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HUMANITIES ESSAY

# On the Matter and Intelligence of the Architectural Model: Arthur Schopenhauer's Psychophysiological Theory of Architecture and Konrad Wachsmann's Design of a Space Structure

Victoria Watson

During the last decades of the twentieth century, the modernist concept of 'space' in architecture became a subject of inquiry for architectural critics and historians. One curiosity arising within the discourse suggested that the thinking of the nineteenth-century philosopher Arthur Schopenhauer was foundational for the concept of 'space' that developed in German aesthetics throughout the nineteenth and into the twentieth centuries, eventually informing modernist architectural theory. This essay looks at the way Schopenhauer used architectural models, not only to clarify his understanding of space, but also to demonstrate what was for him the much more important notion of 'Idea'. It then turns to the German modernist architect Konrad Wachsmann, who was most famous for his seminal book, *The Turning Point of Building* (1961), which advocated the industrialization of building as a project for architecture. The essay asks if Schopenhauer's distinction between 'space' and 'Idea' can illuminate the new 'understanding of space' that Wachsmann thought would arise as a consequence of a systematic industrialization of building. Discussion will focus on a particular section of Wachsmann's book that gives an account of his design of a space structure commissioned by the US Air Force in 1959, taking that project as exemplary of his thinking, working methods and values. It will also take note of the way in which the space structure stimulated the imagination of the American artist, Robert Smithson, who began to envisage the entire planet as encapsulated in an enormous virtual grid – one that was, like a Schopenhauerian 'Idea', supposedly constituted out of mind and matter. To end the essay looks briefly at the notion of 'field,' which, many architects argued at the time, would supersede 'space' as the conceptual mainspring of theory and practice.

**Keywords:** Model; Space; Gravity; Physiology; Aesthetics; Perception

## Introduction

In the discourse on 'space' that became popular in international architecture culture during the last decades of the twentieth century, the nineteenth-century German philosopher, Arthur Schopenhauer (1788–1860), was presented as the originator of the idea that architecture is an art of space. [1] This designation is rather strange, because Schopenhauer believed that space was only of secondary importance to architecture. In his book, *The World as Will and Representation*, published in 1818/19, Schopenhauer stated:

> '*For Architecture, considered only as a fine art, the Ideas of the lowest grades of nature, that is gravity, rigidity, and cohesion, are the proper theme, but not, as has been assumed hitherto, merely regular form, proportion, and symmetry. These are something purely geometrical, properties of space, not Ideas; therefore they cannot be the theme of a fine art.*' [3, p. 414]

University of Westminster, GB, doctorwatson@blueyonder.co.uk

Schopenhauer was well aware that buildings are not only the subject of fine art, that they come in all sorts of different shapes and sizes, are built according to different principles of construction, deploy a variety of materials, and serve a wide range of purposes. But for Schopenhauer, architecture was more than just building, because architecture aimed to produce aesthetic effects, whereas building did not have this explicit purpose. One way in which Schopenhauer justified his argument about architecture's proper theme was through consideration of the architectural model. He argued, if architecture were simply meant to exhibit the properties of 'space', then 'the model would of necessity produce the same effect as the finished work' – but, he continued, 'this is by no means the case, [and] on the contrary, to have an aesthetic effect, works of architecture must throughout be of considerable size.' [3, p. 414]

This essay looks at Schopenhauer's theory of architecture and the distinction that he made between the respective role of 'space' and 'Idea' in the appreciation of architectural works. It then proceeds to ask if there are traces of Schopenhauer's theory to be found in Konrad Wachsmann's thinking about industrialization and its implications for the production of buildings, as articulated in his influential book, *The Turning Point of Building*, which was published in 1961 (**Fig. 1**). The discussion will focus on one specific project by Wachsmann, his design of a space structure. It is interesting to channel the speculations of Schopenhauer and Wachsmann together because both of these German thinkers were interested in architecture as a domain of material practice. But whereas Schopenhauer's outlook was reactionary, in that he believed the most perfect forms were located in the past, Wachsmann's was progressive, and for him the total industrialization of building would lead to new forms in the future. One person who responded to Wachsmann's call to imagine the future was the American artist, Robert Smithson. The essay therefore concludes with Smithson's envisioned future projection of the space structure as an extended field, a worldwide virtual grid with temporal fluctuations, localized in specific areas in the manner of hybrid crystalline structures that were part-building, part-aircraft.

## Schopenhauer's Psychophysiological Theory of Architecture

Arthur Schopenhauer believed the 'proper aesthetic material of architecture' is the antagonism of natural forces, which can be expressed in large masses and so become perceptible to human observers. According to Schopenhauer, works of architecture:

> '*. . . can never be too large, but they can easily be too small. In fact, ceteris paribus, the aesthetic effect is in direct proportion to the size of the buildings, because only great masses make the effectiveness of gravitation apparent and impressive in a high degree.*' [3, p. 414]

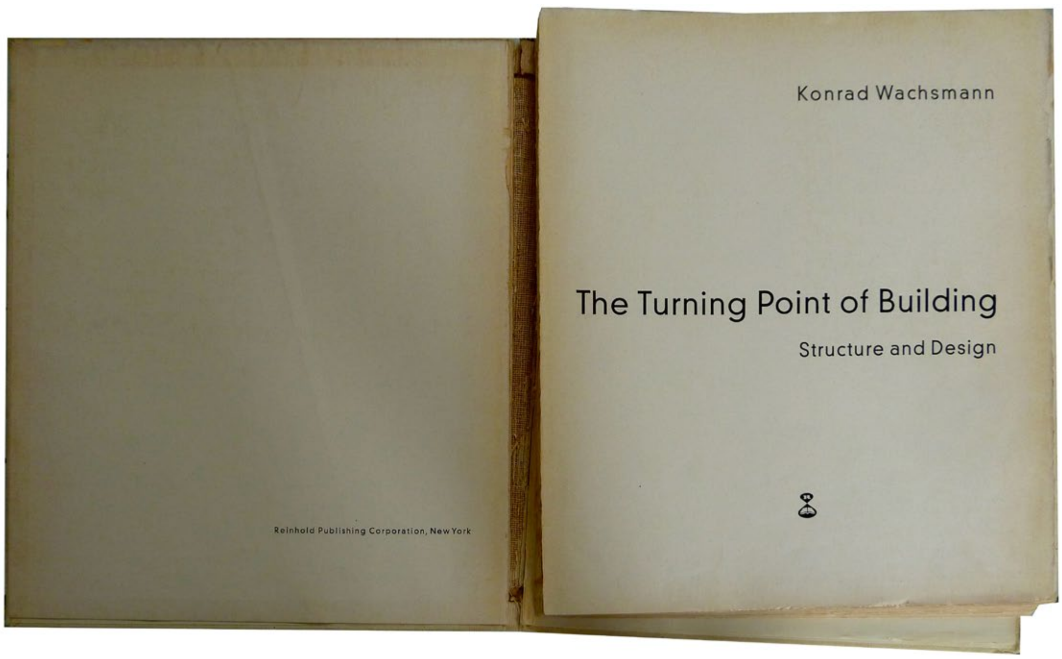



**Figure 1:** Konrad Wachsmann, *The Turning Point of Building* (1961), p. 2–3 (All rights reserved).

Schopenhauer often used the term ‘Idea’ to refer to natural forces – and for him, the purpose of architecture, its proper theme, was the revelation of a specific ‘Idea’, namely gravity. Architecture reveals the ‘Idea’ of gravity to the human observer, who apprehends it in the antagonistic relationship between load and support, as played out particularly in the structural dynamics of stone buildings. The ‘Idea’ of gravity hence becomes subject to architectural expression when it is controlled and calmly expressed in the poised equilibrium of a building made out of stone. The reason that the human observer is able to apprehend the ‘Idea’ of gravity in the stone building is because their body is possessed of a unique kind of intelligence, giving rise to the capacity to ‘understand’ these larger ‘Ideas’.

