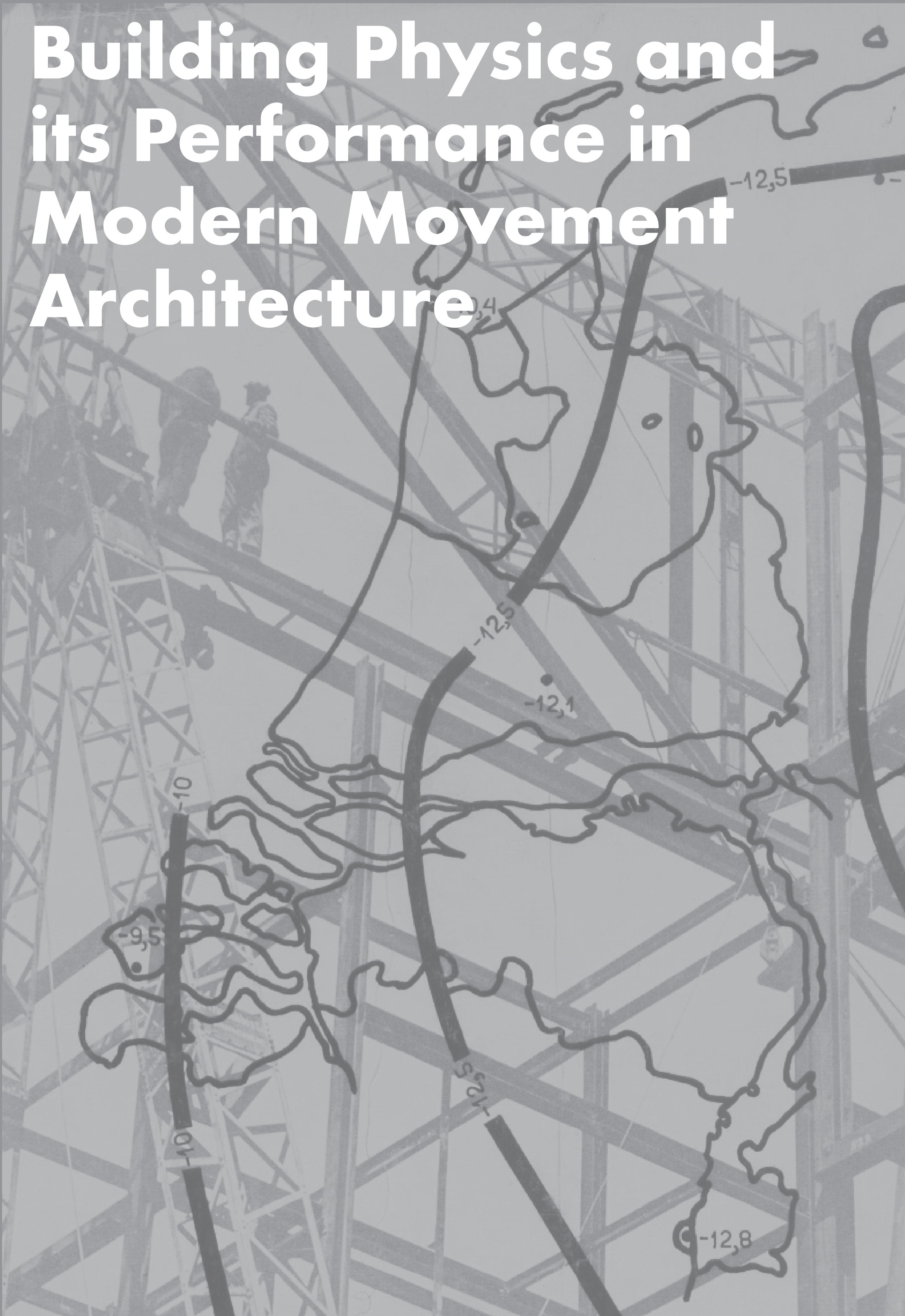
Building Physics and its Performance in Modern Movement Architecture



THE science of Building Physics was developed in Germany from 1880–1940 but its performance in Modern Movement architecture is considered immature and in aspects problematic. Still, some international pioneers found theoretical and practical ways to catch the theme.

