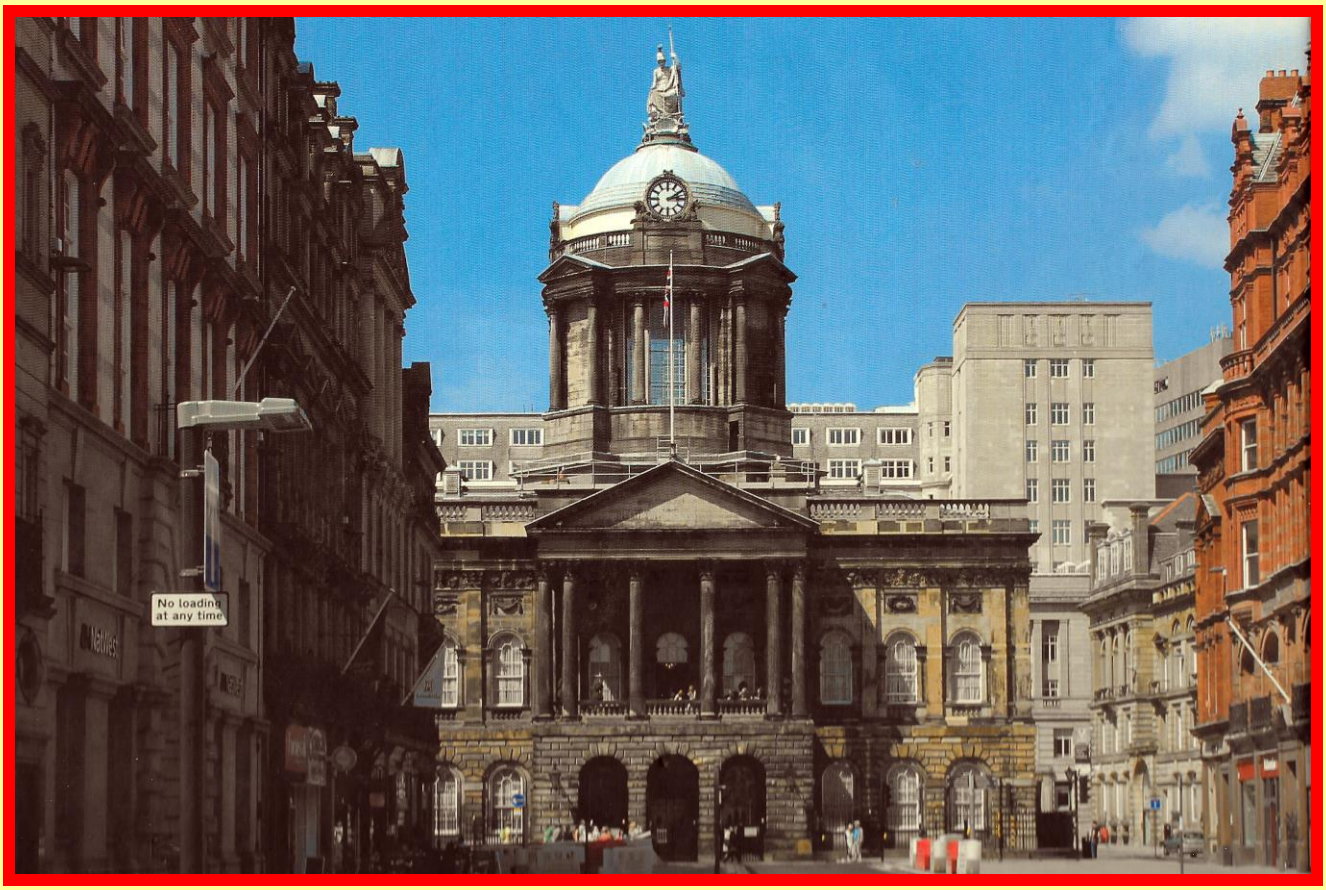
Liverpool Cathedral.

HISTORIC CITIES

GREAT BRITAIN
LIVERPOOL

BRIAN ROBERTS

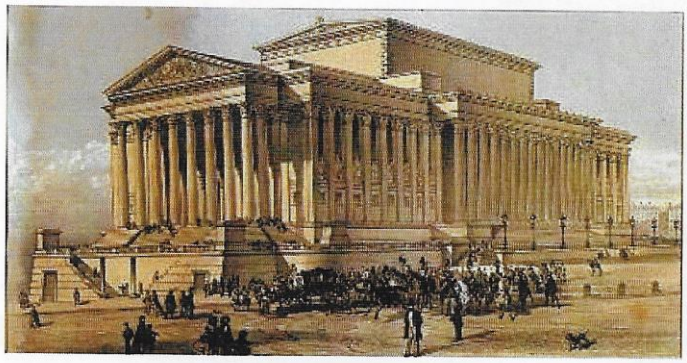
Royal Liver Building.



The Town Hall.

CONTENTS

The Gala Re-Opening of St George's Hall, Liverpool by HRH The Prince of Wales, on 23rd April 2007



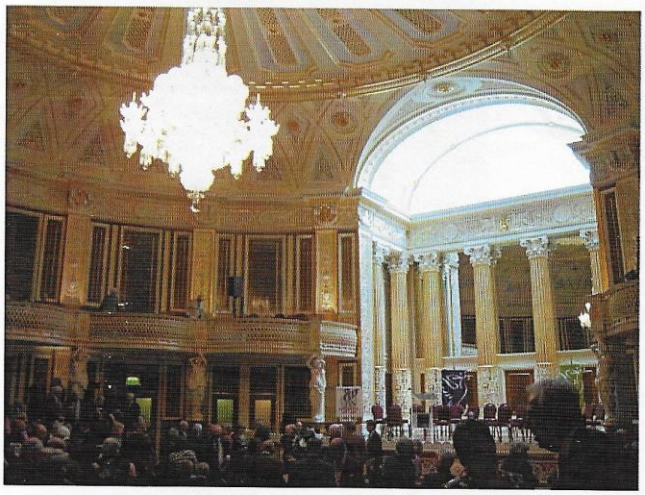
St George's Hall in about 1860

Over a period of about 10 years much of St George's Hall has been restored to its former glory. During this time about £23 million has been spent, the main sources being the Heritage Lottery Fund and Objective 1.

It was fitting that the Hall should be re-opened on St George's Day by The Prince of Wales in view of his intense interest in traditional architecture. HRH The Duke of Gloucester, a qualified architect and Royal Patron of the Hall, was also present.

The CIBSE Heritage group awarded its first 'Blue Plaque' to St George's Hall in 2005 in recognition of its significance in the history of Building Services and particularly air-conditioning. It was therefore very disappointing that during the 'Gala Re-Opening' very little was said about the history of the Hall and nothing at all about the air-conditioning. The whole event was hijacked to a large extent by Liverpool John Moores University who chose this occasion to award its Honorary Fellowship to The Prince of Wales and for him to deliver a speech in its series of Roscoe Lectures. This was an excellent speech delivered straight from the heart about The Prince's belief in the importance of nature over technology. The speech lasted a full 50 minutes and received a prolonged ovation. However, in my opinion, this should have taken place *after* Prince Charles had formally re-opened the Hall with a platform party consisting of local dignitaries for that process. As it was the Lord Mayor of Liverpool cut a very lonely figure surrounded by LJMU hierarchy in full academic regalia and when she eventually invited the Prince to unveil a small commemorative plaque it seemed almost an afterthought. That said Prince Charles' speech was certainly the right way to inaugurate the newly refurbished Small Concert Room, where nearly 32,000 square feet of gold leaf has been applied to the surfaces. This Room was the scene of many 'Penny Readings' by Charles Dickens and supposedly where he gave the first public reading of 'A Christmas Carol'.

The Small Concert Room 23rd April 2007

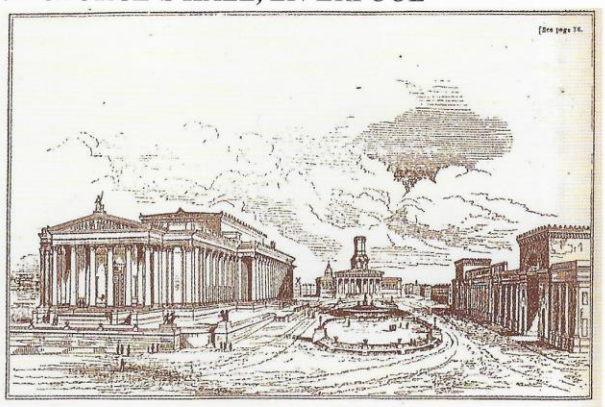


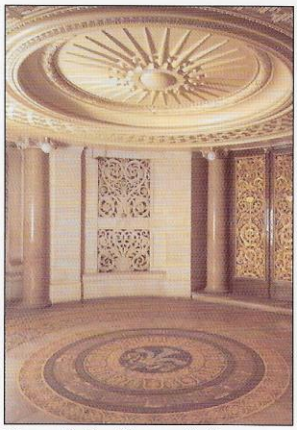
The glossy 'Commemorative Brochure' gives a brief simplified history of St George's Hall and, to some extent, perpetuates the myth that it was all done by a young tragic artistic genius, Harvey Lonsdale Elmes, the James Dean of 19th Century architecture. The well-documented research by John Olley and Loraine Knowles has been largely ignored. For example the Brochure states that 'Elmes took his inspiration from Greek and Roman architecture' when it is known that he never visited Greece or Italy! The amazing coincidence that Elmes won the Competition to design the Assize Courts after he had already won the Competition to design the Concert Hall is not mentioned, nor the fact that he designed grand houses for no less than six members of the building committee who had chosen the Competition winners!

The Brochure does mention that 'The innovative heating and ventilation system, installed (sic) by Dr David Boswell Reid, made it the first air-conditioned public building in Britain' although it seems unlikely that he actually did any 'installing'. We are also told that 'Principle (sic) spaces have been carefully restored to their original finishes' so proof-reading would not seem to be the Liverpool Heritage Office's strong point. This is further emphasised in the new Heritage Centre display board about Reid.

