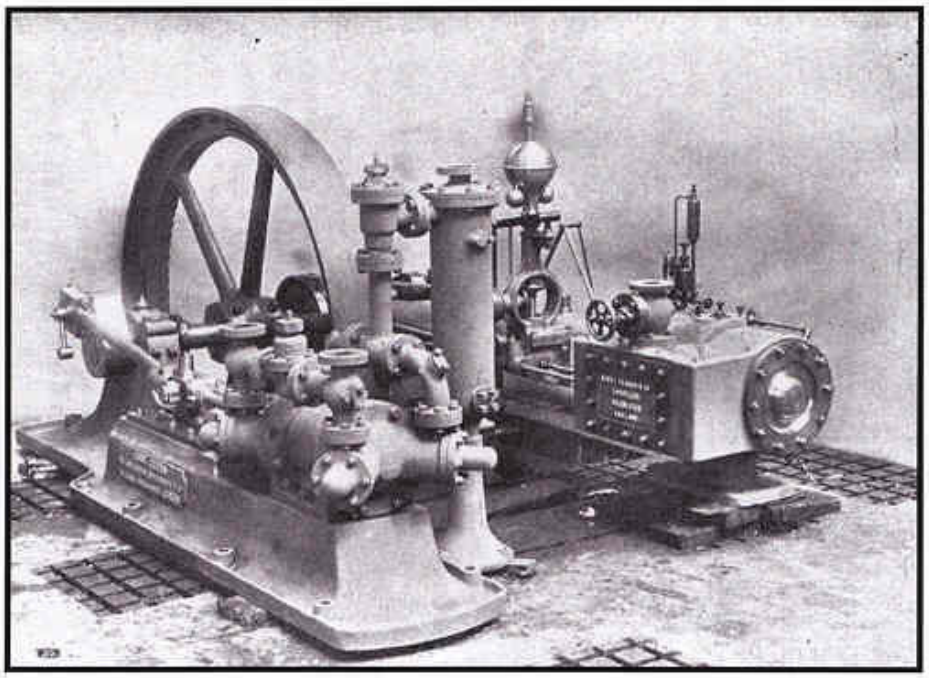
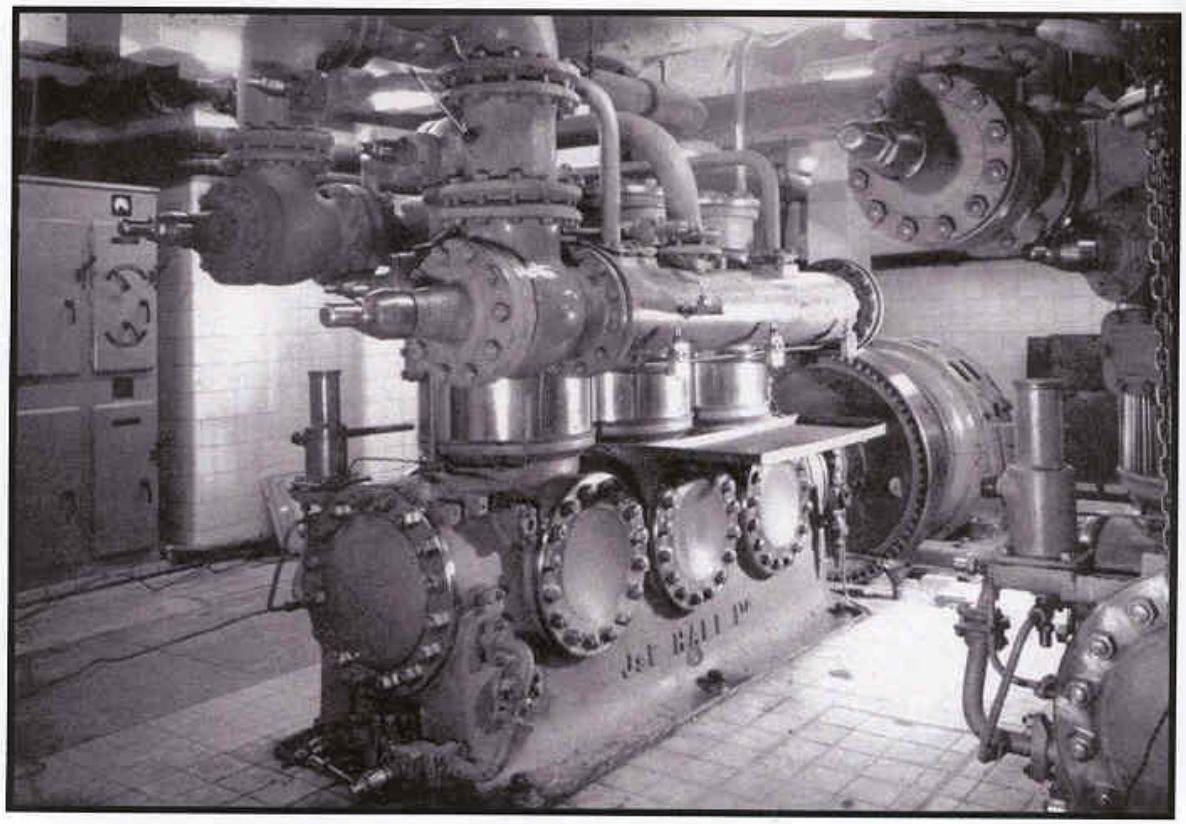


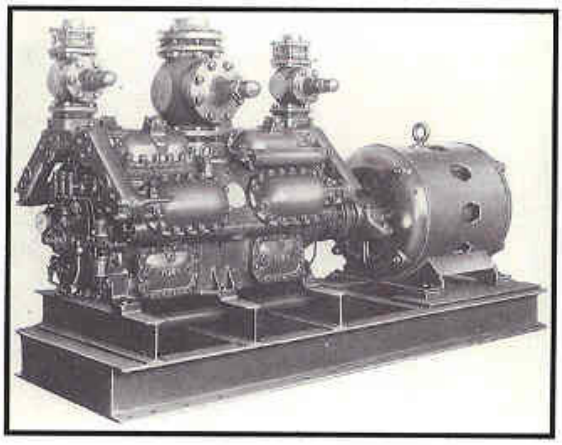
Linde steam engine driven ammonia compressor, early 1900s.

Reciprocating Refrigerating Machines

The prototype machine of Perkins was improved upon by Twining in the USA around 1850, but the first commercially produced machine was that of James Harrison. He was a Scotsman who had emigrated to Australia where he developed a small ice-making machine with a compressor using ethyl ether as the refrigerant. He obtained British patents in 1856 and 1857 and had the firm of Siebe Bros in London construct his machine. Another Scotsman, David Boyle, went to live in the USA where he obtained a patent in 1872 for a compressor using ammonia as the refrigerant. However, it was Professor Carl von Linde who is widely credited as being the inventor to the ammonia compressor, his first machine being constructed in 1876. He made important improvements over the next few years. In 1877, Linde erected a 100 TR plant in England. In 1885 the Linde British Refrigeration Company was set up to manufacture ammonia compression systems and went on to produce machines of different design to the German company.

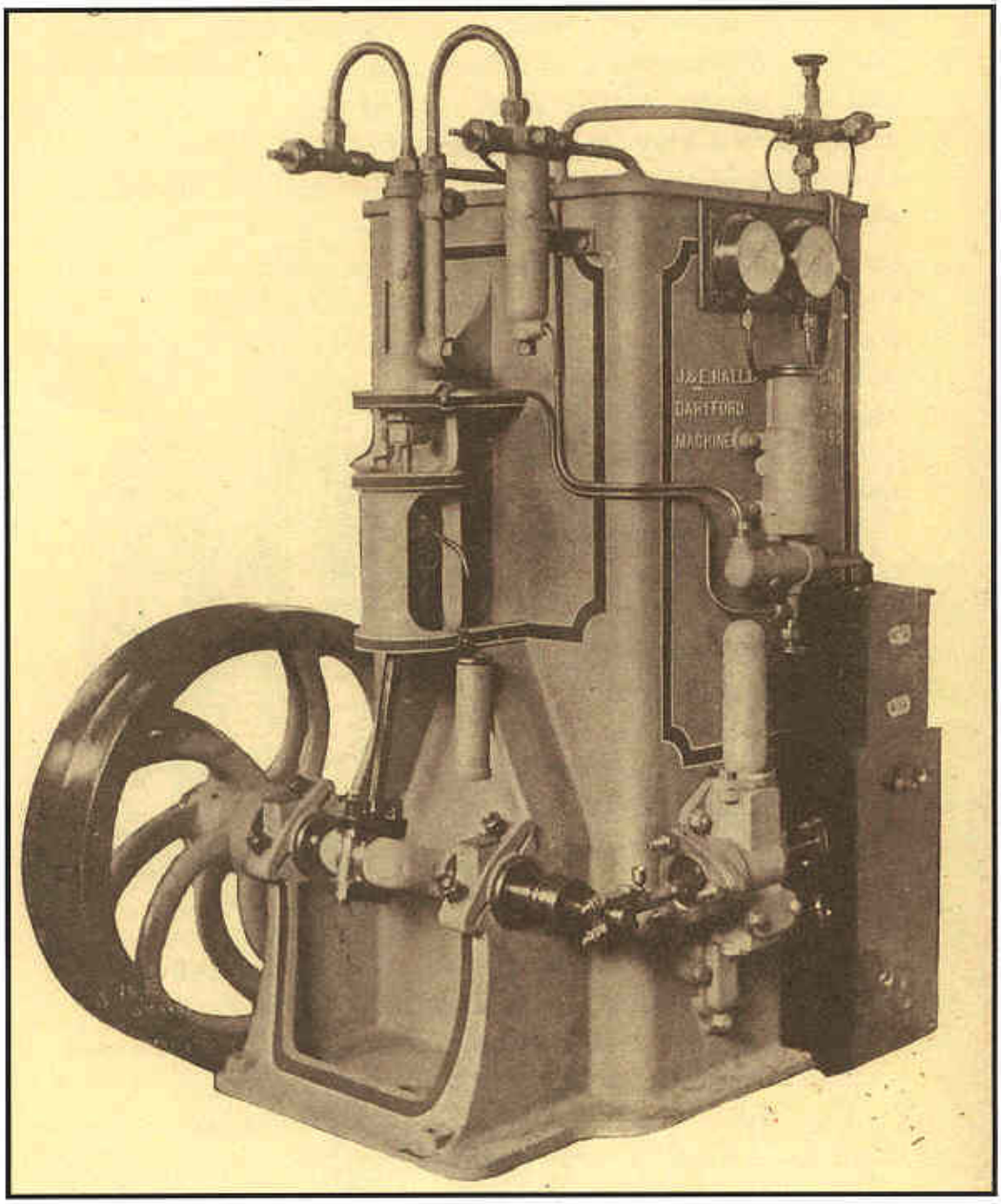


Two 3-cylinder reciprocating refrigerating compressors by J & E Hall, each driven by a 240 hp electric motor. The second machine is partly visible (extreme right). House of Commons air conditioning (Benham & Sons) 1951.

