TRANSFORMATIONS OF THE SHAMBERG HOUSE
Analysis of a plan and planning experimentations, using the instruments of multicriterial analysis as means of research.

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1.0. INTRODUCTION

During the lost years some research programs have been developed aiming to analyse a particular architectonic language, using mathematical and informatic instruments.
Some of these research programs have as second aim the making of a method for creating a geometrical planning-language: most of these studies ore dedicated to the research into the laws which rule the personal style used by an author in certain works
(Cf.7,8,9,10,11,12). Instead, this research programs aims to analyse the planning process , not from the point of view of those who want to reconstruct the laws which describe the stile of a particular author but, by trying to understand the "compositive" process, analysing it by reconstructing the project itself, through a dynamic aggregative process of subsequent parts.
The proposed method, which in this seat is described extremely concisely, can have a didactic interest if associated with an architectural design course, and becomes stimulating for research and for the development of computer aided architectural design systems.
As far as the didactics is concerned, the method should allow the student to have at his disposal an instrument for analysing a project, discovering articulately different aspects connected with the problems of composition.
At the same time it should permit planning experimentations, using the information gathered from the analysis of the project which has been studied.
The computer-graphics techniques are in this case an indispensable support for the development of the work.
An important moment of the initial phase of the work was the choice of the building to be examined for the research program.
Since the object of the study didn't refer to the analysis of the language of a particular author, but to the conception of a single building, the choice of the latter has had a fundamental importance for the success of the experiment.
For analogy, the instruments of linguistics have been adopted, because reputed useful to express in a " discrete " way the complexity of an architecture.
We have tried to limit the problem of the geometrical configuration

of the building starting from the presupposition that it con be defined as a Code. (Cf.4,5)
A Code is formed of a finite group of rules and of a repertory of symbols. (Cf.16)
The building should have a certain complexity, so as to be able to form a sufficiently articulated Code.
A building composed of an extremely simplified system of connections wouldn't be useful because of an excessive lack of inner bands and relations, necessary for the creation of the Code; on the other hand, a very high level of complexity would have led to the impossibility of obtaining any codable rules.
That being stdted the choice has fallen an a plan by Richard Meyer: the Shamberg house (Cf.3).
It is a villa built in the early seventies in the United States (Chappaque, New York, 1972-1974).
This building under an apparent formal simplicity it hides, in reality, a considerable linguistic complexity (see Fig.1).
This because even though it maintains an easily controllable planning criteria, it contains many language ambiguities which turn out to be 5timulating for the creation of a Code.
A brief description of the building follows :
the house is essentially composed of two sorts of spaces. A public space, transparent, planned in a total-high volume, articulated by a series of cylindrical pillars, reserved for the living space; a series of private spaces, small and closed, reserved for the kitchen, the bathrooms and the bedrooms.
The public space, placed an the opposite side of the entrance, enjoys the view of the green end of the woods which spread out beneath the house.
Indoors, two monumental elements characterize the living room space: a curved staircase , which connects the ground-floor to the first floor and a gigantic fire place which spands the whole volume from top to bottom.
The total-high space of the living-room is interrupted by a mezzanine which crossing the glass wall, assumes the function of balcony.

2.0. THE FIRST PHASE (the project from "continuous" becomes "discrete")

Initially we have worked to find out a suitable method to create a numerical model fit for the study of the geometrical language of the house.
This problem involved the decision of selecting the information sufficient to realize the model corresponding to our interests. This has necessarily meant a reduction of the information contained in the original work, leaving however unaltered the information judged fundamental.
The main problem we have faced has been the one of rendering "discrete" the project, so as to be able to face the problems of the research adequately.
This choice, besides, would have contributed to make natural the realization of the geometric-numerical model, useful for the following experimentations.
he have fundamentally based ourselves on the principle deduced from

