RUDOLPH M. SCHINDLER'S BRAXTON HOUSE: THE FIBONACCI AND LUCAS SEQUENCE.

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Abstract: *Most writings on the proportional study of Rudolph Michael Schindler's houses have been descriptive observations rather than in-depth analyses using computational techniques or making pedagogical inferences. At times, the significance of the architect's proportional system has been blatantly ignored. Architectural historians, like David Gebhard (1971), considered Schindler's system merely one practical tool for wood frame structure and construction. It is true that Schindler's unit system was derived from practical needs for his space architecture, but it may be a mistake to consider the system without theoretic implications. Recently, March (1993) interpreted Schindler's proportional method as an analogy with classical proportion, much more than a mere construction tool. When he used a musical analogy to examine the proportional design of the How house, in his paper, "Dr. How's Magical Musical Box," he seems to portray "architecture as frozen music." Schindler left behind numerous built and unbuilt projects, which demonstrate extraordinary spatial complexity as well as variety. To achieve such spatial sophistication, Schindler argues that the architect needs to not only improve his mental image of the space but also possess a system. Consequently, Schindler proposed a proportional system of space reference frame. With this simple technique, the forms of space are freely conceived and precisely measured in the architect's mind. Forms of space are envisioned "by being inside of it" like musicians imagine and articulate their music with notes. By 1928, Schindler had sufficient command of his method in organizing his space and space forms to propose a design, called the Braxton House. This paper first introduces Schindler's proportional system, "Reference Frames in Space," outlines the spatial organization of the house, and finally interprets Schindler's use of proportion in the house in relation to the Fibonacci series and Lucas sequence.*

1. REFERENCE FRAMES IN SPACE

Although Schindler expressed his early interest in a proportional system as early as 1916, it was not clearly expressed until 1946 when Schindler published a comprehensive summary of his proportional system in an article, "Reference Frames in Space." In the article, his idea of proportion is well defined as follows: "Proportion is an alive and expressive tool in the hands of the modern architect who uses its variations freely to give each building its own individual feeling." The system for Schindler is indispensable to the creation of his notion of space architecture as a doctrine of spatial organization. Schindler argued that he started using the system as early as 1920. In fact, an analysis of Schindler's Free Public Library project of 1920 has demonstrated his use of the system. (Park, 1996)

The reasons for his using this system are two fold. First, all locations and sizes of the parts with respect to the whole are precisely identified during the construction process. Thus, no obscure or arbitrarily unrelated measurements are involved in the unit system. Second, the unit grid system offers the means to visualize 'space forms' in three dimensions. He argued, " … it must be a unit which he can carry palpably in his mind in order to be able to deal with space forms easily but accurately in his imagination." Although there are few exceptions, like the Schindler Shelter project where he used a 5-foot unit module, Schindler recommended 48 inches (4-foot) as the basic unit, to be used with simple multiples and with 1/2, 1/3, and 1/4 subdivisions. Among the subdivisions, with only a few exceptions, 1/3 and 1/4 are used for vertical modules in his works. This single unit module with its multiples and subdivisions form the basis of all dimensions of rooms.

This choice has two reasons. First, the unit must be related to the human figure to satisfy all the necessary sizes for rooms, doors, and ceiling heights; second, for practical reasons, the 48-inch module fits the standard dimensions of materials and common construction methods available in California at that time. Pueblo Ribera Court of 1923 is a typical example. This multiple housing project, built in San Diego, is superimposed on 4 foot by 4-foot grid lines. Its vertical module is based on a 16-inch dimensioning system, which controls not only the height of the room but also of all elements including built-in furniture, chair, table, windows, doors, and clerestory, providing, in Schindler words, "a uniform scale."

He utilized his unit system in a square grid pattern. Numbers and letters are laid out on the grid on the floor plans in sequence and the vertical module is identified with an elevation grade. This pattern was original to Schindler. The grid was presented on drawings and on the house in his earlier designs, yet they disappear from the house and, at times, from the drawings. However, this does not mean he abandoned his system; on the contrary, his system remains embedded in the designs as underlying principles.

Thus, every location of the buildings is identified accurately in the convenience of composition and construction. In addition, Schindler used the system to measure room sizes. In his preliminary sketches, his room sizes with the whole numbers on drawings are commonly presented. These numbers are increments of unit multiples with its subdivisions.

