Cooling the city - the history of refrigeration in Sydney

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Cover photographs (clockwise from top):

Peters' Ice Cream theatre advertising slide, 1930s (State Library of Western Australia**)**

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Foreword

Methods of preventing spoilage of perishable foods have been known from prehistoric times, including drying, natural refrigeration and fermentation. Colder climates were conducive to keeping foods cool with blocks of ice or in caves, but the warmer climate in Australia required the importation of ice or the development of other methods of cooling foods.

Sydney's first ice was cut from frozen lakes in Massachusetts in the 1830s and transported all the way to Australia in ships, taking four months and losing almost half the cargo from melting on the way. By the 1840s, ice cream was being made by a chemical refrigeration method using crushed ice and salt to freeze the mixture. But this was slow, small-scale and wasteful, as each batch required new ingredients.

Then in the 1850s, the journalist and inventor James Harrison of Geelong developed a mechanical freezing machine using the more efficient vapour-compression method, which laid the foundation for modern refrigeration equipment. The benefits of preserving food by refrigeration were always clear, and now that it could be achieved in a self-contained system using a recirculated refrigerant, it was only a matter of time before refrigerating machines could be made more economically viable and scaled up to industrial levels.

The Sydney businessman Thomas Sutcliffe Mort was the right man in the right place to bring this to fruition. He owned a diverse collection of businesses producing fresh meat and dairy products in rural areas, and he wanted to be able to transport his perishable produce to Sydney and eventually send the surplus to England.

Mort hired the inventive engineer Eugene Nicolle to improve and upscale the existing refrigerating machinery to achieve his dream. After much experimentation, Mort and Nicolle succeeded in developing what are now called cold chains: freezing works in the country to preserve the produce, refrigerated rail cars to take it to the city, more freezing works at the Sydney docks, and refrigerated ships to send it overseas.

Mort did not quite live to realise his dream of a frozen meat export trade, and in fact made no money from all of his endeavours, but he facilitated systems that greatly benefited those who followed him.

New industries and activities in this country that were created by mechanical refrigeration included ice cream manufacture, ice skating, air conditioning and the settlement of remote areas not served by natural transport systems or electricity. An existing industry such as the brewing and transporting of beer was always uncertain in the hot Australian climate until refrigeration permitted a controlled manufacturing environment and a more reliable end-product.

While importing ice all the way from America to enjoy cool drinks and ice cream seems very quaint today, it gave Sydneysiders a taste for what might be possible. Then, when scientific discoveries in the nineteenth century showed that refrigeration could be achieved by harnessing the properties of gases and thermodynamics, local inventors made rapid progress in the development of suitable machinery.

An outstanding example of local success was the Edward Hallstrom's invention of a kerosene-powered refrigerator in the 1920s that quickly became a great boon to rural properties without electrification. Ten years later, American and European engineers were still struggling to perfect their own version.

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Early methods of food preservation

Perishable foods

Methods of preventing spoilage of food after harvest or slaughter have been practised since prehistoric times. Some of the oldest methods are drying, refrigeration and fermentation. Modern methods include canning, pasteurisation, freezing, irradiation and the addition of chemicals. Advances in packaging materials have also played a major role in modern food preservation.

Food spoilage can be caused by various factors, such as contamination by microorganisms, infestation by insects, or degradation by the enzymes naturally present in food. The microorganisms that typically spoil food are bacteria and fungi (yeasts and moulds). Most bacteria obtain nutrition from the atmosphere and by metabolising certain food constituents, such as carbohydrates and proteins. Bacterial growth is also affected by moisture and temperature.

The most common methods of killing or reducing the growth of microorganisms are the application of heat, the removal of water and the lowering of the temperature during storage. Chemicals are also used as preservatives, but their use is strictly regulated by national food authorities such as Australian Government's statutory agency Food Standards Australia New Zealand, which developed the Food Standards Code[1].

Early food preservation

Ancient people used the natural coolness of caves, root cellars and winter weather to preserve food. Before mechanical methods of refrigeration were introduced, ancient peoples cooled their food with ice transported from the mountains. Wealthy families made use of snow cellars, which were pits dug into the ground and insulated with wood and straw to store the ice.

Using this method, packed snow and ice could be preserved for months. Stored ice was the principal means of refrigeration until the beginning of the twentieth century, and is still used in some areas[2].

Dehydration

Many types of food can be preserved for indefinite periods by extracting the moisture, thereby inhibiting the growth of microorganisms. Dehydration is one of the oldest methods of food preservation: it was used by prehistoric peoples to sun-dry seeds, the North American indigenous people preserved meat by sun-drying slices, the Chinese dried eggs and the Japanese dried fish and rice.

Hot-air dehydration was developed in France in 1795, enabling the commercial production of dehydrated food products, especially spaghetti and other starch products. Modern dehydration methods have largely been stimulated by the advantages of compactness: on average, dehydrated food can have about one fifteenth the bulk of the original or reconstituted product. The need to transport large quantities of food over great distances during World War II created much of the stimulus to perfect dehydration processes.

Dehydration equipment varies in form to suit different food products. A basic design aim is to shorten the drying time, which helps maintain the character of the food product. Drying under vacuum is particularly suitable to fruits and vegetables, and freeze-drying benefits heat-sensitive products by dehydrating in the frozen state without the need to thaw out. Meat is especially suited to freeze-drying, yielding a product of excellent stability that closely resembles fresh meat on rehydration.

Figure 1 Sun-drying fish, Madagascar (Wikipedia)

The dairy industry is one of the largest processors of dehydrated food, including whole milk, skim milk, buttermilk and eggs. Many dairy products are spray-dried, that is, atomised into a fine mist that is brought into contact with hot air, almost instantly removing the moisture content[3].

Fermentation and pickling

Under certain conditions, such as oxidative and alcoholic fermentation, microorganisms do not cause spoilage. The process of pickling is a combination of salting to selectively control microorganisms and fermentation to stabilise the treated tissues. Fresh fruits and vegetables placed in a watery solution for twenty-four hours begin a slow mixed fermentation, and the addition of salt suppresses undesirable microorganism activity. Most green vegetables and fruit can be preserved by pickling.

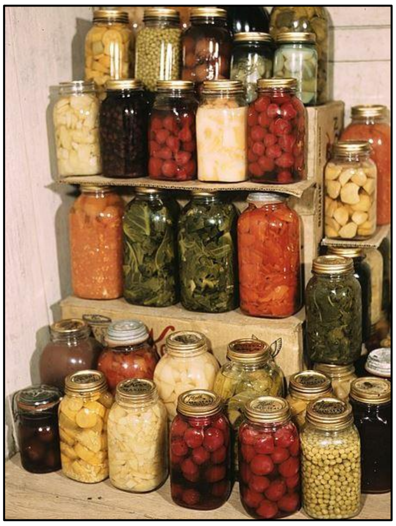


Figure 2 Pickling of food (Wikimedia)

Meat may be preserved by dry curing or with a pickling solution. Ingredients used in curing and pickling meat are sodium nitrate, sodium nitrite, sodium chloride, sugar and vinegar. Curing may be combined with smoking, which acts as a dehydrating agent and coats the meat surfaces with various chemicals[4].

The process of cheese-making involves removing a large part of the water contained in milk, while retaining most of the solids. Since storage life increases as water content decreases, cheese-making can be considered a form of food preservation by the process of milk fermentation. Primitive forms of cheese have been made as a way of preserving milk since humans started domesticating animals. From its birthplace in the Middle East in about 1000 BCE, cheese-making spread as far as England with the expansion of the Roman Empire.

Few, if any, distinct varieties of cheese were developed deliberately. Rather, the cheese made in each locality ripened under the local conditions of air temperature and humidity, bacterial and mould activity and milk source, acquiring certain characteristics of its own. Different varieties appeared largely as a result of accidental changes in the steps of the cheese-making process, and because there was little understanding of the microbiology and chemistry involved, these changes were difficult to duplicate.

The fermentation of milk into cheese requires several steps: inoculating the milk with lactic-acid-producing bacteria, curdling the milk, shrinking by cooking, draining out the whey, salting, pressing and ripening. The four basic ingredients are milk, microorganisms, rennet (enzymes found in the stomachs of ruminant animals that will curdle milk) and salt (to enhance the flavour and help withdraw whey from the curd)[5].

Chemical preservation

Chemical food preservatives are substances which either delay the growth of microorganisms or prevent deterioration of quality during manufacture and distribution. The first of these groups includes some natural food constituents, such as sugar, which is used as a preservative in jams, jellies and in candying fruit. The use of vinegar and salt in pickling and alcohol in brandying also falls into this category.

In addition, some chemicals foreign to food are added to prevent the growth of microorganisms. This includes a long list of chemical compounds such as bleaching agents, neutralisers, stabilisers, firming agents and antioxidants. Sulphur dioxide and various sulphites are probably the most important inorganic chemical preservatives, and are widely used in the preservation of fruits and vegetables and in low concentrations in wine-making[6].

Early attempts at refrigeration

Ice harvesting

Natural ice for food preservation

The northern regions of the United States, from Minnesota to New England, have many lakes and rivers and very cold winters, resulting in an almost endless supply of ice which could be harvested and used for food preservation. Ice harvesting was a very large industry in America for about 150 years, from the early 1800s to the mid-1950s. Ice blocks, usually 16-18 inches thick and 22 inches square, were cut from frozen lakes and rivers in early winter. Each block weighted about 250-300 pounds.

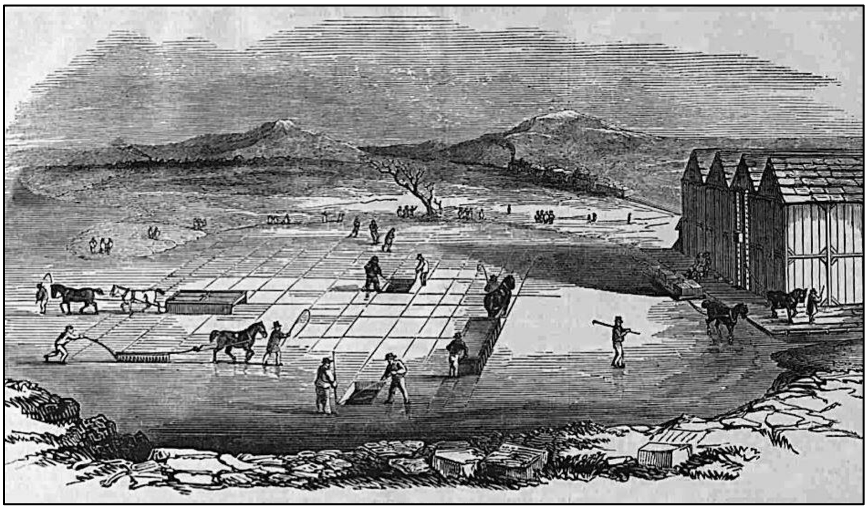


Figure 3 Wenham Lake, 1845 (*Illustrated London News*, 17 May 1845)

The process was started by a horse-drawn plough cutting a grid on the lake surface that defined the blocks to be harvested. The blocks were then cut out using breaker bars and large five-foot hand saws, although by the 1920s circular blades on gas engines replaced the horses and ploughs. The blocks were floated to the shoreline where they were stored in insulated buildings called ice houses. Sawdust and straw was used to insulate the houses, depending on what was available locally. Well-built and maintained ice houses could store ice for a year, or until the next harvest.

Harvesting ice commenced in January and lasted for several weeks. Workers included part-timers such as farmers and carpenters who did not have full-time work over winter. The harvests usually ran twenty four hours a day, using only moonlight and kerosene lanterns at night. In spring, summer and autumn, ice was delivered to homes, businesses and railroads for preserving food. By the late 1880s, ice was the second largest export from the United States, behind cotton. By 1886, 25 million tons had been cut and stored or shipped nationally. However, by this time, mechanical refrigeration equipment allowed ice to be made in warm climates, which heralded the end of the local and world markets for ice[7].

Crystal blocks of Yankee coldness

Frederic Tudor (1783-1864) was the originator of a project to transport a cargo of 130 tons of ice from Boston to Martinique in 1806. He was convinced that in places with warm weather there were people who would welcome cold drinks and other iced refreshments. But the initial venture was not a success when he encountered much resistance in the West Indies to the usefulness of ice. In 1810, he constructed an ice house in Havana after securing a monopoly for the sale of ice from the Governor.

Tudor had a few things in his favour: sea transport was cheap because many ships left Boston empty to collect cargo from the West Indies, ice was free apart from the labour of cutting it, and sawdust (for insulation) was also free as a waste product of the lumber industry. Tudor made his first profits in 1810, but his personal debts far outweighed his income and he spent parts of 1812 and 1813 in a debtor's prison.

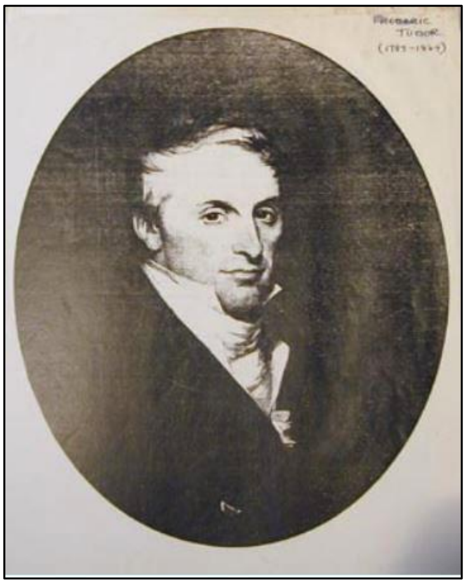


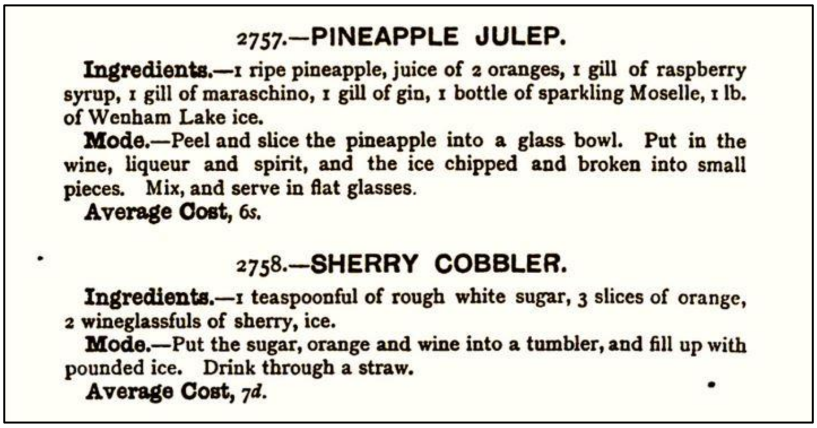
Figure 4 Frederic Tudor (Ice Harvesting USA website)

In 1815, he built an improved ice house In Havana, imported ice from Boston, and sold it mainly to local coffee-house owners in Havana who used his ice to make ice creams. Up to the 1820s, Tudor's endeavours had been restricted to relatively close ports. But in 1833, he determined to try a more enterprising venture, and despatched 200 tons of ice to Calcutta. One of the first shipments to India caused disbelief and amazement among the large crowds of natives who witnessed the unloading of these "crystal blocks of Yankee coldness" at the wharves.

