

DONALD P. SMITH
DESIGNTECH

P378
.Sm539

LIBRARY
MONTANA STATE UNIVERSITY
BOZEMAN

LIBRARY
MONTANA STATE UNIVERSITY

THESIS MOVIE

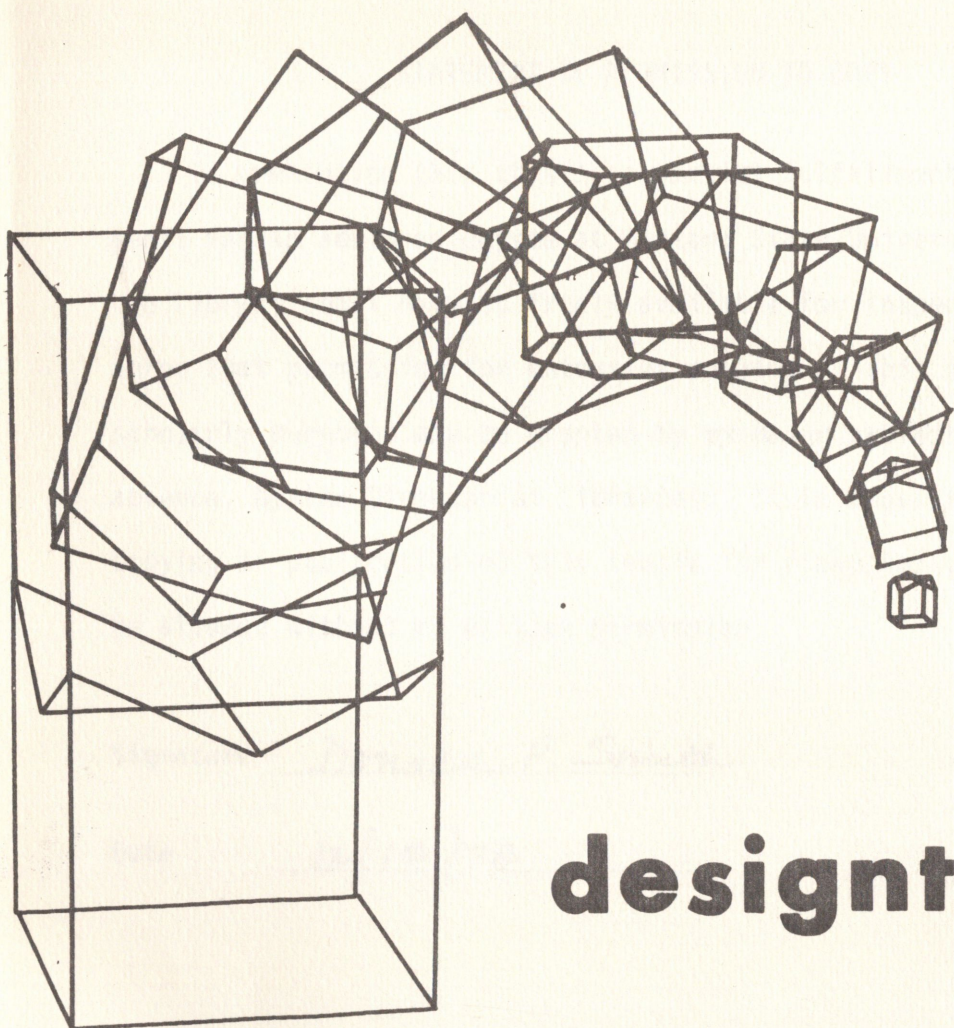
Print

A378

Sm 539

DUFFY SMITH
THESIS MOVIE
FALL 1978

TO BE BOUND WITH
THESIS BOOK.



designtech

a thesis in architecture

STATEMENT OF PERMISSION TO COPY

In presenting this thesis as partial fulfillment of the requirements for an advanced degree at Montana State University, I agree that the Library shall make it freely available for inspection. I further agree that permission for extensive copying of this thesis for scholarly purposes may be granted by my major professor, or, in her absence, by the Director of Libraries. It is understood that any copying or publication of this thesis for financial gain shall not be allowed without my written permission.

Signature Donald P. Smith

Date 12/15/78

DESIGNTECH

Thesis in Architecture

Donald P. Smith December 11, 1978

In partial fulfillment for the degree of Bachelor
of Architecture.

Advisor

CONWAY STOBBA

DESIGNTECH

Architecture Thesis
Montana State University
December, 1978
by

Donald P. Smith

P378
Sm 539

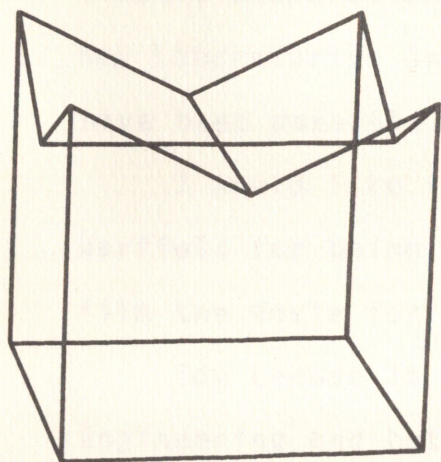
~~ALA 2540~~
~~720.6~~
~~149.6~~
~~Sm 54~~
~~CPT~~

To
the Dog,
and to
Mom and Dad
for all their
patience and love.

CONTENTS

Title Page	i
Dedication	ii
Contents	iii
Acknowledgements	1
Thesis Statement	3
Introduction	4
Introduction to Computers	5
Computer Applications to Design	12
Movement in Design	21
DESIGNTECH	25
Project	29
Documentation of Design	33
Conclusion	34
Glossary	38
Bibliography	41
Topical Bibliography	44
Appendix 1 User Package	47

acknowledgements



My thesis has been an interdisciplinary effort involving people in computer science, film and television, and architecture. It has been a lesson in cooperation between the 'architect' and other specialists, which I have certainly enjoyed and benefited from.

I would like to express my appreciation to my 1st and 2nd quarter thesis advisors, Warren Hampton and Guyton Stubbs, respectively, and to my resource professors, George S. McClure Jr. and Stanford Wyatt. Their interest and suggestions during the course of my thesis have been a great help.

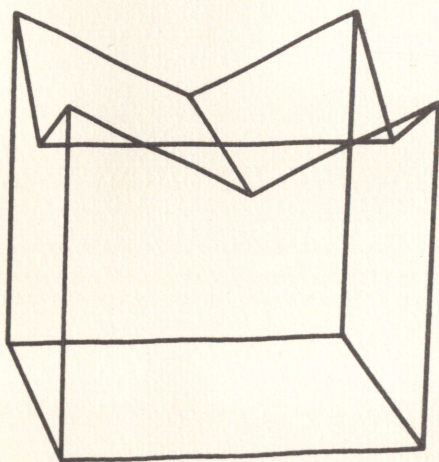
I am especially grateful to Todd Walter, Ray Babcock and Mac Pexton for their very significant contribution of computer programming expertise. Without their enthusiastic cooperation, and the use of the facilities at Ray Laboratories in the 11th hour, my thesis would not have been possible.

I would like to thank Beth-jana Friedberg and Dave Warfield for being interested enough in my project to film the movie for me.

Tom Lehman in Computer Science, D.R. Reichmuth in Engineering and both Carl Smith and Salah Sayed-Ahmed in Film and Television, were instrumental in helping me obtain the necessary assistance in their respective fields, and I am most appreciative of their efforts in my behalf.

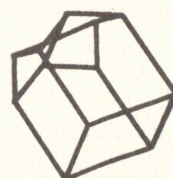
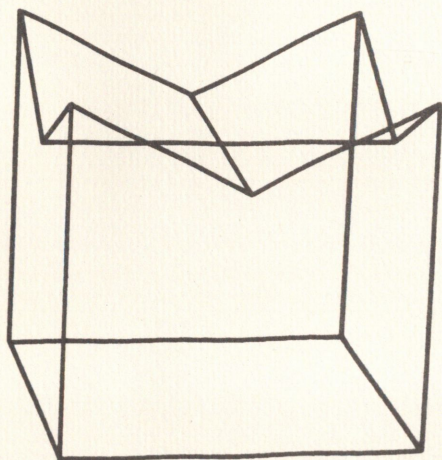
Lastly, I am indebted to the programming work of Phil Winninghof, and to Mitch Conner for the inspiration to pursue computer animation.

thesis statement



THESIS STATEMENT : COMPUTER GRAPHICS CAN BE AN
EFFECTIVE DESIGN TOOL FOR THE ARCHITECT.

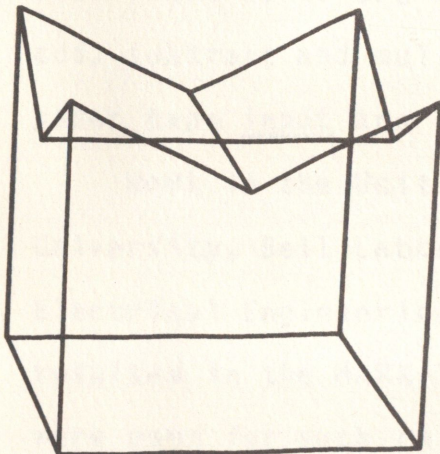
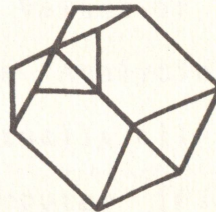
introduction



The computer has established itself in many architectural firms as a useful, if not indispensable, tool, largely in the more easily quantifiable aspects of their practice, such as structural or mechanical design and accounting. While the computer is already being used by some architects as a design tool, its non-prevalence in design, I feel, serves to justify my investigation.

Specifically, my interest in how we can improve our perceptive abilities as designers of the built environment has led me to explore the use of computer-generated perspectives as an aid to design.

introduction to computers



Computers are a derivative of the abacus - man's first calculating machine. The developments of significance to this 5,000 year evolution, as outlined by Kaiman Lee (17, 28), begin with the invention of logarithms in 1614 by John Napier, which made possible the slide rule. A mechanical calculator which operated by means of various gears, dials, levers and rotating wheels, was subsequently constructed by Blaise Pascal in 1642. Two 19th century inventions by Charles Babbage which furthered mechanical calculation, were the "Difference Engine" in 1820, capable of computing values of polynomials to a 6 place accuracy, and his "Analytical Machine" of 1831. The latter had virtually all the important features of the modern digital computer (Please note: underlined words are defined in the glossary). It could add, subtract and multiply, and had a memory capacity, paper tape input and printed output.

Work in the United States in the 1940's, at Harvard University, Bell Laboratories and the Moore School of Electrical Engineering at the University of Pennsylvania, resulted in the MARK 1, ENIAC and UNIVAC 1 computers which were used for such calculating purposes as artillery trajectories and census figures. These computers, referred to as 1st generation, operated with vacuum tubes and were

extremely large and slow, relative to today's machines. The development of transistors in the late 1950's, which reduced the size while increasing the speed of computers, marks the 2nd generation period. The advent of integrated circuitry in the period from 1961-63 had a similar effect on computer size and speed becoming the 3rd generation of computers.

Mitchell (19), refers to an emerging 4th generation, which dates from 1971-72, of macro and micro computer systems. The macro system is an "...interconnection of numerous computers to form large scale computer networks", an example of which is the ILLIAC IV at the University of Illinois. Continued advances in microprocessor technology (miniature electronic circuits), have made possible the manufacture of very small and inexpensive microcomputers. The power and affordability of these minicomputers has had, and will continue to have, enormous impact on the proliferation of computer technology.

The operation of a basic computer system is illustrated in the diagram on the following page from Mitchell (19, p.4). The process is initiated by the input of a program through some input device (See Figure 2, p. 8 for various input and output units). The program is compiled and stored in a computer memory device until the program is called upon to

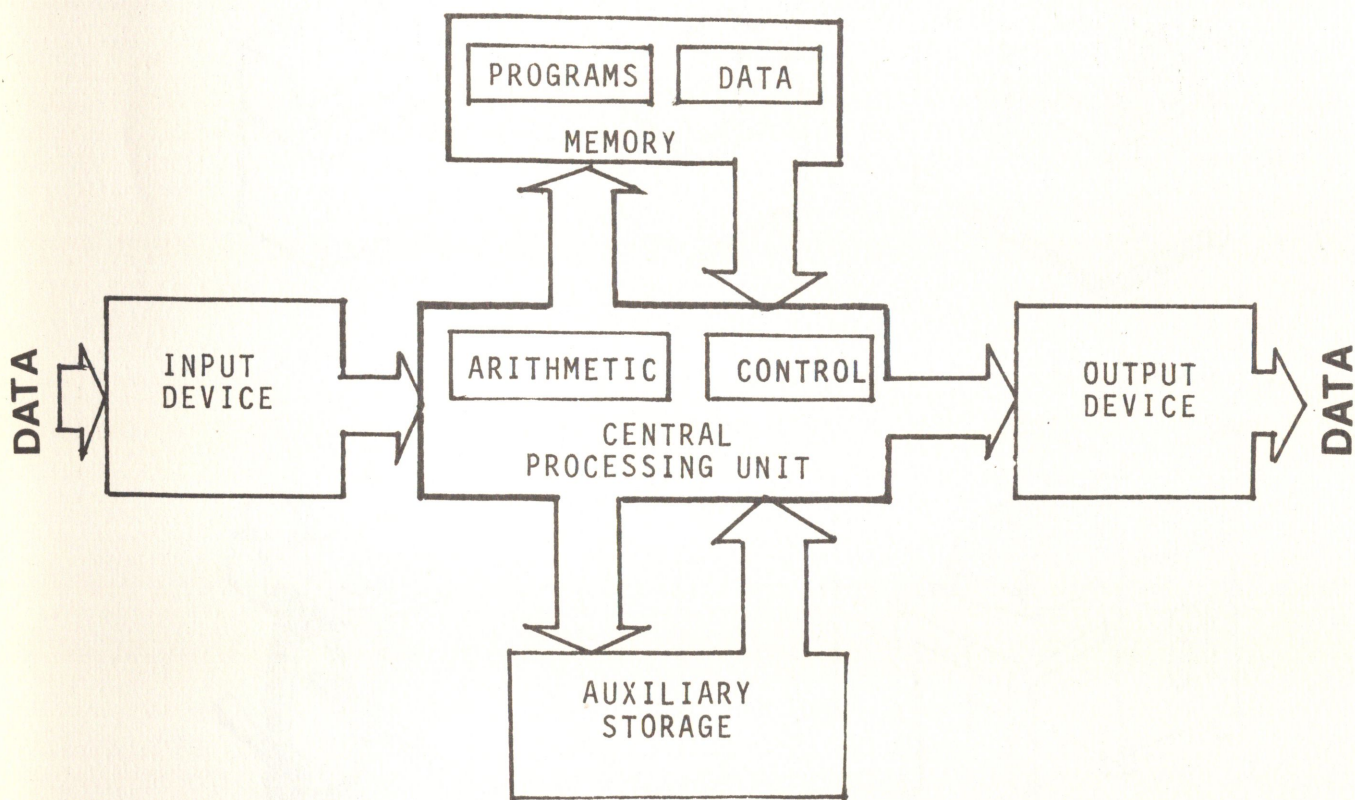
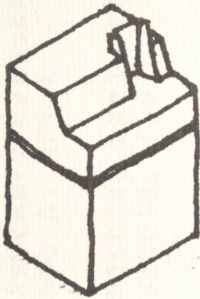


Figure 1. Basic Computer Systems.

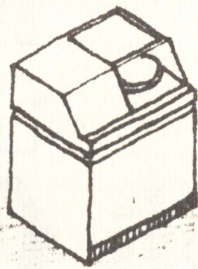
execute its specified instructions. Program execution occurs in the central processing unit (CPU). Results obtained by the program will then be output in whatever form has been specified by the program.

