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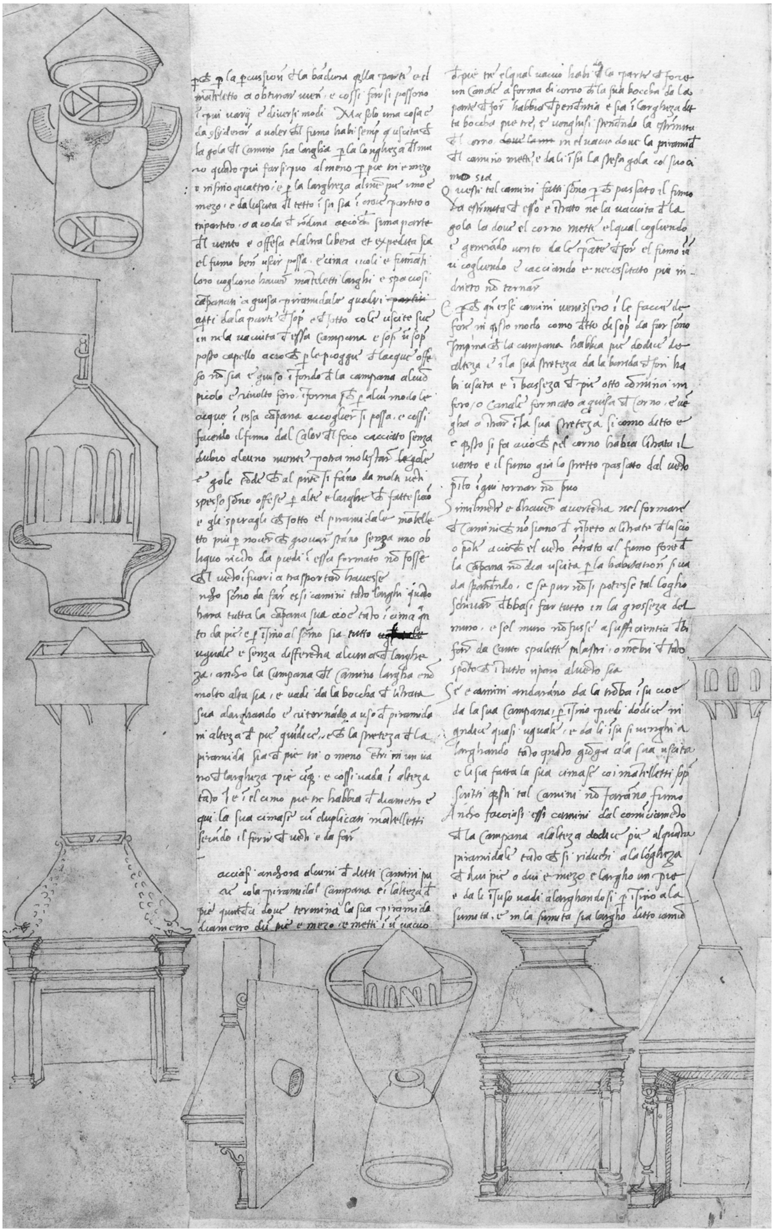

Figure 1.1. Chimney variations by Francesco di Giorgio Martini. From Francesco di Giorgio, *Trattati di architettura ingegneria e arte militare* (between 1500 and 1515). Manuscript on paper of what is probably the first version of the treatise, finished ca. 1476–1477. Beinecke Rare Book and Manuscript Library, Yale University, https://collections.library.yale.edu/catalog/2047311, image 50.

CHAPTER ONE

Exhaling Chimneys

A chimney is a component of a heat source in a room, but it is also much more than that. A chimney is a passage for all kinds of particles, exhalations, and supernatural creatures, a loophole into and out of the world of mysteries and that of the dwelling house. It conflates folklore and domestic technology. Analogous to a windpipe, an air passage connecting the throat with the lungs, a chimney usually runs vertically, extracting exhaust fumes in a confined space from the emitting source to the open air. The term derives from the Old French *cheminee*, which means "fireplace" or "room with a fireplace," its etymology carrying notions of flames and spatial magnitude from the onset.[1] In its early meaning, the term thus designated something to which it later became attached.

If placed in the center of a room, in a house whose exterior walls are free from fireplaces, a chimney can become the dominating element—or one's "superior," as in Herman Melville's short story "I and My Chimney."[2] Reminiscent of the pyramid of Cheops, his chimney is not only big and solid, but also strong in personality, more a personage than merely masonry.[3] Indeed, Melville and his chimney cohabit (in fact, they philosophize together), but they do so unlike common roommates, for his chimney is "the king of the house."[4] Just as a king holds the preeminent position in a monarchy, Melville's chimney occupies the dominant symbolic and geometrical center of his house, a position to which everything else is subordinate. It is the backbone of the house and will outlive every other part.[5] The impression it makes on others is profound, if not awe-inspiring. A token for domestic life, his puffing chimney even protects it from burglary, preventing home invasion by releasing fleeting signs of human activity into the surrounding air. Communicating with the atmosphere, it signals presence and alertness and in so doing, it also ties the interior to the exterior.

But tying the interior to the exterior opens the interior to threats from the outside.[6] Throughout the fifteenth century, witches were held to fly through the air riding on brooms. Yet even if some ascribed magical powers to them, witches still had to fulfil ordinary needs in the eyes of many, among them eating and drinking, and adequate nutrition could easily be found in people's houses. But how to get in? While some thought witches penetrated solid doors, and others believed they simply opened and closed them imperceptibly fast, slipping through the gap without being perceived by residents, many assumed they slipped down the chimney in a fashion not unlike Santa Claus.[7] Indeed, the fireplace seems especially prone to attract intruders. In Alfred Hitchcock's horror-thriller *The Birds*, a host of sparrows shoot down the chimney to invade the house. Someone tilts over the wooden coffee table to block the open fireplace, but the whole living room already has been invaded.

Chimneys also serve as important components of social spaces. Historically, the fireplace was the focus of the daily life of a building's inhabitants. It invites small gatherings and is a place where the inhabitants literally conspire—that is, breathe together. Indeed, at the hearth, the inhabitants and the building itself breathe together, both the fire and their breath consuming oxygen and producing carbon dioxide, a circumstance often repeated by naturalists such as Jean-Henri Fabre (1823–1915), who, in his short text *L'air, nécessaire à la vie*, noted in the late 1850s that an "animal requires air to live, and the candle requires air to burn."[8]

The chimney thus plays an important role in the inhabitants' biological life, as well as their social life, and beyond that, in their environment. It is a vertical structure built to discharge the products of combustion — pollutants, impurities, and carbonic molecules — by a draft of warm air, whose decreased density naturally propels them upward (fig. 1.1). Like a smoker puffing on a cigarette, the flue draws the byproducts of domestic combustion into the atmosphere, and it is because of these exhalations that chimneys, for a long time, have also been a symbol of air pollution, especially in their industrial form as smokestacks.

The chimney can thus signify various things: a mediator in post-medieval superstition, the existence of a cozy family space, technological progress, but also industrialization and with it, complicity in environmental pollution. Most often, it is simply a means to an end, a practical contrivance to evacuate smoke and to keep the fireplace running. Yet the chimney also symbolizes breathing.

