SCIENCE MUSEUM COLLECTION

A note of Building Services Engineering Items From lists held by the CIBSE HERITAGE GROUP

The Science Museum, London

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1 Jan '75

HEATING AND VENTILATING ITEMS HELD BY THE SCIENCE MUSEUM

RECEIVED 11 JUN 1986

S/20

S.M. Reference Number	
1898 - 74	Model of Boyle's ~~system of natural ventilation~~ system applied to a building.
1899 - 75	Model in glass and metal of Acme induction current natural ventilator.
1914 - 70	1:8 Model of Chimney Cowl.
1918 - 227	Model 1:8 Sugg and Sinnance's patent continuous updraught cowl.
1920 - 482	Sectional drawings of old heating boiler from a country house. (Water 'jockets' in brick enclosure).
1926 - 858	6" Copper Archimedian Ventilator (rotating).
1934 - 540	Model of Ice Skating Rink.
1934 - 576	Model Cold Store (of a corner).
1934 - 606	Model Cold Store for meat.
1939 - 232	Early type water radiator.
1959 - 10	Gurney stove (ex Gloucester Cathedral) 1865.
1959 - 54	Circular steam radiator (ex Victoria & Albert Museum).
1959 - 150	Gas-fired room ventilator 1859 (Gasolier).
1961 - 98	Hot Water Radiator (finned) (Austrian) 1880.
1961 - 120	Working Model of heat-pump.
1961 - 154	Rotating vane cowl (1900) - similar to 1926 - 858.
1961 - 209	Cast iron radiator - floral type relief (1900).
1961 - 210	Cast iron radiators (2) with water tray (1900).
1961 - 239	Model of Desagulier's ventilating fan (1.4) circa 1723 as installed at House of Commons.
1962 - 93	Gas ventilating lamp with 25 jets - similar to 1959 - 150.
1963 - 1	Cast iron water radiators ex Kew Gardens C1875 (Formed from vertical pipes).
1964 - 172	Double ventilating slide (C1780) ex cotton mill.
1964 - 173	Centifugal fan for ventilating lavatories. (C1780) ex cotton mill.
1964 - 174	Iron stove for heating cotton mill (C1808)

contd.....

1975

1964 - 241	Model of H & V plant at Atomic Energy Radio Chemical Laboratory, Harwell.
1967 - 195	Circular H.W. Radiator from Oxford University Library C1880.
1967 - 196	Cast iron H.W. Radiator (Corinthian Columns).
1969 - 78	Roof ventilator (natural ventilation) C1890.
1970 - 152	Musgrave Hot Air coke-fired heating furnace C1901.
1970 - 164	Cast iron "Sunbeam" hot water Radiator C1850.
1970 - 165	Cast iron H.W. Radiator C1880.
1970 - 406	Howlett Improved Heat Reclaimer - scale model C1930.
1971 - 419	Air handling unit by Sturtevent C1895. Comprising:- (a) single cylinder vertical steam engine (b) belt driven centrifugal fan (c) cast iron heater battery using the engine's exhaust steam.
1971 - 432	Gas control cock for overhead gas ventilator C1860.
1972 - 54	Cast iron H.W. Radiator from Kew Gardens C1875. (Consists of horizontal pipes).
1972 - 55	Model of gas-fired water heating installation installed at Sandow Institute of Physical Culture C1900.
1973 - 88	Heat exchanger cylinder and valves from 'Recto' central heating system from hospital C1900 - Using Ruston and Hornsby boilers.
1966 - 283	Tobin tube ventilator C1870.
1974 - 373	Cast iron Potterton gas boiler No. 13. C1915.
1974 - 374	Cast iron Potterton gas boiler No. 19. C1930.
1970 - 13	Oil Fired Wilson boiler (domestic) No. 54, Twin Wick.
1965 - 400	Gas fired 'Servotomic' boiler (domestic) - complete with integral radiator C1965.
1974 - 363	Solid fuel boiler by L. White of London (domestic) 19th Century.
1973 - 306	Coke boiler by Watts Boiler Co. C1936 (domestic)
1967 - 197	Finned H.W. Radiator (horizontal pipes) C1860

21

contd......

1966 - 329 'Sauter' electric storage heater 4 kw. C1938. (French).

