Diagrams of a Universal System of Construction in the Work of Konrad Wachsmann: between Representation and Technology

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> The perfectly universal building system may be defined as a three- dimensionally symmetrical, completely axial system, in which the building elements and the joint lines are always identical with the modular planning raster and in which it is possible to form any combination of connections in any direction […] This can only be achieved, however, if the profiles of the vertical and horizontal connections are absolutely identical.
>
> (Wachsmann 1961, p. 78)

> After all technical problems have been solved […] this product should become an universal building method which would enable the designer, architect or engineer to conceive, plan and design any structure according to his own imagination.
>
> (Wachsmann and Woodward 1953, p. 1)

DIAGRAMMATIC SERIES

In 1942, Konrad Wachsmann developed what he called the "Erection Manual to the House Nº 101". Composed of 10 diagrams, this manual was prepared, as Wachsmann explained, "…with the basic principle in mind that anyone no matter how unskilled by following simple directions should be able to erect the General Panel House" (SAdK 1947, p. 1).

The first page of the Manual indicates that just few tools are found to be helpful in erecting this house, the wedge puller, the fillerstrip, the panel- jak, hammer and chisel. Since the system was based on the assemblage of factory- made components, no other tool was needed.

The Manual, divided in 10 diagrams based on a modular grid, is presented in a sequence of drawings from the bottom to the top of the building: sills and girders, floor panels, wall panels, walls and floor filler strips (three diagrams), ceiling (two diagrams), and roof (two diagrams).

Each diagram is based on square units dividing the figure into 31 modules according to the size of the *general panel*. Three colors were used: red, blue and green. Arrows were deployed to indicate direction of movement and sequences of assembly. Numbers were used to indicate the panels setting order. A brief written instruction went below each diagram explaining the sense of numbers, arrows and colors in each case. In some of them the grid corners were additionally marked with A, B, C and D characters. Wachsmann explains, "In these pages you will find the exact erection sequence of all members in the system" (1947, p.1) In fact, despite of the existence of conventional drawings, the whole structure could be deduced and built by using the Erection Manual alone. Since the Manual indicates *assembly sequences*, Wachsmann considered that time and movement were integrated in a diagrammatic representation of a *universal system of construction*.

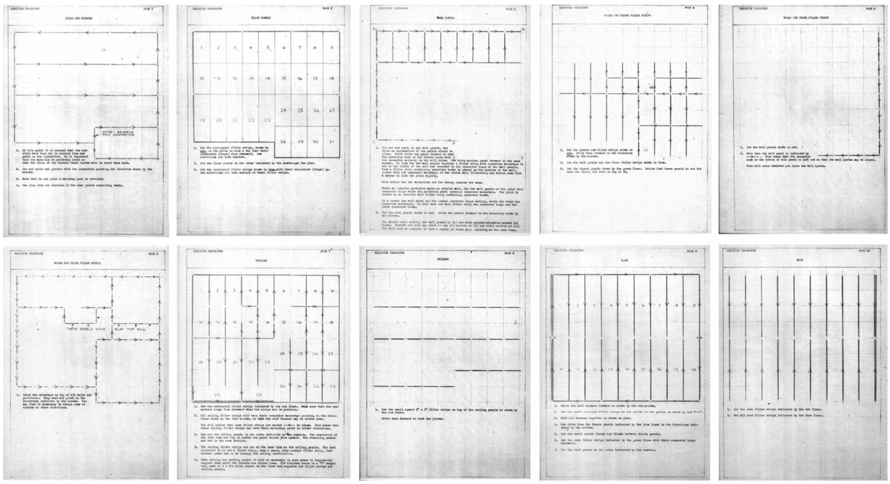

Figure 1. Erection Manual, 1947 (Stiftung Archiv der Akademie der Künste, Berlin)