Schopenhauer thus believed the capacity to understand ‘Ideas’ depends on the physical condition of the body and not on the capacity for rational argumentation based on concepts. Because appreciation of ‘Ideas’ depends on material factors, so it is impossible to convey ‘Ideas’ by means of abstract concepts: in other words, ‘Ideas’ are beyond representation. For Schopenhauer it is the corporeal understanding of ‘Ideas’ that is the direct source of the human feeling for beauty, which means that beauty is something physiological, not ideal, and is a property of the observer’s body as much as of the thing observed. As he explained:

> ‘*By virtue of the demonstrated intellectual nature of perception, the sight of beautiful objects, a beautiful view for example, is also a phenomenon of the brain. Therefore its purity and perfection depend not merely on the object, but also on the quality and constitution of the brain, that is on its form and size, the fineness of its texture, and the stimulation of its activity through the energy of the pulse of the brain-arteries. Accordingly, the picture of the same view appears in different heads, even when the eyes are equally keen, as differently as, say, the first and last impression from a much-used copperplate. To this is due the great difference in the capacities to enjoy the beauties of nature, and consequently to copy them: in other words, to produce the same phenomenon of the brain by means of an entirely different kind of cause, namely dabs of colour on a canvas.*’ [3, p. 24–25]

A painting, therefore, does not produce a direct copy through the paint that is laid down on the canvas. Instead, if it is any good, the painting will affect the brain of the observer, triggering a response that is not unlike the one produced by the natural scene itself.

Schopenhauer’s speculations about the sensitivity of the body are related to an important distinction made by the English proto-scientist, Francis Bacon, way back in the seventeenth century. In his *Silva Silvarum* (1658/70), Bacon made a distinction between ‘perception’, in terms of ‘taking account of’, on the one hand, and ‘sense’ or ‘cognitive experience’ on the other. In the following quote, we notice how the capacity to-take-account-of is thought of as permeating the whole of nature:

> ‘*It is certain, That all Bodies whatsoever, though they have no Sense, yet they have Perception: For when one Body is applied to another, there is a kind of Election, to embrace that which is agreeable, and to exclude or expel that which is ingrate: And whether the Body be alterant or altered, evermore a Perception precedeth Operation: for else all Bodies would be alike one to another. And sometimes this perception in some kind of Bodies is far more subtle then the Sense; so that the Sense is but a dull thing in comparison of it. We see a weather-glass will find the least difference of the Weather in Heat or Cold, when Men find it not. And this Perception also is sometimes at distance, as well as upon the touch; as when the Loadstone draweth Iron, or Flame fireth Naptha of Babylon a great distance off. It is therefore a subject of a very Noble Enquiry, to enquire of the more subtil Perceptions; for it is another Key to open Nature, as well as the Sense, and sometimes better: And besides, it is a principal means of Natural Divination; for that which in these Perceptions appeareth early, in the great effects cometh long after.*’ [4, p. 171]

As the discipline of science developed throughout the seventeenth century, and began to stabilize in the eighteenth century, so Bacon’s distinction came to stand outside the dominant paradigm of scientific inquiry. But just because it stood outside the interests of science at a particular moment does not invalidate the distinction that he made; indeed, today, in areas of knowledge concerned with the structured study of mind and nature, the distinction between taking-account-of and sense is of great interest. I would also suggest that Schopenhauer’s thinking about ‘Ideas’ marks the start of an up-dating of Bacon’s distinction, setting it in a critical relationship with the conceptual thinking of modern science – and that modernist architects like Konrad Wachsmann then went even further, by actually trying to test out, and to realize, the distinction between taking-account-of and sense through the act of building.

Arthur Schopenhauer thought that human intelligence could sometimes be far too sensible, neglecting perception and becoming too bogged down in conceptual thinking. But he also believed it was possible to save intelligence by channelling it away from cognitive tendencies and redirecting it toward the apprehension of 'Ideas'. One way for us to access Schopenhauer's thinking about how such a re-direction might be made possible is by turning to his theory of architecture. Insofar as Schopenhauer was concerned, architecture had already achieved perfection in the buildings of Classical Antiquity, and hence for the modern architect there was little left to do but 'apply the art handed down by the ancients, and to carry out its rules in so far as this is possible under the limitations inevitably imposed on him by want, need, climate, age, and his country.' [3, p. 416] Nor was Schopenhauer the least interested in the way that architects went about the business of designing buildings and, because he thought he already knew the answer, Schopenhauer didn't bother to ask why it is that modern architects work with models. One architect who was practicing around the time that Schopenhauer was conceiving and writing his major philosophical work was Karl Friedrich Schinkel (1781–1841), to whom he made no direct reference – although Schopenhauer did disparage the Neo-Gothic style that was popular with architects in that era, and which Schinkel sometimes deployed in his own designs. The only architect that Schopenhauer did refer to by name was Vitruvius, but even then it was to reprimand the ancient Roman architect for misunderstanding the principle of the column:

> '*. . . the form and proportion of the column in all its parts and dimensions down to the smallest detail, follow from the conception of the adequately appropriate support to a given load, a conception well understood and consistently followed out; therefore to this extent they are determined a priori. It is then clear how absurd is the idea, so often repeated, that the trunks of trees or even the human form (as unfortunately stated even by Vitruvius, IV, 1) were the prototype of the column.*' [3, p. 413–414]

Here Schopenhauer is suggesting there is a cognitive factor involved in architectural design, whereby cognition has a part to play in translating the 'Idea' into the medium of expression, or in this case into building in stone.

Neither was Schopenhauer interested in the symbolic language of architecture, since he dismissed ornament as properly belonging to sculpture, not architecture. For him, it was only the psychophysical effects of buildings that are architecturally valuable. As well as his lack of interest in actual design practices, Schopenhauer made no reference to specific buildings; instead he adduced typical characteristic forms – for example, the form of the Greek temple, the form of the Gothic cathedral – in support of his argument. Schopenhauer's interest in architecture was therefore highly selective and reductive, and of all his reductions the one that is of particular interest here is his attitude to spatial relationships, which he thought were of only secondary importance to architecture. Schopenhauer thought of space as merely the ground of possibility for the apprehension of 'Ideas' and, as we have already seen, he drew attention to the architectural model in order to make this point, observing that the psychophysical experience of looking at a model is nothing like that of an actual building.

Although Schopenhauer was greatly influenced by Immanuel Kant – frequently acknowledging Kant as an important mentor – his attitude toward space was not Kantian. Schopenhauer believed that spatial relationships are grasped intuitively, in a manner that he termed 'the reason of being in space'. Most certainly he did not think of space as a kind of 'Idea', but neither did he think of spatial relationships as abstract forms of cognition:

> '*These relations are peculiar ones, differing entirely from all other possible relations of our representations; neither the Understanding nor the Reason are therefore able to grasp them by means of mere conceptions, and pure intuition a priori alone makes them intelligible to us; for it is impossible by mere conceptions to explain clearly what is meant by above and below, right and left, behind and before, before and after.*' [5, p. 154]

To illustrate the peculiar contribution of spatial relations to human perception and sense, Schopenhauer offered the diagram shown here (**Fig. 2**), asking his reader to notice how 'the mere sight of it without words conveys ten times more persuasion of the truth of the Pythagorean theorem than Euclid's mouse-trap demonstration'. [5, p. 164] Although Schopenhauer did not say so explicitly, he seemed to imply it is the self-evident nature of spatial relationships that endows them with truth.

