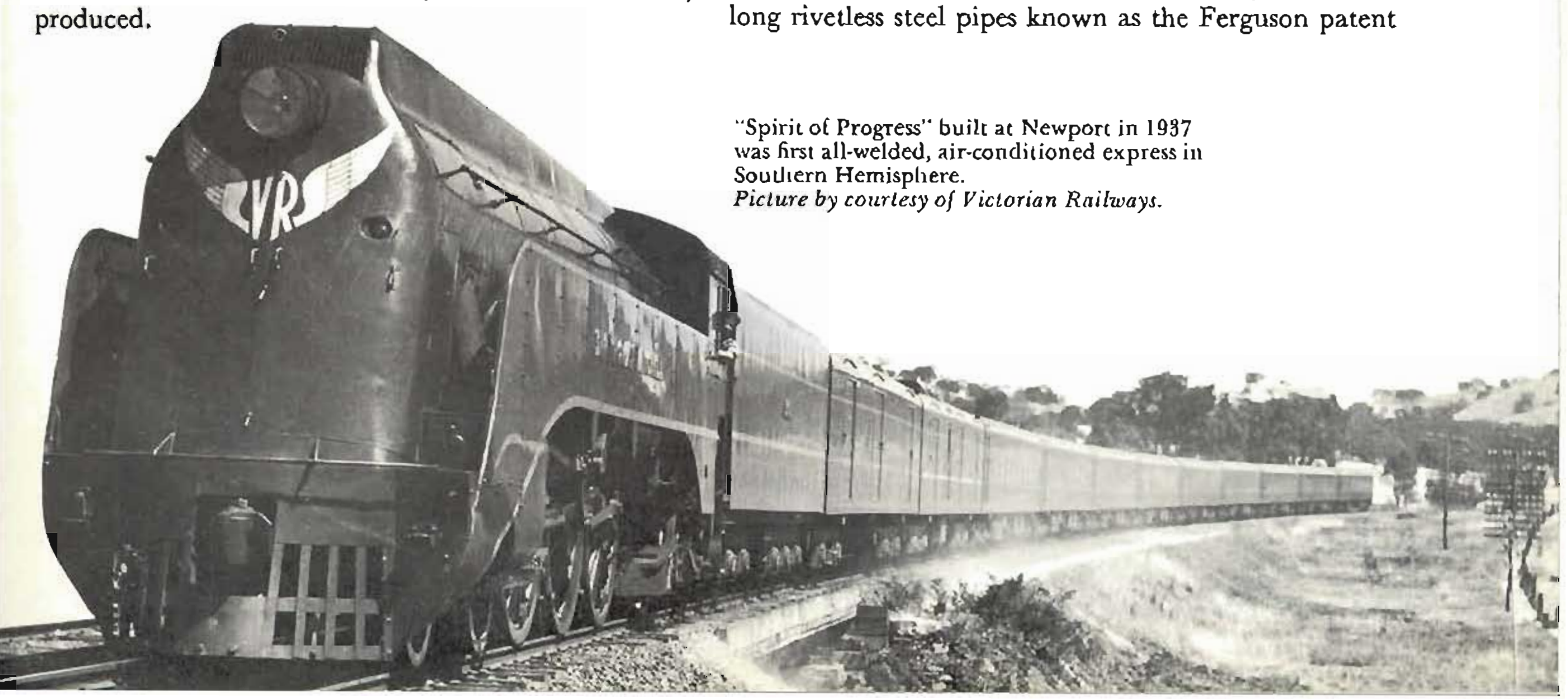
With W. D. Chapman, he designed a 27-ton arc welded open steel truck which began two years of severe testing in 1931. It survived one severe collision test in which a riveted waggon attached to it was severely damaged. According to "The Age" newspaper, the welded truck was known as the railways department's "Phar Lap".

Featonby claimed in papers published overseas that the truck was the first all-welded railway vehicle in the world and his claim was not contested. The railways department noted that the welded truck cost 20 per cent less than a riveted one and it ordered 200 in 1933. More than 12,000 were eventually produced.

Welding was also used at Newport workshops to convert other rolling stock to automatic couplings and for the construction of locomotive tender tanks. In 1937, Newport workshops produced the "Spirit of Progress", the first all-welded, air-conditioned express passenger train in the Southern Hemisphere. When Featonby retired in 1965 as assistant chief mechanical engineer, the Victorian Railways were using more than 1000 welding machines.

The Islington Workshops of the South Australian Railways experimented with the oxy-welding of damaged copper fireboxes (costing about £2500) in locomotives without success in 1924–25, but the workshop manager F. H. Harrison found while abroad in 1928–29 that similar repairs were being carried out with success in France and Germany. At his request, the South Australian Government through its Agent-General in London asked the French Government for the loan of a welder experienced in this work to train personnel at Islington. The French refused. Harrison began training his own welders, successfully using information he had picked up in France and Germany.

Three welding processes—electric, oxy and Linde welding—were used in 1932 in the experimental welding of a section of the 30-inch diameter Goldfields Water Supply pipeline between Mundaring Weir and Kalgoorlie in Western Australia. This £2.8 million pipeline of more than 350 miles had been one of the engineering wonders of the world when it first supplied the goldfields with water in 1903. Laid underground, it was constructed from 60,000 28-feet long rivetless steel pipes known as the Ferguson patent

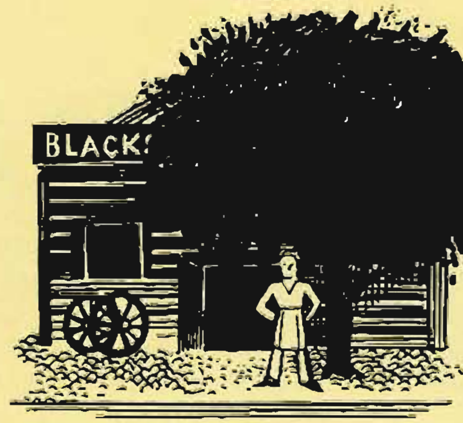


"Spirit of Progress" built at Newport in 1937 was first all-welded, air-conditioned express in Southern Hemisphere.
Picture by courtesy of Victorian Railways.

A DRAMA IN FOUR ACTS.

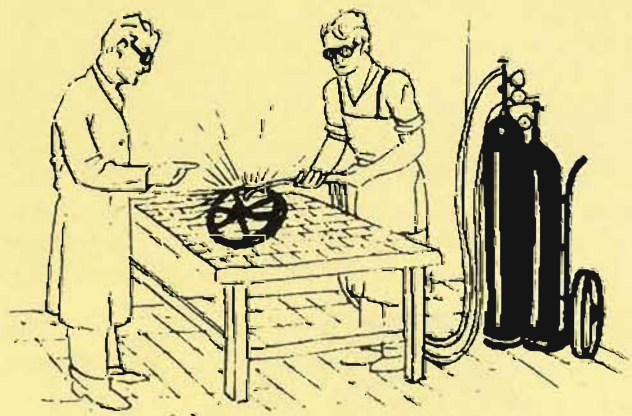
ACT 1 . . . . Depression.

Under a spreading chestnut tree
The village smithy stands.
And stands, and stands, and stands, and stands,
And stands, and stands, and stands.



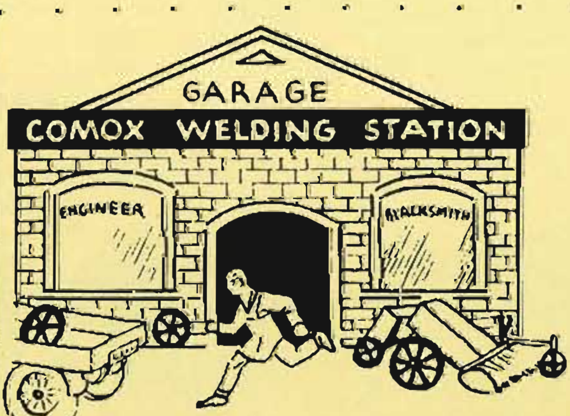
ACT 2 . . . . Inspiration.

Whilst standing 'neath that chestnut tree
He thought out how he could
Bring his old shop right up to date
And change bad times to good.



ACT 3 . . . . Action.

He bought a COMOX Welding Plant
(Instructions given free)
And found that jobs he'd turned away
Were easy as could be.



ACT 4 . . . . Realisation.

They've cut away the chestnut tree
To give the smithy room;
The smith no longer stands—he runs
To keep pace with the BOOM.

lock bar type, which had been invented by Mephan Ferguson, the Melbourne-based engineer, iron founder and pipe manufacturer. This pipe was made in two semi-circular sections which were joined longitudinally by two dovetailed locking bars. The construction engineer, C. Y. O'Connor, chose a simple sleeve joint with a lead packing ring to connect the pipe together and a Perth contractor devised a machine to caulk the joints.

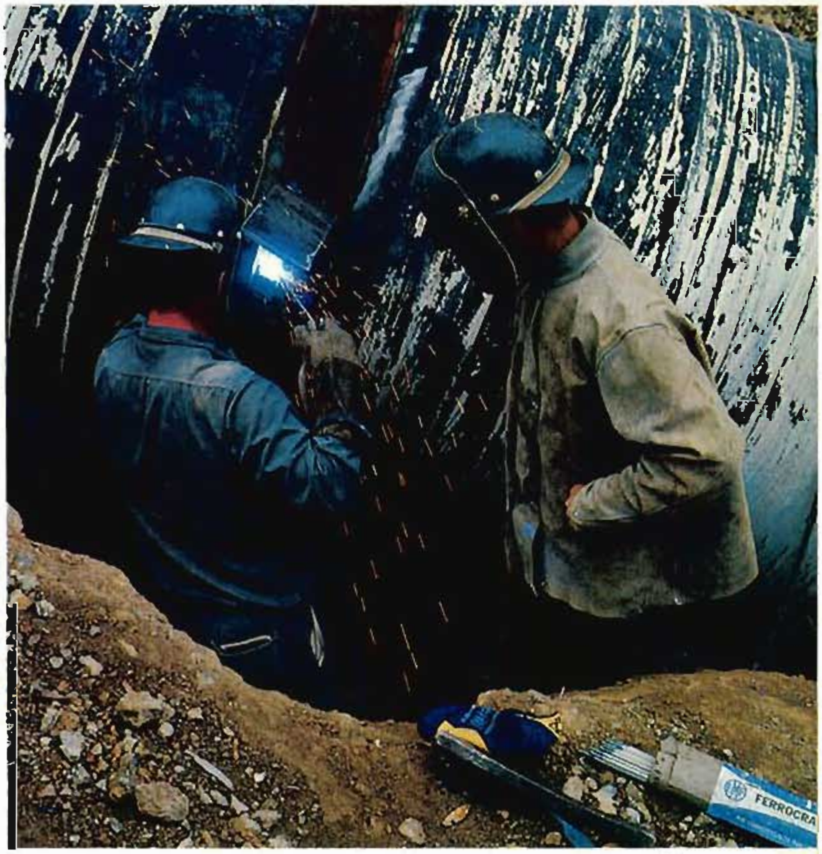
O'Connor had frustrated speculators' attempts to profit from the land resumptions along the pipeline route and he was the target of vicious attacks in the Press. The caulking machine provided a climax to the attacks, with his critics claiming that "this palm-greased humbug and impostor" had reaped substantial financial gains in recommending its use.

On March 10, 1902, O'Connor shot himself on a beach at Fremantle near the harbour which he had earlier constructed. A myth grew among subsequent generations of schoolboys that O'Connor took his own life because the water in the pipeline failed to appear at Coolgardie on the date he had calculated and that it flowed three days after his death. It was pressure of the criticisms however, that unhinged his mind.

"The position has become intolerable", O'Connor said in a note found on his body. "Anxious important work to do, and three commissions of inquiry to attend to . . . The Coolgardie scheme is all right and I would finish it if I got the chance and protection from misrepresentation. But there is no hope for that now. It is better that it should be given to some entirely new man to do, who will be untrammelled by prior responsibility".

In 1917 it was found that the whole pipeline was leaking badly, particularly around the lead joints where severe corrosion had occurred. Over the next 15 years £640,000 was spent on repairs to the pipeline, but the leakage loss more than trebled. The maintenance engineers adhered to O'Connor's theory that flexible joints, such as those provided by the lead joints, were necessary to counter thermal expansion and contraction in the pipeline which carried water at temperatures ranging from 7°C to 40°C. However, they salvaged sound sections of locking bar pipe with the oxy-torch and welded them into 110 ft. lengths which were then lead-jointed. Corrosion around the lead joints persisted.

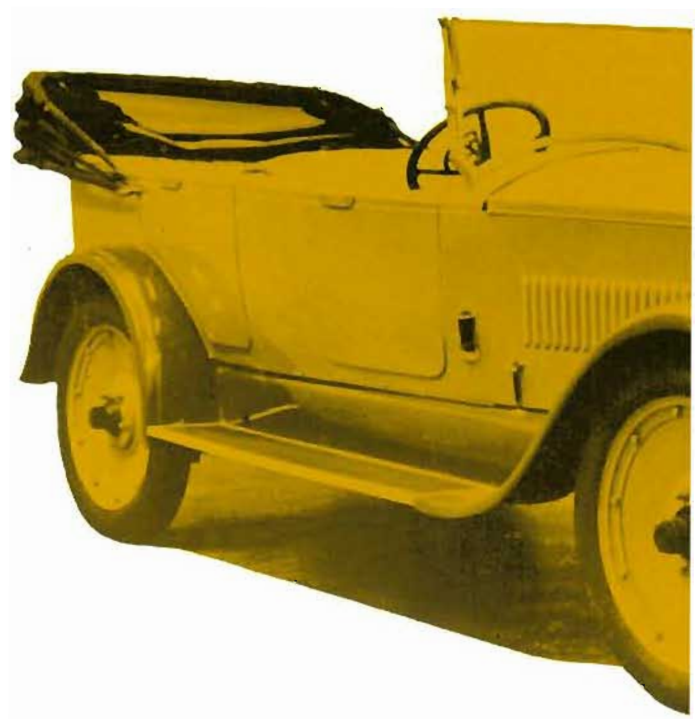
Linde oxy-acetylene pipe welder was the most efficient of all welding systems in the repair of Perth-Kalgoorlie pipeline in 1930s.



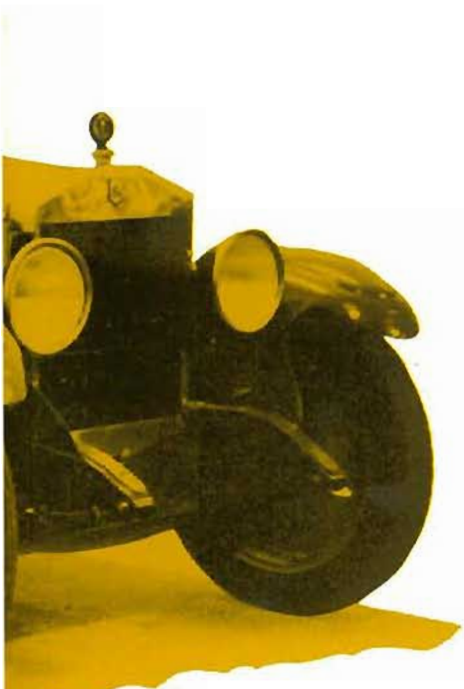
C I G with its depth of experience, is well-equipped to participate in the burgeoning pipeline construction of the 1970s and beyond.

The engineers then decided to attempt all-welded construction over 26 chains of the main. The pipeline was placed above ground, with concrete bolsters and anchors at intervals. The pipes were rotated for butt welding and the semi-automatic Linde oxy-acetylene pipe welder, with its gravity-fed filler rod and pre-heating pilot jet, accomplished the job in half an hour, compared with 2¼ hours for the ordinary oxy-weld and two hours for the electric weld. This experimental welded section was kept empty for a winter and a summer, in ambient temperatures ranging from 2°C to 46°C, before it was joined to the main conduit. Eventually the entire main was reconstructed by welding.

The December, 1938, issue of "Welding News", published by CIG, said that Mephan Ferguson had installed an arc welder at his Melbourne plant in 1889. No details were given, but the date seems improbable. The Bernados carbon arc process was being used to a limited extent in Britain at the time, but Slavianoff had only disclosed his metallic arc system the year before. The Mephan Ferguson company was using Cutler Marsden automatic welding machines in the 1920s with bare wire on their spiral welded pipes. Like the Hume Pipe Company (Aust.) Ltd. and Thompsons Engineering and Pipe Co., it manufactured its own electrodes from Rylands Waratah wire. Mephan Ferguson later developed a system of applying a flux to the wire after it had passed the contact nozzle. The company was acquired in 1955 by Stewarts and Lloyds, which later became a division of Tubemakers of Australia Ltd.



CHAPTER
VIII
GAS
VERSUS ELECTRIC



The "Australian Six" in 1919 boasted oxy-welded sheet metal joints. "There is no solder used," the manufacturers said.

The Australian motor industry began to develop in the 1920s. Holdens Motor Body Builders, of Adelaide, in 1924 produced 22,150 bodies, compared with 3117 in 1920. In Sydney, F. H. Gordon and Co. Ltd. began production of the Australian Six in 1919, using imported components. Their selling brochure pointed out that "all joints of sheet steel are oxy-welded—there is no solder used". About 1000 Australia Six vehicles were produced before the venture was abandoned in 1925.

Writing on the Australian automobile industry in the early 1930s, F. S. Daley, an executive of Holdens, said that welding was largely confined to the body building industry, though it was finding some application in certain spare parts manufacture. He wrote that firms abroad might produce 10 to 12 fully-developed body models a year at the most and manufacture large quantities of each.

"In Australia, on the contrary, the total production by our largest firm may approximate to 25,000 bodies, but cover 50 or more distinctly different models, i.e. bodies for all or any make of car. Moreover, the time allowed for design development, tooling and first production run is approximately three and a half months for a model series, i.e. sedan, tourer, roadster and coupe.

"Remote from the world's markets, and handicapped by communications, plant equipment and processes must of necessity be devised quickly, and cover requirements. The large specialist firms of England and America are far away, and though used to the fullest permissible level, a simplified technique peculiar to the place invariably arises, though the product must meet overseas specifications.

"Massive flash welders or hydromatic spot welders will not be found, but simplified adaptations of the same principles may be observed. This will serve to explain why the majority of welding devices referred to are of local origin, and reasonably abreast of the times".

During the depression, the industrial gas producers stepped up their research for new outlets for oxy-acetylene. One lead, which was to become valuable new business, came from a surprising source. Alex Gatenby, a part-time representative for Allen-Liversidge in Victorian country areas, used an oxy-acetylene torch to burn out rotted sections of a piece of timber and extinguished the flames with carbon dioxide before the sound timber was burnt.

Harold Morgan took the timber to the University of Melbourne, which confirmed that it had been thoroughly sterilised. CSIR officers were interested.

They had been experimenting with creosote in an endeavour to lengthen the life of electricity and telegraph poles which quickly rotted at ground level. They found that the poles would absorb 13.5 lb of the preservative per 100 sq ft if it were brushed on cold. If the pole base, however, was first charred and hot creosote applied, the pole would absorb 62 lb of creosote. The charring also artificially seasoned the timber and removed surface fungus. Oxy-acetylene torches were subsequently used in the preservation of tens of thousands of poles throughout Victoria and in other States. Gatenby later sponsored the Compressed Medical and Industrial Gases company in Melbourne.

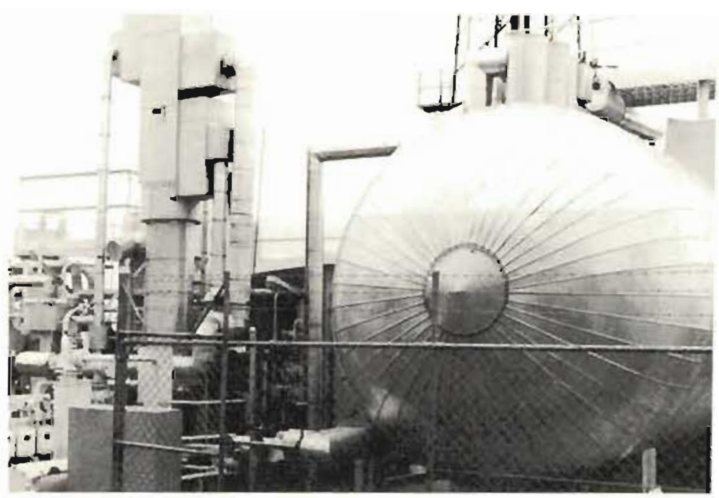
The Grimwades established Carba Dry Ice Ltd. in 1929 to manufacture dry ice, a novelty which W. L. Fanning, the Australian Oxygen works manager, had noticed in the U.S. in 1924. Fanning had been adjutant to Major-General H. W. Grimwade in World War I. Few companies were prepared to experiment with dry ice during the depression and Australian Oxygen had exclusive rights to the marketing of liquid carbon dioxide which was produced in one of the dry ice manufacturing stages.

The growth of electric welding in Australia did not pass unnoticed by the local industrial gas producers, although magazines which Commonwealth Oxygen in Sydney, Australian Oxygen in Melbourne and Western Oxygen in Adelaide and Perth produced each month for welders in the 1920's rarely mentioned the competitive welding systems.

Thomas Heap Cooke, Gardner Waern's managing director, went abroad in 1929 to seek additional agencies which might help to reverse his company's worsening financial situation. Among several that he brought back were agencies for electric welding sets and electrodes. Gardner Waern's electrode business was short-lived. It was eliminated by an additional 25 per cent import duty imposed on electrodes in 1931 at the instigation of EMF and other local electrode manufacturers.

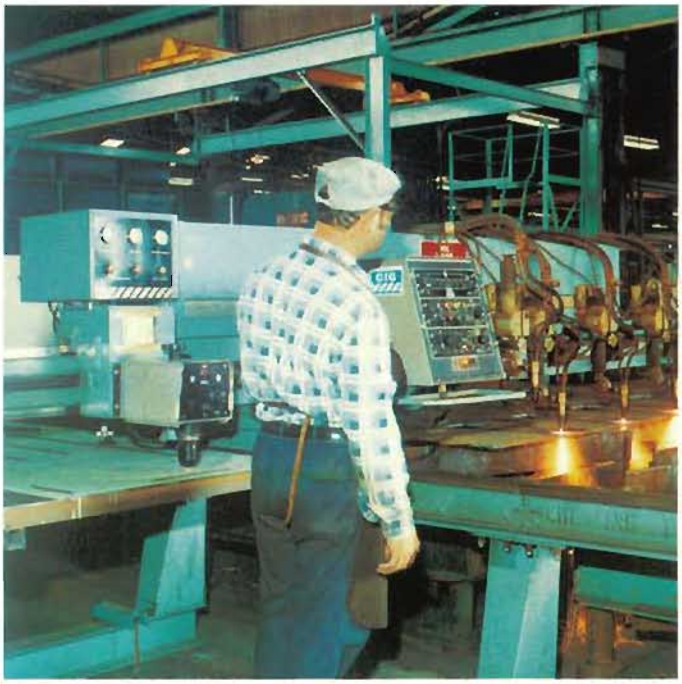
Reporting in 1930 on a study he had made in England on the development of electric welding, Commonwealth Oxygen's John Clack said it seemed

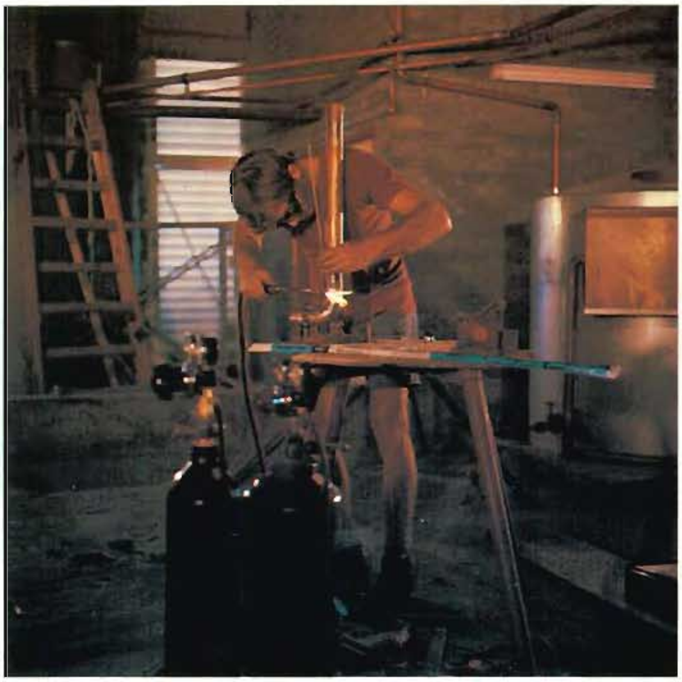
Charring of power and telegraph pole bases with oxy-acetylene torch helped prolong life of the poles.



C I G carbon dioxide production plant is located at a Sydney refinery.

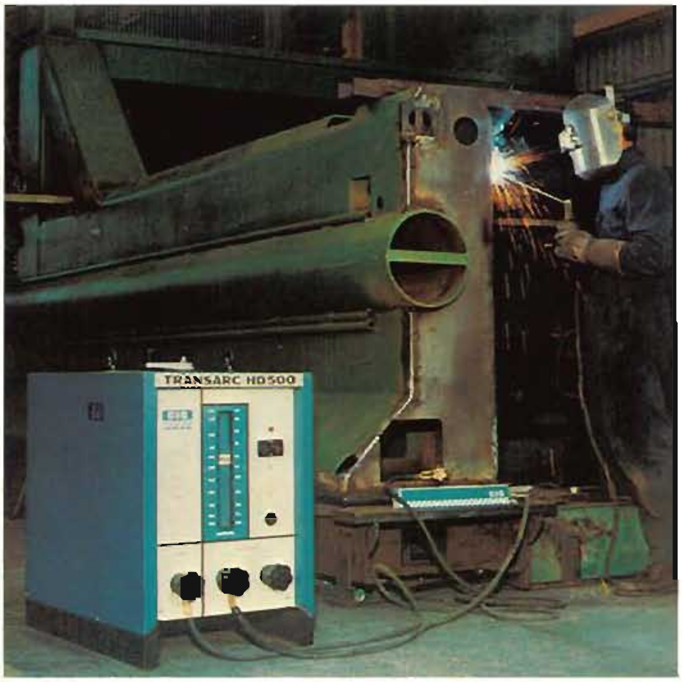
C I G 's multiple blowpipe flame cutting machines provide fully automatic operation.





C I G 's Comet 2 blowpipe ensures accurate flame adjustment for a wide range of welding, cutting and heating applications.

The Transarc HD welding machine is a dependable power source for heavy duty arc welding.



The Transmig 300 semi-automatic welding plant provides this operator with precise control of his M I G welding conditions.

Austox building in Spencer St., was the first in Melbourne to have a welded frame.

that electric arc and resistance welding were superseding oxy-acetylene welding in manufacturing, but they were also expanding the scope for oxy-acetylene cutting, particularly for precision work. As a gas cutting machine consumed far more gas than the welding blowpipe, the encroachment of electric welding actually was an advantage to industrial gas producers.

