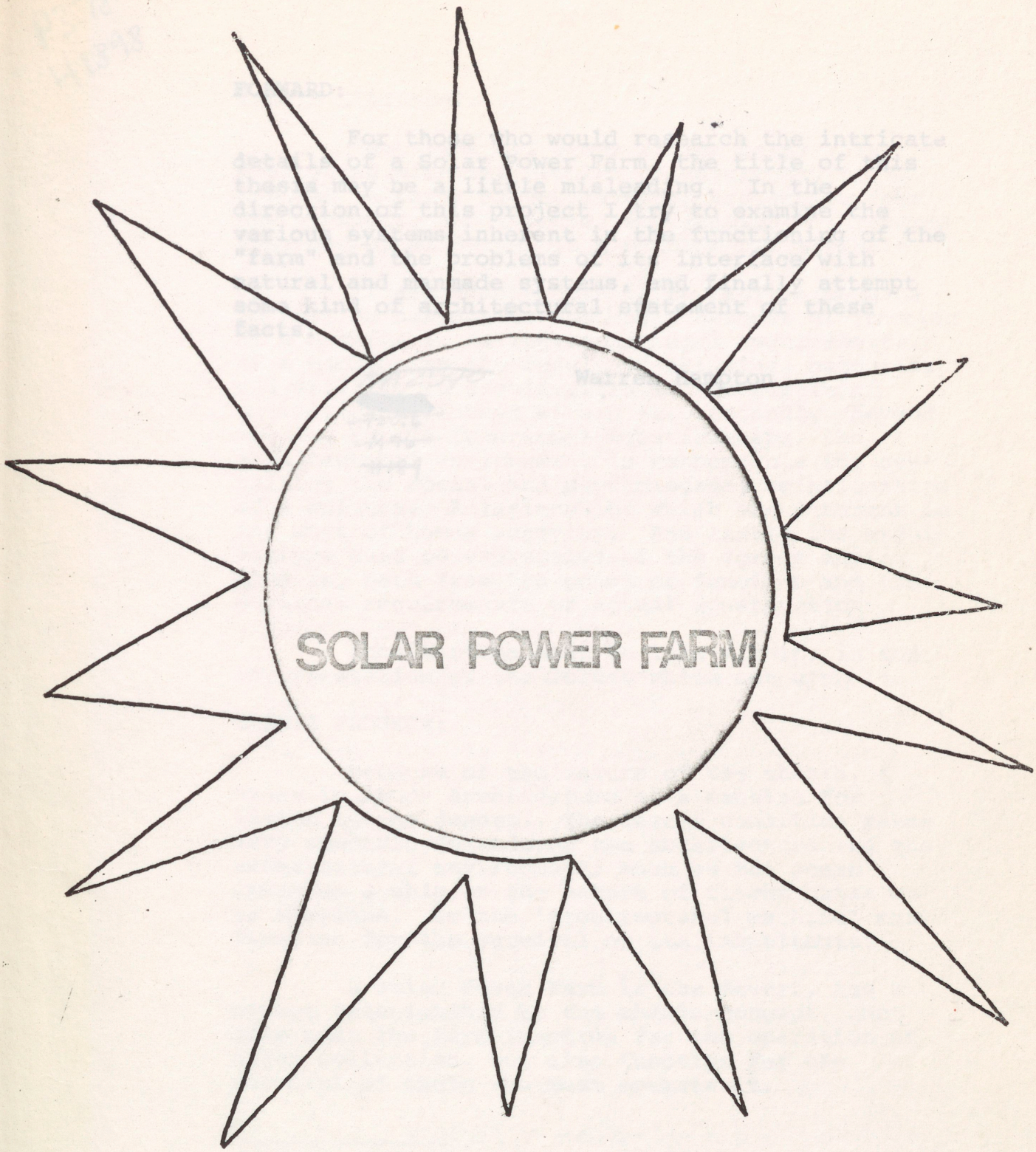
WARREN R. HAMPTON
SOLAR POWER FARM

P378
.H1898

LIBRARY
State University
Montana
BUZZ....



For Yuma, Arizona Undergraduate Thesis In Architectural Design by Warren R. Hampton Submitted to the School of Architecture as partial fulfillment of the requirements for the degree of Bachelor of Architecture at Montana State University, Bozeman, Montana June, 1974. For Yuma, Arizona Undergraduate Thesis In Architectural Design by Warren R. Hampton Submitted to the School of Architecture as partial fulfillment of the requirements for the degree of Bachelor of Architecture at Montana State University, Bozeman, Montana June, 1974.

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H1898

FORWARD:

For those who would research the intricate details of a Solar Power Farm, the title of this thesis may be a little misleading. In the direction of this project I try to examine the various systems inherent in the functioning of the "farm" and the problems of its interface with natural and manmade systems, and finally attempt some kind of architectural statement of these facts.

Warren Hampton

NA2540
[redacted]
720.6
M76
H189

THESIS STATEMENT:

"Man like all other living beings, is confronted with the problem of adjustment to habitat in terms of subsistence, protection from the elements, and defense from enemies."[1] Towards this end ARCHITECTURE IS A MACHINE FOR LIVING.[2]

If architecture is to be truly a machine it must be servant to the basic demands of function as a machine is to its operational requirements. As a machine is the result of grinding, hammering, and drilling so architecture is the result of activities performed within it. Secondly, beyond meeting simple functional relationships, the architectural environment is responsible for sustaining the social and psychological relationships of a culture. Relationships which are inherent in any sort of human activity. And lastly the architecture must be expressive of the forces acting upon it, both from the point of function and the physical requirements of actual construction.

Architecture must be like a ship; in the interpretation of the forces which act upon it.

THESIS PROJECT:

Because of the nature of the thesis, I chose to study architecture as a machine for living in the desert. The desert condition makes very specific demands on the architecture and the architectural environment, much as the ocean makes on a ship or the nature of flight makes on an airplane. So the 'architectural machine' must function for the survival of its inhabitants.

A Solar Power Farm in the desert, has a direct relationship to the thesis concept. Not only must the farm function for the operation of solar collection, but also function for the survival of those who must operate it.

---

[1] White, Leslie A; 'Tools, Techniques, and Energy,' p. 29 from Cultural and Social Anthropology; Peter Hammond editor; Macmillan, New York, 1964.

[2] The reader may note the similarity to a well-known statement by LeCorbusier: 'The house is a machine for living.'

Basically the function of a Solar Farm is to collect large amounts of solar energy for the creation of steam and the generation of electricity. Essentially the sun's energy is captured through a system of solar collectors which transfer the heat to a carrier fluid. This fluid 'carries' the captured heat to a central facility where it is used to convert water to steam, which is sent through a turbine to generate an electric current.

The human implications of this process are that the Solar Farm must provide shelter of two kinds; 1) space for working and 2) space for living. And that these two environments will be specifically delineated by the needs of the inhabitants.

THESIS ADVISOR:

Ilmar Reinvald - Director
School of Architecture MSU

RESOURCE ADVISORS:

Patrick C. Jobes - Assistant Professor
Department of Sociology MSU

William D. Bliss - Professor/Department Head
Department of Psychology MSU

Ifan Payne - Associate Professor
School of Architecture MSU

METHODOLOGY:

I foresee the development of the project to involve a basic sort of research framework:

1. search and discovery of laws and principles (fact-making).

2. known facts (the result of research).

3. analysis, evaluation and organization of facts into meaningful patterns.

4. response to facts in design synthesis.

5. architectural product.

6. evaluation.

For additional information refer to the schedule calendar.

A TENTATIVE SCHEDULE:

JAN		PROGRAM EVALUATION
	DATA COLLECTION	PROBLEM DEFINITIONS & SCOPE
		SITE CONSIDERATIONS
FEB		ENVIRONMENTAL REQUIREMENTS
	IDEA FORMULATION	ENERGY DETERMINANTS
MAR		CONCEPT HYPOTHESIS
		CONCEPT SYNTHESIS
		PROGRESS REPORT MARCH 4, 1974
APR		DESIGN DEVELOPMENT
MAY		FINAL PRESENTATION JUNE 1, 1974
JUNE		THESIS BOOK SUBMITTED JUNE 7, 1974

***WEEKLY MEETINGS WITH ADVISOR

RESEARCH INFO

INFORMATION MATRIX 7
SITE 9
PSYCHOLOGICAL 48
PHYSIOLOGICAL 55
SOCIOLOGICAL 69
POLITICAL 75
ECONOMIC 77
ENERGY 81

SOLAR SYSTEMS LIVING UNIT APPENDIX

PROBLEM:	ESTABLISH GOALS:	ANALYZE FACTS:	DEVELOP CONCEPTS:	DESIGN DIRECTIVES:
1. SITE: PHYSICAL CHARACTERISTICS ECOLOGICAL SYSTEMS LOCAL SURROUNDINGS	PHYSICAL IMPACT	VEGETATION GEOLOGY CLIMATE FLORA FAUNA	FOOD CHAINS SURVIVAL SYSTEMS CLIMATE ECOLOGICAL SYSTEMS	SITE 'FIT'
2. PHYSIOLOGICAL: THERMAL SONIC LUMINOUS BODILY SENSES	PHYSIOLOGICAL EFFECTS	VISUAL AURAL OLFACTORY TASTE TOUCH/SKIN SENSES	METABOLIC REQUIREMENTS	PHYSIOLOGICAL 'FIT'
3. PSYCHOLOGICAL: PERCEPTION	PSYCHOLOGICAL EFFECTS	BEHAVIOR DATA PERCEPTUAL DATA	PSYCHOLOGICAL NEEDS	PSYCHOLOGICAL 'FIT'

4. SOCIOLOGICAL: HUMAN POPULATION	SOCIOLOGICAL IMPACT	SOCIAL STRUCTURES SOCIAL STATISTICS	SOCIOLOGICAL NEEDS	SOCIOLOGICAL 'FIT'
5. POLITICAL: PROPERTY OWNER- SHIP CODES ZONING	OWNERSHIP POLITICAL ASSOC. CODES ZONING	CODES ZONES OWNERSHIP	OPERATIONAL	POLITICAL 'FIT'
6. ECONOMIC: FUNDING MARKET LOCAL ECONOMICS	ECONOMIC IMPACT PROFIT RETURNS VOLUMES	COSTS LAND TAXES TIME	ECONOMIC RETURN MARKET SENSITIVITY	ECONOMIC 'FIT'
7. ENERGY HISTORY SOLAR COLLECTION CONSERVATION	ENERGY EFFECTS	RESOURCES ENERGY PRODUCTION COLLECTION STORAGE	ELECTRICAL: PRODUCTION CONSUMPTION TRANSMISSION	ENERGY 'FIT'

PHYSICAL IMPACT
GEOGRAPHY
GEOLOGY
CLIMATE
FLORA
FAUNA
ENVIRONMENTAL SYSTEMS
SURVIVAL

SOLAR FARM GOALS AND CHARACTERISTICS:

PHYSICAL SITE:

The siting of the Solar Farm must utilize the optimum climatological conditions for the collection of solar energy:

minimum sky cover
maximum possible solar radiation
high daily temperatures, etc.

in coordination with area studies of:

land use
population distribution
land ownership
vegetation, etc.

Essentially climate is the single most important factor in the feasibility of a solar collection facility, consequently the "Farm" must make as little impact on the existing climatic surroundings as possible, in order to maintain the natural conditions which are important to its operations.

Secondly, realizing the complex relationships of existence and survival in the desert, the "Farm" must disturb these systems as little as possible; ideally it should become part of the working whole.

Lastly, the architecture must be a statement of the quality of the desert in the requirements of the human environment, and the physical characteristics of the region.

The following pages of data and maps[3] are representative of the conditions which were considered in making a final site selection:

---

[3]Climatic data from Climatic Atlas of the United States; U.S. Department of Commerce; U.S. Government Printing Office; Washington D.C.; 1968. Photographs are from The National Atlas - The United States of America; United States Department of Interior, Geologic Survey; Washington, D.C.; 1970.

MEAN ANNUAL NUMBER OF DAYS 32°F AND BELOW:

ten days; similar to an area in the Southern United States along the Gulf of Mexico and areas along the West Coast; San Francisco and San Diego.

MEAN ANNUAL NUMBER OF DAYS 90°F AND ABOVE:

170 days; higher than Florida and Southern Texas; highest in the nation.

MEAN LENGTH OF FREEZE - FREE PERIOD BETWEEN THE LAST 32°F IN THE SPRING AND THE FIRST 32°F IN THE AUTUMN:

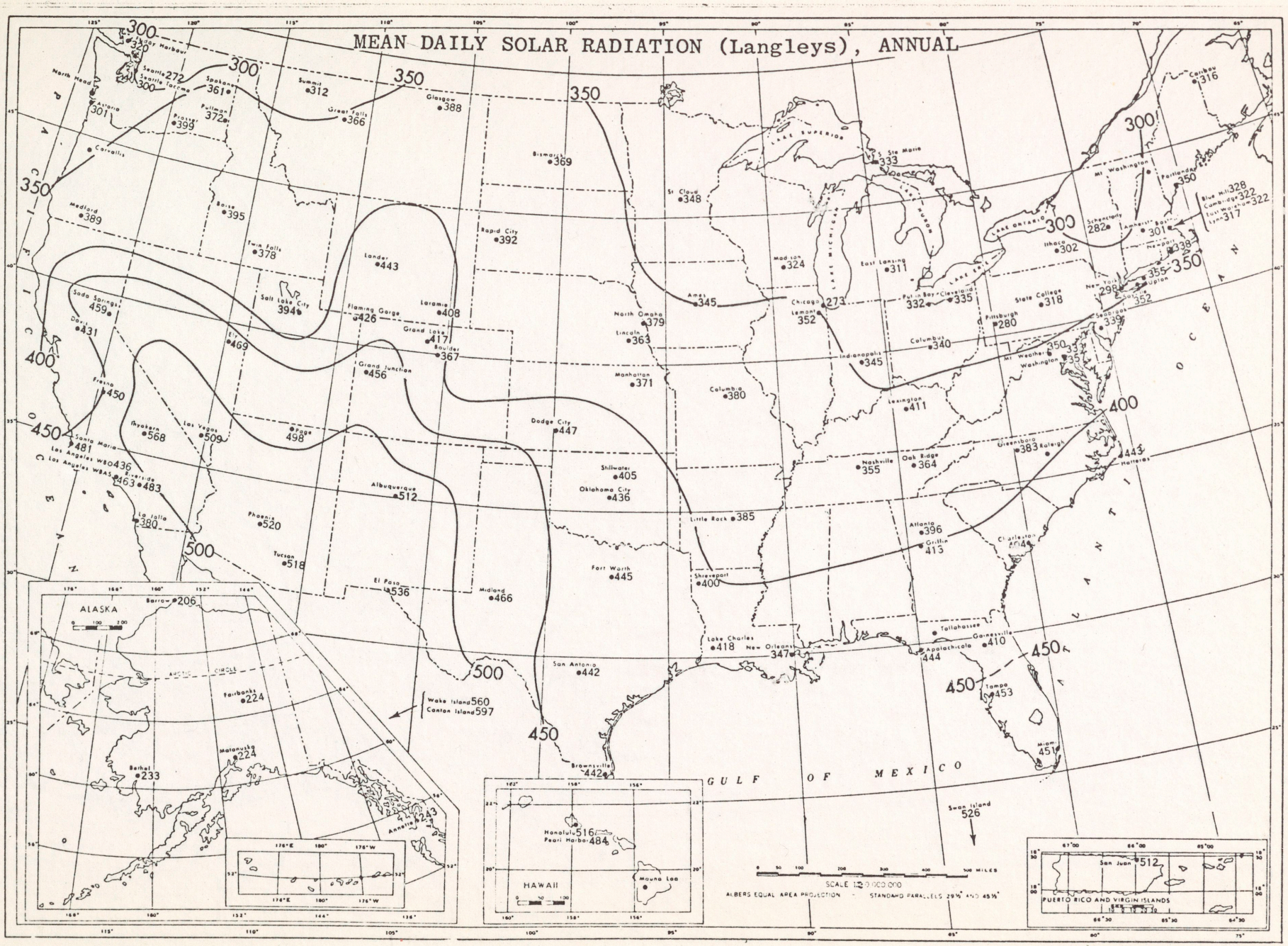
330 days; the same as extreme Southern Texas and Florida and areas along the California Coast.

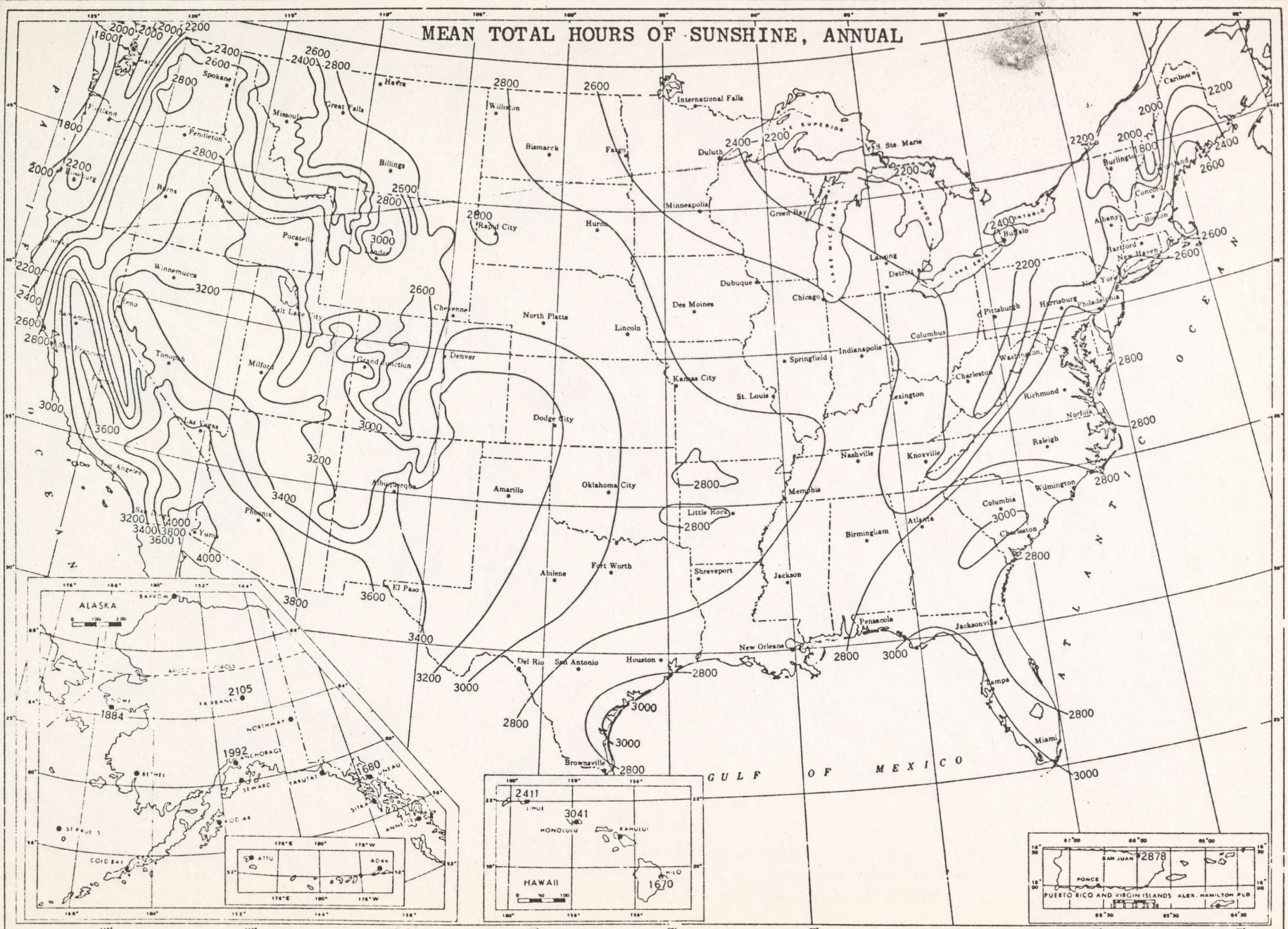
TOTAL ANNUAL PRECIPITATION:

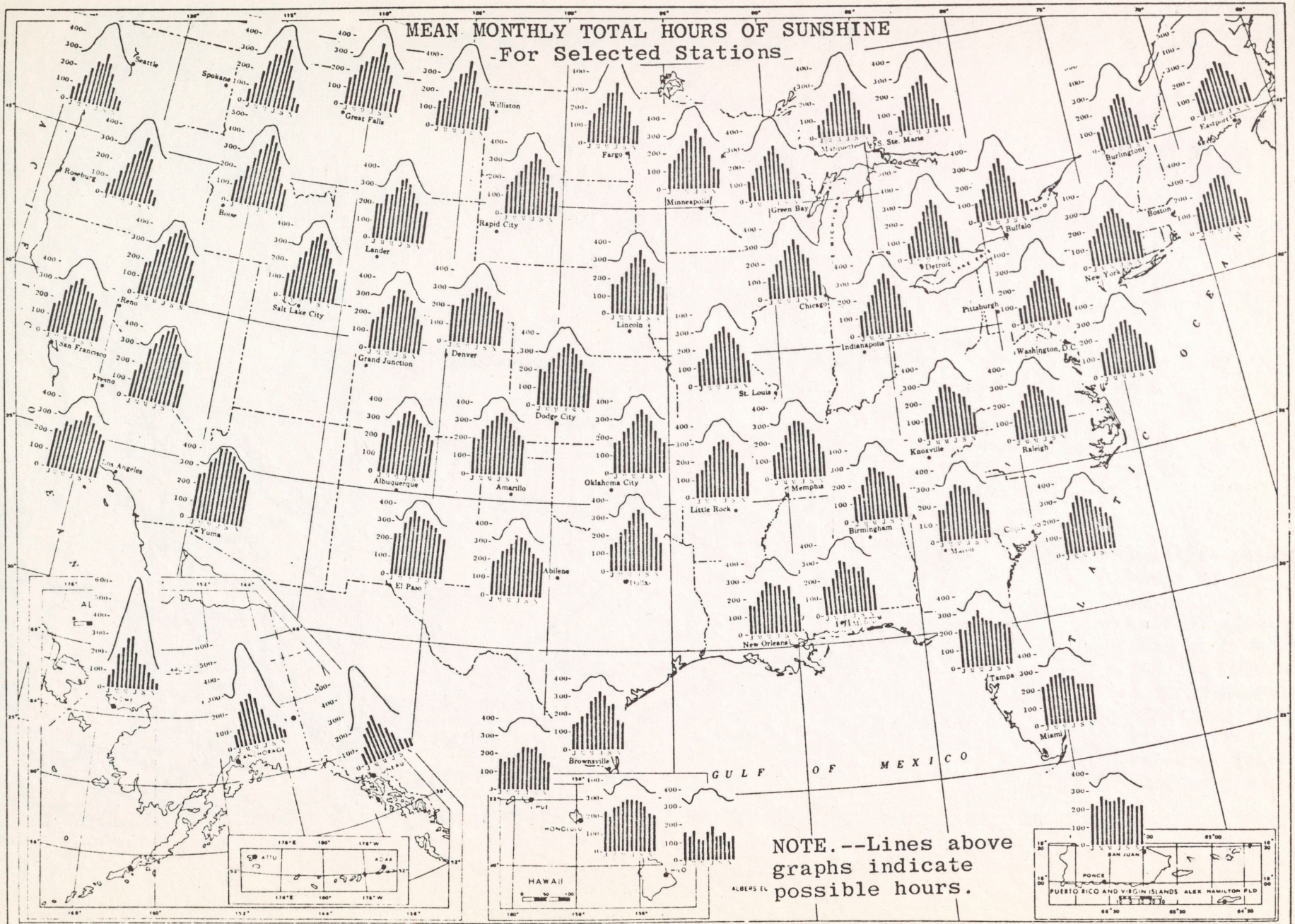
less than 4 inches; the least in the United States except for Death Valley and Mohave Deserts.

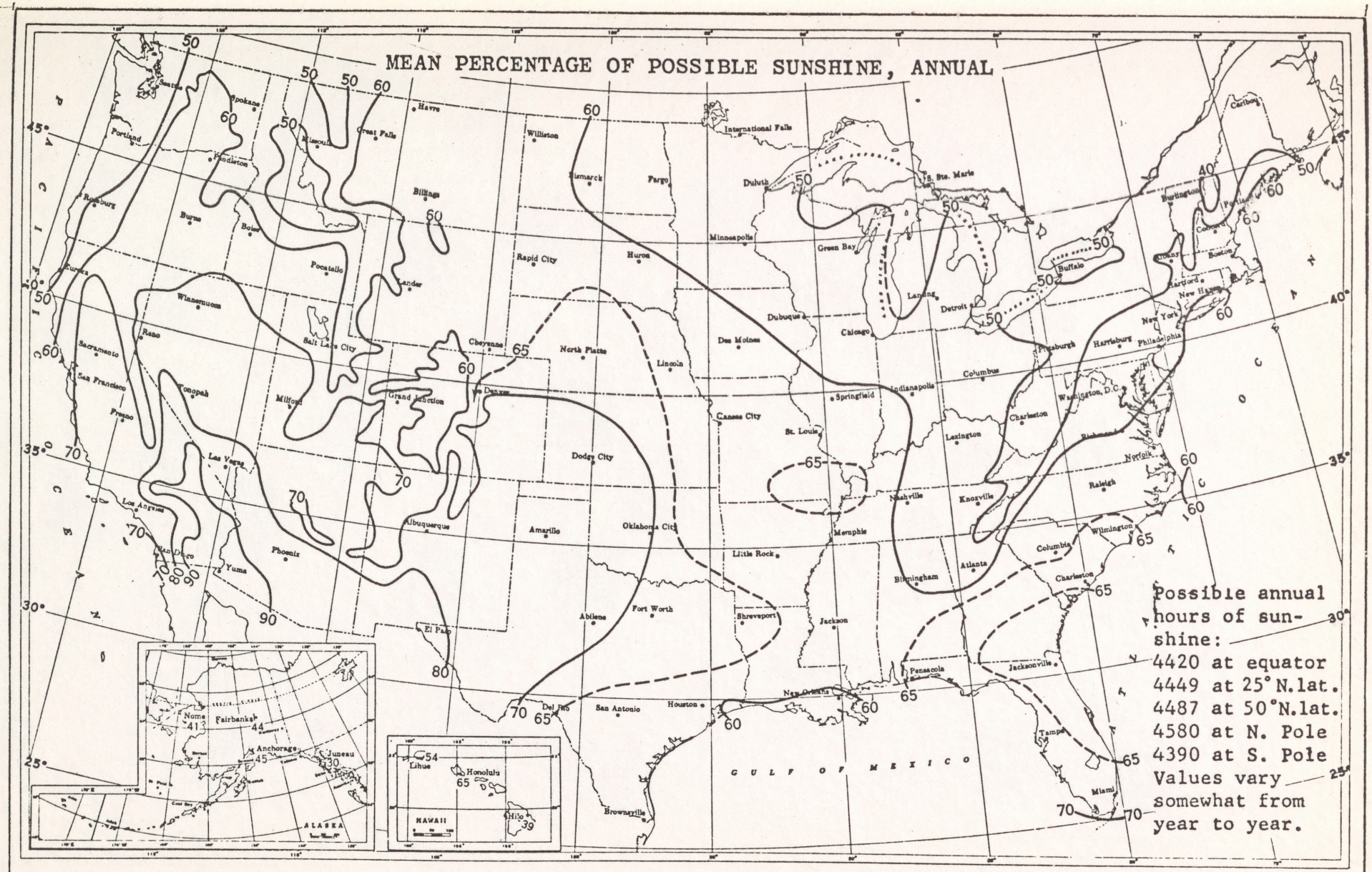
YUMA TEMPERATURES:

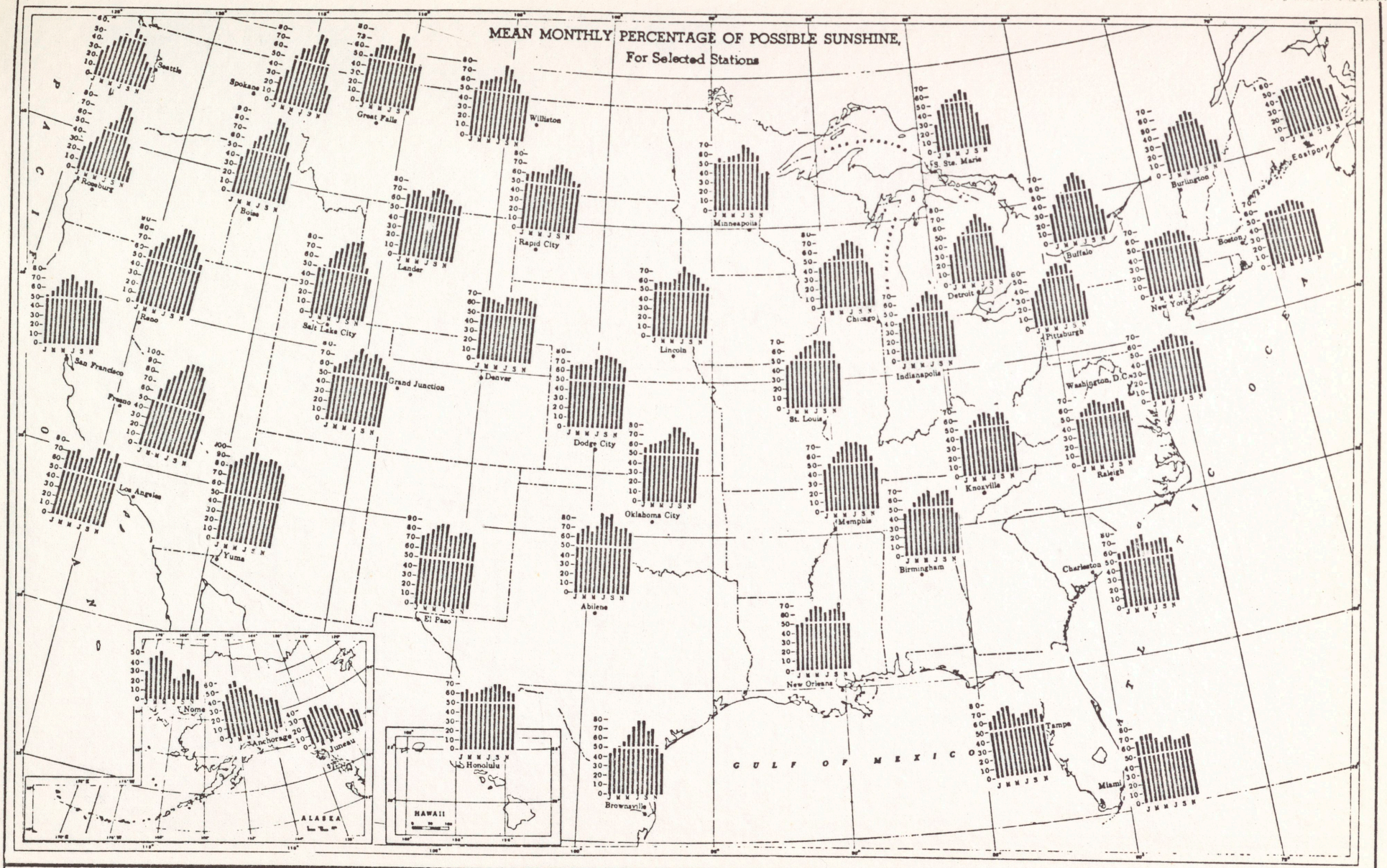
over an 87 year period the next page of data was collected:


MEAN DAILY SOLAR RADIATION (Langleys), ANNUAL
PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ERIE
LAKE ONTARIO
ALASKA
ARCTIC CIRCLE
HAWAII
PUERTO RICO AND VIRGIN ISLANDS
Wake Island 560
Canton Island 597
Swan Island 526
SCALE 1:20 000 000
ALBERS EQUAL AREA PROJECTION — STANDARD PARALLELS 29½° AND 45½°

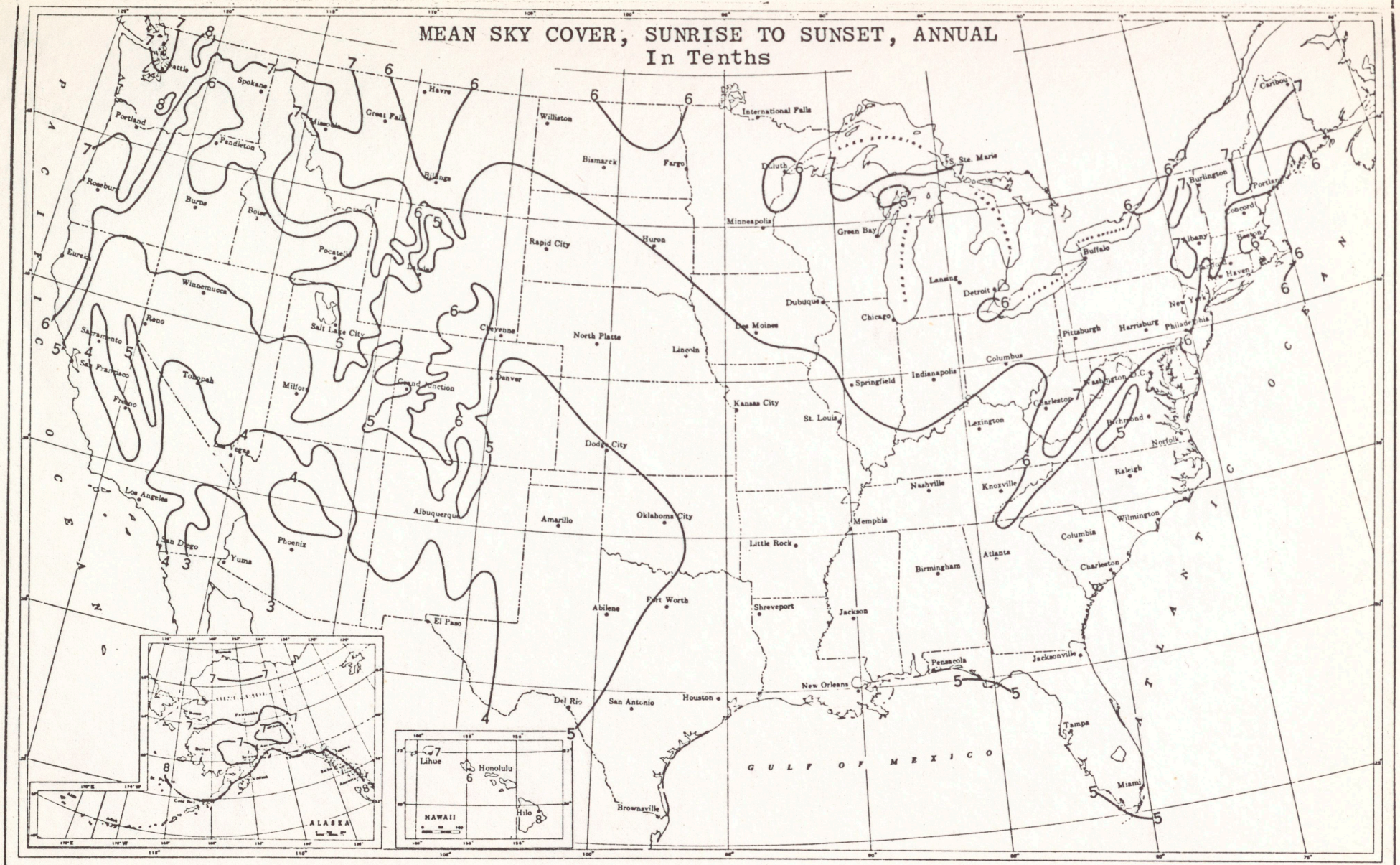

MEAN TOTAL HOURS OF SUNSHINE, ANNUAL
PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO
ALASKA
HAWAII
PUERTO RICO AND VIRGIN ISLANDS ALEX. HAMILTON FLD.
Spokane
Havre
Williston
International Falls
Portland
Missoula
Great Falls
Bismarck
Fargo
Duluth
Sault Ste. Marie
Pendleton
Billings
Minneapolis
Green Bay
Burlington
Concord
Boise
Rapid City
Huron
Pocatello
Buffalo
Albany
Boston
Winnemucca
Lansing
Detroit
Hartford
New Haven
Reno
Cheyenne
Dubuque
Chicago
Salt Lake City
North Platte
Des Moines
Pittsburgh
Harrisburg
Philadelphia
Tonopah
Denver
Lincoln
Columbus
Indianapolis
Springfield
Washington, D.C.
Milford
Grand Junction
Kansas City
Charleston
St. Louis
Lexington
Richmond
Norfolk
Las Vegas
Dodge City
Nashville
Knoxville
Raleigh
Albuquerque
Amarillo
Oklahoma City
Memphis
Wilmington
Columbia
Phoenix
Little Rock
Atlanta
Charleston
Yuma
Birmingham
Abilene
Fort Worth
Shreveport
Jackson
El Paso
Pensacola
Jacksonville
New Orleans
Del Rio
San Antonio
Houston
Tampa
Brownsville
Miami
SAN JUAN
PONCE
2878
2105
1884
1992
1680
2411
3041
1670


MEAN MONTHLY TOTAL HOURS OF SUNSHINE
For Selected Stations
Seattle
Spokane
Great Falls
Williston
Fargo
Minneapolis
Ste. Marie
Marquette
Green Bay
Burlington
Eastport
Rosburg
Boise
Lander
Rapid City
Buffalo
Detroit
Boston
New York
Reno
Salt Lake City
Chicago
Lincoln
Indianapolis
Pittsburgh
Washington, D.C.
San Francisco
Fresno
Grand Junction
Denver
Dodge City
St. Louis
Knoxville
Raleigh
Los Angeles
Albuquerque
Amarillo
Oklahoma City
Memphis
Little Rock
Birmingham
Macon
Yuma
El Paso
Abilene
Dallas
New Orleans
Tampa
Miami
Brownsville
GULF OF MEXICO
ATLANTIC OCEAN
PACIFIC OCEAN
HAWAII
HONOLULU
PUERTO RICO AND VIRGIN ISLANDS
SAN JUAN
PONCE
ALEX HAMILTON FLD
ALBERS EQ
NOTE.--Lines above graphs indicate possible hours.

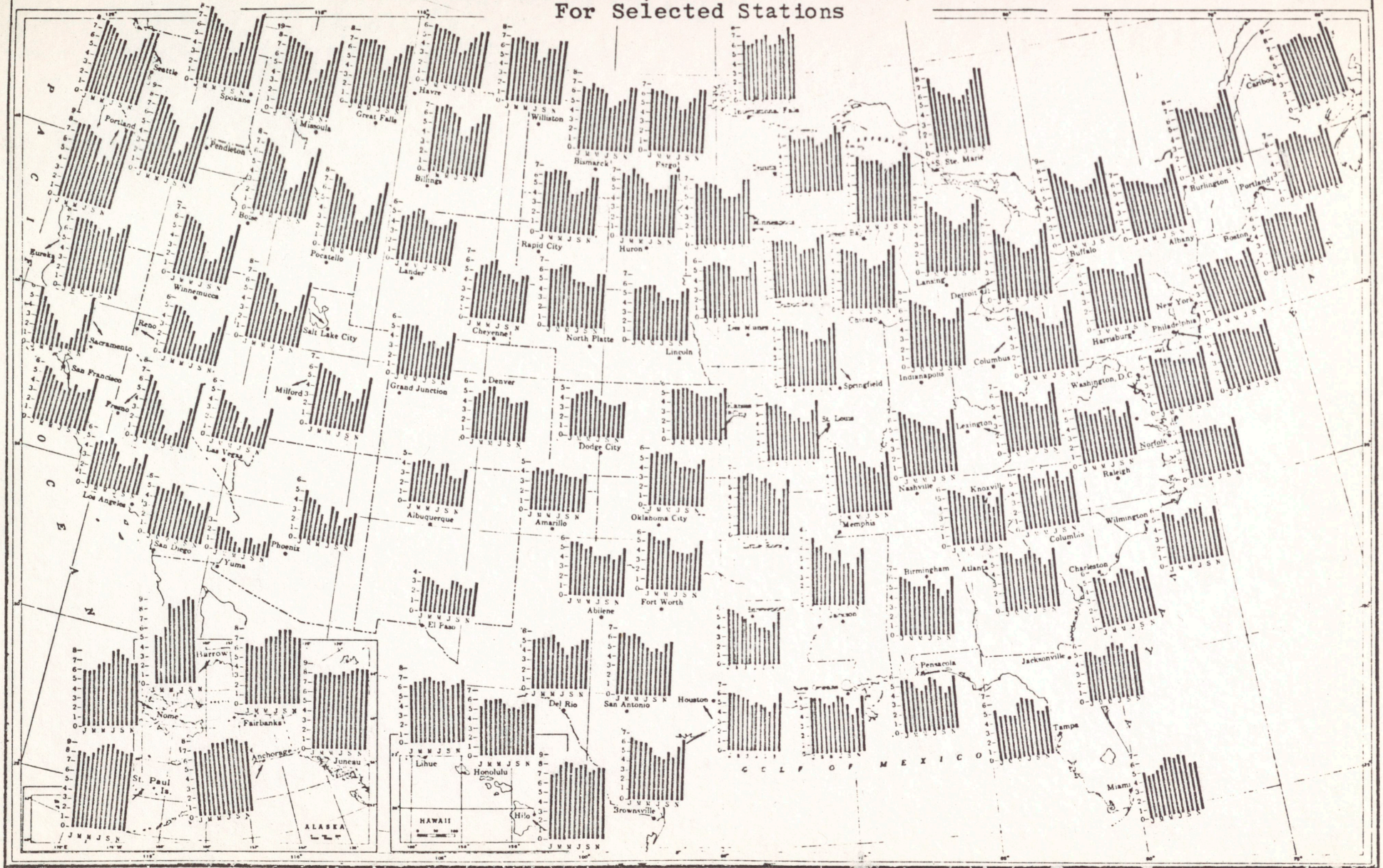

MEAN PERCENTAGE OF POSSIBLE SUNSHINE, ANNUAL
Possible annual hours of sunshine:
4420 at equator
4449 at 25° N.lat.
4487 at 50° N.lat.
4580 at N. Pole
4390 at S. Pole
Values vary somewhat from year to year.
GULF OF MEXICO
ALASKA
HAWAII


MEAN MONTHLY PERCENTAGE OF POSSIBLE SUNSHINE,
For Selected Stations
Seattle
Spokane
Great Falls
Williston
Minneapolis
Ft. Ste. Marie
Burlington
Eastport
Rosmburg
Boise
Rapid City
Lander
Buffalo
Detroit
Boston
New York
Reno
Salt Lake City
Chicago
Pittsburgh
San Francisco
Grand Junction
Denver
Lincoln
Indianapolis
Washington, D.C.
Fresno
Dodge City
St. Louis
Raleigh
Oklahoma City
Knoxville
Los Angeles
Memphis
Yuma
Birmingham
Charleston
El Paso
Abilene
New Orleans
Tampa
Miami
Brownsville
GULF OF MEXICO
Nome
Anchorage
Juneau
Honolulu
ALASKA
HAWAII
200 0 200 400 600 800 1000 Miles
SCALE 1: 20,000,000
ALBERS EQUAL AREA PROJECTION — STANDARD PARALLELS 29½° AND 45½°

MEAN SKY COVER, SUNRISE TO SUNSET, ANNUAL
In Tenths



MEAN MONTHLY SKY COVER, SUNRISE TO SUNSET, In Tenths
For Selected Stations

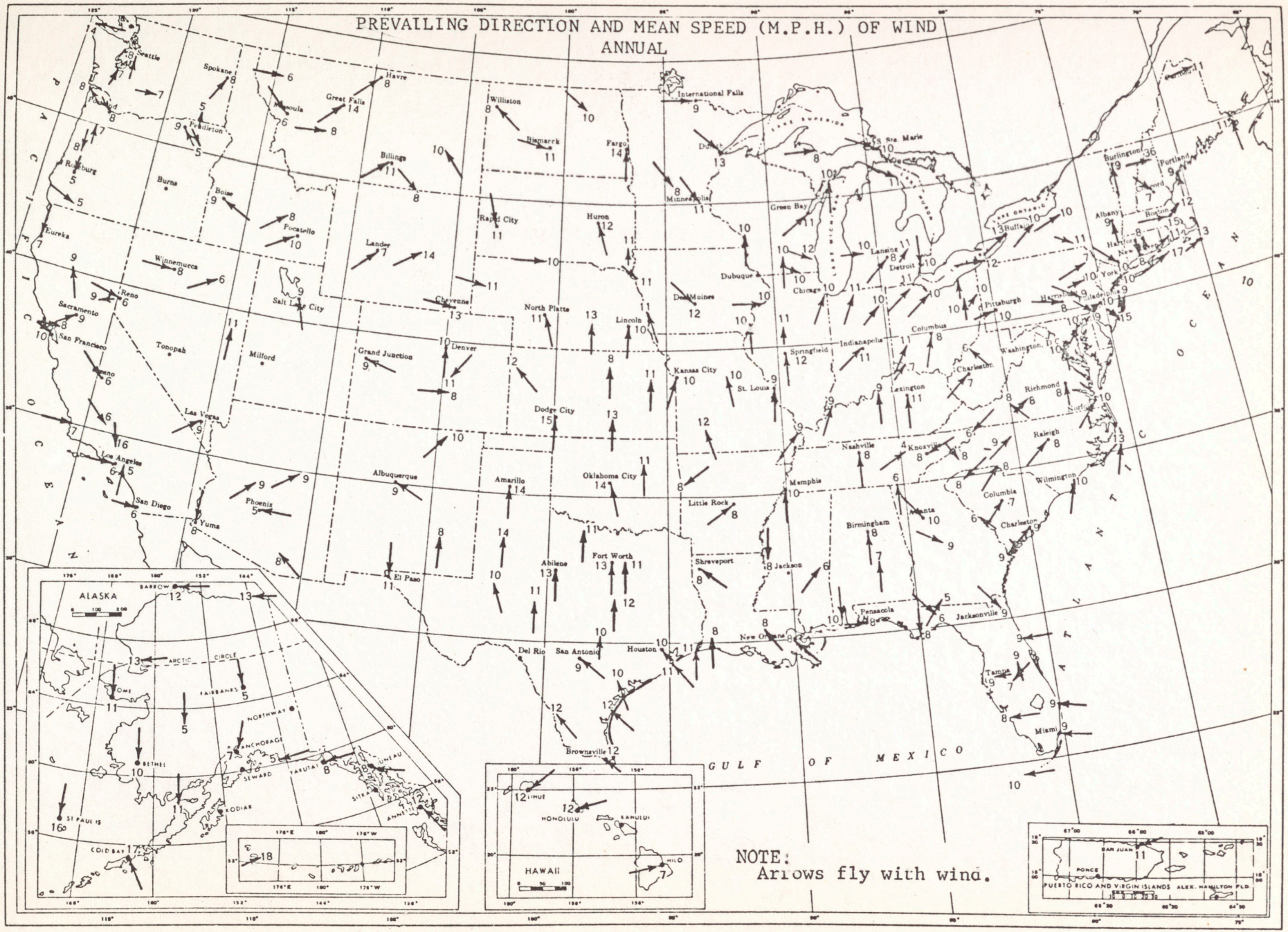


200 0 200 400 600 800 1000 Miles

SCALE 1:20,000,000

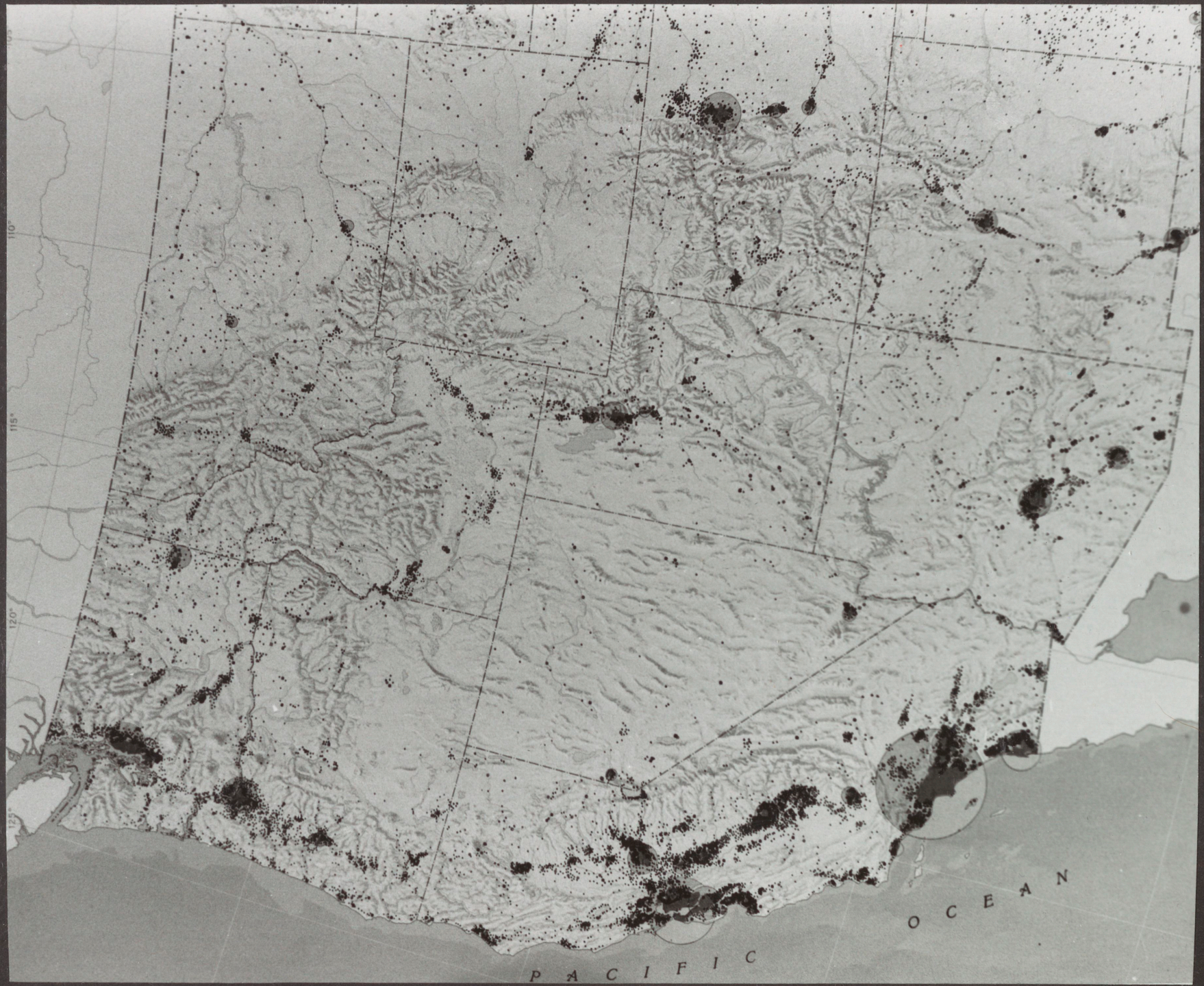
ALBERS EQUAL AREA PROJECTION–STANDARD PARALLELS 29½° AND 45½°

PREVAILING DIRECTION AND MEAN SPEED (M.P.H.) OF WIND
ANNUAL



NOTE:
Arrows fly with wind.