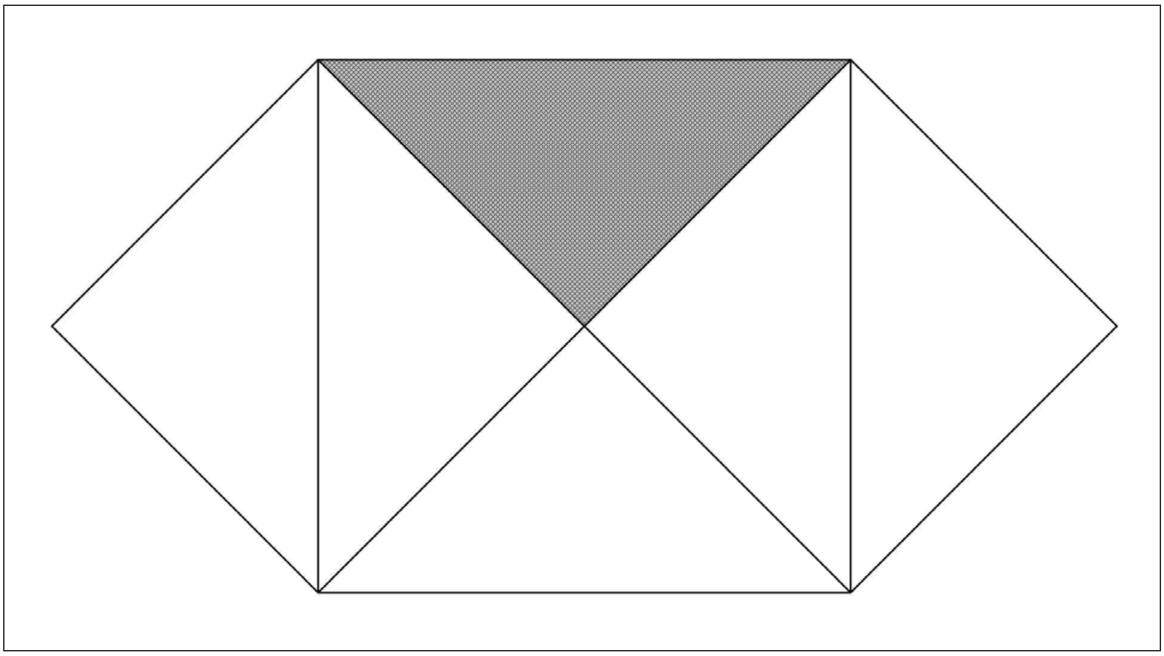


**Figure 2:** The Pythagorean Theorem, as per diagram by Arthur Schopenauer.

## Wachsmann's Design of a Space Structure

Throughout the nineteenth and twentieth centuries, and now into the twenty-first, architects have continued to use models as a silent means of conveying the spatial truths of their designs. One influential figure who was especially inventive in this respect is the German modernist architect, Konrad Wachsmann (1901–1981). It is interesting to study Wachsmann in the light of Schopenhauer's thought because, as we shall see, many of the building systems that he designed were as reductive as Schopenhauer's readings of architecture, being paired down to the expression of a single 'Idea' in a single material.

In his 1961 book, *The Turning Point of Building*, Wachsmann advocated the wholehearted industrialization of building. As he saw it, the great virtue of industrialization was its ability to turn out high-quality products in massive quantities, each one identical to the next. For Wachsmann, mass production meant the embodiment of a virtual system of modular coordination whose parts and their junctions would fit together harmoniously – bringing to the act of building a degree of refinement and precision never before known, including the integration of all the equipment necessary for 'perfect environmental control'. [6, p. 11] The principle of industrialization also implied all kinds of changes to the methods of procuring buildings, and it meant the transfer of the primary location of building production from 'the building site and work bench to the factory' [6, p. 11], such that all building elements would now be prefabricated in the factory and then just assembled on site. On-site assembly meant that new technologies for joining individual building elements together would have to be invented, and these would need to be both functionally and financially efficient. The invention of joints became a key feature of Wachsmann's project of industrialization and *The Turning Point of Building* gave many examples.

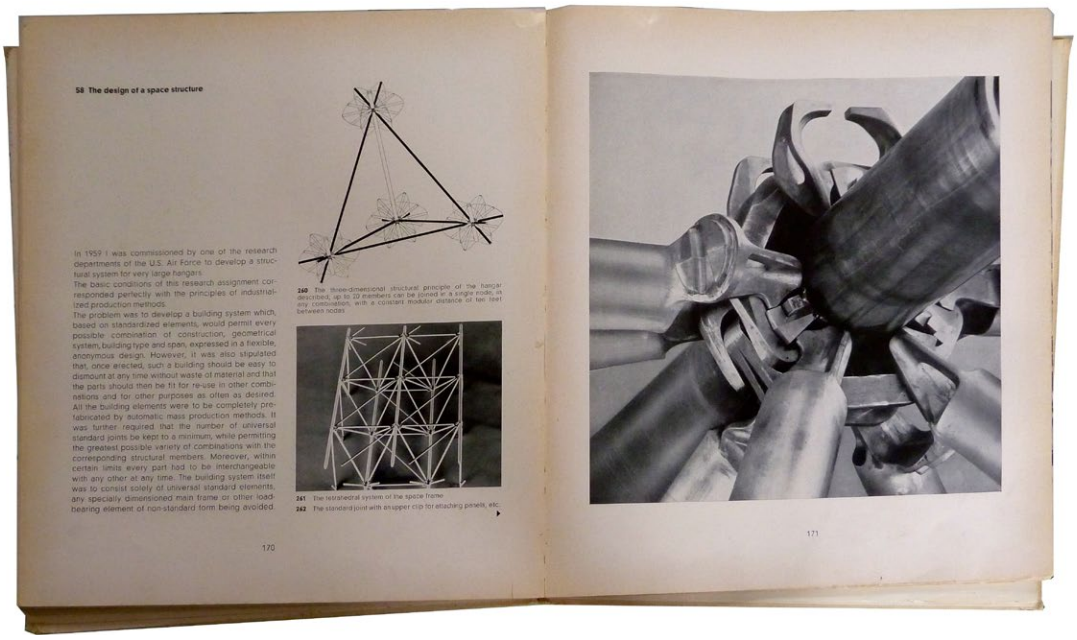
In order to look more closely at Wachsmann's project of industrialization, and its plausible connection to Schopenhaurian thought, we need to turn to one particular item, his design of a space structure. These days anybody wishing to see pictures of Wachsmann's space structure can find them easily on the Internet. For what follows, I will concentrate however on the section on the space structure contained in pages 170–193 in *The Turning Point of Building*, whose relevant pages are reproduced here. This is done because it is important to be aware of the way in which Wachsmann used techniques of visual reproduction, especially photography and printing, to argue in favour of technical reproducibility in building. These images also underline the fact his design of a space structure was never built; it remained a project on paper. In *The Turning Point in Building*, the space structure is represented using four different but interfaced modes of communication: writing, line drawings, black-and-white photographs of 1-to-1 models of joints, and photographs of a scale model of the total assembly. The text is used to inform the reader about several aspects of the space structure that are not apparent from the visual modes of communication. Amongst other things, the writing communicated the intended function of the space structure, which was to serve as an aircraft hanger, and also some of the values Wachsmann attributed to industrialization, which in his view was to express:

> '*. . . a perfectly new spatial experience by technological means, while simultaneously expressing ideas of the conquest of mass and free dynamic space on a scale previously unknown.*' [6, p. 186]

This comment was indicative of a number of Schopenhaurian notions, firstly through the evocation of 'space' as a medium of experience and secondly in its emphasis on technology and dynamics.