By Jos Tomlow

A famous architect reached such a level of enthusiasm (…) that he asserted: 'In the future, one will build in the far North exactly as along the Mediterranean Sea. In few years, his demand has been fulfilled; Architecture has suffered such a defeat, that she will recover only very slowly. Had this been just an aesthetic mistake, then it would probably not have been fatal to a similar degree. But Nature—in this case the climate—will not withhold its revenge, for the fact that she has been so badly ignored.'

Bruno Taut in 1936[1]

BUILDING SCIENCE—*Bauphysik*, in German—is perhaps regarded as a neglected aspect of architectural historiography of the Modern Movement. The innovative side of early modern period architecture includes the design parts such as flat roofs, thin walls, glass curtain walls including shaded screens. To accomplish this new building, materials and systems had to be developed. Some technical questions regarding their application and overall performance are analyzed in this article.

Early Developments in Building Physics

Building Physics is a discipline of building technology which analyzes building materials and systems, specifically in regard to the research of transmission of heat, sound, humidity and air.

One of the key notions in the discipline of Building Physics is the analysis of heat transmission, since it is a quantitative criterion for building quality. The analysis and control of temperature in buildings is often referred to by the k–value on heat transmission, also known as U–value. The k–value is defined by: energy loss—in W/m²K —of 1° C (or 1° K = Kelvin) through a 1 m² wall or ceiling part during one hour. A low k–value implies that heat insulation properties are good and basically one should feel comfortable in the concerning room. When adequate air ventilation is provided, energy may be saved for heating. Empiric results on heat transmission were offered by Jean Baptiste Joseph Fourier and Jean Claude Eugène Péclet already in early 19th century in France. Technicians who worked at large energy plants sought ways to control heat loss of the machinery and of the structures involved. Consequently a group of industrialists took the initiative to research on new insulation materials, like such based on cork. In 1918, the *Forschungsheim für Wärmewirtschaft* near Munich was established as a private research institution, by Prof. Oskar C.W.H. Knoblauch (1862–1946) and became regarded as a singular source for data in the analysis of heat transmission.

Interior air quality and study of degrees of proper air ventilation throughout a building is an important factor of Building Science. Typically interior public spaces such as assembly halls consume large quantities of fresh air in short time. Industrial hygienist Max von Pettenkofer discovered around 1850 in Munich that CO_2 (carbonic acid) is comprised of each individual's outward breath. Pettenkofer proved that the CO_2 quantity is a major factor that must be monitored and measured as part of the quality of used air.

Progressive political forces demanded increased social and medical conditions for those in working class and other social welfare programs. Cholera outbreaks (e.g. Berlin 1831/1832, 1,426 killed; Munich 1854, 3,000; Hamburg 1892, 8,605) and other epidemics which grew from unsanitized conditions where people concentrated (i.e. barracks, prisons, boarding schools), where answered by improvements in general hygienic standards. This discussion was subsequently integrated in the Building Physics approach, defining proper technical standards.

In Berlin, Hermann Rietschel (1847–1914) developed heating and ventilation systems commercially. His contribution to Building Physics is significant due to his scientific and experimental work as a professor on ventilation and heating (1885) at the *Königliche Technische Hochschule* in Berlin. Similarly Friedrich Wilhelm Hermann Fischer (1840–1915) taught courses on heating and ventilation technology at the *Technische Hochschule* in Hannover starting 1876.

In 1907, intellectuals from industry and business founded the *Deutscher Werkbund* e.V. organization with notable members like the architects Peter Behrens, Hermann Muthesius and *Bauhaus* founder Walter Gropius. They recommended industrial standardization throughout Germany as a mean to establish rational working methods combined with guidelines for achieving quality control.

A rather early step towards standardization was the founding in 1917 of the German Norm (DIN: *Deutsche*

Industrie Norm). Following a ten year period, 3,000 German Norms or DIN standards were issued. These technical guidelines were recommended by authorities that set forth regulations from traditional local building codes (*Bauordnungen*). They consisted of a variety of guidelines for light and moisture equipments as well as for construction systems in wood, brick and stone. Still, in practice the standards often were not held, due to risky innovations and simply bad work.

Many building fairs were established in order to disseminate information to the general public about the aim of standardization and to stimulate further research and participation of industry experts. This enabled architects and builders to network with the industry as well as universities and municipal authorities.

