The Temporary and the Permanent

by

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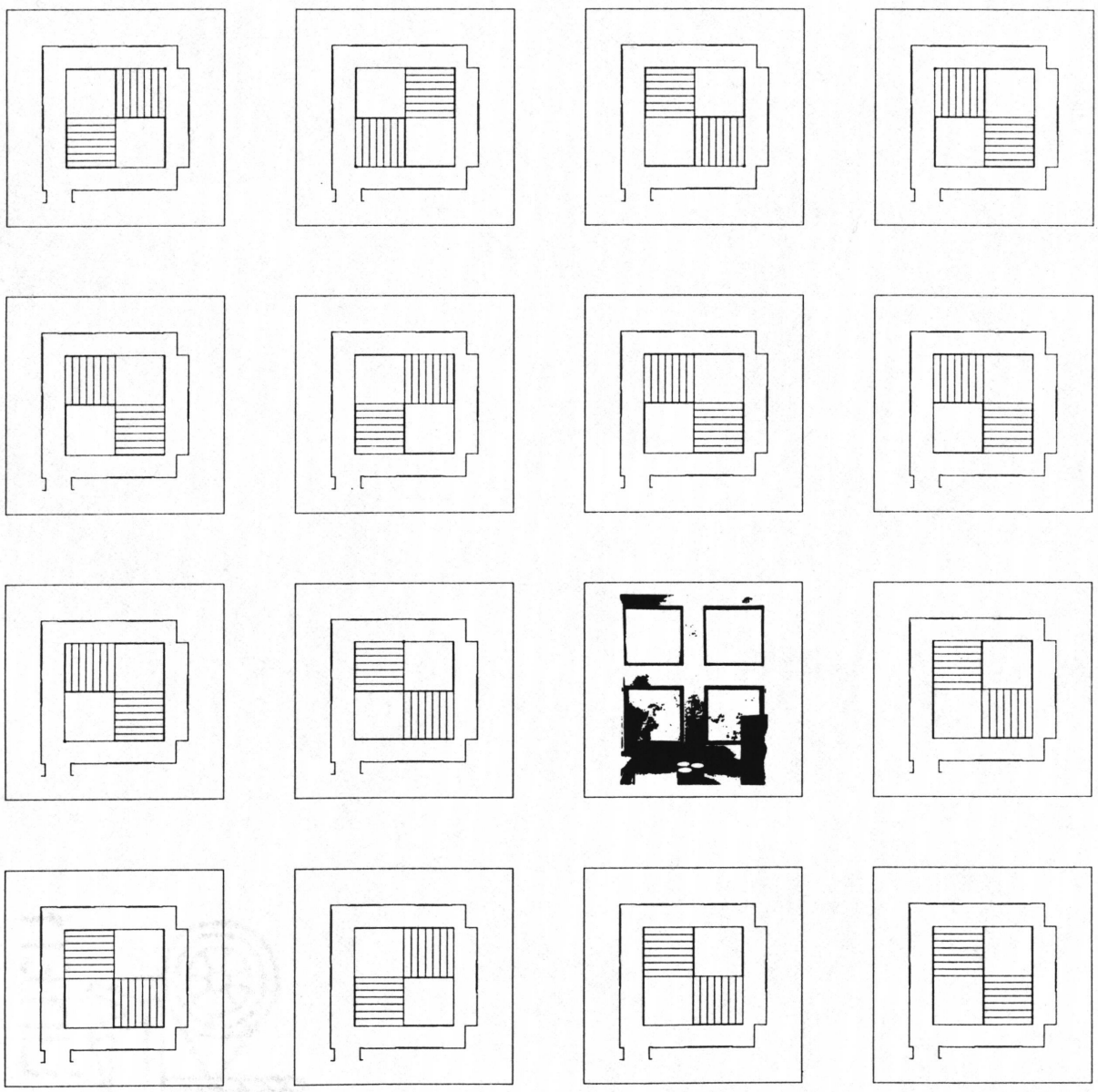
The Temporary and the Permanent

Architectural Order under the Aspect of Flexibility



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Abstract

Since the introduction of mass production, building flexibility has been a leading economic factor in the planning of industrial and commercial facilities. Technological progress not only affects production conditions, but also constantly redefines requirements for spatial quality and the building conception.

For the benefit of architectural meaning, and a work environment that can meet human requirements under changing conditions, planning methods and architectural concepts must distinguish between spaces with different flexibility demands. The sum of functions in a building can be divided in work-related and people-related activities. Work-related activities are production-oriented involving a relatively high degree of technology. People-related activities are oriented toward the basic human needs involving a relatively low degree of flexibility. Whereas work-related functions have a high frequency of change affecting the building in many degrees, people-related spaces hardly ever change experiencing rearrangements rather than construction work. In architectural design, the relationship between these two different types of space finds expression.

As examples in the past show, there is a variety of architectural interpretation of flexibility. The ability to replace elements in a building's metabolic transformation is influenced by architectural order. In the design of a Research and Development Center an order is created serving work and people functions and distinguishing between temporary and permanent areas.

When the design of a building is understood as a creation of ideas, and construction as putting these ideas into reality, then a building is only created once, and every change or growth will be just another construction phase. Under these circumstances, the act of creating the basis for flexibility requires the knowledge about quantity, quality and location of changes at a time when the building, its use and its user configuration do not exist. Since form and function are closely tied together, designing for flexibility will influence form. In the past, what was thought to be the most flexible building tended to have the most unspecific form. It must be the contribution of architecture to achieve both, the adaptability for change, and the ability to express and interpret time, place and meaning.

Acknowledgments

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I Six Questions on
Flexibility in Architecture

What is "Flexibility"?

In architecture, the term 'flexibility' is understood as the fitness of a building for changes in technology, occupants and purpose[1]. Two forms of flexibility must be distinguished: Flexibility for changes within a building and flexibility for growth. Whereas flexibility within a building is often referred to as adaptability, flexibility for growth is the ability to expand. Changes within a building are often of a qualitative nature, expansion is a quantitative change. Buildings may have either or both forms of flexibility. Demands for flexibility can be found in all types of buildings, as long as changes in technology, occupants or purpose must be considered.

However, in non-residential buildings, flexibility is closely tied to economy which influences the decision making criteria in planning and design significantly. Commercial and industrial buildings often experience a higher frequency of changes than residential buildings.

Why is Flexibility a Problem?

Designing for flexibility means designing for unpredictable changes. Progress and economy force organizations to constantly update their resources. This causes a single function as well as the range of functions in a building to vary over time. Organizational relationships in buildings change as companies grow older and functions tend to specialize into individual buildings as the organization matures[2].

In the planning for flexibility, the requirements of quantity and quality assume changes at a point in time, when the building, its purpose and its user configuration do not yet exist. During planning and design, necessary information about size, material or configuration of building elements to guarantee flexibility often cannot be obtained. Due to the lack of knowledge about future changes, a certain degree of flexibility is assumed according to past experience.

Designing for multi-purpose means increasing the complexity of relationships in a building. The accommodation of a variety of possible functions increases the complexity of programmatic interactions and the potential rate of changes. Interactions between a building's technology, users and purpose must be known before implementing the change to predict the impact of a defined alteration on the building. The complexity of possible changes and the coupling of building systems, structure and human activities will result in failure of a building as an entity to adapt to new needs, when the chain reactions caused by a single or several changes unbalance the relationships in a building. As functional requirements of a given situation are reflected in a specific form, reasons for existing buildings failing to adapt to necessary functional changes are closely tied to their design.

In a study on obsolescent industrial buildings in the US[3], most of the reasons for plant closings originated in their design. Building characteristics like insufficient ceiling heights and unusable floor space could not be adapted to new needs. Due to the lack of site and master planning, the building configuration of some companies restricted production improvements. The fact that many work places were in bad condition did not only influence the quality of the product negatively, but harmed the companies' image so that many customers retreated from orders. Often, the operation of the buildings and their maintenance was not considered in decisions of planning, design and construction. As a result, the cost of maintaining the existing situation eventually ended up being more expensive than building a new factory.

Does Flexibility Affect Architecture?

Flexibility influences architecture through the program, the technology, and the aesthetics of a building.

An economic factor, flexibility evaluates a design by its fitness for change. The spatial conception and the

choice of structure and materials will follow the criteria for flexibility established in the program. The indoors must be comfortable for people during all phases of change, causing as little distraction and health risks as possible. Climatic impacts of changed building conditions, such as daylighting and wind, are not only reasons for discomfort, but can also harm the design's original intention and expression.

A sign of our time, flexibilty influences a building's conception, its shape and its details. It is through these latter components that we experience space. However, if a form is defined by its function, and this function is subject to a constant metabolic transformation, the design process will produce a neutral object, lacking architectural expression and meaning.

How Has Flexibility Been Expressed in the Past?

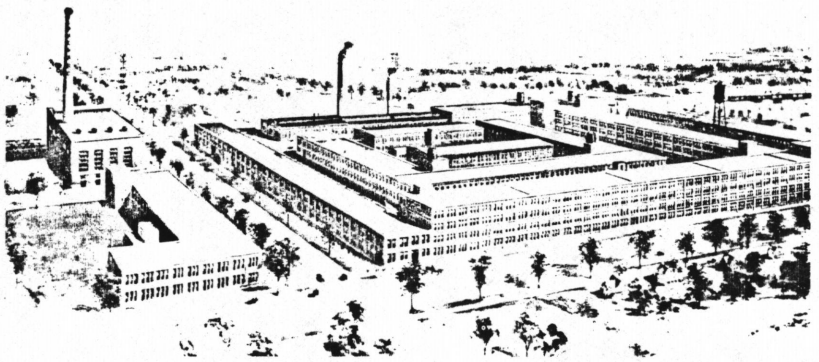
If it is true that form and function correspond with each other, flexibility as a special function must have had influence on architecture in the past.

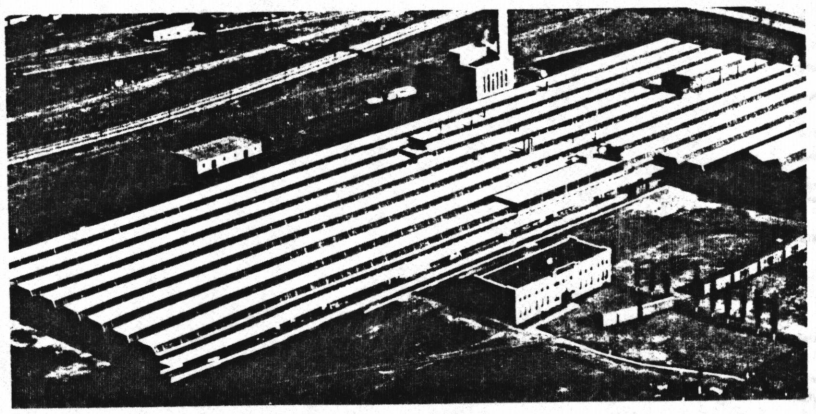
A wide range of different definitions and theories on flexibility throughout the decades resulted in a multitude of design solutions. The following examples developed innovative forms and concepts taking flexibility into consideration.

Albert Kahn: Form Follows Production Flow

"... avoidance of unnecessary ornamentation, simplicity and proper respect for cost of maintenance, make a type which , though strictly utilitarian and functional, has distinct architectural merit." [4]
(Albert Kahn)

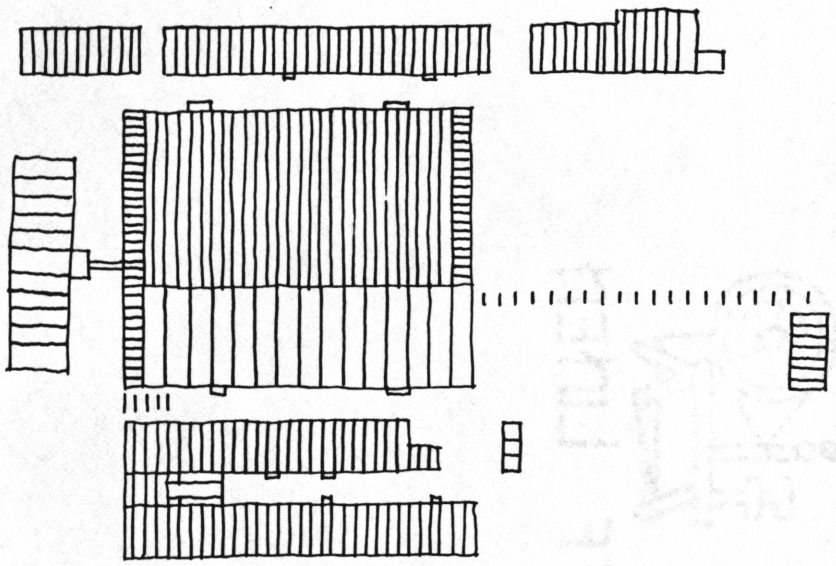
The introduction of the assembly line by Henry Ford in 1913 marked a significant change in the layout of manufacturing facilities. The new product 'automobile' needed to be manufactured in mass production to satisfy the market. For the kind of mass production Henry Ford planned, the design and layout of existing manufacturing plants was too limited. Fast expansion and change in technology that would affect both, the product and the production could not take place in an environment of individually specialized building types with short horizontal span and heavy floor and roof construction. Before 1913, manufacturing a car required a multi-story building, since the material flow was vertical following gravity. However, in the mass production of automobiles, material flow and the fitness for fast expansion determined form and functional relationships. Layout of the production and material handling had a direct influence on production time and cost. Flexibility in both, product and material handling was a key factor in the decision making with emphasis on spatial expansion.





Top right:
Packard Motor Company, 1903

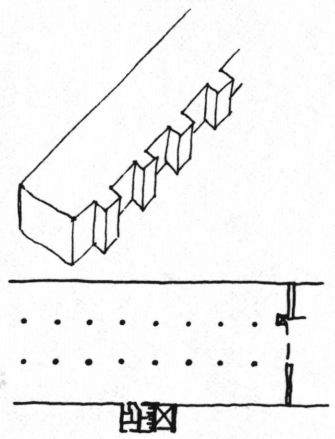
Bottom right:
Commercial Body Plant, 1938



Grid Order
Geo N. Pierce Plant

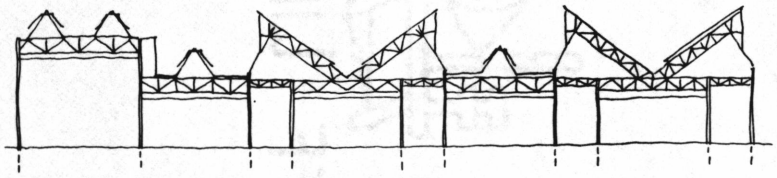
Program, structure and cost were the criteria that directed the design of Albert Kahn's factories. His concern for the suitability of a building to its purpose was what made the material flow the shaping force already in the design phase. Albert Kahn's first industrial buildings followed the traditional model of different building types following functional and structural needs of the processes they were housing. Brick was the predominant building material, and the structural span of these buildings was limited. For the concept of mass production, a new planning approach was necessary. The basis for Albert Kahn's designs is a grid organizing the master plan. Each major building on the site is included. The rectangular grid allows to increase the distance between columns by omitting one or several modular units. In the cross section, bay sizes vary in span and ceiling or roof height, depending on production requirements. In the longitudinal direction, the length of bays can vary depending on process flows. It is in this longitudinal direction that future expansion occurs. Accordingly, other buildings on the site do not interfere with the expansion area. Necessary circulation or connections in the expansion area are held on a temporary level. In case of the Geo N. Pierce Plant, the motor testing building (on the right side of the master plan) was to be the other end of the assembly building, once the last construction phase was reached. In the meantime, a trolley way served as a connection between the two still separate buildings. Albert Kahn used this grid system not only in very early automobile factories, but also later in other branches of manufacturing industries.

The modular grid is the order combining different activities under one roof. However, this concept introduced new requirements for the structural system. As windows alone could not provide the degree of illumination and ventilation needed for the deep floor plans, the new structure had not only an increased span , but also featured skylights providing daylight and ventilation in the production areas. Therefore, width and length of plants could be increased and the distance between machines decreased for the benefit of more usable floor space. Furthermore, the more even light distribution led to more freedom in the layout of production activities. A design criteria that provided flexibility in the everything-under-one-roof concept is the uninterrupted floor space. Functions adjacent to production areas like technical rooms, bathrooms, locker rooms, cafeterias and circulation elements such as staircases had to be separated from production and other expansion areas to accommodate changes in the production flow in an easier and faster way. There are basically four different locations for the support areas: In the Ford Highland Plant (1910), the utilities are pushed to the outside of the production building as separate elements. In the Eagle Plant of 1918, these supporting rooms are housed in a 26 ft wide bay parallel to the production bays. Material for all the bearing parts was wood for easy removal of these spaces in case of expansion. A 40 ft wide gallery with lockers and bathrooms in the center of the Ford Glass Plant (1922) shortened the walking distance between work place and utilities. In the case of the Curtis-Wright plane factory, the circulation system and utility rooms were located in the basement (in connection with the entrance on the building's lower level).



Separation of production and support rooms

Louis Kahn:
Servant and Served



Typical roof structure

The dream of unlimited expansion of manufacturing bays could be lived with the development of improved daylighting through the roof and a transparent column and beam structure that could be asymmetric and irregular where necessary. For the sake of expansion, the grid controlled the master plan in a way that formally produced an unlimited whole. Emphasis of the design effort was on the individuality of production bays making them suitable for planned equipment and material handling . A cross section developed for that purpose could be applied unlimitedly, creating a set of long bays that together formed the entity of activities under one roof. With the strict separation of functions into different bays, adjustments could be made for each production activity separately using the same structural elements. Standardization and repetition of a beam and column system developed to suit a defined purpose of a factory. A change of use could happen as long as the building's structure obeyed to the new requirements.

Material was selected on a project to project basis. For the Ford plants, mainly steel was used which made expansion and changes easier and quicker. Other factories, especially earlier ones, have concrete structures that proofed to have advantages in fire protection and maintenance of parts and surfaces in the industrial environment.

Although most attention was given to the housing of the production, personnel and service areas had gained importance as they found architectural expression.

"... if walls were opened up and made hollow, they could become actual rooms for the accommodation of ducts, pipes, and wires, thus providing services to living spaces without invading them."[5]
(Louis Kahn)

Louis Kahn derived his theory of architecture from the order of functions in living organisms. Like joints and knuckles in a hand, building elements should be expressions of their functions. The aesthetics in the formal interpretation of this function characterizes a building and makes it interesting and individual. As mechanical equipment played an increasingly important role for the supply of living conditions in a building, these functions had to be included in the organization of space. 'Making room' for services therefore meant hiding them permanently, leaving living spaces exclusively for human activities.

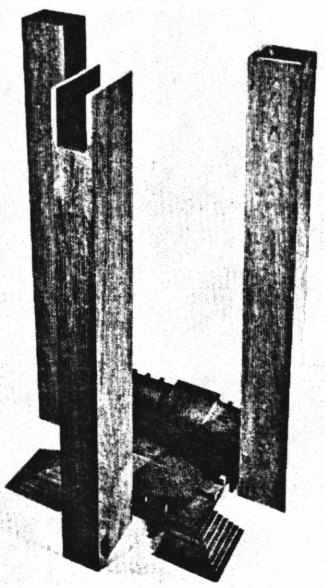
The idea of servant and served spaces is based on a balanced relationship between rooms, a network of many functionally different types of spaces interconnected by their abilities to serve other rooms or being served themselves. The architectural expression of their relationship varies depending from the kind of functions and the dimension of services.

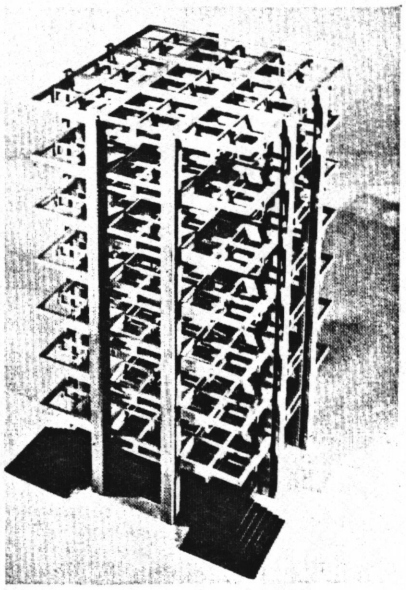
A functional core including kitchen, utility rooms, bathrooms and storage was mainly applied in residences and housing projects where economy and spatial efficiency had to be optimized.

