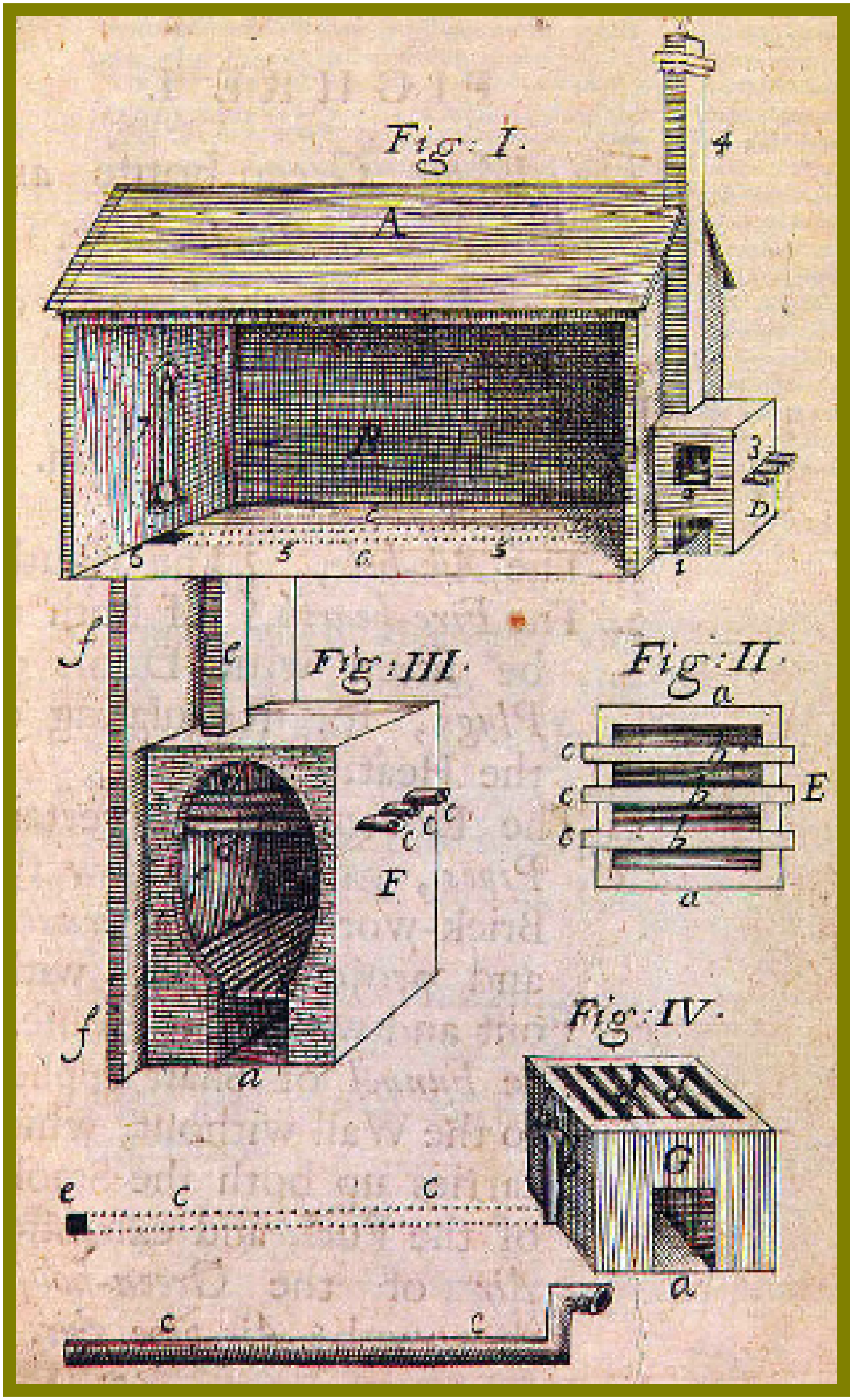
The Great Exhibition Building (Crystal Palace), Hyde Park 1851.
Being a temporary building, it was unheated.

HISTORIC GLASSHOUSES

HEATING AND VENTILATING

BRIAN ROBERTS

EVELYNS HEATED GREENHOUSE



(Kalendarium Hortense 1691).

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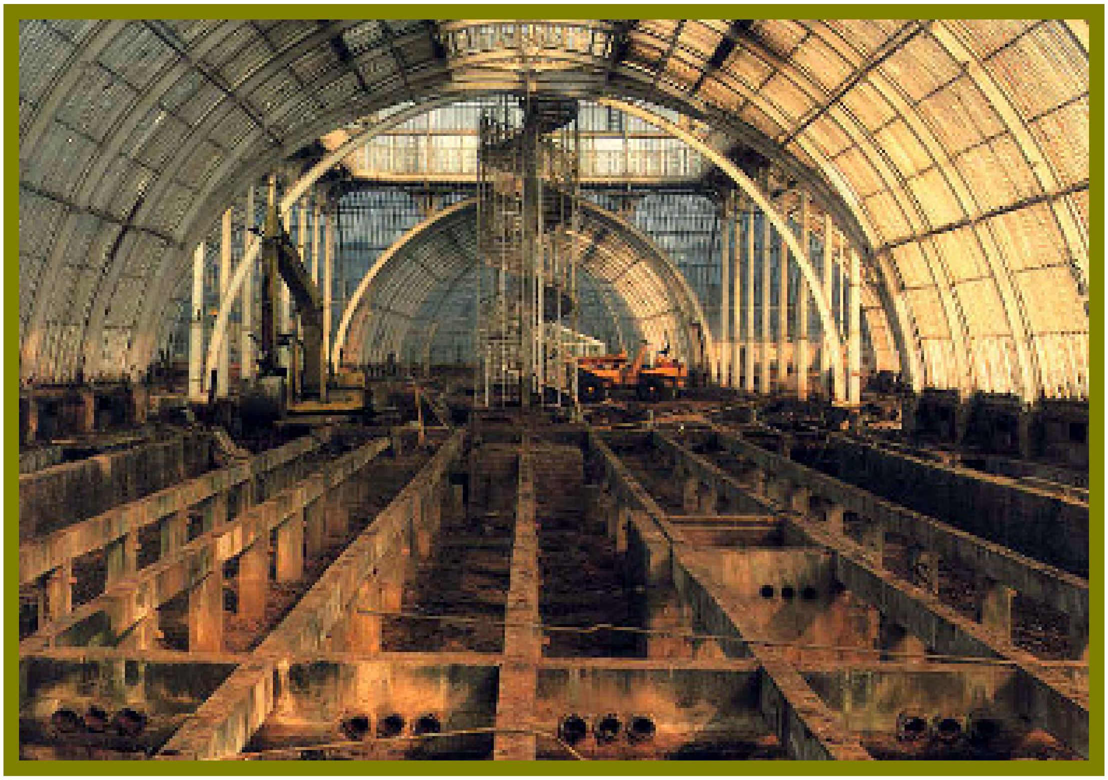
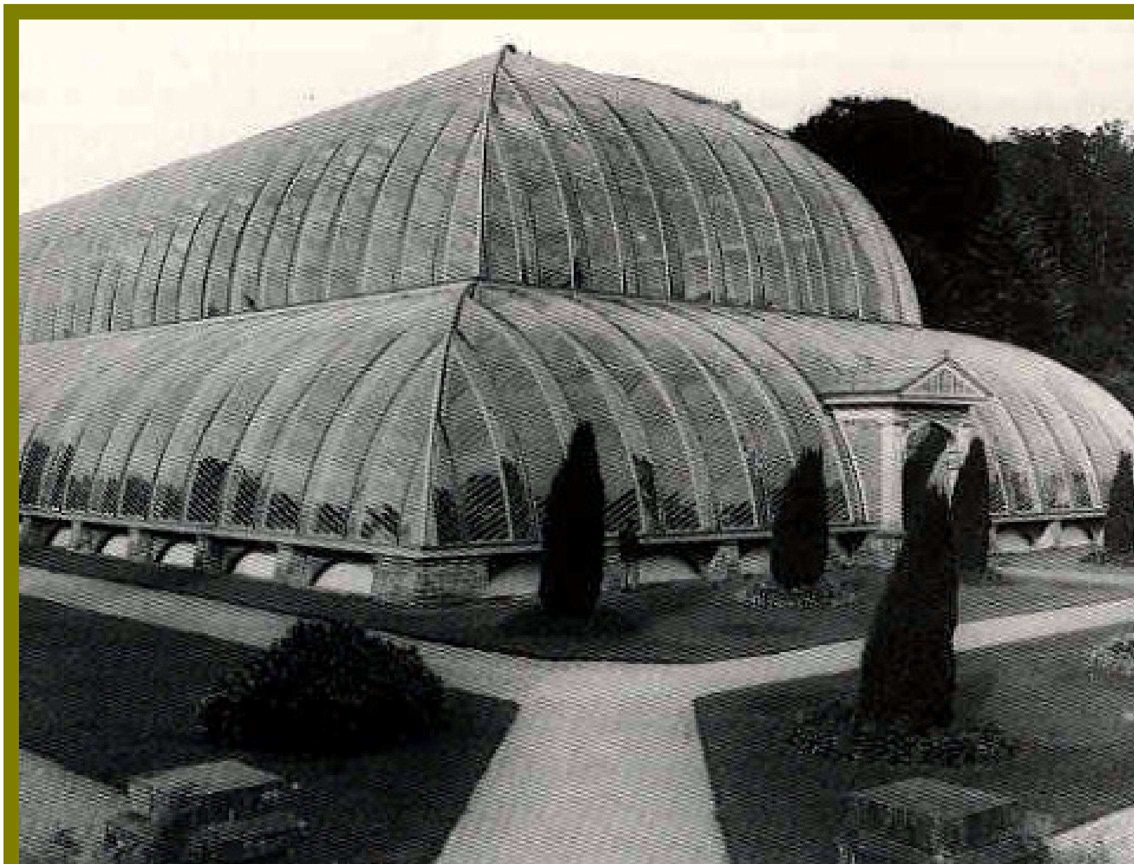


Restoration of Kew Palm House 1985.
Underfloor heating pipes removed.

I have visited those Palm Houses or Gardens
or dealt with the Companies listed in bold

BMR, Budleigh Salterton 2021.

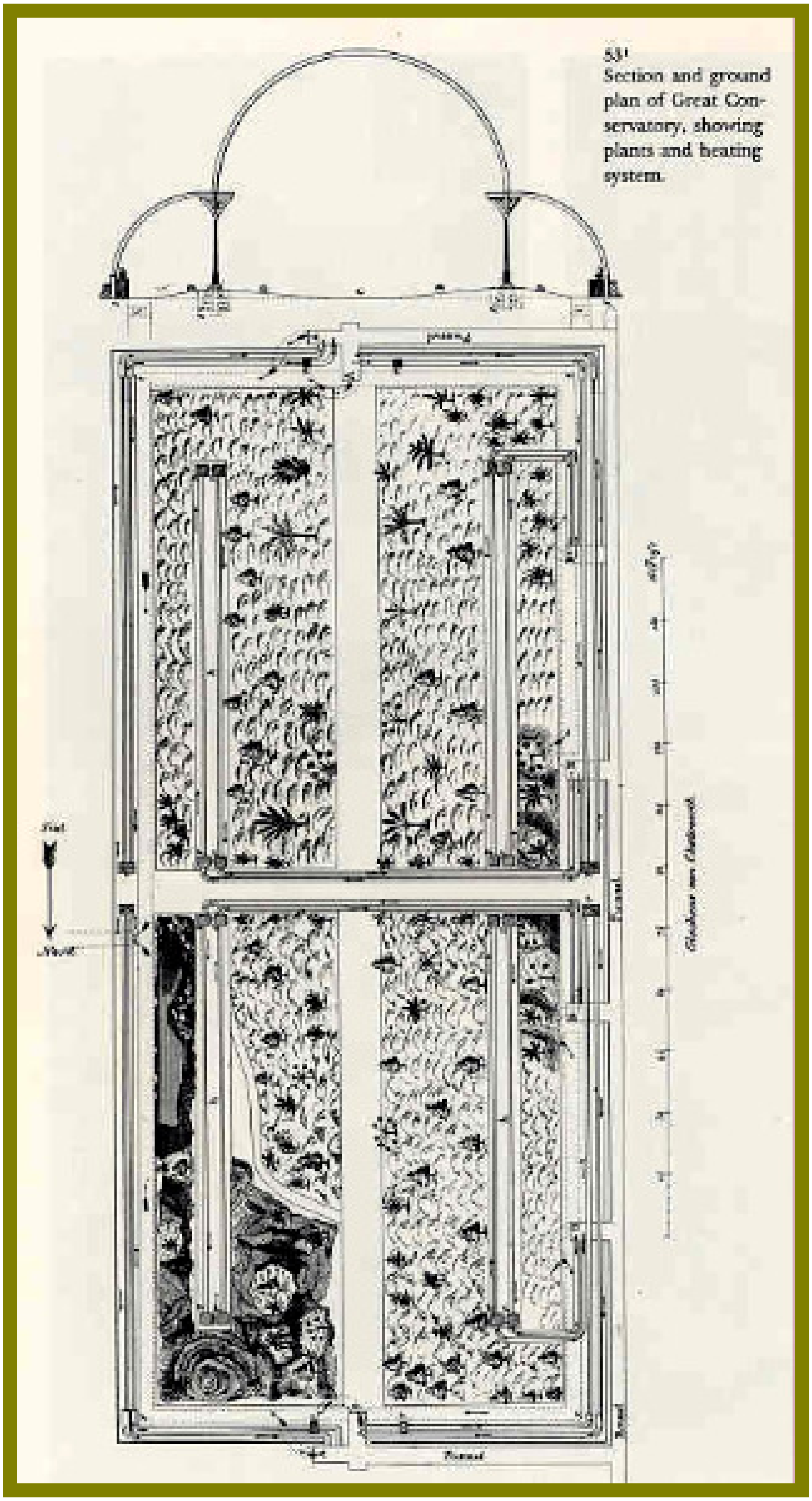
CHATSWORTH GREAT CONSERVATORY



Built in 1840, but blown up in the First World War after plants had died in order to conserve fuel and labour.