By contrast, the four first CIAM meetings (*Congrès Internationaux d'Architecture Moderne*) from 1928 till 1933, were not yet focused on technical themes and lacked understanding the urge for the discipline Building Science.

Building Science and the Modern Movement

It is presumed that a good part of Building Science was known in academic circles circa 1918. However, the question remains on how this knowledge was disseminated to professionals throughout the modern building practice. During the early part of the 20th century, Building Physic theory was not as compelling to architects as they were in academic circles, due to an abundant use of mathematics. While the basic principles of Building Physics had been presented in writings by authors such

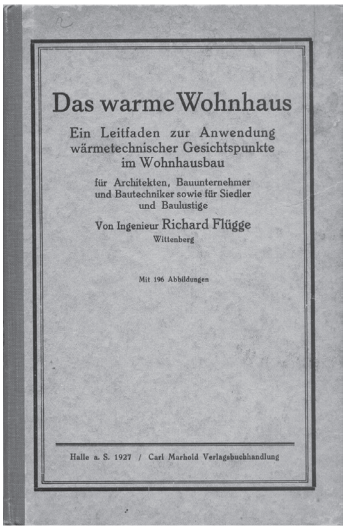


Figure 1. Cover of Flügge, R., *Das warme Wohnhaus – Ein Leitfaden zur Anwendung wärmestechnischer Gesichtspunkte im Wohnungsbau.* Halle, a.s. 1927.

Figure 2. Cover of Rasch, H. u. B., *Wie bauen?, Nr. 2: Materialien und Konstruktionen für industrielle Produktion.* Stuttgart, 1928.

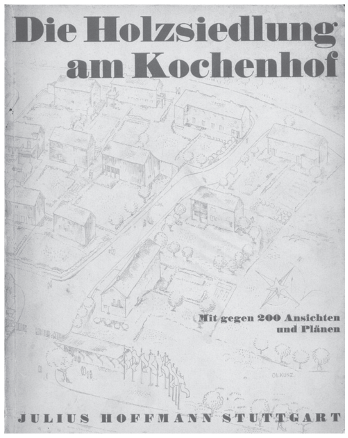


Figure 3. Cover of Schmitthenner, P., *Die Holzsiedlung am Kochenhof — Ausstellung Deutsches Holz für Hausbau und Wohnung*. Stuttgart, 1933, with: Reiher, H. *Wärme-und schalltechische Untersuchungen*, pp. 6–8.

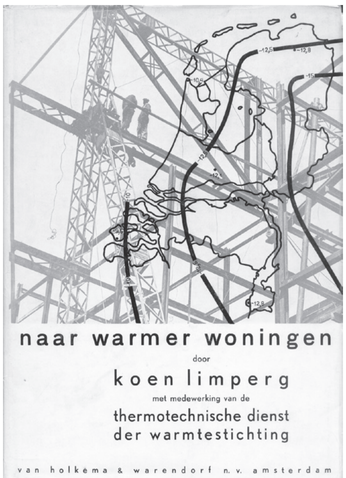


Figure 4. Cover of Limperg, K., *Thermotechnische dienst der warmtestichting. Naar warmer woningen.* Amsterdam, 1936.

Photos by HsZiGr / Jos Tomlow.

as Richard Flügge, Richard Schachner and Eduard Jobst Siedler, a systematic approach and design methodology based on Building Physics still had not been published, let alone been widely circulated around 1930.

Compared with the young *Bauhaus*, universities throughout Germany still followed the elitist tradition of scientific research for design development. Students were taught rather theoretical data knowledge than learning by practice. By comparison, the *Bauhaus* school, provided education and practical training based on new research of building material performance which had been made available through industrial applications. However, methodologically the *Bauhaus* school lacked much of the secure academic approach in its experiments. On the other hand very substantial was the work of Hannes Meyer on the scientific treatment of natural light, which became integrated into architectural design at the *Bauhaus* in Dessau.

Advertisement and product information contributes to Building Science

While hardly official books seem to exist for many aspects of new building materials and systems, information about historical developments can be traced through *grey literature*, like trade journals and advertisements during this period (roofing paper, insulation, steel windows and glass, stucco and tiles, including regulations for its installation). Eminently valuable are both books by the Rasch brothers entitled, *Wie bauen?* (How to build? 1927/1928) since these writings give specific information on the experimental houses of the *Werkbund Weissenhofsiedlung*, 1927 in Stuttgart or Konrad Wachsmann, *Holzhausbau —Technik und Gestaltung*, Berlin 1930 on wooden houses including photos of the building process.

