From Sketches to Computer Images: a Strategy for the Application of Computers in Architectural Design

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Abstract.

The use of computer tools in architectural practice has been steadily increasing in recent years. Many architectural offices are already using computer tools, mostly for production tasks. Hardly any design is being done with the computer. With the new computer tools, architects are confronted with the challenge to use computers to express their design ideas right from conception.

This paper describes a project made for a competition which recently took place in Spain. Sketches and computer models were the only tools used in designing this project. A variety of computer tools were used in different stages of this project: two dimensional drawing tools were used in the early stages, then a three-dimensional modeling program for the development of the design and for the production of final drawings, and a rendering program for final presentation images.

The Architect and the Computer.

The use of computers in architectural offices has been steadily increasing in recent years. Today, it is common to find computer generated images of architectural projects in magazines. Production drawings are more and more frequently made with computer drafting systems. Architectural offices are now using computers to replace specific tasks that were done manually or with less sophisticated techniques earlier. Computer models and renderings are replacing physical models. Image processing is taking over photographic montages and the hard line ink drawing is starting to disappear after the widespread use of drafting systems and plotters.

This state of affairs shows that computers have entered the architectural profession through the door of production and image making. Even though these are important aspects in the making of architecture, they are probably not the most relevant ones. Before production drawings or realistic renderings can be made, a project has to exist first, that is, it has to be conceived.

The role of computers in architectural design has not been yet well understood. The reasons for this lack of understanding are intrinsic to any new tool. First, it takes time to assimilate the possibilities that the now tool can offer. It might take more than one generation to really understand the potential offered by the computer tools, as it happened with the invention of perspective. Secondly, architecture schools still have to integrate computers in the education of architectural design. A new generation of architects, educated to design with computers, still have to make progress. And, finally, computer tools for architecture need to be improved. In most of the cases, the tools that architects use today are not specifically for architecture (as the general purpose modeling systems). On the other hand, the systems that claim to be only for architects show little understanding about how an architect designs.

In order to understand how computers can affect the design process it is necessary first to recognize the relationship that exists between <u>conception</u> and <u>representation</u> in the process of design. For the architect, conceiving and representing are not two separate issues but one and the same thing. A design does not exist until the moment it is expressed through a particular medium, whether this is plans, elevations and sections, cardboard models or computer models. These medium influences the architect in two different ways: determining <u>what</u> and <u>how</u> can be thought (as it is the case with plans, sections and elevations) and imposing a certain aesthetic to the design (the aesthetic of the line on the paper, the collage aesthetic).

A real impact of computers in architectural design will start to occur when the separation between conception and representation no longer exists with regard to the use of computers in architecture. To achieve that it will require that good architects use computers to express their ideas right from conception.

A Competition Project in Granada.

One of the goals of the Chair for Architecture and CAAD at the ETH in Zurich has been to integrate computers in the education of architectural design. Presently, the Chair has reached a level in the equipment and know-how which is difficult to find in an architectural office. We thought it could be a good experience to test how this knowledge and technology could he used in the design of a project, in similar conditions to the ones found in professional practice. A competition in Granada (Spain) motivated me to carry out an architectural project using computers, from conception to final production of drawings.

The purpose behind the competition was to provide ideas for a new headquarter of a Savings Bank in Granada, Spain. Its site was located in the outskirts of the city, in an area that is to be developed in the near future. The gross area of the building was 30,000 squared meters, and a rather detailed brief with program requirements was given to the contestants.

Granada and the Alhambra.

When designing a building in Granada one thinks immediately of the Alhambra, the Moorish fortress which is one of the symbols of the city. In the Alhambra, as it is characteristic of Arab architecture, there is a clear separation between the outside and the inside. From the outside the Alhambra is a fortress made up of massive brick walls with towers and a few small openings, and big doors to enter inside (Figure 1). Passing through these walls, the Alhambra is a luxurious palace whose courtyards are filled with light reflecting in pools, and walls of richly decorated tiles (Figure 2). This extreme separation between the sober outside and the elaborate inside became a main inspiration of the design.

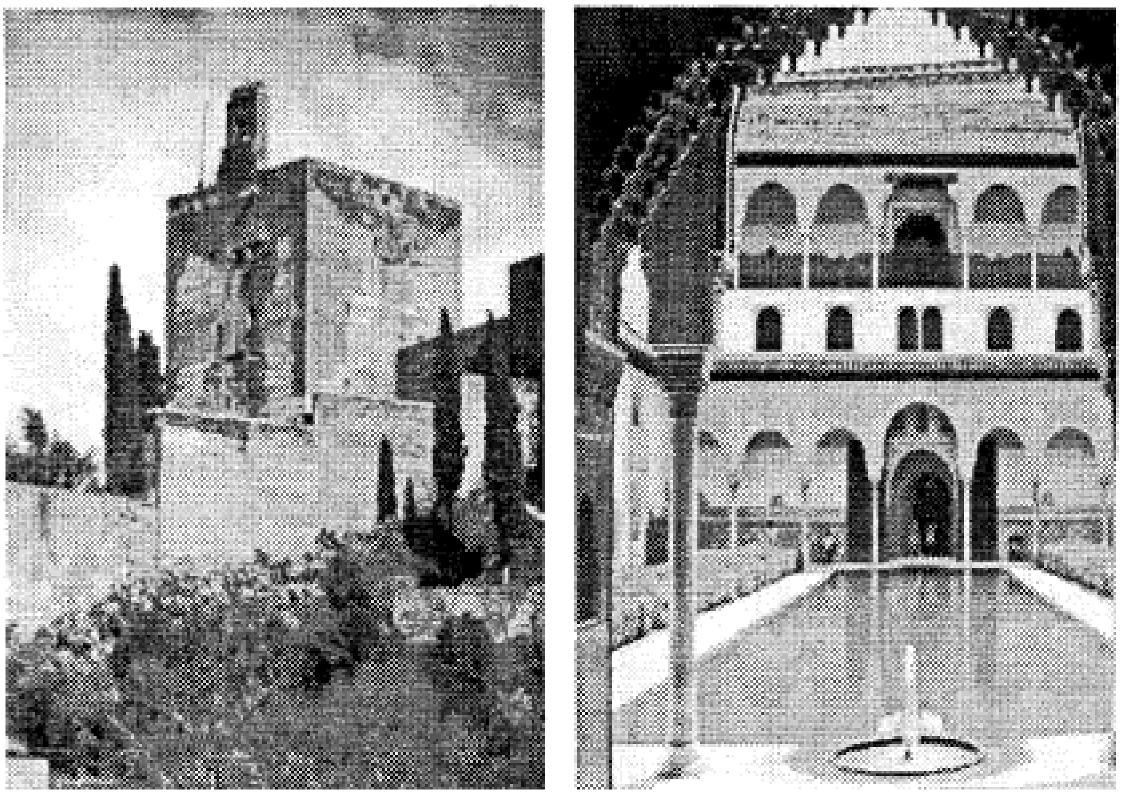

Figure 1, 2. Outside and inside: two contrasting perceptions of the Alhambra.