1963 - 103 Mixing Valve - thermostatically controlled (Leornard)

2

JAN 1975.

total 47 items

APRIL 78.

1975-11	"White Rose" open-fire boiler
1976-635	Vent-Axia "Silent Six" window-mounted extractor fan, 1936.
1976-22	Honeywell Heat Generator c 1910
1976-465	Compressor by G Worssan and Son, London- M.F.W's Patent (No. 19914 of 1901) from a cold room installation at Lythe Hill, Surrey
1976-579	2 Prestcold Presmetic compressors, with evaporator & condensor units
1976-581	Radiator Valve, c.1860 by Kauffer & Co, Mainz, from Templenewsam House Heating system.
1978-100	Carrier "Weathermaker" Air Conditioning Unit. c.1930.

We anticipate collecting a few more items in the near future:- from St Mary's Aylesbury, Perkins equipment - radiator, expansion vessel, pump and a pipe joint (for sectioning), and from A J Mills of Tooley Street a 1906 J & E Hall CO_2 compressor which was directly driven by a 95 rpm D C motor for a brine circulation cold store system.

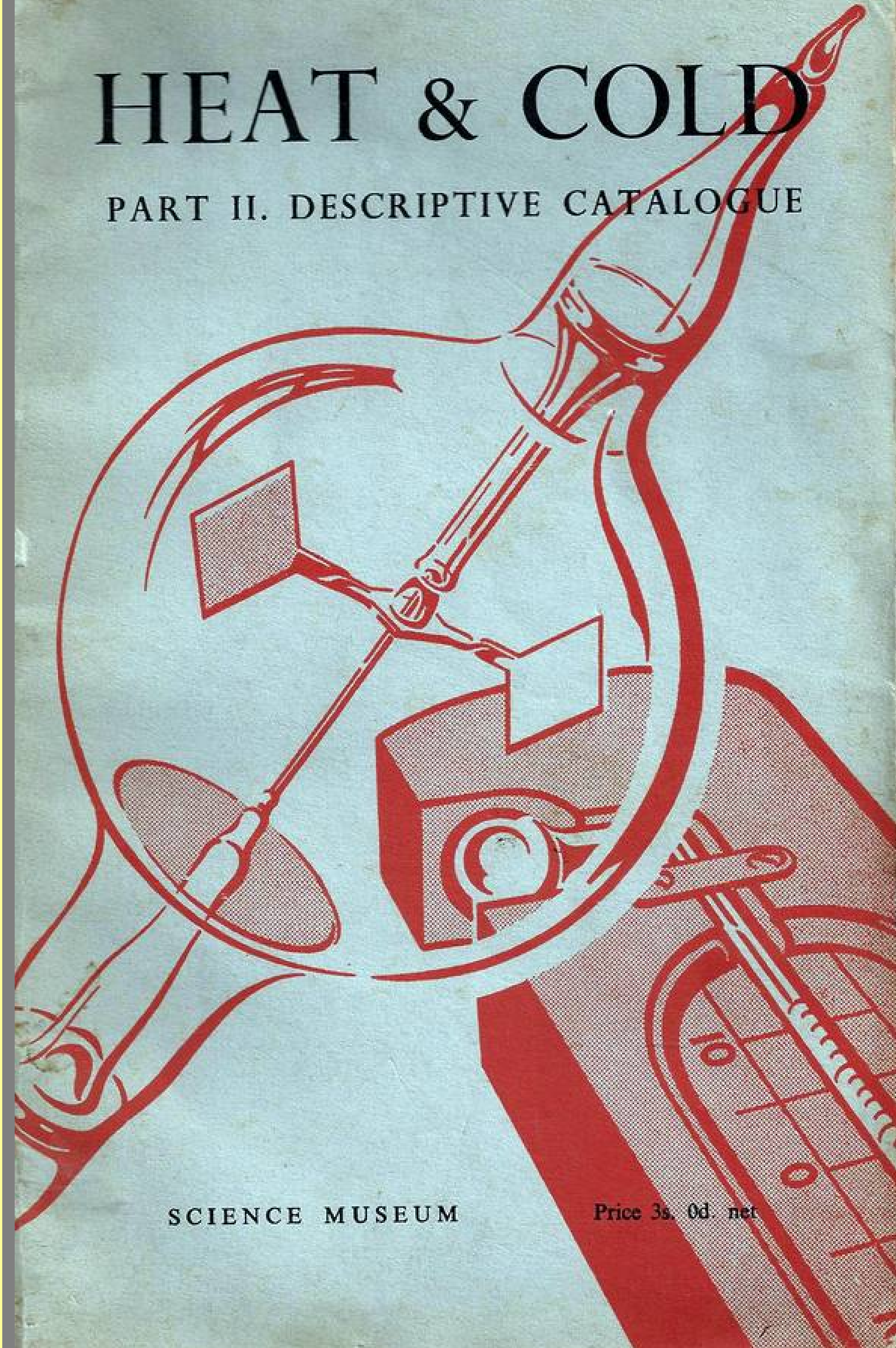
I will send you the inventory numbers for these when obtained, and endeavour to keep you up to date.

