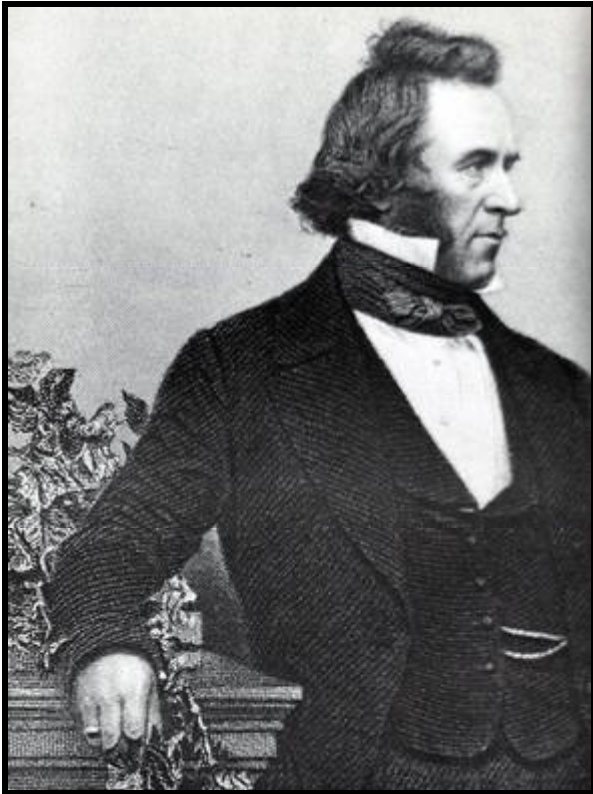


JOSEPH PAXTON: The GREAT STOVE and the CRYSTAL PALACES

by Brian Roberts, CIBSE Heritage Group

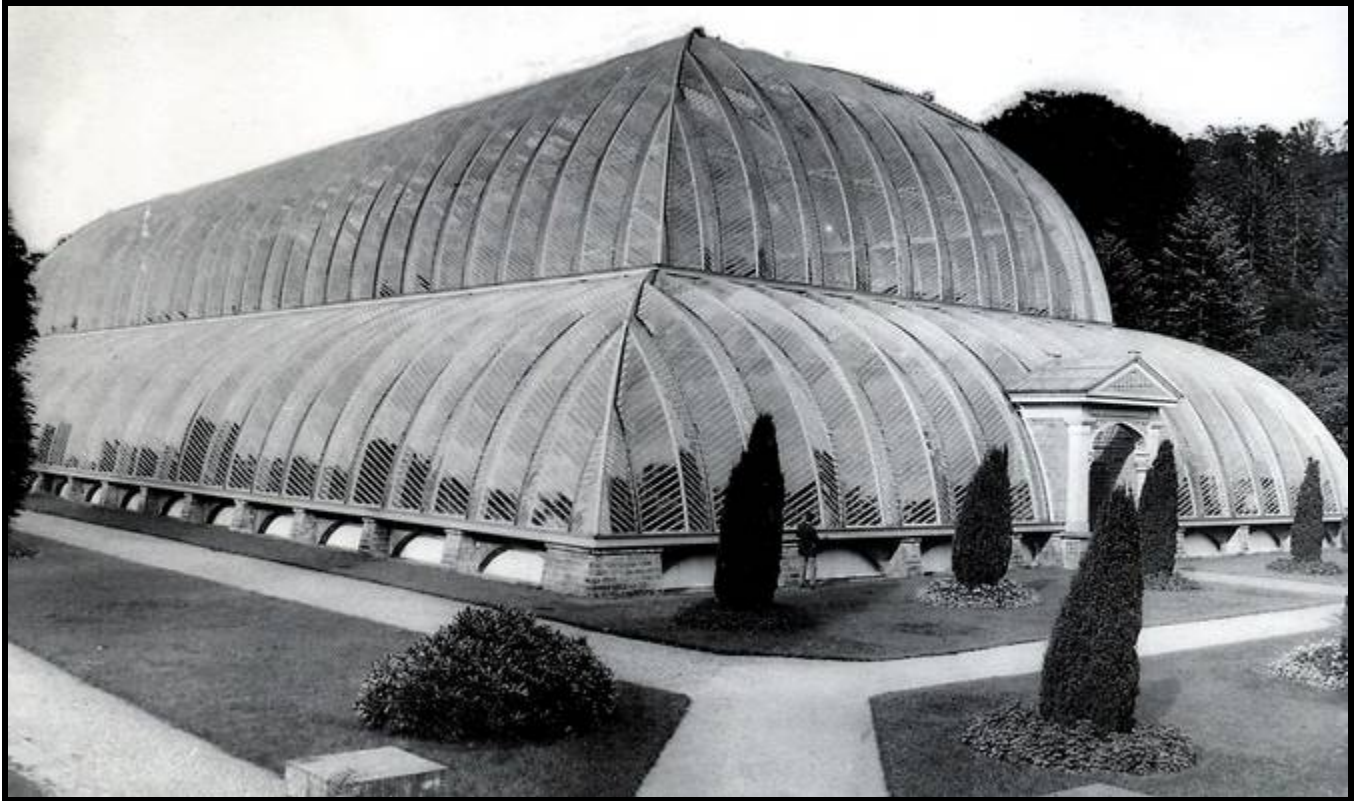


Sir Joseph Paxton, 1803-1865

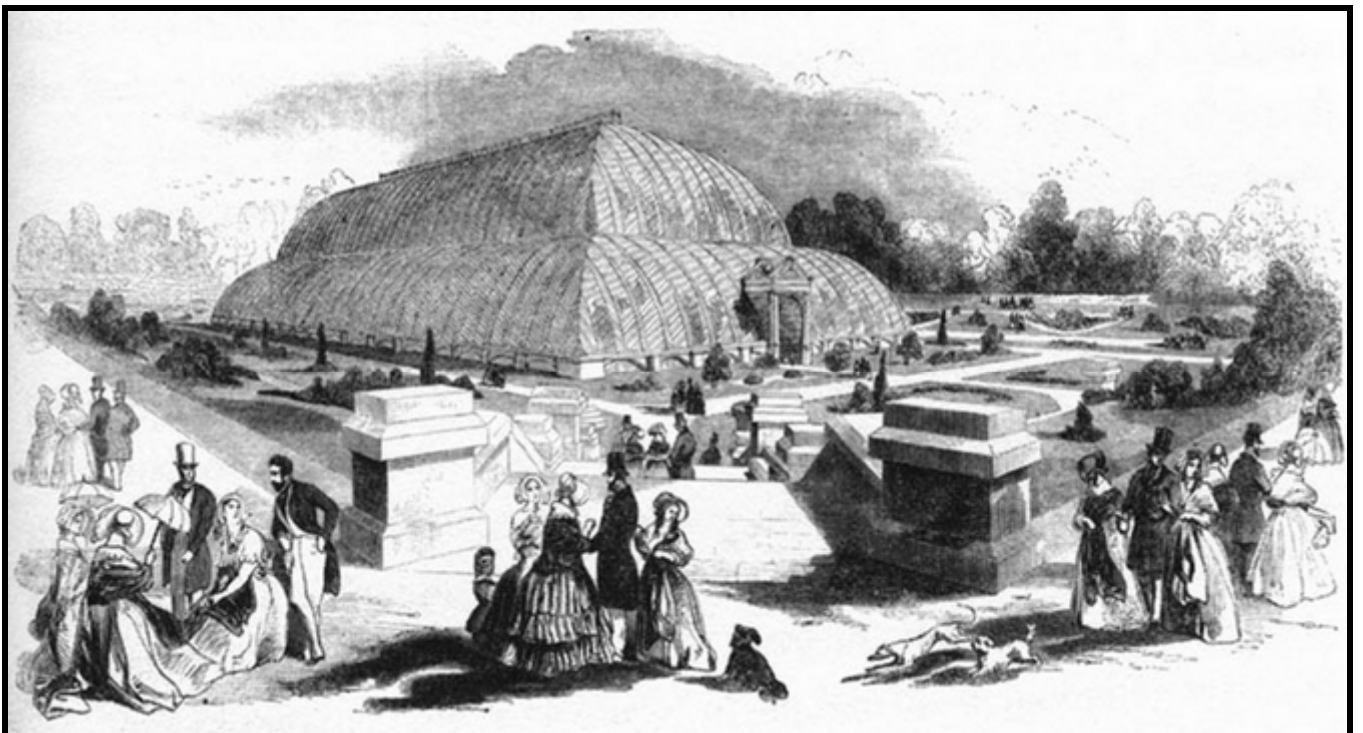
Joseph Paxton was born, the seventh son of a Bedfordshire farmer, on the 3rd August, 1803, at Milton Bryan near Woburn. At the age of fifteen he obtained employment as a garden boy at Battlesden near Woburn and in 1823 went to the Duke of Somerset at Wimbledon and then to the newly-opened gardens of the Horticultural Society which were then leased from the sixth Duke of Devonshire and adjoined Chiswick House. His work attracted the attention of the Duke and in 1826 Paxton took up the post of Head Gardener at Chatsworth. In 1827 he married Miss Sarah Brown, the housekeeper's niece.

CHATSWORTH

Under the patronage of the Duke, Paxton's career flourished. He travelled widely throughout Europe with the Duke, became a speculator in the railways, and designed many glass structures at Chatsworth, the most famous being the Great Stove where in 1841 he converted the old greenhouse of 1697 and added a heating system. It was said that "seven miles of 4-inch pipes, fired by eight boilers hidden underground were needed to heat this massive edifice, with coal brought to the boilers on an underground railway."

