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SPECIAL COLLECTION: Alternatives to air conditioning: policies, design, technologies, behaviours

<LRH>Schoenefeldt

RESEARCH

Technological transitions in climate control: lessons from the House of Lords

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ABSTRACT

Mechanical air-conditioning is only a relatively recent development in countries with moderate temperate climates. It was preceded by earlier, less energy-intensive methods of climate control. These methods were deployed in British public buildings from the 1830s until the mid-20th century, when heritage buildings began to be adapted for air-conditioning. The 19th-century methods for providing thermal comfort are examined within the debating chamber of the House of Lords (part the Houses of Parliament in London, UK). This was equipped with facilities for ventilation, cooling, heating, humidification and air purification. These facilities, introduced in 1854, were in use for 112 years. This example shows the idea that thermal comfort is a cultural practice, which was not independent from the particular technologies or social contexts, but substantively shaped by them. This long operational history provides a basis for critical insights into their performance and operation, and also illuminates the cultural and technical factors leading to their substitution with air-conditioning in 1966.

PRACTICE RELEVANCE

In light of the climate crisis, the architectural profession is required to reappraise the 20th-century practices and reconsider the utility of the historical methods for providing thermal comfort. Revitalising such methods could provide alternatives to air-conditioning in heritage buildings. To address this fundamental question, however, a deep understanding is needed of these past methods. A reconstruction and critical examination of the design, operation and performance of the House of Lords' original 19th-century system reveals the history of its adaptation and provides a basis for understanding and employing original approaches to thermal comfort which can be useful when renovating historical buildings as well as informing new designs This example provides a useful alternative facilities management model of agency and control, based on occupant experience.

KEYWORDS:
air-conditioning; alternative technology; architectural technology; cooling; environmental control; heritage buildings; technological change; temperate climate; thermal comfort

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1. INTRODUCTION: RETRACING TECHNOLOGICAL CHANGE

Since the mid-20th century mechanical air-conditioning has become an increasingly dominant method of climate control globally. Within the history of architecture, however, its use is a relatively recent phenomenon. It is only 114 years ago since the American engineer Willis Carrier (1876–1950) secured the patent for an Apparatus for Treating Air (1906) and 105 years since the Carrier Corporation, the first commercial manufacturer of air-conditioning equipment, was established (Ackermann 2002; Cooper 1998). The invention was significant because it enabled environmental control to be treated as a problem of mechanical engineering rather than a function of architecture. [AQ4] Banham (1969) described air-conditioning as part of a transition from a historic era, where climatic control was largely delivered through structural solutions, to a modern era, where the function of climate control could be fulfilled by mechanical, energy-intensive systems. The concept of climatically controlled spaces, however, was neither new nor dependent on mechanical solutions. In Britain other methods were deployed until the early 20th century (Lerum 2016). Although their application was largely confined to public buildings, these methods were representative of an alternative tradition of climate control. They were transitional technologies that occupied the space between the structural and mechanical eras. First developed in the 1830s, these technologies became well established by the mid-19th century.

This article examines the application of these technologies in the House of Lords, which is the second legislative chamber of the British Parliament. Introduced by the physician Goldsworthy

Gurney (1793–1875) in 1854, these technologies had the key features of modern air-conditioning, but in contrast to its modern counterpart it followed a hybrid approach that combined passive and mechanical solutions. The historical system, however, was distinct from modern systems in terms not only of its technology but also of its engagement with questions of system control and facilities management. Its operation was underpinned by what could be described as an alternative culture of control, which, aside from the physical and physiological aspects, took into consideration the social aspects of thermal comfort. In a review of the development of 20th-century theory of thermal comfort, Cooper (1982) has argued that modern practice has tended to reduce user autonomy, first through automation and second by transferring control from users to the central administration by technical specialists. The operation of the House of Lords, in contrast, demonstrates a culture of participation, which involved collaborations between occupants, mediators as well as technical specialists. This culture is significant because it affected the system's day-to-day operation and the wider debates about the historical practices and the shift towards modern technology.

The remainder of the article is structured as follows. Part 1 provides a reconstruction of the original system created by Gurney. Part 2 investigates its operational history over 112 years and its history provides insights into the experiences of users and technical staff as well as the findings of formal inquiries undertaken by committees, scientists, and engineers to evaluate and improve its performance. Part 3 retraces the discourse and technical inquiries underpinning the transition towards mechanical air-conditioning. This period of transition, which lasted from 1935 until 1966, is significant because it involved the last evaluations of the historical system. In addition to air-conditioning, several alternative schemes, aiming at retaining and improving the historical arrangements, were explored.

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2. METHODS: A DIACHRONIC VIEW OF ARCHITECTURAL TECHNOLOGY

Gurney's system was completed in 1854, but it underwent various adaptations. Some of these adaptations were refinements, undertaken as more practical experience was acquired, whilst others were influenced by the views of occupants. To gain insights into the system's operational history, it is examined through the lens of what Brand (1994) described a diachronic view of architecture. It is concerned with the evolution of buildings over time, looking at their physical form, operation or use. Underlying the diachronic view is a realist perspective because it engages with the practical reality of buildings in use, including the challenges of adaptation of existing structures. Whilst Brand focuses largely on the adaptation for changing uses, the present paper adopted the diachronic view to examine the evolution of climate control practices.

Gurney's system, and later adaptations, have been reconstructed by combining archival research with site investigations. The archival records cover a period of 112 years and comprise letters, photographs, drawings, technical reports, and transcripts of parliamentary committees and debates, which are held at the National Archives, Historic England and the Parliamentary Archives. The majority of records originated from the Office of Works (1854–1940), Ministry of Works (1940–62) and Ministry of Public Building and Works (1962–70). These government departments were responsible at that time for the operation and maintenance of the Houses of Parliament.

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3. PART 1: RECONSTRUCTING GURNEY'S APPROACH TO CLIMATE CONTROL, 1854

This article focuses on Gurney's system, but it needs to be noted that it was the adaptation of an earlier system, completed by architect Charles Barry (1795–1860) in 1847 (Schoenefeldt 2021). Barry's system was only operational for seven years, and Gurney's scheme reused parts of the inherited infrastructure and was underpinned by studies on the performance of Barry's system. Gurney's arrangements remained largely unchanged for 67 years, followed by a period of minor adaptations, but before studying its operational history, it is necessary to study the original design.

