

Order and Form

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## yale art gallery and design center

*designed by Louis I. Kahn*

*Yale Art Gallery and Design Center in New Haven and the Mill Creek Public Housing Project in Philadelphia are among the latest works of LOUIS I. KAHN, Philadelphia architect and Chief Critic of Architectural Design at Yale.*

# order and form

The builders of the past had it much easier than those of the present in one important respect: they did not have to worry about pipes, ducts, conduits and innumerable mechanical intestines. Form, structure and function were all one—clear, visible and sublime. There was nothing to hide: a building could have unshakable integrity.

The upheaval of Western culture that occurred in connection with industrialism led to the borrowing of historical forms from other cultures and was paralleled by a nascent craving for mechanical amenities. The habit arose to conceal the newly invented technology behind the appearance of traditional forms.

Even though traditional forms are being discarded rapidly, the habit of completely divorcing the building shape from mechanics and from the geometry of structure strongly persists. In an analytic fashion, typical of our age of science, the architect, the structural engineer, the mechanical engineer, the interior decorator, work separately on the various aspects of a building producing an assemblage that might happen to be mechanically efficient and visually striking, but which cannot be a work of art for lack of unity, integrity and order. A superficial coat of plaster conceals an often jerry-built structural frame and chaotic mechanical stuffing.

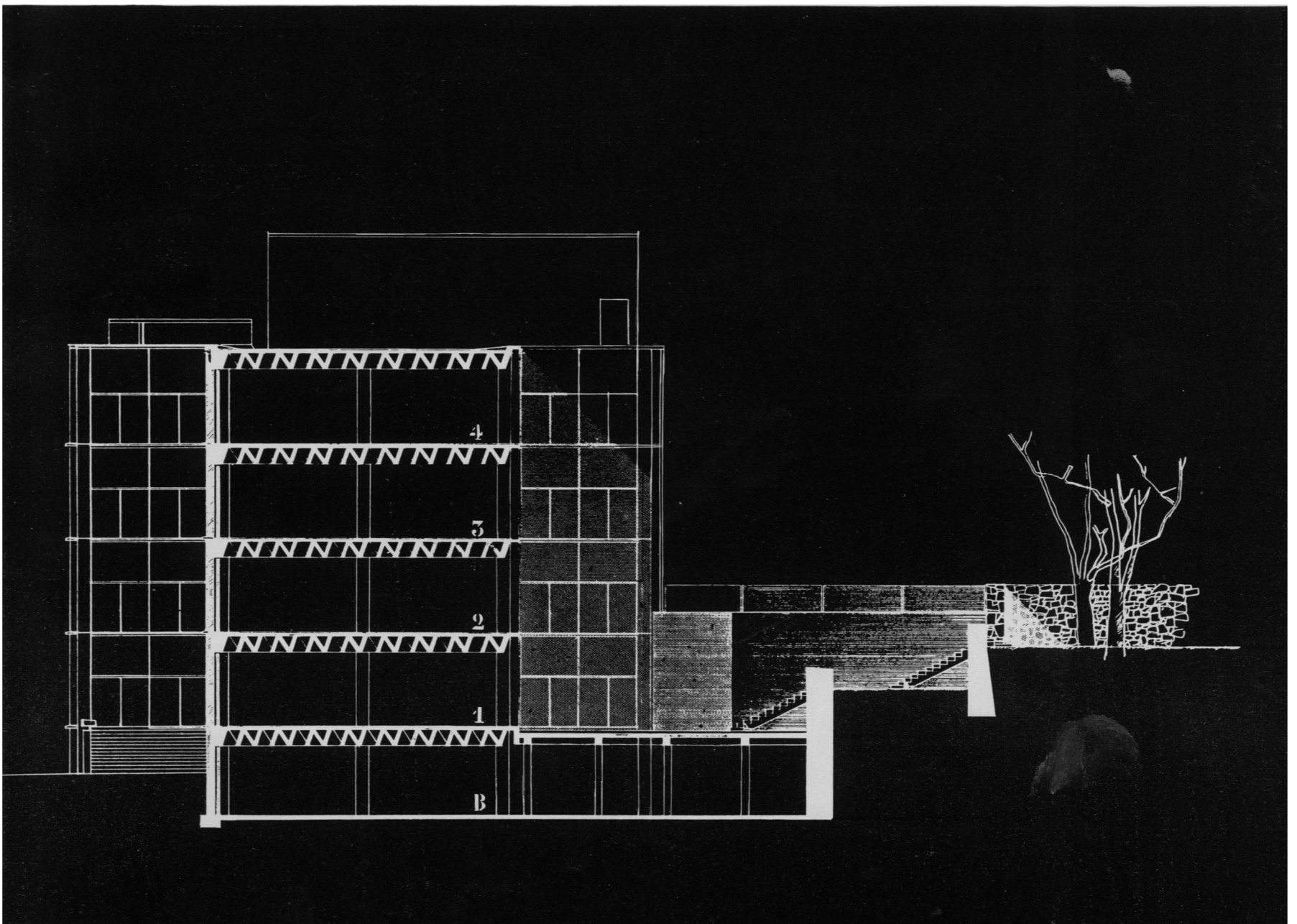
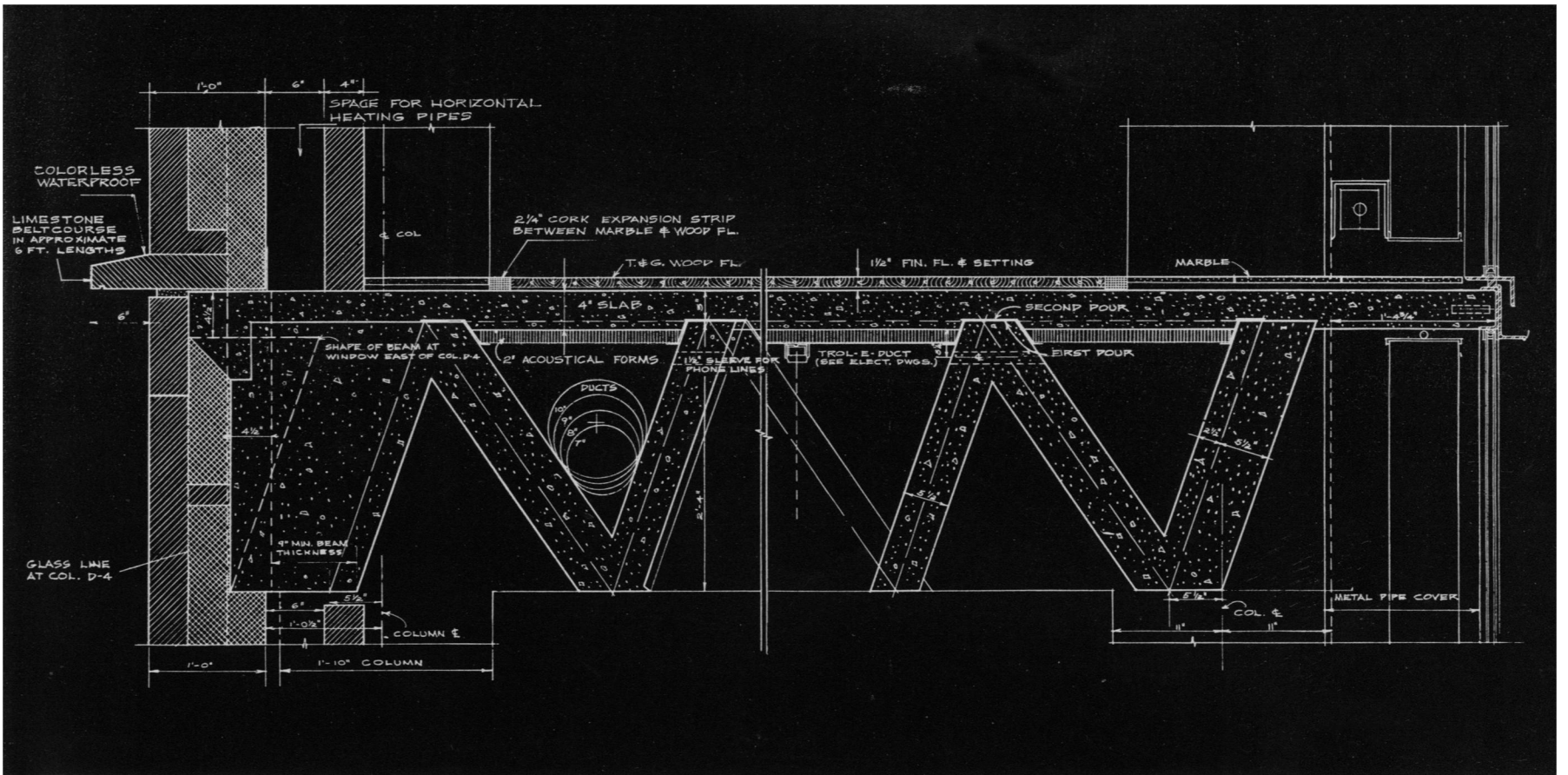
Inspired by the subtle structural integrity and convincing visual order of Gothic structures, Louis I. Kahn, the architect of the new Art Gallery and design center at Yale, set himself the task of creating a space in which the structure and the mechanical equipment—lighting, acoustical and climatic—would all live one life and would become the basic means of artistic expression. Integral unity in form was his first objective.

