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# FROM THE IMMEASURABLE TO THE MEASURABLE

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**Abstract:** The present work is developed at the initial period of Louis I. Kahn's independent work, when he projected the Richards Medical Research Laboratories in the University of Pennsylvania 1957-1964. This building represents the moment when he discovers and apply tools and theoretical fundamentals those would be repeated and applied in his next projects and career. For this reason the study of his timeline is divided and established until 1957, to understand how the work is managed and to find the underlying substrates that make up the project.

The approach comes from two categories, which are the immeasurable and measurable, from the world of ideas to the tangible, trying to open another space for the unspeakable to appear so we can understand the meaning of this building in Kahn's work and in his time. In this way, the work analyzes and classifies these fields, which are established from the words of Kahn when referring to the creative process in his work. This process is the step of the immeasurable (the idea), to the measurable (the building), To be immeasurable again (transcendence from the building). We approach the work from the union of concepts, constituting two fundamental parts, a part called the 'immeasurable to the measurable', and the other one, the 'measurable to the immeasurable'.

**Keywords:** Architecture, Louis I. Kahn, Incommensurable, Measurable, Urbanism.

## 1. Introduction

Until the end of 1940, Kahn worked for the public administration, in different projects for the city of Philadelphia, especially in the social housing area and founded the bases of his architectural thought through his professional experience, trips, as well as, within the teaching activity. When Kahn was forty-seven years old, he began his work as an autonomous architect, presenting a clear search for both: the project and his ideas about architecture.

In a first approximation to his projects, It was possible to detect a search in finding a path in two very clear lines, one of the growth of three-dimensional cells that, when repeated, make up the whole; Another operation is given by the reproduction of a pattern of geometric shapes, designed as capsules that are differentiated by their specificity and which will be articulated by displacements and connections thus achieving that the set is kept together. Parallel in this period, he works with light, and at the same time, the search for an empty space that emerges in the junction spaces, "spaces between", which will then be spaces to serve the building, emerging equivalent to the living spaces.

The search for this individualization is given progressively in each project of his career independently, and somehow, these inquiries have analogies with the architectural production of his time.

In a first analysis of his work, the building chosen as essential in the Richards Medical Research Laboratories (1957-1961) and the annex, the Laboratories of Biology (1962-1964). In this work Kahn discovers the unknown, that is, it materializes a search of years of work on a monumental scale and with a powerful coherence. For this reason, the year 1957 is chosen as a reference year, where there is a cut in the timeline in the architect's work, to understand how the process was conceived until the project of the Richards building, and to establish links with his future work.

From this chosen year we analyzed his writings, professional relationships, ideas for the city, Biology and history, as well as, his trips to Europe, time teaching, buildings and most relevant projects of Kahn's production until the year of the Richards Medical Research construction. From this analysis strategy we intent to understand those aspects as a background for the thought process and for the project, until being able to detect and nominate them in the laboratories.

In the building of Richards laboratories, Kahn discovered the foundation of his work, synthesizing in his materialization years of work and theoretical research. The conclusion of the project is developed in the form of diagrams those present the way through which Kahn transit until reaching the Richards



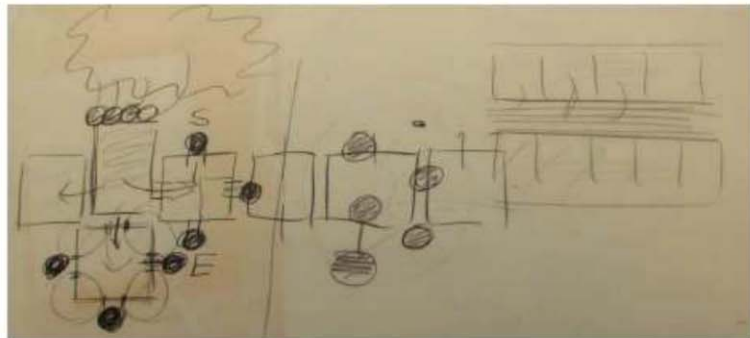
and, how in this building, several layers that use to be seen isolated in previous projects were applied as a whole.