	NORMAL DAILY MAXIMUM	NORMAL DAILY AVERAGE	NORMAL DAILY MINIMUM	NORMAL DAILY RANGE	EXTREME HIGH	EXTREME LOW
JANUARY	69	55	42	23	86	22
FEBRUARY	74	59	44	30	94	25
MARCH	81	66	50	31	100	31
APRIL	88	72	57	31	107	38
MAY	96	80	63	33	120	39
JUNE	103	87	71	32	120	50
JULY	108	94	80	14	120	61
AUGUST	107	93	78	29	119	60
SEPTEMBER	103	88	73	30	123	50
OCTOBER	92	76	61	31	109	38
NOVEMBER	79	64	49	30	98	29
DECEMBER	71	57	43	28	86	22


110°
115°
120°
125°
PACIFIC OCEAN



- Mostly cropland
- 2 Cropland with grazing land
- 3 Cropland with pasture, woodland, and forest
- 4 Irrigated land
- 5 Woodland and forest with some cropland and pasture
- 6 Forest and woodland grazed
- 7 Forest and woodland mostly ungrazed
- 8 Subhumid grassland and semiarid grazing land
- 9 Open woodland grazed (piñon, juniper, aspen groves, chaparral and brush)
- 10 Desert shrubland grazed
- 11 Desert shrubland mostly ungrazed
- 12 Alpine meadows, mountain peaks above timber line, sparse dry tundra, lava flows, and barren land
- 13 Swamp
- 14 Marshland
- 15 Moist tundra and muskeg
- Urban areas—as defined by U.S. Bureau of the Census

DEPARTMENT OF THE INTERIOR

BUREAU OF LAND MANAGEMENT

- Tracts, 50-100% density
- Scattered tracts, approximately 25-50% density
  Small scattered tracts not shown

NATIONAL PARK SERVICE

- National park (NP)
- National monument (NM), national seashore (NS), and national recreation area (NRA)

BUREAU OF INDIAN AFFAIRS

- Indian reservation (IR)

BUREAU OF SPORT FISHERIES AND WILDLIFE

- National wildlife refuge (NWR)

BUREAU OF RECLAMATION

DEPARTMENT OF AGRICULTURE

FOREST SERVICE

- National forest (NF)
- Forest purchase unit (PU)
- National grassland (NG)
- Land utilization project (LU)

AGRICULTURAL RESEARCH SERVICE

DEPARTMENT OF DEFENSE

- ARMY, NAVY, AIR FORCE (AF, AFB), Civil Works Projects of Corps of Engineers, and Marine Corps Base (MCB)

DEPARTMENT OF STATE

- INTERNATIONAL BOUNDARY AND WATER COMMISSION, U.S. AND MEXICO

INDEPENDENT AGENCIES

- ATOMIC ENERGY COMMISSION
- TENNESSEE VALLEY AUTHORITY
- NATIONAL AERONAUTICS AND SPACE ADMINISTRATION



EASTERN FORESTS

1 White–red–jack pine
2 Spruce–fir
3 Longleaf–slash pine
4 Loblolly–shortleaf pine
5 Oak–pine
6 Oak–hickory
7 Oak–gum–cypress
8 Elm–ash–cottonwood
9 Maple–beech–birch
10 Aspen–birch

WESTERN FORESTS AND HAWAII

Douglas-fir
Hemlock–Sitka spruce
Redwood
14 Ponderosa pine
15 White pine
16 Lodgepole pine
17 Larch
18 Fir–spruce
19 Hardwoods
20 Ohia
21 Chaparral
22 Piñyon–juniper

ALASKA FORESTS

COASTAL FORESTS

Hemlock–Sitka spruce

INTERIOR FORESTS

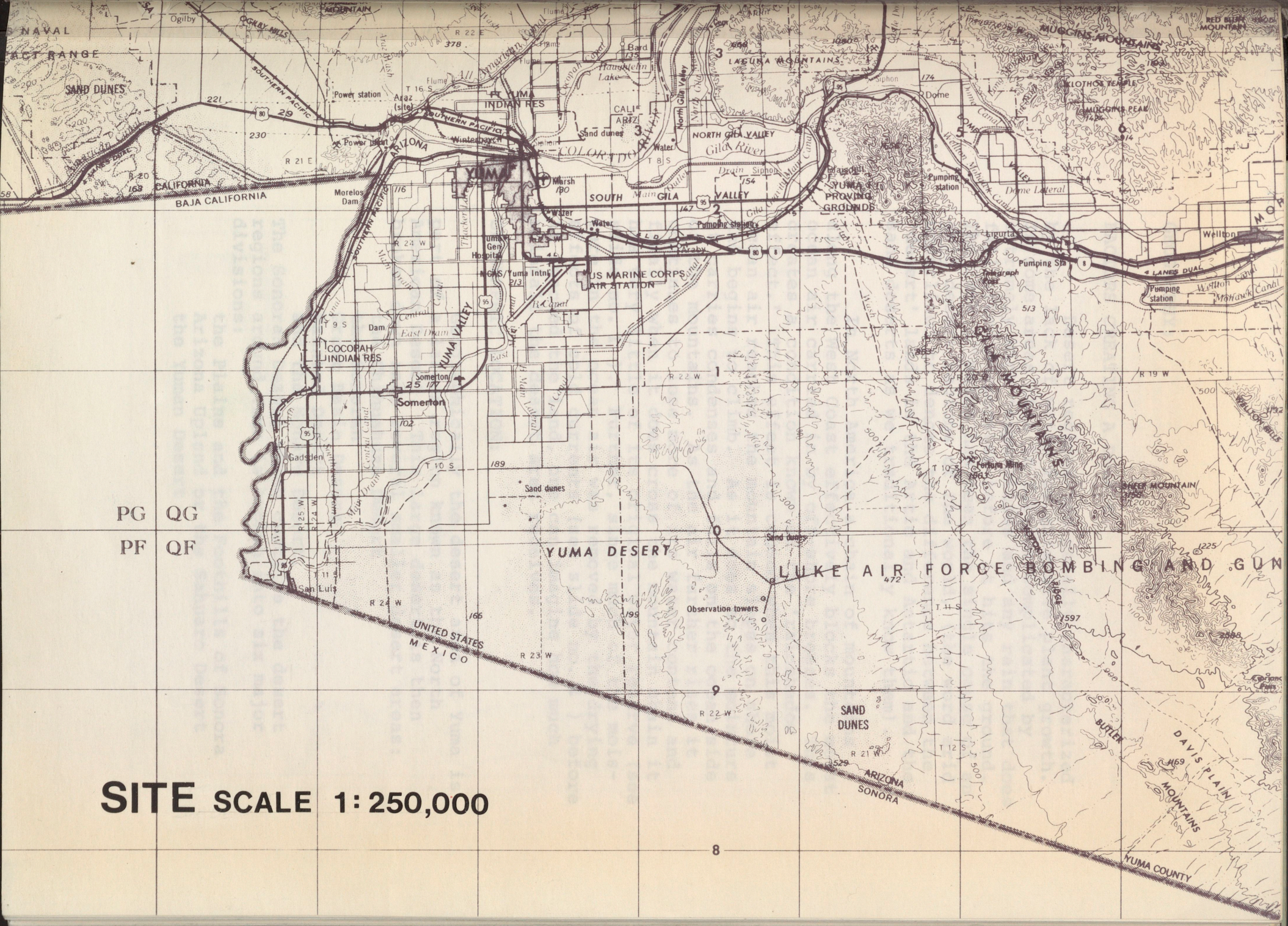
Spruce–hardwoods
Well stocked: commercial

Spruce–hardwoods
Medium to poor: noncommercial

NONFOREST

Land that has never supported forests and land formerly forested which is now developed for other uses




PG QG
PF QF
SITE SCALE 1:250,000
YUMA
FT YUMA INDIAN RES
COCOPAH INDIAN RES
SOUTH GILA VALLEY
NORTH GILA VALLEY
YUMA PROVING GROUNDS
US MARINE CORPS AIR STATION
MCAS/Yuma Intnl
YUMA DESERT
LUKE AIR FORCE BOMBING AND GUN
UNITED STATES
MEXICO
ARIZONA
SONORA
YUMA COUNTY
CALIFORNIA
BAJA CALIFORNIA
SAND DUNES
Somerton
San Luis
Gadsden
Morelos Dam
Wellton
Observation towers
Sand dunes
MUGGINS MOUNTAINS
LAGUNA MOUNTAINS
CLOTHOL TEMPLE
MUGGINS PEAK
BAKER MOUNTAIN
RED BLUFF MOUNTAIN
WELLTON HILLS
DAVIS PLAIN
BUTLER
MOUNTAINS
SOUTHERN PACIFIC
ARIZONA
COLORADO
GILA
YUMA VALLEY
Gila River
Colorado River
Main Canal
Dome Lateral
Wellton Mohawk Canal
Pumping station
Power station
Araz (site)
Ogilby
Ogilby Mills
Dome
Siphon
Drain
Flume
Dam
Marsh
Water
Pumping Stations
Telegraph Line
4 LANES DUAL
R 24 W
R 25 W
R 23 W
R 22 W
R 21 W
R 19 W
T 9 S
T 10 S
T 11 S
T 12 S
T 16 S
R 20
R 21 E
R 22 E

GEOGRAPHY:

FACTORS CREATING A DESERT:

Desert regions are usually characterized by the lack of water for extensive plant growth. In some areas this is further complicated by extremely high temperatures and any rain that does fall often evaporates before it hits the ground. The lack of water has been the single cause of an arid desert regions of the world, (the word arid underlined to denote the difference between the 'desert' lands in the Artic and Antartic and the sand deserts as we traditionally know them).

In North America a chain of mountains along the West Coast effectively blocks the moist ocean air carried in by off-shore breezes. This creates a condition known as the 'rainshadow effect.' This effect is caused when this moist ocean air reaches the mountain slopes on shore and begins to climb. As it does so the moisture it carries condenses and falls on the ocean side of the mountains. As the air further rises it continues to lose more of its water content and finally when it does cross the mountain chain it has very little of its original water reserve (see slide no. 1). Further, since much of the moisture in the ocean air was removed by the drying effects of cold currents (see slide no. 2) before it reached the land, one can imagine how much rainfall the desert area receives.

GEOGRAPHIC LOCATION:

Geographically the desert area of Yuma is part of a larger region known as the North American Desert. This large desert is then broken down into several smaller desert areas:

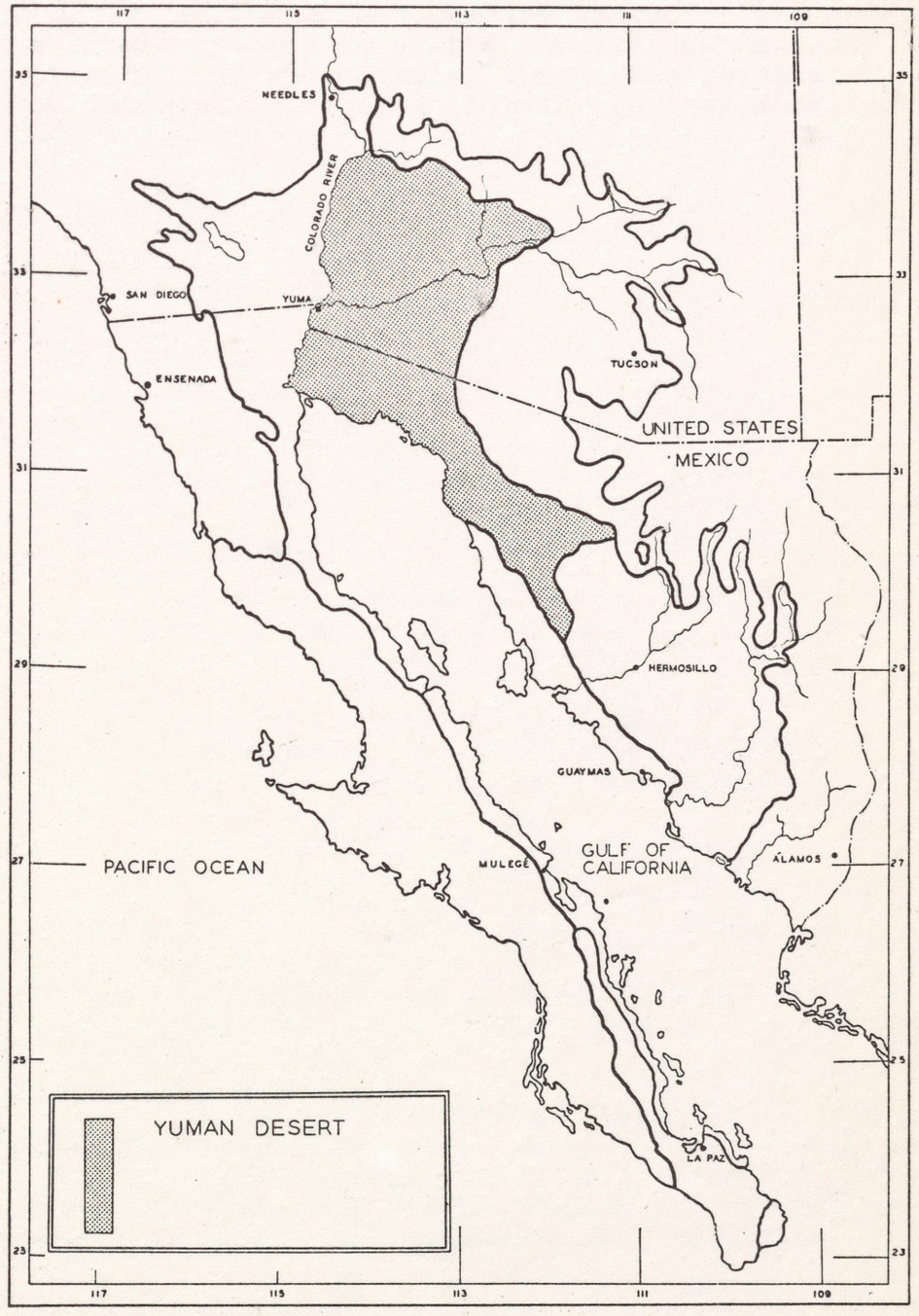
the Chihuahuan Desert
the Sonoran
Great Basin Desert
Painted Desert
and the Mohave Desert.

The Sonoran Desert which contains the desert regions around Yuma is broken into six major divisions:

the Plains and the Foothills of Sonora
Arizona Upland or the Sahuaro Desert
the Yuman Desert

the Colorado Desert of California
Vizcaîno-Magdalena Desert of Baja California and the Gulf Coast Desert.

The area directly South and East of Yuma is known as the Yuman Desert (see diagram below). The Yuman Desert, as all the other desert areas, has special characteristics of animal and plant life in response to its specific geologic and climatologic attributes. These are explained later in this book.



GEOLOGY/ARIZONA:

The area around Yuma is composed of primarily sedimentary deposits:
mainly alluvial gravel, sand, and silt in flood plains, terraces, fans, and pediment cappings but locally includes dune sand, lake deposits and landslide masses.

In the Gila Mountains there are traces of mesozoic granite to quartz diorite; gueiss and granite. To the North of Yuma there is some evidence of volcanic action in the rock formations.

CLIMATE:

Virtually 1/5 of the Earth's surface is desert, but in this area less than 4% of the world's population resides. Mainly due to the extreme climatic factors few human cultures have adapted to these regions. And those than have, have accepted a very strict sort of life style. In the following paragraphs I will try to expose some of the climatological factors that all living things in the desert have had to deal with.

To begin, we may classify a desert according to these characteristics:

low annual rainfall; less than ten inches per year
high average temperatures during the day
occasional cloudburst rainshowers
constant winds
rapid change in temperature from day to night; as much as 70°F within a few hours.

Plants have adapted to these conditions by developing hairy stems, curling leaves, and glossy coverings to protect them from climatic effects. But, man has not the sophisticated mechanisms of the plant and must rely on clothes and shelter to reduce the impact of the harsh climate.

Daily temperatures in the desert can be summarized by (refer to p. 31):

a sharp increase in temperature starting about sunrise
reaching a midafternoon peak
accompaning the rise in air temperature is a great increase in soil temperature (refer to p. 31)
a steady drop in temperature from the afternoon peak continuing till dawn
relative humidity may drop to 12% in the heat of the day and rise to around 60% before dawn
and finally an increase in wind speed from a calm during the night to a fresh breeze toward evening.

In the Sonoran Desert summer lasts from 7 - 9 months. The short spring is a delightful time with cool breezes and moderate temperatures. With the advent of summer, temperatures quickly begin to rise. Relief coming only when the

infrequent and undependable showers dump cooling rain down onto the hot sands (refer to p. 31). In the fall temperatures being to drop again to a more comfortable level. Winter nights are chilly but seldom drop to freezing. In fact, no freezing frosts occur in this desert.

Sand storms in the desert are the enemy of both plants and animals. Essentially these storms follow a pattern:

a 15 m.p.h. wind - sand and dust begin to move

20 m.p.h. - a mild dust storm may develop

30 m.p.h. - a severe dust storm.

Gusty winds are more favorable to sand-storms than are steady winds. Since the force of a gust causes sand to be thrown into the air, to be blown about freely by the calmer wake. In the Sonoran Desert, spring is the windiest time of year.

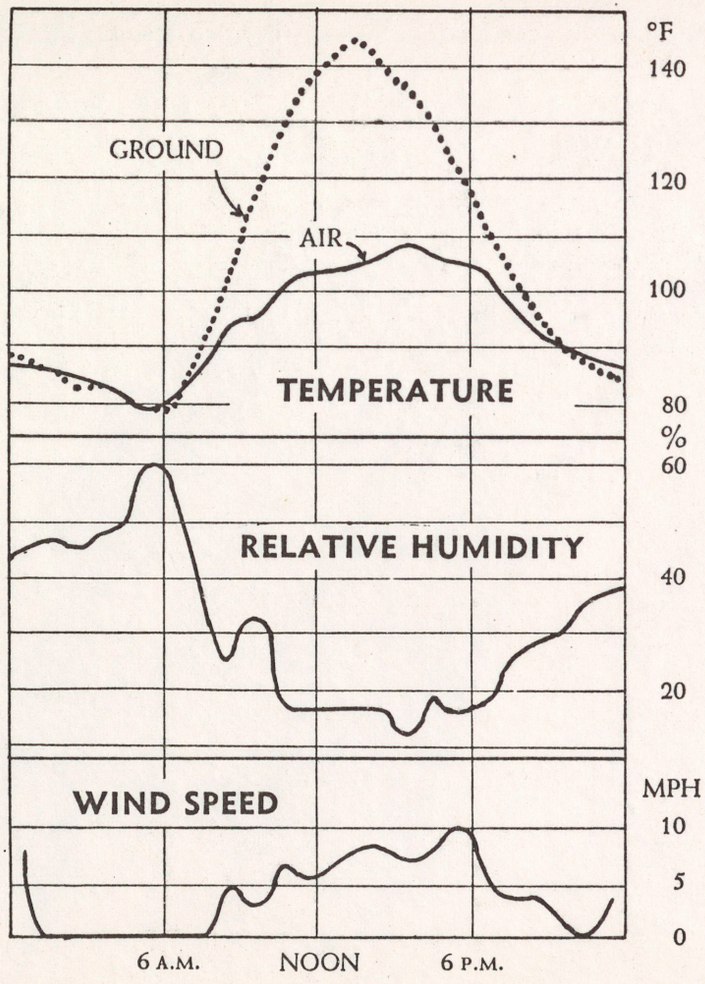
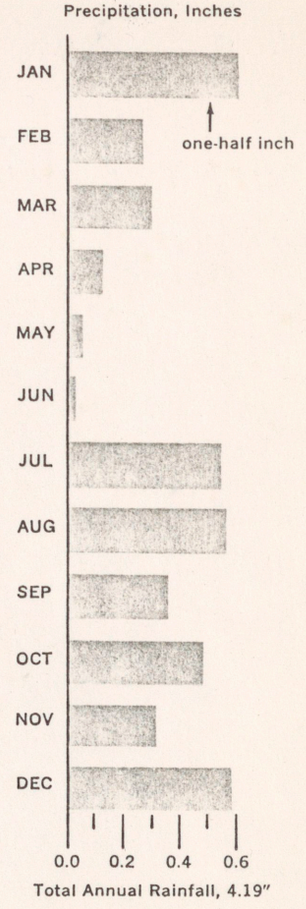
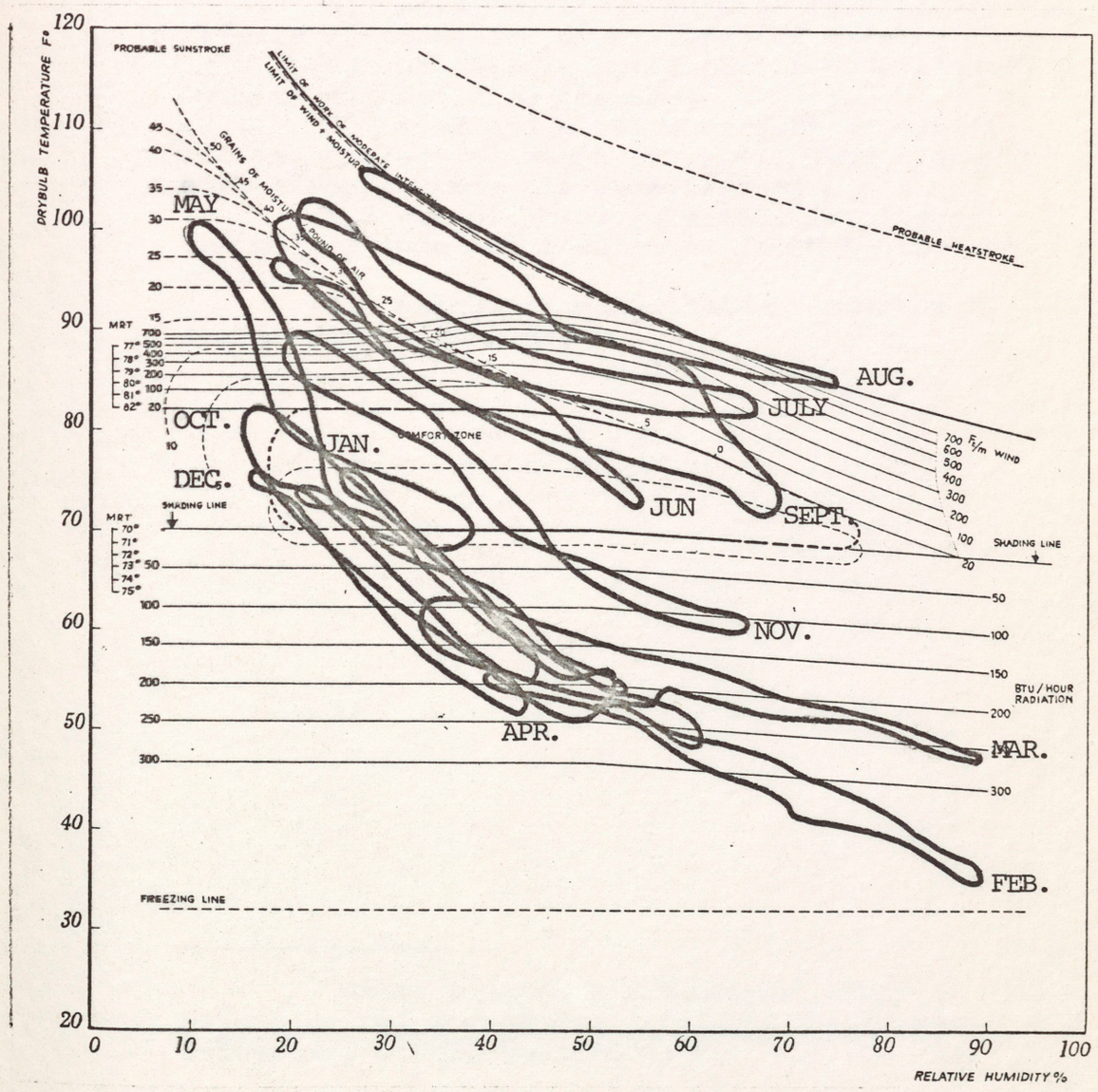


Figure 5. A desert day. Curves of hourly weather observations near Yuma, Arizona, August 5, 1951, a typical day in the Sonoran Desert.



This graph shows the annual rainfall at Twentynine Palms, California, near the northern edge of Joshua Tree National Monument. It illustrates that the Arizona desert has two distinct rainy seasons, one in July and August, another in December and January.

BIOCLIMATIC CHART
FOR YUMA, ARIZONA



ARCHITECTURAL IMPLICATIONS:

The following list of suggestions has been presented as a set of architectural considerations a designer might evaluate in creating a desert environment:

meteorological data applied to 7 architectural principals:[4]

1. site selection and effect of topography
2. orientation in regard to solar effects, wind, temperature, etc.
3. solar control; shading devices and the effects of trees and other kinds of vegetation
4. preferable buildings forms evaluated by external building stresses
5. wind and airflow effects to satisfy bio-meteorological needs in public spaces and in structures lacking air conditioning
6. use of local materials for indoor thermal balance and insulation (both inside and outside)
7. calculation of thermal behavior of architectural structures.

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[4]Hoff, Clayton and Riedesel, Marvin; Physiological Systems in Semiarid Environments; University of New Mexico, 1969.

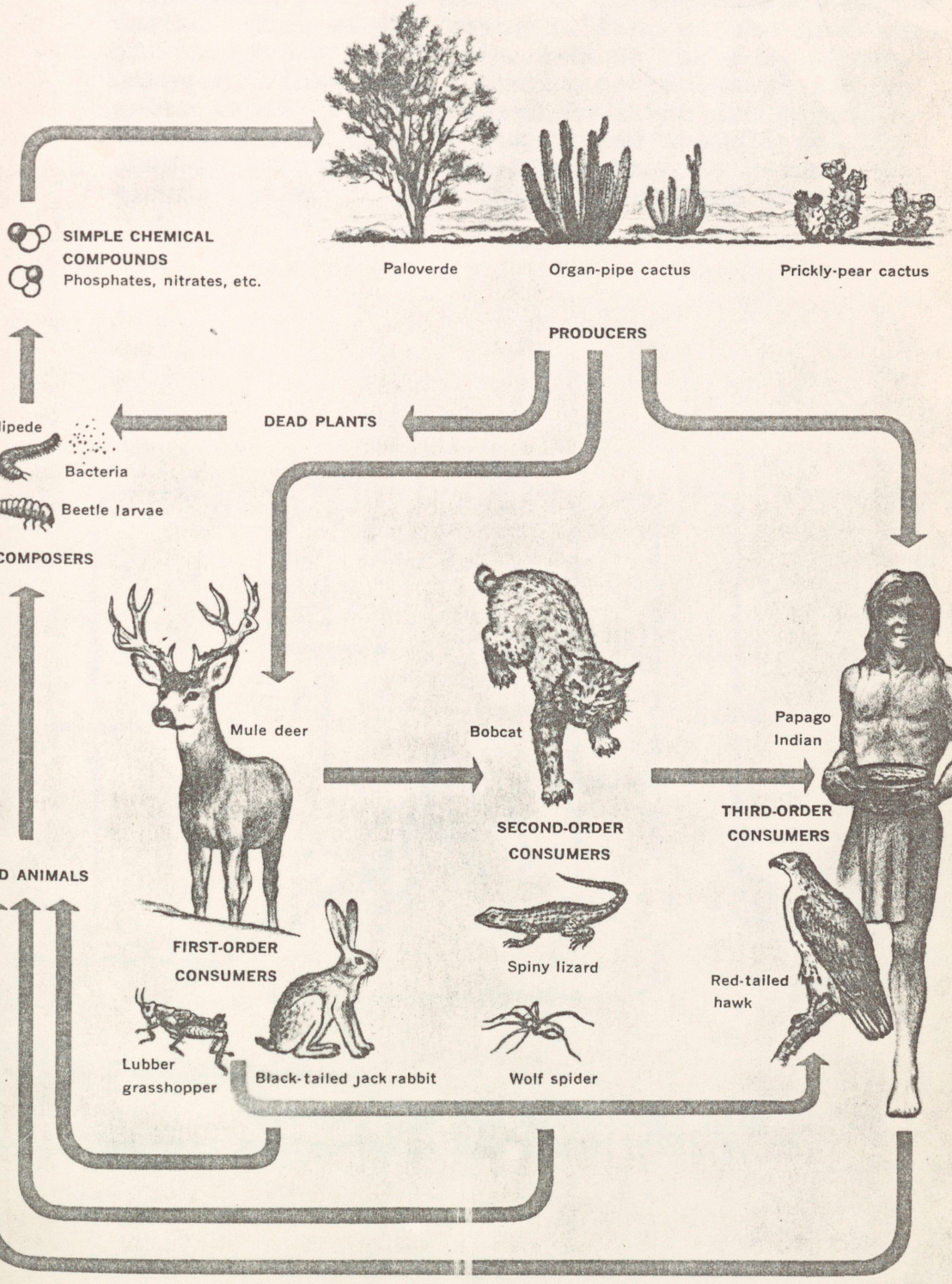
ENVIRONMENTAL SYSTEMS:

THE CHAIN OF LIFE:

Ultimately all the Earth's heat and light comes from the sun; all living things depend on it. Animals, including man cannot use this energy directly except in the form of vitamin D_3, so plants are the agents to transform the sun's energy to a form that the higher animal life can use.

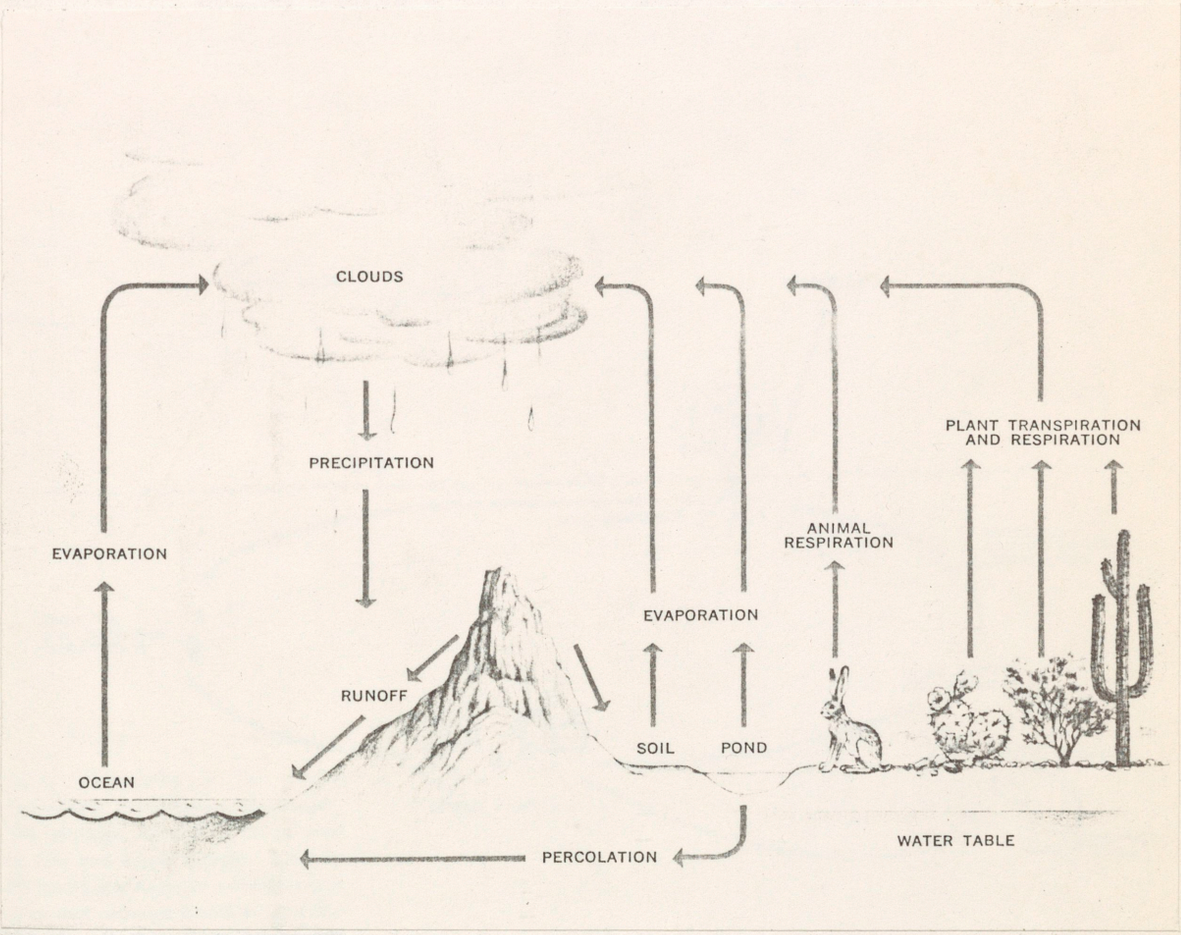
In the green pigments of the plant, chlorophylls use CO_2 from the air, water from the soil, and energy from the sun (sunlight) to produce, through photosynthesis, plant sugar called glucose. This glucose is used within the plant to manufacture all the fats, proteins, and other carbohydrates necessary for plant growth and reproduction. So it is that plants contain a portion of the sun's energy within their structure, and pass this life-giving element on to plant-eating animals.

Summarized in the diagram on page 35 : the low order consumers (deer and rabbits) feed on plants and shrubs and in turn are hunted by the higher order consumers (the bobcat, hawk, and man). When these high order consumers die, their remains serve as food for the decomposers (bacteria and larvae) which break down their bodies and return the simple chemical compounds back into the soil for the use of the plants. And the cycle begins again only to be interrupted if a break occurs in the chain.


SIMPLE CHEMICAL COMPOUNDS
Phosphates, nitrates, etc.
Paloverde
Organ-pipe cactus
Prickly-pear cactus
PRODUCERS
DEAD PLANTS
Millipede
Bacteria
Beetle larvae
DECOMPOSERS
Mule deer
Bobcat
Papago Indian
SECOND-ORDER CONSUMERS
THIRD-ORDER CONSUMERS
DEAD ANIMALS
FIRST-ORDER CONSUMERS
Spiny lizard
Red-tailed hawk
Lubber grasshopper
Black-tailed jack rabbit
Wolf spider

THE CYCLE OF WATER:

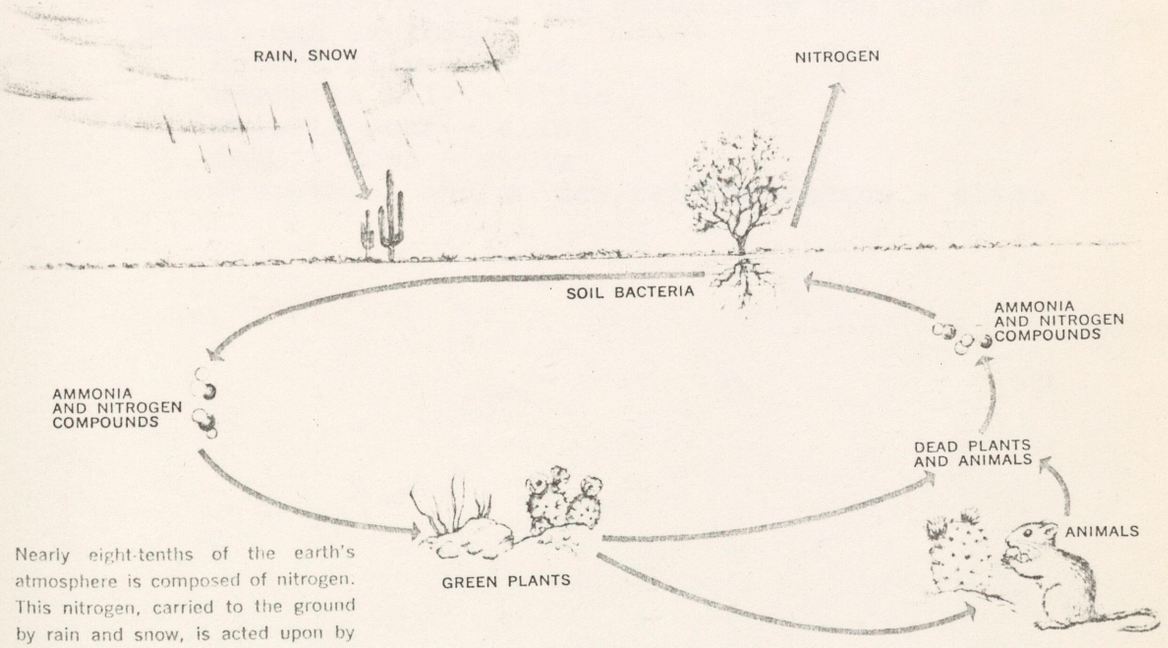
"All plant and animal life depends on water. The ultimate source of all the earth's water is the ocean. When the ocean water evaporates, the vapor condenses to form clouds. The precipitation (rain and snow) from the clouds falls back into the ocean or to the surface of the earth. Much of the water falling on the land runs off in rivers and is returned to the sea. Some, however, sinks into the soil to replenish the water table, or is trapped in lakes and ponds. This water is used by plants and animals and then is returned to the atmosphere to become clouds again."[5] (See diagram below and slides).



[5]Sutton, Ann and Myron; The Life of the Desert; McGraw-Hill; New York; 1966; p. 98.

THE NITROGEN CYCLE:

"Nearly eight-tenths of the earth's atmosphere is composed of nitrogen. This nitrogen, carried to the ground by rain and snow, is acted upon by nitrogen-fixing bacteria and blue-green algae that combine it with oxygen and hydrogen. In turn, these compounds are used by green plants and are passed on to plant-eating animals. The meat-eating animals get their nitrogen by eating plant-eaters. When plants and animals die, they are broken down by decay organisms into ammonia and nitrogen compounds once again. Some of the nitrogen returns to the atmosphere, but some is used again by green plants, and the cycle beings anew."[6] (See diagram below).



Nearly eight-tenths of the earth's atmosphere is composed of nitrogen. This nitrogen, carried to the ground by rain and snow, is acted upon by nitrogen-fixing bacteria and blue-green algae that combine it with oxygen and hydrogen. In turn, these compounds

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[6]Ibid., p. 72.

FLORA:

PLANT LIFE IN THE YUMAN DESERT:

This section is presented in the following series of slides covering the quality and color of the "plants" of the desert. (Also refer to p.). A general list of the local vegetation with an index to slides is as follows:

cresote bush
brittle bush
burro bush
willows
palo verdes
iron woods
smoke trees
sahuaro cactus - slide
ocotillo - slide
gray thorn
cats claw
elephant tree
bear grass
canotia
crucifixion thorn
junco
desert mallow
dune primrose
desert marigold
carnation
fan palms

Some other desert plants not usually found in the Yuman Desert, but which show the color the desert can exhibit:

desert lily - slide
mariposa lily - slide
prickly pear - slide
rabbit bush - slide
pincushion and golden rainbow cactus - slide

FAUNA:

ANIMAL LIFE IN THE YUMAN DESERT:

The following is a list of the animals which inhabit this desert, some with slides as indicated:

antelope squirrel
elf owl
gilded flicker
pocket mice
woodpecker
skunk - slide
kit fox - slide
stink bugs
gila monster (poisonous) - slide
red tail hawk - slide
kangaroo rat - slide
rattlesnake - slide

SURVIVAL:

Perhaps more important than the types of plants or animals that exist in the desert, are the methods they employ to survive in the extreme heat and drought.

Plants are especially interesting because it is they who have adapted most completely to these factors. For instance, the most commonly known desert plant is the cactus. The cactus has developed a tough outer layer which contains the moisture within the body of the plant and keeps out the drying effects of the sun. The cactus has also developed fins to give it strength and to shade its surfaces. And it has spines to ward off enemies that may wish to attack its juicy inner pulp. But these spines act as a second line of defense to shade the body of the cactus from the direct rays of the sun.

The creosote bush, also plentiful in the desert, has developed a waxy coating over its leaves and branches to contain water loss. The shiny surface also serves to reflect the burning rays of the sun. The bush also has root toxins that kill other plants which grow too close and could compete for the scarce water supply.

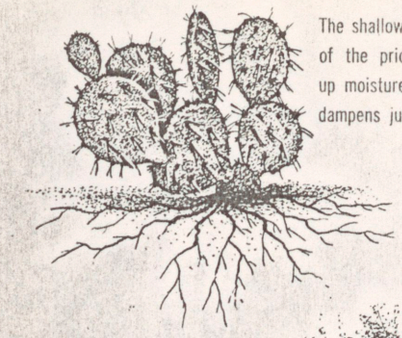
Small desert flowers have a compressed life cycle. Their life cycle from seed to full grown plant is greatly reduced. They bloom and grow when moisture is available; after rains in the summer and winter, and when the water is gone they die leaving behind seeds to grow when the water is again available.

Animals have developed like mechanisms for survival. Birds of the desert may fly through the air in the heat of the day to take advantage of the cooling effects of wind currents across their body. Still other animals such as the rattle snake, make use of available shade to protect them from the heat of the sun.

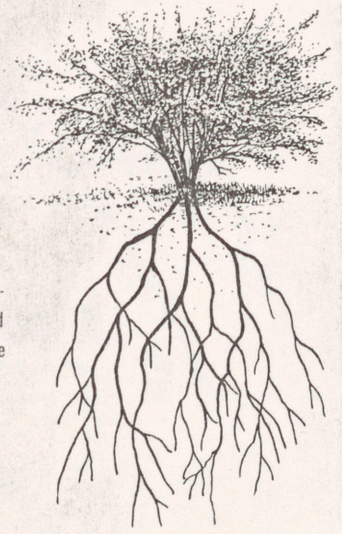
The fox, besides making use of shade, "pants" to release excess heat from his body. The kangaroo rat and the desert toad approach the problem in a different way. When the sun begins to rise and with it temperatures; the toad buries himself in the soil and the kangaroo rat retreats to its underground habitat where temperatures remain a constant 85°F. The rat like the cactus,

has learned to release very little of its body fluids to the atmosphere. The kangaroo rat or jerboa excretes only solid matter and eats part of this to regain any lost moisture. The jerboa gets all the moisture it needs from the plants and animals it consumes.

Another interesting desert "animal" is the tadpole shrimp (see slide no.17). With a compressed style like some plants, the small shrimp must rely on available water for its existence. In the short period a pond or puddle exists in the desert; the shrimp must grow from an egg to an adult. And reproduce before the pond evaporates.