Commonwealth Oxygen had been selling electric welding machines, but as manufacturers of gas equipment they had felt that they should not foster development of the electric process. Now that electric welding did not pose a great threat, Clack arranged with EMF to supply him with electrodes.

Clack also made Reginald Carr of EMF Welding Distributors agree that there would be no price cutting on equivalent grades of electrodes sold in N.S.W. and he was angry when Carr charged the BHP steel mills at Newcastle 10 per cent below list price on an order for 50 cases of electrodes. BHP had been buying imported electrodes until Carr pointed out to the BHP buyer that EMF used wire drawn by the BHP subsidiary, Ryland's.

At that time electrode sales of EMF Welding Distributors averaged about 5 lb a day and an order for one case was considered a good order. The order for 50 cases placed at list price was unprecedented. Carr immediately took a train to Newcastle to thank the BHP buyer and tell him BHP would get the discount. He was never able to convince Clack that he had acted in good faith.

The Grimwades had close contact with electric welding in 1929 when new quarters for Australian Oxygen at 327 Spencer Street, Melbourne, became "the first all-welded city building". The January, 1930, issue of the company's "Oxy-Acetylene News" explained why it had to "swallow its own medicine" and use electric welding which was carried out by Gardner Constructions.

"Welding", the magazine said, "was the uppermost thought in our minds when it was decided to fabricate the steel by this process, and, as at that time there was no information regarding the suitability of our own particular process to embrace steel structural fabrication, the assistance of our worthy contemporary was solicited".

The magazine added that it had since learned that oxy-acetylene welding had been used on a large building erected by Union Carbide and Carbon Research Laboratories, Inc. at Niagara Falls, U.S.A., and it promised that its next issue would contain data on "the first oxy-acetylene welded steel structure to be erected in Victoria". This was the factory built at Abbotsford for Carba Dry Ice, which was completed in August, 1930.

Jack Thompson, a welding demonstrator for Australian Oxygen (his brother, George, was demonstrator at Gardner Waern), tested the welders selected for the Carba building and found them inept. He set about training a new team, but as construction proceeded it became obvious that gas welding was too slow for structural work of this type.

"Welding News" claimed in 1938 that the Union Bank building in Castlereagh Street, Sydney, was welded in 1928. ANZ Banking Group records subsequently showed that this building was completed in August, 1931.

The trusses in the roof of the lecture section in Brisbane's new City Hall were welded in 1928.

The management of Australian Oxygen was reorganised in 1932. Walter Crabtree retired and the Grimwades appointed John B. Arnold as general manager. He went to England that year and acquired the agency for Murex electrodes from ICI in London.

Roy Holland of EMF was friendly with Russell Grimwade who told him that Robert Bryce wanted to get out of the electrode business and that Australian Oxygen was going to manufacture Quasi-Arc and Murex electrodes in Australia. When Holland proved to Grimwade that EMF could sell electrodes at a lower price than Australian Oxygen could make them, Grimwade hastily dropped the manufacturing idea. Instead, both Murex and Australian Oxygen took up shareholdings in EMF and Grimwade and Norman Taylor of ICI-Murex were appointed to the EMF board. At ICI's request, Holland was temporarily seconded to the Murex plant at Walthamstow, London, to show them how to make better electrodes at a cheaper price.

In 1931 Whiting took a Gawrah machine to England to try to sell it to other electrode manufacturers. They were not interested and EMF sent the machine to South Africa where a factory was established in Johannesburg in 1933.

Whiting remained in England and ill health forced him to resign from the company there in 1934. An accountant, J. H. Kirkhope, was appointed managing director of EMF and Holland took over Whiting's position as manager.

Murex later sold its block of 4000 shares in EMF at a profit of £3/10/- per share.

A single morning's mail to the CIG branch in Brisbane, in 1948, contained the following spellings:

Acetylin
Acetyline
Ascetylene
Actylene
Actyelene
Actilene
Aceteylene
Acetlean
Accytlene
Accetylene
Aceteyline
Acetlin
Aceteylne
Acethylene
Accetelene
Settylene
Acetlyne
Acctylenc

Another chose "Setterlean", but many customers, according to the branch, would not even attempt it and merely wrote: "Acty" or "1 bottle of gas".

Comox establishment of an acetylene plant at St. Peters in 1929 astounded its associates.

Early stages of construction of the BHP steelworks at Newcastle. Production began in 1915.

CHAPTER

IX
CRISES IN NEWCASTLE

Gardner Waern had gained new customers for dissolved acetylene through the formation of Oxygen Supply in Sydney and Oxygen Service in Melbourne, but it lost to Allen-Liversidge the business of the Commonwealth Lighthouse Service and certain State Government utilities and also the "Prest-o-Lite" agency. The latter was diminishing in importance because electricity was being used for motor vehicle lights on an increasing scale.

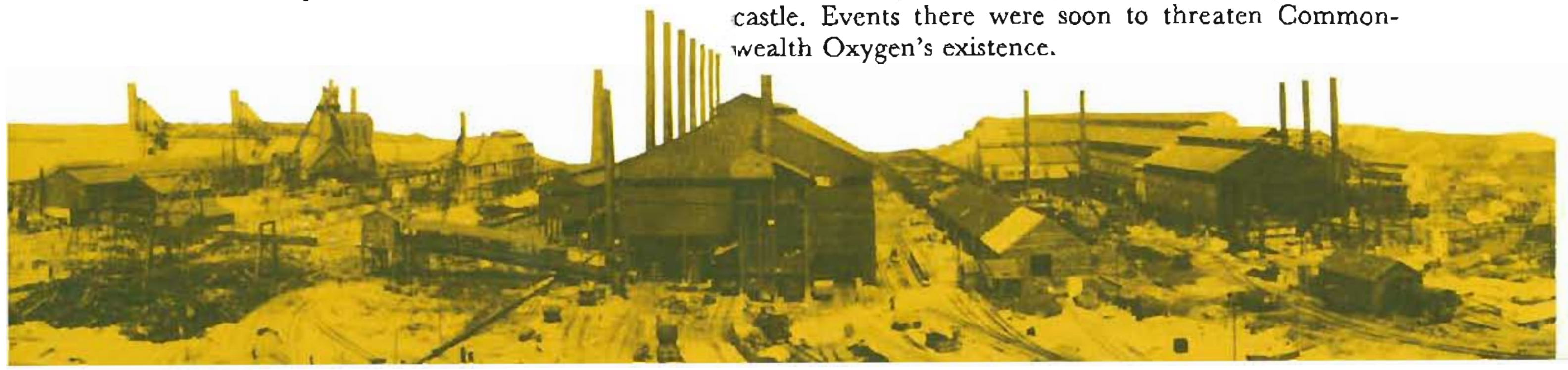
In 1927, Commonwealth Oxygen took over Oxygen Supply and Sydney Snow became a Commonwealth Oxygen director. Oxygen Supply had been marketing about £12,000 worth of Gardner Waern acetylene a year and John Clack believed Allen-Liversidge should pay Commonwealth Oxygen an extra commission if they were to get this business.

Allen-Liversidge directors refused and Clack astounded them in 1929 by setting up Acetylene Supplies Ltd. to manufacture acetylene at a site adjacent to an old brick pit alongside St. Peters railway station.

In a proposal for merging Allen-Liversidge (Australia) and Commonwealth Oxygen in 1928, Clack noted wryly how little it cost to run an acetylene business, adding that it "would not be possible if it were not for the fact that the oxygen interests of Australia were doing the spade work".

Clack considered that another acetylene plant was justified and he recalled how supplies had been disrupted when the Allen-Liversidge plant in Hutchinson Street, Annandale, had blown up in 1923. One employee, Patrick Joseph Kennedy, 25, had been killed. The local council refused to permit the factory to be rebuilt and Allen-Liversidge, for a period, carried on manufacturing operations in the open air. The company's legal advisers considered, however, that the council was acting beyond its powers and they advised Allen-Liversidge to put up temporary premises. Eventually a new factory was built. It incorporated cooling pits and other equipment which greatly reduced the hazards in the acetylene manufacture.

Clack was not concerned about the Allen-Liversidge directors' comments over Acetylene Supplies. Far more important things were happening in Newcastle. Events there were soon to threaten Commonwealth Oxygen's existence.



BHP's Newcastle steelworks before World War II. In 1944 it had 14 open-hearth furnaces.

In 1919 Clack had suggested to the Commonwealth Oxygen board that as Newcastle was "fast becoming, or is, the Sheffield of the Commonwealth" an oxygen plant should be installed there. He pointed out that Newcastle was already second to Sydney in oxygen market importance. Apart from new industries being established there, the BHP steelworks and dockyard at Walsh Island were "expanding at great pace and are becoming larger consumers of oxygen as time goes on".

The company that year had signed a five-year agreement to supply all BHP oxygen requirements in cylinders shipped from Sydney. The board considered the market was safe for the time being and it took no action.

In 1924, a new agreement was made to supply BHP with oxygen up to December 31, 1926, at a price of 6s 6d per 100 cubic feet delivered on the Newcastle wharf. In July, 1926, BHP exercised their option and extended this agreement for a further year.

On September 8, 1926, Fyvie wrote to Clack from the office of Fyvie & Stewart in Melbourne. Fyvie said that the supply of oxygen to the BHP steelworks in Newcastle "has been giving me some little concern and it would be a very serious matter to our company if we should lose this business".

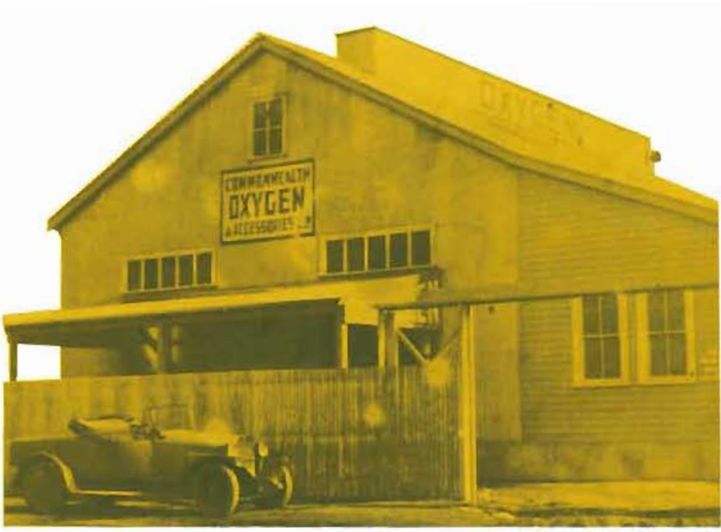
Fyvie said he was thinking of supplying BHP in bulk from an oxygen plant on a site convenient to the steelworks and he asked Clack to take up the matter with the steelworks' manager.

"Mr. Stewart and I have both discussed this matter very fully and we think something of this kind ought to be done without delay, notwithstanding whether there is any truth in the rumour we have heard or not", Fyvie wrote. He did not indicate the substance of the rumour.

On September 20, Fyvie wrote again to the Commonwealth Oxygen office at Balmain: "I am in receipt of your favour of the 16th instant in regard to the position at Newcastle and I am very glad that you think everything is all safe and sound in that locality . . . We are very creditably informed that Chas. Bingham & Co. have sold a plant to Gardner Waern & Co."

Fyvie said Gardner Waern were very strong on bulk supply and no doubt would make every effort "to secure a plum like Newcastle. Whoever secures the steel company in this respect can control Newcastle against all comers. We therefore feel very

Comox works in Clyde St., Hamilton, Newcastle, were established in 1927.



Former Gardner Waern oxygen plant at Port Waratah was bought from BHP in 1932.

uneasy in this connection until we are absolutely certain how the position stands".

The following day Fyvie acknowledged an urgent telegram from Clack which stated that the BHP steelworks' manager, L. Bradford, had confirmed that he had recommended a contract with Gardner Waern to his Melbourne office and that this had been signed.

"You will probably be able to realise", Fyvie wrote, "the shock that we have received in connection with this and although we had written you some considerable time ago on the very subject, apparently you took no action in the matter until now, and we cannot help feeling at the present time that we have been absolutely sleeping on this job and we have lost Newcastle".

In addition to supplying dissolved acetylene, Cooke, of Gardner Waern, had arranged to supply the steelworks with oxygen in cylinders for seven years from January 1, 1928, at prices ranging from 5s 9d down to 5s 7d per 100 cubic feet.

Before the end of 1926 Clack had sent Frank Mahony to open a depot in Newcastle. Mahony's uncle was to become a member of Federal Parliament, his father Government Whip in the N.S.W. Legislative Council and his brother Sergeant at Arms in the State Parliament.

The Grimwades and Commonwealth Oxygen had on order another oxygen plant which they had intended to install in Western Australia. This was diverted to Newcastle and it began operating in March, 1927. Gardner Waern did not get their oxygen plant in operation in time to begin the BHP contract, but Clack graciously consented to sell them the oxygen they required.

Clack was not so gracious with his overall tactics to win back the Newcastle market. He went to Commonwealth Steel, which was not yet a subsidiary of BHP, and offered them a long-term contract for oxygen at 4s 2d per 100 cubic feet. This was 1s 5d cheaper than Gardner Waern's best price to BHP and Clack made sure that BHP got to hear about it. He also tied up other non-BHP companies with similar contracts. Gardner Waern had to rely entirely on BHP and when the steelworks cut its oxygen consumption because of the depression, Gardner Waern were in trouble.

The company had made a profit of £200 in 1927, £1700 in 1928, £1930 in 1929 and £636 in 1930. The 1931 accounts showed a loss of £4714.

BHP's Essington Lewis was head of a "formidable menace" according to Alexander Stewart.

In Melbourne, Oxygen Service had switched to Allen-Liversidge for its supplies. The Gardner Waern board early in 1932 decided to quit the industrial gas business. Their oxygen and acetylene plants in Newcastle were sold to BHP for £22,500 and in the same year Allen-Liversidge bought the remnants of their acetylene business.

For Commonwealth Oxygen, however, the situation could not be worse. BHP was now their competitor and in a strategic position to put them out of business. William Fyvie was abroad and in a letter dated March 31, 1932, Alexander Stewart told him of the crisis and the "formidable menace".

Stewart said he had had a meeting with Essington Lewis, BHP's managing director, who had confirmed the acquisition of Gardner Waern's Newcastle plants.

"He further stated", Stewart wrote, "that it was their intention to embark on the oxygen business generally throughout Australia, centering in Newcastle and supplying the Sydney, Brisbane and South Australian requirements which would be conveyed by their own ships—Gardner Waern would act in these States as their agents . . . He also informed me that they would tender for all Government requirements including the dockyards throughout the States named. They had purchased the business and they intended to develop it and make the most possible use of this asset.

Oxygen lance accelerates removal of unwanted carbon from steel in electric furnace.

"After further discussion I told him that we had been pioneers of the oxygen business in Australia and we always considered that his company had given us a very raw deal in entering into a contract for seven years with Gardner Waern, that we have given them service and met them in every possible way and at much cost and loss to ourselves.

"On further discussion of the whole of trade I pointed out to him that oxygen was not their business, that they were steel masters, and I thought it would be much better if we could come to some equitable agreement . . ."

Oxygen was of major importance to the steel industry for the cutting of scrap. It had been used for about a decade in the U.S. to enrich the blast of air in the blast furnace for iron smelting. From the early 1920s BHP had used oxygen lances to burn through iron and steel skulls in blast furnace and steel furnace tapholes, accomplishing in minutes what had previously required hours of back-breaking work with a hammer and bar. But in Australia in 1932 there was no indication that oxygen would revolutionise the process of steel-making and that oxygen would become very much a part of BHP's business. Essington Lewis agreed to consider any proposal from Commonwealth Oxygen that he considered fair and just as far as his company and its subsidiaries were concerned.

The proposal submitted to British Oxygen in London for approval was for Commonwealth Oxygen to buy the Gardner Waern plants from BHP for £25,000. Commonwealth Oxygen would supply BHP and its subsidiaries with oxygen and acetylene in cylinders for 21 years at prices of 4s 6d per 100 cubic feet for oxygen and 14s for acetylene, less substantial rebates according to consumption.

The subsidiaries involved were Rylands Brothers (Australia) Ltd., Lysaght Brothers and Company Ltd., Lysaght's Newcastle Works Ltd., The Australian Wire Rope Works Ltd., BHP Collieries Pty. Ltd., BHP By-Products Pty. Ltd., Buttweld Pty. Ltd., Bradford Kendall Ltd. and The Structural Engineering Company of W.A. Ltd.

In a letter to British Oxygen's chairman, K. S. Murray, Stewart said that unless the option granted by BHP was exercised by Commonwealth Oxygen, he would view the company's future "as one of circumscribed development and operating on a keen price-cutting market. To Comox it means its future life blood; to the Broken Hill Proprietary Company it means that they will take our most important customers as the profit on the sale of oxygen will not concern them providing they can get turnover and cheap oxygen for their own works.

"There is another factor of which we must not lose sight and that is the great hold and influence which a company operating key industries exercises with our Australian Governments and customers generally. They are also the suppliers of raw material, financing many smaller men, and will claim what business they have to give out for their respective productions. A case in point arose not very long ago where a steamer, the Iron Monarch, was under repairs in dock in Sydney. Although we have the dockyard contract for oxygen and acetylene the Broken Hill Proprietary Company insisted that the oxygen and acetylene used on this vessel had to be their own product".

Murray agreed with his Australian board and the contract was signed with BHP on May 2, 1932. Allen-Liversidge bought the Newcastle acetylene plant from Commonwealth Oxygen.

In a handbook on the use of compressed oxygen published in 1893, Murray had described Fletcher's compressed oxygen injector furnace—a modified form of the early blowpipe encased in refractory material and used mainly for the rapid fusion of metals and treatment of refractory substances at high temperatures.

"It is the opinion of many capable judges that this little furnace will be imitated on a larger and more industrial scale ere long and that oxygen is destined to play an important part in the reduction of refractory ores and in other metallurgical work," Murray wrote prophetically.


BOC
LPG 361D

Hammersmith House (left) is the London headquarters of The British Oxygen Company Limited.

CHAPTER X THE LIQUID OXYGEN BLUFF

British Oxygen, CIG's parent, had an issued capital of £772,000 and assets of £1.7 million when it merged with Allen-Liversidge Ltd in Britain in 1930. A-L had assets of £802,640.

In 1950, BOC employed capital of £20 million and it had 15,000 employees in the UK and abroad. By 1972 capital employed had grown to £237 million and the number of employees to 40,600.

BOC's group sales throughout the world in 1972 totalled £256 million, 14 per cent of which were achieved in Australia and New Zealand.

BOC's 1972 profit before taxation was $22.3 million. In the United Kingdom and Republic of Ireland, BOC owned 39 tonnage plants, supplying daily up to 9,530 tons of oxygen plus nitrogen to steel making and chemical complexes.

It had a fleet of more than 1,300 road tankers and trains of 100-ton cryogenic rail tank cars.

In addition to its traditional industrial gases and welding products, BOC had a wide range of other activities which included the production of micro-wave ovens, vacuum processing plant, tall oil rosin and fatty acids, cryogenic process plants, specialised metal alloys and heart pacemakers, and trading in mineral ores.

BOC had also established substantial interests in frozen food processing and distribution which included a joint venture in Spain.

BOC had shareholdings in several companies in Europe and in 18 countries elsewhere, including Japan and USA.

Compared with the 772,000 issued shares in 1930, BOC's share register in 1972 listed 77,751 shareholders with a total of 203 million 25p shares.

Metal Industries Ltd, which gained boardroom control of the company in 1933, disposed of its BOC shares in 1958. Metal Industries in 1971 controlled a group of companies specialising in electrical, electronic and hydraulic control systems which employed 7,000 people.

John Clack had calculated in 1930 that total annual oxygen sales throughout Australia by all producers was about 41.5 million cubic feet, but the capacity of the plants was 102.5 million cubic feet. By 1938, assuming sales increased by about 8 per cent a year, there would still be a surplus plant capacity of 20 per cent. There were too many producers for the industry to be efficient. Clack had earlier reported rumours that Schemnitz was sponsoring two more companies in Sydney, but the additional companies did not eventuate and Schemnitz later denied he had anything to do with them.

The future direction of the Australian industrial gas industry was, however, being shaped by a series of events in the United Kingdom. World War I had given a substantial stimulus to industrial gas and welding in Britain and Commonwealth Oxygen's parent company, the British Oxygen Company, had emerged from the war in a paramount position among British industrial gas producers. It held the rights to what it considered were the most important patents and it faced an immediate post-war period which was to be marked by a continued expansion in the industrial uses of oxygen and dissolved acetylene.

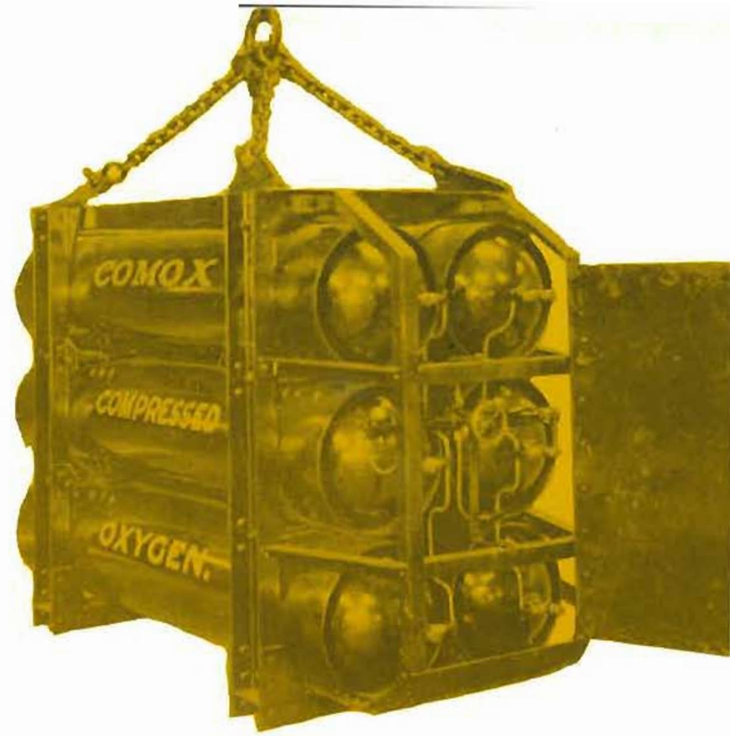
Kenneth Sutherland Murray had been managing director of British Oxygen since 1906 when the company had changed its name from Brin's Oxygen. Murray, formerly a junior railway engineer, had joined Brin's Oxygen in 1886 as an assistant engineer and had been appointed manager of the company in 1889. The original Brin theories on oxygen production were found to be unworkable, but by 1888 the company had erected a plant which produced oxygen satisfactorily by a modification of the barium process.

Murray had been alert, however, to the developments made in oxygen production by the liquefaction and rectification of air with which Dr. Carl von Linde was associated in Germany. He installed a small Linde plant capable of producing 10,000 cubic feet of oxygen in 24 hours to test its merits and he found it far superior to the barium method.

British Oxygen (when still Brin's Oxygen) acquired the rights to Linde patents in the United Kingdom and certain other countries for a cash payment and a quarter of the company's shares. Linde had a seat on the BOC board until the outbreak of war in 1914.

The Linde equipment was capable of extracting only two-thirds of the oxygen contained in the air passing through it and Murray in 1909 bought for £5000 the rights to the Claude modification which improved the extraction rate to almost 100 per cent.

K. S. Murray, BOC chairman, did not believe liquid oxygen would displace cylinders to any great extent.



Before liquid oxygen was introduced, bulk oxygen was supplied in Australia in crates containing six 2000 cu. ft. cylinders.

Liquid oxygen was formed in the Linde process, but it was converted to gaseous oxygen which was compressed into cylinders for transport to customers. This distribution system meant that the industrial gas producers had to maintain large stocks of cylinders.

During World War I, the Germans had developed small plants to produce liquid oxygen for use in explosives. Liquid oxygen by itself was non-explosive, but when combined with an otherwise inert, pulverised, carbonaceous base, an explosive cheaper and more powerful than gelignite resulted. The liquid oxygen could also be converted to normal industrial oxygen gas and after the war the German plants were offered to British firms. Murray began a campaign against them.

An editorial on small oxygen plants in the March, 1922, issue of "Industrial Gases" which he edited, said: "We think a word of warning on the subject may not be out of place, as the selling agents for these small plants almost invariably hail from Germany, and the claims which they put forward do not err on the side of modesty.

"This country is at present regarded by our late enemies as a happy field for propaganda because of the prevailing exchange conditions, and the unrestricted opportunities afforded by our benevolent Government for dumping their products at the gates of British manufacturers".

The editorial suggested that the plants were unsafe, that the quality of oxygen produced was inferior and that they were uneconomical compared with cylinder gas, "except in circumstances where the transport of cylinders is the most serious factor in the cost of oxygen to the consumer".

In December, 1927, another editorial in the magazine said: "It is very certain that if the general distribution of liquid oxygen on the grand scale (described in a German brochure) from large central stations could effect any conspicuous economy it would have been seriously considered long ago . . . We venture to think that this elaborate German proposition would never have been put forward but for the fact that in Germany as in most countries the more practical method of local oxygen supply factories has now been amply provided for and plant manufacturers, having realised that position, are seeking some new outlets for their energies".

Most of Murray's references were to the Heylandt patents relating to methods of producing, storing, transporting and delivering liquid oxygen. The Heylandt process was to revolutionise the pattern of oxygen production and distribution and encourage the large-scale use of oxygen in industry. It was also to result in the merging of British Oxygen with other interests and in the emergence of Steven James Lindsay Hardie as another dominant figure in the company's development.

Where Murray, a staunch Conservative, opposed any proposal in which he detected a flavour of socialism, Hardie was later to become a socialist and chairman of Britain's nationalised Iron and Steel Corporation.

A stern and unsmiling man, Hardie was a chartered accountant who had been a machine-gun specialist in the war, taking part in some of the fiercest fighting in France, Belgium and Germany. He won the DSO, was mentioned in despatches three times and attained the rank of lieutenant-colonel. In 1922 Hardie and Robert Watson McCrone formed Alloa Shipbreaking Company Ltd., which was to become Metal Industries Ltd. It soon had a substantial scrap metal business.

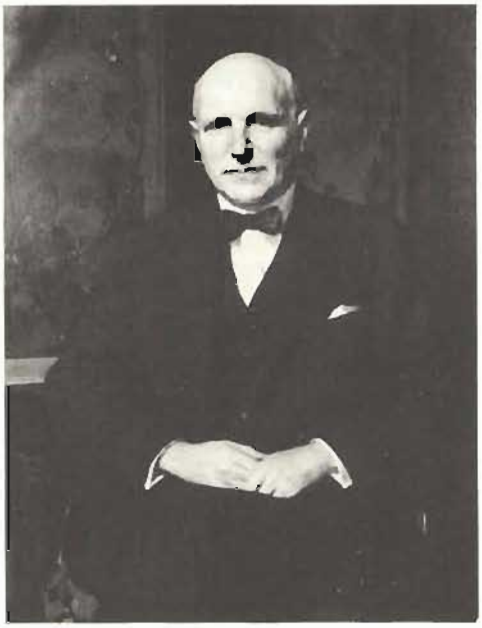
One major source of scrap was the former German Grand Fleet which had been scuttled by its officers at Scapa Flow after the Armistice. An enterprising engineer named Ernest Frank Guelph Cox had bought the salvage rights to the sunken vessels. He raised seven large warships and 25 torpedo boat destroyers and sold them to Hardie's company. Hardie initially obtained oxygen for cutting from British Oxygen. In 1927 he established four gaseous oxygen plants and began selling the oxygen which was surplus to his company's needs.

