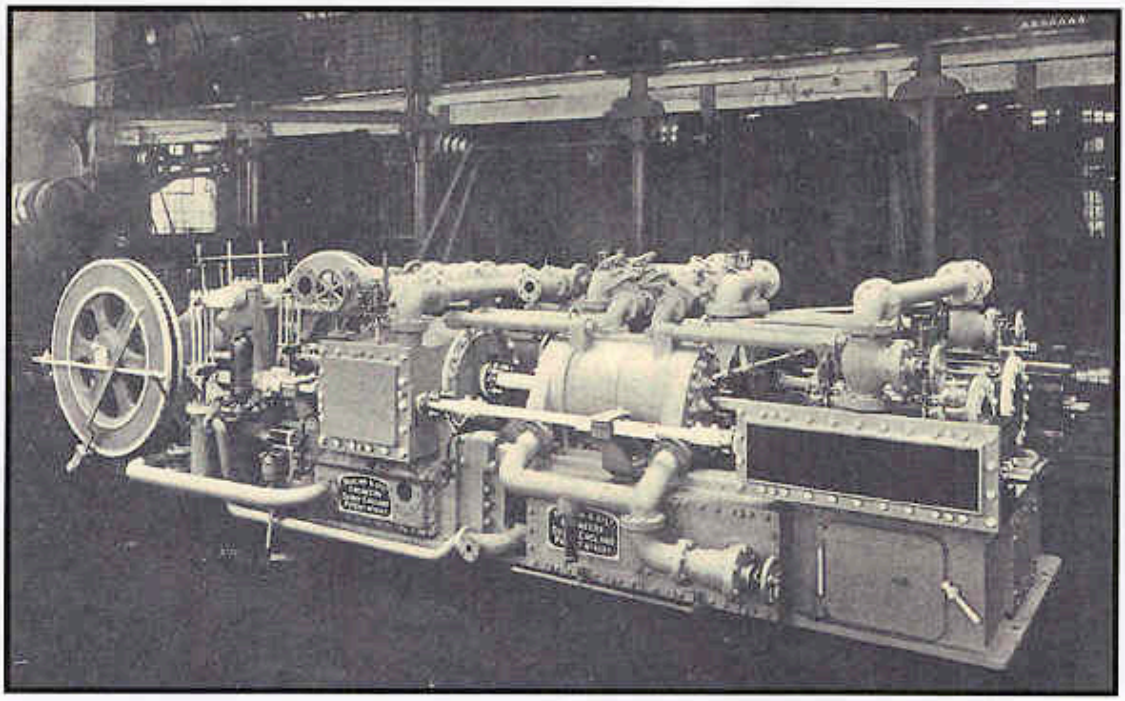
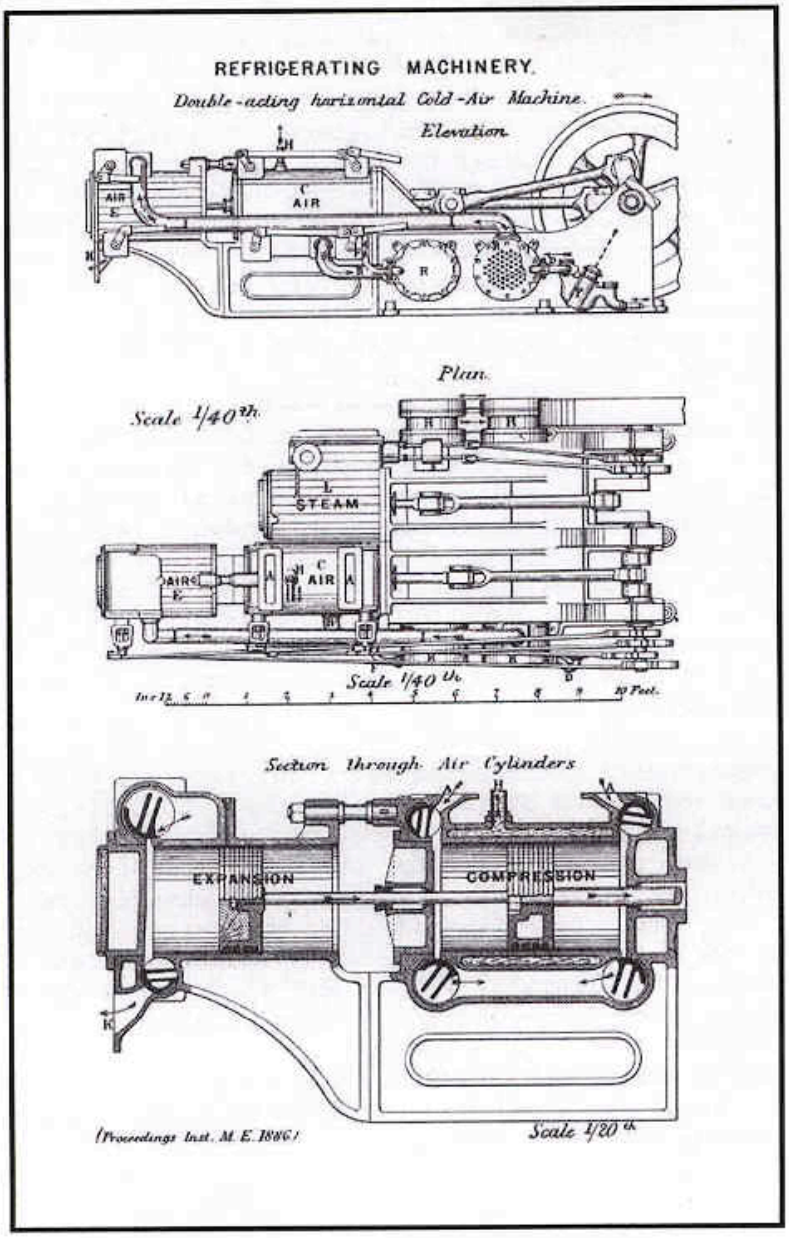


