Inhabitable THERMAL Variations

by

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ABSTRACT

This work investigates the constraints and opportunities of energy conscious building design and their effect on richness and variety of form, connection or continuity between building and landscape, and user choice and control of environmental conditions.

The work is based in a design project which suggested directions to investigate the thermal behavior of earth-like building methods and configurations as contrasted to edge conditions. These two form organizations are explored in terms of their energy use performance and resulting "passive" thermal conditions.

This analysis is done within a framework composed of a catalog of climate, of building elements, and of form configurations. Form configurations are diagrammed and analyzed for thermal performance and behavior. Changes are made in the diagrams to explore the effect of these parameters.

The thesis also presents an attitude about assembling form. The use of metaphors and references to understand how climate is tempered to provide a thermal and physical dimension for inhabition is discussed.

The existence of variations in climate and form are presented as positive activity initiators. The tradeoff between constancy and variation is addressed in terms of building elements, building configurations and use opportunities.

Thesis Supervisor: . . . . Imre Halasz
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PURPOSE

The purpose of this thesis is to investigate the constraints and opportunities of energy-conscious building design and their effect on richness and variety of form, connection or continuity between building and landscape and user choice and control of environmental conditions. Examples and procedures for assembling enclosure will be explored to determine the impacts of "passive" energy gains and the various thermal characteristics of these spaces which result. The ability and extent to which people can directly affect the physical and thermal characteristics of these places will be discussed.

REASON

This work is prompted by interest in the thermal performance and conditions of buildings and its influence as one of the numerous forces which can affect physical form. The issue of energy conservation and passive solar enerty utilization have added a new consideration to the process of designing and building. The question is whether this "new" constraint will result in a new aesthetic or will building approaches, which have been useful through the years, adapt to meet these new criteria.

In the recent past we have experienced a movement to the landscape. The associative qualities of the earth and vegetation have been seen as beneficial to our living and working environments. They are being accepted and designed with. Creation of linear parks, the establishment of wilderness areas, increased use of house plants, backyard gardening, are all evidence for a greater desire for connection to the landscape and the natural environment. The desire to integrate building and site, the motion of connection to the landscape, visual and implied continuity is strong in peoples' minds as well as designers' hearts.

Continuity with the landscape is being achieved through the breaking of the total enclosure. Emphasis on access and views through articulation of the enclosure strengthens this connection. Expanding the building into the landscape in plan and section by minimizing the perceived inside-outside barrier lets those spaces be both out and in.

This direction to relax or eliminate separations between in and out has been sustained and supported by modern technology. The use of steel and glass has allowed continuity of visual connection through the transfer of building load forces, eliminating the need for mass at the building's perimeter. Coupled with these materials are heating, ventilation and cooling technologies which have allowed these new spaces to be constant in environmental characters with great differences between inside and out. The low price of energy allowed this condition to continue. The implied connection to the landscape is achieved only through larger energy expenditures allowing great differences between indoor-outdoor conditions.

We are now faced with the energy crisis, or at least rapidly rising energy costs. This has stimulated a reassessment of building form as well as a search for improved system technology. Energy conservation standards are being enacted in legislatures and funding for alternative energy approaches is widespread.

The design and building industry is reacting in several ways to this energy "challenge". We see many cases where there is no response at all; that is, conventional buildings are built which ignore the need for conservation and result in higher energy costs. This approach may be short lived due to building code revisions.

There is the mechanical system approach which attempts to decrease energy usage through improved or adapted mechanical and lighting systems. There is also the approach to look for alternatives to "new" energy sources, such as wind, sun, tides, fusion, etc. Within this grouping is the active technology group which propose new equipment at a level of sophistication equal to or above today's heating, ventilating and air conditioning systems. The other group is promoting a passive solution to energy needs and conservation. These people advocate increased conservation first and then, using natural systems to supply energy needs (often highly labor intensive) which could have a major impact upon life-style.

There are problems with all these approaches. Basically they overlook the fact that people use the resulting environment and should be able to impact or adjust this association. Energy criteria is often viewed as paramount but the search for the energy optima neglects the multitude of characteristics that constitute an inhabitable environment.

The notion that a building is simply an enclosure with mechanical systems added to make it usable is as wrong as the notion that producing a well insulated or buried box which uses no energy is ecologically sound. These approaches, i.e. to centrally and completely control a building's environment for minimum energy consumption or to totally enclose vast volumes of territory at a constant climate, are misplaced enthusiasms. What is needed is an examination of these extremes and "optimal" solutions based upon human use and response criteria. Building places which are comfortable in many climatic situations is not only a modern technological marvel, but a heritage of learned processes. A look at these from a new direction will be helpful.

In light of the direct challenge of energy conservation one can imagine other impacts or responses which are not only technical. These may include moving to a more accommodating climate. Migration is not that remote an option for most Americans who move often, for other reasons. Changing lifestyle to respond to climatic variations may be seen as a positive direction or as an inconvenience. Buildings which change or have different characteristics over time and allow choice at one time may be a way of accommodating both environmental variables as well as human preferences.

The question then is can richness and variety in architectural form be possible if energy criteria are met? By building this richness we provide for the culturally associative sense of place which people need. Can we build richness at a minimum energy cost and maximize its use? Will this articulation be interpretable by people and promote a sense of connection between people and place? Can the strong reassertment of the importance of landscape and vegetation in people's lives be reinforced through building configuration and form, given increasing energy costs? Will the loss of continuity between landscape and building be the price we pay for energy conservation? Here we must look to nature itself to examine how regions are defined and environmentally moderated to accommodate plant families.

How can people be given control over their environments and their characteristics without sacrificing the whole? Is it possible for individual differences and the group needs to be accommodated? The decentralization of mechanical systems as well as physical spatial definitions is the direction to pursue. The breaking down of an organized whole (space or mechanical system) into subparts which are responsive to the individual will allow this greater control over place and promote interaction between people and environment. Conversely, what may be the starting point, is the aggregation of these smaller units to produce a whole. The seeming decrease in flexibility or efficiency in this approach may be a fallacy due to the extremes which are employed by people to override control when it is not adequate and responsive.

The ultimate question, then, is can we use a problem to initiate an opportunity? Can this opportunity solve the problem and at the same time begin to expand its solution to other problems. Can the need for energy conservation prompt a richness in thermal and physical properties of space? Can we increase the connection between building and landscape, give individual control and choice over that connection, as well as adequately utilizing many resources?

HISTORY OF PROCESSES

The method of investation in this thesis is heavily harbored in a design process. The general chronology of thinking was based first in the development of an actual design project during Spring 1974. This project is described in more detail later. Through the design of actual organizations, building technologies and spaces, certain configurations and potentials for thermal explorations evolved. These were based on the understanding of the environmental forces acting on a building and building responses to these. Design decisions were made based upon an intuitive analysis of proposed places underlying heat flow principles. Judgment was not made through calculation or replication of a previously built diagram. Decisions were strongly weighed in terms of their usability or opportunity generating quality. Configurations which solved problems of energy, programs etc. and generated use and change potentials were sought.

This thesis picks up at the point where design insight leaves off. The work here looks more closely at the actual configurations which evolved in the design process. The investigation of these configurations is not, however, specific for this project but an abstraction or diagramming of the conditions which are prevalent. This is done deliberately to clearly understate the example so it will not be viewed as a design proposal, thus increasing its applicability.

This simplication is also done to state an attitude about energy calculation precision and the fallacy of the optimal solution. It is also an attempt to bring energy design criteria to a visual representation between form and performance which designers may find useful.

The next step is to regard the diagram of form and performance. This new information is then integrated with other design issues and opportunities. This hopefully will result in a rich and responsive environment for people, as well as being energy conservative in performance.

METHOD

The basic method used for examination of diagrammed building configurations is open ended. This work is seen as a framework which can be continually added to, resulting in catalogs of various relations between climate, building technologies, form assemblages and thermal behavior.

The organization of this cataloging is broken into two main groupings. There is first a body of base information, followed by form configurations. The base information is subdivided into climate descriptions, typical and new construction techniques and materials, and various building code information and requirements. These dimensions are also organized internally so information can be very specific and yet the grouping is comprehensive.

Climate is divided into four categories: temperate, hot-humid, hot-dry and cold.

Temperate (Boston) is the only one explored at present. Building elements are divided into five groupings based upon physical properties and functional application. These groups consist of Mass Walls, Panel Walls, Glazed Walls, Roofs and Floors, and Screens. These groupings each contain actual material details and physical property information. These may be expanded at will with new building materials and processes easily added to the matrix. Building code information and requirements can be changed easily in this category to view different impacts based upon changes in building occupancy type or legislative action.

Form configurations are also organized and investigated based upon their physical properties and relationships to building and function. These generic form families or groupings are coded as Earth, Edge, Planting and Thermal Sources. Each of these families is further divided into specific building configurations which are recognizable as typical places. For example, the form grouping Edge may contain a configuration of solarium or porch. In this thesis Earth and Edge families are investigated.

Just as building techniques could easily be added to the base information matrix, numerous configurations can be created and added to the Form Family Matrix. These configurations may be different because of form organization and placement or merely material and construction method employed.

The thermal analysis of each specific configuration is then composed of two basic parts. The first is the overall monthly and yearly energy performance of the given configuration in a given base situation. This is also compared to a control example or base building which is usually a typical structure in use today. The second body of information gives information as to the usability of these places at different periods in the year and between day and night. This information is in the form of temperature readings and qualitative implications of form, thermal comfort, and use opportunities. This portion will also address the potential for individual control and inhabitation.

THERMAL & PHYSICAL METAPHORS

THE EARTH

THE EDGE

EARTH

Building with earth is probably the oldest and most universal of all shelter defining techniques. Using the earth for shelter is first evident in the process of choosing a site for settlement. This step of observing suitable micro climates associated with large and partial earth forms (canyons, valleys, mountains, ridges, etc.) begins the process of inhabitation and leads to the establishment of individual sized shelter. This smaller scale enclosure may also be an existing land form (cave) and provide protection with little or no additional definition. Caves and fractures in the earth's crust historically have become an initiation of settlement site or place.

This process of settlement can be promoted through two mechanisms; first, an indication of building size and form exhibited by the landscape and secondly, the presence of a malleable or responsive composition of earth suitable for excavation or formation into building elements. Farming takes place typically in regions where the earth composition is easily formable and responsive, whereas settlements based upon other activities tend to inhabit suggestive landscapes.

The next strategy in defining shelter or place through earth forming, is the piling or addition of smaller earth composed elements. These can be stacked to produce forms which are both usable by people and reminiscent of the larger composition they were part of. It is through this process that we know most of our "ground" buildings.

In actuality, building with earth or ground is usually a combination of these strategies. Foundations for shelter are either prepared or existing land forms. Regardless of their heritage, they must be able to accept the subsequent stages of enclosure. They also must exhibit characteristics of the large context of which it is a part as well as the smaller needs that sheltering demands. This reciprocal arrangement exists because earth forming is a process through which the larger landscape becomes human sized and inhabitable. Each act or product is then both a historic fact or remnant of what and were it was and an indication of what it can, or is prepared to be.

Metaphors

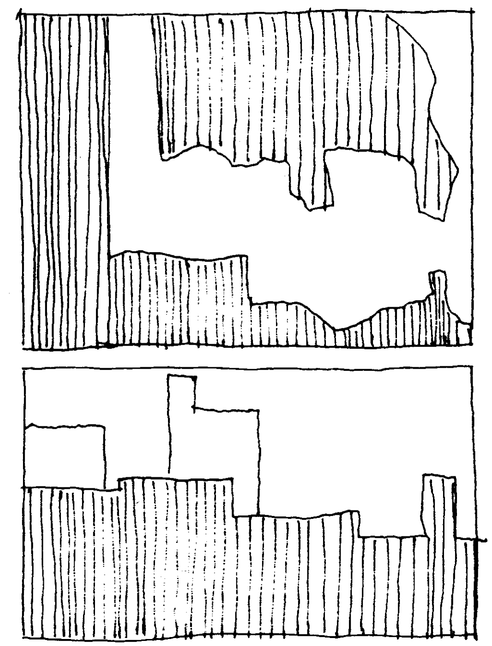
Built ground is defined as the forming of earth or earth materials to a size and form which is responsive and usable for human habitation. The product often is reminiscent of the size and former use as well as indicative of new sizes and potential uses.

There are many metaphors and examples for built ground which can be established for various characteristics of earth. We find that many metaphors hold true across characteristics.

In this discussion we will use the metaphor of earth to yield insight and understanding to the thermal behavior and properties of places defined with built ground. These metaphors are not implied to be optimal or exclusive examples of the form type but they do begin to bridge the gap between the space defining and thermal characteristics of earth building.

The manipulation of earth or earth materials can be viewed as a process of defining regions similar to caves, earth terraces and rock planes or spires. The city can be seen as the metaphor for the assemblage of all earth forming strategies.

The various conditions in caves affected by the external environment are determined by the position and number of openings. If the only opening of the cave is below the enclosed volume, warmed external air will rise and fill the cave yielding a warm insulated and stratified air mass. Caves with their opening above their volumes will trap and stratify the cool



air produced in winter months creating a condition much colder than the ambient environment. Caves with multiple openings will be drafty depending upon the number and placement of openings. These drafts tend to produce conditions less extreme than those in enclosed caves because interaction is increased between inside and out. The fundamental characteristic of earth enclosures is the relative constancy of conditions over the year. Seasonal variations are evidenced but hourly/daily fluctuations are absorbed.

Earth terraces, vertical rock extrusions and plates are metaphors for partial shelter and enclosure with earth. The defined places thermally behave as extensions of earth depending upon the extent of enclosure with ground materials.

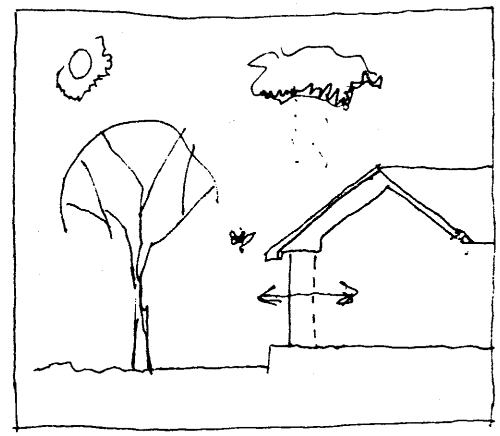
These elements act as thermal stabilizers to level diurnal cycles. Increased exposure to the sun and other forces will gradually erode the relatively static condition of these forms. The period and extent of response of these elements is more frequent and greater than those of the cave due to the increased exposure. The variations of response are also dependent upon the location and orientation of these elements.

EDGE

The dimensions between inside and outside is the point at which architecture must address the largest range of differences. These differences include thermal, insolation, air movement, moisture, pests, privacy and use variations. In addition to the different forces acting on the periphery of a building these conditions themselves change seasonally, daily, and hourly.

The edge must be responsive if it is to be successful in mediating between the need for comfort and the constantly changing environment it is placed in. The interface creates a zone which is both part of the inside activity and outside landscape. Both criteria must be met through an affectable edge or a total separation into two worlds.

This zone between inside and out also functions to orient one in the larger landscape and provides cues to interior activities as well as to provide views and connection from inside to out. Clarity



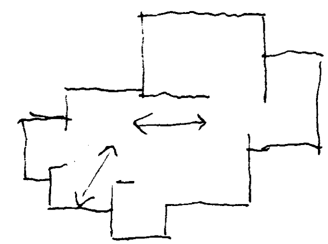
in interior organization can be read from the exterior enclosure. One can also see the footprints of climatic forces acting on a place through the manner in which protection is deployed.

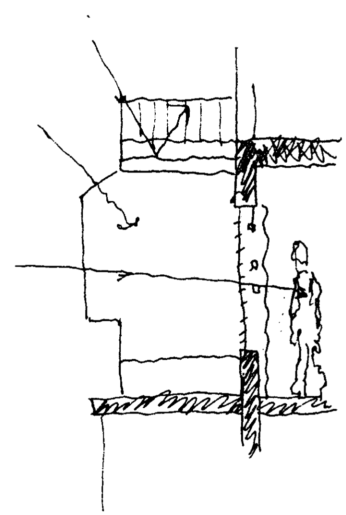
The edge is the region which is exposed to the elements of sun, air, and water. Different uses require diferent amounts of each resource and different levels of their control. This suggestions then that an edge condition would be varied to respond to these various needs. Equality in this region can be supported only through deployment of another system capable of supplementing or negating the effects of environmental resources. This act is, in effect, the creation of another edge which is a network of mechanical control.

These differences in outlook or exposure of use demands suggest an organization or zoning of activities in response to environmental forces as well as interior programmed agencies, where appropriate. Another strategy might be to accomplish the different functions of protection with discreet elements deployed where required. They can be assembled into layers creating a new intermediate dimension. This results in a new usable place which is responsive to environmental forces, yet different from both the overall controlled enclosed space and the external landscape. These layers act as selective screens creating mediated conditions but not equal spaces. This also produces more usable regions and exposure at the edge where it is usually desirable.

The act of building an activity zone which functions as a selective screen yields a place of thermal variation at the edge. These places will be influenced by external conditions yet be habitable. They are usable at times when environmental forces passively produce suitable conditions. The opportunity is also presented to override or supplement these forces when demand is great enough. This can be accomplised through the adjustment of other variables in the layer configuration or through the addition of mechanical system reinforcement.

The result is a building which responds to climatic forces and use demand with equal ease. Usable space can expand and contract without costly maintenance of constant equal conditions. There is now no need to pretend the enclosure of a building is equivalent or that conditions everywhere



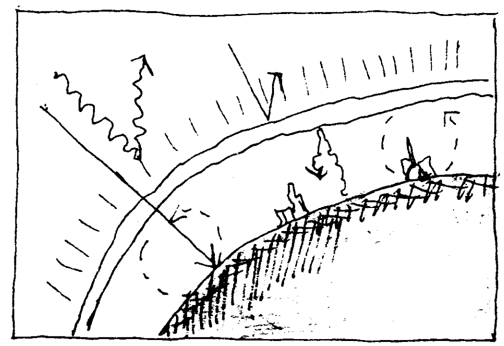


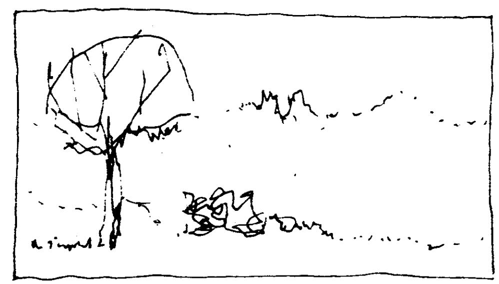
are constant. Control of outlook is then directly in the hands of the user through articulation of the edge or the choosing of a suitable place to be in.

METAPHORS

The boundary between different worlds or microcosms often appears discreet and singular; in fact, they never are in nature. The earth-space system is modulated by an intermediate atmosphere. The air-ocean boundary is overlapping in a sea of moist air. Similar edge conditions result in the earth-air and earth-water systems. Even the interface of cell walls exhibit dimensions of protection or layers which insure survival through their screening function. These metaphors or analogs give insight as to how boundary layers can be produced to provide shelter as well as connection to both worlds.

The atmosphere is a large scale example of successive and selective screening of external influences. It





produces the ultimate inhabitable thermal variation and survival dimension between earth and space. This dimension is composed of layers of different elements and physical properties which function to filter various forces. The net effect of this assemblage is to screen and shade radiation from space, to insulate the earth's surface for thermal inhabitability, to store energy where needed and to provide a transport system for energy flows in the form of wind and rain.

Trees and vegetation are another good example of systems which affect the inhabitability of a place. They are next in a heirarcy of layering for survival. The fact that they also have strong cultural associative qualities is not to be dismissed in favor of their utilitarian function of providing oxygen for the human race.

Vegetation creates its own layering of thermal conditions which modify existing conditions to promote survival of their species. The vegetation types as well as actual leaves, branches, roots, etc. change as a result of different environmental conditions. They act to define an overall dimension in scale with the atmosphere as well as create places at the human use scale.

This foliated assemblage acts to shade, provide moisture, absorb and store solar energy, to produce oxygen and to filter the air. Vegetation is also a very powerful spatial definer and rich in associative qualities.

Clothing is the most affectable layered system people deal with every day. It also exhibits the widest range of functions. Adjustment to meet changing external conditions is possible almost at will. The potential configurations of clothing are almost infinite but they all function to insulate body conditions, reflect or absorb sunlight, retain or shed moisture, and to repel adverse air movements in greater or lesser degrees. The functions of clothing can be accomplished with one garment whose properties will produce the required condition or many garments separated into successive layers which selectively screen environmental forces. The resulting composite will yield an effective equivalent condition but allow greater choice and range of comfort. The single garment approach is very successful where conditions and activities are constant and extreme, which is almost nowhere. But in places where environmental forces and activity are changing, a more responsive approach is necessary. The composite layers solution works fine here.

INITIATION: DESIGN PROJECT

MIT ARTS CENTER

DESIGN PROJECT: MIT ART CENTER
HALASZ STUDIO
SPRING 1977

The program for the MIT Art Center called for a wide range of uses, sizes, and environmental conditions for its varied activities. Large public meeting spaces for exhibitions and performances needed the ability to be controlled. Support for these spaces was needed in the form of workshops, studios, offices, libraries and laboratories. The building was designed to house several semi-independent operations of the arts program at MIT. There was a need to express a sharing of space between identifiable groups as well as to integrate the whole arts complex into the Massachusetts Avenue site and the MIT community. Added to this program was a section for Institute housing presumably associated with the Arts.

Associated with these program needs is a complex and prominent site directly across from MIT' main entrance and adjacent MIT's student union and Chapel. The site is also oriented in a north south direction along the Massachusetts Avenue frontage.

This project posed many interesting and complex problems whose solutions were often in conflict. Questions in this project which prompted this thesis investigation includes: How can energy conservation be achieved in a difficult urban site? How can program clustering be used to define public spaces which interface the outside, provide thermal variety and energy saving benefits? What are the opportunities in thermal zoning? How can a mechanical ventilating system be integrated with building mass to take advantage of winter solar gain and avoid overheating? What are the means to allow passive thermal performance and individual control of the building's environment? The ultimate goal is to integrate a thermal or energy solution to be a physical or activity opportunity utilizing the thermal problem to generate richness in form.

Underlying the desire to explore the opportunities of thermal variations and energy conservation are design values. These values encompass issues of control and ownership, and centralized vs. decentralized organization. Thermal control and supply, decision making and form aggregation can all be addressed on this count. The ability to change over time and a sense of both clarity in image and complexity of experience are fundamental goals in this project.

If inhabitation (settlement, nesting), is to occur, a sense of ownership or association must be able to develop. This will occur if people can have a direct impact upon the physical and environmental qualities of the place they use.

Accompanied with this desire to stimulate a sense of place and ownership is the opinion that the overall form must reflect and respond to this attitude. Decentralized organizations, form aggregations, or clusters reinforce this attitude about inhabitation. Mechanical systems as well as spatial definitions can exhibit qualities and potentials for decentralized control and supply. The concern with change over time will be more easily accommodated if the physical definition as well as thermal sources and environmental controls are able to be broken down into zones of smaller impact.

One way of looking at a building may be as a framework of physical and thermal realities (stabilities) with variable portions at different levels of responsiveness. The levels of impact will vary depending upon the amount of time and expenditure of resources allowed. They may range from opening a window for air and moving a piece of furniture, to choosing a cooler, warmer, larger or smaller space. Change at different levels is allowed because it will not affect the total organization of decentralized elements.

The design of the Arts Center is based upon these values and goals. Solutions to problems were evaluated in terms of their potential to generate future possibilities and provide for other needs. Physical forms were generated which exhibited different relationships to the site and interior distribution.

Spaces defined by these forms would have varied climatic as well as privacy characteristics. It was then seen how the programmed needs could work with these conditions. The process was then on interplay between activity informing physical conditions and vice versa. The myriad goals and constraints led to the development of two basic notions. One is the concept of earth or ground which could be used to be more enclosing and thermally stable. This was used to build major public places when exposed to the external climate and an internal network of distribution and access. When these are used to define activity areas, they house uses which need more control or stability in their environment. Figures 1.1-1.4 show these regions thought of as ground.

The other relationship explored here is that of the edge exposure to outside, street, interior distribution and service networks should be maximized. This would increase the possibility for interaction between functions if desired, as well as allow greater flexibility for future changes. There is a potential conflict in maximizing edge conditions and energy conservation goals. This was responded to by building public distribution zones or interior edges as enclosed but predominantly unheated. This provides interim zones which are basically a layer between inside and out whose climate is somewhere intermediate to both.

These public places become large areas which organize movement through the building, provide differences in network relationship for use groupings, as well as passive energy gainers and ducts for the ventilation system. The potential also exists to heavily plant these areas so they can act as air purification and recharge zones. If the climate becomes too extreme in these zones there are individually controlled devices to reconcile the problem. Infra-red lamps are placed in regions of potential use with vents and shades available to ease summer conditions.

The external edge perimeter is also thought of as a dimensioned layer. On north exposures glazing is minimized and insulation increased. South exposures become more transparent with an insulating zone built out of layers of glazing or panels. Heat gains by these layers would be distributed throughout the building by the ventilating system.

The creation of edges is also evident in the external courtyard. This acts as a more private overflow of interior spaces as well as the area most connected to the street. Cool air from this region and other shaded ground zones is used as fresh air intake for cooler summer ventilation.

The thinking in this project was on a design level in regard to thermal performance. This led to the more indepth study and classification of forms and materials which follows.