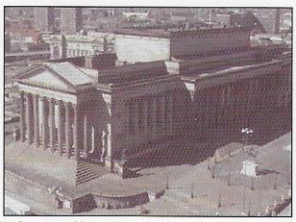
Dr David Boswell Reid

ST GEORGE'S HALL, LIVERPOOL





Beneath the Organ Gallery
1990s

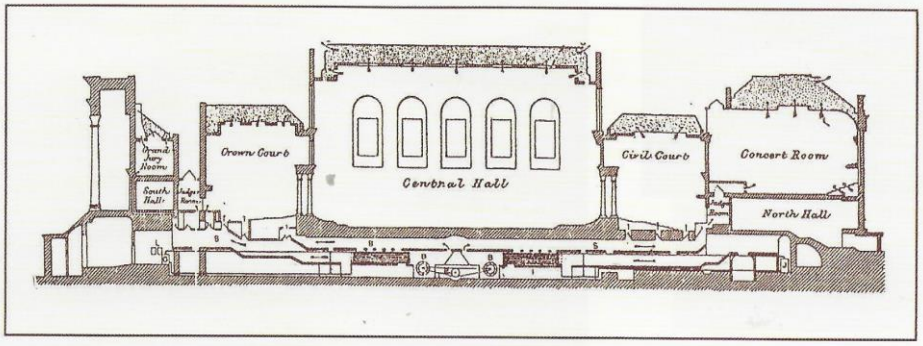


The Hall today

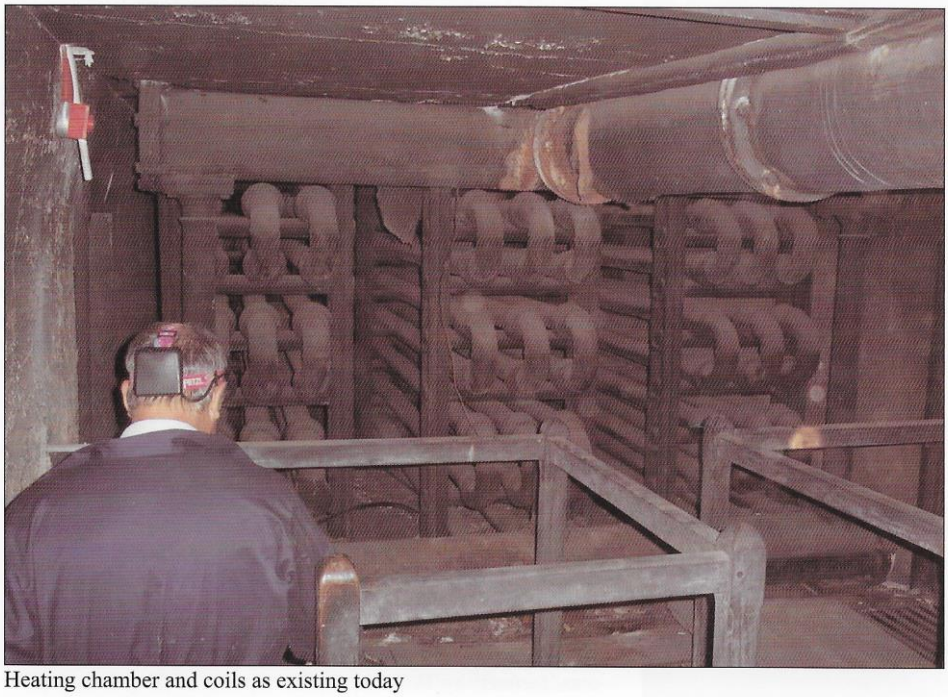
St George's Hall, Liverpool, 1842-51

Harvey Lonsdale Elmes drew up the orginal plans with the interior design inspired by the Roman Baths of Caracalla. The building has been described as perhaps the finest neoclassical building in England. But, when in 1847 Elmes died of consumption at an early age, his great work was completed by Professor C R Cockerell. Dr David Boswell Reid was engaged to design a heating and ventilating system, not included in Elme's scheme but now instigated by the city surveyor, Dr W H Duncan, concerned that infectious diseases seemed to spread due to lack of proper ventilation. [Liverpool had experienced a severe outbreak of cholera in the 1840s.] In Reid's design, air was taken into the building through two shafts and warmed by five batteries of hot water pipes served from four boilers. Natural convection of the heated air was assisted by a 10 hp steam engine driving four 10 ft fans. Cold-water sprays in the main shaft cooled and cleaned the incoming air, which was introduced behind sculptures in the Great Hall and through risers in the seating tiers in other rooms. Vitiated air was exhausted through grilles incorporated in the decorative ceilings, passing into the roof space, its movement aided by gas burners sited in shafts at the corners of the Great Hall. Heating and cooling of the various zones of the building was accomplished by a small army of workers in the basement controlling the passage of air by canvas flaps and doors connected to a system of pulleys and ropes. Much of Reid's system is still in place today.

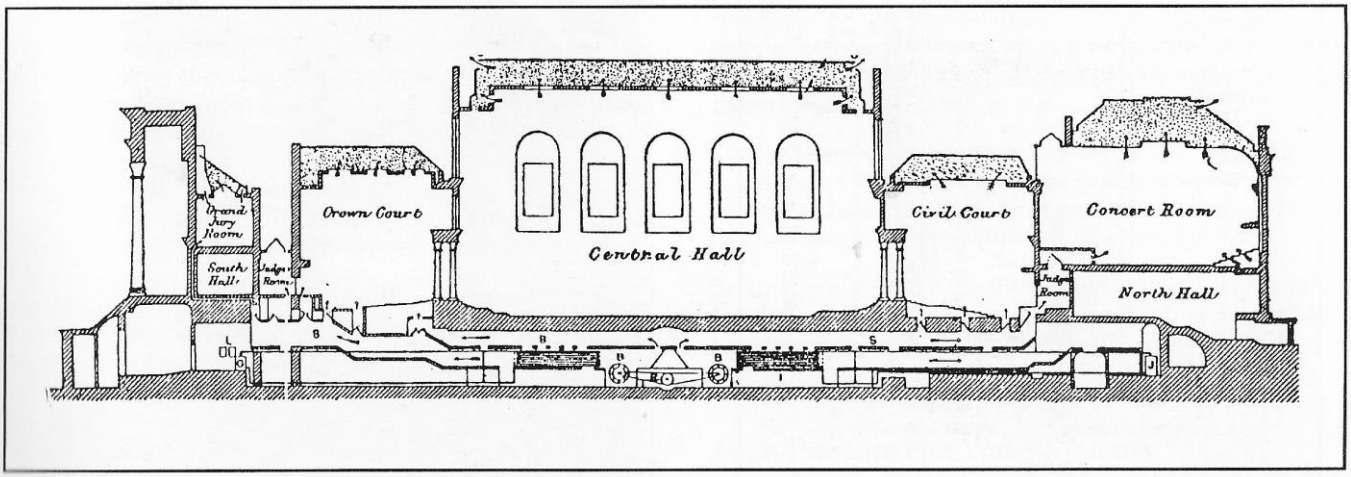
The installation is described in "The Mechanical Ventilation and Warming of St George's Hall, Liverpool," Charles R Honiball, *The Heating and Ventilating Magazine*, Vol.4, New York, October 1907, 15-23.



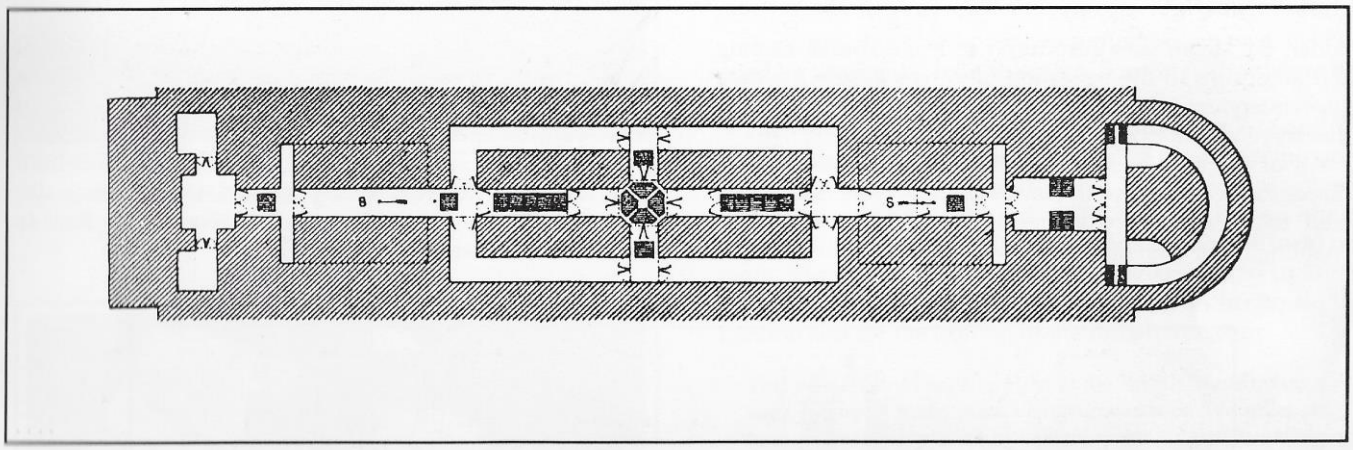
Section illustrating Dr Reid's scheme of 1854