The shallow, wide-spreading roots of the prickly-pear cactus soak up moisture even from rain that dampens just the soil surface.

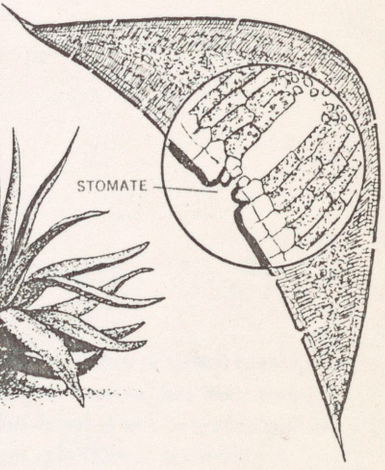


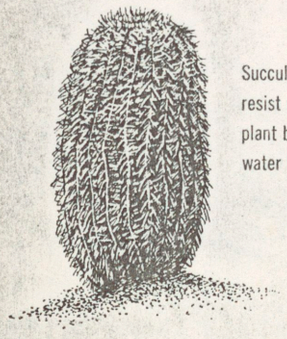
The deep roots of mesquite frequently extend down sixty feet or more to tap the water table.



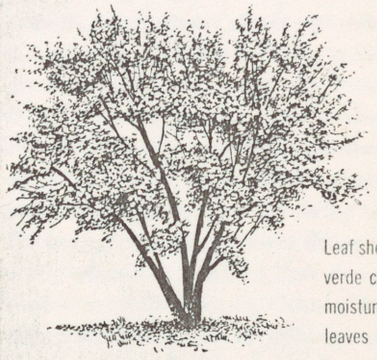
Sunken stomates help the century plant endure drought. Tiny openings on leaf surfaces are necessary for the intake of carbon dioxide and the release of oxygen during photosynthesis. Water also evaporates through stomates, but in the century plant and many others the stomates are placed in shallow pits that help cut down water evaporation by shielding the stomate from drying air currents.

CROSS SECTION OF LEAF



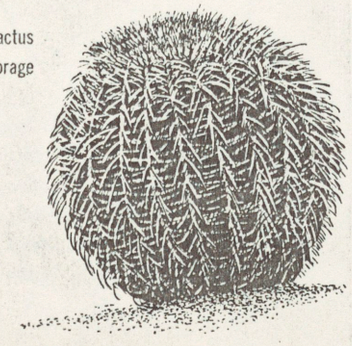


Succulence helps the barrel cactus resist drought. In dry weather the plant becomes shriveled as stored water becomes low.



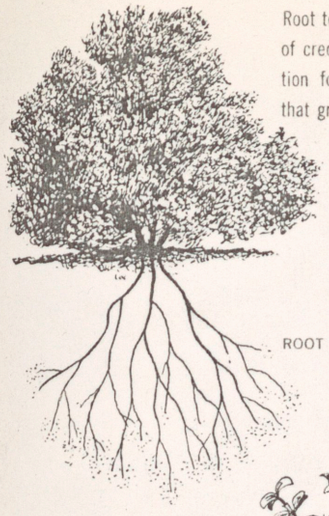
Leaf shedding helps the paloverde conserve water. When moisture is plentiful, tiny leaves manufacture food.

In wet weather the barrel cactus grows plump as special storage cells fill up with water.

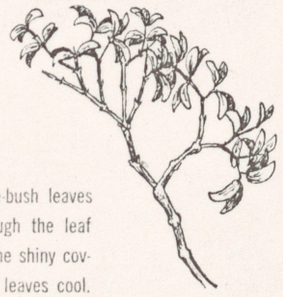




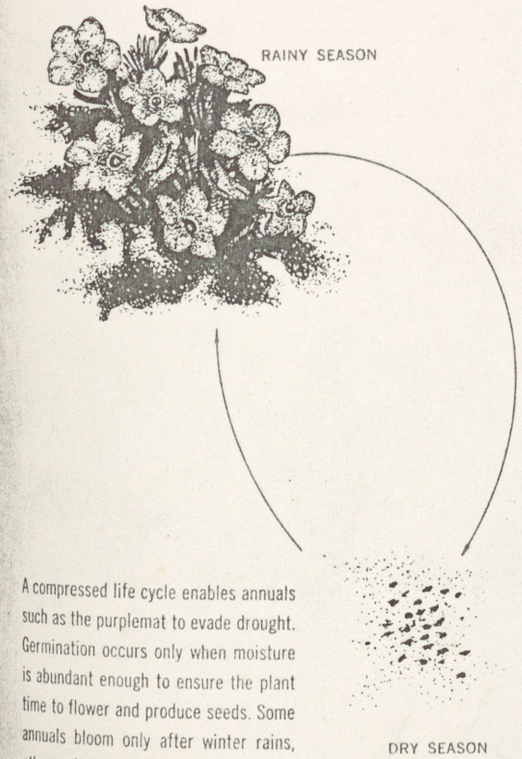
As soon as moisture becomes scarce, the leaves are shed to cut down on water loss, but photosynthesis continues in the chlorophyll-containing bark.



Root toxins produced by the roots of creosote bush reduce competition for water by killing plants that grow too close.



A waxy covering on creosote-bush leaves slows down water loss through the leaf surface. By reflecting heat, the shiny covering may also help to keep leaves cool.

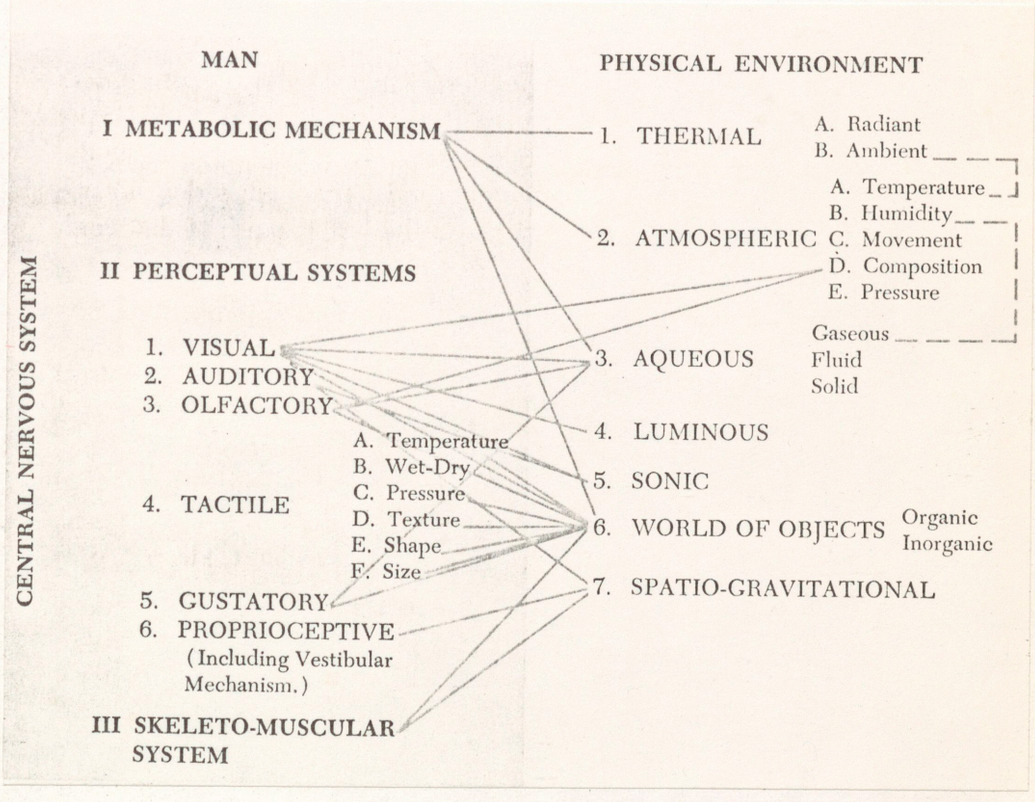


A compressed life cycle enables annuals such as the purplemat to evade drought. Germination occurs only when moisture is abundant enough to ensure the plant time to flower and produce seeds. Some annuals bloom only after winter rains, others after summer rains.

DESIGNED FOR DROUGHT

In the long evolutionary history of desert plants, the crucial factor of their survival has been water supply. Water on the desert is not only scarce, it is undependable. When rain falls, it often falls in torrents. Yet the storms may be followed by long periods with no precipitation at all. Strangely enough, many desert plants use water freely when it is plentiful. During the rainy season, some desert plants actually lose more water through transpiration than do plants living in areas of abundant rainfall. But with the onset of drought, water loss is radically curtailed. Desert plants have evolved a remarkable array of adaptations for surviving water shortages. Cactuses, for instance, resist drought by hoarding water when it is plentiful, then drawing on their reserve when it is scarce. Other plants, such as desert annuals, evade drought by remaining as dormant seeds during dry weather. Still others endure the effects of drought by shedding their leaves, thereby reducing water usage to a minimum. Whether the adaptation is in leaves, stems, or roots, or in a combination of these, whether the adaptation is shedding, rolling, shrinking, or some other, desert plants, on the whole, are perfectly fitted to an environment that offers an abundance of water one day and none the next.

In this second chapter I will try to reveal how the conditions and systems of the desert environment, presented thus far, are perceived by man. Essentially this requires an understanding of the characteristics of the physical environment and how these interact with man's central nervous system. I think the diagram[7] below makes these relationships perfectly clear. In the following pages I will examine man's basic systems of perception; seeing, hearing, smelling, etc., and make an attempt to realize the conditions of the desert environment which are responsible for the stimulation of these senses.



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[7] Fitch, James Marston; American Building 2: The Environmental Forces That Shape It; Houghton Mifflin Co., Boston; 1972; p. 7.

PSYCHOLOGICAL IMPACT
PSYCHOLOGICAL NEEDS

PSYCHOLOGICAL IMPACT:

We may speak of the psychological impact of the Solar Farm from two standpoints: (1) the psychological impressions of the mass of the Solar Farm in the desert landscape and (2) the effects related to humans operating within the Solar Farm facility.

Visually the mass and the 'quality' of this facility make a profound statement on the natural landscape. The long rows of metallic collectors, the tall cooling towers, and the super-human proportions of length and width state the intent of technologic requirements, clearly these requirements preclude a human scale.

To the distant observer the visual impact of the facility may excite feelings of awe, fear, distrust; any number of sensations including distrust. But to the Solar personnel the project will take on a different aspect.

The need for space for 'living' and space for 'working' will surely result in an architectural product responsive to both scales: human and technologic. These 'soft' areas will become the centers for human involvement in the process of solar collection, storage, and generation. Outwardly these structures must be equally as massive as the Solar Farm itself: inwardly they must be responsive to the complex of human requirements. In the following paper the psychological effects of environmental design are presented according to a list to evaluate the performance of my architectural decisions.

PSYCHOLOGICAL NEEDS:

The following list of psychological needs is taken from a paper by Peggy Peterson, University of California at Berkeley, entitled The ID and the Image: Human Needs and Design Implications.

Need/Security

Description: This is a desire to be free from fear, anxiety, care, risk, or danger.

Need/Order

Description: A need to put things in order, to achieve cleanliness, arrangement, organization, balance neatness, tidiness or precision.

Need/Frame of Orientation
Philosophy of Life-Rootedness

Description: This category includes many related ideas. Man needs a consistant and stable way of perceiving and comprehending the world; he needs to feel he belongs to the world and is a part of it. The mature man needs a philosophy of life as a unifying force and orientation.

Need/Solitude
Privacy

Description: This is the complement of the need for affiliation; people need to have some time alone.

Need/Autonomy
Self-determinism, Self-sufficiency and Independence.

Description: This is a need to get free, shake off a restraint, break out of confinement; to resist coercion and restriction; to avoid or quit activities prescribed by domineering authorities; to be independent and free to act according to impulse; to be unattached, irresponsible; to defy convention; to determine one's own behavior.

Need/Identity
Uniqueness

Description: Each individual needs to know who he is and recognize himself as a human being distinct

from others and his surroundings. He needs to be unique. Identity formation is a continuous process; however, adolescence is a particularly important stage in its formation.

Need/Exhibition
Self assertion

Description: A need to make an impression; to be seen and heard; to excite, amaze, fascinate, entertain, shock, intrigue, amuse, or entice others. To assert one's self.

Need/Dominance
Superiority, Power

Description: These terms indicated a need to control one's human environment; to influence or direct the behavior of others by suggestion, seduction, persuasion or command; to dissuade, restrain or prohibit. A desire to be superior, to dominate.

Need/Infaviodance
Avoid Inferiority

Description: This is a rather passive solution to the problem of humiliation. It is a need to avoid humiliation; to quit embarrassing situations or to avoid conditions which may lend to belittlement: The scorn, derision, or indifference to others; to refrain from action because of the fear of failure.

Need/Defendance

Description: Here we have a more active defense of the self against assault, criticism, and blame; a need to conceal or justify a misdeed, failure, or humiliation; to vindicate the ego.

Need/Counteraction

Description: This is an active striving to obliterate a humiliation by resumed action; to master or make up for a failure by restriving. It includes a need to overcome weakness, to repress fear; to efface a dishonor by action; to search for obstacles and difficulties to overcome; to maintain self respect and pride on a high level.

Need/Achievement
Sense of accomplishment, Perfection, Effectance

Description: This is a need to accomplish something difficult; to master, manipulate, or organize physical objects, human beings or ideas, and to do this as rapidly and as independently as possible, to overcome obstacles and attain a high standard; to excel oneself; to rival and surpass others; to increase self regard by the successful exercise of talent. John Atkinson and David McClelland, who have intensively studied achievement, include three categories: unique accomplishment, long-term involvement, and competition with a standard of excellence.

Need/Prestige
Esteem, Personal Admiration

Description: This is the positive side of the humiliation coin. People need to have the respect of others and themselves: recognition.

Need/Aggression

Description: This is a need that people often deny and repress. It is the need to overcome opposition forcefully; to fight, to revenge an injury, to attack, injure or kill another, to oppose forcefully or punish another.

Need/Rejection

Description: This is a need to separate oneself from a disliked object, to exclude, abandon, expel, or remain indifferent to an inferior object, to snub or jilt an object. In short, it is the need to be able to show disapproval.

Need/Deference

Description: People have a need to admire and support a superior, to give praise, to honor, to eulogize, to yield to the influence of an allied other, to emulate an exampler, and to conform to custom. This is a complement of autonomy and aids the prestige of others.

Need/Abasement
Self submission, self surrender

Description: These terms encompass the need to submit passively to external force; to accept injury, blame, criticism, punishment, to surrender; to become resigned to fate, to admit inferiority, error, wrongdoing, or defeat; to confess and atone; to blame, belittle, or mutilate the self; to seek and enjoy pain, punishment, illness and misfortune.

Need/Play
Leisure

Description: This is a complex need that is just beginning to be understood. It is a need to act for "fun" without further purpose; to like to laugh and make jokes; to seek enjoyable relaxation of stress; to participate in games, sports, dancing, drinking parties, cards, etc.

Need/Variety
Sentience

Description: People need change in their life and their environment. D. O. Hebb's experiments at McGill University show that variety is not only the spice of life, but its sustaining force; within a very short time subjects went literally "out of their minds" when they were deprived of all sensory stimulation. People need to seek and enjoy sensuous impressions.

Need/Understanding
Cognitive needs

Description: This need can be thought of as a thirst for knowledge - a need to ask or answer general questions; to speculate, formulate, analyze, and generalize.

Need/Meaningfulness in Life
Goal

Description: To give life meaning man needs a sense of purpose or a goal. Man needs a reason to be (raison d´etre). When this is entirely lacking, man is close to suicide.

Need/Self Actualization, Self Realization
Transcendence

Description: These terms refer to man's need to realize his full potential as a human being - to rise above his animal nature and become a creative person.

Need/Aesthetic

Description: According to Maslow this is the highest of all human needs - the desire for beauty.

SIGHT

SOUND

SMELL

TASTE

SKIN SENSES

PHYSIOLOGICAL NEEDS

SENSES/SIGHT

Of any of the senses man possesses, he relies almost entirely on his visual sense to tell him about his environment. Light reflected from an object is captured in the eye where the image is transmitted to the brain in the form of impulses. In the brain these impulses are processed and analyzed.

In many cases what we "see" is the result of conditioning by our society and what we ourselves chose to "see." A chain reaction can occur where the original object is the first link in a chain of stimuli to a series of remembered associations. One might state; "we 'see' only what our experience tells us we 'know.'"

In the desert the human faculties of sight are unrestricted. But there are certain peculiarities which may affect 'seeing.' In the tremendous amount of sunlight that pours down onto the land areas; intense glare becomes such a problem that vision may be severely restricted. This suggests there should be someway to protect the eye from these effects in the architectural habitat and out in the burning sun of the desert.

The second problem to seeing is that of the 'mirage.' When light strikes an object rays are given off in many directions. In normal circumstances a single observer receives only a small portion of the reflected light on his retina. But in the desert the air near the surface is often hotter and less dense than the air above it. Sometimes several abrupt air layers may occur one above the other. When this happens light rays that were not previously reflected to the observer are refracted back toward him by the atmosphere. If both these images reach the observer he sees two views of the same object; the actual image and the second image above it, inverted because of the angles through which the light is bent as it passes back through the atmosphere.

Presently I have found no indication of a solution to this problem. The important thing is that humans living in the desert recognize the effect for what it is.

SENSES/SOUND

The human ear is a very sensitive and at the same time fragile mechanism. Not only is it capable of distinguishing sounds of low frequency, but also those in the upper ranges. At the same time the ear can 'listen' to a number of sounds radiating from different sources. Through the ear man receives his second most important set of information.

In the desert the abilities of the ear remain unchanged. More important than the actual physiology of hearing in the desert, is the origin of sounds. Animals, not man and his machines, are the primary 'noise-makers.' During the day when temperatures are high they remain quietly in seclusion in the safety of a selected habitat. The only animals that do venture out are a few birds.[8] Night time is when life of the desert and its sounds are most apparent, as the animals come out to hunt and gather food. Humans, accustomed to city life, may have to adjust to these conditions.

The secondary source of noise in the desert will be the actual solar farm itself. A constant hum will be present due to the mechanical functioning of solar collection, steam and power generation and cooling. The other activites that man performs in living and working will add to this pollution. Consequently many of the sounds man will hear, are those he has generated himself.

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[8]The birds may cool their bodies in flight by the wind currents passing over their feathers.

SENSES/SMELL

Smell is very important in man's life, though its influence may be rated below sight and sound. In a closed environment smells have considerable effect.

Six primary qualities of smell have been cited: flowery, fruity, putrid, spicy, burned and resinous. A single odor may not be classified according to any one of these categories, but may result from a mix of odors.

In the desert high temperatures may cause irritation of the nasal passages due to the dry arid conditions. This will be notably present outside synthetic conditioning of the living unit.

The architectural habitat is a primary element in the containing and sometimes the creation of odors. As such careful consideration must be given to air control systems both natural and mechanical, and the filtering of natural and man-made odors.

The following tables[9] explain the sources of contaminants in the air, the tolerable limits of chemical concentrations in the atmosphere, and methods of contaminant control.

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[9]From an architectural thesis by Rafferty, Larry; "An Exercise Encompassing the Design of an Undersea Research Facility;"1973.

METHODS FOR CONTAMINANT CONTROL

CONTAMINANT	METHOD	DEGREE OF DEVELOPMENT	REMARKS
Odor Control	Charcoal	Standard Use	Some hazard due to flammability in hyperbaric chambers. Also removes trace organics
	Purafil	Standard Use	Standard use. Also removes trace contaminates from metabolic processes, cooking and some carbon monoxide. Sensitive to moisture
	Aluminum	Available	Absorbs large molecule contaminates but does not remove methane.
Particulate Matter	0.3 micron Filter	Standard Use	Commercially available.
Hydrocarbons & CO	Hopacalite Catalytic Burner	Standard Use	Performance degrades with moisture. Less effective removing methane. Freon & other contaminates decompose resulting in the release of toxic gases.
CO_2 Removal	Baralyzme Sodasorb	Standard Use	Standard use in habitats & closed and semi-closed breathing apparatus.
	Lithium Hydroxide standard grade	Standard Use	Standard use in habitats & decompression chambers. Dusting & caustiicity are problems.
	Lithium Hydroxide dust-free grade.	Limited to experimental testing.	Coated to eliminate the dusting problem. Not specifically used in diving applications currently.
	Potassium Superoxide	Application in mine rescue and fire fighting equipment.	Control of pO_2 at depth, chemical contamination & moisture control are problems. Removes CO_2 and generates oxygen.
	Lithium Oxide LIO_2	NO SIGNIFICANT DEVELOPMENT	
	Barium Hydroxide $Ba(OH)_2$		
	Sodium Hydroxide NaOH		
	Magnesium Oxide MgO		
	Magnesium Hydroxide $Mg(OH)_2$		
	Calcium Oxide CaO		
	Calcium Hydroxide $Ca(OH)_2$		
	Sodium Peroxide NA_2O_2		
	Lithium Peroxide Li_2O_2		
	Molecular Sieves	Designed & built for use in space simulators. Some foreign evaluation	Performance degrades in presence of organics & moisture. CO_2 must be vented over-board.
	Monoethanolamine (MEA)	Used successfully in nuclear submarines	Efficient system. Some problem with the release of toxic vapors. MEA is a strong alkaline solution. Some operation instability due to oxidation.
	Sulfate-cycle	Feasibility testing for submarine use.	Use for oxygen production & carbon dioxide absorption.
	Ionics Exchange Absorber	Prototype testing for submarine use.	Used for oxygen production & carbon dioxide absorption.
	Algae Culture	Experimental Testing for submarine use.	Used for oxygen production & carbon dioxide removal. High electrical power requirements.
	Polyethylenimine PEI-600	NO SIGNIFICANT DEVELOPMENT	
	Amberlite IR-45		
	Epon 562/Det		
	Cryogenic CO_2 freeze out	Equipment built and tested to date has proben unsatisfactory	Problems are logistics, of supplying the cryogenics, & insulation effectiveness humidity control problems.

SOURCE AND FORM OF CONTAMINANTS

SOURCES	PROCESSES	PRINCIPAL CONTAMINANTS
A. Biological		
Man:		
Respiration	Exhalation, sneezing, coughing, evaporation	CO_2, CO, mucus, bacteria, virus
Flatus	Flatulation	H_2, H_2S, CH_4
Urine	Micturition, spillage, storage, evaporation	Many acids, urea, ammonia, phenols, inorganic salts
Sweat	Perspiration, evaporation	Ammonia, phenol, acids, inorganic salts
Sebum	Secretion, vaporization	Fats, fatty acids, odoriferous substances and acids, desquamated epithelium
Feces	Defecation, spillage, storage, evaporation	Ammonia, phenols, indole, skatole, methyl mercaptan, paracresol, bacteria
Hair, nails	Depilation, clipping, shaving	Particulate debris
Cerumen	Secretion, vaporization	Odoriferous waxes
Microbes	Indigenous body organisms	Bacterial debris, possible infectious organisms
B. Nonbiological		
Food, beverages	Spillage, decomposition, regurgitation	Debris, odors, provide substrates for microbial proliferation
Waste disposal systems	Spillage, leakage, decomposition	Debris, odor, noxious gases microbial proliferation
Construction materials		
Metals	Wear, oxidation, galvanic corrosion	Dust, metallic oxides, H_2
Plastics	Wear, heat	Dust, phenol, formaldehyde, other noxious vapors
Other nonmetals	Wear, decomposition	Dust, substrates for autothropic growths
Paints	Wear, vaporization	Dust, toxic organic vapors
Lubricants	Spillage	Aerosal formation, odors
Electronic gear insulation	Corona discharge, ionization, heat	Ozone, ionized air, phenol, formaldehyde
Electrical motors, batteries	Wear, power generation and conversion	Ozone, ionized air, H_2

Compound	Chemical Formula	Suspected Source	Limit 1 Hour	Limit For 90 Days
Acrolein	CH_2CHCHO	Cooking		-
Arsine	ASH_3	Battery Gassing		0.01 PPM
Ammonia	NH_3	Scrubbers (Metabolic)	400 PPM	25 PPM
Carbon Dioxide	CO_2	Breathing	5%	1%
Carbon Monoxide	CO	*Smoking (Metabolic)	200 PPM	26 PPM
Chlorine	Cl_2	Chlorate candles		0.5 PPM
Ethylene	C_2H_4	Polyethylene Decomposition		-
Formaldehyde	CH_2O	Cooking combustion		-
Freon 12	CCl_2F_2	Air Conditioning		500 PPM
Hydrocarbons (other than CH_4)		Paints		-
Hydrogen	H_2	Battery Gassing		3%
Hydrogen Chloride	HCl	Freon decomposition	50 PPM	0.1 PPM
Hydrogen Flouride	HF	Freon decomposition	5 PPM	0.1 PPM
Mercury	Hg	Equipment/ Thermometers	-	0.05 Mg/M^3
Methane	CH_4	Sanitary Tanks	-	5.3%
Methylalcohol	CH_3OH	-	-	3 PPM
Monoethanolamine	$HOCH_2CH_2NH_2$	CO_2 Scrubbers	100 PPM	1 PPM
Nitrogen Dioxide	NO_2	Burners (Contaminant or hot surfaces)	10 PPM	0.05 PPM
Nitric Oxide	NO	Burners (Contaminant or hot surfaces)	10 PPM	0.05 PPM
Ozone	O_3	Precipitators	1 PPM	0.05 PPM
Phosgene	$CoCl_2$	Freon decomposition	1 PPM	0.05 PPM
Stibine	SbH_3	Battery Gassing	1 PPM	0.05 PPM
Sulfur Dioxide	SO_2	Oxidation Sanitary Tank Gases		-

* Smoking should be prohibited.

CONTAMINANTS AND LIMITS

SENSES/TASTE

The sense of taste and of smell are closely related, so though I discuss them separately the reader should remember that they overlap.

Essentially the taste buds react to four gustatory qualities: sweet, saline, sour and bitter. Many 'tastes' are the result of interaction between several or all of these senses.

Similar to the olfactory receptors; the taste receptors experience a decrease in sensitivity to a certain taste when that substance is present over an extended time period. Once the stimulating substance is removed the receptors regain their original sensitivity.

In architectural applications; the sense of taste must be considered in the presence of odors. Certain smells brought into the throat through the action of breathing, enter the mouth and cause taste residues. Such a reaction may be satisfying or in many cases very distasteful.

Temperature also has an inherent effect on taste. With an increase in temperature of the taste solution and increase in sensitivity of the related taste area (sweet, saline, sour, bitter) is experienced. This implies food storage and preparation controls must be considered.

SENSES/SKIN SENSES

In the interface between the exterior physical environment and the inner metabolic environment of the human body, is the skin. In this layer are sensors which allow us to perceive qualities of temperature, humidity, pressure, shape and texture. The skin also acts to balance the internal temperatures of the body with the external environment of the use of sweat glands and capillaries.

There are certain tolerable limits to the range of fluctuation between temperature of the body and that of the atmosphere. When this limit is exceeded man must rely on artificial means to aid his adaptation; clothes and his architectural habitat. In the desert clothes serve both as heat insulation and water conservation structures.

In the summer and winter clothes provide protection from radiation, high air temperatures, and dry winds during the day, and from rapid cooling during the night. Desert residents have found that loose heavy clothing works to insulate against heat absorption while allowing for air movement next to the body and moisture evaporation from the skin. In some climates loose white clothes have been found to be sufficient to protect against the warm air, sun and sand.

The character of the desert is such that it may cause physiological and psychological stresses. Some of these stresses have been found to be caused by:[10]

1. rapid gain of heat from sun and air.

2. excessive sweating to lose surplus heat through evaporation.

3. elimination of considerable amounts of salt in the sweat secreted.

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[10]All the following data and that on future pages is from Adaptation to the Desert Environment by J.P. Kirmiz; Butterworths, London; 1962.

4. acceleration of blood circulation to transport heat to the body surface for cooling,

5. risk of undergoing "voluntary dehydration" and salt depletion,

6. danger of suffering from heat exhaustion and heat stroke,

7. harmful effects of dust, glare, and sunburn.

One of the major problems of a desert existence is to maintain a heat balance between the body and the atmosphere and at the same time replenish the water and salt that is lost in the process. The metabolic process for heat balancing is sweat secretion. The body automatically assumes this function when temperatures reach a certain level. But to restore levels of water and salt requires a conscious effort of the mind.

In heat balancing in an average day, the normal body temperature 37°C will rise and fall 1°C. With the aid of artificial protection the body can withstand a temperature variations of 122°C (the Sahara at 50°C or in Siberia at -72°C).

Herrington in 1949 outlined the tolerance limits of the human body to heat stress:

Body temperature 37°C	+6°C (rise)
on exposure to cold	-12°C (drop)
increase in cardiac output	1.4-1.7/min.
pulse rate at rest	140/min.
pulse rate with exercise	180/min.
sweat at rest	1800 gal/hr.
sweat secretion w/exercise	3900 gal/hr.

The sweating rates of men in the desert at an air temperature of 37.8°C:

300 gal/hr. sitting in the shade clothed
900 gal/hr. walking in the sun clothed
1150 gal/hr. walking in the sun nude.

Among the factors that influence evaporative water loss in the desert are:

air temperature	solar radiation
wind velocity	relative humidity
clothing	muscular activity
body size	emotional stress
degree of dehydration.	

Water and salt balance:

the intake of water and salt is conditioned by:

a) availability of adequate provisions in the environment

b) individual habit and social customs

c) the physiological mechanisms of thirst and appetite.

Man protects himself against heat gain from the environment by:

1. he avoids heat gain from direct solar radiation, indirect sky and ground radiation and hot air currents by using clothing, shade, and shelter.

2. he reduces heat production by avoiding muscular effort, by increasing relaxation and rest and diminishing food intake (especially protein and fat).

3. he increases heat loss through conduction, convection, radiation and evaporation by exposing a greater area of skin surface to cool atmosphere and air currents and by sweating.

Through acclimatization the human body can adjust to the extremes of the desert. Once this is accomplished there is a tendency to show:

improved heat regulation; pulse rate; pulse pressure; skin and body temperature; salt concentration in sweat and basal oxygen consumption are decreased. And capacity for muscular effort is increased.

The hazards the desert offers to human subsistence can be summarized in the word dehydration. Man's most important single activity will be to avoid dehydration by consuming sufficient quantities of water. He must be careful to guard against voluntary dehydration, since he cannot rely on his bodily mechanisms to signal his needs for fluid intake; man cannot 'thirst' enough in the desert climate to meet the needs of his body (except at rest).

PHYSIOLOGICAL NEEDS:

All animals, humans included, possess a set of basic drives. Drives which must be recognized for a culture to survive,[11]

A list of the basic drives:

1. hunger

2. thirst

3. sexual gratification and procreation

4. the seeking of physical comfort.

The heat and dryness of the desert are factors which may cause unusual stress on metabolic systems. This is manifest in the intensification of certain of the basic drives, hunger, thirst, and the seeking of physical comfort. The architectural environment will be of first importance to protect the solar farm inhabitants from undue bodily stress, in protection from sun, wind and rain. And as such has a direct connection to the 4th basic drive; the seeking of physical comfort, and indirectly the drives of hunger and thirst.

In a paper entitled The ID and the Image: Human Needs and Design Implications, Peggy Peterson has compiled a list of psychological needs and their implications to environmental design. Among the 'needs' in this paper, she presents two which I would consider more correctly categorized as 'physiological needs.' The first seems related to the basic drive for the seeking of physical comfort, the second is a restatement of the drive for sexual gratification and procreation:

Need/Harm Avoidance
Safety Needs. Avoid pain

Description: This need is really a self-protecting device; it implies avoiding pain, physical injury, illness, and death, escaping a dangerous situation, and taking precautionary measures. Individuals

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[11]A culture by the creation of social institutions, can provide for the satiation or restraint of any of these basic drives.

also take great measures to avoid psychological pain. Freud believed that all human behavior was determined by the principle of avoiding pain and seeking pleasure.

Need/Sex

Description: To form and further an erotic relationship - to have sexual intercourse.
Henry Murray is by no means the only person to label sex a need; it is universally recognized as such.

Add to this list:[12]

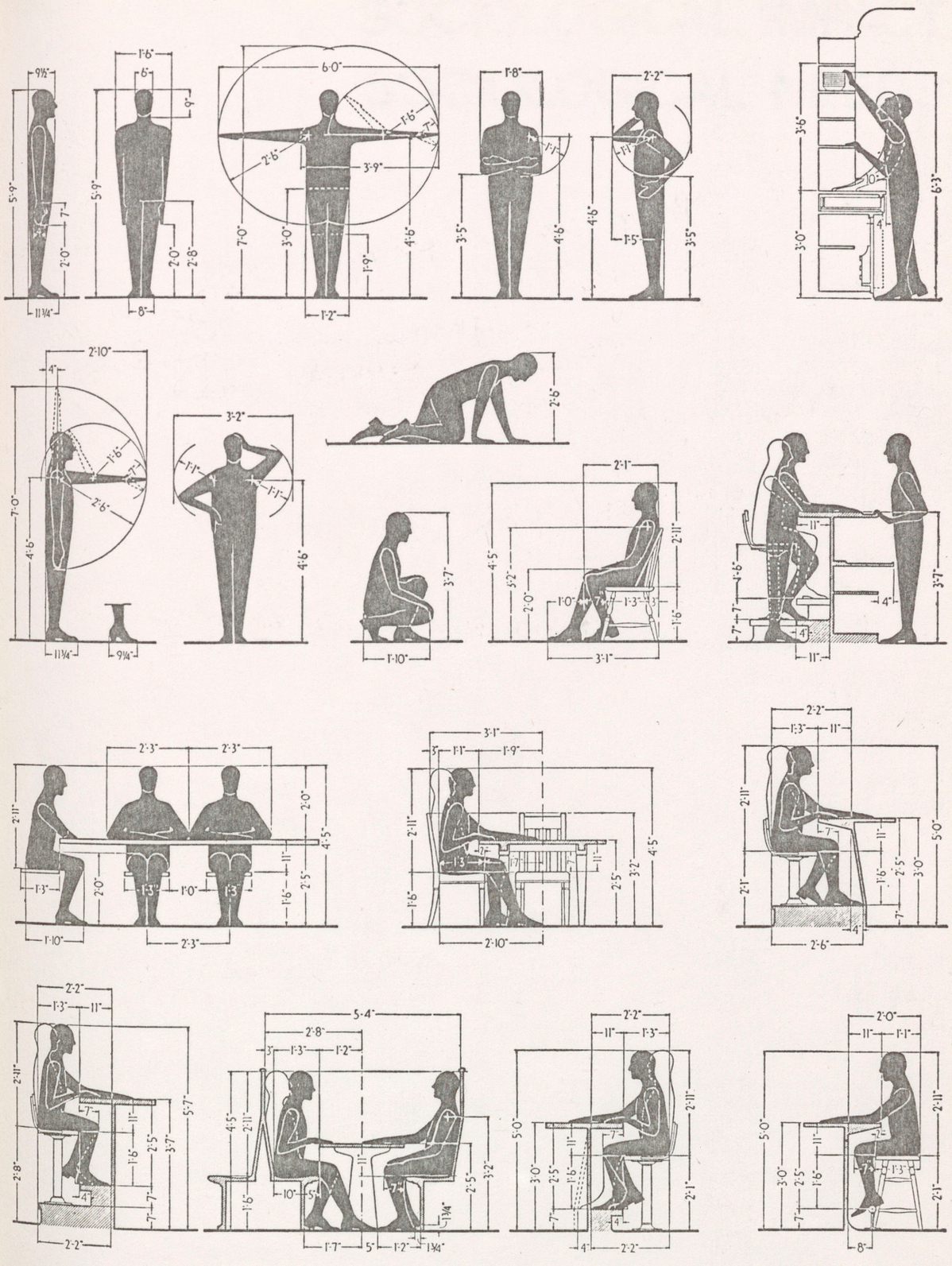
Need/Hunger
Need/Thirst
Need/Physical Comfort

and we have a basic set of physiological needs which we can use to evaluate the performance of a physical environment in relation to human metabolic systems.

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[12]Some persons would consider defecation as one of the physiological needs, I have presumed that this could be implied from the need for physical comfort. As could many other architectural implications.

DIMENSIONS of THE HUMAN FIGURE



Scale of Human Figure 1/4" = 1'-0"

These dimensions are based on the average or normal adult. As clearances are minimum they should be increased when conditions will allow.

Table, desk, and other sitting work-top heights are shown 2'-5"; however some authorities prefer 2'-6" or 2'-6½". See sheets on children's furniture for their sizes and furniture.

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Drawings by Ernest Irving Freese

SOCIOLOGICAL IMPACT
SOCIOLOGICAL NEEDS

SOCIOLOGICAL IMPACT:

The creation of a Solar Farm in the area of Yuma will undoubtedly have the effect of bringing in tradesmen and laborers for the construction and engineers for its operation. Some of these persons will be drawn from the Yuma area; others will come from further away and will require housing and services, which will place loads on existing social conditions.

Presently there is no way to estimate the numbers of people that will be necessary for the construction of the Farm. I have made a decision, based on available data and my own intuition, that 11 people will be needed to operate this first facility. This would include 8 engineers, 1 cook, 1 housekeeper, and 1 biologist. Notably there may be a sociological split between the levels of professions, between the engineers, the houseworkers, and the biologists; it is my assumption that such an instance will not occur. I will assume that the communal society that will be created among the persons who live together and operate the Solar Farm together, will give the solar community a feeling of cohesiveness.

The concepts of sociology as applied to this project can be defined according to 2 headings; the individual and the group. This clearly follows a concept of community vs. privacy.

Individual/Privacy

Privacy and seclusion are essential to human existence in that they provide a separation for an individual from his or her immediate environment. Beyond providing a means for isolation; opportunities must exist for personal experience of environmental situations. Thus two coexisting conditions must be considered:

1) the situation where an individual may isolate himself completely from his surroundings visually, as well as from sounds, smells, etc. and

2) such social relationships must exist that a single person may experience his environment individually through his own senses.

While privacy is important, one must not neglect man's basic social needs of affiliation, nurturance and succorance. Satiation of these needs requires that spaces be provided for inhabitants of the living unit of the Farm, to interact

freely. The architectural environment may encourage such interaction.

Group/Community

Group activity in the living unit will occur at several levels including dining, relaxing and working. Dining will be the most important mechanism for sustaining contact between members of the community. At the relaxation level activities might include card games, and table tennis, at the working level will be the tasks which require group effort such as maintenance and repair.

It is apparent that the developing society on the Solar Farm may stratify according to 3 work activities and professions. The first would occur at the food preparation and housekeeping level, the second at solar maintenance and operations level, and the third would include the scientist whose function it is to study the Solar Farm and its effects on the desert environment. To lessen the feeling of stratification and increase interaction between individuals, certain group activities may be required. The whole group may get involved in such mutually important activities as agriculture, farm maintenance and operation.

The relationships between people can be defined in the context of a single culture, in terms of distances and spaces. On the following pages are two methods of explaining these relations. The first table was created by Edward T. Hall to explain the social and anthropological relationships of interaction. The second table shows how Halls diagram could be derived using speech interference levels, or the amount of background noise that can be tolerated while performing a certain task.

TABLE 1--Table of social distances (from Hall, 1966)

1. Intimate distance.	
close phase--up to 6 ins (150 mm)	audible whisper
far phase--6 ins to 18 ins (150 mm to 450 mm)	intimate utterance
2. Personal distance	
close phase--18 ins to 30 ins (450 mm to 760 mm)	
far phase--2½ ft to 4 ft (760 mm to 1·200 m)	moderate voice personal involvement
3. Social distance	
close phase-- 4 ft to 7 ft (1·200m to 2·200 m)	impersonal business
far phase-- 7 ft to 12 ft (2·200 m to 3·650 m)	formal business
4. Public distance	
close phase--12 ft to 25 ft (3·650 m to 7·300 m)	loud voice planned formal discourse
far phase-- 25 ft and over (7·300 m and over)	public utterance political expression

TABLE 2--Speech interference levels (from Aldersey Williams, 1969)

SIL distance	Voice level and distance for work intelligibility	Nature of communication
45	Normal voice at 3 m	Relaxed conversation Telephone use satisfactory
55	Normal voice at 900 mm Raised voice at 1·8 m Very loud voice at 3·6 m	Continuous conversation in work areas Telephone use slightly difficult
65	Raised voice at 600 mm Very loud voice at 1·2 m Shouting at 2·4 m	Intermittent conversation Telephone use difficult
75	Very loud voice at 300 mm Shouting at 800 - 900 mm	Minimal communication --pre-arranged vocabulary Telephone use impossible
85	Shouting at 300 mm	

SOCIOLOGICAL NEEDS:

Peggy Petersen has included 3 needs which I classify as sociological and not psychological. These 3 needs are what I shall refer to as the sociological needs:

Need/Affiliation

Belongingness, Brotherliness and Relatedness, Cooperation and Social Instinct, Affection and Approval.

Description: This category includes the need for being with others--a desire to please and win affection, to remain loyal to a friend, to enjoyably cooperate or reciprocate with another who resembles or likes the subject. Affiliation has been related to many things, even anxiety seems to diminish as affiliation increases.

Need/Nurturance

Need to be needed. Humanitarianism and Altruism.

Description: These terms encompass the needs to give sympathy and gratify the needs of a helpless object, to assist an object in danger, to feed, help, support, console, protect, comfort, nurse and heal. In short, the need to feel that one is needed and wanted by another human being or by society.

Need/Succorance

Protection

Description: This is the opposite of nurturance. It is the need to have one's needs gratified by the sympathetic aid of an allied object, to be nursed, supported, sustained, surrounded, protected, loved, advised, guided, indulged, forgiven, consoled, to remain close to a devoted protector, to always have a supporter.

POLITICAL SITUATION

POLITICAL SITUATION:

The land under the farm will become property of the Federal government and the people of the United States, as will the farm itself. Hence forth, I foresee that a National Energy Commission should be created which would oversee this facility and others like it, and maintain control over nation-wide power generation and transmission. This commission would be responsible for the operational requirements of all solar farms and other like facilities (coal stations, nuclear plants, etc.).

I have also considered that this body of ruling officials might pass zoning laws and codes to protect air rights, solar angles, etc. of the various farms. And that they would have power to preserve ideal locations for future solar facilities; to keep these sites free from development and exploitation.

POWER FOR THE PEOPLE . . .

ECONOMIC SITUATION

ECONOMIC SITUATION:

The absence of a specific design delineating the features and hidden costs of a Solar Farm, has limited accurate evaluation of costs. Nonetheless the Mienels have resolved costs according to two philosophies: 1) short component lifetime (5 years) and 2) long component lifetime (35 years); summarized in the following table:[13]

Aspect	Short	Long
Lifetime to replacement (yrs.)	5	35
Mass (kg/m^2)	4-8	15-30
Component cost ($/kg)	1.00	1.50
Maintenance cost during 35 yrs	high	low
System conversion efficiency w/m^2)	0.040	0.040
Initial collector cost ($/$m^2$)	4-8	22-45
35 year collector cost ($/$m^2$)	28-56	22-45
Initial collector investment ($/kw)	100-200	560-1120

Using the Mienels figure for the cost of the 35 year collector ($/$m^2$); the Yuma Solar Farm 1 mile square (1.61 km. x 1.61 km.), would cost in the neighborhood of $90 million. I expect that the Federal government would finance this facility through collection of tax monies and the diverting of funds from other Federal agencies such as the Defense Department and Foreign Affairs.

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[13] 'Solar Energy: Option or Illusion;' "ASC/AIA Magapaper;" Summer 1973.

On the local scale the effect of the Solar Farm on Yuman economics will be to boost the job market of the surrounding area. First through the availability of jobs, more persons will migrate to the area, secondly, these persons will need goods and services which may be supplied by Yuma area merchants. After construction of the farm is completed, many of these workers will move on, but a few may remain implanted in the area. Essentially long term jobs will be occupied by those persons responsible for the day-to-day operation of the solar facility; approximately 11 persons.

This first solar farm will probably not operate in the region of profit returns, instead the price for power paid by the consumer will be fed back into the system to take care of operating costs and pay for the initial cost of construction.

What sort of time will evolve before we see the advent of the first solar farm and what will be its life expectancy? In the following table[14] the Mienels point out that the time scale between start of intensive work and research on solar energy and its use by the consumer; specifically the first solar farm will be 10-15 years and another 5-10 years may develop before these are replaced by photovoltaic systems:

Option	Time(yrs.)
Thermal heating of buildings	3-5
Thermal cooling of buildings	4-6
Agricultural dry land fuels.	3-5
Biogenic methane	5-10
Domestic and animal wastes to oil. . .	5-10
Photothermal power systems	10-15
Photovoltaic land power systems. . . .	15-20
Space photovoltaic power systems . . .	20-30

In terms of market the solar farm will supply power to X number of people; depending on individual power demand. Should demand change so would the number of persons served (holding energy output constant). Costs to the individual consumer will largely be the responsibility of the

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[14] Ibid.

Federal government, since it is they who will own and thus control the output of the solar facility. (For additional information on demand refer to the section on ENERGY.)

HISTORY

SOLAR COLLECTION

CONSERVATION

ENERGY PRODUCTION

ELECTRICAL

HISTORY:

THE SOVIETS - JUST DATES AND EVENTS

1926 - Solar kitchen with oven heated by parabolic mirror.

1928 - Research into heat loss of solar devices.

- Solar hot boxes.

1929 - Solar plant.

1930 - Solar water heaters.

1933 - Work stopped on solar plant.

1934 - Hot house.

1939 - 40 portable and stationary distillers.

* * * * *

PRE-1945 SOLAR ENERGY TIME TABLE

ANCIENT

1419 to 1455 B.C.	Amenhotep III - made statue that made noises as sun moved.
212 B.C.	Archimedes - wrote book about the use of spherical mirrors to heat things.
100 B.C.	Geron Alexander - solar fountain
46 to 120 A.D.	Mirrors used to produce fire.
500 A.D.	Antemius - paper on reflecting 24 rays. . . raised temperature to 400° C.

RENAISSANCE

PRIOR TO 16th CENTURY - work was primarily theoretical.