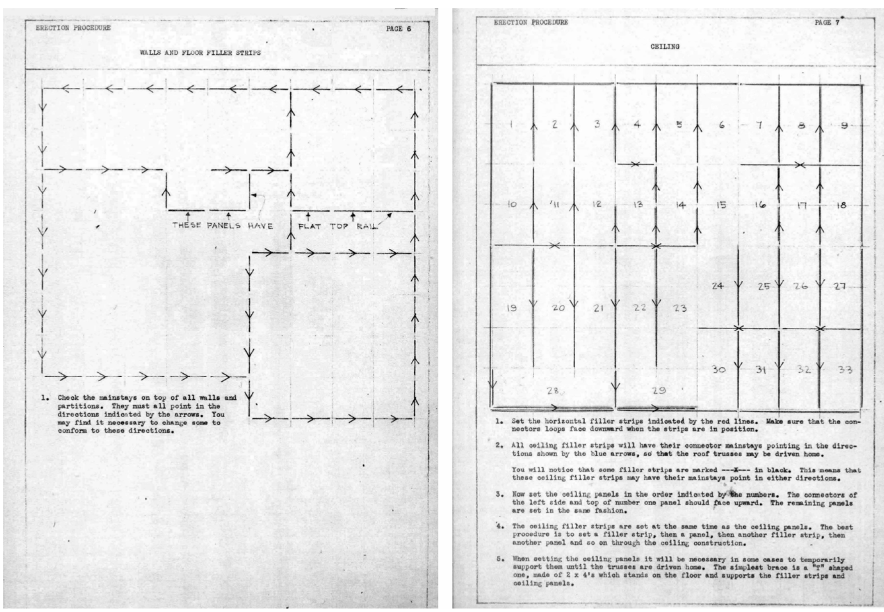

Figure 2. Erection Manual, page 6 (Walls and Floor filler Strips) and page 7 (Ceiling)
(Stiftung Archiv der Akademie der Künste, Berlin)

Complementary to this manual, Wachsmann developed a series of 13 numbered diagrams which were later published in "The Turning Point of Building, Structure and Design" (1961), the English translation of the earlier German edition edited by Krausskopf in 1959. The purpose of this book, as Wachsmann explained, was writing an introductory study of the contemporary problems in building, "given the several inquiries of students, colleagues and friends about the subject" (Wachsmann 1961, p. 6).

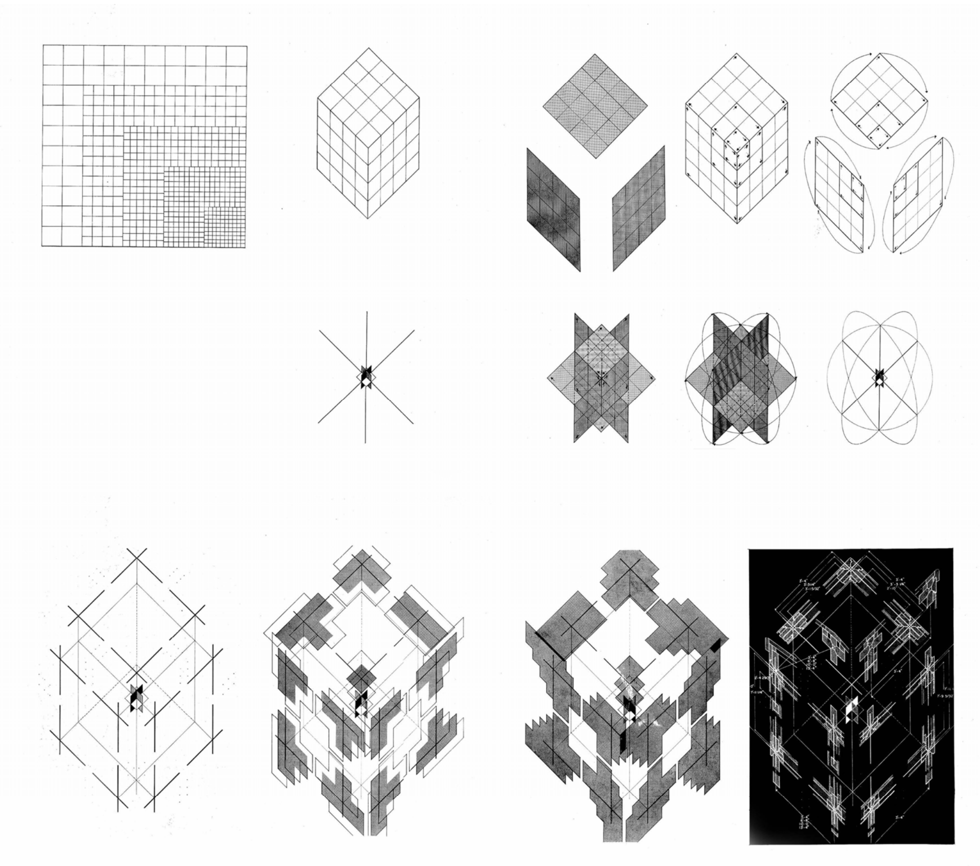

Figure 3. 13 Diagrams: Modular coordination, embracing movement and time, a system of measurement born of industrialization (Wachsmann 1961, p. 59- 61)