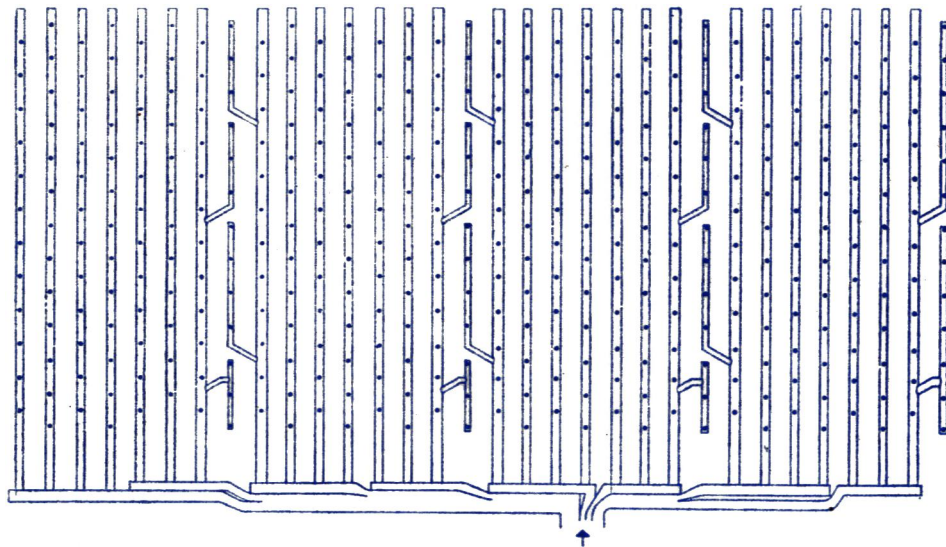
His second objective was permanence. The uses of the building were to be varied—exhibition space, offices, drafting rooms, lounges, workshops. All the future uses could not possibly be anticipated. A building tightly fulfilling the present requirements would quickly become obsolete. Therefore, a universal space was to be created, easily adaptable to new patterns of use.

Finally, it is Mr. Kahn's conviction that order lies at the root of architecture. A discipline of the spirit rather than emotional whims produce works of art. The creative task of the designer is to sense an initial order, which will guide him from then on.

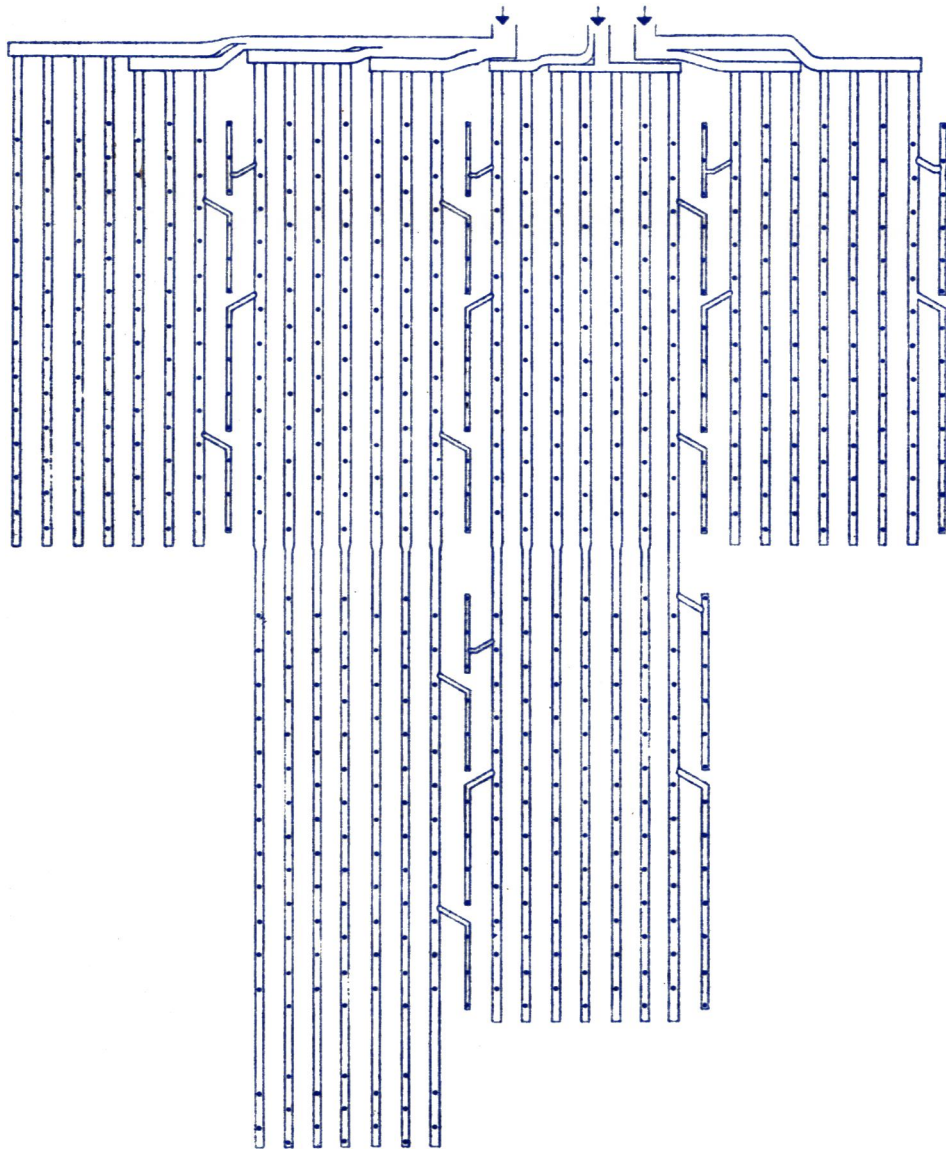
The construction of the Art Gallery gave Louis Kahn an opportunity to realize his convictions. His original idea was to establish an order from which widely spaced columns could be designed, supporting a series of slabs, which would create flexible loft spaces. These could be subdivided, where necessary, by easily removable plywood partitions. The elevator and all vertical ducts would be grouped in one central shaft.



