Designing Properly Lit Homes

The Question of Daylight and Electric Light in the Housing Architecture of Alvar Aalto between 1927 and 1935[1]

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By the end of the 1920s, European architectural modernism had become interested in two important but basically independent issues: the problem of housing and the use of light. The goal of this essay is to demonstrate how architect Alvar Aalto, one of the leading Finnish 'functionalists', studied the problem of daylight and electric light in his housing designs between years 1927 and 1935. Aalto's ideas were drawn from various sources, including illuminating engineering. At first the principles of electric light were most important to Aalto, but gradually he became increasingly interested in daylight. One of the most important motifs of early modernism was the strip window. Aalto adopted it but also tried to develop personal solutions. His experiments with new ideas, however, were best demonstrated in those projects that extended the problems of housing to specific contexts, such as a hospital room or an artist's home. Many of Aalto's ideas, originally unsuccessful, became appreciated later.

INTRODUCTION

By the late 1920s, housing had become recognised as one of the primary design tasks of European architectural modernism. Another important theme was light: Daylight was still valued as a light source, partly due to widespread discussion at that time concerning hygienic conditions. Electric light was rapidly adopted as a new technology. Alvar Aalto, one of the leading modernists in Finland, was interested in both uses of light. The goal of this article is to demonstrate how Aalto's personal ideas about daylight and secondarily electric light appeared in the context of housing and domestic lighting between 1927 and 1935. To do this, it is necessary to address two problems of interpretation.

First, Aalto is largely known for his personal architectural language, especially his use of roof lights. In industrially produced housing, roof lights are rarely seen. Window openings are commonly placed into walls, regardless of the specific value given to light by the designer. While it would undoubtedly be difficult to connect these 'ordinary' windows to Aalto's ideas concerning the use of daylight, my approach has been to explore Aalto's designs more

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broadly and, in this way, uncover the necessary evidence for establishing the impact of his ideas.[2]

The second problem is concerned with the theoretical frame of reference. Lighting is not a new topic for research on Aalto's architecture. However, his renown as a master of light is largely based on finished buildings he designed in the 1950s and thereafter. Several writers, often architects or lighting designers, have referred to these works, which seem to confirm the established principles of daylight design. The fan-shaped libraries of Rovaniemi and Seinäjoki have particularly been discussed in this manner.[3] This later understanding of lighting design is anachronous to earlier designs, requiring a contextual historical analysis.

Between 1927 and 1935, Aalto produced many designs focusing both on electric light and daylight. His inspiration was drawn from various sources. Technology was one of them, though a technological theory of lighting was still developing and would only gradually become disseminated among architects. The interest of architects at that time was to establish useful principles for practical design. For example, Aalto and his contemporaries Poul Henningsen and Le Corbusier (also known as Charles-Édouard Jeanneret) paid quite much attention to ray optics. The 'ray tracing' principle (as I call it here for convenience) was applicable to both lighting and acoustics and could produce aesthetically meaningful plastic forms of reflective surfaces. Apparently, a partial discrepancy arose between the engineering theory of illumination and the architects' conceptions. Another problem concerning daylight, that of the light provided by a vertical opening in a wall surface, however, had implications for both the theory of daylight and for architectural expression. My goal is to demonstrate the relevance of this problem of the *side-lit room* to Aalto's housing design.

Aalto and his wife Aino Marsio-Aalto,[4] an architect who shared a common practice with her husband until her death in 1949, designed many finished housing projects between 1927 and 1935: apartments in the Southwestern Finland Agricultural Cooperative Building (Turku, designed in 1927), the officials' housing for the Wilh. Schauman Company's plywood mill (Joensuu, 1927), a 'standard apartment block' (Turku, 1927), housing for the Paimio Tuberculosis Sanatorium (1930–32), Villa Tammekann (Tartu, Estonia, 1932), and the Aaltos' own home and office (Helsinki, 1935). Those unfinished designs worth mentioning include a block of rental apartments (Turku, 1928), and a high-rise housing area for the M.G. Stenius company (Helsinki, 1934–35). Also, there were small competition entries and other minor or incomplete designs.

Apart from housing, most of Alvar Aalto's designs of this time remained on paper and were never implemented.[5] Many of these belonged to unsuccessful competition entries. In order to follow Aalto's ideas about light, the

most important empirical source for this article has been the remaining drawing collection of Aalto's architectural practice over three decades (c. 1927–1956). For the years 1917–1939, these drawings are available in an eleven-volume published edition, *The Architectural Drawings of Alvar Aalto 1917–1939,* and can be easily referred to by their catalogue number.[6] Other important sources consist of Aalto's own writings and other texts, mainly from Finnish and Swedish sources such as the magazines *Arkkitehti* and *Byggmästaren.*[7]

This narrative is structured as follows: Section two provides an introduction to the relationship between lighting design and housing in early Finnish modernism and the 'asynchronous' relationship between the theories of electric light and daylight. Section three describes the early influences from the theory of lighting on Aalto's work, and his approach to the problem of lighting in his designs. Section four describes the importance of the strip window motif and its use in Aalto's housing projects. In section five, I analyse two of Aalto's designs that involved the problem of housing (but strictly taken did not represent it) and show how window motifs were used in these cases. Section six brings forth the important roof light motifs of Aalto and the uniqueness of their application in housing. Section seven summarises the conclusions and provides some further discussion.

ELECTRIC LIGHT AND DAYLIGHT IN HOUSING

In Scandinavia and Finland, the rise of modernism and public interest in electric light coincided strongly with the end of the 1920s. The importance of electric light in the architectural context was demonstrated by public events where new architecture and good lighting were presented side by side: the Stockholm Exhibition (*Stockholmsutställningen*) in 1930 and the smaller exhibition commemorating the 700th anniversary of the Finnish city of Turku in 1929. This interest in electric lighting was further fuelled by the establishment of engineering societies, such as the Swedish Illuminating Engineering Society, *Svenska Förenginen för Ljuskultur,* established in 1926.[8] In Sweden, the use of electric lighting was fairly well established by 1930, when a collection of previous articles in the periodical *Ljuskulturs monadsblad* was published as *Ljuskulturs handbok.*[9] As Sean F. Johnston has shown for the UK and the United States, illuminating engineering societies favoured co-operation between various professions and mutual interaction between theory, practice and business.[10] The development of lighting was accompanied by rapid technological and social changes.

Strictly speaking, Finland had no illuminating engineering society until after World War II. Nevertheless, similar functions were carried out by a branch office of the Finnish Electricity Association, *Sähkölaitosyhdistyksen*

Valotaloustoimisto (1930–1938). August Marsio, the director of the municipal electricity company of Helsinki, also became the director of this new organisation. Helge Kjäldman, who had a career at the lighting manufacturing company Osram in Finland, became the secretary. Devoted to advancing electric lighting, the office readily arranged in 1930 its first campaign and published a popular guide on domestic lighting.[11]

Kjäldman was also active in writing informative articles and giving lectures on lighting issues. He had already in 1927 and 1930 written about different methods of interior lighting in the Finnish architectural magazine *Arkkitehti*. In these articles, he wrote about the types, efficiencies and proper uses of light fittings, the goals of lighting design, principles of direct and indirect lighting, prevention of glare, methods of diffusing electric light by luminous surfaces, and other similar topics.[12]

Architectural modernism had provided important models for housing, including the arrangement of houses in parallel rows (the *Zeilenbau* principle), new building types and the importance of sufficient window surfaces in housing. The Modernist approach also gave rise to a certain architectural 'language' for the use of windows and housing types. Zeilenbau was actually a lighting principle based on the orientation of terraced or apartment housing. However, as Kirsi Saarikangas has pointed out, there was no accurate starting year for 'functionalist' housing design in Finland. The German model for housing areas *(Siedlungen)* and Zeilenbau were not adopted in Finland until the end of the 1930s, few housing areas of the 1930s being designed according to 'functional' principles.[13]

In Sweden and Finland, the establishment of principles guiding the use of electric light preceded those of daylight. Architects were, to a greater degree than technological professionals, interested in daylight and also were active in writing about it. In 1930, the Swedish *Byggmästaren* published an article on the properties of sunlight, written in Danish and intended for housing design.[14] In the same year, Aalto entered into this discussion through his article 'Asuntomme-probleemina' ('Our dwelling as a problem') in the Finnish *Domus* magazine. Aalto emphasised the importance of light and sun in dwellings and the correct orientation of windows. His themes resembled those espoused in *Byggmästaren*; however, instead of suggesting practical methods, he stressed the general importance of a scientific approach.[15] Similar programmatic tones were used in the writings of *Acceptera,* a book published in Sweden in 1931, which presented the principles of the Zeilenbau in a manner similar to that in an earlier German work, *Befreites Wohnen* (1929).[16] Aalto owned copies of both books.