2. THE HOUSE

The Braxton house was designed for Shore brothers on the beach in Venice, CA by 1928-30 but never built. Gebhard (1980) argued Schindler's interlocking forms of building are indebted to the De Stijl mode, saying, "The year 1928 marks Schindler's full commitment to de Stijl ... the use of intersecting rather than singular volumes to establish their forms. This feature is what most strongly differentiates Schindler's work from that of the closely knit Internationalists – Gropius, Mies, Le Corbusier (Pre-1935) and Neutra." Then, he continued, "the Braxton house shows the architect was slowly giving up his laissez-faire view of Southern California and its climate, and was demanding an increased control over nature." Giella (1985) points out some features of the house, 'the use of Wrightian windows,' 'balanced asymmetry,' 'cantilevered structure.'

There are two major elements of the house: one for the house and the other for a garage. They are connected by a horizontal structure. A courtyard covered with sand occupies the space between. The main building is lifted up from the ground floor. The rectilinear box form dominates its spatial outlook, in Gebhard's words, " ...[a] rectangular box into and out of which secondary volumes projected," and in Giella's words, "a slightly top-heavy composition is created by cantilevering out each successive story from bottom to top." Various box forms are projected, recessed, and interlocked along the longitude axis. It is Schindler's usual practice and signature of his designs.

The ground level preserves an open playground and patio for the natural beach sand, forecourt, outdoor fireplace, the garage, a guestroom, maid's quarters, and furnace. The ground level is an independent unit and there is no interior staircase connecting the ground to the upper level. The major portion of the house is raised above the lot, which might be 'indigenous to all beaches'. The option of the lifted structure may be suitable for the beach house by the necessity of allowing sun and air to reach the entire floor, preserving some part of site beneath for a playground and providing an open outlook to the ocean. On the main level, the architect created a living room, two stories in height. It is open to the Pacific Ocean and enclosed by individual bedrooms on the balcony floor overlooking the living area, and below is the living room, kitchen facilities, dining room where porches are adjacent to dining room and kitchen. Inside the main floor, there is little built-in furniture shown on the drawing compared to his other projects, so that the inner space remains visually unobstructed. And also, like in the Lovell house, finely proportioned window mullions are inset facing the courtyard, and at the same time, door mullions face the ocean side. Three bedrooms on the balcony floor are disposed equally overlooking the Pacific Ocean. The composite roof is used as a terrace; a portion of it is used for sunbathing, a sleeping porch and a small closet.

The whole building is supported by means of five horizontal structures, different from the five reinforced vertical concrete frames in the Lovell house (1929). Rather than using concrete, these structures are made of wooden frames. All space volumes of the house are interlocked along the five major structures.

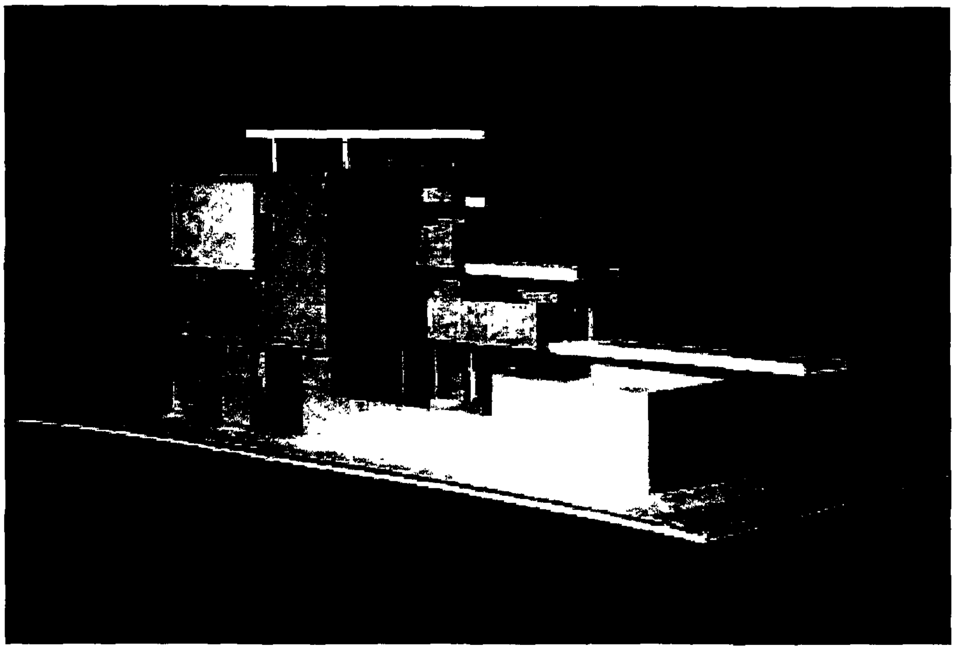

Figure 1. The Braxton house (1928): a quarter-inch scale model fabrication.