The heating of the conservatory was effected by no less than eight boilers beneath the building, feeding seven miles of four-inch iron pipe running in corridors high enough for a man to walk upright in them. The fuel for the boilers was also stored underground, and fed to the furnaces by a small tramway. Ventilation was provided by the iron valves in the basement arches, at the gallery level (i.e. at the springing of the main span), and by ventilators at the top of the conservatory when required.

CHATSWORTH LILY HOUSE



53[1]
Section and ground plan of Great Conservatory, showing plants and heating system.

Plan and section of heating system.

CHATSWORTH THE LILY HOUSE

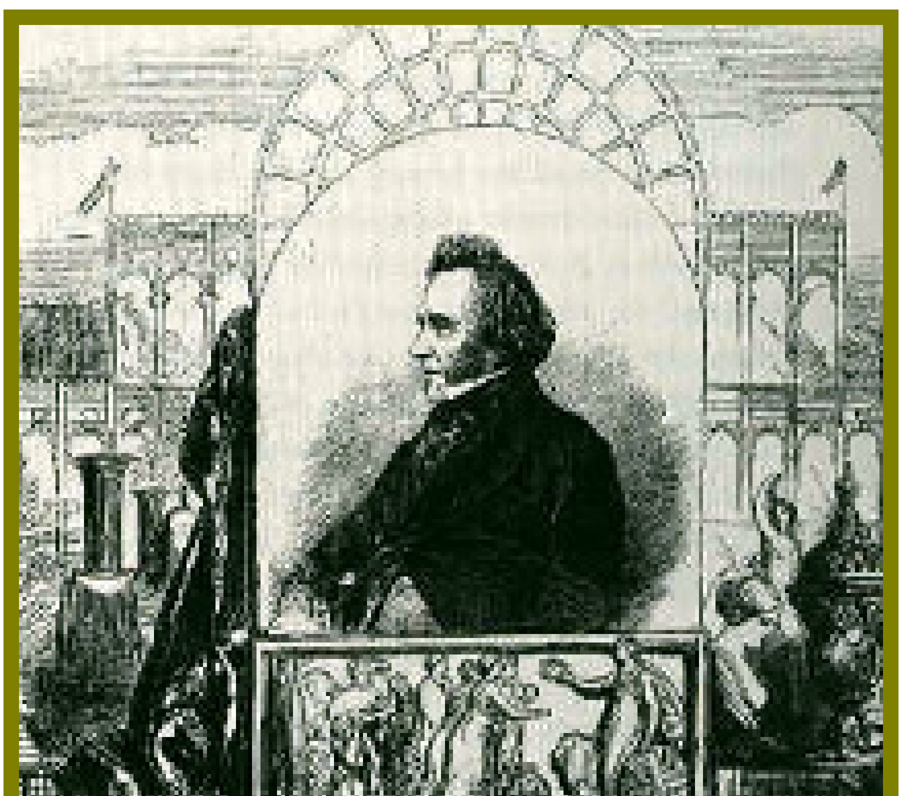
A consideration of the lily house would be incomplete without a further reference to its inhabitants and the ways in which their comfort and well-being were secured. Apart from the main tank there were eight smaller tanks in the angles of the house which held other aquatics: Nymphaea, Nelumbium and Pontederia. The main tank had a central deeper part, 16 ft. in diameter, which contained the soil for the Victoria; embedded in the soil were 4 in. diameter iron heating pipes, whilst 2 in. diameter lead pipes were placed in the shallow part of the tank. The house as a whole was heated by a system of 4 in. iron pipes running round inside the basement walls. Thirty openings between the piers of the basement wall allowed for low-level ventilation, and opening lights in the roof "made to open by simple machinery" gave additional ventilation when required. Four small water-wheels were provided in Victoria's tank to give gentle motion to the water and a cold water supply was placed above each so that the water temperature could be modified as required (average tank temperature 83°–85°F, house 80–90°F). It is interesting to note that Paxton had foreseen the potentialities of electric light—this nearly twenty years before the invention of the dynamo—but had been unable to use it to help Victoria's growth due to its expense; how he would have generated it is not clear, but he was certainly interested in, and experimenting with, electro-magnetic phenomena at various times.[31]

CHATSWORTH: SIR JOSEPH PAXTON

Sir Joseph Paxton, Head Gardener.
Designer of Conservatories at Chatsworth.

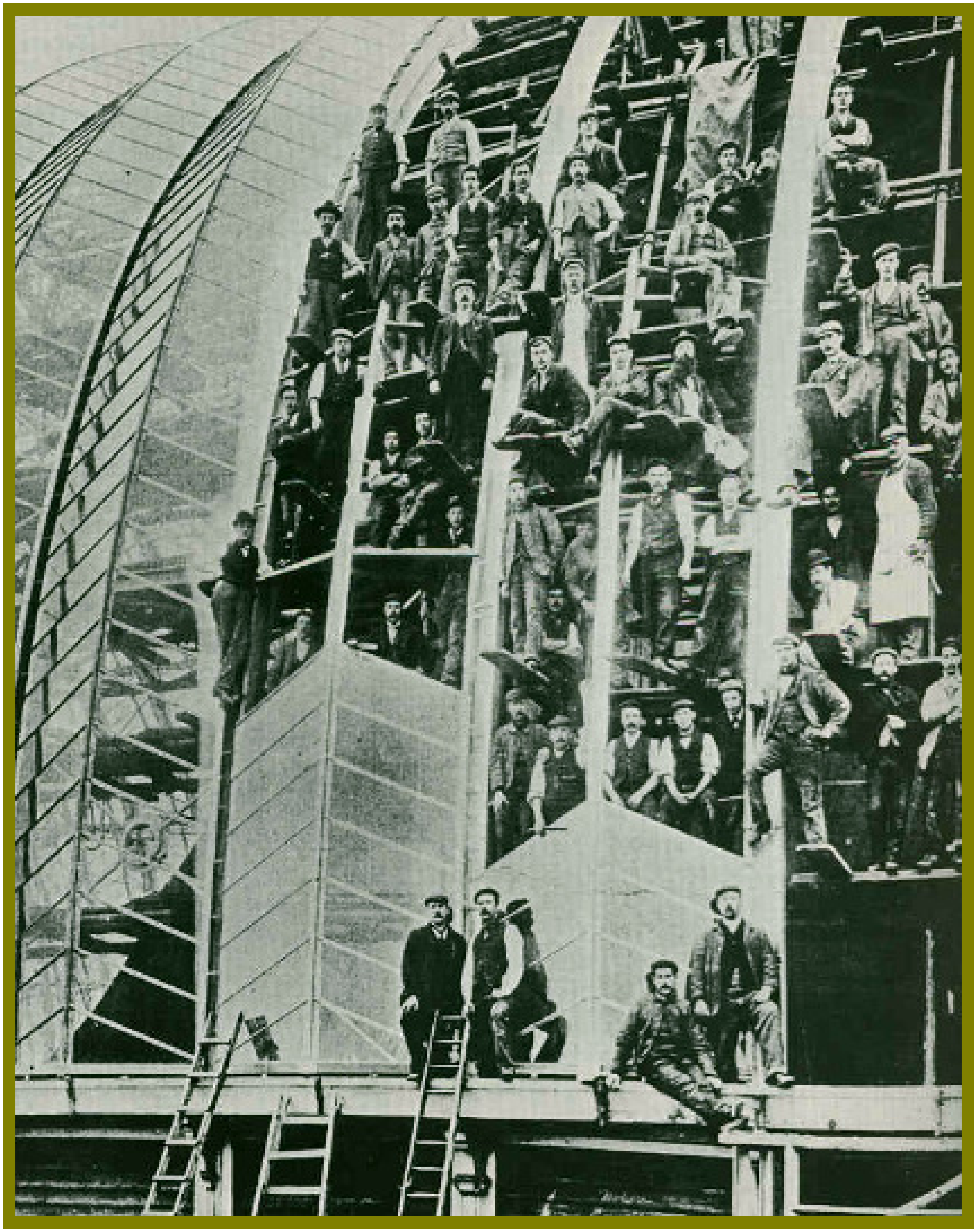
CRYSTAL PALACE, HYDE PARK

The boilerhouse (foreground) which generated steam to power the exhibits in the Machinery Hall of the Great International Exhibition. The Crystal Palace of 1851 in Hyde Park was a temporary structure and unheated.



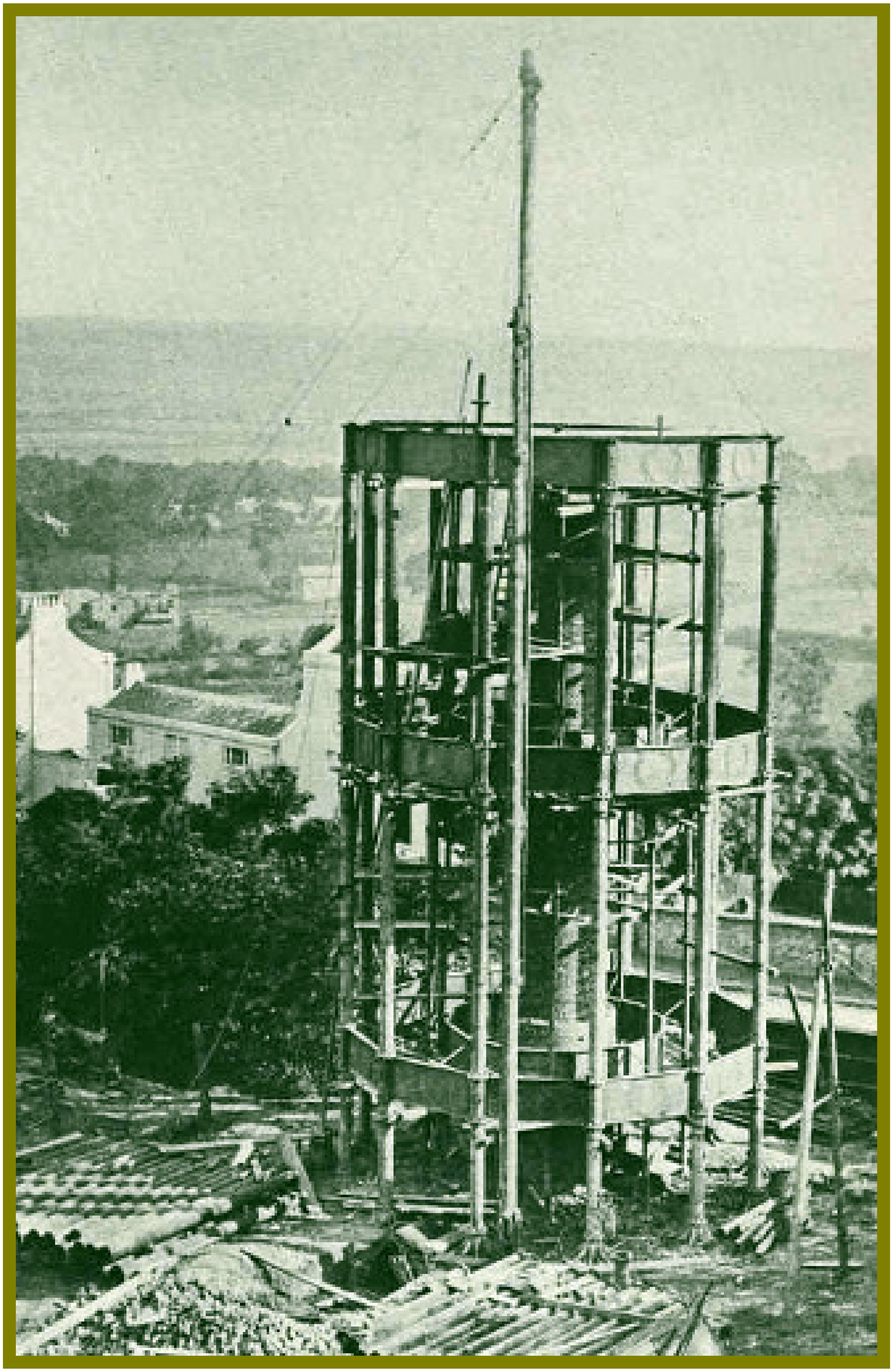
Sir Joseph Paxton, 1803-65, designer of the Crystal Palace.

CRYSTAL PALACE, SYDENHAM



When the Exhibition closed, the Hyde Park Palace was dismantled and rebuilt (and enlarged) in Sydenham, South London where central heating added. The photograph shows the glazing in course of erection.