The organizers of the competition wanted to have a building representing the characteristics of the city. One way to achieve this goal was to bring some of the spirit of the Alhambra into the new design. It was also important to express the strong ties that exist between the Savings Bank and the city. The logo that identifies the firm is a star, the 'estrella nazari' (Figure 3). This shape was incorporated in the design from the very beginning as part of an idea to design a building that would be a symbol for both the Bank and the city.

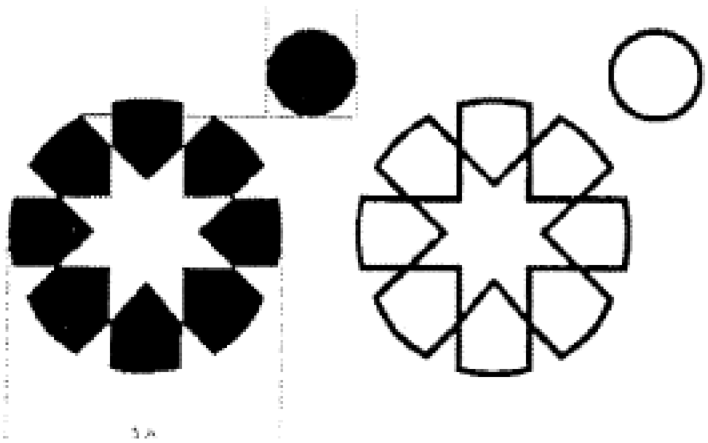

Figure 3. The star that makes the logo of the Savings Bank.

First Ideas: Sketches.

The preliminary ideas of the design were sketched out. Before approaching the computer, I spent some time exploring different issues through sketches as, for example, massing studies, plans, and views from both the outside and inside (Figure 4). A certain image started to consolidate around an idea of a square plan with a courtyard inside, a typology commonly found in many examples of Islamic architecture. The big masses located in the periphery of the square are meant to recreate the image of fortress. This image of the isolated fortress is particularly appropriate for this design, given the fact that no urban context exists at this moment.

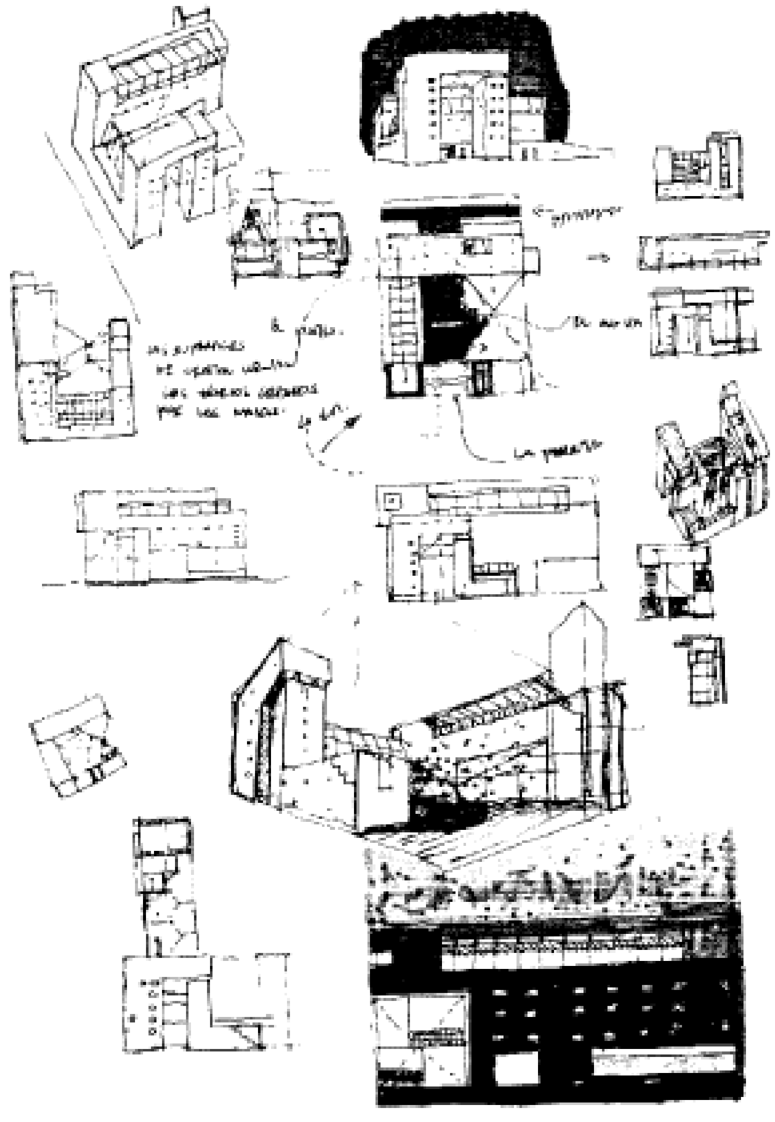

Figure 4. Preliminary sketches.

The central courtyard, or patio, is not completely enclosed. A corner is carved out to facilitate the penetration of light and to create a visual connection between the inside an the outside. (Figure 5)

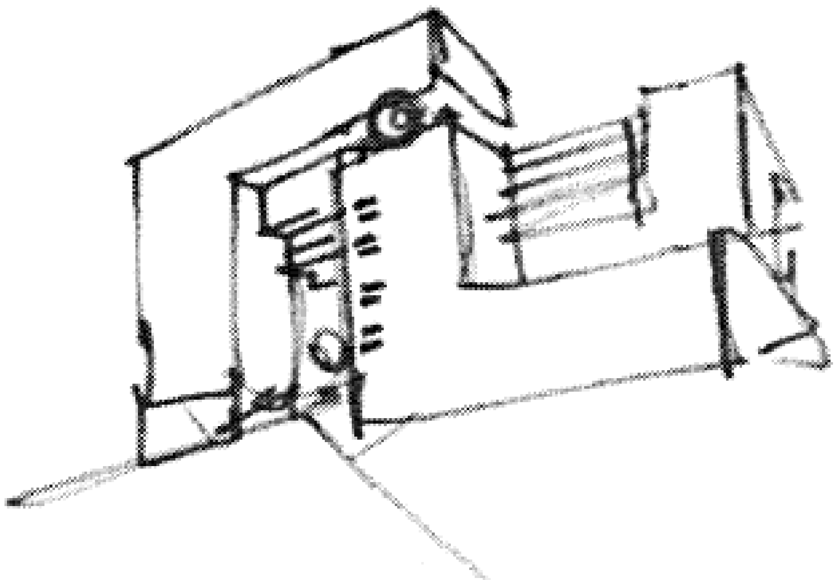

Figure 5. Preliminary sketch.