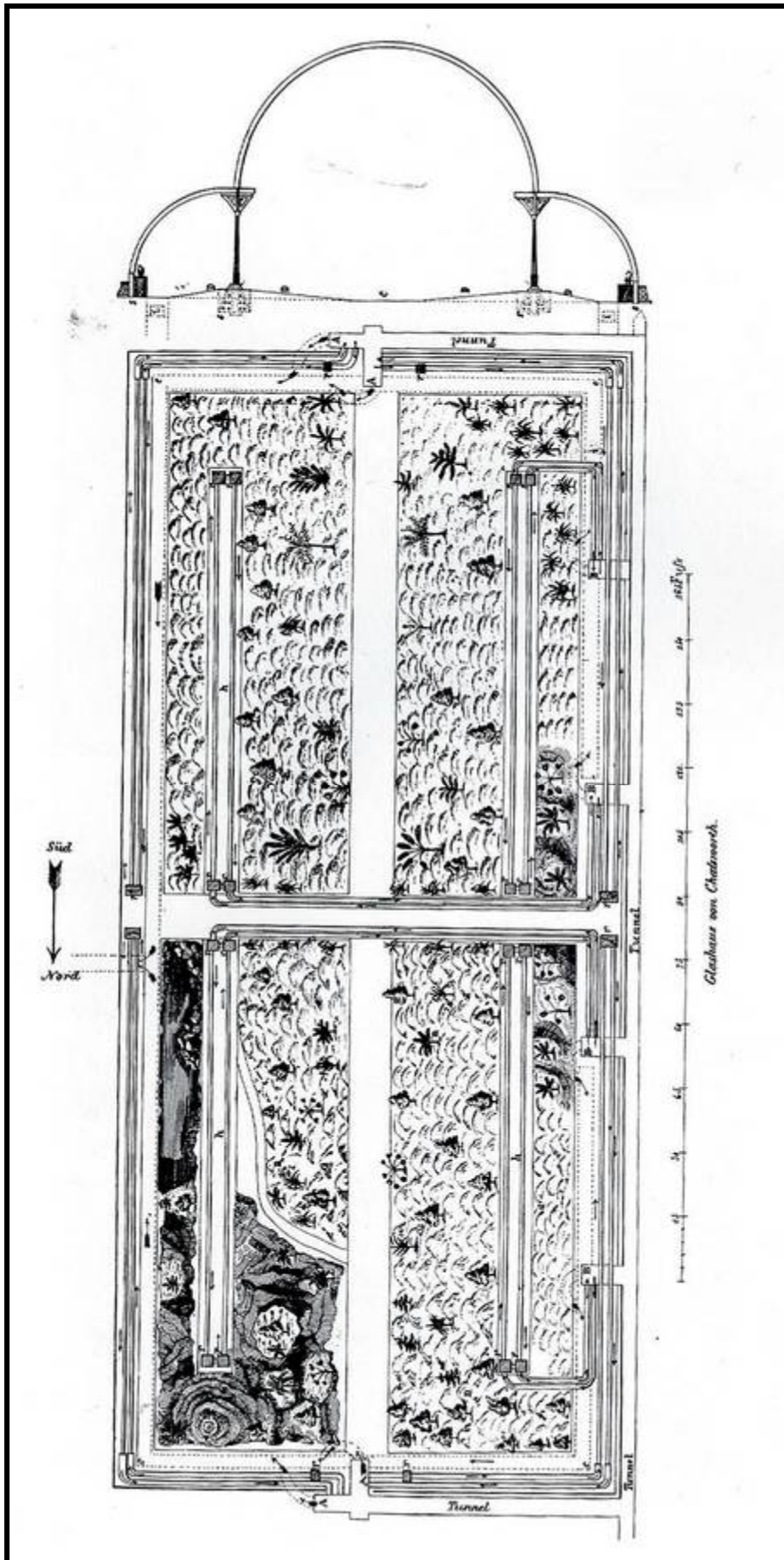


Paxton's Great Stove (Conservatory) at Chatsworth: 84 m long x 37 m wide x 19 m high



*Artist's impression of the Chatsworth Great Stove**

*The word stove derives from Dutch glasshouses which were heated by iron stoves to maintain the temperatures needed by tropical plants in winter. Thus the word "stove" gave its name in England to the building where tropical plants were housed.



Plan of the Great Stove Heating System

During the Great War the gardeners had gone off to fight and coal was not available for non-essential activities and as no heating was available the plants all died. So the building was deliberately blown up in 1920.

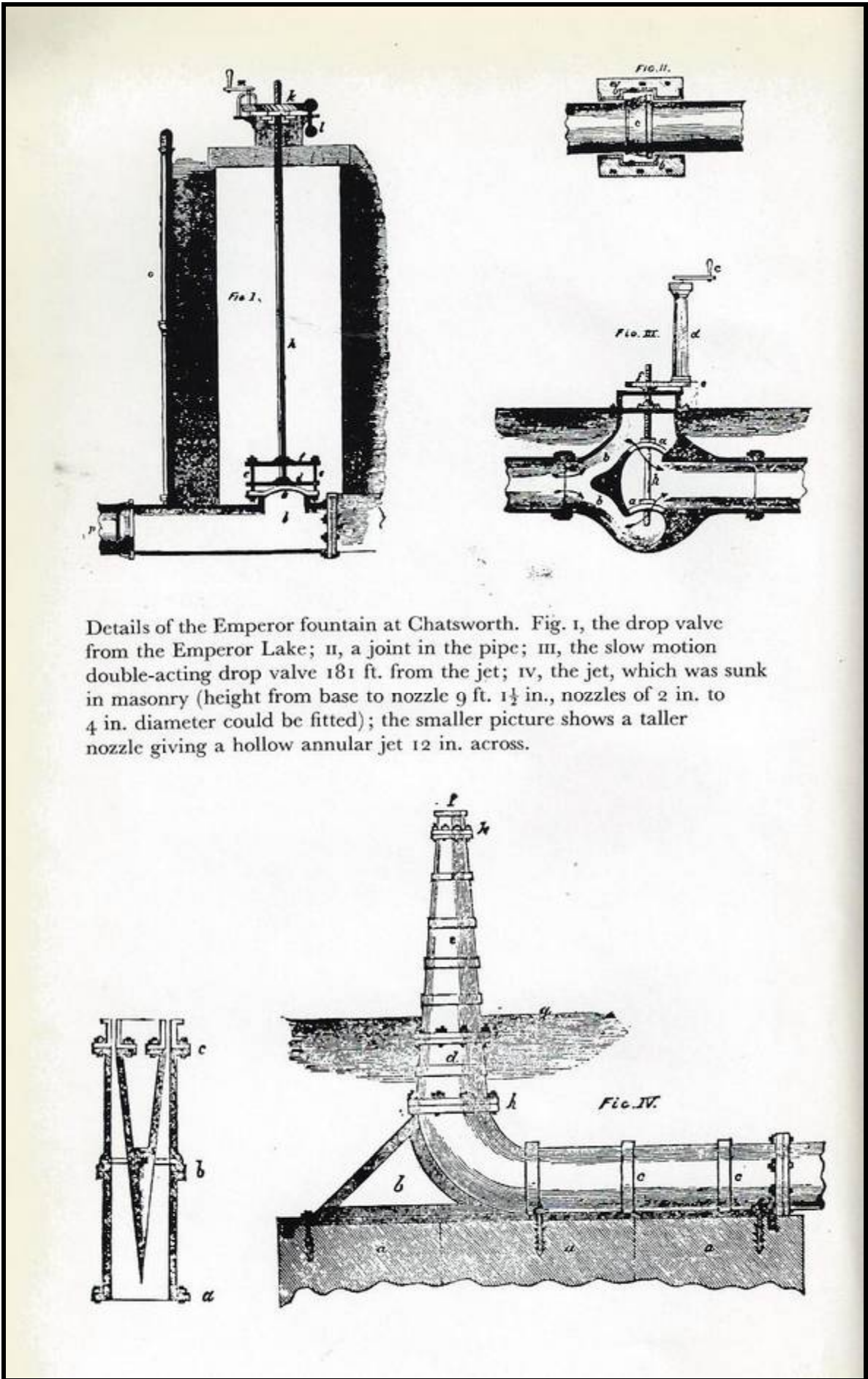
PAXTON'S CHATSWORTH FOUNTAIN



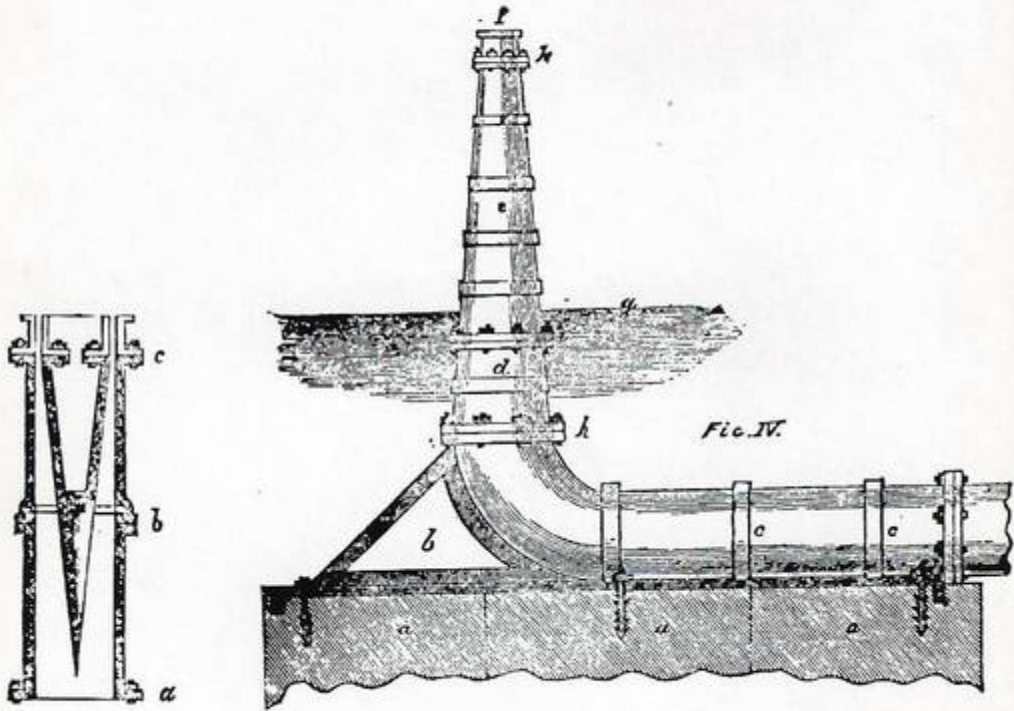
Chatsworth House and the Emperor Fountain

In the early 1840's, in anticipation of a visit to Chatsworth by Czar Nicolas I of Russia, the Duke of Devonshire decided to construct the world's highest fountain. The task fell to Paxton who arranged for an eight acre lake (32,000 square metres) to be dug on the moors 110 m above the house to provide the necessary water pressure. It was finished in 1844 but, alas, the Czar never came.

This "Emperor Fountain" reached a height of 70 m powered by the pressure of water dropping some 122 m through a 40 cm iron pipe (15-inches bore and 1.5 inches thick): "The pipe joints were turned and bored, with clip sockets for additional security. The total fall was 381 feet, including 200 ft at 1 in 2, and even so, it was necessary to cut a trench out of solid rock fifteen feet deep in places, and two ponds had to be crossed as well. Near the fountain there was a double-acting valve, which took five minutes to open or close fully, so that shock damage to the pipes should be avoided. The nozzles of the jet itself could be varied for different effects, and were made of brass, and the normal jet would play to 267 ft, or perhaps 280 ft when the reservoir was quite full."



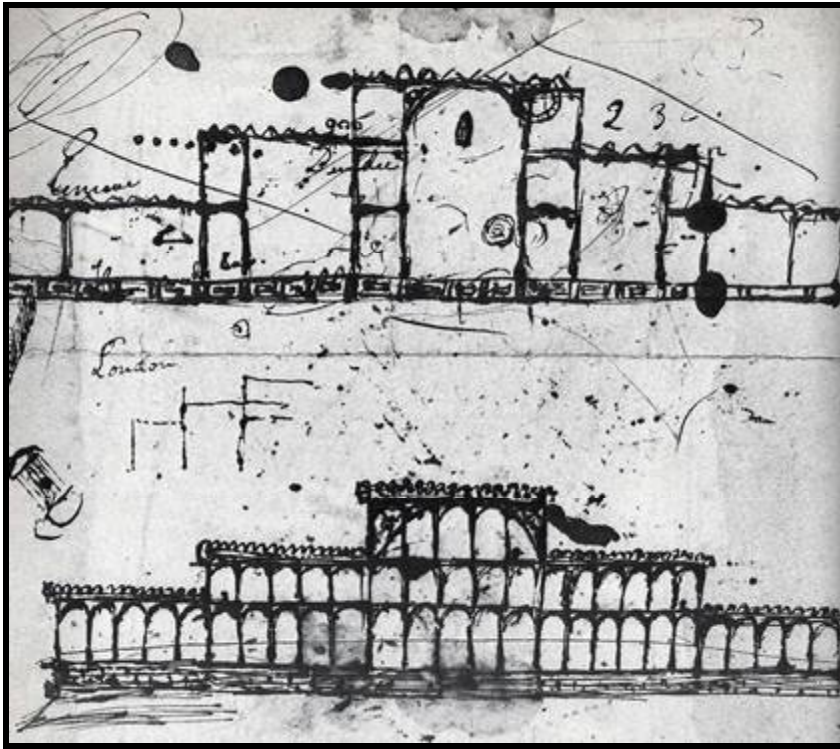
Details of the Emperor fountain at Chatsworth. Fig. I, the drop valve from the Emperor Lake; II, a joint in the pipe; III, the slow motion double-acting drop valve 181 ft. from the jet; IV, the jet, which was sunk in masonry (height from base to nozzle 9 ft. 1½ in., nozzles of 2 in. to 4 in. diameter could be fitted); the smaller picture shows a taller nozzle giving a hollow annular jet 12 in. across.