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3.1 GURNEY'S DESIGN

This climate was managed by combining ventilation with a 19th-century method of 'air-conditioning'. The latter was a warm air central heating system that incorporated facilities for evaporative cooling, humidification and air filtration. The ventilation was driven by the natural convection of warm air ascending tall shafts, which was enhanced with the aid of coke furnaces and controlled through manually operated valves. The debating chamber had two shafts. One was located at roof level (***Figure 1: 1***), which was connected to the extract flues for the Division Lobbies and an air chamber above the ceiling (***Figure 1: 2***) [AQ5] (Office of Works 1967). The second stack comprised a pair of tall shafts (325 ft; 98 m) inside the turrets of

Victoria Tower (***Figure 1: 5***) (House of Commons 1890–91: Q258). These were connected to the House through a passage inside the basement (***Figure 1: 4***). The ceiling was connected to this passage through four vertical flues (***Figure 1: 3***) inside the wall of the Princes Chamber, each equipped with a separate valve (***Figure 1: B***). As the hot air was forced downwards from the ceiling to the basement, these flues were referred to as a 'down pulls'. Air was primarily extracted through openings within the ornamental ceiling beams, but some air was also extracted at floor level (House of Lords 1883a: Q346) at the north end of the chamber; in an area known as the 'bar' the floor could be switched to the Victoria Tower extract network through another valve (***Figure 1: C***).

[AQ6]

Figure 1: Houses of Parliament: diagrammatic cross-section showing the stack ventilation system with control valves.

Source: Author's own drawing.

The fresh air was sourced from two courtyards at ground level and was 'conditioned' inside a large air chamber below the House (***Figure 3***). It was admitted through eight large openings with folding doors that acted as control valves for the supply (***Figure 2: 13***). One half faced the State Officers Court in the west, the other the Peers Court in the east. The doors were operated manually. In winter the air was admitted by opening small panels at the bottom of these doors, whilst in the summer, when larger volumes of air were required for cooling, the complete doors were opened. John Percy, one of the superintendents of the system, reported that they had to be completely open to prevent excessive temperatures during hot weather or when the House was crowded (Percy 1866). Behind the doors the air passed through canvas screens (***Figure 2: 4***), removing dust and soot particles, and then heated, using steam-heated batteries (***Figure 2: 5***), and humidified using two methods. In cold dry weather, the humidity was raised with the aid of steam, using an array of 'vaporisers' (***Figure 2: 11***). In summer, the air was cooled and humidified through fine sprays of water (***Figure 2: 12***) (House of Commons 1864). Note: Gurney's approach to providing thermal comfort in warm weather was distinct from modern methods involving mechanical refrigeration. It relied on the combination of multiple passive techniques. The air temperature was reduced through evaporative cooling, which involved passing air through sprays of cold water. This was provided through sprinklers located inside the two cloisters in front of the air intakes. As it had limited capacity to actively reduce the air temperature, it was complemented by use of solar shading and ventilation, which is explored in the next section.

Figure 2: Cross-section showing features of the environmental system.
Source: Author's own drawing.

Figure 3: Interior of the air chamber, July 1897, showing canvas screens (left), three rows of heating batteries and apertures to the equalising chamber above.
Source: [AQ7] Benjamin Stone, Photograph 19.

After it was 'conditioned', the air ascended through 12 rectangular valves (***Figure 3***) into a 'equalising chamber' above (***Figure 2: 6***), which contained additional steam batteries. Most of the air entered the House through perforated floors, but some was introduced at mid-level, using ornamental openings inside the throne and below the 'Peeresses Gallery' (Office of Works 1867b) [AQ8] (***Figure 2: 16***). The floor, composed of cast-iron gratings and perforated timber panels, was covered with permeable fabric. The original fabric was horsehair, which was later replaced with sisal matting (Ministry of Works 1960) (***Figure 4***). Covering an area of 2950 ft^2 (274 m^2), the perforated floor was intended to reduce the risk of peers being exposed to strong currents, in particular when higher ventilation rates were needed to mitigate the impact of large crowds or hot weather. Referring to trials inside the House of Commons, Gurney claimed that the perforated floors allowed [AQ9] 7000 ft^3 (198,000 litres) of air per minute to be introduced without producing any 'sensible motion' around the body (House of Lords 1854: Q643). Later records, however, show that these quantities, which equated to only 2.3 air changes per hour, were much lower than the eight air changes required for cooling.

Figure 4: Floor composed of iron gratings and a perforated timber panel below a layer of sisal matting.
Source: [AQ10] Ministry of Public Building and Works 1967, G 10708/4.

In the House of Lords, the provision of 'air-conditioning' was confined to a small number of spaces, which were the debating chamber, two Division Lobbies and the corridors behind the galleries (***Figure 5***). The Division Lobbies, which also had grated floors, could be connected to the main air supply through several valves (***Figure 2: 8***) (Office of Works 1867c). In the corridors the supply was through vertical flues, each equipped with an individual valve [AQ11] (***Figure 2:*** ***14***).

Figure 5: Floor plan of the House of Lords.
Source: Author’s own drawing.

<B>**3.2 AN AUXILIARY SYSTEM OF NATURAL VENTILATION**

Conceptually the House resembles a mechanically air-conditioned building, but what distinguishes Gurney’s approach from its modern counterpart is the fact that it was not permanently sealed. Although it was ventilated through openings inside the floor and ceiling and also climatically controlled, it incorporated an auxiliary system of natural ventilation. The idea of introducing openable windows was first explored by a Select Committee in 1854 whilst reappraising Barry’s earlier system. The idea might appear simplistic, but in the first half of the 19th century it was still common for similar types of spaces, such as lecture halls or courtrooms, to be naturally ventilated. In [AQ12] John Soane’s Law Courts (1822–25) in Westminster, for instance, the courtrooms had central heating, whilst the ventilation was provided through doors and windows that were carefully managed by attendants (*The Times* 1878). The implications of adopting similar principles inside the House of Lords were reviewed and the provision of openable windows was endorsed in the Committee’s final report in July 1854.

The Committee consulted Gurney and Barry and also reviewed the outcome of trials inside the House of Commons. Barry was not supportive. In a statement of 4 May 1854, he argued that altering the existing glazing would be complicated and expensive, but also raised concerns about the risk of draughts if windows were opened during sittings (House of Lords 1854: Q495).