One can argue that where computers are available there is no reason for using paper and pencil any more and, furthermore, that the use of sketches eliminates the possibility for computers to really affect the design from its inception. However, both sketching and computer tools are necessary and can complement one another. The intuitive component of the design process, manifested through the sketches, can be complemented by the systematic componnt that a computer adds later on to the process.

Volumetric Studies and Solid Modeling.

The sketches had two different perceptions of the overall massing of the building. The first was to think of the whole mass occupied by the building as a cube that was carved out in order to make the patio inside; and the other, to think of the whole as the result of the articulation of separate parts, like the L-shapes in front and the large volume behind them, which together create the patio.

Three-dimensional models of the ideas sketched on paper were done with a solid modeling program (Figure 6). With the sketches it was not important to decide whether the patio was carved out from the overall mass, or if the individual volumes defined the space. When these ideas were taken to the computer, however, it was necessary to decide between one or other perception, as both could not exist simultaneously in the same computer model. This fact, reduced the interaction with the computer model and restricted the design exploration but, on the other hand, it contributed to systematize the design process right from the beginning.

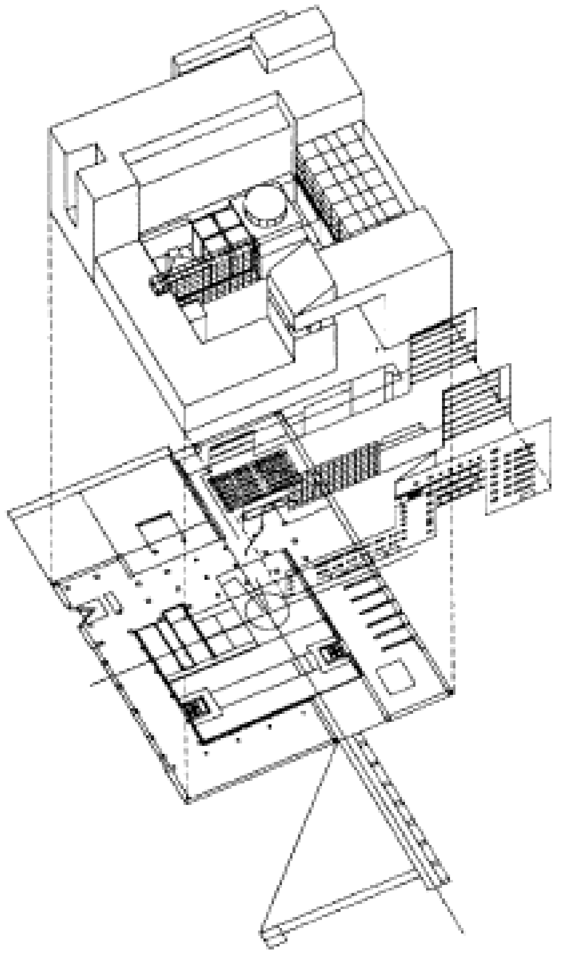

Figure 6. Exploded axonometric showing the vocabulary of solids used at this stage of the design.

The adoption of a typology was particularly useful when the design proceeded with the computer. Having adopted a square with a central plan as a type, the design proceeded with the exploration of formal solutions within the limits set by that type. It was also important to define the vocabulary of elements that was being used, which at that stage in the design were simple solids, like the cylinder and cube that made the pavilions inside the patio. These pavilions act as , mediators' between the human scale and the large scale of the outer masses. Also, they recall the small structures inside the 'Patio de los Leones' in the Alhambra.

Every abstraction implies a qualitative reduction of the overall complexity of issues involved in the design of a building. The assimilation of the building to an object, that takes place in the process of design, is necessary to perceive a building on its completeness. At this moment of the design process the architect operates at the same conceptual level as the sculptor does. An architectural space can be conceived as a result of carving out some mass from the object in much the same way as the sculptor adds and takes material to and from a piece of sculpture. This sort of abstraction used by architects necessarily leaves its imprint in tile building they produce.

Color Compositions of Geometric Shapes.

Simultaneously, when the three-dimensional models were made, plans and elevations were extracted from them and brought to two-dimensional drafting systems. There were certain issues in the design that required to be treated creatively in two dimensions, for example, the plan and the front elevation. The drafting system was an appropriate tool to make abstract compositions of color shapes in plan, and studies of proportions and fenestration in elevation.