A.E. BUTCHER

1978

HEAT & COLD

PART II. DESCRIPTIVE CATALOGUE



SCIENCE MUSEUM

Price 3s. 0d. net

1954

MINISTRY OF EDUCATION · SCIENCE MUSEUM

HANDBOOK OF THE COLLECTION RELATING TO

HEAT AND COLD

By

J. A. Chaldecott, M.Sc., A.Inst.P.

Part II

CATALOGUE OF EXHIBITS WITH DESCRIPTIVE NOTES

LONDON : HER MAJESTY'S STATIONERY OFFICE

1954

PREFACE

The formation of a Museum of Science was first proposed by the Prince Consort after the Great Exhibition in 1851, and in 1857 collections illustrating foods, animal products, examples of structures and building materials, and educational apparatus were brought together and placed on exhibition in South Kensington. The collections of scientific instruments and apparatus were first formed in 1874, but it was only after 1876 that they became of importance. The Special Loan Collection of Scientific Apparatus which was exhibited in that year in the Museum brought together examples of all kinds from various countries, and a large number of these were acquired for the Museum. Subsequently many additions were made, including in 1884 the collection of machinery formed by the Commissioners of Patents, in 1900 the Maudslay Collection of machine tools and marine engine models, and in 1903 the Bennet Woodcroft Collection of engine models and portraits.

Until 1899 the Art Collections and the Science and Engineering Collections together formed the South Kensington Museum, but in that year the name was changed to the Victoria and Albert Museum, which included both Collections until 1909, when it was restricted to the Art Collections; those relating to Science and Technical Industry have since then formed the Science Museum.

The aim of the Science Museum, with its Collections and Science Library, is to aid in the study of scientific and technical development, and to illustrate the application of physical science to technical industry. This is effected by the informative display of objects, diagrams and photographs, arranged to show stages in the progress of each subject up to the present day. Many of the exhibits have been sectioned so that the internal structure can be seen, whilst others have been designed so that they can be operated by visitors or demonstrated to them. A detailed descriptive label accompanies each object on exhibition and further information is often available in the form of Museum handbooks giving historical surveys of many of the subjects treated in the Collections. The Museum catalogues contain the substance of the descriptive labels together with additional information not otherwise readily accessible to visitors to the Museum.

CONTENTS

LIST OF ILLUSTRATIONS

VI. REFRIGERATION

THE following exhibits are concerned only with the attainment of temperatures which are sufficiently low to be of use in the preservation of perishable food-stuffs, or for use in air-conditioning. The production of temperatures only a few degrees above the absolute zero is treated in Chapter VII.

119. WATER-COOLING VESSELS. Presented by Dr. H. E. Hurst, C.M.G.

One of the simplest and most primitive methods of cooling water by means of surface evaporation is illustrated by water vessels from the Sudan. In evaporating, the water extracts heat from its surroundings and so cools the contents. The lowest temperature attainable is the "wet-bulb temperature" of the surrounding air, which may be as much as 20° F. below the air temperature in dry climates.

In the case of the unglazed porous jar, the surface available for evaporation is enormously increased by the formation of minute droplets on the exterior. This is, in fact, the method used by the human skin in regulating body temperature. The cooling effect is very much less in the case of the glazed jar, where evaporation cannot take place from the surface of the vessel. The rate of evaporation depends on the moisture content of the surrounding air and is, therefore, increased if an air current is present to accelerate the removal of vapour. This accounts for part of the chilling of the human body when subjected to a draught.