The "Flat-Roof Discussion" and Conservative Criticism

The Modern Movement was often criticized due to observations which were primarily related to the discipline of Building Science. The argument which famously reoccurred was the design of the flat-roof, leading to publications by Walter Gropius and by contrast, on the conservative side by Paul Schultze-Naumburg, who strongly promoted pitched roofs.

Further public discussion aroused about the housing settlement designed by *Bauhaus* director Walter Gropius, the *Törten-Siedlung* with 256 houses, (1926-1929) in Dessau. Gropius presented passionate writings about design experimentation and supported a shift towards an industrialized building practice. In an editorial article in *Bauhütte* (Volume 12, 1929), a rebuttal of this project documented technical errors and problems associated with the *Törten-Siedlung* dwellings, including photographs which profusely depicted cracks and evidence of moisture problems. Ironically, some information in the article was extracted from reports by the *Reichsforschungsgesellschaft für Wirtschaftlichkeit im Bau- und Wohnungswesen*, a state organization, who had supported the Bauhaus project and which provided a critical analysis of all technical related issues for future building projects. Problematic solutions in the construction of the *Törten-Siedlung* included roof water drainage through the use of concealed rain pipes and a profusion of thermal bridges at the steel windows. In this controversial debate often ideological arguments seemed to win over pragmatic reasoning.

Another relevant dispute between conservatives and progressives is related to the *Kochenhof*-Settlement. Initially proposed by Modern Movement architects Bodo Rasch and Richard Döcker a new settlement in Stuttgart should follow the *Weissenhof* settlement, but this time with wood housing. They and others, like Konrad Wachsmann, had already designed plans for such a settlement. After public discussion, shortly after the start of the Hitler dictatorship in 1933, conservative Paul Schmitthenner and city planner Heinz Wetzel managed to implement this project, with different designers. The *Kochenhof* settlement did illustrate one "progressive" feature which was not included in the design rules suggested for the *Weissenhof* settlement of 1927 by Mies van der Rohe. It was required that contributing architects for the design of *Kochenhof* had to provide structural solutions in wood that complied with defined standards in acoustic and thermal insulation as set out by a Stuttgart University laboratory (see references).

Modern Architects Promoting Building Science

Few key figures were influential in the introduction of Building Physics into Modern Movement architecture. Some architects like Szymon Syrkus from Poland, Johannes Bernardus van Loghem and Koen Limperg from Holland wrote on Building Physics and used it in their own work. Andreas Bugge from Norway defined his own Building Science research.

Szymon Syrkus was the Polish representative in CIAM. Assisted by his wife Helena, he was oriented towards a clear and functionalist interpretation of Building Physics, including tests on differentiated wall systems for steel frame skeletons for residential use. Syrkus presented an invited lecture on exterior walls at the fourth CIAM meeting in 1933 which was published in Holland (see references).

Some architects—plausibly called *Organic Moderns*—while inspired by innovation of the Modern Movement, also were determined to address design to the climate issue. They found a practical balance and understanding of building technology while continuing to design with a

Figure 5. *Haus Schminke* in Löbau, Saxony, 1929-1933, by **Hans Scharoun,** from north east. Photo by Friedegard Eichler HsZiGr.

fresh experimental approach. Both Hans Scharoun and Bruno Taut arguably bypassed many abstract positions of their colleagues presented during that time. Taut's publications show a mature ability to combine a huge building practice with creative writing on functional architecture. His book on the Japanese house deals with the impact of—a foreign—climate on building. To the problem of flat roofs, Bruno Taut had adopted a traditional detail, which avoided the typical hidden gutters behind an attica of the 'white cube' building type. His roofs, for example in the *Hufeisensiedlung* in Britz, Berlin, tend to slope in a pronounced small angle (approx. 2°) to one side, with the gutter cantilevering in front of one façade. The other sides show walls ending in an attic, crowned by exposed bricks. Thus a certain abstract overall shape remains.

Hans Scharoun, with his state of the art design of *Haus Schminke*, took into account the science of Building Physics and complied with the seasonal climate in Saxony through modern and innovative structural and functional design solutions.