To explain how the line drawings and 1-to-1 models operated within the article, we can paraphrase Schopenhauer's comment on the Pythagorean diagram cited above: the mere sight of these images conveys ten times more persuasion of the truth of the space structure design than words ever could. The visual material shows the space structure to be an extensive lattice grid formed by the repetition of a single tetrahedral unit. Its overall form is that of an enormous roof canopy, suspended some way above a ground datum, and supported on four pyramidal substructure elements that are also formed by the repetition of the same tetrahedral unit.

Wachsmann seems to have worked on the modelling of the space structure at two different scales. Firstly, using the scale of 1-to-1, he modeled the building components required – i.e. connectors and rods. (**Fig. 3 right-hand side**, and **Figs. 4, 5, 6, 7**) The connectors were to function as joints between the slender tubular rods in such a way that each rod entered into a precise spatial relation when joined together with other rods. (**Figs. 8, 9, 10**) Then, secondly, at a much smaller scale, Wachsmann modelled the configuration that the space structure would take when many connectors and rods were joined together in the enormous hanger assembly. In order to simulate the appearance of this assembly, as it would appear to the eyes of a human subject, Wachsmann used the smaller model to stage a number of photographed views in which the position of the camera simulated the eye-line of the hypothetical viewing subject. As well as the presence of the built canopy itself, some of these shots were given a minimal contextualization by the insertion of silhouettes of human bodies and airplanes, and by a horizon line that delineated between ground and sky. (**Fig. 9 right-hand side lower image**, and **Fig. 11 right-hand side**) This photographic staging of the model is just enough to convey the sense of the ambient light in a terrestrial environment, whereby stronger light from above and weaker light from below coincide with the pull of gravity and the push of the ground. Of the various modes of representation that Wachsmann used in this section of *The Turning Point of Building*, these staged views are quite special, because they convey the illusion of the space structure as if it were an actual built form and they work on the mind of the reader to make them feel as if they might actually be sharing the same 'space' as the aircraft hangar.


58 The design of a space structure

In 1959 I was commissioned by one of the research departments of the U.S. Air Force to develop a structural system for very large hangars.
The basic conditions of this research assignment corresponded perfectly with the principles of industrialized production methods.
The problem was to develop a building system which, based on standardized elements, would permit every possible combination of construction, geometrical system, building type and span, expressed in a flexible, anonymous design. However, it was also stipulated that, once erected, such a building should be easy to dismount at any time without waste of material and that the parts should then be fit for re-use in other combinations and for other purposes as often as desired. All the building elements were to be completely prefabricated by automatic mass production methods. It was further required that the number of universal standard joints be kept to a minimum, while permitting the greatest possible variety of combinations with the corresponding structural members. Moreover, within certain limits every part had to be interchangeable with any other at any time. The building system itself was to consist solely of universal standard elements, any specially dimensioned main frame or other load-bearing element of non-standard form being avoided.

260 The three-dimensional structural principle of the hangar described; up to 20 members can be joined in a single node, in any combination, with a constant modular distance of ten feet between nodes

261 The tetrahedral system of the space frame
262 The standard joint with an upper clip for attaching panels, etc.

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**Figure 3:** *The Turning Point of Building*, p. 170–171 (All rights reserved).