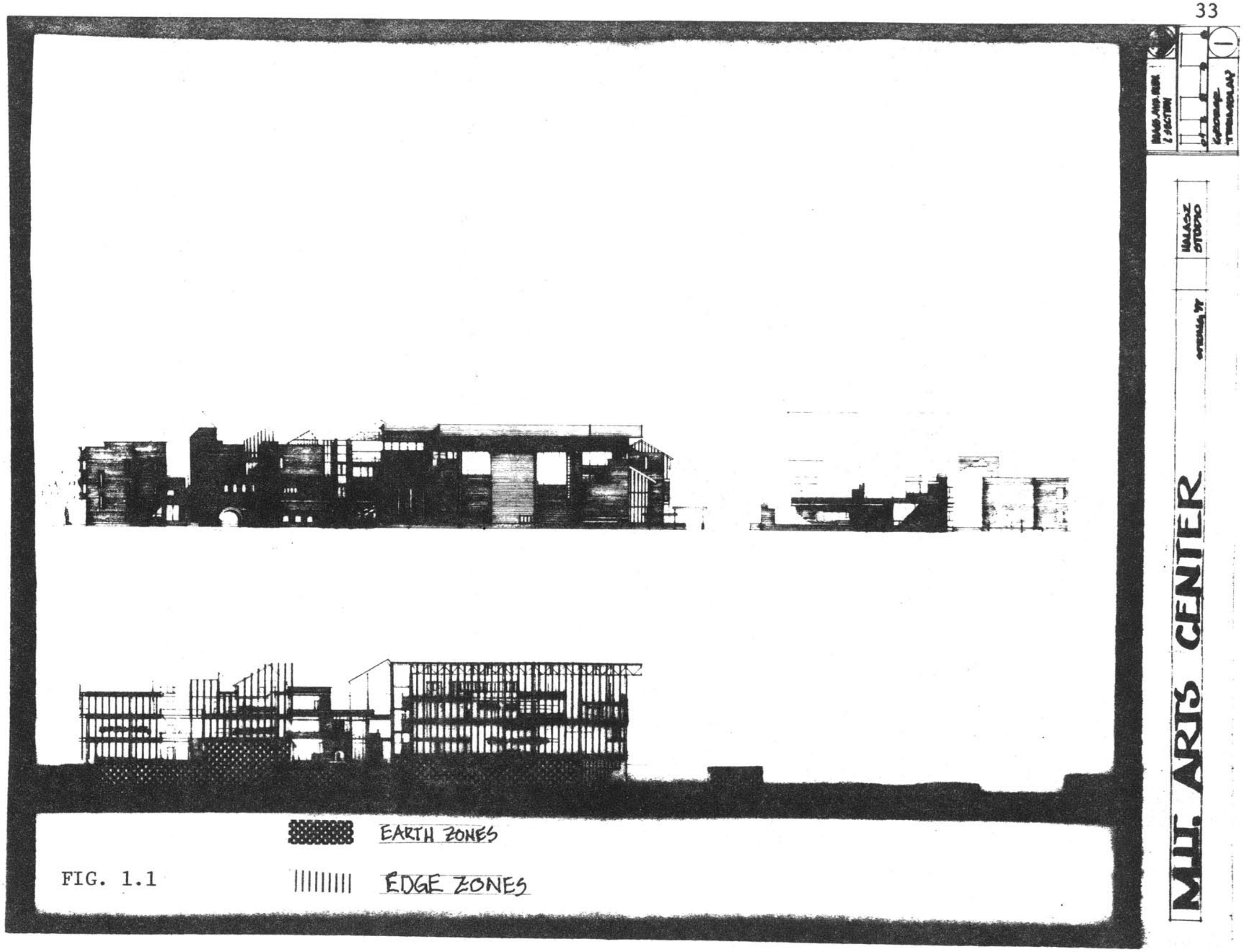


FIG. 1.1

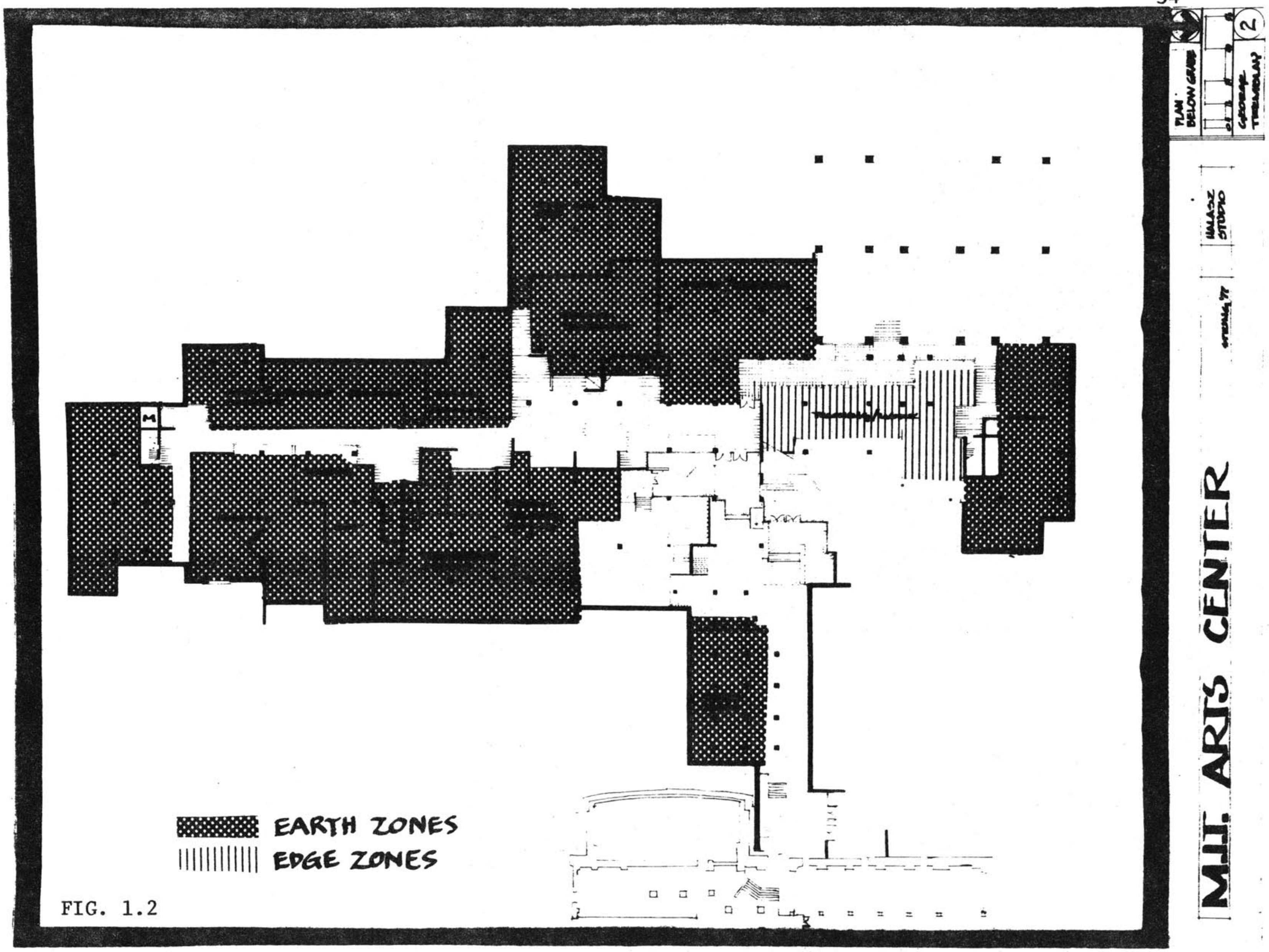


FIG. 1.2

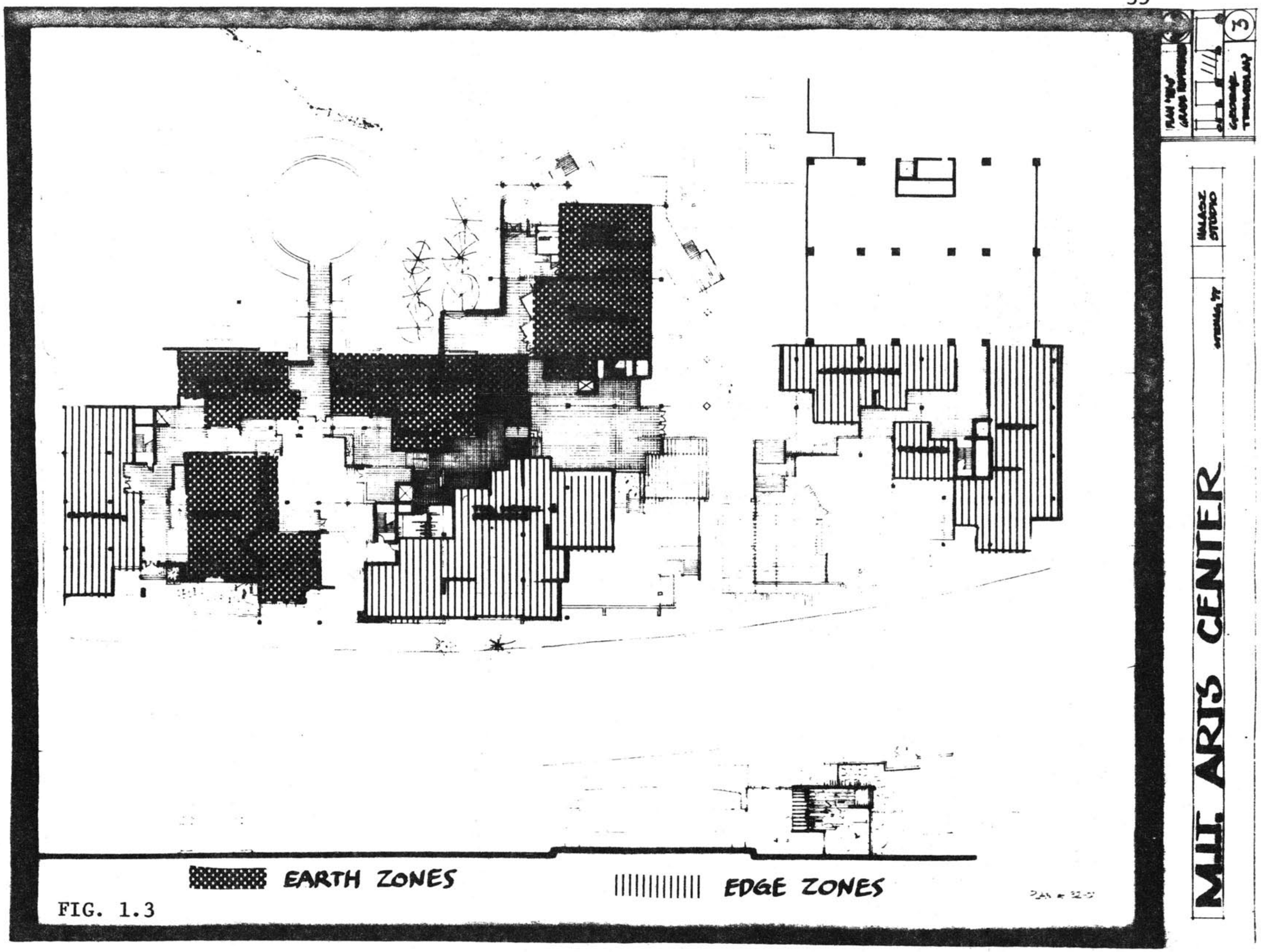


FIG. 1.3

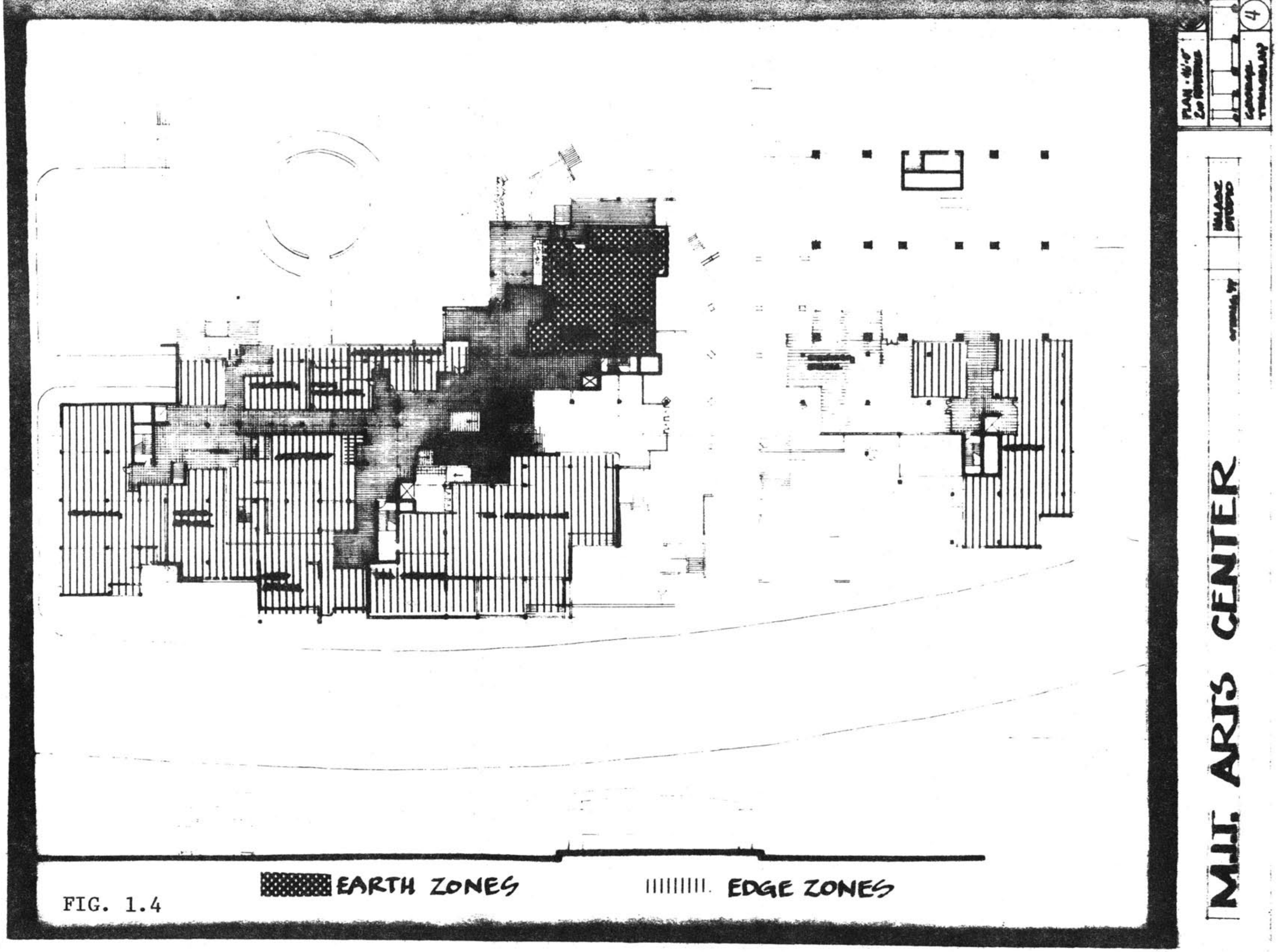


FIG. 1.4

THERMAL ANALYSIS of CONFIGURATIONS

BASE INFORMATION

- Climate
- Building Elements
- Building Code Requirements

THE EARTH

- Overview
- Configurations

THE EDGE

- Overview
- Configurations

The base information is organized into three groups of specific characteristics which impact the energy and thermal performance of buildings. These bodies of information are divided into subgroups which can be increased or updated without altering the remaining body of information. This information will be used to construct building diagrams for a specific climate with actual building wall and roof sections and energy related code requirements. These diagrams will then be analyzed in terms of their thermal performance. It will be easy to explore the impact of adjusting any of these base factors by substitution and recalculation.

BASE INFORMATION

I. Climate

Temperate - Boston
[Hot-Humid - Miami]
[Hot-Dry - Phoenix]
[Cold - Minneapolis]

II. Building Elements

Mass Walls
Panel Walls
Glazed Walls
Roofs and Floors
Screens

III. Building Code Information.

Ventilation Requirements.

CLIMATE

Climate information is divided into four types whose characteristics could have specific impacts upon building form. It has been proposed by many researchers that this classification, promoted by Olgyay in Design with Climate, does not take into account the finer qualities of climate characteristics. The AIA Research Corporation has produced a study proposing 12 groupings based upon the amount of time and extent conditions are outside the comfort zone. This report also lists climatic resources which could be utilized to alleviate this problem. Either framework of climate categorization can be employed in the continuation of this work.

Boston fits into the TEMPERATE zone in Olgyay's classification and Region 1 of the AIARC study.

BUILDING ELEMENTS

The catalog of building elements and material assemblages (Figure 2.2 will be used to make decisions about materials based upon thermal, as well as functional and aesthetic properties. This is only a partial listing which can be updated as new materials are developed and more information is desired.

This list of elements is further broken down into categories based upon both function and physical properties. The material groupings

FIG. 2.1
CLIMATE: BOSTON
TEMPERATE: 40° North Latitude

	January	March	July	September
Temperature				
(a) Mean Monthly	28	37	72	64
(b) Mean Daily max	31	43	80	71
(c) Mean Daily min	20	28	63	46

(d) Degree Days av.									
	1108	1025	841	538	245	98	338	647	1008
		F		A	M	S	O	N	D

Total: 5936

	January	March	July	September
Relative Humidity				
Min/Max 12:00 noon-4:00	60%	56%	58%	60%
12:00 Midnight-6:00	73%	72%	75%	81%

Insolation	January			March			July			September		
Sun Altitude Noon	25°			46°			76°			46°		
BTU/FT^2 at noon	V	H	N	V	H	N	V	H	N	V	H	N
(1) Average	236	110	260	164	170	236	60	240	247	164	170	236
(2) Clear	365	170	402	261	270	375	82	330	340	261	270	375
Hours of Insolation	8:00-6:00 (10)			6:00-6:00 (12)			5:00-8:00 (15)			6:00-7:00 (13)		
Clear Cloudy Days (Average)	C	P Cl.	Cl.	C	P Cl.	Cl.	C	P Cl.	Cl.	C	P Cl.	Cl
C P Cl. Cl.	9	9	13	10	9	12	9	13	9	12	9	9

Wind - M.P.H.	January	March	July	September
Average Wind	W 12.4	W 1.29	S.W. 10.3	S.W. 10.5
Strongest Wind	N.E. 50	S 56	S.W. 47	S. 73

Information from: "Regional Climate Analysis and Design Data, X Boston Area also represent the beginning of a hierarchy based upon the impact a "user" can have upon their deployment in space. Each assemblage has as one of its properties a level of flexibility for installation and change. The ability of these materials to be altered or varied over time is somewhat congruent with their thermal behavior.

The two basic thermal properties evident in materials is the resistance to transmit heat and ability to store heat. These properties are expressed in a resistance value (R) and a heat capacity. These material properties can be generalized as follows. The more a material or cross section is like non-moving air or produces non-moving air between places of temperature extreme, the greater its thermal resistance or insulating value. The greater the density and specific heat of a material the greater will be its heat storage capacity.

Mass Walls

Mass walls are dense material constructions which have a relatively high heat retention capability. They are also mediocre as thermal insulators, especially at the thickness which is commonly used in today's practice. For this reason, the mass walls examined are usually a composite, consisting of a material with good thermal capacity layered with one exhibiting good insulating qualities. A good practice to consider is to layer these composites so the mass is on the interior of the building for greater thermal inertia. This will enable the building to be more constant in thermal variation.

It is not easy to change massive materials once they are in place. They are very continuous and fixed in their deployment and heavy in structural loading. Creating openings is a design opportunity but not a change opportunity for the user.

Panel Walls

Panel Walls exhibit the largest range in thermal characteristics of these groupings. Panels made of most every material are now being used in building construction. The notion of panel connotes an assemblage of relatively light weight and smaller size which is supported by something else. It is therefore seen as inherently more independent and changeable. Panels usually have low heat retention capabilities and therefore will not support a thermal condition through retained heat. They are, however, able to insulate a condition which is supported from another sources because

FIG. THERMAL RESISTANCES (R) of BUILDING ELEMENTS

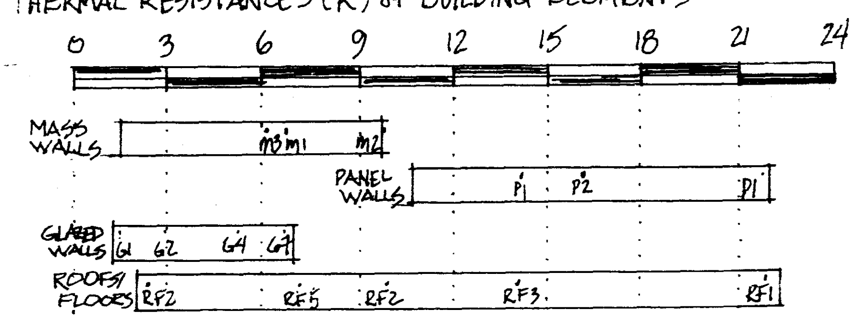
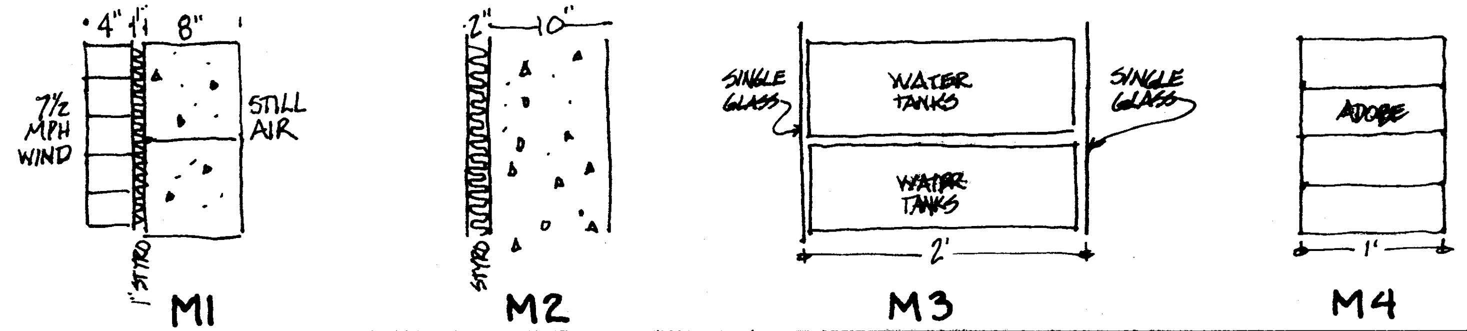


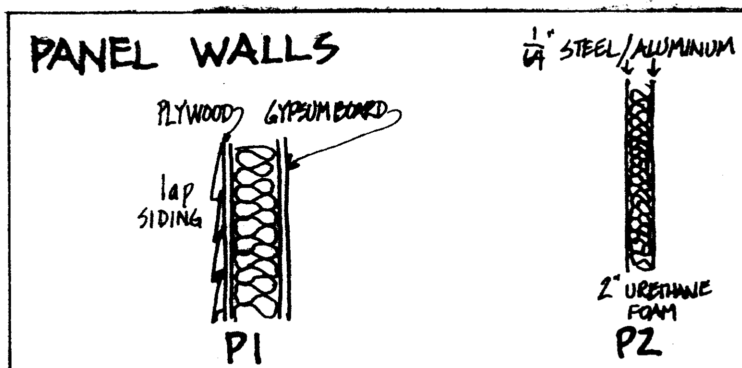
FIG. 2.2a

MASS WALLS



	M1	M2	M3	M4
Thermal Resistance	6.8	10	6.3	
Density	140 lbs./ft^2	92 lbs./ft^2	64 lbs./ft^2	150 lbs./ft^2
Thermal Storage Cap.	17 Btu/ft^2-°F	17 Btu/ft^2-°F	62 Btu/ft^2-°F	25 Btu/ft^2-°F

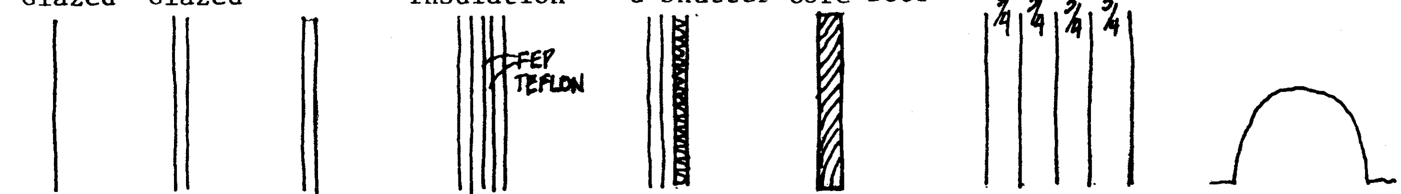
PANEL WALLS



	P1	P2
Thermal Resistance	14.3 w/2"x4" 22.3 w/2"x6"	15.6
Density	15 lbs./ft^2	1.6 lbs./ft^2
Thermal Storage Cap.		

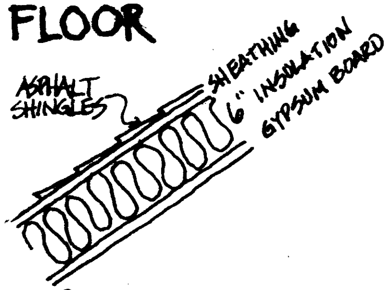
Fig. 2.2b

GLAZED WALLS

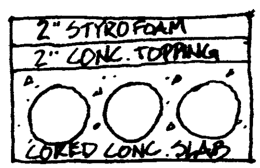


	Single Glazed	Double Glazed	Kalwall	Transparent Insulation	2 Glass & Shutter	Solid Core Door	Heat Mirror	Skylight
	G1	G2	G3	G4	G5	G6	G7	G8
Thermal Resistance	1.8	2.65	3.4	4.5	10	3.0	4.5 @ 71% trans. 6.7 @ 60% trans.	single 0.87 double 1.4
Density	1.6 lb/ft^2	3 lb/ft^2				5.6 lb/ft^2		
Thermal Storage Cap.								

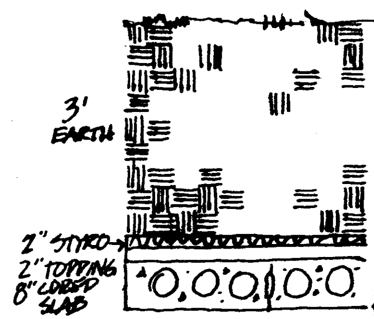
ROOFS/FLOOR



RF1



RF2

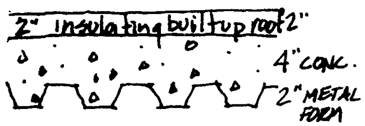


RF7

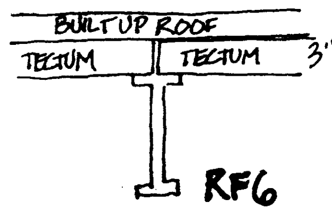
	RF1	RF2	RF7
Thermal Resistance	22.7	2.6 10.1 W2" styrofoam	12.0

FIG. 2.2c

ROOFS/FLOOR



RF4

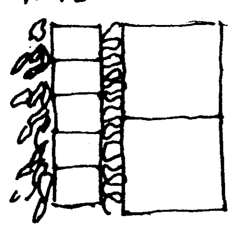


RF6

	RF4	RF6
Thermal Resistance	13.7	6.7
Density	49 lbs/ft^2	12 lbs/ft^2
Thermal Storage Cap.		

SCREENS

VINES

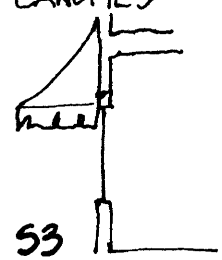


S1

BLINDS

S2

CANOPIES



S3

of their high insulation potentials. They are light weight in their construction and will fluctuate with ambient conditions more periodically than the mass wall group.

Glazed Walls

Glazed walls move farther in the direction of increased response to ambient conditions. They act to connect people with outside conditions visually and thermally unless added measures are taken. Their transparent or translucent quality allows sun to enter interior spaces for warmth and light. This quality yields them zero in heat retention properties. The insulating properties of glazing are poor in relation to other categories, although improvements in technology are being made.

Windows and glazed walls present greater opportunity for change and alteration by the user in response to inside and outside conditions. The addition of further layers of glazing can improve the low heat transmission qualities as well as provide usable spatial dimensions.

Roofs and Floors

The category of Roofs and Floors is more a functional grouping than a thermal behavioral grouping. There are elements in this type which exhibit the range of thermal characters evident in the mass, panel and glazing categories. The ultimate choice of which element to employ depends primarily upon the use which will be housed in the structure and its need for change. Issues of thermal constancy versus variation may also be influential.

Screens

This grouping identifies elements which function to shade light, direct wind, add humidity, etc. as thermal resources. These elements are of both the built and planted varieties. They will usually occur either directly inside or outside the building edge.

It is this scale of element which can be made directly affectable by individuals. This combined with the group glazing can result in a rich, variable and responsive edge.

VENTILATION REQUIREMENTS

Outdoor Fresh Air

FIG. 2.3 Ventilation Requirements

Application	Smoking	Cfm per Person[b] Recommended	Cfm per Person[b] Minimum[c]	Cfm per Sq Ft of Floor[b] Minimum[c]
Apartment				
Average	Some	20	10	....
DeLuxe	Some	20	10	....
Banking space	Occasional	10	7½	....
Barber shops	Considerable	15	10	....
Beauty parlors	Occasional	10	7½	....
Brokers' board rooms	Very heavy	50	20	....
Cocktail bars		40	25	....
Corridors (supply or exhaust)		...	...	0.25
Department stores	None	7½	5	0.05
Directors' rooms	Extreme	50	30	....
Drug stores[e]	Considerable	10	7½	....
Factories[d,f]	None	10	7½	0.10
Five and Ten Cent stores	None	7½	5	....
Funeral parlors	None	10	7½	....
Garages[d]		...	...	1.0
Hospitals				
Operating rooms[f,g]	None	...	...	2.0
Private rooms	None	30	25	0.33
Wards	None	20	10	....
Hotel rooms	Heavy	30	25	0.33
Kitchens				
Restaurant		...	...	4.0
Residence		...	...	2.0
Laboratories[e]	Some	20	15	....
Meeting rooms	Very heavy	50	30	1.25
Offices				
General	Some	15	10	0.25
Private	None	25	15	0.25
Private	Considerable	30	25	0.25
Restaurants				
Cafeteria[e]	Considerable	12	10	....
Dining room[e]	Considerable	15	12	....
Schoolrooms[d]	None	...	...	....
Shop, retail	None	10	7½	....
Theater[d]	None	7½	5	....
Theater	Some	15	10	....
Toilets[d] (exhaust)		...	...	2.0

[a]Taken from present-day practice.
[b]This is contaminant-free air.
[c]*When minimum is used, take the larger of the two.*
[d]See local codes which may govern.
[e]May be governed by exhaust.
[f]May be governed by special sources of contamination or local codes.
[g]All outside air recommended to overcome explosion hazard of anesthetics.

FIG. 2.4 HEAT TRANSFER OF VENTILATION REQUIREMENTS

OUTDOOR FRESH AIR REQUIREMENT		CFM/SF	Heat Transfer Btu/Hr.°F SF
LOW	FACTORIES DEPARTMENT STORES	0.1	0.12
MEDIUM	OFFICES CORRIDORS	0.25	0.27
HIGH	HOTELS HOSPITALS	0.33	0.29

THE EARTH

OVERVIEW:

Aesthetic

Insulation

Constancy vs. Variation

Cooling Opportunities

Heating Opportunities

CONFIGURATIONS:

Base Building

2 Level Below Grade

2 Level Below Grade and Level Bermed

Sloped: 3-1 Level Below Grade

Cut and Fill

Buried

EARTH

The earth is a base for all building in associative and construction terms. The strong connection to the earth of most buildings in the past is a direct result of the structural quality of masonry. Today there is still need for these foundations but structures need not be as broadly supported at the bases.

The act of settlement or inhabitation has associated with it a notion of encampment or huddling to the ground. The need for reference to ground level or newly built ground levels is due to the association between earth, orientation and foundation.

The aesthetics of using earth, as it is evident in nature, to define building levels and partial enclosure is part of a long building heritage. The earth is a powerful symbol of constancy and stability in spatial as well as thermal associations. The process of building with earth is a useful vocabulary of form based on both thermal and symbolic qualities.

INSULATION

The earth is a poor thermal insulator. The ability for earth material to resist heat flow is extremely low (12" earth R - 0.6). It is, in fact, a very good conductor of heat due to its moisture content. Justification for placing buildings beneath ground cannot come from purported high insulation values. One layer of glass with its associated air layers is equal to 3 ft of earth in insulating value.

The thermal property which is important in earth is its high thermal inertia due to mass. Earth has a great ability to store qualities of heat (10-25 Btu/ft^{3}°F). These large quantities of heat can be stored in very low temperature changes. Conversely, earth may be acted upon by great atmospheric temperature fluctuations resulting in high heat loss, but very little change in ground temperature.