Hardie became aware of the Heylandt development and he recognised its potential, particularly in relation to the transport of liquid oxygen in double-walled, vacuum-insulated tanks. One road tanker load of liquid oxygen could be equivalent to hundreds of cylinders of gaseous oxygen. The Heylandt system also incorporated storage tanks and evaporators to enable customers to convert the liquid oxygen to gas at their own premises. Metal Industries bought the Heylandt patent rights for the United Kingdom in 1929 and established Oxygen Industries Ltd. to work the process and sell the liquid oxygen.

On December 3, 1929, the "Financial Times" reported that British Oxygen had acquired the rights for the British Empire to the liquid oxygen system introduced by the Societe L'Air Liquide, of Paris. The newspaper recalled that Murray had said at BOC's last annual meeting that although the system of transporting liquid oxygen might be economically adopted under certain conditions, it was not likely to displace gas cylinders to any great extent.

On October 1, 1930, Commonwealth Oxygen's John Clack said in a report on an overseas visit he had just completed that British Oxygen were now making their own liquid oxygen plants. He said German and American companies had bought the Heylandt rights more or less to suppress the system. Heylandt, however, was using them as proof of the success of the process. "The general impression is that Heylandt is a big bluff", Clack's report added.

Steven Hardie enabled BOC to buy Heylandt's liquid oxygen patents.



In September, 1933, Roy G. Parsons, supervising engineer of Colonial Gas Association Ltd., reported to his company in Melbourne on his investigations in Europe into the feasibility of manufacturing oxygen in Australia.

Colonial Gas had acquired the patent rights for New South Wales and Queensland for the Heylandt system of liquid oxygen transport, storage and evaporators for £5000 and it had an option to buy the rights for the other States for £3000. Before buying the rights, Colonial Gas had discussed the Heylandt process with Russell Grimwade and his brothers. They did not consider the process was worth the money asked.

"As you already know", Parsons wrote in his report to Melbourne, "the Metal Industries and British Oxygen Company came to an arrangement and eventually amalgamated. According to what I could learn from Messrs. Hardie and Schneider (a British Oxygen director), the history of this company and the incidents which led up to the amalgamation are as follows:

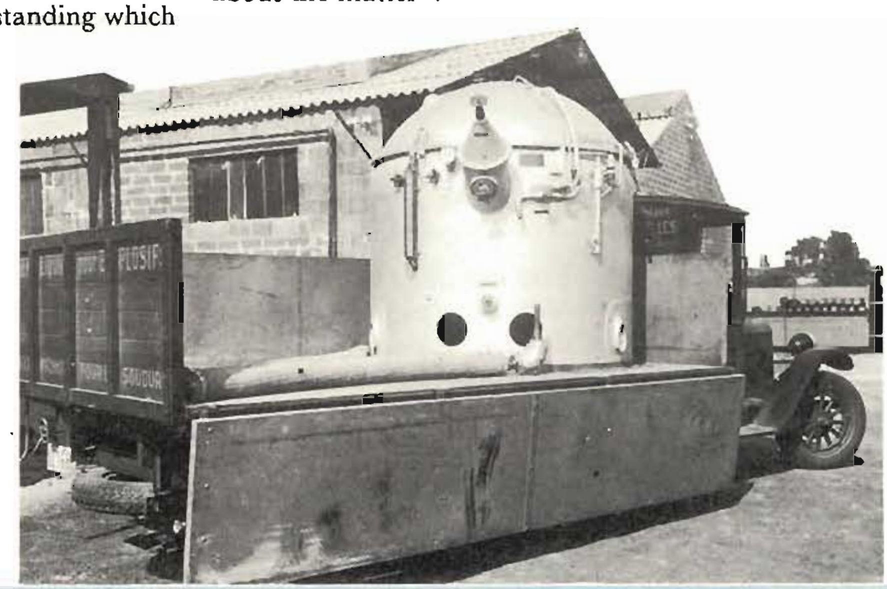
"When the British Oxygen Company found that the Metal Industries company were manufacturing liquid oxygen (they) attacked the German or Heylandt company's English patents on the grounds that the process was not novel or new and therefore was not patentable.

"The matter came before the Court, resulting in a good deal of technical and legal advice being required. The case extended over a period of several months until there were so many professional advisers that the legal fees were costing each company many hundreds of pounds per day. When the Court adjourned to consider the evidence neither party was quite sure how the matter was going to end and I understand that when the British Oxygen Company learned that Mr. Peter Dawson, of whisky fame, with whom the Hardie family is closely associated, had intimated that he was prepared to stand by the Metal Industries company (with further finance), they were invited by the British Oxygen Company to confer on the matter and eventually came to an understanding which led to the amalgamation".

Under the agreement, British Oxygen were assigned 23 Heylandt patents by Metal Industries in return for 350,000 fully paid £1 shares in British Oxygen. Hardie, McCrone and Dr. J. Donald Pollock joined the British Oxygen Board.

Soon after the amalgamation, Colonial Gas Association in Melbourne received a cable from the German patent holders inquiring whether the company would sell its Heylandt interests.

"It appears", said Parsons' report, "that this was done by Mr. Hardie . . . as far as I could gather the matter had not come officially before the British Oxygen Company Board except that Hardie had mentioned it to the chairman, Mr. Murray, who, from what I could gather was not very interested about the matter".



Early Heylandt tanker for the transport of liquid oxygen.

C I G tanker for long distance haulage of liquid oxygen. These vehicles supply Mount Isa, Darwin and Port Hedland.

Parsons met Hardie in London and learnt that his cousin, J. March Hardie, was a partner in the Sydney firm of chartered accountants, H. B. Allard Way & Hardie, and his brother, John A. Hardie, was shire engineer at Cootamundra in New South Wales. Hardie arranged for Parsons to meet Murray, who, according to Parsons, "only talked generalities. A good deal of conversation developed around the value of the Heylandt patents and the recent court case. I did not raise the matter of our rights to the process and after two hours conversation I was about to leave when he asked me whether we were going to start manufacturing in Australia. I told him that I thought that had it not been for the depression we would have been manufacturing".

Murray told Parsons he did not think the Heylandt process had any more than a nuisance value in Australia and he doubted if conditions in Australia were suitable for such a plant. Murray arranged for Parsons to inspect British Oxygen's plant at Edmonton and later he joined Parsons at afternoon tea.

"He did not again mention the question of our interests," Parsons wrote. "I did not raise the matter as somehow I felt that I could sense a feeling at our previous meeting that as the matter did not develop through him it did not concern him".

Parsons noted that British Oxygen in their "most elaborate workshops, were manufacturing expansion engines for attachment to their own design of oxygen production plant. This was stressed to me and I assumed it was to let me see that they were independent of the Heylandt patents so far as the production of oxygen was concerned".

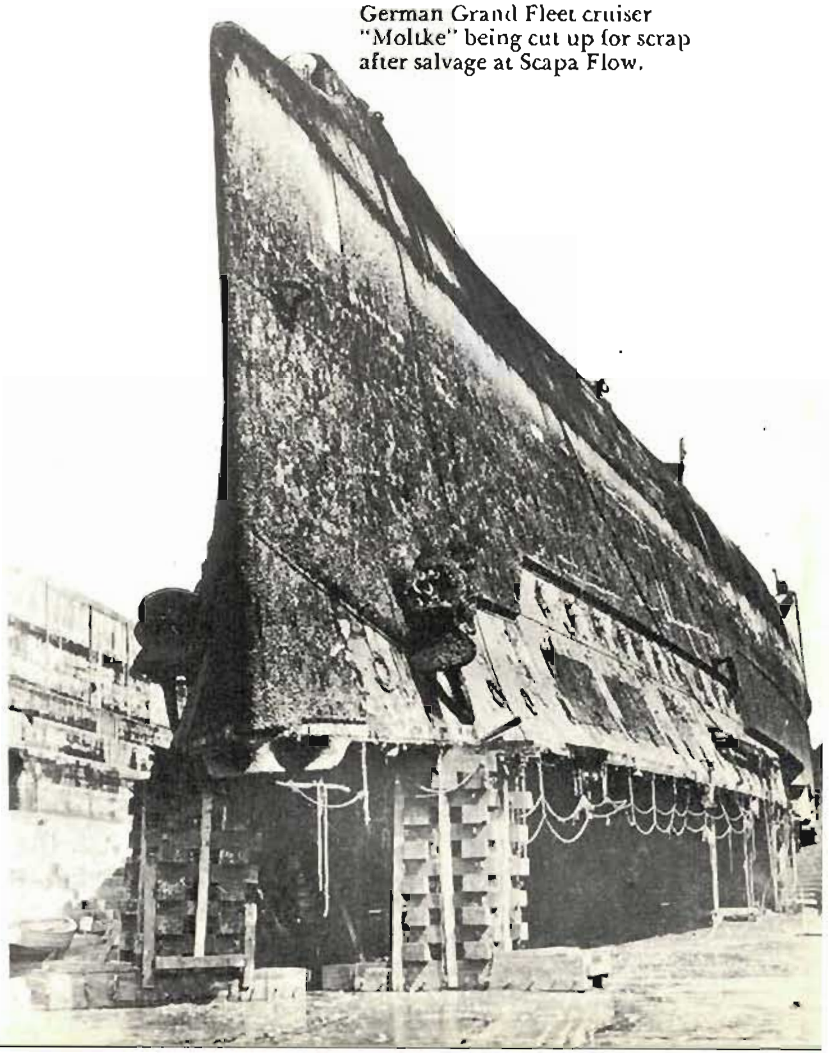
Parsons visited Hardie at his home at Johnstone, 36 miles from Glasgow—Mrs. Hardie drove down to pick him up—and he told Hardie that Murray had not shown any interest in the Heylandt patent rights in Australia.

Hardie told Parsons that his group had acquired a block of shares from the Unilever Company which gave it effective boardroom control of British Oxygen.

"Hardie told me confidentially that Mr. Murray would be retiring at the end of the year and that certain changes would be made in policy," Parsons reported.

While in London, Parsons was contacted by the Australian Oxygen general manager, John B. Arnold, who was eager to learn of the Colonial Gas intentions regarding oxygen manufacture. Arnold appeared in several other European cities which Parsons visited.

"On my return to Melbourne", Parsons' report continued, "I heard all sorts of roundabout rumours of our going into the oxygen business which no doubt accounts for Mr. Geoffrey Grimwade asking me whether we were interested in oxygen cylinders or acetylene. I told Mr. Grimwade that I was not in the position to discuss the matter . . . Both the oxygen companies are very worried about these rumours of our interest in oxygen and this can be understood when one realises that the two Victorian companies only 12 months ago came to an arrangement on a quota basis, the Australian Oxygen Company having 75 per cent and the Oxygen Service Company 25 per cent of total sales. Immediately the arrangement was made prices were increased to 7s 6d per 100 cubic feet, the price last year being, in the case of the Railway contract 3s 9d while other large users were charged 4s 3d and 5s 3d".



German Grand Fleet cruiser "Moltke" being cut up for scrap after salvage at Scapa Flow.

John B. Arnold, Austox general manager, came to a price arrangement with Oxygen Service Company.

Parsons said that in his talks with Hardie in Scotland, Hardie had mentioned that Mr. Allard, of Sydney, had recently been in England and had discussed the Australian gas industry with him. Parsons got the impression that Hardie and Allard had discussed the possibility of one company controlling the industry throughout the Commonwealth. Parsons said Hardie thought there were only three industrial gas producers in Australia when in fact there were eight. Parsons told Hardie he thought the directors of Colonial Gas Association would be prepared to consider associating in a merger scheme.

"This closed the matter and I can only assume that the reopening of the subject must to a considerable extent depend on the position Mr. Hardie finds he and his colleagues are in when the new (British Oxygen) chairman is appointed".

Murray retired from British Oxygen in December, 1933. Dr. Pollock was appointed chairman and Hardie became vice-chairman.

Bulk supply of oxygen to industrial customers became the fashion. In 1955 British Oxygen reported that 75 per cent of the volume of its oxygen sales was supplied by pipe-line into consumers' plant or by tanker. BOC owned half a million oxygen cylinders which were used by more than 99,000 customers. Liquid oxygen, however, later became the main form of supply.

CHAPTER

XI
LET 1935 BE THE YEAR

Sir Alexander Stewart, associated with BOC for 25 years, was appointed C I G 's first chairman.

Parsons tried hard to persuade Colonial Gas to start manufacturing oxygen in Sydney where the market was much larger than in Melbourne. He also pointed out to the board that economic conditions were improving: "The trade returns of the oxygen companies during the last two years returned to normal principally owing to the increased repairs that are made (by welding) in place of new parts and the recent development of charring the bases of electric light and telegraph posts with the oxy-acetylene flame and on which much money is being spent by public authorities concerned".

The board of Colonial Gas included directors who were personal friends of the Grimwades. It decided not to go into oxygen production. It also declined an offer from Parsons to buy the Heylandt rights so that he could set up business on his own account.

Steven Hardie visited Australia in 1934 and arranged to buy the Heylandt rights for £13,750.

In March, 1935, Hardie reported to British Oxygen's annual general meeting at the Grosvenor Hotel, Westminster, on his Australian visit.

"Prior to the amalgamation (in 1930) of The British Oxygen Co.Ltd. and Allen-Liversidge Ltd.", he said, "these respective companies had separate interests in Australia and it was considered advisable that these interests should be amalgamated. The report has already informed you that this has been arranged.

"Australia, as you appreciate, is an immense country, and other units were operating in different States in Australia, and after completion of the amalgamation an invitation was given to these units to join us, which invitation, after negotiation, was accepted by approximately 100 per cent of the shareholders of these other companies (hear, hear)—and as a result The Commonwealth Industrial Gases Limited embraces the whole of the activities of our industries throughout the Commonwealth of Australia".

The companies brought together under the CIG name were:

Commonwealth Oxygen & Accessories Ltd.

Australian Oxygen & Industrial Gases Pty. Ltd.

Allen-Liversidge (Australia) Ltd.

John B. Arnold Pty. Ltd.

Oxygen Service & Manufacturing Co. Pty. Ltd.

Queensland Oxygen Co. Ltd.

Western Oxygen Co. Ltd., South Australia.

Western Oxygen Co. Ltd., Western Australia.

C I G executives at Balmain in 1935. From left: (front row) J. B. Arnold, T. G. Millner, E. H. Wickham, J. F. Clack; (back row) H. B. Coburn, W. M. McKenzie, W. T. Clark, A. A. Cooper, W. P. Bridge.

Phillip Schemnitz did not participate in the merger because he had sold his shares and resigned from Oxygen Service in 1927 to take up agencies for Bohler Steels, M.A.N. and Junker diesel engines, Linde refrigeration and oxygen plants and certain machine tools. The Grimwades offered Carba Dry Ice as part of the merger, but Hardie refused to accept the ailing company.

Hardie added in his report to the annual meeting that CIG was being managed by an all-Australian board of directors of leading industrialists, with a chairman who had been associated with British Oxygen interests for 25 years.

"I am satisfied", he said, "that we have put on a firm footing a national industry in Australia which will play a great part in the future development of industry in the great continent of Australia".

Before resuming his seat, Hardie had "just one word to British industrialists as the great body of our shareholders belong to that class. While in Australia I had the privilege of visiting some of the leading industrial works and was greatly impressed.

"Some of our industrialists here would be well advised to visit and learn at first hand the needs and requirements and desires of Australia, instead of offering to supply that country with what they have to sell and what they think Australia should take.

"The Commonwealth of Australia is a great country and the Australians are a great British nation, and I am satisfied that there is a wide field for the development of industry there for reciprocal trade between our two great countries. They are crying out for us. Let 1935 be the year, or you may be too late!" (Applause.)

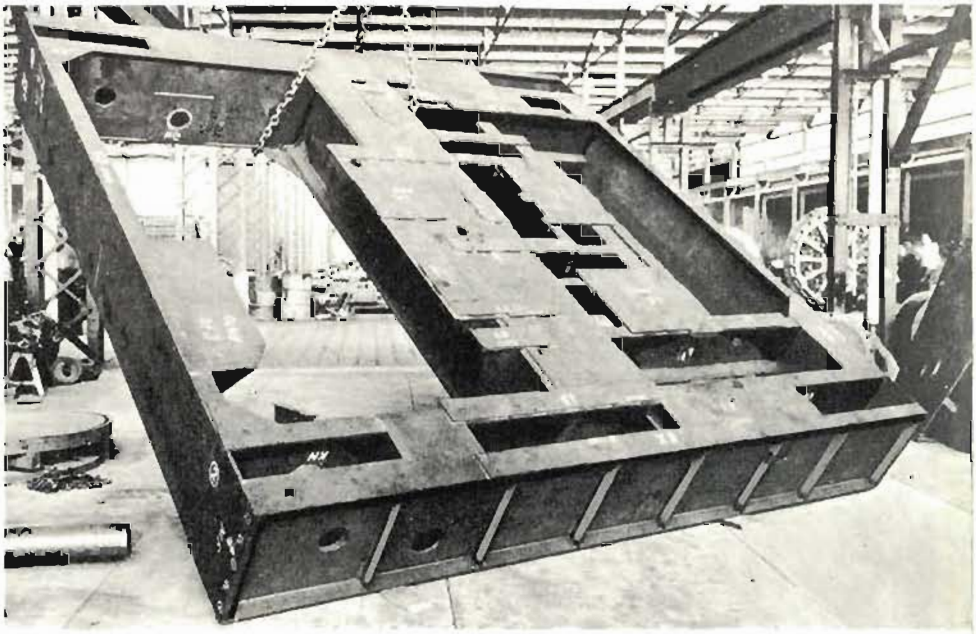
One of the first 55 in. flame cutting machines imported by John Clack.

CIG was incorporated on January 18, 1935, as a holding company in which British Oxygen held about 60 per cent of the shares. Alexander Stewart was appointed chairman and other directors were J. March Hardie (vice-chairman), W. Russell Grimwade, Sydney Snow and Major-General H. W. Grimwade. General Grimwade resigned after a few months and a nephew, Geoffrey Holt Grimwade, was appointed to fill the vacancy.

Steven Hardie included four joint managing directors on the board to form a board of management for the operating subsidiaries. These directors were T. G. Millner (chairman), J. F. Clack (Finance), E. H. Wickham (Sales), and John A. Hardie (Production). John B. Arnold was appointed a joint managing director for Melbourne in 1936. Oxygen Service, Allen-Liversidge and the two Commonwealth Oxygen subsidiaries, Acetylene Supplies and Cylinder Carriers, were wound up at various dates after the amalgamation.

Commonwealth Oxygen took over EMF Welding Distributors in Sydney in 1935 and Reginald Carr shared the consideration he received with Bruce M. Paton who had "all along been my very efficient 2i/c." Carr joined Commonwealth Oxygen on a three-year contract and he took Paton, Bill Bernard and other staff with him. At the end of the contract Carr found himself without a job. He was about to go to

Crab for 100-ton crane was welded at Ruwolt's without jigs or positioners.



Archie Campbell showed James F. Lincoln how Australians measured up.

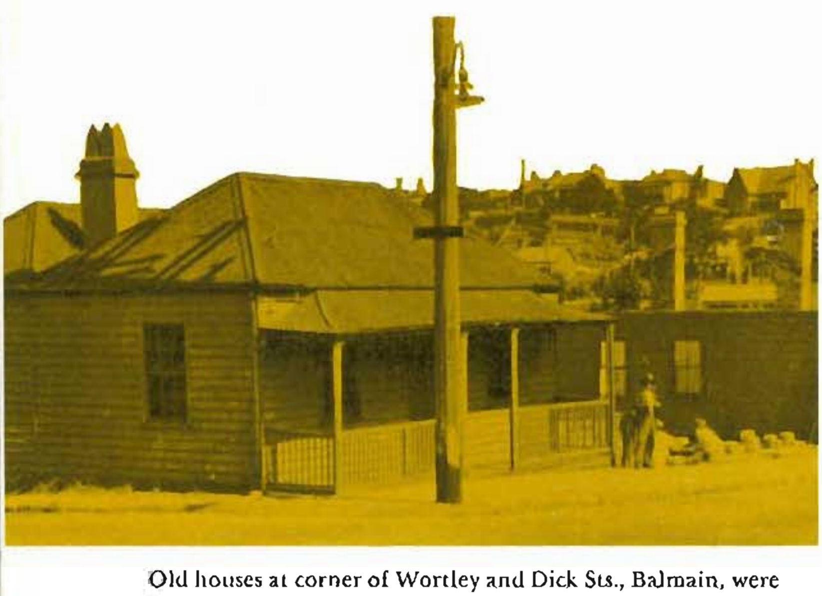
Britain when World War II broke out. David Knox, who had been a leading hand welder at W. G. Pickrell's sheet-metal works in Newtown, had set up Pioneer Welding Company in 1933. He offered Carr a share-holding. Carr and Bernard later bought Knox's shares for £30,000.

Among the jobs on Pioneer Welding's order book were air receivers for the braking systems in new corridor railway carriages which were being built for the N.S.W. Railways. The railways' designers were still suspicious of welding, but they allowed the air receivers to be welded—provided an additional 4 inch wide strap was welded over the seams in case the welding in them failed!

Suspicion of welding was also still deeply implanted in some laymen's minds. George Hamilton, of Commonwealth Oxygen's Newcastle branch, discovered this after he had oxy-welded a poppet head wheel at the Aberdare mine which had fractured in a fire. The miners insisted after the repair that he travel down and up in the cage to show that the wheel was safe before they would resume underground work. John Ogden, one of the founders of Welded Products, related after his retirement how his company had been unable to get official approval for steam-heated platens for presses which they had welded instead of using cast components. Welded Products had patented the design, but the boiler inspector said he could not approve it because it was not covered by the regulations.

Ogden's father, Joseph Ogden, had been blinded by arc flash while welding boiler ends in England in 1899. He was using spiral chips off a lathe as an electrode and was welding without wearing protective glasses. He recovered his eyesight, however, and brought his family to Australia in 1922. In 1931 Joseph Ogden was the production superintendent in the 10-inch mill at the new Australian Iron & Steel plant at Port Kembla and John Ogden was a machine shop chaser in the same plant.

While in Britain in 1930, John Clack had arranged to obtain from British Oxygen three 55-inch profile cutters worth £800 each. Commonwealth Oxygen's board in Sydney was appalled at this transaction. Fyvie asked Clack when he returned to Sydney who was going to buy such expensive machines. Clack replied that he didn't care if they were not sold. If he could get a company to install a profile cutter its cost would soon be paid for by the large amount of oxygen it used. Sydney Snow was not satisfied. He proposed a vote of censure on Clack for buying the machines without seeking approval. Clack replied that the machines had not been purchased, but were on consignment, and he had had the approval of the London board. Snow withdrew his censure motion.



Old houses at corner of Wortley and Dick Sts., Balmain, were pulled down to make way for new Comox offices.

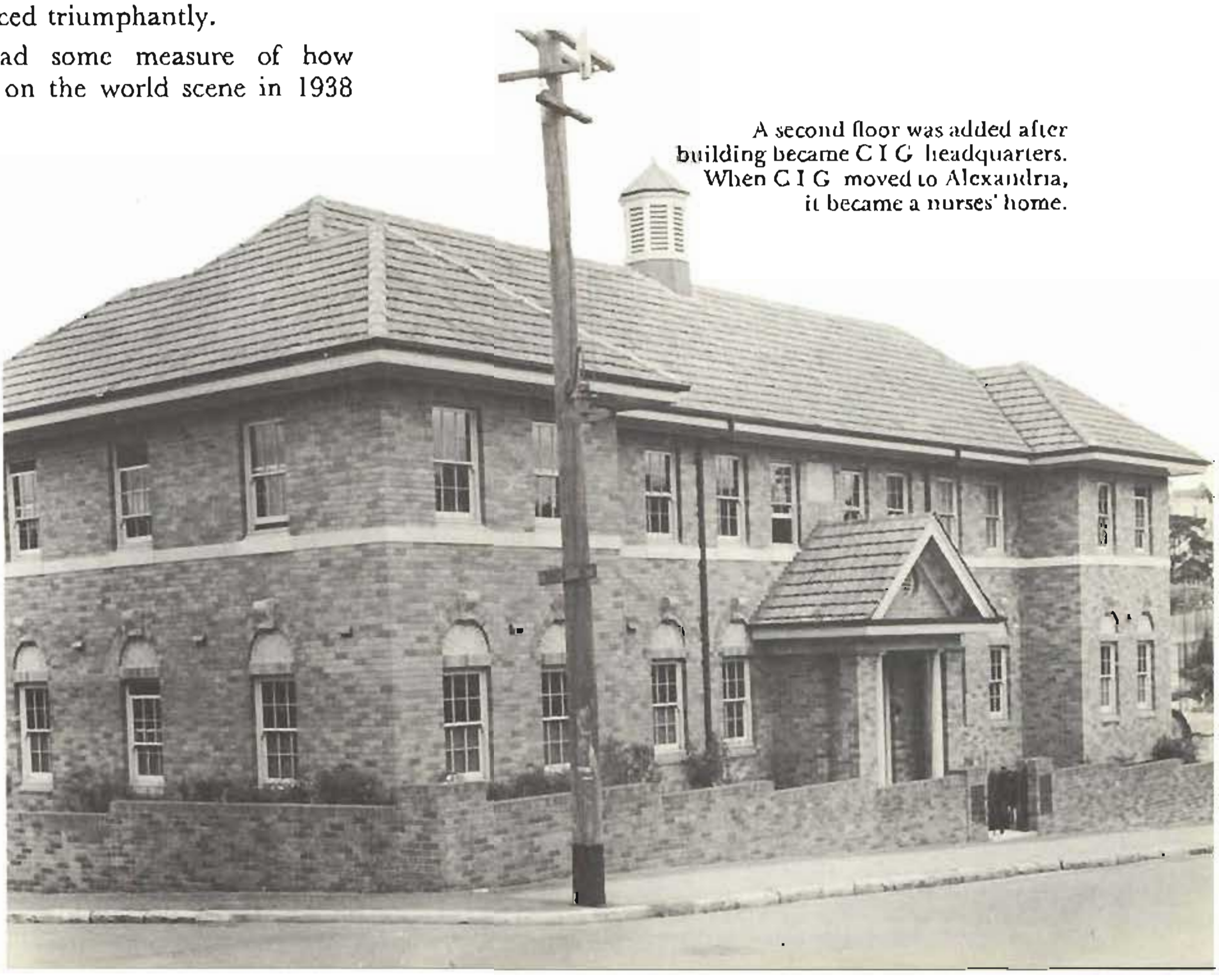
The new offices soon after completion in 1933. They were adjacent to the Comox and Lever Bros. plants.

