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- **A case study on the House of Parliament, 1836 – 1966**

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INTRODUCTION: Taking a historical perspective

The preceding chapters have examined ventilative cooling as a concern of contemporary practice, but historic buildings illustrate that the use of ventilation for cooling has been a much more longstanding practice. It was widely utilised in public buildings throughout 19th century and first half of the 20th century, often in combination with other historic cooling techniques.

Amongst Victorian buildings designed to utilised ventilative cooling, was, the Royal Albert Hall,[1] National Gallery[2] and British Museum but also various market halls and exhibition halls, such as Smithfield market and the Crystal Palace of 1851.[3] Also icons of the modern movement, such as Ludwig Mies van der Rohe's Crown Hall in Chicago, were designed utilise ventilative cooling to mitigate overheating issues. Today the interest in the use of ventilative cooling is driven by a search for more energy efficient cooling techniques, but in the 19th century its use was a necessity, driven by the technical limitations of historic refrigeration methods. As such historic buildings provide setting/ where the challenges of cooling buildings before the introduction of mechanical refrigeration and air conditioning can be studied.

The objective of this chapter is to explore ventilative cooling as a historic practice, using the Houses of Parliament as case study. The debating chamber, subject to significant overheating issues, provide intimate insights into the historic practices, illuminating how ventilative cooling techniques were deployed to mitigate overheating encountered during hot weather and under crowded conditions. Inside the two debating chambers ventilation was utilised for cooling purpose in three different ways. In addition to (1) reducing the indoor air temperature, ventilation was utilized to (2) harness the cooling effect of air movement, (3) and also to cool the architectural fabric, following the principal of night-purge ventilation.

This chapter focuses primarily on the experience within the House of Lords, but excursions will be undertaken into some parallel investigations inside the House of Commons. The latter was built in 1852 but was destroyed during air raids in 1941 and subsequent rebuilt incorporating modern air conditioning and mechanical ventilation technology. In the House of Lords, historic practices of ventilative cooling continued to be deployed for another 16 years. Air conditioning was not introduced in this upper chamber before 1966. Covering the period from 1835 until 1950 this chapter re-examines the experience and knowledge that users, scientific researchers and technical staff had acquired, illuminating the practical challenges of achieving thermal comfort through ventilative cooling, covering both mechanical and natural methods. These not only engaged with the technological but also managerial and user-experience perspectives. To recover these historical experiences with the use of ventilative cooling, it was necessary not only to study its physical architecture, but also its operational history, an area that overlaps with the domain of facilities management. Archival material, such as log-books, letters, scientific reports and parliamentary papers, was used to uncover some of the tentative knowledge acquired through day-to-day observations and user feedback, but also the deeper understanding gained through formal

[1] Schoenefeldt, Henrik; Kohler, Maria, The Royal Standard, *CIBSE Journal*,April 2017, pp. 36-38.
[2] Committee of Council on Education, Report of the Commission on the Heating, Lighting, and Ventilation of the South Kensington Museum (HC 1868-69 Cmd 4206)
[3] Schoenefeldt, Henrik (2011) Adapting Glasshouses for Human use: Environmental Experimentation in Paxton's Designs for the 1851 Great Exhibition Building and the Crystal Palace, Sydenham. Architectural History, 54 (2011). pp. 233-273; Schoenefeldt, Henrik (2008) The Crystal Palace, environmentally considered. Architectural Research Quarterly, 12 (3-4). 283 -294.

scientific investigations.[4] These records offer critical insights into the ways the climate and ventilation managed, using a combination of mechanical and passive strategies, how it had performed and also how it was experienced by users. Several attempts were also made to improve the cooling arrangement, which involved physical and operational changes but also hypothetical design studies, exploring the possibility of more fundamental changes to the historic practices.

PRELIMINARY INVESTIGATIONS

Ventilative cooling at the brief and design stage, 1836-1851

The principles underlying the ventilation system of the House of Lords was the outcome of extensive investigations into the fundamental issues of ventilation and thermal comfort inside legislative chambers, which were untaken after a fire in 1834 had destroyed the original Houses of Parliament. Overheating heating problems had been common inside the original debating chambers, and the decision to create a new purpose-built parliament, offered the opportunity to re-visit these issues in the light of new technologies and scientific research. These inquiries began with the appointment of a Select Committee in 1835, which the House of Commons had charged with the task of consulting experts and reviewing hypothetical proposals for modern ventilation systems. Amongst these was a proposal by the Scottish physician David Boswell Reid, which was significant due to its focus on the physiological aspects of environmental control, highlighting thermal comfort as an important aspect of ventilation in legislative chambers. This focus was reflection of Reid's background in the medical sciences and chemistry. Although Reid did not have a background in architecture or engineering, he had undertaken research into indoor air quality and the thermal comfort, which included experiments on the thermal perception of internal currents, which too account several parameters, such as velocity, direction, distribution and temperature and humidity. Inside a series life-size models, Reid also trialed methods of diffusing the air currents inside hermetically sealed spaces, through the use of perforated floors, ceilings and walls.

In Westminster Reid proposed hold parliamentary sittings within the artificial atmosphere of a hermetically sealed chamber. This chamber was to be supplied with conditioned air through a central ventilation network, containing facilities for cooling, heating and filtration. The air entered through perforated floors and was extracted at the ceiling. **(Figure 1)** The ventilation was driven entirely by the natural convection of hot air ascending a tall shaft. Reid claimed that convection, enhanced artificially with the aid of furnaces, will provide the higher flow rates required to '*ventilate an overcrowed or heated room*'[5] The system had to mitigate the impact of heat derived from external sources, such as sunlight and high outdoor temperatures, as well as internal heat sources, such as gaslights and large numbers of people. The latter was significant as it could reach numbers of 400 in House of Lords and 800 in the House of Commons, during major debates. Reid was aware that his concept would only succeed if the cooling effect produced by the currents of the incoming air can be kept within a comfortable range, taking into account velocity and temperature as interpendent variables. If both are well-managed he believed that it would be '*utterly impossible for it to abstract such quantities of heat from the human body as to make any one feel any inconvenience from it.*'[6] For this purpose he proposed to physically cool and heat the supply air, using hot and cold water pipes, but also to reduce the intensity of the incoming air. His proposal was to cover the entire floor with 10.000 small inlets, arguing that it would allow to prevent excessive currents even if at times when the ventilation had to be boosted. Although Reid's statement focused on the avoidance of exessive air speeds as a source of discomfort, engaged critically with air movement as an aspect of thermal comfort.