Details of Paxton's design for the Emperor Fountain (from Chadwick)

THE HYDE PARK CRYSTAL PALACE

In 1850, the Building Committee of Exhibition Commissioners held an open competition for the design of a building to house the *Great Exhibition of the Works of Industry of All Nations* to be held in London's Hyde Park in 1851. Two hundred and forty-five designs were received including one from Isambard Kingdom Brunel who just happened to be one of the judges. Not one was considered to be satisfactory. On Tuesday 11th June, 1850 while at railway meeting, Paxton produced the famous blotting paper sketch that was to be his basis of a new design (he had now been a designer of glass structures for more than twenty years).

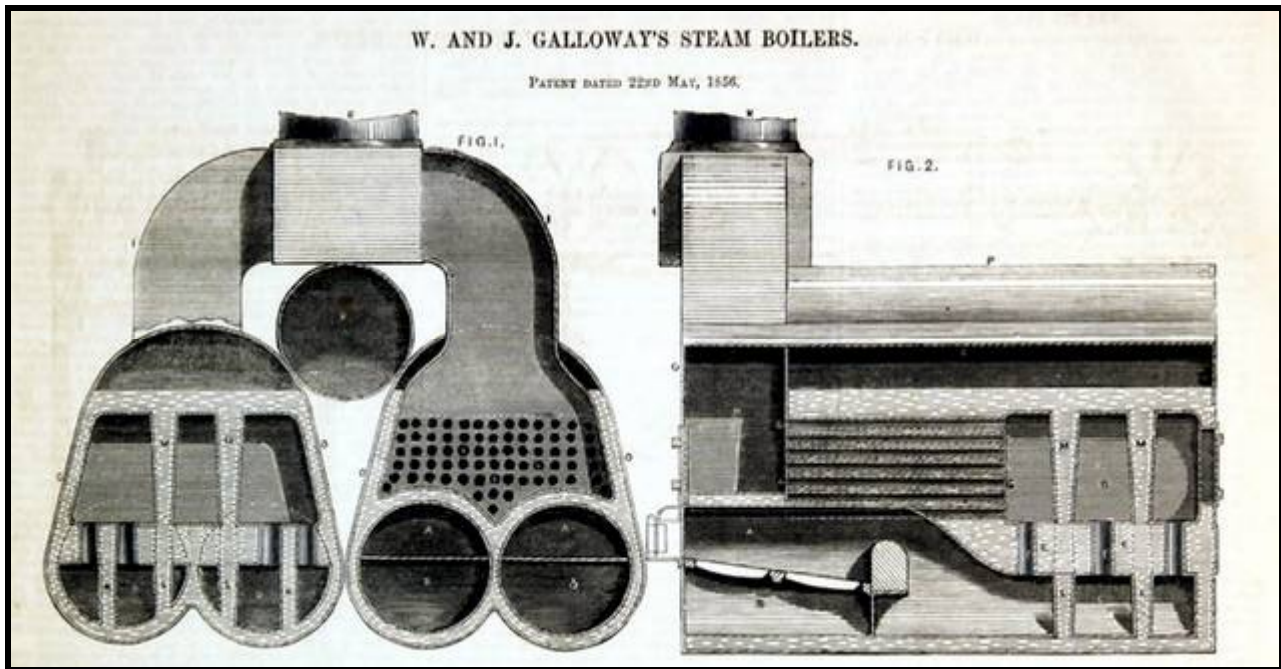


Paxton's sketch of June, 1850

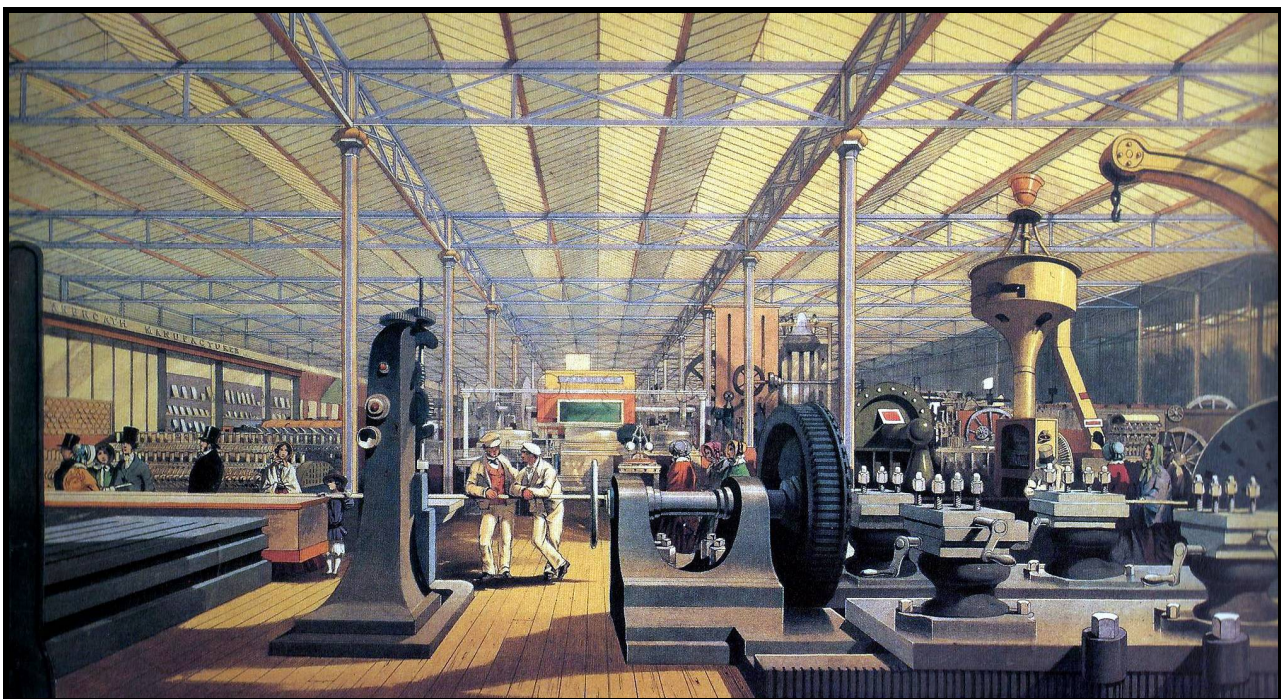


A corner of the Hyde Park Crystal Palace with its external boiler house

After much controversy and various alterations, Paxton's proposal was accepted and the hastily completed building, measuring 562 m long by 124 m wide with an internal height of 39 m, was opened by Queen Victoria on 1st May, 1851. Since it was a temporary building it was unheated. However, a contemporary illustration shows a boiler house, complete with smoking chimneys, adjacent to the main building. This housed four steam boilers serving the powered exhibits in the Moving Machinery Hall. The boilers were manufactured by W & J Galloway and were possibly of the fire-tube type similar to a Lancashire boiler. The Palace was also fitted with a system of hand-operated adjustable louvres for ventilation purposes and an ingenious system for removing roof rainwater by channelling it down the hollow centres of the structural columns.

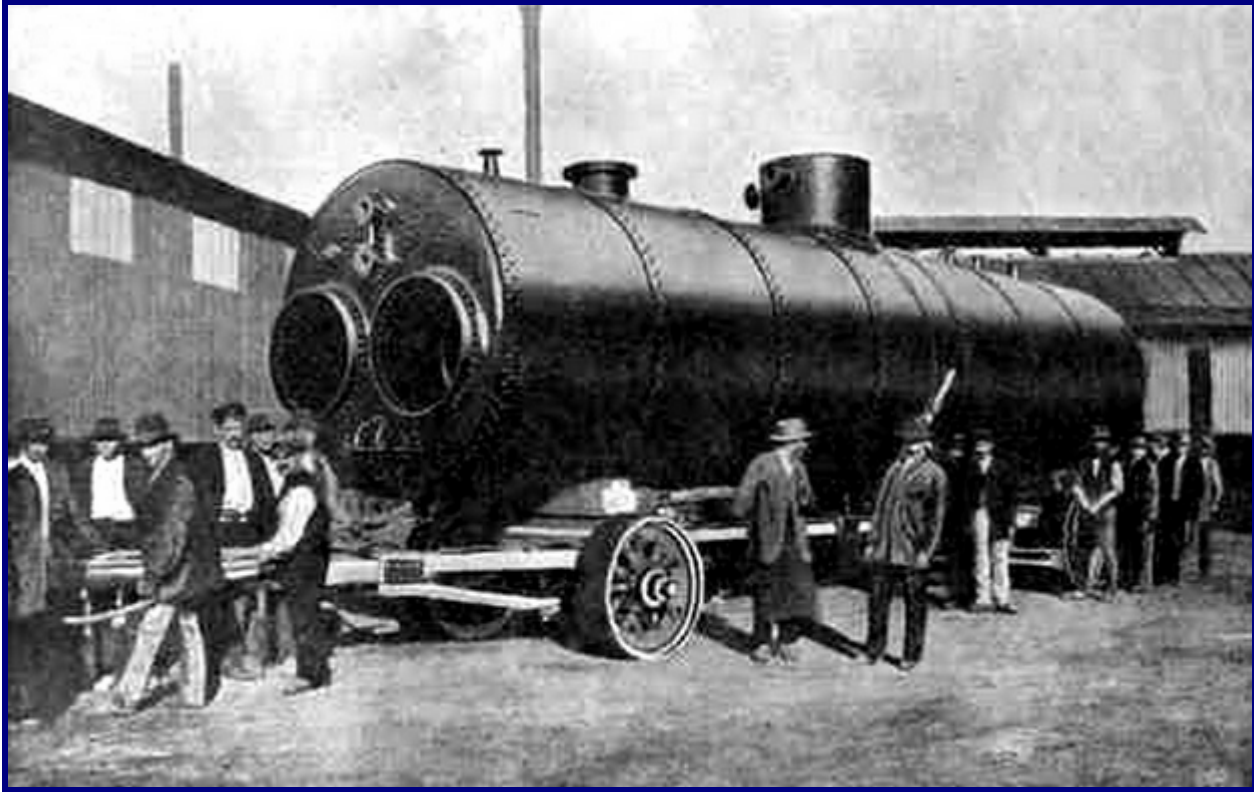


The W & J Galloway Steam Boiler



The Moving Machinery Hall

The original Galloway Company was established in 1806. The brothers William and John manufactured steam engines before 1840 but from 1848 John took a particular interest in steam boilers. The Lancashire type of boiler, which formed the basis of their UK Patent 13532/1851, had been patented earlier by Sir William Fairbairn and John Hetherington in 1844. It is said that W & J Galloway built some 9000 boilers of this type by 1891.