The Ogdens saw one of the profile cutters in operation and they decided to set up Welded Products in 1934 to specialise in profile cutting for the trade. They had no profile cutter and no money, but were able to borrow £400 from Lionel Morrell who became their partner. Then they built a profile cutter of their own in a garage in Newtown.

Their first job was to supply parts for a steel bar cropper to a Rockhampton client. This brought in £80 and their first year's revenue totalled £1500. By 1937, when revenue totalled £18,000, Welded Products were supplying sophisticated metal cutting machines, guillotines, plate bending rolls and other products of their own design. That year they produced a gear eccentric press for the agricultural machinery manufacturers, H. V. McKay, and this was considered a remarkable achivement at the time.

In Melbourne in 1938 Charles Ruwolt was welding Victoria's tallest building—the 12-storey additions to Prince Henry's Hospital. EMF's advertisements in the trade press highlighted the fact that the hospital was built in silence. "Patients in adjacent wards were granted the inestimable boon of immunity from the machine-gun racket of riveting hammers", the advertisments announced triumphantly.

Archie Campbell had some measure of how Australian welding rated on the world scene in 1938 when James F. Lincoln, head of the Lincoln Electric Company, of Cleveland, Ohio, visited the Ruwolt plant. Campbell had just completed welding a large crab for a 100-ton crane which was to be installed at Port Kembla. The crab frame was 14 ft 6 in square by 2 ft 1 in deep and it weighed eight tons. Lincoln was amazed when Campbell told him the crab had been laid up against a column in the shop and downhand welded. Then it was turned over and laid against another column for the welding to be completed. No jigs or positioners were used. When Campbell asked Lincoln how he would weld such a job in the United States, Lincoln replied that it would not even be attempted.



A second floor was added after building became C I G headquarters. When C I G moved to Alexandria, it became a nurses' home.

Lincoln Electric Company (Australia) Pty. Ltd. was incorporated in N.S.W. in 1938 and it began manufacturing electrodes and assembling welding machines from imported components. Joe Hunter, who had transferred to Malcolm Moore Industries when it absorbed Gardner Constructions, became Lincoln Electrics' works manager. The company had 14 employees when W. I. Miskoc arrived from the U.S. to become managing director in 1941. Until 1944, when Lincoln Electric established its own sales network, Stewarts & Lloyds distributed Lincoln products in all States except South Australia where Elder Smith & Co. Ltd. were Lincoln agents.

In 1936 the James F. Lincoln Arc Welding Foundation was created in America and it began world-wide contests, with substantial prizes, for the re-design of all types of products and equipment from other methods of fabrication to that of arc welded fabrication. Several Australians were prize winners. Lincoln Electric had run international essay competitions to foster arc welding since the 1920s.

In 1939 CIG acquired all the shares in EMF and bought out Gatenby's company, Compressed Medical and Industrial Gases, in Melbourne. A new factory to manufacture oxygen and acetylene was completed that year on the site of the present CIG N.S.W. office and plant in Bourke Road, Alexandria.

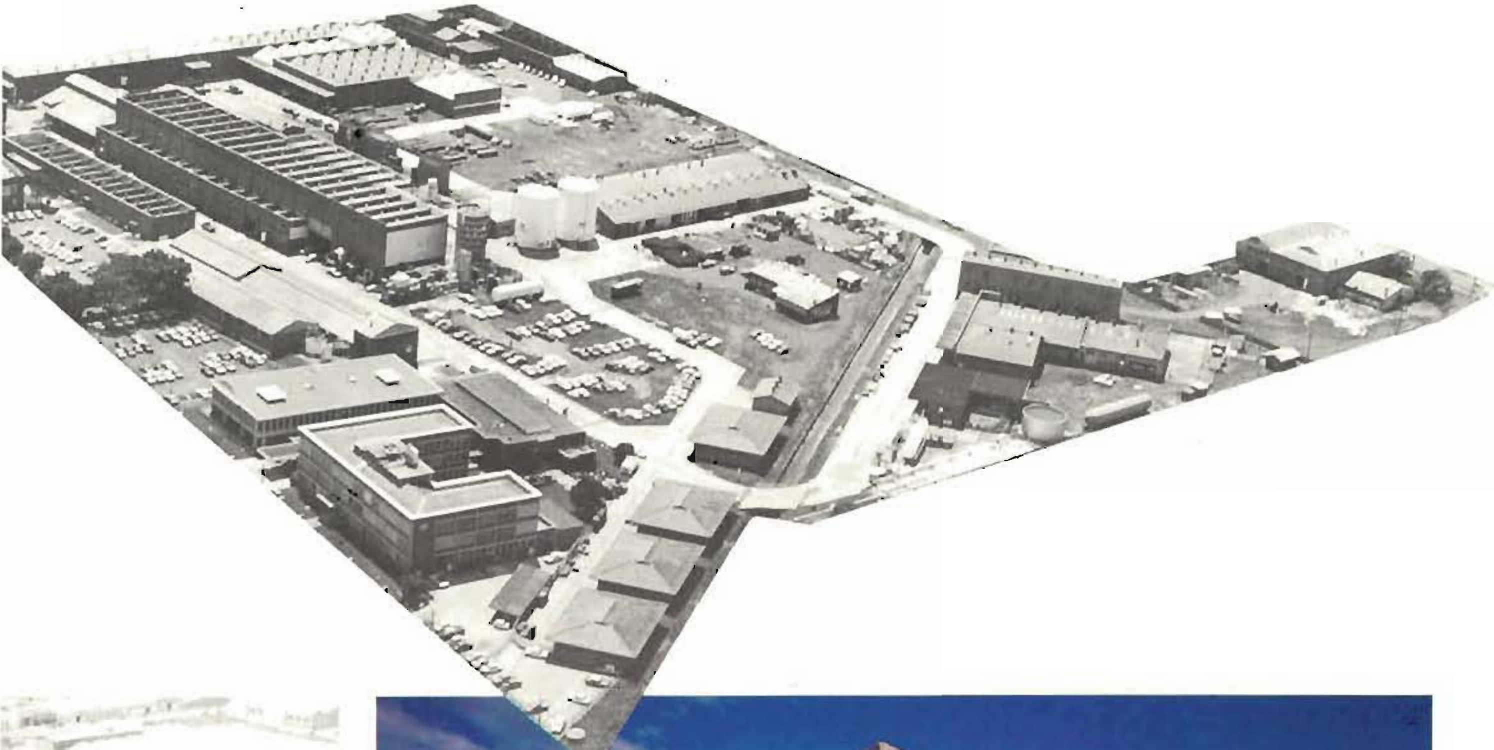
Evans Deakin remained the sole Queensland distributors of EMF until 1966. Stan Coates handled the agency from 1938 until he retired on July 8, 1966. The company was reappointed as CIG distributors in 1972.

Site of C I G 's Sydney complex at corner of Bourke Rd. and Doody St., Alexandria, before construction began about 1936.

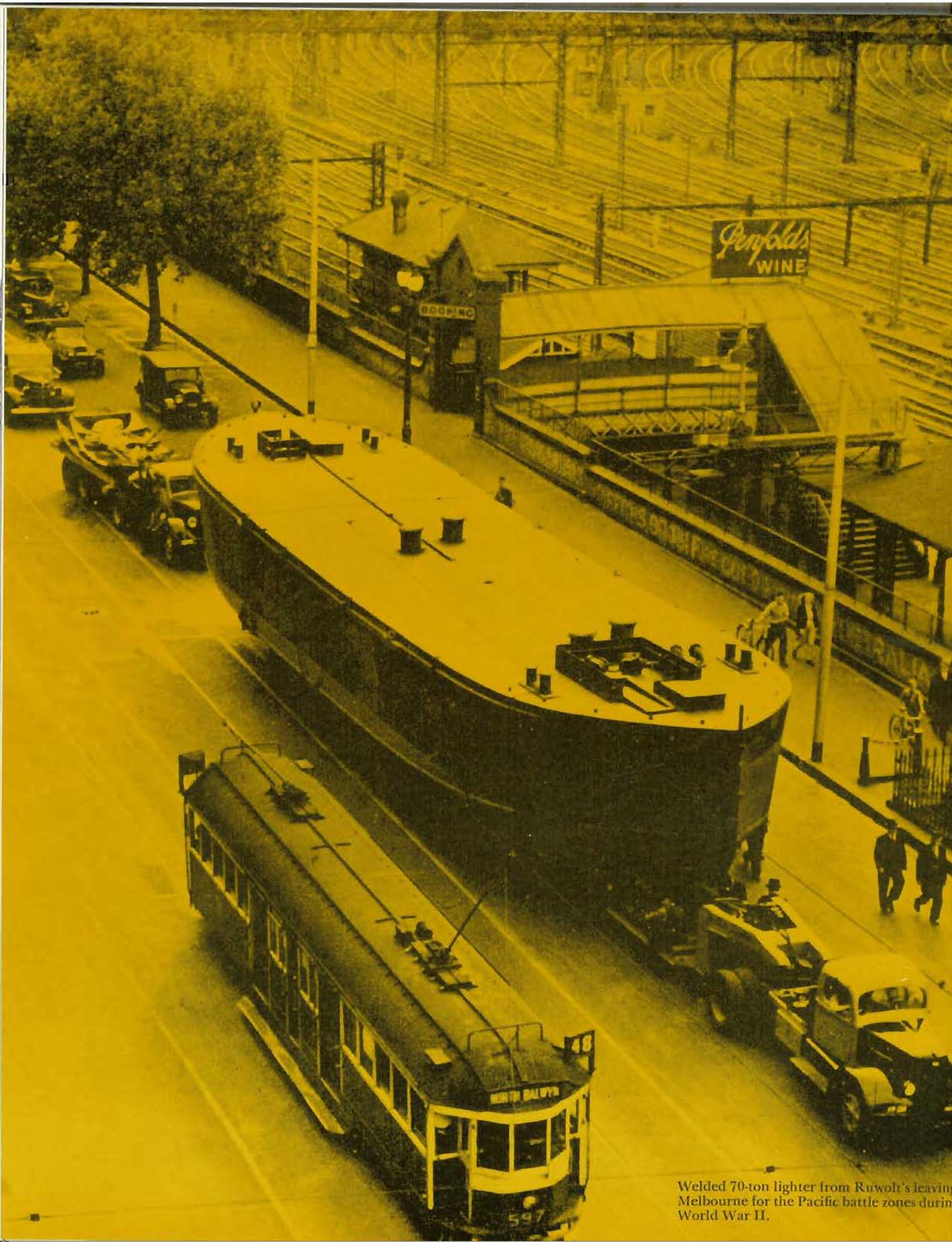
By the mid-1940s buildings occupied about half the site. C I G had Army as neighbours in the field at top right.

CIG Statement of Group Sales, Profit and Funds for Years Ended

	1935 $000	1940 $000	1945 $000	1950 $000	1955 $000	1960 $000	1965 $000	1970 $000	1973 $000
Sales	265	1,989	3,836	6,398	14,715	24,643	32,569	57,018	79,806
Profit after Tax and Interest	72	260	292	744	1,747	2,659	2,824	4,538	5,899
Dividends	68	187	149	350	600	1,100	1,146	2,697	3,311
Funds at Year End	789	1,935	2,261	6,260	12,554	20,677	33,151	61,584	75,967
Total Stockholders' Funds	742	1,762	2,261	4,974	10,554	16,677	31,905	44,818	52,368



One of the buildings in the current Alexandria complex which is pictured above. C I G head office is now at Surry Hills.



Welded 70-ton lighter from Ruwolt's leaving Melbourne for the Pacific battle zones during World War II.

CHAPTER XII THE WELDERS AT WAR

World War II placed immense pressure on Australia's industrialists who were called on to produce a huge range of products they had never before attempted. The war also gave the Australian welder the opportunity to demonstrate his real worth.

There was tremendous increase in welded fabrication and defence work introduced many manufacturers and their employees, including women, to the electrode and the blowpipe.

"Without our expert practical assistance, given in all States, these manufacturers would have had great difficulty in fulfilling their contracts as, today, it is impossible to obtain welders", John Clack said in a report to the CIG board early in the war.

"We have taught inexperienced men to weld, showed manufacturers how to construct the particular work and supervised it to the finish".

Under Essington Lewis, Director General of Munitions, an Ordnance Production Directorate was formed. OPD was led by the top General Motors-Holden men, L. J. Hartnett, as director, and F. S. Daley, as controller. A welding advisory panel, of which Roy Holland was a member, recommended that Joe Hunter be appointed welding consultant to OPD. Hunter was attached to the directorate's production engineering department and later he became the department's manager. By 1943 OPD was handling £70 million worth of defence production.

As well as training hundreds of welders for defence work, CIG was faced with a continuing stream of requests on how to weld the special steels which were increasingly being used for weapons and armour plating.

Joe Hunter was welding consultant to OPD.

Procedures were established, for instance, for welding the high-tensile bullet-proof steel used in the thousands of Bren carriers being manufactured in Australia. The nickel steel carriages for 25-pounder field guns were previously riveted, but CIG developed a welding technique which enabled production of them to be trebled. Campbell at Ruwolt's in Melbourne found that five welded trails for the 25-pounder could be turned out in the time it took to rivet one.

Experiments with resistance welding enabled manufacturers of Owen and Sten gun magazines, army water bottles, petrol drums, smoke bombs and many other items to increase production greatly. The N.S.W. Railways were producing anchor chain for the Royal Australian Navy and CIG participated in evolving a technique for flash-welding the chain.

Technique for flash-welding anchor chain was evolved to assist N.S.W. Government Railways to meet R.A.N. order.

During World War II C I G 's Equipment Division produced spark plug bodies, gun sights and other scarce war supplies.

By adapting and improvising, welding and engineering workshops were able to handle strange assignments. Bill Featonby produced 70-ft welded steel tugboats at the Victorian Railway workshops at Newport, and Ruwolt's produced 80-ft petrol lighters to supply island air strips. Harry Grove turned out Bren carrier components at the Metropolitan Gas Company in Melbourne.

When a ship carrying a large number of roller bearings was sunk and the manufacture of variable pitch aircraft propellors was consequently threatened, CIG's equipment factory machined 3/8 inch rollers from special ball-bearing steel and the rollers were then hardened and ground by the Russell Manufacturing Co. Pty. Ltd. The Army asked for 400 two-pounder gunsights in three days. CIG staff, working day and night, produced them ahead of schedule. The Ministry of Munitions lent CIG three automatic lathes to produce bodies for aviation spark plugs which were in short supply.

To ease the shortage of electrodes, CIG opened an electrode factory in Sydney in 1941, augmenting production from the EMF plant in Melbourne. In 1942 Clack reported to the CIG board that demand for all types of flame cutting machines was "still in excess of our capacity to manufacture and we are still being called on to design new and special types . . . we are manufacturing for an ACI subsidiary a special machine to carry six blowpipes and it is to be used to cut simultaneously six articles which are at present fabricated one at a time by flame cutting".

Welding had started to develop at Cockatoo Docks in Sydney when Ron Joselin joined that company as an apprentice in 1937. Although rivet construction was still being used, most of the internal decks and bulkheads were being welded.

At the beginning of the war the dockyard management sent a team overseas to learn the Block method of all-welded ship constructions. Devised by a shipbuilder at Cowes, the method called for separate upside-down construction of a ship's units in a prefabrication area. From there the units were taken to a building berth, consolidated and welded together in very quick time.

Reverting to peacetime production of C I G products, the Equipment Division developed into one of the largest light engineering plants in Australia.

This was the method which Henry J. Kaiser used in the U.S. to produce the earliest of the 821 Liberty ships turned out by his yards—including one which was built in an incredible 4½ days! The 10,000-ton Liberty ships were designed specifically for one voyage and were much maligned at first. Critics of welding predicted that they would not complete a voyage. However, out of a total of 4694 welded vessels of all types built for the U.S. Maritime Commission during the war, eight were lost because of weld failure.

The Block method enabled production to be increased at Cockatoo Docks, but as research led to improvement in welding methods, equipment and materials, a new method of construction was adopted. It was found to be quicker to build the vessels from the keel up and outfit them with shaft, engines and other components, while construction was taking place.

According to Joselin—he later became Cockatoo Docks' production director—welding played a tremendous part in the turn-round of damaged ships during the war. Welders were able to give the ships with damaged bottoms temporary repairs which produced bottom fairness and enabled them to operate efficiently until it was convenient to give them permanent repair. Severely damaged vessels were able to leave the dock in a matter of days instead of months. More than 12,000 merchant ships underwent repair or refit in Australian yards during the war. Cockatoo handled 750 dockings, half of them merchant marine work.

In Brisbane, the Commonwealth Government asked Dan Evans to get into shipbuilding. Evans Deakin acquired the old Moar's Slip at Kangaroo Point on the Brisbane River and there the keel of a 1200-ton oil fuel lighter for the Navy was laid on July 27, 1940. By the end of the year the yard had an order for 12 corvettes and in 1941 Evans Deakin was commissioned by the new Australian Shipbuilding Board to build four 9000-ton merchant ships. Thirty years later the Kangaroo Point shipyard had become the second biggest in Australia and Evans Deakin was building vessels up to 65,000 tons. BHP's yards at Whyalla were then building 78,000-ton vessels.

The Royal Australian Air Force relied heavily on oxygen and apart from servicing it through normal channels, CIG imported mobile oxygen production units and trained RAAF personnel to operate them.

Wartime construction of small ships in turning cradles enabled difficult overhead welding to be reduced.

CIG's knowledge of industrial gases also assisted the airmen to solve other difficulties. CIG helped, for instance, to eliminate a serious problem which the RAAF was experiencing with auxiliary petrol tanks on fighter aircraft. Incendiary bullets fired into the tanks ignited the air and petrol vapour above the petrol and several aircraft were lost through this cause. A system was developed for replacing the petrol as it was used with a blanket of carbon dioxide gas. It was supplied through a 10 oz cylinder which had a two-way relief valve to prevent the tank from collapsing when the aircraft returned to the ground.

RAAF and CIG personnel redesigned British-made oxygen breathing equipment used early in the war and they were somewhat flattered when this new design was adopted by the British manufacturers.

Oscar Grunden, John B. Arnold's first employee back in the 1920s, had plenty of scope to develop his reputation for inventiveness in the wartime CIG design department. One of his important jobs was to assist the RAAF to develop a rubber suit which would prevent fighter pilots from blacking-out in power dives. He was particularly concerned with the design and manufacture of a special valve which was actuated by the effect of the dive and compensated for it by applying pressure to the various parts of the pilot's body affected by the dive. The G-suit became a successful reality.

With welding established as an invaluable tool in war production at home, the blowpipe and electrode were also proving to be indispensable on the battlefield.

Brigadier George Moran, OBE, of Melbourne, said in his history of the 2/2 Army Field Workshops unit in World War II that from ancient times armies had included craftsmen with strange titles such as lorimer (bridle maker), fletcher (arrow maker), artificer and artillerateur who were responsible for keeping the soldiers' bows, bombards and battering rams in order. Though trained to fight, this role was secondary to their job of helping the soldier of the line. As army equipment became more complex the need for more craftsmen grew. Modern, well-equipped armies required one man in every seven or eight to be a member of the electrical and mechanical engineering corps or its equivalent.

Brigadier W. D. Chapman stated in his presidential address to the Institution of Engineers Australia in 1945 in Sydney that a total of 381 members of the institution were serving or had been serving in the new Royal Australian Electrical Mechanical Engineers in the previous two years.

RAEME grew from the Australian Army Ordnance Corps Mechanical Engineering Branch which was a very small organisation before World War II. In 1928, a total of 23 armament artificers and 15 assistants looked after all the equipment for the field force of seven divisions, as well as the guns and plant of fortresses extending from Thursday Island to Fremantle. By mid-1939, however, the branch had increased to 12 officers and some hundreds of men in the permanent force, with more in the militia and reserve.

In May, 1940, Chapman (then a major) with Captain Moran set up a tent with a table and form in the car park at Caulfield racecourse and began the enlistment and training of men for 2/2 Army Field Workshops, the first of four Australian field workshops to see action in the Middle East.

Moran said in the unit's history: "I had known W. D. Chapman for many years as one of Australia's top engineers, but at this time and during the years that followed, I and many others were to learn of his

John Arnold toasting his first employee, Oscar Grunden (second from left), when Grunden retired from C I G in 1963. Stan Green (left) and Les Thorn are ready to respond.

World War II serviceman using arc welder for equipment maintenance in a base workshop.

Army instructor guiding an apprentice in the use of oxy-acetylene cutter, an important military tool.

RAEME trooper repairing a Centurion tank with arc welder at Nui Dat, the Australian base in Vietnam.

great leadership characteristics. His human understanding, quick perception and his sense of humour were inspirations to us and we knew that we were fortunate to have him as our unit commander and later Chief Ordnance Mechanical Engineer of HQ, AIF Middle East".

The 2/2 workshops reached Egypt late in 1940 after British forces had turned back the Italian drive on Suez, capturing 40,000 of the enemy. The unit was followed soon after by the 2/1 Army Field Workshops which had sailed earlier to the United Kingdom, the 2/3 which was raised with the 7th Australian Division, the main shop of the 2/4 whose recovery sections were in Malaya, Anti-Aircraft Brigade Workshops, Advanced Base Workshops and Light Aid Detachments. All used welding extensively, effectively and not always by orthodox methods. The history of the 2/2 Army Field Workshops was, in a sense, typical of other units engaged on maintenance in the field. Bardia was Australia's first army battle in the war and after the town fell, the Sixth Division AIF prepared for the assault on Tobruk. By then the 57 supporting tanks had covered 500 miles and only six were fit for battle. The GOC, Major-General Iven Mackay, stressed that each tank was worth a battalion of men and 2/2 Army Field Workshops moved two officers and 70 men into the tank lager to assist the overhauls. Despite a shortage of spare parts, hard work and some unorthodox repairs enabled 20 tanks to lead the attack on Tobruk on the night of January 20, 1941.

Twenty men of 6 Recovery Section, including three South Australian welders, moved in with the tanks. Several of the Matilda's had their turrets damaged by shells and their crews were unable to line up their guns. Under fire, the welders cut away damaged sections to free the turrets and five tanks were able to rejoin the battle. The welders—Sgt. William Milbourn Allison (a Western Oxygen employee from 1924) and Privates Ernest Oswald James Dunning and Kenneth Smith—won Military Medals for their work.

"This epic made us proud of our team, and it was probably the first time that spectacular oxy-acetylene cutting plant was operated in exposed forward positions in battle", Brigadier Moran's unit history said.

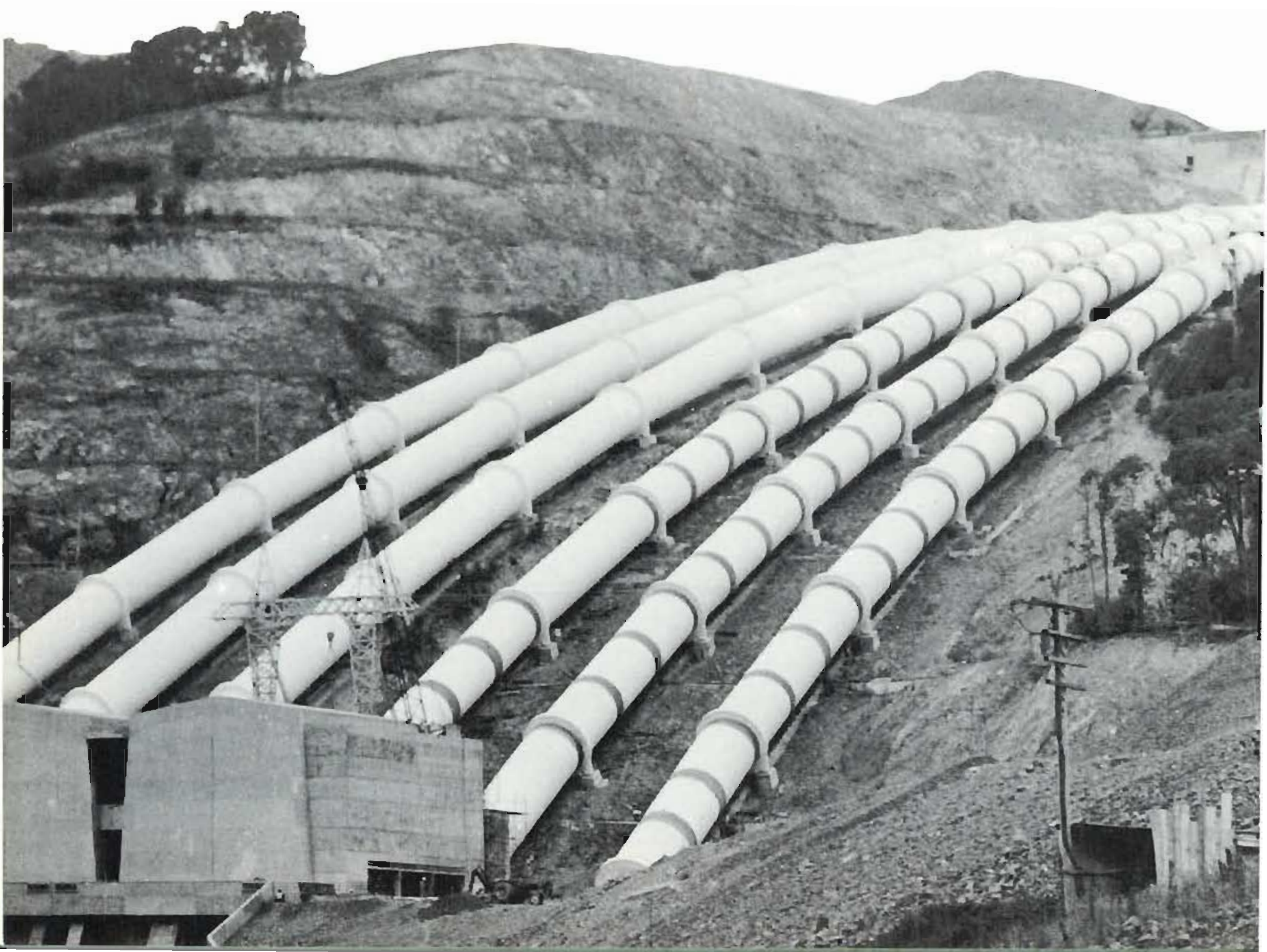
Italian welding plant, plus an oxygen manufacturing unit, captured at Bardia and Tobruk, became useful additions to the unit's resources. The commercial trucks used by the Australian troops were not designed for the Western Desert and their springs became overstressed, often after only 50 miles. Short lengths of old springs were electrically welded, heat treated and hardened in used sump oil, then fitted to disabled vehicles. War photographer Captain Frank Hurley boasted about one such repair to his vehicle: "Still OK after 1500 miles".

The unit's welders in Libya ran out of acetylene when faced with urgent repairs to alloy steel howitzer spades. They found four cylinders in an Italian beacon at Barce airstrip.

