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THESIS PROPOSAL
SPRING '73
ECOLOGICAL LIVING UNIT

I. Problem

Man has greatly modified natural communities the world over. Natural vegetation is destroyed and replaced by ecologically bare areas. In doing so he has destroyed the basic community structure, and simplified and unstablized the ecosystem of the earth.

II. Thesis

The design of an ecosystem for a living complex that aims towards functioning within the world's ecology rather than disrupting it. This will involve the utilization of the essential characteristics of the natural ecosystems as a basis for a biological prototype ecosystem.

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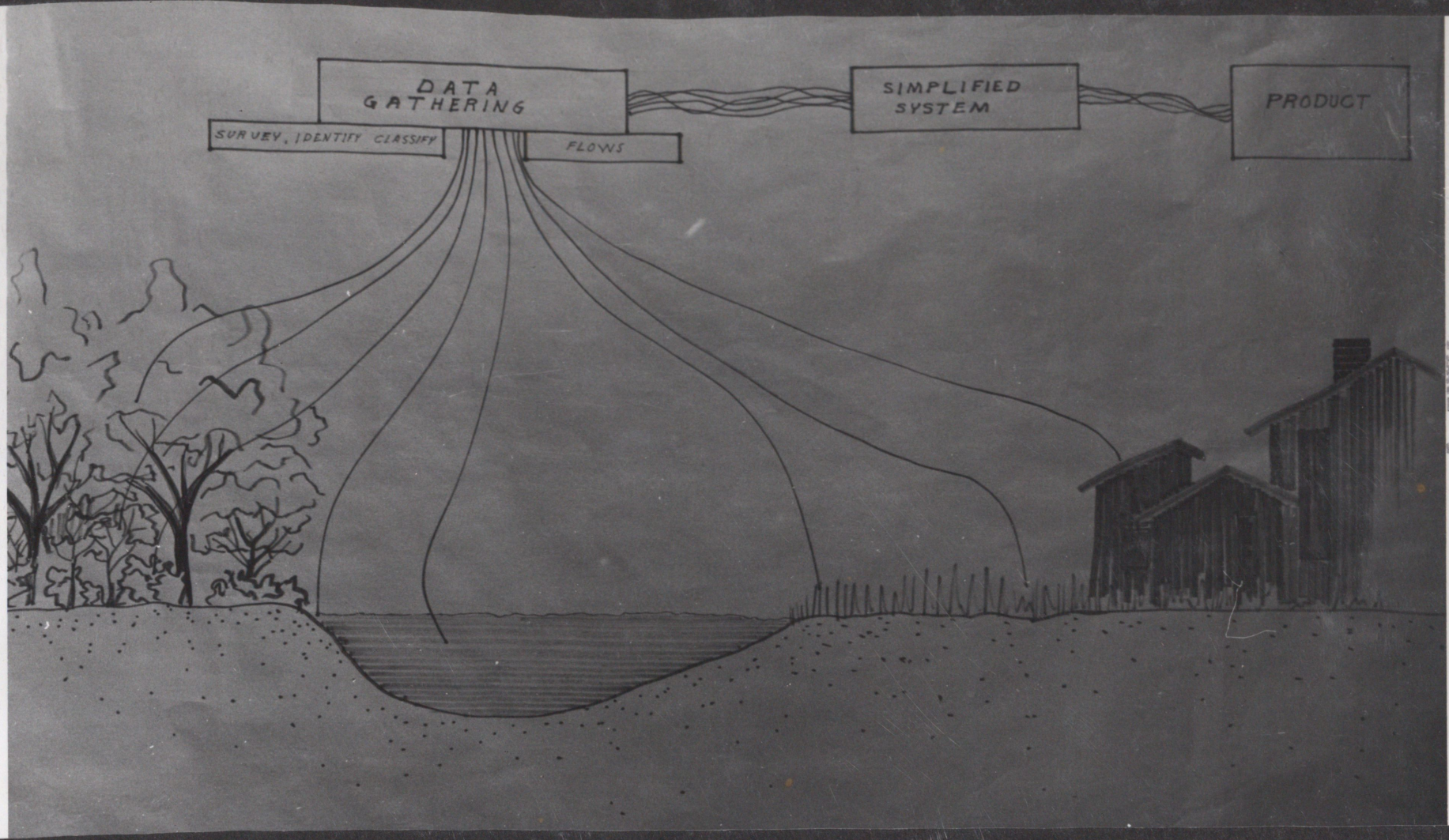

DATA GATHERING
SURVEY, IDENTIFY CLASSIFY
FLOWS
SIMPLIFIED SYSTEM
PRODUCT

PLATE I

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This paper deals with the relationship of nature and man. In its structure and function, nature consists of animals, plants, microoganisms, and human societies. These living parts are in turn joined by invisible pathways overwhich pass chemical materials that cycle round and round being used and reused and over which flow potential energies that cannot be reused. The network of these pathways forms an organized system from the parts. in addition, the more complex systems for self-control have specialized communication circuits such as the behavioral cues passing between animals. In the parts of the system involving human interchange, there are special kinds of information exchange, such as human language, and special units of economic exchange such as dollars. A study of nature and man is thus a study of systems. The budget of fuel energy received by thesystems of nature controls the amount of structure that can exist and the speed at which processes can function. The small ecological systems, the large panoramas that include civilized man, the whole biosphere of the planet earth all receive only certain amounts of energy. Hence we approach man and nature by studying the limited energy of environmental systems.(1) (Plate I)

Odum, Howard T., Environment, Power, and Society, New York, 1971, p. 1.

Briefly going back into history when human societies first became a significant part of the systems of nature, man had to adapt to the food and fuel energy flows available to him, developing the now familiar patterns of human culture. Ethics, folkways, mores, religious teaching, and social psychology guided the individual in his participation in the group and provided means for using energy sources effectively. Sunlight was the energy source and is spread out so evenly that it is not directly available to man until after some has been concentrated and much has been lost by the plants and animals. For survival societies that were able had to gather food and distribute energies within the social system for their successful continuance, and they developed the group organizations necessary for these purposes. The social systems adapted to meet changing conditions such as overcrowding, fluctuations of yield, crises from competitors, and threats from internal disorder.

One self-stimulating principle of primitive group was to allocate control of the energy flow of the group to individuals in proportion to the work they did to increase that flow. Such energy rewards took various forms, such as control of property, political power, and status influence. The economic system was simple, and economic reward often reflected the energy control gained.(2)

Ibid. p. 5.

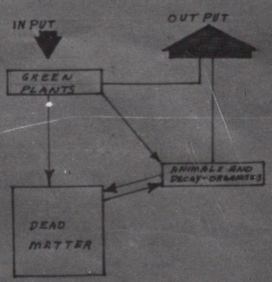
INTERFACE



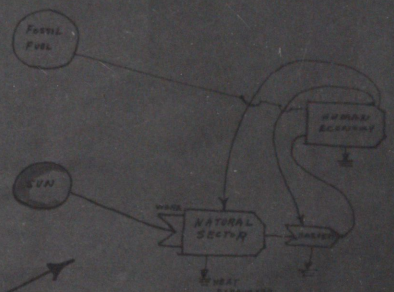
ENERGY

- SOLAR
- FUEL - FOSSIL
- FOOD

RETURNS LITTLE IN BIOLOGICAL NATURE. EMPHASIZES BIOSPHERIC IMBALANCE. CAUSES RAPID DEPLETION OF CHEMICAL AND ENERGY SOURCES



INDUSTRIAL SYSTEM



NEED FOR RECOVERY LOOP SYSTEM

PRESENT ENERGY CONSUMPTION	RESERVES AT PRESENT RATES
43% OIL	20 YRS
32.8% GAS	35 YRS
20% COAL	2 OF 4 CENTURIES
4.2% HYDRO, NUCLEAR, WOOD	

PLATE II

In these earlier times, when man's role in the environmental system was based on sunlight, energy, plant production was very important. Since plant production depended on area, land use was a principal concern of the social system. But only a small part of the earth's surface and the energy flows of the environment was really controlled by man, and the checks and balances of the natural systems prevailed. Man did survive with these regimes, however, his social processes for decisions were based, developed and brought to modern times on the suffered protection of the natural systems.

In modern times man's energetic relation to his environment has changed, for he now has much more fuel under his control, and it enters through a diferent route. Man's new industrialized system now derives its energies from the flows of concentrated fossil fuels, coal, and oil. Much of this energy flow is put back into his environmental system so that his yield of food and critical materials is greater. (Plate II)

The changes have come so fast that man's customs, mores, ethics, and religious patterns may not have adapted to them. We may wonder whether the programs controlling the behavior of the individual human being, whether he is a leader or a person led, are realistic in providing for the best adaption to the new systems of energy flow. Man's

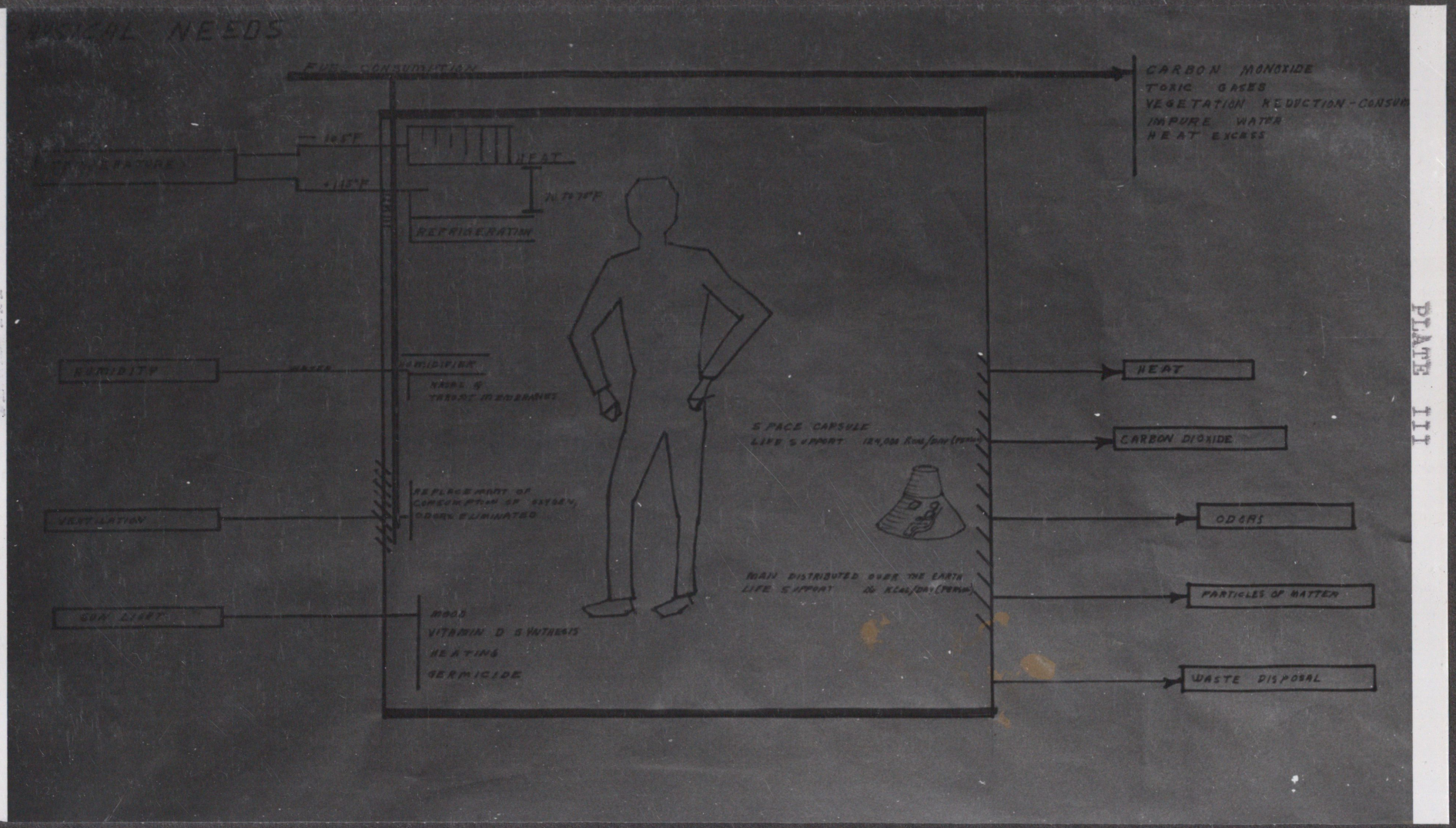
role in the environment is becoming so enormous that his energetic capacity to hurt himself by upsetting the new environmental system is increasing. His system is becoming so large and complex and is changing so rapidly that it is more and more difficult to learn of the patterns in his own fuel supply. Money, energy flows, and causal actions can no longer be easily equated. The accumulation point of money in the network may be much removed from the origin of the work done on the energy inflow, or of the forces causing stress.(3)

Only a small part of the total controlled energy is now processed by the individual person or by work that is recognizably personal. More and more of the energy flows are in the machines of the system. For example the new system maintains higher agricultural yields as a result of fossil fuels being put back into the farms through the use of industrial equipment, industrially manufactured chemicals, and plant varieties kept in adaptation by armies of agricultural specialists supported on the fossil-fuel based economy.

As the industrialized areas increase, how much longer will the biological cycles in the uninhabited environments be able to absorb and regenerate the wastes and thus prevent

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3. Watts, David, Principles of Biogeography, New York, 1970, p. 347.


PLATE III
NEEDS
FUEL CONSUMPTION
CARBON MONOXIDE
TOXIC GASES
VEGETATION REDUCTION - CONSUM
IMPURE WATER
HEAT EXCESS
HEAT
REFRIGERATION
HUMIDITY
HUMIDIFIER
VENTILATION
REPLACEMENT OF CONSUMPTION OF OXYGEN, ODORS ELIMINATED
SUN LIGHT
FOOD
VITAMIN D SYNTHESIS
HEATING
GERMICIDE
SPACE CAPSULE
LIFE SUPPORT
HEAT
CARBON DIOXIDE
ODORS
PARTICLES OF MATTER
WASTE DISPOSAL

self-poisoning of waters and atmosphere? As man's system becomes large enough to control and prevail in the flows of the biosphere, will he understand it well enough to prevent disaster? If his energy sources begin to decline, can he return to a minor energetic position in the earth system without a collapse andextinction to the culture as we now know it?

Man's survival will probably depend on his being able to see what his vast human system has become in relation to preceding and possible earth systems. And he must acquire the necessary understanding rapidly enough to adapt his opinions, folkways, mores, and action programs to the great new systems and provide a continuing survival path for them. Since decisions on such matters in the arena of public affairs are ultimately made according to the beliefs of the citizens, it is the citizens who must somehow include the energetics of systems in their education. In some way the behavior of the large and small systems must be understood and that knowledge must be communicated to the dispersed intelligence of the modern decision appartus. (Plate III)

Beginning a systems view of the earth a thin water and air bathed shell covers the earth-the biosphere- which is bounded on the inside by dense solids and on the outside by the near vacuum of outer space.(Plate IV) Radiant energy from the sun enters the biosphere, and eventually equal

amounts pass outward as flows of heat rediation. In the haze when viewed from high above a few energy flows can be observed. There is suggestion of a great sheet of chlorophyll, there are cyclones, and there are characteristic cloud forms of the weather belts, but the miraculously cascading machinery of parts within parts within parts is not even visible. With the exception of energy flow, the biosphere can be seen as a closed system of the type whose materials are cycled and reused.

The biosphere is the largest ecosystem, but the forests, the seas, and the great cities are systems also. The great chunks of nature also have subsections and zones which are organized by their physical processes and organisms into systems of function. Large and small parts operate on their budgets of energy, and what cannot be done is determined by the simple laws that govern the system. Any phenomenon is controlled both by the working of its smaller parts and by its role in the larger system of which it is a division. Among the subsystems are some based on the concentrated fuel flows that man has the power to control. Elsewhere man participates in systems in which the energy at his disposal is too small to regulate. Because man's power is still insufficient to control the overall biosphere, he is protected in his ignorance by the great stabilizing storages of the oceans and atmosphere. An

accelerating growth of energy flux in man's system, however, is dangerously outdistancing his knowledge of its workings.(4)

With the turning of the earth, the sun comes up on fields, forests, and fjords of the biosphere, and everywhere within the light there is a great breath as tons of oxygen are released from the living photochemical surfaces of green plants which are becoming charged with food storages by the onrush of solar photons. Then when the sun passes in shadows before the night, there is a great exhalation as the oxygen is burned and carbon dioxide pours out, the net result of the maintenance activity of the living machinery. During the day while the oxygen is generated, a great sheet of new chemical potential energy in the form of new organic matter lies newborn about the earth, but as the oxygen is consumed in the darkness, the organic matter disappears like firewood in a bonfire and releases heat through the night.(5)

The living process associated with the cover of green chlorophyll during the lighted period in forests, lakes, oceans, and deserts is called photosynthesis. Because various kinds of living communities have been studied in detail, some estimates can be made of the contribution to the whole system per day. The letter P(for production) is

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4. Watts , p. 181

5. Odum, p. 13.

BASIC FUNCTIONS
(NATURE)



PLATE IV

the abbreviation given to the process.