This building can be read as a manifest of Louis Kahn work, founding the basis of his work, obliterating the contribution of the modern architecture. Kahn searches for a solid architecture instead of a diaphanous and thin one, proposing an overlap of successive layers and walls, building a careful gradation. Through this layout he operates a series of procedures for openings in the wall almost sculptural, so he can build light effects that by being sieved and filtered can convert into an unreal light. The intention is that the analysis of the incommensurable and measurable spheres, in his several approximations of the psyche and the material or vice versa, is that he accomplishes the sound of the incommensurable sphere, that is the transcendence from the building and it's impacts in their time, being this the great legacy of Louis I. Kahn to his time in history and architecture.

## 2. Development

"In the same way, a building must begin in the aura of the immeasurable and pass through the commensurable to arrive at a good term. It is the only way we can build; the only way we can carry it out is through the commensurable. We have to comply with laws, but when the building finally becomes part of life, it evokes immeasurable qualities. The design - which implies the quantity of brick, the method of construction and engineering - is over, and now the spirit of existence comes into play." (Kahn et al. 1961)

This text was written in the year 1961 in a writing entitled "Form and Design", where it makes explicit the two fundamental dimensions - immeasurable and measurable - as part of a project procedure that the building goes from the idea to its construction. If we observe the initial sketches of the Richards Laboratories until the final project, we are able to see that the essence of the original idea persists until the end of the project. *fig. 1*



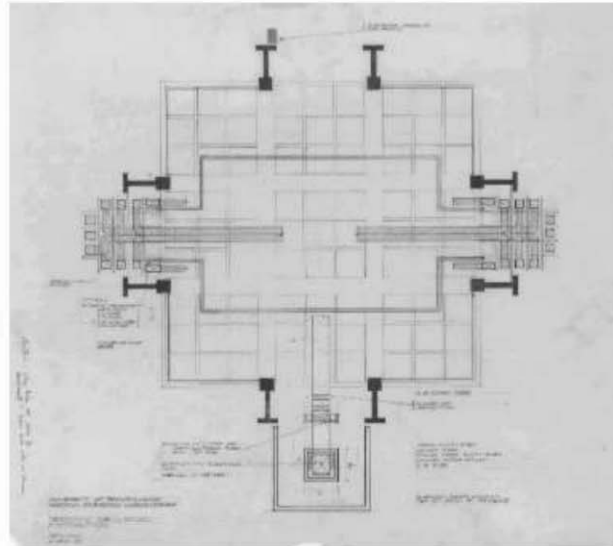
**Fig. 1** The Richards Medical Research Laboratories Sketch. Design by Louis I. Kahn. No sheet 490.1. The Architecture Archives, University of Pennsylvania.

During the development of the project it is noticeable that the primary exchanges are the definition of the structural system, as well as, the materialization of the called server and the service spaces. This interest in architecture for the spaces and advance innovation in the mechanical services were being developed during the fifties. Le Corbusier had indicated the service spaces in his *Unité d'habitation* building in *Marsella*, in 1952, thinking them inside the pillars of the *pilotis*. The same way, Alison and Peter Smithson, in their contest project for the University of Sheffield in 1956, individualizing the mechanical service and people in a horizontal corridor unattached to the building with ducts passing over and people underneath. In 1967, Wallace Harrison let the ducts of the air conditioning in sight at the entrance of the United Nations General Assembly. With time, in 1964, in the Olivetti fabric in Argentina, Marco Zanuso introduced the air conditioning ducts inside the hollowed out beams of prestressed concrete.

This individualization of the service was a concern of architects in his time, especially in the brutalist architecture. On the other hand, the new brutalism -composed by Smithson and Kahn and other architects-, looked closely to the twenties buildings, to a return of the proportions based on professor Wittkower's book – "Architectural Principals in the Age of Humanism" – and in the sensorial value of the materials coming from the Japanese tradition. According to Reyner Ganham, when Kahn exposed the mechanical services in the Richards building, he did it with such force, which instigated the writers to look at that subject with more attention, in such way that had never been achieved before.

In the Richards Laboratory the elements of support, allow the installations to pass through the hollow in the beams and then evacuate in towers unattached to the building, finding a formal logic to optimize the path and establish a space for each mechanical element, generating a controlled system that introduces a more complex order to the work. *fig. 2* The hollow in the structure is only possible in a system that works properly with the voids; for this was invented an extremely new framework for his

time, by the engineer August Komendant, an structure built entirely indoors and assembled piece by piece in the construction site. Once the structure was defined, it should obey an overall logic that allows the installations to pass, free the corners to the light, defining a geometric fundamental order that is configured since the most elemental parts of support pieces to the building as a whole.