Part of the workshops unit was in Tobruk when Rommel besieged it. Another 47 men had been sent to Greece where the Allies were in a desperate situation. On April 22, 1941, the Australians near Mount Olympus received orders to destroy all equipment except oxygen and acetylene cylinders which could be used for demolition to impede the Germans. Over the next eight confused days, 20 of the workshops men were taken prisoner, but the remainder were able to reach HMAS Perth for evacuation to Egypt and Palestine.

Two months later the 4th Recovery Section of 2/2 Army Field Workshops was serving with the Free French Brigade in Syria while 2/3 Army Field Workshops and its three recovery sections were supporting the Australian, British and Indian forces in the short but bitter campaign against the Vichy French. Before the 2/2 unit left Syria with other Australian units in January, 1942, to return to Australia viz Suez, its welders were kept busy in freezing snow-storms welding cracks in the cylinder blocks of more than 100 army vehicles.

Back in Australia, 2/2 Army Field Workshops was formed into other units, some of which served in New Guinea and the Solomons where the welders still had plenty of scope to improvise. When, for instance, the barrel of an Australian Matilda tank's 3-inch mortar was damaged by Japanese fire on Bougainville, the tank was driven to a protective hollow. There a team of welders heated the barrel with oxy-acetylene torches while the tank crew defused a mortar shell. This was fired through the softened barrel, re-aligning the damaged section. The tank went back into action, firing several more rounds before the encounter ended.



CHAPTER

XIII

A MATTER OF DISCIPLINE

Welding had an important function in the first of the major national development projects undertaken in Australia after World War II—the $800-million Snowy Mountains hydro-electric and irrigation scheme. Humes Ltd. were the major contractors for the pressure pipelines connecting the 100 miles of tunnels with those power stations in the scheme which were not built underground. Humes' welding engineer was Ernest J. Hume, son of one of the two brothers who founded Hume Bros. Cement Iron Co. Ltd. in Adelaide in 1910. Hume Pipe Company (Australia) Ltd. was formed in 1920 to acquire that business and in 1924 a separate company, Humes Steel Ltd., was formed to produce welded steel pipes.

This company used electric automatic welding and manufactured its own cotton-coated, flux-impregnated electrodes. Ernest Hume joined the company after 17 years as chief engineer of the South Australian radio stations 5DN and 5 RM, part of the Macquarie network. Well conversant with frequency control problems, he was able to switch to welding with ease and he was to make some significant contributions to the industry.

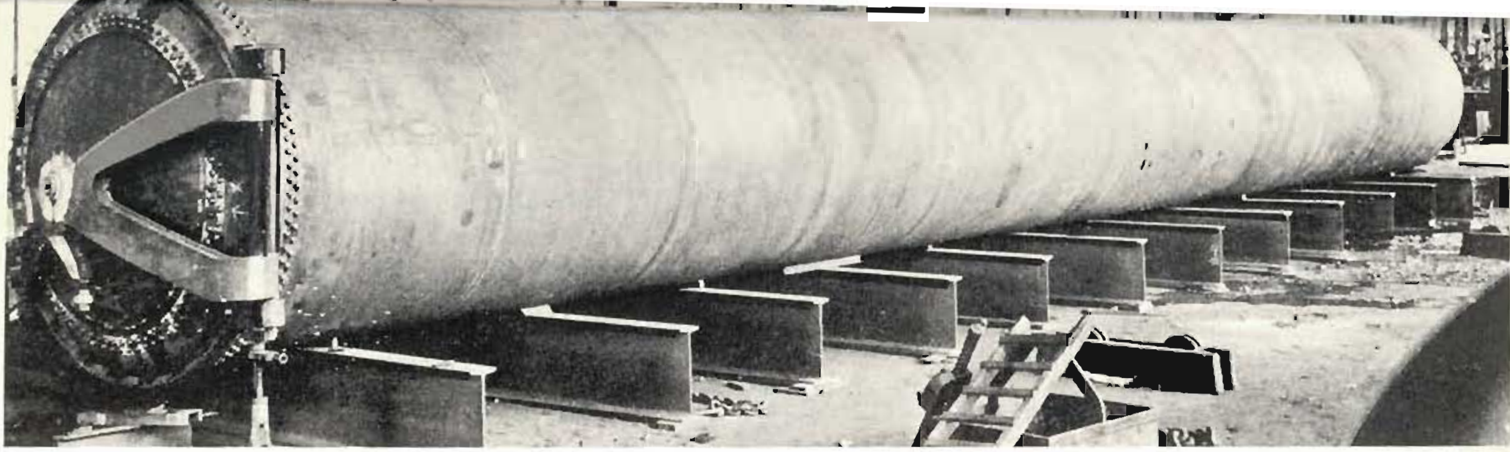
These included development of a light ray beam to eliminate parallax errors in welding seams and a pneumatic system for handling fluxes in submerged arc welding. Humes were also the first to weld pipes 20 inches in diameter by the high frequency induction method which had previously been restricted to pipes of 6–8-inch diameter. Humes Ltd. and Tubemakers of Australia Ltd. formed Steel Mains Ltd. in 1970 to participate jointly in steel pipeline construction services.

W. D. Chapman had been appointed a Commissioner of the State Electricity Commission of Victoria in 1944 and in the following year he became Director of Civil Engineering, Railways Standardisation Division, of the Commonwealth Department of Transport. The University of Western Australia awarded him an honorary Doctorate of Civil Engineering in 1949.

By the end of the 1950s welding was almost totally accepted, but the riveters were still fighting a rear-guard action. The multi-storey office block erected for the Melbourne and Metropolitan Board of Works in 1956 had a riveted frame. Archie Campbell at Ruwolt's about that time produced a large autoclave. Boiler inspectors allowed him to weld the longitudinal seams, but insisted that the peripheral end seams be riveted.

Despite Chapman's pioneering work on welded railway bridges in Victoria almost half a century earlier, the Way and Works Branch of the Victorian Railways was still erecting riveted bridges in 1972.

Snowy Mountains scheme required large-diameter steel pipelines which had to be welded to very strict code.



Large autoclave demonstrated lingering doubts about welding in some quarters. Inspectors insisted end seams be riveted.

Holden manufacture widened scope for welding. This EMF display contained resistance welded parts in early Holdens.

Radiographic testing of welds added greatly to the science of welding and removed much of the lingering doubts about the process. But science is a discipline and the failure of the Kings Bridge in Melbourne in July, 1962, was a spectacular reminder of the human content in welding—a content requiring rigorous discipline from the design stage through to the actual welding and testing of the welds and material.

The Royal Commission into the failure of the £4,000,000 bridge found that cracks were present in the end welds of the cover plates on the tension (lower) flanges of the span which collapsed.

The commissioners said they had asked themselves whether they had judged the incidents by standards "that are too high for ordinary mortals to reach and whether we are demanding higher standards of competence from engineers than we would from doctors, lawyers or other professional men.

"It is, of course, undeniable that a doctor or lawyer who makes a mistake which causes his client to lose life or liberty normally escapes public censure although he may have to answer a charge of negligence in the courts. But engineers generally—and in this case certainly—do not work as individuals in a consultant-client relationship, they work as a team. This certainly brings with it problems of communications and organisation, but it also means that individual engineers are supported by others who can help and check their work".

Development of the Australian mineral processing industries, oil resources and reticulation of natural gas from remote fields involved a considerable amount of welded pipeline construction from the 1950s on. The first of the natural gas lines was the 272-mile stretch between Roma and Brisbane in Queensland. By the end of 1971, 1100 miles of natural gas lines had been laid and another 800 miles were scheduled to link Sydney with the Moomba field in South Australia's Simpson Desert.

The pace of development was, however, not continuous enough for contractors to maintain teams of specialist welders which could be moved from project to project as was the case in the U.S. where 250,000 miles of energy pipelines have been laid. On the completion of an Australian project the welders disbanded and a new team had to be formed for the next project.

In 1966, 1200 welders applied for jobs on a pipeline contract which a Dillingham Corporation of

Australia subsidiary had for the installation of 270,000 linear feet of inter-process pipeline at the 600,000-ton capacity first stage alumina refinery which Queensland Alumina Ltd. was establishing at Gladstone, Queensland. The pipelines ranged in diameter from two to 48 in, with wall thicknesses from $\frac{1}{4}$ in to $\frac{7}{8}$ in. The pipes were mainly carbon steel, but some were nickel lined. Of the applicants, 870 were tested at CIG training centres in Sydney, Melbourne, Brisbane and Adelaide and 130 were selected and trained to weld in any position.

At the same time, CIG personnel in Perth were completing the training of 266 welders who erected the U.S. Navy's VLF radio base at North West Cape.

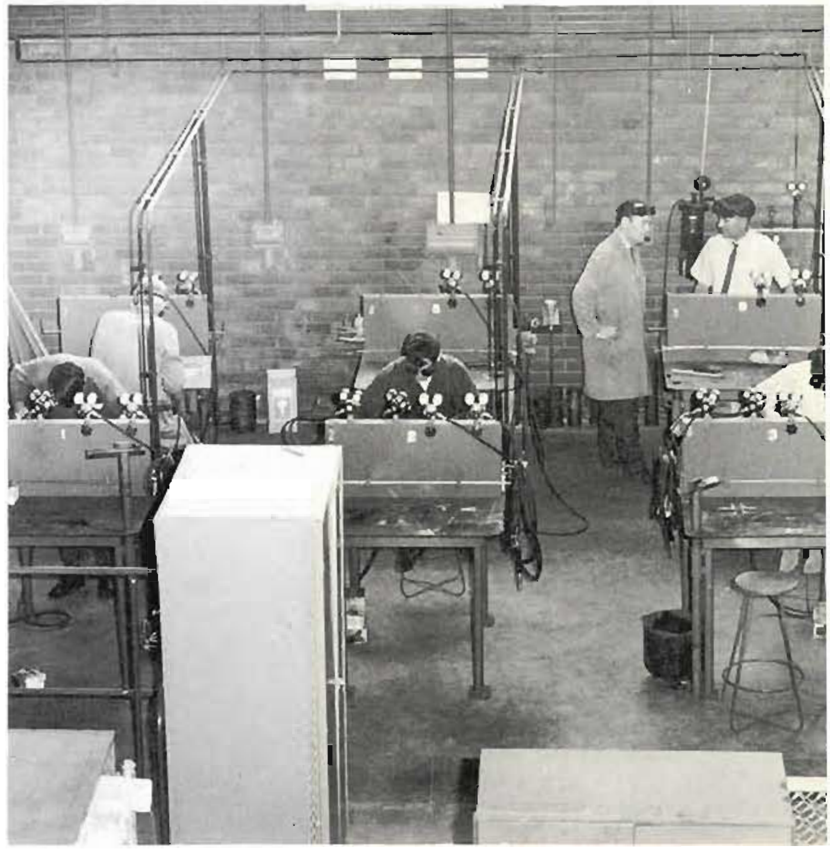
Development of the Holden motor car by General Motors-Holden's Pty. Ltd. in the 1950s greatly increased the scope for resistance welding. The first Holden contained 10,000 spot welds, some seam welding and hundreds of projection welds.

The first Australian-built railway locomotive was constructed at Hudson Bros.' factory at Granville, Sydney, in 1882. Hudson Bros. became Clyde Engineering Company Pty. Ltd., which was for many years the major contractor for rolling stock for the N.S.W. railways. Clyde Engineering retained a large rivet fabrication capacity until 1950, although the company had adopted electric welding for some fabrication in the 1930s.

It switched almost entirely to electric welding in 1950 when it began building the first of more than 200 Clyde-GM diesel electric locomotives. A fully automatic submerged arc welder with a 40 ft boom was installed for this job. In the early 1960s Clyde Engineering was still getting a trickle of orders for rivet construction. These were for such things as slag ladle cars and 400-ton cranes which had not been converted to welding design.

Joe Hunter was appointed principal welding engineer in the Department of the Navy in 1947, a post he held until he retired in 1968.

Very strict codes of welding were developed at Cockatoo Dockyards to meet Royal Australian Navy requirements. Before employment, the dockyard welders were tested in eight positions, four for fillet welds and four for butt welds. Their qualifications were entered in a register and they were only permitted to weld in those positions for which they had qualified.



Welding schools were established by CIG as the need arose to upgrade welders for special industry requirements.

The dockyards became a major fabricator of aluminium which was increasingly adopted for superstructures. In 1957 the dockyards built HMAS Voyager, the first all-welded destroyer to be built in Australia. CIG's technical advice on argonarc welding was sought during the vessel's construction. By an ironic quirk of fate, Major-General Sir Jack Stevens was a member of the CIG board of directors when Voyager, with his son in command, was crushed beneath the bows of the aircraft carrier HMAS Melbourne in Jervis Bay, south of Sydney, in 1964.

Transpak 180, latest machine developed by C I G for M I.G welding, is an ideal unit for sheet metal workshops.

C I G 's M I G welding equipment being used in a car body repair shop.

In 1972 Cockatoo Docks was still using rivets, but riveting was almost an extinct art. During World War II, the dockyards had 40 riveting squads, supported by caulkers, but this capacity had dwindled to four squads.

CIG had first made use of its new Heylandt patents for liquid oxygen transport in 1936 when a liquid oxygen road tanker carrying the equivalent of about 600 cylinders of gaseous oxygen began making two trips a day from Sydney to Port Kembla.

In later decades liquid oxygen assisted the establishment of major mining centres in remote areas of Australia. It was sent by road and rail from Adelaide to Darwin, 1900 miles away. Later Darwin was supplied from Townsville, with a road tanker servicing the giant mining complex of Mount Isa during its 1500-mile journey. Many industries were to install vacuum-insulated liquid oxygen evaporators to reticulate oxygen through their plants. Cockatoo Docks built a unique floating evaporator to carry liquid oxygen across Sydney Harbour to their 44-acre island shipyard.

CIG in 1947 bought out the Robot company which had begun manufacturing electrodes in Victoria during the war. Quasi-Arc was incorporated as a company in Melbourne in 1927, but Robert Bryce continued as Quasi-Arc distributor until CIG acquired Quasi-Arc's Australian operation in 1946. British Oxygen had acquired Quasi-Arc's parent company in Britain in 1937.

Greer Ashburner and Crawford began manufacturing GAC electrodes in Melbourne in 1960 and in 1963 Welding Industries of Australia Pty. Ltd. also began manufacturing electrodes there under licence

In 1957 H.M.A.S. Voyager became the first all-welded destroyer to be built in Australia. Aluminium was used extensively.

from Oerlikon, of Switzerland. After relinquishing the Quasi-Arc agency, Robert Bryce had participated in the formation of Weldex Pty. Ltd. to manufacture Philips electrodes. Weldex was sold to Liquid Air Australia in 1971. Murex had been acquired by CIG in 1969, following BOC's acquisition of the Murex company in the U.K.

Adolph Messer International Co., subsidiary of Messer G.m.b.H. of Frankfurt, and Coyne Cylinder Co., of U.S.A. were the main shareholders in Pacific Oxygen Ltd., which began manufacturing oxygen at Spotswood, Melbourne, in 1957. The company was sold to CIG in 1963.

In 1959, Liquid Air Australia, a subsidiary of the French L'Air Liquide group, also began manufacturing industrial gases and marketing welding equipment and electrodes in Melbourne.

L'Air Liquide had formed British Liquid Air Ltd. in 1906 to work the Claude patents in the United Kingdom. British Oxygen claimed the Claude patents infringed its Hampson and Linde patents and after legal action, which British Oxygen won, it bought the Claude patent rights for Britain.

L'Air Liquide established a subsidiary in Japan in 1910 and Canadian Liquid Air in 1911.

Liquid Air Australia in 1971 established a tonnage plant with a capacity of 140 tons of oxygen a day to supply an ICI plastics factory at Botany, a Sydney suburb. In 13 years of operation, Liquid Air Australia had gained 15 per cent of the Australian market for industrial gases.

Both Liquid Air and CIG were among the parties favouring reduced protection for Australian Commonwealth Carbide Company Limited at the Tariff Board inquiry into the calcium carbide industry in 1969. ACC had operated the plant it had acquired from the Tasmanian Government at Electrona since 1927 and it was seeking an increase in the high rate of protection it had been receiving.

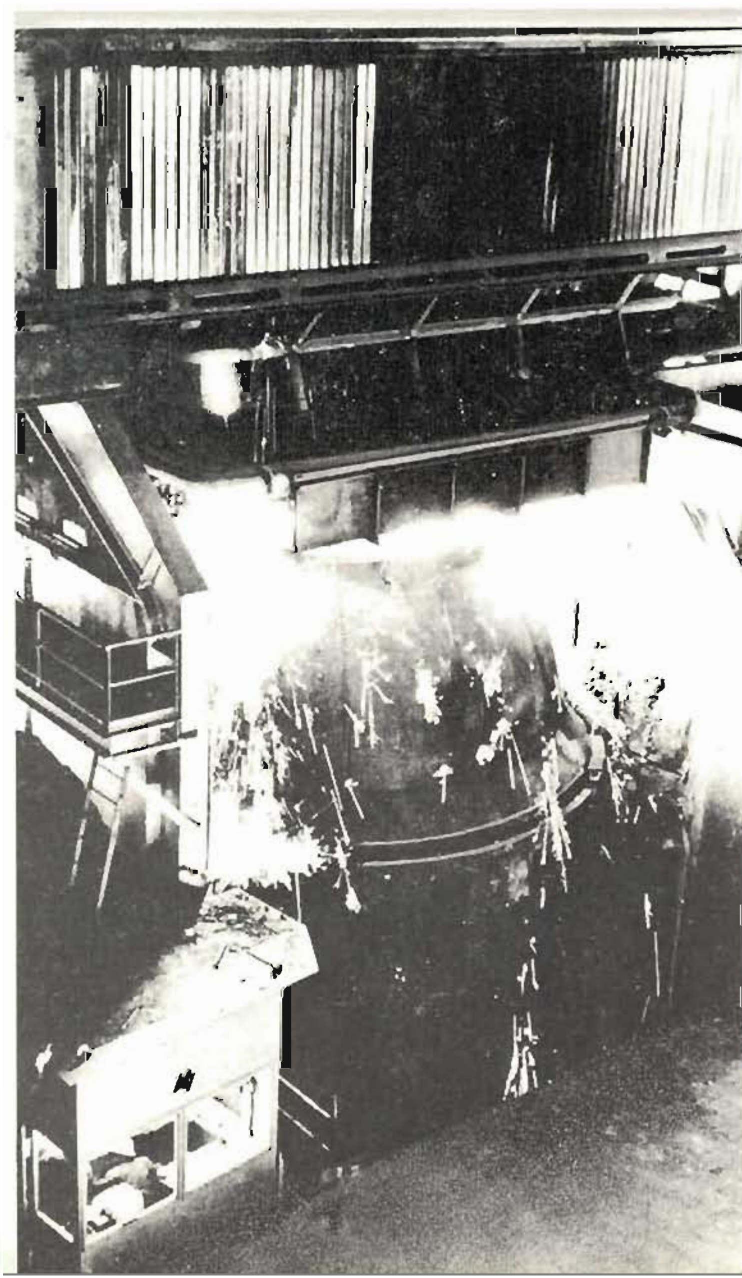
ACC had had many years of generally satisfactory profit levels before a major bushfire in 1967 damaged the works at Electrona and destroyed or damaged about 50 company-owned houses for employees at Electrona and Snug. Electricity was rationed in the same year and another fire in the plant in 1969 temporarily cut production to 40 per cent of installed capacity. The Federal Government granted the company an interest-free loan of $218,000 repayable by equal annual instalments over the last 12 years of a 15-year period.

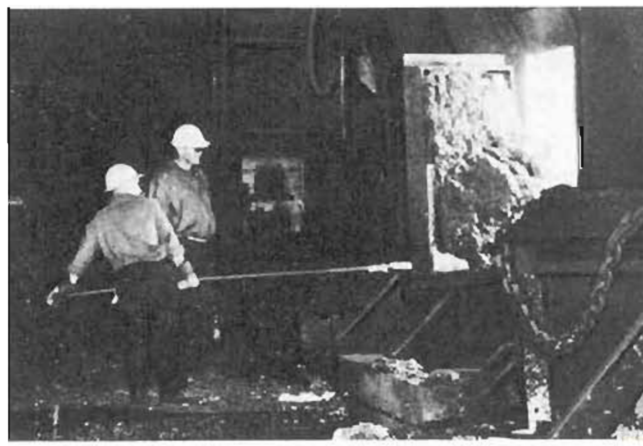
The Tariff Board report, however, disclosed that ACC's total cost of production at the most economical level of output was more than double that of leading overseas producers. The report said that failure by ACC to reduce its production costs was likely to lead within a relatively short time to a contraction of the Australian market for calcium carbide and the demise of the Australian industry. If the industry was unable or unwilling to reduce its costs significantly before the next Tariff Board inquiry, the company would be well advised to use the interim breathing space for the orderly liquidation of its calcium carbide operations.

BOS steelmaking sequence begins with pouring of hot iron into transfer ladle.

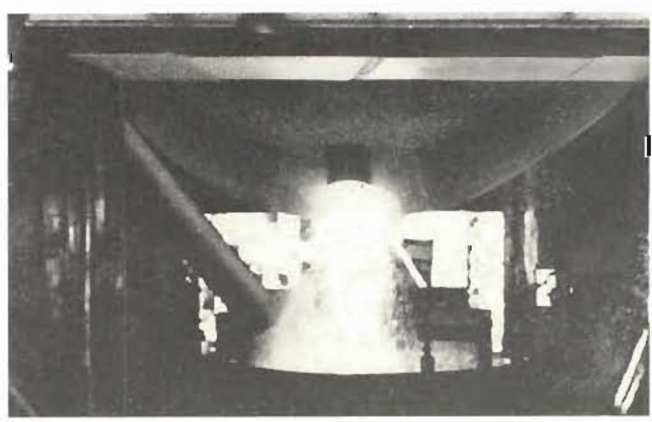
BOS furnace is tilted and charged with scrap. Transfer ladle is then emptied into it.

BOS vessel is righted and oxygen "blow" commences. Hood collects fumes for cleaning.





After 20 minutes, "blow" is turned down and steel sample taken for speedy analysis.



If sample is satisfactory, furnace is tilted to run molten steel through taphole.

CHAPTER XIV
OXYGEN AND STEEL

The early critics of oxy-welding had contended that the oxygen-based flame would "take the life out of steel". Some were to survive to see the opposite proved —that oxygen was an important element in the creation of steel and that the modern steelmill would require vast amounts of oxygen.

Iron is generally produced in a blast furnace through which a blast of super-heated air is blown to improve the combustion of the coke which is used as a fuel and as an agent to reduce the ore to metallic iron. Supplementary fuels, such as oil, tar and/or coke ovens gas, are sometimes injected with the air blast to reduce the amount of coke required. Productivity of the blast furnace is also substantially increased by enriching the air blast with $2\frac{1}{2}$ - $3\frac{1}{2}$ per cent of oxygen.

To produce steel, the high (about four per cent) carbon content of the metallic iron from the blast furnace is lowered, usually to less than one per cent, by an oxidation process in open hearth, BOS (basic oxygen steel-making) or electric furnaces.

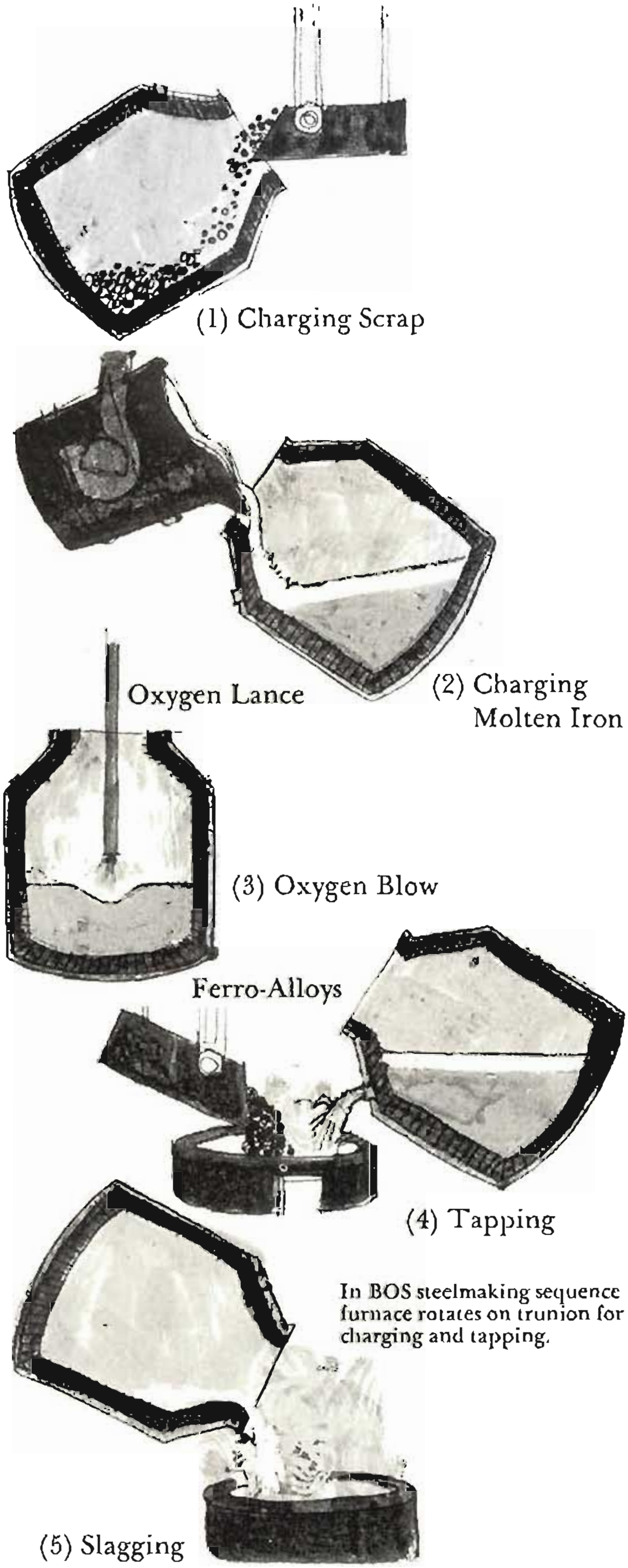
Modern open-hearth furnaces use coke ovens gas, oil or liquid tar as fuel and are equipped with water-cooled oxygen lances which are lowered through the roof so that their tips are about four inches above the molten metal. Gaseous oxygen at the rate of up to 1800 cubic feet per ton of steel produced is blown on to the metal to speed the oxidation of the carbon and other impurities.

Portable oxygen lances are used to tap both open hearth and electric furnaces and they are sometimes used in the electric furnaces to reduce processing times and save electrodes and power.

The term "basic" in the BOS method refers to the alkaline rather than "acid" refractory lining in the BOS furnace, which is simply a barrel-shaped steel shell supported on the tilting mechanism. In the BOS furnace, oxygen at the rate of about 2000 cubic feet per ton of steel produced is used exclusively to oxidise impurities from the molten iron.

The furnace is charged with scrap and then molten blast furnace iron. A water-cooled lance lowered from above blows oxygen on to the metallic charge at high velocity. No external fuel is burned, but tremendous heat is generated as the oxygen reacts with the carbon and impurities in the metal.

