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Reid's short-lived ventilation system for the Permanent Houses of Commons, 1847-54

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Introduction

Between its inauguration in February 1852 and its full destruction by German air raids in 1941, the ventilation system of the Houses of Commons underwent a series of transformations. The original system, designed by the Scottish physician David Boswell Reid, was only used for fourteen months before it was radically transformed by another physician, Goldsworthy Gurney. The design of Reid's short-lived ventilation system in the Houses of Commons has not previously been studied by historians. Studies by Sturrock, Brucemann, Riding, Banham, Collins, Hawkes and Bruegemann, Cook and Port situate the ventilation of the Palace of Westminster within the broader history of environmental design and provide broad overviews of its development [1], but none of these studies discussed Reid"s design for the Permanent House of Commons. Archival research undertaken by the author has shown that its design was distinct from those Reid had deployed in the Temporary House of Commons or the system by which it was replaced in 1854 [2]. It was a more sophisticated system, designed to overcome some of the limitations of the simpler stack ventilation system previously tested in the Temporary House. Over two years, the ventilation had been continuously monitored and subject of numerous scientific studies, yielding detailed insights into its performance. This is the first study to reconstruct the design and performance of Reid"s design for the Permanent House of Commons and the influence of the Temporary Houses. This paper presents a brief overview of the findings of a larger research project undertaken by the author, entitled *Inquiries into the Historic Ventilation System of the Palace of Westminster, 1837-1924.*

Background

The design of the ventilation of the Permanent House builds on a longstanding inquiry starting in the 1830s. Reid presented the concept for a stack ventilation system to the *Select Committee for Ventilation* in August 1835, but was not formally employed to apply his system to Charles Barry and Augustus Pugin"s design for the New Palace of Westminster until 1840. In the meantime, however, he had the opportunity to empirically verify and develop his ideas in a series of temporary buildings, including a model-debating chamber at Reid"s laboratory in Edinburgh and the temporary debating chambers for the Houses of Commons (1836-51) and Houses of Lords (1838-47), before applying them to the actual debating chambers. A study of Reid's experimentation inside the Temporary Houses has been published in *Architectural History* [3]. Between 1840 and 1846, whilst working with Barry"s team, Reid developed a master plan for the ventilation of the Palace. This envisaged a sealed building with air being admitted and exhausted entirely via ventilating towers. Fresh air was to be forced down shafts inside the corner turrets of the Victoria Tower and one larger shaft on the west side of the Clock Tower into the basement with the aid of a steam-driven fan. A third tower, known as the Central Tower, was added by Reid to discharge air and smoke from the entire Palace at a central point. The Palace was based on a „mixed system" in which a fan-driven 'plenum system' was used for the air supply while a „vacuum system" (up-cast shaft) was used for extracting the air [4]. This was a conscious departure from the pure up-cast system of the Temporary House of Commons. Instead of relying entirely on a ventilating stack for providing the motive power for the supply and withdrawal of air, Reid introduced a fan to deal with the supply separately. It was designed to draw fresh air from the top of the two towers, drive air through a network of distribution channels serving the entire building, and gain more control over the quantity of air admitted into the debating chambers independently from the up-cast shaft. The latter was intended to overcome the build-up of negative pressure inside the chamber, an issue that had occurred inside the Temporary House of Commons when the volume of air extracted through the up-cast shaft exceeded the amount of fresh air drawn in through the perforated floor. After six years, however, the process of adapting the architectural plans to Reid"s system failed, mainly due to unsuccessful efforts to establish an effective collaboration between Reid and Barry"s teams. This contributed to serious delays and rising costs. In autumn 1846, Reid"s centralized scheme was abandoned and his responsibility was confined to the House of Commons, while the ventilation for the Houses of Lords and River Front came under Barry"s oversight. Reid"s original scheme was never fully developed, let alone realized, but Reid subsequently employed his original concept to develop his new scheme for the House of Commons, first presented in April 1847. Drawings produced between 1847 and 1851[5] illustrate how Reid had realized his earlier concept within the confines of the House of Commons, including changes that were made following negotiations with the architect [6] Barry's team retained Reid's centralized supply strategy within the areas under its control, but it became physically sealed off from Reid's system in the House of Commons. It had to work independently from Barry's system, requiring Reid to introduce a new arrangement of inlets and discharge shafts. Barry physically divided the central air chamber into two (Fig.1), whereby the House became disconnected from air supply from the Victoria Tower. Reid had access to only one of the original high-level inlets, the Clock Tower. In his original plans the central chamber, forming the core of a centralized air supply serving the entire Palace, was designed as an interface between fresh air passages coming from the Clock and Victoria Tower respectively and was equipped with valves to switch the air supply from one tower to the other, depending on levels of atmospheric pollution. Before discussing the arrangements Reid adopted, it is critical to discuss Reid"s air handling strategy for the Permanent House.

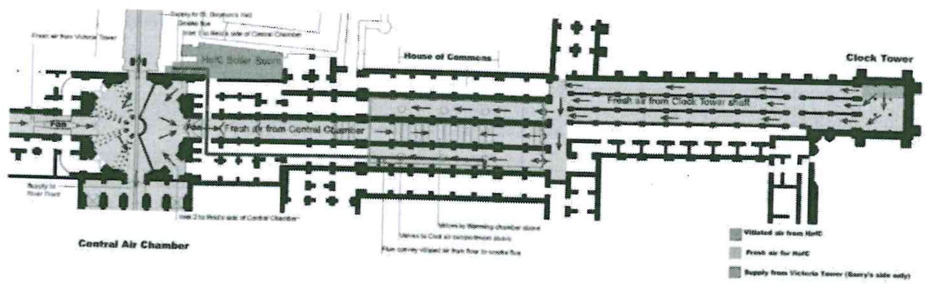

Fig. 1. Floor plans of basement, showing air supply of floor system (drawing: Schoenefeldt).

