

AN INVESTIGATION OF THE POSSIBILITIES WITHIN
THE LIMITATIONS OF PREFABRICATION IN HOUSING TODAY

by

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PREFACE

The text is the development of a design program. In order for the presentation to be clear, diagrams and models were essential. The diagrams have been photographically reproduced and appear in Appendix 1. The text will refer to these diagrams periodically and it is suggested that the reader follow text and diagrams simultaneously. Photographs of the models are presented in Appendix 2 and are also referred to by the text.

INTRODUCTION

The construction industry is organized around a hierarchy of processes. Raw materials are made into building materials or elements (2x4's, plywood sheets, shingles, etc.) which in turn produce a building by the assembly of these elements.

"Prefabrication" is an unprecise term which refers to the process of assembly using components, or groups of elements, rather than the individual elements. For example, a house is constructed with many 2x4's and plywood elements whereas the "prefab" house may consist of a few wall components made from the same elements. The difference is that the first house is strictly produced with on-site labor while the components for the "prefab" unit are mass-produced in a factory, brought to the site and assembled very quickly.

But there is a thin line between conventional and prefab houses. For example, in the conventional house, items such as doors, windows, fireplaces, and kitchen cabinets are actually components in that they are factory produced groups of elements.

Very likely, the term prefabrication originated with the precise meaning of "pre-assembly" of elements into components and has been transformed into one with

a general meaning which refers to any building system based on a modularized system of factory made components even though, by the nature of these components (formed plastic, molded aluminum, etc.) they must necessarily be a factory product of raw materials and in this sense they are actually elements.

Part 1

MAXIMUM AND MINIMUM SOLUTIONS

Existing building systems (such as 5M and YDG of England) have evolved through a design process governed by factors such as economy, structural geometry, structural efficiency, minimum handling, and the multiplication of a basic unit. These are very limiting criteria and as shown in Diagram 1 result in condition number 1, which is a MINIMUM solution. This is a solution, but only where the minimum is "required", such as in a government project for clearing slums or giving the Appalachians houses with which to "improve" their living standards.

But these criteria allow no solution in condition number 2 which is the MAXIMUM solution. And this condition can solve many more problems than condition one in that, by providing the maximum, you can always provide the minimum.

The reason that factory built houses have not yet become consumer items is that the only criterion of the producer has been low price and thus there is no selection on the part of the buyer. (It is cheaper to build one unit 1000 times than 10 units 100 times.) He cannot obtain the variations he desires to make his home a

unique space. In order to eliminate monotony and make building systems appeal to people who want more than the minimum, producers will have to provide more than the minimum.

Diagram 2 refers to the relationship of man to his immediate living space and not of his house to its environment. This excludes the differences that occur between a house in the woods and a house in New York City. The relationship of person to house is a constant factor.

Figure one shows an individual or single family dwelling. The living space is extensive and includes interior-exterior relationships. Many things happen and the living space is alive. Figure two indicates "suburbia" where houses have gotten so close that the interior-exterior relationships have become limited or restricted and all of the activity begins to move inside. The private space is smaller than that of figure one. Figure three shows an urban apartment where the interior-exterior relationship is non-existent and activity becomes contained.

There are current building systems that fit all three living conditions. However the system for condition three is no different than the system for condition one. A system for three offers nothing to compensate for the change in living space that occurs between one

and three. As the living space decrease, the building systems remain constant and so, in effect, the condition three system offers less than a system would at condition one. Not enough is done to make the contained situation (in which all activity happens inside) an exciting space to live inside. A good example is the contrast of dormitory life (condition 3) and off campus life (condition 1). If the dormitories were an exciting space to live in, then people would want to live in them.

Diagram 3 shows the results of these solutions and conditions, the first of which is based on the minimum solution. Designers take the criteria for the minimum solution (maybe in hopes of solving a need for low cost houses) and apply them to condition three, where the maximum is most necessary. This direction ends in new slums or an unused system and never really solves the larger environmental problem. The second direction begins with the idea to re-evaluate the priorities and to provide the maximum, and taking qualities existing only in condition one, introducing them in condition three where the maximum is needed. By solving condition three, reflections can be made to condition two and even to one. This second direction is the one which is chosen here.

Part 2

DESIGN CRITERIA AND PROCESS

This part begins with Diagram 4 and the relationship of physical structure to planning. As shown in sketch A structure in the conventional sense is a governing organization in which the planning is restricted and forced to follow the structural geometry. Panels are placed on grid lines and the dimension between columns dictates room sizes. This results in limited, and sometimes forced, planning, and always a typical house of the minimum solution.

Sketch B shows that this does not have to be true. Spaces can take on other shapes if the restrictions are removed and the structure becomes only a support facility for, and not a limitation of, planning. The violations of A have become the strong points of B.

The top two sketches on diagram 5 contrast two variations of the same four bay grid. The left one corresponds to A while the right shows that the actual dimension between columns does not dominate the room size. Larger and different shaped rooms can occur. (The right sketch contains 50% more area than the left one.) If everything that happens in the plan could also happen in the elevation and section, a space would take

on three dimensional characteristics and a room would be more than just a vertical projection of a two dimensional plan.

The structure now becomes only a three dimensional frame of reference which does not limit or regulate planning but allows and encourages variations and violations.

Diagrams 6 and 7 compare two methods of treating the wall panels and their relation to the space. The first approach uses panels simply to close in the space and this corresponds to the minimum solution. Panels are limited to grid lines, a window is considered to be a hole in the wall to look through, and a door is only a means of getting from one side of a wall to the other. The second approach corresponds to the maximum solution, where the panels are an extension of the space. Walls are not restricted to grid lines and use the structure only as reference. The "window" is a tool with which to create interior-exterior relationships (rather than look out, maybe you can go out - even if there is no beautiful view, the window becomes a means for exciting experiences.) And the "door" is a tool with which to change scale from one space to the next - a transition. If, through method two, all segments of the house are treated in a similar manner to the window and the door

as mentioned, then the house as a summation of these segments will become a better house.

Part 3

SOLUTION

This part, beginning with Diagram 8 shows the result of the direction plus the criteria which is the solution.

The structural frame is a three dimensional grid with each bay being between sixteen and twenty feet square and sixteen feet high. This height allows for two complete levels within a bay and also any level in between such as quarter levels. This produces a three dimensional space.

Organized vertically are the plumbing as well as the elevator and stairways which serve as access to the housing units. In other words, these facilities remain constant while the floors can shift horizontally and any two consecutive floor plans do not have to be identical. The elevators open onto an open area which is sixteen feet high and many bays in area. Being large and open to the outside, these areas provide semi-outdoors space for general use of the residents. The units themselves are one, two, or three bay combinations.

Diagram 9 shows the development of the panel system which will supplement the plan and, rather than enclose, will create variations of the interior spaces. Series one is a group of full bay panels which, when deformed

add floor space, change lighting conditions and spatial qualities. But an unusually large number of panels would be necessary to offer all the desired variations due to the fact that to alter a detail means to have an entirely new panel. Series two shows that the complicated panel shapes of series one can be broken down into more basic shapes that can be added together to form the same panels. To change a detail now means to change only a portion of the full bay. Series three shows that by using all of these smaller pieces (i.e. elements) in several sizes and projections of different lengths and also by offering curved elements, all of the variations of series one can be made with fewer basic shapes. 1000 variations in series one required 1000 panels, whereas 1000 variations in series three requires less than 100 panels.

How this affects the plan can be seen in the one bay sketch on Diagram 10. The rigidity of the bay is removed and the plan becomes "amorphous", with many little sub-spaces and private areas. Some of these exterior elements can be used inside. This produces a merging of the two and a dual usage of some panels. Elements can be used as closets, shelves, tables, seats, doors, kitchen cabinets, etc. As a result, the interior and the exterior elements form not only partitions and

enclosure but also the furniture and the structure within the sixteen foot bay. In other words (Diagram 11) the building elements have become also the living elements.

There is a wide range of elements that can be offered as shown by multiplying the types of panels by the different sizes by the number of projection distances by colors plus special units such as bubbles and other curved surfaces. On the scale within the range of possible combinations, a workable system can be picked out at any point, using criteria such as number of units to be built, life span of the elements, ease of change, and the ranges of application (houses, stores, offices, etc.).

Part 4
APPLICATION

The application of this solution was studied and presented in the form of models, photographs of which appear in Appendix 2.

The first model (Plate 1) is a mass model showing one type of organization possible with the units. No two floors are alike and the whole complex is asymmetrical. The outdoor levels form a space within the complex which, when developed, serves to produce sub-groups of units as well as to unify the complex in terms of organization.

The next series (Plates 2 - 8) is the most important and illustrates that even if the system is organized in a very conventional pattern (symmetrical plans, every floor identical, and the multiplication of a basic unit) that, through the use of a limited number of different elements, the creation of different entry conditions, stair wells, lighting condition, room shapes and sizes, interior-exterior relationships, the use of space outside the bay, etc., will provide the differentiation necessary to make each unit unique in its characteristics.

This system offers to the designer and the resident a selection with which to build units that will be

functional, exciting to live in, and with individuality, meaning different from the neighbors. And in going back to Diagram 2, maybe the characteristics that exist in condition one (single house) making it an exciting place to live cannot be transferred, in the sense of duplication, but can be translated, in the sense of compensations, into condition three.

The remaining plates in Appendix 2 are self explanatory.

CONTINUATION

The theoretical design can stop here. The next step is to investigate materials, production techniques, etc. The program developed can have alternate solutions. In continuation, it will be given to a group of students to use as a model in order that they may develop alternate solutions.