Barry’s reservations are not surprising as the scheme represented a clear departure from his original concept. From 1847 to 1854 the chamber was mechanically ventilated and permanently sealed in order to exclude atmospheric pollution and maintain stable climate conditions. The original windows had two layers of fixed glazing, comprising an inner layer of stained glass and an external layer of clear plate glass. According to Alfred Meeson, a civil engineer who had supervised the operation of Barry’s system, their purpose was to provide:

stratum of air between the two glazings, which would prevent the cooling action of the external atmosphere upon that of the House.

(House of Lords 1854: 104)

Meeson also warned that the opening of windows could result in draughts and loss of control over the temperature, but he admitted that in ‘some states of the weather it might be very pleasant and agreeable’ (House of Lords 1854: Q148).

Gurney, in contrast, advocated the introduction of openable windows (House of Lords 1854: Q437). One key objective, first outlined in his report from 10 April 1854, was to achieve direct communication ‘between the interior of the building and the open air’. He proposed fitting openable windows inside the chamber and corridors. The original intention for the windows, however, was neither to assist nor to replace the stacks, but to refresh the atmosphere before and after sittings. Following the trials in the House of Commons, however, Gurney changed his position. On 8 May 1854, he reported that ‘draughts could be felt, but not offensively’, [AQ13] and in summer he believed that peers:

will like the windows open during sittings, there is a freshness from them which is very agreeable.

(House of Lords 1854: Q692)

In his final report of 17 June 1854, Gurney made some allowance for their deployment during sittings for ‘times when it was desirable’ (Gurney 1854) [AQ14] (***Figure 6***).

Figure 6: Open windows inside the Lords Chamber, 1869.

Source: [AQ15] British Library.

Gurney’s scheme, completed in December 1854, involved substantial changes to Barry’s original glazing. A total of 24 casements, two in each window, were installed inside the debating chamber alone (Office of Works 1854; Barry 1854) (***Figures 1: a*** and ***2: a***). These were operated with cords from the exterior (Ministry of Works 1943a). The chamber windows were also provided with retractable solar blinds (***Figures 2: e***, ***5: e*** and ***7***) to protect the interior from sunlight in the morning and afternoon. Although the House is enclosed with heavy masonry walls, a substantial part of the exterior envelope was glazed. At the upper level glazing accounted for nearly 40% of the wall surface, making the interior highly susceptible to heat loss in winter and solar gains in summer. As the glazing was east and west facing, exposure to sunlight were also highest in summer, when it was not always desirable.

Figure 7: Aerial photograph, January 1948, showing the external shading reinstated after the war.
Source: [AQ16] Historic England Archives, Photograph OP17839.

Further operable lights were introduced in the adjacent lobbies, four in each of the two Division Lobbies (***Figures 2*** and ***5: d***) and 12 inside the corridor at gallery level [AQ17] (***Figure 5: b***) (Office of Works 1929b, 1929c). This arrangement allowed fresh air to be introduced either directly, using the openings windows within the chamber itself, or indirectly, through several doors, which use the windows inside Division Lobbies and gallery corridors (***Figures 1***, ***2*** and ***5: c, f***).

These arrangements illustrate that environmental management was not solely the function of building services. It represented a historical example of a hybrid system, which could be operated in different modes [AQ18] (***Figure 8***). In the sealed mode the air was conditioned, introduced through the floor and extracted through the ceiling with the aid of shafts. In the second mode, some fresh air was introduced through windows at a high level. In the third mode, which was only deployed occasionally to mitigate overheating during large sittings or hot weather, natural ventilation was increased by opening windows and doors on the principal and gallery level (Ministry of Public Building 1964).

Figure 8: Three operational modes.
Source: Author's own drawing

<B>**3.3 THE OPERATIONAL ARCHITECTURE**

The system was operated manually, following a set of environmental monitoring and control procedures. In addition to the ventilation, cooling, heating and humidification, staff had to manage the auxiliary system of windows, doors and shades, and also monitor the internal climate through measurements, direct observations and the review of user feedback. Archival records do not provide details about the degree of control that Gurney aimed to provide, apart from a brief note in a report of 1857, which refers to 'working temperature' of 64°F (18°C) and relative humidity between 55% and 82% (House of Commons 1857). Temperatures were measured with traditional mercury thermometers, whilst dry- and wet-bulb thermometers were deployed to measure relative humidity. Between 1862 and 1889 temperature readings were collected every 30 minutes at different locations within the House (House of Lords 1869a: Q105) and recorded in paper registers (House of Lords 1883a: Q344). Historical photographs show, for instance, that two thermometers were fixed to the wooden screens of the bar (Farmer n.d.) and one near the box for the Usher of the Black Rod (Stone 1897). The collection of data enabled staff to receive constant feedback on the state of the internal climate, and temperature records were also acted as evidence used in conversation with users.[1]

The technical staff also collaborated with senior officials inside the House, who took a central role in communication feedback on user experience and in managing the auxiliary system. Whilst the technical staff was not permitted to enter the chamber during sittings, officials had dedicated seats inside, enabling them to directly interact with the peers. The Lord High Chancellor, who was the presiding officer, sat on the Woolsack in the centre, whilst the Serjeant-at-Arms had a dedicated seat near the throne, and the Usher of the Black Rod occupied a box at the opposite end (House of Lords 1950a). Acting as intermediaries, these officials interacted with the lords about issues of thermal comfort, air quality or the use of windows, and, if necessary, issued instructions to the ventilation department for ad-hoc adjustments.

This level of participation of officials, which continued until the 1960s (Lord Chamberlain 1963), illustrate that Gurney's system was dependent on a social feedback mechanism. This process is not solely a matter of historical interest, but was a central feature of an approach to thermal comfort that took into consideration user experience alongside measurements. User feedback were important in its operation in two ways. In addition to enabling a continual engagement with personal experiences and expectations, it gave the operational staff insights into the full range of thermal stimuli, including those that were not measured as part of the monitoring regime. Amongst such factors was the cooling effect of currents entering through the perforated floors or the impact of natural ventilation. ***Figure 9*** shows the respective role of measurements, direct observation by staff and officials and user feedback in its day-to-management.

Figure 9: Socio-technical control and feedback system.

Note: M = measurements; O = direct observation by staff and officials; and SR = user feedback.

Source: Author’s own drawing.

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4. PART 2: THE OPERATIONAL HISTORY OF THE HOUSE OF LORDS, 1854–1966

The previous section has shown that lords and officials had roles in the operation of the system. Institutional records, covering 112 years of operational history, illustrate that they also participated in investigations into the performance of Gurney’s arrangements. Most of these investigations were initiated by peers and officials rather than engineers. Peers voiced criticism in parliamentary debates, wrote letters to the Office of Works and also exercised influence through Select Committees responsible for the administration.[2] The fact that the membership of these committees comprised lords and officials rather than technologists is significant as it gave users the ability to influence the direction of technical studies undertaken by the Office of Works.

