Inhabited Machines

Genealogy of an Architectural Concept

Monograph

Author(s):
Gleich, Moritz

Publication date:
2023

Permanent link:
https://doi.org/10.3929/ethz-b-000627643

Originally published in:
Exploring Architecture, https://doi.org/10.1515/9783035623772

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Exploring Architecture
Book Series

Moritz Gleich

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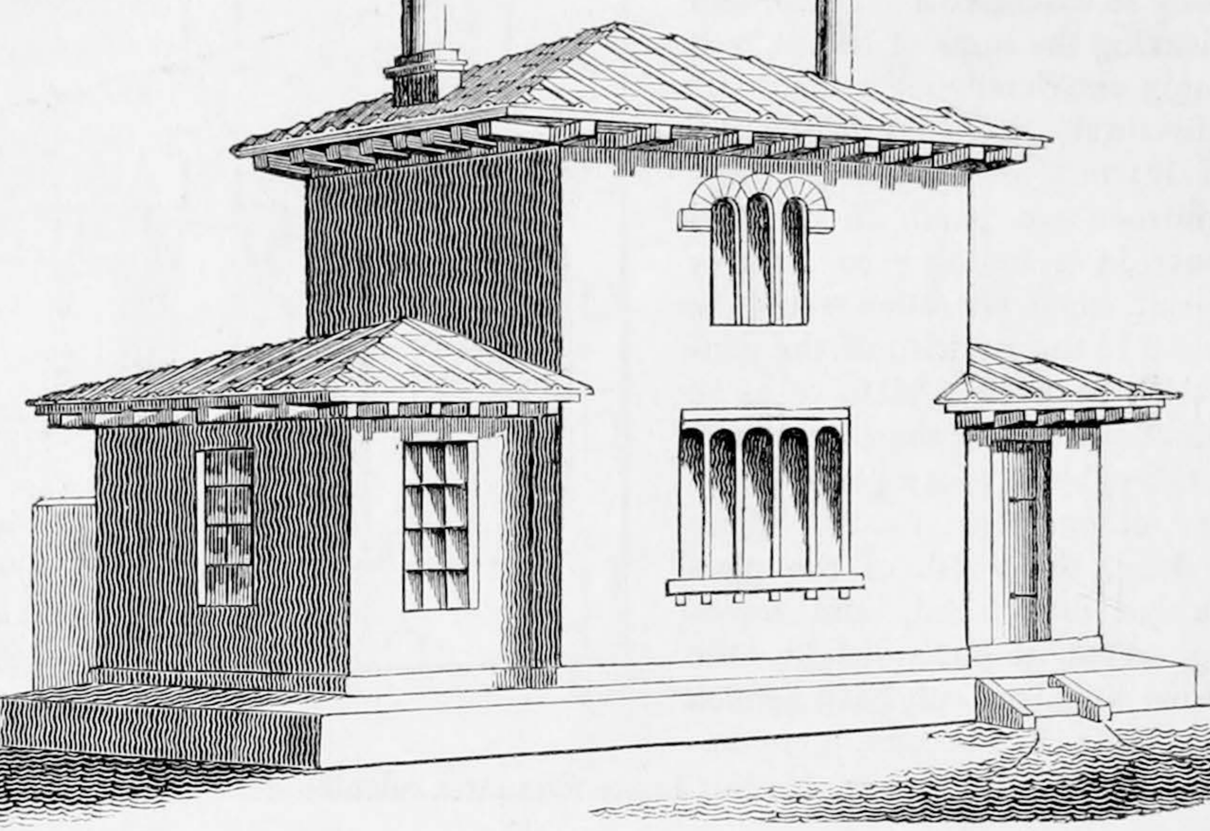
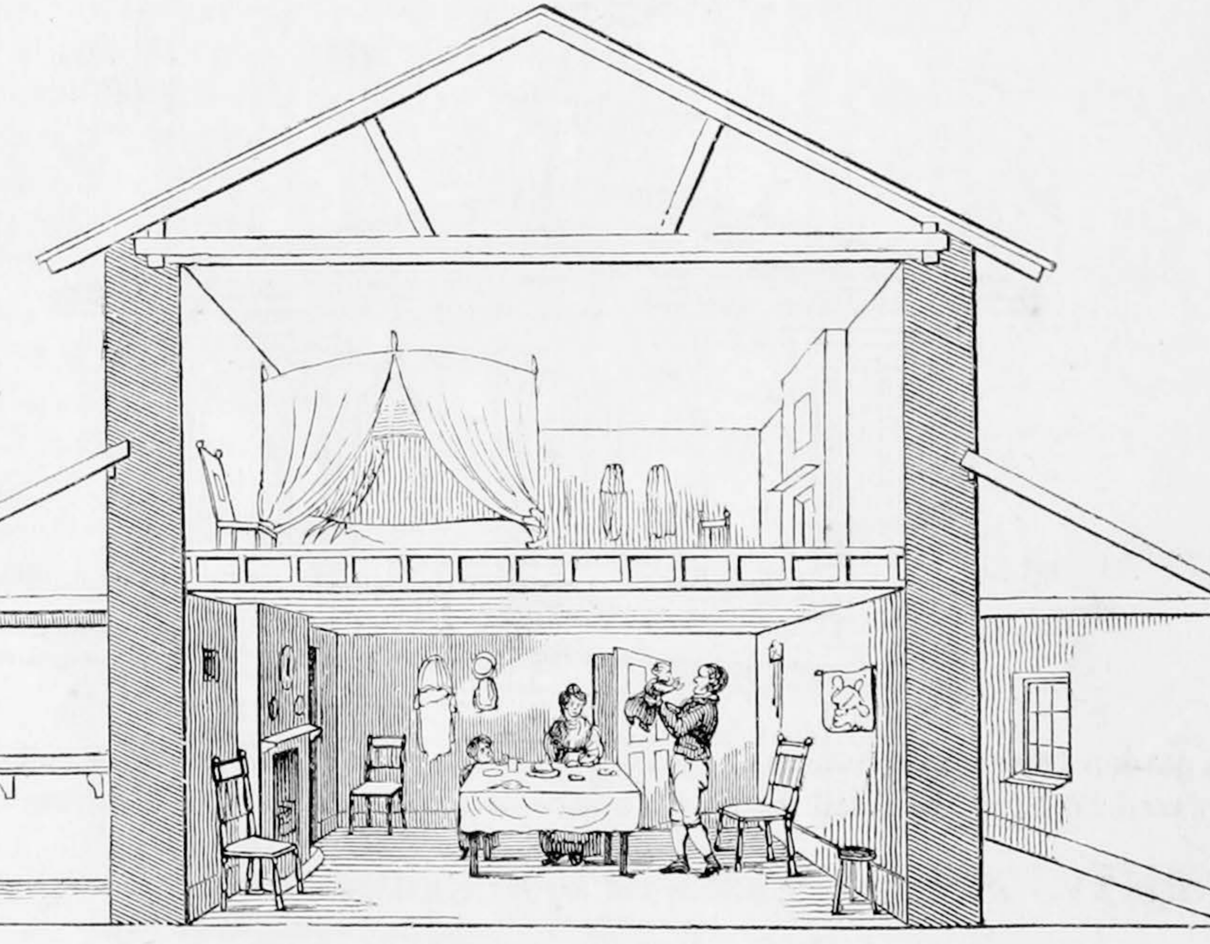
Birkhäuser
Basel





Contents

This new series advances the study of architecture, urbanism, landscape, and design in their respective histories, and as professional, conceptual and intellectual practices. It offers new and unexpected readings of buildings, analysis of disciplinary discourse and historiography, studies of architectural representation and media, and considerations of socioeconomic and cultural-political forces on cultural transformation.

Its volumes will encompass a broad spectrum of periods, regions, and themes, including distinctly cross-disciplinary subjects with close ties to architecture. With a focus on topics informed by contemporary discourses on architecture, landscape, and the city, we work with authors to share scholarship in architectural history that is original and rigorous, as well as engaging and accessible. Shaped by a peer-review process guided by an academic board and a world of accomplished experts, *Exploring Architecture* provides a platform to both emerging authors and established scholars. The books in this series present serious research in a compelling voice to reach readers in architecture and its related fields.

Despite the repeated forecast of its imminent obsolescence, the book remains with us. Its material presence and durability persist. It remains weighty, present, and arguably the most important medium for disseminating attentive scholarship on architecture both in its history and as a matter of thought. Our belief in the amalgamation of thorough academic inquiry, the careful design of books as physical objects, but also the expansion of their reach through open-access distribution form the foundation of *Exploring Architecture*.

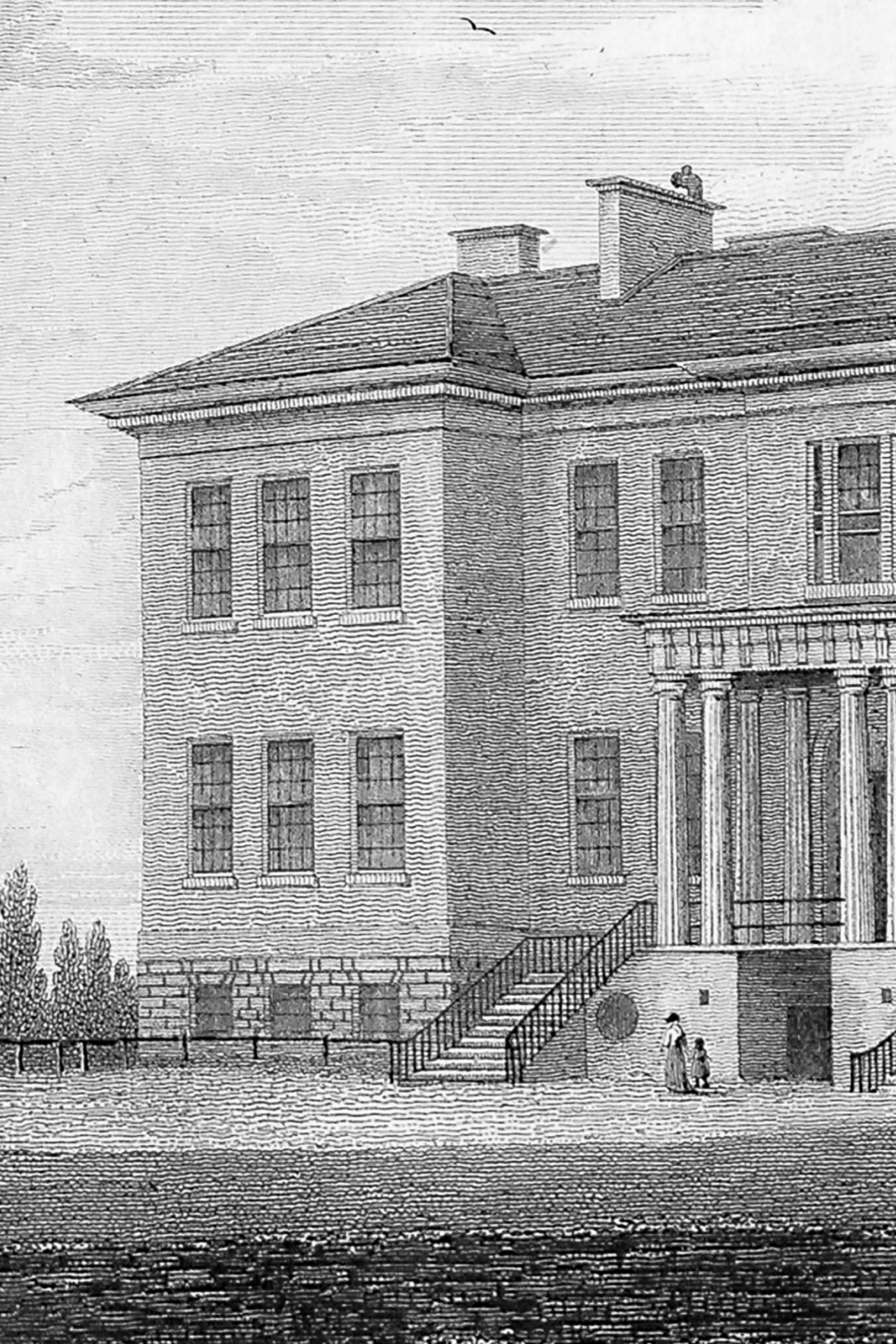
In *Inhabited Machines*, the first volume in this new series, Moritz Gleich presents the history of the machine for living in *avant la lettre*, and through it a prehistory of architectural modernism in France and England. With this, the book resonates in its approach with works like Sigfried Giedion's *Mechanization Takes Command* (1948) or Reyner Banham's *Architecture of the Well-Tempered Environment* (1969). Gleich traces the evolution of the concept of the building as an operative machine and reflects on the consequences of the reframing of the demands placed on architecture in a century-long shift away from aesthetics, beauty, expression, and structural solidity toward requirements of productivity, operability, and repeatability.

The study ranges from considering the control of air, to questioning the social and moral dimensions of technical systems, to the attainment of fixed measures of comfort, thereby locating technical aspects of architecture in a discursive context informed by the scientific developments starting in the last decades of the Ancien Régime and thereby anchored in a legal-philosophical environment that pondered the balance between necessity and luxury.

Crossing disciplines, the book brings together the concerns of architectural historians who have examined the major works and treatises with those of historians of technology who have traced the often-invisible building systems that would go on to decisively shape modern construction. This study thus puts writing on architecture into conversation with such sources as patents, standards, manuals, technical reports, or procedures, expanding the more common correlations between architectural theory and philosophy into a much broader historical-cultural framework.

Inhabited Machines is based on the conviction that it is a combination of new expertise, processes, and actors, rather than the now familiar achievements in form, composition and historicism that initiated a comprehensive reorganization in architecture in the eighteenth and nineteenth centuries. Since this time, buildings have been reimagined not only through mechanical analogies, but also through significant innovations in building systems—from heating and ventilation to circulation and communication. Gleich's book questions the social and cultural messages conveyed by architecture's technical systems.

Marc Armengaud, Reto Geiser, Andrew Leach, Catalina Mejía Moreno, Matthias Noell, Sara Stevens



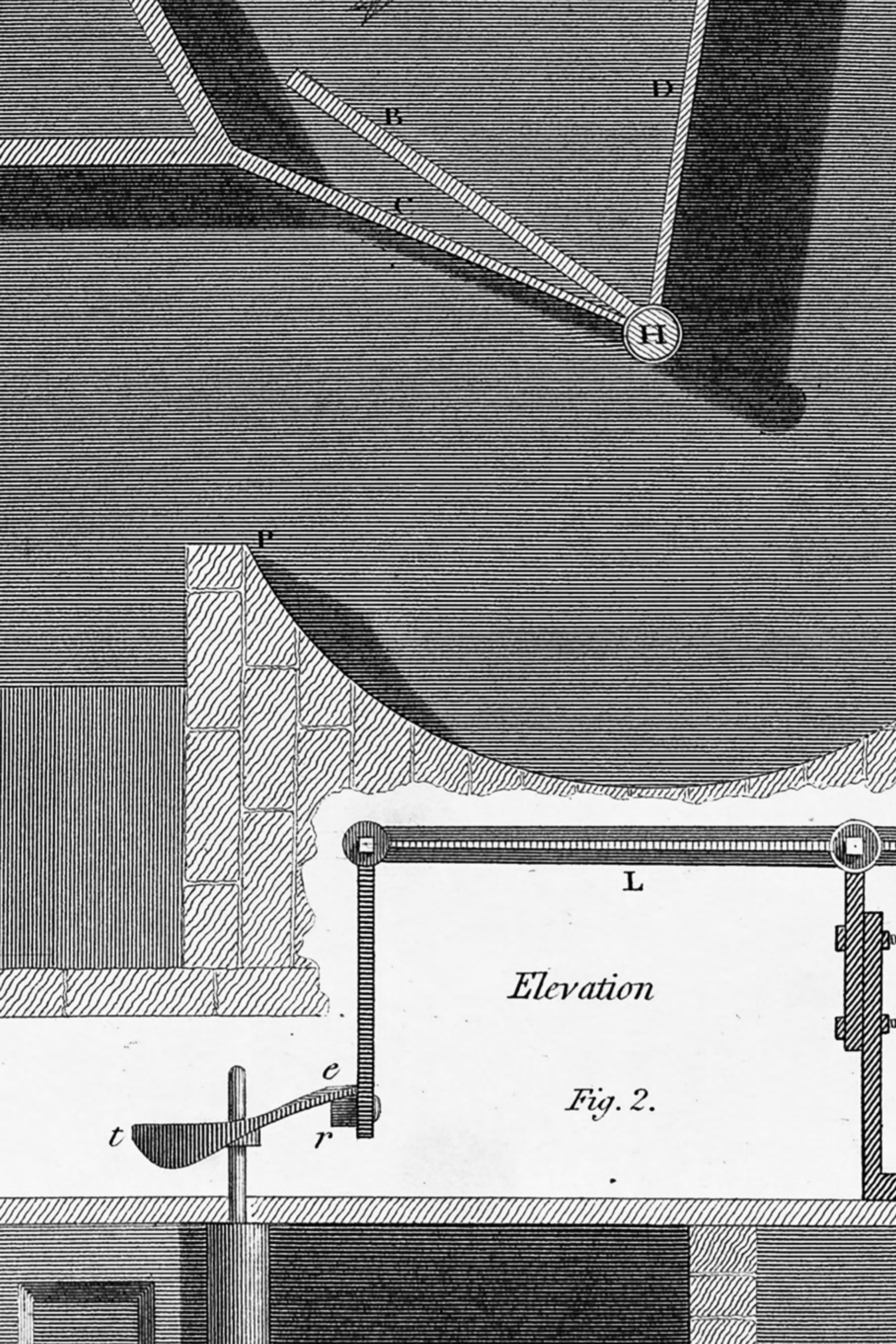
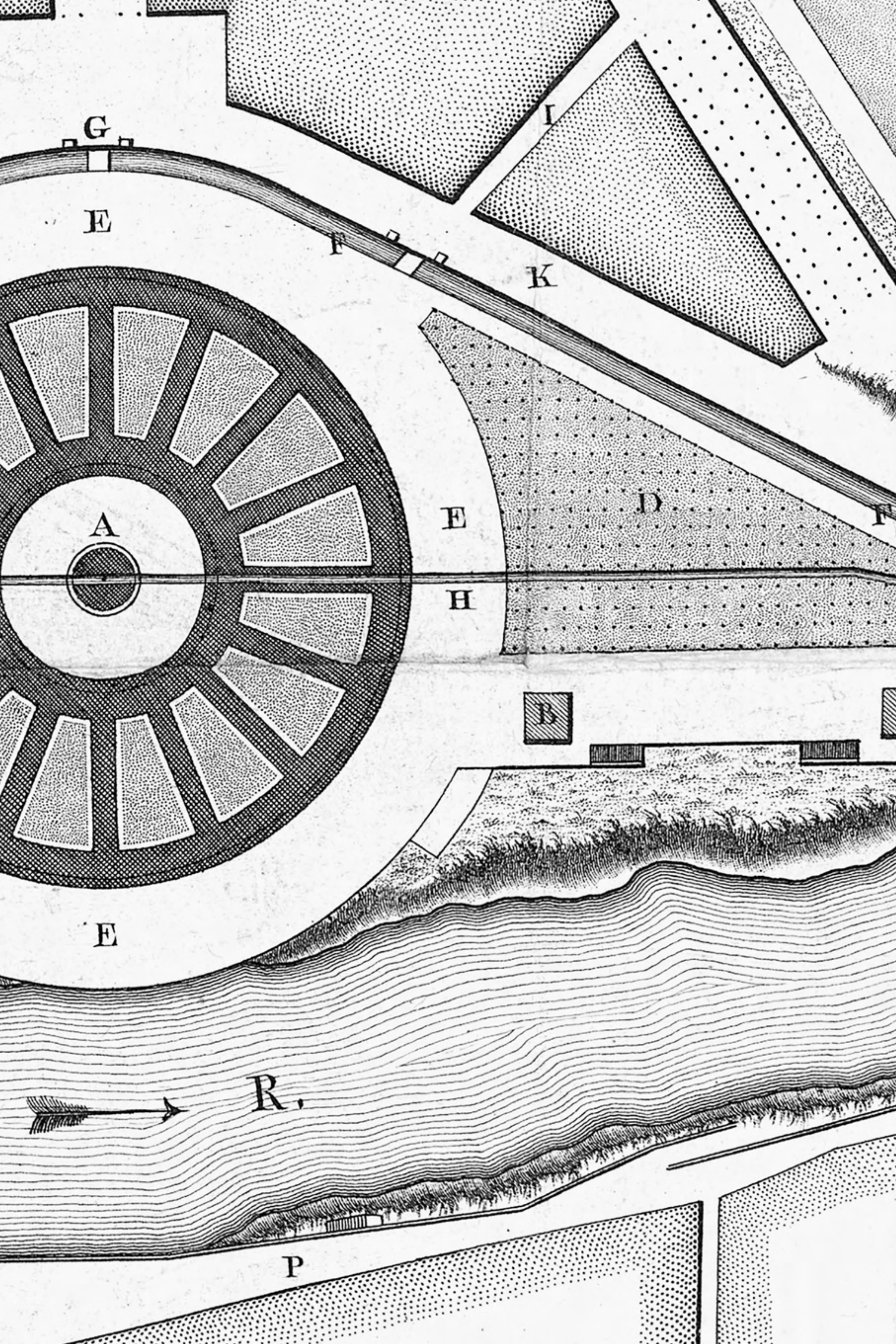


Fig. 2.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There is rarely a guided tour through the Unité d'Habitation in Marseille, rarely a publication about New Objectivity or the International Style, indeed rarely a history of architectural modernism that fails to use the term "machine for living in." At the latest since Le Corbusier's coining of the phrase *machine à habiter* in the early 1920s, the machine has occupied a prominent place in thinking and talking about architecture. After having been embraced by Walter Gropius and other representatives of the Neues Bauen movement, the concept of the "architectural machine" embarked on a long progression with numerous iterations through twentieth-century architecture. Even today, a hundred years later in an era of entirely new technologies, it is common and widespread to make analogies between buildings and machines, devices, and apparatuses. But where does this habit of speaking of buildings using a technological vocabulary come from? What are the ideas and reasons behind this manner of speaking? And what aspects of architecture is the phrase originally associated with?

There is nothing novel in the observation that referring to the house as a machine was in itself not new in the early twentieth century either. The probably best-known precursor to Le Corbusier was the French critic and architect Adolphe Lance, who in 1853 in a professional journal urged his colleagues to henceforth conceive buildings as machines. In his classic study of the *Changing Ideals in Modern Architecture*, the architectural historian Peter Collins correspondingly adopts the premise that the mechanical analogy acquired its first architectural-historical relevance in the mid-nineteenth century. Similarly, numerous other studies dealing with the history of the machine model—in as far as they have even delved back to the nineteenth century at all—have stalled with Lance, often adopting his statements as a mere prefiguration of the program of classic architectural modernism.[1] What this perspective loses sight of is that the mid-nineteenth-century machine model itself already had a prior history and that Lance's dictum was far less the starting point but rather the culmination of a long-running discussion in which a fundamentally new view of built space had been formulated that still remains highly influential today.

This book attempts to delineate a comprehensive genealogy of the concept of the "inhabited machine" by focusing on the era prior to 1850. What were the requisite events that made it possible in the mid-nineteenth century to talk, like Lance, of houses as machines in a renowned architectural journal? What are the roots of the idea of describing architecture in terms of the model of a technical device? And what are the central postulations and arguments based on, which still continue to be associated with this image even today? When Lance formulated his machine comparison in the pages of the *Encyclopédie d'architecture,* he was very deliberately countering the predominant theory of architecture. He not only deplored the fixation of the contemporary debate with absolute values like beauty or stability, but also that these values, as applied to the shaping of the relationship between a building and its inhabitants, ended as a rule in generalized and similarly highly formulaic ideas of spatial division and arrangement. Lance's aim was to challenge this mindset with a radically alternative concept of the built, namely an understanding of an architecture devoid of predetermined solutions, one in which planning did not simply suspend its actions at the stage of crude customary models, one that above all did not react passively to the lives lived within it. In other words, an architecture tailored to the requirements of its occupants, that aided their activities and multiplied the fruits of their labor—briefly put: an architecture that acted according to the modus operandi of a machine.[2] Accordingly, examining the emergence of architectural machine concepts always also entails examining the emergence of a way of thinking that placed people and architecture in a new relation to each other.

This genealogical perspective on the beginnings of the architectural machine concept has a number of forerunners, above all in the works of Michel Foucault. After already having focused on the city and institutions of internment in *Madness and Civilization*,[3] in the 1970s Foucault published a series of studies dedicated to architectural-historical questions in the period between 1750 and 1850 that recurred to the term "machine" in various ways. While *Discipline and Punish* examined the emergence of the prison as a component of an overall "penal machinery,"[4] two collaborative projects addressed the explicit treatment of further building types as machines: *Les Machines à guérir* treated the Paris hospitals in the second half of the eighteenth century as "machines for healing," and *Politiques de l'habitat* looked at housing in the first half of the nineteenth century as a "machine for living in."[5] The trajectory in these inquiries was a thesis of Foucault's that in essence also constitutes the bases of the current work. The premise is that in the late eighteenth century, architecture was ascribed a set of new tasks in relation to the general population, health, and living. Whereas prior to this reflections on the art of building had long been determined by exercising power through aesthetic categories, this now increasingly shifted to issues of serving governance via designing space along economical-rational lines. In this sense, in around 1800, architecture became political—and a machine.[6]

Foucault's work was followed by other studies focusing on the architectural history of the eighteenth and nineteenth centuries from various perspectives that also traced a more exact picture of the causes that led to the emergence of a machine concept. Georges Teyssot has spelled out this issue for residential architecture and Anthony Vidler for hospital architecture, while Robin Middleton extended the field to include social institutions and Thomas A. Markus modern building typologies in general.[7] Nonetheless, what is still lacking is a coherent and concentrated analysis of the genesis of the architectural machine concept, its backgrounds, and the corresponding knowledge that underlay it. Indeed, until now this proposition has in fact often been handicapped by terminological confusions in which contemporary machine terms have been projected backwards onto the examined historical context, or for that matter historical machine terms have been generalized to take on a validity outside their particular contexts. The current book sets out to avoid these pitfalls by adhering as strictly as possible to a discourse-analytically and metaphorologically grounded examination of concrete linguistic and pictorial descriptions of architectural objects as machines or mechanisms.[8]

The aim of the book is not to describe architecture as a machine; rather it is to analyze the description of architecture as a machine. This distinguishes it on the one hand from approaches that tend to explore the long common history of architecture and mechanics in a motivic way,[9] and on the other from those that commence from specific technical or mathematical commonalities in the construction of buildings and machines—be it in Vitruvius's times when machine building counted as part of the discipline of architecture, Galileo Galilei's times when principles of mechanics were transferred to the planning of building structures, or the nineteenth century when both buildings and machines alike were subject to the structural application of iron.[10] Instead, the assumption here is that it is precisely a historically conditioned differentiation between the two objects—buildings and machines—that allowed them to be meaningfully juxtaposed as models and enabled the machine to serve as an architectural concept that transcended purely constructional questions.

Corresponding to this, the current study starts in the mid-eighteenth century with respective developments particular to the field of architecture and the field of mechanics. The scientific and technological upheavals of the Industrial Revolution in this period led to a previously unknown spread and presence of machines, not only as real objects but equally as social and cultural subjects.[11] This development was accompanied by an increased use of mechanical metaphors and analogies in a sense current since the beginnings of the early modern era. Already in antiquity the machine had been used as a model for cosmological, physiological, and political creations, be it made by the hands of god(s) or man. During the Middle Ages, however, a meaning of the Latin *machina* prevailed for a considerable time that related to static constructions such as building scaffolding or siege towers. Applied metaphorically, the word correspondingly above all emphasized the stability of an artificially assembled entity, as in the case of the "world machine" or the "body machine." An echo of this is recognizable in the later use of the word to describe bulky and impressive works of art of all different types.[12] However, in the modern era, and with the growth of new technologies, a shift in meaning took place: from here on, *machina* increasingly pertained instead precisely to moving constructions, in particular those that performed autonomous tasks using energy input. This opened up a new terminological scope for the machine, which along with artificiality above all encompassed aspects such as dynamism, complexity, efficiency, and the determinacy of an object or a process. With industrialization this dynamic machine terminology then experienced a boom at the same time as undergoing a renewed shift in the direction of the economic context of goods manufacturing based on the division of labor.[13]

This change in meaning from the static to the moving machine was also mirrored in its use as a model in architectural contexts. As a rule, the few known cases in which the image of the machine was used to describe architecture before the late eighteenth century emphasize the methodically planned but above all massive and imposing character of the buildings concerned.[14] Thus, for instance, the first edition of Johann Christoph Adelung's *Wörterbuch der hochdeutschen Mundart* (Dictionary of the High German Dialect) from 1777 still read: "The machine [...]. Actually, any artificially assembled thing without life or motion of its own. In this sense, a large house is called an enormous machine."[15] By this point however, architectural machine concepts were germinating elsewhere, and these, on the contrary, placed an emphasis on movement and also in certain senses life.

An important milestone in this process is a presentation from 1786 in which the French physicist Jean-Baptiste Le Roy described the hospital as a "machine for treating the sick."[16] Here, for possibly the first time, a new and modern building type—one designed to have a role in and effect upon society—was associated with a new and modern concept of the machine. In this way, the late eighteenth century saw—according to the core thesis of this study—the beginnings of a dynamic machine term denoting transformed qualities of built space. Set against the background of rapidly changing forms of building and living, from this juncture onwards the word helped to illustrate a set of circumstances that concerned less the construction or the appearance of a building and more its use and usage, otherwise impossible or tortuous to express. This marks the emergence of a discursive linkage that over the following decades and beyond would lead to a huge increase in mechanical analogies in widely varying branches of architecture, and that would remain active until at least around the 1850s when scientific and technological developments spawned renewed shifts in the image of the machine.

As developed in the late eighteenth century, the machine understanding of architecture is encapsulated in this study using the term "operativity." There are three key reasons for this. First, the concept of operativity has a long if little-known lineage in the history and theory of architecture, especially in relation to the topics examined here. Robin Evans already deployed the concept in one of his first texts—the essay in which he rescued Jeremy Bentham's Panopticon from obscurity in the early 1970s—as an analytical category for buildings and material artifacts. According to this, Bentham's design was "operational" by virtue of its conception as a physical means of influencing its inmates: "Bentham conceived," argues Evans, "that an operative set of artifacts, stripped of meaning in the symbolic sense could nevertheless be transmitters of human intention."[17] In his later history of English prisons, Evans declared these "latent powers" and this "active agency" of the built to be a general quality of architecture, with the prison reforms of around 1800 having decisively contributed to its explication.[18] Second, the term "operativity" has undergone a compatible conceptual development in recent German cultural and media studies and has indeed been directly related to spatial circumstances. In this particular context, operativity designates a medially or instrumentally tied *wirken* (action/operation) or effect of a thing on certain natural, symbolic, or social processes. In this specific meaning of the term, in the past it has already been applied in relation to both architecture as a whole and to specific architectural types and elements. From this perspective, doors, for instance, not only represent openings and a formal attribute of the art of building but also act as operators of the fundamental architectural differentiation between inside and outside.[19] Third and foremost, the concept of operativity demarcates a terminological field that is not only accessible theoretically but instead is also firmly etymologically anchored in the language of the eighteenth and nineteenth centuries and was regularly applied in relation to machines and buildings alike. Especially in English, with the verb "to operate," the noun "operation," and the adjective "operative," the different classes of the word were used early on to describe the activity and the quality of both human and non-human actions and effects.[20]

In this sense, the concept of operativity is ultimately also used as an alternative to the terminology that usually frames the aspects of rationality and purpose in architecture, namely that of function and functionality. This terminological substitution was likewise already suggested by Evans, according to whom a project like Bentham's Panopticon is more than simply "functional" in the common sense of the word of serving the requirements of the person who conceived it. Instead, it was designed to transmit an effect out of itself, activate a combined system of social norms and physical controls, and serve as a self-sufficient agent for the improvement of humanity—in short, it was to be "operative."[21] Whereas the adjective "functional" highlights the response of a thing to particular individual or collective concerns, the adjective "operative" underscores the efficacy inherent to a thing. In this respect, the two adjectives therefore denote a similar relationship to that between the terms "tool" and "machine"—in general language comprehension the purpose of the former is supplemented by the autonomy of the latter.[22] However, the term "function" also proves problematic for the arguments developed in this book in terms of its specific architectural-theoretical applications. As Adrian Forty, amongst others, has shown, up until the early twentieth century, and with very few exceptions, the word "function" concerned the relation between the inherent mechanical forces in a building and its external appearance. It was only later, and often still mixed with questions of form, that the word found widespread use in the sense of the effect of buildings on people or social contexts.[23] Therefore it seems more appropriate, both historically and theoretically, to use the term operativity to discuss this effectiveness and its articulation in the image of the machine.

The emergence of this new understanding of the operative potential of architecture should not be understood as a sudden or isolated event, rather as a diverse and widely scattered development in which a new concept of the “inhabited machine” made an appearance step by step at various loci. This progression is traced in this book by largely concentrating on two West European countries, namely Great Britain and France. Considering Britain’s pioneering role in industrialization, it is hardly surprising that the country played a vanguard role in the developments in which the beginnings of a machine concept of architecture were rooted. Great Britain was the first country to experience the technological and social, and thus the architectural impacts of the transition from an agrarian to an industrial society.[24] France on the other hand experienced the comparable economic and architectural changes in a delayed fashion, yet based on its liberal press laws already in the early nineteenth century possessed a lively publishing landscape that heatedly debated the questions of contemporary architecture and also regularly reported on events taking place in its northern neighbor.[25] For this reason both countries are particularly early and clear examples of the interplay between the spatial and discursive processes that formed the basis of the terminology that treated buildings as machines.

The notion of the “inhabited machine” in this analysis does not restrict itself to purely residential buildings, as understood in today’s terms. In the Europe of the early modern era, the terms “dwelling” and “domesticity” extended far beyond the four walls of private architecture to include life in public or institutional buildings, such as cloisters, colleges, or poorhouses. Considering the emergence of the new institutions of the prison, the hospital, and the insane asylum, the eighteenth century actually saw a significant growth in the number of people who “resided” in institutional surroundings for short or long periods of their lives.[26] By specifically targeting the needs and behavior of the people housed within them, as well as their intended impact on the population as a whole, these institutions play a role within the framework dealt with here that was at least as vital as that of residential buildings. On the other hand, what is largely absent in this examination is any consideration of a series of other building types that emerged or became significant during the period—including the factory, administrative buildings, and public facilities such as the museum, theater, and the library—based not only on the fact that they did not provide dwelling space in this respect but also because they were far more seldom framed as machines in a metaphorical sense.

The historical and geographical setting of the current study encompasses not only the previously mentioned Industrial Revolution but also the social and intellectual currents usually subsumed under the label "Enlightenment," and which as such have long been an object of inquiry in architectural history. While as a rule these studies have concerned examining direct links between philosophical thought, on the one hand, and the theoretical architectural discourse, on the other,[27] the approach taken here is one followed in the recent past in strains of historical studies and above all the history of knowledge concerning the Enlightenment Era. In short, this approach can be said to be an expansion of perspective from the contents of intellectual history to include the practical circumstances of their genesis.[28] Instead of focusing on architecture as an academic discipline and an object of theoretical reflection, the route taken here correspondingly involves a detour to include the practical and everyday issues of building, and thus also the fringes and the neighboring fields of the profession of architecture. This is based on the fact that one of the fundamental consequences of the socio-cultural developments of the late eighteenth and early nineteenth centuries was—as will be shown—that architecture came to increasingly be a subject in areas where it had previously only played, if at all, a marginal role.

For this reason, a large majority of the protagonists of this study are neither architects, or at least not trained architects, nor for that matter architectural theorists in the classic sense. The competition between architects and engineers that came about in the course of the eighteenth century has already been referred to in detail by other authors. With the emergence of new building materials such as iron and concrete, as well as the corresponding static-calculation expertise, a growing chasm formed between the two until then interconnected professions, ending sometimes in public conflicts concerning responsibilities and authority.[29] As a matter of fact, however, the era saw architects faced with a whole crowd of new actors who started to encroach upon their ancestral métier. Along with engineers, this included physicians, natural philosophers, legal scholars, manufacturers, or—in the jargon of the times—"projectors," or commercial promoters, guided by economic interests, all of whom began involving themselves in the planning and design of architectural space.[30] In the process, many of them were not content to formulate critical proposals, but instead sat down at the drawing board and developed original designs for technical installations, architectural elements, or entire buildings. Thus, many of the publications dealt with below open with a more or less standard statement, in which the respective authors professed that it was not their intention to interfere in the matters of another profession, but rather to present their personal opinions on selected specific questions of building.[31] In reality, and cumulatively, these lay experts did exactly what they denied setting out to do. Their progressive inroads into the field of architecture successively transformed the discipline and its discourse.

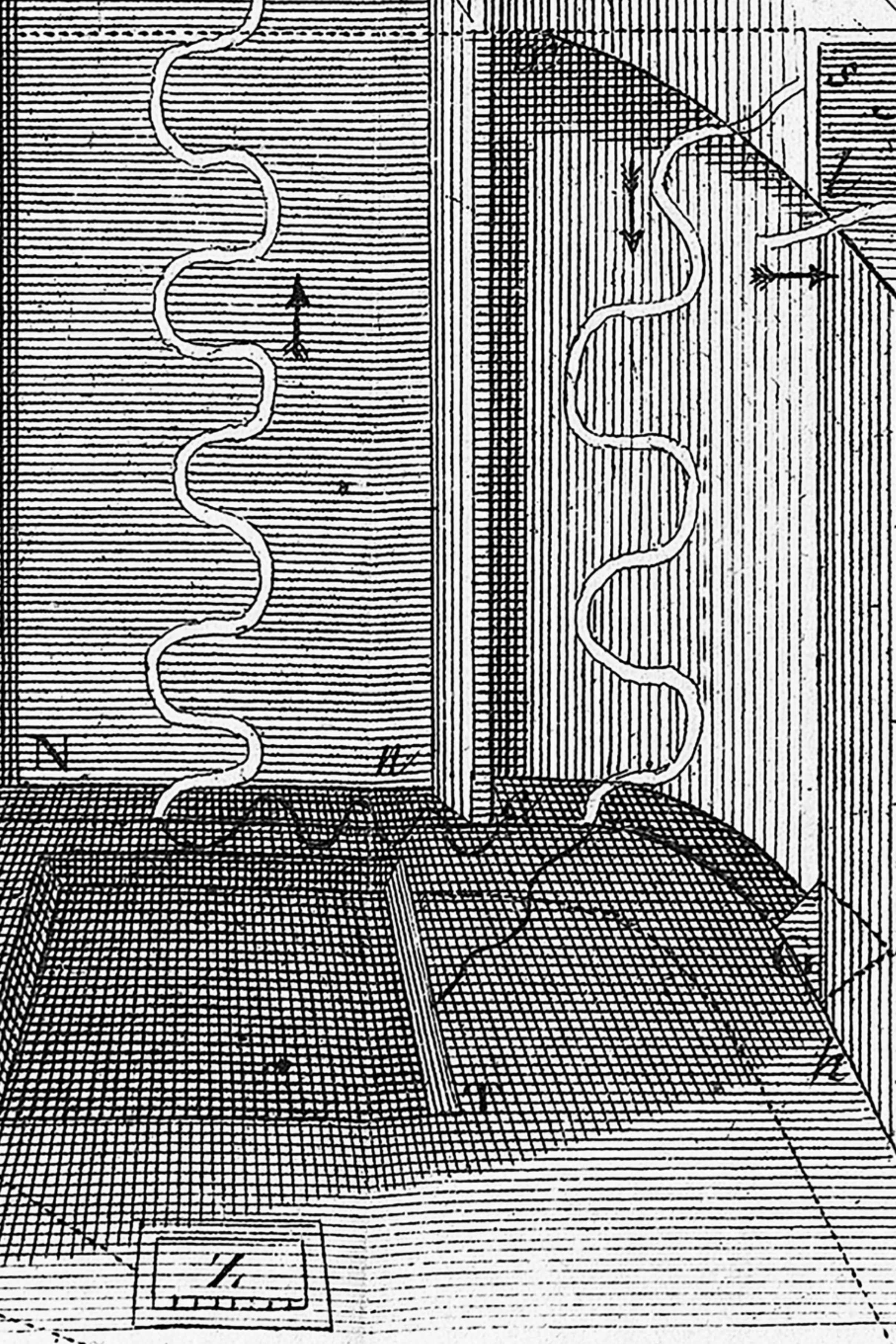
The differing approaches taken by the various actors are also manifestly expressed in their specific choice of images. Traditionally, the counterpart to the machine model was the model of the organism, and the long and convoluted history of both concepts is based to a significant extent on the widespread mechanistic interpretation of living processes that stretches far into the nineteenth century.[32] Nevertheless, towards the end of the eighteenth century the machine and the organism occupied distinct roles in relation to speaking about architecture. The organism model had been common since antiquity in the call to replicate proportional forms according to the human body, but with the turn toward nature in the architectural theory of the era it acquired a renewed relevance.[33] In this context, the mechanism, if used at all, served as a mere counter-image to the visual unity of the parts and the inner logic of the form for which the organism stood. "Thus," declared, for instance, the Romanticist August Wilhelm Schlegel in 1801/02 in his influential lecture on *Kunstlehre*, "the architect has a lot of relationships to observe; it is not enough that he joins parts together as they should be proportioned in themselves and against others according to certain mechanical rules, but he must look at them in their vital coherence."[34] While the scholarly architectural discourse thus positioned living nature at the center of its debates about style or construction, mechanical analogies were almost exclusively resorted to when considering the operative dimensions of buildings. In other words, the model of choice when dealing with the material efficacy of architecture in respect of the daily life of its inhabitants was the machine. This role-allocation would only change again in the course of the nineteenth century with the rise of the vitalistic perspective, when the organism likewise presented itself as a genuinely distinct model for operative processes and, vice versa, the machine first acquired aesthetic argumentative potential.

Many of the actors in this book are connected to each other via overlapping biographies or personal relationships. Thus, for instance, the manufacturer William Strutt, the engineer Thomas Tredgold, and the projector Jean-Frédéric de Chabannes were all at the same time members of the London Royal Society of Arts, giving them, at least theoretically, the opportunity to have exchanged ideas.[35] Moreover, particular places prove to have been creative centers of scientific, technological, and with them architectural innovations in relation to the topics examined here, for example the English Midlands where a profound connection between natural philosophy and the manufacturing economy occurred in the second half of the eighteenth century.[36] On the whole, however, the developments dealt with in this book are neither limitable purely to certain individuals or places nor can they be classified in terms of specific styles or building types. Even within their own disciplines, the actors dealt with do not always represent a coherent group, and although many of the developments originated from the capitals of London and Paris, in both Great Britain and France the impact of these new professions and their findings on architecture was spread across disparate regions. Instead of being based on specific individuals, locations, or organizations, this study therefore instead derives from three different discourses or discussion contexts that form the framework for the formulation of new claims made on built space: climate, morals, and comfort.

Within the period considered, each of these three words stands for a condition that was intended to be influenced by architectural and/or technological means: “climate” describes the atmospheric circumstances within a closed room, “morals” the ethical behavior of the inhabitants, and “comfort” the prevalent feeling of well-being within these rooms. They initially constituted distinct topics, each of them substantiating their own claims on architecture, each of them applying their own processes and means to realize them, and each, last but least, generating their own machine concepts. Simultaneously, numerous personal, content, and conceptual overlaps exist between these fields. Thus, endeavors to address morals were almost unimaginable without the implementation of elaborate climate techniques, while comfort was continuously also defined via its negation within the framework of the improvement of morals, and the desire for comfortable surroundings again formed the basis for the growing demands on interior climate. By intersecting, complementing, and mutually incorporating each other in these ways—and despite their core differences—viewed as a whole, the individual topics of climate, morals, and comfort therefore each represent threads in a common historical development.

The book is divided into three parts corresponding to the three topics and synchronically progressing over a period of roughly one hundred years. The individual parts all follow the same scheme. In the opening section, each topic is contextualized in terms of its role in circa 1780 and outlined from the perspective of its prior historical development since the mid-eighteenth century. Each second section examines a concrete yet unrealized architectural project from around 1800: the rebuilding of the Hôtel-Dieu in Paris, Jeremy Bentham’s Panopticon, and the Project for the Construction of New Houses by Jean-Frédéric de Chabannes. Although, or precisely because none of these projects progressed beyond being sketched out on paper, each of them in particular very clearly demonstrates the architectural ramifications of the topics of climate, morals, and comfort. Moreover, all three projects afford an opportunity to critically reconsider prior studies on the machine and operative conceptualization of architecture. The next sections trace subsequent developments in the three respective fields, along with the emergence and spread of the respective associated forms of building, technology, and knowledge in the first half of the nineteenth century. Each of the final sections consolidates the questions and problems raised using the example of a well-known—and in this case actually realized—building project from the 1840s: the rebuilding of the British Houses of Parliament, the model prison in Pentonville, and the London Reform Club. At the latest with these three buildings it becomes evident that however productive “inhabited machines” may be as an architectural concept, as built structures they very rarely fully achieve the hoped-for effects. All too often life and nature prove themselves unwilling to follow the operations scripted for them.

1 Collins, Changing Ideals, 159; Tafuri, "Machine et mémoire," 204–5; Schürer, *Automatismen und Architektur*, 232–34; Rosner, *Machines for Living*, 1–34.
2 See Lance, "Traité d'architecture," 68.
3 Foucault, *Madness and Civilization*, 199–220.
4 Foucault, *Discipline and Punish*, 64.
5 Foucault et al., *Les Machines à guérir* (2nd ed. published in 1979 in Brussels/Liège); Foucault, *Généalogie des équipements*; Foucault, *Politiques de l'habitat*, and in it, with one the first references to Lance's machine metaphor, in particular Béguin, "Savoirs de la ville."
6 See Foucault, "The Eye of Power," 228; Foucault, "Space, Knowledge and Power," 335–38. On this, see also Wallenstein, *Biopolitics.*
7 Teyssot, *Die Krankheit des Domizils*; Morachiello and Teyssot, *Le macchine imperfette*; Vidler, "Confinement and Cure"; Middleton, "Sickness, Madness and Crime"; Markus, *Buildings and Power*.
8 See, importantly, Foucault, *Archaeology of Knowledge*; Blumenberg, *Paradigms for a Metaphorology*.
9 See, for instance, Prieto, *La ley del reloj*.
10 See, for instance, Lefaivre and Tzonis, "Machine in Architectural Thinking"; Lefaivre and Tzonis, "Mechanization of Architecture"; Peters, *Building the Nineteenth Century*, 351–56.
11 This connection has been especially addressed in the case of Great Britain as a pioneer in the Industrial Revolution. See Ashworth, "Machinery of Reason"; Stewart, *Rise of Public Science*.
12 For general overviews, see Schmidt-Biggemann, "Maschine"; Frieß, *Kunst und Maschine*, 15–22.
13 See Popplow, "Verwendung von lat. machina."
14 One exception is fortress architecture, which was already associated with the machine at an early stage in order to stress the common feature of an embedding in a higher final correlation. See Büchi, "Naturphilosophie, Mathematik und Handwerk."
15 *Versuch eines vollständigen grammatisch-kritischen Wörterbuches der hochdeutschen Mundart* (1777), entry "Maschine." All of the foreign-language quotes in this book have been translated into English by the author, with the emphases corresponding to those in the original.
16 Le Roy "Précis," 598.
17 Evans, "Bentham's Panopticon," 35.
18 Evans, *Fabrication of Virtue*, 6–7 and 417. The notion of "architectural operativity" was also adopted in the mid-1970s by Foucault and the research team around him, most prominently in the original edition of *Discipline and Punish*. See Foucault, *Surveiller et punir*, 174–75. In addition, see Béguin, "Savoirs de la ville," 318–24; Béguin, "La Machine à guerir," 40.
19 See Schäffner, "Elemente architektonischer Medien"; Siegert, "Doors"; Jany, "Operative Räume." On the meaning of the concept of operativity in cultural and media studies, see also Mersch, "Critique of Operativity"; Treeck, "Operieren."
20 *A Dictionary of the English Language* (1785), entries "Operate": "To act; to have agency; to produce effects"; "Operation": "Agency; production of effects; influence"; "Operative": "Having the power of acting; having forcible agency"; and for "Agency": "The quality of acting; the state of being in action; action."
21 Evans, "Bentham's Panopticon," 35.
22 This is presumably also the reason why the actor-network theory at an early stage adopted the machine term to describe non-human power of action. See, for example, Law, "Ordering, Strategy, and Heterogeneity"; Latour, "Where Are the Missing Masses?"
23 Forty, *Words and Buildings*, 174 and 187–88. See also Poerschke, *Architectural Theory of Modernism*, 28–60.
24 On this, see, for example, Allen, *British Industrial Revolution*, 25–105.
25 See Lipstadt, "Early Architectural Periodicals."
26 See Hamlett, *Home in the Institution*, 4–8. See also Cavallo and Evangelisti, *Domestic Institutional Interiors*.
27 For an overview, see Vidler, "Architecture and the Enlightenment."
28 See, in general, Sarasin, "Was ist Wissensgeschichte?" and, specifically on the Enlightenment, Schaffer, "Enlightened Automata."
29 See, pivotally, Saint, *Architect and Engineer*, 485–89; Picon, *French Architects and Engineers*.
30 On this, see already Fortier, "Politique de l'espace parisien." On the figure of the "projector" or "schemer," see Krajewski, "Über Projektemacherei."
31 For a typical example, see Tuke, *Practical Hints*, v.
32 See Fernández-Galiano, *El fuego y la memoria*, 129–61. See also Rykwert, "Organic and Mechanical."
33 See Eck, *Organicism in Nineteenth-Century Architecture.*
34 Schlegel, *Vorlesungen*, 178.
35 See "List of Contributing Members."
36 See, pivotally, Jones, *Industrial Enlightenment*.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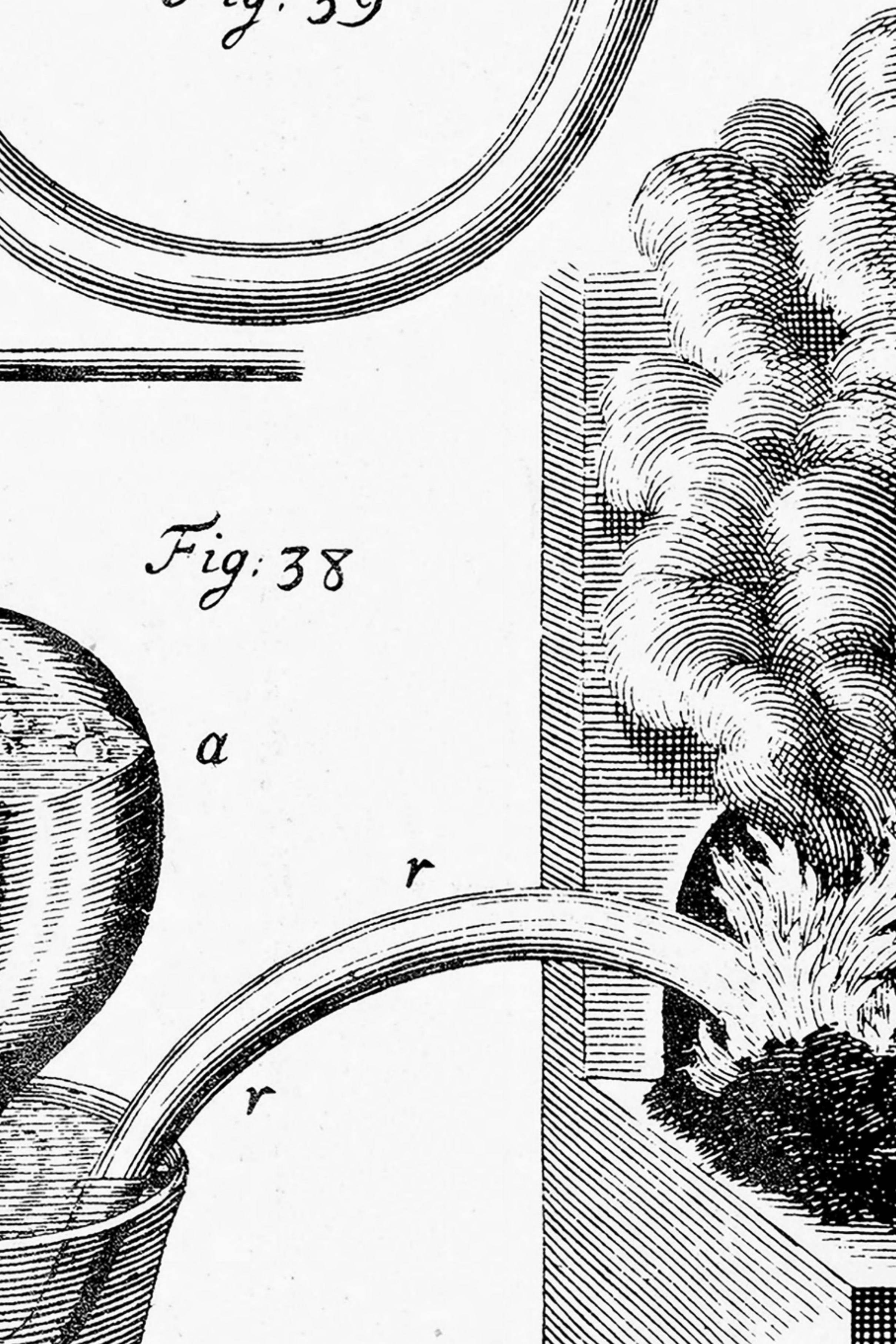
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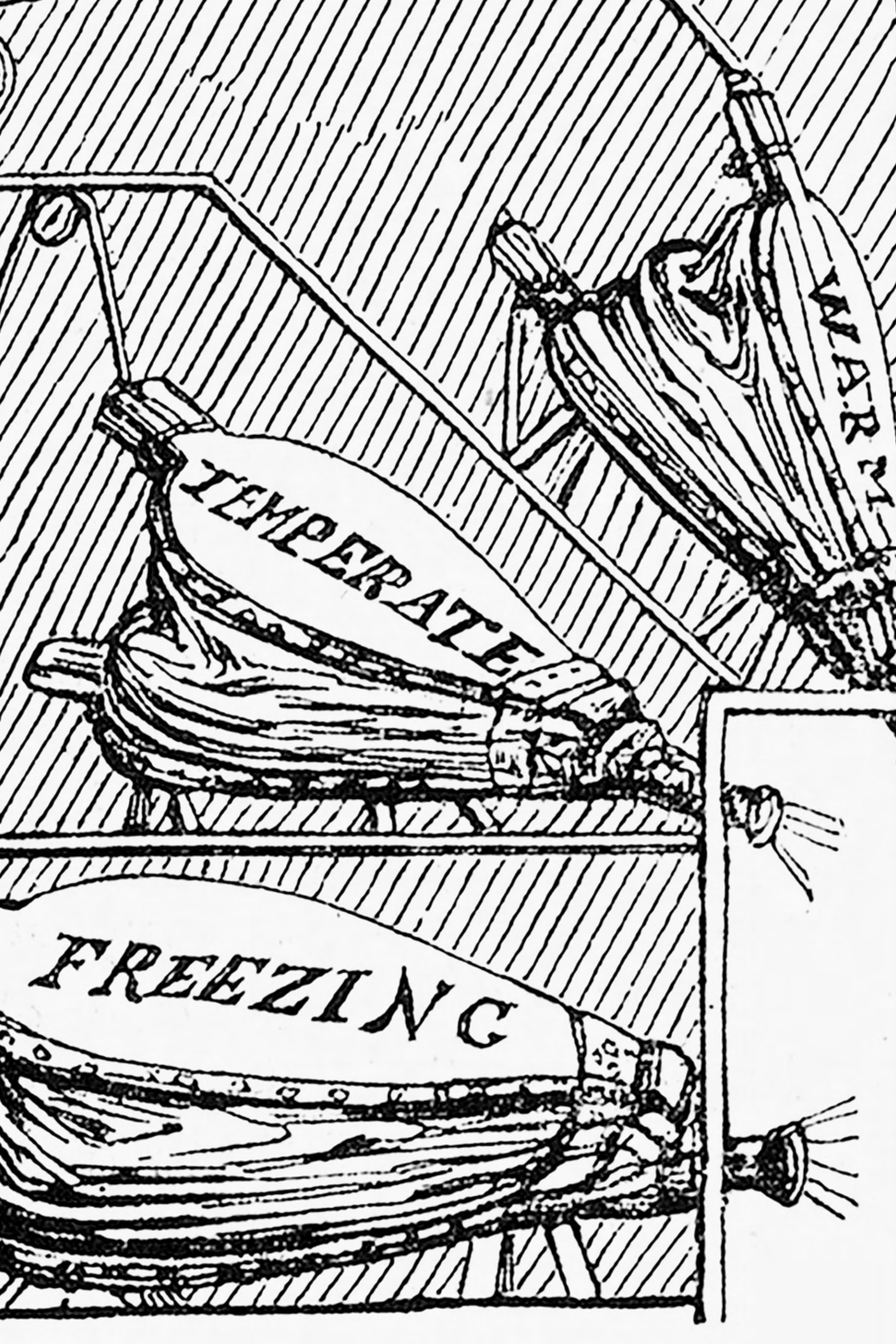


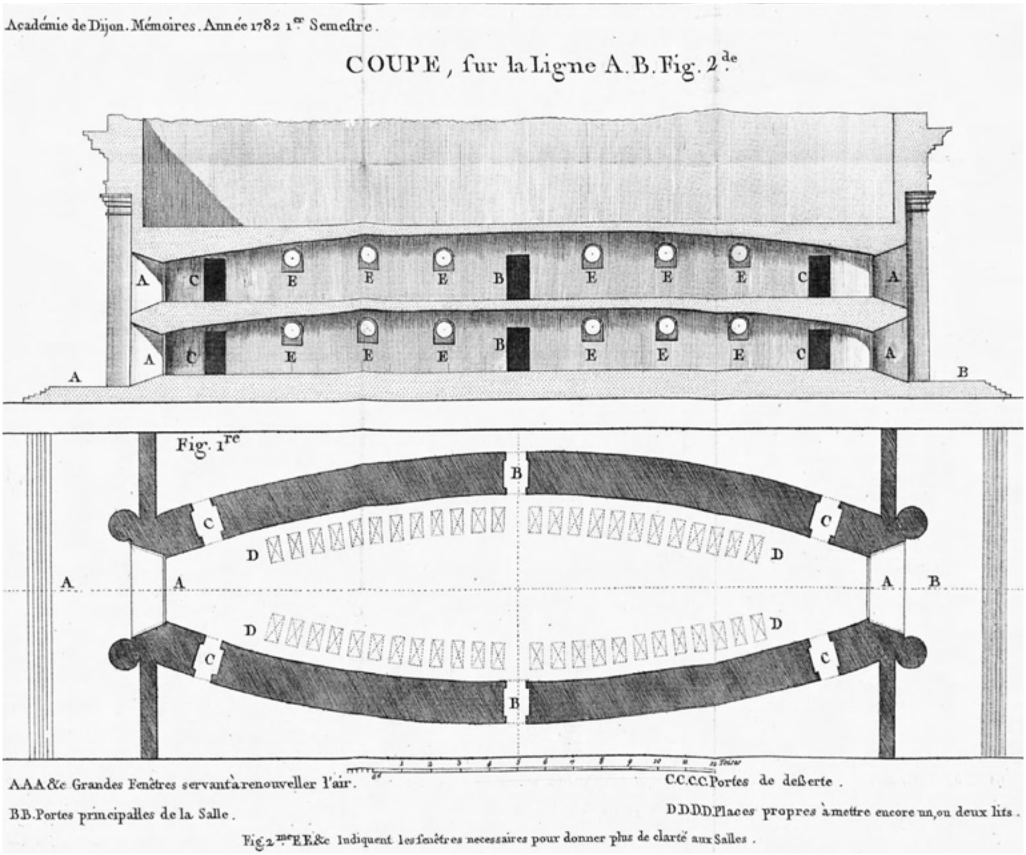
TEMPERATE
FREEZING

I. Climate

Artificial Ventilation

Early in 1780, the Dijon-based physician Hugues Maret designed what was probably the first room formed largely according to fluid-dynamic principles. Prompted by the publication of plans for the construction of new paupers' asylums in Paris, Maret—an epidemic expert and contributor to the *Encyclopédie*—sent a reader's letter to the *Journal de Paris*, France's first daily newspaper, in which he requested the opportunity to express some of his personal views on the form of hospital wards. According to Maret, his observations and experience as a physician had persuaded him that the traditional approach of arranging these spaces in more or less elongated rectangles was unsatisfactory. Quite opposite to an oblong, a hospital ward should be elliptically shaped, bereft of any ornament whatsoever, and equipped with only two large window apertures at either end. This was the only method to ensure, via the simultaneous opening of both windows, that the key "*operation*" of a regular and complete renewal of the air within the ward could be carried out.[1] Maret's initiative was crowned by success: not only was his letter printed as a double-page entry in the *Journal de Paris,* and thus disseminated to the paper's larger readership, but shortly afterwards he also received a high-ranking response. No lesser a figure than Jacques-Germain Soufflot, the royal buildings' inspector, celebrated architect of the later Panthéon, and himself the designer of numerous hospitals, wrote personally to Maret expressing his support for his idea and, moreover, readily giving his assistance in the form of a sketch of an infirmary based on Maret's specifications. → Fig. 1

His resolve reinforced by the encouragement of such a famous representative of the architectural profession, two years later Maret followed up with a short treatise under the title "Mémoire sur la



1
Form follows flow: Hugues Maret's elliptical hospital ward, 1782

construction d'un hôpital" in which he provided a detailed scientific basis for his proposal.[2] Due to its fluid property, air entering a point in a closed room would spread out radially, meaning, according to Maret, that the fundamental form of airflow was cone-shaped. Depending on the design and the alignment of the openings, on the resistances and obstacles in the room, this air-cone either expanded, became deformed, or was diverted. The most vivid example of this was running water, the flow behavior of which visibly followed the same regularities.[3] Derived from the laws of these flow patterns, Maret ultimately arrived at the elliptical form of his double-fenestrated hospital tract: "The properties of the ellipse being that all the rays that start from one focus of this curve will meet at the other after having been reflected by the different points of this line, & ... that this will result in two cones that will each have their apex at one of the windows." The curved lines ensured that the incoming air-cones successively passed through the whole interior of the room unobstructed, providing the impulse for the specific form of the ward in "the shape of an egg cut by a plane parallel to the major axis of the main ellipse."[4] Thus, only a few years after the initial spread of streamlined ship's hulls in the *architectura navalis* based on experimental methods, a comparable technique was introduced into the *architectura civilis*. Maret conceived the contours of his ward as an empirically established interface between a solid object and the enveloping fluid[5] so that the resulting architecture appears submerged in a dynamic medium.

The background to Maret's design constitutes a process that can be described as the discovery of respiratory air. This is not to say that air had not played a role in architecture prior to this—on the contrary, almost every architectural treatise since Vitruvius had stressed the significance of good ventilation at one juncture or another.[6] Nonetheless, it was only in the course of the eighteenth century that air began to be subject to deeper analysis and to be introduced into design decisions transcending the situation of a building and the configuration of its rooms. At the latest with its examination in Robert Boyle's air pump experiments in the second half of the seventeenth century, air became a central component in the natural sciences and an object of profound interest, above all in Great Britain and France, whereby it increasingly also began to excite notice in endeavors beyond the pure knowledge of nature.[7] What to date had been invisible and insignificant in equal measure now began to increasingly also attract inquisitive non-scientific minds. To use an idea of Peter Sloterdijk's, this process can be determined as one of explication, by which Sloterdijk describes the "revealing inclusion of latencies and background data in manifest operations."[8] Perhaps not by coincidence, he illustrates this with reference to a likewise atmospheric phenomenon, namely the use of poison gas in the First World War, which he argues prompted a completely new awareness of humanity's climatic and atmospheric dependency.[9] In a similar manner, long prior to this, a series of events and insights had already, in the mid-eighteenth century, led to a new understanding of air as a technically and scientifically manipulable object, and one worthy of collective and political consideration.

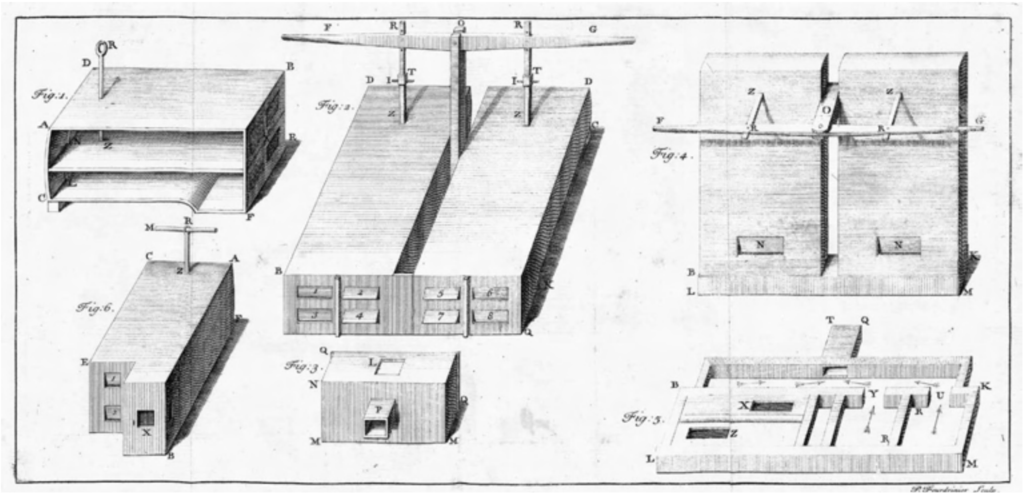
Looked at in terms of its essential features, this development is comparable to that which water as an element had undergone shortly beforehand. As a core factor for millennia in the evolution of civilizations, and prior to it becoming a driving force in the Industrial Revolution, in the eighteenth century water underwent its own scientific revolution, during which increased attention was paid to its multiple forms and their impact on human activities.[10] In this process, the numerous observational, catchment, and canalization experiments, intended to increase not only the understanding but also the operational use of water, focused first and foremost on the kinetic or dynamic character of the fluid—an approach Hugues Maret explicitly transferred to air. Water, like air, became part of a new "world of substances," which both scientific endeavors and spatial interventions drew upon in equal measure.[11] However, whereas the preoccupation with water initially and above all became effective at a territorial or urban level, from the very outset the explication of air was intimately tied to the constructive techniques of architecture.

After having once been perceived as a mysterious and ubiquitous but unquestionably vital fluid, air simultaneously began to be conceived as subject to any number of possible, potentially dangerous, conditional changes: the respiration of living organisms taints it; stagnancy makes it unsuitable to breathe; and it generally has the ability to absorb substances that dissolve from the objects it surrounds, thus causing illnesses and epidemics. Seen from this perspective, this fluid, so essential to life, can suddenly transform itself into a deadly force—a threat, especially in places where large numbers of people congregate, and thus the city as a whole as well as its individual buildings. Facilities in which forms of spatial isolation are organized represented a particular risk, in other words hospitals, prisons, or ships. In this sense, the discovery of air apportioned a fundamental role to architecture, both in its negative and positive effects, to the extent that built space was perceived, in terms of its enclosed nature, as medial, but equally, in terms of its configurability, as remedial to air's dangerous decay.[12] In what follows, the broad brush strokes of this explication process are delineated up to the point around 1780. This is when it achieves, as with Hugues Maret, a far-reaching design-practical relevance, and its history—not by coincidence, as will be shown—also intersects with the emergence of a new machine concept of architecture.

As with gas warfare, in the eighteenth century it was above all fatal events that proved to be catalysts in driving atmospheric explication processes forwards. So it was that in May 1750 a deadly illness that struck down over fifty participants in a trial in London—including the lord mayor, two judges, a lawyer, part of the jury, and numerous visitors—caused enormous trepidation and triggered a veritable upsurge in interest in all things concerning air and breathing.[13] Shortly after the incident, which became popularly known as the "Black Assize," the military physician John Pringle published a small book with the title *Observations on the Nature and Cure of Hospital and Jayl-Fevers*. Pringle identified the baffling court illness as akin to a malignant fever that he had also observed in the army, showing that this, in turn, was identical to the notorious jail, hospital, and ship fevers known at the time. In each of these cases, the cause of the infection was not, as was thought, the institution concerned itself or the character of its inmates, instead it was the corruption of air by the respiration of a crowded mass, as well as the vapors emitted by the sick and by corpses. In the London case, he accordingly surmised that a rampant fever in the adjacent Newgate Prison had spread amongst those present via the exhalations of the prisoners in the dock. The only effective remedy against this form of infection, Pringle's paper concluded, was the adequate airing of the buildings in question: the key to preventing the morbid effect was to stop the accumulation of the putrid air in the first place.[14]

Two years after the London "Black Assize," Pringle published the book *Observations of the Diseases of the Army in Camp and Garrison*, which went through seven editions and is considered as the first contribution to military hygiene,[15] while also constituting an early enunciation of the interaction between medical science and architecture. In it Pringle describes, amongst other phenomena, the ramifications of various natural and artificial surroundings on the health of soldiers, including his observation that the healing of the sick and the wounded occurred more rapidly in airy tents and barns than in common hospitals.[16] From this he drew the elementary and profound conclusion that the hospital itself should be rightly counted amongst the factors that caused disease. "Among the chief causes of sickness and death in an army," he wrote in the foreword, "the Reader will little expect that I should rank, what is intended for its health and preservation, the Hospitals themselves; and that on account of the bad air, and other inconveniences attending them."[17] As a consequence, not only the choice of site was crucial in determining the establishment of a hospital but equally the correct "management" of the air.

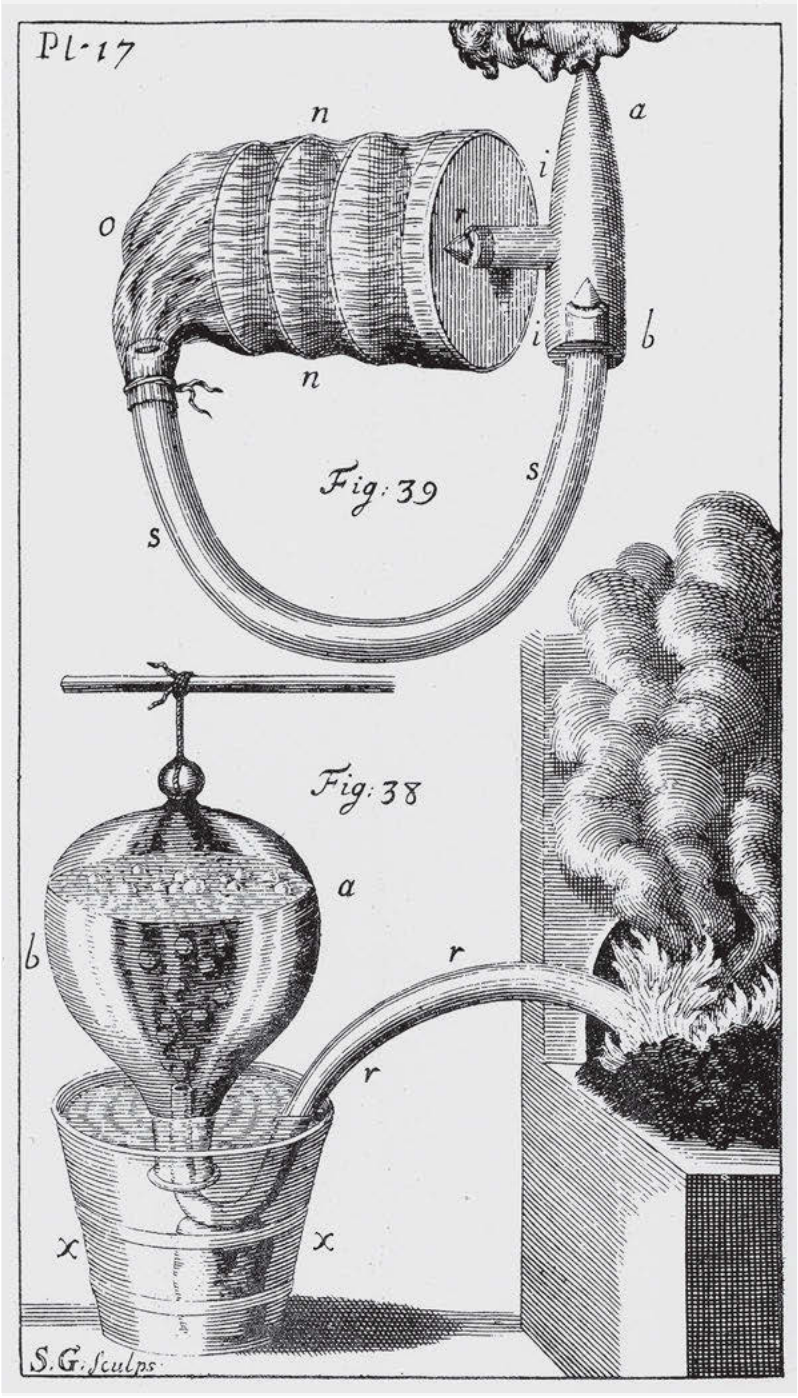
In Pringle's eyes, the best means for such an air "management" was the highly acclaimed invention by the curate and physiologist Dr. Stephen Hales,[18] who some ten years previously had presented his so-called "Ventilator" to the Royal Society, and with it not only a new apparatus but a new terminology. → Fig. 2 Hales's ventilator was primarily developed for ships but was also intended for use in public buildings. Via an arrangement of different pipes and valves, fresh air was channeled into one or more rooms and the used air was extracted.[19] To explain his system, Hales employed the analogy of the respiratory system of an animal: "Were an Animal to be formed of the Size of a large Ship, … there would be ample Provision made to furnish that Animal with a constant Supply of fresh Air,



2
The first “ventilator”: a hand- or wind-driven set of bellows, 1743

by means of large Lungs, which are formed to inspire and breathe out Air in the same manner as these Ventilators do."[20] Over the following years, ventilators based on Hales's model were installed in numerous English hospitals and prisons, including Newgate, as well as in various buildings in continental Europe.[21] Although this did not result in the eradication of the notorious fevers, the mechanism was nevertheless regarded as in important contribution to the improvement of the health of the inmates, and according to Hales's own estimation played a decisive part in making artificial ventilation an aspect in the planning and construction of institutional buildings that enjoyed increasing currency.[22]

In reviewing the importance of Stephen Hales as a protagonist in the explication of air, it is important to recall that his practical role was as crucial as his theoretical one. With the appearance of his *Vegetable Staticks* in 1727, the clergyman—who since his theological studies had undertaken physiological experiments—also made a key contribution to the beginnings of so-called "pneumatic chemistry" and thus to a new scientific understanding of air. Whereas previously air had been regarded as an elementary fluid, one that played an instrumental part in chemical reactions albeit itself not a component in chemical compounds, Hales was able to prove that it possessed both an instrumental and a constitutive function and that it could be "fixed," or in other words act as a building block in other substances, and as such was essential to plant and human metabolisms. As a highly protean substance, it can assume a free, gaseous state in which the particles of other substances float, or its particles can be bound and themselves become fixed components in the material of other bodies. In numerous experiments with a self-constructed pneumatic trough—a rudimentary piece of laboratory equipment for the collection and modification of air—Hales examined how "fixed air" regained and released its original elasticity through the chemical processes of distillation or fermentation.[23] → Fig. 3 The invisible and volatile matter thus acquired an enormous range of meanings and actions: "It is by this amphibious property of air," wrote Hales, "that the main and principal operations of Nature are carried on."[24]



3
Experimental set-ups: personal testing and pneumatic trough in *Vegetable Staticks*, 1727

In short, it is also majorly due to Hales's work that in the latter part of the eighteenth century air began to be treated as a crucial variable in various organic processes. "Henceforth," writes Alain Corbin in his history of smell(ing), "it was thought to act on the living body in multiple ways: by simple contact with the skin or pulmonary membranes, by exchanges through the pores, and by direct or indirect ingestion (since foodstuffs also contained a proportion of air, which could be absorbed into the chyle and hence into the blood)."[25] Air no longer counted simply as one of the *sex res non naturales*, the six health determinants of classic medicine, but instead as the principle agent. Depending on the author, it was blamed for a whole range of various effects on people—through its pressure, its temperature, or its moisture, and, as was widely recognized, through the ingestion of the exhalations or secretions from other bodies or substances. In this, the theory of miasma, popular since the antique, experienced both a shift and a prolongation in that the term no longer covered only the vaporous emissions of the earth but now also included substances and particles dissolved in the air.[26] Because the impact of air on health was said to depend on the level of pollution with these particles and vapors, the Scottish physician and mathematician John Arbuthnot published his *Essay Concerning the Effects of Air on Human Bodies* in 1733 based on Hales's findings, methodologically listing numerable potential admixtures and impurities, as well as their effects.

In France, where Arbuthnot's essay appeared about ten years later, a very similar argument began, albeit with a slight delay. In 1753 the Académie de Dijon launched a competition on the problem of air, won by the physician and botanist François Boissier de Sauvages with his *Dissertation où l'on recherche comment l'air, suivant ses différentes qualités, agit sur le corps humain* (Dissertation on how air, according to its different qualities, acts on the human body). Independently of how exactly it was assumed that air evolved its cleansing or polluting effects and contributed to the emergence or transmission of sickness, however, the necessity of ventilating or airing closed rooms had become a recognized fact, at the latest since the publication of Pringle's writings: whatever air precisely is or does, it should be regularly kept in motion, mixed, and exchanged. Besides mechanisms such as Hales's ventilator and similar inventions, such as Thomas Tidd's portable "Aeolus" ventilator, the discussions in this field also increasingly concentrated on the role of spatial or architectural elements and means, including room size, ceiling height, ventilation openings, and special window constructions.[27]

While the illness-inducing miasmas and the ways they were transported via air remained puzzling in their details, pneumatic chemistry made great strides from the mid-century onward. Numerous physicians and natural scientists now began to experimentally isolate various "airs" or "gases" and to describe their effects on animal organisms. Despite the fact that the continued adherence to the phlogiston theory—the hypothetical substance said to be released with the incineration of all bodies—impeded a thorough analysis, nevertheless there was a better understanding of the respiration process of living creatures, while the concept of air as an element or a chemical compound began to be increasingly doubted. In 1755, Joseph Black extracted a gas that he named "fixed air" based on its ability to penetrate a solid body (today's carbon dioxide); in 1766, Henry Cavendish described a type of air as "inflammable" (today's hydrogen); and in the early 1770s, using a more refined pneumatic trough, Joseph Priestley was able to add, amongst others, "phlogistated" and "dephlogistated air" (today's nitrogen and oxygen).[28]

Thus, even before Antoine Lavoisier's pioneering discoveries, a preliminary scientific and practical dialogue had been established, especially between Britain and France, concerning the nature and correct handling of respiratory air. Around 1780—at the same juncture that Hugues Maret envisioned his streamlined hospital ward—the famous French chemist commenced formulating his findings about oxidation in such a way as to—in the long term—refute the phlogiston theory and thus radically transform the understanding of atmospheric air. For the first time, Lavoisier systematically described air as a mixture of gases and breathing as a combustion process,[29] thereby laying the foundations of modern chemistry. More than this, his work simultaneously updated the discussion about artificial ventilation in that in the numerous publications and lectures in which he propagated his theory of gases he repeatedly, and from the very start, also related his findings to everyday problems and therewith to architectural contexts.

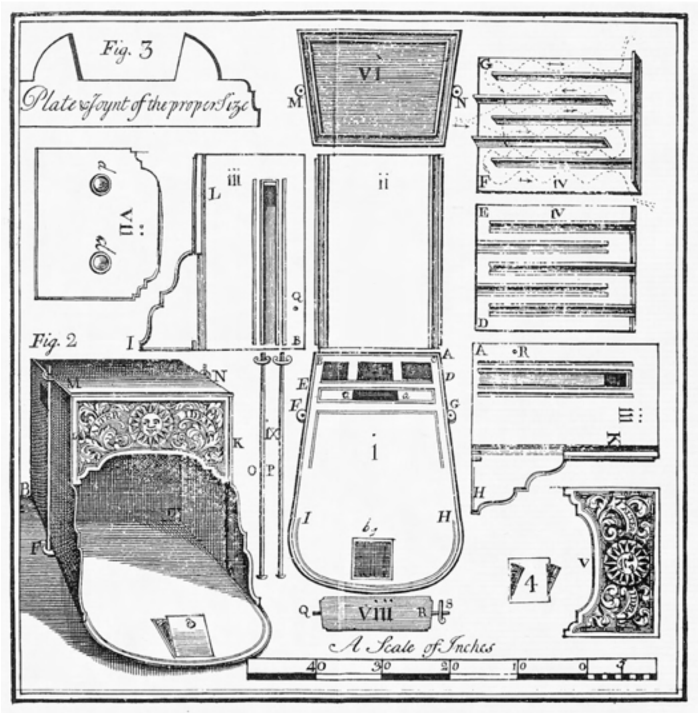
In February 1785, Lavoisier delivered a lecture to the Société royale de médecine with the title "Mémoire sur les altérations qui arrivent à l'air dans plusieurs circonstances où se trouvent les hommes réunis en société" (Memoir on the alterations that happen to the air in several circumstances where humans are gathered in society). In it, he presented the results of an inquiry that, rather unusually, had taken place not in his laboratory but at two sites in Paris that could not have been more different: the theater hall of the Comédie-Française and a dormitory of the Hôpital général almshouse. Lavoisier reported how, equipped with test tubes, and at some considerable effort (his activities during the ongoing theater performance had caused him some embarrassment), he had collected air samples from both rooms. The results had shock potential, because despite the great differences, an identical process was established in both buildings: with the presence of crowds of people, the air within the settings, usually consisting of two parts—"*air vital*" (oxygen) and "*moffète atmosphérique*" (nitrogen)—increasingly came to consist of three parts via the conversion of a part of the oxygen into "*air fixe*" (carbon dioxide). Because the three fluids distribute themselves according to their specific weight and in particular the lighter nitrogen forces its way upward, a circulating movement results in which the used air ascends and is replaced by incoming fresh air.[30] Without this automatic exchange flow, so the conclusion of Lavoisier's lecture, the air in a room—be it in a theater or an almshouse—would be completely contaminated in a matter of hours. And he added that further research into these processes—of which architects at that time were unfortunately entirely unaware—would inevitably result in valuable insights for the planning and building of gathering places.[31] With this Lavoisier formulated not only the basis for the understanding of gaseous exchange that remains valid to the current day, but once more demonstrated a connection between air, breathing, and space that would have fundamental technical, constructional, and discursive effects in the decades to come.

The topic of artificial ventilation was not the only correlation that propelled an architectural explication of air in the eighteenth century. In the same year that Lavoisier held his lecture on the transformation of the atmosphere in gathering spaces, the American statesman, scientist, and inventor Benjamin Franklin penned an open letter to the Dutch physician and botanist Jan Ingenhousz about fireplaces. And whilst Lavoisier was carting his laboratory instruments into Paris institutions to measure the composition of the air in them, in his letter Franklin compared the built room with a piece of laboratory equipment with which to manipulate air. "[I]t will appear absolutely impossible," he wrote, describing the draught triggered by a hearth fire, "that this operation should go on if the tight room is kept shut; for were there any force capable of drawing constantly so much air out of it, it must soon be exhausted like the receiver of an air pump, and no animal could live in it."[32] In other words, it was only the existence of various intentional or unintentional openings that prevented the occurrence of a vacuum in a living room heated by an open fire, similar to that in a glass flask or an air pump.

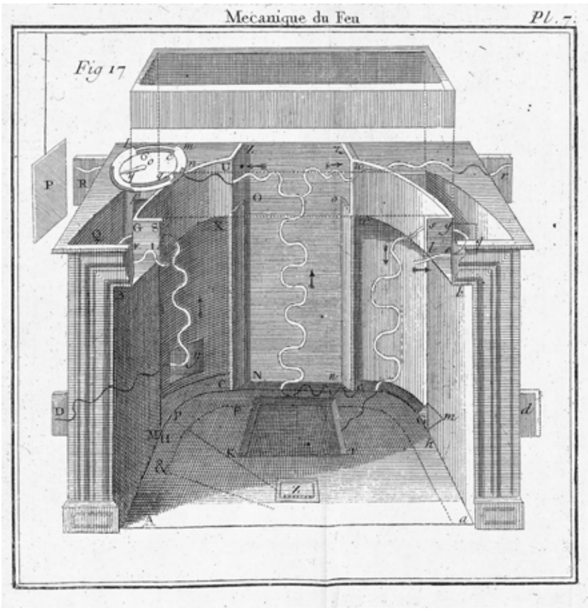
Although breathing likewise played a decisive role in this case, and despite Franklin's familiarity with Lavoisier's research and his own preoccupation with the subject of ventilation,[33] this analogy and the issue addressed within it occur in their own context. Alongside his numerous other scientific and political activities, Franklin was the central figure in a movement dedicated to the optimization of domestic heating methods. Following centuries of minimal developments, in the eighteenth century fireplaces and stoves became a focus of scientifically and technologically informed reformers and entrepreneurs, and as such subject to various theoretical and constructional interventions. This especially concerned open fireplaces, which were particularly widespread in Western Europe and the British colonies, and which due to their high fuel consumption, their one-directional and limited heat output, and above all because of the smoke emissions that affected furniture and inhabitants alike, were perceived as a grave problem by those actors somewhat derisively known as "stove doctors."[34] Within this constellation, air was not treated primarily in terms of breathing, rather in the first instance as an agent of heat transfer. At the same time the focus lay less in institutional buildings and public hygiene, and far more in private living quarters and personal comfort.

At the stage when Franklin wrote his letter on the appropriate construction and use of chimneys in the mid-1780s—aged 79 and after almost eight years as a diplomatic representative in France[35]—he was anything but a novice in the field. His scientific interest in the phenomena of thermal transmission and his endeavors to apply the resulting findings to the improvement of domestic practices had already led him, almost half a century earlier, to develop a novel oven in the winter of 1739/1740, which shortly afterwards was offered for sale in Philadelphia and numerous other American cities. In 1744, a publication appeared titled *An Account of the New Invented Pennsylvanian Fire-Places*—later translated into French, Dutch, German, and Italian—which promoted both the stove and the principles behind it. Since then, Franklin was considered an expert on all questions and problems concerning domestic heating in the scholarly circles of the eighteenth century.[36]

Initially known as the "Pennsylvania fireplace," and later the "Franklin stove," the oven was a circa-80-centimeter-tall cast-iron casing that could be integrated into the openings of already existing or new fireplaces. In this way, Franklin attempted to marry the fuel-saving properties of closed stoves with the social and symbolic qualities of the open fireplace, so prevalent above all in the Anglo-Saxon world. The aim of the construction was, while keeping the visibility of the fire, to separate warmth and smoke from each other: because the smoke gases were channeled into the chimney in a controlled way via an extended flue, the metal plates could impart more heat into the room surroundings. This effect was reinforced even more through the innovation of a so-called "air box," a hollow chamber inside the stove over which the smoke gases flowed on two sides, thus emitting warmed air into the room. The fresh air for the fire and the air box was drawn in from outside via a short floor duct. → Fig. 4 Along with a greater energy yield and less smoke exposure, the stove thus also promised to prevent the



4
Assembly kit: construction drawings for Benjamin Franklin's Pennsylvania fireplace, 1744



5
Applied (fire) mechanics: fireplace construction by Nicolas Gauger, 1713

draughts common to fireplaces and to distribute the warmth more evenly across the room by means of the air flows. The result was intended to be nothing less than a fundamental reorganization of domestic activities: “People need not croud so close round the Fire, but may sit near the Window and have the Benefit of the Light for Reading, Writing, Needle-work, &c. They may sit with Comfort in any Part of the Room.”[37]

Franklin’s 1744 report introduced a series of references with which he sought to substantiate the value of his invention on a technical and theoretical level. In terms of technology, he above all drew on the 1713 book *Mécanique du feu*[38] where, based on some basic thermal-physical assumptions, the French lawyer and experimenter Nicolas Gauger had proposed two decisive constructional alterations to open fireplaces. Rooted in the premise that rays of warmth, like rays of light, were deflected by solid surfaces, and in the process the angles of incidence and reflection corresponded with each other, he designed a parabolically shaped metal fireplace back-wall in order to reflect the greatest possible part of the rays of warmth out into the respective room. In addition he installed a hollow chamber behind the bent metal plate, which was equipped with a connecting flue to the outside and channeled warmed air into the room when the fire was burning.[39] ← Fig. 5 With this, Gauger presented the first detailed and scientifically based description of a heating technique that, along with the thermal radiation of the fire, also exploited the convective property of the air. His “fire mechanics” promised a completely new level of climate control, technically achieved via a control knob incorporated into the fireplace through which warmed and un-warmed air flows could be mixed, enabling the user to regulate the temperature of the living space as desired.[40]

Franklin adopted Gauger’s idea of the air cavity, but in his theoretical explanations he moreover fell back on a series of recent scientific works, including, centrally, the writings of the natural philosophers Martin Clare and John Theophilus Desaguliers. In 1735, Clare had published a treatise with the title *The Motion of Fluids* in which the then current state of knowledge in the fields of hydrostatics and pneumatics had been collected and presented in generally understandable language, including an excursus on the problem of smoky fireplaces.[41] In 1715, Desaguliers had translated Gauger's *Mécanique du feu* into English as *Fires Improv'd*, and in the same year as the appearance of Franklin's report on the Pennsylvania fireplace the second volume of his successful *Course of Experimental Philosophy* was published. This documentation of his public lectures and experiments in Newtonian physics and its practical applications also dealt with fireplaces in a chapter on hydrostatic experiments and in a postscript with the title "Air Changed, Purified, and Conveyed from Place to Place."[42] In his report, Franklin expressed his debt and respect to both authors by mentioning and quoting them, thereby clearly emphasizing that his invention and his attempts to optimize heating techniques was deeply anchored in the wider context of the mechanistic natural philosophy of the eighteenth century.[43]

This rootedness in the experimental sciences constitutes one of the central commonalities between the topic of artificial ventilation and domestic heating. Both in the one and in the other, a Newtonian-derived knowledge of flows and rays, coupled with a growing sensibility for the atmospheric conditions in interior spaces, led to a questioning of the existing practices. In the process, in both cases the initial focus lay in individual mechanisms—such as the Pennsylvania fireplace or Hales's ventilator—that sought to make air manageable based on its physical characteristics. Nevertheless, both the technologies of heating and of ventilation did not remain confined to isolated elements for long; instead, as they developed further, processes of convergence between the respective technologies and architecture became increasingly apparent. Indeed, with the growing understanding of the scientific underpinnings and the integration of innovative fireplaces, stoves, and ventilators in buildings, practical problems emerged that could only be solved via a process of reciprocal adaptation.[44] Expressed differently, at both a constructional and a conceptual level, heating and ventilation methods began to incorporate the surrounding architecture—and vice versa. In the field of artificial ventilation, this process can be seen as reaching its first climax in Hugues Maret's streamlined hospital ward. Here, ventilation techniques have achieved such a degree of convergence with the architectural object that it extends to the fluid-dynamic design of the shape of the room. In the same way, domestic heating becomes an architectural issue in the second half of the eighteenth century and architecture an issue in heating. While Franklin could still treat the Pennsylvania fireplace as an independent object in the mid-1740s, the constructional implications of which are dispensed with in one or two brief "Directions to the Bricklayer," at the latest by the 1780s the theoretical and practical developments in heating technology had reached a point where he had reason to treat the fireplace as an integral part of the architectural ensemble—and moreover to compare it as a whole with a piece of laboratory equipment.

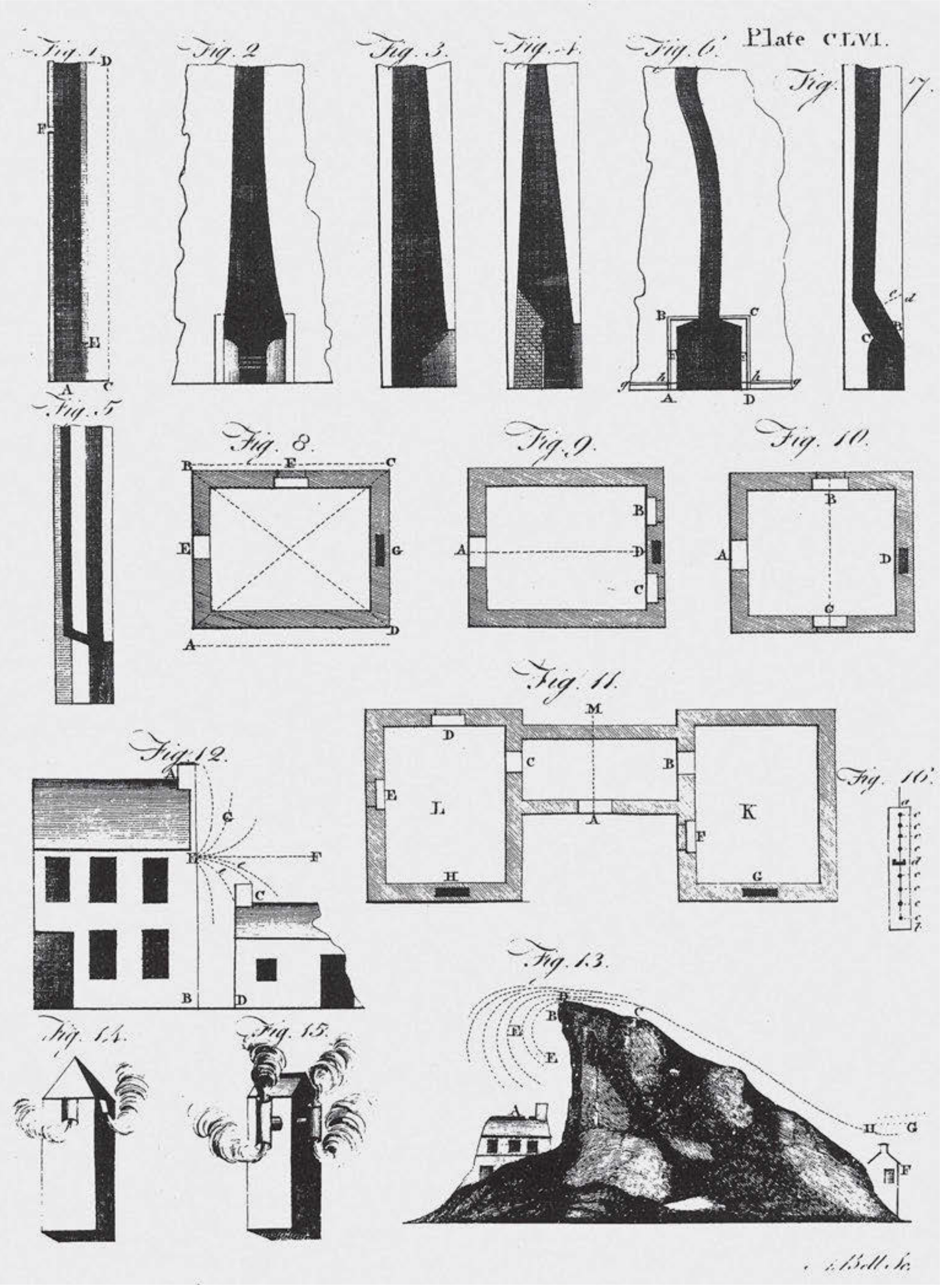
An important stage in this process is represented in the publication of the third volume of the *Encyclopædia Britannica* in 1771. It contains an eight-page entry by the Scottish agricultural economist James Anderson concerning the term "smoke," in which the annoying fume was transformed from a mere heating-technological to an architectural issue at numerous levels. "SMOKE," the entry begins,

> a dense elastic vapour, arising from burning bodies. As this vapour is extremely disagreeable to the senses, and often prejudicial to the health, mankind have fallen upon several contrivances to enjoy the benefit of fire, without being annoyed by smoke. The most universal of these contrivances is a tube leading from the chamber in which the fire is kindled to the top of the building, through which the smoke ascends, and is dispersed into the atmosphere. These tubes are called chimneys; which, when constructed in a proper manner, carry off the smoke entirely, but, when improperly constructed, they carry off the smoke imperfectly, to the great annoyance of the inhabitants.[45]

On the one hand, this short passage describes the nub of the problem, namely the composition of the "tube," commonly known as a chimney, and on the other, it sets it in a wider context, in the sense that as a tube the chimney is not an independent but rather a connecting element that encompasses the room in which the fire burns and the atmosphere into which the smoke is expelled. This aspect is crucial in allowing the author to amend the usual reasons given for a deficient smoke flue—"a fault in the form of the tube, or chimney itself"—by adding two further causal complexes: "II. To some fault in the other parts of the building, and a wrong position of the chimney with respect to these. Or, III. To an improper situation of the house with respect to external objects."[46] These objects include natural and man-made features, such as rises in the landscape or high neighboring buildings that impede the flow of air over and beyond the building and create turbulences, which prevents the air from freely exiting the chimney or even forces it back down. The problem of smoky fireplaces is thereby associated with the classic architectural topic of orientation, updated by a fluid-dynamic comprehension of the relationship between wind and terrain. In this case, the problem can be obviated by situating the building correctly or by deploying a specific chimney pot.[47]

Things are more complicated in the second causal complex addressed by Anderson, namely deficiencies in parts of the building that are not part of the chimney. The first of the two potential defects consists simply of an overly hermetical sealing of the heated rooms. If the room lacks sufficient fresh air to feed the combustion process, the circulation of rising and incoming air is effectively halted and an equilibrium is formed at both ends of the chimney, meaning that the smoke begins to drift into the room. A quick remedy in this case is to open a door or a window, but a better solution is the permanent installation of an independent air inlet like that already recommended by Nicolas Gauger.[48] The second potential defect lies in the positioning of other architectural elements, and thus has to do with the fundamentals of architectural planning. Because, under certain circumstances, any other opening of a room can equally serve as a smoke outlet instead of the intended chimney, it should be situated in a particular relation to doors, windows, and further chimneys.

In order to demonstrate the complex interrelationship between the function of the chimney, the other openings and the prevalent wind direction, Anderson resorts to the floor plan as a familiar architectural presentational means. Using a series of



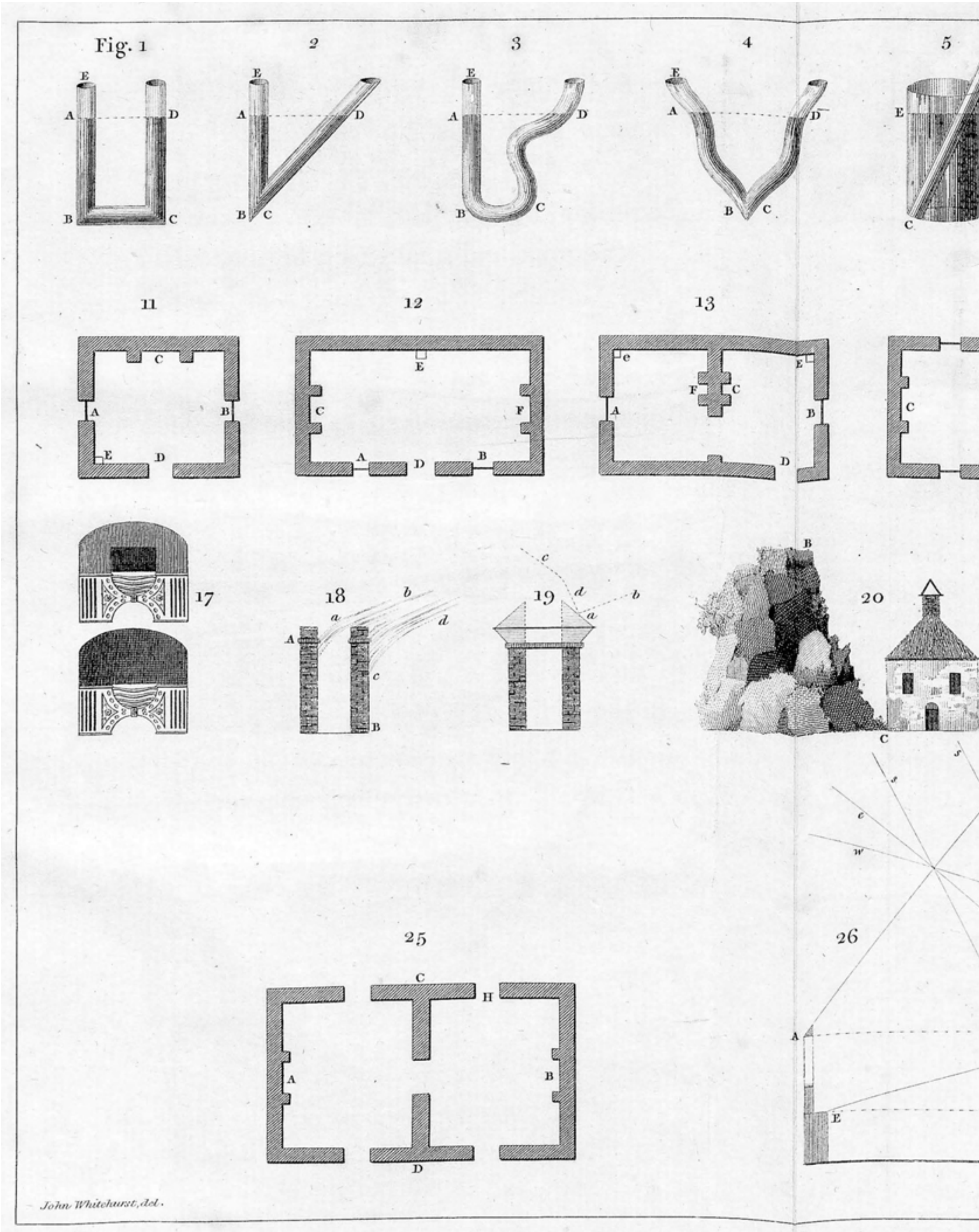
6
Causes of smoky chimneys (letters indicate building elements, dashed lines wind directions), 1771

hypothetical, schematically illustrated buildings, his article iterates numerous successful and failed spatial arrangements, ← Fig. 6 concluding with a general rule that the chimney should be situated on the lee side of a house and the majority of the openings on the windward side. The explicit goal of the entry is to provide the readers of the encyclopedia with the analytical tools with which to independently subject their own or any other building to graphic examination.[49] In this way, the chimney is situated, in the literal sense, in a visibly new relation to architecture. The traditional habits and the symbolic significance that surround this ancient architectural element are supplemented by the scientific logic of pneumatics. With Anderson, the architectural principle of distribution, the representative and functional subdivision of a building, is extended by a physical understanding of distribution that describes the dynamic dispersion of masses.