APPENDIX 1

Diagram 1

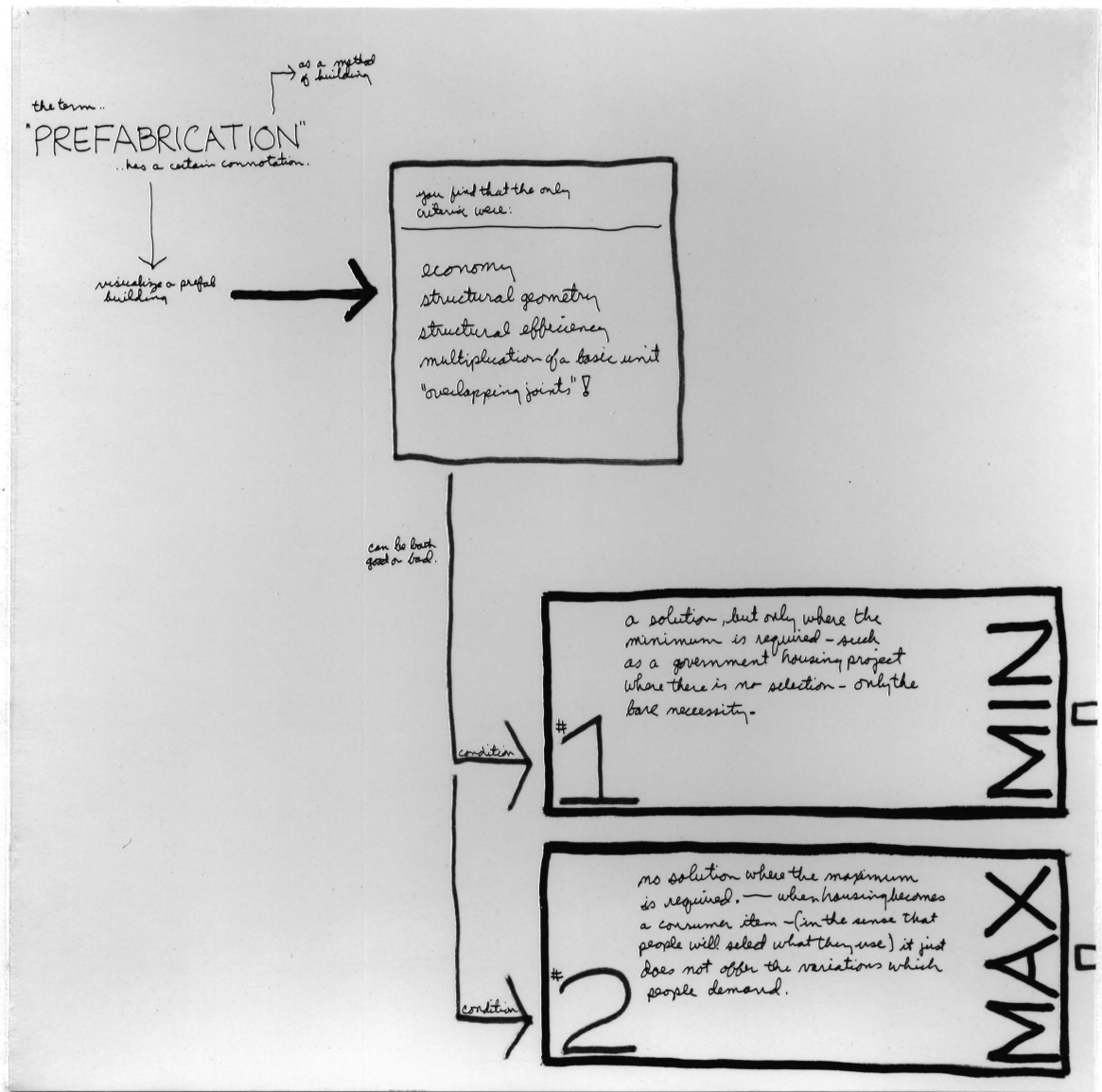


Diagram 2

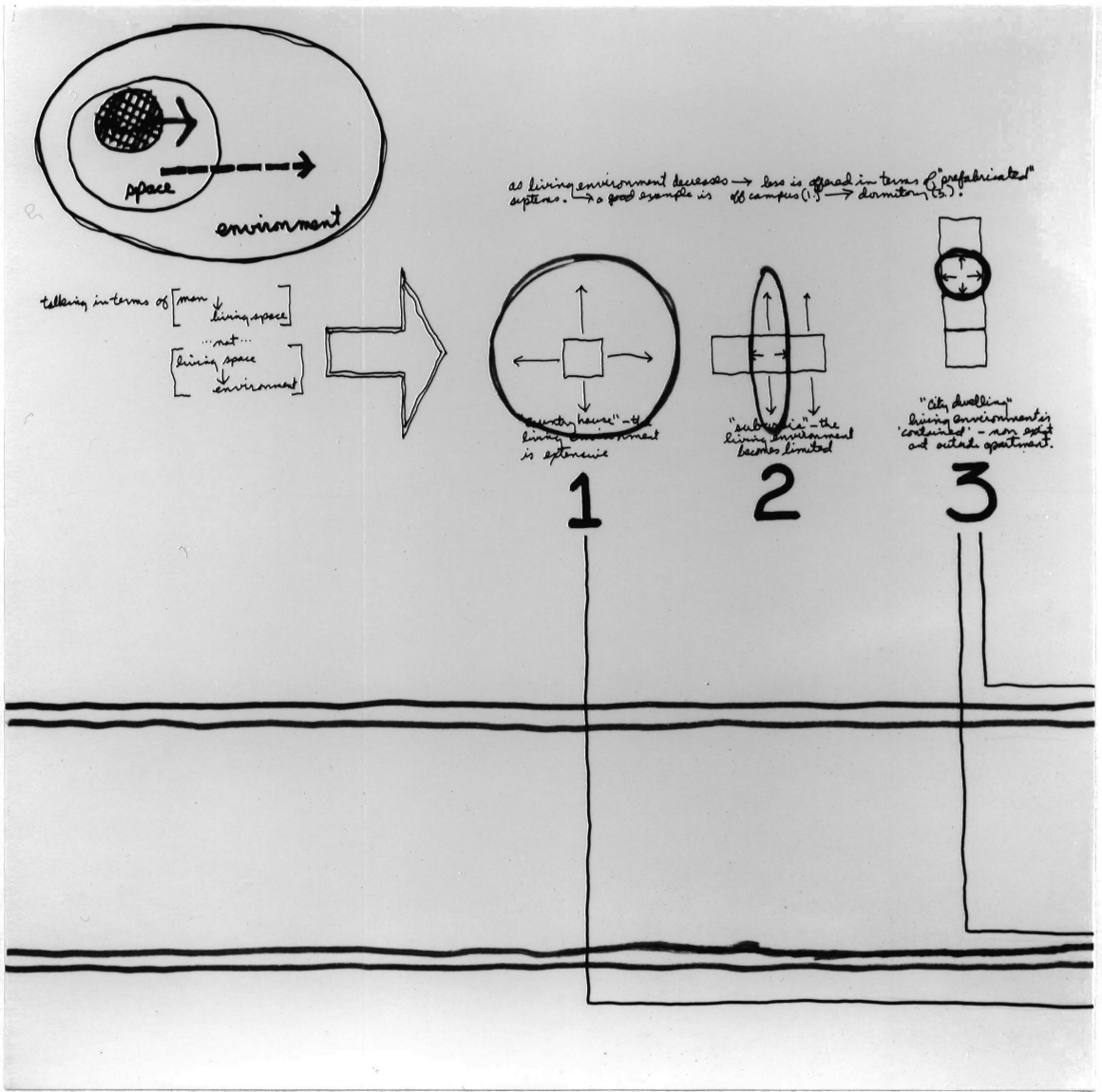


Diagram 3

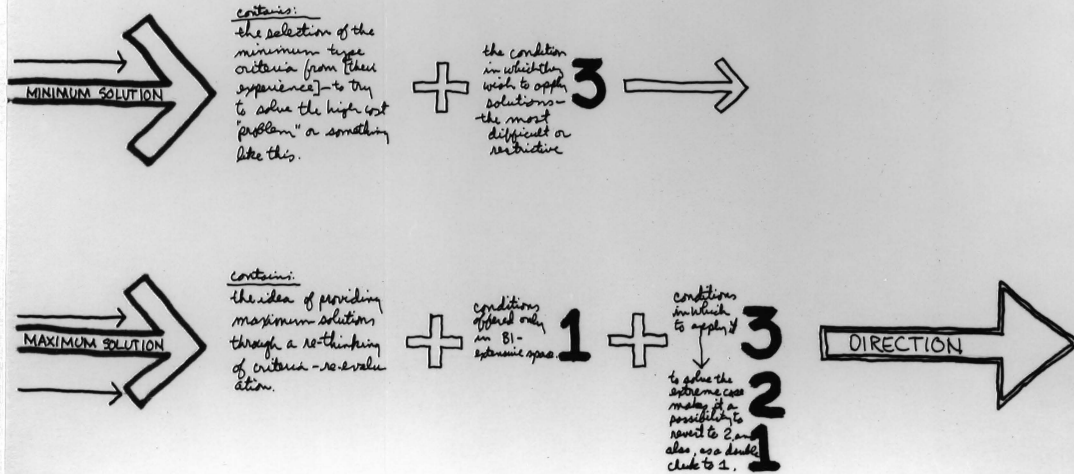
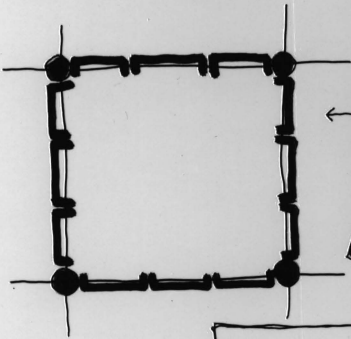
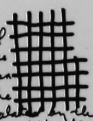


