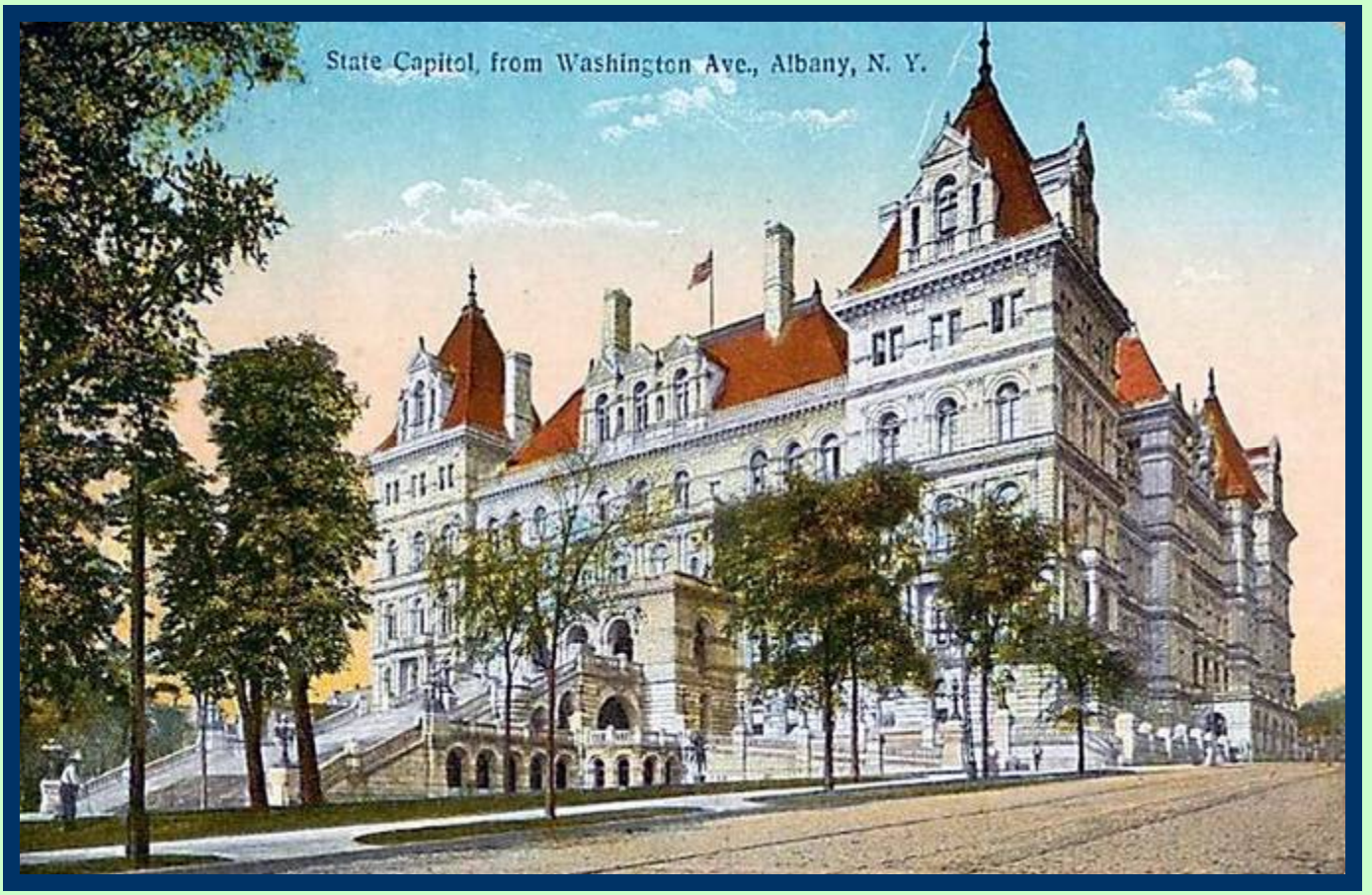
NEW YORK STATE CAPITOL, ALBANY



The massive central tower was never built

THE NEW YORK STATE CAPITOL, ALBANY

Early Systems

The designs of heating and ventilating systems for the New York State Capitol in Albany were to reflect many of the most recent innovations in technology during the later half of the 19th century. "The establishment, within a few years after 1850, of the science of thermodynamics on the basis of the dynamical theory of heat through the geniuses of Joule, Rankine, Clausius and Thomson, marked a dramatic reversal in the comparative states of science and technology. After 1850 science was decisively in the lead.[10]