Throughout architectural history, the house, like its inhabitants, has been said to "breathe." For example, Leon Battista Alberti ascribed parts of the human body to parts of the hearth, instructing his architect readers that the mouth at the bottom of a fireplace ought not to be too prominent. His descriptions are technical and scientific, but also highly metaphorical. When he suggests that "the throat should be deep," he refers to the chimney's height, which should rise well above the roof ridge.[9] The throat, for Alberti, is what traps and channels smoke, while the burning flames in turn help eject it "in the same manner as sound is [expelled] from a trumpet."[10] The chimney exhales. Different ways of exhaling the air can bring about differences in air temperature: exhaling with an open mouth produces warmer air compared with doing it with pursed lips, because the former slows down the force of breath, while the latter sets it in motion, and "so also in a building," Alberti asserts.[11]

As we'll see in what follows, the physiological process of breathing in living beings long has its correlate in a parallel process of ventilation in architecture. The chimney has had both physiological and architectural implications, articulated in terms of an analogy to human respiration in its role of inducing airflow through the lungs and blurring the boundaries between the organism and its surrounding atmosphere, between inside and outside. As a result, in this book, the terms "breathing" and "ventilation" frequently overlap and oscillate in meaning. "Ventilation" privileges the replacement of stale air with fresh air by virtue of mechanical or natural means, while breathing involves the intake of oxygen and the expulsion of carbon dioxide, a process that rests on the respiratory system, primarily in the lungs. In different contexts, the comparison rests on different emphases on the mechanical or organic elements of the comparison of the parts of the house to the parts of the human body. One of the goals of this book is to illuminate the centrality of the notion of breathing within the context of modernist architecture, embracing the heterogeneous implications it holds for living organisms.

Here, like witches or Santa Claus, we enter that topic through the chimney as a special kind of portal. Once inside, the book charts architecture's embeddedness within a culture of pneumatic beings that I am calling "respiratory modernism." In contrast to modernity and modernization — terms that refer to a specific historical period and the transformation of material culture — I understand modernism with Detlef Mertins "as the cultural response that aspires to the status of a new norm."[12] Breathing played a major role in this cultural response, shaping the zones and areas it produced, as well as the accompanying discourse, which I refer to as "breathing space." There are many metaphors and characteristic themes related to this activity, one of which has to do with the idea of the house as chimney.

The House as Chimney

Chimneys always had let smoke spill into the rooms they heated, and in the eighteenth century, a number of inventors set out to do something about it. How they accounted for the fact that smoke ascends was based on the so-called caloric theory, which understood both heat and combustion in terms of an imaginary fluid, the caloric, and not in terms of energy transmission — the caloric, a material substance of heat, was assumed to be what carries smoke along its trajectory from warmer to colder areas.

Scientists such as the British Count Rumford (1753–1814), as well as Benjamin Franklin (1706–1790), set out to enhance the way chimneys draw, as well as to improve their use of fuel and reduce their loss of heat. A title such as Franklin's 1787 *Observations on Smoky Chimneys* testifies to the attention paid to this widespread problem.[13] Franklin's eponymous Franklin stove was a fireplace equipped with a U-shaped duct at its bottom, turning the flue into an inverted siphon. This feature drew smoke downward before directing it up the chimney, effectively preventing it from entering the room. Likewise, Count Rumford's invention, the Rumford fireplace, optimized the updraft of air by reconfiguring the hearth with angled side walls, restraining the chimney's opening, and streamlining its flue.

The reasons for a chimney not to draw where so numerous that one could fine-tune a whole range of parameters: the proportions of the chimney openings; the length of the funnel; two chimneys getting in each other's way; interferences caused by surrounding houses and topographical peculiarities at the level of chimney pots; but also a door's position and its degree of openness in relation to the chimney. Whether understood in terms of caloric theory or in terms of modern thermodynamics, however, the most important aspect of the drawing chimney is that a supply of fresh air must be provided at all times during combustion. Not unlike a breathing animal, it can exhale smoke only for as long as it inhales fresh air through the apertures and crevices of its surrounding room. This incoming air then takes the place of the warm air and smoke, which, in a continuous outward current, leave the interior as long as the process remains active. But while the presence of small carbon particles emitted from a fire render the outflowing air visible, the inflow of fresh air remains invisible. In order to stress this imbalance and to draw attention to the necessary inflow, Franklin succinctly noted that "the chimney wants air."[14]

As a device that, in tandem with a fireplace, could draw fresh air into the house and also extract pollutants from the indoor environment, the role played by the chimney formed a major theme in nineteenth-century discussions on ventilation and hygiene. In this line of thought, a chimney appears Janus-faced, serving the ventilation of interior spaces while also affecting the general atmosphere. The architecture critic Reyner Banham (1922–1988) was perhaps the first to draw attention to awareness of this problem in his seminal 1969 book *The Architecture of the Well-Tempered Environment*.[15] In his chapter on the "satanic" nineteenth century, Banham rightly observed the parallel rise of air pollution and the contamination of interior spaces "by human respiration and the inefficient combustion of illuminants."[16]

However, Banham's focus on the mechanisms and tools for environmental engineering overlooked the particular breathing culture in which they developed, the culture that I call respiratory modernism and that I seek to uncover in this book. My focus will be less on the mechanisms or technical media that create specific spatial environments. Instead, I will explore the analogical patterns between the house and the breathing body in discourses ranging from domestic hygiene to architecture in the modern period from the mid-nineteenth century to the early twentieth, beginning here with the concept of the house as chimney.

Industrial Chimneys

It is rare for chimneys to become fully absorbed into the house as a whole; they typically stand alone as separate, iconic structures. One industrial example, which I will mention only as a foil for the house as chimney, is the first German chimney made of reinforced concrete, masked as a Doric column (fig. 1.2). It dates from the winter of 1906–1907 and served the power station of the Henriettenhütte ironworks at Primkenau (today Przemków), in Lower Silesia. The flue, some 5 feet (1.5 meters) in diameter and 155 feet (47

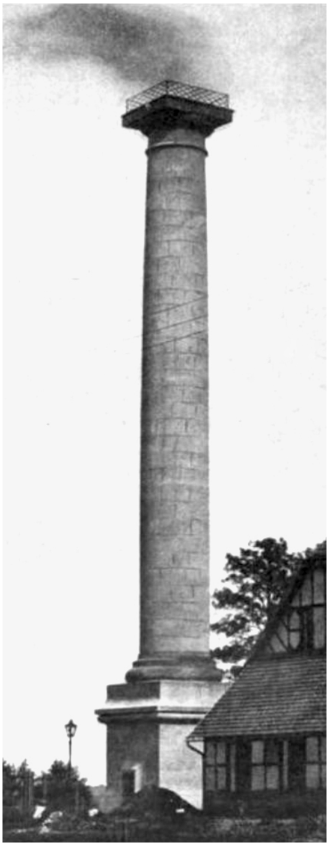

Figure 1.2. Doric smokestack, Primkenau, reproduced in Ludwig Hilberseimer, "Bauten in Eisenbeton und ihre architektonische Gestaltung," in Julius Vischer and Ludwig Hilberseimer, *Beton als Gestalter: Bauten in Eisenbeton und ihre architektonische Gestaltung, Ausgeführte Eisenbetonbauten* (Stuttgart: J. Hoffmann, 1928), p. 15.

meters) high, was tapered toward the top and concealed from the outside. It was wrapped in a cubic pedestal, an unfluted shaft, and a capital—staples of the Doric order. As a historicizing structure, it is reminiscent of the Monument to the Great Fire of London from 1677, and in retrospect, it also evokes Adolf Loos's contribution to the Chicago Tribune Tower competition from 1922. Apart from their common exterior, a riff on the Roman Doric column, all three of these structures share a striking inversion: usually solid and load bearing, they are hollow inside and free-standing in space.