The Select Committee did not recommend the adoption of any specific schemes or technologies, but over the following four years Reid to test and refine idea experimentally, in which questions of thermal comfort remained the focus. These explorations began with trials inside a large physical model, erected at his private laboratory in Edinburgh, and in autumn 1836 he was also

[4] The research is based on archival material held at the National Archives in Kew, Parliamentary Archives and Strategic Estates Archives in Westminster and at Historic England's architectural archive in Swindon.
[5] Oral Statement by Reid given on 21 August 1835, in Report from Select Committee on the Ventilation of the Houses of Parliament (HC 1835 (583), pp. 34-47.
[6] Oral Statement by Reid given on 26 August 1835, in (HC 1835 (583), pp. 47-51.

commissioned to remodel the ventilation of the Temporary House of Commons based on his principles. This was built as provisional debating chamber in 1835 to accommodate sittings until the completion of the parliament building. It was occupied for 15 years and allowed Reid to tested and develop his principles of ventilation under real-life conditions, involving MPs directly in the process of evaluation and improving the thermal environment from a user-experience perspective.[7] Reid discussed his inquiries in his book *Illustrations of the theory and practice of ventilation*, published in 1844. This includes a whole section examining physical factors affecting thermal comfort, including air movement[8] and it also describes how this knowledge was utilised in the day-to-day operation of the Temporary House.

Similar to his earlier proposal the temporary chamber was sealed and supplied with fresh air through a perforated floor. (**Figure 2 & 3)**The air movement was sustained by a large chimney with a coke fire. It was equipped with warm air central heating, which contained arrangements for humidification, air filtrations and cooling. The air was cooled by evaporation, utilising water sprinklers, and by circulating cool water through radiator cases. Attempts were also made to cool the air with natural ice, but these did not go beyond the stage of short trials These methods were complemented by ventilative cooling. Reid reported that the ventilation had to be use to increase comfort in summer and to '*moderate the heat produced by so many on a limited space*'[9]. During ordinary weather and levels of occupancy Reid recommend a supply of 10 cubic feet per minute per person, but in hot weather it was raised to between 40 to 60 cubic feet per minute for cooling. He noted that such levels were necessary if comfortable temperatures were to be maintained without resorting to artificial cooling. Ventilation was the principal cooling method, and Reid exploited three different approaches to improving comfort through ventilation. In addition to night purge cooling, ventilation rates were increased for the purpose of lowering the air temperature and also for harnessing the cooling sensation of currents. The latter was particular critical as high air temperatures could not always be prevented . Reid wrote that '*an atmosphere sultry and oppressive from its high temperature, might be rendered cool and pleasant to the feelings by increasing its velocity, provided the temperature is actually below that of the human frame*.'[10] He claimed that increased air movement, even at a temperature of 75F, 'may be rendered cool and pleasant to the feelings'[11] To successful implement his strategy Reid also had to introduce formal procedures for environmental control and monitoring, which, aside from the systematic recording of temperatures and technical operations incorporated a process for collecting and processing user feedback. This was critical as many physical factors affecting the perception of warmth, including air movement, were not routinely measured. **(Figure 4)** This feedback highlighted some of practical difficulties with implementing his cooling strategy from a user-perspective.[12] MPs reported that the current produced a chill around their feet and legs, in particular during crowded debates or hot weather when the ventilation rate was increased to reduce the air temperature.

This issue was revisited in 1840s when Reid became formally employed by the government as a consultant to work with the architect Charles Barry in the development of the ventilation and central heating for the Houses of Parliament. In the context of the House of Lords Reid explored an alternative approach to supplying air. This resulted in changes to the architecture of the floor. In his scheme, which had been developed between 1842 and 1846, Reid proposed to confine the floor inlets to positions where the feet and legs of the Lords were not exposed to direct currents. This required Reid to carefully plan the positioning of inlets, using any available surfaces, such as skirting boards, wall panels or tables.[13] The air, he argued, was to '*flow in and rise as gently as the*

[7] The application of these principles in Charles Barry's House of Commons is examined in: Schoenefeldt, Henrik, Powers of Politics, Scientific Measurement, and Perception: Evaluating the Performance of the Houses of Commons' First Environmental System, 1852–4', in Horatio Joyce and Edward Gillin, Experiencing Architecture in the nineteenth-century (London: Bloomsbury, 2018), pp. 115-129.
[8] Reid, D B, *Illustrations of the theory and practice of ventilation* (London: Longman, Brown, Green & Longmans, 1844) pp. 184-87

[9] Ibid, p. 179
[10]Ibid, p. 185.
[11]Ibid, p. 295.
[12] Schoenefeldt, Henrik, 'The Temporary Houses of Parliament and David Boswell Reid's architecture of experimentation', Architectural History, 57-2014, pp. 175-215.
[13] Oral statement given by Reid on 19 March 1846, in Select Committee on Westminster Bridge and New Palace, Third report (HC 1846 574), Q990-91.

movement of the air on a mild summer's evening'[14] During ordinary debates the air was supplied through inlets furthest away from the benches to protect Peers from direct currents. A second system of inlets was provide within the benches and inside the gangways.[15] As the air entered through the back of the benches near the feet, the use of these supplies were to be restricted to periods when the main inlets were not sufficient or if requested specifically by Members. On 14 August 1846 Reid said that only intended to activate these inlets only during 'hot and sultry' weather, over periods when the chamber was exceptionally crowded.[16]

> *On extreme nights when Members of the House of Peers might complain of the state of the atmosphere, and wish a still greater portion than could be supplied by those means, then I would propose to bring in the back of the seats and using the steps as surfaces of diffuse ventilation under such control as the Peers themselves might desire*'[17]

The design for this highly complex scheme was never fully resolved. Largely due to delays caused by difficulties with completing his scheme, the House of Lords in 1846 voted to terminate Reid's involvement in the design. The responsibility for completing the system was transferred to the architect. He altered parts of Reid's plans to realise a different approach to achieving comfort, focusing on the interrelationship between air movement, radiant heat and air temperature. In his new scheme the perforated floors were sealed and the inlets for the primary air supply moved into the ceiling. Air was supplied and extracted almost entirely through the ceiling. Supplementary outlets were provided at mid-level, using opening in the coving under the side galleries, and only a small quantity of the air was admitted through outlets at floor level as part of a back-up system.[18] **(Figure 5)** Barry argued that the introducing the air from above would overcome the problems with currents entering close to the body,[19] noting that it was '*impossible to avoid the inconvenience of partial currents when air is admitted from the floor, or near the person*'[20] This had the advantage of allowing cooler and larger quantities of air to be injected at a greater distance from the benches. The temperature of the supply air itself was kept low, and the effect of the cooler air was compensated through the provision of radiant warmth, using underfloor heating. The air introduced through the ceiling was only kept at around 62F(16C), whilst the surface temperature of the floor was raised to 67F(19C).[21]

PERFORMANCE ISSUES
The examination and remodeling of the House of Lords, 1847-55.

Barry's system was in use from 1847 until 1854 and over this period its performance became subject of two formal inquiries, in which the use of ventilative cooling and its implications for thermal comfort was a major focus. These inquiries, coordinated by Select Committees in 1852 and 1854, were undertaken as many Lords were dissatisfied with the thermal conditions. The Office of Works, a government department responsible for managing the operation and maintenance of the Houses of Parliament, also made several technical alterations in an attempt to improve comfort.