3. PROPORTIONAL ANALYSIS OF THE HOUSE

Despite its novel character, curiously enough, the Braxton house has remained to date unexplored in any depth, unlike its contemporaries the Wolfe house (1928) and the Lovell house (1929). In particular, whereas the proportional study of the Lovell house was attempted earlier by August Sarnitz (1986, 1988), that of the Braxton house has never been investigated. Sarnitz's analysis of the Lovell house plans and elevations is based on his belief that simple square and double square determine the overall proportional system of the house. Sarnitz also applied the same method in the analysis of the Free Public Library project.

There are various sets of drawings of the house in the Schindler Archive at the University of California at Santa Barbara, including preliminary sketches, structural and sash details, construction drawings, and well-organized presentation drawings. These sources provide valuable information for the proportional analysis of the house.

On the drawings, dimensions and placements of various spatial forms and details of the house are controlled by Schindler's unit system. The 4-foot unit system is clearly identified in plan with numbers and alphabets, and the 16-inch vertical module in elevation with grades. All major space, details, and structure underlie its subdivisions and multiples where all parts are related to each other in terms of simple unit relations to produce a coherent unity. Most of the major rooms in the construction drawings are measured in whole numbers and written on the drawing as is usually in other designs. Although rooms are frequently not a simple rectangular form, Schindler approximated those to the whole numbers. It appears that simple whole numbers with respect to the space reference frame is easy to grasp its size, as Schindler implied in his space reference frame system.

Given the evidence of the floor plan, the dimensions of the rooms include the following: a guestroom 9-foot x 15-foot, maid room 10-foot x 10-foot, a bathroom 5-foot x 8-foot, a furnace 6-foot x 8-foot on the ground level; the living room 24-foot x 27-foot, the kitchen 10-foot x 16-foot and a porch in front 6-foot x 10-foot, and the entrance 8-foot x 8-foot on the second level; his room 11-foot x 12-foot, her room 14-foot x 16-foot, another bedroom 10-foot x 16-foot on the third floor. The rafters of the horizontal wooden structures are regulated in a 2-foot distance – half of the unit module.

However, dimensions written on the construction drawings are found to be inconsistent with the real dimensions of rooms. The construction documents of Schindler provided actually consist of drawing which other architects might consider schematic like the *instruction to the builder*. Two reasons might be considered: First, this difference relies on their stages of design development, either conceptual or practical, that are common practice in the architectural field. Early schematic designs are primarily conceptual basis, and evolve depending on specific practical requirements in the design process and during fabrication as well as construction. Thus, room sizes shown on the drawings do not always accord with dimensions measured from the drawings, although the former might be what the architect had initially in his mind; rather, the latter is a result of some adjustments. For example, in the Braxton house, the dimension of the guestroom shown on the drawing is 15-foot by 9-foot, yet the real measure of the drawing of the room is 14-foot by 11-foot. Before arriving at a final scheme of a project, exercises of various possible schematic layouts are an almost universal procedure employed by architects, including Schindler. For example, in the Gibling house (1925-26), Schindler provided four different stages of schematic sketches for the plan development until he arrived at the final scheme. Each scheme offers different room sizes from another.

Second, various rooms are not rectangular in shape but interlocked, overlapped, and, at times, zigzagged. In this case it is not possible to present room ratios as a:b, other than approximation. In fact, Schindler approximately measured the room sizes in a rational manner with his unit system to determine its size of each room and probably their proportional relations.