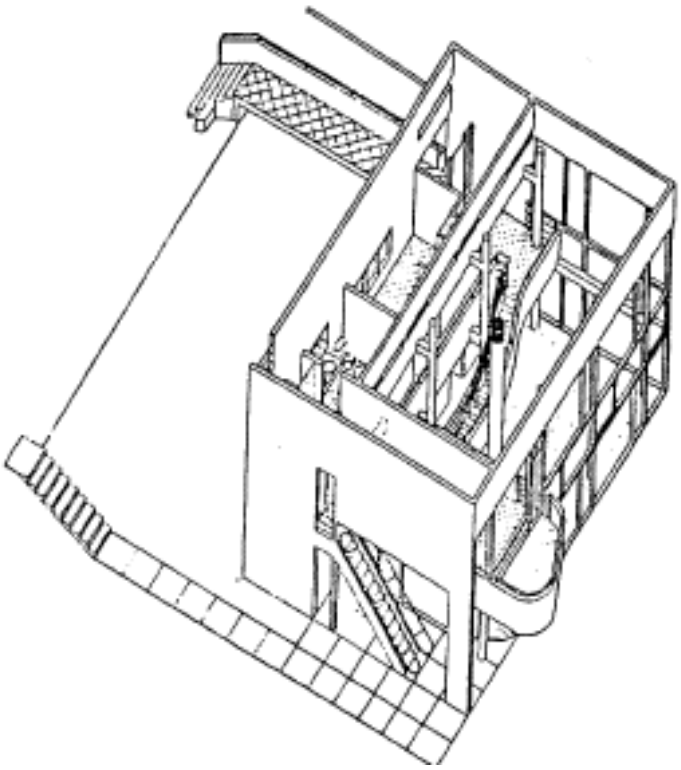
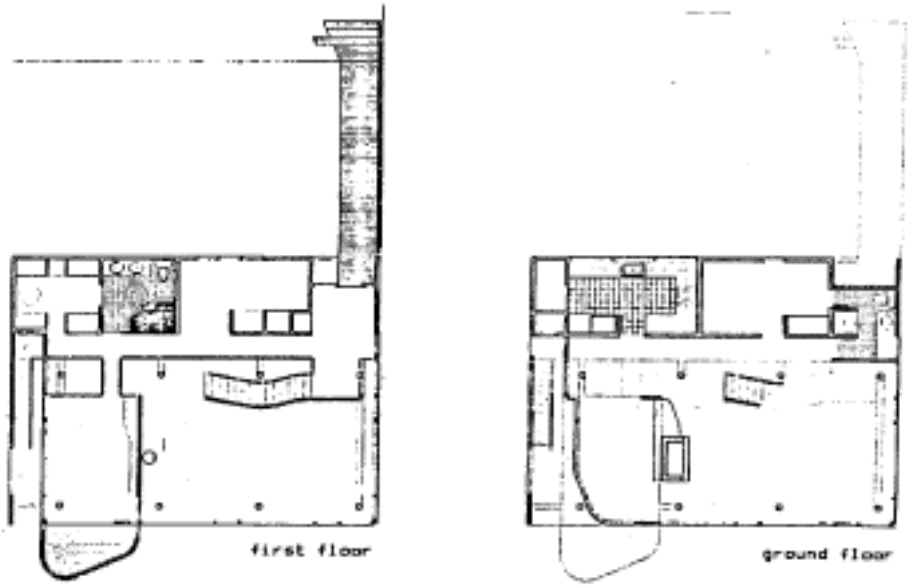


FIG.1



linguistics, which says that a Code can be considered as such so long as it possesses two or more articulations.
Our Code has a double articulation, since it includes:

the FIRST ARTICULATION , significant units: meaning units, (in the spoken language : words, monemes).
In our case, parts of the building which have some sort of independence from the rest of the project finished architectonic OBJECTS.
the SECOND ARTICULATION, distinctive units which take part in the form but do not directly have a meaning, (in the spoken language: elementary sounds, phonemes).
In our case ELEMENTARY TOPOLOGICAL ELEMENTS, the geometrical PRIMITIVES necessary and sufficient to create all the possible OBJECTS; (repertory of the house's universe basic forms).

With a limited quantity of ELEMENTARY TOPOLOGICAL ELEMENTS it is possible to realize theoretically an infinite number of different OBJECTS.
Once we have rendered "discrete" the project it is possible to rebuild it, making it "continuous" again.
In a following phase, from the whole group of OBJECTS we can extract new Groups of OBJECTS; each Group will have certain particular characteristics which will distinguish it from the others.
In a final phase the union of the formed groups will then make the project "continuous" again.