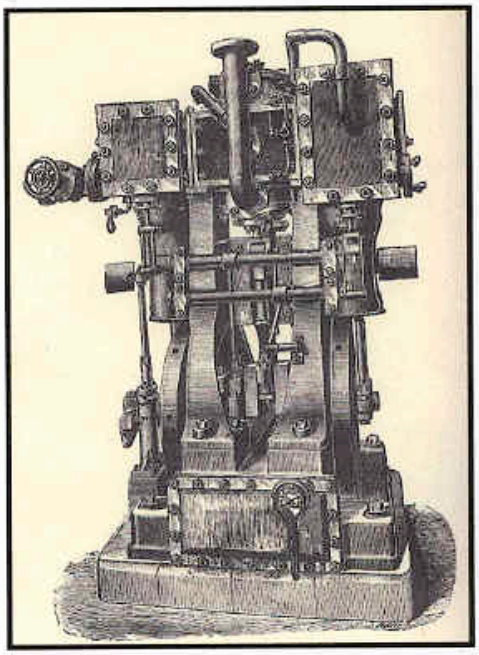
Cold air machine driven by a horizontal steam engine (duty about 170,000 cubic ft/h of air at –65 deg F and requiring about 290 hp) Haslam c.1900.

Cold Air Refrigerating Machines

The steam engine pioneer Richard Trevithick explained the working principles of a cold-air machine in 1828. Prototype machines were made by Gorrie (1844) in the USA, by Kirk (1862) in Britain and by Giffard (1877) in Paris. Commercial manufacture began in England when J & E Hall decided to use the Giffard patent. However, the more successful machine was that produced in Scotland by Bell-Coleman, patented in 1877. Other manufacturers included Haslam, Lightfoot, Siebe Gorman and T & W Cole. The Bell-Coleman machine was widely adopted for use on refrigerated ships. Land applications were mainly for cold stores. By around 1900, cold air machines had fallen in disuse, being largely replaced by the carbon dioxide compression system of J & E Hall.