Diagram 4

the relationship of
STRUCTURE
to planning

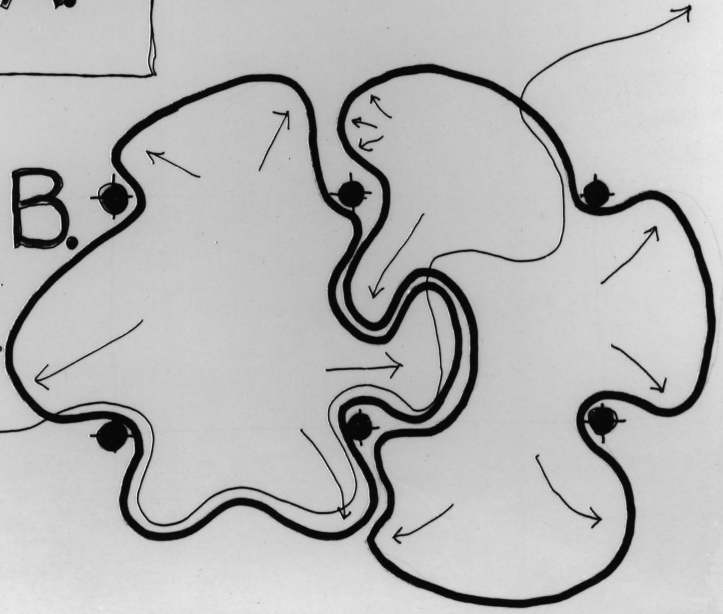


In the conventional sense the structure is a governing organization, where the planning is regulated by the geometry and the dimension between columns governs the sizes of the rooms.



A.

whereas →



(in another sense) the rooms can take other shapes and/or really be rooms at all → restrictions are removed and the structure becomes only support, not a limitation of planning.

the structure is seen as a frame of reference.

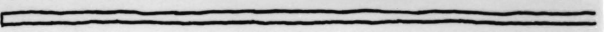
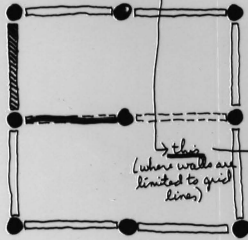


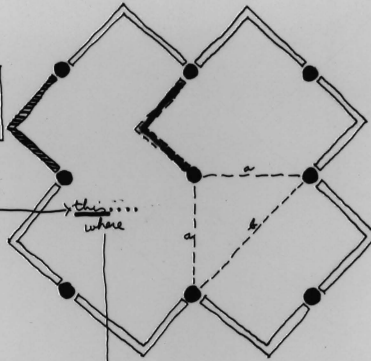
Diagram 5

to illustrate in a more rigid sense

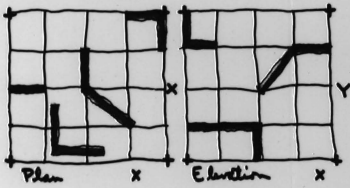


grid of physical structures in both cases, the same

can become



AND...



if... Everything possible in the plan could also be possible in the elevation

- the physical structure has become less restrictive
- more solutions are possible →
- the violations of **A** are the stronger points of **B**.
- the dimension of the actual span between columns is less important in the restrictive sense (this length has less to do with the size of rooms)
- if the structural bay were altered from "a" to "B" condition **A** would reappear — no gain.

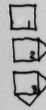


Diagram 6

in the relationship of the
"PANELS"

to the space:

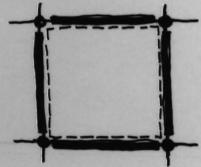
panels as a method of defining an area, or space, can be used in two ways — the first of which is the "contractive" use, and corresponds to offering the minimum

1.

panels are

CLOSING IN

the space



the second of which corresponds to offering the maximum.

2.

panels are a

EXTENSION

of the space

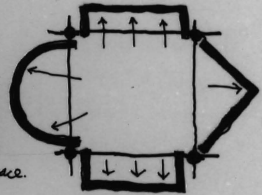


Diagram 7

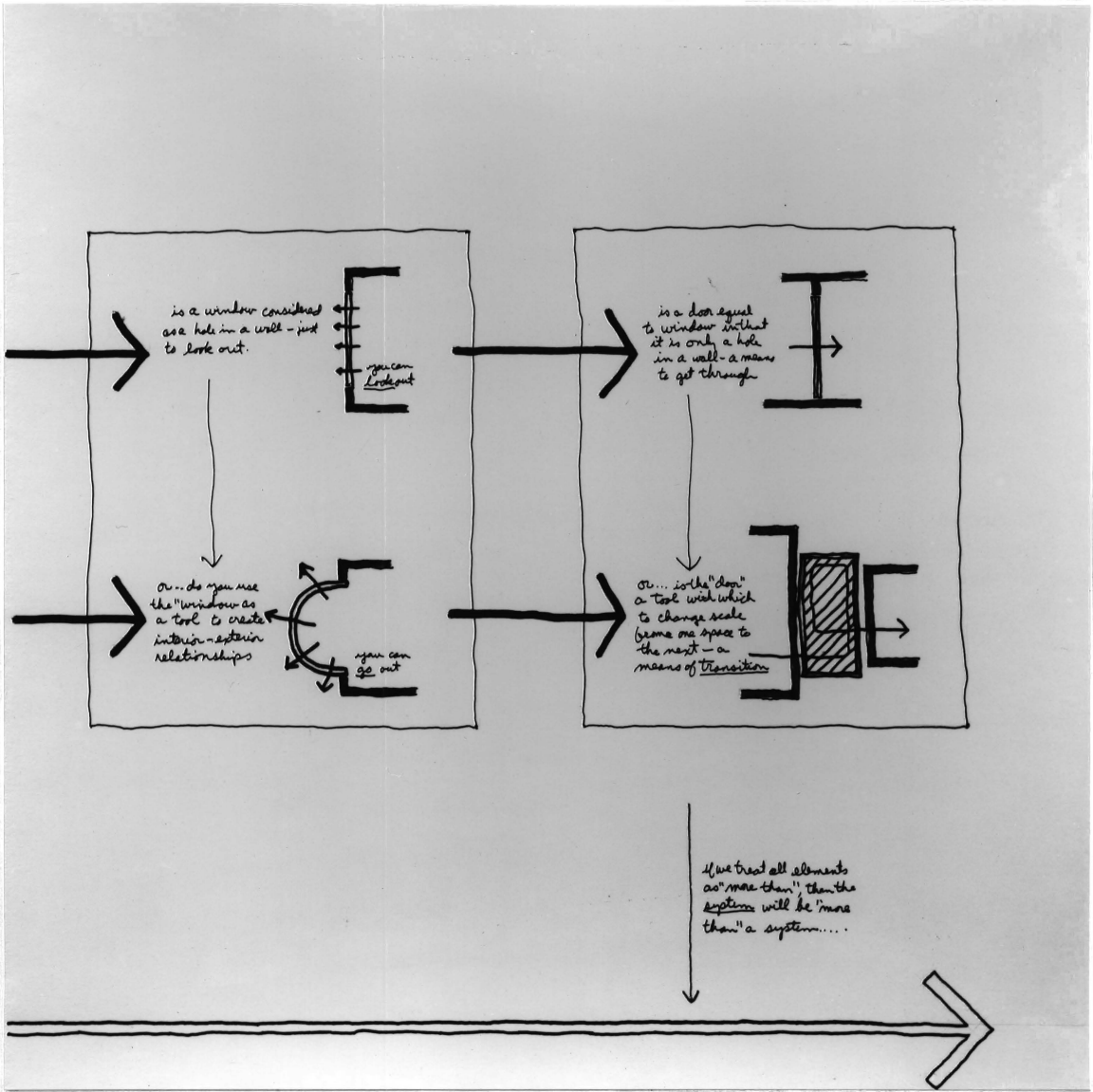
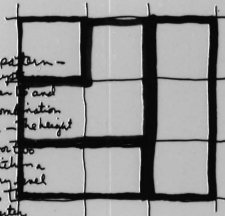


Diagram 8

I
 Organization

Now, taking the division and the criteria - to apply them in working a solution...
 ...housing units...

with a 3-D grid pattern - a multiple bay system each bay is between 10' and 20' cubed or any combination of these numbers - the height being 10' allows for two complete levels within a bay and also any level in between. This means quarter levels, etc.



organization →

1. HORIZONTAL → one bay height

- plan of units - addition of bays
- access to units - by way of common areas

2. VERTICAL

- elevator and stairway - the access to common areas.
- plumbing
- remains the same although horizontal organization may change

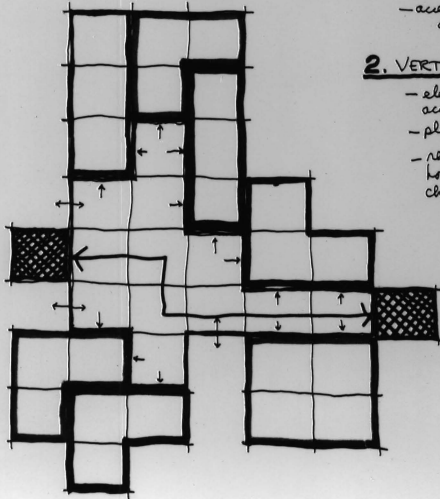
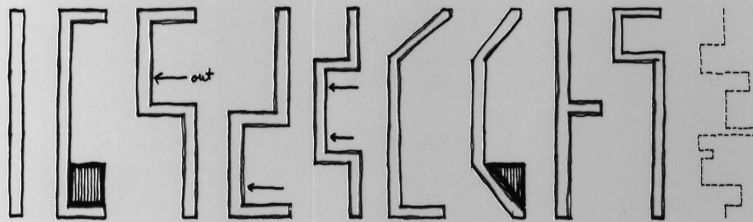


Diagram 9

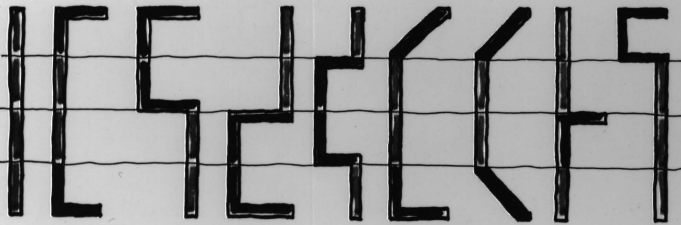
II.
'exterior' system

a system which will
complement the plan and,
rather than enclose, it
will help create interior spaces
it all begins with a series
of 16 x 16 panels.