By the 1830s, Tudor was experiencing competition from rival ice firms around Boston, and by 1855 there were twelve companies engaged in the ice trade. The growth in the ice trade can be seen from the fact that in 1806 130 tons were exported, in 1826 4,000 tons, then in 1856 a phenomenal 146,000 tons.

Tudor eventually did well enough to pay off all his debts and resume living a comfortable life in fashionable Boston society. He died in 1864, but the Tudor Ice Company carried on the name for several years afterwards. At one point in his career, Tudor owned ice houses all over the world, the nearest to Australia being in Singapore.

There were nine main sources of ice around Boston, the most famous of which was Wenham Lake, whose ice graced the tables of high society in London. No dinner party was considered complete without ice from Wenham Lake. It had remarkable purity and an ability to withstand temperature changes that would reduce other ices to mush. Wenham Lake water was reputedly always clear and pure with the bottom covered by white sand. It was fed by springs and received no mud from any of the springs flowing into it. The geologist Sir Charles Lyell attributed the durability to the extreme purity of the ice, being free of air bubbles and salts[8].



2757.—PINEAPPLE JULEP.

Ingredients.—1 ripe pineapple, juice of 2 oranges, 1 gill of raspberry syrup, 1 gill of maraschino, 1 gill of gin, 1 bottle of sparkling Moselle, 1 lb. of Wenham Lake ice.

Mode.—Peel and slice the pineapple into a glass bowl. Put in the wine, liqueur and spirit, and the ice chipped and broken into small pieces. Mix, and serve in flat glasses.

Average Cost, *6s.*

2758.—SHERRY COBBLER.

Ingredients.—1 teaspoonful of rough white sugar, 3 slices of orange, 2 wineglassfuls of sherry, ice.

Mode.—Put the sugar, orange and wine into a tumbler, and fill up with pounded ice. Drink through a straw.

Average Cost, *7d.*

Figure 5 Wenham Lake ice cocktail (Mrs Beeton's Book of Household Management)

The international ice trade

The ice that first cooled Sydney in the 1830s was probably cut about a year earlier from the frozen lakes near Boston, then transported by land to the port, loaded into insulated ships and brought to Sydney. The ice was promoted as being from Wenham Lake, but this was a trade name that hid the real sources at a number of lakes, including Walden Pond. The ice companies were skilled at marketing, with newspapers around the world being provided with stories, long before the ice was actually available in the country. Queen Victoria reputedly developed a taste for Wenham Lake ice, and the company became suppliers "by appointment"[9].

This worldwide transport of ice was achieved without artificial refrigeration. The large volume of ice minimised the surface area exposed to warmer air and hence reduced melting, but the main development was well-insulated ships. Timber, peat, straw and sawdust were used with a triple-walled hull to insulate the cargo. This turned otherwise waste products into valuable commodities, increasing the profitability of sawmills and farms in the Boston area[10].

Although the importation of ice from North America was fairly short-lived, the long-term benefits were the development of the frozen meat trade and the introduction of salmon into Australia. While the frozen meat trade was built on suitable refrigeration technology being available, without the experience of transporting natural ice long distances by ship, the Australian frozen meat trade could not have begun[11].

Chemical refrigeration

Chemical refrigeration is a method of chilling foods by depressing the freezing point of water by adding suitable chemicals to ice. This technique of freezing was not known from any European sources before the sixteenth century[12], but during that century, various authors made reference to the refrigerant effect of adding salt to ice. By the late seventeenth century, sorbets and ice cream were being made using this process[13].

The pot-freezer method of making ice cream uses a large bowl filled with a mixture of crushed ice and salt. In this method, the temperature of the ingredients in the bowl is reduced when the salt causes the ice to partially melt, absorbing latent heat and bringing the ice cream mixture below the freezing point of pure water.

Figure 6 Pot-freezer method (Cala Restaurant)

Freezing point depression works because salt makes it harder for the water molecules to bond together in a rigid structure (ice). When mixed into water, salt will dissolve and break into its elements. So if table salt (sodium chloride - NaCl) is used, the salt will dissolve into separate sodium ions and chloride ions[14]. Ice made in Sydney using chemical refrigeration was available as early as 1848[15].

Gas laws and thermodynamics

Mechanical refrigeration methods make use of the laws governing the behaviour of gases and thermodynamics as the theoretical basis for their operation. The fundamental gas laws describe the behaviour of gases under varying pressure, volume and temperature. They were discovered by the end of the eighteenth century, when scientists worked out that relationships between these three variables in a sample of gas could be obtained which would approximately hold true for all gases.

Boyle's law

In 1662, Robert Boyle systematically studied the relationship between the volume and pressure of a fixed amount of gas at a constant temperature. He observed that the volume of a given amount of gas is inversely proportional to its pressure at a constant temperature[16].

Charles' law

In 1787, Jacques Charles founded Charles' law, or the law of volumes, which states that for a given mass of an ideal gas at constant pressure, the volume is directly proportional to the absolute temperature, assuming a closed system[17].

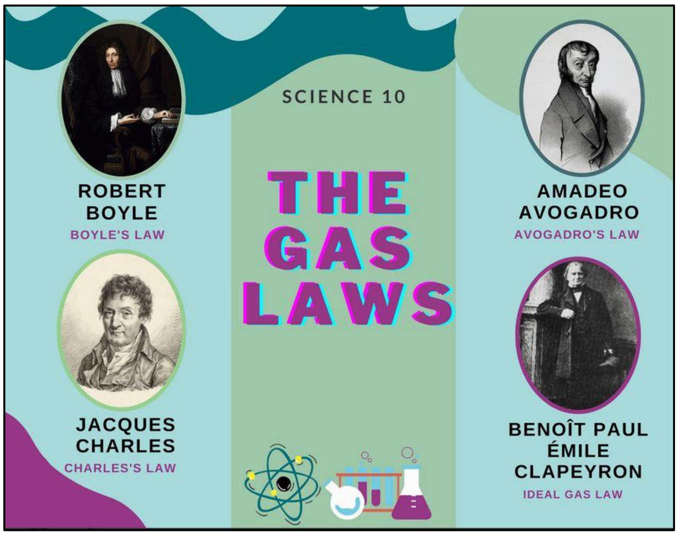


Figure 7 Gas law scientists (Raket website)

Gay-Lussac's law

Joseph Louis Gay-Lussac founded Gay-Lussac's law, or the pressure law, in 1808. It states that the pressure exerted by a given mass and constant volume of an ideal gas on the sides of its container is directly proportional to its absolute temperature[18].

Second law of thermodynamics

The second law of thermodynamics is a physical law based on universal empirical observation concerning heat and energy interconversions. It states that heat always flows spontaneously from hotter to colder regions of matter[19].

The gas laws are in all play when air conditioners and refrigerators are in operation: as the volume of a refrigerant is increased, the pressure decreases, which in turn decreases the temperature[20]. The second law of thermodynamics means that for heat to flow from the area being cooled (the heat source) to the outdoors (the heat sink), an air conditioner or a refrigerator requires work, as it will not flow spontaneously in that direction.

Mechanical refrigeration

Early mechanical methods

Mechanical refrigeration, facilitated by the rapid expansion of gases and known as the vapour-compression method, is the main means of refrigeration today, using techniques that were only discovered in the middle of the nineteenth century. An early refrigeration machine using vapour was built by the American physician John Gorrie in 1844. Commercial refrigeration is believed to have been initiated by the American businessman Alexander Catlin Twining in 1856.

The Frenchman Ferdinand Carre developed a more complex system in 1859, containing rapidly expanding ammonia as a coolant (ammonia liquefies at a much lower temperature that water and can therefore absorb more heat). Carre's refrigerators were widely used, and vapour-compression refrigeration became the most used popular method of cooling.

The mechanical refrigeration process

The basic components of a modern refrigeration system are a compressor, a condenser, an expansion device (which can be a valve, an engine or a turbine) and an evaporator. The gas coolant is first compressed (usually by a piston), which heats the gas, which is then pushed through a tube into the condenser. In the condenser, the winding tube containing the vapour is passed through either circulating air or a bath of water, which removes some of the heat of the compressed gas.

The cooled vapour is then passed through an expansion valve to an area of much lower pressure. As the vapour expands it rapidly cools and draws energy in its expansion from its surroundings. Evaporators may then directly cool a space by letting the now-cold vapour come into contact with the area to be chilled, or may act indirectly by cooling a secondary medium such as water. In most domestic refrigerators, the coil containing the evaporator directly contacts the air in the food compartment. At the end of the process, the now-heated gas is drawn toward the compressor, where the cycle is repeated.

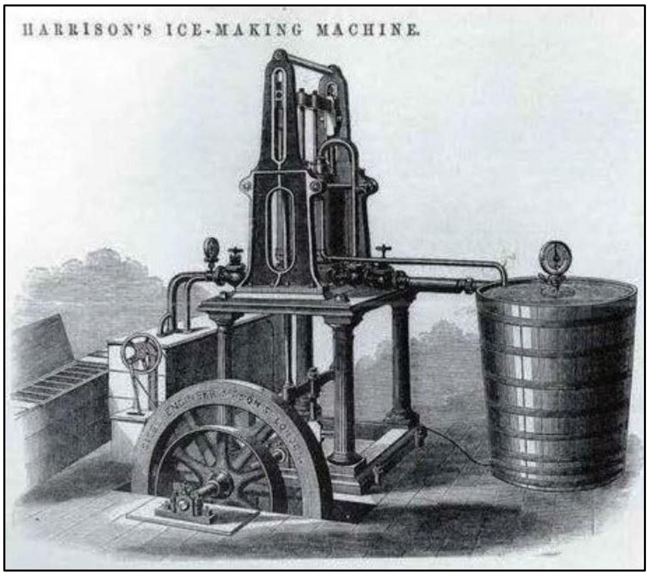


Figure 8 James Harrison's freezing machine (Australian Food Timeline)

Refrigerants good and bad

A refrigerant needs to have a boiling point that is below the target temperature (although this can be adjusted by varying the pressure), a high vapourisation heat, a moderate density in liquid form, a relatively high density in gaseous form, and a high critical temperature (the temperature above which a vapour cannot be restored to liquid form by pressure alone).

Ammonia was a successful refrigerant, but had the severe disadvantage of being unpleasant and toxic if it leaked out. Engineers searched for useful substitutes until the 1920s, when a number of artificial refrigerants were developed. The best known was patented under the brand name Freon, which is odourless and only toxic in extremely large doses.

Freon was a type of CFC (chlorofluorocarbon) that was introduced in 1930 by the DuPont chemical company as an odourless alternative to ammonia with low toxicity. It was used successfully for a number of decades until CFCs were implicated as a major cause of the apparent degradation of the Earth's ozone layer. This could threaten animal life on Earth because ozone absorbs the ultraviolet radiation that can cause skin cancer. The use of Freon in aerosol spray cans was banned in the United States in the late 1970s, and by 1996 most developed countries had banned the production of nearly all types of Freon[21].

The ideal refrigerant should be non-corrosive, non-toxic, non-flammable, with no ozone deletion and no global warming potential. It should preferably be natural, with a well-studied and low environmental impact. Newer refrigerants address the issue of the damage to the environment caused by earlier CFCs and HCFCs (Hydrochlorofluorocarbons), but some raised issues relating to toxicity and flammability[22].

Domestic refrigeration

A refrigerator is a commercial and home appliance consisting of a thermally-insulated compartment and a heat pump that transfers heat from inside to outside the compartment so that the inside is cooled to below room temperature. A refrigerator maintains the temperature to a few degrees above the freezing point of water, usually about 3° to 5°C[23]. A freezer, either a specialised appliance or a portion of a refrigerator, maintains its contents below the freezing point of water. The American Food And Drug Administration recommends that a refrigerator be kept at or below 4°C and a freezer at about -18°C[24].

Figure 9 GE Monitor Top Refrigerator (Museums Victoria)

The refrigerator replaced the icebox, which was a common household appliance for almost a century and a half. Refrigerators for home use were invented in 1913[25]. Frigidaire developed the first self-contained unit in 1916 when it was trading as the Guardian Frigerator Company[26]. The invention of Freon expanded the refrigerator market during the 1930s, providing a safer low-toxicity alternative to earlier refrigerants, such as the corrosive sulphur dioxide or the flammable and toxic methyl format[27].

The first refrigerator in widespread use was the General Electric "Monitor Top" that was introduced in 1927. Its nickname derived from its resemblance to the gun turret on the famous warship *USS Monitor* in the 1860s[28].

The development of refrigeration in Sydney

Sydney's first ice from Massachusetts

Natural ice kept Sydneysiders and their food cool during the heat of summer from 1839 to 1840 and then from 1853 to 1856. But the international ice trade[29] was eventually the victim of an Australian technological development – machine-made ice. From 1857, manufactured ice travelled by ship from Melbourne, but from 1864 the Sydney Ice Company's works on West Street Darlinghurst[30] provided a local source, free from the uncertainties of transport and weather.

The trade in natural ice played a surprisingly important role in creating the modern world. It started the demand for today's ubiquitous refrigerators and freezers, the ready availability of cool drinks and ice creams, and most importantly a dramatic improvement in food hygiene. It led to the development of suitably insulated ships that were required for frozen meat exports[31], and eventually to the thermal insulation used in modern buildings and appliances.