From a simple ascending mode to multiple modes of ventilation

Since 1842 Reid envisaged adopting a system by which fresh air could be supplied upwards through the floor or downwards from the ceiling. The idea builds on thermal comfort studies Reid had conducted inside his model-debating chamber in Edinburgh [7]. He deployed a system of air channel and dampers that allowed the direction of the air current between the ceiling and the floor to be reversed and in his experiments groups of volunteers were tasked with providing feedback on the sensation of air currents at varying velocities and temperatures. It revealed that if the ventilation rate was high currents admitted through the floor produced an uncomfortable chill, but also that it could be overcome by switching the supply to the ceiling, as it created a greater distance between the incoming air and the volunteers. Reid was unable to implement a reversible system in the Temporary House, which constantly operated in an upward mode with air being admitted through a perforated floor and extracted at the ceiling. This was due to the gas lighting, as air could not be supplied through the ceiling without carrying fumes or heat into the body of the House. Trials with alternative lighting arrangements were undertaken, but the issue was never resolved, and, as will be shown later, this simple ascending mode continued to be an issue in the design of the Permanent House. In the Temporary House, observations and user-feedback verified the potential benefits of a ceiling supply. MPs frequently complained about the chill on feet and legs produced by strong currents rising through the floor, in particular on crowded days when the ventilation rate had to be kept exceptionally high to prevent overheating. Reid revisited these issues in the context of the Permanent House by adopting a system that can be operated in multiple modes, depending on the season or level of occupation. The floor level inlets, which were supplied with air from the Clock Tower, were to be used primarily during the summer months and/or when the debating chamber was exceptionally crowded. It allowed using the basement, through which the air from the Clock Tower was conveyed, to passively cool the incoming air. Reid"s original plans for ventilating the Permanent Houses of Commons and Lords, produced between 1842 and 1845, included a first proposal for a system that facilitated air to be supplied and extracted simultaneously at ceiling and floor level or the whole system to be switched between an upward and downward mode. Sketches of the House of Lords (July 1845) outline a proposal for a system by which air was extracted and supplied at the ceiling [8]. The central row of ceiling panels was intended for the extraction of hot air and two rows of side panels for supplying fresh air downwards. Between 1847 and 1852 Reid realized this idea within the design of the Permanent of House Commons, resulting in a more complex system than in the Temporary House of Commons.

The ceiling system

After 1846, Reid's original idea of using the Central Tower as the principal discharge for the entire Palace was abandoned. Barry significantly reduced its height, arguing that a tall tower, which he also objected from a formal architectural perspective, was no longer functionally required. In his new scheme of April 1847 Reid initially proposed retaining the tall tower he had proposed in the early 1840s, but this time it was intended as a high level inlet for the ceiling supply, while the inlet on the top of the Clock Tower served the floor supply [9]. The Central Tower was also intended to substitute the Victoria Tower as a back-up supply for periods when the inlet on top of the Clock Tower was unusable due to atmospheric pollution. Barry rejected the proposal as he planned to use the Central Tower as an up-cast shaft for the House of Lords. The Central Tower, however, was never used for the House of Lords. The project correspondence shows that the Central Tower only ever served as a discharge for hot air from the Central Lobby and surrounding corridors. Fresh air was supplied from the Central Chamber through the cast-iron gratings in the floor of the Lobby and escaped through the oculus in the ceiling vault, which was surrounded by a steam pipe to enhance the stack effect [10] (Fig. 4). After intense negotiations between Reid and Barry, a final scheme for the ceiling supply was agreed. It comprised two inlets [11]. The first constituted a system of operable cast-iron louvres within the roof of the riverfront and a second inlet was inside the octagonal corner turret of St. Stephen's Hall. Channels under the roof conveyed fresh air from these two inlets to the supply air chamber above the House, using a steam-driven fan (Fig. 2). Mirroring the air supply below the House, the ceiling supply was equipped with its own steam-powered fan, heating pipes and equalizing chamber. Once the air passed through the fan at the north end of the Central Tower, it entered a passage lined with heating pipes (Figs. 2, 4). Valves inside partitions enclosing the pipes were used to regulate the quantity of heat imparted into the air. With the aid of the fan, the air was conveyed into an air chamber extending over the central part of the ceiling. The central row of panels was intended to supply fresh air downward into the debating chamber, whilst the side panels were used to extract vitiated air. Sliding valves in the ceiling of the Equalizing Chamber were used to control the quantity of air admitted into the debating chamber (Fig. 3). If operated in the downward mode, the fresh air was to be blown in through the ceiling and extracted through the perforated iron floor. It will be shown later, however, that the downward mode was rarely used due to the failure to devise a suitable lighting system. The vitiated air chamber above the side panels were connected to a new rectangular stone up-cast shaft at the west end of the Commons Lobby, which Reid had introduced as Barry refused access to the Central Tower (Figs. 2, 4).

