

# Things in their best order: technical aspects of the Salk Institute and their role in its design

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*I do not like ducts; I do not like pipes. I hate them really thoroughly, but because I hate them so thoroughly I feel they have to be given their place. If I just hated them and took no care, I think they would invade the building and completely destroy it.*

Louis I. Kahn, 'Not for the Fainthearted', 1971.<sup>1</sup>

*I wish our clever young poets would remember my homely definitions of prose and poetry; that is, prose, – words in their best order; poetry, – the best words in their best order*

Samuel Taylor Coleridge, 'Table Talk', 1827.

**This paper explores the integration of engineering, function and space in the Salk Institute for Biological Studies at La Jolla, California, USA, by Louis Kahn (1959–1967). While traditional interpretation has focused on the Salk's courtyard as a space of uncanny emotional power, this study suggests that the power of this space derives in part from the intensity of Kahn's attention to systems, materials and methods. Using drawings and project correspondence from the Louis I. Kahn archives at the University of Pennsylvania, the paper suggests an alternative understanding of Kahn's work as empirical, evolutionary, and based as much in the prose of engineering as in the claimed poetics of architecture.**

## Introduction

The legacy of Louis I. Kahn's built and spoken work is as enigmatic as it is inspiring, for despite decades of criticism and interpretation the astonishing effects of his spaces and words on the human mind stubbornly resist categorisation. Kahn scholarship has generally fallen into two modes – an attempt to claim his work as essentially classical, and a parallel attempt to elucidate an alleged transcendental sensibility within his forms and spaces. This latter group in particular has dissected Kahn's notoriously elliptical and aphoristic writings, pointing out the uncanny resonance between the unmeasurable qualities of his spaces and the unknowable meanings of his words.<sup>2</sup>

While these attempts to frame Kahn's production have proven fruitful and provocative, they have not fully addressed another side of Kahn's architecture – both built and written – that deals explicitly with the technical nature of architecture. Kahn, of course, did little to discourage metaphysical speculation on the nature of his work, himself describing architecture as the meeting ground between the 'measurable and the unmeasurable.' Yet this language, which Kahn invariably used to present his work to academicians, was not the language he and his associates used on the construction site, or even in the drafting room. There, a rigorous empiricism replaced the speculative intellectual ventures of

Kahn's spoken words, and a profound technical fluency replaced the poetry of his writings. If Kahn was an architectural rhapsodist at the lectern, at the drawing table he took a keen interest in the deluge of prosaic matters that accompany even the simplest of buildings.

Such a consuming interest in the 'nuts and bolts' of architecture is in fact reflected in Kahn's philosophy, though this strain is perhaps less vocal than his more metaphysical pronouncements, and certainly less often noted or interpreted. Within his explorations of Order, Form, and Design, there exists a fine hierarchy of empiricist and pragmatic concepts, matching a grain of designed and constructed orders within his buildings. Even with the prose poem 'Order Is,' the primary departure for explorations of Kahn's metaphysical side, one finds architecture posited as a kind of ontological scaffold, whose constructed nature bridges the gap between the mundane, circumstantial world of everyday building and the potential transcendence of architectural experience.<sup>3</sup> This is perhaps more clearly elucidated in his oft-quoted view that architecture links the 'measurable and the unmeasurable,' beginning and ending in the latter, yet moving through the former during design and construction.<sup>4</sup> Architecture for Kahn was thus the expression of timeless ideals through contingent circumstances, and it was in his view the architect's task to approach as nearly as possible the realms of Order through work that sprang from the messy realities of the everyday.<sup>5</sup>

For Kahn, it was therefore important that architecture not only reflect an overall architectural Order – timeless, immutable, and all-pervasive – but that all

aspects of architectural endeavour be considered in relation to one another, to find the proper *order* of the task and time to hand – immediate, contingent, and applicable locally to a specific instance.<sup>6</sup> This sensibility was most crucial, in Kahn's view, where systems or components met, where joints occurred. Here, the need to express 'how it was done' became for him the 'basis of ornament,' the opportunity to reveal to us the designed and constructed order of a building. If conceived and executed properly, these lower scale orders would hint at a greater sense of 'Order' at the highest ontological level.<sup>7</sup> Kahn therefore repeatedly emphasised the need for architects to understand the inner workings of structural, mechanical and constructional systems to locate and express them best within an ideal hierarchy of spaces and, critically, not to let the requirements of engineering overflow from their proper position into the spaces of Architecture.<sup>8</sup>

This idea found its most robust manifestation in Kahn's integration of structure and services. Kahn famously referred to the resulting hybrid elements as 'hollow stones,' provoking a comparison with the solid constructions of antiquity, but more illustratively he called such spaces 'harbours,' voids carved or injected into large-scale structural elements that would carry mechanical services.<sup>9</sup> Intriguingly, this is exactly the terminology Kahn used to describe his accommodation for the automobile in his Midtown Philadelphia plan of 1953. In both cases, large-scale structural and architectural elements enclosed the rather unsightly realities of circulation, both accommodating and corralling these, preventing their 'taking over' spaces whose spiritual rank was higher. Order, for Kahn, was thus the result of understanding, orchestrating, and

manipulating elements and their concurrent spaces. It was to be teased out of the objective requirements at hand, manifested through structural and architectural components – and most critically, their relationships to one another and to the overall architectural situation. The overall grain of a project for Kahn necessarily reflected an hierarchy of harbouring spaces and forms, all finding their appropriate level within an all-pervasive architectural Order whose traces could be discovered within function, performance, and assembly.

Seen in this light, Kahn was anything but the architectural shaman, or the beaux-arts formalist that traditional interpretation has suggested. Rather, in line with more recent elucidations by Kenneth Frampton and Edward Ford, this reading of Kahn's philosophy suggests that Kahn was ultimately a generalist, who saw the potential for fully integrating building technology, architectural function, and human space.<sup>10</sup> His production can thus be seen as a continuum, interested of course in ancient archetypes, but at the same time fascinated by developments in structural engineering, materials science, and environmental control. In parsing one of his better-known examples, the Salk Institute at La Jolla, California, this paper seeks to demonstrate the potential for a re-reading of Kahn as, at least in part, an orchestrator of systems and spaces, a talented architectural technologist, and a composer not merely of spatial poetry, but of built prose of the highest order.

