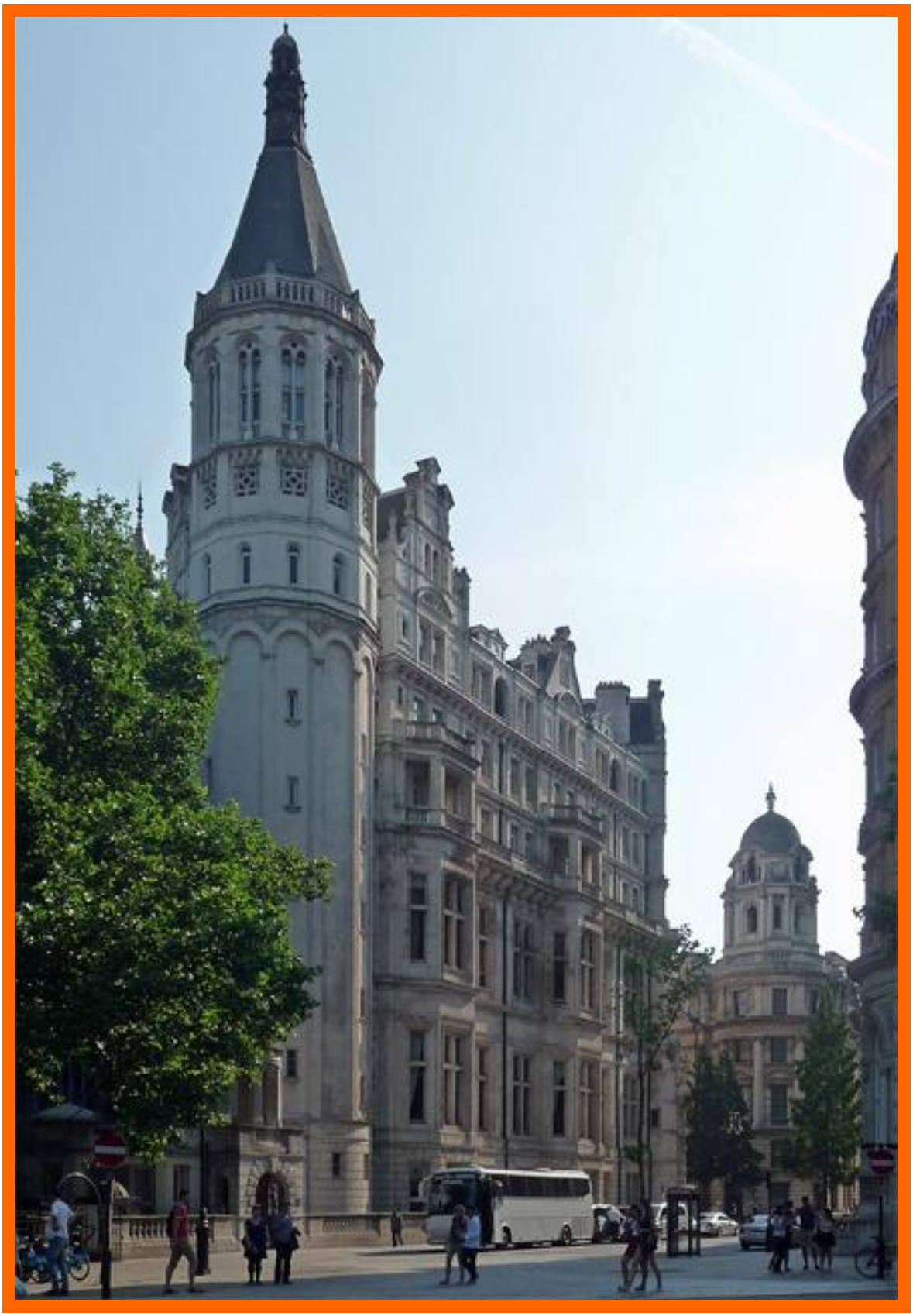
Building Engineering Services
HERITAGE REVISITED
PART SEVEN

Second Edition 2021

Brian Roberts
and the CIBSE Heritage Group

Strangeways HM Prison, designed by Alfred Waterhouse, opened in 1868. A prominent feature is the original 230 ft tall brick tower, once part of the heat-assisted ventilation system. Though not yet proven, the design of the ventilation may have been by the Victorian engineer W. W. Phipson who designed schemes for Waterhouse at the Natural History Museum, the National Liberal Club, the Prudential Assurance (all in London), and Liverpool's Royal Infirmary.

NATIONAL LIBERAL CLUB, LONDON



Built 1885-87 with heating and ventilation by W.W. Phipson.

VICTORIA TEXTILE MILL, WIGAN

The Dinner Hour, Wigan, 1874 (Eyre Crowe, 1820-1910, Manchester Art Gallery)

INTRODUCTION

Part-7:2nd Edition features engineering services in a variety of buildings and structures which have been researched or visited by Heritage Group members, individually or as a group.

CONTENTS

The ROMAN BATHS in BATH

The building housing the hot spring was constructed in the 18th century.

The ROMAN BATHS in BATH

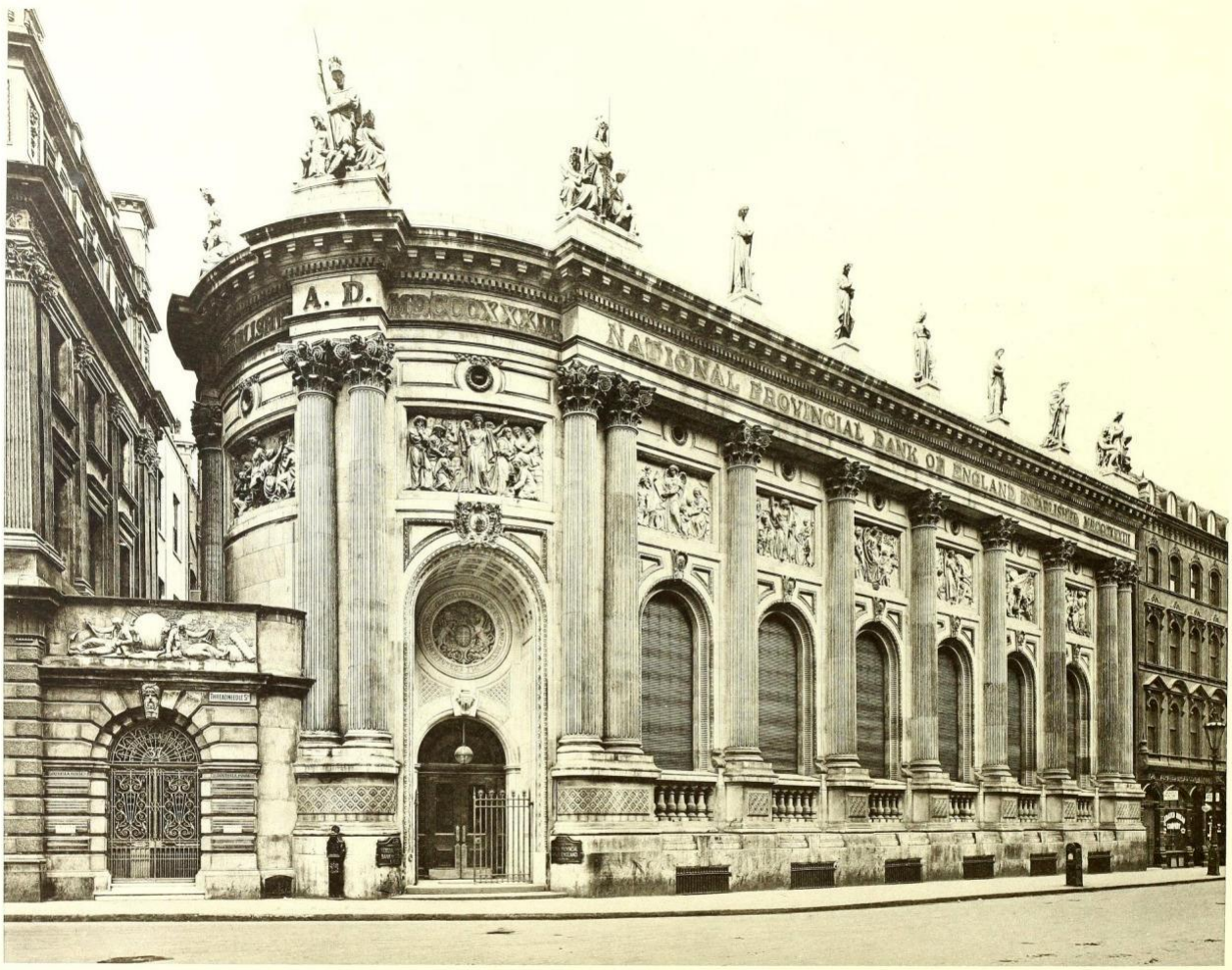
The tile pillars of the Bath hypocaust which once supported the floor above.

The Roman Baths in Bath (Aquae Sulis in Roman Times) date from around 60-70 AD and are a well-preserved "thermae" in Somerset. The hot springs, some as much as 14,000 ft down, force water under pressure, at a temperature up to 96 degF, to the surface.

The hypocaust (hypocaustum) is a system of central heating in a building that produces and circulates hot air below the floor of a room, and may also warm the walls with a series of pipes through which the hot air passes. The earliest reference to such a system suggests that the temple of Ephesus in 350 BC was heated in this manner, although the Roman writer Vitruvius attributes its invention to Sergius Orata in about 80 BC.

Hypocausts were used for heating hot baths and other public buildings in Ancient Rome. The ceiling of the hypocaust was raised above the ground by pillars, called pilae stacks, supporting a layer of tiles, followed by a layer of concrete, then the floor tiles of the rooms above. Hot air and smoke from a wood-fired furnace would circulate through this enclosed area and then up through clay or tile flues in the walls of the rooms above to outlets in the roof, thereby heating the floors and walls of the rooms. These tile flues were referred to as caliducts

NATIONAL PROVINCIAL BANK of ENGLAND, LONDON



THE NATIONAL PROVINCIAL BANK OF ENGLAND, THREADNEEDLE STREET, LONDON.
JOHN GIBSON, ARCHITECT, 1863.

Described as a "magnificent building," the Bank stands at the junction of Bishopsgate and Threadneedle Street, on a site which previously had been occupied by the Flower Pot Tavern. In 1862, John Gibson was appointed architect and went on to design some forty of their branch banks across the country. The engineer Wilson Weatherley Phipson was responsible for the ventilation using the "Systeme Van Hecke," described as a "steam-powered system." While living in Belgium, Phipson had become a friend of Dr Van Hecke and, when his studies at the French School of Engineering were completed, he assisted Van Hecke in the warming and ventilating of hospitals in Belgium, France and Holland. In about 1860, Phipson returned to London and set up as a consulting engineer to introduce the Van Hecke system to Britain where the art of ventilation was in its infancy. Phipson went on to design the ventilation for the National Provincial Banks in Piccadilly and Newcastle, and worked for Gibson at Todmorden Town Hall in Yorkshire. The Bank in Threadneedle survived the threat of demolition in the 1970s and was instead restored.

The ROYAL AQUARIUM and WINTER GARDENS, LONDON

After his death, Phipson's "A Memoir" (1892) lists the Royal Aquarium as one of his projects. Opened in 1876, The Royal Aquarium & Winter Gardens was located at Tothill Street/Princes Street in Westminster, London. A later reference refers to "heating by hot water" and "heating by waste steam," but no details are given.