The phenomenon called "ignition" occurs seconds after the oxygen contacts the metal. Carbon monoxide from the reaction burns to carbon dioxide, producing a brilliant luminous flame at the mouth of the furnace.



In BOS steelmaking sequence furnace rotates on trunion for charging and tapping.

A hood above collects the dense fumes given off during the oxygen blow. These fumes are passed through an electrostatic precipitator which cleans the gases before they are passed to atmosphere and reconstituted by vegetation. A typical cycle for a 200-ton "heat" of steel by the BOS method is about 50 minutes. The cycle for a 460-ton capacity open-hearth furnace equipped with oxygen lances is about seven hours.

Some oxygen dissolves in the molten steel in any type of furnace and if not removed (by additions of ferro silicon, aluminium or some other deoxidiser) prior to or during casting, gaseous products will continue to evolve during solidification. Oxygen in the steel will combine with carbon to form carbon monoxide.

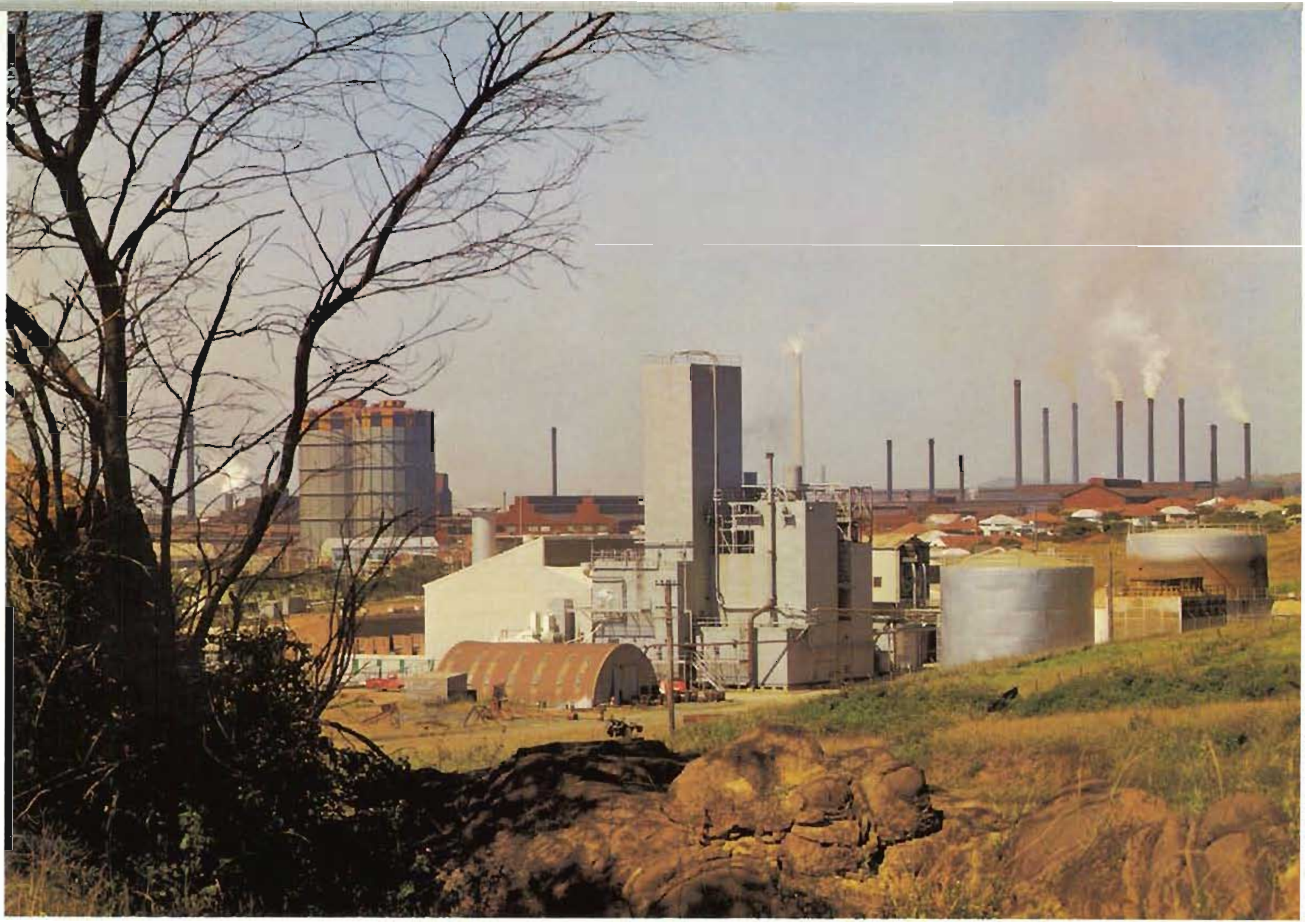
Control of the amount of gas evolved during solidification determines the type of steel ingot. When no gas is evolved, the steel is termed "killed" because it lies quietly in the moulds. Increasing levels of gas evolution produce semi-killed, capped or rimmed steel. Semi-killed steels account for about two-thirds of all steel production.

BHP began steel production at Newcastle in 1915 and by 1944 had 14 open-hearth furnaces there.

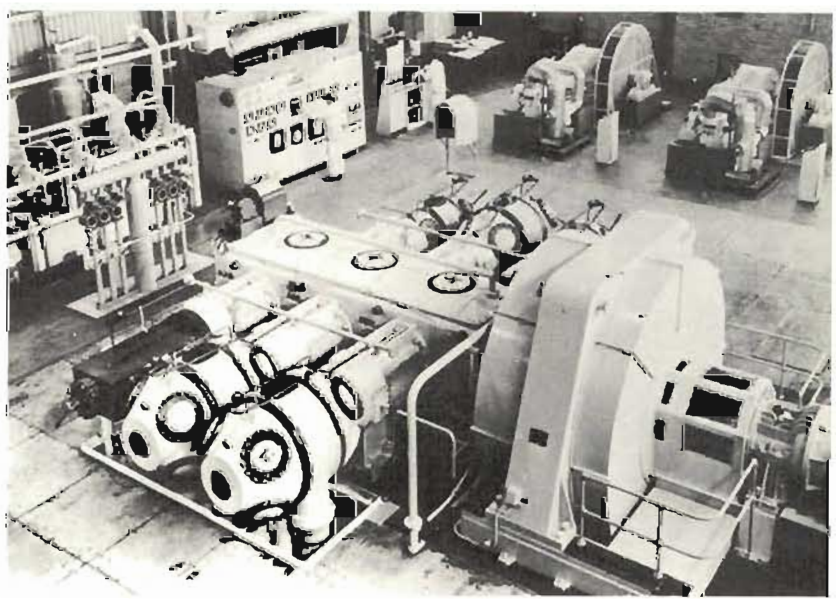
Before establishing itself in Newcastle, BHP had looked at the feasibility of locating at Port Kembla, but had decided that the northern coal was better for making coke and Newcastle already had a deep-sea port.

In 1928 Hoskins Iron & Steel Co. Ltd. in association with the English steel companies, Baldwins Ltd. and Dorman Long & Co. Ltd., and the Australian shipping and coal firm, Howard Smith Ltd., formed Australian Iron and Steel Ltd. to operate a steel mill at Port Kembla. Hoskins had been making steel at Lithgow since 1908, but difficulties with ores, coal and high freight charges had made that plant uneconomic. The first AIS open hearth furnace at Port Kembla was commissioned in 1931. The depression reduced orders to a small fraction of available capacity. AIS was unable to compete with BHP and imported steel and in 1935 BHP acquired all of the AIS shares. Oxygen still had no major role in the steelmaking process, but the rapid development of industry in the Port Kembla area increased the scope for gas welding and cutting.

Electrolytic Refining & Smelting Co. of Australia had begun operations there in 1909, refining copper



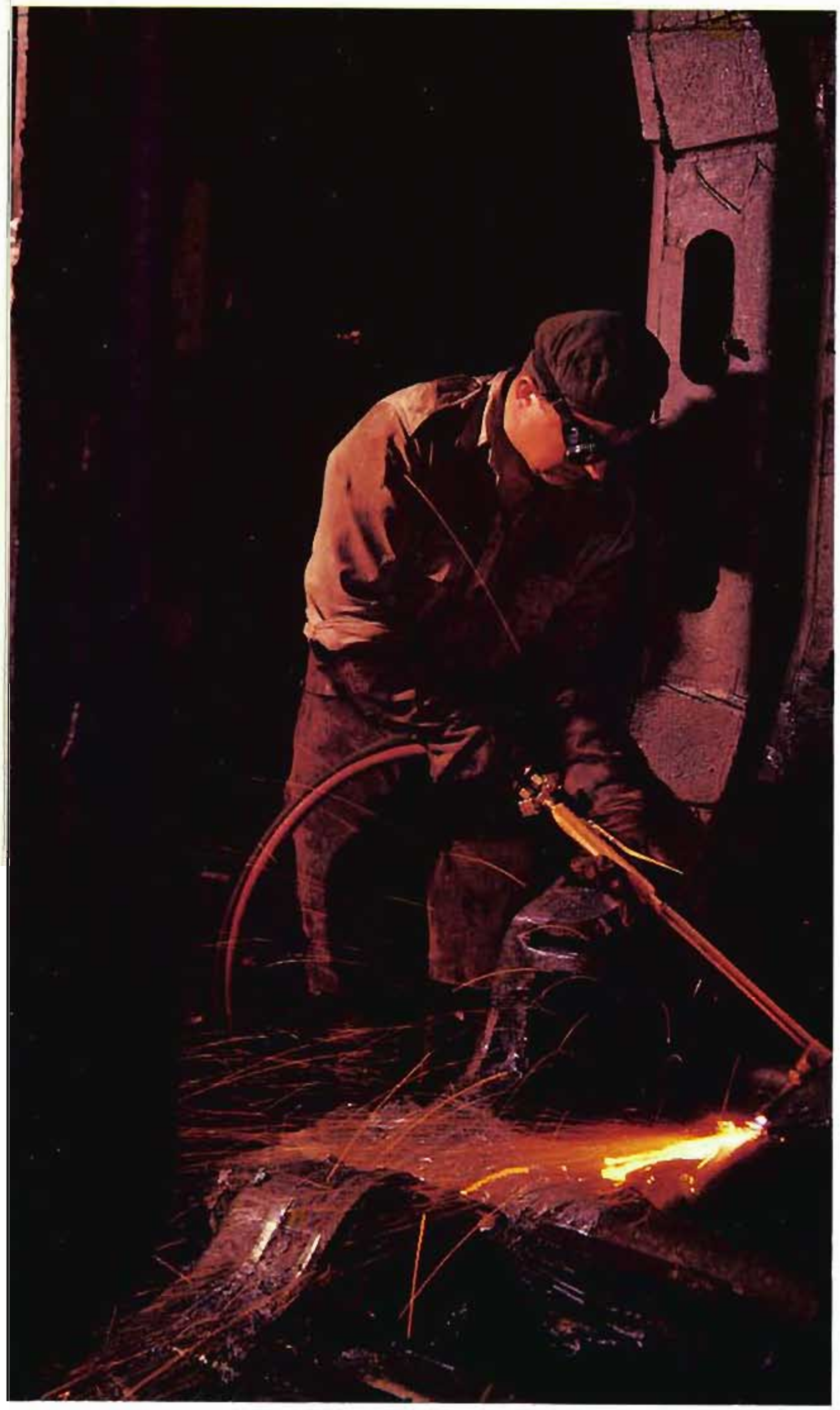
C I G 's tonnage oxygen plant at Port Kembla.
Steelmills are fed from it by pipeline.



Interior of tonnage plant. Its 100-tons-a-day capacity was raised by 566 tons in 1966.

which had been found below the site of the original gold deposits at Mount Morgan. Metal Manufacturers Ltd. began manufacturing copper and brass tube at Port Kembla in 1916 and Australian Fertilisers Ltd. was established in 1921 to produce sulphuric acid and superphosphate. John Lysaght (Australia) Ltd. began production of steel sheet at Port Kembla in 1936. Commonwealth Rolling Mills Pty. Ltd., a joint venture of Lysaght and the American Rolling Mill Co., of Ohio, was formed in 1938 to produce high-finish steel sheet used in automobile bodies, refrigerators and steel furniture.

In 1947 CIG sent Erik Witt to Europe and America to study the then new application of oxygen in steelmaking. In Britain the only experiments being carried out were with the oxygen enrichment of the air blast in a converter, an application which was of little interest to Australia. In the U.S., however, Linde and other industrial gas manufacturers were excited about their tests with oxygen in electric arc and open hearth furnaces.



Hand scarfing has been found to be an economical method of cleaning castings.

The U.S. steel mills were reluctant to divulge much about their processes, but Witt was lucky enough to see the end of an oxygen blow in an electric furnace at one plant. He was staggered by the amount of flames and fumes generated.

Towards the end of 1948 Comsteel in Newcastle was developing a market for stainless steel and it began experimenting with oxygen for the production of stainless steel from scrap. Witt assisted in the experiments which had to be undertaken around 3 a.m. because power was rationed and the electric furnace could not be switched on before midnight. The Comsteel personnel were startled when the oxygen was turned on full flow for the first blow and flames and smoke poured out of the furnace. They thought the furnace was being ruined and wanted to stop the operation, but Witt was able to persuade them to complete the experiments. Comsteel were enthusiastic about the results and all stainless steel heats were subsequently transferred from a small one-ton furnace to a 12-ton unit, using scrap and oxygen.

In 1959, CIG established the first tonnage oxygen plant in the southern hemisphere at Port Kembla in anticipation of the steel industry's adoption of oxygen for the steelmaking process. The installation was supervised by the company's chief construction engineer, J. A. Davidson, who became CIG's managing director in 1968.

The plant produced 100 tons of gaseous oxygen a day and this was stored in liquid form or piped to the steelworks though a two-mile main. The spectacular success of oxygen injection tests led to the five furnaces in the No. 2 open-hearth shop being fitted with oxygen lances. The eight furnaces in the older No. 1 open-hearth shop were of a design which prevented roof lancing. By 1962 AIS at Port Kembla had installed a tonnage plant of its own in addition to buying much of the output of CIG's plant. CIG installed an additional 566-ton-a-day plant in 1966 and by 1971 AIS at Port Kembla was producing 246 tons of oxygen a day in addition to 593 tons a day purchased from CIG.

Construction had then begun on No. 3 steelmaking shop to house two 225-ton capacity BOS furnaces with provision for a third. A 750-ton-per-day oxygen

Liquid oxygen tanker being filled from storage tanks at C I G 's Sydney plant.

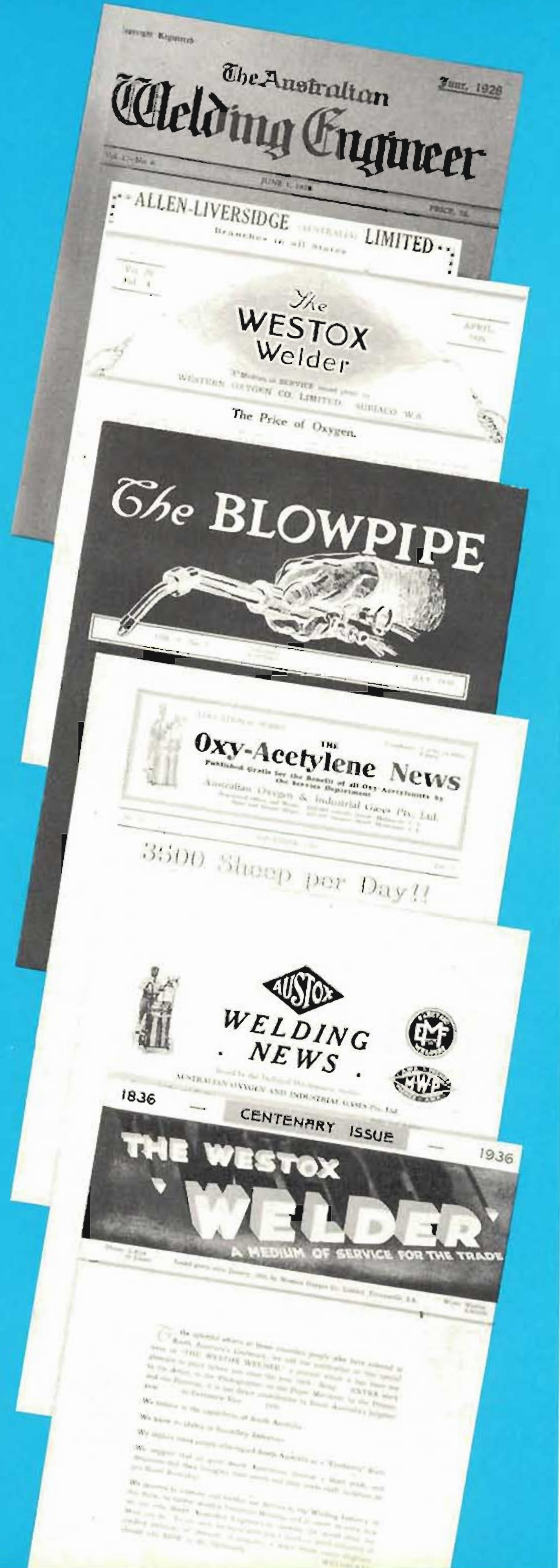
plant was being erected by AIS to fuel the furnaces and provide oxygen enrichment for No. 5 blast furnace, which was commissioned in 1972 as part of the new complex. With the completion of the new AIS tonnage plant, the BHP group's oxygen production capacity outstripped that of the other producers combined.

In Newcastle in 1962 BHP installed two 200-ton BOS furnaces. These had a 50 per cent higher capacity than the 14 open hearths which were progressively closed down, the last in 1965.

The steelworks continued to use vast amounts of oxygen for cutting scrap and heavy sections and for the automatic and manual scarfing of slabs.

Nitrogen, which for decades was mostly a waste by-product of oxygen manufacture, had also assumed importance in steelmaking. CIG began piping nitrogen from its Port Kembla plant to Lysaght's in 1962 to provide the inert atmosphere for the annealing of steel sheet.

The CIG plant was also producing 3500 cubic feet an hour of pure argon for use in electric light bulbs and to shroud and protect the electric welding or cutting arc from the other gases in the air.



Welding journals put out by the industry in the 1920s and 1930s.

CHAPTER XV
THE ART AND MYSTERY

On July 16, 1921, a Brisbane parent signed an indenture which stated that his son "doth put himself Apprentice to Evans Deakin & Coy. . . . to learn the art and mystery of Boilermaking . . ." The indenture also stipulated the personal conduct which would be expected of the lad: ". . . tavern, inns or alehouses he shall not haunt; at cards, dice tables, or any other unlawful games he shall not play; matrimony he shall not contract . . ."

Like boilermaking, welding was an "art and mystery" which could be learnt in conjunction with other trades or at technical colleges. The Working Men's College in Melbourne (it was later known as Melbourne Technical College and then as Royal Melbourne Institute of Technology) offered courses in oxy-welding from 1913–14 and electric welding from 1924.

The head of the welding department, R. G. Knapman, wrote in "The Modern Engineer" in 1939 that six oxy-acetylene units were available for the first classes.

"Troubles experienced in those days", he said, "were cost of oxygen, which was approximately four times the present cost, infrequent or uncertain delivery of oxygen, inefficient torches—compared with the present day standards—which frequently back-fired, and uncertain quality of filler rods with resulting uncertain quality of weld metal".

The Repatriation Department in 1919 erected a new building at the college for the training of returned soldiers and this had a welding room which, however, soon proved inadequate because of the demand for instruction. The college was given an arc welding plant about 1921, but it was an a.c. machine and the electricity supply in the city area at that time was d.c. A generator became available in 1924 and later the Victorian Railways supplied the college with a.c. power for welding purposes.

Industrial gas and welding equipment manufacturers and larger engineering concerns provided part-time instructors and lecturers. In 1933 the lecturers included A. A. Robertson (of Maribyrnong Laboratories), R. A. Holland (EMF), E. Lang (University of Melbourne), E. Hambridge (Gardner Constructions Pty. Ltd.), M. G. Dempster (Country Roads Board), W. D. Chapman (EMF), W. A. Featonby (Victorian Railways), C. C. Westman (Ford Manufacturing Co.) and F. O'Brien (EMF).

By 1939 the department had 46 oxy-welding units, 55 arc welding machines and six oxy-cutting

Samples of advertisements for oxy-welding.

units. The welding and blacksmithing section at the college had a total enrolment of more than 850 and the welding school was claimed to be one of the biggest in the world. Technical colleges in other States also organised welding classes with the manufacturers' assistance.

Each of the industrial gas suppliers produced their own journals from the early 1920s to disseminate technical information on oxy-acetylene welding and cutting. Commonwealth Oxygen produced "The Blowpipe", Australian Oxygen "The Oxy-Acetylene News" and Western Oxygen in Adelaide and Perth "The Westox Welder".

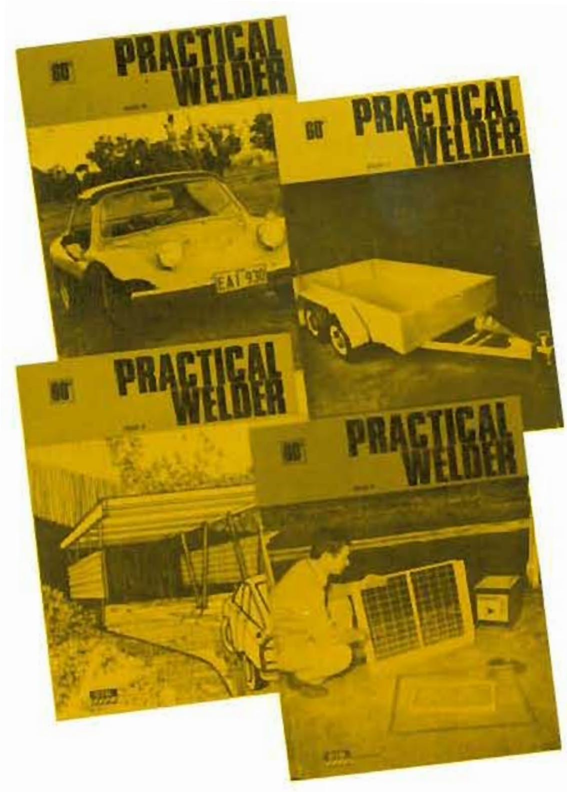
"Welding News", which was to become a major technical publication for welders throughout Australia and overseas, evolved from these journals after the 1935 amalgamation. "Comwelder", the CIG internal magazine, grew from a typewritten newsletter which was started by Harry Coburn during World War II. The journal's name was changed in 1973 to "Kalori", an Aboriginal word meaning "message stick".

The welding industry produced several prolific writers on the welding process and several of their papers achieved world-wide distribution. The writers included Chapman, Featonby, Ted Raymond, W. A. Ozanne, C. P. Keogh (son of the EMF co-founder, Dr. Keogh), Frank Bottomley and Dr. H. Hirst.

On January 29, 1925, Walter Crabtree, Harold Morgan, Ted Raymond, John B. Arnold and W. C. Wetherill convened a meeting to form the Victorian Institute of Welding Engineers. W.L. Fanning told 50 people attending that the engineer had obtained wonderful results from welding "up to a certain point. But he has gained most of his knowledge from failures and bad welds.

"There is very little known of the theoretical side of welding, but metallurgists and chemists are at last beginning to realise how much they can do to assist the process", Fanning said. "The results of their investigations would be most quickly promulgated through such an organisation as the institute we propose."

Fanning said that welding was being used in construction, "but not to anything like the extent that it could be. It usually happens that great difficulty is found in building some part of a metal structure and when all other methods have been tried, welding is adopted as a last resort and in nearly all cases is en-



tirely satisfactory. Had the particular part been designed in the first place for welding, a very great deal of time and expense would have been saved".

Foundation members of the institute were: Andrew Aird, J. B. Arnold, P. W. R. Baker, G. E. Bailey, C. E. Barlow, W. Crabtree, R. J. Dorey, A. J. Doyle, H. Drew, W. L. Fanning, Gardner Waern & Co. Pty. Ltd., E. F. Geere, G. N. Gould, K. O. Grunden, A. C. Henderson, A. Kent, R. G. Knapman, T. B. Meaby, Allen-Liversidge (Australia) Ltd., H. C. Morgan, Noyes Bros Pty. Ltd., F. W. Ogier, B. W. Pollock, E. J. Raymond, A. S. Ridley, H. Rigby, S. N. Rodda, Rylands Bros. (Aust.) Ltd., A. Sadler, H. Thompson, E. K. Varcoe, V. W. Walter, W. C. Wetherill, H. W. Woodgate, Melbourne & Metropolitan Tramway Board.

At a subsequent meeting, S. N. Rodda, principal of the Working Men's College, was elected president and A. Aird of Thompsons Engineering & Pipe Co. Ltd., became vice-president. A consulting engineer, A. Stanley Ridley, was appointed secretary. In January, 1927, Ridley produced the first issue of "The Australian Welding Engineer", the institute's official journal. Ridley also became secretary of the Institution of Automotive Engineers, Australia and of the Association of Charge Engineers, Australia. In 1929 the name of the journal was changed to "Mechanical and Welding Engineer" and in 1932 under the title of "The Modern Engineer" it became the official journal of the three organisations Ridley was serving.

Higher academic institutions, except for a few isolated examples, showed little interest in welding in the 1920s and they continued to produce architects and engineers who had no significant knowledge of the welding process or welding design. One of the most prominent academic champions of welding in the 1920s was Professor J. Neill Greenwood, of the University of Melbourne. He assisted the Welding Institute, not only by propagating welding theory among the engineering profession, but also by giving the welders themselves a deeper knowledge of the metallurgical aspects of welding at his lectures to the institute.

The institute introduced certificates of welding competency which were issued to welders who passed an institute examination.

The Victorian Institute of Welding Engineers decided in 1929 to change its name to the Australian Welding Institute. In Sydney a meeting was convened on July 3, 1930, to form a N.S.W. division of the institute. Twenty-five of the 35 people present applied for membership and Reginald Carr was elected the division's president. The first monthly meeting of the N.S.W. division decided to use Florence Taylor's "Australasian Engineer" as its official journal. The division conducted its first examination for welders in 1935 and there were 16 successful candidates.

Towards the end of 1935 the headquarters of the Australian Welding Institute in Melbourne drafted a revised constitution and bylaws. The N.S.W. division received the revision with hostility, objecting in particular to the provision for Ridley's "Modern Engineer" to be the AWI official journal and to rules for the formation of new branches within a division.

Arguments continued for several years, culminating in the N.S.W. division's decision in 1939 to withdraw from the AWI and establish the Australian Welding Institute Incorporated as a separate body, registering it as a company in N.S.W. The Queensland Institute of Welding Engineers had wound up their State body in 1938 and joined the N.S.W. division of the AWI. In 1941 Newcastle Welding Society wound up and became a branch of the AWI Inc. with K. G. Pullen, chief mechanical engineer of BHP, as branch chairman.

C I G publications catering for other specific trades.