### **The Salk Institute, 1959–1967**

In February 1966, Luis Barragan visited the construction site of the Salk Institute at Kahn's

request to advise on plant selection for the building's central courtyard. The project by then was nearing completion, with both laboratory wings substantially constructed and laboratory fitting out occurring in the north wing. Since the inception of the project, Kahn had struggled with the idea of planting in this space and its predecessors in the design process. Early schemes showed various trees within the courtyard, notably poplars, which would have lent a distinct Mediterranean atmosphere to the space. However, the pungent salt atmosphere of the site obviated this choice, and it seems likely in hindsight that Kahn recognised the inadequacy of these early schemes. Barragan had been called after Kahn had seen his house published and recognised a kindred sense of balance between architecture and landscape. Upon arrival, Barragan noted the stark concrete of the surrounding study towers, the warm tones of the courtyard's bare ground plane, and the distant Pacific horizon. Seeing these, he said that, in his opinion, any planting at all would be a mistake, telling him that Kahn and Salk should 'make a plaza . . . and gain a façade to the sky.'<sup>11</sup> According to Kahn this was agreed at once, although it was not presented formally until late that year. Subsequent studies with Lawrence Halprin only proved the integrity of Barragan's forceful advice, and it may be that Kahn himself had recognised the power of the bare space but had required confirmation by a like-minded designer. The courtyard was thus designed in the negative, its elevations and spatial intricacies derived not from preconceived notions of proportions or imagery, but rather from the imprint of the surrounding buildings' logical conception. The removal of the

assumed planting from the space thus revealed the intrinsic logic of the laboratories' planning, the systematic casting of the concrete walls via exposed form imprints, and the sequential construction of the structure, cladding, and metal fabrications. Barragan's suggestion essentially allowed the ingrained orders of the laboratory and office blocks to express themselves, to form the elevations, massing, and ornament of the courtyard.

Given the genesis of the project, it is to Kahn's great credit that such logic was there to express. Salk's initial programme for the complex was based primarily on his visit in 1959 to Kahn's Richards Medical Laboratories, just being completed in Philadelphia. In the Salk Center's early stages, the floor area and proportions of Richards served as a programmatic model, albeit with Salk's charge that the complex should be of such quality that 'Picasso . . . could be invited as a guest.'. The vagueness of the laboratory programme was eventually structured to assume that 10 major scientists would each require 10,000 square feet of usable, though flexible space with provision for expansion of each research group. These were to be supplemented by study spaces permitting 'privacy and singularity.'<sup>12</sup> While supplemental buildings to this central research core – including housing and a large meeting facility – were indefinitely delayed due to budget issues, the laboratories themselves deserve closer examination, for they demonstrate precisely the orchestration of technical requirements into a unified architectural expression that marked Kahn's greatest works.

Kahn's 1962 scheme, the first developed design shown to Salk, presented a careful layout of the

laboratory blocks along well-defined mechanical and structural principles following extensive work with structural engineer August Komendant and mechanical engineer Fred Dubin. In this scheme, four two-level laboratory blocks were arranged on the site around two planted garden areas. On the garden side of each block, a series of ovoid studies overlooked the gardens and the Pacific Ocean some three hundred yards away. The width of each study was carried through the block as a 10' wide hollow beam. This beam carried air and piped services from a mechanical structure on the opposite side containing air trunking, as well as major piped services and escape routes. Running longitudinally between these 10' service zones, a series of folded plates carried locally directed piped services in an upper, accessible level, and local supply and exhaust in a narrow underbelly. Downstand beams on either side of the air ducts combined with the inclined concrete walls of the upper plates to form a hybrid element in which structure and services occupied the same sectional space, reducing the required floor to floor height for each laboratory. This allowed the blocks to comply with a local height limit, but more importantly the scheme provided accessible, flexible servicing on a regular 10'-0" module, allowing both standardisation and the opportunity for efficient replanning. The folded plate scheme was developed to allow daylight between the folded plates of the upper story, and the transverse service beams formed a natural corridor for fume hoods, chemical closets, and other elements requiring intensive airflow that might otherwise clutter the laboratory areas (Fig. 1).

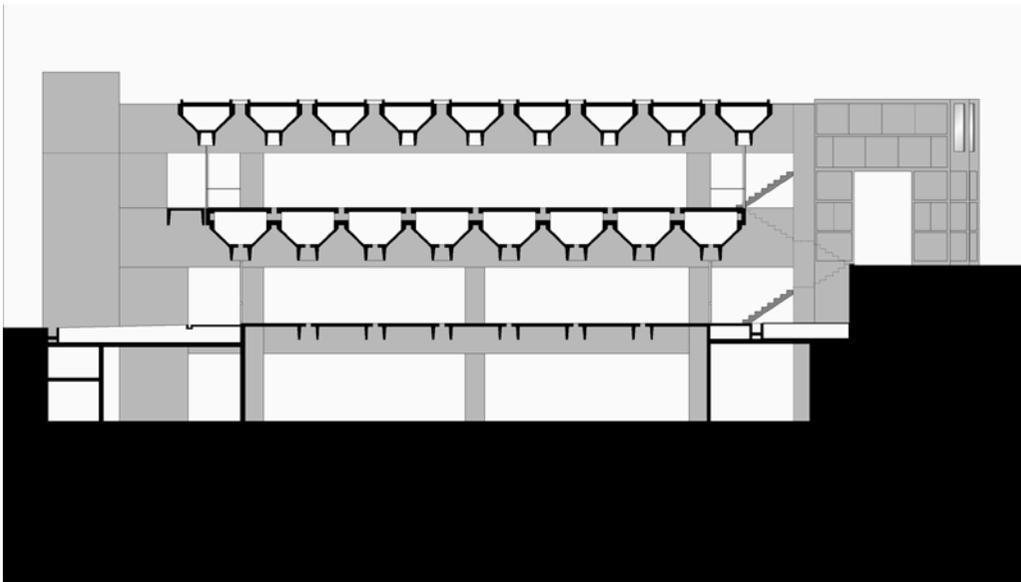


Figure 1. Cross section of early, 'folded plate scheme' showing breathing beams, developed from 1960 to 1962. In Komendant's view, and arguably in Kahn's, this was the 'correct' solution to the problem; however it was eventually dismissed for its lack of flexibility, its lack of interstitial space, and its massing implications. (Diagram by the author from drawings in the Louis I. Kahn Collection, University of Pennsylvania.)