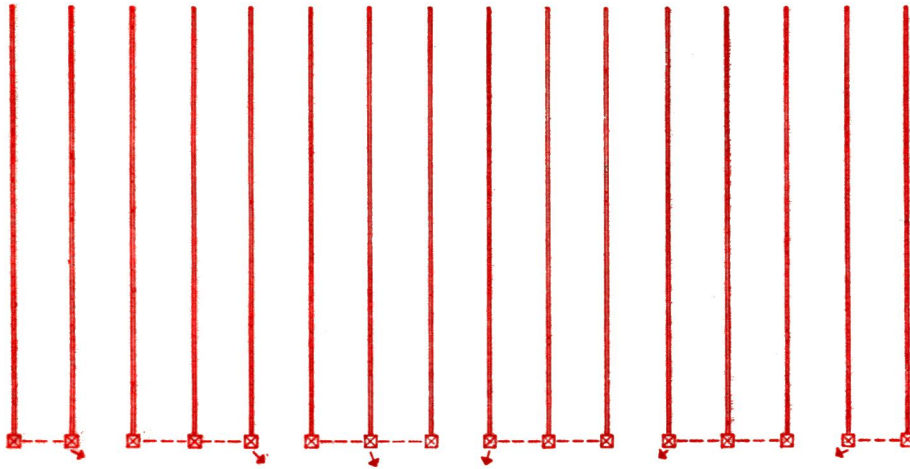




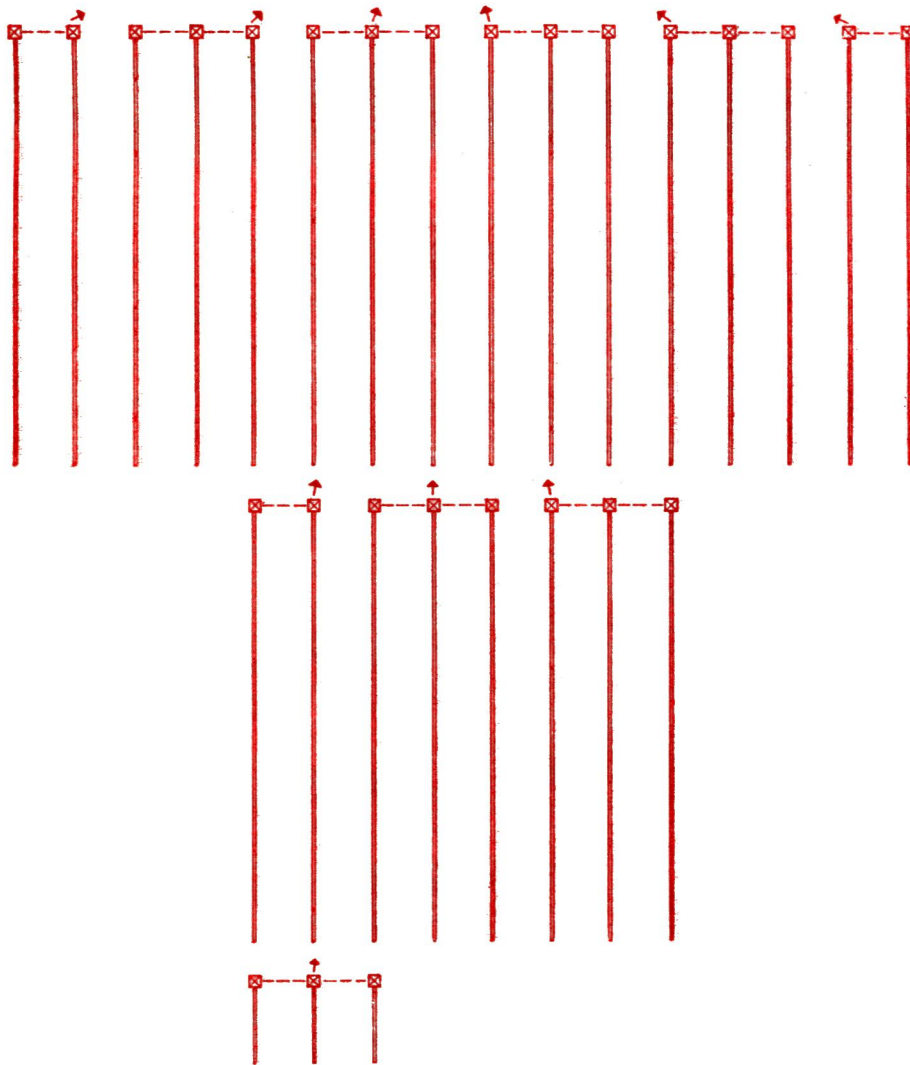
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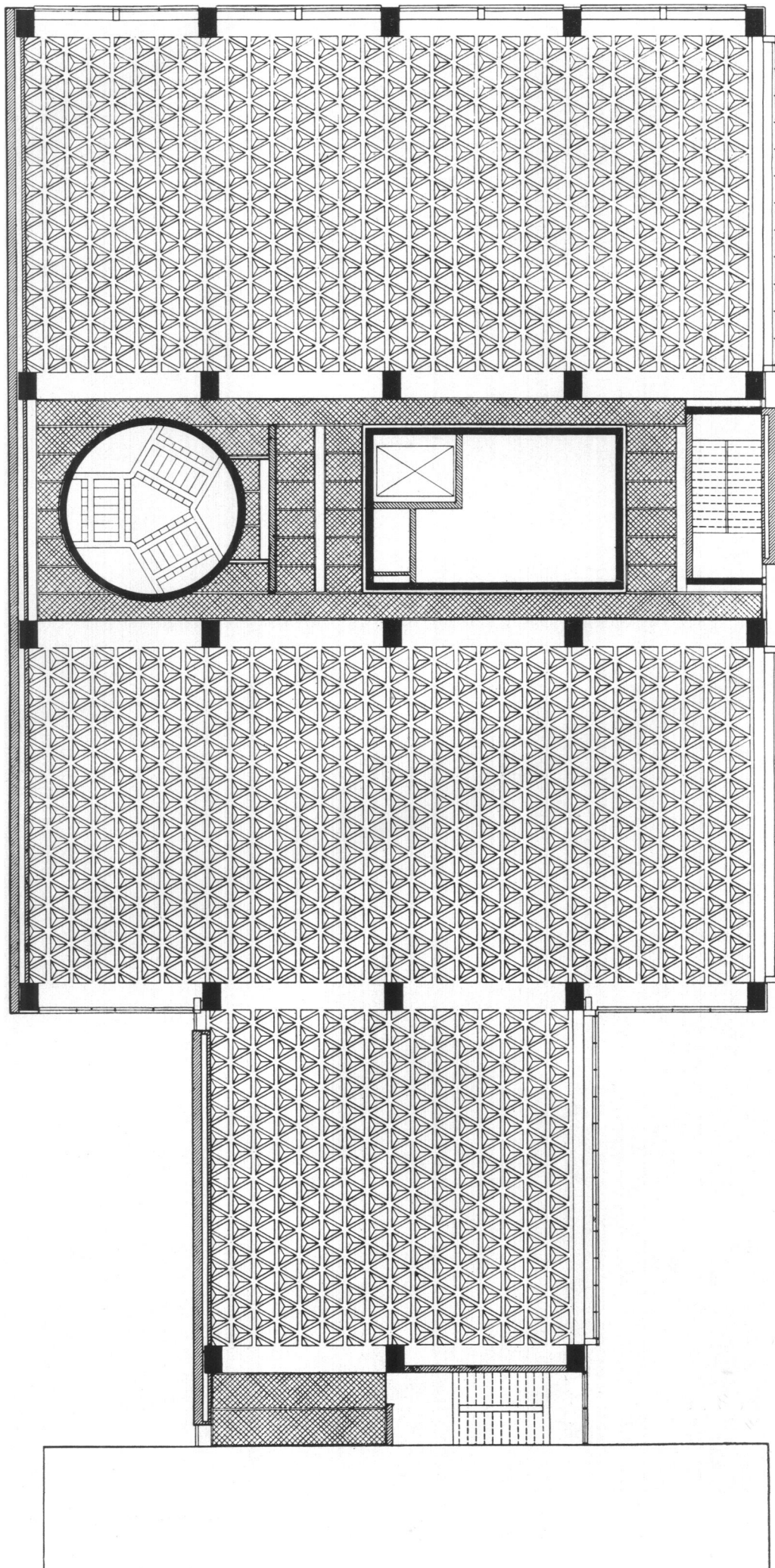
*Ventilation.*



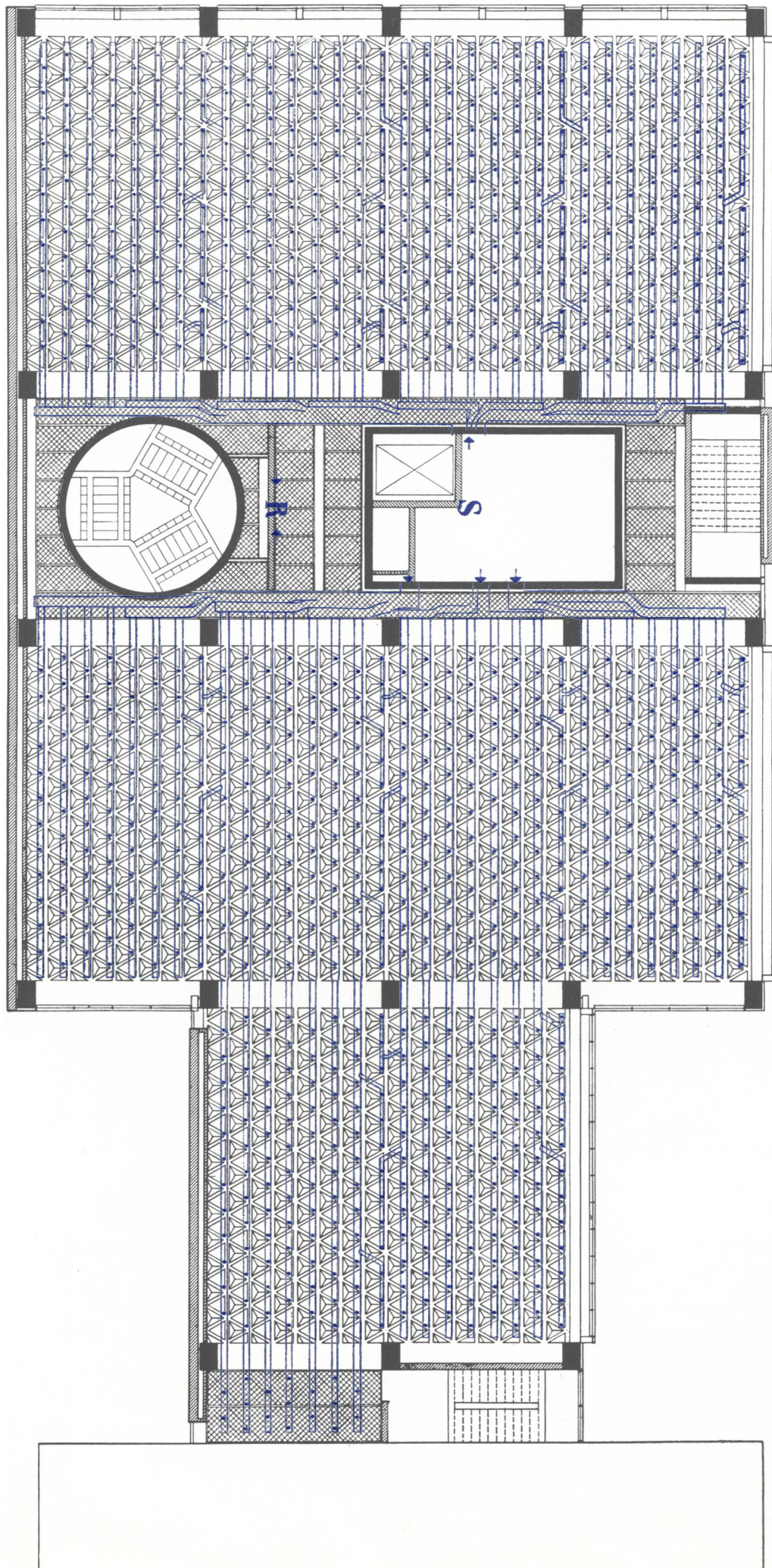
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*Electrical distribution*