Inv. 1933-515, Photo 7056.

120. LESLIE'S FREEZING APPARATUS. Lent by J. J. Griffin & Sons.

A laboratory form of the apparatus with which Leslie, in 1810, succeeded in freezing water by artificial evaporation.

A small pan of porous earthenware containing water is supported over a dish containing sulphuric acid, and the whole is placed under the receiver of an air-pump. On exhausting the receiver the pressure is diminished, consequently the water evaporates rapidly and commences to boil when the pressure is sufficiently reduced. The vapour is absorbed by the sulphuric acid almost as fast as it is formed. As the heat necessary for the evaporation is drawn from the water itself, its temperature is quickly reduced and the water ultimately freezes.

A freezing machine constructed on this principle was introduced by Carré in 1867 (see Catalogue No. 121).

[*See* J. Leslie, *Ann. Chim.*, 1811, 1st series, vol. 78, pp. 177-82; *Phil. Mag.*, 1818, 1st series, vol. 51, pp. 411-21; E. Carré, *C. R. Acad. Sci., Paris,* 1867, vol. 64, pp. 897-8.]

Inv. 1880-10.

121. CARRÉ FREEZING MACHINE. Made by E. Carré.

This apparatus, which is an improvement on that of Leslie, was described by Carré in 1867. It is more conveniently arranged, and enables larger quantities of water to be frozen.

In this case the sulphuric acid is contained in a cylindrical vessel made of an alloy of lead and antimony, and is agitated by a stirrer actuated from the pump lever. One end of this vessel is connected with the air-pump, and the other end with the flask containing the water to be frozen. The effect of stirring the acid is to increase the rate of absorption of the water vapour, and therefore to increase the rate of freezing.

The casting forming the base of the machine bears the name E. Carré.

[*See* E. Carré, *C. R. Acad. Sci., Paris,* 1867, vol. 64, pp. 897-8.] Inv. 1894-114.

122. ELECTROLUX COOLING UNIT (see Plate VI). Made and presented by Electrolux Ltd.

The continuous-absorption refrigeration unit which was developed by Munters and Platen in 1926 has an advantage over the vapour-compression type of cooling unit in that it functions without the aid of mechanical moving parts. The model shown is of the type now employed in many domestic refrigerators and although this particular exhibit is intended for operation by electricity, the unit may readily be adapted to work with a gas or oil flame.

Heat is applied at the centre of the tall annular vessel, known as the boiler, which contains a solution of ammonia in water. Ammonia gas, with some water vapour, is boiled off and rises to pass through the air-cooled water-separator where the water vapour present is condensed to fall back into the boiler. The dry ammonia gas then passes on to the lower part of the condenser to be changed into liquid ammonia by the cooling action of air circulating over the finned pipes of the condenser. The liquid ammonia runs through a U-trap into the evaporator, or low-temperature radiator, where it comes into contact with relatively pure hydrogen. The partial

Refrigeration

This phenomenon was described by Ranque, in 1933, and has since been investigated by Hilsch. The vortex tube used in this demonstration is similar to that described by Blaber in 1950.

[*See* G. Ranque, *J. Phys. Radium*, 1933, 7th series, vol. 4, pp. 112S-115S; R. Hilsch, *Rev. sci. Instrum.*, 1947, vol. 18, pp. 108-13; M. P. Blaber, *J. sci. Instrum.*, 1950, vol. 27, pp. 168-9.]

Inv. 1954-149.

TRANSPARENCIES

126. MAMMOTH FOUND IN ICE IN SIBERIA. From a lantern slide in the possession of J. Raymond, Esq. Inv. 1934-507, Photo 7023.

127. FARMING NATURAL ICE IN NORWAY. From a picture in the possession of United Carlo Gatti, Stevenson & Slaters Ltd. Inv. 1934-513, Photo 7030.

128. DIAGRAM SHOWING AMMONIA-ABSORPTION REFRIGERATION CYCLE.

The ammonia-absorption system depends upon the powerful affinity which ammonia and water have for one another.