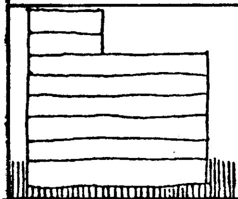
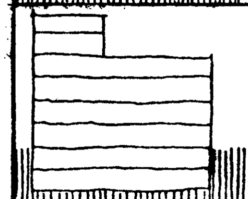
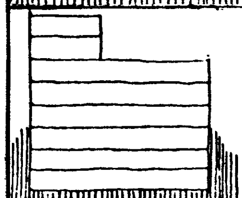
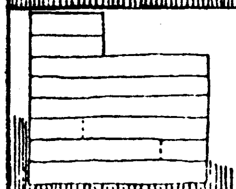
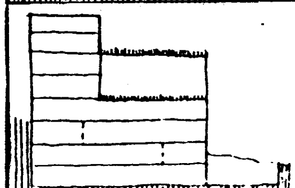
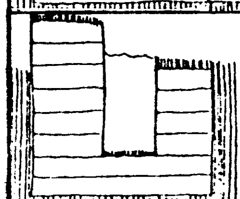
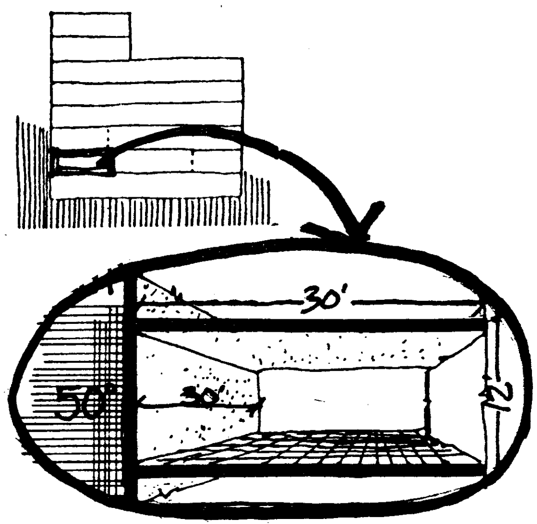
EARTH BUILDING COMPARISON	Conduction Heat Loss Btu/yr-SF	January 21 Solar Gain Potential	% Region/ Type
 Base Bldg. Old / Modern	Old 21,000 Modern 26,400	10^{6}Btu/day 14.5 / 21.7	Earth 15% Edge 85%
 2 Level Below Grade	12,600	12.3	Earth 29% Edge 71%
 2 Level Below Grade - 1 Level Berm	11,400	10.2	Earth 44% Edge 56%
 Sloped 3-1 Level Below Grade	12,800	13.9	Earth 29% Edge 71%
 Cut and Fill	14,000	15.4	Earth 41% Edge 59%
 Buried	13,900	4.5	Earth 93% Edge 7%

FIG. 3.1 Comparison of Earth Configurations

FIG 3.2 Unit Volume of Earth Zone



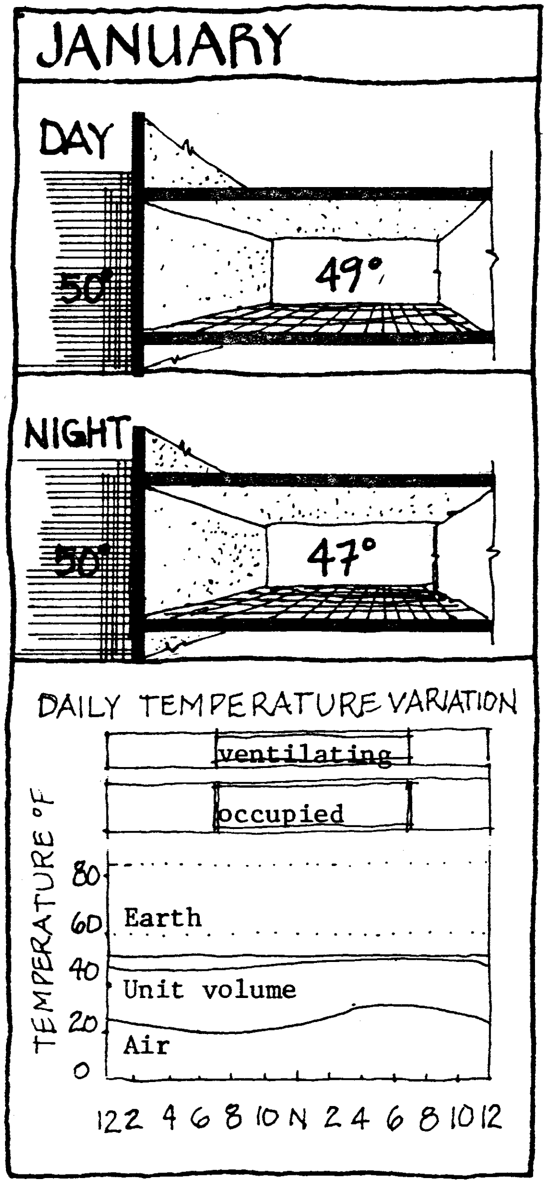
Specifications
Dimensions: 30ftx30ftx12ft. 900 SF
Heat Capacity Perimeter Wall
Floor 27,400 Btu/$^\circ$F
Ventilation: Office Use 0.25CFM/SF
Heat Transfer of Air 276 Btu/Hr$^\circ$F
½ Air Change per hour when not ventilating 194 Btu/Hr$^\circ$F
Lights: 2 watts/SF: 6.8 Btu/SF - 6100 Btu/hr
People: 150 SF/person @ 600 Btu/person hr - 3600 Btu/hr

We can see in Figure 3.1 overall effect on conductive heat loss for buildings in various stages of ground covering. Energy losses due to conduction per unit of area are very close, illustrating little gain in heat loss benefit due to ground insulation. When we add to this the heat loss due to ventilation requirements which are a function of building area, the discrepancies between examples lessen.

CONSTANCY VS. VARIATION

Those portions of buildings which are heavily enclosed with earth do exhibit some thermal benefit. These regions will behave relatively stable in face of external outdoor variations. The fact that the earth is a constant 50°F provides an effective damper upon extreme temperature variations. The mass construction system these buildings are made of will also store a good deal of energy further resisting temperature fluctuations.

FIG. 3.3 Winter Temperature Variations Without Added Heat



Savings resulting from this stable quality will come from decreased size of necessary mechanical equipment, not decreases in energy loss. Mechanical equipment now will not be needed to respond to the extremes in atmospheric swings because energy stored in earth and building will counteract this instantaneous demand.

Figures 3.3-3.7 illustrate the temperature fluctuations experienced in a unit zone whose external edge is earth.

FIG. 3.4 Summer Temperature Variations

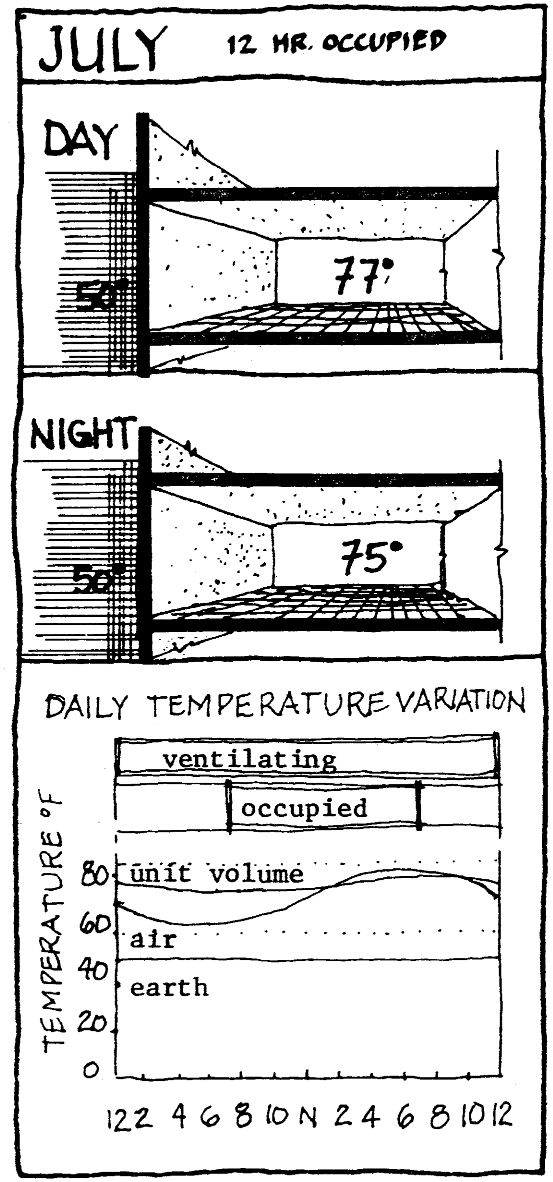


FIG. 3.5-3.7 Summer Temperature Variations: Impact of Altering Occupancy, Flow Rates & Lighting

FIG. 3.5 FIG. 3.6 FIG. 3.7

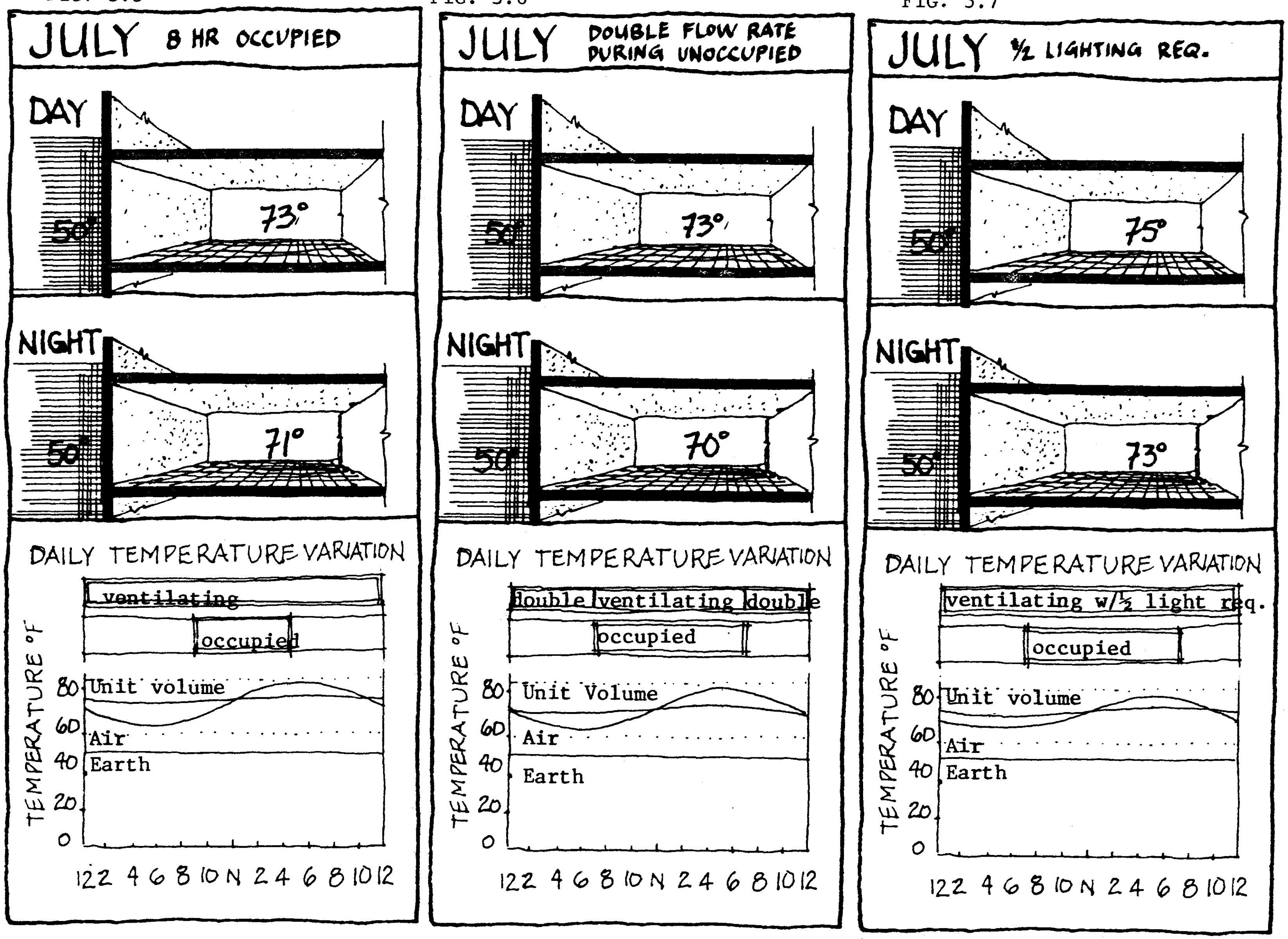
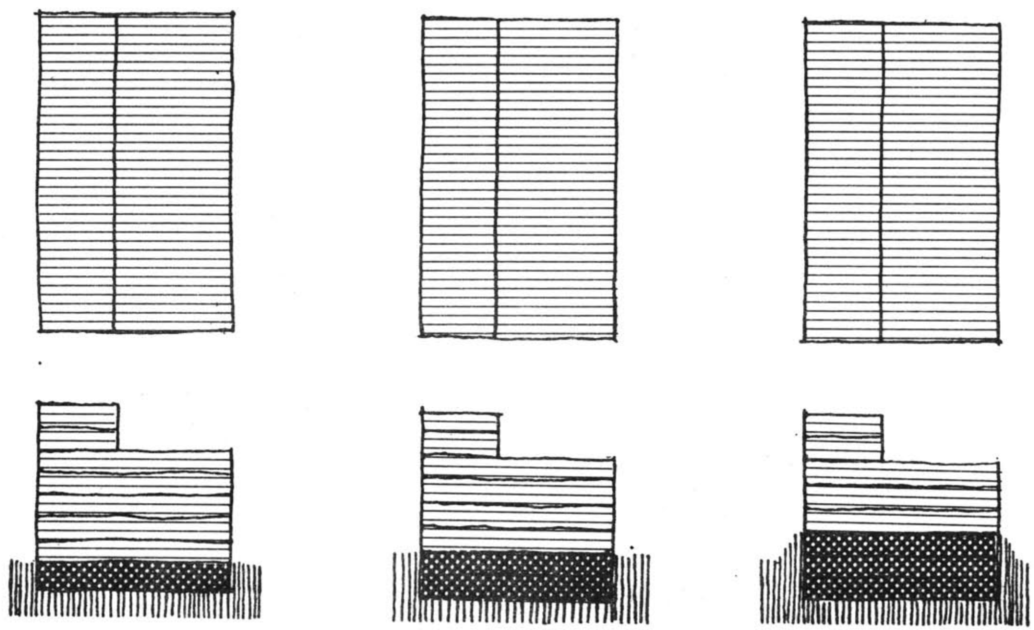


FIG. 3.8 Earth and Edge Zones of Thermal Behavior



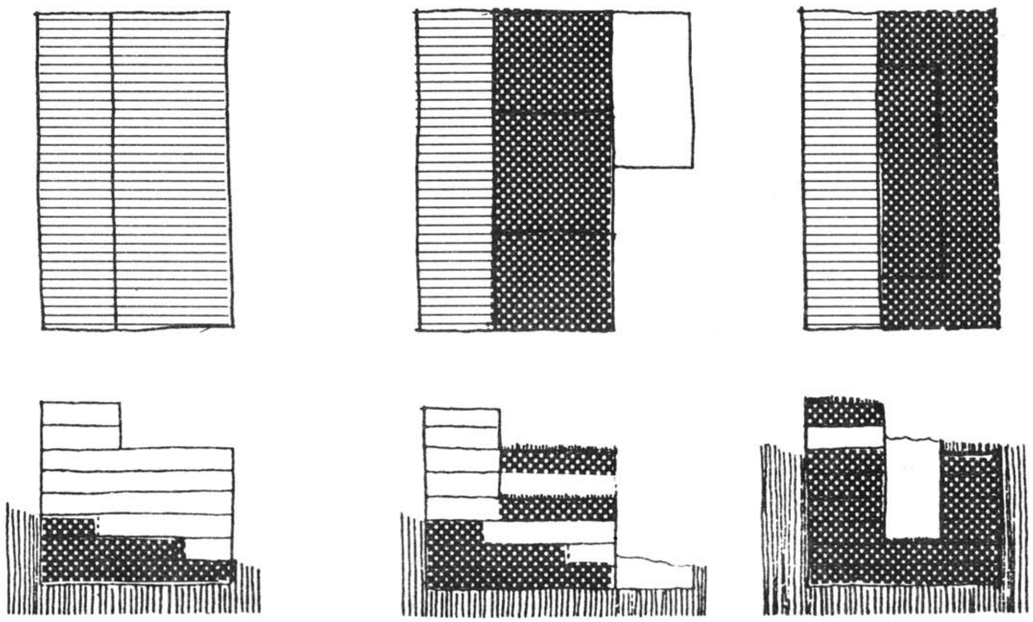
Base Building	2 Level Below Grade	2 Level Below Grade 1 Level Berm
Area: 109,000 SF	Area: 109,000 SF	Area: 109,000 SF
Earth: 16,000 SF 15%	Earth: 32,000 SF 29%	Earth: 48,000 SF 44%
Edge: 93,000 SF 85%	Edge: 77,000 SF 71%	Edge: 61,000 SF 56%

Earth Zone
Edge Zone

The unit zone is taken to be a 30' x 30' x 12' section of building which has as one of its boundaries the exterior earth perimeter. These regions are coded earth in further analysis. Figure 3.2 shows the characteristics of this typical area. The relative amounts of this zone type are also listed in Figures 3.8 and 3.9 for the tested building configurations.

We can use these relative amounts of thermal behavior types to estimate what the

FIG. 3.9 Earth : Edge Zones of Thermal Behavior



Sloped 3-1 Level Below Grade	Cut: Fill	Buried
Area: 109,000 SF	Area: 102,000 SF	Area: 97,000 SF
Earth: 32,000 SF 29%	Earth: 42,000 SF 41%	Earth: 90,000 SF 93%
Edge: 77,000 SF 71%	Edge: 60,000 SF 59%	Edge: 7,000 SF 7%

overall thermal stability of the structure is before considering the addition of mechanical cooling or heating equipment.

During the summer months this unit area enclosed predominantly with earth will assume the temperature of its surroundings if no other force acts upon it. Even though these portions of building experience little direct sunlight which would contribute to heat gain, they are exposed to the heat given off by occupants, lighting and appliances. Because of these heat sources a temperature rise will be experienced. The requirement of controlled ventilation with fresh air will also contribute to heat gain above earth temperature but also acts to carry excess heat away.

Figure 3.4 shows the temperature variation of the unit area in July when the building is occupied for 12 hours and ventilated for 24 hours. The required lighting of 2 watts/ft^2 is considered a heat gain during the occupancy period.

Figures 3.5-3.7 allow us to see the impact of changes in occupancy, ventilation flow rate and lighting levels upon temperature fluctuations. Figure 3.5 shows the impact of changing occupancy to eight hours from twelve. Figure 3.6 studies the impact of doubling the air flow rate in cooler non-occupied periods to increase structural cooling. Figure 3.7 examines the impact of decreasing high standards in overall lighting to one half their current level.

There are many potential strategies to "passively" heat and cool a building.

COOLING OPPORTUNITIES

- Change lighting standards to the use of more individual controlled task lighting.
- Alter occupancy cycles and durations during warmer months.
- Increase air flow rates during times when the outside air temperature is below building temperature.

Precool fresh air through underground ducts before entering the building.

- Use effective shading devices and planning.
- Use controllable, operable windows, vents and mechanical ventilation.

HEATING OPPORTUNITIES

The basic thermal problem in most commercial, office and working environments is heat balance, not total energy demand. Parts of a building may experience overheating because of sun, people, and lights, while other parts are cold. One of the largest components of heat loss in these buildings is heating the required fresh air. The ventilating system can act as the energy transport system, taking heat from where it is excessive to where it is needed.

- Connect ventilating switches to respond to occupancy. When a space is occupied the ventilation can be turned on, when not occupied, off. This could be in a form similar to light switches. In effect we are creating "task" ventilating similar to task lighting.

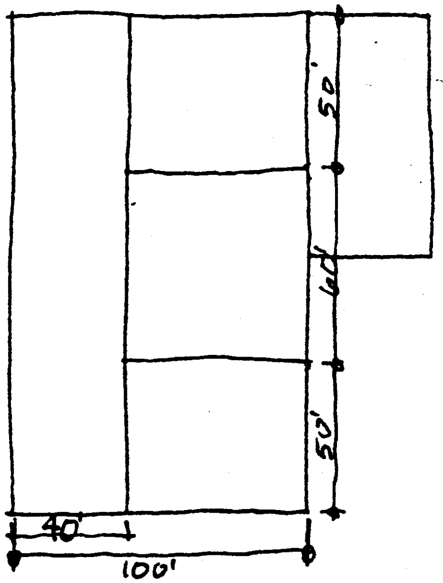
- Use the earth as mass for temperature stability not insulation. If insulation is desired, use a good insulating material to minimize heat loss. This material should optimally be placed outside the mass of the building itself to provide further thermal inertia.

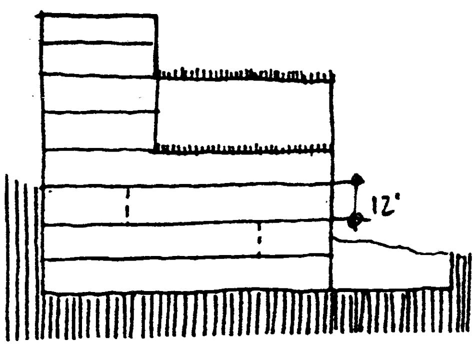
The general desire is to build a base building which supports a climate at the lower end of the comfort zone which can be adjusted by individuals or impacted by exterior weather conditions to a desired situation. This can be utilizing the differences between the earth's thermal stability and thermal fluctuation of the edge to provide both constancy and variety. The level of actual control or fine tune adjustment should be in the hands of the user rather than an optimizing machine.

EARTH CONFIGURATIONS

Building with massive materials and setting spaces into the earth creates environments whose thermal behavior is relatively stable. It has been suggested by many people that this may be a worthwhile strategy to follow for energy conservation. Those diagrams of spaces with various portions enclosed by earth are investigated to see what the thermal and energy impacts of such a strategy are. The method used to explore the effect of earth covering begins by establishing a base building and determining its associated heat loss characteristics. To this earth covering will be added and the building further extended into the ground. The diagram is kept the same as much as possible but in the "cut and fill", and "buried" cases, alterations in building area were necessary. Heat loss per unit area is a resulting common denominator between all the configurations. Changes of area in the buried building occur because some natural light and ventilation is needed. To accomplish this a courtyard light well is introduced so most interior spaces will have some open edge. In the case of the cut and fill example it was desired to show that earth can be added to roofs in ways other than burial. The earth can be worked so great portions of building can be earth-like and still have ample edge condition for light and air.

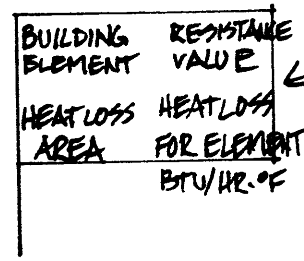
Cut and Fill





CONFIGURATION PROPERTIES

	Mass	Panel	Glazing	Roof Floor	Screen	Req	Btu/Hr°F Conduction
Air Exposed Perimeter		P2 15.6 17500 1122	G2 2.7 17500 6482				7604
Underground Wall	M2 10 11300 1130						1130
Roofs				RF4 13.7 6400 467			467
Earth Covered Roofs				RF7 12 9600 800			800



HEAT LOSS FOR DIFFERENT BUILDING PARTS

Heat Loss		January	March	Season
Loss to Earth	Btu/hr Btu/day Btu/mo	34,700 834,000 25.0×10^6	34,700 834,000 25.0×10^6	275×10^6
Loss to Air	Btu/hr Btu/day Btu/mo	323,000 7.75×10^6 232×10^6	250,000 6.0×10^6 180×10^6	1150×10^6
Total Conduction Heat Loss				1425×10^6
Heat Loss per Season per $Feet^2$				14,000

BASE BUILDING

The base building diagram is a block 100'x160' elongated in the East-West directions. The plan is constant for six floors at which point it narrows to 40'x60' for two additional floors. This results in a total area of 109,000 S.F.

The building is constructed of concrete floor slabs (RF2) and foundation wall (M2). The exposed perimeter wall is calculated for two cases. Glass areas are changed to represent old and modern buildings.

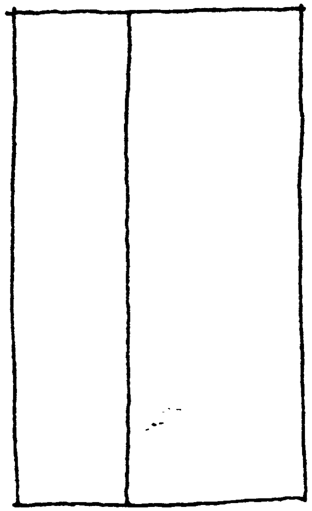
The older masonry building is assumed to have a perimeter composed of 50% single pane glass and 50% masonry cavity wall. In the modern building the amount of glazing is increased to 75%.

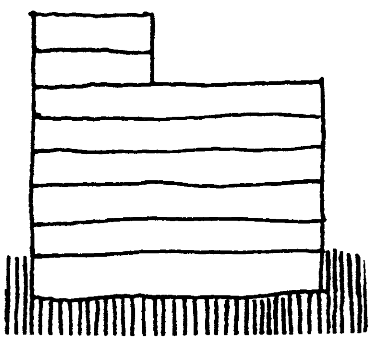
In the base building there is one level below ground which normally is used for a basement. It is possible to make these occupiable spaces if they are designed to be used as such.

We can see from Figure 3.8 that only 15% of the base building could be classified as earth. These buildings are predominantly composed of regions which behave thermally as edges. They will fluctuate in temperature from day to night and need a mechanical system to provide constant condition.

This fluctuation can be decreased if the building is built of mass materials. The concrete construction of the base will serve to store heat in its structure.

Base Building: Old

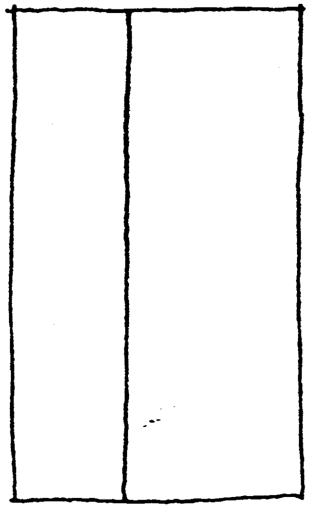




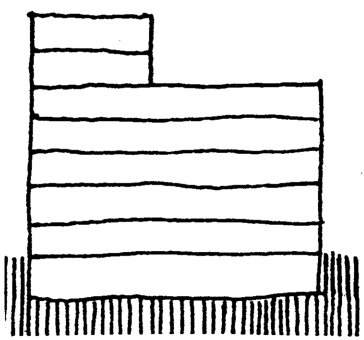
	Mass	Panel	Glazing	Roof Floor	Screen	Req	Btu/Hr °F Conduction
Air Exposed Perimeter	M1 6.8 20,400 3000		G1 1.8 20,400 11300				14,300
Underground Wall	M2 10 6200 620						620
Roofs				RF4 13.7 16000 1168			1168

Heat Loss		January	March	Season
Loss to Earth	Btu/hr Btu/day Btu/mo	11,200 268,000 8.04×10^6	11,200 268,000 8.04×10^6	64.3×10^6
Loss to Air		619,000 14.8×10^6 445×10^6	480,000 11.5×10^6 345×10^6	2210×10^6
Total Conduction Heat Loss				2270×10^6
Heat Loss per Season per $Feet^2$				21,000

Base Building: Modern



	Mass	Panel	Glazing	Roof Floor	Screen	Req	Btu/Hr °F Conduction
Air Exposed Perimeter	M1 6.8 10200 1500		61 1.8 30600 17000				18500
Underground Wall	M2 10 6200 620						6200
Roofs				RF4 13.7 16000 1168			1168



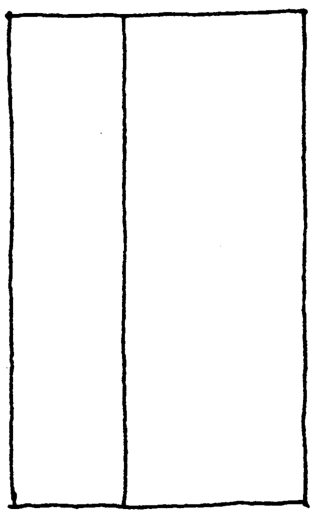
Heat Loss		January	March	Season
Loss to Earth	Btu/hr Btu/day Btu/mo	112,000 268,000 8.04×10^6	112,000 268,000 8.04×10^6	64.3×10^6
Loss to Air	Btu/hr Btu/day Btu/mo	787,000 18.9×10^6 566×10^6	610,000 14.6×10^6 439×10^6	2810×10^6
Total Conduction Heat Loss				2870×10^6
Heat Loss per Season per Feet^2				26,400

2 LEVEL BELOW GRADE

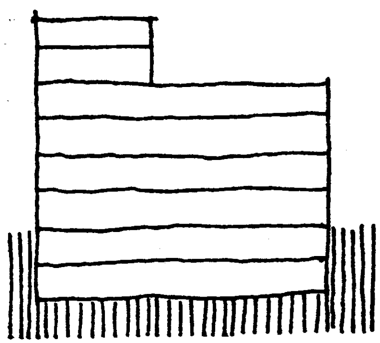
The example cases of earth-like building begins by placing two of the occupied levels below the earth. The glazing is held constant at 50% of the exposed perimeter but is now double glass. A decrease in the overall heat loss per unit area is experienced but with decreased edge opportunity.

The building now can be viewed as being 29% earth-like in thermal stability and 71% edge-like. Ventilation heat losses will become a larger percentage of the heat loss total because conduction losses are decreased over the base building.

2 Level Below Grade



	Mass	Panel	Glazing	Roof Floor	Screen	Req	Btu/Hr°F Conduction
Air exposed Perimeter		P2 15.6 17300 1109	G2 2.7 17300 6407				7500
Underground Wall	M2 10 12500 1250						1250
Roofs				RF4 13.7 16000 1168			1168



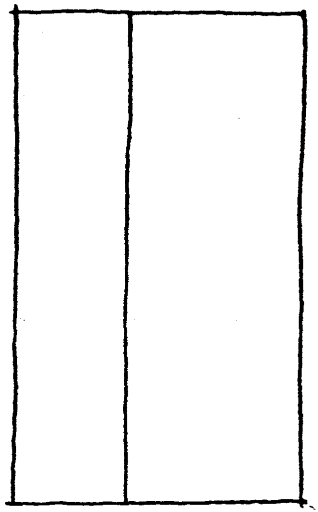
Heat Loss		January	March	Season
Loss to Earth	Btu/hr Btu/day Btu/mo	234,000 562,000 $16.8x10^6$	234,000 562,000 $16.8x10^6$	$134x10^6$
Loss to Air	Btu/hr Btu/day Btu/mo	348,000 $8.55x10^6$ $251x10^6$	270,000 $6.47x10^6$ $194x10^6$	$1240x10^6$
Total Conduction Heat Loss				$1374x10^6$
Heat Loss per Season per $Feet^2$				12,600

Two Levels Below Grade;
1 Level Bermed

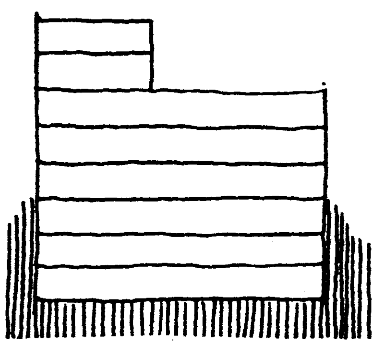
This is a case similar to the previous example with the addition of earth landscaped to cover an additional use level. This level can be punctured to allow light and views were needed. The calculations assume a continuous concrete wall for the three levels covered by earth.

There is a small decrease in energy usage in this configuration over the 2 level below grade example. The thermal behavior of the structure is now 44% earth-like and 56% fluctuating in character.

2 Level Below Grade
1 Level Bermed



	Mass	Panel	Glazing	Roof Floor	Screen	Req	Btu/Hr °F Conduction
Air Exposed Perimeter		P2 15.6 14200 910	G2 2.7 14200 5259				6169
Underground Wall	M2 10 18700 1870						1870
Roofs				RF4 13.7 16000 1168			1168



Heat Loss		January	March	Season
Loss to Earth	Btu/hr Btu/day Btu/mo	33,700 808,000 24.2×10^6	33,700 808,000 24.2×10^6	194×10^6
Loss to Air	Btu/hr Btu/day Btu/mo	294,000 7.04×10^6 211×10^6	227,000 5.46×10^6 164×10^6	1050×10^6
Total Conduction Heat Loss				1240×10^6
Heat Loss per Season per Feet^2				11,400

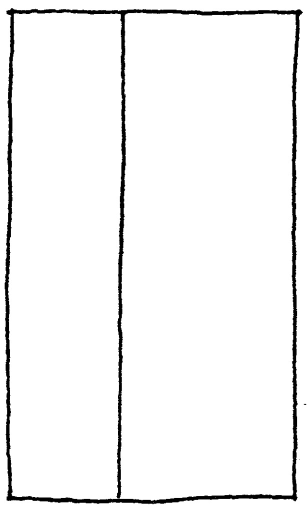
Sloped: 3 Levels to 1 Level Below Grade

The sloped earth example is done to investigate the benefit of covering different elevations with varying amounts of earth. In this example the north elevation is covered up to three levels and the south left relatively open with only 1 level below grade. The east and west elevations have earth terracing at different levels.