Transcripts of interviews with individual Lords, conducted in March 1852, provide some insights into their experience of the conditions. Although the personal experiences were varied, they highlighted draughts and overheating as the main cause of discomfort. The latter was the result of

[14] Oral statement given by Reid on 19 March 1846, in Select Committee on Westminster Bridge and New Palace, Third report (HC 1846 (574)), Q990-91.
[15]Oral statement given by Reid on 4 August 1844, in Select Committee of House of Lords on Progress of Building of Houses of Parliament, *Second Report,* (HL 1844 629), Q35
Q552-554
[16] Interview with Reid, 14 August 1846, in Select Committee of House of Lords on Progress of Building (HL 1846 (719)), Q35
[17] Interview with Reid, 4 August 1844, Lords Progress 1844, Q552.
[18] Oral statement given by 5 April 1852, in Select Committee on Ventilation and Lighting of the House, Second Report (HC 1852 (402)), Q1422.
[19] The New Houses Parliament, *The Times*, 5 April 1847, p. 3
[20] Oral statement given by Charles Barry, 4 May 1854, in Select Committee of the House of Lords appointed to inquire into the possibility of improving the ventilation and lighting of the House, *First Report* (HL 1854 ((384), Q505
[21] Oral statement given by Alfred Meeson, 4 May 1854, (HL 1854 ((384), Q594-7

overcrowding and large heat gains from gaslights and sunlight. Lord De Ros reported that many Peers perceived the atmosphere as dead and artificial, which he attributed to the uniform temperature and the absence any sensible air movement.[22] In contrast, Earl Lonsdale perceived the thermal environment as highly changeable' noting that it was 'sometimes very hot, other times very cold, with cold draughts'. During the sitting on the 29 March 1852, he reported that the temperature had reached 70F, leading to complaints from several Peers and the clerk at the table was sent to the engineer to make a request for adjustments. The temperature was reduced to 66F, but according to Lonsdale it was still 'too hot and oppressive' and argued that there was still a 'deadness and fustiness in the air.'[23] Lord Redesdale noted that the system struggled under crowded conditions. Lord Lansdowne and Early Grey mentioned occasional problems with cold drafts around the legs. Grey reported that the chamber '*was at one time very hot, and then came a current of very cold air to one's feet.*'[24] and also noted that the sunlight entering the large windows caused overheating during the summer months.

In 1852 several alterations were undertaken, which focused on improving the conditions around the benches on the main floor through increased ventilation. These was achieved by introducing a stronger fan for the air supply, increasing the height the ventilation shaft, and by providing new outlets at floor level, which allow hot air to be extracted downwards. These early interventions, however did not succeed in improving comfort, and in 1854 the House of Lords appointed another Select Committee to re-examine this issues. Collaborating with the Office of Work and the superintendent of the ventilation the Committee evaluated the performance of the existing arrangements, conducted technical trials, and engaged Goldsworthy Gurney, a physician with an interest in ventilation, to develop plans for improving the internal conditions. The focus of this inquiry was on overheating and air movement as the main source of thermal discomfort. This inquiries showed that, despite the introduction of a stronger fan, the ventilation was unable to counteract the large heat gains from the gaslights. The attendants generally kept an atmospheric temperature of 65F to 66F, but when the gas lights were turned on it rose 7F within one hour. The lights emitted a large quantities of heat, which caused the indoor temperature to rise and also exposed the Lords sitting inside the galleries to a strong radiant heat. Measurements, taken when the House was unoccupied, showed that the gaslights were capable for raising the temperature from 62F to 68F.[25] In addition the fan increased the intensity of the fresh air currents and these created turbulences around the Lords feet and legs. In March 1854 Alfred Meeson, superintending engineer in charge of the ventilation, conducted a smoke test to study these currents.[26] These showed that the fresh ascending from the centre of the ceiling formed column of cool air whilst the warm air ascended on the sides to the side panels. When hitting the floor, however, the downward currents moved sideways sweeping across the benches, chilling the Lords' feet and legs.[27]

Gurney's proposal, designed to overcome these issues, was adopted in 1854, following a successful trail inside the House of Commons. In the House of Lords Gurney reinstated the use of perforated floors for the air supply. Arguing that it would allow the incoming air to be diffused more effectively, uncovered the cast-iron floor plates and added a layer of '*cord sisal matting*', a coarsely woven fabric that was permeable to air.[28] In a report to committee, dated 10 April 1854, he wrote the Barry's approach was producing a turbulent atmosphere and that his objective was to bring it into a 'quiescent state.'[29] Making reference to his trial in the House of Commons, he argued that the use of perforated floors allowed introducing 7,000 cubic feet of air per minute without producing any 'sensible motion' around the body.[30] The air movement was closely regulated through a system of manual controls, operated by a team of attendants under Gurney's supervision. These

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[22] Oral statement given by Lord De Ros, in (HC 1852 (402)), Q689-94.
[23] Oral statement by Earl Lonsdale in (HC 1852 (402)), Q679
[24] Oral statement given Early Grey in (HC 1852 (402)), Q702.
[25] Oral statement given by Meeson, 17 March 1854, in Select Committee of the House of Lords, appointed to inquire into the possibility of improving the ventilation and lighting of the House (HL 1854, 384), Q55-114; Q130
[26] Meeson, Alfred, 'Experiment on the ventilation of the House of Peers, and General Building, made on Sunday, 26 March 1854,' in (HL 1854 (384)), p. 57.
[27] Oral statement given by Meeson, 17 March 1854, in (HL 1854 (384)), Q84-85.
[28] H.T. Denbon, Report on House of Lords heating and ventilation system, 30 March 1960 [National Archives, Work 11/588, nr. 21-22]; 'Sample of original sisal matting', 1966, item contain in file: [National Archives, Work 11/588]
[29] Letter from Goldsworthy Gurney to Select Committee, 10 April 1854, in (HL 1854, 384), pp 110-11.
[30] Oral statement given by Gurney, 8 May 1854, in (HL 1854 (384)), Q643.

constituted an array of shutters and louvres inside the air chambers. One set of controls were provided to control the air supply and two sets to control the quantity of hot air going into each ventilation shaft. Their position of these control is shown in figures **7 and 8.** The air was also 'conditioned' in air chambers below the floor.[31] The fresh air was introduced through eight large intakes facing the courtyards on the east (Peers Court) and west side (State Officer's Court) of the House. These constituted of large doors with louvers, which were manually adjusted to regulate the air supply. The lower air chamber contained canvas screen (air filtration), steam batteries (heating), and vaporisers (humidification).[32] An evaporative cooling system, constituting an array of 'Fine water jets,' was stationed outside the air intakes.[33] **(Figure 6)** The ceiling of this lower chamber had twelve rectangular valves, by which the 'conditioned' air was directed into an upper air chamber, which was referred as the 'equalising chamber.' Its purpose was ensure that the air entered at uniform temperature and velocity across the floor.