The history of these engagements can be divided into four phases. The first period was characterised by earlier evaluations of Gurney’s system, which was followed by a period of minor adaptations in which new technologies were introduced to enhance its performance. The third phase (1935–62) was dominated by a final reappraisal of the system, using modern scientific methods, and first inquiries into adopting mechanical air-conditioning. The final phase (1962–66) was the development of the first air-conditioning system.

<B>4.1 THE FIRST PERIOD: GURNEY’S ORIGINAL SYSTEM IN USE, 1863–1922

For the first seven years the operation of the system was under Gurney’s direct supervision, but the earliest inquiries into questions of climate control were undertaken the 1860s, when John Percy had succeeded Gurney as superintendent. In July 1865, the administrative Select Committee came to the conclusion that the system was ‘capable of great improvement’, and asked the Office of Works to undertake an investigation (*Daily News* 1865). This inquiry, coordinated by Percy, identified problems with the cooling strategy. In his report, dated 20 February 1866, he wrote that evaporative cooling was not always sufficient to mitigate high temperatures during the summer and that it was necessary to exploit the cooling effect of currents to improve comfort. When the air was warm, Percy noted, [AQ19] ‘a higher velocity will not merely be tolerated, but even may prove agreeable’ (Percy 1866). This approach, however, was difficult to realise in practice because the doors inside the courtyards did not provide enough control to prevent ‘perceptible currents’ around the legs. To gain better control, Percy remodelled the evaporate cooling system and also fitted the doors with adjustable louvres ‘capable of easy and accurate adjustment’ (***Figure 10***).

Figure 10: Interior of the air chamber, 4 March 1966, showing the adjustable louvres of the intakes.

Source: [AQ20] Strategic Estates Archives, Photograph G 10708/2.

Issues with managing currents, however, did not cease. Three years later, they were revisited in response to new complaints. In summer 1869, when the lords had multiple larger debates, the ventilation department had received several reports from peers, and on 16 July 1869, the issue also became the subject of a debate. During this debate, lords mentioned draughts and high temperatures, and some voiced a general scepticism of Gurney’s system, advocating a return a simpler system of openable windows (House of Lords 1869b).

In an oral statement of 27 July 1869, Percy admitted to the Select Committee that the existing cooling strategy, combining increased ventilation with mildly cooled air, had limitations. The desired air temperature could be maintained at most times, apart from periods when exposed to hot weather or crowded conditions (House of Lords 1869a: Q103). Historical data seem to confirm his claim. Between February and June 1869, temperatures ranged from 60°F (15.5°C) to 66°F (19°C), but reached 75°F (24°C) in July (Office of Works 1869). The ability to mitigate high temperatures was limited as the injection of cooled air or a raising of the ventilation rate could cause discomfort. Percy’s observation was that the atmosphere was ‘agreeable to the largest number of persons’ at temperatures 62–64°F if the velocity did not exceed 1 ft 6 inches per second [AQ21] (House of Lords 1869: Q12).

During hot summer days, such conditions were difficult to maintain. Percy reported that he could provide the highest ventilation rate, which was eight air changes per hour, and kept the temperature of the supply air between 58 and 59°F, but he received complaints from peers about ‘cold draughts to their feet’ [AQ22] (House of Lords 1869: Q90–91). The ventilation rate, which equated to 28.5 l/s per person during a high occupancy with 400 peers, was extremely large, and calculations suggest they would have resulted in velocities five times higher than Percy’s upper limit.

<B>**4.2 DIVERGING REGIMES OF A SYSTEM MANAGED IN DIALOGUE**

Percy's statement illustrates the limitations of Gurney's system, but it also drew attention to the issue of peers influencing the opening of windows. In Percy's view this prevented the implementation of an effective cooling strategy. He believed that the interior could be kept cooler if it remained sealed and supplied with cooled air through the floor. In hot weather, he argued, open windows caused internal temperatures to rise, and during cool or windy conditions they produced 'downdraughts of air on the heads of Peers'. He did intend to prohibit the practice, but advised it to be limited to periods when it would not produce 'sensible draughts' (House of Lords 1869a: Q104).

This illustrates that the technical staff and users had different views on the use of natural ventilation, and this was also mirrored in the divisions of operational responsibilities. The technical staff, which focused on the main system, did not have direct control over the windows or shades. Their control was governed by the Lord Chancellor, drawing on his own observations or feedback from fellow peers. His instructions did not always adhere to the control regimes advocated by the engineers, but reflected the expectations of users. As such, it could be argued that environmental control was subject two distinct regimes, reflecting different views on how the climate ought to be managed, and the records show that user interventions could become disruptive [AQ23] (House of Lords 1883: Q327).

Between 1878 and 1886, the interior climate became subject of further debates and inquiries, and these revealed that summer cooling remained the most prominent issue. In July 1878, when internal temperatures as high 75°F (24°C) were recorded (House of Lords 1878). Over the next five years the records do not include any further mentions, but another review was undertaken in 1883. This was led by an ad-hoc Select Committee and chaired by the Lord Chancellor (House of Lords 1883b). This was originally appointed to review the acoustic and seating arrangements, but following a request from the Earl of Milltown, it also revisited questions of climate control (House of Lords 1883c). Percy gave another oral statement in which he largely recounted the points he had raised during the 1869 inquiry. The Select Committee did not make any recommendations, but three years later another review was undertaken. On 26 February 1886, the Earl of Limerick presented a motion asking for the Select Committee to undertake another examination (House of Lords 1886a). The Select Committee only undertook a brief assessment of the temperature records and in its report, published in March 1886, acknowledged that temperature could become 'excessive for either comfort or health 'and instructed the temperatures to be kept at a [AQ24] ‘uniform rate’ of 60°F (15.5°C) (House of Lords 1883a).

<B>**4.3 THE SECOND PERIOD: INCREMENTAL CHANGE AND HYPOTHETICAL DESIGN STUDIES, 1911–62**

The period from 1865 and 1886 has shown that several smaller inquiries had been conducted in response to criticism from peers, but Gurney’s system remained largely unchanged. In the earlier 20th century, however, it entered a new phase, which lasted 38 years and was characterised by hypothetical design studies looking at improvements of the system. These were coordinated by the Engineering Division of the Office of Works, which, established in 1900, employed a team of specialist building services engineers (House of Commons 1914).