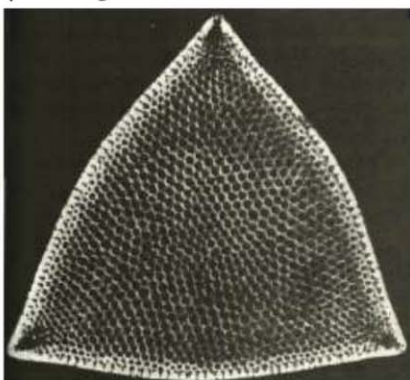


**Fig. 2** Design of the installations step drawing between the beams to the service spaces. Sketch of LIK office. No Sheet 430 IC.490.1.2. The A. A., U. of Penn.

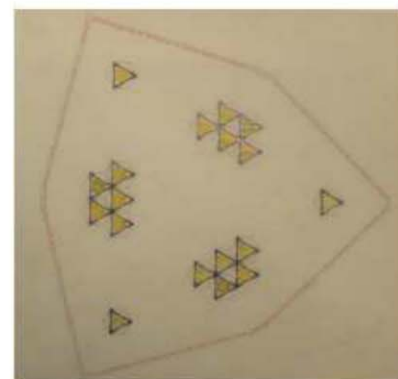
Kahn's work was carried over for a time by a territory that dealt with the spatial poetics generated by the repetition of a platonic geometric form. These works were done together with Anne Tyng, who joint Kahn's office around 1945. Kahn was working since that year in the city of Philadelphia, and the first approximations of a triangular structure were made in the Midtown Development project (1952-1953). The base of the structure is triangular and generates a mesh that fills the entire territory of the five blocks where the intervention is performed. The buildings follow the same formal logic, mainly the circular one destined to be a hotel.

In the building of the Yale Art Gallery (1951-1953) the triangular structure becomes a three-dimensional object, and appears on the roof of the galleries as space mesh of light concrete. In the final version the domes are exchanged for a slab formed of empty and filled tetrahedrons, supported by concrete pillars. They had to eliminate the shear from where the tetrahedrons join the pillars, so the quality of the form would be preserved. With that they were able to reach great spans supported by conventional pillars, making flexible spaces, which can be configured by three types of really thin panels. Some of the panels were openings used for return air and others as background or separator, which are fixed to the roof by adjustable metallic pieces. Through the empty parts of the tetrahedron the ducts and installations pass.

In the early versions of the City Tower project (1952-1953), we can see the work process of Kahn and Tyng and the evolution up to develop to a spatial model extended to the volume as a whole. In the first sketches we see a triangular plan resembling *diatomacea*, a type of algae found in D'Arcy Thompson's book. **fig. 3** In the logic of *diatomacea* growth, we find an analogy with the conformation of the first floors of the building, which adopts the same geometry in the edge as in the mesh that determines the parts. **fig. 4**



**Fig. 3** Photograph of a *diatomacea*, a type of algae found in D'Arcy Thompson's book.



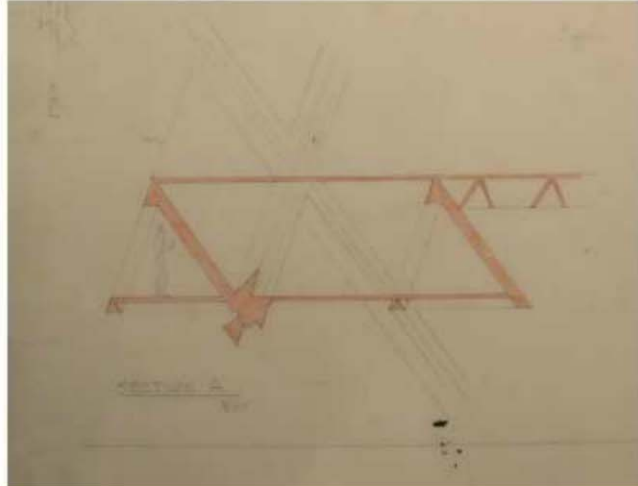
**Fig. 4** LIK initial version sketch of the City Tower. No sheet. 385.1 IC 030.I.A.385.1. The A.A., U. of Penn.