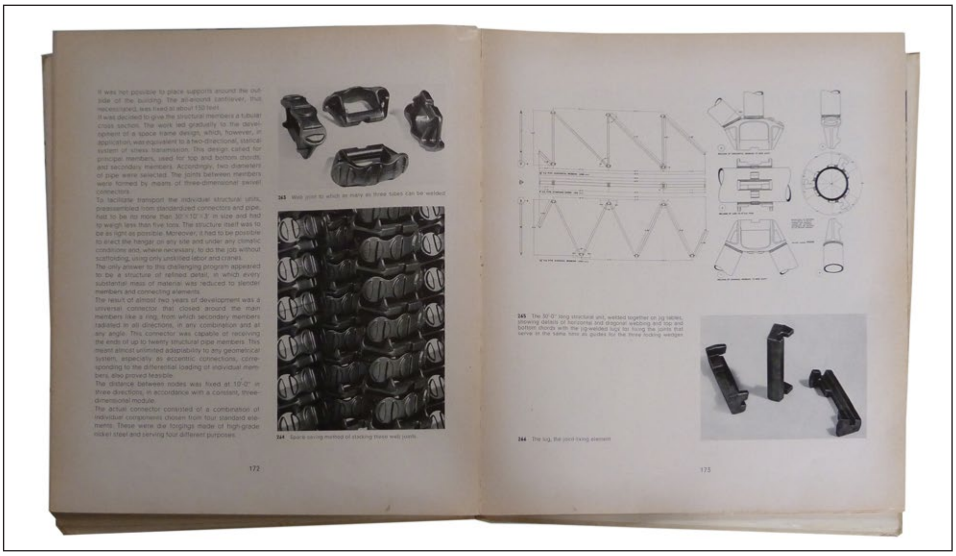

**Figure 4:** *The Turning Point of Building*, p. 172–173 (All rights reserved).

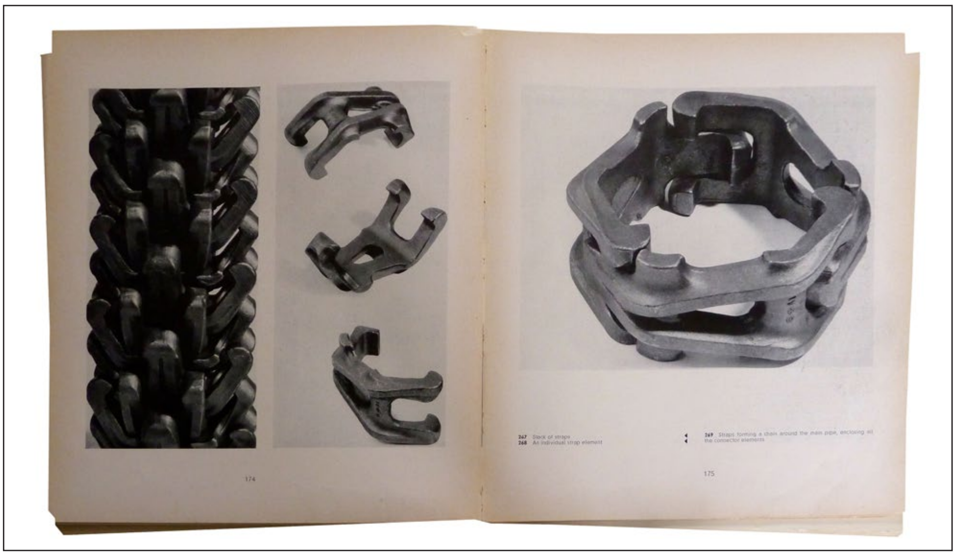

**Figure 5:** *The Turning Point of Building*, p. 174–175 (All rights reserved).

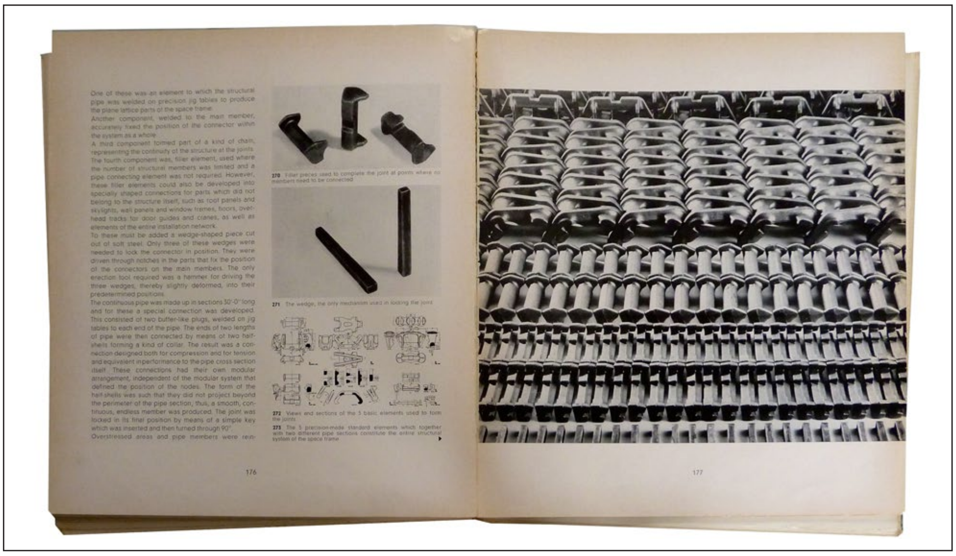

**Figure 6:** *The Turning Point of Building*, p. 176–177 (All rights reserved).

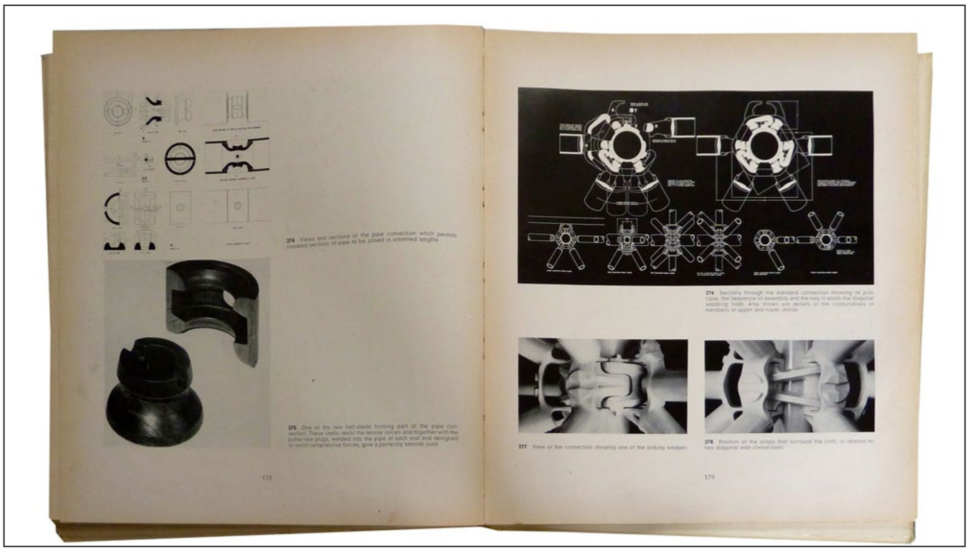

**Figure 7:** *The Turning Point of Building*, p. 178–179 (All rights reserved).

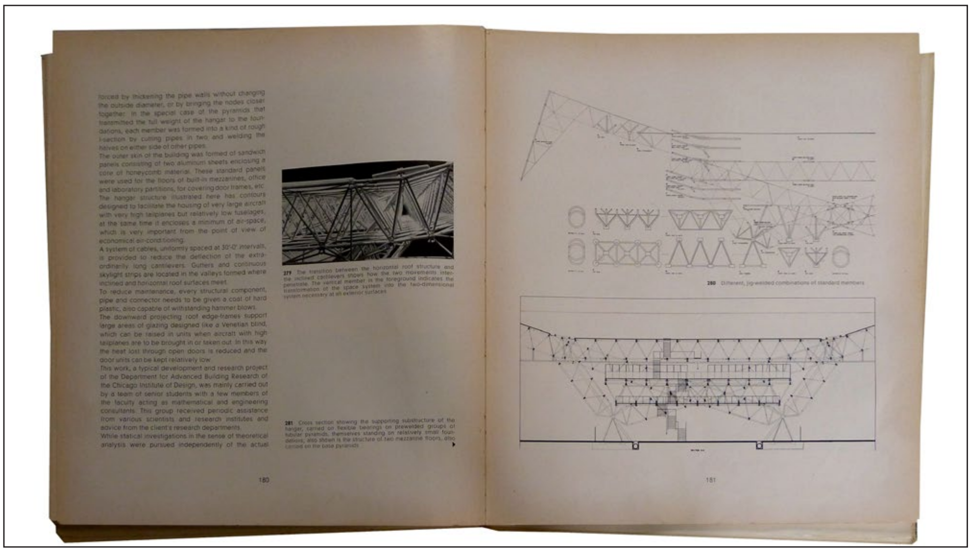

**Figure 8:** *The Turning Point of Building*, p. 180–181 (All rights reserved).

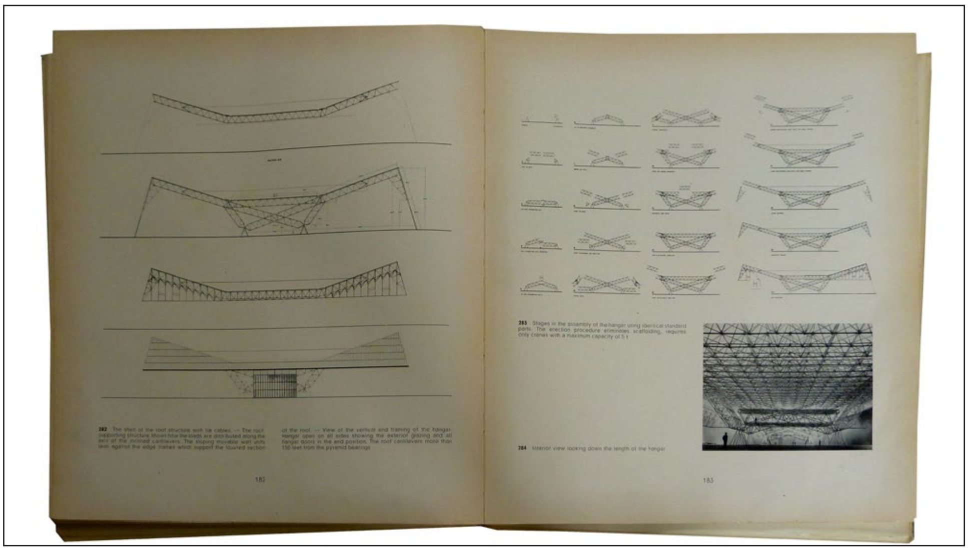

**Figure 9:** *The Turning Point of Building*, p. 182–183 (All rights reserved).

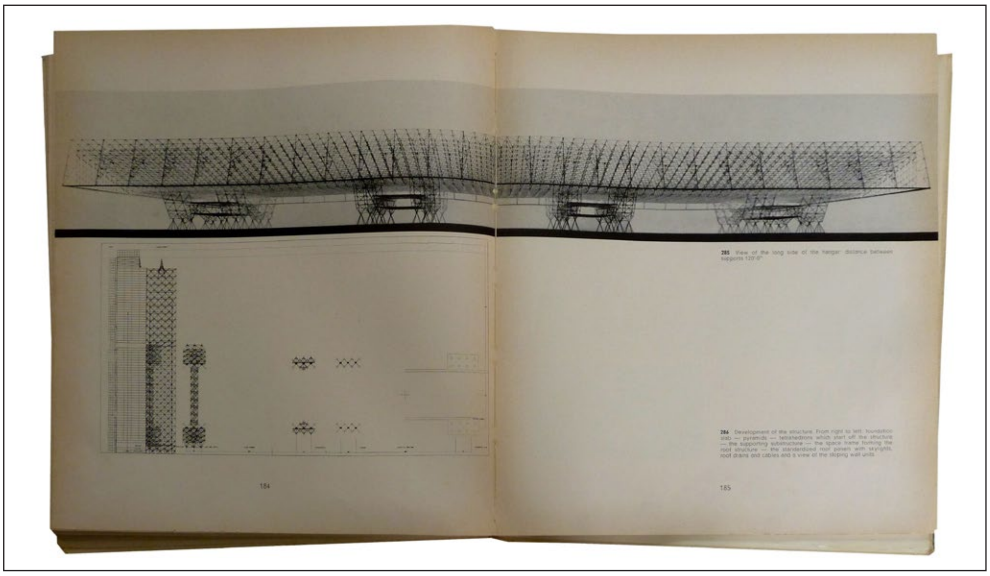

**Figure 10:** *The Turning Point of Building*, p. 184–185 (All rights reserved).

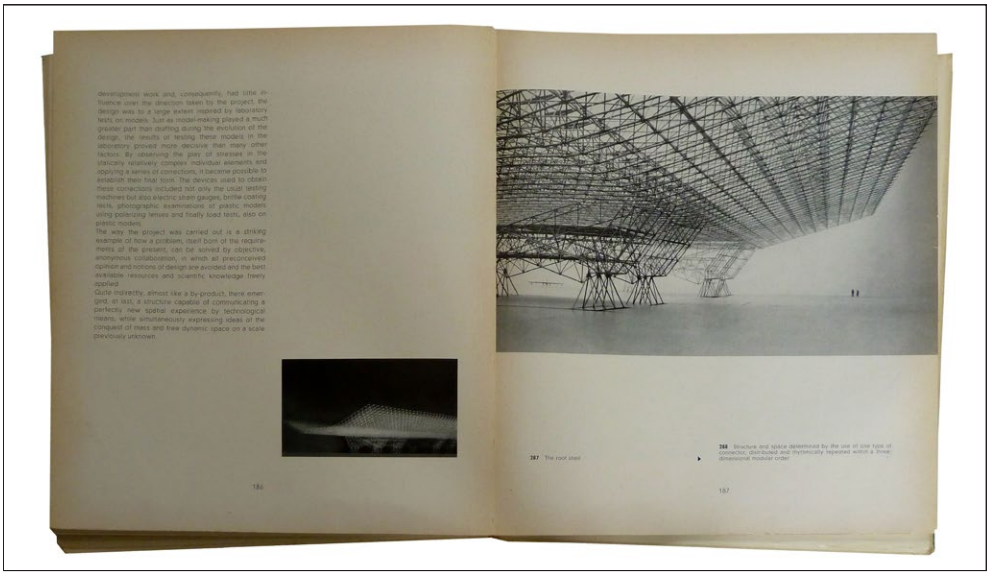

**Figure 11:** *The Turning Point of Building*, p. 186–187 (All rights reserved).

Konrad Wachsmann's use of photography to simulate views offers a way of seeing the architectural model that was unavailable to Schopenhauer. Of course the experience of the model as framed through photography does not bring the presence of the actual space structure any closer to the reader, but it does radically alter their perception of the model. It might be argued that Wachsmann's use of photography brought an additional dimension to the effect of the model, since the photographic technique acts as a persuasive medium. Hence, rather like Schopenhauer's diagram of the Pythagorean theorem, it communicates silently without words. The observer of the photograph intuits the medium but is also able to look through it to the staged views of the space structure (**Figs. 12, 13, 14**).

Percieved through these staged views, Wachsmann's space structure does seem to conform to Schopenhauer's specification for architectural validity, in that it is clearly of considerable size and does appear to explore gravity in quite remarkable ways. Yet at the same time the space structure offers a direct contradiction of Schopenhauer because it is not made of stone. Instead, it is large and voluminous but displays very little mass, and indeed its canopy over-sails the substructure elements in what looks like a remarkable, gravity defying cantilever. Of course it is only the appearance of the defiance of gravity that is actually conveyed by the photographic views – what is missing for the reader is, in Schopenhauer's terms,