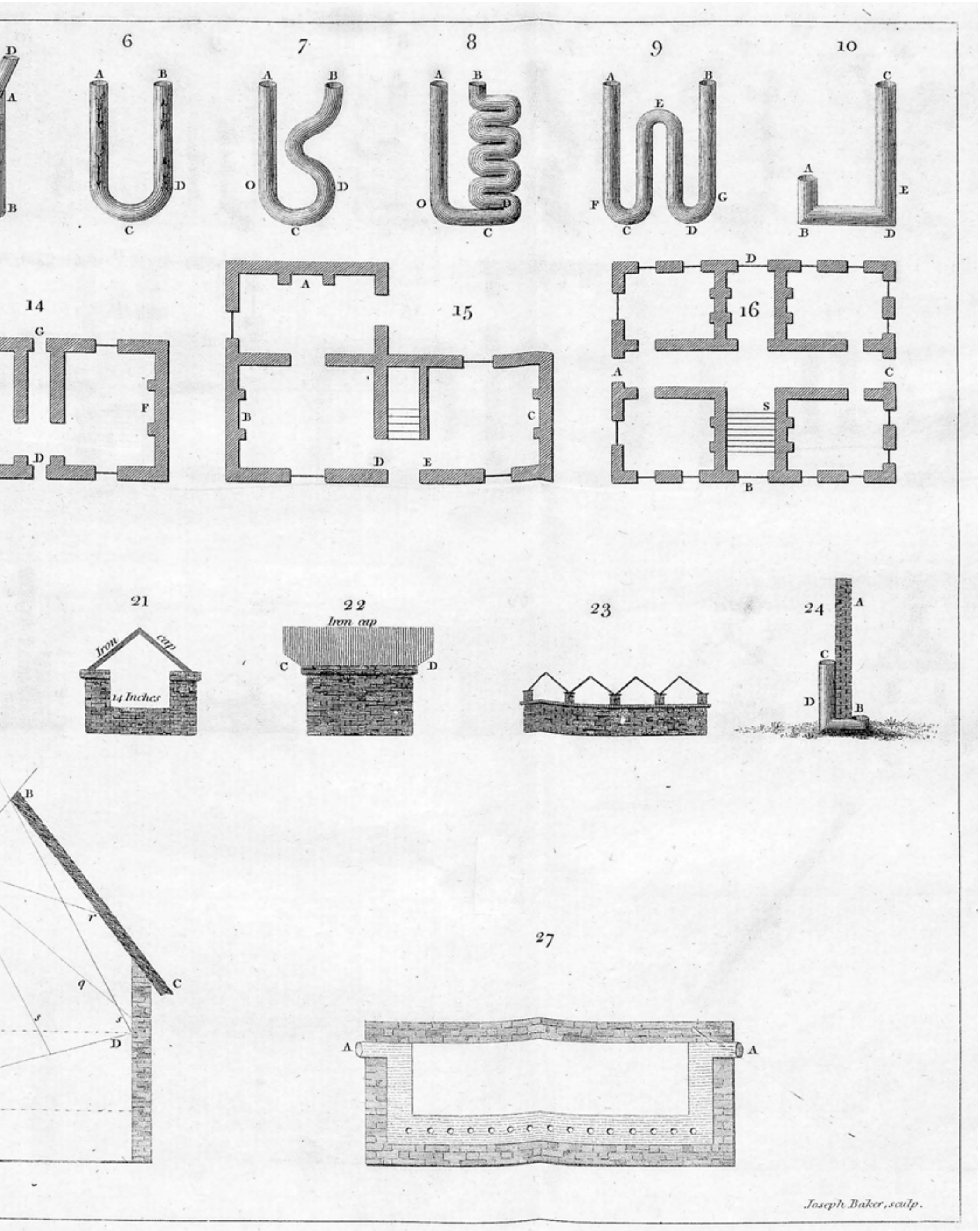
That the art of heating thus creates—quasi as a "chimney effect"—close connections between architecture and the natural sciences also becomes evident in one of the other numerous treatments on the topic that appeared in the late eighteenth century, namely a short treatise by the English watchmaker and scientist John Whitehurst. The title of the book, written in the 1780s and published posthumously in 1794, is *Observations on the Ventilation of Rooms; on the Construction of Chimneys; and on Garden Stoves*, simultaneously heralding a convergence of the topics of heating and ventilation.[50] Whitehurst was a member of both the Royal Society and the Lunar Society, the latter an informal scholarly gathering of scientists and industrialists in the English Midlands that included Joseph Priestley and Benjamin Franklin. Whitehurst was considered an authority in the fields of mechanics and hydraulics, and besides watches manufactured scientific measuring devices and domestic technical installations, such as cooking stoves, water pipes, and fireplaces.[51] While the *Observations* add little to Anderson's article in terms of content, they are nevertheless fascinating in their argumentation and proofs.

Whitehurst's 50-page treatise comes with a folded illustrative plate, containing 27 images set in four rows: the first row shows physical vessels, the second floor plans, the third largely consists of chimney pots, and the fourth shows various other constructions. → Fig. 7 At first glance, the illustration mirrors the basic structure of the book, which in the first chapter deals with the properties of air, in the second artificial ventilation and chimney construction, and in the third the external causes of smoky fireplaces—in other words explanations of scientific principles as a first step, followed by constructional solutions based on them in the two subsequent ones. In fact, however, the text almost entirely abolishes the divisions between the individual rows in the illustrative plate, and thus between science and architecture. As the text progresses, Whitehurst is long since talking about buildings when he is still referring to the representations of physical vessels, and he still writes in terms of the laws of hydraulics and pneumatics whilst treating the depicted floor plans and architectural elements. The result is a kind of “circulating reference” between the fields of building and research. The words and the illustrations establish a reversible route that allows the reader to effortlessly move back and forth between constructional and physical problems and that inextricably interweaves scientific facts with architectural phenomena.[52]

The vehicle for the circular argumentation in the *Observations* is above all those illustrations that depict both architectural and scientific issues at the same time. An example is Figure 5 that generally acts as a hinge between the world of instruments and that of the built environment, which comes after Whitehurst has used the first four illustrations to explain the hydrostatic principle of communicating vessels. The figure shows a tube, sealed at the bottom end, immersed in vessel filled with water. When the tube is opened, the water rises in it to the same level as in the vessel. Smoke rises in a chimney for precisely the same reason, explains Whitehurst, and transposes the reader from the field of hydraulics to that of domestic heating.[53] Figure 9 has a similarly hybrid character, showing a W-shaped tube. Depending on the positioning and sequence of the kindling of two fires, a suction effect is created in the tube that pulls the smoke from one of the two flames downwards and through the bends in the tube. Whitehurst explains that the stoves in the Bank of England rely on precisely the same



7
From vessels to buildings—and back again:
John Whitehurst's *Observations*, 1794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Joseph Baker, sculp.

principle, thus taking his readers from a pneumatic phenomenon into one of the era's most prestigious buildings.[54] This procedure works also at the visual level and in an opposite direction. Figure 24 shows an air inlet that feeds fresh air into the chimney of a cottage. In the text, this flue is described as a construction that punctures a brick wall, equipped with a metal grille on the outside and ending in a wooden box on the inside.[55] However, in picturing this arrangement, the illustration deploys the same graphic means as previously used for physical instruments, and thereby presents the air inlet as a laboratory vessel running beneath the wall. Physical instruments and built structures are also visually put in a logical relation here. At very different levels, Whitehurst's book thus creates an argumentative chain that runs seamlessly between the fields of hydraulics, pneumatics, and architecture.

Set against this background, the relationship that Franklin established in 1785 between the fireplace room and the glass flask of an air pump appears anything but arbitrary. Instead, it presents itself as a direct result of the natural and experimental scientific perspective that architecture was subject to in the second half of the eighteenth century with the development of new heating techniques. Franklin refers to the problem of a room being hermetically sealed by comparing it with the instrument that substantially contributed to the understanding of the physical basis of this very problem. The air pump was one of the first scientific instruments that had allowed the creation of entirely artificial research environments in the seventeenth century,[56] and it was therefore only logical that it be chosen as a (negative) example in subjecting domestic space to a new degree of environmental control. Starting from the fireplace—which for centuries had been considered the most primal element in architecture by architectural theorists—a referential framework has emerged that relates architecture to the latest scientific and technological insights, while at the same time bringing the problem of air into central focus.

Similar to the inquiries into artificial ventilation, the findings of the stove doctors are expressed not least in a criticism of common building practices. Franklin believed that his contemporaries had fallen for false aesthetic principles and blamed architects as being those most responsible for this deficiency: “Architects in general have no other ideas of proportion in the opening of a chimney,” he wrote in his public letter to Jan Ingenhousz, “than what relate to symmetry and beauty, respecting the dimensions of the room; while its true proportion, respecting its function and utility, depends on quite other principles.”[57] For this reason, Franklin instead relied on the residents of a dwelling to realize these principles. His letter was written as guidance with which anyone could independently tackle the problem of a smoky fireplace—and it is hardly surprising that he recommends undertaking an experiment so as to do so. In order to establish the precise amount of fresh air needed for curing a smoky fireplace, his reader was advised to light a medium-sized fire and then vary the opening of the wings of the door to the room until the point was found at which smoke no longer escaped into the room. When multiplied by the door height, the thus determined gap between the door leaf and the doorframe gives the dimension of the required ventilation opening.[58] In this way, the ensemble of the fireplace, building structure, and architectural elements is indeed transformed into an experimental setup, and the inhabitants become experimenters within their own four walls.

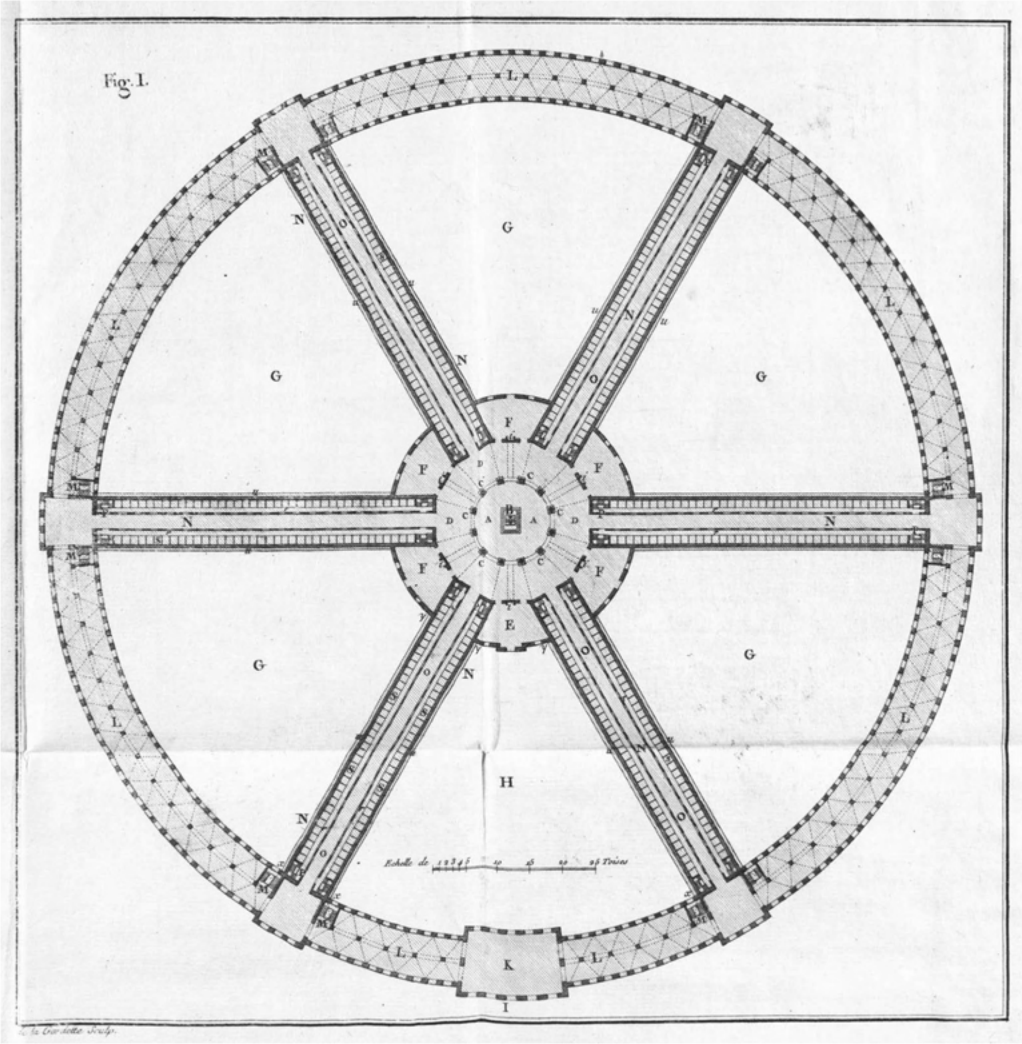
The issue of air, its architectural treatment, and the principles with which to prefix building practice all came to a head in the later eighteenth century in the case of a famous and equally infamous institution. On the night of December 29 to 30, 1772 large parts of the Paris Hôtel-Dieu burnt down, focusing broad public attention on the catastrophic conditions in the centuries-old and already heavily criticized hospital, and triggering a wave of treatises, projects, and designs that continued to appear for years. Borne by the ideal of Enlightenment, by the end of the following decade over two hundred suggestions had been made for or against the relocation, the splitting up, the remodeling, or the complete rebuilding of the complex on the Île de la Cité.[59] Only a small proportion of these proposals originated from trained architects; most of the contributions came from representatives from medicine, philosophy, and economics. The only basic common denominator amongst the numerous entries and initiatives was that the traditional hospital type—usually envisioned since the fifteenth century as a more or less extended rectangular courtyard building with a central chapel[60]—should be replaced by a model better equipped to meet the medical and administrative requirements of the times. The progression and the various positions in this discussion are as relevant for a history of climate control as they are for that of architectural machine concepts.

By this point, at least amongst physicians, adequate ventilation was considered a crucial hospital design principle. Following the fire and Louis XV's decision to dissolve the old Hôtel-Dieu in favor of the expansion of an existing and the building of a new hospital, the initial architectural projects formulated in response already included a design that addressed the issue of the freest possible circulation of air. On the very first page of his 1774 *Mémoire sur la meilleure manière de construire un hôpital de malades* (Memoir on the best manner of building a hospital for the sick), the distinguished physician and professor of anatomy Antoine Petit stressed the significance of water and air as fluids and his profession's qualifications in making allowance for them:

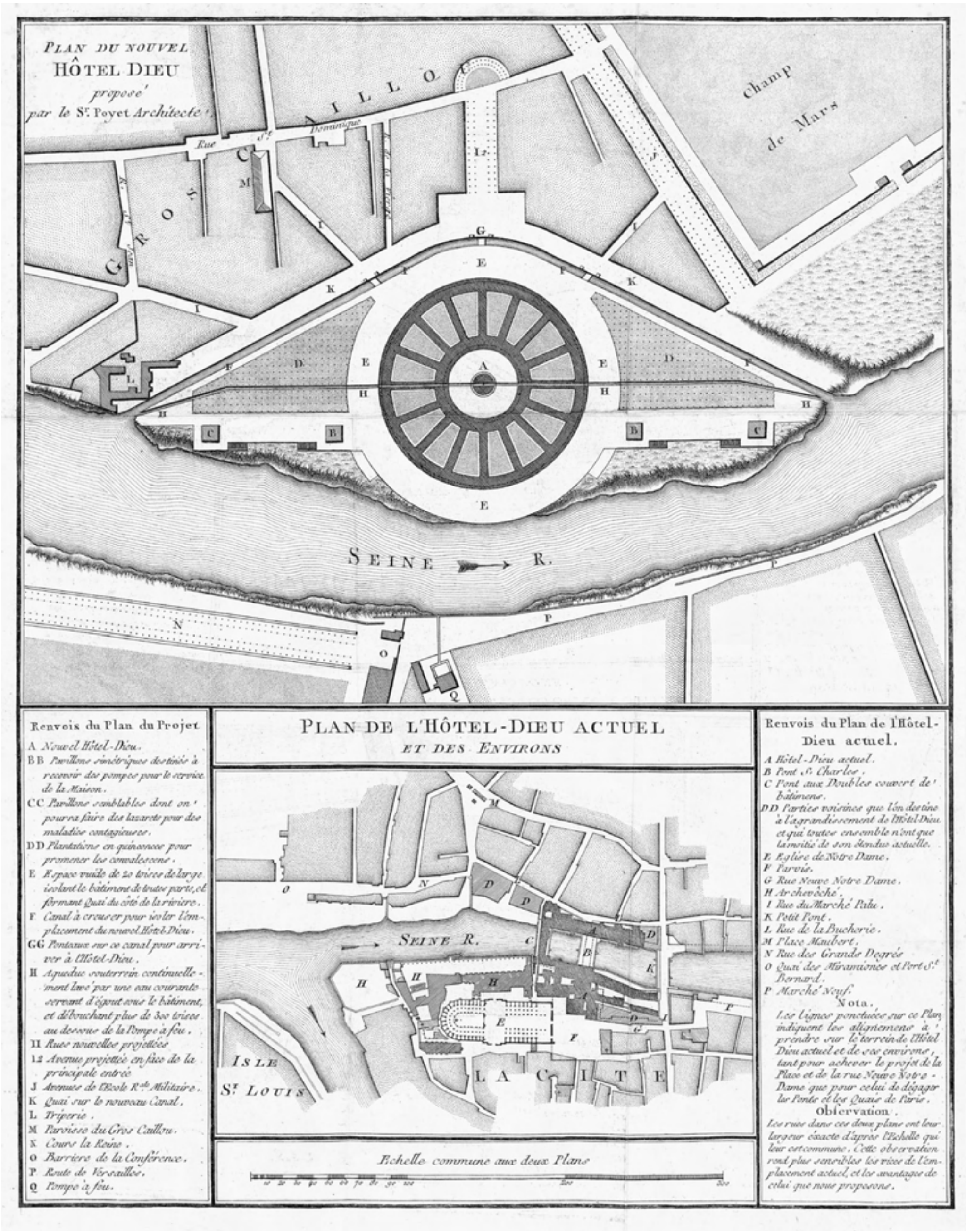
> [I]f it is about building a hospital for the sick, what location is to be chosen? What form of construction is to be preferred? The knowledge given by the study of architecture is not sufficient to make such a difficult choice; it is necessary to know what effect the external agents, such as air, water, exhalations, &c. can produce on the sick, & in what way they can serve or harm their healing. Magnificence & solidity are not enough for such a building, it essentially requires salubrity. This last object can not be treated well except by a Physician.[61]

In terms of where they were to be situated, Petit argued that the hospitals should be moved outside the city walls, and in terms of construction he raised two objections to the traditional rectangular form. Based on improved access, but above all because air could circulate better within them, Petit suggested that hospital buildings be arranged in the form of a monumental star. This is the origin of his well-known radial plan, in which the ray-like wings of the building serving as hospital wards are joined in the center by a chapel and at the periphery by a circular service passage. The core of the design is the chapel, with its domed roof serving a very profane function: its funnel-shaped form is designed to generate suction and set the air throughout the entire building in motion—"the dome placed in the center of the edifice ... will serve as a common ventilator, & will constantly renew the air in all the wards".[62] → Fig. 8

A few years later—the old Hôtel-Dieu was still running, the schemes to dissolve it had in the meantime been stopped,[63] and from Dijon Hugues Maret had introduced his suggestion for the construction of elliptical hospital wards—two architects, likewise from Dijon, went a step further and immersed their suggested hospital building completely in the fluid of the surrounding air. In a short paper, which appeared in 1785 and reignited the discussion



8
Monumental building with integrated ventilation: hospital design by Antoine Petit, 1774



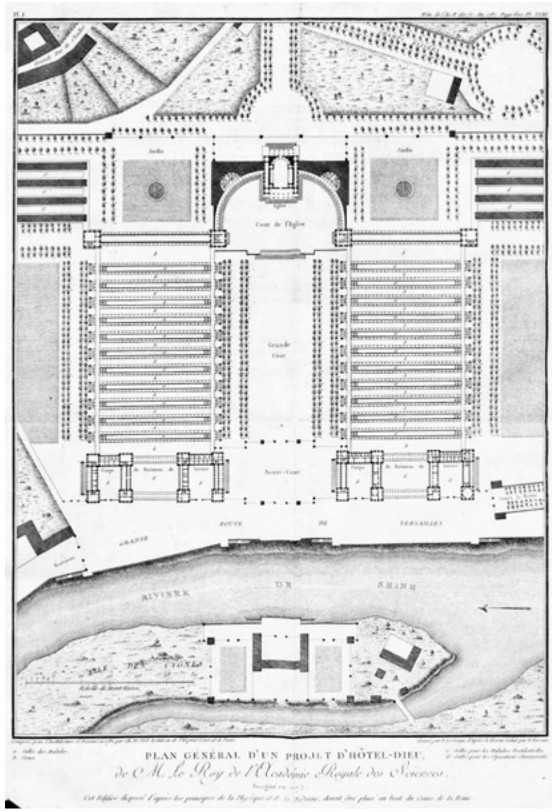
9
An island on an island: hospital design by Bernard Poyet and Philibert Coquéau, 1785

about the Hôtel-Dieu, the building official Bernard Poyet and his employee Claude Philibert Coquéau advocated a speedy relocation of the Hôtel-Dieu to an island on the Seine outside the city and simultaneously proposed a similar project for an enormous star-shaped new building. Due to the crowded location on the Île de la Cité, with its cobweb of narrow alleyways and fire-partition walls, and the labyrinthine arrangement of the wards of the existing complex, Poyet and Coquéau claimed that there was no air circulation whatsoever. Quite the opposite on the on the Île de Cygnes further down-river, where the situation for their design was completely different: "In this island, on the contrary, the mobile atmosphere in which the Hôtel-Dieu will be plunged, will envelop it on all sides, & its continuous movement penetrating by all the openings which will be offering themselves to its direction & which sir Poyet has multiplied as much as possible, will propagate in all the extent of the building."[64] Analogous to the effect of the waters of the Seine around the Île de Cygnes, the new building would be surrounded by the flows of a moving atmosphere. ← Fig. 9

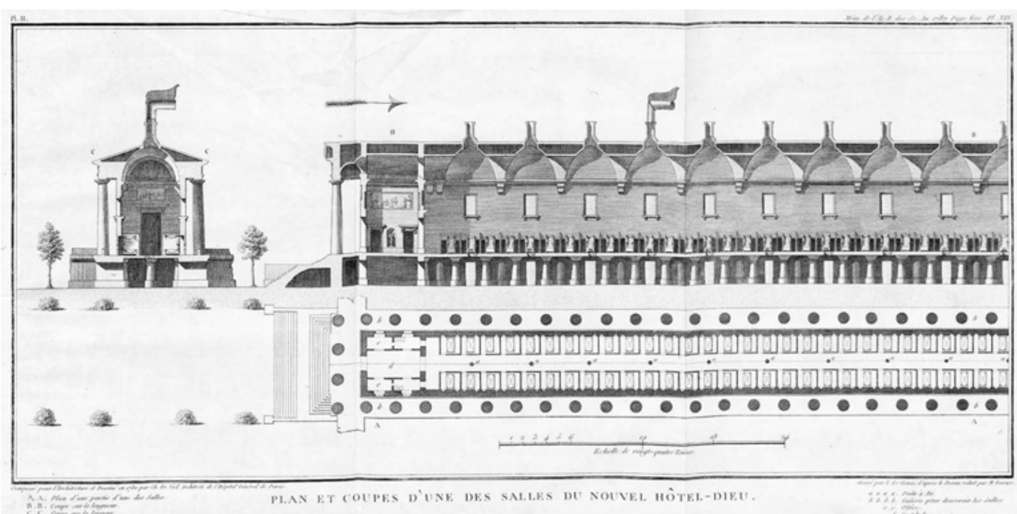
In projects such as these, air had quite obviously begun to represent an original object in architecture and aeration a fundamental spatial practice. Moreover, projects like these also form the context in which a series of dynamic descriptions of architecture as machine first appear. The initiator was the physicist Jean-Baptiste Le Roy, who from the outset had participated in the discussions about the Hôtel-Dieu. Le Roy, the brother of the architect and archaeologist Julien-David, was born in 1720, and since 1751 had been a member of the Académie des sciences. His main preoccupation was the study of electricity, but his work in numerous other scientific fields also examined questions of medicine and hospital building.[65] On December 2, 1786 he presented his own contribution to the debate about the Hôtel-Dieu before the Académie des sciences that was also a summary of a planned book and a concrete hospital project. His key focus in it was the hospital ward, in that it was considered to play a crucial role in the healing process: "Indeed, a hospital ward is, if that may be said, a veritable machine for treating the sick, & it must be considered from this point of view."[66]

With this, the text of Le Roy's lecture is first of all enriched with a novel metaphor. In order to accentuate his project vis-à-vis the hitherto known hospital models, he had already resorted to a series of other images. The innovative aspect of his plans rests in his rejection of the concept of a monumental and cohesive hospital building—be it rectangular or star-shaped—in favor of a collection of isolated and autonomous buildings. "To form an idea of the hospital that I propose," he explained, "it is necessary to imagine the different wards as entirely isolated, & arranged like tents in a camp, or like the pavilions of the gardens of Marli .... By this disposition, each ward is like a sort of island in the air, & surrounded by a considerable volume of this fluid, which the winds can easily carry away & renew by the free access they will have all around."[67] The corresponding presentation drawing shows a double-rowed ensemble of twenty-two parallel-situated, horizontal, elongated buildings. → Fig. 10 Alongside this general layout—which had a few predecessors and which would long serve as a model in hospital planning—the design of the interior of the individual buildings likewise adheres to the primacy of air in that "the inner form can be determined by the properties of the air only."[68] Each of the pavilions was equipped with a ventilation system, consisting of openings in the floor—described by Le Roy as "air wells"—and a series of minor vaults in the ceiling. These vaults merge into chimney pipes that are crowned by wind caps and allow the used air rising from below to escape.[69] → Fig. 11 The detailed description of this arrangement is followed by Le Roy's statement that the aim is to treat the hospital ward as a veritable "machine for treating the sick."

Two years following Le Roy's presentation, the Paris surgeon and anatomist Jacques Tenon attracted attention with his findings about hospitals, in the context of which he similarly deployed a machine terminology. In 1785, Tenon, like Le Roy a member of the Académie des sciences since the 1750s, became part of a hospital commission composed of academy members that included Charles Augustin Coulomb, Pierre-Simon Laplace, and Antoine Lavoisier, and thus some of the leading scientists of the era. Summoned by the French government, the commission's remit was to undertake a general investigation into the hospital problem and to develop a new



10
The hospital as a tent camp: site plan by Jean-Baptiste Le Roy, 1786



11
"[U]ne veritable machine à traiter des malades": hospital ward by Jean-Baptiste Le Roy, 1786

solution for the city of Paris. Between 1786 and 1788, it published three influential reports that essentially recommended replacing the Hôtel-Dieu with four smaller buildings, planned according to the latest medical and scientific insights, on the edges of the city.[70] Nevertheless, Tenon, who could already look back on many years of research into hospitals and who disagreed with the other commission members on a number of points, prepared his own parallel paper, published in 1788 under the title *Mémoires sur les hôpitaux de Paris*. Besides findings from France and other neighboring countries, the treatise incorporated the results of a three-month official research mission to England that he had undertaken a year previously.[71] In even more precise terms than in the reports co-authored with his academy colleagues, the almost 500-page-long book—which had already been viewed as a standard reference work within the Académie des sciences prior to publication and spread Tenon's scientific fame far beyond France—developed a vision of the hospital as an institution in which the design, organization, and management were determined solely by medical goals and health requirements.[72]

Tenon's central question is how hospitals should be conceived and constructed in order to meet the demands of a large and largely impoverished urban population and to adequately respond to the varieties of maladies they suffered from. In his solutions he goes far beyond the core issue of ventilation, which was likewise crucial to him, and focuses the entire hospital building comprehensively on the organism of the sick.[73] Drawing on a broad collection of empirical data, Tenon demonstrates that architectural factors had an impact on mortality rates and healing processes, and that therefore their design had to be directly derived from the human body and the logic of therapeutic interventions. The resulting aspects range from the spatial distribution (arrangement and dimensions of the wards) and individual architectural elements (the height of the stairway steps) to the furniture (bed size and occupancy). In this way, Tenon, for example, deduced the length of the hospital beds from the average patient body height, the width of the nursing space between the beds from the treatment processes, and from these two values the required size of the hospital ward. Similarly, he demonstrated that the type of illness determined the respiratory rate of the patients and therewith their requirements for fresh air, which in turn gave the recommended cubic volume of the wards.[74]

In order to clarify the correlation between architecture and the healing arts established in his investigations, Tenon repeatedly uses the term "instrument." While John Pringle had recognized the hospital building as a factor that promoted disease, Tenon took the obverse position and attributed it with a decisive role in the healing process it was meant to facilitate: "A hospital," he writes in his *Mémoires*, "is to some extent an instrument that facilitates the curing."[75] Following from this, buildings for the mentally ill are especially suited—by virtue of their capacity to form surroundings in which the lunatic can move untroubled and freely—to providing successful treatment and to act as a healing force.[76] This argument regarding the hospital's potentially curative effect appears repeatedly in Tenon's writings, whereby he permitted himself an altogether more candid choice of terminology in his private correspondence. In a letter sent to the medical faculty in Edinburgh on August 27, 1788 accompanying a copy of his *Mémoires*, he describes hospitals not merely as "tools" but more stridently as "manufactories" for the en-mass and economical treatment of the ill.[77] In a further letter, dated September 11 the same year and addressed to the Academy of Sciences in St. Petersburg, Tenon described the hospital ultimately as a "machine."[78]

Thus, at two junctures within a comparatively short period of time, the French hospital debate saw an architectural linkage to the term "machine". These statements, in particular Tenon's, have in the meantime been widely examined and interpreted. The foundations for these inquiries were set by a research group around Michel Foucault in the 1970s with the publication of *Les Machines à guérir*, a set of collected essays on French health policy and hospital architecture in around 1800. The publication elevated Tenon and Le Roy's machine terminology to its title and thus advanced the "curing machine" as a recurring term in the historiography of eighteenth- and nineteenth-century architecture. In the process, the tendency has been to see in the image of the machine a juxtaposition between common architectural understanding and the precise functionality of a mechanism. Anthony Vidler, for example, wrote in 1987 that the expression "machine" signified the repudiation of architectural legacy in favor of an uninhibited empiricism and rational design; in 1992, Robin Middleton expressed the view that the mechanical connotations of the term evidently served to declare traditional concerns in architecture irrelevant.[79] The general tenor of these interpretations was set, to a certain extent, by François Béguin, who in his contribution to *Les Machines à guérir* provided a concise analysis of Tenon's and Le Roy's machine concept.

By introducing his text with the corresponding entry in Diderot and d'Alembert's *Encyclopédie*, Béguin too commences from a classic notion of the machine. The entry, written by d'Alembert for the ninth volume of the reference work and published in 1765, opens with the words: "Machine: In a general sense, means that which is used to augment and regulate the moving forces."[80] Adopting this definition, Béguin primarily assumes the purpose-focused ideas of an augmentation of therapeutic efficiency through new medical procedures and of a regulation of bodily functions via the physical environment behind the concept of the hospital machine.[81] Beyond the article in the *Encyclopédie*, this interpretation could have also drawn its evidence from the immediate historical and biographical context in which Tenon's remarks, and in particular Le Roy's, occurred. Apart from the general interest in the machine in the late eighteenth century, any educated French person was probably familiar with at least two real machines in the 1780s: James Watt's stream engine and the Montgolfier brothers' hot-air balloon, which were demonstrated before Paris crowds in 1783 as the "*machine à feu*," respectively the "*machine aérostatique*." Jean-Baptiste Le Roy was not only a participant in reporting on both inventions,[82] his father and a brother also came from the guild of watchmakers, giving him a family background in one of the key mechanical arts of the eighteenth century, and as a contributor to the *Encyclopédie* he was moreover responsible for over one hundred entries on mechanical engineering and horology.[83] Rich evidence, in other words, to support the conclusion that with the term "machine" he set out to establish a direct connection between the world of functional instruments, mechanisms, and apparatuses and that of architecture.

However, a closer examination of the sources reveals another possible interpretation, or at least that an important detour is required in order to arrive at the hitherto conventional interpretation. Crucially, in the central and oft-cited passage in his letter to the academy in St. Petersburg, Tenon refers not to "*machines à guérir*," rather he uses the term "*machines de physique*." The sentence in question reads:

> The ordinary man sees in hospitals nothing but a resource against indigence, infirmities, and ills; the statesman applies them to the conservation of the soldier, the sailor, the craftsman, the daytaler; the learned societies discover therein one of the most composed machines of physics which it is lastly essential to develop and to direct to the greatest advantage of the suffering man in particular, as well as of society in general.[84]

With the physical machine, Tenon, who is here generalizing his own understanding of the hospital as opposed to that of the European scholarly societies, does not simply mean a physical or material machine as distinct from a hypothetical or imaginary one. In the eighteenth century, the expression "*machine de physique*" is far more a common description for a piece of physical laboratory equipment, in other words a device with the help of which the science of physics can be practiced or demonstrated. The prefix "composed" in Tenon's formulation stands for a device possessing a higher complexity through its composition as two or more machines joined together.[85] In his letter, Tenon is therefore referring to an object that he can confidently assume his Russian colleagues are acquainted with from their own everyday scientific endeavors, or at least from their studies, and his machine terminology has less to do with a mechanical augmentation and regulation of forces and more with natural-philosophical research.

This interpretation is also confirmed by the passage in Le Roy's lecture containing his idea of the machine, to the extent that it apparently relates more to the conceptualization of the hospital and only in a lesser sense to its function. Following Le Roy's illustration of his hospital's elaborate ventilation system, he recommends that its operational functionality be tested by experiment. In order to show how rapidly the air is actually extracted, he proposes using a small-scale replica of the ward filled with smoke. This test setup could, according to Le Roy, serve as a "model" for those who wanted to build his proposed hospital in as much as that he had designed the arrangement of the wards based on numerous observations and the current knowledge of air, but nonetheless was by no means confident that it could not be improved even more. These explanations are then followed by the description of the hospital ward as a machine. But with this, Le Roy's actual argument has not been made, rather it remains to follow as a corollary: "Yet," runs the very next and final sentence in the passage, "every machine is only brought to perfection after a great number of attempts & experiments; &, I repeat, one will never perfect the disposition & construction of hospital wards unless one envisages them in this way."[86] Following from this, the crucial characteristic of the machine—and with it equally the architectural "curing machine"—is that it can only achieve perfection via a lengthy series of trials and errors.

With this, both men, Tenon like Le Roy, situate their hospital projects less in a directly productive context than in an experimental one, presenting them as part of a test arrangement with a specific goal but with an open outcome. This is all the more surprising given that, only shortly prior to this, the machine term was still applied negatively in the hospital debate. A report by the hospital commission, of which Tenon was a member, expressed its criticism of the arrangement and size of the design by Bernard Poyet using the image of an inscrutable machine: "Eh! what complication as that which is born from the movements of this grand machine! … If this vast & complicated machine were absolutely necessary, it would be one more misfortune to be counted in the human miseries, … but this necessity is a question."[87] Contrary to this lament in which the old connotations of the machine as an imposing and massive edifice still resonate, Le Roy and Tenon deploy their scientific machine terminology in an affirmative sense. Whether Tenon's statements were inspired by Le Roy is uncertain, but what is known is that the former was present at the latter's lecture before the Académie des sciences.[88] What can be more certainly assumed is that Le Roy was familiar with the air-pump comparison that Benjamin Franklin had used over a year earlier to describe the configuration of fireplace and fireplace room.[89] But whereas Franklin clearly referred to the concrete effect of a specific piece of laboratory equipment, Le Roy and Tenon tend far more abstractly to the fundamental epistemic character of technical constructions. Their machine terminology firmly sites the hospital building in the context of an experimental philosophy that—rooted in the speculative question "What if …?"—strives towards the discovery and optimization of new phenomena and mechanisms.[90]

It is therefore too truncated to treat Tenon and Le Roy's statements as signifying a caesura in which architecture becomes loaded with functions and collated with objectives. What the emergence of their machine concepts instead marks is, initially, a new level in the material and symbolic linkage between built space and the technical and scientific culture of the waning eighteenth century.[91] In this context, architecture is invested with the capacity to assume the role of both an epistemic object and a technical object. As an epistemic object it represents an entity on which the efforts of empirical knowledge are focused—as in Le Roy's case, the layout of the hospital ward. As a technical object, on the other hand, it itself acts as an environment that encompasses the epistemic object, making it operable and creating the prerequisites for its emergence—as in the process of healing in Tenon's case.[92] These roles overlap in the French hospital debate in the question of air, which was generally acknowledged as a healing factor to be experimentally domesticated using constructional means. In short, for Le Roy and Tenon, architecture acted as a machine in that it advanced to become an object and an instrument of a new therapeutic understanding. In this point, the interpretation given here also corresponds, circularly, with François Béguin's analysis. Ultimately, Béguin assumes that the appearance of the concept of the "curing machine" relates to the emergence of a new interventional trajectory at the crossover between medicine and discipline, the body and the bodily environment, room and therapy, along which medical principles that hitherto had been entrusted to other instruments are transfused onto architecture. In this process, the hospital building takes on the function of producing "'climatic' effects," which consist of the capturing, circulating, and emitting of air, thus lending the architectural form an "operative potential."[93] There are indeed many indications that Le Roy and Tenon's machine terminologies point, in this sense, to an operative quality of the built, but at the same time also articulate the fact that this operability is not simply a given, rather it only becomes tangible via the empirical route of research.

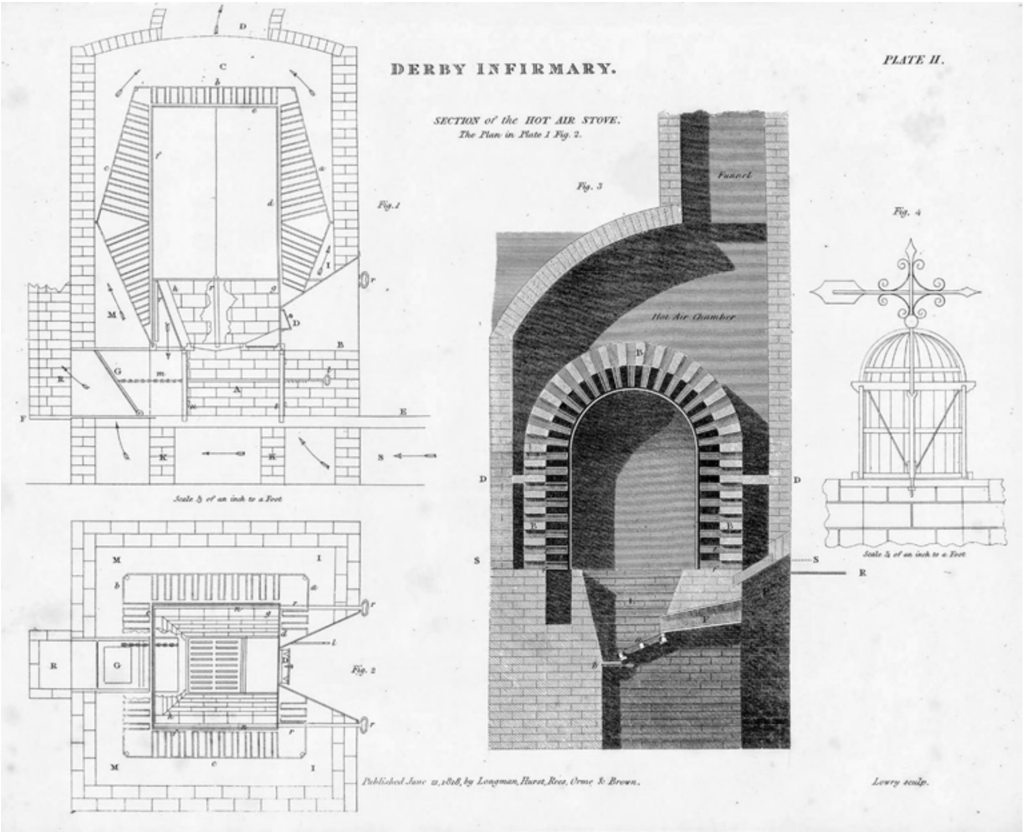
In regard to the by then long-running debate surrounding the Paris Hôtel-Dieu, despite their genuine radicalism, Le Roy and Tenon's contributions similarly failed to serve as a turning point. Even prior to the summer of 1789, when the turmoil of the revolution caused a temporary end to all government projects, the dismissal of the hospital commission and the corresponding cessation of the project for the four new hospitals meant that the continued use of the building complex on the Île de la Cité became fixed official policy.[94] Nevertheless, by consistently conceiving the built space in terms of the substance of air, the process of convalescence, and the goal of healing, the French hospital reformers first made architecture describable, in an operative sense, as a (laboratory) machine.

Domestic Economy

One of the first attempts to systematically combine the ventilation and heating endeavors that emerged in the eighteenth century was undertaken by the cotton manufacturer and inventor William Strutt.[95] Strutt was born in 1756 as the oldest son of Jedediah Strutt, who together with Richard Arkwright and Samuel Need counts amongst the pioneers of the factory system in England. In 1771, the three industrialists set up a water-powered cotton mill in the county of Derbyshire in the East Midlands, and, with the help of skilled workers and Arkwright's water frame, started mass-producing hosiery and knitwear. After the partnership was dissolved, Jedediah Strutt began independently running a series of factories in the Derbyshire area based on his own technical innovations, and that advanced in the early nineteenth century under the management of his sons William, George, and Joseph to become one of the largest textile manufacturers in Great Britain.[96] William Strutt, who throughout his life was involved in designing bridges, public buildings, and housing, was above all responsible for the mechanical issues of the company W. G. & J. Strutt Ltd., which also included the planning of the manufacturing buildings. Without ever having benefited from an architectural or engineering education, in this capacity he took part in the development of a number of key technical mainstays of modern architecture.[97]

In 1792, Strutt designed a factory building for the family firm that would go down in the history of construction engineering as the Derby Cotton Mill. The six-story cotton mill is regarded not only as the first structure with an integrated frame construction but simultaneously as the first fire-resistant multi-story building.[98] In early factory buildings, the spans required to provide production space were generated using timber posts and beams, which in combination with their use (oiling and heat-generating machines, candle lighting, dust accumulation, etc.) represented an enormous fire hazard and thus an economic risk. Around 1790, the number of fire disasters—including in and around Derby—became more frequent, and in March 1791, the destruction of the well-known London Alboin Mills by fire attracted widespread public attention. Because of this, with the planning of a new manufacturing site for his own company, Strutt focused his efforts on developing a load-bearing structure that could minimize the dangers and damages of fire. He conceived a system using cast-iron supports, plastered wooden beams, tiled arches, and wrought-iron tie bars that was quickly copied by other British factory owners, and from which a historical construction lineage can be drawn, ending in the steel skeleton-frame buildings of Chicago.[99]

But the Derby Cotton Mill was ahead of the times in a further respect. For various reasons, including that of fire safety, Strutt equipped it with a technical installation that would have a similar impact on architecture as the skeleton construction: the novel structure in the mill was coupled with a new type of heating and ventilation system, the straightforward yet at the same time fundamental quality of which lay in heating the stories together, not singly, but from one central point. As in other developments, air played a vital role in this innovation. While the stove doctors such as Benjamin Franklin endeavored to harness the convective potential of air to improve the thermal output of a heat source to the immediately surrounding room, Strutt exploited the same phenomenon to distribute warmth beyond the heat source.[100] In order to achieve this, he developed a specific heating apparatus: "[T]he great object," he wrote in a letter about his invention, "is to bring the greatest possible quantity of air in contact with the stove, and that contact to be contained and renewed the longest, and this often also as possible."[101] To do so, Strutt enclosed a normal stove in a honeycomb-like perforated brick mantle—creating a type of stove-building—and connected this structure, independently of the flue, with an incoming and outgoing "air tube."[102] → Fig. 12 The result was a construction that emitted practically no heat radiation yet provided a constant flow of warm air. It is important not only as



12
Nothing but hot air: the warm-air stove developed in 1792–1793 by William Strutt, 1819

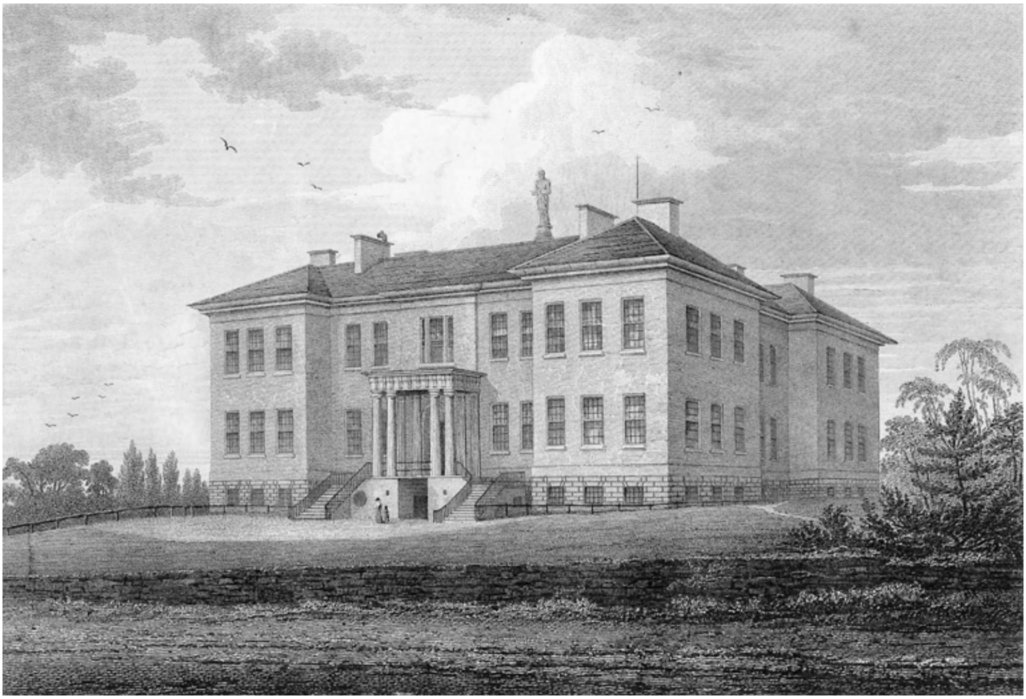
a component in an early central heating system but equally because its architectural application is comparatively well documented.

Strutt himself never published on his inventions, but one of the implementations of his system was comprehensively described in a treatise of 1819 by his friend Charles Sylvester. Sylvester, an inventor, author, and teacher who was above all preoccupied with chemistry and electricity, had moved to Derby in 1807 in order to work for Strutt in various capacities.[103] Over ten years later, he published the results of their cooperation under the peculiar title *The Philosophy of Domestic Economy*. The key term in the title—"domestic economy"—had emerged in the later eighteenth century as an umbrella term for the increasing findings and specifications regarding household management. One of the first books that used it was the *Ladies Library, or, Encyclopedia of Female Knowledge in Every Branch of Domestic Economy*, which had appeared in 1790. Shortly afterwards Maximilian Hazlemore's *Domestic Economy; or, a Complete System of English Housekeeping* marked the beginning of a class of publication that continuously grew in number and size. As well as having a standard main section on recipes, it also included advice on medicine cabinets, bodily hygiene, or gardening.[104] This development shows, first of all, how far the science of economy, by expanding into political economy, had departed from the ancient notion of *oikonomía*,[105] since it is only the detachment from the original meaning as housekeeping that made the pleonastic term domestic economy possible. Simultaneously, this signified a re-import of economic teachings into the context of private households. Sylvester defined domestic economy generally as "[t]hat branch of natural philosophy which has for its object the improvement of domestic life, as far as relates to our food, clothing, and local habitation."[106] Nevertheless, in his book, the science that gives it its title is largely restricted to the technology of central heating and ventilation.

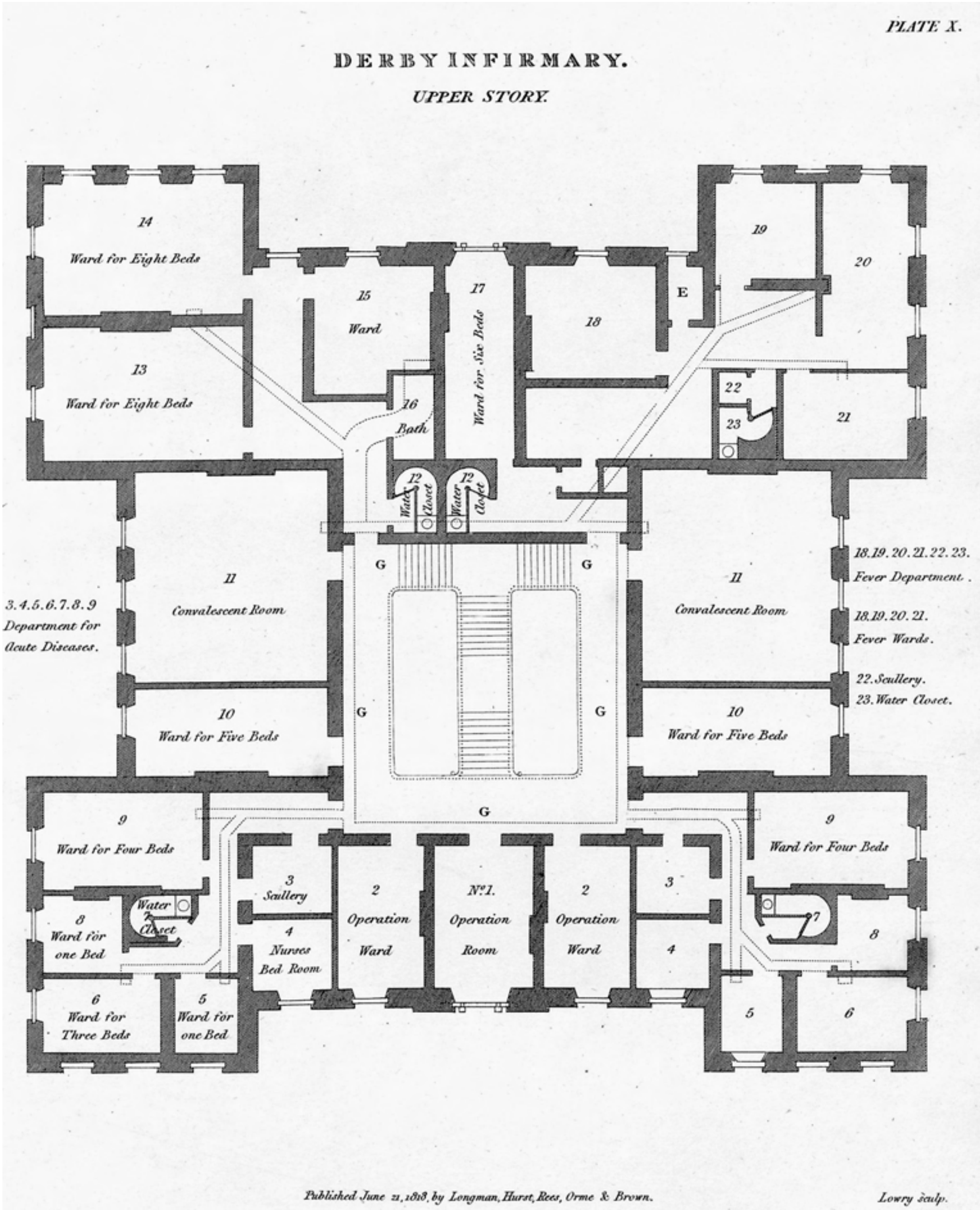
Sylvester demonstrates the function and principles of this technology using the concrete example of a hospital planned and sponsored by William Strutt. The Derbyshire Infirmary, a three-story building to accommodate around one hundred patients, was built between 1804 and 1810 outside Derby as a charitable institution. → Fig. 13 A relatively conventional architectural design—rectangular with a central hall around which the ground and upper floor are arranged—the building nonetheless incorporated the latest medical and technical findings, including a heating and ventilation system conceived by Strutt and Sylvester.[107] This system starts with an air inlet located 70 yards away from the hospital, connected to it via an underground shaft. The shaft enters the building's cellar, from where it runs vertically to the first floor where it merges with a cavity, from which a series of flues set in the ceiling lead to the individual hospital rooms. Sylvester marks the progression of these conduits with dotted lines in the floor plan. → Fig. 14 Further flues run, in turn, from the hospital rooms to the roof, ending in an air outlet situated above the roof ridge. By means of two cowls mounted on the inlet and the outlet, the system is intended to generally ensure a continuous air exchange within the building. In the cellar, set at an experimentally established optimal distance to the first floor, the system is additionally attached to a stove designed by Strutt. Once activated, fresh air is sucked into the building via the underground conduit, fed from the foot of the furnace into and around it, and finally collected in a "hot air chamber." "Here it has attained its full degree of heat," explains Sylvester, "and is now transmitted through different flues to the apartments to be warmed."[108]

The technical facilities of the Derbyshire Infirmary promised nothing less than a combination of the era's two core atmospheric endeavors into a single system: a constant, smoke-free, and above all fireproof distribution of heat, and the controlled exchange of the equally vital and protean element of air. In Sylvester's words:

> It will be admitted by all in the least acquainted with the human economy, that when we require artificial heat, it should be applied in the most equable manner, and not in the way we receive it from a common fire. There is no means of doing this effectually but by our being surrounded by a medium of uniform temperature; and what can be so proper as the air we breath? We ought to have the benefit of its temperature and its oxygen at the same time, and then it should be changed to give place to fresh air supplying additional heat and oxygen.[109]



13
The Derbyshire Infirmary, built 1804–1810, on the frontispiece of the *Philosophy of Domestic Economy*, 1819



14
The upper story of the Derbyshire Infirmary with treatment rooms, patient's rooms, and ventilation flues, 1819

Why not provide both simultaneously—oxygen and heat? The thermal knowledge accumulated throughout the course of the eighteenth century culminates here in a domestic-technological transmission concept: "In this method of warming rooms the air is made the medium of vehicle for supplying caloric."[110]

This innovative technology unquestionably had a number of predecessors. For the antique hypocaust, for example, in which the fumes from a fire flow through floor or wall cavities, it is assumed that the warm air was also directly channeled into the living spaces. It is proven that some castles of the High and Late Middle Ages possessed rudimentary forms of central heating whereby stove-heated air was channeled into adjacent rooms. And a century before the building of the Derbyshire Infirmary, the English garden architect John Evelyn had already suggested that hothouses could be operated using the same principle. Leaving these predecessors, some of them apocryphal, aside, the fact nevertheless remains that it was only in around 1800, with protagonists like Strutt and Sylvester, that a concerted attempt was made to develop central warm-air heating based on scientific findings.[111]

In order to comprehend how a provincial cotton manufacturer could arrive at such a pioneering technology, it is important to consider what was a close correspondence between natural-philosophical inquiry and applied mechanics in Georgian England. Besides the London Royal Society, regional scholarly societies played a key role in this equation, serving as local platforms for the exchange of scientific ideas and at the same time connecting even small cities with the cultural centers of Europe.[112] In 1783, the physician and naturalist Erasmus Darwin, a member of the Birmingham Lunar Society, initiated the founding of one of these associations in Derby in the form of the Derby Philosophical Society. The society was responsible for creating an extensive scientific library, organizing public lectures and courses, and providing local writers, scientists, and industrialists with a forum to discuss the latest findings in fields such as chemistry, electricity, or geology.[113] Strutt was not only a founding member of the Derby Philosophical Society, he was also its most active patron, and following Darwin's death he acted as its president from 1802 to 1815. Therefore, in numerous respects Strutt is a prime example of this crossover in the closely interwoven web between scientific and industrial research that found expression in such philosophical societies. From an early age he was involved in scientific experimentation, was well acquainted with the writings of Isaac Newton, Leonhard Euler and Joseph Priestley, and simultaneously engaged in a dialogue with both contemporary factory owners and natural scientists.[114] Moreover, like many of his colleagues, he ignored the boundaries between the laboratory and the factory, between the workshop and the parlor.

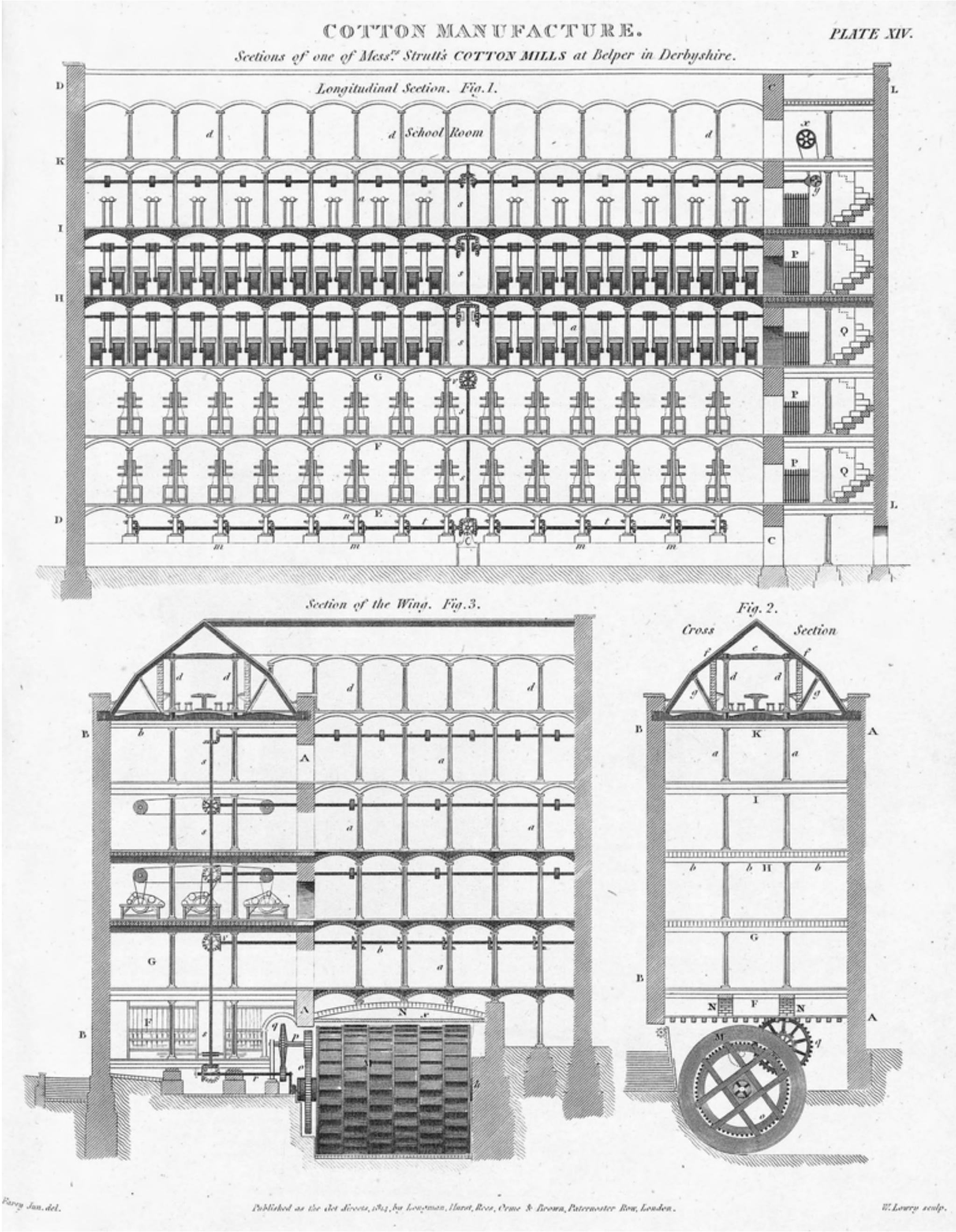
Set against this background of combined commercial and scholarly interests, many protagonists in the Industrial Revolution transformed various settings into "experimental spaces," in other words, into places for the production, testing, and demonstration of scientific knowledge.[115] In this respect, Strutt even went a step further in that he not only based his inventive activities on scientific research and occasionally conducted the connected experiments in his domestic environment, but moreover developed a predilection for applying his findings in private and public spaces far removed from commercial production sites. In this sense, Strutt's heating and ventilation method, like many of his inventions, represents an early leap from industrial architecture to other contexts, in that it was used not only in the family-owned spinning mills and the Derbyshire Infirmary but also in his own residence, St Helens House.[116]

In this context, numerous influences can be identified that potentially assisted Strutt in arriving at the development of his warm-air system. First and foremost, the library of the Derby Philosophical Society provided him with the publications of all the leading scholarly societies of Great Britain and France, including the academies of Paris and Dijon. Fluent in French, Hugues Maret's proposal for an elliptically shaped hospital ward was thus as accessible for him as the lecture in which Jean-Baptiste Le Roy described the hospital as a treatment machine.[117] Moreover, Strutt's direct personal contacts also included key activists in heating and ventilation technology, such as the watchmaker and instrument maker John Whitehurst, who lived in Derby until 1775 and in the 1780s wrote his influential book concerning the ventilation and construction of stoves.[118]

Factory-owning acquaintances of Strutt's began, almost at the same time, to develop central steam-heating systems, which may have served as an inspiration to attempt the same using air. It is also possible that the in-house distribution of tap water, which already enjoyed a certain popularity and of which Whitehurst was also one of the British pioneers,[119] was a model for Strutt. Last but not least, the fact that the first application of Strutt's system took place in a factory gives cause for thought.

Factory buildings such as the Derby Cotton Mill had emerged in the mid-eighteenth century with the growth in production volume and complexity. The core impulse behind this architectural type was the provision of sufficient space for the manufacturing machinery and an efficient spatial relation between the machines and the source of energy to run them. The so-called "prime mover"—a water wheel, steam engine, or other form of propulsion—had to connect with the machines via shafts and gears, providing as efficient a power transmission as possible. In its characteristic multi-story oblong form, the factory was virtually planned around the mechanical ensemble of the production machinery.[120] When the inventor John Heathcoat patented a new system for connecting machines over multiple floors in 1824, he therefore described the factory building simply as a "shell."[121] This aspect is particularly evident in the presentation of a complex that was almost identical to the Derby Cotton Mill, namely the Belper North Mill, built by Strutt between 1803 and 1804.[122] The cross and longitudinal sections of the building clearly show how, starting from a water wheel, the six-story cotton mill is pierced both horizontally and vertically by mechanical wheelwork. → Fig. 15

The arrangement of the production machinery has a remarkable similarity to Strutt's heating and ventilation method: in both cases energetic variables are distributed through the building starting from a central point. While the manufacturing ensemble involves a distribution of moving force from a single engine, the domestic ensemble involves the spread of heated air from a single stove. The fact that Strutt was confronted by similar questions when conceiving his warm-air heating system as in the construction of factory buildings is evident in the fundamental



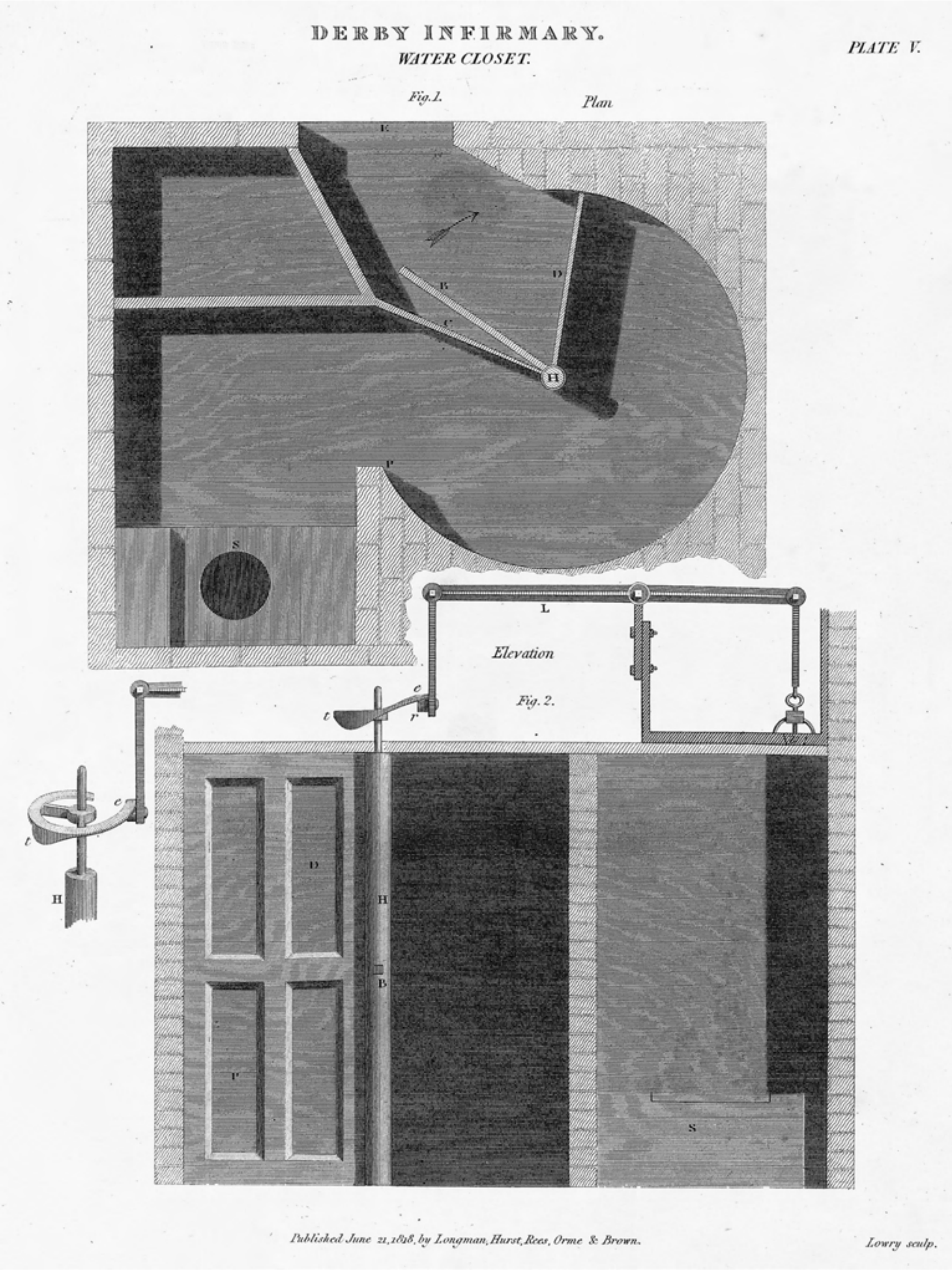
15
The Belper North Mill in an illustration by the machine manufacturer John Farey Jr., 1812

role played by the situating of the oven in relation to the rooms to be heated and the design of the connecting elements that led to them.[123] As an explicit transmission system, his system is therefore arguably based not only on the idea of air as a "transportation medium" but equally that of the penetration of built space with a mechanical ensemble for the distribution of kinetic quantities. In this way the developmental palette of central building-service systems expanded beyond the experimental architectural understandings of the stove and hospital reformers to include the production-technical knowledge of manufacturers. And the term "domestic economy" acquired a further, unintended meaning: as well as encompassing the teachings of rational housekeeping it may also stand for the transfer of economic organizational principles to the field of the home.

As it is, the integration of both production and building-service systems had a profound impact on the conception of buildings. The warm-air system may be far smaller and largely concealed within the structure, but its operative logic encompasses the architectural object in at least as fundamental a manner as that of the factory's production machinery. In the Derbyshire Infirmary, this circumstance is particularly evident in the form of a non-descript safety precaution. In order to stop the centrally-heated upper rooms becoming over-heated, the warm-air system is equipped with a type of emergency valve, situated not, however, at the technical level of the stove but instead at the architectural level of the building. A vertical shaft connects one of the horizontal air flues on the first floor with a small sliding door that can be opened onto the central hall on the ground floor of the hospital. By this means, excess warm air can be channeled downwards and distributed to the ground-floor rooms.[124] Similar to the way in which Strutt transforms the stove into a type of building by enclosing it in a brick shell, he transforms the actual building into a type of stove in which warm airflows circulate through the interior rooms in the same planned manner as the patients and orderlies.

Set against this background, it hardly comes as a surprise that Sylvester's book also contains an early reference to an architectural element designed, like no other, to combine the control of artificial atmospheres with those of people, namely the mechanism later known as the revolving door. All of the entrances to the toilets in the Derbyshire Infirmary are equipped with centrally hinged double-winged doors placed in a cylindrical cavity, and as such principally resembling the installation that the American Theophilus van Kannel would patent in 1888 under the description "storm-door structure".[125] → Fig. 16 The use of these doors activated a whole series of processes: "They are so contrived that the person who enters them, by the action of the door, and without any attention on his part, expels all the foul air; which is, at the same time, replaced by the warm fresh air of the house: and, in returning, leaves this fresh air in its place; whilst by the same action of the door, the basin is washed in the usual manner."[126] This represents the description of a threshold technique, which by being simultaneously open and closed not only guarantees the differential passage of air and people but in addition serves as a ventilator and delegates the act of flushing from the forgetful patients to a reliable mechanism. The basis for the development of this elaborated door device is obviously a conception of architecture as a regulator of generally understood transmission processes. Sylvester describes the underlying principle of the construction with the words "[d]uring the returning motion one of the panels of the door is made a valve."[127] The doors in the Derbyshire Infirmary thus become hydraulic devices—they represent elements of an architectural system that has begun to process atmospheric conditions and the movement of residents alike.

Strutt's heating and ventilation system found a variety of applications in the first decades of the nineteenth century. Various people in Strutt's circle—above all Sylvester, who started a company for the sale of the said systems—installed them in numerous private and public buildings, as well as on board a number of ships, including the *Erebus* and the *Terror* with which John Franklin set out in 1845 on his fateful expedition to find the Northwest Passage.[128] However, Strutt's principles reached their definitive popularity above all thanks to the international publicity given to his residence and the Derbyshire Infirmary as a result of the appearance of Sylvester's *Philosophy of Domestic Economy*. The warm-air system, the toilets, and the numerous other innovations incorporated into both build-



16
A revolving door *avant la lettre*:
William Strutt's water closet, 1819

ings—the Derbyshire Infirmary also included a kitchen roaster, a boiler, a washing machine, a dryer, a steam table, and control clocks for the night watchmen—subsequently prompted a veritable wave of building-service tourism. Innumerable personalities from the spheres of politics, the sciences, and the arts traveled to Derby in the 1810s and 1820s in order to visit Strutt's buildings.[129]

One prominent continental visitor was Karl Friedrich Schinkel, who stopped in Derby during his months-long tour of England in 1826. On June 23, he wrote in his diary: "Visited the famous Infirmary with Mr Strutt, fine, pleasant building in every way .... The famous hot-air heating, water-closet with shutters, movement of air in and out of the rooms, the stale air is drawn off by a rotating ventilator on the roof."[130] Schinkel, whose plans as privy building director at the same time formed the basis for the redevelopment of the Prussian capital, even sketched a small explanatory drawing of the ingenious toilet doors.[131] In this way, news of Strutt's warm-air heating system spread as the core element of a domestic economy that encompassed not merely the kitchen but the whole inhabited space, ranging from the use of architectural elements to the state and temperature of the respiratory air. A further illustrious visitor, the London author and publisher Sir Richard Phillips, accordingly described the Strutts' town house following his visit as a "school of experiment" in which science triumphed over nature and unified to common effect: "Thus steam, gas, heat, hot air, philosophy and mechanics are all brought to bear on these premises, on every branch of domestic economy."[132]

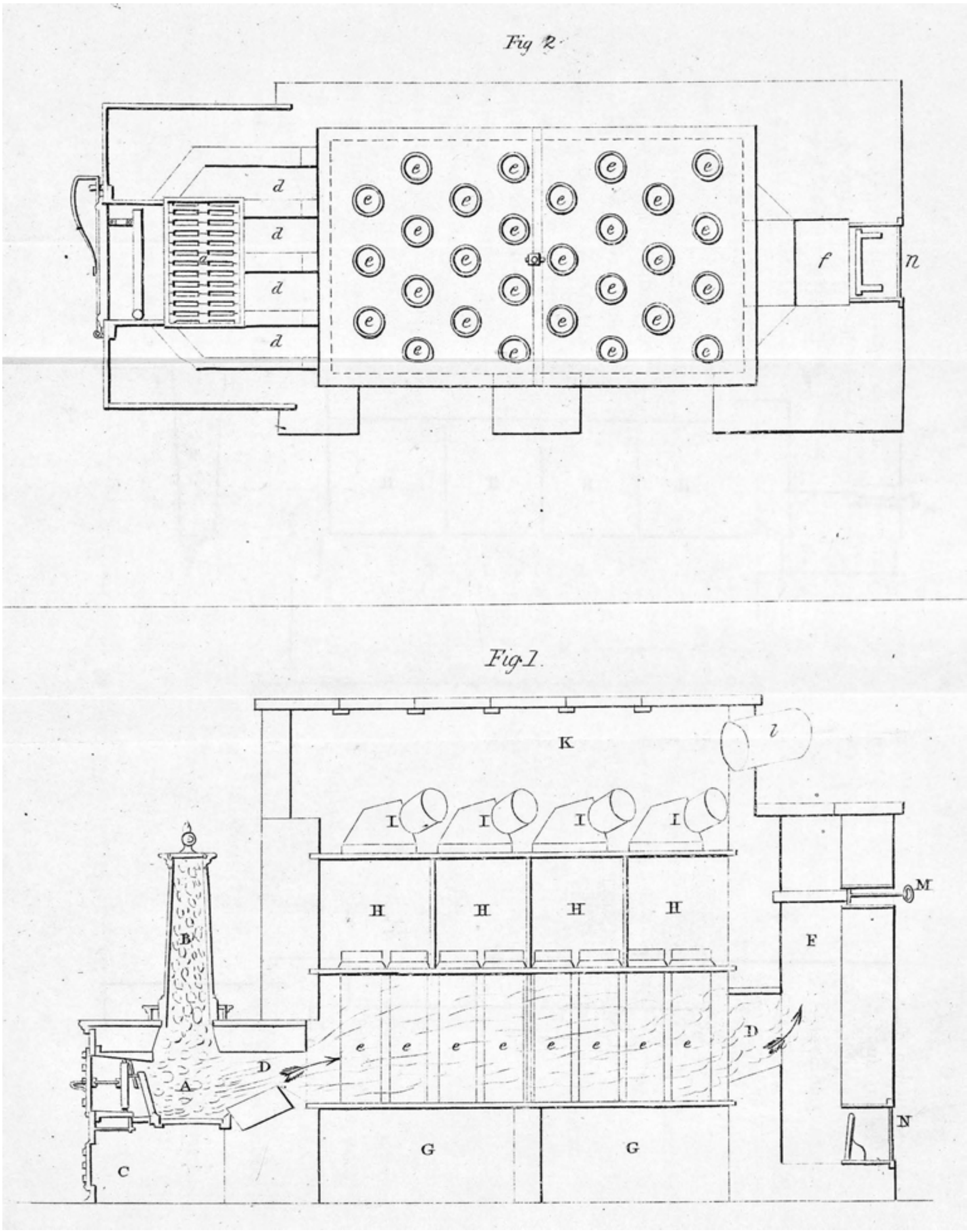
Water, Steam, and Air

By the time Charles Sylvester first presented the technical innovations of the Derbyshire Infirmary in detail in his 1819 *Philosophy of Domestic Economy*, his description was by no means as singular as the underlying inventions had been at the end of the eighteenth century. Instead, the background when the publication appeared was one of intense activity in the development and discussion of the methods of central heating and ventilation. Following the successful model of the warm-air heating system in Derby, not only was the technique adopted and varied by various protagonists but at roughly the same time two other substances were harnessed for central heating: steam and water. As with air, using both substances warmth began to be transported from one location across the various rooms of a building.

Steam advanced to a means of central heating almost simultaneously and in a closely related context with air. Similarly to Strutt, the famous entrepreneurs Matthew Boulton and James Watt began heating individual domestic and manufacturing spaces with the substance with which they were so familiar in the 1780s, and shortly before the turn of the century constructed the first large-scale steam-heating system for the Salford Twist Mill. From 1807 onwards, these and other applications became known to a wide public via the publications of the Scottish engineer Robertson Buchanan.[133] Warm water had apparently already been deployed by a Frenchman named Jean Simon Bonnemain in the 1770s to heat plant incubators, and in the subsequent decades was widely used in conservatories and hothouses. In this respect, warm-water heating points—along with industrial production—to a further impulse behind the emergence of central-heating techniques, namely the cultivation of plants. In particular within the context of the English enthusiasm for hothouses, this background resulted, to begin with, in repeated technological transfers between horticultural and domestic architecture.[134]

With this, the basis for all three significant central-heating methods had been set by around 1800.[135] They constitute the starting point of a development that would soon unfold so rapidly and widely that only a few decades later the first attempt at a historiography was undertaken. In 1845, the engineer and architect Robert Stuart Meikleham published a two-volume history of heating and ventilation, stretching back to ancient Egypt but above all concentrating on the emergence of centralized systems in Europe since the end of the eighteenth century. For the first time, Meikleham, himself simultaneously involved in the dissemination of these systems, united these numerous scattered techniques and their obscure sources into an equally instructive and entertaining "history of personal and fireside comfort."[136] Because the use of warm-water heating in domestic settings began with a certain time lag, the history of the development of centralized systems in his book is initially mainly divided between steam- and air-based methods. These two systems, as Meikleham also reports, competed all the more tenaciously with each other, as well as with the familiar methods of fireplace and stove. In terms of the fireplace, this proved to be particularly the case in England, where the sight of an open fire in living quarters was traditionally highly valued.[137] The upshot of this situation was a state of technical and epistemological openness that lasted for several decades and involved a series of different protagonists, ranging from classic "projectors," or scheme promoters, who tried to extract financial gains from the new technologies, to established engineers and natural scientists who endeavored to define their scientific bases. But whatever the motivations of those involved, their activities had a fundamental effect on the understanding and conception of architecture.

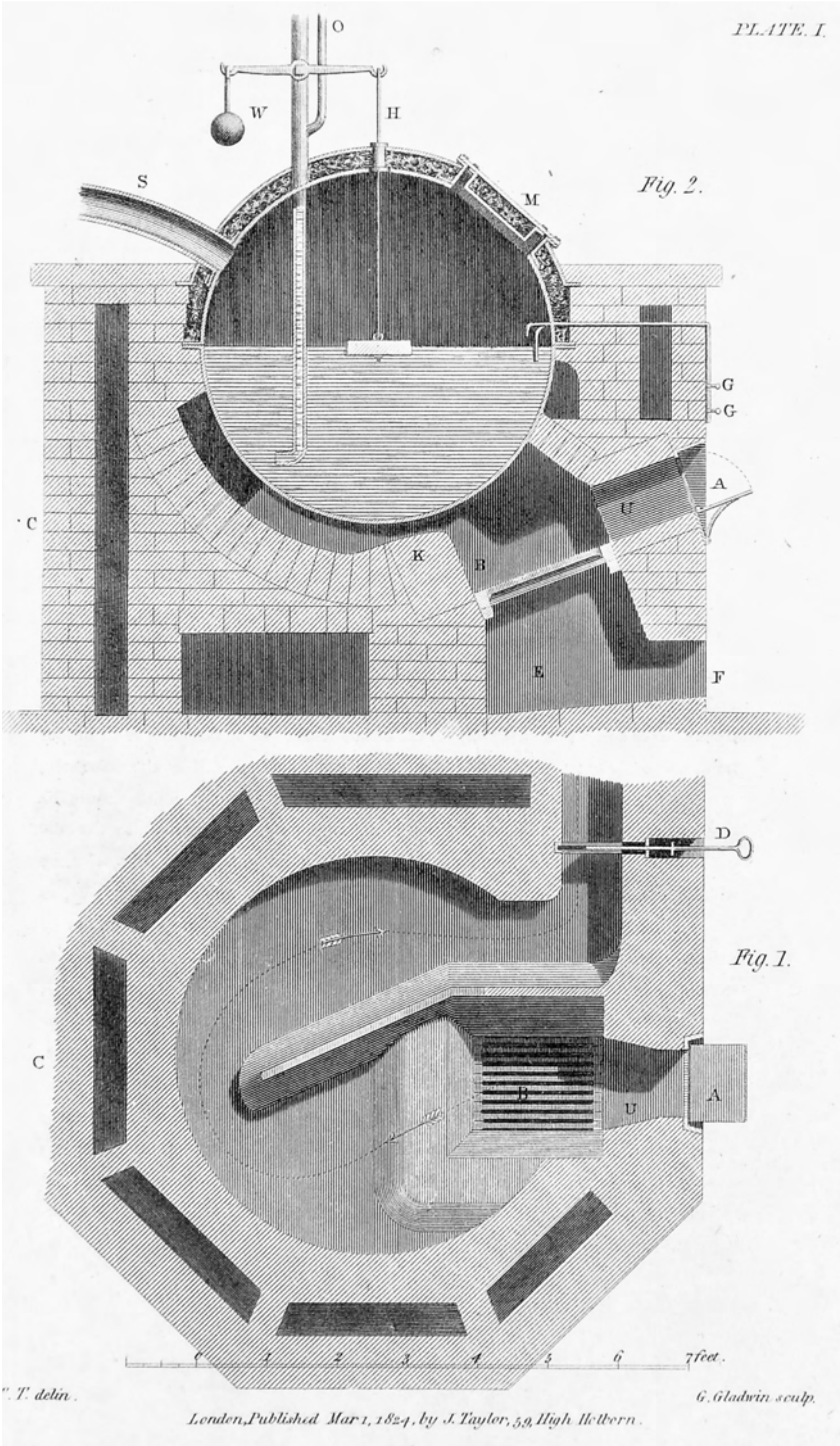
The French nobleman Jean-Frédéric Marquis de Chabannes serves as a typical example of the projector. Already shortly after the turn of the century, he proposed applying centralized heating methods within the framework of a project for the construction of fully mechanized residential buildings.[138] Over ten years after the failure of his scheme, Chabannes founded a company in London that was intended to at least turn a profit out of the climatic part of his plan. After acquiring two relevant patents in 1815, he opened a firm in the center of the city with a salesroom for heating and ventilation systems.[139] Although Chabannes offered all three centralized heating methods, the publications with which he subsequently advertised his systems show him to have been first and foremost an adherent of a warm-air variation that had pronounced similarities with William Strutt's. Chabannes's method involved the channeling, as required, of temperate and purified air from an "air recipient" in the building basement via a system of pipes to the individual rooms, and, following its use by the residents, its extraction by an "air pump" on the roof via further pipes.[140] Like Strutt, to this end Chabannes developed his own stove, which he christened with the meaningful name Calorifere Fumivore. → Fig. 17 "Forced Ventilation," he wrote regarding the resulting method, "not only purifies the air in our habitations



17
The Calorifere Fumivore by Jean-Frédéric de Chabannes, 1818

but is the only means by which the temperature can be easily regulated, all currents of air destroyed, and damps prevented."[141] For a time, Chabannes's firm was evidently successful enough to obtain contracts for prestigious buildings, such as Covent Garden Theatre or the House of Commons. Ultimately, however, the marquis was doomed to failure on this project too. A mere five years after the founding of his enterprise it collapsed under the weight of financial burdens[142]—not, however, without having helped the burgeoning field of building-service technology find some initial applications and public awareness.

Most prominent amongst the natural researchers and engineers who turned their attentions to centralized heating and ventilation in the first decade of the nineteenth century is the figure of Thomas Tredgold. Following an education in cabinetmaking and architecture, Tredgold began, with great success, to write specialist engineering books, focusing on such subjects as the solidity of wood and iron, and railways or steam engines.[143] In 1824, he published the *Principles of Warming and Ventilating*, which went through several editions, was translated shortly after its appearance into French and German, and with its systematic unification of engineering, human physiology, and a notion of climatic comfort, played a key part in establishing the scientific foundations of the eponymous practices. Using empirically based calculations, Tredgold explored both the warmth and air requirements of living spaces and was the first to subject them to a precise thermodynamic calculus.[144] Whereas prior to this the assumption had been that the correlation between spatial volume and heat demand depended on a simple and directly proportional ratio, Tredgold countered with a dynamic understanding of heat loss, including the additional factors of window sizes, surface-to-volume ratios, and inside-to-outside temperature disparities. In a similar manner he related the air needs to the physical requirements of the inhabitants, as well as to other factors such as lighting, thus arriving at an exact minimum air quantity of 4 cubic feet (ca. 113 liters) per person per minute.[145] With this, Tredgold for the first time injected a series of concrete formulas and facts into a field that had hitherto been marked by conjectures and the principle of trial and error,

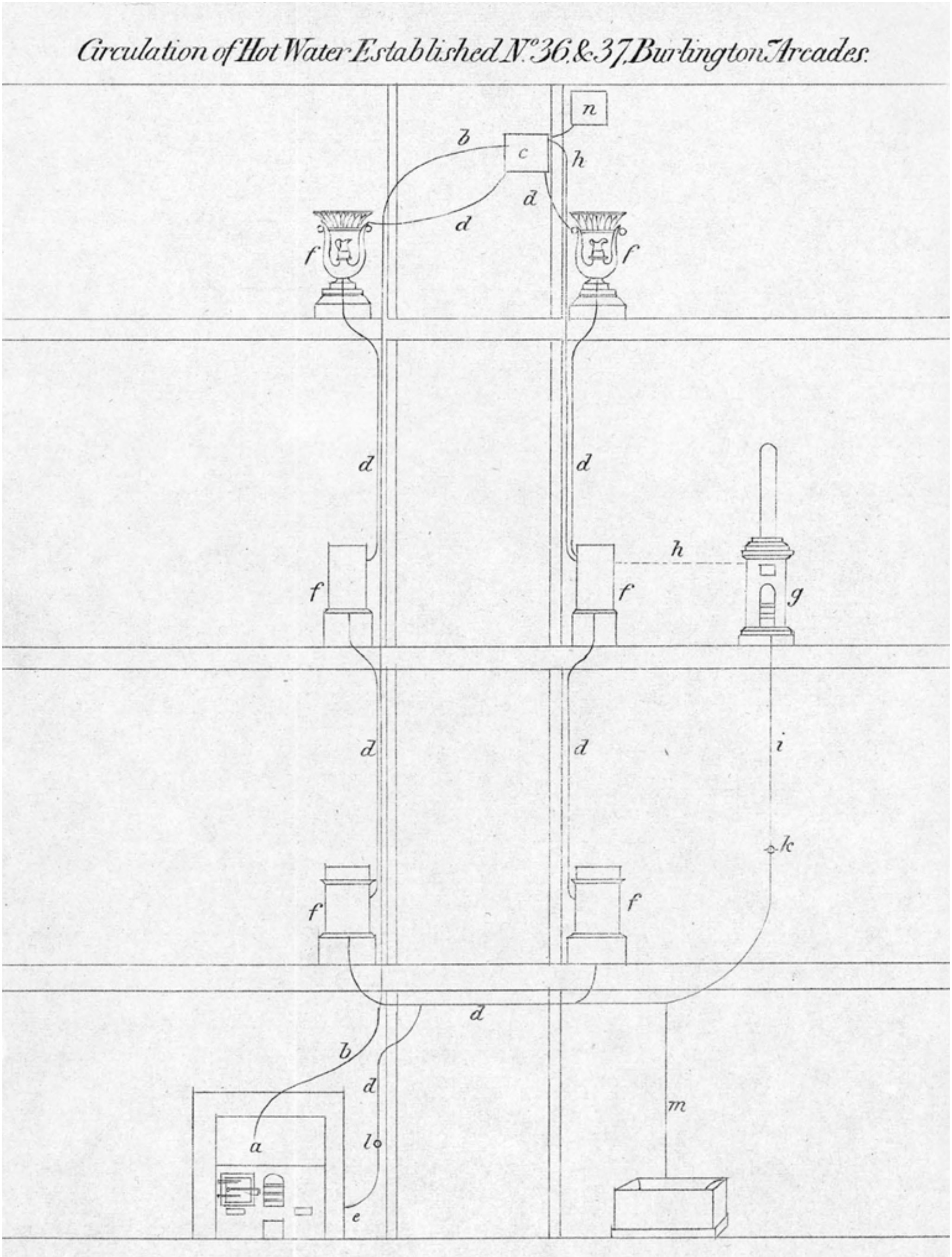


18
Spherical boiler after Thomas Tredgold, 1824

thus establishing a working basis for architects and engineers that would remain valid for decades. Whilst his review includes all the centralized heating methods, as well as the open fireplace, he demonstrates a clear preference for one specific system in the form of steam-powered heating. Similarly to the warm-water method, in this case steam generated from a boiler flows through a closed circulation system made up of iron pipes and vessels. ← Fig. 18 Tredgold pinpoints the advantage of this system above all in its transmission capacity: with the help of steam, heat cannot only be distributed over great distances but also in any conceivable direction, and that with relatively little energy loss.[146]

The issue of transmission is common to all the various systems of the time, as is their technical permeation of built spaces. Regardless of whether air, steam, or water is used, the means of central heating rely on the deployment of ducts and pipes that run from a heat source, usually located on the ground floor or in the cellar, to other areas of the building, and, as applicable, back to the starting point again. Independently of existing circulation structures, these channels cross through walls and ceilings and create new interconnections between the floors, rooms, and apparatuses. If not necessarily within the building itself, this fact becomes visible on the plotting paper. Whilst Charles Sylvester still drew the air ducts in the Derbyshire Infirmary with a small number of dotted lines in the floor plans, these central systems soon acquired a significance and complexity that required them to be comprehensibly and intelligibly delineated in architectural plans as well. In Jean-Frédéric de Chabannes's replication of an early warm-water system in 1819, the system's components are prominently superimposed over the abstract section of a four-story building and show how it is framed, from the cellar to the roof, by a technical assemblage, whereby a single water boiler situated in the kitchen provides heat to a total of six rooms spread over three floors via a network of pipes. → Fig. 19

Besides the economical, safety, and comfort advantages repeatedly stressed by the contemporary protagonists, the central systems also made new forms of building and living possible. At the level of construction, the eschewal of individual fireplaces and stoves, and the contrivances and activities necessary to operate



19
Warm-water system by Jean-Frédéric de Chabannes: boiler (a, g), pipework (b, d, h, i), water tanks (c, n), radiators (f), taps (k, l), bathtub (m), 1819

them, enabled altered spatial layouts and distributions, and at the level of habitation changed human practices and habits. With this, the techniques of central heating responded to a series of demands made on architecture by various different interests at the beginning of the nineteenth century. Thus while industrial spaces needed floor plans on which manufacturing technology could be installed with as few obstacles as possible, domestic and institutional architecture tended to insist on an increasing compartmentalization of the interior space. Having said this, in terms of compartmentalization there were differing motives: in residential buildings it allowed a separation from unwanted external influences, while for disciplinary institutions, the desired outcome was an ever stricter subdivision into isolated and controllable cells. In other words, the central systems serve in the one case to heat a room without having the servant enter, and in the other without allowing the delinquent to exit.

While the rivalry between the different methods was ultimately decided in favor of Tredgold's scientific approach, thus securing the success of the steam and warm-water systems, judged to be more efficient and practicable, figures like the Marquis de Chabannes and his proposed warm-air system nonetheless played an important role in this process. This was due not only to the fact that this method regained ascendency, at least in certain parts of the world, in the early twentieth century as an integral part of air conditioning, with its additional cooling, humidifying, and purification functions, but also because it had wide-ranging conceptual consequences in architecture, as was already clearly evident in the Derbyshire Infirmary. The reason for this is, on the one hand, that from its beginnings warm-air heating was combined with the application of artificial ventilation, and thus above and beyond the room temperature had a second direct relation to the well-being and activities of the inhabitants. On the other hand, this is connected to the fact that air-driven systems, at least in part, always involve the visible side of a building. Transported to their point of arrival, the flows of a warm-air system do not diffuse in hidden pipes and radiators, but within the occupied rooms themselves. Their boundaries become identical to the rooms lived in; the rooms in turn transformed into a direct part of the system. Viewed through the lens of air heating, a basic parameter common to all building-service systems becomes evident: in addition to constructional effects, through which new spatial constellations can be derived, they also contribute fundamentally to a shift in the conceptualization and notion of architecture.

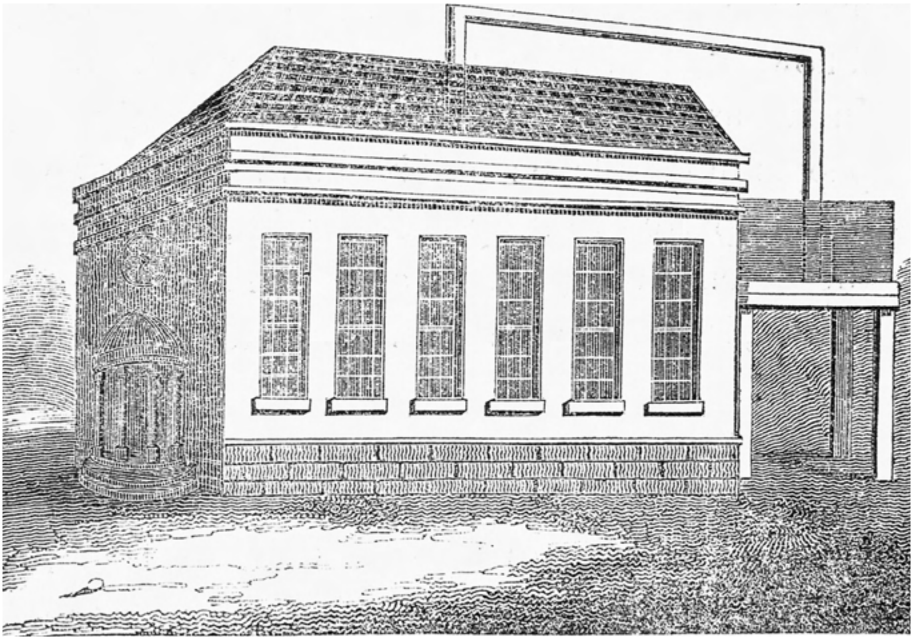
That the topic of ventilation had lost none of its significance vis-à-vis the eighteenth century, and that furthermore in combination with the emergence of central-heating techniques it ushered in a series of continuing ramifications for the comprehension of built space, becomes particularly clear in the work of Anthony Meyler. As an educated physician, who after finishing his dissertation in 1803 started a career as a constructor of ventilation systems, Meyler occupies a place between the figures of the scientist and the projector. His company, with which he installed ventilation systems throughout Great Britain, had a distinctly commercial purpose yet was simultaneously based on a profound body of physiological knowledge.[147] Starting around 1820, Meyler began to outline his mission, involving nothing less than saving human lives, to a wider public in lectures and publications. "Air being the great agent of our existence," as Jean-Frédéric de Chabannes had already expounded, "on its purity depends, in a great degree, our health, and all the comforts of life."[148] Meyler's *Observations on Ventilation* dedicates nearly two hundred pages to precisely this constellation, explaining that respiratory air is an existential category, both medically and socially. His testimonial on his contemporaries is disastrous: without being aware of it, their churches, theaters, and shops—in short each and every building from workers' lodgings to the royal palace—were saturated with pestilent air.[149] The book resorts to several striking images in order to highlight the dangers of the situation and people's heedlessness. Why does someone at an event politely turn down a sip from a friend's glass and yet at the same time blissfully inhale the air breathed out by the whole crowd? Meyler's intention is to make the readers comprehend that the medium they are always and everywhere immersed in has indiscernible yet all the graver consequences for their well-being. "Health", he explains,

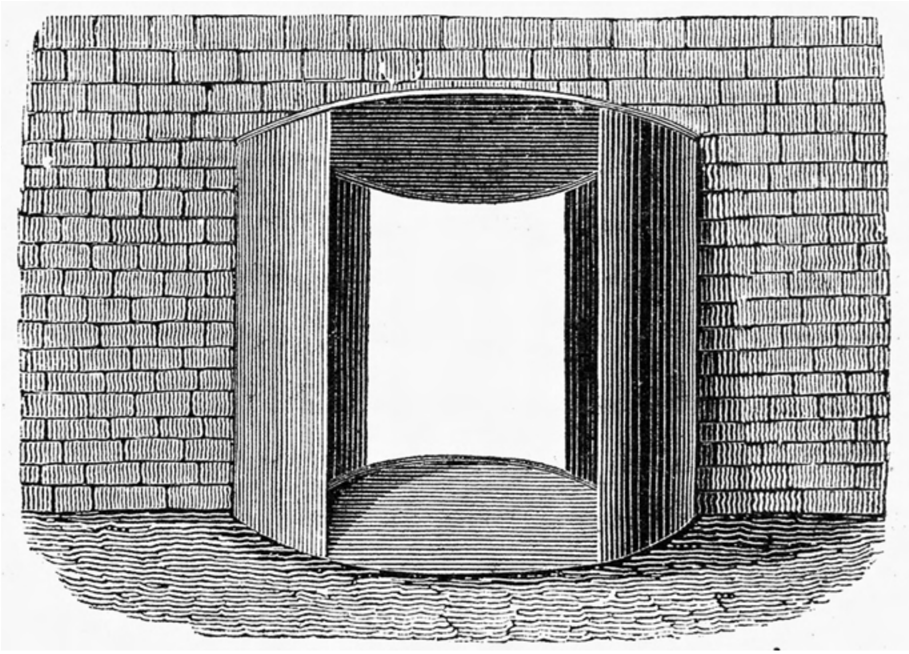
> is not in general, either caused or preserved by the occasional operation of extraordinary and powerful agents, it is sustained by the incessant, but imperceptible influence, of what may appear to many as secondary causes. Yet, surely, no agents can be more powerful in contributing to the health, and consequently to the happiness of life, than the purity of the air which we respire and the well regulated temperature of the medium in which we live.[150]

Naturally, in keeping with their scientific-cum-commercial personas, figures like Meyler did not luridly broadcast the latent dangers of poor ventilation without offering their own appropriate technical remedies. Therefore, while Meyler propagated the principle of thermo-ventilation, which exploits the physical qualities of air for its supply and extraction,[151] the other techniques of air exchange, which were likewise undergoing further refinement at the time, were similarly promoted. Thus was the case of Robert Stuart Meikleham, who first entered the debate about heating and ventilation techniques in 1825 with a detailed publication on the *Theory and Practice of Warming and Ventilating*. In it he recommends the imperative use of mechanical means, provides an overview of the available devices, and explains how, with their help, air flows can be managed in interior spaces. The benefits of the mechanical process, according to Meikleham, lay in it not being dependent upon weather, because as opposed to thermal methods it still promised to function during periods of disadvantageous pressure conditions of high atmospheric humidity.[152]

Together with numerous other pamphlets, articles, and patents in the 1820s concerning the theory and practice of ventilation, Meyler and Meikleham's books contributed to a popularization of building-service installations, but above all also to an awareness of the atmospheric exigencies of living. This development applied to the overall architectural object, which was confronted with an increasingly precise understanding of meteorological variables such as air pressure and air density; and it also applied at a diminished scale to the individual rooms and room sequences, which were examined in ever-greater detail in terms of their micro-climatic status and their impact on the well-being and health of the residents. Meyler, for example, explains in great detail how a badly ventilated multi-story apartment building produces a fatal cycle in which the same air continuously finds its way through the kitchens, living rooms, and bedrooms. Even with combined force, windows, doors, or chimneys could only nullify this cycle under the most favorable of conditions; therefore the provision of a "dry, pure and warm atmosphere" categorically required an additional artificial method.[153]

In this way, the techniques of central heating and ventilation generated the necessity, but equally the vision, for controls of atmospheric processes that were as comprehensive as possible—an idea that had already inspired medicine in the late eighteenth century. In the early 1790s, the physician Thomas Beddoes developed the concept of pneumatic medicine, by which diseases such as lung tuberculosis were supposed to be healed by inhaling particular gases. "[N]othing would so much contribute to the rescue of the art of medicine from its present helpless condition," explained Beddoes, "as the discovery of the means of regulating the constitution of the atmosphere."[154] With his Pneumatic Institution, Beddoes established a research organization where, using various machines and contraptions including an airtight "breathing chamber," the therapeutic effects of the newly discovered types of air were studied.[155] The recognition among British physicians at this time that the natural climate of their homeland was a cause of chronic ailments was as widespread as the habit among wealthy patients to travel to warmer regions as an antidote to poor weather. Therefore, with the spread of a technique promising the artificial regulation of atmospheric conditions in around 1800, the idea of recreating the climate of the selfsame destinations in their own country was a logical step.[156] Based on similar previous suggestions, in 1814 the physician Edward Kentish developed the idea of a Madeira House, named after the Atlantic island uniquely renowned at the time for its steady and health-promoting climate. His vision was to erect a glazed-over park facility outside Bristol in which warm-air heating would provide constant and comfortable weather.[157] His professional colleagues appear to have found his plan as feasible as it was attractive:





20–21
The house as a pressure chamber: entrance
and view of the system by John Vallance, 1823

"without," wrote the *Medical and Physical Journal*, "indeed was a variable atmosphere, and all the miseries of the English climate; but within, the combined advantages of the steady climate of the south of France, and the genial climates of Naples or of Madeira."[158] Southern European conditions in the middle of England—a real measure of the belief in the wonders of central climate techniques at the beginning of the nineteenth century.