We have located inside the universe of the Shamberg House four sorts of ELEMENTARY TOPOLOGICAL ELEMENTS :

- 1 Parallelepiped with its faces parallel to the Cartesian axes
- 2 Solid extruded from polygon
- 3 Solid extruded from a regular polygon
- 4 Surface generated by a varying polygonal (for creating staircases)

These typologies are the minimum number of primitives, in any case sufficient for the articulation of the geometric language of the house.
By means of the ELEWENTARY TOPOLOGICAL ELEMENTS we can built the unities of the second articulation: the OBJECTS.
An OBJECT is obtained with various ELEMENTARY TOPOLOGICAL ELEMENTS combined together by means of Boolean operators, especially sum and difference are adopted.
In practice, not having at our disposal a proper geometrical modeller these operations are only simulated.
An OBJECT, to be considered as such, must be recognizable owing to a considerable degree of autonomy in comparison with the others.
It must own en evident semantic autonomy (Ex. Glass wall, stair case, fire place of the living room).
There is not in theory only one way to render "discrete" a certain work of architecture; it is possible to realize different "sets' of objects, whose summation, in any case, will have to re-establish the continuity of the work itself.

Inside the house we have located the following OBJECT (see Fig. 2):

- WALLS (supporting structure of the back part of the house)
- COLUMNS (supporting structure of the front part of the house)
- BEAMS (linked to the columns)
- 1st CEILING (ground floor)
- 2nd CEILING (first floor)
- COVERING of the back part of the house
- COVERING of the front part of the house
- GLASS WALL of the living room
- EXTERNAL SIDE WALL
- WALL of the back part of the house
- TOP BEAM
- BRIDGE
- EXTERNAL STAIRCASE
- PARTITIONS of the ground floor
- PARTITIONS of the first floor
- HORIZONTAL TOP WINDOW
- MEZZANINE / BALCONY
- LIVING ROOM STAIRCASE
- FIRE PLACE

2.2 SECOND PHASE (Analysis of the relationships between the objects)

The aim of this phase has been that of establishing which relationships run between the objects inside the house. Three fundamental aspects, contributing to the compositive process of project, have been valued: the FUNCTIONAL ambit, the PERCEPTIVE ambit and the MORFOLOGICAL one.
For this purpose we have expressed three different matrices to analyse the three different sorts of relationships which exist between an Object and an other Object (see Fig. 3) .
Each of these is related with the other so as to find out the two objects condition one another, the "conditioning" assumes various different meanings, according to the examination context (the various ambit).
The OBJECTS placed on the lines of the matrix are "conditioned" by the ones on the columns; the OBJECTS on the columns "condition" the arias an the lines.
It is interesting to notice that the relations between the OBJECTS aren't necessarily symmetrical. In fact for each OBJECT we are interested in understanding, in the different ambits, how many objects it conditions and from how many OBJECT it is conditioned and therefore its weight in relation to the others.
Adding up the links present an the lines and an the columns we obtain values that, interpreted in a qualitative way, represent for each OBJECT "how much", In relation to the other OBJECTS, this one conditions or is conditioned. (see Fig. 3)
The matrix is expressed in a totally subjective way; it is important to observe that different designers could give very different answers on the same ambit. Each ambit has a very exact meaning:

- FUNCTIONAL ambit:
  In this ambit we aim to check if, between two OBJECTS, there is a functional and necessary conditioning. This matrix should, in other