In 1934, an article appeared in *Arkkitehti* discussing the orientation of housing according to cardinals, based on German models.[17] This problem can also be recognised in Aalto's designs. The first example was the high-rise

housing area for the M.G. Stenius company in the Munkkiniemi district of Helsinki (1934–35). This project included several sunshine, shading and view studies.[18] Aalto did not follow the Zeilenbau principle but instead, to maximise sea views and already before Sunila, favoured a fan formation.[19]

Even without explicit studies, it is evident that many plans (e.g., those of Aalto's own home and office, designed in 1935) were adapted to daylight conditions. However, without references to specific drawings, standard plan types or other recognisable clues, it is difficult to distinguish between new influences and more traditional architectural skills.

The Zeilenbau principle, orientation of rooms and the general importance of sunshine were essential themes for the use of daylight in Finnish and Swedish architectural sources. As the theoretical basis strengthened, more attention was paid to interior illumination. In 1934, a series of articles was published in four issues of *Byggmästaren,* written by Gunnar Pleijel and Sven Hesslegren. These offered a fairly detailed presentation of the principles of daylight as well as presented scale-model experiments of a side-lit room with a window on one wall. The horizontal illuminance was measured at different distances from the window (Fig. 1).[20] This arrangement was important in that this room type could serve as a model for

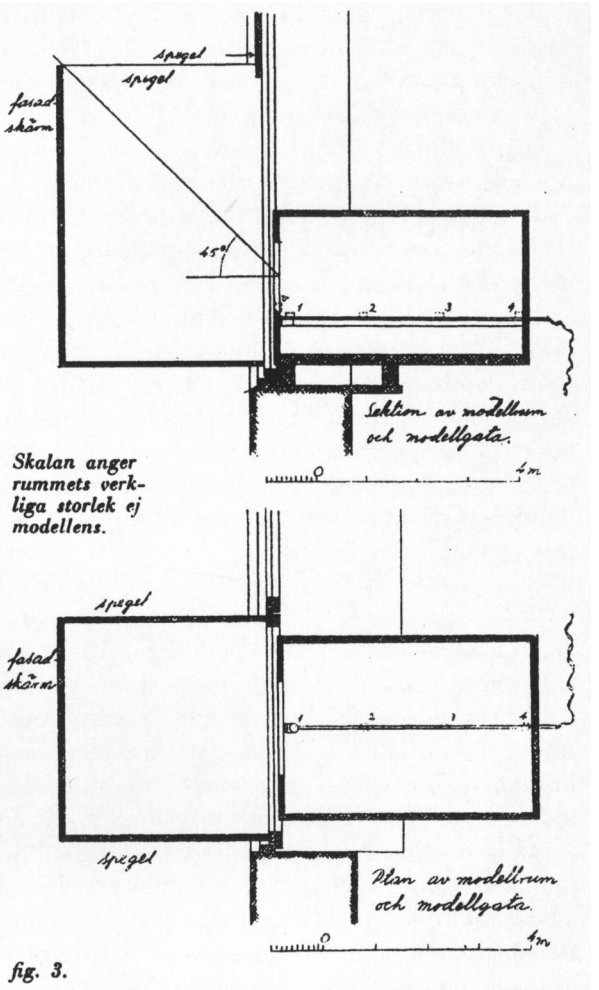

Figure 1. A scale model of the side-lit room presented by Gunnar Pleijel. The outside box had three sides made of mirrors to imitate a free view or the opposite side could be opaque to imitate a street view. Source: *Byggmästaren* no. 35 (1934): 223.

various multi-storey buildings, including schools, hospitals, industrial lofts, and apartments. Such rooms were rectangular and side-lit (i.e., having only one window wall), thus making the distribution of light uneven. This meant that most of the light was concentrated near the windows, with very little reaching the opposite side and from an unfavourable direction. Classrooms were an important special case and were discussed in Gösta Rollin's article *Dagsljus och solljus i skolsalar* (1932) in *Byggmästaren.* Solutions to this problem were also presented in *Das Kind und sein Schulhaus* (1933), a Swiss book also found in Aalto's library.[21]

An important scientific contribution to this problem had been already made around 1928, when the work of H. G. Frühling on applying the coefficients of utilisation method for daylight appeared in Germany.[22] The experimental setup presented by Pleijel was quite analogous, and he acknowledged Frühling's studies. However, I have been unable to find any earlier references to Frühling in the articles of *Arkkitehti* or *Byggmästaren.*

Taken together, this seems to indicate that the principles concerning the architectural use of daylight were gradually emerging, though initially not in a systematic manner. Indeed, occasional considerations of various topics did little to reveal a coherent 'day lighting strategy' that could be used to explain Aalto's designs, such as variations in window sizes, window placements and room depths, in a consistent manner. On the other hand, the articles of Pleijel and Hesselgren as well as studies of the side-lit room reflect advanced understanding of these problems. Eventually, the side-lit room became one of the canonical cases in the 'science of lighting', resulting in a considerable number of research papers on the topic.

AALTO AND THE USE OF ELECTRIC LIGHT

Aalto had personal relations with the central actors in Finnish illuminating engineering. August Marsio was a brother-in-law of Alvar Aalto. Helge Kjäldman, whose public role has already been described above, married architect Aili-Salli Ahde.[23] Aalto also owned a copy of *Ljuskulturs handbok.* Presumably, he was well informed about the technological principles of electric light, and this view can be supported by his designs.

An interesting example in this respect is a simple light fitting designed for the 1930 Minimum Apartment Exhibition (*Pienasuntonäyttely*) in Helsinki. The exhibition represented a Finnish response to the German theme *Die Wohnung für das Existenzminimum,* initiated in the 1929 'CIAM 2' congress in Frankfurt am Main, which Alvar Aalto attended.[24] The problems of daylight and fenestration were included in the basic requirements for housing.[25]

Alvar Aalto was the 'commissioner' of the Helsinki exhibition and wrote two short articles for the accompanying booklet. The Aaltos had designed a

small model apartment for a family of 4–5 persons: a kitchen, a living room and two bedrooms. Although the arrangement of rooms with respect to daylight was not addressed, Alvar Aalto did design some technical solutions for windows: a 'coupled window' and a 'wood-iron-window', both with 'U-glass'. According to the booklet, he had also designed three of the light fittings: a ceiling fitting (see drawing in Fig. 2), a table lamp for the living room, and a 'universal lamp' for one of the two bedrooms.[26] The most essential contents of the Minimum Apartment Exhibition consisted of plan types, interior design and furniture. As Kirsi Saarikangas has pointed out, the functionalist arrangement of the rooms was especially important in small apartments.[27]

These light fittings were designed not only for domestic use. For example, the ceiling fitting was used in two other very different projects: the Turun Sanomat Newspaper Building and the Paimio Sanatorium.[28] This was a typical tendency. The Swedish 'Triplex' fitting was advertised to be 'the most effective and modern light fitting for private homes as well as office and industrial spaces, workshops, hospitals and the like.'[29] It had a long, rotating telescopic arm suspended from the ceiling. It was popular among architects, was also used in the Minimum Apartment Exhibition, and can be seen in many interior photographs of the time, even one representing Aalto's own study in Turku.[30]