Built to commemorate the Great Fire of 1666, the monument's fluted column in London houses a spiral staircase to climb to the viewing platform atop the capital. A pun on the newspaper "column" of the Chicago Tribune, the shaft of Loos's scheme, which was never realized, features a radial array of office spaces around a central core of elevators. A rare case in architectural history, the Doric column at Henriettenhütte might well be the only one ever able to puff.

Above the capital, black smoke quickly dissipated into the atmosphere. Where a gilded urn of fire marks the Monument in London, the German column released a sooty substance that could have only derived from the process of combustion. The rising smoke as an indexical sign for fire is a common trope in semiotics, and in this instance, it also betrayed what was otherwise a suppressed expression of use. Thus animated by smoke, the Doric chimney appears equally cartoonish and comical, as does Loos's scheme for Chicago, but unlike the latter, which was always meant to be a provocation, the former was dead serious. In a 1928 review on ferroconcrete, the German-born architect and city planner Ludwig Hilberseimer mocked this chimney precisely on the grounds of its ostensible falsehood, portraying it as "a smoking triumphal column, standing right next to a faux farmhouse, a dummy arrangement that could not be more perfectly imagined."[17]

Yet even if the ordinary chimney dispenses with such antiquated jackets, not every architect takes pleasure in their soaring elegance. For Emil Fader, a German teacher of architecture, they were a nuisance of the first order, disturbing the design of industrial buildings in the modern period. In 1927, he lamented the unavoidable disorder they would cause in the spatial composition of a plant whose harmony could only suffer under the presence of such purely functional elements. "No matter how high the architectural achievement in the individual building," Fader explained, "it is somehow always disturbed by a chimney, the appearance of which is determined solely by its purpose."[18] With its appearance determined by everything but its purpose, Fader clearly left this Doric chimney out of account. Perhaps it is too special a case, with its historicist jacket, but free-standing as it was, it clearly reflected his aversion. As a discrete element, the smokestack often disrupts formal unity, and Fader, recognizing the complicated nature of industrial buildings, saw full harmony to be forever out of reach.

Only two years earlier, in August 1925, Russian representatives of the Leningrad textile trust ventured to Germany to look at contemporary architecture abroad; in fact, they came to expose themselves to industrial buildings. Earlier in the spring, the newly founded commission for the construction of textile factories had objected to a proposal for the extension of the Red Banner factory in Leningrad, the so-called Krasnoye Znamya. In Berlin, the Russian delegation was soon introduced to Erich Mendelsohn (1887–1953), no doubt the city's most prolific architect at the time. What evoked their curiosity was precisely what Fader would later consider impossible in the context of industrial designs: the house as chimney. As part of the famous hat factory Steinberg, Herrmann & Co., it stands as a classical modernist masterpiece in the small town of Luckenwalde, some forty miles south of Berlin, and was designed and built by Mendelsohn in 1921 (fig. 1.3).

Luckenwalde's Hat Factory

Luckenwalde had long become the cradle of German hat fashion; the town witnessed an increase in textile and metal factories from the mid-nineteenth century onward, and in 1871, the first company adapted its production from textiles to hats.[19] For a long time, the German hat producer Friedrich Steinberg vied with Gustav Herrmann for the best fashion designs, but after merging their companies, they commissioned Mendelsohn to devise a new manufacturing plant on an empty lot on the outskirts of town. It became one of the paradigmatic expressions for an industry of the future, with critics such as Adolf Behne (1885–1948) pointing out the functional layout and its compelling translation into a tight spatial form.[20] The factory's dye house, with its shaftlike hood, recreated the outline of

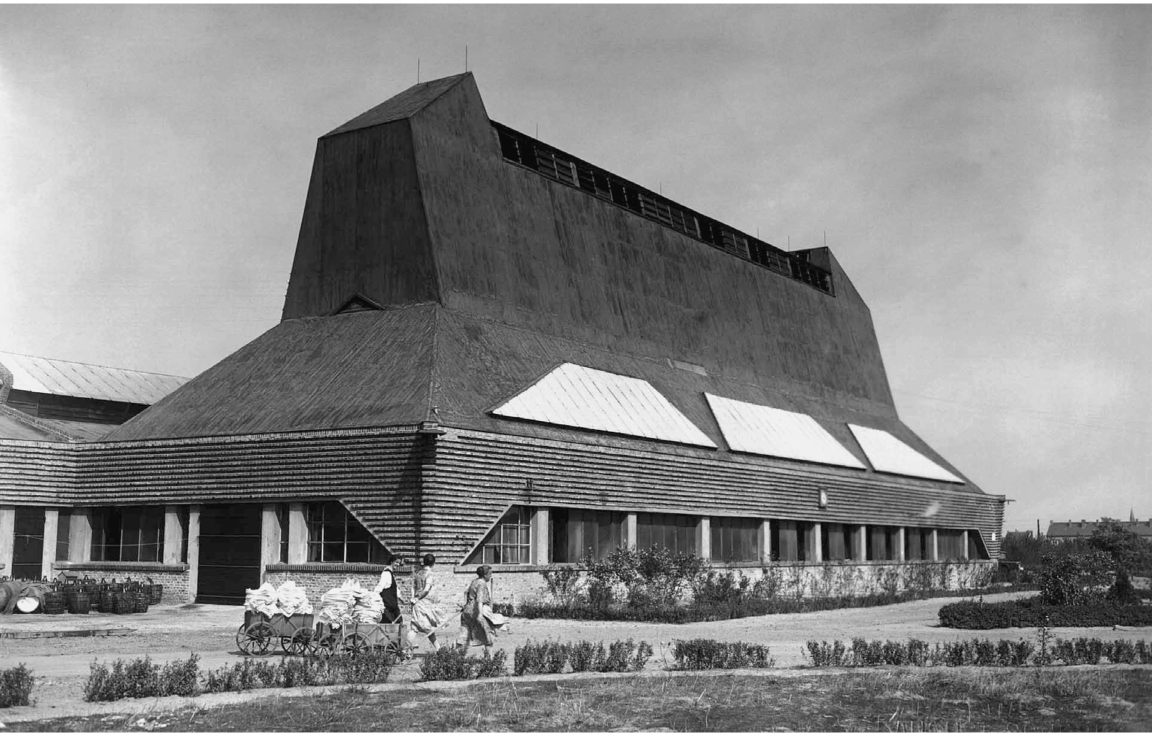

Figure 1.3. Close-up of the dye works, with trapezoidal roof and operable louvers at the ridge. Thomas Drachenberg, *Die Baugeschichte der Stadt Luckenwalde von 1918–1933: Siedlungen, Industriebau, Verwaltungs-, Wohlfahrts- und Privatbauten (Beiträge zur Denkmalpflege im Land Brandenburg)* (Worms: Wernersche, 1999), p. 85.

a hat while at the same time funneling through the roof the toxic fumes building up inside. The whole structure, in other words, acted as a chimney, whose soaring form evinced the upflow of hostile steam inside.