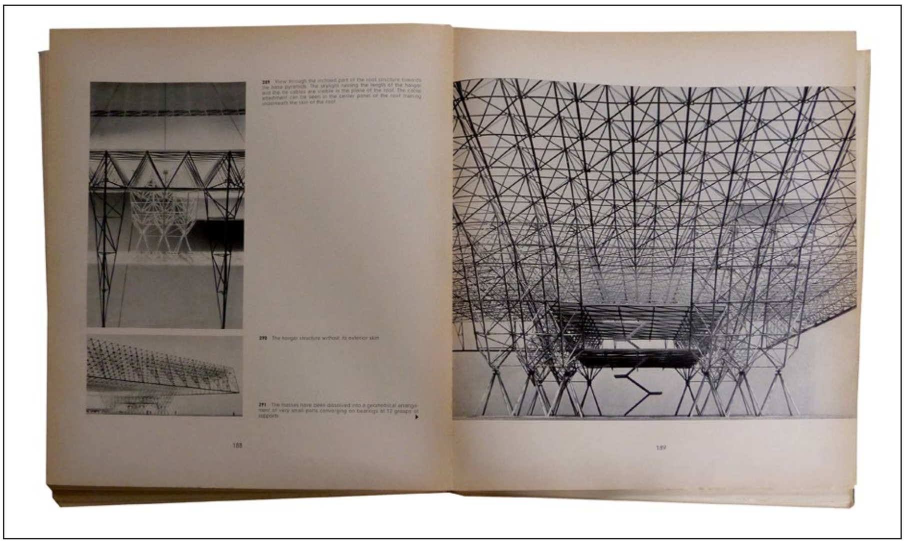

**Figure 12:** *The Turning Point of Building*, p. 188–189 (All rights reserved).

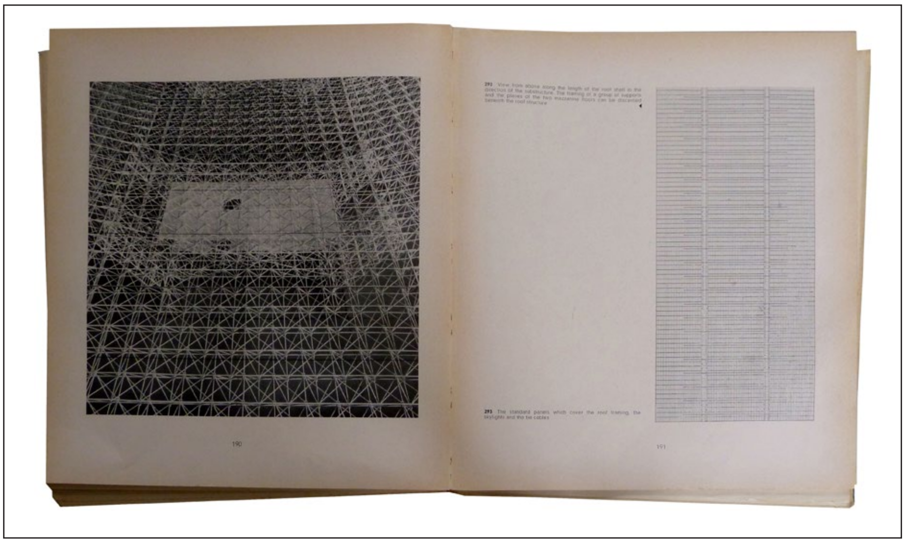

**Figure 13:** *The Turning Point of Building*, p. 190–191 (All rights reserved).

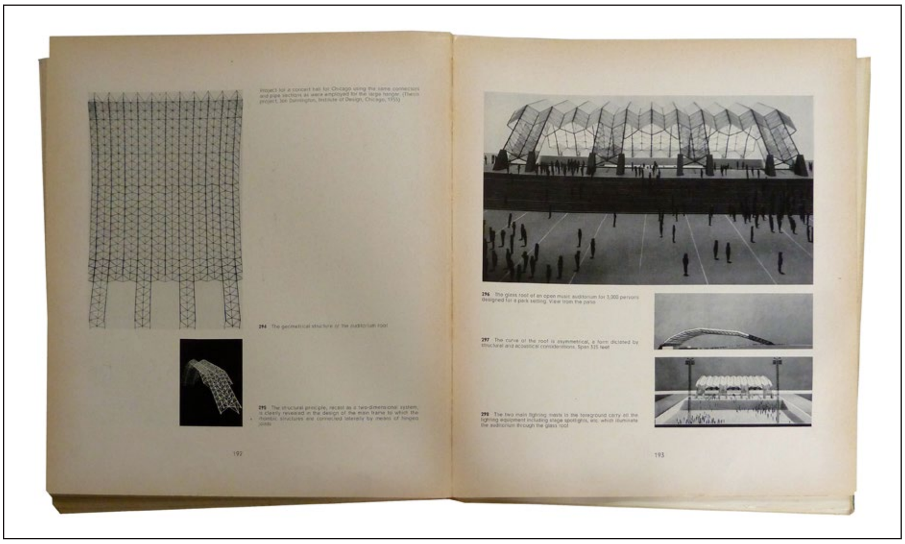

**Figure 14:** *The Turning Point of Building*, p. 192–193 (All rights reserved).

the 'Idea' of gravity, the psychophysical play of forces that would be experienced and understood in the space structure's presence by a human subject who is taking account of it.

Momentarily stepping back from the Schopenhauerian perspective, it is worth also considering how Wachsmann's space structure can be understood from an engineer's viewpoint. In terms of structural engineering, Wachsmann's space structure was a type of space truss. It uses simple, linear elements to cover space in three dimensions. The space truss is effectively a spatial plate made out of discrete elements; it carefully differentiates loads into tensile and compressive forces, and distributes these throughout the entire assembly. One example sometimes given to explain how this kind of structure works is the woven canvas webbing used for the seat of a stool or chair:

> '*If webbing strips are used in one direction, a load applied to one strip will cause it to sag and transfer load to only two sides of the supporting frame. However, if the webbing strips are interwoven in two orthogonal directions the loaded strip is partly supported by all of the others. This reduces the sag of the loaded strip and distributes the applied load more evenly to all sides of the frame. In the second case, each strip does not have to be capable of carrying the full applied load on its own and a lighter structure can be used for the supporting frame. Another advantage is that, if one of the webbing strips breaks, the seat as a whole will still support loads.*' [7, p. 12]

Because the forces are distributed, in part, to all the constitutive elements of the space truss structure, then the kinds of spatial relationships that occur within the trabeated – i.e. column and beam type – structures of the kind that Schopenhauer wrote about, do not apply. Neither do the spatial relationships of planar truss and column structures apply to the space truss, because the more evenly distributed load of the latter means there is much greater freedom to decide where to place the supporting columns below.

Adopting a Schopenhaurian perspective to understand the space truss hence requires consideration of two factors: on the one hand, it is necessary to consider the perception of gravity as an effect of the way loads are accounted for within the material structure, and on the other, it is necessary to consider the way the presence of the material structure affects the body of an observing human subject. It is these two factors taken together that, in Schopenhauer's terms, constitute 'Idea'. The space truss clearly does not reveal the 'Idea' of gravity in the same way as a Classical trabeated structure does, but neither does it reveal gravity in the same way as a planar gravity defying system that is based on beams, two-dimensional trusses and portal frames. Nevertheless, for all these differences, the space truss does emit its own messages about gravity.

Toward the end of the section on the space structure in *The Turning Point of Building*, there is a statement that not only offers further support to the Schopenhaurian reading of the project, but also indicates how Wachsmann's design approach might be understood to – as it were – take Schopenhaurian notions beyond Schopenhauer. Here we find Wachsmann writing about the way the design of his space structure had developed across time. Firstly, he writes that the theoretical analysis and statistical investigations pursued by mathematicians and engineers had little bearing on how the design evolved. This statement supports a Schopenhaurian reading, in that Wachsmann was rejecting knowledge about sense and cognition as a generator of design insights. He then went on to say that the design development was 'inspired by laboratory tests on models'. This notion of laboratory testing implies physical action, and in Schopenhauer's terms, the process of interacting with the model physically enables it to be taken into the realm of 'Ideas'. From the way in which Wachsmann described his laboratory experiments, it seems that he was aware of his practice as doing just that – i.e. using models to go beyond simple verification of spatial relationships and to seek out new 'Ideas'. He wrote:

> '*. . . the results of testing these models proved more decisive than many other factors. By observing the play of stresses in the statically relatively complex individual elements and applying a series of corrections, it became possible to establish their final form. The devices used to obtain these corrections included not only the usual testing machines but also electric strain gauges, brittle coating tests, photographic examinations of plastic models using polarising lenses and finally load tests, also on plastic models.*' [6, p. 186]

Here, Wachsmann is stating that he used models in order to evolve the design. And he seems to understand the devices that he deployed for measuring the model as being extensions of his corporeal intellect, because through them he was able to work on the design by means of 'Ideas', rather than merely confining his thinking to speculations about relationships in space.