CRYSTAL PALACE, SYDENHAM

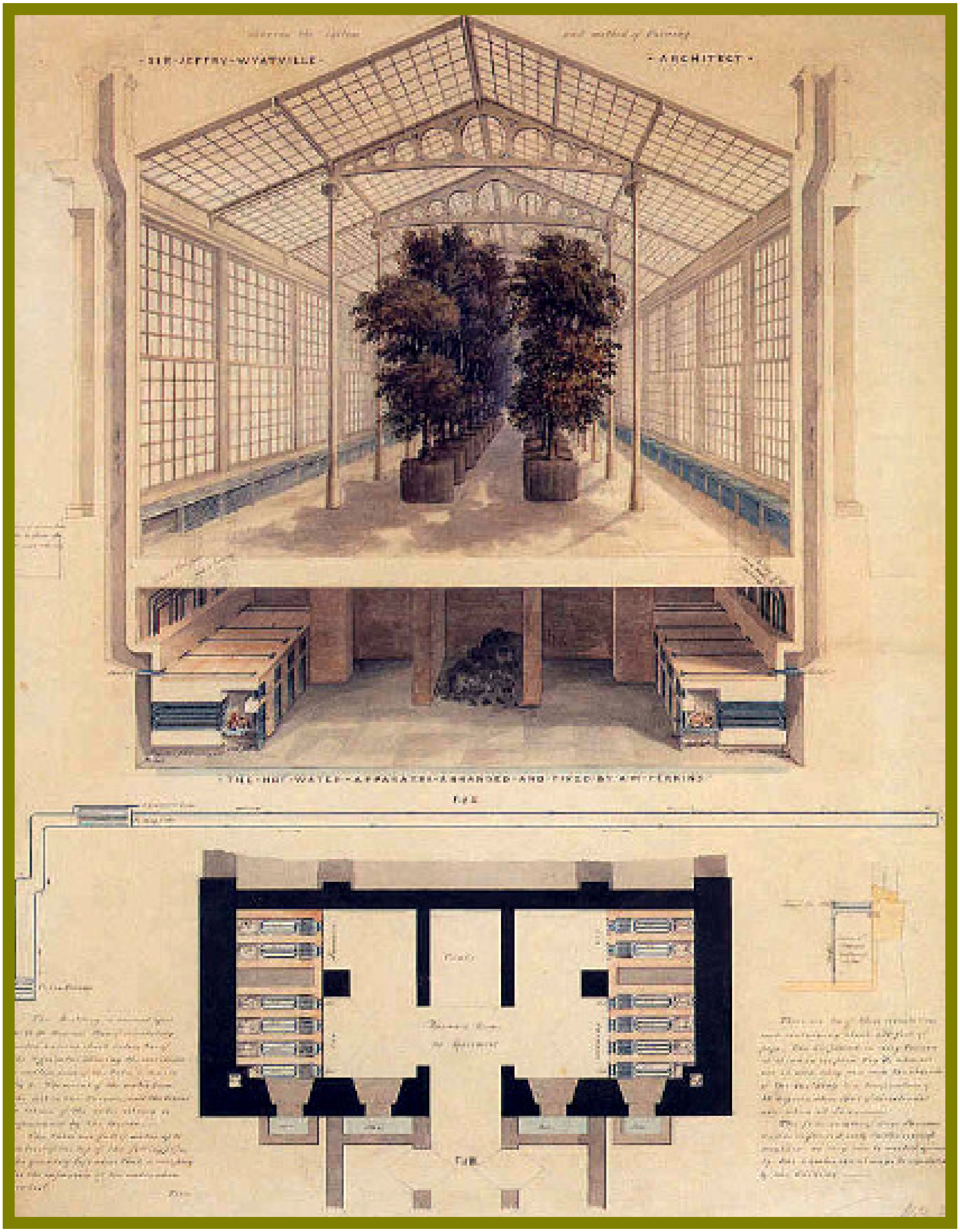


The Sydenham extension included two water towers designed by Brunel.
These also fed the many ornamental fountains in the large adjacent Park and Gardens.

CRYSTAL PALACE, SYDENHAM

As with many of Paxton's building some of the most interesting features were hidden from normal view, but not thereby lacking in importance. Ventilation had been important for the Great Exhibition, and to this was now added the need for heating. This Paxton patterned on his successful experiments in low-pressure hot water heating at Chatsworth. 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 in each wing, and two small ones for the fountain basins at each end of the building containing *Victoria regias* and other tropical aquatics. Four pipes of 9 in. diameter were attached to each boiler, two flow and two return, and each boiler heated a certain transverse section of the Crystal Palace: the length of one flow and return was a mile and three-quarters, and the total length of heating pipes of all kinds was nearly fifty miles. The control of this intricate system was said to be by an unspecified new device invented by Paxton and Henderson.

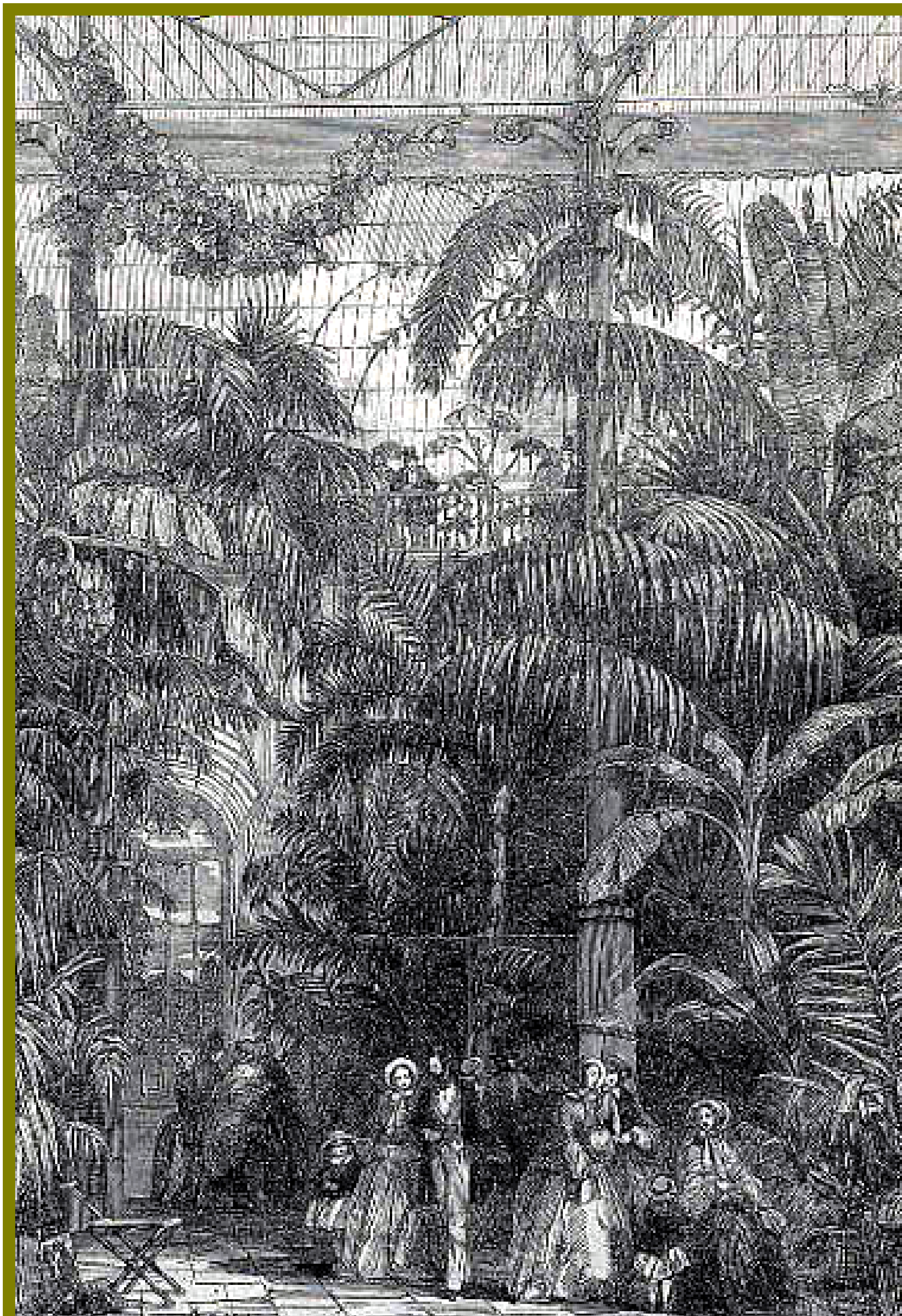
KEW ARCHITECTURAL CONSERVATORY



By John Nash. Renovated Jeffrey Wyatville c.1836.
Provided with an A. M. Perkins high pressure hot water heating system.

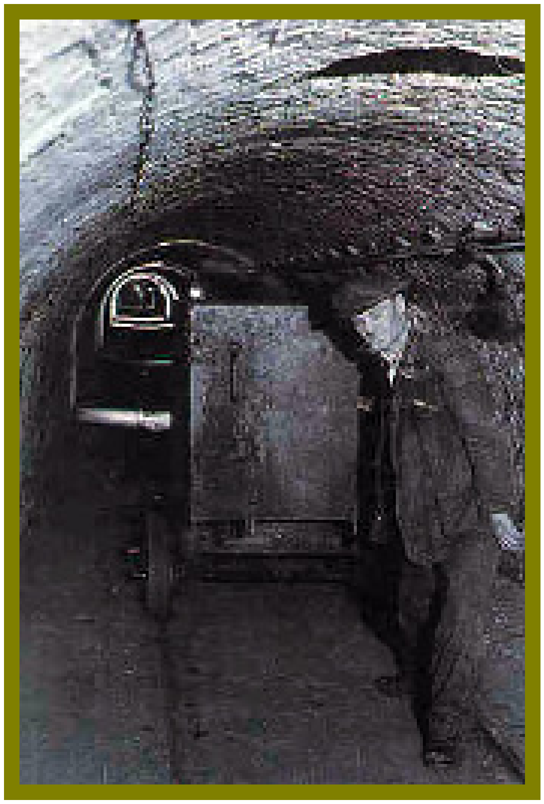
<13>

KEW PALM HOUSE

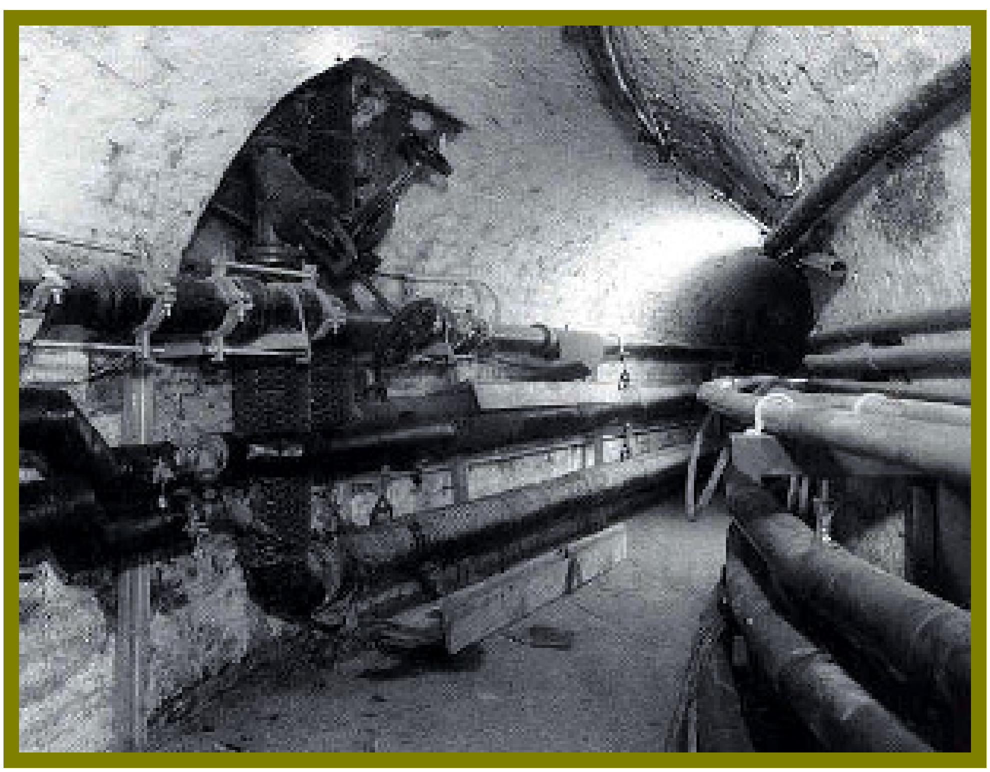


The Palm House 1852 (Engraving from *The Illustrated London News*).

