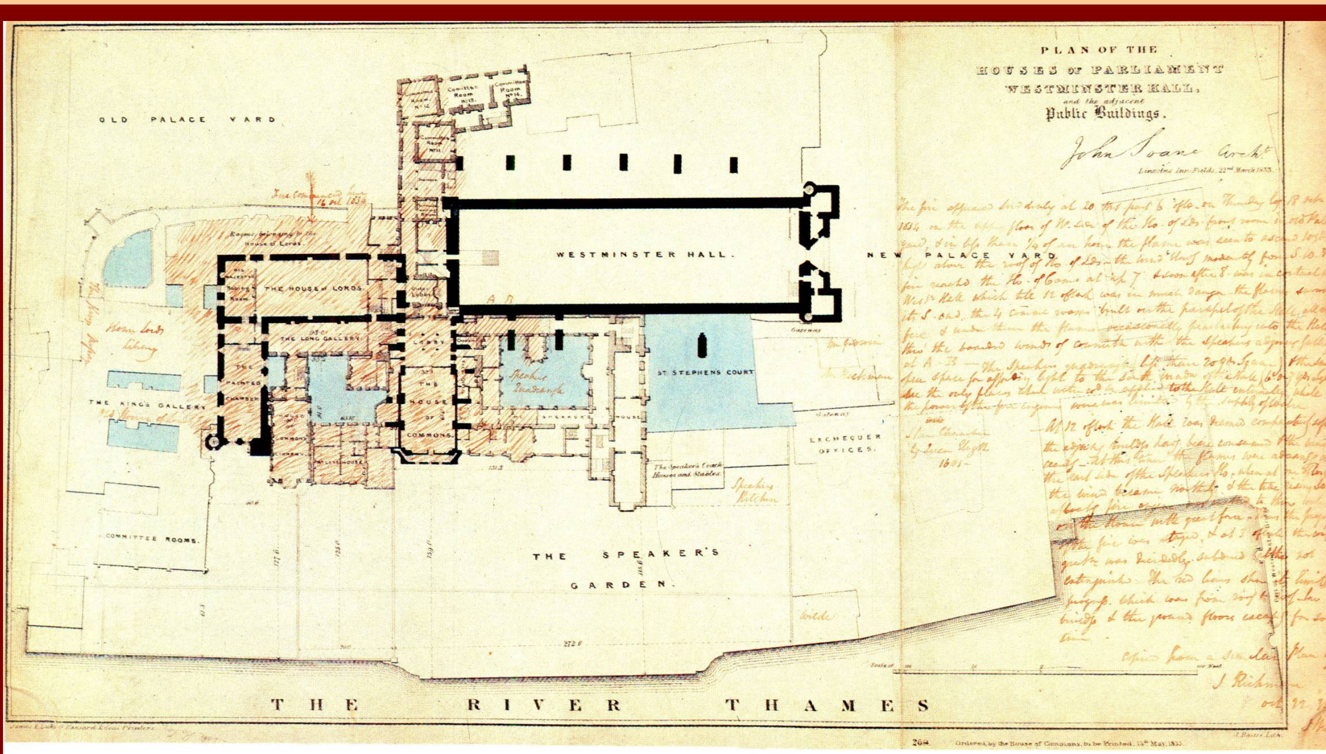
PALACE OF WESTMINSTER



John Rickman's report of the fire of 1834. The shading shows the extent of the damage.

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Nineteenth Century Heating and Ventilation— The Houses of Parliament, London, and the New York State Capitol, Albany

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ABSTRACT
This paper discusses the early developments of steam heating and mechanical ventilation for the Houses of Parliament and the New York State Capitol in Albany. Historically, the study begins with the work of Dr. J.T. Desaguliers and Sir Humphrey Davy on the Houses of Parliament in the 18th and early 19th centuries. The primary focus, however, is on the work of Dr. Boswell Reid after 1834 on the House of Lords and House of Commons and later the work of Thomas Fuller and Isaac Perry on the New York State Capitol in Albany. The paper describes the design of steam heating, air-distribution systems, and filtration as applied to these two early examples of heating and ventilating technology.

