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The Houses of Parliament and Reid's inquiries into user perception

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> *'…sometimes Members come to me, and say the House is very hot, or very cold; I look at the thermometer, and see if so, for different people have different feelings with regard to temperature. People come in very hot, and say, "How cold the House strikes;" and another man says "I have been sitting here half an hour, and I am in fever:" and if I see the thermometers are too high or too low, I give directions accordingly*'[1]
>
> William Gosset, Sergeant-at-Arms, 1839

In 1839 the Sergeant-at-Arms William Gosset had a long interview with a Select Committee appointed to review the effectiveness of the stack ventilation system in the Temporary Houses of Commons. This had been introduced by the physician and chemist David Bothwell Reid in the winter of 1836 and over the following two years the Sergeant-at-Arms had been responsible for gathering and processing oral feedback MPs on their perception of the level of thermal comfort and air quality within the chamber. At time he gave orders to the attendants of the ventilation to make adjustments. In his interview Gosset highlighted the management of the ventilation was confronted with the challenge of reconciling the results of measurements with the subjective feedback from MPs. This concerns about user-perception represented a central theme in Reid's work in the field of ventilation. In addition to scientific research on the physiological effect of air quality and climate he used experimental studies to underpin the development of his ventilation scheme for the Houses of Parliament with empirical evidence. These experiments began with a test chamber in Edinburgh (1836), and was followed by the Temporary Houses of Commons (1836-51) and the Temporary Houses of Lords (1838-47). The temporary debating chambers allowed him to test and refine principles under real-life conditions over a period of fifteen years and directly fed into the development of a highly sophisticated climate control system realized in the Permanent House of Commons (1846-52). This paper provides a brief overview of the role of user perception in the development of Reid ventilation system for the Palace of Westminster. User-perception was used as a performance indicator in the day-to-day management of the ventilation, but also it was also a major design factor underlying the development of the ventilation system for the Permanent Houses of Commons.

1. Empirical approaches

The working methods that were deployed in the development of the Houses of Parliament's ventilation system built on scientific working methods that Reid had developed in the early 1830s to study thermal comfort and air quality. In a lecture entitled Progress of Architecture, Reid explained that these experiments involved human participants, who on their perception of the climatic and atmospheric conditions inside experimental chambers. [2] The aim of these studies was to define new standard ventilation rates, which addressed problems of air quality as well as thermal comfort. He criticized the typical levels of air supply in public building for being too low, resulting in atmospheric conditions that were unpleasant and made occupants feel physically unwell.[3] Although he was not the first to set ventilation standards, Reid criticized existing standards for only defining the minimum required to satisfy metabolic

needs, rather than maintaining thermal comfort or an air quality that is perceived as pleasant. [4] These low rates, he wrote, 'would not give the comfort and maintain the constitution in such good condition as a larger allowance'.[5] To determine the air supply required to achieve an 'agreeable and refreshing atmosphere' Reid undertook experiments with human participants inside closed chambers in which the air supply could be closely controlled. In these experiments Reid relied largely on the subjective feedback from participants, self-reporting on their experience of indoor climate and atmosphere to which they had been exposed. He asked for feedback on the participants' perceived thermal comfort and air quality '*to ascertain the effect of a given supply of air, at a regulated temperature, renewed in the manner he had proposed*'[6] Reid's finding was that 10 cubic feet per minute were an 'ample allowance for an adult'. [7] During warm weather the rate would need increasing to 40 to 60 cubic feet per minute if a comfortable range of temperatures was to be maintained without the use of artificial cooling,[8] but he also observed that the ventilation rate could only be raised to a certain level, before strong internal air currents, rather than high air temperatures, became the main cause of thermal discomfort.[9]

Inside his private laboratory in Edinburgh Reid constructed various experimental rooms to test different ways of introducing and extracting air in sealed rooms.**[10]** For Reid sealed rooms with controlled stack ventilation was a means to achieve a tighter control over the climatic and atmospheric conditions than naturally ventilated rooms with operable windows.[11] Air was admitted and discharged exclusively through perforated ceilings, walls and floors. In one of these rooms fresh air was introduced from above through a perforated ceiling, and in another the perforated surface was extended along the walls, allowing the incoming air currents to be distributed over an even larger area.[12] In yet another chamber air was admitted through a perforated floor and discharged via the ceiling. These studies investigated how thermal comfort could be achieved through the different technical arrangements and by optimising the environmental management. Aiming to experimentally determine the conditions at which people felt comfortable, participants were placed inside these rooms and tasked with reporting on their experience of the state of the atmosphere and the physical sensation produced by air currents of varying velocities, degree of diffusion and temperature. These experiments were not dissimilar to the climate chamber studies undertaken by the Willis Carrier in the 1940s.[13] Through a system of supply and discharge ducts 'air could be made to enter and be withdrawn in any required proportion.'[14] These ventilation principles and the working methodology that Reid has used to test them, provided the foundations for the inquiries that Reid had undertaken in Westminster between 1835 and 1852.

2. *The testing of a model debating chamber*

In August 1835 Reid was invited, alongside other scientists and engineers in the field of ventilation and heating, to advise a House of Commons Select Committee appointed to make an inquiry into ways of ventilating the New Palace of Westminster. He outlined the concept for a model debating chamber, building on the findings of his earlier physiological studies. This chamber was completely sealed and the fresh air was admitted entirely through the floor and extracted through the ceiling. It had two large stacks, one serving as a central air inlet, the other as an outlet for used air. A coke fire inside the discharge shaft was to provide the motive power required to extract vitiated air but also to force fresh air from the top of the inlet shaft into the debating chamber.[15] To prevent MPs feet and legs being exposed strong currents, air currents were diffused by covering the entire floor area with small holes. Reid also submitted a proposal for applying these principles to the Temporary Houses of Commons, which had been erected in Westminster by the architect Robert Smirke in the winter of 1834 after the original Palace had been destroyed in a fire. In their final report the Select Committee did not recommend any specific system to be adopted in the New Palace and Smirke also objected his plans for testing the system in the Temporary House.[16] However, the Committee approved Reid's proposal to erect a mock-up of the