A solution of ammonia and water, technically known as "aqua ammonia", is heated in the generator to a temperature of 215° F., and ammonia vapour with some steam is driven off at a total pressure of 170 lb. per sq. in. This mixture is passed through a unit known as a rectifier, cooled by circulating water, where the steam condenses out and is returned to the generator, whilst the temperature of the ammonia vapour has been reduced to 100° F. The vapour now passes to the condenser, which it leaves as anhydrous liquid at a temperature of about 75° F. It then passes through an expansion valve, reducing the pressure to about 30 lb. per sq. in., and enters the cooling unit where it evaporates at a temperature of 0° F., cooling brine or doing whatever other work may be required. The vapour so formed is led to the absorber, where it becomes intimately mixed with and is absorbed by a stream of weak aqua ammonia coming from the generator controlled by means of a check valve, this weak solution having been pre-cooled by being passed through a counter-flow heat-exchange apparatus and a water-cooled cooler. The strong cool aqua ammonia from the absorber, still under evaporator pressure. is then forced by means of a pump into the generator, having been previously brought into counter-flow heat exchange with the hot weak aqua passing from the generator to the absorber.

Inv. 1934-464, Photo 6944.

129. AMMONIA-ABSORPTION REFRIGERATING PLANT. From photographs supplied by Cadbury Bros. Ltd.

(1) Pumps and generators. Inv. 1934-537.
(2) Generators and heat exchangers. Inv. 1934-538.
(3) Condensers and absorbers. Inv. 1934-539.

130. DIAGRAM SHOWING VAPOUR-COMPRESSION REFRIGERATION CYCLE.

In principle, the vapour-compression cycle is the same for all types of compressor and for all refrigerants. It consists of four operations, compression, condensation, expansion and evaporation, which correspond in theory to the four operations of the ideal Carnot cycle.

Assuming standard working conditions for ammonia, i.e., condensing at 86° F. and evaporating at 5° F., the cycle will be briefly as follows. Ammonia is evaporating in the evaporator coils at a pressure of 19.6 lb. per sq. in. and a temperature of 5° F. The vapour is drawn into the compressor and compressed to 154.5 lb. per sq. in., the process approximating to an adiabatic one and corresponding to the first or adiabatic portion of Carnot's cycle. The gas will be superheated to a fairly high temperature at this stage by reason of the heat of compression, some heat being lost through radiation from the cylinder head and some gained by the heat of friction derived from the working parts of the machine. From the compressor the heated gas passes to the condenser, where it is cooled and condensed, corresponding to the second or isothermal part of Carnot's compression stroke.

The liquid refrigerant may be sub-cooled to about 80° F. but, still under a pressure of 154.5 lb. per sq. in., it passes through an expansion valve, where the pressure is reduced to 19.6 lb. per sq. in. The passage through the valve will bring about the immediate evaporation of 14.8 per cent of the liquid, the latent heat of which serves to cool the remainder of the liquid to evaporation temperature. As all the heat absorbed by this vapour is taken from the liquid there will be no change in the total heat content and this process may, therefore, be described as one of constant heat content. The process should correspond to the first or adiabatic part

Transparencies

pressure of the hydrogen gas in the mixture is sufficiently large for that of the ammonia in the evaporator to be less than the saturation pressure, even at the low temperature of the evaporator, and as a result the ammonia evaporates, the heat required for this being absorbed from the air inside the refrigeration chamber.

The relatively dense mixture of ammonia gas and hydrogen passes through the gas heat-exchanger to the absorber vessel and thence to the absorber where it is met by a stream of warm weak liquor flowing by gravity from the top of the boiler. The liquor passing through the absorber dissolves the ammonia gas from its mixture with hydrogen, and the practically pure hydrogen thereby produced rises by virtue of its low density to leave the absorber at the top and to pass back to the evaporator after being cooled in the gas heat-exchanger.

Strong ammonia solution from the bottom of the absorber vessel passes via the liquid heat-exchanger to a helically coiled pipe surrounding the source of heat inside the boiler and, as a result, bubbles of ammonia gas are formed in the solution which have the effect of raising the superincumbent liquid up the vertical feed pipe to the top of the boiler where it is then discharged to start the cycle of operations over again.

[*See* A. W. Barton, *A Text Book on Heat*, London, 1933, pp. 126-8; *Engineering, Lond.*, 1926, vol. 122, pp. 75-6; 1927, vol. 123, p. 579.] Inv. 1953-36, Photo 728/53.