As recounted in 1925:

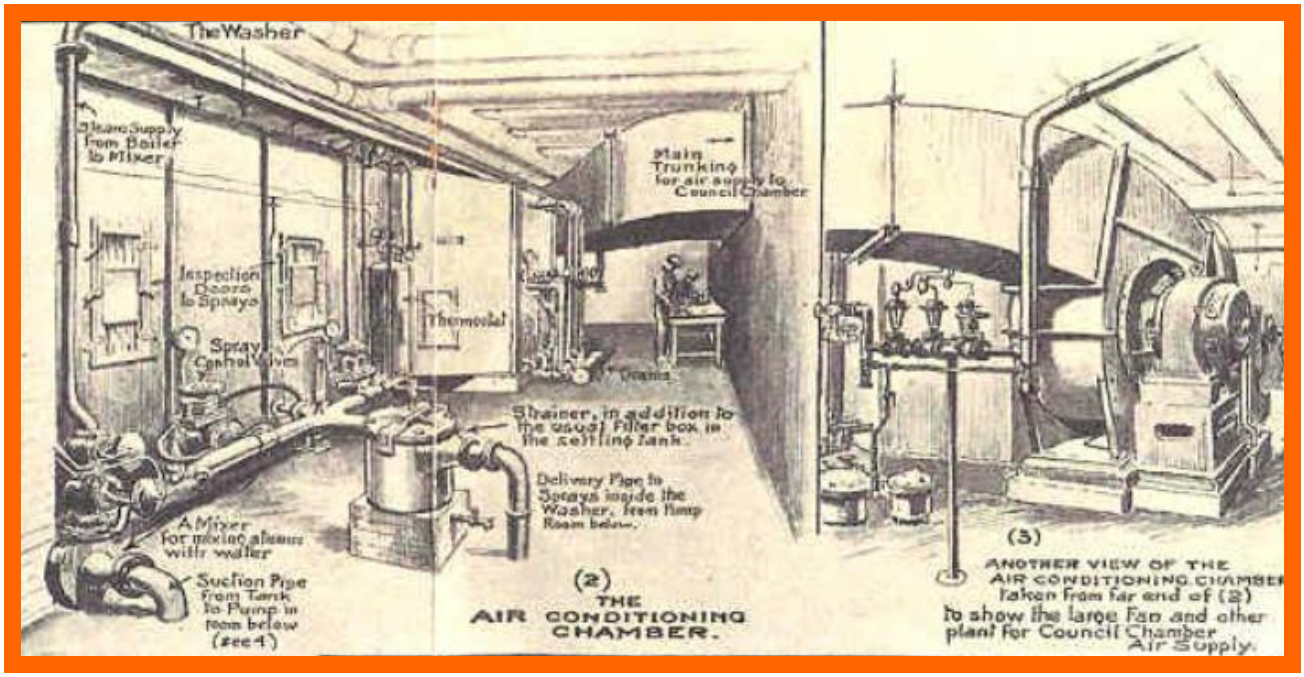
That large red-brick stone-faced building was designed by Mr A. Bedborough, and was 600 ft long by 160 ft wide. It had a theatre at its west end called The Imperial. But it was the Aquarium itself, lined with tanks to which few people paid any attention, with its concerts and dancing Zulus, its swimming ladies, and above all, its Zazel (a female human cannonball) being shot out of a mammoth cannon, that comes back to memory."

The Aquarium obviously made a great impression: "Nearly five million bricks have been used in this building; 600,000 gallons of sea water were to be supplied in casks from Brighton; also listed are W. Edgecumbe Rendel (inventor of a patent glazing system), W. Hudson of Queen's Road, Brighton (sea water supplier) and Brill's Bath Company (sea water transport).

However, in 1925 the Aquarium was demolished and an "immense Central (Methodist) Hall with its vast dome has arisen on the site; Tothill Street has changed out of all recognition."

WESTMINSTER COUNTY HALL, LONDON

Now County Hall, a large 6-storey building in the Edwardian Baroque style opened in 1922



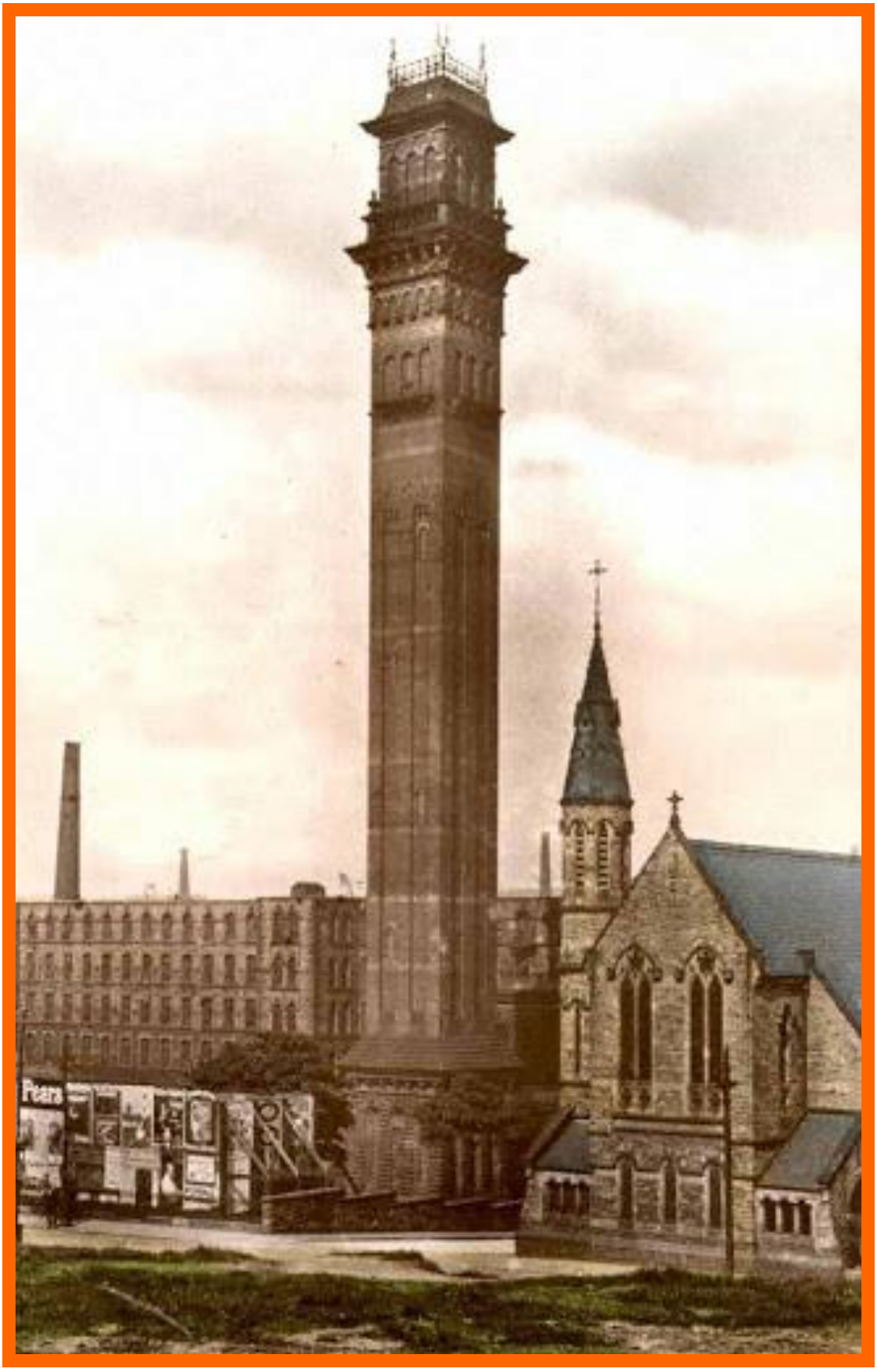
From Scientific American, November 1922.

The building was originally centrally heated by a consortium of contractors, but the Council Chamber itself was air conditioned by Buffalo Forge/Carrier Engineering.

WESTMINSTER COUNTY HALL, LONDON

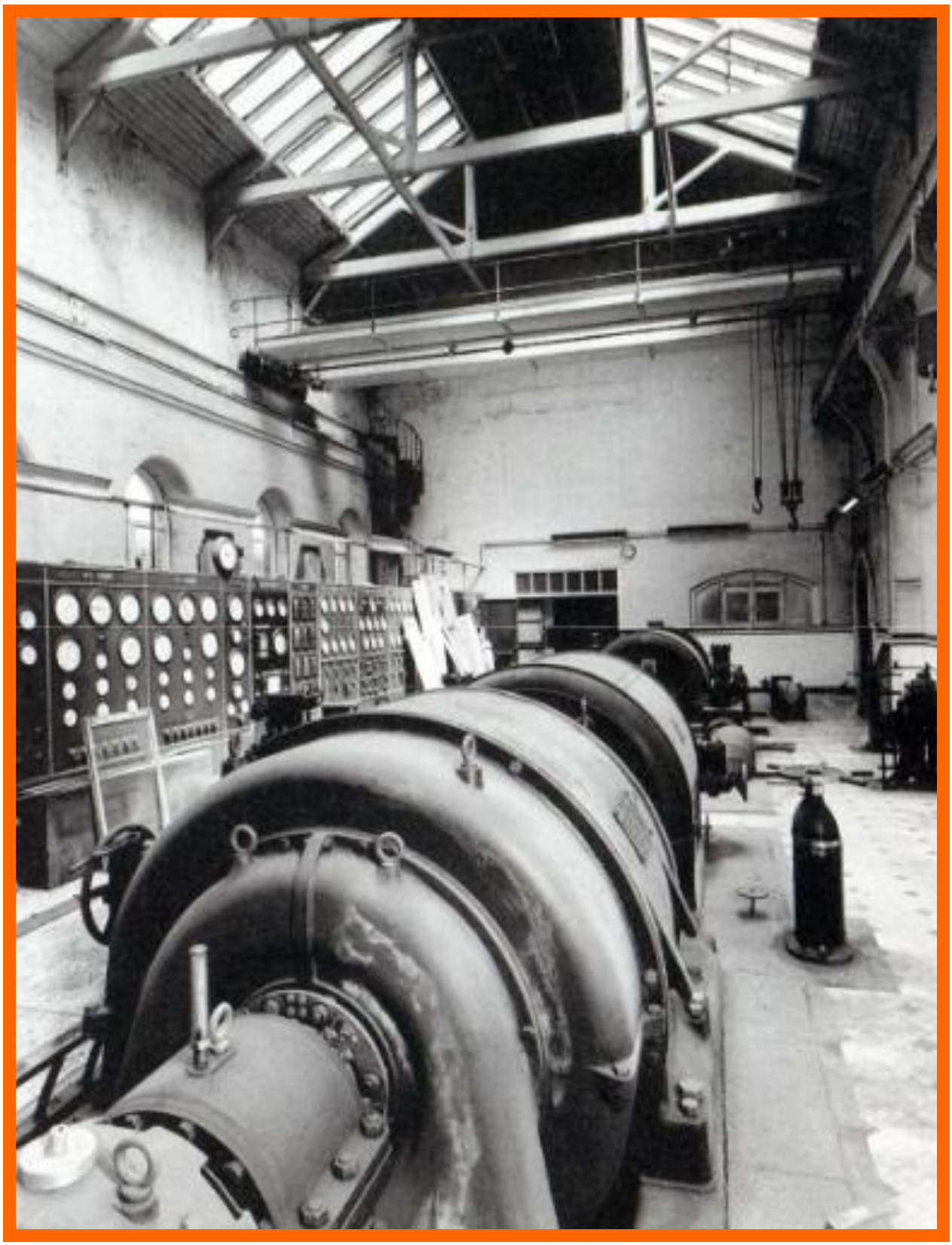
The Council Chamber, New London County Hall, RALPH KNOTT, Architect.