The primary production during the day is called respiration. Estimates of the consumption in the biosphere can be estimated. In the overall equation for consumption, materials are returned to the inorganic state, ready for primary production again. The letter R is the abbreviation for return respiratory consumption flux. Together P and R function simultaneously or consecutively to provide a cycle of chemical elements.(Plate IV)

On the average P and R tend to be equal in a system closed to matter. In summer P tends to exceed R but in winter R tends to exceed P. The carbon dioxide in the air dimishes in the spring and increases in the fall.(6)

The biospheric averages of P and R have been extimated as about one gram of organic matter per square meter per day. This is about four kilocalories of potential energy stored daily as organic matter and burned again. (7)

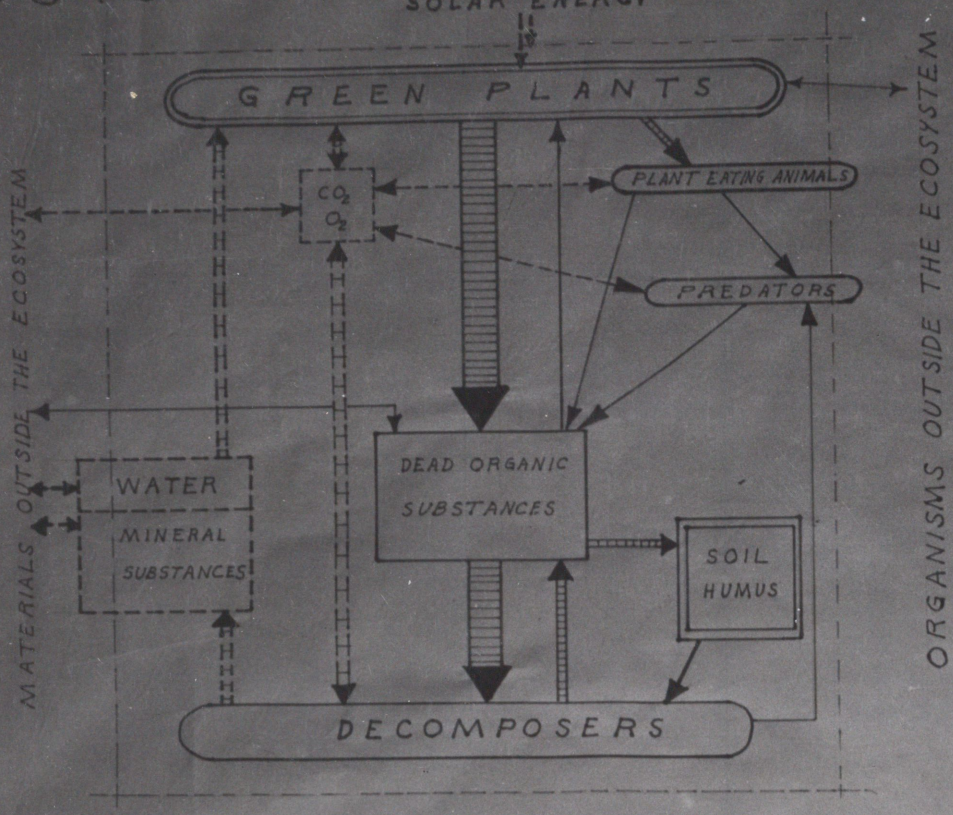
Turning from the mechanics of the system and looking into the complex interaction between biological community and habitat normally referred to as the ecosystem, there are apparent several ecosystems within the main ecosystem of the earth. The common demoninator that brings all the individual ecosystems into one system is the interaction

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6. Keeling, "Concentration and Isotopic Abundance of Atmospheric Carbon Dioxide," Tellus, 12, p. 200, 1960.

7. Odum, p. 15.

ECOSYSTEM



PRIMARY PRODUCERS (AUTOTROPHIC)
SECONDARY PRODUCERS (HETEROTROPHIC)
EASILY DECOMPOSABLE DEAD ORGANIC SUBSTANCES
NOT EASILY " " " "
MINERAL SUBSTANCES
MOVEMENT OF ORGANIC SUBSTANCES
MOVEMENT OF MINERAL SUBSTANCES OR ENERG
LIMITS OF THE ECOSYSTEM

PLATE V

of the links of one or more food chains. These always begin with the primary producers, usually green plants which, with the aid of solar energy, produce carbohydrates and ultimately build up the other organic substances.(Plate V)

Then the secondary producers are apparent and include plant-eating animals or parasites which feed on plants. These consumers serve as food for the predators, e.g. carnivorous insects or birds, and these in turn may be eaten by other predators. Man, like many animals, is omnivorous and so fits into such food chains at various places; thus he has increasingly become the superior competitor. Toxic substances can become concentrated in the food chains and become dangerous, even to man. (8)

Although, quantitatively speaking, the predators usually play only a small role, they can be of decisive significance for the stability and production on some ecosystems in that they control the number of plant-eaters.

Theoretically, the consumers of living plant material and their enemies are not necessarily an essential component of every ecosystem and are almost completely absent from some e.g. in the system comprising a cultivated field protected from pests. The third group of secondary producers, collectively known as decomposers, is however indespensable. To this group belong the plants and animals

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8. Ellenberg, H. Integrated Experimental Ecology, New York 1971, p. 4.

which live on dead organic material. Vast quantities of undecomposed remains would pile up in our woods and other plant formations as well as in stagnant or sluggishly flowing waters. This natural garbage would ultimately make it impossible for the plant roots to reach mineral soil and as is the situation on a raised bog, would force them to get along with less and less nutrient materials. As a consequence, the productivity of most soils, under natural conditions would fall off considerably.

Primary producers and decomposers are therefore essential components of every independent ecosystem, be it on land or in the water. Where one of these groups is absent, the ecosystem is dependent on other ecosystems.

Of course without a certain minimal level of nutrition, the raised bog ecosystem would not be able to exist; the nitrogen, phosphorus, potash, calcium and other substances necessary for the normal growth of green plants, which are collected in the lower layers, are soon no longer accessible to the upward-growing mosses and the vascular plants which accompany them. With the exception of these and other extreme cases, it is characteristic of all ecosystems that they maintain the circulation of material, by which the growing stand is connected with the mineral soil, via their debris and the corresponding decomposers.(9)

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9. Ibid. p. 6.

Man alters the circulation by removing tree trunks or other components from the ecosystem or by cutting down nearly the entire plant community above ground.

Another indispensable substance to an ecosystem is water which is constantly required in large amounts for the life activities of all organisms, but particularly for photosynthesis in green plants and for the circulation of nutrient materials. Thus, the water supply, along with warmth and food supply, is a most important environmental condition.

Food chains and the circulation of water and materials bind the components of every ecosystem closely together. This relationship can also be expressed by the flow of energy which originates as solar radiation, passes through organisms, and finally is discharged into the inorganic environment.

Solar energy is primarily utilized through photosynthesis in green plants. No chemist is as yet capable of producing nutrient and raw material photosynthetically, and the mechanical utilization of solar energy is still rare.

Thus, it may be seen that ecosystems, and especially green plants in them, are of immeasurable value to mankind. Furthermore, they provided most of the raw materials for the coal and petroleum from which we still extract the greater part of our technical energy today. Only atomic energy is capable of making our technology independent of the energy binding capacity of plants.

This brings to the point the effect of the built

environment on nature. Natural vegetation is destroyed and replaced by ecologically bare areas as man introduces his systems. If the functions and elements of any built environment are examined in terms of biological structural components, one or more of them are found missing or are inadequate. Dependence is on the surrounding country side to meet the missing components, e.g. the pollution of rivers.(10)

The one way flow of energy and the circulation of materials are the two basic functional characteristics of ecosystems and principles of general ecology. Energy does not circulate but materials circulate, recirculate and are reutilized many times. Energy that is used once by a given organism or population in an ecosystem is converted to heat and is soon lost from the ecosystem. In the earth's ecosyste, the whole chain of life depends on the continual fixing and transfer of energy and unending cycling, recycling and reutilizing of materials through the ecosystem.

The energy sources of the built environment needs to be re-examined. The present production of power is inefficient, and besides polluting the environment would lead to the depletion of the fossil fuels. Alternative renewable energy sources could be used. Other energy forms besides electricity, e.g. radiant, chemical, thermal, mechical, could be utilized.

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10. Yeang, Ken, Basis for Ecosystem Design, AD/7/72 , p.434

Materials also need to looked into for the built environment; those materials which can be reutilized, or which demand the least amount of energy from the environment. The essential idea is to maintain the equilibrium of the enviroment.

In relation to fuels almost 96% of our present energy consumption is of the following: Oil 43% , gas 32.8%, and coal 20%. Hydro, nuclear and wood make up the balance. Electrical generation consumes about 25% of total fossil fuel primary energy sources annually but provides less than 10% of the power utilized. Even at present rates of consumption, domestic fuel reserves appear to be finite; coal, 2 to 4 centuries, but increasingly expensive to mine and desulphur and expensive to convert to liquid or gaseous fuel; oil, perhaps less than 70 years; and gas less than half that time.(11) We are already depending upon imports of fuels for a great portion of our needs and will be required to do so even more, even if nuclear power supplies half our electrical needs by the year 2000, which is in no way guaranteed, given the radiation,disposal, and environmental problems which must be overcome.

Cost to convert coal to a clean fuel will add to electric power cost; oil and gas imports cost more per BTU than domestic supplies; and costs of pollution control methods, as well as increased costs of capital equipment

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11. Dubin, Fred S., A Wiser use of Electricity and Energy Conservation Through Building Design, Building Systems Design Jan 1973, p. 8.

and installations all make it a foregone conclusion that costs of electricity as well as primary energy sources consumed directly will materially increase more than the cost of other services. The days of cheap power are probably gone forever.

Conservation of fuel energy can be realized by implementing many of the following suggestions in the design the the building. brought out by Dubin.

Reduce the environmental requirements and program as much as possible. These are ultimately the owner's decisions but he must be made aware of the alternatives and of the benefits which will result--including lower operating and life cycle costs for him.

a. Design levels of illumination and the degree of heating, and cooling, and ventilation in low occupancy areas should be lower than for fully occupied areas. In classrooms or offices, for instance, rather than illuminating the entire area to the same intensity, less light might be provided at areas outside the task zone, even when they are in the same room. The effect will actually heighten the interest compared to an evenly lighted space with no variations.

b. Higher relative humidities in the winter will reduce ventilation needs and lower dry bulb temperature requirements for the same degree of comfort with a net gain in fuel reduction. In order to maintain humidities

of 45% or more, double and triple glazing is required. Better U factors which result will also result in lower heating and cooling loads. Savings in capital costs of the smaller HVAC system will more than compensate for the extra cost of the glazing.

c. Reducing the area of glazing also saves initial and operating costs and energy. The loss in natural light will require increased artificial illumination. But this is more than offset in the gain in energy conservation by the reduction of heating and cooling loads.

d. In areas where codes, aesthetic or design considerations establish sizable amounts of glazing, the luminaires at the perimeter should be on a separate switch, or photo cell, to permit operation of those lighting luminaires at the perimeter when there is insufficient natural light. In major multistory office buildings or schools, about 25% of the energy normally used for lighting can be saved if the perimeter is handled in this manner.

e. Since about 50% to 60% of the electrical energy consumed in office buildings, not including heating or cooling is due to lighting, consideration should be given to lowering the overall average levels by about 50%. Better quality of illumination, rather than higher intensities, should be the goal. Since the largest reductions in illuminations levels are possible in the lesser-occupied areas, the resultant levels in the task areas would not be lowered

beyond the visual acuity required to specific tasks. Many recent experiments confirm that lighting levels between 10 and 40 footcandles are sufficient for visual acuity and physiological needs, where levels of 60 to 150 footcandles are now being provided.

f. The air quality of the spaces can be maintained with the reduced volumes of outdoor air by using odor-absorbing devices and better filtration with significant saving in energy and operating costs. The savings in initial costs of fans, and heating and cooling equipment and ductwork is greater than the added costs for better filters or odor absorption equiment.

Select and develop building sites and design the building structre and skin in a manner which will minimize energy consumption:

a. Where two or more sites for a proposed building are equally favorable for all other than energy conservation considerations, the following should be considered.

1. Existing tree, and or buildings provide effective solar control, reduce heat gain, and often shield the building from high winds, also reducing heat losses in the Winter, and saving energy in both seasons.

2. In moderate climates, outdoor air can be used for substantial periods of the year, in place of mechanical refrigeration or heating. Even in climatic zones with severely low Winter temperatures and extremely high summer temperatures

there are more than 500 hours a year that outdoor air can provide comfortable conditions and save considerable fan horsepower, if operable windows are provided.

b. Heating and air conditioning design starts with the building design. Building shape affects its energy consumption. A round building has less surface, hence less heat gain or loss than any other shape for an equal amount of square feet of area. A square building has less surface than a rectangular one for equal square feet area. A rectangular building with the long axis oriented to face north and south suffers less solar gain in the summer. A rectangular building with a one to 2½ side ratio will use 29% less energy for cooling if the short axis faces north and south, rather than east and west. Buildings partially below grade or employing berms reduce solar gains and transmission losses. The cost of insulation to reduce wall and ceiling thermal U factors to 0.06 can be amortized in short periods of time and usually result in reduced initial costs as well for the heating and cooling plant sufficient to offset the cost of the insulation. Thicker wall and roofs for better insulation by using more mass reduces energy consumption and noise as well.

c. Where glazing is used, external solar devices, such as fins, eyebrow reveals, awnings or special blinds enclosed in double sash should be employed. The appearance of the building may be agreeably enhanced by utilizing such

devices as an intergral part of the structure. Light colored finishes in the interior spaces increase the illumination efficiency.

d. Buildings with greater densities such as highrise, megastructures, party walls, require less energy for heating and cooling than an equal amount of building space dispersed in many separate buildings.

Utilizing building materials that require less energy for their production.

a. It requires approximately six times as much electric energy to produce a ton of aluminum as compared with a ton of steel. Under similar analysis the following building materials are comparted for energy costs.

CONSUMPTION OF ENERGY

HIGH	MED.	LOW	MATERIAL
x			Brick
		x	Wood
	x		Finishes
	x		Plastics
x			Aluminum
	x		Steel
	x		Glass
		x	Stone
		x	Gypsum Material
		x	Insulations
	x		Concrete
x			Asphalt

Make better utilization of buildings by combining facilities and systems to take advantage of diversity.

a. Multi-use buildings, such as combination schools and apartment houses, residential apartments and commercial space, office buildings and schools, educational and community facilities and other groupings provide utility and energy diversity, and result in lower energy burdens than the sum of each individual facility standing alone. Other secondary, but by no means unimportant, benefits of multi-use buildings are more efficient land-use, consolidation of transportation facilities, and revival of entire areas especially at night.

B. There are great opportunities to save energy by combining urban systems, for instance, methane gas which is generated at sewage disposal plants can serve as a supplementary fuel for high temperature incinerations or pyrolosis units for solid waste reduction; the heat produced from this process utilized to aid sludge digestion in the sewage treatment plant; the sludge then disposed of in the adjacent pyrolosis plant. Or the merging of an industrial park with an environmental park where metals, glass, aluminum, paper and other recoverable and useful materials are separated and salvaged and delivered directly to the industrial park portion of the complex where the waste materials are reused and new useful products produced. The residue of solid wastes which are not recycled are reduced

in one or more facilities, such as high temperature incinerators, pyrolosis units or other disposal facilities, where waste heat is recovered and distributed to manufacturing facilities in the adjacent industrial park. The industrial part provides employment opportunities in the community.