Case study: Haus Schminke by Hans Scharoun (1929–1933)

The family house was designed and built 1930–1933 for the Anker noodle manufacturer Fritz Schminke, his wife Charlotte and their children, three girls and one boy. All aspects were discussed with the Schminkes in an open, friendly manner, often in letters. Photos by Alice Kerling, showing the Schminke house in 1933, are a beautiful documentation. The main builder was the local *Baumeister* Walter Vetter, who also contributed to the final design. The building was restored by *Werkstatt für Architektur und Denkmalpflege* Pitz & Hoh (1998–2000), with financial support by the *Wüstenrot Foundation*. Since 2009 the house, open for activities, has been operated by the charitable foundation *Stiftung Haus Schminke*, on initiative of the city of Löbau and Hess AG Form + Licht, a leading firm for urban light design.

As the following shows *Haus Schminke* was treated during the restoration with the goal of maximum repair of existing substances, taking a certain energy gap in winter into account.

In the Building Physics analysis of the recent restoration of *Haus Schminke*, Dr. Klaus Graupner states: "Like other buildings of the classic Modern Movement, the *Haus Schminke* has—from today's viewpoint—a deficient heat insulation and holds numerous technical details which are even worse in terms of building science (thermal bridges etc.)". However, surprisingly, Graupner continues: "the historic building *Haus Schminke* did function well from the building science aspect and no climate–conditioned severe damages could be traced."[2]

Description

Haus Schminke is designed along a navigational compass: one direction points in a long west–east direction with the kitchen at the west, the entrance with annex the children's space to the south, and the dining space to the north. The oblique lines of the building plan are parallel to the street, with an orientation of the winter garden to the south east. Both children bedrooms are oriented south, and the parents' bedroom is oriented to the south and east.

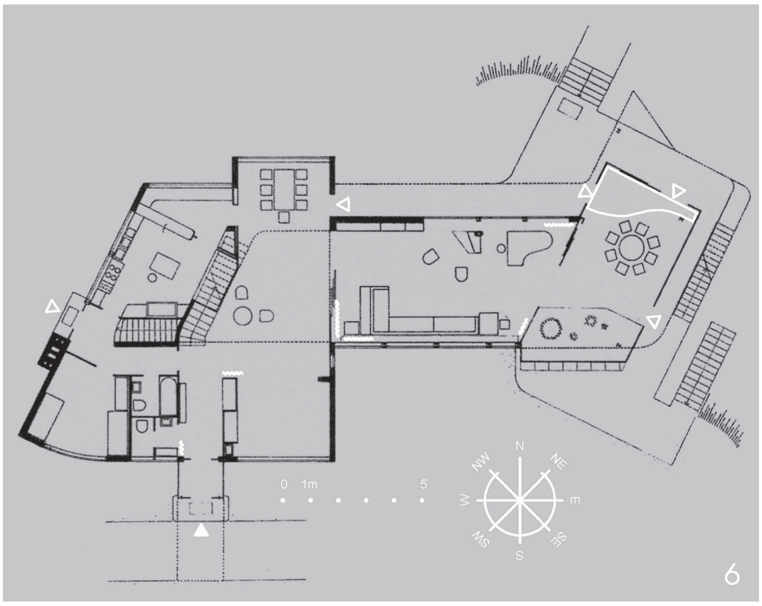
The garden offers a lively view from multiple locations throughout the house. For example, the dining table is connected to the garden through a hole in the wall filled with one big glass pane. The interior of the house seems extend into the garden by a continuous glass wall system including nine doors on three levels.