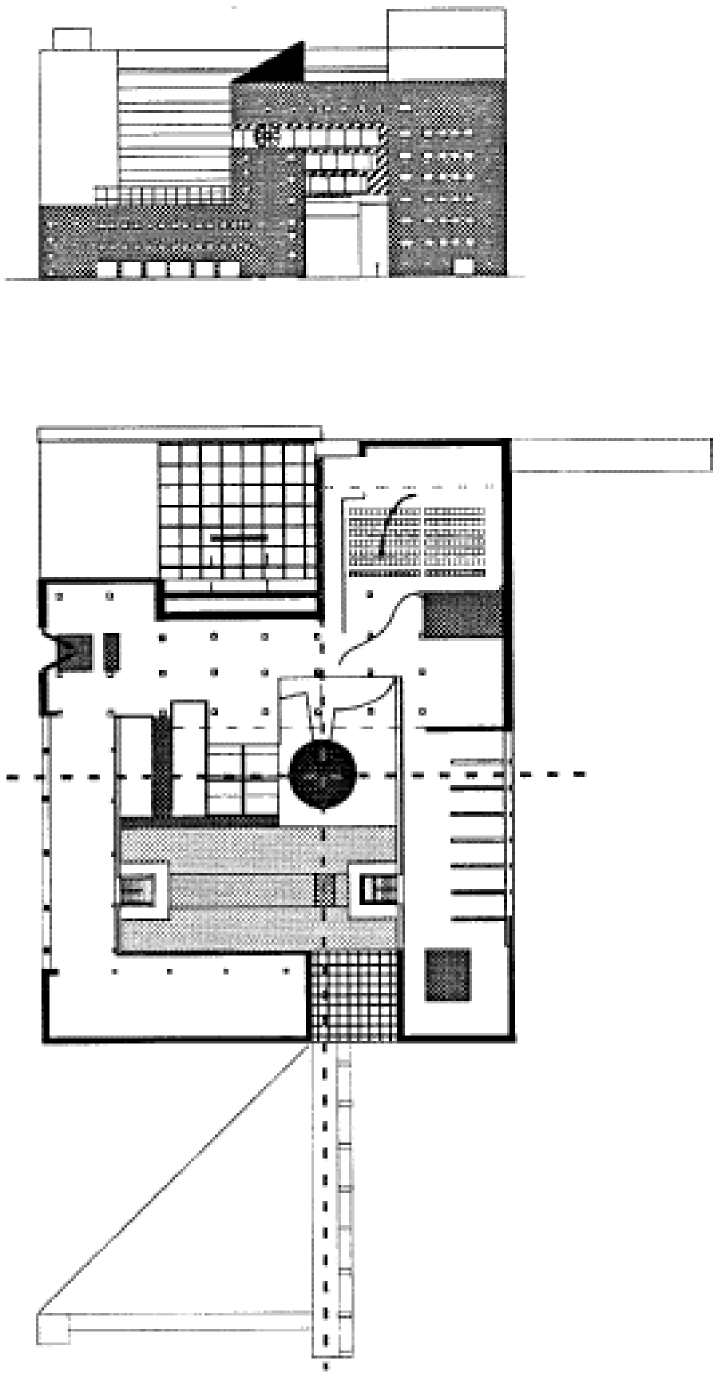

Figure 7. Ground floor plan and front elevation at an early stage of the design process.

The usefulness of the drafting program was based on its capability to create and to modify simple compositions of forms very quickly. The color shapes and lines that were drawn with the program imposed some of their aesthetic on to the design. The plan was considered as an abstract composition of colors shapes and lines representing the different architectural elements (Figure 7). For example, the large rectangle emerging from the upper right corner of the square represented the auditorium, while the red squares at the corners symbolized the cores that gave access to the different stories.

The elevation drawing shown in Figure 7 already contains some of the relevant features of the design. The two L-shapes appear s if one is supported by the other. The logo of the firm, the Arabic star, takes a cylindrical shape and is placed between the two L-shapes. These two L-shapes create a big gap that recalls the big doors that enter the Alhambra,

It is important to match the issues that are being explored at every stage of the design process with the capabilities of every tool. A simple two-dimensional program can be a very powerfu1 tool of the design is suited to its capabilities. Even though abstract compositions are only a simplification of the overall complexity of the design, they are loaded with a content that will unfold later in the process where these symbolic geometric figures are transformed into concrete architectural elements.

From Geometry to Architecture: Models and Drawings.

After the basic features of the design were established, the next step was to transform the simple volumes and shapes into architectural elements. This was probably the most critical moment in the design process of this project. Working with simple objects with a computer is straightforward, but things start to be less clear the moment a building has to be modeled. Given the size and complexity of the project, two critical decisions had then to be made: first, the scale in which the model had to be built, and secondly how much of the building needed to he modeled in three dimensions.

The development of the design focused on the construction of the 3-d model. The initial volumetric studies were further developed with more detail. Singular elements, as the pavilions inside the patio, were modeled and designed in three-dimensions (Figure 8). The cylindrical pavilion, that creates the lobby to the main part of the building, has a spatial frame as a roof. This frame is shaped after the star from the logo of the firm. The door of this pavilion has the shape of a keyhole. This shape is a symbolic reference both to the Bank and to the Moorish arch. The intention behind this symbolic references is to create a building that belongs to a particular place and time, in this case, to a Savings Bank in Granada.

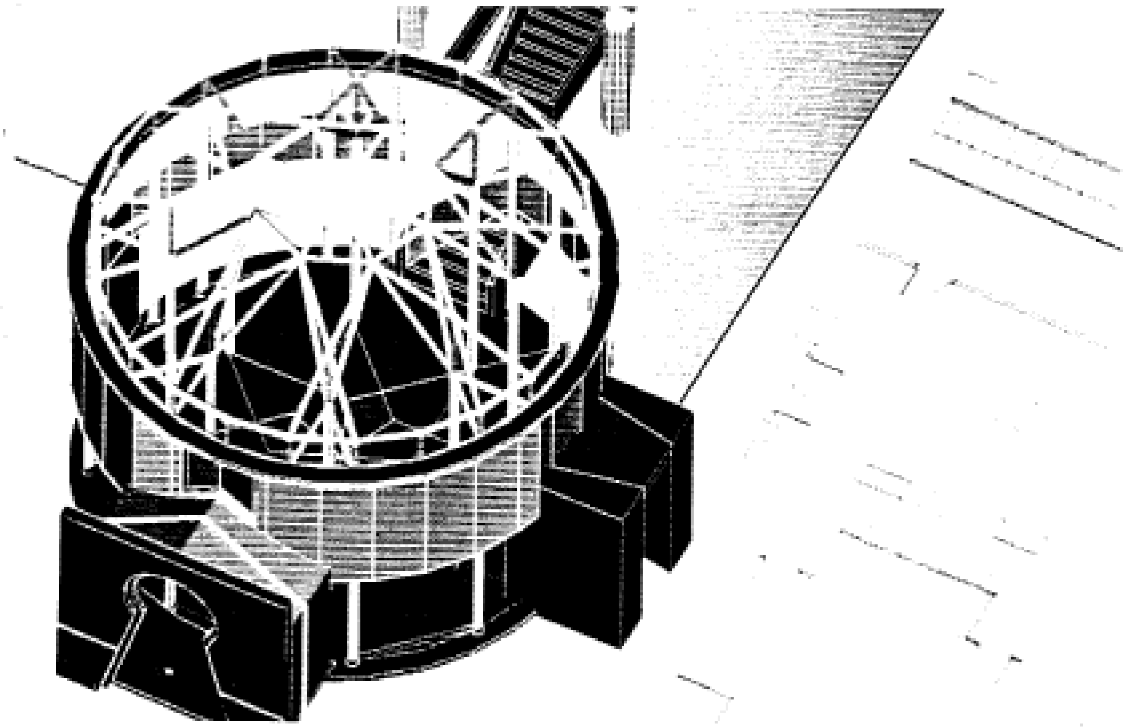

Figure 8. Development of the design of the entrance pavilion located inside the patio.