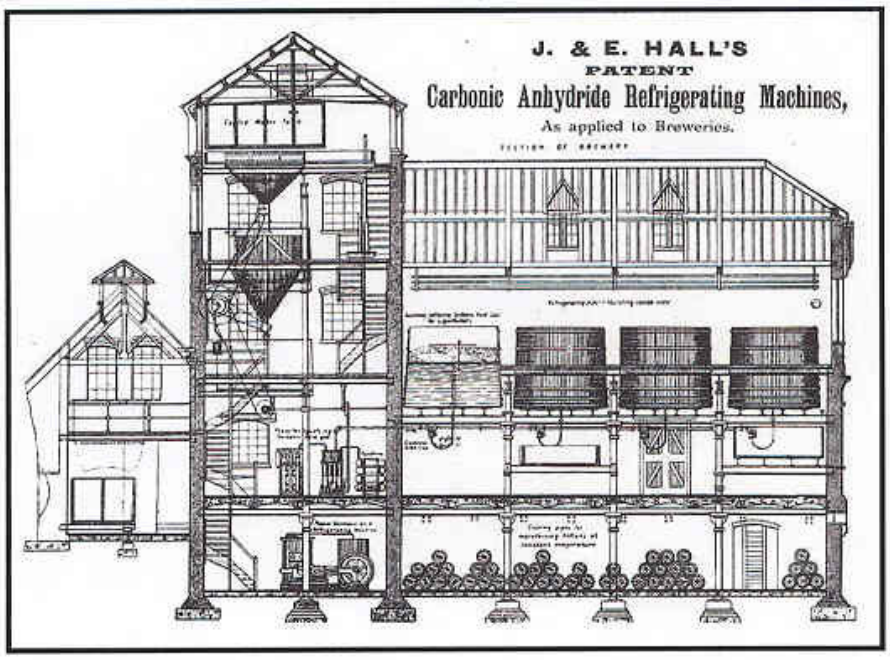


16-cylinder V/W arrangement, direct-drive reciprocating compressor (100 TR), York, 1956.

A mechanical compression machine utilises the evaporation of a liquid refrigerant to absorb heat and lower the temperature of its surroundings at the ***evaporator.*** *The* ***compressor*** *pumps this gas at high pressure to the* ***condenser*** *where the refrigerant vapour is liquefied and rejects heat to raise the temperature of its surroundings A throttling device or* ***expansion valve*** *meters the flow of refrigerant to the evaporator.*

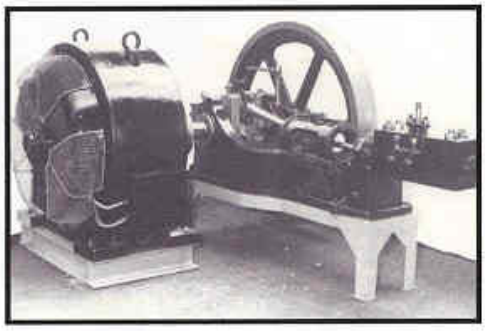


Carbonic Anhydride (carbon-dioxide) belt-driven land type compressor with the steam engine part of the machine itself. J & E Hall of Dartford c.1900

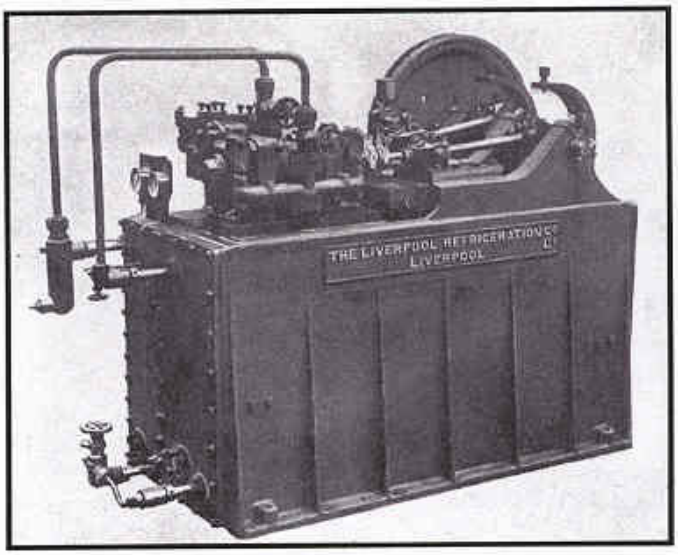


J & E Hall's carbon dioxide machines (lower left) used in a brewery

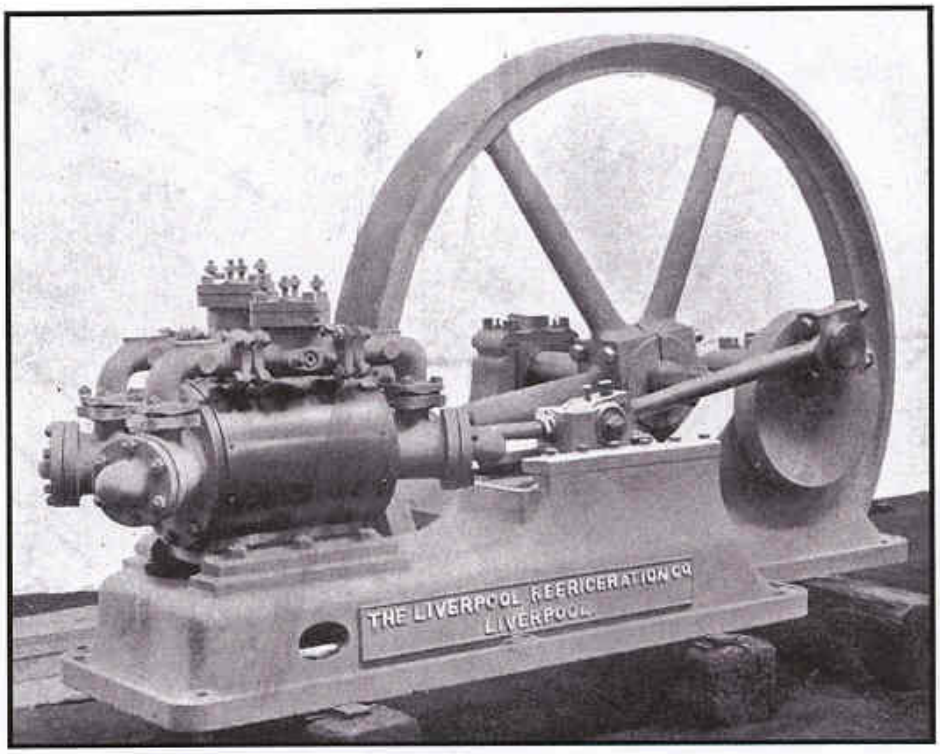
In 1887 J & E Hall acquired the manufacturing rights to the German carbon dioxide refrigerating compressor patents of Franz Windhausen. In 1889 a machine of this type was installed in a frozen meat store in Smithfield Market. On test it exploded. To avoid future accidents Halls invented a safety valve and modified the compressor design. This machine of Halls went on to dominate the refrigerated shipping market and found extensive use on land, particularly in breweries.



Single cylinder electric motor driven carbon dioxide compressor installed in a cold store in London's dockside Tooley Street, J & E Hall 1914.



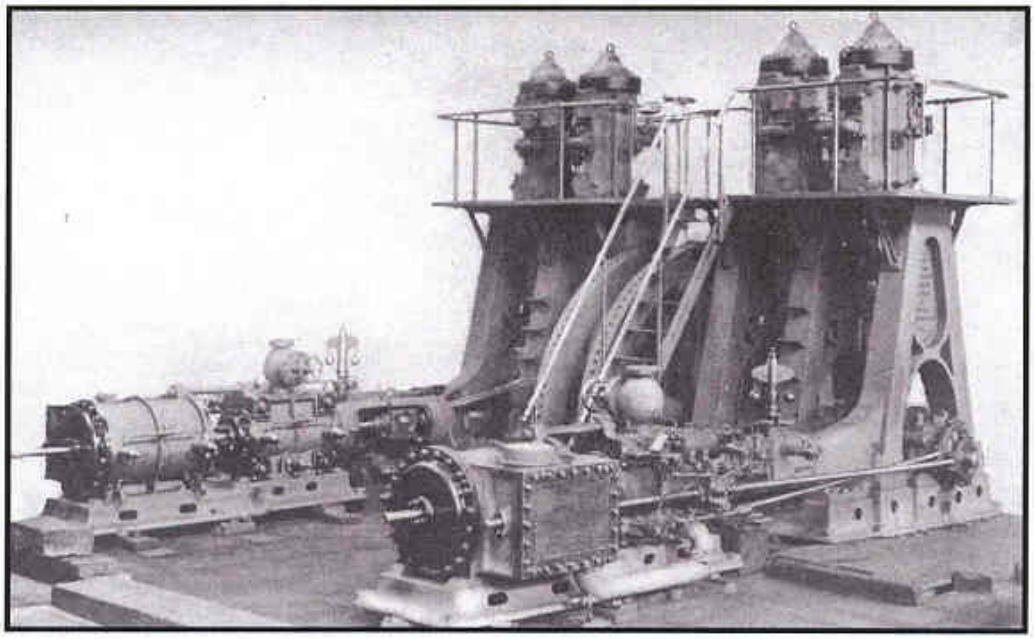
Submerged condenser unit (refrigerant coils in water tank), Liverpool Refrigeration 1908.