The internal climate conditions and their effect on user experience, were closely monitored as part of the routine management procedures. The temperature was monitored, using thermometer in different locations, hourly readings were recorded inside log-books.[34] One of the original log books has survived **(Figure 9)**. It covers the period from 1943 to 1948, during which the Lords chamber was occupied by the House of Commons.[35] Other data was reproduced in letters and parliamentary reports. Air movement, however, was not measured as part of the routine monitoring procedures, and, as the perception of thermal environment was also highly subjective, it was evaluated based on direct observations and user feedback. As a result the system became dependent on regular interaction with users. For this purpose the operational procedures incorporated the principles user engagement that Reid had developed and trialed inside the Temporary Houses of Commons.[36] During sittings the Usher of the Black Rod, and the Lord High Chancellor, who was the presiding officer of the House of Lords, acted as liaisons between the Lords and the attendants. They held the responsible for managing the collection and review of feedback, and were also authorised to give instructions for changes.[37] Sir Augustus Clifford, who served as the Black Rod from 1832 till 1877, reported that his responsibility was to review the complaints made by individuals Lords, and if necessary, give instructions to a team of attendants for ad-hoc adjustments to ventilation or climate.[38] **(Figure 10)**

Integrating window-induced ventilative cooling.

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[31] Report 'General outline of the present ventilating arrangemenets', 18 April 1921 [National Archives: Work 11/202]; The plant is shown in 'Houses of Parliament - Plan of ground floor, Office of Works, 1902 [Strategic Estates Archives: uncatalogued drawing], Plan of Ground floor, Office of Works, November 1937 [Strategic Estates Archives: uncatalogued drawing]

[32] A description of Gurney's can be found in John Billings, The principles of ventilation and heating, and their practical application, (New York: The Sanitary Engineer,1884), pp. 116-18; Question Observations, Hansard, HL Deb 22 July 1878 (vol 241 cc2018-21 2018)

[33] DSRI Advisory Council, 'Ventilation of the House of Lords. Minutes of a meeting', September 1935 [National Archives: DSIR 3/20]

[34] Select Committee on the Office of the Clerk of Parliaments (HL 1869), Q100-105 [Parliamentary Archives: GB-061]

[35] Temperature book House of Lords, from 26 March 1943 to 1 July 1947, Parliamentary Archives, OOW 5 series, book 4)

[36] Schoenefeldt, Henrik, 'The Temporary Houses of Parliament and David Boswell Reid's architecture of experimentation', Architectural History, 57-2014, pp. 175-215. The role of user engagement in the day-to-day management of the climate and ventilation in the House of Commons chamber have been examined in detail in two articles: Henrik Schoenefeldt (2019) The House of Commons: a precedent for post-occupancy evaluation, Building Research & Information, 47:6, pp. 635-665; Henrik Schoenefeldt, The Historic Ventilation System of the House of Commons, 1840-52: revisiting David Boswell Reid's environmental legacy,' Journal of Society of Antiquaries, September 98-2018, pp. 245-95.

[37] Note by H.T. Denbon, 13 January 1956 [National Archives: Work 11/588, nr. 3]

[38] Second report from the Select Committee on Ventilation and Lighting of the House (HC 1852 (402)), Q544-46

Gurney also introduced openable windows inside the House of Lords, discarding the idea of permanently sealed debating chamber.[39] From 1847 up until 1854 the stained glass windows were fixed as Barry and Reid intended the space to be completely sealed from the external atmosphere, aiming to exclude external air pollution and to achieve a more tightly controlled indoor climate. Alfred Meeson, who acted as superintendent of the ventilation during the period, reported that the windows comprised two layers of fixed glazing, constituting an inner layer of stained glass and an external layer of clear 'plate glass.' He noted that its purpose was '*to preserve an equable temperature in the House in very cold weather, by providing space or stratum of air between the two glazings, which would prevent the cooling action of the external atmosphere upon that of the House*,'[40] but also reported that it would keep the interior cooler in summer. Following recommendations of the Select Committee of 1854, these windows were altered retrospectively to integrate operable sections for natural cross-ventilation. In the upper part of each of the 12 windows, two sections were made openable and were equipped with crank mechanism that enabled attendants to operate them remotely. Remains of the window opening mechanisms can still be found on the exterior of the House. **(Figure 12)** Roller blinds had been fixed externally on the west and east elevation to protect the Lords from the glare of the low angle sunlight in the afternoon or morning.[41] **(Figure 11)** During the winter months the windows were temporarily resealed by covering the operable sections with exterior glazing, providing thermal insulation and improve airtightness.[42] Despite these changes, Gurney did not proposed to abandon the original concept of a climate controlled chamber. The use of cross-ventilation, facilitated through operable windows, was not intended to substitute or complement the stack ventilation during parliamentary sittings. In a letter, dated 17 June 1854, Gurney wrote it was introduced exclusively for '*freshening the House*' before and after the House was sittings,[43] and in May 1854 noted that there use during sittings would only be advisable under certain weather conditions,[44] It had to be kept closed during strong winds or when the outdoor temperature was too hot or cold.[45] Gurney, however, did not fundamentally oppose a more extensive use of windows. He noted that it would be at the discretion of the Lords themselves to determine when windows were to be opened. He also admitted that it could help improve comfort during warm weather through increased air movement.

A SYSTEM IN USE
1869-1938.

After Gurney's interventions in the mid-1850s the system remained largely unchanged for seventy years, but it underwent several post-occupancy studies and offered detailed into the performance of the historic cooling strategies. The number and scale of technical inquiries into its performance was small compared to those undertaken inside House of Commons. This was largely due to the fact that the challenge of providing adequate ventilation or climate control inside debating chambers was not as severe inside the House of Lords as sittings were generally smaller and shorter. Two studies, published in the *Antiquaries Journal* (covering period from 1852 to 1854) and *Building Research & Information* (from 1854 to 1941), show that the House of Commons was subject of large numbers of parliamentary inquiries and scientific studies, and it also underwent several physical alterations. Over the same period studies in the House of Lords were confined to several smaller inquiries, conducted in 1869 and 1912, and one larger scientific study conducted between 1935 and 1938. One of the earliest inquiries were conducted in the summer of 1869, responding to complaints from Peers. A discontent with the climate inside the chamber was voiced by several Peers during a sitting on 16 July 1869. Their main concerns was the chill produced by the current entering through the floor, and the Lords also expressed their objecting to being placed inside a sealed room. The Earl of Carnarvon described Gurney's system as '*extremely complicated and highly scientific arrangement*' and reported that complaints had been made recently '*on all*

[39] Oral statement given by Gurney, 24 March 1854, in (HL 1854 (384)), Q436-37.
[40] Oral Statement given by Meeson, 3 July 1854, in (HL 1854 (384)), p 104.
[41]'State Officer's Court', Photograph, circa 1930 [Historic England Archive: AL 1016]
[42] Minute to Secretary of Office of Works , 25 October 1911 [National Archives: WORK 11/124]
[43] Letter from Gurney to Francis Stone, 17 June 1854, in (HL 1854 (384)), pp. 118.
[44] Oral Statement given by Gurney, 8 May 1854, in (HL 1854 (384)), p. 68
[45] Oral statement given by Gurney, 30 March 1854, in (HC 1854 (149), Q 121

sides, sometimes of the frigid and some of the torrid zone'. Earl Stanhope reported that the atmosphere at times felt hot, but at same time the Lords got chilly feet from the air introduced through the floor. He said that '*whilst hot air prevailed above, the feet of the noble Lord were exposed to currents of cold air, which came in from below*'. The Duke of Montrose reported that '*it seemed almost impossible to admit fresh air without causing strong draughts, and cold air all came underneath the benches*'. The Earl of Kimberley and Marquess of Salisbury had objections towards the idea of a sealed environment and advocated adopting a more natural solution, involving the use of windows. The Marquess describes the system as 'artificial' and felt that Peers insufficient personal control over their environment, and the Earl felt that they were at the mercy of the engineers, noting that '*horrors*' were '*endured in that House during the last few days from proceedings of the ventilation philosophers in whose power they were'*.