The decomposition of a design in parts is another condition imposed by a computer modeling program. It was therefore important to have a clear understanding of the structure of the design to he able to break it into parts that could be developed separately. Figure 9 shows the outer walls in isolation from the rest of the elements in the design. Thus, the separation of the outside and inside, which was one of the premises of this project, became implemented in the computer model.

The program used to build the model was a general purpose modeling system that could model three-dimensional objects and make two dimensional drawings, but could not recognize any link between them. The strategy adopted to overcome this limitation was to build the model in three dimensions and then extract the two-dimensional information from it. The main problem was that the consistency between the 3-d model and the drawings could not be maintained by the program itself.

Given the complexity of the building program, it was necessary to modify the plans many times during the design process and one of the most successful experiences in this project was to have plans drawn on the computer. This made it possible to explore different alternatives for the plans layout in order to meet the requirements on surfaces and adjacencies.

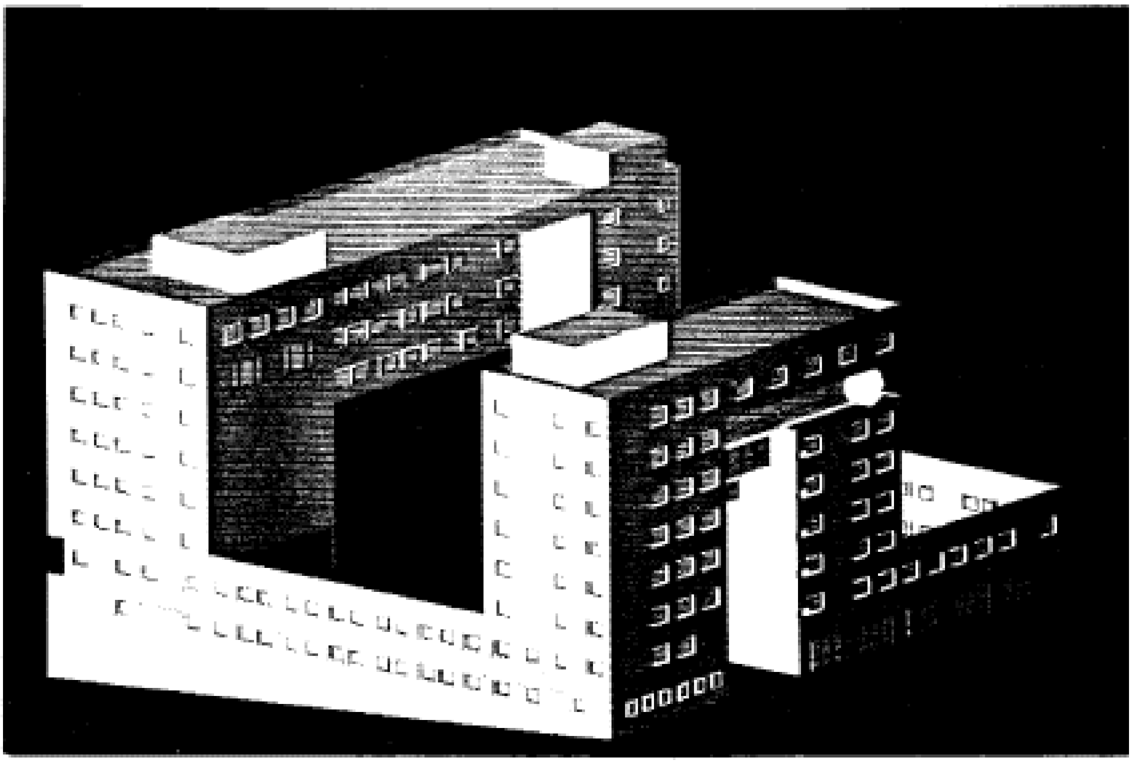

Figure 9. The outer walls as a separate element.

The transformation of geometric volumes and shapes into architectural elements is a critical step in architectural design. Changes from one representation to another imply a change of scale that computers simply cannot understand. In the computer screen, drawings and models are displayed smaller and larger, by zooming in and out. However, this 'scaling' of the image is not the same as the concept of 'architecture scale'. In architecture, scale has to do with the qualitative aspects that are captured by every representation that is made of a building, and not so much with the size of a drawing. This is an important conceptual issue that current computer systems have simply ignored by making computer models scaleless.

The Structure of the Design: its Implementation in the Computer.

An important aspect, related with the recognition of the structure of the design is to implement that structure with the tools provided by the computer. It is important to model the components in a hierarchical fashion, creating more complex elements out of the simplest ones. This makes the model more accessible for further changes, and also facilitates the exploration of formal variants of a particular component.

Some of the components of the design were modeled in a hierarchical fashion, as for example, the gridiron in front of the large volume in the background (Figure 10). This part of the design was modeled from a vocabulary of simple elements (posts, beams, railings) which were then combined in frames which in turn were grouped to make the whole gridiron. The proportions of the different elements were changed several times during the design without having to modify the gridiron itself the curtain wall that lies behind the gridiron was modeled in a similar hierarchical way.