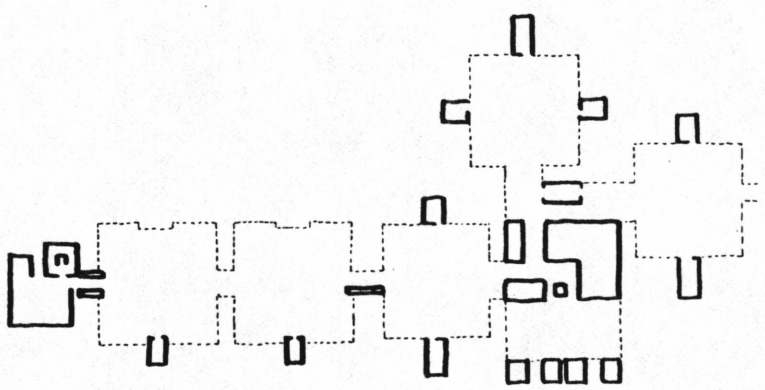
Structural voids in the form of the "breathing ceiling" or the "hollow column" combine structure and mechanical equipment. Vertical and horizontal distribution of air, water and electricity occurs in spaces that at the same time are part of the bearing structure of the building. Central shafts for mechanical equipment and staircases are grouped next to each other as a combined expression of vertical movement.

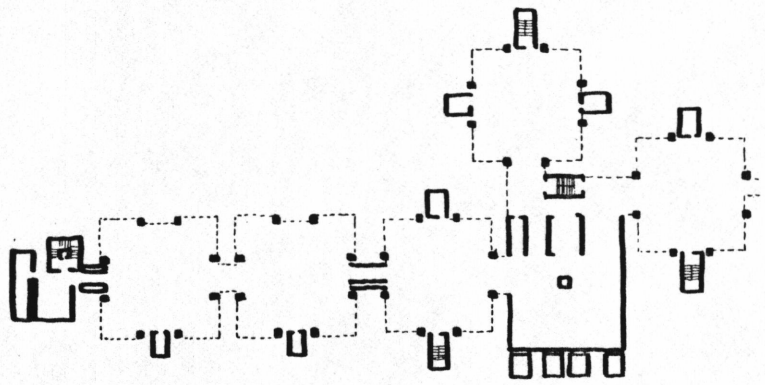
A separate space for the purpose of mechanical services only can be found in buildings where the rearrangement of equipment and space needs to occur independently from each other. For the same reason, human and process services find their expression in a separate set of vertical or horizontal spaces as a distinction between 'people laboratories' and 'pipe laboratories'.

Originally, the intention of organizing the servant elements was to control them, to keep them invisible in the living areas. As the demand for flexibility in buildings grew, the physical separation of servant and served in their architectural order had to find expression. Like structural functions, mechanical equipment was sculptured to communicate its task. However, the pipes themselves always stayed hidden behind an architectural skin.









Top to bottom:

Model studies showing servant shafts (left) and structure (right)

Analysis of servant rooms

Structural Analysis

Servant and served in the elevation

Richards Medical Research Laboratories
Philadelphia, Pennsylvania, 1957 - 61

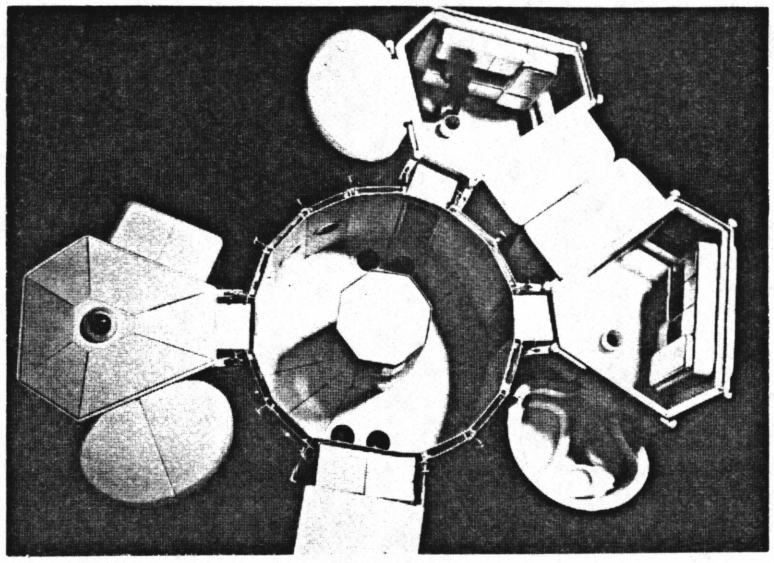
Metabolism: The Capsule

"Architecture from now on will increasingly take on the character of equipment.[6] *"*
(Kisho Kurokawa, 1969)

The metabolist movement dates back to the Japan of 1960, in the background of booming cities that had to exceed their natural patterns of growth to satisfy the new needs of housing. Metabolism therefore addresses urban planning for a society of greater mobility than traditionally experienced.

On the turn point from the energy to the information based society, change and growth in cities threatened to get out of control. Proposals for a new urbanism included Kikutake's 'Tower Shaped City' and 'Marine City' describing the three phases from the 'moveable equipment' to the 'moveable house' and the 'moveable city'.

Mobility and Movement are key issues in Metabolism. Transformation and metamorphosis had to be achieved by means of mass production and prefabrication of houses, a method that did not influence only building construction but also functional and spatial definition of living. The capsule as an architectural unit is thought to house human activities in an object that itself is meaningless, but together with its content evolves to a new form of existence. The capsule's abilities exceeds those of a traditional house in its movability and independence from land. Individuality is maintained by individually different grouping of capsules. As these clusters grow, they create social spaces in a "temporal community". The organization of space is shaped by the force of metabolism. The parts determine the form of the whole. A capsule is the architectural expression of a function. Many of these capsule spaces form an architectural structure defining space temporarily. Space and structure are identical in any number of capsules at any time.



Module of Capsule House, 1970

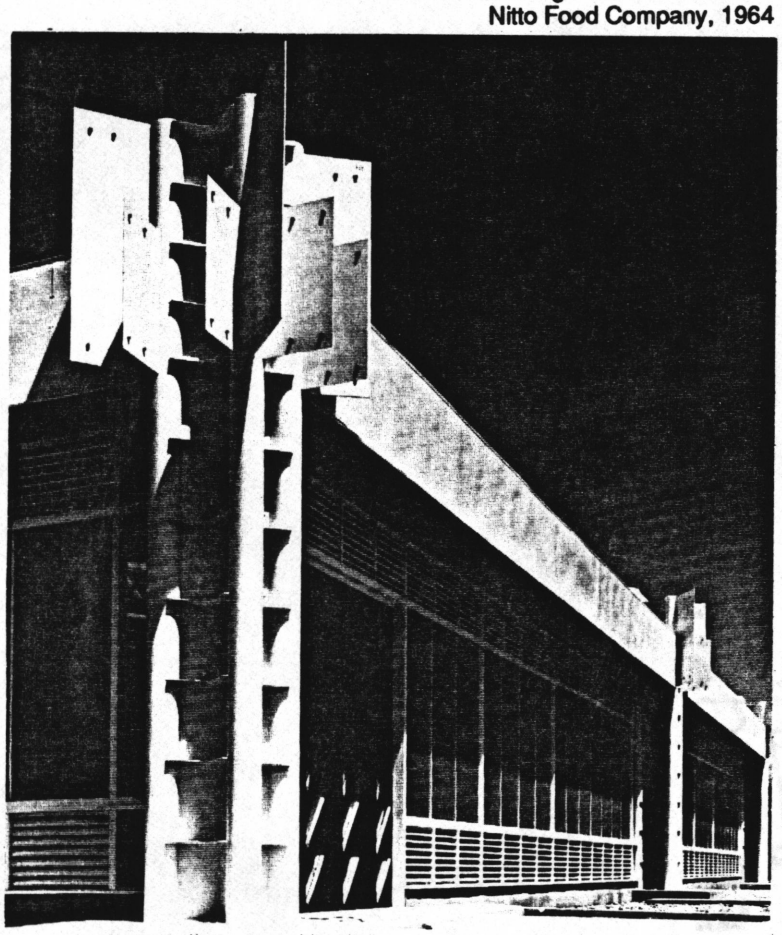
" When architecture is separated into parts and each part performs a complete function it is a functional unit."[7]
(Meta-architecture, 1962)

Metabolism distinguishes between a functional unit and a space unit. A functional unit corresponds with the change of parts to improve durability and adapts to social structures in space and equipment. The parts of the functional unit define this unit in a way that by replacing parts a redefinition of the function is possible. A clear separation of parts when selecting joints and size of parts is the basis for such a condition. Several functions form a space unit connecting servant and served spaces of varying characteristics and activity. Metabolism thrives toward physical separation of units to enhance quality improvement for living. The act of connecting metabolic spaces is thought to give meaning to the otherwise vacant structure and will always lead to a free form. Whereas Louis Kahn's approach balances served and servant rooms in a composition where structure and space are not identical, the metabolist concept supports a hierarchical differentiation of spaces according to their functions housed and their frequency of change.

The capsule is a prefabricated building. Its construction is a composition of functional units. The interchangeability and replacement of parts require standardization and mass production in a modular

system. Functional units and space units have different life cycles due to their different rates of change. A time module assigned to each unit during the production process determines the durability of elements. Exchangeable parts and spaces follow different patterns of dimensioning and durability. A modulation technique necessary to fabricate metabolic units considers dynamic and static modules. Whereas a dynamic module such as that used in the design of a mechanical equipment unit must be able to adapt to changes during its life cycle as a servant unit, a served space such as a bedroom would be an example for the use of a static module where a module for proportion like Le Corbusier's modulor directs design decisions. All modules are based on information about materials, production, processing, movement of parts, functional and space units, and life cycles. Since the conglomeration of different functional units that form a house include the use of different modules, the joint that achieves both separation and connection bears major importance in the design of the metabolist house. This joint follows a multi-dimensional module that focuses on common characteristics of the different elements. A standard measurement only applies to the individual module to guarantee replacement of parts and units, and freedom of form and design. Therefore, a plan for growth and change needs to deal with the individual module of a functional unit as well as with the joint module to produce flexibility in the long range.

Joining Plates
Nitto Food Company, 1964

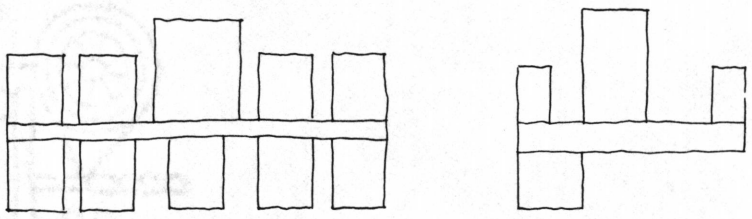


The Spine Concept

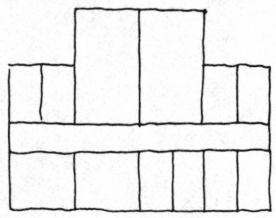
Frequent changes in product, production or management affect space, equipment and people in a facility. In planning the layout of a facility, long and short term objectives must be considered in the site plan. A flexible layout is characterized by easy rearrangements in a short time involving low cost. The spine concept therefore focuses on facility modularity to maintain flexibility. Departments can be altered individually without disrupting the production process. The central axis connects different departments by providing facility services, personnel circulation, material handling and communication systems. As an improvement of material handling, a central storage system can be integrated into the spine. Raw materials, products in process and end products can be combined in one place, shortening travel distances between storage and production.

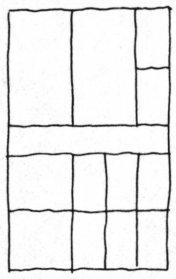
An ordering principle, the spine serves as an element of organization and connection of independent departments. There are basically two ways of expansion:

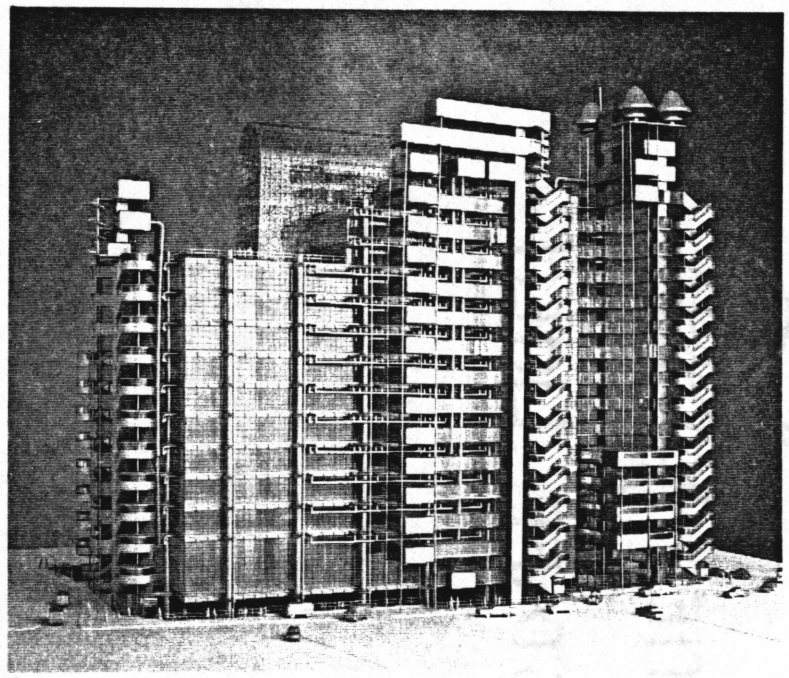
1. Standard-sized modular units contain different functions which can be completely exchanged during the facilities life cycle. The spine itself can form an I-, T- or X-shape.



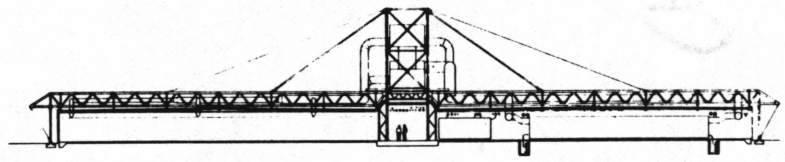
2. Modules with different functions and individually different sizes can be expanded in two directions. Thus, number and size of activities can be altered.



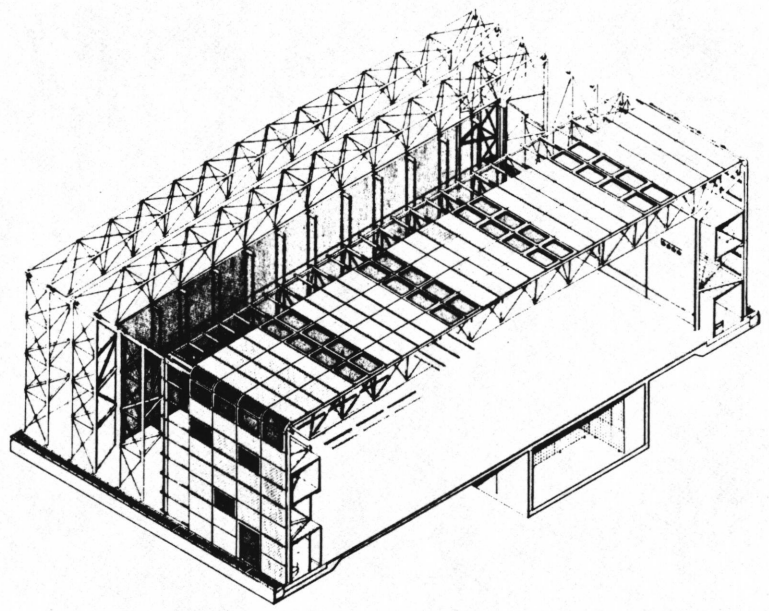




High-Tech Architecture: Inside-Out



Since the mid-70's, a new architectural direction has itself established. For the benefit of interior flexibility, services and structure are pushed to the building's exterior shell where they follow their own set of rules, free from spatial limits. Speaking in terms of servant and served, the relationship between services and space is formal separation. The desire for freedom of spatial organization in the interior and the accessibility to exchangeable units at the exterior causes a layering of building elements. However, the renewable services outside and the flexible space inside is at the expense of a limited form.



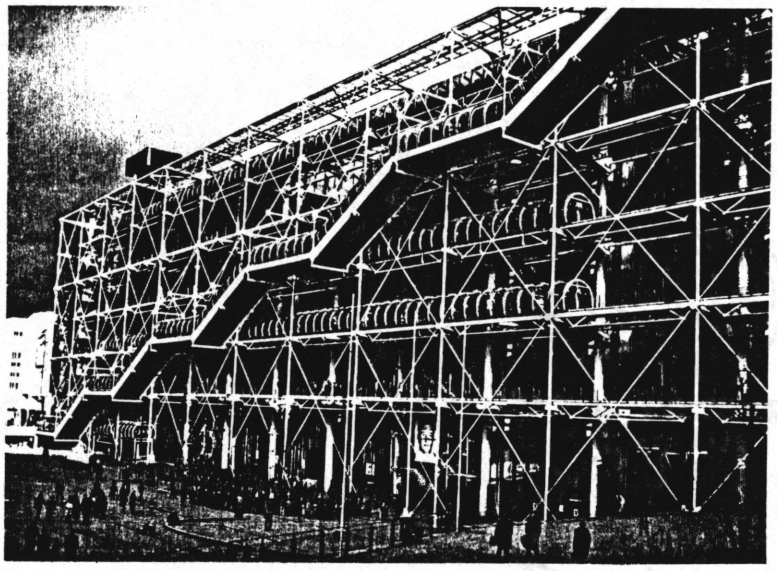
From top to bottom:

Lloyd's London
Model, 1978
Richard Rogers and Partners

Inmos
Section, 1982
Richard Rogers and Partners

Sainsbury Centre for the Visual Arts
1975 - 78
Norman Foster Assoc.

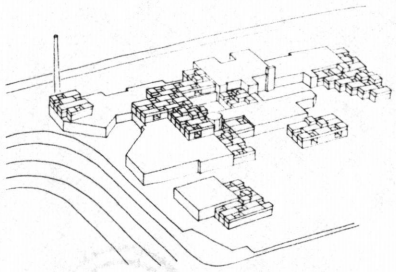
Centre Pompidou
1971 - 77



Herman Hertzberger: Structure as a "Polyvalent Form"

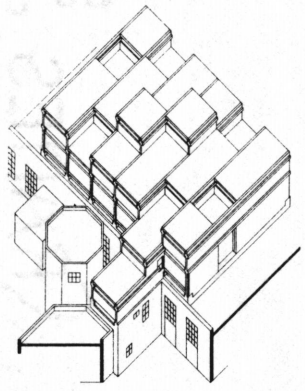
"What we need is a diversity of space in which the different functions can be sublimated to become archetypal forms, which make individual interpretation of the communal living-pattern possible by virtue of their ability to accommodate and absorb, and indeed to induce every desired function and alteration thereof. (...) We must continuously search for archetypal forms which, because they can be associated with multiple meanings, can not only absorb a programme but can also generate one."
(Herman Hertzberger, 1992)

In the structuralist philosophy, changeability is defined by form, function and users. Structure plays the role of the joint in metabolist capsules: changing only little or not at all itself, it makes rearrangements possible in almost unlimited variations. Order is the key to creative freedom in the structural void. Form and structure are dependent on each other, as variations only happen in and around the given rules. Therefore, selecting a structure means setting limits for the changes of form and function. The range of suitable uses and interpretation by people is pre-defined. Different from the functionalist idea that neutrality of building design will allow the accommodation of all possible uses, the structuralist ideal focuses on a set of limited, specified functions that will, individually applied, always produce the best solution. 'Fitness for change' does not always imply best accommodation of the new purpose. In the structuralist philosophy the notion of interpretation of structure by people is essential. The users must be able to rearrange their living and work places in their communal pattern that is influenced by culture. There is no specific form for a specific function. Structure as form can be seen as the permanent basis for the interaction of user and activities.

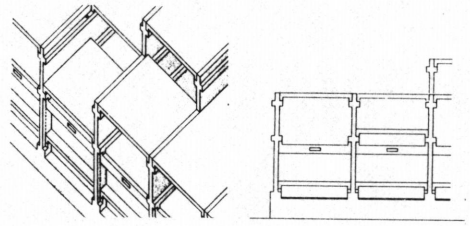


Workspace extension

Roof units



Prefabricated structure



LinMij Laundry, Extension
Amsterdam 1962 - 64

Identity of a building in its environment cannot be evoked by mere form. Rather is identity connected with a certain situation at a certain point in time. As users, use and culture change, this identity has to be re-established periodically. Flexibility in structuralism therefore can be described as the largest common denominator in a program creating an archetype that combines different functions in a structure with individual interpretation and identification. Polyvalent buildings, i.e. buildings that can accept multiple meanings without loosing their identity, reduced to their basic functions, bear the ability to adopt different meanings and functions in the essence of their structure. Structuralism is not concerned with the visual appearance of buildings, but with the characteristics of the form that allows the user to interact with space.

Are Historic Concepts Applicable to New Projects?

Since every building is unique, it is logical that the mere imitation of an architectural design will not lead to a meaningful building. A change in a building location and program will affect form. What applies to the context, also applies to the time factor. The mere imitation of a historic building might have a change in the meaning when put into a different time context.

However, when studying the historic examples above under the aspect of concept, flexibility strongly influenced the order of space.

The separation of servant and served rooms was required for varying reasons, but the desired result always was the uninterrupted floor space, the size of the unobstructed areas as a measurement for flexibility.