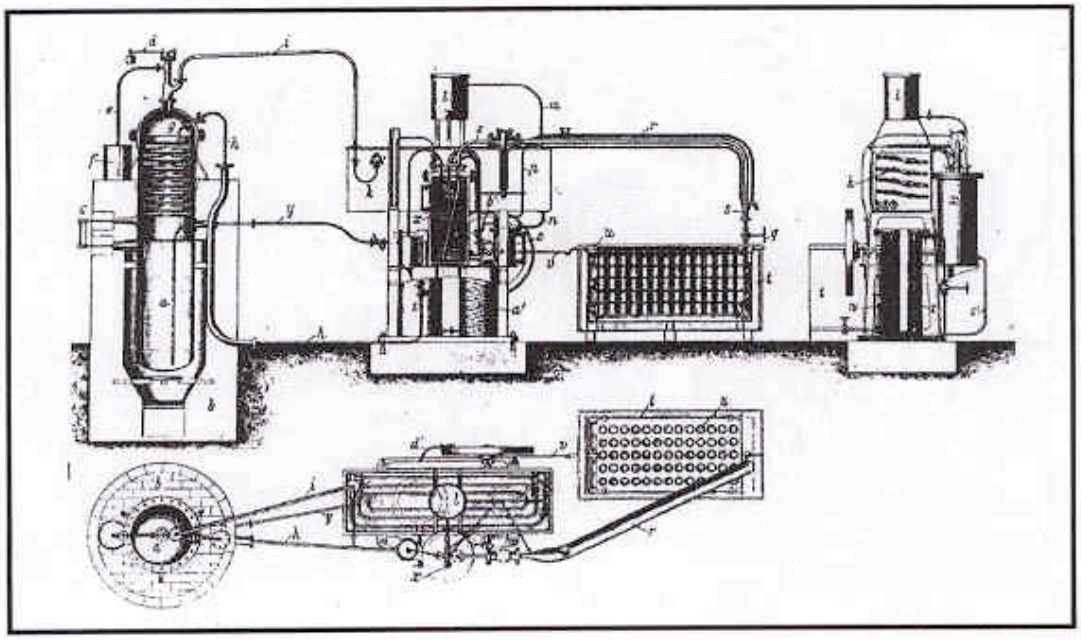


Lightfoot cold-air machine, 1886



Vertical pattern cold-air refrigerating machine (about 5000 cu.ft/hour) Haslam type c.1895.

