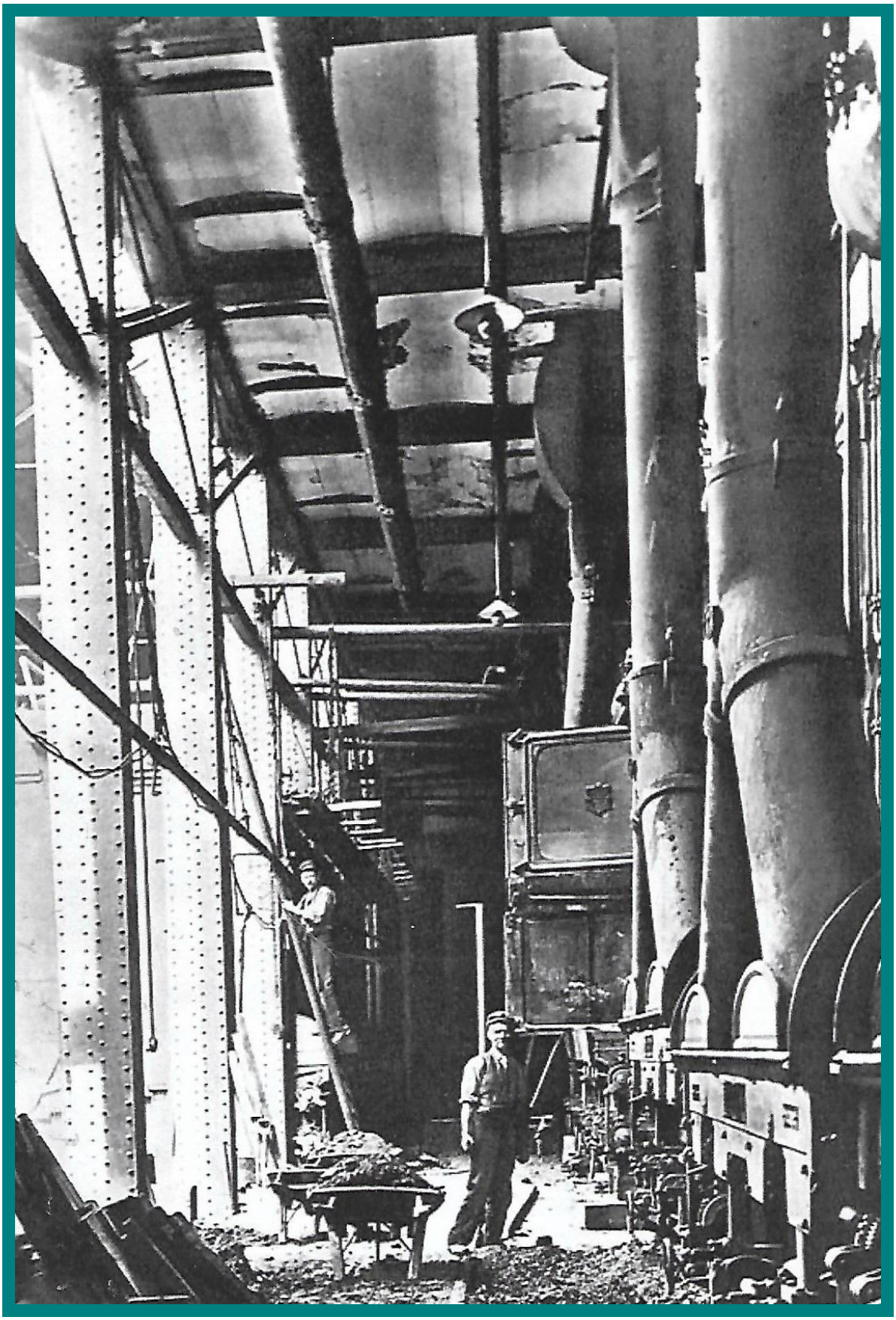
Building Engineering Services
HERITAGE REVISITED
PART SIX

Brian Roberts
and the CIBSE Heritage Group

The Prudential Assurance Building of 1904 in High Holborn, is an early example of CHP (Combined Heat & Power) due to the Victorian engineer Wilson Weatherley Phipson.

BANKSIDE POWER STATION, LONDON



Bankside boilerhouse (City of London Electric Lighting) c.1890.

BURR ISLAND HOTEL, DEVON

A 1928, 25 room, luxury Art Deco Hotel on a private island reached at high tide by tractor.

INTRODUCTION

Part-6 features engineering services in a variety of buildings and transport which have been researched and visited by Heritage Group members, individually or as a group.

CONTENTS

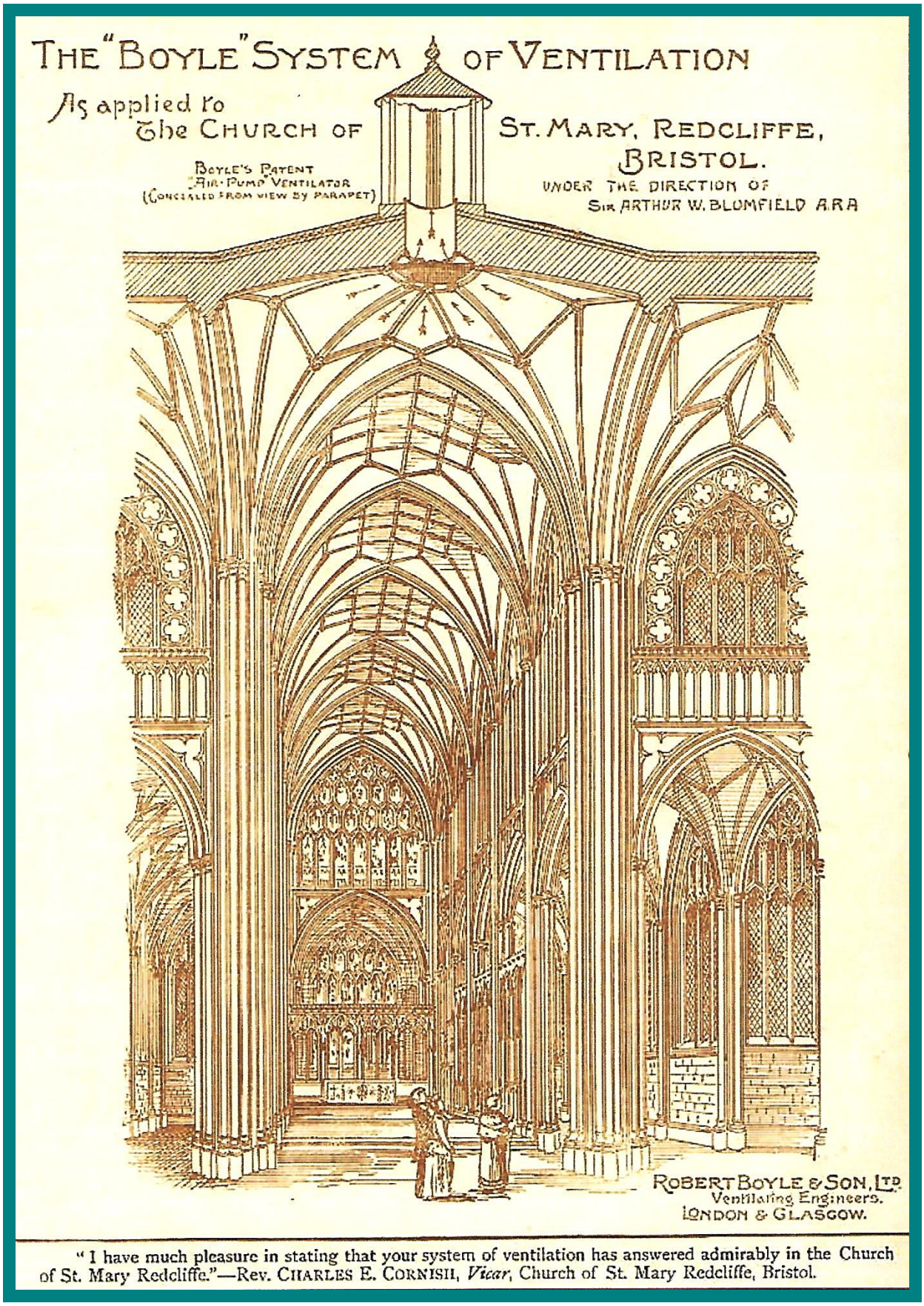
ST. MARY REDCLIFFE, BRISTOL

"The fairest parish church in England"

Parts of the Anglican parish church of St. Mary Redcliffe in Bristol date back to the early 12th century. Much of the present church was built between 1252 and 1370. In 1446, the spire was struck by lightning and fell, not being replaced until 1872 by the present one at 292 ft high. Considered a significant example of Gothic architecture it was described by Queen Elizabeth I as "the fairest, goodliest and most famous parish church in England."

Robert Boyle & Son Ltd was a Victorian firm of ventilating engineers of Glasgow, and later London, who devised and manufactured their so-called "Air Pump" Ventilator, designed to exhaust stale air from an enclosed space. Their catalogue of 1899 features its use in a wide variety of buildings, including the church of St. Mary Redcliffe in Bristol as shown on the next page.

ST. MARY REDCLIFFE, BRISTOL



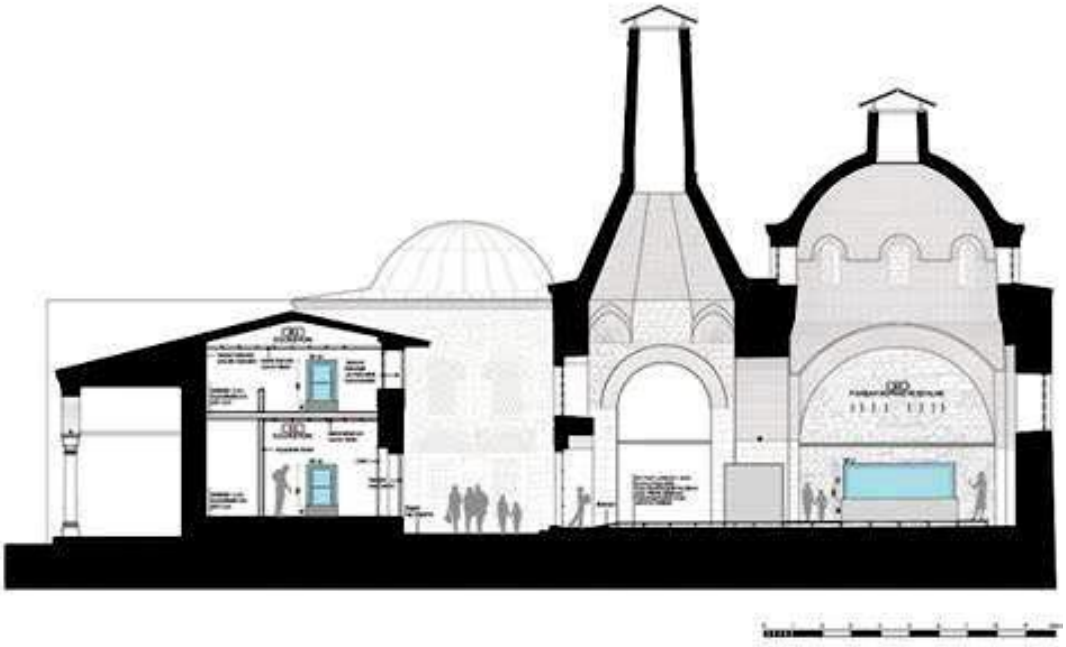
"I have much pleasure in stating that your system of ventilation has answered admirably in the Church of St. Mary Redcliffe."—Rev. CHARLES E. CORNISH, *Vicar*, Church of St. Mary Redcliffe, Bristol.

TOPKAPI KITCHENS, ISTANBUL

The Topkapi Palace in Istanbul, Turkey.

The Topkapi Kitchens.

TOPKAPKI KITCHENS, ISTANBUL



The original kitchens of the Topkapi Palace in Istanbul have been traced back to the 15th century. The present kitchen buildings, now a museum, were remodelled in 1574 and are located on an internal street within the Palace. These ten domed buildings have a total of 20 chimneys arranged in two rows. The kitchens, the largest in the Ottoman Empire, had a staff of 800 to serve meals for 4000 people. There was an Imperial Kitchen and a number of separate kitchens including Harem, the general Palace and for beverages and confectionery. The kitchen buildings also once had dormitories, baths and a mosque.