1551 to 1560	Payre and Lonister - used solar distilling devices for medical compounds.
1615 1646 1671	Martini - Kircher - solar engines were constructed

RENAISSANCE	1722	7 concave mirrors used in ignition system which was used in Trombe's solar furnace later.
	1741	Lomonosov - used lenses and mirrors to get foci at one point.
	1747	Byuffon (Paris) - worked on production of high temperatures--burned lumber and wood house at 68 M.
	1767	Seedbed Principle - multi-glass insulation proposed.
	1860 to 1883	Pifre and Moucheau - used solar heaters to prepare food, distill sulfuric acid; 3-9 absolute atmospheric pressure.
	1866	Erickson - solar motor.
	1890	Tserassky (Moscow) - used mirrors and obtained temperatures at 3500° C to melt metal, etc.
	1901 to 1903	Solar steam boilers at 75% efficiency (California).
MODERN	1907 to 1910	Schuman starts first solar water heating company; begins installations in California.
	1910 to 1913	Most powerful equipment to date by F. Schuman in Taconi and Mydi.
	1913	Solar power plant in Egypt.
	1914	SUN FUN IN THE BATHTUB (What???).
	1920s	France interested in distilling salt water.
	1925	Solar furnace used to synthesize nitric acid.
	1930	V. M. Kohn - solar furnace for chemical research, also proposed 1000 kilowatt solar furnace at Stanford Institute.

In recent times solar energy has been looked upon with renewed interest due to the space program and the impending energy crisis. This interest has lead to great strides forward in the utilization of solar energy in buildings. I am not going to attempt to summarize these developments, instead I refer the interested reader to the following list of solar buildings in the United States and the short solar bibliography that follows.

PAST AND EXISTING SOLAR BUILDING - USA

1. Steve Baer
   Zomeworks
   Corrales, N.M.

2. Robert & Eileen Reines
   Albuerquerque, N.M.

3. MIT Solar house #1
   Cambridge, MASS.

4. MIT Solar house #2
   Cambridge, MASS.

5. MIT Solar house #3
   Cambridge, MASS.

6. MIT Solar house #4
   Cambridge, MASS.

7. G. Ö. G. Löf
   Boulder, CO

8. U.S. Forest Service
   Desert Grassland Station
   Amado, AZ

9. Office Building
   Albuquerque, N.M.

10. G. Ö. G. Löf house (#2)
    Denver, CO

11. AFASE House
    Phoenix, AZ

12. Solar Energy Laboratory
    University of Arizona
    Tucson, AZ

13. H. Thomason, House #1
    Washington, D.C.

14. H. Thomason, House #2
    Washington, D.C.

15. H. Thomason, House #3
    Washington, D.C.

16. H. Thomason, House #4
    Washington, D.C.

17. Telkes, Raymond, Peabody House
    Dover, MASS.

18. House
    State College, N.M.

19. Laboratory
    Princeton, N.J.

20. House
    New Haven
    W. Va.

30. Test House
    Edison Electric Institute
    Philadelphia, PA

31. Demonstration House
    Allentown, PA

32. H. Hay House
    San Louis Obisbo, CA

33. House
    Institute of Energy Conservation
    U of Delaware
    Newart, DE

34. Wilson House
    Martinsburg
    W. VA.

35. Audubon Society Office
    MASS.

36. Bliss House
    U of Arizona
    Tucson, AZ

37. Hay House
    Atascadero
    CA

PAST AND EXISTING SOLAR BUILDING - OUTSIDE THE USA

34. House
Japan

35. Laboratory
Japan

36. House
Capri, Italy

37. House
Odeillo
France

38. Room Units
Great Britain

39. Room Units
W. Germany

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SOLAR COLLECTION:

Solar energy offers mankind a "clean" source of power in abundant and seemingly infinite quantities. What remains is for technology to develop to the point that we may economically collect this energy for use. Basically we may utilize solar energy in the form of heat as in domestic uses or we can directly convert it to electricity.

The first use of solar energy is rather simple process and within the sights of present-day technology. The second is not so easily accomplished. This process has been used in the space program where monetary aspects of the problem were no barrier. Through the use of 'solar cells' satellites and space capsules have been able to converse the Sun's rays directly into electricity to power their working parts. These photovoltaic cells seem to be the ultimate objective of all solar utilization here on Earth. But due to the pressures of economic and technical problems, their widespread use appears distant. Presently the answer relies on capturing the Sun's thermal energy and generating electrical current from this captured power. It appears that this could occur at two levels: the individual home and at the level of a central power station as we have today. Again economic and technical problems (collection, generation, and storage) rule out this system's use in the individual home. While possible integration of such a solar system with present generating stations seems very feasible, and makes this alternative very attractive.

An optimally located (with respect to climate) control power station seems to offer the solution. Operating 24 hours a day it could become a dependable source of electric power. During the day the plant would convert the excess power generated into some sort of storable form. This reserve it would use at night to continue operation. The following report, by Dr. A. B. Mienel summarizes the present 'state-of-the-art' on Solar Power Farms:

REPORT ON

PROGRESS IN SOLAR PHOTOTHERMAL POWER CONVERSION

Presented to the

SUBCOMMITTEE ON ENVIRONMENT
COMMITTEE FOR INTERIOR & INSULAR AFFAIRS
HOUSE OF REPRESENTATIVES

Washington, D. C.
13 June 1973

Aden B. Meinel
Marjorie P. Meinel
Bernard O. Seraphin
Dean B. McKenney

PROGRESS IN SOLAR PHOTOTHERMAL POWER CONVERSION

Aden B. Meinel, Marjorie P. Meinel*, Bernard O Seraphin and Dean B. McKenney*, Optical Sciences Center, University of Arizona, and Helio Associates, Inc.*, Tucson, Arizona.

Presented 13 June by A. B. Meinel.

This Committee has heard today about a wide range of possible uses of solar energy in reducing our demands upon the traditional energy fuels. We wish to present the case for the generation of electrical power from solar energy. There are two basic ways this can be accomplished: 1) via direct conversion using "solar cells" and 2) via thermal conversion using heat to drive conventional turbines. We feel the latter is closer to practical application for the production of electricity from sunlight.

Our research has been directed toward the concept of "solar power farms" as an option for the production of electrical power on a large scale. Our ideas have slowly modified in the light of study and experiments to include electrical power units from community size up to the central power stations typical of utility consortia. We have also noted that spinoff from our studies is applicable to domestic uses of solar heat for home heating and cooling.

There are a few introductory remarks that we would like to make to give you perspective concerning the several applications of solar thermal energy. Thermal applications can be tied to certain levels of increasing technological difficulty as shown in Table I below.

TABLE I

SOLAR THERMAL APPLICATIONS

1-- SWIMMING POOL HEATING	80-85°F
2-- HOUSE & WATER HEATING	140-180°F
3-- HOUSE REFRIGERATION	230-280°F
4-- ELECTRICAL POWER PRODUCTION.....	400-600°F
5-- CHEMICAL PROCESS HEAT	300-900°F

Regular use of solar energy faces a fundamental problem: energy must be stored for use at night and on cloudy days. Ways have been developed to store thermal energy to provide continuity, but it is expensive if many days of energy must be stored. Hydro-storage and underground compressed air storage are also possible. In our experiments to date cloudy weather has proven the major concern. To minimize energy storage requirements one must operate a solar energy collector as many days as possible. Mirror and lens concentrators are particularly sensitive to sky conditions, and hence our research has been devoted to a mode of thermal conversion that is relatively insensitive to haze and sky conditions.

It is also important to remember that the milestone of scientific feasibility is but the first step. In the case of solar energy there are three more milestones of increasing difficulty of achievement: engineering implementation, operational feasibility, and economic reality.

We have now completed a study of photothermal conversion under an NSF-RANN grant (G-30022) and a utility-sponsored measurement program. The principal conclusions are: 1) that highly selective coatings can be made to yield high operating temperatures without recourse to mirror concentrators and which appear thermally stable for the proposed application, and 2) cloud and haze conditions affect mirror collecting systems more seriously than was anticipated, emphasising the importance of selective coatings in making a practical system possible.

We have recently devised and tested a new type of collector that is relatively insensitive to sky conditions and that appears to be potentially inexpensive, but yields temperatures via selective coatings where the limit of performance curves indicate a maximum efficiency of conversion of about 20-25%. We have made full-scale tests of a portion of this collector design and are encouraged to recommend a 1-acre thermal test bed following this design. A 300-sq. foot collector of this "planar" design has been constructed for swimming pool heating in Tucson and will also be used for experiments with home heating and cooling.

. . . . . .

Three years ago Marjorie and I became interested in the possibility of solar energy as a new option and began with a systems study to see where the key points of high technological and economic leverage were to be found. This study also was to determine where the deficiencies of early attempts to harness solar energy were encountered. We concluded that selective coatings were the key to economic high temperature applications of solar energy. On the basis of this study we proposed a program for research in selective coatings to the National Science Foundation which has been successful in making coatings of exceptionally high selectivity that I will refer to later.

Solar power has been non-competitive with conventional power in past years simply because it was not economically attractive. Economics remains the main barrier today. It is therefore imperative that we stress development of new avenues that have high potential leverage on costs. For this reason our research has been directed to two areas:

1) Development of highly selective solar absorbing surfaces, to yield operating temperatures of 500-600^{o}F without use of concentrating mirrors, and

2) development of simple low-cost collector modules utilizing selective coatings .

The NSF-RANN study demonstrated that coatings with selectivity as high as 30 are possible, but additional work is needed to confirm these experiments. At the start of this work the state-of-the-art was selectivity of 10. In recent months we have made coatings with apparent selectivities close to 50. We need to test these new coatings in larger than laboratory-sized samples.

A thermal test bed to handle large samples was constructed by Helio Associates with funding provided by four southwestern utilities, shown in Fig. 1. This unit was designed before we were certain of achieving high selectivity; hence it uses mirror concentrators to boost thermal performance. The utility test bed did confirm that 1000^{o}F can be obtained with only modest optical concentration when older selective coatings are used. The highest selectivity used in the test bed (CM-1) was 14.

The utilities test bed uses a pair of cylindrical mirrors (Fig. 1) to concentrate sunlight on an entrance window in a silvered "thermos bottle" evacuated enclosure. The pipe with the selective coating is mounted inside the vacuum pipe and intercepts the incoming solar energy. The apparatus must track the north-south daily motion of the sun to keep the energy properly focussed on the pipe. Compressed air is pumped through the absorber pipe to measure the amount of energy extracted. This test bed is similar to several larger ones under construction by several companies at the present time.

The thermal test bed confirmed that the required temperatures are reached through the use of selective coatings. The unexpected result was, however, the sensitivity of mirror concentrator systems to weather and dust. It also showed that we and others tend to over-estimate the amount of clear sky, even in Arizona. Mirror collectors will not work on cloudy days and are seriously affected even by haze or thin cirrus clouds. This behavior is because a focussing collector only focusses the disc of the sun: when the disc is obscured the focussing ceases.

We now discount the mirror or lens solar energy collector as a practical answer to solar energy utilization for several reasons. The first is the sensitivity to weather. The second is its need to track the sun, resulting in a moving structure, meaning expense and maintenance. The third is that such a system must have a larger collecting area since it operates fewer days per year and a larger energy storage subsystem to permit continuous operation than would be necessary with the system we are now studying.

We bring these practical questions to your attention to show you that we recognize that solar energy does have real practical problems if we are going to depend on it for "stand-alone" performance. We do not, however, imply that solar has insurmountable problems. We need to be completely honest about the problems since they will in any event surface when one attempts actual use of solar energy. We need answers to the problems.

What is our answer to the serious problem of weather? We feel the answer is the highly selective coatings that we have demonstrated under the NSF-RANN grant, especially those with

selectivity of the order of 50 that we have made since then. We are hopeful of additional NSF support to verify and further demonstrate the usefulness of the new coatings. If we do not have to rely on optical focussing of sunlight we are only concerned with the total brightness downwelling from the sky. A selective coating in a collector that eliminates convection losses will get hot with the typical brightnesses that are observed on bright overcast and hazy days. This characteristic will make these coatings important for efficient domestic applications of solar energy as well as for power production. It will further make the use of solar devices possible in other geographic areas than the southwestern states.

The key to the use of the new selective coatings is the collector. That type of collector is generally called the "flat-plate". The flat-plate has been used for centuries when modest temperatures are desired, but they are not readily amenable to vacuum encapsulation for high temperatures. We have adapted a design used in the space program for rejecting heat from a spacecraft called a "space radiator". In our case we use a modification of the double cusp reflector to gather radiation from sun and sky and direct it to an absorbing pipe located at the apex of the cusp. I have a model here today to illustrate the principle, and used by us to measure the thermal behavior of what we call the "planar" collector. This term indicates that it acts like a flat-plate collector but otherwise does not resemble one. Fig. 2 shows a small section of a full-scale planar collector being tested. Note the relatively unsophisticated test setup that we find satisfactory for measuring thermal behavior of a collector design that could comprise a solar power farm of several square miles of area.

To show you that the planar collector does work like a flat plate collector, Fig. 3 shows our measurements with this crude test bed compared to measurements made in 1911 by H. E. Willsie with his solar plant near Needles, Calif. This Willsie plant, incidentally, was the first solar power unit that could operate at night using stored thermal energy. Its efficiency and temperature were low because it only had black paint as the absorber

to be supplied

Fig. 2. A 2-pipe section of a planar collector panel being tested using black painted pipe. A single window of plastic is shown.

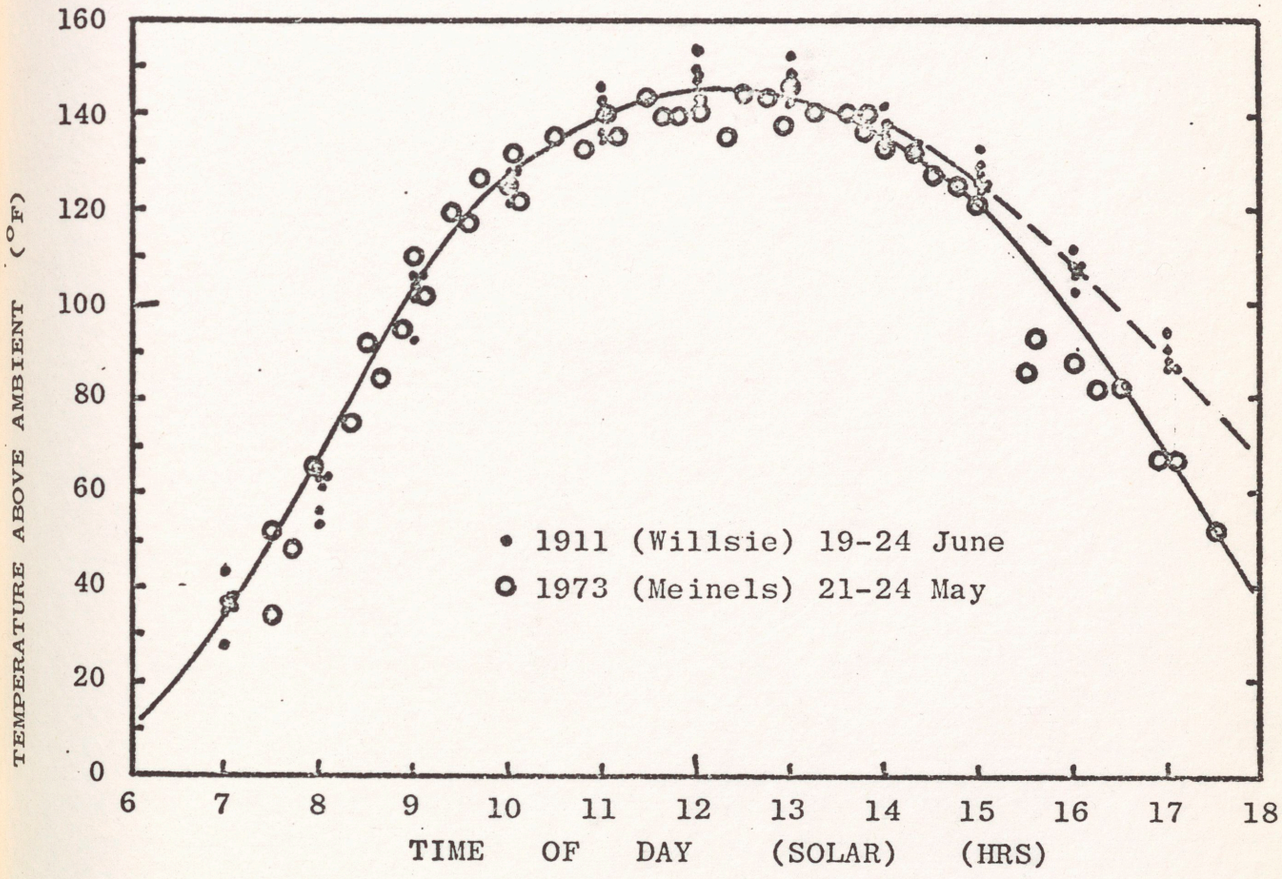


Fig. 3. Measured temperatures as a function of time of day for a flat-plate collector (Willsie, Needles, 1909) and a planar collector module (Meinel, Tucson, 1973) showing that the planar design acts very similar to a flat-plate collector.

To be supplied

Fig. 5. Photograph of a model of a large planal panel module typical of what might be used in a solar power farm. (Artist: W. Meinel)

and used a single cover window to inhibit convection losses. Our planar collector also used black paint and a single cover window for the above temperature measurements.

We expect that a well-designed planar collector module might look more like the model shown in Fig.4. Note that where the absorber pipes are shortened the reflective backing is apparent. In locations where the pipe is installed the optical effect of the small pipe and the reflector is to make the entire panel channel appear black, hence to be absorbent of solar energy.

We have felt that there is potential spinoff of the planar collector concept to domestic applications. In fact, we decided to build a simple test bed of this type to explore how it operates for swimming pool heating and house heating. Fig. 5 shows the test installation at our home in Tucson, which uses the planar design with black plastic pipes. The frame is 8x32 feet and has four planar panel modules. It will be capable of heating a significant portion of our home this winter after the Fall behavior of it in heating the swimming pool has been evaluated.

The only difference between this test installation and one that would test its application for power generation is the absorber pipe assembly. In the present case it is black plastic pipe. In the highest temperature applications that absorber would be replaced by a vacuum-encapsulated pipe coated with our selective coating. We point this out to emphasise that we are not far from the point in time where a demonstration test bed for power production could be built in a short time interval and modest cost.

We have prepared three graphs to summarize the performance of planar collectors, covering the entire range from simple black paint to sophisticated selective absorbers. Fig. 6 shows that air-surrounded absorbers provide operating temperatures in the 200-400^{o}F range. If one removes the air so that convection is zero then the use of selective coatings enables one to use the planar collector up to the order of 800^{o}F.

We have studied six solar power systems over the past year that cover the entire range of possible temperatures, from 100^{o}F to

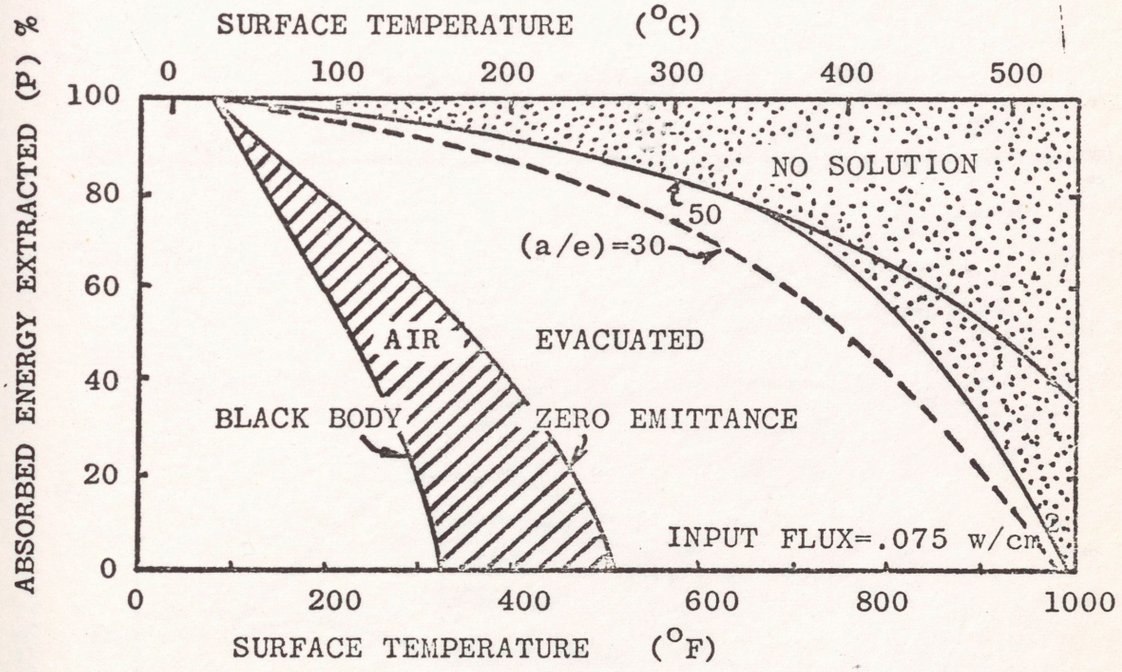
1000°F. These are plotted against theoretical efficiency of conversion to power in Fig. 7. We noted immediately that these studies imply a definite limit to the best performance of a solar thermal power system. If we take the actual efficiency of turbines into account we obtain the "limit to performance" shown in Fig. 8.

We looked up the actual performance of some of the solar energy experiments from early in this century and show the results in Fig. 8. The flat-plate power system built by Shuman near Philadelphia in 1909 actually was rather close to the predicted limit. The point provided from the pioneering work by C. G. Abbot, who is now 101 years old, is a carefully calculated one, and quite in agreement with our predicted limit. The limit determined by the extensive studies by H. Tabor in 1955 also is in substantial agreement with our predicted limit to performance. Early demonstration systems will undoubtedly fall below this curve, but the curve gives us a measure of how far short of ultimate performance any particular system performs.

To summarize our work to date, we have 1) discovered that mirror concentrating collectors are seriously degraded by haze and cloudy skies, but 2) highly selective coatings offer the possibility for a weather-insensitive planar collector. We feel that we have demonstrated that high (a/e) coatings are possible for operation at 400°F. The temperature of 400°F is sufficient to make a first demonstration system for power production to answer operational questions that are hard to answer via paper studies.

We are proposing that a 1-acre demonstration system can be built with a budget of 4 million dollars in three years utilizing the planar panel approach. We think it can answer the question of whether solar thermal power is really an option to be vigorously pursued or the illusion it has been in history to date.

One may ask: is it not possible to answer the engineering questions with smaller test beds as you have already used? The answer is yes, smaller test beds can give significant scientific results, and we would propose them as early steps toward the 1-acre demonstration system. The problem with small units is they do not



Operational domains for the flat plate and planar collectors as a function of surface emittance for air system with 2 cover windows and for evacuated systems.

Fig. 6. Relationship between surface selectivity (a/e) and air or vacuum encapsulation for a flat-plate or a planar collector.

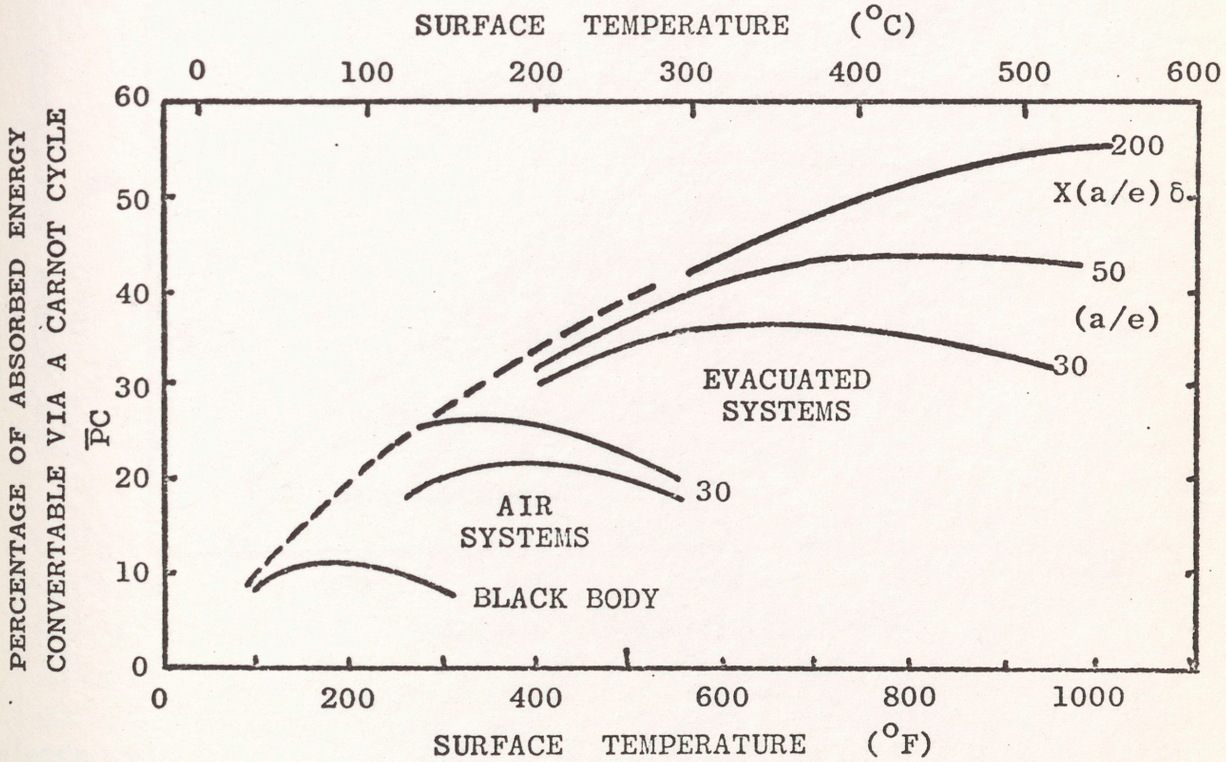
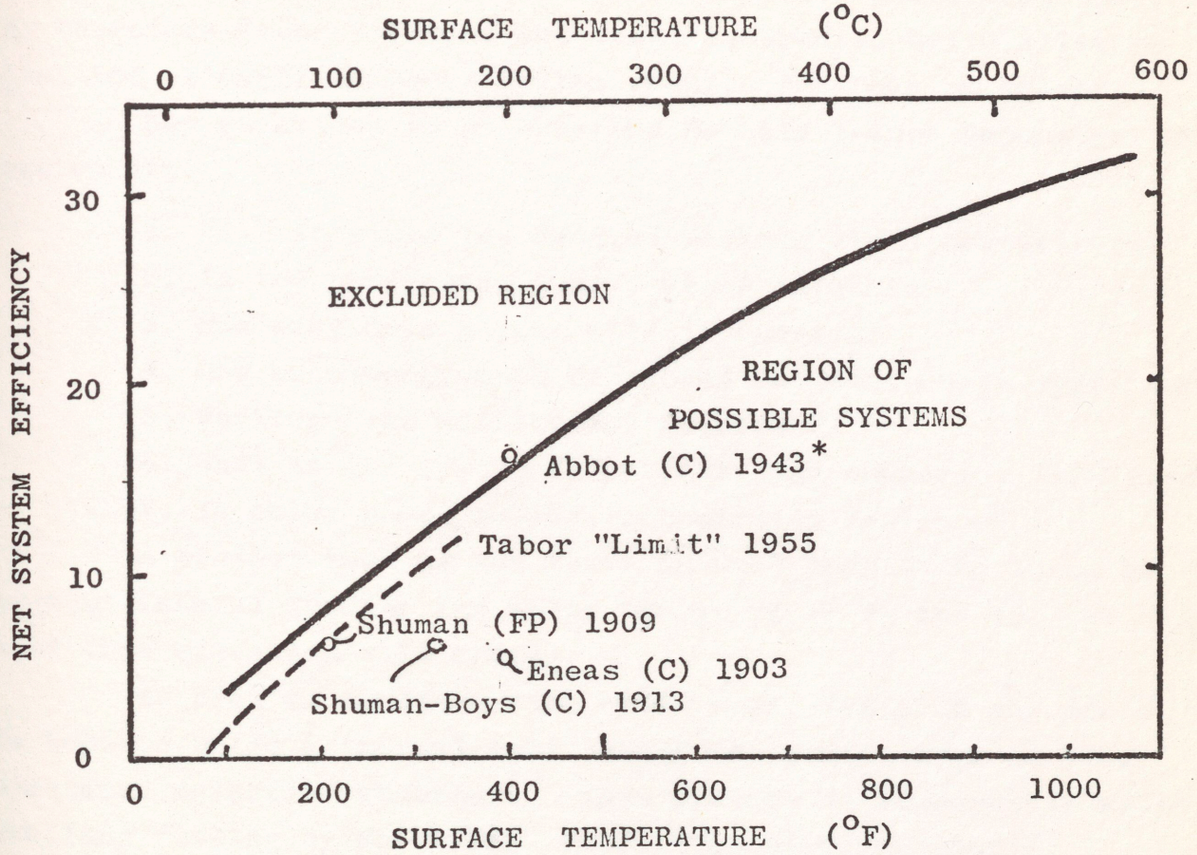


Fig. 7. Performance tracks for six solar photothermal solar power systems, ranging from 100°F to 1000°F operating temperature.



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(C) = Concentrating mirror system

(FP)= Flat-plate system

Fig. 8. Limits of performance for solar thermal power systems based on data shown in Fig. 8. The experimental points are shown to indicate that the proposed limit is in agreement with old data. We propose operating in the 20-30% efficiency range.

carry with them sufficient credibility to satisfy persons of practical inclination. The question of unexpected problems with scale-up to large size cannot be answered with small test beds. We therefore favor the time and cost required to build a 1-acre test bed as small compared to the results that can be gained.

Key questions to be answered by this 1-acre demonstration system are:

1. Will it yield the desired working fluid temperature?
2. Is the percentage energy yield adequate?
3. How many days a year will it operate?
4. How much energy must be stored for continuous operation?
5. What are the maintenance problems?
6. What is the system reliability and component lifetimes?
7. Is solar power really economically feasible?

A project such as the above is well beyond the level of present federal funding for solar energy in FY 74 and 75. We hope that this situation will change.

We plan to continue with small-scale tests in any event. We hope to build a thermal test bed of the planar type to test evacuated selective absorbers. This project is temporarily slowed awaiting funding by NSF-RANN. Production of experimental selective coatings and their laboratory measurement is proceeding under funding from Helio Associates, Inc. Our parallel test of the 8x32 foot planar collector for home and swimming pool heating is personally funded and proceeding rapidly. It is perhaps worth noting that of these two projects the latter is attracting most local interest, illustrating that in spite of present adverse economics people are interested in what solar energy can do for them in the near term.

Solar power farms are a dream that could turn into reality on a shorter time scale than most people realize. The technology is here today. The main problem is how to capitalize the manufacturing facilities needed to get into volume low-cost production. Several hundred million dollars in production facilities would go a long way toward making solar thermal components available

to a volume market, as long as that volume market is assured by either the federal government or the utilities. Steps in this direction require bold action, but the energy crisis will never be solved by timid action. We are willing to stake our reputation that definitive answers can be gained from the construction of 1-acre test beds of the two or three solar thermal design approaches that appear to cover the range of possible systems.

Solar thermal power farms will first appear in the desert regions where conditions are most favorable. Fig. 9 shows a model of an early solar power farm in such a desert setting. Four quadrants of collector rows covert the incoming solar and sky light into heat which is conveyed to thermal storage tanks located in the center of the farm. A steam turbine power plant utilizes this stored heat to produce electrical power. The long tank near the upper end of the central corridor is a water storage tank to hold rainfall runoff from the collectors to be used as cooling water in the wet cooling towers of the power plant. The farm thus operates on income.

The energy balance of a solar power farms is very close to exact, far more so than for any other mode of power generation. One basically is using the solar energy that will arrive at the earth whether we use it or not. No new source of heat has been introduced, other than the blackening of the absorbing pipes, which represents the amount of energy that will be exported to the consuming areas. The heat finally rejected into the environment is therefore that heat which must be returned in order to keep the locality of the solar power farm the same as it was before the farm was built.

Fig. 10 shows the total impact of solar power in terms of planetary scale. This picture of the Sahara and adjacent deserts shows the vastness of the arid lands of the earth. The small square at the edge of the earth is 10,000 sq. miles in area, representing the area of land needed to supply the US with its entire electrical power needs in the year 2000. The larger square represents the area needed to give the 5 billion inhabitants of

the earth the 1973 per capita usage of electrical power that we enjoy in the United States. It seems clear, therefore, that solar energy is indeed God's greatest gift of energy resources to mankind.

13 June 1973
Tucson, Arizona.



Fig. 10. Photograph of the Earth from an Apollo moon mission showing the deserts of Africa and the Middle East. The small squares at the edge of the planet show the total area of solar power farms necessary to meet the US and the world need for electrical power in the year 2000.

ENERGY CONSERVATION:

Today as in no time in the past the world's population must consider energy in the same way they look after agricultural and economic matters. If man is to survive on this planet he must begin to realize the implications of energy conservation, today's architects should be leaders in integrating energy conserving methods into their energy-wasting buildings.

The problems of energy in buildings can be summarized according to 3 stages:

1. the energy required to erect a structure, including energy expense for construction materials

2. the energy required to operate the structure

3. and in time, the energy required to tear down and destroy the outdated structure.

In developing the design for the Solar Farm and the living units which accompany it, I have tried to realize the implications of energy in materials and energy for production. Towards this end, I will attempt to use materials which require minimal energy for their production; natural materials when possible which return to the earth when their usefulness has expired. In the final architectural product I will try to use mechanical and electrical systems which will utilize a minimum of energy resources. And where possible make use of sources of energy which are renewable. The two tables which follow summarize the implications of energy conservation in architecture.

TABLE 1

ENERGY CONSUMPTION IN BASIC MATERIALS PROCESSING

Material	Energy for Unit Production (kwht/ton[a])	Machinery Depreciation[b] (kwht/ton)	Transportation[c] (kwht/ton)	Total (kwht/ton)	No. of Tons Consumed (1968)	Total Energy (kwht)	% of Total Energy Consumption (1968)
1. Steel (rolled)	11,700	700	200	12,600	90 x 10^6 (excluding alloys)	1.13 x 10^{12}	6.20
2. Aluminum (rolled)	66,000	1,000	200	67,200	4.07 x 10^6	2.74 x 10^{11}	1.49
3. Copper (rolled or hard drawn)	20,000	800	200	21,000	2 x 10^6	4.2 x 10^{10}	0.23
4. Silicone, metal, and highgrade steel alloys	58,000	1,000	200	59,200	2 x 10^6	1.19 x 10^{11}	0.65
5. Zinc	13,800	700	200	14,700	1.5 x 10^6	2.2 x 10^{10}	0.12
6. Lead	12,000	700	200	12,900	0.467 x 10^6	6.05 x 10^9	0.04
7. Misc. electrically processed metals	50,000	1,000	200	51,200	2 x 10^6	1.02 x 10^{10}	0.06
8. Titanium (rolled)	140,000	1,000	200	141,200	16 x 10^6	2.24 x 10^9	0.01
9. Cement	2,200	50	50	2,300	74 x 10^6	1.7 x 10^{11}	0.93
10. Sand and Gravel	18	1	2 (short-distance hauling)	21	918 x 10^6	1.83 x 10^{10}	0.10
11. Inorganic chemicals	2,400	100	200	2,700	67 x 10^6	1.8 x 10^{11}	0.98
12. Glass (plate finished)	6,700	300	200	7,200	10^7	7.2 x 10^{10}	0.39
13. Plastics	2,400	300	200	2,900	6 x 10^6	1.74 x 10^{10}	0.10
14. Paper	5,900	300	200	6,400	50.7 x 10^6	3.24 x 10^{11}	1.77
15. Lumber	1.47 per board ft.	0.02 per board ft.	0.02 per board ft.	1.51 per board ft.	3.75 x 10^{10} board ft.	5.66 x 10^{10}	0.31
16. Coal	40	2	—	42	556.7 x 10^6	3.3 x 10^{10}	0.20

[a]In kwht per short ton (2,000 lbs.) unless noted. Throughout the article tons means short tons. Accuracy is ± 15% except as follows. Numbers prepared with should be within 50% of the correct values and those pefaced with are order of magnitude estimates.

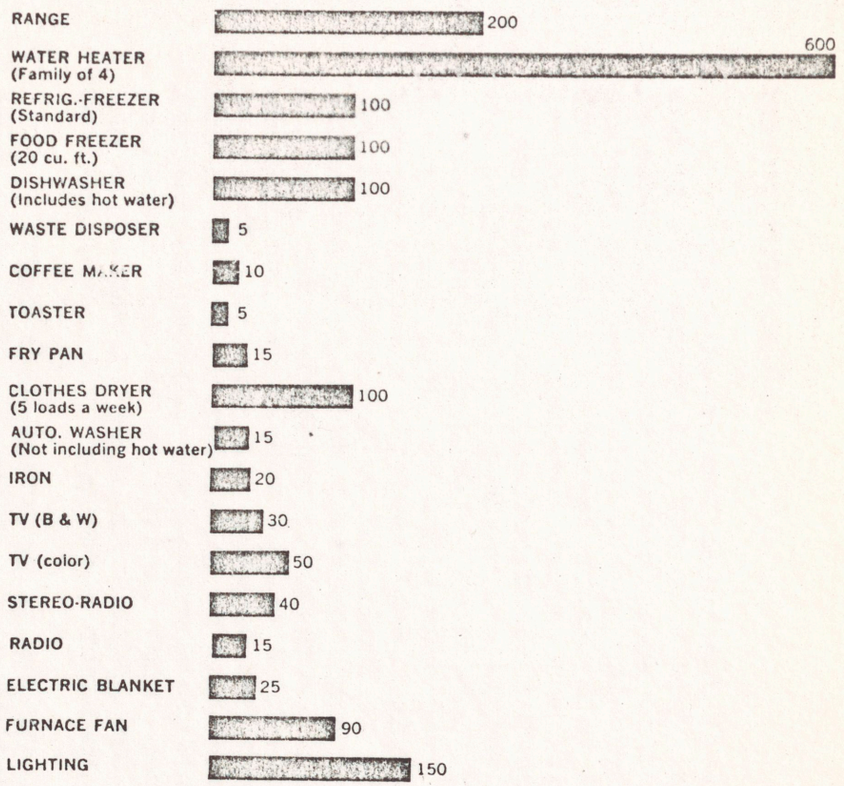
[b]These are order of magnitude numbers derived as follows: steel caiculations are on the basis of one ton of installed equipment (excluding buildings) per annual ton of steel production. Depreciation is calculated on a 30-year straight-line basis. For non-electrically processed metals, the depreciation is taken to be equal to that for steel. Production facilities involving predominantly electrical equipment are amortized over 20 years and therefore the depreciation/ton is 1.5 times that for steel. For non-metals, the depreciation/ton allocation is about 5 percent of the energy required for producing one ton of product.

[c]Figures are the sum of average railroad shipping distance (286 miles—or the average distance between major stops) plus 200 miles truck freight (an approximate value, based on the fact that truck freight is in general comparable to train freight).

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Where the watts go

This chart shows approximately how many kilowatthours are used per month for household electric products. It is based on information collected by the Pacific Power & Light Co. in Portland, Ore.



ENERGY PRODUCTION:

The single most important factor influencing the amount and use of energy in the world is population. The more persons on the Earth the greater the demand for energy and energy-using devices. With increased standard of living population has sky-rocketed during the last century. If we were to map population from 1400 up until the present we would observe a steady increase in numbers (refer to p.112). To project population for the year 2000, we would note that the curve becomes almost a vertical line. Assuming births increase unhampered by political or moral restrictions and that death rates continue to diminish as science and technology progresses, I suggest that we will not experience such a dramatic change in population between the present and the year 2000. Due to increased influence of societies as Zero Population Growth, the Environmentalists, and the increased 'costs' of living, food, gas, clothing, the curve should begin to flatten and at some optimum level may approach a constant figure.

What this means to an energy market is that demand will decrease, that is tend to level off also. Persons should become more energy-minded as such social institutions develop to encourage conservation of energy and materials. The Public must realize we do not have unending resources; we must carefully guard how we use them and reuse them. We must become aware that the fuels such as coal and petroleum are not simply used for power and heat generation. Coal and petroleum supply us with nylon, plastics, and other materials we consider essential to our daily lives. Society must set up a list of priorities for these natural resources. Economics has been largely in control of allocation of resources. For instance (refer to p.113) between the years of 1940 and 1966 the use of coal has been on a steady rise while oil, gas, and hydro power have remained at relatively constant levels. What has happened is that the costs to industry and other users of coal have been less than the actual costs to society. In terms of loss of precious fuel reserves, pollution, etc.; the added costs which industry has not had to bear but which society as a whole has had to absorb. As our resources are used up these costs to society will increase. Farsighted persons and environmentalists have begun to realize these implications and started to look for other sources of power.

From Solar Energy For Man by
Brian Joseph Brinkworth:

1.1 *The human population*

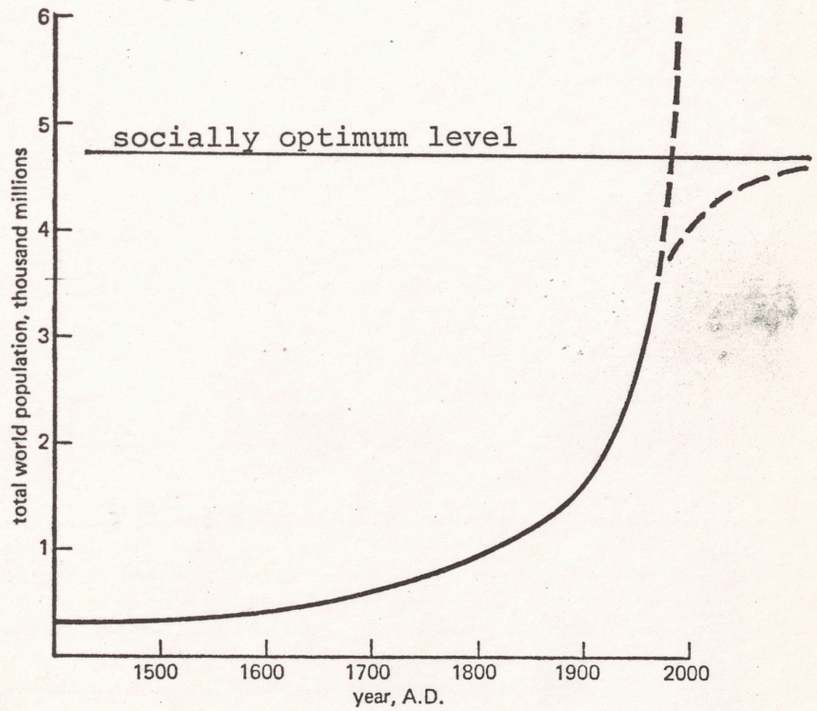


Fig. 1.1 Growth of world population, 1400–2000

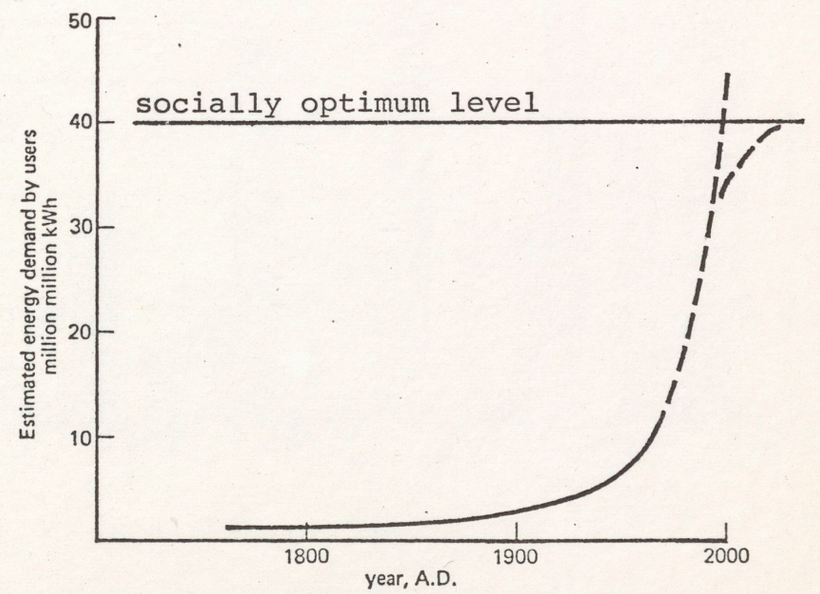
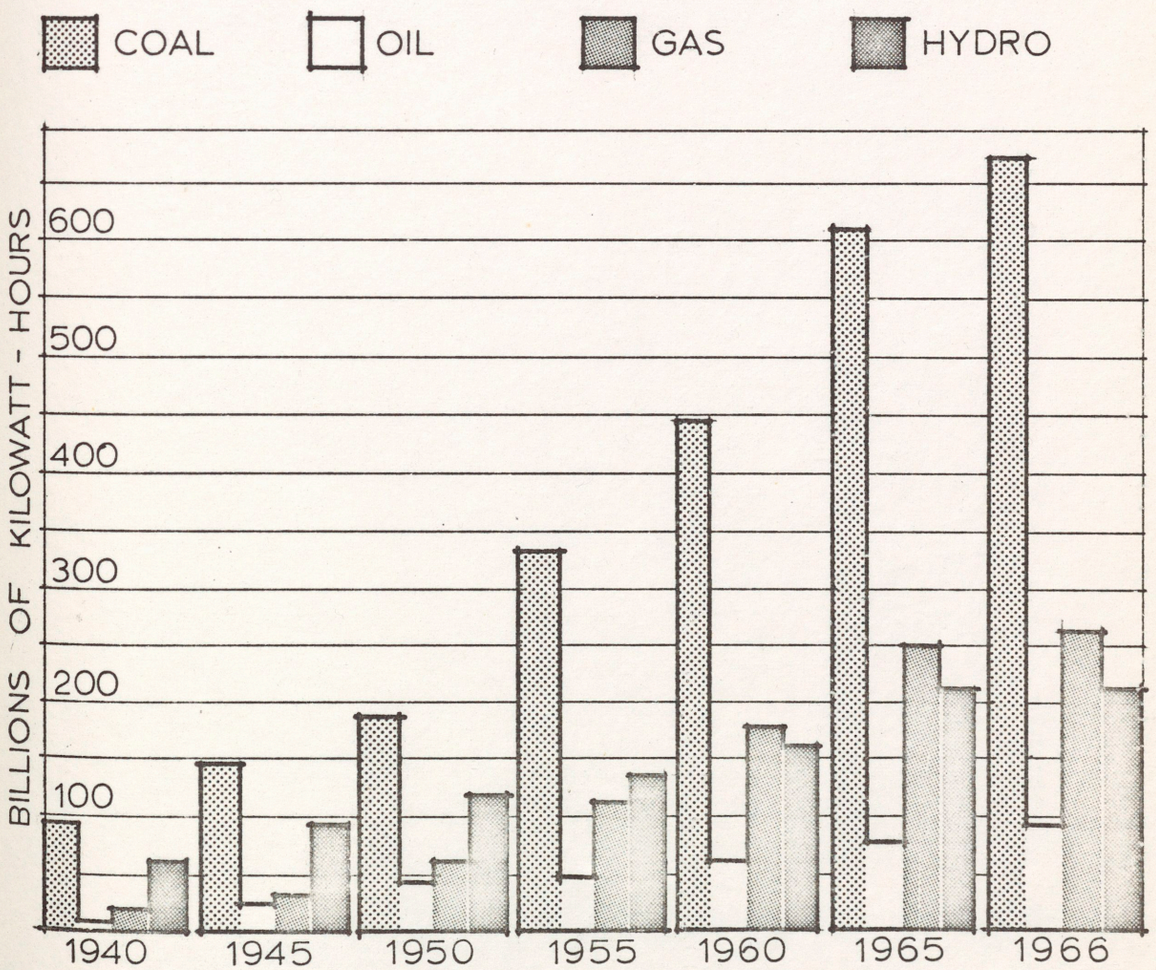


Fig. 1.3 Estimated world energy demand, 1800–2000

ENERGY RESOURCES

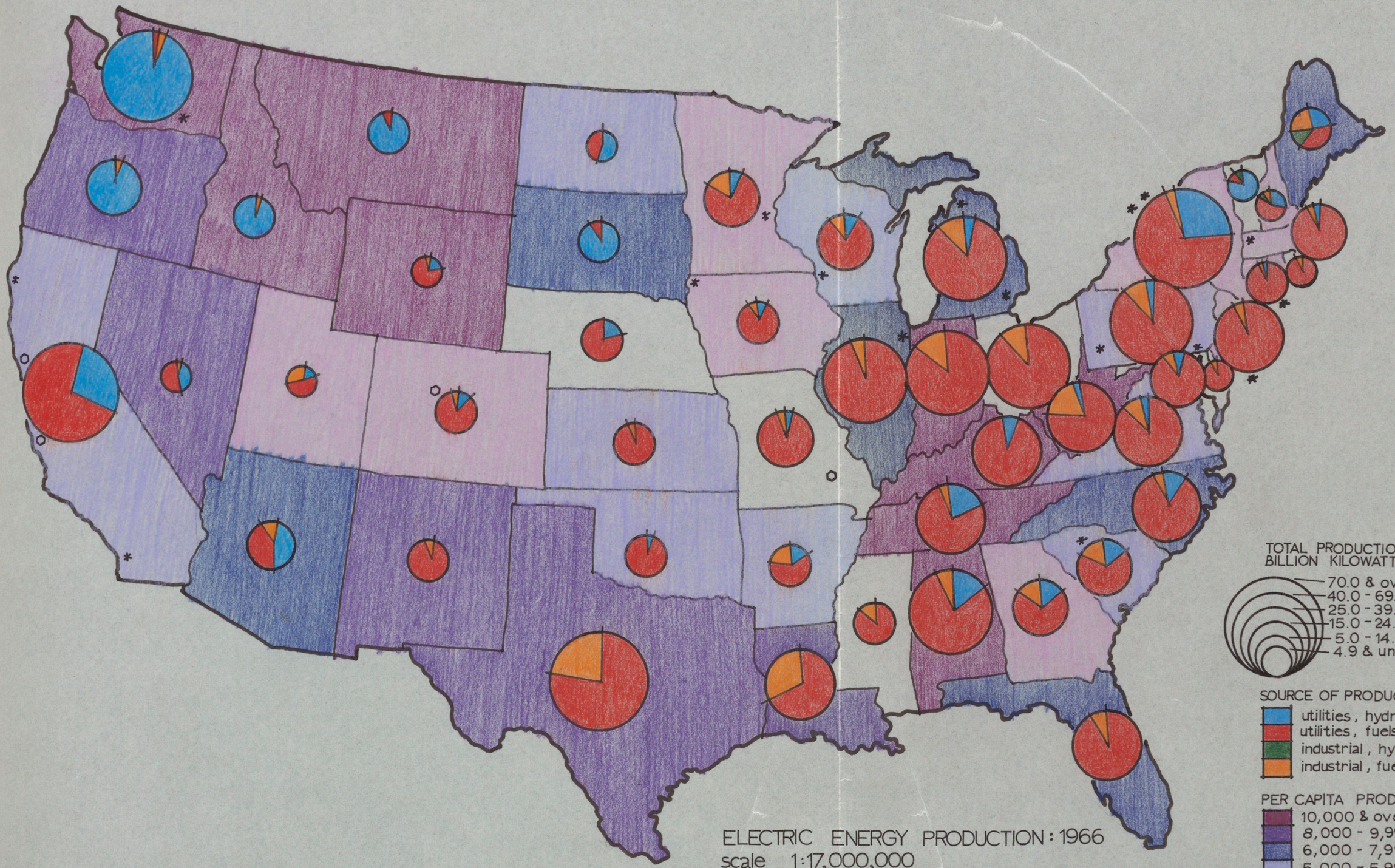


ELECTRICAL PRODUCTION, CONSUMPTION, TRANSMISSION:

In the following diagrams[15] I attempt to show electric energy production and consumption in the United States. Though the data may be a little outdated, the diagrams clearly indicate sources of production and consumption. For instance it is interesting to note that the major source of power in the Northwestern United States is from hydro power. Then to contrast this with the remaining areas of the U.S. which primarily use fossil fuels for power generation. Also worth noting is that the primary user of electricity is industry. It would be my hope that thru the creation and development of solar farms in the South and Southwest interlocking with the existing nationwide power grid; that the drain on fossil fuels in the eastern portion of the United States may be diminished, if not eliminated.