TEXTILE MILLS



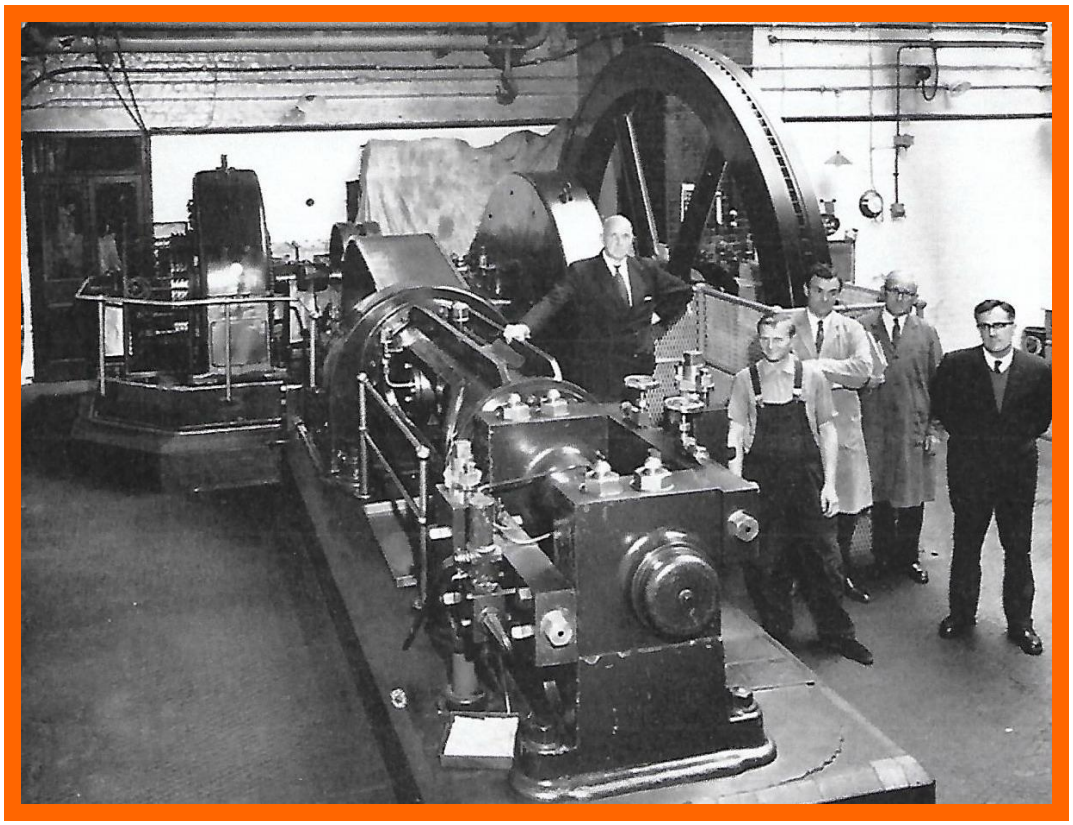
India Mill (300 ft high) chimney, Darwen, Lancashire, country's tallest when completed in 1867.

TEXTILE MILLS



Turbine and switch room at Manningham Mills, Bradford in Yorkshire, 1930s.

REFRIGERATION
J & E HALL, DARTFORD, KENT



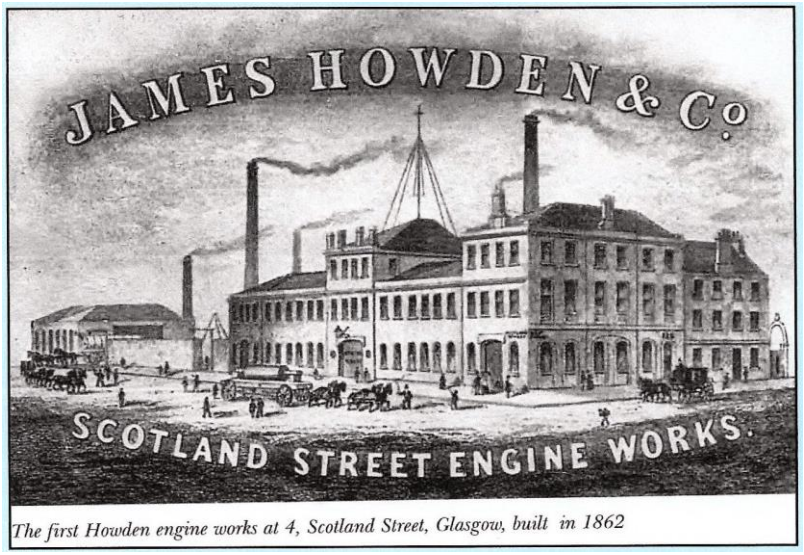
Two horizontal CO_2 machines supplied to Truman's Brewery in 1912.

Female employees of Halls who replaced men in the Forces, 1914-18.

REFRIGERATION
CARRIER ENGINEERING, VICTORIA ST. LONON

Carrier Type 16E absorption chiller in Carrier House, Victoria, London, 1963.

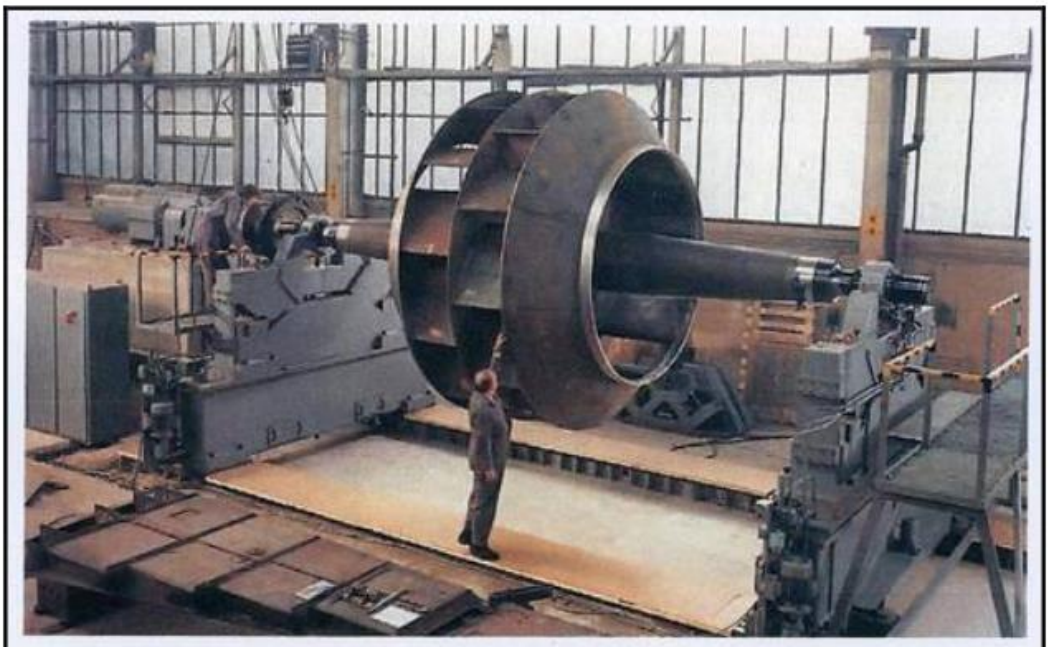
FAN MAKER
JAMES HOWDEN, GLASGOW



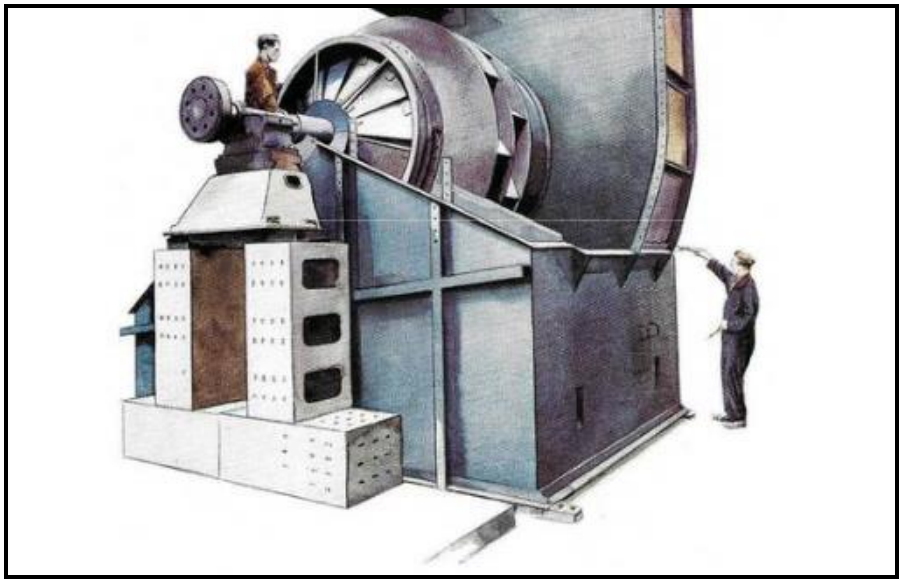
The first Howden engine works at 4, Scotland Street, Glasgow, built in 1862

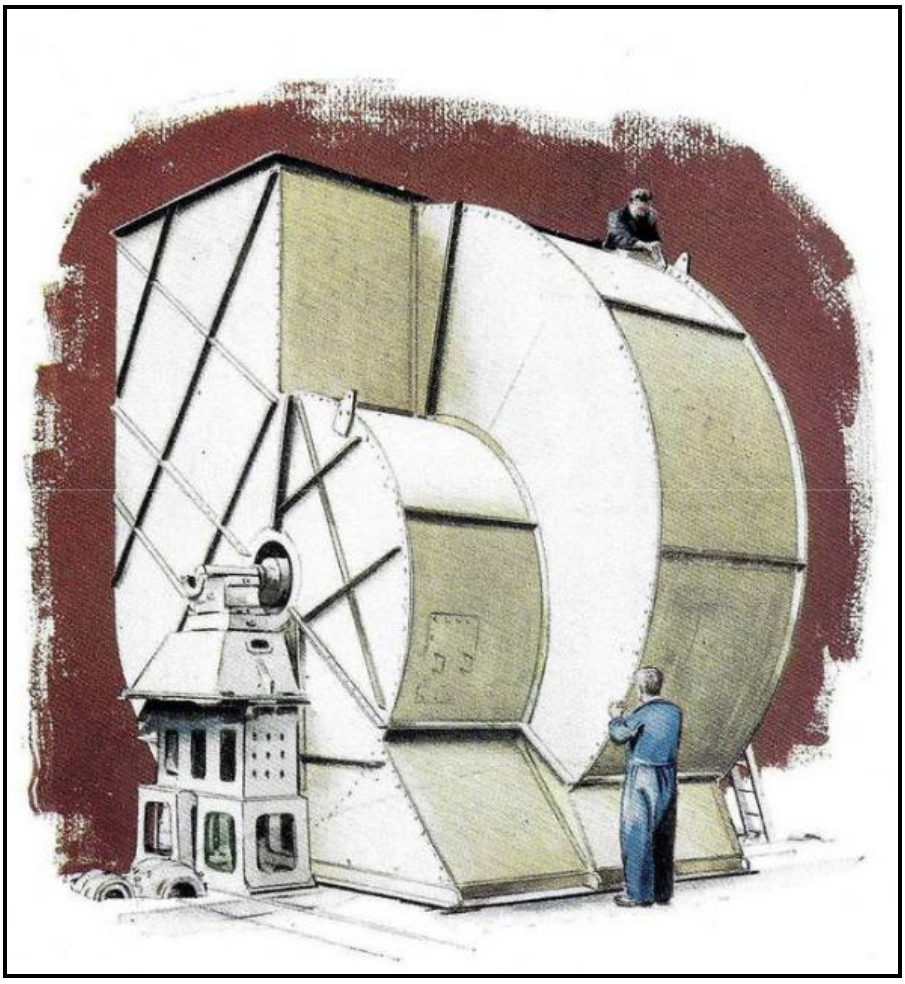
Howden Engine Works, Glasgow, 1862.

In 1854, James Howden set up as a consulting engineer and in the same year established James Howden & Company as a manufacturer of marine equipment. In 1857, he began work on the design and supply of boilers and steam engines for the marine industry. Over the years his Company became involved in the manufacture of fans. As the overall business grew and became profitable, during the second half of the 20th century, the Company took over many of the long-established of the world's leading fan makers, including Sturtevant, Davidson, Buffalo Forge, Airscrew, and later Novenco and Flakt Woods.