It was this feature, in particular, that aroused a great deal of Russian interest. On a warm Sunday in August 1925, two days after receiving a first phone call from the Russian trade mission declaring their interest in the hat factory, Mendelsohn made a day trip to Luckenwalde, mainly to prepare for the upcoming meeting the following day, but also to go swimming in the morning. The Russian delegation had already been to Luckenwalde to examine the structure independently. Over the course of a sweltering summer day with temperatures well above 96 degrees Fahrenheit, the first gathering in his office took place on Monday, August 10, 1925. Mendelsohn's involvement seemed limited to a consultant's role, but with inchoate longings to develop the Leningrad scheme, he was eager to seize upon "the whole affair."[21] Shortly afterward, he succeeded in decoying the Russian committee back to Luckenwalde, where Gustav Herrmann, the industrialist and patron of Mendelsohn, gave a personal tour of his own company, the hat factory Steinberg, Herrmann & Co. "Quite excited and with what seems to be the best success," as Erich wrote to his wife Luise Mendelsohn.[22]

After a long haul and tenacious negotiations, during which the architect's expectations seemed moderate until the very end, Mendelsohn was finally commissioned to build the Russian Red Banner factory. In October 1925, at the invitation of the textile trust, Erich and Luise travelled to Moscow and Leningrad, and with plenty of opportunity for sightseeing, both went to visit all the monuments. The country, imbued with revolutionary spirit, unalloyed energies, and a great deal of optimism, deeply wowed Luise, but the many privations she encountered abroad also left her baffled upon returning to Berlin, where life was comparatively spoiled. With luscious meals, stimulating conversations, and shows by the Russian ballet, she found the stay in Leningrad particularly "exhilarating." For lunch, she often relished caviar and vodka.[23] Her vivid memoirs recall the circumstances that led to the contract in Leningrad, a passage worth quoting at length:

> Among the most fascinating people who came to his office were a group of Russians. Their purpose was to receive information about the dye works which were a part of the Luckenwalde hat factory built in 1921. When Eric [sic] received the commission to build the hat factory he carefully studied the manufacturing process and became appalled by the working conditions of the laborers. The steam of the dye vats permeated the whole shed, in spite of large exhaust fans, which only caused a strong draft and afflicted a large number of workmen with pneumonia. Eric found an excellent solution to this problem, which became widely published in industrial magazines and must have come to the attention of the Russians who planned to build a large textile factory. The principle on which Eric solved the problem of achieving a dry vat shed was a very simple one. He constructed a chimney-like hood over the dye vats and upper arches into which the steam was exhausted. This created a chimney over the whole length of the building and effected constant and uniform air exchange. Eric led the Russians through the entire factory, and they were sufficiently impressed to offer him the commission to build a textile factory with three dye vats close to Leningrad in 1925. Planning a large complex of building for Russia, a rather enigmatic country and unknown to most Europeans, excited not only Eric, but the whole office. A day was set for bringing the plans to Leningrad. and the work in the office extended into the midnight hour. Bach records were played, inexhaustible quantities of coffee were provided—the atmosphere was pregnant with creation. We left for Leningrad in the fall of 1925, one year after Lenin's death. The textile factory was going to be built outside of Leningrad and combined a power station, three dye works, an administration building, and the actual factory—in other words it was a tremendous commission.[24]

Though it is tempting to interpret this anecdote in terms of its optimism, the Russian factory was an endeavor more frustrating and wearisome than Erich Mendelsohn foresaw. In mid-July of 1926, he received a distress signal in the form of a telegram and informed

Luise that he had to leave for Leningrad, working on site for eight days.[25] From there, he avowed on July 31, 1926: "Construction started and—blighted. I try everything possible to repair."[26] But the episode above is also revelatory, because so often when large architectural projects come to fruition, the exact circumstances leading to their formation remain obscure.

The trust commissioned Mendelsohn because of the extraction system embedded in the dye house at Luckenwalde. Luise's record not only brings out her husband's eager resolve to engage in issues of health and industrial safety, but also his vision of space, which, in this case, centered on well-being and formal harmony. Contrary to common industrial plants at the time, the chimney here formed an integral part of the design, a simple solution with the objective to prevent the workers from developing inflammatory lung conditions such as pneumonia. The architect took issues of breathing to heart.

The Luckenwalde factory's geometry was well conceived: the plan, striking and rigid in its symmetry, led to a structure firmly rooted to its site. The photographs authorized for publication, however, countered this assumed state of repose. Presenting the multifaceted geometries of several roofs in diagonal views with often dramatic framings, the factory exuded a dynamism that was further accelerated by the strong black-and-white contrast (fig. 1.4). In fact, the dye house roof became so prominent that several publications, such as Mendelsohn's 1924 issue of the architecture and urban-planning journal *Wasmuths Monatshefte für Baukunst und Städtebau* (Wasmuth's monthly journal for architecture and urban planning), as well as Adolf Behne's *Der moderne Zweckbau* (The modern functional building, 1926) tended to foreground a photograph taken from underneath the gatehouse's roof.[27] With its idiosyncratic clipping, it led the uninformed reader easily to believe that the dye house was the entire factory. But the actual production sheds and the power station were no marginal elements; instead, they formed crucial parts of the organism. Furnished with skylights, the sheds in fact form the centerpiece of the entire complex, bookended by the higher, cubic