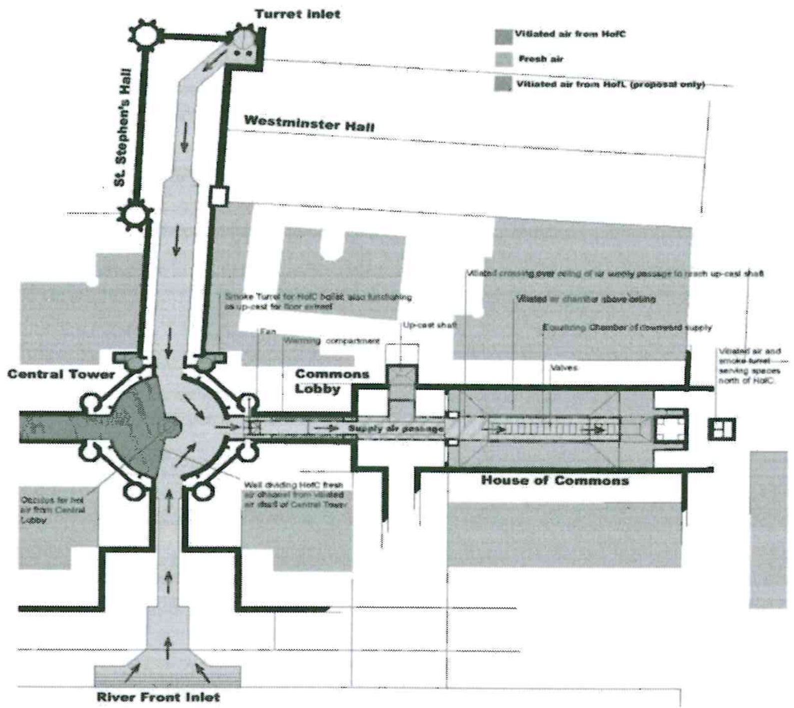

Fig. 2. Plan showing the ceiling system (drawing: Schoenefeldt).

The air entered the up-cast shaft at the base, ascended, at times with the aid of a coke fire, and escaped through the top, which was roofed with iron valves operated manually with the aid of pulleys. Another shaft at the north end of the House was originally proposed for this purpose, but in 1848 was converted into a combined smoke and vitiated air turret for spaces at the northern side of the Palace.

The floor system

The fresh air supply for the main floor and galleries was provided through the basement. Air drawn in through the Clock Tower or the Central Chamber, which had inlets facing the surrounding courts, was conveyed through basement into the air passage below the House (Figs. 2-5). Then it ascended into the heating and cooling chamber at ground floor through openings inside the vaults, which were equipped with canvas valves [12]. The openings in the three central vaults led into a heating compartment with hot water pipes, whilst the openings at north and south end of the chamber were used to convey unheated air into the separate vaults surrounding the heating compartment. At the next stage cool and warmed air rose through separate valves into the Equalizing Chamber above, which was designed for the 'purpose of equalising and adjusting the moisture', temperature and velocity of the air [13]. The temperature was adjusted by regulating the relative quantity of cool and warm air entering the equalizing chamber. Thermometers and hygrometers were used to monitor temperature and humidity.

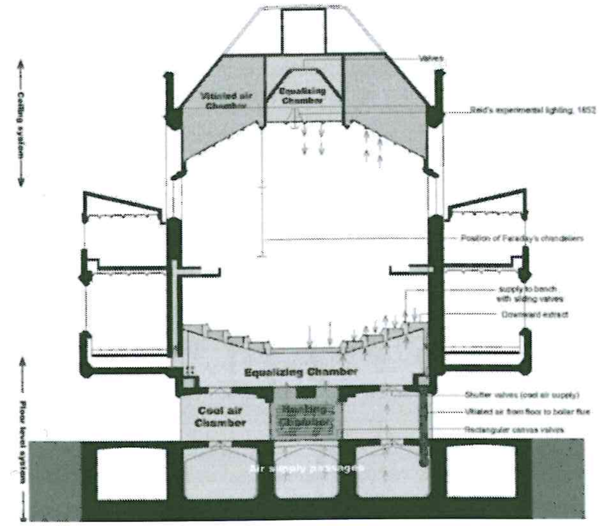

Fig. 3: Cross-section of House of Commons (drawing: Schoenefeldt).

The air entered the debating chamber through the perforated cast-iron panels of the floor, but, in contrast to the Temporary Houses of Commons where air was admitted uniformly across the floor, air was only supplied through areas where MPs were not directly exposed to currents while seated. Air was admitted primarily through parts of the central floor, along the back of the benches and through risers in the gangways. The perforated floor between the benches and in the centre were used for extracting vitiated air downwards. The vitiated air compartment below the floor, were separated from the fresh air within the equalising chamber through wooden partitions and connected with the main up-cast shaft and the boiler flue inside the basement [14].