Based in a three- dimensional modular grid these diagrams correspond to a *system of representation of an axial system of construction*. Belonging to the main tenet proposed by the publication - a *new construction* based on the industrialization of building - these diagrams developed the problem of the module and its coordination. These drawings illustrate what Wachsmann called "Modular coordination, embracing movement and time, a system of measurement born of industrialization" (1961, p. 56).

Wachsmann's argument is carefully illustrated by the gradual development of these 13 diagrams. Evolving from *the variations of a modular grid projected on a plane* (based over an assumed arithmetic progression), a two- dimensional surface is turned into a three- dimensional volume, stating a *three- dimensional system of modular measurement*. By detaching the faces of the cube Wachsmann transformed it in independent planes which would be moved and rotated in any direction as the diagram arrows suggest. This was appointed as the *dynamic relationships of the individual parts* obtained from the subdivided cube. As long as the dimension and movement of these planes are *simultaneously determined*, Wachsmann estimates that time is being additionally expressed by the diagrams; consequently time was considered *indispensable in the measurement of the modul*e. The spatial interpenetration of dynamic planes becomes an *abstract center and point of intersection of reference planes, volumes and bodies*. In such a way, the building components involved would be controlled and coordinated by the abstract representation as it contains the rule for spatial interpenetrations in any possible movement and position. As Wachsmann says, *time and movement were controlled as supplementary ordered system of interpenetrating planes*. Such interpenetration of planes was fundamental in considering that the system itself was based on the notion of assemblage.

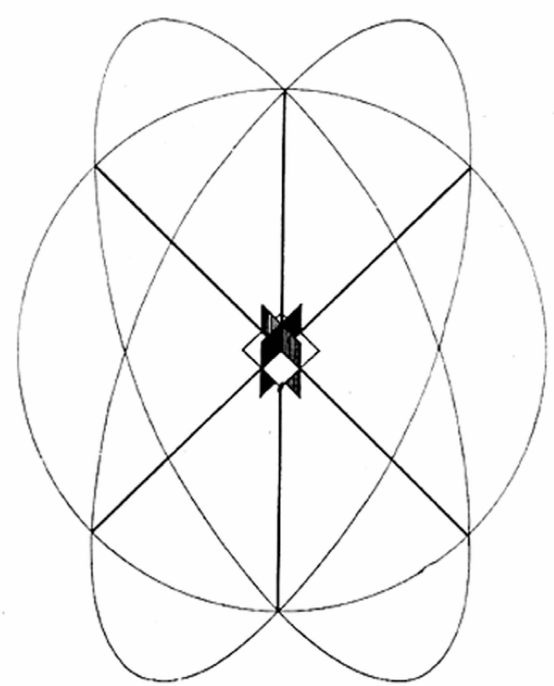

Figure 4. Diagram Nº 75: Symbol of measure, movement and time, into which any imagined form can be fitted within the system (Wachsmann 1961, p. 61)

Hence, diagram Nº 75 is relevant since it becomes "[…] the symbol for measure, movement and time, into which any imagined form can be fitted within the system of relationships assumed" (1961, p. 57).

Finally, four diagrams were created to show how this representation of interpenetration, time and movement, would evolve into rastered lines and imaginary elements towards the final realization of an *axial system of construction*. In fact, the last diagram – highlighted on a black background - contains a practical application of the system, where the interpenetrating planes would be rotated, moved and joined in any desired direction and position by considering time and movement into the process of construction. This final diagram, which encloses the basic principles of the *General Panel System*, indicates panels and joints in any possible situation, either horizontally or vertically. It clearly shows one of the main purposes of such a technical research, the achievement of a single way of joining, or, in Wachsmann's words, a *universal* joining technique to connect any component in any desired position and combination.