This original scheme was a remarkable synthesis of services and structure, and the resulting laboratory space would have been at once functional and strongly articulated. The deep corrugations of the ceiling would have added a visible order to the functionally necessary chaos of a lab environment, particularly at the top level where the recesses would have been flooded with daylight from above. Kahn's placement of the exterior walls – glass partitions designed to frame into the underbelly of the outermost service beams – would also have provided natural daylight with a significant overhang to reduce glare, all within the order and rhythm of the typical module. The development of the folded plate system would have lent a powerful

definition to each module of the labs below, providing a legible organisation of the work and space to viewers within. Finally, Komendant designed the beams themselves as prefabricated units, capable of being post-tensioned and thus efficient in terms of both structure and assembly.

In part, however, this strong modularity seems to have doomed the folded plate scheme. After a year of work, including full structural design and initial approval from Salk, the folded plate scheme was abandoned, and the laboratory blocks redesigned. The initial scheme's strong definition of the spatial module, and its suggestion of a studio-like space for each lab, worked against the ideal of total flexibility, and the ten-foot module appears in hindsight

to have been too coarse to fully service Salk's planned activities. At the same time, there were apparent difficulties in fitting services into the folded beams, a conflict that becomes apparent when the final scheme's duct sizing is noted. Likewise, the pipe chase within the folds of the plate did not allow large-scale re-piping due to its restricted space.<sup>13</sup> Finally, Salk had grave misgivings about the overall plan of the site, and the diffusion of the complex's social space into two separate but equal courtyards. Salk and Kahn agreed to redesign the laboratories around a single courtyard, with the sectional logic of the pipe space simplified to 'give the pipes a floor of their own.'<sup>14</sup> Kahn and his office, while noting that they 'felt the loss of the folded plate scheme,' nonetheless worked with Komendant and Dubin to design a simpler, more efficient sectional scheme employing Vierendeel trusses with services woven between their vertical members. In Komendant's opinion, the revised scheme was less structurally pure than the original, however it allowed greater flexibility in the laboratories' mechanical layouts. The overall footprint of the laboratory block was reduced in size and a third level was added to maintain the floor area. Komendant and Fred Dubin worked to integrate the new structure with the laboratory requirements, while Kahn's office and Salk's in-house laboratory designer Earl Walls developed the interface between the 'pipe floors' and the flexible space below. The trusses supported a perforated concrete lab ceiling that allowed air, pipes, lighting, and exhaust to drop to the floor below on a 5'-0" module, allowing full access to the range of services in each interstitial space (Fig. 2).

This change is notable for two reasons. First, with comparatively little objection, Kahn agreed to give up the 'space-making' folded plates in favour of a technically better solution to the lab problem. Compared to the original scheme, the resulting lab spaces have little of their own architectural character, yet they are profoundly more functional. This is a recognition of the radical performance required of an advanced medical lab, but also that the quality of the overall building lay not merely in the 'served' space of the scientists, but also in the 'servant' space of the ducts and pipes. Second, the relatively enthusiastic response from Kahn to Salk's order reflects a recognition of the value of iterative process, in which the scheme benefited from the shortcomings of the earlier attempts. The design team did not universally share this enthusiasm, in particular Komendant, whose extensive work on the folded plates had led to, in his opinion, the 'correct structural solution.'<sup>15</sup> In one sense, Komendant's criticism is correct, in that the Vierendeel achieves its performance not only through its shape but through a change from concrete to steel tendons in order to support large bending forces.

However, it is worth examining the resulting sectional solution in some detail, for it demonstrates the extent to which Kahn and his consultants understood the integrated nature of the laboratory servicing problem. If the Vierendeel was not the 'purest' of structural solutions, it nevertheless was far superior for both services distribution and laboratory planning on the floors below. The choice of a Vierendeel system stemmed in part from Kahn's earlier work with Komendant at Richards, where

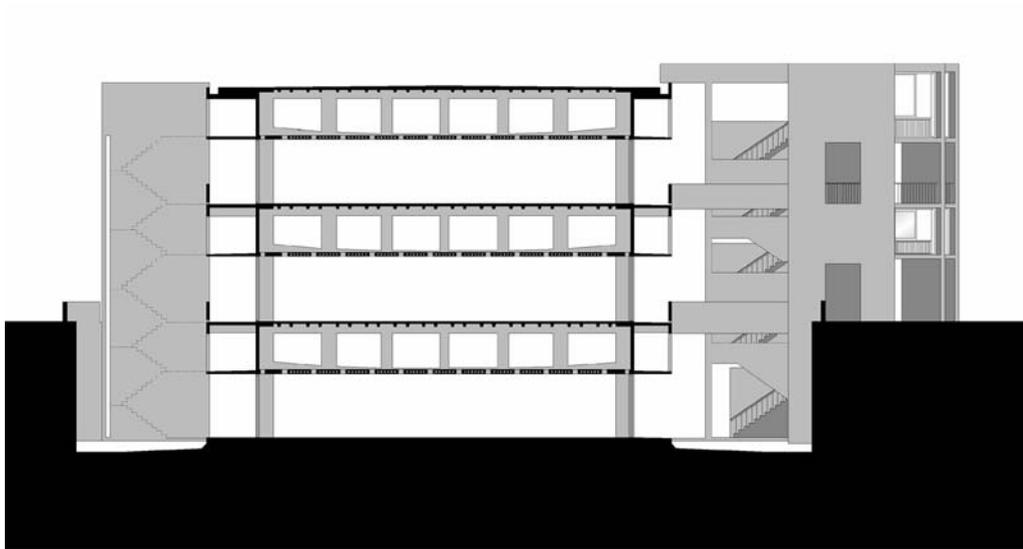


Figure 2. Cross section of the final scheme, developed to provide further flexibility in servicing. (Diagram by the author from drawings in the Louis I. Kahn Collection, University of Pennsylvania.)