BACKGROUND

The technology that has become common to the engineering of buildings today originated primarily with the theories and early developments in heating and ventilating that were developed throughout the 18th and 19th centuries. The experimentation and empirical studies of individuals such as Nicholas Gauger, Benjamin Franklin, Count Rumford, and James Watt contributed a great deal to the understanding of principles of heating and ventilating and created the foundation for the applied technology of the 19th century. Gauger, Franklin, and Rumford's work was primarily in ventilation and efficient stove design. Although steam had been used to distribute heat in 1745 by Col. William Cook, it was not until Watt's experiments on some of the earliest steam heating systems in the 1780s that significant advantages were provided over fireplace heating. In 1791 John Hoyle obtained the first patent for a gravity steam-heating system for greenhouses and churches.

> Col. William Cook first suggested the idea of employing steam as a means of distributing heat, in 1745. Philosophical Transactions, vol. xiii. p. 370, or Abridgement, vol. ix p. 125. It has since been applied in various ways, most of which have been repeatedly secured by patents. The first of these was granted to John Hoyle of Halifax, in 1791, for a method of communicating heat to green-houses, churches, etc. His plan consisted in conveying steam in pipes or tubes, into, round, or through, the place to be warmed: the pipes being first raised to their highest elevation, and then descending with a gentle declivity to a cistern for the condensed steam: the supply of water to the boiler to be regulated by a ball-cock. Repertory of Arts, vol. i. pp. 300-303, old series. This scarcely differs in any thing from Col. Cook's plan, which had been known forty-six years sooner. In 1793, a patent was granted to Joseph Green, whose mode of application was different, and has had the honour of being adopted, with slight alteration of form, by a number of later projectors. His method consisted in passing fresh air through a worm or pipe, immersed in hot water or steam, by which means the purity of the air was to be preserved. When the heat was to be conveyed to a distance, he says, "I inclose the pipes through which the warm air is conveyed in large pipes, to which the steam rises from the

boiler." Repertory of Arts, vol. i. pp. 21, 24, old series. Col. Cook's idea was neglected, no doubt, because it promised too much. Whoever attempted to warm a large suite of apartments by the spare heat of a kitchen-fire would fail; because, so small a quantity of heat is quite inadequate to produce such an effect: but when revived with less pretension, steam was found to be a convenient and economical means of distributing heat.[1]

With the growth of 19th century industrialized, urban society, the "mechanization" of buildings was not only possible, it was a necessity of health as well as progress. In England and the United States, the growing concerns for public health were paralleled by a number of important discoveries in the physical sciences. The discovery of oxygen by Joseph Priestley (England) in 1774 and Carl Scheele (Sweden) in 1773 and experiments on the relation between temperature and pressure, based on the work of Robert Boyle and later work of Jacques-Alexandre Cesar Charles and Joseph Louis Gay - Lussac, led to the invention of the air thermometer, theories of the thermodynamics of air, and the application of these principles to ventilation of buildings. Lavoisier's theories that carbon dioxide is responsible for unhealthy air in confined spaces dominated thinking throughout the 19th century.

As Dr. Boswell Reid observed in 1844:

Before the discoveries of Priestley, Scheele, Lavoisier, and Black, the term Ventilation could have had no distinct and definite meaning, such as is now attached to it. The great lineaments which it presents might then have been unfolded, but the Chemistry of the numerous gases which have since been made known was a blank in the page of science.[2]

Measurements by Sir Humphrey Davy and John Leslie of the content of air and the effects of respiration further contributed to the understanding of ventilation for buildings.

The original heating and ventilating systems for the Houses of Parliament and the New York State Capitol in Albany are examples of the evolving technology of the 19th century that has led to the complete transformation of building design and technology in the 20th century.

The early central heating and ventilating systems of the Houses of Parliament and the distributed heating and ventilating of the New York State Capitol illustrate the changing concepts, innovative attitudes, and technological developments from the beginning to the end of the 19th century.