On 27 July, eleven days after the sitting, John Percy, who had succeeded Gurney as the superintendent of the ventilation, was summoned to give oral evidence to a Lords Select Committee on Office of the Clerk of Parliament, reviewing some of these issues Peers had raised. In his account he referred to the practical challenges of preventing overheating and draughts, which shows that the criticism was not unjustified. Percy reported, that there were no difficulties with controlling the climate during cold weather and under normal levels of occupancy, but the challenge was to maintain comfortable conditions during hot weather and under crowded conditions. The ability to counteract overheating by either injecting cooled air or boosting the ventilation rate was limited due to risk of cold draughts, which depended on the velocity and temperature of the supply air. It was constrained by physiological factors. As the fresh air was introduced through the floor, exposing Peers' legs directly to the current, it was not possible either to introduce cold air or significantly increase the speed without causing discomfort. Percy described his experience with this issue during an important debate held on 18 June 1869. In this day the Lords were debating the Irish Church Bill and the chamber was unusually crowded. In attempt to counteract overheating Percy's staff increased the ventilation rate and also lowered the supply air temperature to 59F, but he received a large number of complaints, and several '*Peers came down to me [Percy] in the air chamber under the House, and complained of cold draughts to their feet*'.[46] Percy thought that '*it is exceedingly objectionable to allow jets of air to impinge upon the legs*' and noted that the atmosphere was '*agreeable to the largest number of persons*' at a temperature of 62F to 64F if the velocity does not exceed 1 feet 6 inches per second, (which equates to 90 feet per minute). This illustrates challenges with the use of ventilative cooling from an operational perspective. Attendants were faced with the challenge of reconciling the requirements of the different, yet closely intertwined environmental functions of ventilation. **(Figure 13)** In addition to renewing the atmosphere (A), ventilation was utilized as means to (B) reducing the indoor air temperature, (C) harnessing the cooling effect of air movement, (D) and also to cool the architectural fabric, following the principal of night-purge ventilation. Whilst the latter could be delivered at times when the chamber was unoccupied, the other three functions could not be addressed separately and had to be carefully balanced to avoid conflict. The ventilation rates required to reduce the internal air temperature or maintain a good air quality, for instance, could result in air movement that were below or above the levels considered desirable from a thermal comfort perspective.

Similar issues were raised again in the summer of 1878. It was brought up by Lord Granville during a sitting on 22 July 1878. He complained about the excessive heat in the chamber, highlighting that the indoor temperatures in July had got to 75F, and also ask Lord Chancellor if the House of Lords, could be provided, similar to the House of Commons, with a cooling system involving the use of ice. In a written reply to Granville, dated 19 July 1878, John Percy claimed that the problem was caused by the opening of windows as it weakened the current of fresh air introduced through the floor, resulting in the temperature in the lower part of the chamber to rise. Percy, referring to his experience with operating the system during the 1860s and 1870s, claimed that the stack system could achieve larger ventilation rates and could maintain a lower air temperature if the chamber was sealed and supplied with cooled air through the floor. [47] During the sitting on 18 July 1878, for

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[46] Oral Statement given by John Percy, 27 July 1869, Select Committee on the Office of the Clerk of Parliaments (HL 1869), Q91-101 [Parliamentary Archives: GB-061]
[47]Letter from Percy to Earl Granville, 19 July 1878, in 'Question, observation', *Hansard*, HL Deb 22 July 1878, vol 241 cc2018-21 2018

instance, Percy's team had closely monitored how the windows affected the internal temperature. From noon till 5pm, when the House was sealed, the temperature was 71ºF(22ºC), it rose to 73ºF(23ºC) after five of the operable window units had been opened, and at 6.30, when this number was increased to eleven, it had reached 75ºF(24ºC).

It has to be noted that windows were opened frequently during sittings than Gurney had intended. Individual Lords frequently requested windows to be opened,[48] claiming that it made the interior feel more comfortable. By the 1870s natural ventilation was deployed routinely during sittings in summer and a formal control regime, regulating the opening and closing of windows, was introduced. The aim of this regime was to limit the admission of direct sunlight, which caused issues with glare and heat gains.[49] The Lord Chancellor, who was responsible for supervising the operation of the windows during sittings, reported that he ordered them to be opened at five every evening, and at times also gave instructions for the ad-hoc adjustments. He reported that solar gains were a significant issue during sunny weather and that external blinds were drawn across the windows to reduce them. During the daytime permission was only granted for '*windows to be opened on the shady side of the House*,' whilst external blinds were drawn across the other side to protect the interior from the sunlight. [50] A sophisticated operational regime regulating the opening and closing of windows was also adopted in the House of Commons, which has been discussed in detail in the author's article in *Building Research and Information*.[51] (Figure ??) These changes were significant as they illuminated the limitation of that Gurney's system. His original idea of creating a sealed and climate controlled space was temporarily abandoned during hot weather. A new operational regime, integrating direct natural ventilation, was introduced retrospectively to overcome these limitations. Despite his concerns about increased air temperatures, Percy also recognise that the windows were enhancing comfort by introducing air movement. He noted that '*if air moves at a high velocity, you can cool yourself even with warm air, upon the principle of fanning,*'. In retrospect it could be argued that the two different modes of ventilative cooling had emerged. The first was **mechanically-induced ventilative cooling**, utilised when the chamber was operated in a sealed mode and air was introduced inclusively through the floor. The second type was **window-induced ventilative cooling**, which was deployed when the chamber was operated in a natural mode, which mostly in summer, and it focused on improving comfort through increasing air movement.

The complaints give the impression that the system was incapable of preventing discomfort during warm weather. Historic measurements of internal temperatures, however, suggest that overheating issues occurred for brief periods during the summer. But what temperatures were encountered inside the chamber?