Aalto was also influenced by his Danish colleague Poul Henningsen, who was very interested in developing the potential of electric light, even if his ideas and goals partly differed from those of professionals in lighting technology. Around 1926, Henningsen had designed his famous *PH lamp,* a light fitting consisting of several vertically arranged curved shades. The 1926 model used three shades made of white glass. A very important aspect of the lamp was the geometric *form* (the logarithmic spiral) that fulfilled the technological principle of even light distribution. In 1927 Henningsen published a detailed account of these principles and technical characteristics of his lamps in a separate booklet. The PH lamp was produced in many versions and was also an example of a universal light fitting.[31]

For his studies, Henningsen had used a specific method that had a clear influence on Aalto. Henningsen's method was based on drawing light rays, emanating from the light source, and their further reflections from curved shade forms. The method provided an opportunity to generate new functional forms for lighting. At that time, Aalto lived in Turku (South-western Finland), where he had moved in 1927, and had good connections to Scandinavia.[32] In 1928, he designed an illuminating system for cinemas and wrote a article entitled *Rationel biograf* about cinema lighting for Henningsen's publication *Kritisk Revy.* The system was based on narrow vertical strips or lamellae that covered the entire walls of the theatre.[33]

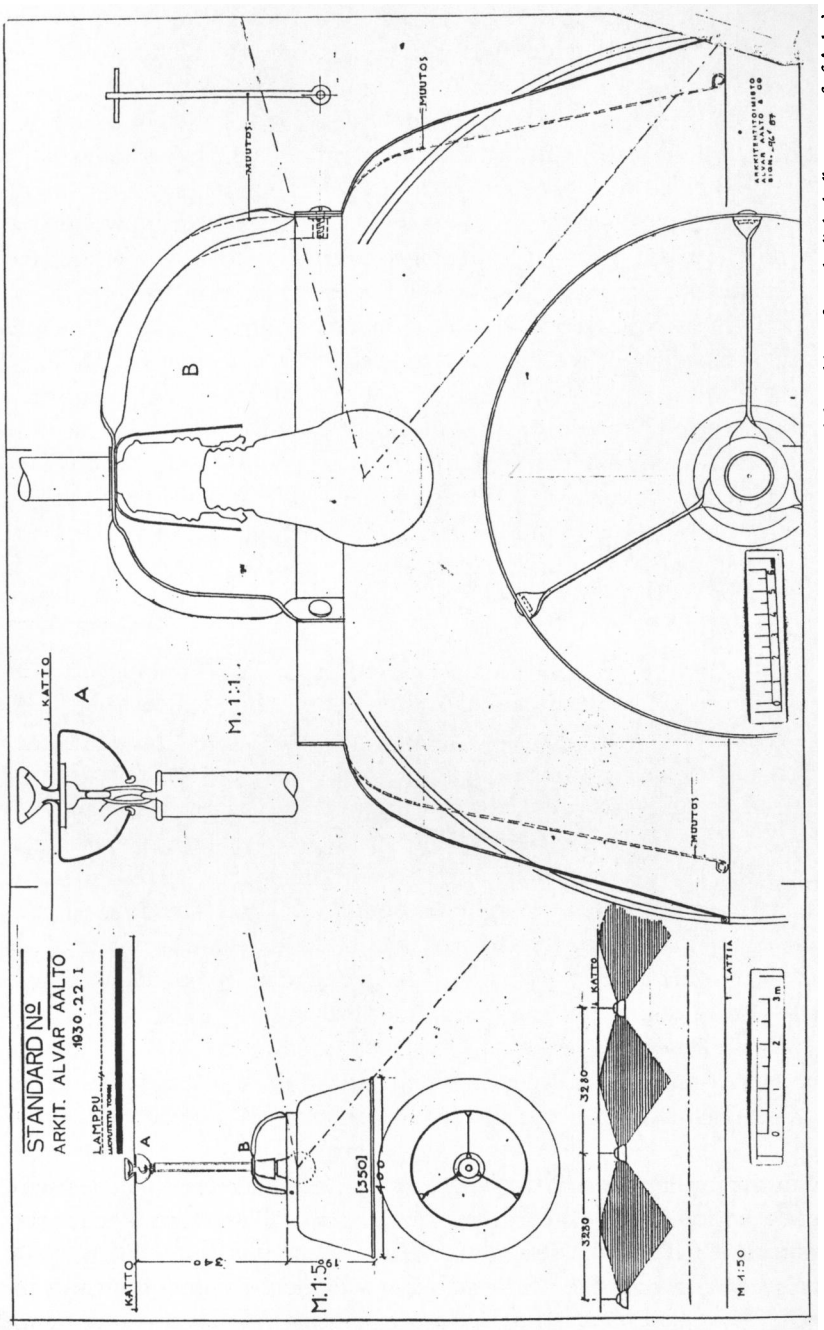

Figure 2. A drawing for a light fitting design, dated to 1930. Notice the lower left corner. The small diagram and dotted lines from the light bulb are proof of Aalto's knowledge about the technological principles of electric light. Source: The drawing collection of the Alvar Aalto Museum, drawing no. 96/87 (used with permission).

Aalto used the original PH lamps in many building interiors. He also designed several of his own light fittings, the principles of which resembled those used in the PH lamp, though they differed in their construction. Aalto's light fittings had several narrow gaps between straight or curved metallic strips (one example can be seen in Fig. 3). Henningsen's ray tracing principle was applied to these designs, which were dated between 1928 and 1932.[34] I have not, however, found evidence of their use in domestic environments.

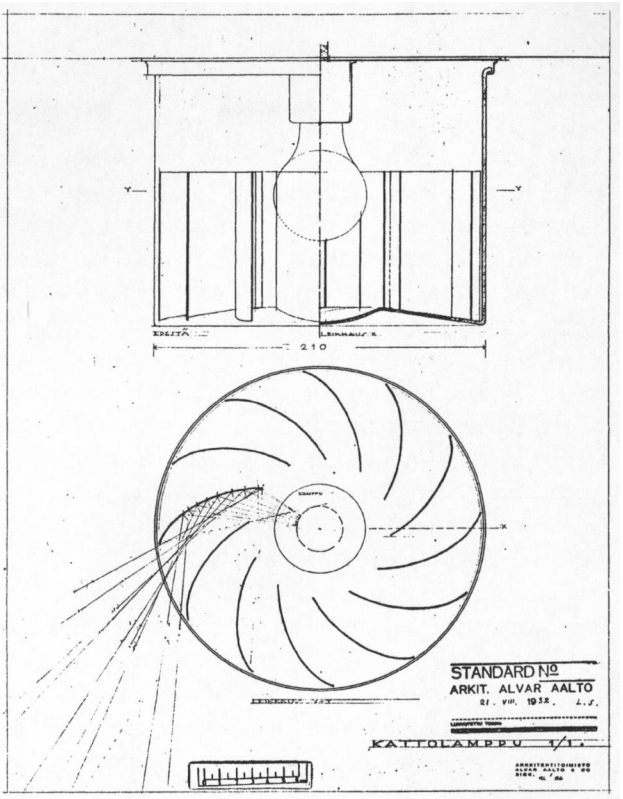

Figure 3. One of Aalto's light fitting constructions dated to 1932 (the first version from 1929). Source: The drawing collection of the Alvar Aalto Museum, drawing no. 96/86 (used with permission).

These designs show a clear tendency towards functional and technological relevance and adaptability using different means. In this phase, Aalto was active in developing his own applications for electric light. According to the prevailing architectural ideal, home lighting was just another case of the more general 'rational' problem of lighting.