model debating chamber to provide it with 'any additional evidence as to the sound and ventilation might be obtained by actual experiment'.[17] The test chamber was erected in Spring 1836, next to the laboratory in Edinburgh. The air was admitted through 50.000 holes within the floor and passed into a cavity above the perforated ceiling before entering a duct, which was connected to the discharge shaft of Reid's laboratory.[18] From early summer 1836 Reid used a similar methodology as in his earlier experiments to empirically evaluate the ventilation from physiological perspective. In a letter to the Commissioners of Woods and Forest, dated 28 March 1838, Reid wrote that the chamber was constructed 'with the view of imitating the various circumstances that present themselves during the debates'.[19] This included studies investigating how the indoor atmosphere and climate was affected by large crowds or by the heat and fumes of gas lighting systems used during debates at night. First experiments, involving groups of over 100 participants, were undertaken in summer 1836. In these studies participants were exposed to different artificial climatic and atmospheric conditions by carefully regulating the temperature, relative humidity or adjusting the intensity of internal air currents.[20] The *Caledonian Mercury* wrote that the 'air was completely renewed by a slow and insensible current every five minutes, and the various changes so gradually induced, that it was impossible to tell when they commenced' and that the chamber was 'filled with warm and cold air, and partially charged with ether and nitrous oxide, at different times'[21] In other experiments the air supply was switch from the floor to the ceiling and participants were tasked with providing evidence of changes in the thermal sensation produced by these currents.[22] The descending currents reportedly improved the ventilation from a thermal comfort perspective as the feet and legs of participants were no longer directly exposed to currents from below, in particular during periods when the chamber was crowded and the ventilation rate had to be raised in order to maintain a good air quality or prevent overheating.[23] The test chamber was equipped with a system of flues and dampers, which allowed the direction and intensity of the incoming air currents to be regulated.[24] These experiments followed an approach that resembles very closely that used in modern psychophysics. According to Ralph Galbraith Hopkinson, psychophysics as a scientific field aims to gain an understanding of how human beings respond to or perceive their thermal, luminous or acoustic environment. Not dissimilar to Reid, Hopkinson found that this required scientists to '*learn how to use people as meters to register for us their experience in the environment*'.[25]

3. The Temporary Houses of Commons

In autumn 1836, following the test in Edinburgh and complaints by MPs about Smirke's ventilation system, Reid was finally granted permission to apply his system to the Temporary Houses of Commons. [26] This enabled him, for the first time, to test his principles under real-life conditions, rather than within the artificial settings of his laboratory. From January 1837 until Spring 1851, when the House finally moved into their new permanent debating chamber, Reid's ventilation system was subject of a number of scientific evaluations, which involved experimental studies, measurements and interviews with regular users, such as MPs and reported.[27] The latter was used as part of investigations into user perception. The ventilation system of the Temporary House cannot be discussed in this paper. An in-depth study of the Temporary Houses of Parliament can be found in *Architectural History*.[28] Similar to Reid's original proposal and the mock-debating chamber, the entire floor, including that in the galleries, was perforated, allowing fresh air to be admitted over the largest possible area. (see drawing) Through this, Reid argued, the fresh air currents were diffused and would only become uncomfortably strong when the chamber was exceptionally crowded and the ventilation had to be boosted to prevent overheating or to maintain the required supply of fresh air.[29] The quantity of air passing through the chamber regulated by adjusting the quantity of hot air exhausted through a large air shaft.

Key:
a: air inlet facing Old Palace Yard lined with air filter.
b: nets with lumps of ice (cooling during extreme heat)
c: water sprinklers for air purification, cooling and humidification
d: air passage with heating system
e: central air chamber
f: air ducts conducting air into equalizing chamber
g: diffusers above air ducts
h: equalizing chamber
i: perforated floor (main floor and gallery level) used for the admission of fresh air
j: perforated pannelled ceiling for the extraction of hot air
k: discharge duct of House of Commons leading to ventilating chimney
l: discharge duct connecting the House of Lords with the ventilating chimney