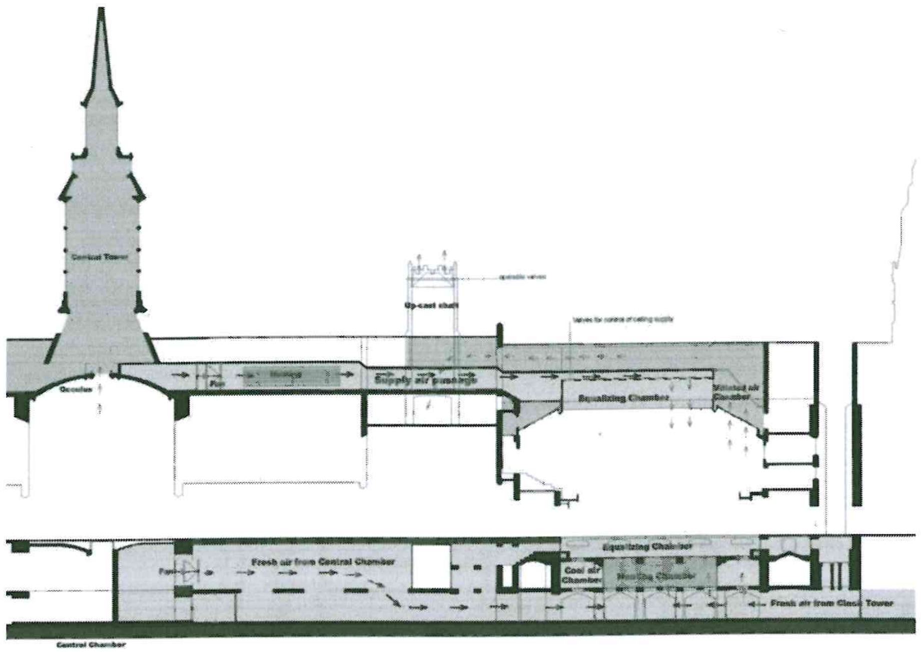

Fig. 4. Section of House of Commons outlining ceiling and floor arrangements. (drawing: Schoenefeldt).

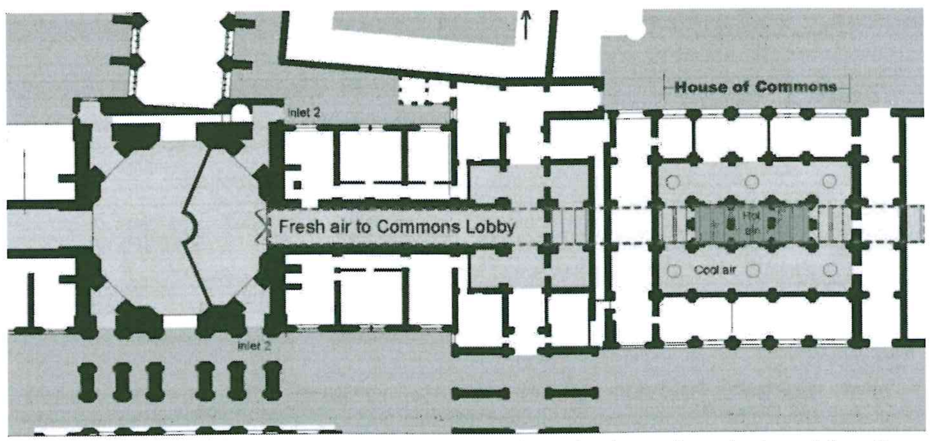

Fig. 5. Ground floor plan showing level of warm and cool air chamber and supply channel from Central Chamber (drawing: Schoenefeldt).

A strategy for improving user-satisfaction

The design of the floor system was intimately connected with Reid"s inquiries into the perception of indoor climates. A system of user-feedback, which the Earl of Shelburne referred to as a 'system of complaint', had been developed over several years in the Temporary House of Commons [15]. Feedback from MPs was used to track changes of thermal perception over time, assess general levels of satisfaction among MPs present, and to identify needs of individuals. Climate control became a highly political process, involving attempts to manage the shared climate according to the feelings of the majority on one side, and to accommodate the demands of individuals through local climates on the other. The ventilation of the Temporary House of Lords, introduced three years after the Temporary House of Commons, was used by Reid for testing an alternative approach to climate control for the Permanent House of Commons. Reid and the Sergeant-at-Arms found that it was impossible to achieve a high satisfaction rate if the climate was uniform throughout the debating chamber. In the House of Lords Reid explored how far user-satisfaction could be increased by creating 'zones of varied atmosphere'. Warm and cold air could be introduced simultaneously into different sections of the chamber, including within each block of benches on opposite sides and around the bar and throne. In the more crowded areas, which were more likely to experience overheating problems, cooler air was introduced, while more sparsely populated areas were supplied with warmer air. In one section the temperature could be as low as 52°F and as high as 75°F in another. This new strategy did not succeed in improving levels of user-satisfaction, but Reid saw it as a first trial of a principle to be fully developed in the Permanent House. In an interview with the 1844 Select Committee he argued that the main issue was not technological, but insufficient user participation since feedback from Peers was scarce even when they felt uncomfortable. The arrangement permitted a high level of control, but attendants relied on regular feedback from individuals occupying the different zones to effectively respond to their specific needs. In the context of the Permanent House, Reid took his concept a step further by allowing the climate to be regulated at individual benches. Each bench had a separate supply duct with sliding valves, which attendants adjusted manually from inside the equalising chamber based on feedback from MPs.