Inside the present museum-kitchen

PALACE OF WESTMINSTER, LONDON

The Palace of Westminster was destroyed by fire in 1834.

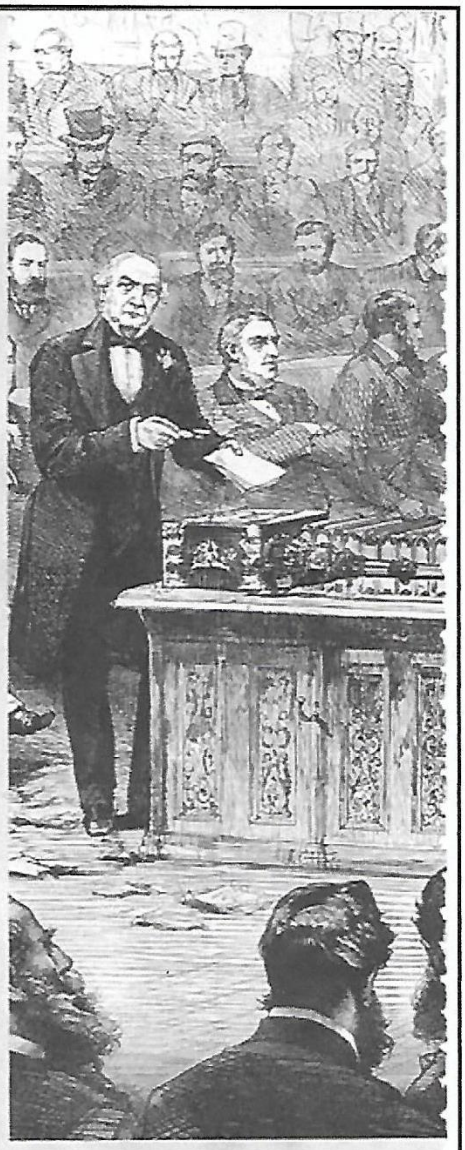
After the fire of 1834, the engineer David Boswell Reid was appointed to design the heating and ventilation. Following numerous disagreements with the architect, Charles Barry, he produced a scheme for the House of Commons only (Barry dealing with the House of Lords). Reid proposed to introduce filtered and humidified air through small holes in the floor and to extract the vitiated air through the ceiling and to the base of a chimney (a system known as "fire-assisted ventilation"). The scheme provided for summer cooling by evaporative water cooling, by passing cold water through a heater battery and, in rare cases, by the use of ice. He also proposed circulating cooler night air through the Chamber (nocturnal ventilation). There were many complaints about his systems and, for the next one hundred years, numerous committees and engineers wrestled unsuccessfully with the problems. It was taken out of their hands when the Chamber was destroyed by enemy action in May, 1941.

Other pioneering engineering works include the installation of steam ejectors by Isaac Shone to raise sewage from basement to the higher level of the street mains and the provision of gas lighting by William Sugg. (Shone's ejectors are still in the basement.) It has also been claimed that Reid's acoustic design proposals were well ahead of his time.

PALACE OF WESTMINSTER, LONDON

THE PIONEER WHO RID *Parliament* OF HOT AIR

In the first of a series of articles looking at the influence of pioneering engineers and buildings, **Dr Neil Sturrock**, chairman of the CIBSE Heritage Group, profiles **David Boswell Reid** – probably the first true building services engineer



David Boswell Reid – the 'grandfather' of air conditioning

Dr David Boswell Reid is considered to be the 'grandfather' of air conditioning engineering, and was also a pioneer in acoustics and lighting design.

He is perhaps most famous for his involvement with the design of the UK Houses of Parliament, in Westminster, a project for which his official title was 'Ventilator'. He is very often unfairly blamed for the failure of the system to provide satisfactory environmental conditions for the building, which he always argued was down to the lack of cooperation afforded him by the architect, Charles Barry.

Reid argued that Barry frequently acted without authority in making alterations that affected the large-scale air movement required for his system to work. Barry, on the other hand, was determined that Reid's grand ideas should not be allowed to control the architecture.

What is rarely reported is that Reid – having been dismissed by the government – was exonerated by an enquiry in February 1852, and awarded more than £3,000 in compensation. He was then allowed to make more than 30 alterations to the building to try to improve matters, but it was never wholly satisfactory, despite the varied attempts of other engineers over subsequent years.

Reid's fascination with ventilation had begun after a fairly circuitous journey through the world of academia at Edinburgh University.

He initially went there to study medicine, following in the footsteps of his father, Dr Peter Reid – who lectured in the Department of Medicine – and his older brother. However, his main interest was in chemistry.

Reid was disappointed to discover Edinburgh offered no classes in practical chemistry, so, in around 1826, he started his own, in some outbuildings at Edinburgh High School. His reputation quickly grew and, in 1828, he was asked by Professor Thomas Hope to help teach chemistry at the university.

Extract from CIBSE Journal paper on David Boswell Reid, January 2015.

CASTLE DROGO, DEVON

The castle is located near Drewsteignton in Devon.

Castle Drogo, built between 1911 and 1930, can only be described as a country house and "mixed-revivalist" castle. It was built for Julius Drewe, the founder of Home & Colonial Stores, and was the last castle to be built in England. The architect was Edwin Lutyens considered by many to be Britain's most famous architect, who designed the 1920 Cenotaph in Whitehall. The castle was given to the National Trust in 1934, the first 20th century building to be acquired by the Trust. It is Grade I listed and undergoing restoration.

The restored Hydro Turbine on the River Teign.

CASTLE DROGO, DEVON

The tiled kitchen stove.

The dish washing arrangements.

SS GREAT BRITAIN, BRISTOL

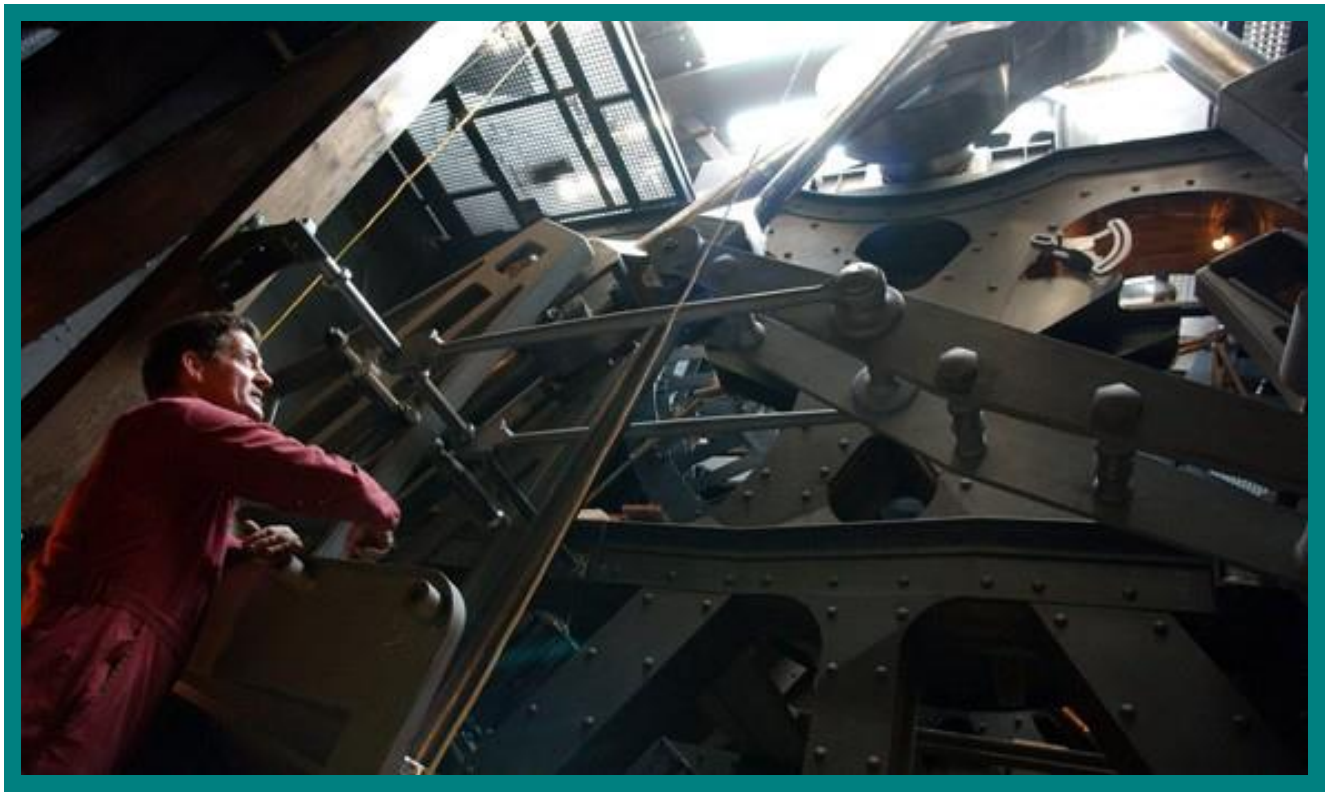
The SS *Great Britain*, passenger steam ship of 1845 and now a museum, in dock in Bristol.

Designed by Kingdom Isambard Brunel for the transatlantic service between Bristol and New York City, she was initially the longest passenger ship in the world and the first to combine an iron hull and a screw propeller in one vessel. The ship is 322 ft in length with a displacement of 3400 tons. She provided four decks of accommodation for a crew of 120 and for some 360 passengers who had cabins and dining and promenade saloons. She was powered by two huge inclined, direct-acting, 2-cylinder engines with twin high pressure cylinders (diameter uncertain) and twin low pressure cylinders (88 inches bore) by 6 ft stroke. She was also provided with secondary masts for sail power.

When launched, *Great Britain* was by far the largest vessel afloat. The high construction cost, and the cost of refloating the ship after it ran aground in what is now Northern Ireland, forced the owners out of business. In 1852, she was salvaged and repaired and carried thousands of immigrants to Australia, was converted to all-sail in 1881, and retired in 1884 to the Falkland Islands. Here she was used as a warehouse, a quarantine ship and coal hulk until being scuttled and sunk in 1937. In 1970, she was raised and repaired enough to be towed back to dry dock in Bristol where originally built. Restored, the SS *Great Britain* is now a visitor attraction and museum ship in Bristol Harbour.

SS GREAT BRITAIN, BRISTOL

Lounge and refreshments.



Down in the engine room.

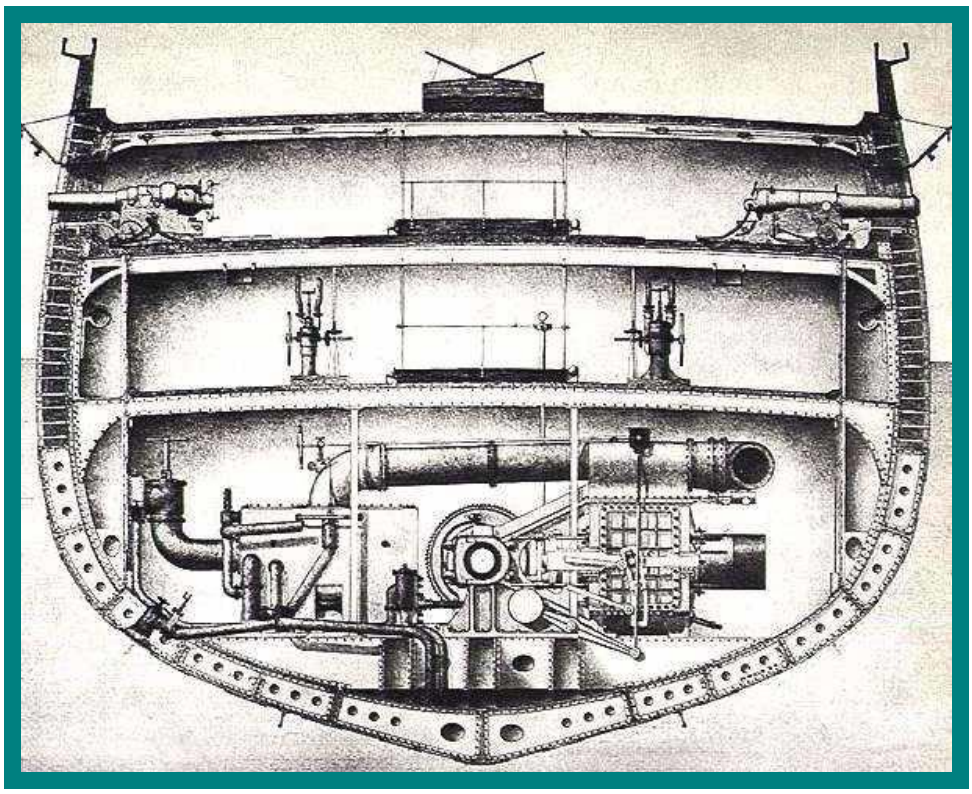
HMS WARRIOR, PORTSMOUTH

HMS *Warrior* anchored in Portsmouth Harbour.