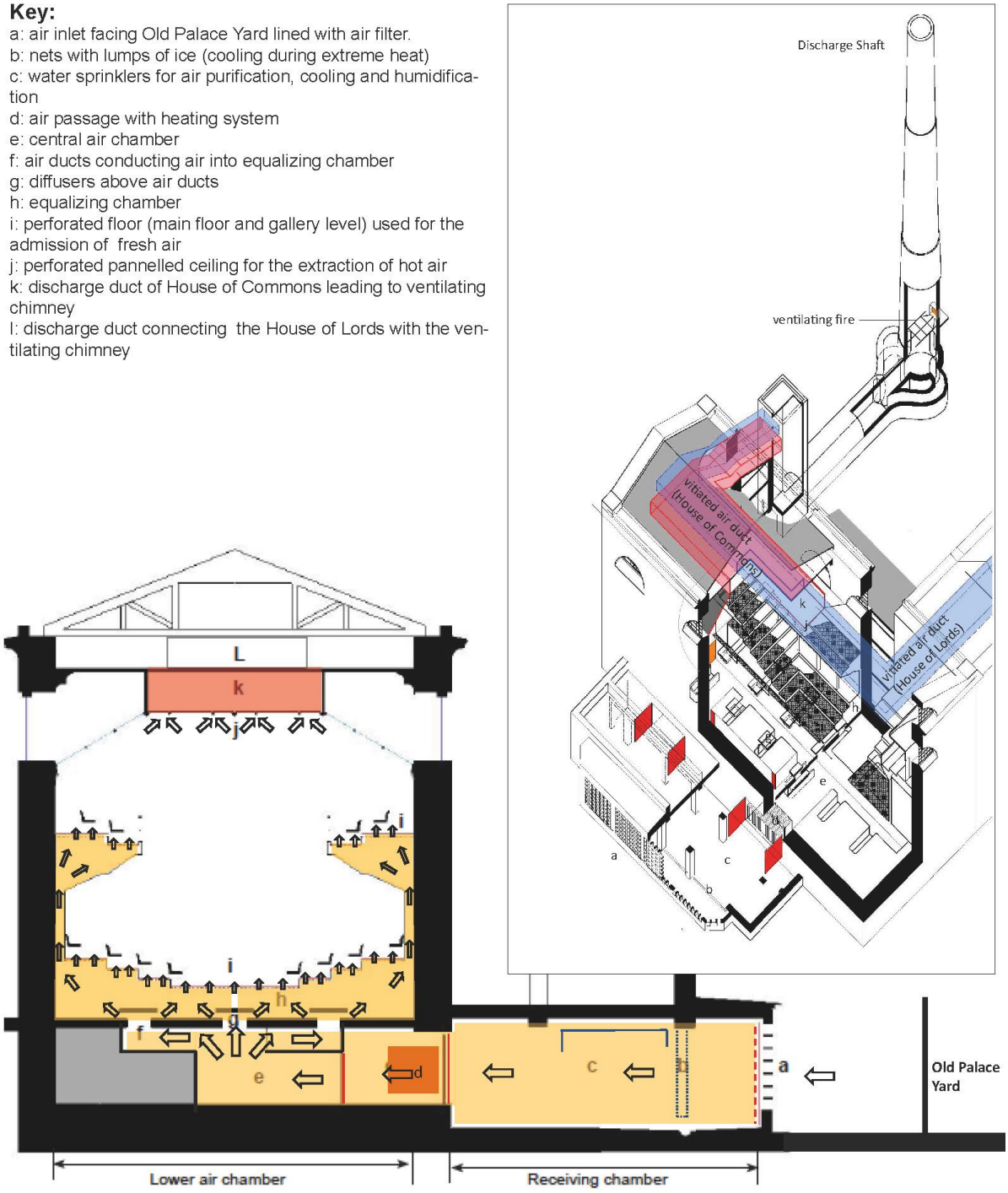

Fig. 1: Cross-section and Axonometric projection, showing the stack ventilation system of the Temporary House of Commons. (Author's own drawing)

In addition to scientific evaluations, the attendants of the ventilation constantly monitored the internal climatic conditions and collected oral feedback from MPs regarding thermal comfort and air quality. During every debate temperatures, the number of people inside the chamber and the position of the valves used to regulate the ventilation rate were recorded hourly in log-books. The operation of the ventilation was supervised by the Sergeant-at-Arms, Sir William Gosset, who directed the chief attendant of the ventilation, Benjamin Riches, to make adjustments.[30] Gosset dealt with complaints from Members and passed orders to

Riches.[31] Thermometers were located, among others, inside the galleries on the east and west side and behind the Speaker's chair on the main floor below.[32] The Department of Woods and Forests transmitted specimens of the collected data to Reid in Edinburgh on a weekly basis, to maintain a constant check on the state of the ventilation. The oral feedback from MPs was collected to monitor aspects of the environment that were highly subjective and/or could not be easily measured with the available technology, such as air purity or the physiological sensation of air currents. Apart from temperature and humidity, no measured data was collected as part of the routine operations.[33] In his *Illustrations of the Theory and Practice* Reid highlighted carbon dioxide levels could not be monitored as easily temperature, as it required chemical analysis of air samples.[34] The consultation of MPs within the chamber became an integral part of the environmental management regime, complementing the measured data.[35] (fig. 2) The Earl of Shelburne referred to it as a 'system of complaint'.[36] In addition to the routine management procedures, ad-hoc changes were made based on evaluations of occupant feedback. The perceived air purity and thermal comfort was carefully studied. During sittings the Sergeant-at-Arms consulted MPs on their perception of comfort before orders for adjustments were passed. In practice the use of occupant feedback posed some challenges. One was the difficulty of achieving mutual agreements among all Members within the chamber. Gosset noted that it was hard to make ad-hoc adjustments to the ventilation based on a consensus of thermal comfort and air purity.[37] Up to 100 adjustments reportedly were made during a single sitting in an effort to keep the MPs satisfied.[38] Performance evaluation thereby became a political as much as a technical affair. Another challenge was obtaining sufficient feedback from users. Reid wrote that MPs at the beginning had been pro-active in feeding their views back to the Sergeant-at-Arms, but over time their participation declined significantly.[39]