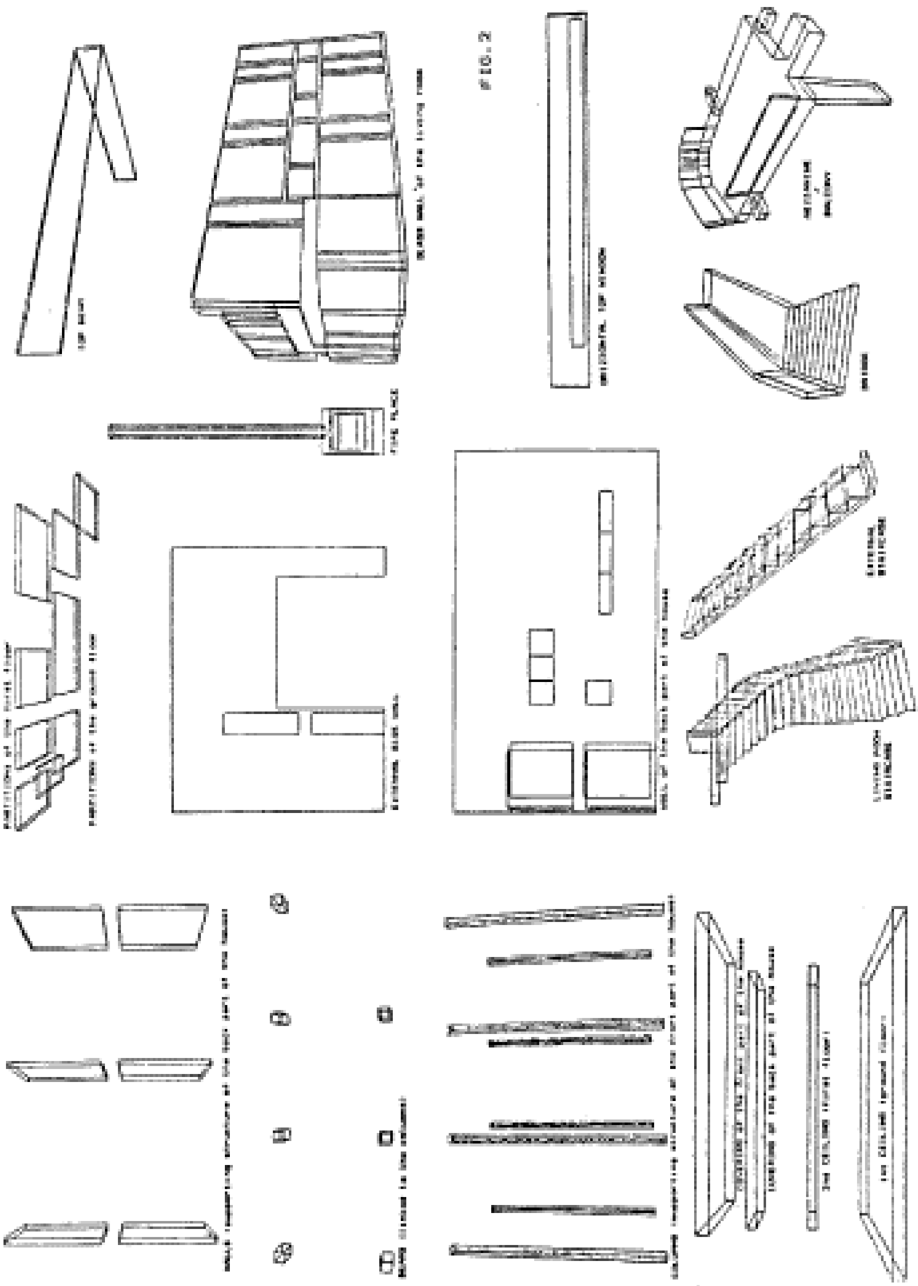
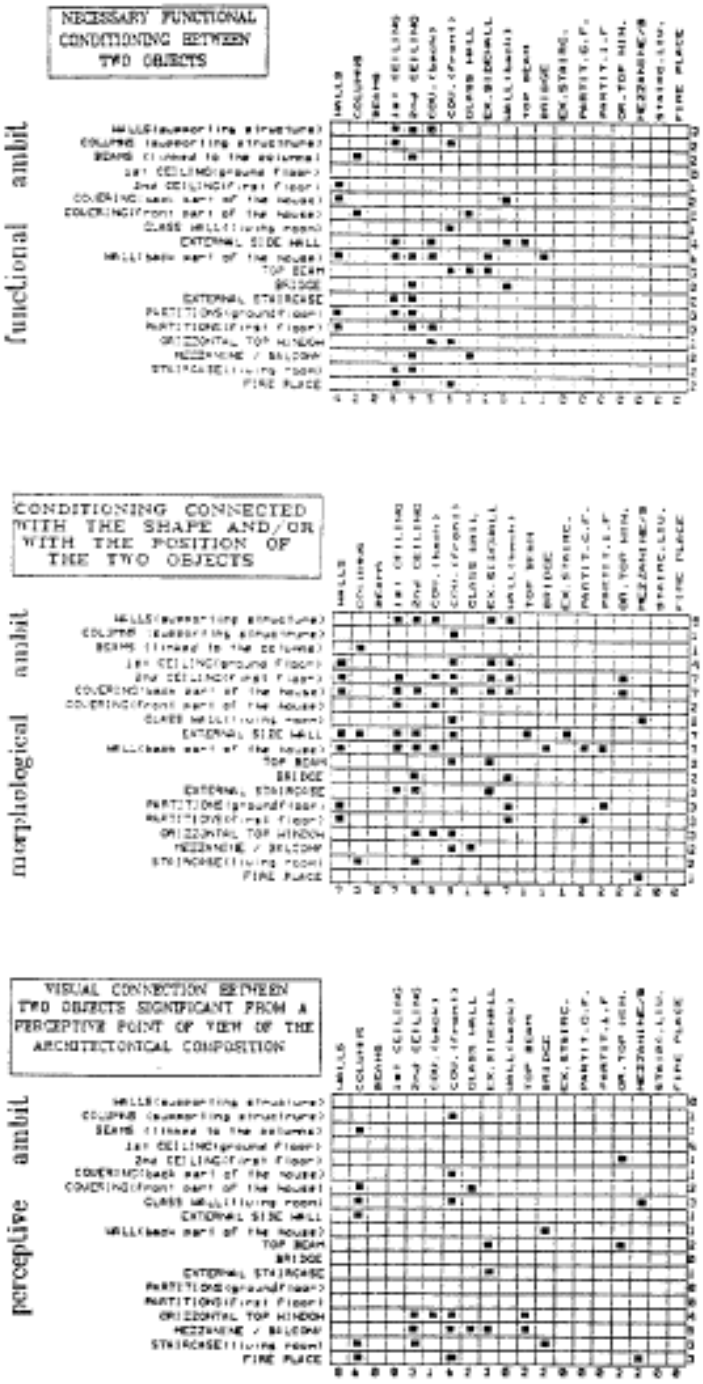