The building's triangulation and structural elements, establish a succession of floor plans positioned in correspondence with pillar growth. By now Kahn understands that the building can be completely coherent through all the parts that compose it, that is to say, a small piece by being submitted to variable proportions, shapes the building as a whole. In the next image it is possible to see the displaced floors which are attached to the post and prestressed vertical beams of the building, they work in a consistent way according to the winds. *fig. 6* The floor plan growth refers to the cell growth, and to the Buckminster Fuller's three-dimensional configurations, now in the City Tower with a structural sophistication, responding to external efforts and being able to exhibit its own dynamic. *fig. 5*



**Fig. 5** Buckminster Fuller investigating the Dymaxion building in MoMA. New York, September, 1959.



**Fig. 6** Section of the City Tower, sketch by LIK. No. sheet 385.83 IC 030.I.A.385.4. The A.A., U. of Penn.

The same order that is established in the building extends as a formal logic, reaching the contiguous territory, using the same mesh as an order capable of being extended in all directions as an alternative to growth. But this movement can be reverse, from the city to the building. It will try, through architecture, to control the urban dynamics, as well as the external factors - wind, light, shadows, gravity - from the same geometric order established by the spatial mesh, extended in all directions and adjusted in precise geometric proportions, sheltering man and his institutions.

From his vision of the city Kahn understands that the definition of the building comes from the dynamics of the same movements, thus arising the form as the speed is reduced. The concept of system of movements grants a design structure that helps architects to think from the city scale until they can understand and develop their individual projects. In this point there is a convergence between Louis Kahn and Edmund Bacon's ideas. For Bacon the city should be able to hold a series of simultaneous movements and different values of perception, for both those who transit by car or by foot.

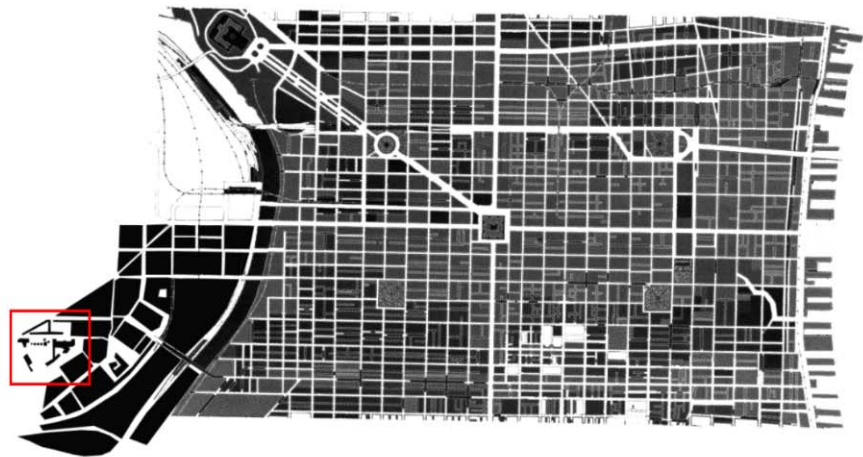
The specificity of the roads can be seen by the street design of the center of Philadelphia, with a multileveled fountain that works as an attraction for the entrance to the city center, and one of the first gardens built underground. Bacon describes how the garden works in "The nature of design", as a place where all kinds of people can experience space, meet and move around. This place also connects two different movements: the pedestrian path and the underground area where subway and trains are located. The design of the Market East Street illustrates the urban solutions that materialize the ideas behind the system of movements, putting together several manners with the pedestrian lane in different levels and also connecting with commercial centers, in a fairly deteriorated area of retail stores. The idea was to create a pedestrian and garden area below the road level, connected with the subway and an extension of the underground commuter train system.

The Penn Center project – where Bacon and Kahn worked -, is a fairly big part of the city, which was released for occupation after the demolition of the former suburban Broad Street station and the set of elevated train tracks, called "Chinese wall", which divided the western part of the town hall into two separated parts. The site belonged to the railways of Pennsylvania that were part of the "general plan of the city" coordinated by the city planning commission.

The base of the urban implantation of Philadelphia was born from an empty square, which was located in the center of the city hall, and is an archetypical representation of the egalitarian thought of its founders that extends throughout the city. It was in this context, initiated by Thomas Hole, in 1983 according to the precepts of its founder William Penn, that Kahn is going to elaborate his ideas for the