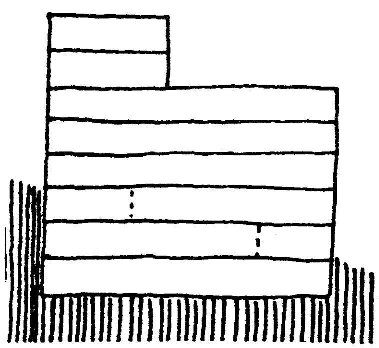
The energy usage in this example is equal to that of the 2 level below grade configuration but exposure to the south is increased. This will allow more sunlight to be utilized in those areas formerly enclosed. The north experiment will also have less surface area exposed to stronger and colder storm winds.

We experience 29% earth-like thermal behavior in this configuration versus 71% edge. We have the edge and earth situation shifted in this example allowing for greater design opportunities. One can take advantage of both enclosed or open zones. The terracing of the earth allows greater access at 3 different levels. This will increase design and organizational opportunities.

Sloped: 3-1 Level Below Grade



	Mass	Panel	Glazing	Roof Floor	Screen	Req	Btu/Hr °F Conduction
Air Exposed Perimeter		P2 15.6 17900 1147	G2 2.7 17900 6630				7777
Underground Wall	M2 10 11300 1130						1130
Roofs				RF4 13.7 16000 1168			1168



Heat Loss		January	March	Season
Loss to Earth	Btu/hr Btu/day Btu/mo	20,300 488,000 14.6×10^6	20,300 488,000 14.6×10^6	117×10^6
Loss to Air	Btu/hr Btu/day Btu/mo	358,000 8.59×10^6 258×10^6	227,000 6.66×10^6 200×10^6	1270×10^6
Total Conduction Heat Loss				1400×10^6
Heat Loss per Season per Feet^2				12,800

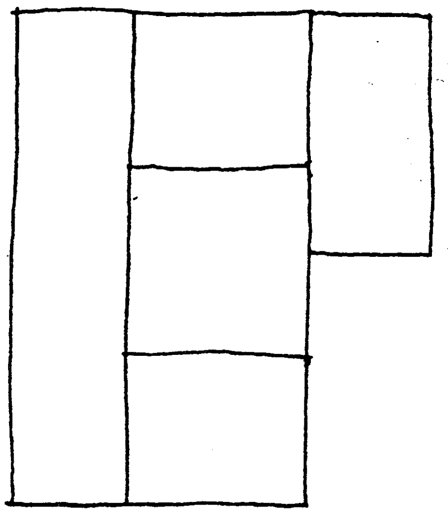
Cut and Fill

The cut and fill example illustrates all three earth forming strategies, excavating, terracing and adding. Here we have increased edge conditions with a small increase in heat loss. The heat loss costs may be traded off with increased edge and solar utilization potentials.

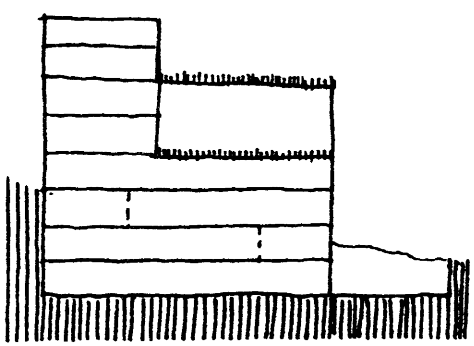
The earth is terraced as in the sloped example with an additional excavation in one corner allowing all levels to have some edge contact. Earth is then added to upper roofs with adjacent use levels taking advantage of the gardens and terraces created. This strategy yields a structure which behaves 41% as earth and 50% as edge.

The act of terracing, excavating and adding creates places which have the earth and edge conditions more closely integrated. This will allow one to take advantage of either at most points. This benefit comes at minimal, if any extra overall energy cost. There will be an added cost due to increased structural loading of the raised earth, however.

Cut and Fill



	Mass	Panel	Glazing	Roof Floor	Screen	Req	Btu/Hr°F Conduction
Air Exposed Perimeter		P2 15.6 17500 1122	G2 2.7 17500 6482				7604
Underground Wall	M2 10 11300 1130						1130
Roofs				RF4 13.7 6400 467			467
Earth Covered Roofs				RF7 12 9600 800			800



Heat Loss		January	March	Season
Loss to Earth	Btu/hr Btu/day Btu/mo	34,700 834,000 25.0×10^6	34,700 834,000 25.0×10^6	275×10^6
Loss to Air	Btu/hr Btu/day Btu/mo	323,000 7.75×10^6 232×10^6	250,000 6.0×10^6 180×10^6	1150×10^6
Total Conduction Heat Loss				1425×10^6
Heat Loss per Season per Feet^2				14,000

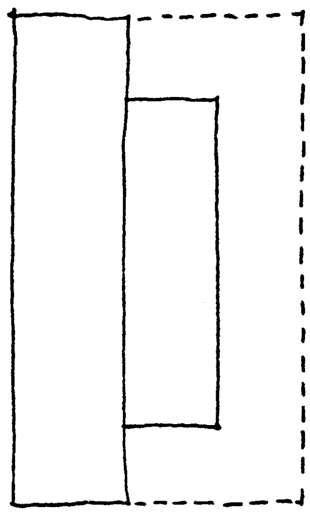
Buried

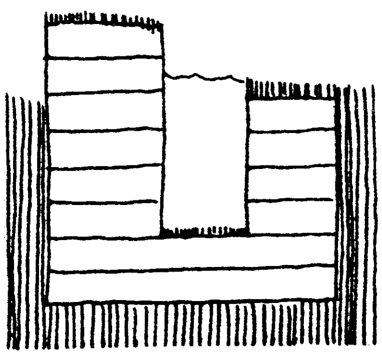
The buried building is the extreme in earth enclosure. The example tested is not totally buried but every horizontal exposed surface is earth covered. The open edges are found in the perimeter walls of the two upper levels and in the added courtyard light well. These were introduced because this designer cannot think of totally burying people. Proponents of this strategy often propose similar open courts, illustrating that underground buildings do not necessarily mean burial.

This example gives only a minimal increase in energy performance over the cut and fill configuration with none of the benefits. It also performs worse than most of the other examples in heat loss figures.

We experience 97% stable thermal behavior in the buried example. This is the only benefit but we no longer have a larger edge opportunity.

Buried





	Mass	Panel	Glazing	Roof Floor	Screen	Re	Btu/HR-°F Conduction
Air Exposed Perimeter		P2 15.6 4800 308	G2 2.7 4800 1778				2086
Courtyard Perimeter		P2 15.6 3100 200	G2 2.7 9400 3472				3672
Underground Wall	M2 10 37400 3740						3740
Buried Roofs				RF7 12 16000 1333			1333

Heat Loss		January	March	Season
Loss to Earth	Btu/hr Btu/day Btu/mo	91,300 2.19×10^6 65.7×10^6	91,300 2.19×10^6 65.7×10^6	526×10^6
Loss to Air	Btu/hr Btu/day Btu/mo	230,000 5.53×10^6 166×10^6	178,000 4.28×10^6 129×10^6	820×10^6
Total Conduction Heat Loss	Btu/year			1346×10^6
Heat Loss per Sq.Ft. Bldg. Area	Btu/year			13,900

THE EDGE

OVERVIEW

Inside: Outside

Temperature Variations

Integrations: Variations vs. Constancy

Shading and Venting

Use Potentials

Orientation

CONFIGURATIONS

Base Building

Solarium 1

Solarium 2

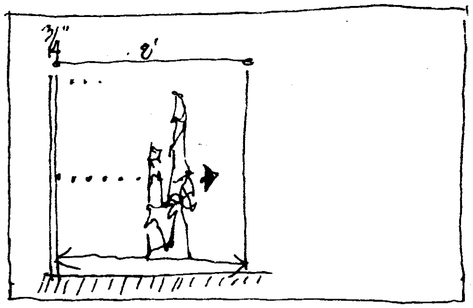
Solarium 3

Solarium 4

INSIDE: OUTSIDE

One example of the articulated edge is the addition of a solarium. This layer of space is similar to adding an overcoat or wind breaker to one's body for that portion of building covered. It can also be looked at as taking a piece of double glazing and separating the glass layers until the space between is large enough to use. This place could also be thought of as a porch or entrance which has been subsequently enclosed so it could be used more often. It may also be the bay window which projects beyond the regular building edge to intercept more light and encounter more views.

All of these produce a boundary between what was normally inside and outside. These articulations create a place whose thermal conditions and spatial dimensions are in variation to those of the base. What is functioning to let light in can provide views and special



place. What was functioning to provide added insulation can be expanded to allow a use. The opportunity suggested by the partial enclosed porch is a space which allows more activity area with minimal additional expense. These additions also create zones whose thermal conditions are between the extreme of inside and outside. As seasons and configurations vary, different environments will be present in this space. The extent to which these are usable depends upon the strategies employed to accept and regulate the climatic forces they are exposed to.

TEMPERATURE VARIATIONS

The layering of a building's edge can create variations in both physical space and thermal conditions. These added layers need not be of the same construction as the core to which they are attached. The use of light weight building technologies, such as panels, glazing, and screens will produce a place whose characteristics directly reflect and fluctuate with adjacent external conditions.

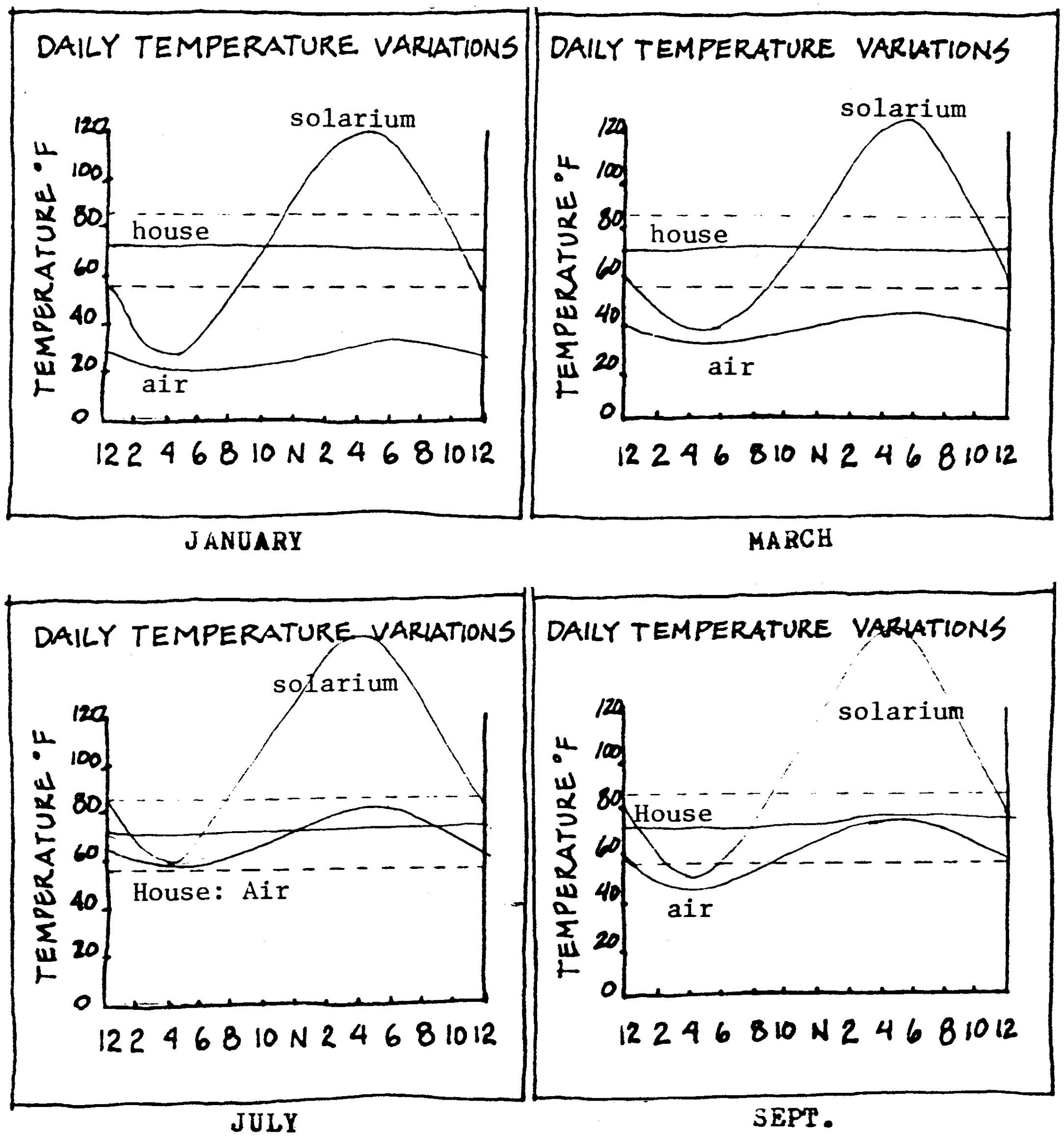
The existence of thermal variations and physical differences in these places suggests that these are the regions in which buildings offer the greatest potential for inhabitation, individual choice and alteration. Extenal fluctuations in temperature insolation, wind and moisture directly affect the character of these peripheral spaces and create a need and opportunity for different mechanisms to control these forces. The level of control is usually most effective at the human scale. Shades, wind scoops, windows, etc. all have the potential to be directly operable by people and are very effective in mediating conditions between inside and outside.

The addition of a room or built layer of single pane glass to the south side of a building will provide a zone which fluctuates greatly in temperature through the seasons as well as from day to night. We can see the extremes which this zone will experience if no provisions are made for heating, ventilating, or shading in Figure 4.1.
These figures are based upon the assumption there is no interconnection between the new layer and the base building.

We can see from these graphs that conditions in a room constructed of light weight will always be near those of the exterior environment unless acted upon by another force, such as sunlight. Seasonal temperature variations for the attached, but separated, solarium range from a low of 22°F at night in January to 154°F during sunny summer days. The high temperatures during the summer months result from calculations which assume no venting or shading (discussed later). These conditions occur when ambient temperatures are 20°F and 80°F respectively.

We can see that temperatures at night almost return to those of the outside if we have no heat source. During the average day we find that the solarium heats up greatly due to incident sunlight. Day to night solarium temperature fluctuations remain relatively constant at 90°-100°F throughout the year. Air temperature at the same time varies approximately 10-20°. From these graphs we can see that there are times when this space is either too

FIG. 4.1 EXTREMES IN THERMALLY ISOLATED SOLARIUM (#1)



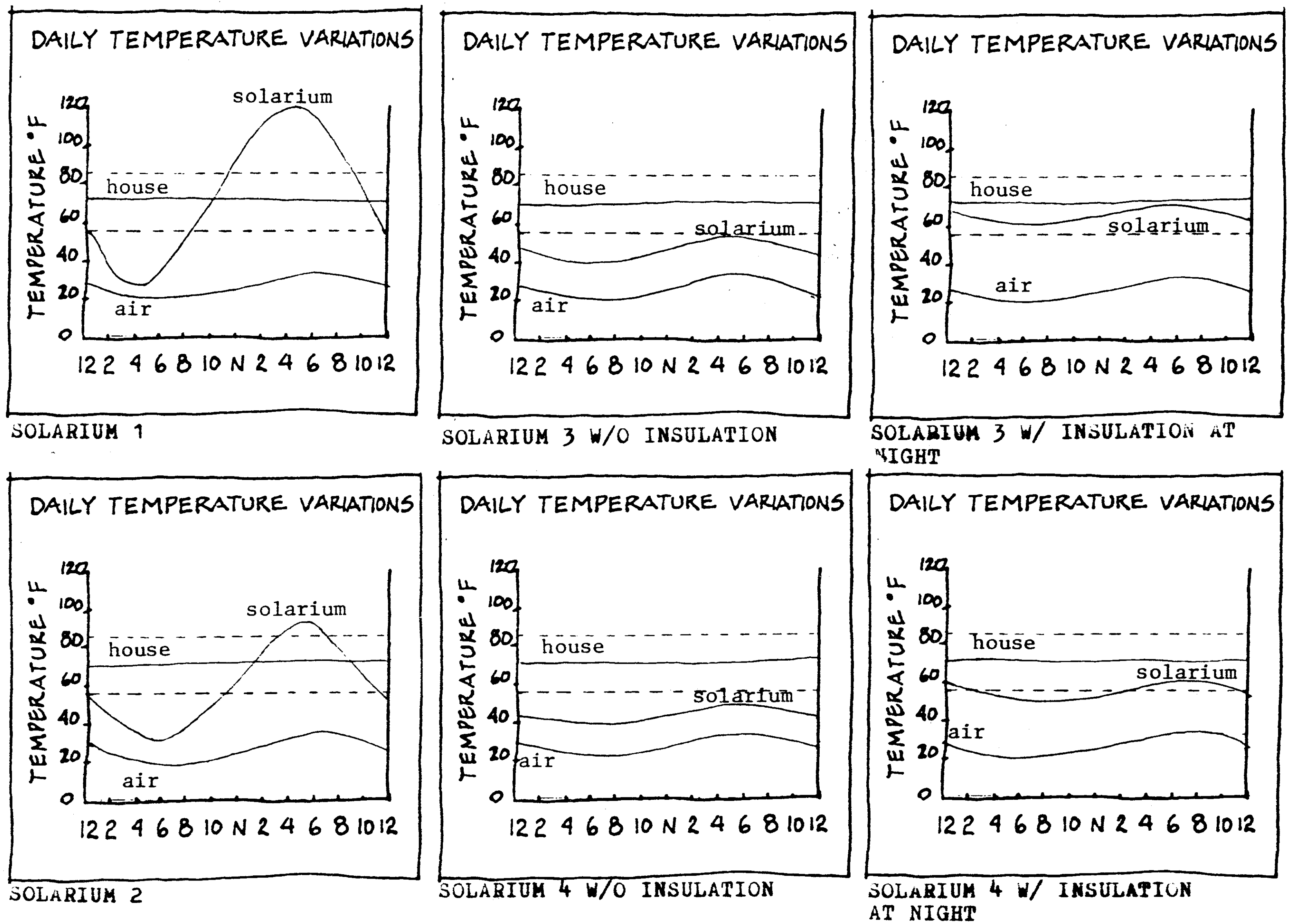
cold or too hot for use without some additional moderating controls. The amount of time it is too cold versus too hot depends upon the season but even in January we experience both extreme conditions. Variations in temperature can be useful, but violent extremes may be intolerable. What we would like, is a flattening of this variation curve so that temperatures may fall within a usable range more often. At the same time we would like to accomplish this without wasting the energy gained during overheated periods or adding additional energy to prevent extreme cooling.

INTEGRATION: VARIATION VS. CONSTANCY

Glazing and panels exhibit characteristics of variation whereas mass walls and elements constitute stabilization or constancy. If we can combine these qualities we result in a dampened fluctuation in extremes without energy loss. Just as we add mass materials to stabilize the space within itself, we can begin to increase integration of the solarium with the relatively constant base.

The integration of the solarium addition with the base building takes place on several levels.
The breaking down of physical separation increases light and views as well as heat flows. The integration of activity and function along this edge takes place as visual and thermal connections are increased. Continuity in use and connection to the

FIG. 4.2 EFFECTS OF SOLARIUM INTEGRATION WITH BASE BUILDING: JANUARY CONDITIONS



landscape are promoted.

We see what the thermal impacts of this integration are in the solarium examples tested. Figure 4.2. Each of these examples becomes successively more thermally connected to the base building.

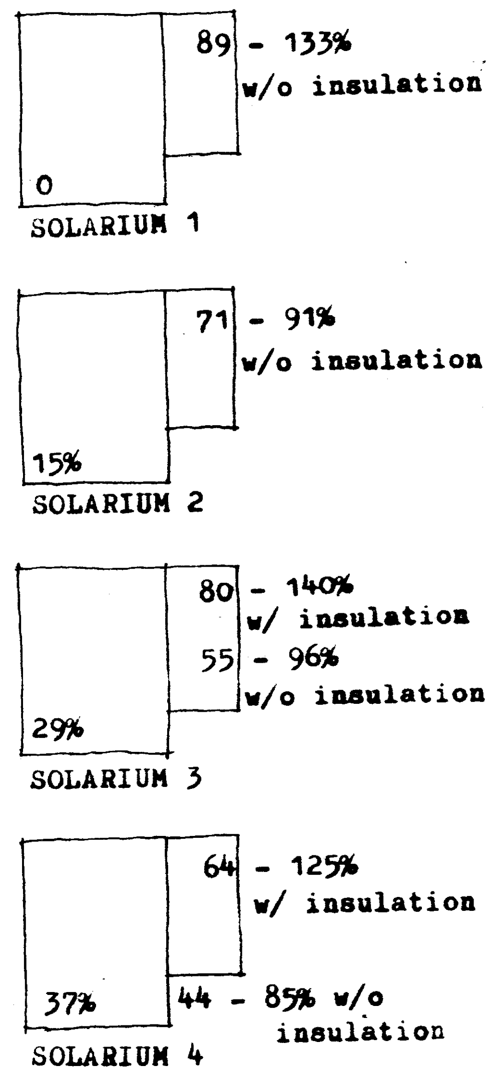
Connection is fostered through several strategies. The use of mass foundation walls which are part of the base structure tend to stabilize solarium temperatures. Changes in the separating wall include the addition of access doors and glazing which allow some of the insolation effects to be experienced by the interior of the base building directly. The use of a mass wall which is at once both heat storage and transparent allows views and light plus temperature stabilization. The addition of a moveable layer of insulation on the exterior solarium wall will isolate the space from outside temperature extremes. This causes the solarium to behave open and fluctuating when desired and closed when thermally necessary. The final integration is the connection of the solarium to the base buildings mechanical heating-ventilating system. Those portions of the separating wall not used for windows are assembled as panels and glazing which act as solar collectors to heat the base building. This integration allows overheated times to be controlled as well as cold times to be supplmentary heated if desired. We can see the effect upon the internal solarium conditions as a result of these integrations in Figure 4.2. We can also see the savings in base building energy use due to supplementary heat given off by the solarium or gained directly through layered glazing. Figure 4.3.

USE POTENTIALS

Places built along the edge of a building have various use potentials. Because they will experience seasonal and daily temperature variations activities may change. The timing of activities may depend upon the passively generated conditions. The decision to use many of these spaces may be one of special choice; the choice to sit in the sun, or be in a cooler zone in the evening.

The addition of plants for humidity, beauty, air purification, heat storage or food production is an opportunity if one of the more temperature stable configurations is used.

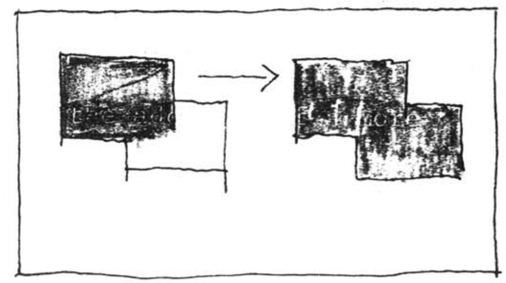
FIG. 4.3 % HEATING LOAD SUPPLIED BY SOLARIUM CONFIGURATIONS

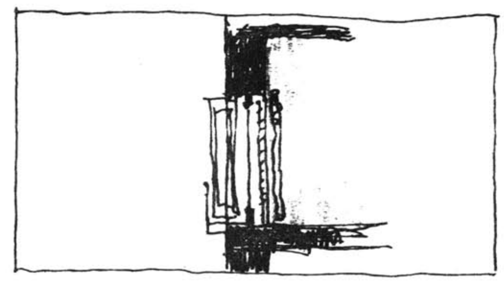


Plants moving in from the landscape promote the continuity between building and landscape desired.

These spaces may be thought of as ancilliary areas. They can be extra spaces derived at little initial cost providing energy savings. When expansion is needed for short times activities can be accommodated. They may be thought of as predominantly day rooms but are useful even at night. When extra space is needed for a party or large numbers of people these spaces are easily utilized. They not only provide extra space and a cool "source" but can be warmed by heat given off by the increased number of people (600-1000Btu/persons hour).

As the need for space increases these places can be utilized. If the need arises for more constant conditions the building's controlled edge may be extended to the extreme layer. These places provide the context for addition or growth.





They are partial places (thermally incomplete) needing only the addition of a more insulating edge to maintain thermal control. Even the great increase in space demand at high density can utilize the benefits of a layered building edge. An assemblage of balcony, shutter, louvre, window and curtain provides the opportunity to respond to most external climatic conditions as well as privacy requirements. The control of these barriers is directly at the individual level with spontaneous response to any alterations. This configuration can be condensed to occupy the same area if density requirements demand more thermal constancy or expanded, as discussed earlier to provide spaces in between.

SHADING AND VENTING

The addition of a solarium to the south side of a building where solar gain is great may cause problems of overheating in the summer months. We can see the high temperatures experienced in the worse case in Figure 4.5 where solarium configuation #1 is not shaded or vented. In this extreme example the solarium will cook at approximately 140°F during parts of the day.

The addition of shading and vegetation will lower the overall incident solar energy absorbed by the solarium. Figure 4.4 shows the amount of sunlight actually experienced when shade is provided in the forms listed.

FIG. 4.4 SHADING COEFFICIENTS of VARIOUS MECHANISMS (amount admitted % total)

Shading Device	Placement Inside	Placement Outside
Vegetation Trees: Light Shading		.50
Metal Venetian Blind	.45	.15
Canvas Shade	.62	.25
Moveable Insulation (white)	.20	

Information from Olgyay "Design with Climate"

The basic strategy is to stop sunlight before it strikes an interior surface. If it is impossible to keep the shading mechanism from the interior of the building, light colored shades should be employed. Articulation of the edge can create places which are shaded in the summer and sunlit in the winter. Overhangs provide such protection and increase the inter-action between inside and out.

Vegetation as a shading mechanism is very effective because it will shade when needed most and allow sun-light to penetrate in the cooler months after the leaves have fallen. It also acts to provide another zone of thermal mediation and spatial definition.

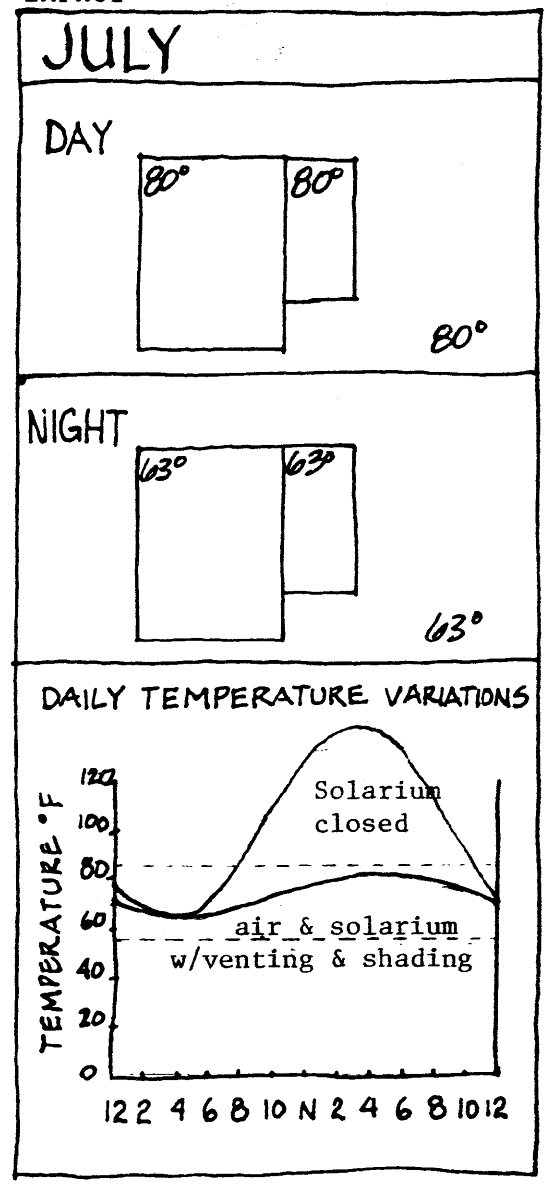
Shading mechanisms such as shade awnings, blinds and movable insulation are also excellent devices because they are directly alterable by the user. Attempts should be made to design enviornments which thermally perform near comfort and allow the user to tune conditions to their desired state. Shading and venting mechanisms which are local in coverage and control should be employed whenever possible.

We can see the effect of various shading strategies in Figure 4.4. The decrease in shading coefficient will result in a proportional reduction in temperature changes in the solarium. Various shading strategies may be employed together to further decrease undesirable summer temperature increases.

Venting is also an attractive option for the solarium. Shading will act to decrease the total energy striking an area and venting will carry off the heated air which results. We can see the effect of venting alone in Figure 4.7 and the combination of shading and venting in Figure 4.5.

Venting is accomplished simply by opening some of the windows in the solarium, building roof vents, or through a mechanical system. Opening windows and roof vents will easily allow adequate air changes to carry

FIG. 4.5 VENTING AND SHADING IMPACT



heated air way. Ten air changes an hour will produce the result in Figure 4.7 but the higher air velocities of breezes will allow even more rapid cooling.