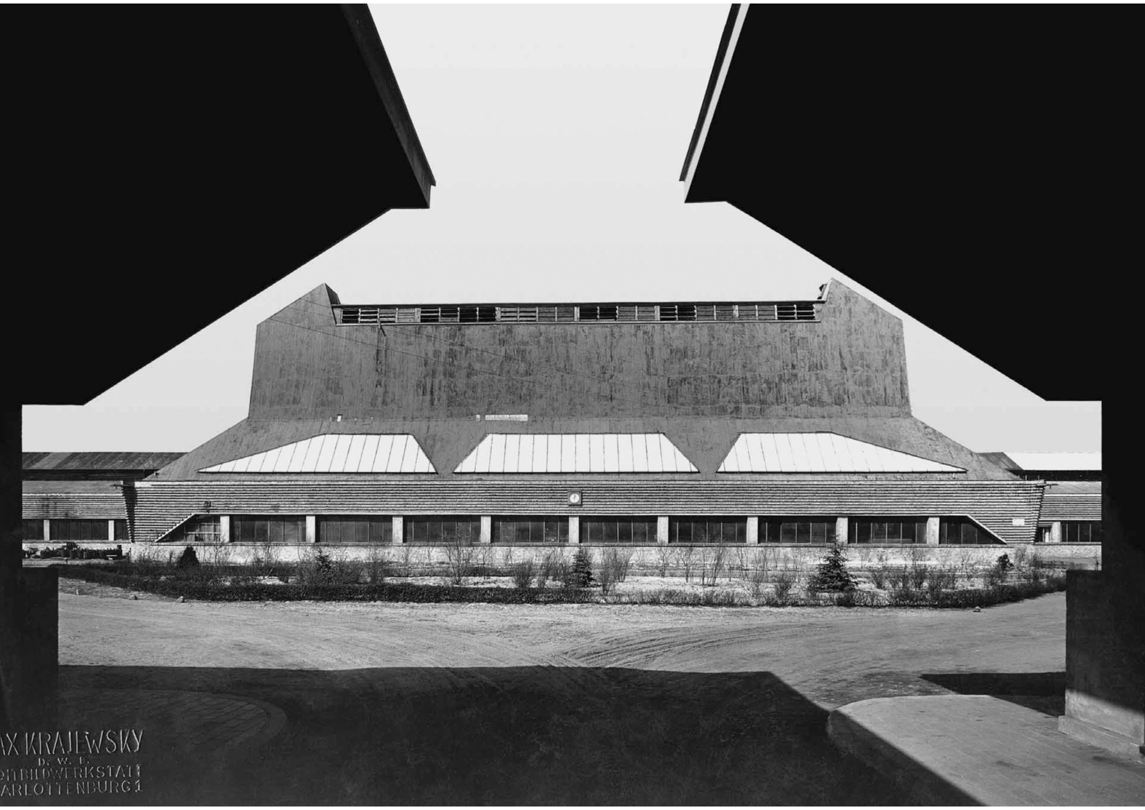

Figure 1.4. View of the dye works from underneath the gate house, which no longer exists. Thomas Drachenberg, *Die Baugeschichte der Stadt Luckenwalde von 1918–1933: Siedlungen, Industriebau, Verwaltungs-, Wohlfahrts- und Privatbauten (Beiträge zur Denkmalpflege im Land Brandenburg)* (Worms: Wernersche, 1999), p. 87.

power station and the popular dye works on both ends of the shorter axis. The height of the manufacturing sheds was echoed in the height of the gatehouse.

A continuous grid governs much of the overall plan and combines the manufacturing sheds with the dye works. Reinforced concrete girders arrayed in the longitudinal direction with an interval of 16.4 feet (5 meters) form the primary structure inside the dye house. Invisible from the outside, they are tapered toward the top and the bottom, resemble pointed arches, and rise up to a height of 33 feet (10 meters). Kinked twice, the girders' geometry in the dye works differs from that of the sheds, but they are also significantly higher. Right above the frames' tip is an extension to the primary construction—part of the reason why it seems reasonable to call it a hood—in the shape of an isosceles trapezoid. Both parts together add up to a considerable height of 58 feet (17.75 meters). Above these trapezoidal frames sits another cap that continues the roof's outline in cross section, and it is here that the sides are louvered, while the top is covered with wooden planks (fig. 1.5). In this way, Mendelsohn could completely close off the hood against the atmospheric environment and the fabrication spaces underneath and vice versa. Opening the upper and lower louvers initiated the natural exhaustion of the steam that accumulated in the dye house without causing much draft. In the crawl space at the top, the felt required for the production of hats was dried and aired.[28]

"Chimney Structure"

Ventilation concerns went beyond the dye works and also informed the design of the production sheds, but here, they were less pronounced. A pitched roof following the outline of the three-hinged frames below incorporated skylights and ventilation openings individually adjustable by pulling cables from below. On either side of every second girder, Mendelsohn had steel bushings built into the timber sidewalls in order to guide the louvers, which, opening outward, helped to create a constant flow of air.[29] In the *Wasmuth*

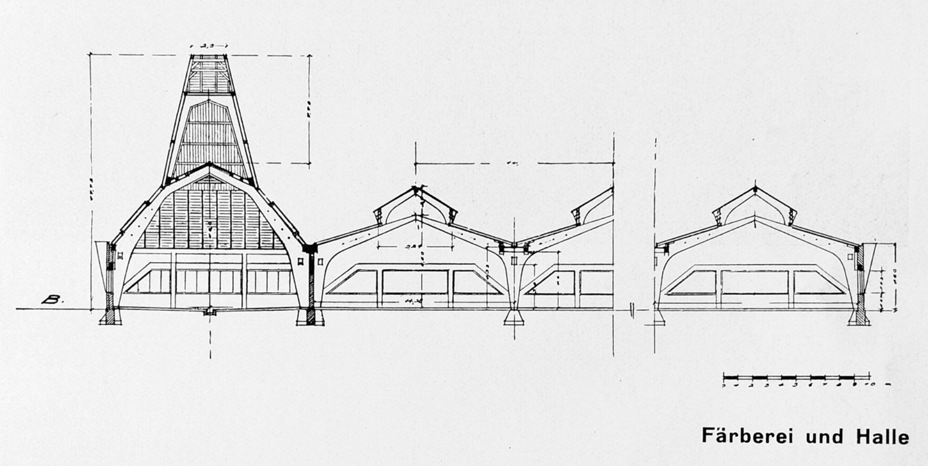

Figure 1.5. Cross section through the dye works and manufacturing sheds. Erich Mendelsohn, *Das Gesamtschaffen des Architekten: Skizzen, Entwürfe, Bauten* (Berlin, R. Mosse, 1930), p. 65.

journal, Mendelsohn also included one interior photograph of the production sheds, but the dye house, both the elegance of its outer appearance, and the performance of its embedded ventilation system, is what received the most attention.

Mendelsohn needed to solve a problem that sooner or later afflicted nearly every worker in the dye vats. Not only did the poisonous fumes cause high humidity levels inside, a situation that negatively affected the workers' lungs as well as the materials required for the production process, it also impeded interior visibility, further complicating the work process. While several methods had been previously tested to solve the steam issue—either smokestacks or fans had been used in order to attenuate the fog's emergence—they all resulted in hitherto unseen problems, including unpleasant side effects such as drafts and an excessive temperature rise. Whereas stacks alone were too exposed to the fluctuation of outside temperatures and thus simply furthered the condensation of steam, fans were either too weak or produced too much turbulence inside.

Mechanical ventilation had been of no avail, and Mendelsohn's hat factory was the first dye works that passed muster. The answer came in the form of negative air pressure, something he had gleaned from a small, still-operating dye factory. According to John Berlowitz, a Berlin-based engineer and contemporary of the German architect, this existing plant reasonably managed to defog the interior by employing an "accidentally abandoned" smokestack. This discovery and years of research on "primitive" structures excited Mendelsohn to graft a chimney onto the dye house.[30] It was, in other words, a conjunction of mastermind and haphazard events, a serendipitous discovery, that led Mendelsohn to envision the dye works' interior space as a flue and its structure as a chimney.

The result is what Berlowitz called "chimney structure" (*Schlotbau*). While the side effects of previous solutions, such as increased draft and an enormous rise of temperature, further damaged the workers' lungs already under threat of the ubiquitous fog, here, the interior was completely free of waste steam, even when operating at full capacity with twenty-four dye tubs. For Berlowitz, it was the architectural problem-solving design that fixed the issue for the first time, primarily through the spatial form itself rather than by auxiliary technologies:

> As far as we know, it is the Berlin-based architect Erich Mendelsohn who managed for the very first time to build a dye works, that, despite its large dimensions, has completely resolved the problem of defogging. Only the insight that the building itself, i.e. its cross section, the arrangement of windows and ventilation ducts, would have to enhance the natural buoyancy of the steam from the outset, brought about radical progress here.[31]

The passage brings out the direct and interdependent relationships between architectural form and individual elements and their effect on thermodynamics. Pressurized outlets for heated air at a height of 7 feet (2.2 meters), just above the factory workers' heads, enhanced the buoyancy force acting upon the dye house, making for a total air exchange in as little as one hour. It proved a most effective way to initiate the stack effect, which is able to move large volumes of air through space, above all work-related events, that is, above the workers' comfort zone, so as not to compromise work sequences. Adjusting the air flow allowed the dye house to respond to seasonal changes and alternating climate conditions; it appeared to operate equally well "during clear, frosty weather or misty rain, during a calm or a strong breeze."[32] In colder weather, warm air from the vents blew toward the factory's bottom in order to heat up lower areas, while the opening direction was flipped during warmer periods to expedite the stack effect.[33]

Most accounts on Mendelsohn's factory refer to the dye house as a kind of *invention*.[34] But the factory was neither a forerunner of modern ventilation systems nor a real innovation. What made the dye works revolutionary in a characteristically modern way was solving a physical problem by translating age-old technology into modern contexts. Mendelsohn's dye house roof, with its skylights and ventilation openings is a simple chimney. He just discovered how to apply its principles to the dye house at the hat factory in Luckenwalde. As we will see, it is the context of respiratory modernism that makes Mendelsohn's adoption of the concept of the house as chimney significant.