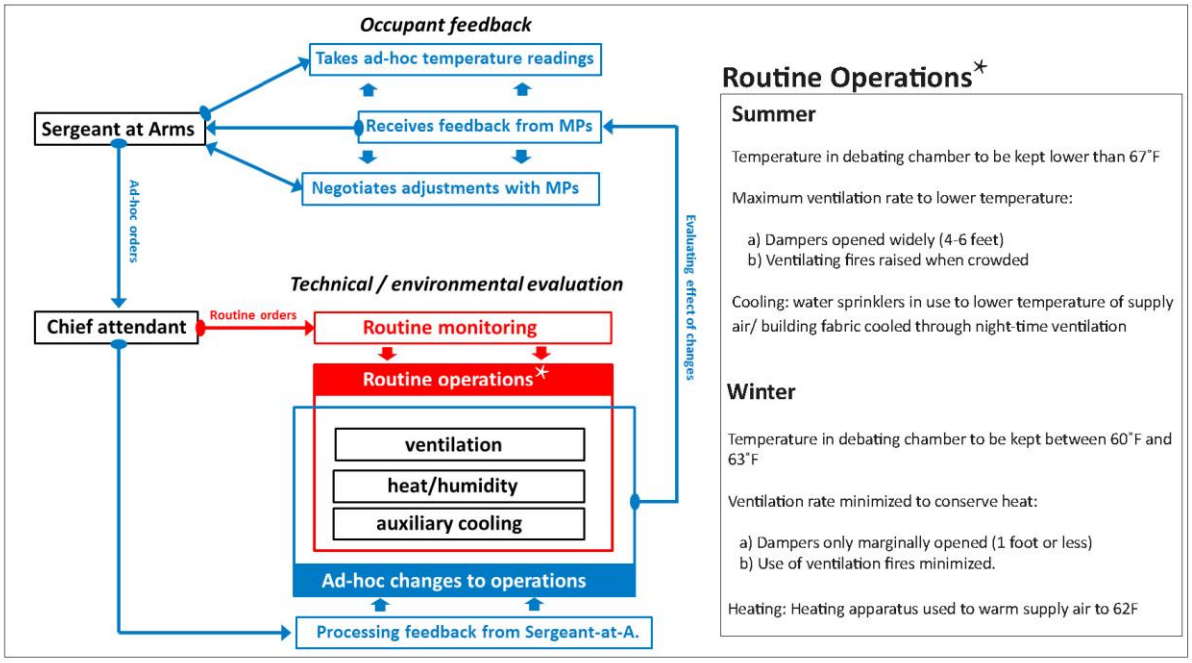

Fig. 2: Diagram showing the operational regime, including occupant feedback system, adopted in the Temporary House of Commons. (Author's own drawing)

4. Technical refinement based on user-perception

This monitoring regime had not existed from the start but it had evolved gradually over five years. In an early technical report on his system from February 1837 Reid highlights that he originally avoided the inclusion of direct user-feedback in the monitoring regime.

Observations inside the mock debating chamber revealed that it was too difficult to achieve mutual agreements on thermal comfort among large groups. He believed that it would be sufficient to set an average temperature and regulate the ventilation rate according to the number of MPs attending.[40] A manual with series of set temperatures was provided (fig.2), but feedback from Members, showed that the perceived temperature was strongly affected by the velocity of the air rising through the perforated floor. When the House was crowded, for instance, the freshness of the atmosphere could only be maintained if the ventilation rate was raised to a level where it produced undesirably strong currents. Under these circumstances the temperature of the supply air needed to be raised to 70F before Members ceased complaining about the sensation of chilly currents.[41] Observations inside the Temporary House reconfirmed the the thermal comfort implications of a system that relying entirely on perforated floors for the air supply. In his original plans Reid envisaged to address issues with currents, by allowing to supply to be switch from the floor to the ceiling. Apart from a brief trial, the stack-driven system in Westminster was constantly operated in an upward mode, which was largely due to the gas-light below the ceiling. The descending fresh air current was found to carry heat and fumes from these lights into the House.[42] In a mock debating chamber, on the contrary, Reid had adopted an arrangements where the gas flames were isolated from the atmosphere of the chamber through a glass ceiling, but he was not permitted to implement the same arrangement at Westminster. Trials with different lighting arrangements were undertaken, but the issue was never successfully resolved.[43]

In early 1837 only the air temperature was measured, but after a few months it became evident that Reid had been naïve in his assumption and that a more complex monitoring regime and which involved reviewing feedback from MPs was required to improver user satisfaction**.** Dissatisfaction with the internal conditions drove various MPs to criticize Reid's system and drove subsequent efforts to refine the system and its management.[44] As temperature measurements on their own were also not sufficient to explain the environmental conditions that the MPs were actually experiencing, the scope of measurements was gradually increased. In 1838, following complaints about an excessively dry and dusty atmosphere, Reid tasked his deputy in London with keeping a register of the relative humidity, which had previously not been monitored.[45] Admitting that a more advanced management regime was required,[46] Reid in 1843 introduced additional thermometers above the ceiling and within the fresh air inlet. This additional data was to provide a better understanding of the effect of weather changes on the system's performance. New columns were added to the original log-sheets for additional data, covering air velocity, use of water and ice for cooling, and fuel for the heating and ventilating furnace. This data was to 'enable the attendants to acquire experience in the various contingencies which they have to meet, and particularly, to enable them to anticipate, as far as possible, every expected change of atmosphere.'[47] This provided the blueprint for the log-book used for the monitoring of the Permanent House of Commons from 1853 through to 1928.[48] In addition to a more comprehensive monitoring system, complaints also drove Reid to gradually introduce a system of full-climatic control. When the ventilation went operational in winter 1836 it was only equipped with a heating apparatus, but it evolved into a more sophisticated environmental system, which included arrangements for air filtration, regulating atmospheric humidity, and the cooling of the supply air.[49]