Monitoring data collected by attendants in the summer of 1869 show that the temperature ranged from 63F to 75F in July. The recordings in a log book covering the period from 1943 to 1947 suggest that overheating issue could be serious but were limited to brief periods, lasting only few days each year. In the summer of 1943 the highest daily peak temperatures, recorded between 27 July 5 August, were between 71F to 73F(23.5C), but for the rest of the summer, they stayed within 64F to 69F. In 1944, when readings were only recorded in June, the temperature was between 61F and 66F, and from June to August 1945 the peak indoor temperatures ranging from 64F to 70F, only reaching 71F on only a single day. In June and July 1946 the temperatures recorded from 60F(15C) to 75F(24C), and two periods with higher temperatures encountered. During the first period, which occurred between 2 July to 12 July, the temperature was constantly between 70F(21C) and 74F(23C). In the second period, which was between 23 to 26 July, it ranged from 69F(20C) to 75F(24C). The highest temperatures occurred in the summer of 1947, beginning in early June 1947 (2-4 June) with temperatures constantly between 74F(23C) and 81F(27C). Another period of overheating occurred between 24 June and 1 July, when the peak indoor temperatures reached 71F(21.5C) to 75F(24C).

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[48] E.g. 'Construction of the House, Resolution', HL Deb 16 July 1869 vol 198 cc4-13 4.

[49] Letter from Perott to Mr Fletcher, 20 April 1943 [National Archives: Work 11/403]

[50] Question Observation, , *Hansard*, HL Deb 22 July 1878 vol 241 cc2018-21

[51] Henrik Schoenefeldt, The House of Commons: a precedent for post-occupancy evaluation, Building Research & Information, 47 6 (2018), pp. 635-665.

Although the data is suggesting that overheating issue were confined to relatively brief periods, individual Lords repeatedly voiced their discontent publicly within the chamber, and pressure to improve comfort became the driving force behind further investigations in the twentieth century. These began with an inquiry into the feasibility of remodeling the existing system between 1911 and 1912, and was followed by study inside the House of Commons (1913-1923), during which the impact of the historic use of ventilative cooling was re-examined from a physiological perspective, drawing on new scientific research and utilizing modern methods of air flow simulations.

THE RE-APPRAISAL OF AN OLD SYSTEM
Studies of ventilative cooling, 1911-1937

In July 1911 the Secretary of the Commissioner of Works received a note reporting that the '*ventilation is not nearly sufficient in hot weather and the atmosphere is at times very oppressive,*' and requesting that a larger number of windows are made to open.[52] Overheating issues had occurred during several sittings in July and August 1911, and had led to an increase in the number of complaints from Peers. The engineers at the Office of Works subsequently reviewed the issue. The chief engineer believed[53] that the existing system was not capable of providing the higher ventilation rates required to prevent overheating in the summer, and highlighted that this issue was further accentuated by the fact that debates had become longer and better attended than in the past. On 27 October 1911 he wrote to the Lord Chamberlain that '*a great deal of complaint - quite justifiable I thought- of the heat during the debates last August*' and that something needs to be done to prevent it from re-occurring in future summers. He subsequently requested the resident engineer of the Houses of Parliament, Arthur Patey, to develop proposals for improving the existing system. Patey argued that the problem could not be resolved by simply opening the windows, but required more substantial and expensive interventions.[54] Similar to Percy in 1860s he claimed that the opening of windows would aggravate, not reduce, overheating problems. In April 1912 Patey presented two schemes for replacing Gurney's system with modern mechanical ventilation driven by electric fans. In one of his schemes he proposed to reverse the direction of the ventilation by moving the main air supply to the ceiling of the chamber. This have involved introducing two large channels, linking the existing ceiling to new air intakes at roof level. In his final report Percy wrote that a supply from the ceiling would eliminate the existing problems with currents entering near the body, stressing that the '*feet are very sensitive to ascending air currents.*'

Problems revisited in the House of Commons.

Due to the high cost of Patey's proposition the inquiry inside the House of Lords was postponed, but further investigations into the cooling effect of internal currents were undertaken inside the House of Commons. This study was significant as it was the first time that the physiological impact of air movement inside the chambers was examined using scientific methods, and it also informed the direction of later studies inside the House of Lords. This was informed by new research into the physiological effects of climates undertaken by Dr Leonard Hill, a physiologist from the Medical Research Council's (MRC) Department of Applied Physiology.[55] His research strong influenced the development of thermal comfort standards for air conditioned environments in the US during the 1920s[56] The first part of the investigation was led by a Select Committee, appointed in 1913, and was continued between 1920 and 1923 by the Office of Works in collaboration with the National Physical Laboratory (NPL). The Committee was appointed in response to a growing discontent that MPs had voiced in several sittings between 1912 and 1913. They criticized the atmosphere for

[52] Letter from Secretary of the Office of Works to Lord Chamberlain, 6 July 1911 [National Archives: Work 11/124]
[53] Letter from Arthur Patey to Chief engineer, 19 October 1911 [National Archives: Work 11/124]
[54] Minute to Secretary of Office of Works , 25 October 1911 [National Archives: Work 11/124]
[55] These studies are examined in more detail in: Henrik Schoenefeldt (2019) The House of Commons: a precedent for post-occupancy evaluation, *Building Research & Information*, 47:6, pp. 635-665.
[56] L. Hill, Martin Flack, James McIntosh, R. A. Rowlands, H. B. Walker, *The Influence of the atmosphere on our health and comfort in confined and crowded places* (Washington: Smithsonian Institution, 1913); L. Hill & A. Campbell, *Health and Environment* (London: E. Arnold, 1925)

being too warm and uniform and complained about draughts around the legs.[57] The latter was been longstanding issue, but had become more severe following the installation of electric fans and reduction in the size of floor inlets in 1904.

The Committee engaged Hill, who between January and March 1914 examined the existing conditions and proposed a scheme remodelling the ventilation based on physiological criteria.[58] In his first report he identified the physiological effect of currents entering through the floor as the main problem. He wrote that the air '*caused a draught which had a cooling effect on the feet and legs of the members whereas there was not sufficient movement of air round their heads and shoulders*'.[59] Hill undertook further measurements of thermal conditions during sittings, using caleometers and kata thermometers, which were scientific instruments used to quantify the cooling effect of currents. Measurements taken under crowded conditions in March 1914 revealed that the cooling rate at the feet was twice as high as around the head. Hill also argued that the currents, aside from producing cold feet, were also responsible for the 'feeling of heaviness, colds and headaches', which had previously been associated with poor air quality.[60]

To overcome this problem he recommended replacing the use of floor inlets and with new apertures set at a higher level.[61] These apertures were to be introduced in the face of the galleries, which, located above MPs' heads, allowed to inject fresh air horizontally into the chamber without exposing them to direct currents. He also recommended maintaining a different type of indoor climate. Arguing that the sense of drowsiness reported by MPs was caused by the breathing of warmed air, he advised a reduction in the atmospheric temperature and the provision of warmth through radiant heaters between the benches. He also considered the conditions as too uniform and recommended introducing a more physiologically stimulating climate with gentle variations in temperature and air movement. The latter was to be achieved by alternating the direction of the currents.