Windows which are operable allow users to adjust to varying conditions of breezes and sunlight. The ability to adjust one's connection to the outside through venting and shading will increase the usability of these places. Where these devices are employed it seems wise to place them near

FIG. 4.6
SHADING IMPACT ON TEMPERATURE

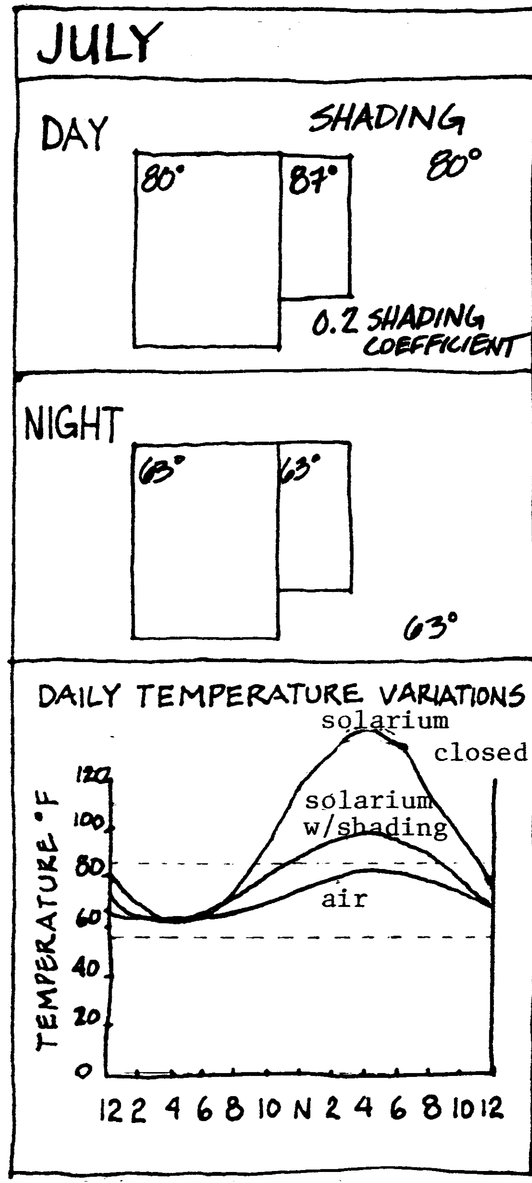
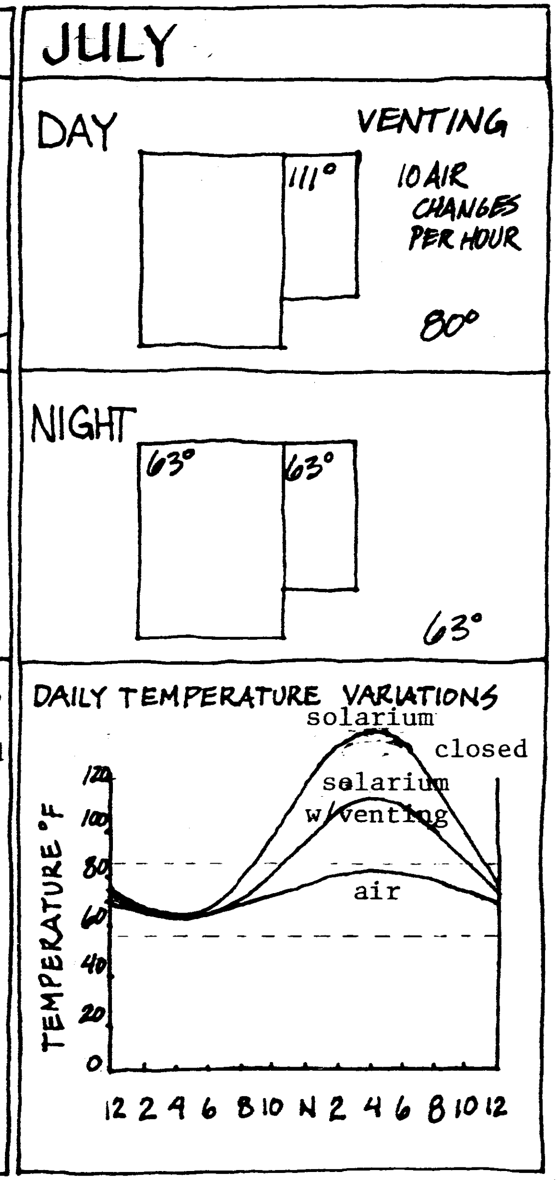


FIG. 4.7
VENTING IMPACT ON TEMPERATURE



the actual place they affect. They should also be accessible to ease their adjustment. Where it is not possible to have a use or direct access to the device, its control should be reachable from the area it influences.

ORIENTATION

The optimal position for maximum solar gain in an attached solarium is on the south elevation. This assumes other facts are equal. Figures 4.8-4.10.

If there are winter shading trees or other obstructions different orientation may be more favorable. When one takes into account solar gain from the summer westerly sun, the optimum orientation becomes shifted to the southeast. Figure

This work does not attempt to investigate optimum orientation and shapes. The conclusions of Olgyay in <u>Design with Climate</u> are suggested for further information. What is important to know is the relative effect of taking

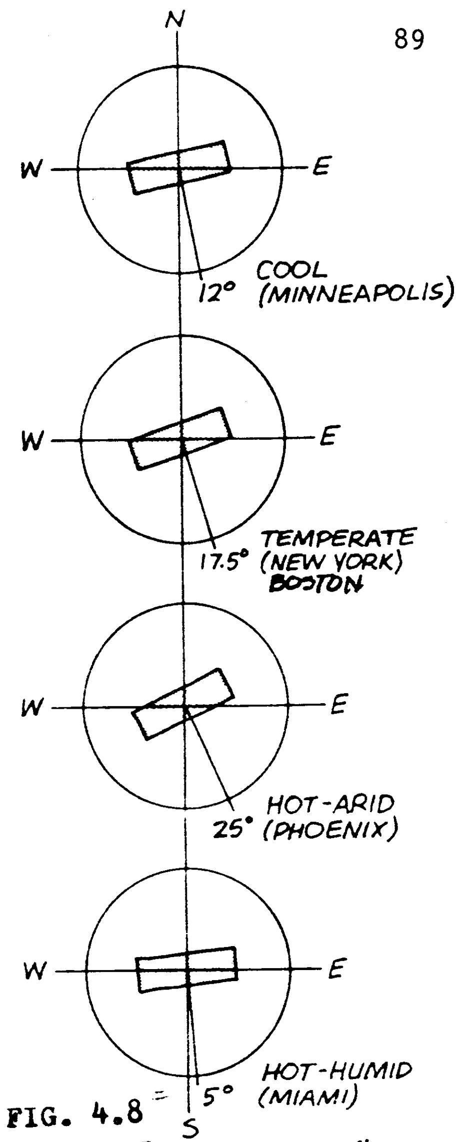


FIG. 4.8

ANDERSON "SOLAR HOME BOOK"

Optimum house orientations for four different U.S. climates.

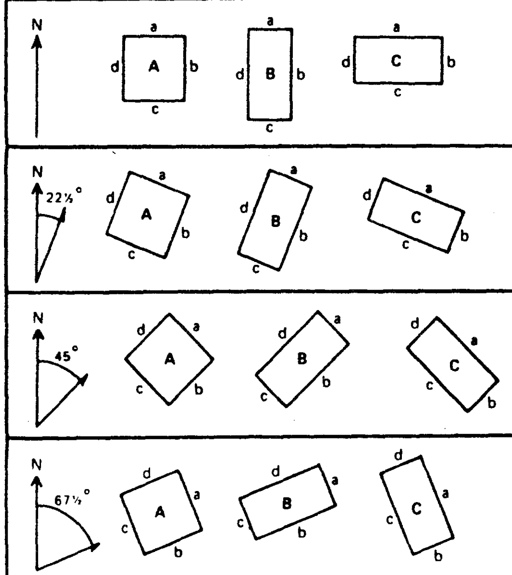
SOLAR HEAT GAIN FACTORS FOR 40°N LATITUDE, WHOLE DAY TOTALS Btu/ft² /day (Values for 21st of each month)												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
N	118	162	224	306	406	**484•**	422	322	232	166	122	98
NNE	123	200	300	400	550	**700•**	550	400	300	200	123	100
NE	127	225	422	654	813	**894•**	821	656	416	226	132	103
ENE	265	439	691	911	1043	**1108•**	1041	903	666	431	260	205
E	508	715	961	1115	1173	1200•†	1163	1090	920	694	504	430
ESE	828	1011	1182	**1218•†**	**1191†**	1179	**1175†**	**1188†**	1131	971	815	748
SE	1174	1285	**1318•**	1199	1068	1007	1047	1163	1266	1234	1151	1104
SSE	1490	**1509•**	1376	1081	848	761	831	1049	1326	1454	1462	1430
S	**1630•†**	**1626†**	**1384†**	978	712	622	694	942	**1344†**	**1566†**	**1596†**	**1482†**
SSW	1490	**1509•**	1370	1081	848	761	831	1049	1326	1454	1462	1430
SW	1174	1285	**1318•**	1199	1068	1007	1047	1163	1266	1234	1151	1104
WSW	828	1011	1182	**1218•†**	**1191†**	1179	**1175†**	**1188†**	1131	971	815	748
W	508	715	961	1115	1173	**1200•†**	1163	1090	920	694	504	430
WNW	265	439	691	911	1043	**1108•**	1041	903	666	431	260	205
NW	127	225	422	658	813	**894•**	821	656	416	226	132	103
NNW	123	200	300	400	550	**700•**	550	400	300	200	123	100
HOR	706	1092	1528	1924	2166	**2242•**	2148	1890	1476	1070	706	564

•month of highest gain for given orientation(s)

†orientation(s) of highest gain in given month

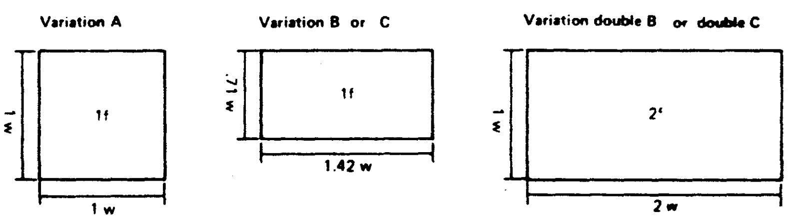
SOURCE: ASHRAE, *Handbook of Fundamentals*, 1970; Koolshade Corporation.

FIG. 4.9



FACADE ORIENTATIONS		INSOLATION ON WALL (Btu/day)				
		a	b	c	d	Total
N	A	118	508	1630	508	2764
	B	84	722	1160	722	2668
	C	168	361	2320	361	3210
	DOUBLE B	118	1016	1630	1016	3780
	DOUBLE C	236	508	3260	508	4612
22½°	A	123	828	1490	265	2406
	B	87	1180	1060	376	2703
	C	174	590	2120	188	3072
	DOUBLE B	123	1656	1490	530	3799
	DOUBLE C	246	828	2980	265	4319
45°	A	127	1174	1174	127	2602
	B	90	1670	835	180	2775
	C	180	835	1670	90	2775
	DOUBLE B	127	2348	1174	254	3903
	DOUBLE C	254	1174	2348	127	3903
67½°	A	265	1490	828	123	2406
	B	188	2120	590	174	3072
	C	376	1060	1180	87	2703
	DOUBLE B	265	2980	828	246	4319
	DOUBLE C	530	1490	1656	123	3799

BUILDING SIZES: RELATIVE WALL AND FLOOR AREAS.



Relative insolation on houses of different shape and orientation – January 21, 40°N Latitude. Listed values represent the insolation on a hypothetical house with w = 1 square foot. To get the daily insolation on a house of similar shape with w = 100 square feet, multiply these numbers by 100.

FIG. 4.10 ANDERSON SOLAR HOME BOOK

the tested south facing solarium configurations and moving them to another facade. Will these places be equally as inhabitable?

East and west orientations receive approximately 30% of the incident solar energy that the south intercepts. Heat gains from this energy is experienced in the morning for the east orientation and afternoon for the west. North orientations will receive approximately 7% of the south total.

We can see the impacts of these solar gains in the daily temperature variation charts for solarium configuration #1 in each of the different elevations. Similar decreases in the maximum temperatures and their timing during the day can be expected for all the configurations. Figs. 4.11, 4.12.

FIG. 4.11
SOUTH ELEVATION SOLARIUM

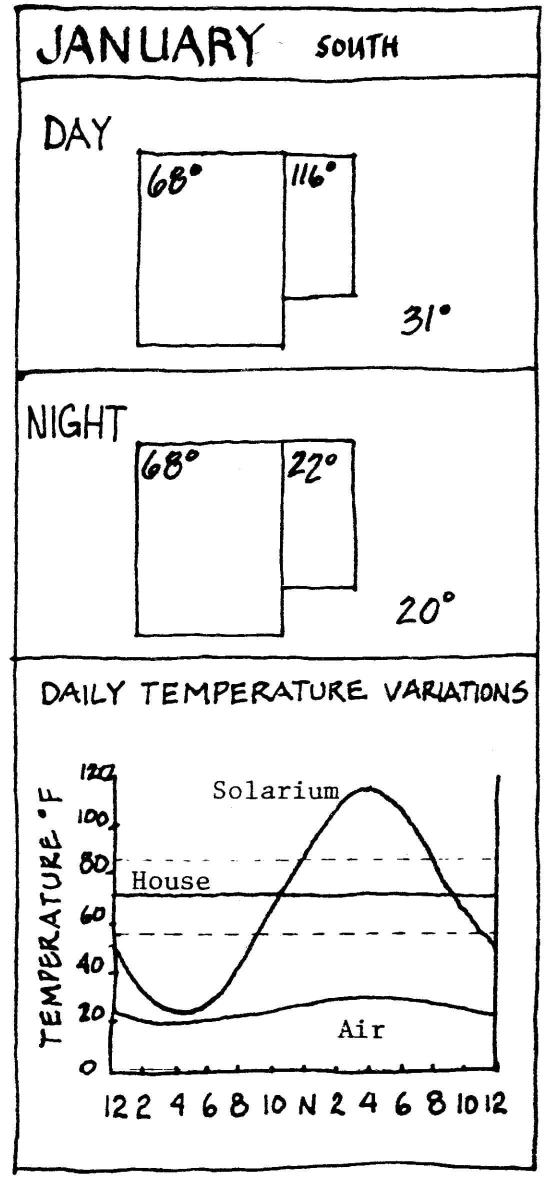
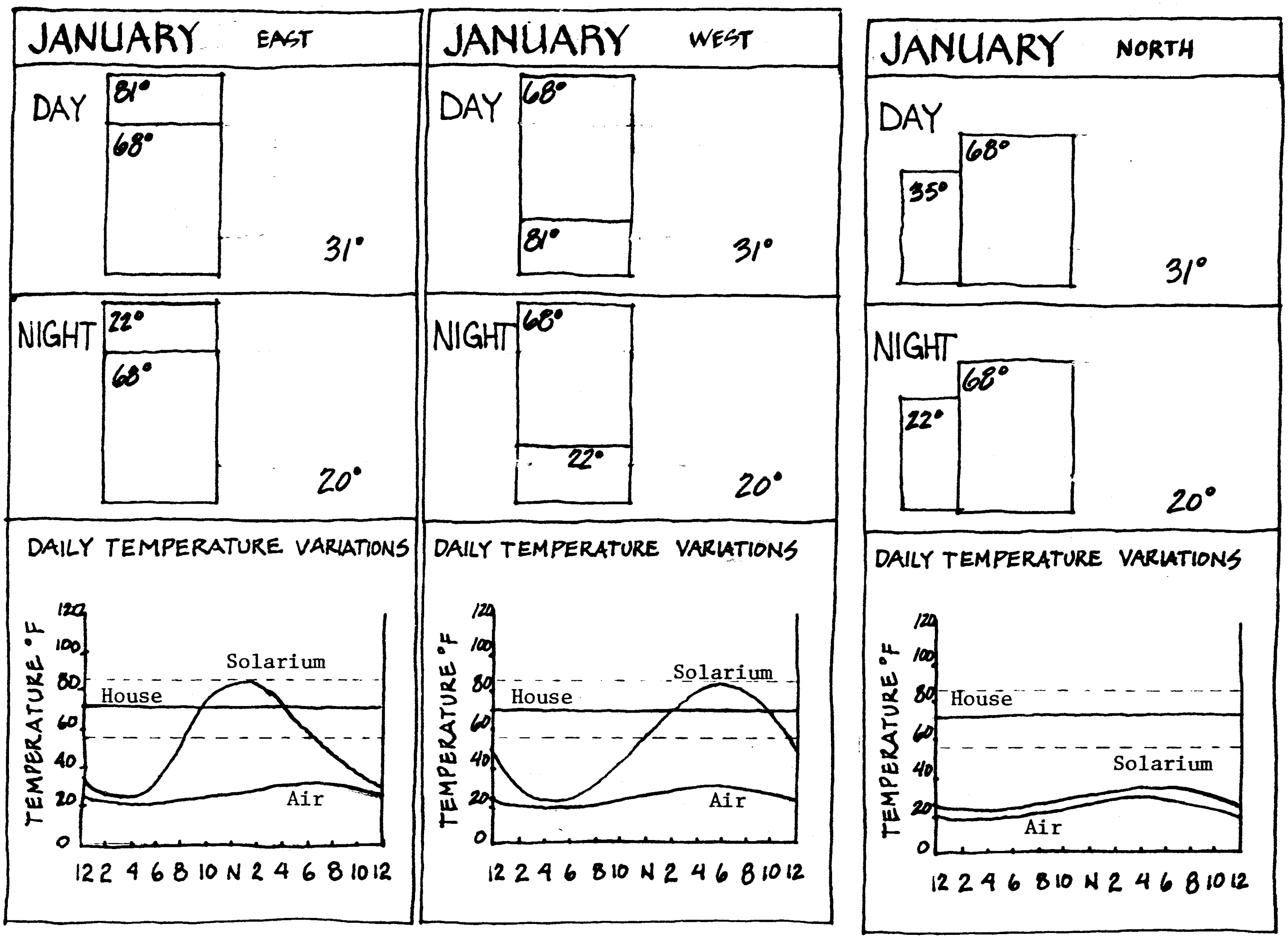


FIG. 4.12 THERMAL CONDITIONS OF SOLARIUMS ON EAST, WEST & NORTH ELEVATIONS



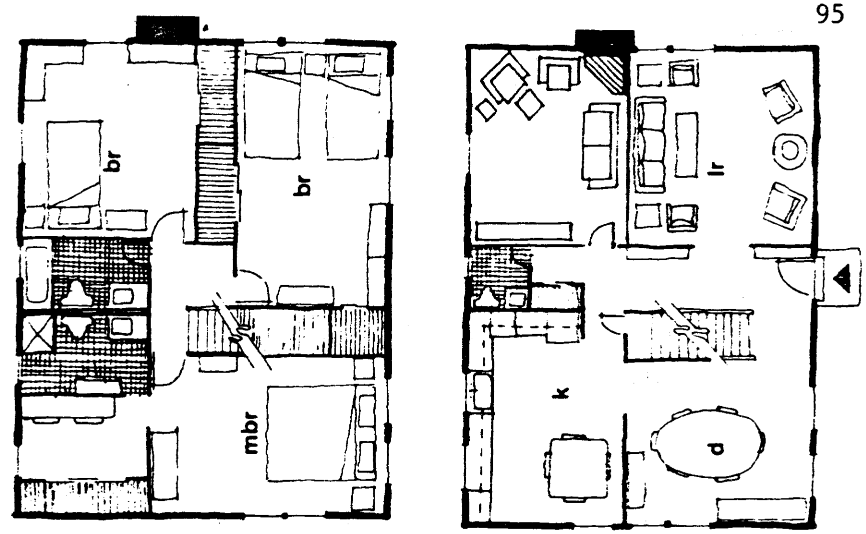
SOLARIUM CONFIGURATIONS

The solarium is one example of an added zone whose temperature and use opportunities will vary. The following examples are diagrams of possible configurations. In each case, the solarium becomes progressively more integrated into the actual workings of the base building.

The base building is a normal two-story, wood-frame structure which is described in Fig. 4.13. The base building remains unchanged in the test examples except for changes in the south wall which separates it from the solarium. A printout sheet is prepared for each configuration. This sheet contains information about the materials used in the south separating wall of the base building and heat loss through these wall sections. The solar gains this structure will experience are given for specific surfaces in daily and monthly totals for January, March, July and September. Interpolation for other months can be done for further calculations one may wish to make. This information is then compared to the heat loss of the solarium and base building to see what the energy saving or deficit is. See Figure 4.14 for page organization.

These calculations are conducted using the noon hour insulation data for average days during the month. This is then reduced by 50% accounting for changes in insolation intensity over the day and reflection losses. This

FIG. 4.13 Base Building
from "Passive Design Ideas for
the Energy Conscious Architect"



Physical Description:

Floor area		1,600 SF
Volume		12,800 CF
Perimeter		114 LF
Exposed surface area:	walls	1,824 SF
	ceilings	800 SF
	total	2,624 SF

Energy Consumption Characteristics (Winter):

Building Element	Area (SF)	"U" Value	Temperature Difference (°F)	Heat Loss (BTUH)	% of Heat Loss
Basement walls	774	4 (SF)		3096	12.2
Basement floor	800	2 (SF)		1600	6.3
Exterior walls	1,429	.068	35	3401	13.4
Windows	342	.504	35	6033	23.8
Glass doors	35	1.13	35	1384	5.5
Solid doors	42	.27	35	397	1.7
Infiltration:					
(CF/hour)	12,200	.018	35	7686	30.3
Ceiling	800	.055	40	1760	6.8

Total BTU/hour	25,357
Total BTU/year	120×10^6
Total BTU/year/SF	75,000

FIG. 4.18a Energy Performance and Characteristics Printout Solarium 4

Solar Gains Btu/hr; Btu/day				
Surface	Jan.	March	July	Sept.
Solarium Floor	15,800 158,000	24,500 294,000	34,600 518,000	24,500 319,000
South Wall M1	9,000 90,000	6,200 74,400	2,300 34,200	6,200 80,600
South Wall P2 and G2 Collector	16,500 165,000	11,500 138,000	4,200 63,000	11,500 150,000
South Wall G2 Direct Gain to Int.	8,500 85,000	5,900 70,800	2,200 32,400	5,900 76,700
Total	49,800 498,000	48,100 577,000	43,300 650,000	48,100 625,000

Heating Load	Btu/day;	Btu/mo.	
Base Building	670,000 20.1×10^6	545,000 16.3×10^6	
Solarium 68° w/insulation 12 hr	383,000 11.5×10^6	296,000 8.89×10^6	
w/o insul.	561,000 16.8×10^6	434,000 13.0×10^6	

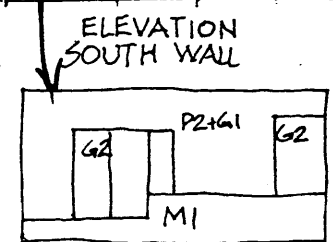
Gains to Building Btu/day; Btu/mo.			
G2 Direct P2+G1 Hybrid	250,000 7.5×10^6	209,000 6.2×10^6	
% Base Bldg Heat Load Supplied	37%	38%	

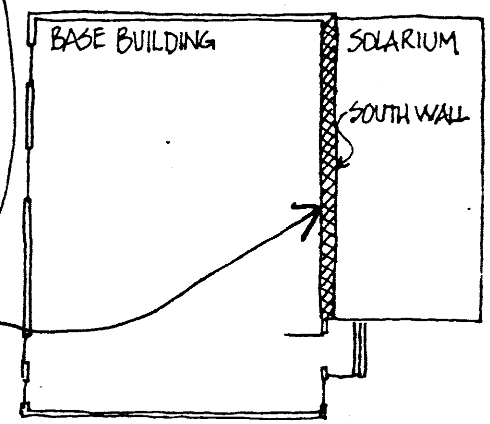
Gains to Solarium Btu/day; Btu/mo.			
Floor M1	248,000 7.44×10^6	368,000 11.1×10^6	
% Solarium Heated Supplied for Solarium 68°	64% with insul. 44% w/o insul.	125% w 12hr insul. 85% w/o insul.	

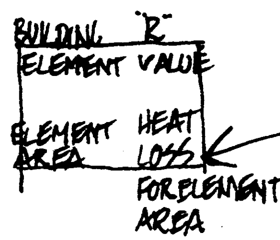
HEAT SUPPLIED TO BASE BUILDING as a % of HEATING LOAD

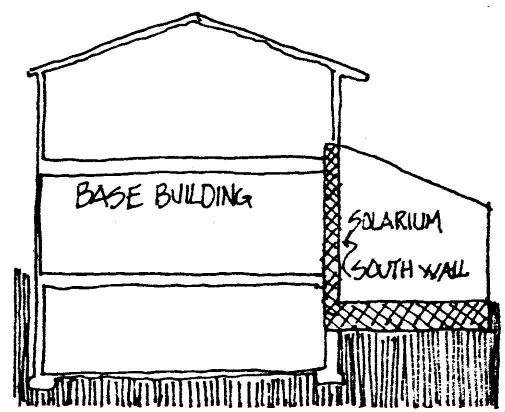
% HEAT SUPPLIED TO KEEP SOLARIUM AT 68°F.

	Mass	Panel	Glazing	Roof	Floor	Screen	Req	Heat Loss Btu/hr°F Con-duction	Infil-tration	Total
South Wall	M1 6.8 76 11.2	P2&G1 17.4 140/8.0	G2 2.7 72/26.7				6.3 288/45.7	45.7	4.3	50.0
Solarium w/o in-sulation			G1 1.8 816/453					453	7300CFH 131	584
Solarium w/insu-lation		G5 10 816/8.6						81.6	7300CFH 131	213









assumes that 50% of the energy striking an area in the configuration will be turned into usable heat. Infiltration rate for the solarium is calculated to be 2 air changes per hour using the crack method. Following the overall performance printout of the simulated configuration is an examination of the interior temperature conditions of these spaces. Temperatures of exterior ambient air, solarium interior temperature, and interior house temperatures are illustrated for the daily extremes and variations over the average day. The dotted horizontal lines represent an adjusted comfort zone between 55°-85°F. This information can be used to illustrate what the process of using the sun passively implies. It will also give some actual printout of conditions in the calculated examples. It is hoped that these implications will be useful to determine materials and dimensions in designing the inhabitable thermal variation desired.

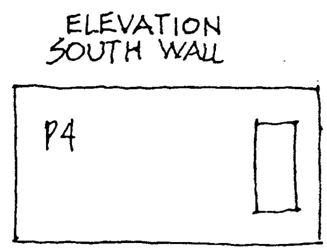
These implications and principles, similarly, apply to larger scaled installations. An approach might be to link many small residential sized areas together in a curtain wall arrangement. These could be connected via the ventilating system of a large building. Each unit could also be independent, working only with its adjacent space. See the design project listed earlier and more detailed "solutions" in the following section.

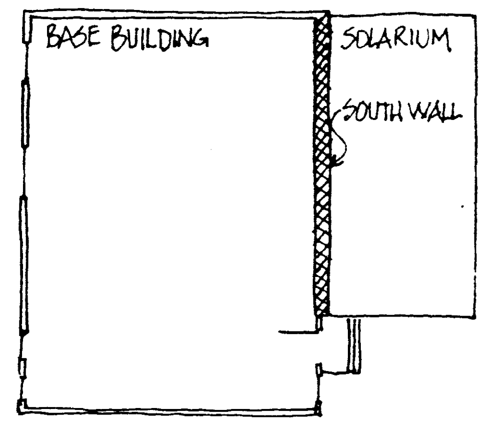
FIG. 4.15a Energy Performance and Characteristics Printout Solarium 1

Solar Gains Btu/hr; Btu/day				
Surface	Jan.	March	July	Sept.
Solarium Floor	15,800 158,000	24,500 294,000	34,600 518,000	24,500 319,000
South Wall	34,000 340,000	23,600 283,000	8,640 130,000	23,600 307,000
Total	49,800 498,000	48,100 577,000	43,200 649,000	48,100 625,000

	Mass	Panel	Glazing	Roof Floor	Screen	Req	Heat Loss Btu/Hr°F Con-duction	Heat Loss Btu/Hr°F Infil-tration	Heat Loss Btu/Hr°F Total
Solarium			G1 1.8 816/453				453	7300CFH 131	584
South Wall		P1 14.3 288 20					20	80 CFH 1.5	21.5

Heating Load Btu/day; Btu/mo.			
	Jan.	March	
Base Building	670,000 20.1×10^6	545,000 16.3×10^6	
Solarium 68°F constant	561,000 16.8×10^6	434,000 13.0×10^6	
Gains to Solarium Btu/day; Btu/mo.			
Floor South Wall	498,000 14.9×10^6	577,000 17.3×10^6	
% Solarium Heat Load Supplied if Kept at 68°	89%	133%	