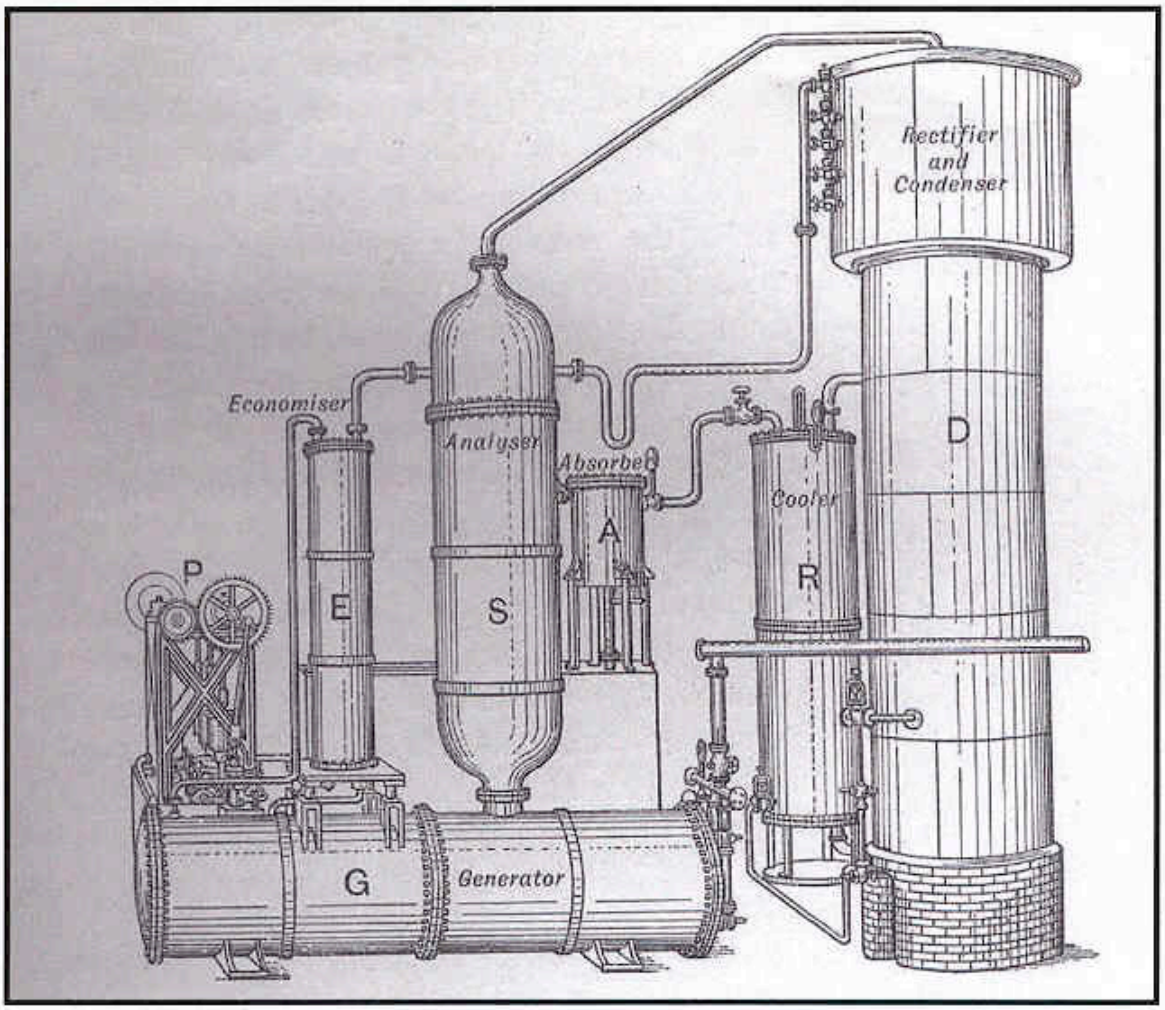
These early machines worked by compressing air (and partly cooling it by water injection), cooling further in a water cooled receiver and then expanding it to a lower pressure which produces a cooling effect.



Ferdinand Carré's continuous absorption machine, 1859. Built commercially by Mignon & Rouart, Paris in a range of sizes to produce 12 to 100 kg of ice..

