When Walls Became Membranes: Le Corbusier, Siegfried Ebeling, and the Concept of the Breathing-Wall Skin

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Following the rising explorations into material and construction technologies, architecture is increasingly pushing the boundaries of surface performance. In so doing, it investigates intersections between the building envelope and the physiology of breathing, exploring its analogy to an organic surface, skin or membrane. This paper revisits the architectural literature of the early twentieth century, in particular the work of Le Corbusier and Siegfried Ebeling, to discuss how the biological analogies related to the building envelope in those days may hold the key to a deeper understanding of its evolving performance.

In the early 1920s, a charcoal and graphite drawing signed by Ludwig Mies van der Rohe came to light, featuring a prismatic skyscraper which appeared to be still under construction due to the fact that its inherent structure remained visible. "We can see the new structural principles most clearly when we use glass in place of the outer walls," Mies wrote with reference to the 1921 Hochhaus am Bahnhof Friedrichstraße project, while adding that such principles were feasible in those days because "in a skeleton building these outer walls do not actually carry weight"[1]. A cog in Mies' theory of the 'skin and bone' structure, the description of the project, as part of a wider exploration, has not been freed from associations to meaning derived from the biological sciences. "Here the destruction of the object as appearance was completed right down to its ultimate intriscicness, and an essentially simple structure remained as archetype, as fundamental as the molecular construction of the elements"[2], Fritz Neumeyer writes in relation to the 'skin and bone' projects of Mies – "a sort of genetic constant of all building"[3]. The interrelation of the molecules, the autonomy of the skin, and eventually the separation between skin and bones, were all concepts articulated through Mies' interpretation of the archetypal architectural division between inner structure and exterior envelope, as seen through the lens of new materials and their influence on building. "Were they not buildings 'without windows' insofar as the windows had become walls?" [4], Neumeyer wonders.

In line with former discussions on the integration of scientific metaphors into the modern architectural discourse, this paper aims to follow up on Neumeyer's ultimate question. In so doing, it will discuss the changing behavior of the building envelope at the beginning of the twentieth century: the hypothesis that besides windows having become walls, walls had become membranes – in their broader definition as breathing, regulating, selectively permeable entities. From here it follows that this discussion envisions to shed fresh light on the biological analogies related to the building envelope, focusing in particular on the work of two of Mies' contemporary architects – Le Corbusier and Siegfried Ebeling – who had both explored the concept of the membrane from within the architectural context. A closer look at both these responses will illuminate the biological analogy that designates the building envelope as a breathing skin and lives on to the present day through an investigation of contemporary architecture into responsive, dynamic façades.[5] It is a discussion that will seek to understand how the said analogy, in its historical precedent, has fostered new methods in the interpretation of the building envelope, not least in a transition of focus from architectural expression to performance.

BREATHING AS AN ARCHITECTURAL PROCESS. LE CORBUSIER'S 'RESPIRATION EXACTE' AND 'MUR NEUTRALISANT' TECHNIQUES

Mies was not alone in exploring the distinction between inner skeleton and exterior envelope at the dawn of the twentieth century. Le Corbusier's 1915 Dom-ino house – communicated through the one-point perspective drawing of a two-floor, open-plan modular skeleton, had anticipated Mies' 'skin and bone' theory and was likewise "a striking demonstration of the separation of structure from enclosure"[6]. Nearly a decade later, in his 1927 "La théorie du toit jardin [The theory of the roof garden]", published in the pages of the Autumn issue of the Architecture Vivante magazine, Le Corbusier describes how the extensive exploration into the properties of reinforced concrete had led to the placement of the columns in the building's inner surface, and to the subsequent independence of the façade. "The façades are no more than light membranes of insulating walls or windows," he goes on to clarify, while mentioning that "the windows, without interruption, can run across one edge of the façade to the other"[7]. The uninteruptedness and autonomy of the building envelope were two characteristics that justified the comparison of the façade element to a membrane, nevertheless they confirmed the analogy only partly.