Imported ice first arrived in Sydney in January 1839 on board the *Tartar* after a voyage of four months from Boston[32]. It carried 250 tons of ice (out of a reported 400 tons that had been loaded, the rest melting on the journey), 22 boxes of refrigerators (at the time these were wooden boxes with a layer of insulation and an inner metal lining) and six ice hooks (presumably for manhandling the blocks of ice).

NOVEL IMPORT.—The American ship *Tartar*, has brought with her about 250 tons of ice, in excellent condition, together with the whole of the *materiel* for the erection of an ice-house. Tuesday, the day of her arrival, was about the hottest day of the present year. At mid-day a lounge in the ice-house, had it been then erected, would have been an exquisite treat.

Figure 10 Sydney's first ice, 1839 (*The Colonist*, 19 January 1839)

The *Sydney Herald* first reported disdainfully that the general public "had no more interest than if the natives skated on it in winter"[33], but a few days later was much more enthusiastic when it suggested erecting a statue in honour of the ship's captain for the "iced punch, which must have been what the ancients called nectar"[34].

The entire cargo of ice and an icehouse which was erected on Moore's Wharf were purchased by the confectioner George Dunsdon of George Street[35]. Ice was available at 3d per pound[36] until 25 March 1839 when the price rose to 6d per pound due to the great wastage of the ice by then.

Even before the ice had been used up, Dunsdon had reportedly arranged for a further shipment[37], which arrived in January 1840 aboard the *Ceylon*, along with twelve boxes of refrigerators[38]. But there is no evidence of further imports of ice to Sydney until 1852.

But the ice trade to Sydney revived in 1853, commencing in March 1853 when the *Monterey* arrived 115 days after leaving Boston[39], carrying 26 boxes of refrigerators, two boxes of ice tools and 366 tons of ice[40].

The next arrival of ice was on board the *Queen of the Seas* in December 1853 carrying a load of 353 tons of ice from Boston[41]. The assured availability of ice led to the promotion of iced drinks: "Iced sherry cobblers, iced brandy smashers, iced lemonade, and iced soda water"[42]. But the demand for ice did not meet the supply that summer in Sydney, possibly because the big sellers of drinks (the pubs and clubs) opted not to use ice, and some of the load was exported back to the United States and the rest dumped in a quarry near Circular Quay to melt[43].

A new shipload of ice arrived in January 1855 with new agents and a new interest in the use of ice, landing 491 tons of ice and an icehouse[44]. The ice had arrived at just the right time in a hot summer. John Poehlman's Café on George Street used some 1,270 kilograms of ice serving sherry cobbler, ice cream, mint juleps and brandy smash as the temperature was climbing to 44° C[45]. Iced drinks were soon available at other establishments, including the Liverpool Arms and Victoria Hotel in Pitt Street[46].

Shiploads of ice arrived through 1856, in January, June and October. By this time, the distribution network was well in place, and ice could be delivered around Sydney. But the Sydney ice trade suddenly stopped after this when advances in technology allowed the manufacture of ice much closer to home[47].

Chemical refrigeration in Sydney

Sydney-made ice was available as early as 1848. Thomas Masters patented a freezing machine in 1843 that used the heat absorption of a chemical mixture to create ice, but had the disadvantage of requiring new chemicals each time it was used[48]. In 1848, the confectioner Thomas Goudie of Pitt Street[49], Thomas Robinson, hairdresser, of George Street[50], and William Blyth, of the Victoria Refreshment Rooms in Pitt Street advertised the availability of ices, iced lemonade, other draughts and "small quantities of raw ice" frozen from pure water daily[51].

By December 1849 these advertisements had stopped, suggesting that the production was uneconomic, and by 1853 American ice imports had recommenced. Lower-cost ice was only available by mechanical (that is, non-chemical) means, and this was the approach pursued by James Harrison of Geelong[52].

James Harrison – the inventor

James Harrison (c1816-1893), journalist and inventor, was born in Dunbartonshire in Scotland. He was apprenticed to a printer in Glasgow where he attended Evening College and later the Glasgow Mechanics' Institution, where he specialised in chemistry. He worked in London as a compositor from 1835, then in 1837 sailed for Sydney with printing equipment for the new *Literary News*, where he worked for five months. In 1839, he joined the *Port Phillip Patriot* under John Pascoe Fawkner who commissioned him to establish the *Geelong Advertiser* the following year.

In the 1850s, he examined the refrigeration apparatus used by Americans Dr. John Gorrie (who was granted the first patent for mechanical refrigeration in 1851[53], and Alexander Twining (who applied for a patent in November 1853), and introduced vapour-compression refrigeration in Australia.

At Geelong, Harrison designed and built the plant for the first Australian manufacture of ice, commencing production and taking out a local patent in 1854. The Bendigo brewers Glasgow & Co soon adopted his principles in a pioneering mechanical refrigerator. In 1860, he joined Peter Nicol

Russell in forming the Sydney Ice Company, but it was soon bought out by rivals. Finding that ice was unnecessary (and therefore unprofitable to manufacture) for many industrial purposes, Harrison designed a revolutionary refrigerator and patented it in 1860. It was used the following year in Scotland to distil paraffin, at about the same time as Twining's machine in the United States.

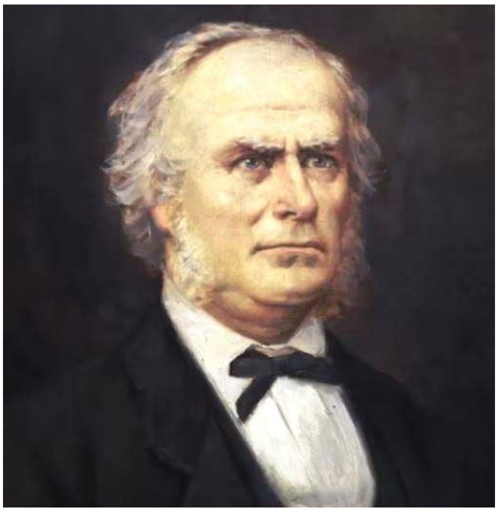


Figure 11 James Harrison (ABC Landline)

As his finances recovered through the 1860s, he began pioneering work on the refrigeration of ships for the export of meat. In 1873 he won a gold medal at the Victorian Exhibition in Melbourne by proving that meat kept frozen for months remained perfectly edible and that it could be shipped to England for 7 shillings a ton[54].

In 1873, Harrison installed an insulated chamber in the *Norfolk* to make a trial shipment of meat to England. There is no doubt he was successful in maintaining meat in excellent condition for times normally required for a voyage to England. His installation aboard the *Norfolk* used the circulation of cold brine around the frozen meat. The meat was frozen on shore, loaded into the cold chamber and in July 1873 the ship sailed. Unfortunately, the consumption of ice was greater than expected, the temperature rose and the meat had to be thrown overboard.

Harrison was ruined by this disaster. He was undoubtedly unlucky, his method should have worked and saved him financially, but it was shown to be unreliable. He had used a passive ice chest, not an active mechanical refrigerator. This was the ultimate goal, and Mort and Nicolle were by then reportedly on the verge of success[55].

Harrison stayed in England, patented his refrigerated ship chambers, improved his earlier patents and resumed journalism. After some nineteen years, he returned to Geelong with his family, where he continued to write and made plans to produce soda. In his early days in Victoria, he was a member of Geelong's first town council in 1850 and represented Geelong and Geelong West in the Legislative Assembly in 1859-60.

Harrison's greatest achievement but also the cause of much of his financial failure stemmed from his inventions in the field of refrigeration. Despite a long struggle to find a profitable market for his ice-making ventures, he is credited with laying the foundation for the refrigeration technology that eventually facilitated the perishable foods industries that contributed to the prosperity of the nation[56].

Eugene Nicolle – the engineer

Eugene Dominique Nicolle (1823-1909), refrigeration engineer, was born at Rouen in France, the son of a florist. He received thorough scientific training in Rouen and after some experience with English and French engineering companies arrived in Australia in 1853. By 1855, he was practising as an engineer in Sydney.

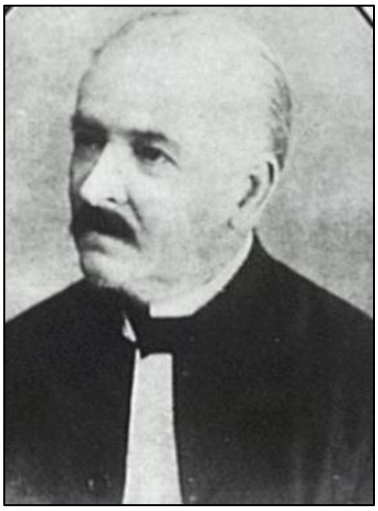


Figure 12 Eugene Nicolle (Wollongong City Libraries)

Nicolle was managing the Wilkinsons' sawmill in Sydney when his first ice-making patent was registered in 1861 in the names of himself and Richard Dawson[57]. Nicolle at first relied on an ammonia absorption method of refrigeration. But he encountered corrosion problems and turned to an air expansion machine. This was also abandoned and he returned to ammonia absorption and later other systems based on solutions of sodium nitrate, sugar, salt and washing soda[58].

In 1862, Dawson and the Wilkinson brothers bought the Sydney Ice Company from Peter Russell and James Harrison with the franchise to use Harrison's machine in New South Wales. They moved the factory from George Street to land leased in Paddington and began producing ice with Nicolle's machine in 1863. He had built an improved machine when the enthusiasm of the pastoralist and politician Augustus Morris diverted him into designing refrigerating machinery for ships. An appeal for subscriptions to finance the project in 1866 was unsuccessful, but in the summer of 1866-67, Nicolle and Morris persuaded Thomas Mort that the scheme was practical[59].

The thrust of refrigeration work in Australia from the 1860s onwards was towards the export of fresh meat to England. This meant travelling through the tropics, a problem not encountered by North Americans, who relied on natural cold. The Americans and Canadians could ship meat to England without too much trouble, especially in winter, but South American and Australian meat exporters had to solve the problems of shipboard refrigeration[60].

With Mort's support, Nicolle demonstrated in 1867 that with his machinery food could be frozen for long periods, and then thawed, cooked and eaten. After an aborted trial shipment of meat to England in 1868, Mort continued his support of Nicolle over the next ten years. Nicolle designed a range of refrigerating equipment to facilitate Mort's plans for transport and storage of chilled and frozen goods. He was a pioneer in developing various heat exchange systems and the mechanical contrivances that made them effective.

In 1875, Nicolle sold to Mort his interest in all their patents except one, which Mort made over to the newly-formed NSW Fresh Food and Ice Company, while guaranteeing Nicolle a three-year appointment as consulting engineer. After his contract expired, Nicolle went to England and France with his family, then returned to New South Wales, where he retired on a large property he owned at Wollongong.

Nicolle's most significant contribution to Australian industry was probably his demonstration in 1867 that it was both possible and safe to freeze food for long periods and then thaw it for human consumption. Even though it would be more than a decade before this was implemented in the Australia to England trade route, it opened the door to the great dream of Australian pastoralists and dairymen, which was to be able to sell their excess production in good years to overseas markets, while having reliable cold storage for their own food to use in leaner times[61].

Norman Selfe – the versatile engineer

Norman Selfe (1839-1911), engineer and educationist, was born at Teddington in Middlesex, the son of a plumber, and arrived in Sydney with his parents in 1855. At seventeen, he was apprenticed to P. N. Russell & Co, reputedly becoming chief draftsman before completing his articles. While there, he designed gunboats for service in the Maori wars[62].

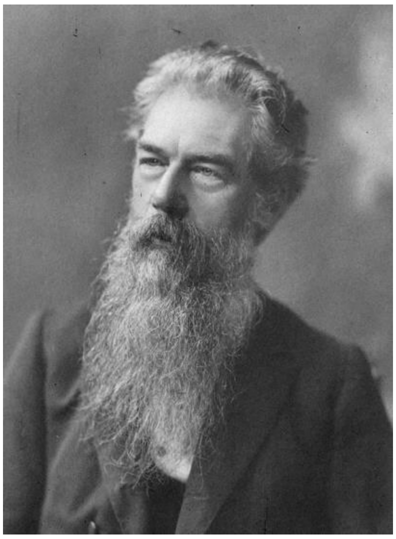


Figure 13 Norman Selfe (State Library of New South Wales)

Selfe achieved international recognition in 1861 when the British journal *The Engineer* published illustrations of his designs for one of the first refrigerating machines. One such machine was installed in the Sydney Ice Company behind the Royal Hotel in George Street, one of the world's earliest commercial refrigeration plants[63]. In 1869, he became chief engineer and draftsman for Thomas Mort's Dock and Engineering Company, designing machinery for the *Governor Blackall*.

Selfe set up in private practice in 1876 and soon became known as a versatile and original engineer[64]. The decades following Selfe's arrival were watershed years in the development of refrigeration technology, and he was closely involved with its evolution. The introduction of refrigeration in the colony revolutionised farming methods, allowed the expansion of settlement, and made possible the export of meat and dairy products. In Sydney itself, refrigeration changed commercial practices and led to the eventual demise of city dairies.

Selfe became an international authority on refrigeration engineering, and wrote articles and eventually a definitive textbook on the subject in 1900[65]. He taught mechanical drawing at the School of Arts as early as 1865, and in 1883 became a member of the Board of Technical Education. He died at Normanhurst, the suburb named after him, in 1911[66].

Thomas Mort - the visionary

Thomas Sutcliffe Mort (1816-1878) was born at Bolton, Lancashire. Brought up in aspiring middle class ideals and comfort, he received a sound and practical education. However, his father's estate was not sufficient to give his sons the start in life they expected. Thomas became a clerk with no prospects until he was offered a position in Sydney, which he saw as an opportunity to restore the family fortunes.