Although these inconsistencies may cause confusion for this analysis, the collection of room dimensions serves as an excellent basis for further explorations of his proportional designs. This proportional analysis solely relies on the architect's room dimensions written on the drawings, since it maintained the architect's original intent of room sizes and their relations to each other before the architect's transfer of the ratios to the practical necessities. Here is a list of all rooms and their relations:

Floor	**Room Names**	**Room Dimensions**	**Space Reference Frame**	**Ratios**	**Decimal Value of the Ratios**
Ground Floor	Guestroom	15 x 9	3 ¾ x 2 ¼	5 : 3	1.67
	Maid room	10 x 10	2 ½ x 2 ½	1 : 1	1.00
	Bathroom	8 x 5	2 x 1 ¼	8 : 5	1.60
	Furnace	8 x 6	2 x ½	4 : 3	1.33
Second Floor	Living room	27 x 24	6 ¾ x 6	9 : 8	1.125
	Kitchen	16 x 10	4 x 2 ½	8 : 5	1.60
	Porch	10 x 6	2 ½ x 1 ½	5 : 3	1.67
	Entrance	8 x 8	2 x 2	1 : 1	1.00

Third Floor	His room	12 x 11	3 x 2 ¾	12 : 11	1.09
	Her room	16 x 14	4 x 3 ½	8 : 7	1.14
	Bedroom	16 x 10	4 x 2 ½	8 : 5	1.60
	Bathroom	10 x 6	2 ½ x 1 ½	5 : 3	1.67

There are some interesting results from the analysis as shown in the table. First, among three fractions that Schindler used which include1/2, 1/3, and 1/4, 1/3 of 48 inches (16-inch) is not used in room dimensions of the plan. Instead, the fraction is used only for the vertical module. The16-inch vertical module measures the room height of the house. It also governs window mullions, door mullions, and the thickness of a series of horizontal structures. Accordingly, it is inferred that Schindler used those fractions separately: 12" increments for plans and those of 16" for elevations.

The door height is his typical 6 feet 8 inches. The room heights vary, but they are subdivisions and multiples of 16 inches vertical module. The room height of the ground floor including the maid, guestroom, furnace, and garage is 8 feet. But the height of the open playground is 10 feet. The height of the kitchen and the dining room in the second floor is 8 feet. The height of the two story high open living room is 14 feet 16 inches. The height of His room and another bedroom is 8 foot 16 inches in the third floor. The height of Her room is 9 foot 8 inches, but that of the bathroom and the dressing room next to Her room is exceptionally 8 feet 10 inches. A series of five horizontal structures are apart 8 feet, except for the height of the first floor, which is 8 feet 9 inches.

Second, these surprisingly few room ratios are worthy of the profound study of their interrelationship. In the house seven different ratios: 1:1, 4:3, 5:3, 8:5, 8:7, 9:8, and 12:11 are collected. There might be a certain relationship between these ratios. In order to deduce relationship of ratios, a particular method as an effective tool is introduced to derive all these ratios. Subsequently, these ratios are identified with the extreme and mean ratio geometrically incorporated in the regular pentagon. The ratios suggest a possible relationship with the Fibonacci sequence, in which each successive number is equal to the sum of the two preceding numbers, 1, 1, 2, 3, 5, 8, 13, 21 ... and the Lucas sequence, 2, 1, 3, 4, 7, 11, 18, 29 ... The ratios of successive numbers of both series converge to approximately 1.618, which is known as the extreme and mean ratio. As goes on to the right in these sequences, the ratios get close to the Golden Ratio, which is 1.618.

Figure 2. A graph showing its successive Fibonacci sequence closes to 1.618.

Its proportion with a regular geometrical pentagon can be identified in the following diagram.