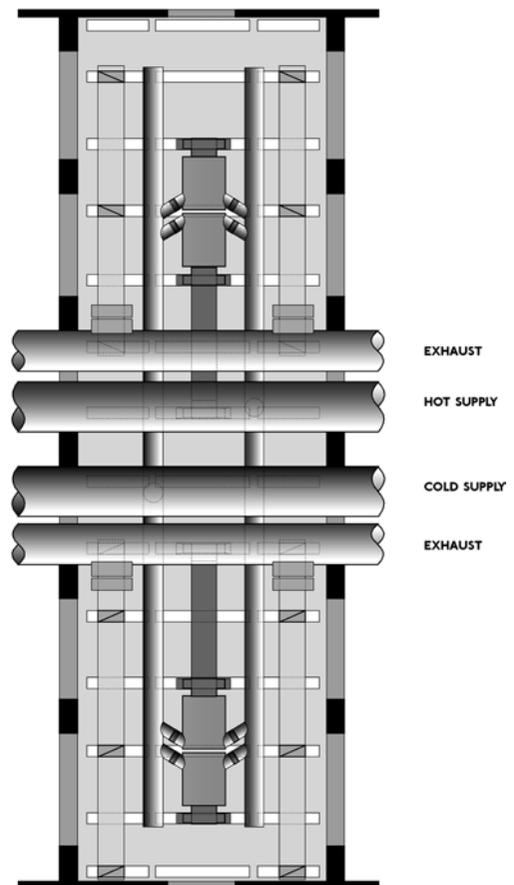
piped and ducted services were woven through the interstitial spaces of similar – though smaller-scale – trusses. At the Salk, Komendant developed an efficient section using cantilevered ends to reduce the maximum bending moment in the middle of each floor plate. These cantilevers provided walkways for moving mechanical equipment in and out of the pipe space while providing shade to the glass laboratory walls below. To reduce the overall floor-to-floor height, Komendant employed pre-stressed cables in the bottom chord of the truss rather than simple steel reinforcing. Vierendeels provided not only the cross-sectional porosity required to move air and services from the mechanical wings located at the eastern edge of the complex, but also freed the concrete slabs between

for service drops. Rarely noted, Komendant's solution to the problem of such a rigid concrete frame in a seismic zone was equally ingenious, involving a series of lead-zinc plates installed between each truss and its adjacent columns. This allowed sectional ductility in the event of an earthquake, restrained only by a set of relatively loose steel tendons passing through each column.<sup>16</sup> The laboratory structure occurred between two sets of outlying structures in each wing, one containing the courtyard studies and the other containing lavatory rooms, vertical service runs, stairs, and lifts. To allow seismic separation, these three zones were clearly separated by movement joints rendered in red neoprene gasketing.

The full functionality of the 'breathing structure' was developed by mechanical engineer Fred Dubin.

Figure 3. Plan of mechanical systems in typical bay. Interwoven between the vertical members of the Vierendeel trusses, supply and exhaust trunks feed minor runs that connect to the grid of service slots in the lab ceiling below. (Diagram by the author from drawings in the Louis I. Kahn Collection, University of Pennsylvania.)

Where the folded plate scheme had relied on a series of vertical towers and transverse trunking, the Vierendeel structural scheme suggested a more straightforward approach. At the eastern end of each laboratory block, a 'mechanical wing' was designed to accommodate chillers, air handlers, and equipment for liquid and gas services. These two wings were connected to one another at the east end of the complex, underneath the raised wall that separates the courtyard from the eucalyptus grove. At each level, the major supply and exhaust ductwork for each laboratory floor enters the interstitial space at the centre of the block, where the voids in the Vierendeel trusses are largest. At each 20'-0" laboratory module, branch supply ducts carry hot and cold air to the edges of the block, where blending boxes mix air to the required temperature. Local ductwork then carries blended air to alternate service slots in the slab. Woven between the supply system, exhaust ductwork takes air from the remaining service slots and returns it to the central trunk.<sup>17</sup> This arrangement places the high-maintenance blending boxes closest to the outboard service corridors, while allowing access to pipe runs in the outer thirds of each interstitial space. The 4'-0" major ducts, located at the centre of the floor plate, do not restrict access to any of the service slots, allowing far greater maintenance and reconfiguration than the folded plate scheme. Additionally, as laboratory planning diagrams by Earl Walls show, the fine grain of the exhaust and supply patterns on the lab floors allowed major reconfigurations to occur – even during the design process – with little or no impact on the services above (Figs 3, 4 and 5).



To Kahn's great credit, the execution of the laboratory section was as disciplined and rigorous as its conception. The functional and conceptual clarity of the Vierendeels was carried through to the various interior and exterior systems. In particular, a

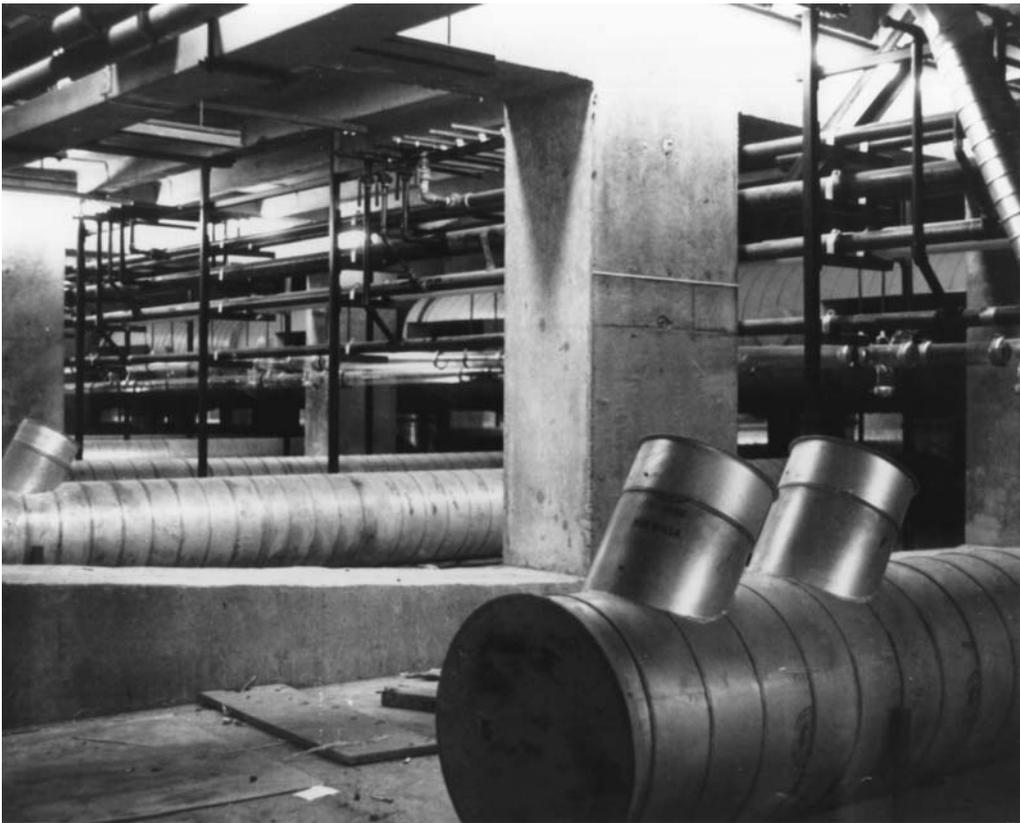


Figure 4. Interior view of interstitial space during HVAC fitout, showing large duct runs (background), local feeder ducts (foreground) and Vierendeel truss. (Copyright 1977, Louis I. Kahn Collection, University of Pennsylvania Historical and Museum Commission.)