KEW HEATING BOILERS

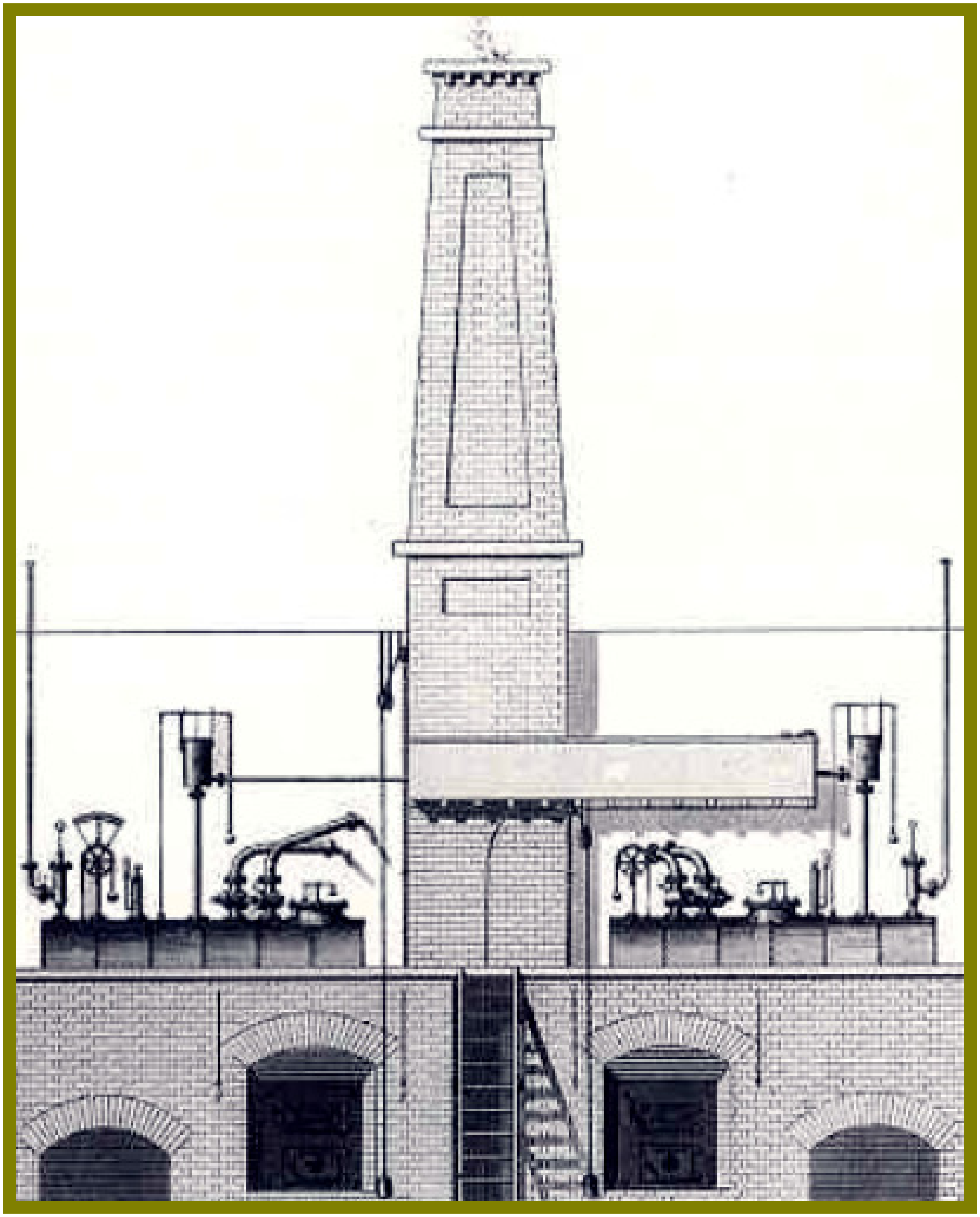


Underground tunnel and railway supplying coke to
the Basement boilers in the Palm House.



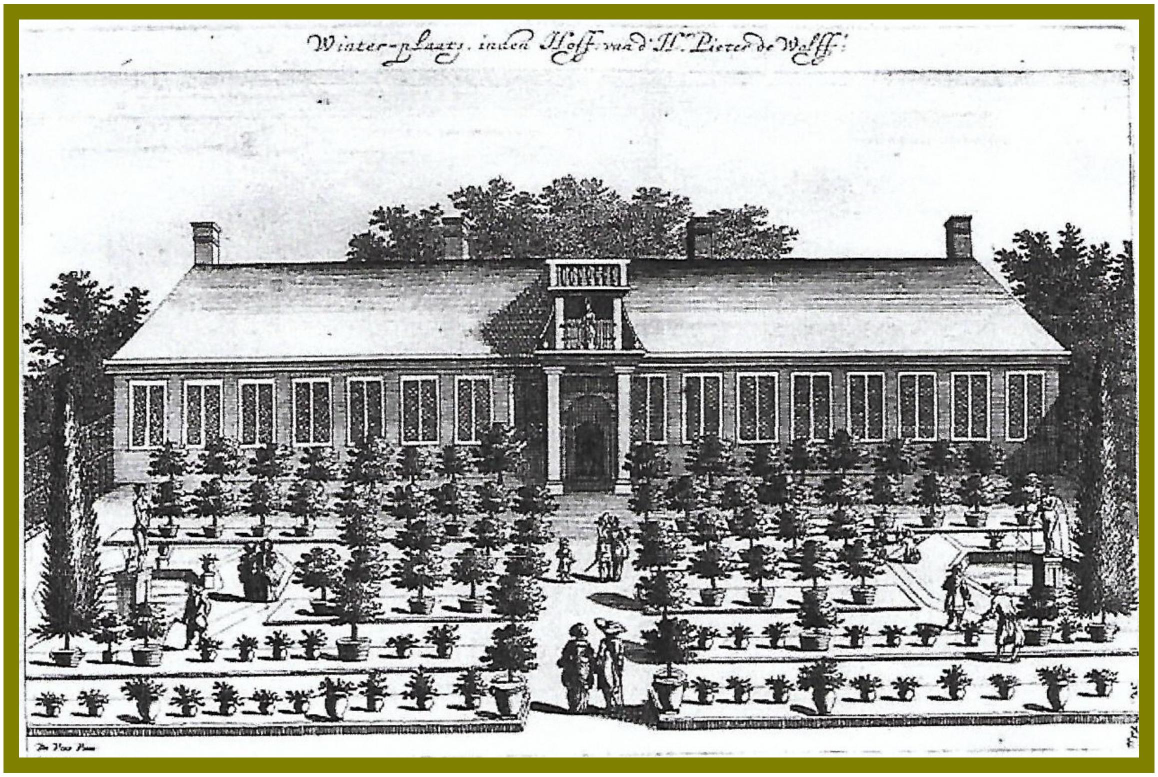
Renovation and re-use of the Victorian tunnel serving the Palm House.

LODDIGE NURSERY, HACKNEY

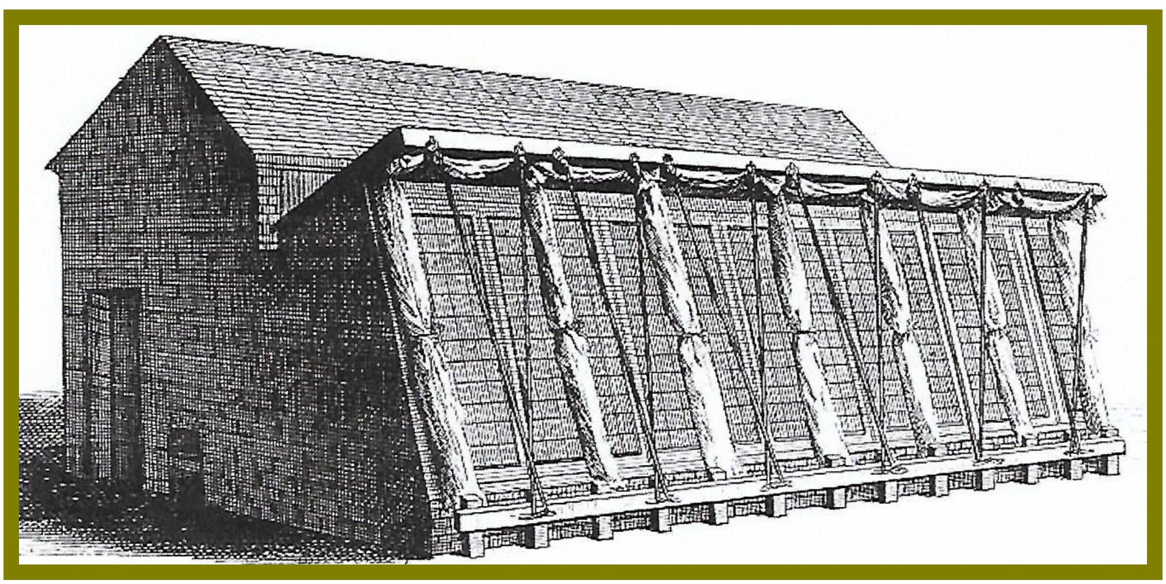


The heating "machinery" at Loddige's nursery in Hackney 1818.
(Drawn by George Loddige).

HOT AIR FORCING HOUSES

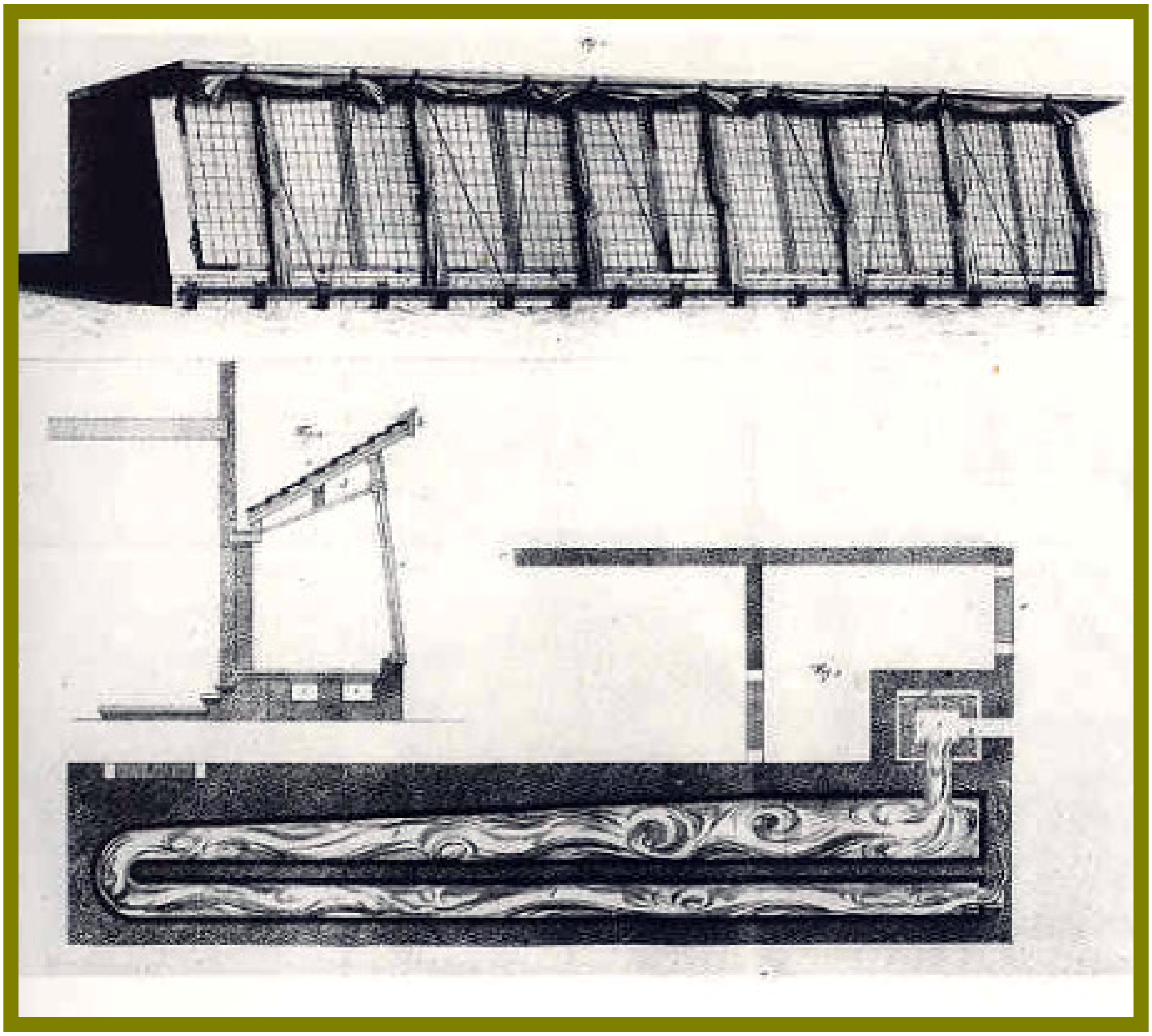


Pieter de Wolff's Dutch Orange House. Note the heating chimneys. (Commelyn 1683).



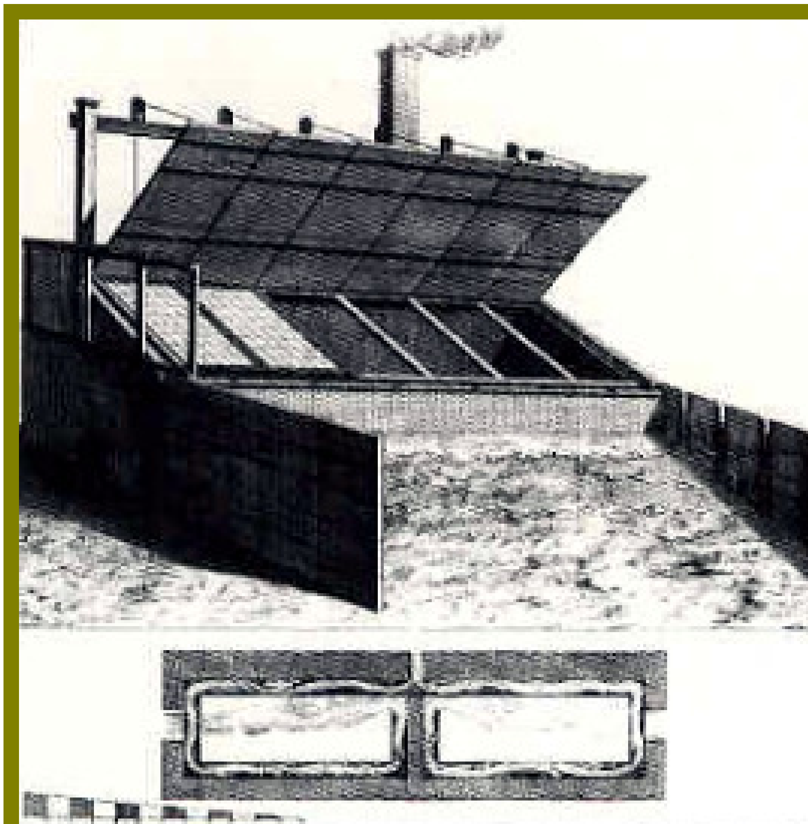
A "Stove" or forcing house using hot air flues.
(Diderot & d'Alembert's Dictionnaire Encyclopedie 1760).