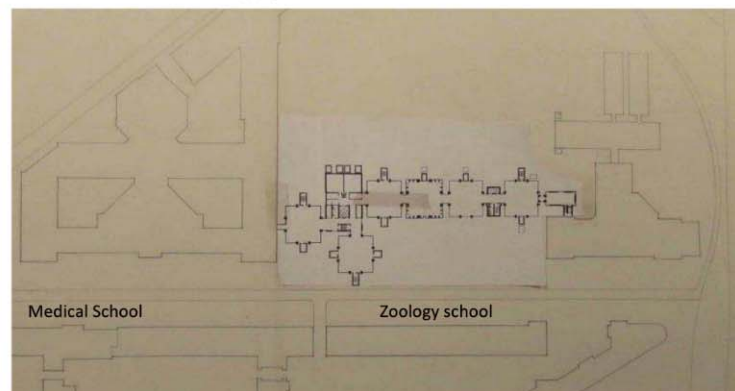


city and is also in this context that the Richards Laboratories in the Campus of The University of Pennsylvania will be inserted. *fig.7*



**Fig. 7** Philadelphia plan with the Richards Laboratories implantation in the left corner.

The place was surrounded by residential buildings, the departments of Zoology and Biology, and a dormitory building, all designed by Cope and Richardson, in neo-gothic style. *fig. 8* The new building is located at 3700 Hamilton Street, within the campus of the University of Pennsylvania. There must be a difference of 2.5 meters in relation to the pedestrian street, where the main facade of the laboratory lies. The highest point is the Zoology building and the lowest point is the School of Medicine; At the back of the site the heights are increasing. Kahn will connect the building to a street parallel to the Hamilton, behind the new building, which will serve as a supply and services.



**Fig. 8** . Photograph of the initial plan of the Richards Medical Research Laboratories. No Sheet 031IC.490.002. LIK drawing. The A. A., U. of Penn.

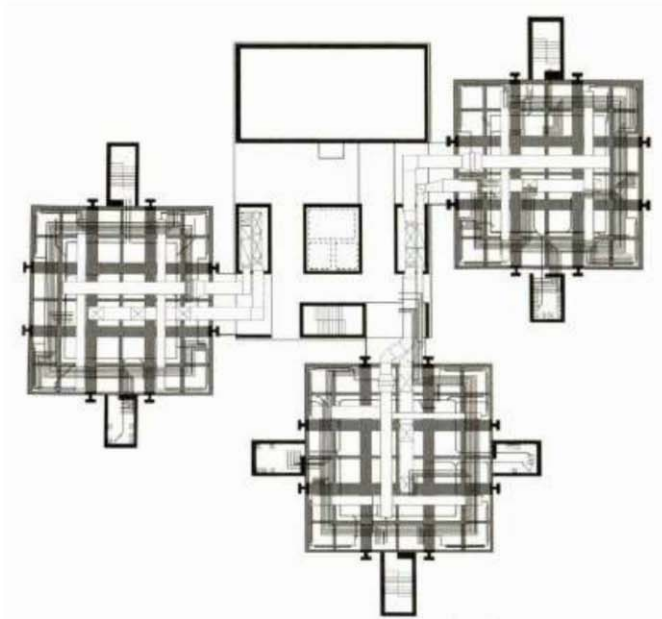
In the year of 1961, the New York museum of modern art, dedicated an exhibition for the Richards laboratories building, describing it as an authority in the United States Architecture in its time. It was still two years before its conclusion, but what is important to highlight in the next paragraph, written by Wilder Green – who was the director assistant of the Department of Architecture and Design at MoMA-, are the guidelines of the building, that somehow he delineated in an incipient way.

“Given a restricted site, it was mandatory that the building take a vertical form, but the ray in which this verticality might be handled arose out of Kahn’s particular interpretation of the program. Two observations by him strongly conditioned the final form of the building. First, that the scientist works alone or in a small group, but may require psychological and actual contact with other groups. Second, that the potentially dangerous working operations require that the service facilities must not interfere with the work spaces and that pernicious fume must be immediately removed.” (Green et al 1961)

Ten years before, the American universities were submitted to fundamental changes, since some had obsolete spaces in comparison to the advanced technology used in medical education. The university medical center needed a new wing, with departments for psychology, microbiology, public health and an experimental group of surgery, which didn’t required being close to the hospital.