series of details deployed throughout the building shows the careful attention paid by Kahn to the physical and technical nature of all building elements, and to their proper place in the experience of the building. This care should necessarily be attributed not only to Kahn, but also to his office staff, in particular the Salk's site architect Jack

MacAllister, and Marshall D. Meyers who remained based in Philadelphia.<sup>18</sup>

Most notable of these to the visitor are the precise yet rugged details of the concrete, which like the Vierendeel trusses perform multiple functions despite their simple conception. Kahn had previously used exposed concrete as a finished

Figure 5. Interior of laboratory space showing overhead ceiling slots with lights mounted perpendicular to the building's 'grain'. (Copyright 1977, Louis I. Kahn Collection, University of Pennsylvania Historical and Museum Commission.)



surface in the Yale Art Gallery and at Richards. However at Yale the ceiling surfaces of the galleries were broken up by the tetrahedral grid, while at Richards the surfaces were precast and therefore predictable – or used as relatively hidden soffit panels. Salk was therefore Kahn's first use of exposed concrete as a primary visual element, and

the explorations and experiments involved in its casting reveal a careful attention to the process of concrete construction, and an empirical process in developing details and systems. Kahn's office employed a full-time staff member to work with the contractor, George Fuller, to develop the concrete formwork. Plywood forms based on standard 4' x



Figure 6. Courtyard shear wall showing pattern of concrete formwork. Vee-shaped edges to the formwork boards were used to leave triangular projections in the walls, casting shadows that emphasised the pattern of their construction. (Photograph by the author.)

12' sheets were organised to provide a consistent module of form joints and tie holes, which were then elaborated by chamfered form edges and dark lead tamping, respectively. This is perhaps the purest expression of Kahn's idea that ornament can spring from the joining of elements, in this case the result of the casting and waterproofing processes. Experiments in colour were carried out during the basement pour, and the agreed mixture of pozzolan was used in the remaining walls. In the courtyard, the concrete frames surrounding the studies were filled with teak and glass infill panels, with shadow-gaps and wood edging used to emphasise the demise lines between poured and assembled elements (Figs 6 and 7).

Less apparent than the concrete were a series of metal details that reveal an often-unexplored area of experimentation in Kahn's office. In the development of the laboratory curtain wall, service slots in the interstitial floor slab, exterior doorframes, and handrails, one sees an attention to a series of details on a finer scale than that of the concrete. In each



Figure 7. View of courtyard studies showing teak infill panels. These were detailed to emphasise their subsidiary role in the constructed order of the Salk, with vertical glass panels delineating their separation from the diagonal shear walls and an overlap drip edge that appears visually to 'catch' the floor line. (Photograph by the author.)

case, the detail's expression is an integration of the overall building's grain or pattern with the specific, smaller-scale function of the component or assembly in question. In this realm, the 'pure' expression of the detail's performance is subordinated to the explication of the whole complex. In other words, the details themselves may appear simple, however this is a 'complex simplicity' in which the overall order of the Salk benefits from the restraint of the particular.

The curtain walls of the Salk occur within the overall framework of the laboratory structure, set back from the overhanging walls of the interstitial space and thus less immediately visible from the courtyard. This is a continuation of the 'eyebrow' sun shading seen in the earlier folded plate scheme, though it is also a result of the structural configuration of the interstitial floors in that the exterior walls of the service corridor provide lateral stability to the Vierendeel system. As a result, the laboratory wall is deeply recessed and obviously a secondary element to the overall concrete system, similar to the teak and glass infill panels of the studies. Upon approach, the glass and steel system further reveals its position in the overall scheme by its relationship to the concrete columns. Unlike contemporary dialogues between frame and skin by, for example, Mies van der Rohe or SOM, the curtain wall here is set outside the column faces, yet it does not continue past them. Instead, the panelisation of the system is made apparent by stopping the curtain wall entirely in front of each column, thus expressing the position and dimension of the concrete structure. Here again, the order of the overall building is the primary expression, however the logic of the window wall's function and fabrication is also clearly expressed. In developing the details for the wall, Kahn's office was ordered to 'programme every detail,' that is, to treat the arrangement and configuration of each component and junction as a new design problem with clearly stated functional and constructional goals.<sup>19</sup> While research on curtain wall systems included standard commercial offerings, including an off-the-rack system from Kawneer, the final

solution involved brake-shaped steel elements and exposed fixings that could be fabricated locally. A similar idea had been employed on the Richards windows, however the window wall at the Salk was a much larger, more prominent installation. Steel was therefore bent to a variety of shapes to provide structural support between the floor and ceiling, to span between the main vertical supports, and to hold glass panes in place. Two types of curtain wall panels were produced, with and without a pivot-hinged door in the centre. A large transom piece was included in each type to permit changing out of the doors and glass as laboratory planning changed, however this proved equally useful during the lab design process as access and routes of escape changed to match an evolving brief. On each frame, the raw edge of the steel was typically left exposed, to make the fabrication process apparent. There is no possible confusion, as there would be in a typical aluminium curtain wall, as to what elements are solid and what are hollow extrusions. Here, the edges of the steel reveal that the structural elements work not by mass but by shape, and that the frame members originated as planar elements. Similarly, the exposed bolts of the system reveal both its assembly process, and its status as a flexible system, as it is apparent to the viewer that any given panel could be simply unbolted and either reconfigured or removed entirely (Fig. 8).