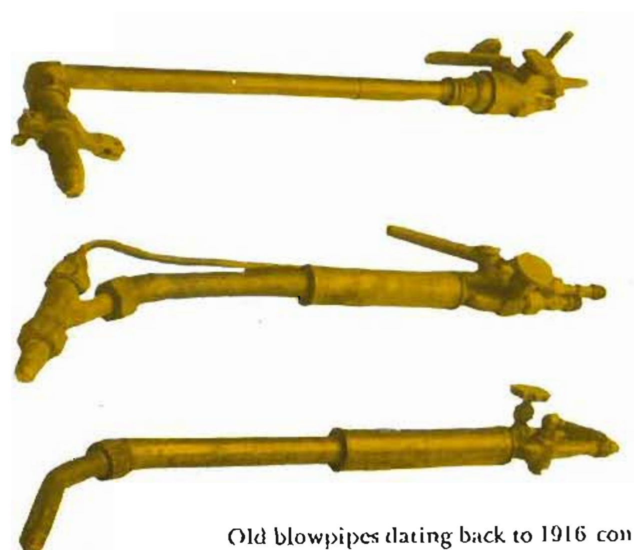
The South Australian Welding Research Club was formed in 1932 and it changed its name to the Adelaide Welding Society in the same year. It retained this name until 1952.

Several attempts were later made to get the rival institutes to form one federal body. Stan Coates recalled after he retired that he attended an unsuccessful meeting for this purpose in Sydney on the day World War II ended in the Pacific.

It was not until 1952 that the two institutes joined to form one federation with State divisions. Frank Bottomley had reason to remember the meeting in the Commercial Travellers' Association building in Melbourne at which the federation was formed. "They were riveting the lift well in the building and you couldn't hear yourself speak", he said.

Bill Miskoe, head of Lincoln Electric in Australia, was appointed chairman of the meeting because as an American he was considered to be neutral in the Victoria-N.S.W. contest. The ballot for the location

"Endurance" regulator of 1920s vintage.



Old blowpipes dating back to 1916 contrast in styling with C I G 's latest models (opposite).

of the federal headquarters was evenly split between Melbourne and Sydney. The meeting then approved Miskoe's view that Adelaide should be the headquarters because it, too, was neutral. Frank Harrison, chief mechanical engineer of the South Australian Railways, became the first federal president. W. A. Bayly, secretary of the local branch of the Australian Institute of Management, was appointed federal secretary. The first Australian welding convention was held in Adelaide in the same year. Federal headquarters of the Australian Welding Institute were later transferred to Sydney. The institute began publishing its own magazine, "The Australian Welding Journal", in 1957.

Until the Australian Welding Research Association was established, research into welding was not attempted on a nationally-organised basis. Government instrumentalities, such as the Snowy Mountains Authority and CSIRO, and companies such as BHP and CIG, had welding research programmes, but industry generally did not have co-ordinated research facilities.

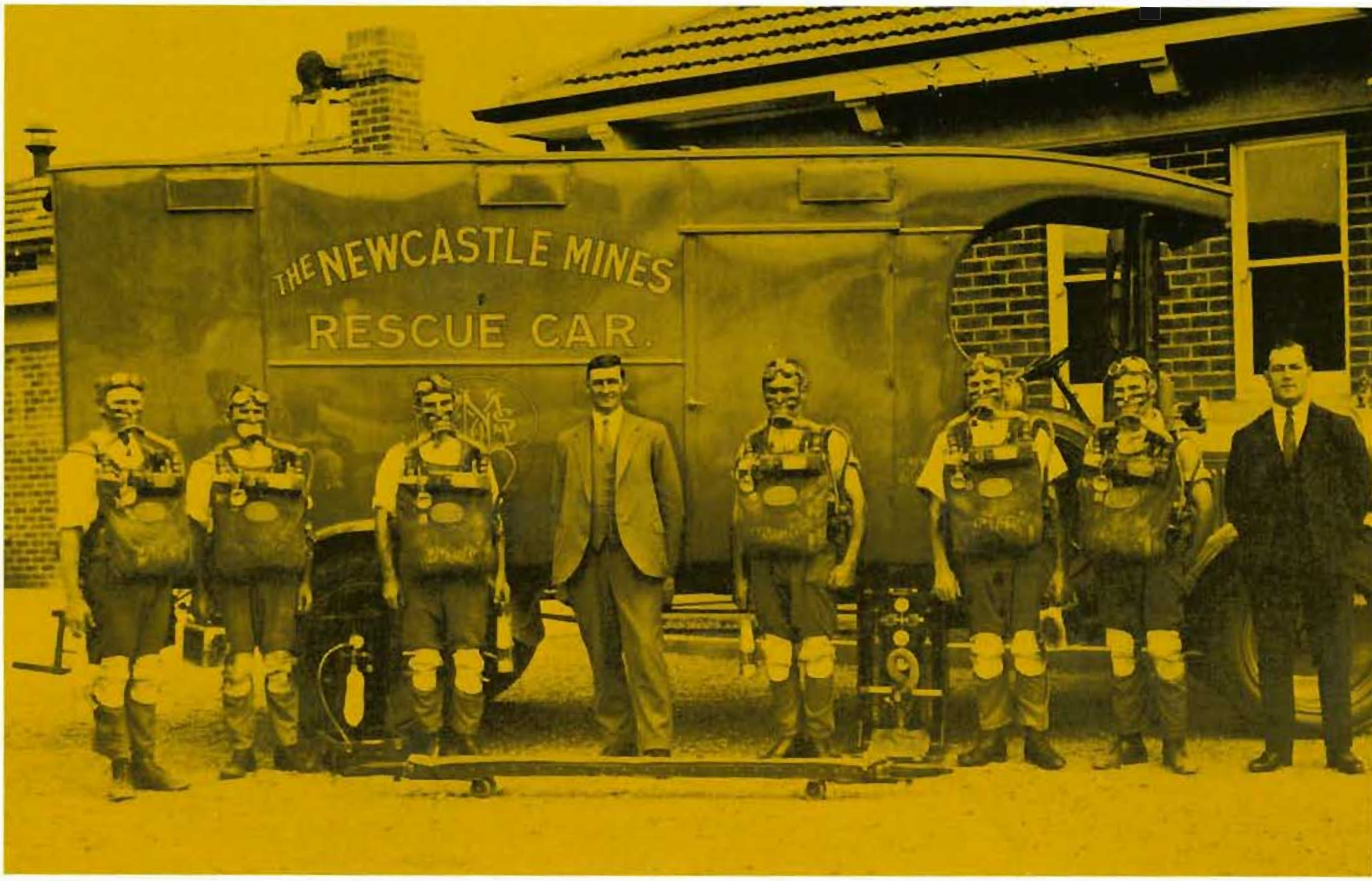
The British Welding Research Association, of which the former EMF man, Ramsay Moon, was the first director, suggested that Australian research be handled by the BWRA which was already well-equipped. In January, 1964, a meeting of leaders of the Australian engineering industry under the chairmanship of a former BWRA director, Professor J. W. Roderick, of the University of Sydney agreed, however, that there was a need to develop research facilities in Australia to meet Australia's own particular needs. AWRA was registered in December that year as a non-profit co-operative and the former commissioner of the Snowy Mountains Authority, Sir William Hudson, was elected chairman.

The objective of AWRA was to become a local authority on welding and to assist in the development of industry by undertaking and promoting research and development in the welding and allied fields. The association was granted a Federal Government subsidy to augment members' fees for the allocation of specific research projects to the universities and other bodies.

A former CIG State general manager, M. W. Padman, who became the AWRA's first secretary-director, said AWRA aimed to develop in academic circles an awareness that welding was worthy of scientific attention. He claimed that even in the 1970s welding was a mysterious sort of art and craft to many, including welders, and the process still carried a lot of old ideas which were not soundly based. AWRA's object was to bring light into the area to give welding the extra status it deserved.

From its inception, AWRA worked in close contact with the Standards Association of Australia which had formed a welding sub-branch of its boiler sectional committee as far back as 1928. At that time, the ASME code contained information which was more destructive than constructive, largely because of the poor quality of the bare wire welding still being practised in America. A tentative SAA code for welding in steel buildings was published in 1931.

Subsequently, as a result of co-operation between the AWI, the SAA and N.S.W. Department of Labour and Industry boiler and pressure vessels section, procedures for the training, supervision, examination and certification of welders were introduced and codes established for all types of welding and safe practice in the welding industry.



Joseph Cooke (4th from left) with the mines rescue unit he trained at Newcastle.

Comox van delivered medical gases in Sydney in 1930s.

CHAPTER XVI
A MATTER OF LIFE

The vital relationship of oxygen to human life and even the name of the gas were unknown when the First Fleet arrived at Sydney Cove. Priestley had isolated the gas in England in 1774, noting that it made his breath feel "peculiarly light and easy for some time", but he failed to appreciate the importance of his discovery. The French scientist, Antoine Lavoisier, in 1789 called Priestley's gas oxygen (from the Greek "oxys", meaning acid, and "gennaro", meaning "I beget") in the mistaken belief that it was a necessary constituent of every acid. Lavoisier, however, worked out the role of oxygen in the fundamental principles of breathing.

Scientists were to discover that, depending on temperature, a man can live weeks without food, days without water, but only minutes without oxygen. Under temperate conditions, two foodless weeks or two waterless days could be lethal. In a desert, a few waterless hours can kill.

Complete deprivation of oxygen in the blood and brain causes irreparable damage after about 90 seconds and it can be fatal after three minutes. Temperature is again a factor. In the state of hypothermia at about 27°C the circulation can be arrested for about 20 minutes. The partial pressure of oxygen in the atmosphere is also important. At 60,000 ft, or in sudden decompression of an aircraft cabin at high altitude, death ensues in about 17 seconds.

The need for speed in correcting critical oxygen deficiencies in patients demanded the development of highly-efficient oxygen supply services for hospitals, doctors' surgeries, ambulance headquarters, mine rescue stations and wherever the need was likely to occur.

The industrial gas producers in Australia gave these services top priority. CIG introduced an around-the-clock emergency service in the major centres, with radio-controlled vehicles available to deliver medical gas and equipment, such as masks, catheters and respirators, even to private homes. Cylinders for medical gas required meticulous maintenance so that the contents would not become contaminated.

The Northern Mine Rescue Station at Abermain on the Newcastle coalfields installed a liquid oxygen storage tank for its mine rescue units in 1970. A Commonwealth Oxygen chief engineer, Joseph Cooke, had demonstrated the value of oxygen breathing apparatus on the coalfields after the Bellbird Colliery disaster on September 1, 1923. An explosion at the mine had killed 21 miners and the mine was sealed to

Some of the early equipment used by anaesthetists which is displayed in their museum in Melbourne.

isolate a fire. The authorities were faced with the prospect of new fires starting when some coal and coke liable to spontaneous combustion was again exposed to air after the mine re-opened.

Cooke had had mine rescue experience in England with Siebe Gorman "Proto" self-contained breathing apparatus and the authorities agreed that this could be used to enable the dangerous material to be removed from the mine. John Clack cabled for 15 sets and Cooke trained a rescue unit to use them. The operation was successful and the mine re-opened in 1925.

Nitrous oxide—"laughing gas"—was one of the first anaesthetics and was used overseas in 1844. Apparatus to administer it was at first inadequate and ether, discovered in 1842, was preferred. Chloroform and other volatile anaesthetics soon followed. Ether was first used in Australia by W. R. Pugh, of Launceston, in 1847 and its use in Sydney and Melbourne followed within weeks.

Nitrous oxide was probably used in Australia before 1870. At first, anaesthetists prepared their own nitrous oxide in a gasometer, but compressed nitrous oxide and oxygen were introduced in 1868.

Nitrous oxide is a good analgesic, but a weak anaesthetic and it often fails to produce the quiescence and muscular relaxation sought by the surgeon. Pure nitrous oxide is an asphyxiant and anaesthetists diluted it with air which contains about 20 per cent oxygen. A 50–50 nitrous oxide–air mixture therefore contains barely 10 per cent oxygen and this low percentage can gravely damage the heart or brain. Understandably, nitrous oxide was used for only minor operations of very short duration. The introduction of compressed oxygen made it possible to administer nitrous oxide for major operations. To enhance the inadequate muscular relaxation produced with nitrous oxide, vaporizers were fitted to equipment so that ether vapour or another volatile agent could be added to the nitrous oxide-oxygen mixture.

The earliest gas anaesthesia apparatus (1844–68) comprised a gasometer, a reservoir bag and a valved face mask. The patient breathed in from the bag and out through the face mask. Since the nitrous oxide was undiluted, administration was asphyxial and very brief.

The next step was to introduce an air port in the mask-carrier so that a part of each inhalation was provided by atmospheric air. The oxygen content of the mixture was still very low and prolonged anaesthesia could be gained only by switching the

C I G 's "Thermocot" is a completely new design in portable infant incubators.

patient over to "full air" when asphyxia became too evident. On his recovery, the administration of nitrous oxide was resumed.

With the introduction of compressed gases, twin stopcocks, one for nitrous oxide and one for oxygen, were adopted. A jet of oxygen was added to the reservoir bag when the patient was deemed to need it. The gas mixture thus fluctuated and the resulting anaesthesia was uneven. Hewitt in 1889 used twin bags, one for nitrous oxide and one for oxygen. They united at a stopcock perforated with holes to which the mask was attached. The anaesthetist could thus give so many "holes" of oxygen together with nitrous oxide. The percentage admixture was unknown, but some control over the oxygen content existed and nitrous oxide-oxygen anaesthesia became possible for major surgical operations.

In 1913, Gwathmey devised the first water-flowmeter. Nitrous oxide and oxygen passed through separate tubes into a common water container. Each tube had a series of small holes through which the gas would bubble as the control valve was opened. By giving so many "holes" of oxygen to so many "holes" of nitrous oxide, a rough estimate of the proportions of the gas mixture could be made. It was not a percentage estimate, but it was a tolerably consistent one, enabling satisfactory anaesthesia to be provided in long surgical operations. Gwathmey's flowmeter formed the basis of Boyle's apparatus which was adopted by the Royal Army Medical Corps in 1915. British Oxygen Company has continued to attach the name of Boyle to its long line of gas apparatus, especially to its standard ether vaporizing bottle.

Between 1918 and 1937 several improved types of flowmeters were evolved. The water-depression flowmeter became the standard of accuracy, but it was not popular with clinical anaesthetists as it required maintenance and the water in it could be spilt or blown out. Several dry-float flowmeters were evolved. They are, however, prone to frictional wear, with loss of accuracy. Magill in 1937 introduced the industrial rotameter, a specialised dry-flowmeter of acceptable accuracy which became standard for clinical use.

Partly as an economy measure to save gas, early anaesthetists adopted the practice of rebreathing. The patient rebreathed the contents of the reservoir bag for a considerable period before being given a fresh gas mixture. It was thought, too, that the normal depth of respiration could not be preserved during anaesthesia unless stimulated by a percentage of carbon dioxide. However, the normal carbon dioxide content of arterial blood is about 5.3 per cent. If the carbon dioxide content in the reservoir bag reaches

C I G 's Major Anaesthetic Apparatus incorporates all known features needed for application of the latest techniques.

this figure carbon dioxide cannot pass out of the lungs. The carbon dioxide content of the blood rises proressively, with dire consequences to the patient. By the 1930s, it began to be realised that an ample flow of fresh gases—about eight litres a minute in an adult—was essential to keep the carbon dioxide content of the blood within normal limits. The practice of rebreathing was therefore abandoned. With the rise of carbon dioxide absorption methods, it was found that respiration was perfectly satisfactory, even though the carbon dioxide content of the inhaled atmosphere was virtually zero.

In 1912, McKesson introduced the "intermittent-flow" apparatus, a demand regulator with controllable parts to set any desired mixture of nitrous oxide and oxygen. The gases could be delivered to the patient under positive pressure without disturbing their percentage admixture. In 1928, McKesson produced his "Nargraft, Model-H", a precision built apparatus of extreme mechanical ingenuity which gave excellent results. In the mid-1930s, however, opinion had swung away from intermittent-flow, positive pressure and rebreathing alike. The new emphasis was on carbon dioxide absorption.

In "to-and-fro" absorption (Waters, 1923), a canister containing soda-lime is placed between the face mask and reservoir bag. The patient breathes to-and-fro through it. At each breath he removes some oxygen from the bag and exhales carbon dioxide. The latter is absorbed in the canister and the nitrous oxide passes into and out of the lungs unchanged. The anaesthetist has only to replace the oxygen consumed and to top up any nitrous oxide lost by chance leakage. In theory one bagful of nitrous oxide and oxygen mixture will last through the whole of a major surgical operation. The carbon dioxide content of the bag will be virtually nil until the soda-lime nears chemical exhaustion.

Ether vapor can be added, if necessary, in the small amount needed to supplement the weak muscle-relaxing action of the nitrous oxide. Other muscular relaxants have become available and the ether supplement now is less often required.

The system is simple and efficient, although the canister is somewhat unwieldy. The "closed circle" absorber is valved, with inhalation occurring through one wide-bored hose and exhalation through another. A soda-lime container is placed in the exhalation hose and quite often in both hoses. The reservoir bag is set at the end of the two hoses and oxygen and ether vapour are admitted into it. The circle absorber is bulkier and more complex than the Waters' canister, but as it is more convenient to use it is usually preferred.

The carbon dioxide absorption technique was probably introduced to economise on gases, but it soon proved to have other major advantages. Respiration is very quiet, favouring access to deeply-placed structures. Body heat, moisture and muscular energy are also conserved. The technique is now almost universal.

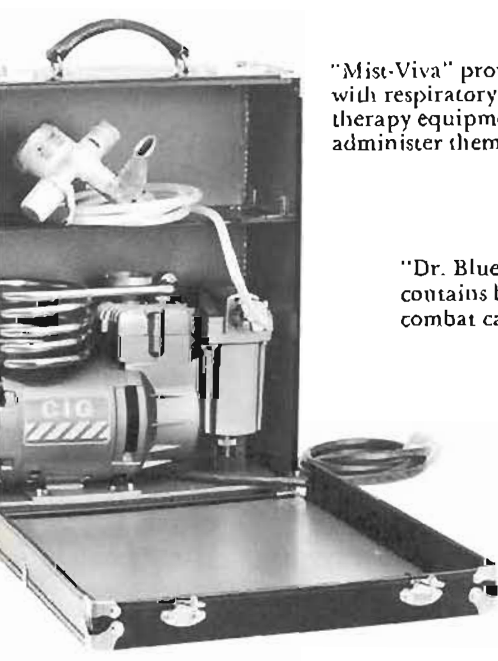
Wells, the man who discovered nitrous oxide, was a dentist and dentists have shown interest in the gas ever since. A valved nasal mask, which left the mouth accessible to the surgeon, was devised in the mid-19th century. Administrations were, however, brief and asphyxial—in fact, smash-and-grab raids upon the teeth! Introduction of compressed oxygen in 1868 facilitated longer administrations. There were, however, still grave problems. The open mouth favoured ingress of air, with dilution of the anaesthetic and an uneven plane of anaesthesia. This was countered (McKesson, 1912) by delivery of the gas under positive pressure, with a spring-loaded valve in the nose piece to prevent its dissipation. The design also allowed the mouth to be skilfully packed to prevent inhalation of blood or debris into the patient's lungs.

The technique was, however, marginal, with a premium on speed and operative skill. By the 1940s there was a tendency to limit the method to relatively simple operations of less than five minutes' duration. Today, the growing proficiency of dentists in block analgesia has reduced the demand for general anaesthesia in dentistry. The nasal gas technique is, however, still sometimes used in brief operations on small children and apprehensive adults.

Brief, asphyxial administrations of nitrous oxide took place in Australian dental surgeries and hospitals as early as the 1870s. Intriguing equipment of the era, including Hewitt's pioneer nitrous oxide-oxygen apparatus of 1889 has been collected by the Australian Society of Anaesthetists.

Nitrous oxide-oxygen for major operations in Australia does not appear to have been recorded before 1923 when G. L. Lillies adopted the technique at the Alfred Hospital, Melbourne. G. Brown was also using the gases about the same time in Adelaide.

Lillies' apparatus was the "Austox", the first Australian-built gas anaesthetic equipment produced by John B. Arnold. It was a primitive device consisting of a stand with yokes for two cylinders of oxygen and two of nitrous oxide. Stopcocks controlled the admission of gases to a reservoir bag which was equipped with a valved face mask. An ether vaporiser, evolved from an industrial oiler-drip, was later added.



"Mist-Viva" provides people with respiratory troubles with therapy equipment they can administer themselves.

"Dr. Blue Bag" contains basic equipment to combat cardiac arrests.

Lillies was, however, able to obtain acceptable results with it in major operations. In 1924 he introduced ethylene from the U.S. Its potency was only marginally greater than that of nitrous oxide, but more oxygen could be administered with it. Ethylene's big drawback was its flammability and hospitals stopped using it about 1930. In the 1970s, however, CIG was supplying hospitals with ethylene oxide, containing freon to eliminate flammability, for the sterilisation of delicate apparatus.

In 1918, the "Safety Gas-Oxygen" apparatus was introduced in the U.S. It used water-depression flowmeters. At Lillies' suggestion, the Alfred Hospital was equipped with the machine in 1925 and several of Australia's earliest professional anaesthetists trained on it. In those days oxygen percentages administered to the patient were still dangerously low—15 per cent was regarded as generous! Rebreathing was also used to a harmful extent.

In the 1930s, the Foregger Company, of New York, built what were probably the most accurate water flowmeters in the world. G. Troup, of Western Australia, designed for Foregger their so-called "Australian" model, a midget apparatus which gained some popularity among anaesthetists.

An Alfred Hospital anaesthetist in 1930 returned from overseas with a McKesson "Nargraf" machine. It attracted much interest and the Alfred Hospital was re-equipped with it. By 1935, however, its high gas consumption, its uncertain calibration for oxygen and the ease with which it could lead to excess rebreathing had become recognised. It was outmoded by the general adoption of carbon dioxide absorption methods.

Australia was late in adopting carbon dioxide absorption which had been used overseas since 1923. An honorable exception among Australian anaesthetists was D. G. Renton, of Melbourne, who began building circle absorbers in his own workshop in 1930. He, more than anyone, popularised the spread of the absorption method throughout Australia. Absorbers of many types—Foregger, McKesson, BOC and others—were imported and these stimulated local designs. About 1930 John B. Arnold produced a prototype of the "New Austox" apparatus which had several similarities to the Foregger equipment. It was never marketed although sales literature was produced for it.

C. Fenton, an Australian Oxygen medical gases representative, did much to interest Australian anaesthetists in nitrous oxide anaesthesia during the 1930s. Other personnel from the company and John B. Arnold's, including Oscar Grunden, Les Thorn and Harry Adams, worked in close collaboration with three anaesthetists from the Alfred Hospital and University of Melbourne—D. G. Renton, R. H. Horton and G. Kaye—on equipment design and engineering.

In 1938, when war was looming, the Australian Army Medical Corps had no equipment for gas anaesthesia. A prototype machine was built by an Alfred Hospital anaesthetist. Streamlined for production by the Arnold and Australian Oxygen men, it emerged at the beginning of 1939 under the name of the "Austox Field Service Model". It had good water flowmeters, an adequate ether vaporiser, a range of valved inhalers and canisters for to-and-fro absorption. The unit was carried in a steel case and it endured a test ride in a tank over mountains in Victoria. About 400 were subsequently manufactured for the Australian armed services at £35 apiece.

"Entonox" nitrous oxide-oxygen inhaler enables ambulancemen to provide a safe relief from pain.

"Oxy-Viva" is a complete portable resuscitation unit.

The apparatus went into action at the battle for Bardia in January, 1941. Some defects showed up. Reducing valves were in short supply in Australia and the field service model relied on long, finely-machined screw valves of bronze. These became scored by the desert sand. The AIF's Middle East anaesthetic adviser, Major G. Kaye, AAMC, procured stainless steel from Australia from which to machine replacements. This machining was done on a treadle lathe under field conditions. Nevertheless, the apparatus did useful work. An anaesthetist from the RAMC even wanted to swap one for 500 lb of ether!

A sophisticated civilian version of the Field Service Model was evolved after the war, but CIG in the 1950s switched to Boyle equipment.

Demands for anaesthetic gases have greatly increased since 1946. Cylinders of oxygen and nitrous oxide soon gave place to central storage cylinders, the gases being piped to wards and operating theatres. Many hospitals now use sufficient oxygen to justify the installation of liquid oxygen storage facilities.

The use of nitrous oxide and oxygen for women in labour has been greatly extended and in this field the Royal Women's Hospital of Melbourne, under the guidance of K. McCaul, has been prominent. Classes are held to teach expectant mothers the relaxation which often renders gas analgesia unnecessary, and to train them in intelligent use of that apparatus.

The modern anaesthetist is not confined to anaesthetic administrations, but embraces a wide range of pre- and post-operative care, blood transfusions, resuscitation and oxygen therapy. In this work, CIG plays a helpful part. Many forms of oxygen tents are produced, as well as humidicribs for the care of premature babies. Several types of respirators are made for industrial use and for the emergency inflation of the lungs in cases of respiratory failure. Some require

C I G "Air-Viva" is a compact portable resuscitator. Squeezing the PVC bag forces air into the lungs.

"Isolette" incubator in use in the intensive care unit at Crown Street Women's Hospital in Sydney.

oxygen and others, intended for beach guards, or ambulance attendants, inflate the lungs with air. Humidifiers are produced to avert the drying effect of oxygen on the mucous membranes in prolonged oxygen therapy. Respirators are also produced for the long-term treatment of patients, such as poliomyelitis victims, unable to breathe for themselves.

Excess oxygen in the blood can cause oxygen poisoning. Naval divers, however, who had been specially selected for their high oxygen tolerance, were trained during World War II to breathe pure oxygen for shallow dives to attach limpet mines to enemy ships. Their apparatus absorbed carbon dioxide from their breath and did not emit tell-tale bubbles. CIG supplied helium to provide a helium-oxygen mixture for the men who had to dive deep for the construction and maintenance of off-shore oil rigs in Bass Strait.

In the late 1960s hyperbaric compression chambers were installed at Prince Henry Hospital in Sydney and Peter McCallum Clinic in Melbourne. In these chambers, patients suffering from a lack of oxygen, can be pressurised in oxygen. They included cases of gas poisoning, carbon monoxide poisoning, gas gangrene and certain heart conditions. The units were also designed for deep X-ray for certain types of cancer, and could also be used to restore oxygen to the blood of members of a sect refusing blood transfusions on religious grounds.

A recent BOC development is the "Entonox" nitrous oxide-oxygen inhaler for the use of ambulance personnel. It enables the patient to give himself, under supervision, a safe relief from pain.

Nitrous oxide has also found some new uses. One is in cryo-surgery where a destructive refrigerant is injected into cancerous or otherwise diseased tissue. Nitrous oxide is well-adapted for this purpose. It is readily available and its freezing point is high enough to avoid the risk of excessive cooling.