Photograph of unknown date of a W & J Galloway Lancashire type boiler



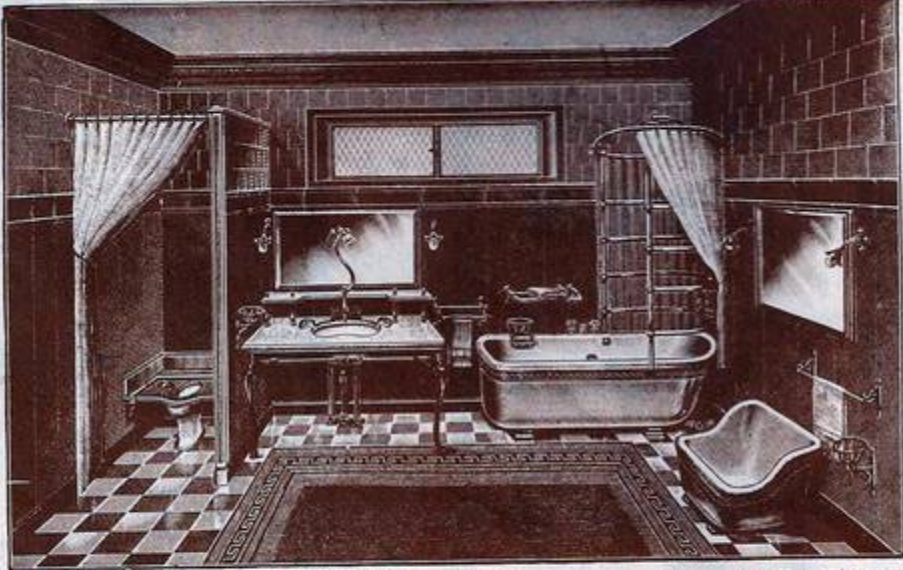
A coal-fired Galloway steam boiler dating from about 1883

THE FIRST PUBLIC TOILETS

Another feature of the Hyde Park Exhibition was the provision of public toilets, initially for men and later for women also. These were installed by George Jennings and were the first public flush toilets. Jennings design was called "Monkey Closets," perhaps an unfortunate description. However, it is recorded that over 800,000 visitors each paid a penny to use the "Retiring Rooms" and for their penny "they got a clean seat, a towel, a comb and a shoe shine." Hence the term "To spend a penny" became a euphemism for going to the toilet.

Jennings was born in 1810 and was an English sanitary engineer and plumber who built a large and thriving business. He married twice and had fifteen children. During the Crimea War, at the request of Florence Nightingale, he headed the Sanitary Commission that went to the Hospital Barracks at Scutari to improve conditions there. This was partly achieved by flushing the sewers and increasing ventilation. Jennings died in 1882.

GEORGE JENNINGS L^{TD.}



SANITARY ENGINEERS and SPECIALISTS
BY ROYAL APPOINTMENT TO
HIS MAJESTY THE KING.
LAMBETH PALACE ROAD, LONDON, S.E.
NEW AND EXTENSIVE SHOWROOMS - - - - INSPECTION INVITED.
Catalogues on Application. ————— Telegrams: "Jennings, London."

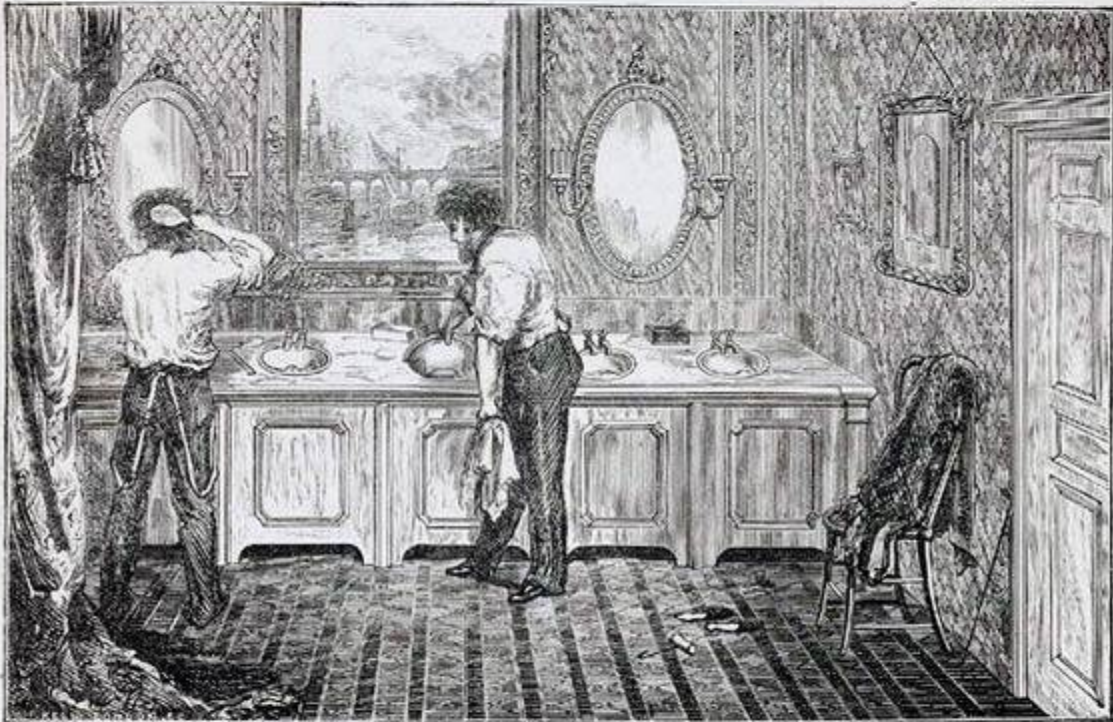
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AWARDED HIGHEST HONOURS AT
THE EXHIBITIONS OF

LONDON, 1851; LONDON, 1862; DUBLIN, 1865; PARIS, 1867; VIENNA, 1873;
LONDON, 1874; NEW YORK, 1874; PARIS, 1875; PHILADELPHIA, 1876;
PARIS, 1878; SYDNEY, 1880; MELBOURNE, 1881.

JENNINGS' LIFT-UP LAVATORIES,

AS ARRANGED FOR THE
RETIRING ROOMS OF HOTELS, CLUBS, RAILWAY STATIONS,
AND OTHER PUBLIC BUILDINGS;
ALSO FOR
MANSIONS, VILLAS, AND EVERY DESCRIPTION OF PRIVATE RESIDENCE.



THE *simplicity* of this arrangement, its *cleanliness*, *freedom from complication*, and *efficiency*, have caused it to be generally adopted.

The deposit left on the surface of basins drained through a grating or plug-hole is not only *objectionable*, but, in Hospitals, Schools, and other Public Buildings, is considered by medical men to be *too often the means of communicating disease*. In a Sanitary point of view, the Patent Lavatories are much to be preferred, as the contents, after use, are "tipped" direct from the basin, by tilting it as shown in the illustration, the soapy matter floating on the surface being of course the first to escape. *The basin, by a recently patented improvement, is so hung that it can, without trouble or mechanical action, be lifted out for cleansing purposes.*

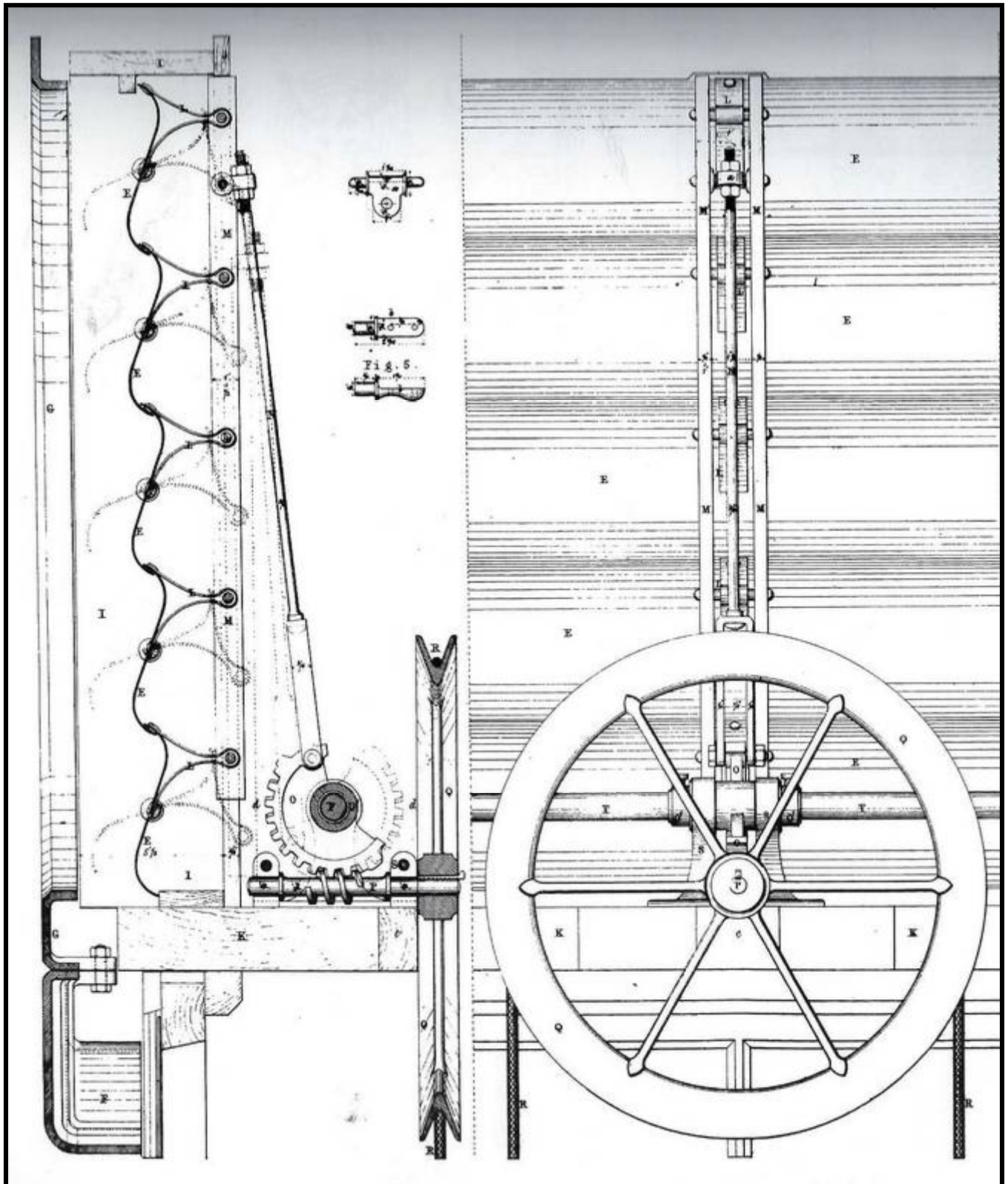
The saving in time effected by the instantaneous discharge of the contents will be appreciated by all who use these Lavatories in a crowded retiring-room.