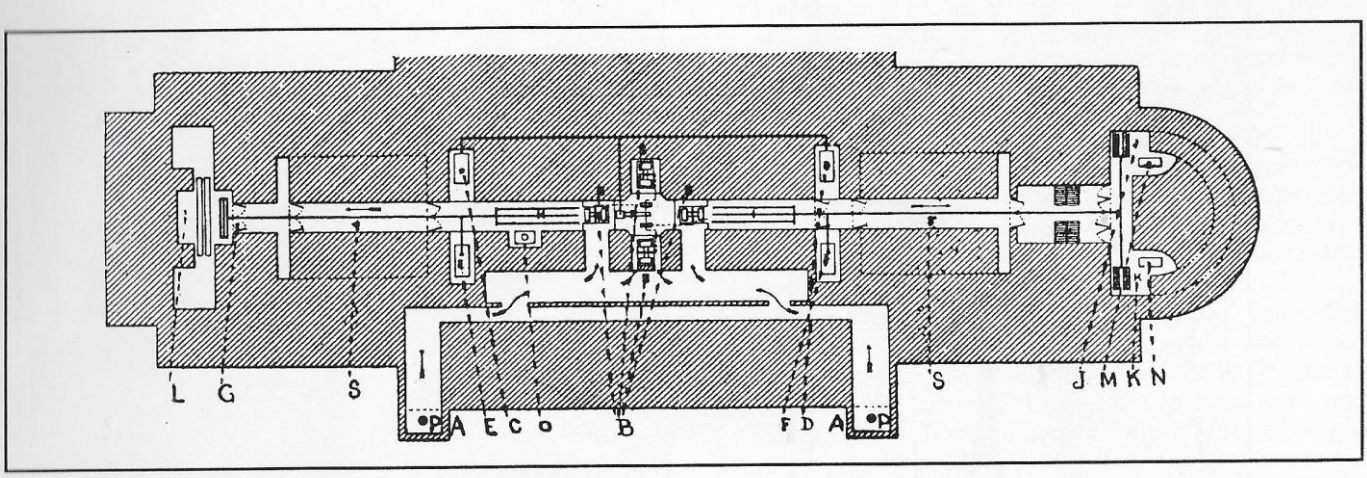
Heating chamber and coils as existing today



a. Longitudinal section of St. George's Hall.



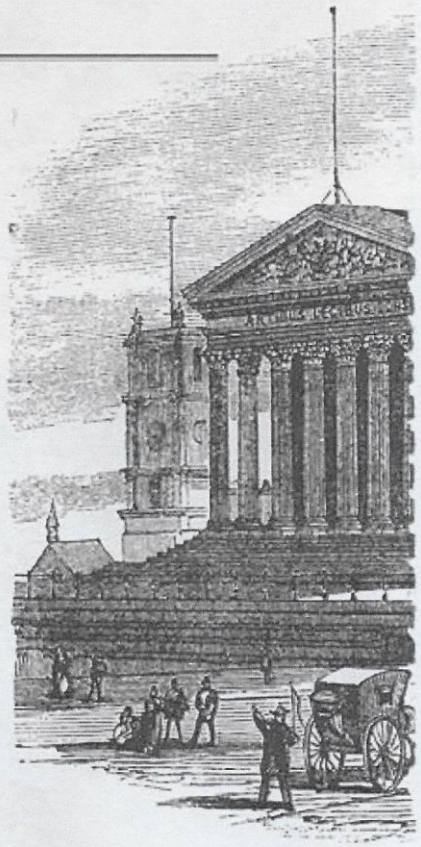
b. Basement plan, St. George's Hall, at level of upper air channels.



c. Basement plan, St. George's Hall, at level of lower ducts.

Figure 7-11 *Section and plans, St. George's Hall, Liverpool, 1854 (from Honiball).*

HALL OF FAME



Neil Sturrock, from CIBSE Heritage Group, explains why Liverpool's St George's Hall was the first air-conditioned building

Described by Queen Victoria as a building 'worthy of ancient Athens', the neo-classical St George's Hall, Liverpool, is the epitome of Grecian grandeur.

But the façade isn't its only claim to fame. The building, which hosted Charles Dickens' world premiere reading of *A Christmas Carol* in 1866, is also home to the world's first modern air conditioning system, designed by Dr David Boswell Reid.

First operated in December 1851, Reid's 'systematic ventilation' led the design of the building, which he claimed was the only one where he had been given a sufficiently free hand to install the system he envisaged.

Although the term 'air conditioning' was first used about 75 years later, this article will show that his system at the Liverpool concert hall had all the necessary elements to describe it that way.

The layout

The building has an unusual – and probably unique – combination of justice and entertainment combined in a single edifice, where five major spaces are spliced together, rather than joined end-to-end.

This combination of functions came about when two separate architectural competitions in 1839 – to design major public buildings in Liverpool – had been won by the same architect, Harvey Lonsdale Elmes of London.

Although Elmes was only 25 years old and relatively inexperienced, he had designed a number of buildings in Prince's Gate and Birdcage Walk in London, and had already won a competition in Liverpool to design a new school for Liverpool College (which later became the Liverpool Collegiate School).

The competitions were for a concert hall (to be funded by public subscription) and the Assize Court Building, to be paid for by a Treasury loan under the Liverpool Improvement Act.

When Elmes was asked how the two might be arranged to create a public forum, he offered to combine the buildings and produce a structure that was bigger than any other throughout the land. This immediately sold the idea to the council.

The influence of Reid

Soon after Elmes' official appointment, he requested that the council consider employing Reid as 'ventilator'.

Elmes was aware of Reid's work at the Palace of Westminster and had almost certainly attended one or more of the lectures Reid gave on ventilation, primarily in London's Exeter Hall.

Reid was formally appointed in July 1841 to fulfil the same role in St George's Hall, making it clear that he would be unable to spend a great deal of time in Liverpool.

The degree of control afforded to Reid is evident in a letter – dated 9 August 1841 – from Elmes to the structural engineer, Robert Rawlinson, less than a month after Reid was appointed.

When referring to the 'positions of the benches both longitudinally and transversely', Elmes instructs Rawlinson to take into account 'the area of 400ft superficial (section) for the vitiated air to pass'. He goes on to say: 'You will oblige me, therefore, by referring to the ventilation plans which are correct.' In a further letter to Rawlinson, dated 27 September 1841, Elmes refers to his 'definitive' plan, saying that: 'Dr Reid wished some alteration made in the course of the smoke flue, which incurs the necessity of placing the bench considerably higher up the ground.'

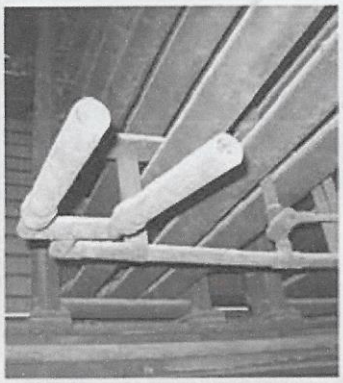
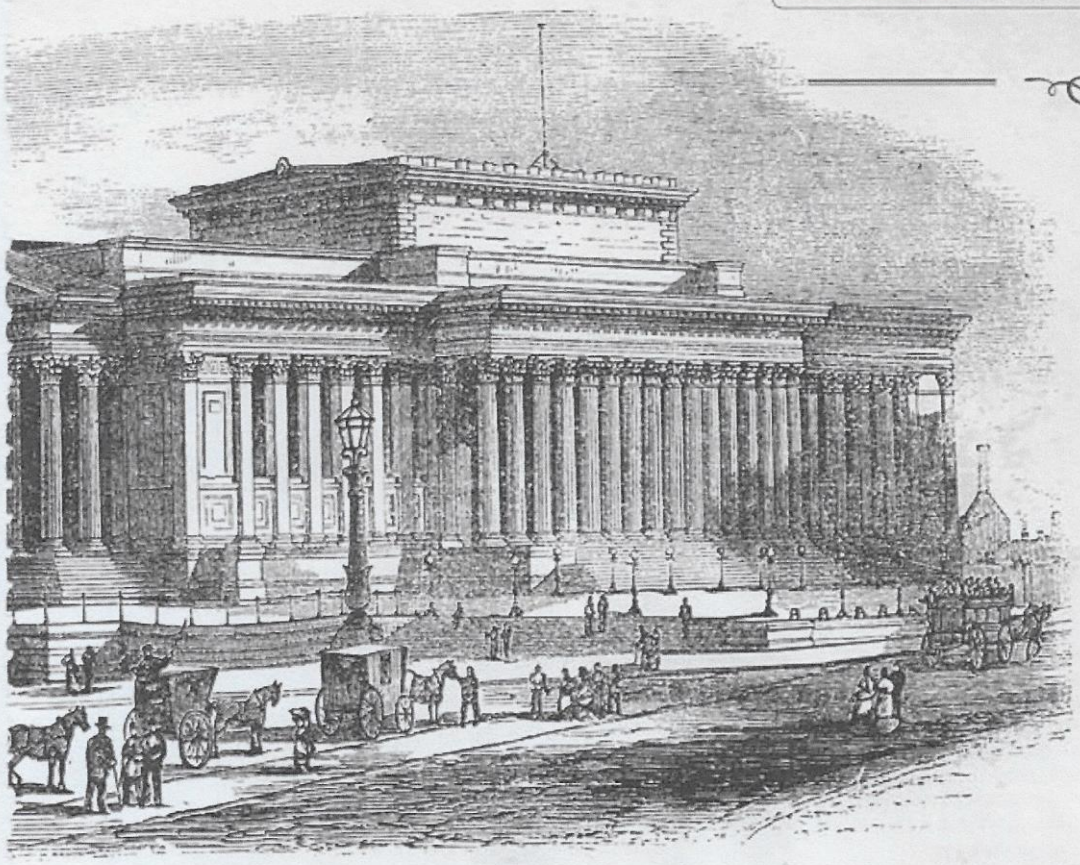


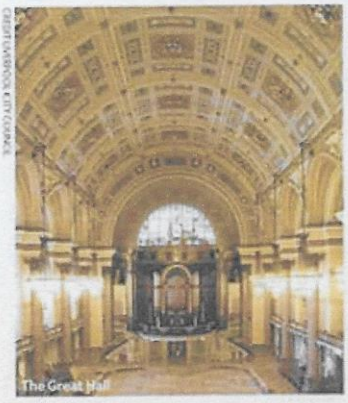
Figure 1: Steam injectors below main heating coil



It is apparent that both architect and structural engineer were being dictated to by the requirements of the 'ventilator' before work had even started on site.