If the laboratory curtain wall transmits a secondary level of building organisation on the exterior, breaking down the scale of the lab blocks while elucidating its own internal logic, the ceiling details within the laboratories themselves perform

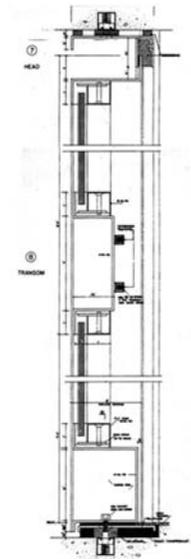


Figure 8. View of typical curtain wall bay and associated detail. Brake-shaped stainless steel was used to support and hold in place large sheets of plate glass. The temporary nature of these panels is suggested by their position outboard of the concrete columns, and by their exposed bolts. Exposed edges transmit the nature of these elements' fabrication. (Photograph by the author, drawing Copyright 1977, Louis I. Kahn Collection, University of Pennsylvania Historical and Museum Commission.)

a similar duty on the interior. A major concern regarding the initial folded-plate scheme had been its relatively large module – 10'-0" on centre. As the Vierendeel scheme developed, a tighter grain was necessary for services access. At the same time this access needed to be coordinated with Komendant's development of slab and beam reinforcing. The result was a regular spacing of slots in the concrete floor on 5'-0' intervals in either direction. Each slot was five feet long by ten inches wide, oriented parallel with the long dimension of the lab floors. As the design progressed, this early decision enabled Dubin's office to work to a regular, reliable module in planning services and air trunking and distribution, while giving Komendant the security of knowing that any late

changes to lab services would not result in structural changes. Essentially, the slot scheme enabled integration by elimination, isolating two systems that would ordinarily find themselves competing for space and position in the concrete system. To form the slots, a custom extrusion was detailed to form continuous aluminium channels, with tracks along either side to accept standardised clips for light fixtures and air diffusers. Alongside each slot, power cables and boxes were positioned to provide power. The tracks were mitered together to create boxes of in-place formwork as the floors were cast, resulting in regularly pierced ceiling and floor slabs. Supply and exhaust registers, pipe drops, and power cables were thus simply organised on an efficient grid that adds regularity to the otherwise

chaotic lab spaces. While the space-making effects of the folded slab would have undoubtedly been more powerful visually, the position of the slots in the ceiling – the one surface in a laboratory that remains uncluttered by equipment, etc. – nonetheless presents the overall scale and grain of the laboratory block to the users within. The 2' x 4' light fixtures that provide illumination to the laboratory areas are a surprisingly effective example of this. Early in the design development phase, Kahn's office worked with manufacturer Edison Price to develop these custom fixtures. Price suggested that the best performance would be achieved by orienting the fixtures parallel to the slots, distributing light along lab benches presumed to be perpendicular to the slots and windows. However, the final arrangement reversed this logic, orienting the fixtures perpendicular to the slots. While this slightly lessened the efficiency of the fixtures, it nevertheless provided a strong cross-grain to the laboratories, emphasising the regular order of the plan from both inside and out. Lights aligned with the slots would have emphasised only the length of the blocks, and it is apparent that Kahn's office was willing to make a small sacrifice in local efficiency in favour of this emphasis on the building's regularity.<sup>20</sup>

Stepping down in scale further, one finds a similar integration of economical construction, expression of materiality, and honest presentation of function in the detailing of various interior and exterior fittings. Throughout the complex, entry doors occur within concrete walls. This is a difficult detailing problem due to the imprecise nature of concrete placement, and the requirement for very precise

tolerances in door hinging and closer operation. A typical solution to this problem is to wrap a doorframe around the wall, giving the hinge a reliable edge and allowing the wall to 'float' within the frame. However to Kahn this would have resulted in a confusing assembly, as the doorframe's dimensions inevitably recalled timber detailing. The search for an articulate expression of the relationship between metal mechanisms and concrete structure led to a simple though elegant detail in which a piece of unistrut was cast into the concrete surrounding the door. A brake-shaped frame could then be bolted to the fixed unistrut, and made true by adjusting the bolts connecting the two pieces of metal. Pivots were then placed at the top, base, and midpoint instead of hinges to ensure smooth operation, and prefabricated doors could then be installed into a reliably vertical frame. The dividing of the door into those elements requiring mechanical precision and those requiring connection to structure enabled very rapid installation, however its final expression is notable for its crisp separation of cast and fabricated elements.

Kahn's office paid similar attention to the 'programmes' of function and fabrication in numerous other details throughout the Salk, including the development of a movable partition system for the laboratories in conjunction with Hausermann, a metal partitions manufacturer in Cleveland, and the hand and guard rails throughout the external staircases. The handrails in particular show both knowledge of the material involved and a resolute confidence in a carefully conceived, though ultimately quite straightforward, approach to detailing issues. Each handrail was formed from

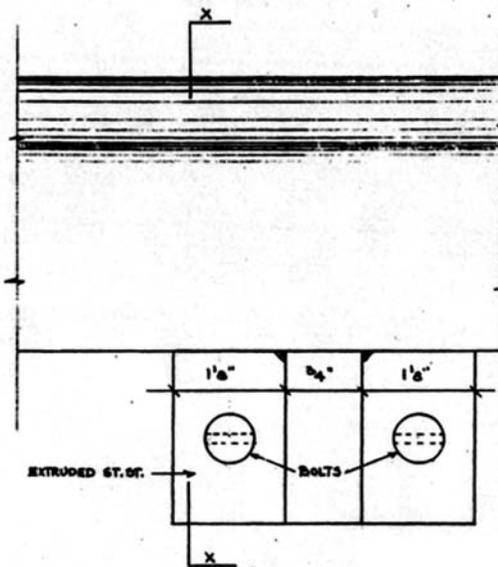
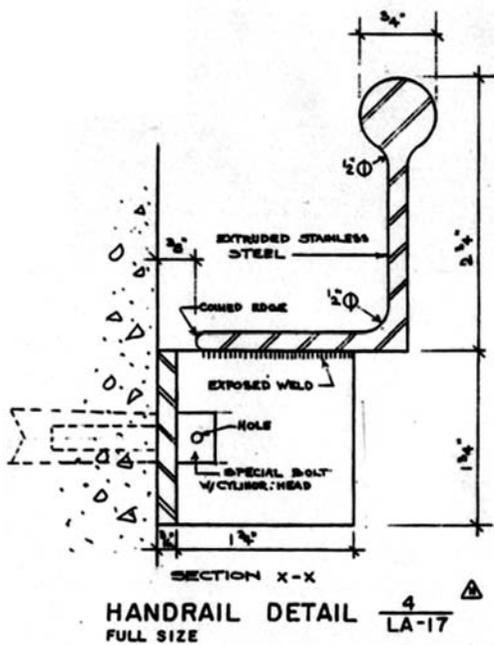


Figure 9. Typical handrail detail. These were fabricated by extruding stainless steel, an uncommon process for ornamental metals as the resulting surface is rough. This finish, however, provides an excellent, comfortable gripping surface, and was thus, in Kahn's view, an ideal match for the handrail's 'programme'. (Copyright 1977, Louis I. Kahn Collection, University of Pennsylvania Historical and Museum Commission.)

a single extrusion of stainless steel – an uncommon process as the resulting surface is often rough from the stress of the metal being forced through a die. In this case, however, the extrusion was designed to include a circular section at the top of the rail, and the grainy surface of this steel shape served to welcome the grip of the hand. It is unlikely that this ultimately inexpensive and quite simple solution to the question of the handrail would have emerged had Kahn not impressed on his staff the need to understand materials not merely from a visual sensibility, but also from a technical and scientific point of view (Fig. 9).