The transition of commands from the architect to the computer and back is accomplished by a series of interfaces, seen most easily in Figure 3, p. 9. The architect, using English, decimal and graphic vocabularies employs a program-

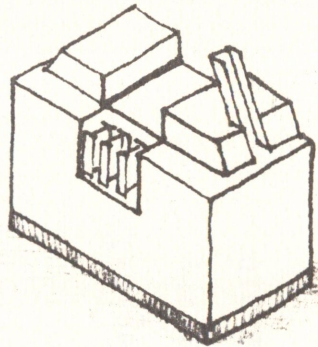
INPUT



CPU
CONTROL
STORAGE



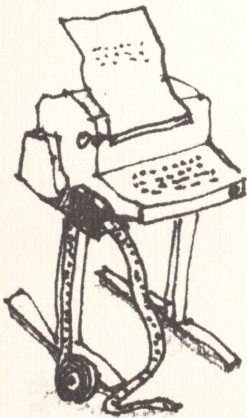
OUTPUT



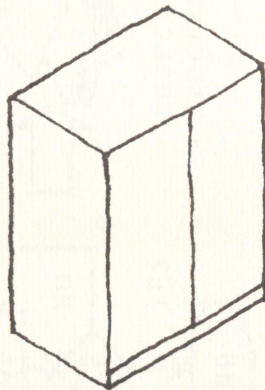
Card Reader

Disk Storage Drive

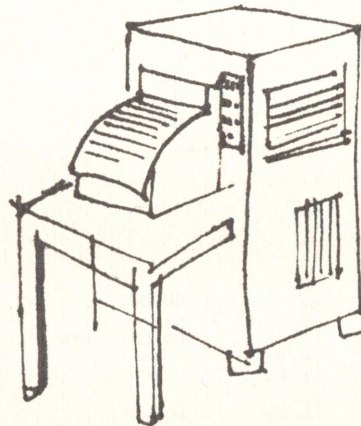
Card Read Punch



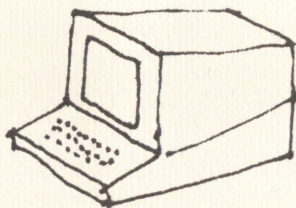
Teletype and
Paper Tape
Reader



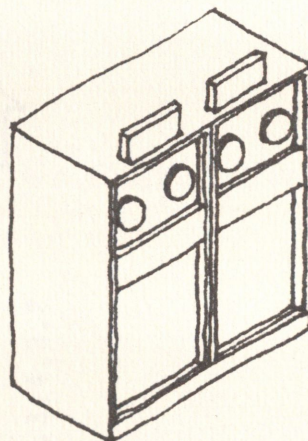
Control Unit



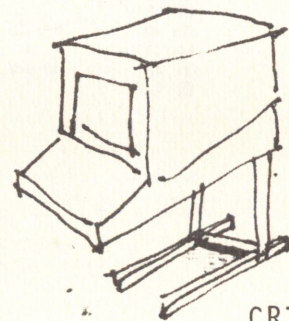
Line Printer



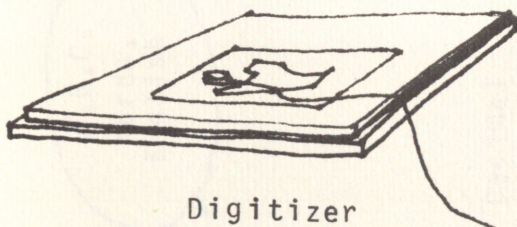
CRT with Light Pen



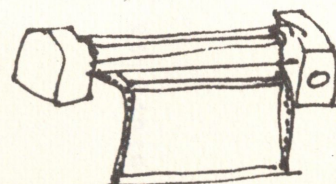
Magnetic Tape
Unit



CRT



Digitizer



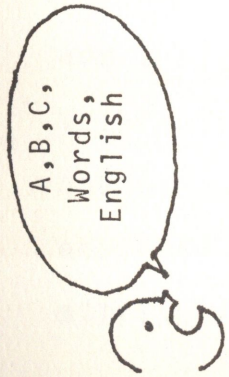
Drum Plotter

Figure 2. Computer Hardware.

A. USER

B. APPLICATION SOFTWARE

C. SYSTEM SOFTWARE



Decimal Numbers
1, 2, 3, 4, 3, 2

Graphics

Programming Language:

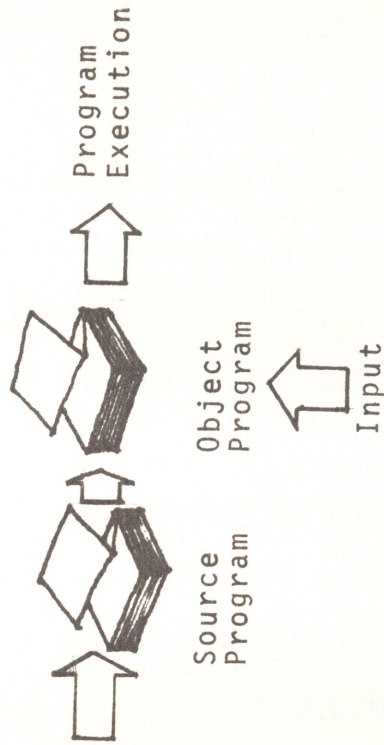
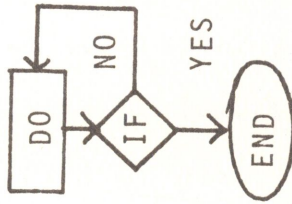
FORTAN
ALGOL
COBOL
PL/1

Compiler:

Assembly Language
ADD A, MPY X

Machine Language
010010, 110100

Programming Logic



X	Y	Z
2.0	5.7	10.6
4.1	3.2	8.8
.	.	.

Converted to a mathematical model

Decimal
To
Binary
011010

Figure 3. Software Interfaces.

ming language such as FORTRAN (Formula Translator), to express his program in a format acceptable by the input devices. The computer however, operates in a machine language in which sequences of binary numbers represent all the conventional letters, decimal numbers or mathematical symbols. (In binary, 0 and 1 are the only two digits used.) They can be represented by switches being on or off, holes in cards or paper tape punched or not punched, and areas on magnetic tape magnetized or not. (Stewart, 28).

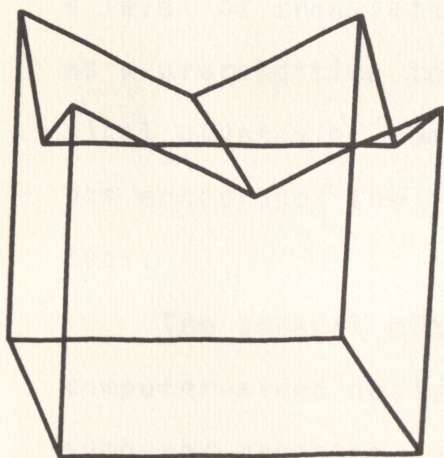
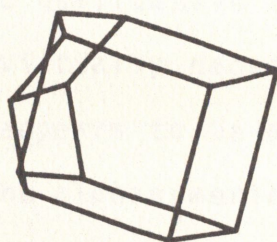
The translation of the source program from a programming to a machine language is accomplished by the compiler. The compiler, and the operating system, which controls input/output, compilation, interpretation, loading and execution are both part of what is collectively referred to as the system software. This term encompasses all the operational programs needed to run the computer system. (Mitchell, 19).

Broadbent (7, pp. 314, 315), presents an interesting analysis of the relative capabilities of the human brain and the computer in a number of different categories. Within its rather narrow range of arithmetic or logical operations, the computer clearly has the edge in speed and accuracy. For example, the computer can operate on 1,000 million or more numbers in one minute, to the brain's ten

7-digit numbers. The computer can receive or output 100 thousand characters per second on magnetic tape, to the brain's 25. Furthermore, while the accuracy of the brain is invariably suspect, that of the computer is certain. However, in the more complex areas of thought associated with design, such as: perception, imagination and reasoned judgement, to name but a few; the brain is capable of creative leaps which may entirely circumvent some tedious procedure in arriving at a solution.

The cost and/or difficulty involved, in applying the computational advantage of the computer to architectural problems is the major determinate of its inroad into the architectural profession. A procedure to accomplish this task is essentially two-fold. First, the necessity of reducing a given problem to a level of computer applicability, requires a careful examination and organization of the problem. I agree with those such as Caudill Rowlett and Scott, (Negroponte, 21 and Eastman, 10, p. 11), who feel that this process can aid the architect in developing a clearer understanding of the problem. The second step is the development of the necessary software to solve the problem. This may involve the skills of a programmer hired by the firm, or the purchase of a program specifically written for that purpose.

computer applications to design



It is not difficult to see why the more easily quantifiable aspects of architectural practice, such as; structural or mechanical problems, have been more readily adapted to computer technology than design. They involve generally well-established sequences of calculations to arrive at solutions, which can easily become computer procedures.

To computerize some aspect of design, on the other hand, requires analysis of the design process and quantification of what are usually considered qualitative variables.

Further, the realm of design virtually necessitates graphic input/output which outwardly appears to be a step further removed from input than via the alphanumeric modes.

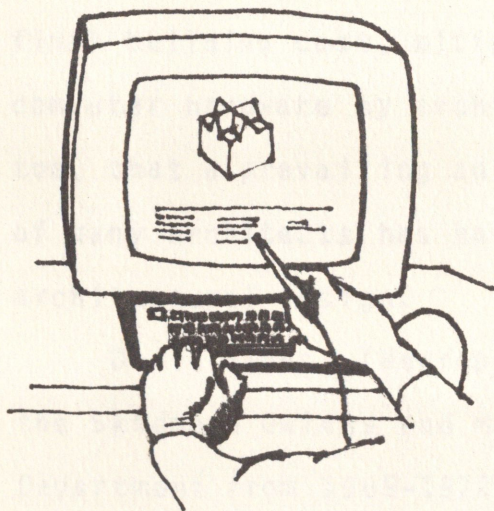
(Refer to the Software Interface chart, Figure 3, p. 9).

In fact, as the chart shows: all three user modes undergo a level of translation in the application software interface as a precondition to computer input. It has been the technical advance of computer graphics in the past decade, that has encouraged the investigation of the computer as a design tool.

The general classification in which most programs in computer-aided design fall, is known as interactive computer graphics. Computer graphics implies visual images drawn by computer output devices, namely, the plotter or cathode ray tube. The CRT is perhaps more synonymous with

interactive graphics as its rapid picture-generating capability provides the means for visual dialog between man and machine. This response, or user interaction, may cause the user to modify input constraints or to select various program options such as rotation, scaling or perspective. CRT drawings which the designer feels are worthwhile can be output as hardcopy (on a plotter or a hardcopy unit attached to the CRT), for further study.

The light pen, (see illustration below), is an example of a hardware advance that has greatly expedited the process of graphic input, and simplified the dialog between man and machine.



CRT With Light Pen.

A photocell sensitive to light, the light pen, allows the user to point to certain commands on a CRT display, which the program will then execute. It can also be used as a crude drawing device which, in conjunction with a program (Atkin, 2, p. 182), is capable of interpreting and re-drawing the sketch. Lines are drawn

by a cursar on the screen, which moves in response to the light pen. The program is able to delineate the sketch by interpolating the crudely-drawn lines.

Notably present in the forefront of computer-aided design have been the automobile and aircraft industries. They are extremely large when compared to most architectural firms, and have been capable of purchasing impressive computer graphic systems. Mitchell (19), considers both their favorable capital position, and the relatively high design development cost as a percentage of the final product cost of a car or plane, the primary reasons for their leadership in the field. On the other hand, the design development cost of a building represents a small fraction of the final building cost, mitigating against capital outlay for computer hardware by architects. It can certainly be said too, that a prevailing anti-computer attitude on the part of many architects has had its own impact on computer-aided architectural design.

David Sides, (Negroponte, 21, p. 135), the head of the Skidmore Owings and Merrill San Francisco Computer Department from 1969-1972, lists the following reasons as to why, to date, the computer's effect on the average architectural firm has been negligible.

- (1) The firm is anti-computer due to hardware cost and an unwillingness to cooperate with other firms in sharing systems. Also few firms feel they have enough projects to justify the expense of programmers.
- (2) The architect himself is anti-computer because of his own egoism and although trained in rational thinking, the logic of computer procedures is still foreign to him.
- (3) The state of the computer art predicates against great leaps forward due to the disillusioning gap between what is feasible in current technology and what is being effectively applied by firms.

The necessity of the computer 'paying it's way' to any architectural firm is inarguable. Caudill Rowlett and Scott and Ellerbe Associates (Negroponte, 21), are two firms which have achieved a significant level of computerization, in spite of a stringent cost justification attitude. There are, as well, examples of architectural and engineering firms associating to share hardware or software. One such Association is APEC (Automated Procedures for Engineering Consultants); an international organization in which standard programs are available to all members (Kennedy, 16, P.226).

There is indeed, a wide gap between the state of the computer art and the level of its current application in practice. For instance, knowing that full color displays of shaded surfaces and fully automated input/output methods have been in limited use for at least 5 years, can be discouraging when, as in my case, the graphics seem crude by comparison. Consoling however, is the fact that mini computer graphics systems are becoming more and more feasible economically all the time, for even the small architectural office.

John Grason (1969), I feel, succinctly groups the various approaches to computer-assisted design into two categories; (1) Computer-implemented design, in which the computer itself makes all the design decisions during some phase of the design process; and (2) Computer-aided design, in which the computer assists the designer. Grason's program is of the latter approach; it is a type of program that has been variously described by Negroponte (22), as "plan recognition", by Weinzapfel (32), as "functional space configuration", and by Mitchell (in Kennedy, 16, p.82), as "multi-constrained spatial synthesis". Each term is, in part, descriptive of what is generally accomplished by this programming paradigm, an example of which is illustrated on the following page.

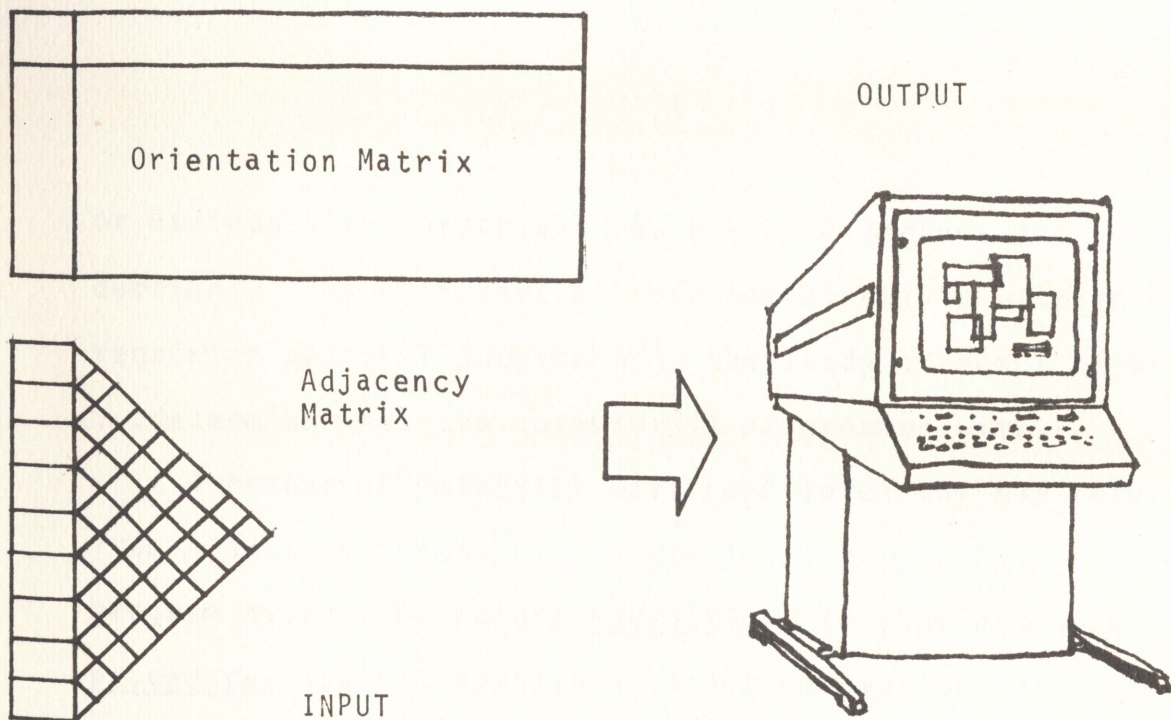


Figure 4 . A Spatial Synthesis Program.