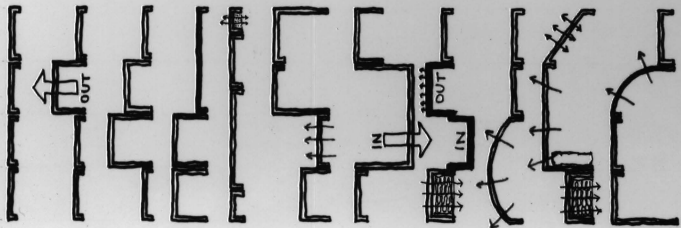
a series of full bar
panels - an unusually
large amount of panel
types arise from the fact
that to alter a detail, the
panel has to be altered.

1.



complicated panel shapes
can be broken down into
more basic components
as shown here. To alter
a detail means to change
only a portion of the
whole panel.

2.



using three dimensional
alternatives panel segments,
by adding them in many
different ways, all of the
desired variations noted
above can be achieved
here with fewer pieces.
[these sketches can be either
plan or section, exterior or
interior walls]

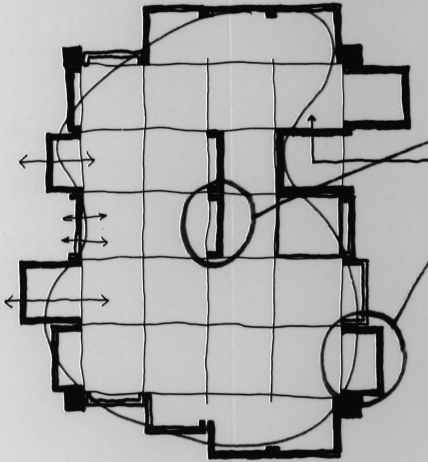
3.



Diagram 10

III.

all of the elements from the previous page combine in different variations to provide the type of plan shown here where the design becomes less restricted and more amorphous



Also, some of the exterior panels can be used inside. Since there can be this dual usage there will be panels that are only exterior, some that can be either interior or exterior, and some that will only be interior.

... obviously, there will have to be specialized variations in both ext. and int systems including the heating, ventilating units, doors, stairs, kitchen sinks, ovens etc....

... Now these elements can also be used as closets, shelves, chairs, tables, beds, etc.



the INT. + EXT. elements become not only partitions and enclosure, but also the furniture and structure for the interior

Diagram 11



in other words...

the BUILDING elements have
become the LIVING elements.

there are still many, many variations
within this system of elements...

... but, in II-2, in order to do 1000 things,
1000 panels are needed, whereas in II-3, to do
1000 things, maybe only 100 panels are needed.

the max # of parts is $[\# \text{types} \times \# \text{sizes} \times \# \text{varieties} \times$
 $\text{class} + \text{windows and doors}] =$



parts to be offload



based on:
units to be built
life span of parts
ease of change
range of applications (houses, stores, etc.)