Reid's system

An air-conditioned building requires control of: temperature (up or down); relative humidity (up or down); air throughput rate; and air filtering or cleaning. Reid's system combined all these elements, although the amount of cooling available depended on the temperature of the town's water in the mains system, as there was no means of refrigeration.



CREDIT: LIVERPOOL CITY COUNCIL

The Great Hall

The temperature of the supply air was controlled by passing it over one or more of the five large heater batteries comprising 4-inch (100mm) cast iron pipes containing hot water in winter and cold water (from the town mains system) in summer.

Another 27 coils were fed from steam boilers, but Reid anticipated that these would only be used in extremely cold weather or for pre-occupancy warm-up. The elaborate arrangement of connecting ducts allowed the final supply temperature to each of the major spaces to be varied by mixing warm air with cold, fresh air.

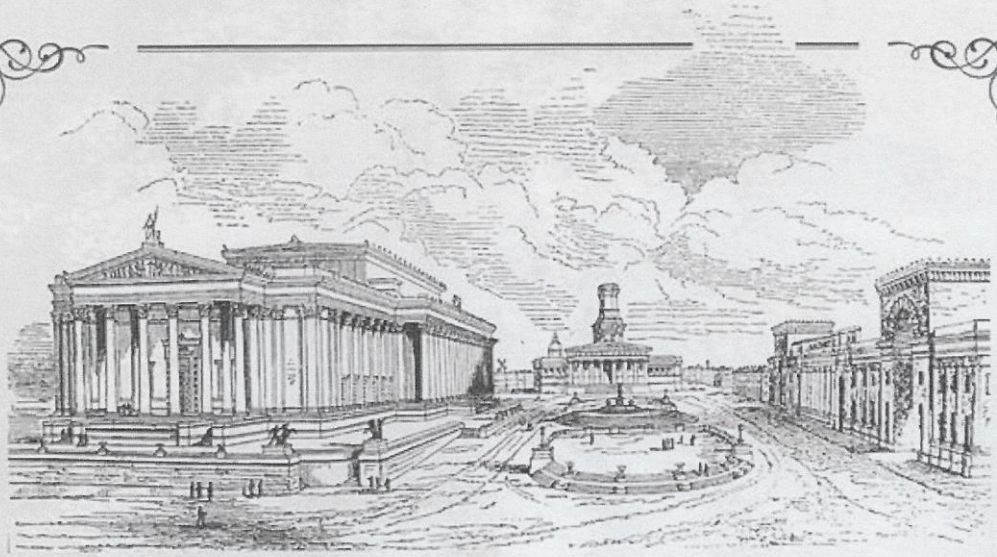
The two main fresh air supply shafts each contained a cold-water fountain providing a fine mist. These reduced the moisture content in summer and provided a degree of adiabatic cooling, but their main purpose was to clean the air. It then passed through a vast thermal labyrinth of brick columns and arches, where impurities would be deposited.

Reid was aware that moisture needed to be added to the warmed air in winter for the occupants' wellbeing. This was achieved through nozzles that injected steam directly into the airstream. This came from a small boiler, which had been included in his design for this sole purpose (Figure 1).

The air was extracted by feeding the vitiated air into four exhaust shafts (see panel, 'Proposed extract tower', on page 62), although air from the main hall roof space could pass directly outside. The original main hall roof had upstands with glass louvres for this purpose.

The four exhaust shafts had braziers of coal constantly burning at the bottom; these were replaced by gas jets after a few years to reduce labour.

Special attention was given to the roof space of the Crown Court: being at the south end of the building, in sunny weather the vitiated



air could discharge directly outside, with the extract rate being boosted by solar gain to the attic.

The air supply rate could be increased using large paddle fans driven by a steam engine, but Reid's instruction manual[1] makes it clear that this should only be necessary in the summer when the stack effect would be insufficient, or in winter for preoccupancy warm-up.

There were four fans, each 10ft (3m) in diameter with eight 5ft (1.5m) by 2ft 6in (0.75m) blades. These could be made to operate individually or in any combination, and the 'mechanical' supply rate could be varied from approximately 1,000 to 50,000 cfm (0.5 to 25m³/s).

Typical arrangement

The small concert room system is almost identical to that applied more than 160 years later in the 2014 Stirling Prize-winning Everyman Theatre.

Fresh air for the concert room is taken from slightly above street level (in the 19th century Lime Street would have been heavily contaminated with horse manure), cleaned and passed through the thermal labyrinth before reaching the central distribution chambers.

This air is then either passed through – or around – the Great North Water Apparatus (one of two major hot water coils) containing 72 30ft (10m)-long pipes, each 4-inch (100mm) in diameter.

The air then passes along the main supply duct and splits left and right (west and east) before rising up two vertical shafts, arriving under the seating.

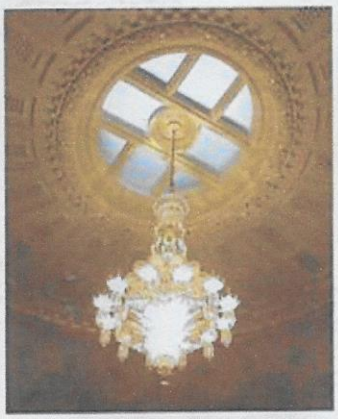


Figure 2: Concert Room ceiling showing roof-light and air outlets

Air was delivered into the concert room primarily through a continuous grille in the riser under each row of seats, and additional supply came from the front of the stage and the front of the seating. Extra fresh air – delivered from special fresh air towers behind the lower roof parapet – can be supplied directly into the concert room from either side of the stage.

The vitiated air passed into the roof space through numerous apertures in the ceiling, each with an adjustable flap behind it. In addition, and especially when the gas jets were lit on the chandelier, the glass quadrants

> The four exhaust shafts had braziers of coal constantly burning at the bottom; these were replaced by gas jets after a few years to reduce labour

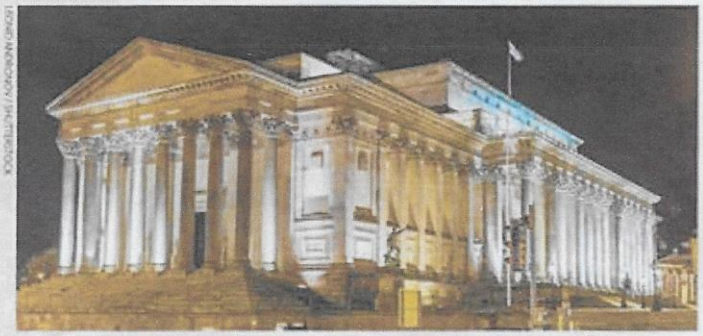
in the roof light over the chandelier could be opened to allow excess heat to escape (see Figure 2 on page 60).

Reid had persuaded the building committee that his system could be much smaller if the main hall was not used for functions while the courts were in session.

However, he made allowances to ensure that the concert room and the adjacent (north) court could be used simultaneously, and the direction the vitiated air from the concert room took depended on this.

Under normal circumstances the air from the concert room went to the north-east exhaust shaft but, if this court was also being used, the air from the concert room went to the north-west exhaust shaft. This ensured that sufficient drawing power could be applied to both at the same time.

LEONID GROSOV/SHUTTERSTOCK



LEONID MARKOV/SHUTTERSTOCK

The first air-conditioned building?

It could be argued that this was not Reid's first attempt at air-conditioning a large space, and that the honour should go to the Temporary House of Commons in 1836.

However, St George's Hall was the first building where such a system was integrated fully into its design and construction – both the architect and structural engineer relied on Reid to let them know his requirements before even the bench levels could be set.

Reid's system was first used when the courts came into session on 8 December 1851, while the Houses of Parliament – using a similar system – were not used until February 1852. **CJ**

● A complete history of the design and construction of St George's Hall can be found on the Heritage Group website. Read more on the pioneering work of David Boswell Reid in 'The pioneer who rid Parliament of hot air', January 2015 *CIBSE Journal*.

References:

1 *Diagrams of the Ventilation of St George's Hall and the New Assize Courts*, D B Reid, 1855 (Liverpool Record Office).

2 HEVAC heritage http://bit.ly/1Mevuvy

3 *Illustrations of the Theory and Practice of Ventilation*, D B Reid, Longmans, London, 1844.

PROPOSED EXTRACT TOWER

By the time Elmes was being asked to consider the arrangement of the two competition buildings, the council decided to construct another building housing daily courts, including magistrates' courts and a bridewell (central lock-up); this was also indicated on his plans.

Reid saw this as an opportunity to incorporate a communal extract tower for all three buildings, similar to the stand-alone tower he designed for the Temporary House of Commons.