THE STRIP WINDOW

Early in the twentieth century, European modernism had adopted a specific form of the wall window, the strip window (or ribbon window). The roots of the motif resided in those construction methods that tended to liberate walls from their traditional load-bearing function. Particularly important was the 'daylight factory' born around 1900, which arose as a development of multi-storey industrial loft buildings, whose outer walls had been gradually

replaced by large window surfaces.[35] Siegfried Giedion has also stressed the importance of the 'Chicago window' used in American office buildings of the 1880s.[36]

In European modernism, the early exponents of the strip window were Mies van der Rohe and Le Corbusier. Strip windows can be seen, for example, in a famous illustration of the office building project of Ludwig Mies van der Rohe (1922–23). Later, the motif became one of Le Corbusier 'five points' of architecture.[37] Already his Dom-ino project around 1914–15 had presented a structural basis for the strip window, the system of floor slabs supported by columns, detached from the facade system. A window form resembling the strip window was also used in his Maison Citrohan project (1919–1920). In a later description of Maison Citrohan, Le Corbusier suggested having adopted the form from industrial buildings.[38] The Citrohan type was realised for the Weissenhof Exhibition in 1927.[39] However, an eleven-meter-long strip window had already been realised by 1924 for the 'Little house' that Le Corbusier (according to his later description) drew for his parents with Pierre Jeanneret during 1922–23.[40]

Early architectural modernism was interested in the apparent lighting capabilities of the strip window. In his book *Une maison – un palais* (1928), Le Corbusier had two fairly unelaborated drawings for the light distribution of a side-lit room. He presented 'zones' of illumination, not daylight factors[41] or illuminance values. The first drawing presented the strip window ('fenêtre "en longeur"') and the other one the traditional narrow wall windows ('fenêtres en "hauteur"').[42] Le Corbusier stressed the importance of facades as providers of light, and the necessity of liberating their composition, also concerning the minimum apartment problem.[43] Similarly, André Lurçat was also interested in the strip window. In his book *Architecture*, Lurçat enthusiastically described their potential, but without providing any illustrations or other practical guidance. Aalto wrote a positive review about the book in 1929.[44]

However, the architectural motif preceded serious scientific studies of the subject. When such studies emerged (for example, those of H. G. Frühling mentioned above), they were fairly general and were not strictly bound to any predefined window form. Instead, they provided calculation methods for the assessment of various solutions. Thus, the architectural discourse of the 1920s associated with the application of the strip form remained partly separate from the scientific discourse.

It is not exactly known where Aalto got the strip motif. One plausible explanation, given by Göran Schildt, was the apartment house designed by Walter Gropius for the Weissenhof Siedlung. German influences on the later use of the strip motif may have also influenced Aalto, since he owned several books about German architecture.[45] On the other hand, due to the international nature of modernism, it is difficult to separate various

influences from each other. During 1928, the Aaltos travelled to Denmark, the Netherlands and France and visited, for example, the apartment buildings of Le Corbusier and André Lurçat.[46]

The exact origin of Aalto's strip motif is not crucial in this context. More important is the fact that he was well aware of its possibilities and applied it in various designs. In November 1927, the Aaltos drew a block of rented flats, whose façade and relatively short window strips were quite similar to the model given by Gropius. At the same time, this motif was also used for the Turun Sanomat Newspaper Building. It was subsequently used in the two intermediate versions of the Viipuri Library (1928–29), in two designs for tuberculosis sanatoriums, one for Kälviä, Finland (1929) and another for Zagreb, Yugoslavia (1931), as well as in the final version of the Paimio Sanatorium (1929–32). A large-scale application for housing was incorporated in the previously mentioned high-rise housing area in Munkkiniemi, Helsinki.

An interesting curved application of the strip form appeared early in an entry for the summer house competition of the *Aitta* magazine, held in 1928. The plan resembled a circular sector, with a small court at the centre and a curved strip window around the outer wall (Fig. 4).[47]

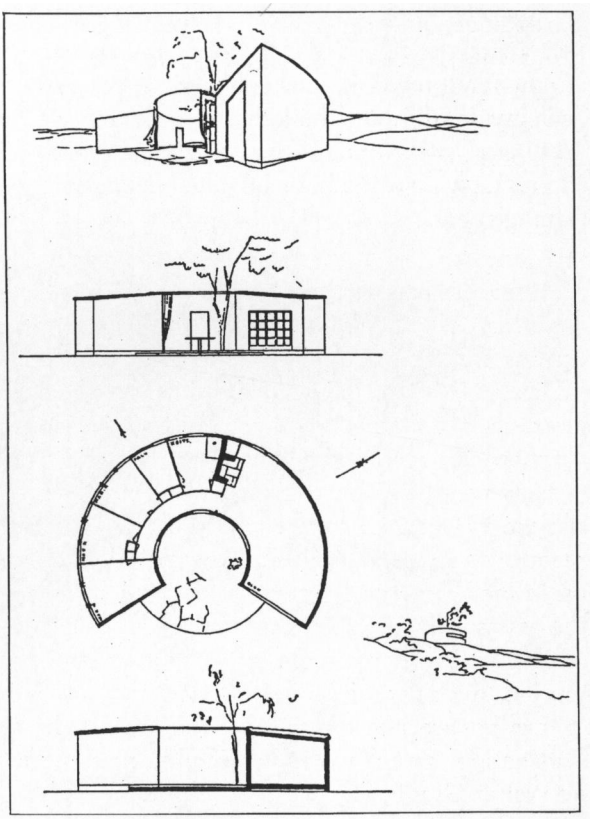

Figure 4. Aalto's proposal 'Merry go round' for the summer house competition in 1928 of the Aitta magazine. The strip window can be seen only in the tiny illustration. Source: *Aitta* no. 5 (1928): 52.

In spite of the prompt use of the strip window, it may have also perplexed Aalto. Almost by definition, it was a solution of planar facades and 'cubic' building forms. This is to say that one of the most basic architectural motifs of new modernism exhibited a *lack of plasticity.* Nevertheless, Aalto was interested in

plastic forms. I have found two potential sources for his interest. The first could have been German industrial architecture, about which Aalto owned a book. On the other hand, curved forms can also be attributed to the ray tracing principle described earlier. In addition to lighting, it could also be applied for large-scale room acoustics.[48]

An example of such acoustic problems was the unsuccessful competition entry for the Vallila Church (1929), which adopted the principle of Salle Pleyel in Paris.[49] Le Corbusier had used the same principle in his entry for the Palais des Nations in Genève competition. Another example demonstrating the use of plastic forms for lighting was the competition entry for the Vierumäki Sports Institute (1930). Aalto developed an unusual and bold modification of the standard tennis hall type of that period (Fig. 5). Despite some success (Aalto was awarded third prize), it was not realised. A similar, though more modest form, was built for the Toppila-Vaara Pulp Mill in Oulu, Finland (1930).[50]

Apart from these examples, Aalto did further 'experimenting' by suggesting various skylight and clerestory motifs between 1928 and 1934. According to my interpretation, they demonstrate his desire to expand his repertoire of window motifs and building forms. However, for housing, he preferred 'ordinary' wall windows and the strip motif. His typical innovations for domestic windows were structural: steel frames, glazing types and ventilation arrangements.

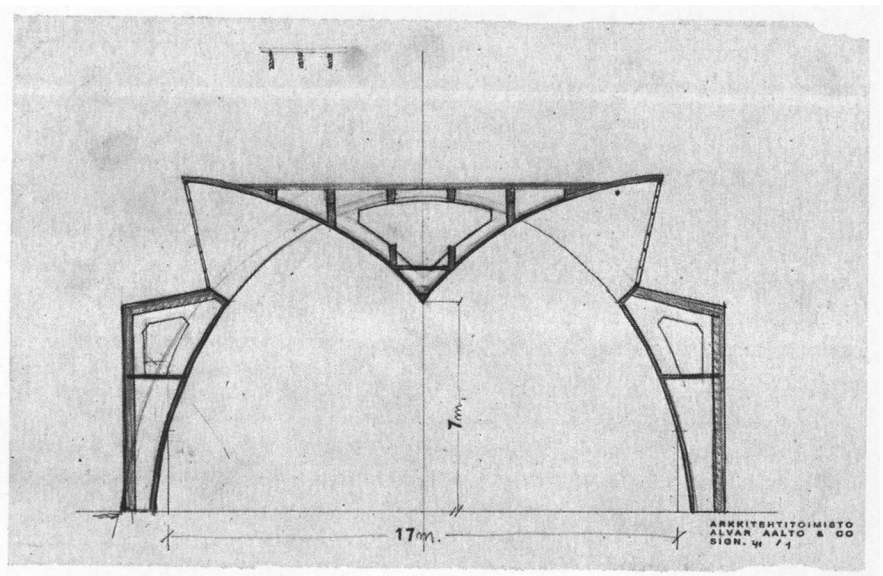

Figure 5. A cross section of the competition entry for Vierumäki Sports Institute. Source: The drawing collection of the Alvar Aalto Museum, drawing no. 41/1 (used with permission).