The building is an articulation of work spaces and service spaces that are intimately linked for the proper functioning of the whole. A spatial articulation based on a cell that undergoes a scalar modification according to its uses. At the same time, each tower is a model that can be repeated and

adapted to each context, that is to say, a square with eight pillars placed on the third part of the side, releasing the corners. The space between the pillars houses the air filtering towers and the emergency stairs. The structure consists of a prefabricated system of pillars and beams. The beams intercept the pillars, leaving the corners in overhangs. These beams conform a system of spatial meshes, which are subjected to several formal alterations, until their complete definition. In the generated emptiness inside the beams, the apparent installations of water, electricity, ventilation, etc; will be placed. The laboratories were conceived on requirements based on mechanical systems under the initial care of Fred Dubin, who defined the plumbing lines and the requirements of the codes of descents. The square initially of 13.72 meters (45 feet, that initially were 47) was the result defined by the team of consultants, that was freed of columns and walls. This allowed a central lowering of services which gave it greater flexibility. Komendant was in favor of leaving the exposed beams, without ceiling, in order to show the logic of the structure. **fig. 9**



**Fig. 9** Diagram that show the joint work of the structure, mechanical service and plumbing system. Taken from LESLIE, Thomas. *Louis I. Kahn. Building Art and Building Science*. George Braziller, New York, 2005. p. 102.

This allowed, in the case of the Richards, the facilities to be distributed in an apparent way and a logic of passage was created that obeyed an order. The structure is a spatial grid that is configured in nine major spaces, subdivided into four smaller ones, on which the slab that is also apparent is supported. The whole is a prismatic spatial structure that obeys a structural, mechanical logic and a reasoning of whole.

The structural system was revealed as an alternative, since by means of its empty configuration it allowed all to coexist. The architectural space not only deploys the mechanical services around its square cells in the service sub-towers, but takes them to the ceiling to feed and clean the harmful air of the laboratories. Thus this intricate manipulation of empty spaces, in various dimensions and senses, is made possible by means of Vierendeel beams which by their arrangement create a three-dimensional mesh of cubic forms.

Kahn's intention was for the entire process of the great machine to be read from the outside. In the same way that he saw the city as a succession of major flows or fast tracks that lose flow and size until arrive at the destination, similarly, it structures the arrival of these complex systems of supply of facilities necessary for the building to operate in an intricate system of empty spaces that interact and connect with each other.

The pieces of the building came dismantled, even the edge beams that remained in cantilever. The pillars were also manufactured in pieces and then assembled in parts. The post-tensioning system, which is based on the permanent application of compressive forces on the axis of the element, allowed carrying out the Kahn architectural project that did not present intermediate pillars in the big lights. Both beams and pillars were post-tensioned through individual steel cables with the use of hydraulic jacks, finally attached to the structure by anchors at each end to prevent water ingress and protect the reinforcement from corrosion. The joints between two adjacent members were also sealed.



The structure set of the Richards is constituted by two construction systems, a pre-fabricated one for the towers in the laboratories "A", "B" and "C", and another system of concrete poured in site that was isolated in tower "X" and in the service towers that embrace the building. The concrete poured in site system was the conventional one. The frame is settled between the outer and inner formwork of the planes of the walls, and the concrete mixers bring the cement to the place. The cement is loaded into the forms and compacted by hand through vibrating machines *fig. 10*



**Fig. 10** Photograph that show both construction systems, the pre-fabricated pieces and the poured in site at the "X" tower. Archive No. : 030. IV.A.490.12.51.The A.A., U. of Penn.

Kahn tried to solve a complex system of connections where the structure, the architecture, the mechanical services and their intricate relations are shown in essence. Through its parts, the building speaks of an idea of order that governs and determines. The joints of the columns reveal the constructive process, its form of assemblage and the reason for its support, which is interpreted from the idea of order of the whole. In the Richards building case, the structure had to be deployed three-dimensionally and with it, all gears - installations, machinery, fluids, etc.

The interstice becomes the fundamental space through which the three parts are connected and from where it is possible to think of the building as a whole. The special unfoldings developed in a three-dimensional way, both in the ceiling and in the perimeter, as well as in the various gaps that sew the building from its limits. The geometry found and institute the order of each part and the set, which is an operation that Kahn uses since his first projects, where he appropriates a form and manipulates it in different scales until reaching the limits of the project. In this case the geometric order is defined by a square, which generates a series of voids where will be structured the entire complex machine that the project establishes so that the laboratory could work.

### 3. Conclusion

The Richards laboratory worked as a datum within Kahn's work, since up to this point the architect had experimented with two work processes: that of the space cell which, when repeated three-dimensionally, forms the set; and on the other hand, the repetition of a square pattern that, when dislocated, kept its essential characteristics analogous. Kahn's work was carried over for a time by a territory that dealt with the spatial poetics generated by the repetition of a platonic geometric form. The other operation is given by the repetition of an abstract pattern of geometric shapes, designed as capsules that are differentiated by their specificity and that will be articulated by displacements and connections, thus achieving the set to stay together.