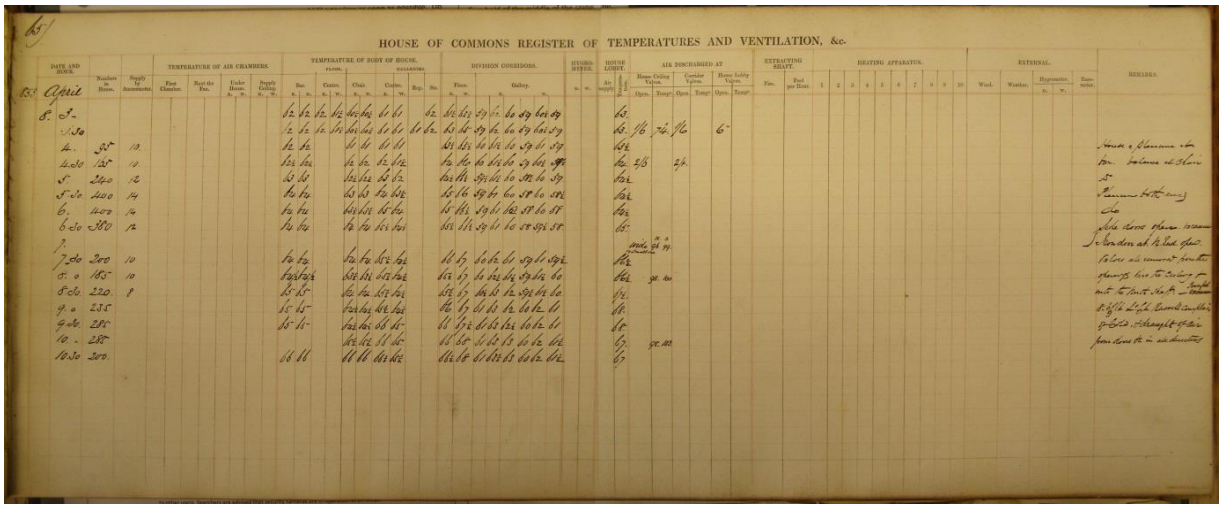

Fig. 3: Page (8 April 1853) from the original log-book used to record measured data and oral feedback from MPs in the Permanent House of Commons. (Parliamentary Archives, OOW/5)

5. The Temporary House of Lords as the test-bed for an alternative approach, 1838-47

Two years after Reid had applied his system in the House of Commons, he was also commissioned to make alterations to the ventilation in the Temporary House of Lords. Numerous complaints about the poor air quality and thermal discomfort had been made since December 1834 and in summer 1835 became the subject of a parliamentary inquiry.[50] In 1839 Reid was commissioned to address the issue, [51] but he also used the House of Lords as the test-bed for a new approach to environmental management that was different from the House of Commons. He stated that continued disagreement among individual MPs about thermal comfort made it impossible to achieve a high satisfaction rate if the climate within the chamber was uniform throughout. In the House of Lords his objective was to explore how far levels of satisfaction could be increased by delivering local climates within different parts of the chamber.[52] Although the climate could not be tailored to each individual, the management was able to create some climatic variation throughout the chamber. In the more crowded areas for instance, where there was a greater tendency to overheating, cooler air was introduced, while areas that were more sparsely populated could be supplied with warmer air. Air of different temperatures and velocities could be introduced at the benches on opposite sides as well as around the bar and the throne, producing cooler or warmer zones within the chamber.(fig. 4) At times the difference in temperature in the air introduced in one section could be as low as 52°F and as high as 75°F in another.[53] Fresh air was supplied through a cavity behind the wall panelling, from under the benches and tables and through grills in the risers of the raked floor.[54] Fresh air was purified, humidified, heated or cooled in the tempering chamber below the main floor,[55] and to gain more control over the supply and independently from the pressure of the stack, Reid introduced a separate plenum system.[56] Used air was extracted through a series of circular openings inside the ceiling, which were connected to the discharge shaft of the House of Commons via a large duct.[57]

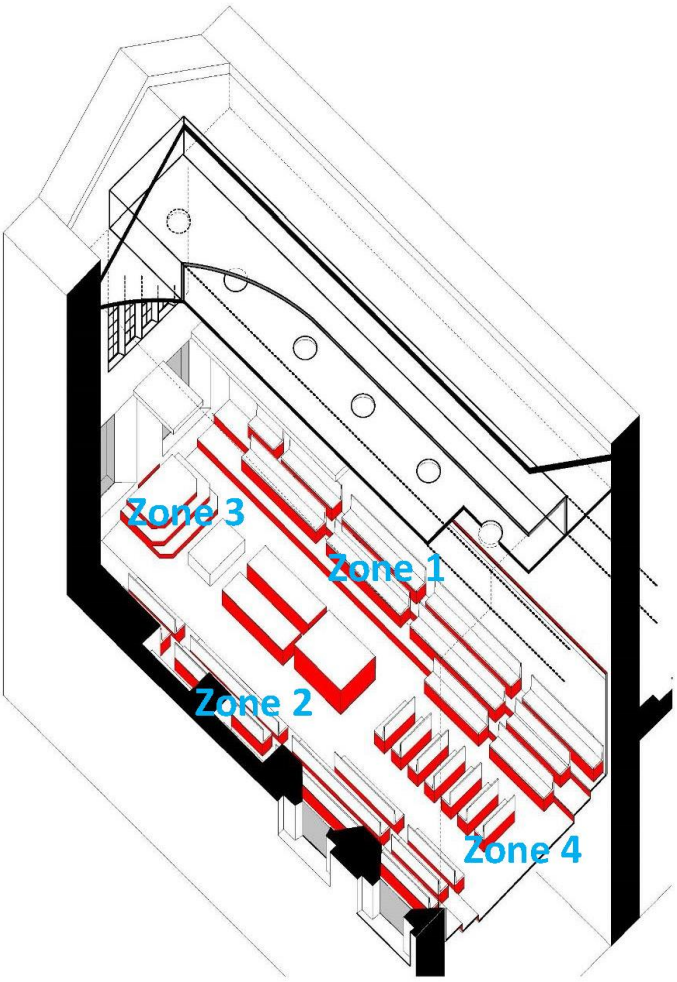

Fig. 4: Axonometric projection showing interior of Temporary Houses of Lords.