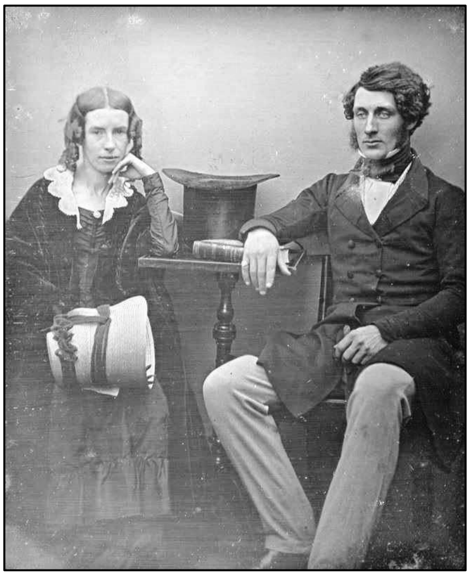


Figure 14 Thomas and Theresa Mort, c1847 (National Portrait Gallery)

He arrived in Sydney in February 1838 and was followed later by his brothers Henry (1818-1900) and James (1824-1879). Thomas became a clerk at Aspinall, Browne & Co and gained extensive experience in local and international commerce. In 1843, he set himself up as an auctioneer and soon prospered in wool and general sales[67]. By the 1840s, wool had become Australia's main export, with an annual wool clip of over two million kilograms[68].

Mort was innovative in running regular sales where only wool was offered, drawing specialised buyers and sellers together. In the 1850s, he provided facilities for growers to consign wool through him for sale in London. He eventually developed an integrated set of services that pioneered the operations of later wool-broking firms[69]. Mort found himself in the right place at the right time to implement these innovations, which helped to established international wool markets for Australia[70].

In the mid-1860s, Mort started to think about refrigeration as a solution to some of his problems. He had various pastoral assets (producing perishable products) and a large manufacturing plant. In addition, he was a milk and butter producer at his farm at Bodalla on the New South Wales South Coast, and wanted better access for his produce to the Sydney market.

Between 1866 and 1878 he financed experiments by the French engineer Eugene Nicolle to design and produce refrigeration machinery suitable for ships, trains and cold-storage depots. Successful land trials prompted a premature public subscription to finance a trial shipment of frozen meat to London in 1868. Another subscription was opened in 1875 for a shipment loaded in the *Northam* in 1877, but the cargo was removed before sailing due to a mechanical defect. In the end, their machinery was never used in the overseas frozen meat trade, but Mort and Nicolle were able to develop commercially viable refrigeration systems for domestic trade. These systems were used in the NSW Fresh Food and Ice Company which was formed in 1875.

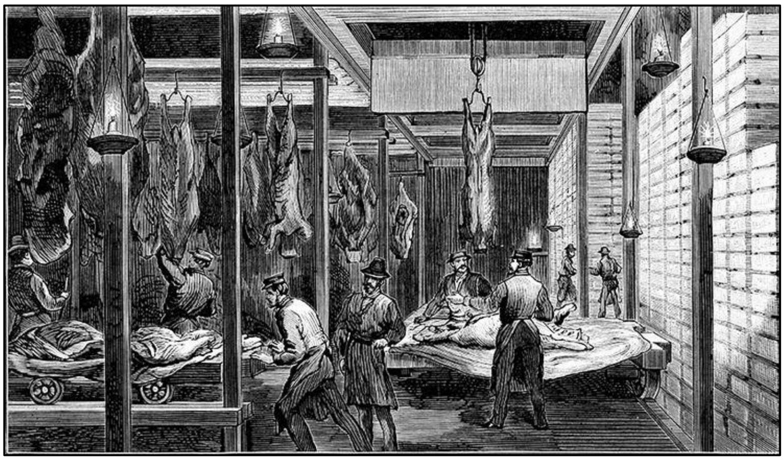


Figure 15 Mort Freezing Works, Darling Harbour 1876 (State Library of Victoria)

Thomas Mort's endeavours were essentially pioneering what are now called "cold chains", which are supply chains that use refrigeration to maintain the integrity and quality of perishable goods. Goods commonly distributed in cold chains include fresh agricultural produce, seafood, frozen food, chemicals and pharmaceutical products[71]. A well-functioning cold chain requires an uninterrupted sequence of refrigerated production, storage and distribution activities along with associated equipment and logistics. These maintain the desired low temperature range to ensure the safety and quality of the perishable or sensitive goods.

While Mort spent more than £100,000 on the development of refrigeration equipment and achieved a negligible return, like other ventures in Mort's career the investment was essentially a community service that was not justified by normal economic criteria, but which benefited those who succeeded him in his areas of enterprise[72].

Mort's business Mort & Co became Mort & Co Ltd in 1883, and merged with R. Goldsborough & Co in 188 to form Goldsborough Mort & Co Ltd. In 1963, a merger formed Elders Smith Goldsborough Mort Ltd, which traded until 1982. The present business is named Elders Ltd[73].

Success in transporting frozen meat to England was finally achieved two years after Thomas Mort's death. In 1878, a group of Queenslanders, including Thomas McIlwraith (pastoralist and Premier of

Queensland), fitted the steamer *Strathleven* with air compression/expansion refrigeration equipment. Meat and some experimental kegs of butter were loaded from chill rooms in Sydney and Melbourne and frozen on board. The ship left Melbourne in December 1879 and arrived in London in February 1880. The meat was in excellent condition on arrival and sold well.

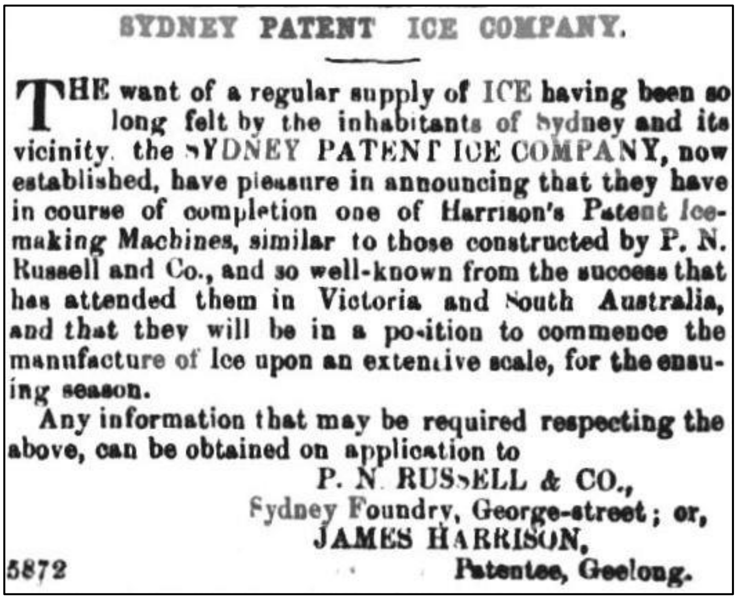
Following this successful start, the steamship *Protos* was charted, fitted with refrigeration equipment and the chamber insulated with wool. It sailed in November 1880 with lamb, mutton and butter, all of which arrived safely in England in January 1881. The wool insulation was also sold for a profit in London.

This promising start was well received in London, where refrigerated stores to receive such cargo had already been established. But a serious impediment for the Australian exporters was a lack of sufficient refrigerated space on board the ships. Ship owners were hesitant to install refrigerated space without long-term contracts, which were not forthcoming from exporters who wanted cheaper transport rates. However, Government intervention solved this problem in the 1890s[74].

The Sydney Ice Company

The Sydney Ice Company was established in 1860 by P. N. Russell & Co and James Harrison, with Norman Selfe as the chief engineer. The company was bought out in 1862 by a company that wished to suppress it in favour of their own development[75]. The company started advertising in September 1860, initially calling itself the Sydney Patent Ice Company. At the time, they had almost completed building one of James Harrison's patented ice-making machines[76].

By December the Sydney Ice Company was in full operation, and a continuous supply of ice could be ordered in fifteen-pound blocks[77]. The same month, the firm advertised that via their agent, William Watson of Robin Hood Lane (off George Street), subscribers would be supplied at 25/- per month with thirty pounds of ice a week, in two deliveries of fifteen pounds each[78].



SYDNEY PATENT ICE COMPANY.

THE want of a regular supply of ICE having been so long felt by the inhabitants of Sydney and its vicinity, the SYDNEY PATENT ICE COMPANY, now established, have pleasure in announcing that they have in course of completion one of Harrison's Patent Ice-making Machines, similar to those constructed by P. N. Russell and Co., and so well-known from the success that has attended them in Victoria and South Australia, and that they will be in a position to commence the manufacture of Ice upon an extensive scale, for the ensuing season.

Any information that may be required respecting the above, can be obtained on application to

P. N. RUSSELL & CO.,
Sydney Foundry, George-street; or,
JAMES HARRISON,
5872 Patentee, Geelong.

Figure 16 Sydney Ice Co advert, 1860 (*Maitland Mercury*, 29 September 1860)

The *Sydney Morning Herald* reported that the ice-making machine was in four parts: the air pump, the refrigerating vessel, the condenser and the freezing troughs. The refrigerating vessel contained ether which was evaporated, and was intersected by 150 pipes through which there was a constant current of salt water. A portion of ether was abstracted with every stroke of the air pump, which deprived the spirit of the heat it contained, and thereby imparted a sudden and intense coldness to the adjacent stream. The manufacturing works had been inspected by the Governor-General and other scientific gentlemen, who showed great interest in the process[79].

The *Sydney Mail* published an article a week later, detailing the operation of the ice machine. There was no perceptible waste in the ice-making process, which was important as the process used 80 pounds of ether, at a cost of 10 shillings a pound. For the refrigerating process, sulphuric ether was used, made from sulphuric acid and nitre, both imported from England as neither was manufactured in New South Wales. The speed of the pump was carefully controlled to avoid the freezing of the salt water (which remains liquid at a lower temperature than fresh water). This problem occurred a few days earlier, causing the operation to stop when the temperature was brought down to 23°F. For smooth operation, the temperature needed to be kept between 26°F and 30°F.

Some refrigerators for preserving meat and cooling wine were available in Sydney, consisting of a box with a double cover and a false bottom. They are of American manufacture, sold at prices of £2 and above. The value of readily available ice in any quantity should soon be appreciated by a variety of industries, especially butchers and poulterers, brewers and distillers (who can now cool their wort during brewing and distilling), and in the production of butter and cheese[80].

At the end of 1861, an article in the *Albury Banner and Wodonga Express*, where an ice works had opened in Franklin Street, was aimed at dispelled rumours that the ice was contaminated by the ether and salt used in its manufacture, and that was no good because it was not as clear as Wenham Lake ice. The local ice factory could turn out three tons a day, at a low price which all could afford[81].

As mentioned in the section on Eugene Nicolle, in 1862 Richard Dawson and the Wilkinson brothers bought the Sydney Ice Company from Peter Russell and James Harrison with the franchise to use Harrison's machine in New South Wales. They moved the factory from George Street to land leased in Paddington and began the production of ice in 1863[82].

NSW Fresh Food and Ice Company

The company is established

From 1866 until his death in 1878, Thomas Mort financed experiments by Eugene Nicolle to design and produce refrigeration machinery suitable for ships, trains and cold-storage depots. In the end, their machinery was never used in the frozen meat export trade, but Mort and Nicolle were able to develop commercially viable refrigeration systems for domestic trade, which were used by the NSW Fresh Food & Ice Co after it was formed in 1875. This included a slaughtering and chilling works at Bowenfels in the Blue Mountains (on the outskirts of Lithgow), a cold store at Darling Harbour, milk depots in the Southern Highlands, and refrigerated railway vans for transporting meat and milk[83].

To dispel the public's doubts about the safety of frozen meat, in September 1875 Mort organised an excursion to the Lithgow Valley to inspect the works of the company. The 300 influential guests included the President and members of the Legislative Council, the Speaker and members of the Legislative Assembly, the Colonial Secretary and members of the present and late Governments, managers of banks, insurance companies and leading representatives from almost every commercial, agricultural and pastoral interest in the colony.

On arrival, the guests sat down to a splendid repast, consisting of beef, mutton, ham, beefsteak pie, turkey, roast fowl, Wonga pigeon pie and lobster, along with jellies, tarts and creams. All of the above had been kept fresh by the freezing process for the previous fifteen to eighteen months. It was all pronounced to be excellent, and quite indistinguishable from the fresh food they had eaten the previous day.

Thomas Mort then gave the assembled worthies an interesting account of the trials he had gone through to perfect the freezing process, whose success was proven that day. The beef they had eaten was killed at Bathurst in June 1874, and the guests agreed that it had lost none of its sweetness or flavour. The pigeon pie contained Wonga pigeons which had been shot in March 1874. The pie crust was then cooked and kept perfectly until the present day.

Speaking to his guests after the meal, Mort could not resist mentioning that the writers in the *Food Journal* had said his quest was impossible, and he then quoted from an edition of *The Times*, whose editor looked upon him as a good but very misguided colonist. Mort concluded by saying that the object and aim of all his experiments and works could be summed up in the few words: "there shall be no more waste". He said that he knew from the beginning of his quest that the truth was at the bottom of the well, but he had no idea the well was so deep.

He could see the time approaching when the overabundance of this country would make up for the deficiencies of another, and the superabundance of one year would make up for the scant harvest of its successor, because cold arrests all change in produce. He attributed Faraday's magic wand as giving the key note, while invention did the rest (the English scientist Michael Faraday discovered in 1820 that by compressing and liquefying ammonia he could cool the surrounding air when the ammonia was allowed to evaporate).

Mort was also arranging for large supplies of pure milk from the area around Bowral. He claimed there was land in that area that was never subject to drought, as he saw dew on the grass every morning, whatever the season. He would be able to sell his milk to retail vendors in Sydney for a lower price than they would pay for milk from the cows near or in Sydney. Also, tons of fish would be caught on the coast near Illawarra and delivered to the freezing room, from which it would be transported to the retailers.

Eugene Nicolle had invented a very simple machine to enable meat placed on board ship to be kept frozen, with no possibility of injury on the voyage. The principle of the machine was the same as Mort's domestic refrigerator, in which cold was produced by dissolving nitrate of ammonia in an equal weight of water. A very low degree of cold could be attained, and the nitrate could be continually recovered by evaporating the water. The first load of meat would be sent to New Caledonia, where the Government there was satisfied that its requirements would be met by the frozen meat, so they stopped issuing contracts for live meat for the indefinite future[84].

Early attempt to export frozen meat

By January 1876, Thomas Mort's workers were busy constructing an ice freezing machine in a factory at Paddington to be used on board a ship to initiate the overseas export trade in frozen meat. It was hoped that it would be ready in about two months' time[85]. However, the freezing works at Darling Harbour had suffered a major fire the previous December, and replacement fittings were not completed until late in 1876[86]. In October, the NSW Fresh Food and Ice Company commenced supplying a limited amount of milk from farmers in Bowral and Moss Vale to the Sydney market, using refrigerated railway vans[87].