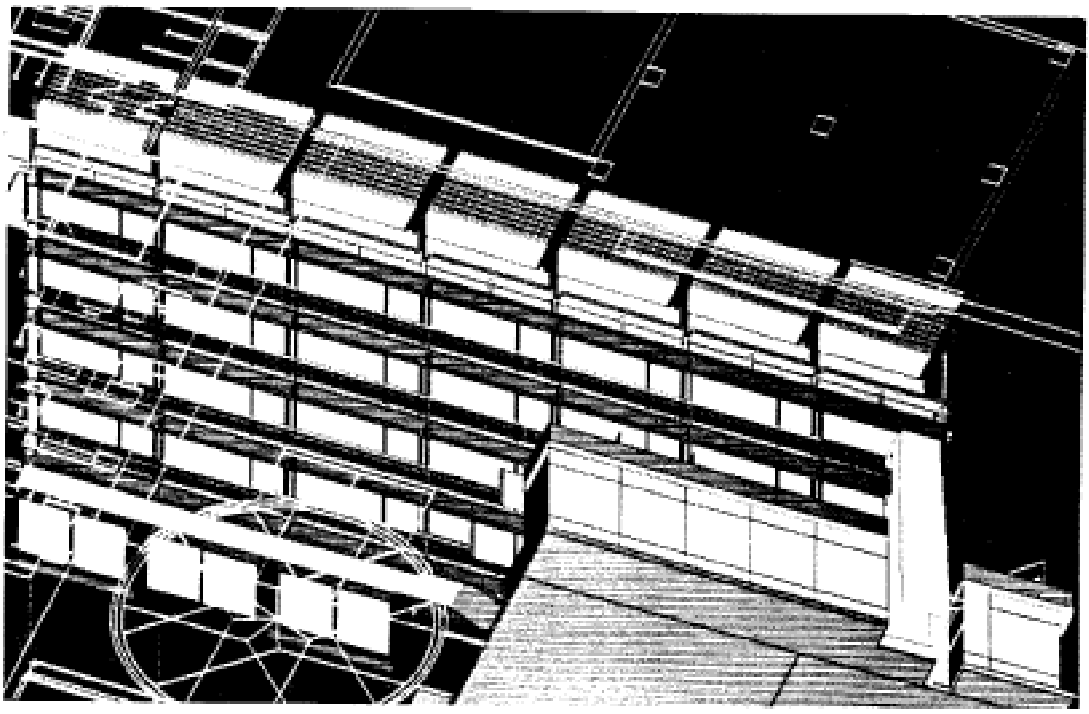

Figure 10. Inner facade curtain wall and gridiron: modeling with hierarchical structures.

This part of the design was carried out using a program developed by the Chair. This program is based on the paradigm of types and instances. It allows to create a vocabulary of elements and to organize it in a hierarchical fashion. These elements can be instantiated in the model and then modified and replaced by other elements using some simple interactive fools. Designing with a computer becomes meaningful when a link between the design concept and the design tool can be established. Once again the identity between conception and representation is the issue at stake.

Space and Light: Renderings.

The rendered images reflect one of the main ideas of the design, namely, the contrast between inside and outside. From the outside, the building appears as a solid mass of brick. The up and down rhythm of the masses can be caught by the eye. The open corner allows a hint of the inside of the building to be exposed. When the building is approached from one of the access corners some parts of the interior can be perceived. (Figure 11)

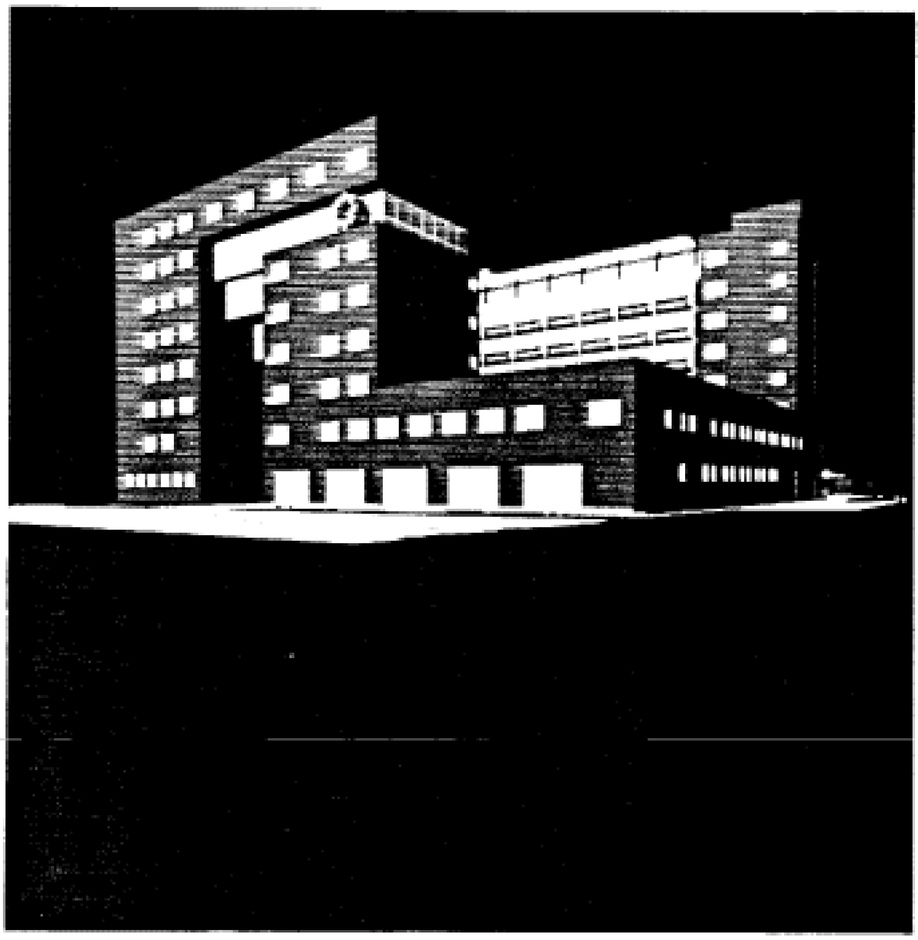

Figure 11. The inside is perceived through the open corner.

The big gap created by the L-shapes makes the main entrance to the patio. A path marked by the tile in the pavement leads towards the patio. From the patio some of the inner dependencies located at ground level can be already accessible. The cylindrical pavilion acts as a threshold before actually getting inside the building. (Figure 12)

Figure 12. The path leading to the entrance pavilion inside the patio.

The space enclosed by this pavilion acts as a transition between the patio and the interior of the office buildings (Figure 13). The gridiron of the back facade can be perceived through the transparent roof of this pavilion.

Figure 13. Looking up through the roof of the entrance pavilion.

In contrast to the sober brick of the outside, the inside has materials of metal, glass and tile. The result is a space filled with multiple reflections from the glass and metal sheathing of the inner facades and from the tile and pools in the pavements. (Figure 14)

Computer renderings can be an excellent tool to express the material and spatial qualities of the design of a building. With renderings, though, both the bad and the good aspects of the design show tip. If the proportions of the spaces or the level of detail of the model are not appropriate, the result will not be satisfactory. In this regard, the rendering acts as a final test for the design.