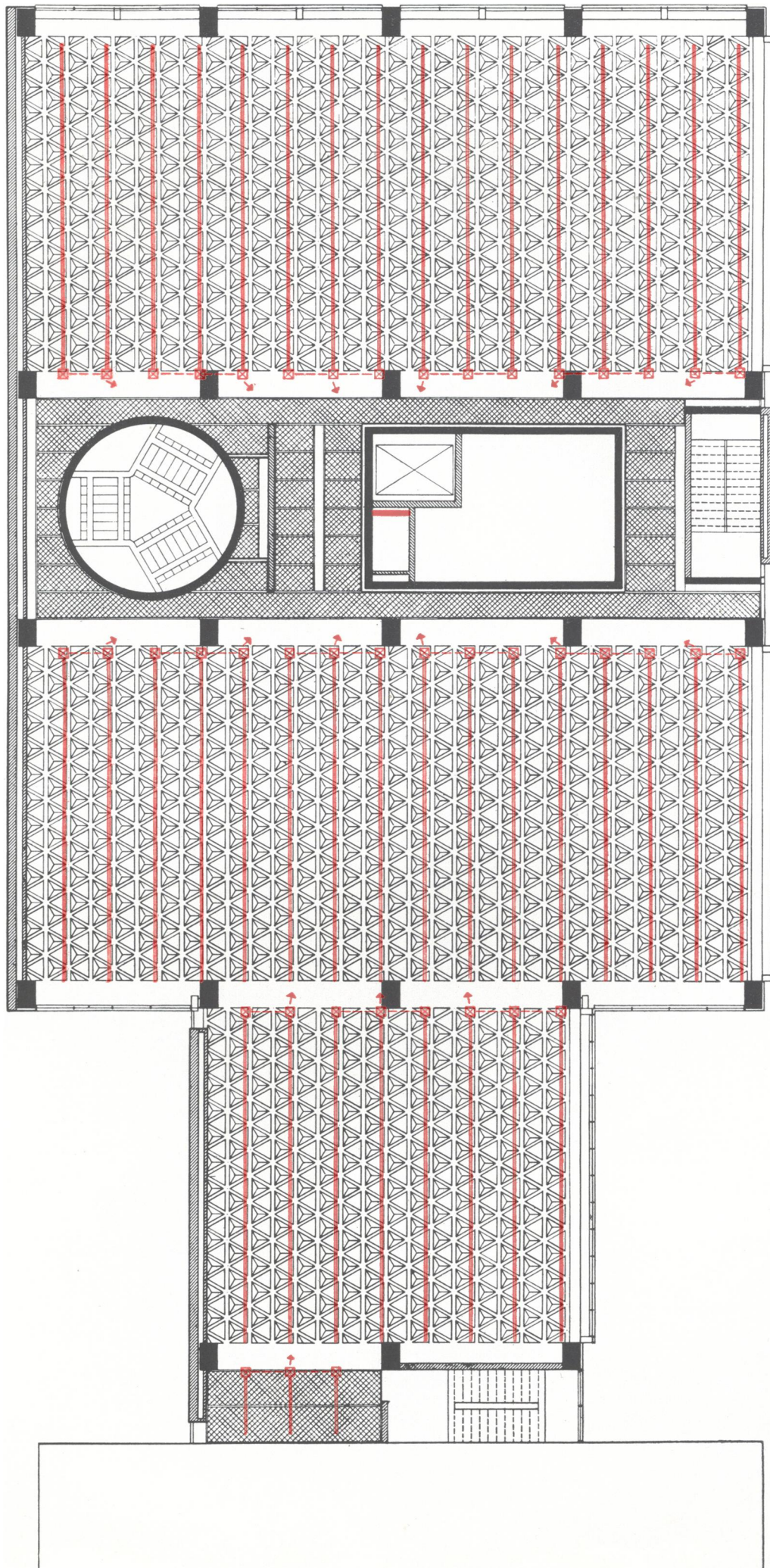


*Reflected ceiling plan*

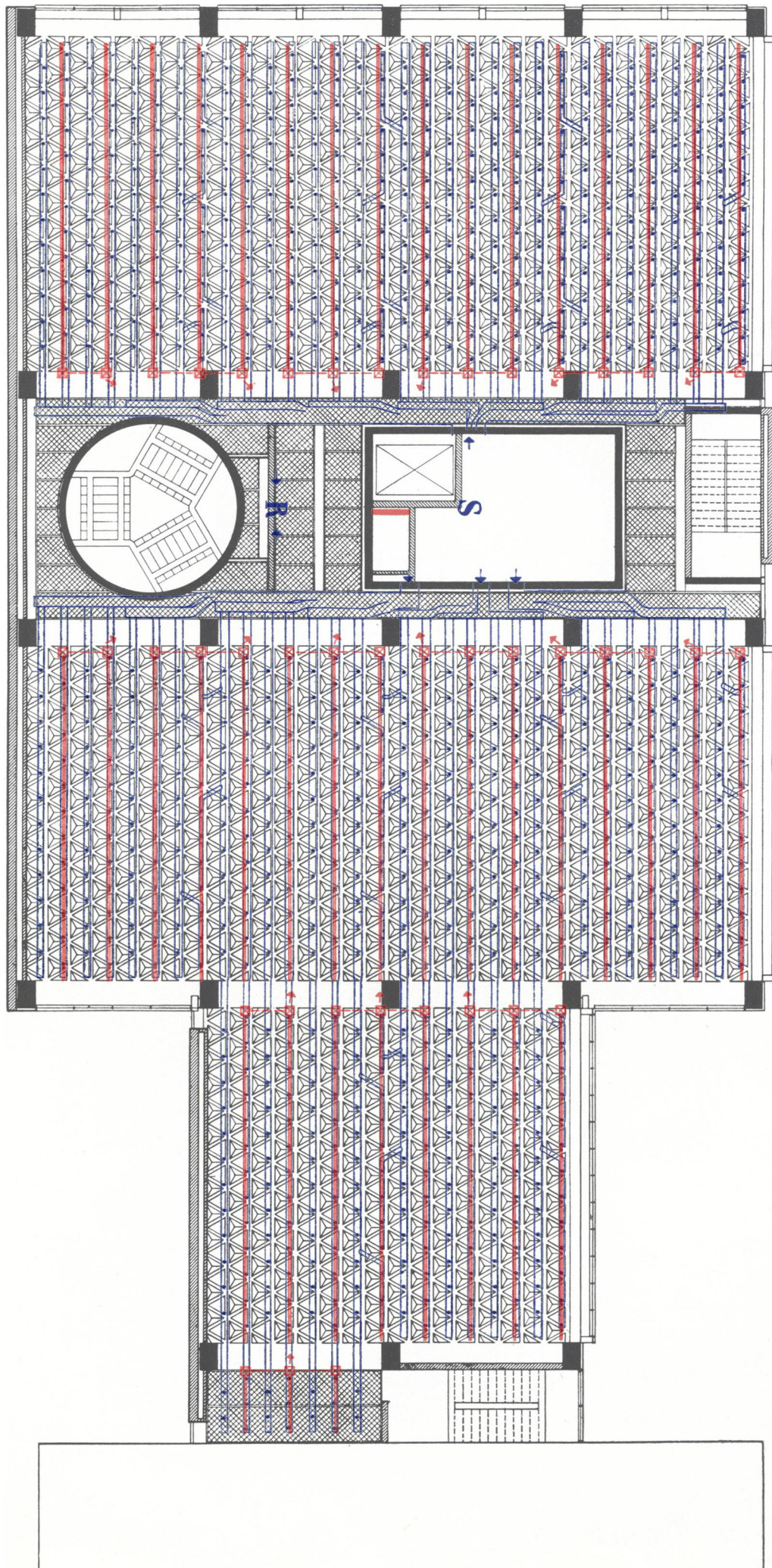


*Reflected ceiling plan*

***Ventilation.***



*Reflected ceiling plan*  
***Electrical distribution***



Reflected ceiling plan  
*Electrical distribution*  
*Ventilation.*

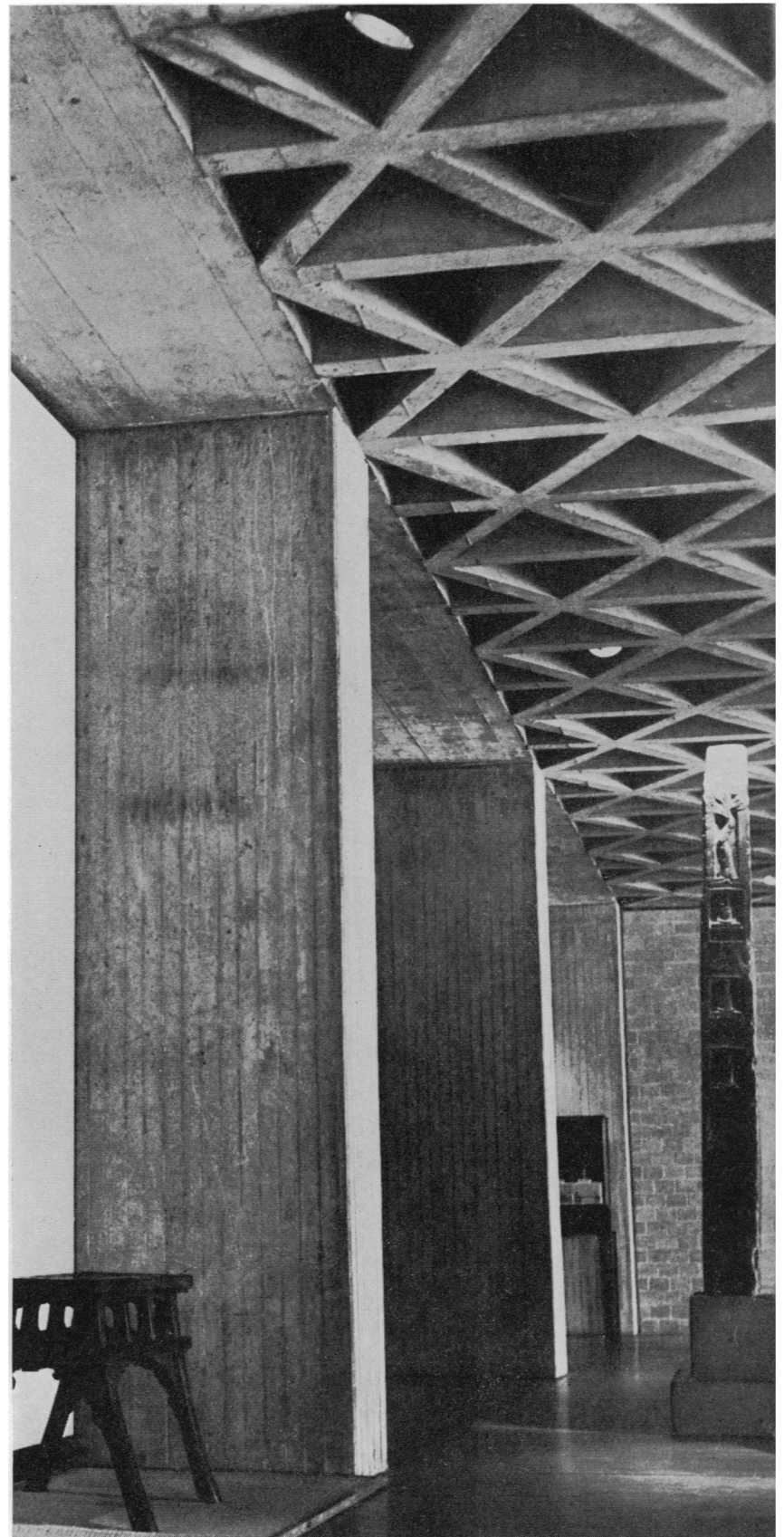


But what would the slabs be like? Would they be vaulted? The idea did not leave Mr. Kahn's mind that, somehow, the slabs should be hollow, with air-conditioning ducts running inside. At that time, Buckminster Fuller was lecturing at Yale on his triangulated spherical structures. Suddenly, it occurred to Louis Kahn: the slabs could be triangulated "space frames!" He built a model in which, as Henry A. Pfisterer, the consulting engineer points out, "... a continuous plane element was fastened to the apices of open-base, hollow, equilateral tetrahedrons, joined at the vertices of the triangles in the lower plane". Structurally, this defined a "parallel chord, multi-planar system of equilateral triangles with