'EXTENDING' THE PROBLEMS OF HOUSING

It would seem that Aalto's attitude towards the problems of housing was subordinate to the restrictions of the genre. However, this was not the whole truth, as can be demonstrated by two specific projects that were *related* to the problem of housing.

First, there was the design of the patient room of the Paimio Tuberculosis Sanatorium. Aalto clearly understood that the sanatorium would be the home for long-term tuberculosis patients. He paid much attention to the arrangement of the rooms where the patients would be lying in their beds. Both the windows and indirect electric lighting were adapted to this condition. The window was extended from the ceiling to the floor and the lower sill was specially rounded (Fig. 6). The ceiling was painted dark except for a bright area that reflected indirect light from the light fitting. This version was designed following the deadline (January 31, 1929) for the competition.[51]

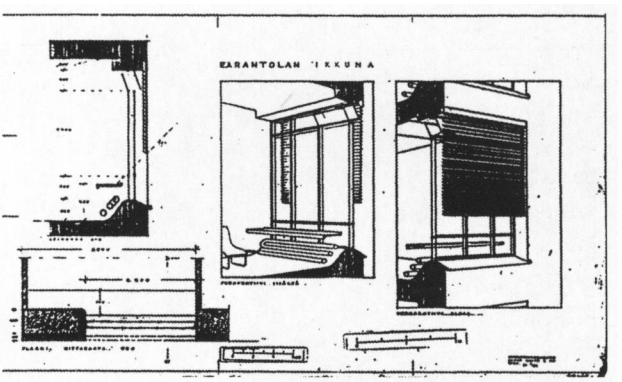

Figure 6. The Paimio patient's room. Source: The drawing collection of the Alvar Aalto Museum, drawing no. 50/181 (used with permission).

The other case was Aalto's competition entry for the Lallukka Artists' Home in 1931. In this design, the problem was to ensure sufficient lighting for artistic work, while also providing a satisfactory dwelling. Of Aalto's two entries, the one entitled 'Lucca' presented a daring solution, in which the window was placed along the shorter wall of the room. Instead of limiting the relative room depth compared to the distance of the upper window sill from the floor, Aalto tried to improve lighting by raising the sill itself. The idea was to bend the edge of each floor structure (and respectively the ceilings) upwards to allow more light into the room (Fig. 7).[52] The jury did not accept this solution, though the discussion that followed revealed that at least Hilding Ekelund, the editor-in-chief of *Arkkitehti* at the time, had recognized the idea.[53]

In these examples, the problem of daylight was related to structural problems. In Paimio, the rooms belonged to the structural wing system of a hospital, while in Lallukka the solution was used to relieve the effects of

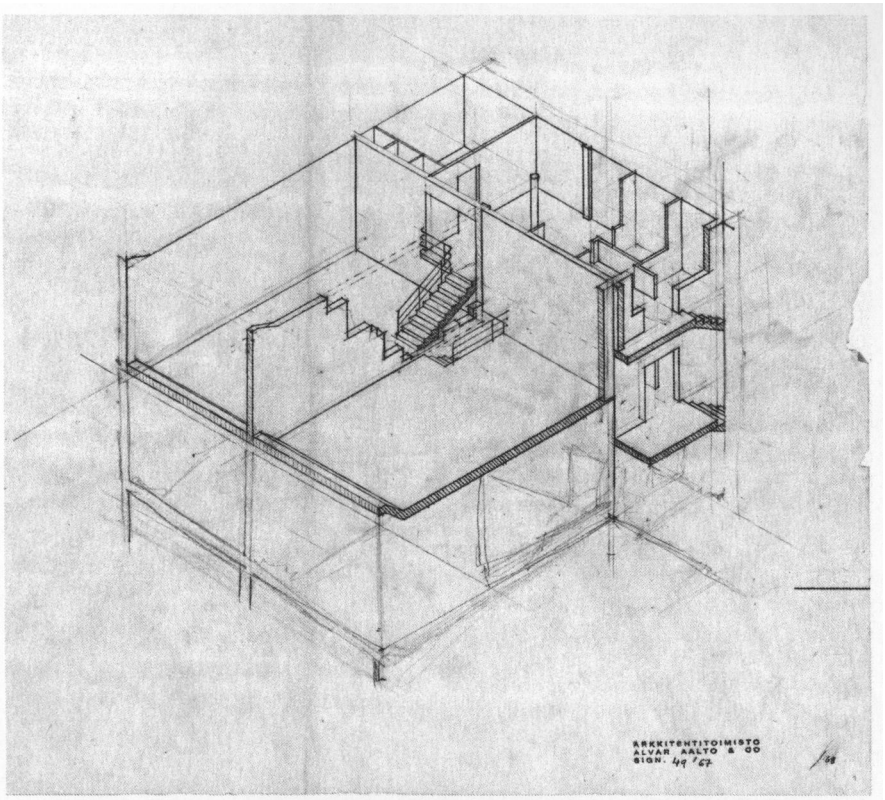

Figure 7. The design for the Lallukka Artists' Home (pseudonym 'Lucca'). Source: The drawing collection of the Alvar Aalto Museum, drawing no. 49/67 (used with permission).

exceptional room depths. Most likely, the solution of Lallukka represented a further development of Paimio. Aalto also presented the same idea in two other competition entries in 1931: the Zagreb Central Hospital and the extension for the University of Helsinki.[54] All these designs were made during a relatively short period and had common features. None of them were successful.

These projects demonstrate the importance of the side-lit room and, at the same time, Aalto's efforts to develop the motif from its standard form, as well as the difficulty of incorporating such efforts into standard housing design. An interesting singular motif resembling this principle was designed for the Chief physician's house (c. 1930–1932) of the Paimio Sanatorium. An inclined light well structure provided illumination from a strip window to the entrance hall of the apartment. This was one of Aalto's typical 'experiments' with new ideas.[55]

I suggest that the two cases, Paimio and Lallukka, can be seen as *extensions*

to the problems of housing. Aalto himself saw the close relation between dwellings and more specific establishments. In the booklet for the Minimum Apartment Exhibition of 1930 he wrote: 'The minimum apartment is possible because a part of the dwellers' activities has been removed outside of it – to common rooms – a school, a sports ground, a library, a concert hall, a speech auditorium, etc.'[56] These were the very cases Aalto was interested in – and for which he developed many solutions concerning light and acoustics.[57] For him, there was a relationship between the problems of the dwelling and those of more specialised rooms, and the architect was compelled to tackle these still unsolved problems. On the other hand, it was much more difficult to improve ordinary apartment houses, since these already had adequate structural and window systems.

THE RARE USE OF ROOF LIGHTS

The most important of Aalto's window inventions of this time was the cone-shaped round skylight (also called the barrel skylight). It evolved in essentially three stages from the round roof openings in the printing hall of the Turun Sanomat Building (1928) to a complete 'roof system' of the Viipuri Library, inaugurated in 1935. In the Viipuri Library, a grid of round slightly conical light wells deep enough to diffuse all direct sunlight covered the entire ceiling of the library halls (Fig. 8). It is not necessary to discuss this relatively complex development here.[58]

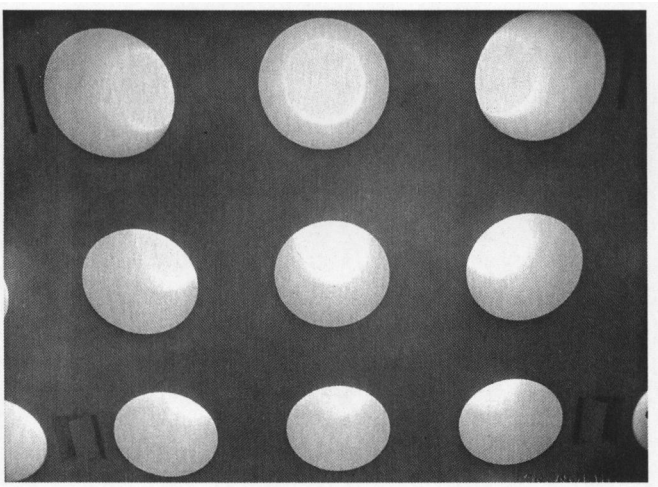

Figure 8. The roof lights of the Viipuri Library. Source: The collection of the Alvar Aalto Museum (used with permission).