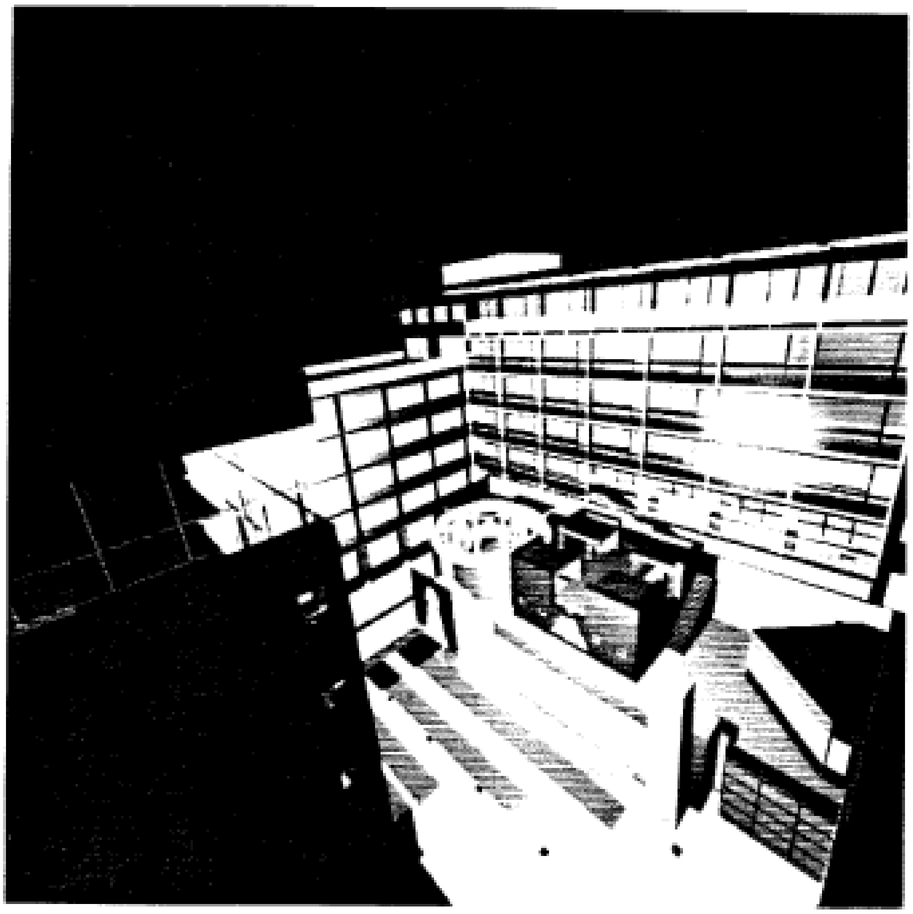

Figure 14. View of the patio.

Drawings: From the Screen on to the Paper.

It is a common belief that a three-dimensional computer model can be the source of all sort of outputs: plans, elevations, sections, renderings, as well as quantitative data like surface calculations. In fact, it is very difficult that one representation embeds all the others and behind that difficulty lies some important conceptual issues that are not being considered by current modeling programs. Also, from a more practical point of view, the drawing of a plan to 1:50 scale cannot be the same as the one of a plan to 1:200 scale regarding the level of detail, weight of the line, size of the text, and so on. The same can be said for the renderings made from the computer model. Sometimes the level of detail of the model is too small, so the model will look 'cartoonish' on the screen. Increasing the detailing of the model will solve the problem, but too much detail will be inadequate for a 1:200 scale elevation produced from it, for example.

The 'types and instances' program was used to overcome these difficulties. Each window, for example, was modeled with different 'levels of detail', so that it was possible to have multiple representations of the same 3-d model. Then, when a plan or elevation to 1:200 scale was needed, a simplified representation of the window was used. Conversely, when the model was used for renderings the more detailed windows replaced of the simple ones.

Being aware of the specific requirements of every representation, the strategy that was adopted was to concentrate on the 3-d model up to the moment that the final drawings and images had to be produced. After certain stage in the design, every representation was treated separately. The detailing of the 3-d model was carried to the level necessary to express the tectonic and spatial qualities of the building, and the plans, sections and elevations were worked out to the level of detail necessary for the 1:200 scale (see following figures).

With computers, the drawing has to be actually drawn in one media, the screen, and then produced on another one, the paper. This separation does not occur in manual drawing. Because of this separation between the screen and the paper, some time had to be spent in adjusting both medias through trial and error. This caused some unnecessary delayed in the production of the final drawings. A photographic technique was used to print the drawings directly from the computer files. Renderings were electronically transferred to slides and from them, paper prints were made.

Conclusions.

Computer technology has already reached the level in which it can be a useful tool for architects. As architects gain more experience working with computers and computer programs become easier to use, the usefulness of computer tools will become even greater. Even the most simple of the existing computer graphics applications is doted with an aesthetic which can influence decisively the work that is made with it. This aesthetic, embedded in the technology, needs to find its counterpart in architecture itself. When the separation of conception and representation with regard to the use of computers no longer exists, a new architecture will necessarily have to emerge. Then, the challenge for architects will be the integration of the new conceptual tools, and the architecture that is produced with them, into the mainstream of architectural tradition.

Acknowledgements.