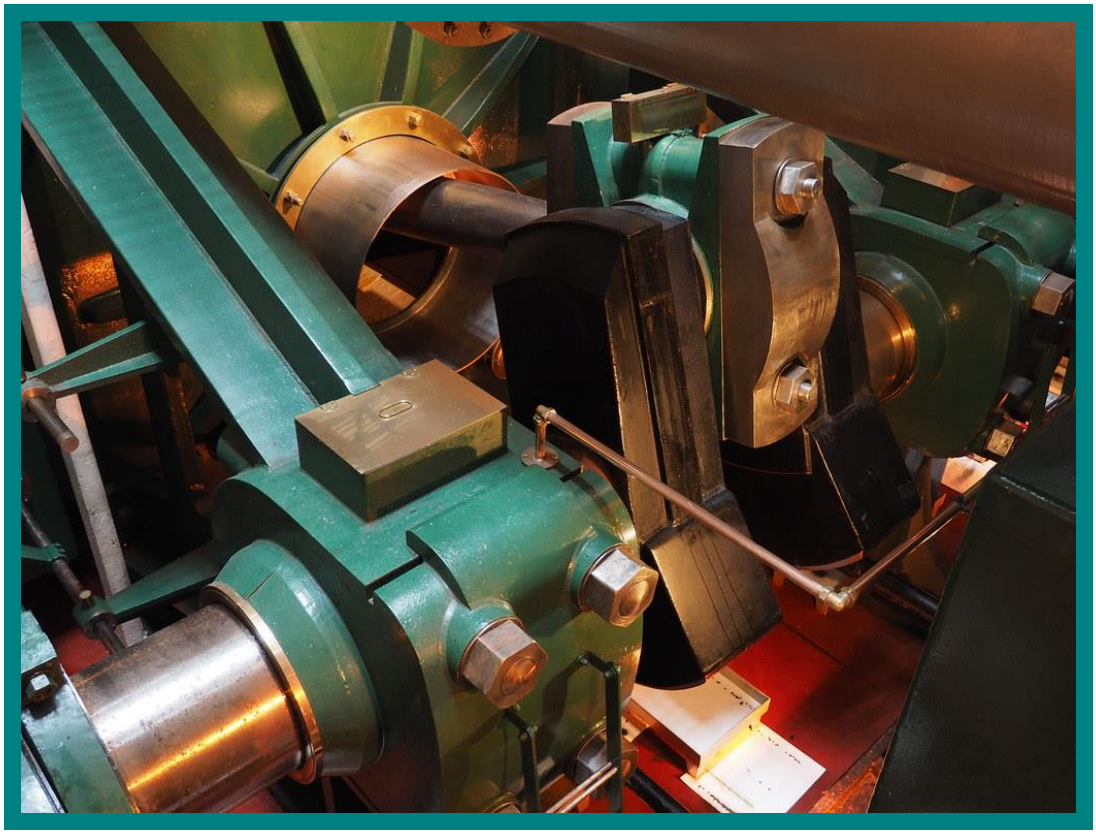
The Royal Navel warship HMS *Warrior* built in 1861, and now a museum, is a 4O-gun steam-powered armoured frigate. *Warrior* and her sister ship HMS *Black Prince* were the first-ever armour-plated, iron-hulled warships. They were built in response to France's launching in 1859 of the first ocean-going ironclad warship, the *Gloire*. But the French vessel still had a wooden hull.

***Warrior* is 420 ft long overall, having a beam of 58 ft, a draught of nearly 27 ft and a displacement of 9137 tons. The ends of the hull are subdivided by transverse watertight bulkheads. The decks are arranged into 92 compartments and the hull has a double bottom underneath the engine and boiler rooms. *Warrior* had a two-cylinder trunk engine using steam from 10 rectangular boilers, the engine producing 5772 indicated hp, driving a 26 ton propeller, and giving a speed, when undergoing trials, of 14 knots (16.2 mph) under steam only. Warrior was rigged with for sail (total 48,400 sq ft). When under sail only, to reduce drag, the propeller could be hoisted into the ship and the telescopic funnels lowered. However, following the 1871 launching of the mastless HMS *Devastation*, she was places in reserve in 1875 and decommissioned in 1883.**

HMS WARRIOR, PORTSMOUTH



Section through *Warrior* showing the engine and double-hull arrangement.



Reconstruction of part of the engine driving mechanism.

PEAK TRAMWAY, HONG KONG

Opened on 28 May 1888, it had taken three years to build the Peak Tramway system.

The Peak Tram is a funicular railway which runs from Central district to Victoria Peak, covers a distance of 0.87 miles climbing some 1300 ft. It is a single track with an unusual gauge for what was once a British Colony, very slightly under 5 ft, and described as "Russian Gauge." The single rail track, with a passing loop, employs two trams connected to a power-driven haulage cable. There are four intermediate request stops, each station having two platforms on opposite sides- one for boarding, the other for exiting the tram. When opened, the line used a static steam engine to power the haulage cable and at first it was used only by residents of Victoria Peak. It was considered a marvel of engineering upon its completion and later became a popular tourist attraction affording spectacular views of the harbour and Kowloon (and nowadays the skyscrapers).

In 1926, the steam engine was replaced by an electric motor. In 1956, the original two wooden tramcars were replaced with three of the latest metal-bodied type (one spare). Then in 1989, the system was completely rebuilt by a Swiss company, being provided with new track, a computerised control system and two new two-car trams. Starting in 2019, the system is again being upgraded.

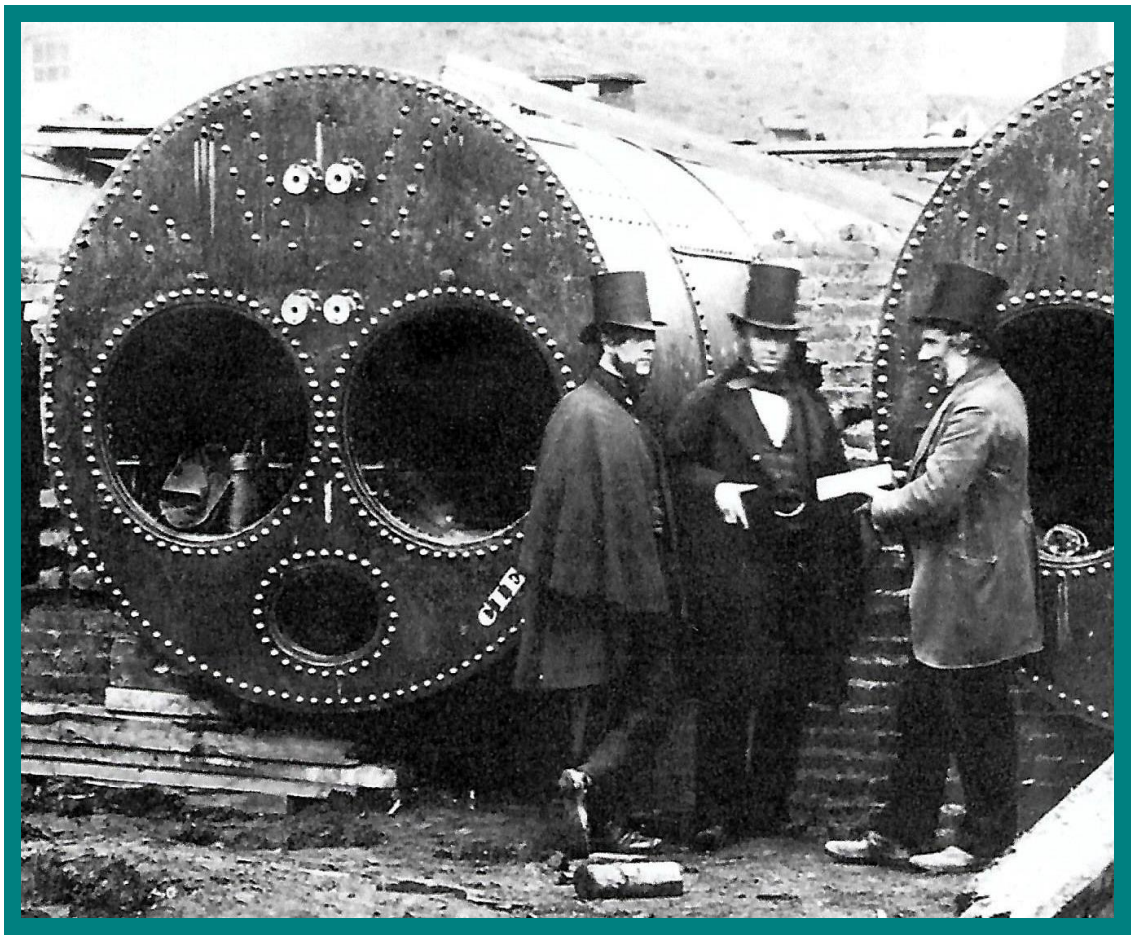
PEAK TRAMWAY, HONG KONG

One of two Tramcars ascending the Peak (the other simultaneously descending).

Tramcar at the terminus.

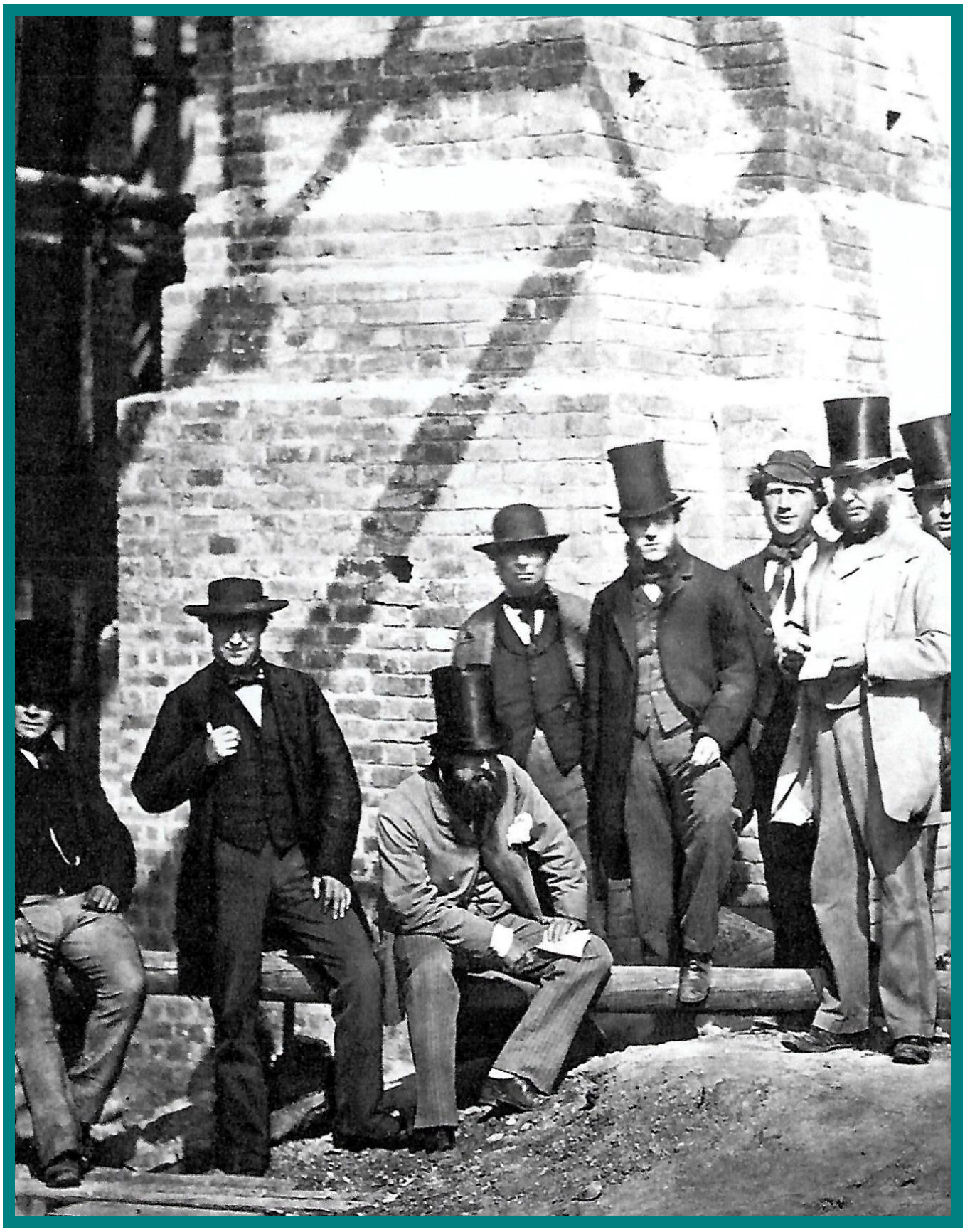
INTERNATIONAL EXHIBITION, LONDON

Opening of the International Exhibition 1862.