In their ability to form a continuous surface around the building, and admit views, light and thermal energy, the glass façades that complemented the iron skeletons of that time justified to a great extent their

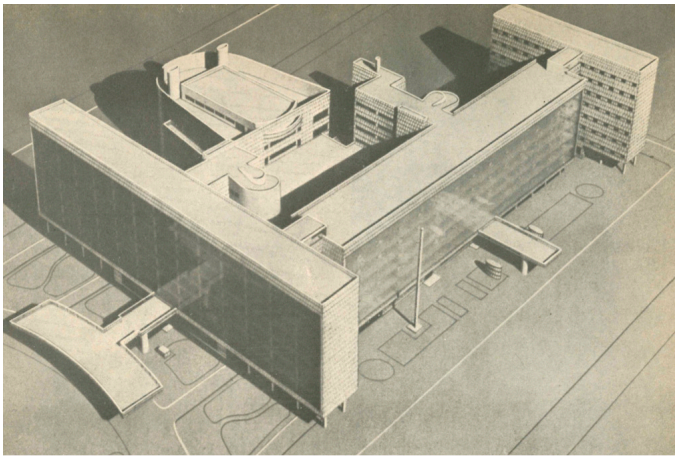

Figure 1: Le Corbusier, Pierre Jeanneret, Centrosoyuz building, 1928 | Source: Willy Boesiger, Le Corbusier (Zurich: Artemis, 1972): 56.

characterization as membranes. This fact, however, gave rise to the question of whether such envelopes could assume additional functional characteristics of the traditional solid wall, such as the provision of security, the filtering of sound and the regulation of temperature; in brief, to mediate efficiently between interior and exterior environments. The growing demand for the insulation of the continuous glass envelopes, which proliferated at that time, as well as the need for ventilation of the spaces found therein, had gradually shifted architects' attention from the problem of the separation of structure from enclosure towards the performance of the enclosure itself. To this demand, Le Corbusier famously responded with the 'exact respiration [respiration exacte]' and 'neutralizing wall [mur neutralisant]' techniques, aiming to infuse 'living air' into the double outer layer of the building – as his 1935 essay "Le Verre, matériau fondamental de l'architecture moderne [Glass, The Fundamental Material of Modern Architecture]" suggests. His response incorporated a process borrowed from the field of physiology; the adaptation of glass walls to their surrounding environment was, in his words, "simply a question of the lungs"[8] – breathing, responding, regulating.

As we breathe fresh air through our membranous bodies, the building envelope, he hypothesized, ought to similarly function as a breathing organism, processing and regulating air. "Our invention, to stop the air at 18°C undergoing any external influence"[9], he explained. "These walls are envisaged in glass, stone, or mixed forms, consisting of a double membrane with a space of a few centimeters between them"[10], Le Corbusier noted as regards a building envelope within which regulated air would circulate, so as to maintain the temperature of the interior space on a fixed level. Not only was this double surface envisioned to substitute the façades of the building, but in correspondence to the continuity of the skin, it was intended to enclose the full volume of the building, "underneath, up the walls, over the roof terrace"[11].

More than its aesthetic and perceptive qualities, the building envelope is placed here under scrutiny concerning its performance – the impact on the mediation between interior and exterior environments –, and the terminology affiliated to the human skin is being deployed in order to articulate this influence. The concept of maintaining temperature at the fixed level of 18 degrees Celsius aimed at rendering the temperature and humidity conditions in the interior space of the building appropriate, and at admitting an ineffable amount of sunlight in its interior. It aligned with the architect's visions of a standardized type of architecture, one independent from the climatic conditions of the surroundings, and it relied greatly on the regulating properties of the building exterior. Even though this intervention in the building envelope was described by Le Corbusier as a 'breathing' system, fresh air was not meant to find its way into the interior space. Instead, the latter would be mechanically ventilated and fresh air would solely spread within the exterior wall, leaving the enclosed volume of the building completely airtight, so as to benefit from the insulation benefits provided by the double-skin wall.