FIG. 2


NECESSARY FUNCTIONAL CONDITIONING BETWEEN TWO OBJECTS
functional ambit
CONDITIONING CONNECTED WITH THE SHAPE AND/OR WITH THE POSITION OF THE TWO OBJECTS
morphological ambit
VISUAL CONNECTION BETWEEN TWO OBJECTS SIGNIFICANT FROM A PERCEPTIVE POINT OF VIEW OF THE ARCHITECTONICAL COMPOSITION
perceptive ambit

F- I G. 3

words, give information about this theoretical freedom degrees of the OBJECT in relation to the other.
Ex. the second ceiling (first floor) CONDITIONS the living room staircase.

- MORFOLOGICAL ambit
In this ambit we aim to check if, between two OBJECTS there is a conditioning connected with the shape and/or with the position of the two OBJECTS. In other words, an OBJECT conditions another if a theoretical transformation of the former would necessarily involve an alteration of the latter.
Ex. the mezzanine/balcony is CONDITIONED by the living room/glass wall.
- PERCEPTIVE ambit
In this ambit we aim to check if, between two OBJECTS there is a visual connection which can be significant from the perceptive paint of view of the architectural composition.
Ex. the side wall is CONDITIONED by the columns.

The meaning of these matrices is more legible if we represent them in form of graphs, in which the existing connections will be represented by paths, by OBJECTS and by nodes. The vertices connected by several paths are the ones with the greatest "weight". There will be one graph with OBJECTS that "condition" and one graph with OBJECTS which are "conditioned", for each of the three ambit.

2.3 THIRD PHASE (utilization of the multicriterial analysis)

Up to this moment each OBJECT has been examined independently in each of the three ambits; the next phase consists in reconducting the information, gatered up to now in a disaggregated way, to an aggregated form, so as to be able for analyse globally the plan.
The aim of this phase is to find out which of the groups of OBJECTS (parts of the plan) have a temporal priority in relation to the others, considering at the same time all three ambits.
In other words we try to obtain a sort of classification of the parts of the building. This order should give directions about how to reconstruct the project in a temporal sequence in which the most "conditioning" parts should appear first, and the other parts should follow as they loose importance.
For this purpose, to obtain the requested synthesis, we have thought of utilizing a technique typical of the multicriterial analysis in particular a decision support system (Cf.14).
In the decision support system a series of alternatives ("actions") are confronted and valued according to certain criteria. In our case, being particularly interested in obtaining a classification of elements we have used the "ELECTRE II' method (Cf.15). In our case the OBJECTS correspond to the "actions" and the Functional Morphological and Perceptive ambits correspond to the criteria.
The three matrices are used, at this point, to draw the "valuations" of the OBJECTS in relation to the three ambits (criteria).
The value obtained summing up the existing links is utilized for every single OBJECT in relation to each criterium. The value represents a qualitative measure. Utilising the "Electre II" method two classifications can be obtained: in the first one the