From a geometric description, (area, minimum and maximum length), rooms are drawn as rectangles according to their respective sizes. Then, based on one or more constraint matrices specifying physical adjacencies and perhaps orientation, (seen on the left in the figure), the rooms are graphically manipulated by the computer which attempts to find arrangements which optimize the input criteria.

It is in the development of these constraints that I believe the architect can begin to interject his own more subjective feelings such as; what type of light (i.e. natural, south), is required in a space; or whether one space must relate visually to another. Other spatial determinates might be circulation, functional requirements

or various site responses. As put by Broadbent (7, Introduction), "The architect's 'soft-edged' skills - those requiring personal judgement in the study of human needs, ...determine what the computer is programmed with."

A number of potential plan configurations may result from slight modifications to the input hierarchy. This program type is by nature heuristic. In contrast to a procedure, spatial synthesis cannot be expected to arrive at a definitive solution. The computer would continue to search for an optimal solution if not programmed to be satisfied at a certain level.

I would summarize the advantages of a spatial synthesis program as: (1) It is useful in dealing with the more complex building programs (i.e. health care facility design); (2) As a research tool, it can be used to illustrate the manifestation of specific changes to the design criteria on resulting plan configurations, and (3) It can generate many more possible solutions than feasible by manual techniques.

Another approach to computer-aided design is the Building Description System (BDS) at Carnegie-Mellon University (Eastman, 11). The technique of the BDS program is to catalog numerous types of building components, ranging from geometric volumes to joists or columns. A building is

then designed by the interactive composing of these elements, as Eastman (11, p. 46) says, "...much as one would a balsa model." Eastman continues, (p. 50):

The remote manipulation of elements in three dimensions is quite different from making multiple drawings of them in two dimensions. A different way of thinking about design is encouraged by BDS. My own reaction is that the new mental perspective that evolves with it's use is both more realistic - when construction is considered - and more thorough. With an infinite number of perspective views available on the display, visual analysis is significantly enhanced.

Comprehensive lists of computer-aided design applications can be found in; Mitchell (19, pp. 76-78), Campion (8, pp. 8-10), and Stewart (27). Eastman (10, p. 7), divides the building into functional subsystems as

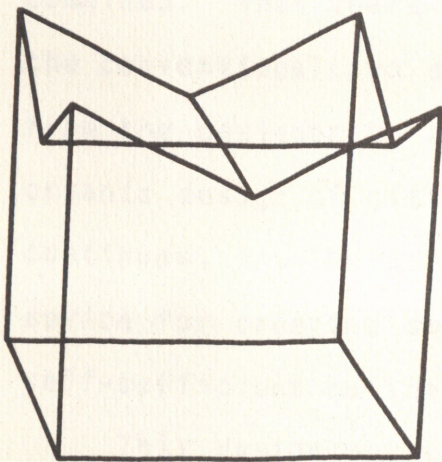
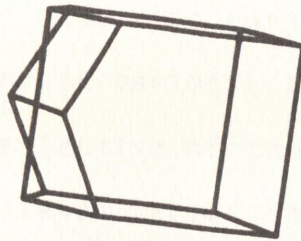
seen at right. Existing	1 - Site
computer aided design pro-	2 - Exterior Shell
grams have direct applica-	3 - Structure
tion to literally all seven	4 - Spatial Arrangement
aspects. My program has an	5 - Mechanical Services
impact primarily on 1, 2,	6 - Materials
and 6.	7 - Interior Furnishings.

Figure 5 . Building Divided into Functional Subsystems.

Architects will always be under pressure to produce the best possible design in the least amount of time. The computer's capacity for storage and fast retrieval of information in graphic or text formats such as specifications, details and working drawings, can be of great importance in a profession already bogged down in the diversity of its informational requirements.

The most important concept to be emphasized in computer aided design is multiple re-use of data. By this is meant development of an integrated computer-assisted design system which can effectively use the data base of the building for many other calculations; orthographic and perspective drawings; environmental controls, structural and mechanical analyses; estimating and scheduling to name only some of the possibilities.

movement in design



As Philip Thiel points out in "Processional Architecture (31, p. 24), there are clear historical instances in which movement has been an organizing design concept in architecture. The Egyptian temple, for example, was a linear progression of spaces which successively decreased in size and in level of illumination. The Greeks and Japanese also consciously designed for movement to create a sense of anticipation in the approach to their temples, by alternately revealing and obscuring parts of the building.

The architecture of certain periods, according to Edmund Bacon (3), is also reflective of the prevailing design methodology. The Medieval period, he contends, was characterized by an intuitive flow of experience among its designers who were generally architect and master builder combined. Thus there was no separation of tasks requiring the conventional two dimensional graphic communication from the designer to builder, the result being a highly organic design of cities. Renaissance design, Bacon continues, saw the advent of scientific perspective as a device for ordering space which produced generally single self-sufficient buildings detached from their surroundings.

This design method has been referred to as "the Perspectivist Tradition" by Conner (9), who asserts that it has been a dominant feature of urban design for over

400 years. By its static visual field, this method implies both a fixed point in space and in time.

Time does emerge as a conscious design element in the Baroque Period however (Bacon, 3). Here the technique of separating architectural elements brings about a dynamic movement between them by directing the participant through a spatial experience. (Please refer to Fig. 6, p. 23)

The Modern period has been described by Bacon (3), as a "space-time continuum", but is such a concept discernable in current design methodology? Philip Thiel and Lawrence Halprin are concerned with time and have developed 'scoring' techniques for environmental perception similar to the way music or dance are 'scored'. However, the prevailing design attitude does not appear to consciously deal with this subject.

Fundamentally, the difference between architecture and the other temporal arts (music, dance, drama and film) is the state of the audience. While the latter determine the type, rate and sequence of presentation to a voluntary and alert audience; the architect has little direct control over the rate and sequence of the observer. (Thiel, 31, p. 28).

More precisely, movement in dance or drama is of the visual field, while the observer is stationary. The opposite is the case in architecture, where the observer is usually in motion. Dynamic change in spatial position over time

HISTORICAL DESIGN METHODOLOGY

PERIOD

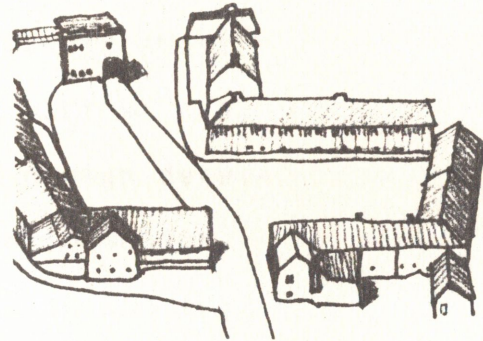
DESIGN CONCEPT

IDEA/Form MANIFESTATION

MEDIEVAL

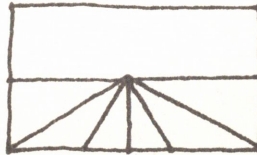
Intuitive
design

Awareness of total
environment. Const-
ruction closely
integrated to its
environment.

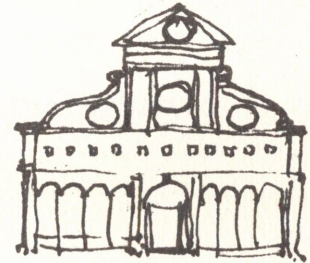


RENAISSANCE

Individual
centered
design



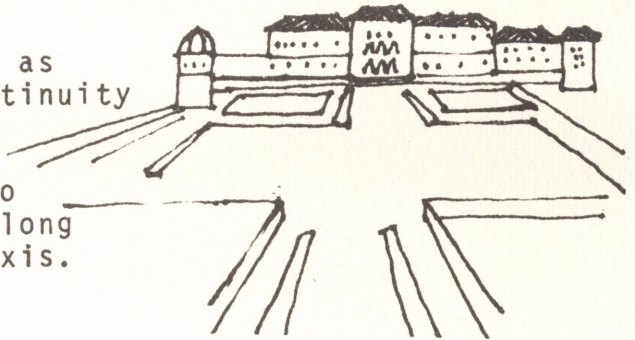
rational, rigid one
point perspective of
a single object in
space.



BAROQUE

single
movement
system

Experience as
simple continuity
in time.
Structures
relating to
movement along
a single axis.



MODERN

simultaneous
movement
systems

space-time
relativity.

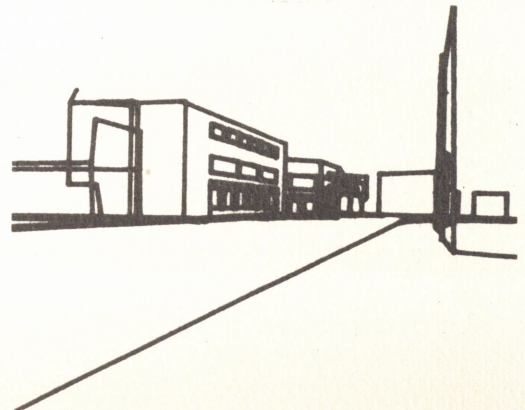
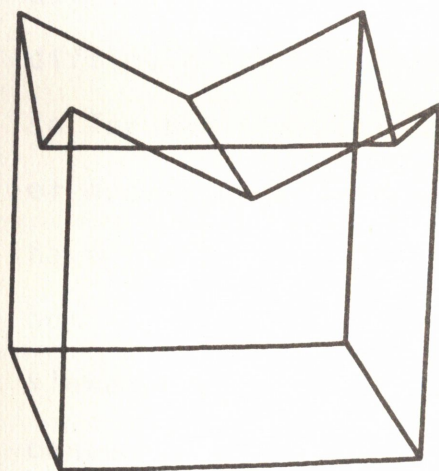
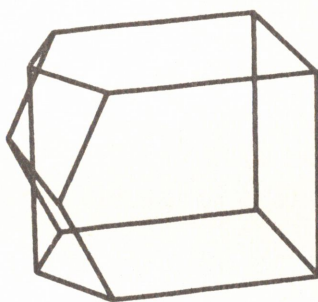


Figure 6.

would seem to be the essence of what is meant by a 'space-time continuum'.

Few would debate, I feel, that one of our foremost objectives as designers is to visualize, as best we can, what our spaces will look like during their design development. If most architecture is experienced in motion, then our ability to foresee what we design with the traditional static drawings is questionable at best. It is the challenge of architecture, from its fixed position in space, to exert a consciously-designed influence on the dynamic observer.

designtech



DESIGNTECH, is a perspective-generating program capable of drawing three point perspectives of a building from any viewpoint, looking in any direction. The program has been written to be user-interactive enabling the designer, while working at a CRT terminal, to try different viewpoints, different scale factors or alternative design solutions. When the user wishes to retain a certain view, he merely requests a hard copy drawing of what is seen on the CRT.

I have pursued this particular aspect of computer graphics largely due to an attitude that as designers, we almost invariably fail to adequately perceive what we design. This I feel, is the result of our reliance on the prevailing architectural drawings (the plan, section and elevation), which are planar, unrealistic abstractions difficult for even the trained eye to understand. What is difficult for the architect to visualize, becomes even more so for the client. Thus we frequently turn to perspectives or models to aid in this objective, but unfortunately both have their limitations. Models, unless photographed at a human scale view, are inately deceptive, as they are usually viewed from above. They are also perhaps the most time-consuming of media to produce.

Perspectives too, can be deceiving if not carefully drawn, but are, I feel, a more accurate and facile repre-

sentation of space. What I consider to be the limitations of conventional perspective drawings, namely time and accuracy of preparation, can be overcome by computer-generated perspectives, with the only problem that of expense.

As the graphs below from Mitchell (19, p. 90) indicate, the cost of the initial computer perspective is likely to exceed that of a manual one, but thereafter, the cost of additional views increases very slightly as compared with manual production. This is because once the data necessary to describe the building has been input to the computer, each additional view requires only the specification of view position and view point; two 3-dimensional coordinates.

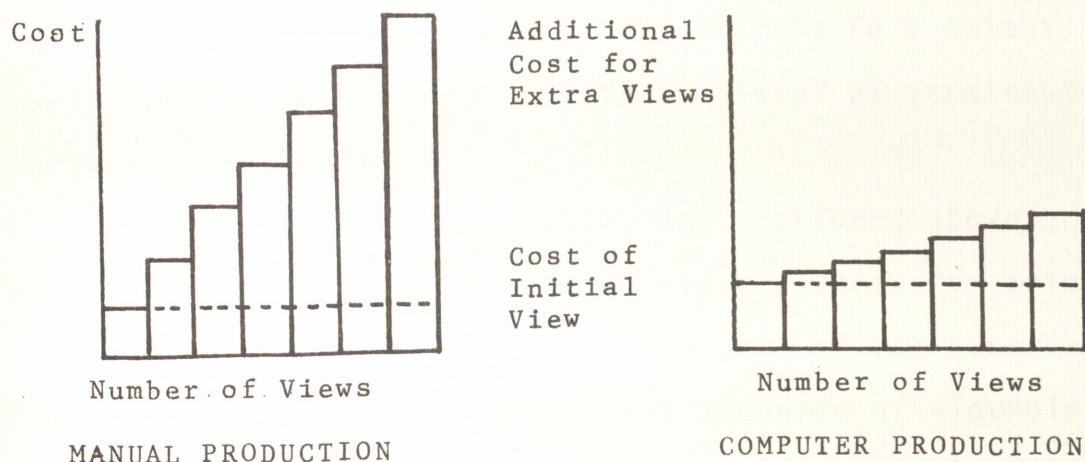


Figure 7 . Relative Cost of Manual and Computer Perspective.

Both the expense of manual perspective and the aforementioned proclivity towards planar drawings seem to dictate a pattern of presenting only one or two perspectives (if used) of a design, again limiting the usefulness of the tool. Quite often in fact, a bird's eye view is chosen, which although useful as a massing study, shares the same limitations as the model, in that the building will not be seen from this view.

The advantages of computer generated perspectives are: (1) Drawings from any viewpoint can be rapidly produced, from which more complete renderings and materials studies can be undertaken. (2) Complex relationships between buildings can be visualized which would be extremely difficult by manual techniques. (3) A design can be fully documented in a manner readily discernible to a client which will significantly improve the level of architect-client communication.

In addition to the capabilities mentioned above, there is the potential, which I have explored, for animation studies to simulate movement on the part of the observer. This is accomplished by inputting a sequence of viewpoints describing a path of movement such as, for example, an approach to the building. The computer then outputs a series of perspectives from a gradually changing viewpoint,

which can be filmed by traditional animation techniques. It is this capability that I feel, holds the most promise for significantly changing and hopefully improving the means by which we can 'pre-experience' the spaces we are designing.

In Figure 8 below, I have illustrated the basic components and sequence of the animation process. The categories (from Bonsteel, 6) are: (1) the Mathematical Model, (2) the Machine Hardware and (3) the Presentation Medium.