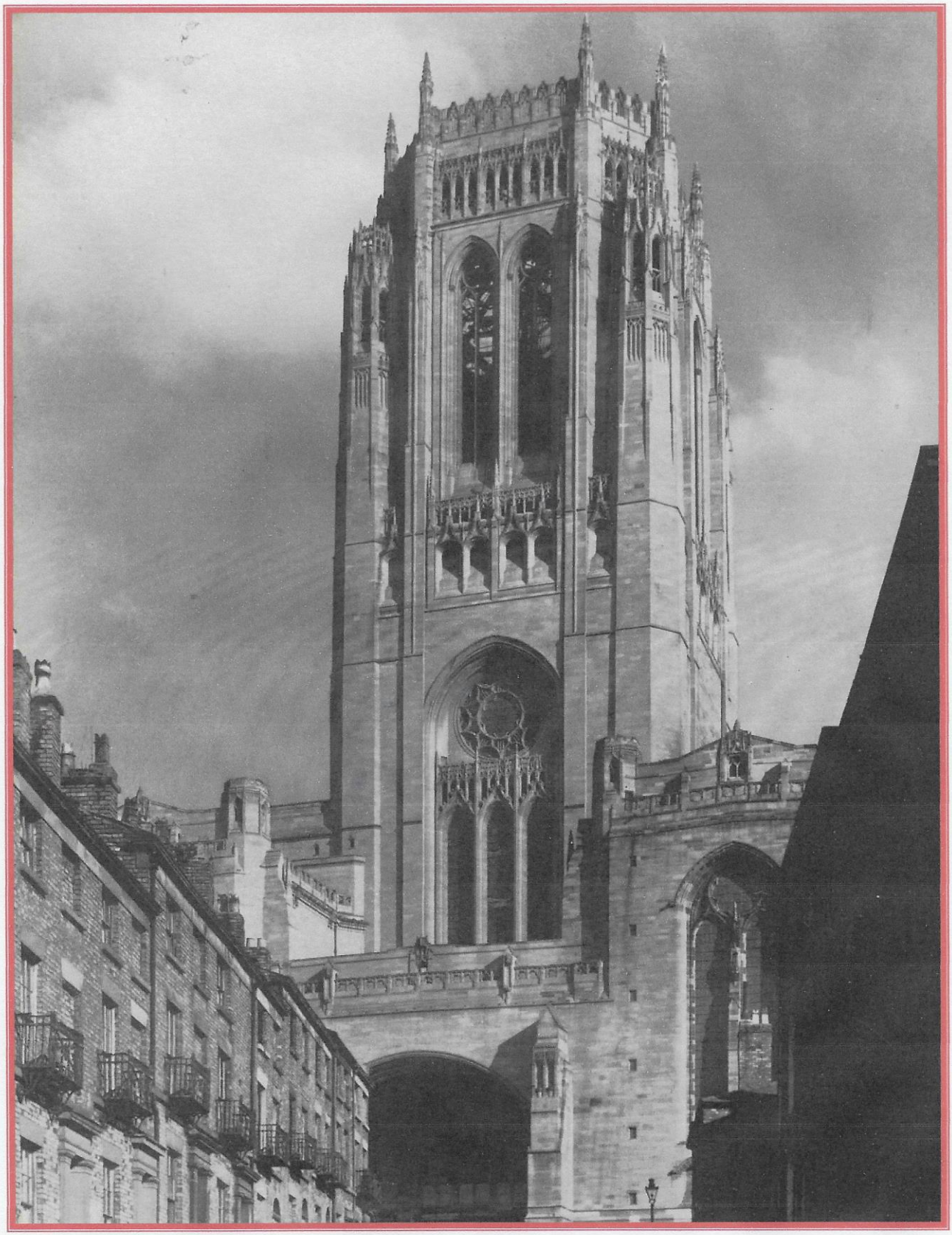
The extract tower was to be 30ft (9m) in diameter at the bottom, and about 200ft (65m) high with a furnace burning permanently at its base. It was to be connected to the larger building(s) by underground tunnels so all vitiated air and chimney smoke would pass through it.

Elmes' drawing (on page 60), which appears in Reid's 1844 book[3], shows how it might appear. All of the 110 fireplace chimneys in the main building were to have flues that turned downwards. However, in April 1845, it was decided that the smaller building would not be built at that time (the Liverpool main bridewell and magistrates' courts were eventually built around 1859 on a site nearer to the town hall).

The north end of the 'forum' was to be closed off by the daily courts and bridewell. The building on the right was the now-demolished classical front to Lime Street Station, which had been designed by borough architect John Foster Junior, in 1835.

In 1845 the Council decided that there were insufficient funds for the daily courts building but, by then, St George's Hall was up to principal floor level and all the lower elements of the Reid extract system had been completed, so the way vitiated air and chimney effluent were to be extracted had to be completely reconsidered.

The tunnel connecting the lowest level of St George's Hall to the proposed exhaust tower was then bricked up and forgotten about. (After working closely with the hall manager, this underground system is scheduled to be reopened for inspection later this year). Four new exhaust ducts were then incorporated into the building and these terminate at the four corners of the highest roof behind the parapet.



Liverpool Cathedral

LIVERPOOL CATHEDRAL

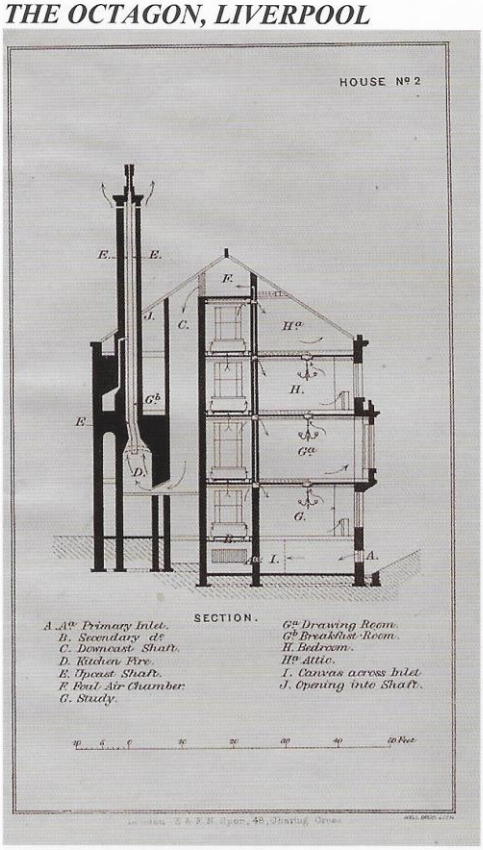
Irregular only in their verbs, the Romans believed in warm feet and cool heads, and so invented a hot air system circulating under the floors of their villas. In our unsettled era, when so many staggering innovations grow obsolete while still in infancy, it is pleasing to note that for one purpose at least the hypocaust remains unbeaten. This is in the special field of the cathedral, where we have the problem of a huge space only needing to be warmed for the first few feet above the floor.

The heating of Liverpool Cathedral was planned before the foundations were laid and it was therefore possible to install a modern version of the hypocaust, which turned the entire floor into a vast radiator. We used the Roman method because its structure has been proved to survive intact for nearly two thousand years, and cathedrals must be made to last.

At the time we prepared this design ducts in the floor itself were considered more permanent than metal pipes embedded in it; but just before the last war, when we were asked to design the system for the new cathedral at Guildford, we decided that copper pipes laid in concrete just below the floor surface were likely to prove as permanent and offered certain advantages of simplicity and economy. It is rather easier, for example, to pump hot water through small pipes than hot air through small ducts. More recently, we have used the same system in Sheffield and Manchester Cathedrals and it will also be used in future extensions at Liverpool.

There, air heated by gas-fired appliances is forced by electrically-driven fans through a closed system of small ducts immediately below the floor surface, the same air being continuously circulated so that the ducts do not become choked by dust. In this way the floor surface can be maintained at a temperature sufficient to warm comfortably the occupied part of the cathedral with notable economy, and without being too hot for the feet.

THE OCTAGON, LIVERPOOL



The House

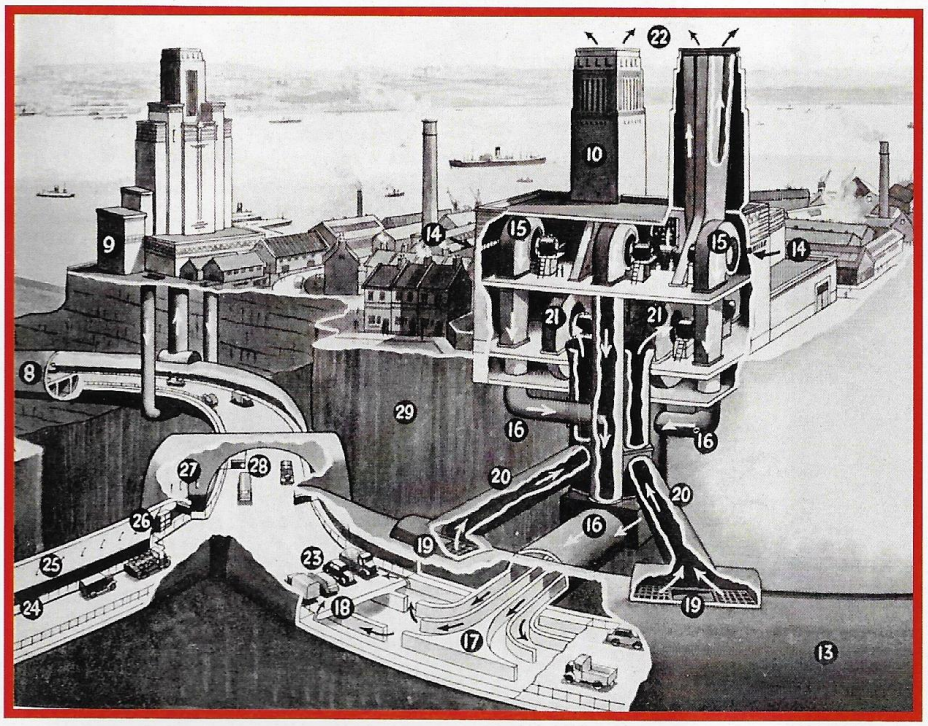
The Octagon, Liverpool, 1867

Dr Hayward's ventilation scheme for his house, the Octagon, is described in the 1872 textbook, *Health and Comfort in House Building*. Fresh air was collected and warmed in the basement. The roof space was used as a foul air chamber into which the vitiated air of all the rooms was collected, being drawn by the kitchen fire into a shaft passing down to the ground floor, then ascending behind the fire and up the kitchen chimney stack [an arrangement not uncommon at this time]. However, a feature of the design is the way in which all principal rooms opened off closed lobbies, separated by doors from the hall and staircase, which formed a vertical supply duct delivering filtered warmed air. Conventional fireplaces and ventilating gas lamps, arranged to promote the desired air circulation patterns, supplemented the heating. The original scheme included five coils of Perkins' one-inch diameter hot water pipes (presumably a high-pressure system) but new low pressure hot water heating was installed around 1970.