The final diagram represents the General Panel House as one possible application of a wider way of thinking expressed in such a diagrammatic representation. It proves that Wachsmann's theoretical scope was much more ambitious. He sought a *general theory of construction* in which the case of the General Panel System was no other than a specific attempt of consummation. Other examples are found in the ARMCO System (1953), and in the projects developed with students at the Advanced Building Research Programme of the Illinois Institute of Technology (1950 onwards), the Salzburg Summer Academy (1957), etc.

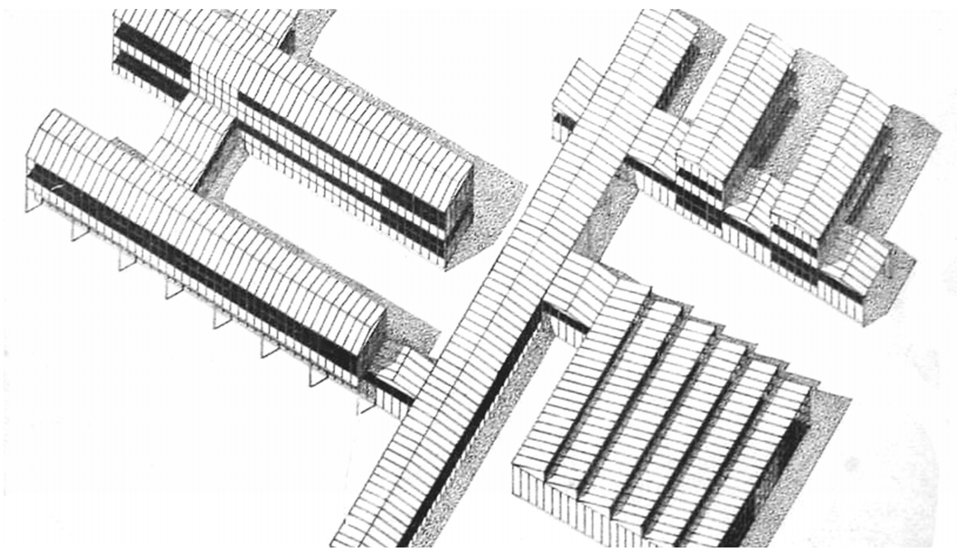

Figure 5. General Panel System applied to a larger configuration (Stiftung Archiv der Akademie der Künste, Berlin)

In fact, for the ARMCO steel structure Wachsmann proposed: “These elements shall be created in such a way that one should be able to plan a building of any shape and form beginning from a one-story structure to the unlimited height skyscraper” (SAdK 1953. p. 1), including also the possibility of creating *any desired curve* (1953, p. 1) That intention was already visible in the General Panel Corporation, since house Nº 101 was thought to be a modal possibility on a system designed to produce larger configurations.

This enterprise not only supposed the creation of a new way of building, but also engaged in the task of producing new ways of representation such as the Erection Manual and those 13 diagrams, including the symbol for measure, time and movement.

CRITICAL LITERATURE

Konrad Wachsmann has an ambiguous reputation within the history of modern architecture and building technology. Having gained international acclamation for the space frames and arresting joints he developed for the U.S. Air Force in 1959, at the same time he was (together with Walter Gropius) protagonist of one of the saddest episodes in the history of Modern Architecture, the commercial failure of the General Panel System; in the words of Reyner Banham, this system

> […] might have been a minor incident in the history of prefabrication, but it was a compete disaster within modern architecture, since it marked the failure of one of the most cared dreams of Modernism
>
> (Banham 1986, p. 29).

This two-fold reputation explains the manner in which the work of Konrad Wachsmann lacks a common assessment within architectural critique. The ambiguity of his reputation relates to the difficulty in the assessment of his real achievements in the field of architecture and building technology.

The way in which his work has been widely praised is exemplified by John D. Entenza in proposing that Wachsmann

> Is one of those identities that is by the way of being a kind of monument […] He is a creature of science as it inadvertently approaches poetry […] There is some mysterious genetic composition that has ignited this man […] for this kind of unique creature, there is no prototype – only disciple
>
> (Entenza, 1967).