In February 1914 The Committee endorsed the scheme, and after the First World War the feasibility of Hill's proposal was evaluated through experiments. To test the impact of the proposed changes the NPL conducted air flow simulations inside scale models, which were followed by test with a life size mock-up inside the debating chamber.[62]

Return to the House of Lords, 1935-37

In the mid-1920 a few changes were made to the House of Lords, but these did not go beyond the installation of a simple mechanical air extract to boost the ventilation capability. This replaced the original coke fires. Inquiries into further and more substantial alterations, however, were conducted in the 1930s. This was initiated by a motion that the Marquess of Linlithgow had presented to the House on 24 July 1935. He demanded the appointment of a Select Committee charged with leading an inquiry into the feasibility of introducing 'an up-date air-conditioning' system, arguing that this new technology would great control over the climates'. The motion was withdrawn after agreeing that engineers at the Office of Work would lead the inquiry on behalf of the Lords. A large study, focusing on the climate conditions inside the chamber were conducted between 1935 and 1936, which involved a collaboration between J.A. Macintyre, chief engineer at the Office of Works, and the physiologist Dr Thomas Bedford from the MRC, who, similar to Hill, was leading researcher into thermal comfort.[63]

The aim of the study was to examine the causes of discomfort, taking into account the effect of temperature, humidity and air movement, and determine if air conditioning would be required to

[57] House of Commons, 27 March 1912 debate (vol. 36 col. 428–9 428); House of Commons, 4 June debate 1912 (vol. 39 col. 69–84 69); House of Commons, 10 October 1912 debate (vol. 42 col. 504)
[58] House of Commons. Frank Baines, Memorandum, 18 November 1924, (HC 1931 Cmd. 3871).
[59] Hill, L. Report on development of research since 1913, May 1926 [National Archives: DSIR 3 / 20]
[60] Monotony of air and speech, *The Times*, 27 March 1914, p. 12.
[61] Monotony in the commons atmosphere, *The Times*, 1 May 1914, p. 5.
[62] These studies have been examined in detail in: Henrik Schoenefeldt, Re-appraising and rebuilding the environment in the House of Commons, 1913-1950, *ASHRAE Journal 2019*
[63]T. Bedford (1936) *The warmth factor in comfort at work*, Reports of the Industrial Health Research Board Nr 76

overcome them.[64] From October 1935 to September 1936 the temperature and relative humidity of the atmosphere inside the chamber was systematically monitored using self-recording thermometers and hygrometers, yielding data for a whole year.[65] In addition Bedford undertook two in-depth studies examining the velocities of the internal currents, one focusing on the winter, [66] the other on the summer conditions. The chief engineer also produced two reports, summarising and discussing the findings of the monitoring and Bedford's studies. The monitoring was originally intended to be complemented by user studies, looking at the Peers' experience of the climate conditions. For this purpose Bedford proposed to undertake (1) user surveys, involving the use of paper questionnaires, (2) face-to-face interviews and (3) also to ask a few Peers to keep a personal log on their experience .[67] This part of the study was developed and discussed between December 1935 and February 1936, but was abandoned due reluctance amongst the Lords to participate.[68]

The studies focusing on the summer conditions was undertaken between June and October 1936.[69] Measurements were taken in nine locations at head height and floor level. In addition temperature, measurements were taken of the velocity, variability and the cooling rate of air movement, using hot-wire anemometers and kata-thermometers. In his final report to the Office of Works, dated 18 November 1936, Bedford concluded that the high indoor temperatures, combined with insufficient air movement, were the main cause of discomfort. The original data shows that high indoor temperature were common during the summer. **(Figure 14)** Between November and March the indoor temperature ranged from 56F(13.3C) to 70F(19.4C) and on most days stayed within 62F(16.6C) to 65F(18.3C). During the warmer weather between May and August, however, it had reached 70F(21C) or above on 33 days. The highest temperatures were recorded in June. In this month it range from 64F(18C) to 77F(25C), reaching 70F or above on 14 days. Referencing thermal comfort standards for factory workers, Bedford argued that it exceeded air temperature of 64F to 68F should be perceived as '*comfortable by the majority of persons when sitting still*.' Bedford's report did not include data on occupancy or outdoor temperature, an analysis, undertaken by the author using historic weather data from the Kew Observatory, suggest that when the indoor temperatures reached 70F or higher, the interior was always marginally cooler than outdoors. The different varied from 1F to 7F(0.5C to 4C). This, however, was rarely sufficient to mitigate overheating.

The study also found that the velocities of air entering through the floor was much lower during summer month than during the heating season, further aggravating the sensation of warmth. Due to the natural convection produced by the heated air, the velocities were three times as high, typically around 40 feet per minute, but at times reached up to 80 feet per minute. Bedford concluded that the atmosphere generally did not have enough air movement. None of the velocities recorded by Bedford reached 100 feet per minute, which today is considered the threshold at which currents become noticeable. He argued that the use of a large perforated floor had indeed succeeded in meeting Gurney's objective of keeping velocities very low, even when the ventilation was operating at the maximum rate of 8 air changes per hour. According to readings taken between June and October 1936 the average air velocity was 8 to 14 feet per minute. This led Bedford to conclude that the chill around the feet was likely to have been caused by the low temperature rather than the velocity of the incoming air. The currents entering through the floor never reached velocities high enough to cause discomfort around the feet. He wrote that *'impression of draughts near bar may be due to the lower temperature and greater variability of the air currents*'.[70]

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[64] Ventilation of the House of Lords, Minutes of a meeting DSRI Advisory Council, undated, but after 16 September 1935 [National Archives: DSIR 3/20]; J. A. Macintyre, Report: 'Houses of Parliament – Lords Chamber', 18 December 1935 [National Archives: Work 11 357]

[65] Two sets of charts of climate data: 'Daily maximum and minimum Temperature and humidity, House of Lords, near Bar, 1 October 1835 to 30 September 1936 (National Archives: AE. 2670/4); Daily maximum and minimum Temperature and humidity, House of Lords, near Throne', 1 October 1835 to 30 September 1936 (National Archives: AE. 2670/40]

[66]Report House of Lords – Ventilation, Bedford, January 1936. (NA: Work 11 358)

[67] Letter from Bedford to Chief Engineer, 10 January 1936 [National Archives: Work 11/358]

[68] Letter from Henry Radeley to Patrick Duff, 19 February 1936 [National Archives: Work 11/358]; Letter from Patrick Duff to Henry Radeley, 31 January 1936 [National Archives: Work 11/358]; Letter from Henry Radeley to Patrick Duff, 3 February 1936. [National Archives: Work 11/358]

[69] Letter from Bedford to Chief Engineer, 18 November 1936. [National Archives: Work 11/358]

[70] Ibid.

Another set of measurements was taken between on 24 June and 17 August 1936 to determine the relative effect of the fan, windows and heating system on the strength of the internal air currents. Bedford undertook separate observations of the conditions when the chamber was operated in a sealed mode or with the windows open. These showed that the opening of windows only led to a marginal elevation in the indoor temperatures, yet noticeably improved thermal comfort by providing more air movement inside the chamber. These not only caused a significant increase in air movement but also resulted in greater variation of speed,[71] both of which, he argued, were important for comfort. He wrote that the '*rather greater velocities which prevailed when the windows were open had a noticeable influence on our comfort*,' and the air also felt fresher, but when closed '*there was a regular feeling of deadness*.' This was significant as it provided, for the first time, scientific evidence that open windows were improving thermal comfort, which hitherto had only been an assumption based on personal experience.