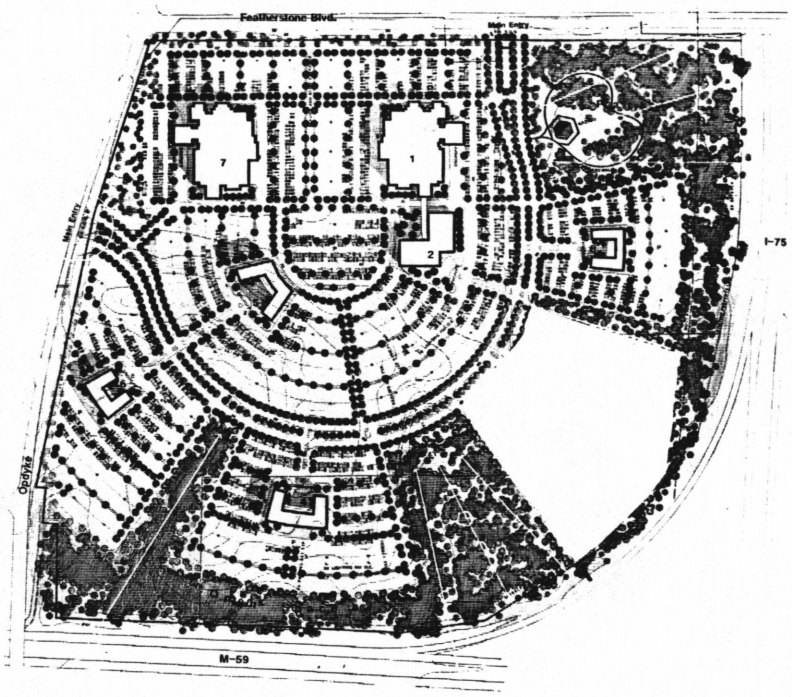
When selecting the structure, construction economy was an additional criterion. Modularity and standardization were common denominators in all examples stated. The replacement and addition of building parts and spaces was directly influenced by flexibility demands. The degree to which these changes could be made quantified flexibility and - in some cases - the life time of a building.

Servant and served order, structural economy, modularity and standardization are reappearing issues and seem to be independent from time and location. Therefore, these topics most probably will have to be addressed again in future projects. Studying the historic solutions under these aspects has the advantage of being able to compare the desired with the achieved flexibility over a longer period of time. With the lack of knowledge about future changes in early design stages, potential problems could so anticipated.

Which Current Aspects of Flexibility Challenge Architecture?

Under the impression of the transition from the energy based to the information based society, the sharp differences between blue and white collar work place smoothened. The number of white collar workers in manufacturing are increasing, and factory work places in their organization and settings do not look very different from offices any more. Worker productivity is found to be crucial to achieving quality, adding people oriented criteria to the traditionally process oriented work situation. Under these circumstances, modularity and standardization as pure repetition of identical elements can hardly be an architectural response. Also, buildings with processes requiring a larger degree of high-technology rather tend to adapt to changes than to grow. If a building's function changes at all, the indoor conditions must be adaptable. Accessibility of equipment spaces will therefore be more important than structural expansion. With an increased need for air conditioning and cable management, walls, floors, and ceilings, besides their structural function, more and more must fulfill servicing duties replacing visible ductwork and service shafts. Again, flexibility means uninterrupted floor space, but this time, the architectural elements experience a redefinition. Traditional functions such as daylighting as a function of the facade need to be supported by technology to achieve satisfactory results. With a variety of 'building shells' to accommodate the new functions, the difference between a space and the void of a hollow structural element may vanish. Architecture must provide a greater order to not only support flexibility, but at the same time explain the relationships of different parts in a design. The innovations in building technology are a challenge to produce more meaningful architecture with emphasis on the people using it.

A Research and Development Center



The first chapter dealt with the theoretical background of flexibility on the one hand, and projects resulting from related demands on the other hand. One characteristics among others in building design, flexibility was isolated and focused separately. In reality, the complexity of decisions that need to be made during the planning of a project does not allow an one-directional approach.

The second chapter therefore wants to explore flexibility demands in the design context, that is also influenced by program and site conditions. The prerequisites in selecting the design project were an industrial or commercial, human work environment, and a building use representative for the current state of technology.

Program and site were not changed during the design process. However, the objective was to include organizational and topographical considerations into a conceptual approach, rather than presenting a project ready to be built.

It was hoped that the design process would unveil critical aspects for the embedding of functional and technological concerns into the architectural concept.

If flexibility is one element in the complex network that characterizes a building, then there should be a number of architectural topics relating to flexibility aspects in the building context.

The selected Research and Development Center fulfilled the prerequisites and promised architectural challenges in respect to the program and the site.

A sign of time, research and development is a growing branch in commercial and industrial enterprises and involves a high degree of technology which typically produces a great demand for building flexibility.

The presented Research and Development Center consists of offices for administrative and representative purposes (headquarters), the research and development facility, and a test facility. The subject of research are fuel injection valves. Experiments are conducted in chemical, mechanical and electronic laboratories as well as on engines and cars. The facility is open to customers which requires a visitor-friendly design of all areas. The project needs to be built in at least two construction phases, about 114,000 sq. ft. at a time. The parking area should be located adjacent to the R&D center, with about 400 parking lots required at the time of the first construction phase. Due to the subject of research involving fuel, building design must consider the risk of explosion.

The site measures about 15 acres and is located in an industrial park near Detroit, Michigan, at the intersection of two major highways in north-south and east-west direction. A circular road provides access for cars, people and infrastructure to the parcel. Neighboring the site in the southwest are forested wetlands, an area that will be permanently excluded from construction activity. There are a number of rare trees worthwhile protecting on the south corner of the parcel. These trees are to be preserved as far as possible. The difference in height between the wetlands and the highest point on the site is 36 ft. The site drops also toward the north for 12 ft. in a smooth slope.

Architectural Idea

"The city of Sophronia is made up of two half-cities. In one there is the great roller coaster with its steep humps, the carousel with its chain spokes, the Ferris wheel of spinning cages, the death-ride with crouching motorcyclists, the big top with the clump of trapezes hanging in the middle. The other half-city is of stone and marble and cement, with the bank, the factories, the palaces, the slaughterhouse , the school, and all the rest. One of the half-cities is permanent, the other is temporary, and when the period of sojourn is over, they uproot it, dismantle it , and take it off, transplanting it to the vacant lots of another half-city.

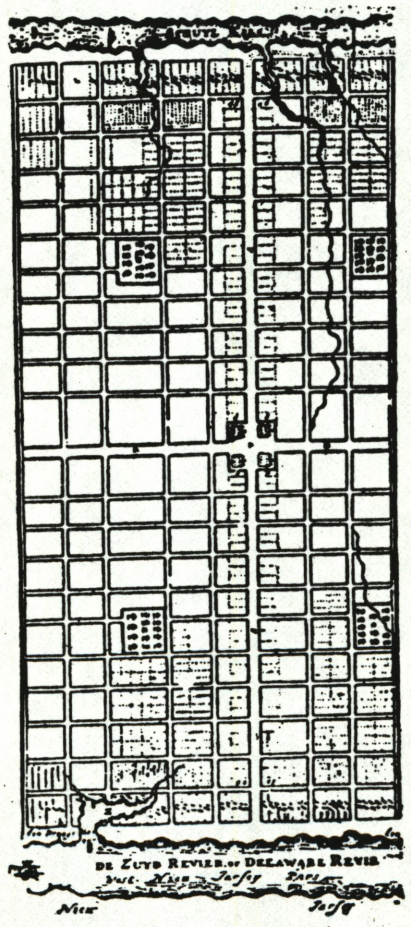
And so every year the day comes when the workmen remove the marble pediments, lower the stone walls, the cement pylons, take down the Ministry, the monument, the docks, the petroleum refinery, the hospital, load them on trailers, to follow from stand to stand their annual itinerary. Here remains the half-Sophronia of the shooting-galleries and the carousels, the shout suspended from the cart of the headlong roller coaster, and it begins to count the months, the days it must wait before the caravan returns and a complete life can begin again."[8]

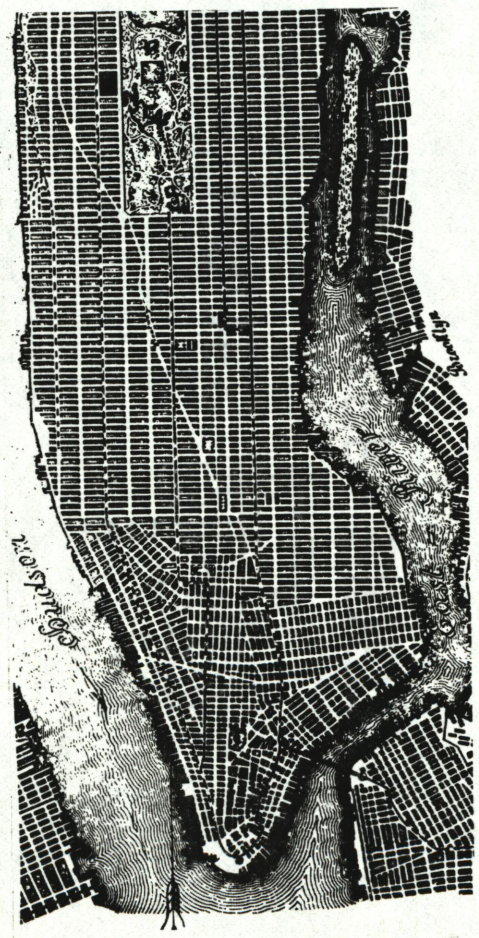
— (Italo Calvino, Invisible Cities)

Order: The Research and Development Center as a City

The city analogy is quite suitable in many aspects. A city as a form of organization includes a variety of activities that produce changes altering its parts in the interior and exterior. A network of traffic or circulation areas is the basic ordering principle. There are basically two different forms of cities: one bases on a square, the other on a radial grid. Whereas the square grid can grow into all four winds just limited by topography, the radial grid has a clear, defined center from which growth occurs in rings around the existing. Orientation in the square grid is determined by the network of streets, whereas in the radial grid the center is focused.

The blocks in the radial grid are defined in an increasingly stricter way the more they lie toward the center. The square blocks have the principal size of each lot in common, but create hierarchy or any other order by their form, size and placement of elements in relationship to the whole. Each city block has its own context giving it individuality. Dealing with its contextual environment, a block is independent for its basic purposes and needs. As a part of the whole, it relates to others as a part of their context and is hooked up to the network organizing individual blocks. Within each block, there is spatial and structural freedom for the design of individual contexts and functions.





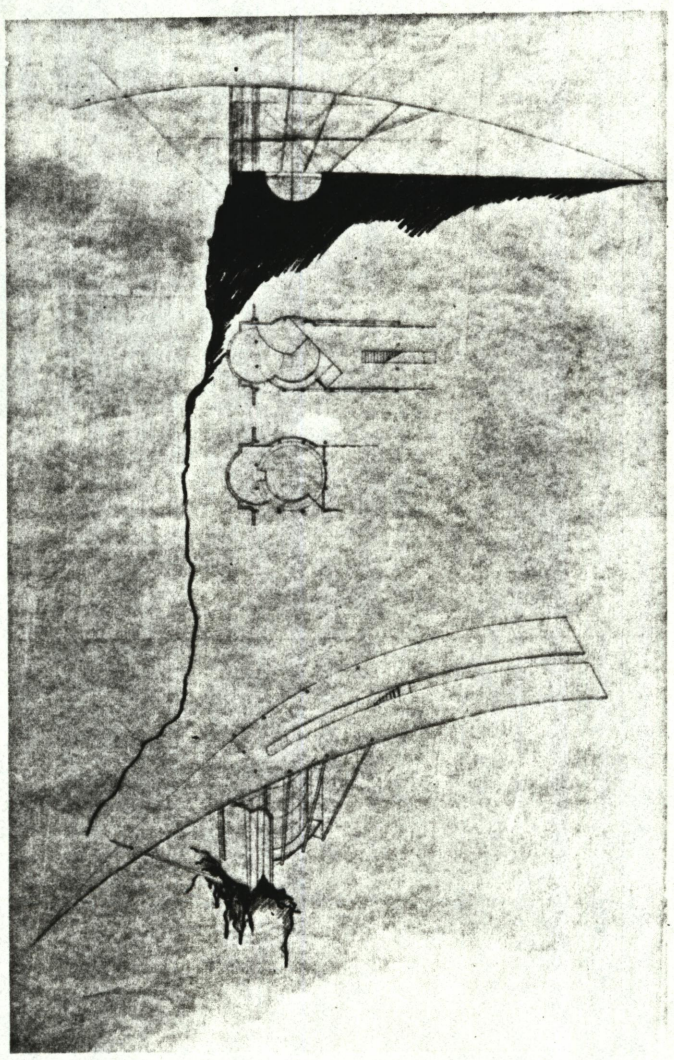
Top:
Munich, inner city ring

Bottom left:
The city grid of Philadelphia, Pennsylvania by Penn

Bottom right:
The Broadway cutting a diagonal into the city grid

The order in the master plan must allow to add or change parts without changing the whole. If the sum is bigger than its parts, a variety of different functions and forms can be included and still be part of the whole. In the case given, where there is no order suggested by the context, the master plan defines an order with basic rules that apply to every part while maximizing freedom of design.

Studying architectural order to develop a set of rules therefore is essential. In a studio project, I applied Palladio's theory of proportion in architecture to the design of a "Place to Stay for the Weekend'. The new situation created a linear conception instead of the centralized one favorized by Palladio. Context, form and time had changed, howcver, the rules provided an organization for the building allowing the architectural elements to be redefined according to the given conditions.



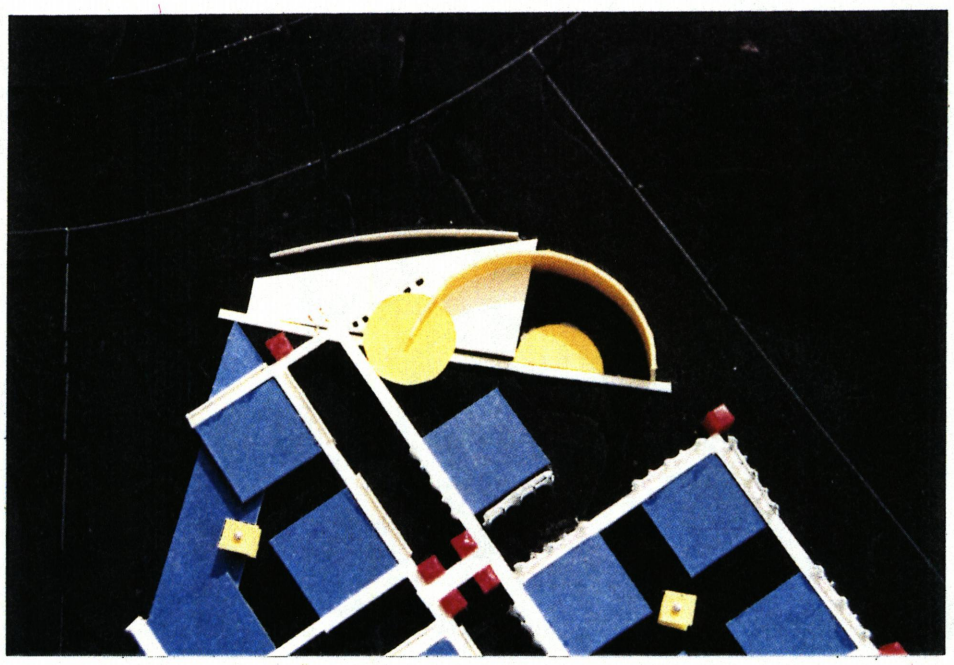
"A Place to Stay for the Weekend"
Studio project applying Palladio's proportions in architecture

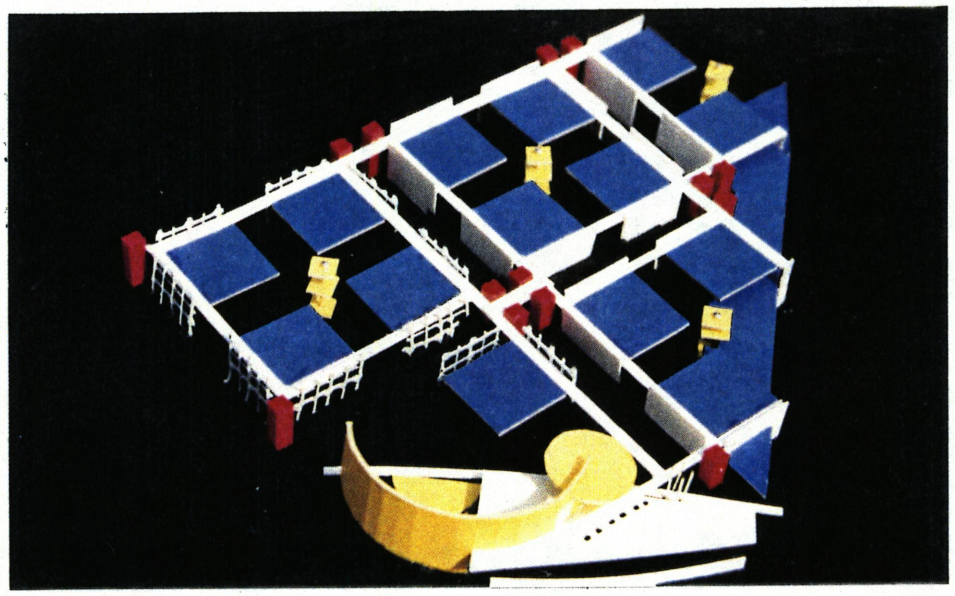
In the first model studies, the theme of separation and connection of functions and forms is obvious. Mechanical equipment (red), circulation (white lines) and social areas (yellow towers) are separated from work areas (blue). The administration is differentiated from the research by form. Parking (white shape) is located between the inside and the outside of the whole, and there is a strong connection between parking and entrance. In the social areas represented as yellow towers, facilities that are common for all work areas are combined and accessible for a larger number of people. Bathrooms, kitchen, copy rooms, meeting rooms, etc. serve as functional connection between different departments and are not affected by a varying number of users. The mechanical equipment (red) is exposed from the work areas for maintenance and exchange of parts. By combining these towers, they can temporarily fulfill the tasks of each other in case of emergency or renovation. The exclusion of the towers leaves the work areas uninterrupted with two sides as possible connectors to other work areas. Up to four units can be combined to one big complex. A diagonal band stops the otherwise unlimited order where the wetlands start, creating an elevation that is unique among the others.

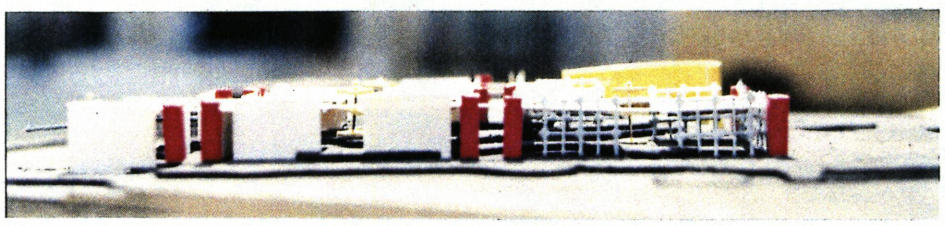
The square was chosen to represent a shape that does not have a particular direction. The circle as a part of the square stands for a special function like meeting rooms. The order is dissolved where the density of people is largest: The administration is beginning and end. Metamorphosis starts here. The whole complex includes large work areas, but does not want to combine everything under one roof: Streets between different work areas and the main circulation on the roof will improve orientation in the Research and Development Center, and will protect the individual areas from disturbances.

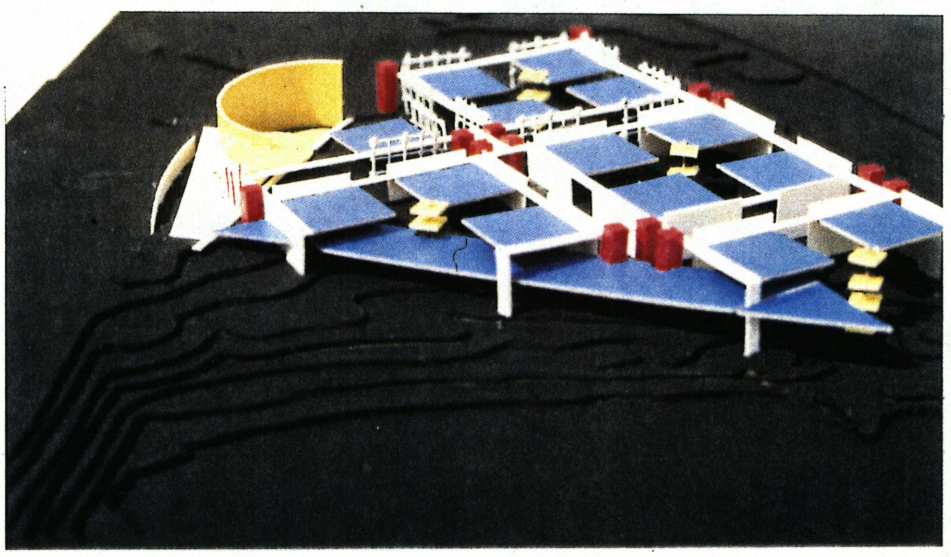
Further studies introduced a circular traffic pattern in the center of the project as connection of the work areas. However, this would limit the choice of the first construction phase to the four center squares to maintain the connection.