The handrails at the Salk reflect at the most intimate scale the spirit of investigation and testing that occurred throughout the design of the entire complex. Kahn's office was not only a studio, it was also an informal research centre guided largely by senior architect David Wisdom, in which materials, components, and assemblies were investigated as much for their physical and functional properties as for their aesthetics. In this respect, the buildings produced by Kahn and his staff are in many ways related as much to industrial design as they are to architecture. Throughout, an empirical approach to design and problem solving in which iterative

process, testing of hypotheses, and integration of technical and compositional knowledge played key roles are all much in evidence. The value that Kahn assigned to this methodology is evidenced by the expressions of these systems and details within the overall building. Ordering principles – whether they be the overall module of the complex, or the anthropomorphic dimensions of the human hand, or the dimensions of material based on production processes – are all made clear to the eye, and are referenced to one another in complex though apparent ways. The lab curtain wall, for example, displays at once the module of the structural grid, the working dimensions of plate glass, and the fabricational procedure of brake-shaping steel. At the same time, the wall allows us to see the laboratory module beyond; it admits diffused, shaded daylight into the work areas, and points out its status as both an infill system and a (potentially) temporary construction. In their extraordinary multi-valence, these systems attest to the balance achieved between function, constructional efficiency, structural performance, and human perception, a constant process of revelation and explanation, and a perpetual shrinking of the distance between our contingent experience and the platonic realm of Order.

At the dedication ceremonies for the Salk, Rabbi Morton J. Cohn spoke of the relationship between God and man in terms of the scientific work to be performed in the laboratories:

Finite man cannot penetrate all the mysteries of the Infinite. Yet the manifestations of the Divine Reality are all about us, and it is from the rearward that we know God. Even as a ship sails the ocean

and leaves its wake behind, so God may be known by his divine footprints in the realm of our physical universe . . .

The great sages of science, too, have revealed God's glory as they have unfolded the secrets of God's universe and man's being. Surely the man of science, in his search for the 'how' of nature and of human nature, is the collaborator of the philosopher and the religionist, who seek to answer the 'why' of human conduct.<sup>21</sup>

There is here a neat parallel with Kahn's definition of architecture as a link between the 'measurable and the immeasurable.'<sup>22</sup> His discussions with Salk during the design and construction of the Institute undoubtedly gave impetus to his developing neo-Platonist architectural philosophy, as Salk's occasionally mystical pronouncements seem to presage much of Kahn's later musings. In both cases, there is the idea of physical science as a touchstone by which the mysteries of nature and science might be made known, the 'wake' by which we recognise whatever deity may be present. In Kahn's case, it is apparent that the technical achievement of the Salk's architecture – its materiality, detailing, and overall pragmatic organisation – provides the manifestation of something greater, as the experience of the courtyard attests. The 'how' and the 'why' of architecture are, as in the physical world, connected by our perception, intuition, and internal conception of a greater order – the 'Oneness' of the Neo-Platonists represented by the 'Order' of Kahn. On a simpler level, Rabbi Cohn's observation that science is at its highest levels an activity with philosophical and religious overtones is a precise parallel to Kahn's

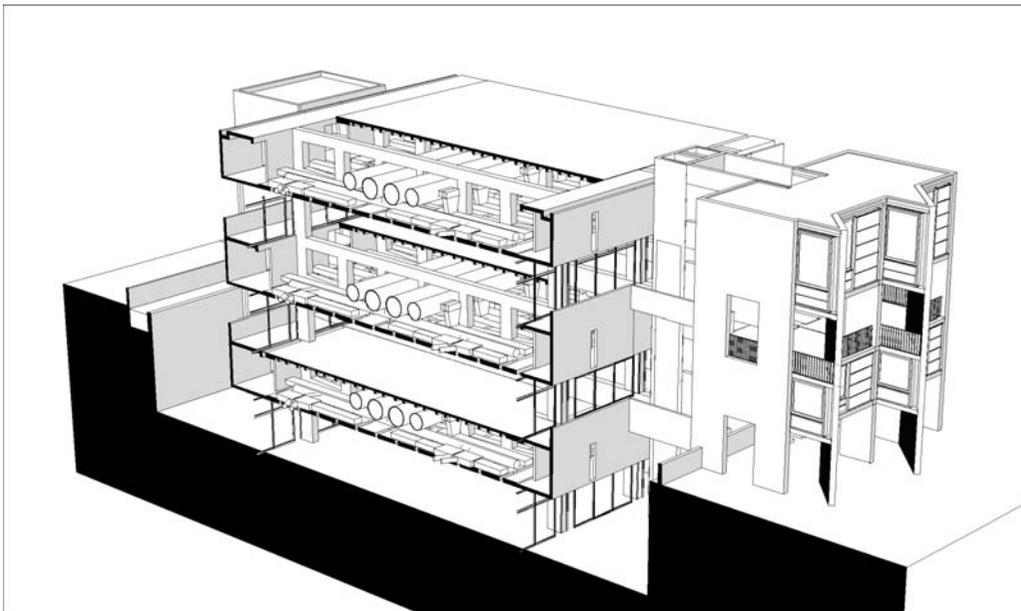


Figure 10. Cutaway view of a typical laboratory bay. While standard interpretations of the Salk focus on the emotional power of the courtyard, the integration of structure, systems, function and space in the labs themselves reveals a side of Kahn's practice that focused on the expressive integration of these elements. (Drawing by the author based on construction drawings in the Louis I. Kahn Collection, University of Pennsylvania.)

bivalent practice of architecture. In Kahn's case technical knowledge, as banal as the metallurgical properties of a handrail material, could be productively integrated into an overall orchestration of material and sensation with striking effects. Kahn's architecture thus transcends its earthy origins, productively blurring the 'how' and 'why' of architecture even as the scientist examines the overlap between the mechanics and meanings of human nature and conduct.