A 3.55m Z9 double inlet fan impeller being prepared for balancing on the Hoffman balance testing machine in the Glasgow Scotland Street works

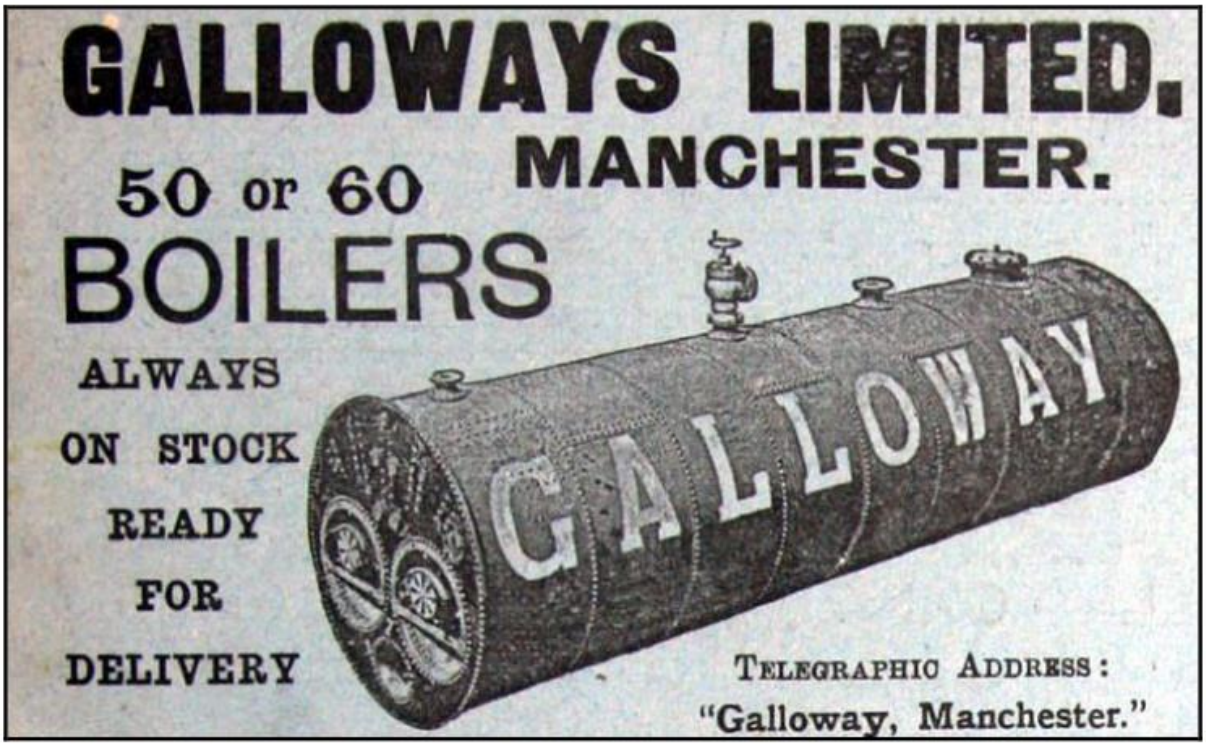
FAN MAKER
JAMES HOWDEN, GLASGOW



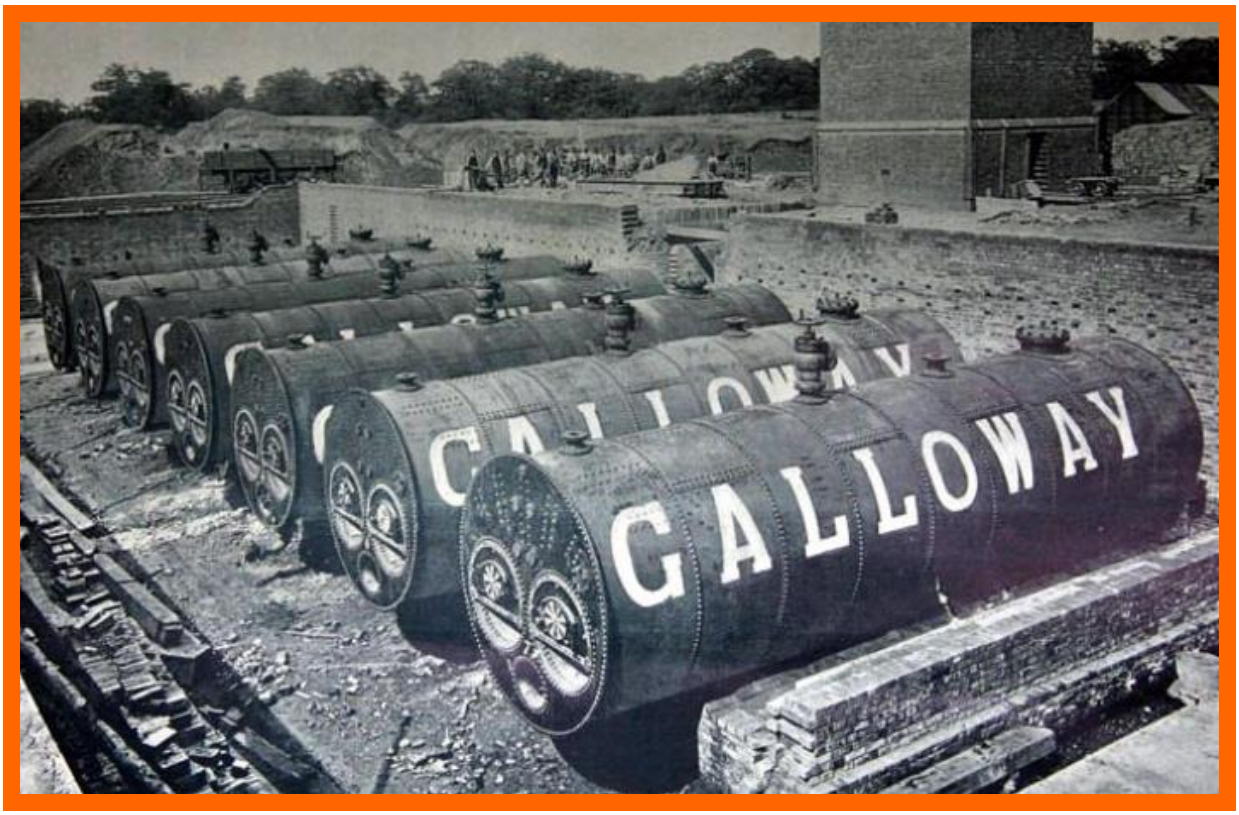


Artist's impressions of Howden induced-draught fans from "The History of the Company" 1954.

BOILER MAKER
W & J GALLOWAY, MANCHESTER

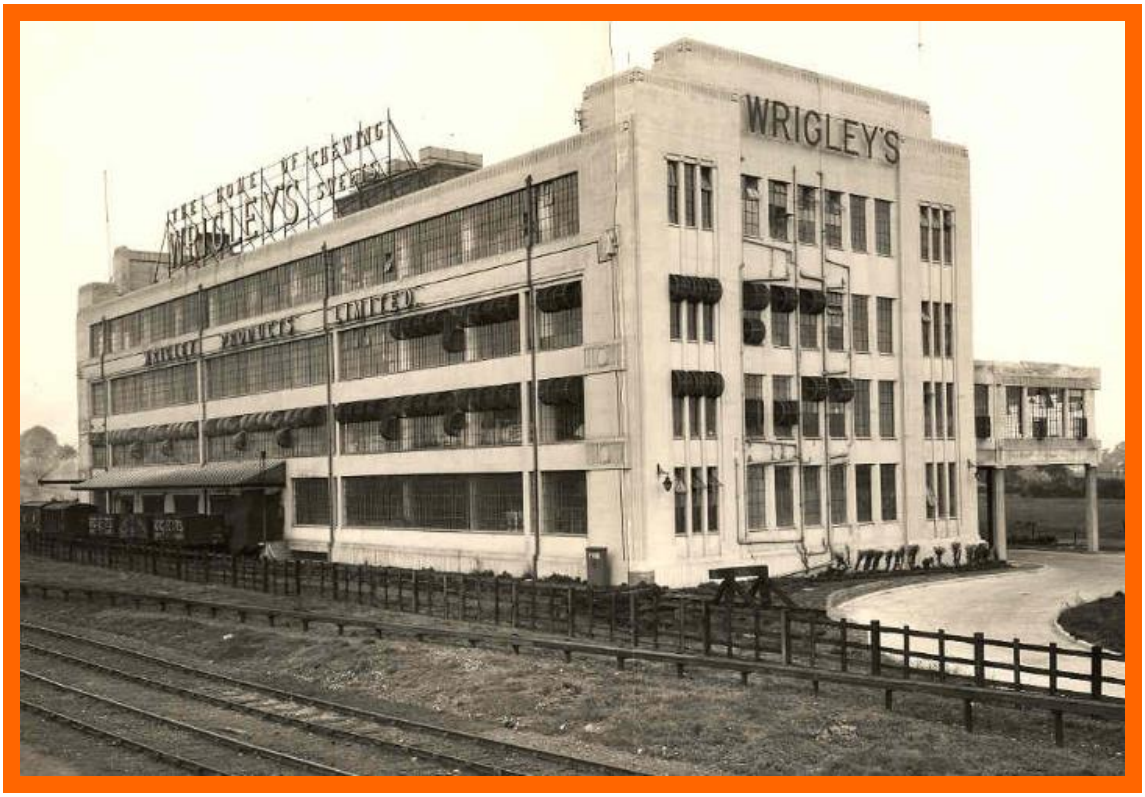


In 1835, the brothers William and John Galloway set up in business.

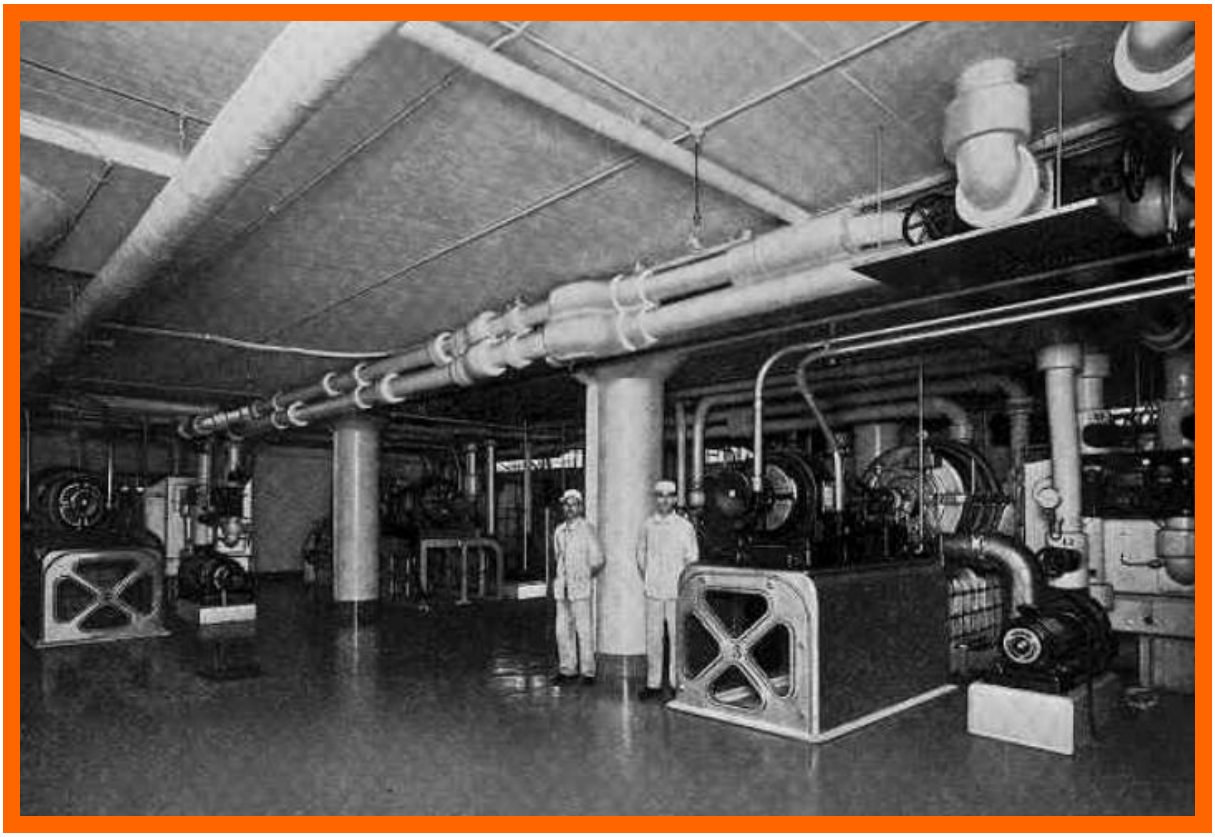


The Company improved the design of steam boilers, manufacturing some 9000 boilers by 1891.