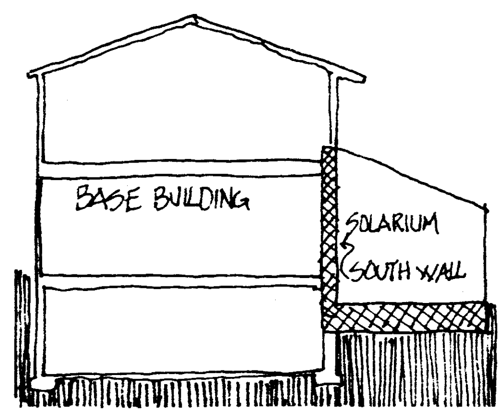
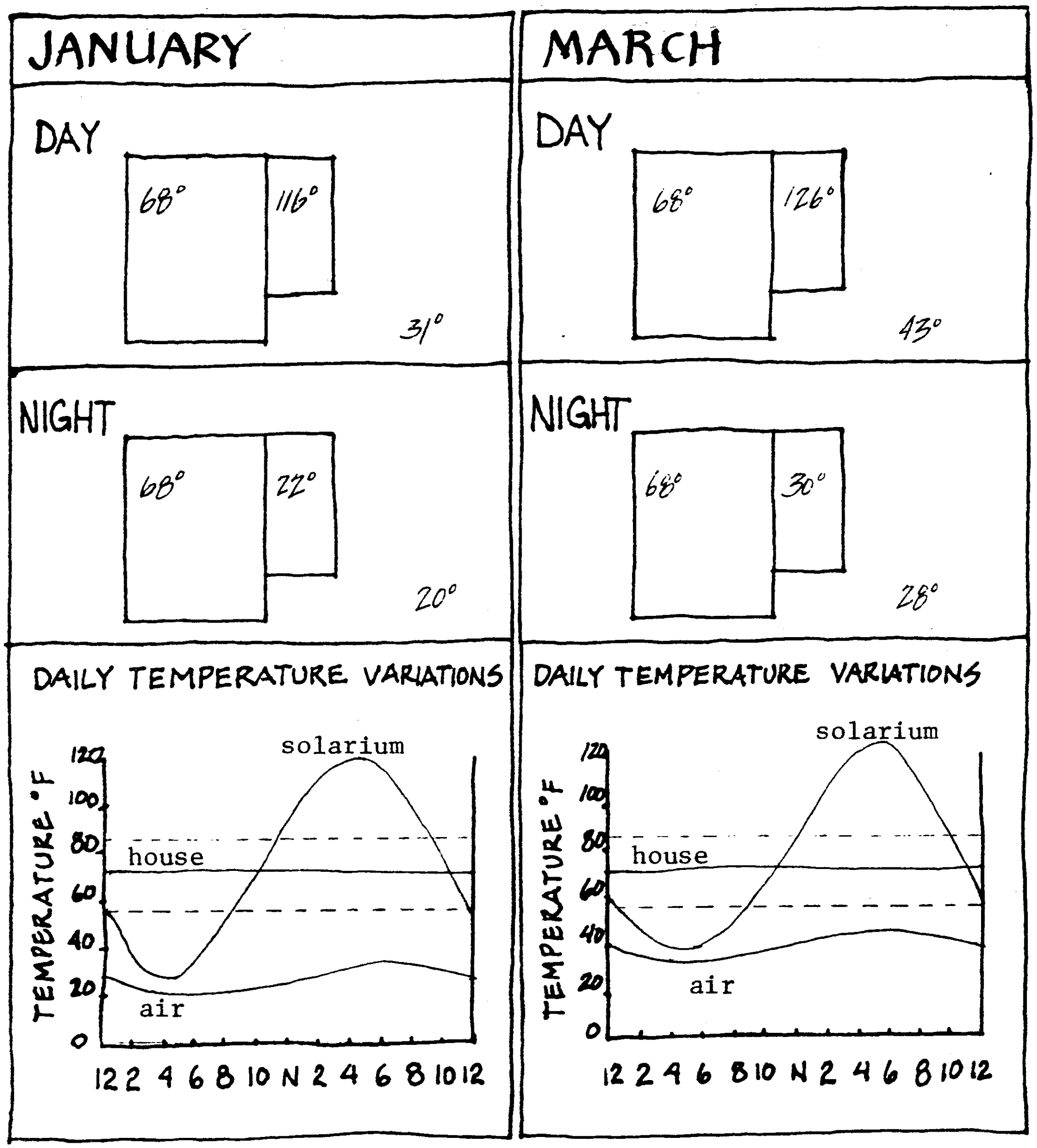
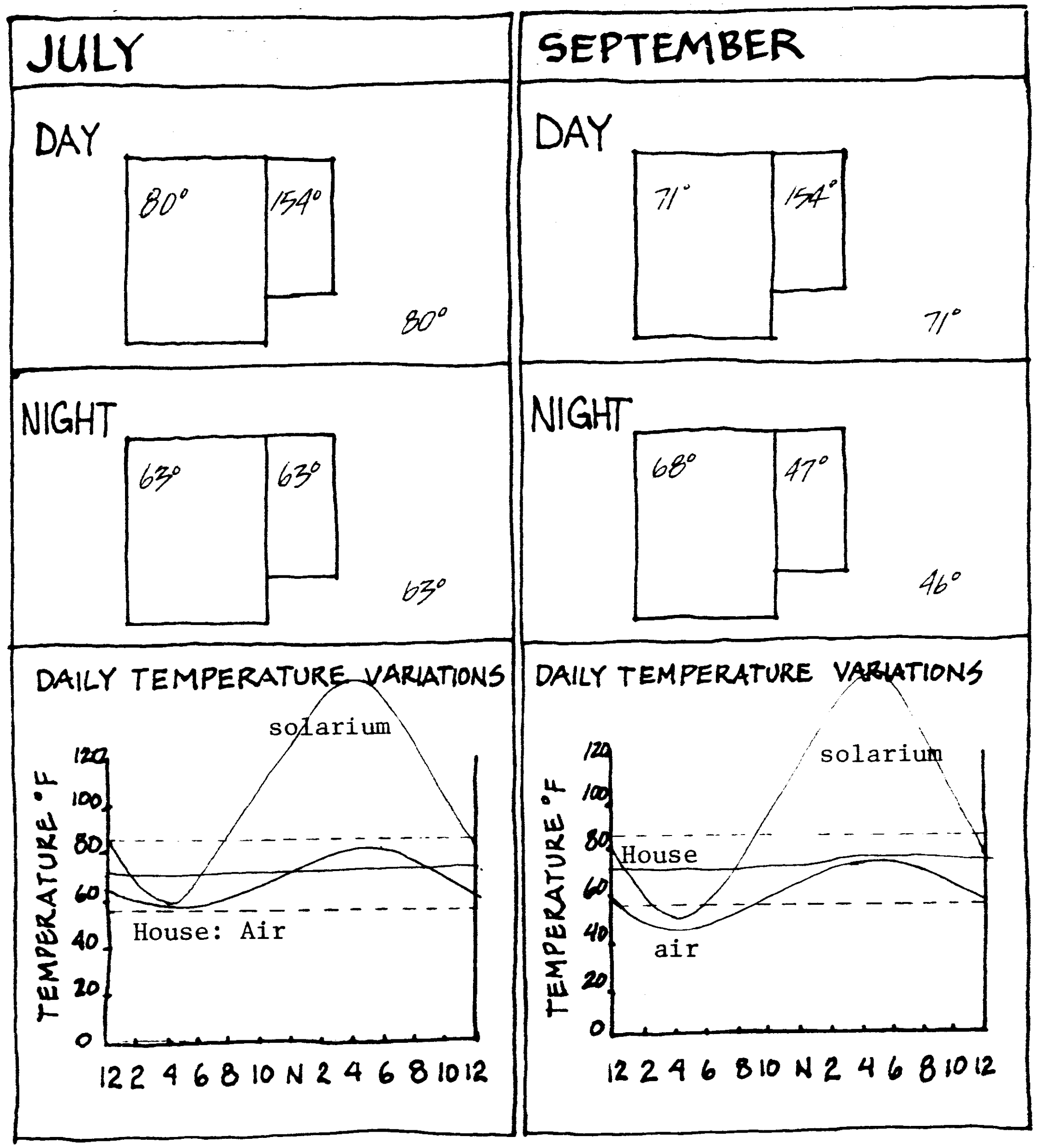


FIG. 4.15b Solarium 1 Temperature Variations



Solarium 1 is basically isolated from the base building except for an access door and insulated shared wall. The interior is thermally isolated from the solarium. The solarium is single glazed and the south wall insulated wood frame construction. It is assumed there is no heat storage capacity in the floor or wall of the solarium. Even with only an access door between the solarium and the base building, some use and energy benefits are possible.

FIG. 4.15c Solarium 1 Temperature Variations



During over-heating times, the door could be opened to supplement house heat. In the cooler evenings, the door could be opened to warm the solarium if extra space was needed. A heating supply register with an openable and closable damper could also be provided.

FIG. 4.16a Energy Performance and Characteristics Printout, Solarium 2

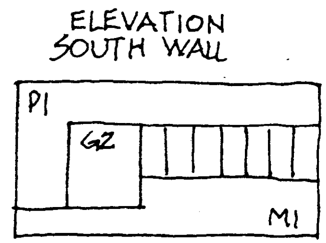
Solar Gains Btu/hr; Btu/day				
Surface	Jan.	March	July	Sept.
Solarium Floor	15,800 158,000	24,500 294,000	34,600 518,000	24,500 318,000
Solarium (So) Wall P1	13,600 136,000	9,450 113,000	3,500 51,800	9,450 123,000
South Wall M1	10,100 101,000	7,080 85,000	2,600 39,000	7,080 92,000
South Wall G2;Direct Gain Inside	10,100 101,000	7,080 85,000	2,600 39,000	7,080 92,000
Total	49,600 496,000	48,100 577,000	43,300 650,000	48,100 625,000

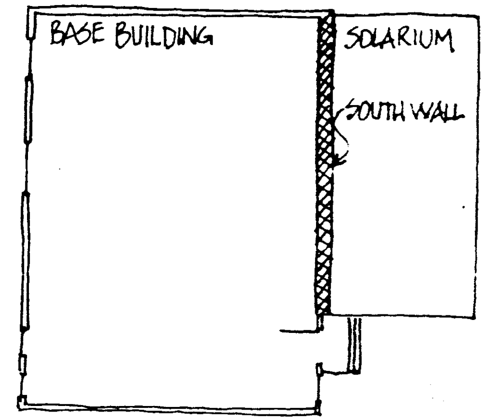
Heating Load	Btu/day;	Btu/mo.	
Base 68° Building	670,000 20.1×10^6	545,000 16.3×10^6	
Solarium if Kept at 68°	561,000 16.8×10^6	434,000 13.0×10^6	

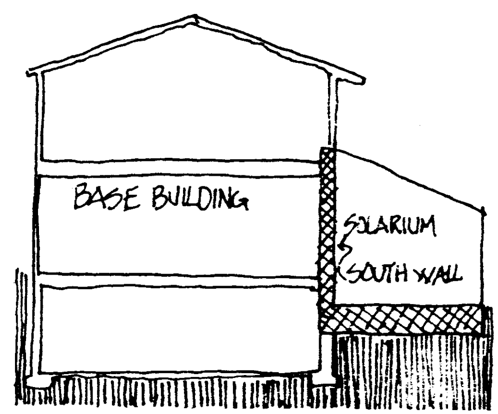
Gains to Building	Btu/day;	Btu/mo.	
G2 Direct South Wall	101,000 3.03×10^6	85,000 2.55×10^6	
% Base Bldg Heat Load Passive Solar Supplied	15%	16%	

Gains to Solarium	Btu/day;	Btu/mo.	
Floor, P1,M1	395,000 11.9×10^6	492,000 14.8×10^6	
% Solarium Heat Load Supplied for Constant 68°	71%	91%	

	Mass	Panel	Glazing	Roof Floor	Screen	Req	Heat Loss Btu/Hr°F Con-duction	Infil-tration	Total
South Wall	M1 G8 90/13.2	P1/14.3 108/7.5	G2/2.7 90/33.3			5.3	54	5.3	59.3
Solarium			G1 1.8 316/453				453	7300CFH 131	584





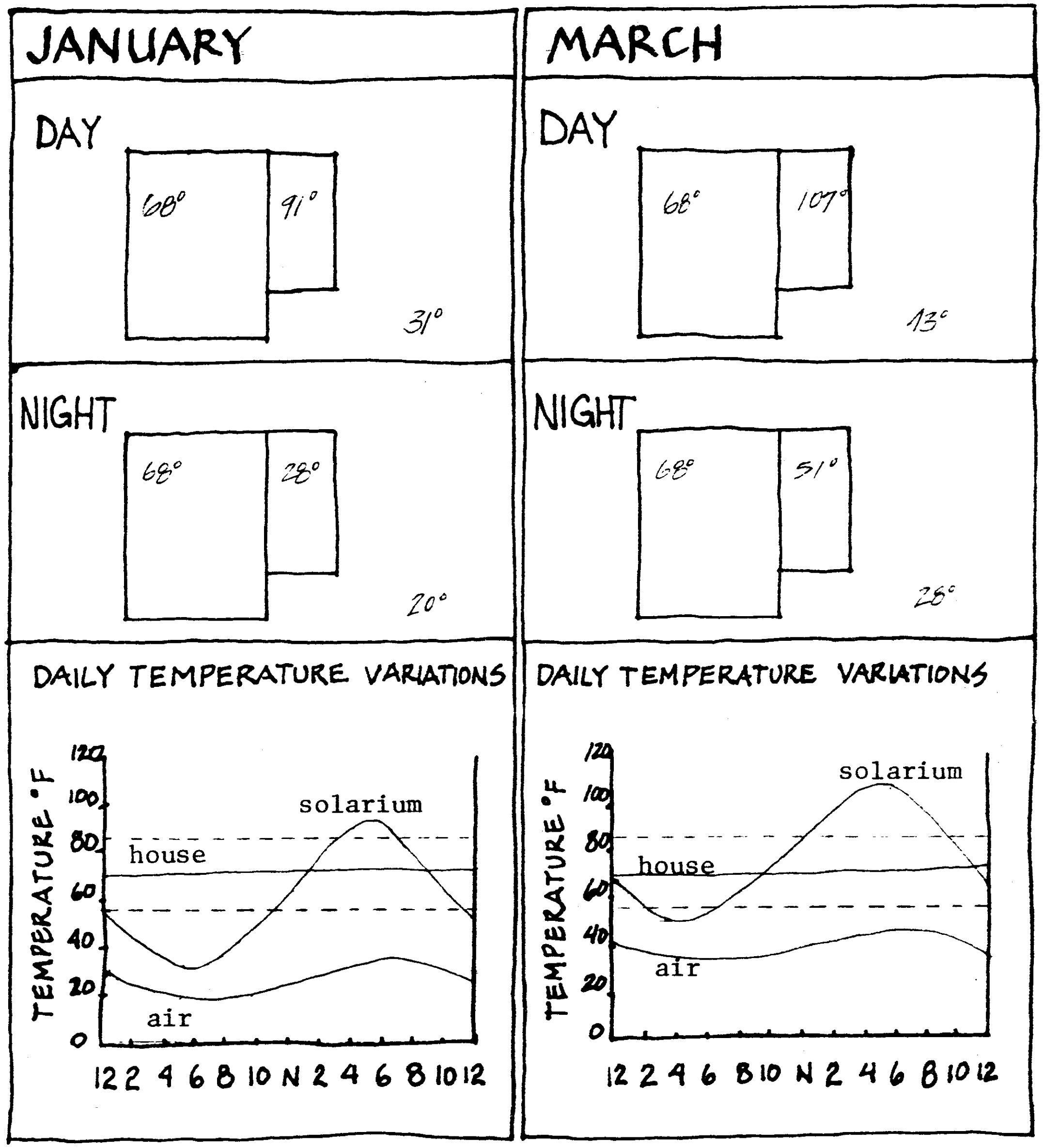


Solarium 2

Solarium 2 begins to become integrated with the base building through the addition of double glazed windows and sliding glass doors in the south wall. The masonry foundation and solarium floor are now being used as heat-storing masses.

In this case, we now experience some direct sunlight and heat gain in the interior of the base house. This is providing 15-16% of the base building's heating requirement. If it was

FIG. 4.16b Solarium 2 Temperature Variations



desired to keep the solarium at a constant 68° (the same as the house), we see that only 10-30% more energy need be added to supplement the sun. The addition of increased connection to the base building and thermal storage mass acts to make the solarium's climate more usable. Opening windows and doors act to thermally and spatially connect the interior to the solarium when desired and isolate it when necessary.

FIG. 4.17 a Energy Performance and Characteristics Printout Solarium 3

Solar Gains Btu/hr; Btu/day				
Surface	Jan.	March	July	Sept.
Solarium Floor	15,800 158,000	24,500 294,000	34,600 518,000	34,500 318,000
South Wall M1	10,600 106,000	7,080 85,000	2,600 39,000	7,080 92,000
South Wall M3	9,200 92,000	6,400 76,800	2,340 35,100	6,400 83,100
Interior Bld Thru Glazing	14,200 142,000	9,840 118,000	3,600 54,000	9,840 128,000
Total	49,800 498,000	47,800 574,000	43,100 647,000	47,800 621,000

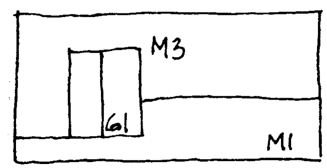
Heating Load Btu/day; Btu/mo.		
Base Building	670,000 20.1×10^6	545,000 16×10^6
Solarium 68° w 12hr insulation	383,000 11.5×10^6	396,000 8.89×10^6
w/o insulat.	561,000 16.8×10^6	434,000 13.0×10^6

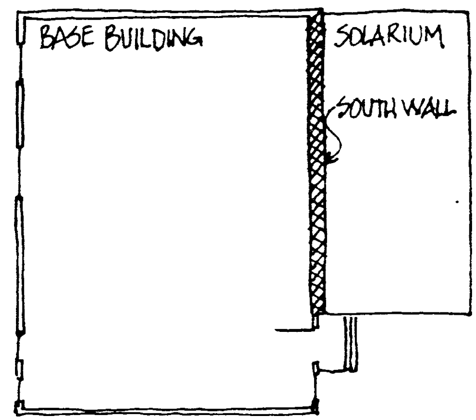
Gains to Building Btu/day; Btu/mo.		
Glazing 50% M3	188,000 5.64×10^6	156,000 4.69×10^6
% of Base Bldg Heat Load Supplied	28%	29%

Gains to Solarium Btu/day; Btu/mo.		
Floor, M1 50% M3	310,000 9.30×10^6	417,000 12.5×10^6
% of Solarium Heat Load if 68° w or w/o Insulation	80% w 12hr ins. 55% w/o insulation	140% w 12hr ins. 96% w/o insulation

	Mass	Panel	Glazing	Roof Floor	Screen	Req	Heat Loss Btu/Hr°F Con-duction	Infil-tration	Total
South Wall	M1 6.8 90/13.2	M3 6.3 156/ 24.8	G1 1.8 42/23.3			4.7 288/ 61.3	61.3	272CFH 4.9	66.2
Solarium w/o insulation			G1 1.8 816/ 453				453	7300CFH 131	584
Solarium w/insulation			G5 10 816/81.6				81.6	131	213

ELEVATION SOUTH WALL





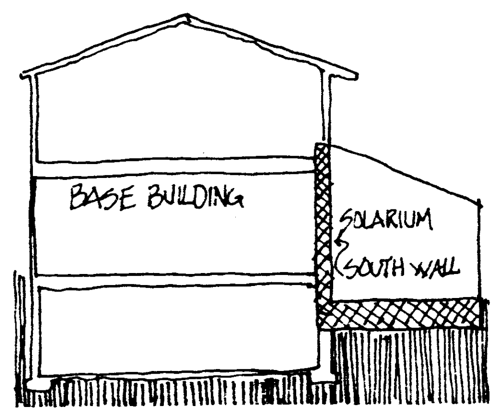
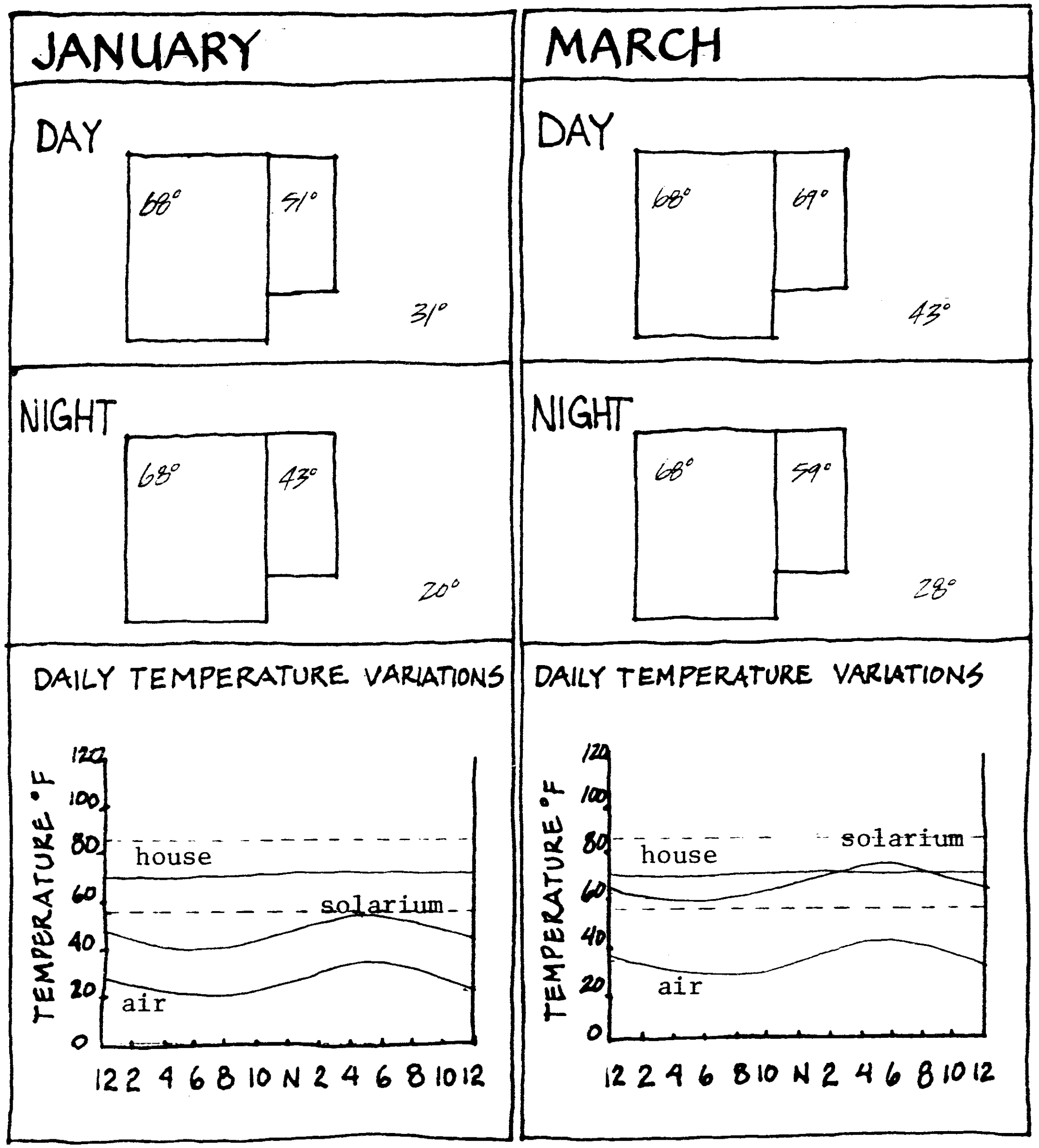


FIG. 4.17b Solarium 3 Temperature Variations (No Insulation)



Solarium 3

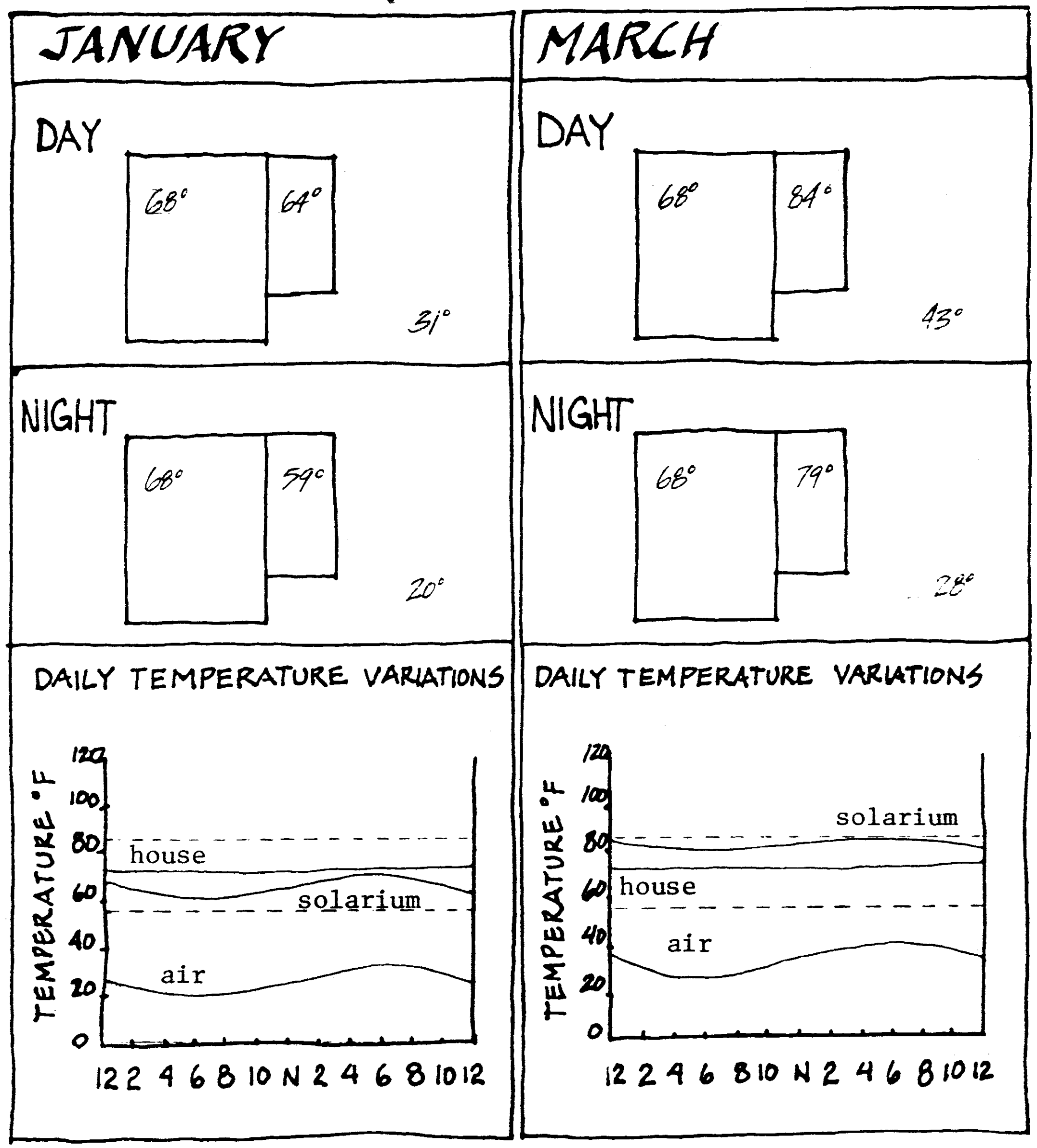
Solarium 3 begins to take actual measures to provide passive solar heat for the base building and solarium. It has also increased visual connection between inside to outside over Solarium 2. The south wall is built of two layers of glass separated by a zone whose area is 50% open and 50% heat storage containers (water bins). This wall becomes a passive solar collector which absorbs heat during the day and radiates to both the solarium and to base building during the night.

Direct sunlight and heat will also be experienced through the transparent sections. Sliding glass access doors are still present to allow activity connection.

The decrease in temperature extremes is due to this thermal mass. The solarium temperatures fall near and in the comfort zone more often than before.

To further increase the usability of this space, a layer of movable insulation

FIG. 4.17c Solarium 3 Temperature Variations (with night insulation)



is added at night which will increase the R-value of the glass wall from 1.8 to 10. This will decrease the heat lost in the evening and result in warmer solarium temperatures. The insulation can also act as a shade in the summer to decrease excessive solar gain by approximately 80%. We can see we are providing 80-140% of the solarium's heating needs if kept at a constant temperature of 68%. The base building is being provided with 28-29% of its winter heating needs with this configuration.

FIG. 4.18a Energy Performance and Characteristics Printout Solarium 4

Solar Gains Btu/hr; Btu/day				
Surface	Jan.	March	July	Sept.
Solarium Floor	15,800 158,000	24,500 294,000	34,600 518,000	24,500 319,000
South Wall M1	9,000 90,000	6,200 74,400	2,300 34,200	6,200 80,600
South Wall P2 and G2 Collector	16,500 165,000	11,500 138,000	4,200 63,000	11,500 150,000
South Wall G2 Direct Gain to Int.	8,500 85,000	5,900 70,800	2,200 32,400	5,900 76,700
Total	49,800 498,000	48,100 577,000	43,300 650,000	48,100 625,000

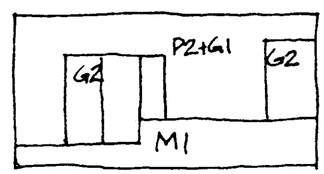
Heating Load	Btu/day;	Btu/mo.	
Base Building	670,000 $20.1x10^6$	545,000 $16.3x10^6$	
Solarium 68° w/insulation	383,000 $11.5x10^6$	296,000 $8.89x10^6$	
12 hr} w/o insul.	561,000 $16.8x10^6$	434,000 $13.0x10^6$	

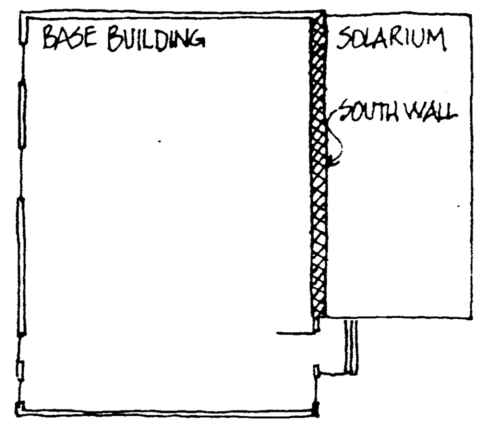
Gains to Building	Btu/day;	Btu/mo.	
G2 Direct P2+G1 Hybrid	250,000 $7.5x10^6$	209,000 $6.2x10^6$	
% Base Bldg Heat Load Supplied	37%	38%	

Gains to Solarium	Btu/day;	Btu/mo.	
Floor M1	248,000 $7.44x10^6$	368,000 $11.1x10^6$	
% Solarium Heated	64% with insul.	125% w 12hr insul.	
Supplied for Solarium 68°	44%w/o insul.	85% w/o insul.	