Engineers inspecting the boilers.

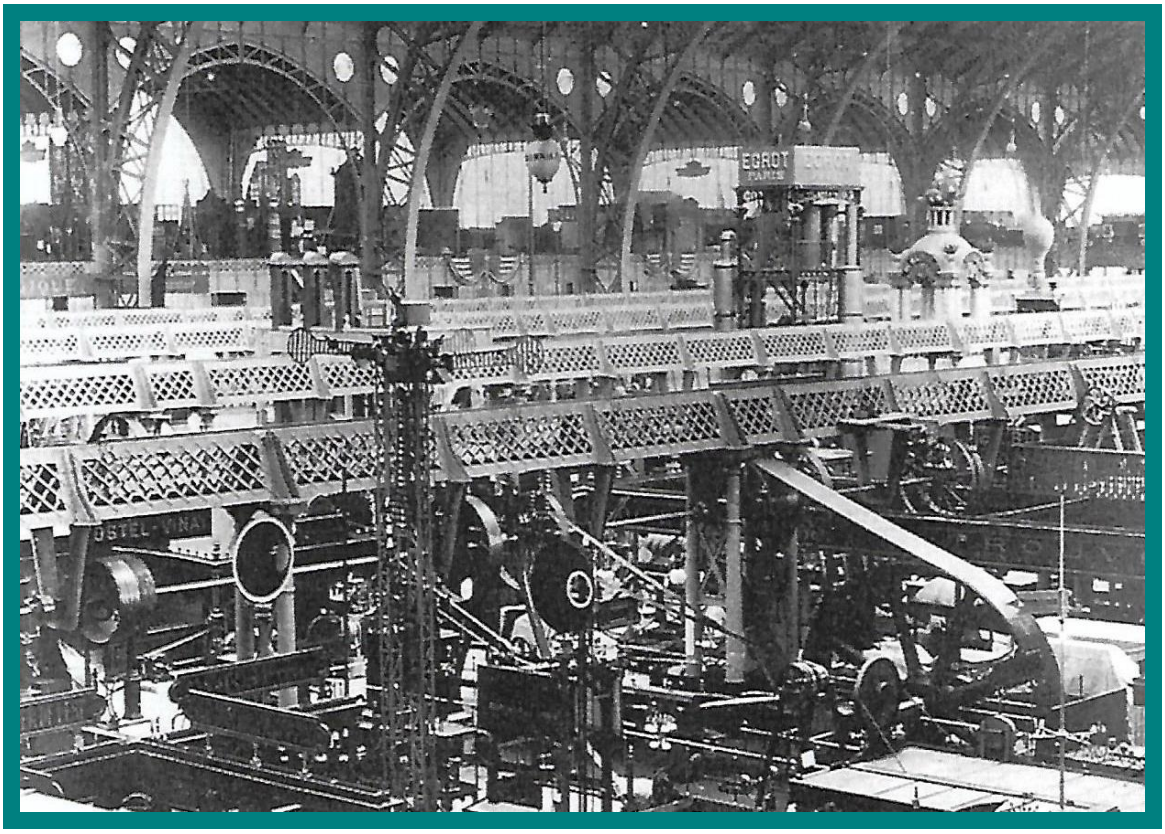
INTERNATIONAL EXHIBITION, LONDON



Foremen at the building of the International Exhibition.

PALAIS des MACHINES, PARIS

The *Palais des Machines* opened in Paris in 1900.



The *Pontes Roulants*, an electrically-driven gantry used for moving machinery.

PALAIS des MACHINES, PARIS

Machinery exhibits in the *Palais des Machines*, 1900.

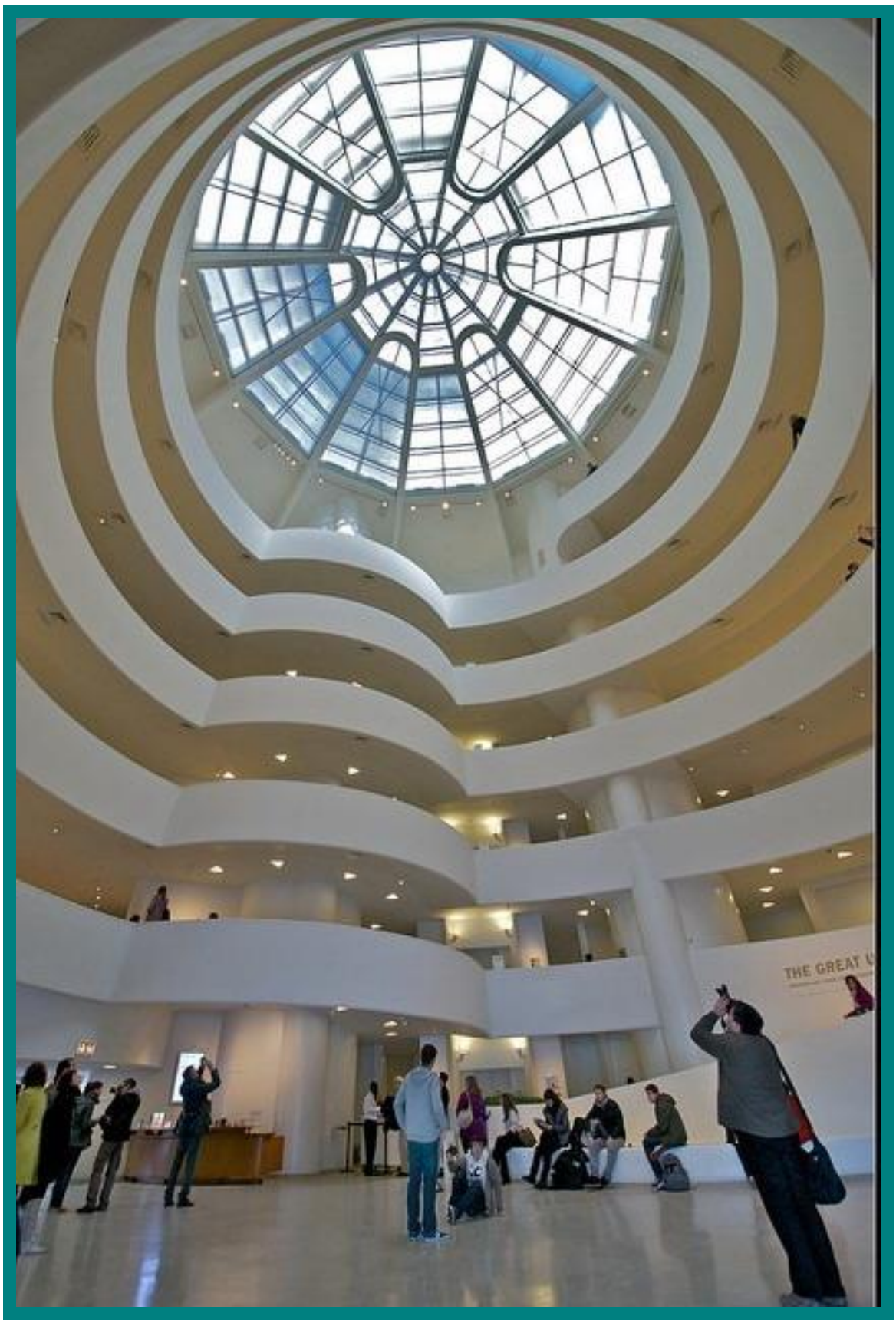
GUGGENHEIM MUSEUM, NEW YORK

The Solomon R. Guggenheim Museum (The Guggenheim), Corner of 5th Avenue, New York City.

The Guggenheim is a permanently expanding collection of Impressionist, Post-Impressionist, Early Modern and Contemporary Art. Established in 1939, the present building, designed by the architect Frank Lloyd Wright, opened in 1959. Wright dispensed with the traditional museum layout in which visitors are led through a series of interconnecting rooms. His plan was for visitors to ride to the top of his building by elevator and then walk at a leisurely pace along the gentle slope of a continuously sloping ramp (circling the inside edge of the building); visitors viewing the works of art as they descended. Wright's cylindrical design, wider at the top than at the bottom is said to have been conceived as *A Temple of the Spirit.* This open rotunda arrangement affords visitors the unusual possibility of seeing simultaneously various groups of art on different levels.

Many parts of Wright's original plan were not carried out, including his somewhat surprise intention to have the building exterior finished in red. Also, in the original construction an important feature, the huge domed skylight had been covered, spoiling Wright's carefully articulated lighting effects. Fortunately, this was corrected in 1992 when the skylight was restored to its original design.

GUGGENHEIM MUSEUM, NEW YORK



The Guggenheim with its spiral galleries and domed skylight.

UNIVERSITY of GLASGOW

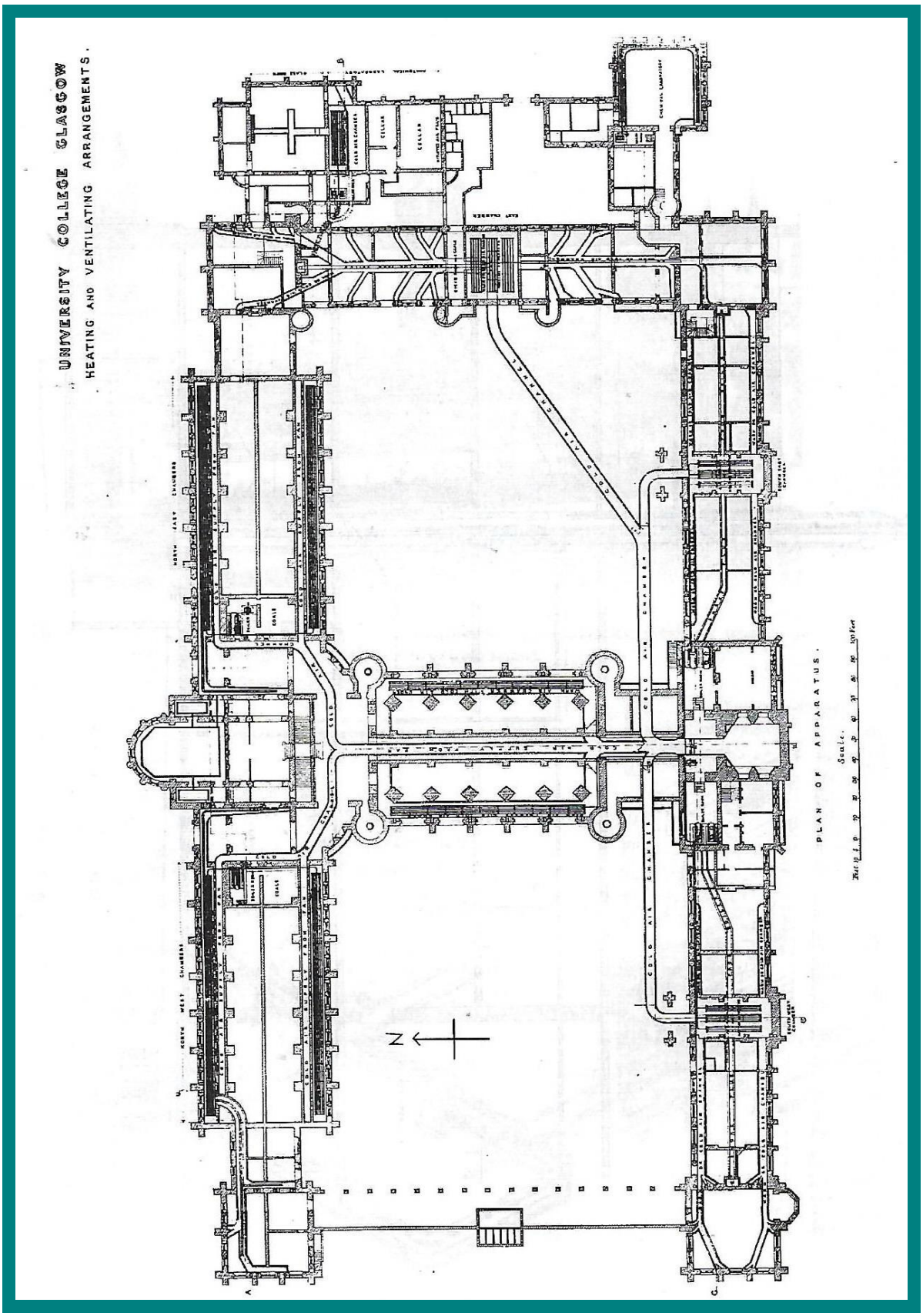
The University of Glasgow, Gilmore Hill, built 1866-70: Architect George Gilbert Scott.