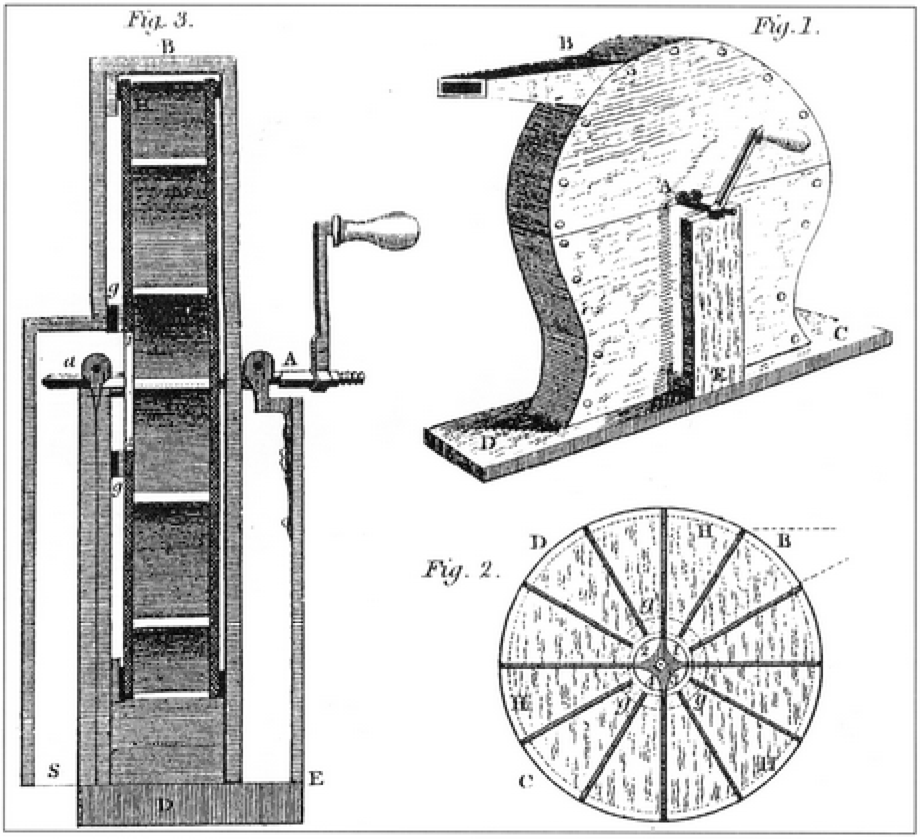
Much of this research is based on previous work on the history of HVAC in the Albany State Capitol done as part of the historic structures report for the restoration master plan. For the extensive research and documentation, the author must thank Pamela Hawkes and Wesley Haynes. Research on the Houses of Parliament was derived primarily from the library collection of the history of science and medicine at Yale University in New Haven.

THE HOUSES OF PARLIAMENT

One of the original fan ventilating systems for the Houses of Parliament was designed by Dr. J. T. Desaguliers in 1734, the earliest of which was operated in the House of Commons for many years. It was a paddle wheel type fan, seven feet in diameter, with one-foot-wide radial blades rotating in a casing.

Previous to the appointment of the committee on acoustics and ventilation, the state of the atmosphere in both Houses of Parliament appears to have again and again attracted attention from the time of Sir Christopher Wren to Sir Humphrey Davy. Numerous references are made to the condition of the air in the House, which is often described as foul, rancid, or pestiferous. I understand from Mr. Bellamy, that so late as in 1790, charcoal braziers were used for heating the House, no means being taken to carry off the carbonic acid produced before the members assembled.[3]

In 1811, prior to the burning of the Houses of Parliament, Sir Humprey Davy had taken over the responsibility of improving the ventilating systems. Davy introduced numerous holes in the floor to



46. *Fanning Wheel of Dr Desaguliers, 1735. Used in the House of Commons, where the term ventilator was used to describe the man employed to turn the crank handle which operated the fan. Philosophical Transactions (abridged), VIII, 1735, plate II.*