## A New Understanding of Space

Wachsmann's work on industrialization can be understood as symptomatic of a problem that consistently arises in architectural practice, which is the question of how to maintain control over the design as it is realized in building construction. The reason that control is a problem for architects is because, professionally, architects are divorced from the activity of building. As the profession of architecture developed in the late-nineteenth and twentieth centuries, so too the relationships between design and construction were formalized in building contracts. The division between the activity of design, which was the task of the architect, and construction, the task of the building contractor, thus became reflected in the building contract documents (i.e. the package of drawings and written descriptions of the intended built form). These documents never were intended to be a complete set of instructions for how to construct a building. Instead, there remained considerable scope within them for contractors to decide upon construction methods, building technologies, sequences, procedures and precautions to ensure site safety. Construction drawings indicate therefore a possible design and its constructional solution, but their main purpose is to serve as the basis of a legal agreement between the client and the contractor. In this agreement, the architect may be written in as the client's agent, but they are not a direct party to the contract. This is why the architect loses considerable control over their design whenever it transitions into the construction process.

One way that architects could maintain control is by adopting the kind of reductive, Schopenhaurian approach taken by Wachsmann, whereby the possibilities for the building's realization are determined by the spatial logic of a limited menu of components – these being, in the case of the space structure, just two components, a joint and a connector. What is both alarming and compelling about this kind of minimalization of design is that it has the potential for infinite formal expansion, and in this respect it belongs to a particular category of aesthetic experience that is sometimes termed the 'sublime'. One person who was struck by the sublimity of Wachsman's space structure was the American artist, Robert Smithson (1938–1973). Just six years after Wachsmann produced *The Turning Point of Building*, Smithson published an essay in which he played upon the sublime aspect of the space structure. The essay was entitled 'Towards the Development of an Air Terminal Site', and was first published in the journal *Artforum* in 1967.

In his essay, Smithson picks up on a connection made in *The Turning Point of Building* between the space structure and the large, man-bearing kites designed and built by Alexander Graham Bell in the late-nineteenth and early-twentieth centuries. Just like the space structure, Bell's kites were lattice truss structures formed by the repetition of a single tetrahedral unit. Wachsmann seems to have admired Bell, describing him as:

> '*A thinker who questioned everything and was tireless in pursuing innovation; to him every problem and area of study seemed important enough to be drawn into the sphere of intense personal interest . . . His expansive energies not only allowed him to become a specialist in his profession but enabled him to make his chief interest the complex questioning of his times in general.*' [6, p. 29]

Wachsmann must have looked upon his own activity as a continuation of the same tradition of innovation, and in this sense his space structure can be read as homage to Bell. For Robert Smithson, however, the tetrahedral units of the space truss meant something different. They reminded him of the satellite module of the global network survey system known as SECOR, an all-weather geodetic survey system used in the late-1960s and described in these terms:

> '*The system consisted of a satellite and 4 ground stations. 3 at geographical points where the co-ordinates had been surveyed accurately and the fourth at an unknown location. Radio waves were flashed from the ground stations to the satellite and returned. The position of the satellite at any time was fixed by the measured ranges from the 3 known stations. Using these precisely established satellite positions as a base, ranges from the satellite to the unknown station were used to compute the position of the unknown station. Geodetic SECOR allows continents and islands to be brought within the same geodetic global grid.*' [8]

It was the thought of the virtual extension of the space structure into a geodetic grid that really interested Smithson, since for him it signified a new understanding of space, which he poetically described as 'a crystalline structure of time'. The new space would encompass the entire globe and establish a grid connection between sites on the ground and points in the sky. One day, predicted Smithson, there will be aircraft shaped on the basis of the crystalline grid and when that happens the naming of aircraft will change.

No longer called after animals, 'such as DHC 2 Beavers; Vampire T; Chipmunk T.Mk. 20; Dove 8s; Hawker Furies; Turkey; etc.', these bold new aircraft would be called after crystals. Smithson gave some examples: 'Rhombohedral T.2; Orthorhombic 60; Tetragonal Terror; Hexagonal Star Dust 49'. [9, p. 53] He then proceeded to describe what these crystalline aircraft would look like, predicting that they would require very large runways:

> '*The enormous scale of the runways will isolate such aircraft into "buildings" for short spaces of time, then these "buildings" will disappear. The principle runways will extend from 11,000 feet to 14,000 feet, or about the length of Central Park. Consider an aircraft in the shape of an enormous "slab" hovering over such an expanse.*' [9, p. 58]

The disappearing aircraft/buildings that Robert Smithson was imagining here can be understood as locally informed regions of a virtual continuum in which space structure and aircraft/building were distinguished by their relative densities alone; their appearing and disappearing was thus conceived as moments in a field of energy that encompasses the entire planet. This new understanding of space-as-field proposes a single event that is both topographically and chronologically extended.

Given the trajectory of this essay – beginning in the mid-twentieth century, when 'space' was a subject of inquiry for architectural critics and historians – it would seem appropriate to end on the concept of 'field'. Because, running in tandem with the interests of historians in space, was the rival claim of a group of architects that space had now been transcended in favour of a contemporary interest in field. One participant in the discourses around the notion of field is Patrick Schuhmacher, an architectural theorist and partner in the firm of Zaha Hadid Architects. In his recently published book, *The Autopoiesis of Architecture* (2010/11), Schuhmacher explains the concept of field:

> '*We might think of large continuous interiors such as open office landscapes, airport departure lounges or big exhibition halls of the kind used for trade fairs. Such interiors are visually infinitely deep and contain swarms of partitions, swarms of desks and swarms of light fixtures. The roof over such an interior might be held up by a forest of columns, or by the variegated thicket of a continuous space-frame . . . In each case the constitution and order of the territory are no longer composed of a small number of parts, but by an uncountable mass of particles . . . This is one of the key characteristics of working with fields. One has to handle so many elements that any attempt to keep track or pay attention to all elements is utterly hopeless . . . Every quality is produced by many elements acting together. In contrast, in modern compositions and the spaces they shape every individual element matters, is noticed, and carefully placed in the overall balance.*' [10, p. 423–424]

Sadly, Wachsmann's space structure still remains a project on paper, yet Schuhmacher's space-frame has actually been realized. It is deployed for example in Zaha Hadid's Heydar Aliyev Center in Baku, Azerbaijan. Here, although it is hidden from view, the space-frame plays an essential role in shaping and supporting the flowing curvaceous building envelope – which, as the architects explain, merges the ground and roof in a continuous flow of 'urban plaza, figure and ground, interior and exterior'. [11, p. 81] At Baku it is the plasticity of the seamed continuous white surface that the architects value, and not the dynamics of the structural system. Their Baku space-frame is covered in chalk-white panels that together produce an envelope that ripples and unfolds as it rises out of the ground, like an enormous white plaster-cast shell. The building is impossible to read in terms of support and load, and indeed one wonders what Schopenhauer would have made of it?

Perhaps it would have affected him with the feeling of fluidity, which he understood to be the primary satisfaction of architecture's 'sister art', by which he meant 'the artistic arrangement of water'. [2, p. 217] But fluidity for Schopenhauer meant more than emulating wavy shapes; it meant mobility and transparency too, these being properties that the Baku building does not have. On the other hand, he might have understood the Baku building as a contemporary modification of Gothic architecture. Although Schopenhauer did not like the external appearance of Gothic buildings, he was impressed by their vaulted interiors, in which he thought the antagonism of load and support gave way to feelings of weightless and 'eternal security'. [3, p. 418] But again the poetics don't quite fit, because there are no internal vaults or 'slender, crystalline, aspiring, pillars' to be found in the Baku building, just the undulating envelope, rising-from and dropping-down to the ground. From the Schopenhaurian perspective, it is probably a hybrid of the two qualities – part fluid, part weightless – that best captures the Baku form.

## Competing Interests
The author has no competing interests to declare.

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