In addintion to these suggestions, new priorities for housing man in reverence to nature should be applied.

a. Build using the most abundant of local material or those whose production seems to cause the least amount of damage to the land.

b. Build simply utilizing as few materials as possible. But don't skimp on important things like first-class water proofing and super-extra double insulation. They will be repaid in the life of the building as brought out earlier.

c. Build permanently; instant domes and throw-away buildings sound appealing but their use gives nature not time to heal the sounds of construction before the next round starts. Each time we move, uproot, repave, regrade, or break ground, we tear the fragile fabric of life on the land, a fabric which may have taken decades or even centuries to develop. We must build more permanent buildings. Inside their occupancy and decor can be changed whenever necessary.

d. Build naturally; make sure the project and its site, whether one house is involved or a thousand do most of the following:

1. create pure air--trees, shrubs, vines, grasses, clean burning fuels or non-polluting heat energy sources.

2. create pure water--slow runoff, mulch, percolation

3. Store rain water--ponding, percolation, ground water.

4. produce their own food--gardens , greenhouses,

5. create rich soil--mulch, compost, orgainc fertilizing.

6. use solar energy--heating

7. create silence--dense plantings, sound insulations.

8. consume their own wastes--live organically, methane generation.

9. maintain themselves--permanent materials, earth cover, good water proofing.

10. match nature's pace--build permanently, keep population density in relation to the immediate nature to support it.

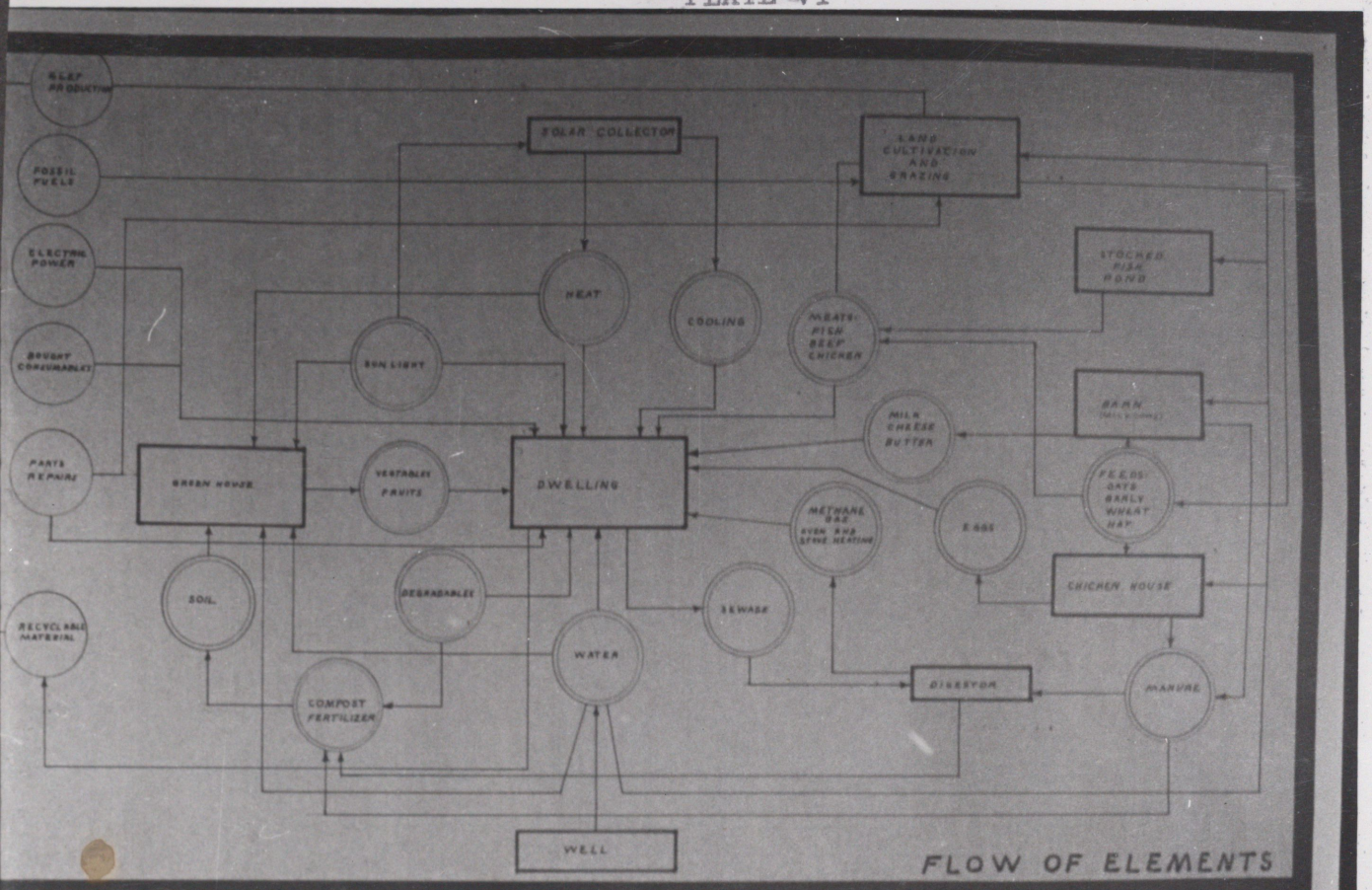
11. provide wildlife habitat--dense plantings, berries

12. moderate climate and weather--windbreak, dense groves of natural plants.

13. provide human habitat of acceptance.

From this study then shall evolve an application of the principles set forth. The physical aspect is to be a habitation unit for four married couples employed on a ranch. The ranch itself is approximately 40 miles from the nearest main urban center where it obtains the bulk of its commodities. It is apparent that considerable

PLATE VI


KELP PRODUCTION
SOLAR COLLECTOR
LAND CULTIVATION AND GRAZING
FOSSIL FUELS
ELECTRIC POWER
HEAT
COOLING
STOCKED FISH POND
MEATS: FISH BEEF CHICKEN
BOUGHT CONSUMABLES
SUN LIGHT
BARN
MILK CHEESE BUTTER
PARTS REPAIRS
GREEN HOUSE
VEGTABLES FRUITS
DWELLING
FEEDS: OATS BARLY WHEAT HAY
METHANE GAS COOK AND STOVE HEATING
EGGS
SOIL
DEGRADABLES
SEWAGE
CHICKEN HOUSE
RECYCLABLE MATERIAL
WATER
DIGESTOR
MANURE
COMPOST FERTILIZER
WELL
FLOW OF ELEMENTS


N

amounts of energy would be expended concerning transportation in this sisuation. The idea then is make the ranch more self-sufficient so as to reduce dependence on the energy for transportation. The following digram indicates the general flow of materials and energy that would be required to increased self-sufficiency and reduction of energy consumption of fossil fuels. (Plate VI)

The main purpose of the ranch is beef production so beef is the main outgoing product in the system, with recyclable material such as tires and scrap iron also outgoing. Those elements brought in to the system include fossil fuels, lubricants, electricty, repair parts, and some bought consumables such as salts, sugar, etc. The use of fossil fuels can be reduced further by utilizing the methane as fuel for the machinery, generation of electrical power, and heating. The methane gas would be produced on the site and actual production and utilization will be examined in more detail later.

The other means of becoming more self-sufficient is accomplished by the use of solar heating in the living unit, and growing or raising as much as possible the food consumed on the ranch. This aspect is accomplished through the function of the garden, green house, milkcows, chickens, and stocked fish pond.

The basic living unit itself is to be a single building for the four married couples. The idea here is that energy can be saved by providing common spaces that would otherwise

need to be duplicated in four separate living units and would have a higher utilization in the single building proposal than in the four separate unit. The actual common spaces and personal or private spaces will be dealt with later. Energy is also conserved through less exterior wall surface meaning less heat transfer and load, less construction material, and maintenence.

On the operation of the household, there would be one couple in charge of delegation of work, bookkeeping, etc. They would also have the control of screening the applicants and would be the ones that stayed on from year to year. A contract of some time period would have to be negoiated by the parties so as to develop a commitment to the living style involved.

The couples would be limited to 1 or 2 children and this limit would be built in by the pay scale on the ranch. If the children were unproductive as far as work was concerned it would cost that couple extra so more than 2 children per couple would create an economic hardship for them. The other drawback for the children would be the distance to the nearest school at 15 miles and the chances of being snowed in at times in the winter.

As for the kitchen operation or preparing meals, this activity would have to be worked out among the individuals. Either the one person that enjoys cooking does it consistently or trades off time periods with other work duties

so as not to overcrowd and create extra conflict in the situation.

More on the living and operation of the household will be brought out by the building program or requirements, however a bit of technology on methane production and solar heating shall be covered following since it bears a strong relation to the building design.

Recent emphasis has been on the so-called energy crisis, which is basically a fear that there will not be enough fuel. Of course, fossil fuel will ultimately run out, but for the short term, however, a more serious question is that the environmental burden of producing, transporting, and burning natural fuels will ultimately be unbearable. Mining coal in particular, directly despoils the land. Burning of all fuels, with the possible exception of natural gas, introduces unendurable pollutants into the air. Transportation of fuels or power, whether by pipeline, by high-voltage line, or piecemeal, causes various forms of environmental damage. Steam power generation plants (nuclear or fossil fuel) have the additional disadvantages of creating thermal water pollution. For diverse reasons, therefore alternative energy sources are desperately needed.

The methane generation plant produces a clean fuel, very similar to natural gas, using a waste product which must be otherwise disposed of or left to pollute. There-

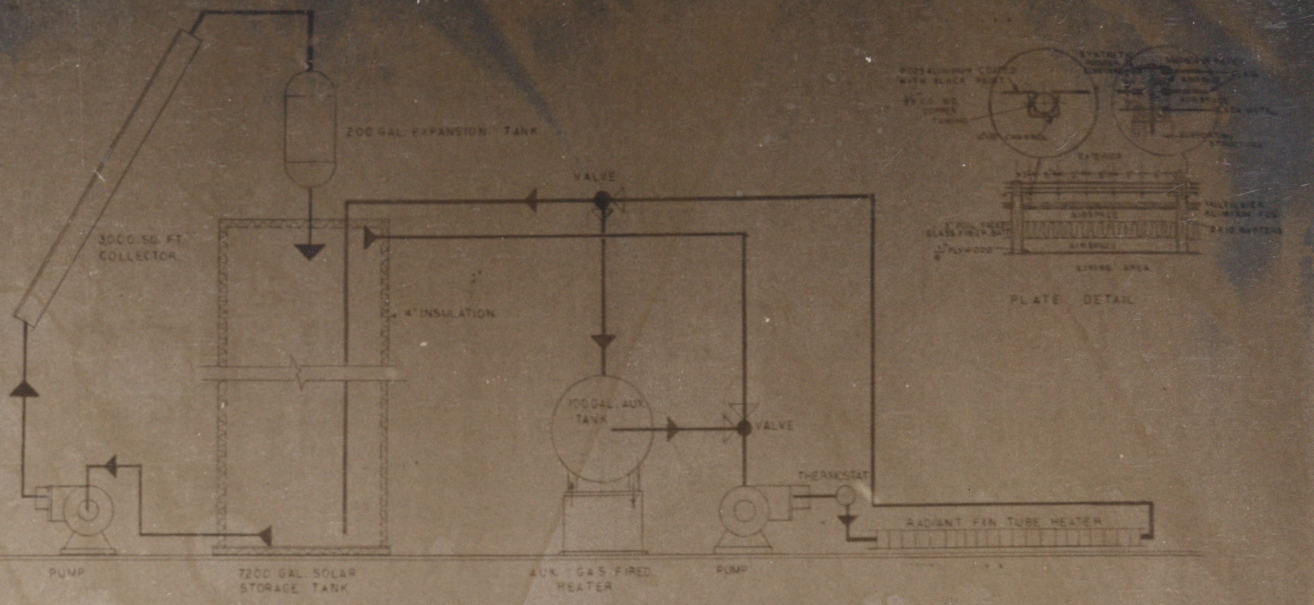
fore, no minig or extraction need be done, and a pollution is a negligible worry. In addition, neither the manure nor the fuel need be transported, since they are consumed on the spot. When integrated into the farm total system, methane recovery from manure would appear to be an excellent alternative to present energy quandaries. Complete use of manure available in the U.S. would add approximately 25% to the present gas supply. Many farm animals are currently raised in concentration, due to shortage of available land and for reasons of efficiency. Animal excrement particularly poultry, swine, and cattle, has thus become an environmental problem. Aminmal excreta is odorous, harbors pathogenic microorganisms, and attracts flies. In addition, the run-off from animal waste overloads the streams with nitrogen components and organic substances.(12)

The methane recovery unit would provide substantial assistance in dealing with these waste problems. First, the unit is sealed from the air, minimizing odor and insect problems. Second, digestion of the material and lack of oxygen effectively kills all pathogens. The final effluent is a rich fertilizer, as well as an organic one, and if properly used, will help to rectify nutrient impoverishment of the soils. Thus, form the point of view of waste treatment, enclosed anrobic digestion for methane recovery is an excellent

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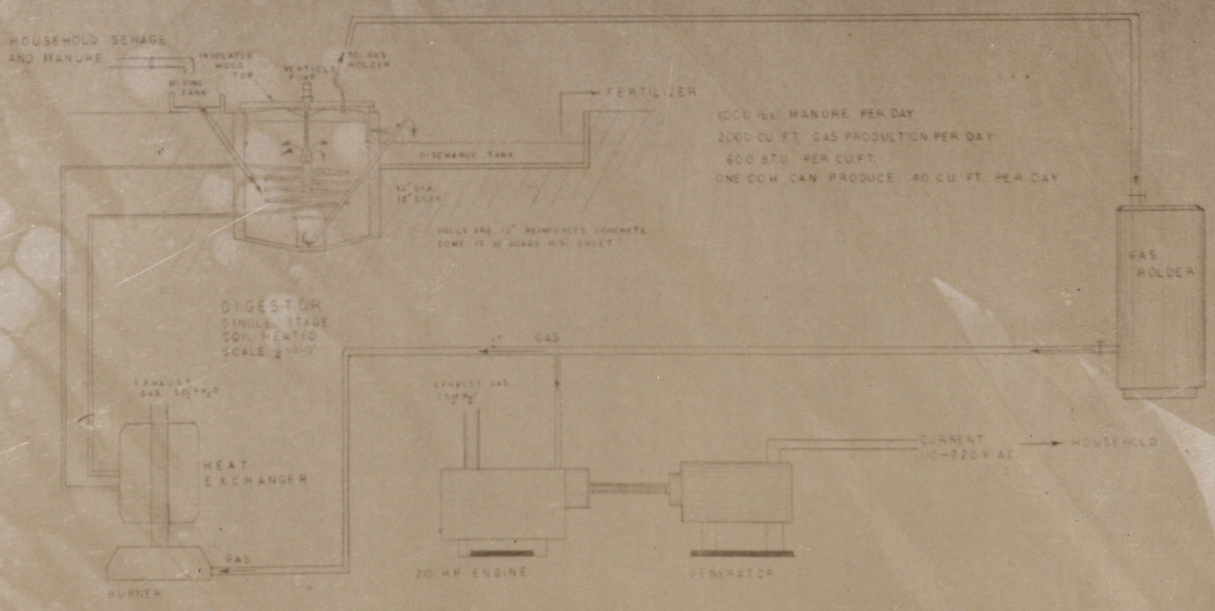
12. Methane and Fertilizer from Sewage and Wastes, Biotechnic Land Report 7, 1972, p. 3.

PLATE VII



SOLAR HEATING

THESIS PROJECT
ECO-LIVING
BY LES SIROKY '74



METHANE GENERATION

THESIS PROJECT
ECO-LIVING
BY LES SIROKY '74

method.

All ecological processes are ultimately circular; substances pass from one form to another, finally returning to their original state to begin again. Building from a unit to biologically treat animal waste and human waste recovering clean fuel and organic fertilizer, ia a way to cooperate with natures cycle and stablize and preserve the condition of the lands. It is more than just another technological endeavor, but a forerunner of an entirely new method of coping with the environment.(13.)