However, the new technology also excited a desire for climatically fully controllable rooms beyond purely medical uses. In its most extreme form, this is exhibited in a patent from 1820 in which a man named John Vallance synthesized some of the technical innovations popularized shortly beforehand in Charles Sylvester's *Philosophy of Domestic Economy* into a universal architectural concept. The patent title alone reads like a summary of the promises of central heating and ventilation systems: "Method and Apparatus for freeing rooms and buildings, whether public or private, from the distressing heat, sometimes experienced in them; and of keeping them constantly cool, and of pleasant temperature, whether they are crowded to excess, or empty; and also whether the weather be hot or cold."[159] Vallance envisioned the construction of buildings that, following the hermetic sealing of all of the windows and joints, possessed a mere two openings. The first, the entrance, is equipped with a revolving door, which as in the Derbyshire Infirmary would allow passage to people but not air. The second opening is set in the roof and is connected via a pipe to a water valve, allowing air to escape, but only at a certain atmospheric pressure. Vallance's plan was then to inject warmed or cooled air into the sealed construction by mechanical means. The resulting excess pressure was intended to turn even the smallest remaining gap into an outlet instead of an inlet for airflows, thus creating a constant and comfortably temperate interior climate.[160] ← Figs. 20–21

Vallance's proposal for hermetically sealed buildings was not exactly warmly embraced: the editors of the *London Journal of Arts and Sciences* judged his invention in their patent review as downright "impracticable and ridiculous."[161] His idea for a complete climatic separation of the inside and the outside was obviously too radical for his contemporaries, and the consequences for the appearance and the occupancy of the building too peculiar. Nevertheless, over twenty years later Robert Stuart Meikleham would rehabilitate Vallance's plan by dedicating two whole pages to it in his *History of Warming and Ventilating* and bestowing it with the complement "most ingenious."[162] And indeed, from Meikleham's perspective—from the viewpoint of historical writing that treated the design of artificial climates as a basic human ability, and set against the background of the increasing popularity of building-service installations—Vallance's construction could indeed appear as a stroke of genius in its promise of nothing less than the permanent decoupling of inhabited space from the vagaries of the surrounding atmosphere.

From Storage to Transmission

Sooner or later, the fundamental constructional and conceptual impacts of central heating and ventilation technologies also manifested themselves in the discursive field. Together with systems such as those of William Strutt or John Vallance, new forms of speaking about and depicting architecture likewise emerged. As with the technical installations themselves, these forms of enunciation successively advanced to become an integral part of building in the first half of the nineteenth century. A principle aspect in this development was the appearance of a terminology that can be described as "medial." Besides the word "medium" itself, the terms applied in the context of central systems included ones like "channel," "transmission," or "communication." They related, on the one hand, to the ambient air surrounding humans both indoors and outdoors, and on the other, to the substances via which the respective heating technologies transmitted warmth. Although these forms of speech should not be understood in terms of today's technological media for the spread of news and information, they nonetheless mark a decisive shift in the comprehension of architecture. Already in antiquity, the Latin word "*medium*" was used in a spatial sense to describe the center of an object or the middle-point between two or more objects. However, at the beginning of the eighteenth century it underwent a critical turn in the context of Isaac Newton's mechanical writings, where it was now used to designate an "in-between" with the capacity to establish connections and to transmit forces or effects. Since then, the term "medium" also invested an object with the significance of being a factor, an active entity, or the means to an end.[163] With the technologies of central heating and ventilation, it is this physical-mechanical notion of "medium" that entered into the context of the built space and that, sited there, prompted a new way of thinking in terms of relations, influence factors, and transmission processes. Together with other expressions and visual elements, it now served to describe and plan that which, with the help of this technique, took place "amid" or "in the middle of" mechanical and architectural constructions.

Following around three decades of rapid development in the field, in 1837 the *Popular Treatise on the Warming and Ventilation of Buildings* appeared, representing concentrated evidence of the discursive effects of central climate technologies, as well as being the first publication on the subject to have been written by a classically trained architect. In the book, the author Charles James Richardson, a former pupil and assistant of Sir John Soane's, refers in numerous passages to the celebrated neo-classicist, who had died shortly beforehand.[164] As it happened, Richardson had had the opportunity to physically encounter various central heating and ventilation systems during his many years working in Soane's office. Soane had applied the new technology since the beginning of his career in the 1790s, and had later experimented with all the corresponding methods in his residential and office building in Lincoln's Inn Fields in London. Ultimately, these technologies afforded him the interwoven yet open spatial planning for which the building became so famous.[165] However, whereas Soane only once ever referred in detail to heating technology in his *Lectures on Architecture* held between 1809 and 1836,[166] Richardson decided to dedicate an entire treatise to the subject. The stated aim of Richardson's book is to provide an overall survey of the developments of the previous years, written in easily accessible language.[167] During the period, the technique of central heating and ventilation had not only spread widely, it had also enjoyed a scientific ennoblement. For instance, the Scottish physician Neil Arnott had described it as a crucial art in his standard natural-philosophical work *Elements of Physics*, and the well-known landscape architect John Claudius Loudon had repeatedly referred to it in glowing terms in his very recent *Encyclopædia of Cottage, Farm and Villa Architecture*.[168]

Although the word "medium" had previously been occasionally deployed in relation to central systems—as in Charles Sylvester's *Philosophy of Domestic Economy* or Anthony Meyler's *Observations on Ventilation*—Richardson's *Popular Treatise* is veritably saturated with the term, ranging from the use of substances as a "circulating medium for transmitting heat" to the need for a "formal medium" to steer the circulation flow. And at a different level, the seventeen zincographic plates in the lavishly made book are referred to as the "medium of the Plates."[169] At the same time, the term "communication" occurs in multiple passages, applied not in the common architectural sense of the spatial interconnections, nor in the sense of inter-human exchange, as in the discussion around the architecture of moral enhancement, but rather in the sense of the transmission of physical entities. Whereas to date "communication" in planning contexts had involved a door or a corridor, it now designates a thermal relationship: "heat is communicated to the atmosphere of the building."[170] That the aspect being seized upon here is an idea of certain architectural communication and transmission processes is especially evident in the description of the functioning of specific systems, for example that of Jean-Frédéric de Chabannes' Calorifere Fumivore, praised by Richardson for its ability to "send" any amount of warmed air to the individual rooms of a mansion.[171]

In this respect Richardson's treatise marks, already through its vocabulary, an architectural moment that is perhaps best described by referring to media studies. Early on in this discipline, the field of inquiry involved not only the information systems used to store, process, and transmit news, but extended to other communication systems that equally regulated the movement of people and objects. According to this line of thought, communication systems not only include a variety of media, from language to road networks, but also the notion that these can also be potentially analyzed in terms of information systems.[172] Indeed, it is possible to relate the emergence of central building-service systems to two fundamental theses that were formulated to describe information systems. The first is a functional one and concerns the transition between the two media operations of storage and transmission. Accordingly, by equipping them with central systems, built spaces no longer only served as a receptacle for the warmth generated by a heat source but also assist in precisely transmitting it. The second, related, thesis is a historical one and concerns—if not in significance then in principle—an epochal transformation postulated to have occurred in the history of media. Just as the discovery of writing had liberated linguistic communication from the necessary presence of a speaker, so central heating detaches warmth and the heat source from each other, making domestic heating independent of the presence of a fire. While media studies primarily focuses on the effects of these transitions in their social and cultural contexts, they nonetheless also reveal far-reaching consequences in the field of architecture.

Richardson makes considerable efforts to spell out to his readers the advantages of the climatic-technical transition from storage to transmission in terms of living comforts. Thus, for instance, he explains how a gentleman whose house is serviced by a central system can dispense with the reliance on domestic servants to become master of his own domestic atmosphere: "He could provide in all his rooms pure air and pleasant warmth, could sit in any of them without being subjected to hot or cold draughts, and regulate the admission and discharge of air with equal ease, whether he were the sole occupant, or the entertainer of a considerable party."[173] In addition to their use, however, the implications that this transition has for the design and understanding of buildings also become clearly apparent in examining Richardson's work. Three central aspects can be isolated in the remarks given in the *Popular Treatise* in this respect. The first is that the architectural object and its elements enter into a new systemic context. This mutual dependency of the individual parts of a house and the requirement that they be arranged referentially to each other is above all evident in the case of faultily laid-out heating systems. They show, in Richardson's words, "that the openings for the purpose of ventilation must be placed with reference to the system introduced in the rooms in order to become efficient."[174] This places a particular emphasis on how doors and windows are located: "Serious professional attention should always be given, not only to the form of the flue, but the position of the chimney breast, with the relative situations of doors and windows."[175] The second aspect is that the architectural structure undergoes a process involving both a literal and figurative "closure." Besides the actual sealing of the interior rooms, multifunctional elements are also allocated precisely defined purposes. "With the warming and ventilation of a dwelling, managed by this apparatus," writes Richardson regarding one of the systems introduced in his book, "we should not depend for the supply of pure air in our rooms on the action of doors and windows. Let them remain as tightly closed as the skill of a modern joiner can make them ...." And further, "'The doors are meant to admit the occupants to the chambers, and the windows to give the light.'"[176] Third, in such closed domestic systems the input and the output of climatic factors are offset vis-à-vis one another, above all the quantity of air entering or leaving a building: "In admitting a regular quantity of pure air, warmed to an agreeable temperature, it becomes necessary that a corresponding proportion of air should be displaced. Unless this is attended to, no system of warming in a private building will be found successful and satisfactory."[177]

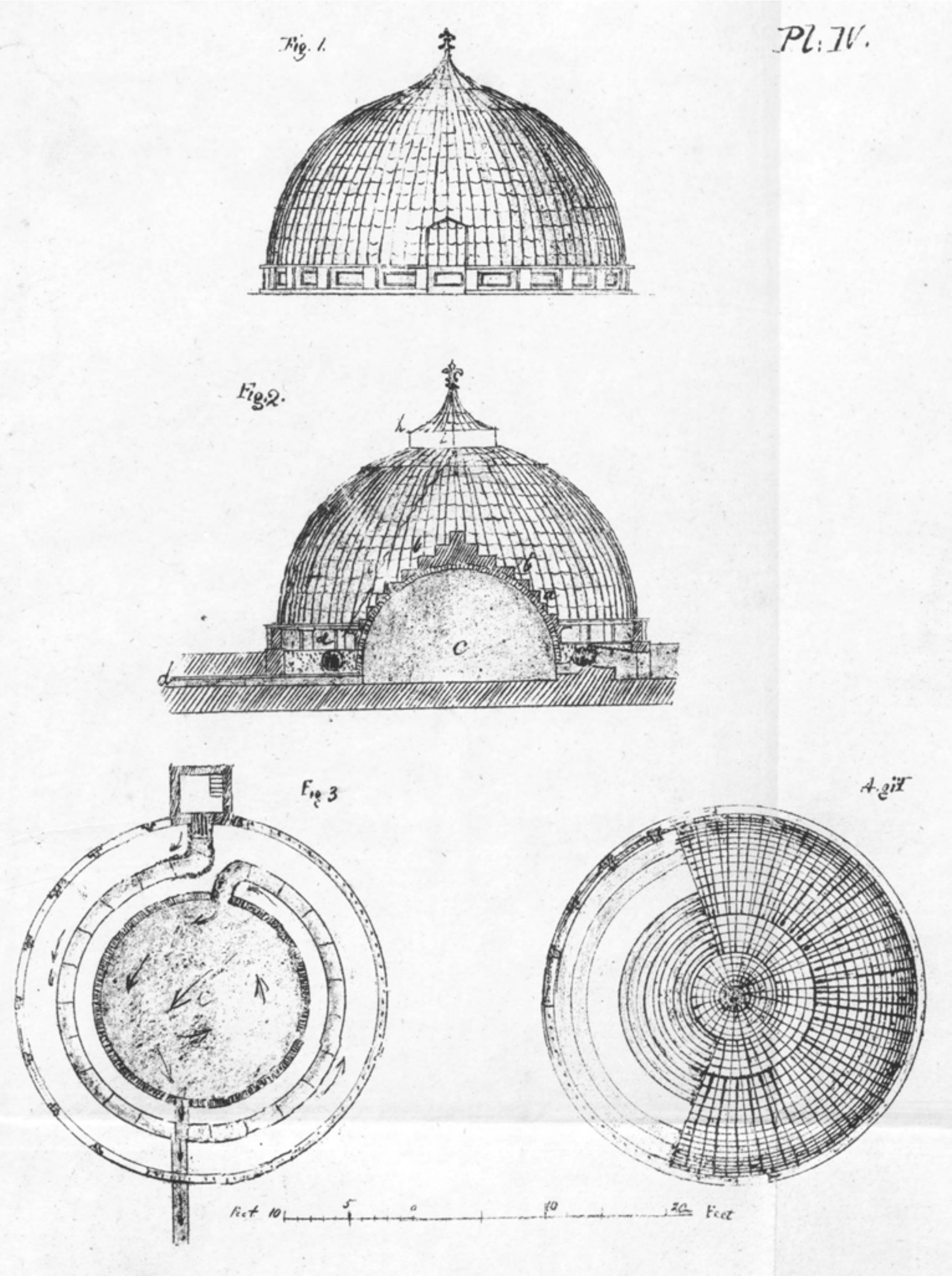
Together, these the aspects support a further proposition in media studies, namely that while media or communication systems serve to bridge spaces and differences, they do not simply transcend or annul these spaces but rather occupy and define them.[178] From the referential relation that emerges between the building elements to the exact calibration of the air amounts fed in and extracted, it can be seen how, also in the field of architecture, the implementation of transmission systems creates not only altered spatial connections but how the established constructional and symbolic concepts of building were extended by a new operational logic. One of the fundamental consequences of this logic was to treat centrally serviced buildings less as static constructions or a collection of distinct places and more as spatial continuities subject to thermal dynamics. As such, it is no coincidence that Richardson crowns the staircase—an element usually treated as peripheral—as the most important element of a house, because from his perspective it serves "communication" in a dual sense: both that of the inhabitants and that of climatic variables.[179]

However, the transition from storage to transmission is not only evident at a linguistic level in what was new terminology, it also expresses itself at a visual level in a new presentational technique. As a visual counterpart to the terms "medium" and "communication," the first half of the nineteenth century also saw the spread of a specific symbol: the arrow. It is no coincidence that here too Charles James Richardson played a pioneering role in being one of the first architects to widely deploy arrows to indicate movements and directional flows in his book's illustrational plates. The science of domestic heating had been accompanied by scattered uses of the arrow since its beginnings in the eighteenth century—and the use of the symbol in spatial contexts actually appears to genuinely be connected to this particular science. To date, the origins of the arrow sign have been located in hydrology, or to be precise in the first volume of Bernard de Bélidor's *Architecture hydraulique* from 1737.[180] Bélidor used numerous fletched arrows in the illustrations of the book to designate the direction of flow of canals and courses of water, and may indeed have played a major part in establishing it as a fixed feature in engineering and natural-science drawings. Nevertheless, this representational device had already been applied in the context of domestic technology around twenty-five years earlier. In the *Mécanique du feu*, Nicolas Gauger's influential book on the art of heating, arrow signs were used to trace the movement of air within his newly developed fireplace ← Fig. 5—"the head of the small arrows," reads the book, "shows when it rises, or descends, or which way it goes."[181]

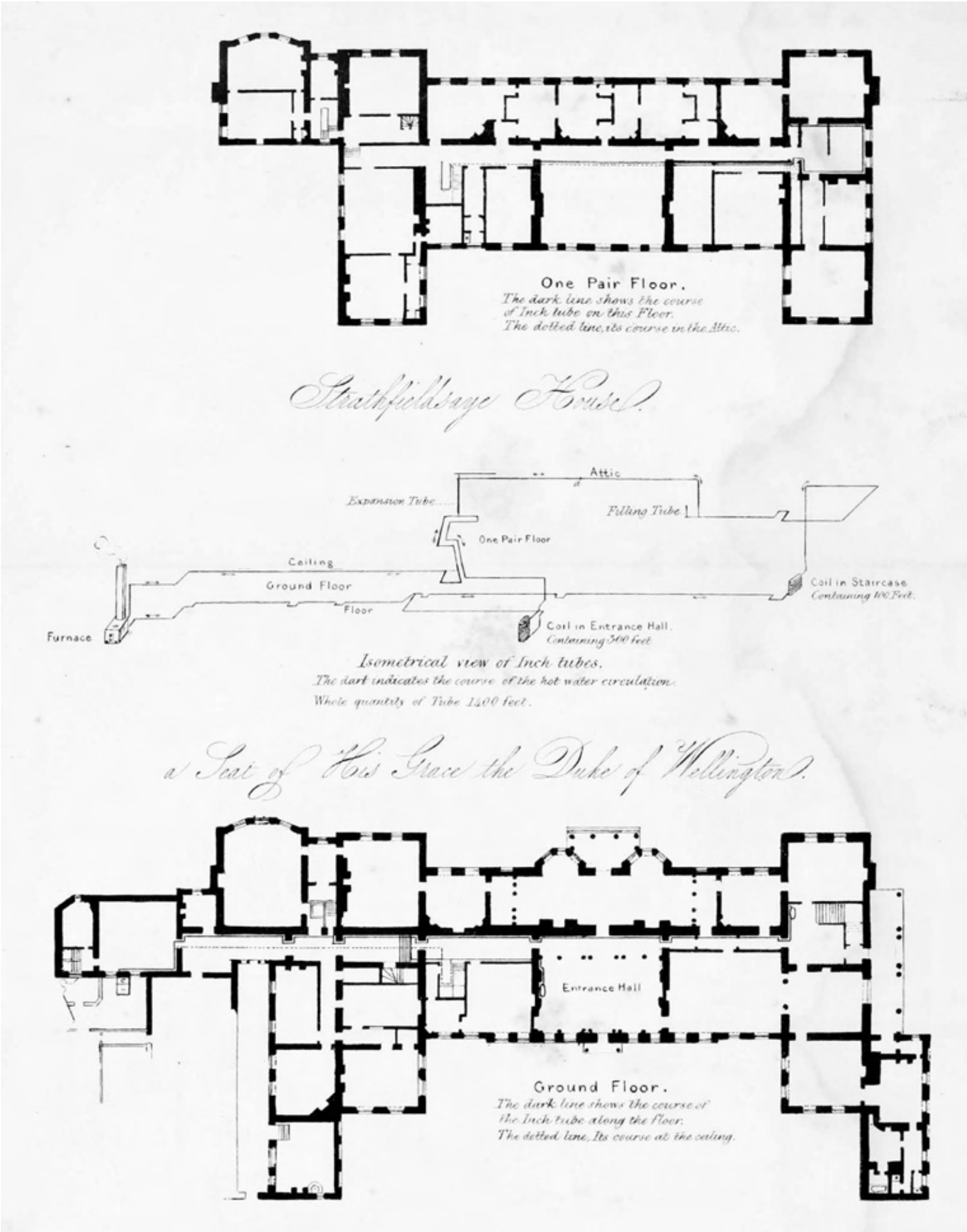
Due to the fact that Gauger's book, including its very title, demonstrated the influence of Newton's teachings, the use of the arrow sign possibly has not just a functional but also a historical affinity with the modern term media in that the term and the sign apparently equally originated in the context of classical mechanics. Be this as it may, in the early 1740s Stephen Hales and Benjamin

Franklin, and with them two of the most prominent natural scientists of the era, adopted the fletched arrow to illustrate their innovations in domestic engineering: Hales his ventilator and Franklin his Pennsylvanian fireplace. ← Figs. 2, 4 While Gauger and Franklin still combined their arrows with intricate lines to increase comprehension, in Hales's case only the bare symbol is used to show the path of the air in his invention. In this way, over the course of a few decades, waving pennants and wiggly lines—common elements for centuries in the visualization of air, wind, or smoke[182]—were replaced by a more precise and rational illustrative process. The feathers, which adorned the arrow sign well into the nineteenth century, echoed the function of the arrow as part of a bowed weapon, giving it not only a directional index but also a visible association with the dynamic nature of the projectile.[183]

Progressing from technical drawings, the arrow was integrated, literally step-by-step, into architectural plans. After spending comparatively long constricted to individual apparatuses and their surroundings, within a short period in the early nineteenth century it made inroads into inhabited space. Not by accident, this infusion took place as a result of the appearance of systems whose logic tended to encompass the entire structure of the building, meaning that the functional techniques of central heating and ventilation systems and the methods deployed to represent them would appear to be fundamentally related. In the case of pioneers like Charles Sylvester, Jean-Frédéric de Chabannes, or Thomas Tredgold, the arrows are still closely tied to the apparatuses and installations used to generate heat and distribute it throughout the house, ← Figs. 12, 17, 18 but in the exponentially expanding literature on building services after 1820 they begin to evince an increasing autonomy in the ground plans, elevations, and sections. One early and special example is provided by John Claudius Loudon in 1817 with his depiction of one of his centrally heated, curvilinear hothouses. Because the piping was set under the walkways in the building, the arrows indicate both the route of the smoke and that followed by a visitor inspecting the plants. → Fig. 22 Twenty years later, Charles James Richardson deployed arrows in his treatise to make both the air flows from warm-air systems and the directional



22
Hemispheric hothouse by John Claudius Loudon, in which both smoke and visitors circulate, 1817



23
The warm-water heating at Stratfield Saye House, seat of the Duke of Wellington, in plans by Charles James Richardson, 1837

flows within the partly isometrically drawn piping of steam and warm-water systems traceable.

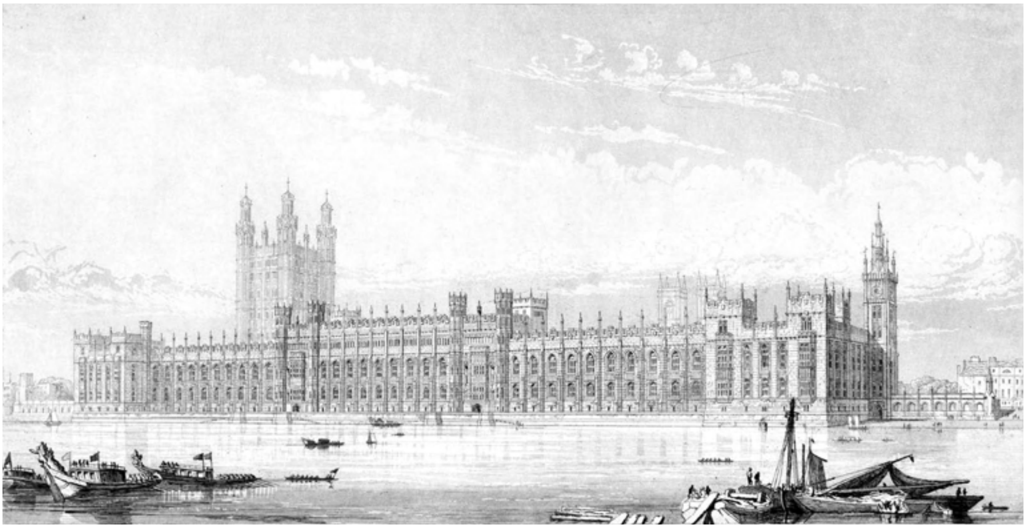
Richardson can obviously rely on a readership that by this point was well acquainted with reading arrows as symbolizing various processes, especially in those cases where a curved shaft indicates not only a direction but also a path of movement. ← Fig. 23 In this context, the arrow acts in a dual sense as a concrete means for the operative approach that occurs in architecture with the event of climate technology and the transition from storage to transmission. On the one hand, it visualizes—as with the wiggly lines used till then to symbolize air or smoke—processes and conditions that, due to their ephemeral nature, could not otherwise be reproduced. On the other hand, it serves—and this with far more precision than bundles of lines—to render the illustrated substance manageable on paper.[184] By using it, the behavior of the invisible and transient element of air becomes observable and explorable in the design stage. A passage in the second edition of Richardson's treatise on the operation of a ventilation system states that "[T]he current is intended to take the direction shown by the arrows."[185] Here, the arrow stands for both a presentational and a planning instrument, with the help of which actual situations can be analyzed and reflected upon in advance.

With the appearance of the arrow, the geometric and statical information traditionally supplied by an architectural drawing is given an additional aspect, namely the ability to represent temporally consecutive processes. For this reason, the arrow sign did not remain reserved for technical contexts for long, rather it quickly became a general and enduring instrument for the illustration and planning of spatial events.[186] Nevertheless, to begin with the arrow is the most eye-catching result of the medial understanding of architecture that originated with the emergence of new heating and ventilation techniques in around 1800, allowing as it did a depiction of those "communications" put into effect, based on central systems, "amidst" buildings. With this, and in equal measure, the structure and the illustration of built spaces acquired new forms of operativity—once in relation to thermal processes and once in relation to symbolic ones.

THE HOUSES OF PARLIAMENT

It was the engulfing of the Paris Hôtel-Dieu by flames that first brought the problem of climatic control to wide attention in France during the Ancien Régime, and it was a catastrophic fire that after many decades of technical development similarly focused interest on the topic in Great Britain.[187] On October 16, 1834 workers used the heating stoves in the cellars of the London Houses of Parliament to burn a large quantity of tally sticks that had become obsolete after a tax reform had finally replaced them with paper documents. The stoves overheated so badly that a fire broke out, consuming large parts of the old royal palace in a matter of hours, including the chambers of the House of Commons and the House of Lords. Ideas of permanently relocating the parliament building were quickly abandoned, and under the supervision of a parliamentary commission, a plan was drawn up to rebuild on the same site. In spring 1836, a public and anonymous competition was won by the architect Charles Barry with his neo-Gothic design. The decision marked the preliminary highpoint in the Gothic Revival that had spread in Britain since the eighteenth century, and practically anointed neo-Gothic as the national style with which Britain attempted to draw on its glorious medieval past. During the next decades, the new Westminster Palace, with its monumental vertically structured facade, landmark clock tower, and over 30,000-square-meters of floor space, arose from the site on the northern bank of the Thames.[188] → Fig. 24 However, the fire disaster of 1834 marked not only the beginnings of a new parliament building and today's world-famous postcard motif, it also resulted in a dogged personal disagreement concerning the technical equipment of a building that escalated into an unprecedented public debate.

From the outset, the building preparations for the new Houses of Parliament were flanked by ideas concerning the atmospheric



24
Charles Barry’s winning competition entry for
the new Houses of Parliament, 1836

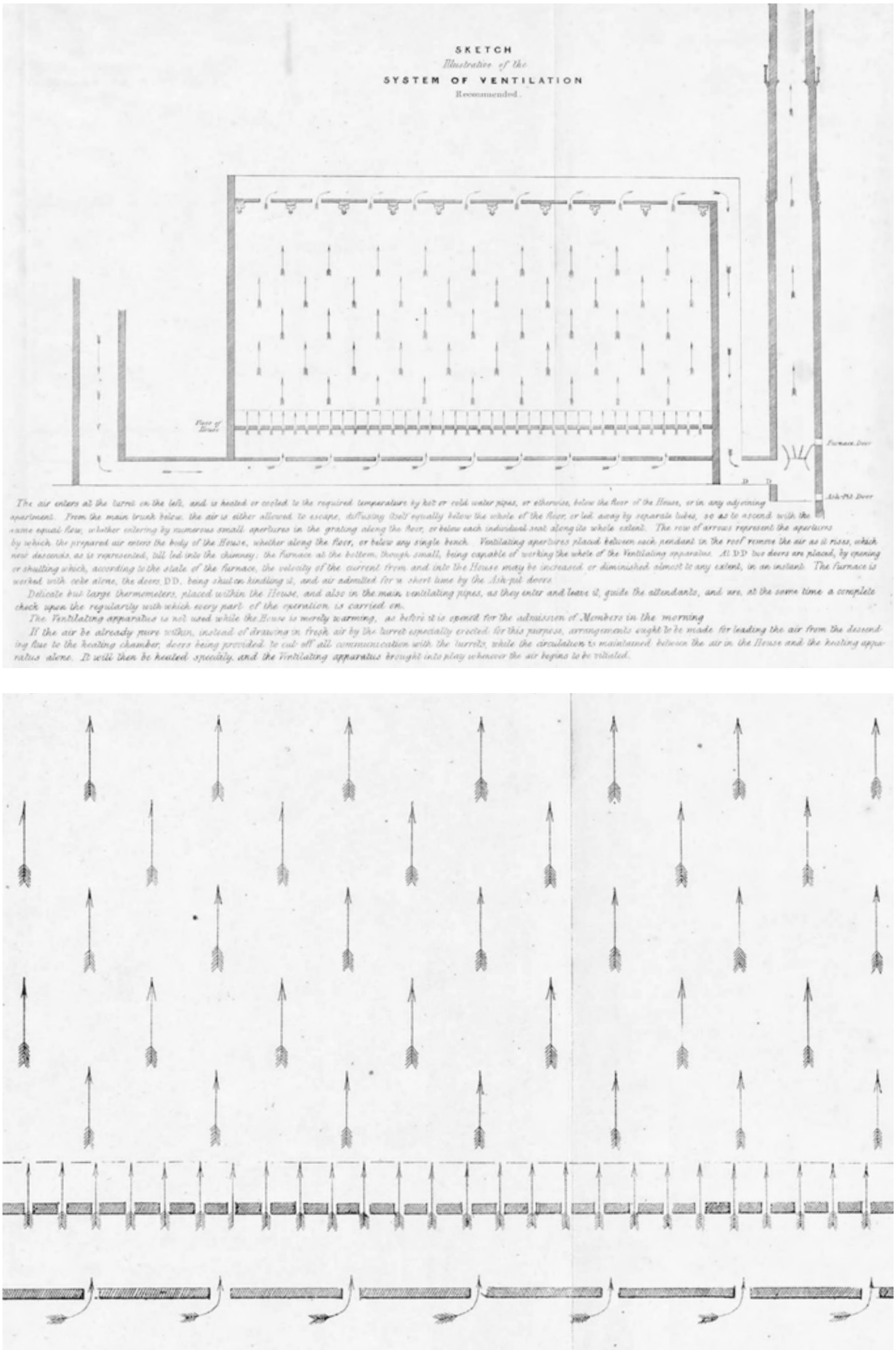
conditions in which its political transactions would be held. The reason for this circumspection was, on the one hand, due to the generally increased interest in interior climate, and, on the other, to over two centuries of unhappiness about the perceived deficiencies of the old palace rooms for gatherings of parliament and the failed attempts to remediate them via remodeling and mechanical installations. The history of these attempts stretches back to 1660 when the architect Christopher Wren cut four large holes in the roof of the House of Commons in order to alleviate the oppressive heat that built up during sittings, although actually causing cold down-draughts and more resentment from the members of parliament. This was the first in a series of architectural and technical endeavors—including the installation of one of John Theophilus Desaguliers' ventilators—that stretched to the time the fire broke out, a few years prior to which Jean-Frédéric de Chabannes, with modest success, had carried out the installation of one of his steam-based heating and ventilation systems.[189] In this respect, Westminster Palace demonstrates a close connection with the history of building services, its walls serving as a veritable testing ground where, for decades and more, various means were explored by which to optimize the parliamentary climate.

Therefore in 1834, when the erection of a new parliament building became crucial, one of the most important requirements was to ensure better atmospheric conditions. This was one aspect in a remit that was already hardly lacking in specifications, caused by the fact that the Houses of Parliament was not only where both chambers gathered but also where the monarch, as the third body in parliament, sat. In addition to a large quantity of different rooms—not only the assembly halls of the upper and lower houses and the royal chambers, but innumerable offices, lobbies, libraries, and ancillary rooms—the brief also required compliance with a multitude of safety-related, protocolary, and customary demands from the various groups of users. The resulting program was so complex that the *Morning Herald* compared the projected building to a sturdy and yet intricate machine: "A powerful machine, of nicest force,—calculated at once for the most vigorous and gentle operation, as the different occasions shall demand,—of wondrous power, but composed of a multitude of parts,—adjusted to a thousand special functions, yet combining for the production of one grand general effect."[190] Here, the machine terminology serves not only to set the theme of an ensemble of parts and the whole but, very concretely, to equally describe the architectural operativity that was to distinguish the future building. This, according to the daily newspaper, was rooted in the fact that the building of the parliament involved not only the exterior appearance but its role in guaranteeing legislative actions: "The building of a new House of Commons is not a question of four walls placed here or there, built by this architect or that, in this or that style; but the question by what machinery shall the legislative functions be best performed."[191] Included amongst the central design criteria listed in the article, the aspects "Form" and "Space" are correspondingly followed by the points "Sound," "Warmth," and "Ventilation."[192]

Almost simultaneously to the launch of the architectural competition, a Select Committee had therefore been "appointed to consider the best mode of ventilating and warming the new Houses of Parliament, and of rendering the same favourable to the transmission of sound."[193] In summer 1835, it began hearing evidence from selected individuals, amongst them national authorities such as the architect Robert Smirke, responsible for the building of the temporary parliamentary chambers, the physician George Birkbeck, and the natural scientists Michael Faraday and William Thomas Brande, as well as the relatively unknown experts Charles Sylvester and David Boswell Reid. Sylvester, an engineer and author of the 1819 *Philosophy of Domestic Economy*, presumably owed his invitation to the fact that Edward Strutt, the oldest son of his long-time employer William Strutt, was one of the commission members. Reid's appearance apparently took place thanks to a visit—only a few months prior to the Houses of Parliament burning down—by a delegation of members of the upper and lower houses to the physician's laboratory and lecture rooms during the annual meeting of the British Association for the Advancement of Science in Edinburgh. After studying medicine, Reid, born in Edinburgh in 1805, had begun to teach practical chemistry as a private lecturer, and to this end had erected a classroom building in his hometown in the early 1830s.

During their visit, he had successfully presented the acoustical and technical installations in his building to the delegation, amongst them an elaborate ventilation system for the extraction of smoke and chemical fumes.[194] In his evidence to the Select Committee, Reid not only stood out by virtue of his theoretical and practical knowledge in the fields of sound transmission, heating, and ventilation, but also by presenting first plans for the proposed assembly chambers.[195] → Fig. 25 The commission was impressed enough to entrust Reid, at least for test purposes, with realizing the relevant installations for the temporary House of Commons. His proposals, as the final report formulated it, were, as far as possible, to be subject to a "test of actual experiment."[196]

In the following year Reid transformed both the provisional buildings of the Westminster Palace site and his own classroom building into a laboratory for building-service experiments. After a series of trials in Edinburgh using variously scaled building models to carry out respiratory tests replicating up to 250 people, in fall 1836 he was given permission to intervene in the temporary House of Commons building designed by Robert Smirke.[197] His alterations encompassed the construction of a ventilation shaft in one of the palace courtyards, as well as extensive remodelings in the interior of the assembly chamber. In order to improve the acoustics, Reid proposed a lowered ceiling, illuminated from above, equipped with tapered edges to improve the circulation of air. In the redesigned hall, he then incorporated a heating and ventilation system based on the principle of thermo-ventilation. Via a perforated wall, fresh air was sucked from outside the building, purified using various mechanisms, warmed or cooled according to requirement, and then fed into a compartment underneath the assembly room. → Figs. 26–28 From there, the treated air ascended during the sittings of parliament through innumerable small holes in the floor of the hall, and was finally extracted out again through apertures in the ceiling to a heating stove at the bottom of the ventilation shaft, ejected in a last step from here to above the roofs of the palace.[198] On November 5 the same year, the London *Times* reported that this acoustic and climatic innovation had been successfully tested under real-life conditions in a series of experiments using test



25
Arrowed sketch: David Boswell Reid's design
for the ventilation system in the temporary
House of Commons, 1835

Fig. 1.

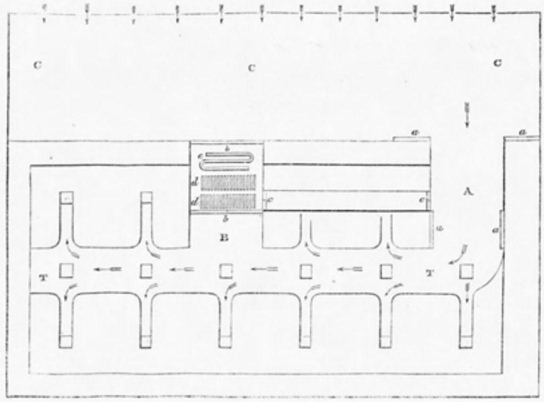


Fig. 2.

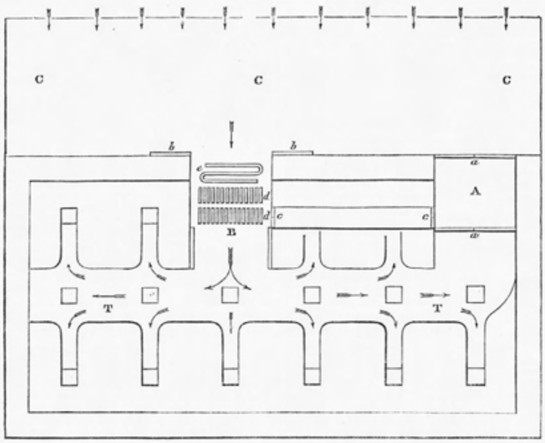
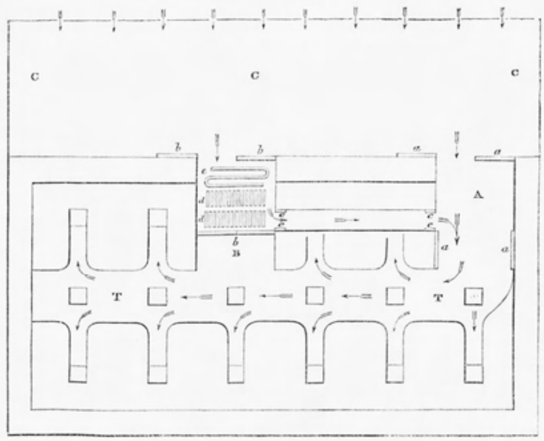


Fig. 3.



26–28
The basement floor of the temporary House of Commons with arrangements for cold, warm, and mixed air, 1837

speakers and several hundred soldiers as a test public. These alterations apparently also proved effective during the subsequent assembly periods in that Reid ultimately received the assignment not only to likewise remodel the temporary House of Lords but also to supervise the technical installations in the new parliament building.[199]

Therefore, in January 1840, when the foundation stone-laying ceremony became imminent following extensive administrative and constructional preparations, the Office of Woods responsible for the rebuilding of the Houses of Parliament issued two letters, one addressed to the architect Charles Barry and one to David Boswell Reid. Prior to this, both men had been officially entrusted with their responsibilities at a fixed annual salary: Barry, naturally, until the completion of the project, and Reid for longer, until the close of business of the first legislative period.[200] The purpose of the letters, written by Commissioner Alexander Milne, was to inform each of them of their rights and duties in regards to the other and thus to formulate the basic formalities of their cooperation. The letter to Barry read:

> Arrangements having been made by this Board, under the sanction of the Lords of the Treasury, for placing the ventilation of the Houses of Parliament in charge of Dr. Reid, I am, on behalf of the Board, to desire that Dr. Reid may receive from you, from time to time, as the architect of the building, such assistance as he may require in regard to the plans which have been prepared under your inspection for his use, and that generally, in order to second as much as possible the objects which have induced the Government to select Dr. Reid for the superintendence of this important service, you will, in all matters of detail connected with the structure and arrangement of the new buildings, afford him every requisite facility and assistance in carrying it into effect.[201]

Together with a copy of the letter to Barry, Reid received a communication that included the following formulation:

> I have, on behalf of the Board, to transmit to you copy of a letter which has been addressed to Mr. Barry, acquainting him with the service on which you are employed, and desiring that, as the architect of the new building, he will afford you every requisite facility and assistance in carrying it into effect.
>
> I am, on the other hand, to direct your attention to the progress which has been made and is now making in the erection of the new Houses, and to impress upon you the expediency from time to time of making such arrangements with Mr. Barry on points involving any interference with the structure of the building as shall at the same time secure the best means for giving effect to your plans, and render any recourse to alterations and extra works unnecessary.[202]

These instructions created considerable scope for misunderstandings. Although both parties were urged to inform the other about their plans and progress from time to time, and to support the endeavors of the other as far as possible (in a further letter Reid was also instructed to defer to Barry in questions regarding the solidity and architectural character of the building[203]), nonetheless the hierarchy between the two positions, the relative dovetailing of their two tasks, who bore final responsibility, and which entity would mediate should it come to disagreements between them all remained vague.

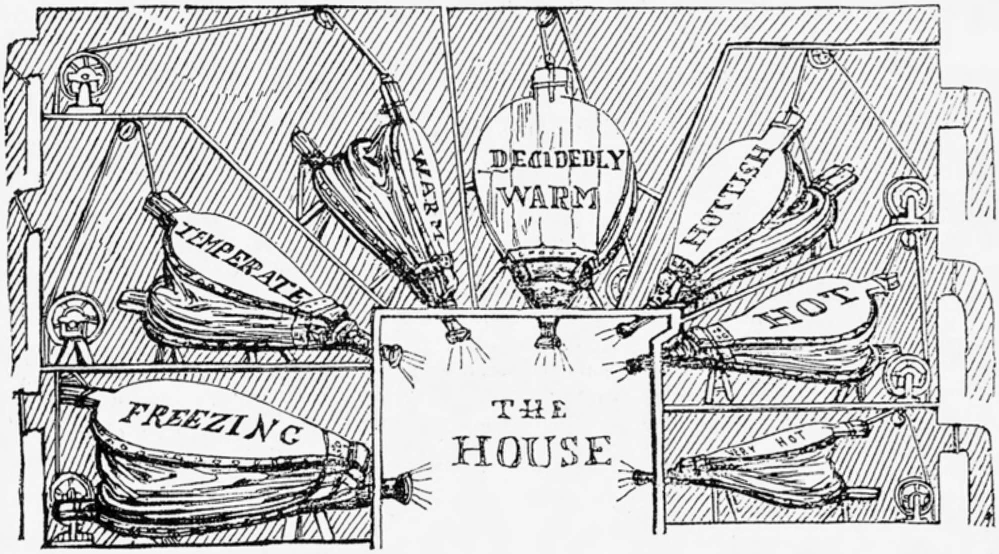
The upshot was a division of labor that was undoubtedly unique in modern architectural history. On the one side was Barry, who at the time of his appointment could look back on a long and successful career as an architect of churches, country homes, and club houses, and had been instructed to design a new parliament building according to the traditional rules of the art of building. On the other was Reid, who for lack of a professional title was often referred to as a "ventilator," charged as an independent figure with the job of realizing certain atmospheric conditions within the same building. Deploying no less constructional means but on a far less confident footing, he had to guarantee the climatic essentials for the successful workings of parliament.[204] As was to be expected, this constellation soon created problems, forming the basis of a quarrel that would unfold over the next five years and last until the 1850s, involving dozens of parliamentary commissions and the British press, and which at its climax even obliged the British prime minister to take sides in an architectural dispute.[205] Due to the prestige of the object involved and the institutional background, this controversy produced thousands of pages of documents—from discussion minutes to expert reports and newspaper articles—giving a unique insight into the hopes and difficulties associated with climate technology in the mid-nineteenth century.

The precise origins of the differences between Barry and Reid can no longer be reconstructed, but they broke to the surface in 1843 and 1844 with the first building delays when both sides addressed the commissioner responsible with complaints about each other's professionalism and willingness to cooperate. Barry criticized, amongst other aspects, that Reid's claims to space were completely excessive, that he had failed to produce drawings outlining his requirements, and in general was incapable of reading architectural plans. Reid, for his part, bemoaned the fact that Barry's architectural drawings were unfit for his purposes and that Barry kept inserting major changes without informing him about them.[206] In early 1845, the difficulties on the building site of the House of Lords came to a head and work on what was by far the most ostentatious palace area began to fall seriously behind schedule. While Reid claimed that Barry's planning was blocking essential installations and piping, Barry complained that his counterpart's innumerable flues and apertures were torpedoing the design and endangering fire safety. Verbal confrontations evidently ensued between the two men, because as of mid-1845 both of them refused to communicate except in writing, and later in any form whatsoever.[207] This led to the absurd situation where over a certain length of time two protagonists undertook works on the same building, independently of one another and each armed with their own plans. Consequently, rival groups of workers under the architect and the ventilator literally obstructed each other: "For instance," reported Reid, "sometimes the men working in my flues will encounter others who have penetrated them from the gas flues. At one time we found the vitiated air flue connected with the fresh air flues. At other times we have found openings knocked in the wall and the flues rearranged in connection with the gas operations, and all this during the sitting of the Houses, without any intimation being given to me."[208]

Due to the continuing confrontations, both chambers initiated enquiries, thereby entangling architectural with political differences. Whereas the House of Commons tended to support the ventilator, the members of the House of Lords—who were far less happy with conditions in their temporary residence—demanded that all authority be transferred to the architect.[209] At the same time, the catastrophic conditions on the country's most famous building site did not fail to catch the public eye. Both the daily press and the recently emerging professional journals, such as *The Builder*, began to show an interest in what was happening with the new building. Due to the newfangled character of his remit and the proverbial fugacity of his working material, most opinions were unsupportive of Reid, who faced an endless barrage of air puns. Thus, the London *Times* referred to him simply as "the great puffer" (May 27, 1846), or, in reference to the Catholic officer who had tried to blow up the Houses of Parliament in 1605, as the "arial Guy Fawkes," whose "ventilation whimsies" were the sole cause of the delays and thus endangered nothing less than the very welfare of legislative authority (August 17, 1846). → Fig. 29 Reid tried to defend himself against these defamations, but without much success—the type and scale of his plans were too alien to the broad mainstream.[210] Meanwhile, in early 1846, work on the palace ground to a complete halt; the situation between Barry and Reid had obviously become irretrievably deadlocked. The government commissioner was asked during one of the numerous boards of enquiry, "Is not it your impression that it is impossible for these two gentlemen to work on together satisfactorily?" to which he candidly answered, "I am afraid so."[211]

But where precisely lay the problem? Why did the cooperation between Reid and Barry fail so spectacularly? Why did contemporary observers feel that a successful solution was impossible to find? Is there a reason beyond the complexity of the program, the unhappy division of responsibilities, and the claimed complicated

DR. REID'S PROCESS.



Some curiosity has been excited in the public mind to know what is really the process by which Dr. Reid proposes to blow, not only hot and cold, but all the intermediate degrees of tepid, freezing, and temperate, into the Houses of Parliament. We can only conceive that he contemplates suspending a series of bellows in the roof of the building, all of which will be worked by machinery hung on ropes, and running along upon pulleys. The ropes may be so arranged that any member may pull one of them as he would a bell, and thus discharge upon himself any amount or quality of atmosphere he may feel a fancy for. Lord Brougham, who is very fond of an opportunity of giving himself a puff, will thus be always in a position to indulge in his favourite luxury.

One would imagine that such a contrivance as that we have described would hardly justify the extreme self-conceit of Dr. Reid, the originator of the plan; but it must be remembered that the self-importance and conceit of the man who blows the bellows, have become the subject of a proverb. There is, it will be seen, every kind of air in Dr. Reid's atmospheric catalogue, but one. We need scarcely say that the single air which is wanting is the air of practicability.

29
One of numerous caricatures of David Boswell Reid's plans from the satirical magazine *Punch*, 1846

characters of both men that explains why their cooperation so magnificently miscarried? Besides these ultimately contingent reasons, another key factor in the clash between Reid and Barry can undoubtedly be found in the fact that they personally embodied two completely contrary ideas of architecture. What became manifest in the new British parliament building and the special division of tasks—and finally escalated to breaking point—was therefore not merely a personal disagreement, but rather a growing, decades-long conflict between customary architectural principles, on the one side, and the operative principles of climate control, on the other. From this perspective, the controversy over the Houses of Parliament is as singular as it is paradigmatic. The perhaps unique historical constellation, in which the lead architect was placed opposite an independent ventilator, openly reveals the participants' differing approaches as well as the difficulties in making them compatible with each other. Perhaps more clearly than ever before, what the episode shows is the way in which central heating and ventilation procedures involved the arrival not only of new technical systems but also new actors and new knowledge.

The influence of these new protagonists had already been mirrored in the composition of the planning commission for the new parliament building, which along with architects included experts in medicine, engineering, and the natural sciences. This new ascendency then became evident—ultimately disastrously—in the personal constellation that placed someone completely alien to the architectural discipline alongside Barry and invested him with equal rights to intervene in the building designed by Barry. From the outset, Barry tried to assert himself against this directive, and thus preserve his right to his role as *architéktos*, in other words as the chief builder. As opposed to Reid, he firstly could rely on the support of an established profession, both in the form of his colleagues—who argued in favor of the ancestral rights of their guild before the commissions of enquiry—and in the form of the emerging professional press. "[I]t is too bad that an architect's operations should be suspended, his designs altered, and his views interfered with," wrote for instance *The Builder* on 28 June 1845 about the quarrel and Reid's persistent attempts to exert influence over the building process. Secondly, simply by force of his working materials, Barry was in a position to create permanent realities that were difficult to alter. This power of the architect to establish irreversible facts was something Reid would specifically criticize in the course of the dispute. "[P]ermit me to say," he complained during the hearings, "that he who has the power of bricks and mortar has built a case against me."[212] In the last resort, it was this tradition and stalwart authority that would prevail in the quarrel over the Houses of Parliament. A good five years after building work had begun, and due to the continuing delays, the ventilator was stripped, bit by bit, of his role and it was transferred back to the architect. Following decisions in 1846 and then 1852, Reid first lost responsibility for the House of Lords and finally for all of the rest of the building to Barry.[213]

While disagreeable protagonists can be countered like this with bricks and mortar and administrative measures, things proved more difficult regarding their knowledge. As opposed to Barry, who never wrote about his practice, Reid had, from the beginning, recorded his work in publications. Since the early 1830s, he had authored a series of successful chemistry textbooks, and with his involvement for the British parliament he had additionally begun disseminating his knowledge of the climatic and acoustical design of interior spaces in short articles.[214] In the mid-1840s, shortly before the clash with Barry escalated, Reid had combined these forms of publication into a 450-page treatise with the title *Illustrations of the Theory and Practice of Ventilation*. Conceived as a theoretical and practical primer on the topic of artificial ventilation, the book equally represented a polemic on the ventilator's understanding of architecture. Even in the passages that do not deal with the Houses of Parliament, the dispute that was concurrently arising on the building site shines through. After having already criticized architecture's concentration on the aspects of shelter, stability, and beauty in the introduction, in a chapter titled "Architecture and Ventilation," Reid goes as far as to demand a root-and-branch realignment of the classic principles of design: "[T]he architect shall always design in unison with the principles of ventilation, and make them a primary, instead of a mere secondary, consideration, in his structural arrangements."[215]

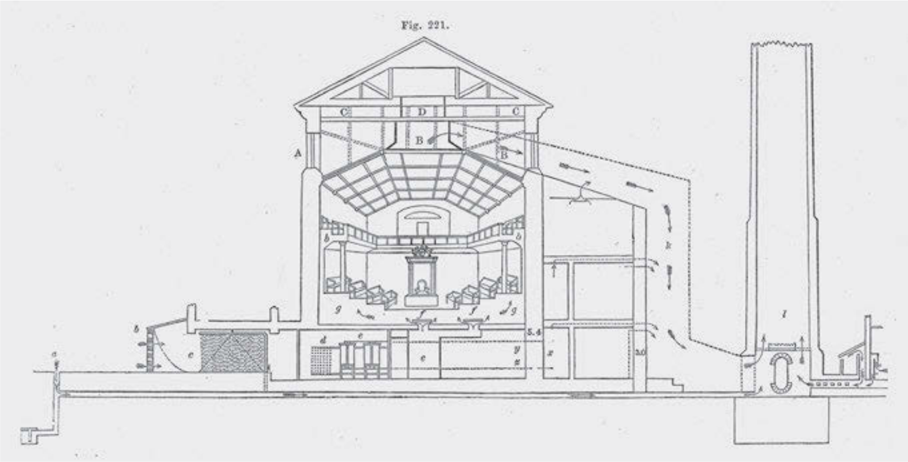
Reid's *Illustrations* was intended to provide a detailed scientific basis for his call for a re-evaluation of building practice. With reference to scientific authorities such as Joseph Priestley, Antoine Lavoisier, or Thomas Tredgold, and to his own experiments, Reid develops a broad theory of heating and ventilation that is significantly based on the concept of atmosphere. His constant point of reference is the various surrounding air ambiences in which humans exist—be it those of the Earth, the city, or a building—and the physical and chemical processes that continuously cause changes within them. "We live at the bottom of an arial ocean,"[216] he writes, in order to make his readers comprehend that they are permanently immersed in a fluid on which not only their respiration depends but also via which they experience sensations such as heat, light, or sound. From this follows the ideal of an architecture that primarily serves to provide and regulate air. And if Reid could not achieve this ideal in the London Houses of Parliament, there was nothing stopping him propagating it in his book in the form of a radical designation of built space:

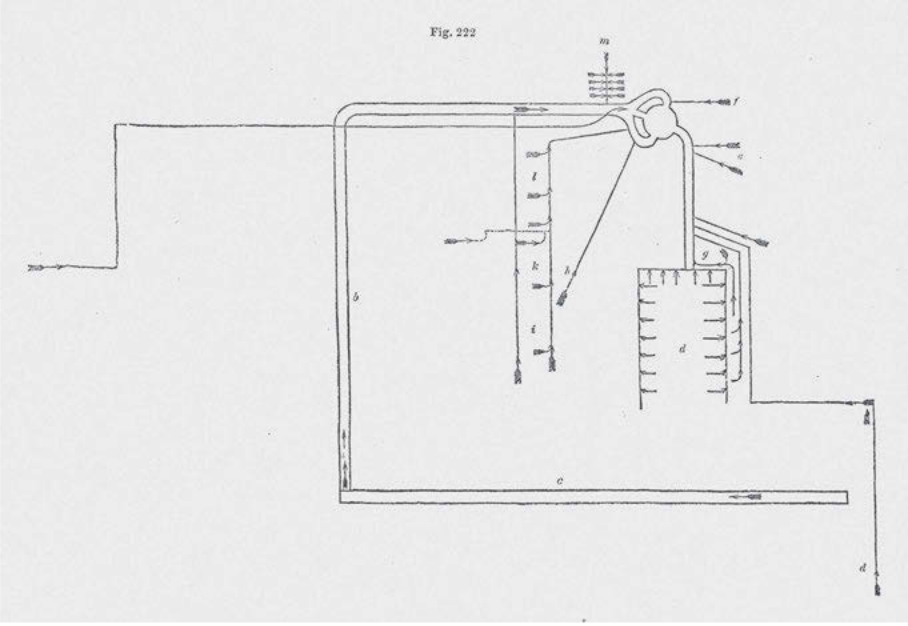
> After all, though the invisible air is too apt to be forgotten amidst the more obvious attractions of architectural art, still, in a practical point of view, the visible structure is only the shell or body of that interior atmosphere without which existence could not be supported, while it is also the medium of intellectual communication, and the channel through which heat, light and electricity convey their influence upon the human frame. It is no exaggeration to say, that along with those means of defence and seclusion which they naturally present, the great and primary object of architecture is to afford the power of sustaining an artificial atmosphere, such as the constitution under each variety of local circumstances may require.[217]

Architecture as the mere envelope of an inhabited atmosphere—with this definition Reid, on the one hand, anticipated later theoretical developments by many decades, and on the other, he summarizes a concept in the mid-nineteenth century that had been looming since the late eighteen century. The origins of the idea of viewing air as an independent feature in architecture can be traced back to the early endeavors in artificial ventilation in the infirmary plans of Maret, Tenon, and Le Roy with which the current analysis opened. More sharply formulated, and updated with the newest natural-scientific findings, Reid articulates a now matured view that that built space should no longer be comprehended only as a constructional, aesthetic, or functional context, but equally as a climatic one.

It is demonstrated in numerous ways in *Illustrations* that this was not devoid of consequences for the conceptualization and design of what Reid described as architecture's "visible structure." What is above all striking are the over 320 illustrations in the book in which the architectural object is not only reduced to a small number of stylized elements, with the invisible movement of air within them visualized using innumerable arrows, but that it is moreover abstracted to schemata containing—similarly to a wiring diagram—only the topological information relevant for the building services.[218] → Figs. 30–31 Equally significant is the effort made in the book to explain the processual character of air-conditioned rooms by resorting to tangible analogies. At one point Reid likens the ventilated building to a musical instrument, at another to a sailing ship, because in neither case is the object a finished work, rather both can only fulfill their purpose by virtue of constant attention and care.[219] But Reid's approach becomes clearest in those passages where he describes buildings as "apparatuses" or "machines." With these expressions he again occupies a lineage stretching back to the pioneers of climate control. However, while Benjamin Franklin compared the domestic space to an air pump in order to emphasize the negative consequences of badly conceived fireplaces, with Reid this device had advanced to become a design model. "The movement of air," he writes about the work on the temporary House of Commons, "from its ingress to its egress, was regulated as in a pneumatic machine, the house, in this respect, being treated as a piece of apparatus."[220]

Set against this background, it becomes evident why the cooperation between Reid and Barry was doomed to fail, why their disagreements led to such an impasse. It was the equal division





30–31
Section and schematic diagram: the ventilation system in the temporary House of Commons in *Illustrations of the Theory and Practice of Ventilation*, 1844

of responsibilities between the architect and the ventilator itself that robbed them of the basis to work jointly in that it led to the explication of two different paradigms. Whereas Barry attempted to design a parliament building that was as ostentatious as it was functional, Reid, as his counterpart, concentrated purely on specific atmospheric conditions and processes. This made each door, each stair, each ornament, every single building element in Westminster Palace into a potential cause for argument, because each and every one no longer only belonged to the traditional architectural order but simultaneously was also part of a new and purely operative logic of climate control. How deeply the rifts between these two positions ran emerges at the latest in the images used. Whereas contemporaries labeled the projected building a machine due to its innumerable specifications, the idea of a machine suggests itself to Reid precisely in the concentration on the specific aspect of climate. Barry and Reid, it could be said, not only worked on the same construction site with stone and mortar on two different buildings, they also worked on two contrary architectures of knowledge.

1 Maret, "Lettre de M. Maret."
2 Maret, "Mémoire sur la construction." The treatise is appended to Soufflot's letter dated April 21, 1780. See also Lamarre, "Le Médecin."
3 Maret, "Mémoire sur la construction," 33–41. Maret fails to give references for his assumptions concerning the movement of air, but they nonetheless accord with the Newtonian-influenced natural philosophy of the eighteenth century that considered fluids as a mixture of particles that individually obeyed the laws of mechanics. For an overview, see Calero, *Fluid Mechanics*, 1–41.
4 Maret, "Mémoire sur la construction," 45–48.
5 See Siegert, "Waterlines."
6 See Emmons and Frascari, "Making Visible the Invisible."
7 See Shapin and Schaffer, *Leviathan*.
8 Sloterdijk, "Airquakes," 41.
9 Ibid., 15–21. See further Latour, "air."
10 See Guillerme, "Water for the City," 14–16.
11 See Fortier, "Politique de l'espace parisien," 53–55.
12 On this point, see the essential texts Etlin, "L'Air"; Kisacky, "Breathing Room."
13 Creighton, *History of Epidemics*, 93–94.
14 Pringle, *Hospital and Jayl-Fevers*, 4–8, 48; Janssen, *Letter*, 47–50.
15 See Selwyn, "Sir John Pringle."
16 Pringle, *Diseases of the Army*, 102–5, 132.
17 Ibid., viii.
18 Ibid., 121–35.
19 Hales, *Description of Ventilators*, x, 15–23. A similar apparatus, based on the principle of the fan propeller, was presented to the Royal Society in 1734 by the French native natural philosopher John Teophilus Desaguliers with the title "An Account of an Instrument or Machine for Changing the Air of the Room of Sick People in a Little Time." See Desaguliers, "Account," 564–68.
20 Hales, *Description of Ventilators*, 39.
21 See Hales, *Treatise on Ventilators*, 14–31, 62–63.
22 See Pringle, "Account."
23 See Allan and Schofield, *Stephen Hales*, 8–19, 38–43.
24 Hales, *Vegetable Staticks*, v.
25 Corbin, *Foul and the Fragrant*, 11.
26 See Riley, *Avoid Disease,* 15–19.
27 See Tidd, *Aeolus*. A discussion about spatial and architectural instruments is to be found, for instance, in Duhamel de Monceau, *Moyens*, 215–26, and Hanway, *Serious Considerations*, 48–58. For an overview, see Kisacky, "Breathing Room," 253–72.
28 See Crosland, "'Slippery Substances'"; Perrin, "Chemical Revolution," 267–68.
29 See Perrin, "Chemical Revolution," 270–73.
30 Lavoisier, "Mémoire," 576–79.
31 Ibid., 580–81. On Lavoisier's involvement in spatial issues, see also Duveen and Klickstein, "Lavoisier's Contributions."
32 Franklin, "Letter to Dr. Ingenhousz," 5. The letter is dated August 28, 1785 and was read before the American Philosophical Society on October 21 the same year.
33 See Klooster, "Franklin and Lavoisier." Franklin's preoccupation with questions of ventilation is above all evident in his joint work with the Scottish physician Alexander Small. See Oberg, *Papers of Benjamin Franklin*, 283–85.
34 For an overview, see Donaldson and Nagengast, *Heat & Cold*, 25–29; and, with a focus on France, Gallo, "Modernité technique," esp. 130–57.
35 For the background history of the letter, see Doren, *Benjamin Franklin*, 727–28.
36 See Edgerton, "Franklin Stove," 207.
37 Franklin, *New Invented Fire-Places*, 23.
38 Ibid., 5, 10.
39 Gauger*, La Mécanique du feu*, 3–15, 30–44. In the process Gauger highlighted not only the heat-transferring but the health-promoting properties of air, and by mentioning the possibility of feeding it into adjoining rooms thought out the basic features of central heating. Ibid., 42–43, 57–60. See further Faber, *Entwicklungsstufen der häuslichen Heizung*, 50.
40 Gauger, *La Mécanique du feu*, 217.
41 Clare, *Motion of Fluids*, 220–26.
42 See Desaguliers, *Experimental Philosophy*, 208–9, 556–68.
43 Franklin *New Invented Fire-Places*, 8, 29. See also Cohen, *Franklin and Newton*, esp. 243–66.
44 On the comparable process of the convergence of technical objects and its roots in the shrinking of the intervals between science and technology, see Simondon, *Mode of Existence*, 19–22.
45 [Anderson,] "Smoke," 607. Five years after the article, an expanded version appeared, extended with constructional advice for masons and architects. See Anderson, *Practical Treatise on Chimneys*.
46 [Anderson,] "Smoke," 607.
47 Ibid., 611–12.
48 Ibid., 610.
49 Ibid., 610–11.
50 Announced in 1782, the book was first published in 1788 after Whitehurst's death based on bequeathed manuscripts. For the announcement, see Whitehurst, *Works of John Whitehurst*, 14–15. On the

posthumous publication, see the foreword by the editor and physician Robert Willan in Whitehurst, *Ventilation of Rooms*, n.p.

51 See Craven, *Derby Townhouse*, 40–51, 100–102, 118–19.

52 See Latour "Circulating Reference."

53 Whitehurst, *Ventilation of Rooms*, 5.

54 Ibid., 7–9. Whitehurst possibly served as an advisor to the architect Sir Robert Taylor for the heating system in the Bank of England. See Craven, *Derby Townhouse*, 118–19.

55 Whitehurst, *Ventilation of Rooms*, 28–29.

56 See Helden, "Modern Scientific Instrument," 62, 67.

57 Franklin "Letter to Dr. Ingenhousz," 10.

58 Ibid., 6–7. Such experimental instructions are also to be found elsewhere, an early and extensive example being the treatise on chimneys by the French physicist Léopold de Genneté. See Genneté, *Nouvelle construction de cheminée*.

59 See the summary in Salaün, "Hôpital et utopie." Despite occasional inaccuracies, the most comprehensive description of the discussion is still to be found in Candille, "Projets de translation."

60 For an overview, see Akehurst, "Hospital Architecture."

61 Petit, *Mémoire*, 1–2.

62 Ibid., 14.

63 See Candille, "Projets de translation," 351–55.

64 Coquéau and Poyet, *Mémoire*, 32.

65 See Greenbaum, "Tempest in the Academy," 123–25.

66 Le Roy, "Précis," 598. According to Le Roy, the gap between the first formulation of his ideas and their publication lasted many years. Based on this, he had already developed the concept for a hospital in 1773 that he then had the architect Charles-François Viel draw up in 1776 and presented to the Académie des sciences on April 9 and May 10, 1777. However, these lectures were neither documented nor published. On this point, see Greenbaum, "Tempest in the Academy," 127–31.

67 Le Roy, "Précis," 594. Here, Le Roy alludes, on the one hand, to the guest pavilions of the Château de Marly, Louis's XIV's hunting palace, and, on the other, he refers to the work of John Pringle, who he had explicitly named a few pages earlier and two of whose texts he had already translated in the 1770s. At this time hospital wards arranged as single buildings already existed in both England and France, although Le Roy was not necessarily familiar with them. See Greenbaum, "Tempest in the Academy," 136–37.

68 Le Roy, "Précis," 594.

69 Ibid., 595–97. The application of similar ventilation pipes, albeit for sucking air in, had already been suggested in 1783 by Le Roy for prisons and apartment buildings. See Le Roy, "Mémoire."

70 See Greenbaum, "Jean-Sylvain Bailly."

71 See Greenbaum, "Commercial Treaty."

72 See Greenbaum, "'Measure of Civilization,'" 43–44.

73 See ibid., 48–49.

74 Tenon, *Mémoires sur les hôpitaux*, 186–89.

75 Ibid., 393.

76 Ibid., 216, 393.

77 Tenon to the Faculty of Medicine, Edinburgh, August 27, 1788, BNF, NAF 11357, 19.

78 Tenon to the Academy of Sciences, St Petersburg, September 11, 1788, ibid., 129–30.

79 Vidler, "Confinement and Cure," 61; Middleton, "Sickness, Madness and Crime," pt. 1, 20.

80 Cited after Béguin, "La Machine à guerir," 39.

81 Ibid.

82 See Le Roy et al., "Rapport"; Delambre, "Notice."

83 See J–B., "Leroy (Jean-Baptiste)"; Kafker, "A List of Contributors," 112.

84 Tenon to the Academy of Sciences, St Petersburg, September 11, 1788, BNF, NAF 11357, 129–30. The first edition of *Les Machines à guérir* contains a quote from Tenon with the phrase, "La plus complète, la plus austère et la plus simple des machines à guérir." See Fortier, "La Politique de l'espace," 75. Nevertheless, this quote is not sourced and was cut from the second revised edition of the volume. A further quote from Tenon, prefaced to both editions as a motto, is reproduced with the phrase "*machines à traiter les maladies*." In the original, however, the passage uses the expression "*manufactures pour traiter les maladies*." Tenon to the Faculty of Medicine, Edinburgh, August 27, 1788, BNF, NAF 11357, 19.

85 Pieter van Musschenbroek's *Essai de physique* for instance contains a five-page "Liste de diverses machines, de physique, de mathematique, d'anatomie, et de chirurgie," including, right at the beginning, various "*pompes*" or "*machines pneumatiques*." Musschenbroek, *Essai de physique*, 1–8 (appendix). In the *Dictionnaire universel de mathematique et de physique*, on the other hand, the term "*Machine pneumatique*" is explained as: "Physical machine used to

pull air out of vessels & compress it inside them. It serves to conduct experiments to study the properties & effects of air." The entry, as was customary, goes on to differentiate between simple ("*Machine pneumatique simple*") and combined machines ("*Machine pneumatique composée*"). "Machine pneumatique," 102–3.

86 Le Roy, "Précis," 597–98.

87 *Extrait des registres de l'Académie royale*, 98.

88 Besides Le Roy, the list of attendees for December 2, 1786 includes numerous other members of the hospital commission, because the final part of the first report was presented the same day. See "Samedy 2. Decembre."

89 In the summer after his departure from France, Franklin sent Le Roy the second volume of the *Transactions of the American Philosophical Society*, and his accompanying letter explicitly pointed to the open letter printed in it to their mutual friend Jan Ingenhousz, containing the said comparison. See Franklin to Jean-Baptiste Le Roy, August 15, 1786, Papers of Benjamin Franklin. Vice versa, in October 1788, Franklin received a copy of his *Précis d'un ouvrage sur les hôpitaux* from Le Roy. See Franklin to Jean-Baptiste Le Roy, October 25, 1788, ibid. The two scientists had been friends since the early 1750s and exchanged letters and writings for almost forty years. See Doren, *Benjamin Franklin*, 657–58.

90 On this, see the contributions in Gooding, Pinch, and Schaffer, *Uses of Experiment*.

91 See (dedicated to the "machines of physics") Galison, *Image and Logic*, xvii, 1–7.

92 See Rheinberger, *History of Epistemic Things*, 24–37.

93 See Béguin, "La Machine à guerir," 39–40.

94 See Greenbaum, "Jean-Sylvain Bailly," 274–75.

95 Parts of this and the following two chapters are based on Gleich, "From Storage to Transmission."

96 See Fitton and Wadsworth, *Strutts and the Arkwrights*, 169–90.

97 See Hacker, "William Strutt"; Egerton, "William Strutt."

98 See Johnson and Skempton, "Strutt's Cotton Mills," 180–84; Johnson and Skempton, "First Iron Frames."

99 See Johnson and Skempton, "First Iron Frames," 176–78.

100 See Egerton, "William Strutt."

101 Cited after ibid., 81.

102 Cited after ibid., 78.

103 Sylvester was, amongst other roles, tutor to William Strutt's son Edward. He published numerous chemistry papers showing that he was a disciple of the still widespread caloric heat theory. See Inkster, "Charles Sylvester," 114–15.

104 Steele, *Ladies Library*; Hazlemore, *Domestic Economy*. The *Ladies Library* had already been appearing, minus the subtitle, since 1714.

105 On this, see Brunner, "Das 'Ganze Haus.'"

106 Sylvester, *Domestic Economy*, 1.

107 See Leveaux, *Derbyshire Infirmary*, 7–18. See also Elliott, "Derbyshire General Infirmary"; Stevenson, *Medicine and Magnificence*, 218–33.

108 Sylvester, *Domestic Economy*, 19.

109 Ibid., 53.

110 Ibid., 13.

111 See Bruegmann, "Central Heating," 144–46. For an overview of potential predecessors, see also Vetter, "Geschichte der Zentralheizungstechnik," 10–18. Industrial-archaeological artefacts would suggest that Richard Arkwright had already used a central warm-air system in his factories several years before Strutt, but whether they were actually part of the original construction or installed later remains unclear. See Arkwright Society, *Arkwright*, n.p.

112 See Musson and Robinson, *Science and Technology*; Inkster and Morrell, *Metropolis and Province*.

113 See Elliott, *Derby Philosophers*, 69–85.

114 Strutt, who also became a fellow of the Royal Society in 1817, was on friendly terms, amongst others, with the chemist Joseph Priestley, the author and inventor Richard Lovell Edgeworth, the porcelain manufacturer Josiah Wedgwood, and the steam engine manufacturers Matthew Boulton and James Watt—all of them members of the Lunar Society—as well as with the chemist and physicist John Dalton, the brothers Jeremy and Samuel Bentham, the paper manufacturer Charles Bage, and the cotton industrialist and utopian Robert Owen. See Egerton, "Achievements of William Strutt," 153–83. On Strutt as a "*savant-fabricant*," see also Jones, *Industrial Enlightenment*, 125.

115 See, on this, Stewart, "Experimental Spaces."

116 St Helens House, built in 1767 by Joseph Pickford in Palladian style, was acquired by Strutt in 1803 and extensively remodeled. See Craven, *Derby Townhouse*, 93–94.

117 For the library holdings of the Derby Philosophical Society, see Robinson, "Derby Philosophical Society."

118 See Craven, *John Whitehurst*, 225–336.

119 See ibid., 79–81, 100–102.
120 See Tann, *Development of the Factory*, 149–69.
121 Heathcoat, Method of combining machinery.
122 The main difference to the Derby Cotton Mill is that in the Belper North Mill both the supports and the beams are made of iron, making it one of the first multi-story buildings with a completely iron frame. See Johnson and Skempton, "First Iron Frames," 178–83.
123 Sylvester, *Domestic Economy*, 12–13.
124 Ibid., 45–46.
125 Van Kannel, Storm-door structure. For the history of the revolving door, see Buzard, "Perpetual Revolution."
126 Sylvester, *Domestic Economy*, vi. A similar mechanism had been installed thirty years earlier by the prison reformer John Howard in the wards of London's Guy's Hospital, built by William Blackburn. See Howard, *Principal Lazarettos*, 135–36. In around 1800 it apparently achieved a certain popularity and became known abroad as the "English method." See the corresponding report in Wellens-De Donder, *Enquête sur les hôpitaux*, 117–18.
127 Sylvester, *Domestic Economy*, 49.
128 See Egerton, "William Strutt," 84–85.
129 See Elliott, "Derbyshire General Infirmary," 85–86.
130 Schinkel, *English Journey*, 134.
131 Ibid., plate 118.
132 Phillips, *Personal Tour*, 119.
133 Buchanan, *Essay*, 7. See further Buchanan, *Practical and Descriptive Essays*; Buchanan, *Treatise*.
134 In his 1817 *Remarks on the Construction of Hothouses*, John Claudius Loudon, for instance, discusses not only the suitability of various heating and ventilation methods for botanical purposes but repeatedly refers to the possibility of transferring them to living spaces. On this, see also Valen, "On the Horticultural Origins."
135 As with air-heating systems, there is also a series of apocryphal forerunners for steam and warm-water systems, but a continuous development only started at the turn of the eighteenth to the nineteenth century. For key accounts, see Bruegmann, "Central Heating"; Manfredi, *La scoperta dell'acqua calda*. On the delayed introduction of central heating techniques in France, largely based on English models, see Guillerme, "Chaleur et chauffage"; Gallo, "Nouveaux modes de chauffage."
136 Bernan [Meikleham], *History*, 1:vi. For Meikleham's biography, see Dickinson and Gomme, "Robert Stuart Meikleham."
137 See Billington, "Heating and Ventilating," 122.
138 For more information on Chabannes, see the section "The Project for the Construction of New Houses" in this book.
139 See Meade and Saint, "Marquis de Chabannes," 204–5. The patents from 1815 were submitted under the titles "Extracting from fuel a larger quantity of caloric than ordinary, and applying it to warm several rooms by one fire" (British Patent 3,875) and "Conducting air, and regulating the temperature, in houses and other buildings, and warming and cooling either air or liquids" (British Patent 3,963). See Woodcroft, *Alphabetical Index*, 96.
140 Chabannes, *Explanation*, 5–6.
141 Ibid., 43.
142 See Meade and Saint, "Marquis de Chabannes," 209.
143 See *Oxford Dictionary of National Biography* (2004), entry "Tredgold, Thomas."
144 See Addis, "Use of Scientific Calculations," 135.
145 Tredgold, *Principles*, 46–76. With his minimum air quantity, Tredgold established a norm on which numerous successors would work further. See Browne, "L'Air du logement," 71–84.
146 Tredgold, *Principles*, 18–19.
147 On Meyler and the general attention paid to ventilation, see Janković, *Confronting the Climate*, 84–91.
148 Chabannes, *Explanation*, 5.
149 Meyler, *Observations on Ventilation*, 2.
150 Ibid., 194.
151 Ibid., 184–94.
152 Engineer [Meikleham], *Theory and Practice*, 133–43.
153 Meyler, *Observations on Ventilation*, 176–77, 194.
154 Beddoes, *Observations*, 147.
155 See Stansfield, *Thomas Beddoes*, 145–74.
156 See ibid; Janković, *Confronting the Climate*, 119–50.
157 Kentish, *Account of Baths*, 8–12.
158 "Account of Baths," 62.
159 "Recent Patents," 26.
160 Vallance, *Observations on Ventilation*, 70–79. See also Vallance, *Letter*. The various patents that Vallance acquired in the 1810s and 1820s are listed in Woodcroft, *Alphabetical Index*, 582.
161 "Recent Patents," 28.
162 Bernan [Meikleham], *History*, 2:96.
163 See Spitzer, "Milieu and Ambiance," esp. 36–40. See further Canguilhem, "Living and Its Milieu."
164 Richardson, *Popular Treatise*, iii–iv, vii–viii, 53.
165 See Willmert, "Heating Methods." See also Hawkes, *Environmental Imagination*, 4–12.

166 Soane, *Lectures on Architecture*, 123–26.
167 Richardson discusses all the current methods of heating and ventilation, but not without, as was usual, giving preference to one particular system in the form of the high-pressure warm-water system developed by Angier March Perkins. Richardson, *Popular Treatise*, viii.
168 Arnott, *Elements of Physics*, 386–92; Loudon, *Encyclopædia*.
169 Richardson, *Popular Treatise*, iv, 26, 57.
170 Ibid., 28. For contemporary uses of the term "communication" in the sense of spatial connections, see, for instance, Chambers, *Civil Architecture*, 4th ed., 329, 412.
171 Richardson, *Popular Treatise*, 62.
172 See Kittler, "History of Communication Media."
173 Richardson, *Popular Treatise*, 72.
174 Ibid., 63.
175 Ibid., 12.
176 Ibid., 71, 74.
177 Ibid., 58.
178 See Krämer, *Media, Messenger, Transmission*, as well as Schabacher, "Rohrposten," with specific reference to a physical system of transportation.
179 Richardson, *Popular Treatise*, 65.
180 See, for instance, Gombrich, "Pictorial Instructions"; Lavarde, "La Flèche."
181 Gauger, *La Mécanique du feu*, 262.
182 See Emmons and Frascari, "Making Visible the Invisible," 90–93.
183 See Ladewig, "Geschicke des Pfeils."
184 See Krämer, "Operative Bildlichkeit," esp. 104–5.
185 Richardson, *Popular Treatise*, 2nd ed., 117.
186 See Stalder and Gleich, "Stirling's Arrows."
187 The following section is partly based on Gleich, "Architect and Service Architect".
188 For a fundamental overview of the history of the Houses of Parliament, the disastrous fire, and the new building, see Port, *Houses of Parliament*, and, specifically concerning the new building, Crook and Port, *King's Works*, 573–626. On Gothic Revival, see the overview in Bergdoll, *European Architecture 1750–1890*, 139–70.
189 See Wyman, *Ventilation*, 214–19; Billington, "Heating and Ventilating," 129.
190 Cited after "New House of Commons", 165.
191 Ibid.
192 Ibid., 166.
193 UK Parliament, *Ventilation of the Houses*. See also Inman, *Report of the Committee*.
194 See Reid, *David Boswell Reid*, 5–12; Port, *Houses of Parliament*, 219.
195 UK Parliament, *Ventilation of the Houses of Parliament*, 34–51.
196 Ibid., iv.
197 See in detail, Schoenefeldt, "Temporary Houses of Parliament."
198 Reid, *Brief Outlines*.
199 Crook and Port, *King's Works*, 603–4.
200 Ibid.
201 UK Parliament, *Ventilation and Lighting of the House*, 575.
202 Ibid., 575–76.
203 Ibid., 577.
204 The system developed by Reid for this purpose was essentially based on the same principles as in the alterations to the temporary assembly halls, albeit expanded to a far larger scale. His plans proposed emitting the smoke and the used air from all the parts of the building through a central tower in the middle of the palace. See Schoenefeldt, "Reid's Short-Lived Ventilation System," 167–68.
205 On this, as well as on the general role of scientific knowledge in the construction of the Houses of Parliament, see Gillin, *Victorian Palace of Science*, esp. 121–83.
206 UK Parliament, *Building of the Houses*, 5–16.
207 Ibid.; Crook and Port, *King's Works*, 616–17.
208 UK Parliament, *Ventilation and Lighting of the House*, 76.
209 See Crook and Port, *King's Works*, 225–28, 617–20.
210 Reid, *Ventilation*. Reid's short pamphlet was likewise subject to caricature. See, for instance, "Reid-Ventilation."
211 UK Parliament, *Building of the Houses*, 16.
212 UK Parliament, *Ventilation and Lighting of the House*, 49.
213 Crook and Port, *King's Works*, 618, 626.
214 In 1830, Reid published *Elements of Chemistry*, followed in 1836 by *Rudiments of Chemistry* as part of *Chambers's Educational Course*, both books going through numerous new editions up until the 1950s. For his contributions on climatic and acoustical questions, see, for instance, Reid, "Construction of Public Buildings"; Reid, "Reid's Lectures." In 1843, Reid also became a member of the Health of Towns Association headed by Edwin Chadwick, contributing an investigation into sanitary conditions in North-East England to its 1845 *Second Report into the State of Large Towns and Populous Districts*.
215 Reid, *Theory and Practice*, 70. Reid's publications after being dismissed as the ventilator of the Houses of Parliament show that this formulation was not simply a whim but a fundamental critique of the architectural profession. In 1855, he gave a lecture in London in which he compared style to an arbitrary dress and declared

the actual reality of architecture to lie in lighting, acoustics, and ventilation. See Reid, "Revision of Architecture." Following his emigration to America, a series of lectures appeared in which he described architecture as a profession in transition and detailed an architectural curriculum with its basic components consisting of chemistry, meteorology, physiology, and other natural sciences. See Reid, "Progress of Architecture."

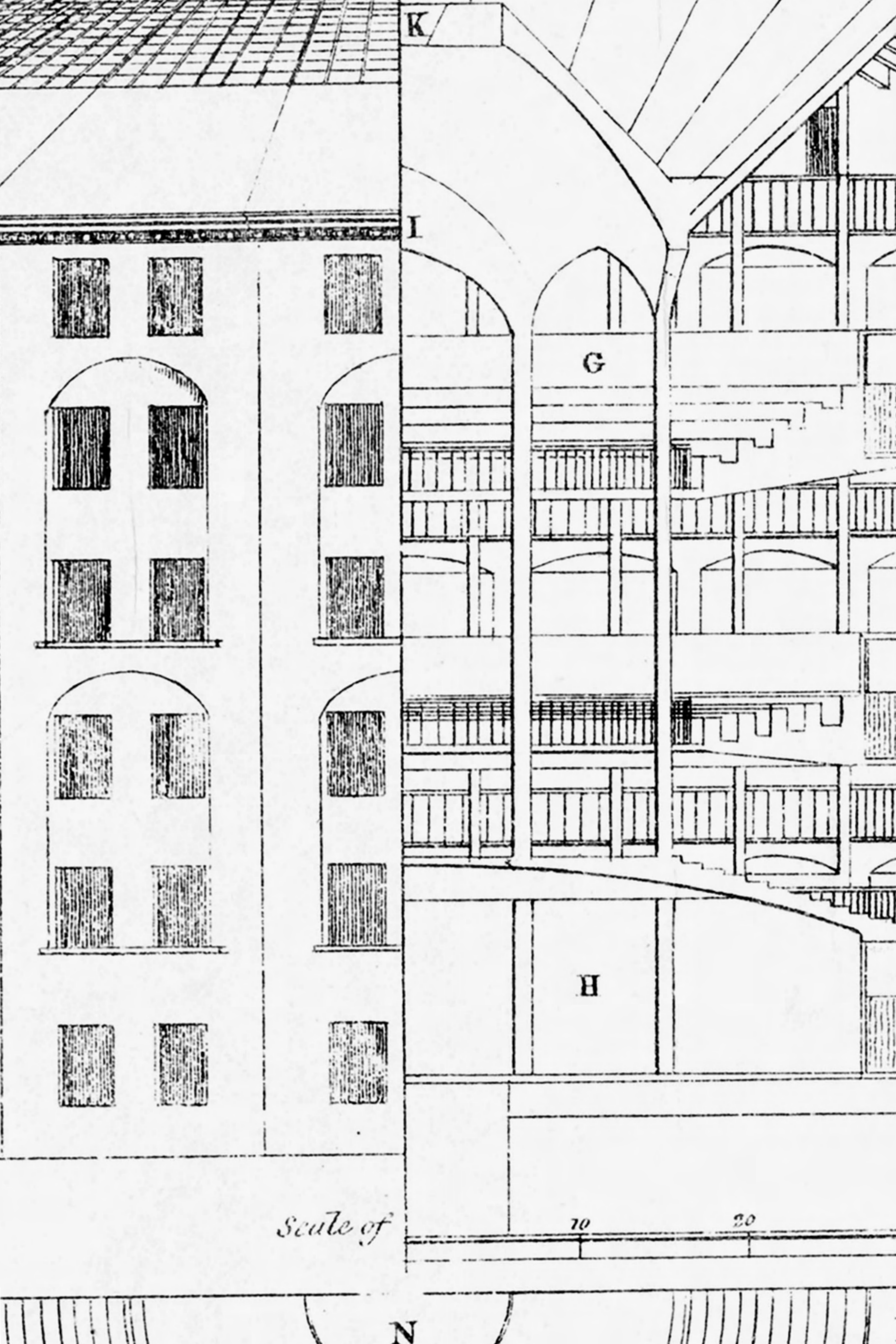
216 Reid, *Theory and Practice*, 142.

217 Ibid., 71.

218 Ibid., 442–47.

219 Ibid., xii–xiii, 294. For a similar comparison, see Wyman, *Practical Treatise on Ventilation*, 225.

220 Reid, *Theory and Practice*, 274. See also ibid., viii.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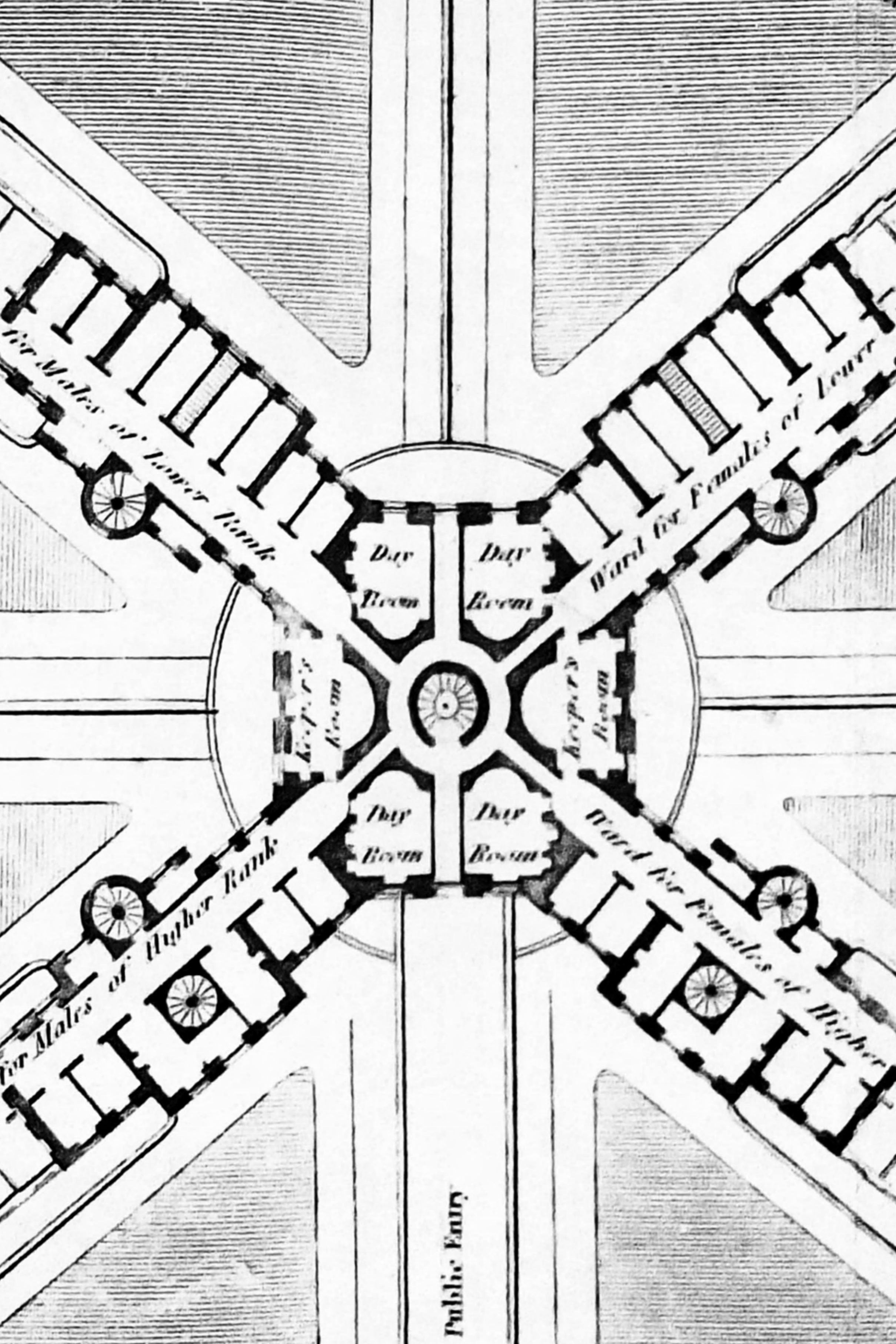
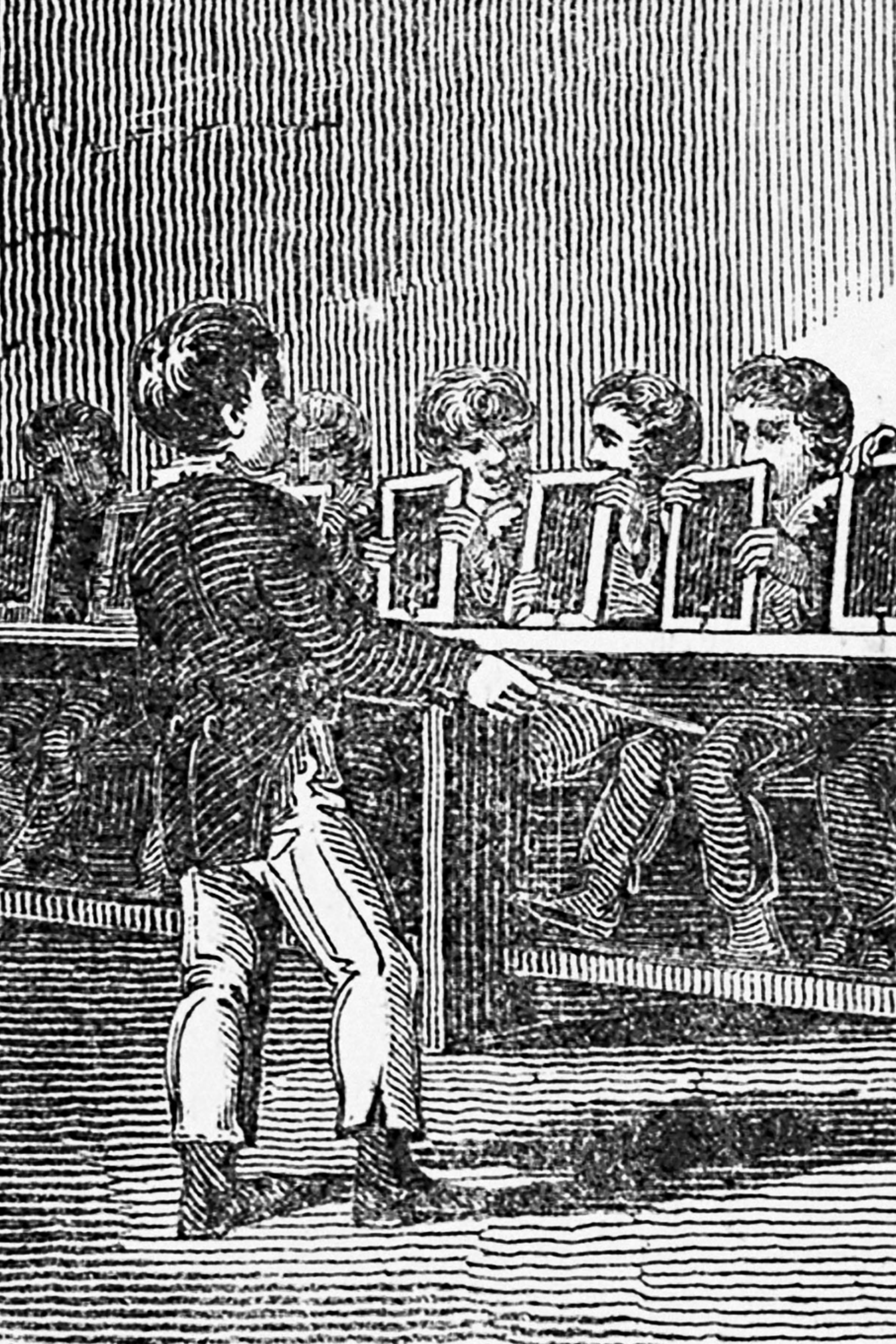


for Males of Lower Rank
Ward for Females of Lower
Day Room
Day Room
Keeper's Room
Keeper's Room
Day Room
Day Room
for Males of Higher Rank
Ward for Females of Higher
Public Entry

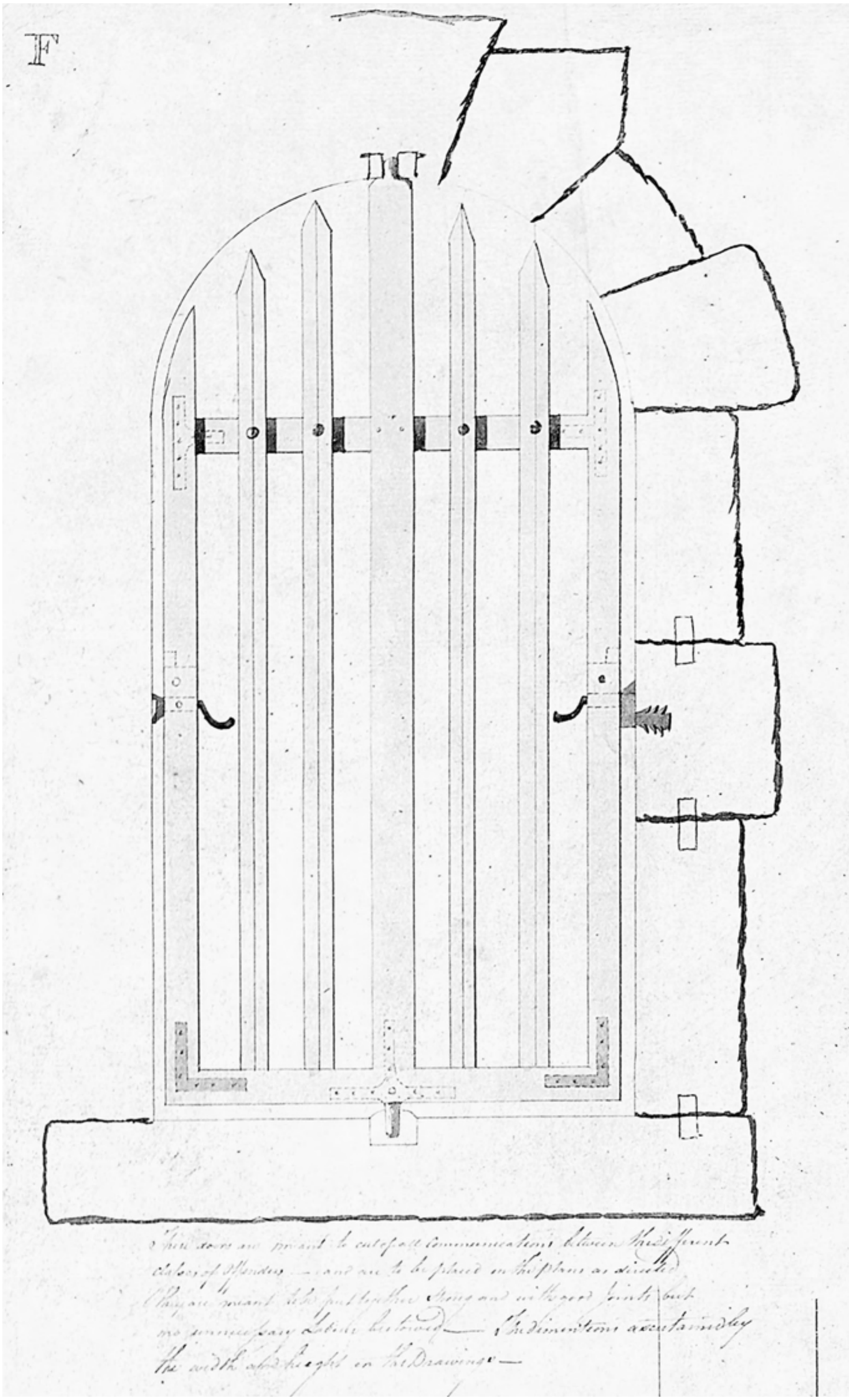


II. Morals

Evil Communication

At the beginning of 1785, the English architect William Blackburn wrote a seemingly paradoxical sentence on one of his plans. "These doors," he noted beneath a detail drawing, "are meant to cut of all communications between the different classes of offenders."[1] → Fig. 32 This sentence appears contradictory because while the properties of a door include its capacity to be closed, its purpose nonetheless involves it being openable and the state of being closed can be reversed again at any juncture. As a hinge, the door annuls the separation of two rooms established by a wall.[2] In architectural-theoretical terms, doors have correspondingly been traditionally considered as points of passage, connection, entrance and exit, whereby in the architectural discourse around 1800, it is precisely communicative terminology that is deployed to describe it—as a *means of communication* or simply *communications*.[3] In this sense, if one wanted to avoid any exchange between different rooms or various groups of people, even for a contemporary reader the obvious choice would have probably been a closed wall rather than a door. However, the object Blackburn spoke of was no ordinary door, and the building for which he conceived it was no ordinary architectural brief. In order to understand how this ostensibly contradictory proposal—to hinder communication through communication—came about, it is important to situate Blackburn's plan in the context of British penal reforms in the second half of the eighteenth century, and in particular among the intricate interconnections between architecture and the elastic term of "morals" that arose within this framework.

In 1783, Blackburn was commissioned by the county of Gloucestershire in South West England to prepare designs for a series of prisons to replace the aging local penal facilities. The initiative



32
An anti-communication device: door design
by William Blackburn, 1785

for this program of renewal originated above all with Sir George Onesiphorus Paul, the Oxford-educated son of a rich wool manufacturer. G. O. Paul had been elected High Sheriff of Gloucestershire in 1780, and shortly afterward had begun reforming the county's penal system.[4] The resultant Gloucestershire Act, which in 1785 empowered the county to build the planned facilities, was the first and most influential in a series of similar local initiatives and played an important role in the history of the overall British penal system. In the years prior to this, initial efforts had already been made to create a reformed and centralized prison system in Great Britain, 1779 having seen the passing of the Penitentiary Act, by which the national government was entrusted with the building of two large national prisons, one for men and one for women.[5] Although the law had a considerable indirect impact, it largely remained redundant and its stipulations were never realized. It was therefore initially left to limited local initiatives, such as that by G. O. Paul in Gloucestershire, to try and achieve the goals of the Penitentiary Act.

The contents of the Penitentiary Act originated to a considerable extent in the joint endeavors of the judge and professor of law Sir William Blackstone, the lawyer and state secretary William Eden, and the famous prison reformer John Howard. In 1771, Eden had published the book *Principles of Penal Law* in which he had considered the death penalty and public executions as inefficient and brutal, but prison sentences and deportations to penal colonies, on the other hand, as too publicly inconspicuous and as having too little deterrent value, and had instead suggested forms of continuous public punishment such as punitive labor on state building projects. Like many scholars, Eden was highly influenced by the Italian legal philosopher Cesare Beccaria, who had criticized the wide use of capital punishment in his 1764 *Dei delitti e delle pene* and instead pleaded for the principle of commensurability. Eden's ideas failed to find practical realization in Great Britain, but theoretical proposals like his made the topic of penal law a central plank in the political agenda of the era, raising it to an object of discussion moved by rational thought. Whereas Eden thus represents the worldly and legal-philosophical side of a generally emerging movement in penal reform, Howard stands as an exemplary figure for its religious and philanthropic side.[6] Howard had become High Sheriff of his home county of Bedfordshire in 1773, and in the same year had taken on the extensive prison inspections, the description of which in his 1777 *The State of the Prisons* made him one of the most reputable and influential reformers of his times. His book collects detailed reports of the architectural, administrative, and health conditions in several hundred prisons in England, Scotland, Wales, and other countries, including plans, empirical data, and proposed improvements. The core motivation in Howard's tireless journeys across Europe was his belief that the comforting and purification of sinners was a worldly fight against evil.[7] His work therefore represents the continuation of a long tradition of humanitarian interventions on behalf of prisoners, whereby given the increasing demands for a more apt and humane penal system his efforts fell on far more fertile ground.

This general sea change in opinion regarding the penal system was accompanied in the mid-1770s by a concrete event. With the onset of the American War of Independence, the British government was deprived of its accustomed destination for penal deportations. With this, imprisonment, which to date had primarily served for holding suspects and accused in custody or for the coercive detention of debtors and witnesses, became a serious penal policy alternative.[8] Up until then, one of the main reasons for the rejection of prison sentences and prisons had been that in multiple senses they were seen as loci for corruption. On the one hand, prisons were a threat to physical health, above all due to the rampant gaol fever within their walls. Based on the work of John Pringle, this was understood as an illness that was spread via tainted air and poisonous vapors, and that could only be eradicated through artificial ventilation. These illnesses were seen, first and foremost, as a danger to innocent persons working in or living close to prisons, but increasingly also came to be seen as a source of penal unruliness in that the arbitrariness of a deadly infection perverted the principle of proportionality. On the other hand, prisons were seen as endangering public morals, a threat that emanated both from the inmates themselves and from deficient administration. The placement of experienced hardened criminals together with petty first-time offenders was considered as problematic as the widespread corrupt behavior of the prison guards.