In about 1865, the University decided that adequate ventilation and warming of the planned complex of buildings was to be a priority. The Committee set up to deal with this included many eminent scientists and engineers, notably William John MacQuorne Rankine (who developed the Rankine Cycle for heat engines) and Sir William Thompson (later Lord Kelvin, who gave his name to the Absolute Temperature scale). Being aware of the work of the engineer Wilson Weatherly Phipson, he was appointed to design a scheme to meet the Committee's numbered requirements which included:

No.5: The fresh air should be supplied hot and cold and each class room be provided with a means of using it.
No.9: The fresh air (for the building) should be drawn from a place where the air is always pure.
No.10: The fresh air should be forced in by one or any required number of suitable machines.

Phipson's scheme was vast to match the scale of the buildings. The air for the entire complex travelled from inlets at the top of the central clock tower to a plenum chamber and was then supplied to the four corners of the complex, using a steam-driven fan (described as screw-type) of 7 ft 6 inches diameter, through underground passages to local gravity-fed hot water heating coils each having an adjacent Cornish boiler. There was no mechanical extract, the exhaust to atmosphere being heat-assisted. The design met the Committee's No.9 & 10 requirements but failed to completely satisfy No.5. The resulting system met with mixed reactions.

UNIVERSITY of GLASGOW



Phipson's scheme of ventilating and warming for the University.

ROYAL HOLLOWAY COLLEGE, EGHAM

The Royal Holloway College at Egham in Surrey, built 1879-87. Architect W.H. Crosland.

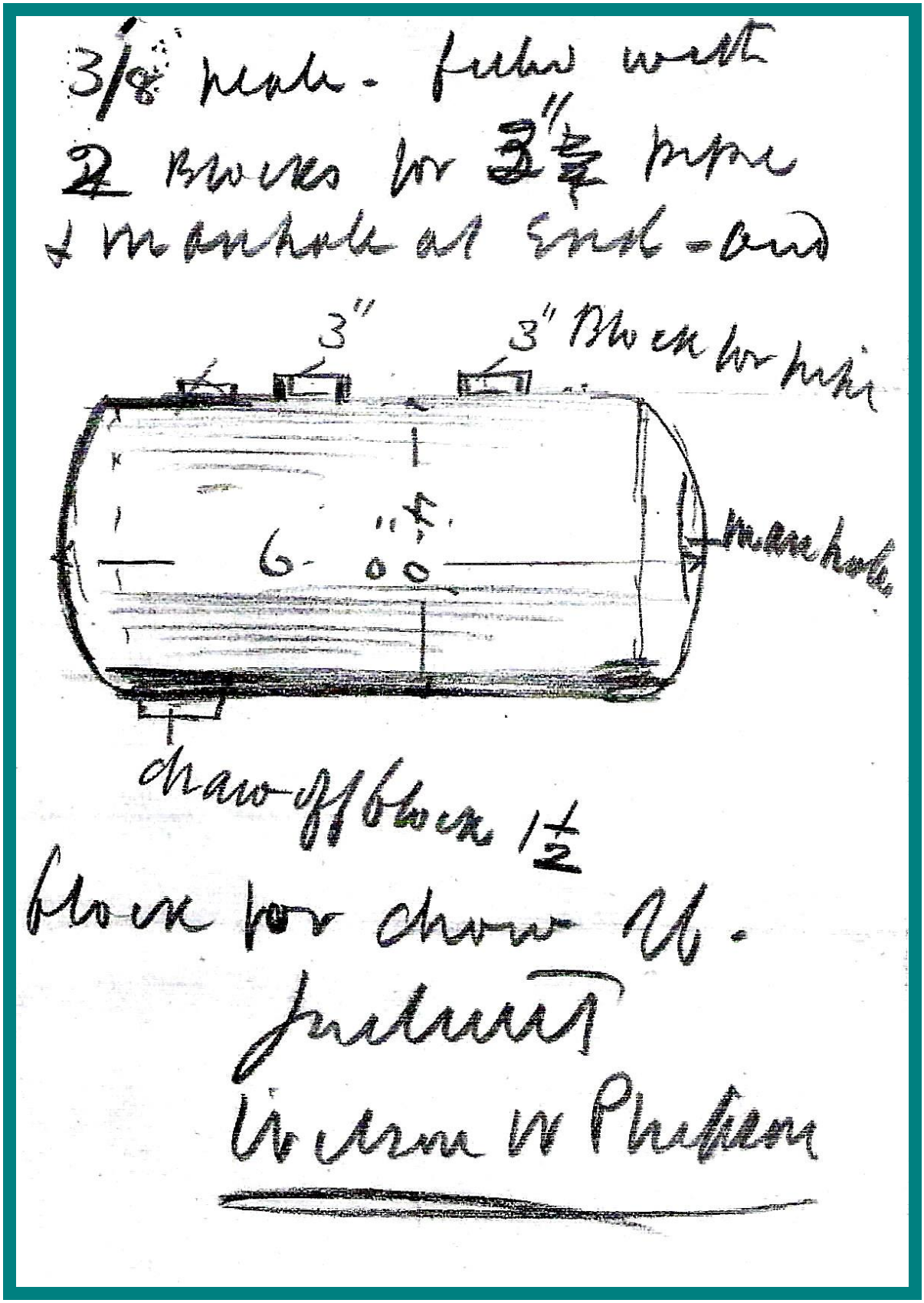
The architect Crosland was a pupil of Sir George Gilbert Scott with whom Phipson had worked on the University of Glasgow, and this is possibly how Phipson became appointed as building services engineer, both for Holloway College and for its twin building, the Holloway Sanatorium. These buildings were funded by the Victorian business man and philanthropist Thomas Holloway who had made his fortune from patent medicine (Holloway's pills). The enormous college building, one of the first for women, was built to a rectangular plan, 550 ft by 376 ft, with two courts and with 6-storey east and west wings containing all student accommodation.

The Phipson Collection in the Heritage Group Archive contains a number of original working documents (all handwritten), ranging from correspondence with suppliers, priced Bills of Quantities and Phipson's reports. They provide details of the cost of various items:

Cooking Apparatus (Benham & Sons) £1315; Steam Boilers (Fraser & Fraser, 3 No.) £1863; Steam & Condense tube, fittings, valves, brackets and radiators (Thomas Noakes) £4487. 12s. 0d; Special made radiators (Hart, Son, Peard) £470. 16s. 0d; Hot & Cold Water Supply from Heaters, £960.

The cost of these items varies as the contract progressed. There are also items for labour, lodgings, railway fares and carriage and 7.5% for contingencies with a note "add 30%" presumably to cover overheads and profit. The comparison of estimates, from competing contractors. ranges from £10,215 to £10,804, but they are not identified and there are no details of the award of contract.

ROYAL HOLLOWAY COLLEGE, EGHAM



Phipson's sketch and enquiry of 2 May 1882 to Fraser & Fraser for a cylinder.
The quotation came back on 4 May for the sum of £27. 10s. 0d.

NATIONAL COLLEGE, LONDON

For HEATING, VENTILATING, REFRIGERATION & FAN ENGINEEERING

Students (1955-56 Course) outside Ingall House Hostel

The National College for Heating, Ventilating Refrigeration & Fan Engineering was set up in 1948, located in an old building near south London's Elephant & Castle and opposite the then Borough Polytechnic (now London South Bank University). It had an initial intake for the one-year Diploma course of some fifty trainees, mostly student apprentices from contractors across the UK, particularly the larger firms such as Haden and Brightside. The entry requirement was possession of the Ordinary National Certificate in Mechanical Engineering or equivalent. About forty students from outside London stayed in Ingall House, a College Hostel near Crystal Palace.

Students were taught design in the main building engineering services plus subjects such as noise & vibration and fan engineering, and attended laboratories in the nearby Polytechnic for mechanics of fluids and electro-technology. Students also visited installations around London (including that at St. Helier Hospital, pp.42-43). In 1947, the College admitted eight students with the Diploma or a Degree to their advanced Associateship Course, each student carrying out research in a specialist subject and writing a thesis. In 1960, the National College transferred to a new building, with advanced equipment, part of the Polytechnic across the road. In later years, Building Services Engineering Degree courses were set up in a number of Universities.

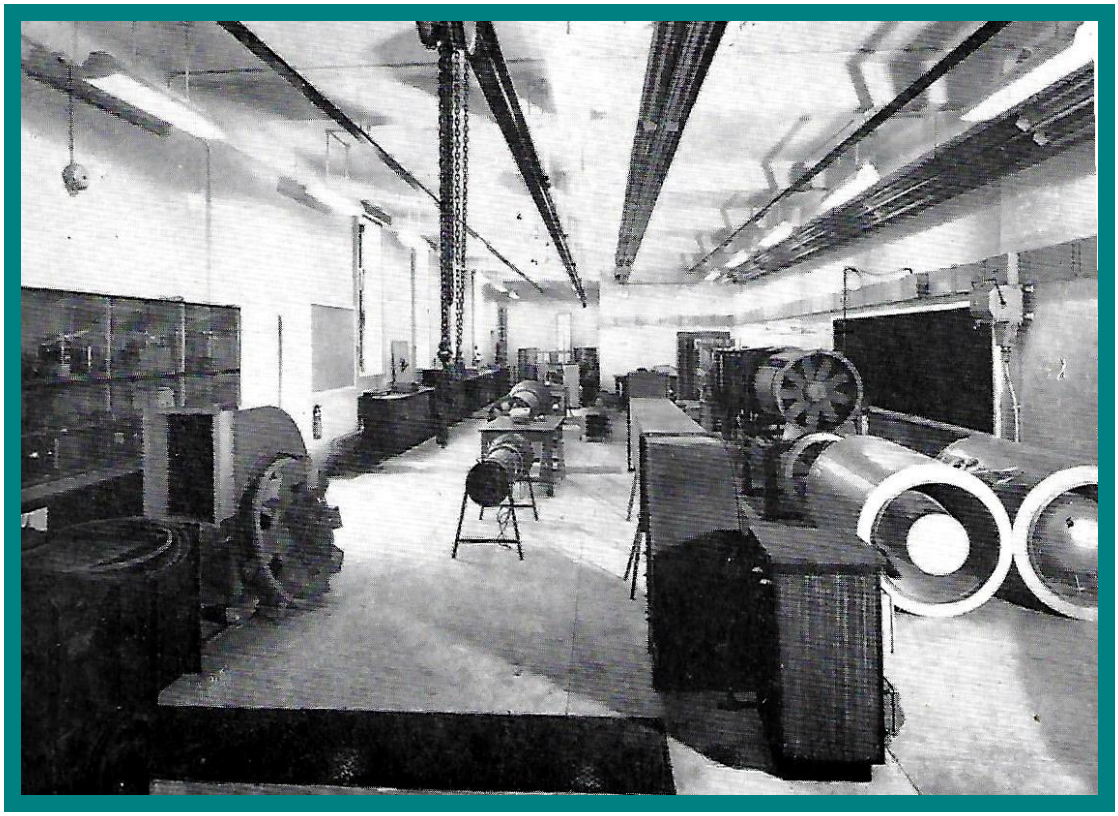
NATIONAL COLLEGE, LONDON

For HEATING, VENTILATING, REFRIGERATION & FAN ENGINEEERING

National College Staff - 1952?