---

[15] From The National Atlas - The United States of America.



ELECTRIC ENERGY PRODUCTION : 1966
scale 1:17,000,000

TOTAL CONSUMPTION
BILLION KILOWATT-HOURS

- 70.0 & over
- 40.0 - 69.9
- 25.0 - 39.9
- 15.0 - 24.9
- 5.0 - 14.9
- 4.9 & under

TYPE OF CONSUMPTION

- residential
- commercial
- industrial
- other

PER CAPITA CONSUMPTION (KWhr)

- 10,000 & over
- 8,000 - 9,999
- 6,000 - 7,999
- 5,000 - 5,999
- 4,000 - 4,999
- 3,999 & under

ELECTRIC ENERGY CONSUMPTION : 1966
scale 1:17,000,000

SOLAR FARM SYSTEMS

DESIGN PHILOSOPHY:

Briefly stated; I believe that all architecture exists to serve people. Housing the most subservient form of structure: industrial facilities on the opposite end of the scale. Towards this end architecture exists to coordinate the requirements of 'living' and 'survival.' Broadly interpreted; any distinguishable form of architecture can be found to support some portion of human existence. Industrial plants manufacture products necessary to life; housing behaves to benefit life styles. As such all ARCHITECTURE IS A MACHINE FOR LIVING.

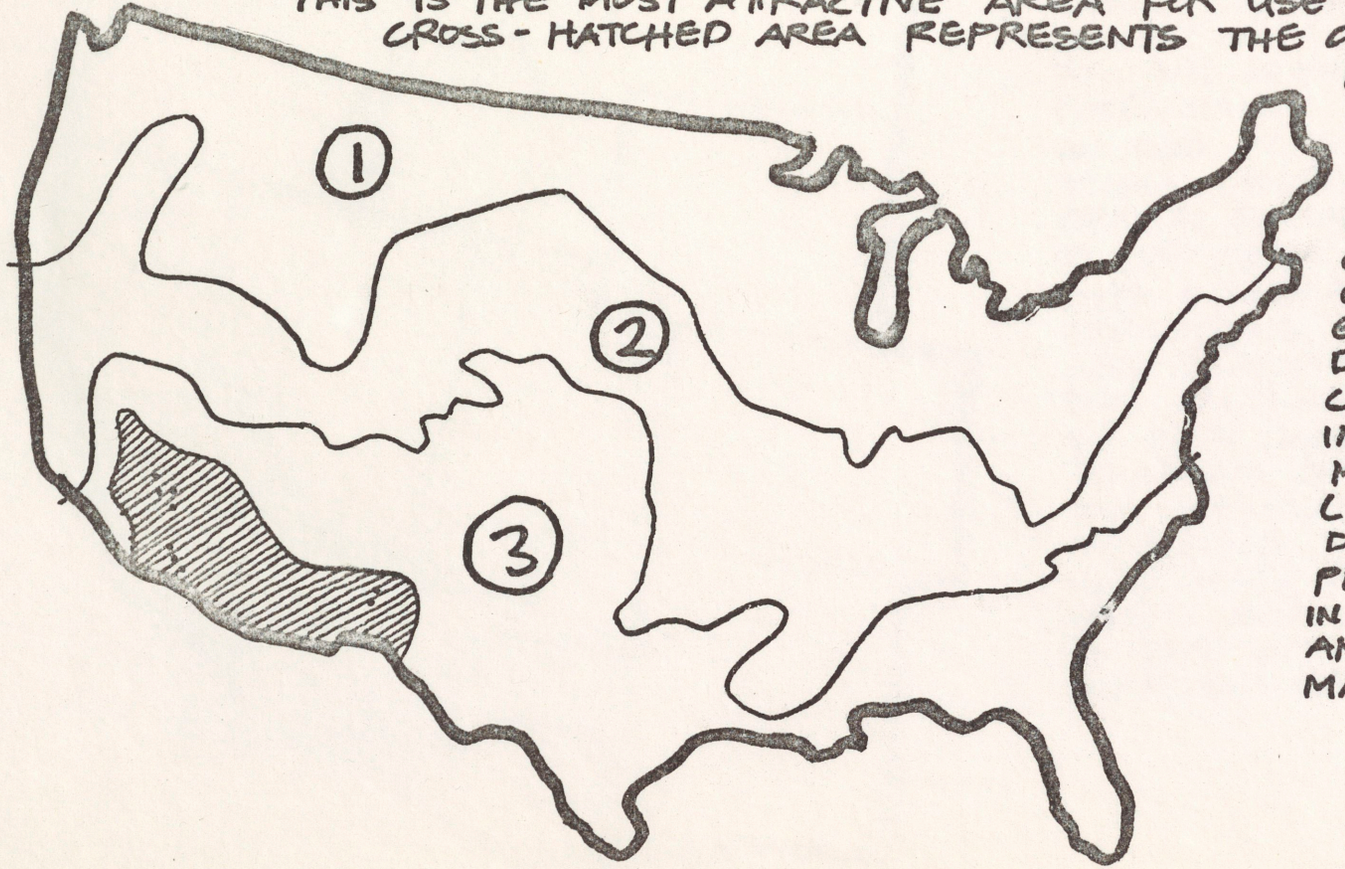
Industrial architecture should be expressive of the process that is performed to obtain a particular product or commodity. Housing is responsible to the activities coexistent within it. Each is charged with the expression of these facts.

Thus I believe good architecture is the result of carefully interfacing systems. Activity systems, mechanical systems, aesthetic systems, etc. working together to create an optimally functioning whole.

The design process begins by careful analyzations of systems appropriate to a given project. For the Solar Farm I spent considerable time refining and analyzing the various systems for collection, storage, generation, etc. And finally I responded in the design solution to the different systems and in the following diagrams I explain what these systems are.

SOLAR FEASIBILITY :

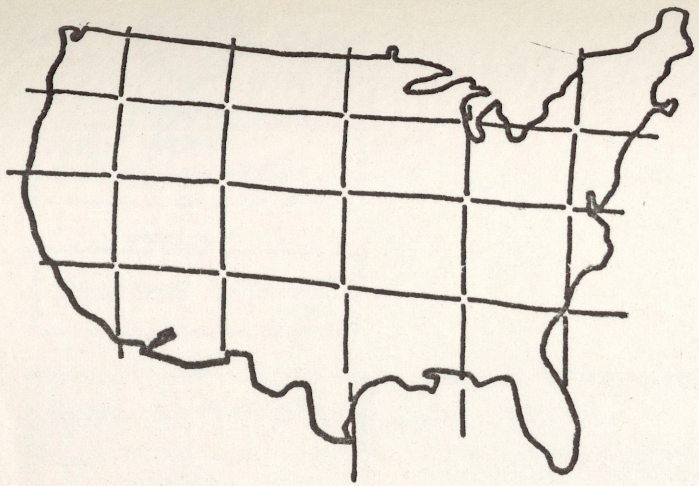
ESSENTIALLY WE KNOW FROM RECENT STUDIES OF ECONOMICS AND EXISTING TECHNOLOGY THAT THE U.S. CAN BE DIVIDED INTO 3 REGIONS OF SOLAR FEASIBILITY. REGION ① IS AN AREA OF MINIMUM FEASIBILITY. REGION ② REPRESENTS AN AREA OF PRESENT ENGINEERING FEASIBILITY. USING PRESENT TECHNOLOGY THIS AREA CAN UTILIZE SOLAR ENERGY TO FULFILL PARTIAL DEMANDS FOR ENERGY IN HOUSING AND INDUSTRY. REGION ③ IS THE ZONE OF MAX. FEASIBILITY; THIS IS THE MOST ATTRACTIVE AREA FOR USE OF SOLAR ENERGY. THE CROSS-HATCHED AREA REPRESENTS THE OPTIMUM CLIMATOLOGICAL REGION FOR COLLECTION OF SOLAR POWER. THIS WOULD BE AN OPTIMUM LOCATION FOR A SOLAR FARM. BECAUSE OF PRESENT REQUIREMENTS IN THE SYSTEM OF COLLECTION AND POWER GENERATION i.e. THE DEMAND FOR WATER AS A COOLING AGENT, FACILITIES IN THE NEAR FUTURE MAY LOCATE ALONG RIVERS (THE BLACK DOTS). DEPENDING ON ENGINEERING PROGRESS, SOLAR FARMS IN THE FUTURE MAY LOCATE ANYWHERE IN THE ZONE OF MAXIMUM FEASIBILITY.



SOLAR FARM ONE:

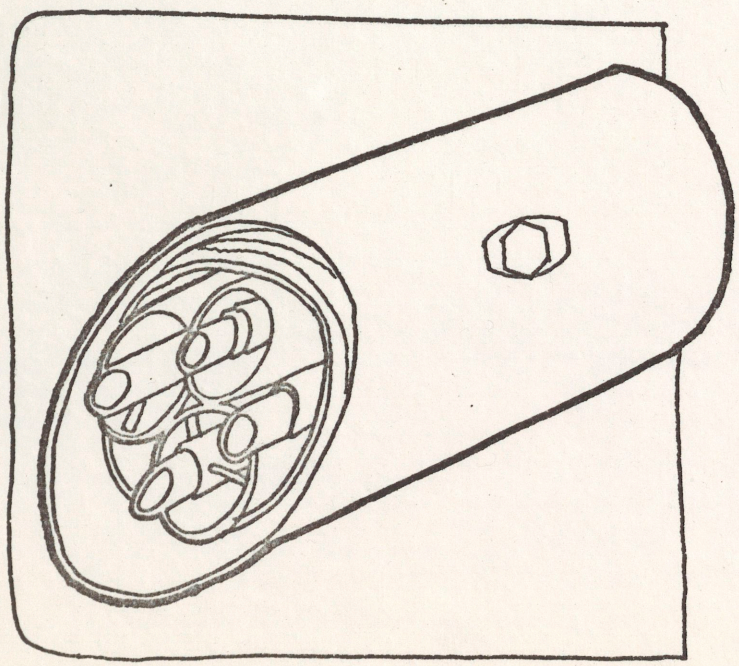


UPON OPTIMIZING THE CONDITIONS OF CLIMATE, POPULATION, VEGETATION, ETC. I CHOSE THE AREA DIRECTLY ADJOINING YUMA, ARIZ. AS AN IDEAL LOCATION FOR THE FIRST IN A SERIES OF SOLAR GENERATING FACILITIES. THE YUMA DESERT IS THE SITE FOR SOLAR FARM I. BASED ON A ROUGH FIGURE PRESENTED BY THE MIENELS: 1 SQ. MILE AREA CAN POTENTIALLY SUPPLY THE POWER FOR 60,000 PERSONS. THE AREA OF THE YUMA DESERT COULD SUPPLY THE POWER DEMANDS OF 5 MILLION PEOPLE, IF THE AREA WERE TOTALLY COVERED WITH COLLECTORS. THE OBVIOUS RESTRICTIONS ON SUCH A PROPOSITION ARE ECONOMICS, TECHNOLOGY, AND THE AVAILABILITY OF MATERIALS TO GO INTO CONSTRUCTION AND MAINTENANCE OF THE FACILITY. REALIZING THE IMPLICATIONS OF SUCH AN OVERWHELMING PROJECT I CHOSE TO WORK WITH A BASE AREA OF 1 SQUARE MILE, CAPABLE OF SUPPLYING POWER TO THE CITY OF YUMA AND CERTAIN SURROUNDING AREAS.



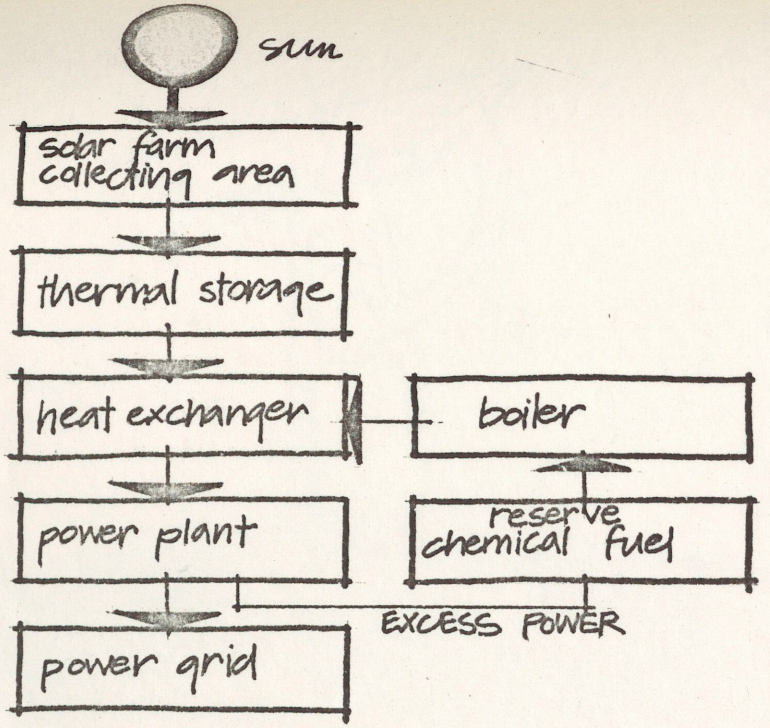
TRANSMISSION:

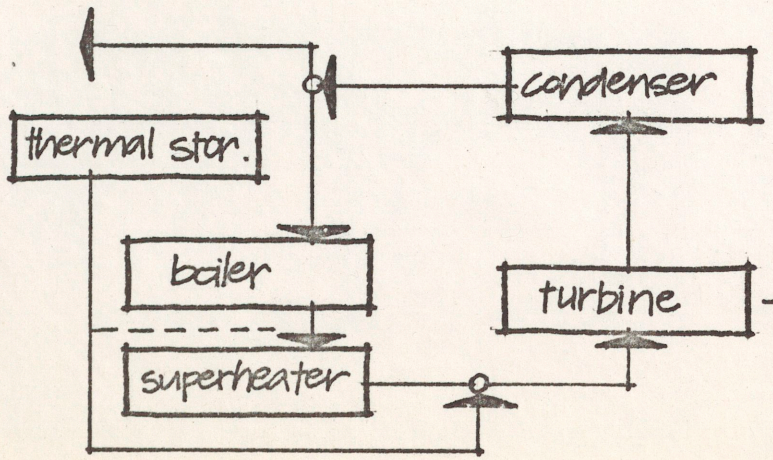
PRESENTLY THERE EXISTS A SYSTEM OF CONNECTING POWER PLANTS AND CITIES OF USERS. THIS GRID IS CAPABLE OF TRANSMITTING POWER FROM A PLANT ON THE WEST COAST TO A USER ON THE EAST COAST. GENERALLY EVERY POWER PLANT IN THE U.S. IS LINKED INTO THIS SYSTEM. A SOLAR POWER FARM AT YUMA WILL ALSO HAVE TO LINK INTO THE POWER-SHARING SYSTEM TO DISTRIBUTE THE ELECTRICITY IT GENERATES INTO THE ELECTRIC ECONOMY.



POWER LINES:

ONE OF THE RESTRICTIONS ON THE LOCATION OF POWER GENERATING FACILITIES IS THE ABILITY OF PRESENT TRANSMISSION LINES TO TRANSMIT POWER TO THE USER. THE LOSS OF TRANSMITTED POWER THROUGH HEATING OF TRANSMISSION CABLES HAS PUT PROFOUND RESTRICTIONS ON DISTANCES THAT LINES CAN REACH ECONOMICALLY. A DR. ROBERT W. MEYERHOFF OF UNION CARBIDE HAS DEVELOPED AN UNDERGROUND CABLE SYSTEM WHICH PROVIDES AN INTERESTING SOLUTION TO THE PROBLEM. THREE POWER CABLES IN AN INSULATED TUBE ARE COOLED BY LIQUID HELIUM TO -452°F. AT THIS TEMPERATURE THE CABLES CAN CARRY CURRENTS WHICH WOULD TREMENDOUSLY OVERHEAT TODAY'S POWER CABLES.



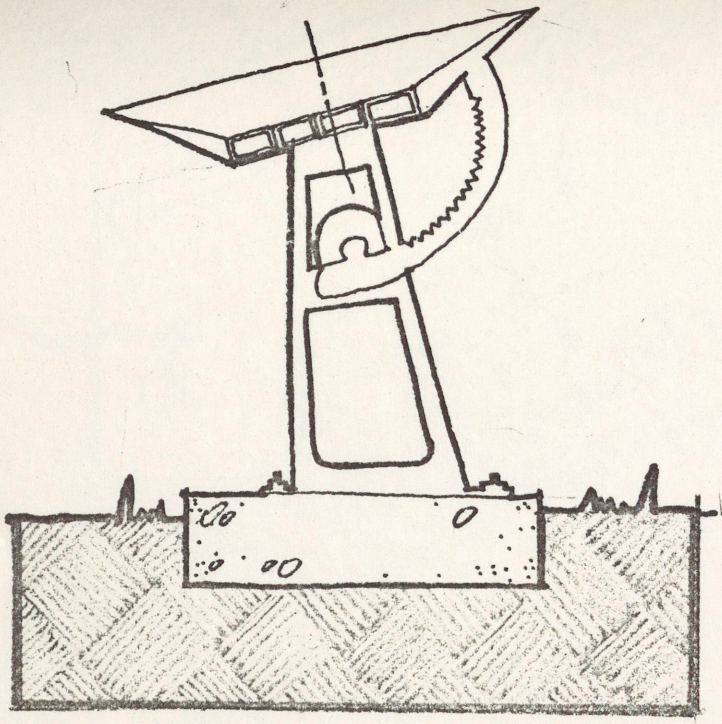


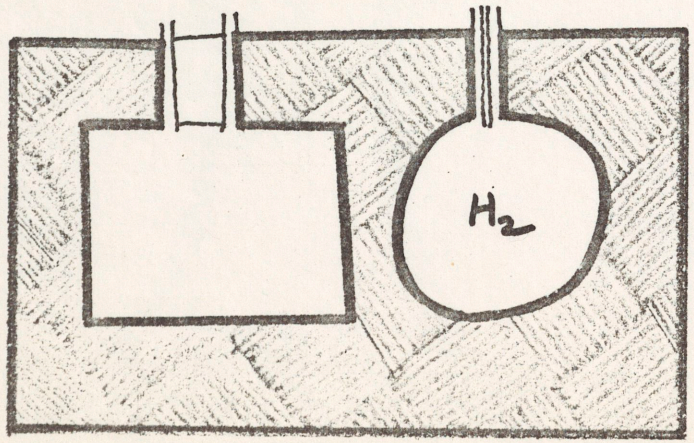
SOLAR STSTEMS:

ULTIMATELY SOLAR FARMS WOULD HAVE THE CAPABILITY TO OPERATE 24-HOURS, 365 DAYS A YEAR, ON DAYS WHEN THE SUN SHINES AND ON DAYS WHEN IT DOESN'T. TO FACILITATE SUCH AN OPERATION SOLAR FARMS MUST UTILIZE SOME TYPE OF CHEMICAL RESERVE FUEL. (CHEMICAL BECAUSE OF DEMAND FOR STORAGE OVER A LONG PERIOD). THIS COULD BE EASILY ACCOMPLISHED BY CONVERTING EXCESS ELECTRIC ENERGY TO HYDROGEN, WHICH COULD THEN BE BURNED AT A LATER DATE TO RECOVER RESERVE HEAT. IN THE DIAGRAM SOLAR COLLECTORS CONVERT SUNLIGHT INTO HEAT WHICH IS CONVEYED BY A CHEMICAL FLUID (NOT WATER) TO A THERMAL STORAGE TANK. THE POWER PLANT IS SEPARATE FROM COLLECTORS SO IT MIGHT OPERATE INDEPENDENTLY OF FLUCTUATION IN SOLAR ENERGY. THE HEAT EXCHANGER WOULD SUPPLY POWER TO THE PLANT. RESERVE FUEL WOULD BE USED ON CLOUDY DAYS AND IN THE WINTER (ALSO FOR 24 HR. OPERATION). UTILIZING SOLAR ENERGY AT 1000°F COULD ACHIEVE A NET EFFICIENCY OF 30 PERCENT.

STEAM CYCLE:

IN THE POWER PLANT THERMAL ENERGY IS BROUGHT FROM STORAGE THROUGH SUPERHEATER (IF NECESSARY) TO CONVERT WATER TO SUPER-HEATED STEAM. WHICH IS SENT THRU THE TURBINE TO GENERATE ELECTRICITY. THE STEAM MUST THEN BE COOLED BACK TO WATER FOR REUSE. AFTER COOLING THE WATER MAY GO THRU STORAGE AGAIN OR INTO THE BOILER BURNING RESERVE FUEL.





COLLECTION:

THE IMPLICATIONS OF THE MECHANISM FOR COLLECTION ARE:

1) A GLASS COVER TO PROTECT THE COLLECTING SURFACE WHILE ADMITTING SUNLIGHT, ALSO A THERMAL BARRIER

2) A COLLECTOR TO CONCENTRATE AND COLLECT SOLAR RADIATION AND TRANSMIT ITS HEAT TO A CARRIER FLUID

3) AN ENCLOSURE TO PROTECT AND GIVE STRUCTURE TO THE COLLECTOR AND GLASS SHIELD

4) A VARIABLE ANGLE TO ALLOW FOR CHANGES IN SUN ANGLE, EITHER HOURLY OR ACCORDING TO THE SEASONS

5) STRUCTURAL COLUMN TO RAISE THE COLLECTOR OFF THE GROUND

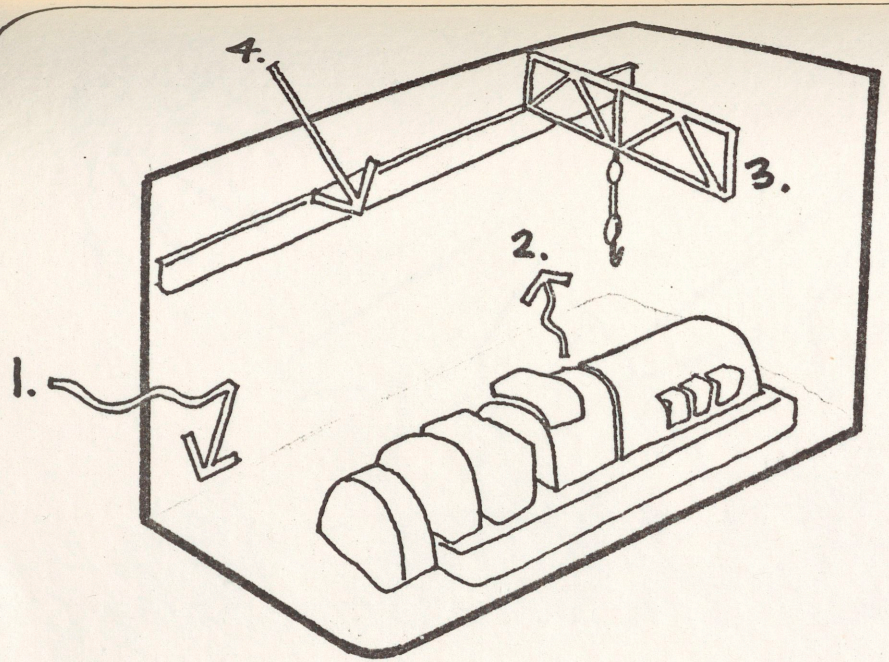
6) A SOLID CONCRETE BASE TO STABALIZE THE COLLECTOR.

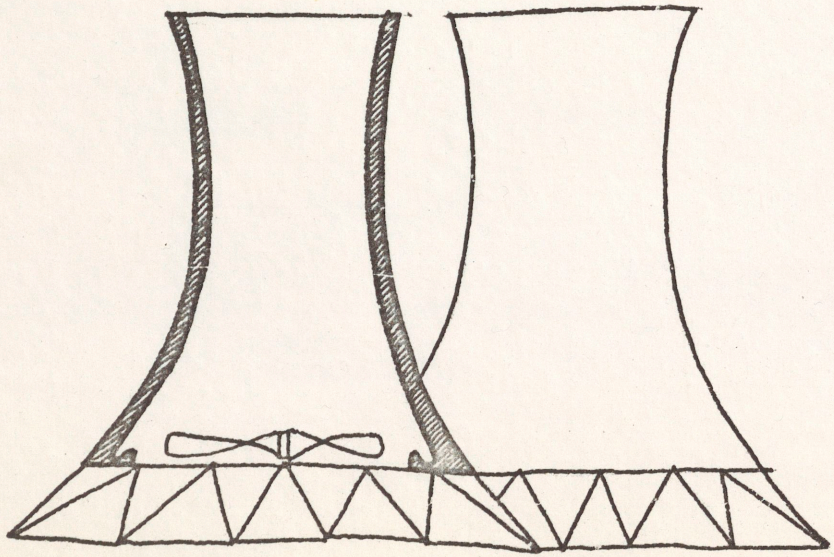
7) COLLECTORS WOULD BE IN ROWS SET ONE RIGHT AFTER ANOTHER

THE MAJORITY OF CONSTRUCTION WILL BE FROM METAL WITH THE EXCEPTION OF THE CONCRETE BASE AND THE GLASS SHIELD.

STORAGE:

SYSTEMS OF THE SOLAR FARM REQUIRE 2 BASIC TYPES OF STORAGE: 1) THERMAL STORAGE TO RETAIN COLLECTED HEAT FROM SUN. LOCATEABLE UNDERGROUND TO USE THERMAL INSULATION OF EARTH. 2) STORAGE FOR RESERVE CHEMICAL FUEL H_2. H_2 WILL PROBABLY BE HELD IN ATMOSPHERIC CONTAINERS (SPHERICAL SHAPE). STORE UNDERGROUND TO KEEP TEMPERATURE RELATIVELY CONSTANT, TO GUARD AGAINST THE EXPANDING AND CONTRACTING OF THE HYDROGEN GAS.





GENERATION:

THE ENVIRONMENT WHICH ENCLOSES THE STEAM TURBINES WILL HAVE CERTAIN 'LOADS' PLACED ON IT:

1) THE STRUCTURE MUST REFLECT THE RADIATION FROM THE SUN TO KEEP THE INTERNAL ENVIRONMENT RELATIVELY COOL.

2) THE GENERATORS WILL LOOSE HEAT; THERE SHOULD BE SOME WAY TO LIMIT HEAT BUILD-UP

3) THE TURBINES MAY NEED MAINTENANCE THERE SHOULD BE SOME METHOD TO MOVE HEAVY MACHINE PARTS

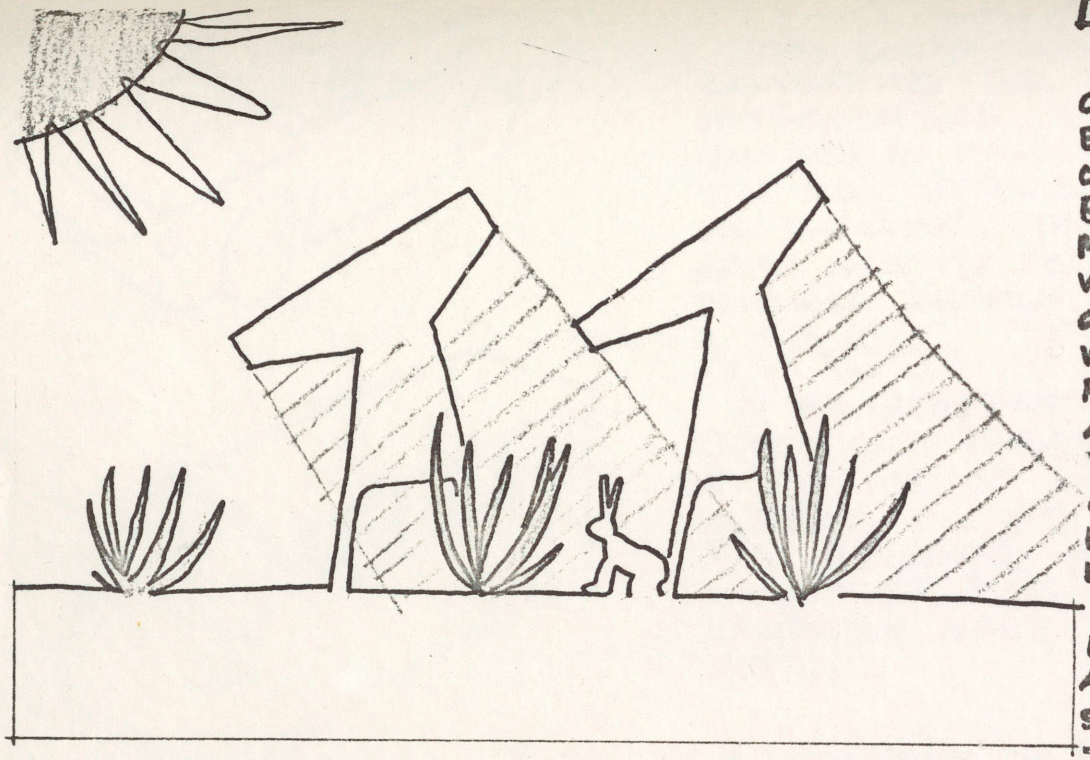
4) NATURAL LIGHT SHOULD BE INDIRECT, COULD ENTER THRU CONTROLLED NORTH LIGHT

5) THERE SHOULD BE TRUCK ACCESS TO TRANSPORT PARTS TO AND FROM THE FARM.

COOLING:

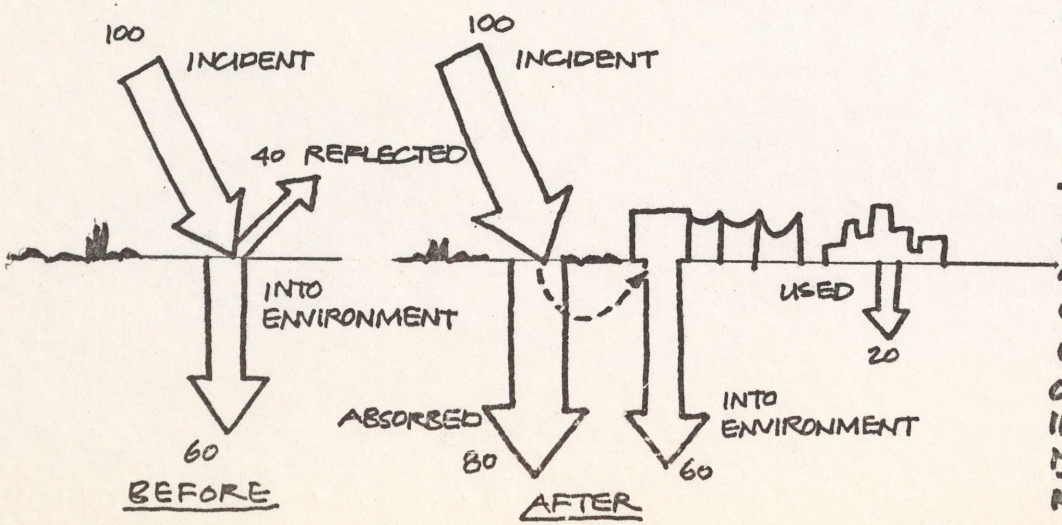
IN THE STEAM CYCLE WATER IN THE FORM OF CTEAM IS COOLED BACK INTO THE LIQUID STATE BY RELEASING HEAT INTO THE ATMOSPHERE, BY THE USE OF COOLING TOWERS. IN THE TOWERS WATER IS SPRAYED OUT AT THE TOP AND AS IT FALLS SOME EVAPORATES CREATING A COOLING EFFECT. A GOOD DEAL OF THE WATER (H_2O) IS LOST TO THE ATMOSPHERE BY EVAPORATION; THAT PORTION WHICH REACHES THE BASE IS RETURNED FOR USE IN THE STEAM CYCLE. IN SOME CASES FANS ARE USED TO SUPPLEMENT AIR MOVEMENT AND DECREASE THE HEIGHT OF THE TOWERS, WHICH CAN 600 FT. IN DIAM. AT THE BASE AND 500 FT. HIGH.

ENVIRONMENT :

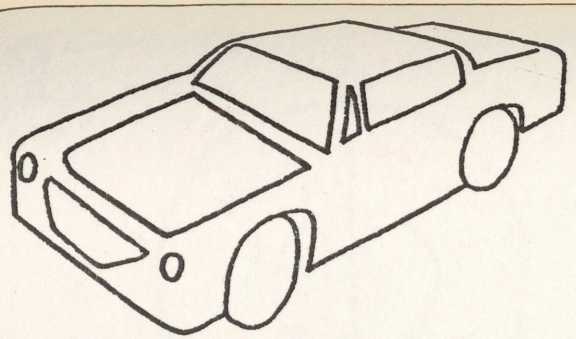


IN COLLECTION OF SOLAR ENERGY, THE COLLECTORS WILL BE REMOVING RADIANT ENERGY THAT WOULD FALL ON THE SURFACE OF THE DESERT. LESSENING THE FACTOR OF BURNING SUN, PLANT AND ANIMAL LIFE MAY GROW. • SOME ENERGY COLLECTED WILL BE LOST THRU 'HEAT LEAKS.' • PART OF THE RAIN FALLING ON THE DESERT WILL BE COLLECTED FOR USE IN THE SOLAR FACILITY, FURTHER EFFECTING PLANT AND ANIMAL LIFE. • THE COOLING TOWERS WILL OPENLY RELEASE LARGE QUANTITIES OF HUMIDITY TO THE ARID ENVIRONMENT. FURTHER TECHNOLOGIC DEVELOPMENT WILL REMEDY THIS.

ULTIMATELY BY PLACING THE SOLAR FARM ON THE DESERT LANDSCAPE WE ARE CHANGING SYSTEMS OF SURVIVAL & SUCCESSION, THE NITROGEN CYCLE AND THE WATER CYCLE. WHEN THESE CONFLICTS ARE SOLVED WE WILL HAVE A FINER SOLUTION.

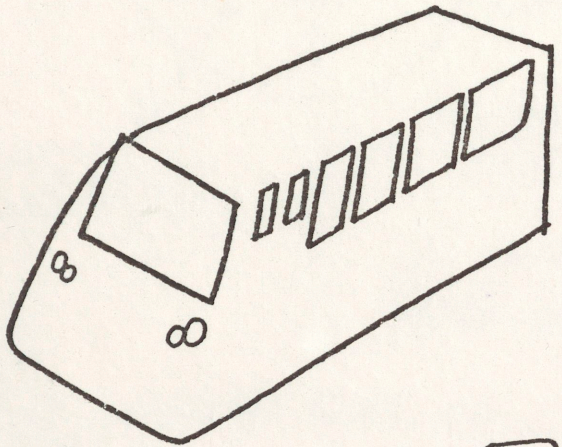


THERMAL BALANCE IS PROBABLY THE MAJOR ENVIRONMENTAL CONCERN. COLLECTION OF SOLAR ENERGY MAY ALTER DESERT CLIMATE. HEAT LOSSES OCCUR ALL ALONG THE SYSTEM OF SOLAR COLLECTION. AT THE TURBINE 60 % OF INITIAL HEAT IS REJECTED (AT 540°C) IN THE DESERT THIS THERMAL RELEASE MUST BE RETURNED TO THE ENVIRONMENT TO PRESERVE NATURAL HEAT BALANCE



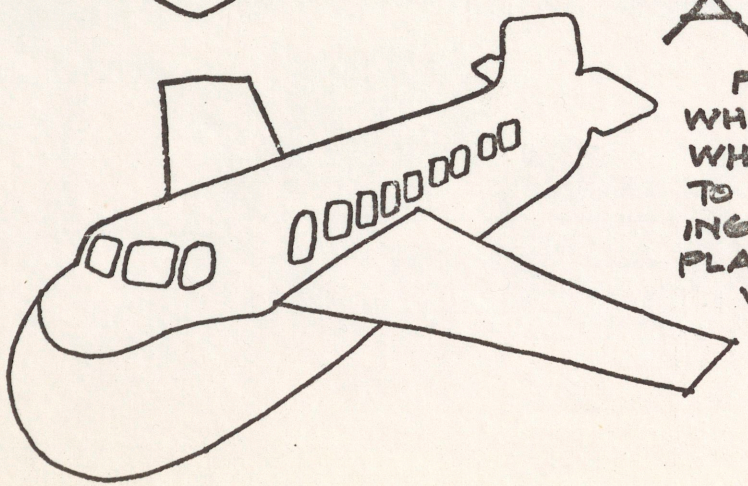
HYDROGEN CAR:

THE SOLAR FARM COULD BECOME A FUEL STATION BY CONVERTING THE EXCESS POWER GENERATED INTO HYDROGEN GAS. THIS GAS COULD BE EXPORTED AND BURNED IN FAMILY CARS THROUGHOUT ARIZONA AND THE U.S. HYDROGEN CAN BE BURNED MUCH THE SAME AS GASOLINE. THE ADVANTAGES TO THE 'HYDROGEN CAR' ARE ITS POLLUTION-FREE OPERATION AND ITS ENDLESS SUPPLY OF FUEL (WATER).



MASS TRANSIT:

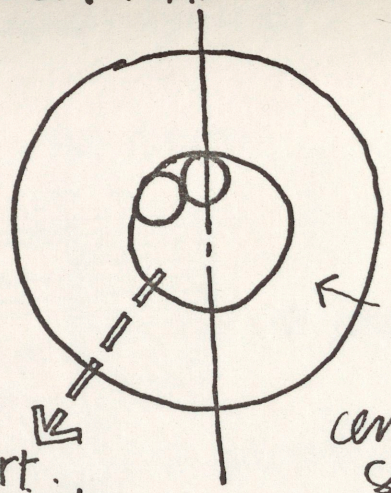
IN AN ELECTRIC ECONOMY SOLAR FACILITIES COULD POTENTIALLY CREATE; MASS TRANSIT MAY CHANGE OVER TO THE USE OF ELECTRICITY. B.A.R.T. IS SUCH A SYSTEM. IN THE FUTURE ALL ELECTRIC BUSES MAY DEVELOPE WHICH COULD CARRY A DAY'S SUPPLY OF FUEL IN ITS OWN BATTERIES. NO MORE OVERHEAD WIRES, SUPPLYING POWER ALONG EACH STREET.



AIRPLANES:

PLANES MAY LEARN A LESSON FROM ROCKET SHIPS WHICH USE HYDROGEN AND OXYGEN FOR FUEL. WHAT COULD BE A MORE POLLUTION-FREE WAY TO OPERATE AN AIRPLANE? INSTEAD OF EXHAUSTING COMBUSTED GASES AND SMOKE, THESE NEW PLANES COULD BE LEAVING BEHIND STREAMS OF WATER VAPOR — CLOUDS.

1. CONCEPT: north-south axis



vehicle access

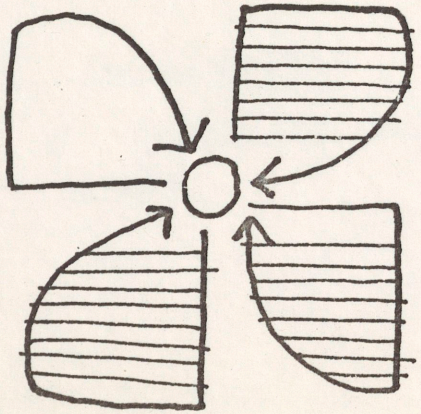
collector area

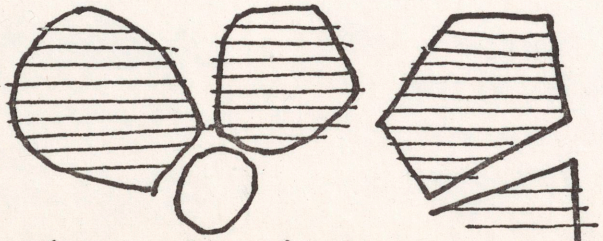
central generation and storage.

export electricity

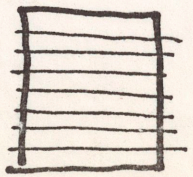
- all points equi-distant from center facility.

2. GEOMETRYS OF A SOLAR FARM



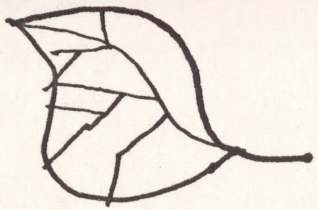


rows of collectors must orient east-west.

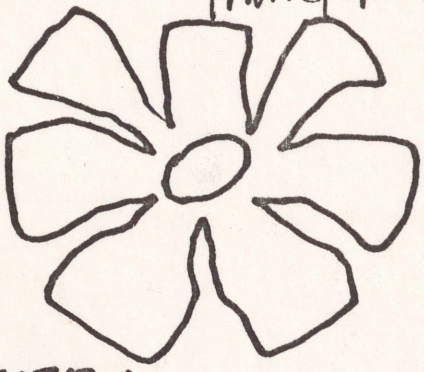


the square:
the most simple statement of mechanics, and function.

NATURAL SYSTEMS:

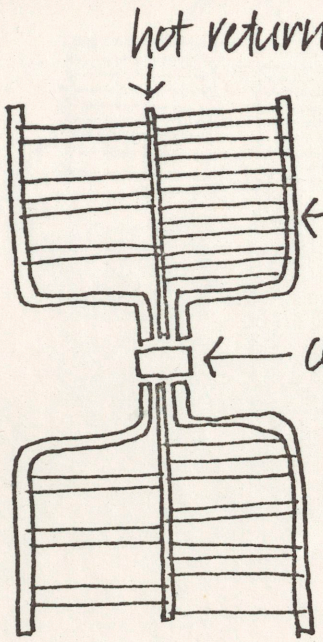


LEAF/
leaf surface collects solar energy and transfers to spine.