the top surface providing the floor, and with alternate inclined triangles, in each of the three directions also made solid". Electric bus bars and air conditioning ducts would run in the cavities of the floor system, making it into one huge lung, which would supply the space below with air, light and power. The busy pattern of deep, open tetrahedrons would help to break up the sound and cut down the noise in the large exhibition spaces.

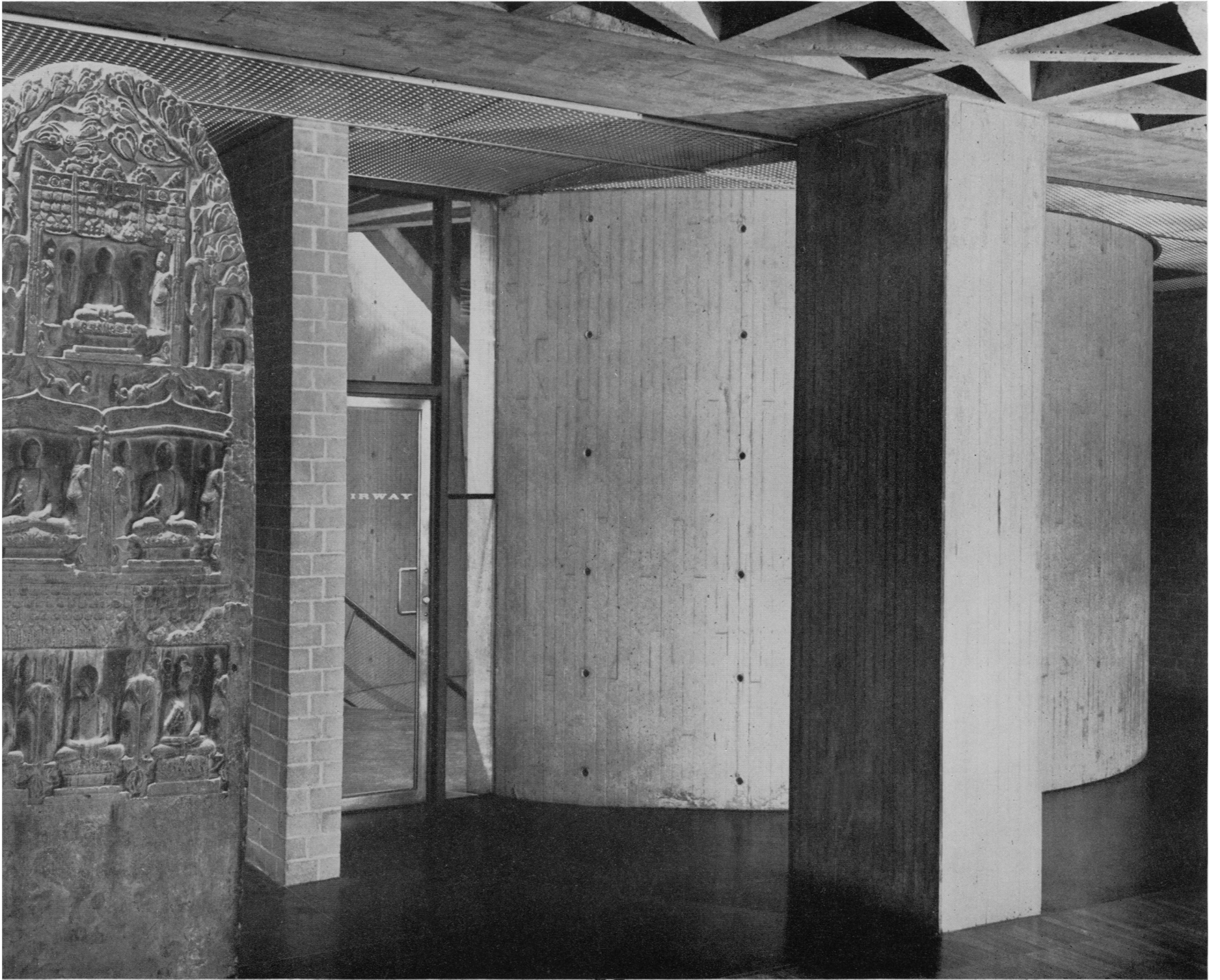
The structural model could not be literally translated into reinforced concrete, for the small crosssections at the points of contact between tetrahedrons would not transmit shear forces. For the final design, a modified system was accepted by Mr. Pfisterer. This system "consists of concrete T-beams, with deep inclined stems spanning 40 feet between centers of supporting girders, combined with triangular inclined bridging elements", which have the visual effect of the original concept, and provide accessibility for electrical and mechanical distribution.