Opportunities to intervene into the constructed boundary between interior and exterior space, in terms of thermal control, had arisen for Le Corbusier as early as in 1916, and the double-glazed parts of the Villa Schowb's envelope, which were to be evolved further in the case of the 1927 Palais de la Société des Nations competition project in Paris, and its own double-glazed skin. The 1928 Centrosoyuz ministry building in Moscow (Fig. 1) however would be the first project initially conceived to include both the 'respiration exacte' and 'mur neutralisant' techniques. The axonometric plan of the building, which provides two enlarged sections of the interior of the building and the façade, testifies the simultaneous presence of both techniques (Fig. 2). First, the 'respiration exacte', here 'aeration ponctuelle', which envisaged the circulation of air at the fixed temperature of 18 degrees Celsius within the interior space of the building, and it was signed by the engineer and acoustics expert Gustave Lyon[12], and second, the 'neutralizing wall' made of glass, which provided the circulation of dry air – cold or warm according to the season – within the hermetically-sealed, double-skin façade of the building, bearing the signature of Le Corbusier and Pierre Jeanneret.

Although glass, for Le Corbusier, embodied the "ideal of the de-materialized building skin, the minimum membrane between indoors and out"[13], its extensive use in replacement of the load-bearing wall ignored significant environmental qualities and carried along important issues to reflect upon and to solve. The layers of glass that contained warmed air on the interior, according to this technique, were criticized by architecture historian Reyner Banham, who described them as "clip-on elements" – added posteriorly on the structure and aiming at replacing the "performance factors that a massive wall had contained homogeneously and organically"[14]. Although the 'respiration exacte' and 'mur neutralisant' techniques would come to an early conclusion, they stood for an early indication of explorations into the mediation between interior and exterior environments, of regulated air as an integral material of built space, paving the way for forthcoming examples of responsive architectural skins. More than a clip-on element, regulated air would soon act as a "life support" system[15]: it would permeate through the building exterior and expand across the interior space of a building, accounting for a principal factor in the achievement of comfort and hygiene.

BRIDGING HUMAN AND CONSTRUCTED SKINS. SIEGFRIED EBELING AND THE CONCEPT OF THE 'WANDHAUT'

At the same period that Le Corbusier was exploring the application of the 'respiration exacte' and 'mur neutralisant' techniques in the context

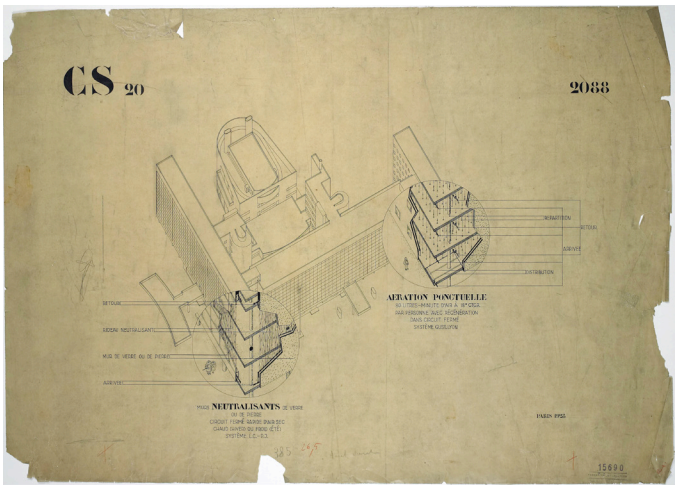

Figure 2: Le Corbusier, Pierre Jeanneret, Gustave Lyon, Centrosoyuz building, 1928 | Source: Fondation Le Corbusier Paris

of architecture, the Bauhaus-alumnus Siegfried Ebeling, on German grounds this time, was elaborating his idea of a 'breathing wall-skin [Wandhaut]', therewith his vision of an energy-efficient building envelope. By comparing constructed space to the physio-logical membrane, in his 1926 book entitled "Space as Membrane [Raum als Membran]," Ebeling accentuated not only the necessity to explore the intersections between biology and architecture, but also the importance to consider the environmental impact of building.

A common ground of the wider artistic and architectural movement that saw the intersection of modernity with concepts of organicism, among which Mies and Ebeling[16], had been the work of nature philosopher and biologist Raoul Francé, who "conceived of the world as an intricate system of nested and interlocking ecosystems"[17]. In a similar prism, Ebeling envisioned an architectural stance interrelated with its environment; a stance organically intertwined with the various technological apparatuses, the surrounding human, environmental, and cosmic spheres. The arrangement of walls and openings is here determined by the things that are found in both the living world and in the environment, as well as by the relationship that architecture is envisioned to establish with the latter.[18] "The massive porous encased space of today," Ebeling stressed, "will become a membrane between our body as core and the plasmatic energies of the wider environment through the creation of new structural relationships".[19]