The methane gas generator is basically a large tank with an inlet for manure mixed with water, and outlet for digested material and a gas-tight dome for sealing the top. (Plate VII) The principle on which the plants operate is that of anaerobic fermentation. Certain microorganisms present in animal feces, when isolated from the air, digest carbonaceous material producing methane, CH_4. Biochemically the process involves several types of organisms and occurs in stages, reduction of matter to increasingly simpler chemical compounds and finally methane and some carbon dioxide. In addition, small amounts of hydrogen sulphide, traces of nitrogen, and other substances are sometimes produced. Generally the gas produced is 60% to 70% CH_4. The caloric value of this gas is approximately 600 BTU/cu. ft. The gas

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13. Ibid, p. 4

may be purified by bubbling through lime-water and passing over iron filings (H_2S removal) with natural gas. Methane is the purest fuel known, reacting with air to produce carbon dioxide and water both harmless natural-occuring substances. The gas can be used anywhere that propane, butane, natural gas, or (with minor modifications) gasoline or oil are used. For engines, methane is superior, burning cleaner and resulting in longer engine life.

Anaerobic digestion occurs most rapidly in two temperature tanges: Mesophilic--80to 105 F and thermophilic--120 to 140F. In general the higher the temperature the more gas produced. Agitation of the material increases production by permitting greater contact between organism and food.(14) Digestion proceeds most rapidly when solid content is about 10%. Hence, dilution of manure with an equal part of water is required.

All types of manure and other organic matter can be used in the digestor. Chicken manure is the best, followed by pig and cow manure in that order. In addition, horse, sheep and human excreta can be used. No-manure materials such as dry and green leaves, grasses, vegetable matter, organic garbage, and the flesh of dead animals may be placed in the digestor. Vegetable matter, however, should be separately fermented in a batch-feed digestor, that is, one

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14. Ibid p. 4.

fed periodically, say once every few months instead of continuously. Vegetable matter produces approximately seven times as much gas as manure, by weight, but takes longer to digest. The best arrangement, if vegetable matter is to be fermented is to use a separate tank and pipe the gas to the same holder as used for the manure digestion. Some nitrogen may gave to be added to vegetable digestors, as the carbon to nitrogen ratio should not be higher than 30 to 1. The amount of gas produced depends on the attendant conditions, but especially on the quality of the fermenting material and the temperature. In a tank maintained at 95 F with some agitation, 2 cu. ft. gas per pound of manure seems a reasonable output. One cow could therefore produce 40 cu.ft. of gas in one day.(15)

Much of the same reasoning for using the methane gas can also be applied to the use of solar energy for heating. Therefore the technology of solar heating shall be dealt with in the following.

Statistical results of solar radiation on horizontal surfaces are available in Weather Brueau Publications.(Plate VII) In buildings, however, differently oriented surfaces , walls and roofs, receive various amounts of radiation. Extensive calculations have been made and equations have been develpped to estimate the amount of solar radiation received on differ-

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15. Ibid p. 6.

TOTAL HOURS OF SUNSHINE PER MONTH FOR NORTH CENTRAL MONTANA

JAN	FEB	MAR	APR.	MAY	JUNE
140	160	220	260	280	300

JULY	AUG	SEPT	OCT	NOV	DEC.
380	320	260	200	120	120

$\overline{H}$ = BTU/FT²/DAY

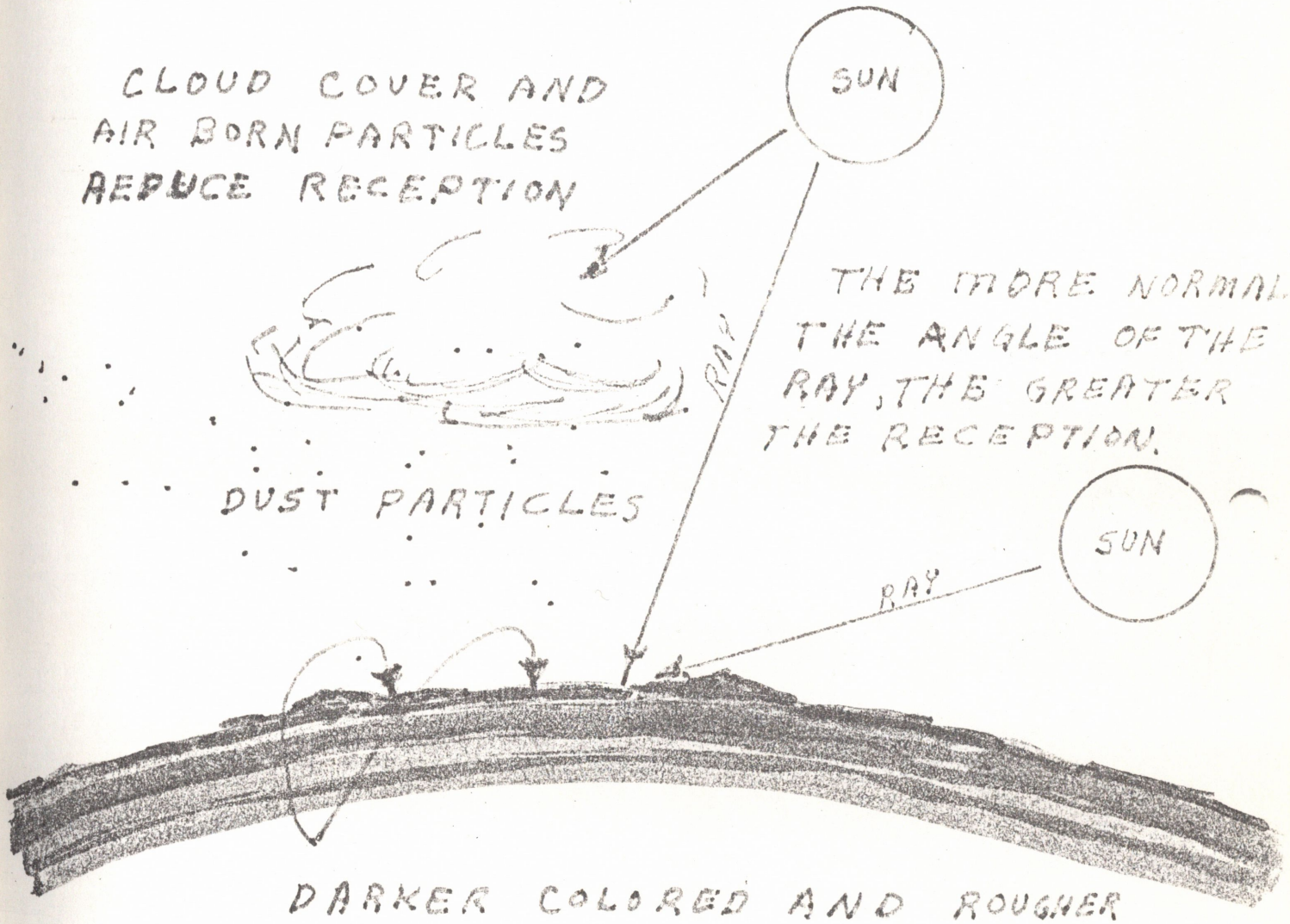
K_t = TERRISTRIAL RADIATION

t_o = AMBIENT TEMPERATURE

	JAN	FEB	MAR	APR.	MAY	JUNE
$\overline{H}$	524	869.4	1369	1621	1970	2179
K_t	0.552	.596	0.631	0.551	0.565	0.580
t_o	25.4	27.6	35.6	47.7	57.5	64.3

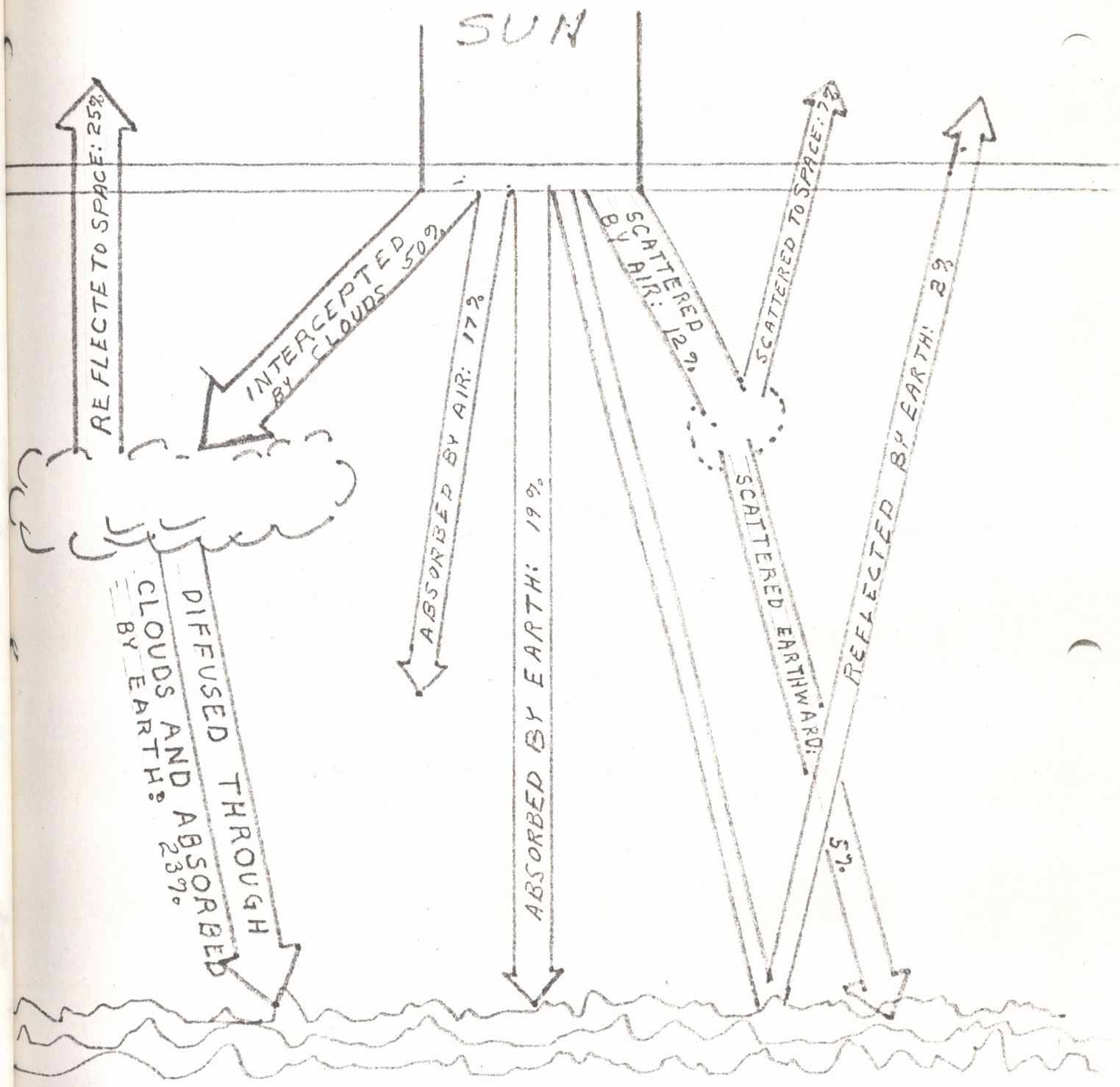
	JULY	AUG	SEPT	OCT	NOV	DEC.
$\overline{H}$	2383	1986	1536	984	575	420
K_t	0.656	0.627	0.626	0.579	0.503	0.518
t_o	738	71.3	60.6	51.4	38.0	27.1

FACTORS INFLUENCING RECEPTION OF SOLAR ENERGY BY THE EARTH.



DARKER COLORED AND ROUGHER SURFACES ABSORB MORE RADIATION

ALSO NUMBER OF HOURS OF SUN LIGHT PER DAY



OF THE RADIANT ENERGY REACHING THE SURFACE OF THE EARTH:

23 % IS DIFFUSED

19 % DIRECTLY FROM THE SUN

5 % RECIEVED FROM SCATTERED

ently oriented and tilted surfaces. The south side has a favorable relationship with the seasons, receiving the largest amount of heat in the winter time and relatively little in summer. East and west are less advantageous, and of the two, west is less desirable, due to high afternoon temperatures, which are coupled with radiation effects in summer. The north side receives its maximum impact in the summer but still receives relatively little radiation in comparison to the horizontal which receives the most radiation of all surfaces in the summer. It is evident, then, that a heat collector surface should have southern orientation. Tilting a south-facing surface will change the amount of heat received by radiation. The idea is to tilt the collector surface so the angle is receiving the most direct rays of the sun. This can only be accomplished by a movable plate that changes angle and moves with the sun continuously. Since it is very expensive to accomplish this with the scale involved a fixed plate of increased size over that of the movable plate is normally used. The plate then is oriented directly south and tilted at the angle from horizontal equivilent to the latitude plus 10 to 15 degrees.

Several research projects have been concerned with solar heat collectors. Air-spaced, glass panes were used to prevent heat loss from a black metal absorber plate. Air or water circulation was used to carry heat from the black plate to a heat storage bin. It has been realized that the

use of multiple air-spaced panes can diminish heat losses from the black plate, but increasing number of panes diminish the transmission of solar energy. A collector with two or three glass panes represents the standard collector used at the present time. (Plate VII)

Heat storage is on of the major problems of solar house heating. Economically acceptable heat storage methods must occup a small volume of the house, because this volume is rather expensive.

In conventional homes, the heater-room generally does not occupy more than four percent of the total volume of the house.(16)

Water and rocks have been suggested as the most available heat storage materials, heat being stored in their specific heat. On cubic foot of water has a heat storage capacity of 62.5 btu/F, while one cubic foot of solid rock has about 36btu/F. Assuming a temperature rise of 30 F, the heat-storage capacity of one cubic foot of water will be 1880 btu and that of rock 1080 btu. Telkes suggested a use of heat storage materials which melt at a moderate temperature level and store heat as their heat of fusinn, or heat of transition. Low cost salt hydrates can be used for this purpose. Their heat of fusion is around 100btu per pound or a cubic foot can store 9000 to 10,000 btu as their heat of fusion at the transition temperature. However,

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16. Olgyay, Aladar , Design Criteria of Solar Heated Houses Proceedings of the UN Conference on New Sources of Energy, p.200

no system has been developed to make this feasible. In the systems utilizing water about 2.35 gallons per square foot of collector, has a heat capacity of 19.55 btu/F sq. ft. of collector and consequently a one degree rise for each 19.55 btu/sq.ft. collected. Six hours of collection in one day at the long-term average rate of 90.9 btu/sqft. hr. would cause a temperature rise of approximately 28F. If the storage at start of collection were at the minimum economical recovery temperature, 82.5F thetemperature at the end of collection would be very near optimum.(17)

The present arrangement of the collecting and heating system is shown in plate VII. Water from storage is circulated through the collector at the rate of 8.36 lb/sqft. hr., and returned to storage by way of the expansion tank. The expansion tank functions to reduce pressure fluctuation with temperature change.

Water from solar energy storage is pumped through the heating system heat exchanger and returned to the tank from which it was withdrawn. The same is true when the auxiliary unit is utilized for space heating. The return water from the heat exchanger when operating on the auxiliary unit will be warmer than the solar storage when this storage has been fully depleted for space heating purposes.

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17. Ibid. p. 201

The two sources of hot water for the heat exchanger must be connected in parallel rather than series to prevent heat exchanger returns from raising the temperature of storage by the addition of relatively high cost auxiliary heat, thus increasing storage losses and impairing collector efficiency by raising the inlet temperature.

The auxiliary heating system must be capable of supplying the maximum probable heating demand plus the domestic hot water requirement of the house. Extremely cold weather is generally accompanied by clear skies and high solar incidence, but the possibility of conditions combining extreme cold and lack of insolation following a prolonged period of overcast weather during which the energy storage has been depleted makes this criterion necessary. In a system where domestic hot water is heated to the temperature of solar storage and then topped up in the auxiliary unit, the temperature level of the auxiliary is determined by the necessary domestic hot water temperature.(18)

The form of the auxiliary heating system depends on the location of the solar house and local fuel availability. A hot water heater fired by the most economical locally available fuel has been found satisfactory where both auxiliary space heating and domestic hot water are required. In other systems, a conventional hot air furnace for space

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18. Engebretson, C.D., The use of Solar Energy for Space Heating , Proceedings of the U.N. Conference on New Sources of Energy. p. 164

heating and a water heater for domestic hot water heating would be utilized to advantage.