The "PATENT TIP-UP BASINS" will be found in the Residences of Royalty, the Nobility, and Gentry, and in all the principal Clubs, Hotels, Railway Stations, Theatres, and Public Buildings in London, the Provinces, and the principal Cities throughout the European and American Continents, and as a *guarantee of their efficiency bear the name and address in full of the Patentee.*

GEORGE JENNINGS, SANITARY ENGINEER, STANGATE, S.E.

MAY 16/84.

VENTILATION



The adjustable ventilation louvres

The Exhibition closed in the October and the Commissioners decided that the Crystal Palace should be pulled down and Hyde Park returned to its former condition, but Paxton had other ideas.

THE SYDENHAM CRYSTAL PALACE

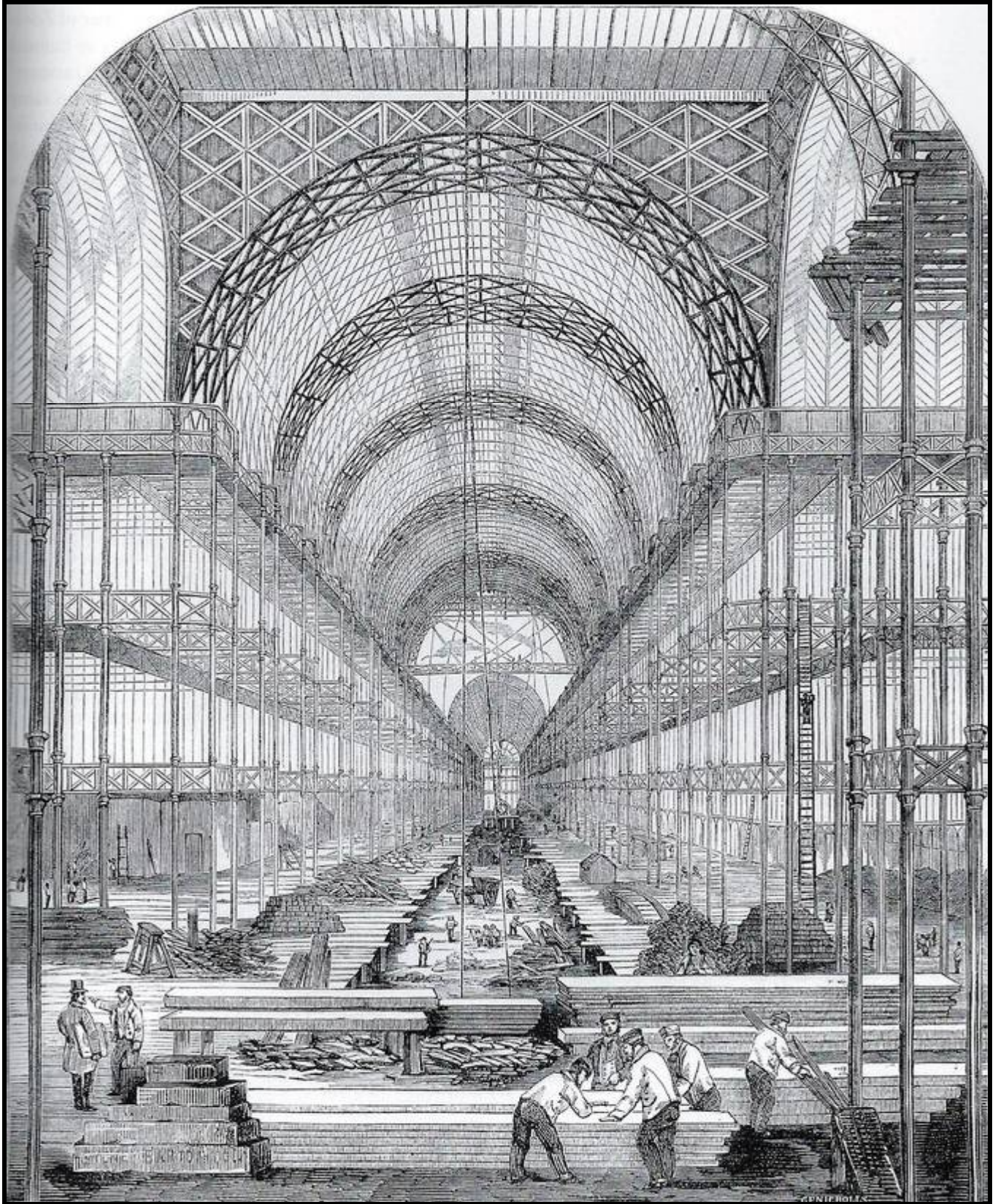


The Sydenham Crystal Palace and Gardens

Intense arguments raged over the future of the Hyde Park Crystal Palace. Paxton (now Sir Joseph) suggested that with the addition of a heating system it could be turned into a Winter Garden. Others talked of making it a Museum or a Conservatory at Kew or removing it to Battersea Park. Paxton argued that throwing it away would be a wanton destruction of £160,000 worth of public property. However, on 19th April, 1852, the House of Commons voted for its removal.

But Paxton was not to be outdone and having secured a capital of half a million pounds he, with others, floated a company to buy the building and purchase a new site. This new Crystal Palace Company bought the building from the builders, Fox & Henderson, for £70,000 (it was never the property of the Commissioners). The chosen site was Penge Place in Kent which included the summit of the ridge of Sydenham Hill.

This new Crystal Palace was patterned on the Hyde Park building with a number of significant changes. The central transept was raised and two subsidiary transepts added; because of a fall in the ground a basement was necessary and the three-storey structure became a four and in the centre it became a six-storey one. The new building was 490 m long by 95 m wide and 51 m high at the central transept. While less than the Hyde Park building in total floor area and in both length and width, the Sydenham Palace had some 80% more area of glass surface. It also had a massive heating system and a complicated arrangement of twin water towers feeding spectacular fountains and ornamental lakes in the associated gardens.



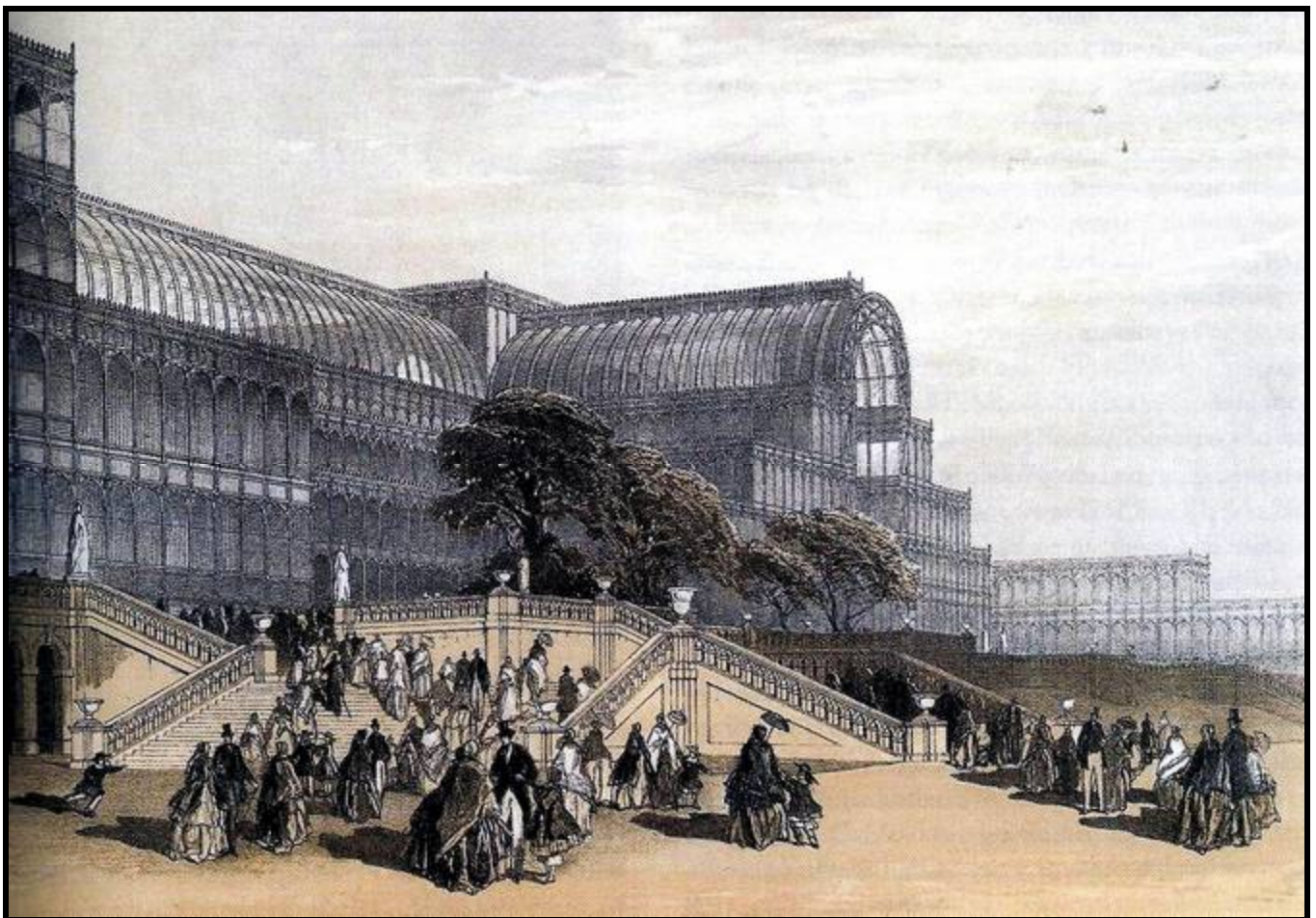
The interior of the Sydenham Crystal Palace while under construction, November 1853

Paxton patterned his heating design on his successful experiments in low-pressure hot water heating at Chatsworth. He worked three hours a day for three weeks on this task.

At Sydenham, “an access roadway ran through the basement storey of the building and here no less than twenty-two boilers were arranged in pairs, each holding 11,000 gallons of water; one extra boiler was added at the north end for a display of tropical plants, two in the lower storeys of each wing and two smaller ones for the fountain basins at each end of the building..... Four pipes of 9-inch diameter were attached to each boiler, two flow and two return and each boiler heated a transverse section of the Crystal Palace: the length of one flow and return was a mile and three-quarters, and the total length of all heating pipes of all kinds was nearly fifty miles.” The manufacturer of the hot water heating boilers has not been determined.

An 1854 Guide noted “...it has remained an unsolved problem how far, and in what quantity, water could be made to travel through pipes –flowing and return by means of the propulsion of heat from the boiler.” This suggests that gravity circulation was employed, i.e. pumps were not used. Was this the case?