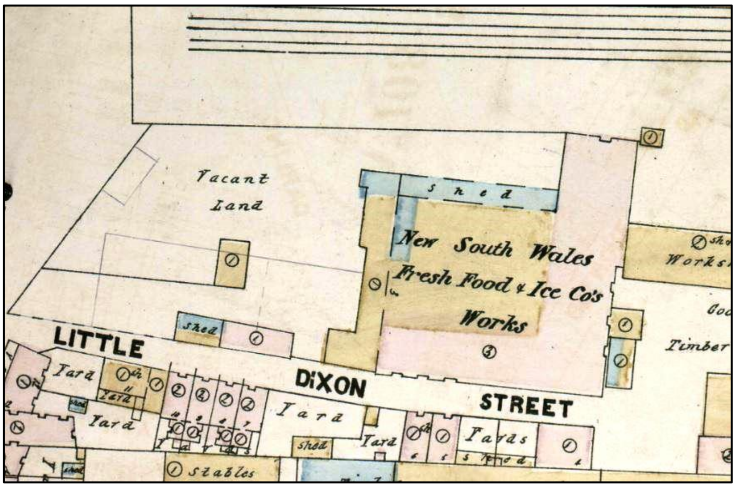


Figure 17 NSW Fresh Food & Ice Co, 1880 (Dove's Plans of Sydney)

In early 1877, Thomas Mort was finally ready to equip a ship with cold storage facilities to test the practicality of carrying meat carcasses to England. Arrangements were made for the steamship *Northam* to take on board 700 tons of cargo, and it was hoped to be ready for departure in May[88]. However, in July when the cold storage equipment had been installed and all the passengers and other cargo were on board, a major fault occurred in the evaporating pan, which could not be fixed in a few days.

Figure 18 NSW Fresh Food & Ice Co, 1937 (City of Sydney Archives)

The ship was obliged to depart without the cargo of frozen meat. However, the company's staff travelled on the ship to England, where the defect would be remedied. The cancellation was a bitter blow to Mort, as there had been almost interminable delays to take every possible precaution to ensure success, and when it seemed almost certain, a part of the machinery gave way and the meat could not be loaded on board until repairs were carried out[89].

After the aborted trial run of exported meat, Thomas Mort turned his attention again to tackling the ongoing resistance to frozen foods by the public. In September 1877, he put on another luncheon to demonstrate the quality of meat and fish preserved by freezing, this time in his freezing works at Dixon Street, Darling Harbour. The bill of fare for the novel occasion was boiled snapper, fried garfish, fillets of whiting, roast beef (hot and cold), corned rounds of beef (hot and cold), boiled and roast mutton.

The opinion expressed by one and all was that the meat was better than that usually supplied by butchers. Mort explained that the animals from which his meat was taken had not been injured by travel, as the bullocks killed for Sydney consumption invariably were (this was the reason Mort's slaughterhouse and freezing works were located west of the Great Dividing Range: to avoid the difficult mountainous trek to Sydney). The frozen condition does not affect the natural juices of the meat, as they remain frozen until the meat is thawed out.

Figure 19 Ice delivery van (National Library of Australia)

Thomas Mort said that his freezing process dispelled statements made in Europe that meat could not be preserved by the freezing process without injury. He contended that meat sold in Europe was not frozen solid enough (as his had been), which meant that decomposition set in early and progressed rapidly after the thawing process commenced[90]. Mort's success in preserving meat and fish compared to the problems experienced in Europe seemed to be partly because his meat was frozen as soon as the animals were killed so bacterial growth did not start (his Lithgow slaughterhouse was situated alongside as the freezing works), and he froze his produce to a much lower temperature so that any possible bacterial growth was arrested.

Death of T S Mort

Thomas Mort died unexpectedly in May 1878 after achieving much in his life, but without realising his great dream of opening a frozen meat export trade to England. He appeared to be well until about three days before his death from a congestion of the lungs, as that was when he was first reported to be seriously ill[91]. The glowing obituary published in the *Sydney Morning Herald* is worth repeating in full, as it typifies the very high esteem in which he was held by all who knew him:

"It will be in a very wide circle indeed that the news will be received with regret that Mr. Thomas Mort has ceased from his labours. His name in New South Wales has been a household word, synonymous with public spirit and enterprise. Sanguine and enthusiastic almost to a fault, he was passionately fond of large schemes and of pressing forward to the realisation of grand ideas. He also had his full share of the suffering that comes from the rebuffs that ardent spirits are destined to encounter.

The pioneers in the path of progress get a good many pricks and scars in the work of clearing the jungle, and though those who moralise comfortably in the rear can lament the lack of patience and prudence, the highways of civilisation would be much less traversable if it were not for the uncalculating self-sacrifice of those imprudent zealots who are more fired by the ideal than able to count the cost of getting towards it. It was to Mr. Mort that Port Jackson owed its first dry dock, though the enterprise was more remunerative to the public than to himself. During the latter part of his life, he has been devoted to the project of preserving meat by cold, and of bringing into a commercial shape his ideas for transmitting the Australian surplus to English markets.

Though incessantly battled by ever fresh difficulties, he never bated a jot or tittle (sic) of his faith in the soundness of his principle. But hope deferred had doubtless something to do with making the heart sick. Mr. Mort's last illness was due to a cold that turned into inflammation of the lungs, complicated with other symptoms. He died at Bodalla, his country farm, which he loved so well, and where he had been lavish of his enthusiasm for improvements. We fear that we may wait some time for his successor"[92].

Peters Milk takes over

The NSW Fresh Food and Ice Company continued in business at Darling Harbour until the early 1950s, when it began to trade at a loss. In 1951, the company reported a loss of £13,399, and results the following year continued to be unfavourable. In April 1952, the company directors recommended to shareholders that they approve a takeover offer by Peters Consolidated Milk Industries Ltd. At this time, the Fresh Food and Ice Company handled about a third of Sydney's milk supplies, and was one of the New South Wales Milk Board's two agent companies for the pasteurisation and distribution of the city's milk[93]. Peters Consolidated Milk was descended from the original Peters Ice Cream business.

The following month, over 90% of NSW Fresh Food and Ice shareholders ratified the takeover agreement[94], which was reported in October 1952 to be an important step in the development of the Peters Organisation. By this time, the Fresh Food and Ice Company was an old-established firm that was engaged in the manufacture and distribution of several food products. Its principal activities comprised whole milk distribution, bread and ice manufacture, as well as running a large providoring and cold storage business.

Its head office and works on the corner of Harbour and Liverpool Streets, adjacent to the Darling Harbour Goods Yards, covered 3.75 acres[95]. The company intended to change its name to Peters (Property Holdings) Pty Ltd, and a new building scheme at Darling Harbour was being planned to house the headquarters of both companies[96].

Domestic refrigerator manufacturing in Sydney

There were few refrigerator manufacturers that were originally established in Sydney. Household names such as Westinghouse (American), Kelvinator (American) and Fisher & Paykel (New Zealand) may have had factories in Australia at one point, but they are overseas companies. Edward Hallstrom's kerosene-powered refrigerator was probably the most significant home-grown manufacturer.

Icyball Refrigerator

Icyball is the name given to two early refrigerators, one made by Australian Edward Hallstrom in the 1920s and put into production in 1928[97]. The other, designed by Canadian David Forbes Keith, was occasionally being sold in Australia at about the same time[98]. Both are unusual in that they required kerosene rather than electricity for cooling. They could run for a day on a cup of kerosene, allowing rural users without electricity the benefits of refrigeration at very little running cost.

The first newspaper advertisement for the Icyball refrigerator was in December 1927[99], with the first deliveries starting in January 1928[100]. An article in the *Farmer and Settler* newspaper in December 1927 provided people in rural areas with information on the operation of this novel appliance. It used a cooking stove to keep a food compartment cold. There were no other running costs, and the machine only needed to be reheated every thirty hours on a stove. It would provide refrigeration for some 24 to 26 hours, and it was not necessary to replace the refrigerant liquid[101].

Figure 20 Hallstrom refrigerator advert, 1937 (The Daily Telegraph, 2 October 1937)

There were many advertisements for the Icyball refrigerators in city and country newspapers, but the Crosley model was only mentioned once in 1928, and the vast majority of those sold were made by Hallstrom. Crosley was a widely-advertised brand of radio receivers from 1927 onwards.

However, the Crosley Icyball was advertised widely from the end of 1935. Priced at £39/17/6, it made ice cubes and kept food fresh in the hottest weather with no electricity or gas, at an operating cost of 2d per day[102].

In August 1935, *The Land* newspaper contrasted Edward Hallstrom's success with European and American refrigeration engineers and inventors, who had experienced great difficulty in producing non-electric semi-automatic refrigerators. This field of manufacture had numerous models placed on the market then recalled and production stopped[103].

In October 1937, *The Daily Telegraph*, quoting the 19 May 1937 edition of the American trade journal *Air Conditioning and Refrigeration News*, reported that an absorption model manufactured by the Hallstrom Non-electric Refrigerator Company of Sydney was sold in Australia under several brand names. The Hallstrom kerosene-burning refrigerator outsold all other types of refrigerator in Australia – electric, gas, or ice. It somewhat resembled the familiar (in the United States) Crosley Icyball, the first non-electric refrigerator to be sold to farms. The chief improvement was that the unit did not have to be lifted from the tank to the food-storage cabinet.

At least five American laboratories were known to be working feverishly on the development of absorption-type refrigerating units. This project posed a set of unusually difficult problems, and they had not yet been overcome. One rural customer wrote in to say their Hallstrom refrigerator purchased in December 1935 used only 1.5 pints of kerosene a day in the hottest weather, and they have had 150 pounds of fresh meat in it at one time. What they used to pay in hot weather food wastage would pay the outlay on the refrigerator.

Different advertised models ranged from the maple or steel chest of 2.2 cubic feet (£28/10), two models at 5 cubic feet (£39/10 to £43/10), up to a maple chest at 10 cubic feet (£78/10). Manufactured by Hallstrom Pty Ltd of 462-464 Willoughby Road, Willoughby, with agents in every country town in Australia. The company boasted many thousands of users of their refrigerators throughout Australia and the Pacific Islands. Advertisements mentioned Hallstrom's ten years of experience in the field[104].

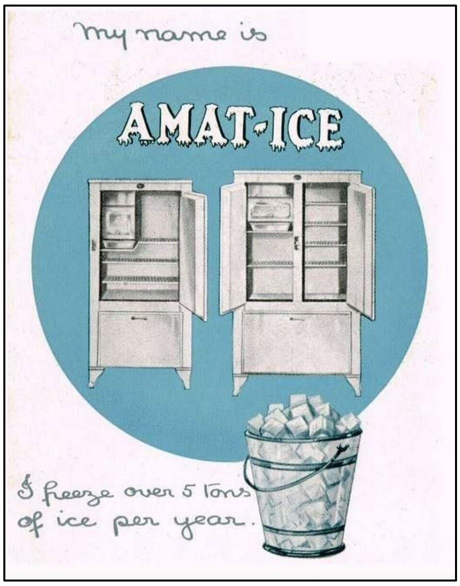


Figure 21 AMAT-ICE refrigerator advert (A J Baker Company)

In addition to the Icyball, a small factory in the inner Sydney suburb of Waterloo began to manufacture AMAT-ICE domestic and commercial refrigerators in 1931[105]. This refrigerator was a product of the General Refrigerating Division of Mauri Bros & Thomson Ltd, which was founded in the nineteenth century. The name AMAT stands for “Australian Made for Australian Trade”[106]. The company’s refrigerators were made throughout the 1930s[107].

Benefits of refrigeration and freezing

New industries and activities

The creation of an export trade in chilled and frozen food between Australia and England, already described above, was one of the most important economic benefits of refrigeration. But freezing techniques also benefited Australians in the leisure and entertainment fields as well. In particular, Sydneysiders could enjoy ice cream and ice skating, both already familiar in northern hemisphere countries with cold climates, but unknown in this country until the late nineteenth century.

Ice cream manufacturing

The origins of frozen desserts are obscure, although several historical accounts exist. A Roman cookbook from the first century includes recipes for sweet desserts sprinkled with snow, and there are Persian records from the second century for sweetened drinks chilled with ice[108].

Ice cream production became easier with the discovery of the endothermic effect[109]. An endothermic process is a chemical or physical process that absorbs heat from its surroundings. Prior to this, cream could easily be chilled but not frozen. The addition of salt lowered the melting point of ice by several degrees, drawing heat from the cream mixture and allowing it to freeze. During the sixteenth century, European authors referred to the refrigerant effect of adding salt to ice. By the end of the seventeenth century, ice cream was being made using this process[110].

The spread of ice cream throughout Europe is often attributed to Marco Polo. While not mentioned in any of his writings, he is credited with introducing sorbet-style desserts to Italy after learning of them during his travels in China. Before modern refrigeration, ice cream was a luxury item reserved for special occasions. It was laborious: ice was cut from lakes and ponds during winter and stored in holes in the ground or in ice-houses insulated by straw. Many Americans, including American Presidents George Washington and Thomas Jefferson, cut and stored ice in winter for use in summer.

Ice cream was made by hand in a large bowl placed beside a tub filled with ice and salt, called the pot-freezer method[111]. In this method, the temperature of the ingredients in the bowl is reduced by the mixture of crushed ice and salt. The salted water is cooled by the ice, and the action of the salt on the ice causes it to start melting, absorbing latent heat and lowering the mixture to well below the freezing point of fresh water.

The hand-cranked churn, which also used ice and salt for cooling, replaced the pot-freezer method. It produced smoother ice cream and was faster. The first American patent for this method was in 1843. The development of industrial refrigeration by the German engineer Carl von Linde in the 1870s eliminated the need to cut and store natural ice. The continuous-process freezer was first developed by Clarence Vogt, and when it was perfected in 1926 commercial mass production and the birth of the modern ice cream industry began[112].

The Sydney pioneers

The first advertisement for ice cream in Sydney was by Martin Gill in February 1839. He operated the Victoria Confectionary Establishment next door to the Victoria Theatre. He must have purchased some of the speculative cargo of Wenham Lake ice that arrived in Sydney that month and used the pot-freezer method to make small batches of ice cream for the refreshment of theatre-goers[113].