Decorative cornice grille

Present interior

The Octagon and its ventilation features in "The Architecture of the Well-Tempered Environment," Reyner Banham, The Architectural Press, London, 1969, 35-39.



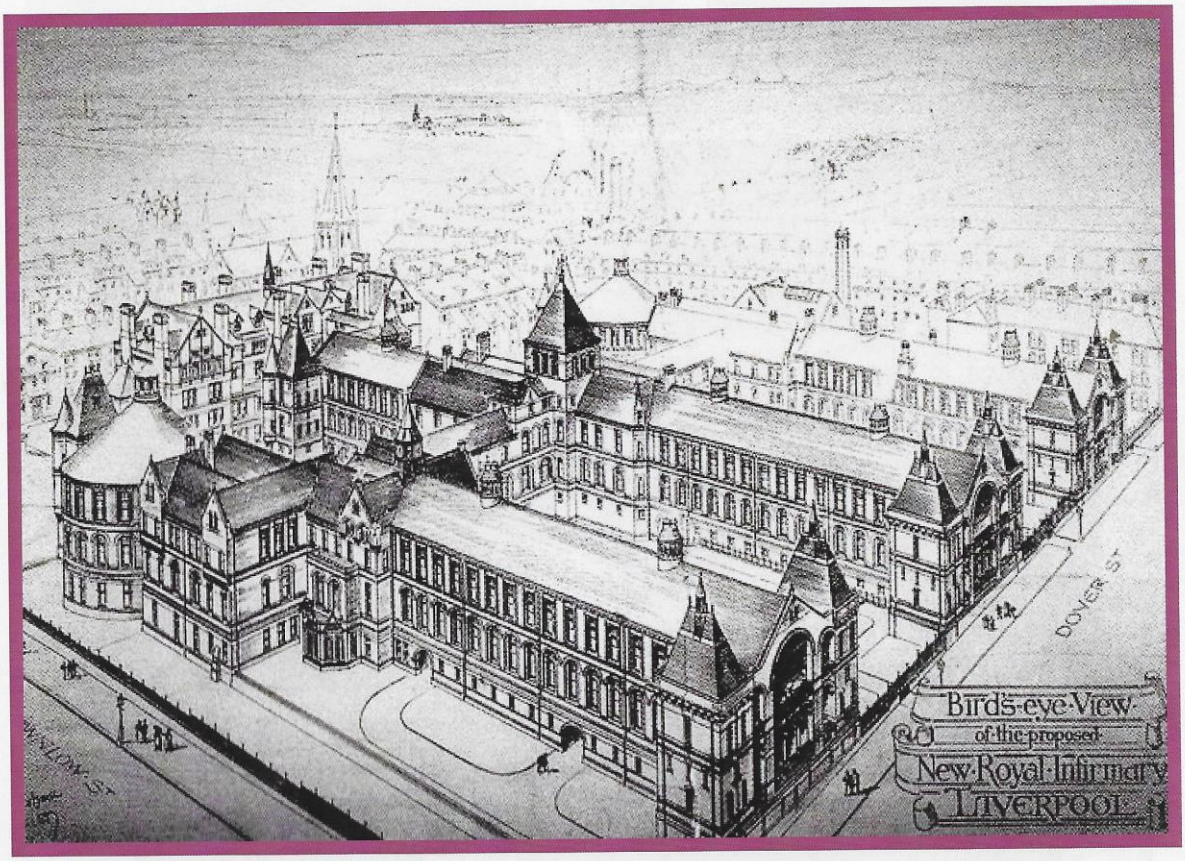
Congratulations to Heritage Group Vice-Chairman Neil Sturrock for producing a book to celebrate the 75th Anniversary of the Merseyside & North Wales Region of CIBSE. (The illustration shows the Woodside Ventilation Station, Birkenhead, in 1934).

The Heritage Group September Meeting was held in Liverpool with visits to the Mersey Tunnel ventilation plant, St George's Hall and the Town Hall where there are ornamental heating stoves thought to be of French origin. The one on the right is about 8 ft tall.

CIBSE HERITAGE GROUP

Newsletter No. 32 June 2015

The Heritage Group January visit was to the Liverpool Royal Infirmary.

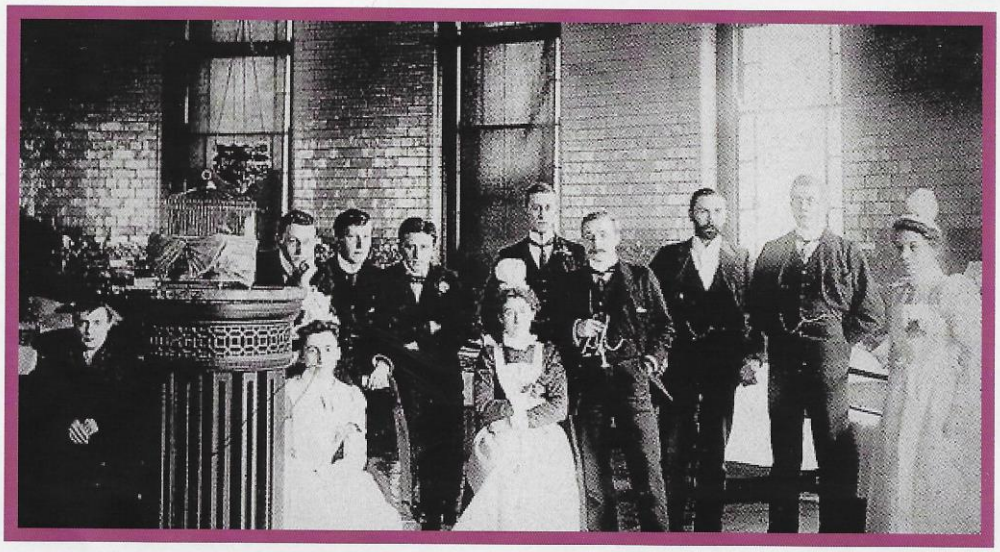


In 1885, the architect Alfred Waterhouse was commissioned to design the new hospital. He finalised his plans in 1887 with a scheme that included eight Nightingale pavilion-style wards and two circular ward blocks. His design included an operating theatre and viewing gallery, a lecture theatre, a chapel and mortuary and a station for horse-drawn ambulances with stables and hay and harness store. The builder was Messrs Home & Green. The final cost was £181,000 and the hospital was opened in 1889 with a commemorative ball held in St George's Hall. The building services engineer was Wilson Weatherley Phipson who designed a steam heating system employing 2 x 50 hp Galloway steam boilers serving Longden "Sunbeam" radiators, kitchen, ventilation coils, laundry, pumped services and disinfection apparatus. Today, there are 21st century gas-powered electricity generator sets installed within the old 19th century Phipson boiler house, operating with an adjacent, modern energy centre.

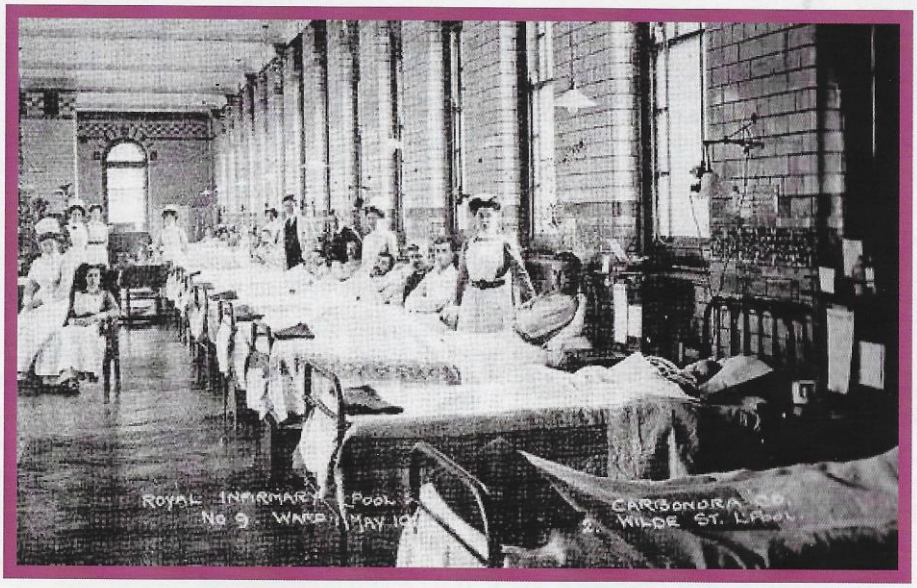
Contemporary photographs of Liverpool Royal Infirmary from the Heritage Group Archives. See also Victorian Hospitals on our website.