The model also studies a variety of shapes that can be introduced in the existing order. However, the slightly twisted square exceeds the rules of the given form.

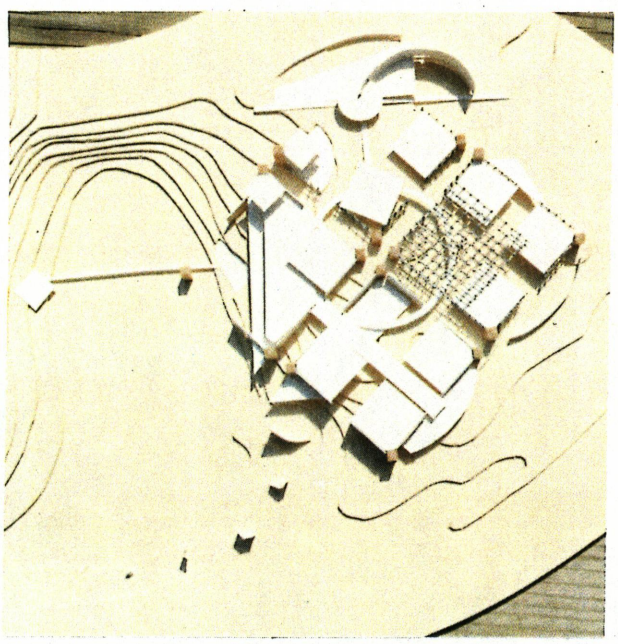


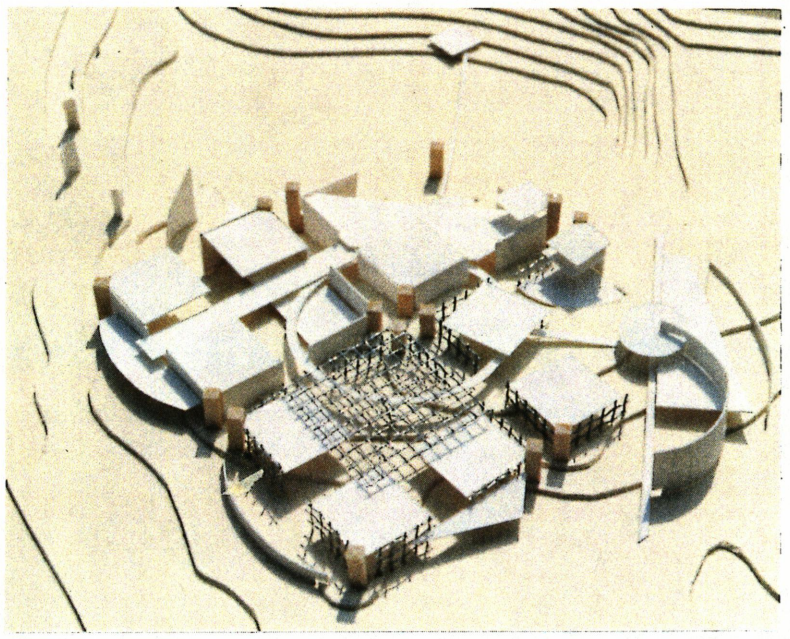


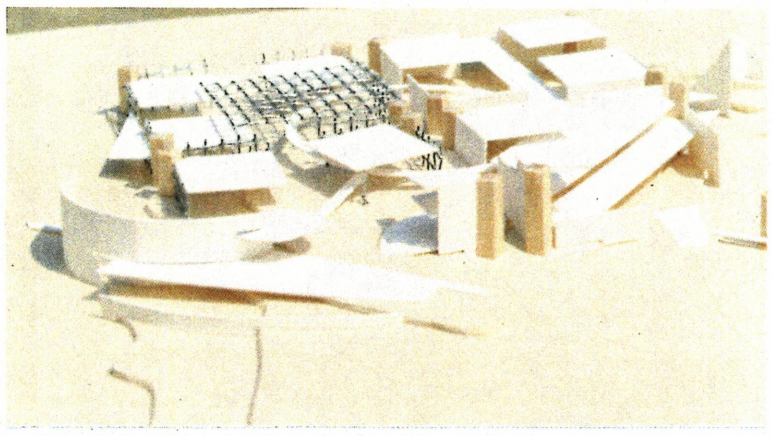


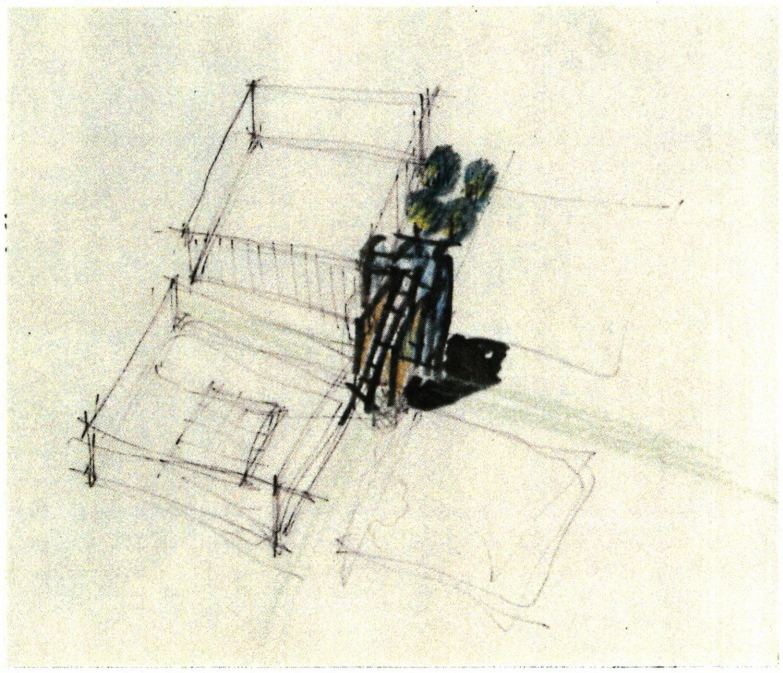


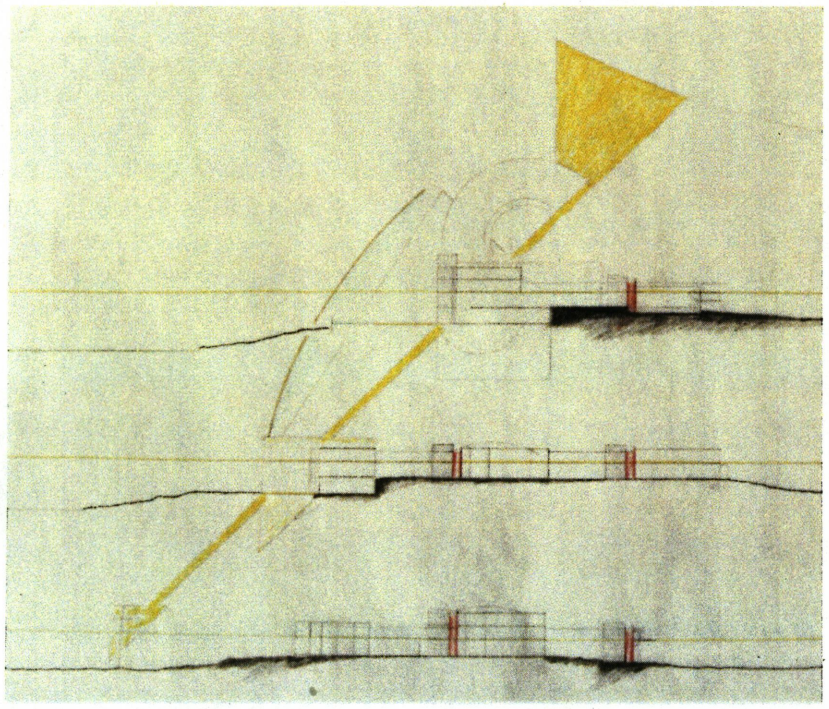
First studies on order
Red: Mechanical equipment
White: Circulation
Yellow: Social areas











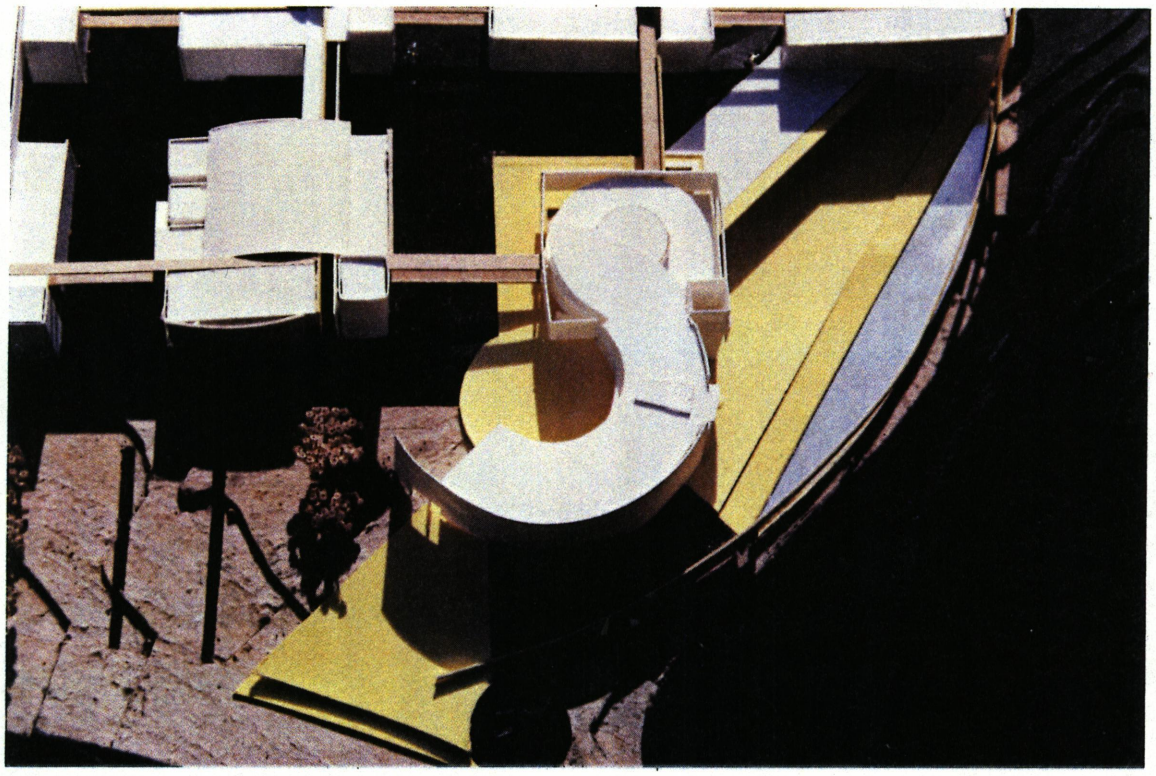
Concept

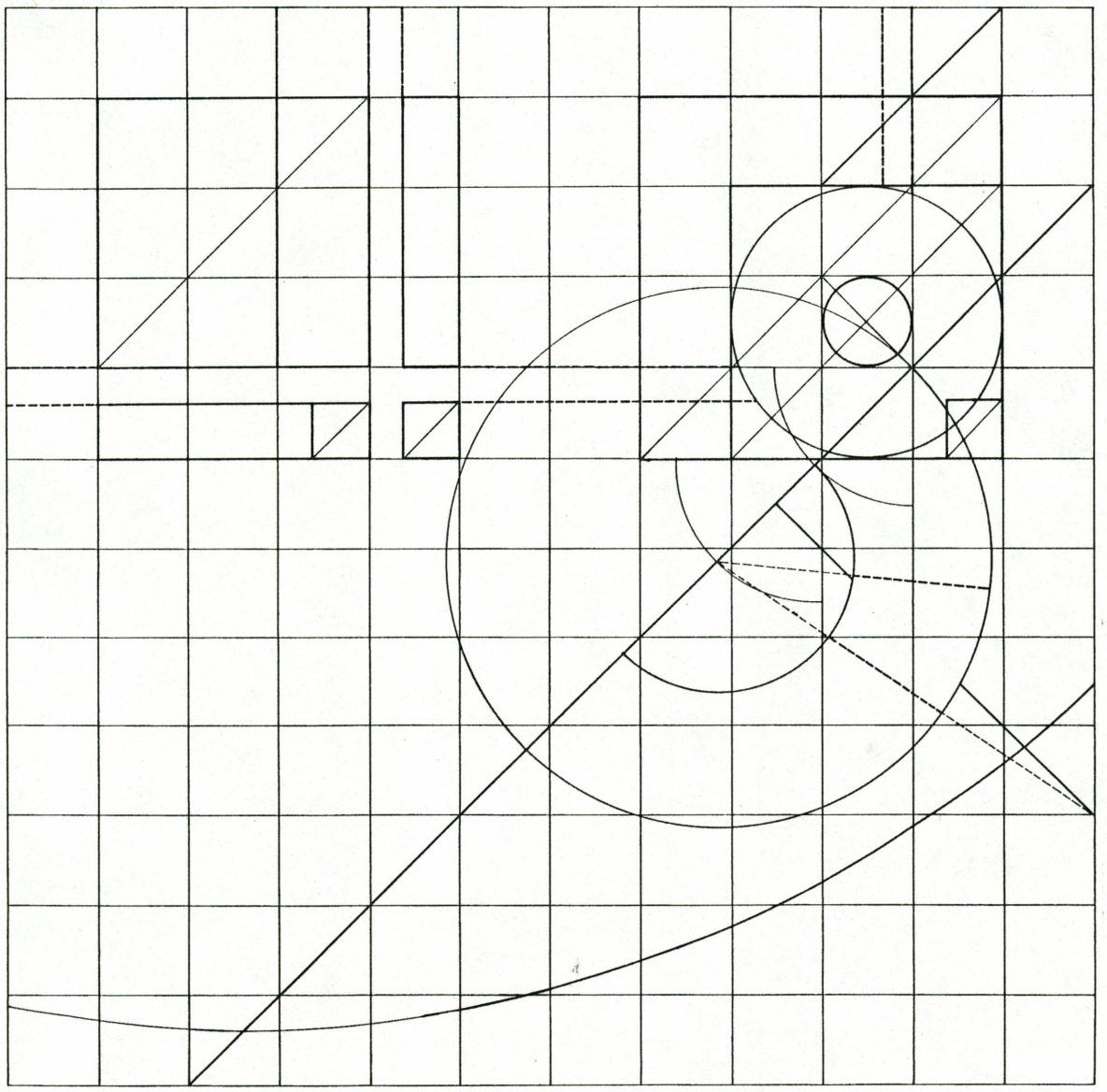
The master plan is based on two city grids and two basic roles of a work environment: to accommodate people and work processes.

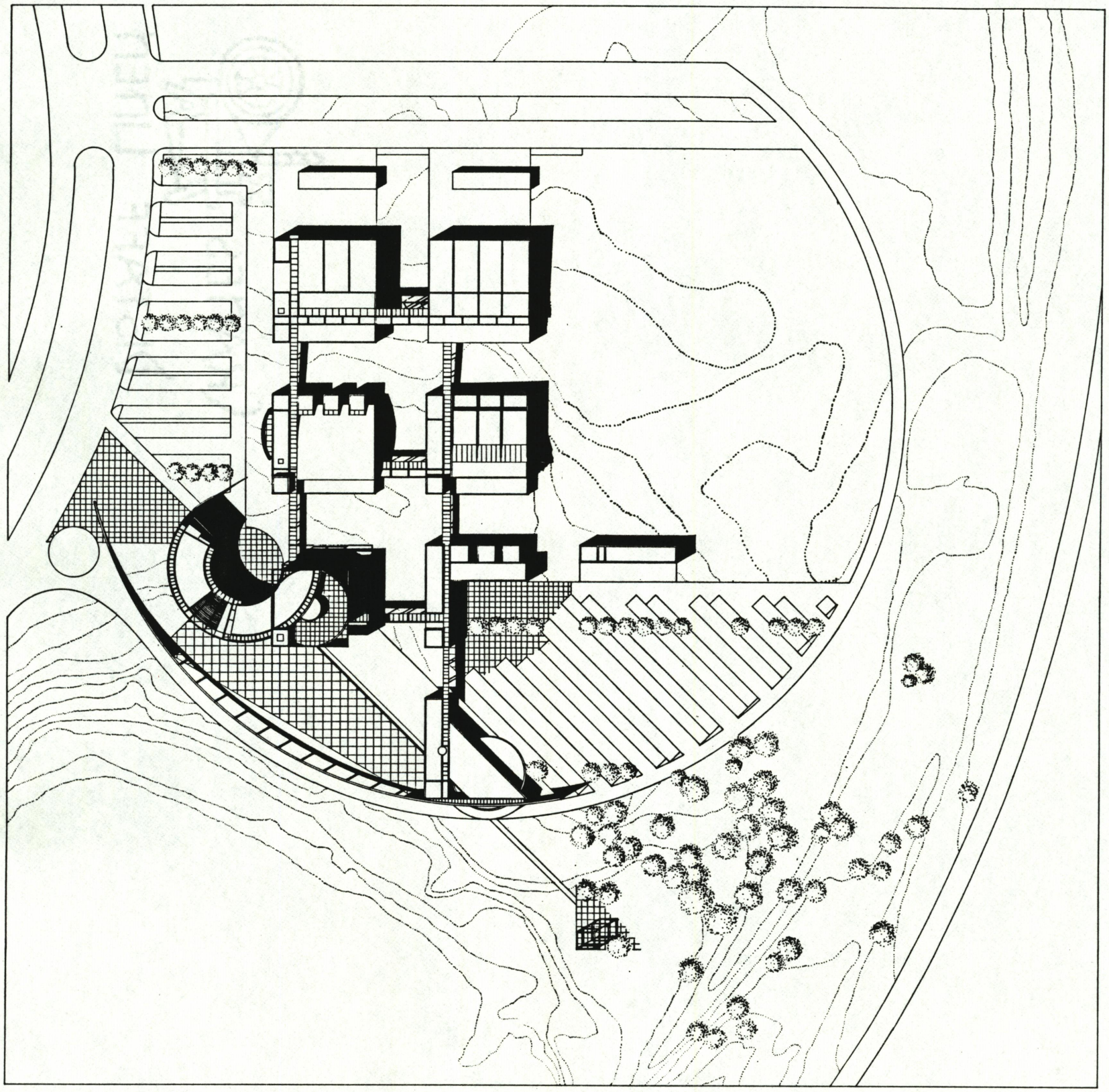
The individual buildings have in common a square of 108 ft. separated by a street of 54 ft. to each side. Connected with each other by passages on the second floor, each building is specified to fulfill a limited set of functions. From north to south, there is a development from the limited to the unlimited and from the private to the public. Transformation comes to a metamorphosis in the south where technology meets nature. A circular wall defines inside and outside at a place where the density of people is largest. From here, the diagonal departs representing the human part. It includes the "Place to Eat' and the 'Place to Be'. The diagonal and the buildings connected with it define the permanent part of the project.

The blocks in the north of the diagonal follow a strict rectangular pattern based on the circulation and traffic pattern that is permanent, itself being temporary.
The space between the buildings is accessible for fire engines and delivery trucks. Main traffic is kept on the periphery for the benefit of green pedestrian areas.