With the definition of space as a physiological membrane, Ebeling distanced himself from the then proliferating architectural mo-dels associated with the stiffness and rigidity of concrete and glass construction and sought instead to define a building envelope that would form and inform a self-sufficient type of architecture, in terms of energy consumption. It was the concept of an 'uninterrupted skin' which held central role to his description of an architectural type informed by the properties of the biological membrane. "Ebeling was the first to understand that thanks to new materials and new technological installations the wall might henceforth be apprehended as a permeable membrane", architecture historian Laurent Stalder writes, going on to observe that Ebeling saw architecture as interconnected with the various energies comprising and surrounding the built artifact, therefore challenging well-established definitions of a "traditional uniform, autonomous, and yet multifunctional architectural space"[20] (Fig. 4).

And while for Le Corbusier glass served as a pivotal material for his 'exact respiration' and 'neutralizing wall' techniques, Ebeling sought instead for an alternative response to the concept of the 'breathing' building envelope, in terms of materiality. He intended the building envelope to be constructed out of wood, mud, stone, or their substitute materials, and notably he participated in a broad research into the realization of building prototypes made entirely out of metal. The year that the "Raum als Membran" came to light saw Ebeling being occupied with an additional task: serving as a member of Hugo Junkers' main research team on metallic buildings – in the context of the 'Stahlbau' project – he had the opportunity to assess his theoretical observations in practice. Part of this assessment was the 1930 All-Metal Circular House (Fig. 4), which aimed at admitting the maximum amount of natural light due to its round form and the absence of internal walls or partitions, considered to be a step forward to the definition of a self-sufficient house.

The nearest Ebeling arrives to the mention of glass in the book is when he refers to a "thinner medium that is penetrated by rays of light of variable quality, alternating periodically," in his synopsis of the state of architecture in those days, pointing out the thinness and the permeability of this medium in terms of light admittance; or when he describes an "indifferent spatial enclosure" and, by extension, an indifferent "spatial tension," which appears to be particularly lifeless in grey daylight.[21] His theory kept a differentiated position towards the then widespread building envelopes, constructed in their majority out of glass. Despite its thinness and ability to admit, under certain circumstances, light and visibility, glass was unable to filter air through its continuous surface. It remained an element which would still have to "close and open, not only in one but in many directions"[22] in order to perform such action. It was therefore linked to a series of deficiencies and triggered a reassessment of the relationship it established with both the interior and exterior environments. Through a biological approach to architecture, this relationship would be expressed in terms of porosity: it would allow boundaries to become fluid and space to become flowing. In the spirit of Le Corbusier's perimetric enclosure of regulated air, here "the inside and the outside, the upper and the lower, fuse into unity"[23].

Following Fritz Neumeyer, "as a surface indissolubly connected to the body of the building, the exterior wall or façade does not only produce an optical effect but also a spatial one. Like skin which transpires, a façade tell us that behind it there is something which develops in depth and which at the same time expresses itself on the outside"[24]. Similarly, Ebeling aspired for a plasmatic relation between structure and enclosure, originating from within and being projected outwards. It was an organic unity that Ebeling aspired to, able to perform a mediation between interior and exterior space, materiality and performance, human and constructed space.

As László Moholy-Nagy would similarly put forward a few years later, "the last and highest stage of spatial creation is evidently its grasp from the standpoint of biological possibilities"[25]. More precisely, an approach

Figure 3: Siegfried Ebeling, Raum als Membran, Dessau 1926, Cover | Source: Siegfried Ebeling, Spyros Papapetros, ed., Space as Membrane, London 2010.

towards the constructed space through the prism of biology "did not have to do with a 'sculptural' exterior, but only with space relationships, which establish the content of experience necessary for a plan of creation"[26]. A precursor to Moholy-Nagy's observation that architecture should aim at establishing spatial relationships rather than inquiries into form, Ebeling had also stressed that importance of spatial 'content [Gehalt]' over 'external appearance [Gestalt]'[27]. For him, the conception of the building envelope as a membrane had first and foremost a biological importance; biological not only in the sense of borrowing meaning from the physiological terrain, but also in terms of emulating a physiological process and, at the same time, influencing the physical condition of the human occupant of architecture. And this because the building envelope as membrane – envisioned as "a path for future architecture"[28] – bore a dual task: the definition of both the space-enclosing wall that would exclude the harmful elements in the atmosphere and the surface that would admit all the necessary elements in the interior space.