The history of architecture is full of lanterns and femerells (from Old French *fumeraille*, derived from the Latin *fumus*, meaning "smoke"), small, open structures placed in the ridge for the purpose of lighting and ventilation. Provided with slatted apertures, such roof lanterns, or louvers, were to dissipate smoke and vitiated air emerging in the interior of medieval buildings.[35] Even the production sheds' structural system is called *Laternenshed* in German, an obvious reference to the lanterns running along the roof's gable. An alternative to the sawtooth roof, it was commonly used throughout

Europe, and not only for industrial buildings.[36] Glassed lanterns span the intervals between each concrete frame, and in combination with pitched roofs, the structural frames yield higher interior spaces with enhanced ventilation.[37]

Even if Mendelsohn stayed aloof from inspirations common at the time, the copious precedents he resorted to were diverse to an extent that they finally ended in smoke, as architect and historian Bruno Zevi remarked.[38] One precedent he doesn't mention can be seen in a cutaway section reminiscent of the dye works, not least because it is rendered in brick, but also on the grounds of its outline and general proportion. It is included in Philibert de L'Orme's architectural treatise *Le premier tome de l'architecture*, published in 1567.[39] A French architect and writer, de L'Orme (1514–1570) put together one of the great treatises on architecture and instructed the master builders of the French Renaissance in the general layout of schemes as much as in the different ways of assembling them. In this manual—the first and only volume of what was intended to be a two-volume treatise—a woodcut shows an abstract kitchen whose brick walls, 10 to 12 feet (3 to 3.6 meters) high, are punctured by doors and windows on the ground level (fig. 1.6). After a horizontal kink far above door height, the exterior walls bend inside, two converging lines in section that eventually lead to something that vaguely looks like a baroque lantern, except that it is not cylindrical. The kitchen is defined by four walls, and in de L'Orme's own words, by what is called "the lantern or chimney pipe" (*la laterne ou tuyau de cheminée*). This cap is four times narrower than the kitchen and opens itself to the outside by virtue of three narrow vents in each wall, so that the smoke quickly disappears. Embellished by a cornice, a small, circumferential wall is built on brackets (or mutules) around the lantern, shielding the vents against the wind while at the same time maintaining the upflow of smoke. Like the cap, the small cupola above features a double-layered shell of which the inner one is perforated "in order to release the smoke" (*pour donner issue à la fumée*) at the top. The release system remains

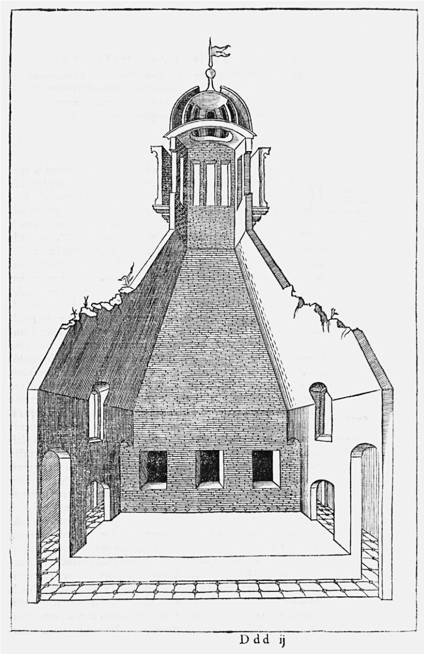

Figure 1.6. The house as chimney: cross section through a kitchen. Philibert de L'Orme, *Le premier tome de l'architecture* (Paris: Federic Morel, 1567), p. 276.

invisible from the outside. This illustration reveals the blueprint for Luckenwalde, even if structurally, it was altogether different. If the house as chimney was a thing in architectural history, this kitchen could be the genre's apotheosis.

Respiratory Modernism

What makes Mendelsohn's use of the chimney to solve the problem of ventilation in the Luckenwalde dye works significant is the place it occupies in the culture of respiratory modernism that had been developing since the mid-nineteenth century in Germany and beyond. The articulation of the concept of the house as chimney as an element of respiratory modernism is a product of the growing cultural awareness of breathing during that period and a broader understanding of the essential need for fresh air.

While concerns about air have long permeated architectural treatises since Vitruvius, there was a particular confluence of physiological knowledge and a heightened awareness of breathing and the functioning of the human lungs is a phenomenon specific to Anglo-European culture beginning around the end of the nineteenth century.[40] Among social and health reformers, educators, and engineers, experimental hygienists and physiologists, chimneys, fireplaces, and furnaces flared up in debates about ventilation. Chimneys offered a simple solution for obtaining a change of air in a room. A number of publications repeated a central admonition, dire and relentlessly didactic: a constant supply of fresh air is vitally important for living organisms. Voices demanding breathable air abounded. The works of hygienists in particular raised awareness about the consequences of encasing breathing subjects, and they took concerns with ventilation increasingly seriously. Yet no one conveyed the sense of urgency with more sensational effect than the American ventilation expert Lewis W. Leeds, who in 1869 warned his readers that without a continuous supply of fresh air they "will surely die."[41] It was absolutely critical, however, he argued that this current of air be as imperceptible as possible — a claim we will revisit later in this book.

Throughout the nineteenth century, people were said to consume atmospheric energy in the form of oxygen much like a burning fireplace. In their book on domestic science, *The American Woman's Home* (1869), Catherine Beecher (1800–1878) and Harriet Beecher Stowe (1811–1896) observed that analogous to the workings of a chimney, drawing in air and thus keeping the flames burning, the human organism requires oxygen to combust the fuel absorbed as part of the daily diet: there are "two modes of nourishing the body, one is by food and the other by air."[42] And much like the fire's exhaust and its concomitant soot, human respiration produces air-polluting substances through metabolic processes. Scientific advances had shown that human air pollution by respiration depletes the amount of oxygen inside an apartment, which therefore required replacement by ventilation.

The dominant debates on the theory of ventilation throughout the second half of the nineteenth century thus were anthropocentric, considering breathing human beings as the most significant part of the equation, the chief reason for air exchange. To a large extent, these writers remained within the discourses of health and hygiene about domestic ventilation and at the periphery of architectural discourse.[43] However, conceptually, these debates stressed the fact that space is not empty, but rather filled with air.[44] Air thus was to become a real substance for architecture.