The issue with the use of natural ventilation, however, was that it was not reliable, as it was dependent on the external wind conditions. On 10 July 1936, when there was 'slight breeze outside' the windows were found to significantly increase the air movement. During the time the chamber was sealed the velocity was observed to range from 5 to 20 feet per minute, but this increased to a range of 10 to 65 feet per minute after the windows had been opened.[72] **(Figure 15)** On 17 August 1936, when the weather was 'calm', the velocity was no higher than 35 feet per minute.[73] To improve thermal comfort Bedford proposed replacing the evaporate cooling system with mechanical refrigeration and but to increase the air movement with the aid of mechanical ventilation. Arguing that '*increased turbulence*' is needed to make the air more 'refreshing' during hot weather he proposed, similar to Hill's scheme for the House of Commons, to move the outlets from the floor to the gallery level and inject air horizontally above the heads. Air was to be introduced at high velocities from both sides simultaneously, producing eddies in the centre, which, Bedford claimed, would '*prevent stagnation at the level of the benches*'

In two reports, dated 7 and 17 December 1936, the chief engineer reviewed the findings of Bedford's studies and also made a series of recommendations. He concluded that the main issue was summer cooling, and dismissing the historic water sprays as ineffective, he recommended introducing mechanical refrigeration,[74] but as an initial step he proposed a simple intervention: agitating the atmosphere with the aid of open ceiling fans. On 16 February 1937 a Joint Committee, composed of scientists from the MRC and DSRI, reviewed Bedford and engineers reports. Its advice was to provide night-time ventilation to cool down the fabric, minimise the admission of outside air during daytime, which involved keeping the building sealed, and to increase in air movement mechanically, using ceiling fans that could be operated at varying speeds, ranging from 40 to 60 feet per minute.[75] None of these recommendations, however were ever realized, and the idea of enhancing comfort through a new approach to ventilative cooling was also discarded after the Second World War. Several investigations, undertaken in 1950 and 1963, were limited to feasibility studies looking at the installation of air conditioning.[76] Responding to increasing pressure from the Lords it was first piloted 1965 and fully implemented between 1966 and 1966.[77]

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[71] Sample record of hot-wire anemometer observations, 17 August 1936. (NA: Work 11/358); Recordings of velocities, 10 July 1936, enclosed in letter from Thomas Bedford to Chief Engineer of Office of Works, 18 November 1936. [National Archives: Work 11/358]
[72] Recordings of velocities, 10 July 1936, enclosed in letter from Thomas Bedford to Chief Engineer of Office of Works, 18 November 1936. [National Archives: Work 11/358]
[73] Sample record of hot-wire anemometer observations, 17 August 1936. [National Archives: Work 11/358]
Note: It is to be noted, however, that these were still very low rates from a physiological perspective. According to modern standards velocities of 50 feet per minute (15 meters) or less are unnoticeable, only when above 50 and up to 100 feet per minute (30 meters) produce noticeable yet pleasant currents. Above they 100 become constantly noticeable, but only above 200 feet (60 meters) become a nuisance.
[74] House of Lords ventilation – Report by Board's chief engineer (Mr Macintyre), dated 7 December 1936, on Summer investigation [National Archives: Work 11/358]
[75] Committee on Heating and Ventilation problems, Minutes of meeting, 16 February 1937 [National Archives: DSIR 3/20]
[76] Report from N. Sizer, 11 July 1950 [National Archives: NA: Work 11/525]
Denbon, Chamber of the House of Lords: Air conditioning, 13 December 1955 [National Archives: Work 11/588, nr. 3]; H.T. Denbon, Report on House of Lords heating and ventilation system, 30 March 1960 [National Archives: Work 11/588, nr. 21-22]
[77]Report on 'House of Lords Proposed Air conditioning, 23 April 1965 [National Archives: Work 11/588, nr. 144]

CONCLUSION: Evolving practice

Taking a historical perspective this chapter has investigated the practical application of ventilative cooling practices in the House of Lords. These practices, observed over a period of 100 years, were characterised by a focus on the environmental and physiological rather than technological dimension of climate control.

The environment was controlled manually, and it involved extensive interactions between attendants, users and the technology. The ability to effectively manage the internal conditions was highly dependent on the continual gathering of data about its performance in use, including measured data on the physical conditions as well as qualitative data on users experience.
In the context of the day-to-day operations attendants acquired such knowledge through environmental monitoring, direct observations and also by reviewing reports from users. It was complemented by more in-depth inquiries, which were led by scientists and engineers. These inquiries engaged with the operational and physical design parameters of ventilative cooling. **(Figure 16)** Operational regimes were adjusted, existing arrangements remodelled, and several design studies, anticipating more intrusive physical alterations, were also conducted in the 20th century. The understanding of ventilative cooling in practice was not static but evolving.

In these studies much focus was on the cooling sensation caused by air movement, recognising its risk to cause discomfort but also its potential to enhance thermal comfort during warm weather. It was an important physical factor alongside temperature and humidity, but at the core of these inquiries, was an engagement with the subjective nature of thermal comfort. This resulted in the need for collaboration with physiologists, who provided the specialist knowledge and skills required to evaluate and improve the thermal environment. The day-to-day implementation of ventilative cooling principles was also highly dependent on user participation. Users could not be treated as passive observers, but as active participants in an ongoing process of evaluating and adapting the thermal environment. As such, it could be argued, that ventilative cooling was an inherently socio-technical practice.

Today the physical features, let alone the more intangible cultural practices associated with its day-to-day operation, have become redundant. This was the direct result of the introduction of modern mechanical services in the mid-20th century. Significant architectural features, such as the perforated floors, are currently hidden underneath a new floor, equipped with an array of modern inlets grills. These and earlier changes in the 19th century have illuminated the extent to which historic practices of environmental control had affected the House of Lords architecturally, and as such also their significance to building conservation. The redundant features are physical evidence of historic approaches to ventilative cooling, and archival research, has helped to reconstruct their design, operation and performance. This raises the question if a deeper understanding of past environmental practices that engages critically with their potentials and limitations, could inform contemporary conservation practice. In buildings of high historic significance, where the scope for physical interventions is limited, a critical reconstruction of historic practices could potentially provide a new approach to balancing the requirements of heritage and sustainability.[78]

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[78] Henrik Schoenefeldt, Historic research as an applied science - A collaborative project at the Palace of Westminster shows how academic research can provide a better understanding of environmental technology in historic buildings, *Contrast, Journal of the Institute of Historic Building Conservation*, July 2018, pp. 15-17; 'Back to the Future', *CIBSE Journal*, November 2017, pp. 24-27; Making History, *CIBSE Journal*, September 2018 pp. 28-30.