The early concerns of the Capitol commissioners with heating and ventilating the new State Capitol were noted in the circular for the 1866 design competition, which directed that "special attention must be given to the best mode of ventilation, heating and lighting; and apparatus for the purpose which requires the use of steam power to be placed outside of the building." The commissioners further stated that, "In addition to any other mode of heating that may be proposed, the system of open fire places is considered desirable," and a writer for the New York Evening Post commented, somewhat ironically, that "the sad experience of the last quarter of a century, during which many members of the legislature have been disabled and hurried to the grave by the pestilential atmosphere of the chambers appears to have fixed the commissioners in the purpose to secure ventilation by the old-fashioned fire place till the discoveries of the science hall have provided sure means of relief in other ways[11].

These sentiments notwithstanding, Thomas Fuller reported that:

> It is intended that the air which is admitted to the legislative, judicial and some of the other large chambers shall be prepared in regard to purity, temperature hydrostation and pressure before it is sent from the reservoirs, so that it will enter these chambers in the best condition for comfort and health. The vitiated air will be carried off in separate ducts before it has had time to mongle with the pure air admitted.[12]

Fuller ended his description by expressing confidence that "the plan which will be developed will render this one of the best ventilated public buildings in the world."[13]

On April 3, 1878, with the north section of the building nearly complete, a contract for "steam heating apparatus" was signed with Federick Tudor and Company of Boston.[14] Frederick Tudor was a ventilating engineer who later designed mechanical systems for the Metropolitan Opera House (1883) and the Union League Club (1887), both in New York City. A brief article in Scientific American that same year described the Capitol system in some detail:

> The space to be provided for is 300 by 400 feet, 100 feet high, and the cost of the system is to be about $30,000. The engineer in the basement will have entire control of the atmosphere of the

Architect Thomas Fuller, 1823-1898 (born Bath Somerset)

building, and will be supplied with indicators showing the temperature of every room in the edifice, and in the case of the two large assembly rooms that temperature of different parts of the rooms. After being drawn over the boilers by two 8 foot 3 ton exhaust fans, the air supply passes through two steam coils having a surface of 10,000 square feet each. Thence it goes to a chamber where it is mixed with cold air until the requisite temperature is attained, when it is caught into the blowers for distribution through large zinc tubes. By a movement of the damper determining the flow of hot and cold air to the mixing chamber, an even temperature will be secured. The system will be operated by six 54 horse power Buckeye condensing engines to work the fans. The engine will have a 14 inch cylinder, 28 inch stroke, and will run at 15 pounds pressure. As an offset to the cooling surface of the many 5 by 15 windows, pipes are run behind the mop boards and will throw up from regular vents radiation from live steam.[15]

Air was circulated through vertical masonry flues located within the walls and entered the chambers through bronze wall grates, which were supplied by M. Delahanty and Son of Albany. Exhaust air escaped through chimmney stacks that had been made part of the decorative scheme at the roof level. The decorative chimmneys in most of the offices appear never to have been used as hearths, despite the earlier suggestions of the commissioners. American Architect and Building News called this "a very economical method," and the system was quite similar to that designed in 1855 for the newly enlarged U.S. Capitol under the direction of Joseph Nason.

Criticisms

A critique of the Albany Capitol system was published in the February 1879 issue of The Plumber and Sanitary Engineer by Robert Briggs, an engineer who had designed the fan system used at the U.S. Capitol and was a "recognized authority" on heating and ventilation. He agreed that the heating apparatus should be sufficient but stated that the fans provided would generate "a very inadequate air supply." Declaring that "the distribution of heat from a central point by currents of air of controlled and uniform temperature" had been considered a "novel method" 20 years before, he raised the following objectives:

> To satisfy the requirements of exposed rooms, which in common with others, are to derive their heat from the air currents, these currents must have a temperature above the comfortable point for free ventilation in less exposed and more fully occupied chambers, so that the latter will have their air supply limited, not by the calls for ventilation, but by the necessity of not over-heating. To ensure the desirable supply of air for heating or for ventilating in all the rooms, where a register control for each or many of them is placed in the hands of the occupants of the rooms, there is demanded very judicious, to say the least, construction of the ducts; while to force the temperature of the air currents in extended ramifications, there will be called for some hitherto unattained excellence in guarding against loss of heat by conduction of walls, or whatever material, zinc not excepted.