Rich Sedgeley, Eric Woodcock, ?, George Bellinger, Bryan Lawrence, ?, L J Fischer, Jock Armstrong, J W Cowan

Bill Osborne, E W 'Artie' Shaw, Mrs S Dixon, Neville Billington, Sue Tanner, Bob Webb, P J Hagger



The new 1960's Fan Laboratory

MIDLAND HOTEL, MANCHESTER

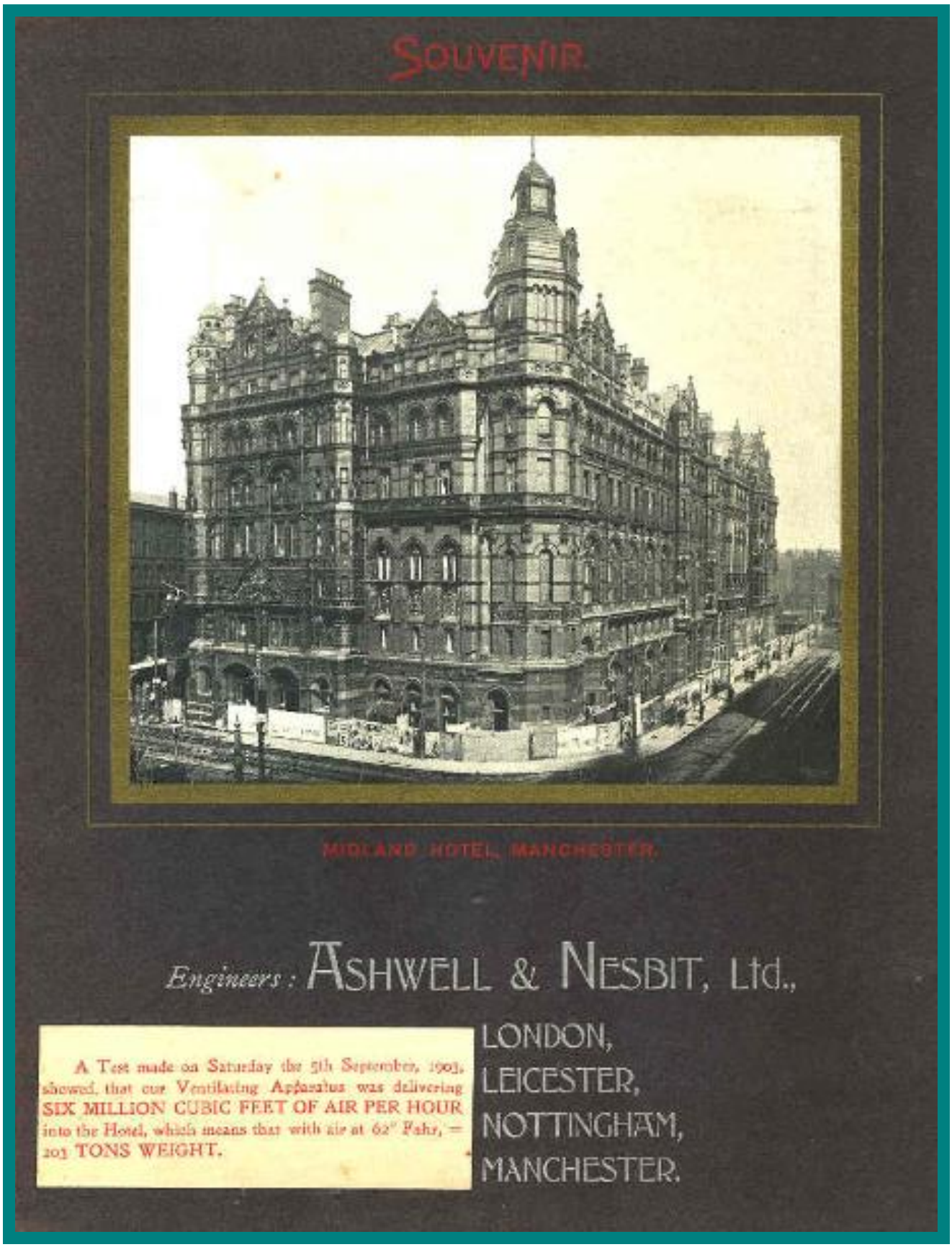
Today's Manchester Midland Hotel.

Built between 1898 and 1903, the Midland, designed by Charles Trubshaw, was opposite Manchester Central railway station, terminus for express trains to London St. Pancras. Constructed with a steel frame, it was clad in a mixture of brown terracotta, red brick and polished granite in the Edwardian Baroque style. It featured a roof terrace and a 1000 seat theatre. (It is said that it had been noted by Adolf Hitler, a student of architecture, as a possible Nazi Headquarters in Britain).

The "warming and ventilating" was carried out by the Leicester firm of Ashwell & Nesbit who installed two different systems, described as follows*: Corridors, entrances, and a few of the principal bed and sitting rooms are warmed by direct radiators; but the main portion of the building embracing the smoking room, billiard room, lounge, coffee room, reading room, ball room, etc., is supplied with fresh warmed air from the battery chambers situated in the sub-basement....."* **There were two 20 hp fans. Three Locomotive type boilers, supplied high pressure steam (100 psig) to a "Heater Room" where it was reduced to atmospheric pressure serving "radiating surfaces." Condensate was collected by the patented *Nuconomiser* system of steam traps. Domestic hot water service was provided by large calorifiers in the heater room.**

A sticker on a 1903 brochure (next page) proudly boasts that the ventilation system delivers "six million cubic feet of air per hour," this weighing "203 tons."

MIDLAND HOTEL, MANCHESTER



Souvenir Brochure of 1903 by the H&V Engineers, Ashwell & Nesbit (Heritage Group Archive).

PENINSULA HOTEL, HONG KONG

The Peninsula is renowned its fleet of 14 Rolls Royce limousines.

The Peninsula Hotel in Kowloon, Hong Kong, which opened in 1928, is a luxury hotel in the Colonial style. Referred to as "the finest hotel east of Suez" it became a popular meeting place for the local community and a Mecca for visiting Hollywood film stars. The original building was not air conditioned, but amazingly was totally centrally heated with radiators in all 168 bedrooms and in bathrooms, corridors and public rooms. The electrical installation was impressive with 4000 lamps and 1450 wall-plug outlets. Public rooms were provided with 185 ceiling fans. A cold storage plant comprised multiple rooms for fresh and frozen provisions and an ice plant with a production capacity of 10 tons of clear ice per day. (It is said that even the garbage was stored frozen until collection). The hotel was served by four passenger lifts (each with capacity of 13 passengers at 300 ft per minute), two luggage and one food lift.

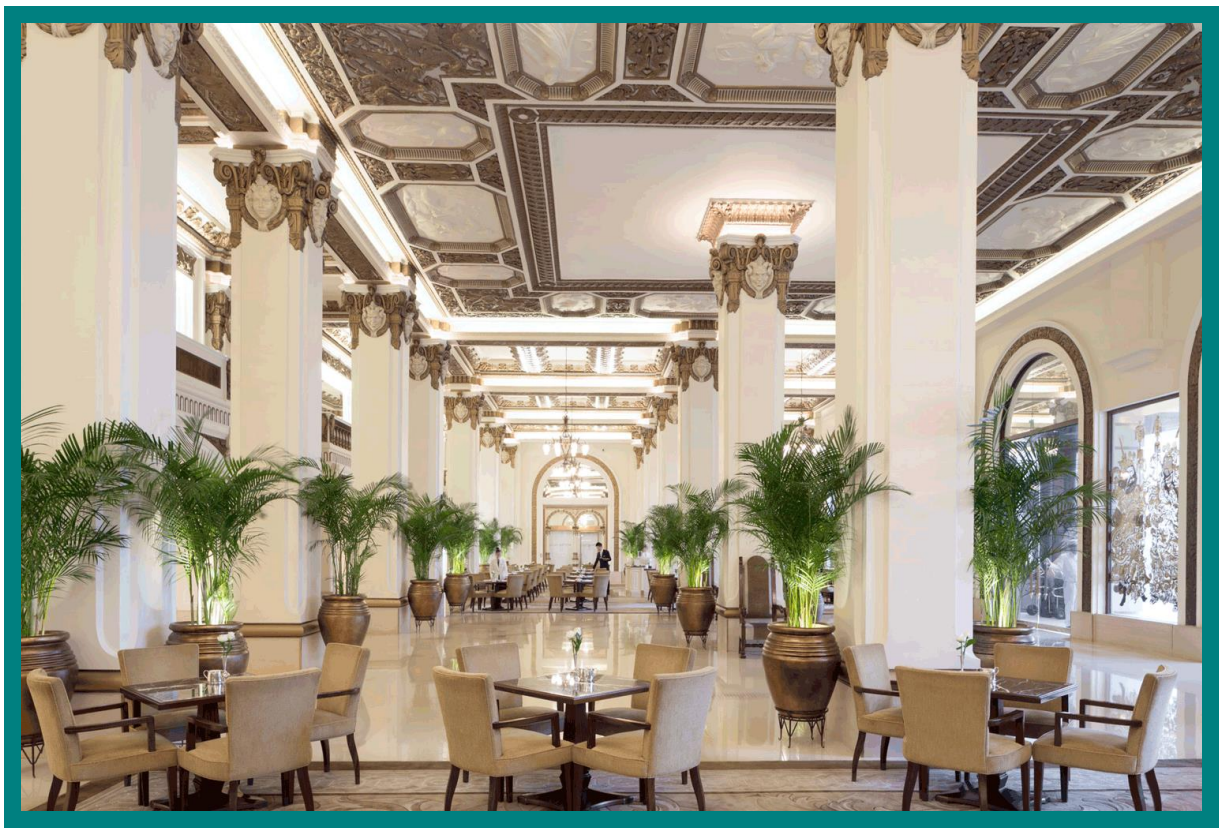
Before the 1960s, guest room and public rooms were air conditioned by fan coils and reciprocating chillers. Back of the house and office areas were provided with window units. In the 1960s, open-type R11 centrifugal chillers with sea water condensing were installed. The fan-coil system was thereafter regularly reinstalled of reconditioned, being changed at some point to 4-pipe operation. In 1994, a 30-storey addition was added behind the original hotel, bringing the total of bedrooms to 300.

PENINSULA HOTEL, HONG KONG

Summer season in the 1930s.

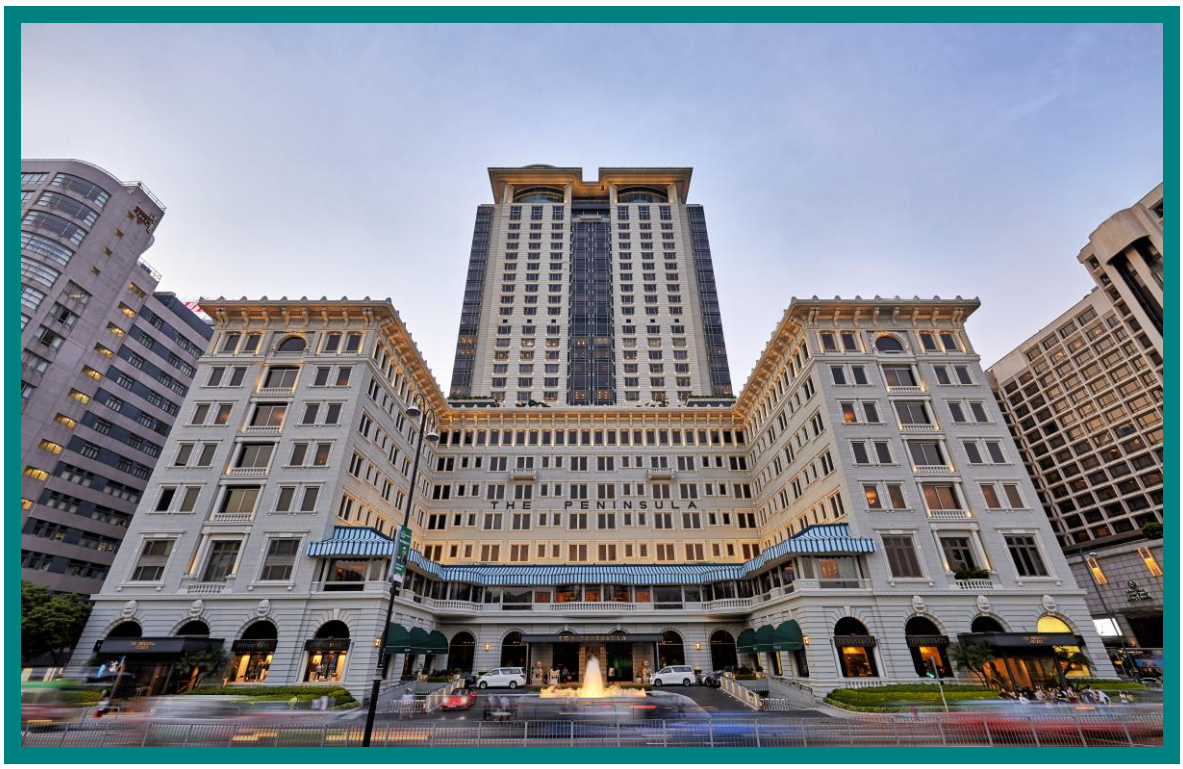
PENINSULA HOTEL, HONG KONG

The original lobby complete with ceiling fans.