DUTCH FORCING FRAME



18th century Dutch forcing frame with a heated flue system

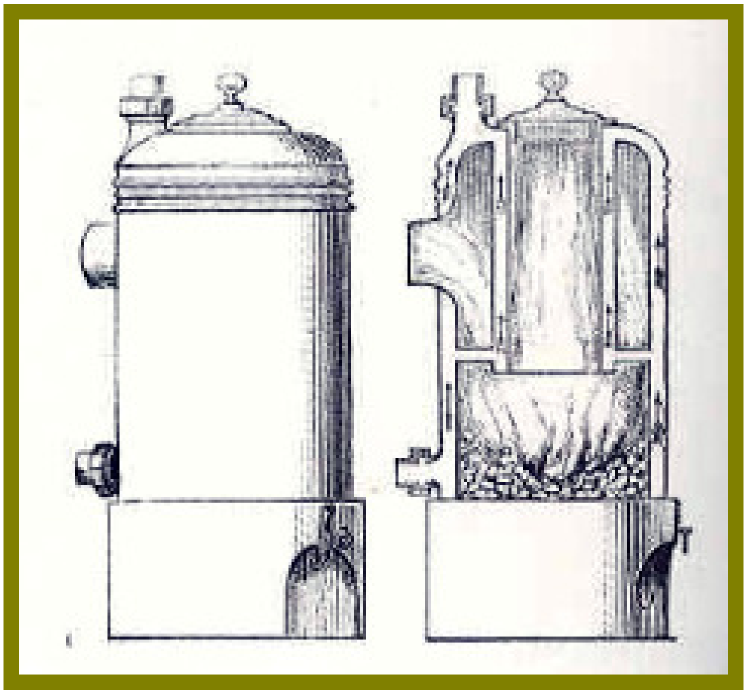
DUTCH FORCING FRAME
OXFORD BOTANIC GARDEN



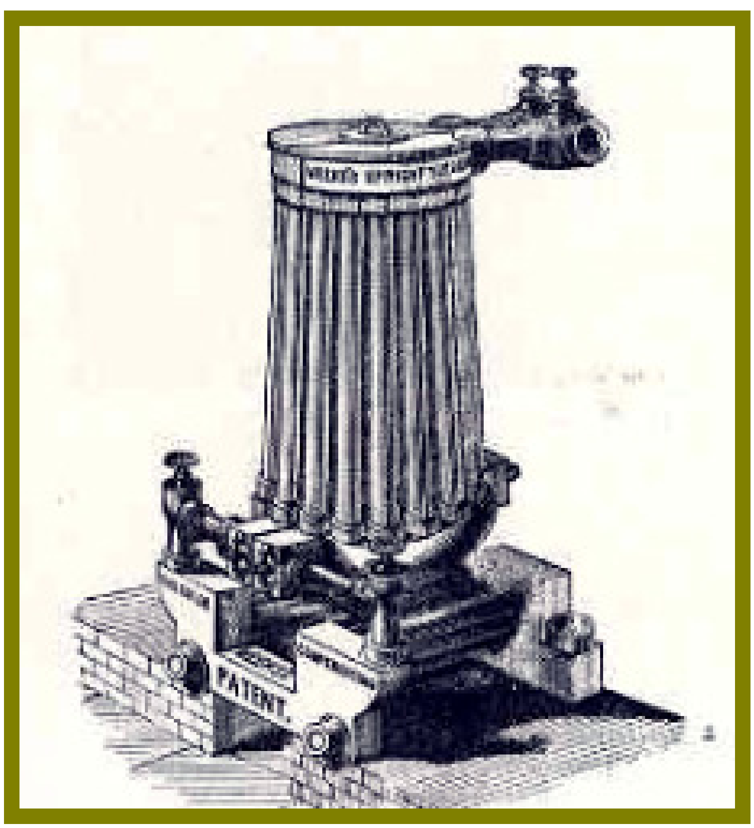
Flue heated Dutch forcing frame 1737.

Oxford Botanical Gardens 1771.

GEORGE STEPHENSON
MESSRS. WEEK

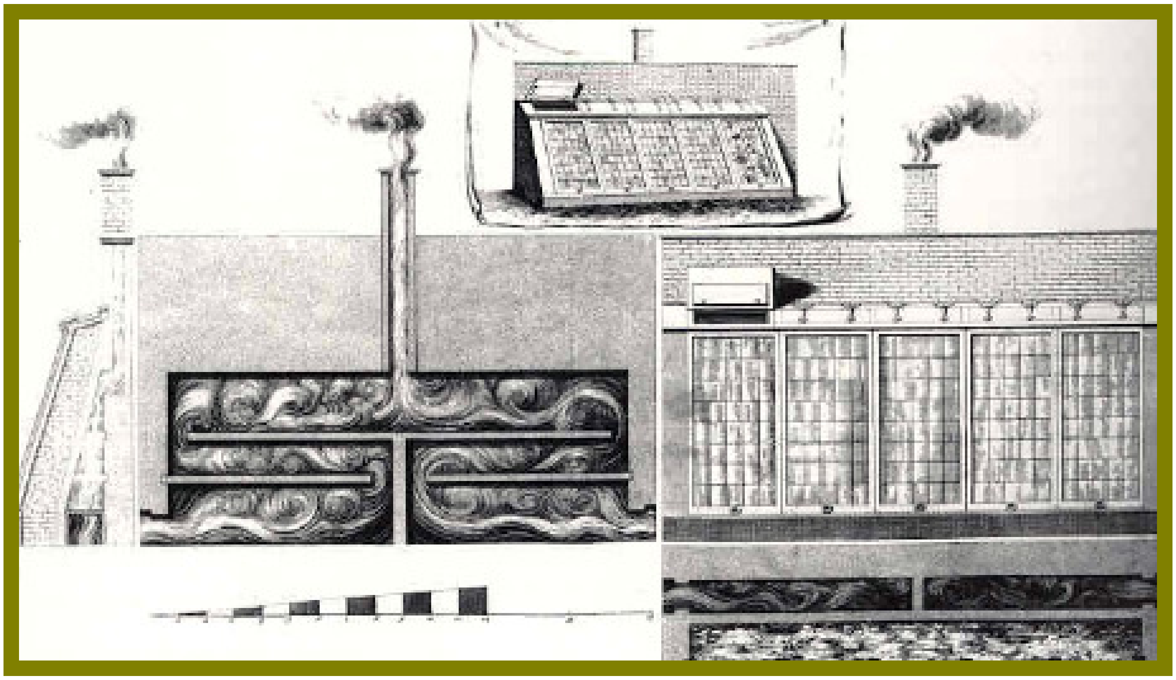


George Stephenson's double-cylinder boiler.
(The Book of the Garden, Chas. McIntosh 1853).



Week's upright tubular boiler 1851.

DUTCH FORCING FRAME



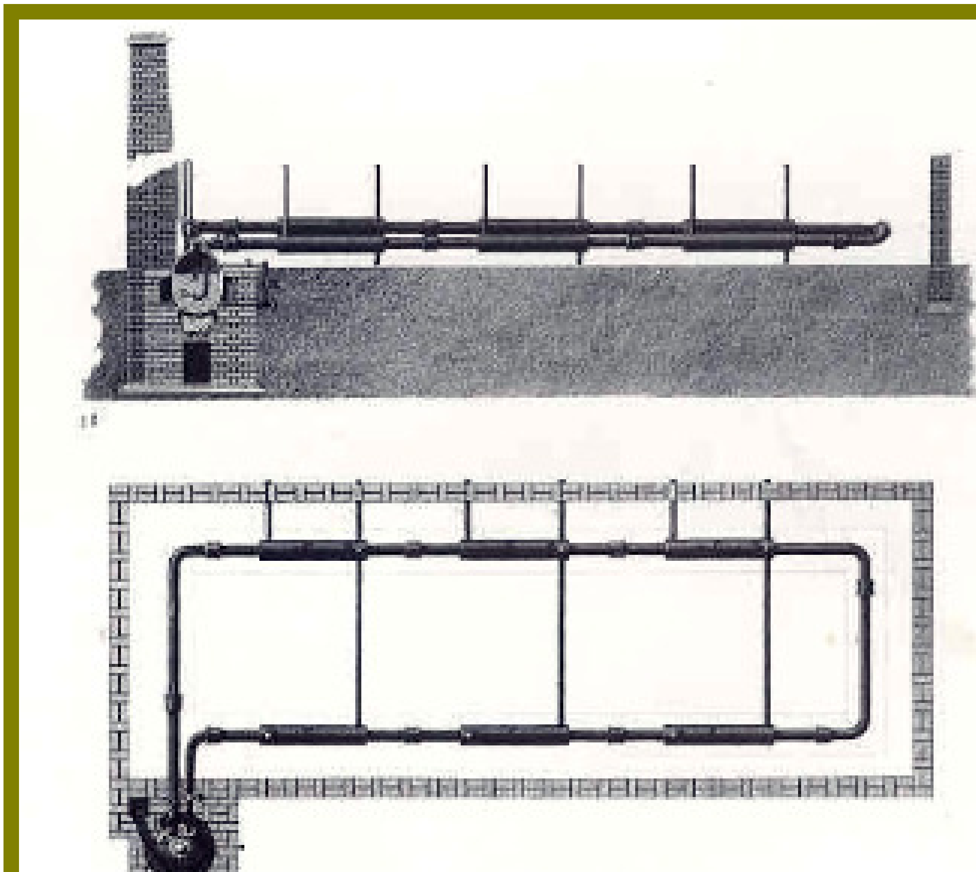
Dutch forcing frame with back wall flue 1737

STEAM HEATED VINERY

Steam heated vinery by James Brown (Trans. Horticultural Soc. 1818).

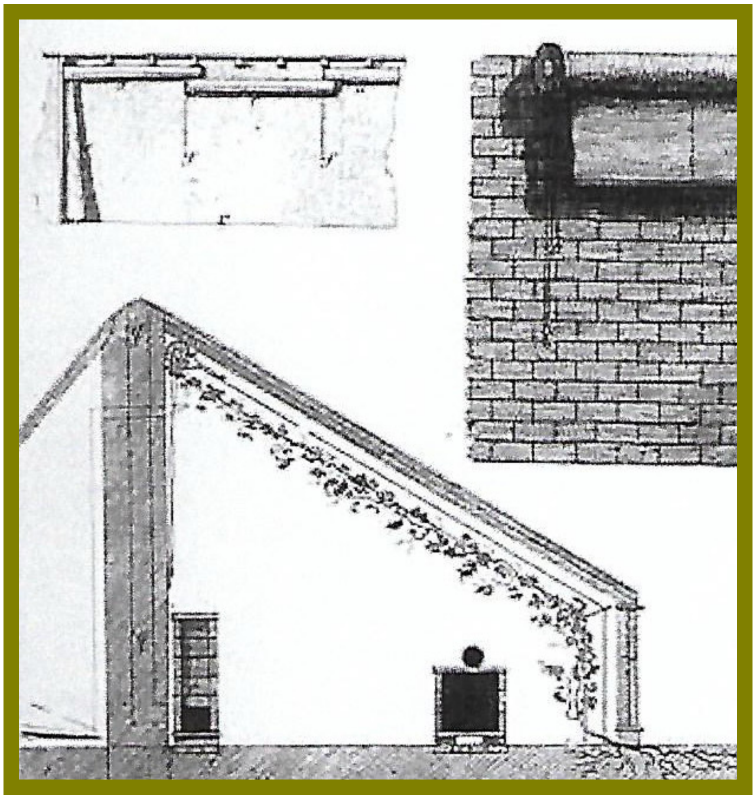
ST PETERSBURG GARDENS
HAIGS STEAM APPARATUS

Heating system at the Imperial Gardens, Taurida Palace, St. Petersburg.
(Trans. Horticultural Soc. 1822).

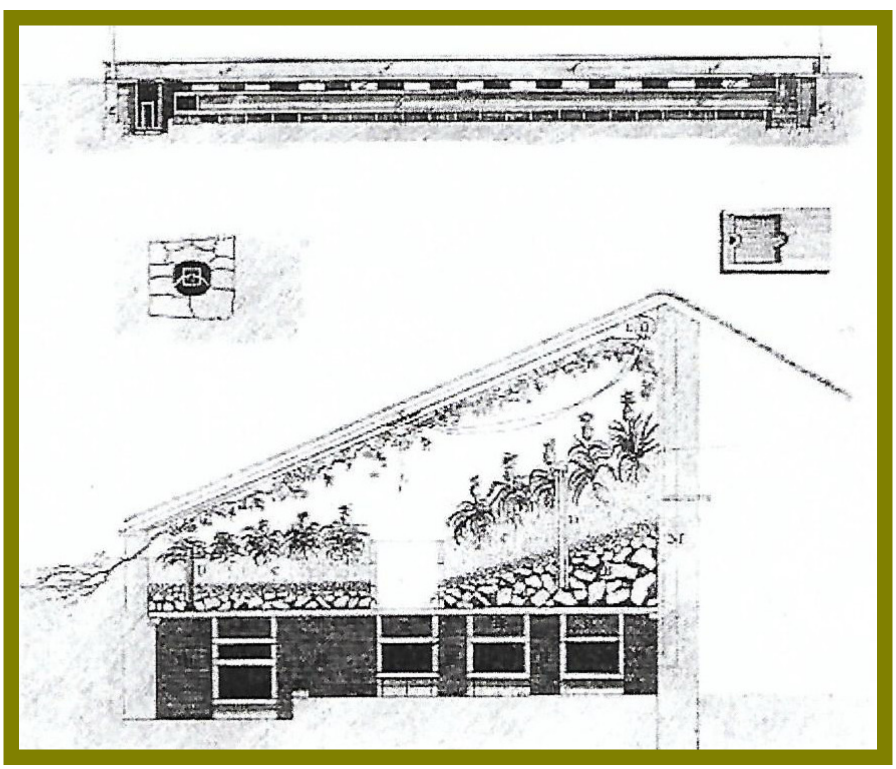


Hague's "Steam Apparatus" applied to a hothouse by Joseph Hayward.
(Trans. Horticultural Society 1822).