The Hospital in 1908

The Outpatients Department opening on 6 March 1911



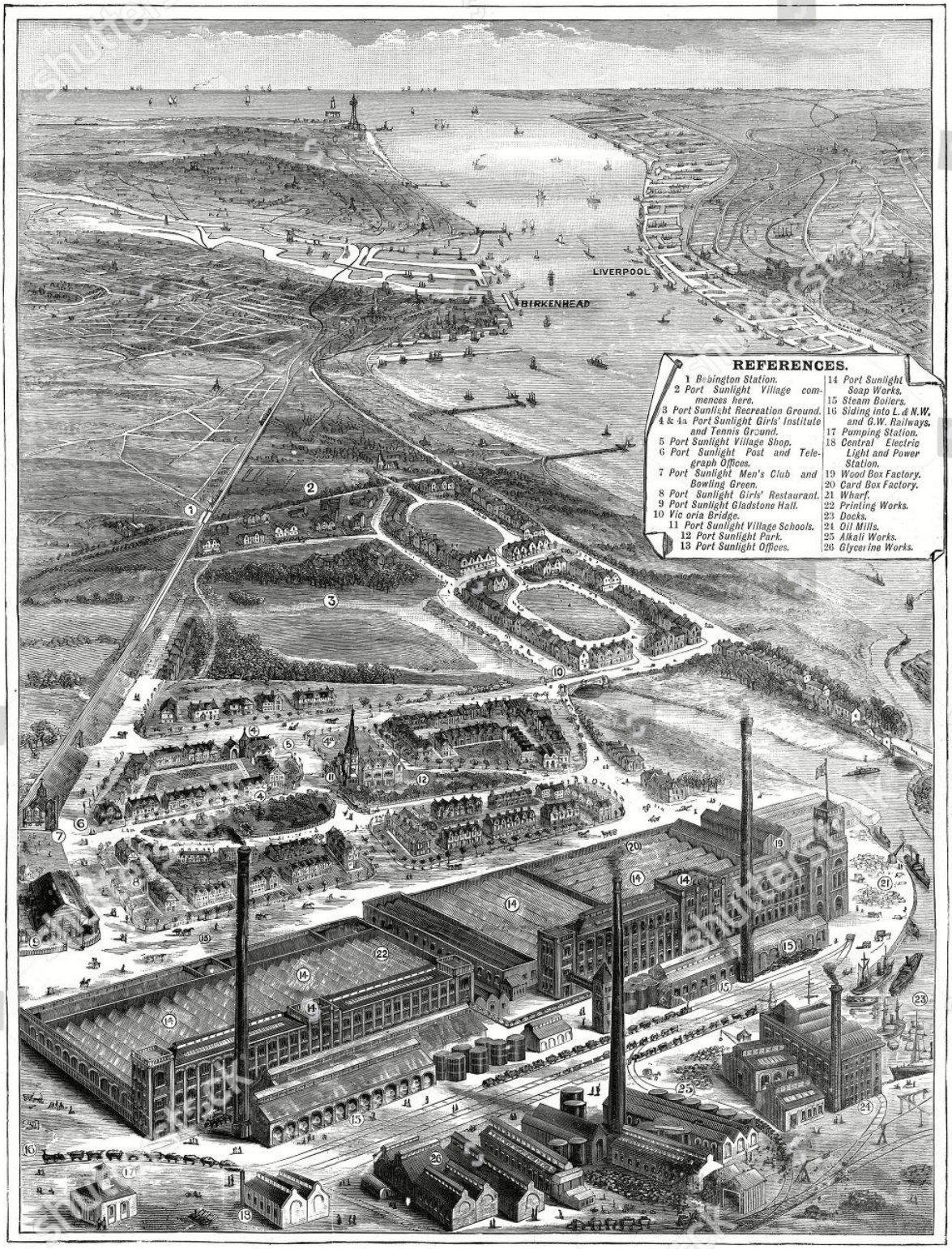
A group of doctors and nurses in a Circular Ward with (left) an ornamental radiator



Postcard dated May1911 showing one of the four Nightingale Wards

PORT SUNLIGHT

Where SUNLIGHT and LIFEBUOY SOAPS are Made.



A BIRD'S-EYE VIEW OF WORKS AND VILLAGE.

LEVER BROTHERS LIMITED. PORT SUNLIGHT. CHESHIRE.