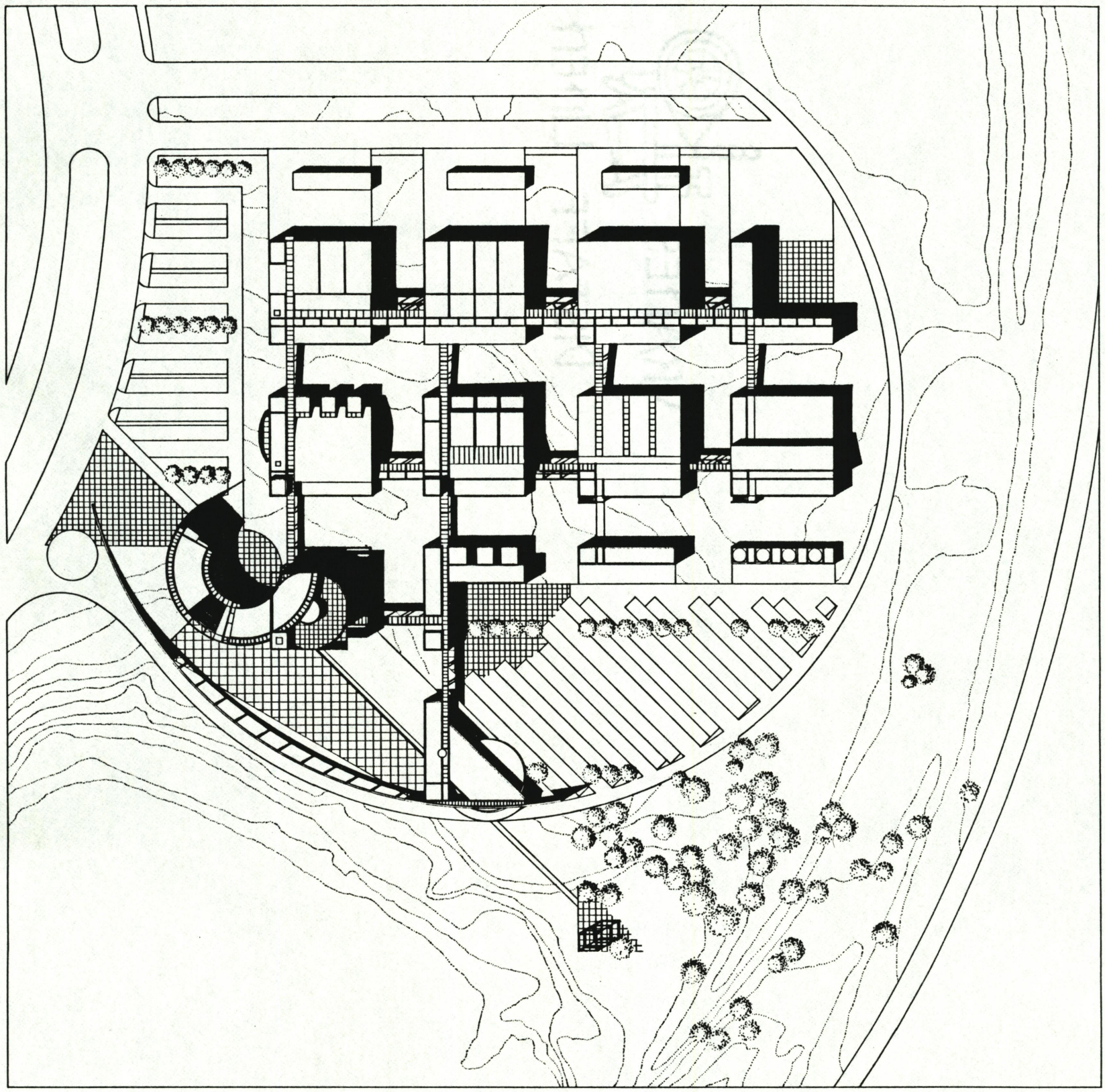
Right:
Rectangular meets Diagonal



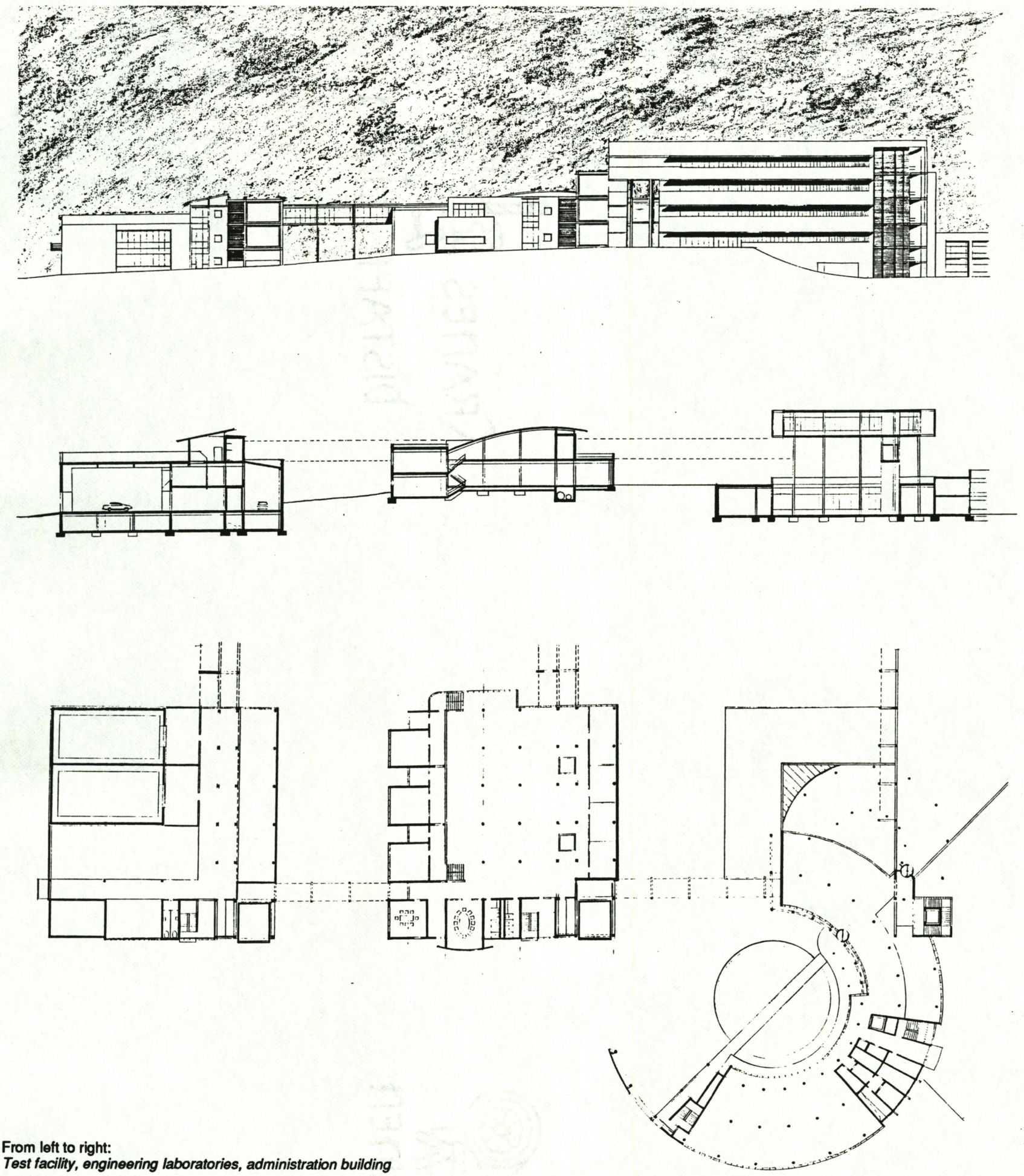




First construction phase

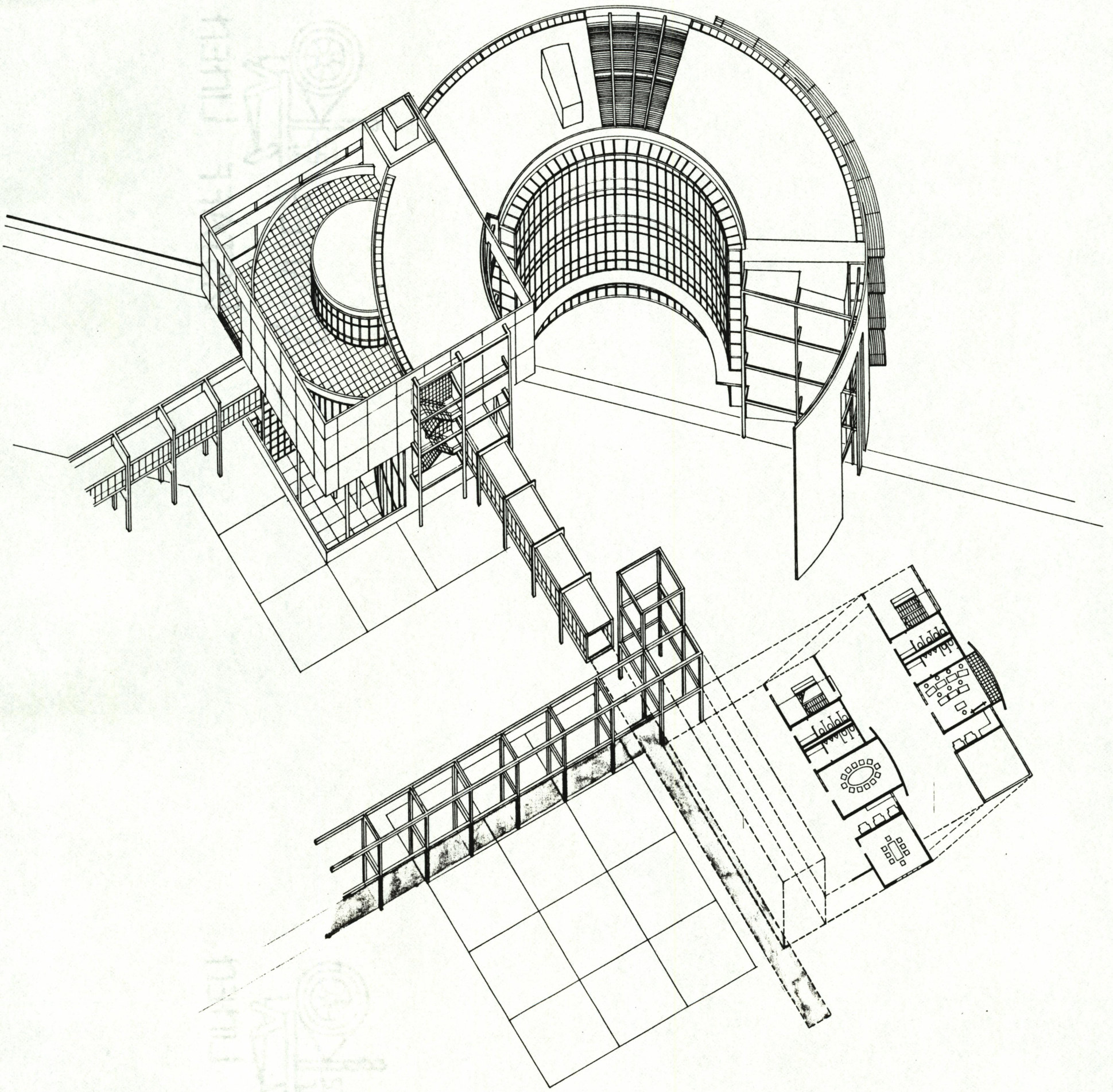


Last construction phase



From left to right:
Test facility, engineering laboratories, administration building

From top to bottom:
Elevation, section, ground floor



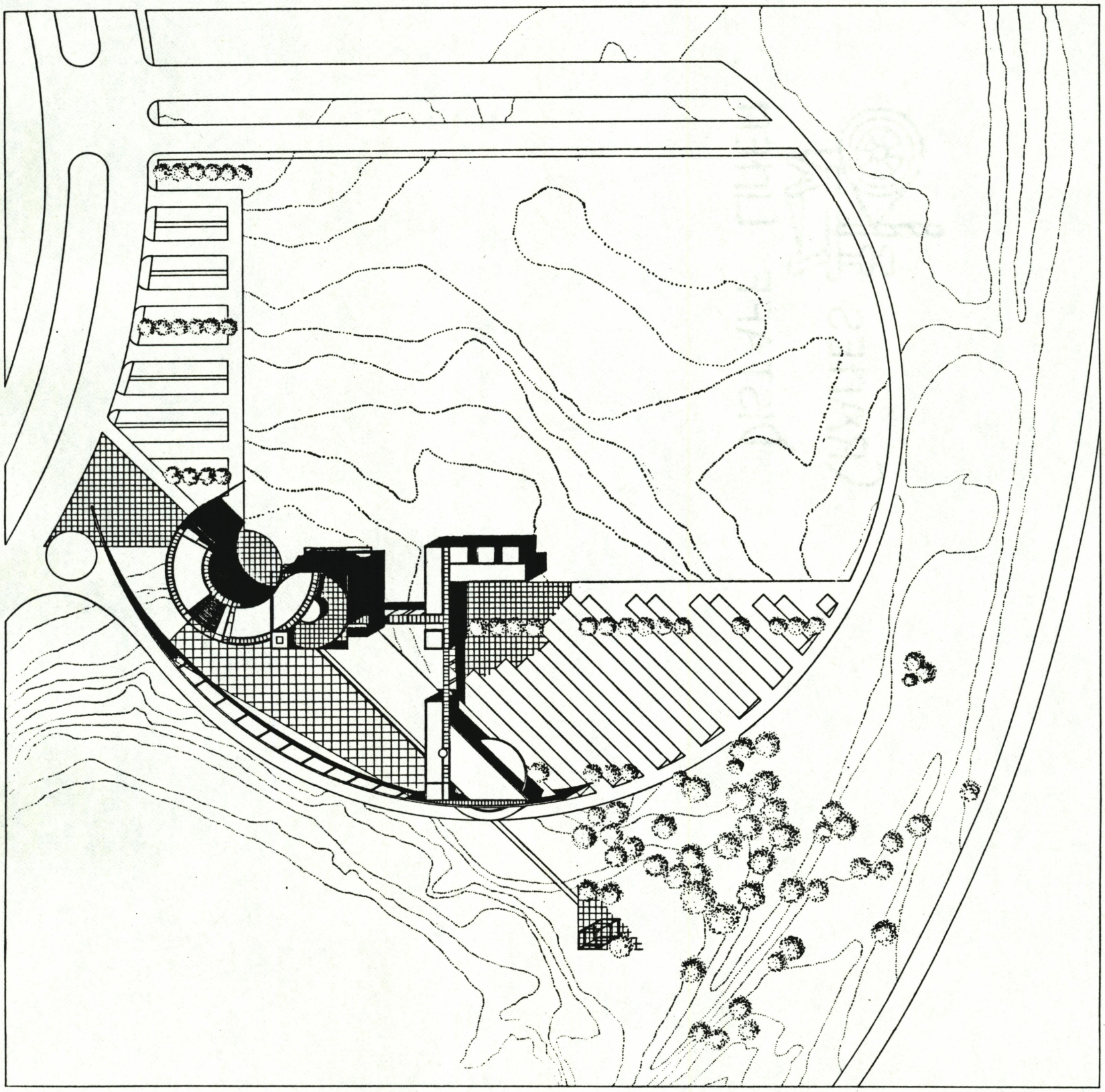
Permanent Buildings

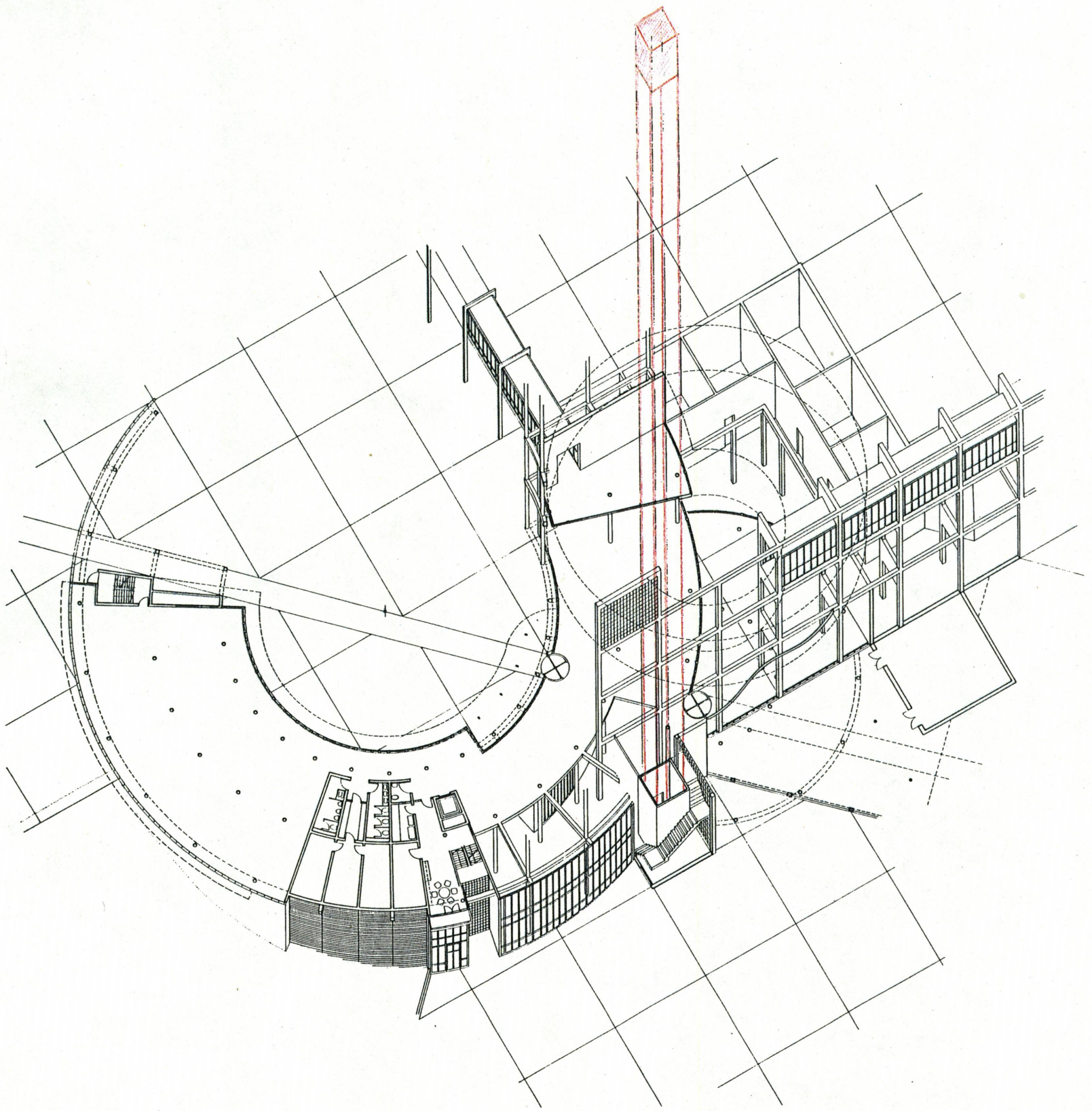
In the southeast, anchoring the diagonal is the administration building. Still in the rules of the basic concept, it has the most expressive form. Besides office space for administrative purposes, it is the 'gate' to the site, the entrance. For visitors coming from the parking area in the north or for employees driving along the outside of the circular plaza, this building is the first view of the complex. The visitor area includes meeting rooms and an auditorium on the plaza level and connects with the main circulation on the second floor that guides through the whole R&D center. Computer rooms and spaces with a higher need for security are located in the atrium building next to the administration. The office building has a permanent form, alterations, i.e. rearrangements of office settings, are expected in the interior only. All servant spaces are combined in a central core leaving accessibility to mechanical rooms from the south facade. Although the necessary floor space for laboratories and the test facility may increase, there will be a limit for required office space for administration purposes. Therefore, there are only two construction phases planned for this building, The core is included in the first stage, the unconnected part in the west will be added later.

The cafeteria neighboring the administration at the diagonal contains a security check on the plaza level before entering the employee parking area. This building is permanent and is part of the first construction phase, since a larger number of employees eating at the restaurant can be accommodated by introducing more shifts affecting the management rather than the building itself.

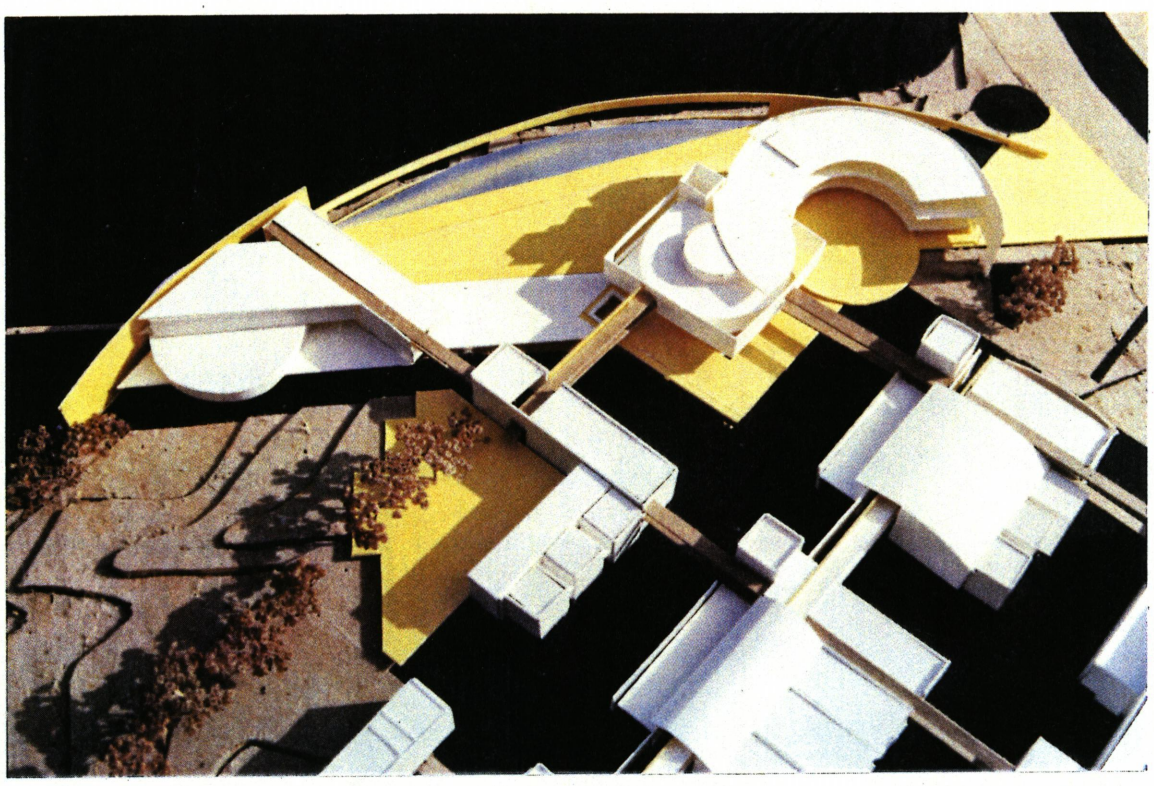
A path leads to a place outside the circle. This place represents the being side of people.