	Mass	Panel	Glazing	Roof Floor	Screen	Req	Heat Loss Btu/hr°F Con-duction	Infil-tration	Total
South Wall	M1 6.8 76 11.2	P2&G1 17.4 140/8.0	G2 2.7 72/26.7			6.3 288/45.7	45.7	4.3	50.0
Solarium w/o insulation			G1 1.8 816/453				453	7300CFH 131	584
Solarium w/insulation		G5 10 816/8.6					81.6	7300CFH 131	213

ELEVATION SOUTH WALL





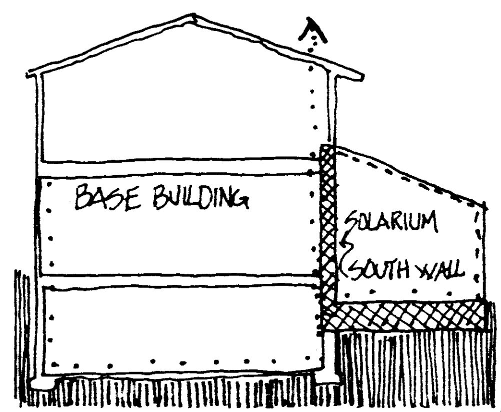
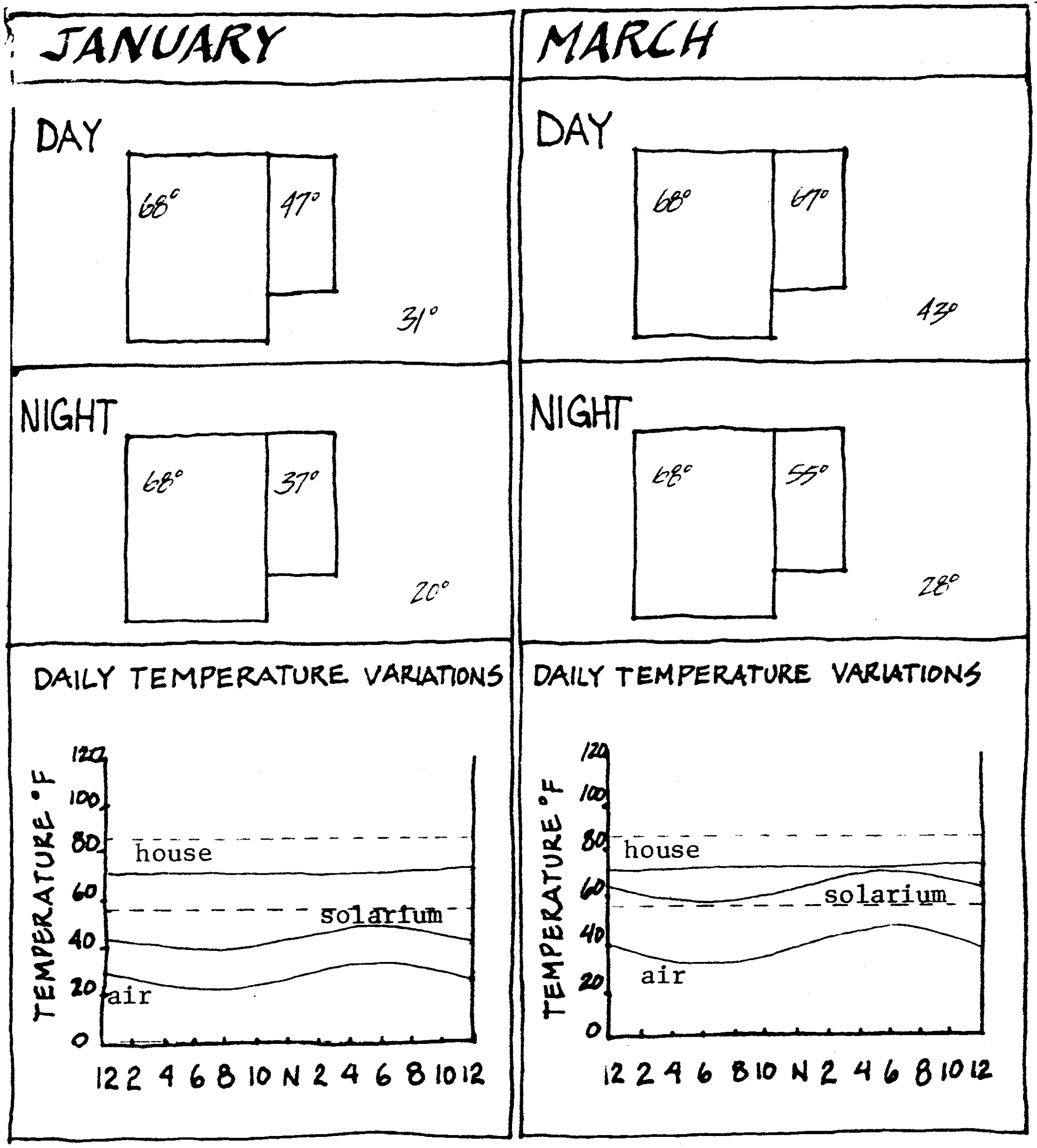
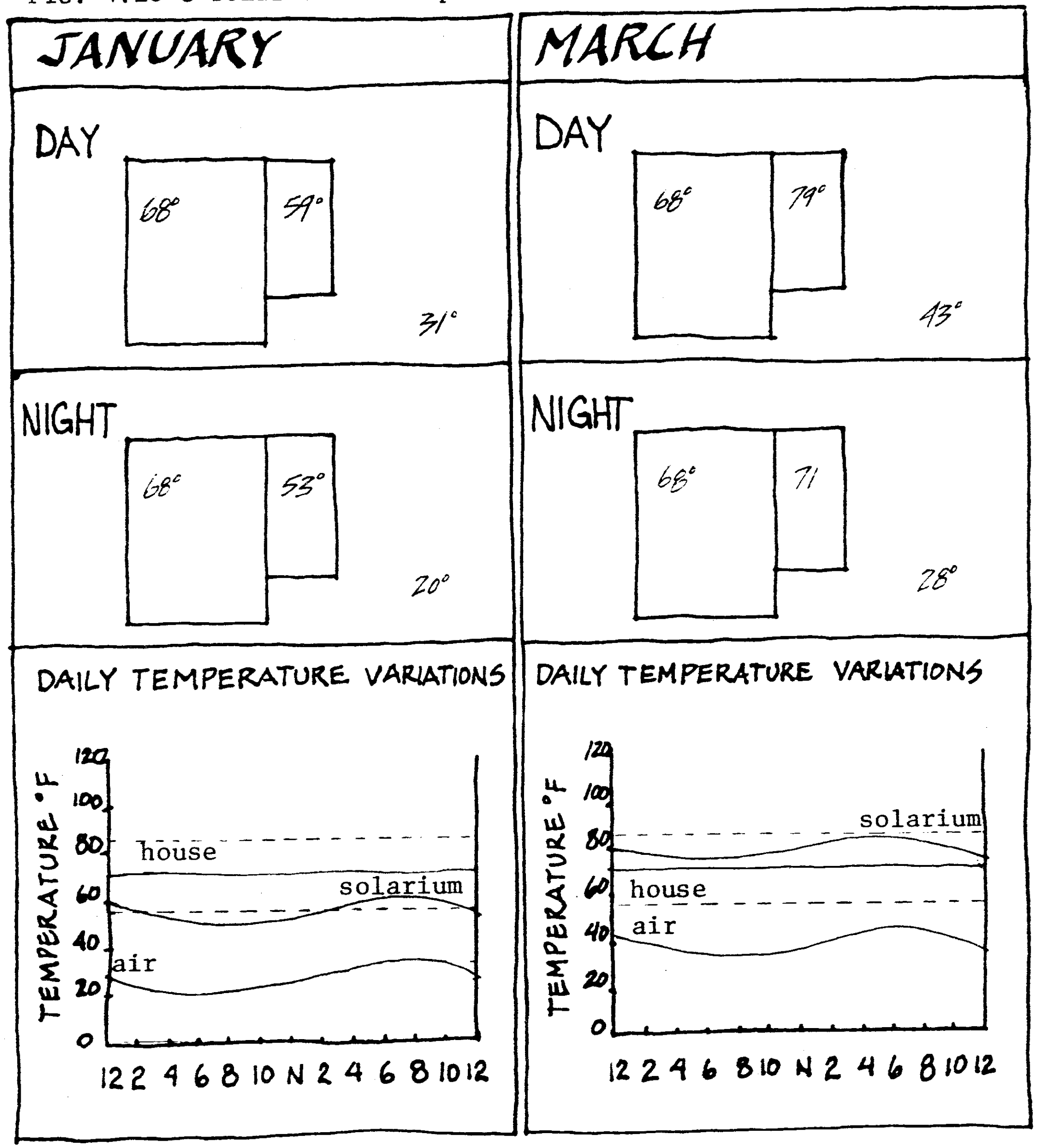


FIG. 4.18b Solarium 4 Temperature Variations (no insulation)



Solarium 4 represents a total integration of energy supply mechanisms between solarium and base building. Direct sunlight and energy gain is supplied to both spaces. Heat storage is taking place in the solarium floors and mass walls. A combination glass and panel wall is assembled on the south wall to create an "active" solar collector. The mechanical air heating system is connected to take warmer air from the solarium and distribute it throughout the base building, or to place it in thermal storage for future use.

FIG. 4.18 c Solarium 4 Temperature Variations (with night insul.)



This air handling system will also allow summer venting for increased cooling. The addition of the insulating panels to the interior glazed surface further increases the livability of the solarium.

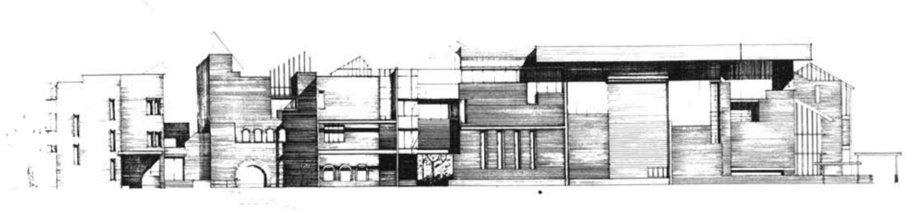
In this configuration 37-38% of the building's winter heating needs are being supplied. We also find 64-125% of the solarium needs are provided if insulation is in place at night and 44-85% if not.

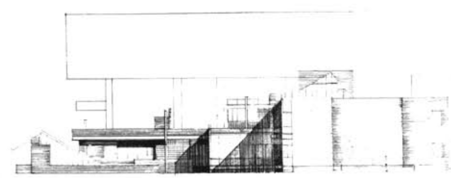
APPENDIX

DRAWINGS

PROGRAM

CALCULATIONS





MASS. AVE. ELEV. & SECTION

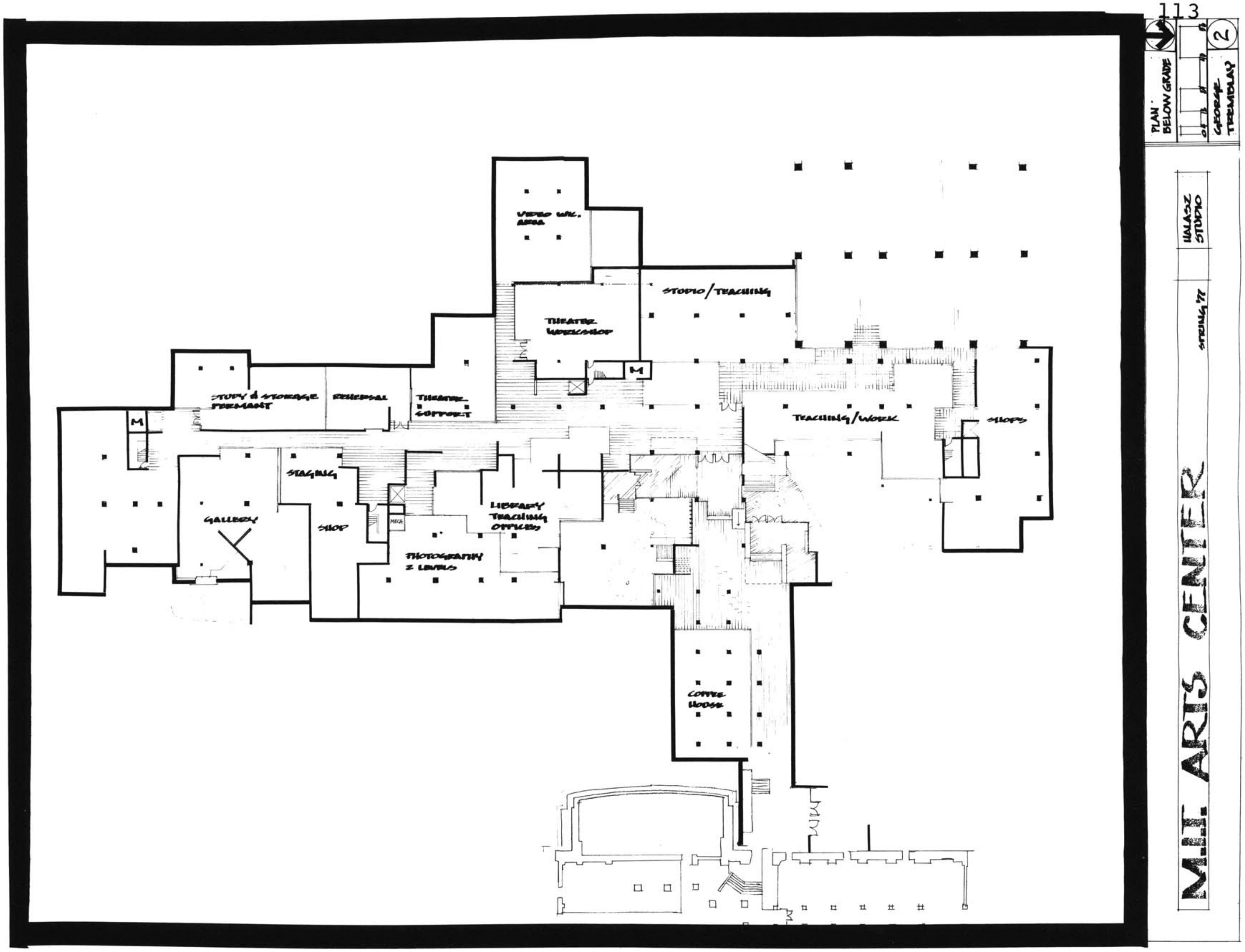
GEORGE TREMBLAY

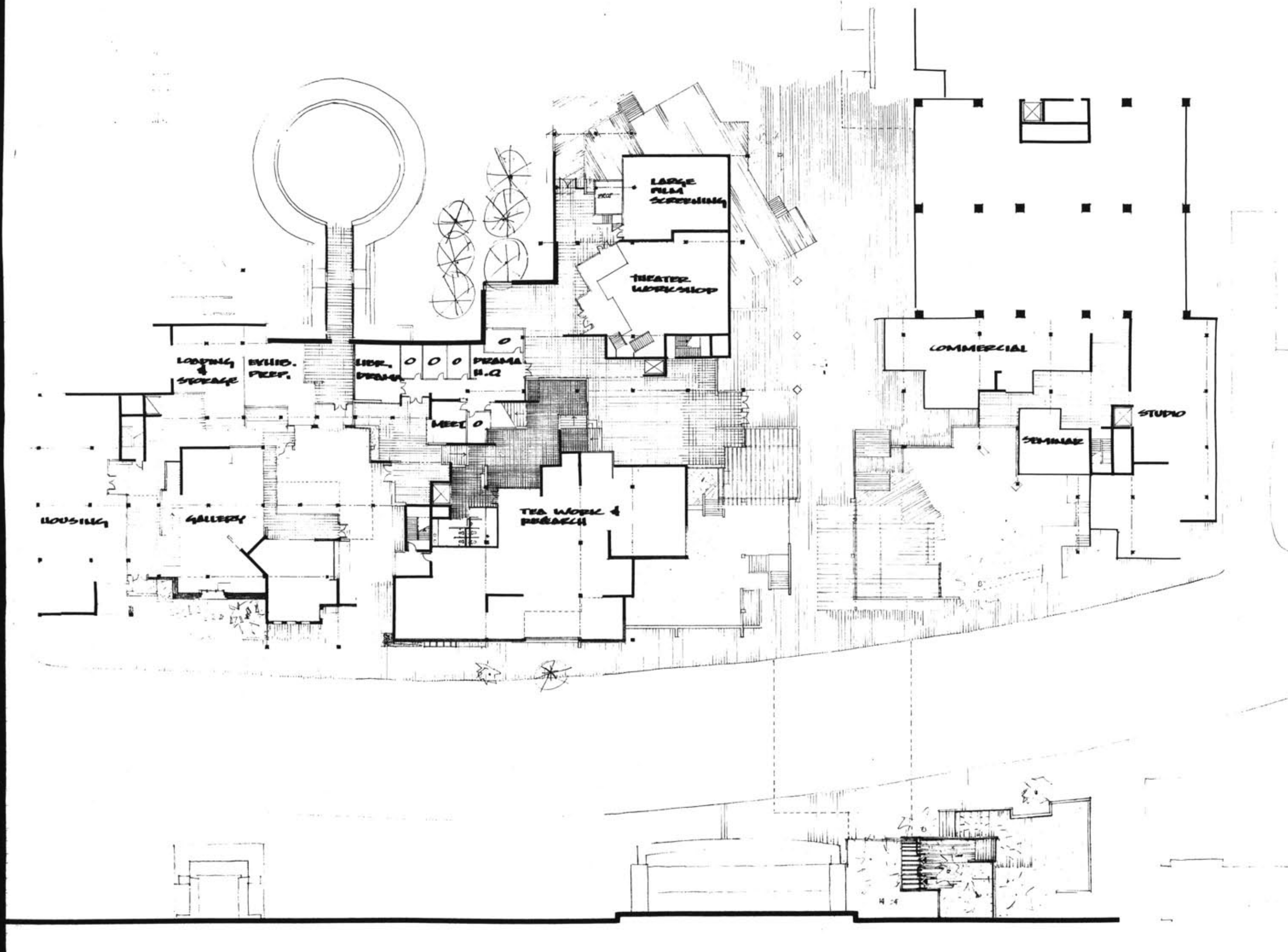
1

HALASZ STUDIO

SPRING '77

MIT ARTS CENTER


VIDEO WK. AREA
STUDIO/TEACHING
THEATER WORKSHOP
M
STUDY & STORAGE PERMANENT
REHEARSAL
THEATER SUPPORT
TEACHING/WORK
SHOPS
STAGING
LIBRARY TEACHING OFFICES
GALLERY
SHOP
MECH
PHOTOGRAPHY 2 LEVELS
COFFEE HOUSE
PLAN · BELOW GRADE
GEORGE TREMBLAY
2
HALASZ STUDIO
SPRING '77
M.I.T. ARTS CENTER



PLAN AT 32'-0"

PLAN @ 32'-0" GRADE REFERENCE

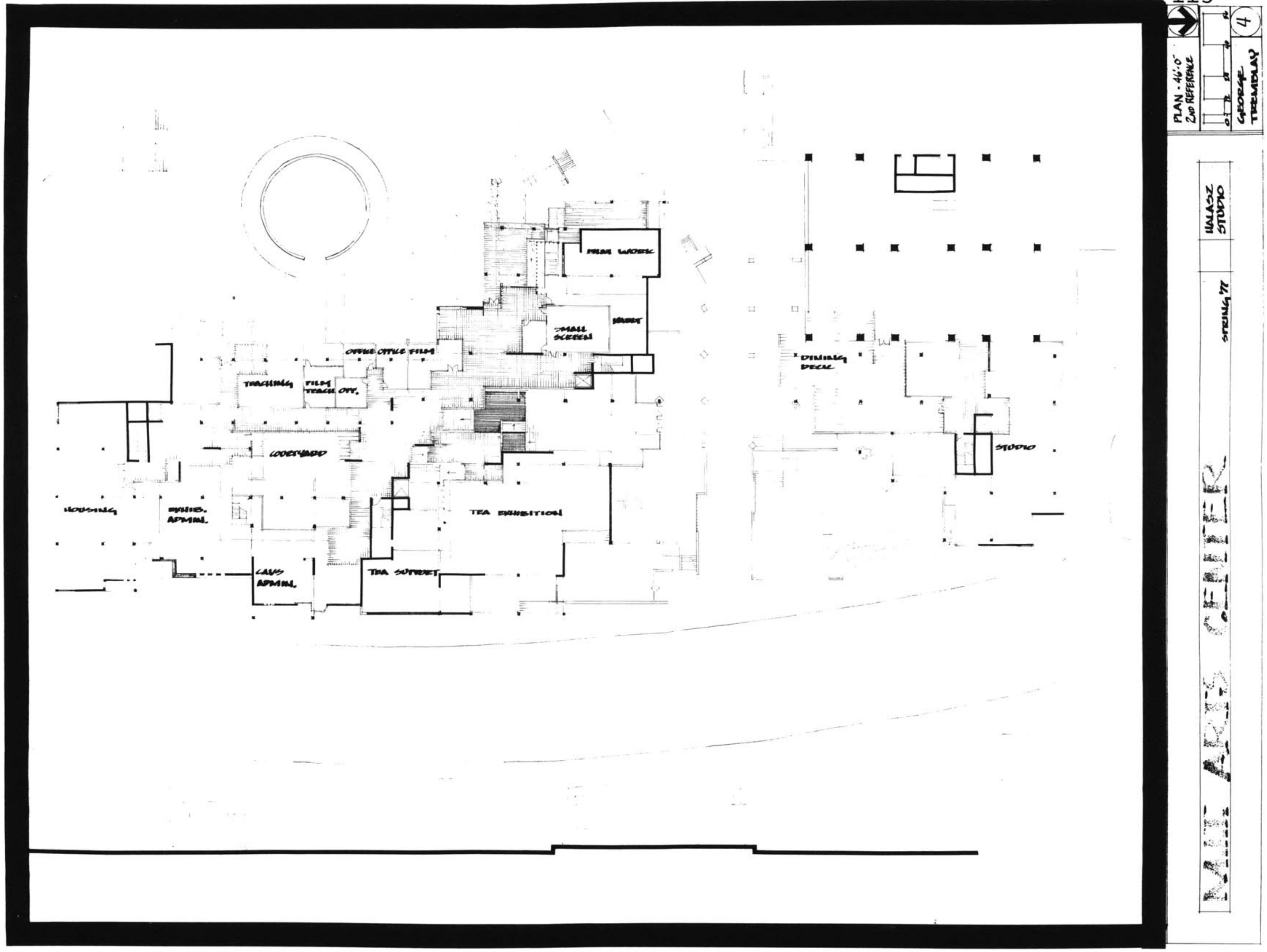
GEORGE TREMBLAY

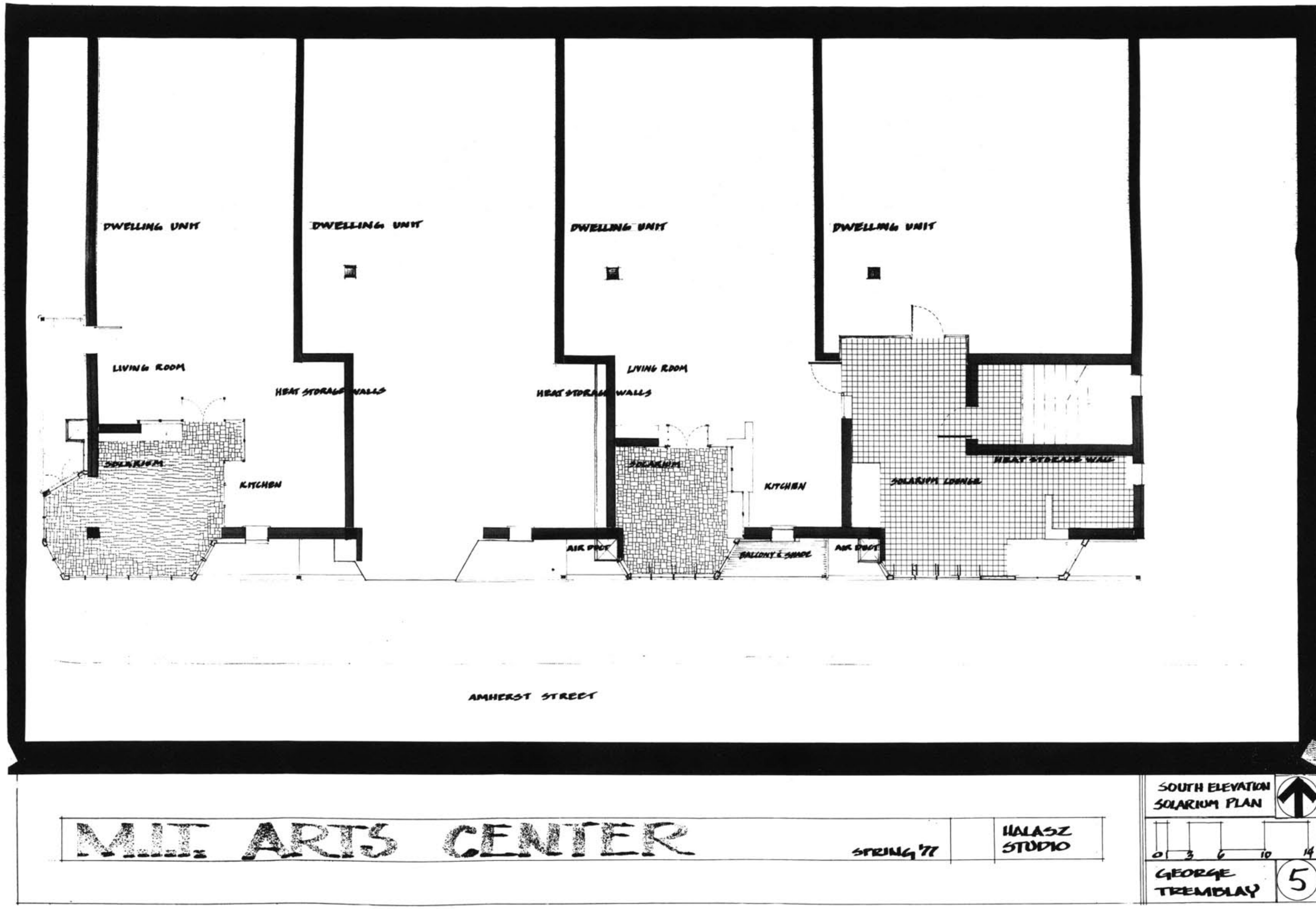
3

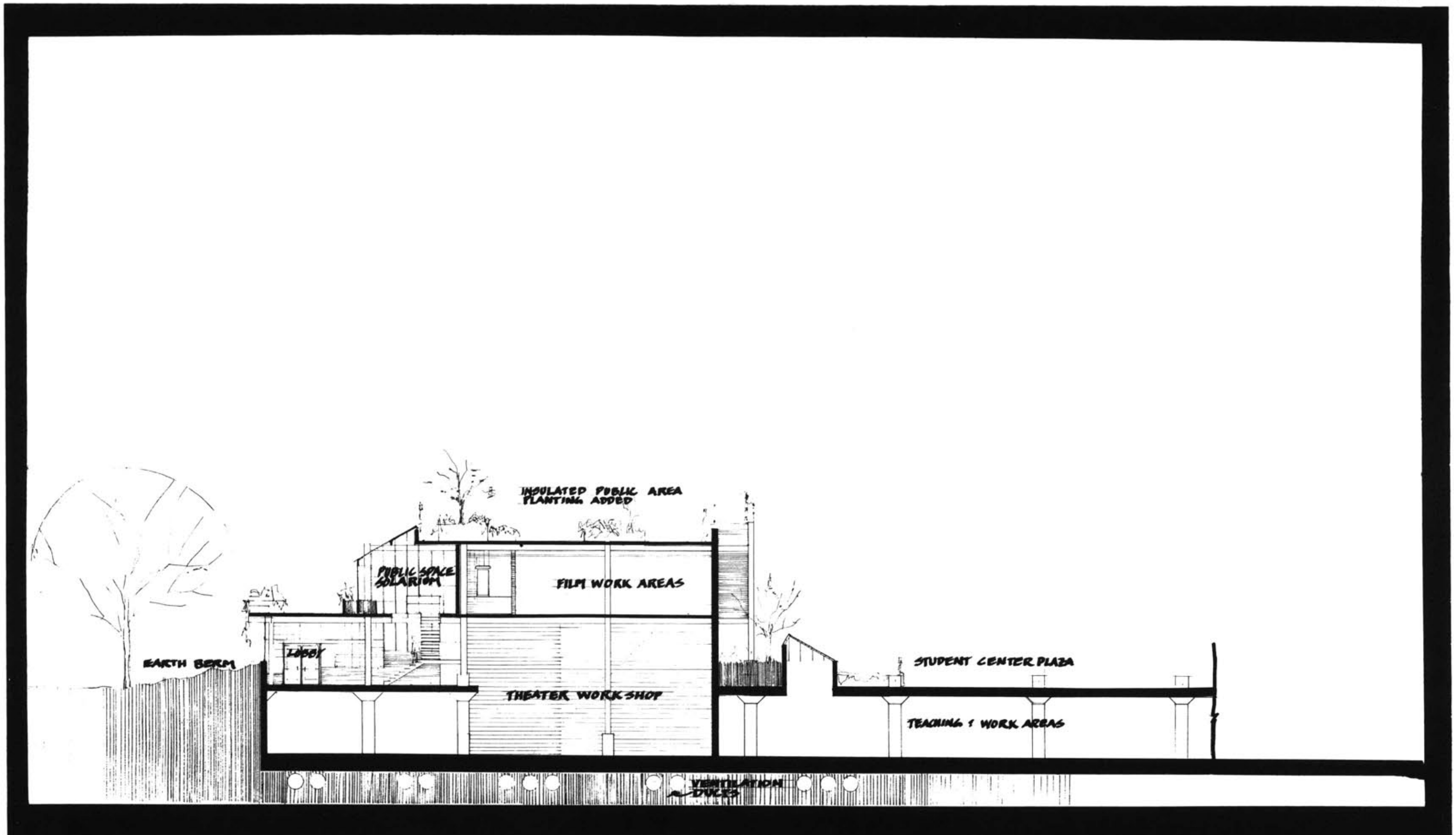
HALASZ STUDIO

SPRING '77

M.I.T. ARTS CENTER


FILM WORK
SMALL SCREEN
OFFICE OFFICE FILM
TEACHING
FILM TEACH OFF.
COURTYARD
HOUSING
EXHIB. ADMIN.
CAVS ADMIN.
TEA SUPPORT
TEA EXHIBITION
DINING DECK
STUDIO
4
PLAN - 46'-0"
2ND REFERENCE
GEORGE TREMBLAY
HALASZ STUDIO
SPRING '77
MIT ARTS CENTER


DWELLING UNIT
DWELLING UNIT
DWELLING UNIT
DWELLING UNIT
LIVING ROOM
HEAT STORAGE WALLS
HEAT STORAGE WALLS
LIVING ROOM
SOLARIUM
KITCHEN
SOLARIUM
KITCHEN
HEAT STORAGE WALL
SOLARIUM LOUNGE
AIR DUCT
BALCONY & SHADE
AIR DUCT
AMHERST STREET
M.I.T. ARTS CENTER
SPRING '77
HALASZ STUDIO
SOUTH ELEVATION
SOLARIUM PLAN
0 3 6 10 14
GEORGE TREMBLAY
5



M.I.T. ARTS CENTER

SPRING '77

HALASZ STUDIO

SECTION THRU GROUND REGION

0 2 6 12 20 28

GEORGE TREMBLAY

6

Theater for the Environmental Arts

SPACE REQUIREMENTS

Approximately 15,000 s.f. net plus a minimum of 7000 s.f. outdoor working space

Theater for the Environmental Arts facilities:
exhibitions laboratory,
experimental workshop and research space,
support spaces for workshop and exhibitions area, including wood- and metal-working shop, sound studio, computer terminal, storage, lockers, and showers,
assigned, specialized research spaces including media studio, film/video technology workshop,
outdoor work space accessible from shops

SPECIAL REQUIREMENTS

Space structuring: large, clear, flexible, hangar-like workshop and exhibitions spaces; likely construction of temporary structures inside

Environmental controls and equipment: all surfaces attachable and flexible; equipped for full range of sound and visual productions; video and computer cables; adequate plumbing and electrical supply

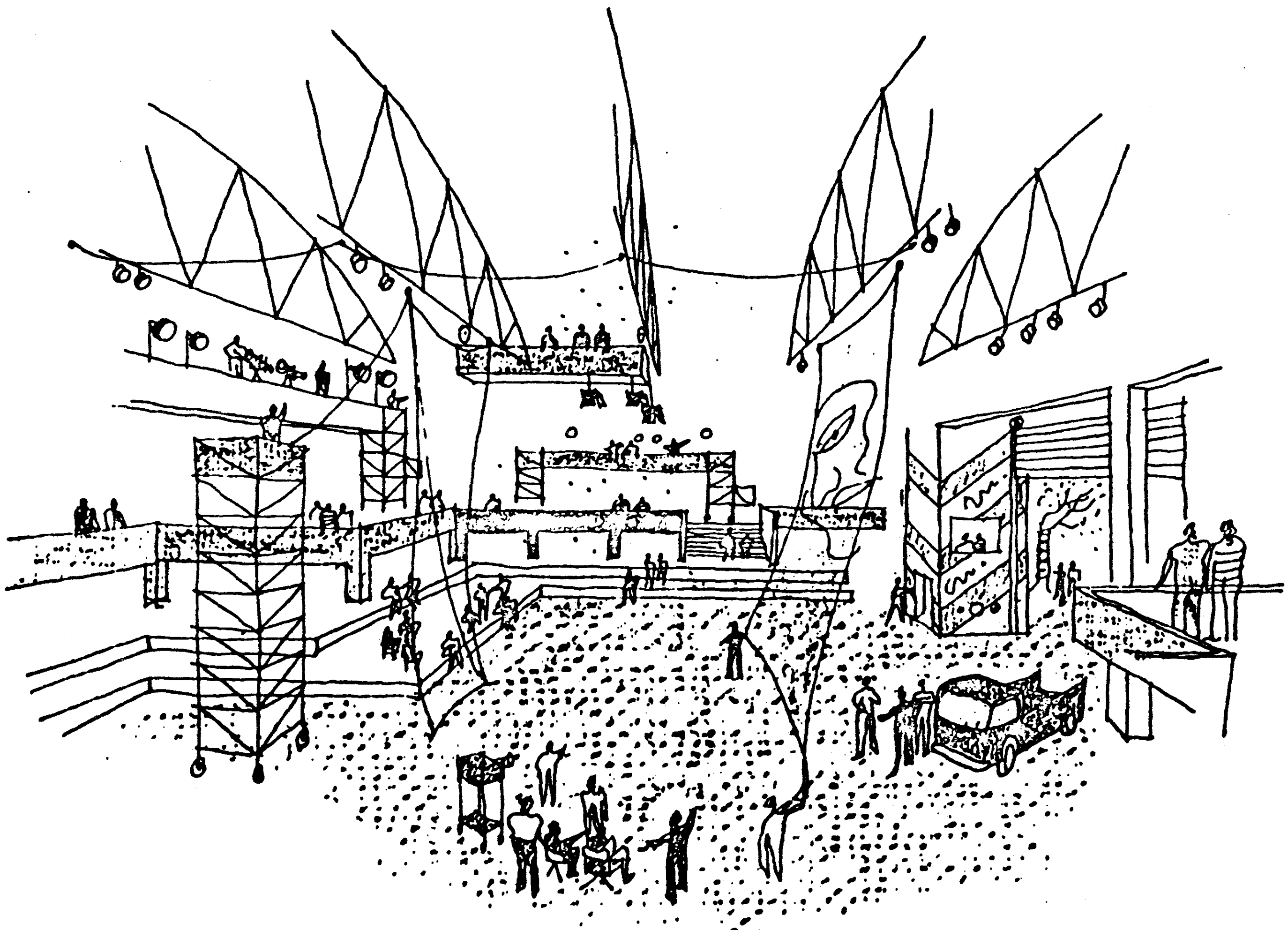
Location: accessible to a public audience; convenient service access

The large experimental facility sometimes called the "Theater for the Environmental Arts" is necessary for collaboration and experimentation with media and performance technologies. Large scale media presentations and events would be developed and installed in the T.E.A.'s workshops and exhibitions laboratory; such projects would be the basis for the developing research and professional teaching programs in environmental art and in performance technology and media.