The discourse on ventilation in the nineteenth century usually attributed notions of wholesomeness and naturalness to fireplaces, because they outmatched stoves to a considerable extent in their ability to draw off deteriorated air.[45] Stoves were chiefly too weak. The theory of ventilation thus can hardly be separated from the concomitant question of warming the air in a room, especially since many ventilation systems relied on differences in temperature and air pressure between indoors and outdoors. Heating the air was the single most important way to propel it inside a flue, which, like no other architectural element, lent itself to consummating air's renewal in a house.[46] However, while a fire's drawing power is an ingenious means to force air along a predetermined passage (as well as through chinks and cracks entirely unpremeditated), it is also prone to fail because of its dependence on atmospheric fluctuations.[47] If there are none, the system collapses. The flue itself has no power to draw, nor is air able to move independently. At the same time, because of solar radiation and the ensuing differences in temperature, air is never really at rest. The question was how to deal with this movement, especially during different seasons. In the summer, when the inside and outside temperatures begin to correlate, the effects of fire on ventilation tend to break down.

If a flue is not already part of the house, disgorging its interior vapors outward, "wooden troughs or channels may be made to answer the purpose," the American physician and sanitarian John Griscom, suggested in 1854. He wanted them jutting into the sky, "somewhat in the manner of a chimney," running vertically toward the attic, where they should end in flues made of iron or brick.[48] Griscom highlighted the continuous flow of vapors, particles, and gases through which the outside atmosphere, the inside atmosphere, and the resident are inextricably tied together. Among the different methods of ventilation, he found chimneys to be the best for warming and oxygenating a house, because a flue slightly warmer than its surroundings resonates naturally with human respiration, removing the impure air that breathing produces while drawing the same quantity of fresh air into the house.

It was this feature, in particular—the natural ability of the chimney to provide a healthy atmosphere within the house—that created mounting excitement among health promoters around the middle of the nineteenth century. The British inventor and godfather of systematic ventilation, David Boswell Reid (1805–1863), offered one of the foundational texts on the subject in 1844. For some, he is a modernist *avant la lettre*, because he defined architecture in terms of space, as a material shell that merely supports an interior atmosphere.[49] Thus wrapped in architecture, this artificial atmosphere is "in reality, to every building what the breath of life is to the human frame—the vivifying principle, without which they would be tenantless and uninhabitable."[50] By analogy, ventilation is to architecture what breathing is for living organisms (fig. 1.7). In his treatise, he offers a variety of cases related to the convergence of body and space, the proximity between structure and creature. Ideally, the provision of fresh air and the removal of vitiated air would employ two independent apertures administering the inflow and outflow of air inside a closed space. In rare cases, however, Reid allowed a single aperture, "as in the case of ordinary respiration, where the mouth and nostrils serve as a passage for air," with alternating patterns of intake and removal.[51] If human breathing was ordinary, he seems to suggest, in architecture it was still something special, which is why he demanded that ventilation concerns be accommodated from the outset.

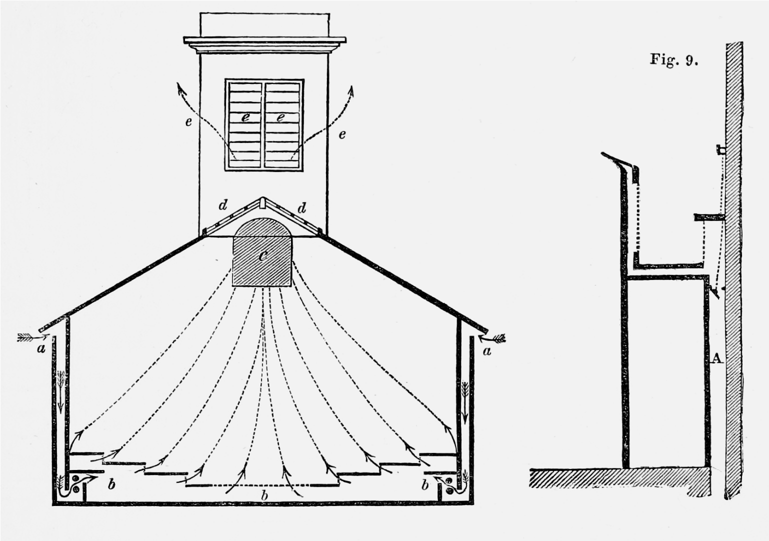

Figure 1.7. Illustration of the house as chimney in the form of a Scotch church. David Boswell Reid, *Illustrations of the Theory and Practice of Ventilation: With Remarks on Warming, Exclusive Lighting, and the Communication of Sound* (London: Longman, Brown, Green & Longmans, 1844), p. 47.

As a passionate advocate of integrated designs, Reid focused on the economic, but issues of health were of equal value. And health was at risk. For Reid, one of the greatest evils of his time originated from truncating the chimney, one of the prevailing alterations in the dwelling house. The resulting reduction in height, together with the helter-skelter arrangement of fireplaces in the interior, left "the zone of respiration" (by which he meant the space from which the air is received when inspired) mainly impure.[52] In 1844, flames and chimneys made an able conjunction as long as they were high enough. All it took was an adroit expert to achieve this.

In France the same year, for the same reasons—the relation of architecture to ventilation and hence to human respiration and health via the provision of fresh air and the removal of vitiated air—architect César Denis Daly (1811–1894) found fault with the Beaux-Arts tradition to impart beauty on forms while at the same time ignoring issues of heating and ventilation. Although his profession knew all too well how to study and mimic nature, he argued, it knew little about the inner workings of the body. If one took nature seriously, one would realize that "animated beings are organized in a way that the sheer fact of respiration is enough to provoke in them a phenomenon of combustion, which maintains the heat in their entire body, and to discharge the deleterious gases from the lungs which so much require this removal."[53] Nature, in other words, had more to offer architects than just the laws of proportion and harmony; Daly called upon his fellow architects to embrace it radically, to learn from it, rather than merely to observe it. The physiological function of the human body was just as important for architecture as was the notion of harmony. Respiration naturally entailed ventilation.

Bad Air

But respiration entailed ventilation because respiration produced bad air. With various competing systems emerging in regard to heating and ventilation, for there to be natural air exchange, almost everyone agreed on the need for open doors and windows during the summer and some sort of chimney discharging the waste products of respiration during the winter. The interior came to be seen as toxic due to anthropogenic pollution, but not in the way as we understand it today, as emissions of human-produced substances such as greenhouse gases and other industrial pollutants. Rather, the human breath itself was seen to produce harmful interior environments simply by discharging carbon dioxide.[54]

In the United States, for instance, Lewis W. Leeds published a series of lectures he had delivered at the Franklin Institute in Philadelphia in the winter of 1866–1867. *Lectures on Ventilation*

(1869), covers a topic that chimes with an opinion shared among experimental hygienists: "Our own breath is our greatest enemy."[55] Ventilation was not simply imperative because humans *inhale* air, Leeds noted, but precisely because they *exhale* it. Breathing inside he deemed noxious and declared, "it is not in the external atmosphere that we must look for the greatest impurities, but it is in our own houses that the blighting, withering curse of foul air is to be found."[56]

Leeds gave weight to his claims with a series of compelling illustrations that visualized airflow using gradients of colored point clouds, rather than traditional arrows and vectors (fig. 1.8). By contrast, a cross section of a hospital ward relies on arrows to indicate the direction of airflow within the interior and its expulsion through chimney pipes and lanterns—a principle that parallels the ventilation strategy later employed at Luckenwalde (fig. 1.9). In the case of this ward, wind currents support ridge ventilation by flowing over angled roof boards that deflect the air without allowing it to enter the interior. This deflection creates a partial vacuum that draws air out of the building. Such illustrations raise important questions about the ways in which to represent a medium that is typically invisible—except when revealed by the presence of recognizable pollutant particles.