By quoting Eberhard, the editorial comment to Wachsmann’s *Towards Industrialization of Buildings* (AIA Journal, March 1972) shares this appraisal by saying: “When one becomes interested in the problems and prospects of industrialization in the building field, there is one name that stands out as a pioneer and innovator: Konrad Wachsmann" (AIA 1972, p. 33**)** Even further the article states:

> The work Wachsmann has been doing […] may become as fundamental to future industrial technologies as was the work of his friend Albert Einstein to nuclear physics
> (1972, p. 33).

For them, the work of Konrad Wachsmann had *anticipated the future*. Robertson Ward explains that Mies and Wachsmann were close friends, "Mies' 'God is in the details' was matched by Wachsmann's 'A building's message is the fact'" (Ward 1972, p. 35) More recently, Christian Thomsen has proposed that Wachsmann, together with Fuller, belonged to the "peacemakers of an international movement of science- and technology- oriented architecture" (Thomsen 1994, p. 76).

Within these circles, Wachsmann was portrayed as a creature of the science that approaches poetry, a unique kind of man of some mysterious genetic composition; the pioneer and innovator that become the Einstein of industrialized building technologies, and who anticipated the future by linking science, technology, and architecture.

On the other extreme, this positive reception encountered adversaries. For Barry Russell, Wachsmann was partly responsible for

> […] the strange contradictions encountered in recent developments in building systems in this connection. It is a commitment to a philosophy of machine production, which however attractive bore little relation to what was actually happening in the industry
> (Russell 1981. p. 318).

It is precisely in the success or failure of Wachsmann's proposals for an industrialized construction where the divergence of assessments is best exemplified, including the different reasons critics and theoreticians have proposed to explain the failure of the *General Panel Corporation*.

As it was documented by Gilbert Herbert, the General Panel Corporation was *a resounding commercial failure* (Herbert 1984, p. 307). The direct causes of failure, Gilbert proposes, lay not "in any substantial degree, in the architectural conception, nor in the technological means, nor in the translation by industry of that conception into the reality of building components" (1984, p. 307) but elsewhere. However, Gilbert asserts in suggesting the paradoxical nature of such a highly sophisticated technology. He says, "In a sense the very high quality of the product contained within it the seeds of failure. What an irony is here! Held up by constant redesigning, in a search for an ever- better technical solution…" (Herbert 1984, p. 309) Certainly the same conclusion is proposed

by Reyner Banham in saying: "we can ask ourselves if it was precisely in the design of details the responsibility for the disaster" (Banham 1986, pp. 28-29).
For Kenneth Frampton, instead, the failure was related with lack of funding and socio- cultural conditions:

> It is licit to suppose that two factors had contributed in a decisive way to the failure of the General Panel System; the first related to the socio- cultural problem of 'accessibility'; the second coming from the derived lack of adequate funding. Wachsmann avoided any iconographic element commonly associated to the image of a house
>
> (Frampton 1988, p. 43).

For Frampton, the reasons of failure were not related in any sense to the technology or the complexity of details. It was rather connected to the struggle between modern architectural expression and people's social expectations. For him, its failure was a real loss since *a generalized adoption of the General Panel House would have provided the American suburbia levels of urbanity much more elevated than those achieved in the last four decades* (1988, p. 43). Nothing could be more distant from Banham's understanding, when proposing that the General Panel House was "…a dwelling- concept of the utmost banality" (Banham 1996, p. 53).

In one way or another, the failure of the system is not in doubt. It was seen sometimes as a problem of funding and expression (Frampton), or as a matter of technical sophistication (Herbert); or as the natural outcome of a *solution coming from an intellectual attitude that was fundamentally wrong* (Banham). Interestingly, the debate about the system seems to remain unsolved, as well as Wachsmann's reputation is still a matter of dispute. A recent issue of "Detail Magazine" (2001) has portrayed Wachsmann and his General Panel System as "enormously successful in the post- war construction period" (Detail 2001, v. 41 Nº 4, p. 627).

REPRESENTATION AND TECHNOLOGY

From the systems of representation developed by Wachsmann in the form of an Erection Manual and 13 symbolic diagrams, it becomes clear that the General Panel was a modal variation of a more ambitious ideal. He searched for a universal system of construction in which the Erection Manual was part of the reconfiguration of architecture by means of assemblage.