APPENDIX 2

Plate 1
MASS MODEL

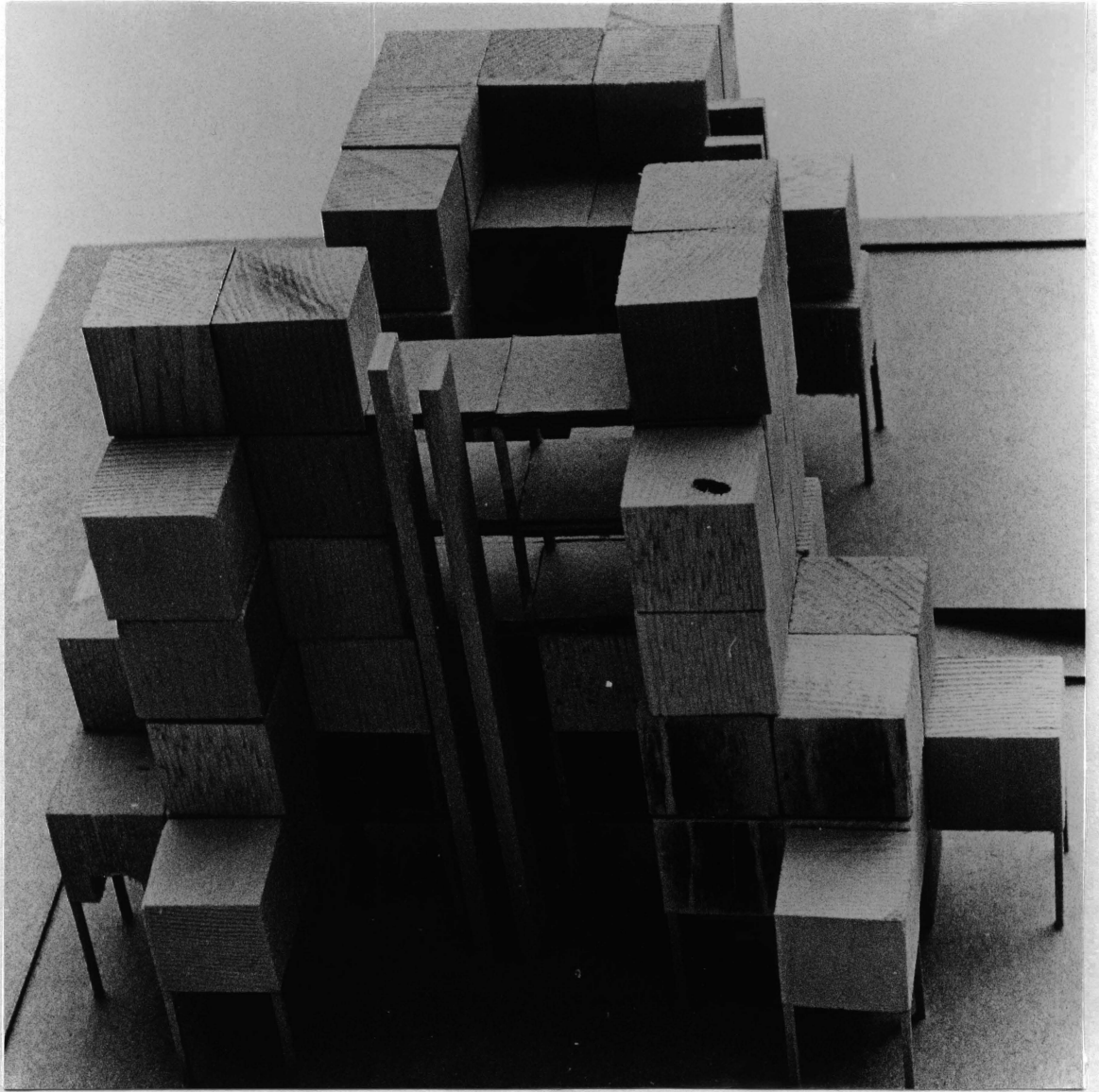


Plate 2

A BASIC UNIT AND A SET OF ELEMENTS

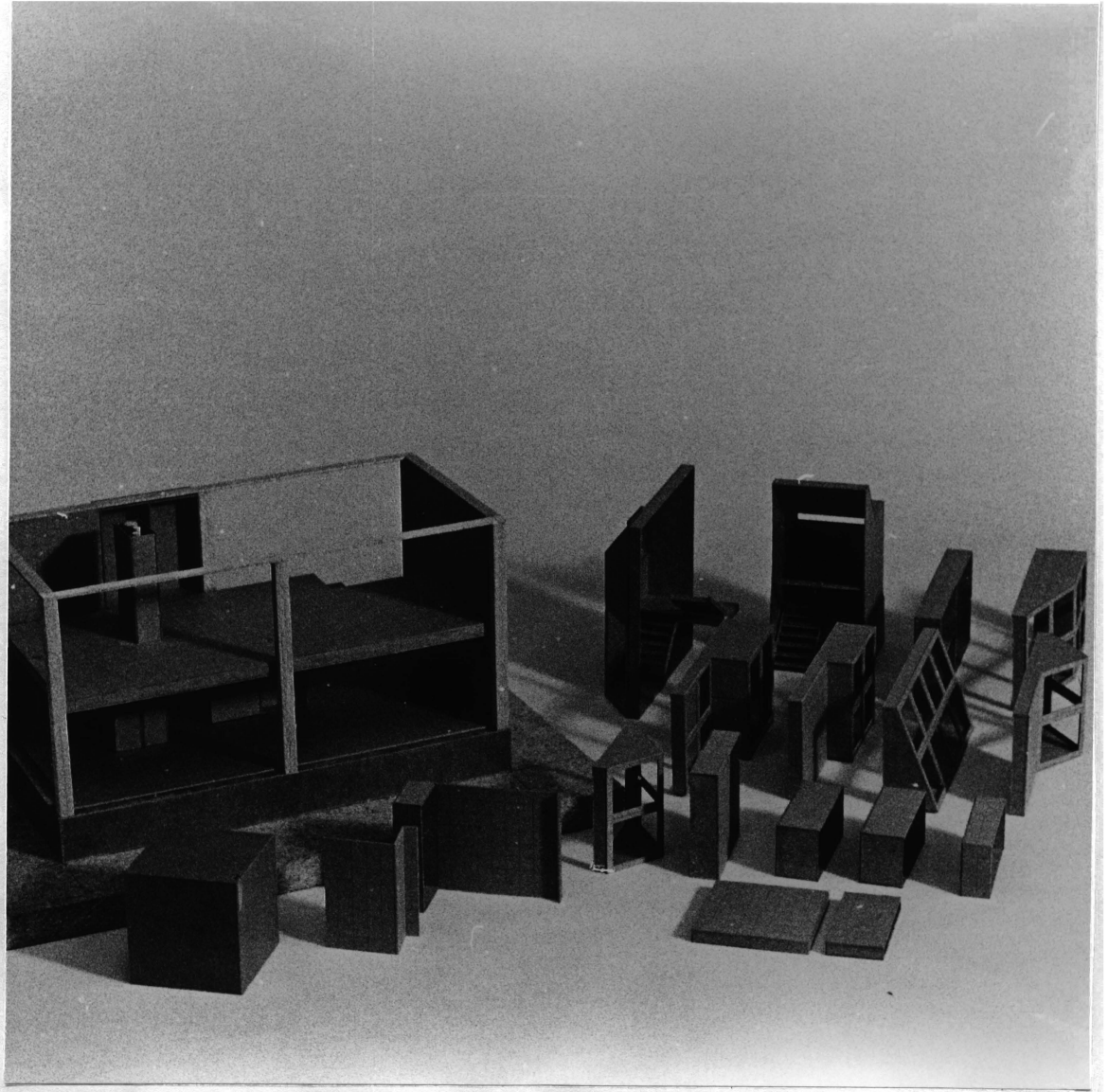


Plate 3
VARIATION 1

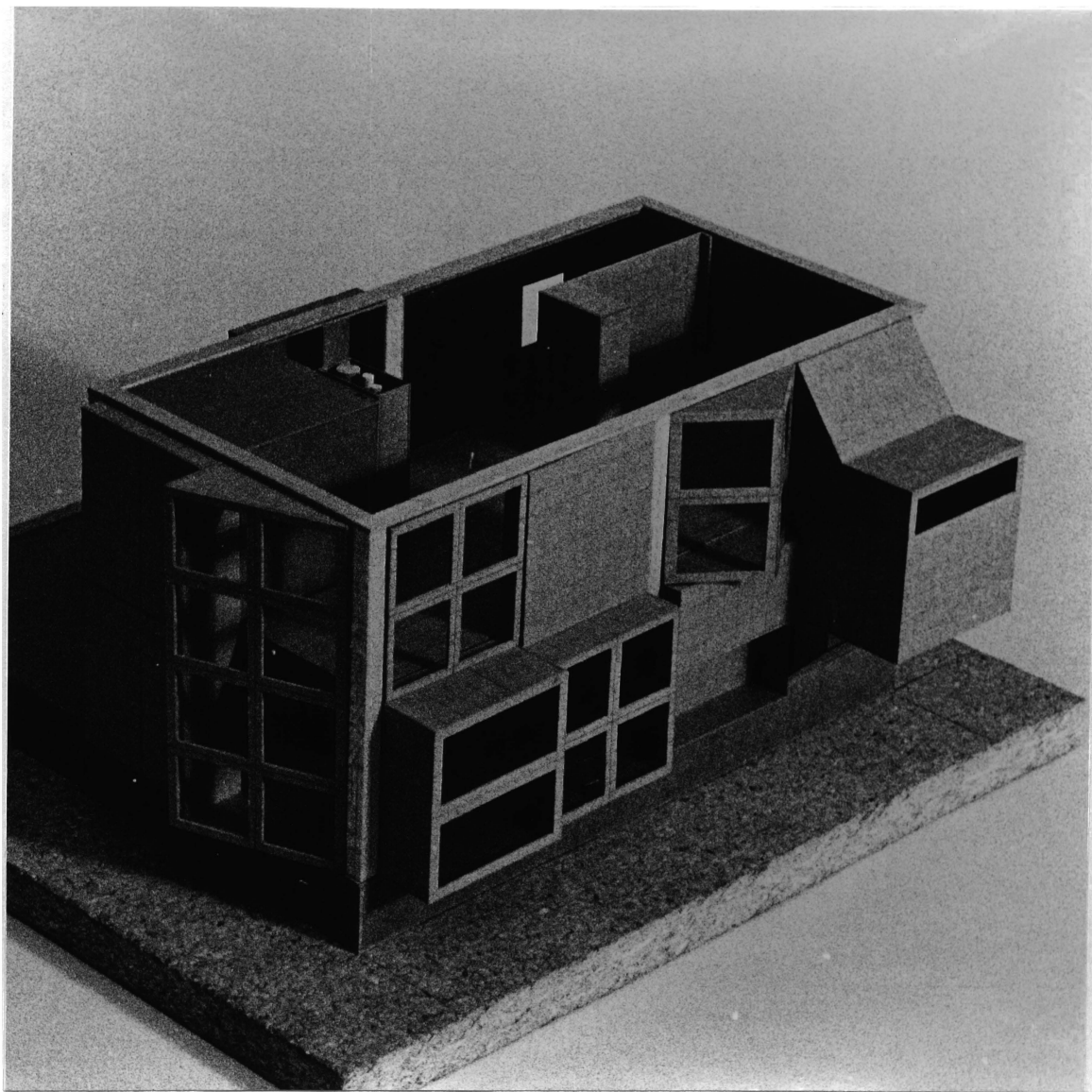


Plate 4

VARIATION 2

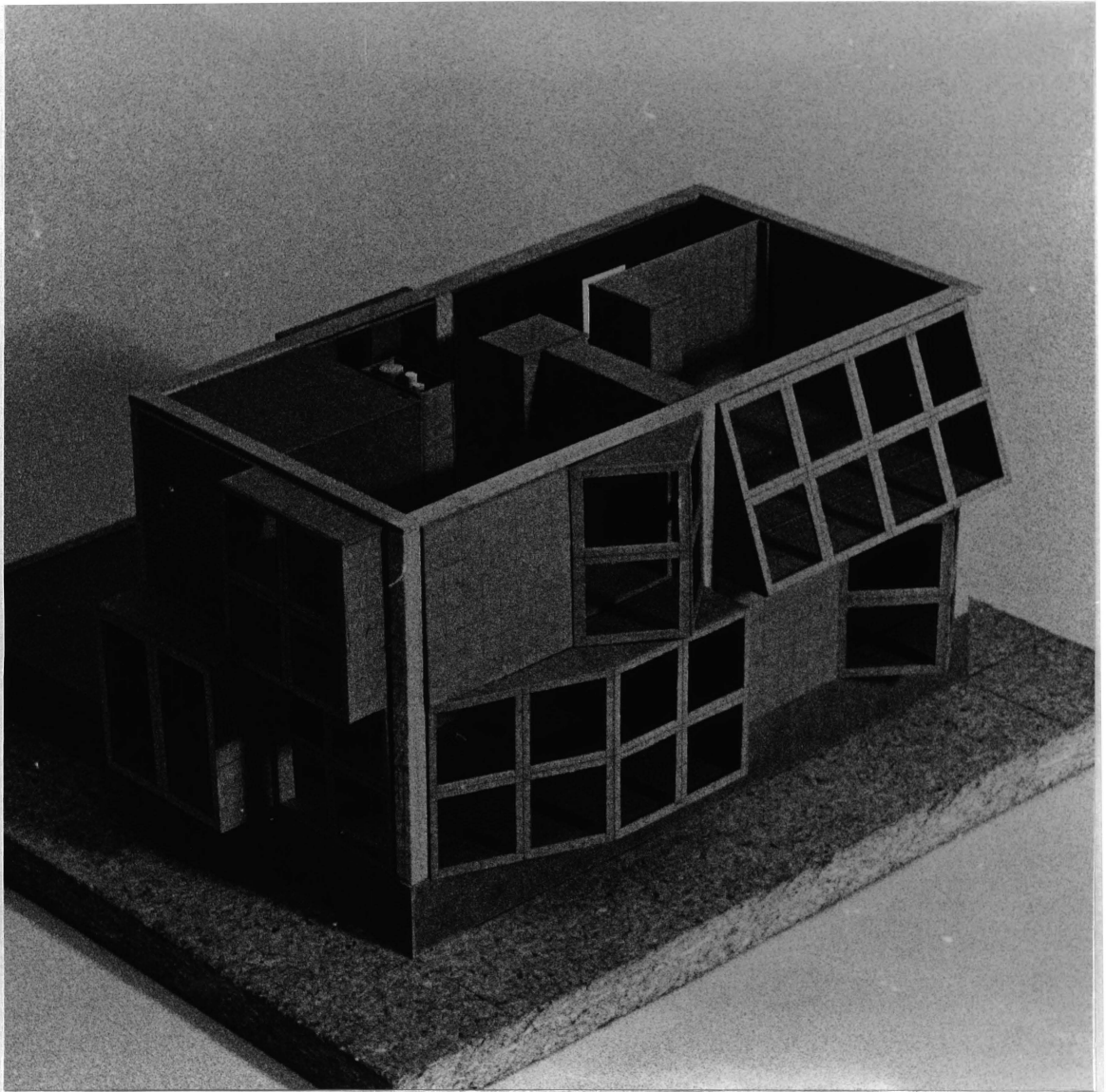


Plate 5
VARIATION 3

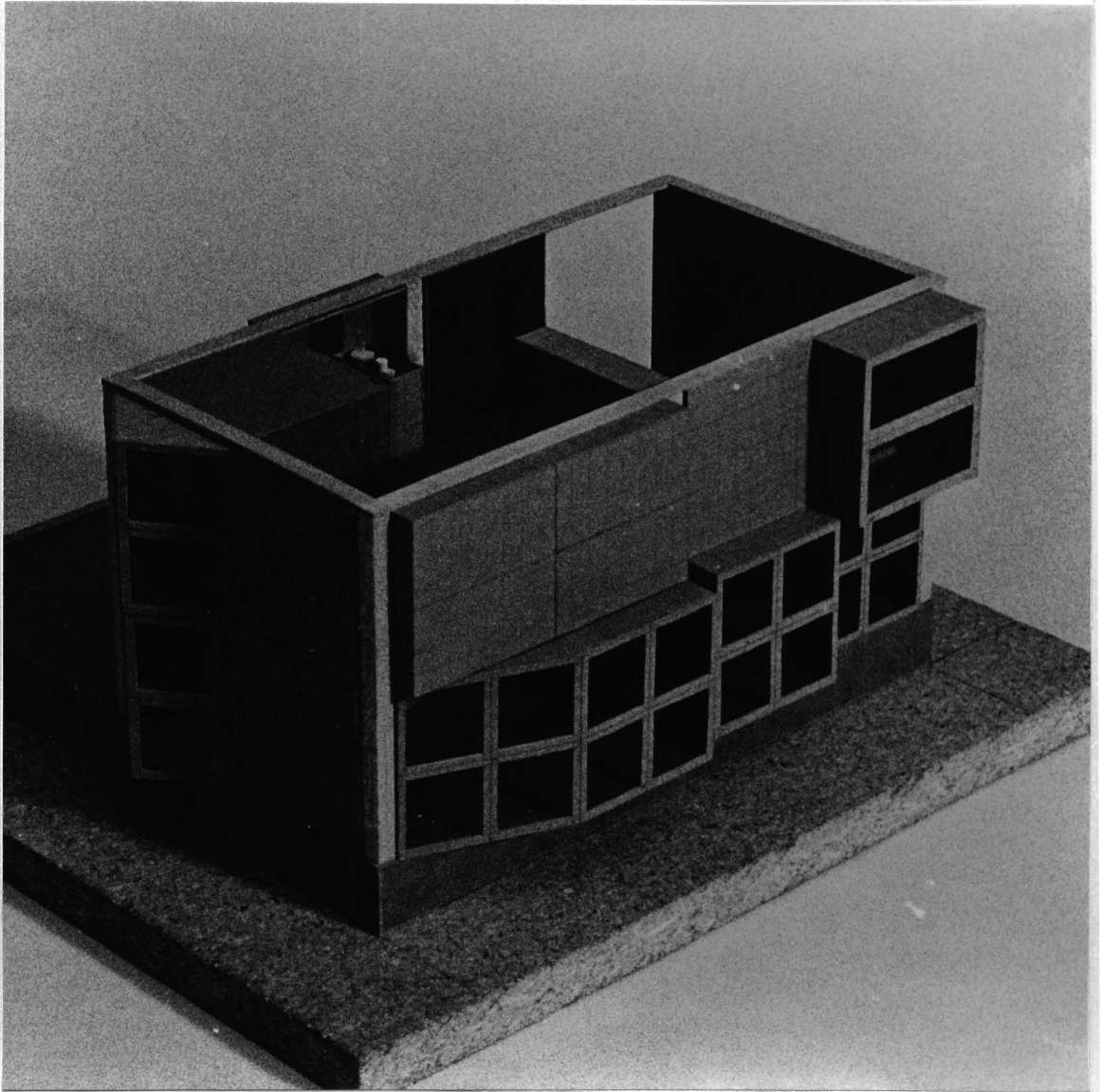


Plate 6
VARIATION 4

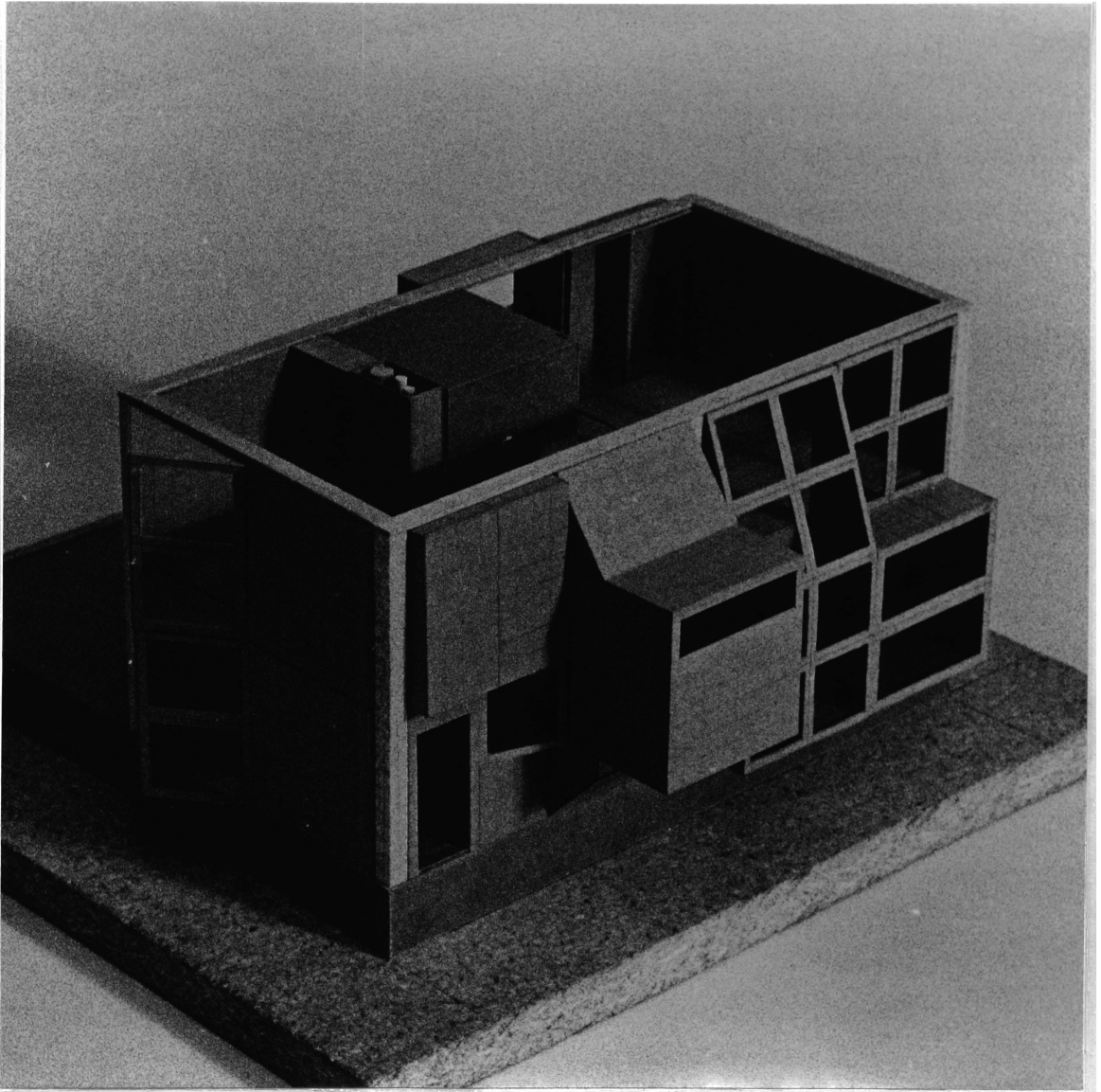


Plate 7
VARIATION 5