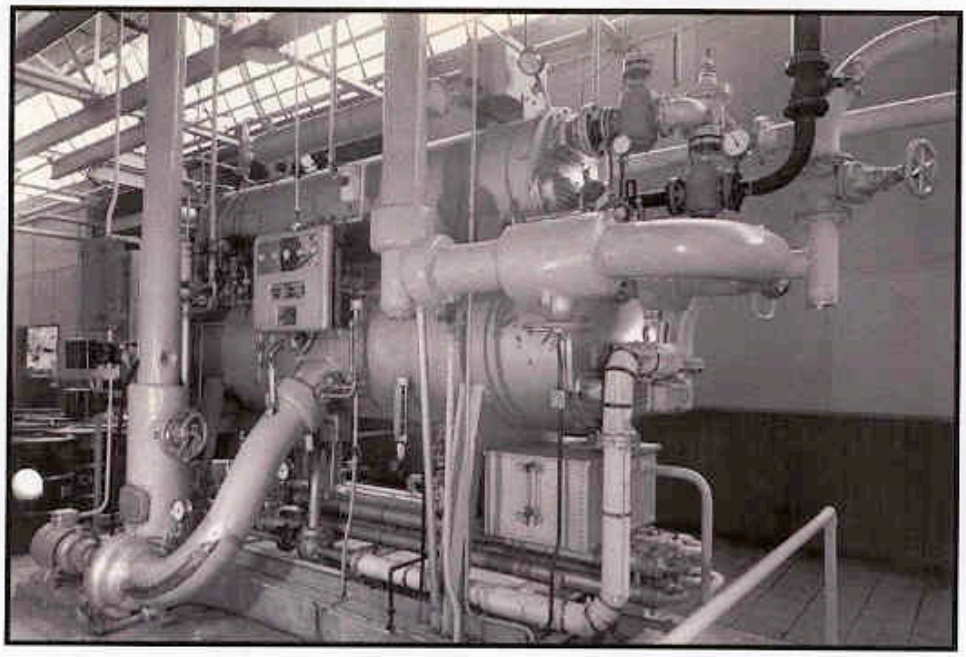
Absorption Refrigerating Machines

The first absorption machine was introduced in France in 1859, being later manufactured in Great Britain by Reece and Stanley, who improved it, the latter replacing the naked flame heater by a steam heater in 1875. Pontifex & Wood of London installed a machine at Meux's London Brewery in 1876. Absorption machines proved to be very successful in the USA, less so in Britain, where the principal manufacturer was the Haslam Foundry of Derby incorporated with Pontifex & Wood. These used ammonia as the absorbent and water as the refrigerant. By the 1890s, the reciprocating compressor reigned supreme. The absorption unit regained some favour around the 1930s. The Italian engineer Guido Mauri, working in London in 1926, developed an absorption machine that was first used for the manufacture of solid carbon dioxide (dry ice). A development breakthrough came in the USA in 1945 when Carrier introduced large machines using lithium bromide in place of ammonia.



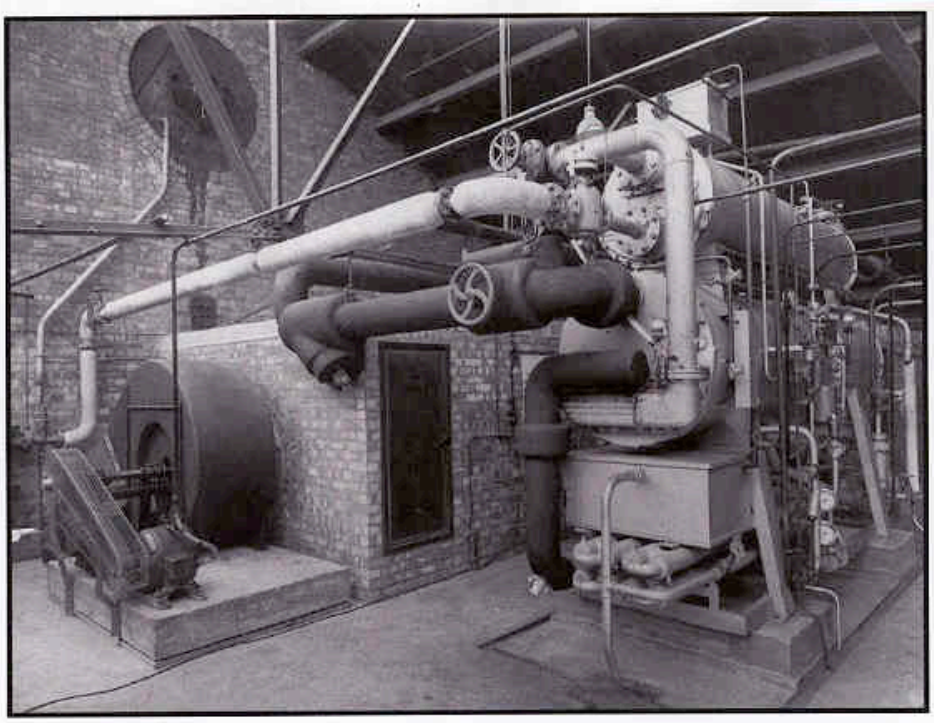
Ammonia absorption refrigerating machine made by Pontifex & Wood (later Haslam), probably c.1900.
In 1876 a similar machine was installed in Meux's London Brewery producing 25 tonnes of ice per day.