The earliest design studies were undertaken in response to overheating issues during an exceptionally hot summer in 1911. In July, the Office of Works received a note saying that the:

> ventilation is not nearly sufficient in hot weather and the atmosphere is at times very oppressive

and that the lords wished a larger number of openable windows (Office of Works 1911). Whilst acknowledging occasional issues with high temperature, the resident engineer, Arthur Patey, did not believe that they could be resolved through a larger number of openable windows (Patey 1911a). Following his advice, Chief Engineer Howard McFerran informed the Lord Great Chamberlain that improvements could only be achieved if the system were substantially remodelled (McFerran 1911). Over the following six months, Patey collaborated with Dr Louis Parkes, sanitary advisor to the Office of Works, to produce two schemes that look at the problem from physiological and technical perspectives (Patey 1911b).

The first scheme reversed the direction of the ventilation by moving the air supply to the ceiling. Parkes endorsed this arrangement as it would prevent currents entering near the body, even when the ventilation rates were boosted with electrically powered fans (Patey 1912b). It had two pairs of fans, one for the supply at roof level and another serving the floor level extract, located inside Victoria Tower. The second scheme (***Figure 11***) remodelled the air intake, following principles that were previously adopted inside the House of Commons (Schoenefeldt 2019). It involved introducing three intakes on the river terrace, which were linked to the House through passages at basement level. The supply air was driven by electric fans and conditioned using a system of radiators, water jets and air filters (Patey 1912a).

Figure 11: Floor plan of the scheme for new air intake, 1912.
[AQ 1 = Intakes on the terrace; 2 = tempering radiator; 3 = wire gauze filters and water sprayers; 4 = fans; 5 = heating batteries; 6 = damper to switch between cold air (bypass) and the heating mode; 7 = air passage; 8 = damper to divert the supply to the fog filter during heavy smog; 9 = fog filter (during heavy smog only); 10 = valves for supply to the chamber above; blue = cold air; and pink = warm air.
Source: [AQ25] National Archives.

Due to the high costs, none of the proposals was realised, and following the outbreak of the First World War in 1914, the inquiries were paused for six years. The only change, completed in 1923, was the installation of electric extract fans, which replaced the use of stacks with coke fires (Office of Works 1923). Although they were never implemented, Patey's proposals represented a significant change in the approach to improving climate control. He did not go as far as introducing mechanical air-conditioning, but Patey was the first to consider the application of new technologies. This raised the question whether the historical system could be retained and improved through minor adaptions, or needed replacing.

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5. PART 3: TRANSITION TO MECHANICAL AIR-CONDITIONING

<B>5.1 FIRST ENQUIRIES, 1935–37

The idea of an air-conditioned chamber was first proposed by peers in 1935. On 24 July, the Marquess of Linlithgow presented a motion, asking the Offices Committee to consider the introduction 'of an up-to-date air conditioning plant', claiming that modern technology could offer a higher level of control. The Earl of Onslow, who acted as its chairman, considered the matter too technical for the Offices Committee, and referred the query to the Engineering Division. This subsequently conducted a large scientific investigation to evaluate the performance of the existing system and determine whether air-conditioning would be necessary to achieve adequate levels of comfort (Macintyre 1935).

Figure 12: Temperature and humidity recorded inside the House of Lords, October 1935 and September 1936.

Source: Author's own drawing.

In his final report dated 18 November 1936, Dr Thomas Bedford, a physiologist from the Medical Research Council (MRC) who was renowned for his pioneering research on thermal comfort, concluded that high indoor temperatures, combined with insufficient air movement, were the main cause of discomfort in summer (Bedford 1936c). His study yielded detailed data on the internal conditions (Office of Works 1936a, 1936b), but did not include data of the external conditions. An analysis, undertaken using historical weather data from the observatory at Kensington Palace, London (***Figure 12***), suggests that the interior was always marginally cooler than outdoors. Although this was not always sufficient for comfort, problems with excessive temperatures or relative humidity only occurred for short periods. The MRC wrote that at temperatures between 65°F (18°C) and 70°F (21°C), which was typical for the chamber, a relative humidity of 35–65% would be acceptable from a thermal comfort perspective. At 70°F (21°C), it noted, discomfort would only be experienced if the relatively humidity either fell below 25% or exceeded 70% (Bedford 1938). The historical data suggest that such conditions only occurred briefly. Temperature above 70°F (21°C) were encountered on 15 days over the monitoring period. Most of these occurred during the hottest period of the year (18–26 June) when outdoor temperatures of 76°F (24.4°C) to 83°F (28°C) were recorded. On these days, the internal temperature ranged from 72°F (22°C) to 77°F (25°C). In May, July and August, temperatures between 72°F (22°C) and 73°F (23C) were recorded on only five days. Relative humidity in excess of 70% was recorded on 49 days between June and September 1936, but only coincided with indoor temperatures of 70°F (21°C) or above on five days.

The study also concluded that the opening of windows only caused a marginal rise in temperature in summer, but noticeably improved comfort by increasing air movement (Bedford 1936d, 1936e). These findings were significant because they not only challenged earlier claims by engineers that the interior had to be sealed for Gurney's cooling strategy to be effective, but also provided evidence that supported the claims by peers that opening windows could improve comfort, which hitherto had only been an assumption based on personal experience.

The final verdict of the study was that air-conditioning could help to improve conditions in summer, but also that additional changes were necessary to provide air movement. Following a principle that had been tested inside the House of Commons in the 1920s (Schoenefeldt

2022), Bedford proposed to relocate the air supply from the floor to the gallery level and create an artificial breeze by injecting air horizontally into the space.

As this proposal would have required substantial and expensive alterations, the Office of Works explored cheaper alternatives. John Macintyre, the engineer who had reviewed Bedford's scheme, suggested agitating the air through a simple arrangements of ceiling fan instead of remodelling the supply (Macintyre 1936). At the beginning of 1937, a technical committee with staff from the Office of Works and MRC reviewed Bedford's and Macintyre's reports. Aware of the cost implications, it recommended mostly operational changes. During the daytime, it advised keeping the windows sealed and shaded and providing air movement through ceiling fans (DSIR 1937), whilst during the night windows were to be opened to cool the structural fabric naturally. Neither the smaller interventions nor Bedford's scheme was implemented, and following the outbreak of the Second World War in 1939, the inquiries were intermitted for a decade.