The complicated job of pouring the intricate rib system was facilitated by an ingenious system of re-usable metal forms, developed by the Contractor, the George B. H. Macomber Co. The metal forms of the ribs were securely screwed to a plywood deck to avoid uplift and broken edges; then the ribs were poured with stirrups protruding, to provide anchorage with the top slab, which was poured after removal of outer rib forms and supported, during placement, by acoustical material which forms the ceiling of the cavities between tetrahedrons. The air conditioning ducts and electrical conduits were put into the rib system before the top slab was poured. Such an integrated sequence of work-processes required precise coordination of all trades and tight schedules, yet resulted in an overall time saving.

It is the conviction of Mr. Kahn that if a new tradition of ornament is to be born in our age, that ornament will stem from the methods of construction. Mr. Kahn loves the construction joint, the form imprint; he hates patch-up work. Thus he left the tetrahedral rib structure raw, without cleaning or painting, to keep the freshness of surface which derived from its forms. The day the first forms were stripped and the tetrahedrons appeared in daylight was an event anticipated weeks in advance.



*Photograph on opposite page by John Ebstel.*



*Photo by John Ebstel.*

*Left: Cylindrical enclosure of the triangular stairway, shown on page 50.*

*Right: Gallery floor, demonstrating flexibility of lighting and "pogo-stick" panels.*



*Photo by Louis Glaessman.*



*Photograph by Louis Glessmann.*





The workmen, realizing that materials will be left exposed and that whatever is done in the beginning will remain visible, showed conscientious care. Several left conventional jobs which were under way in the city at the same time, to work on a project that stimulated their interest and pride. Notable results of their efforts are: the high quality of wood formwork on the concrete columns; the precision of brickwork on the South facade and of the exposed interior concrete-block walls. Kenneth Froberg, the superintendent on the job, should be credited with maintaining high standards of workmanship throughout. The working drawings were prepared by the office of Douglas Orr, Architect, from drawings furnished by Mr. Kahn.

By a sensitive use of joints, textures and form imprints, Mr. Kahn lovingly expresses the potentially noble character of his materials: concrete, wood, glazed brick, small concrete block and the steel of the window wall. One might feel that only persons, who are in flight from themselves, who need plaster and wallpaper for their emotional security, can be uncomfortable in this building. Its planes speak of Being and Truth. In its spaces there is no room for the interior decorator.

The building is also a striking lesson in the utilization of light in architecture. Practically all the illumination is provided by two types of lighting fixture, which are mounted within the tetrahedral cavities on trolley duct fittings, permitting instantaneous removal or attachment of any unit at

any point on the ceiling. Both fixtures were designed and manufactured for the Gallery by Edison Price Inc., of New York.\* The lighting consultant was Richard Kelly. The overall ceiling impression is an exciting pattern of triangles of light.

Acoustically, the ceiling system catches much of the excessive noise in the tetrahedral pattern, where it is broken up and absorbed by the soft material at the soffit. The air distribution through the round ducts, visible if one looks straight up into the ceiling, is also efficient. Display background in exhibit areas is provided by instantly removable plywood panels, suggested by George Howe. They stand on rubber-tipped feet and have similar spring-mounted "pogo-stick" projections at the top, which press against the ceiling.

Conceptually, visually and functionally, Mr. Kahn's tetrahedral slab, which is really THE feature of the Gallery, must be termed a major success. The price for it was paid, first, in terms of money: the forming and placing costs of concrete were high. However, this expense was

\* The "Elipsol", used to illuminate non-exhibit areas, has a focusing mechanism to control illumination and distribution. Making use of the natural shielding of the tetrahedron the fixture's silverbowl lamp and reflector have no brightness at direct glare angles; the semi-specular reflector finish creates a relatively large source area, which reduces reflected glare. The beam distribution is calculated to reduce spill on the tetrahedron surface to a minimum.—The "Parlite" is a fixture to light specific objects in exhibit areas. Surface brightness of the lamp and the Spredlens are shielded, and an external handle allows the exhibitor to rotate the fixture and to swivel it in vertical angle.



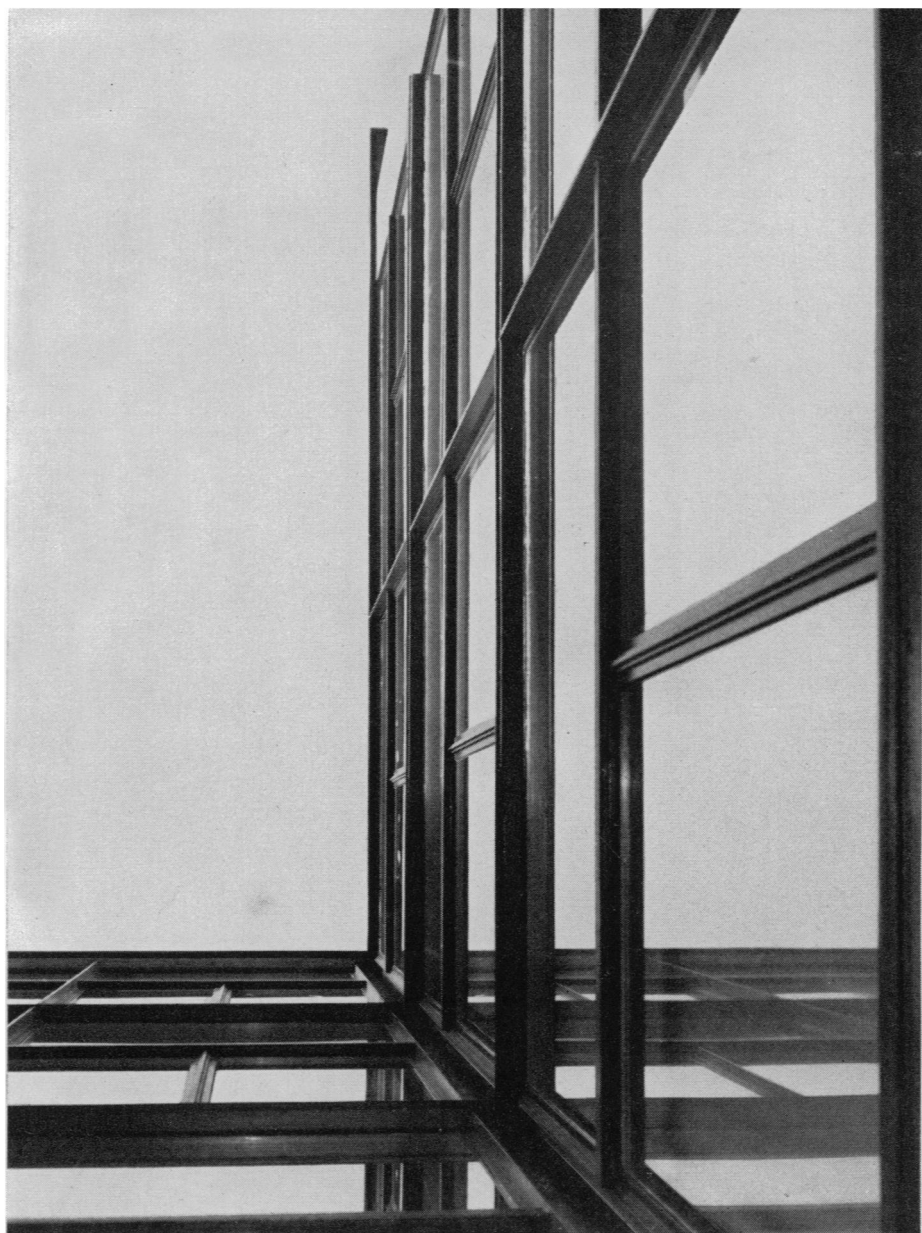
*Text by Boris Pushkarev. Photographs not otherwise noted by Sanford Meech.*

offset by lack of plaster and acoustical tile—the only finish in the building is paint on metal and plywood. Thus the total cost stayed within the budget. Second, the price was payed in terms of structural efficiency: with a design live load of 100 lb. per sq. ft., the weight of the floor system amounts to 155 lb. per sq. ft., and its overall depth is 2' 4". Naturally, such a system is very rigid — the maximum center deflection on the 40' span under double live load (a test, required by the building code) was merely .211 inches. The excessive weight could have been, theoretically, cut down by using lighter cross-sections of the concrete ribs (these are at present 5" for main ribs and 3½" for stiffening members, based on 1½" fireproofing). However, the concrete placing experience indicated that the thicknesses used are a reasonable minimum for cast-in-place work of this type.