123. DIAGRAM SHOWING GENERAL ARRANGEMENT OF THE ELECTROLUX COOLING UNIT. Prepared in the Museum.

The general hydrogen circulation and that of ammonia liquid or gas are indicated on the coloured diagram which provides a sectional view of the basic Electrolux cooling unit.

Inv. 1954-7, Photo 45/54.

124. COOLING UNIT FOR AIRCRAFT CABINS. Made and lent by Sir George Godfrey & Partners Ltd.

One of the problems associated with high-speed flying has been the maintenance of reasonably cool working conditions for the pilot inside the cabin of the aircraft. Skin-friction heat, generated solely by the passage of an aircraft through the air, raises the temperature of the surface of an aircraft flying at 600 m.p.h. by approximately 36° C. (97° F.) and it is, therefore, essential to provide a high-speed jet aircraft with a small refrigeration unit in order to reduce the temperature of the air inside the cabin so that the pilot does not suffer from heat exhaustion. The sectioned model shown here has been designed for use in "Vampire" and "Venom" aircraft.

The unit operates on the air-cycle principle, air being first compressed, then cooled, and subsequently expanded through a nozzle ring and turbine to emerge at a much lower temperature.

Pressurised air, bled from the main gas-turbine engine compressor, is first precooled and then supplied to the compressor inlet port of the cooling unit where its direction is changed from an axial to a radial flow by the action of the impeller mounted at the left-hand end of the centre rotor shaft. The velocity of this air is increased by being centrifuged through the decreasing space between the impeller blades, and the air then passes between the stationary vanes of the diffuser ring where its pressure is automatically increased; this change in air pressure is accompanied by a corresponding rise in air temperature.

On leaving the compressor outlet port of the unit, the air is ducted to a separate air-to-air heat exchanger (not present in the exhibit) before passing to the turbine inlet port. The cooled air from the heat exchanger then enters a volute and passes through a nozzle ring to the inward-flow radial turbine wheel, mounted at the right-hand end of the centre rotor shaft, where the air is expanded and its pressure reduced in driving the turbine wheel at a speed of approximately 60,000 r.p.m. This reduction in pressure is accompanied by a corresponding reduction in temperature so that the air, on leaving the turbine outlet, is at the pressure and temperature required in the aircraft cabin.

The whole unit, exclusive of precooler and heat exchanger, weighs only 9½ lb. and it is capable of handling a mass flow of from 7 to 20 lb. of air per minute at a turbine speed of 60,000 r.p.m. Inv. 1953-191, Photo 46/54.

125. APPARATUS FOR DEMONSTRATING COOLING BY THE EXPANSION OF AIR IN A CENTRIFUGAL FIELD. Made in the Museum Workshops.

Air under a pressure of about 4 lb. per sq. in. is admitted through a tangential nozzle to the inside of a cylindrical tube made of Perspex, where the rotating air stream produced within the tube gives rise to a region of increased pressure near the walls and one of decreased pressure near the axis of the tube. The presence inside the tube and close to the nozzle of a diaphragm with a small central opening facilitates the separation of air from these two regions; air from the central part of the tube escapes through the opening in the diaphragm to emerge at one end of the tube whilst the remaining air leaves the tube at the other end where it passes through a simple throttling valve.

Three thermometers are provided, to indicate the temperature of the air immediately prior to entering the nozzle and the temperatures of the air streams emerging from both ends of the tube. The readings of these thermometers show that air escaping through the central diaphragm is colder, and the remaining air warmer, than the air supplied to the nozzle.

of the Carnot expansion stroke and would, in fact do so if an expansion cylinder were used instead of an expansion valve. This constitutes the only theoretical difference between the actual and ideal cycles. It involves a slight loss of refrigerating effect which is more than compensated for by the greater simplicity and convenience of the expansion valve.

The remaining liquid (85.2 per cent) now evaporates in the evaporator at 5° F., extracting heat from its surroundings, this part of the cycle corresponding to the second or isothermal part of the Carnot expansion stroke. Inv. 1934-464, Photo 6943.

131. PERKINS' VAPOUR-COMPRESSION MACHINE (1834).

The illustration is of Jacob Perkins' ice machine, made for him by John Hague.