CONFECTIONERY

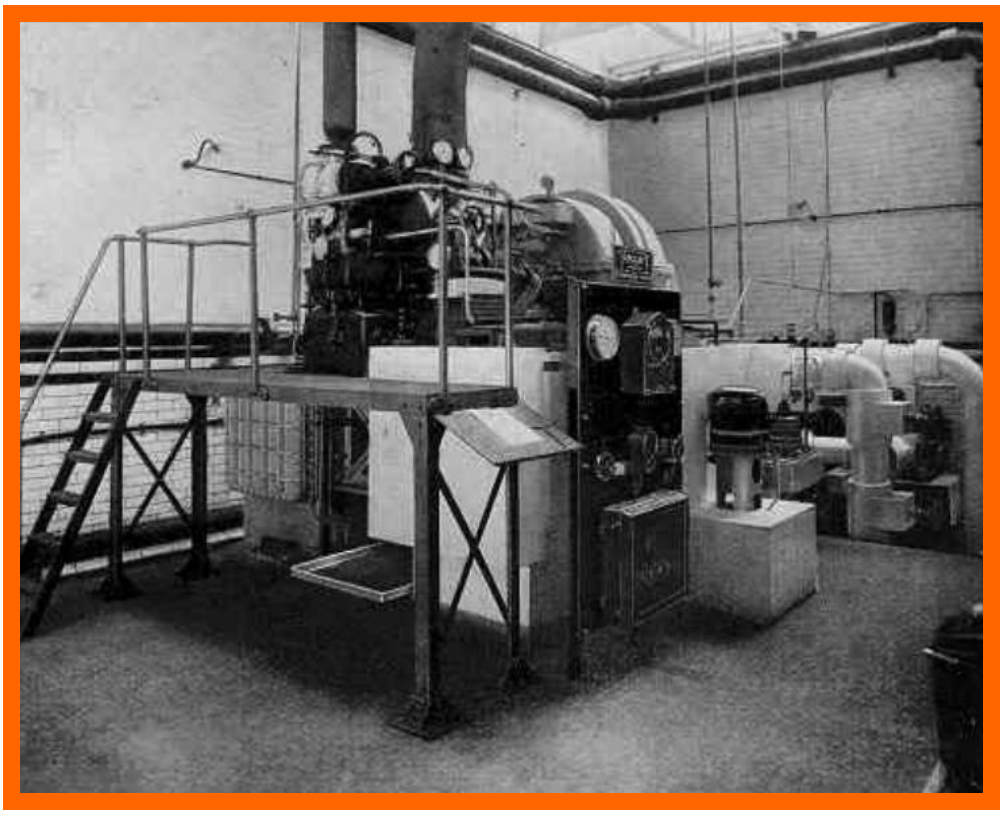


Wrigley's Products, Wembley, c.1928.

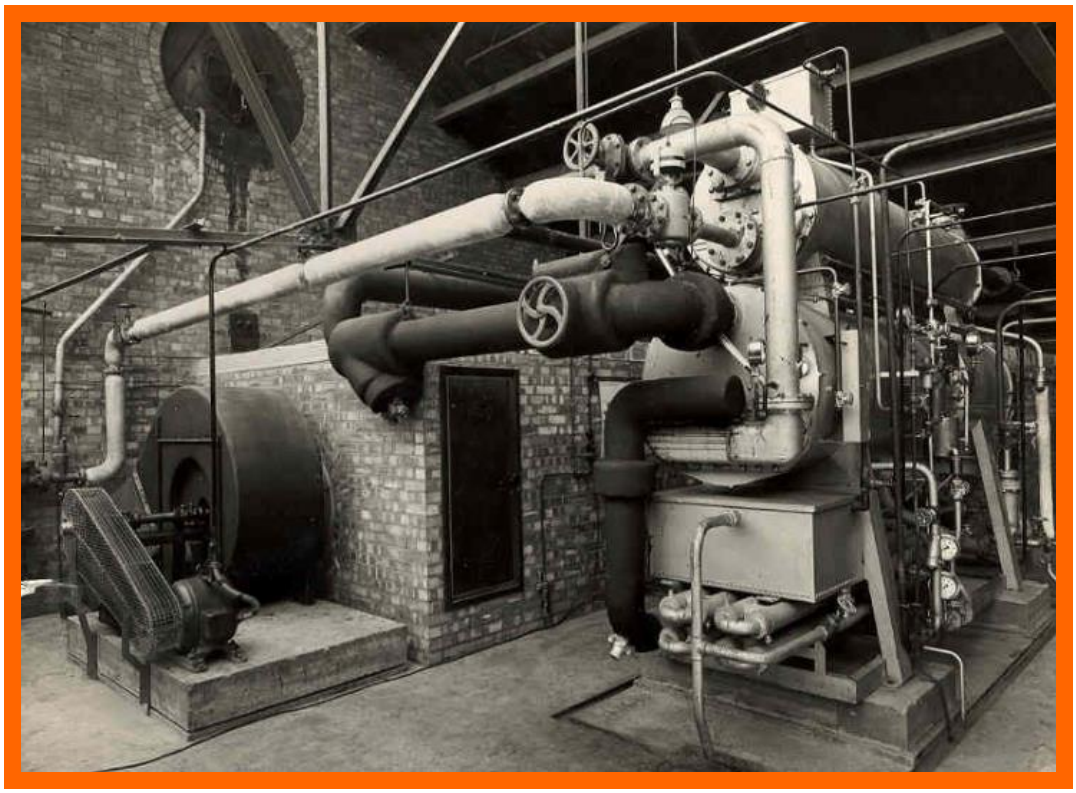


Three Carrier centrifugal water chillers (350 TR total) at Wrigleys, c.1928.

CONFECTIONERY



Carrier steam turbine centrifugal water chiller (200 TR) at James Terry & Sons, York, c.1928.



Carrier absorption water chiller (100 TR) at Mars Ltd, Slough, 1960s.

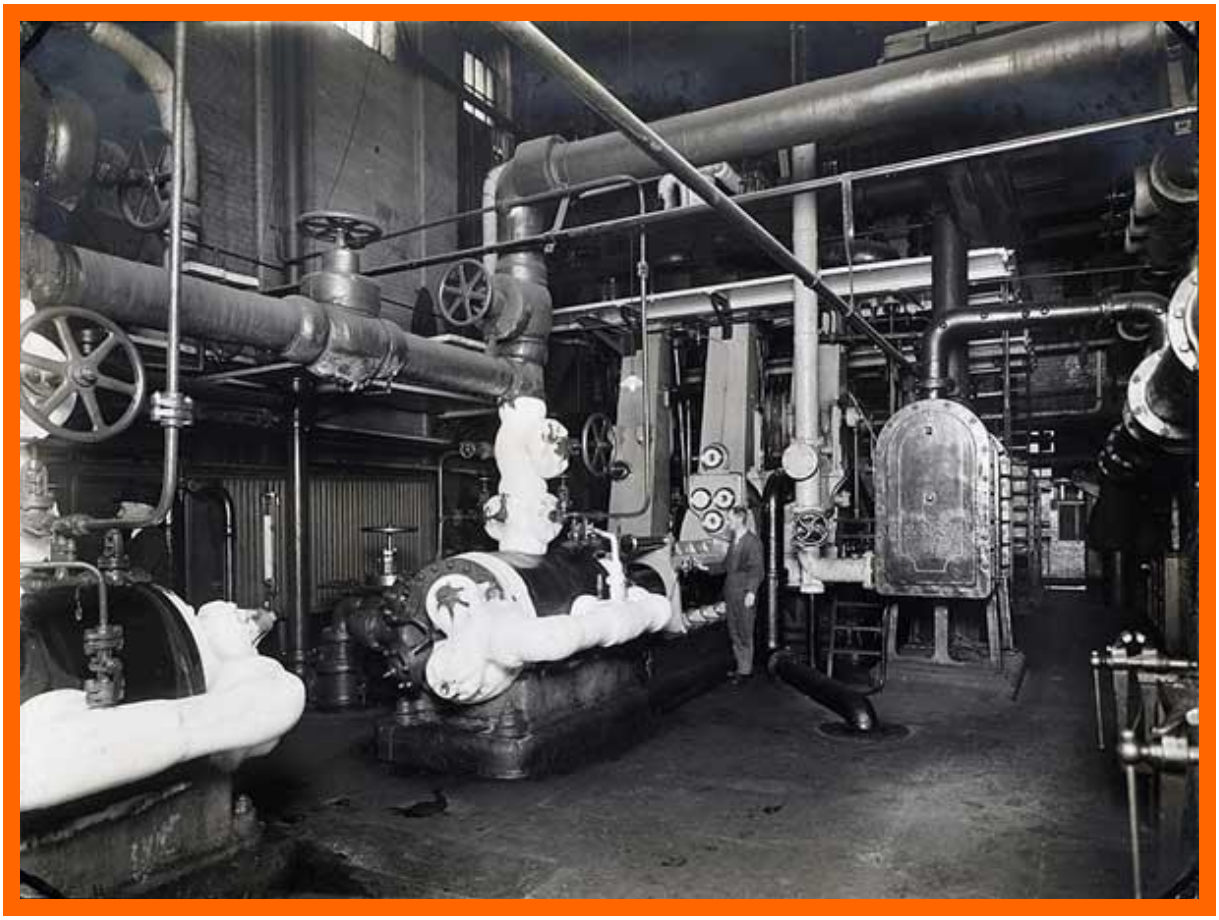
CONFECTIONERY

Carrier absorption water chiller (150 TR) at J. Lyons, Greenford, c.1962.

Two Carrier absorption water chillers at James Pascall, Mitcham, 1960s.

ICE FACTORY

The Grimsby Ice Factory of 1901.



The Pontifex refrigeration machines.

ICE FACTORY

The J & E Hall refrigeration compressors.
All photographs from The Grimsby Ice Factory Trust.

MARY ROSE MUSEUM, PORTSMOUTH

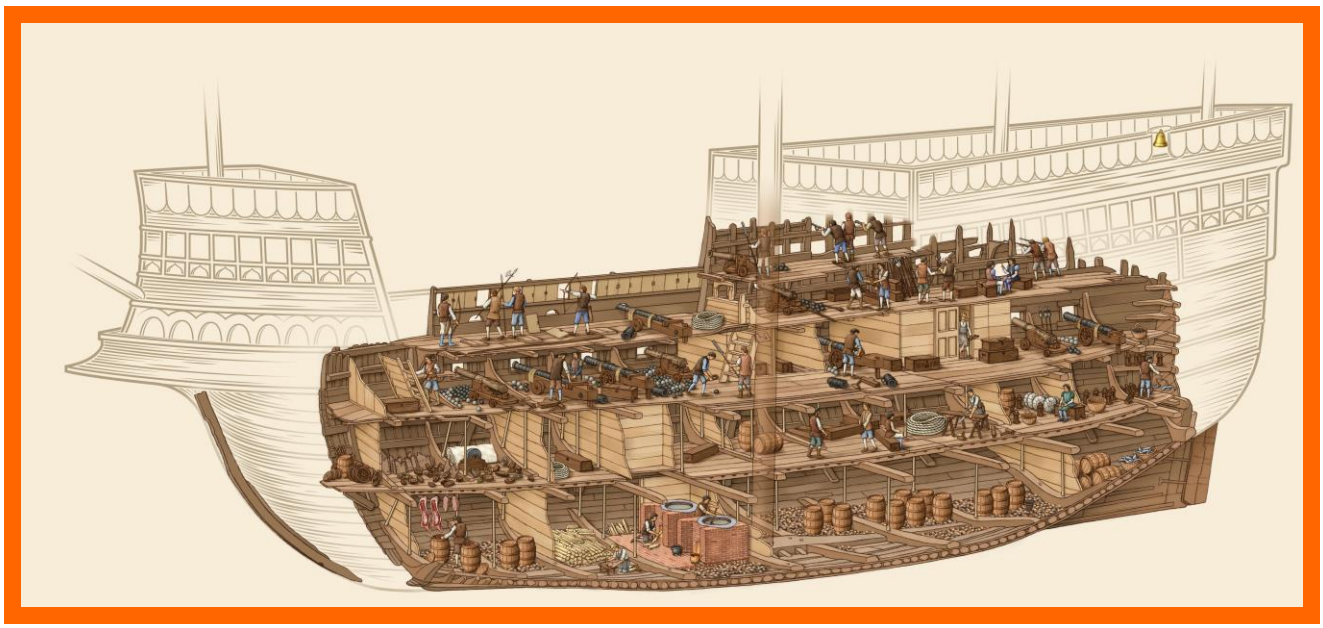
The Mary Rose Museum close by Portsmouth Harbour

The Mary Rose is a warship of the English Navy of King Henry VIII. She served for 33 years in several wars against France and Scotland. After being substantially rebuilt in 1536 she saw her last action in July 1545 when leading an attack on the galleys of the French invasion fleet, sinking in the Solent, off the Isle of Wight.