The post-occupancy history

The performance of the ventilation was systematically monitored and recorded in logbooks as part of the day-to-day operational procedures. Indoor temperatures were logged hourly by the messenger of the Sergeant-at-Arms. Eight fixed thermometers were positioned inside the debating chamber. Thermometers were fixed to the back wall of the four main galleries, while the remaining four thermometers were installed on the main floor. One was near the Speaker's chair, another behind the Sergeant-at-Arms chair and the other two thermometers were placed within the opposition and government benches. The Sergeant-at-Arms was responsible for co-ordination of the monitoring, collecting and assessing complaints from MPs about air quality and thermal comfort, and sending orders to the superintendent who managed the team of attendants working the heating and ventilation. Reid was superintendent until November 1852, and was succeeded by the engineer Alfred Meeson. Lord Charles Russell, the Sergeant-at-Arms from 1848 to 1875, reported that he was the 'usual medium of communication, as respects the ventilation, between Dr. Reid and the Members' [16]. The log-sheets record this process through written notes referring to observations, user-feedback and operational procedures, including the switching of air supplies in response to heavy fogs. Records were also kept of complaints and orders sent by the Sergeant-at-Arms. On 13 April 1853 the attendant noted that the 'Speaker complained of draughts round his head and chair' and on 29 April that the 'reporters expressed their gratification at the comfort of the gallery'. On 2 May it was noted that the 'temperature rose suddenly' when the galleries got crowded and that the ceiling supply was activated to reduce it [17]. This system of collecting and processing user-feedback had been developed inside the Temporary House of Commons to address the subjective nature of thermal comfort. Reid was aware of the limitations of this approach, admitting that it was unfeasible to 'hit the individual tastes of everyone, and of course, we never attempted it, but we work to an average' and that there was 'scarcely a meeting of the House at which there are not some Members who would like the temperature to be at 55F degrees, and others at 70F or 72F" [18]. In the Permanent House attendants were asked to maintain ranges of temperatures and humidity, which, according to an analysis of MPs comments collected inside the Temporary House, resulted in the least number of complaints. Reid reported that 'when there is a difference between 5F between the dry thermometer and wet-bulb thermometer next to it, I have the least number of complaints'. The logbooks illustrate that attendants made ad-hoc adjustments to their routine settings based on user-feedback. The MPs perception of temperature, relative humidity or air currents became the primary measure of performance as only temperatures were measured, but not other important factors such as humidity, air velocity or radiant heat. In addition to the monitoring, a number of technical inquiries into the performance of the system were undertaken by engineers and scientists between 1852 and 1854, co-ordinated by the Board of Works and four different Select Committees. Interviews were also conducted with MPs to gain insight into their experience of the system form the point of air quality and thermal comfort [19].

The first trial

On 3 February 1852, the day when the House was inaugurated, the ventilation went operational for the first time. Reid and his attendants reportedly struggled with preventing the interior from overheating and numerous MPs condemned the system as a failure. The issue became the subject of several debates at the House of Commons; Reid was questioned at the Bar [20]. In a Memorandum Reid defended his system, arguing that the overheating problems were the results of the unfinished state of the ventilation arrangements and Barry"s interference in important aspects of the design, including the gas lighting, which had prevented the use of the ceiling supply after sunset. Complaints continued and at another debate on 16 March 1852 Lord Manners demanded an independent examination. On 25 and 26 March the Select Committee, appointed to inquire into these issues, conducted interviews with the Speaker, Sergeant-at-Arms and five MPs on their experience. These felt that the chamber was uncomfortable due to strong draughts and variations in temperature and also reported that the air was often too dry causing MPs to cough and suffer from 'considerable irritation in the chest and throat'. The Speaker, referring to a severe instance during the sitting on 24 March 1852 wrote that 'the temperature was exceedingly oppressive; there was also a great dryness in the air. I sent once or twice to Dr. Reid to beg that he would make some change in the state of the air, for it was so dry that it caused an irritation in the throat, and I could hear the Members coughing all around" [21]. The Sergeant-at-Arms reported that Reid"s team failed lowering the temperature following his orders and argued that the indoor climate was more susceptible to variations in the number of people in the chamber than in the Temporary House. The Speaker observed that the air quality varied significantly from day to day, and that attendants struggled with keeping temperature within comfortable levels when the House was crowded.

On 12 March 1852, the House of Commons ordered an independent scientific examination of the system. Goldsworthy Gurney and the architect Samuel Daukes were commissioned for two separate examinations, which yielded deeper insights into some of the issues MPs had reported. Daukes, who had collaborated with the heating engineer Henry Cruger Price, described the combined plenum and vacuum system as too complicated to work in practice and recommended returning to a pure up-cast system. Gurney came to similar conclusions in his first report from 5 April 1852 [22]. He wrote that the arrangement of inlets and outlets produced conflicting air currents that disturbed the internal atmosphere. This was followed by a more systematic examination, which Gurney undertook with the engineers James Mather, John Hutchinsons and James Hann and documented in his second report dated 13 April 1852 [23]. Their examinations revealed sensible stratification of hot and cold air within the chamber. At floor level the mean air temperature was between 62-64F, but above the seat rose to 70F and in the galleries to 73F. They found that not enough cool air was admitted to keep temperatures down. Although the stack was effective the air flow rate was restricted by the quantity of fresh air entering through the floor. Spot measurements confirmed that the atmospheric humidity was low. Tests with differential barometers and anemometers revealed that atmospheric pressure in the chamber was lower than outdoors, resulting in air rushing in with a great force when doors were opened, ranging from 420 to 1300 feet per minute. Gurney"s diagnosis was that the quantity of air admitted through the floor was not sufficient to match the quantity of air drawn out of the chamber through the up-cast shaft, and that increasing the area for the admission of air would achieve a better balance. In his third report of 19 May 1852, Gurney recommended enlarging the area of the floor inlets to increase the volume of fresh air that could be admitted [24]. His recommendations were discussed by the Select Committee but were not implemented until the issue was re-visited by another Select Committee in 1854 following pressure from MPs. In several letters Reid described Gurney's tests as a premature assessment of the general soundness of his ventilation system as the fan driven supply, a key part of his combined plenum and up-cast strategy, had not been operational until Easter [25]. From February till March 1852 the ventilation had operated in a pure vacuum mode and internal draughts occurred, as he could not draw on the assistance of the fans to prevent the stack from producing a low pressure inside the chamber. During Gurney"s tests the installation of the basement fan was unfinished whilst the heat of the chandeliers prevented using the fan above the ceiling. In a Memorandum to the Board of Works, (7 February 1852) Reid wrote that apart from a few tests and during the daytime debates when artificial light was not required, the descending supply had not been used [26]. Reid argued that the problem could be overcome by adopting a lighting arrangement that he had developed in 1848 as part of his design for the ceiling supply. In his proposal gaslights were placed inside conical hoods that terminated in fume extraction flues connected with the up-cast shaft. By placing these extraction hoods above the ceiling panels, Reid claimed, fresh air could pass through gaps around the edge of the ceiling panels without exposure to heat or fumes [27].