The ultimate goal was to create a system of construction based in a total and universal compatibility of elements. The size and shape of the final building had to correspond to the combination of elements throughout simple numerical operations, by adding, subtracting, dividing or multiplying the measure of the initial unit acknowledged as the *module*. Therefore, finding the coherence of measurement for any possible component was the fundamental task of technological research, towards a universal assemblage. Technology was forced to accommodate this fundamental theoretical insight.

In considering all the different dimensions involved in the industrial production of components and the assembly process, Wachsmann proposed 12 modular categories from which technical research will be intended to the achievement of a single unit, universally applicable, that would emerge as the *common denominator* of those twelve modular categories or, as the outcome of the *reciprocal relationships* between them. A universal and comprehensive module had to emerge from the consideration of them all.

The same reductive principle operated in the establishment of the elements. The *element module*, for instance, clearly embodies this kind of whim. As Wachsmann explains, it makes the theoretical assumption on the existence of a *universal surface* which is "…an element with so many physical properties that, abstractly expressed, it can serve any purpose" (Wachsmann 1961, p. 62).

In Wachsmann's theory, the establishment of few elements to work with, namely a unified single module, the multi- purpose surface and the universal joining technique were stated as a matter of technological research; few elements that would be combined throughout mathematical operations within a single formula of construction. Building as science, ideally, will develop into a strategy of combination of categories, assembled under the dimensional coordination of a universal module of measurement, and by the creation of a universal joining technique. Wachsmann believed that this approach,

> […] not only appears convenient in relation to industrial production but, more particularly is in harmony with the universal joining technique, used in assembly, which makes no distinction between types of element
>
> (1961, p. 62).

The standardized parts and the numerical operations involved were not directly related to the building but to an open system of possible configurations that are controlled in advance by the given basic unit, the module. What the diagrams represent it is not a building but a system constituted by the relation of parts, a fundamental *module*, some numerical operations, *time and movement*.

The nature of this scope is fully contained in Wachsmann writings. "The Turning Point of Building" provides evidence of such a plan. However, Wachsmann vocabulary was not coming just from the facts of industrialization. Notions already well spread in the modernist a*vant- garde*, together with terms borrowed from modern physics were widely employed. While *universality* and *interpenetration* were part of the ideological programme of the early modernism; time, motion and energy are taken from a scientific vocabulary in considering that "Time, motion and energy determine the framework within which a building can be conceived and developed" (1961, p. 9).

The way of drawing such a theory, as it is contained in diagram Nº 75, reminds one also of the symbolic representation of the atom by Ernest Rutherford in 1911, in which the negative charged electrons orbit around the nucleus as the planets around the sun. This kind of representation coincides with Wachsmann's symbol of measure, movement and time.

As in physics, energy, time and motion enter into the Wachsmann's equation of a general theory of construction. It was a formulation planed to construct any kind of building in any possible stage of flexible development, from within a perfectly coordinated *universal building system*.

Wachsmann's goal of relating *time*, *movement*, *matter* and *energy* in a single representation would be considered the diagrammatic version of a *unified building theory* based on universal elements, joints and modules. But, unlike Einstein's algebraic formula, Wachsmann's equation remained a diagram and a symbol, just as drawing Nº 75; or as the 'Directional Diagram', the utmost idealization of this kind of representation, something in between Leonardo's 'Vitruvian Man' and Rutherford's 'atomic model' applied to construction.

It is possible to see the manner in which a way of representation is permeated by the fascination sparked by the *atomic theory*, aimed to achieve the *atom of construction*, the ultimate indivisible unit from which any kind of building could be described, deduced, design and built. It is not just a universal system of construction, but a system, ideally described, by a universal formula in which modules, joints, and elements were meant to be coordinated within a system of representation based in a series of diagrams.

This system of representation was proposed under the assumption that 'Directional Diagram' and 'Erection Manual' were internally related by an underling modular grid, a bridge between the symbolic and the operative nature of the representation of a new construction.

The relevance of this proposition for the history of construction within modernism lies in the manner in which creation in architecture was no longer related to the design of a building, but to the design of a building system. The task was to create new ways of construction that, consequently, would bring a new form and a new architecture. As long as form was the outcome of construction, design was internalized within the system. Because it was *universal*, architecture as a whole was now claimed to be contained within a diagrammatic formula of construction: architecture as a whole was now contained into the 'Directional Diagram' and its operative extension in the 'Erection Manual'.