The wreck was discovered in 1971 and, after much hard work, was raised in 1982, together with weapons, sailing equipment, naval supplies and many of the objects used by the crew. The methods used to dry out and preserve the remains of the vessel, involving spraying with chemical solutions, is a story in itself.

An interesting comparison is with the Swedish warship Vasa which foundered in Stockholm Harbour on her maiden voyage in 1628. Raising the Vasa was more straightforward as the hull was upright and virtually intact. Recovered in 1959-61, similar drying out and preservation techniques were used and the vessel is now housed in a permanent museum in Stockholm.

MARY ROSE MUSEUM, PORTSMOUTH



Cut-away drawing of how the salvaged section of the Mary Rose may have looked.

The Mary Rose in the Portsmouth Museum.

RMS TITANIC MUSEUM, BELFAST

The Titanic Belfast opened in 2012 as a museum recording Belfast's maritime heritage and is located on the site of the former Harland & Wolff shipyard, who built and launched the RMS Titanic, which sailed on its maiden voyage to New York in 1912, carrying 1317 passengers and a crew of 885. The tragedy of this great liner that struck an iceberg and sank with a terrible loss of lives is well documented. Perhaps, what is not so well known are the impressive details of the men and machines that powered the ship.

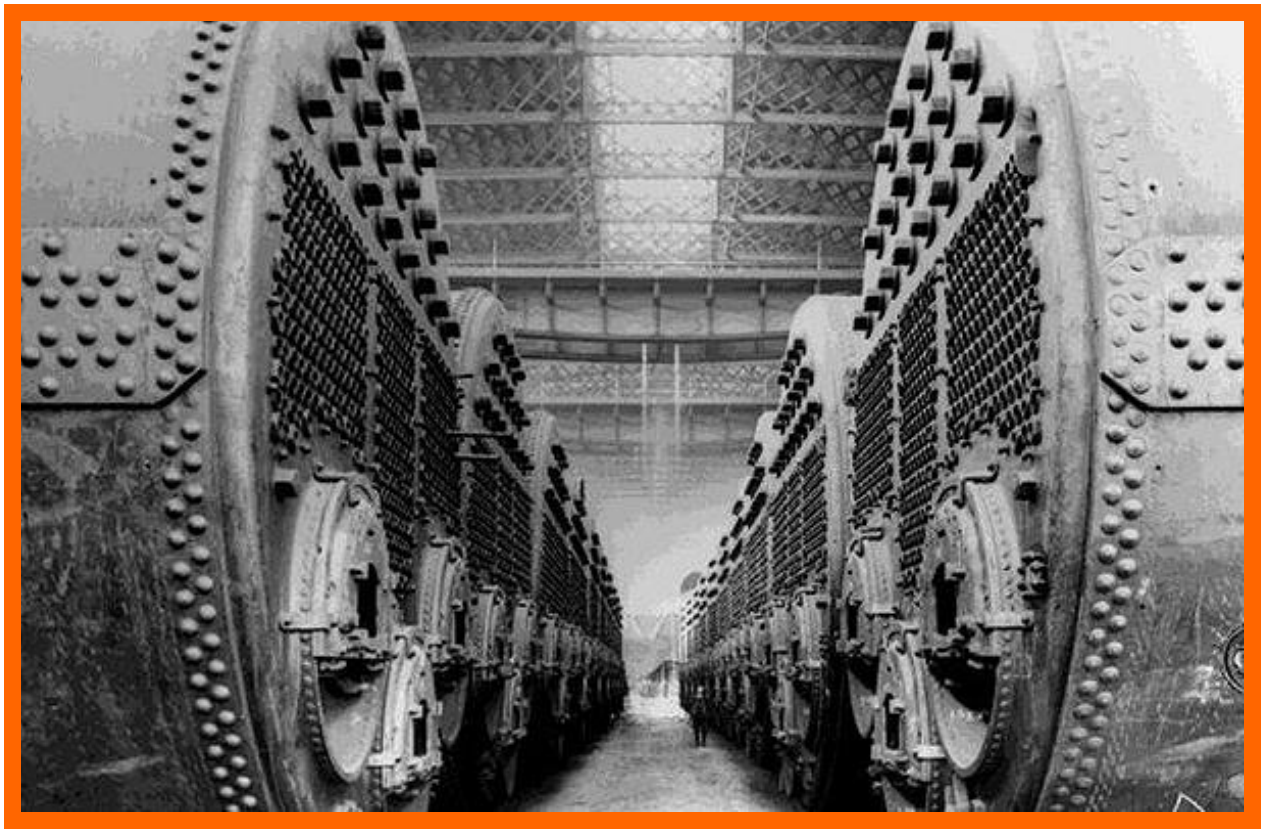
The Titanic was equipped with three main engines: two reciprocating, four-cylinder, triple-expansion steam engines (total 30,000 hp) and one low pressure Parsons turbine (16,000 hp). There was a total of 29 high-pressure steam boilers (next page) which powered the main engines, the turbine using exhaust steam from these main engines.

The boilers contained a total of 159 furnaces and used 600 tons of coal a day which had to be shovelled into them by a stoking crew of 176 firemen working around the clock. The work was dirty, dangerous and relentless. The main bunkers held 6600 tons of coal with an additional 1100 tons in Hold 3. The crew had to dump some 100 tons of ash into the sea each day.

The electrical installation had four 400 kW steam-driven generators with a further two 30 kW emergency generators. As these were sited at the stern of the liner, the electricity supply continued until the last minute as the stricken Titanic plunged bow first beneath the Atlantic.

RMS TITANIC MUSEUM, BELFAST

The Titanic was 883 ft long, 92 ft maximum beam, with a total height from bottom of keel to top of bridge of 104 ft, displacing 52,310 tons.



The Titanic steam boilers awaiting delivery. Out of a total of twenty-nine, 26 were double-ended, 15 ft 9 inches diameter and 20 ft long, each weighing 90 tons and holding 48 tons of water. The size may be judged by the man standing halfway down the right-hand side.

HMS BELFAST, LONDON

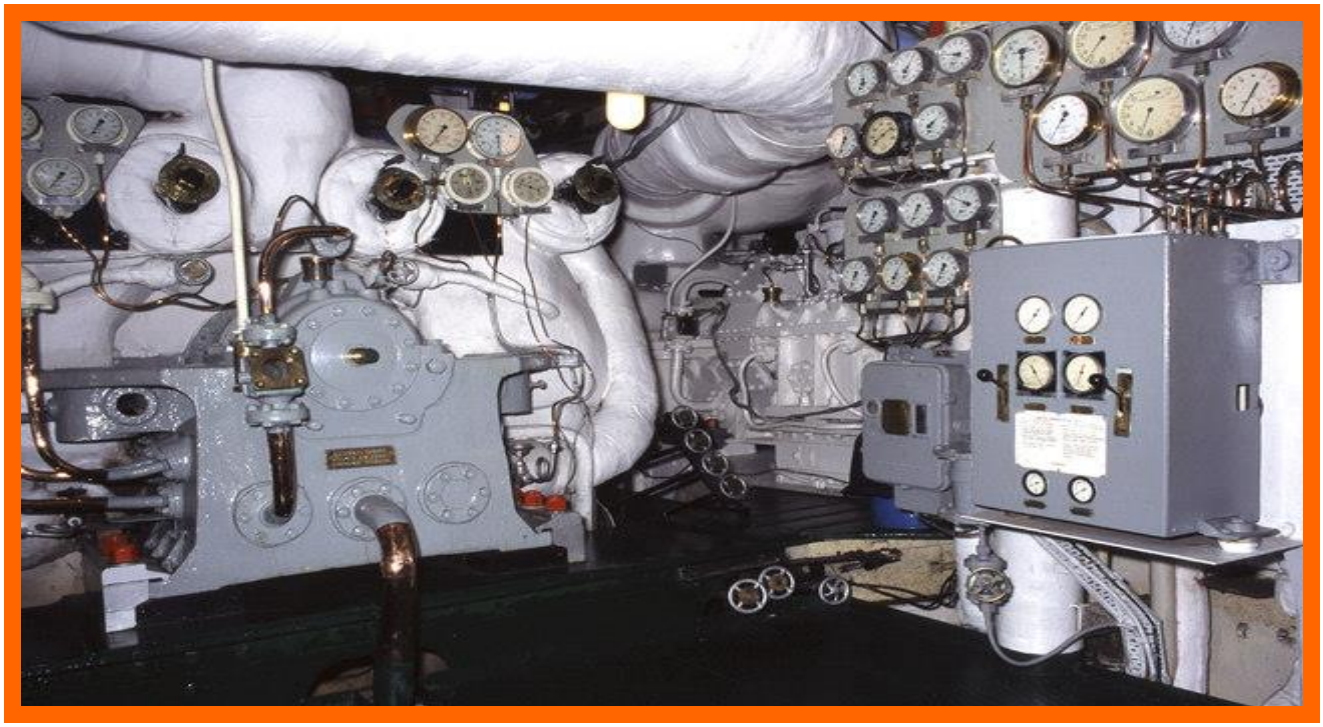
HMS Belfast, now a tourist attraction, moored on the River Thames in London.

HMS Belfast is a Town Class light cruiser built for the Royal Navy and christened on St Patrick's Day in 1938. Commissioned in 1939, shortly before the outbreak of the Second World War, Belfast was initially part of the Royal Naval blockade of Germany, but in November 1939 struck a German mine. After two years undergoing extensive repairs, Belfast returned to duty in November 1942 with improved firepower, radar equipment and armour, playing a important part escorting Artic convoys to Russia and then, in 1943, assisting in the destruction of the German warship Scharnhorst; later seeing active service during the Korean War before being decommissioned in 1963.

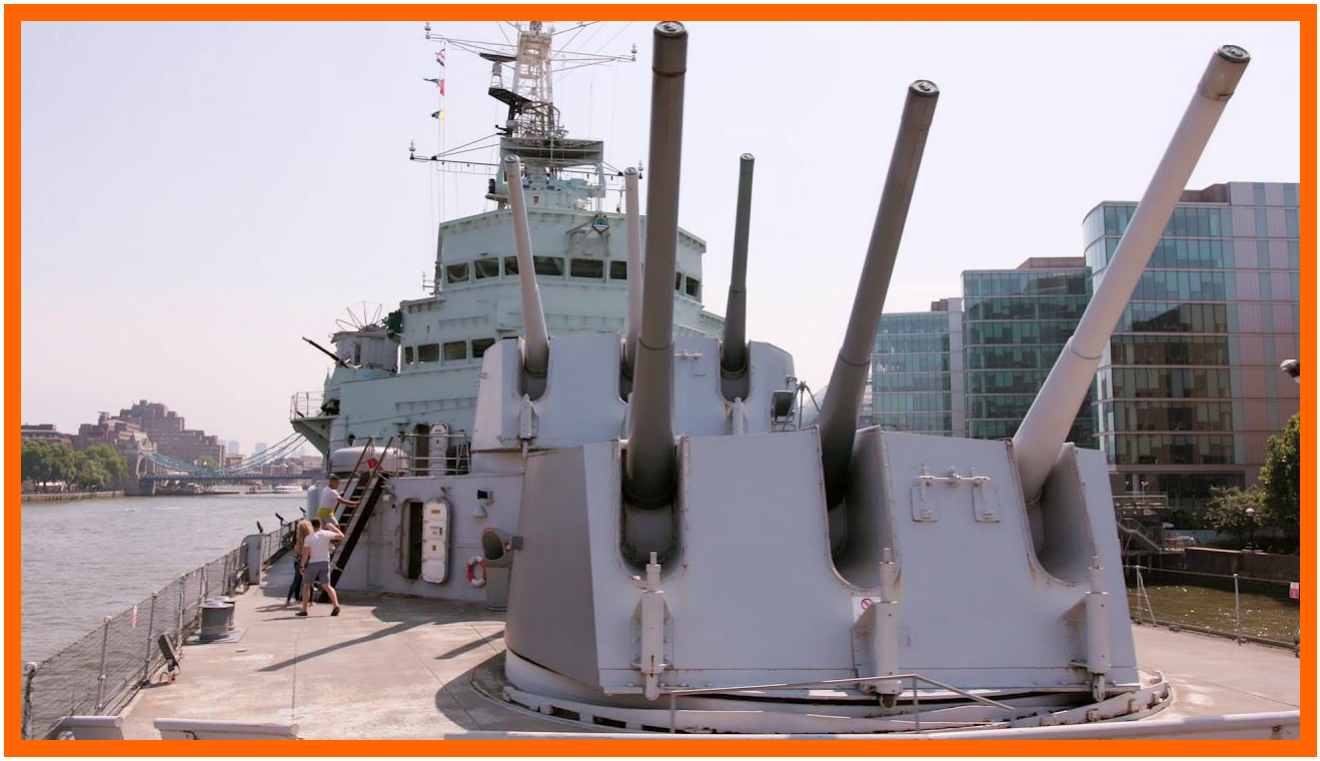
Belfast had an overall length of 613 feet, a beam of 63 ft and a draught of 17 ft, displacing 17,500 tons. She was propelled by Parsons geared steam turbines, driving four propellers, steam being supplied by four three-drum oil-fired Admiralty water tube boilers, giving her a speed of 32.5 knots (37.4 mph) and a maximum range of 8600 nautical miles.