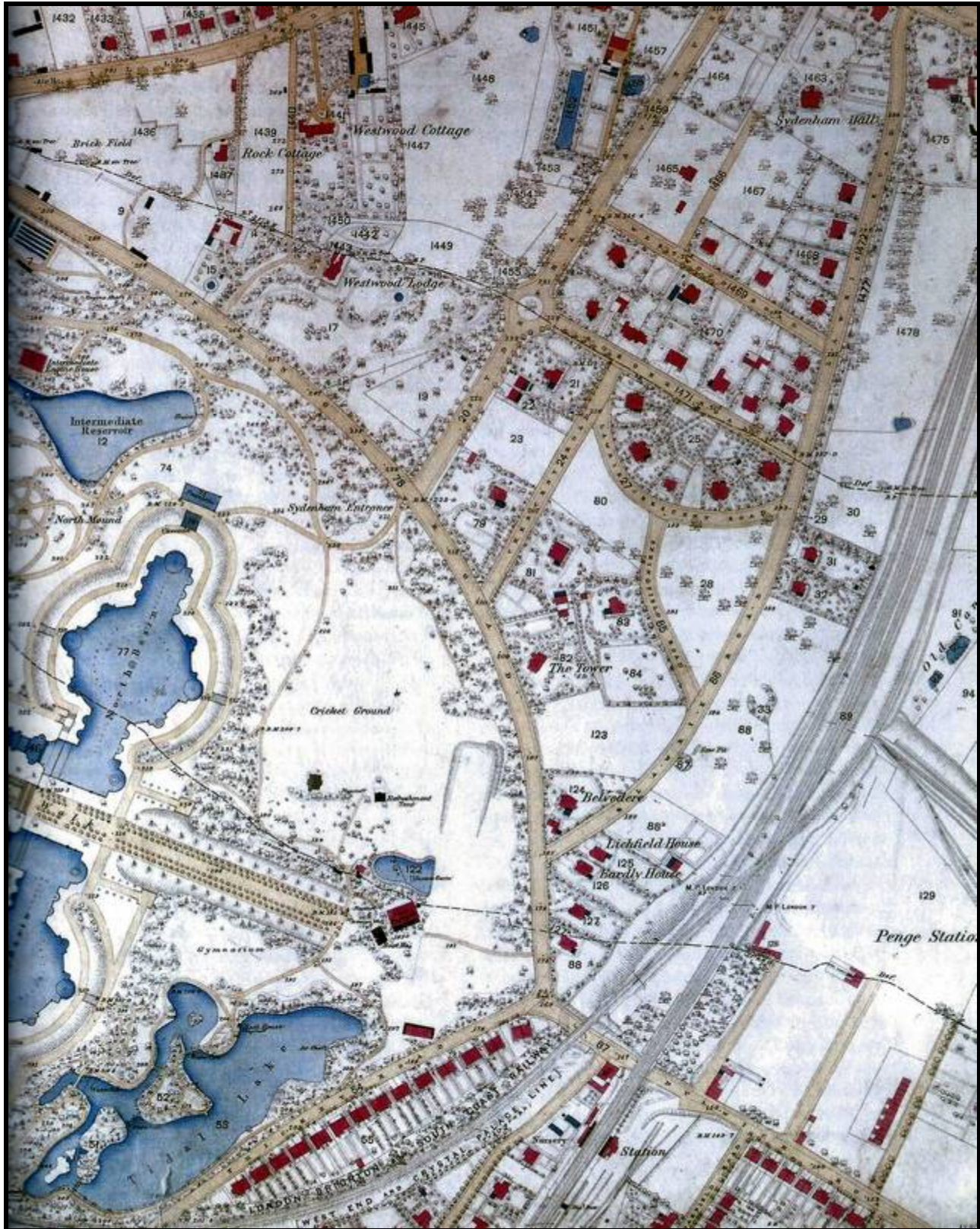
To ensure circulation of air throughout the winter “ventilators have been introduced directly from the main building into each furnace, where the air, so brought, being consumed by the fire, the atmosphere in the Palace is continually renewed.”



The North Transept of the Palace in 1854

SYDENHAM CRYSTAL PALACE WATER WORKS

Paxton's scheme for the water works in the garden was intended to surpass in grandeur both those at Chatsworth and Versailles. He envisaged an Italian Terrace with six fountains and below it a circular fountain, the water-temple, the cascades and twin fountains with jets reaching a height of over 70 m, all with a total of 11,788 jets.



1862 Sydenham Crystal Palace Gardens (East) showing the water features (from Piggott)
From right to left the blue areas of water are: (122) Basin, (53) Tidal Lake, (48) South Basin, (77) North Basin, (12) Intermediate Reservoir

PAXTON'S DESIGN

His first concern was the water supply and having considered that from local supply companies to be inadequate he drove an artesian well at the bottom of the park "with a brick shaft 8 ft 6 inches in diameter reaching down 247 ft," (later to 570 ft) which he estimated could deliver a daily supply of 100,000 gallons.... "Next to the artesian well, a small engine (20 hp?) is placed which raises the water to be permanently maintained in the reservoirs and in the basins of the fountains....."

Phillips' Guide of 1854, published before completion of the water towers, described the design of the water systems. "Three reservoirs have been formed at different levels in the grounds, the lowest one (with 2 x 40 hp engines) being on the same level as the largest basins placed nearly at the base of the hill; the second, or intermediate reservoir, is higher up, and in line with a basin in the central walk; Attached to this (centre or intermediate) reservoir are also engines (4 x 40 hp) which pump the water back to the upper reservoir....."

The third, or upper reservoir, stands on the top of the hill immediately adjoining the north end of the building (and) contains the water required for the use of the building, and for the fountains throughout the grounds.

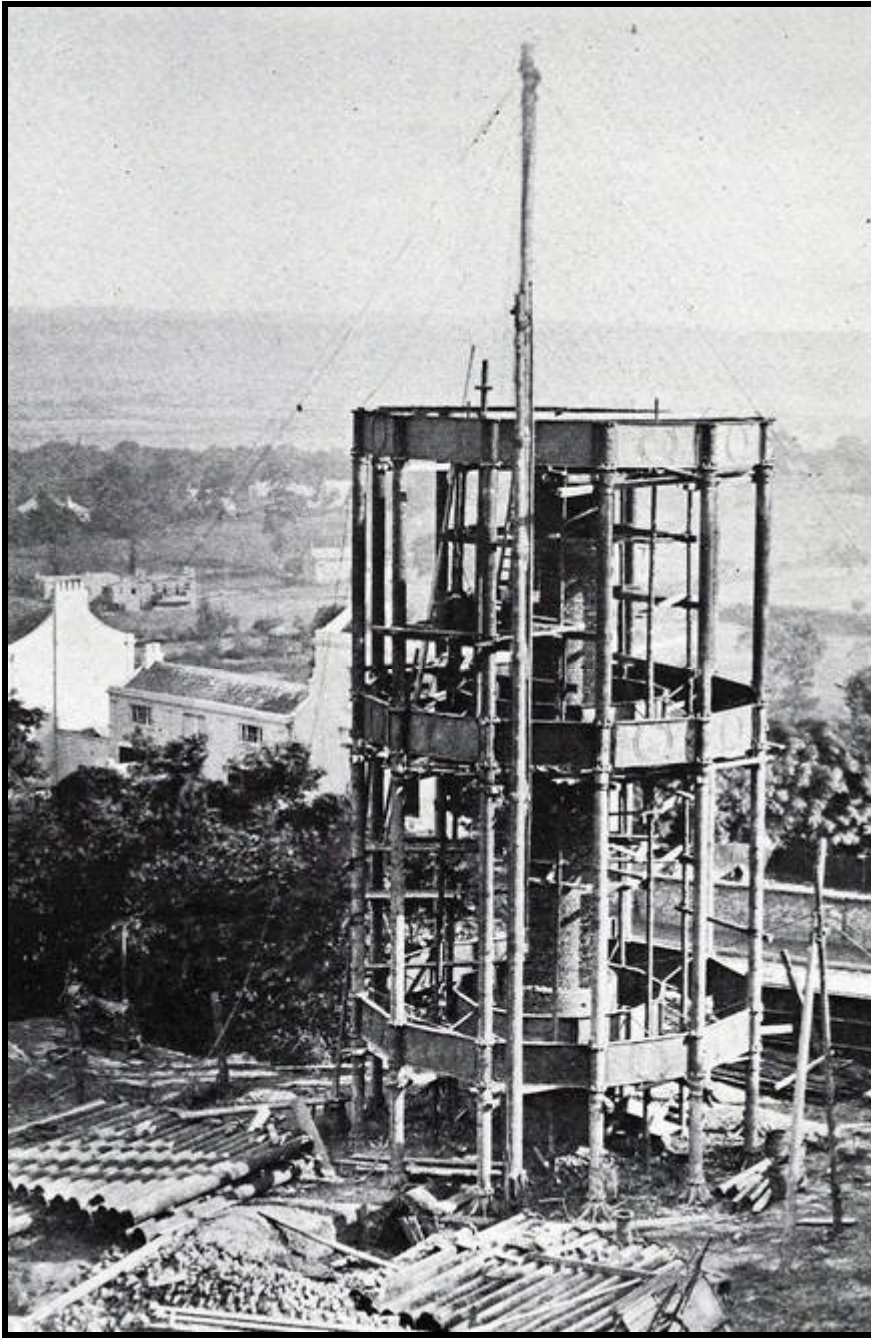
Close to this reservoir is an engine-house, containing the steam-engines (2 x 30 hp) that raise part of the water in the reservoir into two large tanks (each capable of holding 200,000 gallons of water), placed at the summit of the square towers terminating the wings. From these towers the water flows to the basins in the grounds, and there throw up jets of 70 to 120 feet in height. These engines likewise lift to a proper elevation the water necessary for the interior of the building, and for making proper provision against fire.....

The engine power employed is that of three hundred and twenty horses; the water itself is conveyed to and from the reservoirs in pipes varying from three feet to one inch in diameter; and the weight of piping may be set down at 4000 tons, its length, roughly estimated, at ten miles."

The scheme was deemed by many to be a colossal extravagance and suffered many failures. The water tanks in Paxton's first water towers failed and Isambard Kingdom Brunel was called in to redesign the supporting structures. The inauguration ceremony was delayed by many leaks from small pipes and in October 1855 an 18-inch diameter pipe "exploded under the pressure of 1000 tons of water." It was also recorded that "none of the fountains inside the Palace worked, the pumps were still clogged and the engine and engine-house were submerged."

Over time, the operation and maintenance of the water works proved difficult and expensive. By the 1890's the great fountain basins had been filled in and others features rarely used. "Paxton's extravagance over the waterworks was widely thought to have ruined the Company."