The absorption cycle relies on chemical solutions and external heat. It uses an absorption solution (absorbent plus refrigerant) that can absorb refrigerant vapour, and a refrigerant that boils (flash cools itself) when subjected to a lower pressure. Very early machines used ammonia as the absorbent. Water is sprayed into an ***evaporator R*** *maintained at a high vacuum, so that a portion of the water flashes into vapour and cools the remainder. The water vapour is then absorbed in the* ***absorber A*** *and the resulting solution is heated in the* ***generator G*** *to drive off the moisture. This is liquefied in the* ***condenser D*** *before returning to the evaporator.*
A ***heat exchanger E*** *is usually added to improve the efficiency of the cycle.*

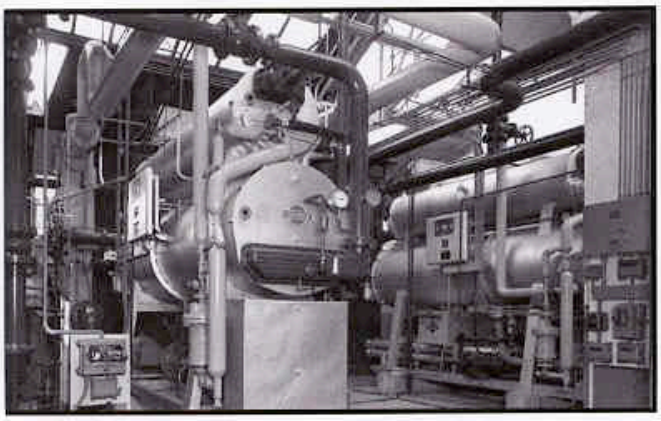


Experimental absorption type water-chilling machine built by Carrier Engineering Co, London. Installed at the factory of Mars Ltd, Slough in 1949 (Model 16B, capacity 150 TR).

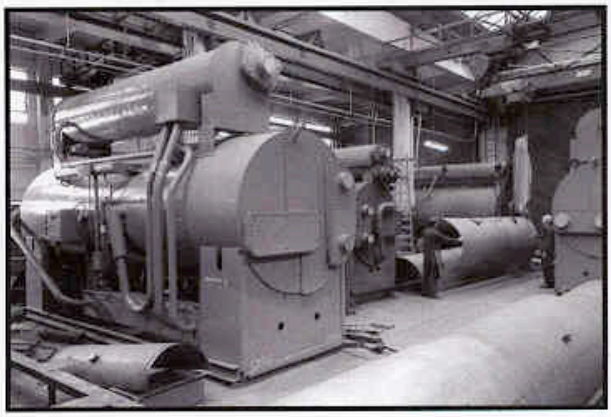
It was the post-war economic situation that led the UK Company, Carrier Engineering, to investigate producing the absorption machine in Britain. Before the war they had imported centrifugal machines from the USA, but this was no longer possible due to dollar exchange restrictions. The relatively small British market meant it was not an economical proposition to set up local centrifugal manufacture. It was decided to start manufacturing absorption machines based on the American design at their Wembley factory. An experimental machine was tested at Mars in Slough in 1949. The first true working installations were in 1950 at BBC, Lime Grove Studios and for the confectionery manufacturers, James Pascall at Mitcham. It was soon discovered that the "open circuit" design, which required external vacuum-tight connections, posed practical difficulties and by 1956 a "closed circuit" design that overcame these problems was developed. Production continued until the 1970s, a major air conditioning project being a 3000 TR installation at Hallamshire Hospital in Sheffield. From the mid-1960s, absorption chillers were marketed in the UK by York and by Trane. However, historical interest is centred on early machines by Pontifex & Wood and those manufactured by Carrier during the 1950s..