The satisfactory operation of a solar house requires two basically independent control systems. One system must concern itself with the circumstances surrounding the collector and energy storage unit to control energy collection while the other must monitor conditions in the living space and regulate energy utilization in response to space heating demands. While these two processes are not entirely unrelated they are not sufficiently concurrent to permit a single control system to suffice.

The fundamental requirement of the collector control is that it respond to solar radiation in the plane of the collector surface while being aware of the temperature of the storage unit. It must function to initiate and sustain collector operation through all periods during which the radiation incident on the surface is great enough to permit withdrawal of a quantity of heat of equal or greater value than the energy required to operate the collector.

One satisfactory means is the installation of resistance type sensors in the collector and in the storage unit, the sensors in turn being connected electrically in the legs of an alternating current bridge circuit. An electronic relay responding to circuit unbalance will performthe control operations once the circuit has been cali-

brated and adjusted. Any mechanism capable of comparing these two temperatures with reasonable accuracy can be applied.(19)

The space heating control is required to function to maintain living space temperature within predetermined limits using as much energy from solar energy as possible and then supplementing this with heat from the auxiliary system. Aconventional thermostat bimetal can be used to initiate operation of the heating system pump. As long as the temperature of storage is sufficiently high to satisfy heating demand, this operation is all that is required. However, if the temperature of the living space should continue to fall even with solar heating, another similar device can be utilized to permit heat to be supplied to the house by the auxiliary system. When the demand no longer requires auxiliary operation, the second bimetal of the thermostat returns the system to solar operation. (20)

A solar heated housewill differ from a conventional one. From the above data, generalizations can be derived for its design. It is obvious that the dimensions will differ in various regions according to the local ratio of sunshine hours to degree days. Detailed calculations should be made but for preliminary planning the following

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19. Ibid. p166

20. Ibid. p. 167

recommendation could be followed:

1. For each two spuare feet floor areaof the house, one spuare foot of collector surface is required.

2. The heat-storage area of the house, will occupy about 4% of the floor area.

3. The insulation of the walls should have a U factor of 0.13, or lower. The windows should be double glazed. The ratio of window surfaces to wall surfaces is 1 ; 3, or 20 percent fenestration.(21)

The economic aspect of solar-heating feasibility can be expressed by a comparison with the usual heating systems. This comparison must be based not only upon initial installation costs, but also upon operational expenses since the fuel, so to speak, is built in a solar-heated house. Thus, to get the whole picture, the expense of a 20-year house operation period is a realistic basis for comparison. Considering an average oil-geated house in a 5000 to 6000 degree-day year zone, with a heating equipment cost of $1800 and ayearly consumption of 1300gal. of oil. The yearly operational expenses will run around $180 per year or about 10%of the installation costs. The present value of future fuel savings ($180)/yr based on a interest rate of 4½% in a 20 year period is $2340. Adding to this

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21. Olgyay, p204.

the installation cost of the conventional fuel operated heating system the total amount is $4140, a sum representing the equivalent of keeping the house heated for 20 years. This amount is 2.3 times larger than the installation cost of the heating equipment. Thus a design criterion can be established: a solar-heated house will break even, economically if the installation of the system costs 2.3 times as much as a conventional heating equipment. If it costs less, it will save money as well as fuel energy.(22) In other cost comparisons a $2.50 to $4.00 cost per square foot of collector surface will make it feasible over a 20 year period or sooner.

It is probable that separate solar heating systems cannot be marketed as independent units the same way as conventional furnaces, but the solution is in the building of complete solar heated homes. On the basis of experience solar heating systems and the design of the house must be integrated.

Thus this being the general direction of the building toward conserving energy the following is the statement of the requirements for this type of operation.

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22. Ibid. p 205.

S I T E A N A L Y S I S

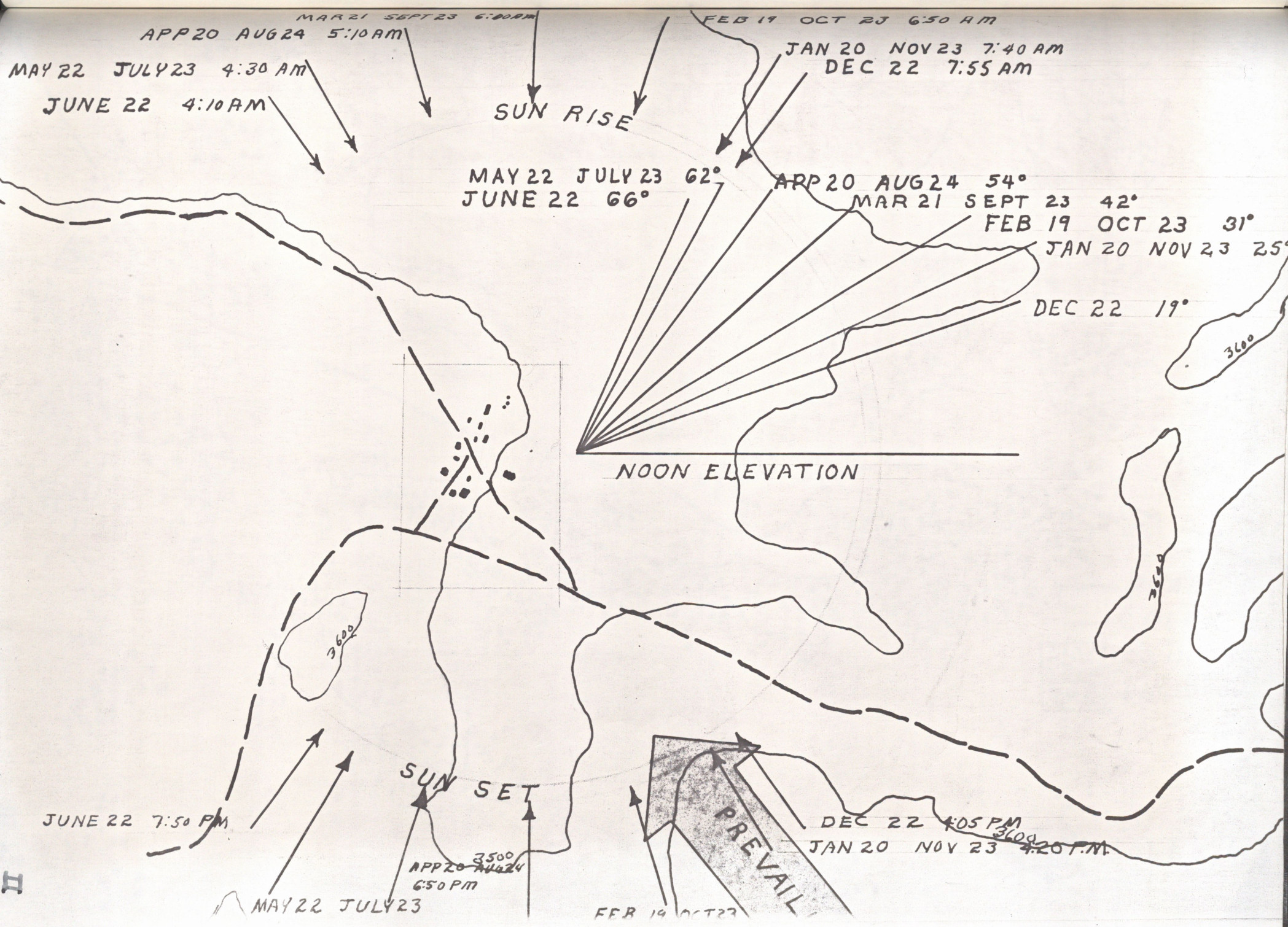
I. Roads, trails, contours.

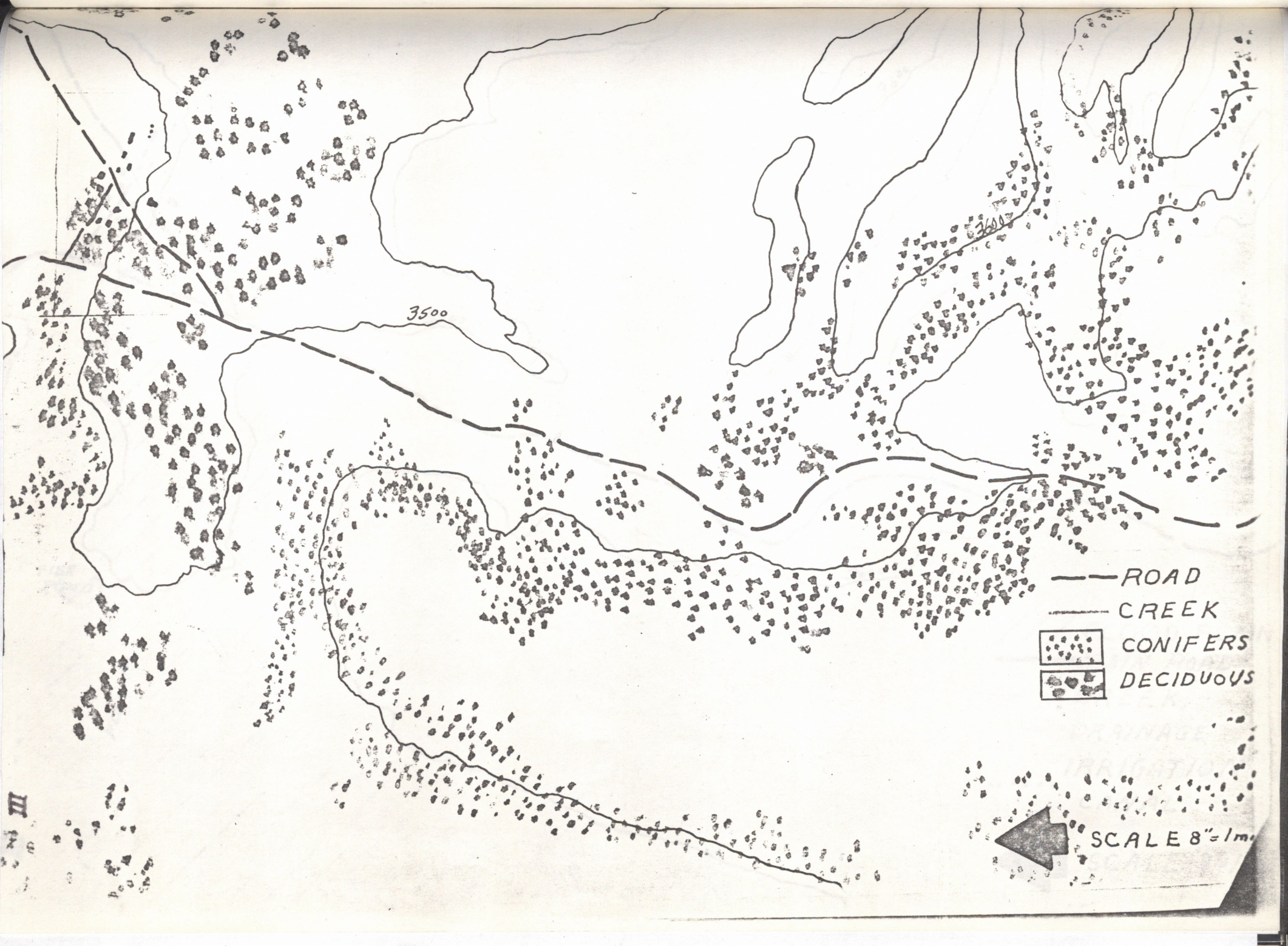
II. Sun and wind.

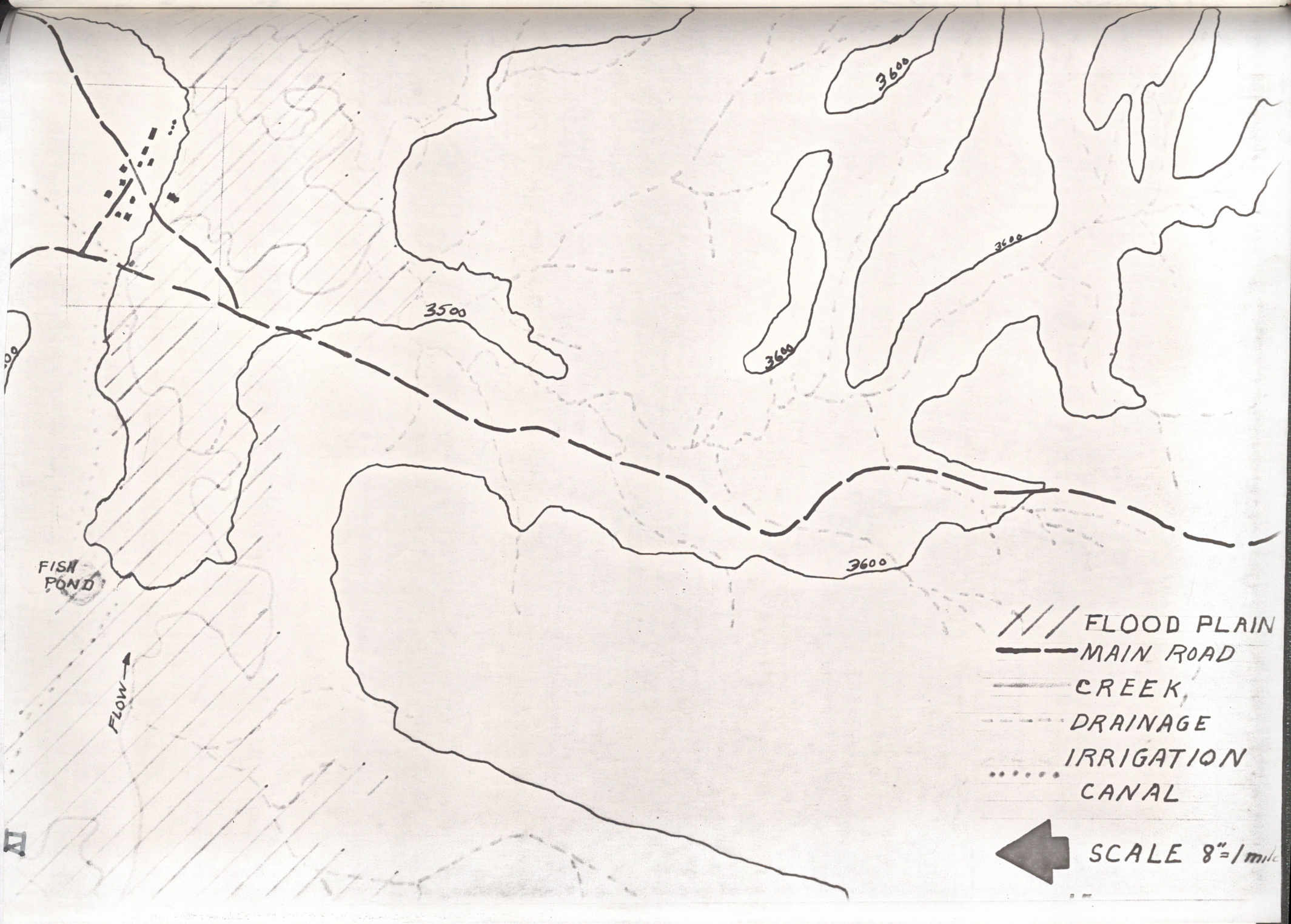
III. Vegetation.

IV. Drainage.


3500
20
40
60
80
3600
3700
MAIN ROAD
TRAILS


MAR 21 SEPT 23 6:00 AM
APP 20 AUG 24 5:10 AM
MAY 22 JULY 23 4:30 AM
JUNE 22 4:10 AM
SUN RISE
FEB 19 OCT 23 6:50 AM
JAN 20 NOV 23 7:40 AM
DEC 22 7:55 AM
MAY 22 JULY 23 62°
JUNE 22 66°
APP 20 AUG 24 54°
MAR 21 SEPT 23 42°
FEB 19 OCT 23 31°
JAN 20 NOV 23 25°
DEC 22 19°
NOON ELEVATION
3600
3600
3600
SUN SET
JUNE 22 7:50 PM
APP 20 AUG 24 3500
6:50 PM
MAY 22 JULY 23
PREVAIL
DEC 22 4:05 PM
JAN 20 NOV 23 4:20 P.M.
FEB 19 OCT 23


3500
3600
ROAD
CREEK
CONIFERS
DECIDUOUS
SCALE 8"=1m


3600
3500
3600
3600
3600
FISH POND
FLOW
/// FLOOD PLAIN
MAIN ROAD
CREEK
DRAINAGE
IRRIGATION
CANAL
SCALE 8"=1 mile

V I E W S







NORTH



SOUTH



SOUTHEAST



SOUTHWEST



EAST



WEST

LIVING UNIT REQUIREMENTS

ENERGY USE

ROOM
EQUIPMENT

ROOM
AREA

LIVING
CONSIDERATIONS

LOCATION - RELATIONSHIP

REQUIREMENTS

10 FT. CDLS. GEN. ILLUM.

AUX. HEAT SYSTEM
SYSTEM CONTROLS
HOT DOMESTIC
WATER STORAGE
METHANE GAS
SUPPLY
SEWER MAIN
WATER MAIN

MECHANICAL
160 Sq. Ft.