Belt-driven compressor, Liverpool Refrigeration 1908

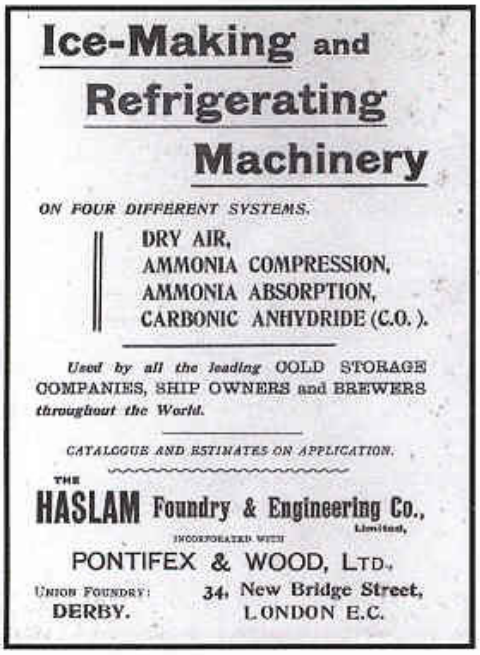
In 1874 Raoul Pictet of Switzerland designed the first sulphur dioxide refrigerating compressor. This type of machine proved popular in continental Europe. In England it was made by William Douglas & Sons from 1899 to 1926. (This firm later used compressors from the Vilter, the American manufacturer).

Another British manufacturer, from before 1890, was Louis Sterne in Glasgow, who initially used De La Vergne ammonia compressors in some designs. In the early 1900s, compressors were also manufactured by Haslam & Company in Derby, and by Liverpool Refrigeration.

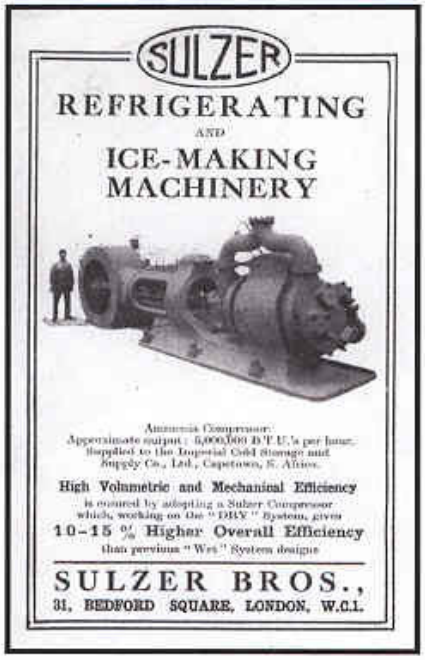


Two compound horizontal steam engines, each driving 2-vertical double acting De La Vergne ammonia compressors, L Sterne c.1900.

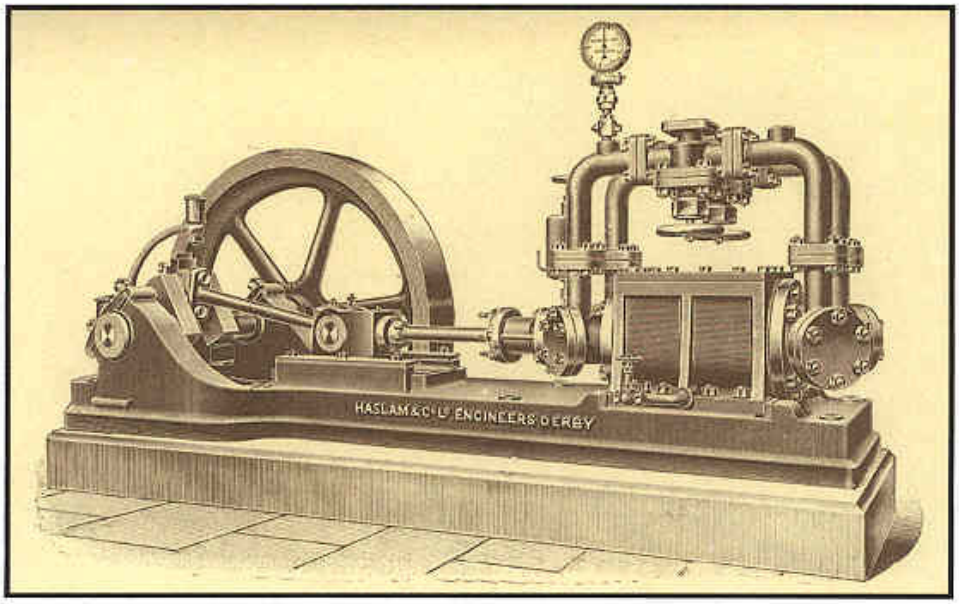
Early British compressors had horizontal cylinders while vertical cylinders were common in the USA. The first large compressors, driven by steam engines, operated at very low speeds, about 60 rev/min in 1900. They occupied considerable space but often lasted for fifty years or more. Gradually speeds increased, reaching over 200 rev/min by 1916. By the 1920s the steam engine drive had largely given way to electric motors and belt drive gave way to direct drive.



Haslam with Pontifex & Wood 1902



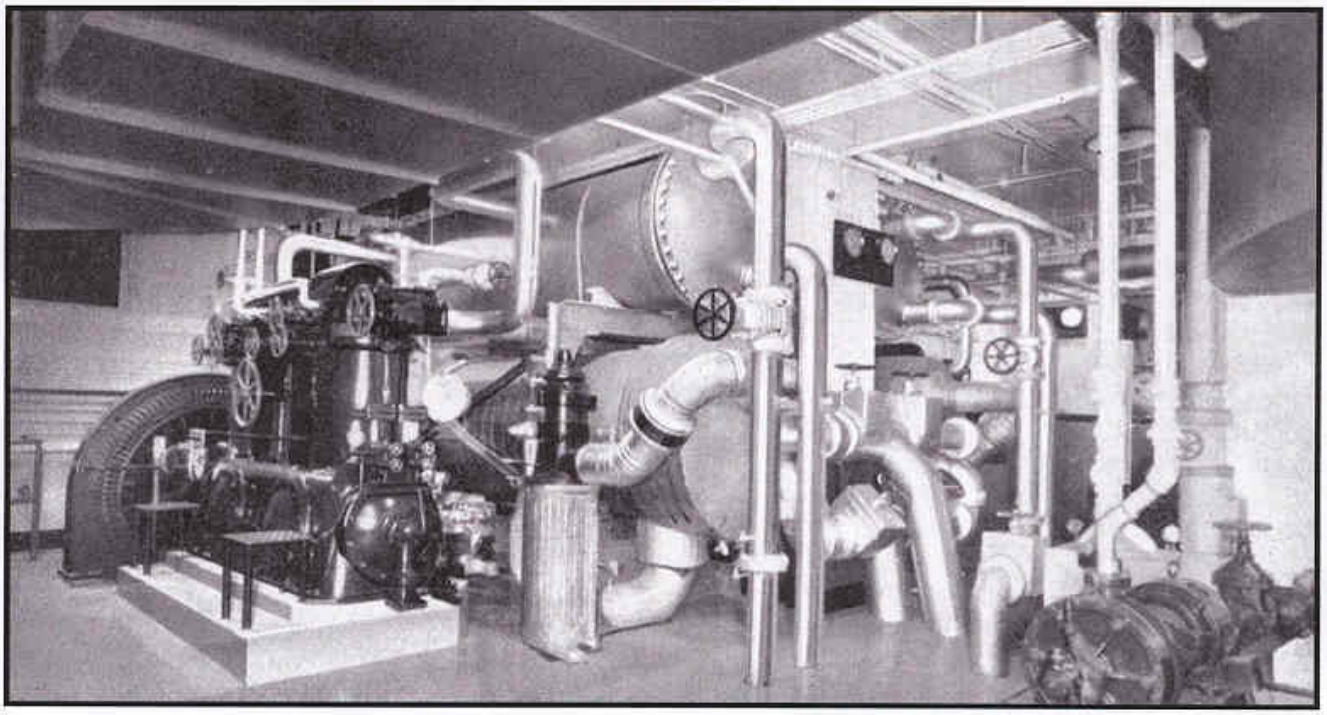
Ammonia compressor, Sulzer (410 TR) 1921



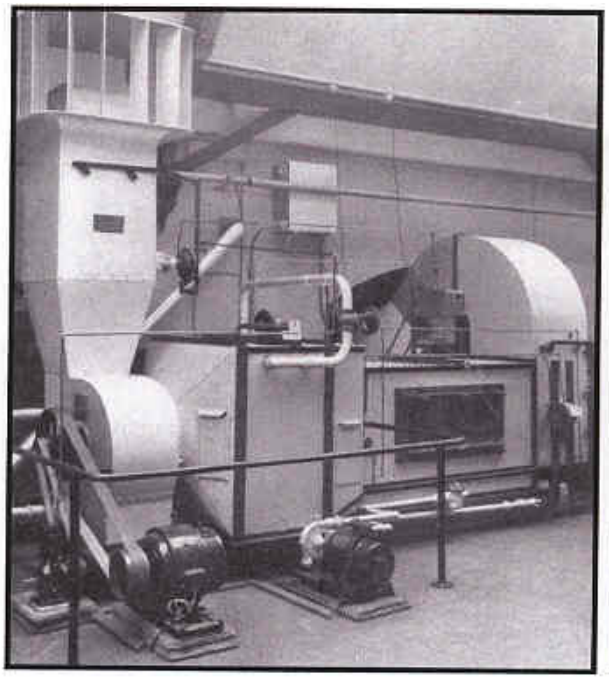
Belt-driven compressor, Haslam & Company, Derby 1908

Other makers providing reciprocating compressor equipment for the UK market post World War II include Lightfoot Refrigeration at Wembley, Sulzer Bros of Switzerland and York Shipley, London (York Corp, USA).