"conditioning" OBJECTS; in the second the "conditioned" OBJECTS.
As the "ELECTRE" methods allow to give the criteria various "weights", it is possible to shape different "sceneries," according to the "weight" given for each ambit. In reality this means analysing the building stressing one aspect more than others, but without neglecting completely the other two. Every analysis carried out through a different "scenery" should give the planner more significant and stimulating information about that ambit in particular.
In our case we have experimented four different scenarios (the numerical value refers to the "weight" given to each ambit):

- 1 Functional (0.333), Morphological (0.333), Perceptive (0,333)
- 2 Functional (0.250), Morphological (0.500), Perceptive (0,250)
- 3 Functional (0.500), Morphological (0.250),.Perceptive (0,250)
- 4 Functional (0.250), Morphological (0.250), Perceptive (0,500)

For each scenery, using the "ELECTRE II" method, two different classifications can be obtained, but they do not yet permit the Individuation of groups of qualitatively different OBJECTS.

We are interested in obtaining the following groups :

- PRIMARY OBJECTS: they are strongly "conditioning' and weakly "conditioned". These OBJECTS, once determined inside the plan will condition all the following choices-of the planning.

- CRITICAL OBJECTS: they are both strongly "conditioning" and strongly "conditioned". These are the most delicate points of the plan; operating on these the conception of the architectural work can be brought up for discussion again.

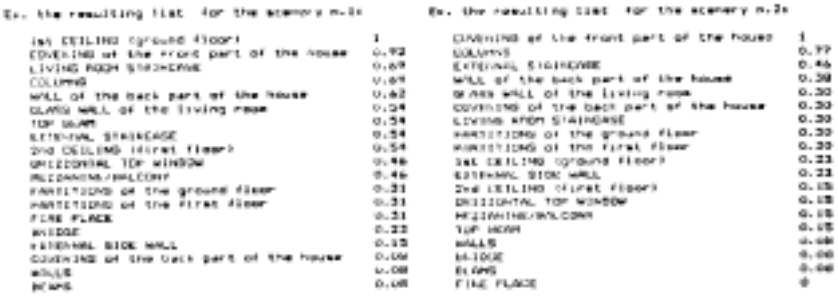
The PRIMARY and the CRIT1CAL objects are therefore those which

contribute to determine this guiding configuration of the plan.

- SECONDARY OBJECTS: they are weakly "conditioning" and strongly "conditioned" objects. These are parts of the plan which develop as a consequence of the previous classes.