Main armament consisted of twelve 6-inch guns in four triple turrets with secondary fire power from twelve 4-inch guns. Anti-aircraft protection was provided by sixteen 2-pounder "pom-pom" guns and two Vickers machine guns. Belfast was also equipped with sixteen torpedo tubes and carried fifteen depth charges. Though a cruiser, she also had an aviation capability from two catapult-launched Supermarine Walrus amphibious biplanes, operated by the Fleet Air Arm, that had to be recovered from the water after landing by two cranes, one mounted either side of the funnel.

HMS BELFAST, LONDON

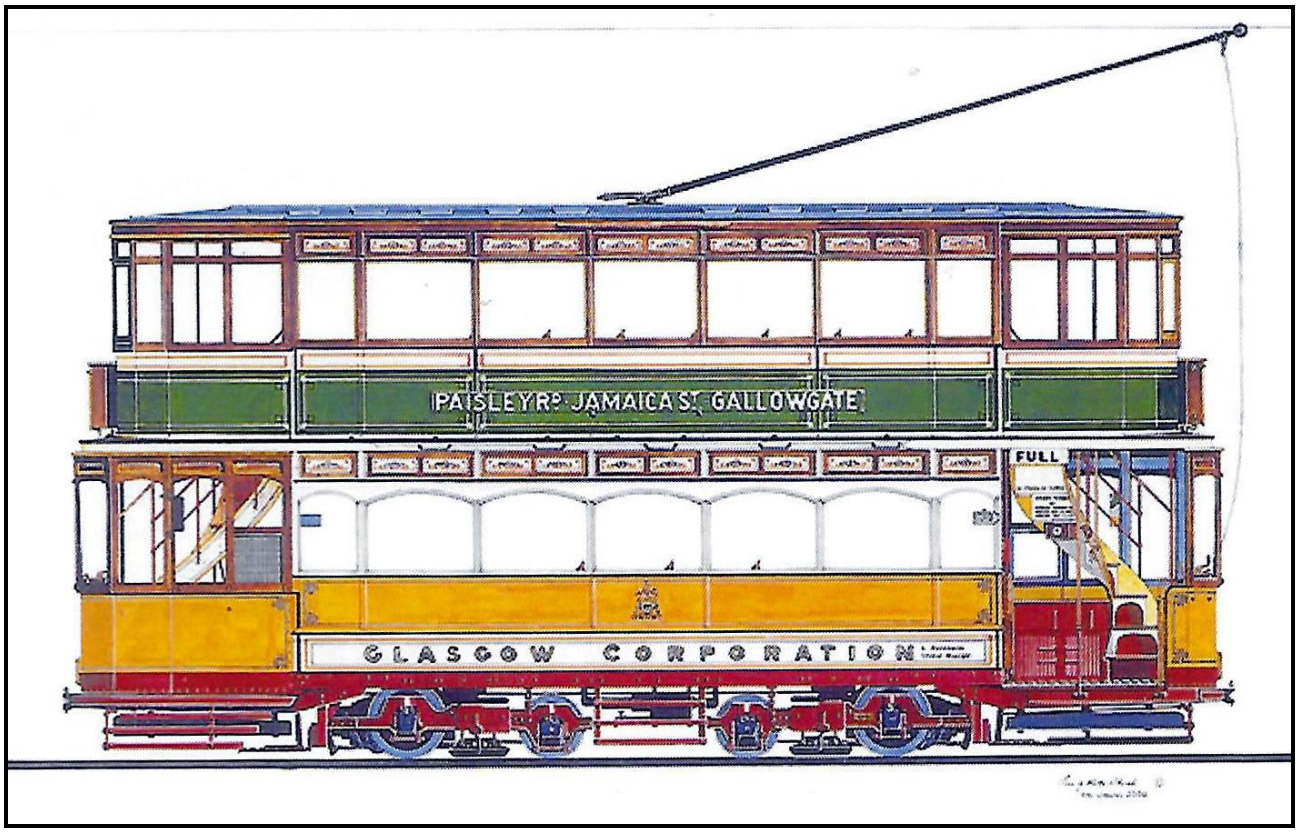


Forward engine room.



Six 6-inch guns in two triple turrets in front of the bridge.

GLASGOW MUSEUM OF TRANSPORT



Line drawing of a 1920s Glasgow Corporation Tramcar by the late Ian Stewart (1939-2018).

Ian was on the Heritage Group for 20 years, serving as Treasurer. He was on various Tramway Societies, and wrote two books on the history of Glasgow Trams, producing exquisite line drawings like the example above.

GLASGOW MUSEUM OF TRANSPORT

The Museum of Transport first opened in 1964 in a disused tram depot, following the closure of the Glasgow tramway system. After being housed in Kelvin Hall for a number of years, since 2011 it has been a feature of the Riverside Museum in Glasgow Harbour on the River Clyde.

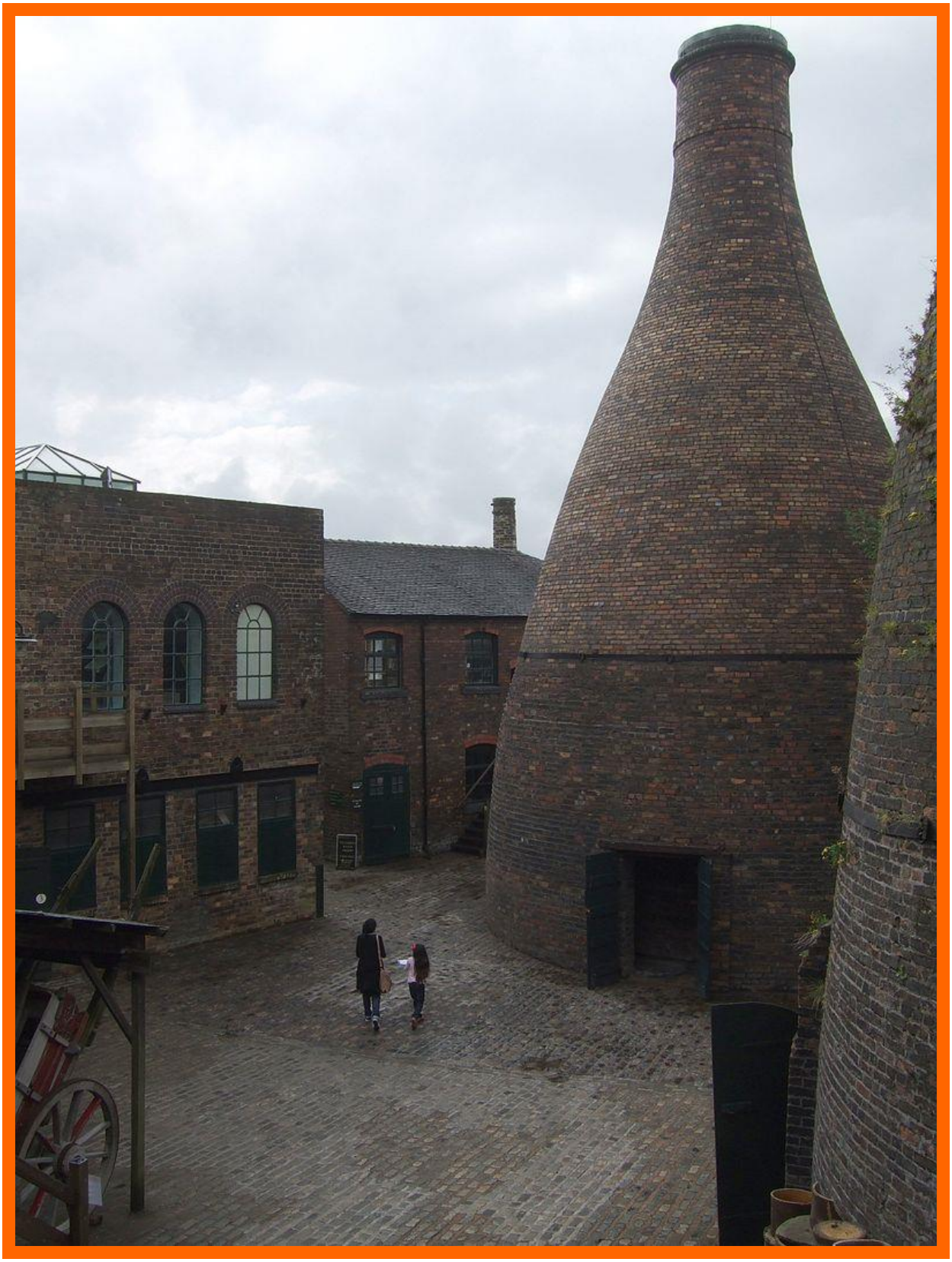
GLADSTONE POTTERY MUSEUM STOKE-ON-TRENT

Examples of ornamental and decorated water-closets.

The Gladstone Pottery Museum is a working museum of a medium-sized coal-fired pottery, located in Longton, Stoke-on-Trent, typical of those once common in the North Staffordshire area at the time of the Industrial Revolution. A factory first opened on the site in 1787 producing earthenware, decorated plates and dishes for Josiah Wedgwood. In 1876, it was renamed Gladstone after the politician. Despite the name, the museum is a complex of buildings from two works, the Gladstone and the Roslyn, having Grade II* listing, the protected structures including the kilns.

In the process of making tableware, the clay and ground bone were mixed in the *sliphouse*. Bowls, plates and saucers were *pressed*, *jiggered* and *jolleyed* or *moulded* from the *slip*. The green (un-fired) china was left to dry in the *greenhouse*. At the same time the *saggars* that would hold them in the kiln were made. The museum is centred on the Roslyn pottery. It contains two biscuit ovens and two larger glost ovens. In addition are two enamel kilns. A tandem compound steam engine by Marshall & Sons, of Gainsborough, Lincolnshire is in place but it is turned by an electric motor.

GLADSTONE POTTERY MUSEUM STOKE-ON-TRENT



The Courtyard and a Bottle Kiln.