ROYAL LIVER BUILDING c.1915

EXCHANGE FLAGS c.1895

PIER HEAD 1930

PRINCE'S LANDING STAGE 1907

CUSTOM HOUSE 1891

ALBERT DOCK 1895

ORIEL CHAMBERS 1949

TOWN HALL INTERIOR 1948

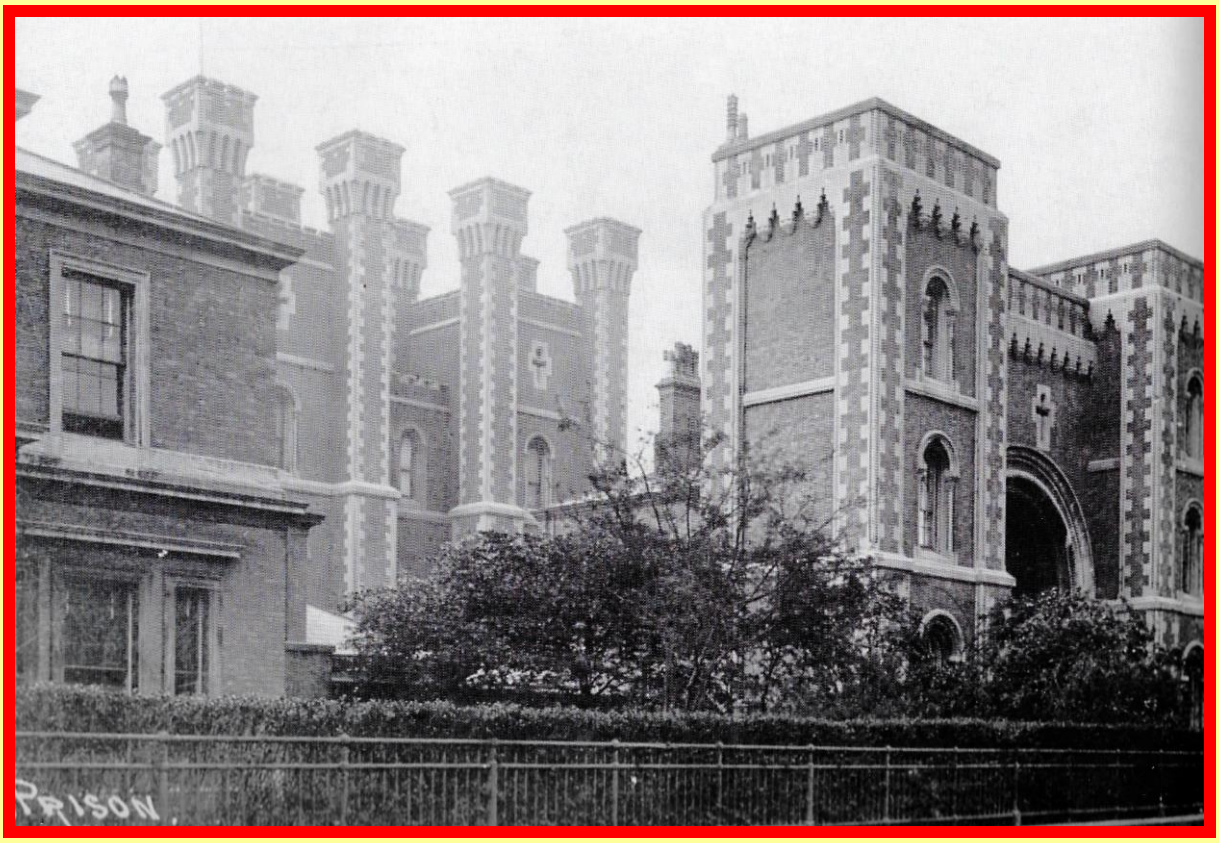
ST. JOHN'S MARKET 1897

ST. GEORGE'S HALL c.1896

WILLIAM BROWN STREET 1896

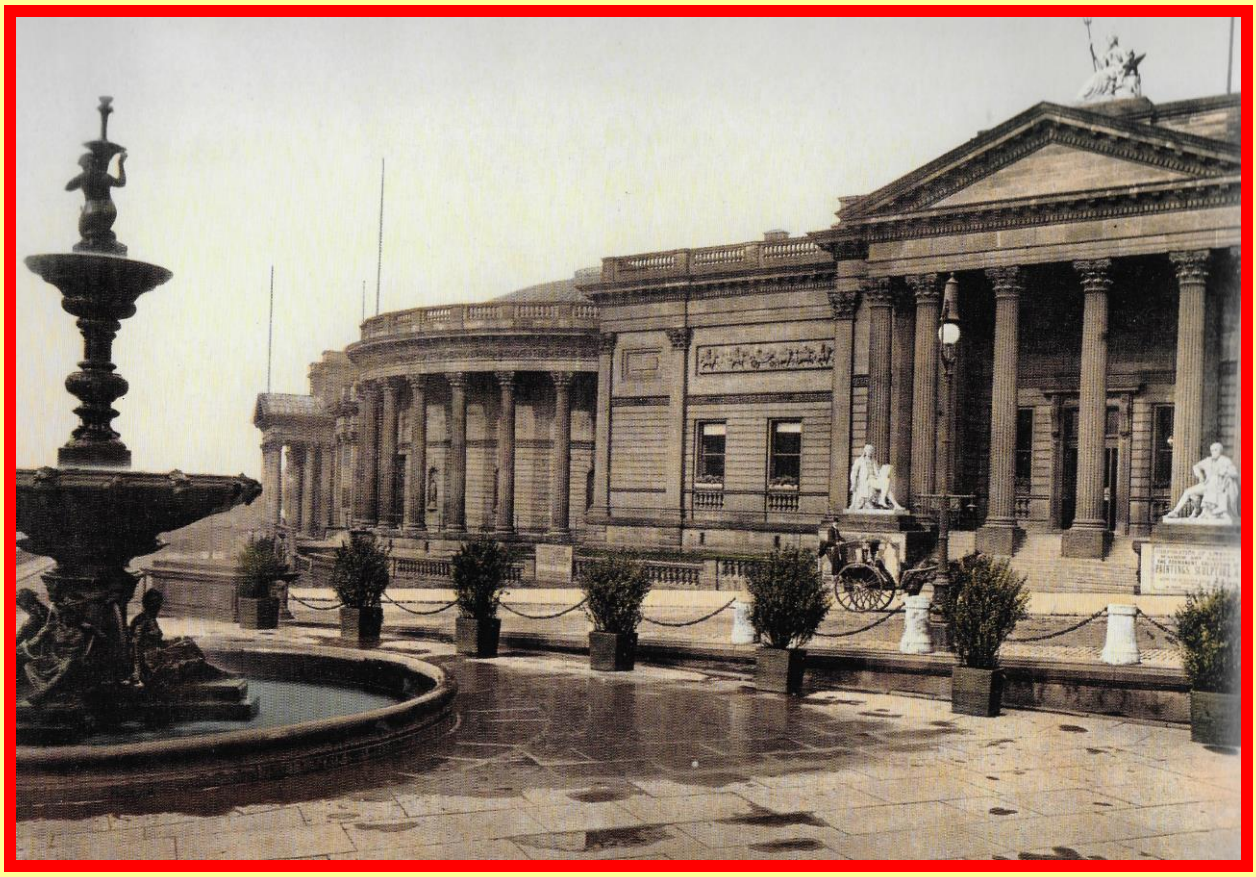
MUNICIPAL BUILDINGS, DALE STREET 1949

WALTON GAOL 1907



QUEENSWAY TUNNEL OPENING 1934

WALKER ART GALLERY 1896



ST. GEORGE'S PLATEAU, MAY DAY 1914

CENTRAL STATION 1911

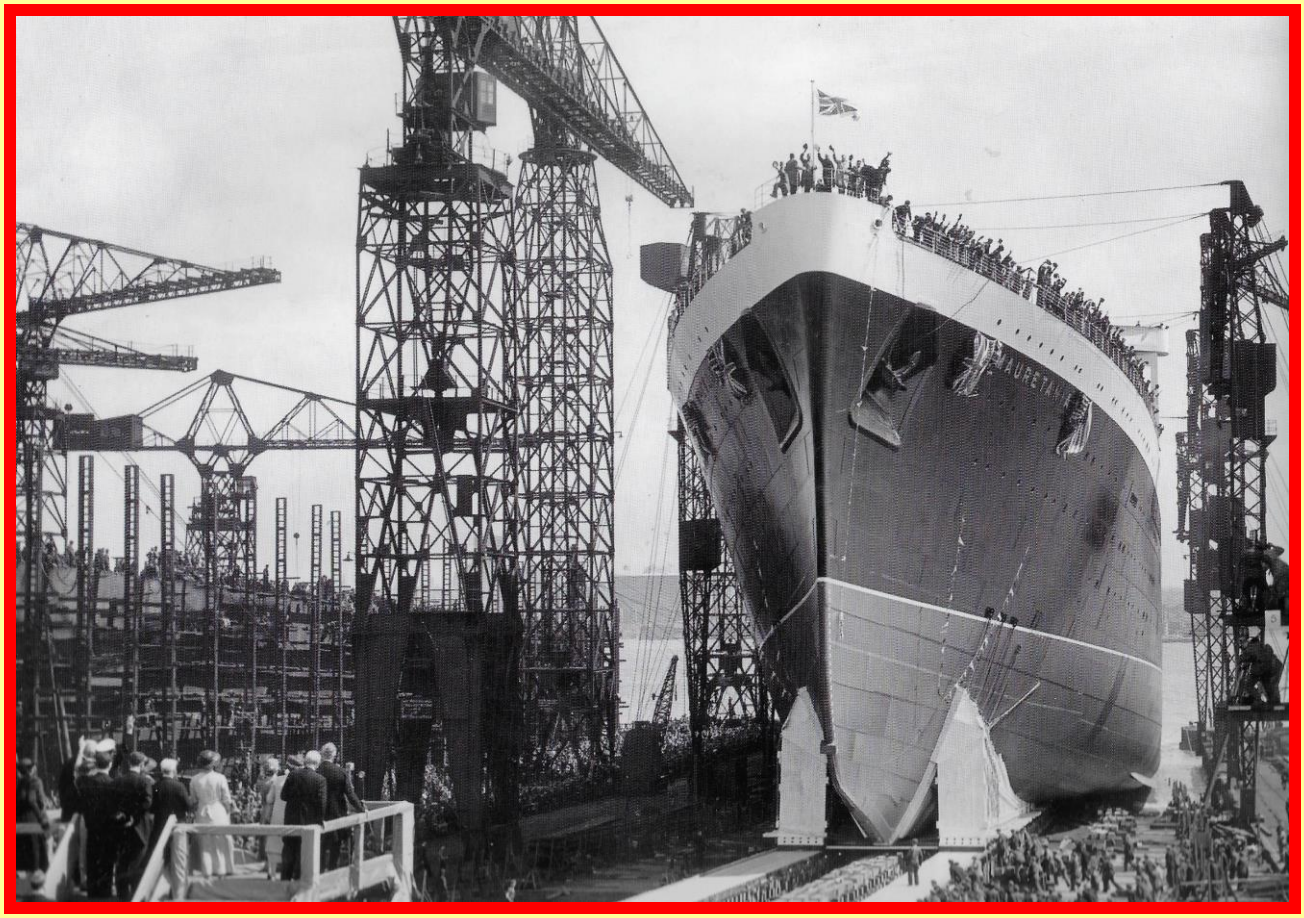
LIME STREET STATION 1953

ADELPHI HOTEL BEING BUILT c.1913

PHILHARMONIC HALL 1898

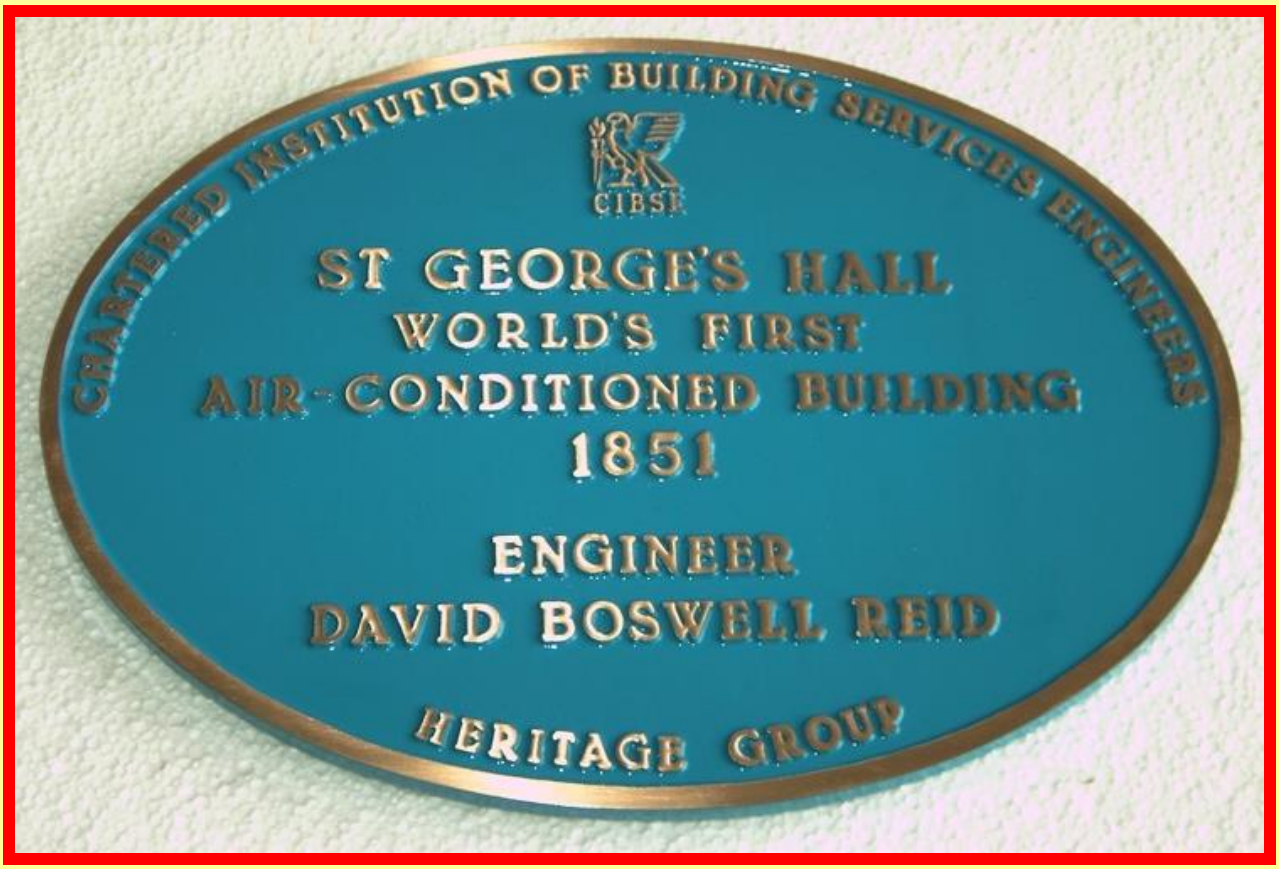
ANGLICAN CATHEDRAL 1938

CAMMELL LAIRD 1938



MARINE LAKE, SOUTHPORT 1890

NEW BRIGHTON PIER 1898



CIBSE Heritage Group plaque on St, George's Hall.

HISTORIC CITIES

GREAT BRITAIN
LIVERPOOL

REFERENCES AND FURTHER READING

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1978 Buildings of Liverpool, Liverpool Heritage Bureau, Liverpool City Planning Department.
1994 Heat & Cold: Mastering the Great Indoors, Barry Donaldson and Bernard Nagengast, ASHRAE, Atlanta, GA, USA.
2012 Liverpool: Then and Now, Mike Royden, Batsford/Pavilion Books, London.
2015 Hall of Fame (St. Georges Hall, Liverpool), Neil Sturrock, CIBSE Journal, November.
2021 The Mersey Tunnel: Liverpool-Birkenhead, Brian Roberts, CIBSE Heritage Group.

See also: CIBSE Heritage Group website/E-Books General/Organisations [by Chapter]:
2008 Merseyside & North Wales Region of CIBSE: 75th Anniversary, Neil Sturrock.
[2] St. Georges Hall [3] The Doctor's House [3a] Town Hall [4] Main Bridewell
[5] Argyle St Bridewell [7] Picton Library [8] Anglican Cathedral [9] Royal Liver Building
[10] Mersey Tunnel [14] Daily Post.

BRIAN ROBERTS, Budleigh Salterton, 2022