Early on, the physical and psychological processes of corruption in prisons were perceived as events determined by a joint dynamic: the phenomenon of contamination. Contemporary medicine was predicated on a belief in a link between moral behavior and physical well-being, explaining why hospitals incorporated numerous elements of an institutional penal regime. Conversely, prison reformers supported their initiatives by referring to the conceptual insights from the medical profession.[9] "[B]ad Habits," the lawyer and author Henry Fielding wrote as early as 1751 in a legal-theoretical essay, "are as infectious by Example, as the Plague by Contact." Many correctional institutions accordingly were nothing more than "Schools of Vice, Seminaries of Idleness, and Common-shores of Nastiness and Disease."[10] This presumption of a relation between pathological and psychological contagiousness was still held a generation later by Howard. At the end of a passage dealing with the causes and effects of gaol fever, he wrote: "The general prevalence and spread of wickedness in prisons, and abroad by the discharged prisoners, will now be as easily accounted for, as the propagation of disease."[11] This sentiment contained not only the promise to make the spread of wicked behavior as explainable as the spread of disease, but similarly an expectation that morals could be invigorated just as health could.

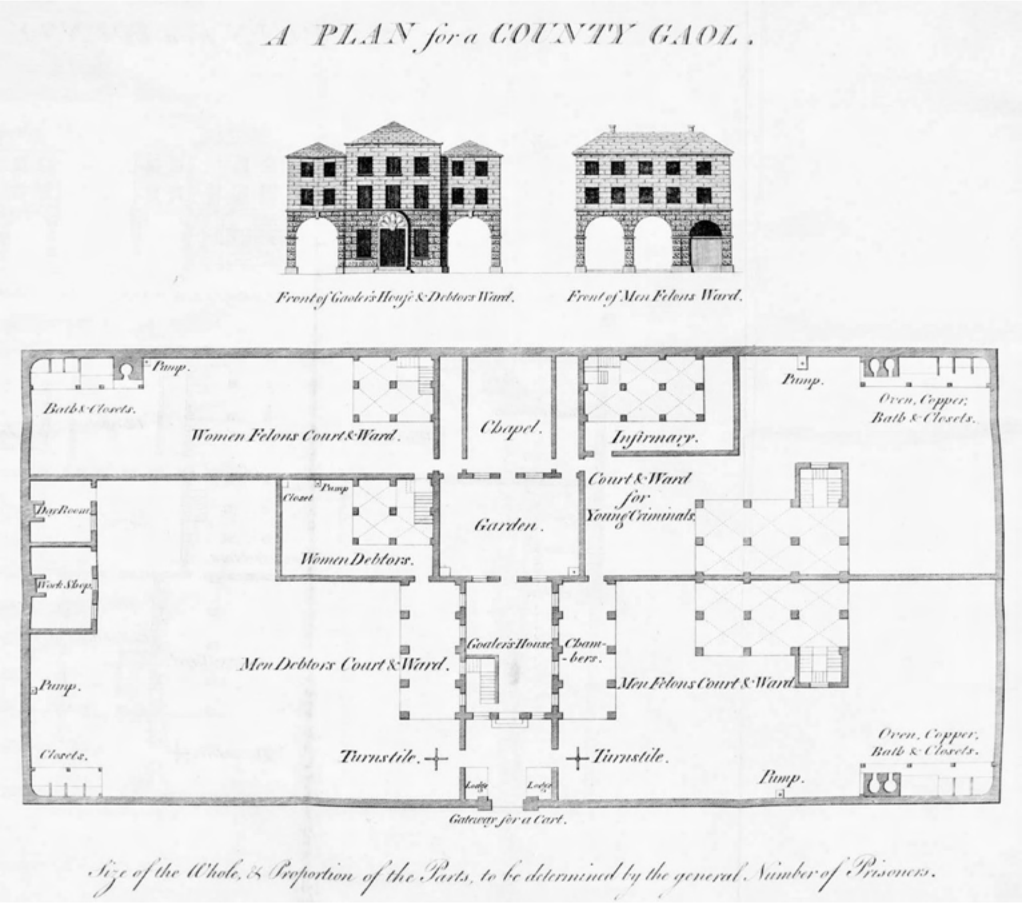
The writings of Fielding and Howard mark an important shift. Instead of merely trying to protect society, the penal system increasingly began to aspire to effecting an alteration in the attitudes and conduct of the prisoners. In the course of the eighteenth century, an originally religious morality, including its ideas of decency, its promises of remedy, and its mechanisms of control, was absorbed into the state legal and penal system.[12] Accordingly, in the early 1750s, Fielding had proposed the condition of solitude as the best form of treating spiritual maladjustment.[13] What in religion and philosophy had traditionally been a self-chosen path to contemplation and repentance, solitude in a legally imposed form was now intended to similarly guarantee an isolation from pernicious influences and the possibility of reflection and contrition.

Precisely for culprits, so the conviction of the reformers, the protracted and uninterrupted confrontation with their inner selves could be a tormenting punishment but also a means of catharsis.[14] In 1776, the philanthropist Jonas Hanway ennobled this principle in the title of his polemic *Solitude in Imprisonment*, in which he suggested building a prison in London containing individual cells for criminals due to be deported or executed, thus adding a prominent voice to the idea that sentenced criminals be placed in solitary confinement. The starting point for Hanway's praise of solitude is a quote from the First Epistle to the Corinthians in the New Testament, namely the axiom that "*evil communication corrupts good manners*."[15] With this, Hanway—alongside the pastor Samuel Denne, who a few years earlier in a public letter had recommended the isolated incarceration of prisoners and warned against "corruption by communication"[16]—was one of the first to frame his reform ideas using the term "communication."

Hanway and Denne's use of the term communication was significantly different to the original Latin meaning, as in the conveying and sharing of material goods. In their case, communication describes immaterial contact and a mental exchange between two people, a concept that was heavily influenced by early Christian beliefs and that had gained in plausibility in the seventeenth century via the exploration of physical processes such as magnetism and gravity.[17] Within the framework of prison reform, the concept combines with the medical idea of contagion. Accordingly, via evil communication, in other words when prisoners were able to converse freely and swap experiences, bad behavioral habits could spread practically epidemically within a prison community. The sole means by which to combat this scourge was to suppress all contacts between prisoners: "*imprisonment in solitude* as the only engine."[18] The prison building that Hanway designed in crude brushstrokes in his pamphlet was to put this condition experimentally into action: "The great art in the contrivance of this building will be, to prevent all kinds of communication between one prisoner and another."[19] This objective is of no small significance in terms of architectural history. Up until then, and as a rule, architecture (at least implicitly) had been understood as a locus and frame for communication: when not a means for repulsing enemies or other threats, it served to gather people together, for them to share in dialog and understanding. It was no coincidence that Vitruvius located the beginnings of the history of architecture as having occurred simultaneously with the emergence of language and the first human conversations. When an architectural design was aimed at interpersonal exchange, it did so by providing it with a specific space. A telling example is the *parloir*, or the visiting and drawing room, its name derived from the Old French word for talking. But conversely, with the intentional prevention of communication—with an architecture that is explicitly built versus conversation—a radically different issue arises that would have fundamental ramifications for the conception of architectural space.

Solitude—as a condition that ideally allows only communication with one's own self—would shortly later become one of the central aspects of the Penitentiary Act. Together with forced labor, which had been applied in correctional institutions and reformatories since the mid-sixteenth century to improve delinquents, and alongside the religious guidance practiced since the Middle Ages, it formed the core program of the reformed penal system as defined in the wording of the law in early 1779: "solitary imprisonment, accompanied by well-regulated labour, and religious instruction … might be the means, under Providence, not only deterring others from the commission of … crimes, but also of reforming the individuals."[20] The aim, as clarified by the co-author of the law, William Blackstone, in a commentary, was "to preserve and amend the health of the unhappy offenders, to inure them to habits of industry, to guard them from pernicious company, accustom them to serious reflection, and to teach them both the principles and practice of every christian and moral duty."[21] Following this line of thought, the job of the new prison was to delve deeper than the old correctional facilities—the procedures of which were geared to the docility and with it the intellect of the inmates—in order to also transform what was understood as the human soul. It is in this context that the contemporary term "reform" acquired its characteristic double-meaning: the reforming of the practices and conditions of the penal system were to create circumstances that in turn would enable a reforming of the moral characters of the prisoners.[22]

The realization and the running of the two national penitentiaries envisioned in the Penitentiary Act were to be orientated on the specifications set out in the law. Shortly after being passed, the national government instructed a three-person commission, to which John Howard belonged, to purchase land and initiate the erection of the two buildings, which upon completion were to be placed under state administration.[23] However, the parties to the Penitentiary Act were faced with a vital problem, namely the almost complete lack of models or precedents of how the provisions for a reformed and reforming penal institution could be architecturally realized. Up until then, and as a rule, two types of buildings had served as prisons: small, arbitrarily planned, and often converted buildings, or expansive complexes marked by their formality and axial nature. In terms of spatial and sanitary conditions, neither of these types matched the expectations of the reformers. With its closed triple courtyards, London's rebuilt Newgate Prison, initiated following the Black Assize of 1750, for instance, was already considered out of date while it was being built in the 1770s, and was heavily criticized by contemporaries like Jonas Hanway.[24] Accordingly, in his *The State of the Prisons* John Howard had written that "the first thing to be taken into consideration" in penal reform "is the *Prison itself*," and had appended his book with a design for an ideal county prison. The plan, showing a row of oblong blocks set on arcades, was intended as the basis for further layouts that could be further refined.[25] → Fig. 33 As it was, however, Howard and the commission failed to even agree as to where the two state prisons should be built. After prolonged discussions, a further commission was formed in 1781, and in the same year it decided to launch an open architectural competition for two plots to the south of London.[26] The members of this commission were equally aware of the fact that what they were searching for had no precedents in architectural history. "Our undertaking," wrote the physician Thomas Bowdler to one of the participating architects, "is so different from anything that ever was built in this country that a person may be very fit for building a church or palace and very unfit for being architect to the penitentiary houses."[27]



33
Model plan for a county prison by John Howard, 1777

The first prize in the competition for the state penitentiaries went to William Blackburn, a man who had been fully unknown until then. Born in 1750, Blackburn had initially trained as a surveyor before then studying as one of the first architects at the Royal Academy of Arts and subsequently becoming a surveyor for various institutions, such as the London St Thomas' and Guy's Hospitals. His winning submission for the competition instantly made him a nationally known figure and secured him a short but intense career as a prison architect. Up until his early death in 1790, Blackburn produced plans for over fifteen penal institutions scattered across the whole of England.[28] Nonetheless, his successful and now lost design for both of the state facilities was never realized. In fall 1782, financing for the two buildings foreseen in the Penitentiary Act was surprisingly blocked, apparently because the government recoiled at the costs of being permanently involved in the prison system, intending instead to return to the practice of deportations. Almost three decades were to pass before similar plans to establish a national prison emerged again in Great Britain.[29] This is the overall backdrop against which initiatives such as those by G. O. Paul in Gloucestershire were developed. Faced with overcrowded prisons, persistent criticisms of existing penal conditions, and the inactivity of the central government, county administrations began to self-sufficiently realize the reform endeavors of the late eighteenth century in concrete prison projects, one of the key goals in this process being the elimination of "evil communication."

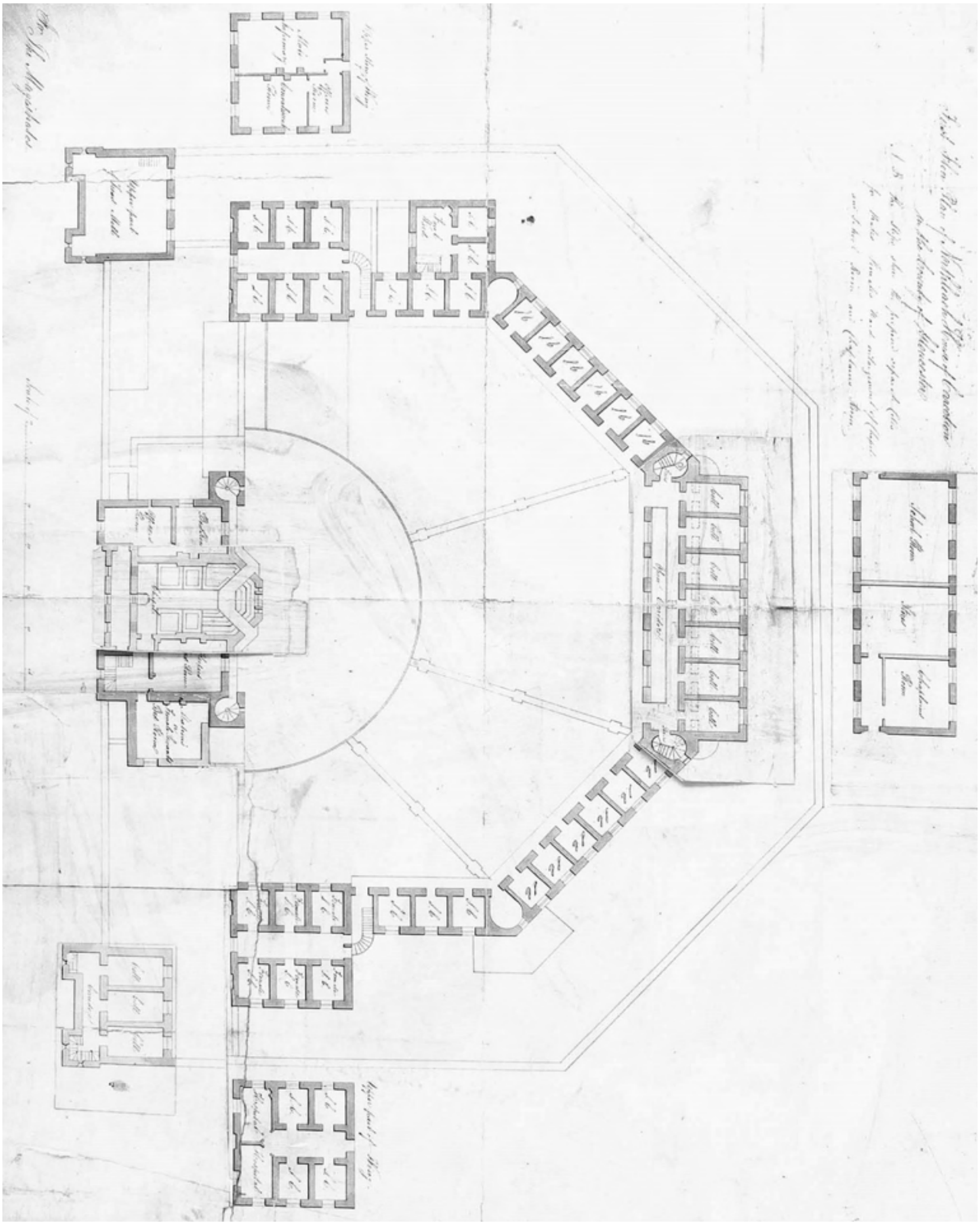
Opening vs. Closing

The prison reforms in Gloucestershire were to become exemplary for the whole of England, but had another cause besides the passivity of the government in London: in 1783, gaol fever broke out in the county's old prison. As High Sheriff, G. O. Paul seized on the dangerous situation as a reason to begin promoting a fundamental modernization of the county's penal buildings. Similarly to John Howard, he advocated that prisoners be incarcerated under hygienic conditions, with sufficient food, and freed from the usual mistreatment, secured via regular controls by the magistracy.[30] One of the arguments widespread amongst reform opponents was that prison sentences served under such conditions would lose their deterrent effect, therefore Paul was at pains to paint the reform prison, despite all its humanity, as a fearsome place and pointedly distanced it from all connotations of a concept that was gaining currency in the language of private inhabitance. "I am far from thinking that Prisons should be Places of *Comfort*," he wrote, rather "[t]hey should be Places of real Terror"[31]—a terror, however, that should no longer include physical injury to the prisoner. The aim was a penal economy precisely calibrated between the two poles of well-being and privation: "the Situation should be calculated to produce Reflection; the food such, as will support Life, and preserve Health, but by no Means animate the Spirits. Dejection and Solitude are the natural Parents of Reflection."[32]

From this, as well as from the rulings of British law, Paul derived the three main functions of a prison: "SAFE CUSTODY," as the basis of the regime of enforcement; "HEALTH," as a key aspect for the well-being of society; and "SEPERATION," as the highest principle in all efforts to improve the inmates.[33] In fall 1783, he presented his plan for the establishment of a system of new prisons to the county's magistrates, going into detail about the possibilities and limitations of prison architecture. "It would indeed be insulting your Understandings with a Chimera, should I presume to offer to your Attention a Plan of Reform depending solely for its Effect on Principle of Construction," he explained to the nobles and church leaders. Instead, "moral Effects can be produced only by moral Means."[34] The goals of a reformed penal system were therefore to be realized in Gloucestershire through a combination of architecture, on the one hand, and strict regulations, on the other. "[I]n stating public Reformation as the Consequence of our Design," said Paul, "I have presumed on a spirited Co-operation of all the Powers of Magistracy."[35]

Paul's initiative met with success and he was able to persuade the county of Gloucestershire to erect five buildings to house a total of 350 inmates, and with it to undertake one of the most comprehensive reform endeavors of the period. Along with four correctional institutions divided between Northleach, Littledean, Horsley, and Lawford's Gate, the key element of the project was a county prison in Gloucester that was to serve jointly as a correctional and a penal institution for around two hundred inmates. Apparently acting on a recommendation by Howard, William Blackburn—who had recently shot to fame through the national prison competition—was commissioned with the planning of all five buildings. The plans, presented by Blackburn in Gloucester in April 1785,[36] are a paradigmatic expression of the attempt to transform the prison building into a means for transmitting "moral effects," or at least to design it so that morality-inducing imprisonment could take place within its confines. In both the ground plans and in the architectural elements, Blackburn developed a nuanced set of operations in order to meet the reform goals. In each of the building designs for the county, the key requirements of safety, health, and separation—which are to be found formulated with slight variations by many contemporary authors—are realized by deploying highly original and formative constructional solutions. It is this particular ingenuity that led architectural historian Robin Evans to identify Blackburn's work as the point where the doctrine of prison reform was first translated into building practice and prison planning was transformed into a type of "technology."[37]

In this context, the requirements of security and separation were relatively easy to combine. Security is one of the core remits in a prison, with detention as the legal aim and confinement its architectural means. However, in around 1780 the traditional means of preventing escape—walls, bars, and chains—were supplemented by attempts to use construction to improve the "polity" of the prison, in the sense of the prevailing order and control within its confines. To achieve this, Blackburn introduced a series of innovative floor-plan forms based on radial geometries.[38] In the case of Northleach Bridewell, built between 1789 and 1791 in east Gloucestershire, the cell wing is arranged in a semicircle around a central building, from which both the prison yards and the entrances to the cells can be overseen in the half-round of the institution. → Fig. 34 This strategy of observation continues on a smaller scale in the form of the so-called "inspection holes" drawn into many of the plans—spy holes pierced

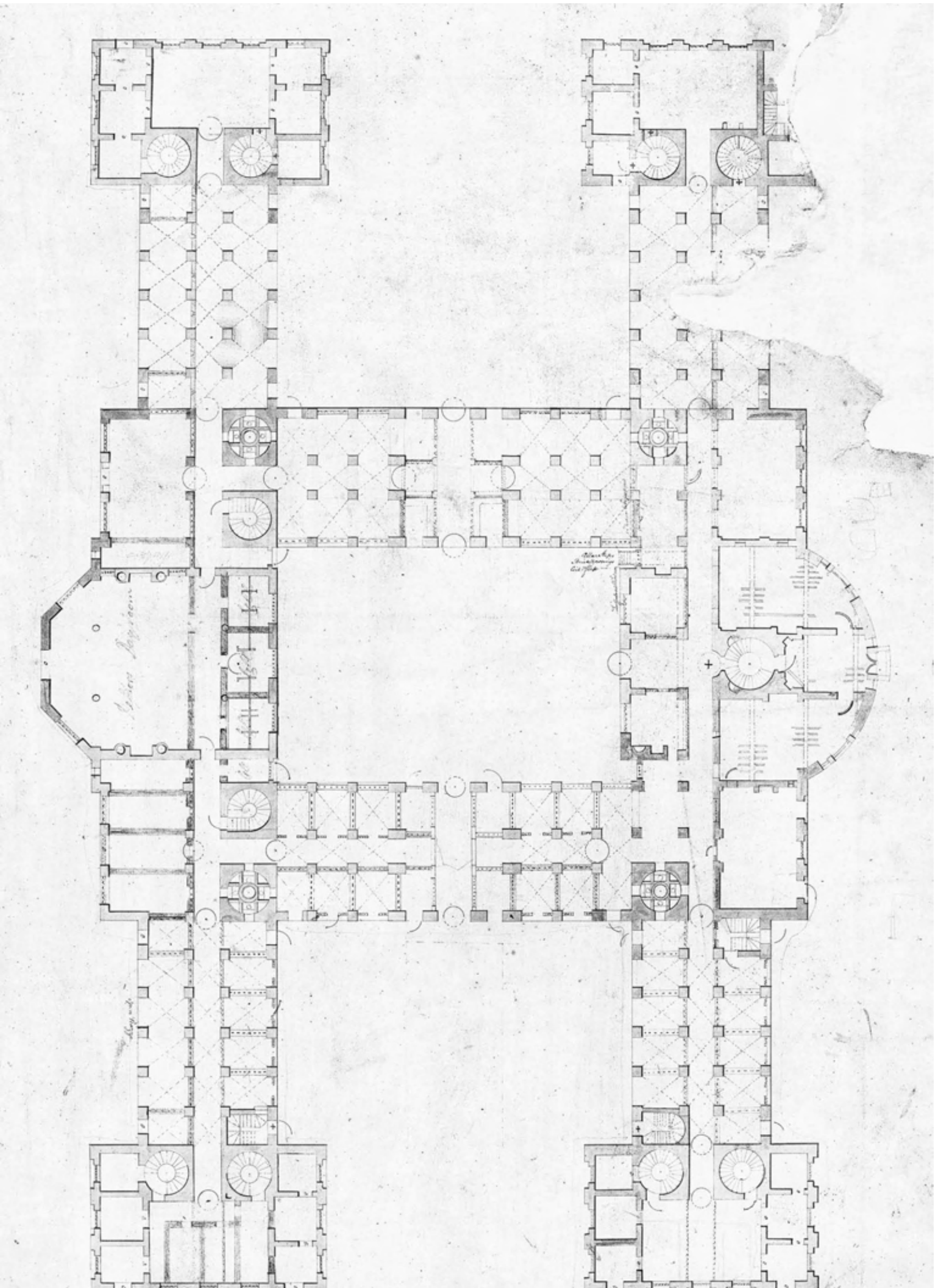


34
Surveyable: William Blackburn’s Northleach Bridewell, 1785

into the walls through which the insides of rooms and cells could be inconspicuously controlled.[39] While these measures did not yet provide the kind of total monitoring of the prisoners proposed by Jeremy Bentham shortly afterwards, Blackburn's designs are nonetheless the first to deploy surveillance practices and a corresponding centralization of the prison authority.

These security precautions are complemented by a multilevel procedure of separation, which simultaneously consisted of an order of classification and a system of spatial subdivision. The wings of the new county prison in Gloucester, an oblong courtyard building likewise built between 1789 and 1791, initially divide three different institutions from one another: first a prison overseen by the sheriff for prisoners awaiting trial, those in contempt of court, debtors, and those sentenced to death; second a penitentiary overseen by the magistracy for sentenced criminals, prisoners whose death sentences had been rescinded, and those awaiting deportation; and third a bridewell, likewise overseen by the magistracy, for petty delinquents. All three sections, each of them additionally divided between male and female inmates, are split up into day rooms and individual cells for nocturnal isolation, while the penitentiary part is additionally equipped with cells for permanent solitary confinement.[40] → Fig. 35 In this sense, Gloucester prison is an exemplary realization of what Michel Foucault described as a "*tableaux vivant*": a parcellation-based, simultaneously real and ideal configuration of people in a complex space of hierarchies, functions, and architecture.[41]

A far more difficult objective than integrating the aspects of security and separation was their combination with the demands of health, which above all involved adequate ventilation. Whereas the first two procedures concerned the closing and subdividing of space, the latter is based on opening and breaching it. This conflict between the operations of opening and closing advanced to become a similarly fundamental yet productive problem in prison building in the late eighteenth century in that it resulted in an explication process, in the course of which the architectural construction was repeatedly examined with great precision in terms of its potential to isolate or expose. In this process, new architectural forms



35
Tableau vivant: William Blackburn's Gloucester county prison, 1785

and elements were deployed and the perception and application of existing ones was transformed: "The old simple schema of confinement and enclosure—thick walls, a heavy gate that prevents entering or leaving—began to be replaced by the calculation of openings, of filled and empty spaces, passages and transparancies."[42] In the 1780s, numerous authors started to try and bridge the gap between the opposing demands in prison building, some of them with curious suggestions. In his *Thoughts on the Construction and Polity of Prisons*, the physician John Jebb, for instance, proposed solving the contradiction between the free circulation or air and secure enclosure by erecting the prison walls at the bottom of a trench.[43] Blackburn also tackles this problem commencing from the ground plan, by elongating it to give as much exposure as possible to the building surfaces in the Northleach Bridewell, or by splitting the building up into a series of freestanding pavilions in the county prison in Dorchester[44]—a layout propagated at exactly the same time in France by Jean-Baptiste Le Roy for the "treatment machine" of the hospital. To a certain extent, procedures such as these even heightened prison security in that a facility consisting of freestanding buildings could be better observed. Conversely, however, all-too-open or expansive planning made the control by the prison guards more difficult.[45]

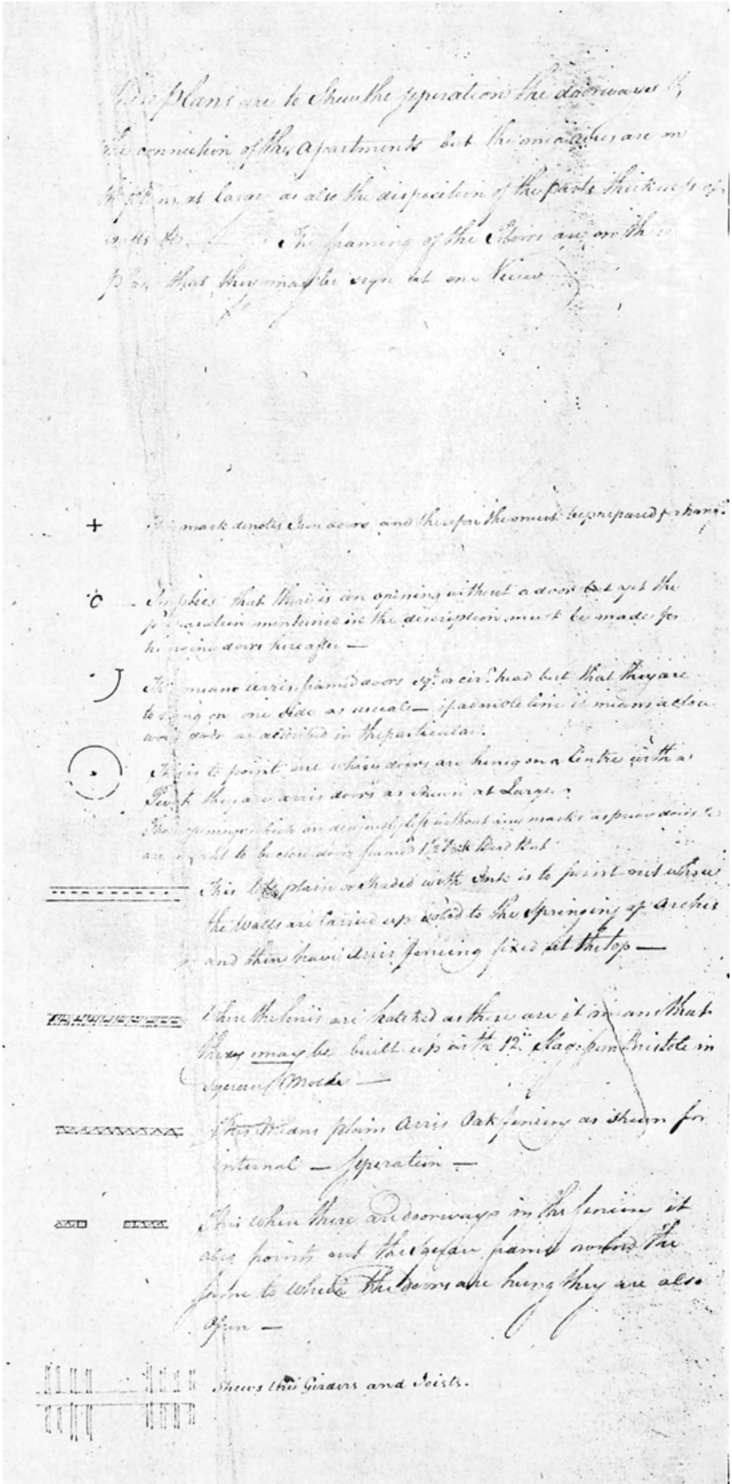
This process of negotiation between opening and closing took place not just horizontally but also vertically. In a series of his projects, including for the county prison in Gloucester and Littledean Bridewell, built between 1788 and 1791 in the west of Gloucestershire, Blackburn placed the cell blocks on rows of arcades, as suggested by John Howard a few years beforehand.[46] By this means, the raised cells are not only better ventilated, they also impede attempts to escape. Moreover, the health requirements meant that the "inspection holes" in Blackburn's buildings were coupled with numerous so-called "air holes."[47] The significance of counterbalancing the architectural operations of opening and closing in the reformed prison becomes at the latest evident in the diligence with which the placing and execution of these ventilation apertures are specified in the floor plans and sections. "[A]ir-holes … managed as to exclude conversation, while they admit air," runs a description to the plans that Blackburn drew up for the county of Dorset.[48] Even in the tiniest details, it had to be considered that each and every opening within the prison could also potentially serve as a channel for evil communication.

But in order to understand why even the doors in Blackburn's designs were to prevent exchanges between prisoners, it is necessary to consider another problem that has received little attention in architectural history, namely the fact that prisons are not only places of confinement but also of bustling motion. Precisely because the tableau of the prison is "*vivant*," it fails to resolve itself in the ideal partitioning and categorization system of tables and taxonomies. Quite the opposite: everyday prison life requires innumerable movements within and through the real space of the institution. In the Gloucester county prison, for example, the inmates had to exit their cells daily for marches to the washing room and the chapel, as well as to exercise and work in the treadmill. The prisoners, in turn, received regular visits from the director, the chaplain, the taskmaster, and at least twice a week from a physician. Added to this was the distribution of food, the arrival and departure of new and old prisoners, and the cell controls by the guards.[49] The sites for all these motions were hallways, galleries, and corridors. Slowly proliferating throughout the Western world since the seventeenth century, the definitive arrival of these architectural elements in the mid-eighteenth century was due, not coincidentally, to the increasing construction of architectures seeking to impose a disciplinary regime based on cellular isolation, in turn meaning that the required spatial subdivision called for the simultaneous introduction of independent circulation spaces.[50] As such, a further core challenge in reformed prisons was to likewise meet the criteria of security, health, and separation during the traffic of people in the hallways and corridors and as inmates and staff moved through the circulation system. It might even be ventured that the issue of precise and smooth movements of individuals *between* various locations is as characteristic for disciplinary space as their confinement *in* particular locations.

Be that as it may, Blackburn also preoccupied himself with the problem of movement through a careful blend of spatial planning and architectural elements. An increasingly popular method in the

1780s of isolating prisoners from each other while they were moving involved the simple measure of splitting double-loaded corridors into divided single-loaded corridors with a wall. By contrast, in his plans Blackburn often tried to connect the parts of the building so that the different circulation routes never crossed in the first place, for example in the county prison in Dorchester, where on the one side the cellblock is reached via a corridor and on the other via a gallery, giving the two-story building wing four independently accessible zones.[51] At the critical points of the resulting routes—places at which encounters between the various occupants could not be excluded—Blackburn resorts to placing the specific door construction that he claimed had the power to block all communication between the prisoners.[52]

Blackburn's "door" is actually a cross between a classic turnstile (originally designed to make fencing permeable to people but not livestock) and a revolving door, which found its first application in architecture around the same time (designed to be permeable to people but not atmospheric influences). If, in general, doors allow a "differential accumulation," in other words a reversible gathering of things within an enclosed space,[53] the task of these centrally mounted variants can be described as the enabling of a "differential passage," their aim being to give free passage to certain elements and forms of movement and to block others. This was also the sense in which John Howard had already recommended the use of revolving barriers in his *The State of the Prisons*. In his model plan for a county prison, two devices described as a "Turnstile" are located at the passageways between the forecourt and the prison yards, forcing prisoners to enter singly in an organized manner and preventing them from exiting collectively or in a disorderly manner.[54] In Blackburn's case, the revolving doors obviously have the additional function of linking rooms and building areas together while at the same time hindering various classes of prisoner from communicating with each other. By pitting the two central meanings of the contemporary term "communication" against each other—spatial interconnection and human conversation—they in fact achieve the ostensibly paradoxical operation of deterring communication through communication.[55]


These Plans are to Shew the seperation the doorways &
the connection of the Apartments but the more particulars are in
the plans at large as also the disposition of the parts thickness of
walls &c. — The framing of the floors are on the
plan that they may be seen at one view

+ This mark denotes Iron doors and therefore the must be prepared for them.

Implies that there is an opening without a door but yet the preparation mentioned in the description must be made for hanging doors hereafter —

This means were framed doors &c. or circ. head but that they are to swing on one side as usual — if a double line it means a close wood door as described in the particular.

This is to point out where doors are hung on a Centre with a Pivot they are Iron doors as shewn at Large.

[illegible]

This line plain or shaded with Ink is to point out where the Walls are carried up solid to the Springing of Arches and then have Iron fencing fixed at the top —

When the lines are hatched as these are it means that they may be built up with 12" Flags from Bristol in Square Moulds —

This means plain Iron Oak fencing as shewn for internal — seperation —

This when there are doorways in the fencing it also points out the Iron frames round the frame to which the doors are hung they are also open —

Shews the Girders and Joists.

36
Signatures of segregation: legends to the plans for the Gloucester county prison, 1785

It appears only logical that the contradictory processes of opening and closing crystallize in a threshold technology whose characteristic nature lies in being simultaneously permeable yet non-permeable. At the same time, Blackburn's revolving door is only the most arresting element in a broad architectural repertoire that shows how the attempt to seize the volatile substance of morals results in an explication of constructional practices. The plan at the heart of G. O. Paul's prison reform project, the floor plan of the Gloucester county prison, contains an entire arsenal of newly developed or reimagined architectural elements. Allowing different degrees of separation and connection, each of them is registered with their own symbol in the design drawings. A key explains the signatures, ranging from a cross to dashed lines, and to the revolving doors are added iron doors, common doors, and last but not least openings without doors. The key also lists four types of room dividers, which, executed in different materials and construction methods, create various levels of segregation, thus supplanting the traditional wall—partitions equipped with ventilation slits or barriers completely constructed as fencing. ← Fig. 36 The accumulation alone conjures up a tableau of efforts to orchestrate human movements and interactions through architectural means. However, this endeavor becomes all the more manifest in the explanations that Blackburn prefixes to his design: "These Plans," he writes above the key, "are to show the separation, the doorways & the connection of the apartments."[56] With this he describes the quintessential characteristic that actually distinguishes any floor plan, but by explicitly stressing it once more formulates wherein the problem of the reformed and the reforming prison lies. Blackburn's plans are, first and foremost, differentiated and multilayered systems of divisions, transits, and connections. Their prime concern is—under the primacy of its prevention—literally the planning of "communication."

The beginnings of British penal reform have to be considered within the framework of a far broader socio-political reform movement, in which prisons were only one of a whole range of institutions whose role and function were subject to critical reappraisal. Alongside the Christian-driven philanthropy of John Howard or G. O. Paul, these aspirations above all sprang from rational Utilitarianism and the materialist philosophy of the Enlightenment. In the third part of the eighteenth century, faced with a conservative and corrupt government and an impending war with the American colonies, numerous British scientists, legal scholars, and clergymen strove to usher in a general change in the predominant political, religious, and moral state of affairs. One of the centers of this movement was the so-called "Bowood Group," a gathering of politicians and intellectuals who since the 1770s had joined an orbit around the Whig politician Lord Shelburne. Among the leading lights of the group, which met regularly at Shelburne's family estate Bowood House in South West England, were the theologian and natural scientist Joseph Priestley and the jurist Jeremy Bentham.[57] The relationship between these two intellectuals would come to have an exemplary and decisive impact on the British reform movement, not only because Priestley, born in 1733, served as the ideal of a scientific and social reformer for the fifteen-years younger Bentham, but also because it marked a momentous connection between natural and moral philosophical inquiries.[58]

Priestley's scientific endeavors were based on a firm belief that these could better the individual, and with that society as a whole. His credo was that progress in the field of natural philosophy would simultaneously act to morally and spiritually edify individuals and increase general human well-being. This faith in the practical character of science had already been formulated by

Priestley in the foreword to his first natural scientific publication, an early essay on electricity: “the immediate use of natural science is the power it gives us over nature, by means of the knowledge we acquire of its laws; whereby human life is, in its present state, made more comfortable and happy.”[59] This combined theistic interest in explaining natural phenomena and improving living conditions was also what drove Priestley’s interest to the new science of pneumatic chemistry. Since the late 1760s, one of the key focal points of his work, which led him, among other things, to discover oxygen, had been the examination of air and other gases. A deeper understanding of the processes of breathing, combustion, and regeneration on the one hand promised to provide insights into a decisive aspect of divine creation, and on the other supplied a basis from which concrete steps could be taken to achieve collective welfare through proposals to purify the atmosphere of cities and buildings.[60]

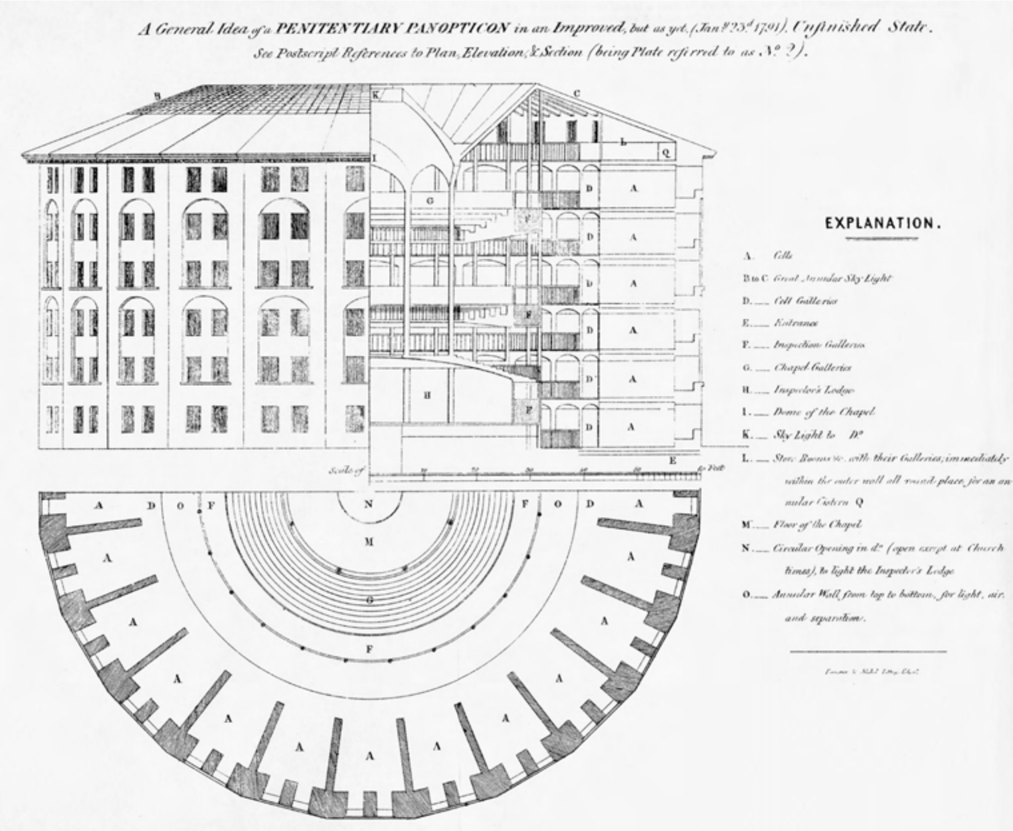
Bentham, who shared both Priestley’s specific interest in pneumatic chemistry and his general interest in the production of progressive knowledge, rigorously transported the principles from both fields into the areas of legal and social reform. After completing his studies, he had dedicated himself to free thought and to writing about legislation, and with his 1776 *Fragment on Government* had published his first highly acclaimed book. “Correspondent to *discovery* and *improvement* in the natural world,” reads the foreword, “is *reformation* in the moral.”[61] The same paragraph likewise contains the hedonistic calculus that would guide all of his future work, namely that the greatest happiness of the greatest number of people is the measure that determines what is right and what is wrong. The formula is reinforced by a direct comparison with the contemporary discoveries concerning air: “If it be of importance and of use to us to know the principles of the element we breathe, surely it is not of much less importance, nor of much less use, to comprehend the principles, and endeavour at the improvement of those *laws,* by which alone we breathe it in security.”[62] This articulation of an alliance between inquiries into the activities of natural matter and of social living proved fundamental for the British reform movement, in which findings about the composition and interaction of substances repeatedly formed the starting point for ideas about the individual and social progress.

As such it was only a small step from pneumatic chemistry to the science of pneumatology, understood as the philosophical study of spirits and the soul. Two years after the appearance of the *Fragment on Government*, Priestley, in his outline of an ideal curriculum, directly related natural philosophy as "knowledge of the external world" to moral philosophy as "knowledge of the structure of our own minds, and its various affections and operations."[63] The basis of this equivalence is a materialist notion of the human mind, rooted in the work of John Locke and David Hartley, that no longer distinguished between body and soul, both of which could be equally subject to physical analysis. Priestley, like Bentham, refined a sensationalist theory, according to which the content and actions of human understanding were attributable to combinations and permutations of sensations originating in impressions formed from the external world. As a consequence, sights, sounds, tastes, smells, and touches not only formed the raw material of human perception but, if the higher categories of pain and pleasure were likewise included, also of ideas of right and wrong.[64] In this way, morals became a branch of psychology, which in turn became negotiable as a part of physiology. From this, Bentham developed the concept of "moral pathology" as a mental and legislative counterpart to the medical science of the same name. "When thus applied," he explained in a text written in the late 1770s, "moral *pathology*, would consist in the knowledge of the feelings, affections, passions, and their effects upon happiness. Legislation, which hitherto has been founded principally upon the quicksands of instinct and prejudice, ought at length to be placed upon the immoveable basis of feelings and experience: a moral thermometer is required, which should exhibit every degree of happiness and suffering."[65] Due to its direct relation to the physiology and the environment of the body, pneumatic chemistry, so the argument, provided the relevant resources for such a study of the mind and the forces acting on it.[66]

With this, the knowledge of air and its corruption and purification became, once again, the basis of spatially rooted reform. Having already been the concrete cause of the numerous constructional and technical interventions for the improvement of interior climate that emerged in the second half of the eighteenth century, it now simultaneously gave rise to a general theory of moral economy, the architectural ramifications of which would be no less profound. Bentham's reform initiatives expressed themselves in legislative but equally in various worldly projects: he devised an instrument to measure air quality, the so-called Athanor, and plans for an improved cembalo, a new legal faculty, a shipping canal through Nicaragua, or an expedition to Botany Bay in Australia.[67] Above all, however, he concerned himself with the development of a concept for a building that would make the environmental influences that he and Priestley so fervently explored fully controllable, namely the Panopticon. This notorious "simple idea in Architecture" would occupy Bentham until the end of his life, promising, like no other of his schemes, a way of gaining control over the functions and development of the human mind.[68] The closed space of the Panopticon building was intended, for the first time, to subject the perceptions and sensations of its inmates to a regime of precise and scientifically based moral management.

From the beginning, the Panopticon was designed to be applied to a whole series of institutions: for prisons as much as for manufactories, and for insane asylums, hospitals, or schools. Nonetheless, the elaboration of its concept was set against the concrete background of British penal reform. Since the late 1770s, Bentham, in whose legal- and moral-theoretical reflections the topic of punishment played a continuous role, had been an active participant in the discussion concerning the renewal of the penal and prison system. In 1778, he had published the commentary *A View of the Hard Labour Bill*, and with it had played a certain part in the Penitentiary Act passed in the following year.[69] While much of the act remained a dead letter, and the national penitentiaries envisioned by it were never built, Bentham's interest in the problem of imprisonment remained unabated in the period that followed when reform initiatives shifted to the local level. In the mid-1780s, a visit to his brother in Russia occasioned the idea of his "inspection house." As a naval engineer, Samuel Bentham had been in service to Prince Potemkin since 1780, and in this function had designed a shipyard in which the workers could be supervised from a central position. Prompted by an architectural competition for a new prison for the county of Middlesex, in a series of letters written in late 1786, Jeremy Bentham refined this concept into a general organizational and architectural principle. Back in England, and increasingly convinced of the significance of his idea, in 1791 he published the "Panopticon Letters," supplemented with two postscripts, in his book *Panopticon; or, the Inspection-House*, thereby commencing an almost twenty-year-long campaign for the building of a panoptical prison.[70]

Today, Bentham's idea is generally considered as the quintessential "architecture machine." The well-known principle of its design—involving a multistory and inwardly opened cell tract organized circularly around a central observation tower, providing the guards with an overview of the cells without themselves being seen—has produced innumerable descriptions as "machine," "apparatus," or "mechanism", → Fig. 37 with Michel Foucault's 1975 study *Discipline and Punish* undoubtedly playing a seminal role. In it, Foucault not only elaborated on the birth of the prison as the beginning of modern "disciplinary societies," referring to Bentham's architectural project as a model for their functioning and effects, but in the process also applied a multifaceted machine vocabulary.[71] By this point, however, this technical terminology in fact already enjoyed a certain tradition. In one of the first critical twentieth-century accounts of philosophical Utilitarianism, the Panopticon had already been understood as a machine. "The Panopticon," wrote the English constitutional scholar Albert Venn Dicey in a 1905 study of public opinion and legislation, "was a mechanical contrivance from which, if rightly used, he [Bentham], after the manner of ingenious projectors, expected untold benefits for mankind."[72] A few years later, the poet and penal reformer George Ives published a universal history of penal methods in which he generally described the modern cell-prison as a machine and formulated the provocative thesis that Foucault would later focus his book on, namely that the enlightened legal and judicial reforms at the turn of the eighteenth to the nineteenth century represented not only a progression toward a more humane penal system but had also ushered in the development of incomparably more complex and far-reaching



37
A widely-cited “apparatus”: Jeremy Bentham’s Panopticon, 1791

measures of subjugation. "[T]hey removed a good many of the then existing scandals and cruelties," Ives said of the British prisoner reformers, "yet inaugurated a machine for the infliction of suffering, compared with which the old barbarities were short and relatively merciful." Moreover, Ives's book also already contains the formative image in which not only the inmates but everyone involved in the penal institution are seen as prisoners in a self-perpetuating machinery—a "relentless and immovable machine in which they all were but as wheels."[73]

As the twentieth century progressed, the analysis of the (panoptic) prison as a machine took on increasingly socio-critical implications. In 1949, a short and little-known text by Aldous Huxley appeared in which the machine term was prominently used, to a certain extent preempting Foucault's concept of panopticism. The text—the foreword to a volume of high-quality prints of Piranesi's *Carceri* engravings—is devoted to the artistic representability of the imperatives of modern rationalization. Within this framework, Huxley develops the thesis that in the development commenced by Bentham the prison had been transformed from a "sub-humanly anarchical" into a "sub-humanly mechanical" institution. As a result, the tormenting feeling of finding oneself in the insides of a machine—in a "realized ideal of absolute tidiness and perfect regimentation"—had progressed to become the main feature of punishment. Around a century after Bentham's death, and after the horrors of the Holocaust, in Huxley's opinion the spirit of the Panopticon had also taken hold in other places: "Today every efficient office, every up-to-date factory is a panoptical prison, in which the worker suffers ... from the consciousness of being inside a machine."[74]

Foucault's highly influential study on the birth of the prison definitively paved the way for this interpretation. *Discipline and Punish* teems with machinery phrases and their synonyms. It refers to "judicial," "state," "war," "police," "power," "administrative," "penal," "disciplinary," "human," "prison," and many more "machineries," "machines," or "apparatuses."[75] Like Gilles Deleuze and Félix Guattari, and as derived from Lewis Mumford, Foucault uses the term machine for both technical and social contexts.[76] His main motive in this is obviously to stress the anonymous and above all autonomous character of a type of control he refers to as "disciplinary power." "The power in the hierarchized surveillance of the disciplines is not possessed as a thing, or transferred as a property; it functions like a piece of machinery. And, although it is true that its pyramidal organization gives it a 'head', it is the apparatus as whole that produces 'power' and distributes individuals in this permanent and continuous field."[77] This becomes explicit in the "architectural apparatus" of the Panopticon: "Prison-punishment, prison-apparatus."[78] The assumption that the de-individualized and automatized power of Bentham's Panopticon had found its architectural-spatial realization via a "concerted distribution of bodies, surfaces, lights, gazes" results in the book's technicized but equally apodictic diagnosis of the times: "We are … in the panoptic machine, invested by its effects of power, which we bring to ourselves since we are part of its mechanism."[79] With this the French (post-)structuralism of the 1970s shaped a critical school of thought that viewed society, prisons, and in particular Bentham's Panopticon, as an all-encompassing machine.

In all this, the question that was left aside is what terms Bentham himself used in the late eighteenth century to articulate his architectural idea and to what extent they correspond with these later interpretations. This much in advance: Bentham's language is devoid of any Huxleyian or Foucaultian machine terminology. Although elsewhere he demonstrates a familiar use of machine metaphors in his thinking,[80] the word is not used with reference to institutional or architectural projects in either his Panopticon writings or other contemporary publications, including in his private manuscripts. When Bentham talks of "Panopticon Machinery" in relation to the "inspection house," it refers to the concrete work machinery, such as the sawing machine developed by his brother Samuel that was to be installed there.[81] Nevertheless, this is not to say that the writings with which he promoted his project from 1791 onward are lacking in technical terminologies. Instead, the crucial thing is to contextualize these examples within contemporary language use, Bentham's overall philosophy, and the constructional details of his architectural design, and to categorize them correctly within the history of architectural machine concepts.

Bentham comes relatively close to the term "machine" in the oft-quoted foreword to the Panopticon Letters when he outlines his idea as an "engine." It was a "new mode of obtaining power of mind over mind, in a quantity hitherto without example: and that, to a degree equally without example, secured by whoever chooses to have it so, against abuse.—Such is the engine: such the work that may be done with it."[82] This representation of the Panopticon as an apparatus of mental transformation is further refined in a letter sent to the Jacobin Jacques Pierre Brissot, along with a French version of his book, in an attempt to interest post-revolutionary France in his project. It evokes a technology that at the latest since the seventeenth century was considered the ideal type of the driving and working engine: "it is a mill for grinding rogues honest, and idle men industrious."[83] More than this, the Panopticon Letters themselves promised that the building would organize everyday prison life with "clock-work regularity," thereby accepting the transformation (and anticipating the corresponding criticisms) of the inmates into human machines: "the result of this high-wrought contrivance might … be constructing a set of *machines* under the similitude of *men*."[84] While it remains open to what extent these rare mechanical connotations articulate a general means–ends relationship or concrete operational models, Bentham anyway shifts to other images when dealing with the actual architectural construction of the Panopticon, where the project appears less as an engine and far more as a living organism.

The juncture at which Bentham provides a detailed description of the architectural arrangement and structure of his building—what he himself describes as the "anatomy of the prison"—occurs in the postscripts to the Panopticon Letters. Here, the building becomes, for him, an "artificial body" that is invigorated and set in motion by the focal point of the observation tower, described repeatedly in organic metaphors. On the one hand, this is the focus where all the communication channels coalesce as "nerves," and on the other, the tower is the "heart" of the complex from where the all-seeing eye of the governor can range. Via these bodily vessels—arteries, veins, bundles of nerves—the "vivifying influence" of the principle of inspection spreads out through the building.[85] The decisive factor in this use of bodily metaphors probably lies in the literally central role Bentham attributed to the sensory perceptions of seeing and hearing in his scheme. As is well known, the overlying and pervasive principle of the Panopticon lay in the observation of the prisoners, firstly via a form of spatial layout that established a state of permanent visibility. According to Bentham, this idea originated in a visit by his brother to the École militaire in Paris in which the long rows of sleeping compartments could be inspected through spy holes in the doors. In the Panopticon, this capacity to inspect rooms successively is transformed into an act of simultaneous observation via a circular space,[86] thereby perfecting similar efforts of controlling found at the same time in projects by William Blackburn and other prison architects. Analogous to this system of visual surveillance, Bentham designed a method of acoustic permeation. His proposal involved connecting the central inspection box to the individual cells via metal tubes so as to allow specific verbal commands to be given to the separate inmates.[87] Thus, the "communication problems" pinpointed by the reform movement—the architectural planning of spatial connections while simultaneously hindering spoken exchanges—was complemented with the idea of a special system to impart information: "Communication, impeded in as far as it is dangerous, is, instead of being retarded, accelerated, where it is of use."[88] Later, presumably due to the difficulty of avoiding them also providing a reverse channel to the prisoners, these tubes were reserved only for communications between the prison director and the guards. But despite this, this combination of centralized hearing and seeing in the director's box resulted in a comparison with the integrative and coordinating functions of a nerve center: "hence issue all *orders*: here centre all *reports*."[89]

Viewed from the perspective of the correspondence between organic and mechanical analogies that remained current well into the nineteenth century, the body imagery in the Panopticon postscripts could actually be read in terms of a machine, but the fundamental and simultaneously overarching term that Bentham reserved for his architectural project, and that semantically also encompassed the engine, the clock, and the mill, is anyway another one. At every point where Bentham expounds on the uses and opportunities of his architectural idea, he first and foremost uses the word "instrument."[90] In the Panopticon book, he refers to it as "my instrument" and a "great and new invented instrument of government"; in the foreword to the French translation as a "very energetic and useful instrument."[91] Even in his old age he remained faithful to the phrase, still describing his design as a "magnificent instrument with which I then dreamed of revolutionizing the world."[92] This instrument terminology encapsulates an understanding of the connection between means and ends, cause and effect, in which Bentham's Utilitarian thinking was deeply rooted. In this sense, and ignoring the numerous works by the author on the principle of utility, the Panopticon writings propagate solitude as a "necessary instrument" and incarceration as an "instrument of justice," and equivalently reward as the "engine of discipline" and labor as the "engine of punishment."[93]

Bentham's terminology, like his entire philosophical approach, has to be seen as intimately tied to the contemporary natural sciences. Indeed, as in the case of the machine terminology used by the French reformers Jean-Baptiste Le Roy and Jacques Tenon, to a certain extent it appears to have sprung directly from the context of experimental scientific practice. Thus, early on, Bentham, while still himself involved in chemical research, used the example of a natural-philosophical experiment to encapsulate the meaning of the term. In an unpublished draft chapter from around 1778 with the title "Happiness and Unhappiness," he derives the core relationship between instrument and cause that was so fundamental to his Utilitarian thinking from observations regarding how mercury rises in a barometer. Whereas in general parlance both air and air pressure were indiscriminately seen as causing it to climb, Bentham suggested that the two terms be precisely differentiated. According to him, air pressure, as a specific modus of air as a substance, was the cause, while air itself was the instrument of the phenomenon. Gleaned from this, the result is a generally utilizable and semantically comparatively exact distinction between cause and instrument, or expressed differently between the principle of the operativity of an instrument and its actual operation: "By a Cause, I mean not the instrument itself, but the action of the instrument."[94]

From the beginning of his career, Bentham apparently also applied this notion of the instrument to architecture. Already in the 1776 introduction to an unpublished draft of a general legal code, written many years prior to the development of his Panopticon, Bentham stated that "[a]rchitecture (is instrumental) produces Happiness by securing men's persons from the deleturious influences of Heat, Cold, and Moisture that is of some of the occasional causes of dissolution: by securing the instruments of enjoyment against dispersion and depositions by giving its own productions a form agreable to the eye."[95] From this vantage point, built space presented itself as an essential component in the hedonistic calculus, its social purpose consisting, via its aesthetic and climatic properties, in maximizing happiness and minimizing pain. In the case of the Panopticon, the outer appearance of which Bentham paid comparatively little attention to, this principle is manifested above all in the deployment of elaborate building services. The first postscript contains a detailed description of a warm air system, similar to that used by the wool manufacturers in the Midlands at the same time. A radial network of pipes was designed to inject fresh air, heated by a modified Franklin stove, into the individual cells, and eject the used air back out again above the building.[96] Whereas to date the integration of single stoves and ventilation openings had sufficed in the heating and ventilation methods of the prison reformers, Bentham thereby modernized them using the latest technology: the distribution of warmth and air is carried out in as centralized a way as that of spoken commands and visual fields.[97]

A few years after presenting it, Bentham went further and explicitly framed his Panopticon principle in terms of an instrument. The 1798 publication "Outline of a Work entitled Pauper Management Improved" sketched out a utopian plan for a National Charity Company for Great Britain by which 250 panoptic workhouses were to be evenly distributed across the country. Amongst the many benefits the program was to bring was an enhancement and spread of useful knowledge from various fields, such as the art of healing, bookkeeping, or domestic economy, including via dietary, medical, and social experiments on the inmates. As a result, the proposed system of "industry-houses" was invested with the character of a universal instrument: “might it not then be styled *a polychrest—an instrument of many uses*?”[98] This expression, from the Medieval Latin “*polychrestus*” and taken from Francis Bacon, serves Bentham to yet again root both his term “instrument” and his building project in the epistemological tradition of the natural sciences.[99] A few pages later, he then goes on to formulate an unequivocal comparison between the activities of the natural philosophers, preoccupied as they were with examining and experimenting with the properties and transformation of substances, and his own practices, which via spatial means undertook the equivalent in the human field. “O chemists!” exclaims Bentham, “—much have your crucibles shown us of dead matter;—but our industry-house is a crucible for men!”[100] Here, the melting pot, which at the same time began its life as a metaphor for cultural assimilation, is used in an attempt to reinvigorate the architectural idea of the Panopticon by once again drawing attention to the experimental and transformational character of its building design.[101]

As is well known, Bentham failed during his lifetime to persuade either the British or any other government to construct panoptic prisons or workhouses. Following years of political and legal squabbles, the British government, which had initially accepted plans to build a national Panopticon penitentiary, finally rejected its realization in 1813.[102] The Panopticon—at least in terms of matching Bentham’s basic ideas and requirements—remained unbuilt, and the design therefore never had the widespread impact on prison architecture that it did in stirring people’s minds and emotions. Despite this, Bentham’s project and writings did have a crucial twofold influence on the late-eighteenth-century reform movement. First, they established the principle of central surveillance as a fixed architectural and organizational factor. The Panopticon perfected the idea of inspection to such an extent that soon every floor plan that incorporated the proliferating element of a central observation post was described as “panoptic.”[103] Second, Bentham’s proposals for the first time articulated, in great detail, the desire to mold an institution that would enable complete control of the bodies and minds of the inmates. As the most comprehensive and radical attempt to create fully calculable environmental conditions via administrative and constructional elements, the idea of the “inspection house” trenchantly encapsulates the reform endeavors of the times. In this, however, Bentham’s contribution consists less in fixing the scheme in the image of a merciless machine than in formulating it in the precise vocabulary of a Utilitarian principle founded in natural philosophy. By explicitly distinguishing between cause and effect, between a condition and the modes of its occurrence and appearance, he opened up an equally categorical discourse concerning the fundamental yet open agency of built space. Bentham made architecture comprehensible as a moral “instrument,” and thereby not as a necessarily but first of all as a potentially operative object. Nevertheless, it would not take long before this understanding became the basis of a discussion in which buildings were indeed identified with machines.

The School System

Around the same time as Jeremy Bentham elaborated his design for the Panopticon, the American chemist, physician, and politician Benjamin Rush gave a lecture in Benjamin Franklin's house about the social consequences of public punishment. Referring to the search for alternative penal methods, he explained that "[i]f the invention of a machine for facilitating labour, has been repaid with the gratitude of a country, how much more will that man deserve, who shall invent the most speedy and effectual methods of restoring the vicious part of mankind to virtue and happiness, and of extirpating a portion of vice from the world?"[104] Rush himself rose to the challenge, and shortly afterward launched various campaigns aimed at such ventures as the establishment of solitary confinement in the state of Pennsylvania or the setting up of a psychiatric ward at Philadelphia Hospital. Parallel to this, he began research into psychology that resulted in one of the first attempts to catalog all the physical factors that affected human behavior.[105] He also developed a "thermometer" that measured the influence of drinks on the moral and physical constitution, ranging from water (bringing health and wealth) to rum (bringing death and dungeon).[106] But Rush's utterances can also be seen as a general call that would be followed by numerous other protagonists over the coming decades relating to a wide variety of virtues and vices, whereby they would treat their work on the relative methods and institutions far more concretely as the development of machines than Rush could have imagined when making his analogy.

Comparatively speaking, hardly any other institution was so often associated with the term "machine" in the first half of the nineteenth century than the school.[107] In the process, a development emerges that can be said to be characteristic for the context of morals: beginning with its use as a description of social circumstances, with time the machine model was also increasingly applied to architectural connections, before finally serving to address the specific interaction between social and spatial organization. In terms of the school, this development started with two British educational reformers, Joseph Lancaster and Dr. Andrew Bell. In around 1800, both men began propagating the so-called “monitorial system,” a school model in which slightly older children under the guidance of a teacher or supervisor acted as monitors to teach a larger number of younger children. Bell and Lancaster’s pedagogical innovation was a response to the question of the education of the poor, which was increasingly considered problematic in the late eighteenth century. Since the 1780s, the enormous growth, and above all the concentration of the population in the industrial and trade centers, coupled with the emergence of social reform initiatives, had led to various ideas concerning the schooling of children from impoverished backgrounds. The main aim behind these endeavors was to combat the social perils of the growth of a large number of uneducated and possibly seditious youths. Thus, while penal and prison reform involved ways to deal with actual disobedience, an important factor in the establishment of public primary schools was how to handle potential disobedience.[108]

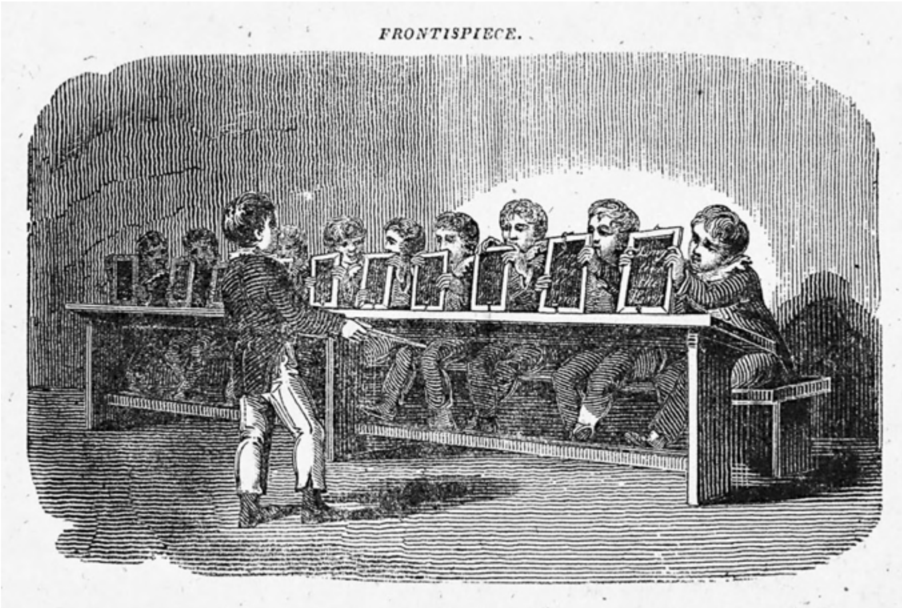
Set against this background, the monitorial system could be promoted as a cheap and effective solution. Born in 1753, the Scottish clergyman Andrew Bell developed the idea in the late 1780s while in charge of an orphanage in Madras in India. Faced with a lack of teaching staff, he deployed boys aged eleven to fourteen as “teachers” and those aged seven to eleven as “assistant-teachers,” enabling a school of 200 children to be taught in groups. Upon returning to England, in 1797 he published his experiences with the method in a short volume titled *An Experiment in Education*, and a year later his suggestions were first applied in a parish school in London. At the same time, the twenty-five-year-old English Quaker Joseph Lancaster began developing a similar system, likewise in London, and in 1801 built his first single-room school building, publishing the results in 1803 under the title *Improvements in Education*.[109] Thus, the period around 1800 saw the emergence of two systems, Bell's and Lancaster's, that would dominate the topic of popular education for decades and sometimes in competition with each other. Both systems quickly attracted active followers who helped publicize and demonstrate the benefits of the respective systems.[110]

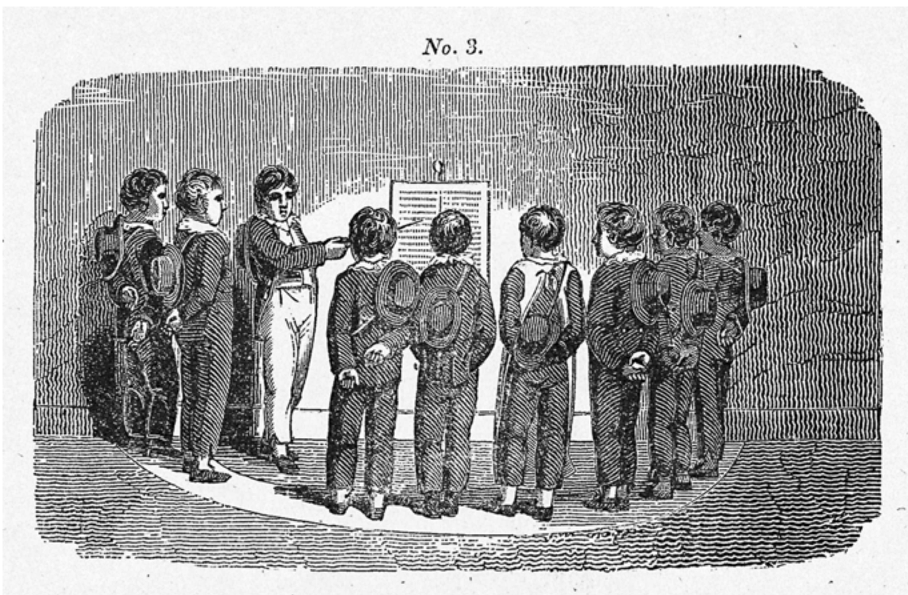
Bell's writings provide a vivid example of how the machine term was gradually incorporated into the arguments of the educational reformers. While still absent in the first edition of *An Experiment in Education*, it first appears in the second 1805 edition in the description of the role of the schoolmaster. As the chief supervisor, he stands at the pinnacle of the pyramid-shaped monitorial system and is vested with crucial tasks of surveillance and control. "Next (and last if there be no Superintendent)," wrote Bell in his list of the different functional positions in his method, "comes the Schoolmaster, whose province it is to watch over and to conduct this machine in all its parts and operations, and see the various offices, which I have described, carried into effect. From his place (chair or desk) he overlooks the whole School, and gives life and motion to every member of it."[111] In its third edition, published in a distinctly expanded form in 1807 as *An Analysis of the Experiment of Education*, Bell additionally compared his method's supervisory regime to that of an army regiment or a naval ship, and these in turn to a complex machine.[112] In the fourth and definitive edition of the book, which appeared a year later, the machine terms already run to dozens. Moreover, *The Madras School* also contains what must be the most concrete denomination of Bell's metaphorical frame of reference, modeling his system on industrial propulsion and production machinery: "Like the steam engine, or spinning machinery, it diminishes labour and multiplies work, but in the degree which does not admit of the same limits. For unlike the mechanical powers, this intellectual and moral engine, the more work it has to perform, the greater is the degree of perfection to which it is carried."[113] Unlike a steam engine, the monitorial system was unhindered by any technical restrictions such as friction or wear and tear. But otherwise, in terms of time economy, costs, and also punishments, the method was directly attuned to the great technical innovations of the factory era. The critical point of comparison was the division of labor, whereby this related to both the teaching activity and its contents. In that sense, the mechanical therefore described not only the general increase in performance but equally the actual division of and interaction between personnel and pedagogical elements in the monitorial system. The automating effect that this approach promised to deliver had been stressed by Bell from the outset: “After this manner the school teaches itself.”[114]

Bell’s concept of the “school machine” was deeply influenced by the political-economy theories of the age, according to which the division of labor represented one of the core factors in the growth of production and wealth, with technical innovation playing a key role in the equation. In his 1776 *The Wealth of Nations*, Adam Smith had described productivity growth as being dependent on three circumstances: the greater manual skill of the individual workers, the saving of time in switching between various operations, and the invention of machines that lightened and shortened the work, allowing a sole worker to undertake the work of many.[115] Bell’s teaching principles resonate closely with these criteria, which quickly became his supporters’ crowning argument. In 1809, the English social reformer Sir Thomas Bernard wrote, in reference to the hypothetical first figure to apply Smith’s division of labor, “But that man, whatever his merit, did no more service to *mechanical*, than Dr. Bell has done to *intellectual* operations. It is the division of labour in his schools, that leaves the master the easy task of directing the movements of the whole machine instead of toiling ineffectually at a single part.”[116] However, Bell and Bernard were able to invoke Smith not only in terms of processes of division of labor but also in the application of their machine and system terminology. In an essay written in the mid-eighteenth century and published posthumously in 1795 concerning the history of scientific methods, Smith had drawn a fundamental analogy between the constructive activity of machine builders and the system-, or theory-building activity of philosophers: “Systems in many respects resemble machines. A machine is a little system, created to perform, as well as to connect together, in reality, those different movements and effects which the artist has occasion for. A system is an imaginary machine, invented to connect together in the fancy those different movements and effects which are already in reality performed."[117] Set against this background, the discussion of the monitory system as a machine to perform mental work represents simply an additional twist in the basic comparability of ideational and real mechanisms.

It comes as no surprise that Bell's and Lancaster's teachings were particularly enthusiastically taken up in the context of industrial production. Quite apart from the fact that the factory and the monitorial system were organizationally similar, the establishment of schools was a concrete feature of industrial management. As early as 1799, the famous Welsh industrialist and utopian Robert Owen had founded a school for children under six based on the monitorial system at the outset of his efforts to improve local working and living conditions in the cotton mill in New Lanark in Scotland, expanded in 1809 in the form of a double-story building housing his New Institution for the Formation of Character.[118] With this, the idea of the "school machine" was inserted into a context that already lent itself to mechanical analogies. In his *New View of Society*, published in 1813, in which he acknowledged Bell and Lancaster as the "most important benefactors of the human race," Owen formulated a cardinal parallel between the supervision of "inanimate" and "animate machines," between manufacturing technology and the work force, describing the latter as "living machinery."[119] Later, Owen used a terminology similar to the devotees of the Bell and Lancaster schools in outlining his plan for a model socialist community: "A machine it truly is, that will simplify and facilitate in a very remarkable manner, all the operations of human life, and multiply rational and permanently desirable enjoyments."[120] From 1813 onward, Jeremy Bentham acted as Owen's business partner in New Lanark, and in his *Chrestomathia*, published in 1816, proposed the construction of panoptic schools based on the monitorial system, thereby reanimating both his inspectorial and instrument principles. The Chrestomathic School, a twelve-sided building ordering nine hundred children around a central teacher's desk, is based on its Ancient Greek name, "*conductive to useful learning.*"[121] Bentham proved to be a child of his times and describes the teaching method applied in the school moreover as an "intellectual machine."[122] But it was by no means only manufacturers and dyedin-the-wool Utilitarians who availed themselves of this mode of language. Romantics, such as William Wordsworth and his fellow Lake Poets, equally praised the monitorial system in their works as a "mechanical" achievement. Robert Southey described the new method in 1812 as a "moral steam-engine," a statement that was seconded by Samuel Taylor Coleridge four years later with the words "this incomparable machine, this vast moral steam-engine."[123]

Consequently, the early-nineteenth-century British education reform generated a concept of the school as an operational system based on the division of labor, with its procedures, once initiated, reproducing themselves. Initially, this "school machine" had little architectural content. What Bell and Lancaster are primarily describing in their monitorial system is a pedagogical and social organizational form, which beyond the relative positioning of the participating individuals involves next to no spatial specifications. Bell, in particular, remained vague about the architectural requirements of his method, and in 1808 still expressed what he saw as their irrelevance: "The chief and great expense," he wrote regarding the education of destitute children, "consists in a roof to cover them. The rest, under the Madras system of tuition, is quite inconsiderable."[124] But this state of indifference was not to last long. Shortly afterward, Lancaster, who from the start had shown himself to be more receptive to the potential significance of architectural aspects, began making precise specifications in his publications about the physical layout and fixtures of the school building.[125] In 1809, he published *Hints and Directions for Building, Fitting Up, and Arranging School Rooms on the British System of Education*, conceived as a practical building guide to accompany *The British System of Education* that appeared a year later. The book argued for the introduction of a novel arrangement in which the schoolroom was dominated by two rows of desks, used for writing exercises and facing the teacher's desk at the top end. At the sides is space for aisles in which the pupils receive lessons in reading and arithmetic while standing. Shortly afterward, Bell's supporters proposed an exact opposite arrangement, in which the desks run along the edges of the room and the central space is reserved for lessons while standing. In both systems the classroom serves as a means to organize the various groups of pupils as well

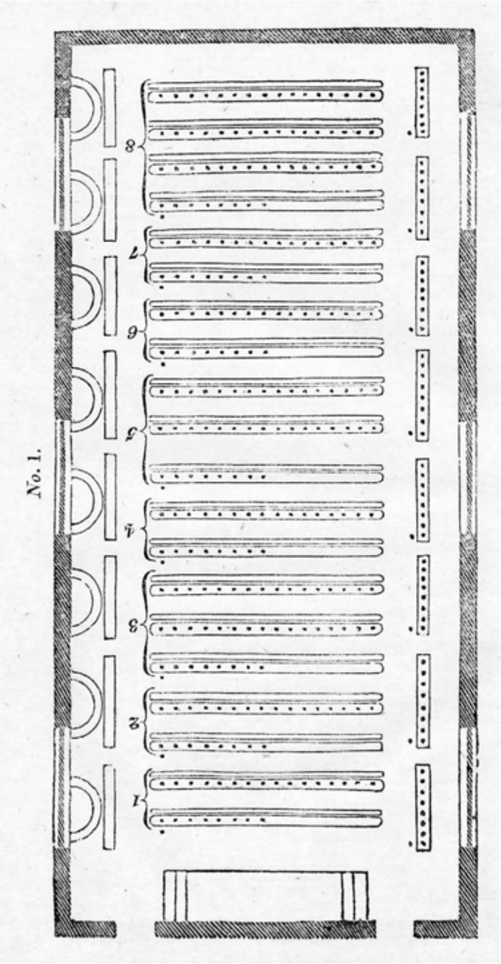


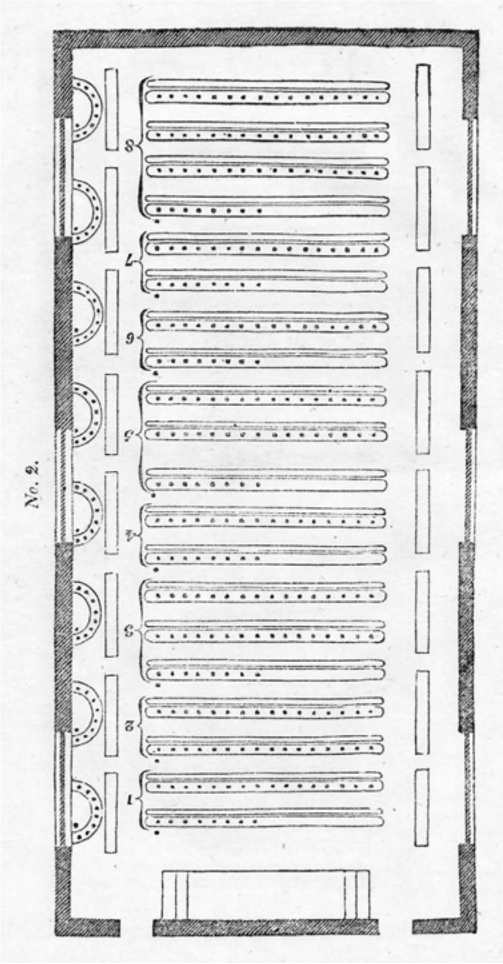


38–39
Lessons at a desk and standing, after Joseph Lancaster, 1810

as the individual pupils. While the assistant teachers rotate with the groups between the spatially separated curricula, the pupils within the groups are continuously arranged according to their individual abilities, meaning that their performance always has spatial consequences and that their spatial array always mirrors the current state of how they are competitively ranked.[126]

In *The British System of Education*, and under the motto "A PLACE FOR EVERY THING, AND EVERY THING IN ITS PLACE," Lancaster converts his arrangement into a meticulously described model plan of a classroom for 320 children.[127] It measures approximately 10 by 20 meters and accommodates twenty-two rows of desks, which are placed so that the pupils and supervisors can circulate freely between them. In the longitudinal aisles are semicircular floor markings for lessons which pupils received while standing, and fixed to the walls are appliances to which to attach teaching material. ← Figs. 38–39 Starting from a raised platform with the teacher's desk, the floor inclines gradually upward so that all the desks remain equally in view. For economic and acoustic reasons, the walls are unplastered, and to avoid injuries the corners and edges of the firmly secured furniture are rounded.[128] Nevertheless, the fundamental role that architecture acquires in the operations of the monitorial system is clearly legible not only in its detailed written description but also in the use of a completely new presentational technique. Lancaster's 1810 book contains two floor plans depicting the layout of the building, the fittings and fixtures (with the rows of desks numbered according to the class), and the floor markings, but moreover also a diagrammatic aspect, whereby small dots symbolize individual pupils or assistant teachers. → Figs. 40–41 In military literature, this way of representing individuals with geometrical figures or alphanumerical characters stretches back to the sixteenth century,[129] but in terms of construction drawings it was a complete novelty. The method enables Lancaster to show two key moments in his teaching method: the pupils always switch between the different teaching stations at the sound of a bell, which is not simply a necessary part of the curriculum but has an explicitly pedagogical function as a dispersing element. In plan no. 1, one group each has left their desks and waits in line to walk together to the

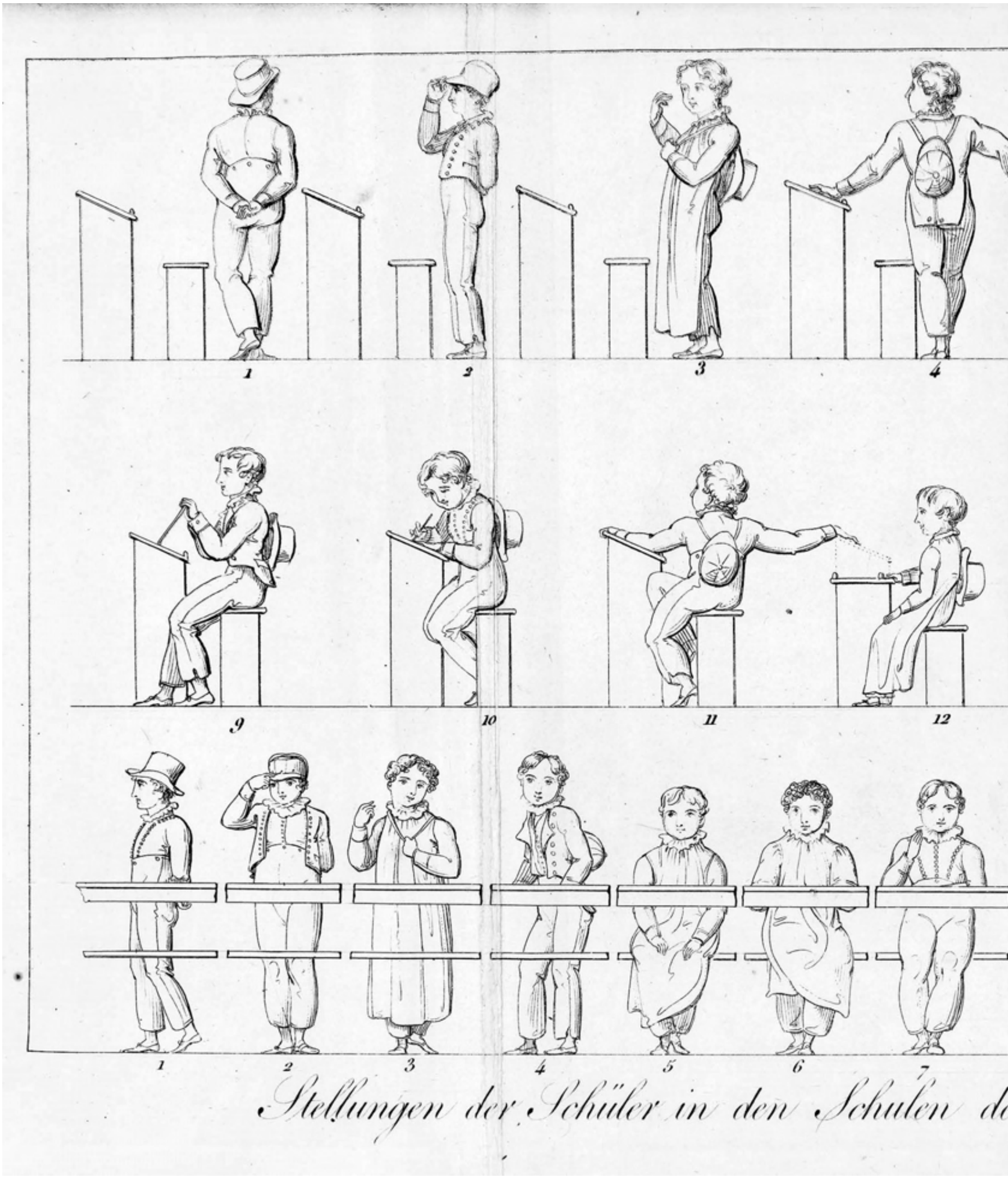




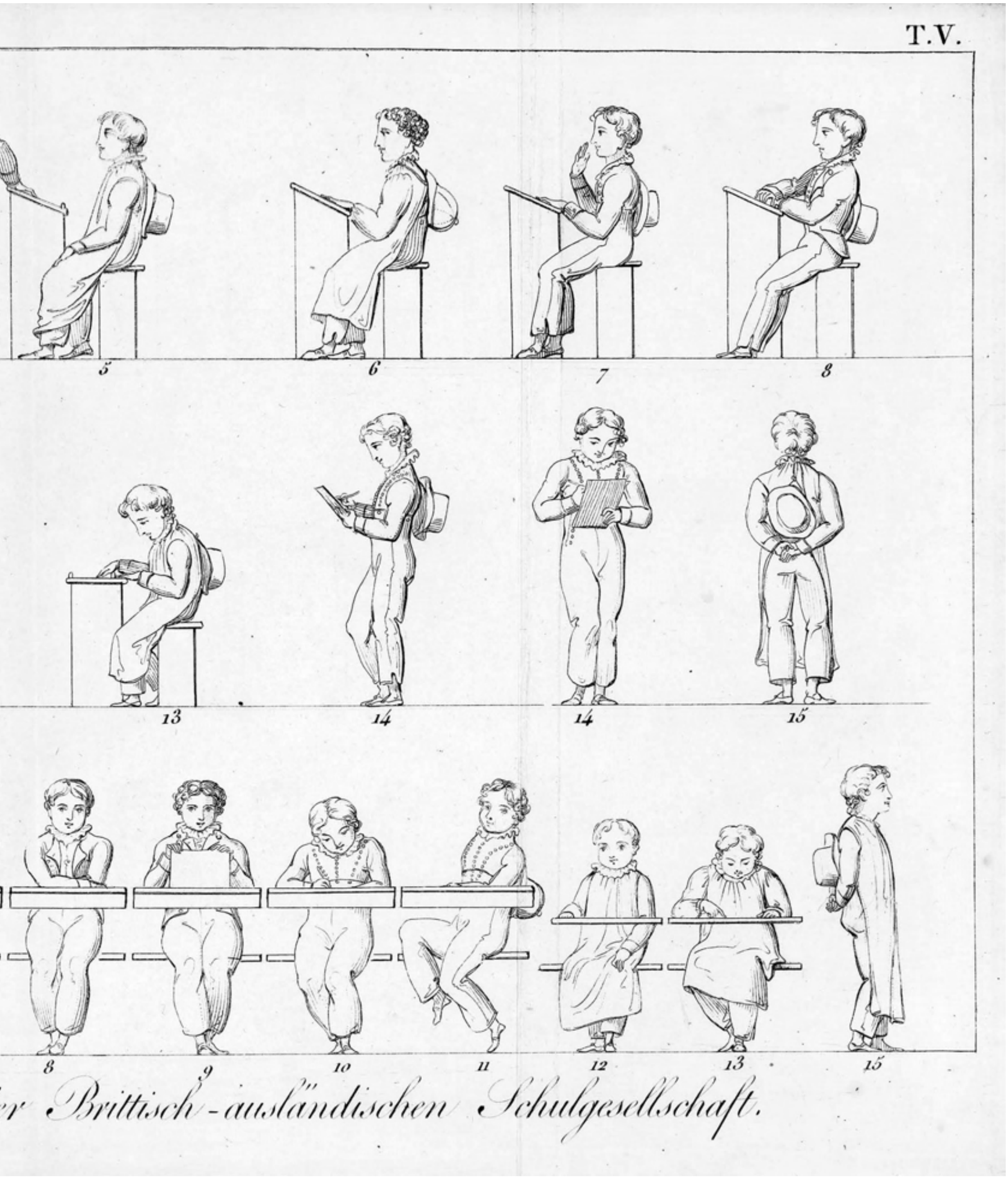
40–41
Schoolroom with pupils and assistant teachers: diagrammatic illustration by Joseph Lancaster, 1810

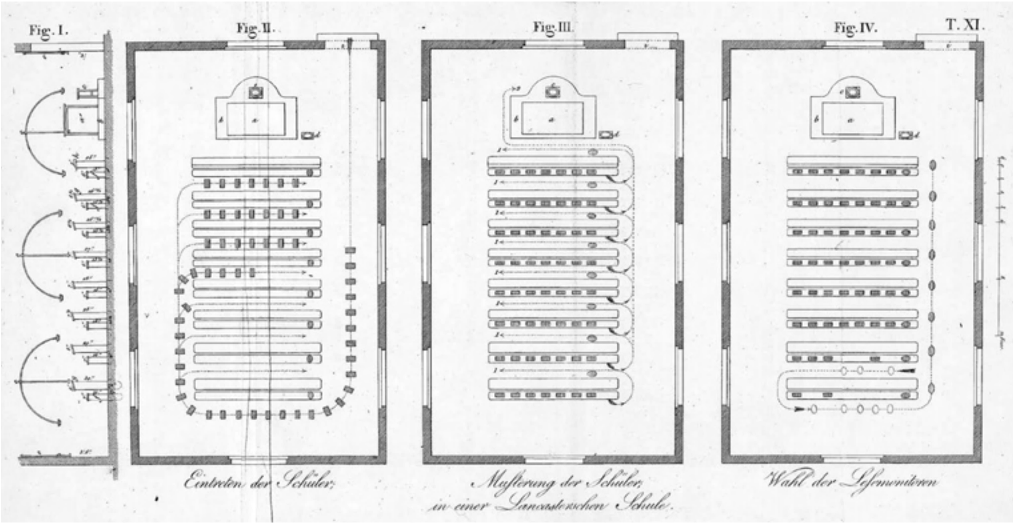
other side of the room. In plan no. 2, the groups have reached the exercise stations and are ready to receive a lesson while standing. Considered simply for themselves, the dots therefore represent the precise positioning of each and every individual, while seen in successive overview the plans show their movement. "The passages round the school-room," explains the commentary to the plates, "contribute greatly to the order and activity of the school."[130] Thus, while Bell set the semantic foundations for the concept of the "school machine," Lancaster translates its operational procedures into built space, at the same time expanding the architectural plan to include the potential to represent them.

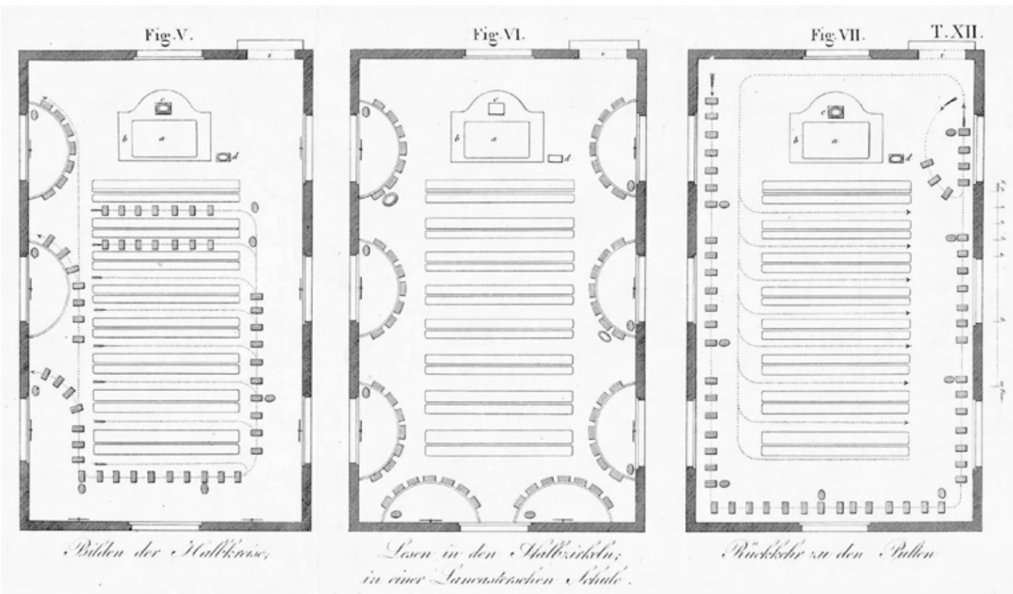
As the pedagogical and didactic means of the monitorial system became more refined, so the spatial positioning and movements of the individuals involved in the lessons became considered and planned with increasing precision. The relevant manuals contain more and more detailed descriptions and illustrations of the assemblage of pupils, classroom, and school furnishing, stretching to even include individual postures and gestures. In 1818, the German-born physician and natural scientist Joseph Hamel published a book that not only introduced the Bell-Lancaster system to a continental European public but also contained a series of plates that established a new representational standard. On the one hand, the plates illustrate detailed drawings of the exact postures of the pupils at particular moments during the lessons → Fig. 42 : sitting down and removing their hats → Fig. 42: 1–5 ; cleaning, demonstrating, and writing on the blackboard → Fig. 42: 6–10 ; standing up → Fig. 42: 11 ; writing exercises for younger pupils → Fig. 42: 12–13 ; and lessons while standing.[131] → Fig. 42: 14–15 On the other hand, the plates also show, abstractly, the positions of the pupils and teachers in the floor plan of the school, taking Lancaster's illustrative method further. While Lancaster required two separate illustrations in order to visualize a change of place, Hamel introduces fletched arrows and dashed lines, two elements that allow him to depict both the various states of the system and the corresponding movements at the same time.[132] → Figs. 43–44 Just as in heating and ventilation technology, in which the protagonists simultaneously began displaying flows of air, steam, and water using arrows, the planning of spatial dynamics evidently



42
Physical postures and gestures in teaching, after Joseph Hamel, 1818





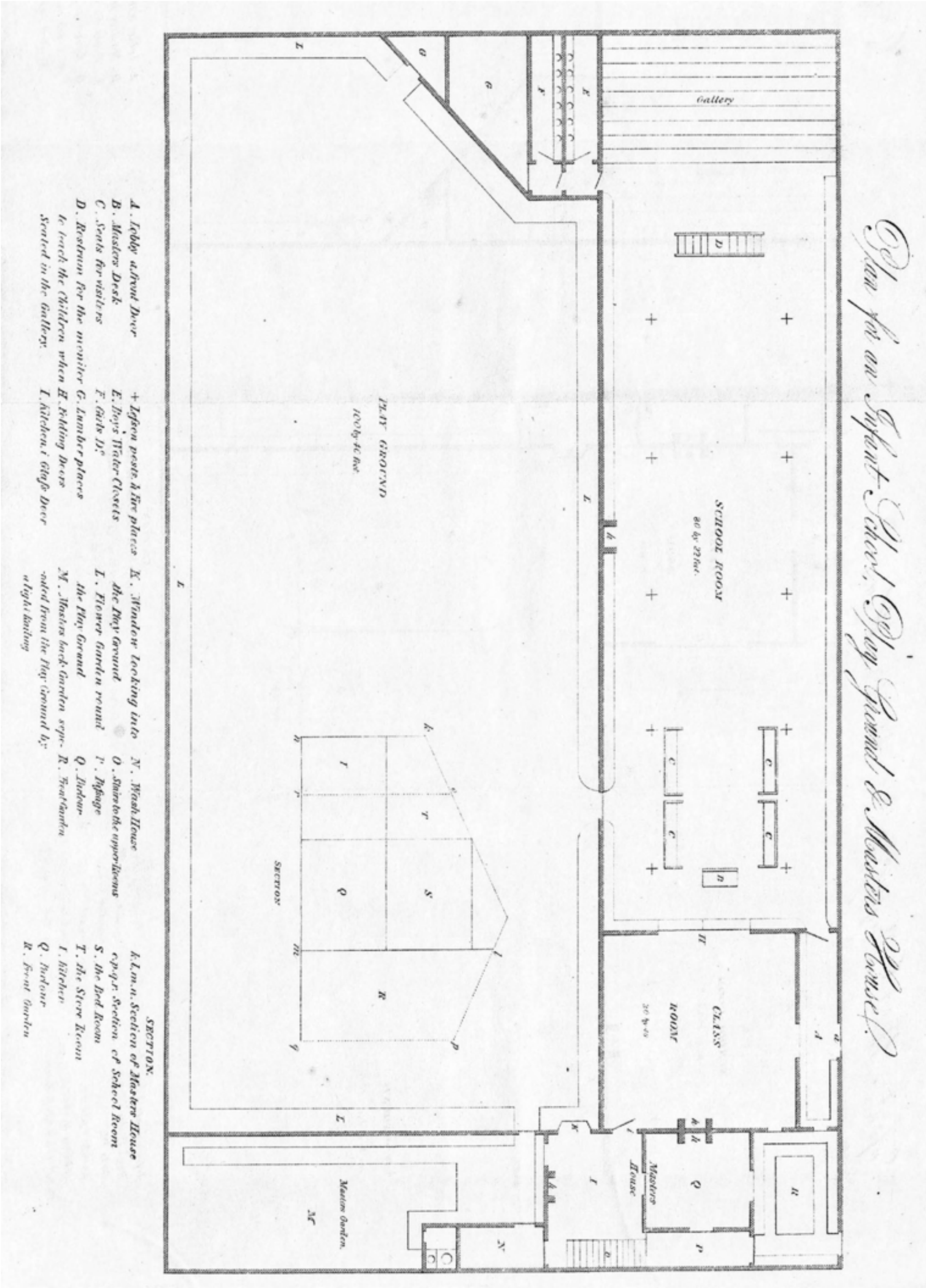


43–44
Schoolroom with pupils, assistant teachers, and teachers: diagrammatic illustration by Joseph Hamel, 1818

also assumed a significance within the context of morals that made a new representational operativity desirable.