J .C. LOUDON

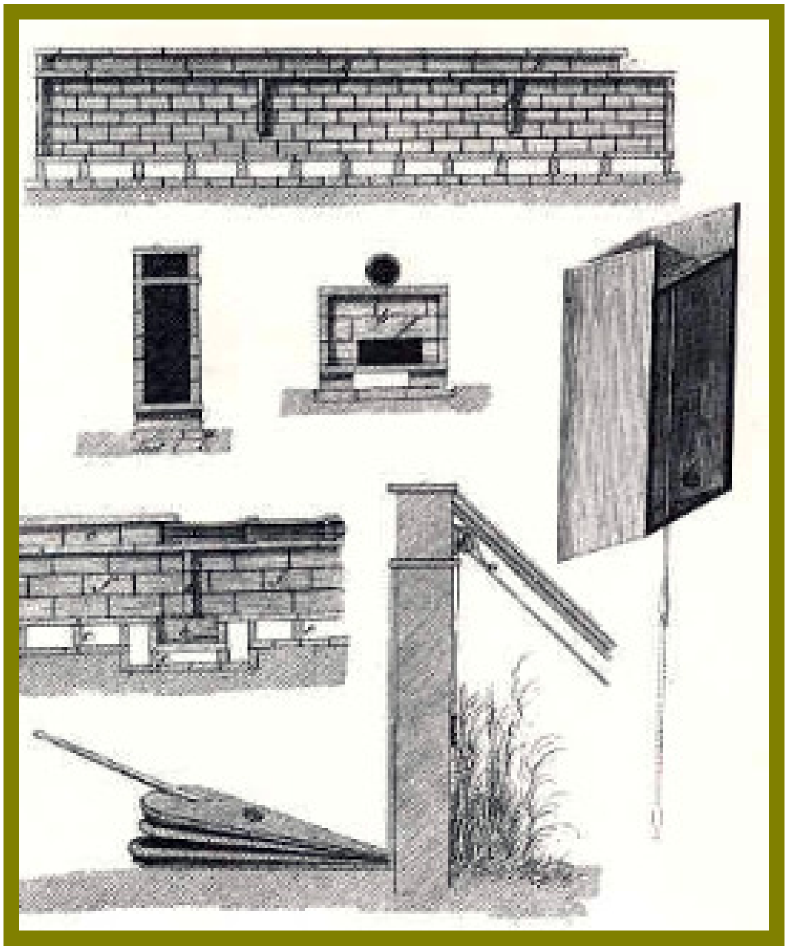


Loudon's early smoke flue and blinds for night-time insulation.
(From his Treatise of 1805).

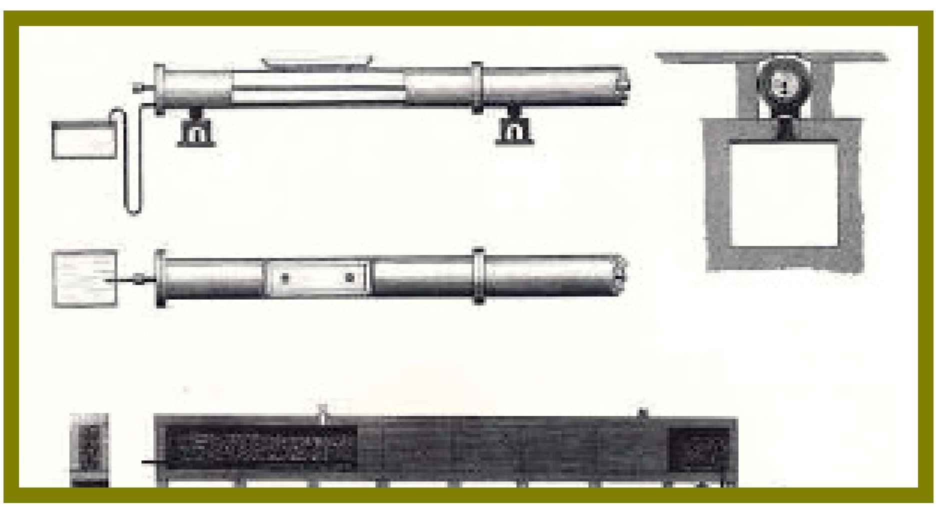


Loudon's hothouse design with the space around the flues filled with water
to aid humidification (his Treatise of 1805)

J. C. LOUDON
HENRY STOTHERT

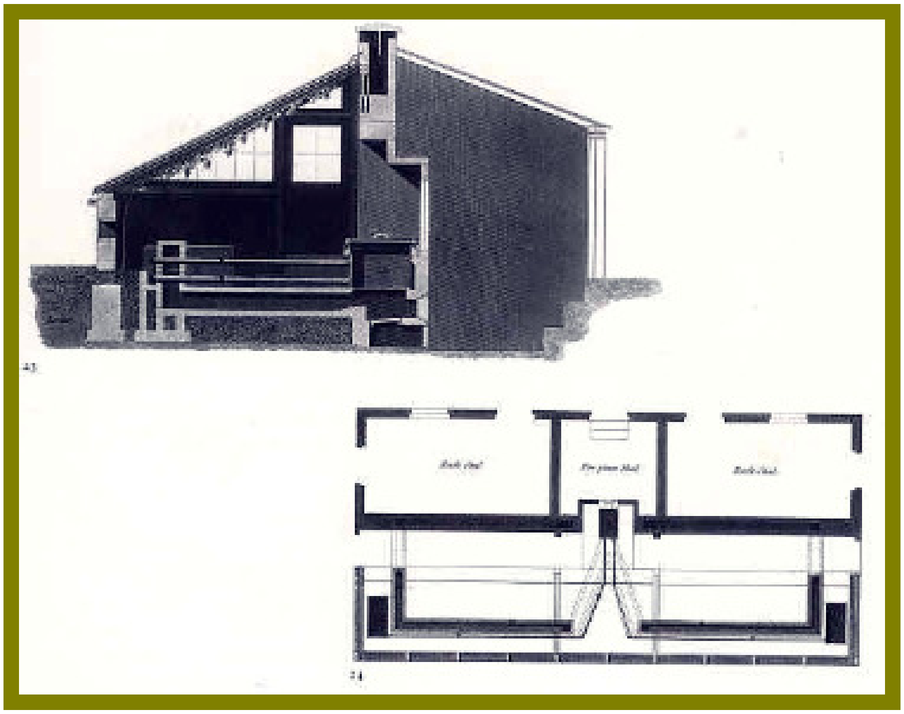


Loudon's early smoke flue and system of blinds for night-time insulation.
Complete with bellows for "air replenishment". (From his Treatise of 1805).

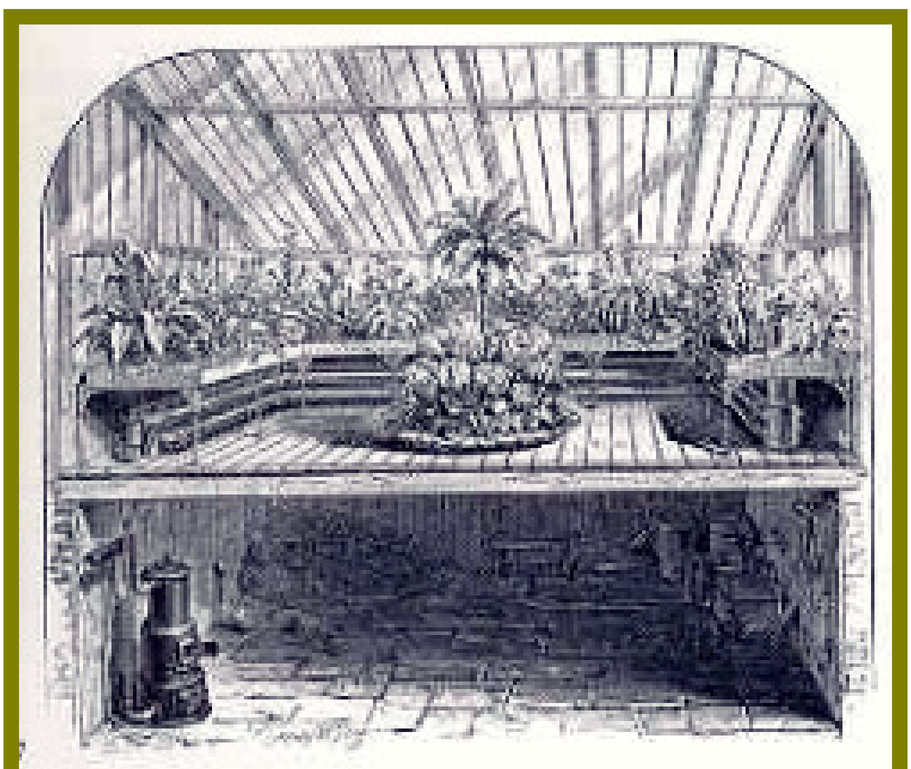


Henry Stotherts' methods of heating by steam.
(Trans. Horticultural Soc. 1895).

W. ATKINSON, ABERAMEN
HITCHENS & CO. NEW YORK

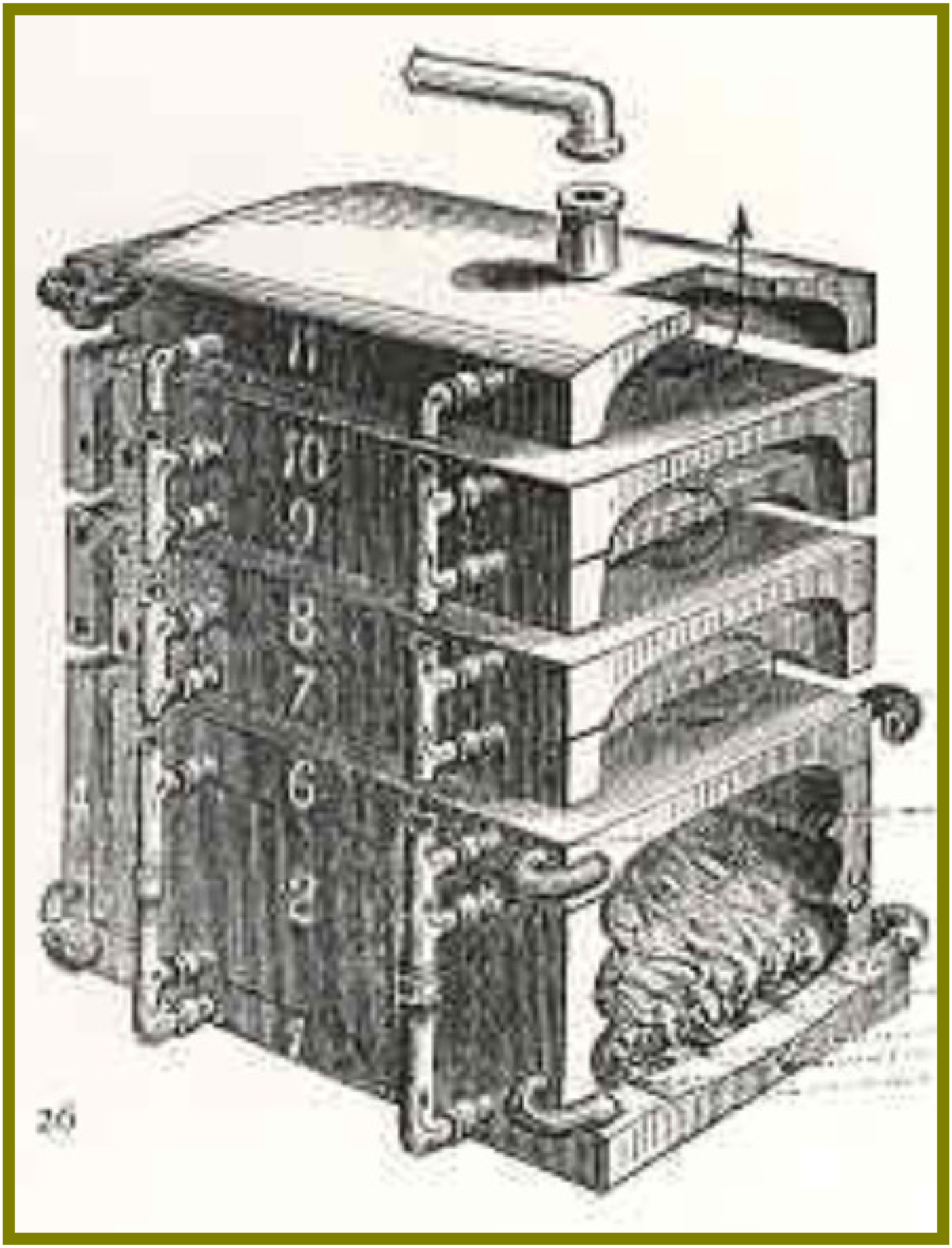


Atkinson's hot water heating for Anthony Bates 1822.
(Trans. Horticultural Soc. VII 1830).