"The more we reveal nature's material connections, and the more we feel the need to make our cities true urban landscapes," Ebeling describes, "the clearer it becomes that the character of the skin or membrane between the exterior space and the dimensions of the body basically relates to the way in which the space is defined and dimensioned on a psycho-physical level"[29]. Living as we do in highly regulated environments, Siegfried Ebeling's visions merit further research; on the one hand, because they reflect on the potential of interdisciplinary synergies, which may link architectural practice with the biological sciences, and on the other, because they may contribute to the growing discussions on ecology from within the field of architectural discussions.

BUILDING AS SKIN. MEDIATING BETWEEN SPACE, HUMAN DYNAMICS, AND THE ENVIRONMENT AT LARGE

"It was not that the opening and the perforation of the wall did not exist as a wish or a problem, nor that this task had not been solved," architect Arthur Korn wrote at the end of the 1920s, in his outlook on glass in modern architecture, "but that this real closure and separation was never achieved through a membrane"[30]. The examples discussed above have attempted to illuminate such achievement. As "the solid architectural wall was melting away under the pressure of modernity"[31], both Le Corbusier and Ebeling found a fertile ground in the reasoning informed by the biological sciences, so as to reflect on issues concerned with the architectural boundary – on problems of enclosure and openness, resilience and lightness, form and performance. Their reflections were not entirely new. The origins of the biological analogies related to the building envelope can be traced much earlier in the course of modern architectural history.[32] As architecture historian Didem Ekici has recently demonstrated, the preoccupation of the eighteenth century with concepts of hygiene, efficient ventilation and heating, led to the conception of "the dwelling as a skin" – a conception that "allowed architects to perceive the boundary between interior and exterior in more ambiguous terms"[33]. It was however the proliferation of new materials, such as glass and steel, of construction techniques, and of the cross-between the scientific and artistic disciplines, at the beginning of the twentieth century, that allowed architects to push the boundaries of the architectural surface. It was modernism that "rendered ambiguous the role of the wall as a device of definition, confinement and separation and as carrier of symbolic dressing"[34], shifting attention away from its traditional definition and on its mediatory performance.

In his broader discussion of the metaphors deriving from the fields of biology and mechanics, in the context of the modern architectural discourse, Adrian Forty argues that the metaphors of 'respiration' and 'breathing' have not "caught on"[35]. And this because they allude to an open system with undefined limits – an idea not appealing to architects. In contrast, the 'circulation' metaphor, understood both as the flow of air and the movement of substances, has become an integral principle of the built artifact. The attempts to bridge the building envelope with the physiology of breathing, previously explored, have nevertheless demonstrated the richness that such attempt entails, in referring to the human body not only as an entity that lends itself to the interpretation of the architectural artifact, but also as an entity which one should address when conceiving and constructing architecture. Inasmuch as the building envelope is a threshold that surrounds and defines space, it also provides a space for human experience, in establishing an efficient relationship with the natural environment.

Today, the performance of the building envelope, in terms of mediation between constructed, human and natural environments, appears to represent a shared ground for scholars outside the range of architecture. "What is the envelope of this space? Through which door do you get