Briggs then said that if the air supply was not to be varied and "the engineer in the basement" to have complete control, disturbances within adjacent rooms of different sizes and uses would still be inevitable. He further wrote:

> The provision of auxiliary heating surfaces to meet the cooling effect of high windows and to intercept the currents which they establish in a room is of unquestionable utility. But pipes, heating or otherwise, "behind mop boards," cannot be admitted to form part of any well devised arrangement. If it is wished to place coils or "radiators" at the bottoms of the windows, a hinged panel can be made to close them in, and the construction must admit of their existence.[16]

Frederick Tudor also provided gas and steam fittings for the south portion of the building in May and June of 1880. The completed system was described in some detail in 1884 by historian H. G. Phelps who wrote:

> The Heating Apparatus for the whole building is placed under the central court, in the cellar, where are two batteries of six steel boilers each or twelve in all, aggregating 650 horse power.

There are two principal heating chambers, containing together 60,000 square feet of heating surface; two engines, with an automatic cut-off gear, of 200 horse power each, with connections so that either or both can be used; two large steam pumps for the elevators and two feed pumps. The engines furnish power to four ventilating fans of a united capacity of 20,000 cubic feet of fresh air per minute. There is also an exhaust fan, which forces out foul air from the flues that do not have a natural draught, which has a capacity of 90,000 cubic feet per minute. Of the supply fans, one is for the Senate, one for the south side and wings, 132,000. These quantities are capable of being increased by a greater speed of the engines, which is sixth revolutions per minute. Besides the main heating chambers, where the entire air is warmed, at each window, in the floor is a marble slab, seven feet long and two feet wide, heated by steam pipes beneath it. These merely naturalized the effect of the large cooling surfaces of the windows, which are five feet by seventeen feet in dimensions. These slabs alone are nearly sufficient to maintain the temperature of the rooms. As the supply of air is constant, means are provided for regulating its temperatures, to prevent over-heating. This is done precisely as water is tempered for a bath, and it is not often that air is supplied over eighty degrees except for rapid heating up. The entire air supply to the Senate chamber is through registers in the floor and concealed openings in the bases of the furniture. In both Senate and Assembly the removal of foul air is from the top of the room, and the quantity of fresh air supplied per person, including all possible occupants of the galleries, is up to the standard required by the best authorities.[17]

Improvements in the 1880s

As construction work progressed and additional areas of the building were occupied, the system was expanded. Isaac G. Perry devised a system combining the existing indirect steam heat with auxiliary direct heating and described the improvements in his Annual Report for 1885:

The steam for warming this portion of the building is suppled by two lines of pipes, each ten inches in diameter, which connected with the boilers under the building....These pipes are continued through the corridors running north and south, and supply steam to all the rising lines and branches connected with all the direct radiators throughout the western section of the building.

Two lines of steam pipe, each eight inches in diameter, extend to the two western courts. Each line is supplied with an eight-inch gate valve ... to furnish the steam for the indirect radiators and engines for driving the fans for forcing the warm air through the flues to the various apartments for warming and ventilating the western section of the building.

These lines of pipes are provided with all the necessary reliefs to carry the water of condensation to the return pipes as fast as the condensation takes place. The steam pipes are thoroughly covered with an asbestos covering to prevent the radiation of heat and the unnecessary condensation of steam in the basement.

The rising lines and branches for supplying the direct radiators with steam are fitted with gate valves in the basement, so arranged that steam may be shut off from any portion or all of the direct radiators of the western section of the building. The warm air furnished by the indirect radiation will be sufficient to warm all the apartments, except in extreme cold weather. Tubular radiators have been placed under each window on the ground and gallery floors. The rooms on the entrance and principal floors are provided with radiators, each 2 by 9 feet, placed on a level with the floors under each window. The vertical and floor radiators are connected to steam and return pipes, all properly fitted with valves. Automatic air valves are also placed on each of the radiators, which discharge the air through pipes connected with the drains in the basement. By this means the foul air will not escape into the rooms.