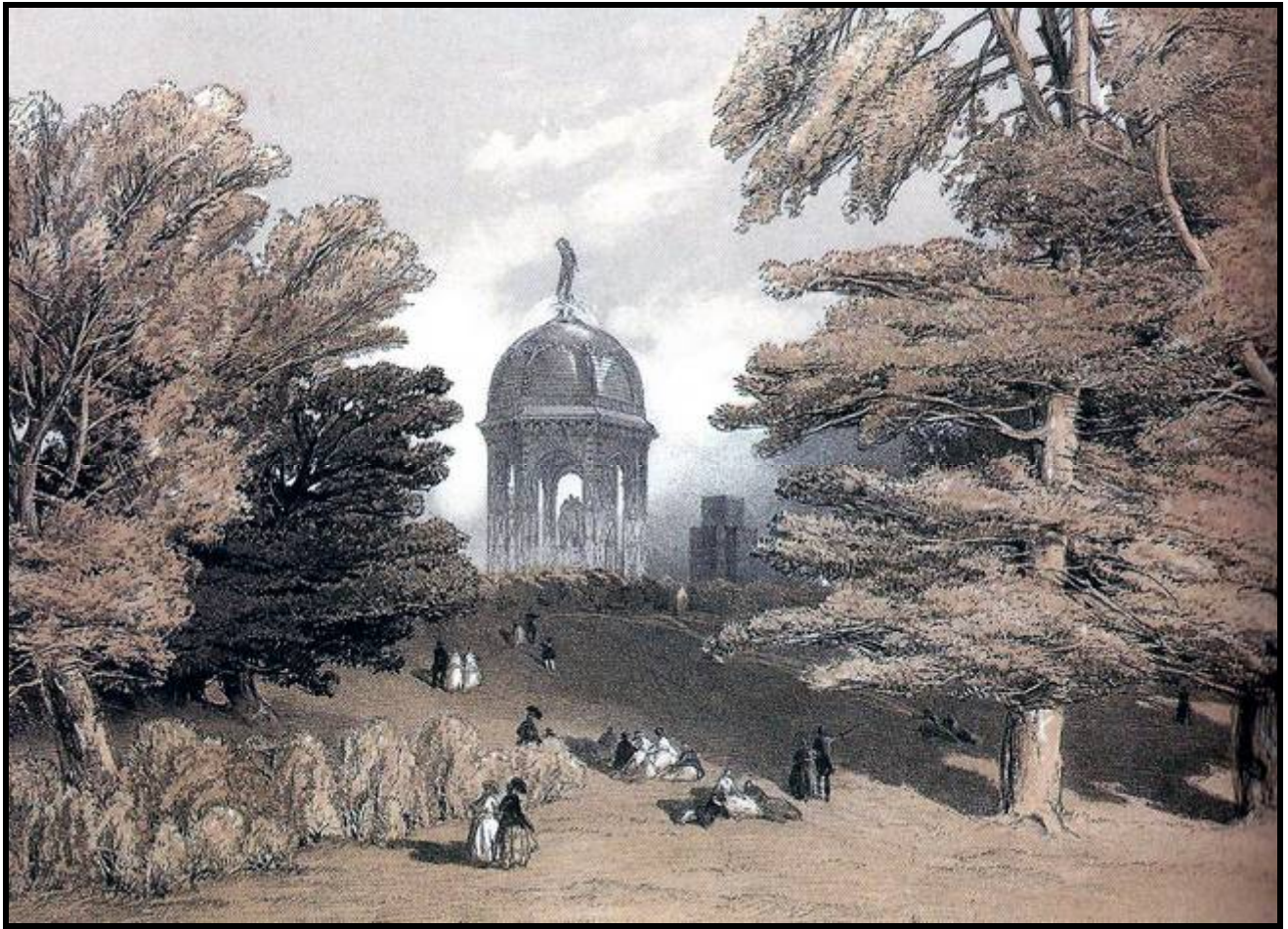
BRUNEL'S WATER TOWERS



Brunel's south water tower under construction

After initial difficulties, Brunel designed two water towers, each 86 m high, to stand at either end of the building to house a 200,000 gallons capacity water tank with water raised to this high level storage by two “30 horsepower” steam engines and also housing the flues from the heating system. Each water tower supplied the 72 m high central jet for one of the two principal fountains in the park. As previously stated, a contemporary account records “the water itself is conveyed.....in pipes varying from three feet to one-inch in diameter: and the weight of piping may be set down at 4000 tons, its length, roughly estimated, at ten miles.”

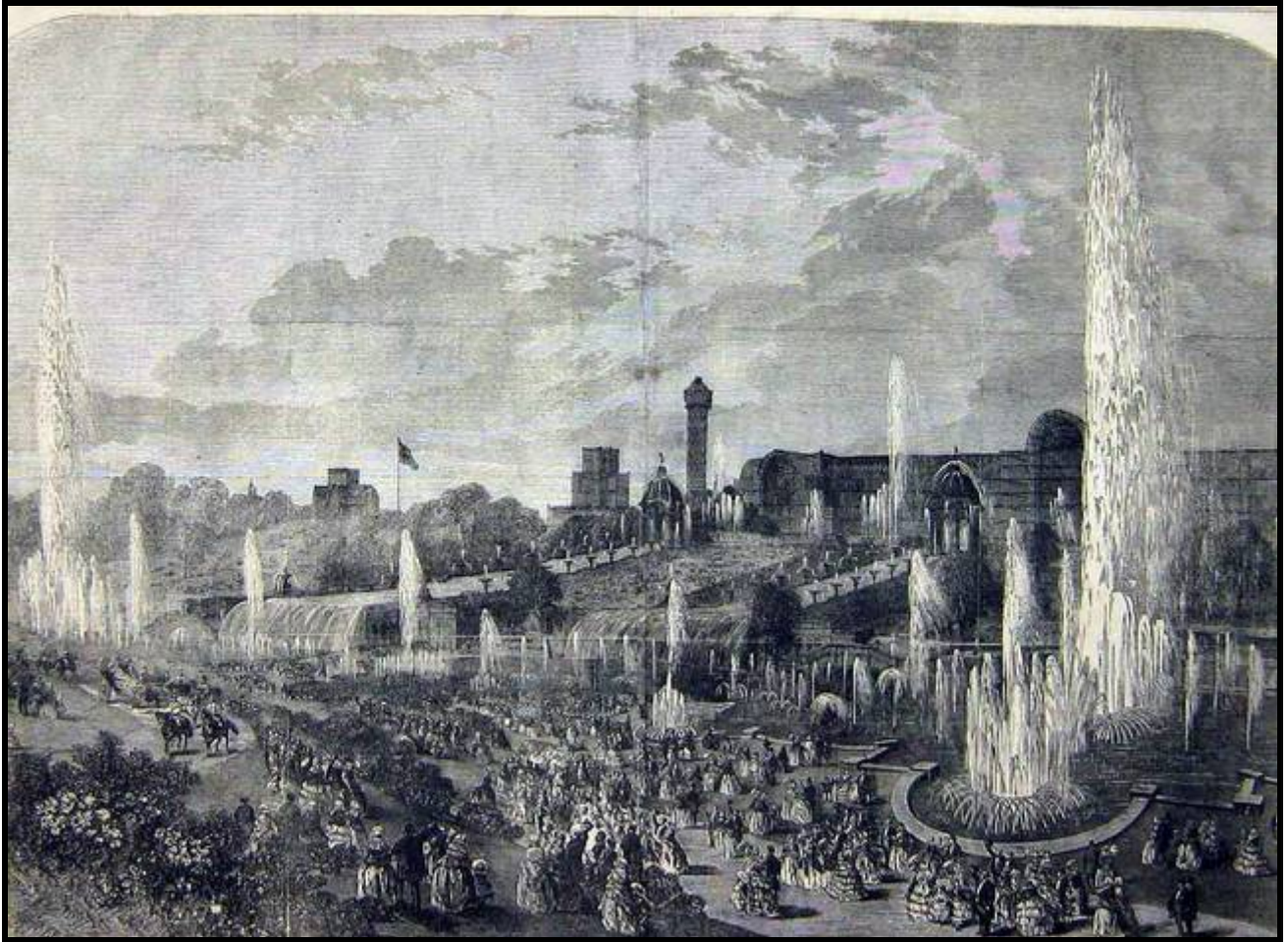
In 1894, Waygood's patent water-balanced lift, which took 30 seconds to reach the top, was installed, providing a view of thirty miles on a clear day.



View in the Park: Part of the Fountains display- The Cascade Temple, 1854



The Crystal Palace High Level Railway Station, with Brunel's South Tower behind, 1865



Antique print of the 1856 inauguration of the fountains, supplied from the water towers



Undated photograph of the Sydenham Crystal Palace showing the south water tower

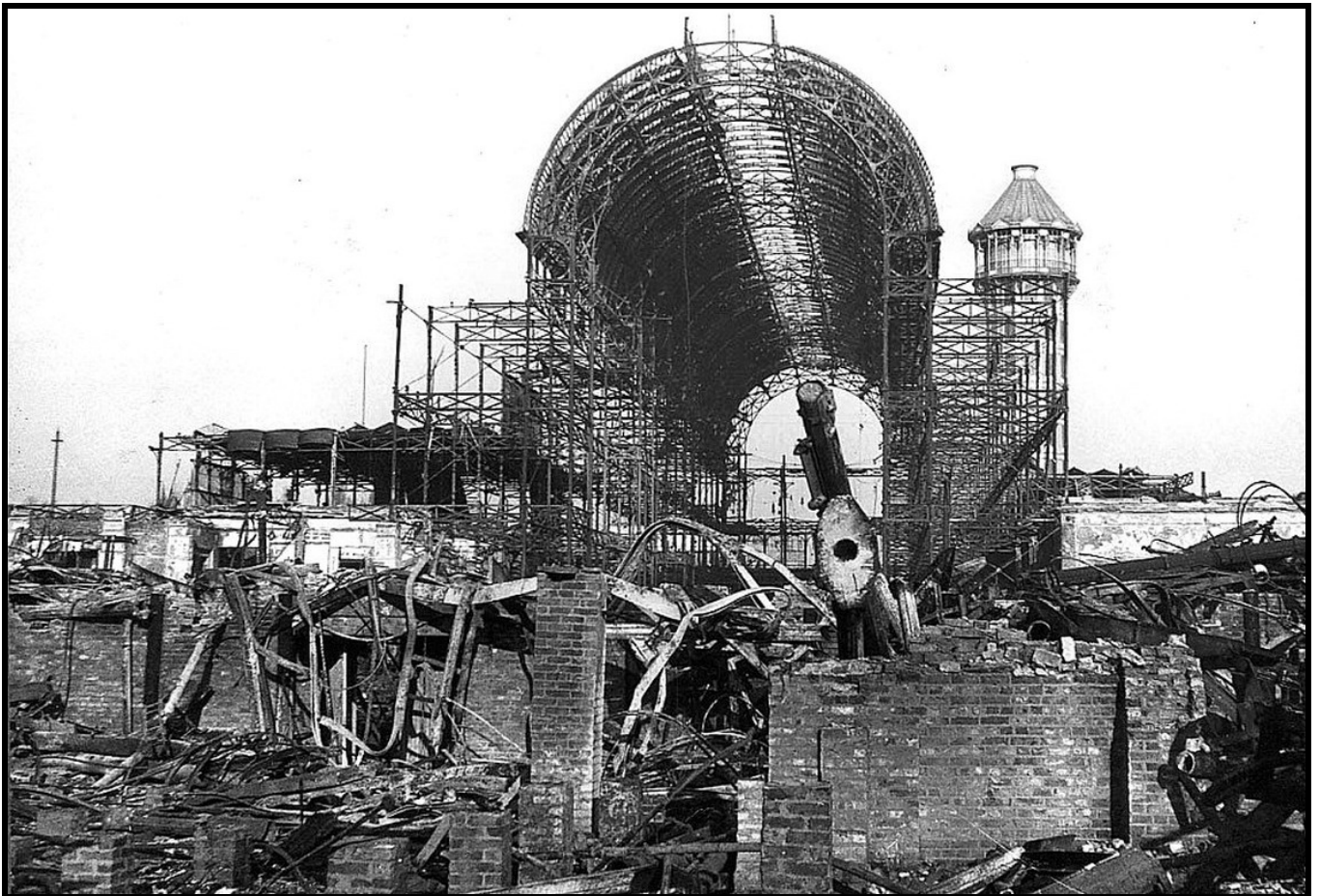
THE FIRE

After Paxton's death, his Crystal Palace continued but with ever-decreasing revenues until the main building was completely destroyed by fire in 1936. Some say it was a tragic accident, others believe it was an insurance scam. The towers survived, but were demolished in the 1940's to stop them becoming a London landmark for enemy bombers.