(Author's own drawing)

This new strategy did not succeed in increasing user-satisfaction. The idea of managing the different climatic zones based on oral feedback was found to be difficult to implement. The Peers had various debates about the indoor climate, which illustrates how they had perceived the internal conditions. Lord Campbell wrote that the system was successful in maintaining a good air quality but the main problem was insufficient control over the temperature and currents.[58] During a debate in February 1843 he complained that the '*alternate heat and cold of the place made it at one time a cold bath, and at another a vapour bath*'.[59] On 5 June 1845 Lord Brougham complained about the wretched state of the atmosphere and Campbell reported that some Peers 'suffered so severely last night from the imperfect ventilation, and the sudden draughts of hot and cold air'[60] In 24 April 1846 Lord Brougham notes that the 'Lords were sometimes broiling and sometimes freezing'.[61] For Reid the main issue was not technical but the communication between the Peers and the attendants of the ventilation. During an interview with the 1844 Select Committee Reid stated that the technology permitted a high level of control over the temperature and velocity of air currents, but the attendants relied on regular feedback from individuals occupying different areas to effectively respond to their specific needs. Critical feedback had been very limited, even when the Peers felt uncomfortable in the part they were occupying.[62]

6. Towards the Personalization of environmental control

Despite widespread disapproval Reid pursued developing the idea of more personalized climates in the 1840s, whilst working on the ventilation for the Permanent Houses of Commons and Lords in the New Palace of Westminster. Reid started developing a stack ventilation system to be incorporated in Charles Barry's architectural scheme for the New Palace of Westminster in 1840.[63] He developed first concepts for a system providing personalized climates in his early proposals for ventilating the two permanent debating chamber inside the Palace, which were finally implemented in the Permanent Houses of Commons between 1846 and 1852.(fig. 5) These final arrangements cannot be discussed in detail in this paper, but a more in-depth study has been published in *Studies in the History of Construction*.[64] Reid realized another system following similar principles in St. George's Hall in Liverpool.[65] A more complex air handling strategy, following similar principles tested in the mock-debating, was adopted to provide attendance with the flexibility to operate the ventilation in different modes. To allow the system be operated in an upward or downward mode two separate air supplies with their own tempering chambers were introduced, one above the ceiling and another below the main floor. Facilities for addressing individual differences in perceived thermal comfort through the creation of local climates was increased by allowing the climate of each bench to be individually adjusted in response to requests from users.[66]

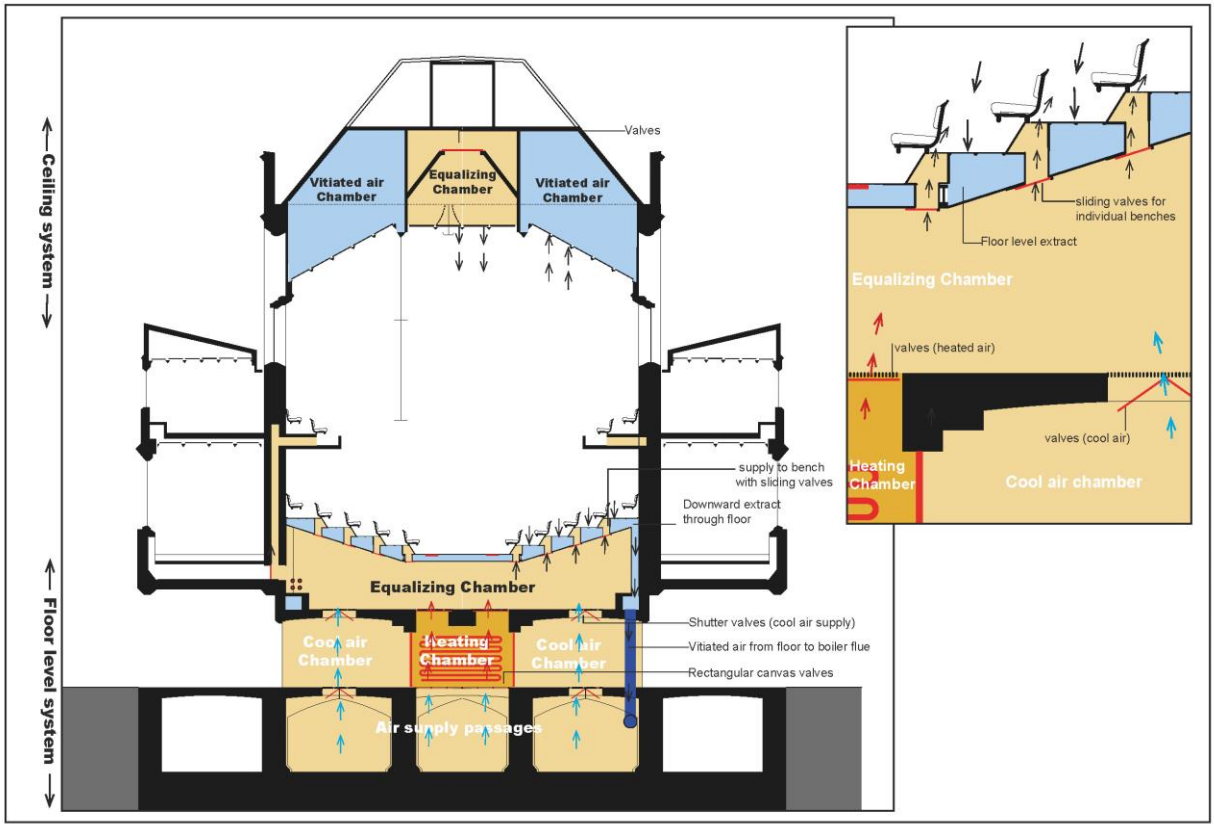

Fig. 5: Cross-sections of House of Commons, showing how air was handled at ceiling and floor level. (author's own drawings)

In contrast to the Temporary House of Commons, where fresh air was admitted uniformly across the entire floor, the floor inlets in the Permanent House were confined, as far as possible, to areas where Members were not exposed to incoming currents. The main air supply was through central floor between the table and bar,[67] but fresh air was also admitted through the perforated floor along the back of the benches and through the risers in the gangways. Separate inlets were provided for the Speaker's chair and within the crowded

areas around the table.[68] The supply in each of these areas was designed to be regulated independently, involving over 60 individual sliding valves that could be manually adjusted by attendants from inside the equalizing chamber. Working drawings and written notes from 1851 illustrate that each bench and riser was provided with a separate supply duct and valve.[69] The humidity, temperature and velocity of the fresh air admitted was regulated inside the Equalizing Chamber, below the main floor.[70] Thermometers and hygrometers were situated inside the equalising chamber, allowing the attendant to closely monitor the temperature and relative humidity of the air. The temperature was adjusted by regulating the relative quantity of cool and heat air admitted through separate valves from the air tempering chamber on the level below. This chamber had central heating compartment with hot water pipes, surround by a cool air chamber, through which unheated air could pass directly from the basement into the equalizing chamber. The fresh was supplied primarily from the top of the Clock Tower and was conveyed to the House through air passages in the basement.