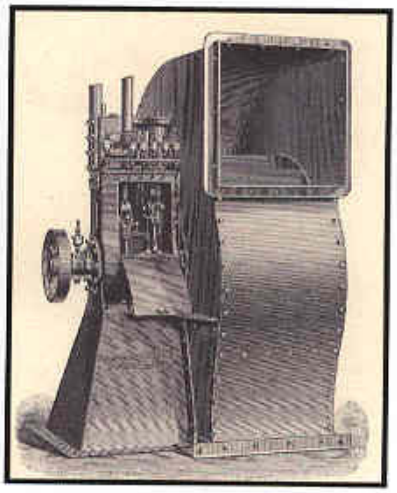
After the War reciprocating compressor design improvements and mass production methods, similar to those in motorcar engine manufacture, were introduced. Units became available with from 1 to 16 cylinders, the larger numbers being arranged in V, W or radial formation. Compressors used direct drive motors running at 1450 or even 2800 rev/min. York Shipley manufactured equipment in the UK. A number of American air conditioning manufacturers marketed refrigerating equipment, particularly packaged water chillers, in the UK. Firms included Carlyle (US Carrier), American Standard, Trane Company, Chrysler and Dunham-Bush.



Reciprocating water-chilling unit for air conditioning, York-Shipley 1936



Air conditioning plant in Chamber of Commerce Textile Testing House, Manchester, Carrier Engineering 1920s.



Centrifugal fan driven by double-enclosed steam engine, Sturtevant Eng 1906.

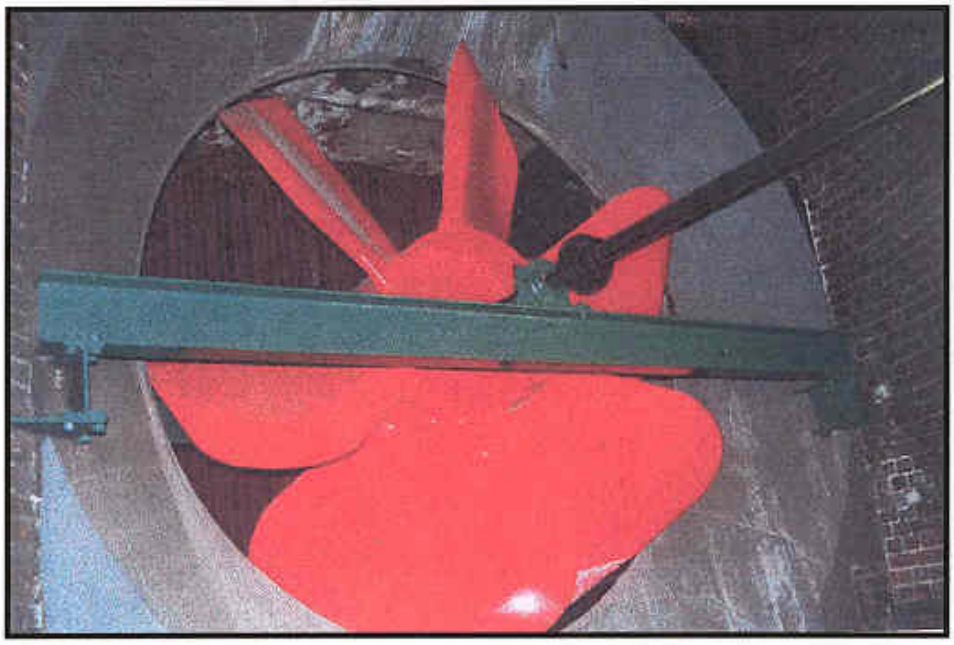
AN INTRODUCTION TO AIR CONDITIONING

The function of air conditioning is to provide and maintain an artificial environment within a building enclosure, for the comfort and welfare of the occupants, for the efficiency or effectiveness of a manufacturing process, or to maintain the quality and life of a stored product.

Full year-round air conditioning provides simultaneous control of room temperature, relative humidity, fresh air ventilation, air cleanliness, air motion and room sound level.

Equipment includes fans for moving air, ducts for conveying air, with grilles, diffusers and room terminal units for distributing air and sometimes controlling its heating or cooling effect. Main plant items include filters for air cleaning, coils for air heating, coils and spray apparatus for air cooling and dehumidifying (reducing the amount of moisture in the air), various devices for humidifying (adding moisture), attenuators for sound control, and dampers (regulators) for air volume or mixing control.

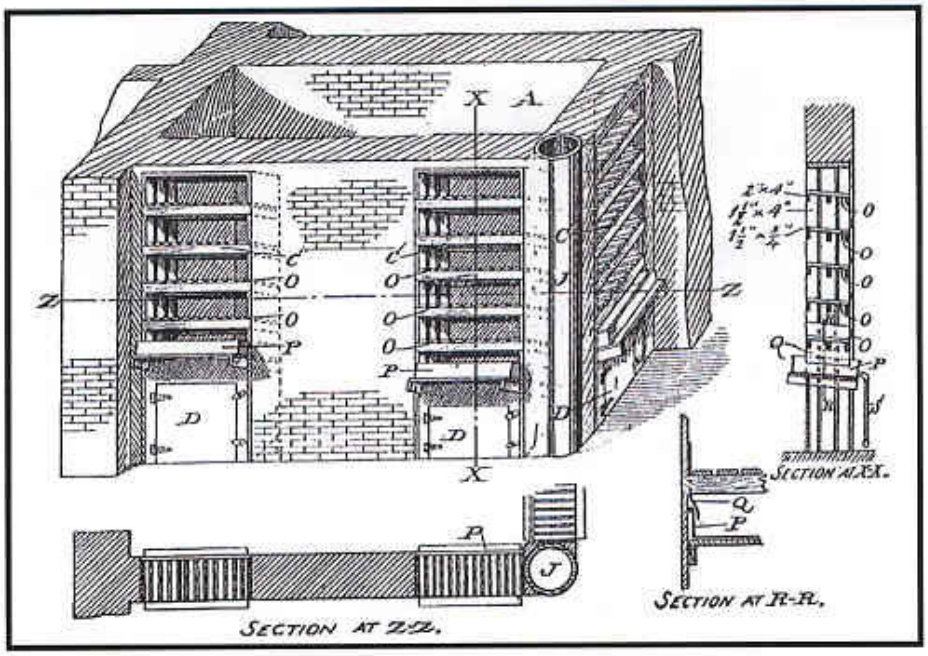
The Royal English Opera House, London, the dream of Richard D'Oyly Carte, built by T E Holloway with architect T E Collcut, 1899. "Far below the stage its own current was manufactured....the electro-motors also supplied the house with fresh air, passed over ice in summer, and hot-water pipes in winter. Stale air was electrically extracted, a very early use of air conditioning." However, it failed commercially and in 1892 reopened as the Palace Theatre of Varieties.



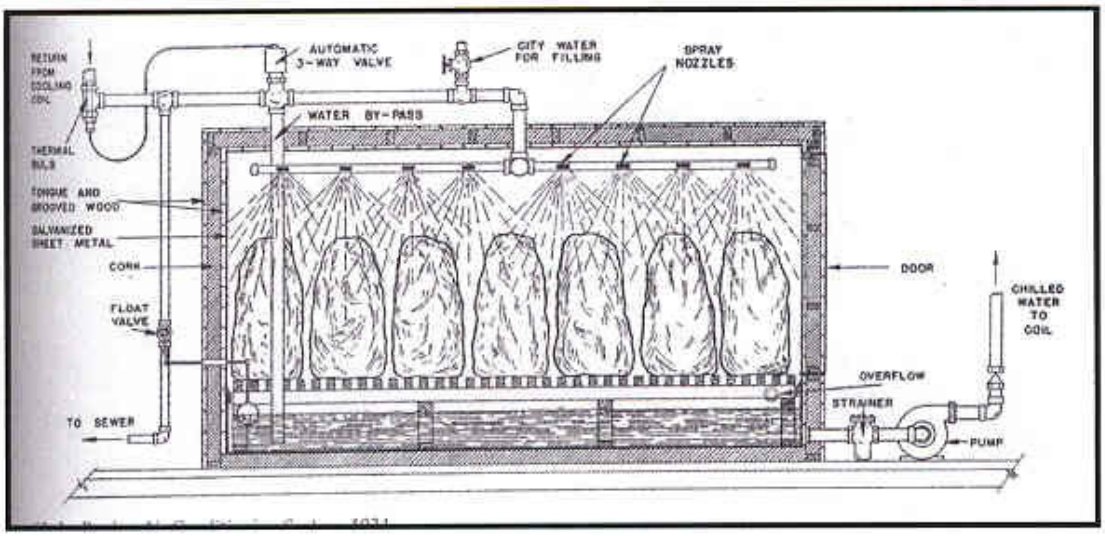
Steam driven propeller fan of about 1.5 m diameter mounted in builders work chamber c.1900.