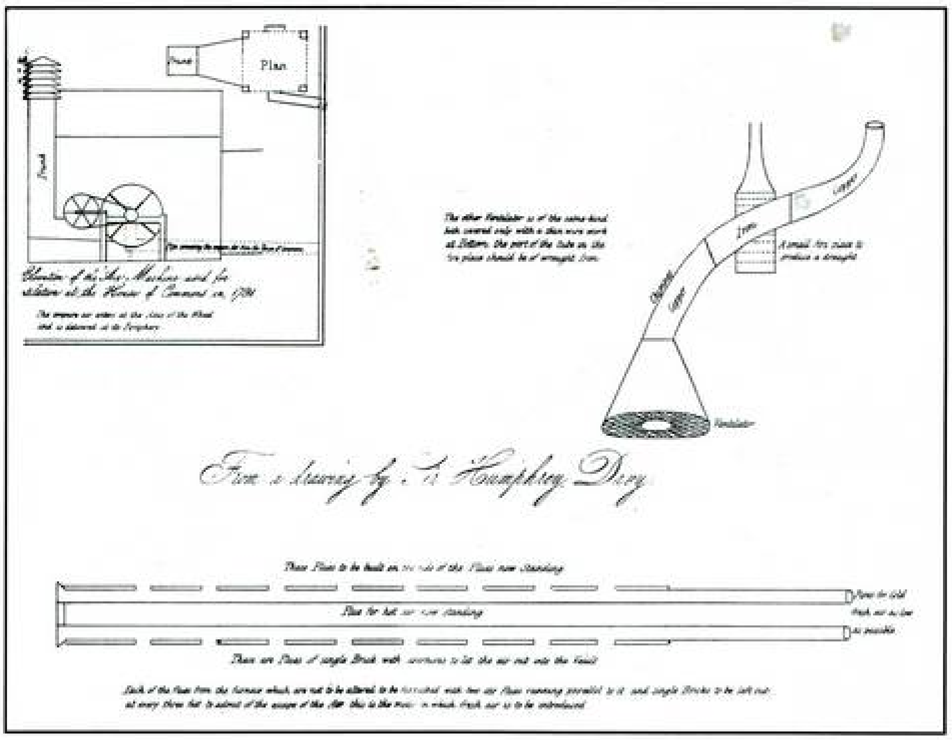


Figure 7-3 *Sir Humphrey Davy, ventilation for the House of Commons, 1811 (from C.J. Richardson, 1837).*

distribute heat more evenly throughout the rooms and installed ceiling screens with heated metal tubes to accelerate velocity of the upward air movement and increase the overall ventilation. The Marquis de Chabannes later provided steam heating for the House of Commons, based on theories from Sir Thomas Tredgold's Principles of Warming and Ventilating Public Buildings published in 1836.

> The progress of Ventilation received a great impetus from the appointment of a Committee of the House of Commons, on Acoustics and Ventilation, in the year 1835, on the motion of Benjamin Hawes, Esp., M. P. Numerous parliamentary documents, not only connected with the Houses of Parliament, but also with other Public Buildings, with private Dwelling-Houses, and with Mines, Ships, and Manufactories, shew the extent to which it has lately formed a leading object of consideration. It constitutes one of the most important items to which the attention of the Health of Towns' Commission is directed. The various statistical and sanatory reports that have been issued from the Home Office, and from the Medical Departments of the Army and of the Navy, under the direction of Sir James M'Grigor and Sir William Burnett, add much interesting information on the same question. And, if we look to the medical profession generally, the observations of Sir James Clarke on Consumption, and on the Sanative Influence of Climate, the remarks of Dr. Combe, Dr. James Johnston, Dr. Forbes, Dr. Southwood Smith, and numerous others, and the ingenious suggestions and improvements introduced by Dr. Arnott, all shew how broadly the necessity of improved Ventilation is appreciated, more especially since Tredgold had the merity of placing this subject in a more consistent position than it had ever previously presented.[4]

The subsequent development of techniques for heating and ventilating reached a much more sophisticated level of complexity in the systems designed for the Houses of Parliament by Dr. Boswell Reid, a professor of chemistry. With the burning of the Houses of Parliament in 1834, and their later rebuilding according to the designs of Sir Charles Barry and Augustus Welby Pugin, Reid was commissioned to improve upon the previous heating and ventilating systems.

As Reid himself commented in 1836:

> Perhaps no buildings have been subjected to such numerous experiments as the Houses of Parliament, to which Sir Christopher Wren, the Marquis of Chabannes, Mr. Davies, Sir Humphrey Davy, and many others, directed their attention; and it may afford some clue to the diversity of practice if it be remembered that the area of discharge provided by Sir Humphry Davy in the present House of Commons (at that time the House of Lords) was one foot, whereas at present it is fifty feet.[5]

Some of the principles of ventilation that Reid had derived from Tredgold are illustrated in the following discussion:

> The power of ventilation in a room should obviously be adapted to the greatest number of people it is supposed to contain at one time; and it is obvious that we had better err in excess than defect. Perhaps, however, a few examples, in round numbers, will afford my readers a more distinct idea of the quantity of air it is desirable to exchange in a minute in a crowded room. We have found (art. 61.) that there should be four feet per minute for each individual: therefore, when a room contains 200 people, there should be 800 cubic feet of air changed every minute; or a little more than would fill a room nine feet square and nine feet high. For 400 people, there should be 1600 cubic feet of fresh air every minute, to preserve the air from becoming vitiated; and so on in proportion. When we consider the actual ventilation of crowded rooms, it will not appear wonderful that they feel oppressive and disagreeable. And in estimating these quantities, if we have not been very strict in taking the lowest results, neither can we be assured that any ventilators will be of that perfect construction which would be necessary for the noxious part alone to be removed; and, therefore, the balance of purity will be barely sustained.[6]

Reid introduced air conditioning, artificial humidification, and chemical air purification. Use of a large chimney to create induced ventilation significantly improved system performance and, most importantly, air quality. The chimney was 120 feet high, 8 feet in diameter at top, and 11 feet in diameter at bottom and provided a ventilating capacity that was estimated at an equivalent of 25 hp. The grate for the fire that induced this ventilation was 25 ft^2 in area.