7. An unsuccessful experiment

Transcripts of debates and parliamentary papers reveal that the MPs were highly dissatisfied with the climatic conditions inside the new House, and as before, were very vocal demanding remedial measures.[71] Between 1852 and 1854 the new ventilation became the subject of inquiries by four separate parliamentary committees and several independent scientific studies were commissioned, investigating the causes of discomfort.[72] These inquiries revealed that that this sophisticated management strategy that Reid had proposed was never been fully put into practice. This was partly due to the (1) design of the gas lighting, which, as in the Temporary House, prevented the use of the ceiling supply,[73] and partly as (2) critical features never completed and due to (3) complexity of the monitoring and management regime. Managing a complex operations which were required to respond to changes in the weather or number of MPs, let alone to feedback from users, was a major managerial task. As these operations were done completely manually, without the aid of modern computerized monitoring and control, the system's performance relied heavily on the effective co-ordination of the recording and adjustment procedures. A large volume of data had to be gathered, interpreted and communicated alongside adjustments to ventilation dampers and the heating, cooling and air filtration systems. Failure to satisfy the MPs, however, led to the system being abandoned in 1854, only two after it went first operational. It was the demands of the occupant, in the case an occupant of unusually high influence and power that led to the fall of Reid's system.

8. Conclusion

This paper has explored how user-perception has acted as a major driving force in the development of Reid's design for the ventilation of Houses of Commons and in evaluating its performance. User perception became a central measure in evaluating the effectiveness of ventilation system from the point of thermal comfort or air quality. Reid tested environmental monitoring regimes that combined measurements with the review of oral feedback from users. This was adopted first to account for various aspects of the environment that had not been monitored but also to gain an understanding of the perceived environment and how this differed from what the measurements were suggesting. In *The Architecture of the Well-Tempered Environment* Raynar Banham stressed the reliance of 19th century scientists on the human senses in their efforts to study of the environment of enclosed spaces.[74] The 'measurable' and the 'perceived', however, were integrated not only to gain a comprehensive understanding of environmental conditions inside the chamber, but also to monitor these climate and atmosphere affected occupants. 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. This included experiments with 'concensus-based' and 'personalised' approaches to environmental control, which have remained the subject of conflicting philosophies of thermal comfort up to the present day. The BRE's Environmental Building in the UK, for instance, combines a central BMS system with remote control. The latter permitted users to adapt the indoor environment to their personal preferences by manually overriding the central system. The work in Westminster reflected a highly developed understanding of the role of the occupant-environment relationship in environmental design, which resembles very closely that of current methods post-occupancy evaluations, in which user-surveys are combined with the environmental monitoring. Reid's work, however, predated the modern methods of post-occupancy evaluation developed in the 1960s,[75] including those used in Ellie Morgan's Wallasey School, by 130 years.

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[3] 1837-38 (277) Ventilation of the House. Letter from Dr. Reid to the Viscount Duncannon, in reply to observations addressed to His Lordship by Sir Frederick Trench.
[4] Ibid.
[5] Reid, Progress, p. 153
[6] Letter from Reid to the Council of the University College, London, 1837 in Testimonials regarding Dr. Reid's qualification as a lecturer on chemistry and teacher of practical chemistry, April 1837 (UCL Library, Hume Tracts)
[7] Reid, Progress, p. 153
[8] 1837-38 (277) Ventilation of the House. Letter from Dr. Reid to the Viscount Duncannon, in reply to observations addressed to His Lordship by Sir Frederick Trench.
[9] Progress, pp. 153f
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[18] 'Philosophical Society', *Caledonian Mercury*, 28 July 1836
[19] 1837-38 (277) Ventilation of the House. Letter from Dr. Reid to the Viscount Duncannon, 28 March 1838.
[20] American Dwelling, pp. xv-xxxvii; Reid, *Illustrations*, pp. 177, 86, Reid, Reid, Progress, p. 164-77; Letter from Dr. Reid to the Viscount Duncannon, 28 March 1838.
[21] 'Philosophical Society', *Caledonian Mercury*, 28 July 1836
[22] Letter from Dr. Reid to the Viscount Duncannon, 28 March 1838; Reid, Illustrations, p. 273.
[23] Letter from Reid to Duncannon, 28 March 1838
[24] Drawings of the damper system were included in 1837-38 (277) Letter from Dr. Reid to the Viscount Duncannon, 28 March 1838.
[25] Note: The modern psychophysiological approach has been described, among others, by R.G. Hopkinson, Architectural Physics: Lighting (London: HMSO, 1963)
[26] Letter from the Treasury to the Commissioners of Woods, 26 August 1836 (National Archives: Work 11/12, Nr. 7); Letter from the Treasury to the Office of Woods, 26 August 1836 (National Archives, work11/12, nr. 7); Letter from the Office of Woods to Reid, 13 September 1836 (National Archives, work11/12, nr. 8); 'Miscellanea', *Champion*, 3 October 1836, p. 1; 'London', *Caledonian Mercury*, 17 October 1836, p. 2.
[27] Note: Some of the experiments are described in: Report from the Select Committee on Lighting the House (HC 1839, 501); Report from the Select Committee on Ventilation of the New Houses of Parliament(HC 1842, 536); Report of the Select Committee on the Houses of Parliament(HC 448, 1844); Arnott, Memorandum of an inspection made by me, this Day, the 22nd of December 1837, of the arrangement for ventilating and warming the House of Commons' in Hansard HC deb 23 December 1837, vol. 41 cols 329-332.
[28] Schoenefeldt, Henrik, The Temporary Houses of Parliament and David Boswell Reid's architecture of experimentation, *Architectural History*, 57-2014, pp. 175-215.
[29] Illustrations, 1844, p. 274; 'House of Commons', *Sheffield Independent,* 12 November, 1836, p. 1; 1837 (21) Ventilation of the House, Letter from Dr. Reid to Lord Duncannon, 4 February 1837, relative to the acoustic and ventilating arrangements lately made in the House of Commons.
[30] 1839 Select Committee, Q 744
[31] Reid, illustrations, p. 325.
[32] Reid, illustrations, p. 327f; 1839 Lighting Committee, pp. 75f
[33] Select Committee on Lighting the House, Report from the Select Committee on Lighting the House (HC 1839, 501), Q 622
[34] Reid, Illustrations on the Theory, , p. 65-69
[35] Wyman, Morril, treatise on ventilation, p. 224.
[36] Report of the Select Committee on the Houses of Parliament (HC SC 448, 1844)
[37] 1839 Lighting Committee, Q 758