Aalto was very proud of this solution, which became the basis for further variations on the same motif. It was his invention and provided diffuse, evenly distributed light, especially suitable for large one-storey interiors. Later, Aalto discovered its usefulness for museum lighting and compared his proposal for the Tallinn Art Museum with traditional solutions.[59] The round skylight was also recommended for

museum lighting by Aalto's colleague Hilding Ekelund in the architectural section of the Finnish 'Book of Inventions' *(Keksintöjen kirja),* published in 1938.[60]

The round skylight was a lighting device for flat roof surfaces and in this way, I would suggest, also a kind of counterpart for the strip window. The invention of the round skylight might also have diminished Aalto's interest in strip forms. Indeed, some years later, in 1940, Aalto presented a comparison of 'ordinary windows' and skylights in his writing 'The Humanizing of Architecture'.[61]

Despite the crucial importance of the round skylight in Aalto's work, it was not applied in any notable way to housing. During the 1930s, this innovation was exploited by Aalto in only a few examples. One of these was Aalto's own home and office designed for Munkkiniemi, Helsinki, in 1935. There round skylights were used in the cupboard and the bathroom. One reason for the solution might have been the desire to keep the street facade closed. Later, the motif was used in the Villa Mairea, designed around 1938 for Maire and Harry Gullichsen. In early design stages, it was also suggested for the art gallery extension of the villa, which was dropped from the final version (another example of the later recurring museum theme).[62]

Round skylights were also used in other modest buildings, such as in the workers' sauna for the Sunila industrial area (1937–38) and in the stair halls of some apartment and terraced houses. Many of these were built for industrial workers, since the Aaltos developed many designs for the Finnish wood and paper industry at the time. However, all these uses were sporadic compared to the later extensive use of round skylights for public buildings.

Besides the round skylight, Aalto had also been very interested in clerestory motifs and, as stated before, proposed them in several designs. It is not easy to say why Aalto did not apply them in housing at this phase. Other architects, such as Hugo Häring and Le Corbusier, had used them in their housing projects.[63] The lack of suitable housing projects and the dominance of other design tasks (including Aalto's mostly futile efforts to gain recognition in architectural competitions) could provide one explanation. Clerestory forms became increasingly important toward the end of the 1940s.

CONCLUSION

Alvar Aalto was aware of the importance of daylight for the modern movement. However, his individual designs present several problems of interpretation. First, the general understanding of daylight design, also typical for current scientific research on the topic, is not readily applicable to Aalto's work. For example, it is not relevant to separate problems of electric light and daylight too strongly. Around 1930, Aalto was considerably

influenced by the latter, as well as the work of Poul Henningsen influenced Aalto fairly much.

Second, the historical development of theoretical principles was fairly complex. It was a gradual process, and the mutual relation of theories of electric light and daylight was asynchronous, as has been demonstrated in Finnish and Swedish context. Concerning daylight, the availability of sunlight was fairly important in the beginning, with the side lit room eventually becoming an important problem due to its wide applicability.

Third, the dissemination and reception of technological research among architects merged with their own ideas. The use of the strip window preceded serious technological analyses. In Aalto's case, the use of the ray tracing principle appeared to be relatively important. It was based on models advanced by other architects, including Henningsen and Le Corbusier. On the other hand, Aalto's designs were less influenced by the principle of Zeilenbau, despite its general importance.

Aalto's attitude towards the strip window was equivocal. He used it on several occasions but also presented alternative interpretations and redevelopments, which cannot be directly attributed to external models. Aalto's efforts to develop the strip window did not emerge in ordinary housing projects but on special occasions, such as a patient room or an artist studio. These 'boundary cases' also demonstrate the difficulty of interpreting Aalto's intentions.

It is possible to suggest several reasons why Aalto's ideas were not more prominently accepted for housing. From the end of the 1920s to the 1930s, the ongoing discussion concentrated on the minimum apartment problem. The functionalist plan favoured such small plans. On the other hand, room dimensions probably did not become critical for daylight design in such cases. *Air, light and heat* were general goals for dwellings. They were important also in Aalto's designs. However, his individual interest in light was perhaps not completely fulfilled within the inherent spatial and structural restrictions of standard housing.

It is also possible that Aalto treated different tasks in different ways. He gave priority to public tasks. The most ambitious examples of his formal solutions were designed for large interiors. Such buildings had a 'typological past', a tradition of recognised problem formulations and spatial solutions. His goals concerning housing might have been more modest: their attraction lies in their human scale, details and materials. In housing, much attention was paid to the arrangement of housing plans and city planning. I believe that Aalto was looking for something more: 'well-defined' lighting problems, which were not generally to be found in ordinary housing design but were present in the cases of Paimio and Lallukka.

Architectural modernism interpreted technological forms by adopting a certain formal language, façade architecture and site layout. Aalto's solutions were partly idiosyncratic and differed from the available models. However, a detailed study of his designs suggests that he was genuinely interested in technology and tried to develop solutions that fulfill functional requirements. Many of his motifs were at first unsuccessful but became appreciated later. Despite the original failure of the upward slanting window opening, it eventually became a common solution in his public buildings of the 1950s.

NOTES

1 The first version of this article was presented at the ICOHTEC 2008 Symposium in Victoria, Canada. I wish to give my thanks to the Jenny and Antti Wihuri Foundation, the Finnish Cultural Foundation and the Finnish Foundation for Technology Promotion, all of which have supported my earlier studies on Aalto. The Alvar Aalto Museum has kindly provided drawings and photographs for Figures 2–3 and 5–8.

2 Domestic lighting was quite marginally represented in my doctoral dissertation on the development of Aalto's window motifs and other lighting solutions for daylight and electric light between 1927 and 1956. See Markku Norvasuo, *Taivaskattoinen huone, Ylävalon tematiikka Alvar Aallon arkkitehtuurissa 1927–1956,* Publications of the Centre for Urban and Regional Studies A 37 (Espoo: Helsinki University of Technology, 2009).

3 See for example Fuller Moore, 'Daylighting: Six Aalto Libraries', *AIA Journal* (June 1983): 58–69; William M. C. Lam, *Sunlighting as formgiver for architecture* (New York: Van Nostrand Reinhold, 1986), passim; Colin St. John Wilson, *The Other Tradition of Modern Architecture: The Uncompleted Project* (London: Academy Editions, 1995), 86–93; N. Baker, A. Fanchiotti & K. Steemers, eds., *Daylighting in Architecture: A European Reference Book* (London: James & James, 1993), especially chapter 11; Merete Madsen, *Lysrum – som begreb og redskap,* Ph.d.-afhandling (København: Kunstakademiets Arkitektskole, 2004). Madsen has references also to earlier designs of Aalto.

4 About the work of Aino Aalto see *Aino Aalto,* ed. Ulla Kinnunen ([s.l.]: Alvar Aalto Foundation & Alvar Aalto Museum, 2004). Beyond some known cases, it is not easy to assess Aino's role concerning designs that have been attributed to Alvar Aalto. She worked for many of the most famous building projects and was responsible for some of them. She also designed light fittings and, after 1935, was involved in the work of the Artek design company.

5 Various clerestory arrangements, roof lights, as well as entire rooms included in these designs exhibited notably strong plastic forms. In my dissertation, I have argued that many of these forms were technologically motivated but later, after being detached from their original context, became part of Aalto's characteristic idiom. See Norvasuo, *op. cit.* (2).