> Fig. 221 gives a connected view of the different points referred to in the preceding paragraphs; (a) the vitiated air from the drain in Old Palace Yard, controlled by the underground ventiduct, and conveyed directly to the shaft; (b) the fresh air entrance when the air is taken from Old Palace Yard, with suspended fibrous veil, 42 feet by 18 feet, for excluding mechanical impurities; (c) temporary apparatus for moistening or washing the air; (d e) the hot air chamber communicating with (e), the lower air chamber, which receives warm, cold, or mixed air, according to the temperature required; (f f) deflectors for diffusing the air in the equalizing chamber (g g); (b b) the supply for the galleries conveyed from (g), by the channels between (b) and (g); the dotted lines above (y), and below (z), shew the flow and return-pipes from the hot water boiler, which is placed at (x), and supplies the hot water apparatus in (d e). The large arrows from the ventilating chamber (B), indicate the progress of the air to the ventilating shaft, while small arrows indicate the discharge of vitiated air from the libraries and various other places in the vicinity of the shaft. (A) indicates the external windows; (C C) the original altitude of the ceiling; and (D) the vitiated air channel from the House of Peers, communicating ultimately with the shaft that ventilates the House of Commons.[7]

Fresh air was brought in through louvered openings from the courtyards on both sides of the house. The air was filtered and purified by a filtration system that Reid employed, called Guy Fawkes' vault. It could filter, wash, and chemically purify the air by soaking numerous guaze filtering screens with chlorine, carbonic acid, or nitrous acid.

In addition to air purification, the artificial humidification of ventilating air was first attempted by Reid in 1836. Reid goes on to describe the scheme of that year:

> A chamber was provided for moistening, drying, cooling, and producing other alterations in the air, besides those effected by the hot-water apparatus. This chamber was provided from the commencement, and on one occasion, shortly after the House opened, subsequent to the completion of the ventilation, seventy gallons of water were evaporated at a single setting.[8]

The air was filtered through a veil, 42 ft long and 18 ft, 6 in deep; it was introduced into the chamber through nearly a million holes in the floor and was similar to the arrangement made by Davy. In addition to his understanding of chemical purification of ventilation air, Reid was one of the first to conceive of air purification in large cities, where he proposed adopting the following measures for air purification:

- exclusion of soot by filtration,
- washing,
- washing with lime water and the addition of ammonia (to neutralize acids),
- addition of chlorine or nitrous oxides to decompose animal or vegetable matter,
- warming by steam or other means.

During the cold and damp periods of fall and winter, heating was provided in both the House of Lords and House of Commons by batteries of steam heaters, or steam cockles, as they were called. These steam cockles were based primarily on the designs originated by Watt. The House of Lords was heated by two steam "cockles" located at the air intake to the equalizing chamber (see illustration). The House of Commons was also heated by two steam "cockles," but they were located to allow for full or partial heating of outside air to allow greater control of space temperatures. For cooling the House of Lords and House of Commons were provided with rows of large blocks of ice across which the air was passed. Although the cooling effect was relatively small in terms of lowering temperature, the reduced humidity made the long Parliamentary sessions more bearable. The air was brought into equalizing chambers, or plenums, where it was heated or cooled.

A series of large, manually operated, air intake dampers controlled the mixing of outside air with the heated air to maintain desired temperatures.

The air, from the principal drain in Old Palace Yard, which contaminated the air entering the houses, was controlled and conveyed away by an under ground ventiduct communicating with the shaft.

Numerous other sources of offensive air were controlled in the same manner.

The quantity of air supplied to the House of Commons was placed under the control of a single valve, so that the movement could at any time be arrested at a moment's notice, or adjusted to any proportion between zero and the highest power that can be commanded.[9]

The air was discharged to the room through grilles beneath the various rows of seats in the House of Commons.

Portrait of Sir Charles Barry by H. W. Pickersgill.