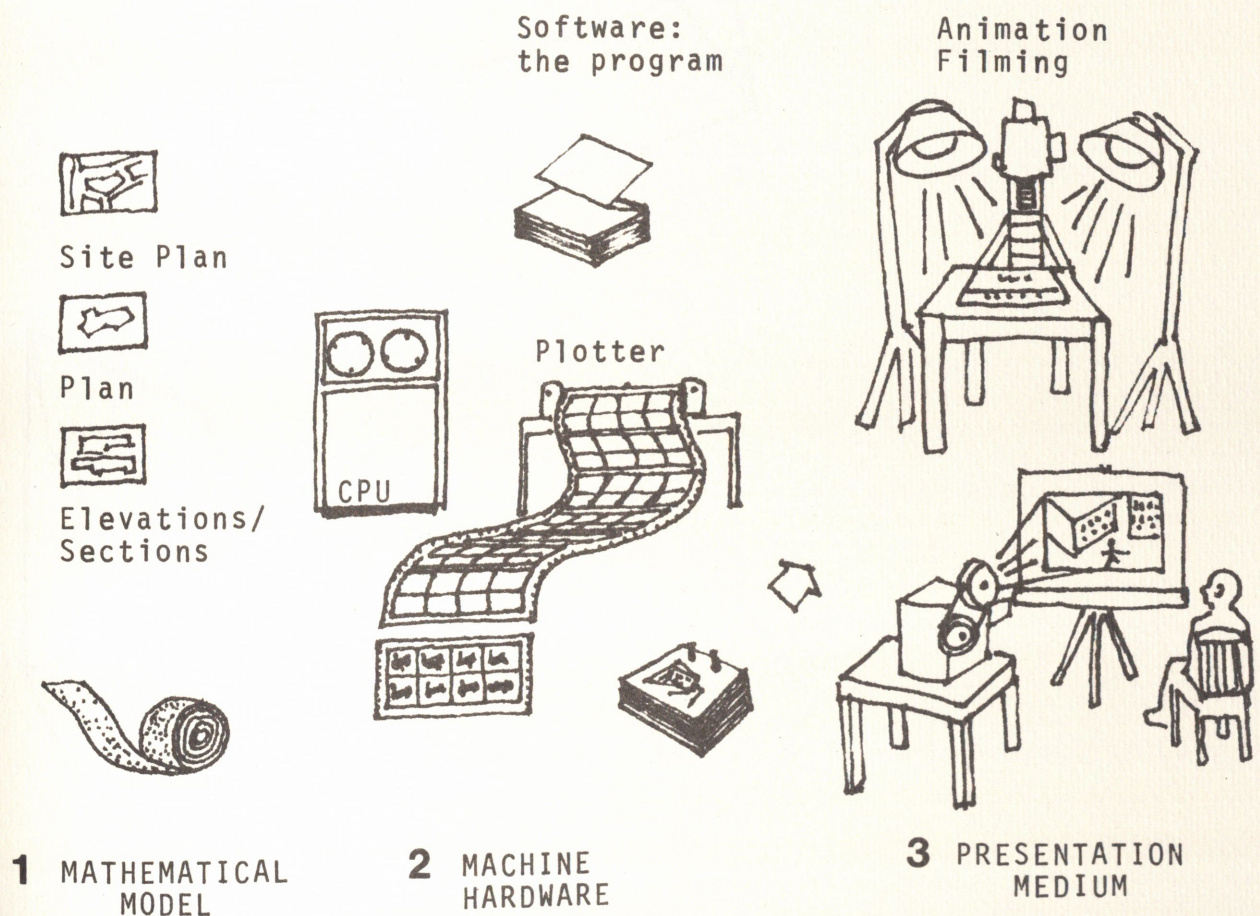
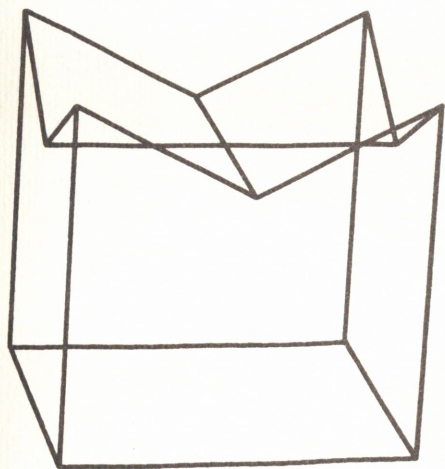
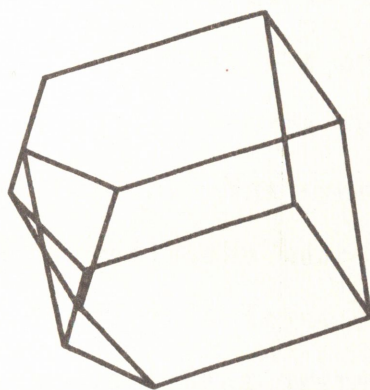


Figure 8 . Sequence of Computer Animation

project



The emphasis of my thesis inquiry has been first; to investigate the role of the computer in design, from which a determination was made regarding what aspect, in particular, to pursue. And second; to explore the use of the computer in the design of a building.

The project I have chosen to design is a Senior Citizens' Center and Housing Complex in Rock Springs, Wyoming. As can be seen on the Regional map on the following page (Fig. 9), Rock Springs is located in Southwestern Wyoming: a largely semi-arid region. The average yearly precipitation is only 3.22", while the mean annual temperature is a low 37.6°. (City of Rock Springs, 1974). Strong design considerations are a consistent westerly wind, and the very apparent lack of water and vegetation.

The route chosen for the Union Pacific Railroad in the 1860's and the presence of nearby coal deposits, were, together, responsible for the location of Rock Springs. Rock Springs is a rapidly-growing community of approximately 27,000 and will continue to grow due to the vast mineral wealth of the surrounding area. (City of Rock Springs, 1974).

My exploration of Rock Springs produced several potential sites which, their respective amenities aside, were representative of current development alternatives in the town. They were: an outlying site where the new develop-

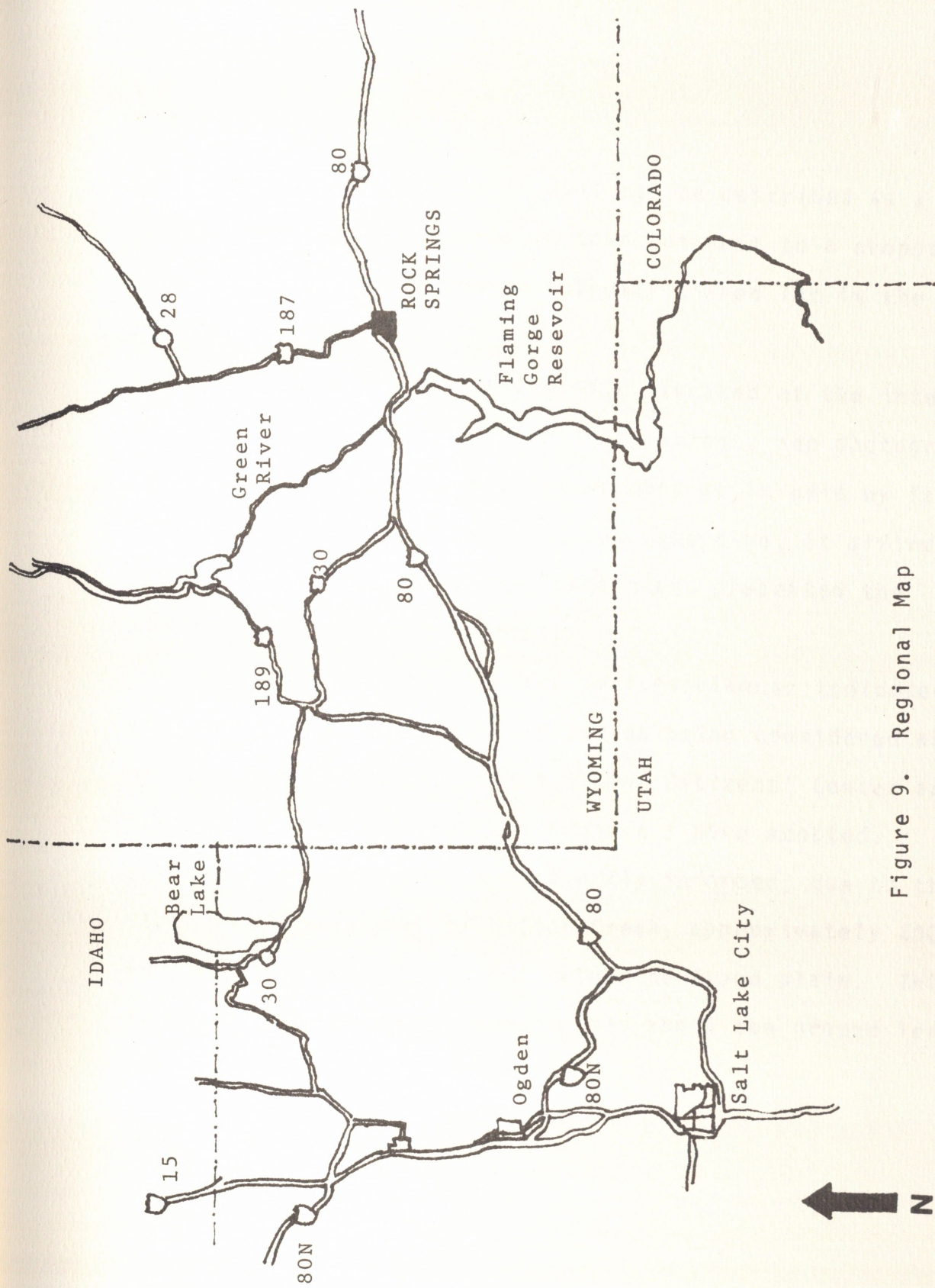
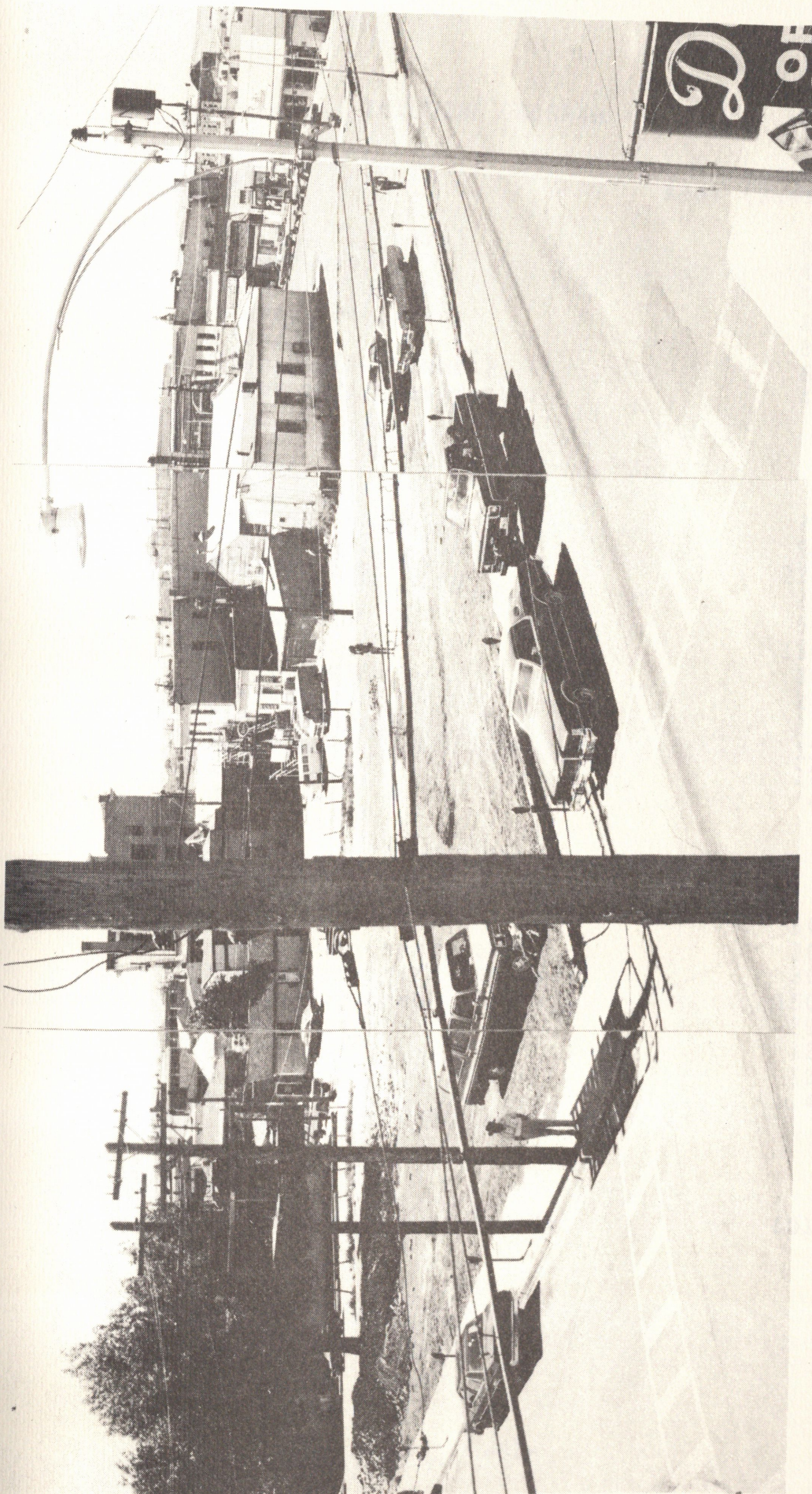


Figure 9. Regional Map

ment is occurring; a site in what can be described as a transitional zone - closer to town but next to a shopping center; and an empty, quite uniquely shaped lot in the downtown area.

My choice of the in-town site (located at the intersection of Pilot Butte Avenue and K Street, see photograph on page following...), was rather easy as it held by far the most aesthetic appeal. At the same time, it affirmed a preference for infill development and presented the challenge of an urban context.

Discussions with the Rock Springs Planner indicated that the Pilot Butte avenue site was being considered as an appropriate location for a Senior Citizens' Center and Housing for the elderly, the project I have adopted. Unfortunately, as I was subsequently informed; due to the flash flood potential of Bitter Creek, approximately 2000' to the west, the site is 12' below the flood plain. This is why the building has been raised above the ground level parking area.



BUILDING SITE.

