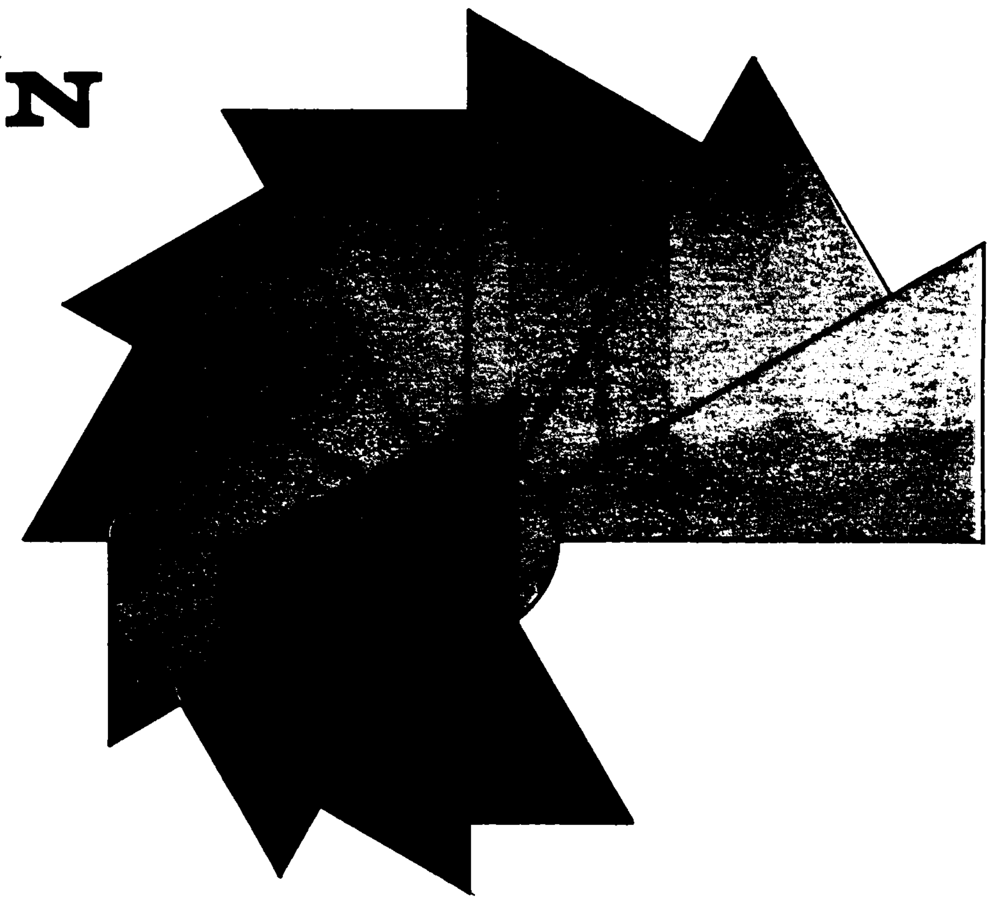
SOLAR

thesis program

# A SOLAR ENERGIES COMMISSION BUILDING



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by gary l. townsend

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# INTRODUCTION

Among the many problems facing us today are two crises that are more closely linked than is generally realized. We are beginning to choke on the waste of our machine age, and we are in sight of the end of fuel supplies for those machines which are the causes of environmental pollution. We continue to demand energy and more energy for the technological life we lead; and in so doing we foul the air, earth, and water while we reach ever nearer the bottom of the fuel bin.

As the world continues to develop its technology at such a rapid pace, certain contributions to this ever increasing technological boom are lagging far behind. The one real lag lies in the area of power resources. The conventional systems of power supplies are being rapidly depleted. The one real source of unlimited power has virtually been untapped, that of the sun.

Up to now the expenditure for solar energy research and development has been practically nil, and most of the work in this direction has been done by independent researchers. For years these solar prophets have pleaded, cajoled, and threatened. They have also blueprinted solutions to our problems. At last, in the face of serious environmental problems, they are being taken more seriously. The time seems ever more propitious for the coming age of the oldest source of energy there is.

This thesis combines some of their discoveries and thoughts into a center for their continued progress: a place for them to document their findings, research laboratories, library and technical reference, seminar and lecture areas, public and private exhibition space, and administrative offices on the corporate level made up of interested individuals connected with solar energy.

# CURRENT TRENDS

## the why ?

## ENERGY RESOURCES

Total energy use in the United States in 1970 amounted to 69 million billion BTU's. Seventeen million billion of these, or about 25 per cent, were used for production of electrical energy. They produced 1.7 million million Kwhr's; but during the generation process, about 2/3 of the original total BTU's were dissipated, so that the 1.7 million million Kwhr's is actually roughly equivalent to 5.7 million billion BTU's. If the amount of Kwhr's consumed by the construction and operation phases of the building industry are gathered together, they represent just under 50 per cent of all electrical usage and therefore about 12 per cent of the total energy usage for all purposes in the country today. (3:p.28)

### Coal Resources

One group of geologists, viewing with alarm the steadily increasing power requirements of modern man, warn that the world's coal resources won't last much beyond the end of the twentieth century. The Federal Geological Survey estimated the remaining coal reserves of the United States, including Alaska, at 1,660 billion short tons; at the 1968 rate of consumption of 369 million tons, this would mean that the United States reserves would last some 4,000 years. In Great Britain, the optimists estimate 250 years, the pessimists only 150 years. (The wide discrepancies stem from widely different estimates of consumption.) (1:p.8)