From the encounter with history, Kahn discovers two possible ways to be investigated in his work, one is the work of piercing the walls obtaining an enigmatic light as opposed to glazed and thin skins of the modern movement. The other way refers to the search for an identity of space through its form, light, constructive system, etc. It is the answer that Kahn was trying to find when wondering what the building 'wants to be', and in this way, confront the idea of a flexible and mutable place of modernism. Beyond being the individualization of mechanical services, the great contribution of the Richards building was the masterly coexistence of the three fundamental categories that were implicit in the

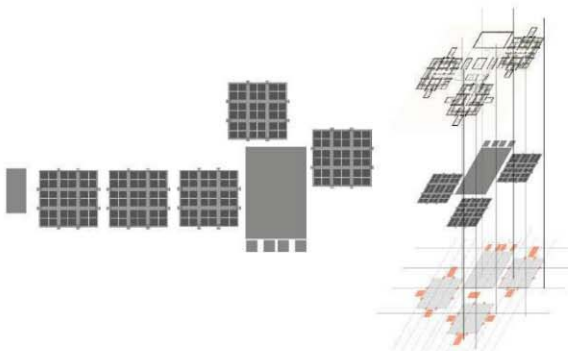


order of the project: structure, architecture and mechanical services. **fig. 11** This is the place where the form is revealed, where the mechanics of the fluids are in harmony with the structure and the architecture through the structural system. Without this technological machine it would be impossible to operate the laboratories, since it requires complex systems of fluids and installations operating synchronously with the architectural space.

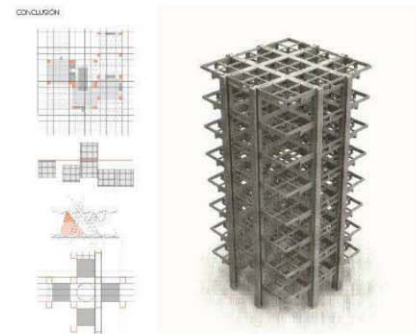
This reminds us of Kahn when he plans the city, thinking about the braking architecture and the urban movement system that establishes two types of spaces, the architecture to inhabit and the architecture of the car. When he looked at the city, he realized that each speed needed a type of space to receive it, the ports, canals and docks, according to the speed of the tracks. Kahn transposed this logic of connections and braking movements to the laboratory building, which must respond to a series of flow variables and connections with scales and spaces for every need. On the other hand, when Kahn thinks about the architectural space, he invariably extends the interior space to the outside, ratifying the idea that it does not end in its limits, but extends beyond its borders into the distant space. In this way, the cell that adopts as the generator of the project, will be obsessively present in various scales of the building, from the alveoli of the structure, the coverings, the enclosures, the plant, the entrance hall, the gardens, to that small cube of granite that delimits the access to the building and reminds us when passing by, the form that rules the building and that dilates towards the landscape. That is to say, for Kahn, the operation of the macro scale to the micro-scale is able to be reversed, allowing the building with the same formal logic extend towards the city.

On the other hand, in the Richards lab building, Kahn stated all his previous experiments on a monumental scale, the capsules of the Adler and De Vore houses, the voids that sewn the Yale ceilings, the extension of the cell to the city, the hollows of the pillars of Trenton, the opening of the walls for light to emerge, the work of the mass that despite being made of parts, has an expressive force that is born from the manipulation of material and the work of light and shadow. **fig. 12** The design procedure in future buildings is synthesized in Richard's Laboratories, later these strategies are developed on a larger scale and with emphasis on certain elements in relation to the idea of order of each project.

If we try to take a look back to the past, we will see that in the end, Kahn seeks the coexistence of the underlying layers from the depths of the immeasurable, moving them to the measurable. It establishes an inexhaustible dialogue between opposites, architecture and the city, light and shadow, the column and the wall, the empty and the full, the past and the present, in a suspended time where the layers sediment and fossilize in his work. Thus they overcome the static of space-time, making it possible to wander in history, in an erratic time that articulates incessantly, the immeasurable and measurable.



**Fig. 11** Diagram showing the laboratories like a synthesis of the structures, mechanical and plumbing systems and architecture.



**Fig. 12** The Richards's Laboratories like the concretization of the previous projects.

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