This ideal, of course, was a theoretical one. Technology was forced to accommodate to a modernist ‘theoretical agenda’, tinged by a ‘scientific’ commitment. While it is pointless to reassess the success or failure of *prefabricated building systems*, it is worthy to present the way in which *technical research* was encouraged by an often unacknowledged goal: the internalization of complexity by means of representation.

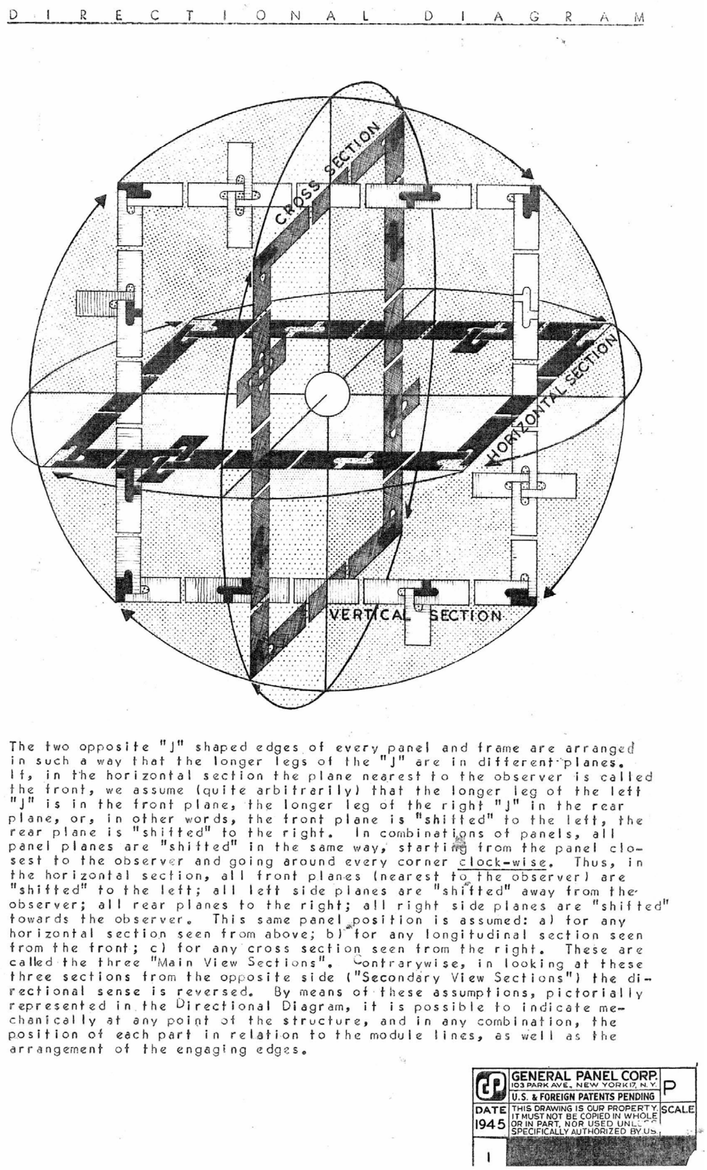

Figure 6. Konrad Wachsmann. Directional Diagram for the General Panel System
(Stiftung Archiv der Akademie der Künste, Berlin)

This analysis is not aimed at adding another explanation to the failure of the General Panel System, but to contextualize Wachsmann's work within a much wider scope contained in the diagrammatic and symbolic representation of a 'unified formula' of construction. Together with this it is relevant to reveal the theoretical nature of the complex relationships between the narratives of modernism and building technology, regarding the manner in which theoretical expectations affect and determine technological research. This lays open not only the nature of such a 'universal system' of construction, but also its formulation as both discourse and representation.

This constitutes an extraordinary and problematic event in the recent history of construction; a specific moment that established the conditions for the formulation of a *universal system of construction* and the creation of alternative ways of representation. Perhaps an illusion, it belonged to the fertile ground of modernist scientific speculation, powerfully expressed throughout the Wachsmann's writings and diagrams.

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