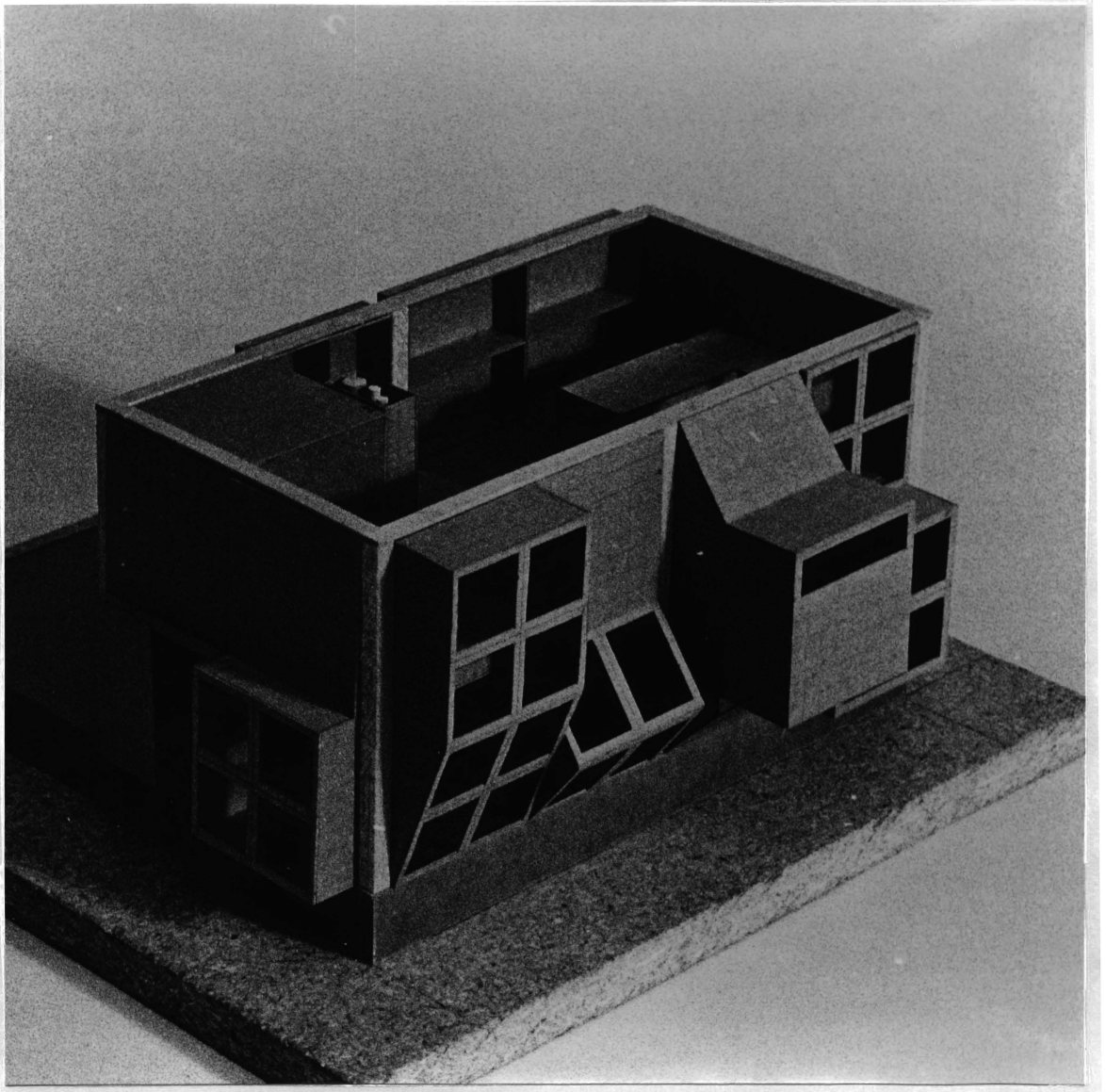


Plate 8
VARIATION 6

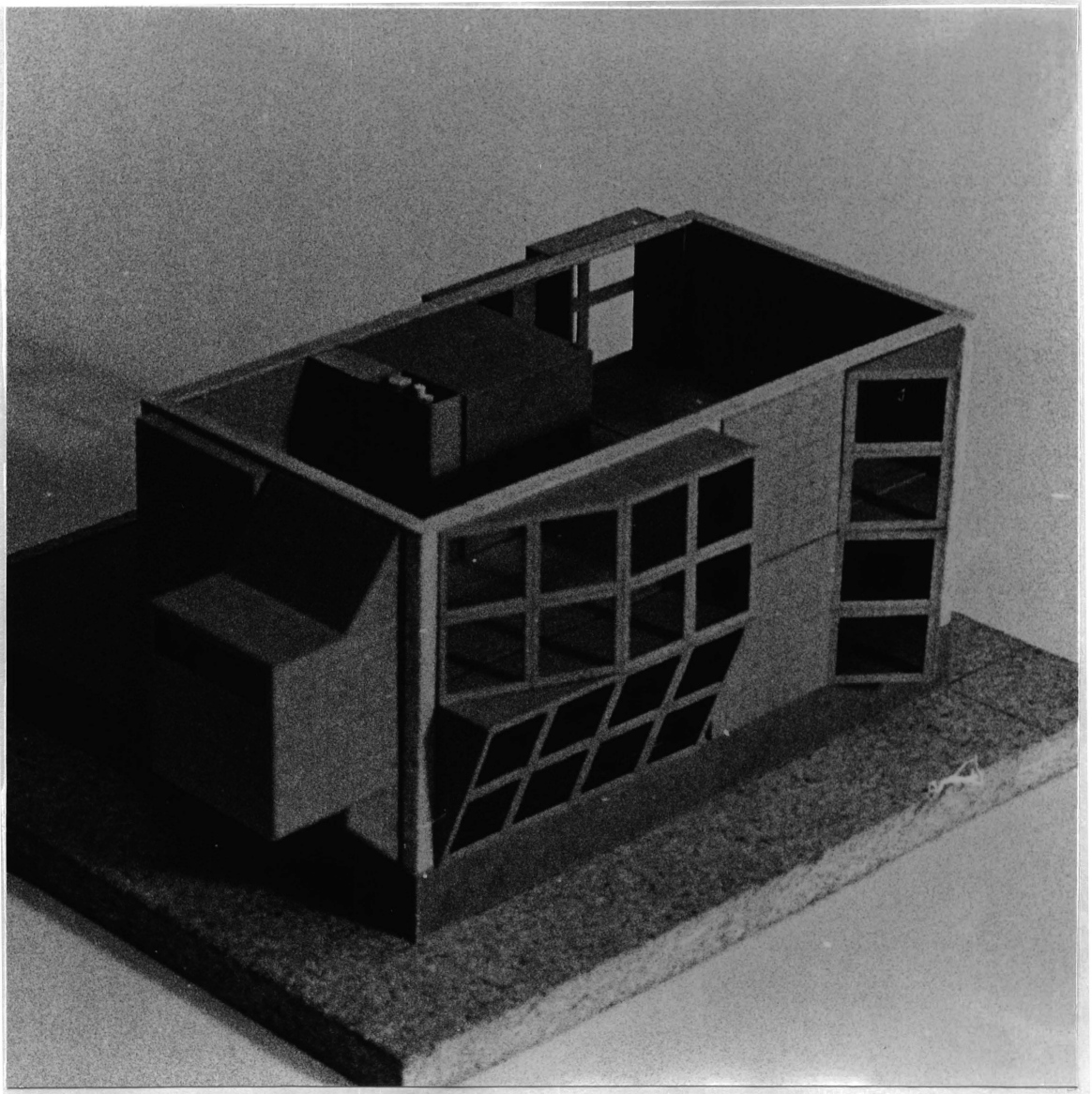


Plate 9

PLAN OF APARTMENT COMPLEX

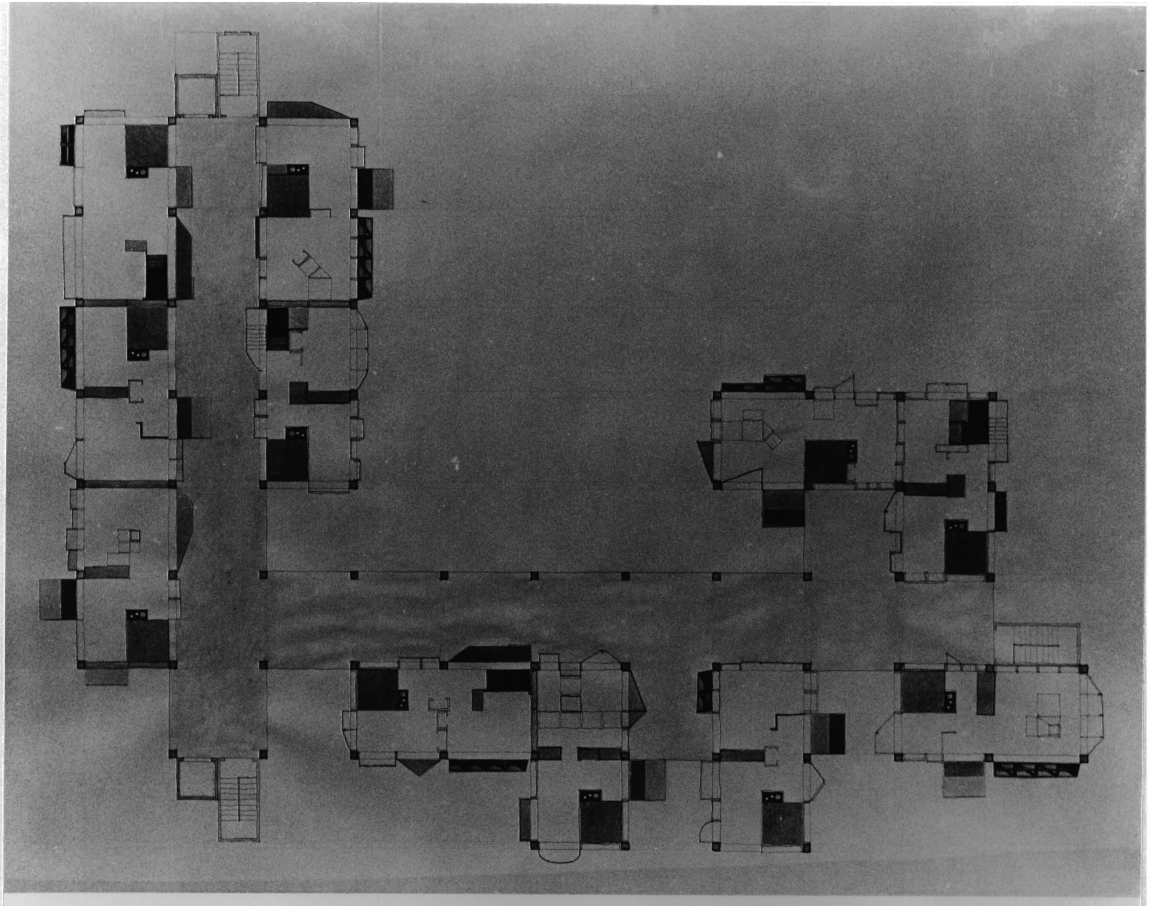


Plate 10

ELEVATION OF APARTMENT COMPLEX

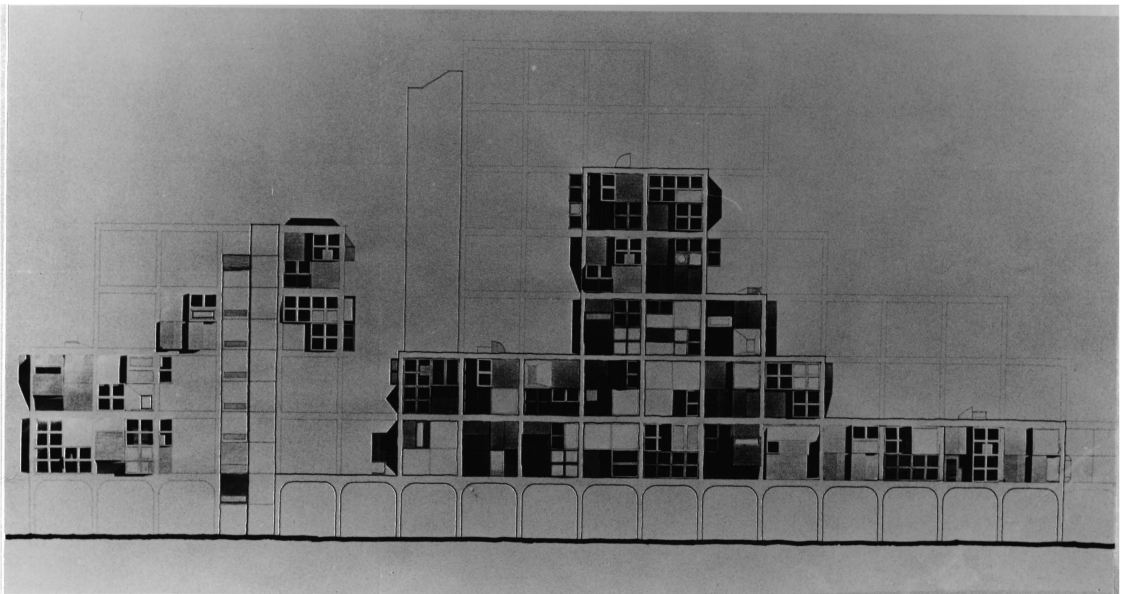


Plate 11

THE VARIATION IN MINIMUM SOLUTION

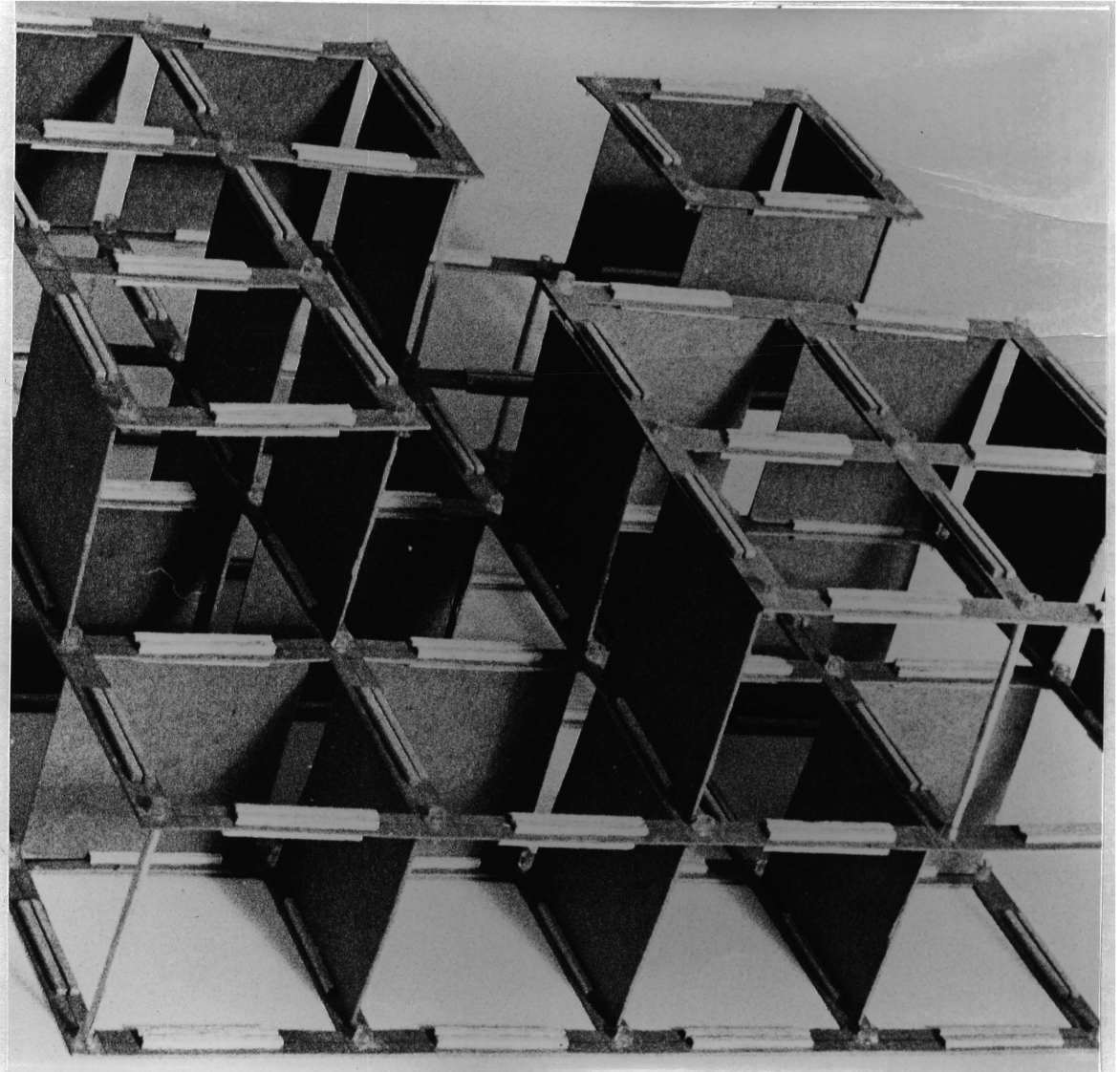
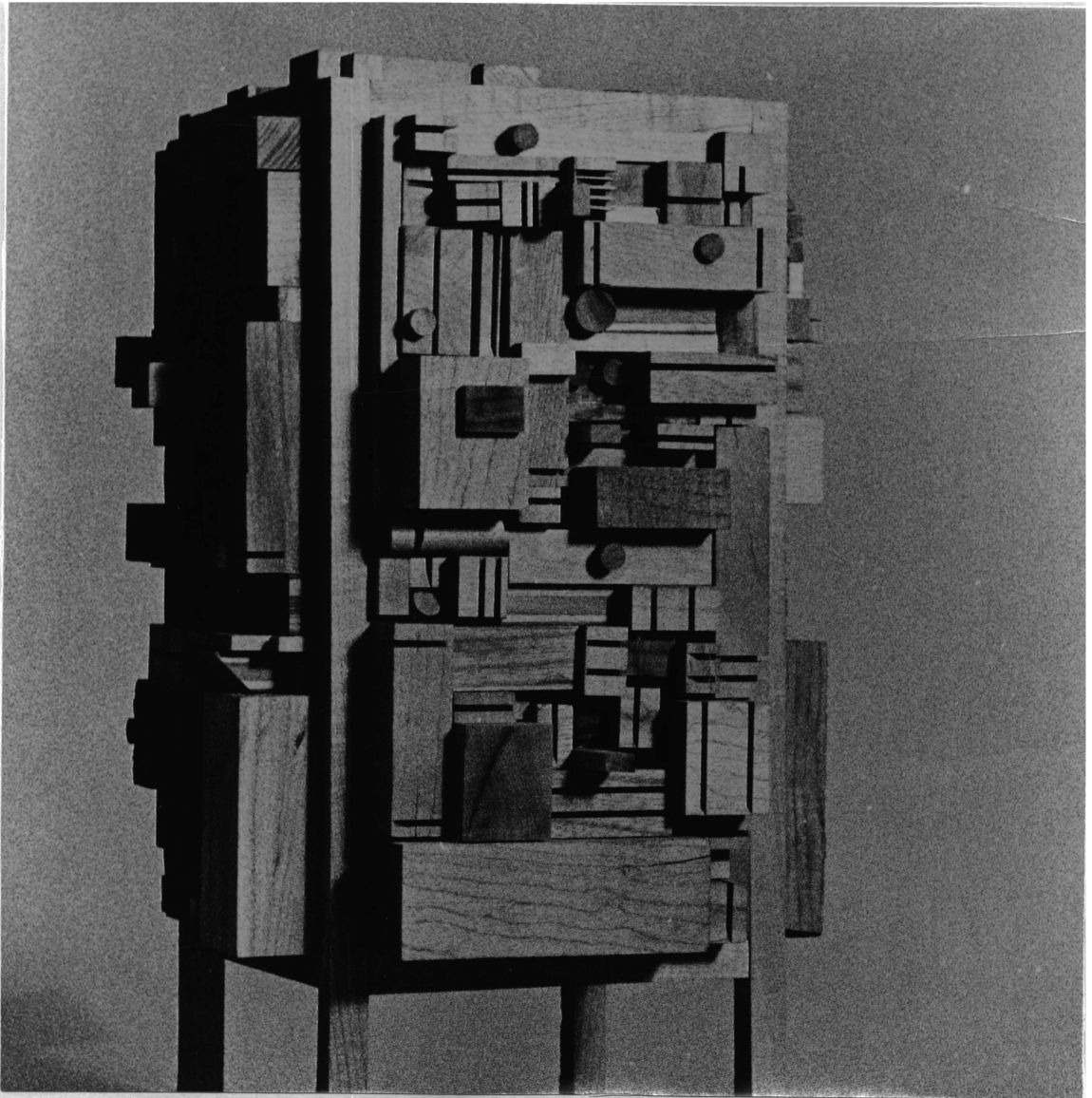


Plate 12

THE VARIATION AVAILABLE IN THE MAXIMUM SOLUTION



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the scanned document**

AN INVESTIGATION OF THE POSSIBILITIES WITHIN
THE LIMITATIONS OF PREFABRICATION IN HOUSING TODAY

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ABSTRACT

This thesis is the development of a design program.

Current housing systems, while offering a shelter, provide very little more in terms of differentiation and variation of units, or any selection on the part of the resident. This is termed the minimum solution and can result in monotonous housing developments, discontent among inhabitants, and in general, dislike for "prefabricated houses."

But, through re-evaluation of design priorities, and developing the maximum solution, which does contain many variations and a wide selection for the owner, an industrialized system of building can offer each person a unique unit and in turn, make "prefabricated houses" desirable to live in.