Martin Gill was the only person to advertise ice cream for some years until 1848, when Thomas Goudie, a cook, pastry chef and confectioner of 284 Pitt Street advertised that he had bought one of Robinson's celebrated freezing machines and would be able to supply Cream and Water Ices daily from 12 o'clock, and on every evening the theatre was open. The ices would be prepared according to the rules laid down by Thomas Masters, inventor and patenter of the freezing machine, confectioner to the Royal Zoological Gardens[114].

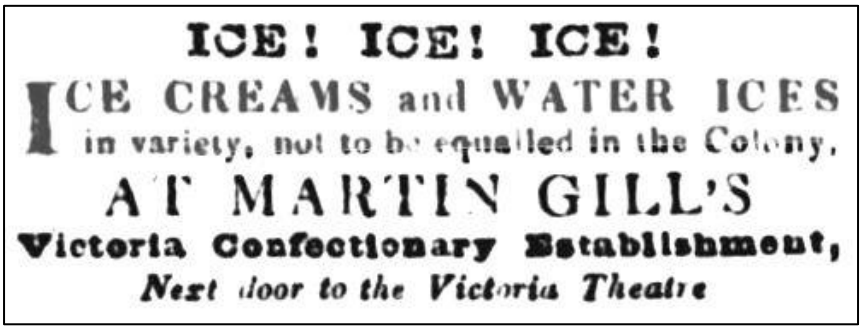


Figure 22 First ice cream advert, 1839 (*The Herald*, 1 February 1839)

The following year, William Blyth of 281 Pitt Street advertised that he had commenced selling ice cream and water ices at the Victoria Refreshment Rooms. He had recently received a quantity of ice moulds, pints and quarts, and three tons of freezing powder which would be for sale in small quantities for cooling wines and other drinks, at 8d per pound. He intended making ice cream, which would be ready daily. Families could be supplied with ice in moulds, also rough ice, iced lemonade, soda water, etc[115].

By 1851, T. W. Foster was advertising that he had imported a large quantity of freezing mixture, with two large double-action freezing machines from the manufacturer (and inventor) Thomas Masters of Oxford Street London. He was then selling water ices, ice creams, sherry cobblers, etc, also iced lemonade and soda water. He also had pint and quart moulds for ice creams, ornamented with fruit or otherwise. Freezing mixture was offered for sale in large or small quantities, as the advertiser had up to a ton to dispose of, at 518 George Street[116]. By then, the enterprising Mr. Foster seemed to be making ice cream on a larger scale than a couple of years earlier.

In March 1870, a new American ice cream beverage fountain was being advertised, as seen at the Paris Exhibition of 1867, and patronised by the Royal Family. Messrs M. Boam and Company was about to open at 249 Pitt Street for the sale of these celebrated ice cream drinks[117]. By this time, the ice cream drink dispensers would have been chilled using the vapour-compression method. This was much less wasteful than the pot-freezer method used by the first Sydney ice cream makers up to 1851, which required the addition of more freezing mixture (which was a type of salt) for each batch.

Podesta Ice Cream – the first factory

The first ice cream makers in Sydney were very much at the cottage industry level, making small batches in a back room to be sold in their shop. The *Sands' Sydney Directory* of 1910 does not list any ice cream factories (Peters Ice Creams were being made by then, but the company was only listed as part of the Eastern Suburbs Cold Storage and Ice Company at Paddington and not separately in the Trade section)[118]. It was not until the 1880s that the first Sydney ice cream factory was started by a family of Italian immigrants.

Giovanni "John" Podesta (1860-1927) was born in the small town of Chiavari in the Italian province of Genoa. He migrated to Melbourne in November 1882 with his younger brother Louis[119], where they established the Podesta Ice Cream Delicacy Company[120].

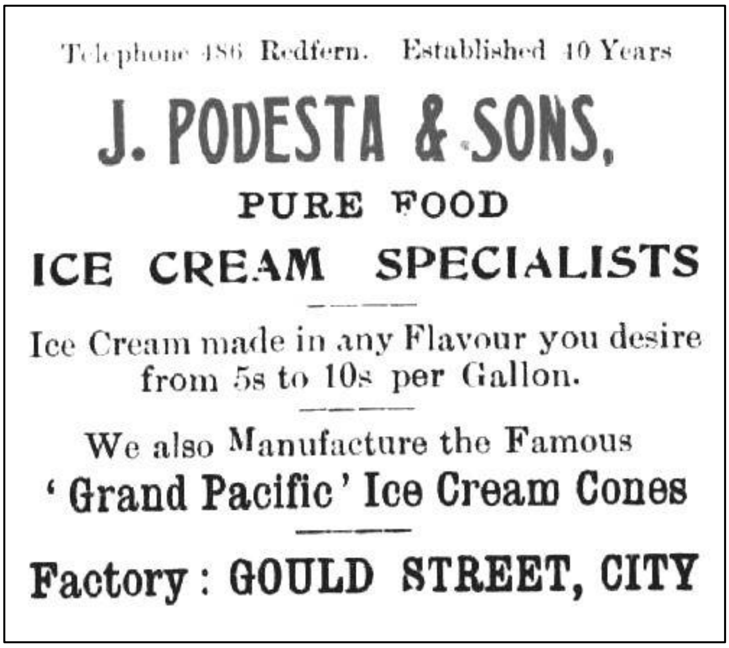


Figure 23 Podesta advert, 915 (*Oceania*, 30 January 1915)

John moved to Sydney in April 1887[121] where he re-established his ice cream factory. Once his three sons John, Louis and Frank joined the business it was known as Podesta & Sons[122]. By 1915, the factory was located at 29-31 Gould Street, off Regent Street[123]. The street is now called Goold Street, Chippendale.

A featured story about the family in the National Library of Australia website noted that from its early days in Melbourne, the Podesta Company was most notable for the family members finding themselves in the news for a variety of mild scandals. In January 1885, John Podesta was fined £1 for obstructing Melbourne's Flinders Lane with his ice cream cart. He was taken off to a police cell rather than simply being issued a summons, which *The Herald* suspected was probably because he was a foreigner[124].

Figure 24 Keep Your Temper gambling token (National Library of Australia)

The same month, a ten-year old girl named Maud Nicholls, wearing a Salvation Army uniform and carrying copies of the *War Cry*, was arrested by Melbourne police for tendering a counterfeit coin to Louis Podesta[125]. The girl asked Louis if he could exchange the coin for smaller change. He handed over a pound's worth of silver without realising until later that he had been handed a Keep your Temper gambling token (issued in the Victorian era as a bit of friendly advice for players of the card game whist[126]. Louis may have seen the funny side of the situation because he later dropped the charges against the girl[127].

In November 1897, John Podesta was apparently accused of dodgy practices in his Sydney factory, as he issued a notice in the *Sunday Times* announcing that he would give £50 to the Sydney Hospital if anyone could prove that he was careless in the manufacture of ice cream, pointing out that he had been in business for fifteen years[128].

In 1900, one of the family's vendors was fined for violating Sunday trading laws in 1900 (at a time when you couldn't do anything even vaguely entertaining or fun on the Sabbath[129]). The following year, John Podesta was fined for receiving thirteen stolen bottles of flavouring essence[130]. In March 1915, a newspaper article on the ice cream industry in Sydney mentioned that J. Podesta & Sons was the original ice cream maker in Sydney. At the time, they were planning to greatly extend their output[131].

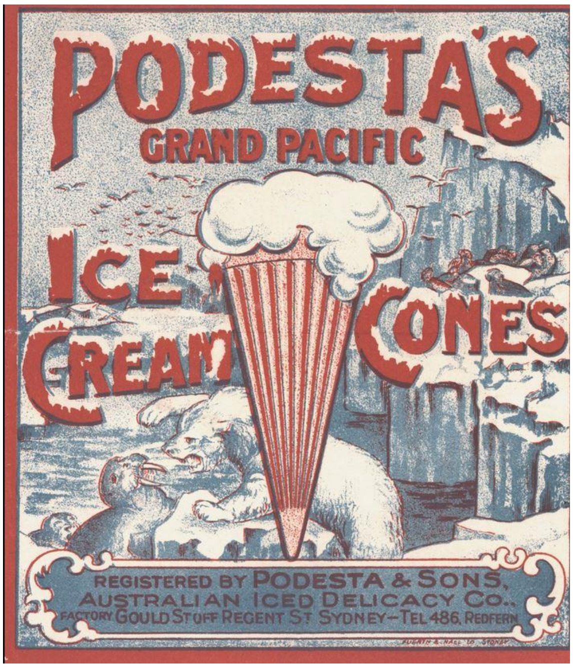


Figure 25 Podesta ice cream advert (National Library of Australia)

John Podesta died in 1927[132], and the company continued in the same location until 1931[133], after which the family decided to closed its doors and leased the factory building[134] during the economic downturn of the early 1930s. The Podesta family were successful pioneers of commercial ice cream manufacturing in Australia, and managed to survive the 1890s economic Depression when indulgences like ice creams must have been hard to sell, but did not make it through the next Great Depression from 1930 onwards.

Peters Ice Cream - the Health Food of a Nation

Frederick Augustus Bolles Peters (1866-1937) was born in Michigan, son of a farmer and miller. He worked as a salesman, becoming sales manager for the Union Manufacturing Company of Toledo Ohio. He visited Sydney in the 1890s to check the exports of a failing New York company in which he had an interest. After the American business collapsed, he returned to America where his father advised him: “Son, the place to find your money is where you lost it”.

His father’s words still ringing in his ears, Peters returned to Sydney in 1899 and commenced business with several agencies, including the Union Manufacturing Company. In the early 1900s, he manufactured Peters Pile Cure, but being homesick and craving ice cream (which was not easily available), he decided to lease two rooms in an ice factory at Paddington and set up Peters American Delicacy Company Limited in August 1907, using his mother’s recipe.

Figure 26 Peters' Ice Cream factory, Paddington (Google maps)

The company did well, and in 1923 a new factory was opened at Redfern in 1923 to make the “Health Food of a Nation” and business flourished. Peters continued opening branches across the nation through the 1920s. He was largely responsible for introducing Australians to the small refrigerated cabinet, which he hired out to retailers.

Peters attributed his success to modern equipment, good staff and a strong emphasis on cleanliness and quality control of his product. He maintained excellent staff relations, paid all employees an annual cash bonus based on the company’s yearly dividend and encouraged them to become shareholders. His business suffered in the Depression, but he kept his staff intact.

Figure 27 Hubert Opperman in Peters' advert (State Library of Victoria)

He took little interest in politics, but as a leader of the American community in Sydney, he encouraged closer trading relations between Australia and the USA, and was a vice-president of the Royal South Sydney Hospital. He married four times, and after surviving the first three, his fourth wife (whom he married in 1936) survived him after he died in 1937.

Peters Ice Cream continued to market itself as a health food until the 1970s, when Government regulations clamped down on health claims such as this[135]. The company was taken over by the Adelaide Steamship Company (known as AdSteam) in the late 1980s, and then by Pacific Dunlop upon the collapse of AdSteam. Pacific Dunlop sold its food assets in the mid-1990s to Nestle, which continues to make many of the company's products[136].

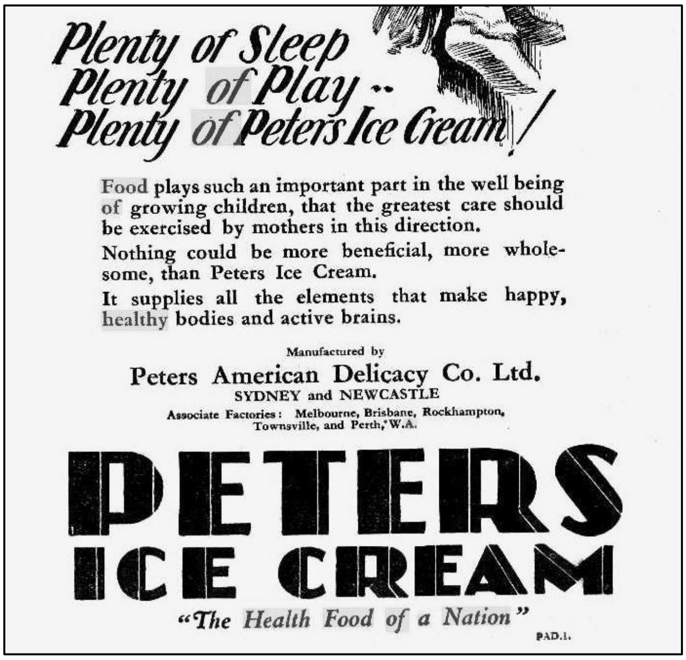


Figure 28 Peters' health claims, 1929 (*The Daily Telegraph*, 13 November 1929)

There were several other ice cream manufacturers in Sydney (eight were listed in the 1920 *Sands' Sydney Directory*[137]), but Podesta and Peters were selected to describe in this history because the former was the pioneer and the latter was the probably the most famous. Streets is also a major ice cream brand, but the company commenced in Corrimal in 1920, moved to Sydney for a while, then moved back out to Minto in the 1990s. Despite marketing the popular Cornetto, Golden Gaytime, Magnum and Paddle Pop varieties, Streets is not a Sydney company in quite the same way as the others.

Ice skating

Skating on frozen lakes and rivers has been common in northern Europe for hundreds of years, especially after sharpened metal skates were developed by the Dutch in the thirteenth or fourteenth century[138]. Early attempts at the construction of artificial ice rinks were made in the 1840s, using a substitute for natural ice consisting of a mixture of hog's lard and various salts. The world's first mechanically-frozen ice rink, known as the Glaciarium in London, was reported in the 9 June 1844 edition of *Little's Living Age* magazine[139].

By 1844, venues using artificial ice fell out of favour as customers grew tired of the smelly ice substitute. It wasn't until the 1870s that refrigeration technology developed to the point where natural ice could feasibly be used in a skating rink. The world's first mechanically-frozen ice rink was also called the Glaciarium, opened by Professor John Gamgee in a tent in Chelsea, London, in January 1876.

The Manchester Real Ice Skating Company purchased the exclusive use of Professor Gamgee's process, and in January 1877 opened what was considered the world's first skatable ice rink at Rusholme in Manchester. But the rink was not a success, as the high maintenance costs required a very high entrance fee that few people could afford, and the rink closed in 1879[140].