BUILDING PROGRAM

Ground Floor

Area (Square Meters)

Parking (10 cars)	82.20
Greenhouse	42.24
Main entry/lobby	56.18
Storage/receiving	21.84
Laundry	88.96
Storage (residents)	60.00
Lobby area (residents)	44.80

Second Floor

Kitchen	72.24
Dining	80.72
Multipurpose	225.00
Coatroom	10.12
Administration	54.60
Main lounge	150.00
South lounge	88.00
Terrace	27.00
Storage	21.16
Mensroom	12.88
Womensroom	12.88
Janitor	4.68

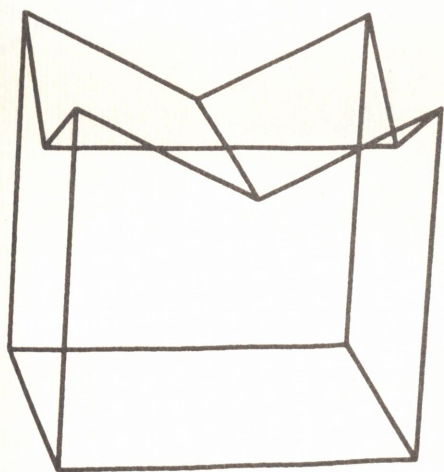
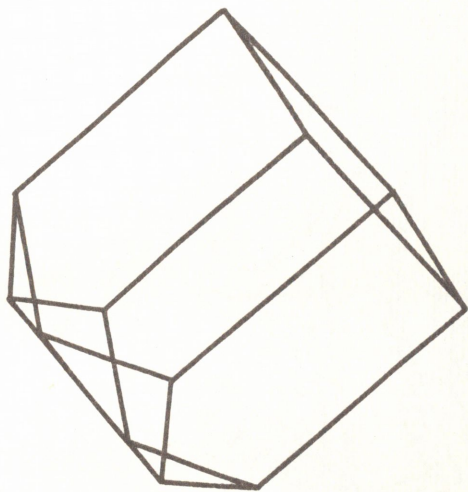
Third Floor

Card room	54.60
Meeting or craft room 1	36.00
Meeting or craft room 2	36.00
Recreation area	150.00
Mechanical	29.92
Mensroom	12.88
Womensroom	12.88
Janitor	4.68

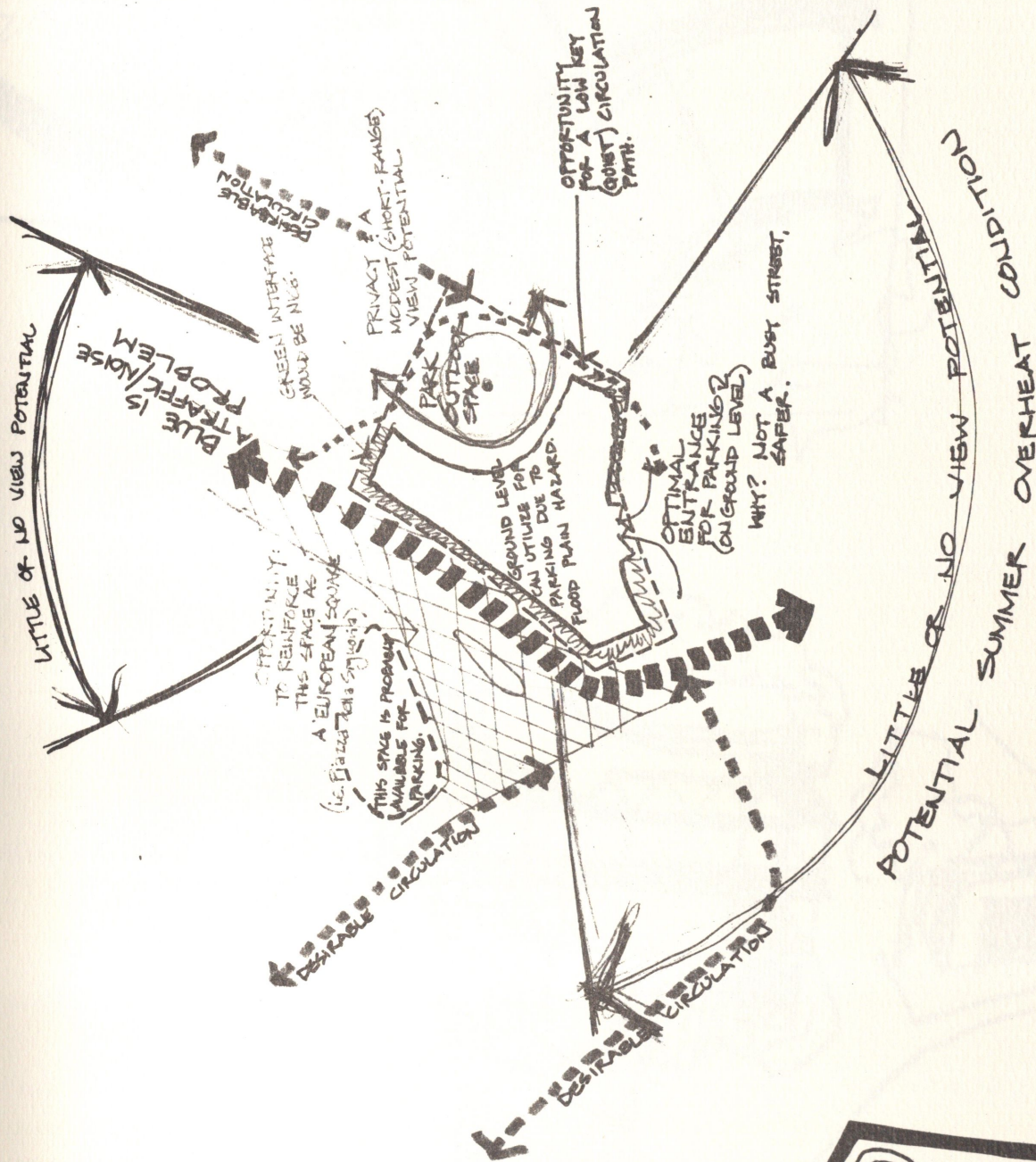
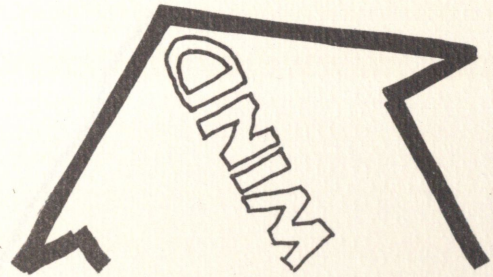
Housing

10 Units at 60.16m ² /unit	601.60
---------------------------------------	--------

documentation of design



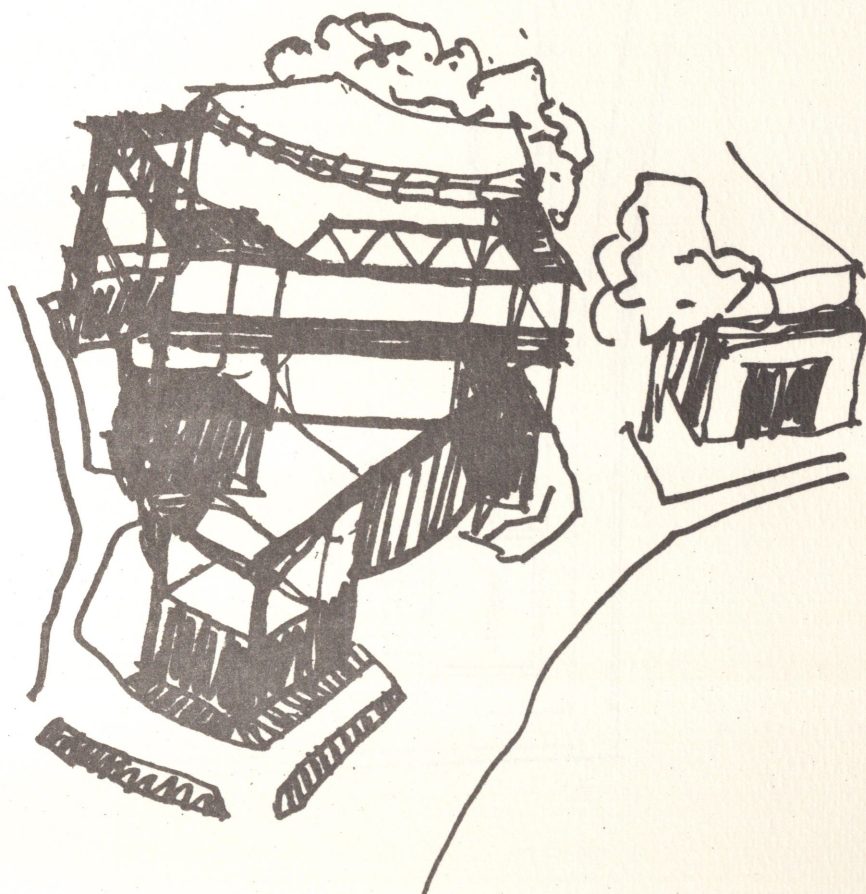
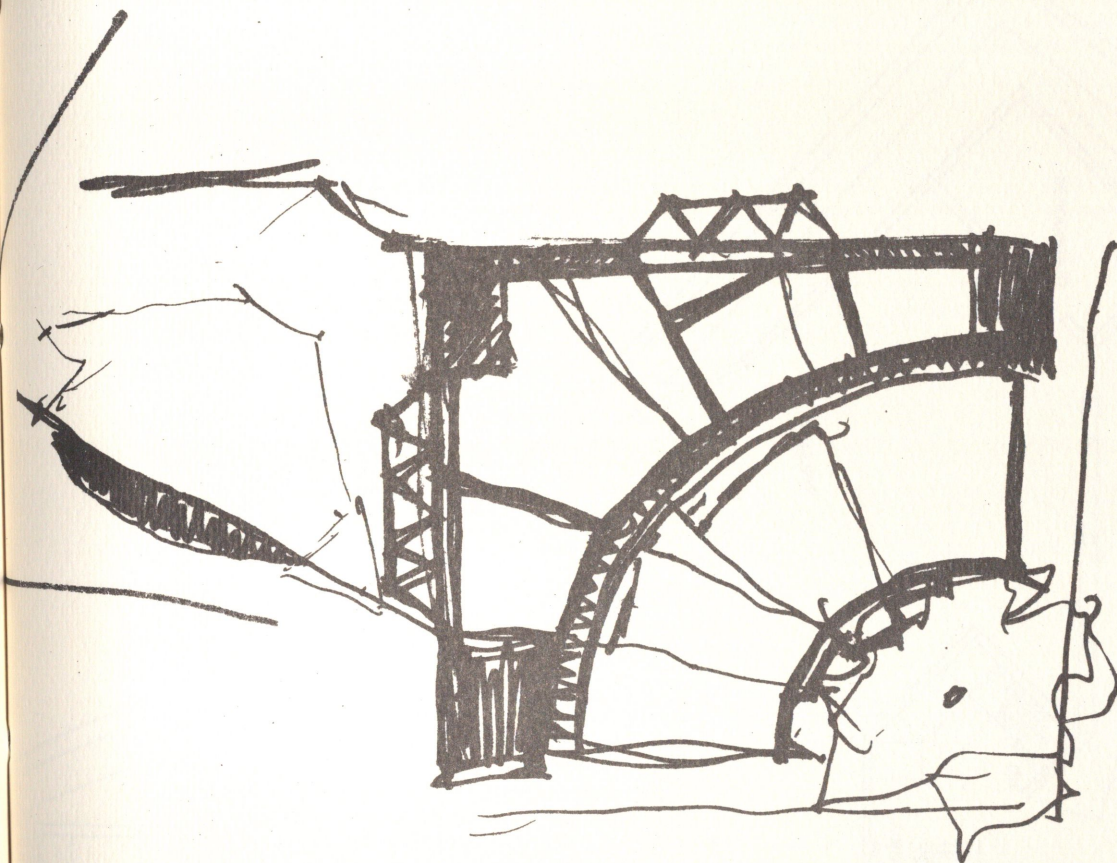
PARK

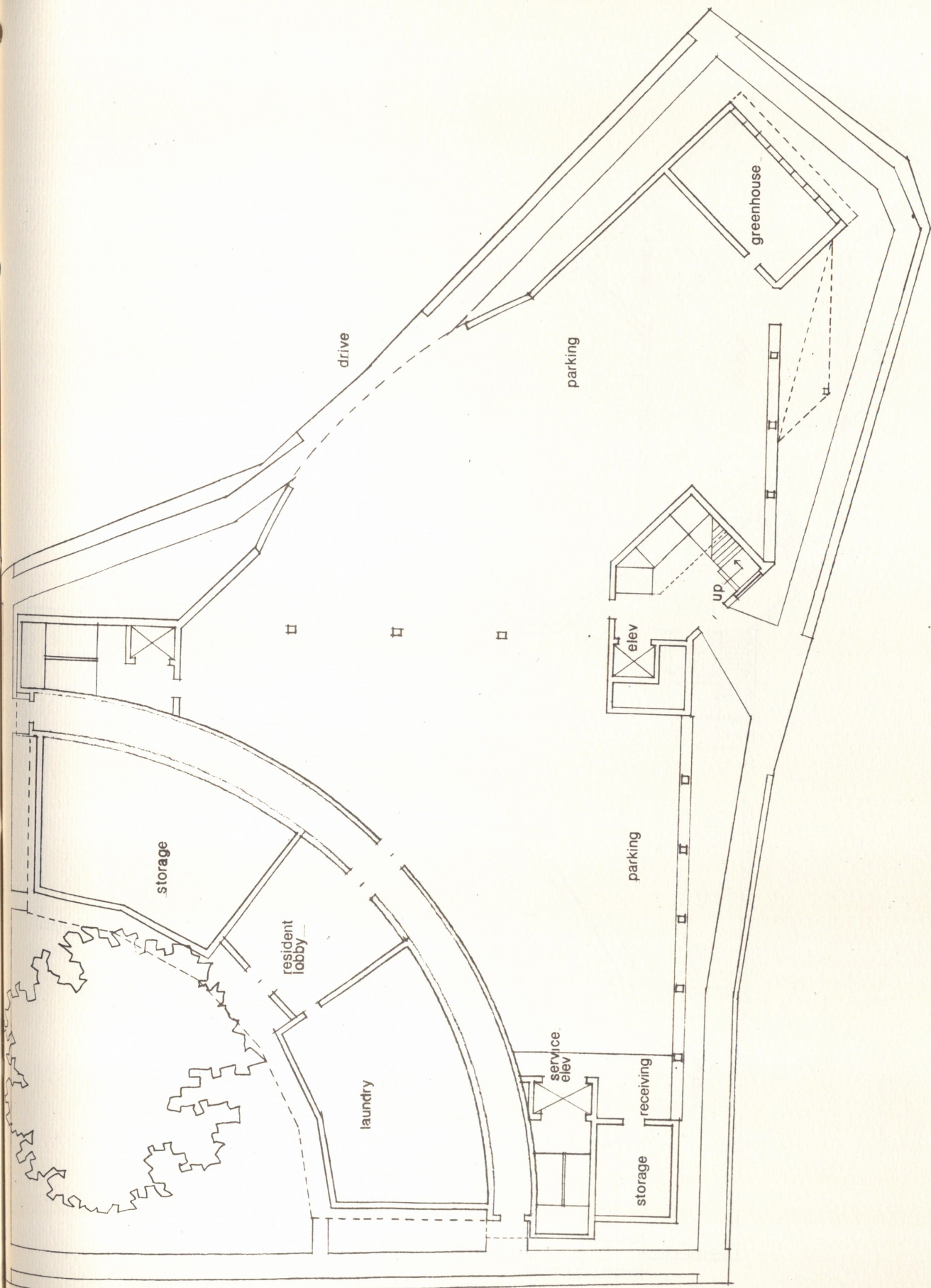


SITE:
THE SITE ITSELF PRESENTS
A UNIQUE OPPORTUNITY
REINFORCING ITS INTERESTING
CONFIGURATION.