In large measure, the achievement of such elegance in the Salk Institute's overall solution was due to the balance achieved by Kahn in orchestrating such a diverse set of often-contradictory

requirements. No single system dominates the composition – not the architectural, the structural, nor the environmental. Each element, each function, is assigned its own carefully assessed position in the overall, synergetic whole, and out of the pedestrian requirements of each a synthesis is achieved that touches not merely our senses, but our deepest feelings of spirituality and poetics. Kahn did not have at his disposal the 'best things' of Coleridge's epigram – 'Gold,' he had said in his 1944 address on Monumentality 'belongs to the sculptor.'<sup>23</sup> Rather, out of crude earth, concrete, glass and metal, the Salk stands as testament to the power of architectural prose. Like the steel

frames of the laboratory windows, it is not the material itself that we recognise, rather it is how that material has been intelligently shaped, and the expression of the forces at work in that element that touch our senses and our consciousness. This is a 'how' so thoughtfully conceived and executed with such discipline that its very technical realisation touches on the 'why' of its own existence, and of architectural Order as a whole (Fig. 10).

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### Notes and references

1. Louis I. Kahn, 'Not for the Fainthearted' in Alessandra Latour, *Louis I. Kahn, Writings, Lectures, Interviews* (New York, Rizzoli, 1991), pp. 258–263.
2. The theme of Kahn as a latent classicist is best seen in the essays for David Brownlee and David De Long, *Louis I. Kahn: In the Realm of Architecture* (New York, Rizzoli, 1991), in particular Vincent Scully's Introduction. (pp. 12–14). The interpretation of Kahn's philosophy in relation to mystico-religious traditions is most famously taken up in John Lobell, *Between Silence and Light: Spirit in the Architecture of Louis I. Kahn* (Boulder, Shambala, 1979).
3. LIK, 'Order Is,' in Latour, *op. cit.* The idea of an ontological scaffold is borrowed from Frederick Copleston's description of Plotinus' Neo-Platonist philosophy in *A History of Philosophy. Volume 1: Greece and Rome* (rep. New York, Bantam Doubleday, 1993), pp. 463–475.
4. 'A building has to start in the unmeasurable aura and go through the measurable to be accomplished. It is the only way you can build, the only way you can get it into being is through the measurable. You must follow the laws but in the end when the building becomes part of living it evokes unmeasurable qualities. The design involving quantities of brick, method of construction, engineering is over, and the spirit of existence takes over.' LIK, 'Form Into Design' in Latour, *op. cit.*, p. 117.
5. 'I think we are constantly confusing design and order. Order includes all the designs of construction – mechanical and spiritual, and design is merely the process of fitting them into conditions and coming up with a certain experience which strengthens and even enriches the order.' LIK, 'Architecture and the University,' in Latour, *op. cit.*, p. 55.
6. 'I believe you must know about the mechanical equipment and also about your affinity for structural members.' LIK, 'A Statement' in Latour, *op. cit.*, p. 54.
7. 'If we were to train ourselves to draw as we build, from the bottom up, stopping our pencils at the joints of pouring or erecting, ornament would evolve out of our love for the perfection of construction and we would develop new methods of construction. It would follow that the pasting on of lighting and acoustical material, the burying of tortured unwanted ducts, conduits, and pipelines would become intolerable.' LIK, 'How to Develop New Methods of Construction' in Latour, *op. cit.*, p. 57.
8. 'Nothing must intrude to blur the statement of how a space is made.' LIK, 'Order in Architecture' in Latour, *op. cit.*, p. 79.

9. LIK, 'Toward a Plan for Midtown Philadelphia' in Latour, *op. cit.*, p. 45. The reference to mechanical 'harbours' is in 'Order in Architecture' in Latour, *op. cit.*, p. 80.
10. Kenneth Frampton, 'Louis Kahn: Modernization and the New Monumentality, 1944–1972' in *Studies in Tectonic Culture* (Cambridge, MIT Press, 1995), pp. 209–246; and Edward Ford, 'Louis Kahn, Sigurd Lewerentz, and the New Brutalism: 1954–1974' in *The Details of Modern Architecture* (Cambridge, MIT Press, 1996), pp. 305–348.
11. Barragan quoted by LIK in letter to James Britton of Urban Design Review, 12 June 1973. LIK Archives, University of Pennsylvania, Box LIK 27 – 'Salk Institute for Biological Studies, La Jolla, CA.'
12. 'Abstract of Program for the Institute of Biology at Torrey Pines, La Jolla, San Diego.' N.d. LIK Archives, University of Pennsylvania Box LIK 27 – 'Salk Institute for Biological Studies, La Jolla, CA.'
13. Conversation with Jack MacAllister, La Jolla, CA., 12 June 2001.
14. *Ibid.*
15. 'Nobody likes to make a design twice, especially if it will be second best.' August Komendant, *My 18 Years with Architect Louis Kahn* (Englewood, Aloray Publishers, 1975), p. 51. More laconically, Kahn reported that his 'structural engineer was not for change.' LIK, 'Remarks.' *Perspecta 9/10* (New Haven, Yale University, 1965), p. 333.
16. 'Laboratory for Life Science Designed to Defy Time . . . Designing the Concrete Vierendeels.' *Engineering News-Record* January 27, 1966, pp. 79–83.
17. This arrangement occurs only in the north wing, which was the first to be completed. The south wing, shelved for several years, was outfitted with a more energy-efficient VAV air system in the early 1970s, although the access strategy remains similar. I am grateful to Bob Lizzarraga, facilities manager at the Salk, for allowing me access to these interstitial spaces and clarifying their functional layouts.
18. The following overview of the Salk details is based on a conversation with Jack MacAllister on site in La Jolla in June 2001, to whom credit is due for pointing out the 'five details' described below.
19. Conversation with Jack MacAllister, La Jolla, CA, June, 2001.
20. 31 July 1963 letter from MDM to JM, Box LIK 27, LIK Archives, University of Pennsylvania, 'Salk Institute for Biological Studies, La Jolla, California'.
21. Rabbi Morton J. Cohn, *The Address of Consecration Dedicating the Site of the Salk Institute for Biological Studies at San Diego California*, 2 June 1962. Contained in Salk Institute for Biological Studies file, the San Diego Public Library 'California Room.'
22. LIK, 'Form and Design.' in Vincent Scully, *Louis I. Kahn (Makers of Contemporary Architecture Series)*. (New York, Braziller, 1962), p. 114.
23. LIK, 'Monumentality' in Paul Zucker, ed., *New Architecture and City Planning* (New York, Philosophical Library, Inc., 1944), p. 577.