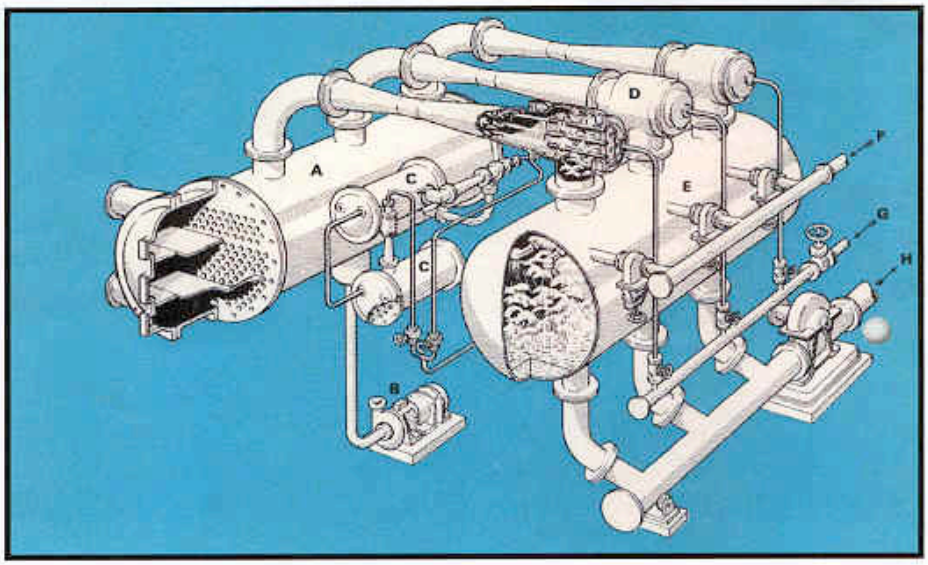
Absorption type water-chilling refrigerating machine built by Carrier Engineering Company, London. Installed at J Lyons & Co, Greenford, Middlesex, c.1950 (Model 16B, capacity 150 TR)



Absorption machine at James Pascall, Mitcham, Carrier type 16B, 1950s.



Absorption 16JA chiller production at Carrier, Wembley 1960s.