Air filter of coconut fibre ropes moistened by water sprinklers c.1900

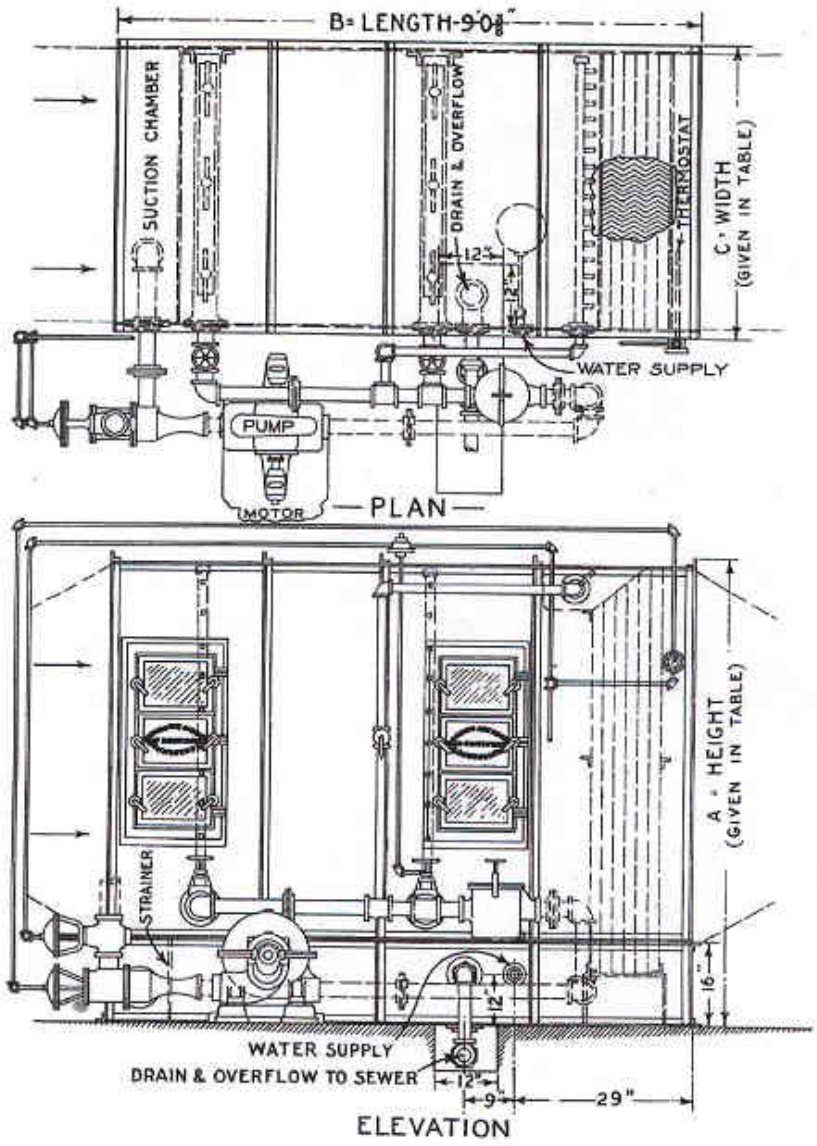
Plain tube hot water air heater coil 1903



Arrangement of racks for carrying ice blocks in the builders work supply duct of an early air conditioning system, 1891

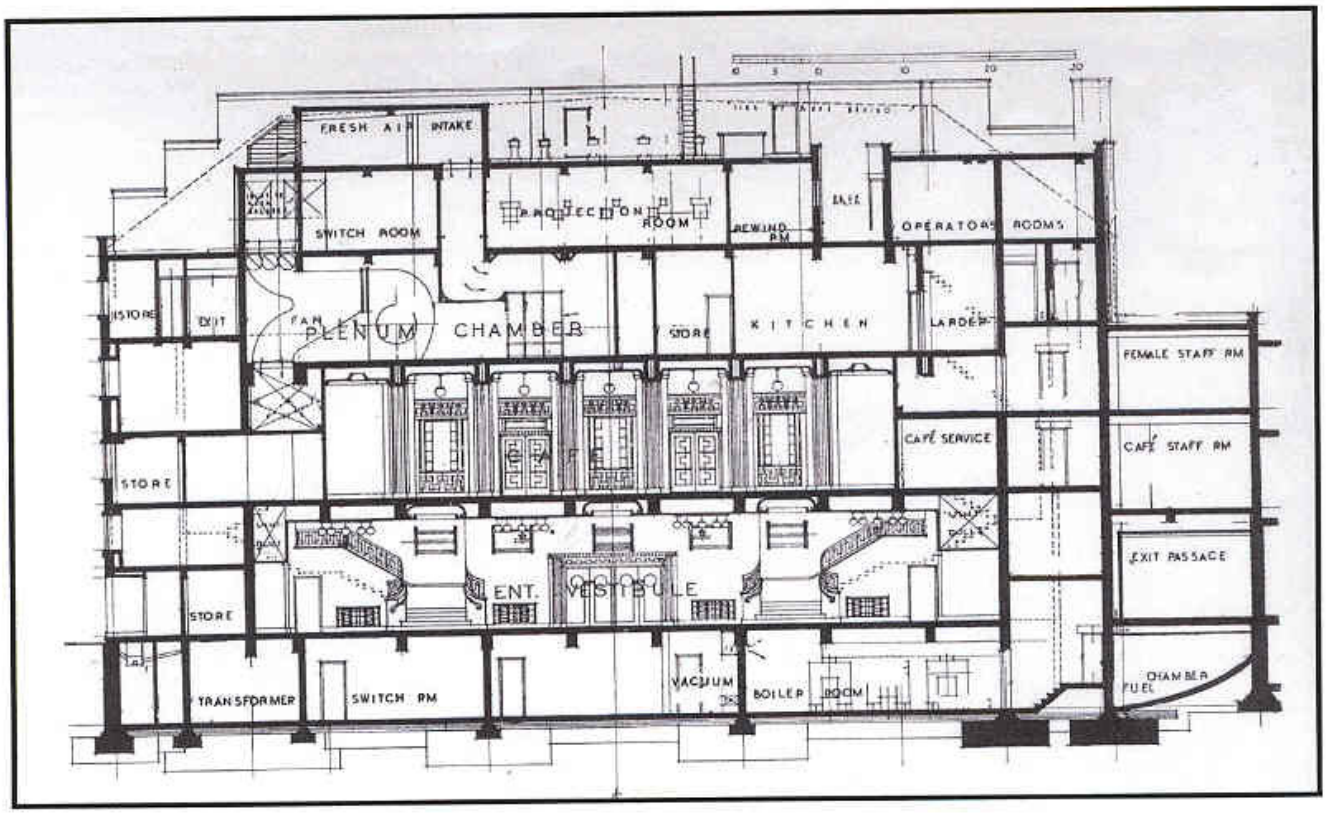


Chilled water for air conditioning obtained from an ice bunker system, 1934



Spray type air washer (air flow left to right) Buffalo Forge 1913

The base of the washer unit is a water tank with a suction chamber (left). A pump draws water from this chamber, through a strainer, and delivers it to two vertical banks of nozzles where it is sprayed as a fine mist into the air stream providing evaporative cooling and washing dirt particles from the air before falling back into the tank to be recirculated.



Section through the Gaumont Palace, Chelsea, London, 1936.

The cinema is provided with a plenum ventilation system incorporating a spray washer which provides evaporative cooling. There is no refrigeration.
Fresh air is taken in at roof level (top left) and drawn into a plenum chamber where it passes through a washer and into the fan, being discharged into the auditorium through two branch ducts.
There is a switch room below the fresh air intake while the basement houses a transformer, another switch room, a central vacuum cleaning plant, 3 hot water heating boilers with mechanical stokers and a 10 tonne coal store.