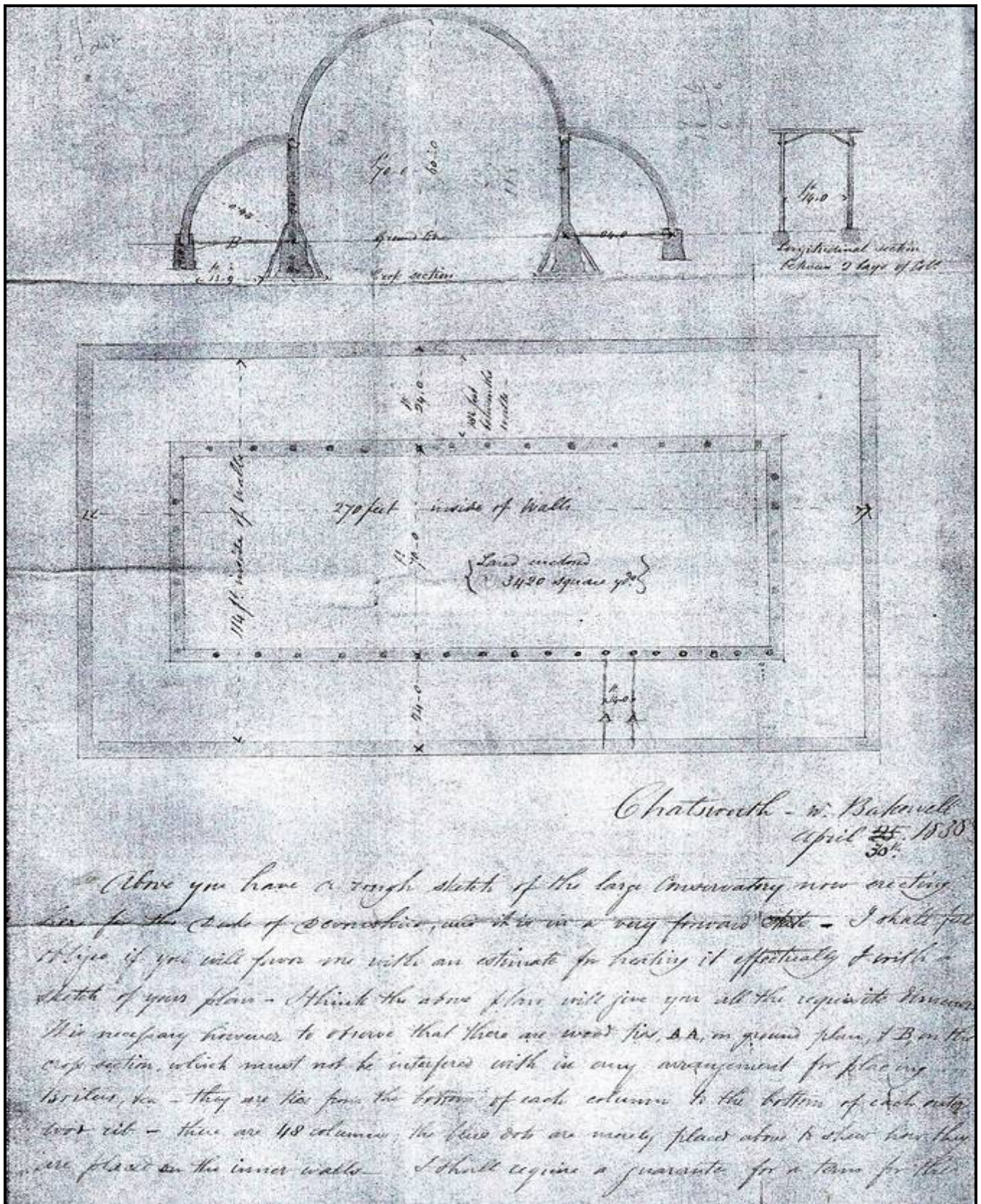


The fire raged out of control



The morning after, the Sydenham Crystal Palace was in ruins, but the water towers were intact

APPENDIX: PAXTON LETTER DESCRIBING INTENDED HEATING SYSTEM FOR THE GREAT CONSERVATORY (From CHATSWORTH LIBRARY)



Chatsworth - w. Bakerwell
April 25th 1830

As you have a rough sketch of the large Conservatory now erecting
for the Duke of Devonshire, and it is in a very forward state - I shall feel
obliged if you will favor me with an estimate for heating it effectually & with a
sketch of your plan - I think the above plan will give you all the requisite dimensions.
It is necessary however to observe that there are wood pits, A.A. on ground plan, & B. on the
cross section, which must not be interfered with in any arrangement for placing
boilers, &c. - they are pits for the bottom of each column to the bottom of each outer
wood rib - there are 48 columns, the blue dots are merely placed about to show how they
are placed on the inner walls - I shall require a guarantee for a term for the

effectual heating of the whole area, and also for the perfect construction of all the joints & the soundness of the materials - no inferior workmanship or materials whatever - The heating power to be placed inside of the building, under ground, near the outside walls - All excavations, removing earth, & masonry I propose doing myself - the Contractor's part will be to provide boiler with all necessary apparatus, no gas pipes, safety valves, flue pipe, fire box, steam & hot water pipes, &c, & to connect & erect all the iron work, finding white lead, &c - delivering & erecting them here at a fixed sum -

I am not aware of any plan equal to hot water carried in pipes completely around the house & also inside of the inner walls which support the columns, and also from the great width between the walls (70 feet) a double row of pipes may be necessary between them -

I do not however wish to dictate the method of heating, where it done in the most effectual & permanent manner is my object - I shall be happy to hear from you as early as possible -

Your obedient servant
Joseph Paxton.

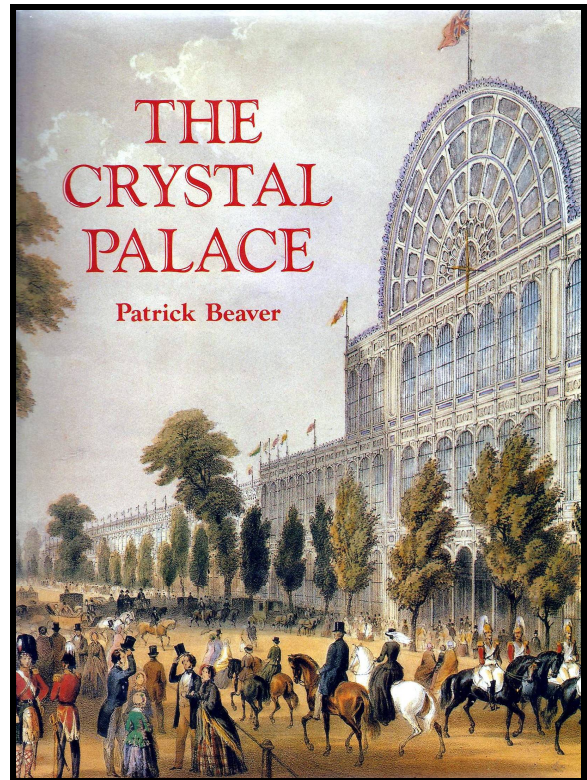
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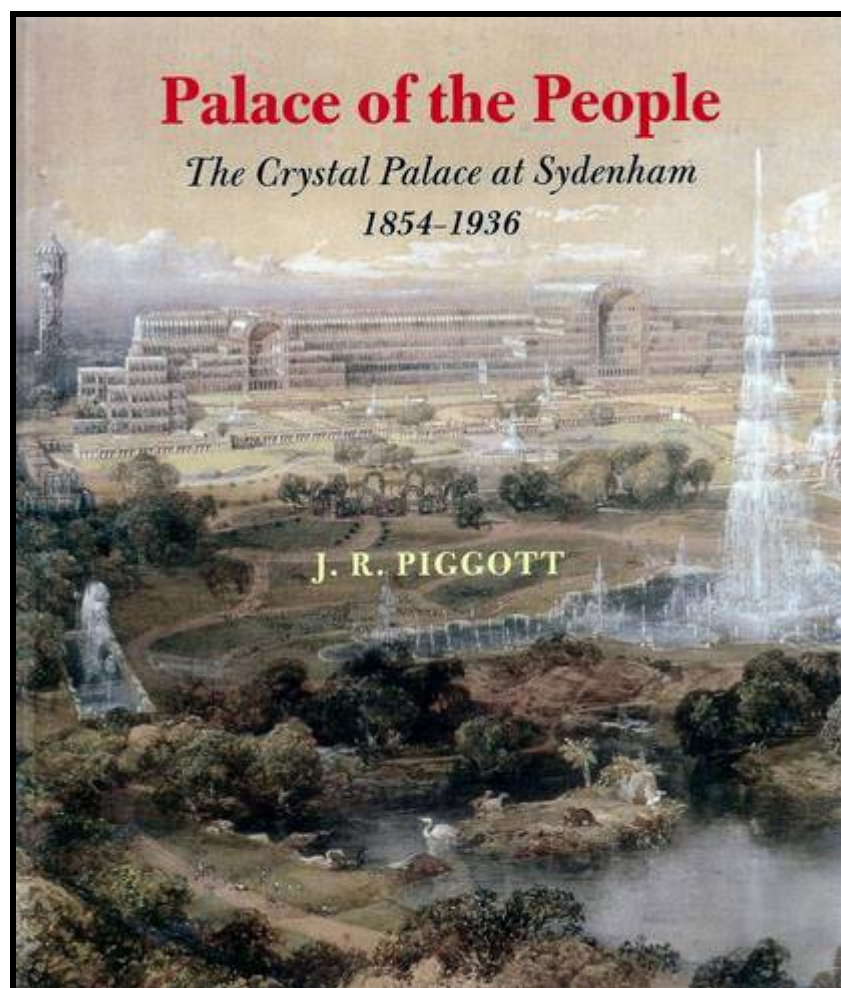
POSTSCRIPT & FURTHER READING



1854



1986



2004

EPILOGUE



Sir Joseph Paxton died in 1865 and is buried at St Peter's Church in the village and parish of Edensor in Derbyshire.

William Makepeace Thackeray, one of the leading novelists of the Victorian era, was moved to write a poem about the opening of the Crystal Palace:

As though 'twere by a wizard's rod
As blazing arch of lucid glass
Leaps like a fountain from the grass
To meet the sun.

A quiet green, but few days since;
With cattle browsing in the shade,
And lo! long lines of bright arcade
In order raised!

A palace as for a fairy prince,
A rare pavilion, such as man
Saw never since mankind began,
And built and glazed.