A basic requirement of Bell and Lancaster's methods was that those pupils who acted as monitors possess at least minimal teaching skills, and therefore they inevitably worked less well in teaching children under seven. As early-childhood learning received more attention in the course of the 1810s, also through Robert Owen's endeavors, the development of modified processes and arrangements became necessary—a context in which school architecture also underwent further elaboration. In 1820, a model school opened in London that would serve as the impetus for a countrywide network of institutions for infant education over the coming years.[133] Its founder, the teacher Samuel Wilderspin, thereby initiated two developments that would have a long-term impact on education both in the United Kingdom and abroad, while simultaneously further reinforcing the school machine concept and its architectural connotations. First, Wilderspin went back to a greater emphasis on direct learning with the teacher. Teaching assistants were only to be deployed in his schools to a limited extent, and only in those areas of teaching that he described as the "mechanical parts of the system."[134] Second, he pioneered a series of new architectural elements designed to facilitate the pedagogical goals of the school. These included the playground, which as a small "world" was intended to demonstrate the behavior of the pupils when left to their own devices and thus the educational results of the system; a "classroom" split off from the rest of the school building, providing uninterrupted surroundings in which the teacher could instruct single groups of pupils; and the "gallery", a part of the school equipped with progressively raised rows of seats toward the back, making the teacher visible to all the pupils during collective instruction.[135] All three elements occupy a prominent position in the plan appended to Wilderspin's publication *Infant Education*. → Fig. 45

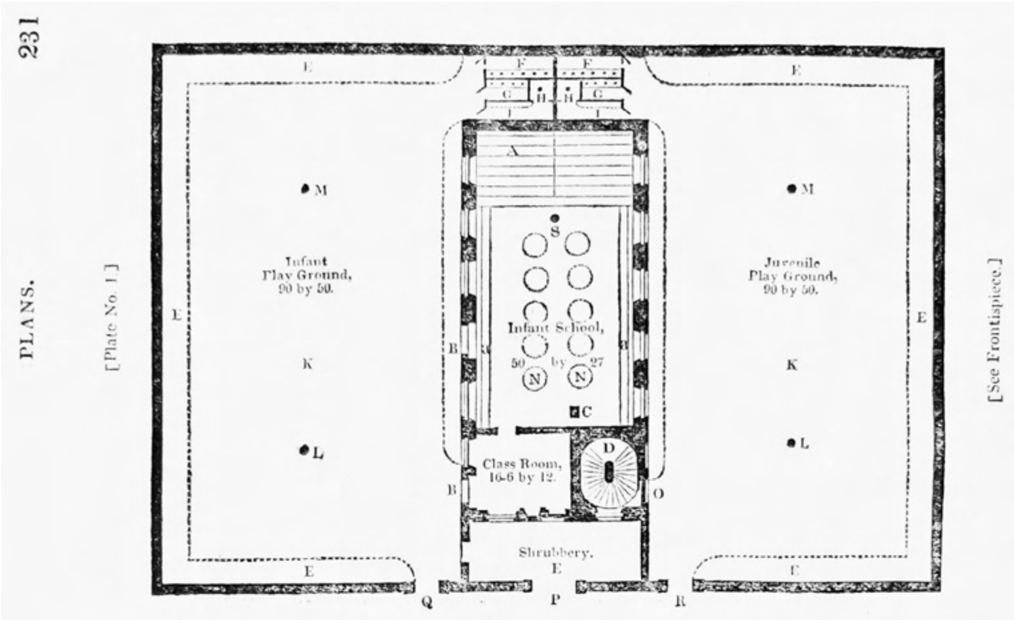
How these individual aspects of more-or-less "mechanical" teaching, spatial movement, and the specific architectural elements finally coalesced into a universal concept of the "school machine" is evident in the case of David Stow in the 1830s. Stow, originally a merchant, began running a Sunday school for the children of impov-

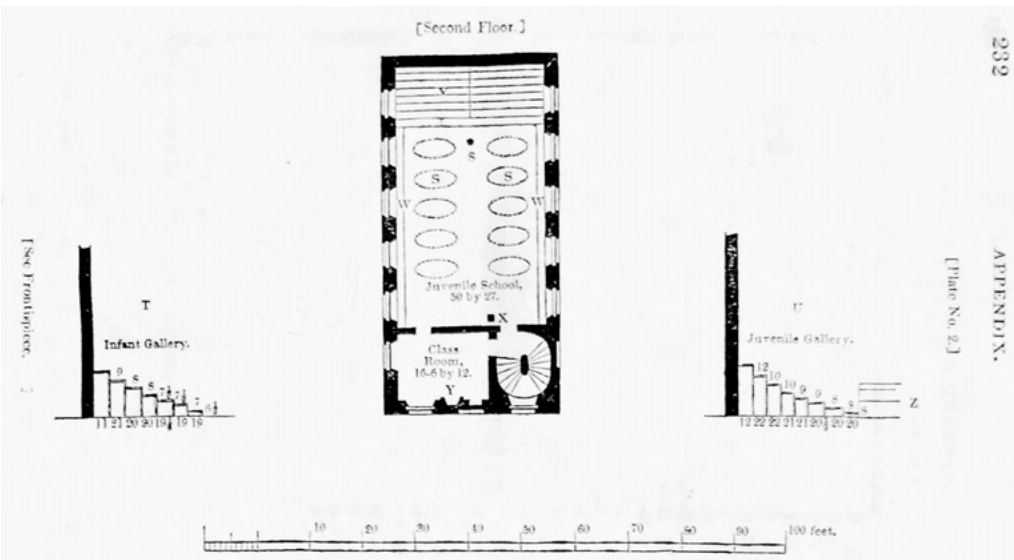


45
Model plan for a school with playground, classroom, and gallery by Samuel Wilderspin, 1825

erished families in 1816 in Glasgow, but the modest successes of a single day's teaching forced him to search for alternative models outside Scotland—"to look abroad for a more efficient moral engine," as he would later write.[136] The resulting school system combined elements of the methods of Wilderspin, Owen, Lancaster, Bell, and other predecessors. From the late 1820s onward, Stow, together with the Infant School Society founded by himself, accelerated the building of a number of schools for children and youths in Glasgow, and in the early 1830s he began disseminating his ideas in a series of publications, which in numerous editions count among the most influential educational handbooks in nineteenth-century Britain. The first to appear was *Infant Training* in 1833, followed in 1834 by *Moral Training*, and in 1836 by *The Training System*.[137] One of the reasons for the success of Stow's publications was no doubt that they incorporated model plans for community schools of different sizes based on simple demographic calculations, thus supplying concrete specifications for initiatives, charities, or magistratures who wanted to provide the local population with the titled "moral training." → Figs. 46–47

Stow's books are not only infused with a concept of the school as a "moral motor" but simultaneously systematically connect this concept with a series of material and spatial conditions. This combination starts even in the table of contents where Stow summarizes the aspects concerning the physical side of teaching—the school building and the classroom, but equally teaching materials like the picture boards—under the bald title "The Apparatus."[138] This is continued at those junctures where he discusses the arrangement of and the interaction between the individual building parts in his model plans. For instance, the churches that Stow proposes to be built together with the schools in the framework of combined "Parochial Institutions": "We connect the church with the schools, both to show how ground may be saved, and also, because such forms one of the most important parts of the machinery for moral training."[139] And it extends as far as the characterization of individual building elements, such as the gallery, which Stow designates as an "indispensible part of the machinery." The "social principle" of the overall system is correspondingly concentrated in these rows





46–47
Built “machinery”: model plans for a combined nursery and primary school by David Stow, 1836

of benches by virtue of guaranteeing, better than any other spatial arrangement, the collective attention of the school children.[140]

According to Stow's specifications, during the lessons the classes move in a circle through the school. After being supervised by the assistant teacher in the general schoolroom, they are then tested by the teacher in the immediately adjoining classroom. From there the pupils move to the playground until the arrival of a subsequent class gives the signal to return to the schoolroom. "This rotary movement continues until the prescribed time allotted to that part of the system is exhausted."[141] The school building is conceived according to these sequences: the playground, for instance, was required to have a direct connection both to the classroom and the schoolroom, and should be additionally surveyable by the vigilant teacher via a window. Thus, in Stow's model the content and timing of the lessons are tightly interlinked with the spatial arrangement of the school building, definitively transforming the "machinery" of the school into an organizational construct with architectural dimensions. Over a decade later, at a point when the monitorial system had lost much of its attraction again, an English book on the arrangement and organization of school buildings would still read: "all parts of the scholastic machine must be properly adjusted, every wheel must perform its appointed work … the whole machine of the school-room is set in motion."[142]

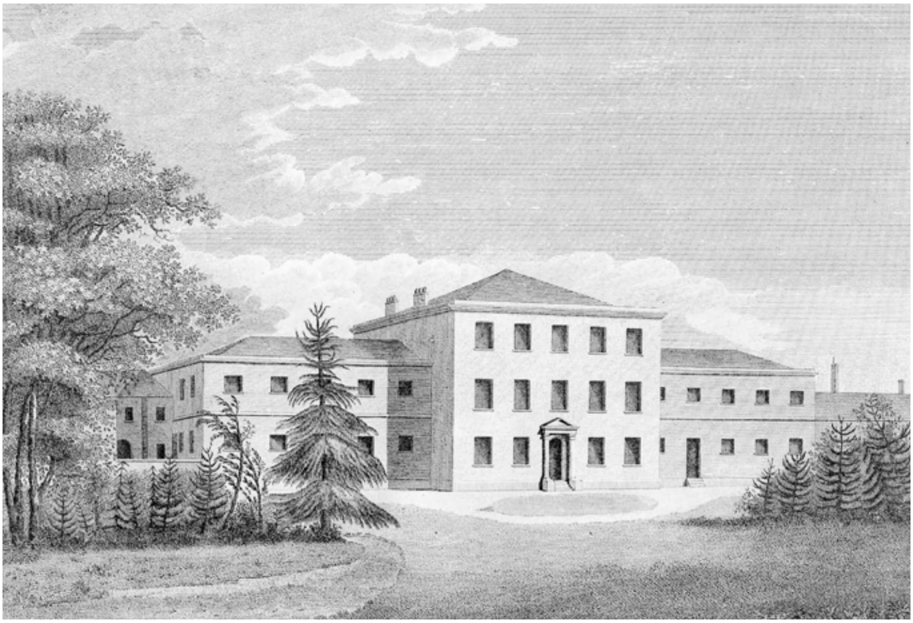
The Psychiatric Environment

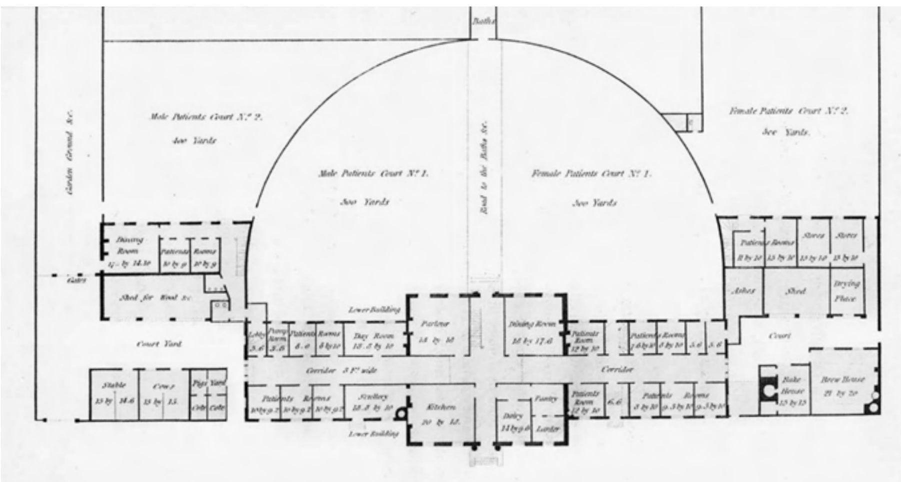
As opposed to the numerous machine terms applied concerning schools, in connection with another key institution it is the initial absence that is noticeable. The authoritative publications in English and French that accompanied the emergence of psychiatric asylums are largely bereft of mechanical or machinery concepts. And this is the case despite the fact that the development of psychiatric facilities was based on a motive generally related to that of the school, namely the efforts to align the institutional modes of operation and organizational procedures as comprehensively as possible with the layout and structure of the respective buildings, thereby exercising a positive influence on the morals of the inmates and visitors. In his 1850 description, the American physician and asylum director Luther V. Bell uses a wording similar to the statements regarding schools, including the reference to industrial production: "An Asylum or more properly a Hospital for the Insane may justly be considered an architectural contrivance as peculiar and characteristic to carry out its designs, as is any edifice for manufacturing purposes to meet its specific end. It is emphatically an instrument of treatment."[143] Subsequently, at the latest in the second half of the nineteenth century, the psychiatric asylum also came to be explicitly described as a machine. "An asylum," explained the English physician and inventor Joseph Mortimer Granville in 1877 in relation to the spatial questions of asylum planning, "is a special apparatus for the cure of lunacy."[144] If such utterances were initially absent, nonetheless the understandings that underlay them are, once again, to be originally found in the period around 1800. This pivotally involved the spread of a psychiatric method called "moral treatment" that placed a new emphasis on the patients' surroundings in general and their accommodation in particular. Importantly, the fact that this was not accompanied by the use of mechanical references may have to do with the precise way in which the psychiatric setting was meant to impact the patient.

The eighteenth century saw the emergence of a notion of insanity that no longer viewed it as a hopeless and God-given fate, but rather as curable through moderate forms of guidance and education. In scattered private and public institutions, measures were first developed that shifted away from what had to date often been brutal methods of coercion and confinement to more liberal and personal forms of treatment. At the end of the century, these tendencies led to a psychiatric movement defined by its focus on the rational and emotional instead of the possible physical causes of madness—moral treatment. Via a wide spectrum of non-medical and non-physiological processes, this movement attempted to actively engage the patients in their process of recovery, for instance by trying to give them the self-control to deal with their illness themselves.[145] Because the shape of the immediate environment was one of the basic aspects of this process, more attention was paid to the patients' surroundings. The role that built space acquired in this context prompted Philippe Pinel, the well-known French physician who played a decisive part in the development of moral treatment, in his main work of 1801 to call for architects in future to closely coordinate their work with psychiatrists when building sanatoriums.[146]

A subsequent example of such a successful liaison between the architectural and healing professions is an English institution that opened just before the turn of the century but only had its full effect around fifteen years later, based on a popular book. The York Retreat, founded in 1796 at the initiative of the Quaker William Tuke outside the city of York, and the treatments practiced there, were discussed in detail in 1813 in the *Description of the Retreat*, written by his grandson Samuel Tuke. The book outlines how the old regime of reformatories and madhouses, in which mentally ill people were usually held in custody, including their "apparatus of chains, darkness, and anodynes," had been replaced by a comprehensive system of sensitive and benevolent care in the retreat built especially for this purpose.[147] The building, designed by the architect John Bevans, is situated on a hill surrounded by countryside and enclosed by courtyards and gardens. It consists of a central, three-story administration building and two double-story wings in which double-loaded corridors lead to the day and sleeping rooms of the patients. Offering close personal care, regular religious instruction, and light physical activities, the homely-like facility was equipped to treat the ailments of around fifty patients. → Figs. 48–49

In Britain, the publication of Tuke's book, which drew international attention to the therapeutic-architectural concept of the York Retreat, had been proceeded by a set of interrelated developments, including an increasing awareness of the needs of the psychologically ill, the first legal regulations for their adequate care, and various regional initiatives for the building of new psychiatric facilities.[148] In Glasgow, Scotland, one such initiative led to the founding of a municipal commission shortly after the turn of the century that had appointed local architect William Stark to produce plans for an insane asylum building. After visiting numerous psychiatric institutions across the country, and before commencing construction, in 1807 Stark published the much-noticed *Remarks on Public*





48–49
Prototype: the York Retreat by
William Tuke and John Bevans, 1796

Hospitals for the Cure of Mental Derangement. In it, he formulated a direct connection between the layout of the asylum building and the recovery process of the patients. "[D]efects of arrangement," he explained, "must unavoidably affect the patient, and operate both against his comfort and his cure."[149] The resulting design goal was concisely described on the first page of his book:

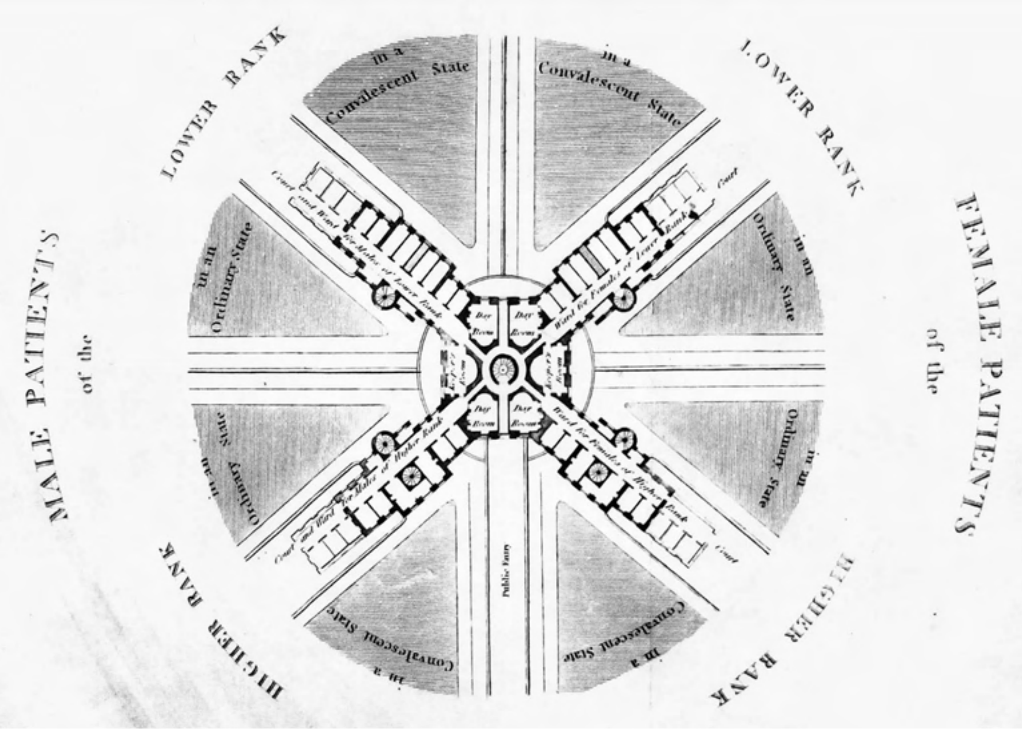
> A system of arrangement of a very minute and apparently complicated kind, united to great ease and simplicity of management: a superintendence unusually active and efficient, which follows and watches every motion of the patient while it insures to him a more than ordinary degree of individual liberty, of exemption from restraint and bondage, of personal security, of ease, comfort, and enjoyment.[150]

As with the prison, the psychiatric institution is determined by what at first glance appear to be irreconcilable principles—on the one hand, a control regime, and on the other, the priority of free movement. Added to this, and like in other fields, in around 1800 systems of classification acquired greater significance in the psychiatric context. The separation of the patients into various groups was intended to allow a more precise calibration of the methods of treatment, as well as preventing disturbance and unwanted contacts. In Stark's case, these requirements resulted in a design that in many respects has echoes of a prison: the cross-shaped floor plan allows the corridors to be inspected from a central intersection in the building axes; at the same time the patients, divided according to sex, income, and state of health, were localized in what was a clearly divided architectural tableau. → Figs. 50–51

While the psychiatric asylum shared essential characteristics with the prison, it nevertheless distinguished itself in one decisive point. Samuel Tuke addresses this factor in detail in his second publication, the 1815 *Practical Hints on the Construction and Economy of Pauper Lunatic Asylums*. According to him, next to the separation of the patients according to sex and their state of health, and as well as a simple system of constant inspection, the fourth

General View of the Plan of Classification, and of the Distribution of the Classes in the GLASGOW LUNATIC ASYLUM.

MALE PATIENTS,	of the Higher Rank.	Frantic,	Ground story—remote ward	of the Front Wing,	Right Hand.
		Incurable,	Ditto, nearest the centre		
		Convalescent,	Principal story		
		In an ordinary state,	Second story		
	of the Lower Rank.	Frantic,	Ground story—remote ward	of the Back Wing,	
		Incurable,	Ditto, nearest the centre		
		Convalescent,	Principal story		
		In an ordinary state,	Second story		
FEMALE PATIENTS,	of the Higher Rank.	Frantic,	Ground story—remote ward	of the Front Wing,	Left Hand.
		Incurable,	Ditto, nearest the centre		
		Convalescent,	Principal story		
		In an ordinary state,	Second story		
	of the Lower Rank.	Frantic,	Ground story—remote ward	of the Back Wing,	
		Incurable,	Ditto, nearest the centre		
		Convalescent,	Principal story		
		In an ordinary state,	Second story		



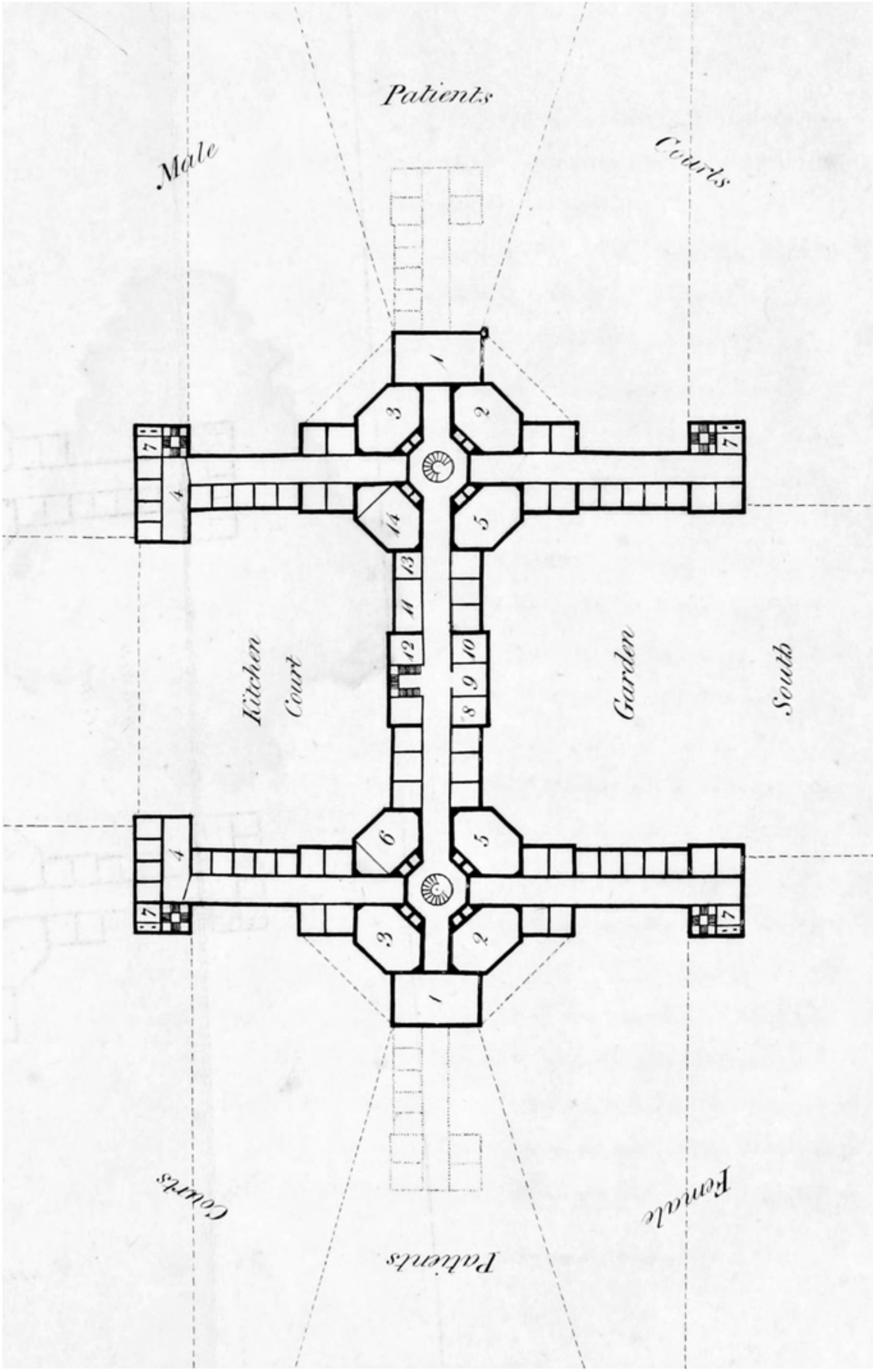
50–51
From table to plan: William Stark's Glasgow asylum, 1810.

and final main goal when building an asylum was that "the accommodation for the patients should be cheerful, and afford as much opportunity for voluntary change of place and variety of scene, as is compatible with security."[151] Because, contrary to popular opinion, the mentally ill were highly susceptible to external sensations and madness was often associated with a high degree of restlessness, insane asylums should be cheerful places—so the argument—and provide the inmates with variable and diverting sceneries. It is no coincidence that the term "comfort," which shortly prior to this had begun its life in the context of private residential architecture, should assume a centrality in the discussion about asylum architecture. First, an ideally precise tailoring of the physical spatial dimensions to the everyday needs and activities of the occupants is likewise a key factor in a psychiatric context; second, the reformers were genuinely interested in creating "domestic" surroundings. This attention to the emotions and well-being of the patients, as well as their relatives and friends, is firstly reflected in the external character of the buildings, designed to betray their actual objective as little as possible and to avoid any suggestions of coercion or incarceration. Possibly, this is precisely why there was a certain reticence about bestowing machine connotations on psychiatric asylums. In the first half of the nineteenth century, their architecture was invested with operative aspects as much as prisons or schools were, but simultaneously it was designed so as to always camouflage them.

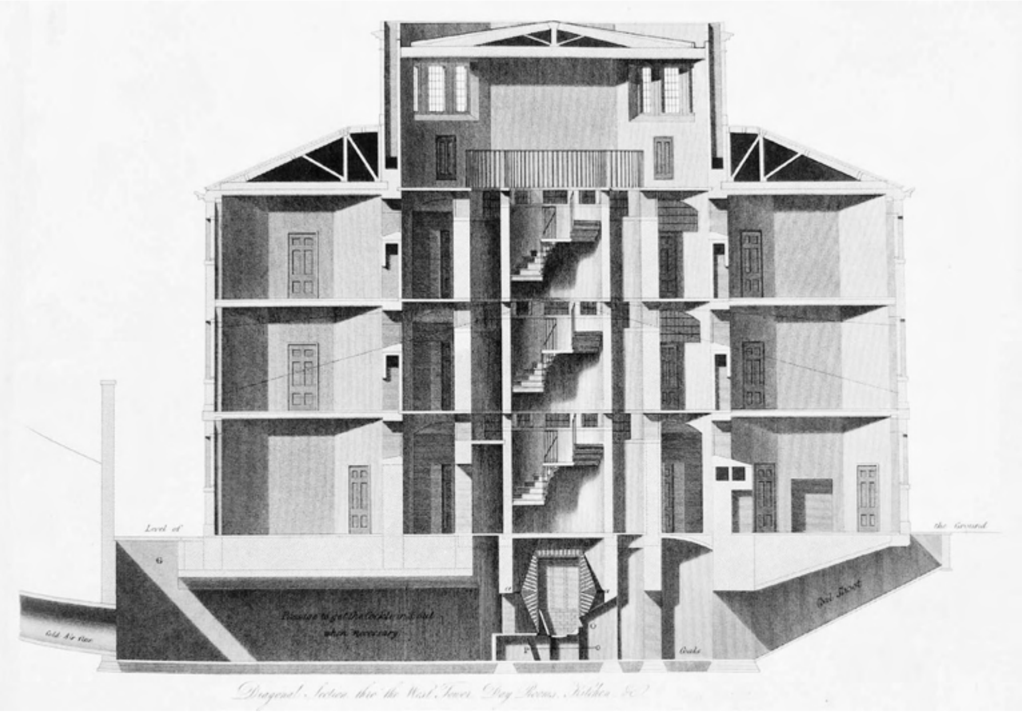
As already evident in the case of the archetype of the York Retreat, this attempt to influence the patients effectively yet subtly via design means reached from the building's surroundings down to individual architectural elements. Outdoors, this resulted in efforts to reinforce the already pastoral situation of the asylum by arranging the surrounding gardens so as to provide varied vegetation and varying perspectives out over the landscape. The different courtyards attached to the complex, used for exercises, are enclosed by walls set at calculated heights to prevent escapes but not to obstruct the views out beyond. The courtyards additionally provide a home to various small animals, such as rabbits and chickens, meant to trigger feelings of benevolence and social behavior among the inmates.[152] As applied at the same time to the idea of the cottage, here the immediate garden environment forms an integral part of the architectural layout. The asylum building itself is invested with a planned domestic character, while inside modern heating, ventilation, and noise-minimization techniques guarantee an atmosphere that is both controlled and curative.[153] This attention to the atmosphere also defines the fixtures: the doors to the patient rooms, for example, are soundproofed and equipped with small openings that facilitate ventilation at the same time as allowing unobtrusive inspections by the wardens. Moreover, they deliberately open only to the corridor, preventing them being blocked by the patients. The windows dispense with lattices and instead are built using cast-iron glazing bars, giving a similar level of security but allowing more light in and avoiding the impression of institutional incarceration.[154]

Overall, the windows are a prime example of how far the design ideas for a therapeutic environment extend in the context of moral treatment. Samuel Tuke devotes a number of pages to the window as an element in *Practical Hints*, not based on its architectural character but on how the patients perceive and use it. In order to stop the windowpanes from being wantonly destroyed, the solution to date had been to place the window apertures in insane asylums as high as possible, out of reach of the inmates. For Tuke this was a typical example of exaggerated caution in asylum architecture, negating the desired tranquil atmosphere and depriving the patients of the medicinal views outside. He counters the usual practice with a small theory of vandalism, which he expands to form a general design maxim: "The fact is—the increase of temptation is more than equivalent to the increase of facility."[155] Accordingly, the best way to protect the windowpanes in a psychiatric institution is to make them as accessible as possible.

Ideas such as these found their preliminary highpoint in the project for the West Riding Pauper Lunatic Asylum, opened in 1818 in Wakefield in North England, which combined many of the organizational and architectural innovations of the preceding decades. Tuke acted as an advisor on the project, and his *Practical Hints* actually contained a multitude of concrete instructions on how to build this very asylum. His joint work with the local architects C. Watson and J. P. Pritchett produced a design containing rooms for



52
West Riding Pauper Lunatic Asylum: dayrooms and workrooms (1–3, 5), wings for refractory patients (4), service rooms (6, 8–14), sanitary rooms (7), 1815



53
Centrally organized: heating system and stairwell in the Wakefield Pauper Lunatic Asylum, 1819

150 patients spread out over three floors and an H-shaped ground plan. ← Fig. 52 While the four wings of the plan are laid out to accommodate the needs of the patients, classified according to sex and state of health, the interfaces are clear examples of the attempt to combine the greatest security with the best possible comfort. At the two points where the axes of the building meet, circular staircases are placed, establishing separate circulation: they are inaccessible for the patients but are designed to give the staff quick access to all the parts of the building.[156] In addition, these intersections are overlaid by two other central systems, namely climate control and surveillance. A detailed cross-section shows one of the staircases with the adjoining rooms and the cellar with one of Strutt's hot-air stoves, and above them three vertical observation posts, each of them inserted at half-story height in the stairwell. ← Fig. 53 The stoves distribute warm air through the building; from the surveillance points the physicians and wardens can constantly monitor the corridors and day rooms of the asylum.[157] Watson and Pritchett made a considerable effort to enunciate the visual permeation that the arrangement allows with the help of a diagrammatic addition. "The point at which the dotted lines meet, in the middle of the staircase," they explain in their documentation, "is the height of the eye of a person of an ordinary stature; the dotted lines therefore show how much of the rooms are seen from the landing."[158] In other words, in this case the medical gaze is so closely allied to the structure of the building that it is given graphic expression in the architectural plan.

With projects such as the West Riding Pauper Lunatic Asylum, which like the York Retreat long remained an international reference project for the construction of psychiatric institutions, the discussion regarding psychiatric architecture simultaneously reached a point where its operative character began to be openly addressed. In the same year as the opening of the asylum in Wakefield, the psychiatrist Jean-Etienne Dominique Esquirol submitted a short treatise on care facilities for the mentally ill to the French ministry of the interior. Esquirol, one of the founders of scientific psychiatry in France, had trained under Philippe Pinel and since 1811 had worked in the Hôpital de la Salpêtrière in Paris.[159] Following the example of John Howard's *State of the Prisons*, his treatise brought together insights from his own work and those gathered during numerous inspection tours. The conclusion of the submission was a recommendation that the French government should build a new series of supra-regional and specialized psychiatric asylums. However, the plans for these facilities were too crucial to their success, pleaded Esquirol, like Pinel before him, for them to be left solely to the architects. He supports his claim with an argument that, like Bentham, focuses on the term "instrument" and that the physician Jacques Tenon had very similarly raised within the framework of the French hospital discussion in the 1780s.[160] Whilst in a normal hospital the principle was to organize the nursing care as simply and economically as possible, in the case of the insane asylum it was the building itself that had to be conceived as a medical instrument: "A hospital for the insane," wrote Esquirol, "is an instrument for healing."[161]

The Prison Building

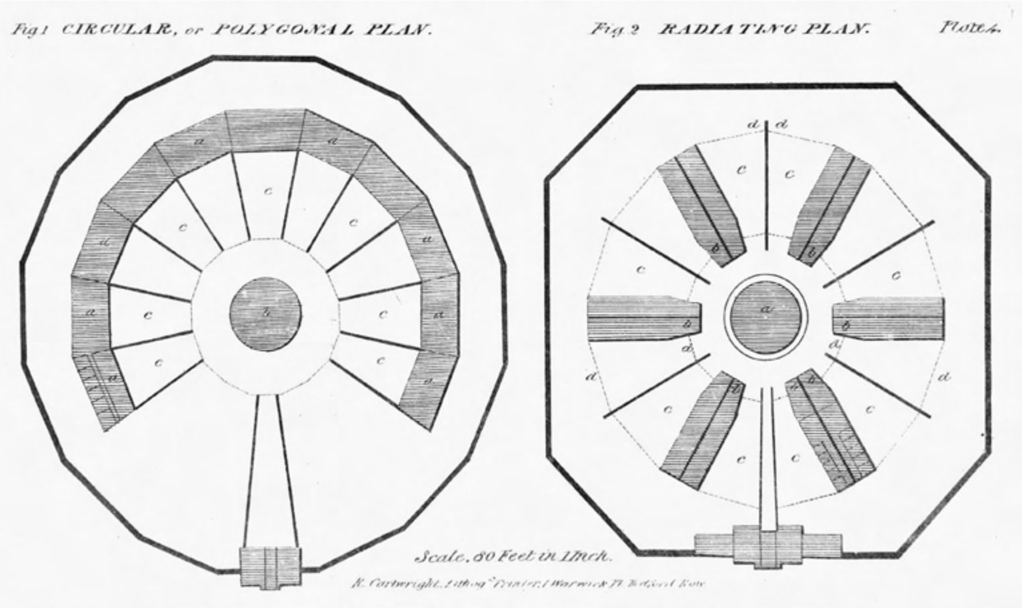
"[T]he English," wrote the French architect and painter Louis-Pierre Baltard in 1829 in his *Architectonographie des prisons*, "carry in all their works the genius of mechanics, which was perfected among them, and so they want their buildings to function as a machine driven by the action of a single engine."[162] The statement not only reflects the fact that prisons counted among the institutions that were treated as machines in the first half of the nineteenth century, it also shows that a transnational exchange and comparison of architectural ideas was underway in the field. Following the comprehensive reforms in penal and prison systems in Great Britain in the waning eighteenth century, the other nations in Western Europe began to follow suit in uneven succession. In the case of France, due to the static social and political circumstances prior to the revolution of 1789, and afterwards due to the constant upheavals and wars, comparable developments remained largely absent.[163] With the end of the Napoleonic Era, however, France likewise experienced a flurry of reform endeavors. A key date in this respect is the year 1819, when growing public pressure led to an increase in the financial budget for departmental prisons and a royal society for the general improvement of the penal system was founded. The Société royale pour l'amélioration des prisons consisted of 320 honorary members, from whose ranks the so-called Conseil général des prisons was in turn formed, an official body invested with powers to supervise and issue directives. Two years later came the Société de la morale chrétienne, an independent association of liberal thinkers that likewise dedicated itself to questions of crime and punishment. Set against this background, numerous publications appeared in the 1820s that addressed the renewal of the French penal and prison systems from different political and religious perspectives.[164]

The book in which Louis-Pierre Baltard scrutinized the mechanical thinking of the English appears in this context as the first French-language publication dealing exclusively with the architecture of prisons. It was dedicated to the royal heir Louis-Antoine de France as the president of the Société royale pour l'amélioration des prisons, and compares over thirty floor plans from different countries and periods. Baltard made a considerable effort to illustrate both the historical development and the current state of prison architecture, and from them to draw lessons for France's contemporary needs. Along with the ground plan of the historic Newgate Prison, England is represented in the plates with three more recent plans.[165] Baltard essentially recognized the pioneering work and the wealth of ideas produced by his English professional colleagues in the field of prison architecture at the time, but the central place given to their plans in his book was also due to a critical view of their efforts. In order to classify his flanking arguments, it is first necessary to quickly review the state of affairs on the other side of the Channel.

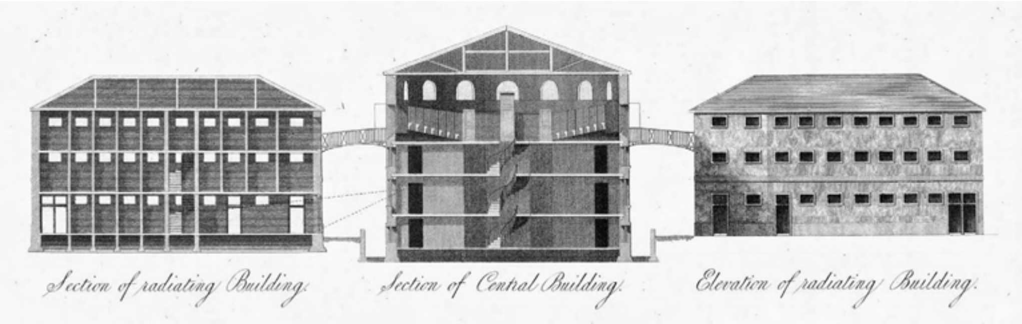
By the time Baltard wrote his book, for some time British prison reform had experienced a phase of consolidation. Since the turn of the century, numerous older institutions had been closed, while simultaneously new ones were being built or existing ones remodeled. These renewals, which had begun in the 1780s, had been framed by the continued acceptance of a series of established assumptions: evil communication was still considered infectious, the establishment of a central institutional authority was still decisive, and the uppermost goal continued to be the purification of delinquents. Correspondingly, prison designs remained distinguished by the desire to seize control of the spirits and bodies of the inmates, although this now occurred less as a mode of tentative experiments and more in the sense of variations and refinements of existing ideas and concepts.[166] When the architect Richard Ingleman outlined the "science of Prison Building" in 1808, he consequently described it as stationary or even regressive. Pioneers such as John Howard and William Blackburn had managed to provide fundamental models, but in certain respects the prisons built according to their guidelines were nonetheless considered inadequate. Specifically, Ingleman complained that the exterior yards were insufficiently divided or could not be surveyed by the guards, or that the boundary walls were so low that the prisoners could see outside, and the ventilation apertures allowed conversations to be conducted over several stories.[167] If these points in fact echo the long-known problems of opening and closing, nonetheless perceptible shifts were also taking place in what underpinned them. Whereas in the late eighteenth century the building and organization of prisons had been determined by the three principles of security, health, and separation, in the first decades of the nineteenth century these aspects were replaced by a new trinity. Because the demands of security and health were seen as having been sufficiently provided for, attention in prisons shifted, as in other institutions, to processes that promised to fortify morals. This applied in particular to the principles of classification, inspection, and work, all three of which were now seized upon as having a positive impact on the character development of the prisoners.[168]

The classification of prisoners had already been a common practice in the early reform prisons; therefore the elaboration of this technique took place less at the level of new architectural measures and more in a continual increase in the stipulated classes. Between 1815 and 1830, the number of categories into which the prisoners in British prisons were divided constantly multiplied. In addition to distinctions between sex and state of health, new classifications based on the crimes committed and procedural status provided an almost inexhaustible number of differentiations. Because the number of categories inevitably related to the number of building tracts and architectural sub-segments, this logic ultimately found expression in the emergence of increasingly dense and complicated ground-plan geometries. Work, too, had previously constituted an important part of the penal system, but in the nineteenth century, with the (re)introduction of an infamous apparatus, it took on a wholly different character. Starting in the 1820s, new forms of treadmills began to become widespread—a device used for centuries to generate propulsion, but now in many prisons divorced from any productive performance whatsoever and transformed into a naked instrument of coercion. Based on the assumption that the moral component of activity consisted of its regularity rather than its productivity, these treadmills served nothing more than to reduce the work of the prisoners to an inescapable and measurable sequential motion. Due to its profound psychological effects and the difficulty in enforcing it, the concept of solitary confinement had been temporarily abandoned again in around 1800, thus only to be replaced by the creation of a new means of deterrence: a machine of senseless and monotonous drudgery. But the most profound implications in terms of prison design were caused by the third principle, that of inspection. Quintessentially, it describes the visual surveillance of the inmates by the guards, and both parties in turn by the director of the institution. This was the procedure that Jeremy Bentham had elevated above all others and had condensed in the "architectural idea" of the Panopticon. In fact, however, the ambition to achieve an all-seeing inspection regime—and with it the model that spread successfully in the first third of the nineteenth century—had already manifested itself earlier, namely in the two star- and ring-shaped prison layouts drawn up by William Blackburn in the 1780s. Indeed, over much of the period in question, the discussion regarding prisons in Britain reads as an ongoing competition between radial and polygonal plans. → Fig. 54

One of the most zealous proponents of the polygonal plan was George Peter Holford. From 1810 onward, as a member of parliament he chaired the commission responsible for finally recommending the abandonment of the plans for a state-run Panopticon prison and then supervised the construction of what was the first actually built national penitentiary. Millbank Prison, with one thousand inmates



54
Contrasting forms: polygonal versus radial prison floor plans, 1828



55
Model radial plan from the Society for the Improvement of Prison Discipline, 1826

the largest in Europe, was opened in London in 1821 based on a ground plan of six pentagons arranged around a central hexagon. The resulting closed inner prison yards were each surveyed from a central observation tower and were considered to be the complex's special security feature.[169] The radial plan was above all propagated by the Society for the Improvement of Prison Discipline (SIPD). Founded in 1816, the charitable organization subsequently successfully dedicated itself to advances in the administration and building of penal institutions. In 1826, it published the volume *Remarks on the Form and Construction of Prisons* in which it criticized the polygonal prison form, in particular due to its poorer ventilation and larger distances, and instead repeating its praise for the radial plan as a universal panacea. Based on the dual main goals of "*classification*" and "*constant and unobserved inspection*," nine model plans by the architect George Thomas Bullar were presented, all of them functioning according to the same scheme and hardly any less rigorous in terms of surveillance than Bentham's Panopticon.[170] Radiating out from a central building, containing the director's private quarters and a chapel, are two to seven wings housing the prisoners' cells and work rooms, between which the prison yards are located. In order to maintain an overview of the complex despite its growth in size, when they reach a set number the cell-wings are moved away from the central building and are connected to it via an iron gallery. Serving the same purpose, the corners of the wings are tapered along the sightlines, their ends glazed, and the stories of the central segment are raised a few feet above the levels in the rest of the building.[171] The result is an architectural core that conceptually and visually determines the entire complex and around which the tracts for the individual classes of prisoner are organized. ← Fig. 55

This is precisely the starting point for Louis-Pierre Baltard's criticisms in *Architectonographie des prisons*. All of the more recent English designs presented in his book are based on radial plans. One of them shows the county prison in Bury St Edmunds built by George Byfield in 1802 and thus one of the first prisons to be constructed in the nineteenth century according to a radial ground plan. The other two, identified by Baltard as simply coming from London, resemble, down to the details, the radial-formed designs by Bullar and the SIPD.

Baltard was himself the architect of a number of prisons, and as a disciple of classification and hard labor he was very much a proponent of modern principles.[172] Nonetheless, in reviewing the designs based on the all-dominating criterium of central inspection, which he correspondingly assigns to a "panoptic system," he sees nothing less than a violation of the rules of the art of architecture. Instead, he expresses his preference for buildings such as the Maison de Force in Ghent in Belgium, built in 1772 as an octagon with radial transverse connections, or more generally buildings with a rectangular ground plan. Baltard's explicit argument rejecting the English forms is that mono-centric complexes provide worse circulation, plus the disadvantages of a "static" central surveillance, but his explanations equally resonate with a barely suppressed unease that radial plans essentially break with academic canons.[173]

Although this confrontation between the traditional techniques of neoclassical composition and the pragmatic approaches of the reform architects also took place at the same time in Great Britain,[174] Baltard's *Architectonographie* sharpens it to a rivalry between two cultures: the French, in which occidental architecture is defended, and the English, where buildings were brazenly conceived as machines. A similar sentiment had already been expressed by the author Louis-Augustin-Aimé Marquet-Vasselot in 1823 in his book about the establishment of central prisons, where he had described the imperative of surveillance derived from Bentham's teachings as "machinic obedience."[175] While comments such as these were to a certain extent based on crude national clichés, they nevertheless still articulate a metaphorically well-thought-out critique. This critique concerns a practice of design that, according to Baltard, is so enslaved to the "power of necessity" that it ignores the "sincerity of the forms," and even fails to recoil at oblique angles as long as they serve the sightlines. It is a critique of designs that are seen as being driven by one sole idea, as if by an "engine." And, last but not least, it is a critique of architects who obey the "spirit of the system" to such excess that they become pure "mechanics."[176]

However, Baltard's views very soon became outmoded as his compatriots avidly began clamoring for their prisons to operate analogous to machines. One year after the appearance of *Architectonographie*, Louis-Philippe's seizure of power re-fired the French prison reform movement. In the same year as the July Revolution of 1830, a new post for the General Inspectorate of the Departmental Prisons was created, headed by the young lawyer Charles Lucas, known for his treatise—awarded a prize by the Société de la morale chrétienne—against the death penalty. A short while later, the ministry of the interior sent two equally young magistrates—Alexis de Tocqueville and Gustave de Beaumont—on a research tour of North America. De Tocqueville and Beaumont returned from their journey not only with their famous report on the political system in the United States but also with consequential information about the country's penal and prison system.[177] Beaumont and de Tocqueville's *Du système pénitentiaire aux États-Unis* appeared in 1833, in essence describing two competing isolation regimes. In the prison in Auburn, New York, in operation since 1818, the prisoners spent their nights in solitary confinement and their days in common labor in complete forced silence; in the prison in Cherry Hill, Philadelphia, opened in 1829, the prisoners were kept permanently in isolation.[178] The limitations of classification procedures were becoming slowly evident—despite ever more differentiated systems of segregation, crime rates were still rising, and above all recidivism—and hence the American prison experiments excited great interest across the whole of Europe, as well as acrimonious debates on their pros and cons. Whereas the one side viewed complete spatial isolation as inhumane and counterproductive due to its potential psychic implications, the other side considered a system of silent common labor enforced by guard controls as unreliable and as having too little deterrent value. The only point of consensus was that it was vital to prevent prisoners from communicating with each other, a factor in which prison architecture played a key role.[179]

For both the supporters and the opponents of solitary confinement, this debate concerning the forms and degree of isolation increased the importance attributed to the organization of prison space. For the politician Adrien de Gasparin, state secretary in the ministry of the interior and a proponent of solitary confinement, the significance of the prison building was indisputable. Why trust in human regulation and control when one could rely upon a dependable architectural arrangement? “It is evident,” he wrote in an 1836 report, “that if this moral action, so uncertain, can be substituted for the blind, but secure, action of a material agent, such as the one provided by a suitable disposition of buildings, there will be a greater chance of success in combating the danger of communications between the prisoners.”[180] The crucial role played by architecture was similarly recognized by the general inspector Charles Lucas, albeit as an opponent of isolated imprisonment, in his fundamental work *De la réforme des prisons* that appeared in the same year as Gasparin’s report. In his opinion, it was no longer adequate to simply confine prisoners under lock and key, they had to be kept under strict observation and subjected to disciplinary measures through architectural means. “[T]oday the role of the architect is entirely changed,” he explained: it was now “a moral problem which he must oppose to the attempts of escape; it is necessary for him, so to speak, to transfer the understanding of the discipline into stone.”[181] Therefore, on whichever side of the debate the protagonists stood in the mid-1830s regarding prison design, built space was increasingly explicitly treated in terms of its potential, as a stone-built agent, to improve morals.

Within this discussion there was a marked tendency to resort to the term “machine,” as is particularly evident in the case of the lawyer Louis-Mathurin Moreau-Christophe, a vehement campaigner for solitary confinement and who over the following years developed a veritable theory of the prison machine. A prison inspector in the Département Seine since 1830, Moreau-Christophe was appointed a member of the general inspectorate in 1837, a role that henceforth placed him in a rivalry with Lucas. Whereas Lucas followed a philanthropic approach aimed at the moral and religious improvement of the prisoners through humane prison conditions, Moreau-Christophe was more skeptical about the reforming potential of the penal system, instead viewing it first and foremost as a means of deterrence and retribution.[182] Already in his earliest publication *De l’état actuel des prisons en France*, a report printed as the first part of a two-volume work, Moreau-Christophe declared his intention to examine “the wheelwork of the mechanism of our prisons,” and this from the threshold to the roof.[183] The second part of the work, *De la réforme des prisons en France*, concerns the redesign of the “actual state” described in the first volume, and in particular that of the “administrative machine.”[184] It also contains a basic outline of what Moreau-Christophe sought to describe with the term “machine”:

> A good administrative machine can thus alone operate the reform that the law can only order. But for the machine to function with regularity, with ensemble, with fruit, its numerous and complicated cogs must simplify and standardize by attaching themselves to a common axis; in a word, its cogs must receive, from a single motor placed at their center, the unity of action, of movement, of life, without which they would rotate in contrary directions, and would destroy the very force of their principle of rotation.[185]

Moreau-Christophe thereby pinpoints precisely what Baltard had rejected as an architectural model: the propulsion of a large number of parts via a central engine with the goal of producing a higher effect. The passage may be coined to fit administrative processes, but in Moreau-Christophe’s thinking this is only marginally removed from the actual prison space. In the same book, he declares the architect to be the “first executor of the sentence,” whose job it is to transform the prison into an “instrument of torment” and to harness it as comprehensively as possible to the act of punishment. “Every door he places has a painful, terrible signification; every hammer stroke he makes has a deep resonance ….”[186] Should there be any remaining doubt, in his next publication—a report on an exploratory tour of West European prisons—Moreau-Christophe explicitly states that his machine concept extends equally to the architecture and that for him the prison building was not merely a minor cog in the machinery of the penal system, rather it itself was a mechanical entity. “This prison, built according to Howard’s plans,” he writes about the Salford New Bailey, designed in 1787 by William Blackburn on a radial plan, “is the most complicated machine one can imagine.”[187]

In terms of the organization of the French prison system, it was the camp around Moreau-Christophe that ultimately prevailed. In around 1840, and set against the backdrop of continuous debates, prison discipline became stricter, accompanied by the step-by-step introduction of solitary confinement by the government. In 1836, the newly appointed interior minister Adrien de Gasparin ordered that all new or refurbished prisons should be built according to a single-cell principle. Two years later he issued regulations for the central prisons, including that inmates be subject to complete silence.[188] A new delegation, this time consisting of the lawyer Frédéric Demetz and the architect Abel Blouet, was sent to examine North American penitentiaries a second time, their report again praising the spatial isolation at Cherry Hill and recommending that the same be applied in France.[189] In 1841, the ministry of the interior, assisted by Blouet, published an extensive and richly illustrated compendium of floor plans in which solitary confinement was promoted as an ideal penal model and declaring the isolation cell to be the most important part of any prison project.[190] Together with surveillance, it was intended to utilize a capacity inherent in architecture—the "force of buildings"—in order to prevent both escapes and communication between the prisoners.[191] Lastly, solitary confinement won the day because of this belief in its potential to enforce a penal regime regardless of human factors. Stones and walls were considered more merciless but equally more reliable than any human order. Within the logic of the prison machine, the introduction of single cells promised to create an auto-regulatory moment. "With solitary imprisonment everything can run with order and regularity, even with chiefs of lesser capacity," ran the 1843 translation of a Dutch book on isolation that Moreau-Christophe wrote a foreword to, "because the *machinery*, if I may say so, works, so to speak, by itself, and by the sole virtue of its driving principle."[192]

That this image of the self-autonomous operations of a prison machine was not just the fantasy of maverick figures, and instead by this point had become a general maxim of the whole reform movement, is apparent in the broad dissemination of a text passage written by Moreau-Christophe himself in the same year. In 1843, in the course of legislative proposals for prison reform that would inconclusively preoccupy the French parliament until the February Revolution of 1848, Alexis de Tocqueville produced an expert report reiterating all of the penal issues of the previous decade: constantly rising criminality, the unsatisfactory state of the prisons, the deficiencies of systems of classification, the various types of (North American) prisons, and above all the costs and the advantages and disadvantages of solitary confinement.[193] In the middle of de Tocqueville's argument, a specific institution is given as an example: the prison in Fontevraud, built within the walls of a medieval cloister and ruled over by its director with an iron fist. Its exemplary nature lay in the fact, according to an inspection report by Moreau-Christophe, that its architecture and administration uniquely produced a flawless whole: "Physical order reigns everywhere; no noise, no tumult, no loud conversation. The movements are so regular here, so calm, so perfect, that it looks like a machine accomplishing its mechanical function, without the friction of any cogs."[194] Due to the official status of the expert report in which it appeared, but also apparently due to its explanatory force, this passage would be cited or paraphrased on numerous occasions, both in France and abroad, in the following two years.[195]

As such, Louis-Pierre Baltard, who remained active as an architect into the 1840s, was able to witness how the machine advanced to become a core term in the European prison debate. In the course of this evolution, the machine concept was detached from the principle of centralized inspection and became a cipher for the entire disposition of the penal institution. As with the other "moral motors"—the psychiatric asylum, and above all the school—the term assisted in addressing general organizational processes, their linkage with spatial settings, and not least the architectural arrangement itself. In so doing, the semantics of the mechanical range from a simple instrumental characterization of the built space as a "means to ..." through to a differentiated representation of spatiotemporal procedures. In this, the use of the machine concept culminates in conjunction with an entirely new emphasis on the reforming power of stones—a logical dual climax in that the mechanical processes of propulsion, friction, or rectified movement apparently formed an ideal repertoire for a description of architectural (inter)action.

THE MODEL PRISON

In 1852, a book appeared in which the English clergyman John T. Burt outlined the construction and management of penitentiaries as an exact science. According to him, exact sciences are distinguished by the fact that they reduce the Laws of Nature to specific rules and then apply and follow these rules with the greatest possible prudence. Currently, Burt said, it was observable that agricultural methods were acquiring a new scientific precision. A close examination of small differences in effort made all the greater differences in terms of yields. But why was this accuracy not being similarly applied to moral improvement? "While the exactness of science is brought to bear upon the culture of the lifeless clod, is scientific precision to be neglected in eradicating the vices and educating the virtues of the human mind?"[196] As a prison chaplain, Burt was intimately acquainted with the métier. In this position—which had assumed an ever-greater importance in the course of the prison reforms—he was responsible for general religious instruction, as well as for the individual salvation of the inmates. In that sense, his postulate no doubt struck quite a deep cord with contemporary reform endeavors—perhaps deeper than he himself was aware of—in that during the preceding two decades the conceptualization of prisons had indeed taken on a decidedly scientific character. Generally speaking, in the mid-nineteenth century, architecture began to be determined by an increasingly more methodological approach, while the attempts to influence the morals of the residents via architectural arrangements were supplemented by processes that originated directly from the experimental sciences. While in the context of heating and ventilation techniques the attempts to master interior climate based on empirical methods had been ongoing for some time, a similar impulse now became evident in terms of human nature. This involved not only test arrangements in which individual architectural elements were scrutinized, but in the case of London's famous Pentonville Prison even encompassed an entire building, explicitly understood as an experiment by which to generate natural-scientific knowledge.

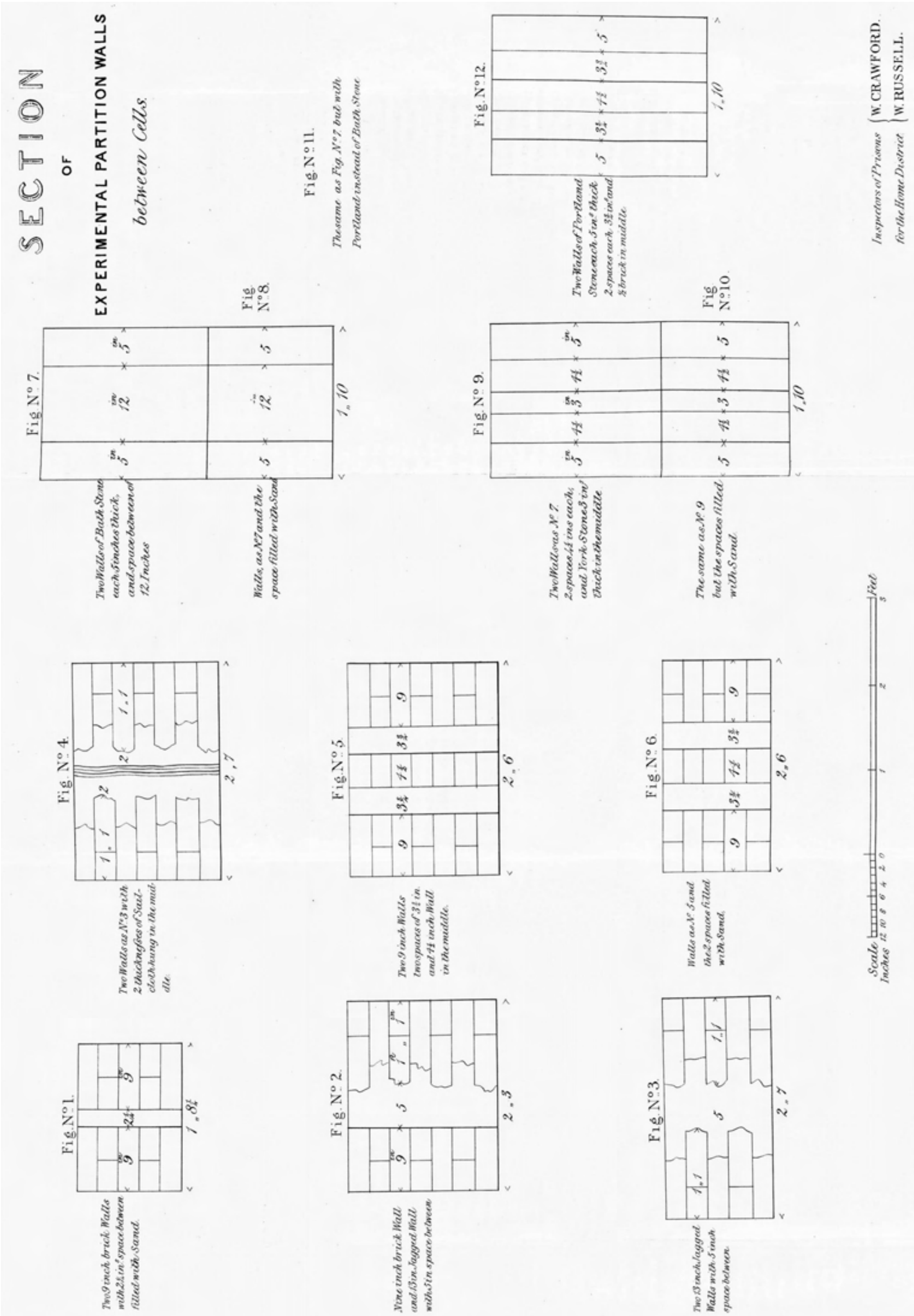
The beginnings of this scientific approach can be dated back to around 1830 when news of the breakthroughs in the North American penal and prison system began to spread in Europe. As in the rest of Europe, these descriptions of the "silent" and the "separate" systems, in which all exchanges between the prisoners were repressed by either human or spatial arrangements, fueled the discussion in Britain regarding the state and the future of penal policy. By this point, the very country in which the prison reform movement had been born still lacked a uniform prison system, and the existing prisons, based on principles of classification, were viewed increasingly critically. Therefore, in the quest for a new approach, the focus fell on the country's former colonies.[197] In 1833, the newly elected Whig government sent the philanthropist William Crawford, a founding member and secretary of the London Society for the Improvement of Prison Discipline (SIPD), on a journey to inspect the penitentiaries in the United States. His extensive report came down decisively in favor of the separate system and recommended that certain types of criminal be incarcerated in isolation. "Solitary imprisonment," ran Crawford's conclusions from his tour, "is not only an exemplary punishment but a powerful agent in the reformation of morals. It inevitably tends to arrest the progress of corruption. In the silence of the cell, contamination cannot be received or imparted."[198] Two years later, new legislation finally established a new inspectorate of national prisons, responsible to the British Home Office, and Crawford was appointed to one of its two leading posts. The second was occupied by the clergyman Whitworth Russell, a similarly passionate believer in solitary confinement who had previously served as chaplain in the state-run Millbank Prison. The two inspectors had no authority to issue directives—their task was above all to compile an annual report on the English prisons. Nevertheless, Crawford and Russell by no means restricted themselves to describing actual conditions, rather they created a specialist department that operated between the prisons, parliament, and the Home Office, issuing recommendations, expert opinions, and plans, and thus exercising a significant influence on developments in the years to come.[199]

The first annual report, which appeared in March 1836, already largely consisted of a plea to adopt the system of solitary confinement. Based on an examination of Newgate Prison in London, it demanded a rigorous response to the greatest of prison scourges—"gaol contamination." This form of spiritual pollution encompassed just about everything that a delinquent was capable of in terms of language: "blasphemy, obscenity, demoralizing intercourse, profane jesting, instruction in crime, boasting of criminal adventures, gambling, combinations to defeat justice, concerted efforts at escape, conspiracy to effect future depredations," and so on.[200] Adhering wholeheartedly to the tradition set by the early reformers and supported by new observations, Crawford and Russell viewed the prison above all as a hotbed of evil communication. This continued to be seen as the main reason why prisons were failing to improve morals—instead, by all accounts, they were doing the opposite, namely contributing to their overall social corruption.[201] The two inspectors' arguments were based on a simple transmitter-receiver model, in which messages were communicated via specific conduits from one person or place to another, where they then perniciously took hold. In his report on America, Crawford had already warned that with a free circulation of the prisoners among each other, the constant arrivals and releases meant that "channels of communication" were opened up between the inside and outside world.[202] These and the internal channels should be combated with the separate system, which was dependent neither on the alertness of the guards nor the dependability of the director. To support their argument, Crawford and Russell resorted to a trope that is a hallmark of all of the institutional "moral engines" of the first half of the nineteenth century: their self-activeness. "The [separate] system may almost be said to perform its own work, and to do it well, and without intermission."[203]

In their second annual report, which appeared in April 1837, the two inspectors went one step further by giving concrete recommendations for the design of the separate system, and thus addressing constructional questions. With the exception of Sunday religious services, if the prisoners were to spend their days and nights in single cells, then the core issue was to develop principles for the design of prisons that were structurally and technically fit to accommodate the corresponding large number of inhabitable cells. To this end, the report contains a number of model plans for single-cell-prisons for four to five hundred inmates, accompanied by one for an ideal cell equipped with all the features understood to be immediately necessary for existence.[204] Due to the fact that all contact—other than with the staff and visitors—between the prisoners was to be blocked, the aim was above all to design the cells in such a way that they became impermeable for all undesired communications. "It is our object," explained Crawford and Russell, "by means of good construction, to guard, with the greatest possible success, against the carrying on of intercourse between prisoners confined in contiguous apartments."[205] This aspect particularly concerned the physical barriers between the individual habitative units, and the report contains a detailed description of the efforts that Crawford and Russell had undertaken in the previous months to ensure that dividing walls prevented interaction. In this process, the aspiration to harness human morals via architectural means did indeed assume the character of an exact science.

In October 1835, part of the Millbank Prison was destroyed by fire, providing a welcome opportunity to test cell-wall constructions under real-life conditions. A decade after its opening, the prison was perceived as a failure, and it was known that its structure allowed prisoners to interact with each other, in particular that the ventilation appliances acted as a "medium of communication."[206] The following summer, accompanying the rebuilding work, Crawford and Russell successfully applied to erect a series of "experimental cells" in the wing that had been destroyed.[207] Just how seriously the scientific character of this exercise was taken is already evident in the personalities gathered together to carry it out: along with Sir Robert Smirke, the architect of Millbank Prison, and George Thomas Bullar, the SIPD's prison expert, the group included the natural philosophers David Boswell Reid and Michael Faraday.[208] Reid had successfully designed the heating and ventilation system for the temporary House of Commons shortly beforehand, and his work for the British parliament was yet to fall into disrepute. Faraday was already considered an eminent authority in the fields of chemistry and electricity, and had a reputation as an outstanding experimenter, often consulted by state organizations as an expert.[209] Moreover, both men were active in the young discipline of acoustics: Faraday, who also pursued questions of sound in the framework of his electromagnetic inquiries, more at a theoretical level, Reid, who was preoccupied with the climatic and acoustic design of public buildings, more at a practical level.[210] But in assisting the prison inspectors, both of them had to invert their professional premises. Whereas the architecture of the preceding decades—be it in churches, theaters, or parliament buildings—had been planned evermore precisely in terms of resonating sound,[211] the aim in this case was to explicitly counter it. This operation marks a turning point in the history of the wall that could be easily missed but is in fact all the more significant. Beside their load-bearing function, walls had perennially had a dividing purpose, but here, possibly for the first time, the segregating aspect acquires a methodological character.[212]

The test design used by Crawford and Russell and their group in the second half of 1836 to explore the communication-preventive potential of the wall apparently came from Faraday. Initially, Smirke had erected two test cells according to the specifications stipulated by the inspectors, in which both the separating walls and the ventilation equipment had proved to be sound-permeable. While the latter factor was solved by arranging the ventilation pipes differently, the sound-porosity of walls remained a fundamental problem. Consequently, Faraday supervised a process that he was well-acquainted with from his laboratory, namely a test series: twelve different wall constructions were successively built and examined in terms of their respective ability to suppress comprehensible communication, with the results carefully recorded.[213] The undertaking involved, on the one hand, varying the thickness, the material, and the structure of the wall; and on the other, the volume and the pitch of the vocal or percussive attempts to interact. → Fig. 56 Unlike prior material testing, the object was to examine not the resilience of a construction to mechanical-physical forces but instead to specific



56
Test environment: sound-insulated wall constructions, after William Crawford and Whitworth Russell, 1837

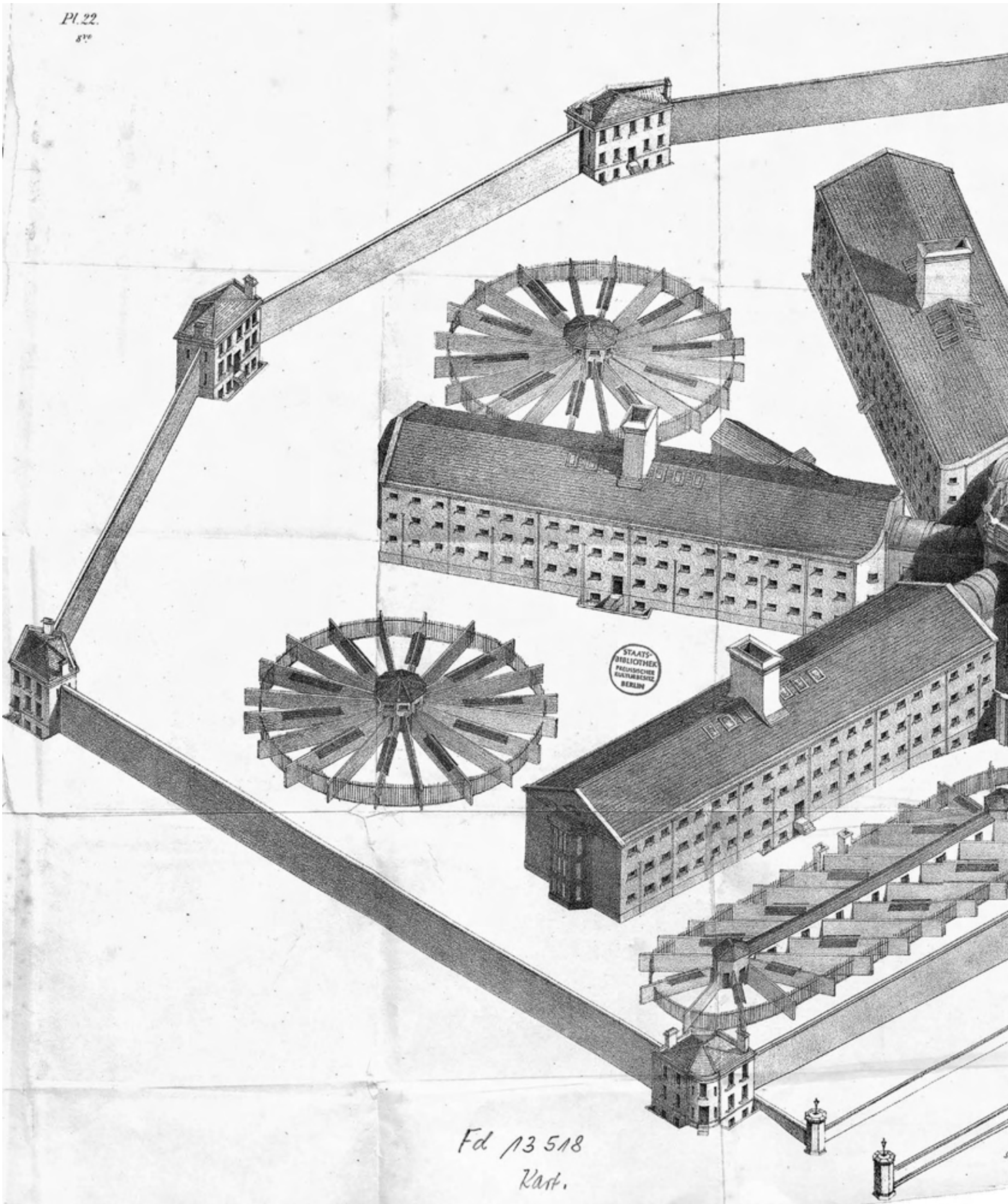
human actions.[214] The various one-to-one models demonstrated perceptible differences—in some cases only single syllables, in others no significant sound whatsoever was audible—but ultimately Crawford and Russell were happy with all of the constructions: "any one of those partitions which we have caused to be constructed renders the communication so extremely difficult, that, for all practical purposes, entire separation is secured."[215]

In this sense the wall was successfully conceived as an insurmountable communicative barrier. However, as presented, the actual point of the experimental series proved not to be the complete isolation of the prison cell but how it interfered with another "channel of communication." The more difficult it was to reach prisoners in the neighboring cell, the easier it was for possible noises and communications to penetrate the prison corridor. "Thus have we at once (that which is most important in a prison) facility of communication with the officer on duty, and extreme difficulty of communication with the prisoners in adjoining cells, together with the complete discouragement of any attempt at clandestine communication, by the certainty of immediate detection."[216] Consequently, whereas since the end of the eighteenth century prison planning had wanted to play different forms of communication off against each other through opening and closing, here this process targets the level of different addressees and single phonetic sequences.

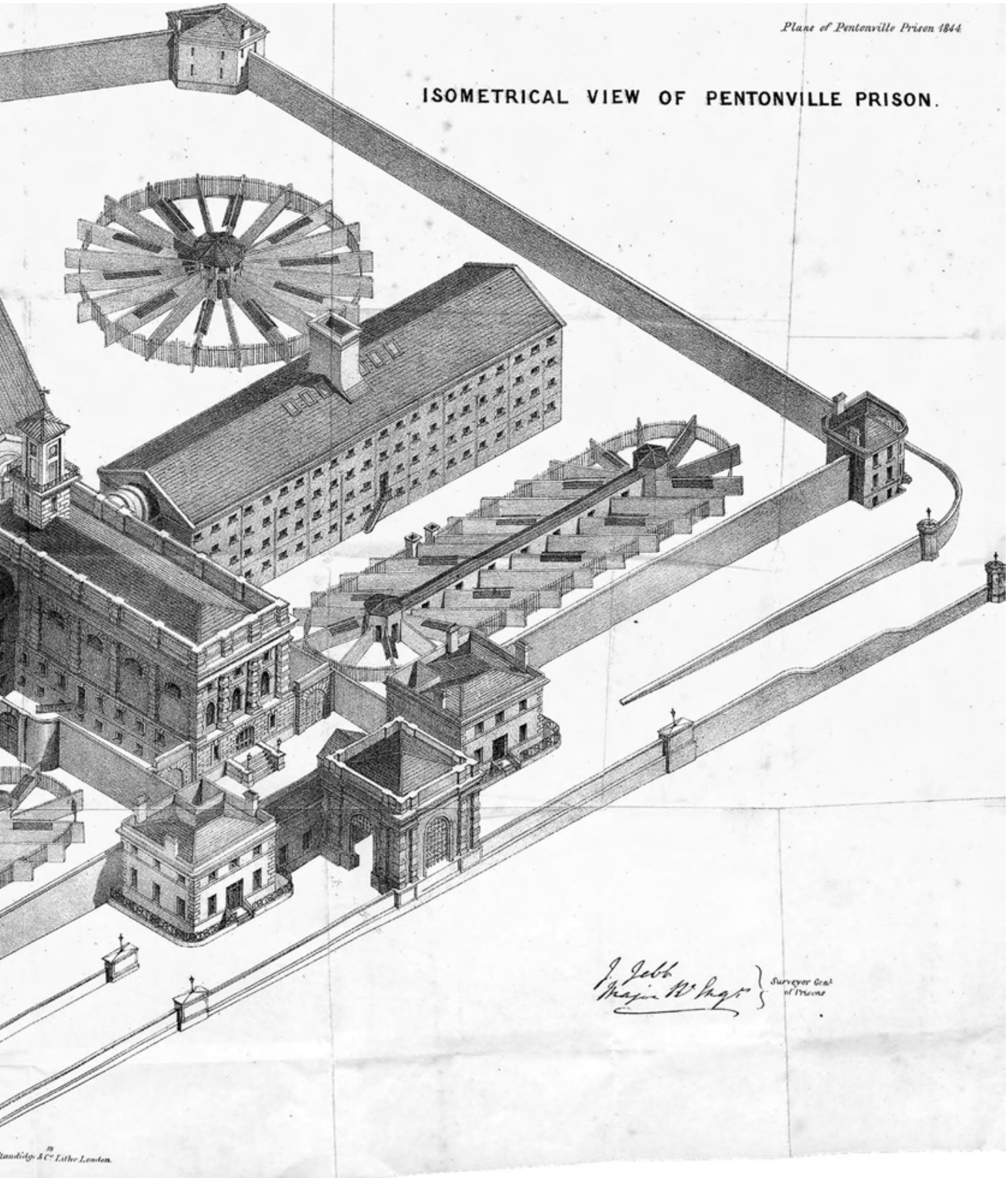
Representing a crucial step in the explication history of the wall, this simultaneously proved to be a mere harbinger of a methodology that a short time later would be broadened to the entire prison building. Already in 1835, a proposal had been made in the British parliament to erect a "model prison" under the supervision of the new inspectorate,[217] and by late 1838 this building project had acquired—analogous to the wall trials—a test character "in which the merits of the separate system might be experimentally ascertained."[218] These were the words of the military engineer Joshua Jebb, who had served in the Royal Engineers since 1812 and in the meantime had joined the inspectorate to provide Crawford and Russell with constructional expertise.[219] Together, they elaborated a prison plan that was intended to act as a prototype for the whole country in the future.

The program for this prospective model prison was first formulated in the inspectors' third annual report, described, hardly surprisingly, as the vision of a penitentiary that operated with such regularity and reliability that it resembled a machine: "In short, upon the offender in his separate cell all the moral machinery of the system is brought to bear with as much force and effect as if the prison contained no other culprit but himself."[220] As in the French prison debate, the concept of the machine stood for the frictionless organizational-architectural assemblage that promised to engulf the delinquents in a properly imposed separate system. For the inspectors, a key aspect of this was the psychological impression produced by a situation of complete, quasi-mechanical external control: "When the culprit sees that a complicated machinery is in action around him for the purpose of restraining his violence, or of keeping watch over his conduct, he is naturally led to compare his own strength and ingenuity with the means which are used to render them unavailing for any mischievous purpose."[221]

The erection of this "moral machinery" was endorsed by parliament in 1839, together with the passing of legislation that legalized the use of solitary confinement. A year later, in April 1840, the foundation stone for the new prison was laid on a circa-4-hectar site in the London borough of Islington.[222] The plans were compiled by Jebb, together with Crawford and Russell, and largely followed the principles that the latter two men had enunciated in the first two annual reports. Following Jebb's suggestion, the architect Charles Barry was charged with planning the parts of the prison where a decorative character was considered desirable. He developed Italianate facades for the portal, the porter's lodge, the interior courtyards, and the residences of the director and the chaplain, but the supervision of the realization of the designs, and the overall building, was delegated to Jebb.[223] Even while still under construction, what became Pentonville Prison acquired a Europe-wide status as the most modern facility of its type. Despite this, the distinctive feature of the project lay less in the creation of a fundamentally new prison model and more in the systematic combination of a series of already existing ideas, concepts, and techniques. It was based on a radial plan, similar to that developed by William Blackburn in the



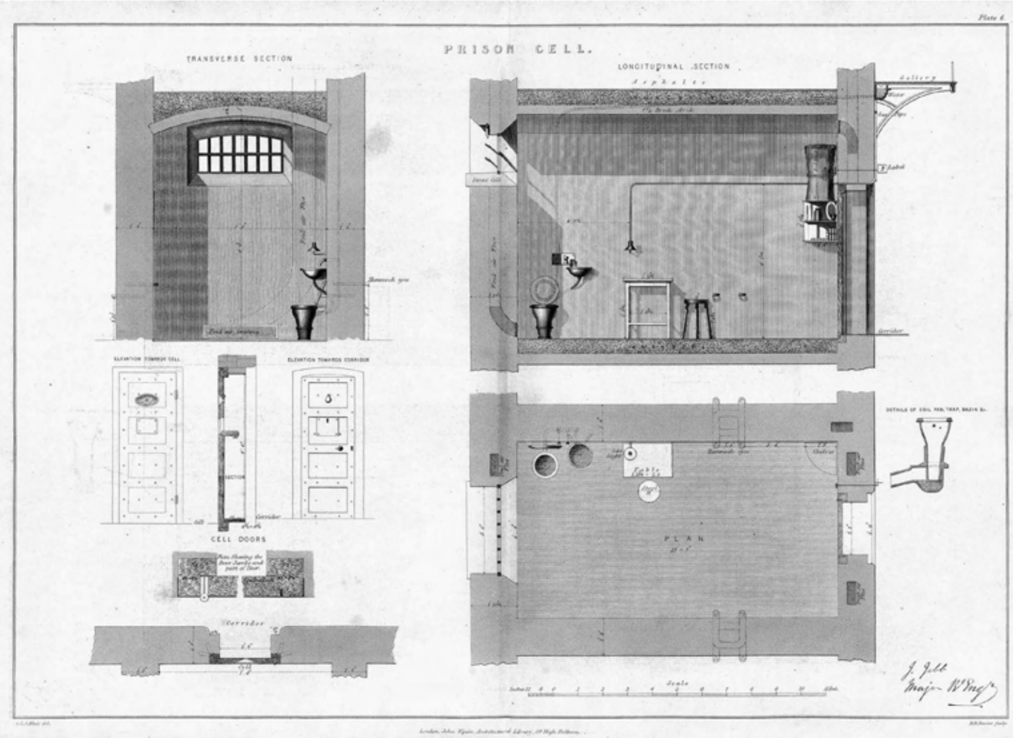
57
Pentonville Prison: radial building with four wings, 1844


Plane of Pentonville Prison 1844
ISOMETRICAL VIEW OF PENTONVILLE PRISON.
J. Jebb
Major R. Engrs
Surveyor Genl. of Prisons

late eighteenth century and propagated since the 1820s by the SIPD. Four three-story wings housing a total of 520 cells were arranged in a semicircle around an administration tract with the chapel. ← Fig. 57 The cell tracts converged in an open hall and were accessed on the upper floors via cast-iron galleries, giving a roughly panoptical space in which all of the circulation zones and cell doors were viewable from a central point. "[E]very movement within the prison, whether of an officer or a prisoner," wrote Jebb in the parliamentary report documenting the building, "is therefore under constant observation and control".[224] → Fig. 58

However, the actual "engine" at Pentonville, in the contemporary sense of an all-driving spatial principle, was embodied less in central surveillance than in isolation—the key feature of the new prison building that promised to prohibit all human irregularity in the penal system. "By an effectual *physical* restraint," ran the third annual report on the separate system, "it escapes all the inconveniences incident to the exercise of a *moral* restraint."[225] Together with this belief in the role of material coercion, the interior of the cells became the focus of attention: "When the dimensions of a healthy, well ventilated, and conveniently furnished cell are fixed … there shall be in every prison precisely the same degree of restraint for every separate inmate,—a restraint arising from the very walls around him."[226] Correspondingly, Jebb invested a considerable part of his engineering skills in the design of the over five hundred cells of the model prison. Every aspect of these identical spatial units was examined in terms both of its role in providing the inmates with the necessities of life and its potential capacity as a means of communication. For instance, the window openings of the circa 64-square-foot-large cells were placed at a height of approximately 6 feet, barred, fixed shut, and additionally fitted with structured glass, meaning that of the window's various purposes only its function to provide daylight remained. → Fig. 59 In order to still feed breathing air into the cells, Jebb resorted instead to a central heating and ventilation system. As with the overall project, in this case the authors applied an experimental approach. Two competing engineering businesses—George & James Haden and one headed by Charles Sylvester, who together with William Strutt

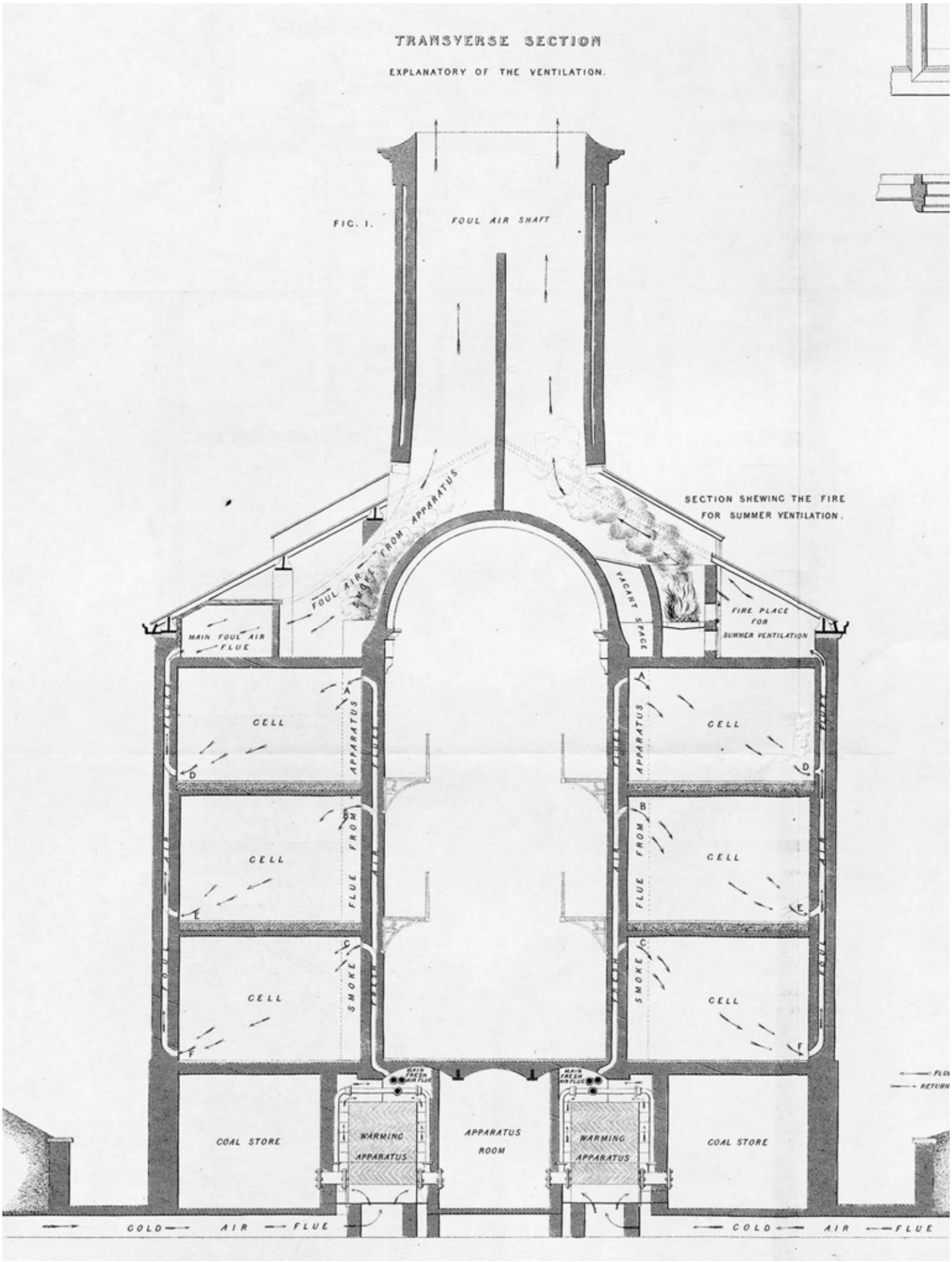
58
Pentonville Prison: “panoptic” interior, 1844



59
Pentonville Prison: solitary confinement
cell, 1844

had developed one of the first warm-air heating methods—were both appointed to install their systems in each half of the prison on a trial basis.[227] As a result, the Hadens were commissioned to equip the entire building with a thermo-ventilation system, very similar to the one being installed by David Boswell Reid at the same time in the Houses of Parliament. In this system, the structure of the building was conceived as a cluster of cavities into which maximally controlled air was to be fed along the lines of a pneumatic apparatus.[228] As such, in Pentonville Prison, the concept of the climatic "architectural machine" overlaps with that of a moral "architectural machine". → Fig. 60

Beside the windows and the heating and ventilation system, the model prison used numerous other architectural and technical elements to achieve isolation. Enveloped in thick, 1-foot-6-inch brick walls and secured with metal-covered doors, the cells were connected to additional central systems in the form of a water supply, a gas pipe, and a signaling mechanism.[229] Nonetheless, this method of technically facilitated exclusion encountered problems when it came to the issue of how to organize the movement and stationary detention of the prisoners outside their own four walls. The cells had to be left at least for the weekly religious services and the daily physical exercises, presenting Jebb with various constructional challenges. To accommodate the physical exercises, he developed a facility in which walled-off prison yards were arranged in pie-shaped segments around a surveillance tower.[230] The prison chapel, in which both religious and secular instruction took place, demanded a more complicated solution. In order to prevent the prisoners from interacting with one another despite being in the same room, the entire inclined congregation area was divided into single wooden cabins. The cabins provided a view of the pulpit and conversely of the inmates, but prevented the latter from having contact with each other.[231] As with many other nodes in the model prison, the filling of the auditorium with prisoners involved combining the building structure with a strict time regime. In order to shepherd the prisoners as quickly and as orderly as possible to their places, a mechanical device was used that allowed all the cubicles in a single row to be locked simultaneously. This was supplemented

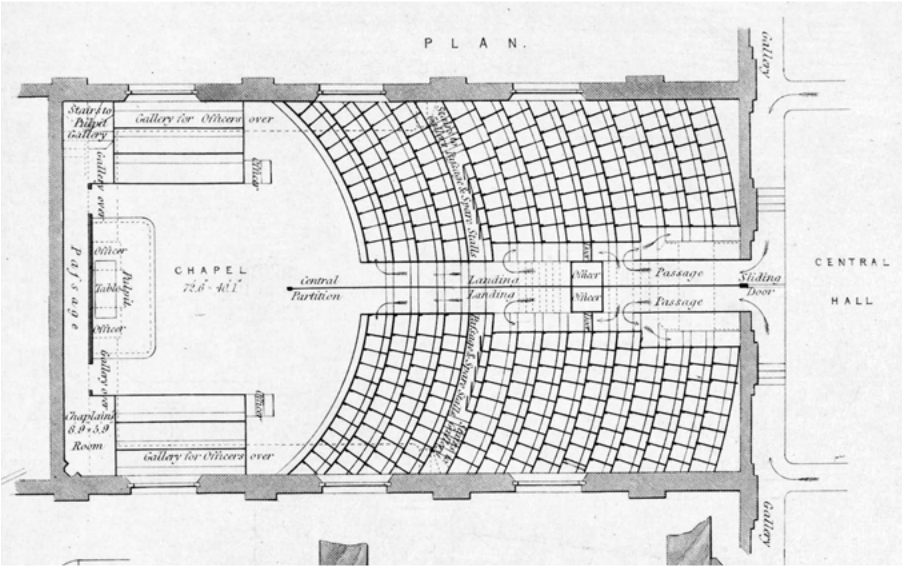


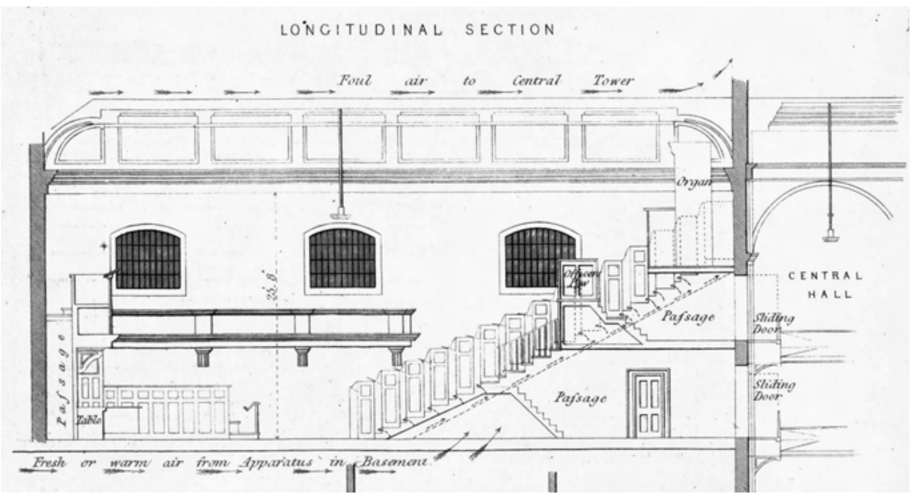
60
Pentonville Prison: thermo-ventilation system, 1844

by a precise planning of the routes leading to and from the chapel, producing a layout that was meant to fill the 260 seating spaces in the chapel in just seven minutes.[232]

Jebb documented the model prison building in numerous publications, in which the prison chapel and the elaborate technique for filling it were also presented with the help of an "Explanatory Plan." The plan's explanatory nature lies in the illustration of the progression of the prisoners through the system of routes in the chapel using a series of small arrows. Starting from the central hall, these arrows run around two corners into a passageway underneath the stands, and from there, with a 180-degree-turn, up to the stands themselves.[233] → Figs. 61–62 Shortly prior to this, the arrow sign had become established as a graphic element depicting flows of air, steam, and water in technical and architectural drawings.[234] In addition, it had been applied for quite some time in British military engineering practice to indicate the trajectories of projectiles.[235] Nonetheless, at this juncture the use of arrows to represent human circulation on an architectural plan had very few predecessors. As in the school setting, it appears to be imminently associated with the specific disposition of a building type designed to exercise a moral effect on the users.[236] For the design of institutions whose impact was meant to emanate directly from the walls, a symbol was apparently needed in order to faithfully record the ramifications of the design decisions. And for buildings in which the control of movement was a priority, this symbol had to have the capacity to represent temporarily consecutive processes. It is therefore only at first glance strange when Jebb uses arrows on one and the same plate to illustrate both flows of air and prisoners: "moral engines" require human actions to be planned as precisely as those of thermal processes in "climatic apparatuses."

The Pentonville experiment was as much of a success as it was a failure. It was successful in that the building—not least due to the wide dissemination of the construction drawings—advanced to become a real model on which numerous prisons were internationally built in the following decades. In England, where since 1839 all prison buildings had to be authorized by Jebb, by 1845 a total of fifty prisons had been built based on the Pentonville plan. At





61–62
Pentonville Prison: occupancy and ventilation
of the chapel, 1844

the same time, the plan, in conjunction with the separate system, spread across continental Europe. In France, thirty new prisons adapted for solitary confinement had been commissioned by 1846, including the Mazas Prison in Paris, similar to Pentonville in its six wings. In Berlin, the new Moabit Prison represented an exact copy of the London model prison in all but the facade.[237] Nevertheless, the Pentonville experiment was also a failure because the attempt to prevent all exchanges between the prisoners using constructional means ultimately proved to be futile. Almost twenty years after the opening of the prison, a parliamentary report provided a list of the violations of the prison rules registered over the span of the previous year, the large majority of them concerning infractions of the ban on communication. This particularly included violations in which, despite all precautions to the contrary, the architectural structure served as medium: "writing or talking, or making signals to other prisoners, or communicating through the water taps, or by knocking on the cell doors."[238] The will and the ingenuity of the prisoners to interact with each other were evidently stronger than any brick wall.

But even if the aim of completely isolating the prisoners was not achieved, the endeavors of Jebb, Crawford, and Russell were far from inconsequential. The Pentonville model prison represents the zenith of half a century of continuous efforts to deploy architecture to have a reforming effect on the bodies and minds of its inhabitants. The London prison and its numerous documentations articulate a body of knowledge that established fundamental connections between built space and—precisely also in their negation—elementary human activities such as seeing, hearing, or moving. In its various forms and contents, this knowledge still remained long active when the unconditional belief in the reforming power of architecture had faded. The success story of such a directional symbol as the arrow is perhaps the clearest proof of this.

1 Gloucestershire Quarter Sessions, Littledean, Original Plans, ca.1785, GA, Q/AG/4, F.
2 For a key text, see Simmel, "Bridge and Door."
3 See, for instance, Chambers, *Civil Architecture*, 3rd ed., 105. The first two editions of the treatise, published in 1759, are still devoid of the term "communication" in the same passage.
4 See Whiting, *Prison Reform*, 6–12.
5 See ibid.; McConville, *English Prison Administration*, 98–100, 107–8.
6 See Harding et al., *Imprisonment*, 109–12. On the aspects of criminal theory and philanthropic practice, see also Foucault, "Truth and Juridical Forms."
7 On Howard, see Ignatieff, *Just Measure of Pain*, 47–57.
8 See McConville, *English Prison Administration*, 1–5, 84–88, 107–8.
9 See Ignatieff, *Just Measure of Pain*, 59–61; Evans, *Fabrication of Virtue*, 115–17.
10 Fielding, *Enquiry*, 4, 63.
11 Howard, *State of the Prisons*, 20.
12 See Foucault, "Truth and Juridical Forms"; Foucault, *Punitive Society*, 82–121.
13 Fielding, *Proposal*, 76.
14 See McConville, *English Prison Administration*, 95–98.
15 Hanway, *Solitude in Imprisonment*, 88. "Be not deceived: evil communications corrupt good manners" is the passage in the King James Bible, 1 Corinthians 15:33. The adage, attributed to Paul the Apostle, which probably warns against those denying the Resurrection of Christ and which in the original uses the term *ὁμιλία* (AG: intercourse, conversation), was already current as a dictum in Greek antiquity. See Conzelmann, *Brief an die Korinther*, 341.
16 Denne, *Letter*, 37.
17 See Peters, *Speaking into the Air*, 6–10, 63–74, 77–80.
18 Hanway, *Solitude in Imprisonment*, 61. Elsewhere he also uses the term "communication" for the transmission of diseases. See, for instance, Hanway, *Serious Considerations*, 59–61.
19 Hanway, *Solitude in Imprisonment*, 113.
20 Penitentiary Act, 19 Geo. III. c.74.
21 Blackstone, *Commentaries*, 371.
22 See Forsythe, *Reform of Prisoners*, esp. 15–43.
23 See McConville, *English Prison Administration*, 108.
24 Hanway, *Solitude in Imprisonment*, 79. See further Markus, *Buildings and Power*, 118–23. .
25 Howard, *State of the Prisons*, 40–48.
26 See McConville, *English Prison Administration*, 108–9.
27 Cited after Ignatieff, *Just Measure of Pain*, 95.
28 See *Oxford Dictionary of National Biography* (2004), entry "Blackburn, William."
29 See Harding et al., *Imprisonment*, 118–19 and 130–31.
30 See Paul, *Defects of Prisons*, 3–7. For the connection between Paul and Howard, see Cooper, "Ideas and Their Execution."
31 Paul, *Defects of Prisons*, 8.
32 Ibid., 21.
33 Ibid., 30–32.
34 Ibid., 60.
35 Ibid.
36 See Moir, "Sir George Onesiphorus Paul," 211; Whiting, *Prison Reform*, 11–13.
37 See Evans, *Fabrication of Virtue*, 118, 142–81.
38 On the development of new prison ground plans around 1800 and Blackburn's role, see Johnston, *Forms of Constraint*, 46–63.
39 Gloucestershire Quarter Sessions, County Gaol Gloucester, Original Plans, ca.1785, GA, Q/AG/1, III; Gloucestershire Quarter Sessions, Littledean Bridewell, Littledean, GA, Q/AG/4, C.
40 See Whiting, *Prison Reform*, 18–19.
41 Foucault, *Discipline and Punish*, 148.
42 Ibid., 172. On the conflict between opening and closing, see also Foucault, "Eye of Power."
43 Jebb, *Polity of Prisons*, 3–5.
44 On the Dorchester county prison, built between 1789 and 1795, see Weinstock, "Dorchester Model Prison."
45 Jebb, *Polity of Prisons*, 6–7.
46 Howard, *State of the Prisons*, 42.
47 As an example, Gloucestershire Quarter Sessions, County Gaol Gloucester, GA, Q/AG/1, IV, VII, X; Gloucestershire Quarter Sessions, Northleach, Original Plans, ca.1785, GA, Q/AG/5.
48 Alken, *Dorset County Gaol*, 1.
49 UK Parliament, Third Report of the Inspectors, 1: 45–46.
50 See Evans, "Figures, Doors and Passages"; Jarzombek, "Corridor Spaces."
51 Blackburn additionally connects the individual pavilions of the building by iron bridges. See Weinstock, "Dorchester Model Prison," 96.
52 Beside the plans for the Littledean Bridewell, on which Blackburn notes the appended sentence and which provide for two revolving doors at the entrances of the building's chapel, corresponding devices are also to be found on the plans for the Northleach Bridewell and the Dorchester county prison. By far the greatest number of examples, however, are to be found in the Gloucester county prison, with over twenty.

53 Johnson [Latour], "Mixing Humans and Nonhumans," 299.
54 Howard, *State of the Prisons*, 79.
55 The 6th edition of *Dr Johnson's Dictionary* in 1785 defines the term, on the one hand, as "Common boundary or inlet; passage or means, by which from one place there is a way without interruption to another," and, on the other, as "The act of imparting benefits or knowledge", "Interchange of knowledge; good intelligence between several persons," and "Conference; conversation." *A Dictionary of the English Language* (1785), entry "Communication."
56 Gloucestershire Quarter Sessions, County Gaol Gloucester, GA, Q/AG/1, I.
57 See Ignatieff, *Just Measure of Pain*, 63–67.
58 See Schaffer, "States of Mind," 252–73.
59 Priestley, *Present State of Electricity*, xix.
60 See McEvoy, "Joseph Priestley," 16–18, 93–96, 156–58.
61 Bentham, "Fragment on Government," 227.
62 Ibid.
63 Priestley, *Observations Relating to Education*, 27.
64 See McEvoy, "Joseph Priestley," 18–20.
65 Bentham, "Principles," 304.
66 See Schaffer, "States of Mind," 266–73.
67 On Athanor, see Bentham, "To Joseph Priestley." On Bentham's other projects, see Mack, *Jeremy Bentham*, 137.
68 Bentham, "Panopticon," 39.
69 On this topic, see Semple, *Bentham's Prison*, 42–61.
70 See ibid., 98–105. See also Werrett, "Potemkin and the Panopticon."
71 Foucault, *Discipline and Punish*, esp. 195–228.
72 Dicey, *Law and Public Opinion*, 129–30.
73 Ives, *History of Penal Methods*, 171, 216.
74 Huxley, *Prisons*, 15. Even prior to World War II, Huxley had described his era as one of "new Romanticism," characterized by an infantile enthusiasm for machines, citing Le Corbusier's dictum of the house as a "machine for living in" as proof. Huxley, "New Romanticism," 211–20.
75 Foucault, *Discipline and Punish*, 26, 76, 116, 125, 138, 173, 177, 178, 211, 213, 215, 235, 236, 243, 244, 245, 255, 271, 285, 292, 296, 306, 307.
76 In their two volumes of *Capitalism and Schizophrenia*, Deleuze and Guattari analyze the capitalist social order, or the modern state, as a "megamachine," referring to Lewis Mumford. Deleuze and Guattari, *Anti-Oedipus*, 154–56; Deleuze and Guattari, *Thousand Plateaus*, 427–28 and 456–57. In *Discipline and Punish* Foucault shows himself in turn to be deeply indebted to the work of Deleuze and Guattari. See Foucault, *Discipline and Punish*, 309.
77 Foucault, *Discipline and Punish*, 177. On this, see also Behrent, "Foucault and Technology," 80–90.
78 Foucault, *Discipline and Punish*, 201, 234.
79 Ibid., 202, 217. In the same year that Foucault spread this ominous message, the original version of an essay by the psychoanalyst and Lacan disciple Jacques-Alain Miller appeared, in which he described the Panopticon as an "apparatus" and a "universal machine," identifying it with Utilitarianism's repressive impulses. Miller, "Jeremy Bentham's Panoptic Device," 3.
80 For example, in the 1770s Bentham used the phrases "Machine of Jurisprudence" and "machine of Law" (Bentham, "Libels Justification," UCL, JB/070, 204, 285), referred in 1780 to the "great machine of government" (Bentham, "Prefat.," UCL, JB/027, 161), and at the time the Panopticon plan emerged spoke of the "machine of Justice" (Bentham, "Certainty Evidence," UCL, JB/051, 9).
81 See, for instance, Bentham, "Panopticon Machinery," UCL, JB/117, 24.
82 Bentham, "Panopticon," 39.
83 Bentham, "To Jaques Pierre Brissot," 342. A French edition of the Panopticon Letters appeared in precisely the same year on the basis of a directive from the National Assembly. On the ideal type of the mill, see Jakob, *Maschine, Mentales Modell, Metapher*, 245–46.
84 Bentham, "Panopticon," 85, 64.
85 Ibid., 83–84, 92.
86 Ibid., 63.
87 Ibid., 41
88 Ibid., 70.
89 Ibid., 84.
90 In *Dr Johnson's Dictionary*, for instance, the entries on the engine and the clock are defined with the term "instrument," that on the mill with the term "motor." *A Dictionary of the English Language* (1785), entries "Clock", "Engine", and "Mill." The relevant definitions of "instrument" read: "A tool used for any work or purpose," "The agent. It is used of persons as well as things, but of persons very often in an ill sense," and "That by means whereof something is done." Ibid., entry "Instrument."
91 Bentham, "Panopticon," 102, 66; Bentham, *Traités de législation*, 1–2.
92 Cited after Bowring, "Memoirs of Jeremy Bentham," 572.
93 Bentham, "Panopticon," 72, 108, 63, 150.

94 Bentham, "Value of a Pain or Pleasure," UCL, JB/027, 30.

95 Bentham, "Introd. Encyclopaedical Sketch," UCL, JB/027, 15. The insertion "is instrumental" is a marginal note by Bentham that vis-à-vis the sentence cited could have both a supplementary and a summarizing function.

96 Bentham, "Panopticon," 110–18. Among others, Bentham was acquainted with the entrepreneur and inventor William Strutt. See Egerton, "Achievements of William Strutt," 43–44.

97 Despite this, the fundamental difficulty of preventing technical communication channels likewise providing human ones also remained in Bentham's project. See Bentham, "Panopticon," 115.

98 Bentham, "Tracts on Poor Laws," 428. On the National Charity Company, see ibid., 369–72; on the prognosticated dissemination of knowledge, see ibid., 424–28.

99 In his *Novum organum* (1620), Francis Bacon used the term "polychrest" for his twenty-eight prerogative instances of the interpretation of Nature, meaning those cases and instruments that apply to multiple things or are often applied. See Bacon, *Novum organum scientiarum*, 317–18.

100 Bentham, "Tracts on Poor Laws," 437.

101 On the image of cultural "melting," see Cunliffe, "Crèvecoeur Revisited." That Bentham, alongside organizational questions, also viewed the actual construction of the Panopticon as an experimental exercise is evident in his repeated proposals to build provisional wooden variations of his designs. See, for instance, Bentham, "Bicetre Proposal," UCL, JB/117, 18.

102 See Semple, *Bentham's Prison*, 265–79.

103 See Evans, *Fabrication of Virtue*, 227–30.

104 The lecture, delivered in March 1787, was published in the same year in America and Britain in book form. Rush, *Effects of Public Punishments*, 27.

105 See Hawke, *Benjamin Rush*, 358–80.

106 Rush, *Effects of Spirituous Liquors*, 13.

107 On this, see crucially Markus, "The School as Machine"; Markus, *Buildings and Power*, 41–94.

108 See Lawson and Silver, *Social History of Education*, 226–34.

109 For the historical origins of both systems, see Salmon, *Practical Parts*, vii–li.

110 See Lawson and Silver, *Social History of Education*, 241–42.

111 Bell, *Experiment in Education*, 2nd ed., 13–14.

112 Bell, *Analysis of the Experiment*, 10, 106.

113 Bell, *Madras School*, 36–37. See further ibid., 3, 111.

114 Bell, *Experiment in Education*, 24.

115 Smith, *Wealth of Nations*, 9.

116 Bernard, "Preface," 35–36.

117 Smith, *Essays on Philosophical Subjects*, 44. For Smith's general influence on primary schooling in the nineteenth century, see Hamilton, "Adam Smith."

118 Perhaps influenced by the factory owner William Strutt, this also involved the operation of a central warm-air system. See Markus, *Buildings and Power*, 69–70. On the friendship between Owen and the Strutt family, see Fitton and Wadsworth, *Strutts and the Arkwrights*, 182–84. For their part, from 1809 onward William Strutt and his brother Joseph established, like Owen, schools based on the Lancaster system. See Egerton, "Achievements of William Strutt," 168–69.

119 Owen, *New View of Society*, 25, 71–77. This analogical field remained active for decades. As late as 1835, the Scottish natural scientist Andrew Ure wrote, dealing with secular and religious education in factories: "It is, therefore, excessively the interest of every mill-owner, to organize his moral machinery on equally sound principles with his mechanical, for otherwise he will never command the steady hands, watchful eyes, and prompt co-operation, essential to excellence of product." Ure, *Philosophy of Manufactures*, 417. On the similarity between questions of organization in schools and companies, see also Miller, "Factories, Monitorial Schools."