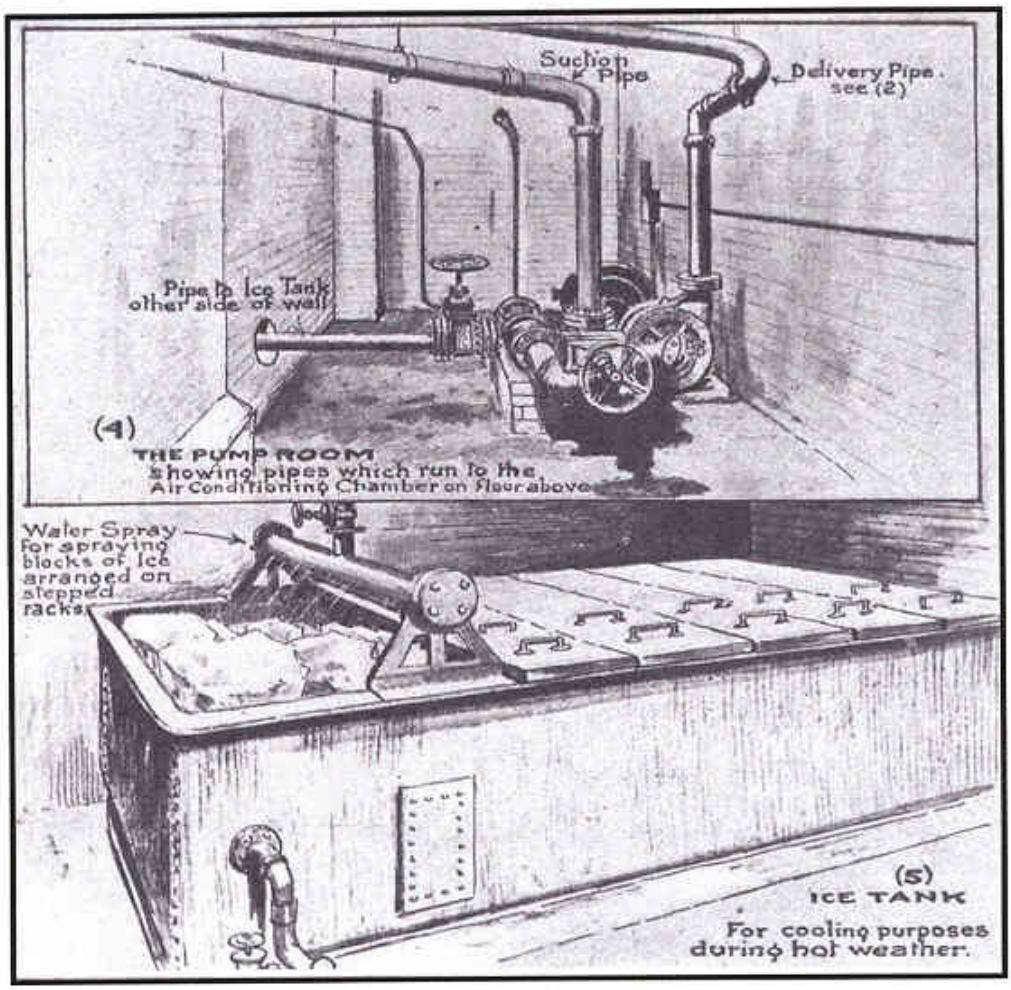
Early Installations

The Victorian era saw a number of attempts at cooling and ventilating. Gas lighting in many buildings contributed to high internal temperatures and the rising currents of hot air were often discharged through roof outlets with cooler fresh air make-up admitted at low level. The House of Commons, rebuilt after the fire of 1834, used water sprays in the fresh air inlets to cool and clean the air; later ice-blocks were placed in the supply air ducts. A more successful system was that installed in St George's Hall, Liverpool, in 1851, which employed cold-water sprays in the main inlet shaft. In 1865, G N Haden & Sons used a primitive air washer for cooling at the now demolished Manchester Assize Courts. But none of these systems employed refrigeration plant. Possibly the first to do so was that installed in 1882 at the Royal Assize courts in the Strand, where Haden installed an air conditioning system with a chilled water air washer, steam-driven fans and a J & E Hall refrigerating machine "with a cooling capacity of 2 tons of ice per hour" (48 TR). Early British air conditioning systems in London included those at County Hall, the BBC and the Warner Theatre in Leicester Square (see following pages). A number of early installations were for luxury cinemas, the first being at the Carlton Theatre in the Haymarket (1927), followed by the Empire, Leicester Square (1928) and the Paramount Theatres in Manchester (1930) and Leeds (1932). However in the 1920s and 30s the vast majority of cinemas were equipped with recirculating spray washer systems (no refrigeration) as at the Gaumont Palace Chelsea (opposite page).

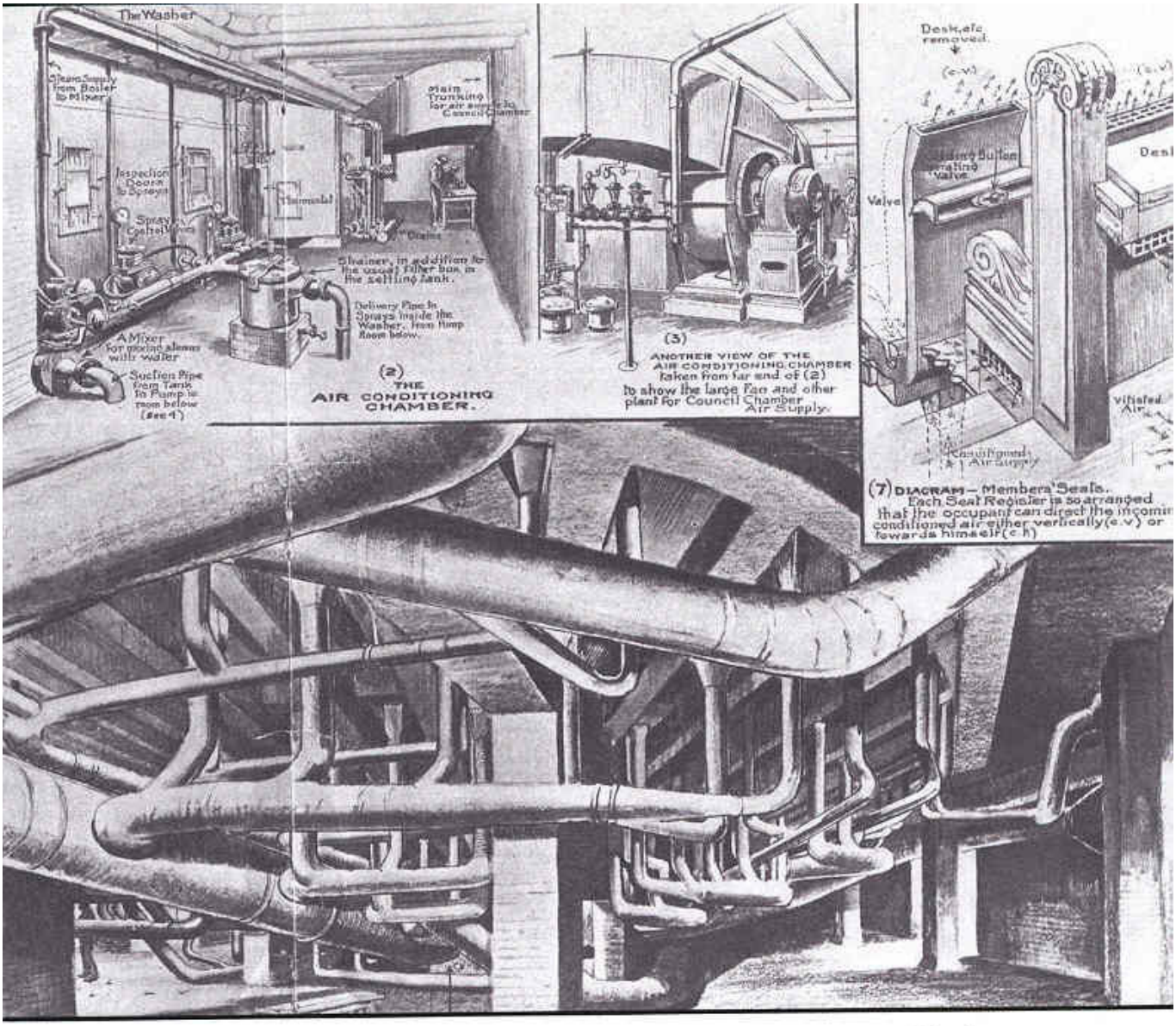
System Types

There are basically three types of air conditioning system, classified according to the type of cooling medium employed: (1) all-air (2) air-water (3) unitary refrigerant systems. Early systems, except for room units, are all-air type where the conditioned air is conveyed at low velocity through a system of builder's work or sheet metal ducts to the spaces served. Horizontal ducts and vertical shafts may be of walk-through size. Plant may also be housed in builder's work chambers or connected by sheet metal ducts.

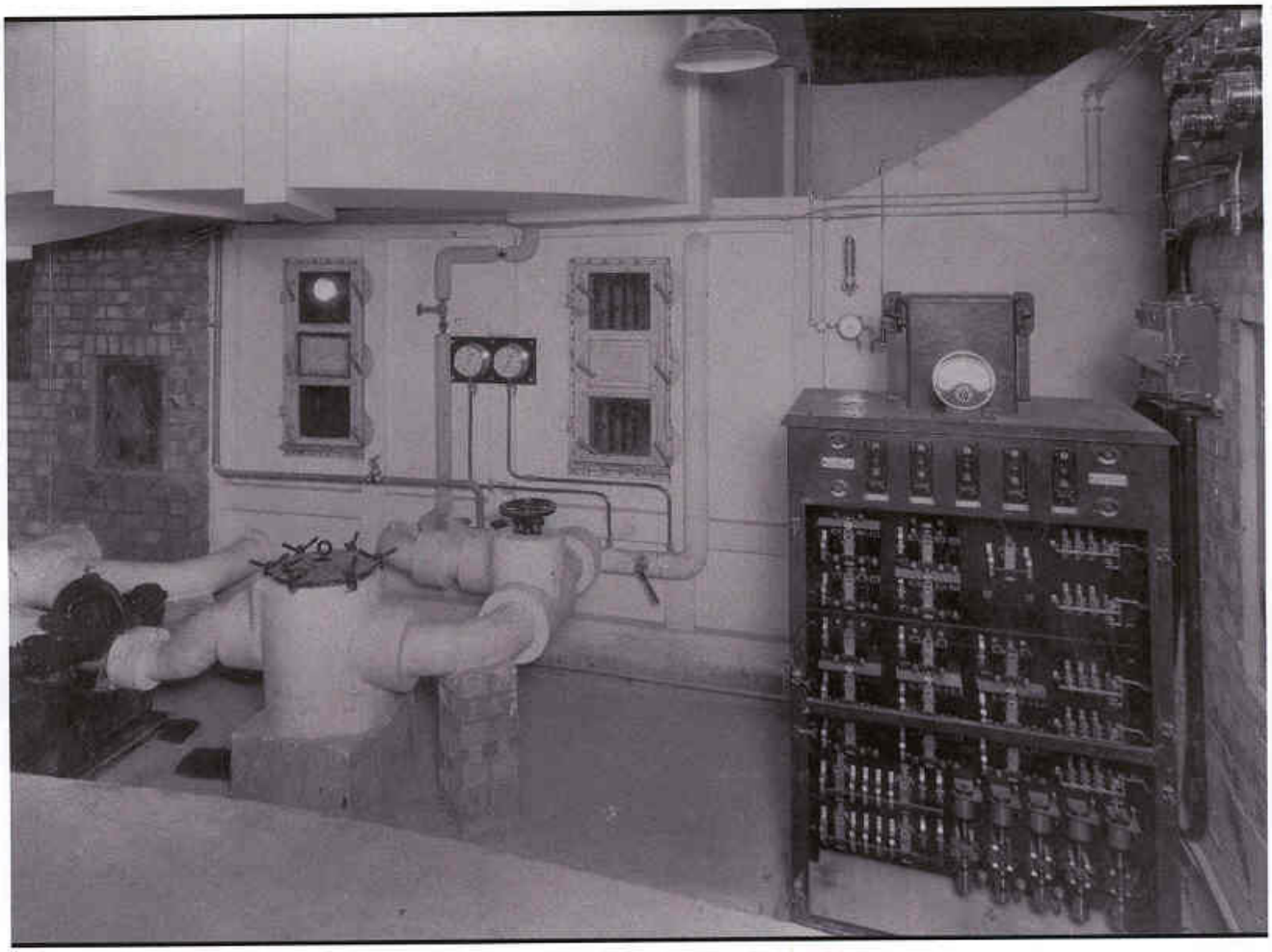
From around 1960, many UK air conditioning systems were of the high velocity type (smaller duct sizes) but may be identified by having terminal units typically above false ceilings or in the spaces serves. Air-water systems generally use room units also. The variations in system design and equipment types require to be evaluated by experienced engineers.