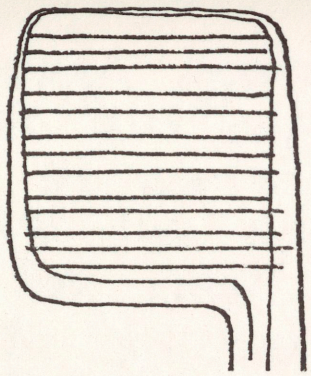


FLOWER/
a natural system introducing a center-functioning geometry.

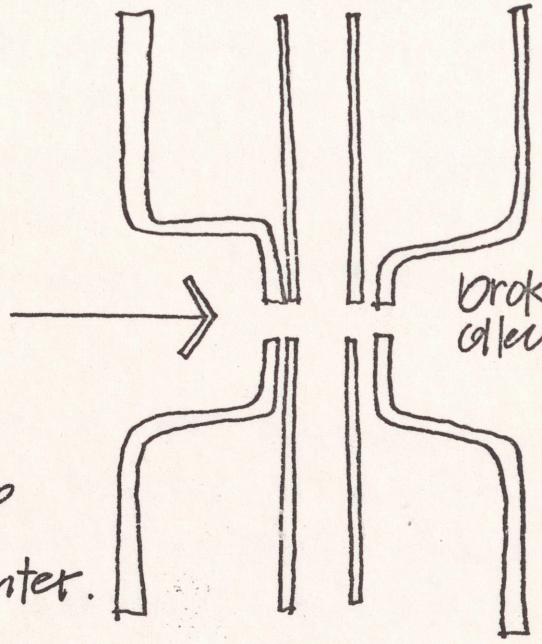
3. "LEAF CONCEPT".



- natural form indicative of system.



response to flow.
natural structure as the leaf.

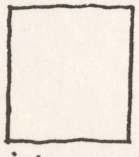


broken into 4 collector areas.

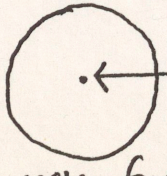
use 4 areas:
1. to break up large areas.
2. open up center.

4. GEOMETRY

a geometry which reflects a center.

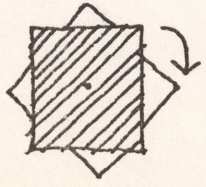


sides: no center functional.



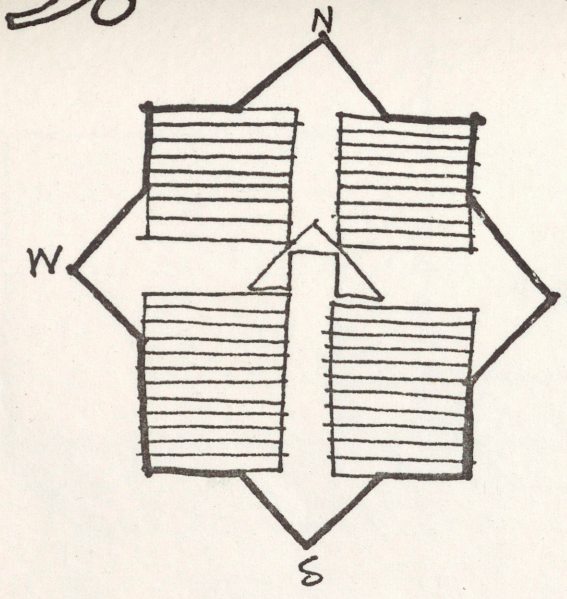
non-functional

the essence of the operation of solar collection.
1. north-south orientation
2. rectangular collecting areas.
3. symbolism.



rotation of a square within a square.
implications to center.

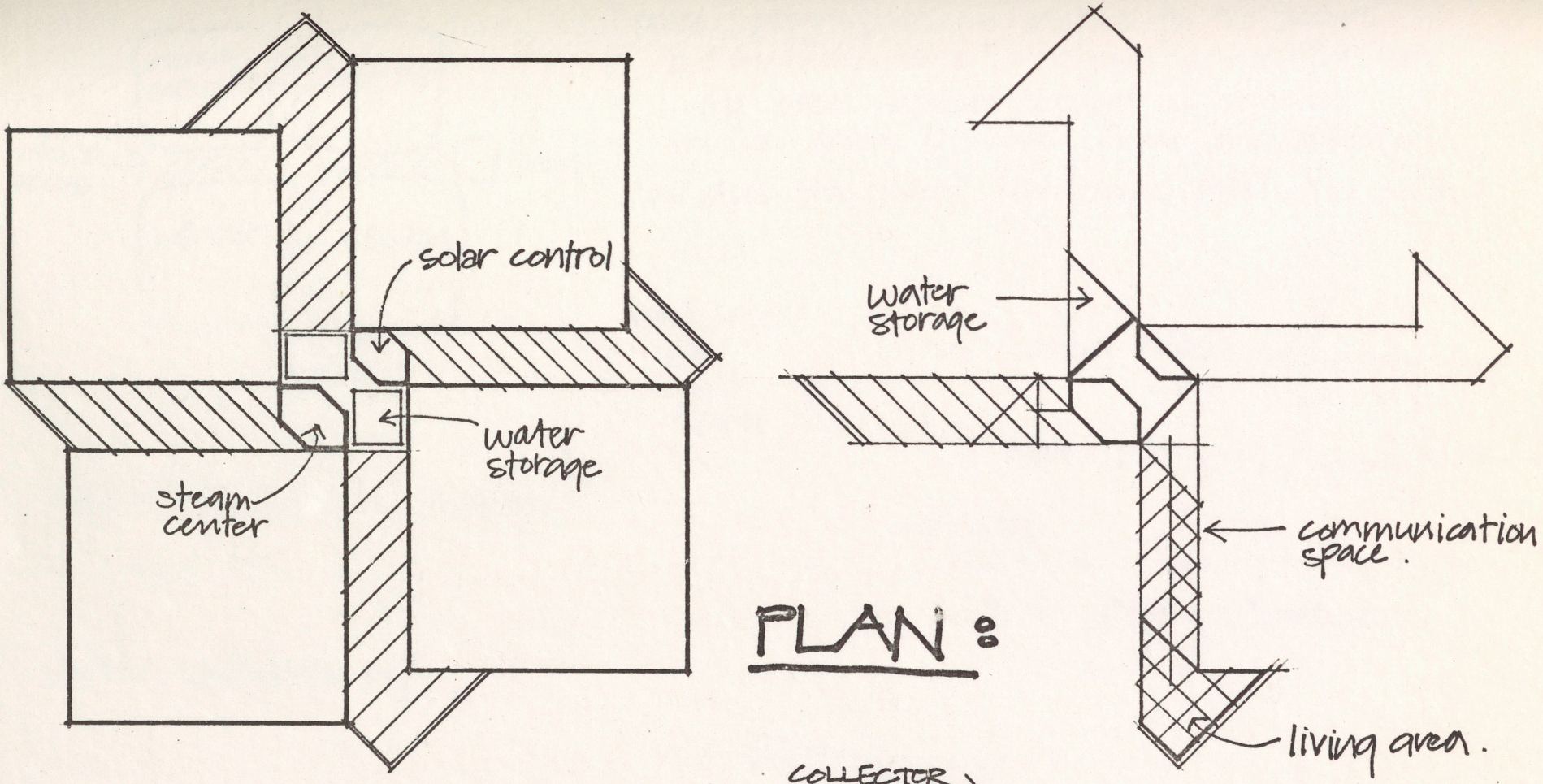
50 THE PLAN



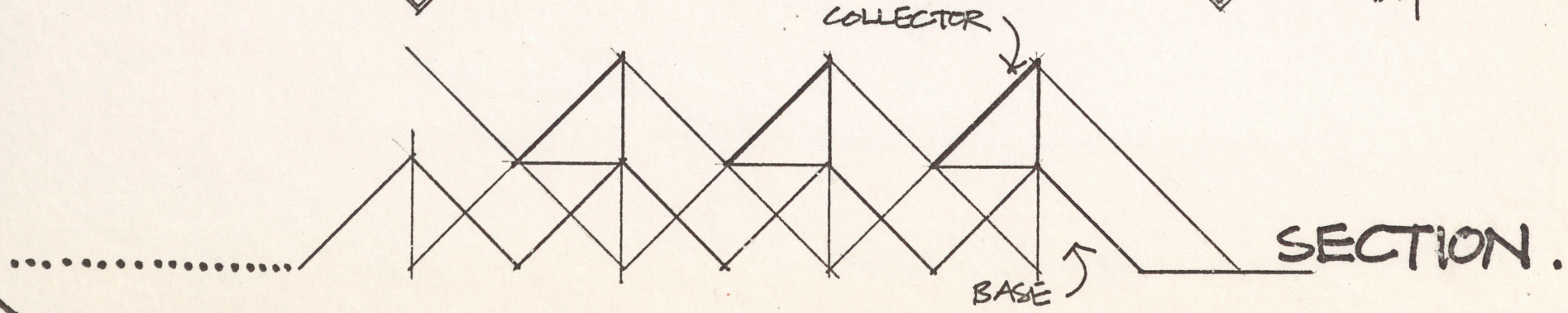
through geometry I attempted to derive a form which was expressive of process. The importance of the center. To accomplish this I began to rotate the square on an imaginary center. The result was a star shape at the left.

In twisting the square about itself I began to feel that this motion might have some effect on the center and the geometry would reveal this.

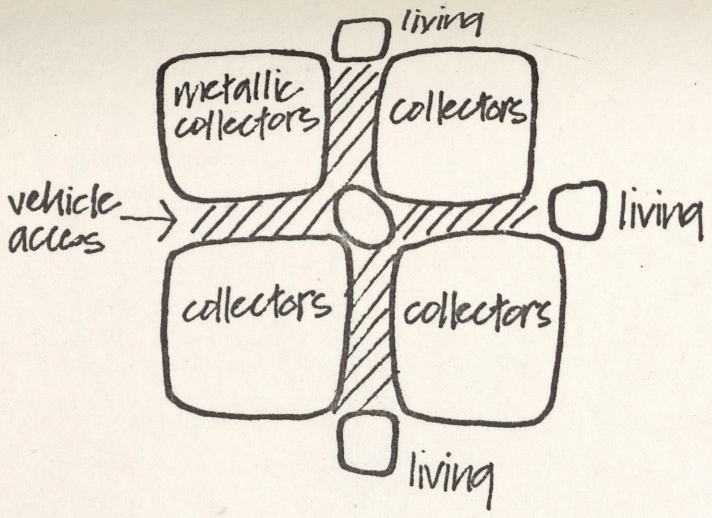
Basically I found a 45° systems working with the square form began to organize the complete geometry and the four linear corridors. I further carried this 45° system into the 3rd dimension when I discovered the optimum angle for the collector was 45° also. And the system began to shape and form the character of the collecting machinery. (See following page).



PLAN :



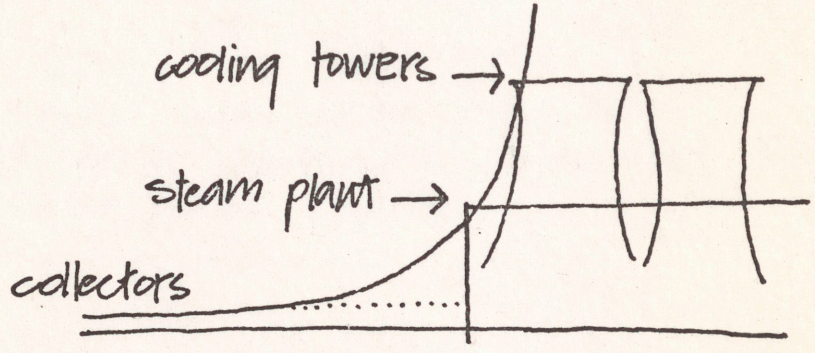
SECTION.



1. 4 metallic collector areas separated by soft areas - trees, plants, etc. - native to the desert.
2. a 'metallic core' - steam generation, etc.
3. living areas around exterior as needed.
4. vehicle access to core from one direction.

how does the desert landscape meet the farm?

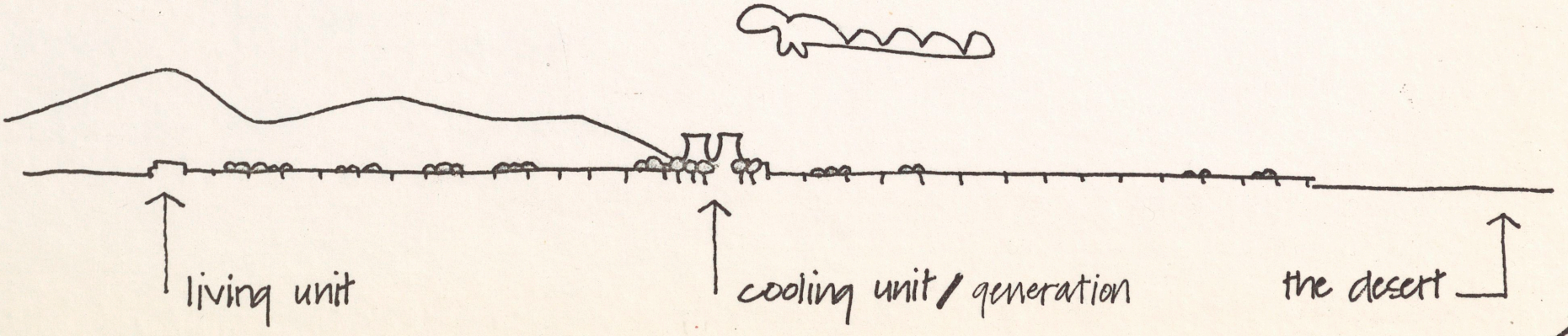
landscape:
- sky
- sand
- metal



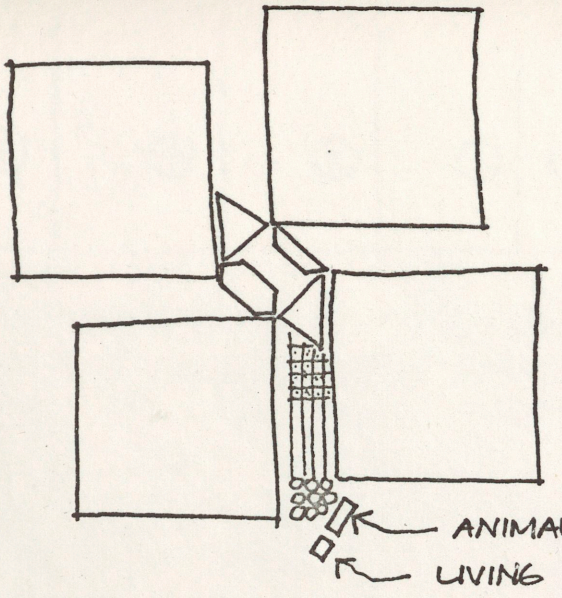
3-D ORGANIZATION.

ORGANIZATIONAL IDEAS:

NIFTY ELEVATION/



CONCEPT IA: 'A SOLAR FARM SURVIVAL KIT:



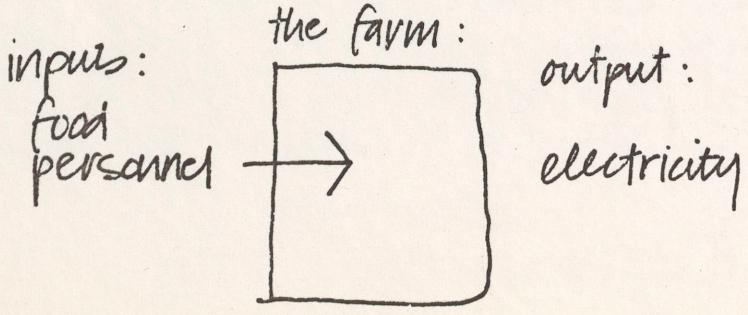
The solar farm to include farming: cattle ranching chickens, etc. The inhabitants of the farm grow the food they need for their survival. People in this situation live on the farm for extended periods of time.



Hydrogen powered farm machinery, using fuel produced at the solar farm station.

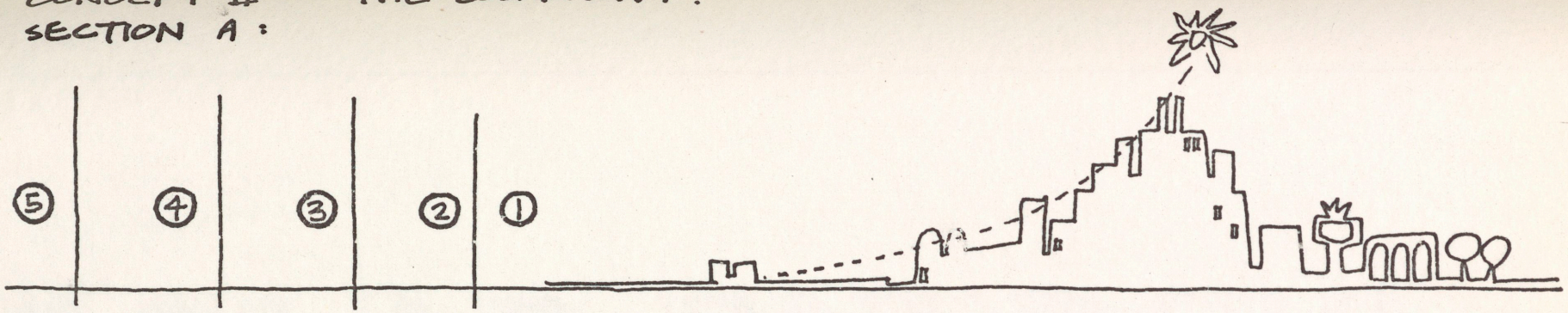
CONCEPT IB:

The farm relies on the services and supply lines from the nearest community. People live on the farm for short periods of time.



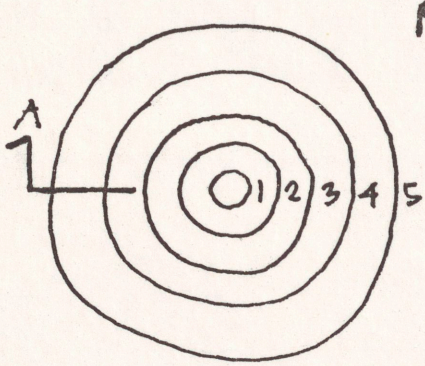
CONCEPT II : 'THE SOLAR CITY'

SECTION A :



Reorganization of cities according to the laws of energy. Cities which grow around and use the power supplied by the farm at its heart. Each city's size is delimited by the amount of energy supplied from the core — population control at last!! The end of urban sprawl!! and slums!

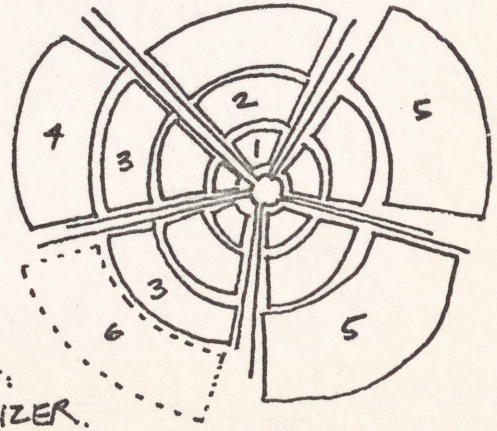
PLAN OF THE 'NEW CITY'



SOLAR FARM CORE
ZONE 1 INDUSTRIAL
Z2 OFFICE CORE
Z3 LIGHT COMMERCIAL
Z4 HOUSING
Z5 NATURAL LAND.

REFINED IDEA :

Realizing the complications of communication and transportation across the core (solar farm). The solar could more rightly locate on the extremes of the city, and along with belts of farming form the bounds of the city.

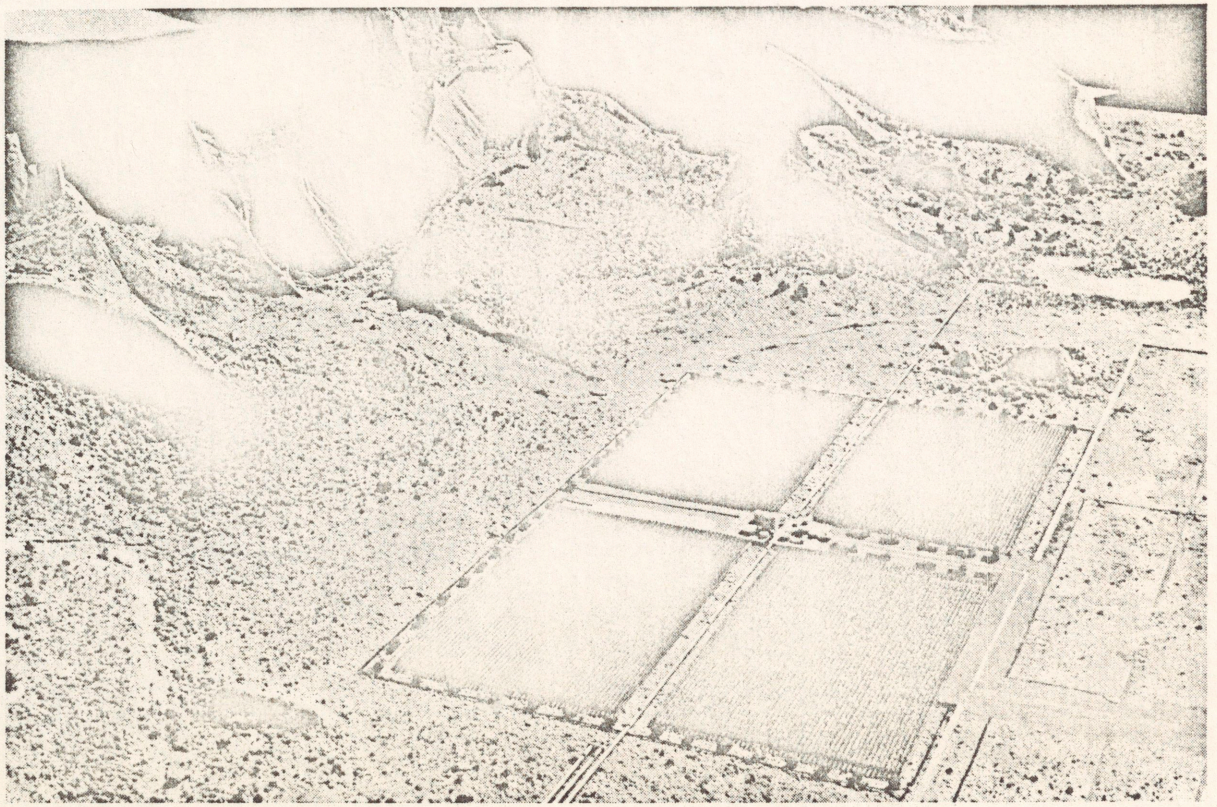


'THE AUTONOMOUS CITY'

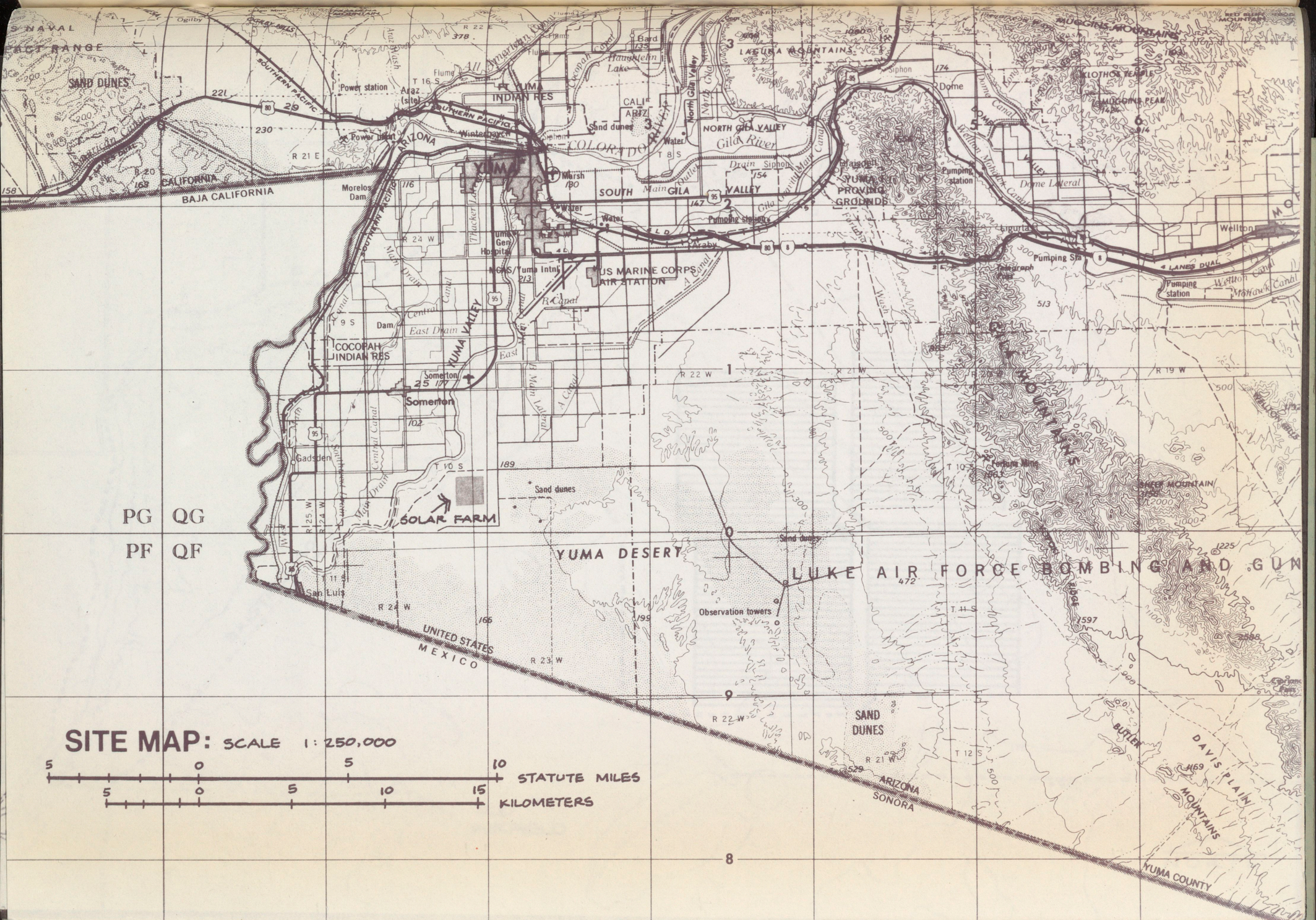
1 OFFICE CORE
2 COMMERCIAL AND HOUSING
3 INDUSTRIAL
4 SOLAR FARM SUPPLYING POWER TO THE CITY.
5 BELTS OF FARMING.
6 SEWAGE DISPOSAL UNIT: WASTE USED FOR FERTILIZER.

SOLAR ENERGY:

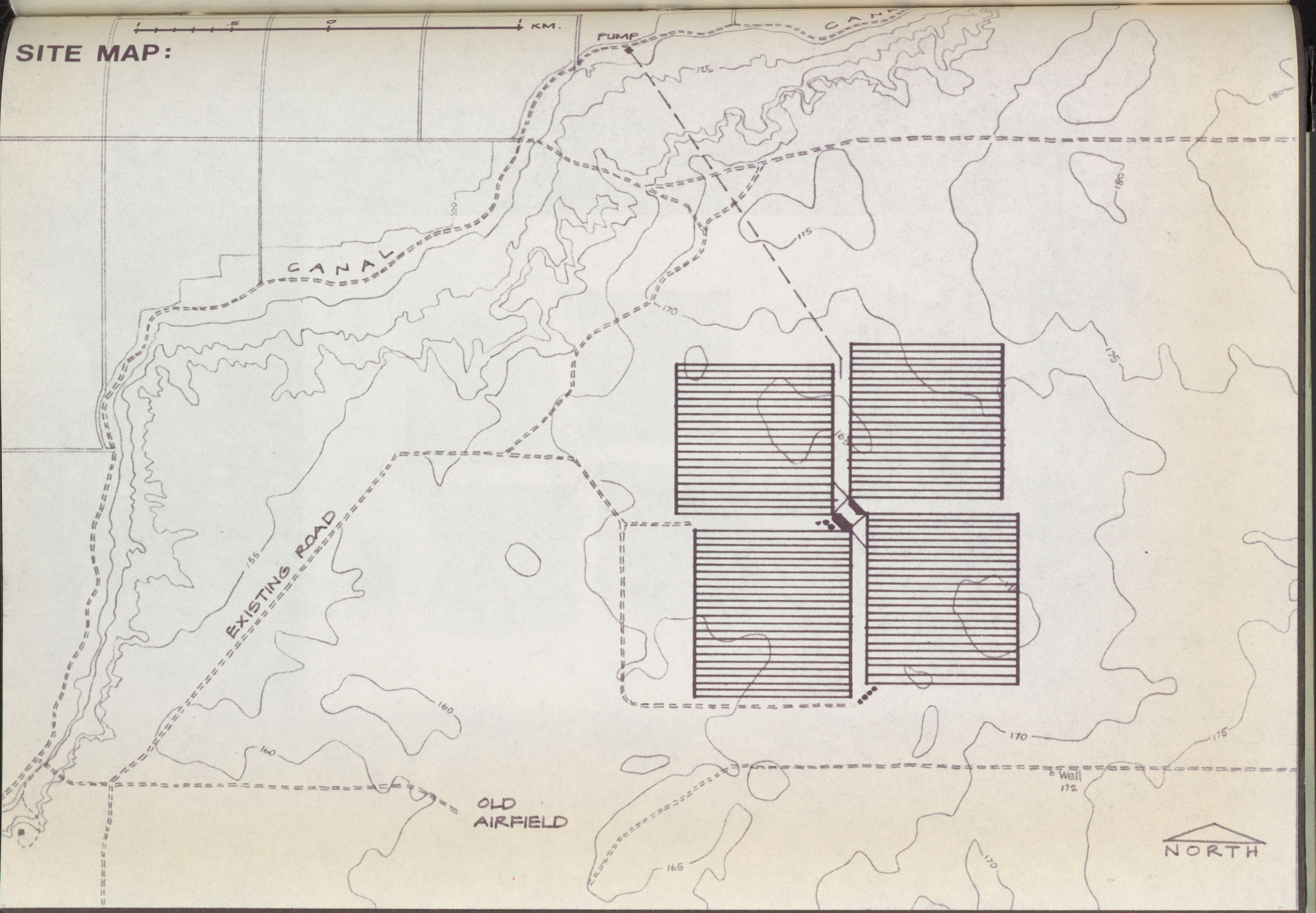
Option or Illusion

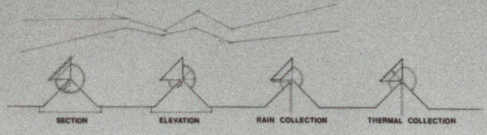


Aden B. and Marjorie Meinel


PG QG
PF QF
SITE MAP: SCALE 1:250,000
5 0 5 10 STATUTE MILES
5 0 5 10 15 KILOMETERS
YUMA
YUMA INDIAN RES
COCOPAH INDIAN RES
Somerton
San Luis
Gadsden
SOLAR FARM
YUMA DESERT
LUKE AIR FORCE BOMBING AND GUN
UNITED STATES
MEXICO
ARIZONA
SONORA
YUMA COUNTY
SAND DUNES
SOUTH GILA VALLEY
NORTH GILA VALLEY
YUMA VALLEY
Gila River
COLORADO RIVER
LAGUNA MOUNTAINS
MUGGINS MOUNTAINS
KLOTHO TEMPLE
MUGGINS PEAK
BAKER MOUNTAIN
DAVIS PLAIN
MOUNTAINS
BUTLER
YUMA PROVING GROUND
US MARINE CORPS AIR STATION
MCAS/Yuma Intnl
Yuma Gen Hospital
Morelos Dam
Araz (site)
Wellton
Wellton Canal
Mohawk Canal
Observation towers
Sand dunes
Power station
Pumping station
Pumping Sta
Dome
Siphon
Drain
Flume
Water
Marsh
Dam
Tunnel
Bridge
Overpass
Underpass
Ogilby
SAND DUNES
NAVAL
ACT RANGE
CALIFORNIA
BAJA CALIFORNIA
SOUTHERN PACIFIC
ARIZONA
Main Gila
Dome Lateral
Wellton Hills
Tinajas Altas Mts
Gila Gravity Main Canal
Mohawk Canal
Wellton Mohawk Canal
Yuma Main Canal
Central Canal
East Main Canal
East Drain
Main Drain
Thacker Lake
Haughtelin Lake
Bard
Araz
Winterhaven
Laguna Dam
Imperial Dam
Imperial Canal
All American Canal
Coronado Canal
Dome Canal
Dome Wellton Mohawk Canal
Dome Lateral
Pumping station
Drain Siphon
Gila Gravity Main Canal
Florida
Telegraph
Laguna Mine
Tinajas Altas
Baker Mountain
Butler
Davis Plain
Mountains
Wellton Hills
Yuma Main Canal
East Main Canal
Main Drain
Central Canal
East

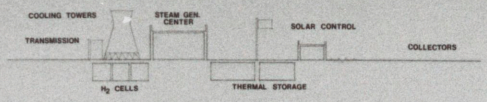
SITE MAP:


0 .5 1 KM.
PUMP
CANAL
CANAL
EXISTING ROAD
OLD AIRFIELD
Well 172
NORTH
155
160
160
165
170
170
175
175
180
180
185

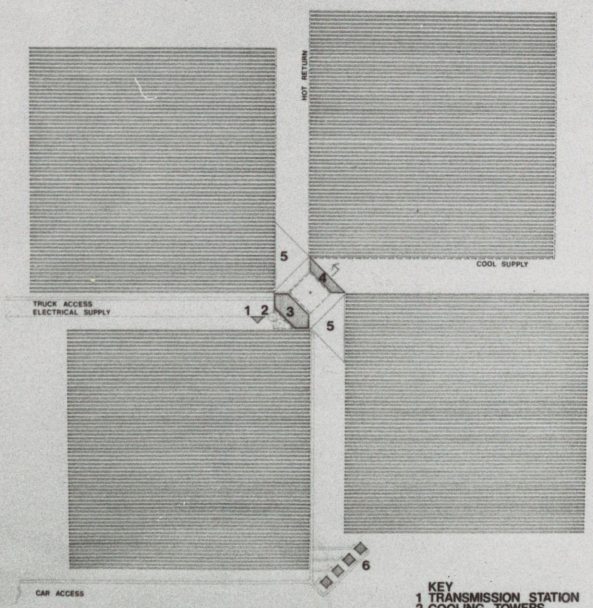


SECTION THRU COLLECTORS

0 5



SECTION THRU CORE



KEY
1 TRANSMISSION STATION
2 COOLING TOWERS
3 GENERATION CORE
4 SOLAR CONTROL
5 WATER STORAGE
6 LIVING UNITS

SYSTEMS PLAN

LIVING UNIT DESIGN

In the desert, man's own activities and the essential factors of his environment, such as soil, vegetation, animals and climate are all conditioned by water! The natural forces at work have inevitably shaped man's way of life in matters of clothing, shelter, diet, work, rest and sleep, customs and traditions.

J. P. Kirmiz

DESIGN PHILOSOPHY:

Design is a linear process. I believe that with the statement of the problem, the design process proceeds along a basic spinal core to a solution. Along the way the designer may depart from this linear path to examine a particular concept or aspect of the problem. After completing his research he returns again to this central spine to change or reaffirm his original assumptions.

In the design of the living unit I followed this linear philosophy. Beginning with the realization of the problem, I carefully delineated the character of the inhabitants of the unit as to profession, responsibility, and their associated 'living' functions or activities. From this set of activities I examined the implications of each individual activity according to physiological, sociological and psychological criteria. My basic assumptions were:

1. That I could graphically record and present the design decisions I made along the way and

2. in following the linear structure I could obtain an optimal solution.

In the diagrams and text that follow I present the design steps.

OPERATIONS:

PERSONNEL:
1 COOK
1 HOUSEKEEPER "
8 ENGINEERS 2
1 BIOLOGIST — medical personnel.
1 SOCIOLOGIST
1 PHYSIOLOGIST } TEMPORARY (VISITING)
1 PSYCHOLOGIST

DAYTIME ACTIVITY:	NIGHTIME ACTIVITY:
(AFTER SUNRISE)	(AFTER SUNSET)
SOLAR OPERATIONS	SLEEP
RESEARCH & STUDY	MAINTENANCE & REPAIR
HOUSEHOLD ACTIVITIES	FARMING
~~ALL~~ most INDOOR ACTIVITIES	MOST OUTDOOR ACTIVITIES

BREAKFAST

COOK

SLEEP • HYGIENE DRESSING • FOOD PREPARATION • SERVING • CLEAN-UP FARMING RELAXING • AFTERNOON ACTIVITIES •

FOOD PREPARATION • SERVING • MEAL PLANNING RELAXING • EVENING ACTIVITIES • HYGIENE DRESSING

clean up.

HOUSEKEEPER

SLEEP • HYGIENE DRESSING • ASSIST COOK EATING • FARMING HOUSEKEEPING • SEWING WASHING IRONING • ASSIST COOK • EATING •

EVENING ACTIVITIES • HYGIENE DRESSING

ENGINEERS

SLEEP • HYGIENE DRESSING • EATING • STEAM PLANT MAINTENANCE • HYGIENE • EATING • EVENING ACTIVITIES •

HYGIENE DRESSING

Visiting **SCIENTISTS**

SLEEP • HYGIENE DRESSING • EATING • STUDY RESEARCH • GROUP MEETING • EATING • RELAX STUDY • HYGIENE DRESSING

ACTIVITY: washing dishes NUMBER: food 1

PERSONNEL: 1

PARAMETERS

PHYSIOLOGICAL:

THERMAL CONTROLS:

ATMOSPHERIC / AQUEOUS:

LUMINOUS: 150 footcandles.

SONIC: 70 db.

SOCIOLOGICAL:

COMMUNITY / PRIVACY:

CHARACTER:

SOCIAL DISTANCE:

SOCIAL NEED:

NUTURANCE 1 2 3 4 5 SUCCORANCE

PSYCHOLOGICAL:

ORDER (1) 2 3 4 5 VARIETY

AFFILIATION 1 2 3 4 5 SOLITUDE

AUTONOMY 1 2 3 4 5 DEFERENCE

EXHIBITION 1 2 3 4 5 OBSERVANCE

MEANINGFULNESS IN LIFE: work oriented

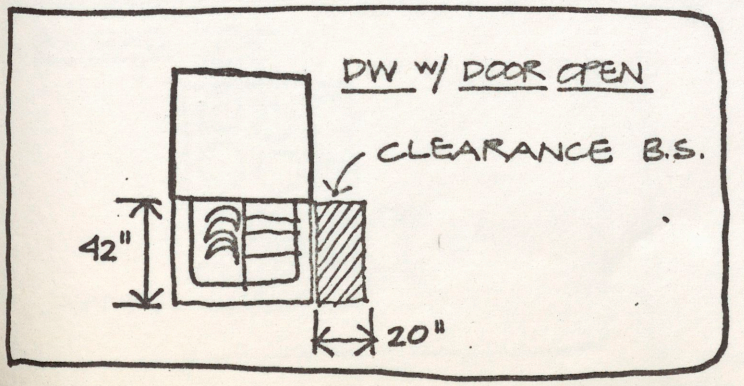
UNDERSTANDING:

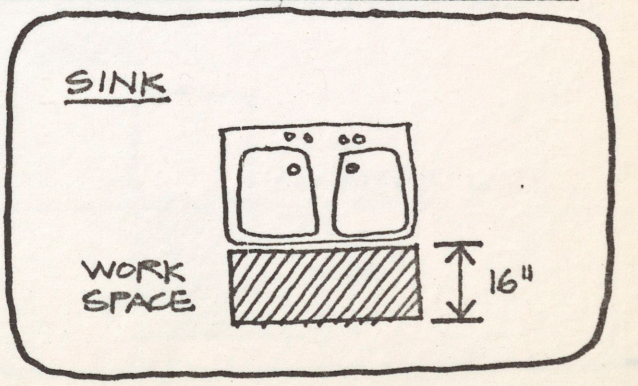
SELF-ACTUALIZATION:

ENVIRONMENTAL LOADS: hot and cold water, sewage conn

EQUIPMENT: dishwasher, double sink

DIMENSIONS: dw 26" D x 24" W x 36" H, sink 21" x 32"





ACTIVITY: cooking NUMBER: food 2

PERSONNEL: 1 or 2

PARAMETERS

PHYSIOLOGICAL:

THERMAL CONTROLS:

ATMOSPHERIC / AQUEOUS:

LUMINOUS: 150 footcandles:

SONIC:

SOCIOLOGICAL:

COMMUNITY / PRIVACY:

CHARACTER:

SOCIAL DISTANCE:

SOCIAL NEED:

NUTURANCE 1 2 3 4 5 SUCCORANCE

PSYCHOLOGICAL:

ORDER	1 2 3 (4) 5	VARIETY
AFFILIATION	1 2 3 4 5	SOLITUDE
AUTONOMY	1 2 3 4 5	DEFERENCE
EXHIBITION	1 2 3 4 5	OBSERVANCE

MEANINGFULNESS IN LIFE: work oriented.

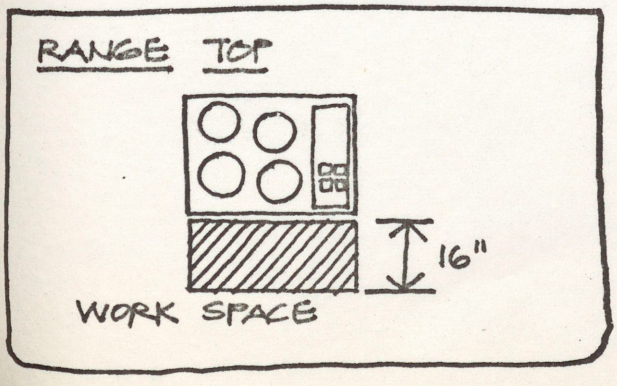
UNDERSTANDING: creative cooking

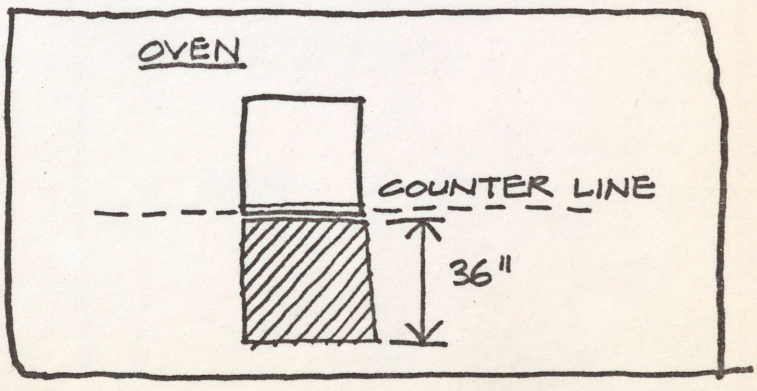
SELF-ACTUALIZATION: creative cooking

ENVIRONMENTAL LOADS: heat, odors

EQUIPMENT: range, 32" L x 20" W x 6" D, oven 24" W x 24" D x 46" H

DIMENSIONS: (as below):





ACTIVITY: food preparation NUMBER: food 3

PERSONNEL: 1 or 2

PARAMETERS

PHYSIOLOGICAL:

THERMAL CONTROLS:

ATMOSPHERIC / AQUEOUS:

LUMINOUS: 150 footcandles.

SONIC:

SOCIOLOGICAL:

COMMUNITY / PRIVACY:

CHARACTER:

SOCIAL DISTANCE:

SOCIAL NEED:

NUTURANCE 1 2 3 4 5 SUCCORANCE

PSYCHOLOGICAL:

ORDER 1 2 3 (4) 5 VARIETY

AFFILIATION 1 2 3 4 5 SOLITUDE

AUTONOMY 1 2 3 4 5 DEFERENCE

EXHIBITION 1 2 3 4 5 OBSERVANCE

MEANINGFULNESS IN LIFE: work oriented.

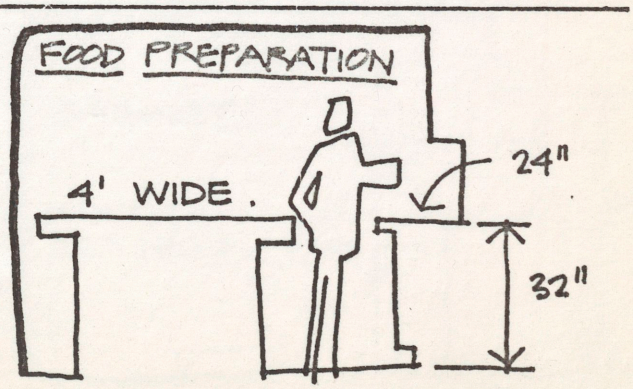
UNDERSTANDING: creative cooking.

SELF-ACTUALIZATION: creative cooking.

ENVIRONMENTAL LOADS:

EQUIPMENT: counter space, table

DIMENSIONS:



ACTIVITY: storing NUMBER: food 4

PERSONNEL:

PARAMETERS

PHYSIOLOGICAL:

THERMAL CONTROLS:

ATMOSPHERIC / AQUEOUS:

LUMINOUS:

SONIC: 45 db

SOCIOLOGICAL:

COMMUNITY / PRIVACY:

CHARACTER:

SOCIAL DISTANCE:

SOCIAL NEED:

NUTURANCE 1 2 3 4 5 SUCCORANCE

PSYCHOLOGICAL:

ORDER 1 2 3 4 5 VARIETY

AFFILIATION 1 2 3 4 5 SOLITUDE

AUTONOMY 1 2 3 4 5 DEFERENCE

EXHIBITION 1 2 3 4 5 OBSERVANCE

MEANINGFULNESS IN LIFE:

UNDERSTANDING:

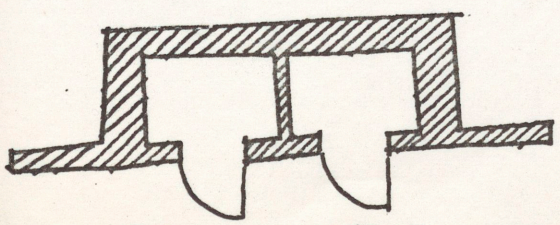
SELF-ACTUALIZATION:

ENVIRONMENTAL LOADS:

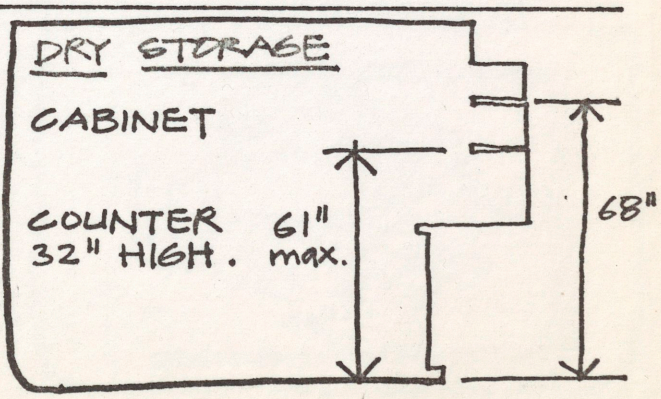
EQUIPMENT: refrigerator, cabinet storage

DIMENSIONS:

COLD STORAGE



DRY STORAGE



ACTIVITY: dining (large group) NUMBER: din. 1

PERSONNEL: 3 - 12

PARAMETERS

PHYSIOLOGICAL:

THERMAL CONTROLS:

ATMOSPHERIC / AQUEOUS:

LUMINOUS: 15 footcandles

SONIC:

SOCIOLOGICAL:

COMMUNITY / PRIVACY: communal.