120 Owen, *County of Lanark*, 46–47.

121 Bentham, "Chrestomathia," 8.

122 Ibid., 5.

123 Southey, *New System of Education*, 152; Coleridge, *Statesman's Manual*, 51.

124 Bell, *Madras School*, 116.

125 Lancaster had already included "bad accommodation" as one of the main problems of pauper education in his first book. See Lancaster, *Improvements in Education*, 29. For a categorization of Bell and Lancaster's work in the architectural history of the school, see also Seaborne, *English School*, 135–42.

126 See Seaborne, *English School*, 139; Markus, *Buildings and Power*, 57.

127 Lancaster, *British System of Education*, 3.

128 Lancaster, *Hints and Directions*, 9–27. In the process, Lancaster also shows himself to be up to date with the latest heating and ventilation technology, suggesting that a central steam or warm-air heating system be installed. Ibid., 19–20.

129 See Wasinski, "Making War Possible."
130 Lancaster, *British System of Education*, 54–55.
131 Hamel, *Der gegenseitige Unterricht*, 157, 175–76, 191–97. The illustrations in Hamel's book, which also appeared in French, Italian, and Russian, are based on a placard issued a year earlier by a French priest named Abbé Picot under the title *Ecoles pour l'enseignement mutuel élémentaire.*
132 Ibid., 232–33.
133 See Seaborne, *English School*, 142–43; McCann, "Samuel Wilderspin."
134 Wilderspin, *Infant Education*, 47. The term "mechanical" had been applied since the beginning of the century to characterize uniform and routine processes in teaching. See, for instance, Trimmer, *Comparative View*, 84, 144. A report by the Poor Law Commission defined the term in 1841 as follows: "the mechanical daily routine; that is in assisting the teacher in assembling the class in order, in procuring and preserving silence and attention, in distributing the books, slates, pens, &c., in superintending lessons in which moral training forms no element, such as writing and ciphering." Kay, "Norwood School of Industry," 106.
135 Wilderspin, *Infant Education*, 59, 72, 201–2.
136 Stow, *Training System*, 57.
137 See Seaborne, *English School*, 144–45; Cruickshank, "David Stow."
138 Stow, *Training System*, x.
139 Stow, *Moral Training*, 287.
140 Stow, *Training System*, 69.
141 Ibid., 122.
142 Harris, *School-Room*, 57.
143 Cited after Dix, *State Hospital for the Insane*, 20.
144 Granville, *Care and Cure*, 15.
145 For an overview, see Laffey, "Psychiatric Therapy."
146 Pinel, *Traité médico-philosophique*, 179.
147 Tuke, *Description of the Retreat*, 107. See further Digby, "Moral Treatment," 52–54.
148 See Smith, *Public Lunatic Asylums*, 12–51; Scull, "Victorian Lunatic Asylum."
149 Stark, *Construction of Public Hospitals*, 7. On Stark and the Glasgow asylum, see also Snedden, "Environment and Architecture."
150 Stark, *Construction of Public Hospitals*, 13.
151 Tuke, *Practical Hints*, 11.
152 Tuke, *Description of the Retreat*, 94–96.
153 Ibid., 97–107. See also Edington, "Space for Moral Management."
154 Tuke, *Description of the Retreat*, 100–105.
155 Tuke, *Practical Hints*, 37.
156 Watson and Pritchett, *Pauper Lunatic Asylum*, 27.
157 Ibid., 27, 31–34.
158 Ibid., 30.
159 On the development of French psychiatry, with a focus on the building of asylums, see Pinon, *L'Hospice de Charenton*, 15–53.
160 Tenon, *Mémoires sur les hôpitaux*, 216, 393.
161 Esquirol, "Des Établissemens," 421. Esquirol repeated his formulation the same year in Esquirol, "Manie," 464. In 1838, he expanded his statement to read: "A lunatic asylum is an instrument of healing, in the hands of a skillful doctor, it is the most powerful therapeutic agent against mental illness." Esquirol, "Préambule," 398.
162 Baltard, *Architectonographie*, 18.
163 For a brief overview of the West European reform movements, see Johnston, *Forms of Constraint*, 88–122.
164 See Wright, *Guillotine & Liberty*, 53–62.
165 Baltard, *Architectonographie*, 23, plates 24, 27–29.
166 See Evans, *Fabrication of Virtue*, 236–67.
167 Ingleman, *Explanation of the Plans*, 2–3.
168 On this and the following paragraph, see Evans, *Fabrication of Virtue*, 260–309.
169 Holford, *General Penitentiary at Millbank*, esp. 371–94.
170 Committee of the Society for the Improvement of Prison Discipline, *Construction of Prisons*, 19, 34.
171 Ibid., 44–47.
172 On Baltard and his prisons, see Pinon, *Louis-Pierre et Victor Baltard*, 47–49.
173 Baltard, *Architectonographie*, 18–19, 32–35.
174 See Evans, *Fabrication of Virtue*, 271–75.
175 Marquet-Vasselot, *Maisons centrales de détention*, 44–45.
176 Baltard, *Architectonographie*, 18, 23.
177 See Wright, *Guillotine & Liberty*, 62–63; Petit, *Ces peines obscures*, 220–22.
178 Beaumont and Tocqueville, *Système pénitentiaire aux États-Unis*, 37–72.
179 Henriques, "Separate System," 72–73. On this, see further also Petit, "Aspects de l'espace carcéral," 157–69.
180 Gasparin, "Rapport," 57.
181 Lucas, *Réforme des prisons*, 69.
182 For an overview of the various positions, see also Petit, "L'amendement."
183 Moreau-Christophe, *L'état actuel des prisons*, xliii.
184 Moreau-Christophe, *Réforme des prisons*, 268.
185 Ibid., 268–69.
186 Ibid., 379.
187 Moreau-Christophe, *Rapport*, 32.

188 See Wright, *Guillotine & Liberty*, 67–69.
189 Demetz and Blouet, *Rapport*, 3–46.
190 Ministère de l'Intérieur, *Instruction et programme*, 6–7.
191 Ibid., 9.
192 Suringar, *Réclusion individuelle des détenus*, 15.
193 Tocqueville, "Rapport." On the history of the reform law, see Wright, *Guillotine & Liberty*, 72–80.
194 Tocqueville, "Rapport," 241.
195 For instance as a second publication in Tocqueville, "Rapport de M. de Tocqueville," 243, and Tocqueville, "Rapport par M. de Tocqueville," 14, as well as abroad in Hoorbeke, *Système pénitentiaire*, 194, and Würth, *Fortschritte des Gefängniswesens*, 31.
196 Burt, *System of Separate Confinement*, 255.
197 See Brodie, Croom, and Davies, *English Prisons*, 84–85.
198 UK Parliament, *Report of William Crawford*, 12.
199 See Harding et al., *Imprisonment*, 143–54.
200 UK Parliament, *Reports of the Inspectors*, 78.
201 Ibid., 70–71.
202 UK Parliament, *Report of William Crawford*, 11.
203 UK Parliament, *Reports of the Inspectors*, 79.
204 UK Parliament, *Second Report of the Inspectors*, 32, plates B–N.
205 Ibid., 21.
206 Home Office, Prisons Entry Books, Series I, TNA, HO 21/7, 54.
207 Home Office, Prisons Correspondence and Papers, TNA, HO 20/3, n.p. See Home Office, Prisons Entry Books, TNA, HO 21/7, 181, 189–90. See also Tomlinson, "Victorian Prisons," 110–11, 236; Evans, *Fabrication of Virtue*, 335–37.
208 The description of the trials appeared in translation the same year, incorporated in the reports by the French inspectors Frédéric Demetz and Abel Blouet, explaining why some sources claim that Blouet participated in the experiments. Nevertheless, in neither his account nor in Crawford and Russell's is there any evidence that he did. See Demetz and Blouet, *Rapport*, 85–92.
209 See Cantor, Gooding, and James, *Faraday*, esp. 39–42. Prior to this, Faraday had already been active in Millbank in connection with the disinfection of the building. See Griffiths, *Memorials of Millbank*, 91. He was also connected to Reid and Smirke in the contemporaneous planning of the new Houses of Parliament in London.
210 See Williams, *Michael Faraday*, 178–81; Reid, "Construction of Public Buildings."
211 See Tkaczyk, "Listening in Circles."
212 See Evans, "Rights of Retreat." See also Gethmann, "Übertragung und Speicherung."
213 UK Parliament, *Second Report of the Inspectors*, 21.
214 For a history of material testing experiments going back to Leonardo da Vinci, see Kurrer, *Geschichte der Baustatik*, esp. 380–439.
215 UK Parliament, *Second Report of the Inspectors*, 23.
216 Ibid.
217 UK Parliament, *First Report from the Select Committee*, 72.
218 Home Office, Prisons Entry Books, TNA, HO 21/8, 204.
219 On Jebb and his commitment, see Weiler, "Army Architects," 222–49.
220 UK Parliament, *Third Report of the Inspectors*, 28. In the preceding report it was still the silent system that had appeared under the machine cipher, albeit as an error-prone variation: "what a cumbrous, complicated piece of machinery does the whole system exhibit, and how soon and how frequently are its movements liable to be deranged or stopped!" UK Parliament, *Second Report of the Inspectors*, 8.
221 UK Parliament, *Third Report of the Inspectors*, 19.
222 Crook and Port, *King's Works*, 630.
223 Ibid., 631.
224 Jebb, *Pentonville Prison*, 8. On this, see also Evans, *Fabrication of Virtue*, 342–43.
225 UK Parliament, *Third Report of the Inspectors*, 27.
226 Ibid.
227 Home Office, Prisons Entry Books, TNA, HO 21/9; Tomlinson, "Victorian Prisons," 116.
228 The Hadens, who had already introduced their procedure in the third annual inspectors' report, simply reversed the direction by channeling the air to the ceilings of the individual cells and extracting it again at floor-level. See Jebb, *Pentonville Prison*, 17–28. See also, including reference to David Boswell Reid, Jebb, "Construction and Ventilation."
229 Jebb, *Pentonville Prison*, 28–29.
230 Ibid., 16.
231 Ibid., 8. A comparable solution had already previously been proposed by Jonas Hanway. See Hanway, *Solitude in Imprisonment*, 118.
232 Jebb, *Pentonville Prison*, 15–16.233 Ibid., plate 4. A further sketch on the same plate uses more arrows to show the actual

entries to the individual rows of seats. See also Jebb, *Modern Prisons*, plate 3; Jebb, “Construction and Ventilation,” plate XII.

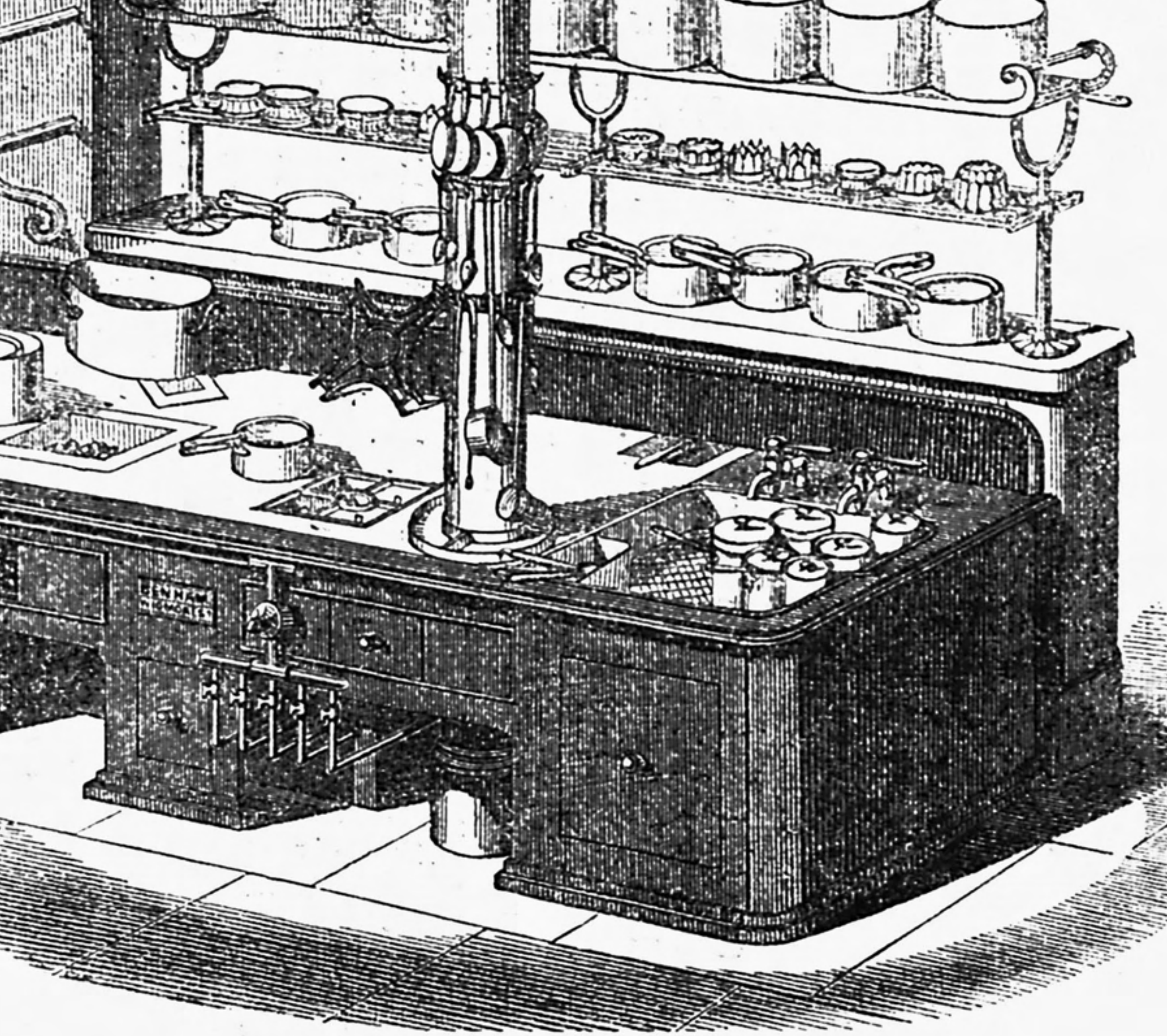
234 On this, see the section "Central Systems" in this book.

235 See, for example, Pasley, *Operations of a Siege*, 192.

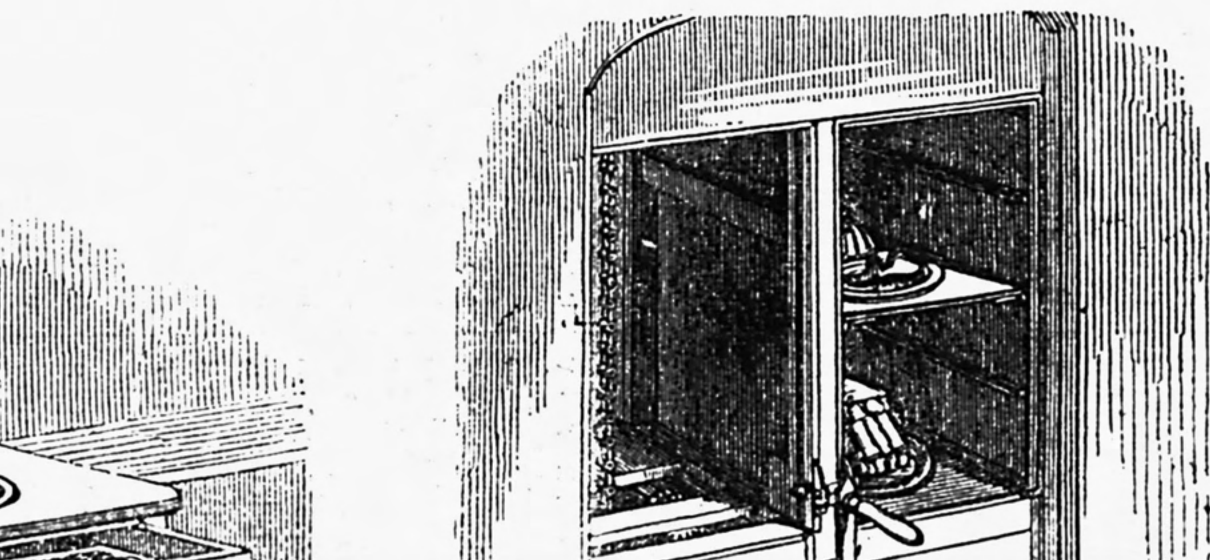
236 Arrows had already appeared in the fourth report of the prisons’ inspectors. See UK Parliament, *Fourth Report of the Inspectors*, plate II. The ground plan compendium published by the French ministry of the interior in 1841 likewise uses numerous arrows to mark the approaches to the prisons. See Ministère de l’Intérieur, *Instruction et programme*, plates 1, 3, 5, 7, 9, 11.

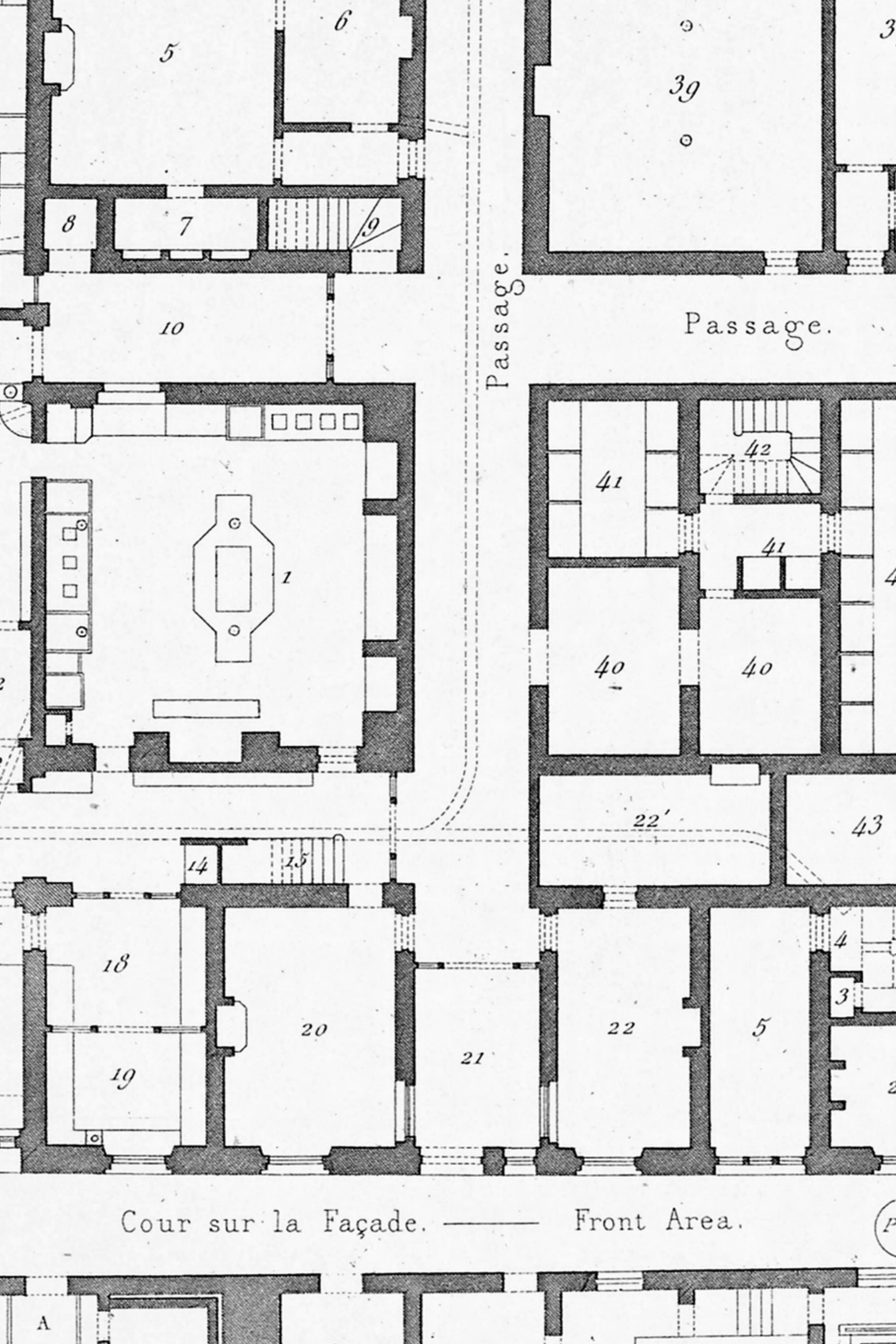
237 See Weiler, “Army Architects,” 224; Evans, *Fabrication of Virtue*, 384.

238 UK Parliament, *Reports of the Directors*, 3.



GAS STOVES, BAIN MARIE, &c.





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Passage.
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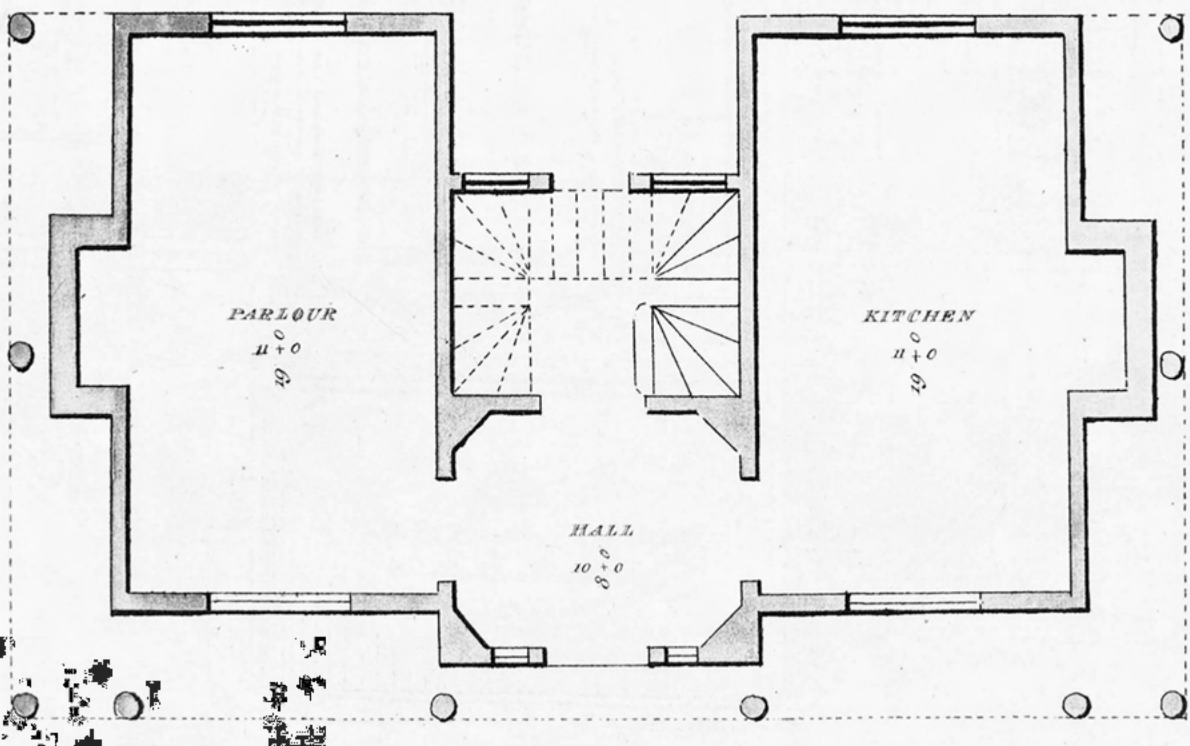
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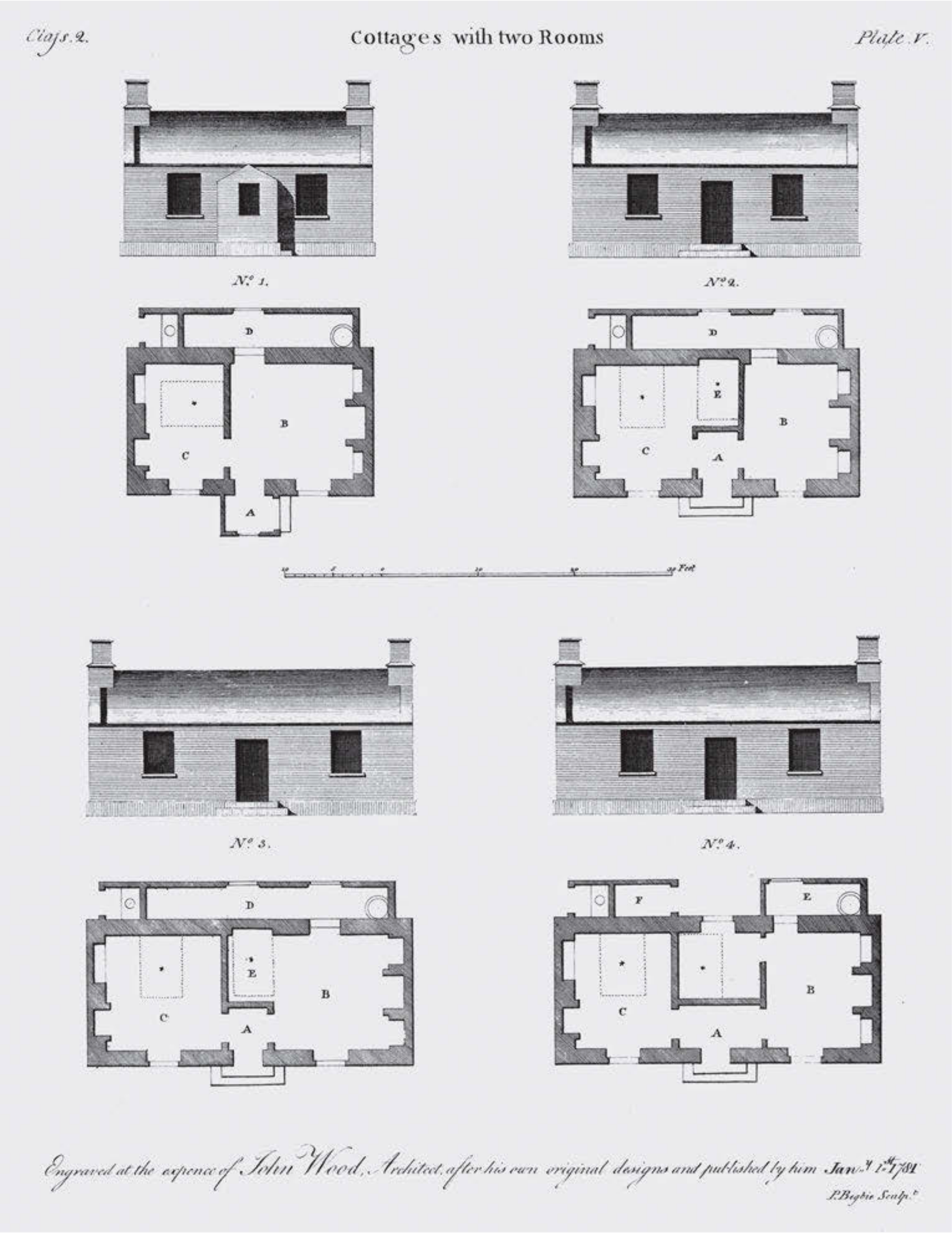
III. Comfort

Between Consolation and Ease

In 1781, the English architect John Wood, the son of John Wood the Elder, published a series of plans for workers' cottages based on seven constructional principles. The second of these principles—following the stipulation that the buildings be dry, and thereby promote health—bears the title "WARM, CHEARFUL, and COMFORTABLE."[1] Solid walls, a wind-protected entry, and rooms facing south and east should give the dwelling the eponymous qualities and ensure that when the occupants came back from a hard day's work they would take pleasure in returning home and would live there contentedly.[2] Wood's preoccupation with cottages was generally driven by the question, "how far they might be rendered more comfortable to the poor inhabitants."[3] → Fig. 63 The use of the adjective "comfortable" in this context would hardly raise an eyebrow today, but at the time was far from self-evident. When an expanded edition of Wood's plans appeared in 1792, it was in fact the very first architecture publication to have the word as a noun in the title: *A Series of Plans for Cottages or Habitations of the Labourer … To Which Is Added, an Introduction, Containing Many Useful Observations on This Class of Building; Tending to the Comfort of the Poor and Advantage of the Builder*. The aim here, in broad brushstrokes, is to examine the shift in terminology, and with it in subject matter, in order to establish how this term "comfort" came to be adopted in architectural vocabulary and what Wood's printed intervention in the early 1780s meant in terms of the understanding of living space.

In Britain, the verb "to comfort" was a loanword from the French and had been in use since the High Middle Ages, applied since the early seventeenth century also in connection with habitation. Nonetheless, well into the eighteenth century its meaning,



63
“WARM, CHEARFUL, and COMFORTABLE”:
model plans for cottages by John Wood, 1781

etymologically rooted in the phrase “to invigorate to a great degree,” had above all emotional-spiritual connotations, and as such was only indirectly compatible with architectural elements such as walls or window openings. The noun “comfort” above all described various forms of psychological consolation, both in the sense of an invigoration when suffering mental pain and an actual amelioration of this pain. It was highly religiously colored and predominantly promised assistance through belief in God. Even in residential contexts, the term comfort signified far less the designation of material correlations than the emotional support provided by one’s own house as a place of family, privacy, and pious devotion. When used, alternatively, in a physical context, it as a rule related to the human body and its organs, coupled with the corresponding medical or dietary connotations.[4] It was only in the course of the eighteenth century that a gradual shift in meaning took place, in which the consolations of comfort came to also basically encompass the relief and encouragement offered by a person’s immediate material surroundings.

A central point of departure in this physical concept of comfort derives from the philosophical debate concerning the relation between luxury and necessity that started in around 1700. By this juncture, luxury had already long been an object of reflection and criticism, and under the offense of profligacy it had been repeatedly discussed as imperiling both individual character and the overall religious or social order. Relatively undisputed, necessity, on the other hand, described fundamental and natural human needs. Within the framework of the emerging development of political economy, both of these categories acquired an altered meaning and were reconfigured in relation to each other. By conceiving necessity as being formed by market and cultural forces, political economy simultaneously deconstructed the term luxury. It demonstrated that things that were considered luxurious in one context could be bare necessities in another, and as a mediator between them an equalizing concept emerged that was intended to describe not only needs in a context-related way but similarly the measure of their fulfillment: comfort.[5] In his famous *Fable of the Bees* from 1714, in which he defended vice and luxury as promoters of prosperity, Bernard Mandeville set out to show that all needs higher than those of bare survival were socially constructed and therefore luxuries—or otherwise comforts: “The Comforts of Life are likewise so various and extensive, that no body can tell what People mean by them, except he knows what Life they lead.”[6] For Mandeville, comfort advanced to become a morally neutral expression with which to describe material circumstances worth striving for: “convenient Houses, handsome Furniture, good Fires in Winter, pleasant Gardens in Summer, neat Cloaths, and Money enough to bring up their Children … are the necessary Comforts of Life.”[7]

While mid-eighteenth-century economic theory set out to establish comfort as a legitimizing motive in consumption, at the same time this consumption came to increasingly include the design of the home and its environment. Already in 1739, in a commentary in the journal *Common Sense*, the arguments of the economists were concretely applied to questions of architecture: “I am far from censuring in all Cases, the Pleasure and the Magnificence of Building and Gardening;” wrote the anonymous author concerning squander in building, “it is at least a very pardonable Excess in those, whose Ranks and Fortunes conspiring enable them to raise, and entitle them to possess such noble and sumptuous Monuments; … Much less would I deny to Persons of inferior Rank and smaller Fortunes, the real Comfort of convenient Habitations.”[8] Comfort in this case assumes not only the meaning of domestic amenity; instead, alongside its subjective connotation as a “feeling of coziness,” what appears is an objective connotation of the “characteristic of coziness” related to the surroundings. With this, the word enters into semantic competition with a series of terms that had accompanied architectural thinking for far longer and that at the latest since the late seventeenth century had been used to define the convivialities of a house.

In English, the words were “convenience,” “commodity,” and “ease”; in French “*convenance*,” “*commodité,*” and “*aisance*,” traditionally used to express the contentedness of a person with their physical surroundings. A crucial reason for the role that these words played in characterizing amenity value lay in their connection to the architectural technique of distribution. At around the same time that political economy started, with the help of the term comfort, to critically question the categories of luxury and necessity, in architectural theory a discussion began that treated the arrangement of living space as an independent topic, equal in importance to questions of construction and decoration. In aristocratic mansions on both sides of the Channel, an increasingly differentiated system of spatial organization developed, one that particularly in France was raised to a type of national art form. Whereas the layout and subdivision of lavish interior spaces had long been determined by rules of geometry, proportion, and disposition, and had a limited relation to the actual use of the rooms, now French architects elevated the distributive adaptation of the house to the needs and habits of their occupants to a central design objective.[9] "The distribution," stipulated the architect and interior designer Germain Boffrand in his 1745 *Livre d'architecture*, "regulates the extent of a house: it must be proportionate to the number of people who have to go there, or live in it. The size of the courts & the rooms must be proportionate to their use, & the arrangement of all parts must have a linkage & connection convenient to habitation, so that all parts are relative to the whole."[10] The stated aim was to ideally tailor the living spaces to the social etiquette and individual requirements of the inhabitants. This is encapsulated in the term "*commodité*," which unlike in the previous century no longer describes the propriety of proportions and furnishings but instead relates directly to the contentedness of the householder. "This part of architecture," continues Boffrand in his definition, "has for its object the commodity of the master of the house: he cannot be commodious if all that surrounds him is not placed conveniently at his service, which must be done with ease."[11] Expressed in its essence, distribution regulates the "serviceability" and therefore the amenity of the domestic surroundings.

In the course of the eighteenth century, the process of distribution underwent a refinement with a progressive multiplication and specialization of the interior rooms. Thus, French architect Jacques-François Blondel ultimately differentiated between six sorts of rooms, spread across three types of *appartements*, in other words combined spatial complexes. Each of these spatial complexes was assigned a specific purpose and was regulated by a codified sequence of rooms. The *appartements de parade* served to formally receive visitors, the *appartements de société* were for family gatherings and entertaining friends, while the owner's personal activities took place in the *appartements privés*.[12] The result is a complex framework in which the house is divided into a series of carefully separated and defined areas—some of them private and intimate, some open and ostentatious, and others designated for the servants—coupled with the fixing of distinct and hierarchized routes through the building.[13] This shift was accompanied by an increasing attention paid to the domestic furniture. In his *L'Homme du monde éclairé par les arts*, an epistolary novel set in aristocratic society, Blondel compares the furniture in an illustrious Paris townhouse with the common furnishings of yesteryear: "The shape of the furniture, above all, stimulates the imagination. One can almost not rest there, without experiencing an emotion that the old couches never caused, & these enormous armchairs that swallow up body, soul & mind."[14] In general, the eighteenth century saw a gradual modulation of furniture to fit the human body, its posture, and its gestures. Chairs became less rigid in form, allowing the sitter to relax and adopt a more cultivated poise; storage furniture, such as dressers, was equipped with more practicable and smoother-running drawers. The key locus of all these changes were the residencies of the high nobility, but with time these new practices—together with the efforts to modify houses to suit everyday activities—were also adopted in the homes of the lower aristocracy and the upper bourgeois.[15]

In Britain, where a close connection between the technique of distribution and the pursuit of pleasant living surroundings likewise emerged, the term comfort started to be used in this context around the middle of the eighteenth century, displacing the primacy of the word "commodity," and as a competitor to "convenience" simultaneously acquiring increasingly pronounced physical-material connotations.[16] "Your rooms are not large at Carton, but they lie so well together, I think it a comfortable house," wrote, for instance, the First Baroness Holland, Lady Caroline Lennox, in fall 1764 to her sister Emily, the Marchioness of Kildare, regarding her Irish countryseat, Carton House.[17] Beside the room layout, this sentiment touches upon a further novel aspect of the term comfort: the reason why the baroness praises her sister's house is above all the advantage the arrangement of the rooms gives in terms of heating them in that the adjoining rooms allow the temperature to be regulated by opening and closing the various doors.

This sentiment is by no means an idiosyncratic one, as the growing appreciation of the characteristics of living space did indeed go hand-in-hand with a general growing sensibility for its atmospheric provisions—the level of warmth, the amount of ventilation, and how smoky it was. This is where the topic of comfort clearly overlaps with that of climate, also in that the emerging techniques of heating and ventilation were designed to serve not only public buildings but also private homes. Reformers and inventors like the American statesman Benjamin Franklin, who since the 1740s had tried to modify the sometimes centuries-old traditions of domestic heating by applying new scientific and technical standards, wanted above all to improve the well-being and health of their contemporaries. And so it was that in the second half of the century, the smoky fireplace practically became an epitome of a lack of comfort: "No situation in life can be more uncomfortable and unhealthy," wrote the builder Robert Clavering in 1779 in his *Essay on the Construction and Building of Chimneys*, "than residing in a smoky house: it is not only offensive to our sensations, but destroys all domestic enjoyment."[18] Conversely, the norms of good chimney building became the guarantee of a homeliness that transcended architectural types: "principles of a conveniency, the due execution of which is necessary to render every habitation comfortable, from the cottage to the palace!"[19]

Despite these crossovers, there are also significant differences between the fields of climatization and comfort. From the outset, comfort was by no means confined only to atmospheric conditions; instead it increasingly incorporated the techniques of heating and ventilation into a wider range of domestic activities and emphasized the actions necessary for their execution. It is in this sense that the author and lexicographer Samuel Johnson reminded his readers in 1775 that life unfortunately did not consist only of glorious acts: "[I]t must be remembered," he explained in an account of his journey to the Outer Hebrides,

> that life consists not of a series of illustrious actions, or elegant enjoyments; the greater part of our time passes in compliance with necessities, in the performance of daily duties, in the removal of small inconveniencies, in the procurement of petty pleasures; and we are well or ill at ease, as the main stream of life glides on smoothly, or is ruffled by small obstacles and frequent interruption.[20]

Johnson's observation appears in a passage about windows and relates to the fact that in Scotland their construction was rather impracticable to handle. Instead of being equipped with hinges, the windows were set in guiderails and had to be pushed upward and then held in place to allow them to stay open for any length of time due to a lack of catches. The room could be aired, but it constituted a considerable inconvenience—in Johnson's words a "turbulence" in the flow of life. Johnson's liquid metaphors serve to above all highlight the factor of time: according to this, things that are convenient or agreeable are defined by their capacity to be integrated without friction into temporal everyday procedures or that enable such to run without a hitch. Shortly after, the word "comfort" would take an almost predestined place as the term for this idea of smoothness.

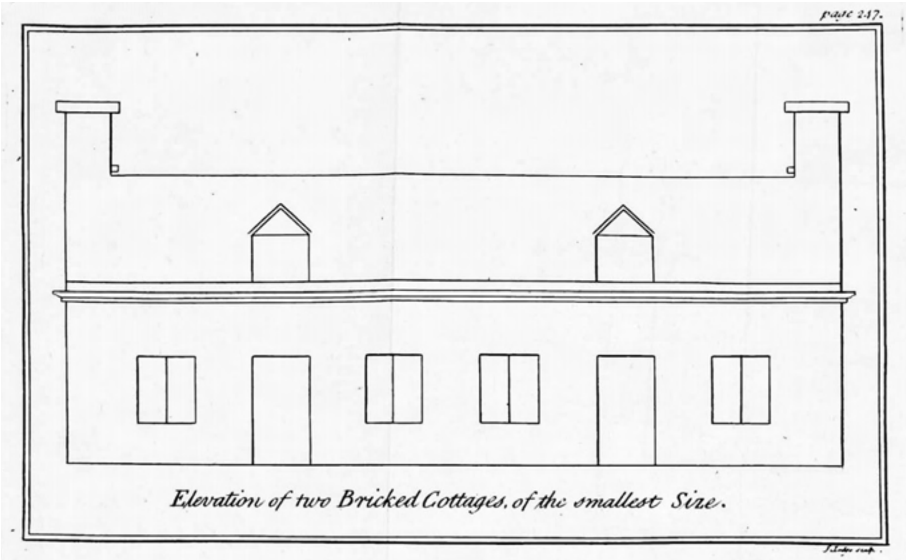
Cottage Comforts

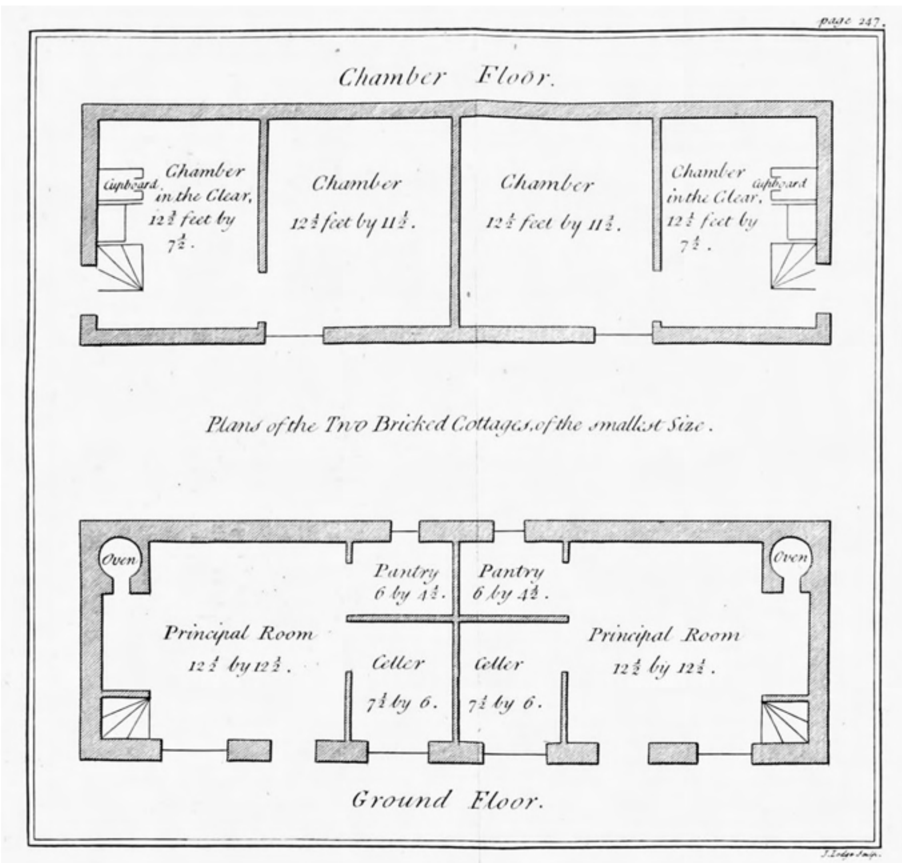
Contrary to what might be instinctively imagined, the first building type to be identified with the concept of comfort was not the noble city palace or the stately manor house, instead it was far more nondescript. As it is, John Wood's *Series of Plans* was not only the first architectural publication to raise comfort to a constructional principle and to adopt the word in the main title, it was also the first that bore the expression "cottage" in the heading. This combination of terms would prove to be formative. In the following decades, a plethora of English-language publications on the topic of the small, as a rule single-story country dwelling would appear, all of them expounding "comfortable" as a primary design principle. Thus, it was the cottage that came to embody the (minimal) standards for what constituted a comfortable house.[21] The reasons for this close connection lies, on the one hand, in the universality of the term comfort. From the outset, its equalizing nature made it equally relatable to privileged self-interests and to the different motivations underlying the care of others. On the other hand, this connection between the idea of comfort and the cottage as a type is rooted in the role occupied by small country buildings in the architectural discourse of the late eighteenth century. Hardly any other building type was able to combine such a wide spectrum of expectations and endeavors at the time: from recreational buildings, in which the rich could fleetingly enjoy living frugally, to emergency shelter, meeting the elementary needs of the poorest of the poor for survival.

Initially, the growing interest in small country dwellings flowed from a broader movement among the English upper classes that idealized life beyond the cities. As part of this enthusiasm, the cottage progressed from being an ordinary lodging for country laborers, a synonym for the poverty and misery of the non-propertied English tenant farmer, to become a highly esteemed building type, sometimes designed with considerable artistic flair and the focus of eminent architects, including in their publications.[22] This ascendency began in the mid-eighteenth century with the appearance of a series of sample books for garden houses, the cottage being one of a variety of buildings belonging to the architectural reservoir of the flourishing landscape architecture movement, and which by virtue of their ephemeral nature and manageable size opened up a rich scope for constructional and stylistic designs.[23] In 1750, the prominent architectural theorist Robert Morris published his book *Rural Architecture*, containing architectural designs for both farm dwellers and pleasure seekers; and in 1752, William and John Halfpenny published a volume with the title *Rural Architecture in the Gothick Taste* dedicated solely to buildings for leisure. Both of these early publications already dealt with the fundamental circumstances constituting agreeable and pleasant habitation under the term "convenience." The rudimentary architectural nature of the designs, which also included associations with the "origins" of architecture and in particular Marc-Antoine Laugier's Primitive Hut, stimulated ideas about the elementary requirements of manmade lodgings, such as shelter from wind and weather or the availability of water, sustenance, and fuel. "[T]his ESSAY on the Primitive State of Building," wrote Morris in the introduction to *Rural Architecture*, "will naturally lead me to consider the *Convenience*, *Proportion*, and *Regularity*, as well as the Purity and Simplicity, of Designing."[24]

However, a further source—and perhaps the more consequential locus connecting the cottage with comfort—comes from an entirely different context, namely the connex between humanistic and agricultural reform. Particularly in Britain, the agricultural revolution of the seventeenth and eighteenth centuries had resulted in the impoverishment of large swathes of the working rural population, and with it precisely the class who traditionally dwelled in cottages. By the last third of the eighteenth century, the plight of the rural population was attracting public attention, bringing with it growing criticisms of large landowners for neglecting their paternalistic duties to care for and house their laborers.[25] Authors such as the land manager Nathaniel Kent began to suggest that landowners should improve the living conditions of their workers and tenants, both in their own and the general interest. In 1775, Kent published the book *Hints to Gentlemen of Landed Property*, which as well as tips on arable farming and animal husbandry also contained a chapter of "Reflections on the Great Importance of Cottages." In it, observations on the relation between economic and social reforms were directly tied to the design of laborers' lodgings. Embedded in a drastic portrait of the living conditions of the English rural population, Kent wrote: "ESTATES being of no value without hands to cultivate them, the labourer is one of the most valuable members of society; without him the richest soil is not worth owning. His situation then should be considered, and made at least comfortable, if it were merely out of good policy."[26] Kent by no means expected that cottages be built to be genteel or expensive, rather that they be basically clean and dry. His ideas were illustrated with the aid of a series of simple views, floor plans, and tables of cost calculations for buildings of various sizes and constructions, based on the premise of a few essential requirements: "All that is requisite, is a warm comfortable plain room, for the poor inhabitants to eat their morsel in, an oven to bake their bread, a little receptacle for their small beer and provision, and two wholesome lodging apartments, one for the man and his wife, and another for his children."[27] → Figs. 64–65

The cottage plans published by John Wood six years later have exactly the same intention. They are likewise addressed to a "man of property" and focus on the building of housing for rural laborers as a simultaneously economic and humanistic enterprise.[28] As opposed to Kent, however, Wood was well known in the field of architecture, and in his *Series of Plans,* the nationally renowned neoclassicist brought his established expertise to bear on the simplest category of housing in an effort to improve the structural and material standards of the lodgings of his impoverished fellow human beings. In his justification of choice of subject—"that a palace is nothing more than a cottage IMPROVED"[29]—one might detect both the echoes of antique references and the pragmatic insight that the stove-builder Robert Clavering had expressed shortly prior to this, namely that certain conditions leading to homeliness applied as fundamentally to a modest hut as they did to a grand palace. According to Wood, his plans were based on empirical inquiries into the lives of rural laborers in as much as the constructional principles he proposed were meant as a response to concrete deficiencies in West England at the time: "in order to make myself master of the subject, it was necessary for me to feel as the cottager himself; ... and for that end to visit him; to enquire after the conveniences he wanted, and into the inconveniences he laboured under."[30] The existing buildings described by Wood were generally damp and clammy due to their location or their sunken architecture, cold and dark due to the positioning of the doors and windows, or uncomfortable because they were too cramped and low. Wood's counterproposal in his book is a two-room model cottage for families with one or two children, expandable via a modular compositional system to up to four rooms for families of eight people or more. With an extremely basic and symmetrical design, the building was based on a rectangular floor plan that separated the living and sleeping areas, as well as the sleeping places for children from those of adults, and was equipped with a fireplace and large windows—all with the aim "to render the industrious labourer a warm, comfortable, and healthy habitation."[31]





64–65
From landowners for land laborers:
model plan for a semi-detached cottage by
Nathaniel Kent, 1775

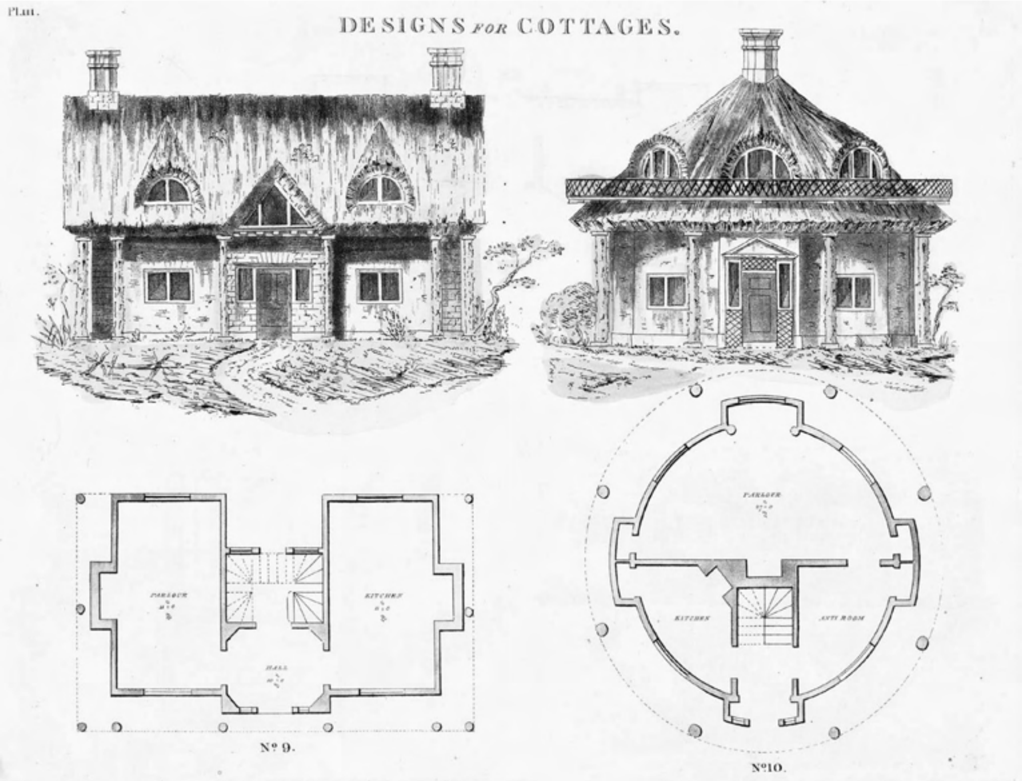
While landscape architecture, perpetuated by the advent of the picturesque, saw an ongoing exploration of recreational buildings that reached its preliminary climax in around 1800 with the emergence of the *cottage ornée* and the luxurious *cottage-villa*, in the agricultural economy the cottage was treated further in terms of providing housing for workers.[32] In this process, one particular statement by Nathaniel Kent shows not only how far the significance of comfort had shifted away from spiritual consolation to basic aspects of material life, it also demonstrates that the building of laborers' cottages was by no means a solely philanthropic endeavor. Kent's *Hints to Gentlemen of Landed Property* had afforded him public recognition, and in the late 1780s he was hired by Thomas Coke, the First Earl of Leicester, to evaluate his smallholdings. In his report, presented in 1789, Kent wrote: "I think it as necessary to provide plain and comfortable habitations for the Poor as it is to provide comfortable and convenient buildings for cattle." Therefore, adequate lodgings for rural laborers were to be treated as one of the prime interests of a landowner, not least because, as social animals, people—as current political events in France clearly showed—were able to revolt: "these sort of cottages will tend to enhance his [the landlord's] property for they [the poor] will be permanently fixed to the soil and having some Interest in their Dwellings and possessing comforts superior to those who have not the same advantages will be the last men to risk them by joining occasional Tumults."[33]

As such, improving the living comfort of rural workers advanced to become a main plank in English agricultural policy in the late eighteenth century. In the years that followed, both state institutions, such as the Board of Agriculture, established in 1793, and private initiatives, such as the Society for Bettering the Conditions and Increasing the Comforts of the Poor (SBCP), founded in 1796, dedicated themselves to cottage architecture, investing it with the power of a governing practice with which to influence the behavior of the rural population. In a text first published in 1797, Thomas Bernard, a barrister and founder of the SBCP, promoted supporting workers in purchasing and building their cottages by explicitly referring to their pacifying effects as residential property: "Freehold Cottages and gardens, do not only attach the owners to their country, but are also the surest pledges and securities for their conduct."[34] The use of the word "conduct" in this context is highly significant, as in its dual sense it can mean both the stricter or looser governance of other individuals and groups and the more or less conform behavior of a person themselves. As formulated by Kent and Bernard, the purpose of the worker's cottage correspondingly presents itself as the "conduct of conduct": it is intended to achieve a specific aim, yet at the same time dispenses with force or violence, instead seeking to steer the eventuality of behavioral patterns.[35]

By making certain activities easier and others more onerous, the worker's cottage structures the sphere of action of its inhabitants and serves, in the literal sense, to shape a space of possibility. As already evident in John Wood's designs, this endeavor extended down to the placing of the beds, their ideal situation drawn into the plans in broken lines.[36] Therefore, as the archetype of a comfortable building the cottage evinces a core ambiguity of comfort: on the one hand, it provides undeniable benefits for people's lives, yet, on the other, in permeating every-day and intimate activities it also opens up new possibilities for the exercise of power.[37] In order to pinpoint this ambivalence, one could schematically distinguish between "casual" and "disciplinary" comfort. Consequently, "casual comfort" describes the self-determined pursuit and acquisition of conveniences related to the physical surroundings, while "disciplinary comfort" refers to the architecturally mediated organization of the domestic and family life of others.[38] Despite their differing characteristics and chronologies, both forms of comfort nonetheless articulate two sides of a combined development in that they are equally rooted in a new and in-depth focus on the design of private living space.

Importantly in this respect, it is precisely this ambiguity that enabled comfort to advance to become a simultaneously specific and universal architectural concept at the turn of eighteenth to the nineteenth century. Often, it was the same protagonists who designed "comfortable" model cottages for workers' families and "comfortable" cottage-villas for the rich. One example is the architect Charles Middleton, whose volume *Picturesque and Architectural Views for Cottages, Farm Houses, and Country Villas* contains buildings for the accommodation of servants and such for the reception of country outings side by side on the same plate.[39] → Fig. 66 In his *Observations on the Theory and Practice of Landscape Gardening*, the famous landscape architect Humphry Repton likewise concentrates on both the building of aristocratic country manors and simple laborers' lodgings in equal measure.[40] The common denominators are, on the one side, the external appearance, the aim being to incorporate both building types picturesquely in the landscape, and, on the other, the comfort achieved within them. Repton derives his general design principles for both architectural types from ideas about two factors, namely proportion and fitness: "Under relative fitness I include the comfort, the convenience, the character, and every circumstance of a place, that renders it the desireable habitation of man, and adapts it to the uses of each individual proprietor."[41] But in whatever form domestic comfort expresses itself in around 1800, importantly the core issue is always to directly model living space to the needs of its inhabitants.

In this sense, the cottage as an architectural type is exemplary for the adaptation—subsumed under the leitmotif of comfort and homeliness—of the house to match modes of daily life. At the same time, the cottage, as well as the cottage literature that flourished well into the mid-nineteenth century, marks the beginning of a long-term national preeminence in the endeavors in this field. For decades, England remained the generally recognized home of comfortable living, and it was only with a noticeable delay that the term, and with it the associated architectural and technical practices, would spread to the European continent and to the former American colonies. Thus it was that the German historian and economic scientist Wilhelm Roscher was able in 1854 to look back on a tradition in economic thinking that had established comfort as an independent theoretical category over a century earlier, writing that, "The direction which luxury takes in times when civilization is advanced, is towards the real, healthy and tasteful enjoyment of life, rather than an inconvenient display. This tendency is exceedingly well expressed by the English word *comfort*, and it is in modern England that the luxury of the second period has found it[s] happiest development."[42]

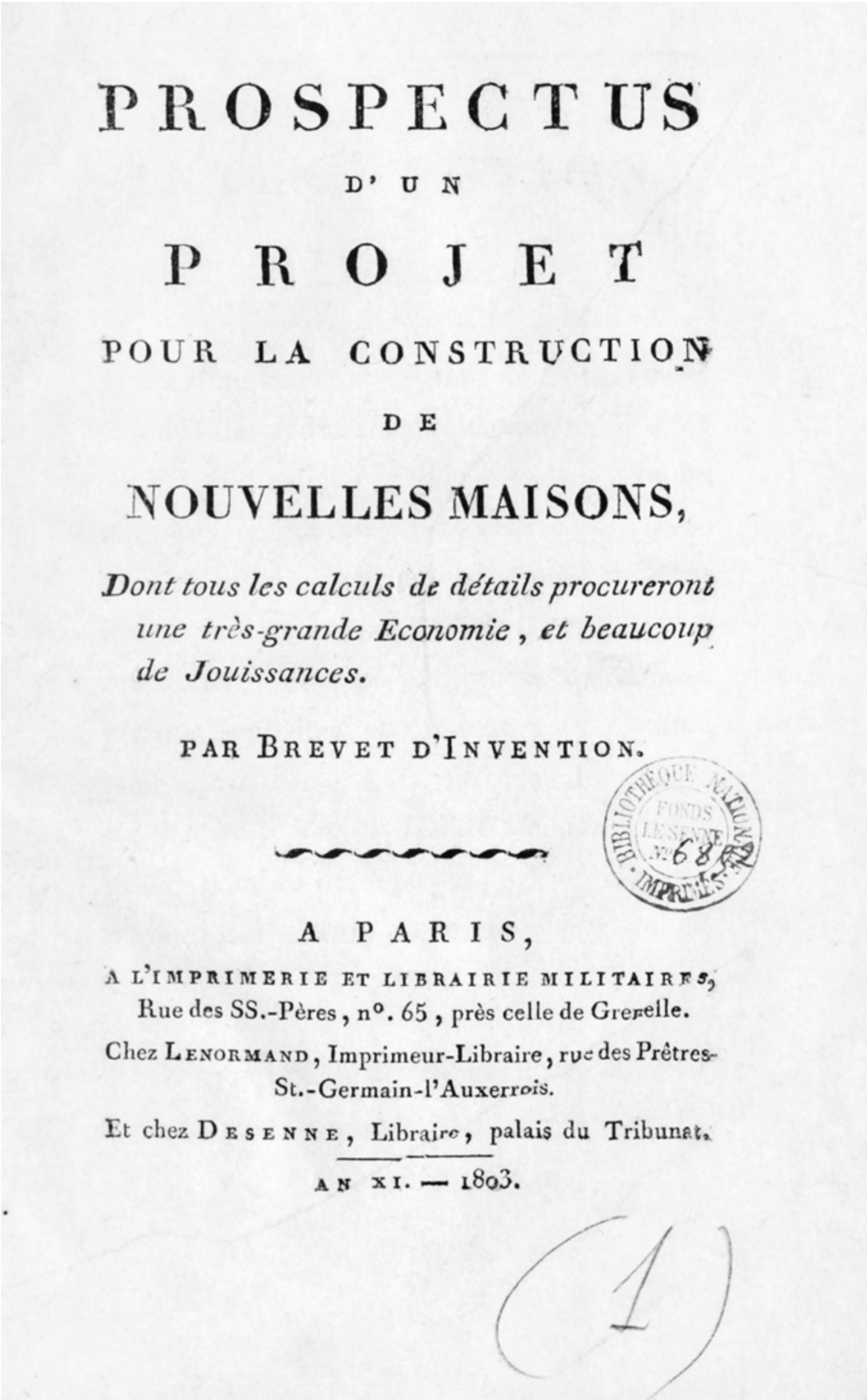


66
First, work; then, pleasure: cottage designs by Charles Middleton, 1793

THE PROJECT FOR THE CONSTRUCTION OF NEW HOUSES

Although the concept of comfort remained very much a British affair well into the 1830s, the document that probably best describes its architectural implications in the early nineteenth century is in fact French. In 1802, in Year XI of the Republic, the projector Jean-Frédéric Marquis de Chabannes, together with the English engineer James Henderson, applied for a French patent for an invention that he shortly afterwards publicly advertised in a prospectus. → Fig. 67 The brochure, entitled *Prospectus d'un project pour la construction de nouvelles maisons*, was addressed to well-off private individuals, offering them the opportunity to acquire rental rights in a completely novel type of housing. Coupled with a saving in costs, the building, planned in Paris, was to provide previously unknown joys of living: "An entirely new construction method, simpler, faster, more advantageous for all kinds of distributions, especially for large sites, and above all more solid, while infinitely more economical due to the multiplied combination of all details relating to it, must provide the greatest advantages."[43] Potential customers were called upon to subscribe with one of five named notaries, specifying their preferred district of the city. The patent rights to the invention, it was explained, covered the shortest possible time frame of five years, ensuring that the practical effects could spread as quickly and widely as possible.[44]

The contents and the origins of the proposal make the Project for the Construction of New Houses unique in architectural and technological history. It not only encapsulates the adoption of building-service innovations in post-revolutionary France in striking detail but moreover generally presents these innovations, previously scattered and scarcely documented over the preceding decades, in a uniquely consolidated form. Most of the brochure, published in 1803, is written in the form of a fictional letter—a written genre



PROSPECTUS

D'UN

PROJET

POUR LA CONSTRUCTION

DE

NOUVELLES MAISONS,

Dont tous les calculs de détails procureront une très-grande Economie, et beaucoup de Jouissances.

PAR BREVET D'INVENTION.

A PARIS,

A L'IMPRIMERIE ET LIBRAIRIE MILITAIRES,
Rue des SS.-Pères, nº. 65, près celle de Grenelle.

Chez LENORMAND, Imprimeur-Libraire, rue des Prêtres-St.-Germain-l'Auxerrois.

Et chez DESENNE, Libraire, palais du Tribunat.

AN XI. — 1803.

67
Property brochure: the Project for the Construction of New Houses by Jean-Frédéric de Chabannes, 1803

that had become a popular certificate of authenticity in the eighteenth century.[45] Spread across some forty pages, a visitor to Paris details his stay in one of the houses planned by Chabannes to a friend as if they already existed. The exuberance of the account contrasts starkly with the dry description of the patent granted in 1804, consisting of over fifty pages and sixteen illustrations and forming a set of precise technical specifications.[46] Taken together, the two documents comprehensively chart the promises, goals, and ramifications associated with the introduction of new technical elements, installations, and constructions in domestic surroundings in around 1800.

What follows is a synthesis of the one-to-one content of Chabannes's pamphlet and the corresponding patent coupled with a historical analysis, with a particular focus on the autodiegetic, internally focused narration of the fictional letter. This approach gives a particularly clear insight not only into the complexity and multilayered nature of the Project for New Houses but equally its promised spatial and above all temporal effects on the daily lives of its future inhabitants. To this end, the following extended indented quotes summarize the portrayal of Chabannes's planned buildings by his anonymous male visitor as faithfully as possible in English translation:

> My dear friend,
>
> In my previous letters I have told you about all the sights that embellish the Capital of France; today I will tell you about a new and most interesting establishment. Taking a walk the other day, I noticed from a distance the long colonnade of a magnificent building. Curious to learn the purpose of this building, I knocked on the nearest door: surprised, I heard a bell, although I had hardly moved the knocker. The door opened immediately and I found myself in a vestibule: opposite, was a double door communicating with the staircase, but opening only when the first door was closed. To the left and right were doors to the antechamber and the kitchen. The cook came to ask what I wished.—To know what this

> large building is intended for, I said.—For the use of several people, she replied: they are different homes; and, if you are curious to know the details, please follow me.—With pleasure, I said.—Well! Let us enter the kitchen first, it is, as you see, as clean as a dairy. This table of white fir, which runs almost all around, serves to heat as many pots as required by means of steam, the effects of which I will explain to you.

One of the first extraordinary aspects of Chabannes's brochure is the clientele he addresses. His venture appears to be less an enticement to the rising bourgeoisie and more to the upper classes, deprived, as they were, of their accustomed possibilities by expropriation and increasing inflation. Already in its very first sentence, the prospectus promises to guarantee respectable living standards despite shrinking net worth and rising costs. With this, Chabannes's houses are intended to provide what the term comfort means in its original sense: consolation and affirmation, in this case in the face of the disappearance of ancestral privileges. Although Chabannes is acquainted with the English word "comfort,"[47] his text is tailored to his readership and instead uses the terms common in France at the time, namely "*aisé*," "*commodité*," and above all "*jouissance*." Nonetheless, the techniques and mechanisms described by Chabannes are precisely of the type that would become associated with the concept of comfort in the decades to come.

It is no coincidence that Chabannes's fictional author is English, an ideal figure for a project that represented a transnational transfer of ideas from Britain to France. Chabannes himself had only returned from years of exile in France a year prior to his publication. As the head of a venerable noble family, the events of the French Revolution had threatened his position, and in fall 1789 he had emigrated to Constantinople. He served in the émigré counter-revolutionary army, took part in the invasion of Quiberon in 1795, was taken prisoner, escaped, and finally managed to settle with his family in London. Seven years later, he returned to his native country, where he set about trying to restore the family's wealth, on the one hand via the restitution of former properties, and on the other by marketing technological innovations. Already during his exile, Chabannes had dabbled in speculative ventures involving the construction of greenhouses and the optimization of fuel burning, and had been granted a patent for a method of producing coal briquettes.[48] With his Project for the Construction of New Houses he apparently set out to make ideas acquired in England profitable on the French housing market. His patent and his brochure contain numerous mentions of English models, and he would later relate the impact of his years abroad in general terms: “I was struck, as every foreigner must naturally be, with the general manner of building houses, and the similitude between the habitations of the midling class, and even those of the poorest persons, with those of the great, in multiplicity of the first conveniences of domestic comfort.”[49] In his fictional letter, Chabannes reverses the perspective and lets an Englishman—or better said the cook who had welcomed him—excitedly report on the comfortable architectural achievements of the French.

> When I open this cock, the steam circulates all around the kitchen in this pipe; and when I open these other cocks that you see by each pot, it brings the water in them to boil faster than any fire could do. … When I have served dinner, I close the cock and open this other one; then the steam descends into a well under the house and moves a pump that lifts water into a reservoir on the roof, from where it goes wherever we need it. … When the cock is still closed, and my mistress wants to bathe, the same steam rises into her bath when I turn this other cock, and heats it up in less than a quarter of an hour; it also heats vessels in several rooms of the house, where my mistress prepares her tea or chocolate; and her maid makes coffee without having to come down here. … —Oh! You have no idea of all the services this kitchen can provide. … There is an ordinary wood fire on this side, and if you look up you will see a spit turning by itself and only waiting for my orders. … Everything is so easy here, that I do not need any help, just as my husband does all the housekeeping by himself.

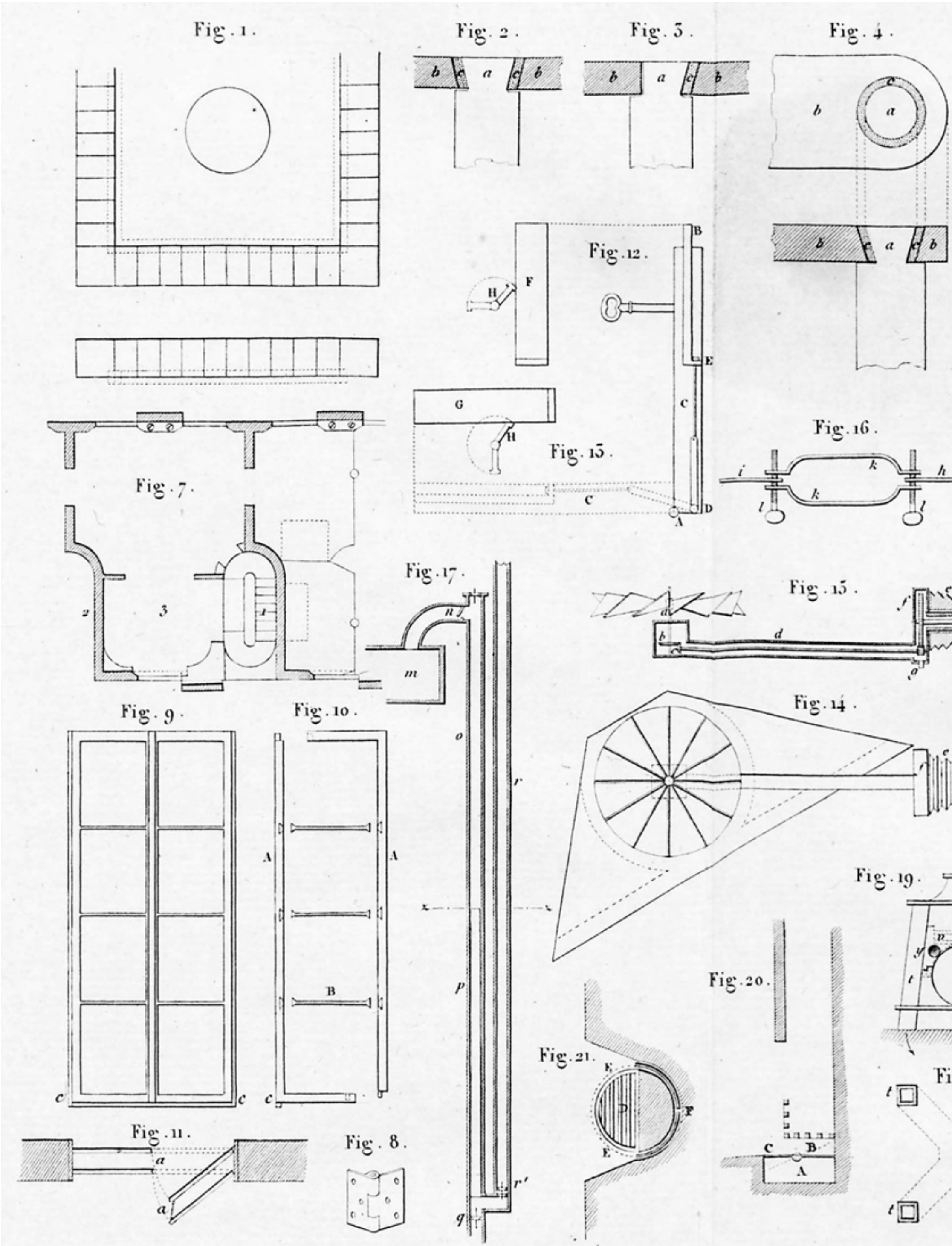
> —As we had a long conversation, and she occasionally opened pots that gave off the scent of excellent dishes, I find a great fault in your kitchen, I said. All the things you season should not spread a very pleasant smell in the chambers.—This is an inconvenience you never experience here, she replied; and here is the reason: you see this little door at the top of the ceiling, it communicates with the chimney pipe; and all the odor and vapor escape by there. … But the bell is ringing, excuse me, I am finding out what is wanted.—What is the purpose of this needle that you are moving?—To answer my master, she said—How, to answer him?—Yes, she said, come closer and you will see: when it rang, I looked at this dial and saw the needle on the line: "*You may let enter*." And I put that same needle on this line beside it. "*There is a monsieur here who would like to speak to you*."—As she said this, the needle moved by itself to the line: "*Let him upstairs*." How is it possible, I asked, that he orders and hears you this way, without you having to go up and down every time? You have just seen it, she answered: he has in his study, as Madame in her bedroom, and in the salon, similar dials, where the same questions and answers are written. As the needle in his room communicates to this one by a brass wire, it sets itself on the same line as above. The many questions and answers here relate to all that is most usual for his service, and only in unforeseen cases do I have to go up, so that we are not disturbed ten times a day: that is almost worth a servant. But my master knows that you are here, he has asked to make you come up, would you please follow me and I will explain something else to you.

The most important aspect of the Project for the Construction of New Houses is undoubtedly the mass introduction of building-service mechanisms. Items of equipment and installations of this type had already begun to spread in the eighteenth century as individual appliances. The technique of communicating via bell signals, for instance, had developed over the century from single bells, to pulley wires connecting neighboring rooms, to complicated systems connecting masters and servants with each other in distant rooms my means of cables. But despite some of these devices having a long provenance—the wind-driven roaster, for instance, attributed to Michelangelo, where a wind wheel installed in the chimney drove a rotating spit—they had been very rarely documented in writing prior to 1800.[50] As an aristocrat, Chabannes, with his easy access to the best addresses in both France and England, probably knew quite a few of these devices from first-hand personal experience. He was almost certainly acquainted with the much-visited London townhouse of Benjamin Thompson, Count Rumford, which boasted numerous building-service innovations and possibly served as a direct model for the Paris project. In early 1802, shortly before Chabannes launched his venture, the Swiss natural philosopher Marc-Auguste Pictet published a letter reporting on his visit as a guest in Thompson's house, relating its various conveniences and recommending the new word "*confortable*" to describe it.[51]

The achievement of Chabannes's project lies in its adoption of a plurality of these diverse mechanisms, positioning them at the heart of domestic architecture and uniting them, at least on paper, into a single turnkey building. → Figs. 68–69 "All these machines," he writes at the end of his description of the structure of the planned buildings, "are joined by other important inventions and combinations."[52] The construction of the building was to merge with numerous other mechanisms to form a whole that combined the advantages of refined living with economic rationality—"in a word, everything that one could imagine to decrease the expenses, and to contribute to the economy and the elegance in the construction, the distribution, or the arrangement of the interior of a house."[53] In order to achieve this goal, a series of profound convergence or integration processes between architecture and technology come into effect: on the one hand, as already evident in the optimization of domestic methods of heating, between the building and the mechanisms; and on the other between the individual mechanisms themselves. The repercussions of this architectural-technical ensemble can be roughly divided into two separate frameworks: they either relate to the atmosphere of the house or the activities undertaken within it.

In terms of both aspects, Chabannes's houses initially involve the deployment of a series of autonomous contrivances. Concerning atmosphere, this includes the double-door in the entrance that prevents dirt and cold air being admitted, or the fireplaces and the partly mobile stoves that allow warmth to be flexibly regulated. → Figs. 68–69: 18–29 With installations like the kitchen hood and the water closet, → Fig. 68: 32 this climatic aspect is widened to include an olfactory dimension, and with the soundproofing built into the floors an acoustic one. Regarding domestic activities, the independent apparatuses include, along with the automatic roasting spit, → Fig. 68: 14–15 constructional elements like the kitchen-to-dining room hatch or furniture like the separable table, which all serve to make everyday actions less onerous or indeed substitute them as far as possible. These isolated devices, their set deployment at precise points having a cumulative effect on everyday domestic living, are juxtaposed with a series of distribution systems, their impact originating from the fact that they are effective in at least two locations simultaneously. The role of these devices is not to alter conditions and actions within the house at localized points, rather to connect remote rooms with each other by traversing through walls and levels, and thereby transmitting substances or forces.

Assisted by pumps, tanks, and pipework, → Fig. 68: 17 air, water, and steam were to circulate in Chabannes's buildings, with steam providing a source of warmth as well as kinetic energy. By this means, various domestic operations could be decentralized and simultaneously automated yet centrally controlled, the origin and regulatory point of a large part of the system being the kitchen. Chabannes describes the result as an increase in the availability of services coupled with a simultaneous reduction in the work performed and distances covered by the servants. However, the overall effect would have been modest, were it not for the fact that the air, water, and steam conduits were complemented by a crucial additional technology, namely a system for the transmission of information. As outlined in the brochure, the equipment composed of pointers, dials, and wires—named a "*Télégraphe domestique*" in the patent specification → Fig. 69: 33 —allowed communication to occur between separate rooms in the house.[54] As opposed to



68
Technical and construction details for the Project for New Houses, 1804

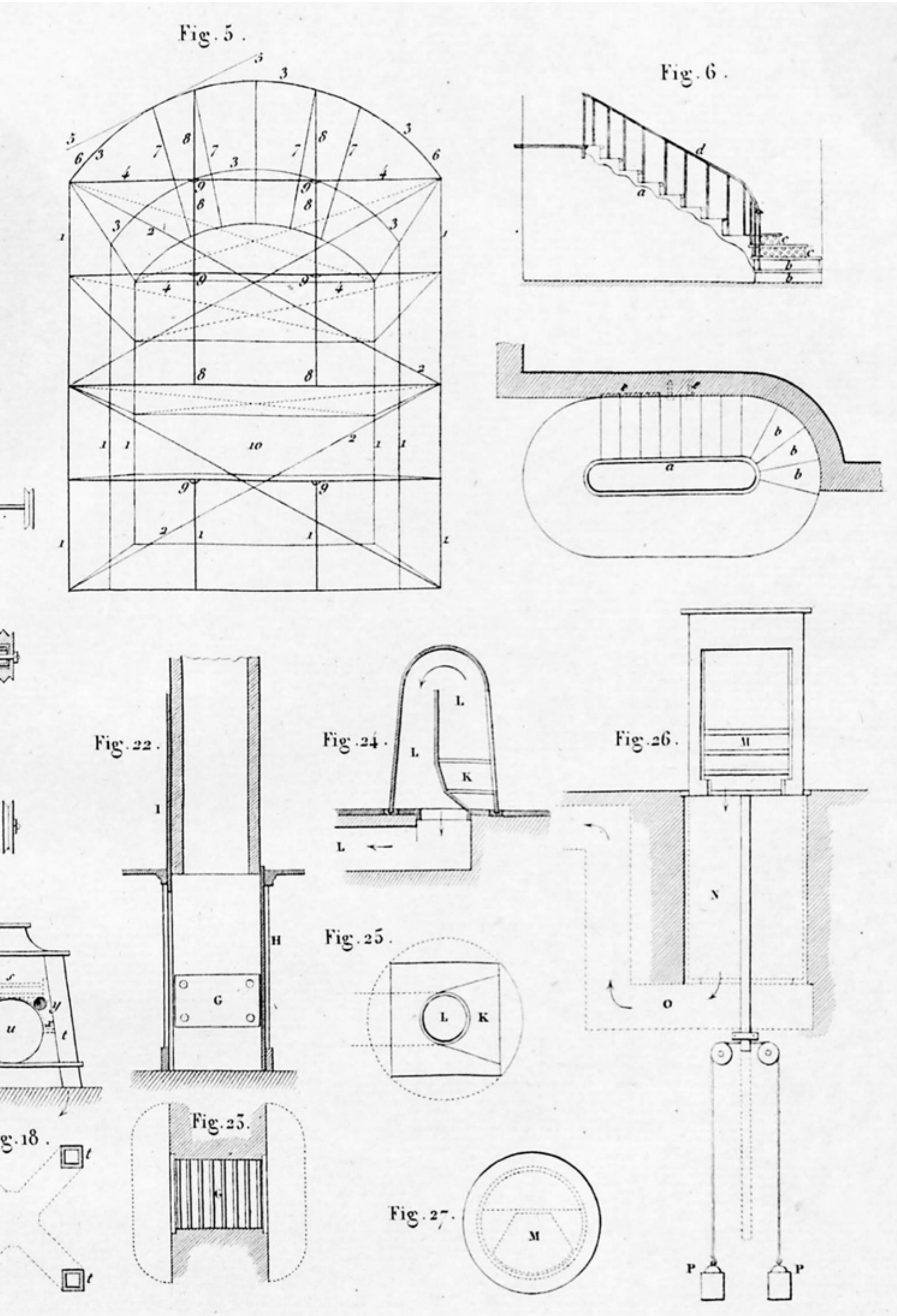


Fig. 5.
Fig. 6.
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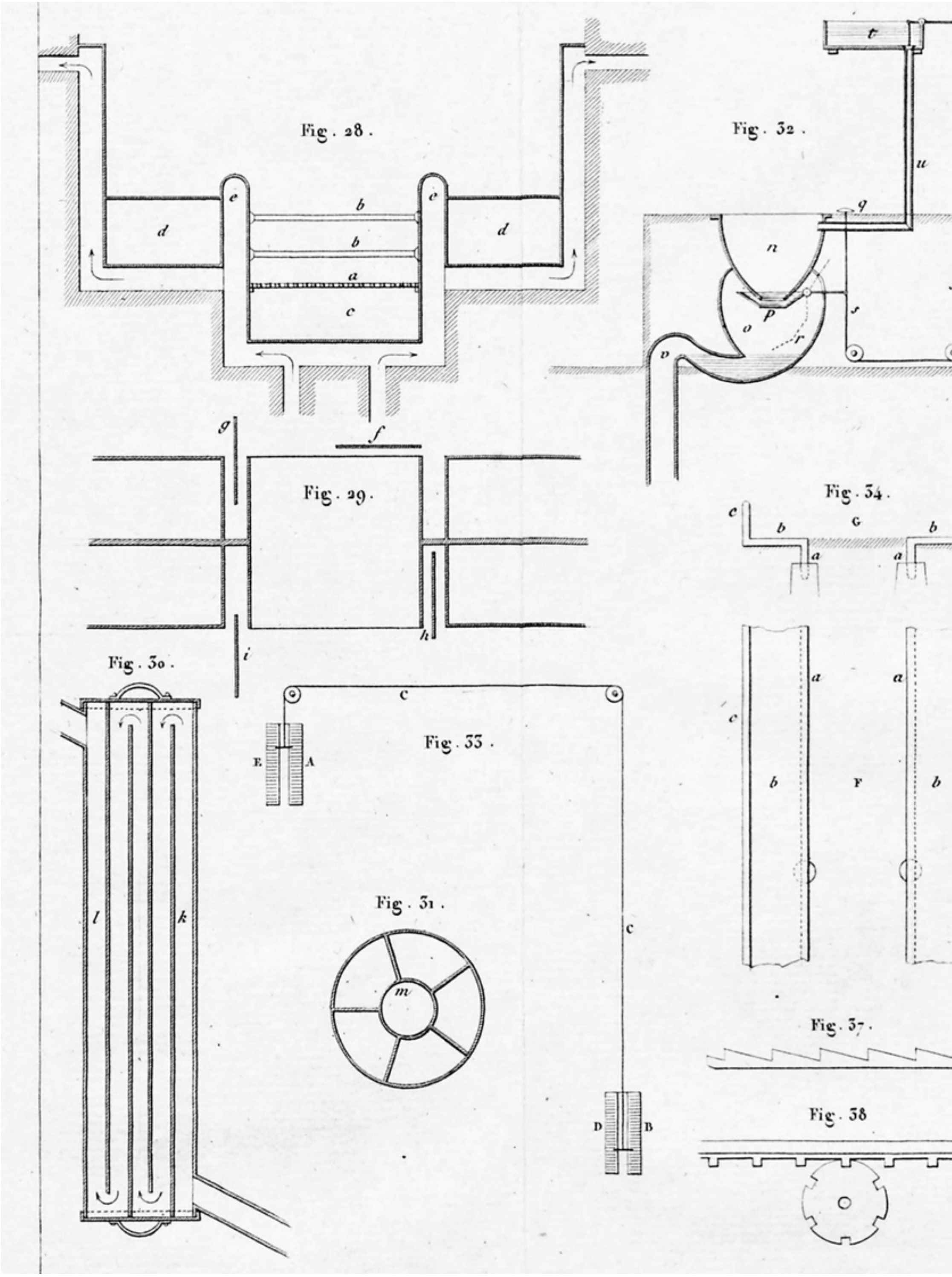


69
Technical and construction details for the Project for New Houses, 1804

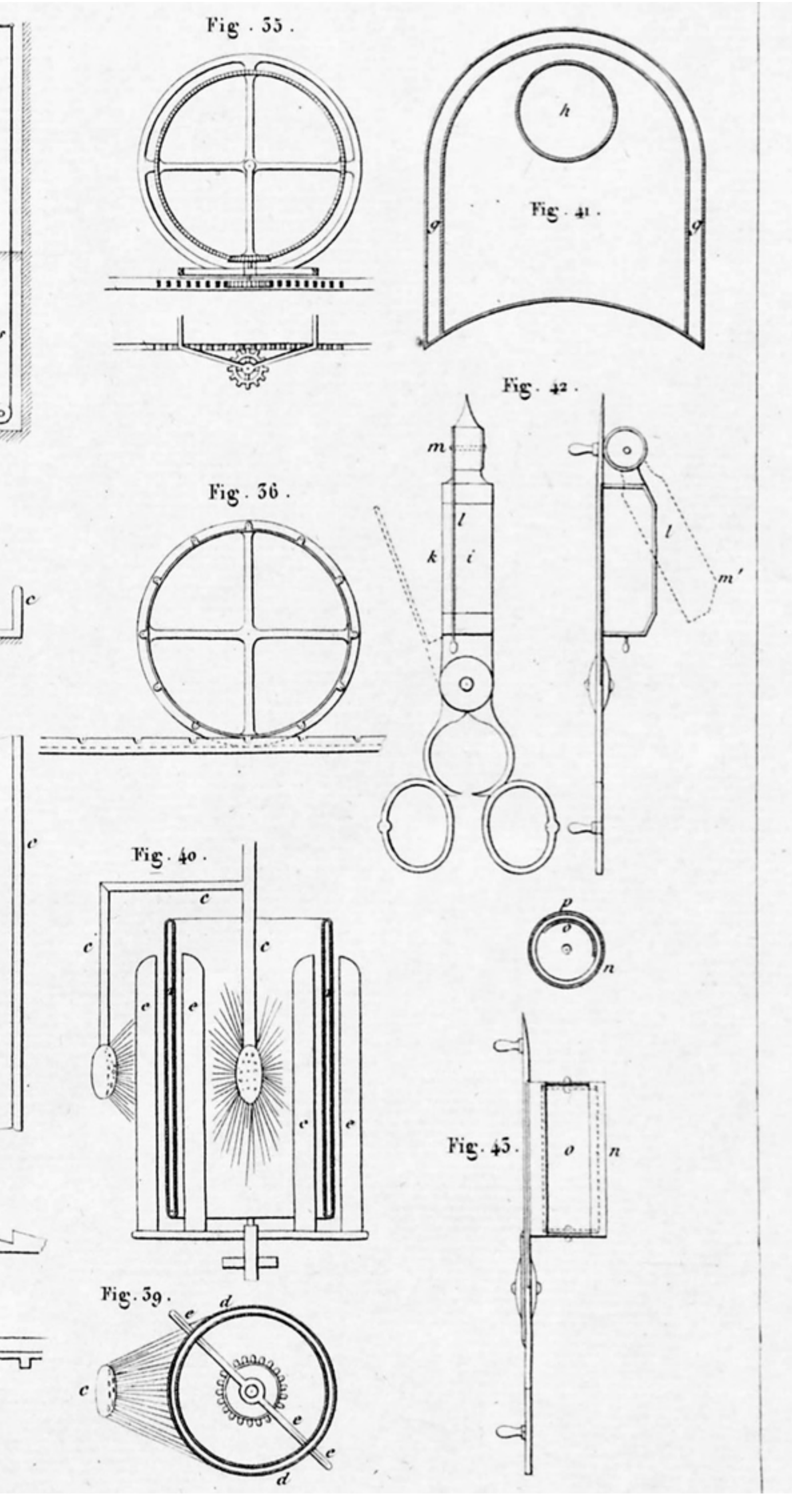


Fig. 35.
Fig. 41.
Fig. 42.
Fig. 36.
Fig. 40.
Fig. 43.
Fig. 39.

conventional bell systems, which only enabled a general service request to be conveyed, Chabannes's system was equipped with a discreet range of messages, making it possible to send more nuanced communications. In this way, the flows of substances and energy are supplemented by a flow of information, acting to steer movements within the house and dispensing with the need to repeat many of the routes normally required to receive and carry out instructions.[55] Like in the case of territorial infrastructures and communication systems, by speeding up and spatially compressing previous practices these domestic distribution services have a profound impact on the conceptualization of space, time, and distance. Chabannes's fictional cook can suddenly operate in multiple locations at the same time, while his fictional master of the house is already appraised of the purpose of his guests' visits even before coming face to face with them.

> We went back through the little vestibule, and entered a small antechamber.—This antechamber is for the servants of visitors, she said; they never go upstairs, nor the workers, whose feet are always dirty. So, you will see how clean the stairs are.—But which way do the masters go?—Through this double door which divides the vestibule in two and at the same time prevents the cold from outside from communicating into the staircase. ... —With these words she opened a small door, and we entered a hall lit by the lightest staircase I have ever seen. ... —I would never dare to climb these stairs, I said, they could not carry me.—Don't be afraid, it would carry 500 persons heavier than you; it is entirely of cast iron.—How, of cast iron! These steps, which look like precious wood, this bronze railing is of cast iron?—Yes, monsieur, and well painted, is it not? ... —Truly, your staircase enchants me, I thought there were no better than ours in England; but this one is infinitely cleaner and more elegant ....
>
> I entered the first floor in a kind of antechamber: having opened the door of a very beautiful salon, the cook left me to notify her master and return to her post. The

salon had two windows onto a beautiful garden. I opened one of them to admire from the balcony the interior facade, which was all the more beautiful for being a perfect square, ornated with columns on all sides; and that the garden, laid out with simplicity and taste, offered a mixture of flowers and foreign shrubs, as pleasing to the eye as to the nose. I went back into the salon to await the master of the house; but when I wanted to close the window, I found that there were two instead of one, and that one followed the movement of the other .... As I admired this work, the master entered.—You seem surprised, he said, by the lightness of these windows. My cook told me, monsieur, that you are a foreigner, and curiosity has brought you to my house; I will gladly satisfy you and be the cicerone of my house. First of all, these windows are made of cast iron .... This seems to surprise you, but I will show you much smaller and finer work, such as door hinges, bolts, locks, cylinders, and a thousand other articles of the same metal, made in molds, and as solid and twenty times cheaper than from the hand of a workman. Cast iron is like a new invention, which has only been used with great success in England for about 30 years, but which could almost be said in its infancy, because of all the progress it is susceptible to: its wise use is one of the main foundations of this house, and will contribute infinitely to the improvement of all our interior conveniences. You admire these windows, you have admired the staircase; well! part of the floors, the roof, the supports of this house, the balustrades, statues, and vases which adorn it, are of the same metal; the toilets; the water pump; in a word, almost everything is of cast iron, down to this fireplace, which you might have thought of bronze and marble, if I had not told you. It is placed between the two windows; if there were three, I would have placed it under the middle one. It could also be placed anywhere else: the smoke would pass under the floor .... —Pardon me for interrupting you, monsieur, but what do you mean by that? Why not have the smoke rise through chimney pipes in

> the walls, as usual?—For the very good reason, he replied, that there is no reason for it.—But where do you install them?—In the same columns that are the beauty and ornament of these houses, which carry nothing but their own weight, and are nothing but simple chimneys. The smoke is communicated to them through a small pipe in the wall of the fireplace, and exits by those vases and statues which adorn the balustrade, and are nothing but simple cowls. This way, we run no risk of fire, need not fear that some ignorant or negligent worker has placed a beam near pipes which no longer exist, nor to see our carpets and floors soiled by chimney sweeps.

A second field exploited by Chabannes to achieve his desire for novelty in his project, and which is directly tied to the building services, is the wholescale introduction of cast iron, above all in the context of the domestic architecture. Its decorative use in features such as banisters, stairs, or floor slabs had already grown in the eighteenth century with its increasing production as a material, and in both England and France cast and wrought iron had made its first pioneering appearance as a structural element.[56] Shortly before the turn of the century, cast iron had started to be widely applied for structural purposes in the textile mills in the Midlands of England,[57] but with his plan to construct an entire apartment building from cellar to roof entirely in iron, Chabannes went a decisive step further. Apart from rare apocryphal exceptions, for instance in the memoirs of the Venetian writer Giacomo Casanova, such a proposal was undoubtedly unique on either side of the Channel in the early nineteenth century.[58]

Along with the general economic and aesthetic benefits, Chabannes above all stresses the advantages offered by cast iron as a manufacturing technology for combining architectural and technical building components. The particular joining properties of cast-metal parts ← Fig. 68: 2–4 play a key role both in the construction and in the use and maintenance of his new houses. By exploiting this molding process, as Chabannes explains, large numbers of assembled structures can be created from prefabricated parts at a comparatively cheap cost, regardless of whether they were a basic load-bearing structure ← Fig. 68: 5 or individual elements such as staircases or window constructions.[59] ← Fig. 68: 6, 8–11 Here, Chabannes follows the same constructional-system thinking that was being adopted in bridge building at the time, and where the prime focus no longer lay in built forms, rather in standardized elements and connections.[60] In addition, Chabannes naturally took pains to also refer to the central contemporary arguments of greater fire safety and improved spatial use. One of the main reasons for the simultaneous development of iron structural framework construction in industrial architecture, and equally for the use of iron in theater building, was the material's high fire resistance. The second significant factor was the effort to address the need for space in factories by providing the best possible open floor plans. In Chabannes's case, however, the disposable floor space is used not to accommodate machinery but to improve the domestic room layout

> The salon is fairly well sized; but tonight, when we have company, these two doors will be opened: and as they are double and fold together, it will unite with the adjoining room to form one large room. The bedroom is reached by a passage between the staircase and the wall; but as my wife is dressing, we will go back the way you came. … All the houses of this square vary more or less, according to the taste or size of the families of the inhabitant; for it has been left to us to distribute the interior as we wish. The second floor of my house is distributed into two bedrooms, two baths, and two dressing rooms. … Above these rooms, in which my children live, are three or four rooms in the attic, which are used by our servants …. Downstairs is the dining room; we will go there if you like.
>
> You seem to be bothered by the heat of the staircase? Let us leave the door of the salon open, and it will soon adjust itself to the temperature which prevails throughout the house all year round, and never varies more than two or three degrees. The kitchen fire alone, and the smoke circulating

> in the columns which ornament the staircase, render us this important service, and save us more than three quarters of the fuel consumed in our apartments. We use the fire almost exclusively for the pleasure of seeing it; for as no cold air can enter either through the windows or the front door, and the staircase is the warmest part of the house, every time we open a door we heat the room instead of cooling it. This dining room is of good size; it accommodates 24 persons, and that is more than we need; for when we give large balls or festivities, we have a room for that purpose, where I will take you in a moment. The room is heated by this fireplace as well as a heat vent that comes from the kitchen fire. All the service is done through this double cupboard, which serves as a sideboard and also warms the dishes. A single servant is all we need, and we are never bothered by draughts while we are at table.

The third aspect promoted by Chabannes in his project is the architectural arrangement of the rooms. This feature is the one that it is most akin to existing traditions and the conventional concept of *commodité*, albeit with the commonplace processes supplemented by the ability of Chabannes's fictional master of the house to personally determine the design and occupancy of the rooms, in this case by initially independently deciding on their basic layout in his house and then spontaneously doubling the size of the salon should circumstances or the number of guests require. ← Fig. 68: 7 This flexibility of the floor plan makes modifying domestic space to the habits and requirements of the inhabitants—an ideal that emerged in the previous century under the keyword "distribution"—even more personal and situational. At the same time Chabannes manages to fit the spatial needs befitting an aristocratic or upper-bourgeois family into the confines of the three-story rowhouse. One of the central means to do so—and perhaps the most utopian aspect of the project—is the introduction of collective facilities, such as the ballroom, and connected with them the strict access restrictions. At numerous junctures, Chabannes explains how, in combination with an exclusive circulation system, the block-perimeter form of his ensemble prevents unauthorized persons from entering, and with it any social intermingling, thus increasing security. To achieve this, he envisions a circumferential gallery set facing the interior courtyards, just as Charles Fourier would use shortly afterward as an elementary element serving a very similar function in his well-known *phalanstère*. ← Fig. 68: 1 The result resembles the closed living complexes that existed in London at the time and would indeed be built in Paris from the mid-century onward, referred to in modern parlance as gated communities.[61]

> If you like, we will open the window and take a tour of the garden.—With pleasure, I said, and I cannot tell you how delightful that walk was.—Each house is like the one just described, at least on the outside, and the whole forms one of the most beautiful palaces ever built. In front of each house is an almost imperceptible little iron fence, which prevents walkers from approaching too closely, and forms a small private garden. The rest of the garden is public to all owners; but there are most severe rules against possible abuse. ... After we have walked one more round, we will go back, and I will take you to the hall, where I am giving a ball and a big dinner tonight.
>
> We passed through the dining room again, where we found the table set for 24 persons.—I can hardly believe it, I said, what a charming table! How could they build it so quickly?—Nothing was built, he answered, all this was already there when we passed. Have you not noticed these flower baskets? Well, they are the same; they decorate the dining room during the day, and spread pleasure during the dinner. Around these baskets we put these light boards, which are wide enough for the dishes they hide under the baskets during the day; in this way we do not have the problem of these large tables, which always take up so much space in a dining room. ... Let us continue: I still have to show you the ballroom, the banquet room, the music room, the theater room, and the school rooms.

> Please, what do you mean? You have shown me your whole charming little house, from top to bottom; where should all these new large rooms be, they do not fit in with the rest of your house?—Follow me down; I will tell you the details on the way. ... —On this side are my wine and wood cellars, he continued, and the place where my laundry is done; I do not need to tell you that there is no lack of hot water; and in the same vat we can brew beer .... Let us go out that other door. I suddenly found myself in a very fine gallery, very well lit by small windows on the garden side.—You seem surprised, he said; I will explain this mystery to you: this gallery runs all around the square, and each of us has an entrance; it has no communication either with the garden or with the street; in the evening it is sufficiently lit, and we visit our neighbors without needing a carriage nor being exposed to the injuries of the weather. ...
>
> The four houses in the four corners have no communication with the garden; the ground floor of the first, to which I lead you, is let to a man who takes care of the illuminations, the music, the suppers at a fixed price; and thus we can give dinners or balls without noise or inconvenience, when we do not want them in our houses. ... Through this vestibule and this beautiful staircase, you come to the first floor; above it is another hall of the same size; in one we dance, in the other we dine. ... The same applies to a small theatre on the opposite corner, which holds up to two hundred persons .... At the third corner is a very fine concert hall, subject to the same regulations; and in the fourth is a house of education, or instruction, the advantages of which we enjoy exclusively. ... We also have separate yards, stables, and sheds.

What these three particular aspects of Chabannes's project—the spatial arrangement and division, the use of cast iron, and the incorporation of building services—have in common is that they ultimately set out to address the one and the same problem of aristocratic living, namely the act and procedures of serving. Chabannes's fictional master of the house repeatedly emphasizes to his equally fictional visitor how the technical and architectural installations in his house perform functions that previously required domestic personnel. "[T]hat is almost worth a servant," Chabannes, for instance, scripts the cook to say about the domestic telegraph.[62] The work of expensive domestic servants, who were anyway also seen as a nuisance, was to be assumed as far as possible by cheap and reliable artifacts. Nevertheless, the shift from being waited upon by human to non-human actors is seldom as smooth as it first appears. Instead, the transformation from human to technical assistants involves a new paradigm of service, in which the masters and mistresses of the house are required to fulfill their own wishes and requirements. This introduction of self service reverses the traditional serving hierarchy into its opposite: where once the master of the house wanted to be served by a flock of servants, now a multitude of appliances demand to be operated by him. If we add to this the restricted functions and the precise operating specifications of specialized equipment, with the accumulation of building services, these dependencies can become even more acute.[63] Having said this, Chabannes's project also demonstrates that these shifts in power not only represent an unintended consequence of the mechanization of living but can also be in the intended interests of the users. This issue becomes particular evident with the example of a technical innovation that the fictional visitor describes at the very end of his letter.

> —I would be curious, I said, to ask the one who built all these houses the particulars of his property, and I am anxious to buy one; would you be so kind to give me his address?—With pleasure, I will write it down for you: let us go back to my house, for I can only let you out by the front door.—Ah!, he said, I have left my door open. How do you know, I asked; you cannot see it from here?—I will explain it to you in a moment; would you mind leaving the door open and giving me the key?—With pleasure, I said, but no matter how hard I turned it, it would not come out.—Well, now you see why I knew I left the door open; there is a secret in that lock which prevents the key from coming out whenever the door

> is not locked, and as I noticed that I did not have the key in my pocket, I was sure I had left it open. Now lock it, and the key will come out without a hitch. So, with a lock like that, we are safe, and we can never leave a door open by mistake, nor any of our people by negligence or bad faith. ...
>
> Here is the address you want, and where you can get all the construction details, as well as the conditions, etc., etc.—Monsieur, I am infinitely obliged to you for all the kindness you have shown me, and I am determined to become the owner of a house similar to yours as of today.[64]

In Chabannes's houses, locking mechanisms where the key can only be extracted when doors are closed are intended to banish the vice of leaving doors open.[65] ← Fig. 68: 12–13 Over two hundred years later, this particular mechanism still enjoys a certain notoriety, based less however on its continuing use than on the role it assumes in an influential text by the technology sociologist Bruno Latour. With the name *La clef de Berlin*, Latour took a very similar locking device as the title of one of his books, making it a focus of his description of the relationship between humans and technology. The singular double-beard of the so-called "Berlin Key," which at the time the book appeared was only still to be found in occasional tenement buildings in the German capital, is a textbook representation of the concept of symmetrical anthropology, in which both humans and things are invested, in equal measure, with agency and therefore in the mediation of social relationships. By obliging the door to be locked, the key, together with the corresponding lock, translates the demand "please lock the door" into a dependable mechanism, thereby successfully mediating between the front door, the worried house owner, and the forgetful or disobedient tenants. Thus, the ominous Prussian locksmith to whom Latour attributes this invention succeeds, by means of a technical artifact, to impose a collective discipline on the tenants to close the door, at least until they—and with this caveat Latour explicitly distances himself from Foucault's concept of discipline— come up with a way of subverting it.[66]

As a historical document, Chabannes's prospectus not only points to the fact that the technique Latour describes is probably attributable to a Georgian or Napoleonic rather than a Prussian locksmith, but also that his interpretation of it as an instrument for disciplining others anyway falls short. Chabannes's fictional master of the house explicitly praises the patented locking mechanism as something that is to his own advantage. It helps against the failings of careless domestics, but above all it gives its owner himself reassurance about his door, freeing him of the worry about whether he has left it open or not. Instead of rigid discipline and flexible anti-program, the automatically enforcing lock therefore preempts a different Foucauldian concept: the technologies of the self. What this concept involves are procedures that allow individuals to question, monitor, and train their own behavior as part of a "care of the self." In this sense, the history of hygiene, which as the doctrine and practice of bodily care has distinct overlaps with the concept of comfort, has been repeatedly treated as a history of a technology of the self.[67] Set against this background, Chabannes's safety lock indicates the emergence of a (self-)technology with the role of regulating general domestic living. Whether as a Berlin, Paris, or London key, it serves the self-imposed control of such an everyday and basic action as the closing of doors. With this, domestic comfort acquires yet another facet. It can be applied as a means of disciplining others, yet in its "casual" variation it also offers the inhabitants a scope of conduct—in the form of working on themselves.