The lobby as it is today.

PENINSULA HOTEL, HONG KONG



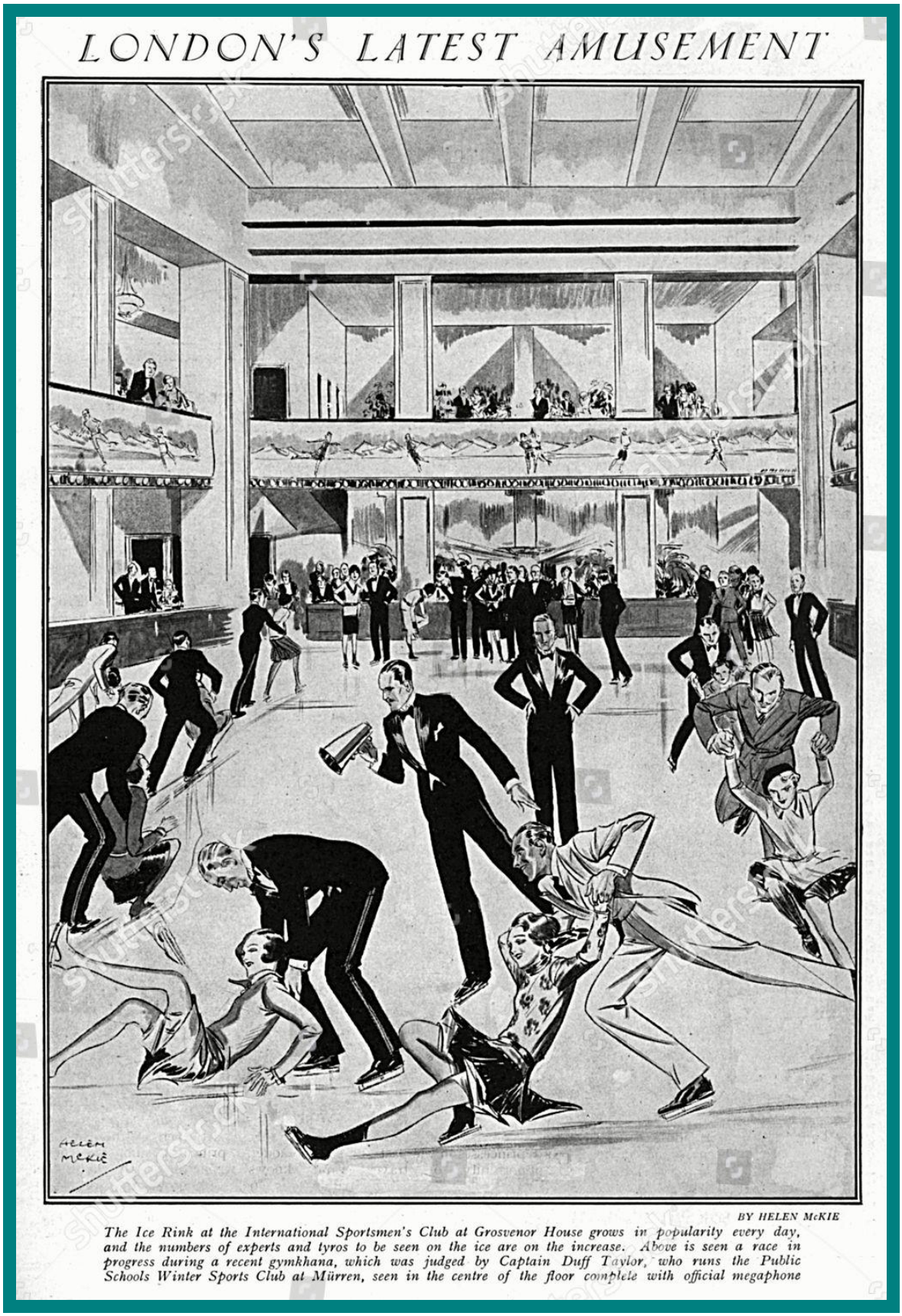
The Peninsula Hotel with the added 30-storey tower behind.

The refrigeration chiller plant room.

GROSVENOR HOUSE HOTEL, LONDON

Built in the 1920s, and opened in 1928, the Hotel sits on the site of the former residence of the Dukes of Westminster. In the 1940s, the Grand Room served as an U.S.A. Officers' Mess.

GROSVENOR HOUSE HOTEL, LONDON



The Grand Hall was initially a large and popular ice-skating rink.

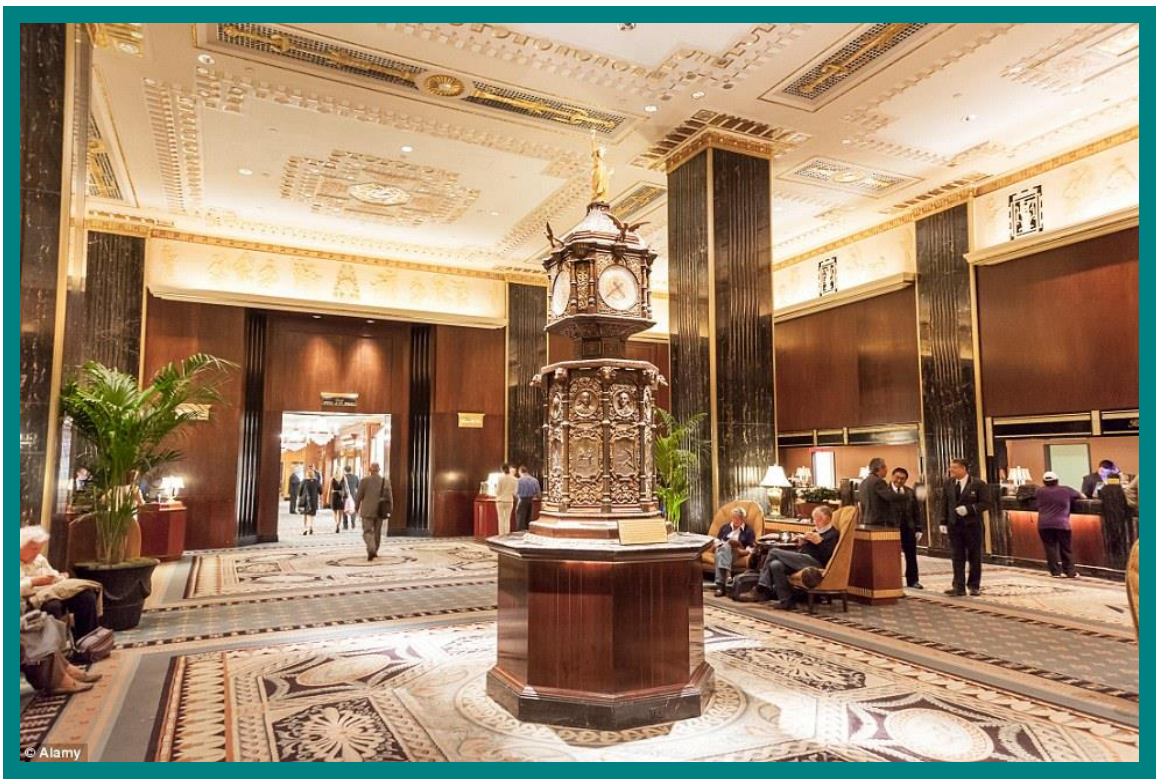
WALDORF ASTORIA HOTEL, NEW YORK

The Grand Entrance to the Hotel.

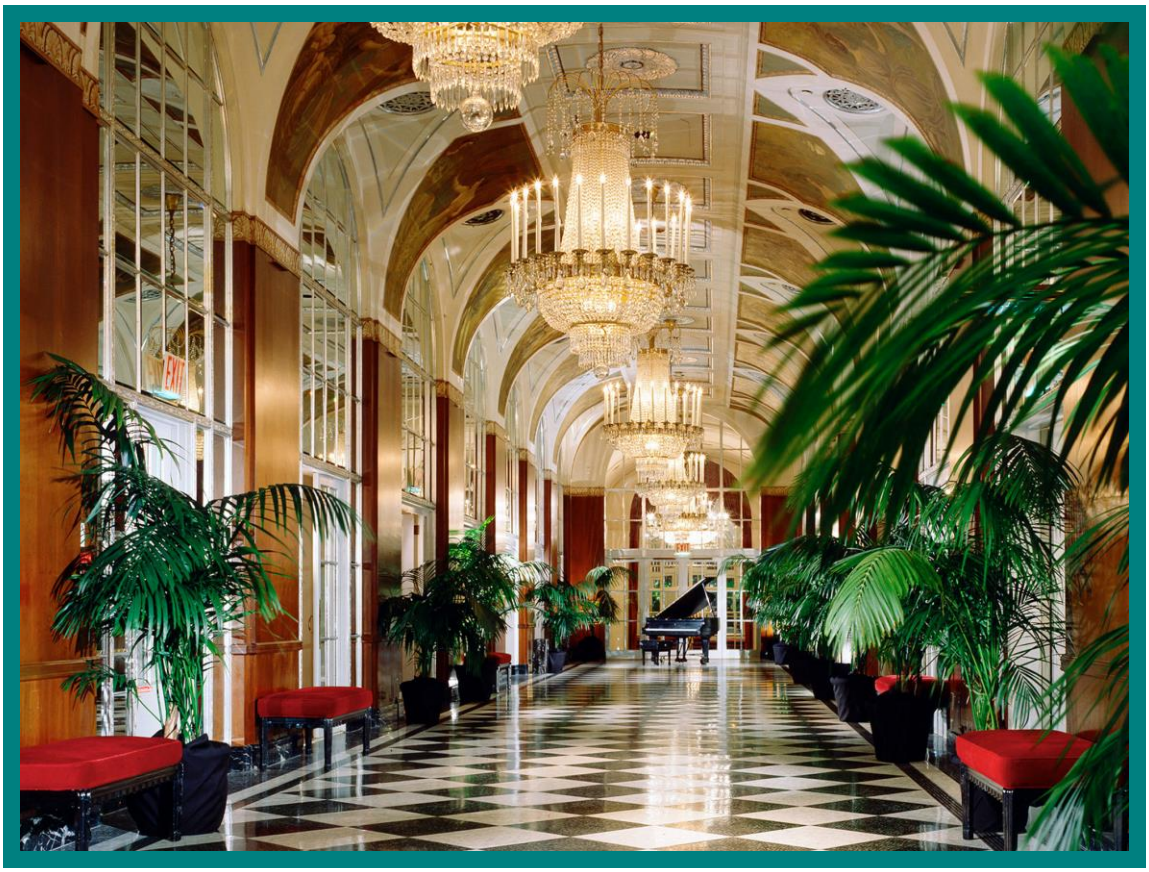
The New York Waldorf Astoria and Towers is a luxury hotel in Midtown Manhattan, at 47-storey (625 ft) high, it was built in the Art Deco style, opening in 1931. The architects were Schultze and Weaver. It remained the world's tallest hotel until 1963. The original Waldorf-Astoria (with a hyphen) was built in two stages as separate hotels along 5th Avenue and was demolished in 1929 to make way for the construction of the Empire State Building. During the nineteen-thirties, the hotel gained international renown for its lavish dinner parties. It is known as being the venue for many significant business and political meetings, including the World Peace Conference held at the hotel in March 1949.