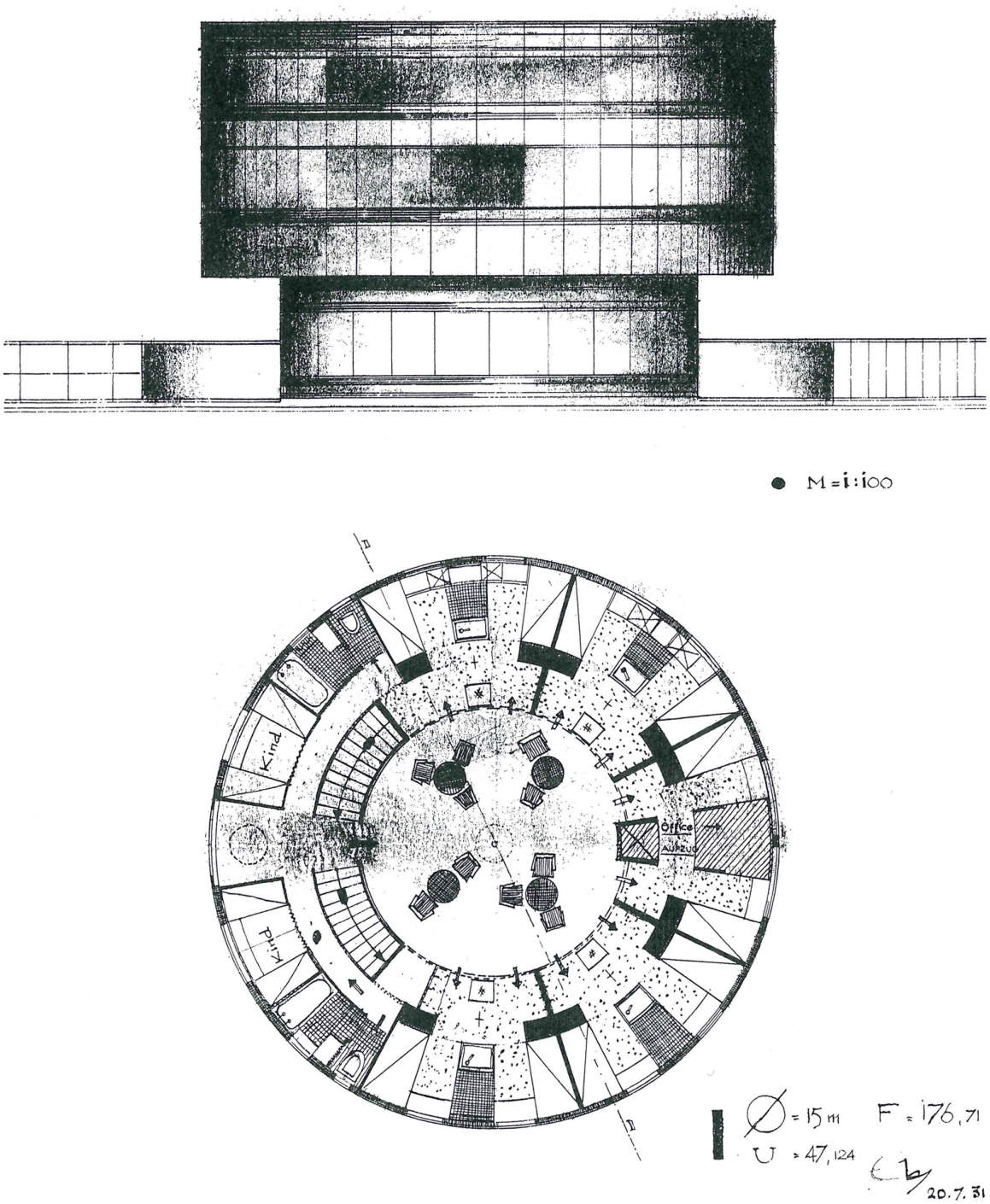

Figure 4: Siegfried Ebeling, All-metal Circular House, 1931 | Source: Walter Scheiffele, Das leichte Haus. Utopie und Realitaet der Membranarchitektur (Leipzig: Spektor, 2015): 86 .

in and out? What sort of air do you breathe in it?"[36], philosopher and sociologist Bruno Latour asks. In the context of the current and most importantly the forthcoming environmental and sociocultural meanings, the analogies of the building envelope to a porous, breathing organism merit further research. "Part of the adventure of Modern architecture is that it has also rendered the apparently immaterial sides of being – namely human residence in an atmospheric setting – explicit in technical and aesthetic terms,"[37] philosopher Peter Sloterdijk observes, with reference to architecture's constructed atmospheres. If the rise of the 'building as skin' concept has previously called into question the performance of the building exterior, in terms of permeability, natural air and light admittance, today emphasis is being placed on the air that circulates within and outside of architectural boundaries. It is by looking further than the discursive significance of the biological analogies in architecture, and into their role as vehicles for the improvement of the building performance and the anticipation of forthcoming design phenomena, that new perspectives to the negotiation between built artifact, human dynamics and the environment at large will open up.

ENDNOTES

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