The pump room and ice tank Part of the air conditioning plant serving the Council Chamber at County Hall, Westminster (London County Council) 1922.

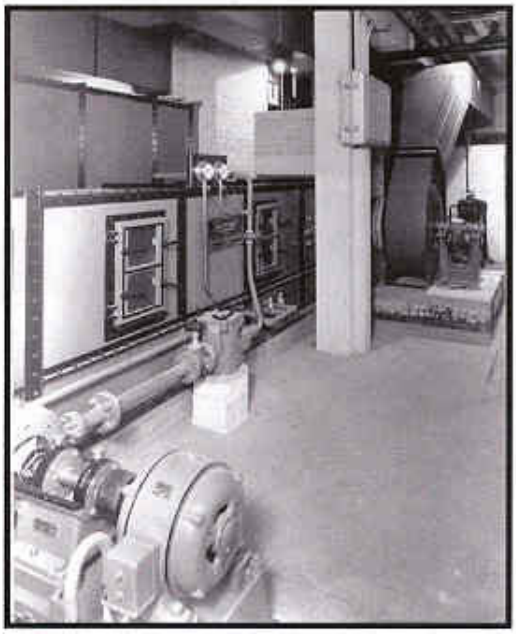


Part of composite diagram illustrating the air conditioning plant serving the Council Chamber at County Hall, Westminster (London County Council) 1922.
The lower diagram shows the convoluted system of air distribution ductwork, nicknamed "the octopus" under the Chamber.

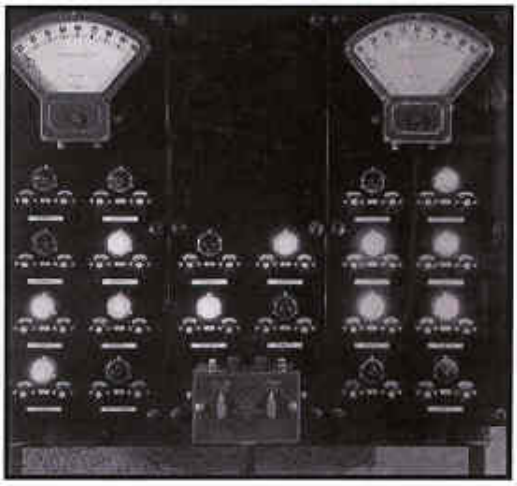


Air conditioning plant at BBC Broadcasting House, Portland Place, London, 1931.
The insulated piping (left & centre foreground) includes a pump that circulates chilled water from the refrigerating plant to and back from the spray washer (centre background). (Carrier Engineering Company, London).
Note the electrical panel (right foreground).