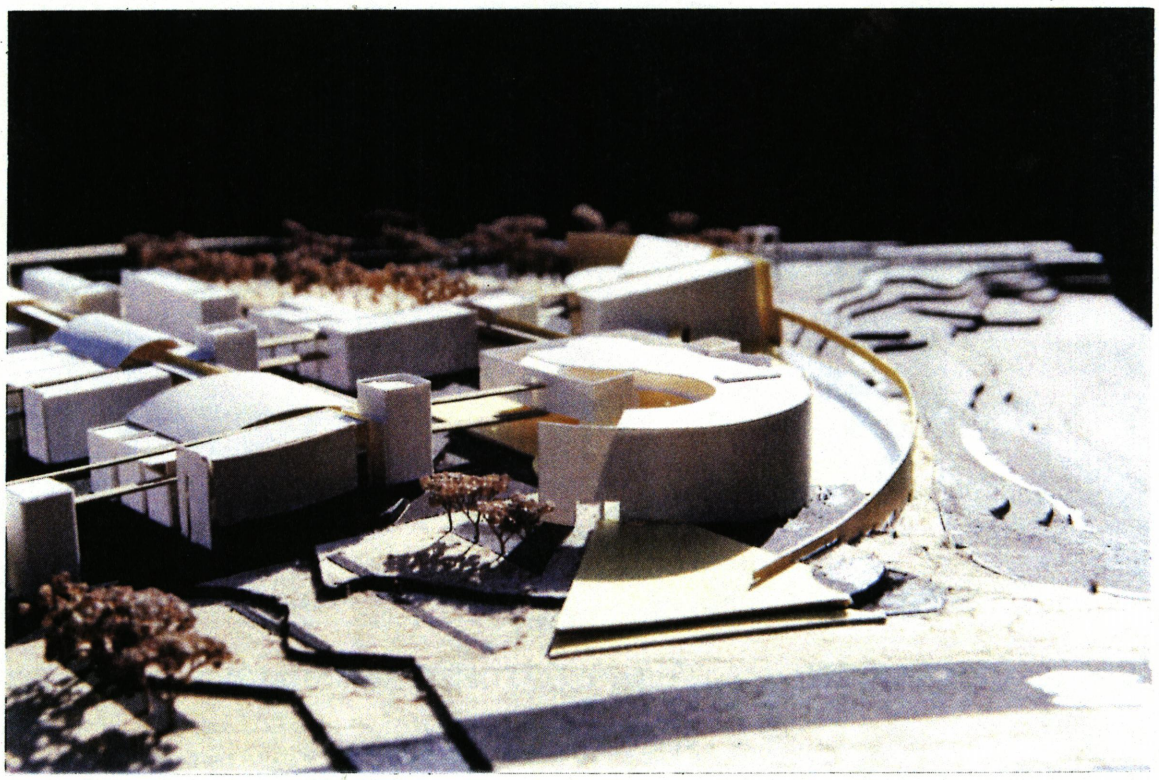
Adjacent to the employee parking are external storage buildings. Employees enter the complex through the employees entrance next to the parking lot. This building also contains offices and shops for maintenance personnel.

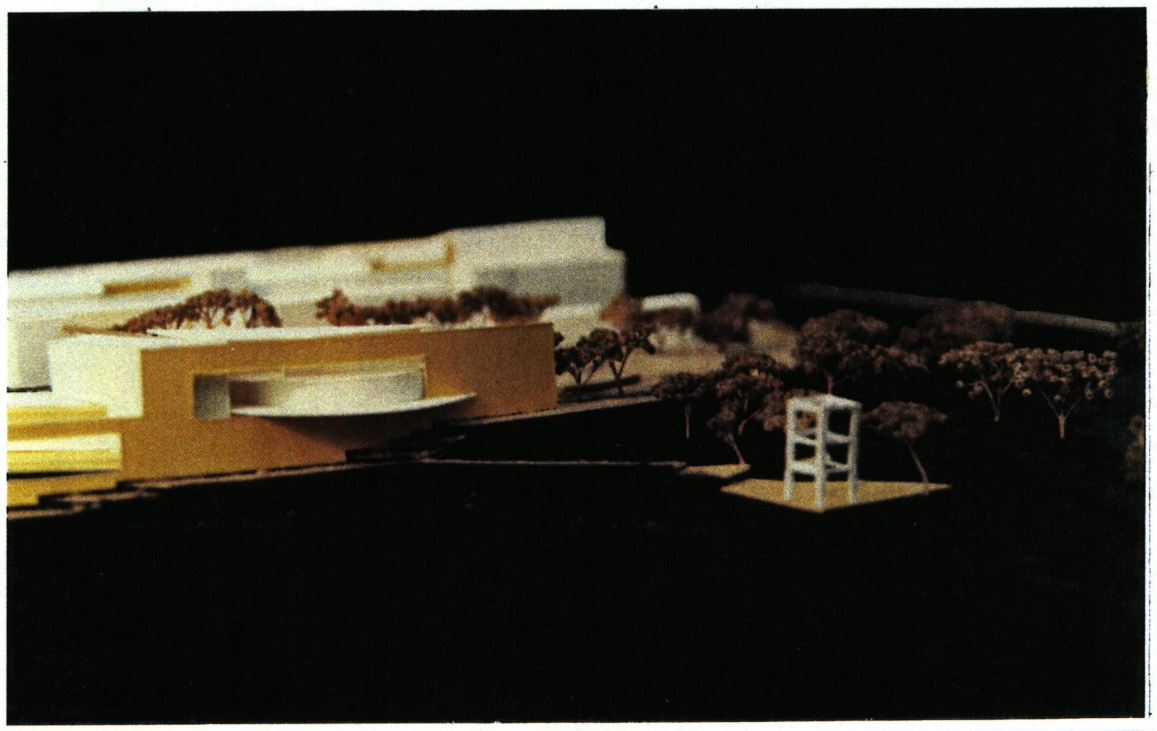




Administration building: the entrance as beginning and end
Analysis of walkways







From top to bottom:
Employees' entrance

View from the main street

A 'Place to Eat 'and a 'Place to Be'

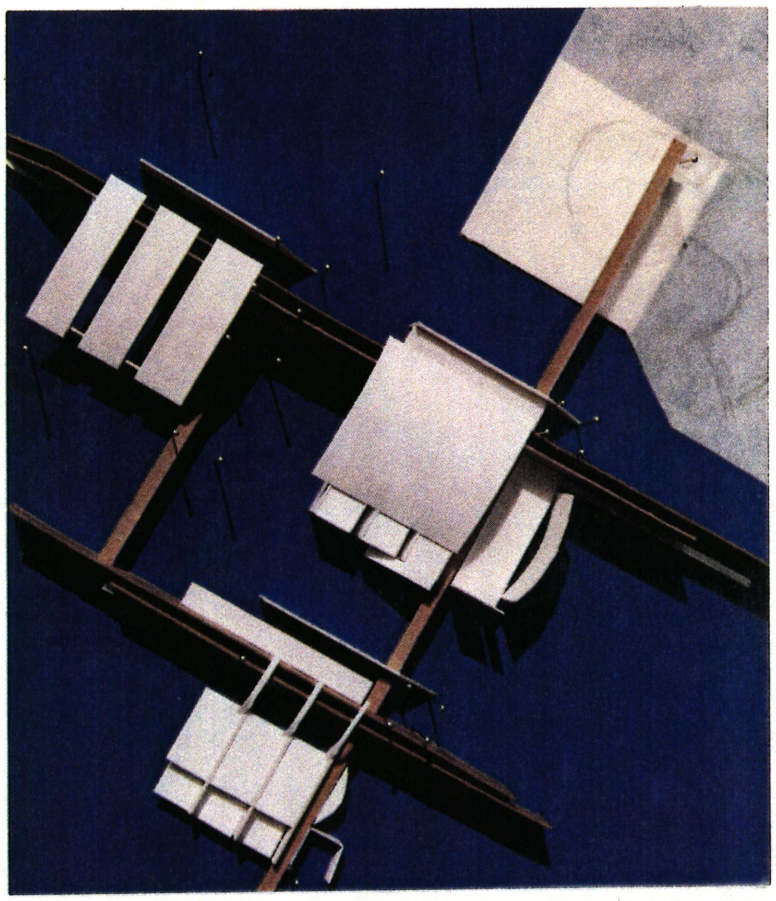
Temporary Buildings

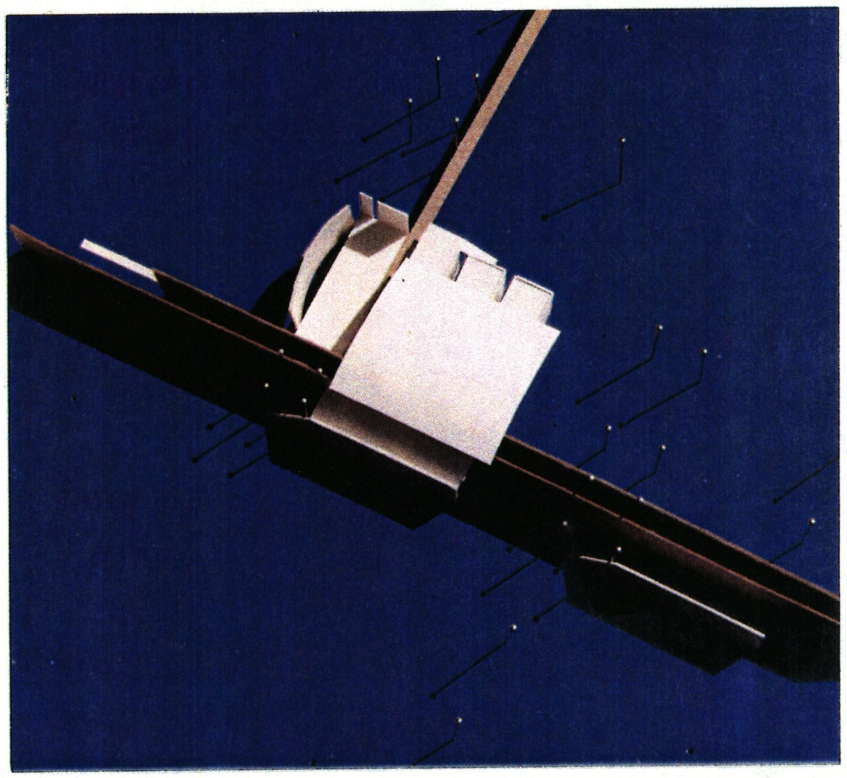
Technical offices, labs and the garage for tests of engines and cars are temporary buildings, where setup of experiments and technology changes rapidly. Connected by the passages on the second floor, labs and garages are lined up along an axis combining similar functions on each axis. The test facility on the north side has a separate access for the delivery of cars and engines. Equipment and explosive fluids can be stored in the auxiliary buildings in front of the test facility.

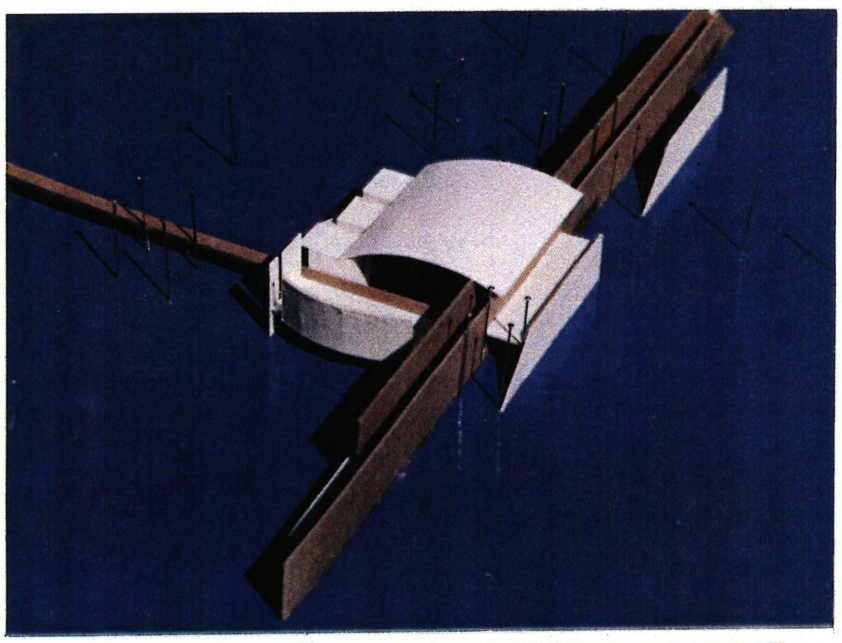
As a basic rule, each building bases on a square of 108 ft. with 3 ft. as smallest increment. A mixture of enclosed and open spaces is achieved by organizing the enclosed rooms along the facades for natural light and ventilation, and the open spaces toward the center where conditioned air and skylights replace the functional duty of windows. Basically, there are three areas to be organized: the work area, the social rooms, and the building services.

Social rooms and necessary staircases for circulation and emergency are permanent spaces forming a network of circulation on the second floor. Mechanical equipment for the social areas and the work spaces have a permanent structure, but must be accessible for qualitative changes.

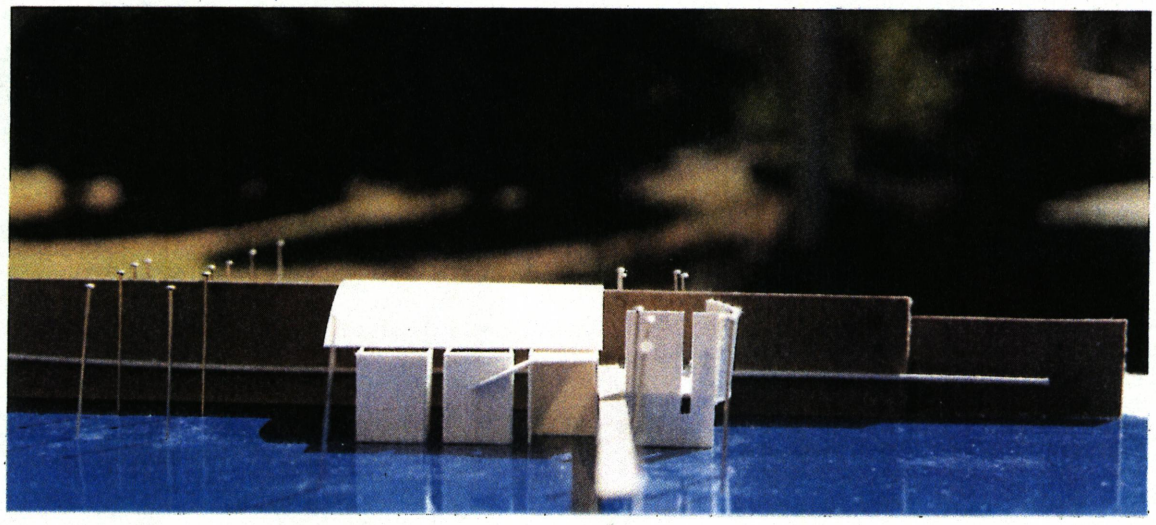
The work area is defined as temporary. Open staircases and additional horizontal circulation paths are introduced to serve a temporary use.