For Lord Seymour from the Office of Works, the incompatibility of the lighting with the ventilation system exemplified the implications of insufficient cooperation in the design process. The gas lighting had been designed by Barry and Michael Faraday to harmonize with the gothic style of the oak ceiling without consulting Reid [28]. It comprised chandeliers that were hung from the edge of central part of ceiling and came down to the gallery. The intense heat emitted by the lights became a cause of discomfort, in particular within the gallery, as it heated up the atmosphere in the upper part of the chamber and exposed MPs and visitors to a strong radiant heat. It prevented the use of the ceiling supply as the descending current carried hot air into the body of the House. After consulting several technical experts the Select Committee authorized Reid to implement his proposed alterations [29]. Over the 1852 Easter Recess Reid modified the ceiling arrangements and trial lights were installed. Although this provided Reid with the opportunity to adopt his original idea of an integrated lighting system, it is surprising that the lighting arrangement implemented over this period neither adhered to the original principle, nor facilitated the use of the downward supply through the central part of the ceiling. Instead Reid moved the downward supply from the centre to the side panels, and the central area was connected to extract shaft. The gaslights were composed of pyramidal reflectors with rings of open gas flames suspended below it. The reflectors were open at the top to allow the gas fumes and the foul air of the chamber to ascend into the new vitiated air chamber above [30]. In two letters from June 1852 Reid claimed that conditions had markedly improved [31]. A first trial of the modified system was conducted during the sitting on 19 April 1852. The tests started at 4pm, during which the coke fires in the ventilation shaft were only kept at a low heat. It was run in a pure up-cast mode as, according to Reid, the heat from people and lights was sufficient to drive the ventilation. Over the afternoon the chamber had an average temperature of 66F and at 7pm the temperature in the gallery was between 65F and 67F [32]. Reid wrote that the modification had reduced the temperature difference between the floor and the gallery, which is also confirmed by the readings in the logbooks. These show that the difference was previously as high as 8F, but after 19 April 1852 never exceeded 3F. Despite the fact that the readings had also been taken during a warmer and busier period, the average daily temperatures in the gallery had fallen by 2F to between 64F to 69F and on the main floor ranged between 57F to 71F.

The House under Alfred Meeson's Stewardship

In September 1852 Reid was authorized to finish parts of the proposed alterations that were not finished over Easter [33], but he was unable to complete the work by November 1852 when his employment was terminated and his role transferred to Meeson. This deprived him of the opportunity to pursue his efforts in getting the system operating as he had envisaged. In January 1853 Meeson submitted a report to the Board of Works, highlighting the need for further work to get the ventilation working more effectively [34]. One issue was the control of the temperature and air supply, largely as the system of control valves below the House was incomplete or poorly executed, resulting in air entering through parts of the perforated floor unchecked. This included the perforated floor between the benches, leading to complaints from MPs about their feet and legs being constantly exposed to cold currents. Meeson also criticized the management of Reid's system for requiring an overwhelmingly large number of operations and recommended simplifying it. He also urged the Office of Works to replace Reid's lighting system as it neither eliminated overheating issues in the galleries nor facilitated the use of the downward mode of ventilation at night. In March 1853 a Standing Committee, composed of the First Commissioner of Works and the engineers Joseph Locke and Robert Stephenson, was appointed to review the recommendations [35]. Gurney was tasked with introducing a new lighting arrangement, which was installed in April 1853 but was criticized by Meeson for failing to address the problem with downward supply [36]. Lights were moved above the ceiling and isolated from the atmosphere of the chamber by a layer of glass substituting the oak panels. Measurements by Gurney"s assistants showed that, whilst succeeding in reducing radiant heat and extracting fumes through separate flues without contaminating the atmosphere, the lighting still elevated the air temperature inside the intended equalizing chamber to between 89F and 123F, too high to be used as supply air. In response, Meeson in March 1854 re-adopted the downward supply through the side panels. The state of the ventilation continued to be the subject of parliamentary debates and led to the appointment of another Select Committee in March 1854, which directed the final examination of Reid's system and recommended it to be decommissioned [37]. In its first report (31 March 1854) the Committee wrote that Reid's ventilation was

'condemned by common consent' as unsatisfactory [38]. Gurney was re-summoned as a technical advisor. Interviews also revealed that the effective management of the complex system presented the most longstanding challenge. The Speaker and Meeson reported that attendants could not raise or lower the temperature at the required speed and that the heating system was not responsive enough to deal with the sudden change in attendance from 150 to 650 within a single sitting. To avoid the difficulties and labour required to operate two separate systems Gurney advocated an alternative system where equilibrium between the incoming and outgoing air is maintained naturally. He proposed returning to a pure up-cast system with local inlets designed to respond directly to the pressure of the stack. Gurney remodelled the ventilation over Easter 1854 [39]. The fan-driven supplies in the basement and above the ceiling were abandoned and incoming and outgoing air was driven exclusively by the pull of two up-cast shafts. The existing shaft was retained but the Clock Tower was converted into the main up-cast shaft. He thereby returned to the type of stack-driven systems with which Reid had begun his inquiries, but it operated in a mixed downward and upward mode. Using Reid"s roof level inlets, air was introduced through the side panels of the ceiling, and extracted downward through the centre of the main floor, driven by the pull of the Clock Tower. Air above the gallery was extracted through centre of the ceiling by means of Reid"s up-cast shaft and the Clock Tower via four down-pull shafts at the north end. An upward supply was provided through the benches and parts of the central floor [40].