[*See* F. Bramwell, *J. Soc. Arts*, 1883, vol. 31, pp. 76-7; T. C. Crawhall, *Ice cold Stor.*, 1934, vol. 37, pp. 129-30 and 142.] Inv. 1934-508, Photo 7186.

132. HARRISON'S REFRIGERATING MACHINES. From illustrations supplied by Illustrated London News Ltd.

(1) Ether-compression machine (1858). Inv. 1934-509, Photo 7027.
(2) International Exhibition model (1862). Inv. 1934-512, Photo 7025.

133. EARLY COLD-AIR REFRIGERATING MACHINE. From a photograph supplied by J. & E. Hall Ltd. Inv. 1934-515, Photo 7029.

134. ICE STORE IN CHELSEA (1851). From illustrations supplied by Illustrated London News Ltd.

(1) Exterior view. Inv. 1934-510, Photo 7028.
(2) Interior view. Inv. 1934-511, Photo 7026.

135. ICE-COOLED MEAT SHIP (1877). From an illustration supplied by Illustrated London News Ltd. Inv. 1934-514, Photo 7024.

136. COMMERCIAL ICE-MAKING PLANT. From photographs supplied by L. Sterne & Co. Ltd., and J. Piqué, Esq.

(1) Ammonia compressors. Inv. 1934-527.
(2) Pumps. Inv. 1934-528.
(3) Fitting ice cans. Inv. 1934-529.
(4) Ice tipped from cans. Inv. 1934-530.
(5) Ice ready for despatch. Inv. 1934-531.
(6) Loading trawlers with crushed ice. Inv. 1934-532.

137. QUICK FREEZING. From photographs supplied by J. Piqué, Esq.

(1) S.S. "Arctic Queen". Inv. 1934-533.
(2) Brine tanks. Inv. 1934-534.
(3) Cold store. Inv. 1934-535.

138. COLD STORAGE AT ROYAL ALBERT DOCKS. From photographs supplied by The Port of London Authority.

Inv. 1934-520, Photos 7005, 7006, 7007 and 7008.

139. USES OF REFRIGERATION. Photographs supplied by J. & E. Hall Ltd., and York Shipley & Co. Ltd.

(1) Beer cellar. Inv. 1934-522, Photo 7010.
(2) Abattoir. Inv. 1934-523.
(3) Testing motor car starters. Inv. 1934-524.
(4) Testing aeroplane instruments. Inv. 1934-525.
(5) Food research. Inv. 1934-526.
(6) Skating rink. Inv. 1934-521, Photo 7008A.

MODELS

140. FESTIVAL HALL HEAT PUMP. Presented by Matthew Hall & Co. Ltd.

Refrigerators function by extracting heat from the contents of the cold chamber and by transferring this heat to an external radiator where it can be dissipated to the surroundings. Thus the domestic refrigerator serves to heat the room in which it stands although the quantity of heat derived in this way is small. By changing the contents of the cold chamber as soon as they have been cooled, the refrigerator can be used to provide continuous heating ; this is the principle on which the heat pump is based.

The model exhibited is of the heat pump installed at the Royal Festival Hall, in 1951, to provide part of the heating for the building as well as the whole of the cooling required in summer.

The heat pump is driven by two Rolls-Royce Merlin aircraft engines, converted to run on town gas, and the main source of heat is the River Thames, though additional heat is extracted from the engine exhausts and cooling systems. A centrifugal pump delivers river water, at a maximum rate of 1,800 gallons a minute, for circulation through a shell-and-tube heat exchanger (the evaporator), where it gives up heat to boil the liquid refrigerant in the shells at low temperature and pressure. The water, thus cooled through 4° to 6° F., passes back direct to the river. The refrigerant (Freon 12), after boiling in the shell of the evaporator, is then compressed in two stages to the pressure needed for condensation at the temperature appropriate to the hot-water system. After passing through an oil separator, the refrigerant then condenses in the shell of a second shell-and-tube heat exchanger (the condenser), where it gives up a large quantity of heat to water which is circulating through the tubes from the concert hall. The refrigerant then passes through two automatic float-valves to return in liquid form to the evaporator ready to start the cycle again.