It is not known whether any subscribers for Chabannes's houses actually registered with the notaries, or whether his plans ever progressed any further than their prospective stage. Over ten years after launching his venture, the marquis was forced to flee to England once again, this time from his creditors, certainly suggesting that the business plans had failed.[68] Despite this, what the *Prospectus d'un projet pour la construction de nouvelles maisons* presents is a synthesis of various contemporary developments that was potentially thoroughly achievable in terms of their technical state of advancement at the time. In around 1800, the innovations that Chabannes has his fictional visitor describe were largely still in their infancy and little known, but they nevertheless mostly had real-world predecessors and were indeed adopted in England, France, and other countries in the years that followed. What the prospectus entirely lacks, on the other hand, is any mention of portable or textile elements, such as seating or other furnishings, and is likewise void of any references to wallpaper, carpets, or curtains. These were all hallmarks of comfort in the decades previously, and their absence marks a crucial break with the prior conventions of comfortable living. As a type of "smart home" or "house of the future" *avant la lettre*, the Project for New Houses concentrates entirely on the technical opportunities of the times and then exemplarily combines these opportunities—all under one roof.

In this process, the descriptions of the Project for New Houses revolve around one central term. Chabannes's overall writings contain numerous forms of the word "communication," and the brochure and the patent specification are full of the corresponding inflections, applied both in the context of the arrangement of the rooms and in that of the construction and the building services, whereby it is important to emphasize a crucial distinction. Sometimes the innovations serve to explicitly ensure communication, in the sense of transmitting movements and energies or connecting rooms and building elements, but at other junctures they act to explicitly suppress communication, as in the case of the kitchen vent, designed to prevent the spread of odors.[69] In some cases, the efforts to promote and impede communication even overlap in one and the same object, an example being the double door at the entrance to the house, which connects the indoors with the outdoors yet at the same time stops cold air from entering.[70] The pleasures and conveniences that Chabannes's project promises its inhabitants are ultimately based on techniques of communication and anti-communication in equal measure. Just as purposefully as the living space is made porous to some influences, it is sealed to others. By the end of his tour, the fictional English visitor intuitively grasps the equalizing nature of this new form of modern comfort, formulating his praise in a succession of oxymora: "Almost no fire, and always warm; fewer servants, and infinitely better served; hot water, cold water at will; a multitude of useful and pleasant combinations; all the advantages of a large house, and all the economy and pleasantness of a small one ...: Here is all that you have shown me, and that I want, from today, to share with you."[71]

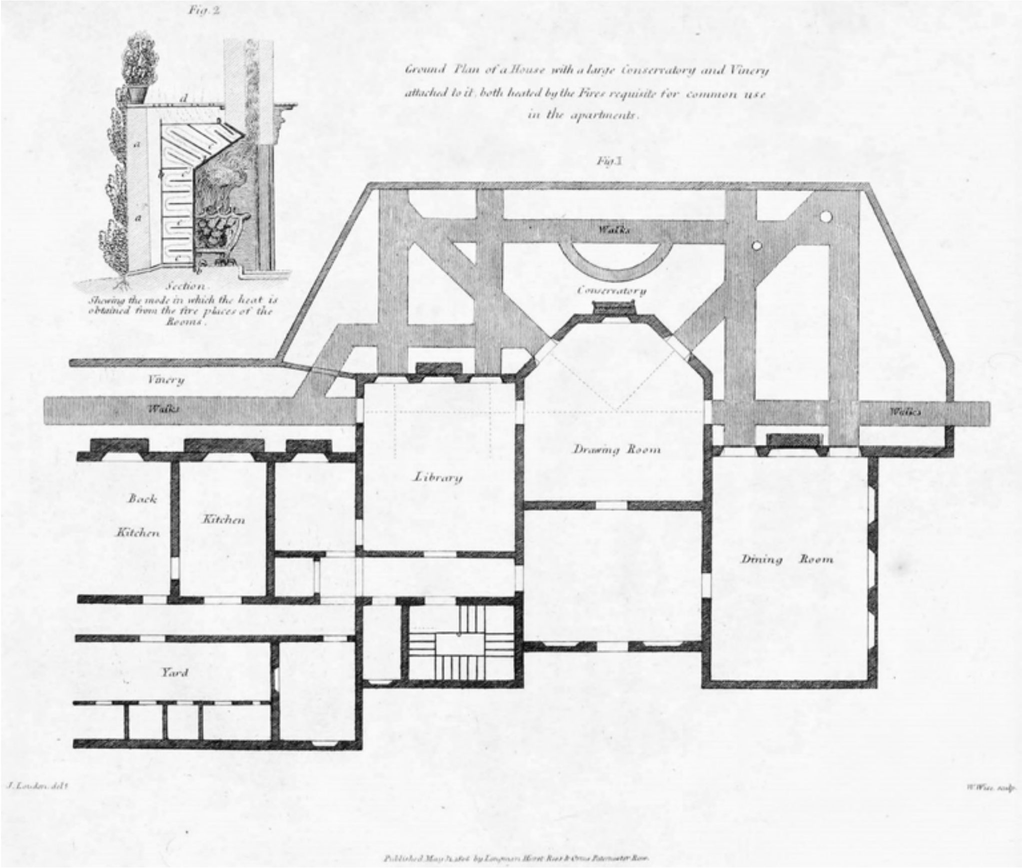
J. C. Loudon

At approximately the same time that Jean-Frédéric de Chabannes initiated his Project for New Houses in Paris, the young John Claudius Loudon began a forty-year career in publishing in London, during which he would have a substantial influence on Western understanding of the built environment. Born in 1783 in Scotland, after training as a horticulturalist and landscape gardener he studied biology, botany, and agriculture at the University of Edinburgh before beginning his career as a landscape architect.

His practical work, but soon above all his writings—taken up due to a rheumatic paralysis—quickly made him one of the leading exponents in the field of garden, landscape, and greenhouse architecture.[72] In the course of his publication work, Loudon came to increasingly concentrate on the planning of enclosed spaces; and while he gradually progressed from country homes to town houses, and finally domestic architecture in general, his thinking also more and more encompassed ideas of living, and with it comfort. In this sense, Loudon's work represents a prime example of the development of comfort from a marginal term closely associated with rural dwellings to a fundamental architectural and technological concept in the nineteenth century.

Even in his earliest books, Loudon transcended the boundaries of horticulture and turned to the question of rural residency. Following his first publications on the planting of public squares and a short book on greenhouses, his two-volume *Treatise on Forming, Improving and Managing Country Residences* appeared in 1806. It was an appeal to the aesthetic and moral sentiments of rich land owners, coupled with an evident philosophical claim. Practical questions regarding the accommodation of the gentry and their tenants or servants appear only in passing. Loudon stresses the importance of keeping workers' lodgings warm and convenient, and thereby "more comfortable," and refers to the valuable work by Benjamin Franklin and Count Rumford in this regard, but only engages superficially with aspects such as room layout or building services.[73] Despite this, one particular passage in the first volume of the treatise highlights Loudon's key interest in technically innovative spatial concepts. In the chapter on "Ornamental Gardening" he suggests connecting a residence that lacks vistas, due to its location, to a greenhouse. The glazed construction, which extends along the entire south side of the double-story house, was intended to compensate for the missing views by providing the occupants with a glimpse of greenery. The nub of the design consists of the combined heating of the residence and the greenhouse—the stoves of the building are situated so that they warm both the rooms and the plants.[74] At the same time, the sequence of rooms and the sightlines—indicated by Loudon in the plan using dashed lines—of both parts of the building are carefully aligned with each other: architecture and horticulture form an ensemble in which the boundaries between the two disciplines blur. → Fig. 70 Here for the first time, in the midst of detailed remarks on style and taste in landscaping, appears a pragmatic approach to living space that would play a central role in Loudon's later work.

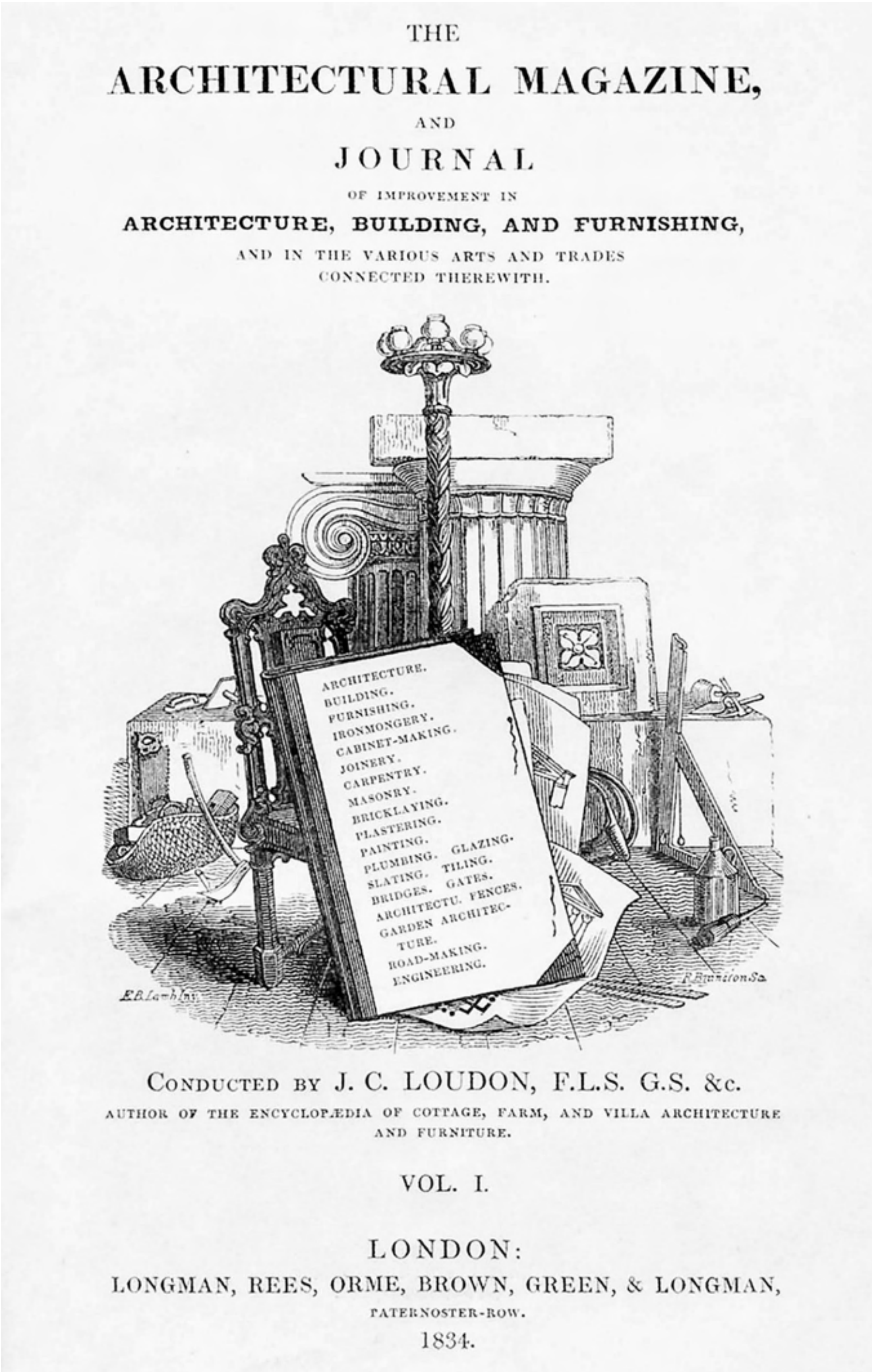
A little less than three decades later, Loudon published his *Encyclopædia of Cottage, Farm, and Villa Architecture and Furniture*, dedicating over a thousand printed pages and hundreds of illustrations to a treatment of the technical, aesthetic, and social aspects of domestic architecture, including considerable space dealing with questions of daily living. And while his *Treatise on Country Residences* largely left the term "comfort" unmentioned, in the *Encyclopædia* it now appears in almost every second paragraph, as well as in the central objective of the compendium: "The main object," reads the first sentence of the introduction, "is to improve the dwellings of the great mass of society, in the temperate regions of both hemispheres: a secondary object is to create and diffuse among mankind, generally, a taste for architectural comforts and beauties."[75] Shortly afterwards Loudon founded the



70
Fine outlooks: combined residence and greenhouse by J. C. Loudon, 1806

Architectural Magazine, which as Britain's first architectural journal supplemented the already broad topical spectrum covered in his encyclopedia by including urban architecture. The aim of the journal was the "study of comfort," or at least that is how a reader put it in a letter to the editor in one of the first issues.[76] Taken together, both publications served in effect to focus attention on the architectural and technical means of designing comfortable lodgings—in other words ones that were warm, dry, well lit, and well ventilated. For too long, wrote Loudon in the encyclopedia, architects had concentrated their efforts on public buildings and palaces; it was now time that their spirit of innovation also stretched to the housing of society at large.[77] The upshots of this program are clearly recognizable on the title page and the table of contents of the first volume of the journal. → Fig. 71 Along with the usual theoretical and historical professional themes, the section on "Practical Architecture and Building" contains, for instance, a contribution with the title "Remarks on Closets, &c., in Sitting-Rooms"; under "Warming and Ventilating," one concerning the "Ventilation of Living-Rooms, &c."; and under the section "Fittings-Up and Furniture," one on "A Simple and Effective Preventive for the Slamming of a Passage Door."[78]

Where does this deep preoccupation with the practical aspects of domestic building originate? Why do ostensibly minor details, such as living-room ventilation, fitted closets, and slamming doors, suddenly become so important? And why is the word "comfort" accorded such a central role in this context? The fact that in the course of Loudon's career Romantic ideals and questions of style—both in greenhouse and domestic architecture—increasingly gave way to issues of construction and technology, as well as to a general humanist interest, is usually attributed to his own personal evolvement. According to this reading, the turning point was an extensive tour Loudon undertook of Europe, including many months spent in Russia in the winter of 1813 to 1814, after which he increasingly began to address various architectural forms under the common perspective of providing well-tempered environments. An additional influence is seen in his friendship with Jeremy Bentham, who following his death Loudon would describe



THE
ARCHITECTURAL MAGAZINE,
AND
JOURNAL
OF IMPROVEMENT IN
ARCHITECTURE, BUILDING, AND FURNISHING,
AND IN THE VARIOUS ARTS AND TRADES
CONNECTED THEREWITH.

CONDUCTED BY J. C. LOUDON, F.L.S. G.S. &c.
AUTHOR OF THE ENCYCLOPÆDIA OF COTTAGE, FARM, AND VILLA ARCHITECTURE
AND FURNITURE.

VOL. I.

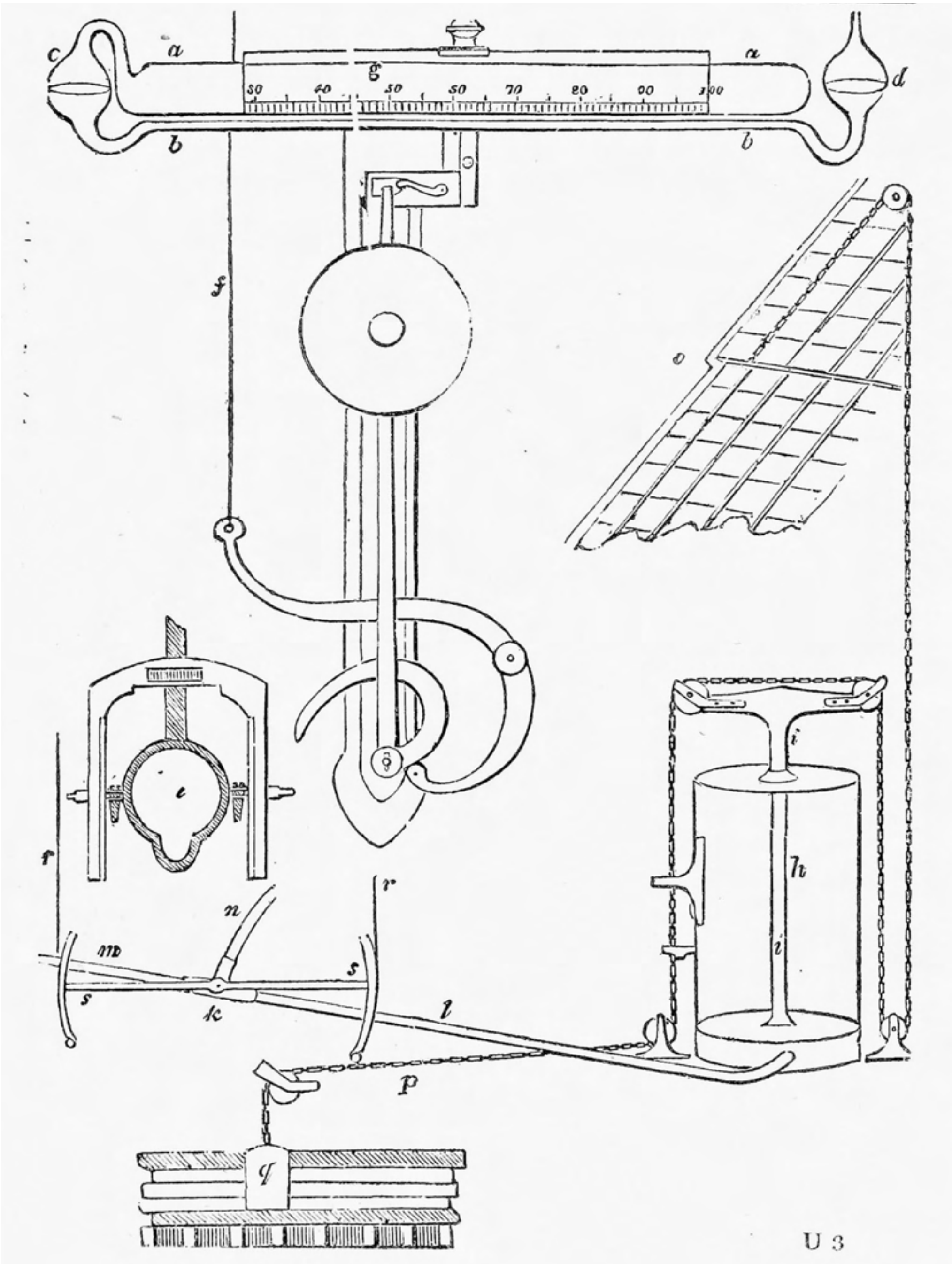
LONDON:
LONGMAN, REES, ORME, BROWN, GREEN, & LONGMAN,
PATERNOSTER-ROW.
1834.

71
From architecture to plumbing:
The Architectural Magazine, 1834

as one of the greatest benefactors of humanity since the beginning of Christianity. Likewise considered significant was Loudon's marriage to the author Jane Webb in 1830, who had included numerous futuristic-like inventions such as chemically air-conditioned buildings in her anonymous early science fiction novel *The Mummy!*[79] Nonetheless, along with these biographical influences it is also possible to identify general reasons for the sea change in Loudon's architectural thinking. This above all includes a widespread growing interest in domestic engineering in Great Britain during the Industrial Revolution, as well as a fundamental shift in their medial dissemination.

Together with the overall number of technological innovations, developments since the end of the eighteenth century also saw an increase in the number of innovations targeted at building and living. This equally involved the construction and servicing of buildings, as well as single architectural elements and furnishings. Between 1800 and 1830, the annual number of British patents doubled from around one hundred to approximately two hundred, whereby a continual increase can be seen in precise sectors like "Window-Sashes, Frames, &c.," "Doors and Panels," or "Furniture and Cabinet-Ware."[80] To begin with, the patent-holders included, at least as far as constructional-technical developments were concerned, a scattering of architects, but the field quickly came to be dominated by engineers, machine builders, and professional inventors. One example is the projector Ralph Dodd, who in 1808, after various canal, tunnel, and bridge construction projects, was the first person in England to patent an entirely iron-made building, as previously envisioned by the Marquis de Chabannes.[81] In this context, it is important to keep in mind that due to the cost and the complexity of the procedures involved, patent protection was only applied for in a small percentage of inventions. Instead, many developments were documented in regular printed publications, occasionally even deserving a full book, such as the 1814 *Observations on the Principle and Construction of Water-Closets, Chimneys, and Bell-Hanging* by the Scottish surveyor John Phair. Prefaced with the apology that the topic was not noble but nonetheless in the interests of the nobility, the book expands on Phair's ideas for all three apparatuses. As with the Project for New Houses and many other inventions of the time, in this case the ultimate aim was to improve the olfactory, climatic, and acoustic atmosphere inside a house via communicatory and anti-communicatory mechanisms, for instance with bell systems with signals audible to the recipient but not the sender.[82]

These numerous contemporary technical innovations are also echoed in Loudon's publications. His greenhouse work in London, which he commenced after his tour of Europe, was based to an equal extent on research into glass and iron construction and on heating and ventilation methods. In 1817, his *Remarks on the Construction of Hothouses* appeared, detailing the latest forms of greenhouse technology. A year later, Loudon presented his curvilinear glasshouse, its spherical form designed to guarantee a maximum amount of sun exposure, while at the same time praised by contemporaries as a beautiful building without it imitating any historical precedents.[83] That Loudon's preoccupation with greenhouses focused not only on the art of horticulture but also involved an intrinsic interest in architecture as a whole is evident from the full title of the publication that accompanied the building: *Sketches of Curvilinear Hothouses; with a Description of the Various Purposes in Horticultural and General Architecture, to Which a Solid Iron Sash Bar (Lately Invented) Is Applicable*. Together with the constructional solutions, Loudon's aim was to also transfer techniques of climate regulation to housing, including above all a process described as "*Artificial regulation*."[84] In 1816, James Kewley had patented a thermometer that was designed to act as a trigger for other mechanisms, for instance a fire alarm.[85] Loudon took this invention to develop a device with the ability to control heating and ventilation in greenhouses, and proposed that the same technique be used to similar effect in houses.[86] → Fig. 72 This idea of firing a stove and opening windows via an automatic mechanism probably represents the first time that the concept of feedback control was incorporated into domestic architecture. And indeed, a few years later Loudon even developed a plan to cover whole country manors or even entire settlements with glass roofs and to artificially regulate the climate beneath them.[87]



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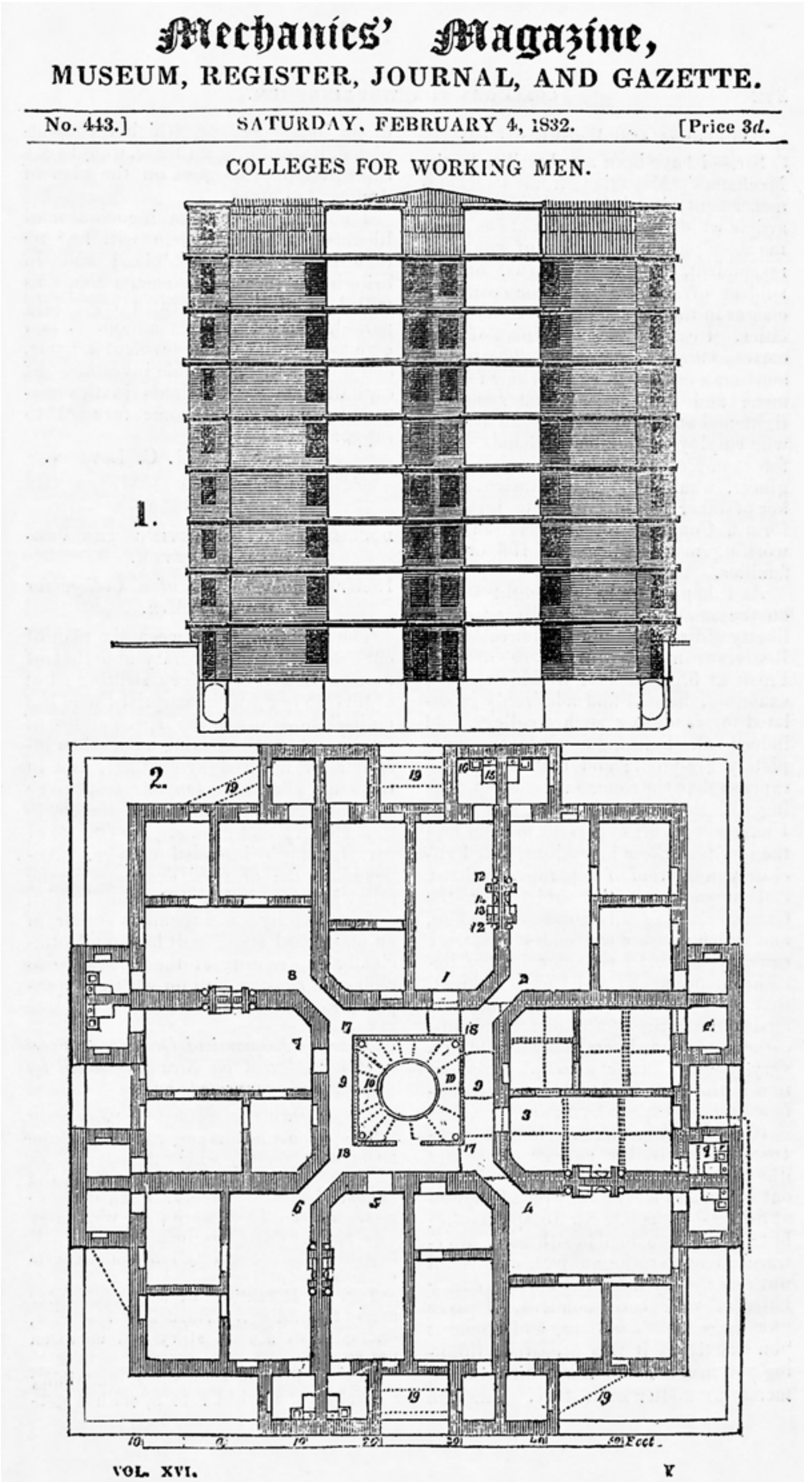
Control engineering: the "Automaton Gardener," 1826

While the growing number of inventions came to be integrated into individual architectural projects and publications, in the first two decades of the nineteenth century, the written exchange of ideas about them remained relatively limited. Apart from the specific field of central heating and ventilation methods—where a lively debate took place about the advantages and disadvantages of the various respective systems—there was largely an initial lack of any coherent discussion concerning the broader field of building services. This situation changed in the 1820s with a development that itself in turn was driven by technical progress. More liberal laws, growing public demand, and last but not least improvements in production technology led to a boom in the market for print media, with popular scientific journals being a major beneficiary of the trend.[88] These periodical publications, which played a crucial role in the accelerated spread of practical and theoretical knowledge in the nineteenth century, included the bulletins known as “Mechanics’ Magazines” that were specially addressed to engineers, craftsmen, and other technical enthusiasts, and that regularly supplied their readerships with the latest news from the world of machines and mechanisms. Up until then, technical inventions had only appeared sporadically in gazettes as one of many topics, for instance in the *Gentleman’s Magazine*, founded in 1731, or as verbatim patent texts, as documented, for instance, since 1794 in the *Repertory of Arts*. Now, however, a whole series of periodicals appeared in quick succession that dealt with developments in the field far more rapidly and in far greater detail, often supplemented by commentaries and richly illustrated, such as the *London Journal of Arts and Sciences* (1820), the genre-defining *Mechanics’ Magazine* (1823), and the *Repertory of Patent Inventions* (1825).[89] Along with heating techniques, kitchen appliances, and lighting, much of the content of these publications concentrated on construction and building services, and so the emerging journal market provided a discursive framework for the innumerable appliances and installations developed since the previous century that intervened in the everyday activities and procedures of residential living.

Loudon was also an active participant in this media innovation.[90] On the one hand, he was an early pioneer in this new journal market with the appearance in 1826 of his *Gardener's Magazine*, the first bulletin dedicated entirely to horticulture. On the other, he was a contributor to other papers, including those focused on news about technical progress. In early 1832, *Mechanics' Magazine* published a letter by Loudon, one of its first subscribers, in which he responded to an article by the inventor and railway engineer William Bridges Adams in the same publication. In December 1831, Adams had presented a plan for workers' apartments under the pseudonym Junius Redivivus involving the building of a five-story courtyard building with a fireproof cast-iron construction, central heating and lighting, and an assortment of collective facilities for four hundred families. These social amenities included a kindergarten with a constant and healthy climate designed to guarantee ideal conditions for child development. "Children," wrote Adams, "may then be reared as easily as grapes and pine apples."[91] This sentence alone must have excited the horticulturalist Loudon to reply. He praises Adams's proposal as a source of potential improvement, but only to then expand on his own plans for a multistory workers' apartment building, apparently already drafted in 1818. The defining characteristic of the design, which envisions three-room apartments for a total of sixty-four families spread across a rectangular ground plan and seven floors, is a centrally situated and heated circulation core, shaped as a spiraled ramp, coupled with a number of subsidiary service cores providing water for a toilet and steam for heating, cooking, and washing in the individual flats. In addition to these building services, the housing project features new chimney stoves and a recently developed fireproof cement floor.[92] As such, Loudon's contribution matched the progress-orientated scientific program of the *Mechanics' Magazine* so well that it took pride of place as an elevation and a floor plan on the title page of the journal shortly thereafter. → Fig. 73

The role played by the concept of comfort in these general currents can be best demonstrated by a long entry in the 1816 reference work *English Synonymes Explained* in which "comfort" and "pleasure" are juxtaposed as matching words:


Mechanics' Magazine,
MUSEUM, REGISTER, JOURNAL, AND GAZETTE.

No. 443.] SATURDAY, FEBRUARY 4, 1832. [Price 3*d*.

COLLEGES FOR WORKING MEN.

73
Cover story: multistory workers' housing project by J. C. Loudon, 1832

> Comfort*, that genuine English word, describes what England only affords: we may find* pleasure *in every country; but* comfort *is to be found in our own country only: the grand feature in* comfort *is substantiality; in that of* pleasure *is warmth.* Pleasure *is quickly succeded by pain; it is the lot of humanity that to every* pleasure *there should be an alloy:* comfort *is that portion of* pleasure *which seems to lie exempt from this disadvantage; it is the most durable sort of* pleasure*.* Comfort *must be sought for at home;* pleasure *is pursued abroad:* comfort *depends upon a thousand nameless trifels which daily arise; it is the relief of a pain, the heightening of a gratification, the supply of a want, the removal of an inconvenience.* Pleasure *is the companion of luxury and abundance; it dwells in the palaces of the rich and the abodes of the voluptuary: but* comfort *is within the reach of the poorest, and the portion who know to husband their means, and to adopt their enjoyments to their habits and circumstances in life.* Comfort *is less than* pleasure *in the detail; it is more than* pleasure *in the aggregate*.[93]

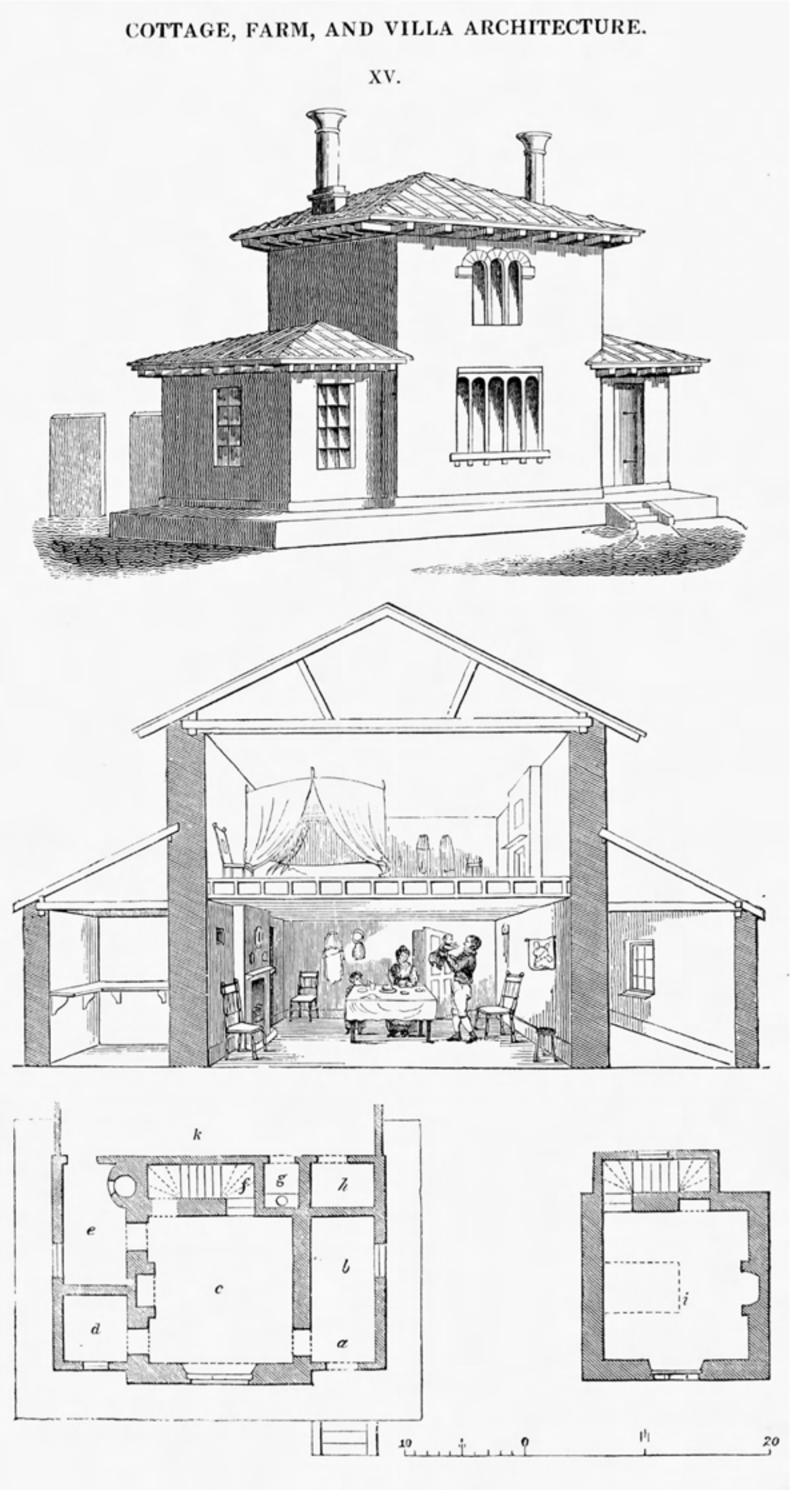
Irrespective of its nationalist overtones, the passage is ideal in explaining the close link that evolved in the first third of the nineteenth century between the word “comfort” and the idea of convenient and technically optimized living surroundings. First it shows the strong bond between comfort and the notion of home, including the critical aspect of one’s own four walls; second the connotations of the term in small everyday details, and with it precisely the field of intervention of building services; and third the underlying egalitarian idea, which resonates with the social-reforming impetus behind many contemporary housing projects. Thus, while the term “comfort” advanced to become a watchword for the architectural and technological developments of the era, it itself concomitantly assumed an increasing technical-material composition. It is therefore hardly surprising to encounter a statement in a lecture on artificial ventilation from 1818 that could have come directly from the lexicon entry cited above: “The comforts and pleasures of life,” wrote the physician Anthony Meyler regarding the design of indoor climate, "depend less on a succession of high wrought luxuries and enjoyments, than on the removal of small, but perpetual sources of minor inconveniencies; and perhaps the lesser courtesies of life, and the participation of the more trifling, but habitual gratifications, constitute the chief sum of human happiness."[94]

Taken together, this excurse outlines some of the key influences behind Loudon's publications in the 1830s: the author's biographical development, leading to an increasingly pragmatic approach; the growing number of mechanical and architectural devices aimed at residential living space; the improvements in print media, allowing information to be spread more cheaply and quickly; and a comfort terminology that focused on everyday material amenities. In its stated objective to assemble the entire existing knowledge about building "comfortable" and "beautiful" (rural) housing, the *Encyclopædia of Cottage, Farm, and Villa Architecture* places a heavy emphasis on technological methods, going so far as to even harness the debate about beauty to the ends of comfort: "Ornament enhances comfort, and tends to refine the mind."[95] Alongside numerous purpose-made model designs and articles, the reference work brings together an unparalleled collection of projects and concepts that in the preceding decades had explored novel architectural ideas, and with it transformed the understanding of built space—extending from Benjamin Thompson's kitchens to the school plans of Joseph Lancaster, and on to William Strutt's technical installations.[96] Added to this, Loudon's *Architectural Magazine* presented a format that was able to also quickly depict future innovations. The introduction to the first issue of the magazine precisely diagnoses the dynamic of progress in which it itself was rooted:

> [I]mproved articles of dress led to the necessity of having improved pieces of furniture to contain them; the use of seacoal led to the improvement of fireplaces; the use of knives and forks led to improved stoves and other arrangements for cookery; and these, and an infinity of other domestic ameliorations, led gradually to the better construction of houses.[97]

No other media was better suited to participating in this accelerating process than the periodical journal. The *Architectural Magazine* admittedly only lasted four years, but its program was carried on by a whole series of other journals, such as *Civil Engineer and Architect's Journal* (1837), the *Surveyor, Engineer and Architect* (1840), and the highly influential *The Builder* (1842). Therefore, Loudon's magazine represents a pioneering enterprise in what was a profound shift in the architectural discourse, both in terms of media and content. For centuries, the treatise had reigned supreme as the platform for the negotiation of architectural knowledge, only to be now fundamentally challenged by the magazine with its topicality and its practical focus.[98]

It is no coincidence that the *Architectural Magazine* and the *Encyclopædia* both opened with articles concerning the basic rules about selecting a residence and the design of cottages.[99] In so doing, Loudon not only returns to the roots of the architectural-theoretical discussion about comfort, but it shows that the simple rural housing type continued to serve as an ideal model by which to reflect on the provision of minimum living standards—standards that, in Loudon's words, every laborer should and every nobleman could live with.[100] The designs for the various model worker's family cottages presented in the first chapter of the *Encyclopædia* are based on three fundamental principles: raising the building on a platform, the relative positioning of the chimneys, and the economical use of substances like fuel, water, and slurry. The spatial arrangement, building services, and architectural elements, but likewise the garden attached to the house, are adapted down to the smallest detail to the daily procedures of wage labor, agricultural subsistence, and family life.[101] → Fig. 74 Greatest attention is paid, however, to the mechanisms that act to control climatic conditions within the cottage. Besides open fireplaces, the model cottages also contained a stove in the cellar for baking, brewing, and heating water, as well as to heat the floor of the ground story. For ventilation, all of the rooms were equipped with at least one sash window and the kitchen and cellar with a ventilation duct.[102] This, said Loudon, was because however rich a resident was and however large his house, "one room can only be used at a time, by either the poor man who has no other, or the rich man who has several; and that room can only be made comfortable by being warm,



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“A good many comforts”: Cottage for a Childless Couple [!], 1836

dry, light, well ventilated, and convenient."[103] Whereas prior to this technical processes of climatization were addressed in terms of their ability to increase comfort, here they assume an explicit primacy: without them a room cannot even be classed as comfortable in the first place.

César Daly

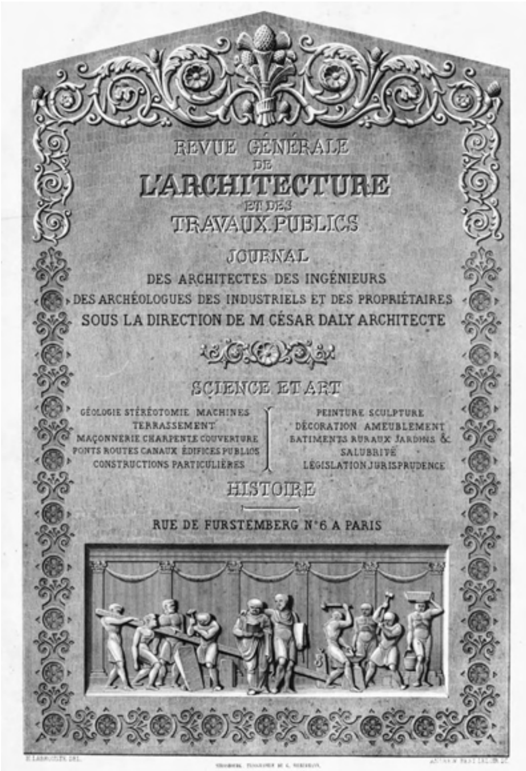
With the establishment of the idea of domestic comfort in Britain, its export abroad also grew. In France, an increased use of the term—initially often with the English "m" instead of the French "n"—took place not least because of the return of thousands of emigrants after the Restoration. In the mid-1830s, *comfort* had its literary debut in Honoré de Balzac's novels, afterward repeatedly appearing in his *Comédie humaine* in the context of portrayals of bourgeois interiors.[104] In subsequent years, it also made a short-lived guest appearance in the major French dictionaries, before a related meaning of the old term *confort* ultimately prevailed. The supplementary volume to the *Dictionnaire de l'Académie française* listed "*comfort*" as a neologism in 1842, defining it as "Material wellbeing; ease of life."[105] Whatever the spelling, from 1830 the term comfort entered into French vocabulary to express the wellness of a person in connection with their immediate physical surroundings. Thereby, the issue was still a balancing-act in a long-familiar discussion, because over a century after first being raised, the question of the relation between luxury and necessity had still not been decided. Where was the boundary between justified needs and harmful profligacy? Did the acquisition of useful items lead to a general improvement in living conditions or did unbridled consumption lead to moral decline? In 1828, the writer Charles Nodier unceremoniously suggested simply bypassing the debate with the help of a new adjective. "*Confortable.* A very intelligible and very necessary Anglicism in French, where it has no equivalent. This word expresses a certain state of commodity and well-being that comes close to pleasure, and which all humans naturally aspire, without this tendency being imputed to softness and laxity of morals."[106]

As in Britain, it was above all the newly launched journals that transmitted the concept of comfort into the field of architecture, beginning in 1832 with the weekly *La Propriété*. Although architectural journalism had long existed in France by this point, starting at the turn of the century with the *Journal des bâtiments civils*,[107] nonetheless the *Propriété* broke with its predecessors both in terms of format and content. Printed in quarto instead of the customary octavo, it was able to accommodate double rows of columns, thereby improving the layout of the text and the incorporation of illustrations; and it broadened the familiar thematic scope with its goal—as already manifest in its title—to treat architecture in all its facets as property, "in relation to the art, the construction, the decoration, the economic and industrial processes, the *comfortable*, etc."[108] This intention was lauded in the first issue of the *Architectural Magazine*—praise that was only logical considering that the French publication's program, its cheap cover price, and its targeting of a broad public appeal promised to achieve precisely what J. C. Loudon's journal wanted to do in Great Britain.[109] Two years after its launch, the *Propriété* took over the *L'Architecte*, founded in the same year and likewise strongly focused on current and practical knowledge, and which along with plastering methods and construction machinery had also dealt with building services, such as toilets and warm-water heating. In 1834, the newly merged magazine published an article on "Architecture civile en Angleterre" in which the anonymous author had little praise for English style and constructional quality, but was all the more enthusiastic about its disposition, economy, and functionality. In particular, the French reader was encouraged to emulate English domestic life as a state of intimate happiness, regardless of whether in the company of people or things:

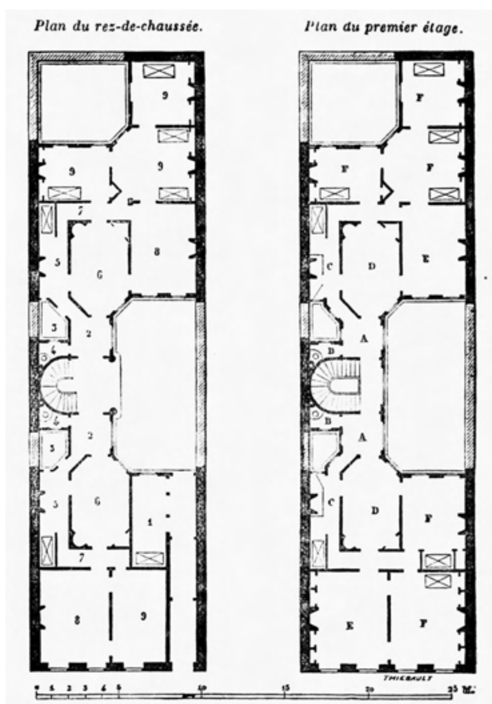
> The domestic well-being is not among any people the object of such solicitude as in England, and what is called *comfort* there expresses in the widest sense that joy of intimacy that one savors at home, with one's family, if one has one, or with one's flowers, one's furniture, and one's books, if for the moment one possesses only this mute yet expressive society.[110]

The *Propriété* itself became the object of a merger process in the same year that resulted in a periodical called *Le Moniteur industriel*, which only dealt with architecture as an aside. Nevertheless, the path taken was resumed again a short time later, including the employment of the same journalists, by the *Revue générale de l'architecture et des travaux publics*, founded in 1840 by César Daly.[111] → Fig. 75 Unlike its short-lived predecessor, the quarto *Revue générale* would remain France's leading architectural magazine for decades, and until 1890 reported about the entire spectrum of issues associated with the design of the built environment, initially once and then twice a month. Daly, born in 1811 to a French mother and an Irish-English prisoner-of-war father, spent his childhood in England, returning to France at the age of seventeen. Following his architectural education, he soon took to writing and published his first articles in the mid-1830s before beginning to pursue the idea of his own journal.[112] Like Loudon before him, Daly explicitly turned to the flexible and open format of the periodical in order to extend the discussion about architecture to also encompass everyday and practical questions. Alongside his stated quest for a contemporary style, the introduction to the first issue of *Revue générale* already formulates the factor that would determine its editorial policy for the next fifty years, namely a belief in the social relevance of architecture. According to Daly, the art of building is an activity that touches on all fields of human life, and as such should rest less on abstract formulas and more on concrete experience. In his opinion, only a periodical publication had the power to free architects and engineers from their creative isolation, to provide them with a collective forum, and at the same time keep pace with the acceleration in developments. His intention, as he summed it up, was therefore not to follow art for art's sake or science for science's sake, instead his publication would concern itself with generating a "*useful effect*" through which true progress in the profession expressed itself.[113]

With its sections entitled "*Theorie*" and "*Pratique*," the *Revue générale* ran two columns regularly dedicated to the current scientific, constructional, and technical findings in the world of building. Alongside contributions on the role of Symbolism in art,



75
From geology to hygiene: t*he Revue générale de l'architecture et des travaux publics*, 1840



76
Apartment building by Hector Horeau: porter's lodge (1), antechamber (2), courtyard (3), toilet (4), kitchen (5), dining room (6), corridor (7), salon (8), bedroom (9), 1840

as editor, Daly was not afraid to use these sections to write, for instance, about newly developed types of blinds. The architectural theory on which this radically open program was based was condensed by him in a travelogue from England, which appeared in the first year of the journal, under the slogan: "*As the cause, so the effect. As the society, so its architecture!!*"[114] According to this there was a causal relation between architecture and society, between the lives of the people and the buildings in which they lead them, in which changes in the one part of the equation were inevitably mirrored in the other. This axiom allowed Daly to assume a dual critical stance: it was equally the basis for the argument that only social transformations could produce a new architectural style as it was for the claim that these transformations could be achieved by means of architecture. "Architecture," wrote Daly to his readers following the February Revolution, "is the great instrument of modern reforms."[115]

Daly's preferred field for this type of thinking was the apartment building and the bourgeois apartment. The beginnings of the discussion of this new type, which in the 1860s and 1870s culminated in his multivolume *Architecture privée au XIXe siècle*, lie in early issues of the *Revue générale* in a series of articles titled "Architecture domestique."[116] The first of these articles combines a summary of past developments with a report on the current state of affairs, concluding that after the leveling of earning capacities had led to the loss of the traditional town palace as an architectural remit and as an urban monument, the common tenement building had become a serious contender to replace it. For a long time this building type had tended to be constructed simply, but in the meantime it was becoming ever more ornamented and treated as a work of art, whereby its pictorial representation and the discussion about its aesthetic qualities were growing. With this development, according to Daly, it had become all the more important to also peer behind the facades and to study the floor plans of the buildings. It was not sufficient for the apartments to be richly and elegantly decorated, for them to be covered tastefully in marble, mirrors, and gold—above all, lodgings had to be comfortable.[117] Daly's report set a good example and presented plans for a newly completed Paris apartment building that in a restricted space had managed to organize uniform lighting, separately independent rooms, and access routes that provided quick, convenient, and easy service. ← Fig. 76 "[T]he demand for the commodious and comfortable has become generalized," stated Daly in the next article, and the "program" of an apartment should correspondingly address the manifold and complex requirements of its inhabitants as comprehensively as possible—not least because history taught that this type of correspondence was the foundation for the creation of beautiful forms.[118]

It can be assumed that like the general social and historical outlook of the *Revue générale*, the understanding of the beautiful and the comfortable expressed in these lines was strongly influenced by contemporary French social utopianism. Daly not only cultivated contact with various representatives of Saint-Simonianism but also remained associated with Fourierism throughout his life, in particular through a close friendship with the economist Victor Considerant.[119] Charles Fourier's proposals to organize society in the form of small, self-sufficient communes and to establish them based on a *phalanstère* of cooperative apartments were never directly mentioned in the *Revue générale*. However, Daly reprinted articles from Fourierist publications, and as a quid pro quo allowed the latter to reproduce contributions to his journal. He participated in plans for a *phalanstère* in Condé-sur-Vesgre and one in Texas in America, and repeatedly uttered thoughts coined by the movement.[120] Thus, for instance, his maxim of *utilité* and his causal understanding of architecture and society had been previously formulated by Considerant in his *Considérations sociales sur l'architectonique* in the mid-1830s. In it, Considerant had elaborated Fourier's idea for a double-wing *phalanstère* building derived from the Palace of Versailles into a general architectural model, and the book simultaneously served Daly as a source for a progressive concept of domestic comfort.

In both Fourier's original plans and in Considerant's adaptation, the architectural element of the *rue-galerie* plays a decisive role in the realization of a new social order within the *phalanstère*. This "gallery-street" represents a glazed walkway that ran around the first floor of the wings of the *phalanstère* and connected the apartments with the communal rooms. From the early 1820s, it acted in Fourier's work as one of the "material dispositions" of the "mechanism" of harmony, before ultimately becoming its crucial component.[121] In Considerant's diction, which updated the *phalanstère* with the very latest technology, various forms of "communication" overlap in the *rue-galerie*: it is the spatial connection through which the social life of the community pulsates, and simultaneously the place where the effects of the conduits of various building services are most noticeable.[122] "The greatest concern of this organization is communication," wrote Roland Barthes appositely in relation to the topography of the *phalanstère*.[123] By making the residents the "master" over flows of water, air, warmth, and light, the architecture of the *phalanstère* "universalizes" comfort and wellbeing. Here, comfort is a completely fluid entity—not only as a result of various circulation movements but also in that it itself circulates through the utopian space of the *phalanstère*. "It is easy to see," explains Considerant, "how these overall dispositions are favorable to general cleanliness, how much they make comfort circulate, and contribute to strip the domestic service of what is dirty, repulsive, and often hideous in the households of Civilization."[124]

This idea of comfort is echoed in the *Revue générale* at both a technical and a conceptual level, whereby there was nothing self-evident about propagating the comfortable in contemporary France. On the contrary, the discussion about the correct application and possible consequences of "material well-being" raged on in the 1840s. In her *Lettres parisiennes*, the poet Delphine de Girardin, for instance, wrote that it was undoubtedly right to have copied English *comfort* but that the French would have been better advised to have also assumed their simple ways of using it.[125] In a contribution to the *Revue des deux mondes*, the philosopher Victor Cousin went as far as to claim that enslaving the art of building to *commodité* and *confort* was equal to murdering architecture.[126] Against this chorus of voices, Daly had always agitated for the English model of comfortable living. Heavily influenced by the culture of the neighboring country and fluent in its language, from an early stage London's gentleman's clubs had served him as an architectural model—less due to their social exclusiveness than because of their ability, as private buildings, to integrate intimate with public rooms as well as incorporating numerous helpful building services. Thus, he enthusiastically describes the buildings designed by Charles Barry in the 1830s for the Travellers Club and the Reform Club to his French readers, because they were equipped with all the comfort and luxury that British industry had to offer, right down to the use of machines to transport all the items that a visitor would be loath to encounter on the stairs.[127] As it was, the editor, journalists, and guest contributors to the *Revue générale* fed their readers a regular diet of innovative architectural and technical ideas associated with the ideal of comfort. This includes, for instance, texts by Daly on heating and ventilation, by the Fourierist engineer Perreymond on public hygiene, by the architect-engineer A. Romand on settlements covered with glass domes, or by Marcellin Jobard, director of the Belgian Museum of Industry, on iron architecture.[128] Daly himself even used the concept of comfort in texts that dealt more with historical or archaeological matters, thereby investing it with an overarching historical value. Thus, while commenting on the publication of a book outlining the proposal to reconstruct the utopian Abbey of Thélème from François Rabelais's novel *Gargantua*, Daly once again took the opportunity to expound his thoughts on the connection between social organization and habitation as the "material envelope" of humanity. Accordingly, even Rabelais—whom Daly sets at the beginning of a lineage of architectural utopians including Thomas More, Robert Owen, and Charles Fourier—was described as having been guided by a love of comfort in designing his fictional abbey.[129]

In retrospect therefore, if by the mid-nineteenth century the term "comfort" had acquired overtly affirmative connotations in France, particularly as applied to architectural contexts, Daly and his journal can be said to have played a major part in this development. Thus, in 1851, over a decade after the launch of the *Revue générale*, articles in popular weekly magazines such as *L'Illustration* unequivocally treated the comfortable as an essential characteristic of interior space. "This word," wrote the fashion journalist Constance Aubert in her column about the "Moers parisiennes,"

> comprehends everything related to usual habits. It is not luxury, it is not caprice, it is not the objects of absolute necessity. It is the thousand resources of which the well-being and the savoir-vivre are composed. The comfortable begins with the household utensils, it ends with the search for adornment; it addresses itself to the rich as to the embarrassed persons; when it is not an improvement, then it is an economy.[130]

As a new catchphrase, comfort described—for the fantastical space of social utopia and the bourgeois living rooms of the French republic alike—an egalitarian sense of well-being created as a cumulative effect of the manifold resources of architecture, ranging from textile to technical elements: "it's the comfortable furniture—whether it is covered with wool or silk; it's the carpets under the feet, the portieres as preservatives, the blinds at the windows, the double doors to the apartment—whether it is on the first or the third floor."[131]

While the cottage was the first building type to be comprehensively associated with the material concept of comfort, what was also visible in this conjunction was a fundamental ambivalence. Depending on whether the context was an aristocratic cottage-villa or a simple laborer's abode, domestic comfort could either be presented as a self-selected convenience or a subtle means of control. While in the following decades casual comfort advanced to become a central aspect of noble living (albeit not without unfolding its partly intentional compulsions) on both sides of the Channel, its disciplinary variant was by no means ignored, rather it underwent, with slight delays, similarly profound developments. This took place against the background of growing urban impoverishment and within the framework of state and charitable initiatives that for political, economic, or philanthropic reasons set out to improve the living conditions of the poor and the working population, leading in the process to an increasing focus on their habitation. Up until this point, attempts to use architecture to influence the physical and spiritual morals of their occupants had been restricted to institutions such as prisons and the activities of individual landowners vis-à-vis their tenants, and this new focus meant that urban lodgings now also became a battleground in the fight against vice and disease.[132] The concept of comfort played an important role in this context. On the one hand, the inadequate living conditions of those in need were viewed in terms of a lack of comfort, or an "uncomfort," and, on the other, comfort offered the potential not only to provide purely material amelioration but to positively influence the behavior of the inhabitants.

These attempts to reform urban dwelling conditions were rooted in the larger rising public sanitation movement that emerged in parallel in numerous European states. In Paris, a Conseil de salubrité had already existed since the turn of the century, its role being to advise the municipal authorities in hygiene and medical affairs. In 1829, the *Annales d'hygiène publique et de médecine légale* had been founded, with the participation of the famous physicians Louis-René Villermé and Alexandre Parent-Duchâtelet, and since then France had had a central printed organ that served as a mouthpiece for sanitary reform issues.[133] The Paris Conseil de salubrité, the *Annales d'hygiène publique*, and particularly Villermé were subsequently to play a substantial part in questions of housing construction and domestic hygiene. Their interventions were predicated on the assumption that the characteristics of a place and the health of its inhabitants were intimately connected. "It seems, in general," explained the physician Claude Lachaise already in the early 1820s in his *Topographie médicale de Paris*, "that mortality is a direct result of the narrowness of streets, the height of houses and the crowding of households."[134] Given this insight, Lachaise was also one of the first people to demand a reversal of values in the design of urban space with such vehemence: "[A]rchitecture seems, at all times, to have sacrificed everything to the eye, and to have forgotten that the elegance of forms and the rules of symmetry are only secondary objects which must be subordinated to interests of the first order, such as the needs of health." The spirit of architecture, according to Lachaise, had to let itself be illuminated by the "torch of physics."[135] Shortly afterward, the Conseil de salubrité correspondingly complained that most architects lacked the physical and medical knowledge to realize conditions that could make lodgings health-promoting.[136]

That these worries about housing —along with those concerning well-being—were from the outset also immutably tied to the conduct of the inhabitants is not only evident in Lachaise's reference to the "physical and moral constitution of man"[137] but also in various contemporary publications. One example is the *Petit Producteur français*, where the economist and mathematician Charles Dupin provided small industrial and agricultural producers, a mainstay of French society, with practical work and living advice, but also delved deeply into dwelling conditions. A house that is clean and orderly can, according to the author, do much more than fortify health; above that it has qualities “which make life more commodious and which, contributing to well-being …, contribute to the purification of family virtues and social mores.”[138] As in the discussion about prisons and other institutions of confinement, in public sanitation physical and spiritual well-being were only one step removed from each other. When the *Annales d’hygiène* spelled out its editorial program at the end of the 1820s, the “moral order” was declared to be one of the axiomatic professional fields of hygienists alongside epidemics or hospitals.[139] Miserable living conditions, ran the argument, posed not only a threat to the health of the poor but also barred them from adopting the values and habits of the middle classes.

Therefore, even before France was hit by the cholera epidemic of the 1830s, the economic and political significance of urban housing, and with it the role of architects and developers, had been widely discussed. While this debate was initially led by a phalanx of physicians, natural scientists, and civil servants, as it progressed the voices of the architects themselves began to become increasingly loud. For instance, the later Fourierist Aristide Vincent, who in an 1830 article on a new method for manufacturing bricks, explained that considering the growing need for convenient and clean lodgings, architecture had to become a science and the architect had to swap from being simply a draughtsman to a scholar steeped in the calculus of expediency and economy.[140] Hubert Rohault de Fleury represents at least one member of the profession who would soon follow this appeal. As cholera already began spreading to the European continent, the Département Seine commissioned Rohault de Fleury, together with the physician Antoine Petit and the police official Adolphe Trébuchet, to investigate the cause of the alarmingly dire dwelling conditions registered in large parts of the city. The resulting report, covering almost forty pages, examined a typical Paris tenement building according to sanitary criteria, from the cellar to the attic and from the street to the courtyard. It divided up the structure of the building in a system of surfaces, cubatures, and openings, and explored the health impacts that these factors had in their respective dimensions. Along with the disposition of light, air, and water, the report concentrated on the everyday activities of the residents.

For instance, according to the section on cleaning: "The surface of the living rooms must be large enough so that the furniture that one wants to place there does not cover them too much, and does not prevent the sweeping which must maintain the cleanliness at all points, mainly in the angles and the recesses."[141] Just as window sizes were questioned in terms of lighting, and ceiling heights in terms of air exchange, Rohault de Fleury and his colleagues questioned the living space in terms of its ability to be cleaned.

The cholera epidemic, which reached France in March 1832 and took the lives of over 18,000 people in Paris alone, was the ultimate proof of the existence of a connection between the dwelling place and the death rate of the inhabitants. The epidemic produced numerous investigations that repeatedly established correlations between the number of victims and the state of particular buildings and streets, in turn leading to an inevitable call for living conditions to be improved and an increasing focus on housing.[142] In 1837, the physician Pierre-Adolphe Piorry took the statistical findings of Villermé, Parent-Duchâtelet, and other hygienists to write one of the to-date most detailed studies of the impact of dwelling conditions on human health with his *Dissertation sur les habitations privées*. Like Rohault de Fleury and his colleagues, he reduced domestic architecture to its elementary components and then analyzed the impact that these had on the human body. The set of factors considered stretched from climate and light to electricity. "Finally," explained Piorry in a preliminary conclusion, "in all this, the physiological knowledge will have to direct the use of physical means, applied to sanitize the human habitation."[143] Along with numerous architectural elements, such as windows, fireplaces, or water pipes, Piorry even examined the walls—albeit not as material, visual, or acoustic barriers, but instead as an element that, like others, facilitated the transmission of substances. Piorry's scientifically informed eye even honed in on the capillary processes taking place within the building materials, for instance those responsible for the introduction of small amounts of water into buildings. If the problem was to ensure tolerable moisture levels within living spaces, then this permeable quality of outer and inner walls was a relevant factor.[144] Piorry's investigations ultimately resulted in a plea to invest workers' lodgings with an attribute that was concurrently finding supremacy in the salons of the French bourgeoisie: “It would be necessary finally to encourage, even by means of premiums, the contractors to build, in the cities, houses intended for the workers, houses in which they could, at prices in relation to their resources, be lodged healthily, and, as the English say, in a comfortable way.”[145]

In the meantime, in its spiritual home in Great Britain, where public health and urban housing also increasingly became a topic of interest in the 1830s, the term comfort had likewise shifted to a new context. Already during the cholera epidemic, the physician James Philipps Kay had published a short book analyzing the *Moral and Physical Condition of the Working Classes* in Manchester, and the yearly reports of the Poor Law Commission, founded in 1834, had repeatedly examined the connection between the location of dwellings and the prevalence of disease, including specific reference to architectural aspects.[146] Swayed by the repeated outbreaks of cholera and typhoid, in 1840 the British government installed a special commission in the form of the Select Committee on the Health of Towns to inquire into the problems by questioning experts in the field. In its final report the same year, the commission called for wide-sweeping administrative measures, such as the introduction of a general building law, and unequivocally highlighted the socio-economic consequences of unhealthy dwelling environments. “Independent of the physical evils to the working classes … the dirt, damp, and discomfort so frequently found in and about the habitations of the poorer people in these great towns, has a most pernicious and powerful effect on their moral feelings … and thereby takes away a strong and useful stimulus to industry and exertion.”[147] However, the real founding document of the sanitary movement in Great Britain is unquestionably Edwin Chadwick’s famous *Report on an Inquiry into the Sanitary Condition of the Labouring Population* from 1842. As secretary to the Poor Law Commission, Chadwick was commissioned to undertake a comprehensive survey of living conditions in the nation’s villages and towns. Lasting many years, and with the help of the physicians James Philipps Kay, Neil Arnott, and Thomas Southwood Smith, he produced a 457-page report based on written questionnaires and personal inspections, thereby supporting his “sanitary idea” in unparalleled detail—his conviction that longevity of life and people’s health was dependent on the environment in which they lived. Still adhering to the miasma theory, he harvested an irrefutable body of evidence that there was a correlation between unhygienic living conditions and the outbreak of infectious diseases, and that the remedy to the problem was to be found less in medical methods and far more in techniques such as sewage and waste disposal.[148] Although the focus of the report concentrated on failings extraneous to housing and recommended countermeasures in the field of urban infrastructure, the construction of private and public buildings nonetheless also played a role in his analysis.[149]

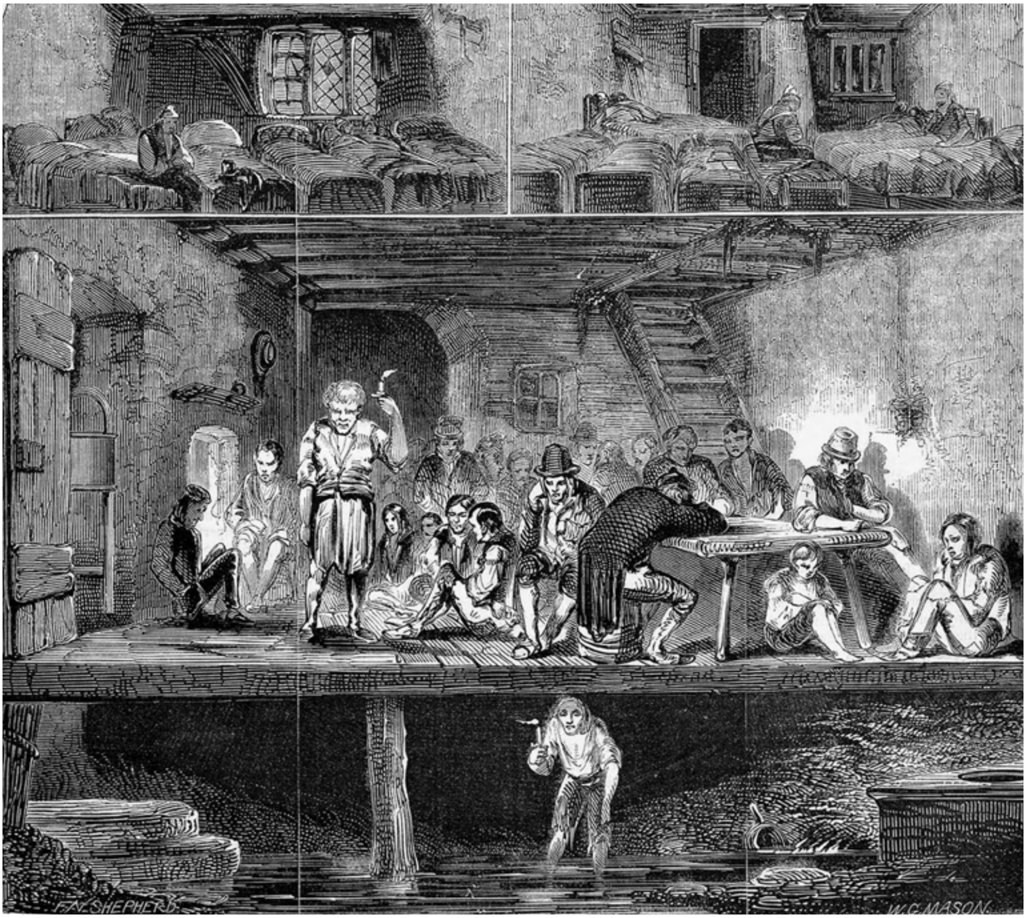
Chadwick’s report, like that of the Select Committee on the Health of Towns, failed to have the desired legislative traction, but nevertheless generated a newfound interest in the state of working class districts in British towns and moved parliament to instigate a new special commission, the Royal Commission for Inquiring into the State of Large Towns and Populous Districts. The results of this commission, presented in a preliminary form in 1844 and definitively in 1845 with the force of a government report, confirmed many of Chadwick’s findings, at the same time decisively refocusing the problem to dwelling interiors. A large part of the inquiries consisted of inspecting workers’ lodgings, identifying their poor construction, inadequate ventilation, and overcrowding as the core causes of the spread of diseases and the resulting inability to work.[150] Here, at the latest, the correlation between habitation and health underwent a logical reversal: if dwelling had a negative impact, the obverse was also true and it could be turned into a positive force. “A clean, fresh, and well-ordered house exercises over its inmates a moral, no less than a physical influence, and has a direct tendency to make the members of a family sober, peaceable, and considerate of the feelings and happiness of each other,” explained Southwood Smith to the commission during his evidence, thus formulating one of the future principles of the reform movement.[151] Thus, by the 1840s, the full squalor of British cities had at least been officially recognized. It would take a further three years, and the threat of a renewed cholera epidemic, until the legal basis for state health control was created in the form of the 1848 Public Health Act, but nonetheless the revelations of the Royal Commission also led to the immediate founding of a series of private groups involved in propagating urban housing reforms through publications and concrete building projects.[152]

Three influential initiatives were launched alone in the year that the Royal Commission's report was published: the Health of Towns Association, which whipped up publicity for the housing question under Southwood Smith's leadership; the Association for the Promotion of Cleanliness among the Poor, dedicated to the building of public baths and washhouses; and the Society for the Improvement of the Condition of the Labouring Classes (SICLC), which focused on the development and realization of model plans for housing for the poor, also supported by Southwood Smith. The activities of these groups were closely followed in the pages of *The Builder*, founded in 1842—as in the case of casual comfort, periodicals also played an important role in the spread of this, its kindred disciplinary type. From its first issue onward *The Builder*, edited by George Godwin, provided ample space in its columns for the concerns of sanitary and housing reform. Corresponding to the individual initiatives, the magazine repeatedly emphasized that improvements in public health could not be achieved by doctors, sanitary reformers, or government officials alone, instead stressing that the issue of the misery and overpopulation in Britain's towns also required new forms of architecture and a new awareness among architects. "An important duty therefore, in the progress of social amelioration," read an 1847 article, "is that of the architect."[153]

The Scottish physician Hector Gavin would go a step further and demanded that architects specifically specialize in workers' housing. In the later 1840s, Gavin, a member of the Health of Towns Association and later secretary of the General Board of Health created by the Public Health Act, began publishing a loose series of books on public health.[154] In his 1847 *Unhealthiness of London*, he attempted, using statistical calculations, to demonstrate the link between population mortality and domicile in various European countries, British regions, and London boroughs. *Sanitary Ramblings*, which appeared a year later, presented a cartographically based report of inspection tours undertaken by Gavin in the streets and houses in the London working-class neighborhood of Bethnal Green. → Fig. 77 Finally, in 1851, Gavin's *The Habitations of the Industrial Classes* appeared, concentrating entirely on the design of tenement buildings and aiming to provide the working classes with the "modest comforts of an English home."[155] In chapters dealing with site, building materials, and external and internal layouts, Gavin was at pains to show the intricate linkages between living spaces and the activities undertaken within them: "It is essential that a house intended to be a building in which human beings are to live and perform all the offices of life, should permit the performance of these offices, and preserve the individual from external and injurious influences. It is the casket which should contain the precious jewel, and should be fashioned accordingly."[156] The task of designing the corresponding buildings was allotted by Gavin to the figure of the "scientific" or "sanitary architect"—"a specialist, created, as it were, by the discoveries of medical men, and their correct appreciation of the vast influence of local agencies in the production of disease."[157]

It is perfectly possible that Gavin's call for sanitary architects was modeled on the person of Henry Roberts. Roberts' endeavors in the mid-nineteenth century to translate the goals of sanitary reform into architectural designs were largely unparalleled at the time. Along with his London office, he also voluntarily headed all of the SICLC's building projects from its inception onward, an activity he summarized in his successful 1850 publication *The Dwellings of the Labouring Classes*.[158] The SICLC, which with its royal patronage and low rates of return can be considered one of the first charitable housing associations, developed concepts for tenement buildings designed to experimentally address the specific living conditions of the working classes—effective not simply in the form of plans and calculations but in real built architecture.[159]

The first SICLC project was the 1844 Model Dwellings, a double-row complex with two-story tenement houses in the London borough of Pentonville, providing space for twenty-three families and thirty single women. "In their arrangement," wrote Roberts in his book, "the main object has been to combine every point essential to the health, comfort, and moral habits of the industrious classes



77
Living conditions in the West End of London
after an illustration by Hector Gavin, 1848

and their families, particular attention being paid to *ventilation, drainage, and an ample supply of water.*"[160] Following the same stipulations, in the following years he developed a series of lodging houses with sleeping halls for youths, men, or women. These types of accommodations were notorious flashpoints, making the SICLC's emancipatory intentions all the more concrete in this context. The Model Lodging House, erected in 1846 in Bloomsbury, London, combined, according to Roberts, "all those conveniences which, whilst conducting to the health and physical comfort of the inmates, tend to increase their self-respect, and elevate them in the scale of moral and intellectual beings."[161] This was followed in 1848 by the Model Houses for Families, a project that besides its sheer dimensions was of particular significance in that it stood at the heart of an ongoing debate since the beginning of the reform movement. This concerned multistory apartment houses, whose economic advantages as a building type were self-evident but which simultaneously provoked serious reservations regarding the uncontrolled spread of diseases, quarrels, and bad manners. Differing positions on this point had already been expressed in the report of the Select Committee on the Health of Towns, with Chadwick, for instance, warning that maintaining order in a multi-family house required the force and discipline of a warship.[162] Therefore, as the SICLC began planning a tenement block with apartments for forty-eight families, Roberts attempted to separate the residential units from each other as effectively as possible and to create a maximum degree of domestic privacy. Instead of stairwells, the building is equipped with open flights of steps and galleries facing the courtyard so that the tenants, after entering the block via the main entrance, only step inside again through their own apartment door. Once again, different forms of communication are played off against each other—by abstaining from "internal communications," the "communication of contagious diseases" was to be prevented.[163]

In the same year that it appeared, Roberts' *The Dwellings of the Labouring Classes* was translated into French on the personal instructions of Charles-Louis-Napoléon Bonaparte. Louis-Napoléon knew the work of the SICLC and its in-house architect from his years of exile in London, the intention of the translation being to spread its ideas in his native country.[164] The publication was already guaranteed a certain readership due to the fact that it appeared in the midst of a discussion that ran along very similar lines to that in Great Britain. Set against the background of a growing awareness of the social and political explosiveness of the housing problem, in the course of the 1840s France had likewise seen a rising chorus of demands for state intervention.[165] In addition, swayed by professional publications, in particular César Daly's *Revue générale*, the goal of health-promoting housing came to be increasingly discussed also among architects. As early as 1842, in an article on dwellings for agricultural laborers, Daly had reminded his readers that the "physical milieu" of architecture had a fundamental impact on morals. "[A]rchitecture," he explained in connection with the material state of buildings, "has a direct and powerful effect on all minds."[166] From the mid-1840s onward, the *Revue générale* then printed a running series of articles presenting plans or ideas for the improvement of dwelling conditions for the working population.[167]

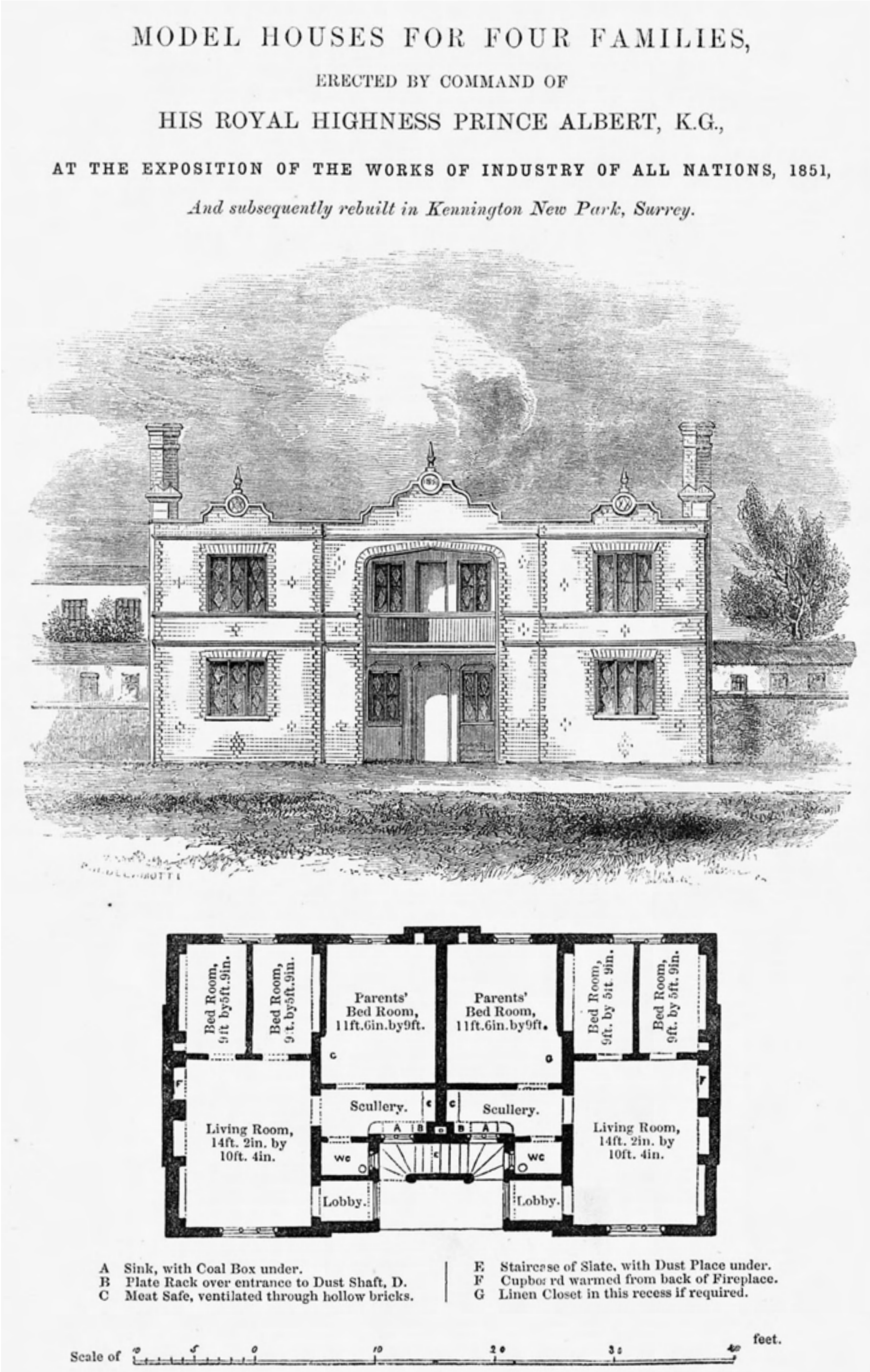
While Daly, as a Fourierist and republican, stood for the reformist or even utopian motives in this endeavor, conservative groups forming at the time began to similarly focus on housing for workers and the poor, albeit driven by fears of preserving the existing order. One example is a group centered on the Catholic politician Armand de Melun, who in 1845 started the *Annales de la Charité* championing a paternalistic form of charity.[168] The tectonic shifts that followed the political upheavals of 1848 gave both sides of the movement a momentum and seeded numerous workers' housing projects. One example is the historian Henri Dameth, a Fourier disciple, who resurrected the familiar concept of the *phalanstère*, this time in the form of a workers' town designed as an "ark of alliance" and a "temple of fraternity" to reform the lives of its inhabitants through technical and architectural means: "the [*worker's*] *Town*," wrote Dameth, "can become the peaceful instrument of all reasonable material and moral improvements."[169] In the same year, work began on the building of what would become Paris's first workers' housing estate, soon to become known as the Cité Napoléon due to the support of the French president. Finished in 1851, the three-story building complex in the 9th

Arrondissement contained 194 apartments, partly accessed via glazed walkways, and various communal facilities such as a washing kitchen, a drying room, and a bathhouse.

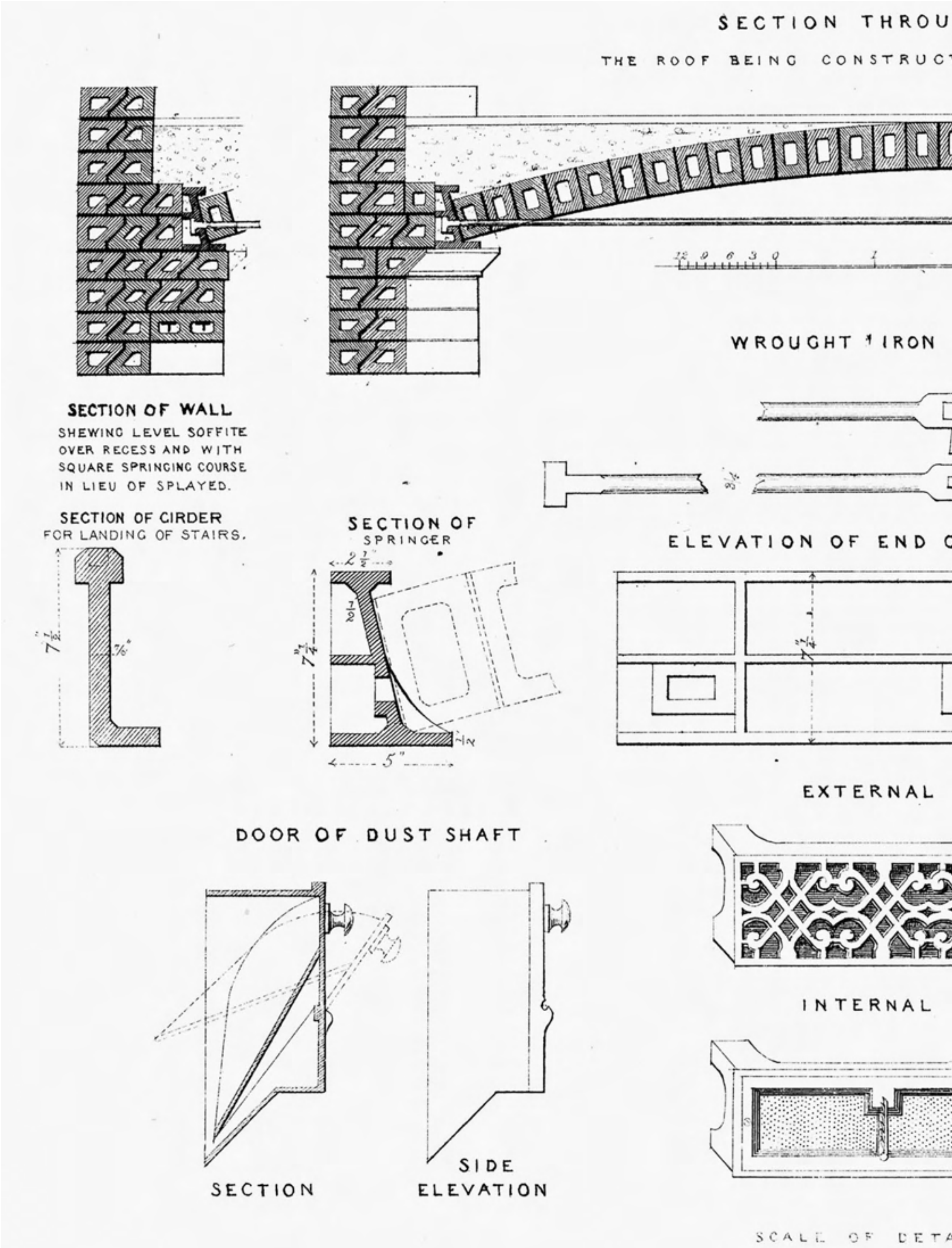
This and other similar initial housing projects triggered the debate in France to which the translation of Henry Roberts' book was to contribute. The core issue in this discussion was the question as to how many working-class families could be accommodated in a restricted space without it having a negative effect on physical and moral health. In the *Annales de la Charité,* the prison architect Romain Harou-Romain warned that voicing support for workers' housing estates was equivalent to voicing support for Socialism. By weakening family bonds and encouraging immoral contacts, the principle of communal living endangered the complementary principle of a *chez soi*, which as both a real place and a personal mindset guaranteed individual freedom and dignity.[170] Louis-René Villermé, on the other hand, was convinced by the idea of planned workers' villages but nonetheless doubted that projects like the Cité Napoléon were adequately dimensioned to prevent pernicious exchanges between the residents and the sexes.[171] Instead, he sketched out his counterproposal in an architectural complex composed of freestanding single-family houses, which by virtue of its layout constricted certain interactions between and within families. The buildings were to be arranged across a greenfield site, avoiding debauched conversations in the passageways and blocking the sound of conversations in adjoining rooms and views from one apartment into another.[172] These interventions, extending even to the sightlines between neighbors, were intended to inscribe conditions of intimacy into the domestic environment that shielded the inhabitants from one another, but above all protected them against themselves.

Meanwhile, Roberts and the SICLC had acquired final international fame with a renewed project that constituted a built architectural contribution to the discussion. Under the patronage of Prince Albert, the president of the SICLC, one of their projects achieved the privilege of being incorporated into the official program of the Great Exhibition of 1851. In record time, a two-story building was erected on the opposite side of the street from the Crystal Palace, consisting of four tenement units of identical layout, and theoretically extendable both vertically and horizontally.[173] → Fig. 78 As with previous projects, great attention was paid to the basic requirements of ventilation, drainage, and fresh-water supply, while the entryways were exposed, mirroring those in the SICLC's block in Bloomsbury. Mr. Bendigo Buster, the fictional satirical figure in Charles Dickens's magazine *Household Words*, who provided one of the most detailed surviving descriptions of the building at Hyde Park, explained: "the stairs are outside in that covered recess, in order that each family may go home without crossing a neighbour's threshold."[174] In addition to the focus on building services and access, the Model Houses for Four Families also exemplarily manifest a further aspect of sanitary architecture dating back to the earliest plans for worker's cottages, namely the attempt to achieve maximum precision in the programming of the domestic spaces. While the floor plan in Roberts' work serves, on the one hand, to organize the previously unpredictable movements of the inhabitants, coupled with various interior fittings and fixtures it is also used to translate the undifferentiated use of the living spaces—an aspect often lamented in the reports of the sanitary reformers—into a system of separate and well-defined spheres of activity.[175]

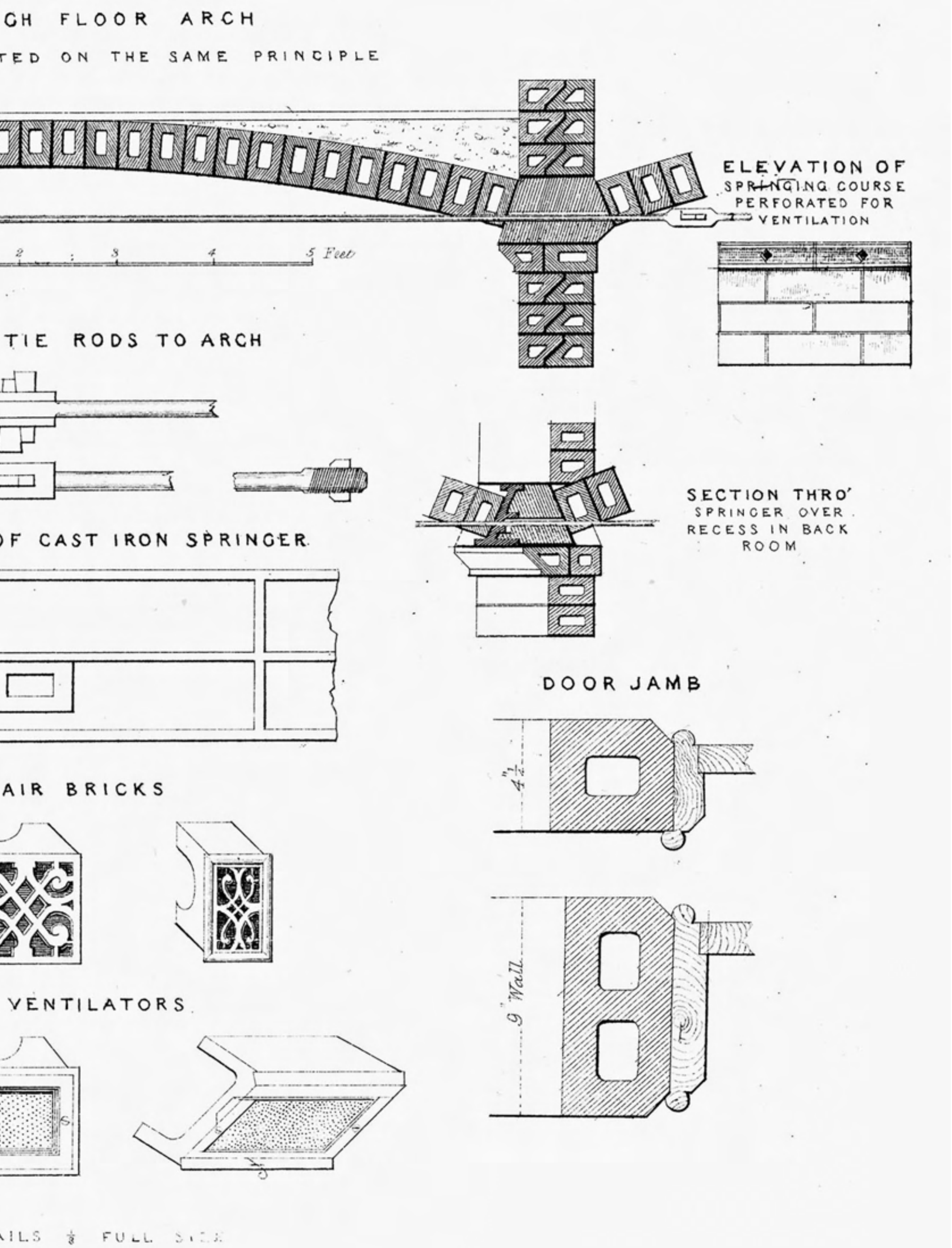
This spatial programming starts with the layouts of the living and sleeping quarters in the individual units. "One evil consequence inseparable from a deficiency of bed-rooms," explains Gavin in his book *Habitations of the Industrial Classes* published the same year, "is a low state of morality, a breaking down of those feelings of delicacy that ought to be most carefully preserved in families of young persons of both sexes growing up to maturity."[176] For this reason the model flats are equipped with three different bedrooms, each with their own entrances and windows—for girls, boys, and parents. In addition, the situational relation of the rooms to the shared living room establishes certain forms of decorum. While the two children's bedrooms lead directly off from the living room—"an opportunity … for the exercise of parental watchfulness, without the unwholesome crowding of the living room, by its use as a sleeping apartment"—the parents' bedroom is entered via an anteroom—"an arrangement in many respects preferable to a direct approach from the living room,



78
Crowd-puller: model tenement building by Henry Roberts at the Great Exhibition, 1851



79
Sanitary architecture: construction details
by Henry Roberts, 1851


GH FLOOR ARCH
TED ON THE SAME PRINCIPLE
2 3 4 5 Feet
ELEVATION OF SPRINGING COURSE PERFORATED FOR VENTILATION
TIE RODS TO ARCH
SECTION THRO' SPRINGER OVER RECESS IN BACK ROOM
OF CAST IRON SPRINGER
DOOR JAMB
4½"
AIR BRICKS
9" Wall
VENTILATORS

particularly in case of sickness."[177] This endeavor to prescribe particular patterns of use, together with the spatial arrangement, continues in the fixtures and furnishings. "In all dwellings," writes Gavin, "the internal arrangements materially conduce either to the comfort and happiness, or to the discomfort and wretchedness of the inhabitants. … Shelves, cupboards, and closets, dust-bins, proper conveniences, outhouses or sheds, and the necessary domestic conveniences and appurtenances, are essentially requisite."[178] Roberts' apartments are correspondingly equipped with a sideboard that can be folded up against the window when not in use, shelves fixed out of reach of the children, and a washing kitchen containing a sink, a drying rack, a coal scuttle, and a rubbish chute.[179] The attempt to influence the behavior of the inhabitants through architecture even extends to the construction of the walls and the ceilings. The entire structure of the building was executed in so-called "hollow brickwork," a type of brick developed by Roberts himself and beneficial in terms of construction economy, fire safety, and above all interior climate. Moreover, the air enclosed in the bricks was designed to not only prevent the transfer of cold and heat but also noises, thus securing absolute privacy for the individual rooms. ← Fig. 79

The Model Houses for Four Families attracted over 250,000 visitors, and with the Council Medal was awarded the Great Exhibition's highest prize.[180] It clearly demonstrates the extent to which "disciplinary" comfort was similarly based on shaping the atmospheric conditions and daily actions of habitation via spatial and technical means. As opposed to the "casual" variation, however, the aim was less to ease the burden of daily chores—be it those of the master of the house or of the servants—and to compress existing spatial programs; instead, it was far more about reliably establishing certain activities and habits in the first place. Many of the layouts and fixtures that entered into housing in the course of the sanitary movement therefore bring not only conveniences but also precise prescriptions with them. One such example is the foldable sideboard in the living room of the model apartments, on which Mr. Bendigo Buster smugly commented, "it's indifferent whether you say that a model cottager is forced to make pies on the window shutter, or to barricade his window with a dresser—both statements are true."[181]

By inevitably combining activities like the baking of a cake and the opening of a window with each other, the piece of furniture does indeed exercise a certain “coercion.” After the sanitary reformers, by dint of their investigative and statistical tools, had revealed the everyday conditions of the poor and the workers in previously unknown detail, and after establishing a fundamental connection between housing and living habits, sanitary architects like Henry Roberts then amalgamated this knowledge with designs that were in turn intended to reciprocally influence the lives of their inhabitants. And so it was that living space became a core element in the conduct of its residents—in Gavin’s words, “it forms the entire groundwork upon which much of the moral and social improvement of the population must be based.”[182]

COMFORT MACHINES

Between 1830 and 1850, a current of discussion emerged, as the previous chapters have shown, on both sides of the Channel that interrogated private housing in terms of the basic aspects of well-being, health, and morals. In this process, a counterpart to the idea of comfort as the self-chosen arrangement of domestic surroundings to suit personal physical and daily needs emerged, namely in the form of the idea of a sanitary comfort, calling for these adjustments to be extended, at least within certain limits, to other members of society—be it for political, economic, or philanthropic reasons. To a greater extent than ever before, these dual developments led to living space being thought of in connection with daily routines, domestic work, and interpersonal communication. As with the processes of climate control and the efforts to foster morals, this concentration on the physiological and social activities of residents had conceptual consequences for the architectural object in that the "comfortable" perspective on the operative qualities of buildings ultimately also entailed an architectural machine concept. This concept is most clearly expressed in the well-known review that the French architect Adolphe Lance published in the mid-nineteenth century of the book *Traité d'architecture* by Léonce Reynaud. "A house," reads the key passage in the review, "is an instrument, a machine so to speak."[183] A closer examination of Lance and his statement reveals not only how deeply this idea was rooted in the contemporary discussion about comfort but also how far the respective genealogies of its unforced and forced forms overlapped in it with each other.

Lance was involved in the field of building in France both as a practicing architect and a journalist. Born in Calvados in 1813, since his training under the architects Louis Visconti and Abel Blouet he had worked as a constructor and conservator of private and public buildings, but had turned to writing at an early stage.[184] In 1847, he was accepted as a member of the Société centrale des architectes (SCA), the French professional architectural association founded in 1840, and in the same year he launched his own journal, the *Moniteur des architectes*. While the *Moniteur* pursued a comparatively traditional architectural journalistic agenda, drawing heavily from the academic context, Lance's activities in connection with the SCA related closely to the technical and hygienic issues of the day. One of his first official roles for the association was to examine the acoustics and optics of public assembly rooms.[185] In 1850, the year in which the French parliament passed its first law to combat unhealthy dwelling conditions in the form of the Loi sur les logements insalubres, Adolphe Lance was appointed to sit on an SCA commission—initiated by the architect Romain Harou-Romain together with four other professional colleagues—to inquire into the requisite constructional underpinnings of the law. Referencing the major publications on sanitary architecture—from Rohault de Fleury's early studies to Henry Roberts' recently translated book—the commission issued a sixty-page report with detailed recommendations on the improvement of the homes of the poor, as well as other social groups.[186] With the report, Lance, whose name appeared as the report's author, proved himself to have a full command of the latest French and British findings in the field of health-promoting housing.

Shortly afterward, Lance was appointed the chief editor of a further architectural journal, giving him the opportunity to combine the issues dealt with by the SCA with those discussed in the pages of *Moniteur des architectes*. The *Encyclopédie d'architecture* had been launched in 1851 by the editor Balthazar Bance and the engraver Victor Calliat as a monthly, and initially purely illustrated, revue. Lance joined the journal a year later with the task of supplementing the journal with an edited text section. Thus, in its second year—the first in which Lance participated—the journal contained not only large-format illustrations of historic Paris buildings like the Sainte-Chapelle or the Hôtel de Beauvais but also numerous contributions on contemporary construction- and material-technical issues, as well as a succession of articles on housing renovation and a multi-part series of extracts from a book by the architect

Charles Gourlier dealing with the sanitary conditions of Paris's streets and apartment blocks.[187] In March 1853, at the beginning of *Encyclopédie d'architecture*'s third year, the journal then printed the widely discussed contribution in which Lance called for the house to be understood as a machine.

By this juncture, the concept of the architectural machine was not altogether new in the context of comfort either. Over the previous decades, private domestic spaces and the activities they hosted had been repeatedly described using machine terminologies in various ways, in particular in relation to the provision of service to the inhabitants—a development in which fictional literature played no small part. In 1822, the American bestselling author Washington Irving published the short-story collection *Bracebridge Hall*, its narrative set in a fictional English country estate. In the chapter "Family Servants," Irving has the first-person narrator praise the smoothness and unobtrusiveness with which the venerable family is waited upon with the words "you are not persecuted by the process of making you comfortable." The activities in the manor house that gives the novel its title, which was based on various real buildings, run like a finely tuned mechanism. "The work of the house is performed as if by magic, but it is the magic of system. Nothing is done by fits and starts, nor at awkward seasons; the whole goes on like well-oiled clockwork, where there is no noise nor jarring in its operations."[188] A few years later, the German architect and author Friedrich Maximilian Hessemer openly transmuted this characterization to the architectural object itself. In the introduction to his book about medieval architectural ornamentation, Hessemer describes—not without lamenting it—the shift in values that had made the private apartment into the "temple of our days." It nowadays formed a "field of effectivity" in which everyone is bound "in all directions of his activity" and "his thinking and feeling to the interior of the house … as his luxury and his comfort momentarily require." Hessemer then goes on to outline the conceptual ramifications in words that are remarkably similar to Lance's: "Easily modifiable, docile to the changing dictates of taste, graceful and elegant, convenient, and meeting a thousand refined needs and sophisticated singularities, the building is supposed to be, in a sense, an artificially assembled machine for all the domestic pursuits of life."[189] Again, a few years later, in the dystopian science-fiction novel *Le Monde tel qu'il sera* by the French storyteller Émile Souvestre, it is the servants who are concretely replaced by a "domestic mechanism." Souvestre's dark vision of life in the year 3000 includes, amongst other aspects, the idea of a "well-machined house" in which the previous human actions of being waited upon are executed by innumerable mechanisms and apparatuses, thus allowing people to become fully spatially isolated.[190]

In Lance's case the machine analogy is not only positively connoted, it was also probably the first time it was formulated in a publication that saw itself as an official organ of the architectural discipline. The context in which it occurred was a multi-part review of the first volume of an architectural treatise published three years earlier by the well-known architect and engineer Léonce Reynaud. The treatise was in turn based on a course of lectures that Reynaud had given since 1837 as professor of architecture at the École Polytechnique dealing with the materials of building, in particular constructions made of stone, timber, and iron. Educated at the École nationale des ponts et chaussées and highly influenced by Saint-Simonianism, Reynaud's treatise bore testimony to his relatively liberal and progressive views:[191] in the introduction he breaks the art of architecture down into the Vitruvian categories of *solidité, commodité* and *beauté*, whereby he accords *commodité* superiority. Architecture, according to Reynaud, was born out of material necessity, meaning that its uppermost objective was usefulness. Within the framework of the useful, constructional decisions should be guided by the free quest for orders, simplicity, and harmony, while he conversely rejected all strict rules and rigid methods.[192] In the section on iron construction Reynaud goes on to state the fundamental importance of industry and science for progress in architecture: "The public … feels perfectly that this art cannot remain foreign to the progress of science and industry, and … it is justifiably astonished to find almost exclusively, in our buildings, the elementary forms and proportions of Greece and Rome."[193]

The basic tone of Lance's review was sympathetic. He commends Reynaud for breaking with the treatise tradition of proffering readymade solutions and that Reynaud did not treat taste and the profession as infallible, and instead set out to school individual judgment. Summing up, he describes the publication as a "service to the art" that would be of use to those spirits eager to learn in general and young architects in particular.[194] Simultaneously, Lance took Reynaud's analysis as an impetus to make specific suggestions for the second, as yet unpublished, part of the treatise. In particular Lance takes Reynaud's statements concerning progress in architecture as an impetus to call for a closer examination of a new and to-date little-researched side of civil architecture. Reynaud, in Lance's opinion, had only addressed the impact of industry and science in terms of constructions, their stability, and their elegance. The question, however, was whether this was sufficient.