Mr. Kahn acknowledges that, while formulating his design concept, he was not fully aware of the potentialities of multi-planar truss systems. If he were building the Gallery today, he most probably would have followed the geometry of the ceiling through in the spacing of the columns, and thus come closer to the translation of forces. A hexagonal

module, for instance, would have enabled him to transmit direct loads in all six directions, instead of only in two, and thus would make the system a genuine "space frame". Such a system would make possible cantilevers along the edges of the building, which would eliminate some awkward intersections and the basic inconsistency of a triangular order inscribed into a rectangular one; the number of columns would be reduced. A non-rectangular column module could also have stimulated a rich expression of the inside on the outside. Today, the north wall (mostly of glass) has very elegant proportions and a strong play of mass and shadow, while the south wall (all brick) has a quiet, dignified serenity of its own, which respects the adjacent old Gallery. Both walls are expressed as screens applied from the outside, and are not intimately related to the inside nor to each other.

Mr. Kahn would be the last to claim that his building is without faults. Still, to stand in Weir Court on a calm evening and to look through the transparent walls to the layer upon layer of tetrahedrons, permeated by their inner glow, is to feel that this building has a vitality of its own: permanent and worthy of endurance.



Louis Glessmann



*Detail of stairway to sculpture court. Granite slabs rest on inclined reinforced concrete beams; the two lower slabs rest on the ground.*

*Skillful use of standard steel sections gives richness and plasticity to glass curtain wall.*



Louis Glessmann





**Order is****Design** is form-making in order

Form emerges out of a system of construction

Growth is a construction

In **order** is creative forceIn **design** is the means—where with what when with how much

The nature of space reflects what it wants to be

Is the auditorium a Stradavarius

or is it an ear

Is the auditorium a creative instrument

keyed to Bach or Bartok

played by the conductor

or is it a convention hall

In the nature of space is the spirit and the will to exist a certain way

**Design** must closely follow that will

Therefore a stripe painted horse is not a zebra.

Before a railroad station is a building

it wants to be a street

it grows out of the needs of street

out of the order of movement

A meeting of contours englazed.

Thru the nature—why

Thru the **order**—whatThru **design**—how

A Form emerges from the structural elements inherent in the form.

A dome is not conceived when questions arise how to build it.

Nervi grows an arch

Fuller grows a dome

Mozart's compositions are designs

They are exercises of **order**—intuitive**Design** encourages more designs

Designs derive their imagery from order

Imagery is the memory—the Form

Style is an adopted order

The same **order** created the elephant and created man

They are different designs

Begun from different aspirations

Shaped from different circumstances

**Order does not imply Beauty**

The same order created the dwarf and Adonis

**Design** is not making Beauty

Beauty emerges from selection

affinities

integration

love

Art is a form making life in order—psychic

**Order is intangible**

It is a level of creative consciousness

forever becoming higher in level

The higher the order the more diversity in **design****Order supports integration**

From what the space wants to be the unfamiliar may be revealed to the architect.

From order he will derive creative force and power of self criticism

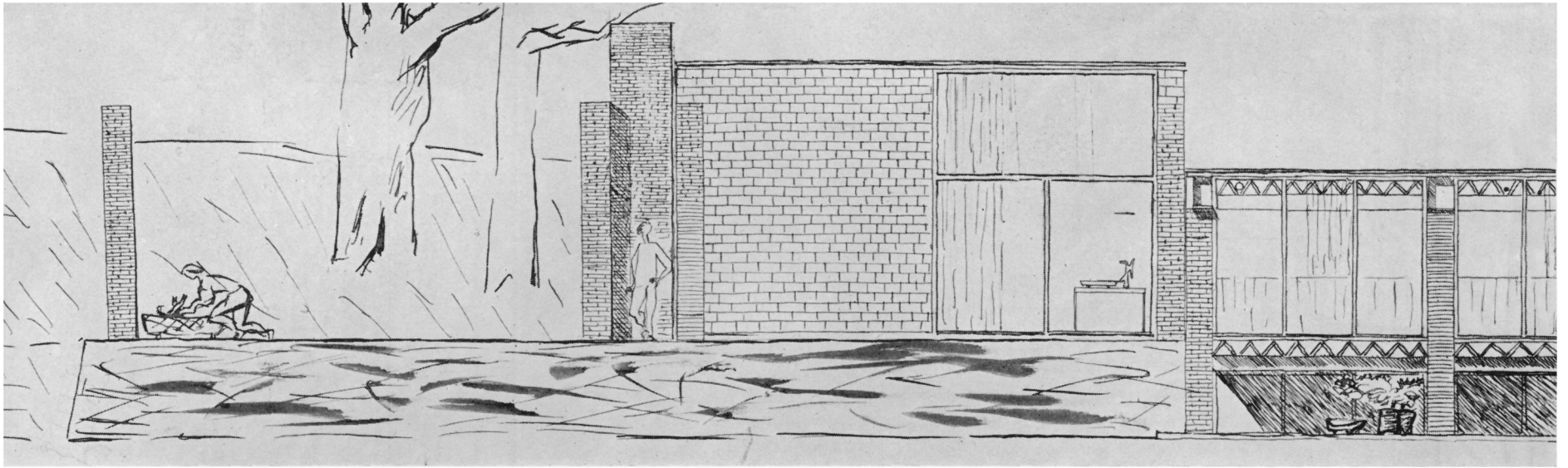
to give form to this unfamiliar.

Beauty will evolve

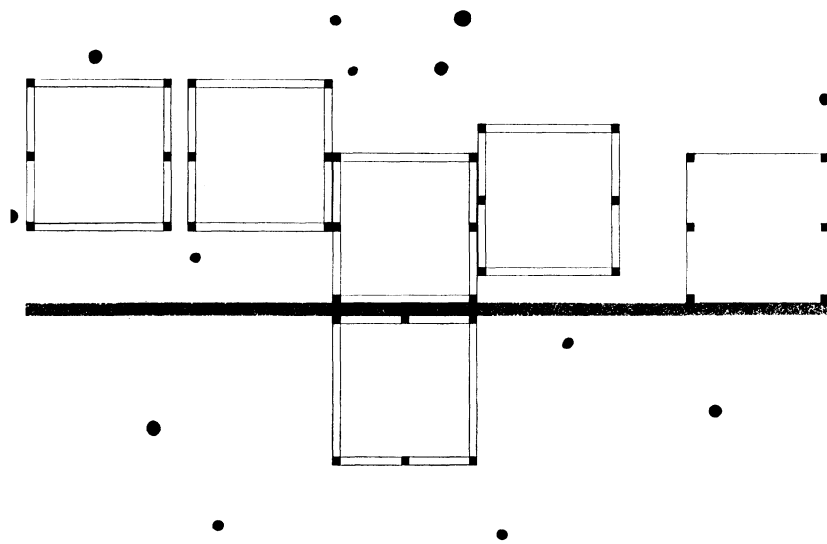
**Louis I. Kahn**

Night photo by Lionel Freedman.

Color photo by John Ebstel.