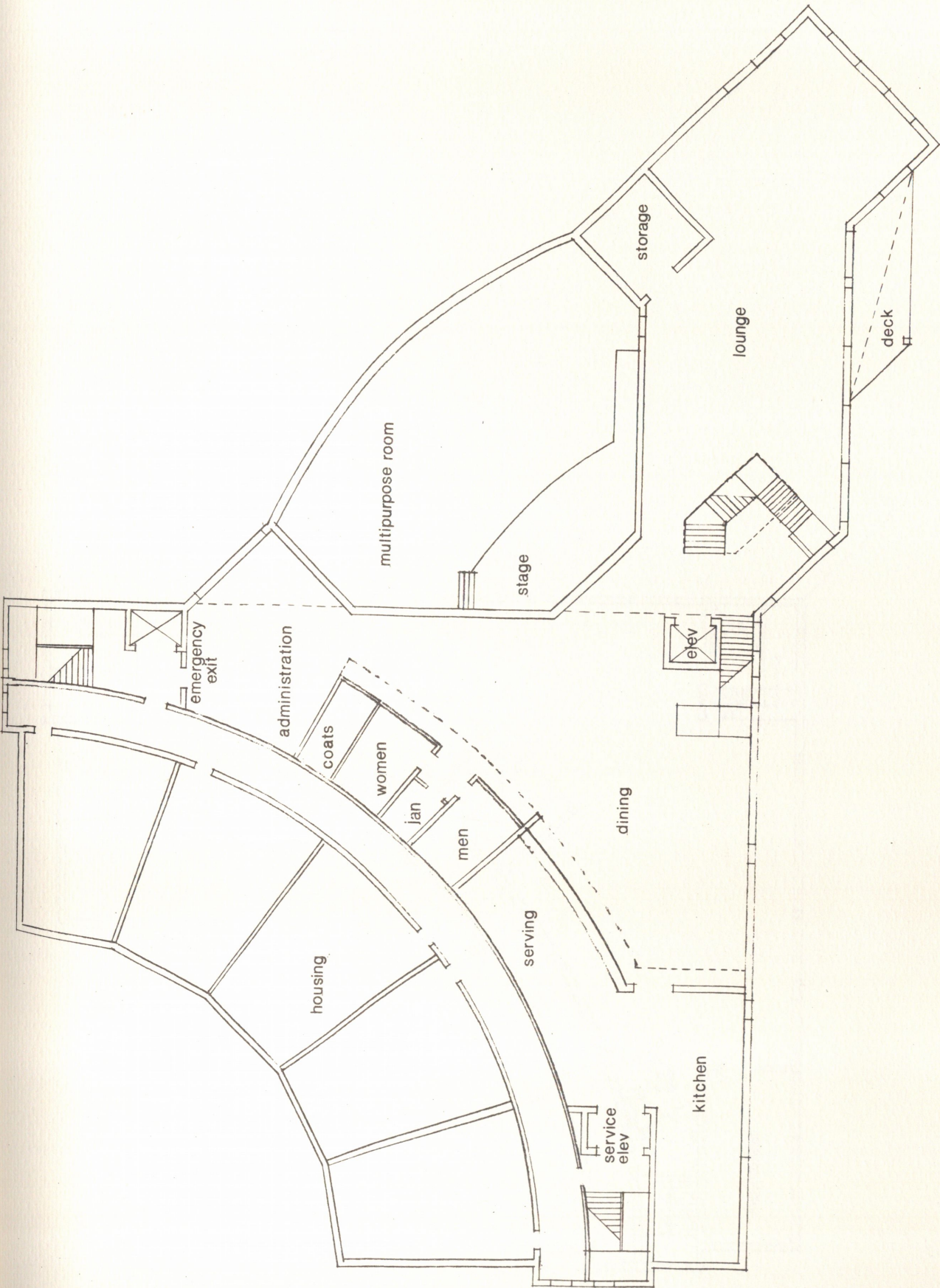
29,580 ± .656 ACRES

SITE: PROBLEM OPPORTUNITIES

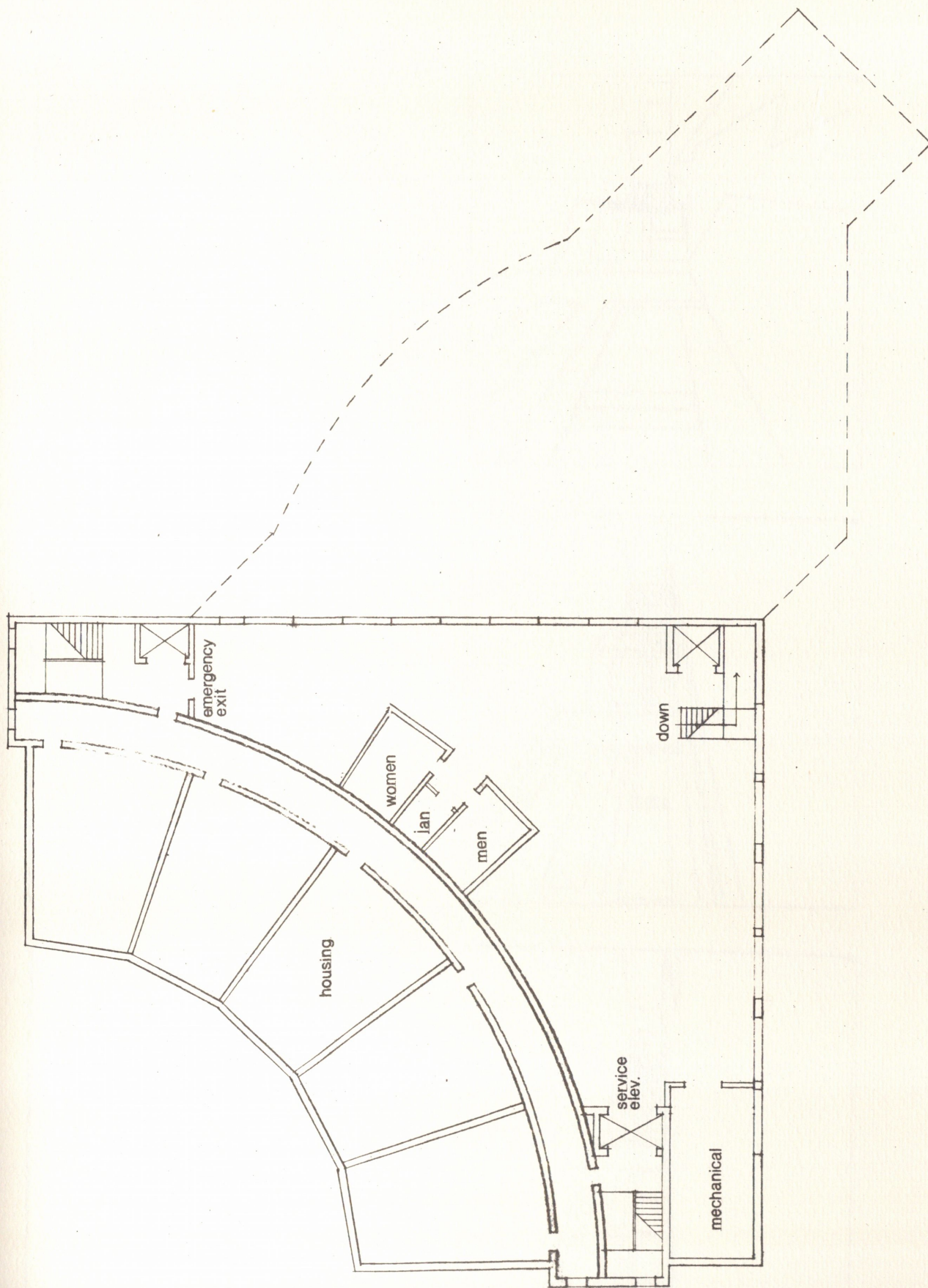




GROUND
1-200 m.

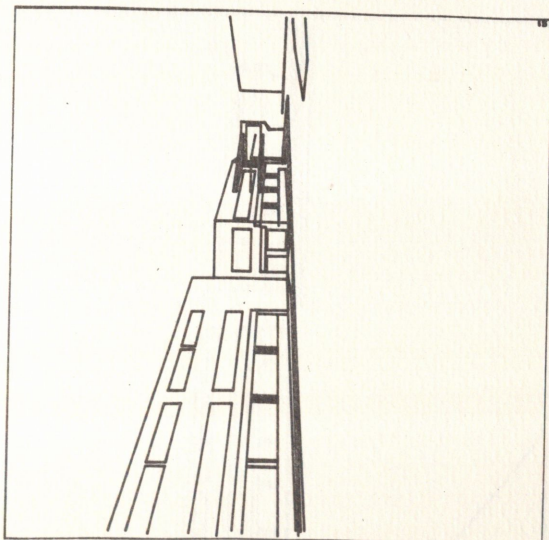
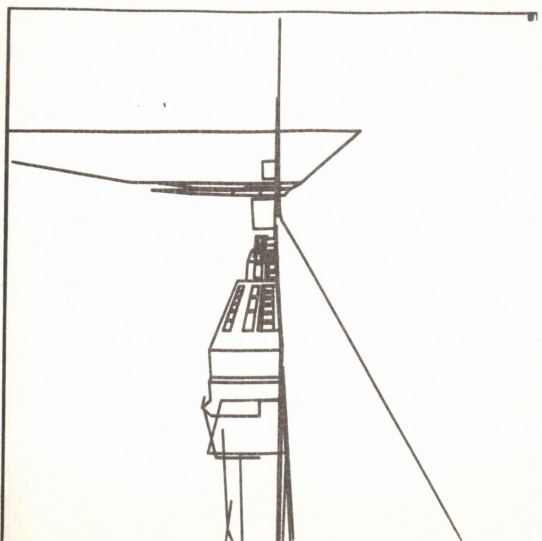
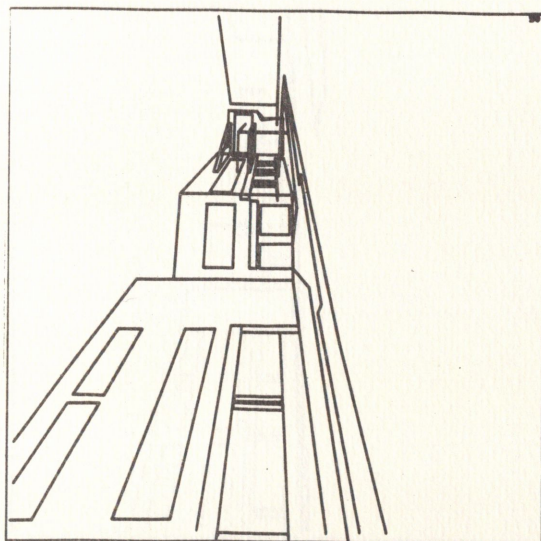
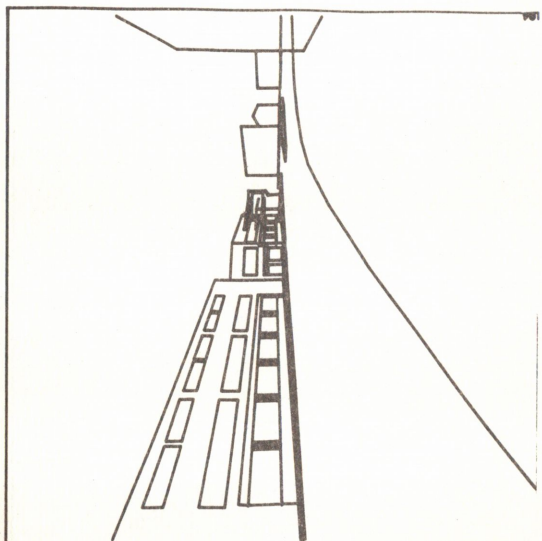
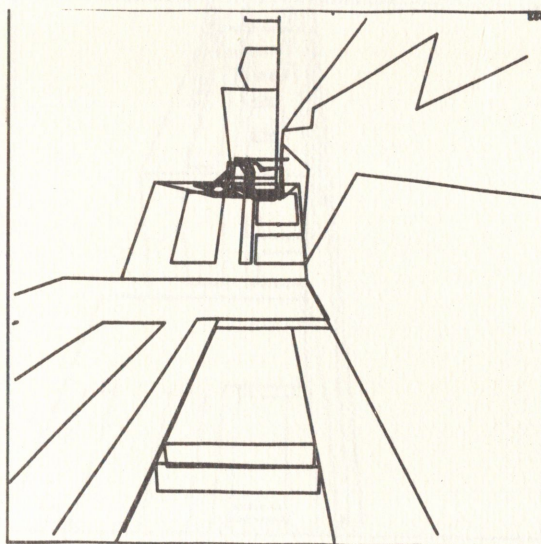
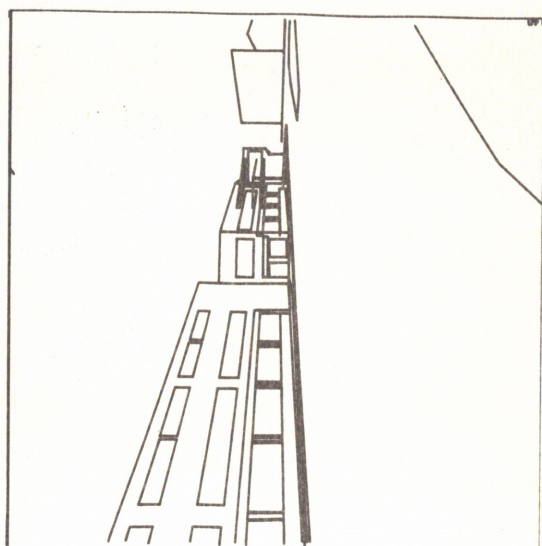


2ND
1-200 m.

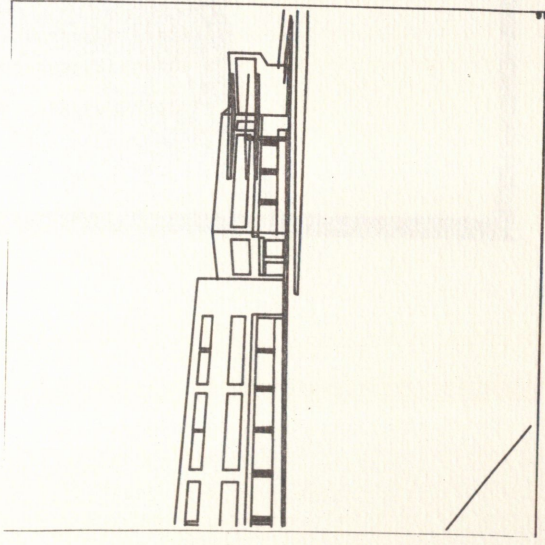
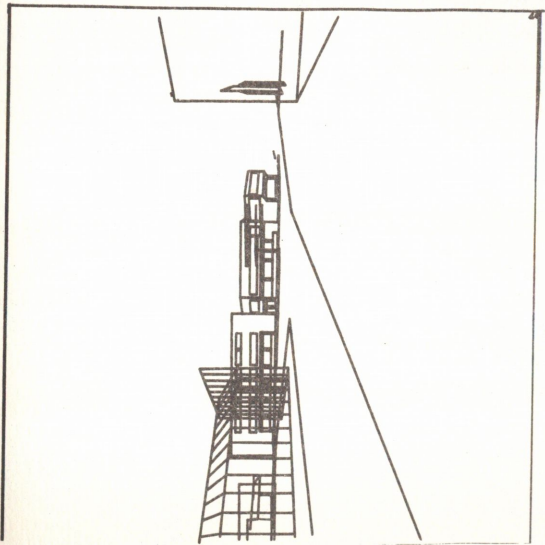
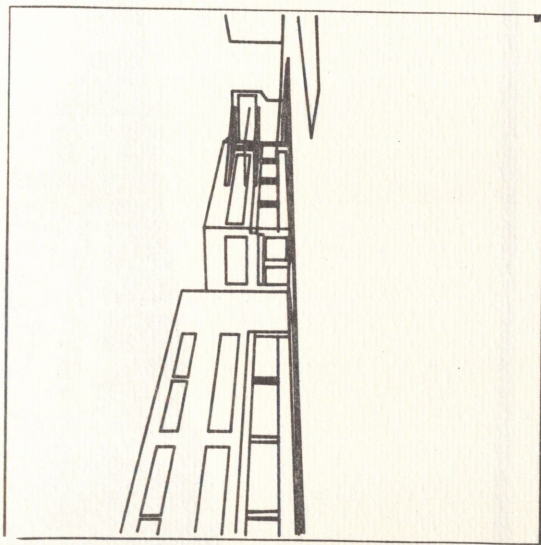
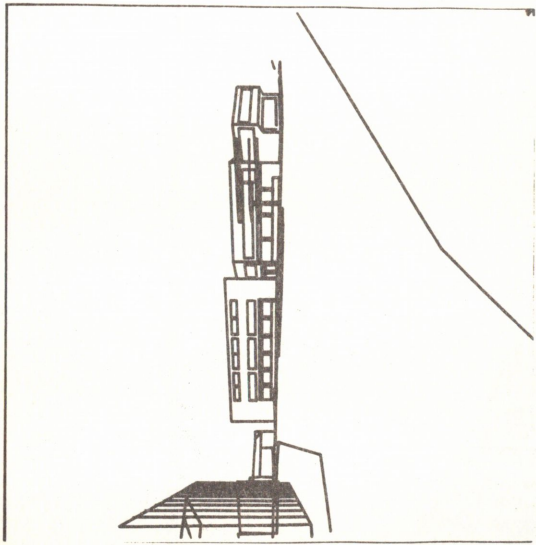
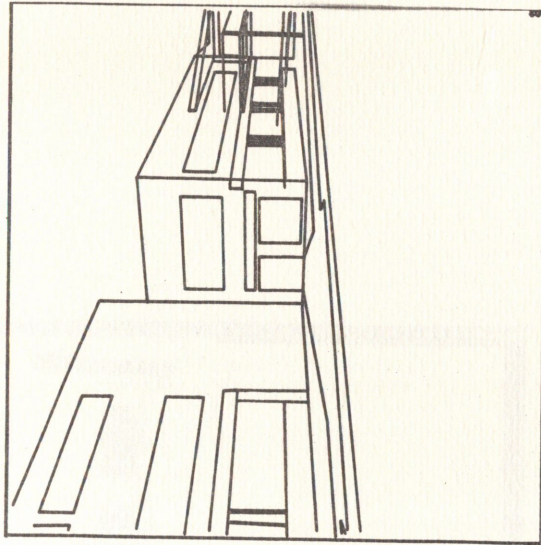
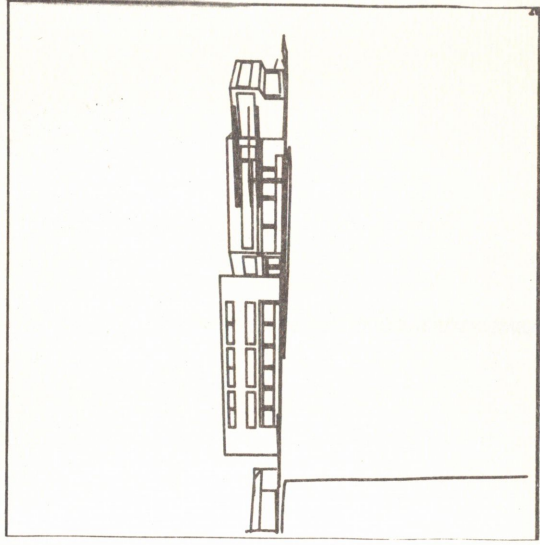