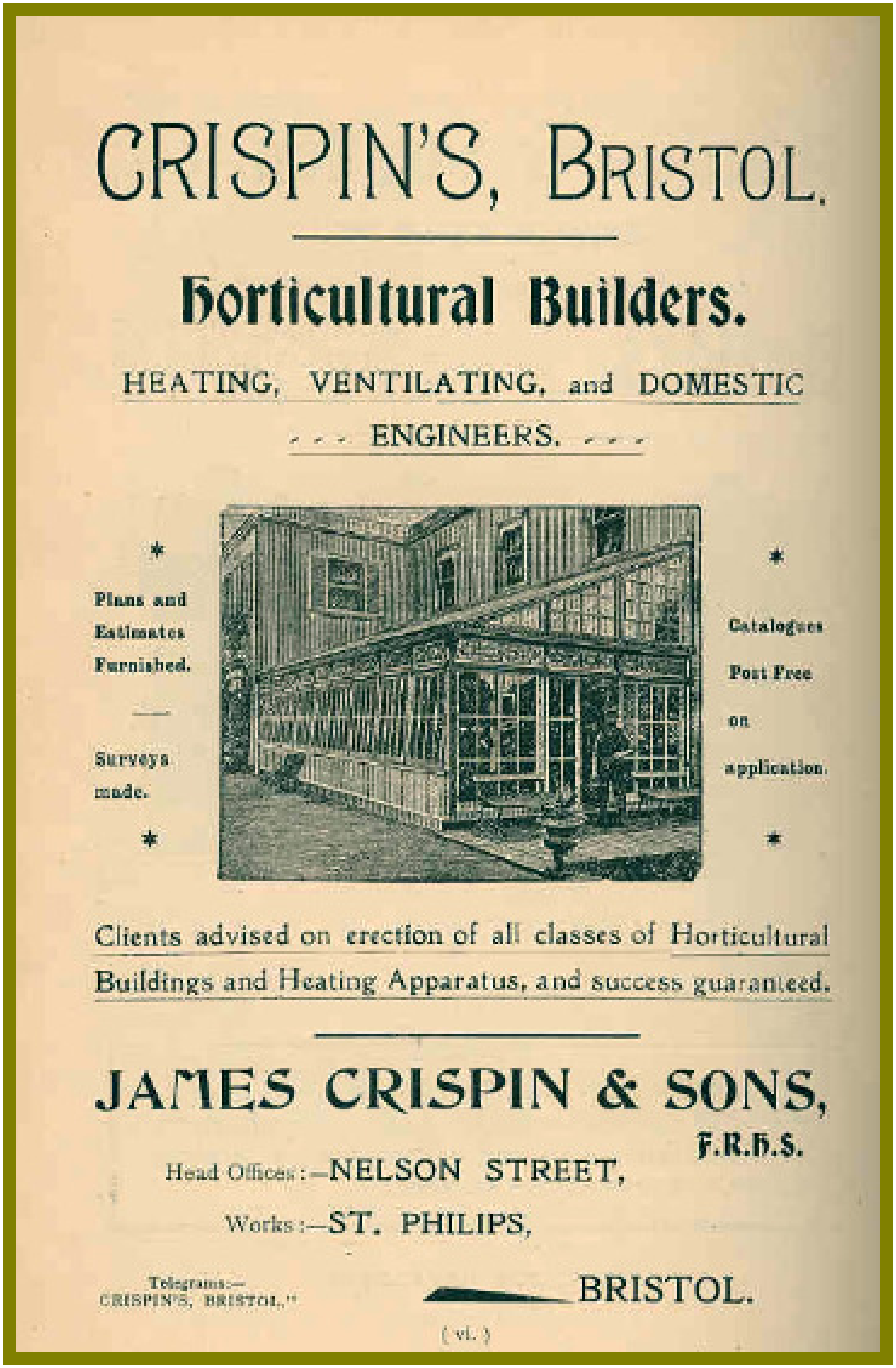
Hitchens & Co. hot water boiler, New York 1889

HORIZONTAL SECTIONAL BOILER



Make uncertain, possibly James Keith or Tangye.

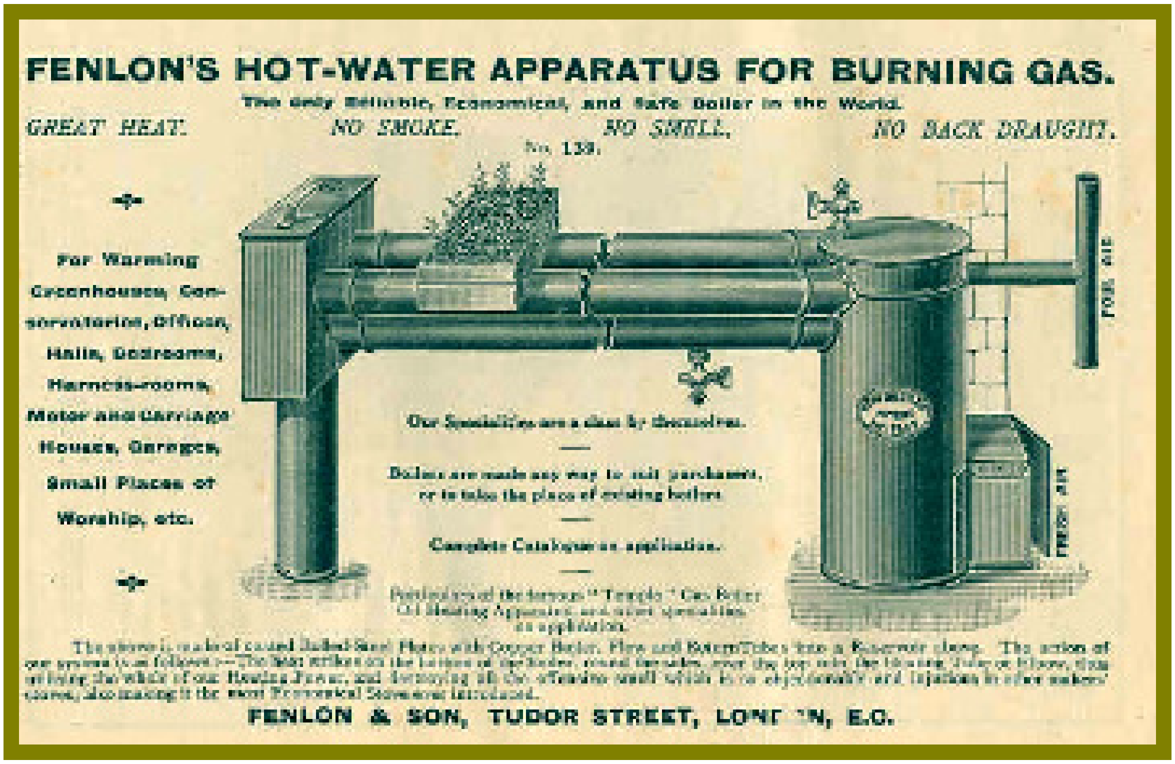
JAMES CRISPIN & SONS, BRISTOL



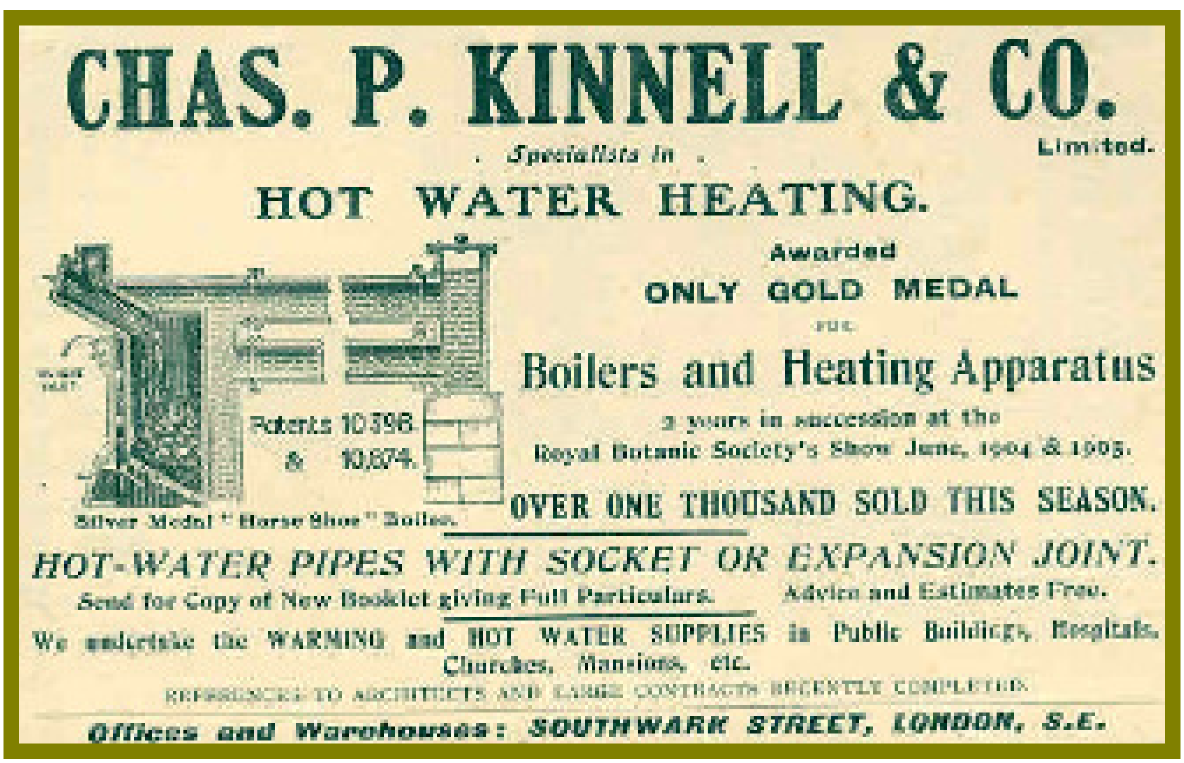
George Crispin was President IHVE 1905-6.

W & S DEARDS, HARLOW

FENLON & SON, LONDON



CHAS. P. KINNELL, LONDON



FLETCHER LOWNDES, WESTMINSTER

R. HALLIDAY, MANCHESTER

CHAS. FRAZERS EXORS, NORWICH

iv

CHAS. FRAZER'S EXORS.,

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6ft. x 4ft.	2	5	0
8ft. x 4ft.	3	5	0
12ft. x 4ft.	4	10	0
12ft. x 6ft.	5	15	0
16ft. x 6ft.	7	10	0
20ft. x 6ft.	8	15	0
24ft. x 6ft.	10	5	0

	£	s.	d.
4ft. x 6ft.	2	12	6
8ft. x 6ft.	4	2	6
12ft. x 6ft.	5	15	6
16ft. x 6ft.	7	5	0
20ft. x 6ft.	8	15	6
24ft. x 6ft.	10	10	0

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8ft. x 4ft.	2	12	0
12ft. x 4ft.	3	10	0
16ft. x 4ft.	4	10	0
20ft. x 4ft.	5	10	0

REDUCED CASH PRICES.

	£	s.	d.
6ft. x 4ft.	2	2	0
9ft. x 4ft.	3	0	0
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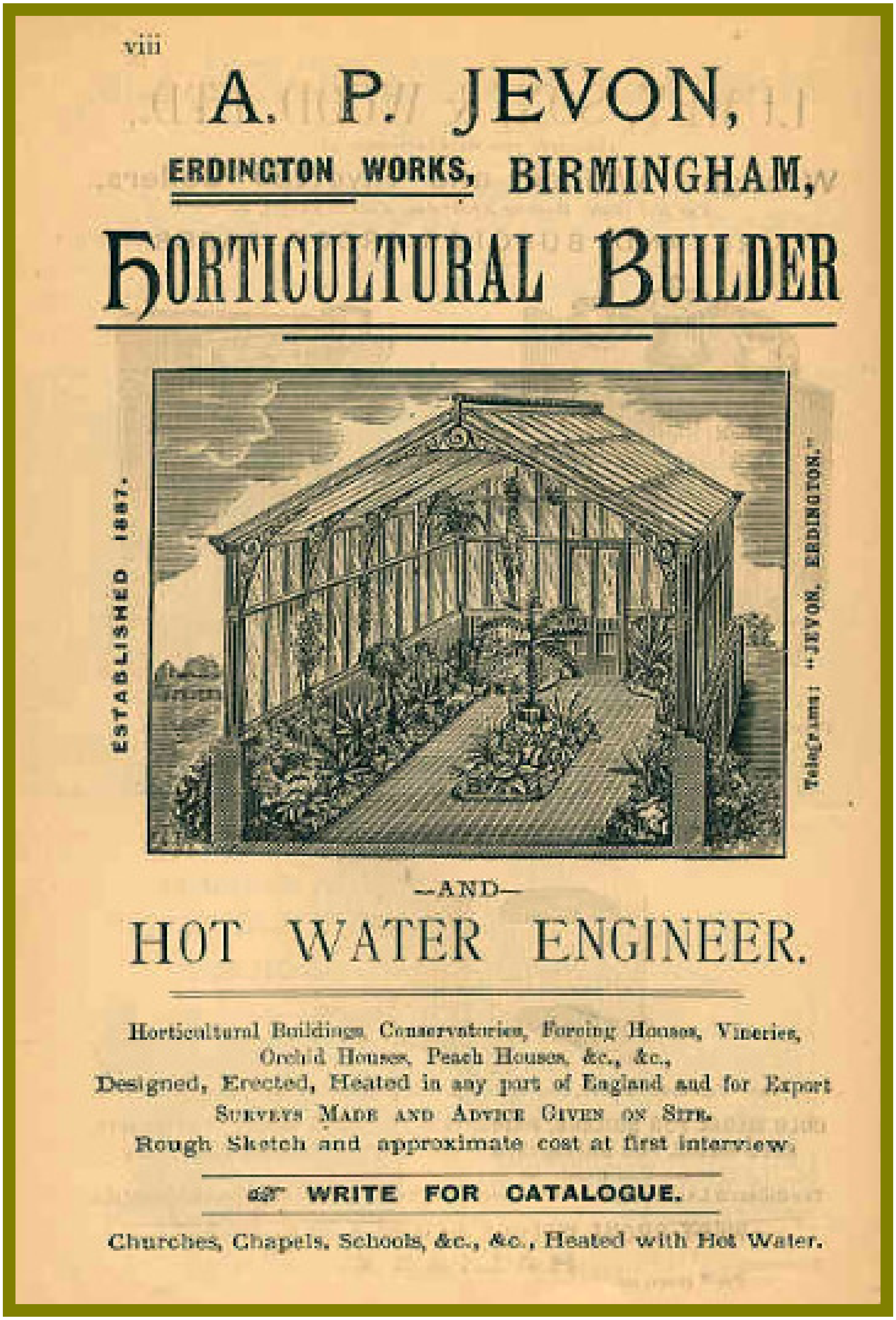
A. P. JEVON, BIRMINGHAM