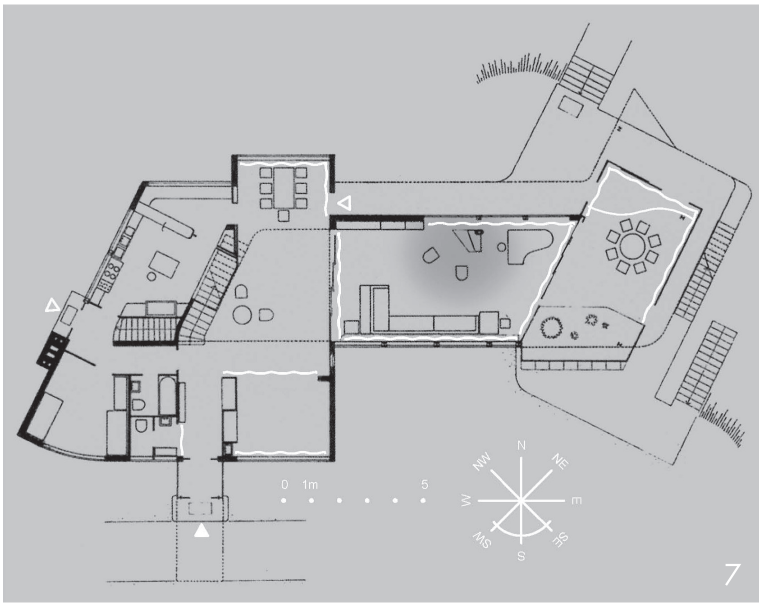
The living space itself is spacious enhanced by the non–rectangular plan and oblique shapes in a vertical direction, like the stairs in the hall and outside the winter garden. The metal stairs and balconies draw upon naval architecture, which became a common feature in the work of Hans Scharoun, who grew up in Bremerhaven. The house was equipped with operable windows which easily allow the possibility for cross ventilation, also in the vast cellar area.

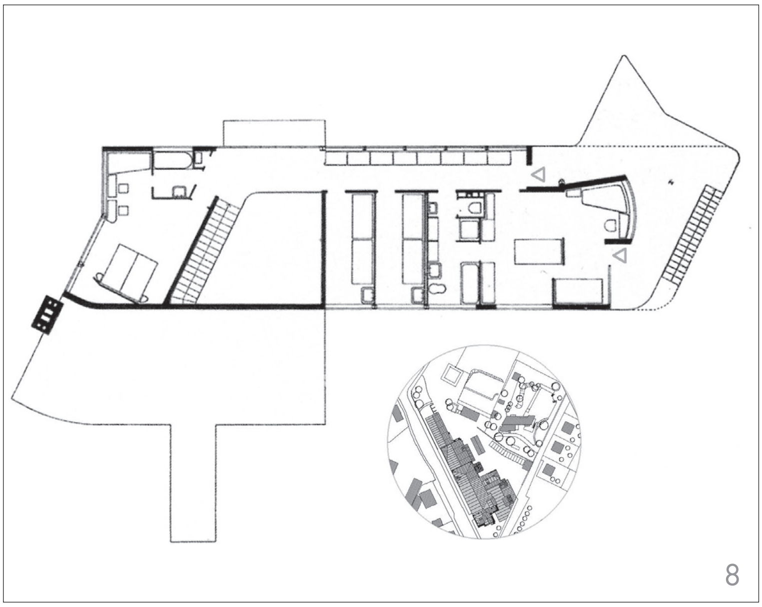
Thus, by current standards today, the building is functionally well suited during mild weather months. However, given that there are huge glass areas throughout the walls, the question on how the building performs over the long cold season from October to March in the Saxony region arises. The heating system includes a sophisticated use of radiators which are equally spaced directly in front of a parapet wall and adjacent to sitting areas. It was laid out by engineer Alois Ranzi and its concept could be used entirely, including many parts like radiators, after the restoration, what is a very rare achievement.

The unique design for heating of the winter garden integrates unobstructed views between the house interior spaces and the exterior garden. Deepened recessed areas surrounded by plants and an indoor fish pond were combined with compact radiators and pipe coils. In other parts of the winter garden, convector elements appear beneath the floor. Through a flat metal grid, cold air travels from the high storey glass panes onto these floor areas and the hot pipe coils transform the air temperature into a more comfortable heat level. The shape of the interior border of this grid is curved, simulating the natural shapes of the adjacent garden and in the same time allowing person's entrance to clean their shoes from dust.

For colder times appropriate measures were found to create warm spaces within the house. Huge sliding doors were made partly in glass and could enclose the living







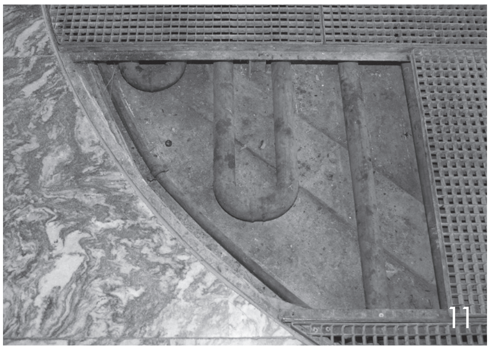


Figure 6. First floor plan of *Haus Schminke* during the warm season, with indication of exterior doors and curtains drawn back. Redrawn by Jan Fallgatter Hochschule Zittau/Görlitz. Original plan printed with kind permission by Löbau city authorities.