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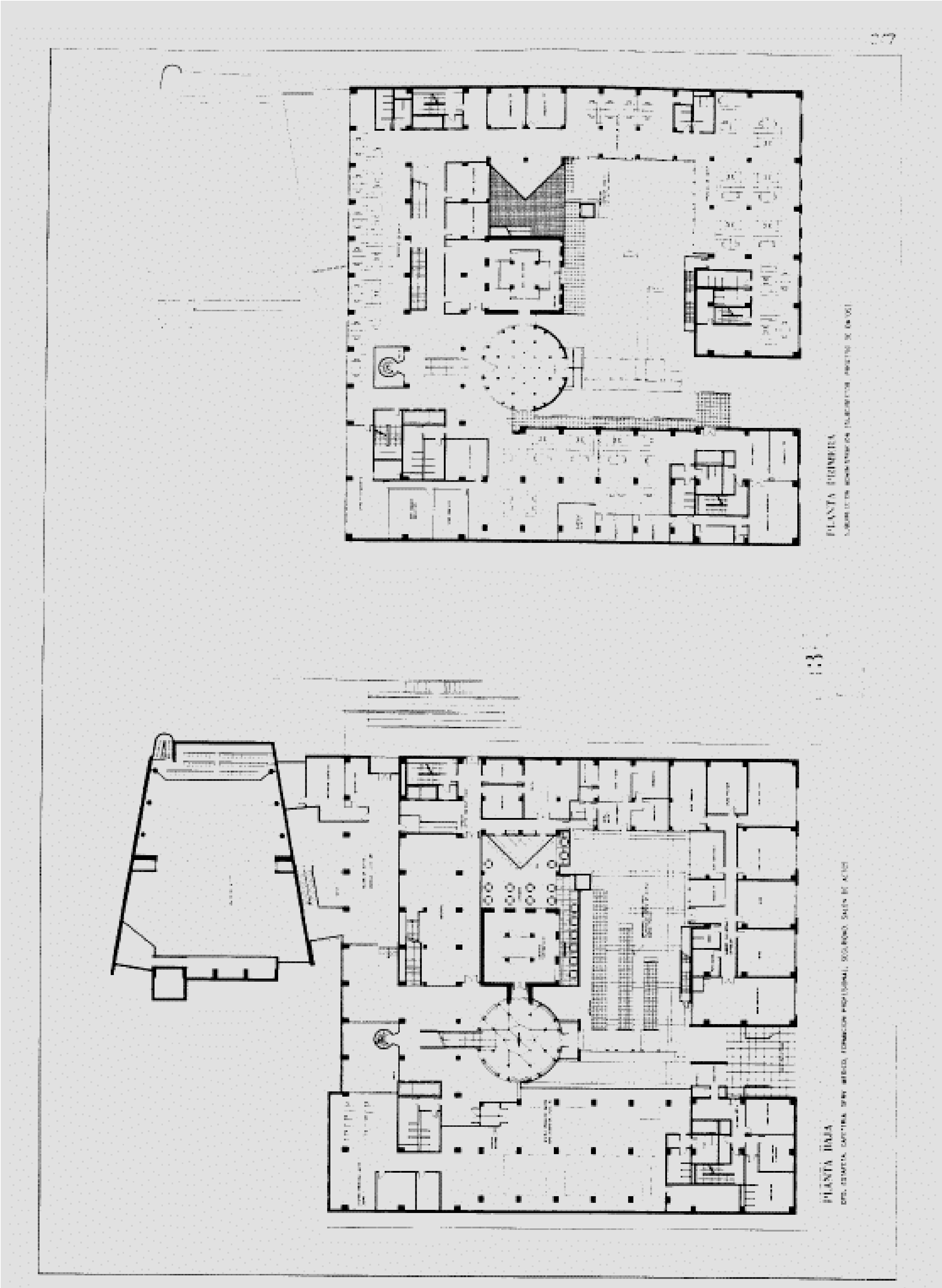
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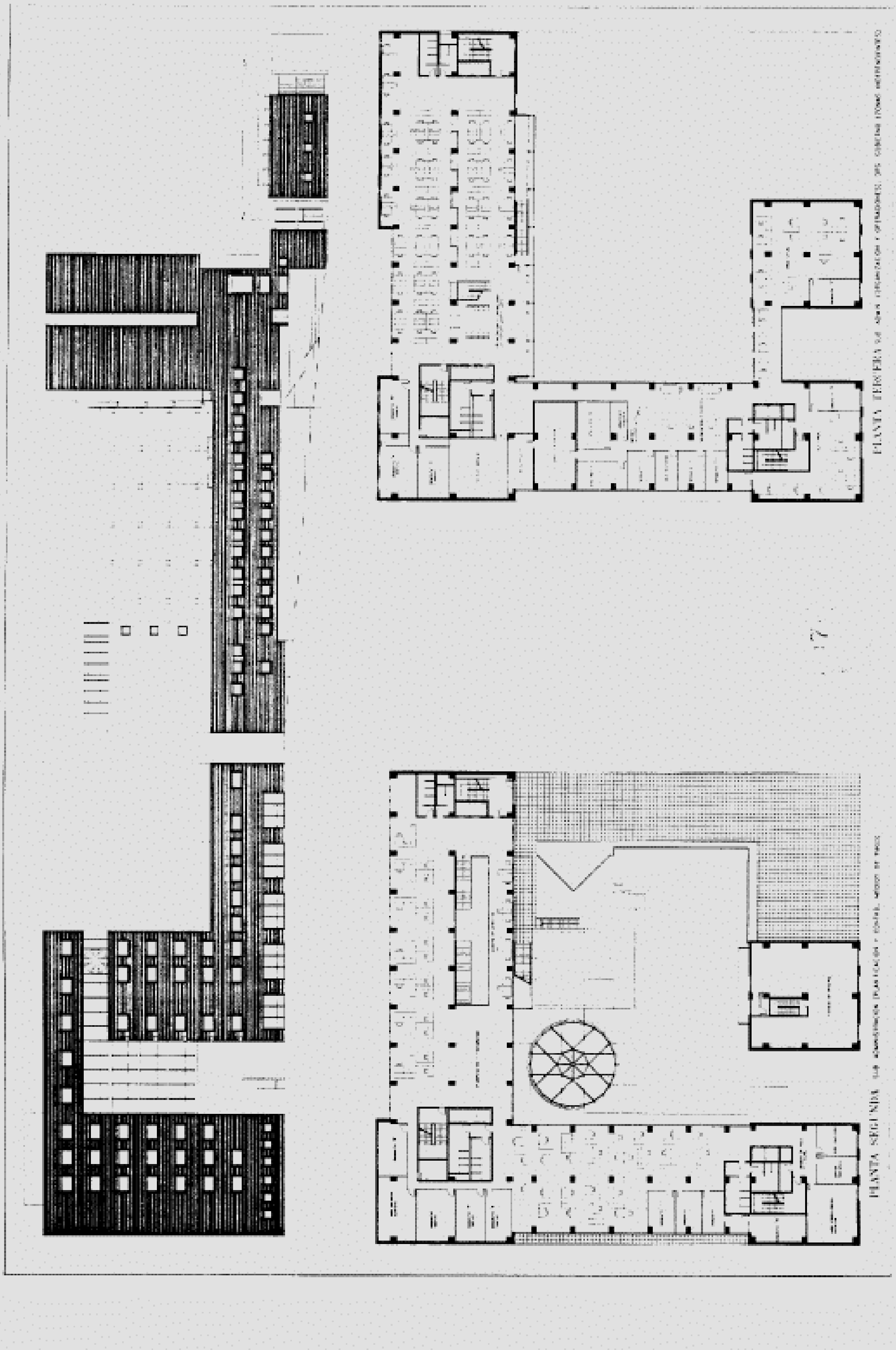
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