The corridors are supplied with seven radiators continuing a total of 810 square feet of heating surface, which run directly from the basement of the points where the radiators are placed, and are connected with the high and low pressure steam.

Isaac G Perry, 1822-1904

These four lines of return pipes for the western portion of the building are each six inches in diameter, and connect with the boilers. Two of these lines extend from the boilers the entire length of the western portion of the building, and convey the water of condensation from the various steam lines and direct radiators to the boilers by gravity. The other lines of return pipes run directly to the boilers through the two western courts. These lines of pipes return the water of condensation from the main steam pipes and direct radiators in the staircase, and are made ready for the attachment of the indirect radiators to be located in chambers, from which the warm air will be supplied and forced into the apartments by two fans for warming and ventilating all of the western section of the building, when the system is fully completed.

The three lines of steam pipes supplying the steam for the eastern portion of the building have been disconnected and gate valves put in, so that the heat could be regulated. Eight radiators of 780 square feet have been placed in rooms of the fourth story of the east end.

A line of five-inch water pipe has been connected with the water meter, and extended the entire length of the west end of the building, for the purpose of leaving in equal distribution of water at each point where rising mains are taken up to the upper story. There have been used in the western section of the building something more than 26,000 feet of steam pipe.[18]

At the time of the expansion of the steam heating system, the increased capacity and complexity of the system and defects in the earlier plans had strained the capacity of the heating and power plant to a point where the health and safety of the building occupants were in danger. The main heating and power plant in the basement had never been well integrated within the building program and the system was proving costly and inefficient to operate.

Even more dangerous was the boiler system itself. Regulating valves were hidden by piles of coals in the basement coal bunkers. Faulty rivets and joints in the boilers and steam connections posed a constant threat of explosion, and, though the boilers were rated as capable of withstanding pressure of 110 lbs per square foot, the engineers never qualified them to exceed 75 lbs per square foot.

Superintendent of Public Buildings Andrews had called Governor Cleveland's attention to the matter in 1884, and, although Cleveland had suggested to the legislature removing the power and heating plant to a location outside the building, the proposal died in committee. The issue was renewed with more vigor by the Assembly Ways and Means Committee to select a site and erect thereon a boiler-house, coal sheds, and necessary appurtenaces; to remove threat to the boilers now in use in the basement of the capitol.[19] Andrews purchased a plot of land on Hawk Street, 300 feet north of the Capitol and extending back 165 feet on Lafayette and Elk Street.

On February 5, 1886, Superintendent Andrews reported to the legislature on the progress of the work, recommending an appropriation to "fit up the space left after the removal of the old boilers for better accommodation of the electric light plant" and for the purchase of an auxiliary electric engine.[20] The new power plant was complete by January 28, 1887, when Superintendent Andrews, Engineer W. J. Norwood, and Electrician William McDonald invited the press to tour the facilities.

Ventilation

No sooner had the problem of faulty boilers been solved, when ventilating defects became evident. During the winter of 1885-86, five workers from one department in the Capitol building were treated for health problems linked by the State Board of Health to "the unwholesomeness of the rooms of the Capitol."[21]

A detailed report, including plans prepared by Perry and approved by the State Board of Health, was presented. Perry proposed placing convective flues throughout the building, many in existing chimneys. For the Senate chamber, he proposed cutting stone and brick walls on the corridor side to enlarge the two chimney flues and extend them up through the attic by galvanized ducts. Coils of steam pipes placed in the ducts would create the draft. In the Assembly chamber, metal conduits placed in the existing northwest chimney flue would draw the air out. A system of horizontal ducts

below the corridors, connecting vertical ducts and pipes drawn by fans, was proposed for offices in the northern and southern sections. The committee recommended having the plan checked by two expert engineers before implementation.[22]

Again, no action was taken on the report, but the problem did not disappear. On March 13, 1889, the Board of Health submitted to the Assembly virtually the same report it had made 22 months earlier.[23] The second report further proposed reconstructing the deteriorated sewer and drainage systems.