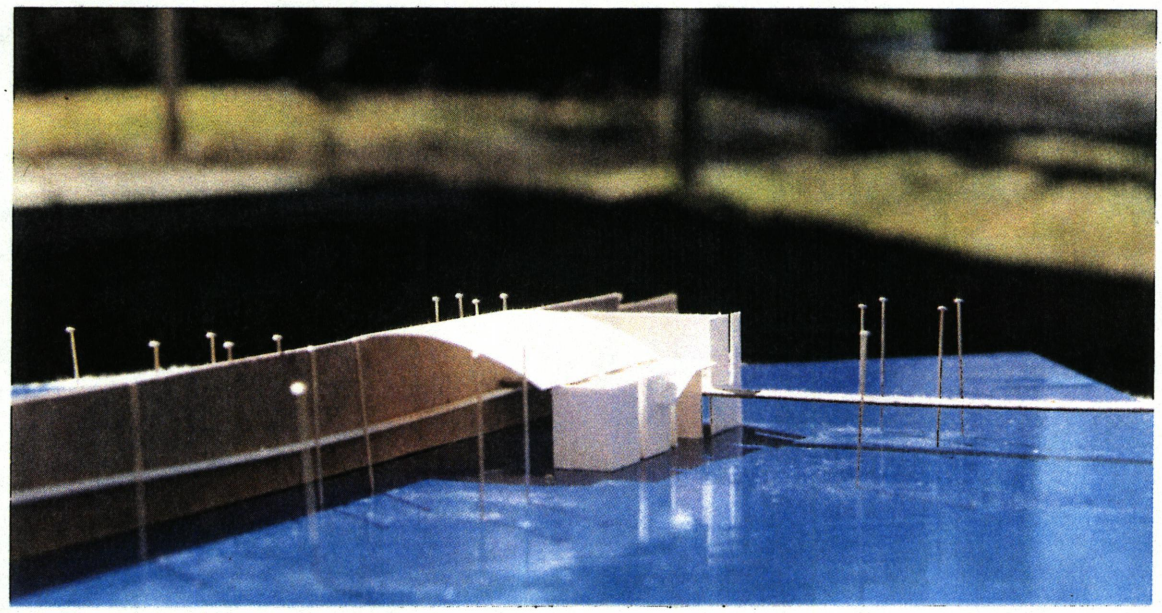


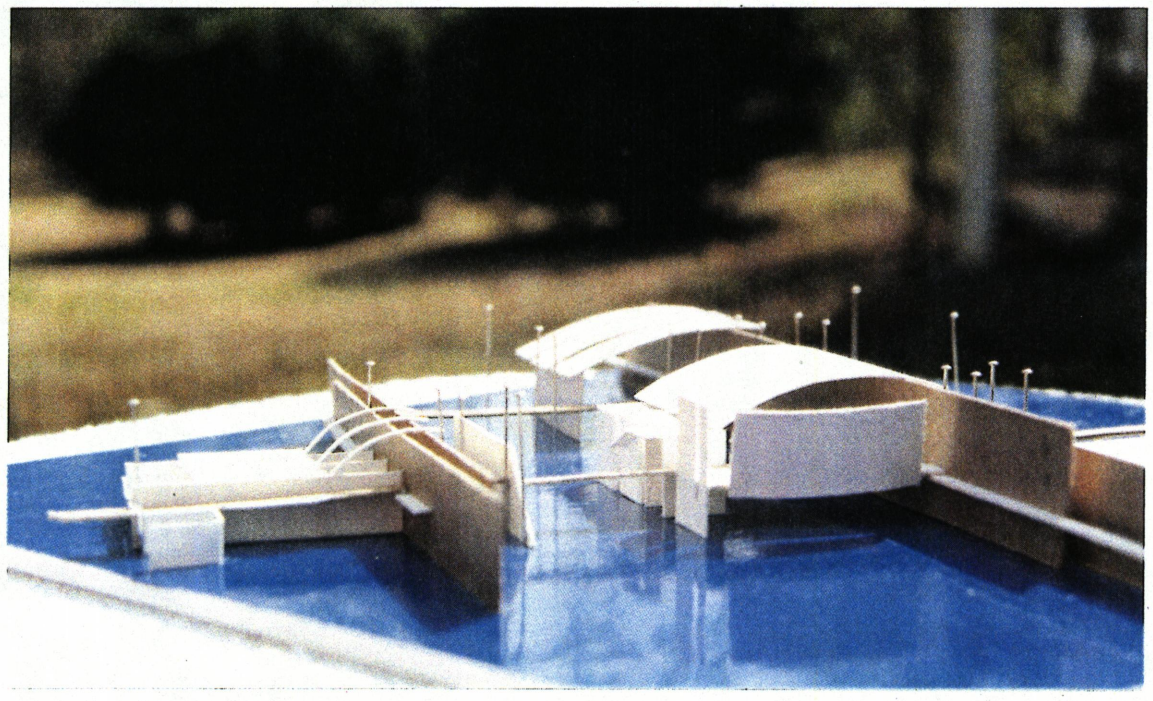




Walkways and service wall as ordering principles

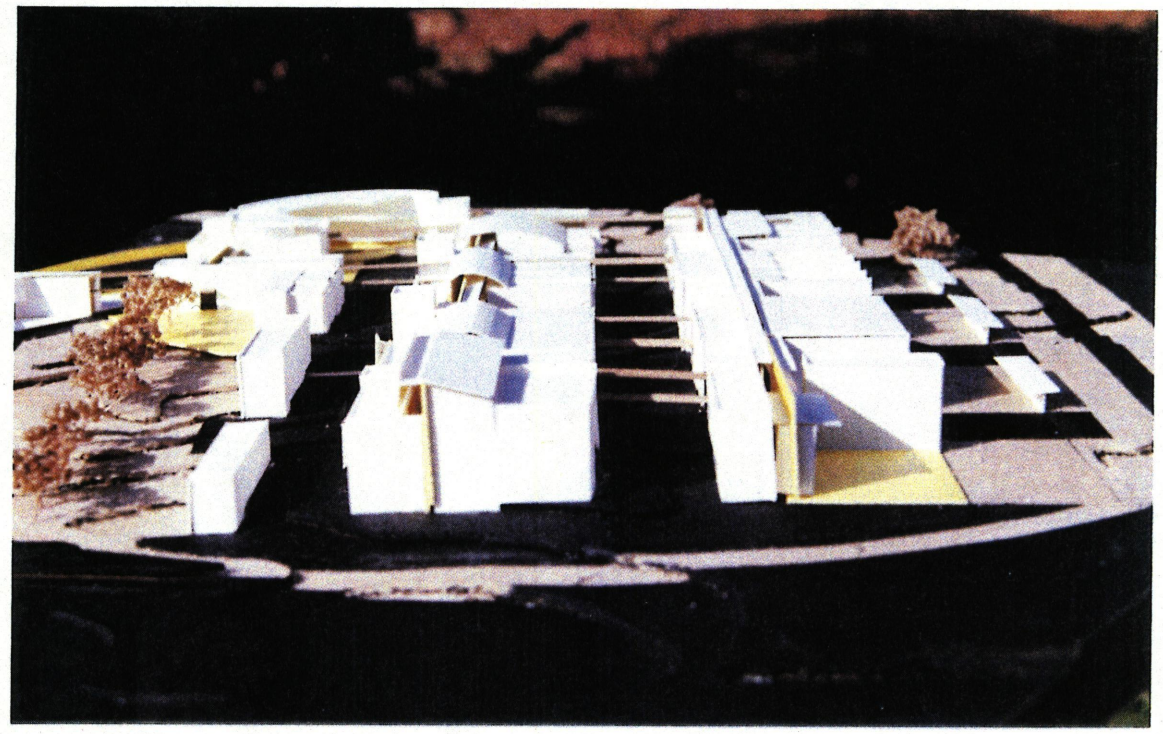


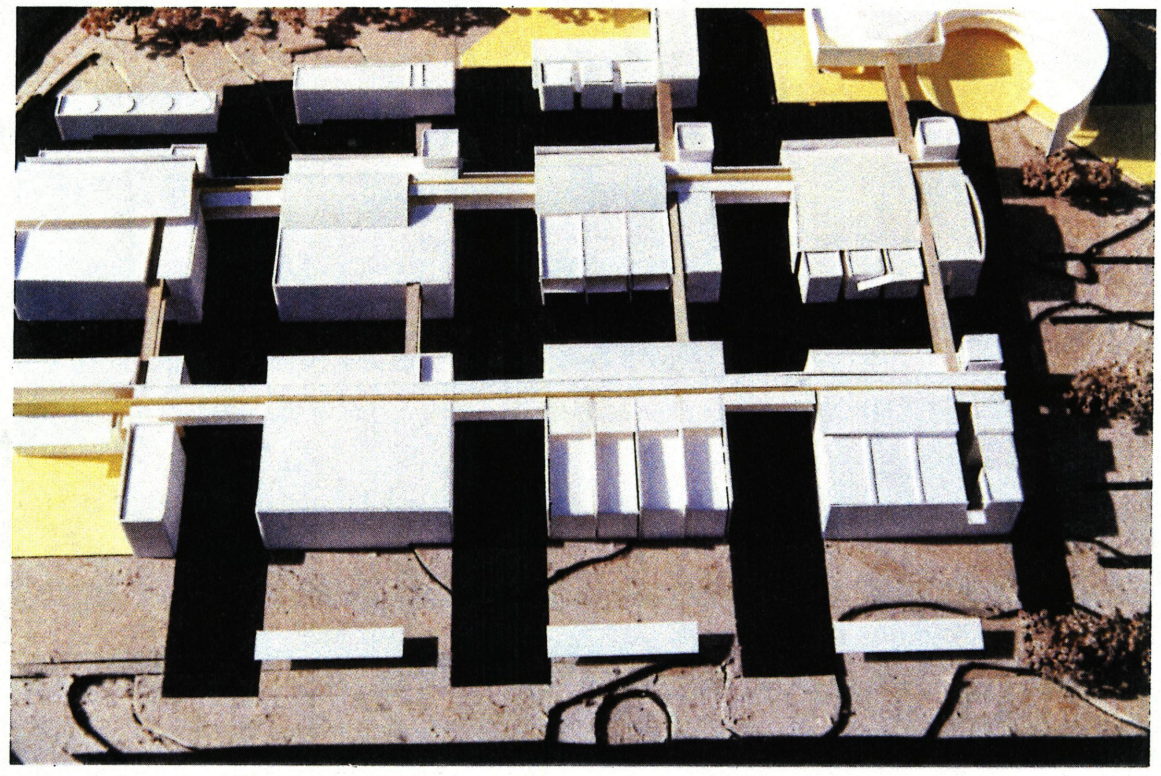


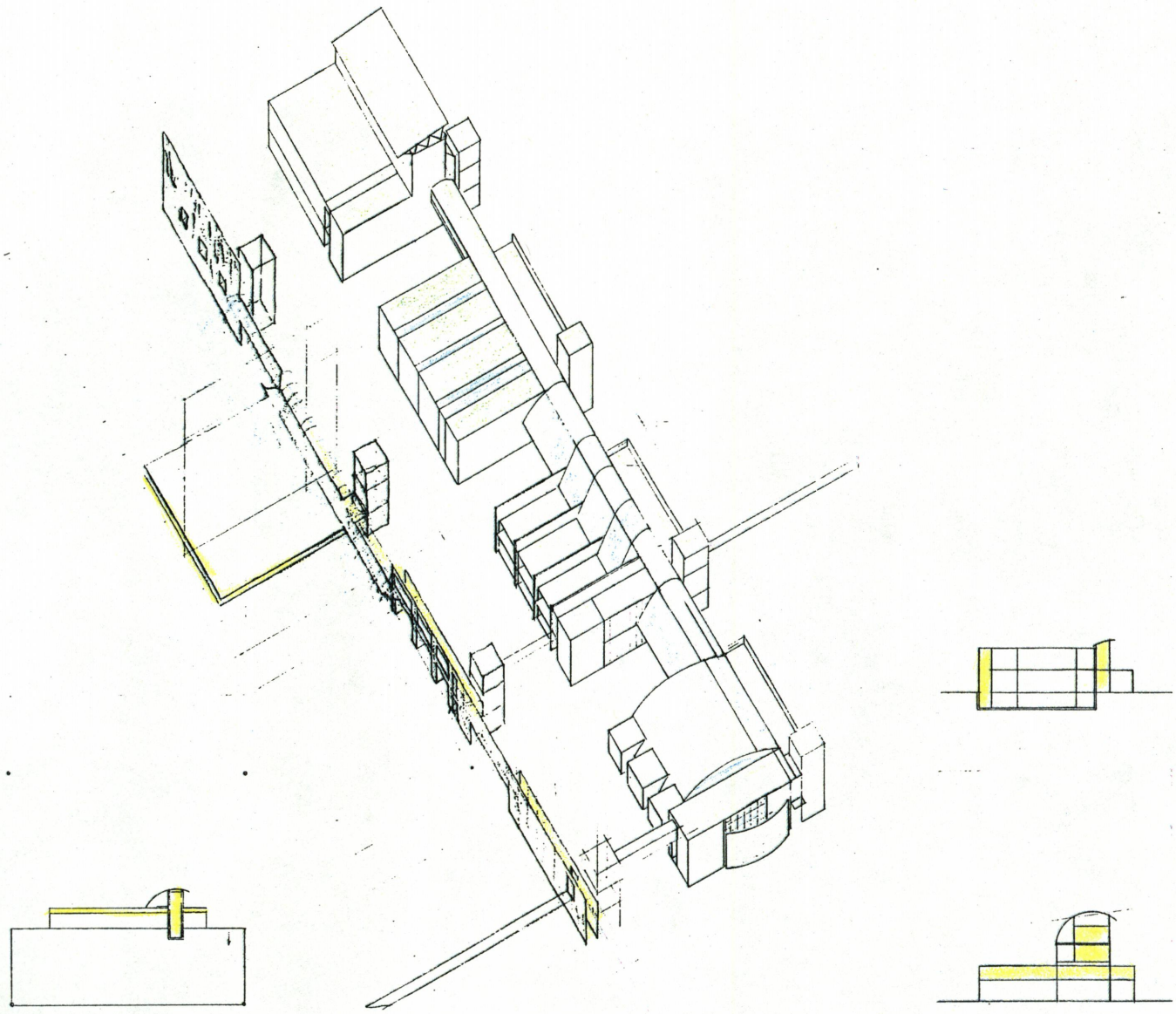


Order and Form

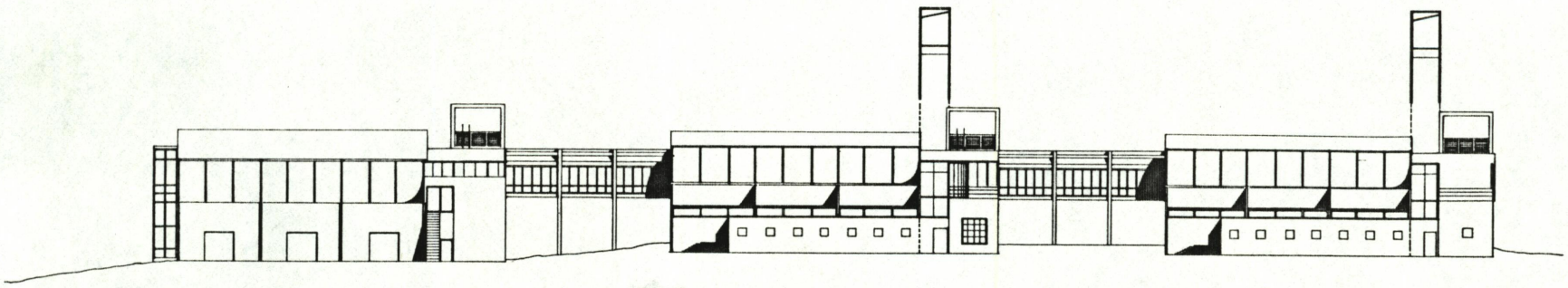
The transition from the temporary to the permanent is a change from the unlimited to the limited influencing the ability of contextual interpretation in architecture. The buildings with the least limitation in the existing order are the most neutral ones and, from this point of view, could be built at any other location. However, since the topography does not provide two identical conditions, each building, put in its place, will have to respond to its context individually. Therefore, each unit will have unique features that relate to its specific location on the site. So, in addition to the walkways and the service wall as parts of the general concept, and function and degree of technology as internal conditions, topos will influence architectural form.

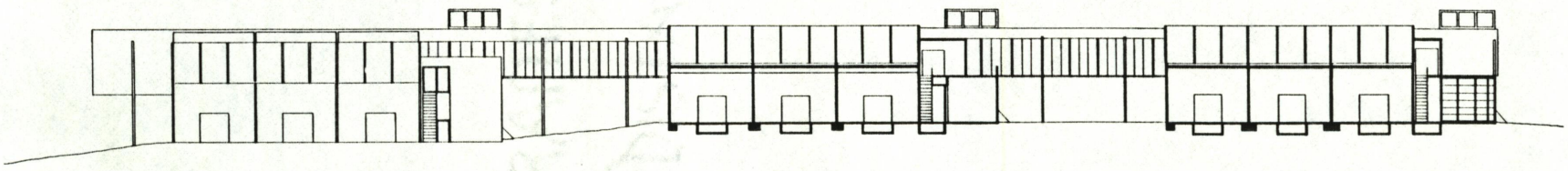


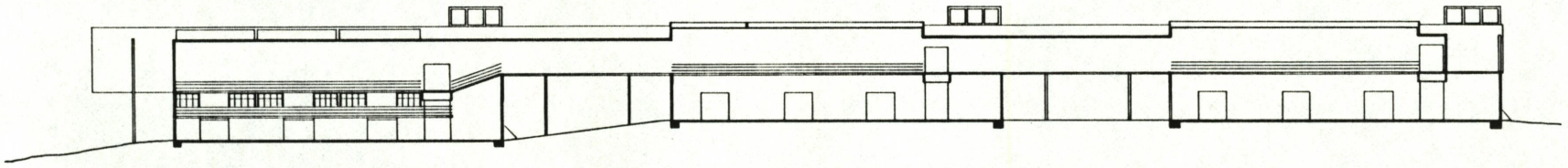


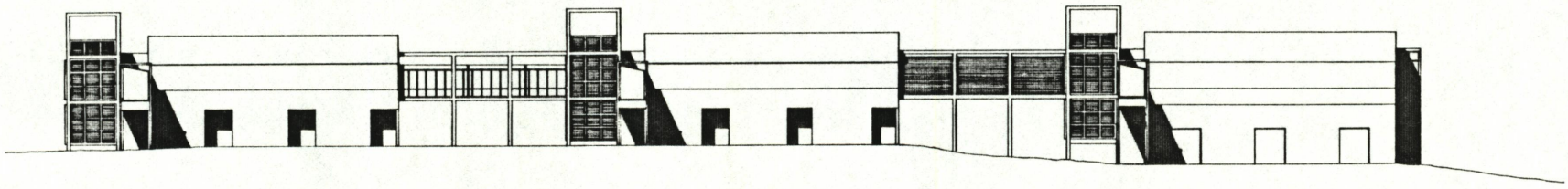


Transformation of the service wall







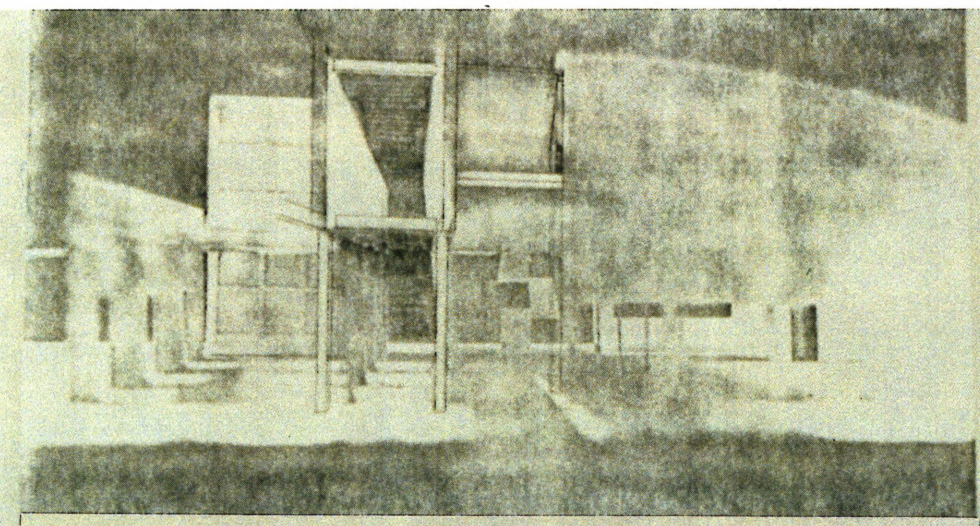


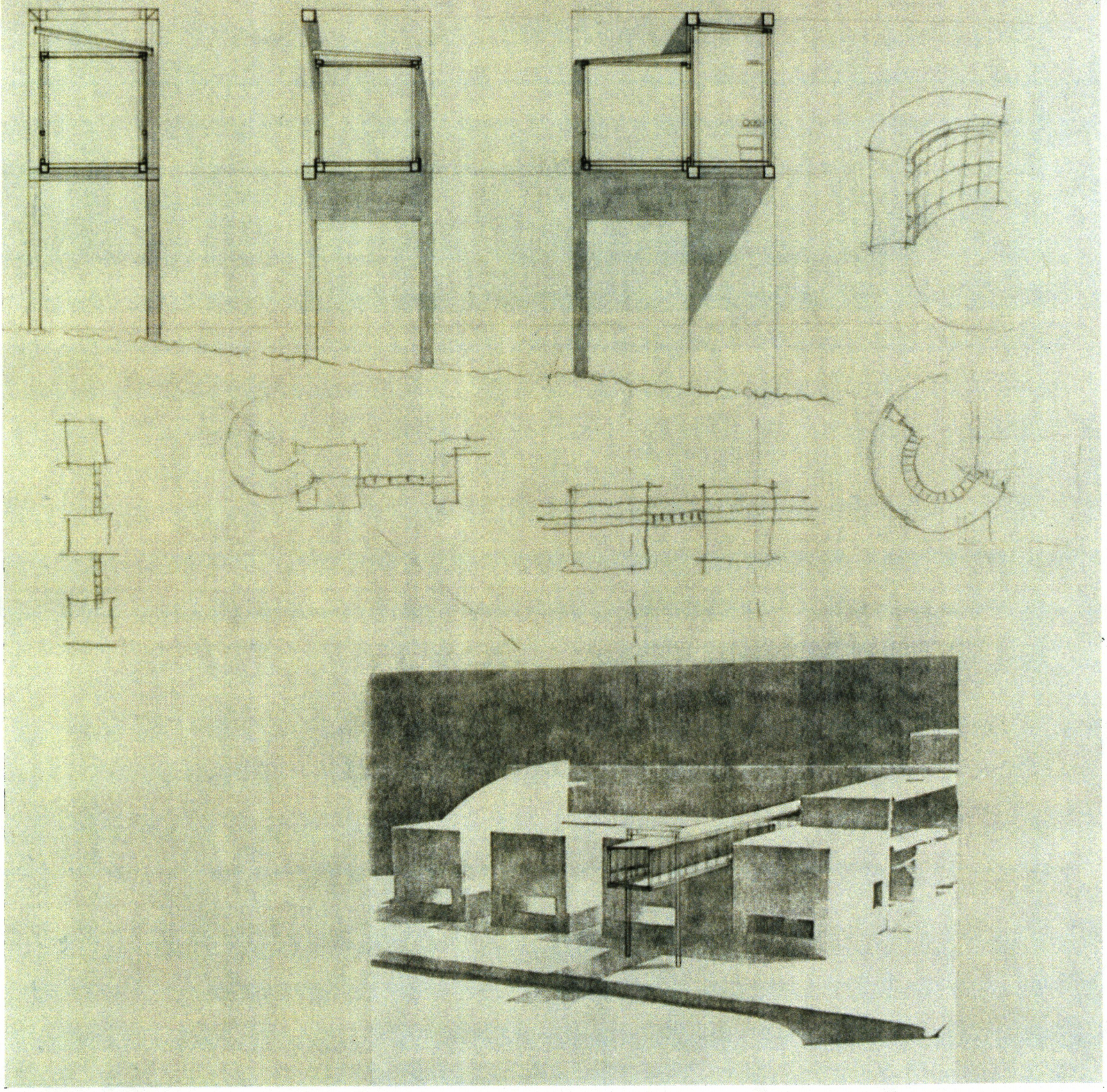
From top to bottom:
North elevation

Cross section

Section along the service wall

South elevation



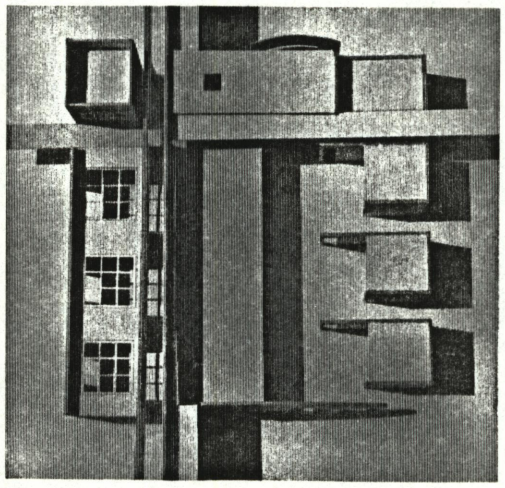


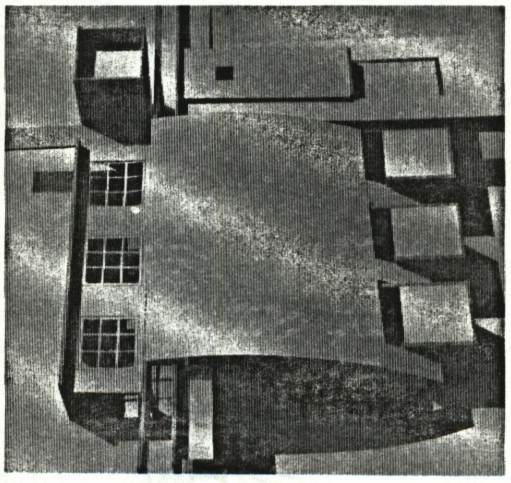
"Let us try to imagine the unimaginable: an absolutely neutral building. It is neither a good building nor a bad one. In size, it is big enough to be recognizable as having serviceable internal capacity, but not so big as to be imposing. In shape, it is a simple rectangular solid, reasonably proportioned. Its sides and roof are perfectly flat, and its corners are right angles. Is sits on level ground. Its door is centered on one long face, the most natural location, for it is at the point of the building exterior closest to the building center, from which all parts of the interior are easily accessible. Its window openings are regularly spaced. Its color is flat, pale gray. It is so featureless that nothing can be read of its structure or of its construction materials. It is respectable, but obviously without interest.
But now let us imagine conditions that our dull little building might respond to. ..."
(Stanley Abercrombie, 1984)