<B>**5.2 THE HOUSE OF LORDS UNDER TEMPORARY OCCUPATION, 1941–50**

In May 1941, the House of Commons chamber was destroyed by German incendiary bombs, whilst the House of Lords, which had suffered comparatively minor damage, was repaired and altered to function as a temporary home for the House of Commons. The lords decanted to a small temporary chamber inside the King's Robing Room at the south end of the Royal Gallery. Amongst the alterations to the historic Lords Chamber was the enlargement of the seating area (House of Lords 1949), installation of acoustic panels (NPL 1941), and repairs of war damage to the windows and Gurney's system [AQ26] (House of Lords 1943). The changes to Gurney' system included the introduction of steam radiators (***Figure 10***) and the reinstatement of the air intakes and evaporate cooling [AQ27] (House of Commons 1947a, 1947b).

Members of Parliament occupied the Lords Chamber from June 1941 to October 1950, and despite the higher occupancy, the number of complaints about the climate was low, a fact that significantly influenced later discussions about air-conditioning after the war. During the war years, the records only include evidence of two complaints regarding the climate (House of Commons 1943a, 1943b). Instead, most of the criticism was about the [AQ28] 'absence of daylight' (House of Commons 1942a, 1942b), but due to blackout requirements, glazing was only reintroduced during the summer of 1945 (Ministry of Works 1943b). Similar to Gurney's original design, the new windows had two layers of glazing and external blinds (Ministry of

Works 1943c, 1947), but the number of openable casement was reduced by half, and instead of reinstating the old system of ropes, casements were fitted with mechanical winding gears that were manually operated from the exterior. The Speaker of the House of Commons was charged with directing the opening and closing of the new windows and blinds (Burgess 1946) [AQ29] (***Figure 13***).

Figure 13: Details of windows with operating gear, 20 October 1943.

Note: 1 = Hand-operated gear on the exterior with a handle; 2 = upper boxes; 3 = vertical rod linking the hand-operated gear to the upper gearbox; 4 = horizontal rod linking the upper gearbox to the levers of two openable casements; 5 = levers; 6 = vertical rod linking the bottom and top levers of the casements; 7 = openable casement; and 8 = two layers of fixed glazing with stained glass internally and plain glass externally.

Source: National Archives, Work 11 Series, Box 443.

<B>**5.3 SIMPLE RESTORATION DURING DECANT, 1950–51**

In October 1950, the Members of Parliament moved into their new chamber, but the lords continued to sit in the Robing Room for another six months to allow their chamber to be restored [AQ30] (House of Lords 1850c, 1850d). This focused largely on the interior, but a subcommittee appointed by the Offices Committee to plan the restoration [AQ31] (House of Lords 1850a, 1850b), was commissioned by the ministry to revisit Bedford’s original proposal from 1936. In final report of July 1950, the ministry concluded that it would be difficult to implemented without causing damage to the historic fabric (Sizer 1950). In the autumn, when the ministry’s Maintenance Division had taken over the coordination of the restoration programme, the inquiry was discontinued and instead it explored a series of smaller interventions. The original estimates and specifications show that the Maintenance Division proposed to introduce an electrical monitoring system and replace the canvas screens with a mechanical air purification system (Mole 1950). Only the monitoring system was adopted, which was a first step towards the mechanisation of environmental monitoring procedures. Although staff still had to take record readings and enter them manually into paper logbooks, the technology simplified this process by enabling staff to take readings remotely. The conventional thermometers inside the chamber and lobbies were replaced with seven ‘distance reading thermometers’ which could be read remotely from a control panel at the north end of the chamber (Ministry of Works 1951).

<B>**5.4 RETURN TO THE OLD HOUSE, 1951**

The lords returned to their historical chamber on 29 May 1951 (House of Lords 1951a), and four months later the ministry's Engineering Division briefly revisited the question of air-conditioning, but, as before, it concluded that the problems were not sufficiently serious to justify the expense and postponed its inquiries. The ministry only reconsidered the adoption of air-conditioning after five years, following a request from the Lord Great Chamberlain, Marquis of Cholmondeley. A short inquiry was completed in January 1956. An engineer, H. T. Denbon, produced a proposal and concluded that it was feasible to install air-conditioning equipment without damaging the interior. His proposal was to place it inside the roof space and introduce conditioned air from the top using the historical ceiling apertures.

However, the cost of the proposed installation, estimated at £100,000, was still high and considered too expensive by the Leader of the House, Alec Douglas-Home (Denbon 1956).

No further alterations were undertaken for three years, but criticism of the climate did not cease. In the summer of 1959, Cholmondeley asked the Offices Committee to consider another inquiry. The Sergeant-at-Arms observed that a 'general dissatisfaction' was voiced by its members [AQ32] 'about the ventilation arrangements in the chamber, both in warm summer weather and in winter' (Mackintosh 1959). The Offices Committee also believed that the climate could only be materially improved through air-conditioning, but considered the cost prohibitive. Instead, Cholmondeley proposed that the resident engineer, Thomas Hoyland, investigate how the situation could instead be 'ameliorated at moderate expense' (Mackintosh 1959). In August 1959, Hoyland presented his preliminary report, which provided a first technical appraisal of Gurney's system in its post-war state (Hoyland 1959). He identified cooling and humidity control as the main issue. In winter, he noted, the atmosphere was difficult to breath as the relative humidity was too low, whilst the historical method of evaporative cooling was not always effective. He attributed it to the fact that the sprinklers were fed with ordinary mains water without being chilled, and that air inside the courtyards was also often too hot, reaching temperatures of up to 85°F (29°C).

Over the following two years, Hoyland and Denbon trialled various technical interventions to rectify these shortfalls (Bull 1959). Amongst these were experiments with automating temperature control through thermostatic devices (Cunliffe 1960a). Denbon found that these thermostats achieved 'a constant temperature in the chamber within reasonable limits' in winter, but did not help to regulate of relative humidity or prevent high temperatures in summer. A brief trial with mechanical humidification was undertaken, but it was discontinued due to the noise of the equipment (Mackintosh 1959). The installation of more silent equipment, estimated to cost £3000, was considered too expensive (Cunliffe 1960a). The last alteration was the installation of a new, more silent, extractor fan, which, by reducing noise levels, allowed the mechanical ventilation to operate at higher rates during sittings (Cunliffe 1960b). On 30 March 1960, Denbon sent a summary of his findings to the Lord Chamberlain in which he admitted that the level of improvement that could be achieved with a small budget was limited (Denbon 1960).