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MESSENGER & CO. LOUGHBOROUGH

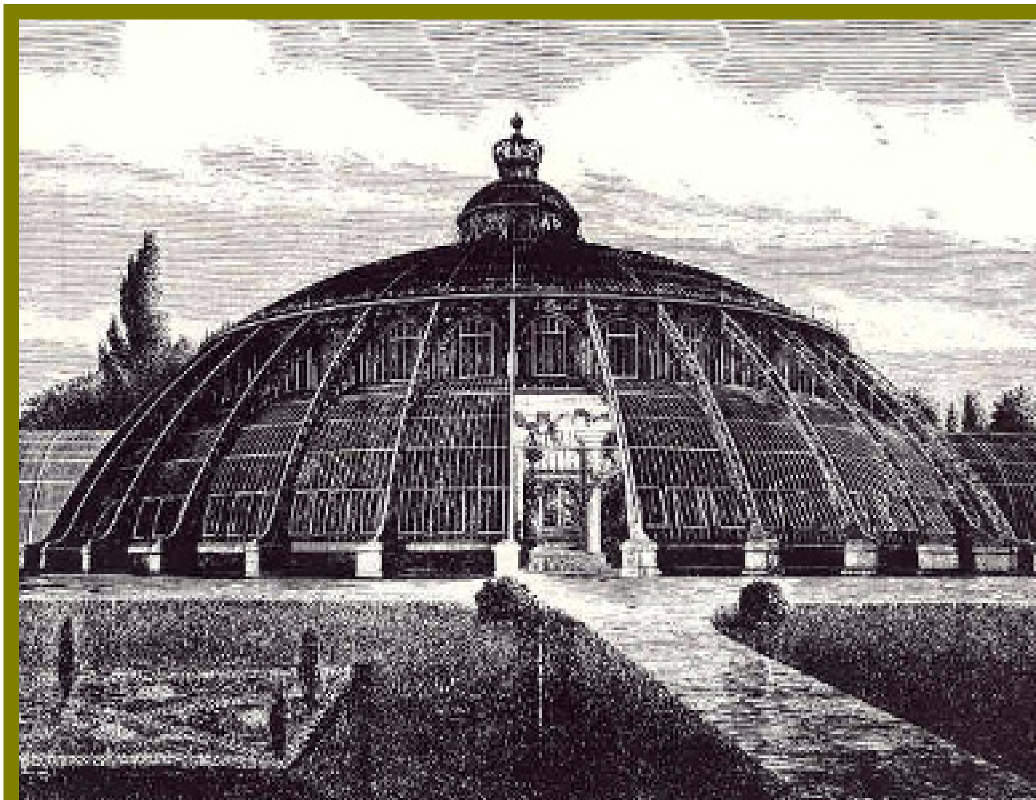
12-HOURS STOVE SYNDICATE

BERLIN HOTEL WINTER GARDENS

Central Hotel, Berlin 1881

Central Hotel Winter Garden

BRUSSELS WINTER GARDENS



The Winter Gardens, Brussels c.1876

The central heating plant was built next to the winter garden, with a chimney capped with a minaret. Three miles of pipe, covered with cast-iron gratings, are housed in channels in the ambulatory of the circular building and exposed in the wings along the walls. Double glazing is used. In the upper part of the dome it is fixed to the outside; in the lower part it is on the inside, so that the space frame can be seen from the outside. This arrangement brings about a sense of excitement when one sees the proportions between the continuous glass skin of the upper part and the glass surface broken into segments by the ribs of the lower part of the dome.

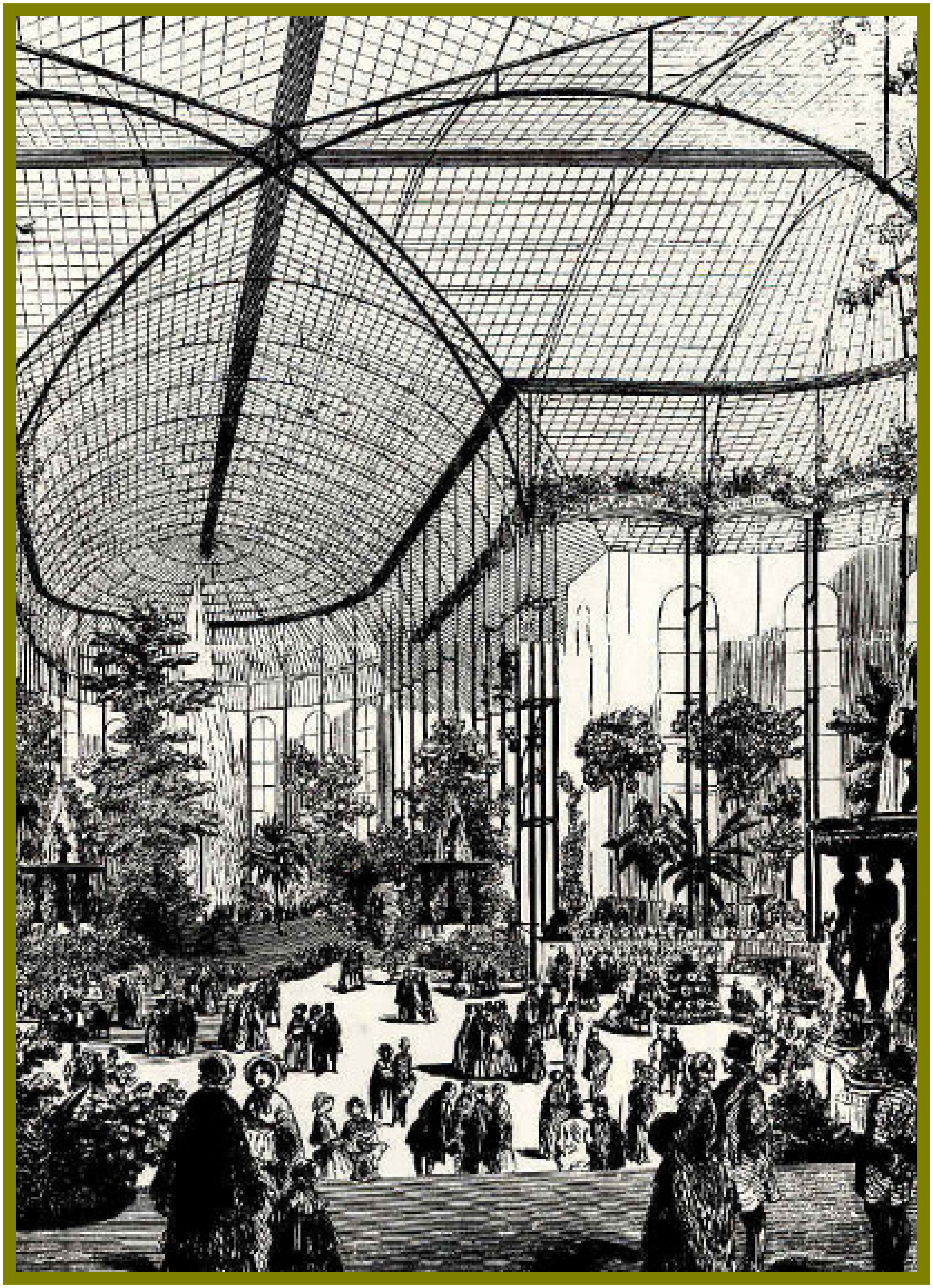
MUNICH GREAT PALM HOUSE

Great Palm House c.1865 (Note the smoking chimneys)

MUNICH GREAT PALM HOUSE

The boilers were accommodated in the basement of the building. The hot-water pipes were laid 2 feet deep in brickwork channels, covered by iron gratings. To bring the cold air descending at the outer walls into the circulation system, there were branching channels leading off the main ones toward the basement wall and discharging hot air there. These too were covered with iron gratings. The entire heating plant was made by Haag of Augsburg. A contemporary observer noted that "the ventilation must be more powerful in the tropical houses than in the temperate houses. To this end the basement wall is pierced every [9 feet, 4 inches] by openings [12 inches] wide and [6 inches] high, which can be closed with cast-iron shutters. In addition, the sliding glass panes in the upper ring of the palm house's dome can be moved by mechanical means. There are also two ventilating louvers in each of the east and west walls at the level of the upper gallery. To renew the air in the tropical and temperate houses there are further openings in the north side masonry wall below the lean-to roof, which communicate by conduits with the outside air and which can be closed from the inside by shutters. A window on rollers on the south wall of the temperate house can be moved in each space between the sash bars; in the tropical house only half of the area has this arrangement."[127]

PARIS WINTER GARDEN

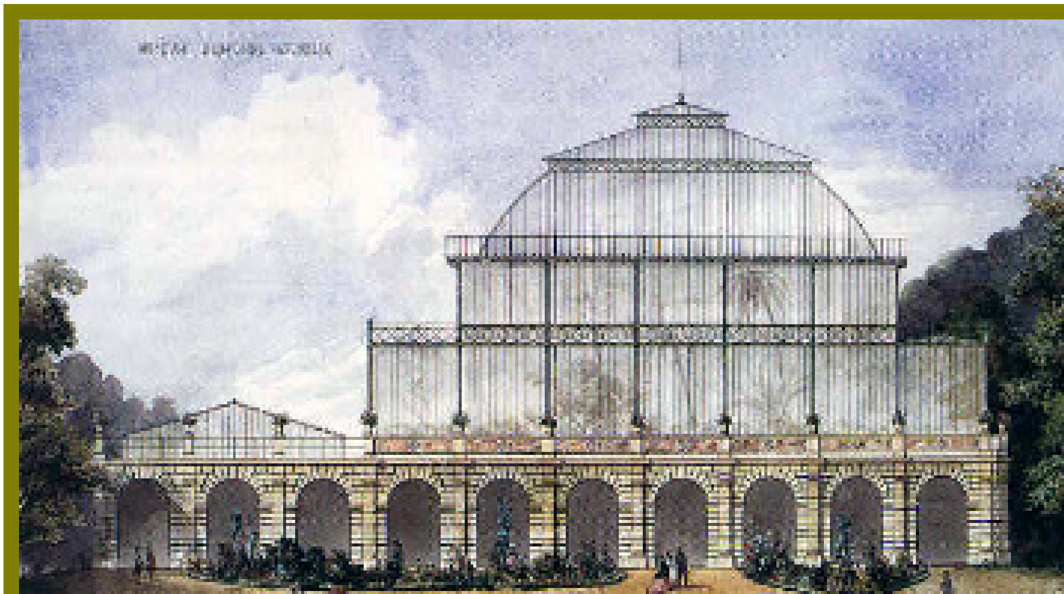


Jardin d'Hiver, Paris 1853.

PARIS WINTER GARDEN

The tropical plants in the left pavilion and its wings, particularly the palms, needed a minimum temperature of 15°C. The right pavilion, intended as a temperate house, required a minimum temperature of 5°C. The main heating system was a steam system; a warm-air system was used as a supplement. Boilers with hot-water pipes and two steam boilers served to generate the heat. The former were installed in the basement behind the left pavilion. The heated air was ducted in through tunnels to the glass fronts and expelled upward at a temperature of 50°C. To prevent the plants from drying out, the hot air was humidified by passing it over a pool of warm water before it entered the hothouse. The two steam boilers were installed in the foundations below the hot-water boilers. The steam was fed through copper pipes in four 4-inch-diameter cast-iron tubes, which had a slight slope so that any condensed water could flow back to the boiler. The pipes ran along the facade in a channel covered with cast-iron gratings. A water-spray installation contributed to the environment. Rotatable ventilating flaps driven by a rod in the middle, and opening windows in the glass skin, provided ventilation. The windows in the lantern also had similar actuating shafts, which were operated by chains. The conservatories were single glazed.

PARIS WINTER GARDEN



Proposal of 1854

The structure of the building is a simple one, but neither in technical nor in artistic aspects could it be called perfect. All the ironwork is painted white, which is highly deleterious to the base columns. A gallery runs all round the winter garden, above the columns, which is used partly to display plants aloft, partly to provide the best means of distributing the artificial rain, finally to carry the candles and other forms of illumination used on great festive occasions. Gas is not used for lighting because it has been found to have a harmful effect on the plants. The illumination is by wax candles. Were the company in a better financial state, it would have by now installed oil lamps or resin gas, which does not harm the plants. Heating is by steam, which is circulated through copper tubes, because the hot-water heating system which was installed initially was not sufficient for this large space. The waterwork system is excellent. It is operated by an 8 horsepower steam engine.

COLOGNE WINTER GARDEN

Botanic Gardens 1864

FRANKFURT WINTER GARDEN

A Perkins high-pressure water heating system was installed for heating. The pipes had a total length of over 10,800 feet, and the heating was by three stoves The side galleries were heated by the waste steam from an engine used in the waterworks in the garden. In 1893 a central low-pressure hot-water system was added to the old heating plant.[71]

Note on the heating systems

REFERENCES AND FURTHER READING

By way of contrast: a modern glasshouse from 2002
The Palm Garden at the World Financial Centre in New York

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