CENTRAL LOCATION

ELECTRICAL: 3 OUTLETS
10 FT. CDLS. GEN ILLUM
80 FT. CDLS AT MIRRORS
SEWAGE DRAIN
HOT AND COLD WATER SUPPLY
MECH. VENTILATION

PER ROOM
3 SINKS
1 WATER CLOSET
1 BATH-SHOWER
3 MIRRORS
TILE FLOOR

BATH ROOMS
3 @ 90 Sq Ft

NATURAL LIGHT
NATURAL VENTILATION

ADJ. TO BEDROOMS
NEAR LIVING AREAS
ADJ TO MECHANICAL

ELECTRICAL: 4 OUTLETS
10 FT. CDLS GEN ILLUM.
60 FT. CDLS AT WORK AREAS

PER ROOM
1 DOUBLE OR
2 SINGLE BEDS
CLOSET
STORAGE DRAWERS
TABLES
LAMPS
SEATING
RUG FLOOR

BEDROOMS

6 @ 225 sq ft
4 ADULT & 2 CHILDREN

NATURAL LIGHT
NATURAL VENTILATION
VIEWS

AWAY FROM LATE
ACTIVITY NOISE
COOLER ZONES OF HOUSE

ELECTRICAL: 4 OUTLETS
60 FTCDLS GEN. ILLUM.

2 - 3'x6' TABLES
12 CHAIRS
CHINA STORAGE
TILE FLOOR

DINING

180 Sq Ft.

VIEWS
SUN LIGHT
NATURAL VENTILATION

ADJ TO KITCHEN
SEATING FOR 8 - 12
ACCESS TO OUTSIDE

ELECTRICAL: 3 OUTLETS

30 FT. CDLS. ILLUM.

FLOOR DRAIN IN LOCKER

WALK IN LOCKER

OPEN SHELVES

CLOSED STORAGE

TILE FLOOR

PANTRY

160 Sq Ft

ADJ TO KITCHEN

SERVICE ACCESS

ELECTRICAL - 4 OUTLETS

60 FT CDLS. GEN. ILLUM

100 FT CDLS. AT WORK AREAS

HOT & COLD WATER SUPPLY

SEWAGE DRAIN

METHANE GAS SUPPLY

WASHER

DRYER

IRONING BOARD

IRONER

UTILITY SINK

SOAP STORAGE

LINEN STORAGE

TILE FLOOR

LAUNDRY

160 Sq Ft

VIEWS

SUN LIGHT

NATURAL VENTILATON

ACCESS TO OUTSIDE

COMMON LIVING AREA

ELECTRICAL 3-6 OUTLETS PER AREA.

40 FT. CDLS. GEN. ILLUM

80-100 FT CDLS STUDY AREAS

FIRE PLACE

- ACTIVITY AREAS

T.V. VIEWING

CRAFTS

LEATHER

SEWING

MUSIC

READING - STUDY

TABLE TENNIS

POOL

ETC.

RUG FLOOR

LIVING ROOMS

3-4 @ 200-300 Sq ft.

VIEWS

SUN LIGHT

NATURAL VENTILATION

ACCESS TO OUTSIDE

GENERAL SEATING AREAS

ELECTRICAL: 2-110 V. OUTLETS

20 FTCDLS GENERAL ILLUM

100 FTCDLS AT DESK

DESK

2-3 CHAIRS

LAMP

FILING CABINETS

RUG FLOOR.

OFFICE

100 Sq ft

EASY ACCESS BY VISITORS

ELECTRICAL: 4 OUTLETS
10 FT. CDLS. GEN. ILLUM.
150 FT CDLS FLUORESCENT LIGHTING
HOT & COLD WATER SUPPLY
SEWAGE DRAIN

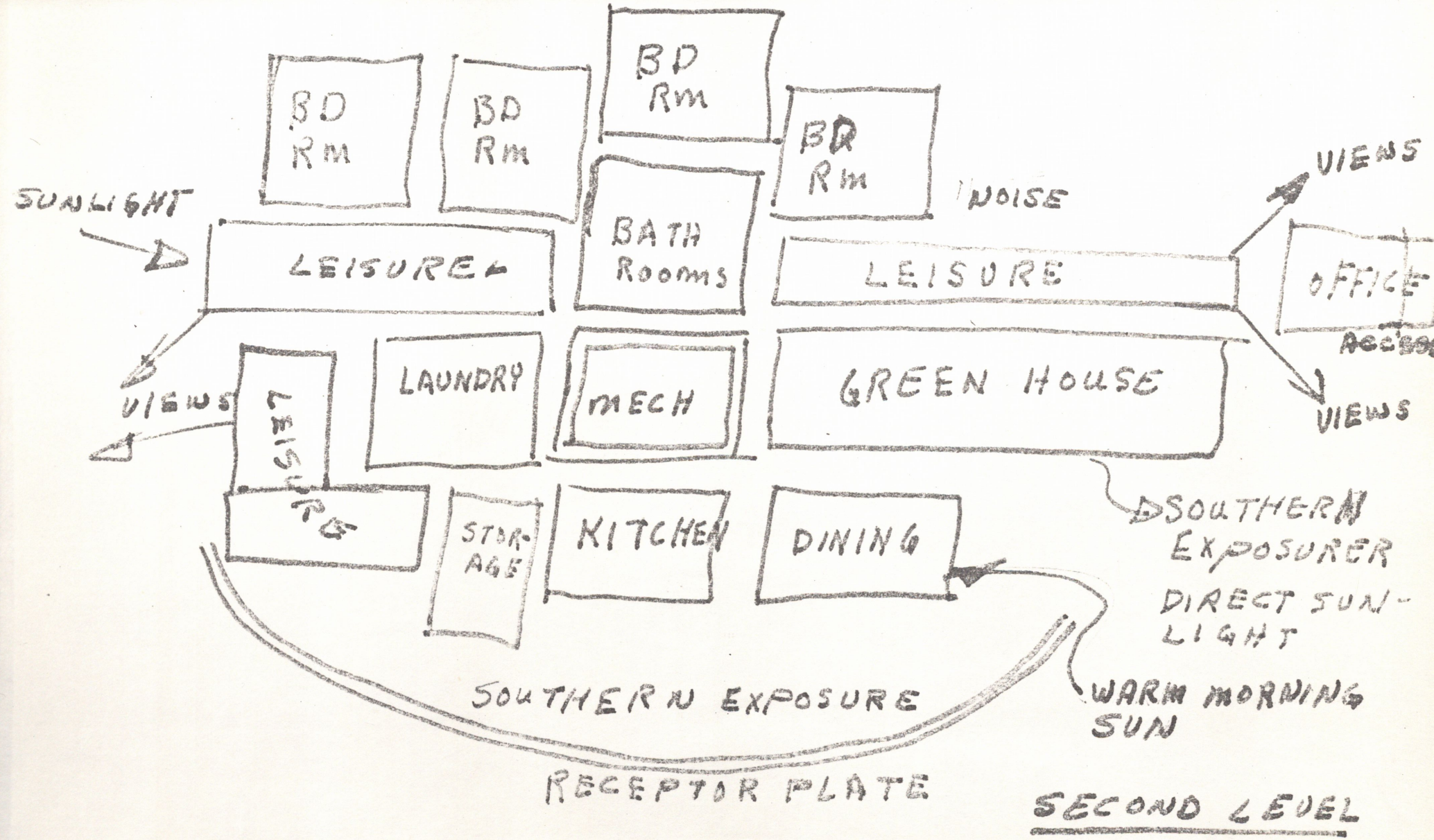
PLANTING BEDS
UTILITY SINK
SOIL & FERTILIZER
STORAGE
WOOD FLOOR

GREENHOUSE

500 Sq ft

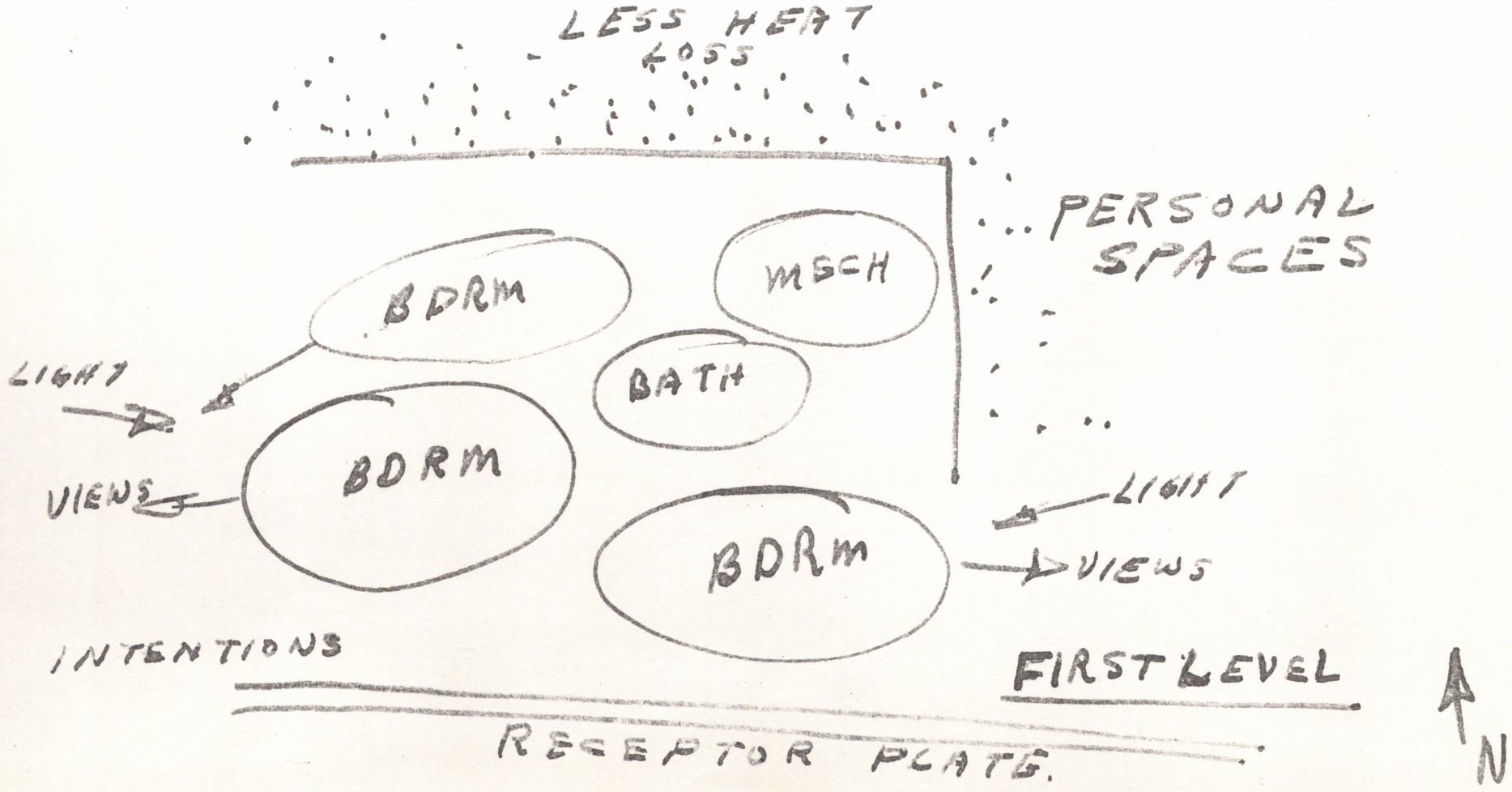
DIRECT SUNLIGHT
NATURAL VENTILATION

SOUTHERN EXPOSURE
UPPER FLOORS OF HOUSE
TO ACCOMODATE NATURAL
HEAT FLOW OF HOUSE.