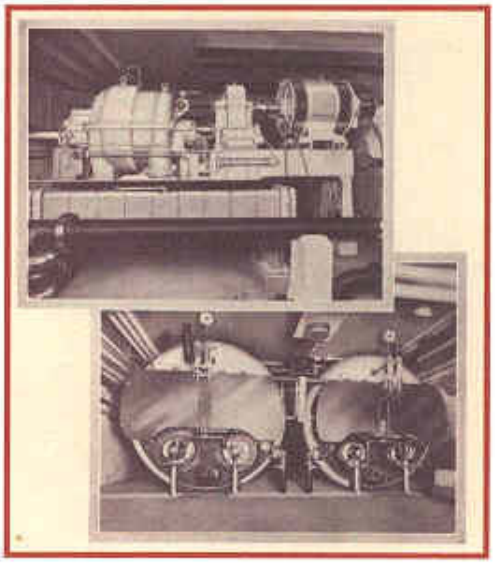
BBC brochure, Carrier Engineering Co



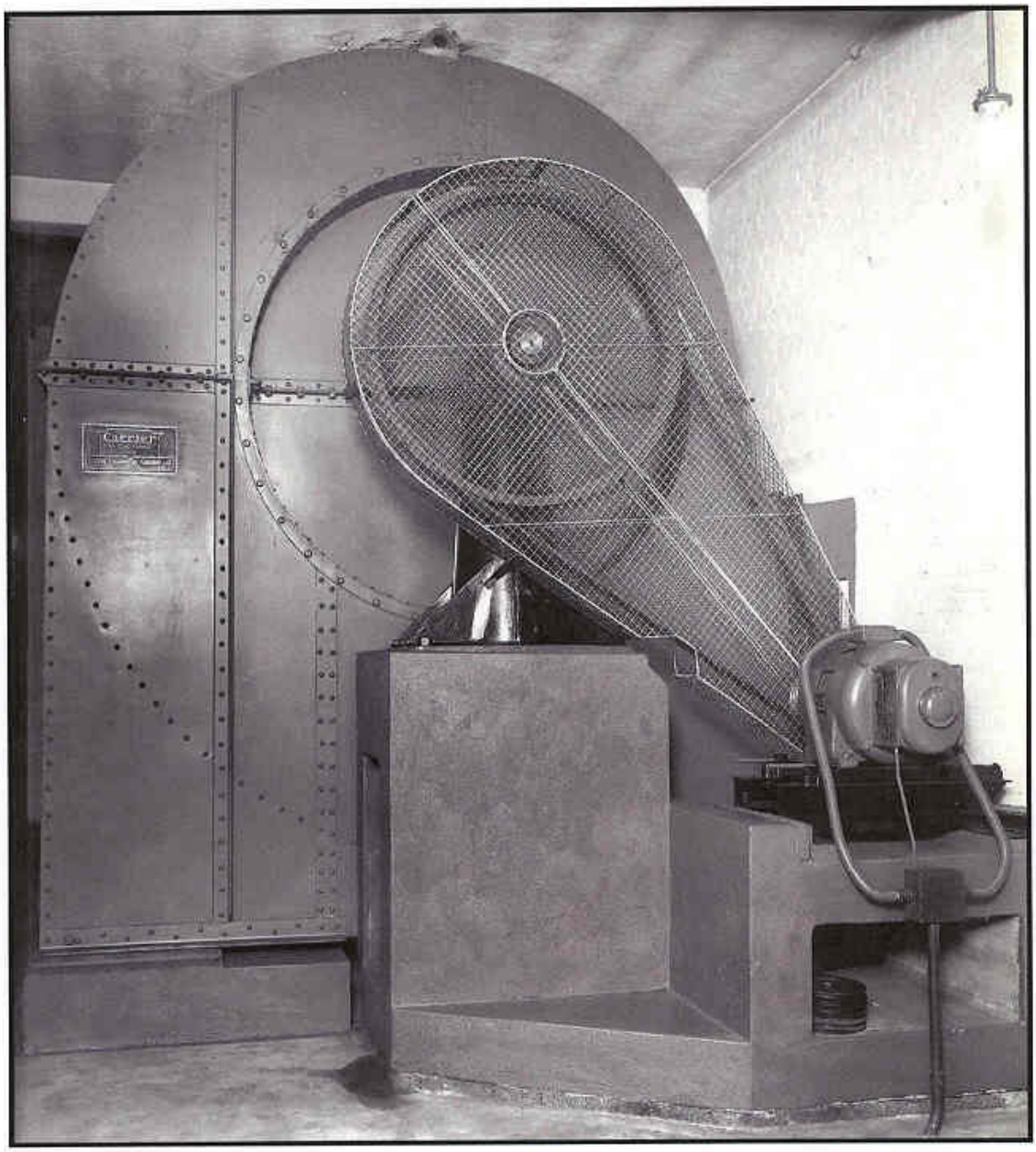
Supply air conditioning plant



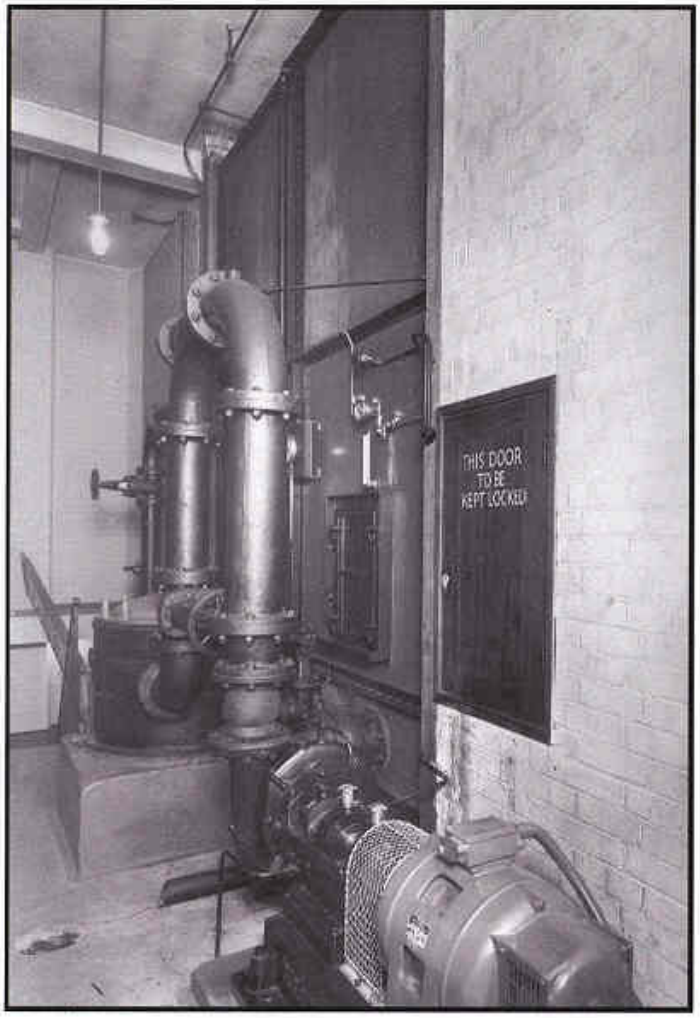
Fan control & indicator panel



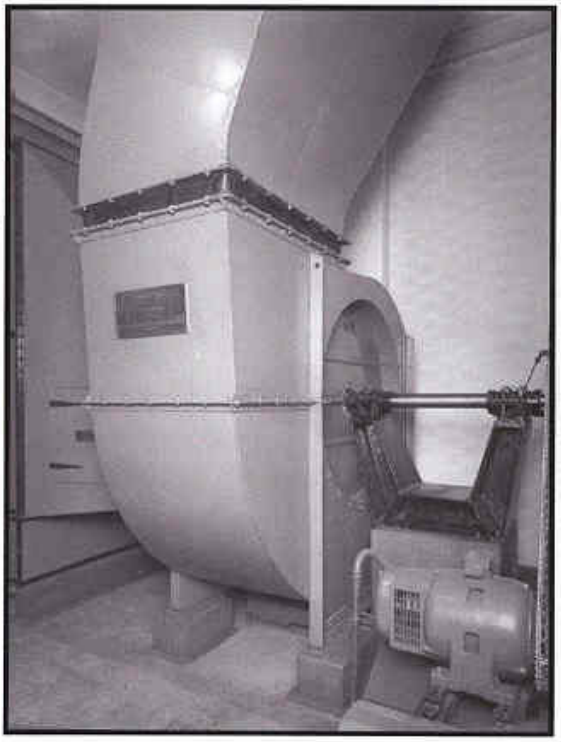
Top: Centrifugal water chiller
Bottom: Oil-fired steam boilers



Centrifugal extract fan arranged for bottom discharge (to the right). Note the relatively small electric motor (which suggests a low duct resistance) driving the large fan pulley by v-belts. Part of the air conditioning at the Warner Theatre, Leicester Square, London. (Carrier Engineering Co), 1938.

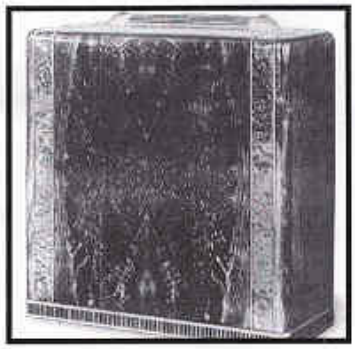


Spray washer for air conditioning with piping strainer (left backgound) and spray pump (right foreground. Warner Theatre, Leicester Square.



Right; Centrifugal supply air fan

Console room air conditioner Frigidaire 1936

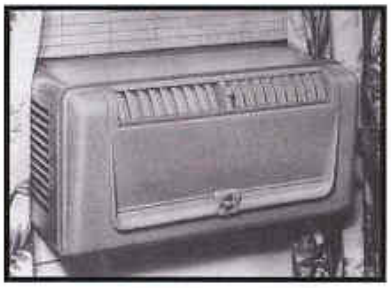


Room air conditioning unit with rotary grille and walnut finish cabinet, York c.1938

Room Air Conditioning Units

The room air conditioner was an American invention of the 1920s, developed into a practical unit in the 1930s. Henry Galson for De La Vergne patented the first hermetic unit in 1932, which went into commercial manufacture with reverse-cycle capability (heating) in 1933. The patent rights were sold in 1937 to a consortium of manufacturers: General Electric, Westinghouse, Frigidaire, Carrier and Sturtevant. Just prior to World War II, a few units were to be found in the UK. Frigidaire was mentioned in trade magazines and Carrier UK sold units under the Weathermaster label. By the early 1950s the US market reached some 1.2 million units with 65 manufacturers, being dominated by Fedders, Mitchell and Carrier. Post war the UK market was very small. Some units were imported. A few special units were manufactured in the UK. The last 25 years has seen a wide acceptance of air conditioning units for smaller commercial premises and offices, these being generally of the split-system type with the compressor/condenser housed in a remote outdoor section. Any surviving examples from the 1930-50s are of engineering interest.

Window-box conditioner, USAC c.1950



Window box, York 1950s

FURTHER READING

1895. *Refrigerating and Ice-Making Machinery*, A J Wallis-Tayler, Crosby Lockwood & Son.

1908. *The Mechanical Production of Cold,* Sir J A Ewing, Cambridge at the University Press.

1908. *Refrigeration,* J Wemyss Anderson, Longmans, Green & Co, London

1921. *Cold Storage and Ice Making*, B H Springett, Sir Isaac Pitman, London.

1952. *Father of Air Conditioning, Willis Haviland Carrier,* Margaret Ingels, Country Life Press, Garden City, USA.

1956. *Refrigeration and Air Conditioning,* Richard C Jordan & Gayle B Priester, 2nd edit; Chap.1 *The History of Refrigeration*, Constable & Co, London.

1975. *Air Conditioning and Ventilation of Buildings*, Derek J Croome-Gale & Brian M Roberts, Pergamon Press, Oxford.

1979. *A History of Refrigeration throughout the World,* Roger Thévenot, International Institute of Refrigeration, Paris.

1982. *Building Services Engineering: A Review of Its Development,* Neville S Billington & Brian M Roberts; Chap.5 *Refrigeration,* Chap.6 *Air Conditioning,* Pergamon Press, Oxford.

1985. *Halls of Dartford 1785-1985*, Harry Miller, Hutchinson Benham, London.

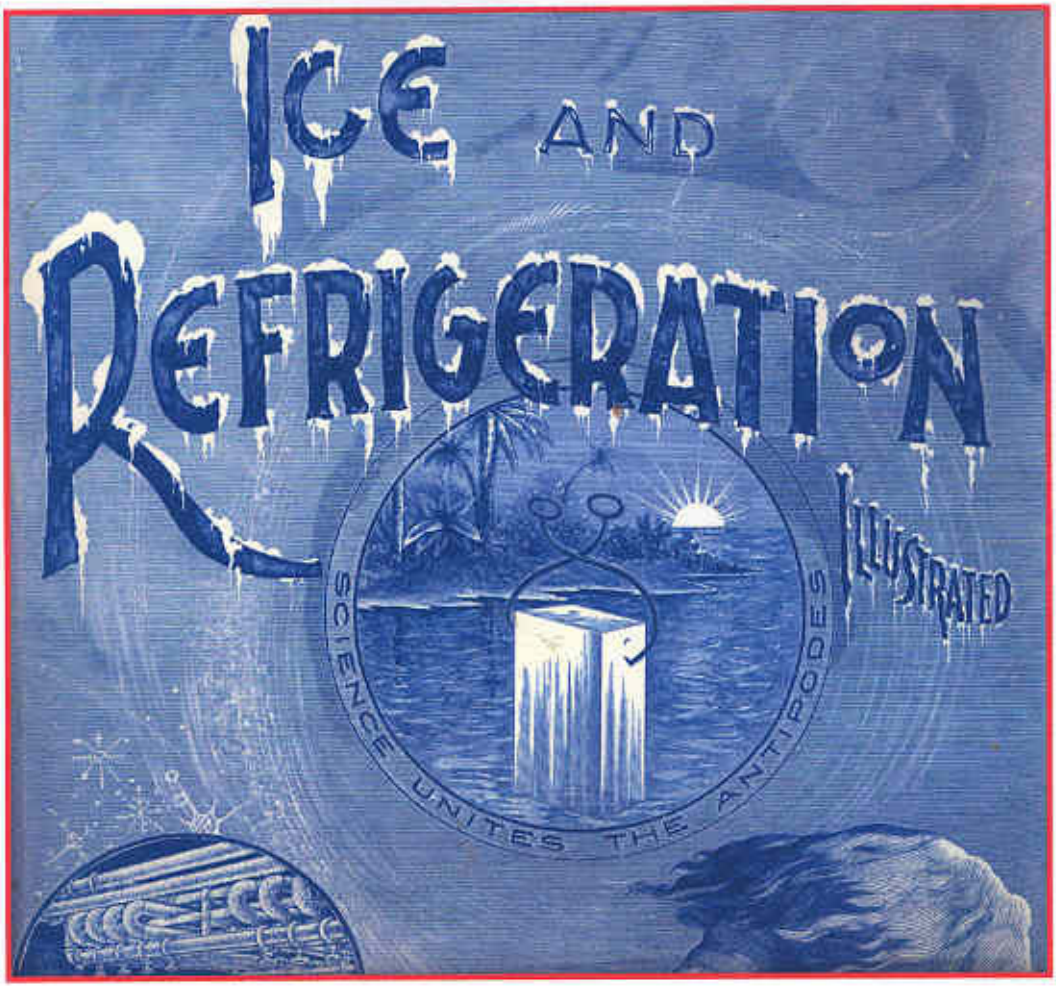
1994. *Heat & Cold: Mastering the Great Indoors,* Barry Donaldson & Bernard Nagengast, The American Society of Heating, Refrigerating and Air-Conditioning Engineers, Atlanta, GA, USA.

1997. *The Quest for Comfort* (Centenary of the Chartered Institution of Building Services Engineers) Brian Roberts, IMI Waterheating Ltd.

1997. *The Legend of York International*, Jeffrey L Rodengen, Write Stuff Syndicate Inc, Fort Lauderdale, FL, USA.

2004. *Manufacturing the Weather: The History of Carrier Engineering Co Ltd, London 1921-70,* Brian Roberts (in preparation).

Additional information is available on the website of the CIBSE Heritage Group at **www.hevac-heritage.org**


ICE AND
REFRIGERATION
ILLUSTRATED
SCIENCE UNITES THE ANTIPODES