CHARACTER:

SOCIAL DISTANCE: personal 18 - 30 ins social 4 - 7 FT.

SOCIAL NEED:

NUTURANCE 1 2 (3) 4 5 SUCCORANCE

PSYCHOLOGICAL:

ORDER	1 2 3 4 5	VARIETY
AFFILIATION	1 (2) 3 4 5	SOLITUDE
AUTONOMY	1 2 3 4 5	DEFERENCE
EXHIBITION	(1) 2 3 4 5	OBSERVANCE

MEANINGFULNESS IN LIFE: human interaction.

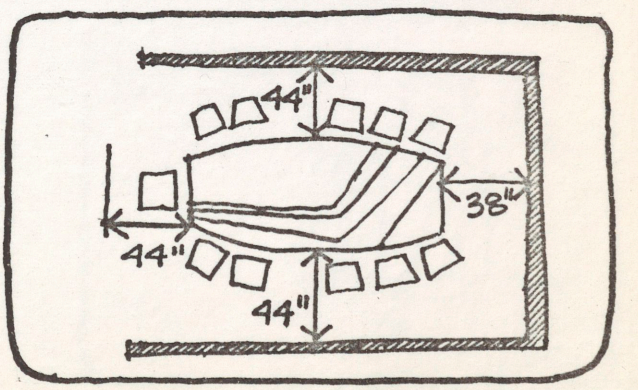
UNDERSTANDING: group discussions.

SELF - ACTUALIZATION: social realization.

ENVIRONMENTAL LOADS:

EQUIPMENT: 1 table, 12 chairs. w/ table 10'L x 4'W.

DIMENSIONS:



ACTIVITY: dining (small group) NUMBER: din. 2

PERSONNEL: 1 - 2

PARAMETERS

PHYSIOLOGICAL:

THERMAL CONTROLS:

ATMOSPHERIC / AQUEOUS:

LUMINOUS: 15 footcandles.

SONIC:

SOCIOLOGICAL:

COMMUNITY / PRIVACY:

CHARACTER:

SOCIAL DISTANCE:

SOCIAL NEED:

NUTURANCE 1 2 (3) 4 5 SUCCORANCE

PSYCHOLOGICAL:

ORDER 1 2 3 4 5 VARIETY

AFFILIATION 1 2 3 4 5 SOLITUDE

AUTONOMY 1 2 3 4 5 DEFERENCE

EXHIBITION 1 2 3 4 5 OBSERVANCE

MEANINGFULNESS IN LIFE:

UNDERSTANDING:

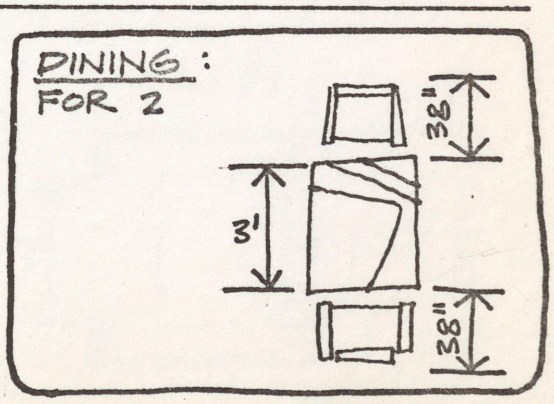
SELF-ACTUALIZATION:

ENVIRONMENTAL LOADS:

EQUIPMENT: 1 table, 2 chairs. w/ table 3' L x 2'-6" W

DIMENSIONS:

DINING:
FOR 2



ACTIVITY: vehicle storage NUMBER: _____

PERSONNEL: _____

PARAMETERS

PHYSIOLOGICAL:

THERMAL CONTROLS: _____

ATMOSPHERIC / AQUEOUS: _____

LUMINOUS: _____

SONIC: _____

SOCIOLOGICAL:

COMMUNITY / PRIVACY: _____

CHARACTER: _____ _____

SOCIAL DISTANCE: _____

SOCIAL NEED:

NUTURANCE 1 2 3 4 5 SUCCORANCE

PSYCHOLOGICAL:

ORDER 1 2 3 4 5 VARIETY

AFFILIATION 1 2 3 4 5 SOLITUDE

AUTONOMY 1 2 3 4 5 DEFERENCE

EXHIBITION 1 2 3 4 5 OBSERVANCE

MEANINGFULNESS IN LIFE: _____

UNDERSTANDING: _____

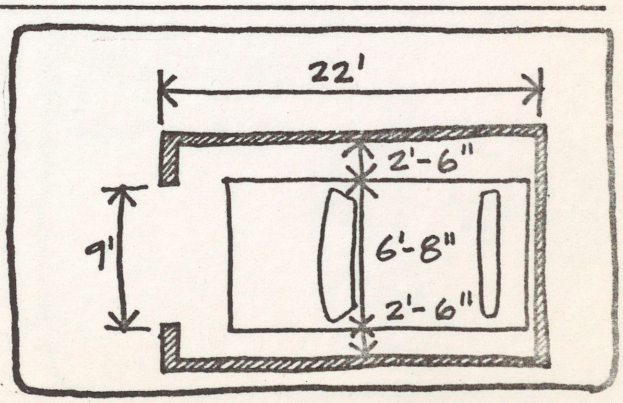
SELF- ACTUALIZATION: _____

ENVIRONMENTAL LOADS: _____

EQUIPMENT: transportation vehicle

_____

DIMENSIONS: _____



ACTIVITY: television NUMBER: group 1

PERSONNEL: 1 – 12

PARAMETERS

PHYSIOLOGICAL:

THERMAL CONTROLS: _____

ATMOSPHERIC / AQUEOUS: _____

LUMINOUS: 10 footcandles.

SONIC: _____

SOCIOLOGICAL:

COMMUNITY / PRIVACY: communal.

CHARACTER: sociopetal / monocentered.

SOCIAL DISTANCE: personal 18 - 30 ins

SOCIAL NEED:

NUTURANCE 1 2 3 4 5 SUCCORANCE

PSYCHOLOGICAL:

ORDER 1 2 3 4 (5) VARIETY

AFFILIATION 1 2 3 4 5 SOLITUDE

AUTONOMY 1 2 3 4 5 DEFERENCE

EXHIBITION 1 2 3 4 5 OBSERVANCE

MEANINGFULNESS IN LIFE: _____

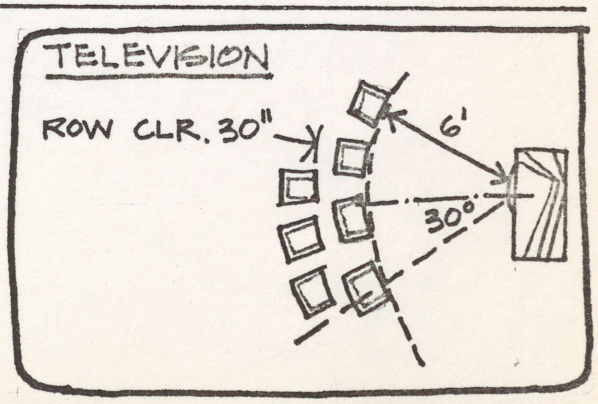
UNDERSTANDING: acquisition of knowledge.

SELF-ACTUALIZATION: _____

ENVIRONMENTAL LOADS: _____

EQUIPMENT: 1 television 32"W X 18"D X 30" H, seating

DIMENSIONS: _____



ACTIVITY: games NUMBER: group 2

PERSONNEL: 2 - 6

PARAMETERS

PHYSIOLOGICAL:

THERMAL CONTROLS:

ATMOSPHERIC / AQUEOUS:

LUMINOUS: 30 footcandles

SONIC:

SOCIOLOGICAL:

COMMUNITY / PRIVACY: communal

CHARACTER: sociopetal / monocentered

SOCIAL DISTANCE:

SOCIAL NEED:

NUTURANCE 1 2 (3) 4 5 SUCCORANCE

PSYCHOLOGICAL:

ORDER 1 2 3 4 (5) VARIETY

AFFILIATION 1 (2) 3 4 5 SOLITUDE

AUTONOMY 1 2 3 4 5 DEFERENCE

EXHIBITION (1) 2 3 4 5 OBSERVANCE

MEANINGFULNESS IN LIFE: human interaction

UNDERSTANDING: group discussions

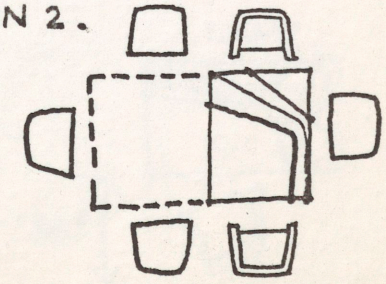
SELF-ACTUALIZATION: social realization

ENVIRONMENTAL LOADS:

EQUIPMENT: table, 6 chairs,

DIMENSIONS:

GAMES: (FLEXIBLE)
SEE DIN 2.



ACTIVITY: general purpose. NUMBER: group 3

PERSONNEL: variable.

PARAMETERS

PHYSIOLOGICAL:

THERMAL CONTROLS:

ATMOSPHERIC / AQUEOUS:

LUMINOUS: 10 footcandles.

SONIC:

SOCIOLOGICAL:

COMMUNITY / PRIVACY: communal.

CHARACTER: sociopetal / multicentered.

SOCIAL DISTANCE: variable.

SOCIAL NEED:

NUTURANCE 1 2 (3) 4 5 SUCCORANCE

PSYCHOLOGICAL:

ORDER 1 2 3 4 (5) VARIETY

AFFILIATION 1 (2) 3 4 5 SOLITUDE

AUTONOMY 1 2 3 4 5 DEFERENCE

EXHIBITION (1) 2 3 4 5 OBSERVANCE

MEANINGFULNESS IN LIFE: human interaction.

UNDERSTANDING: group discussions.

SELF-ACTUALIZATION: social realization

ENVIRONMENTAL LOADS:

EQUIPMENT:

DIMENSIONS:

ACTIVITY: reading / individual study NUMBER: _____

PERSONNEL: 1

PARAMETERS

PHYSIOLOGICAL:

THERMAL CONTROLS: _____

ATMOSPHERIC / AQUEOUS: _____

LUMINOUS: reading 30 fc. study 70 fc.

SONIC: _____

SOCIOLOGICAL:

COMMUNITY / PRIVACY: private

CHARACTER: _____

SOCIAL DISTANCE: _____

SOCIAL NEED:

NUTURANCE 1 2 3 4 5 SUCCORANCE

PSYCHOLOGICAL:

ORDER	1 2 3 4 5	VARIETY
AFFILIATION	1 2 3 4 (5)	SOLITUDE
AUTONOMY	(1) 2 3 4 5	DEFERENCE
EXHIBITION	1 2 3 4 5	OBSERVANCE

MEANINGFULNESS IN LIFE: _____

UNDERSTANDING: acquisition of knowledge.

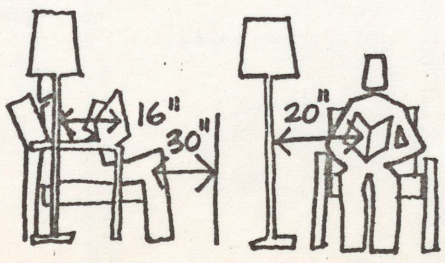
SELF-ACTUALIZATION: creative writing, drawing.

ENVIRONMENTAL LOADS: noise control.

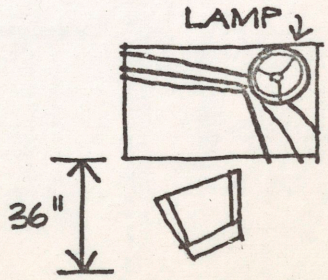
EQUIPMENT: desk 4'L x 2'D x 2'-6" H, chair, lamp.

DIMENSIONS: _____

READING: EYE LEVEL LAMP



STUDY:



ACTIVITY: hygiene (bodily) NUMBER: hygiene 1

PERSONNEL: variable

PARAMETERS

PHYSIOLOGICAL:

THERMAL CONTROLS: _____

ATMOSPHERIC / AQUEOUS: _____

LUMINOUS: 50 footcandles.

SONIC: _____

SOCIOLOGICAL:

COMMUNITY / PRIVACY: private.

CHARACTER: _____

SOCIAL DISTANCE: _____

SOCIAL NEED:

NUTURANCE 1 2 3 4 5 SUCCORANCE

PSYCHOLOGICAL:

ORDER (1) 2 3 4 5 VARIETY

AFFILIATION 1 2 3 (4) 5 SOLITUDE

AUTONOMY 1 2 3 4 5 DEFERENCE

EXHIBITION 1 2 3 (4) 5 OBSERVANCE

MEANINGFULNESS IN LIFE: _____

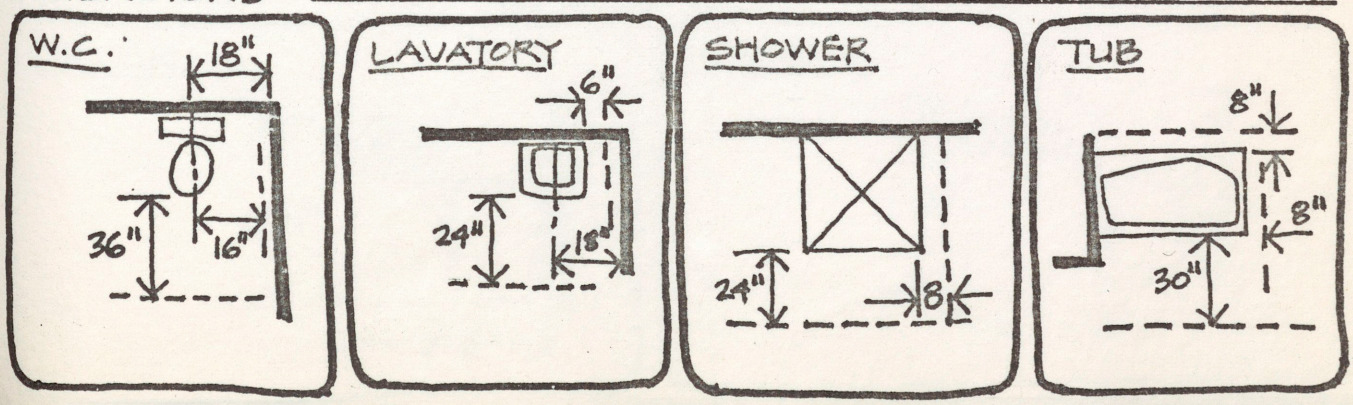
UNDERSTANDING: _____

SELF-ACTUALIZATION: _____

ENVIRONMENTAL LOADS: heat, humidity, odors, water conn.

EQUIPMENT: tub, toilet, shower, sink.

DIMENSIONS:



ACTIVITY: hygiene (clothes) NUMBER: hygiene 2

PERSONNEL: 1

PARAMETERS

PHYSIOLOGICAL:

THERMAL CONTROLS:

ATMOSPHERIC / AQUEOUS:

LUMINOUS: ironing 50 fc. washer & dryer 30 fc.

SONIC:

SOCIOLOGICAL:

COMMUNITY / PRIVACY: private

CHARACTER:

SOCIAL DISTANCE:

SOCIAL NEED:

NUTURANCE 1 2 3 4 5 SUCCORANCE

PSYCHOLOGICAL:

ORDER (1) 2 3 4 5 VARIETY

AFFILIATION 1 2 3 4 5 SOLITUDE

AUTONOMY 1 2 3 4 5 DEFERENCE

EXHIBITION 1 2 3 4 5 OBSERVANCE

MEANINGFULNESS IN LIFE: work oriented.

UNDERSTANDING:

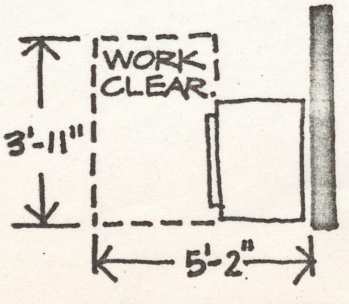
SELF-ACTUALIZATION:

ENVIRONMENTAL LOADS: water & sewer, heat.

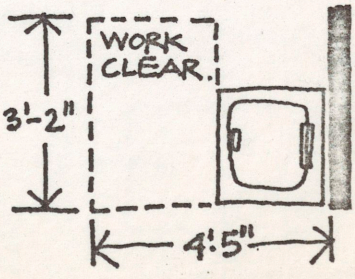
EQUIPMENT: dryer 31" W x 26" D, washer 26" W x 26" D.

DIMENSIONS: as below.

DRYER:



WASHER:



ACTIVITY: sleeping NUMBER: _____

PERSONNEL: 1

PARAMETERS

PHYSIOLOGICAL:

THERMAL CONTROLS: _____

ATMOSPHERIC / AQUEOUS: _____

LUMINOUS: general lighting 10 fc. reading 70 fc.

SONIC: _____

SOCIOLOGICAL:

COMMUNITY / PRIVACY: private.

CHARACTER: _____

SOCIAL DISTANCE: _____

SOCIAL NEED:

NUTURANCE 1 2 3 4 5 SUCCORANCE

PSYCHOLOGICAL:

ORDER 1 2 3 4 5 VARIETY

AFFILIATION 1 2 3 (4) 5 SOLITUDE

AUTONOMY (1) 2 3 4 5 DEFERENCE

EXHIBITION 1 2 3 4 5 OBSERVANCE

MEANINGFULNESS IN LIFE: _____

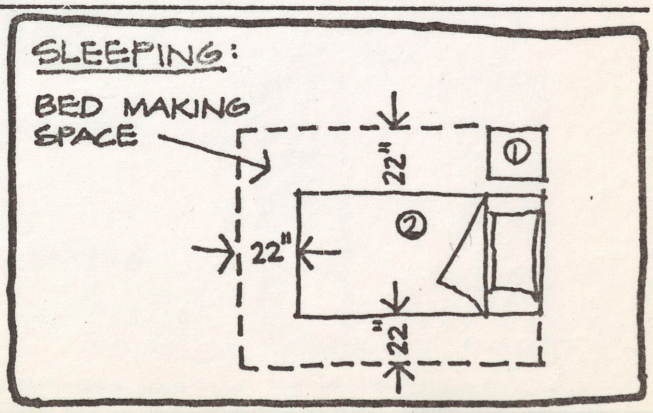
UNDERSTANDING: _____

SELF-ACTUALIZATION: _____

ENVIRONMENTAL LOADS: noise control

EQUIPMENT: night table① bed② 3' x 7' or 4'-6" x 7'.

DIMENSIONS: _____



ACTIVITY: dressing NUMBER: _____

PERSONNEL: 1

PARAMETERS

PHYSIOLOGICAL:

THERMAL CONTROLS: _____

ATMOSPHERIC / AQUEOUS: _____

LUMINOUS: 50 footcandles.

SONIC: _____

SOCIOLOGICAL:

COMMUNITY / PRIVACY: private

CHARACTER: _____

SOCIAL DISTANCE: _____

SOCIAL NEED:

NUTURANCE 1 2 3 4 5 SUCCORANCE

PSYCHOLOGICAL:

ORDER 1 (2) 3 4 5 VARIETY

AFFILIATION 1 2 3 (4) 5 SOLITUDE

AUTONOMY 1 2 3 4 5 DEFERENCE

EXHIBITION 1 2 3 4 5 OBSERVANCE

MEANINGFULNESS IN LIFE: _____

UNDERSTANDING: _____

SELF-ACTUALIZATION: _____

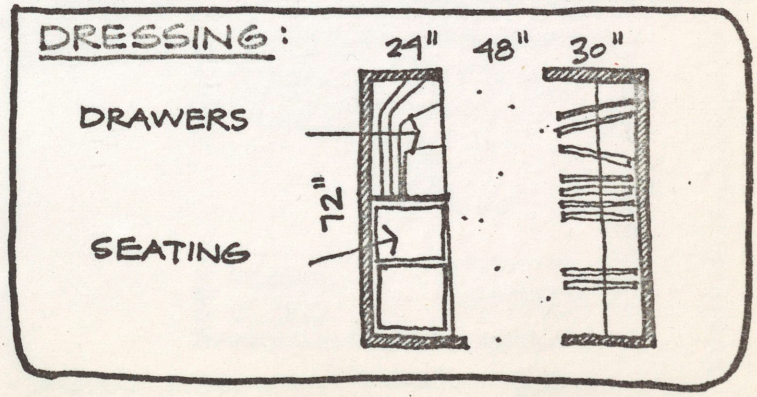
ENVIRONMENTAL LOADS: _____

EQUIPMENT: _____

_____

DIMENSIONS: 8'-6" x 6'-0"

DRESSING:



ACTIVITY: wood shop NUMBER: _____

PERSONNEL: variable.

PARAMETERS

PHYSIOLOGICAL:

THERMAL CONTROLS: _____

ATMOSPHERIC / AQUEOUS: _____

LUMINOUS: 70 footcandles.

SONIC: 100 db.

SOCIOLOGICAL:

COMMUNITY / PRIVACY: _____

CHARACTER: _____

SOCIAL DISTANCE: _____

SOCIAL NEED:

NUTURANCE 1 2 3 4 5 SUCCORANCE

PSYCHOLOGICAL:

ORDER 1 2 3 4 (5) VARIETY

AFFILIATION 1 2 3 (4) 5 SOLITUDE

AUTONOMY 1 2 3 4 5 DEFERENCE

EXHIBITION 1 2 3 4 5 OBSERVANCE

MEANINGFULNESS IN LIFE: _____

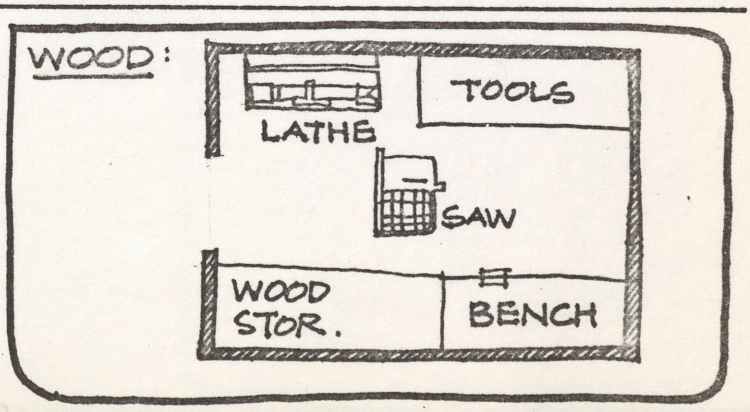
UNDERSTANDING: creative woodworking.

SELF-ACTUALIZATION: creative woodworking.

ENVIRONMENTAL LOADS: noise, dust.

EQUIPMENT: misc. tools, rest as shown.

DIMENSIONS: 12'W x 16'L.



ACTIVITY: sewing NUMBER: work 1

PERSONNEL: 1

PARAMETERS

PHYSIOLOGICAL:

THERMAL CONTROLS:

ATMOSPHERIC / AQUEOUS:

LUMINOUS: variable 200 - 30 ft.

SONIC:

SOCIOLOGICAL:

COMMUNITY / PRIVACY: private

CHARACTER:

SOCIAL DISTANCE:

SOCIAL NEED:

NUTURANCE 1 2 3 4 5 SUCCORANCE

PSYCHOLOGICAL:

ORDER	1 2 3 (4) 5	VARIETY
AFFILIATION	1 2 3 4 5	SOLITUDE
AUTONOMY	1 2 3 4 5	DEFERENCE
EXHIBITION	1 2 3 4 5	OBSERVANCE

MEANINGFULNESS IN LIFE: work oriented

UNDERSTANDING: creative sewing

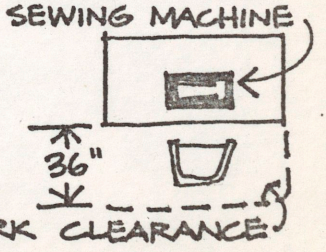
SELF-ACTUALIZATION: creative sewing

ENVIRONMENTAL LOADS:

EQUIPMENT: sewing machine, table 2' x 5', chair

DIMENSIONS:

SEWING:



ACTIVITY: ironing & folding NUMBER: work 2

PERSONNEL: 1

PARAMETERS

PHYSIOLOGICAL:

THERMAL CONTROLS:

ATMOSPHERIC / AQUEOUS:

LUMINOUS: 50 footcandles

SONIC:

SOCIOLOGICAL:

COMMUNITY / PRIVACY: private

CHARACTER:

SOCIAL DISTANCE:

SOCIAL NEED:

NUTURANCE 1 2 3 4 5 SUCCORANCE

PSYCHOLOGICAL:

ORDER (1) 2 3 4 5 VARIETY

AFFILIATION 1 2 3 4 5 SOLITUDE

AUTONOMY 1 2 3 4 5 DEFERENCE

EXHIBITION 1 2 3 4 5 OBSERVANCE

MEANINGFULNESS IN LIFE: work oriented

UNDERSTANDING:

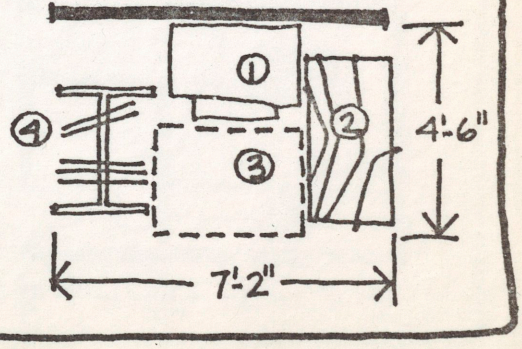
SELF-ACTUALIZATION:

ENVIRONMENTAL LOADS: heat

EQUIPMENT: ironer 16" x 36" w/ Lapboard 6" x 27" ①, table 24" x 48" ②, work space ③ 21" x 38", hanging bar ④ 24" x 36"

DIMENSIONS:

IRONING:



ACTIVITY: lab/scientific study NUMBER: work 3

PERSONNEL: 1

PARAMETERS

PHYSIOLOGICAL:

THERMAL CONTROLS:

ATMOSPHERIC / AQUEOUS:

LUMINOUS: 150 - 200 footcandles.

SONIC:

SOCIOLOGICAL:

COMMUNITY / PRIVACY: private.

CHARACTER:

SOCIAL DISTANCE:

SOCIAL NEED:

NUTURANCE 1 2 3 4 5 SUCCORANCE

PSYCHOLOGICAL:

ORDER 1 2 3 (4) 5 VARIETY

AFFILIATION 1 2 3 4 (5) SOLITUDE

AUTONOMY (1) 2 3 4 5 DEFERENCE

EXHIBITION 1 2 3 4 5 OBSERVANCE

MEANINGFULNESS IN LIFE: work oriented

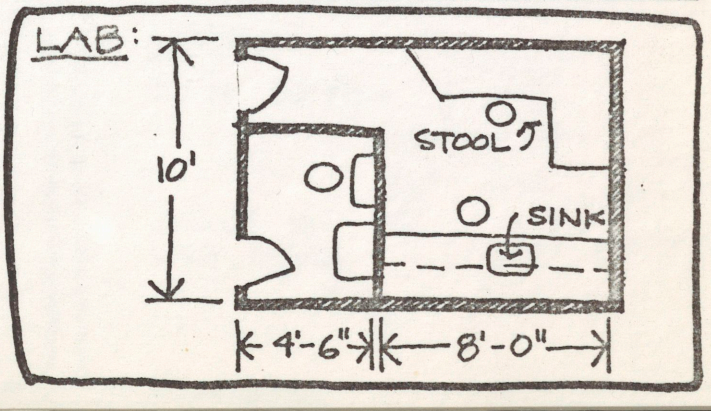
UNDERSTANDING: scientific study.

SELF-ACTUALIZATION: scientific study.

ENVIRONMENTAL LOADS: water, sewer, smells

EQUIPMENT: stools, storage, sink, etc.

DIMENSIONS: as below



ACTIVITY: control & office. NUMBER: sd/ap 1

PERSONNEL: 2

PARAMETERS

PHYSIOLOGICAL:

THERMAL CONTROLS: _____

ATMOSPHERIC / AQUEOUS: _____

LUMINOUS: 70 footcandles

SONIC: _____

SOCIOLOGICAL:

COMMUNITY / PRIVACY: _____

CHARACTER: _____

SOCIAL DISTANCE: _____

SOCIAL NEED:

NUTURANCE 1 2 3 4 5 SUCCORANCE

PSYCHOLOGICAL:

ORDER 1 (2) 3 4 5 VARIETY

AFFILIATION 1 2 3 4 5 SOLITUDE

AUTONOMY 1 2 3 4 5 DEFERENCE

EXHIBITION 1 2 3 4 5 OBSERVANCE

MEANINGFULNESS IN LIFE: work oriented

UNDERSTANDING: _____

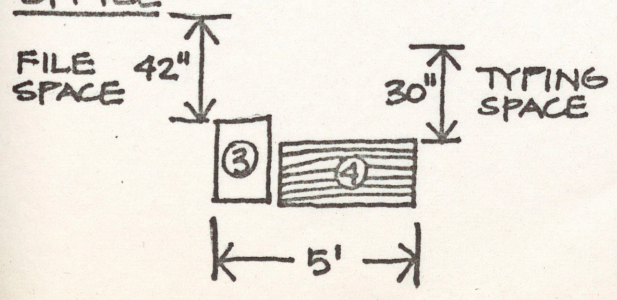
SELF-ACTUALIZATION: _____

ENVIRONMENTAL LOADS: _____

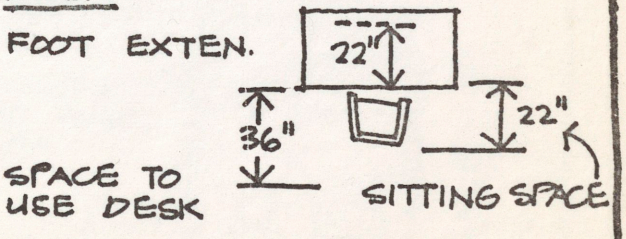
EQUIPMENT: desk 60" x 30", chairs, file 16" x 28" (3)
typewriter table (4) 36" x 16".

DIMENSIONS: _____

OFFICE:



DESK:



ACTIVITY: hygiene (bodily) NUMBER: 501/of 2

PERSONNEL: 1

PARAMETERS

PHYSIOLOGICAL:

THERMAL CONTROLS:

ATMOSPHERIC / AQUEOUS:

LUMINOUS: 30 footcandles.

SONIC:

SOCIOLOGICAL:

COMMUNITY / PRIVACY: private

CHARACTER:

SOCIAL DISTANCE:

SOCIAL NEED:

NUTURANCE 1 2 3 4 5 SUCCORANCE

PSYCHOLOGICAL:

ORDER (1) 2 3 4 5 VARIETY

AFFILIATION 1 2 3 (4) 5 SOLITUDE

AUTONOMY 1 2 3 4 5 DEFERENCE

EXHIBITION 1 2 3 4 5 OBSERVANCE

MEANINGFULNESS IN LIFE:

UNDERSTANDING:

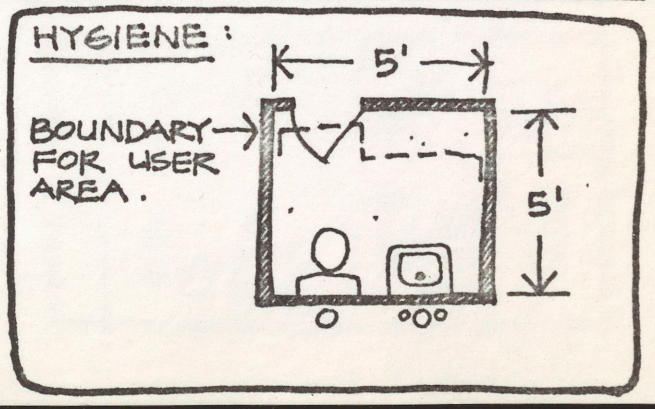
SELF-ACTUALIZATION:

ENVIRONMENTAL LOADS: water, sewer, odor

EQUIPMENT: toilet, sink.

DIMENSIONS:

HYGIENE:



ACTIVITY: machine shop NUMBER: sol/op 3

PERSONNEL: 2 - 4

PARAMETERS

PHYSIOLOGICAL:

THERMAL CONTROLS: _____

ATMOSPHERIC / AQUEOUS: _____

LUMINOUS: _____

SONIC: _____

SOCIOLOGICAL:

COMMUNITY / PRIVACY: _____

CHARACTER: _____

SOCIAL DISTANCE: _____

SOCIAL NEED:

NUTURANCE 1 2 3 4 5 SUCCORANCE

PSYCHOLOGICAL:

ORDER	1 (2) 3 4 5	VARIETY
AFFILIATION	1 2 3 4 5	SOLITUDE
AUTONOMY	1 2 3 4 5	DEFERENCE
EXHIBITION	1 2 3 4 5	OBSERVANCE

MEANINGFULNESS IN LIFE: work oriented.

UNDERSTANDING: _____

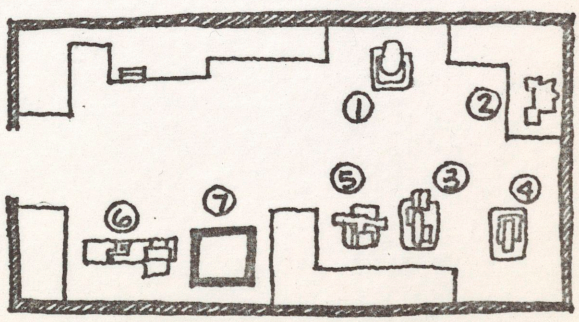
SELF-ACTUALIZATION: _____

ENVIRONMENTAL LOADS: noise, odors

EQUIPMENT: drill press①, grinder②, shaper③, band saw④, milling machine⑤, lathe⑥, furnace⑦.

DIMENSIONS: 32'L X 16'W

METAL:



activity categories:

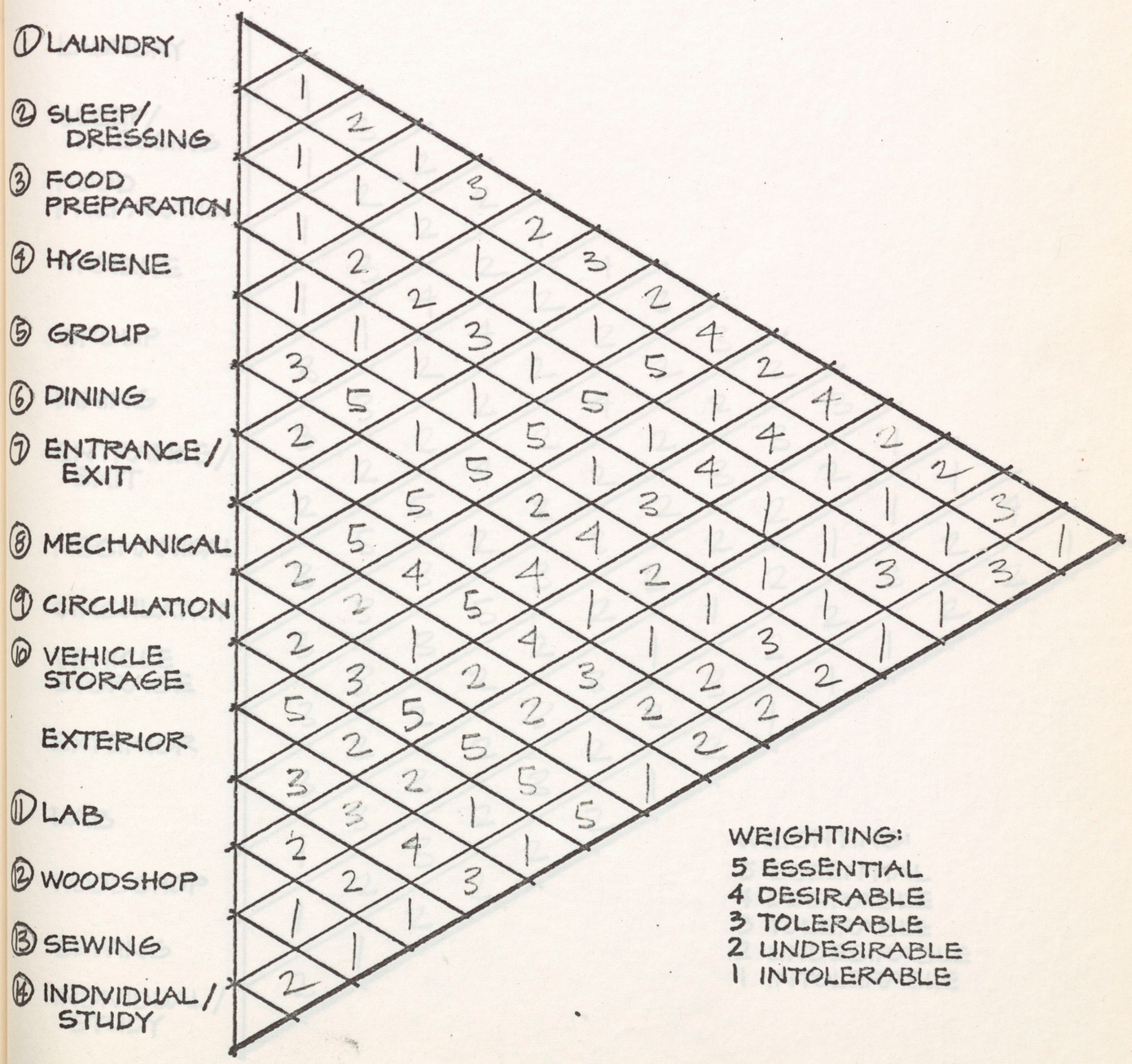
1. food preparation / small dining — 230 FT^2
2. dining — 220 FT^2
3. group — 500 FT^2
4. hygiene — 200 FT^2
5. laundry — 65 FT^2
6. sleep / dressing — 1520 FT^2
7. lab — 130 FT^2
8. woodshop — 192 FT^2
9. vehicle storage — 264 FT^2
10. sewing — 35 FT^2
11. individual study — 360 FT^2
12. mechanical — 220 FT^2
13. entrance / exit.

TOTAL — 3940 FT^2 ≈ 4000 FT^2

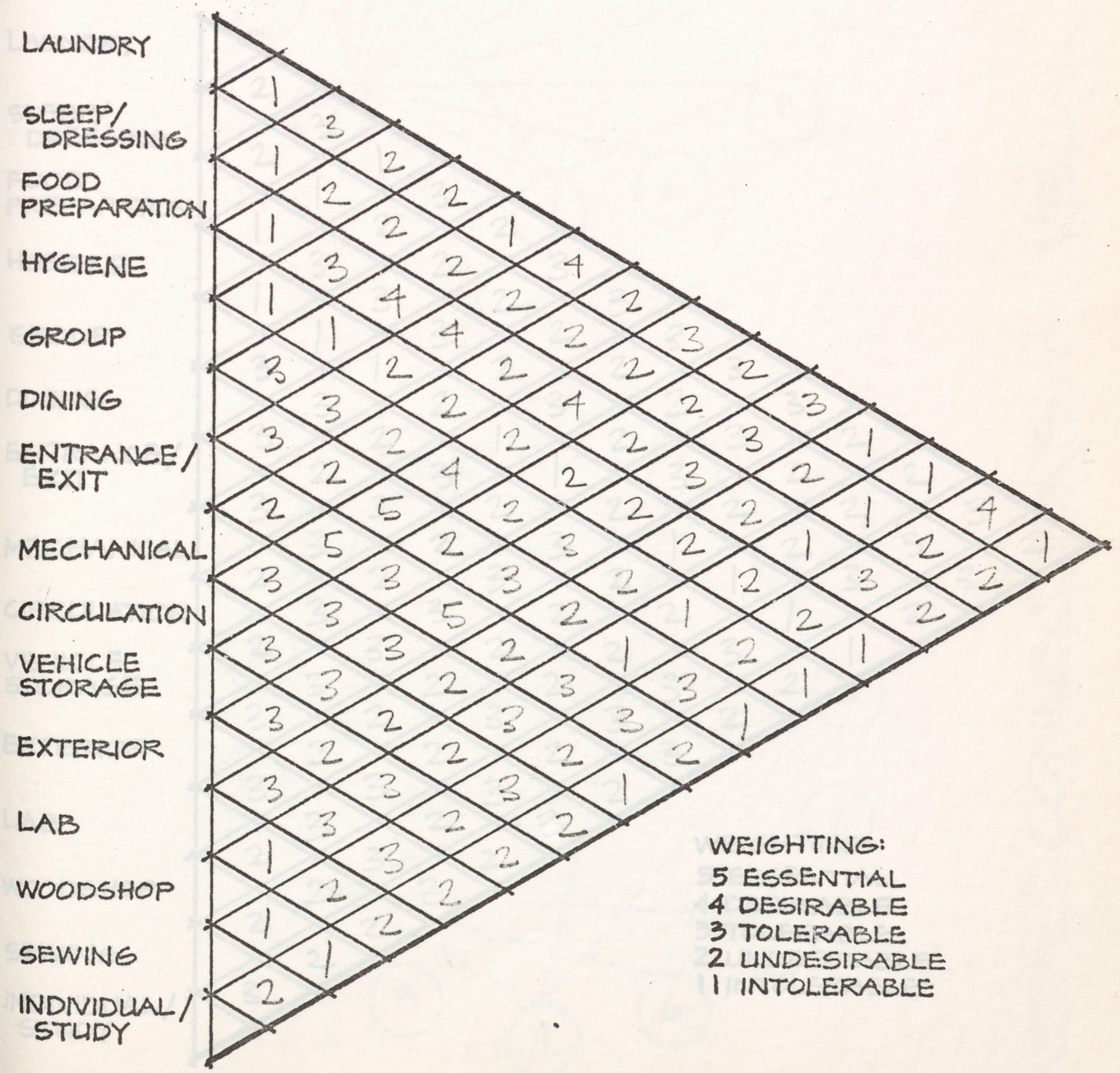
solar farm operations.