SECOND LEVEL

INTENTIONS


LESS HEAT LOSS
PERSONAL SPACES
BDRM
MSCH
BATH
BDRM
BDRM
LIGHT
VIEWS
LIGHT
VIEWS
INTENTIONS
FIRST LEVEL
RECEPTOR PLATE
N

L I V I N G U N I T D E S I G N E D

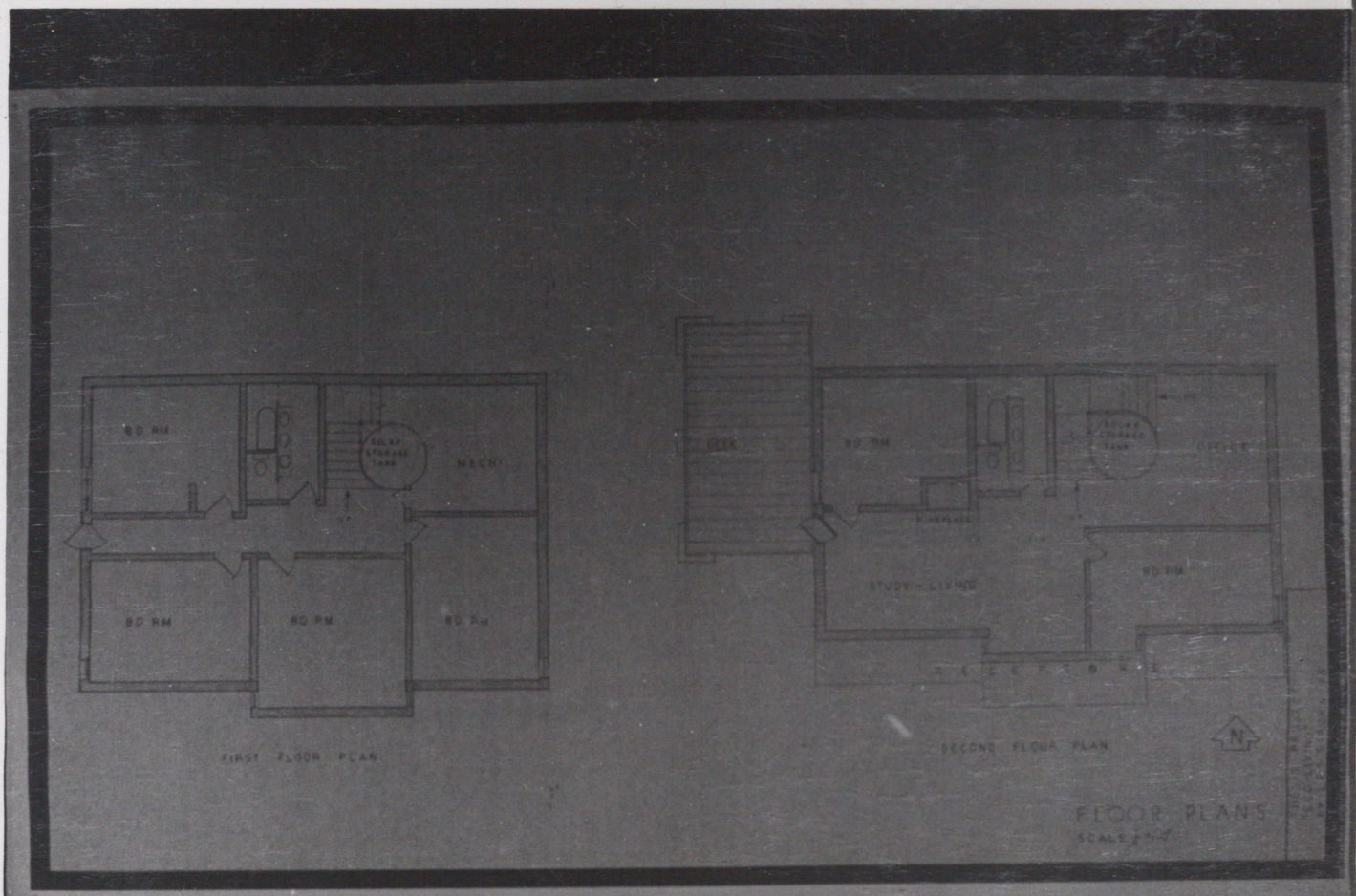
PLAN OF FLOOR LEVELS

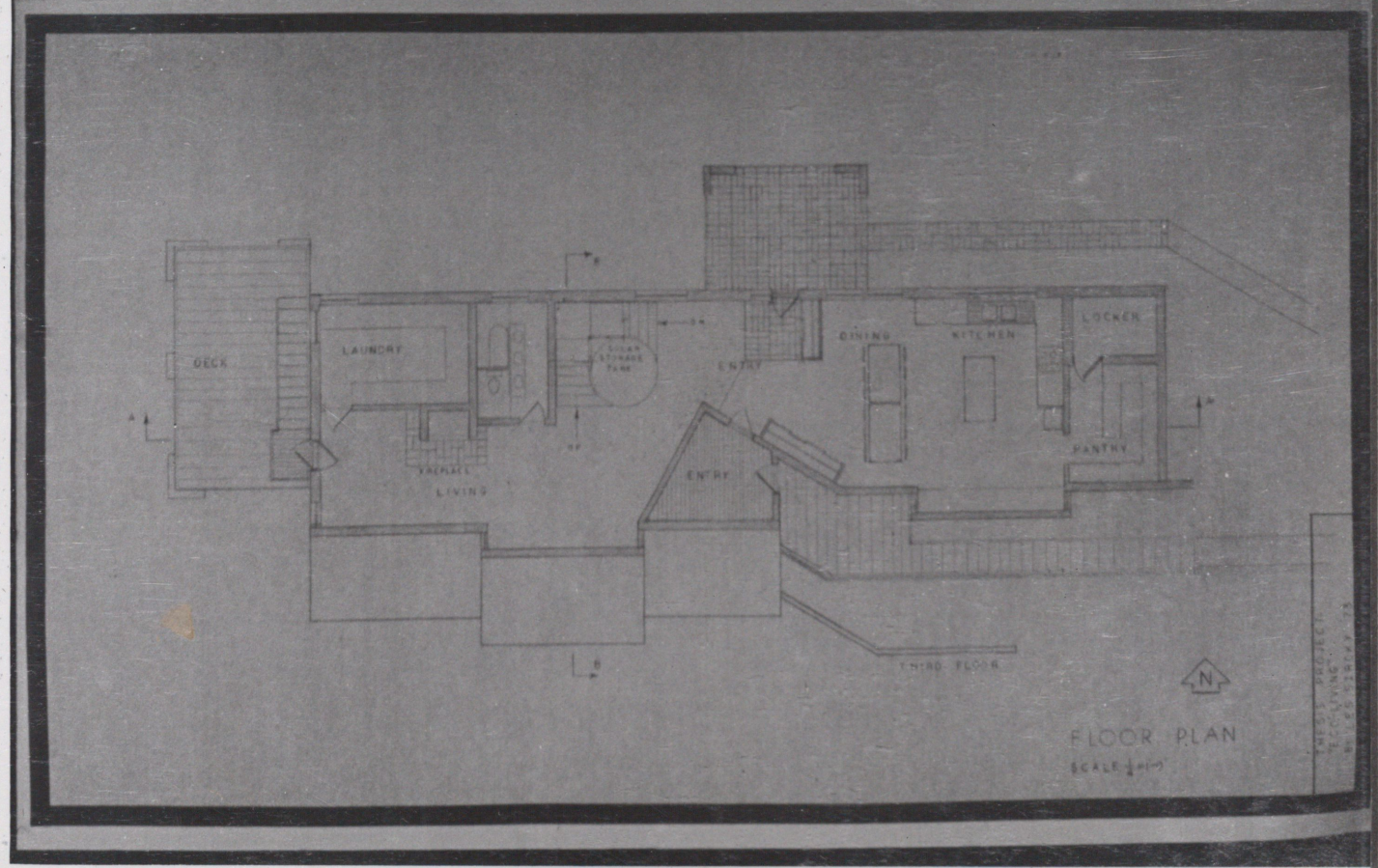
ELEVATIONS

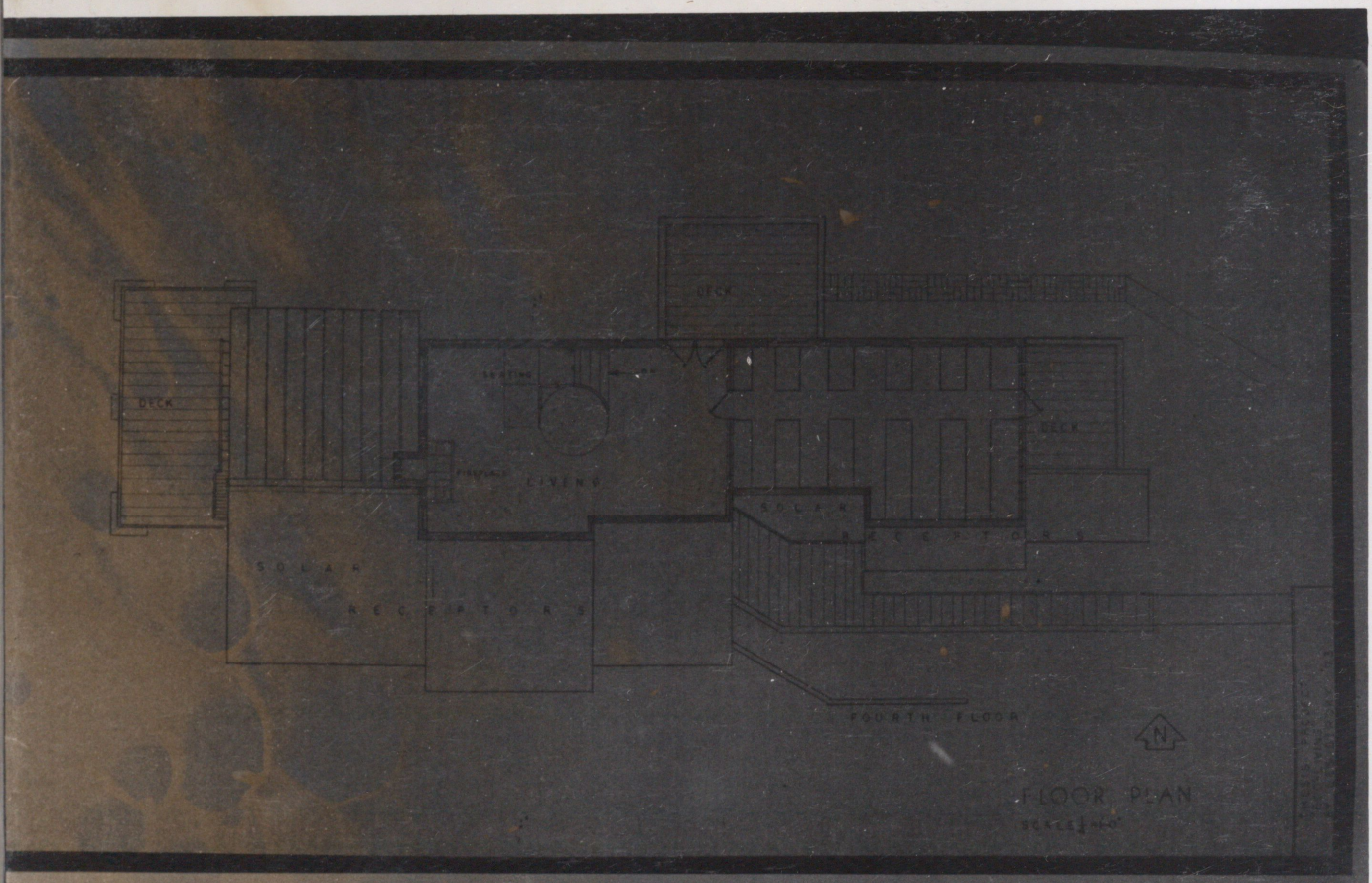
SECTIONS

MODEL PHOTOGRAPHS

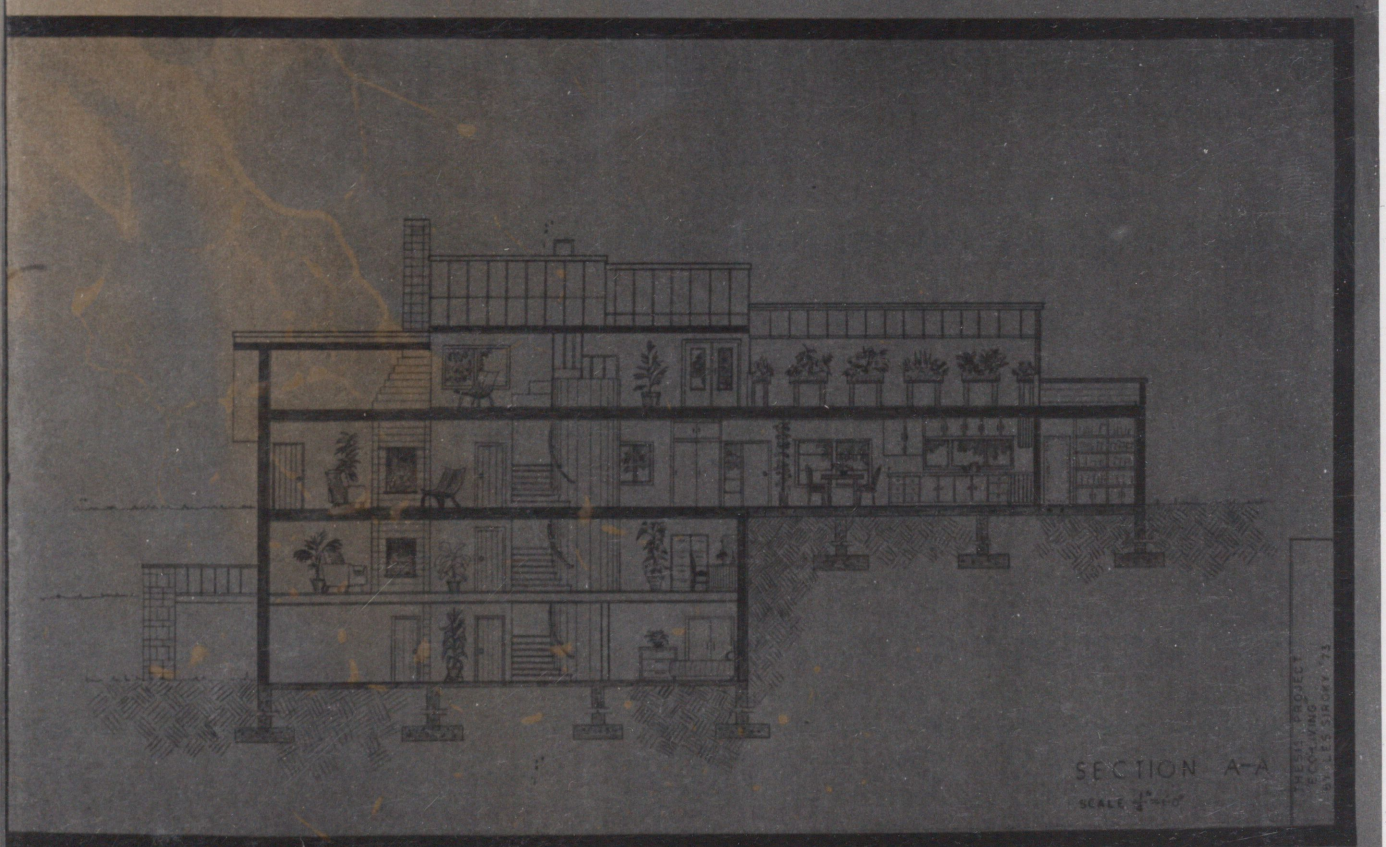
SOLAR HEATING COST COMPARISON


BD RM
SOLAR STORAGE TANK
MECH'
BD RM
BD RM
BD RM
FIRST FLOOR PLAN
DECK
BD RM
OFFICE
FIREPLACE
STUDY - LIVING
BD RM
SECOND FLOOR PLAN
N
FLOOR PLANS
SCALE 1/8"=1'-0"

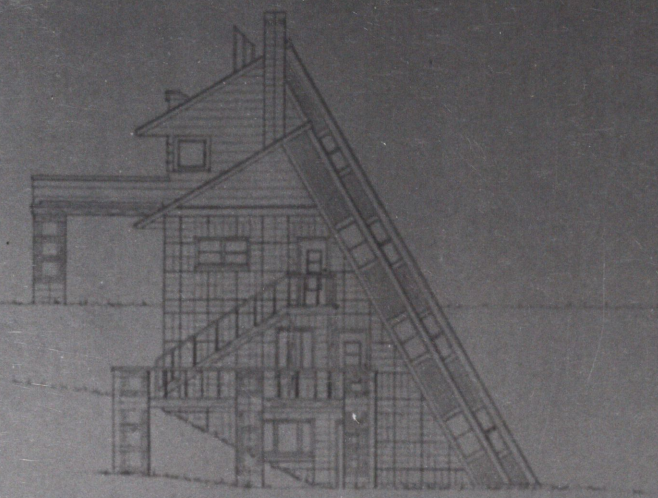

DECK
LAUNDRY
SOLAR STORAGE TANK
ENTRY
DINING
KITCHEN
LOCKER
PANTRY
FIREPLACE
LIVING
ENTRY
THIRD FLOOR
N
FLOOR PLAN
SCALE 1/8"=1'-0"