> [W]ould it not be possible to go further, and to envisage also our buildings or our houses in their relations to the man who frequents them or inhabits them, not only to determine their general dispositions and their distribution, but to discover also the thousand special applications, the multiplied facilities, the economies of time and forces, that the introduction of the processes conquered by the progress of sciences and industry into our dwellings could provide to domestic life? A house is an instrument, a machine so to speak, which not only serves as a shelter for the man but must, as much as possible, adapt itself to all his needs, assist his activity and multiply the product of his work.[195]

The house as an operating and helping machine—with this, Lance quite deliberately touches upon the foundations of the architectural theory of the times. The full scope of his image becomes apparent in knowing that it not only positioned him against the reduction of architectural progress to construction and style, but that it also declared him to be an adversary of the organism model that Reynaud and other rationalists cultivated in their writings. Informed by the ideas of comparative anatomy, Reynaud had prominently used the organism analogy in the introduction to his treatise where he compared buildings with God's living creatures. Like them, architecture demanded an intimate bond between form and function, an equivalence between the inside and the outside, a well-ordered and simple disposition.[196] Lance initially seized upon this in his review by writing, not entirely devoid of mockery, that Reynaud's book seemed to him to be an operation on a cadaver, an anatomy of architecture, and expressed the hope that the second volume would provide the relevant physiology—"the living art, in the multiplicity of its manifestations and in the variety of its developments."[197] In the conclusion to his text he nonetheless uses the machine as a model that expresses activity and multiplicity in a completely different way and that is not in the least bit concerned with questions of appearance, harmony, and beauty. Lance deploys the machine analogy to highlight the operative dimensions of architecture and to factor its residents into the equation—not simply as educated observers but as everyday users.

To a certain extent, Lance's radical definition of architecture can be explained by the author's own architectural undertakings. Since the 1840s, Lance had been occupied with realizing numerous town palaces, apartment buildings, and other residences in Le Havre, Paris, and their surroundings. According to the written characterization of these buildings handed down by a disciple and friend of Lance's called Laroque, the reputation Lance acquired through these projects lay in the introduction of precisely the "thousand special applications" and "multiplied facilities" that he wanted to see incorporated in the official repertoire of architecture.

> The most incontestable merit of Adolphe Lance's private constructions resides in the study of very well comprised distributions, with regard to the numerous requirements of modern habitation, distributions in which he has always known how to avoid complicated combinations and infinite divisions, which often turn our apartments into compartmentalized boxes .... Finally there is reason to insist on the very complicated program of heating, lighting, bell wiring, toilet and bathroom installations, hot and cold water pipes on all floors, etc., etc.,

> that the proprietors of Le Havre, people accustomed to all the refinements of English comfort, have imposed on him and which our colleague always knew how to deal with to his honor ….[198]

In this way, Lance shows himself to be an adept in casual comfort—a true ambassador of amenity equal to Loudon in Britain or Daly in their shared nation of France. The definition of architecture formulated in the pages of *Encyclopédie d'architecture*, however, likewise clearly echoes the issues of sanitary housing reform in which Lance had been involved since at the latest the 1840s. Like no other, this field of inquiry had preoccupied itself over the previous years in examining the connection between dwellings and their inhabitants, in the process emphasizing the social, political, and not least economic significance of domestic space. To the machine images of literary authors such as Irving, Hessemer, and Souvestre, Lance adds precisely the analytical and socio-economic approach that underlies his report on housing improvement for the SCA, allowing him to preface it with the claim that the private dwelling was nothing more than the "mold" of individual existence:

> When one thinks of the influence that the habitation can have on the physical and moral life of individuals; when one reflects that our home becomes like the mold of our intimate life and of our domestic habits; that it is the place of our rest after everyday's work, and the center of our dearest affections; one is rightly surprised that the philosophers, the moralists, and generally all those who have put themselves as preceptors of the people, have not understood that the reform of the habitation of the poor includes all the reforms that are loudly claimed for him.[199]

As an architect, Lance was well acquainted with the requirements of noble living and obviously availed himself, with virtuosity, of all the techniques and processes of the comfortable that had permeated into domestic space and daily life over the past decades. As a journalist and reformer, he was well aware of the goals and problems of the promotion of health and morals through housing, expressed not only in his use of the terms "economy" and "work" but not least in a further comparison that he draws in his review of Reynaud's treatise: "Our house, may we be forgiven this slightly bizarre metaphor, is the factory where we produce the innumerable acts of our private life."[200] His demand to think of the house as a machine merges findings from both fields: the dwelling appears not only as a place where the desires and requirements of the inhabitants are fulfilled quasi-mechanically, but also as a space so intricately intermeshed with their activities that it confronts them in the manner of a technical object.

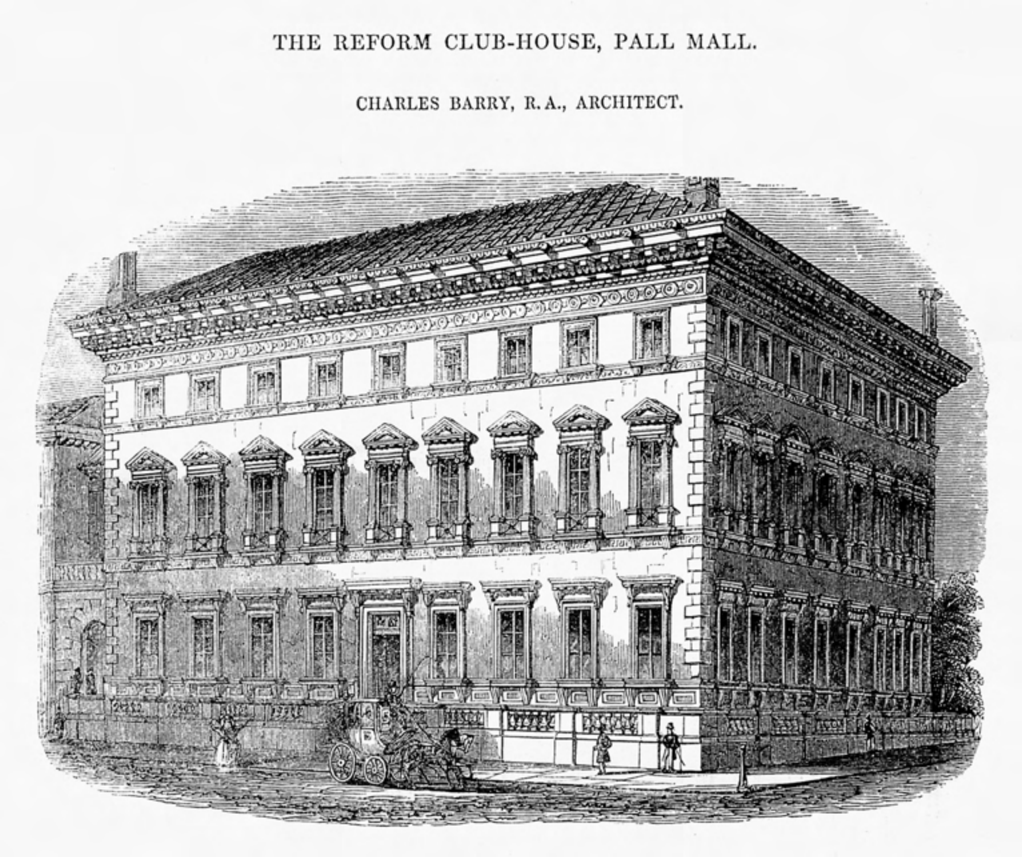
THE REFORM CLUB

The heart of any gentleman's club was the so-called "coffee room." It was not only the place, as the name suggests, where coffee and other hot beverages were enjoyed, but also where various daily meals were consumed and banquets and other festivities were held. Considering the fact that the coffee room was also associated with the roots of the gentleman's club in the coffeehouse culture of the seventeenth century, as a room it uniquely stood for the emblematical conviviality of the institution. The coffee room of the London Reform Club was described in the illustrated 1841 volume *London Interiors* as follows:

> The floor is of oak, inlaid and polished; the windows open to the south, and when this room is brilliantly lighted up, the rich hues of the Persian carpets, the snowy whiteness of the table-cloths, and the speaking eloquence of dumb waiters, glittering with polished plate, and rich cut glass, give evidence of that combination of wealth with utility, the refinement of which is to be expressed only by a word at once original and intensely national,—COMFORT.[201]

Designed by Charles Barry, with this the Reform Club building had already been successfully identified as the quintessence of the English national category of comfort in the very year of its completion.

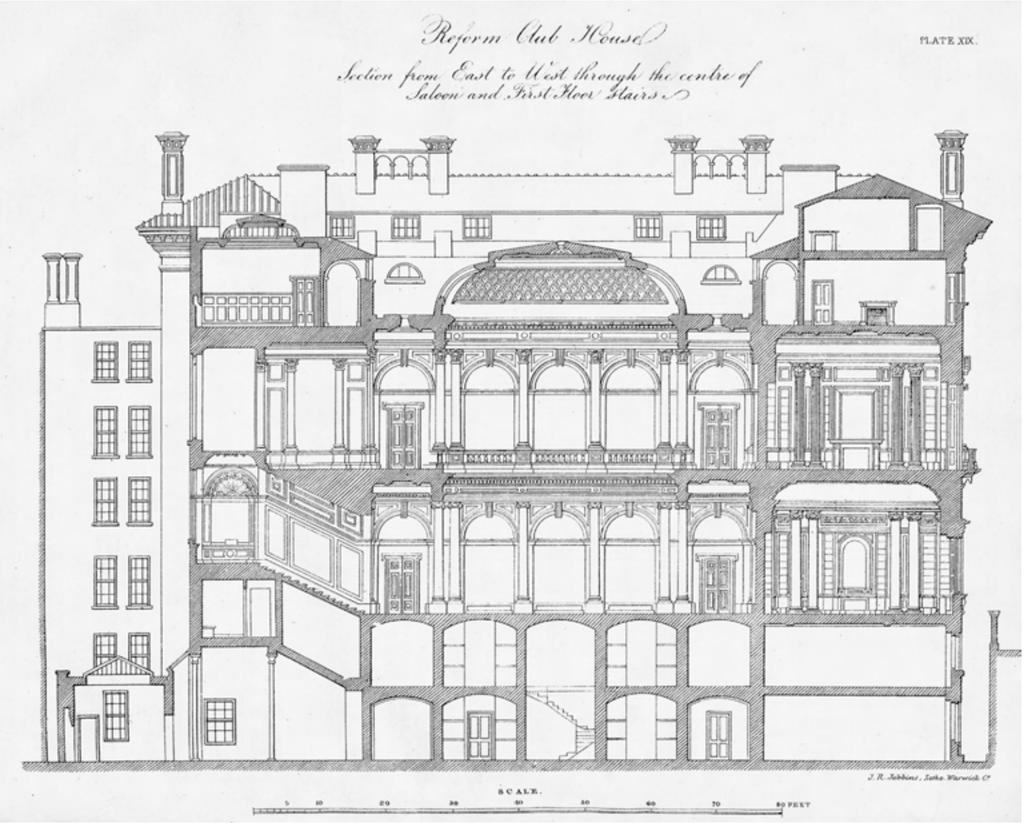
As one of the first gentleman's clubs in Britain, the Reform Club had been founded in 1836. Its existence and its name derived from the Reform Act of 1832, which had ushered in a sweeping transformation of the electoral system in England and Wales. While the conservative Tories had opposed the Reform Act, and following their defeat had founded the Carlton Club to improve



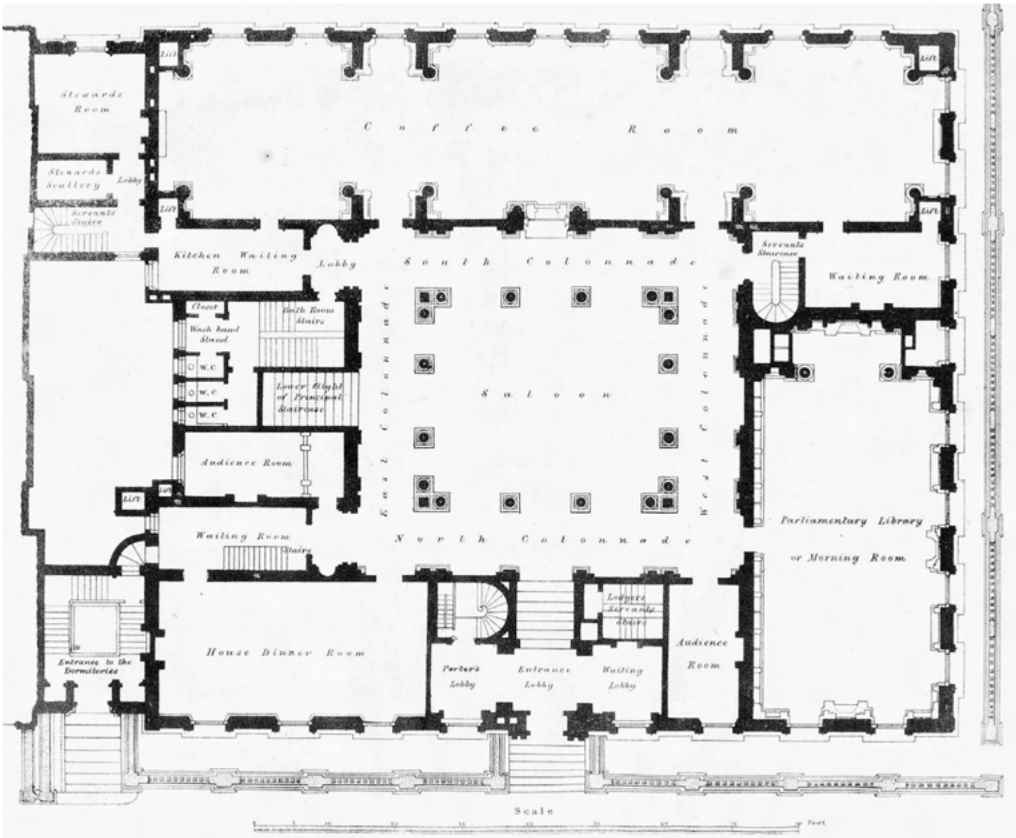
80
The Reform Club: street view, 1840

party coordination, the radical Whigs had started the Reform Club with the aim of supporting liberal ideas. Despite their contrary strategic motives, both clubs nevertheless largely adhered to an idea already established by a set of non-political associations since the beginning of the nineteenth century—such as the United Service Club (for military officers), the Travellers Club (for tourists), or the Athenaeum Club (for scientists)—offering a closed number of upper-class male members their own prestigious and comfortable address in which to relax and converse.[202] The Reform Club was initially housed in an existing building at 104 Pall Mall in the St James's district, and was thus, like many other London clubs, immediately adjacent to the government buildings of the City of Westminster. Due to lack of space, it was decided in 1837 to hold an architectural competition to build a new and larger club, occupying the same and three other adjacent plots. The winning architect, Charles Barry, had won the competition for the new Houses of Parliament only a year earlier, and in 1829 had already designed the neighboring Travellers Club.

Like the Travellers Club, the Reform Club was also erected in a palazzo style, albeit on a far larger scale.[203] ← Fig. 80 Behind its Italianate facade lay a six-story building, including a cellar, a mezzanine, and an attic floor resting on a floor plan of 30 by 40 meters. The two lower floors included the kitchen, storage rooms, offices, and bathrooms. The two upper floors were mainly reserved for bedrooms: the attic story for staff, and the second upper story—a novelty for London clubs—for members. The two elaborately designed middle floors were the stage for public club activities. They shared a glazed-roofed courtyard, accessible from the street by a few steps and through a lobby, forming the core of the building. On the ground floor, arranged around the courtyard, were a reception and dining hall, a library, and the coffee room; on the first floor—accessed via a gallery—various social rooms, meeting, billiard, and card rooms, a smoking room, and a further library. Along with the main staircase, connecting the ground floor with the first floor, and an exterior staircase leading directly to the bedrooms, the entire building was also accessed via numerous service staircases. → Figs. 81–82



81
The Reform Club: east–west section, 1840



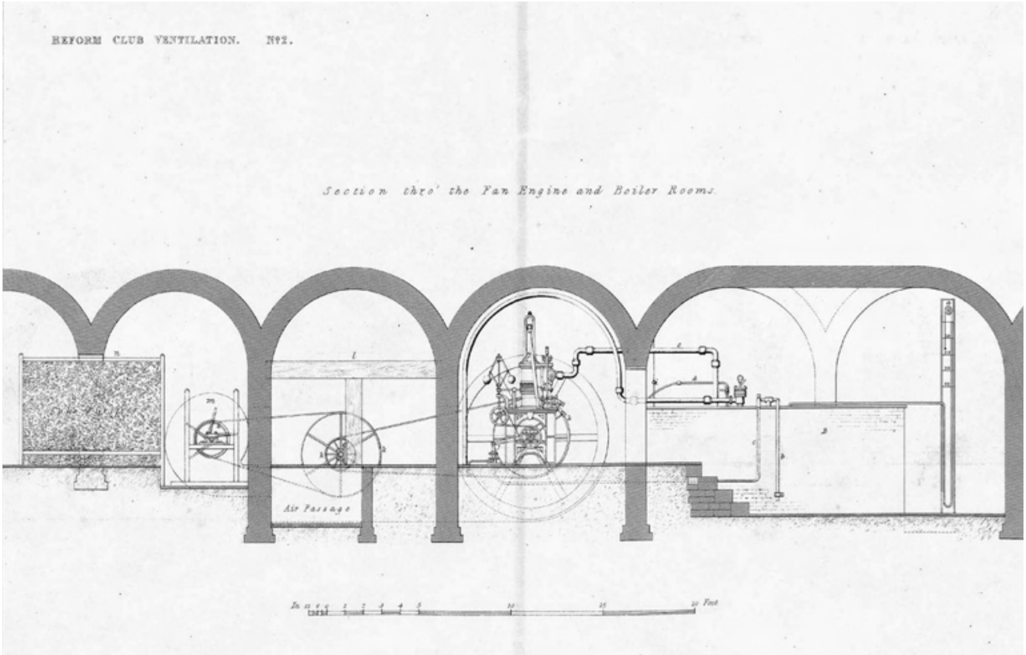
82
The Reform Club: floor plan, 1840

Taken as a whole, Barry's design conformed to the expectations while setting new standards of what constituted a nineteenth-century gentleman's club. On the one hand, the members were to enjoy the full range of amenities they were accustomed to at home under the roof of their club. Alongside a varied spatial program for the different social, business, and regenerative activities of the day, this in particular also included prompt service provided by a host of human and also increasingly mechanical servants. At the same time, the club was supposed to supply a male privacy and conviviality that the private home was, as a rule, unable to provide. To begin with, this above all meant the chance to gamble and consume alcohol, but with time these pursuits were supplemented by less frivolous forms of association.[204] The way in which the Reform Club successfully responded to these partly conflicting claims quickly made it the epitome of club and domestic culture in Great Britain. Soon after opening its doors, the building on Pall Mall became a coveted badge of belonging to the liberal yet noble British upper class. It is no coincidence that the club served Jules Verne as both the starting point and the sole necessary pedigree of his world-journeying protagonist in his 1873 *Around the World in Eighty Days*: "Phileas Fogg was a member of the Reform, and that was all."[205]

The Reform Club achieved its rapid fame not only because of its imposing exterior, its tasteful furnishings, and its illustrious membership, but above all due to the numerous technical refinements that Barry incorporated into the building. As opposed to the Houses of Parliament, where Barry was confronted with an independent ventilator, or Pentonville Prison, where he was simply responsible for designing the facade, in this case the building services were executed by contractual partners under his sole supervision. This did not mean that the individual appliances necessarily functioned any better—the heating and the ventilation in the club caused problems for many decades[206]—but unlike the Houses of Parliament they at least did not end in public controversy about the building. A cost-estimate submitted by the company Manby and Price during construction lists the following installations: "Bell hangings, Kitchen fittings, Gas fittings, Lifting machines, Lighting apparatus, Steam engine and well."[207] While the bell pulls, together with speaking tubes and the lifts, formed the communication system of the building, and the gas fittings supplied the lighting system and kitchen with fuel, the steam engine served as the literal linchpin of the overall building-service ensemble. → Fig. 83 Situated in a cavern outside the building, it pumped and heated tap water, propelled the total of five dumb waiters and goods lifts, powered numerous kitchen appliances, and formed the heart of the combined heating and ventilation system. This system, developed by the engineer John Oldham and installed by the Easton & Amos company, was based on the power of steam in a double sense: it heated air and simultaneously drove a ventilator, via which the air was then pumped into the rooms of the club through ducts and discreetly hidden apertures.[208]

Among these innovations, it was above all the Reform Club's cellar, the kingdom of its celebrated head chef Alexis Soyer, that secured it its eminent reputation. Soyer had been in charge of the club's gastronomic menu since its founding, and his extraordinary culinary creations had contributed in no small part to its social fame. Soyer had spent his career not only preparing dishes but he had also preoccupied himself with the design of the requisite premises and equipment, and the new building provided him with the first opportunity to realize his ideas within a spatial setting conceived entirely according to his ideas.[209] Together with Barry, he designed a complex in the basement of the clubhouse that would in time advance to become the most famous model kitchen in the whole of Europe. It is worthwhile quoting at length from one of the many contemporary descriptions of the kitchen, all the more so because in this case the perspective provided by the Vicomtesse de Malleville is presented as a glimpse into the "machine room" of the prestigious building.

> We now quit the upper regions and follow Mr Scott, the secretary of the club, and the politest and most obliging Cicerone in the world. Theatrically speaking, we have as yet only seen the stage and its sumptuous decorations from the boxes and pit; we now go behind the scenes, among the scene-shifters and machinists. But unlike in a theater, we

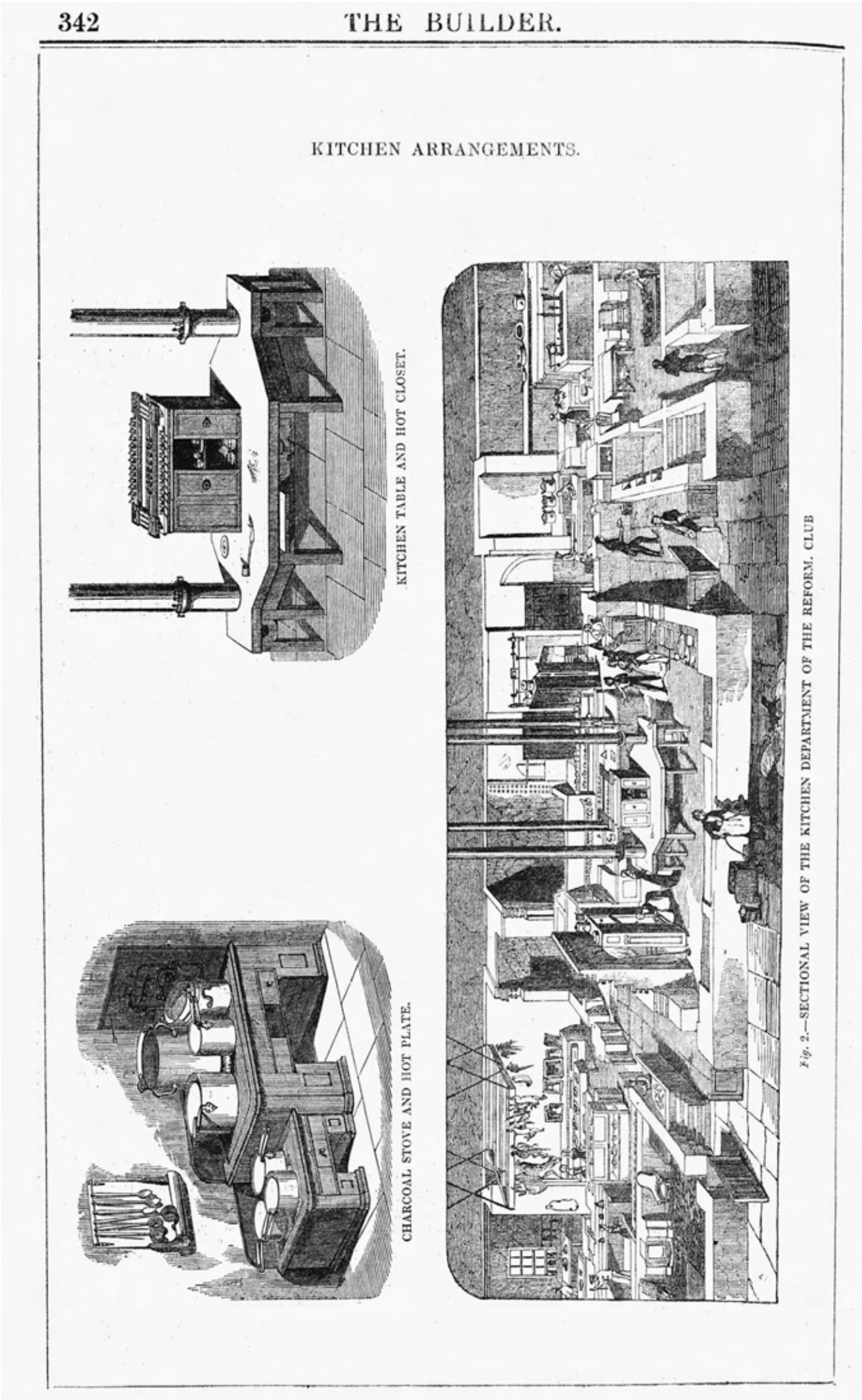


83
Heat and power source: the Reform Club's steam engine, 1840

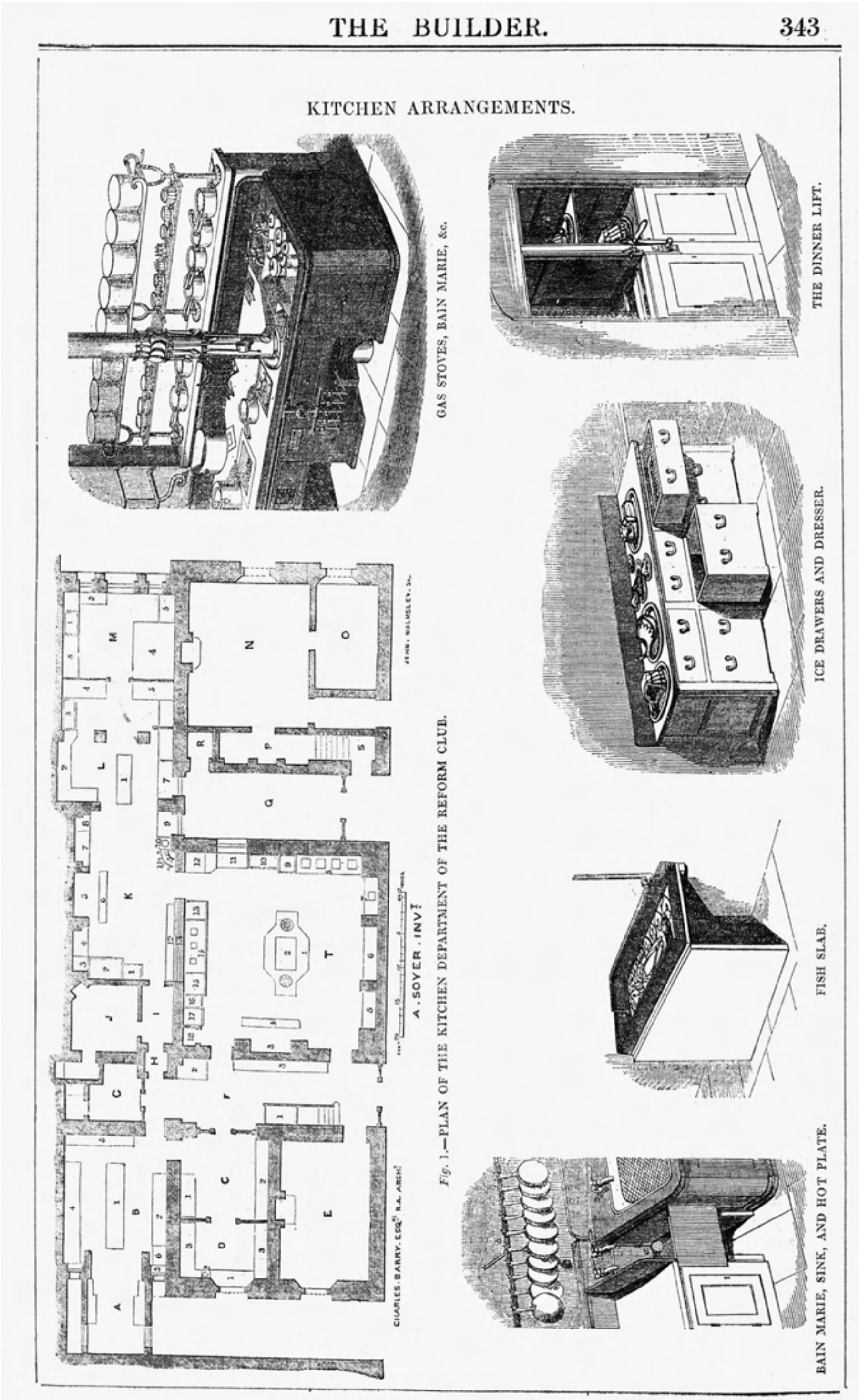
> see no naked walls behind the scenes—no tattered draperies—no floors strewed with sawdust. This fine apartment is the kitchen—spacious as a ball-room, kept in the finest order, and white as a young bride. All-powerful steam, the noise which salutes your ear as you enter, here performs a variety of offices: it diffuses a uniform heat to large rows of dishes, warms the dishes that have been called for, and that are in waiting to be sent above; it turns the spits, draws the water, carries up the coal, and moves the plate like an intelligent and indefatigable servant. Stay a while before this octagonal apparatus, which occupies the centre of the place. Around you the water boils and the stew-pans bubble, and a little further on is a moveable furnace, before which pieces of meat are converted into savoury rotis; here are sauces and gravies, stews, broths, soups, &c. In the distance are Dutch ovens, marble mortars, lighted stoves, iced plates of metal for fish, and various compartments for vegetables, fruits, roots, and spices. After this inadequate, though prodigious nomenclature, the reader may perhaps picture to himself a state of general confusion, a disordered assemblage, resembling that of a heap of oyster-shells. If so, he is mistaken; for, in fact, you see very little, or scarcely anything of all the objects above-described. The order of their arrangement is so perfect, their distribution as a whole, and in their relative bearings to one another, all are so intelligently considered, that you require the aid of a guide to direct you in exploring them, and a good deal of time to classify in your mind all your discoveries.[210]

The vicomtesse finishes her report with the sentiment that in an era of utilitarianism and the quest for the comfortable there was more to learn from this kitchen than from the remains of the Colosseum, the Parthenon, or ancient Memphis. And as it was, the rooms in the cellar of the Reform Club attracted so many visitors in the 1840s that it could indeed be said to vie with the sites of antiquity. This ostensibly back-stage tour of the building increasingly became part of a carefully staged orchestration, and Soyer himself stoked this curiosity with the help of various publications. After initially issuing a lithograph with a perspective section of the premises, he then went on to present the kitchen in detail in his richly illustrated bestselling cook books. → Figs. 84–85 With this, the endeavor to improve the contemporary art of cooking was explicitly tied to the improvement of contemporary kitchen appliances. “I dare hope,” declared Soyer, “that my humble efforts will have the effect of producing hereafter a reform in the art of building and fitting up a kitchen which, without being of an immoderate size, contains all that can be wished for as regards saving of time, comfort, regularity, cleanliness, and economy.”[211]

The Reform Club thus manifoldly meets the ideal of a building tailored to the specific requirements and activities of its occupants via numerous appliances, and it is moreover quite possible that Adolphe Lance envisaged the building on London’s Pall Mall in coining his dictum of the house as a machine in the early 1850s. As it is, Barry’s design exploits precisely those time- and power-saving economies that prompted the French author and architect to counter the customary stipulations of architecture with the vision of a building that interacts with its users like a technical object. Having said this, if the Reform Club embodies the mid-nineteenth-century concept of an “inhabited machine,” it similarly signals an end of the same concept—in the sense of a point at which the first signs of an exhaustion become evident and it began to be replaced by another concept. Significantly, these early indications of a shift express themselves again in the texts of a French architectural journalist, namely César Daly. From its outset, Daly’s *Revue générale de l’architecture et des travaux publics* had been obviously fascinated by English club architecture, and in its first volume had already crowned Barry’s buildings as model examples of a monumental private architecture.[212] Daly had journeyed to England in 1843, after which the journal had repeatedly announced the forthcoming appearance of a detailed report on the Reform Club,[213] but it would be almost another fifteen years before an extensive article about the London “Club de la Réforme” would appear in the pages of the *Revue générale*. And when it did, the building was not paired with the analogy of a comfort machine but figured as a serving organism.



84–85
Model kitchen: the kingdom of Alexis Soyer,
1846


THE BUILDER.
343
KITCHEN ARRANGEMENTS.
GAS STOVES, BAIN MARIE, &c.
THE DINNER LIFT.
ICE DRAWERS AND DRESSER.
FISH SLAB.
BAIN MARIE, SINK, AND HOT PLATE.
Fig. 1.—PLAN OF THE KITCHEN DEPARTMENT OF THE REFORM CLUB.
CHARLES BARRY, ESQ.RE R.A. ARCH.T
A. SOYER. INV.T

Daly's critique of the Reform Club opens with the usual praise for the many conveniences of a gentleman's club—"hotel, restaurant, café, reading room, conversation circle, etc., but all this in a discreet, dignified, honorable and distinguished style."[214] Then comes a detailed description of the nine elaborately designed illustrations—elevations, sections, and plans—accompanying the article. → Fig. 86 But what made the Reform Club a fundamentally modern building, explained Daly in the final part of the text, was not its facade or its floor plan, rather something more intimate, something imperceptible, but that nonetheless was evident persistently and everywhere in the form of a general comfort.

> This edifice is not an inert mass of stone, brick and iron; it is almost a living body, with its circulatory and nervous systems. In these walls, so motionless to the eye, circulate in fact gases, vapours, fluids, liquids; on exploring them one discovers flues, conduits, wires—the arteries, veins, and nerves of this new organic being—by which are carried warmth in winter, fresh air in summer, and in every season, light—warm water—cold water—food—and all the numerous accessories which a high civilisation demands. By these concealed roads the will itself travels, orders to servants pass, clocks are regulated, and, thanks to their aid, the abominable iron bell-wires cease to disfigure the corners of rooms. In this monument, modern science is our servant; she is prompt, obedient, nice (as she can be at pleasure), and discreet,—as all men know.[215]

A house as a body permeated by bloodstreams and nerves—with this comparison Daly picks up a topic that he had likewise already initiated in the 1840s. In an 1844 text in the *Revue générale* about heating and ventilation, he complained that a lot was known about the disposition, the proportion, and the construction of buildings, but that the finished architecture nevertheless often lacked a vital spark: "the building coming out of the hands of the architect is most often a still lifeless being; it is a superb corpse without breathing apparatus; it lacks the circulation of the pure air necessary for

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“New organic being”: the Reform Club (cellar level) in an illustration in the *Revue générale*, 1857

the supply of the people who live in it, and the means to evacuate the vitiated air, whose outflow it is important to organize as it is formed."[216] One aspect of this reference to a living building in this and the later Reform Club article is that it forms a statement about the general state of the architectural profession. In the one text, this encapsulates the question why architects refused to also extend applying imitations of nature, with which they were well acquainted, to other areas of building; in the other it concerns the observation that the growing complexity in the arts was not per se bad, but instead represented a natural progress.[217] At the same time, the concept of the organism in both cases acted as a way of concretely addressing how physical processes, such as the flow of substances and information, were transmitted through a building.

Daly's inclination to hypostatize architecture as a living being can be explained to a certain extent by his affinity to Fourierism. In his 1834 *Considérations sociales sur l'architectonique*, Victor Considerant had already termed the gallery of the *phalanstère* an artery that sustained the body of the building with life—"it is the channel through which life circulates in the great *phalansterian* body; it is the artery that carries the blood from the heart to all the veins"—and described the windows and doors of the houses in Paris as mouths struggling for air in the poisoned atmosphere of the city.[218] Very similar comparisons had also emerged with the spread of central heating and ventilation systems, in particular in connection with warm-water technologies where the structure of the building was virtually supplemented by a closed circulation system. "It has been frequently and aptly compared with the circulation of the blood in the human frame," wrote, for instance, the architect Charles James Richardson in 1837 on warm-water heating.[219] But Daly's choice of terminology also appears to substantiate a more profound shift in which two interconnected epistemological thrusts overlap. First, processes had been noted in the analysis of built structures for some time that could no longer or only to a very limited extent be described by mechanical analogies. Second, with the discovery of the vitalistic principle, since the beginning of the nineteenth century the concept of the organism had correspondingly assumed a new meaning, and with it for the first time a new explanatory potential that fundamentally distinguished it from that of the machine.[220]

These two epistemological shifts had already merged together in an exemplary form by the end of the 1830s in the work of the physician Pierre-Adolphe Piorry. In his inquiry into the impact of dwellings on their residents, amongst other aspects Piorry also dealt extensively with the subject of ventilation. In relation to the discussion concerning the amount of fresh air that should be fed into a room, he explained that it was insufficient to merely factor in the dimensions of the respective rooms and the size of their doors and windows: "Indeed, the smallest opening in an apartment is sufficient to mix the air from outside with that from inside."[221] As with the problem of damp, Piorry focused his attention on the element of the wall and the fact that substances could permeate into a building even through the tiniest of pores. As proof for this idea he took an example from the world of plants: although the pulses of the yellow bladder-senna were entirely sealed, an exchange of gases demonstratively took place between their inner and outer parts.[222] By this point, this type of phenomenon, where a transportation of substances occurred through separating layers, had already been subject to research in the natural sciences for several years. In 1826, the French botanist Henri Dutrochet had introduced the neologisms of endosmosis and exosmosis to describe this process,[223] which Piorry then translated to the field of architecture, together with the phenomena they described: "Whether these are phenomena of endosmosis, or whether they take place by any other cause, the facts prove to what extent gases have a tendency to mix, and the air from outside an apartment to penetrate into the interior."[224] After decades of using mechanical terms to describe the processes and techniques of ventilation—even stretching to the concept of buildings as "pneumatic machines"—this juncture signifies a rupture where the idea of mechanism was replaced by a genuinely organic model.

Daly's architectural criticism did not delve as deep as the field of osmotic processes, but it likewise adopted the concept of the organism in order to underpin his arguments with the latest natural-scientific findings. Almost throughout his entire time as editor of the *Revue générale* he developed a concept of organic evolution, according to which architectural details were not isolated elements but rather components in a transformational chain. Following the theories of Jean-Baptiste de Lamarck, this chain ran from a simple to a more complex stage in a process of permanently progressing transformations.[225] Ultimately, Daly would transfer this approach into a plea for an "organic school," which contrary to the backward-looking currents of the era would show the way to the architecture of the future. "We have named it thus," he wrote concerning this school, "because it is, in relation to the *historical* and *eclectic* schools, what *organized*, vegetable and animal *life* is, in relation to the *inorganized existence* of the rocks that form the *substratum* of the world; because it must sprout and develop in the manner of *living germs*, and not constitute itself like the minerals by way of *juxtaposition of inert elements*."[226]

It is precisely this vitalistic differentiation between the organized life of plants and animals and the unorganized existence of stones that also appears in Daly's characterization of the Reform Club. The ducts, tubes, and wires that permeate Barry's club building turn it into a "living body," thus crucially distinguishing it from the innate mass of common buildings. By using the expression of the organized being, Daly probably very deliberately exploits a term defined by Immanuel Kant in the *Critique of Pure Reason* in distinction to the machine. "An organised being is then not a mere machine," ran the passage in the book that first appeared in French translation in 1846, "for that has merely *moving* power, but it possesses in itself *formative* power of a self-propagating kind which it communicates to its materials though they have it not of themselves; it organises them, in fact, and this cannot be explained by the mere mechanical faculty of motion."[227] With this, the Reform Club marks not only a juncture at which technically assisted comfort reached its preliminary zenith in the cipher of the gentleman's club, but also the moment at which the operative qualities of comfortable living entered a new descriptive context—one in which the respective arrangements and installations no longer operate as the cogs of a machine but now represent the organ system of a living body. While this meant that aspects such as savings in time or force receded into the background, and those such as circulation or metabolism pushed to the foreground, one aspect nonetheless remained unchanged: the endeavor to highlight the processes and operations with which domestic comfort enveloped the bodies and daily lives of its inhabitants.

1 The plans were published posthumously in 1788 in book form. See Wood, *Series of Plans*, 3.
2 The five other principles demand that the buildings be convenient, at least 12 feet wide, built in pairs, constructed economically, and equipped with a garden. Ibid., 4–6.
3 Ibid., 1.
4 See Mühlmann, “Luxus und Komfort,” 173–87.
5 See Crowley, *Invention of Comfort*, 142–59.
6 Mandeville, *Fable of the Bees*, 109.
7 Ibid., 166.
8 “Of Luxury.”
9 On this, see Eleb-Vidal and Debarre-Blanchard, *Architectures de la vie privée*, 39–73.
10 Boffrand, *Livre d’architecture*, 11.
11 Ibid. On the history of the term *commodité*, see Szambien, *Symétrie, goût, caractère*, 85–91.
12 See Eleb-Vidal and Debarre-Blanchard, *Architectures de la vie privée*, 50–58. See also Antoine Quatremère de Quincy, *Encyclopédie méthodique: Architecture* (Paris, 1788), entry “Chambre.”
13 See Dubbini, “Idea of Comfort,” 86–88.
14 Blondel, *L’Homme du monde*, 92.
15 See Dubbini, “Idea of Comfort,” 88–89. On furnishings, see also Giedion, *Mechanization Takes Command*, 260–62, 305–18.
16 See Mühlmann, “Luxus und Komfort,” 184. For an English-language discussion of forms of distribution as “commodious” or “convenient,” see, for instance, Ware, *Complete Body of Architecture*, 321–28.
17 Fitzgerald, *Correspondence of Emily*, 419.
18 Clavering, *Building of Chimneys*, iii.
19 Ibid., 1.
20 Johnson, *Western Islands of Scotland*, 44.
21 See Crowley, *Invention of Comfort*, 216–23. On the essential role of the cottage in the British architectural discourse, see also Teyssot, “Cottages et pittoresque.”
22 See Maudlin, *Idea of the Cottage*, 1–16.
23 See ibid., 31–34.
24 Morris, *Rural Architecture*, n.p.
25 See Maudlin, *Idea of the Cottage*, 104–6. See also Lloyd, “Cottage Conversations.”
26 Kent, *Hints to Gentlemen*, 228.
27 Ibid., 232.
28 Wood, *Series of Plans*, 1.
29 Ibid.
30 Ibid.
31 Ibid., 24.
32 See Maudlin, *Idea of the Cottage*, 7–10.
33 Cited after Robinson, *Georgian Model Farms*, 109.
34 Bernard, “Account of a Cottage,” 415.
35 On this, see importantly Foucault, “The Subject and Power,” 789–90.
36 Wood, *Series of Plans*, esp. 23–27.
37 On this, based on Walter Benjamin and Sigfried Giedion, see Maldonado, “The Idea of Comfort.”
38 This differentiation is derived from a study of the emergence of the industrial workers’ town, in which Lion Murard and Patrik Zylberman distinguish between an “*intimité aisée*” and an “*intimité disciplinaire*.” Murard and Zylberman, *Ville, habitat et intimité*, 186–89. François Béguin describes comfort in this sense also as a “soft discipline.” Béguin, “Savoirs de la ville,” 253–63.
39 Middleton, *Picturesque and Architectural Views*, 1 and plate III.
40 Repton, *Observations*, 137–38, 142–43.
41 Ibid., 2.
42 Roscher, *Principles of Political Economy*, 230.
43 Chabannes, *Prospectus*, viii.
44 Ibid., xiv–xv, 43–46.
45 On this, see Picard, *Illusion der Wirklichkeit*, 9–14.
46 Chabannes and Henderson, Nouvelles manières économiques. The patent was published as Chabannes and Henderson, “Brevet d’invention.” Nothing is known about James Henderson and his role in the project. The brochure was reprinted, together with extracts from the patent specification, under a false title and date as Chabannes, “Maisons entièrement automatiques.”
47 See, for instance, Chabannes, *Composition of Oeconomical Fuel*, iv, vi, 36.
48 See *Dictionnaire de biographie française* (1959), entry “Chabannes (Jean-Baptiste-Marie-Fréderic de)”; Meade and Saint, “Marquis de Chabannes.” See further Gallo, “Marquis de Chabannes.” The patent for a “Machine for separating coals” (British Patent no. 2364) was granted to Chabannes in December 1799. Woodcroft, *Alphabetical Index*, 96. *Composition of Oeconomical Fuel*, Chabannes’s first publication, appeared two years later. At the same time as acquiring the French patent for his Project for New Houses, Chabannes also received one for a method of constructing public coaches. See Chabannes, Voitures dites vélocifères.
49 Chabannes, *Forced Ventilation*, iii.
50 See Girouard, *English Country House*, 262–66. For France, see Perrot, *Sonnettes à domestiques*. On the wind-driven roasting spit and other early kitchen devices, see Benker, *In alten Küchen*, 39–41.

51 As in Chabannes's design, the house on Brompton Row was equipped with double windows, a heatable gallery, folding-out furniture, the latest stoves in the kitchen and living rooms, as well as an extendable dining room. See Pictet, "Neuvième lettre," 386–92. On this, see also Ellis, *Benjamin Thompson*, 426–29.
52 Chabannes, *Prospectus*, xiii–xiv.
53 Ibid.
54 Chabannes and Henderson, Nouvelles manières économiques, 83.
55 On this, see also Sprenger, "Elektrifizierte Schwellen," with the example of the electric bell, which became popular in the 1830s.
56 For the decorative use of cast iron, see Gloag and Bridgewater, *Cast Iron in Architecture*, 53–56. On the general spread of iron as a building material, see Guedes, "Iron in Building"; Schädlich, *Eisen in der Architektur*.
57 See Bannister, "First Iron-Framed Buildings."
58 In his memoirs, written in the 1790s, Casanova wrote that during his stay in St Petersburg he had visited a house belonging to the industrialist Pavel Grigorievich Demidov that was entirely built of iron, right down to the furniture. See Casanova, *Mémoires*, 119.
59 On this, see especially Chabannes and Henderson, Nouvelles manières économiques, 69–72.
60 See Peters, *Building the Nineteenth Century*, 40–42.
61 For a short overview, see Glasze, "Bewachte Wohnkomplexe."
62 Chabannes, *Prospectus*, 10.
63 For an essential overview, see Krajewski, *The Server*, 250–94.
64 Chabannes, *Prospectus*, 1–42.
65 Chabannes and Henderson, Nouvelles manières économiques, 13–14.
66 Latour, *La clef de Berlin*, 33–46.
67 For a central text, see Foucault, "Preface." On hygiene, see Rey, "Hygiène"; Sarasin, *Reizbare Maschinen*.
68 See *Dictionnaire de biographie française* (1959), entry "Chabannes (Jean-Baptiste-Marie-Fréderic de)."
69 Chabannes, *Prospectus*, xiv. As with its English counterpart, the French term "*communication*" also encompasses a wide spectrum of material and immaterial processes: "It sometimes designates the *idea of sharing* or *of transfer*, as in *communication of movement*; that of *contiguity*, *community*, & *continuity*, as in *communication of two canals*, *doors of communication*; that of *exhibition by one person to another*, as in *communication of pieces*, &c." *Encyclopédie ou Dictionnaire raisonné des sciences, des arts et des métiers* (1753), entry "Communication."
70 Chabannes, *Prospectus*, 2, 10.
71 Ibid., 41–42.
72 See Simo, *Loudon and the Landscape*, 1–16.
73 Loudon, *Country Residences*, 137–41.
74 Ibid., 346–49.
75 Loudon, *Encyclopædia*, 1.
76 The reader recommended a particular plate-warmer to the journal, the reason being "as you study comfort." Wilson, "Plate-Warmer," 216.
77 Loudon, *Encyclopædia*, 2.
78 *The Architectural Magazine* 1 (1834).
79 See Simo, *Loudon and the Landscape*, 5–6, 97–110, 247–48.
80 On the patent system in general, see Dutton, *Patent System*; Sullivan, "The Revolution of Ideas." For a content overview, see Woodcroft, *Subject-Matter Index*, 112–29.
81 See Woodcroft, *Alphabetical Index*, 165. On Dodd's further projects, see James, "Ralph Dodd."
82 Phair, *Observations*.
83 See Simo, *Loudon and the Landscape*, 111–18; Guedes, "Iron in Building," 196–99.
84 Loudon, *Construction of Hothouses*, 71.
85 On Kewley's invention and the history of the temperature regulator stretching back to the seventeenth century, see Ramsey, "Thermostat or Heat Governor."
86 Loudon, *Construction of Hothouses*, 71.
87 Loudon, *Encyclopædia of Gardening*, 926.
88 See Sheets-Pyenson, "Popular Science Periodicals." In general, see also Cantor and Shuttleworth, *Science Serialized*.
89 For an overview of the British technical journals up to 1830, see Guedes, "Iron in Building" (Appendix A), 6–112.
90 On this, see Dewis, *Loudons*; Hultzsch, "From Encyclopaedia to Magazine."
91 Redivivus [Bridges Adams], "Better Housing," 170.
92 Loudon, "Colleges for Working Men." Shortly afterward, Adams in turn showed that he had a high opinion of Loudon's project. See Redivivus [Bridges Adams], "Colleges for Working Men."
93 Crabb, *English Synonymes Explained*, 234.
94 Meyler, *Observations on Ventilation*, 194.
95 Loudon, *Encyclopædia*, 94.
96 Ibid., 699–702, 711–15, 733–70.
97 "Introduction," 2.
98 On this, with the example of the architectural image, see Picon, "Traité à la revue."
99 Kent, "Choosing a Dwelling-House"; Loudon, *Encyclopædia*, 8–26.
100 Loudon, *Encyclopædia*, 8.

101 Set against this background, Philippe Gresset states that Loudon's houses and gardens related to each other like the dynamic and energetic forces of a machine, although there is no such formulation in Loudon's own writing. See Gresset, "1830." See further Macarthur: "Colonies at Home."
102 Loudon, *Encyclopædia*, 9–20.
103 Ibid., 8.
104 See Balzac, "La Fleur des pois," 31. The term was also used in later versions of *La Peau de chagrin* (1831), as well as in *La Vieille fille* (1837), *Honorine* (1843), *La Rabouilleuse* (1843), and *Le Cousin Pons* (1847).
105 *Complément du Dictionnaire de l'Académie française* (1842), entry "Confort." The supplement to the *Dictionnaire national* of 1856 still lists both terms alongside each other under the same definition. See *Dictionnaire national ou dictionnaire universel de la langue française* (1856), entry "Comfort ou Confort." The subsequent editions of both dictionaries in 1870, respectively 1878, only listed *confort*. The early adherence to the Anglicism may well be connected to the fear that the new English meaning of comfort might be confused with the original French one (in the sense of reinforcement and assistance). On this, see Arnault, "Sur quelques mots anglais," 245–47.
106 Nodier, *Examen critique des dictionnaires*, 117.
107 See Lipstadt, "Early Architectural Periodicals." For an alphabetical index of all French-language architectural journals between 1800 and 1970, see Leniaud and Bouvier, *Les Périodiques d'architecture*.
108 "Prospectus et specimen," 2.
109 "Review," 43–44.
110 "Architecture civile," 3.
111 The *Propriété* was initially absorbed into the *Journal des travaux publics, des beaux-arts, du commerce et de la propriété*, which a year later became the *Moniteur industriel*. See Leniaud and Bouvier, *Les Périodiques d'architecture*, 273. On the *Revue générale* and its position in the history of the French architectural press, see Saboya, *Presse et architecture*, 65–68.
112 See Van Zanten, "Form and Society"; Becherer, *Science Plus Sentiment*, 1–14.
113 Daly, "Introduction," 6.
114 Daly, "Voyage d'un architecte," 157.
115 Daly, "Adresse a nos lecteurs," 450. On this, see also Saboya, *Presse et architecture*, 124–27, 190–91.
116 On this, see also Lipstadt, "Housing the Bourgeoisie."
117 Daly, "Architecture domestique de Paris."
118 Daly, "Architecture domestique monumentale," 199.
119 See Saboya, *Presse et architecture*, 127–136. See also Papayanis, "César Daly."
120 On this and the general influence of Utopian Socialism on French architecture, see Centre de recherche architecturale, *Socialisme utopique et architecture*; Marrey, "Les Realisations des utopistes."
121 See Fourier, *Traité de l'association domestique-agricole*, 36–42; Fourier, *Le Nouveau monde industriel*, 149. Based on the Fourierist terminology, Walter Benjamin described the *phalanstère* as "machinery," albeit referring only indirectly to its architecture. Benjamin, "Paris," 166.
122 Considerant, *Considérations sociales sur l'architectonique*, 39, 44.
123 Barthes, *Sade, Fourier, Loyola*, 112.
124 Considerant, *Considérations sociales sur l'architectonique*, 44–48.
125 Girardin, "Lettre III," 282.
126 Cousin, "Du Beau," 418.
127 Daly, "Architecture privée monumentale," 328.
128 Daly, "Du Chauffage"; Perreymond, "Salubrité publique"; Romand, "Maison sous verre"; Jobard, "Architecture métallurgique." A thematically arranged overview of the contributions to the *Revue générale* is provided in Debarre and Eleb, *Architecture domestique*, 82–92. On the spread of the corresponding technologies in France, see also Charpy, "Le Théâtre des objets," 23–141.
129 Daly, "Rabelais," 198.
130 Aubert, "Moers parisiennes."
131 Ibid.
132 See Evans, "Rookeries and Model Dwellings," 26; Béguin, "Savoirs de la ville," 217–24, 253–63. See further Wohl, *The Eternal Slum*, 1–20.
133 See La Berge, *Mission and Method*, 18–26; Coleman, *Death Is a Social Disease*, 14–24.
134 Lachaise, *Topographie médicale de Paris*, 203.
135 Ibid., 125, 149.
136 Petit, "Conseil de salubrité," 343.
137 Lachaise, *Topographie médicale de Paris*, 8.
138 Dupin, *Le Petit Producteur français*, 102.
139 "Prospectus," vii.
140 Vincent, "Fabrication économique," 118–19. On this, see also Browne, "L'Air du logement," 16–17.
141 Petit, Trébuchet, and Rohault de Fleury, *Rapport sur la salubrité*, 19.
142 Along with inquiry reports on the individual Paris neighborhoods and specific building types, an official concluding report, with contributions by Villermé and Parent-

Duchâtelets, was issued as Benoiston de Châteauneuf, *Choléra morbus dans Paris*. On this, see Le Meé, "Le Choléra."

143 Piorry, *Les Habitations privées*, 90–91.

144 Ibid., 55–56, 87–88. On this, see also Browne, "L'Air du logement," 119–22.

145 Piorry, *Les Habitations privées*, 93.

146 See, for example, relating to the ventilation of urban children's homes, Arnott, "Reception of Pauper Children."

147 UK Parliament, *Health of Towns*, xiv.

148 On this and the sanitary movement in general, see Rosen, *History of Public Health*, 106–21; Tarn, *Five Per Cent Philanthropy*, 1–2.

149 UK Parliament, *Sanitary Condition*, 98–153.

150 Commissioners for Inquiring into the State of Large Towns and Populous Districts, *First Report*, xxiv. The contributors also included the "ventilator" David Boswell Reid. See ibid., 118–19.

151 Ibid., 29.

152 See Tarn, *Five Per Cent Philanthropy*, 3–10.

153 "Improvement of the Dwellings," 286.

154 On Gavin, see Spriggs, "Hector Gavin."

155 Gavin, *Habitations*, vii.

156 Ibid., 24.

157 Ibid., 11, 78. The label "sanitary architect" became more widespread, especially after it was used in 1858 by the well-known naturalist Richard Owen in his capacity as the president of the British Association for the Advancement of Science. See Owen, "Address," cii.

158 The book is based on a lecture that Roberts gave in January 1850 to the Royal Institute of British Architects. On Roberts, see Curl, *Henry Roberts*, 11–61.

159 See Tarn, *Five Per Cent Philanthropy*, 15–20.

160 Roberts, *Dwellings*, 6.

161 Ibid., 9.

162 UK Parliament, *Sanitary Condition*, 274.

163 Roberts, *Dwellings*, 10–11. On this, see also Curl, *Henry Roberts*, 87–97.

164 For Louis-Napoléon Bonaparte's commitment and social housing in France in general, see Guerrand, *Propriétaires & locataires*, 99–109. .

165 On this, see the overview in Bullock and Read, *Movement for Housing Reform*, 286–92.

166 Daly, "Architecture rurale," 67–68.

167 For the sixth year alone, see Daly, "Nouvelle architecture"; Daly, "Nouvelle architecture domestique"; Daly, "Architecture domestique économique"; "Des habitations des ouvriers." The latter represents a series of extracts from Ducpétiaux, *L'Amélioration des habitations*, the first French-language publication dedicated entirely to workers' tenement buildings.

168 See Bullock and Read, *Movement for Housing Reform*, 289–91.

169 Dameth, *Cités de l'union*, 6–7.

170 Harou-Romain, "Des Cités ouvrières." On the discussion surrounding the Cité Napoléon, see also Guerrand, *Propriétaires & locataires*, 79–82.

171 Villermé, "Sur les cités ouvrières," 248. The essay also appeared as a monograph in the same year.

172 Ibid., 258. For a detailed treatment, see Murard and Zylberman, *Ville, habitat et intimité*, 151–74.

173 On the project and its origins, see Curl, *Henry Roberts*, 97–108; Leckie, "Exhibition Model Dwellings."

174 Morley, "Mr. Bendigo Buster," 339.

175 On this, see also Evans, "Rookeries and Model Dwellings," 31–32.

176 Gavin, *Habitations*, 72–73.

177 Society for Improving the Condition of the Labouring Classes, *Plans and Suggestions*, 4.

178 Gavin, *Habitations*, 39.

179 Morley, "Mr. Bendigo Buster," 338–41; Society for Improving the Condition of the Labouring Classes, *Plans and Suggestions*, 4.

180 See Curl, *Henry Roberts*, 97–98.

181 Morley, "Mr. Bendigo Buster," 338–39.

182 Gavin, *Habitations*, 30.

183 Lance, "Traité d'architecture," 68.

184 On Lance's life and work, see Bouvier, *L'Édition d'architecture*, 124–35.

185 See Lance, *Acoustique et optique*.

186 Lance, *L'Assainissement des maisons insalubres*.

187 See "Ferronnerie"; "Assainissement des habitations"; Gourlier, "Des Voies publiques."

188 Crayon [Irving], *Bracebridge Hall*, 38. On the genesis of Irving's novel, see Jones, *Washington Irving*, 201–32.

189 Hessemer, *Arabische und alt-italienische Bau-Verzierungen*, 20. The second edition of Hessemer's book appeared in 1852, and thus a year before Lance made his machine comparison.

190 Souvestre, *Le Monde*, 54–55 and 63.

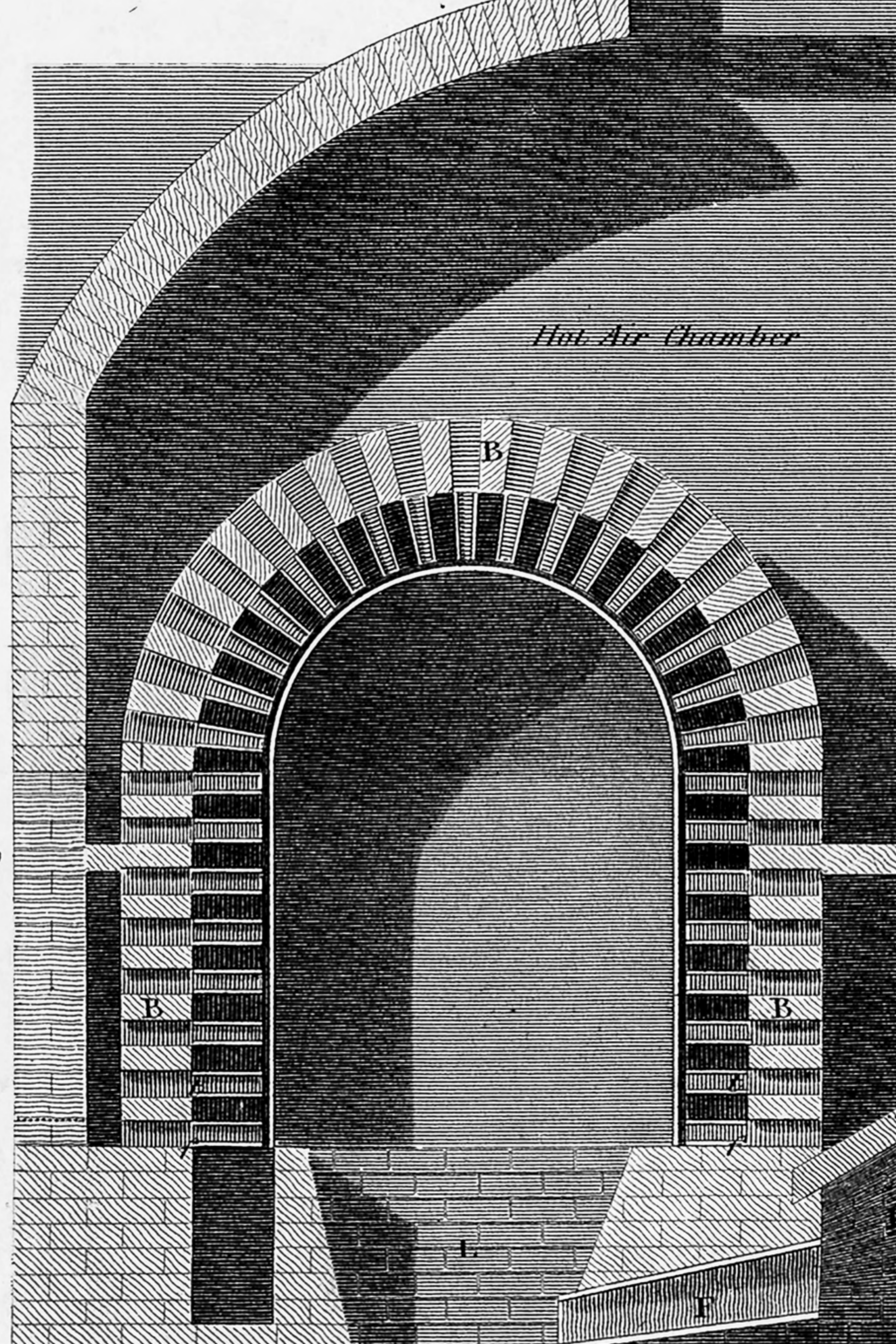
191 See Pevsner, *Some Architectural Writers*, 203–7; Middleton, "Reynaud and Viollet-le-Duc," 36–37, 47.

192 Reynaud, *Traité d'architecture*, vi, 3–4. The second volume of Reynaud's treatise appeared in 1858 and dealt with compositional principles, architectural elements, and building types.

193 Ibid., 448.

194 Lance, "Traité d'architecture," 34, 48, 68–69.

195 Ibid., 68.
196 Reynaud, *Traité d'architecture*, 10. On this, see Bressani, *Eugène-Emmanuel Viollet-le-Duc*, 267–302. Reynaud had already made a similar comparison in 1834 in an article for the *Encyclopédie nouvelle*. See Bergdoll, *European Architecture 1750–1890*, 15.
197 Lance, "Traité d'architecture," 49–50.
198 Cited after Lucas, *Adolphe Lance*, 25–26.
199 Lance, *L'Assainissement des maisons insalubres*, 5.
200 Lance, "Traité d'architecture," 68.
201 *London Interiors*, 148.
202 For the development of the gentleman's club from the London coffeehouse, see Milne-Smith, *London Clubland*, 18–28. On the history of the Reform Club, see Woodbridge, *Reform Club*, 1–9.
203 On this and club architecture in general, see "Reform Club"; Olley, "Reform Club."
204 See Milne-Smith, *London Clubland*, 109–21.
205 Verne, *Around the World*, 2.
206 See Woodbridge, *Reform Club*, 54, 61–62.
207 Ibid., 59. The tendering for the installations is given with precise requirements in Davy, "Specifications," n.p.
208 Ure, "Reform Club"; Spencer, "System of Combining." On John Oldham's heating and ventilation system that was previously installed in the Bank of England, see also Williams, "Mr. Oldham's System."
209 See Bhattacharya, "Kitchen Magic"; Cowen, *Relish*, 41–42, 47.
210 "Club Houses," 79–80. The Vicomtesse de Malleville's report originally appeared in French in the *Courier de l'Europe*.
211 Soyer, *Gastronomic Regenerator*, 629. On this, see also Cowen, *Relish*, 61, 88–107.
212 Daly, "Architecture privée monumentale."
213 "Petite Correspondance"; Daly, "Introduction," 4–5. For Daly's journey to England and his acquaintance with Barry, see Saboya, *Presse et architecture*, 158, 290–91.
214 Daly, "Reform Club," 343–44.
215 Ibid., 346–47. The English translation of this passage comes from a presentation of the *Revue générale* that appeared two years later in the *Builder*. See "French Opinions," 481.
216 Daly, "Du Chauffage," 118.
217 Ibid.; Daly, "Reform Club," 347.
218 Considerant, *Considérations sociales sur l'architectonique*, 12, 39.
219 Richardson, *Popular Treatise*, 21. Amongst other sources, Richardson is probably referring here to Chabannes, *Forced Ventilation*, 62–63, or to the appendix of the same publication.
220 For the historical setting of this development, see Foucault, *Order of Things*, 263–79; for its content dimension, Canguilhem, "Machine and Organism."
221 Piorry, *Les Habitations privées*, 88.
222 Ibid.
223 Dutrochet, *L'Agent immediat*, 115, 126. The example of the fruit of the yellow bladder-senna probably comes from Bérard, "Maturation des fruits."
224 Piorry, *Les Habitations privées*, 88.
225 See Becherer, *Science Plus Sentiment*, 92–103.
226 Daly, "Ma nouvelle publication," 164.
227 Kant, *Critique of Judgement*, 278.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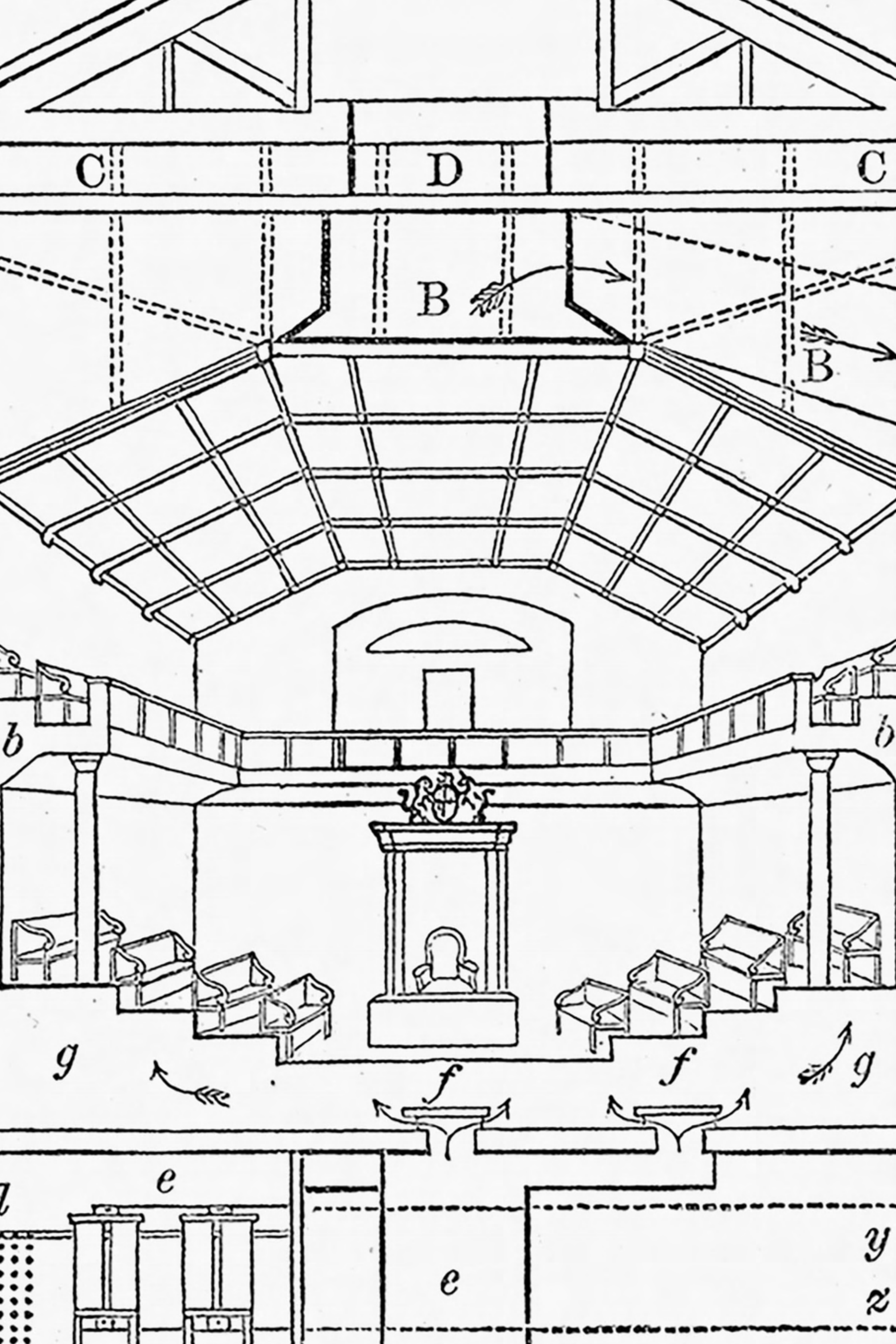
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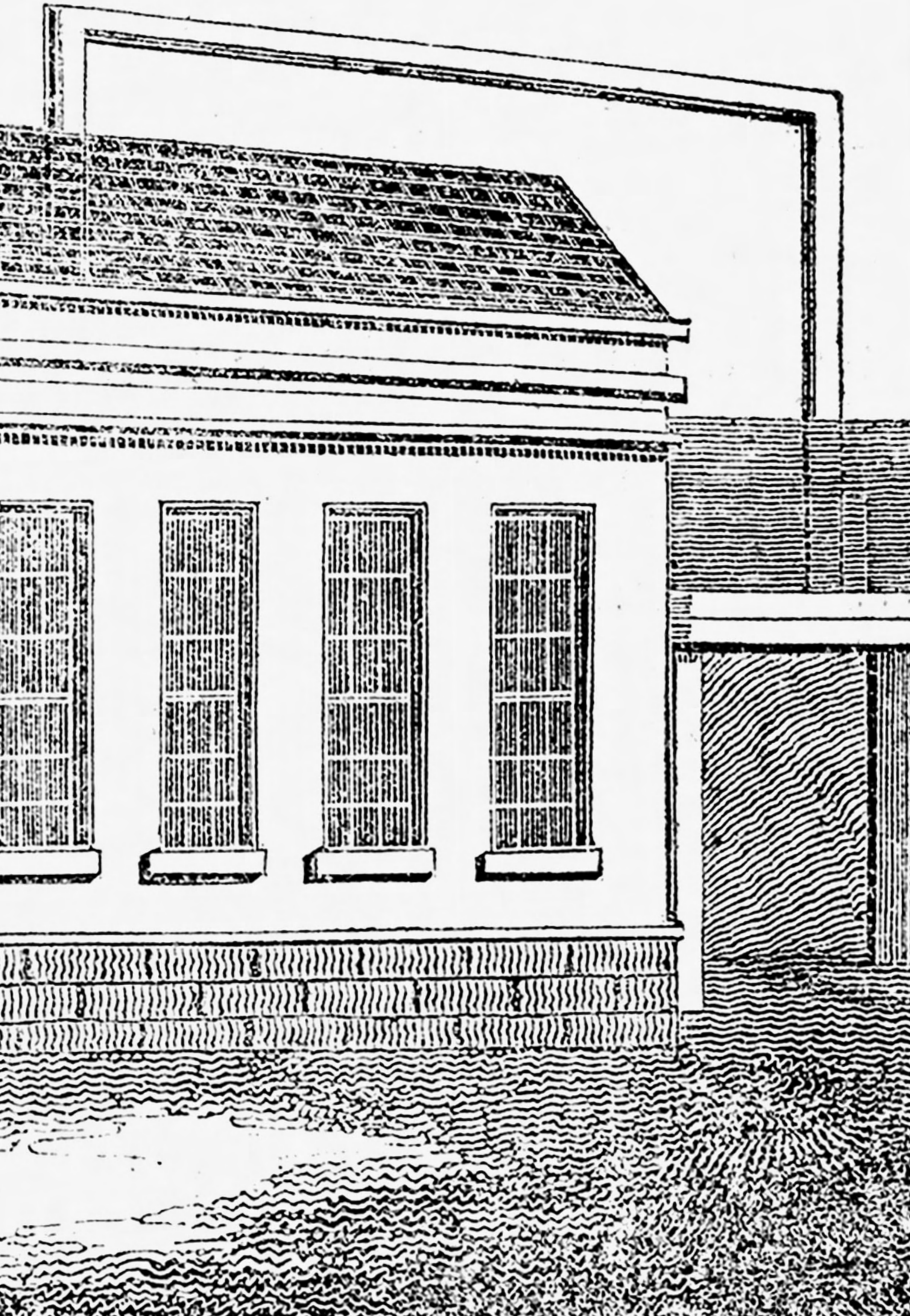

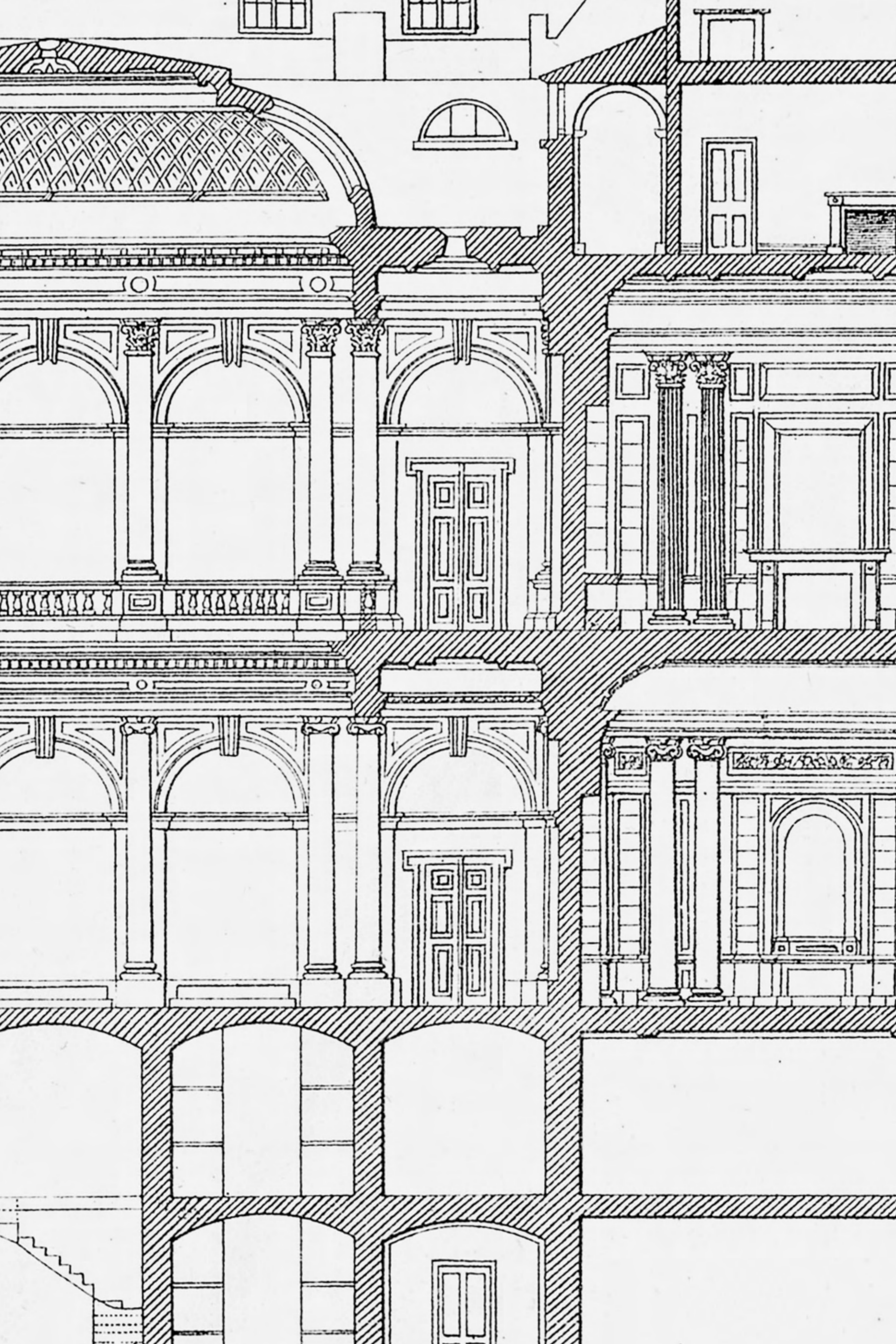

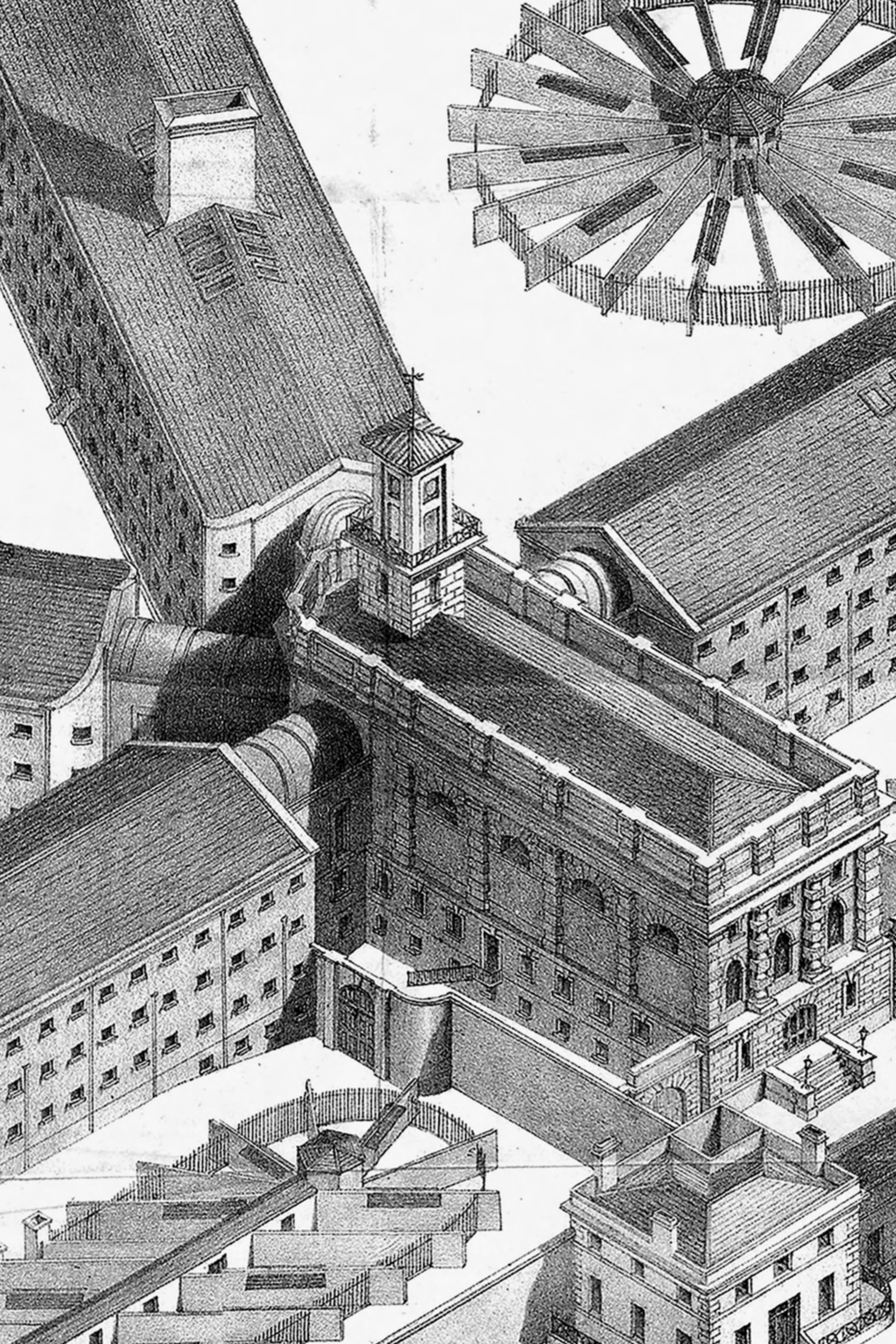

CONCLUSION

When, in the middle of the nineteenth century, the *Encyclopédie d'architecture* called on its readers to conceive the house as a machine, this—as this current study shows—had already been carried into effect dozens of times beforehand. Over the preceding decades, numerous authors had preempted the French architectural critic Adolphe Lance and exploited the terminology of machines and mechanisms to describe architectural objects and contexts. From the late eighteenth century onward, certain areas of architecture, such as institutional building, show themselves to have been veritably infused with a mechanical logic. Despite this, the built environment was barely an exception in this respect—in fact, there was hardly an area of life in the first half of the nineteenth century that was not associated with some form of machine or mechanical thinking. For this reason, already in 1829 the Scottish essayist Thomas Carlyle had pronounced the ushering in of a new era:

> It is the Age of Machinery, in every outward and inward sense of that word; the age which, with its whole undivided might, forwards, teaches and practises the great art of adapting means to ends. Nothing is now done directly, or by hand; all is by rule and calculated contrivance. For the simplest operation, some helps and accompaniments, some cunning abbreviating process is in readiness.[1]

Devoid of mechanical understanding, said Carlyle, nothing was any longer understandable.

Notwithstanding its ubiquity, this machine reasoning had widely differing motives, trajectories, and consequences in the manifold fields in which it was applied. Taking the example of architecture, it becomes evident that even within the boundaries of one and the same discipline, thinking "mechanically"—i.e., to follow Carlyle, by applying the art of means and ends—had very different meanings. Strictly speaking, the three discursive contexts traced in this study actually each produced their own respective machine concepts: from the "climate machine" to the "moral machine" and stretching to the "comfort machine." Below, to conclude, is a short recapitulation of the differences and singularities of these varying architectural concepts, before the focus turns to the commonalities that allow them to be jointly treated under the transcending and connective idea of the house as an "inhabited machine." Lastly, a series of reasons are presented as to why the genealogy of the concept can be rightly seen as having reached a preliminary close in the mid-nineteenth century.

In terms of the subject of indoor climate, it becomes apparent how the emergence of new ventilation and heating techniques and their development as central building-service systems led to an understanding of the building as a "pneumatic apparatus." The degree of conceptual abstraction involved was comparatively small: the apparatus or rather machine terminology served first and foremost to explicate the systematic relationship between the building structure and the surrounding atmosphere and the climatic and thermodynamic processes that took place within it. The application and combination of architectural elements as partitions, openings, or valves are thereby set in a direct relationship to those mechanical elements used in the operation of devices such as the air pump. However, addressing the issue of climate control not only created an understanding of the building shell as a technical object that treated architecture as an operator of atmospheric conditions, but moreover resulted in an idea of the residential environment as a physical milieu or "medium" that was intricately connected to the organism of the inhabitant.

In terms of morals, on the other hand, it becomes clearly evident how the application of architecture for the conduct and disciplining of individuals led to the concept of built space as a "moral machinery." Like climate technology, the aim, as a rule, was to exploit architectural means to organize temporally consecutive processes, with the decisive difference being that instead of relating to natural entities, such as air, these apply to living bodies. For this reason, the construction of “moral motors” did not simply exhaust itself in material arrangements, rather it involved hybrid assemblages of architecture, individuals, and rules, aimed, on the one hand, at actions such as walking, looking, or hearing, and, on the other, the contents of the human mind and spirit. While the physical connotations of the architectural machine concept thus increased, at the same time its level of abstraction also grew. Besides the technical-mechanical condition of built structures, this concept also addressed the constructional interrelationship between the parts and the whole, as well as ideals of frictionless spatial organization.

Lastly, in connection with comfort, it has been demonstrated how a new awareness for the general circumstances and amenities of domestic living created an idea of houses as “comforting machines.” As a wide-sweeping and predominant concept with which to designate the quality of habitation, comfort assumed a synthesizing role vis-à-vis the topics of climate and morals. This was due to the fact that the state of being comfortable was based, among other factors, on both the use of climate technologies and the spatio-temporal organization of human activities, including the actions of servants and those served upon alike. The chores that were lightened, shortened, or eliminated through comfort do not equate to a simple dichotomy between freedom of action and external control but instead also encompass forms of self-service and self-disciplining. This is a crucial point, because it expounds the problems of a deterministic understanding of architectural machine concepts: to the same extent that it involves the conduct of others, it can equally apply to the conduct of oneself. The concept of the architectural “comfort machine” merges these aspects together in the image of a time- and effort-saving technical device, ranging from the concrete demand of adapting building services and domestic fittings to meet the economy of movement of the inhabitants to the more abstract notion of the house as a means of enhancing the social power of production.

The underlying common denominator in all three concepts—apart from the fact that each of them involves an ideal belief that soon jars with reality—consists of them all being centered on reflections concerning the operativity of architecture in the sense of its immediate physical impact on certain natural or social circumstances. In its varying formations, shades, and degrees of abstraction, the concept of the architectural machine always refers to the concrete material efficacy of particular spatial layouts or situations. In this, both the aim and the premise—even when ostensibly involving controlling air flows, structuring organizational processes, or introducing technical refinements—always concern the inhabitants. Contrary to what is sometimes claimed, as both an actual and metaphorical process the "mechanization" of architecture in the first half of the nineteenth century therefore resulted not in the exclusion of the human being[2] but rather conversely in an increasingly closer connection between the built and their bodies, actions, and thinking. This common denominator between the problems of climate, morals, and comfort is moreover reinforced by a series of specific motifs that have been recurrent themes throughout all three parts of this book.

A first motif, which runs through many of the projects examined, is that of experimentation. One of the very first machine concepts dealt with in this book already established an explicit link between the spatial processes of architecture and the empirical methods of natural philosophy. Thus, when the French physician Jacques Tenon referred to the hospital as a "*machine de physique*" in 1788, the image he conjures up is not that of common working machines, but rather those that assist, as laboratory apparatuses, in the experimental chambers of his time in conducting scientific tests and in generating new knowledge. This experimental approach to built space was subsequently repeatedly stressed, regardless of whether it concerned techniques of climate control, institutions for the improvement of morals, or the design of comfortable surroundings. One reason for the growth of this approach undoubtedly lay in the popularization of science since the seventeenth century, in the course of which a general understanding of empirical procedures became widespread.[3] However, the boom in the experimental also rests in the fact that an architecture that focused on an immediate interaction with its inhabitants was hard to perfect simply on paper. For an increasing number of tasks that buildings were expected to perform since the late eighteenth century, just as with the machines of the era, any estimation of their success or failure could only take place after they had been concretely constructed and tried and tested in terms of their practical use. This is especially evident in the case of the series of trials undertaken by the military engineer Joshua Jebb and the natural researcher Michael Faraday in the 1830s in their attempt to design soundproof prison cells: only with the construction of numerous 1:1 models and the testing of these models under real conditions were they finally able to arrive at precise propositions for an optimal method of constructing the dividing walls. In this way, the operative perspective on space was often combined with an experimental approach to how to design it.

A second motif, which plays a manifold role in the foregoing analysis, is communication. This is only logical, in that between the seventeenth and the nineteenth centuries, thinking about machines was also intimately aligned to this same motif. As associated with machines, communication was addressed both in the sense of the conveyance of motion and power and in terms of its regulation and control.[4] In the architectural context, from around 1800 onward, the term "communication" began to be exploited across its full spectrum to the extent that it designated spatial linkages and material or ideal transmission processes in equal measure. Particularly in English, the word was applied, on the one hand, to architectural elements, for instance the corridor, and, on the other, to the processes that were to be controlled using the selfsame elements. This conjuncture once again demonstrates the synthesizing role played by comfort. Whereas in the framework of climate the endeavor is above all to promote communication in the form of installing channels of physical transmission, and in the case of morals conversely to stymie communication by blocking particular kinds of intellectual exchange, to a large extent comfort presents itself as the result of a negotiation process between forms of communication and anti-communication. The significance that generally conceived (anti-)communication processes thereby acquired is evident not least in the specific attention paid in the first half of the nineteenth century to the architectural element of the door, namely as a threshold where various of these processes overlap. In this study, doors repeatedly play a decisive part as simultaneously connecting and separating elements: be it as a hybrid device, which differentiates between dissimilar transmission processes, like William Blackburn's revolving doors or William Strutt's toilet entrances; or be it as an autonomous mechanism which regulates the action of closing, like Jean-Frédéric de Chabannes's security locks.

A third motif, which plays a key role in this analysis, is the arrow symbol. This visual element likewise occurs at critical junctures in various parts of the study. After appearing on architectural plans almost simultaneously in respect to climate and morals in around 1820, at the latest since the mid-nineteenth century it also finds genuine use in the context of comfort.[5] Thereby the arrow, and with it the kindred dashed line, not only connects the differing thematic fields of climate, morals, and comfort to each other, at the same time it is also closely tied to the motifs of experimentation and communication. Fundamentally, with the help of the arrow, architectural drawing acquires the opportunity to visualize temporal correlations. From here on, the standard information concerning geometry and statics could be supplemented by procedural and performative information, documenting the operations and relations intended to take place in the scaled spaces. With this, it became possible to depict movements, transmissions, or connections—in short "communications"—on an architectural plan. Besides its representational character, the arrow also possesses an instrumental one that corresponds to the experimental approach to building. By allowing spatio-temporal processes, such as the movement of airflows, to be tested on the drawing board, it could serve as a reflective tool to assist in decision-making already at the design stage. It is undoubtedly no coincidence that the arrow literally moved, both in its representational and instrumental functions, from technical to architectural drawings, embodying as it did the graphic counterpart to a discourse that treats inhabited space in terms of the machine.

Regardless of the peculiarities and differences that characterize the topics of climate, morals, and comfort, the web of commonalities and cross-references is so intricately interwoven that what it forms can be referred to as the emergence of a cohesive operative understanding of architecture. However, identifying the concept of the machine as the interconnecting element in this thinking is not a mere retrospective theoretical positing; instead, to a certain extent it was already determined during the examined timeframe itself. Not only did the appearance of the concept of the architectural machine in the pages of the *Encyclopédie d'architecture* earn it a seal of approval from an official organ of the architectural discipline, but Adolphe Lance in his 1853 article also dissociated it from the specific contexts it had hitherto been applied to. Firstly, this was because as applied to residential comfort his machine model occupied comparatively wide parameters, and secondly, because he used it in his critique of an architectural treatise that in turn sought to address the art of building in its entirety and spanned the vast arch from construction materials to building types. Thus, at the latest with Lance, the machine had advanced to become a general model of architectural description.

Nonetheless, at the same time—virtually simultaneously to it acquiring this ultimate badge of legitimization—various ruptures and bifurcations began to make themselves apparent with regards to the concept of the "inhabited machine." As shown in the last chapter of this book dealing with the notion of comfort, approaching the mid-nineteenth century the machine began to face competition from the organism in terms of its explicative potential. With the ascendency of the vitalistic principle, organic entities and processes provided a new alternative model for architectural demands. In addition to this shift between the image of the machine to that of the organism, two other caesura can be identified that occurred in around 1850 in terms of the image of the machine itself, both of which were to have a long-term impact on its use in the context of the built environment. While these ruptures represent crucial moments in the general history of the architectural machine concept, they also provide reasons why this particular study concludes, at least preliminarily, where it does, in that—expressed differently—they mark the beginning of a new chapter in the concept of the "inhabited machine."

The first caesura in the concept of the "inhabited machine" in the mid-nineteenth century concerns the understanding of the machine per se. This rupture was prominently addressed by Michel

Serres in the framework of his differentiation between mechanics, thermodynamics, and information theory, which Serres reads as three different historical paradigms whose applications and effects are not only restricted to technological and scientific theories but also encompass cultural and artistic expressions. According to Serres, the transition from the machine to the motor, or in that sense from mechanics to thermodynamics, was accompanied by a crucial transformation that he situates as having occurred in the 1820s with the thermodynamic findings of Sadi Carnot and Joseph Fourier, but definitively "before the (World) Expo."[6] The function of the steam engine— a key symbol of the Industrial Revolution—is based less on the spatial transportation of matter, than on in its transformation. As opposed to the classic machine that exploits a pre-existing motion, it uses heat to create force itself. Thus, with thermodynamics the mechanics of solid bodies gives way to the logic of fluent transfers, of transition and exchange, which finds an echo in numerous realms of living.[7] In relation to architecture, this change became evident at the latest toward the end of the nineteenth century. When the French novelist Émile Zola places a Paris department store at the center of his 1882 novel *Au Bonheur des Dames*, the model for the building was now that of a steam engine. "Denise began to feel as if she were watching a machine working at full pressure, communicating its movement even as far as the windows," reads the passage in which Zola's protagonist first observes the busy emporium.[8] In the following five hundred pages, the *Ladies' Paradise*—derived from existing buildings like the Grands Magasins du Louvre and the Au Bon Marché—is repeatedly hypostatized as a high-pressured steam engine, whereby this indeed applies above all to processes of transformation: from capital to goods, from wares to income, or from passersby to customers.[9] Here, the vectorial architecture machine has given way to a transformational architectural machine.

The second rupture that the concept of the "inhabited machine" underwent in around 1850 concerns a fundamental shift in terms of the architectural aspects described with the model of the machine. As the foregoing analysis has shown, up until the mid-nineteenth century machine connotations served primarily to emphasize the material and the spatial aspects of the built vis-à-vis its visual effect. From Jacques Tenon to Joshua Jebb, and stretching to Adolphe Lance, the machine was a means of promoting an architecture focused less on questions of style, proportions, or decoration, and more on those of immediate physical effects. However, in the course of the 1840s, a variant machine model began to be applied that aimed, quite to the contrary, to express stylistic or formal arguments. This shift can be seen especially in the theoretical works of the American sculptor Horatio Greenough, who not coincidentally is also considered a pioneer of functionalism and the formula "form follows function."[10] Greenough developed his corresponding arguments as part of his ideas of what could constitute genuine North American architecture. As he explained in his key text, first published in 1843, what the viewer perceived in natural objects as beautiful was not, for instance, particular forms or colors, but far more the consistency and harmony of the assembled parts, the subordination of the details to a whole—in essence the adaption of the forms to the functions.[11] As an example of the successful application of this rule in the field of human constructions, he introduces the image of the evolution of a hypothetical and initially bulky and cumbersome invention to it becoming a "compact, effective, and beautiful engine,"[12] coupled in particular with the object of the sailing boat: "Observe the ship at sea! Mark the majestic form of her hull as she rushes through the water, observe the graceful bend of her body, the gentle transition from round to flat, the grasp of her keel, the leap of her bows, the symmetry and rich tracery of her spars and rigging, and those grand wind muscles, her sails."[13] The thing that excites Greenough about motors and ships has very clearly less to do with the operative interaction between mechanical parts and far more to do with their mutual proportionality. With this, the machine has become something that is no longer the embodiment of an ideal only in its construction, use, and function, but also in its external appearance.

As such, Greenough's ideas are rooted in an artistic recognition of technological forms that in the decades that followed would be further refined by architects such as Eugène Emmanuel Viollet-le-Duc, and that would find their full apotheosis in the machine aesthetic and machine metaphors of classic modernism.[14] In turn, the transition from mechanical to thermodynamic systems and their further development in information-processing technologies continues to play a role in the computerization of architecture and architectural production, and still influences our understanding of the object and model of the machine to the present day.[15] But the concept of the “inhabited machine” traced here since the 1780s does not necessarily come to end because of this. For the various machine models neither fully supplant nor preclude each other—instead, they are perpetuated in tandem and continue to mutually overlap.[16] One of the most telling examples for this is at the same time one of the most famous, namely Le Corbusier’s concept of the *machine à habiter*—a fundamental mix of economic and visual arguments. Above all, however, the developments in the mid-nineteenth century did not mark the end of the understandings of built space whose emergence this study has tried to trace with the concept of the architectural machine: a recognition of the immediate technical, epistemological, and social effectiveness of architecture; an insight into the active role played by installations, architectural elements, and spatial layouts in natural and artificial contexts; an awareness of the intimate connections between the architectural structure and the health, attitudes, and actions of its inhabitants—in short, an operative knowledge of architecture.

1 Carlyle, “Signs of the Times,” 100.
2 See Lefaivre and Tzonis, “Mechanization of Architecture,” 140.
3 See, for instance, Stewart, *Rise of Public Science*.
4 See Séris, *Machine et communication*, 451–59.
5 See, for instance, the illustrations of shortened routes to increase “home comforts” with the help of dashed lines in Fowler, *A Home for All*, figs. 13–14.
6 Serres, “C’était avant l’exposition (universelle).”
7 See Serres, *Hermès IV*, 41–86.
8 Zola, *Ladies’ Paradise*, 16.
9 See Serres, *Feux et signaux*, 282–95.
10 See Kruft, *Geschichte der Architekturtheorie*, 400–403.
11 See Greenough, “American Architecture,” 57–8. See also Greenough, “Structure and Organization.”
12 Greenough, “American Architecture,” 59.
13 Ibid., 27. A very similar argument was developed a few years later by the English architectural historian James Fergusson. See Fergusson *True Principles of Beauty*, 157–58.
14 On Viollet-le-Duc, see Bressani, *Architecture and Historical Imagination*, 407–50. On later machine aesthetics, see, for example, Guillén, “Scientific Management’s Lost Aesthetic.”
15 On this, see, for example, Vrachliotis, *Geregelte Verhältnisse*, 199–229.
16 See the contributions in Gleich and Stalder, *Architecture/Machine*.


ARCHITECTURE.
BUILDING.
FURNISHING.
IRONMONGERY.
CABINET-MAKING.
JOINERY.
CARPENTRY.
MASONRY.
BRICKLAYING.
PLASTERING.
PAINTING.
PLUMBING. GLAZING.
SLATING. TILING.
BRIDGES. GATES.
ARCHITECTU. FENCES.
GARDEN ARCHITEC-
TURE.
ROAD-MAKING.
ENGINEERING.

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ACKNOWLEDGEMENTS

I would like to thank Laurent Stalder, who has supported this work since we first met in 2011 at a symposium in Weimar on “Service Architecture” and who invited me to ETH Zurich to pursue my project. I likewise thank Markus Krajewski—one of the organizers of the said symposium—who (together with Bernhard Siegert) excited my interest in architecture while I was studying media culture at the Bauhaus-Universität in Weimar, and who supervised the dissertation on which this book is based as a second assessor. My thanks to Barry Bergdoll for his willingness to critically read the dissertation in his role as third assessor. Any remaining deficiencies in the content of the text are naturally entirely my own responsibility.

The research for this study would have been impossible without the help of the many anonymous hands and machines that over the past decades have advanced the digitization of historical printed works. I am grateful to Thomas Skelton-Robinson for the faithful and fluent translation of the manuscript into English, Sue Pickett for the attentive proofreading of the resulting text and Jennifer Bartmess for the help with the index. Reto Geiser and the members of the board were kind enough to include this book in the series *Exploring Architecture*—to them, as well as David Marold and Bettina R. Algieri from Birkhäuser Verlag, my thanks for their invariably professional and friendly cooperation.

Finally, I would like to thank my parents Helma and Alfred Gleich, my wife Katja Gleich, and all my friends for having continually accompanied and supported me, regardless of how strange they must have thought my endeavor was at times.

ABOUT THE AUTHOR

Moritz Gleich studied communication and media studies at Freie Universität Berlin, Bauhaus University of Weimar and the University of California Santa Barbara. He then joined the Institute for the History and Theory of Architecture (gta) at ETH Zurich as a scientific assistant. Additionally, he taught at the University of Basel Institute of Media Studies and conducted research at the Bartlett School of Architecture in London. In 2018, he completed his doctoral degree at ETH Zurich with a dissertation on the genealogy of machinic concepts in architecture. Gleich has lectured and published internationally, including in edited volumes and journals such as *Grey Room*, *AA Files*, *Perspecta* and *Zeitschrift für Medienwissenschaft*. He has been director of the gta Verlag since 2019.

Moritz Gleich
Institute for the History and Theory of Architecture (gta), ETH Zurich, Switzerland
moritz.gleich@gta.arch.ethz.ch

Published with the support of the Swiss National Science Foundation.

Acquisitions Editor
David Marold, Birkhäuser Verlag, Vienna, Austria

Content and Production Editor
Bettina R. Algieri, Birkhäuser Verlag, Vienna, Austria

Translation from German to English
Thomas Skelton-Robinson

Proofreading
Sue Pickett, Thomas Skelton-Robinson

Series Design Concept
MG&Co., Noëmi Mollet and Reto Geiser

Design and Typesetting
MG&Co., Noëmi Mollet and Reto Geiser, with Christian Ortiz

Image Editing
Pixelstorm, Vienna, Austria

Printing
Beltz Grafische Betriebe GmbH, Bad Langensalza, Germany

Typefaces
GT America, GT Super (Grilli Type)

Paper
Magno Natural, 120 g/m^2

Library of Congress Control Number: 2022930910

Bibliographic information published by the German National Library
The German National Library lists this publication in the Deutsche Nationalbibliografie; detailed bibliographic data are available on the Internet at http://dnb.dnb.de

ISBN 978-3-0356-2376-5
e-ISBN (PDF) 978-3-0356-2377-2
DOI: https://doi.org/10.1515/9783035623772

Published by Birkhäuser Verlag GmbH, Basel
P.O. Box 44, 4009 Basel, Switzerland
Part of Walter de Gruyter GmbH, Berlin/Boston

9 8 7 6 5 4 3 2 1

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