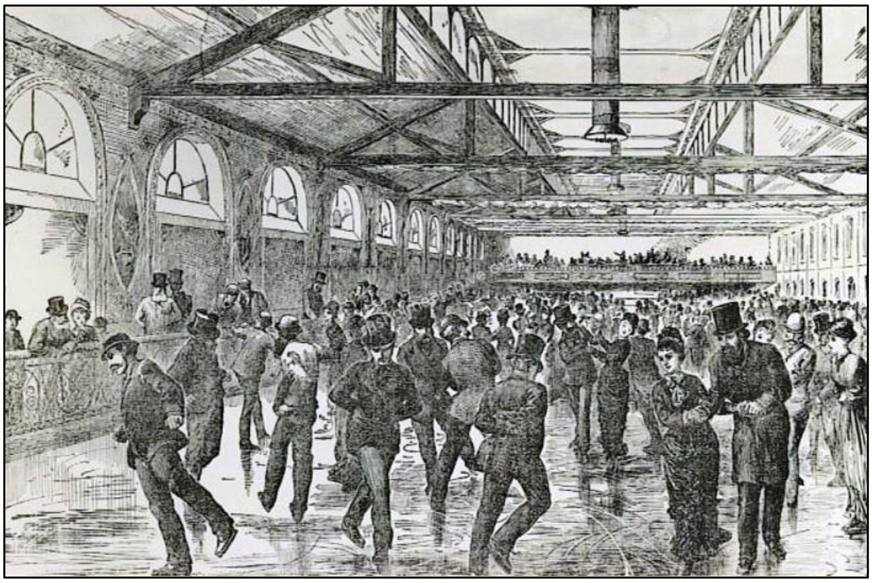


Figure 29 Rusholme ice rink, 1877 (Rusholme & Victoria Park archive)

An arena with a mechanically frozen ice surface can be built in any climate when it is installed in a properly-built space. This consists of a bed of sand or sometimes a slab of concrete, through which (or on top of which) pipes run. The pipes carry a chilled fluid (usually either salt brine, or water containing antifreeze, or a refrigerant in the case of smaller rinks). The chilled pipes can lower the temperature of the slab so that water placed on top will freeze.

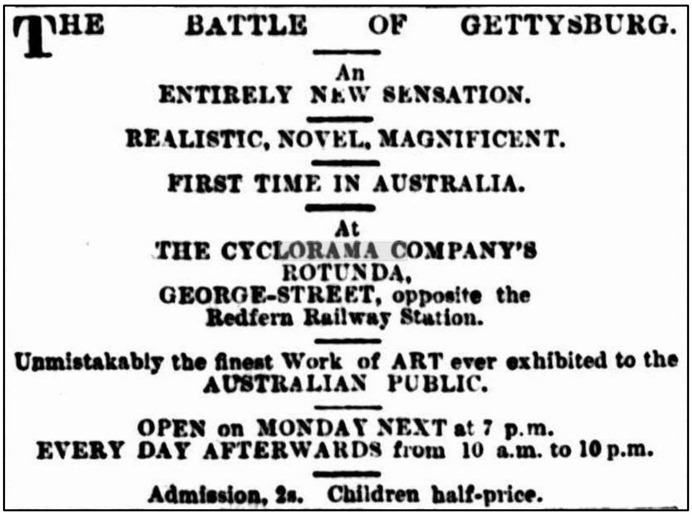
Modern ice rinks used for sports events have a specific procedure for preparing the surface. When the pipes are cold, a thin layer of water is sprayed on the sand or concrete to seal and level it. This first layer of ice is painted white or pale blue, then markings needed for sports such as ice hockey or curling are placed, along with logos and other decorations. Another thin layer of water is sprayed on top and frozen until the ice is built up to a thickness of 19mm to 38mm[141].

Cyclorama

Sydney's first ice rink was previously the site of an extravagant entertainment called a Cyclorama. In May 1888, *The Daily Telegraph* wrote that Sydney's version would be similar to those in other cities in America and Europe, and would consist of an enormous oil painting some 400 feet long and fifty feet high, exhibited in a circular form. A building would be erected for the purpose, and the scene would depict famous battlefields. A combination of real objects and those depicted on the canvas would provide a very realistic effect[142].

Tenders were advertised a few months later for the construction of a rotunda or Cyclorama in George Street, to be designed and built by the ever-versatile engineer Norman Selfe[143]. Meanwhile, an American Cyclorama of the Battle of Waterloo was brought to Melbourne for exhibition in October 1888, where a large, circular building was being constructed, expected to be ready by the Christmas holidays[144].

Sydney's Cyclorama was opened in March 1889 near present-day Railway Square by a glittering assemblage of dignitaries, including the Governor Lord Carrington and the Premier Sir Henry and Lady Parkes. The exhibition depicted the Battle of Gettysburg[145], a decisive three-day battle during the American Civil War in July 1863. The battle resulted in more than 50,000 casualties, and represented a turning point towards the eventual Union victory in the war in 1865[146].



THE BATTLE OF GETTYSBURG.

An ENTIRELY NEW SENSATION.

REALISTIC, NOVEL, MAGNIFICENT.

FIRST TIME IN AUSTRALIA.

At THE CYCLORAMA COMPANY'S ROTUNDA, GEORGE-STREET, opposite the Redfern Railway Station.

Unmistakably the finest Work of ART ever exhibited to the AUSTRALIAN PUBLIC.

OPEN on MONDAY NEXT at 7 p.m.
EVERY DAY AFTERWARDS from 10 a.m. to 10 p.m.

Admission, 2s. Children half-price.

Figure 30 Sydney Cyclorama opening (*Sydney Morning Herald*, 18 March 1889)

The Gettysburg Cyclorama was painted by the French artist Paul Philippoteaux in 1883. Three major copies were made of the huge work for display in different locations around the world. The work depicts Pickett's Charge, a failed infantry assault ordered by the Confederate General Robert E. Lee that was the climax of the Battle of Gettysburg. The intended effect was to immerse the viewer in the scene being depicted, often with the addition of foreground models and life-size replicas to enhance the illusion[147].

Figure 31 Battle of Gettysburg Cyclorama (Paul Philippoteaux, 1883)

Patrons of the exhibition were treated to a spectacular audio-visual experience, giving them the impression of being in the centre of the action. While it was static, it was enlivened by the use of mirrors, magnifiers and battleground sound effects[148]. By 1891 there were five cycloramas operating in Australia, one each in Adelaide, Launceston and Sydney, and two in Melbourne[149].

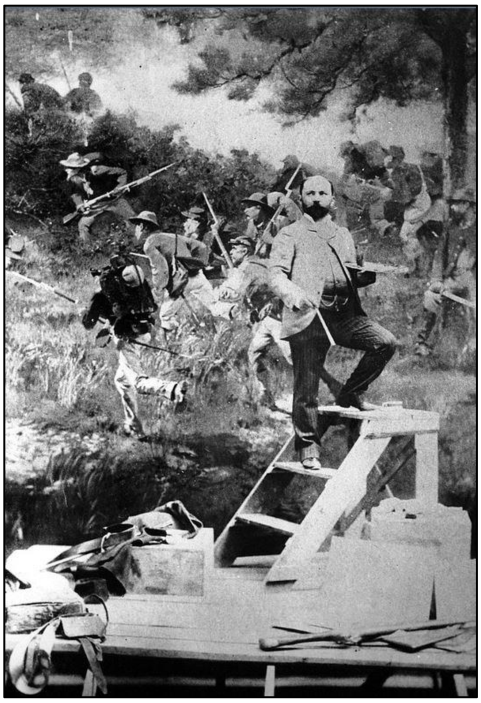


Figure 32 Paul Philippoteaux, c1883 (Gettysburg National Military Park)

In July 1895, the Cyclorama closed for two months to change the exhibition[150]. It reopened in September with a new exhibition (that was recently shown in Adelaide) representing Jerusalem at the time of the Crucifixion, featuring a daily lecture and musical effects[151]. By January 1900, the new-fangled Cinematograph and a series of ''illusions" were added as a sideshow to the exhibition[152]. The Battle of Gettysburg exhibition returned in January 1905, along with films and other sideshows[153].

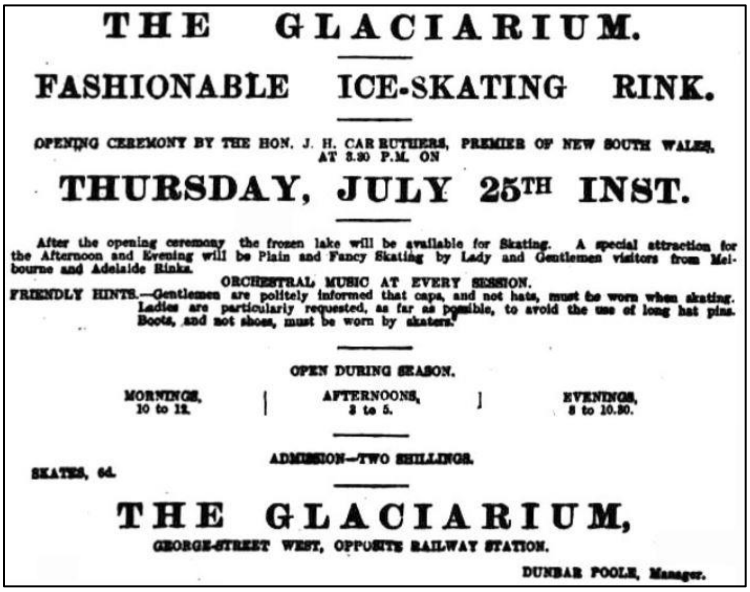
However, Cycloramas struggled financially during the 1890s economic depression, and their realism was challenged soon afterwards by the advent of motion pictures[154]. In July 1906, the management of the Sydney Cyclorama announced that it would close the following month. It was claimed that the great battle scene, which originally cost £10,000 to stage, was seen by over 800,000 patrons during the eighteen years it was on exhibition. It eventually featured new moving pictures, illusions and descriptive songs[155].

The venue finally closed in August and the giant oil painting of the Battle of Gettysburg was sold to a New Zealand company[156].

Glaciarium

The Sydney Glaciarium was the first indoor ice skating venue in New South Wales. It was constructed on the site of the former Cyclorama near Railway Square (originally known as Central Square). A proposal for the Sydney Glaciarium at 849 George Street was published in November 1906, stating that it would include an ice skating surface of 180 feet by 80 feet with coiled pipes containing brine covered in 6 inches of water ice[157].

It was opened to the public by Premier Joseph Carruthers in July 1907 in front of an estimated 200 spectators. After the first season finished in November, a wooden floor was put down to use the venue for other purposes in the warmer months[158]. Thomas James West secured the venue for the screening of films that summer[159].


THE GLACIARIUM.

FASHIONABLE ICE-SKATING RINK.

OPENING CEREMONY BY THE HON. J. H. CARRUTHERS, PREMIER OF NEW SOUTH WALES, AT 3.30 P.M. ON

THURSDAY, JULY 25TH INST.

After the opening ceremony the frozen lake will be available for Skating. A special attraction for the Afternoon and Evening will be Plain and Fancy Skating by Lady and Gentlemen visitors from Melbourne and Adelaide Rinks.

ORCHESTRAL MUSIC AT EVERY SESSION.

FRIENDLY HINTS.—Gentlemen are politely informed that caps, and not hats, must be worn when skating. Ladies are particularly requested, as far as possible, to avoid the use of long hat pins. Boots, and not shoes, must be worn by skaters.

OPEN DURING SEASON.

MORNINGS, 10 to 12. | AFTERNOONS, 3 to 5. | EVENINGS, 8 to 10.30.

ADMISSION—TWO SHILLINGS.

SKATES, 6d.

THE GLACIARIUM,

GEORGE-STREET WEST, OPPOSITE RAILWAY STATION.

DUNBAR POOLE, Manager.

Figure 33 Glaciarium opening, 1907 (*Sydney Morning Herald*, 20 July 1907)

Ice hockey matches between Victoria and New South Wales representative teams began almost immediately, from August 1907[160]. In the second ice skating season, plans were drawn to facilitate ice hockey matches between an Australian team made up of Glaciarium patrons and teams drawn from the crews of various visiting American warships that were part of the Great White Fleet. Though the Americans had not been on skates for three years, they beat the Australians 5-1 in the first match in August 1908[161].

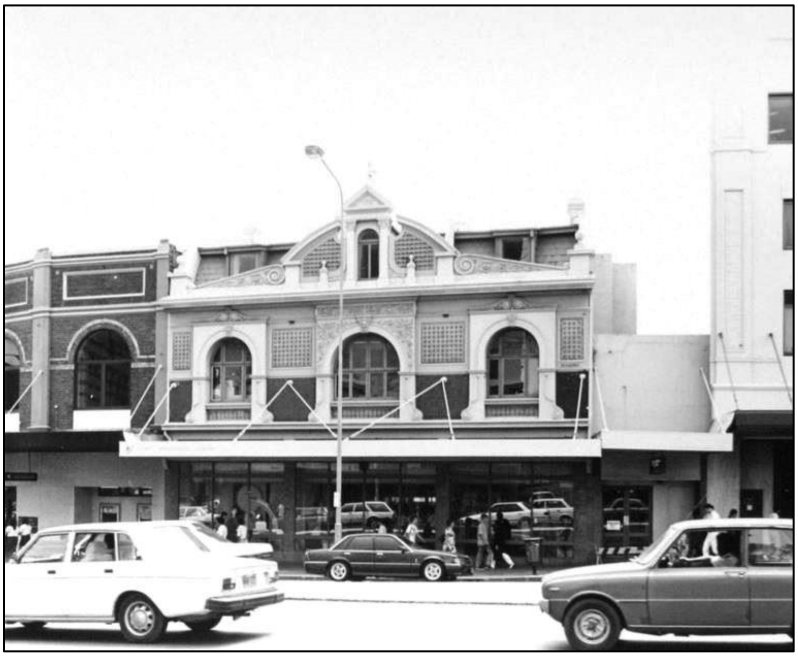


Figure 34 Sydney Glaciarium, 1989 (City of Sydney Archives)

The Americans played with much larger hockey sticks than the Australians[162]. They later visited Melbourne where they played a local team. As the Americans were short of two players, each team played with five men a side, and this played an important part in establishing the codified version ice hockey in Australia[163]. The rink was sometimes leased by circuses, and a damaged or warped floor was reportedly caused by an elephant[164].