The facility would also give undergraduate students unique opportunities to become exposed to and involved in the most advanced work being done by professional artists on the faculty, visiting fellows at the Center for Advanced Visual Studies, and advanced students. This facility implies growth in technical, supervisory, research, and teaching staff, and in operating budget.

The Theater for the Environmental Arts is seen as a complex of working and exhibitions spaces centered around a large, equipped, and controlled teaching workshop for direct experimentation with the visual arts and with sound in a form and at a scale that can affect the environment. This workshop would be surrounded by smaller and more specialized research spaces used by the Center for Advanced Visual Studies and by the Film and Environmental Art programs. It would connect to an equipped outdoor working space and to a more formal exhibitions laboratory where experimental productions and displays could be staged for public audiences.

The facility must be located in the general campus environment in such a way that performances, displays, and events, can be opened to impromptu involvement, public exposure, and criticism without either imposing them on a captive audience or jeopardizing the environmental controls necessary for media work.



SPACE REQUIREMENTS

Range of 12,000-15,000 s.f. net including 1500 s.f. net for video facilities

Drama facilities:
acting workshop and rehearsal center,
informal meeting places,
faculty offices,
support spaces (lockers, shops, storage)

Video facilities:
video editing stations,
video studio

SPECIAL REQUIREMENTS

Space structuring: main workshop should be a high, clear, flexible space with flat floor and movable seating and staging

Environmental controls and equipment: controllable lighting; acoustic treatment, video cable, ventilation and temperature controls

Location: near related activities if possible; accessible from public transportation

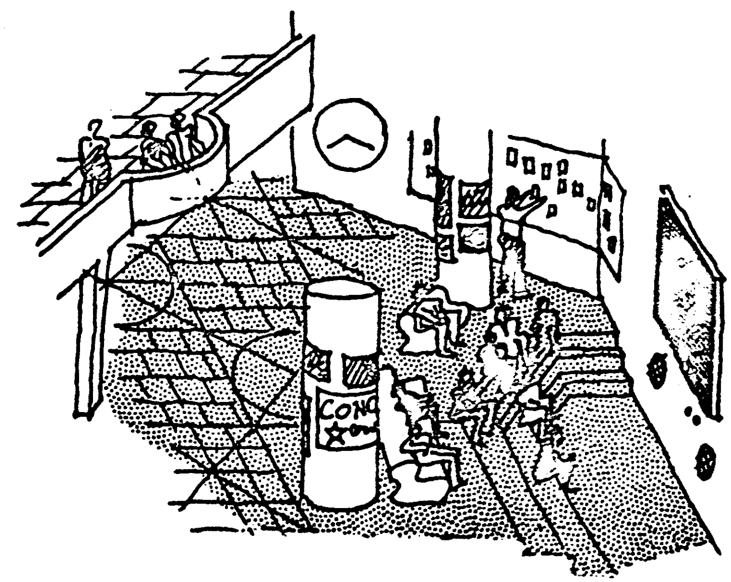
Drama at M.I.T. is a growing part of the Humanities Department's teaching program in Literature and a long-standing and popular extra-curricular activity. In a fully developed teaching program in Drama, which would require substantial new funding, work would range from traditional dramatic productions and dramatic writing (plays and film and television scripts) to more experimental multi-media theater emerging through potential collaboration with Film and Environmental Art.

The presence of a stronger Drama program would especially benefit the growing interest in video. The directions of growth in the Drama and Film programs over the past several years show a common interest in video's applications to dramatic performances, both in documenting events and in contributing to the performance settings themselves. Proximity of theater rehearsal, video production, and mixed media experimentation would be mutually stimulating and would lead to important changes and developments in all programs.

The teaching of acting is seen as the core of any future Drama program and would be the basis for collaboration with Film/Video and other programs. Acting, and corollary studies of dance as movement, are also of general educational benefit to students who in many instances will develop careers in public or academic life that require both empathy and public performance. For acting studies, students need the flexibility, privacy, and control of an equipped teaching workshop as well as occasional public exposure of their work through performances and video recordings.

The focus of this project would thus be an acting workshop or theater laboratory where most of the non-classroom teaching would take place and where experimental and informal productions could be staged. This place would be the visible and identifiable "home" for the academic and extra-curricular Drama program. Surrounding the main workshop space would be a variety of informal meeting and working areas, faculty offices, and more specialized shops for producing videotapes and for building stage sets.

This project would not satisfy all the space needs for Drama, even for the current program. It is assumed that a more formal theater setting such as that now provided by Kresge's Little Theater would be available for full scheduling by the academic and extra-curricular programs in Drama.



SPACE REQUIREMENTS

Approx. 34,000 s.f. net, including workshop space accessible to other programs in the Architecture Department; additional outdoor working space; use of the Theater for the Environmental Arts

Possible inclusion of the Student Art Association, additional 4000-5000 s.f.

Photography facilities:
teaching gallery open to the public,
studios for teaching and working,
outdoor work space,
production spaces (darkrooms, finishing areas),
faculty offices and equipment cage with storage

Visible Language Workshop:
teaching gallery (with Photography),
layout studio and teaching space (with Visual Design)
production spaces (darkrooms, finishing areas,
offset press, print-making),
media lab,
faculty offices,
storage

SPECIAL REQUIREMENTS

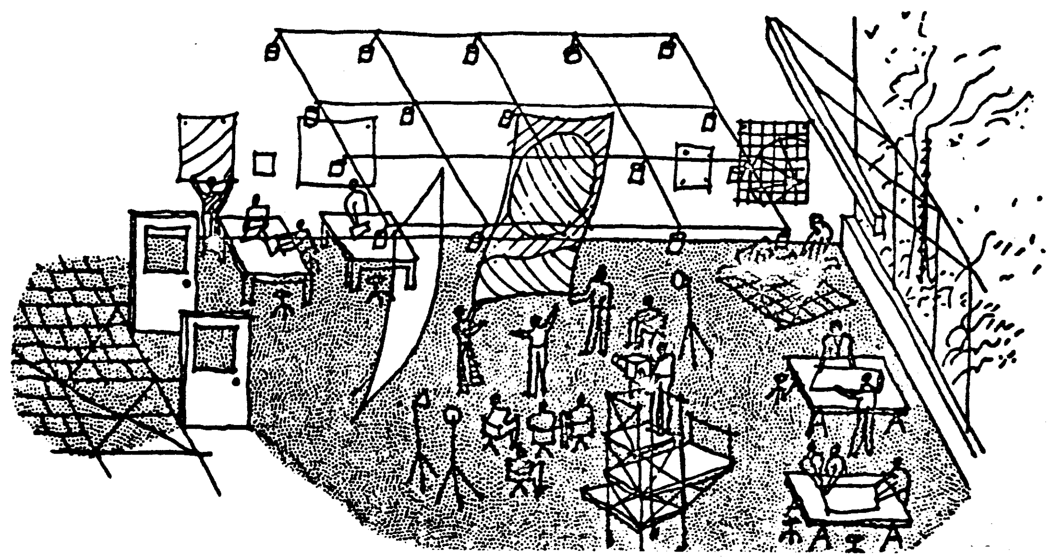
Space structuring: high, clear, flexible spaces for studios

Environmental controls: variety of natural and artificial lighting; adequate plumbing and electrical supply; ventilation and temperature controls

Location: near other Architecture Department activities; convenient to public circulation for galleries and screening rooms

The Visual Arts offer students the opportunity to integrate personal experience with visual expression and communication through hands-on work in various media. Students in Photography, Visible Language Workshop, Visual Design, Environmental Art, and Film need to work directly with the demands of the media and at the same time need to be made aware of the cultural context of their work through parallel studies in history, theory, and criticism.

The teaching programs commonly have design, production, display, and evaluation components which call for a variety of excellent conditions for working and presentations. Students in these programs need to have immediate access to workshops and spaces for projects and exhibitions, and need to encounter in their studies a variety of working methods and media.



Visual Design and Environmental Art facilities:
shared display area,
studios with access to outdoor work space,
controlled light lab,
darkroom,
machine shop and contiguous crude work space,
faculty teaching offices,
shared seminar room

Film/Video facilities:
large screening room accessible to public audiences,
smaller screening room and studio,
support for screening (projection room, sound studio, film vault) also used for teaching and production,
film production spaces,
video production spaces,
equipment cage and workshop,
faculty offices and work stations

Student Art Association facilities:
separate display area,
pottery studios and kiln rooms,
photography darkrooms,
studios for crafts, drawing, and painting,
student lockers and storage,
administrative offices

Consolidating the visual studies programs which are presently in widely scattered locations would produce a lively and efficient work center where faculty and students can evolve new patterns of collaboration and technical innovation. Some production spaces and studios could be shared among these programs; the combination can also create a centralized media resource for the whole School of Architecture and Planning, perhaps including some of the computer-related activities which now work closely with the visual arts.

This project, whose chief advantage is in joining these inter-related activities, should also be sited in such a way as to bring them closer to the rest of the Architecture Department and to make them more visible within Institute circulation. Because the undergraduate teaching programs must be closely associated with the graduate programs and with the most advanced creative work and research being done in the arts at M.I.T., the visual arts teaching workshops should have strong programmatic and perhaps physical links to the Theater for the Environmental Art, the Center for Advanced Visual Studies, and the Exhibitions program.

The extra-curricular Student Art Association, generally allied with the visual studies curricula in interests though not in administration, might also be included in this project. It allows students and others at M.I.T. to try out various arts and crafts in an unpressured and informal way. Although the types of facilities required are similar, there would not be much overlapping since the nature of the activities requires a more casual use of facilities than do the organized teaching programs.

Exhibitions & Advanced Study ~~Center~~

SPACE REQUIREMENTS

Approximately 11,000 s.f. net for Exhibitions; 9000 s.f. net for CAVS; plus use of the Theater for the Environmental Arts and outdoor work and display space

Exhibitions facilities:
box-type gallery for temporary exhibits,
study galleries for the permanent collections,
corridor gallery for informal exhibits,
pocket gallery for student exhibits,
outdoor space for sculpture and events,
curatorial, installation, and storage space,
administrative space

CAVS facilities:
individual studios for fellows,
common media studio,
student reserve space for undergraduate projects,
specialized workshops,
administrative areas

SPECIAL REQUIREMENTS

Space structuring: large volumes of well-equipped and flexible space

Environmental controls: variety of natural and artificial lighting; adequate plumbing and electrical supply; temperature and humidity controls; acoustic treatment

Stringent security measures

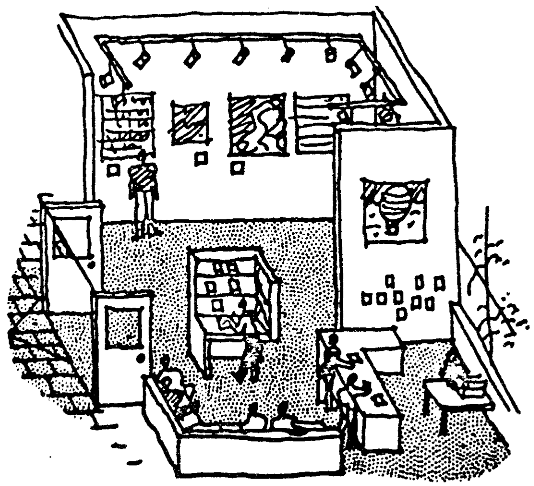
Location: convenient to public transporatation and to main Institute circulation

The Exhibitions program is an important visual, cultural, and educational resource for the Institute because it exposes members of the community to historical and contemporary works of art both throughout M.I.T.'s public spaces and under specially controlled gallery conditions. First-hand experience and study of works of art are vital for students in art history and humanities subjects and for students in visual arts studios. The Exhibitions program must also reflect the kinds of creative work being done at M.I.T., and thus has special opportunities for innovative display of some of the most advanced developments in the arts today through the Center for Advanced Visual Studies and other programs.

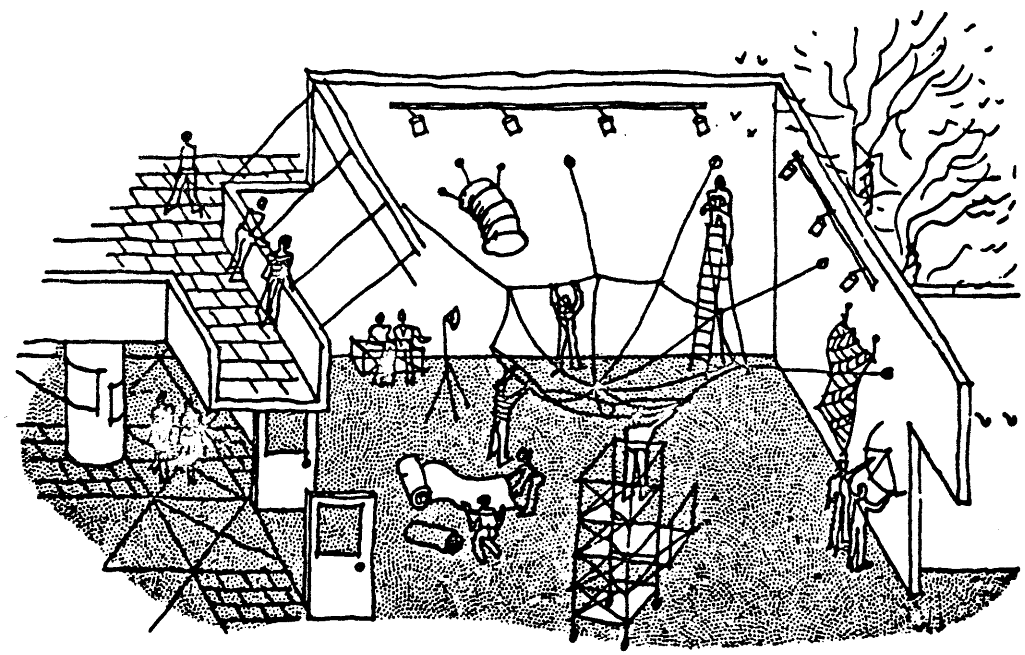
The Center for Advanced Visual Studies is the primary source of M.I.T.'s leadership in and contact with professional arts fields. It provides working spaces and support for visiting artists in the visual arts and sound. Their presence on campus acts as catalyst to interdisciplinary projects in art, science, and technology, both at advanced levels of research and for undergraduates. The Center's fellows require excellent, private working environments and must also have the opportunity to make public presentations of their work.

Coupling these programs would create a mutually supportive working context where places for contemplation and viewing could be provided alongside places for active investigation and presentation.

The Exhibitions program and the Center for Advanced Visual Studies require a variety of public and private indoor and outdoor spaces. Their facilities include a series of "event spaces", possibly related



to the experimental Theater for the Environmental Arts which is described in the following pages. These event spaces would be a center for collaborative projects and would attract audiences from the M.I.T. and greater Boston communities. The facilities should therefore be sited convenient to public transportation and to Memorial Drive. In addition to these publicly accessible spaces, there should be rougher and more private workshops where much of the teaching and research would take place, shielded from continual public view.



EXHIBITIONS

A. Gallery spaces

1. BOX-TYPE GALLERY 3000-3500sf

(essentially a larger, better equipped, and more flexible version of Hayden Gallery, for temporary exhibits and display of permanent collection)

-large, high, clear space (apx. 16' ceiling)

-must be subdivisible in variety of ways

-flexible lighting, sound system

-attachable ceiling

-plumbing (1 set outlets & drain), ample electrical supply

-video hook-up (maybe computer cable?)

-may be skylit but screenable

-no sprinklers--use other type of fire equipment

2. EXHIBITION-LAB considered part of Theater for the Environmental Arts

3. CORRIDOR GALLERY sf not designated

(similar to present Hayden corridor gallery but with better, more secure wall-mounting system)

-adjustable spotlighting

-TV security monitor

4. POCKET GALLERY 500 sf

(an extension of public corridor for student exhibits)

-same requirements as ocrridor gallery

5. OUTDOOR EXHIBIT

(assume that site for Exh. program's facilities could have adjacent outdoor exhibit area; if combined with T.E.A., this outdoor area might also be for work space--discussed under T.E.A.)

B. Installation and support spaces

1. STUDY/STORAGE SPACE FOR PERMANENT COLLECTION 1500-2000sf

-rolling racks, shelving

-vault-like; very secure; TV security monitor?

-temperature and humidity controls

-no sprinklers--use other type of fire suppressant

2. "HOLDING" STORAGE 400-500sf

-large empty space for receiving, holding crates

-near loading dock and accessible to gallery

-secure

UNCRATING STORAGE 200sf

-secure, same as above

3. INSTALLATION FURNITURE STORAGE 500-600sf

-less secure than above

-for storing flats, pedestals, gallery furniture, display hardware, vitrines, etc.

-either part of gallery or next to installation shop with direct connection to gallery

4. FRAMING ROOM & STORAGE 300sf

-near or part of shops, installation, uncrating

-secure

-a "clean room"

5. INSTALLATION STAGING SPACE 1000sf

CARPENTRY SHOP 400sf

-noise separation from galleries

-for non-portable tools, have lockable tools crib also

PAINT SHOP 200sf

-100sf spray paint booth and storage

6. LOADING AREA, SERVICE 400sf

C. Administrative Areas 1250sf

-conference room

-common work area

-individual work stations for:

director of exh., 5 staff, CVA chairman

EXHIBITIONS TOTAL

Galleries (not counting exh. lab.)	3500-4000sf
Support	4900-5600sf
Administration	1250 sf
	9650-10850sf

plus outdoor space?

and nearby food facility, lecture hall for 150-200 (otherwise assume kitchenette)

CAVS

1. individual studies for fellows

6 1-person @ 300 (minimum)

6 2-person @ 400 (minimum) 4200sf

2. undergraduate project space 600sf

"student reserve" (minimum)

3. reception 450sf

director 250sf

conference/seminar (minimum) 300sf

archives/library/reference 250sf

4. workshops, etc.

darkroom, photo areas 650sf

(small gang darkroom @300, individual darkroom @100, wet and dry finishing areas @250)

5. common media studio 1500-2000sf

highly equipped, changeable video, plumbing, electrical, flex. lighting, etc.

6. assume workshop part of adjacent T.E.A. or add at least 1000sf to CAVS itself for

shop and another 750 for associated mock-up lab or crude work space

7. storage (projects, equipt, mat'ls) 500-800sf

total apx 9000sf

THEATER FOR THE ENVIRONMENTAL ARTS

The uses of the T.E.A. and its needs for service, environmental controls and space structuring are described in the A.E.S. report (the 1st one) on pp. 23-24, and in Walker Tennis Court project pp. 46-48. The square footages are not quite right though because we've shifted around what "belongs" to the T.E.A. versus what "belongs" to CAVS, Exhibitions, etc. Programming and administration of T.E.A. is another issue not dealt with here but it clearly implies new program growth, and is currently under discussion. If we assume the Walker site, we assume a smaller T.E.A. than might be located elsewhere, but we also assume that it would be more "finished" given the publicness of that site, so I think the cite issue/trade-off will all wash.

1. "Exhibitions lab"
   - public presentation segment of TEA 4000sf
   - requirements are similar to those for the box-type gallery described under Exhibitions
   - <u>must</u> have computer and video cables, plumbing, adequate electrical supply, flexible theater-type lighting, attachable and accessible ceiling, high level of security, etc.
2. T.E.A. work and research space 6000sf
   - a big "dirt studio"
   - more crude than the exh.-lab
   - lots of hook-ups--video, computer,

lighting, plumbing, sound,
drive-in truck access perhaps--
large serviceability

-natural light desirable but should be screenable

3. Supports to this work space

-wood and metal (+?) shop with some crude work sapce (most of work would be done in TEA itself)	1200sf
-storage	1000sf
-sound studio	400sf
-computer terminal room	500sf
-projection booth(s)	200sf
-lockers and showers	(small)

4. Assigned research space associated with TEA

-(media studio of the CAVS, 1500sf would be one, but is accounted for under CAVS)

-assume about 2 more similar spaces to be used by research groups:

-film technology workshop @600sf

-another @1000sf — 1600sf

5. Outdoor work space — 7000sf

-equipped outdoor work space--some planting, some hard surfaces

-connections for plumbing, ample electrical, possibly hook-up for video, computer-run events

-accessible directly from shops

ENV. ART, VISUAL DESIGN, PHOTOGARPHY, VLW

This is a plan based on sharing of production and studio space among these programs. If they were not to be housed in the same place, the total cost would surely be greater.

A. Production areas and support

Gang darkroom 16 enlargers (Pho,VD)	800sf
Gang darkroom 5 enlargers (VLW)	250sf
Copy camera & copy wet area (VLW)	150sf
Clean, wet, light finishing area (Pho,VD,VLW)	1000sf
Drying area (Pho,VD,VLW)	50sf
Loading rooms, indiv. darkrooms 4@80 (Pho,VD,VLW)	320sf
Color darkrooms 3@150	450sf
Dirty wet light finishing area (VLW)	300sf
Drymount/cutting area, large enough for 16 people to work in at once during class, plus a few extra people at the same time (Pho,VD,VLW)	750sf
Cage-dispensary for equipt and supplies and office	500sf
Storage next to cage	750sf
VLW production studio	1200sf
VLW media lab (machine room, computer and video cable)	500sf
VLW offset press (part of prod. studio)	300sf
Controlled light lab (Vis. Des.)	500sf
VLW copy animation (computer and video, with video lab)	150sf
4 individual darkrooms at 120	480sf

B. Studios and other teaching areas

exhibitions area/teaching gallery (VLW,Pho,VD)	1000sf
Seminar room with projection, video (all)	500sf

Lounge--informal meeting and teaching area (all) 300sf

Library archives (VLW, Pho) 600 for stored mat'ls, 150 for study areas 750sf

Studio: open, clean studio for teaching, demonstration, in-class work (Pho,VLW) with variable lighting, ceiling grid, tackable wall surfaces, movable partitions 1500sf

Studio workshops: 3 class studios for Env. Art & Vis Des, sometimes VLW layout with some individual work space (desks, stools, bulletin boards, storage), some common work space (clear) and some meeting space (tables and chairs) 4000sf

Grad. student work stations 1000sf (like studio workshop)

Project reserves (for visiting fac'y special projects) (all) studio 500, office 150 650sf

C. Teaching offices/studios for faculty 10@300 3000sf

- natural and variable artificial lighting
- plumbing
- durable floor, attachable ceiling, tackable walls
- good sound proofing
- some will have need for desks or tables and seating arrangement for small groups

D. Shops

- machine shop for working with metal, wood, glass, plastic, maybe some ceramics 3000sf
- crude work space, mock-up lab 750sf

-cage, office for technical assts	250sf
-service, receiving	250sf
-storage	800sf
	5050sf

E. Outdoor work space

-directly accessible from shops

-equipped: power, plumbing, lighting, maybe simple metal attachable framework?

FILM AND DRAMA WORKSHOPS

This project is essentially the same as that in Jim Czajka's thesis. The student broadcasting stations would remain where they are though. Otherwise, the top floor of Walker (the gym) is converted into an acting workshop surrounded by meeting and office spaces and workrooms. For collaboration between film/video and drama there need to be a couple video facilities there, too.

Assumptions about the building:

-probably an exterior stair and elevator tower

-the main high space of the gym would probably remain relatively clear, with permanent structures built in there as seating, etc.

-the balconied areas would probably be kept as 2-stories

If I can find it, I'll include Jim's plan and program along with the supporting material.

FILM

1. Large screening	1500sf
-fixed seating for 200±	
-sound and light locks	
Small screening and studio	800sf
-more informal than large screening	
-may be used for variety of activities	
Video studio	800sf
-taping and screening	
Small seminar, screening capacity	400sf
2. Headquarters and sec'y	400sf
3 fac'y work and teaching offices @250	750sf
3. projection booth/room	200sf
sound room, sound transmission @100	200sf

8 film edit @100	800sf
1 film cutting (Kellar machine) @100	100sf
4 video edit @80	320sf
video mixing	600sf
video sound	500sf
film vault (secure, temp-humidity controls)	200sf
film equipt cage and office for technical assistants	600sf
video storage, cage and office for technical assistants	500sf
4. public waiting (screening room spillout)	200sf
film common room with lockers	300sf

Film would also have a research space associated with the TEA, along with use of the TEA spaces themselves.

APPENDIX: CALCULATION FORMULAS

1. Solarium Temperature (Instantaneous)

Day $$T_{solarium} = \frac{H_{sun} + H_{other}}{H_c + H_{infil}} + T_{out}$$

$T_{solarium}$ = Temperature in Solarium

H_{sun} = Insolation in (Btu/hr)

H_{other} = Heat Gain, from people, appliances, lights, etc.

H_c = Heat loss from conduction (Btu/hr ^oF)

$H_{infilt.}$ = Heat Loss due to air infiltration Btu/hr ^oF

T_{out} = Temperature of outside air

2. Solarium Temperature (Instantaneous)

Night

$$T_{solarium} = \frac{H_{s.wall}\ T_{in} + T_{out}\ (H_c + H_{infilt}) + H_{other}}{H_{wall} + H_c + H_{infilt}}$$

$H_{s.wall}$ = Heat loss to solarium from base through south wall (Btu/hr ^oF)

T_{in} = Temperature in Base Building (^oF)

T_{out} = Temperature of outside air (^oF)

H_c = Heat loss due to conduction through solarium wall (Btu/hr ^oF)

H_{infilt} = Heat loss due to air infiltration through solarium wall (Btu/hr ^oF)

H_{other} = Heat gain from other sources, i.e. lights, people, appliances.

3. Daily Solarium Average Temperature (24 Hours)

$$T_{solarium\ av.} = \frac{H_{sun} + H_{other}}{(H_c + H_{infilt})24} + T_{out\ av.}$$

H_{sun} = Daily heat gain from insolation

H_{other} = Daily heat gain from other sources

H_c = Heat loss due to conduction (Btu/hr ^oF)

H_{infilt} = Heat loss due to air infiltration (Btu/hr ^oF)

4. Change in Storage Temperature in Solarium During Day

$$\Delta T_{storage} = \frac{H_{sun} - H_T\ t\ T_{initial} + H_T\ T_{out}}{(H.C. + \frac{H_T t}{2})}$$

$T_{storage}$ = change in heat storage temperature (assumed = air temp. of solarium)

H_{sun} = Daily insulation Btu/day

H_T = Total heat loss through solarium wall (Conduction + Infiltration) (Btu/hr ^oF)

t = duration of day (hours of sunlight)

$T_{initial}$ = initial storage temperature in the morning

T_{out} = daily air temperature maximum

H.C. = heat sotrage capacity of thermal mass

5. <u>Change in Storage Temperature During Night</u>

$$\Delta T_{storage} = \frac{H_T t\ T_{initial} - (H_T t\ T_{out})}{H.C. + H_T\ t/2}$$

$T_{storage}$ = Change in Thermal Storage Temperature of Solarium

H_T = Total heat loss of Solarium; Conduction and Infiltration (Btu/hr ^{o}F)

t = duration of night time cooling

$T_{initial}$ = initial storage temperature; temperature at end of day

T_{out} = Night minimum air temperature

H.C. = Thermal heat storage capacity

FUTURE EXPANSIONS

PLANTED FORM

Shelter Belts

Gardens

Plantings

Water

POINT THERMAL SOURCES

Hearth, Fireplace, Stove

Lamps, Infra red Lamps, Heaters

Solar Storage

Heat Diffusers, Radiators, Convectors

Air Conditioners, Heat Pumps, Furnaces

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