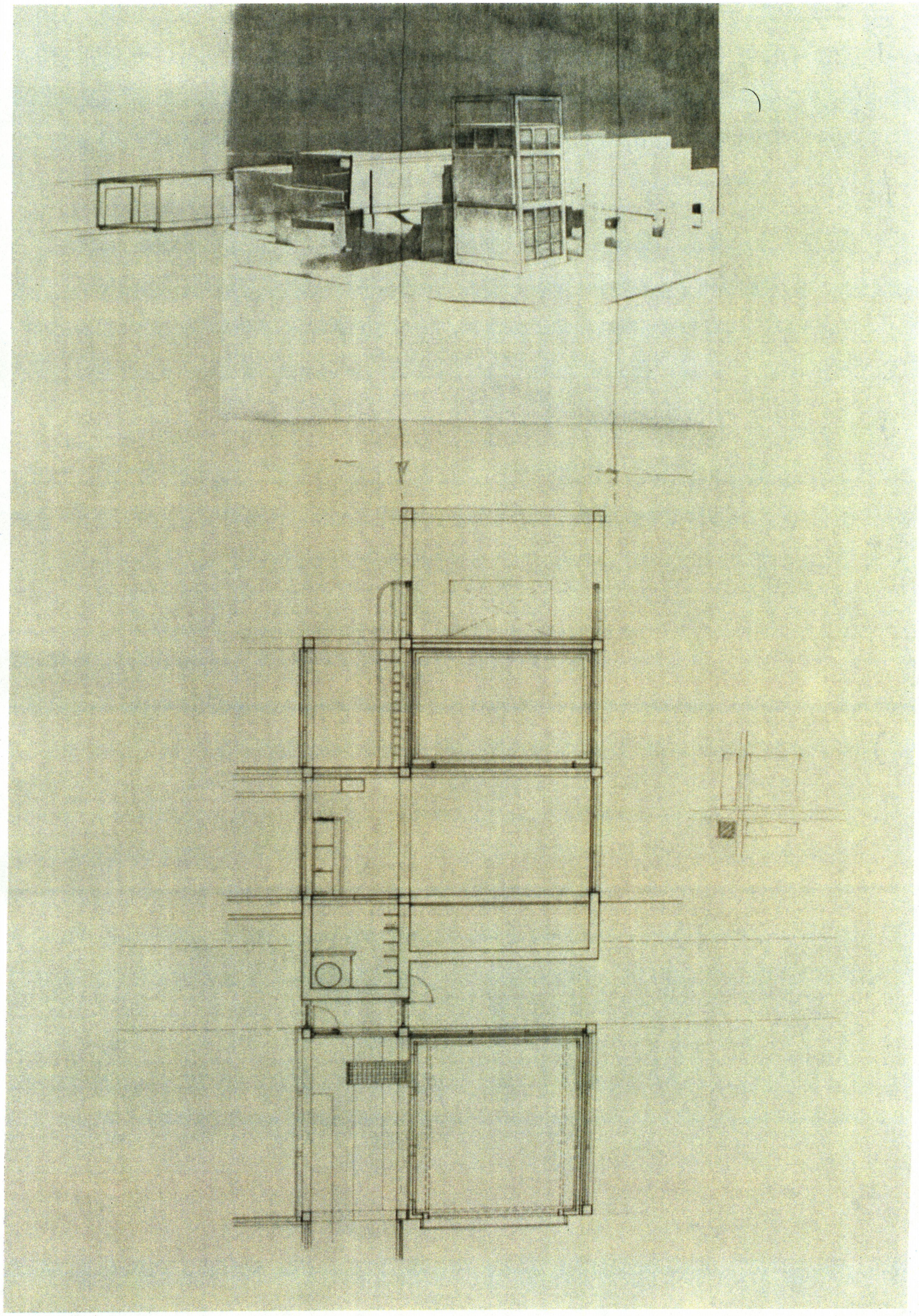
The basic rules of order produce a neutral building. Put in its context, the theoretical framework will take on its specific shape. So, having the greatest freedom of formal expression (or the least defined features), the temporary buildings will respond to organization, function, and technology in the parts that are affected in particular by people (interior condition) and surroundings (exterior condition).

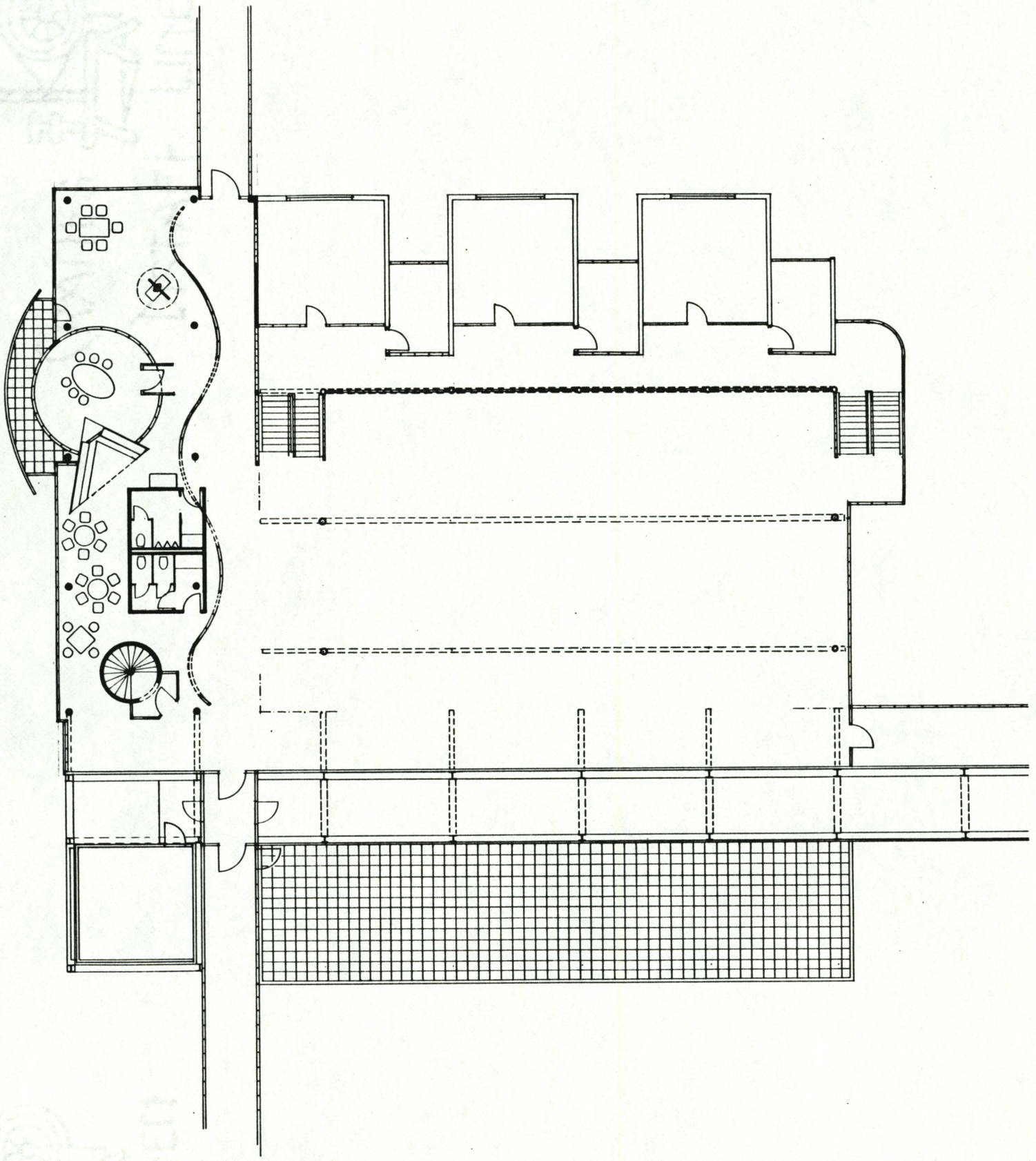
The 'Advanced Technical Office' will serve as an example.

This office is a combination of offices for managers and engineers, CAD work stations, an open landscape, meeting and social rooms, a print room and a photo dark room. The organization of the work environment is a temporary setting and suggests a mixture of enclosed spaces for one or two persons and a large open space for bigger groups or teams. The use of the temporary area as a work environment is strongly connected with processing information. Therefore, floors and/or ceilings must be accessible for changes in cable management and equipment. The structure in this part is preferably steel to maintain the ability of replacing elements or the whole temporary area without affecting the permanent parts. The servicing wall is adaptable to different environmental conditions. Here, it functions as a return air plenum, supported by the shape of the roof over the temporary work space directing the warm air produced by people and equipment toward the air intakes. The tower on the south side of the building is a feature of the "theoretical framework" defined in the principle order. Its adaptation is limited to the exchangeable mechanical units and its height as a result from space needed to house the building specific services. The social zone in the east includes meeting rooms and a lunch area as permanent functions. This zone together with the circulation space is built in concrete. During renovation or construction, the work areas can so be isolated without interrupting the connection between the buildings. The grid of emergency escapes is laid out in a way that includes necessary staircases in the concrete part. The large open spaces get their natural light mainly from the east and west elevation. The CAD workstations are located on the first floor, where electrical light will be needed to adjust for this special work condition . The open landscape office on the second floor in addition will have skylights in the north. The offices for small groups are equipped with individually operable windows. Responding to demands for privacy and to the sloped condition of the site, enclosed offices and print rooms are located half a story lower than the rest of the building.

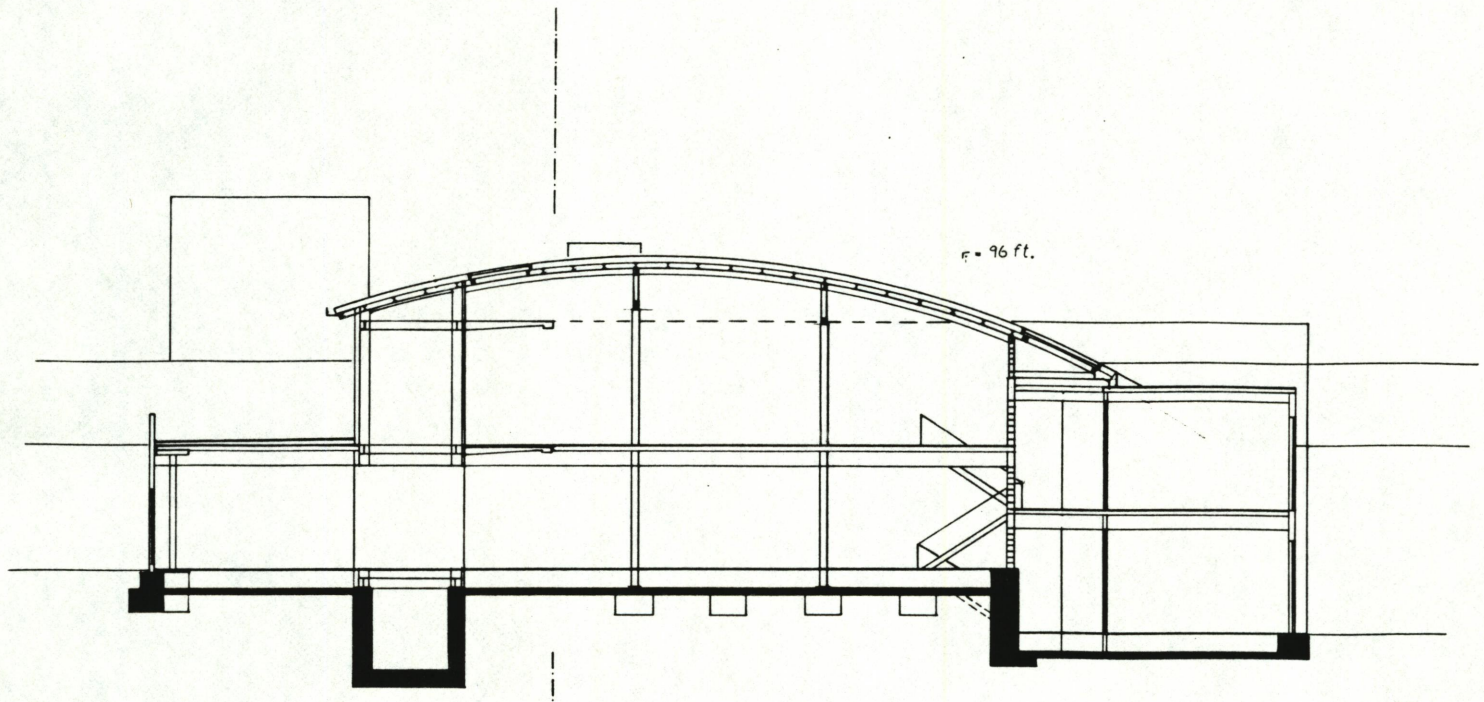


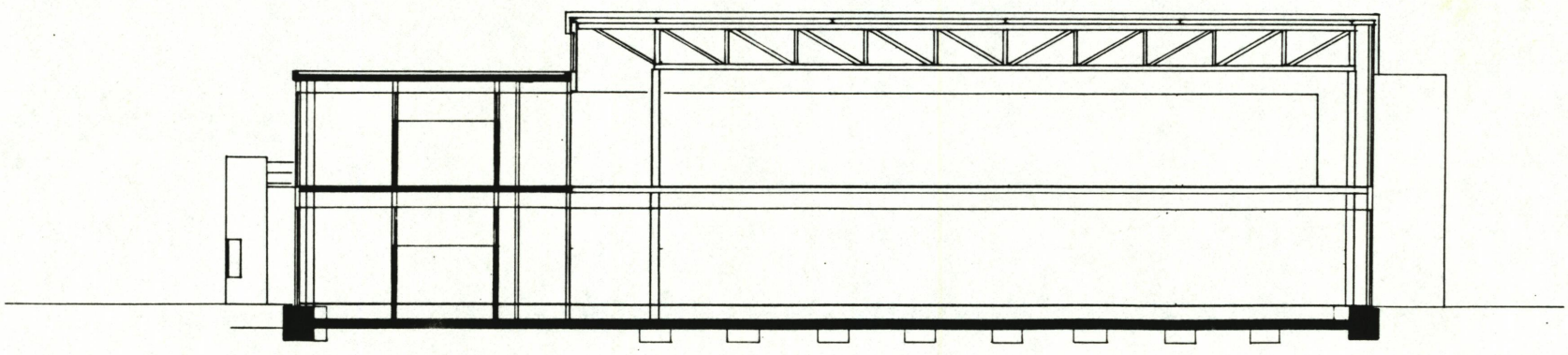




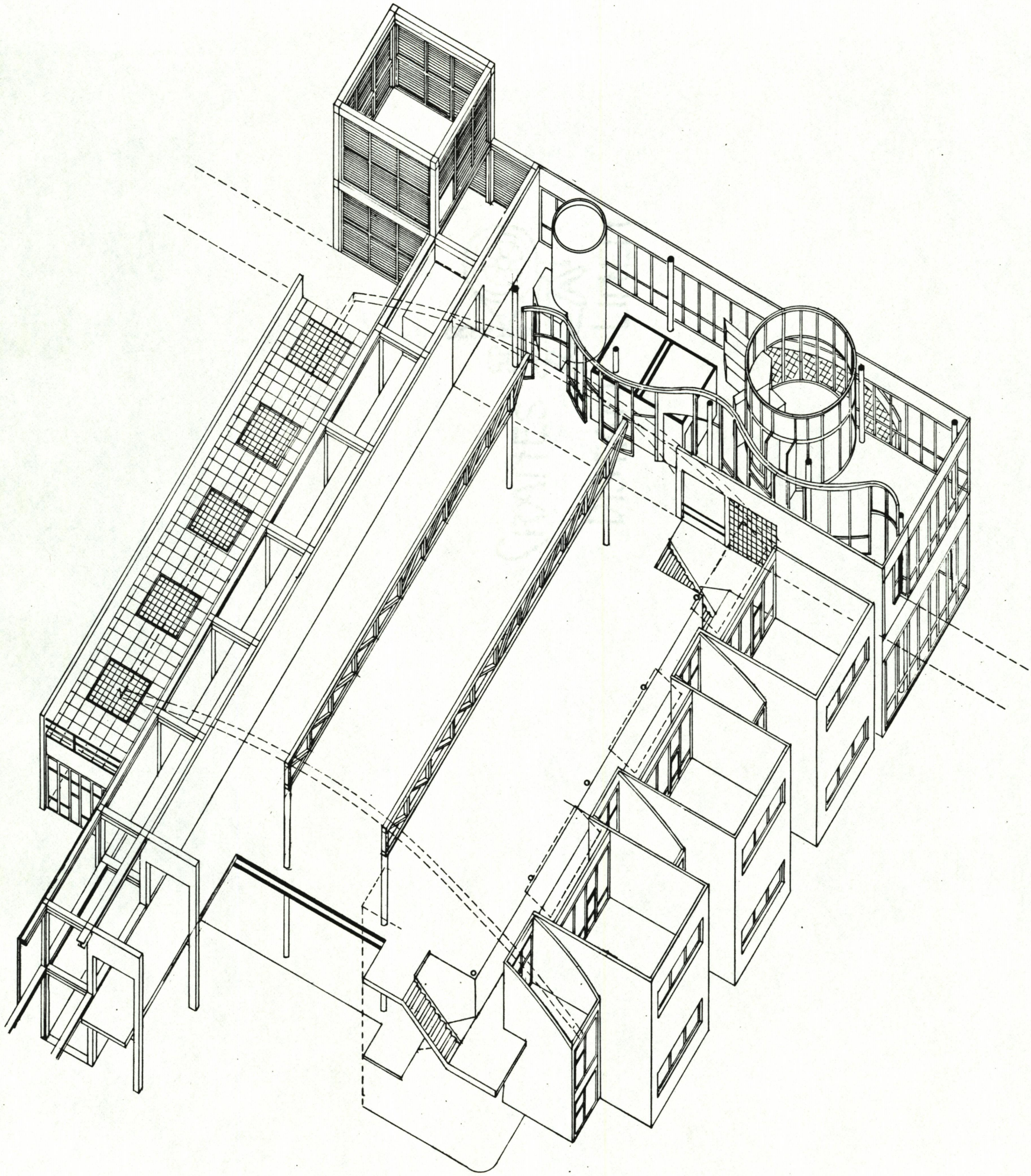


Second floor with social area





Sections



Conclusion

This thesis examined the expression of organization, function, and technology affected by aspects of people and site context as an architectural measurement of flexibility.

The order of elements defines the guidelines that organize the accommodation of metabolic processes. These guidelines serve both temporary and permanent functions. Whereas temporary areas focus on work related demands, permanent spaces are oriented toward people and their basic needs such as privacy and communication. The separation of the two types is necessary to respect their different frequencies of change. Building elements for circulation and mechanical equipment connect both areas. The identification with the building lies in these connections and the permanent spaces that have the most defined form and the least freedom for the design of its components. The network of work and people related spaces must be maintained in the whole project as well as in its parts.

Repetition, hierarchy, and transformation were the principles of order in this primarily conceptual study. Future studies should explore the applicability of The Permanent and the Temporary in projects featuring a more complex order, various grids, and overlays such as found in cases of expansions to existing situations. Also, the impact of the described zoning on the building elements and their design needs further exploration. In a study of building materials suitable for flexible buildings, the aging and replacement of building parts is an interesting aspect in the suggested theory.

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