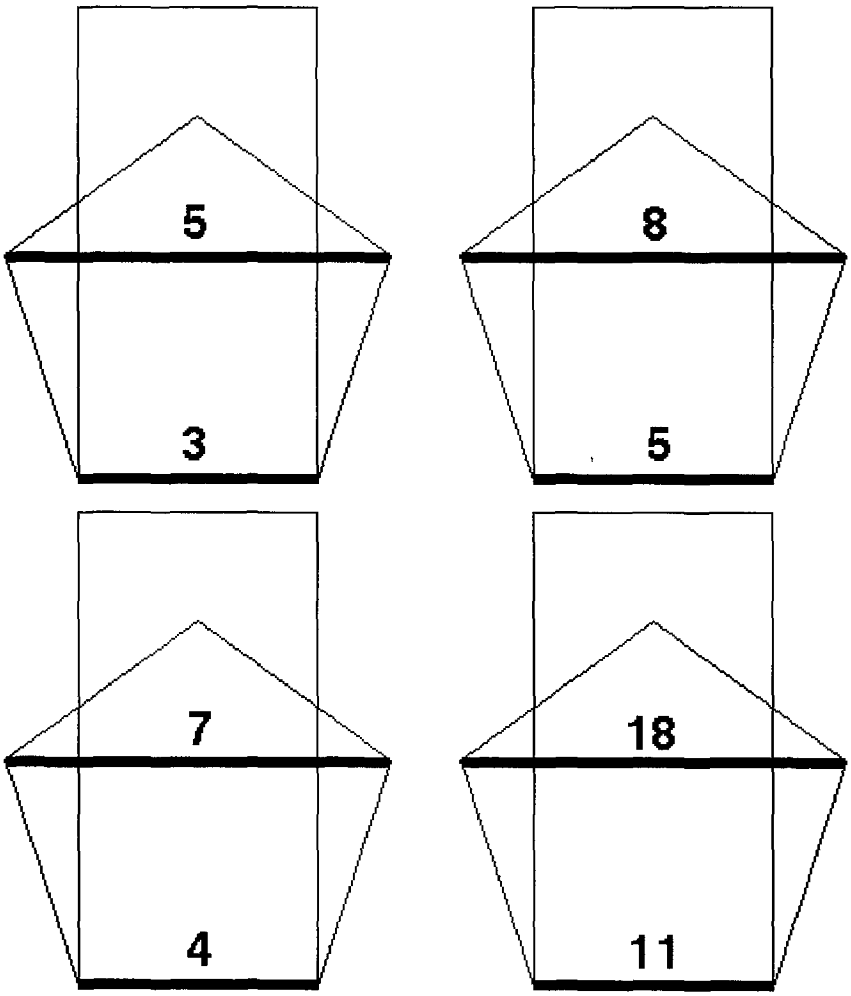

Figure 3. A double square and pentagon with root 5.

Ratios including 1:1, 4:3, 5:3, and 8:5 are certainly among these. Geometric constructions using existing ratios on the drawings derive new proportional ratios. By computing other ratios of the two series together, the remaining three ratios can be constructed: $7/4 \div 2/1 = 8/7$, $4/3 \div 3/2 = 9/8$, and $18/11 \div 3/2 = 12/11$. All ratios are derived directly from other ratios previously used. The implication of these newly constructed ratios with old ones is that all room ratios become associated each other, thus a ratio consistency is achieved. Schindler might deliberately incorporate sizes of each room in his projects. This computation is delineated in the following diagrams.

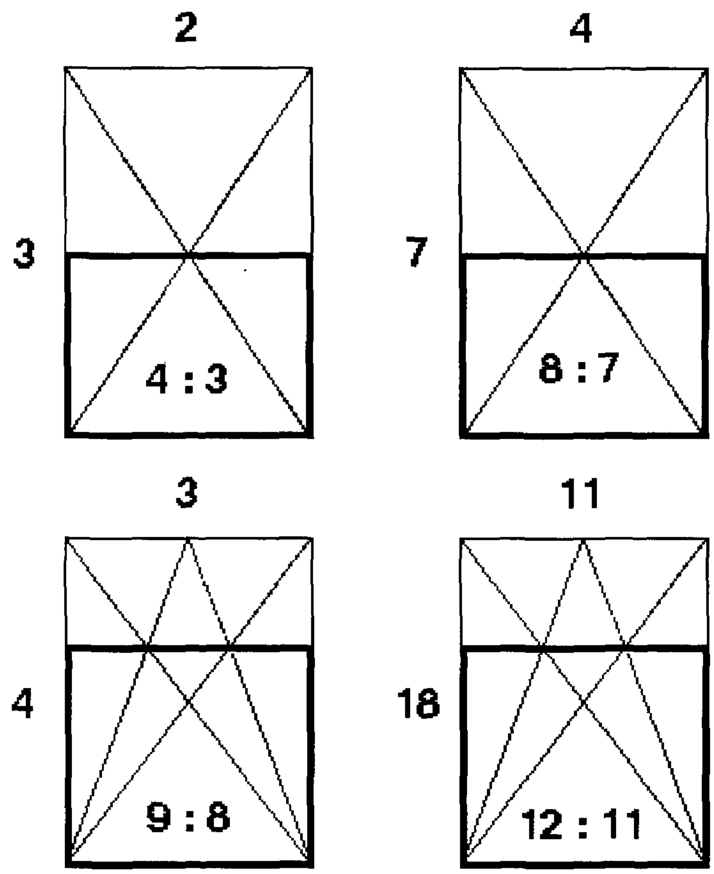

Figure 4. Geometric construction of the room ratios.