The internal layout of the present hotel is ever-changing as restoration and improvements continue. For example, in 2009 the main hotel had 1235 single and double rooms and 208 mini-suites, while the Waldorf Towers, from the 28th to 42nd floors, had 181 rooms (115 were suites with one to four bedrooms). The hotel has three restaurants and its own version of the famous Harry's Bar in Venice (a favourite of Ernest Hemingway). The Waldorf Astoria remains one of the world's most prestigious and well-known hotels.

WALDORF ASTORIA HOTEL, NEW YORK



The Grand Entrance Foyer.



A section of the magnificent interior.

HARRODS DEPT. STORE, LONDON

Harrods Department Store in London's Knightsbridge opened in 1905 and has 330 departments covering 1.1 million sq.ft making it one of the largest stores in Europe.

HARRODS DEPT. STORE, LONDON

The "Moving Staircase"

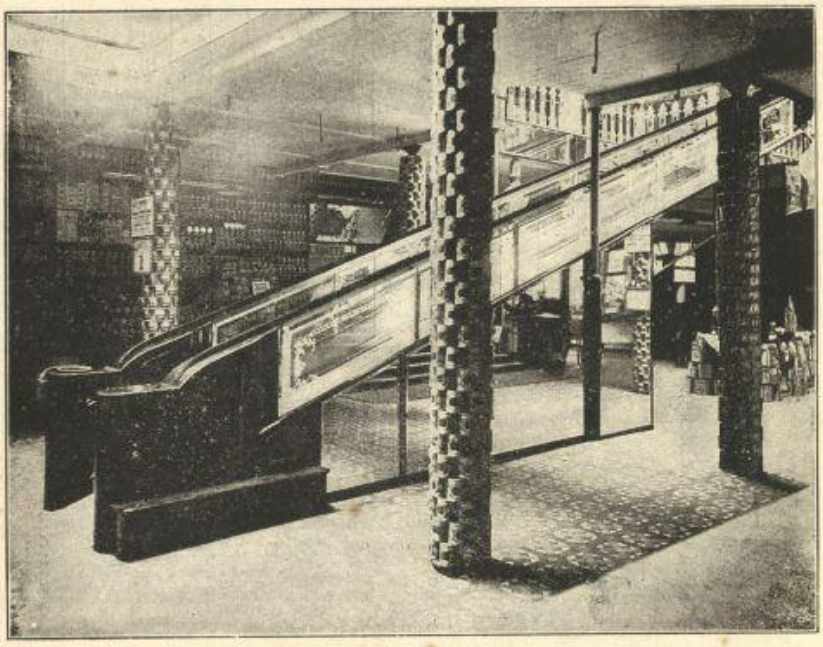
PRESS OPINIONS:—

Warehouseman and Draper.

"There can be no doubt as to the usefulness of the invention, and they should soon be in general use in railway stations, public buildings, hotels, warehouses, &c.

Tenders and Contracts.

"The possibilities before the new staircase seem endless. As far as the shops are concerned, it seems as though it would solve the difficulty of getting people to do their shopping higher than the first floor."



Morning Post.

"A remarkable substitute for the ordinary lift or elevator, which is quite a novelty in this country. . . . . There need never be any of those vexatious waits which occur when an ordinary lift is in use."

Sketch.

"By a delightful movement which is both exhilarating and fascinating, you are carried from floor to floor without the least effort and without any of those unpleasant thrills which lifts always succeed in giving to nervous persons. . . . . I think they will find it so popular that there will scarcely be a store or a great trading business in London that will not be glad to institute the same invention."

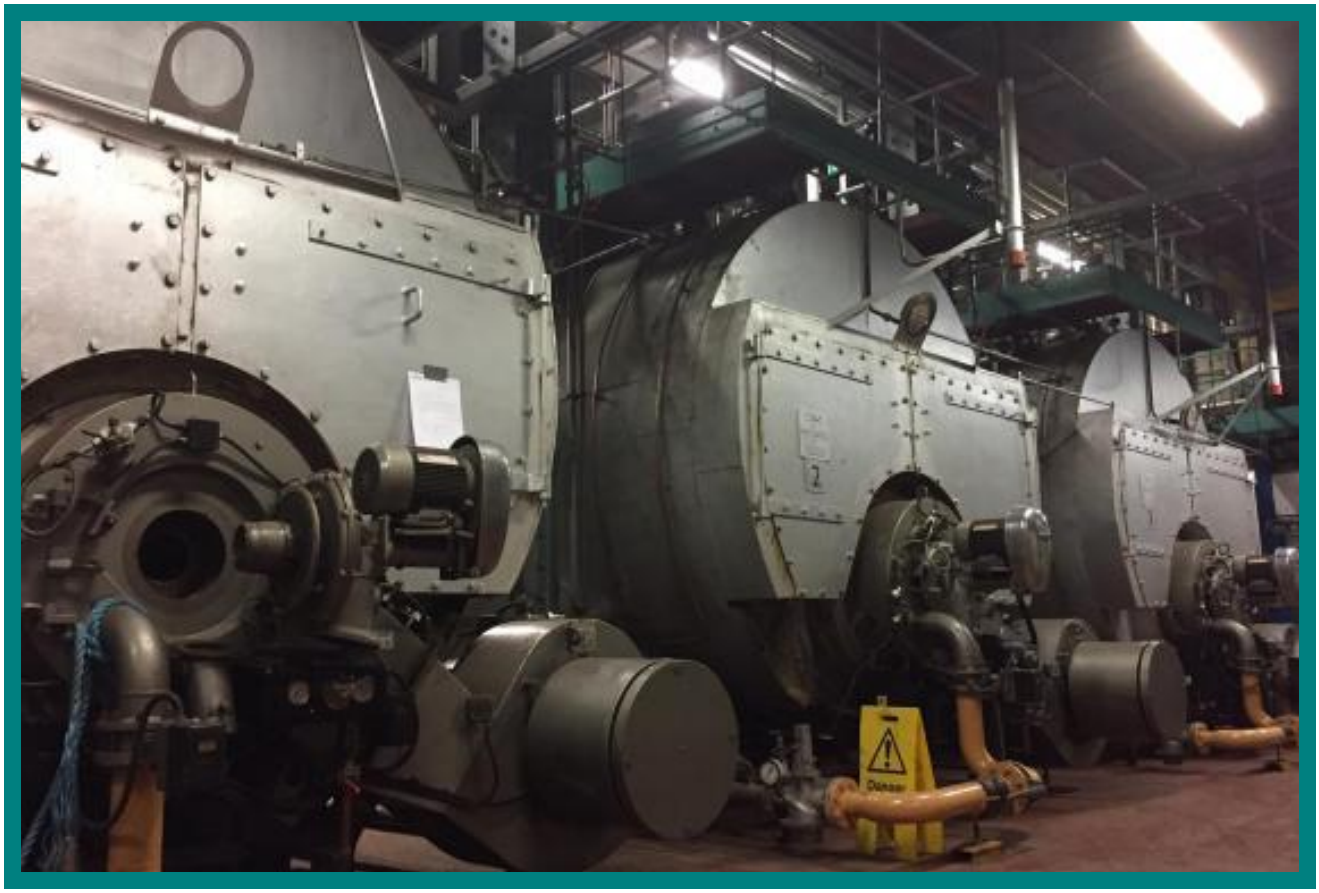
In 1898, Harrods had installed England's first "Moving Staircase," a forerunner of the escalator this was a moving flat woven-leather conveyor belt.

ST. HELIER HOSPITAL, SURREY

St. Helier Hospital in Carshalton, Surrey.

The hospital was commissioned in 1934 and designed in the "thirties modernist style", the foundation stone laid by Queen Mary in 1938. The consulting engineer for mechanical services was J. Roger Preston & Partners. The successful tender for this work is recorded as £153,500. At this time, hospital steam and condensate services were extensive, being the primary source for heating, hot water and used in kitchens, laundries and for sterilisation. The hospital was one of only two new hospitals built in this country between the two world wars. It received its first patients in February 1941, during the Second World War.

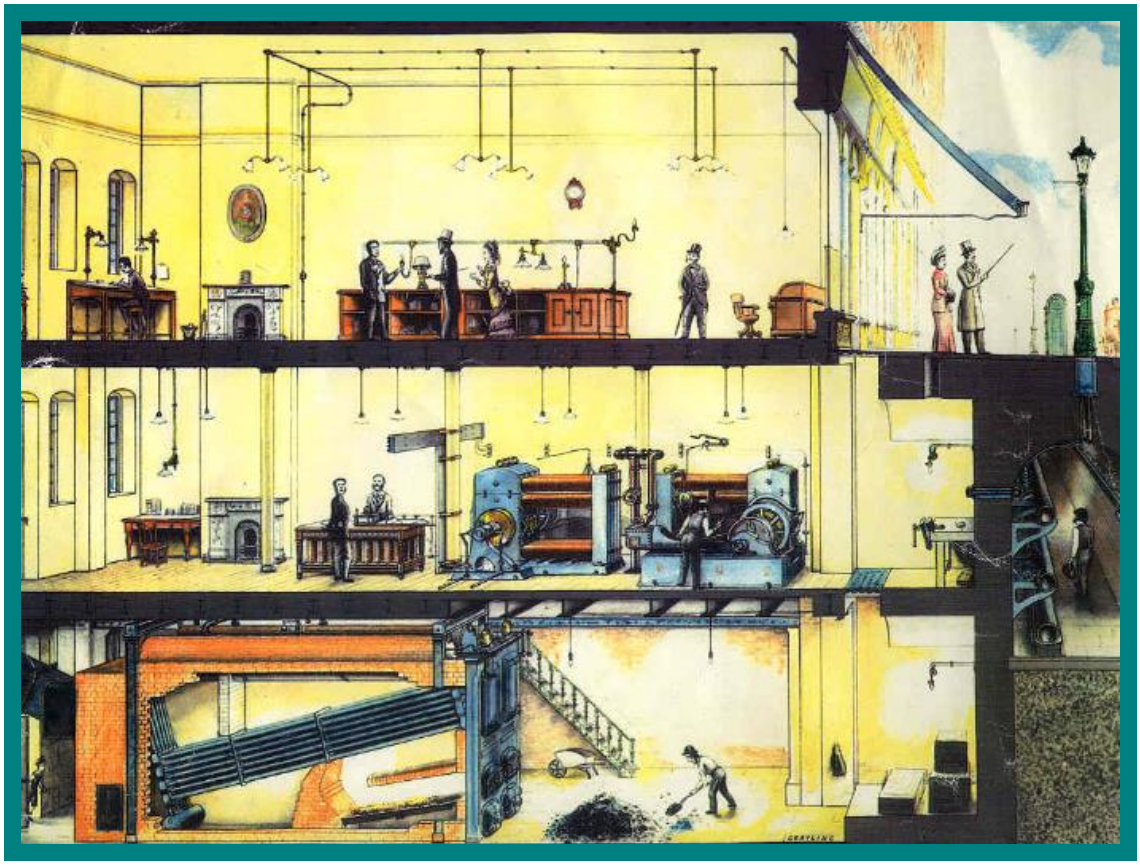
ST. HELIER HOSPITAL, SURREY



The three existing large (each "12 tonne") steam boilers, which replaced the original.

In the first month of operation, the hospital was damaged by a parachute mine during a bombing raid. Further damage was caused in later raids and it was twice struck by flying bombs in June 1944. During the mid-1950s, Diploma students from the National College were given a tour of the large boiler house where the steam boilers were coal-fired by an automatic hopper-feed system. Work on replacing and upgrading the hospital's engineering services has been taking place since 2019. This includes replacing the three present ageing steam boilers "with six megawatt , high-efficiency, low temperature hot water boilers.....a technical challenge as the old boilers will need to be taken out piece by piece from the basement." Meanwhile, the lighting throughout the hospital has been upgraded with LED high-efficiency lamps; the operating theatres are having new air handling units and replacement air conditioning is being provided for critical areas. A plan to connect the hospital to a local district heating system which used incinerator plant waste heat proved impractical from both the technical and financial viewpoint.

HIGH HOLBORN POWER STATION LONDON



The World's First Public Steam Power Station.

Opened in 1882, at 57 High Holborn, London, the power station was equipped with Edison "Jumbo" dynamos, a Porter-Allen 125 hp horizontal steam engine and Babcock & Wilcox water tube boilers. It operated at 110 volts DC.