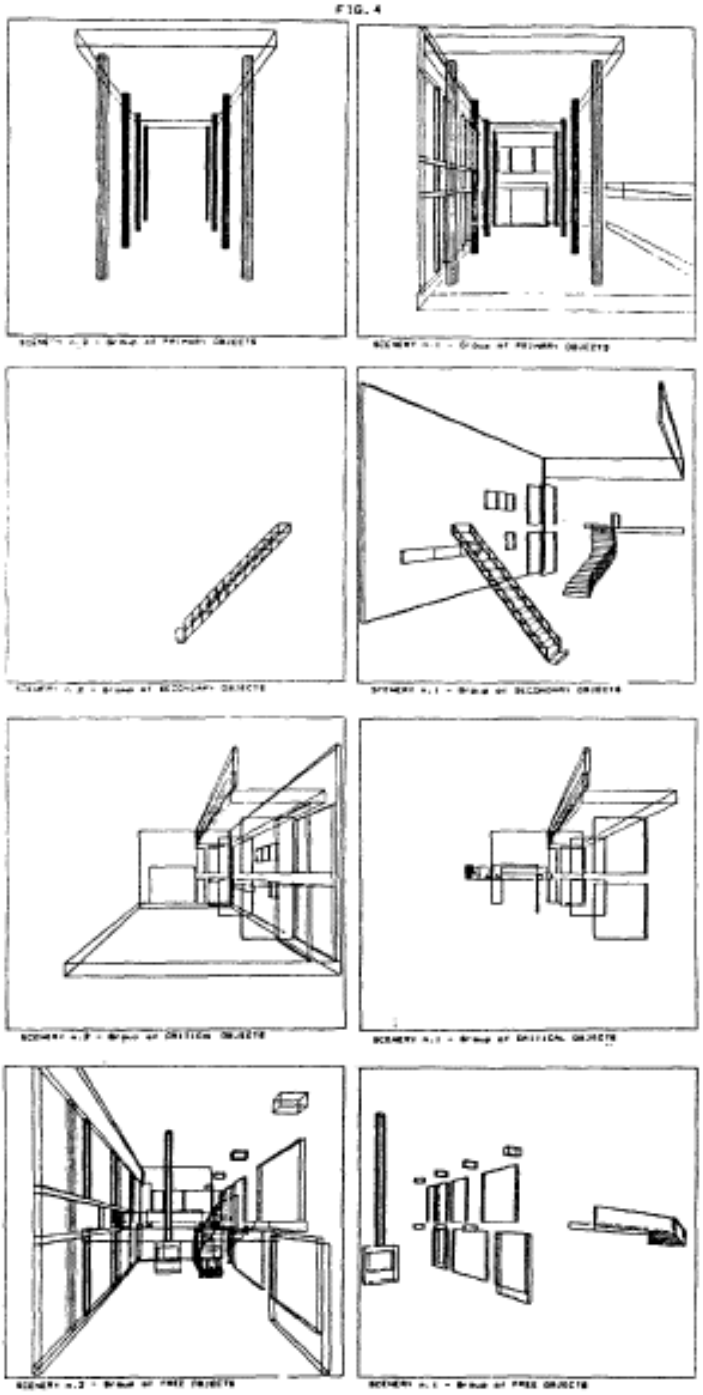
- FREE OBJECTS: they are both weakly "conditioning" and weakly"conditioned" object. These are parts which develop rather autonomous by relation in the previous classes.

It is important to notice that the four classes have an operative value if used as a planning instrument: in fact they fictive function of temporal sequence in the construction of the plan itself.
The individuation of the group was obtained through two phases
- the first one permitted the individuation of all the OBJECTS in similar positions in bath classifications (CRITICAL and FREE OBJECTS), and the individuation of all the objects in very distant positions (PRIMARY AND SECONDARY OBJECTS).
This has been possible by drawing out an index referred to the steadiness of the position of the UBJECTS inside the classifications (Cf.16).



Afterwards compdring the respective positions resulted by the classification, obtained by "ELECTRE II" method, we have easily achieved the four distinct groups of OBJECTS (see Fig 4).

FIG. 4



2.4. FOURTH PHASE (planning experimentation)

Up to now the method permits, therefore, the analysis of the significant aspects of a plan from various points of view.
With the achieved results it is possible to carry out planning experimentations, working an the different groups.
It is obvious that all the studied aspects only refer to problems of geometric configurations, all the other aspects connected to the complexity of an architectural work (function, symbol etc.) are left out.
Various experiences are possible, for example:
after having selected a particularly interesting scenery, it is possible to retrace entirely the compositive process, re-planning the whole building, facing, first of all, the PRIMARY OBJECTS GROUP and gradually all the others. The choice of a particular scenery (an especially interesting ambit) orients the planning on a particular angle: it permits the realization of a plain in which the aspects referred to that ambit in particular, prevale on the other ones.
For example having selected as predominant the MORPHOLOGICAL ambit, those OBJECS which can modify the shape of the others will become particularly "conditioning".
The qualities of the different GROUPS contribute in giving useful directions to face the new plan.
Another sort of experience could be the one which intends to carry out some alterations on the house plan, but leaving unaltered those parts which, according to the analysis, are the most conditioning (the GROUPS of the PRIMARY and of the CRITICAL OBJECTS) and altering the other ports (the GROUPS all the SECONDARY and of FREE OBJECTS).
On the basis of this principle some variation have been brought, working on a scenery in which the prevailing interest was the MORPHOLOGICAL one.
Some projects have been carried out following this last indication; two of these is shown as examples (see Fig. 5).
At this point through three-dimensional representations, obtained aided by the computer; it is possible to compare the plans and carry out visual verifications on the Language.
With perspective representations of this accomplished models, various solutions are possible because any view-point is exactly identical for every alternatives.
Technical foot-notes:
the utilized software, both the one related to the graphic representations and the one for the decisional model was entirely created in the Department.
The hardware at our disposal was very restricted: IBM PC and OLIVETTI M24; for the drawings a GRAFTEC MP 1000 Plotter.