3RD
1-200 m.

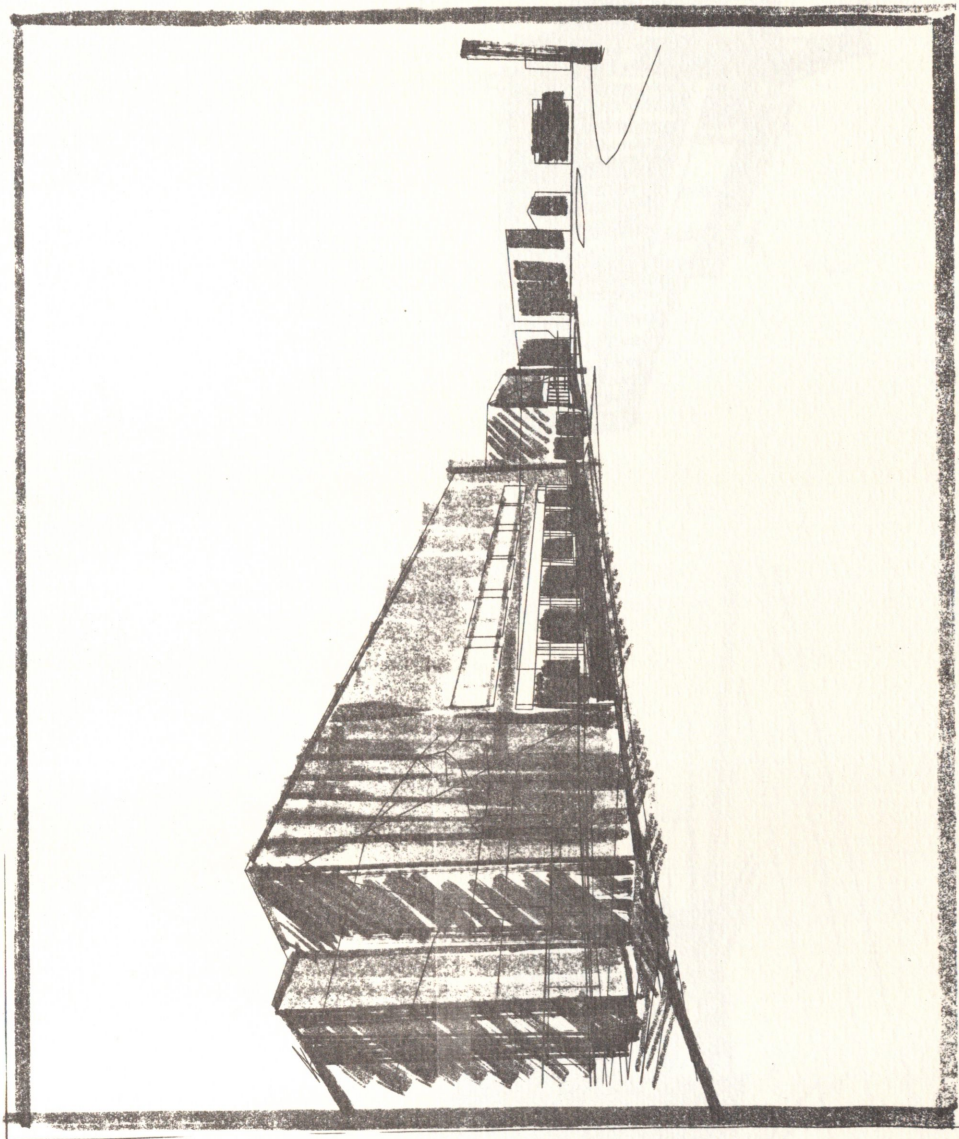
SEQUENCE

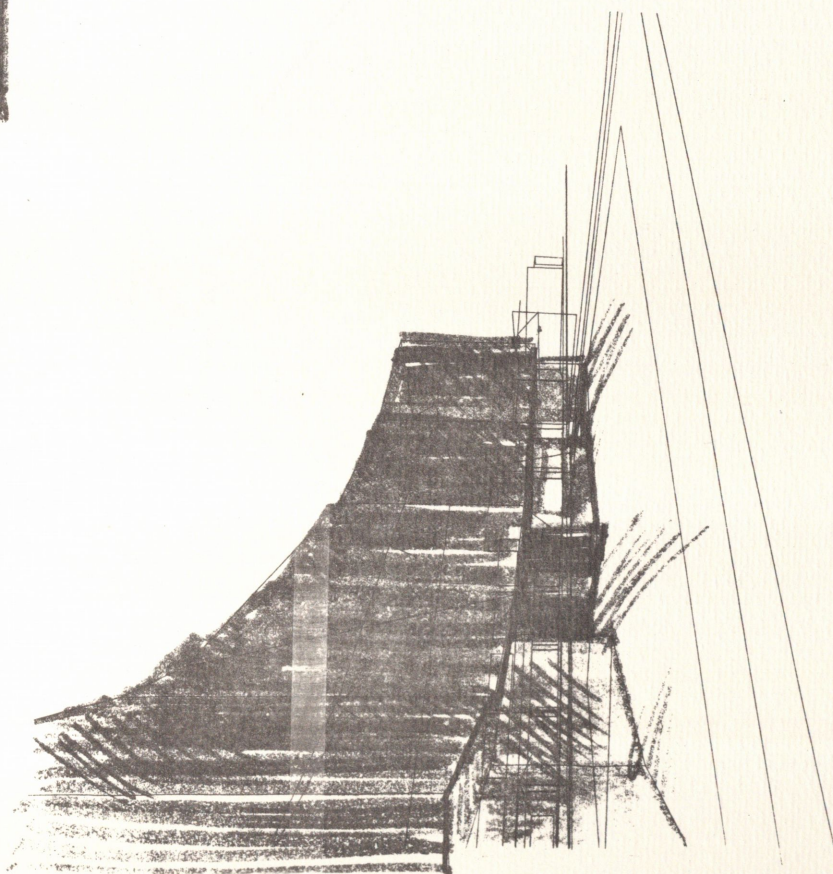
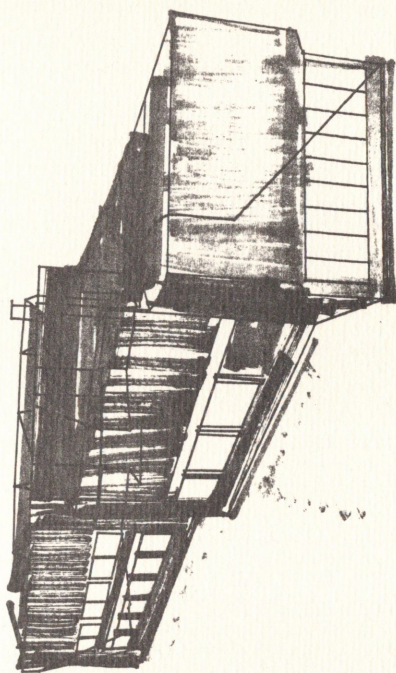
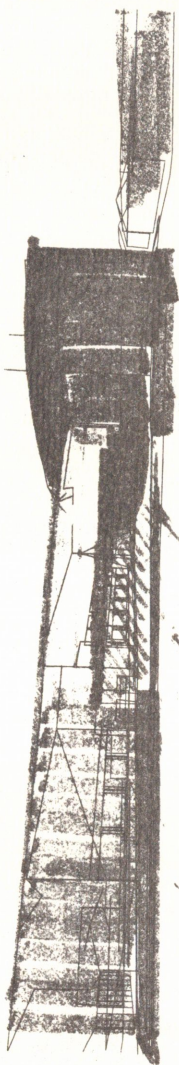


SEQUENCE 1

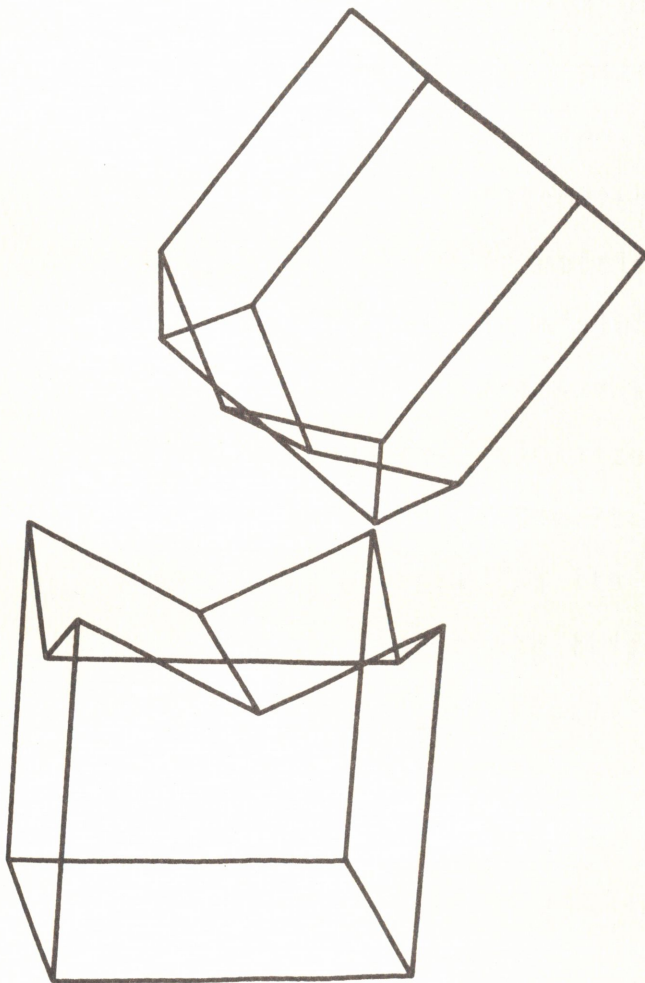


SEQUENCE 2





conclusion



I have encountered several problems in the course of dealing with the computer that I would like to elucidate for the benefit of those who might wish to pursue this study. The single most significant problem not only in computer drawn perspectives, but in computer aided design in general, is the input of the mathematical description of the building. The digitizing/editing process can be long and painstaking and can potentially be a limiting force on the level of graphic detail



attempted. My building was designed in metric, which is almost a necessity in digitizing. In addition, larger scale drawings are easier to work with and more accurately digitized.

The Engineering Department is in the process of significantly upgrading its digitizing capabilities which will greatly accelerate this procedure. What is required are; one, convenient access to a CRT on which one can see an immediate display of the data file, and two, fast input and reliable storage and retrieve of data. (i.e. magnetic tape or equivalent). I had the benefit of neither.

The second most significant problem I faced was the lack of a "hidden line algorithm". This is a program

which removes lines which would be obscured by planes in front of them. Hidden line removal is a very complex programming problem if one recalls the fact that the computer does not 'see' but rather detects all visual elements mathematically and thus must calculate whether one plane is physically obscuring another (Campion, 8, p. 183). The result of this handicap was a great deal more time spent editing data to optimize graphic clarity as much as possible.

The third, and by no means least, problem has been one of mechanical breakdown of the MSU drum plotter, followed by an erratic performance of the Calcomp plotter I'm currently using. The transfer from the MSU SIGMA 7 to the Ray Laboratories PRIME system had an enormous compensation though, in that once the program was transferred, it was relatively easy to make it intercompatible with the CRT. I cannot overstress the need for rapid interactive visual response in any phase of computer aided design.

Excessive plotter time and expense, can be a severe detriment to computer animation of hardcopy drawings. My film for example, will run between 2 and 3 minutes requiring approximately 1,000 plotter images. The animation has been filmed at two frames per image to

achieve smooth movement of the viewer. The increment between viewpoints varies from $2\frac{1}{2}$ to 1 foot, the greater interstice used when farther away from the building. Techniques for filming directly from the face of a CRT are more economically feasible in the long run, I feel, for computer animation (provided the necessary hardware is available).

Several worthwhile criteria for evaluating a manual versus computer-aided design technique mentioned by Eastman (10, p.7) are; cost, quality of solution, time required and breadth of application. In the outline below, I've responded to the criteria with computer-aided design in general, in mind.

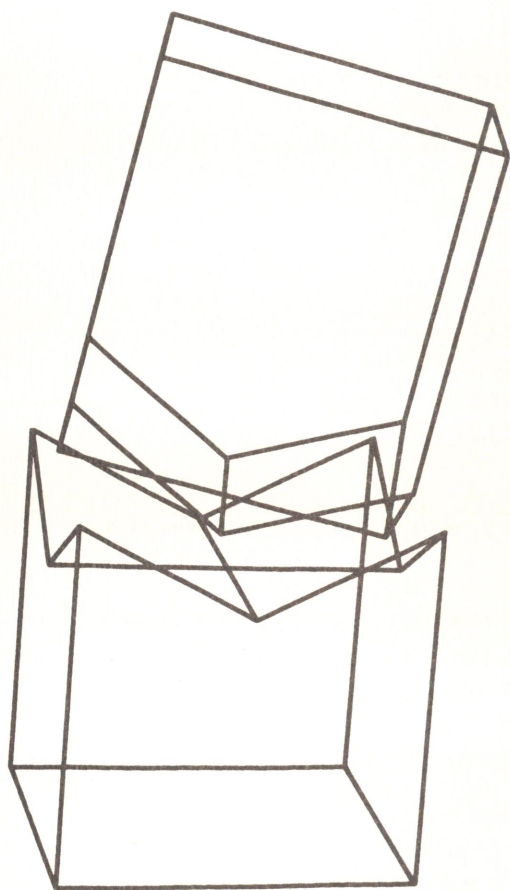
- Cost
 - Hardware - affordable, generally decreasing.
 - Software - generally rising, professional labor required.
- Time
 - can significantly decrease time required for many tasks.
- Breadth of Application
 - possibly limited in small projects, others unlimited.