Conclusion:

This article has provided an overview of Reid's historic design for the ventilation of the House of Commons, the underlying objectives and showed that it acted as a setting for technical experimentation, in which Reid's sophisticated system could be tested under real-life conditions. It was continuously monitored, the subject of scientific studies and user-appraisals, and various modifications were made to address issues encountered. In retrospect, but contrary to Reid's intention, the ventilation of the Permanent House became another short-lived experiment, not dissimilar to the Temporary Houses. The complexity of the system, being seen as unmanageable, led to it being abandoned and replaced with a simpler, less technical solution. The research suggests that the system aspired to a level of sophistication that was not achievable with the technology available at the time. Reid anticipated the type of cybernetic system that only became fully feasible in the 20th century with the development of remotely controlled motorized actuators, electronic sensors and computerized building management systems. As such it raises the question how far modern technology could have helped to realize Reid"s original vision.

References

[1] M. Port, *The Houses of Parliament*, New Haven: Publisher?, 1976), pp. 218-31; C. Riding and J. Riding (eds), *The Houses of Parliament: History, Art, Architecture* (London: Publisher, 2000; P. Collins, *Changing Ideals in Modern Architecture, 1750–1950,* Montreal: Taylor and Francis, 1998; N. Sturrock; P. Lawson-Smith, "The Grandfather of Air-Conditioning", in *Proceedings of the Second International Congress on Construction History*, 2006, pp. 2981–2998; R. Brucemann, "19th Century Mechanical System Designs", *Journal of Architectural Education*," 30 (1977), pp. 11-15; R. Bruegmann, "Central Heating and Forced Ventilation: Origins and Effects on Architectural Design", *Journal of the Society of*

Architectural Historians, 37 (1978), pp. 143-160.
[2] E.g. Correspondence of the Department of Woods and Forests, 1840-54 (National Archives, work 11/12); Correspondence of Commissioners for Completion of New Palace of Westminster, 1848-51; National Archives; work 11/13).
[3] H. Schoenefeldt, "The Temporary Houses of Parliament and David Boswell Reid"s architecture of experimentation", *Architectural History*, 57, 2014, pp. 175-215.
[4] Report from the Select Committee on Ventilation of the New Houses of Parliament (HC 1841, 51-2); Report from the Select Committee on Ventilation of the New Houses of Parliament (HC 1842, 536); Reports from the Select Committee of the House of Lords appointed to inquire into the progress of the building of the Houses of Parliament(HL 1846, 719); Report from the Select Committee on Westminster Bridge and new palace (HC 1846, 177).
[5] e.g. Plans for the ventilation of the Houses of Commons, Reid, 5 April 1947 (National Archives, work (works 29/3000-3059).
[6] For detailed study of design process: H. Schoenefeldt, *Architectural and scientific principles in the design of the Houses of Parliament*, in New Directions in Gothic Revival Studies, Leuven: Leuven University Press, KADOC-Artes Series, 2015.
[7] H. Schoenefeldt, "The Temporary Houses of Parliament and David Boswell Reid"s architecture of experimentation", *Architectural History*, 57, 2014, pp. 175-215.
[8] Air supply and discharge within the ceiling of the House of Lords and Victoria Hall, 16 July 1845 (works 29/2897), Proposal for ventilation arrangements inside the roof of the House of Lords, section and plan, January 1845 (works 29/2996), work 29/2888, Detail of ceiling construction in House of Lords, 10 July 1846, work 29/3035, House of Lords, Plan of principal floor, 1845 (work 29/2894); Section through Victoria Hall, 1845 (work 2883); Plan above the Ceiling, House of Lords and Victoria Hall, undated, 1845 (works 29/2888).
[9] For detailed study of design process: H. Schoenefeldt, *Architectural and scientific principles in the design of the Houses of Parliament*, in New Directions in Gothic Revival Studies, Leuven: Leuven University Press, KADOC-Artes Series, 2015.
[10] First report from the Select Committee on the Ventilation of the House (HC SC 1854, 149).
[11] Air supply inside metal roof of Rover Front serving the House of Commons, 7 June 1848 (work 29/3066); Smoke duct and fresh air supply above St. Stephen"s Hall, 22 June 1848 (work 29/3067); Air inlet inside turrets at Stephen"s Hall and louvres inside metal roof of River Front, 29 June 1848(work 29/3067); Plan and sections of supply air channel over groins of St.Stephen"s Hall, 27 December 1851(work 29/2960).
[12] Half- plan, showing arrangements of air valves in the ceiling of the basement and the floor of the equalizing chamber, dated 5 April 1847 (Work 29/3026); Section through chamber, 5 April 1847 (Work 29/3029).
[13] Second report from the Select Committee on Ventilation and Lighting of the House (HC SC 1852, 402)
[14] Plan showing air supply tubes serving individual benches, April 1847 (National Archives, Work 29/3046) Ceiling of equalizing chamber under house with supply tubes, valves and flaps, 23 June 1851, (National Archives, Work 29/3100).
[15] Report of the Select Committee on the Houses of Parliament (HC SC 448, 1844)
[16] Second report from the Select Committee on Ventilation and Lighting of the House (HC SC 1852, 402)
[17] Registers of temperature control and ventilation for the House of Commons 1853-4 (Parliamentary Archives, OOW/5).