When the heat pump is required to cool the hall in summer, the flow of river and of hall water are transposed so that the river water circulates through the condenser, whence it absorbs heat in condensing the Freon, and the hall water passes through the evaporator, where it is cooled by the evaporating Freon.

Storage tanks and associated pipelines are provided so that the Freon can be evacuated from the plant, should any part require dismantling.

[*See* P. E. Montagnon & A. L. Ruckley, *J. Inst. Fuel*, 1954, vol. 27, pp. 170-92 ; *Industr. Heat. Engr*, 1950, vol. 12, pp. 226-9 and 234; 1951, vol. 13, pp. 198-203 and 206; *Engineer, Lond.*, 1951, vol. 191, pp. 859-61; 1954, vol. 197, pp. 184-5; *Engineering, Lond.*, 1951, vol. 171, pp. 741-3 and pl. 60.] Inv. 1954-461.

141. COLD-AIR REFRIGERATING MACHINE AND COLD ROOM. Presented by The Lightfoot Refrigeration Co. Ltd.

Machines of this type differ from other refrigerating machines in so far as their action does not depend upon a change of state of the working substance. The cold-air machine was largely used at one time and was, in fact, responsible for the early development of refrigerated ships, but, on account of its low efficiency, it is now more or less obsolete.

Air is drawn from the cold room into the lower cylinder, where it is compressed to about 3 or 4 atmospheres, the heat of compression being removed in a water cooler. The air is then admitted under pressure to the upper cylinder through a valve which closes after about one-third of the stroke, and is expanded to atmospheric pressure while doing work against the piston. In this way it is cooled adiabatically to an extremely low temperature and is discharged to the cold room on the up-stroke of the piston. Although the temperature of the expelled air may be as low as −80° F. or even −100° F., the amount of heat actually removed will be relatively small on account of the low specific heat of air.

The circulation of the air through the machine is shown on a separate diagram which accompanies the exhibit. Inv. 1930-121, Photo 7098.

142. COLD STORE COOLED BY WATER EVAPORATION. Presented by The University of Cambridge and The Department of Scientific and Industrial Research.

The principle of cooling by water evaporation is of value commercially where very low temperatures and precise control are not essential.

The store is cooled by air reduced in temperature by passing through pipes covered with an absorbent material which is kept saturated with moisture. Baffle walls are provided to assist the circulation of air round the pipes. Inv. 1933-624, Photo 7058.

Models

IX. PORTRAITS

THESE portraits represent some of the distinguished workers who have contributed to our knowledge of the science of heat.

167. ETCHING OF PRINCE RUPERT (1619-1682). Bequeathed by Mrs. A. Bennet Woodcroft. Inv. 1903-158.

168. ETCHING OF COUNT RUMFORD (1753-1814). Bequeathed by Mrs. A. Bennet Woodcroft. Inv. 1903-157, Photo 4148.

169. ENGRAVING OF WILLIAM HYDE WOLLASTON (1766-1828). Bequeathed by Mrs. A. Bennet Woodcroft.

The engraving was made by Willm. Skelton, of 1, Stafford Place, Pimlico, from a painting by John Jackson, R.A. Inv. 1903-159, Photo 8597.

170. ENGRAVING OF SIR JOHN LESLIE (1766-1832). Bequeathed by Mrs. A. Bennet Woodcroft. Inv. 1903-220.

171. ENGRAVING OF SIR HUMPHRY DAVY (1778-1829).

Engraved by Roffe and published by J. Lunbird, of 143, Strand, London. Inv. 1943-188, Photo 138/47.

172. PHOTOGRAPH OF THOMAS ANDREWS (1813-1885). Presented by Miss M. K. Andrews. Inv. 1904-51.

173. PHOTOGRAPH OF JAMES PRESCOTT JOULE (1818-1889).

The original portrait in oils, by John Collier, from which this photograph has been taken, is in the rooms of the Royal Society of London. Inv. 1950-215, Photo 328/49.

174. TRANSPARENCY SHOWING LORD KELVIN (1824-1907). From a portrait in the Science Library. Inv. 1934-519, Photo 7032A.

175. TRANSPARENCY SHOWING CARL VON LINDE (1842-1934).

This portrait was taken from a book by J. T. Critchell & J. Raymond, entitled *A History of the Frozen Meat Trade*, London, 1912. Inv. 1934-518, Photo 7035.

Portraits