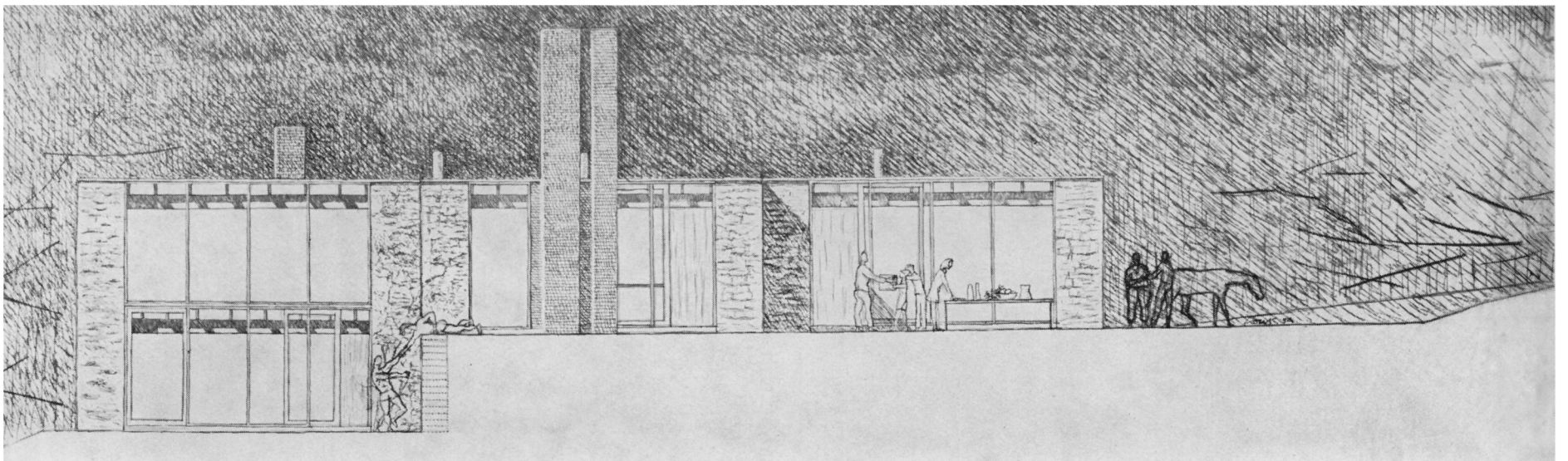


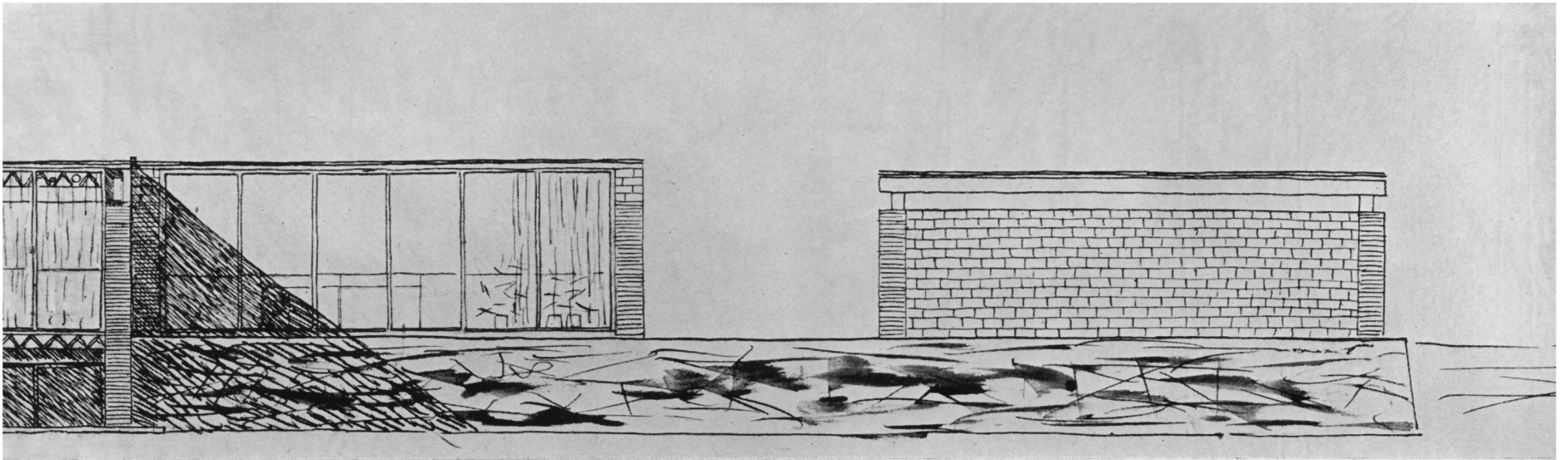
*de Vore*



*The Kitchen wants to be the Living Room.  
 The Bed Room wants to be a little house by itself.  
 The car is the room on wheels.  
 In searching for the nature of the spaces of house  
 might they not be separated a distance from each other  
 theoretically before they are brought together.  
 A predetermined total form might inhibit what the  
 various spaces want to be. Architectural interpretations  
 accepted without reflection could obscure the  
 search for signs of a true nature and a higher order.  
 The order of construction should suggest an even  
 greater variety or design in the interpretations  
 of what space aspires to become and more versatility  
 in expression of the ever present problems of  
 levels, services, the sun, the wind and the rain.*

*Adler*





## two houses

Each house is a cluster of square areas 26' on a side. They grow out of the same order. The designs are different.

### *Adler*

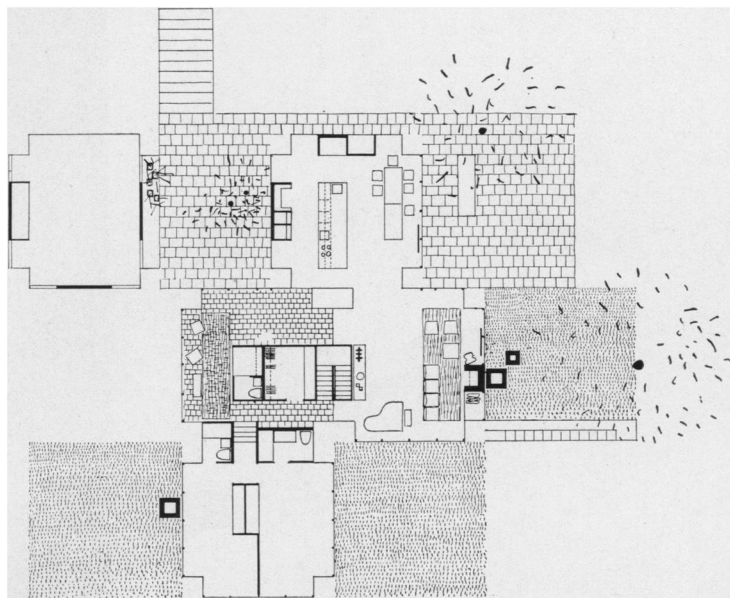
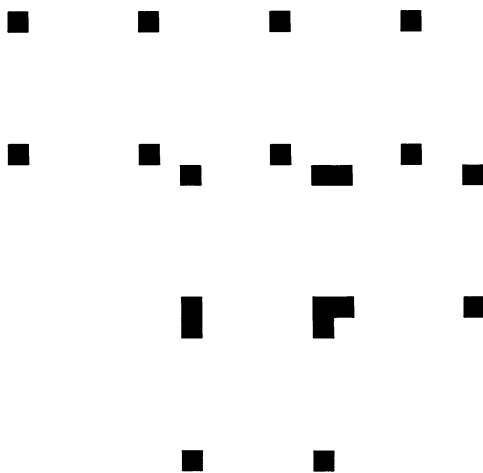
*Stone piers 3'6" square in the four corners of each square area. Each square is a whole structure. Criss-cross timber roof rests on the inner edges of the piers. Each square roof area is supported independently, drained independently and seen as an entity from the ground and from above. Piers gathered to form space for closets, bath rooms, fire places, vertical shafts, for ducts and a well for a stairway. The system of criss-cross joists inherently makes possible the construction for well and also the cantilever to complete the roof or the floor. To satisfy the order the design purposely created the piers heavier than necessary for support.*

### *DeVore*

*Six 18" square brick piers to the square. Roof joists are pairs of 2 x 12's inclined to each other at 60°. Spaces between piers enclosed by brick cavity wall and by glass. Brick of cavity walls laid in non supporting manner to distinguish from the brick supporting piers. Hollow lead "little houses" are inserted in the unprotected spaces left on the piers. One of these is open at the top in each square roof area acting as a roof drain and has a tongue for spouting.*

The intention in these 2 houses is an order of construction which provides the avenues to harbor today's complex mechanical requirements including complete air conditioning.

In the Adler House the ducts are visible. In the De Vore house, round black ducts are tucked in the "V" areas of the roof system and are not visible. Both systems express their purpose though the circumstances lead to the use of different materials and different devices. Design is not a product, it is a means.



The assembly building rests on a circular plaza cut into the slope of a 5 acre estate.

The retaining wall following the rise in the land casts a half moon shadow on the plaza.

The car dock is inclined with the land and designed for slow movement.

Parking is separated from movement by posts as tall as a man about 20' apart which also serves to light the cobbled paving of the dock.

The circular sidewalk follows the 6% slope of the dock at and above the plaza level and continues on to dip below the plaza level for the circulation needs toward east.

The rest of the site will be developed as places for relaxation and the enjoyment of nature's designs.

Beth Knesset or House of Assembly is on two levels each for a different purpose. On the lower or plaza level is the auditorium and its needs for social and cultural purposes. The higher level is the Synagogue.

Beth Sefer or House of Books (school) adjoins the lower level of the Knesseth. The classrooms communicate with a long interior open court for study and contemplation.

Three major column clusters of 9 columns each in the form of an open triangle 26' on the side support a tetrahedral space slab. These three areas of support unfold loosely to form entrance porticoes and porches on the north and south and unfold and again unfold to form Beth Midrash or Study Chapel on the east behind the Bimah.

Each column cluster harbors a stairway as though captured in a great hollow trunk. The columns thus spread grips the floor and roof structure like outspread fingers.

It is what the space wants to be. A place to assemble under a tree.

*Louis I. Kahn*

*This page: second level*

*Opposite page: ground level*

# a synagogue

(adath jeshurun of philadelphia)