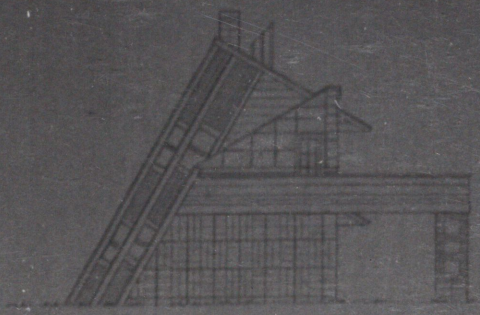
FLOOR PLAN



SECTION A-A



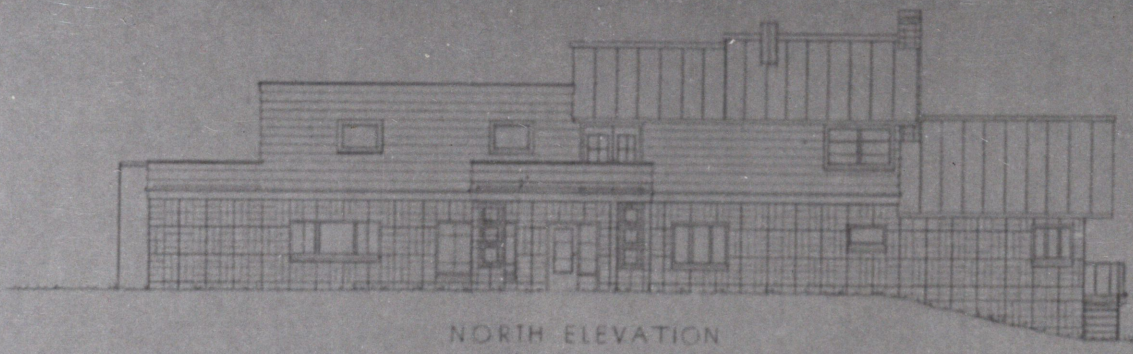
WEST ELEVATION



EAST ELEVATION

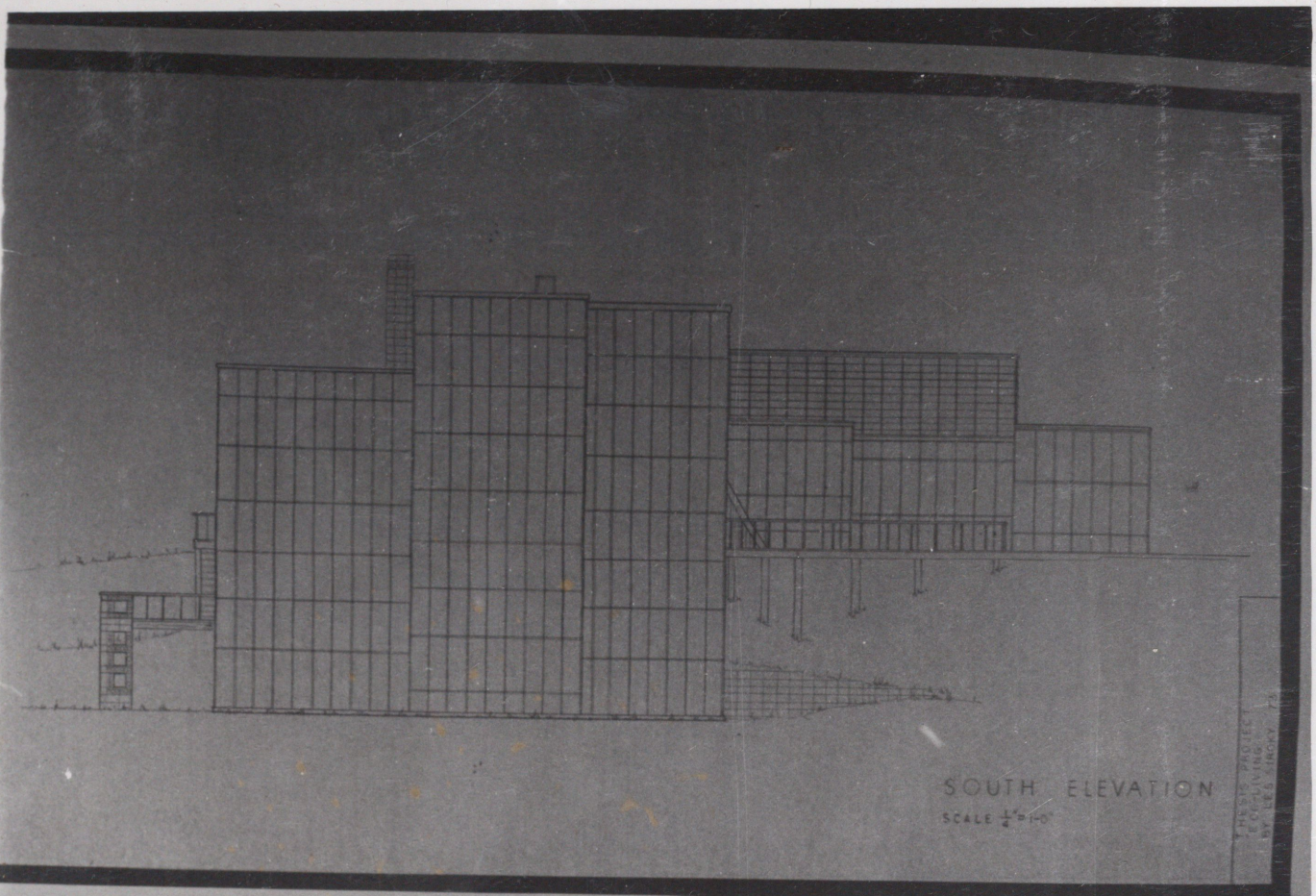
ELEVATIONS

SCALE 1/4"=1'0"



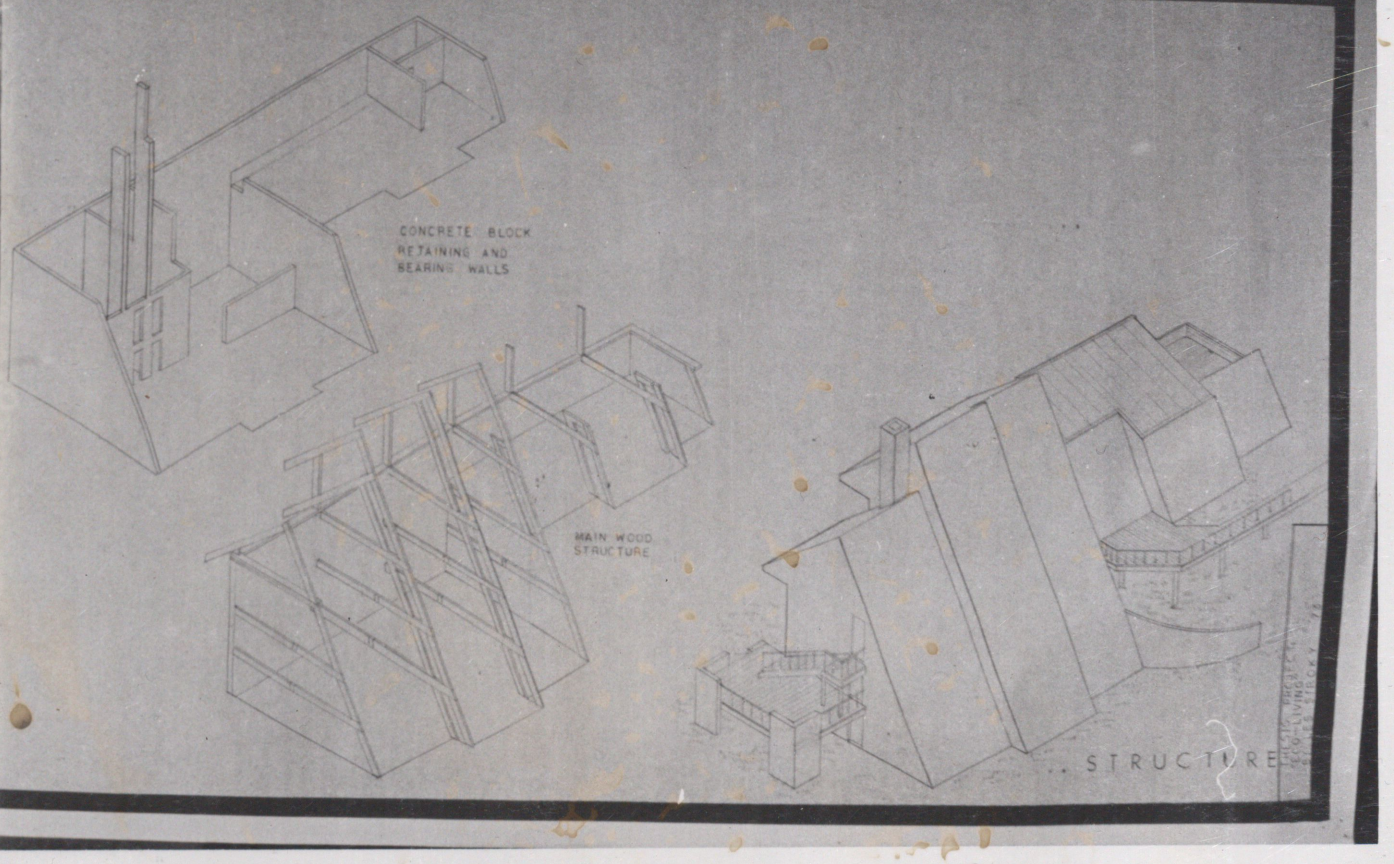
NORTH ELEVATION

SCALE 1/4"=1'0"



SOUTH ELEVATION

SCALE 1/4"=1'-0"



STRUCTURE



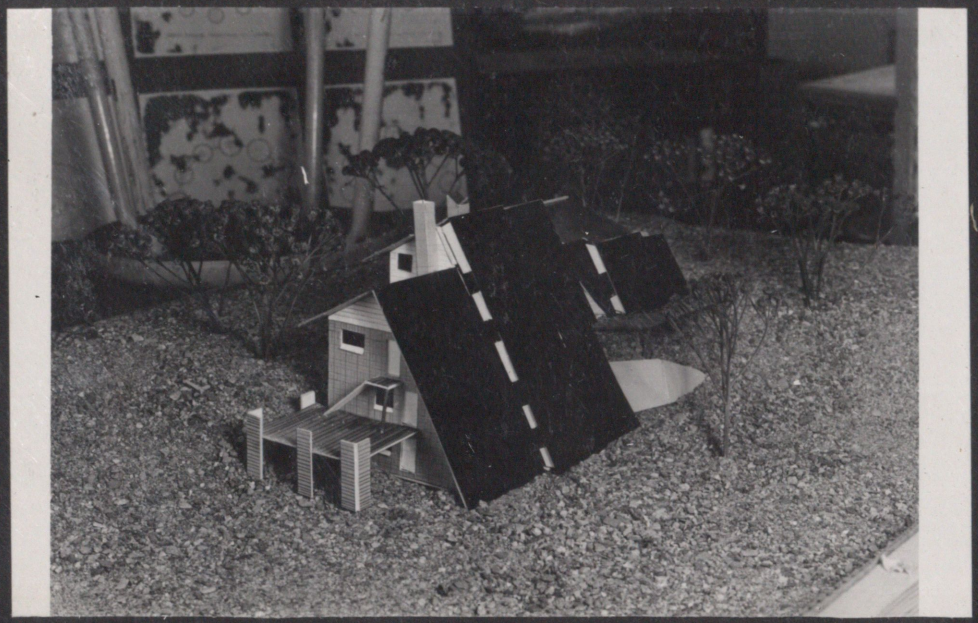
SECTION B-B
SCALE 1/4"=1'-0"

WOOD FRAME WALL SECTION

BLOCK WALL SECTION

WALL BELOW GRADE SECTION

SECTIONS







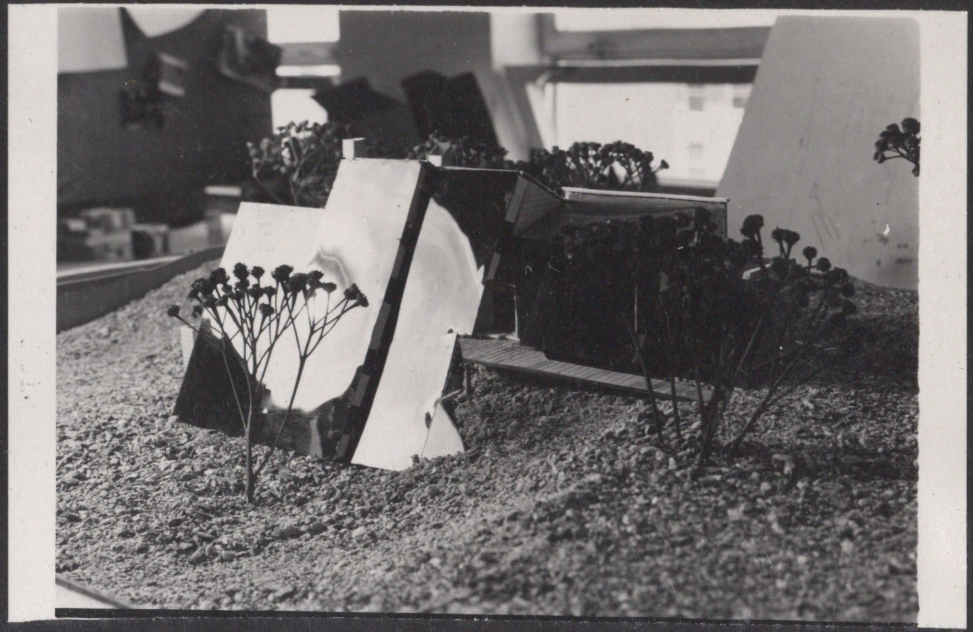
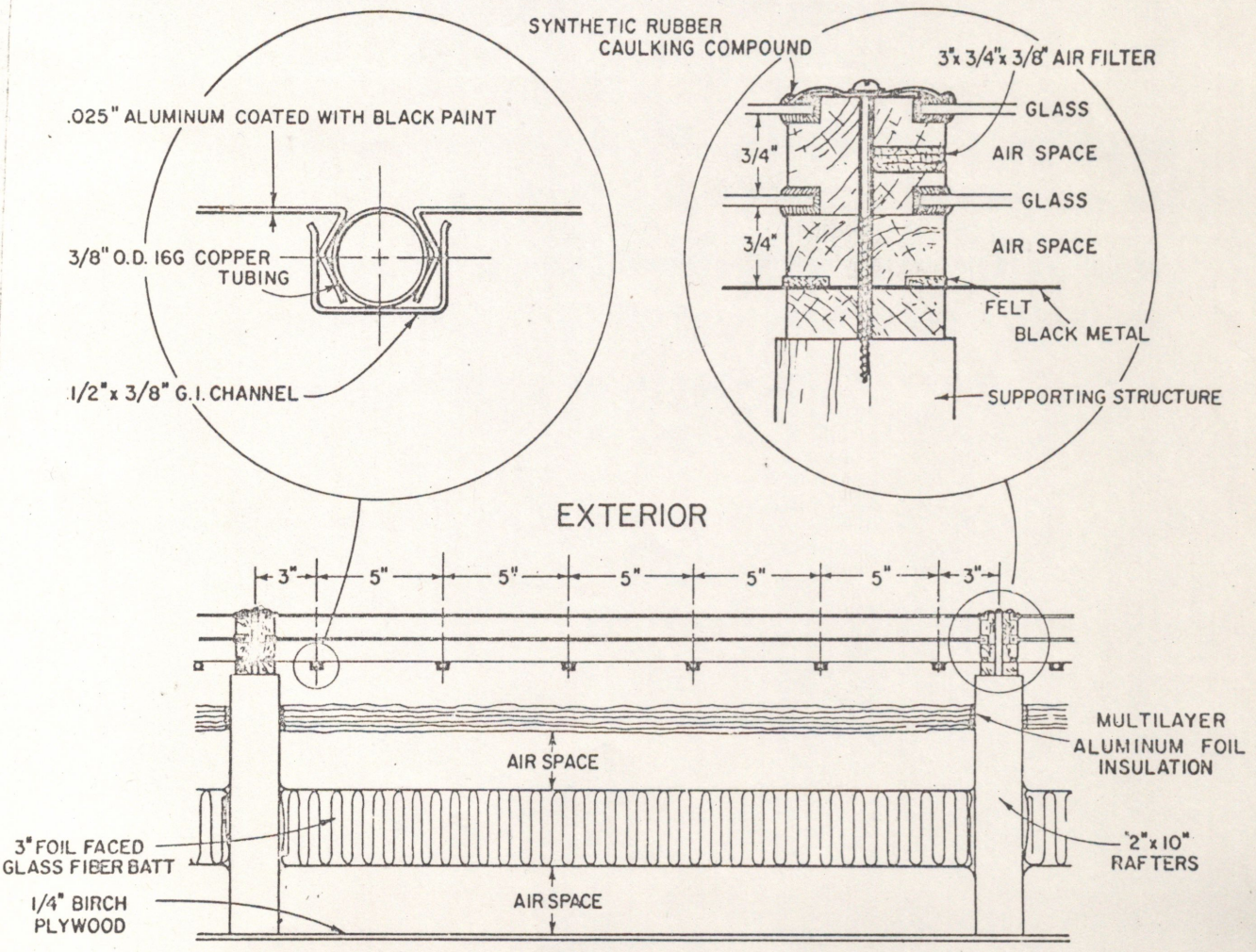


PLATE COSTS

	Cost Per Square Foot
Glass - eighth inch double strength 6,000 sq. ft. @$2000 by the job. ----------	$ 0.60
Aluminum Sheet 24"x 8' 0.025" Thick ----------	0.70
Copper tubing- 3/8" Dia, 16 g. Three per foot sgrare ----------	0.90
Foil backed insulation- 6" Wool Glass---------	0.17
Fasteners, mastic , etc. ----------	0.30
Total cost per square foot ----------	$ 2.67
Total plate cost ----------	$8010.00



LIVING AREA

COST COMPARISON

Plate cost ----------	$ 8010.00
Solar storage tank ----------	1500.00
Total solar cost ----------	9510.00

Furnace installation ---------	$ 4000.00
Fuel cost per year (fuel oil @ $0.20 per gal.) ----------	560.00

Solar cost = Furnace plus Fuel cost per year x years

9510 = 4000 plus 560 x?years

9.8= ? years

The results show that the solar installation would pay for itself in fuel saving indapproximately 10 years under average operating conditions. This indicates it to be very feasible for this operation; the narmal comparison generally figures out to 20 years.

CONCLUSION:

The use of the solar energy in the building had a strong influence on the outcome of the building design. A large amount of southern surface area has to be devoted to the receptor plate thus it creates a very long narrow building. The southern elevation then takes on a machine like appearance in contrast to the northern elevation which relates back to the present building forms. The east and west elevations give the strongest feeling of the total building with the technological aspect of the sloped plates in contrast to the basic building forms of today.

Jury evaluation pointed out that the house had a machine or industrial feeling and should perhaps have a more natural feeling since the idea of living in harmony with nature is its basic aim. However, the machine quality resulted from the solar energy usage and the criteria that efficient and economical means were to be employed which would related to the agricultural communities.

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