The rink was built over the freezing plant of the Sydney Cold Stores (located next door at 702-720 Harris Street), which provided the ice surface and heated the seating and service areas. The original management, South Pole Ice Rink Limited, was absorbed by Sydney Cold Stores Limited in 1920 when the rink reopened after World War I[165]. The Glaciarium building, with a seating capacity of up to 1500 people, was designed in the Federation Freestyle with Anglo-Dutch influences, and at the time was considered something entirely new to the people of Sydney.

The skating rink was closed in 1955, after which it housed Technocity, a group of computer and technology retailers. All but the façade has now been demolished and a multi-storey apartment block constructed, to provide accommodation for students at the nearby University of Technology Sydney. The George Street frontage is heritage-protected as a place of high architectural significance, due in part to its connection to ice skating history[166].

Royal Ice Palais

The Royal Hall of Industries was constructed by the Royal Agricultural Society in Driver Avenue, Moore Park, opening in February 1913. Designed in the Federation style of the day, the interior is a huge, bright space of 5,400 square metres, with a striking vaulted ceiling and natural light flooding in through cathedral windows[167]. The hall was intended as an exhibition space during the annual Royal Easter Show, then as a roller skating venue for the rest of the year.

From September 1920, the hall was transformed into a popular summer dance hall known as the Palais Royal, directed by George C. Irving, a business partner of the Canadian skater and entrepreneur James Bendrodt[168]. The venue continued to be used as a dance hall until it closed in 1937.

In June 1938, James Bendrodt reopened the Hall of Industries in Moore Park as the Royal Ice Palais ice skating rink, managed by Mr. Dunbar Poole, who was formerly the manager of the Sydney Glaciarium from 1907 to 1931. The venue had been completely transformed with murals decorated with mountain scenery and a star-studded blue ceiling[169]. After arriving in 1910, Bendrodt prospered as a trick skater in Sydney and on country tours with his business partner George Irving. Appointed manager of the new Imperial Roller Rink in Hyde Park, he soon fostered an exclusive and decorous image that was to characterise all of his enterprises[170].

Figure 35 Royal ice Palais reopening, 1941 (*Sydney Morning Herald*, 30 March 1941)

The ambitious James Bendrodt had big plans for the new ice rink, and he invited the Ice Hockey Association of New South Wales to prepare plans for a season of ice hockey matches once a week. As well as public skating, the Ice Palais Figure Skating Club would entertain and amaze the visitors with demonstrations of trick and formation skating[171]. Overseas ice skating champions would be brought out to give exhibitions of new skating techniques to entertain local ice skating enthusiasts[172].

At the end of the ice skating season in October 1941, the Hall of Industries was given over to the wartime military authorities, and the 2nd Military District Finance Office commenced operation in March 1942[173]. The Army used the hall until October 1946, when it was handed back to the Royal Agricultural Society to resume peacetime use. The Royal Ice Palais also resumed operation after the war, and by August 1948 was again advertising the attraction of Billy Romaine's music[174]. However, the venture only lasted until 1952, when the hall was closed and the plant and equipment sold[175]. The Ice Palais Pty Ltd filed for bankruptcy in 1954[176].

Prince Alfred Park

When the Glaciarium closed in 1955, Sydney was reportedly left without an ice rink[177]. When the old Exhibition Building in Prince Alfred Park was demolished in 1954, plans were drawn up for a new swimming pool complex on the site. The initial plan was to use the pool for swimming in summer and then ice it over for winter skating[178], and there was no separate ice rink in the first plan in 1954. But this must have been too expensive, as a separate ice rink appeared in later plans for the project. An open-sided roof with a windbreak of moveable fibreglass panels was also planned for the skating rink, but this was not built at the time[179].

The two pools (main and wading) were built at the same time as the skating rink, and both were officially opened in December 1958 by the Lord Mayor Alderman Henry Jensen[180]. The skating rink was open for public use at the start of the next winter in June 1959[181]. But the uncovered rink was always at the mercy of strong winter winds and rain, making it almost impossible to maintain a good skating surface. The City Council was unwilling to spend the estimated £50,000 on a cover (with a windbreak) as originally planned, after already spending £74,000 to construct the rink[182]. The skating rink was closed for a few days soon after it opened due to bad weather[183].

In 1975, the Sydney City Council selected Noel (Pat) Burley, founder of Burley's Ice Rinks, to cover the rink with a roof, making it possible to open all year. The newly-covered rink reopened in October 1976. The ice in the rink was kept at a significantly lower temperature than most outdoor rinks, allowing a much harder and faster skating surface. The new roof enabled much more reliable programming of ice hockey games, training and recreational skating, as bad weather or hot days no longer led to rescheduling of activities[184].

Figure 36 Prince Alfred Park ice rink, 1961 (City of Sydney Archives)

The rink was advertised as Pat Burley's Iceland, completely weatherproof and open all year[185]. Burley was the architect of ice hockey in Australia during the late 1970s, and the Sydney All Stars ice hockey team played at the Prince Alfred Park rink[186]. The skating rink closed in 1985, became derelict and was demolished in about 1993[187]. The site was then grassed over to become a part of the current swimming pool surroundings.

Settlement of remote areas

Refrigeration allowed the settlement of areas not on the main transport channels of rivers, harbours and valley trails. Cities were able to exist in inhospitable areas, such as Houston and Las Vegas in the United States.

Across rural regions of Australia, the refrigerator was designed to support families who were largely dependent on food they had grown or slaughtered themselves. Without refrigeration, they were assured only intermittent or irregular supplies of perishable foods. Many remote farms were often a long distance from electrification or a cold chain.

The kerosene refrigerator was the great invention that facilitated territorial expansion in Western and Central Australia, as a reliable electricity supply was not necessary to keep food cold. A refrigerator reduced the improvisations needed to keep food safe in remote areas, such as scalding milk or parboiling meat. Meals could also be prepared in advance and kept cold until required[188].

Liquefaction of industrial gases

Liquefaction of gases is the physical conversion of a gas into a liquid, usually by condensation. It is a complex process that uses various compressions and expansions to achieve high pressures and very low temperatures. Liquefaction is used for scientific, industrial and commercial purposes, and is one of the major benefits of refrigeration technology in today's world.

Many gases can be liquefied by simply cooling at atmospheric pressure, while a few, such as carbon dioxide, require pressurisation as well. Liquefaction is commonly used for the storage of gases, for example the widely-used fuel LPG (liquid petroleum gas), and in refrigeration and air conditioning. Ammonia was one of the first refrigerant gases, and is still in widespread use in industrial refrigeration. It can be transported in liquid form in pressurised or refrigerated vessels.

Liquid oxygen is also transported to hospitals for conversion to gas for patients with breathing problems, and liquid nitrogen is used in the medical field for cryosurgery (which is the use of extreme cold to destroy diseased tissue, especially skin conditions). Liquid chlorine is transported for eventual solution with water to use in water purification, bleaching of textiles, and the manufacture of numerous organic compounds.

Air conditioning

Air conditioning is the process of removing heat from an enclosed space to achieve a more comfortable interior temperature, and in some cases also controlling the humidity of internal air. Heat pumps are similar to air conditioners, but use a reversing valve to allow them to both heat and cool an enclosed space, as required. Air conditioners typically use vapour-compression refrigeration, and range in size from small units used in vehicles or single rooms to massive units that can cool large buildings.

Passive techniques for cooling buildings, such as double walls with air flow between[189], remained widespread until the twentieth century when they were replaced by powered air conditioning. However, the high cost of operating air conditioners has led to passive techniques being revived and modified for twenty-first century architectural designs[190].

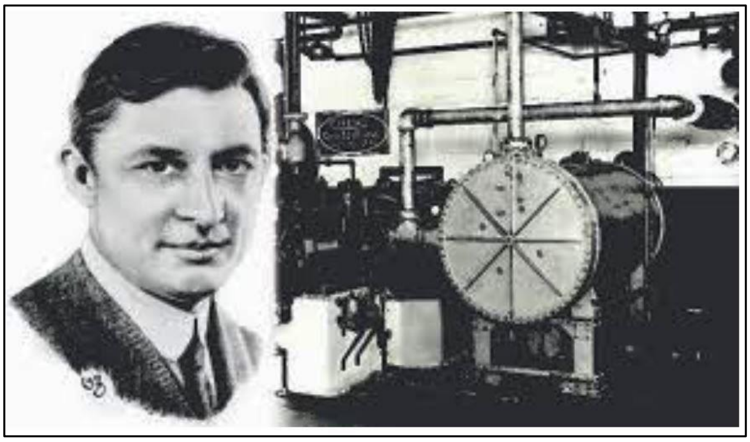


Figure 37 Willis Carrier (World Creative Science Academy)

The first modern electrical air conditioning unit was built in 1902 by the American inventor Willis H. Carrier[191], who installed his first air conditioning system in a lithographing and publishing company in New York[192], to help maintain consistent paper dimensions and ink alignment at the printing plant. He later formed the Carrier Air Conditioning Company, which by 2020 employed 53,000 people[193].

In hot weather, air conditioning can prevent heat stroke, dehydration, kidney failure and other issues due to hyperthermia. Heat waves are the most lethal type of weather phenomenon in the United States[194] and elsewhere.

Air conditioning is a major user of electric power worldwide, and there is some push by the United Nations to increase the energy efficiency of air conditioners[195]. The International Energy Agency estimated that cooling buildings uses about 20% of the total electricity used in the buildings, or about 10% of global electricity consumption[196].

Refrigerants have also caused and continue to cause serious environmental issues, including ozone depletion and climate change, as several countries have not yet ratified the 2016 Kigali Amendment to the 1987 Montreal Protocol (on Substances that Delete the Ozone Layer) to reduce the production and use of hydrofluorocarbon refrigerants[197].

Improvement of existing processes

The ability to preserve perishable food for longer, to produce cool drinks in hot weather and to transport temperature-sensitive pharmaceutical products are probably the most widespread benefits of refrigeration. But there are particular areas of industry that produce much improved goods if refrigeration is made available to part of the production process.

A cooling tower is an industrial device that rejects waste heat to the atmosphere through the cooling action of a coolant stream, usually a stream of water, to a lower temperature. Common applications include the circulating water used in oil refineries, petrochemical and other chemical plants, thermal power stations and nuclear power stations.

Brewing

For the first hundred years of the colony of New South Wales, the lack of refrigeration meant that brewing was a very precarious business. All sorts of things could go wrong in the brewing process, so poor quality and waste predominated. Brewers did not know why beer production was so unreliable, as there was little understanding of the causes of why beer would vary so much from batch to batch, producing so much wastage.

The main problem was that British brewing methods, transported to Australia, were not suitable for the warmer climate here. The “top” fermentation process that was used in Britain suited cooler climates, where the combined ingredients were ideally fermented at 7°C. There were also problems in the early colony with transporting beer from the breweries to the pubs. Beer had to be sent out in sweltering heat on horse-drawn carriages, often over bumpy roads and dirt tracks. It frequently deteriorated under these conditions, only to be returned to the brewer by the disgruntled publican.

By the 1850s and 1860s, a change in drinking preferences started to emerge, especially in the United States and Germany. People began to favour a new style of beer called lager: it was lighter, less intoxicating, more gaseous and better-conditioned than ales and porters. Lager was a beer that was much more suited to hot Australian conditions where men often wanted a long drink rather than a strong one. The *Australian Brewers’ Journal* in the January 1886 edition referred to lager as the beer of the future: they predicted that in this hot country, people will prefer their beer cold, full of gas and a long drink for their money.

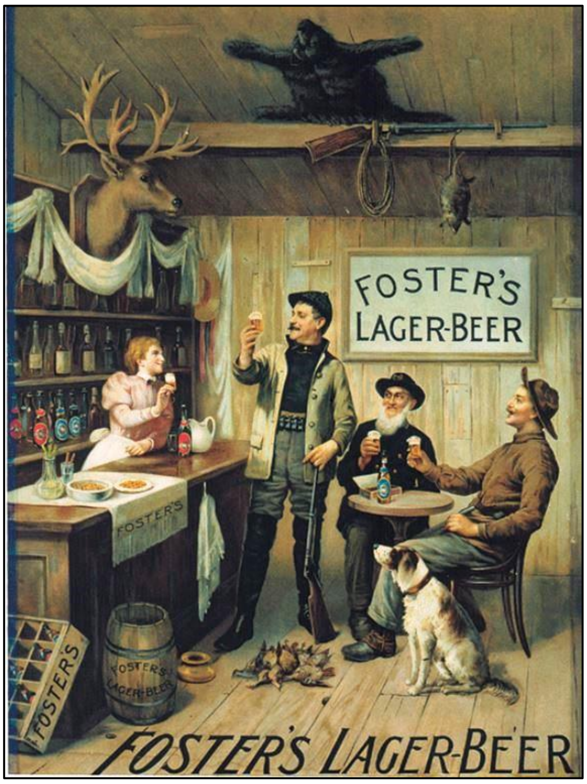


Figure 38 Foster's Lager (Australian Beer Posters)

But they pointed out that to achieve this, the beer must be packed in ice and the temperature kept down from the start of fermentation until it was handed to the thirsty customer. James Harrison from Geelong had some early success with mechanical refrigeration using the ether compression method, when a refrigerator based on his design was installed in a brewery at Bendigo in 1860[198].

But lager was slow to gain acceptance, and it was only when the Foster brothers arrived in Melbourne from New York and started production of Foster’s Lager in November 1888 that it took off. They built an ultra-modern lager brewery in Collingwood, installing lager brewing machinery and an ice-making plant, all imported from the United States. The product was an instant success: the drinking public liked it and the quality was consistently good. Their success inspired other breweries to start making lager.

Louis Pasteur studied the French beer industry in the 1870s and discovered that the yeast contained bacteria and this was turning the beer sour at times. He suggested that a heat process he had developed for the wine industry would kill most of impurities and improve the reliability of beer making. Part of the secret of Fosters Lager's success was the pasteurisation process of immersing the beer in hot water after it was bottled. Since the 1930s, virtually all beer produced in Australia has been lager, so the predictions in the *Australian Brewers' Journal* have come about[199].

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