6 *The Architectural Drawings of Alvar Aalto 1917-1939,* vols. 1–11, with introduction and project descriptions by Göran Schildt, prepared by the Alvar Aalto Archive in collaboration with the Museum of Finnish Architecture, Helsinki, and the Alvar Aalto Museum, Jyväskylä, transl. by Timothy Binham (New York: Garland Publishing Inc, 1994). All drawings from this paper are presented in this work and referred to by the notation 'ADA', followed by the class and individual number, according to the drawing collection of the Alvar Aalto Museum. For example 'ADA 3, 252 # 43/314' refers to vol. 3, page 252, drawing no. 43/314.

7 Later drawings (not mentioned here) are available at the Alvar Aalto Museum and have also been assigned individual numbers, except many later works primarily after the 1950s. For an edited catalogue of Aalto's designs see Göran Schildt, *Alvar Aalto: A Life's Work – Architecture, Design and Art* (Helsinki: Otava, 1994). The design years have been taken mostly from this catalogue.

8 Jan Garnert, *Anden i lampan: Etnologiska perspektiv på ljus och mörker* (Stockholm: Carlssons, 1993), 181–182, 267–268 (note 1). Alvar Aalto and Erik Bryggman designed the Turku exhibition architecture. The history of electrification in Finland has been well documented in Timo Myllyntaus, *Electrifying Finland: The Transfer of a New Technology into a Late Industrialising Economy,* ETLA The Research Institute of the Finnish Economy Series A15 (London: Macmillan Academic and Professional Ltd, 1991).

9 *Ljuskulturs Handbok* (Stockholm: Svenska Föreningen för Ljuskultur, 1930).

10 Sean F. Johnston, *A History of Light and Colour Measurement: Science in the Shadows* (Bristol & Philadelphia: Institute of Physics Publishing, 2001), 80–86 and passim. Johnston has also referred to the historically vague position of light measurement (which includes photometry, colorimetry and radiometry; especially the first two are background disciplines for illuminating engineering) in the scientific avant-garde and, consequently, its 'persistent straddling of disciplinary boundaries'. *Ibid.*, 8–9, 243–248.

11 'Sähkölaitosyhdistyksen Valotaloustoimisto', *Voima ja valo* nos. 5-6 (1930): 170–171; Niilo Jernvall, 'Valaistuksen kehityksestä maassamme v:sta 1925 alkaen', *Voima ja valo* no. 4 (1949): 98–102, passim; Niilo Honkala, *Suomen Sähkölaitosyhdistys 1926–1966* (Helsinki: Suomen Sähkölaitosyhdistys, 1966), 100, 217; Oiva Turpeinen, *Energiaa pääkaupungille: Sähkölaitostoimintaa Helsingissä 1884–1984* (Helsinki: Helsingin kaupungin energialaitos, 1984), 81–83.

12 H. Kjäldman, 'Teknilliset vaatimukset tarkoituksenmukaisia valaistussuhteita järjestettäessä', *Arkkitehti* (1927) no. 3: 36–42; H. Kjäldman, 'Valo ja rakennustaide', *Arkkitehti* no. 3 (1930): 12–15.

13 Kirsi Saarikangas, *Asunnon muodonmuutoksia: Puhtauden estetiikka ja sukupuoli modernissa arkkitehtuurissa,* Suomalaisen Kirjallisuuden Seuran toimituksia 860 (Helsinki: SKS, 2002), 229–233, 529 (note 9). The term 'functionalism' refers here to the Finnish modern style of the 1920s and 1930s.

14 Henning Wolmer, 'Om sollysets rationelle udnyttelse i boligen', *Byggmästaren* (1930): 37–45.

15 Alvar Aalto, 'Asuntomme-probleemina', *Domus* no. 8-10 (1930): 176–189. (The Finnish *Domus* magazine was published in 1930–1933.)

16 Gunnar Asplund, Wolter Gahn, Sven Markelius, Gregor Paulsson, Eskil Sundahl & Uno Åhren, *Acceptera* (Stockholm: Bokförlagsaktiebolaget Tiden, 1931); *Befreites Wohnen,* 86 Bilder eingeleitet von Sigfried Giedion, Herausgeber Dr. Emil Schaeffer (Zürich: Orell Füssli Verlag, 1929).

17 The article was based on Scandinavian answers to an enquiry organised by *Internationaler Verband für Wohnugswesen.* 'Asuntotalon suuntaus', *Arkkitehti* (1934): 161–163. Such a scheme by Walter Schwagenscheidt had also been presented concerning the CIAM year 1929 theme; see *Die Wohnung für das Existenzminimum,* Auf Grund der Erbebnisse des II. Internationalen Kongresses für Neues Bauen, sowie der vom Städtischen Hochbauamt in Frankfurt am Main veranstalteten Wander-Austellung, Herausgeber: Internationale Kongresse für Neues Bauen Zürich, Dritte Auflage (Stuttgart: Julius Hoffmann Verlag, 1933), 47 ('Tabelle für die Anordnung der Räume zur Sonnenbahn').

18 See for example ADA 6, 133 # 83/46–47; 134 # 83/48; 145 # 83/73; 147 # 83/75–76. Typically the studies were made for the autumn equinox.

19 Göran Schildt, *Alvar Aalto: A Life's Work – Architecture, Design and Art* (Helsinki: Otava, 1994), 209. Also the plan of the Sunila housing area (1936–) was based on a 'fan' shape.

20 Sven Hesselgren & Gunnar Pleijel, 'Till frågan om bostadsrummens dagsbelysning' [four articles] in *Byggmästaren* no. 29, Arkitektupplagan 10 (1934): 174–177; *Byggmästaren* no. 32, Arkitektupplagan 11 (1934): 206–208; *Byggmästaren* no. 35, Arkitektupplagan 12 (1934): 222–226 and *Byggmästaren* no. 38, Arkitektupplagan 13 (1934): 245–250. Illuminance, expressed in luxes, is the amount of light (the total luminous flux) falling on a surface per unit area.

21 Gösta Rollin, 'Dagsljus och solljus i skolsalar', *Byggmästaren* no. 5, Arkitektupplagan 2 (1932):

23–30; W. v. Gonzenbach, Werner M. Moser & Willi Schohaus, *Das Kind und sein Schulhaus. Ein Beitrag zur Reform des Schulhausbauens* (Zürich: Schweizer-Spiegel-Verlag, 1933).

22 H. G. Frühling, *Die Beleuchtung von Innenräumen durch Tageslicht, ihre Messung und ihre Berechnung nach der Wirkungsgradmethode,* Lichttechnische Hefte der Deutschen Beleuchtungstechischen Gesellschaft E. V., Zweites Heft (Berlin: Union Deutsche Verlagsgesellschaft Zweigniederlassung Berlin, [s.a.]). The year is somewhat uncertain. According the Online-Katalog of Technische Universität Berlin, Universitätsbibliothek, Frühling's dissertation *Tagesbeleuchtung von Innenräumen, ihre Messung und ihre Berechnung nach der Wirkungsgradmethode* was published in 1927–28. http://ublibsprod.ub.tu-berlin.de (accessed December 6, 2008).

23 *Suomen Sähköinsinööriliitto r.y. Matrikkeli 1926–1951 [= Finlands Elektroingenjörsförbund r.f. Matrikel 1926–1951.],* ed. Ole Fraser (Helsinki: Suomen Sähköinsinööriliitto, 1951), 131–132, 174–175; *Suomen insinöörejä ja arkkitehtejä 1948 Ingenjörer och arkitekter i Finland,* STS:n ja TFiF:n julkaisema matrikkeli [= Matrikel utgiven av TFiF och STS] (Vaasa, 1948), 316. I am also grateful to Kaarina Mikonranta, the chief curator of the Alvar Aalto Museum, for clarification of these personal relationships.

24 Eric Mumford, *The CIAM Discourse on Urbanism, 1928–1960* (Cambridge, MA & London: The MIT Press. 2000), 34.

25 *Die Wohnung für das Existenzminimum,* 25–26, 31, 35–36. For example the organisation of facades, quality of light, interior arrangements and the need of artificial light were briefly discussed. The basic functions of a window were illumination, ventilation and visibility.

26 *Pienasunto?,* Pienasuntojen rationalisoimisosaston julkaisu Taideteollisuusnäyttelyssä 1930 ([Helsinki], 1930), 26–30; ADA 4, 118 # 96/87.