Leeds doesn't mention carbon dioxide as the pollutant—he sticks to "air" throughout—but an important study that focused attention on CO_2 already had been carried out by the German chemist and experimental hygienist Max von Pettenkofer (1818–1901).[57] Early in March 1857, he began to accumulate empirical data to determine the threshold when air stopped being pure. He took air samples in various rooms in Munich throughout the year: in his office at the physiological institute, in a lecture hall of Justus von Liebig's laboratory, in a beer tavern, as well as in a classroom. Soon attuned to every nuance of the interior atmosphere, he reasoned that air begins to cause discomfort once the concentration of carbon dioxide exceeds one part per thousand.[58]

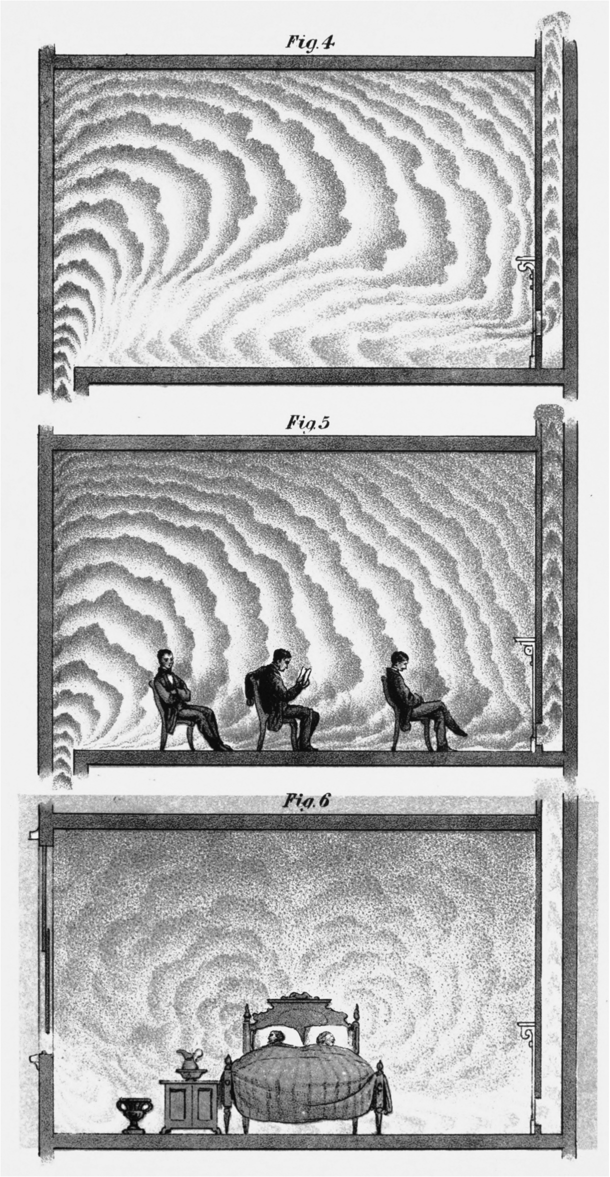

Figure 1.8. Illustration of fresh warm air entering the room. Lewis W. Leeds, *Lectures on Ventilation* (New York: John Wiley & Son, 1869), p. 29.

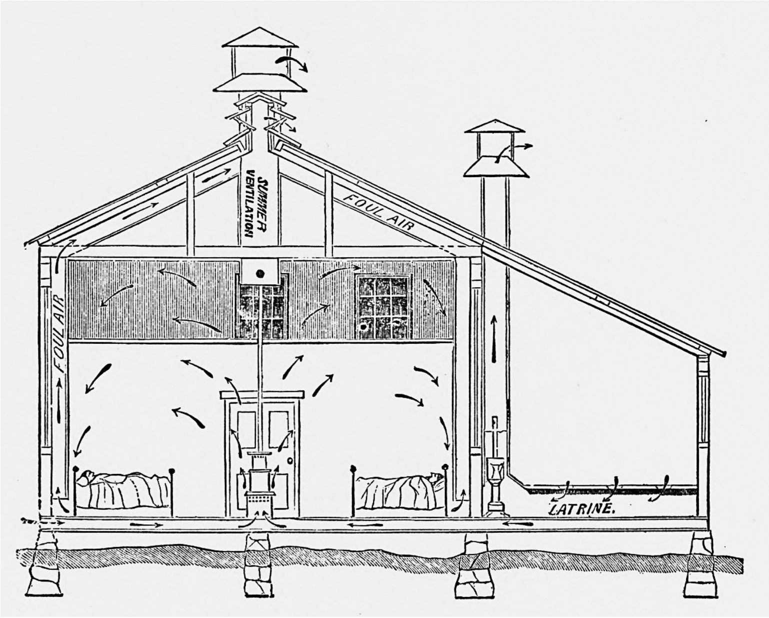

Figure 1.9. Illustration of the so-called ridge ventilation. Lewis W. Leeds, *Lectures on Ventilation* (New York: John Wiley & Son, 1869), p. 53.

Carbon dioxide is not in and of itself responsible for increasing discomfort, but Pettenkofer, like fellow scientists of his time, took it as a standard for the various impurities that saturate the air. Once organic sources of effluvia — rotting garbage, human and animal excreta — were diligently eliminated, what was left as the cause of bad air were respiration and perspiration. Where domestic cleanliness reached its limits, Pettenkofer considered ventilation crucial to restore what human respiration rendered impure.

But exactly how much ventilation was necessary to meet the desired change of air? In order to answer that question conclusively, Pettenkofer needed to determine the extent of natural air change in a scientific fashion. If one could add the amount of carbon dioxide a human being discharged per hour to the standard portion contained in the air, one could then project a concentration and compare it subsequently with a sample. If both numbers did not match, the discrepancy must be owing to a certain amount of natural ventilation, induced, for instance, through differences in temperature between the inside and the outside. This is exactly what Pettenkofer did. Most of the findings undergirding his experiments thus stemmed from the world of physiology. They postulated, for instance, the need for an hourly influx of 2,100 cubic feet (60 cubic meters) of fresh air per person.[59]

Some four years later, his curiosity gave rise to a wacky contraption that in 1863 he introduced to the readership of a Bavarian specialist journal.[60] The objective of this so-called "respiration apparatus" (*Respirations-Apparat*) was to monitor over a period of at least twenty-four hours the precise amount of carbonic acid excreted through the skin and lungs of larger animals and humans while simultaneously accounting for the physiological processes (such as food intake) occurring during that time.[61] By inspecting the air that entered and left a cubic volume, which he imagined to resemble a living room, Pettenkofer sought to quantify the extent to which carbon acid and water in the air at the outlet is increased by a person staying inside.[62] Made of sheet iron and glass, it measured 8 feet (2.4 meters) on both sides, provided a volume of 512 cubic feet (12.7 cubic meters), and was conceived as a kind of domestic air passage in which a living organism could reside as naturally as possible (fig. 1.10). The cell was almost airtight, sealed with wax, and featured apertures, three circular holes in the door, where the air, drawn out by a pump with two alternating cylinders, was automatically replaced.

Because of these apertures, and gaps around the joints, Pettenkofer saw his respiration space as being able to "communicate freely with the atmosphere," and it was this property, atmospheric communication, he ascribed to the ideal dwelling house more broadly.[63]

(continued...)

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