Of historical interest is "Carbogen", a mixture of carbon dioxide (usually 5 per cent) with oxygen. This mixture was proposed (Henderson, 1927) as a respiratory stimulant in cases of narcotic or anaesthetic overdosage, or of carbon monoxide poisoning. Millions of cylinders of it were used for these purposes around the world in the period 1927–47. It was also used to stimulate respiration after operations in the hope of averting post-anaesthetic pneumonia, so much dreaded in the pre-antibiotic era. Doctors began to realise that the mixture, while stimulating respiration, also risked disturbing the chemistry of the blood to a dangerous extent.

In 1939, the Australian Society of Anaesthetists began to form a museum of past and present anaesthetic apparatus. An unexpected wealth of material was found in the junk rooms of hospitals and on instrument dealers' top shelves. Collection was halted by the war and when it resumed the Army supplied two sets of everything the AAMC used during the hostilities. CIG donated two examples of everything it then made and the company has continued these donations. In 1955, the collection was moved to the Royal Australasian College of Surgeons in Melbourne, under the curatorship of Dr. H. P. Penn.

The museum has adopted a novel approach in displaying this material. Where available, two specimens of each exhibit are shown. One is left, where possible, in working order. The other is sectioned to reveal its internal structure and operating principles. It is then described from several angles—its structure, physiological principles on which it is based, the soundness of design, the reasons why it represented an advance upon earlier machines and the reasons why it became obsolete. In these terms the museum has been recognised within its field as one of the world's significant collections. It has even been the venue for a meeting of the Australian Association of Museums.

Automatic scarfing machine installed by C I G
at Port Kembla steelworks.

CHAPTER XVII

TODAY AND TOMORROW

By 1973 Australia had a population of approximately 13 million compared with 3.7 million in 1901 and 6.8 million when CIG was formed in 1935. Australia had become one of the 12 top trading nations in the world. Australia's per capita Gross National Product was seventh highest in the world, ahead of many nations which were mature well before the First Fleet arrived at Sydney Cove.

Of the Australian work force of 5.6 million, the manufacturing industries employed almost 30 per cent. Manufacturing produced 28 per cent of the GNP—a percentage exceeded by few other industrialised countries—and 20 per cent of the nation's exports.

In the immediate post-World War II period Australian manufacturers were hampered in their adoption of new technology, particularly where heavy capital investment was required, by the relative smallness of the domestic market. Development from the early 1960s of export markets for manufactured goods helped to alleviate this handicap and acceptance of technological innovations tended to accelerate.

The innovations in welding and oxy-cutting methods over the period were numerous and far-reaching. Perhaps the most revolutionary was the welder's use of a shielding gas in conjunction with the electric arc, combining as it were both the gas and electric welding processes.

America was the first to use an inert gas, such as helium or argon, to surround a non-consumable electrode like tungsten. It was first applied in the welding of magnesium early in World War II and soon it was being used to weld aluminium. This new flux-free process, now known as TIG (tungsten inert gas) soon swept the world. CIG introduced the process to Australia in 1947, using argon which was easier to obtain in Australia than helium. One of the early applications for TIG here was in the production of stainless steel beer barrels.

The next development was the use of gas shielding with a consumable bare wire and America also pioneered in this field. CIG also introduced the process into Australia and the first application was in the welding of bronze vessels by CSR Chemicals. Again argon was favoured and the process, known as MIG (metal inert gas), opened up new fields in the welding of aluminium.

Attempts to apply the MIG process to the welding of steel did not meet with much success until a cheaper gas, carbon dioxide, was used in conjunction with special consumable wires. Carbon dioxide is not an inert gas and hence this process became known as MAG (metal active gas).

Another radical development has been the introduction of the Russian process known as electroslag welding which enables heavy plate sections to be welded vertically in one pass. It uses conductive slag which is melted by an electric current. Water-cooled copper shoes on each side of the weld line control the molten weld metal until it solidifies. Electroslag welding was introduced into Australia by CIG in the late 1960s and many welds previously regarded as impossible or uneconomic to perform by other means have been successfully accomplished. A more recent development has been the introduction of the consumable guide.

A feature of the new generation of welding equipment has been its increasing automation. At best, having preset various controls, the operator has only to press the start button; at worst, he has little more to do than guide the welding torch. The operator requires less skill but more knowledge than in manual welding and the possibility of human error is reduced.

The swing to automatic welding processes which coincided with a recession in capital expenditure in Australia produced a 12 per cent decline in CIG's manual electrode production from 5 million lb in May 1971 to 4.37 million lb in May 1972. This decline was one of the factors which forced CIG to close its Murex factory at Hobart and consolidate its Australian and export electrode production at its Preston factory in Melbourne.

Sophisticated oxy-cutting machines which were introduced into Australia in the early 1960s, eliminated the need, which had existed even before John Clack imported his controversial 55-inch profile cutters 30 years earlier, for steel plates to be marked out by hand or for templates to be produced to guide the cutting torches.

The new machines had photo-electric devices which read the lines of the drawing of the plate shape and guided the cutting heads accordingly. The early machines worked on drawings of the actual plate size and this was a problem where large sections and large drawings were involved. Later models used drawings of up to 1/10th actual size and the machines automatically cut the plate in the required ratio.

On some multiple ratio cutters provision is made for plasma torch cutting heads to handle stainless steel, aluminium, titanium and other metals which cannot be cut efficiently by oxy-fuel gas torches. In plasma arc cutting the gas is heated to about 20,000°C in an electric arc struck between the electrode in the torch and the plate. This heat ionises the gas to form a plasma which melts the metal.

"Do you take this woman to be your lawful welded wife?"

Tape and numerically controlled oxy-cutting machines had not been adopted in Australia by 1973. The main potential users, the shipyards, did not have the capacity to build vessels of more than 80,000 tons and relatively few ships by world standards were being constructed.

Where John Clack's profile cutters had cost £800 each in 1930, the new generation multi-ratio cutters cost upwards of $50,000. For a computerised cutter, the manufacturer or shipyard faced an investment of more than $100,000.

According to 'The Australian' newspaper's list of the top 1000 companies in the Commonwealth in 1973, CIG topped the industrial and fuel gas sector of industry in terms of net profit, capital employed and earnings per share growth. Among the industrial plant and machinery producers it ranked fifth in terms of profit, and capital employed. Among all public companies, CIG was 42nd in terms of capital employed, 41st in net profit, 36th in market capitalisation and 183rd in return on capital. Here was evidence of Steven Hardie's 1935 claim that "we have put on a firm footing a national industry in Australia which will play a great part in the future development of industry in the great continent of Australia."

Although compressed oxygen, dissolved acetylene and electrodes remained the company's major revenue sources, CIG was widening its base in terms of products and geographical area. It was a large producer of liquid nitrogen for food freezing and nitrogen consumption for inert atmospheres was increasing rapidly with the expansion of continuous galvanising, float glass and petrochemicals.

CIG had become a strong contender in the carbon dioxide and dry ice market where the Carba company, spurned by Steven Hardie in 1935 and now a Colonial Sugar Refinery subsidiary, was entrenched.

Outside Australia, CIG expertise and products were assisting the development of neighbouring territories. The company participated with local interests in the operations of CIG Fiji Limited. CIG New Guinea had branches in Lae and Bougainville in the emerging Territory of Papua and New Guinea. CIG had established carbon dioxide and acetylene production facilities in Indonesia in conjunction with Indonesian Government-owned firms and it owned 70 per cent of Thai Industrial Gases in Bangkok.

With 3800 employees, CIG was a vigorous and sound organisation, well-equipped to advance with Australian industry towards the 21st century.

The year 2000 will be the 91st anniversary of Russell Grimwade's demonstration of air liquefaction in Melbourne and of William Fyvie's introduction of gas welding and cutting. It will also be the 65th anniversary of the formation of CIG.

The path to that jubilee looks exciting. Annual output of Australia's manufacturing industry over the last 25 years rose by more than 700 per cent and its growth is likely to be even more pronounced in the next quarter of a century.

On current trends Australia's population is expected to reach about 20 million by the year 2000.

Oxygen plant and cylinder dock at the Lae plant of C I G 's New Guinea subsidiary.

Buddhist monk blessing equipment at the opening of Thai Industrial Gases in Bangkok. C I G owns 70 per cent of the company.

With a broader domestic market the Australian manufacturer will have more incentive to sponsor technological innovations which in turn will help him to be more competitive on international markets. World population in the period is expected to swell from 3700 million to 6000 million, more than half in the Asian region.

The last 50 years have seen considerable progress in screwed fastenings, but the increasing cost of labour in the next 30 years will force development of less labour intensive fastenings than nuts and bolts. High-speed welding and other means of permanently joining metals or plastics will find increasing application in the fabrication of machines. Where repairs are required, apertures will be cut in the relevant part of the machine and after repair these will be sealed by patches or inserts. This method could revolutionise the shape of machines in that their design would no longer be restricted by the limitations of screwed fastenings for access.

Welding has constantly improved since William Fyvie's demonstration in 1909 and further refinements can be expected. One likely new candidate as a cutting and welding tool of the future is the laser beam. CIG's parent, British Oxygen Company, has already produced the world's first laser-cutting machine for industry and the British Welding Institute has deepwelded a 0.062 cm thick nickel alloy with a laser beam.

The laser shows promise of remarkable industrial versatility because it can be used for cutting all kinds of metal, plastic, glass, ceramics, leather, textiles, composites and wood. It can also weld metals, plastics and composites. One of the problems of the laser in metalworking is that 95 per cent of its energy can be reflected from a clean, cold metal surface. At present it has only been harnessed to cut and weld thin metal sheets. For general industry it is not yet an economical proposition.

Ultrasonic weld testing of a process pipeline at a Sydney chemical plant.

The British Oxygen machine was designed for cutting slots in plywood formes used in carton manufacturing.

The lesser known atmospheric gases—krypton, xenon, helium, neon—have already attained importance in electronics, cryogenics and specialised lighting applications and with other gases could contribute further to human progress in the fields of microchemistry, nuclear engineering, surgery and various forms of analysis.

As a logical extension of its medical gas and equipment services, CIG had entered the industrial safety products field in 1971. With man's increasing concern about the quality of his environment, there is little doubt that he will have equal concern about the safety of his working environment and will be less prepared to expose any of his body to possible injury. He will demand new designs to replace the cumbersome and sometimes uncomfortable protective gear of today, stipulating not only safety effectiveness, but also something that is attractive to wear. CIG will be a party to this safety revolution.

Industrial gas manufacturers and users alike look forward to the day when lightweight cylinders for industrial gas distribution will be feasible. Much of the industry's effort is devoted to the continual transport of thousands of tons of costly deadweight. CIG alone has about a million cylinders, representing an investment of some $30 million.

Aluminium alloys, if they could be reinforced with carbon fibre, might offer one solution to the problem of cutting the cylinder weight while retaining safety standards. Carbon fibre has a higher tensile strength than titanium and less than half its weight.

The cost of carbon fibre, $600 a kilo, is expected to fall as higher usage stimulates production economies.

With the growth in the world's population it seems likely that food production and processing in Australia for international markets will be greatly intensified. If we were able to desalinate Lake Eyre, we could turn the dead heart of Australia into a highly efficient meat production centre and international grain and vegetable area.

The rice production potential of northern Australia has already been demonstrated—although defeated for the time being by magpie geese—and in the Australia of the future the shallow Gulf of Carpentaria could be turned into a gigantic fish farm. It is not ridiculous to suggest that bulk carriers of the future will leave Australian ports laden not with mineral ores but with pre-cooked frozen meals.

We have already seen the advent of convenience foods and it seems likely that by the year 2000 the value of convenience will be so high that most of the foods we consume will require virtually no domestic preparation. The current methods of cooking, which generate such a vast quantity of smelly gases and decomposed vegetable matter, will be superseded by various forms of microwave and other indirect heating methods which will be able to heat and cook food inside its package. It might even be possible, after cooking the food in its package, to eat the package as well. What a contribution this could be to solving the problem of garbage disposal!

The ore-carrying role of bulk carriers could diminish as Australia herself undertakes more of the processing of her mineral wealth. The role of oxygen in the reduction of refractory ores in Australia has by no means reached the fulfilment of K. S. Murray's prophecy and large plants will undoubtedly become a common sight alongside blast furnaces and smelters in the outback. Liquid nitrogen could also gain a more important role in ore reduction. The Japanese, for instance, have already found that blast furnaces pressurised with nitrogen have a substantially higher productivity.

The discoveries of vast fields of natural gas will add significant dimensions to Australian industry, with the potential for sponsoring among other things the local fabrication of a national pipeline grid thousands of miles in length and the local construction of sophisticated LNG tankers to carry the product to overseas markets.

CIG is poised to participate in this natural gas industry development with its expertise in high quality pipeline reticulation, liquefaction processes, fluidic control devices and design, assembly and testing of pipeline systems.

In looking ahead the people of CIG are mindful of their responsibility to help conserve natural resources for future generations. It has been no sudden leap aboard the ecological bandwagon. In 1935, the year CIG was established, one of CIG's foundation directors, Russell Grimwade, who was president of the chemicals section of the Australian and New Zealand Association for the Advancement of Science, warned of the consequences of the profligate encroachment of man upon his environment.

Grimwade said the story of industrial developments of the past century was "one of complete extravagance in the utilisation of the world's resources wherein man's ingenuity has so far defeated or temporarily postponed the bankruptcy that is the inevitable end of a disregard of a source of income—dissipation of capital."

In 1973, CIG's managing director, J. A. Davidson, was more optimistic that the bankruptcy could be avoided.

He said: "We have seen man develop through the era when he was fighting for his existence, to a stage where he has learned by his ingenuity to harness progressively the world's resources for his personal comfort. With such skill there appears no limit to his consumption.

"We now pass to an era where man must learn to limit the consumption of raw materials in order to control his environment and husband his resources.

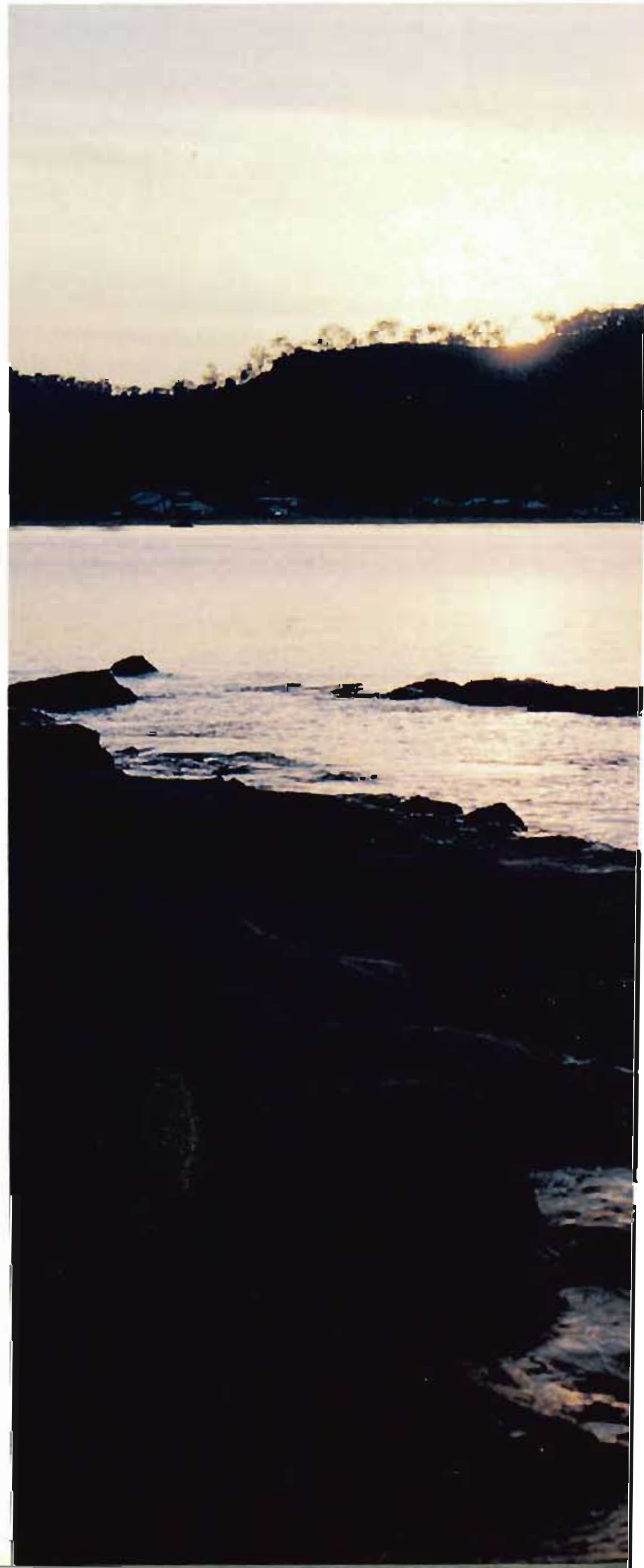
"Gases will play an increasingly important role in these future developments as oxygen is an important element in many life cycles. Where oxygen has been depleted, either in the atmosphere or in the waters, there will be need to re-establish acceptable levels.

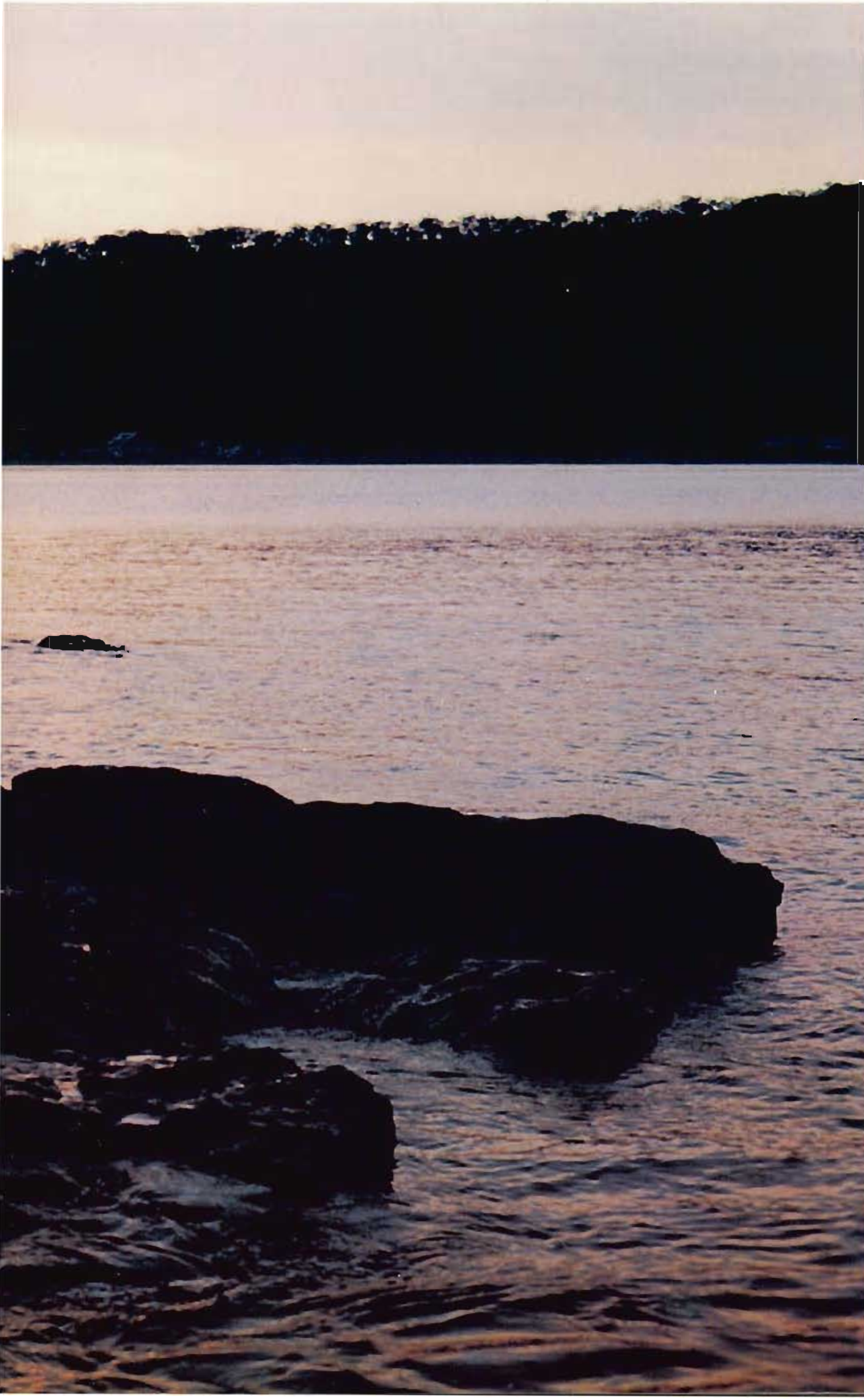
"It has been suggested that hydrogen might well replace many hydrocarbons as a basic fuel because the products of the combustion of hydrogen form water which does not pollute the environment.

"Many of the pollutants of the atmosphere are gaseous and, as the removal of these obnoxious gases from effluents becomes more important, we could see increasing interest in their commercial application in other processes where they might replace more valuable chemicals.

"I have no doubt that man's ingenuity will, in the course of time, find a way of adapting what is a waste product in one process, to a useful product in another," he concluded.

The opportunities for the future indeed look immense. Like the old-time welders, CIG will pursue them . . . with enthusiasm burning.





K. O. Humphreys

J. A. Davidson

CHAIRMEN

Sir Alexander Stewart	1935 - 44
J. March Hardie	1944 - 55
R. N. Cadwallader	1955 - 58
S. G. Rowe	1958 - 64
Sir Ronald Irish	1964 - 68
K. O. Humphreys	1968 -

CHIEF EXECUTIVES

T. G. Millner	1935 - 37
J. F. Clack	1937 - 45
Position Vacant	1945 - 46
J. H. Martin	1946 - 53
N. Daniel	1953 - 59
R. G. C. Stephenson	1959 - 68
J. A. Davidson	1968 -

CIG DIRECTORS

Sir Alexander Stewart	1935 - 56
J. March Hardie	1935 - 55
Major-General Harold Grimwade	1935
Sir Russell Grimwade	1935 - 53
Sir Sydney Snow	1935 - 58
G. H. Grimwade	1935 - 60
J. F. Clack	1935 - 45
J. A. Hardie	1935 - 53
T. G. Millner	1935 - 63
E. H. Wickham	1935 - 37
J. B. Arnold	1936 - 66
S. J. L. Hardie	1937 - 50
R. A. Holland	1944 - 47
J. S. Hutchison	1951 - 72
N. Daniel	1953 - 59
J. H. Martin	1953 - 54
H. C. Morgan	1953 - 58
R. N. Cadwallader	1954 - 58
A. W. Stewart	1956 -
Sir Jack Stevens	1957 - 69
R. C. Booth	1957 - 64
S. G. Rowe	1958 - 64
R. G. C. Stephenson	1959 - 68
R. R. Law-Smith	1959 -
Andrew Grimwade	1960 -
Sir Ronald Irish	1964 - 68
K. O. Humphreys	1964 -
W. R. D. Stevenson	1968 -
J. A. Davidson	1968 -
L. E. Smith	1969 -
E. D. Edmundson	1971 - 72
Sir Richard Randall	1971 -
R. McR. Grinlinton	1972 -
D. K. Allston	1973 -
R. T. Hardwick	1973 -
D. W. N. Pitts	1974 -

CIG SUBSIDIARIES

	Place of Incorporation	Group Ownership %
C.I.G. (New South Wales) Pty. Ltd.	New South Wales	100
Harris Calorific (Aust.) Pty. Ltd.	Victoria	100
Quasi-Arc Pty. Ltd.	Victoria	100
C.I.G. New Guinea Pty. Ltd.	Papua New Guinea	100
C.I.G. Bougainville Pty. Ltd.	Papua New Guinea	100
C.I.G. Fiji Ltd.	Fiji	55
Emperor Industrial Gases Ltd.	Fiji	55
Duracast Pty. Ltd.	New South Wales	100
Exmur Pty. Ltd.	Tasmania	100
Thai Industrial Gases Ltd.	Thailand	70
Cobalide (Industrial) Pty. Ltd.	New South Wales	100
Cutting Edges Pty. Ltd.	New South Wales	100
Cutting Edges (Qld.) Pty. Ltd.	Queensland	100
Cutting Edges (Vic.) Pty. Ltd.	Victoria	100
Exiss Holdings Pty. Ltd.	Victoria	100
Exiss Pty. Ltd.	Victoria	100
Exiss (Overseas) Pty. Ltd.	Victoria	100
Exiss (Perth) Pty. Ltd.	Western Australia	100
Exiss (N.S.W.) Pty. Ltd.	New South Wales	100
P.T. Industrial Gases Indonesia	Indonesia	65
Hammersmith Insurance Co. Ltd.	Bermuda	100
Kippax Limited	Hong Kong	100

MANAGEMENT TEAM/1974

CORPORATE

Managing Director	J. A. Davidson	
	W. J. Gregory	Company Secretary
	B. A. Gollan	Assistant Company Secretary
	G. A. Scott	General Manager—Medishield
	R. W. Crapper	Engineering Manager
Finance Division	T. R. Buckmaster	Chief Executive
	T. S. Felton	Chief Accountant
	B. J. Wrigley	Group Finance Manager
	K. J. J. Tipping	Group Auditor
	G. C. Early	Tax and Insurance Manager
Management Services Division	J. W. Ross	Chief Executive
	P. F. Garvan	Group Manager—Corporate Planning and Market Research
	N. H. Herbert	Group Personnel Manager
	R. K. Treherne-Thomas	Group Manager—Staff Training and Development
	B. W. Warner	Group Advertising and Public Relations Manager

OPERATING

Gases Division	R. T. Hardwick	Chief Executive
	J. P. Best	Administration Manager
	A. W. Butler	General Manager—New South Wales
	D. L. Bryant	General Manager—Victoria
	G. C. Plenty	General Manager—South Queensland
	J. G. Shumack	General Manager—North Australia
	B. F. Dalby	General Manager—South Australia
	R. L. Rogerson	General Manager—Western Australia
	B. M. Schmitzer	General Manager—Tasmania
Equipment Division	D. K. Allston	Chief Executive
	G. Cooke	Controller
	W. J. Dawson	Divisional Personnel Manager
	A. R. Morris	General Manager—Gas Equipment
	R. B. A. Noack	General Manager—Equipment Subsidiaries
	D. J. Daffey	General Manager—Welding Consumables
	R. A. Stringer	General Manager—Electric Welding Equipment
	R. H. Millar	Manager—Safety Products
	D. H. Kenneally	Manager—Murex
	G. T. McPherson	Export Manager
	R. F. Pfeil	Manager—Spray Equipment
Subsidiaries Division	B. A. Rathborne	Chief Executive
	J. Magno	Manager—Business Development
	G. Mealing	Commercial Manager—Subsidiaries
	B. M. Quin-Conroy	General Manager—P.T. Industrial Gases Indonesia
	P. T. Ford	Manager—Thai Industrial Gases Ltd.
	J. E. Barter	Manager—C.I.G. New Guinea Pty. Ltd.
	A. Pfeiffer	Manager—C.I.G. Fiji Ltd.
	R. T. C. Macarthur	General Manager—Cutting Edges Pty. Ltd.
	V. J. Gwynne	Manager—Gas Cylinders