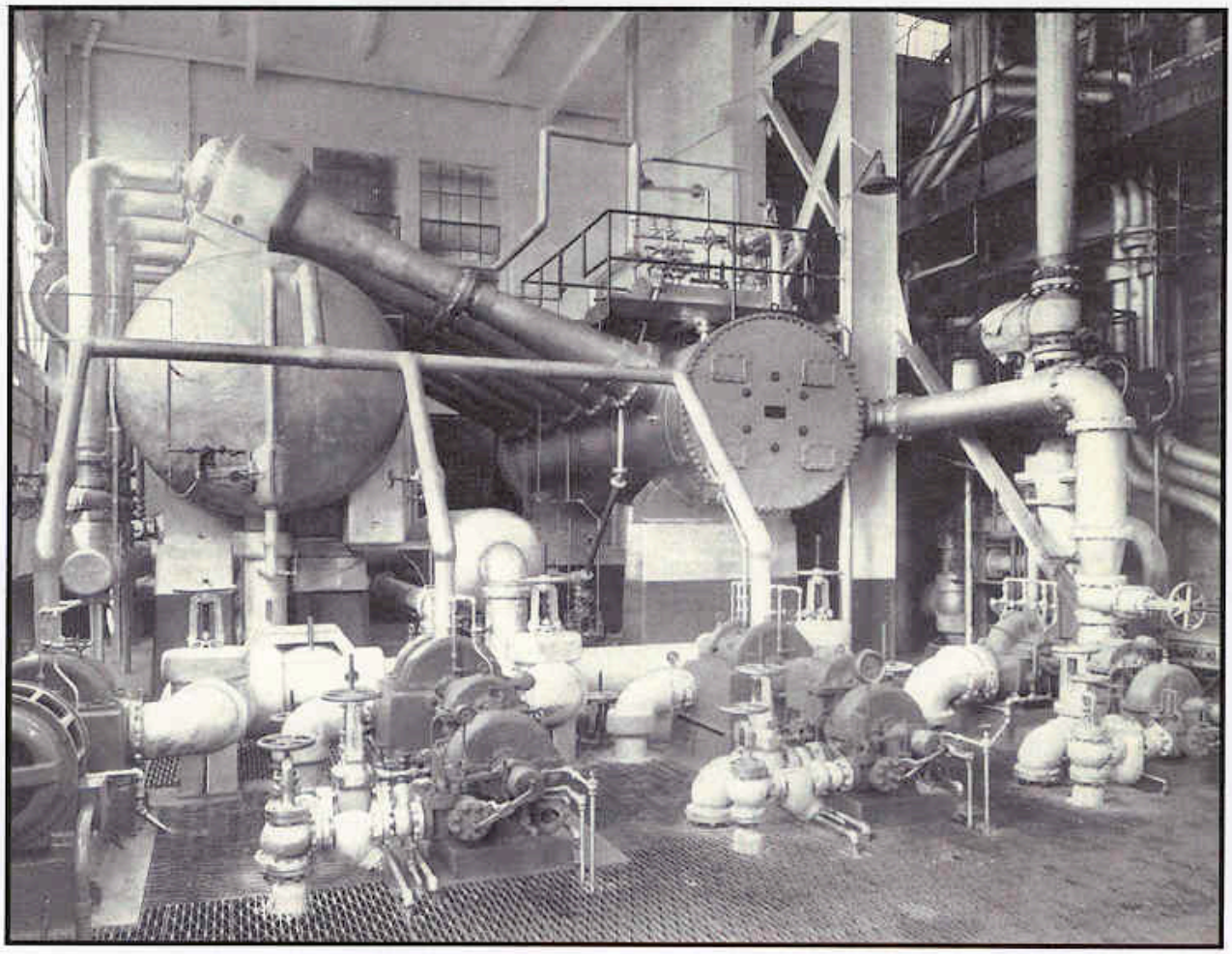


Steam-jet refrigeration unit, Foster Wheeler, c.1969
A condenser ***D*** *steam jets* ***E*** *flash chamber*

Steam-Jet (Vacuum) Refrigerating Machines

The possibility of using jets for the production of cold was envisaged in a patent of 1884. In about 1902, Charles Parsons (inventor of the steam turbine) worked on steam-jet cooling. Independently, the Frenchman Maurice Leblanc invented the steam ejector refrigerating apparatus in 1905 and, with Westinghouse, built the first successful machine in Paris in 1910. However, a great inconvenience was the large consumption of water, but the possibility of using waste steam weighed in its favour.

From around 1910, a number of machines were installed in breweries and chemical factories, but the First World War saw steam-jet apparatus installed in warships, particularly those of the French and Russian navies, for keeping magazines cool. A more efficient machine was developed in 1928 and attracted interest in the USA for producing cold water for a wide variety of industrial processes and a small number of air conditioning applications. American manufacturers included Elliot, Ingersoll Rand and Worthington. Carrier produced a small unit for air conditioning railway passenger coaches. As far as is known, the only British manufacturer was Foster Wheeler, their equipment being used for the air conditioning of the public rooms on the liners *RMS Queen Mary* and *RMS Queen Elizabeth*. Otherwise, steam-jet machines found only limited use after the 1930s and by the 1970s had almost entirely disappeared. It is doubtful if any are still operational in England.



Steam-Jet (vacuum) refrigerating plant, Foster Wheeler (830 TR) believed 1940s.

The system operates by injecting high-pressure steam through jet nozzles (top left), entraining water vapour from a flash chamber (below the nozzles), the mixture then being compressed by passing through a series of diffusers (running top left to centre) before being expanded into a condenser (centre). The heat lost in producing water vapour cools the water in the flash chamber, which operates under vacuum conditions.