The quality of a solution is perhaps the most important criteria since its impact is manifested in all of the above. Evaluating the quality of design solution

made possible by computer generated perspectives; I definitely feel that the perceptive capability of my program afforded the potential of a more realistically designed and graphically communicated project. From the early site perspectives I received, I was able to get an overall impression of the space created by the surrounding buildings. Plotter breakdown prevented output of initial massing studies, but some design alterations were made from later perspectives of the building which provided accurate views and overall clarity only remotely possible by manual perspective.

The time required for the development of DESIGNTech has prevented its animation aspect to be used by me in design development. However, with the tool developed, I think it can be seen from the movie that design alternatives can be studied in animation from which design modifications could be made.

glossary



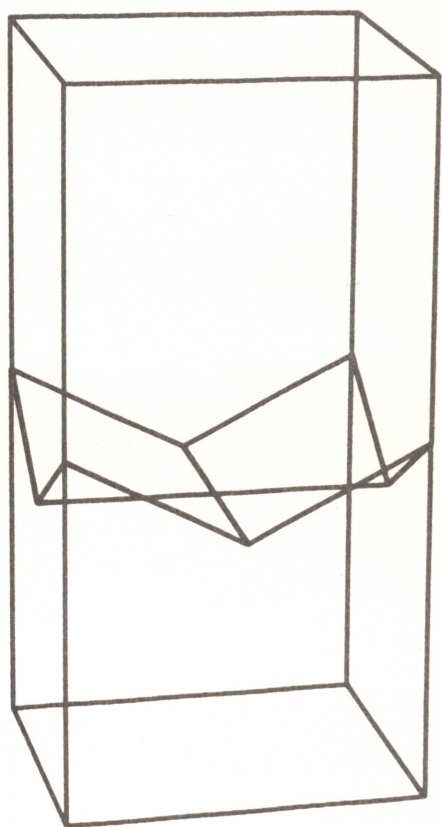
- Algorithm - A process or procedure (used in a computer program) for the solution of a problem, which can be guaranteed to terminate (reach a solution).
- Computer, Digital - Solves problems by operating on discrete data representing variables, by performing arithmetic and logical processes on these data.
- CPU - Central Processing Unit. The heart of the computer. Contains the main storage, arithmetic unit and special register groups. (See Figure 2 , p. 8).
- CRT - Cathode Ray Tube. An input/output device which is capable of graphic display of pictures or alpha-numeric characters on a T.V.-like screen. Input is achieved via keyboard. (See Figure 2 , p.8).
- Digitize - To convert the measurement of a physical variable (i.e. a point representing the corner of a building), into a numerical value, thereby expressing the quantity in digital form.
- Hardware - The computer and it's related equipment.
- Heuristic - Pertaining to exploratory methods of problem solving in which solutions are discovered by evaluation of the progress made toward final result. Self-discovery, intelligently guided guesswork.
- Input Units - Electronic machines that feed or introduce data to the CPU. Examples; digitizer, paper tape reader, card reader, magnetic tape reader, console keyboard, CRT. (See Figure 2 , p.8).

- Interactive - A general category of computer program-
Computer ing which communicates to the user
Graphics through graphic images. Allows the user
to interact with the computer by selecting
different program options or modifying
the data base.
- Output - Electronic machines that print or display
Units data which has been processed by the
program. Examples; high speed line print-
ers, dot printers, plotters, punching
machine for cards or tapes, CRT's and
others. (See Figure 2 , p. 8).
- Peripherals - Input/Output units augmenting the CPU.
- Plotter - A hard copy output device which draws on
paper by responding to X and Y coordin-
ates given to it by the computer. (See
Figure 2 , p. 8).
- Procedure - A chain of computational events sometimes
consisting of a single strand, but more
often branching into several or many
strands.
- Program - A plan for solving a problem. A series of
instructions or commands written by the
programmer, read by the computer, and
stored in memory. Based on these input
instructions, the computer performs some
operation(s) on the data provided to it by
the user.
- Software - The totality of programs and routines used
to extend the capabilities of computers.
- Subroutine - A procedure or an algorithm which is part
of a larger program.

Symbiosis - The usually advantageous or necessary
living together of two species of organisms.

Glossary Sources: (Stewart, Teicholz and Lee, 28)
(Newman and Sproull, 24)
The American College Dictionary,
Random House, 1947.

bibliography



1. Arnheim, Rudolf. The Dynamics of Architectural Form. University of California Press, 1977.
2. Atkin, William Wilson. Architectural Presentation Techniques. New York: Van Nostrand Reinhold Co., 1976.
3. Bacon, Edmund N. Design of Cities. New York: The Viking Press, 1967.
4. Bazjanac, V. "Computer Simulation in Architectural and Urban Design: A Realistic Assessment", in Kennedy, Michael. Proceedings, pp. 50-54.
5. Bechtel, Robert B. "Human Movement and Preference", Architect-Researcher's Conference 1966. New York: AIA, 1967.
6. Bonsteel, David L. and Donnette, James. The Suzzallo Quad: A Computed Graphics Simulation of Sequential Experience. Seattle: University of Washington, 1969.
7. Broadbent, Geoffrey. Design in Architecture. London: John Wiley & Sons, 1973.
8. Campion, David. Computers in Architectural Design. London: Elsevier Publishing Company, 1968.
9. Conner, Mitchel, S. "RSVP Cycles". Architecture Thesis, Montana State University, 1976.
- ✓10. Eastman, Charles M. Spatial Synthesis in Computer-Aided Building Design. New York: John Wiley & Sons, 1975.
- ✓11. Eastman, Charles M. "The Use of Computers Instead of Drawings in Building Design", AIA Journal, March 1975, pp. 46-50.

12. Grason, John. "Methods for the Computer-Implemented Solution of a Class of 'Floor Plan' Design Problems", unpublished doctoral dissertation. Pittsburgh, Penn.: Carnegie Mellon University, Department of Electrical Engineering, 1969.
13. Halas, John and Manvell, Roger. Design in Motion. England: William Clowes & Sons Ltd., 1962.
14. Hall, Edward, T. "Art, Space and the Human Experience. in Kepes, Gyorgy. Arts of the Environment. New York: George Braziller, 1970, pp. 52-59.
15. Hendren, Philip A. A System for Dynamic Simulation. Oklahoma State University, 1967.
- ✓16. Kennedy, Michael, Compiler. Proceedings of the Kentucky Workshop on Computer Applications to Environmental Design. University of Kentucky, 1972.
17. Lee, Kaiman. Computer Programs in Environmental Design. Boston: Environmental Design & Research Center, 1974.
18. Milne, Murray, Ed. Computer Graphics in Architecture and Design. New Haven: Yale School of Art and Architecture, 1969.
19. Mitchell, William J. Computer-Aided Architectural Design. New York: Petrocelli/Charter, 1977.
20. Mitchell, William J., Editor. Environmental Design: Research and Practice. EDRA Proceedings, 3/ar 8 Conference. UCLA. January 1972, Regents of the University of California.
- ✓21. Negroponte, Nicholas, Ed. Computer Aids to Design and Architecture. New York: Petrocelli/Charter, 1975.

- ✓22. Negroponte, Nicholas. Soft Architecture Machines.
Cambridge: The MIT Press, 1975.
23. Newman, William, M. "Graphic Systems for Computer-Aided Design", in Mitchell, W.J., Environmental Design, pp. 22-6-1.
24. Newman, William M. and Sproull, Robert F. Principles of Interactive Computer Graphics. New York: McGraw-Hill Book Co., 1973.
25. Sides, David. "Notes on Computers and Architecture", in Negroponte, Computer Aids to Design and Architecture, pp. 124-130.
26. Rock Springs, City of. Department of Engineering, Planning and Community Development. Economic & Population Forecasts 1974-1995. July 1974.
27. Stewart, Clifford, and Lee, Kaiman. "Comprospace: Interactive Computer Graphics in the Real World", in Mitchell, W. J., Environmental Design, p.22-9-1.
28. Stewart, Clifford Douglas: Teicholz, Eric: Lee, Kaiman: Editors. Computer Architecture Programs. Boston: Center for Environmental Research. 1970.
29. Thiel, Philip. "An Experiment in Space Notation", The Architecture Review, May, 1962, pp. 326-329.
30. Thiel, Philip. "A Sequence-Experience Notation", The Town Planning Review, April, 1961, pp. 33-52.
31. Thiel, Philip. "Processional Architecture". AIA Journal, February 1964, pp. 23-28.
- ✓32. Weinzapfel, Guy. "Following the Yellow Brick Road". in Negroponte, N., Computer Aids to Design and Architecture. pp. 91-102.

TOPICAL BIBLIOGRAPHY

COMPUTER REFERENCES

22. Atkin, William Wilson. Architectural Presentation Techniques.
7. Broadbent, Geoffrey. Design in Architecture.
8. Campion, David. Computers in Architectural Design.
10. Eastman, Charles M. Spatial Synthesis in Computer-Aided Building Design.
- ✓11. Eastman, Charles M. "The Use of Computers Instead of Drawings in Building Design", AIA Journal.
12. Grason, John. "Methods for the Computer-Implemented Solution of a Class of 'Floor Plan' Design Problems", unpublished doctoral dissertation, Carnegie Mellon Univ., Pittsburgh, Penn.
16. Kennedy, Michael, Compiler. Proceedings of the Kentucky Workshop on Computer Applications to Environmental Design. University of Kentucky, 1972.
17. Lee, Kaiman. Computer Programs in Environmental Design.
18. Milne, Murray, Ed. Computer Graphics in Architecture and Design.
19. Mitchell, William J. Computer-Aided Architectural Design.
20. Mitchell, William J., Editor. Environmental Design: Research and Practice.
21. Negroponte, Nicholas, Ed. Computer Aids to Design and Architecture.
22. Negroponte, Nicholas. Soft Architecture Machines.
23. Newman, William, M. "Graphic Systems for Computer-Aided Design", Environmental Design.
24. Newman, William M., and Sproull, Robert F. Principles of Interactive Computer Graphics.

25. Sides, David. "Notes on Computers and Architecture".
Computer Aids to Design and Architecture.
27. Stewart, Clifford D., and Lee, Kaiman. "Comprospace:
Interactive Computer Graphics in the Real World",
Environmental Design.
28. Stewart, Clifford Douglas; Teicholz, Eric; Lee,
Kaiman: Editors, Computer Architecture Programs.
32. Weinzapfel, Guy. "Following the Yellow Brick Road".
Computer Aids to Design and Architecture.

COMPUTER ANIMATION

4. Bazjanac, V. "Computer Simulation in Architectural
and Urban Design: A Realistic Assessment".
Proceedings.
6. Bonsteel, David L. and Donnette, James. The
Suzzallo Quad: A Computed Graphics Simulation
of Sequential Experience.
15. Hendren, Philip A. A System for Dynamic Simulation.
16. Kennedy, Michael, Compiler. Proceedings of the
Kentucky Workshop on Computer Applications to
Environmental Design.

MOVEMENT IN DESIGN

1. Arnheim, Rudolf. The Dynamics of Architectural Form.
3. Bacon, Edmund N. Design of Cities.
5. Bechtel, Robert B. "Human Movement and Preference",
Architect-Researcher's Conference 1966.
9. Conner, Mitchell, S. "RSVP Cycles". Architecture
Thesis, Montana State University.
29. Thiel, Philip. "An Experiment in Space Notation".
The Architecture Review.

30. Thiel, Philip. "A Sequence-Experience Notation".
The Town Planning Review.
31. Thiel, Philip. "Processional Architecture".
AIA Journal.

GENERAL REFERENCE

26. Rock Springs, City of. Economic & Population
Forecasts 1974-1995.

Appendix 1

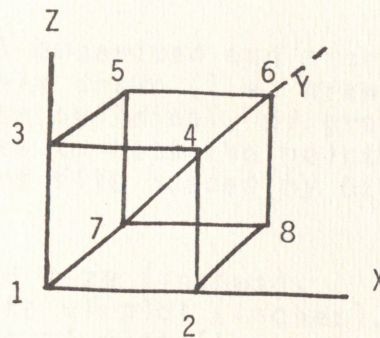
DESIGNTECH User Package

DESIGNTECH is an interactive computer graphics program capable of drawing three point perspectives of an object from any viewpoint, in any direction.

The points to which the computer will draw or move (without drawing) are three dimensional coordinates, X, Y, Z. The process of digitizing, (describing points in space as X, Y, Z coordinates), can be accomplished manually as seen in the drawing at right. The X and Y axes are the ground plane or the plane of a plan drawing. The Z axis is the vertical dimension.

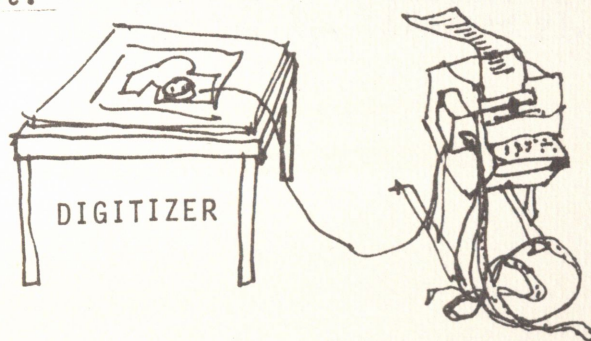
A cube is represented by 8 points.
The coordinates for these 8 points are:

#	X	Y	Z
1	0	0	0
2	4	0	0
3	0	0	4
4	4	0	4
5	0	4	4
6	4	4	4
7	0	4	0
8	4	4	0



Point File

Simple shapes can be digitized by manually locating the coordinates from a sketch as shown here. A similar technique can be used on a floor plan drawing by overlaying the drawing with an X, Y coordinate grid from which the X and Y points can be located and interpolated if necessary. Presumably the heights of various elements are known or can be obtained from an elevation-type drawing to use as the Z coordinates. More complex drawings can be digitized on a digitizer which automatically inputs the points to a computer as seen here. Instructions on how to use the digitizer can be obtained in the Engineering Department.



The computer uses files to store the data necessary for the program to operate on. The first file is the point file, which lists the X, Y, Z coordinates for the points which are numbered. In the example shown, the computer will associate point 1 with the coordinate 0,0,0. A second file lists the draw sequence you would like the computer to follow. A draw sequence for the cube is shown here. The computer will instruct the plotter or scope to draw starting at point 1 to point 2 and so on. The zeros in the sequence cause the plotter to move without drawing to the next point.

```
1,2,8,7,1,3
5,7,0,8,6,5
0,6,4,3,0,4
2
```

DRAW SEQUENCE

Data files should be well organized and stored in modules which can be selectively drawn (i.e. draw only the north and east sides of the building), or grouped with other files. This applies to both the point and the draw sequence files. The third file needed by DESIGNTech contains:

Record 1: A - total field size (inches),
 B - total length of plot (inches),
 C - total width of plot (inches),
 D - 'lines', (lines = 1 means outline plots).

Example: A,B,C,1 (all $\leq$ 25" on MSU plotter).

Record 2: X,Y,Z location you want to look 'to'.

Record 3: X,Y,Z location you want to look 'from'.

A repetition of 2 and 3 is allowed for more views. For each view there must be a pair of X,Y,Z points. The animation views were accomplished using a short FORTRAN program to increment and read in successive views from a point X_1, Y_1, Z_1 to X_2, Y_2, Z_2 . (Record 2).

MONTANA STATE UNIVERSITY LIBRARIES
stks 720.6.M76Sm54 CA
Designtech /



3 1762 00158772 2

1111