27 Saarikangas, *op. cit.* (13), 258–259, 332.

28 *Domus* nos. 8–10 (1930), *op. cit.* (15), 186 (photograph); *Golden Bell and Beehive: Light fittings designed by Alvar and Aino Aalto,* text by Kaarina Minkonranta, ed. Katariina Pakoma, Design by Alvar Aalto no 1 (Jyväskylä: Alvar Aalto Museum 2002), 23.

29 'Triplexarmaturen är effektivaste och modernaste belysningsarmatur för såväl privathem som kontors- och industrilokaler, verkstäder, sjukhus o. dyl.' An advertisement of Nya A.-B. Galco from Stockholm in *Arkitektur och samhälle* ([Stockholm]: Spektrum, [s.a.]), 133.

30 *Pienasunto?, op. cit.* (26), 32; *Domus* nos. 8–10 (1930), *op. cit.* (15), 193 (photograph); Göran Schildt, *Alvar Aalto: the Decisive Years,* transl. Timothy Binham ([Helsinki]: Otava, 1986), 20 (photograph).

31 Poul Henningsen, *Rummets belysning med særlig henblik paa anvendelsen af P.H.-Lampen* (København: Dansk Andels Trykkeri, 1927). A general history of the PH lamp can be found in *Tænd! PH lampens historie,* ed. Tina Jørstian & Poul Erik Munk Nielsen (København: Gyldendal, 1994).

32 As described by Schildt, *op. cit.* (30), 19.

33 Alvar Aalto, 'Rationell biograf', *Kritisk revy* (1928), no. 3: 66–70, available at: http://www.kb.dk/ktss/kritisk/ (accessed July 6, 2010).

34 ADA 4, 102 # 96/38, 117 # 96/86, 118 # 96/88, 119 # 96/90. There are also other drawings related to these models, and some other examples.

35 For the history of daylight and windows in American industrial architecture between 1840 and 1940, see Betsy Hunter Bradley, *The Works: The Industrial Architecture of the United States* (New York: Oxford University Press, 1999).

36 Sigfried Giedion, *Space, Time and Architecture: the Growth of a New Tradition,* The Charles Eliot Norton lectures for 1938–39, 5th edition, revised and enlarged (Cambridge, Massachusetts: Harvard University Press, 1949), 307, 315–316.

37 Presented for example in Alfred Roth, *Zwei Wohnhäuser von Le Corbusier und Pierre Jeanneret,* Fünf Punkte zu einer neuen Architektur von Le Corbusier und Pierre Jeanneret, Geleitwort von

Prof. Dr. Hans Hildebrandt (Stuttgart: Akad. Verlag Dr. Fr. Wedekind & Co, 1927), 6–7. The importance of sunlight was also stressed in this source.

38 *Le Corbusier et Pierre Jeanneret, Oeuvre complète 1910–1929,* publiée par W. Boesiger et O. Stonorov, introduction et textes par Le Corbusier, septième édition (Zurich: Les Éditions Girsberger 1960 [1937]), 23–26, 31.

39 Alan Colquhoun, *Modern Architecture,* Oxford History of Art (New York: Oxford University Press, 2002), 143-148.

40 Le Corbusier, *Une petite maison,* 3e edition (Zürich & München: Verlag für Architektur Artemis, 1981 [1954]), 5, 30.

41 Daylight factor (DF, in per cents) is the measure of indoor daylight illuminance at a given location as a percentage of unobstructed horizontal outdoor illuminance from the sky (direct sunlight is excluded).

42 Le Corbusier, *Une maison – un palais, 'A la recherche d'une unité architecturale'* (Paris: Les éditions G. Crès et Cie, 1928), 98–106. According to Reyner Banham Le Corbusier had presented such drawings already in 1926 in the *Journal de Psychologie Normale.* Reyner Banham, *Theory and Design in the First Machine Age* (London: Architectural Press, 1960), 239.

43 *Die Wohnung für das Existenzminimum,* 25. The title of the article written by Le Corbusier and Pierre Jeanneret was 'Analyse des elements fondamentaux du problem de la "maison minimum"', *op. cit.* (38), 24–33.

44 André Lurçat, *Architecture* (Paris: Au Sans Pareil, 1929), 135–136; Alvar Aalto, 'Kirjallisuutta: Lurçat', *Arkkitehti* no. 6 (1929): 98.

45 In addition to those cited elsewhere in this article should be mentioned also Walter Gropius, *Bauhausbauten Dessau,* Schriftleitung Walter Gropius & L. Moholy-Nagy, Bauhausbücher 12 (München: Albert Langen Verlag, 1930); Ludwig Hilberseimer, *Groszstadt Architektur* (Stuttgart: Julius Hoffman, 1927) and Heinz & Bodo Rasch, *Wie bauen? Bau und Einrichtung der Werkbundsiedlung am Weißenhof in Stuttgart 1927,* Mit einem Vorwort von Adolf Behne (Stuttgart: Akadem. Verlag Dr. Fr. Wedekind & Co., 1927).

46 Described in Schildt, *op.cit.* (30), 54–58.

47 *Aitta* no. 3 (1928): 60–61; *Aitta* no. 4 (1928): 63 and *Aitta* no. 6 (1928): 35–45. One example of this standard plan has been built according to Schildt, *op.cit.* (19), 225. A simple strip motif was also used in the other proposal submitted by Aalto.

48 Julius Vischer & Ludwig Hilberseimer, *Beton als Gestalter: Bauten in Eisenbeton und ihre Architektonische Gestaltung, Ausgeführte Eisenbetonbauten,* Die Baubücher, Band 5 (Stuttgart: Julius Hoffman, 1928). Some writers have attributed Aalto's plastic forms strongly to German expressionism. However, in doing so, they apparently have not paid attention to the potential influence of acoustics and the 'ray tracing' method.

49 ADA 4, 14 #20/375; 'Vallilan kirkkokilpailu', *Arkkitehti* (1929) no. 2: 25–30.

50 ADA 5, 4 #41/1; Schildt, *op.cit.* (19), 72; ADA 8, 64 # 70/74.

51 ADA 4, 212 # 50/181; Schildt, *op.cit.* (19), 68.

52 ADA 5, 318 # 49/67.

53 'Juho ja M. Lallukan taiteilijakodin luonnoskilpailu', *Arkkitehti* (1931): 58–63.

54 ADA 5, 272 # 50/607, 338 # 42/10. It is interesting to note that in a later publication, the section of the Paimio patient wing has been altered according to the 1931 principle. However this version has not been carried out in Paimio. See *Alvar Aalto,* ed. Karl Fleig (Zürich: Editions Girsberger, 1963), 33.

55 ADA 4, 337 # 50/337.

56 *Pienasunto?, op. cit.* (26), 25; translated by M. Norvasuo.

57 Churches were often considered 'auditoriums' in the 1930s, as was also demonstrated by Aalto's Vallila design.

58 In my dissertation, I have reconstructed this development; see Norvasuo, *op. cit.* (2). It agrees to a large extent with Aalto's own later account; see Alvar Aalto, 'Rautatalo', *Arkkitehti* no. 9 (1955): 129–137.

59 'Tallinnan taidemuseokilpailu', *Arkkitehti* (1937): 65–70. This was Aalto's description of his proposal and its lighting principles.

60 Hilding Ekelund, 'Uudenaikaiset rakennukset', 442, in *Keksintöjen kirja, Rakennustaide ja rakennustekniikka*, ed. Carolus Lindberg (Porvoo & Helsinki: Werner Söderström osakeyhtiö, 1938), 335–508.

61 Alvar Aalto, 'The Humanizing of Architecture: Functionalism Must Take the Human Point of View to Achieve Its Full Effectiveness', *The Technology Review* (Nov. 1940): 14–16, 36.

62 ADA 10, 107 # 84/411, 108 # 84/414, 110 # 84/420.

63 An example of Häring's work was the Flachsiedlung Schalendach housing project, described for example in Uno Åhren, 'Byggnadutställningen i Berlin', *Byggmästaren,* Arkitektupplagan (1931): 105–119.