EDDYSTONE LIGHTHOUSE
SMEATON'S TOWER, PLYMOUTH HOE

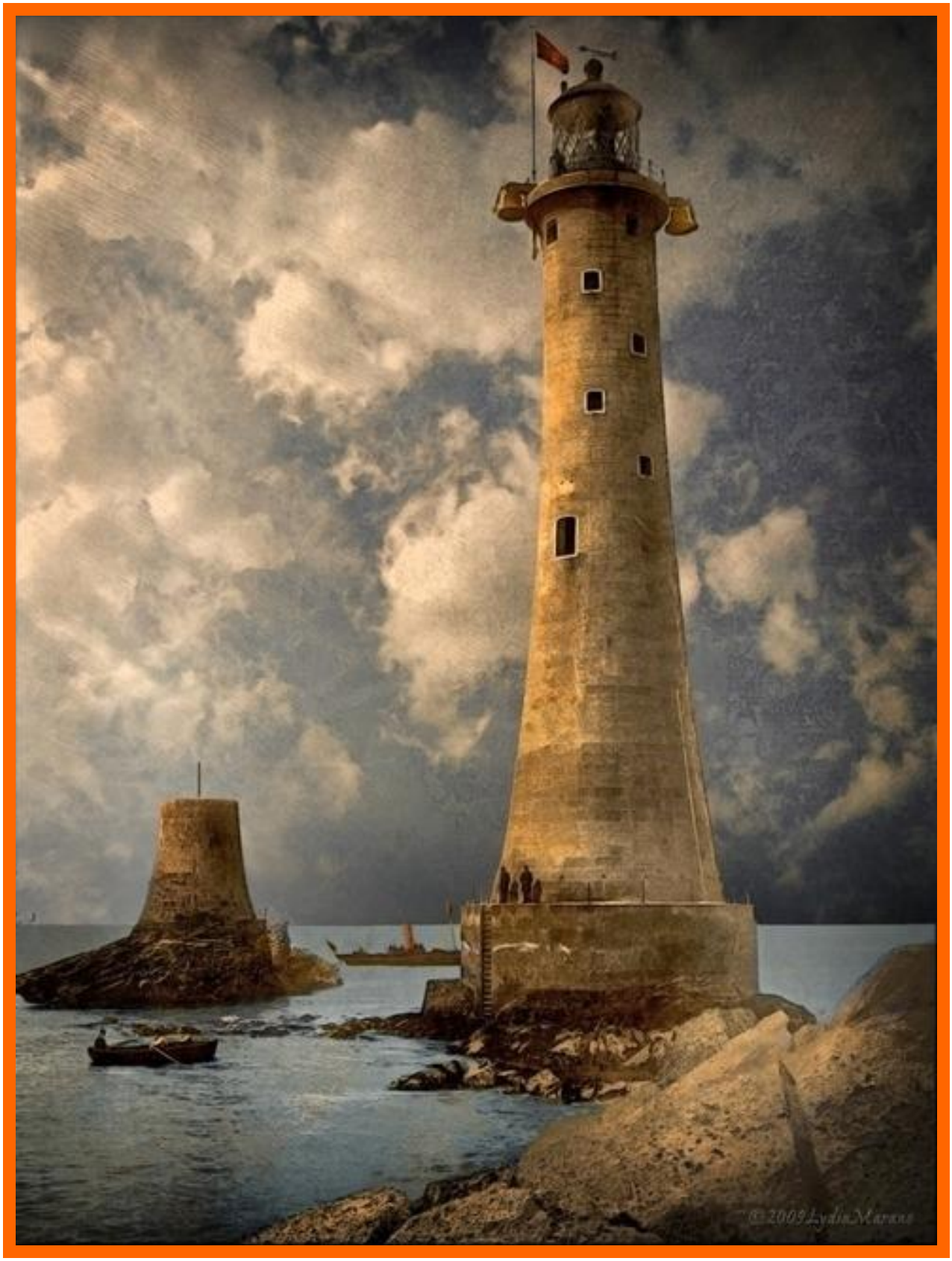
Plymouth Hoe today

In December 1858, the South Foreland lighthouse off Dover was the first to use electric light. The most famous lighthouse is the Eddystone off Rame head in Cornwall. From the time it was first lit in 1698 there have been four lighthouses which illustrate the changes in sources of illumination over some 300 years: candles, Argand lamps, oil lamps and electricity. There have also been major changes in the method of magnifying the illuminating power of the light. First came mirrors and then parabolic reflectors, but in 1847 a catadioptric magnifying systems was installed, using prisms rather than reflectors, being the first such installation in a lighthouse.

The third Eddystone lighthouse by Smeaton was decommissioned in 1877 after severe storm damage to its foundations. It was dismantled and a shorter version reassembled on Plymouth Hoe where it is now a famous tourist attraction.

The present lighthouse (161 ft high) stands close to the stub of Smeaton's lighthouse, employing a light visible at 22 nautical miles, now remotely monitored and controlled by Trinity House.

EDDYSTONE LIGHTHOUSE
SMEATON'S TOWER, PLYMOUTH HOE



The fourth Eddystone lighthouse next to the stub of Smeatons.

GRIMSBY DOCK TOWER

The Tower and Harbour at sunset. ***(Fay Palmer, Grimsby Photographic Society)***

The Dock Tower houses an hydraulic accumulator and is a maritime landmark at the entrance to the Royal Docks in Grimsby. The principle of the accumulator was developed by Sir William Armstrong (1810-1900, considered the Father of Hydraulic Engineering) and used in his shipyard works at Newcastle-on-Tyne. He also made use of it in his mansion at Cragside in Northumberland, the first house in the world to be lit by hydro-electricity.

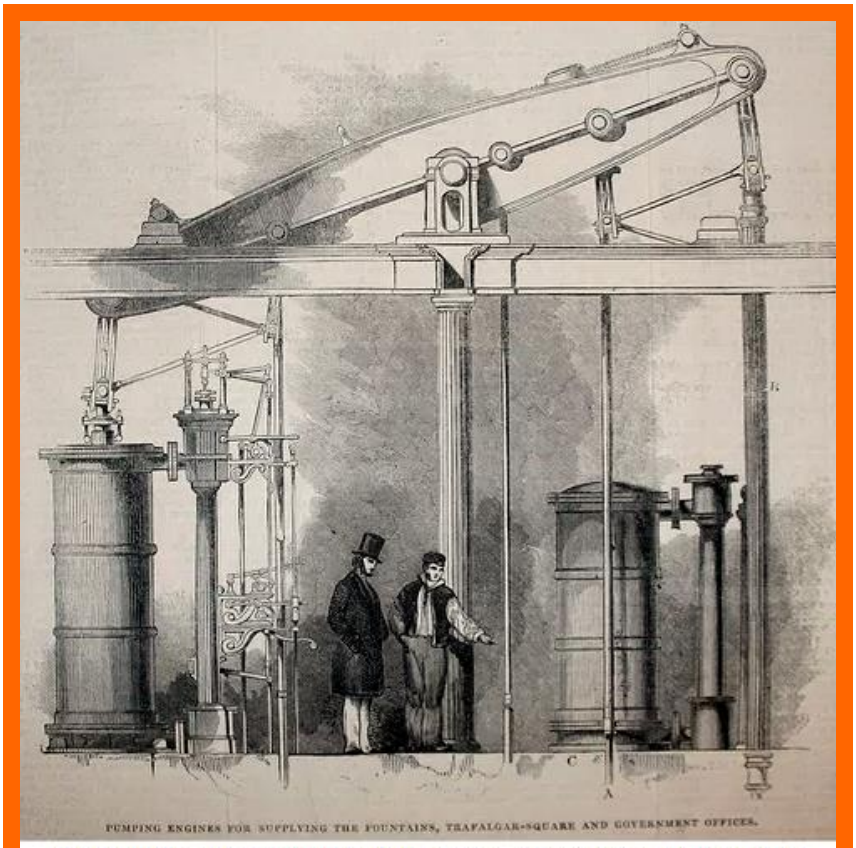
Constructed in 1852, the Grimsby Dock Tower housed a 30,000 gallons water reservoir at a height of 200 ft providing the hydraulic power to operate the dock's lock gates, sluices and power fifteen quayside cranes. The reservoir was topped up from an underground well by two 10 inch pumps, operated by a duplicate, 25 hp horizontal engine, supplying water through a 13 inch diameter cast-iron piping system. In 1892, a new nearby hydraulic tower took over these operations using the developed "weighted accumulator" system, employing a 300 tons weight to achieve pressurisation. (The most famous example of this system was once used, in conjunction with Lancashire steam boilers, to power the bascules for lifting the road sections at London's Tower Bridge).

Grimsby Tower with its lift removed, the top only accessible by a spiral staircase, is no longer in use but remains protected by a Grade I listing.

GRIMSBY DOCK TOWER

The hydraulic Grimsby Dock Tower stands at a height of 300 ft.

TRAFALGAR SQUARE FOUNTAINS, LONDON



The pump for the fountains in Trafalgar Square, 1845, Illustrated London News

In 1845, water for the fountains was pumped by a steam engine, being drawn from artesian wells. The pumping system was replaced by G N Haden & Sons in the late 1930s and again upgraded in 2009.

Trafalgar Square, 1845, from the London Illustrated News

TRAFALGAR SQUARE FOUNTAINS, LONDON

The Trafalgar Square fountains are next to the famous 2500 tons, 169 ft high Column which carries the 18 ft tall statue of Britain's naval hero, Admiral Lord Nelson.

BIG BEN, ELIZABETH TOWER, LONDON

The tower and clock, dating from 1859.

BIG BEN, ELIZABETH TOWER, LONDON

Big Ben's mechanism was constructed by the clock maker Edward John Dent; after his death in 1853 his stepson Frederick Dent completed the work.

Big Ben is the nickname for the Great Bell of the striking clock in the 1859 (315 ft high) Tower, also originally nicknamed Big Ben, now the Elizabeth Tower, in the Palace of Westminster. The four clock dials (23 ft diameter), one on each face of the tower and the tower itself were designed by Augustus Pugin, Sir Charles Barry being the architect for the Palace.

Big Ben weighing 13.5 tons is the largest of the clock's five bells, the others being between 1 and 4 tons. The clock is still worked by its original Victorian mechanism, though there is now an electric backup. The clock is remarkably accurate. On the top of the pendulum is a small stack of old penny coins. Adding or removing a coin will change the speed of the clock by 0.4 seconds per day.

Up to the present day, the clock has only been accessible by climbing the tower's 334 steps, but the current restorations and improvements include a plan to install a lift.

BLACKPOOL TOWER

When the 519 ft high Tower opened in 1894 it was the tallest man-made structure in the British Empire, said to have been inspired by the Eiffel Tower in Paris. It is claimed that the first ever electric crane was used in its construction. It originally had two passenger lifts, operated hydraulically by three Crossley gas engines, but these were replaced in 1952 by Otis electric lifts.

BLACKPOOL TOWER

An original Tower hydraulic passenger lift.

The Tower Ballroom designated a Grade I listed building in 1973.

Blackpool Tower is a well-known tourist attraction in Lancashire, and is also the common name for the Tower Buildings, an entertainment complex comprising the Tower itself and the Tower Ballroom and Tower Circus.

BATTERSEA POWER STATION, LONDON

Battersea Power Station in London, on the south bank of the River Thames, is easily recognisable thanks to its iconic 4-chimney (337 ft high) structure.

London's coal-fired Battersea Power Station is now decommissioned. It comprises two power stations. Battersea-A was built between 1929 and 1935. The building of Battersea-B was started over 1937-41, but construction paused during the Second World War, being completed in 1947. It was one of the world's largest brick buildings, notable for its Art Deco interior and fittings. It also served the first Pimlico District Heating Scheme of 1600 homes on the north side of the river by utilising waste heat. Now enlarged and modernised the heat comes from a combined heat and power (CHP) plant in Churchill Gardens.

Power Stations A & B combined had a power output of 509 MW, the third largest in the UK at the time when it was also reported to be the most thermally efficient power station in the world. Records of the plant in Station-A notes there were three giant turbine generators, two of 92,000 hp with an even larger third of 140,000 hp, giving a total output of 243 MW, all supplied with high-pressure steam (600 psig) from six hopper-fed coal-fired boilers.

BATTERSEA POWER STATION, LONDON

Just a part of the complex operating and monitoring control panels.

CABOT TOWER, BRISTOL

The 105 ft high Cabot Tower stands on Brandon Hill in Bristol. The foundation stone was laid in 1897 (the year of the founding of the IHVE). The tower was completed in 1898 in memory of John Cabot who sailed from Bristol in the *Matthew* to land in what was later to become Canada. A proposed passenger lift was never installed, but the tower now has a light flashing "Cabot Tower, Brandon Hill, Bristol" in Morse Code.