Thus, all room ratios of the project are suggestive of methods of computation coming out of the geometric and proportional construction. By this method, all other room ratios are constructed with regard to each other. Schindler might be aware of such ideas as he wrote, "We must realize that 'proportion' is not any more a simple mathematical relationship (Golden Rule, etc.) which can be applied universally in all buildings as it was in classical times." However, it is incorrect to suppose Schindler derived his room ratios this way or mathematically. Perhaps, some sort of computing procedure may have been involved in the architect's mind. The architect could choose the whole number of room dimensions in the project with reasons to reference proportions derived from simple geometry or to practical solutions to the problems of a particular design.

4. SUMMARY

The proportional design of Schindler's Braxton house has been analyzed with regard to the Fibonacci or Lucas sequence. It is unlikely that while designing the project, Schindler calculated those numbers and their ratios with deliberate intent relying on the particular computational method. As discussed, the architect had no particular belief of "a simple mathematical relation" or "Golden Rule." Thus, the analysis has based on the hypothetic speculation rather than documented evidence of the architect. Also it is hard to believe Schindler favored these individual room proportions as a whole or their relation to one another.

That does not mean, however, that the analysis is useless. Even if the architect never claimed that his theory of proportion is based on a particular mathematical ground, there are some implications inherent in his designs where each room associates with others in terms of their ratios. Schindler wrote, "The house of the future is a symphony of 'space forms' - each room a necessary and unavoidable part of the whole." In the design, the architect's approach was extremely simple. The composition of various rooms did not have to follow mere mathematical play of rules but have to express its relations in size between rooms so as to form an "organic unity": a whole composed of related parts in orderly arrangement.

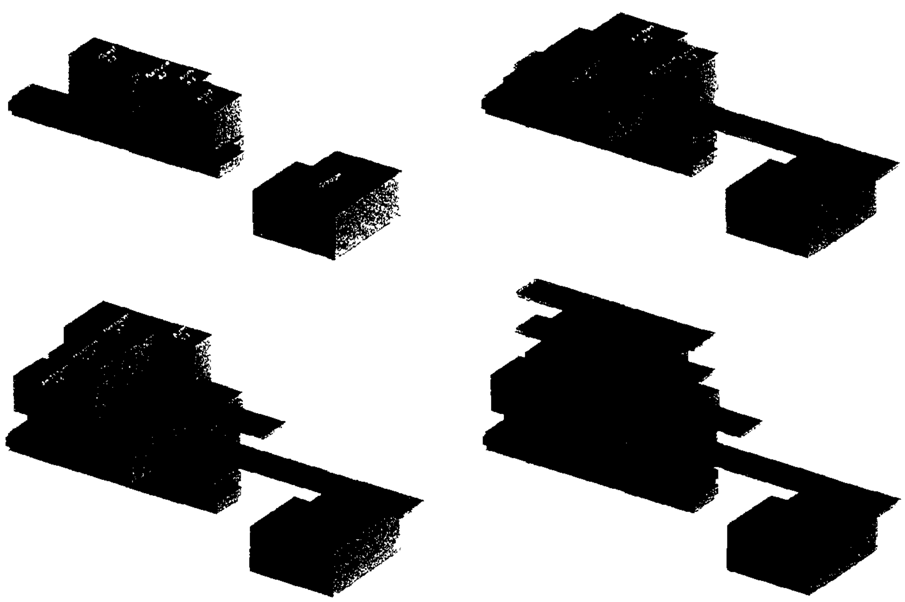

Figure 5. 3-D representation of rooms with their ratios hung on the horizontal structures.

Although speculative, the proportional relations of those ratios examined in this article represent a valid method for analyzing proportional relationship of the rooms in the house, their harmonic use in the spatial organization of the design. Consequently, it could be said that the house is composed of simple room ratios and their relations in its entirety. Their relations in 3-D space are constructed to illustrate its integrity.

Therefore, the observation leads to a conclusion that proportional relations of these ratios tie together in a cohesive whole in a single design, thus creating such a complex design. Whether the design was intentional or arrived at by chance, R. M. Schindler must have a splendid sense of proportional eyes to project such a simple and rational system to a very complex spatial composition.

5. ACKNOWLEDGEMENT

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