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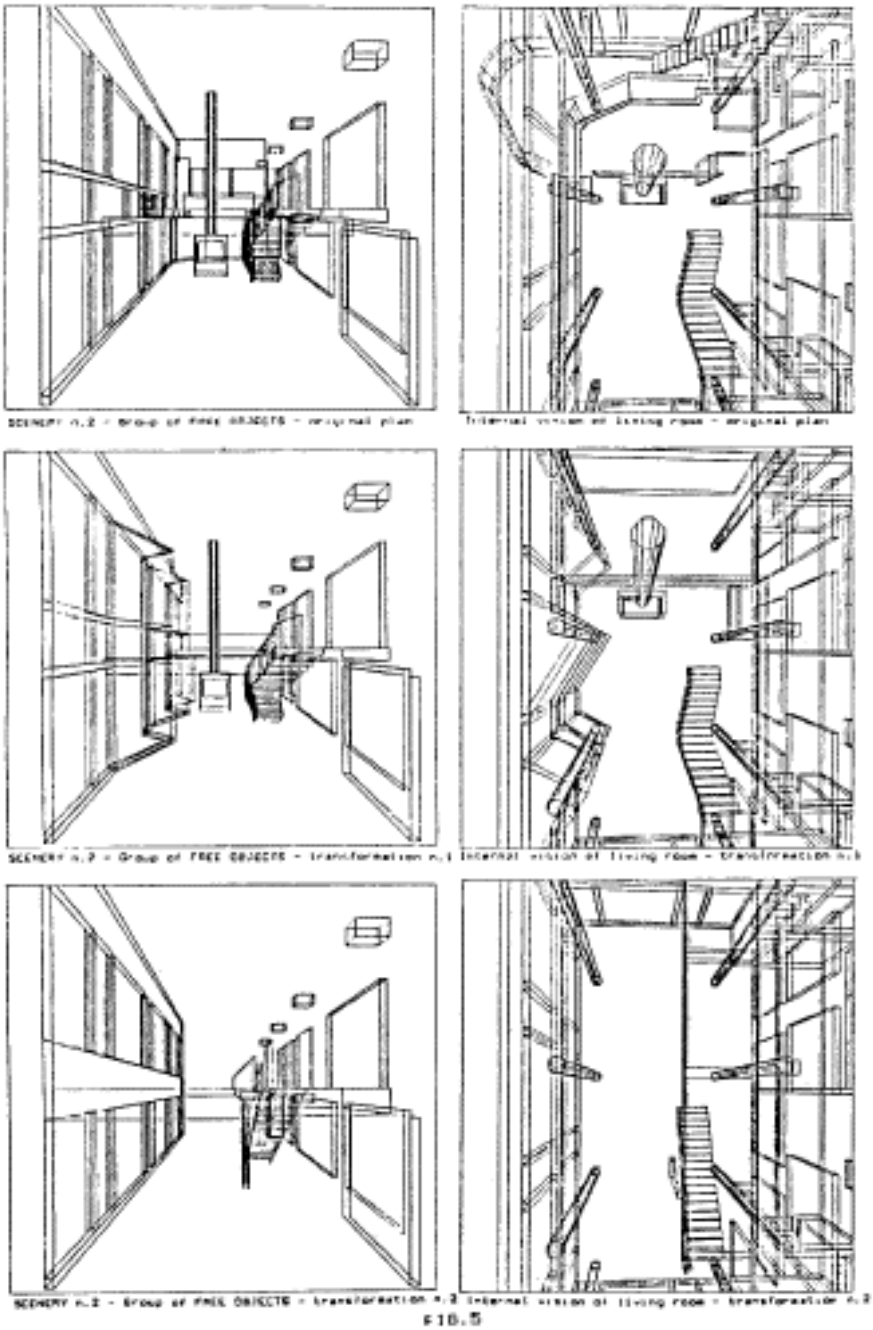

FIG.5

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