[18] Second report from the Select Committee on Ventilation and Lighting of the House (HC SC 1852, 402).
[19] First report from the Select Committee on the Ventilation of the House; (HC SC 1854, 149); Third report from the Select Committee on Ventilation of the House (HC SC 1854, 403); Report from the Select Committee of the House of Lords, appointed to inquire into the possibility of improving the ventilation and the lighting of the House (HL SC 1854, 384).
[20] The Queen"s Speech – Report of Address, Hansard, HC Deb 04 February 1852 vol 119 cc162-72; Imperial Parliament, *Daily News*, 5 February 1852, p. 3; Editorial, *Builder*, 10-471, 14 February 1852, p. 97; Ventilation of the House, Hansard, HC Deb 11 February 1852 vol 119 cc400-16; Reid, David Boswell, Report of Measures required for the health and comfort of the honourable the house of commons, in obedience to resolution of the house dated the 11 February 1852, dated 10 March 1852 (National Archives, work 11/14 nr. 711-14).
[21] Second report from the Select Committee on Ventilation and Lighting of the House (HC SC 1852, 402)
[22] First report of Mr. Goldsworthy Gurney on the ventilation of the new House of Commons, 6 April 1852, in Second report from the Select Committee on Ventilation and Lighting of the House (HC SC 1852, 402); pp. 586.
[23] Warming and ventilation of the House. Second report of Mr. Goldsworthy Gurney on the ventilation of the new House of Commons. (HC 1852, 252-371).
[24] Third Report of Mr. Goldsworthy Gurney on the ventilation of the new House of Commons, 19 May 1852, in Second report from the Select Committee on Ventilation and Lighting of the House (HC SC 1852, 402); pp. 592-99.
[25] Letter from Reid to Board of Works, 20 March 1852 (Work 11/14 nr. 698, 721-3); Letter from Gurney to Office of Works, 27 March 1852, Work 11/14 nr. 725; Letter from Office of Works to Reid, 29 March 1852, Work 11/14 nr. 726; Letter from Reid to Office of Works, 30 March 1852, Work 11/14 nr. 728.
[26] Memoranda submitted to chief commissioner of the office of Works, 7 February 1851 (National Archives, work 11/14 nr. 678).
[27] (Statement accompanying Dr. Reid's letter to the Commissioners of Woods, 10 March 1848 (National Archives, Work 11/13 nr. 387); Set of 9 drawing outlining a lighting scheme, Reid, 10 March 1848,(National Archives, works 29/2820-28).
[28] Ventilation of the House, Hansard, HC Deb 11 February 1852 vol 119 cc400-16 400).
[29] Second report from the Select Committee on Ventilation and Lighting of the House (HC SC 1852, 402).
[30] Dr. Reid System of Lighting the House of Commons, *Illustrated London News*, 24 April 1852, p. 317.
[31] Letter from Reid to Commissioners of Works, 26 June 1852); Supplementary Report of measures required for the health and comfort of the House of Commons, 29 June 1852).
[32] Second report from the Select Committee on Ventilation and Lighting of the House (HC SC 1852, 402)
[33] (Letter from Commissioners of Works to Reid, 9 September 1852); (Letter from Reid to Manners, 27 August 1852; Letter from Commissioners of Works to Reid, 21 September 1852.
[34] (First Letter from Meeson to Commissioner of Works, 8 January 1853, works 11/14 nr. 767, First Report on the State of the Warming of the Warming, Ventilating, and Lighting arrangements throughout the building, Meeson, December 1852, works 11/14, nr. 768-81).
[35] „Supply - Miscellaneous Estimates", Hansard, HC Deb 04 August 1853 vol 129 cc1297-318); Ventilation and Lighting of the House Committee. Report of the Standing Committee on the Ventilating

and Lighting the House of Commons (HC 1852-53, 570); Report of Mr. Goldsworthy Gurney to the Commissioners of Works, respecting the lighting of the House of Commons (HC 1852-53, 911).

[36] (Supply - Miscellaneous Estimates, HC Deb 04 August 1853 vol 129 cc1297-318); Letter from Meeson to Commissioners of Works, 11 March 1853. (National Archives, work 11/14 nr. 829); (Letter from Meeson to Commissioner of Works, 11 March 1853, National Archives, work 11/14, nr. 829).

[37] „Supply", Hansard, HC Deb 4 August 1853, vol. 129, cc1297-3180; „Ventilation of the House", Hansard, HC Deb 17 February 1853 vol. 124 cc180-1; 'Supply', Hansard, HC Deb 19 May 1853 vol 127 cc388-422.

[38] First report from the Select Committee on the Ventilation of the House; (HC SC 1854, 149).

[39] Second Report from the Select Committee on Ventilation of the (HC SC 1854, 270); Report from the Select Committee of the House of Lords, appointed to inquire into the possibility of improving the ventilation and the lighting of the House (HL SC 1854, 384); Third report from the Select Committee on Ventilation of the House (HC SC 1854, 403).

[40] „Supply", Hansard, HC Deb 4 August 1853, vol. 129, cc1297-3180; „Ventilation of the House", Hansard, HC Deb 17 February 1853 vol. 124 cc180-1; 'Supply', Hansard, HC Deb 19 May 1853 vol 127 cc388-422[31] First report from the Select Committee on the Ventilation of the House; (HC SC 1854, 149).

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