[38] Wyman, Morril, A practical treatise on ventilation (London: Chapman Brothers, 1846) p. 224.
[39] Select Committee on the Houses of Parliament, Report of the Select Committee on the Houses of Parliament(HC 448, 1844) Q324-27, 387
[40] Letter from Reid to Duncannon, 4 February 1837; Reid, David, *Brief outlines illustrative of the alterations in the House of Commons, in reference to the acoustic and ventilating arrangements* (Edinburgh, 1837)
[41] Report of the Select Committee on the Houses of Parliament(HC 448, 1844), Q557.
[42] Letter F. Trench to Lord Duncannon, 6 May 1838, in Ventilation and Lighting of the House (HC 1837-8, 358, p. 5.
[43] Select Committee on Ventilation and Lighting of the House, Second report from the Select Committee on Ventilation and Lighting of the House (HC 1852, 402); Select Committee on Lighting the House, Report from the Select Committee on Lighting the House (HC 1839, 501)
[44] 'Ventilation of the House of Commons', *Morning Post*, 29 December 1837, p. 1; Savage, James, 'To the editor of the Times', *The Times*, 21 March 1837, p. 5; To John Bull', *John Bull*, 8 September 1839, p. 429; Trench, Frederick,'The new light'*Morning Post*, 19 August 1839.
[45] Letter from Trench to Duncannon, 22 April 1838
[46] Letter from Reid to Ducannon, 28 March 1838
[47] Reid, *Illustrations*, p. 325.
[48] E.g. Registers of temperature control and ventilation for the House of Commons 1853-1928 (Parliamentary Archives, OOW/5)
[49] Letter from Reid to the Chancellor of the Exchequer, 17 June 1837; Reid, Brief Outlines, p. 14; 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)
[50] 'The House of Parliament', *Morning Post*, 26 December 1834, p. 4.
[51] Reid, Illustrations, 1844, pp. 271.
[52] Select committee on Houses of Parliament, Report of Select Committee on Houses of Parliament (HC 1844, 448), Q317-23.
[53] 1844 Committee on Houses, Q322
[54] Reid, Illustrations, p. 284-93
[55] Reid, Illustrations, p. 284-93
[56] Select Committee on Ventilation and Lighting of the House, Second report from the Select Committee on Ventilation and Lighting of the House (HC 1852, 402), Q511-542
[57] Brayley, *history,* pp. 463-4
[58] Letter from Lord Campbell, 11 September 1843, in Extracts from official documents, reports (UCL Library, Hume Tracts)
[59] The New Houses of Parliament, HL Deb 21 February 1843 vol 66 cc1033-6
[60] The new houses of parliament, HL Deb 05 June 1845 vol 81 cc120-2
[61] Progress of the New Houses of Parliament, HL Deb 24 April 1846 vol 85 cc970-6
[62] 1844 Select Committee on Houses, Q317-28,387; Reid, Illustrations pp. 292-3.
[63] A detailed study on the design development process, including the collaboration between Reid and Barry's teams can be found in: Schoenefeldt, Henrik, 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)
[64] Schoenefeldt, Henrik, 'Reid's short-lived ventilation system for the Permanent Houses of Commons' 1847-54, in Studies in the History of Construction: The Proceedings of the Second Annual Construction History Society Conference 2015 and International Colloquium on Construction History, 20-21 March 2015, Queens' College, University of Cambridge, (Cambridge: Construction History Society, 2015), pp. 167-180.
[65] Mackenzie, William, On the mechanical ventilation and warming of St. George's Hall, Liverpool, *Proceedings of the Institution of Mechanical Engineers*, 1863, pp. 194-208; Reid, Diagrams of the Ventilation of St. George's Hall, To the right Worshipful the Mayor and Corporation of Liverpool and the Law Courts Committee, under whose direction and superintendence St. George's Hall and the New Assize Courts have been constructed, 21 May 1855 (Liverpool Record Office)
[66] 1844 Committee on Houses, Q317-28,387
[67] Interview with Reid, 30 April 1852, in 1852 Select Committee (SC 1852 Q3545)
[68] 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);
[69] 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).
[70] Second report from the Select Committee on Ventilation and Lighting of the House (HC SC 1852, 402)
[71] E.g. Imperial Parliament, Daily News, 5 February 1852, p. 3, Memorandum submitted by Reid to the Commissioners of Works, 7 February 1852 (work 11/14 nr. 678); Ventilation of the House, HC Deb 06 February 1852 vol 119 cc231-4 231, Ventilation of the House, HC Deb 11 February 1852 vol 119 cc400-16.
[72] Second report of Mr. Goldsworthy Gurney on the ventilation of the new House of Commons. (HC 1852, 252 (371); Second report from the Select Committee on Ventilation and Lighting of the House. HC 1852 (402); 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); First report from the Select Committee on the Ventilation of the House (HC 1854, 149), 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)
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