The ventilation and drainage plan was implemented by Perry with great success. (Supervising Commissioners of the Capitol 1891). Among the space renovated were the Assembly Chamber and related suites. Perry described the new systems as follows:

> Under the arches and directly in front of the windows on the north side of the Assembly Chamber and under the Speaker's rooms are placed and connected ten stacks of radiators, containing a total of 2,464 square feet of indirect radiating surface. The supply and return pipes for this heating surface have been carried directly from the main steam supply and return lines in the basement with valves, and connected to each and all sections may be shut off and under the Assembly Chamber floor, or the entire surface shut off in the basement in the main supply. The fresh air supplies to this indirect radiation are taken from large openings cut through the main walls of the Assembly Chamber, and the air is brought under the indirect radiators and warmed by passing over the heated surfaces and discharged through registers into the rooms. Louvers for controlling the fresh air have been built into the walls and are operated in the same manner as those in the court room below. About four thousand feet of steam and return pipe has been used in this work. In order to furnish steam for the required heating surface, it becomes necessary to enlarge the main supply pipe for a long distance in the basement from four to six inches in diameter.[24]

The added equipment included about 12,000 feet of additional heating surface; two six-foot fans run by a 30 HP engine; and seven motors and fans located within the ventilating shafts.[25] On January 26, 1891, Dr. Lewis Balch, secretary of the State Board of Health, reported that an anemometer test revealed "the air in various apartments was being changed at an average rate of once an hour, the results being better than expected without the aid of mechanical appliances."[26] All the work was not complete at that time, however, for the extensive amount of cutting through solid masonry had slowed reconstruction of the ducts.[27]

The improvements made to the Assembly chamber required extensive alteration by 1897. The problem stemmed from the source of the air supply and difficulties encountered in maintaining the 1890 system properly. Air supply was still drawn down from the roof into the central courtyard to the heating coils located in the basement, passing near the lavatory ventilators which fouled the air.

While circulating through the basement, the air picked up the smell of oil before being directed to the Assembly chamber. Furthermore, wire cloth screens intended to filter the air were located in the space below the chamber floor and difficult to service. The floor registers themselves had become, according to Perry, receptacles for "cigar stubs, partially smoked cigarettes, tobacco quids, expectorations and the sweepings of the floor, thereby making a poisonous combination which so impregnated the air as to render it unwholesome and liable to cause serious illness."[28] To correct the problem, Perry and engineer Norwood removed the existing indirect radiators below the floor at the north end of the chamber and installed plenums, or "commodus air-chambers," and new radiators to better control the temperature of the air. Fresh air was drawn directly into the "heating room" by a new roof-mounted air intake approximately nine feet in diameter and distributed above the Assembly chamber ceiling by two main inlets that branched out to eight ceiling registers. The registers were fabricated in copper to resemble the carved ceiling panels. The size of the exhaust flues in the chimneys was increased and a new, larger ventilating fan installed to produce a complete change of the air in the chamber every ten minutes, or a total of 4,000,000 cubic feet of air per hour. This new system also served the rooms of the speaker, clerk, and eastern lobby, and was one of the first examples of automatic control by means of thermostats in the Capitol.[29]

A similar heating and ventilating system was installed in the Senate chamber at the same time. Fresh air was drawn in from window openings on State Street, "where vitiation from dust or other impurities is impossible owing to their great height from the street," by a nine-foot-diameter fan, then mixed in a heating chamber containing four steam-heating coils. Distribution of the heated air was through the ceiling registers; exhaust continued to exit through the chimney flues. Some 3,000,000 cubic feet of air was exchanged each hour through the Senate chamber and its third and fourth floor lobbies.[30]

Seven committee rooms for the Senate and the third and fourth stories of the tower were also overhauled in 1897 with new heating and ventilating systems. The treatment given these rooms by Perry and Norwood was to draw fresh air into the rooms through new openings or "apertures" (sic) cut through the exterior walls below the windows. The air was warmed by steam radiators, then exhausted through new vertical metal flues introduced into the brick partition walls with two registers, one near the ceiling. The second-floor exhaust flues were connected at the top by a large horizontal duct extending from the Senate staircase to the chimney located in the southwest corner of the center court. The ductwork in the tower area was located ablve the rooms serviced, leading to a ventilating shaft. In both cases, to conceal the ductwork, Perry installed "paneled and molded sheet steel, supported on rolled steel "I" beams beneath the old ceilings." This approach marks the first introduction of a dropped ceiling in the capitol to conceal mechanical equipment. Although this system has since been rendered obsolete, an example of the pressed metal ceiling survives today in room 401.[31]