office — 60 FT^2
bathroom — 25 FT^2
shop — 512 FT^2

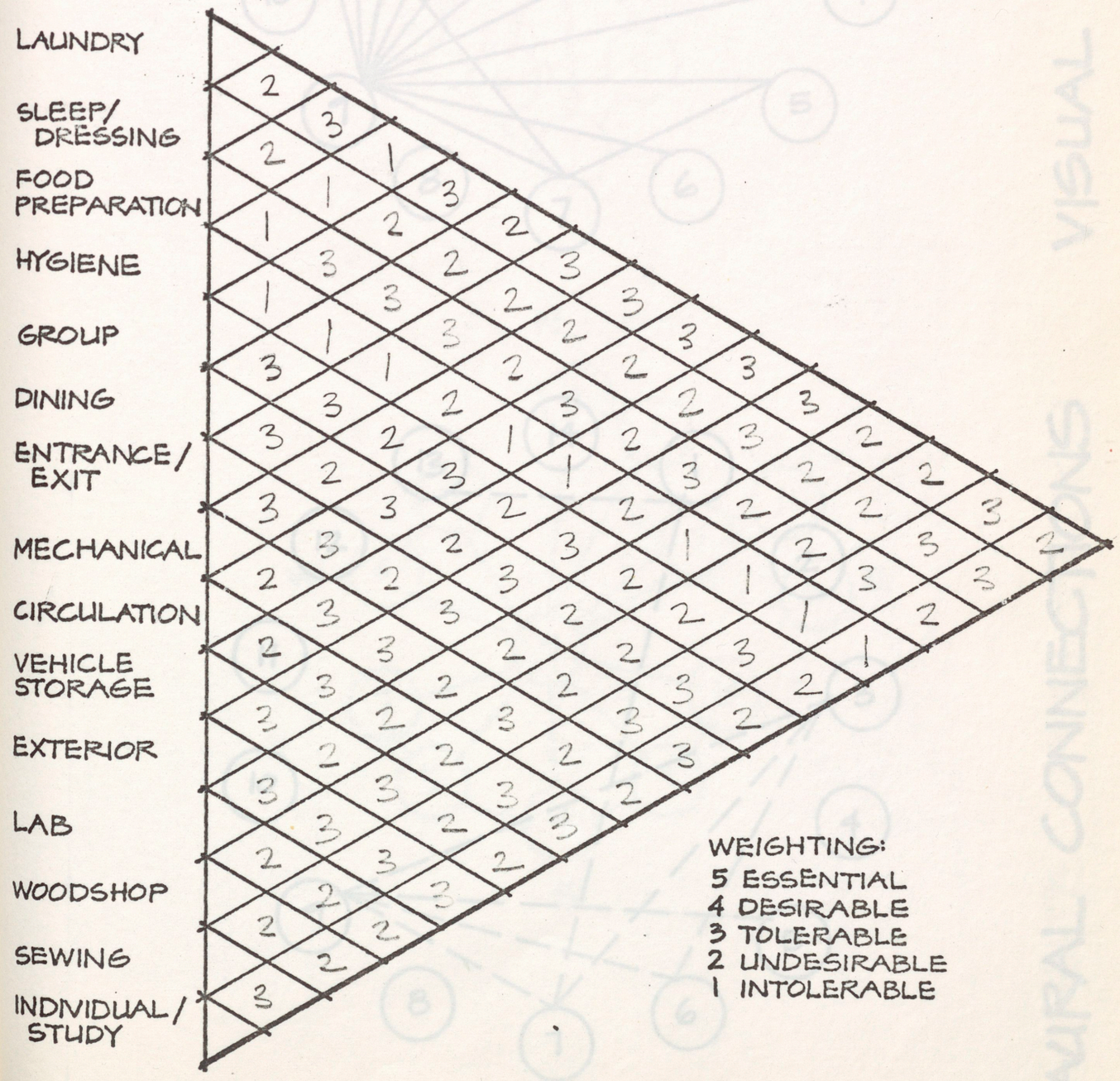
VISUAL CONNECTIONS



AUDITORY CONNECTIONS



OLFACTORY CONNECTIONS



WEIGHTING:
5 ESSENTIAL
4 DESIRABLE
3 TOLERABLE
2 UNDESIRABLE
1 INTOLERABLE

AURAL CONNECTIONS VISUAL CONNECTIONS

VISUAL CONNECTIONS

AURAL CONNECTIONS

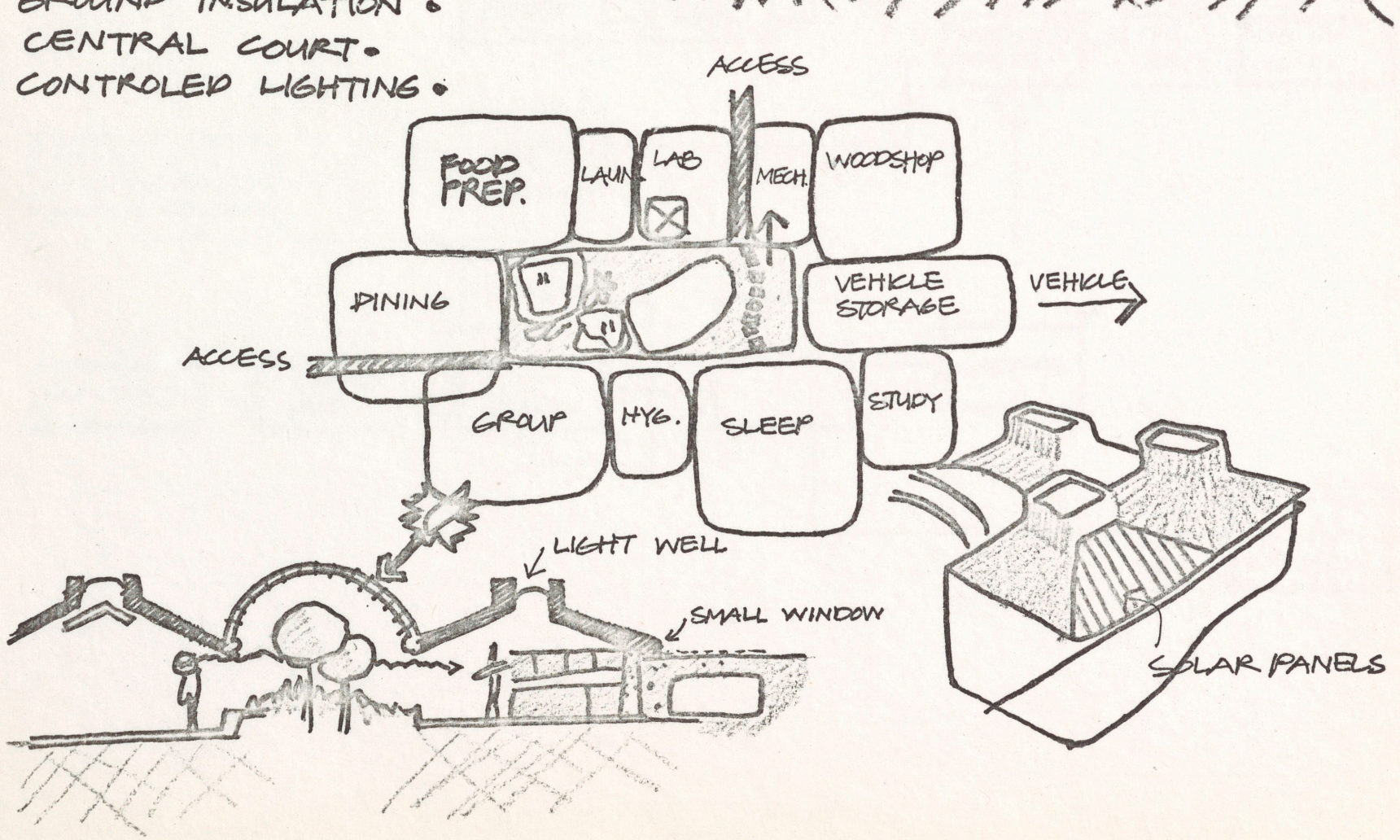
SITE ORIENTATION VISUAL + AURAL

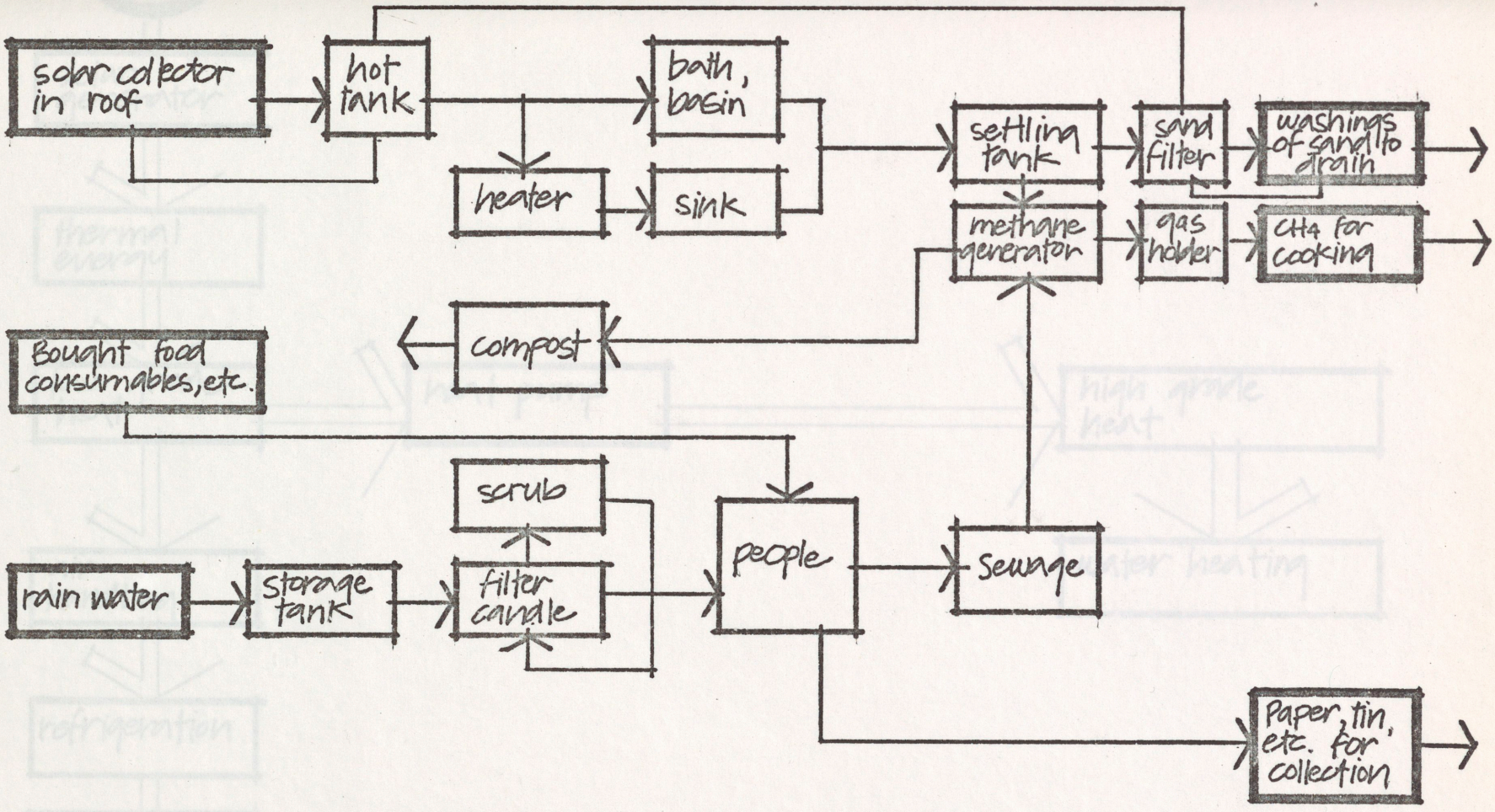
CONCEPT I :

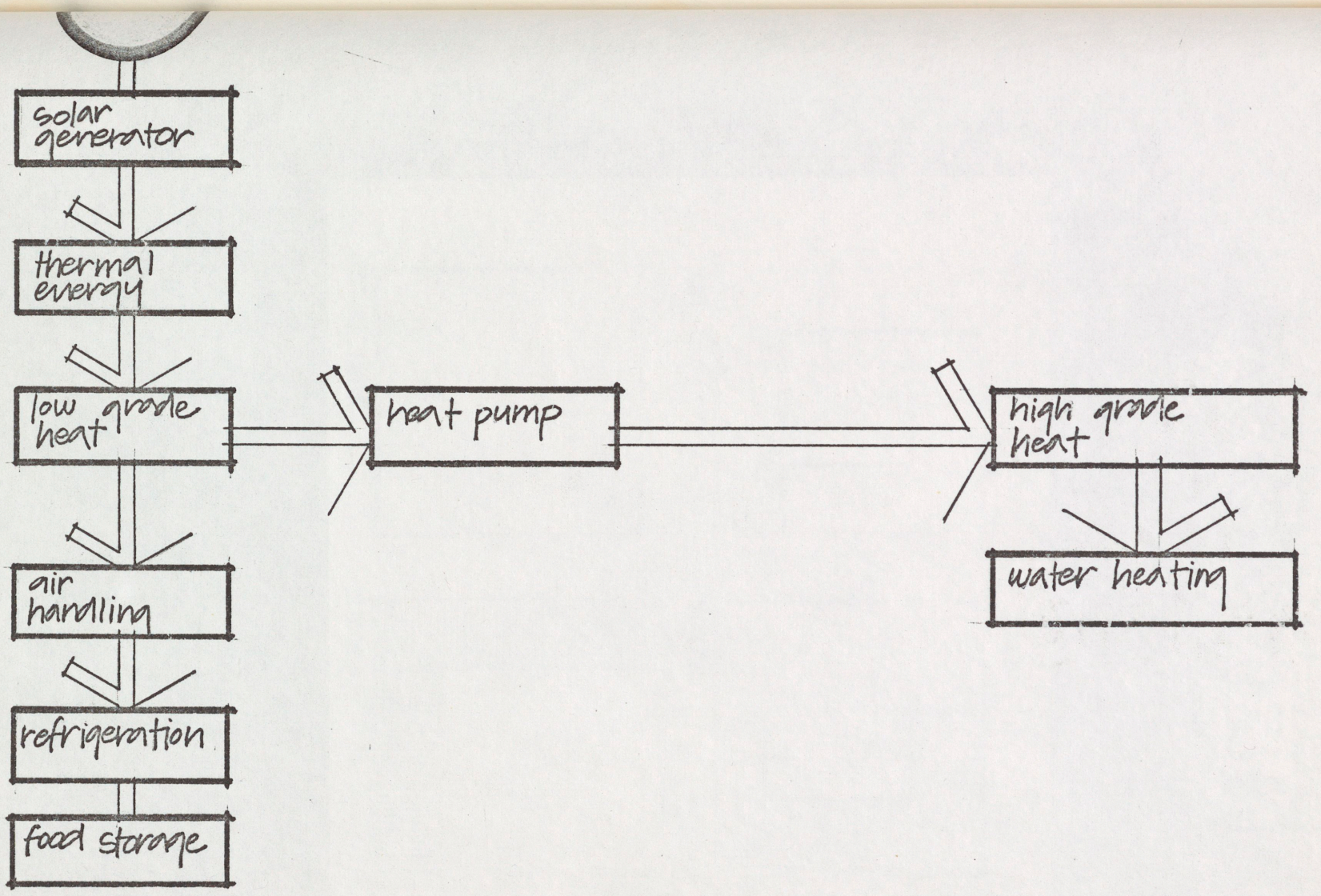
• THE MODULOR UNIT •

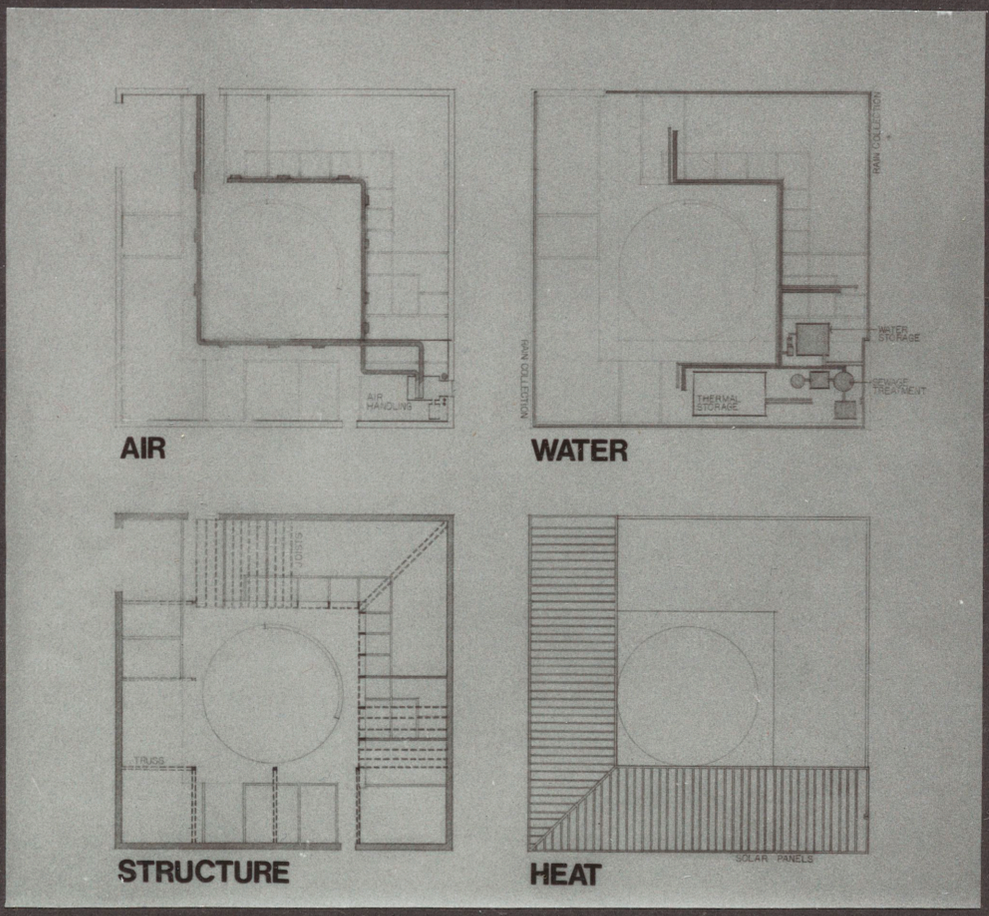


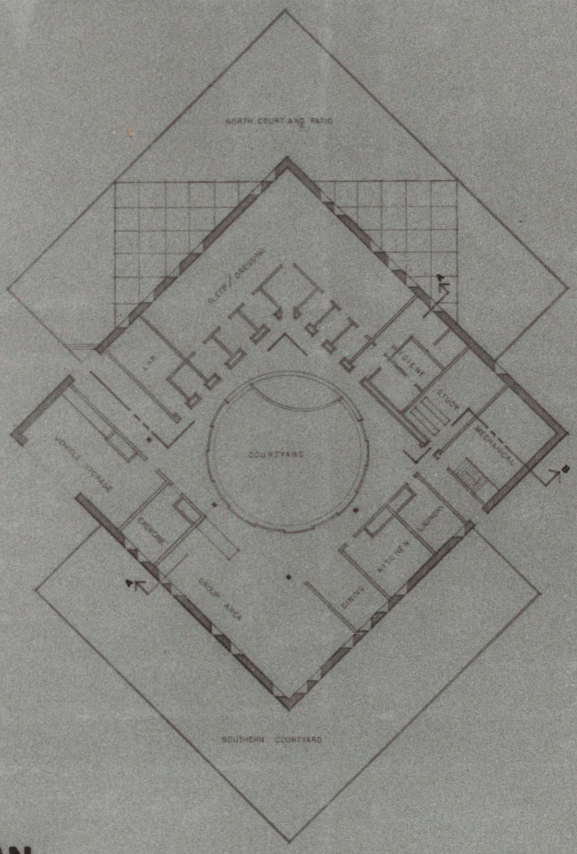
• GROUND INSULATION •
• CENTRAL COURT •
• CONTROLED LIGHTING •



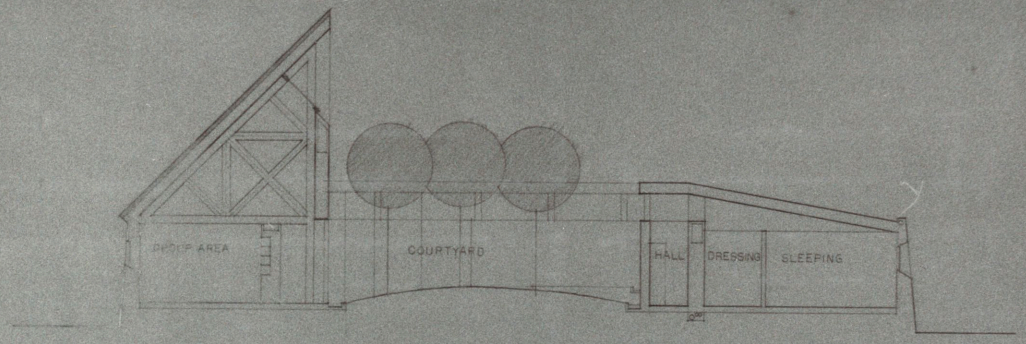

solar collector in roof
hot tank
bath, basin
heater
sink
settling tank
sand filter
washings of sand to drain
methane generator
gas holder
CH4 for cooking
compost
Bought food consumables, etc.
scrub
rain water
storage tank
filter candle
people
sewage
Paper, tin, etc. for collection


solar generator
thermal energy
low grade heat
heat pump
high grade heat
air handling
water heating
refrigeration
food storage

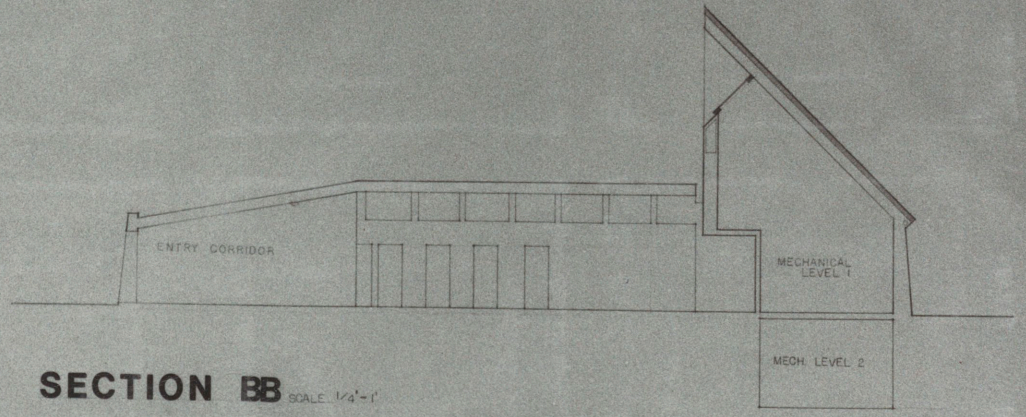

AIR HANDLING
AIR
RAIN COLLECTION
WATER STORAGE
SEWAGE TREATMENT
THERMAL STORAGE
WATER
TRUSS
STRUCTURE
SOLAR PANELS
HEAT



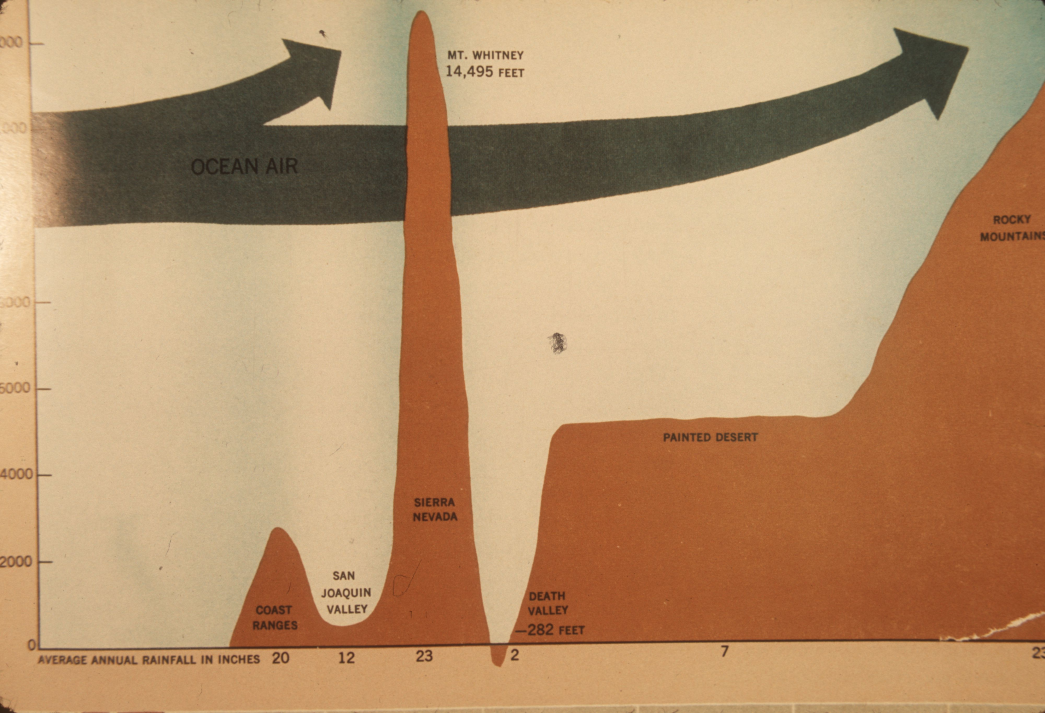
PLAN SCALE 1/8"-1'



SECTION AA SCALE 1/4"-1'



SECTION BB SCALE 1/4"-1'


MT. WHITNEY
14,495 FEET
OCEAN AIR
ROCKY MOUNTAINS
PAINTED DESERT
SIERRA NEVADA
SAN JOAQUIN VALLEY
COAST RANGES
DEATH VALLEY
—282 FEET
6000
5000
4000
2000
0
AVERAGE ANNUAL RAINFALL IN INCHES 20 12 23 2 7

OCEAN AIR

NORTH
AMERICAN
DESERT

CALIFORNIA CURRENT





















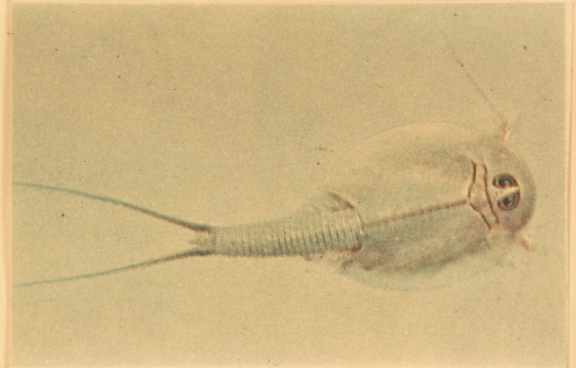




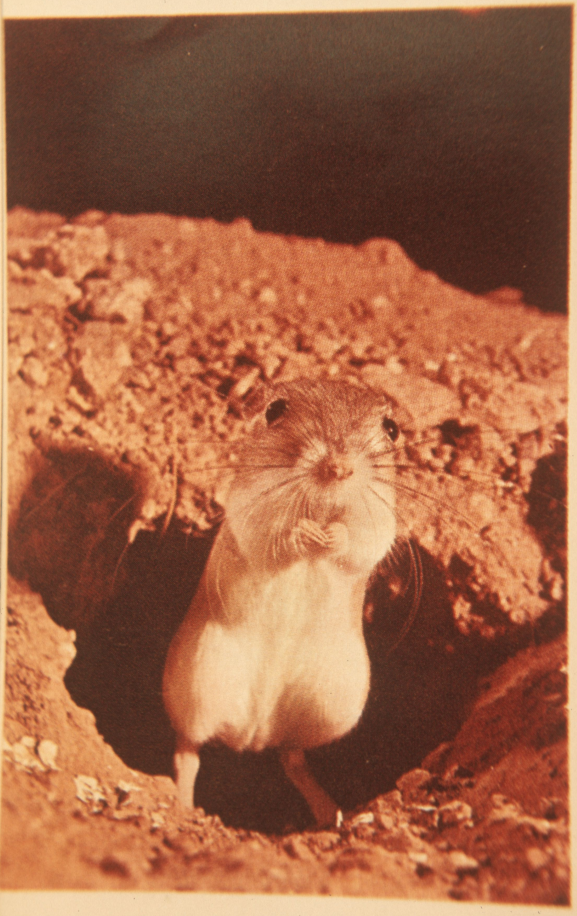












One of the most perfectly













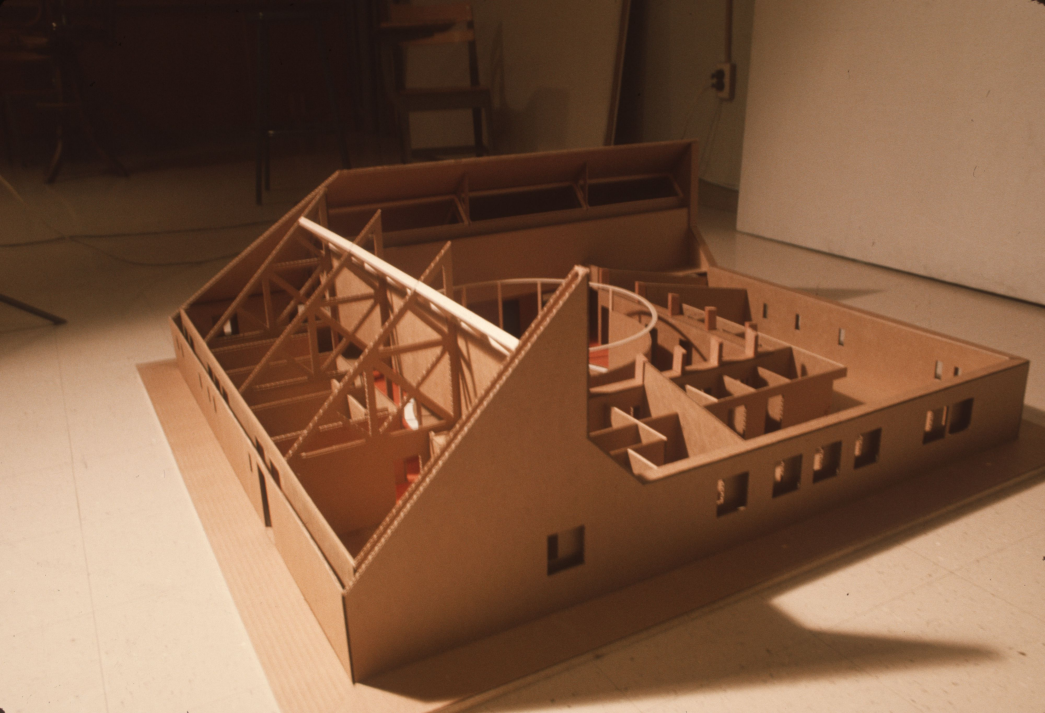


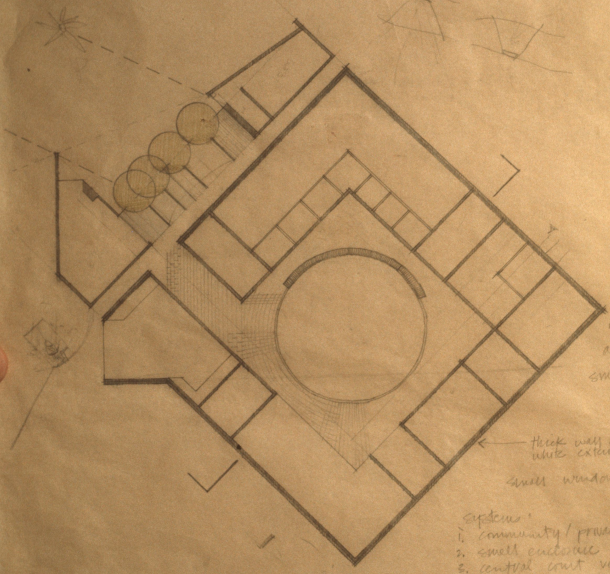


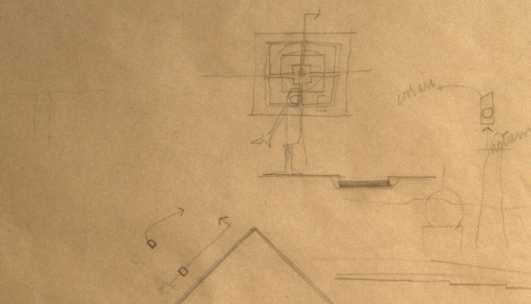


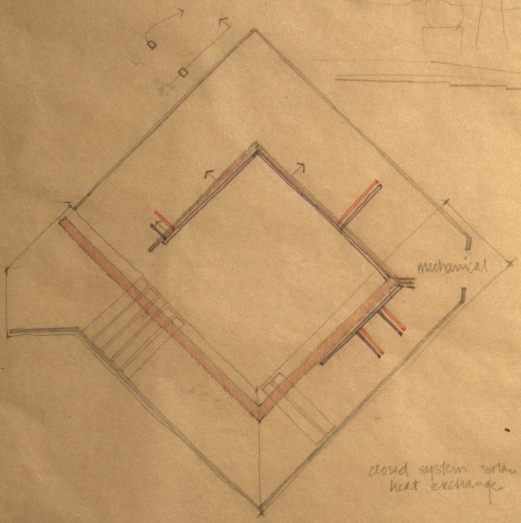







"knee" pulling
around court
small enclosure
thick wall
white exterior
small windows throughout
systems:
1. community / privacy - walls
2. small enclosure
3. central court ventilation
natural ventilation
4. circulation
5.





closed system solar collection
heat exchange

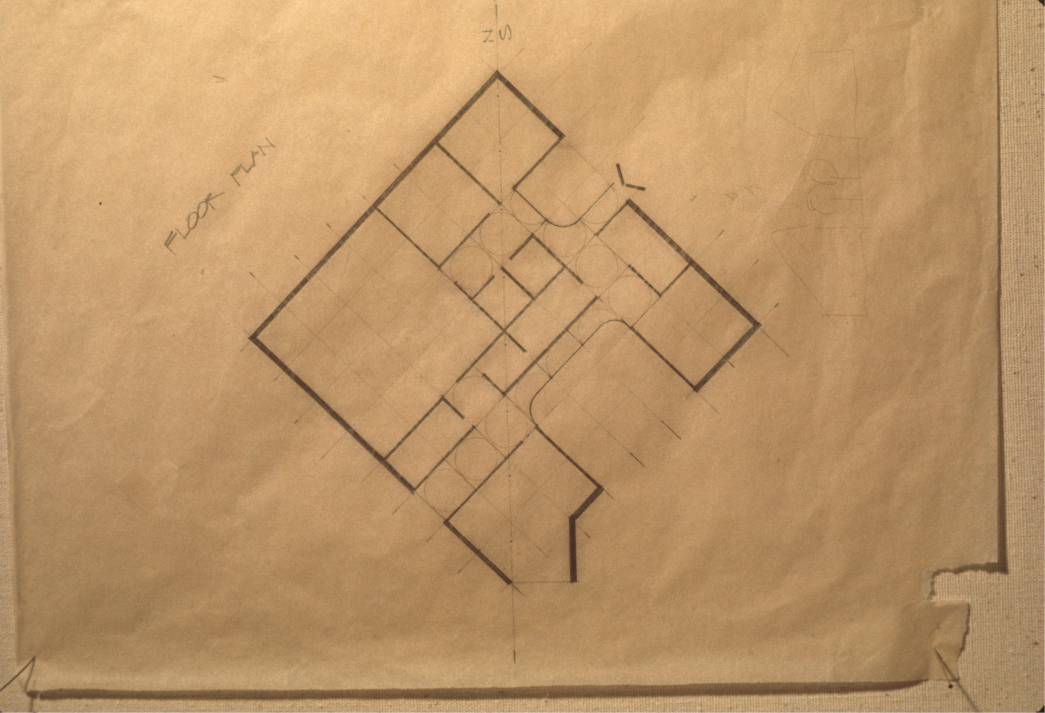


· mechanical system ·
zone living system
zone
water - sewer

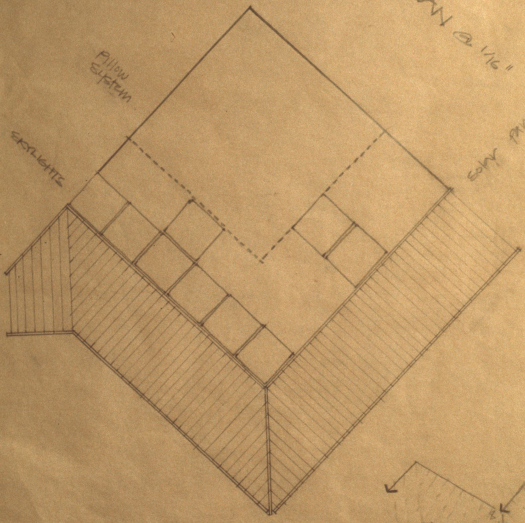


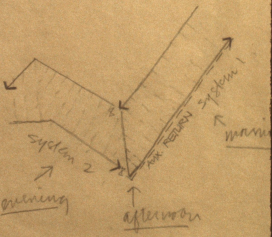


- open court
1. natural ventilation
- soft area on south
2. water collection and
3. community / privacy
4. light into the space
- north light

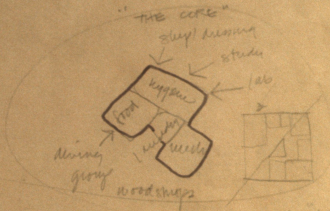

N
FLOOR PLAN

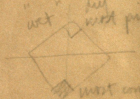
ROOF PLAN @ 1/16"



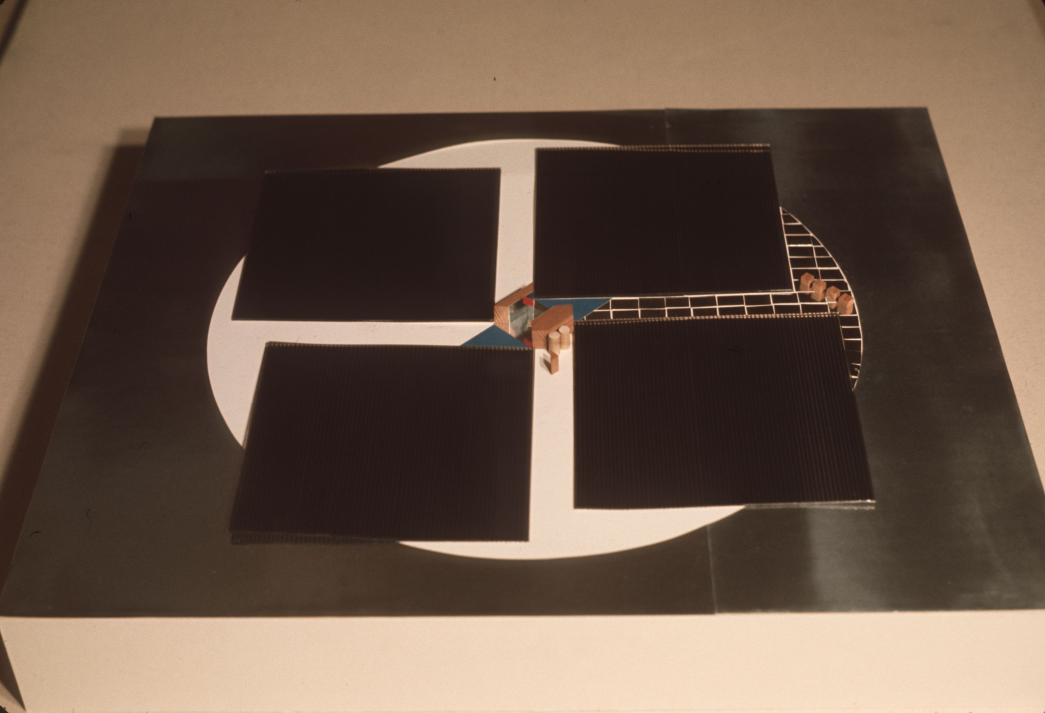


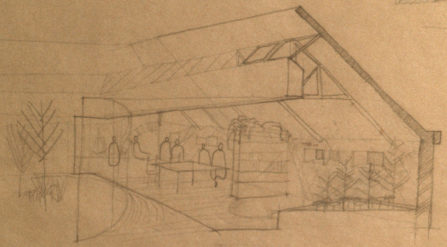

more private
steps
Vehicle
ABSORBENT PILLOWS
DRAIN
ROOF

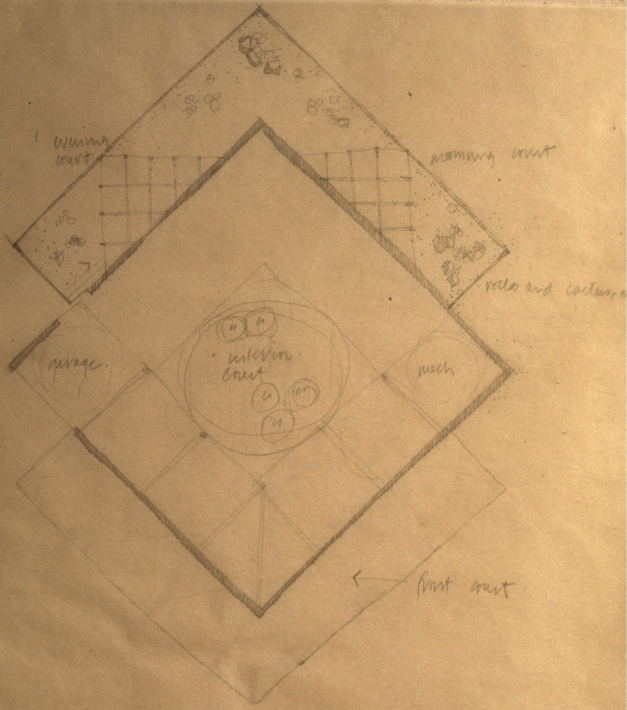

"THE CORE"
sleep/ dressing
studies
lab
eqpmt
food
gym
medical
dining
group
woodshops

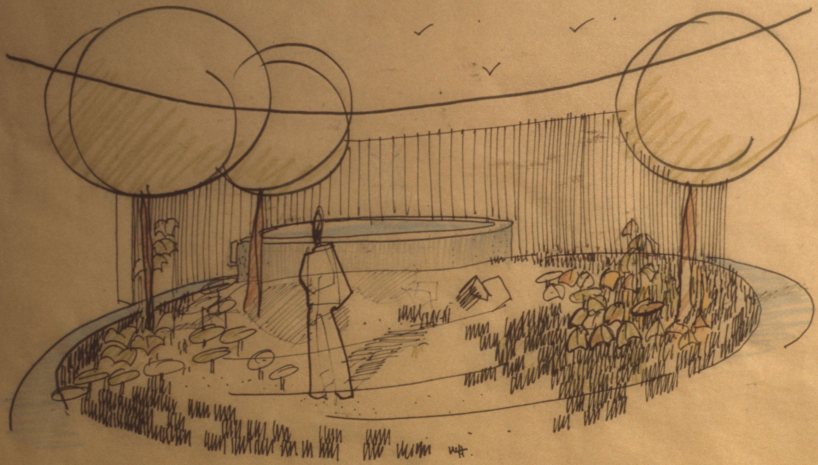

"art"
"sci"
with private
most command

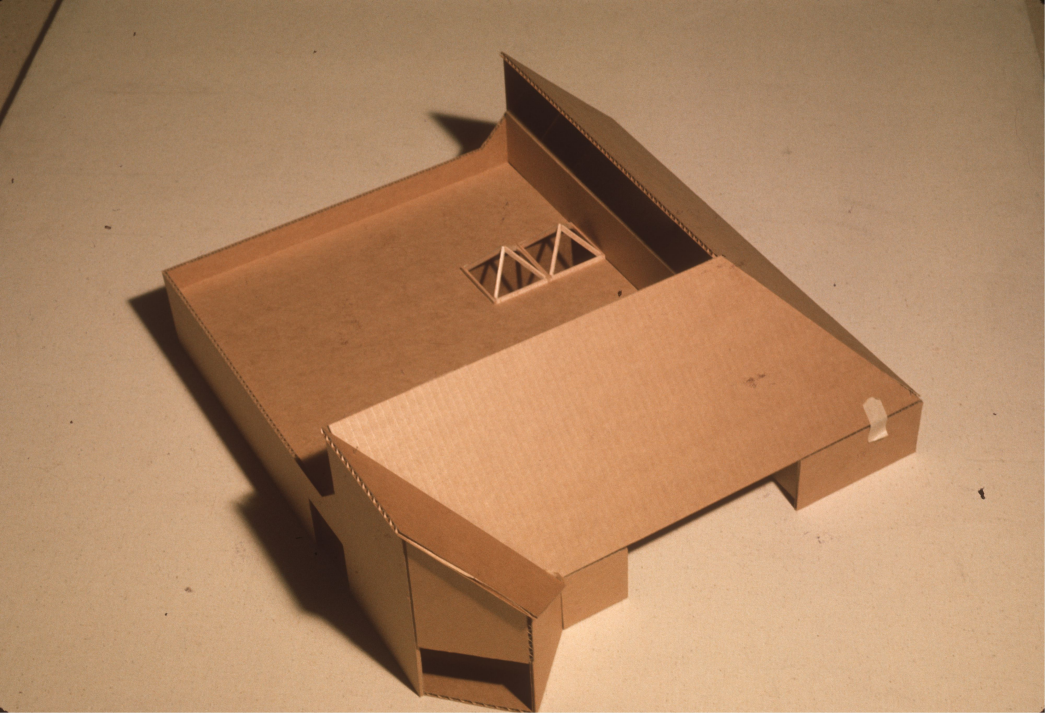
S
group.
class.
woodshop
vehicle storage
food
eqpmt
medical
study
lab
sleep/ dressing
steady light
uniform light
cool area
W
E
N

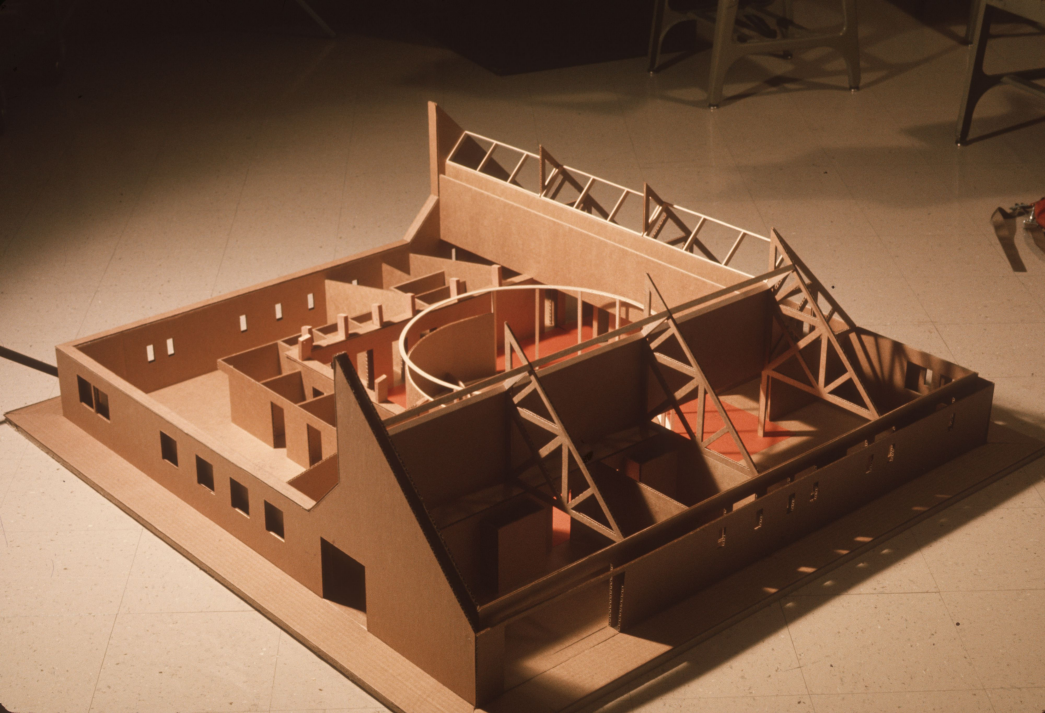


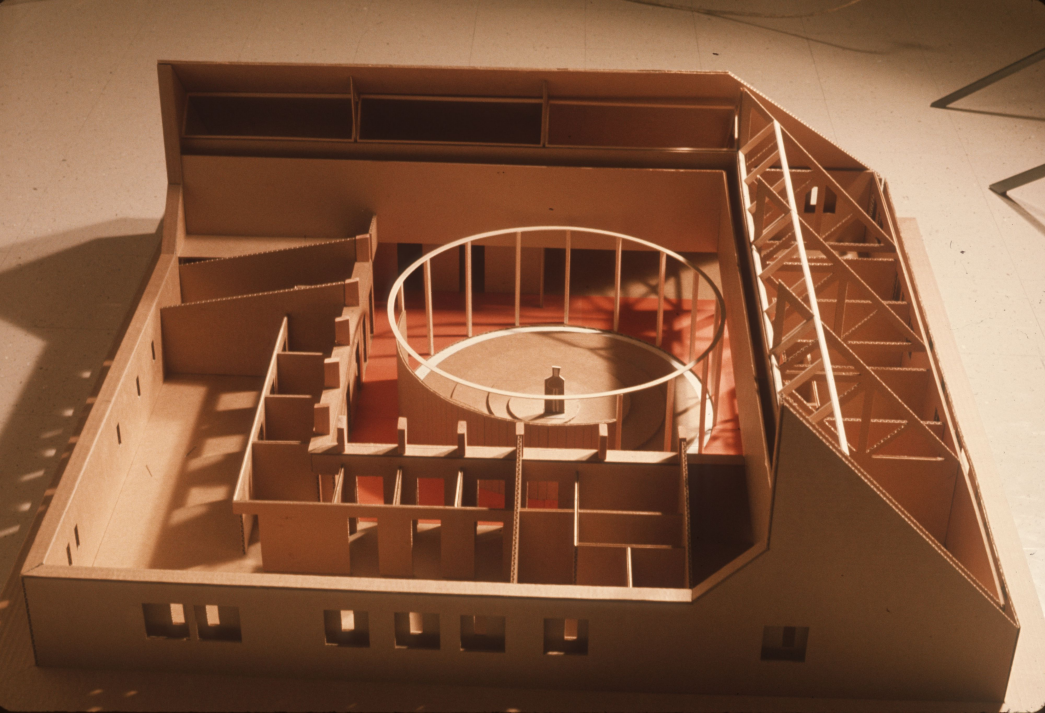



swimming court
swimming court
garage
interior court
mech
front court









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