<B>5.5 TRANSITIONING TOWARDS A FIRST AIR-CONDITIONING SYSTEM, 1962–66

These investigations show that the engineers had significant limitations imposed on what could be done. Without access to adequate funding, they could only implement minor interventions, whilst peers continued to voice their dissatisfaction. Between 1961 and 1963, attitudes towards the cost or practical benefits of air-conditioning also began to change. In 1963, Cholmondeley initiated a new inquiry in response to criticism by Lord Amphthill. During a sitting on 18 March 1963, he stated that:

> my throat gets drier and drier, I often wish your Lordships could do your work in the same pleasant temperature and humidity as exists in the making and packing rooms in our factories. Seriously, my Lords, something should be done about the ventilation of this Chamber.
>
> (House of Lords 1963a)

Although it was only a single remark, it prompted Cholmondeley to commission a new investigation (Mackintosh 1963). In contrast to previous inquiries, Cholmondeley no longer objected to the idea on cost grounds, and also felt more confident that H.M. Treasury would fund it [AQ33] (Ministry of Public Building 1864). The Engineering Division subsequently reviewed the previous studies and also examined technological advances that had been made since Denbon’s inquiry of 1956. One important development was the introduction of high-velocity fans, which enabled the use of smaller ducts and made it easier to accommodate air-conditioning within the historic fabric (Bedford 1963). The Office Committee approved a feasibility study on 31 July 1963, and this time also considered the adoption of air-conditioning ‘a matter of urgency’ (House of Lords 1963b). In three months, the Engineering Division completed the feasibility study and structural surveys, which were coordinated by the building services engineer, J. C. Knight. The purpose of the survey was to gain a better understanding of the existing system and how far it could provide the space required to accommodate the air-conditioning equipment without damaging the historic fabric.

At the end of November 1963, the Engineering Division had completed a cost estimate, report and drawings (***Figure 14***) for a first detailed proposal (Ministry of Public Building 1963). These show that the entire system was to be placed inside the existing air chambers below the House, but none of the old masonry shafts was reused. As it was considered impossible to provide outlets at gallery level without interfering with the ornamental panels (Waterman 1964), they had to be provided at floor level. The use of perforated floors, however, was to be discontinued and replaced with a series of rectangular floor grills below the benches. They were linked to four air-handling units through metal ducts. The intention was to subdivide the debating into four separate zones to enable the interior climate to be controlled locally. Each plant was linked to a separate set of sensors inside the chamber, and provided with automated controls, enabling it to react to any climatic changes caused by fluctuations in occupancy level or weather conditions (Barrow 1964a; Engineering Division 1963). The air extract continued at the ceiling. As a result of these constraints, the proposed system only allowed the atmosphere on the principal floor to be air-conditioned.

Figure 14: Proposed air-conditioning system, November 1963, show ductwork and the configuration of floor grills.
Source: National Archives, Work 11 Series, Box 588.

<B>**5.6 EXPERIMENTAL VERIFICATION, 1964–65**

Knight advised that the design was tested and refined through physical experiments. Their purpose was to predict how far the new configuration of outlets would produce uncomfortable current around the benches (Bowley 1964a).

The proposal was to install a life-size mock-up of the system inside the House. It was composed of a single air-handling unit, which was attached to new grills underneath four rows of benches through flexible ducts (***Figure 15***). The objective was to test the arrangement *in situ* and also to [AQ34] ‘obtain the reaction of Peers to the various alternative methods of introducing air’ (Barrow 1964b).

The trials were undertaken in April 1965. Victor Medvei, Chief Medical Advisor to H.M. Treasury, stressed that:

> [AQ35] great care must be taken to reduce the draught to a minimum and the temperature of the air coming in from below should not be kept too low.
>
> (Medvei 1964)

The first demonstration, conducted on 8 April, was attended by the Sergeant-at-Arms and seven peers, four of whom were members of the Offices Committee. The engineers reported that the participant feedback was positive, but following requests from Lord Merthyr, Chairman of the Office Committee, additional demonstrations were undertaken during actual sittings on 13–14 April 1965, with attendance of 100–200 peers (Ministry of Public Building 1965a). On these two days the interior temperature was closely monitored (Ministry of Public Building 1965b) and the Serjeant-at-Arms also observed the peers to obtain their [AQ36] ‘reaction to air movement from the floor’ (Ministry of Public Building 1965c). The Sergeant did not receive any complaints about currents and the engineers’ log mentions only ‘one complaint of overheating at 4.40 approx’ on 14 April 1965 (Ministry of Public Building 1965d). Although the test phase was only brief, the engineers considered it sufficient to verify the viability of the new configuration of outlets from a comfort perspective. The full air-conditioning system was completed and operational in October 1966 (House of Commons 1966), which marked the end of a prolonged period of transition from historical to modern principles of climate control.

Figure 15: Sketch of the mock-up system, June 1965.
Source: [AQ37] Parliamentary Archives, POW/1/13.

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6. CONCLUSIONS: RECOVERING THE ENVIRONMENTAL HERITAGE

The operational history of the House of Lords has elucidated a process of technological change within a historic building. This has demonstrated that practices of environmental control were subject to changes, and these were the outcome of critical engagements with the system’s performance, considering the perspectives of consultants, operators and users. It underwent several cycles of reappraisal, and these reflected a gradual change in the approach to improving climate control. Over the first 50 years the focus was on the assessment and refinement of Gurney's original principles, but from 1911, it shifted towards enhancements through modern technologies. These enhancements continued to follow rather than disrupt the original principles, but during the final phase, which began in 1935, adherence to the original principles began to fade and the final installation of mechanical air-conditioning in 1966 marked a clear break. This break resulted in the decommissioning of the historical technical arrangements, which, aside from the early methods of 'air-conditioning', constitute auxiliary systems of natural ventilation and shading. However, these changes were not solely technological. They also involved the discontinuation of the complex social processes associated with the historical system.

<B>6.1 EPHEMERAL ARCHITECTURES OF CHANGE

This research did not explore whether the new technology was more effective than its historical predecessor or if occupants were satisfied with the thermal comfort provision of the new mechanical air-conditioning system, but it showed that its decommissioning was not driven by evidence of the technical deficiencies alone, but also by a shift in attitude towards 19th-century technology amongst engineers and occupants. The primary focuses of this shift in attitude was on thermal comfort, whilst current concerns, such as energy efficiency, carbon emissions or operational costs associated with mechanical solutions, did not receive any considerations. Occupants were no longer prepared to tolerate the levels of thermal comfort of the previous decades, and from the mid-1930s engineers also began to adopt the view that adequate climate conditions could not always be maintained without air-conditioning.