Figure 7. First floor plan of *Haus Schminke* during the cold season, showing central fireplace (dark spot) and main curtain locations as well as closed sliding doors. Redrawn by Jan Fallgatter, HsZiGr. Original plan printed with kind permission by Löbau city authorities.

Figure 8. Second floor plan of *Haus Schminke*. Inset: site plan of Schminke house and garden, adjacent to the Anker noodle firm Redrawn by Jan Fallgatter, HsZiGr. Inset plan by Martin Meßer, HsZiGr. Original plan printed with kind permission by Löbau city authorities.

Figure 9. *Haus Schminke*. Living room with view to winter garden through sliding doors showing curtains. In small distance in front of the piano was the fireplace; compare plan. Photo by Jens Freudenberg, HsZiGr.

Figure 10. *Haus Schminke*. Sliding doors between high hall and living space. Photo by Jens Freudenberg, HsZiGr.

Figure 11. *Haus Schminke*. Winter garden with removed grid element over under-floor heating Photo by Jens Freudenberg, HsZiGr.

room (approx. 60 m²) from the hallway space and from the winter garden. Thus it prevents heat from dissipating up into the second floor and away from the main living spaces on the main floor. An interesting parallel may be observed with the *Schröder House* by Gerrit Rietveld in Utrecht (Holland) from 1925, where sliding doors reduced draft effects in winter. Also the normally open stairway could be closed with window elements. By art critics this is mostly interpreted only in a functional sense instead of its effect on building physics. Interior wooden boards served in front of high placed windows as additional insulation in winter. Rietveld had prepared intelligent store places for these boards in summer time.

In order to enhance heat insulation additional devices were installed at glass areas in Schminke house. Exterior Venetian blinds with rolling shutters constructed of thin laths ensure that a standing air layer (3 cm) provides an insulation effect. On the interior, heavy drapes were perhaps even more effective in also providing insulation. These curtains in bias fabric (*Diagonalstoff*) were designed and woven by Otti Berger from Berlin with different colours.

Most surprisingly, however, in the original living room, a free standing small fireplace with slender chimney provided fast heat. It was turned away from the nearby piano, thus not exposing it to direct heat radiation. Thus a perfect concept for a cosy living space had been realised.

From a Building Physics point of view, the original design of *Haus Schminke* is sensible, that is, if one agrees with the comfort level accepted by its original inhabitants. In the 19th century, a building like *Haus Schminke* did not exist for various technical reasons. Its design grew out of concepts brought on by the discipline of Building Physics within the experimentation of the Modern Movement and with great care on how to orient a building in respect to sun and daylight.

Notes

1. For references and further literature please consult: *Climate and Building Physics in the Modern Movement*, proceedings of the 9th International **docomomo** Technology Seminar, June 24/25 2005, Löbau. Preservation Technology Dossier 9, September 2006, Tomlow, J. (ed.), O. Wedebrunn (co-ed.), Wissenschaftliche Berichte der Hochschule Zittau/Görlitz (FH) Heft 88.2006 (Sonderheft) Nr. 2168-2179, hrsg. v. R. Hampel, Zittau 2006, ISBN 3-9811021-2-6 and ISBN 978-3-9811021-2-3.
2. Graupner, K., Lobers, F., "Bauklimatische Aspekte, Heizungs und Lüftungskonzept", *Scharoun. Haus Schminke, Die Geschichte einer Instandsetzung*, ed. by B. Burkhardt, Stuttgart, 2001, 120-135.

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Jos Tomlow

Jos Tomlow is Professor for Art and Architectural History at the Hochschule Zittau/Görlitz in Germany and member of the German **docomomo** working party since 1990 as well as of **docomomo** ISC-T.

The Dutch author wishes to address words of gratitude to all those many friends and colleagues who contributed to this research.
The author also expresses thanks to Kyle Normandin for his editorial support.