The substantial cost for the installation of mechanical air-conditioning, alongside the impact of two world wars, however, led to its adoption being delayed by 30 years. Over this period engineers had to confine themselves to minor alterations. Only in the mid-1960s did the House of Lords administration feel that it could justify the cost. The debates about installation costs are significant because they are underpinned by the fundamental question of how far the lords would accept some thermal discomfort, even if it were moderate and confined to brief periods. It also needs to be noted that advocacy for air-conditioning was largely founded on the opinion of some peers. Between 1935 and 1964, the air-conditioning question was revisited multiple times in response to comments from individuals, yet this represented only the view of a small, yet vocal, minority. Their comments cannot be considered objective evidence of building performance.

By providing a critical understanding of the relationship between architecture and climate control, this research also touches on issues of historic building conservation. The changes of the 20th century represented a disruption of a historical relationship characterised by a hybrid of architectural and technological approaches to climate control. In the House of Lords, as in other public buildings of the 19th century, the introduction of air-conditioning resulted in the historical environmental features becoming redundant. Some were lost, but most lay dormant within the fabric. Although currently inactive, these features are the tangible evidence of the transient environmental heritage of architecture. This research suggests that the evolution of climate control practices of historical buildings can only be fully understood if they are viewed as a process of continual engagement, in which past and current arrangements represent no more than transient positions.

<B>**6.2 A HERITAGE-LED APPROACH TO ENVIRONMENTAL DESIGN**

Vidar (2015) and Short (2017), amongst others, have argued that past environmental principles could provide lessons for the modern sustainable architecture, but this article suggests that the future restoration of historic public buildings offers the opportunity to re-examine the utility of past principles and explore how far their revival could provide the basis for what could be described a heritage-led approach to sustainable system design. In contrast to the principles of engineering design deployed in the design of new buildings, this heritage-led approach begins with a recovery of knowledge of the environmental principles underlying the original design of existing buildings. The study of operational histories of environmental technologies, which has been demonstrated here, can provide the foundation for such a heritage-led approach. It can provide designers with the knowledge needed to reappraise the past rejection of historical principles in favour of mechanical engineering solutions. The history of past inquiries suggests that the verdict of the 1960s was not definitive nor are the physical changes irreversible, with climate change providing the impetus for future reappraisals. These need to engage with changes in the cultural definition of comfort. Historically summer temperature of 75°F (24°C) were considered unacceptable, but according to current technical guidance, the House never experienced overheating. The highest temperature found in the archival records, 77°F (25°C), is acceptable according to current Chartered Institution of Building Services Engineers (CIBSE) guidance for non-airconditioned office buildings, and overheating only occurs in non-airconditioned environments if the temperature exceeds 28°C (82.4F) for more than 1% of the occupied period (CIBSE 2006: 1.11–1.12).

To fully appreciate the system, however, its performance needs to be assessed in the light of its social approach to delivering comfort, which sheds critical light on current and late 20th-century practices of facilities management. [AQ38] According to Cooper (1982), modern approaches to facilities management involve the 'expropriation from building occupants of user autonomy' through a transfer to automated systems and a paternalistic model of centralised control, and administration by technical specialists on the occupant's behalf. In the House of Lords, the system was operated by technical specialists who were tasked to maintain physical conditions that were believed to satisfy the majority of occupants in most circumstances. These, however, could be adjusted any time to reflect changes in occupants' perception of the thermal environment. If viewed through the lens of Cooper's critique, the historical system demonstrates an alternative approach to environmental control, which attempted to reconcile user autonomy with centralised management. This approach closely aligns with the principles of adaptive comfort theory, which is based on the assumption that occupants feel comfortable in a greater range of conditions if they are given the opportunity to adapt to their environment, either through personal changes, such as clothing, activity or posture, or by allowing them to adjust the controls of the environmental system (Humphreys *et al.* 2020). In the House of Lords, occupants could effect some changes to the ventilation, climate conditions or the use of windows, but as it was a shared space of opportunities for adjustment had to be paired with a process of mediation, which was convened by officials rather than technologists. These officials were occupants themselves, had the authority to influence the operation, but they also advocated for the views and demands of their co-occupants in communications with the technical staff. Their view of how the system ought to be managed did not always align with those of technical operators. It involved an ongoing process of negotiation between user- and specialist-led approaches to control.

These mechanisms of user participation were critical for the practical implementation of the historical approach to thermal comfort. Without mechanical refrigeration, the House relied on the combination of multiple techniques for cooling, and intimate knowledge of occupant experience of the combined effect of these methods was fundamental to their practical implementation. As a direct result, delivering thermal comfort was highly dependent on complex social processes, and these can be considered part of the intangible heritage of past environmental practices. These provide evidence of the idea that thermal comfort is a cultural practice, which was not independent from the particular technologies or social contexts, but substantively shaped by them. The 20th-century theory of thermal comfort was strongly influenced by the development of design standards for air-conditioned environments. In the case of the House of Lords, it was shaped by the capabilities and limitations of 19th-century technologies. This was most clearly illustrated by the passive cooling strategy. As its capacity to reduce air temperature was relatively limited compared with modern systems with mechanical refrigeration, it had to exploit other physiological mechanisms to achieve thermal comfort, such as the cooling sensation of increased air movement. This demonstrated an alternative culture of thermal comfort, which was characterised by the utilisation of multiple approaches to delivering human comfort in hot weather, which varied over time, yielding a system with a high degree of operational agility. Therefore, if the critical revival of historical methods of climate control is to provide an alternative to air-conditioning, its design needs to be based on an understanding of these alternative cultures. Designers need not only to engage with the technical design aspects, such as the relative environmental functions of architectural fabric and building services, but also to develop an understanding of their implications for the culture of facilities management.

<A>**NOTES**

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[1] The technical staff was employed by HM Office of Works, a government department that, from 1854 to 1943, was in charge of managing the parliamentary estate. It had set up the Department of Ventilation, Warming and Lighting to coordinate the operation and maintenance of building services across Parliament.

[2] From 1864 to 1889, the Lords administration was led by the Select Committee on the Office of the Clerk of the Parliaments and Office of the Gentleman Usher of the Black Rod. From 1890, the committee became known as the House of Lords Offices Committee (House of Commons 1894).