Among the European nations, West Germany leads with coal reserves for 1,792,000 billion kilowatthours, or more conveniently 1.8 quadrillion kwh. Next comes Great Britain with 1,368,000 billion kwh (1.4 quadrillion); France, a poor third, trails with a mere 96,000 billion (96 trillion) kilowatthours of reserve. (1:p.8)

Among the many other technical factors is the fact that the exploitation of coal seams is becoming more and more difficult as time goes on. Coal, at the present rate, has a life expectancy of 2,300 years. However, if the present rate of increase continues (and with gasification it would be increasingly exploited), it will be exhausted in 111 years. If reserves of five times the known resources were uncovered and made available, they would be exhausted in 150 years. (2:p.39)

## Petroleum

The status of our oil reserves is substantially less favorable than in the case of coal. According to a 1960 report of the U. S. Bureau of Mines, the estimated proved reserves of world petroleum as of December, 1958, were about 273 billion barrels (of 42 U. S. gallons each). While this represented an increase of some 167 per cent since December, 1951, the sad fact is that the demand is beginning to outstrip the capacity. The United States, which dominated the world's oil industry until about 1950 and produced more than half the world's oil, is now a net importer of crude petroleum; and the center of the world's known reserves has moved from the United States to the Middle East. The estimated U. S. crude petroleum reserves, according to the American Petroleum Institute and The American Gas Association, were 30.5 billion barrels. At the same time the United States demand for petroleum products was 3.3 billion barrels a year--so that if the United States had to be entirely self-supporting in petroleum, it would have less than ten years' supply of oil left in all of its wells. (2:p.9)

The U. S. Bureau of Mines report predicts that by 1975 the total U. S. demand for petroleum products will be 17 million barrels a day, or 6.2 billion barrels a year. This compares with the 1961 world crude oil production of 8.2 billion barrels. Total world crude oil demand will more than double by 1975. "As of 1960, world capacity is only 5 million barrels a day above present (1960) production of 18 million barrels a day. Oil will be plentiful for the next 15 or 20 years in spite of a great increase in demand. . . ." (1:p.9) In sight is the possible transportation of natural gas on a worldwide basis as a liquid carried in specially designed tankers.

Shifting from a scarce energy source to a momentarily more abundant one offers no particular encouragement. Gas and oil are used interchangeably for heating. Coal is used directly as well as indirectly through coal gasification and electricity production. Electricity, produced by gas, is used for heating--this, in competition with that heating done directly by gas. (2:p.39)

Number Two Oil is burned in gas turbine generators to heat houses that have since turned to electricity because they can no longer get Number Two Oil. As an option, refineries can refine petroleum for gasoline, for home heating oil, or for producing petro-chemical synthetics. As long as we have our primary commitment to fossil fuels, as we have for the next three decades at least, the shortages will have to be countered by changes in every energy-consuming field. (2:p.39)

The oil reserves of the Middle East are estimated by the same authorities as about 174 billion barrels, or about 65 per cent of the world's reserves. Next comes the Soviet Union, with an estimated 27 billion barrels. Then Venezuela, with about 16.5 billion barrels. Note that at the predicted 1975 rate of consumption, Venezuela's reserves would be used up in less than three years if the United States had no other source of supply. (1:p.9)

Western Europe's reserves are estimated at only 1.4 billion barrels; its production in 1961 (excluding Rumania) amounted to some 110 million barrels--about eleven days' supply for the oil-hungry United States if it were wholly dependent on Western European refineries. According to recent evidence of petroleum geologists, however, West Germany which produces about 42 million barrels a year, may be able to stretch its oil reserves a little longer than previously expected. It is a noteworthy fact that West Germany, with its oil reserves representing 593 billion kilowatthours, has almost caught up with Rumania. The latter is, of course, the largest European oil-producing nation (86.3 million barrels in 1961) and has the largest European reserves (enough for 644 billion kilowatthours). (1:p.10)

So far as the situation in other oil producing countries is concerned, the outlook is not too bright. Although the proved reserves of the Middle East have increased 239 per cent since 1951, the estimated 174 billion barrels would last the world only thirty years at the present consumption rate of 6.6 billion barrels; if this doubles or triples by 1975 as predicted, the 174 billion barrels of Middle East oil will accordingly last only about eight or ten years. (1:p.10)

The productive capacity of the Far East--i.e., Indonesia and Borneo--may last for about twenty years; that of Africa, not more than ten. The oil reserves of the Eastern Block of nations are estimated to be good for about twenty years at the current rate of exploitation, which averages about 100 million barrels. The Soviet Union, according to 1961 estimates, produces 1.2 billion barrels yearly, compared with approximately 2.6 billion barrels produced by the United States in the same year. (1:p.10)

All in all, the petroleum situation is alarming since the world reserves remain fairly static while the world consumption increases in almost geometric proportion. The

U. S. Bureau of Mines refers to United States increased consumption as a constant compound annual growth rate of 3.71 per cent from 1957. Up to now, the discovery of new oil reserves has been sufficient to counteract the recurring pessimism about the future oil supplies of the world. Although withdrawals from these reserves have increased from year to year, it has always been possible to offset them (as in the United States, Canada and West Germany) by new discoveries which have occasionally amounted to as much as twelve times the current volume of production. (1:p.10)

But the future of the world's oil supply, from the year 1970 on, seems to be largely a matter of chance. Even if we take the optimistic view and extend the deadlines on coal and oil by a few more decades, we will still not have answered the question at the beginning. Then what do we do for fuel? (1:p.10)

Hydroelectric

Water power is of considerable interest because there is little likelihood of its being exhausted in the next millennium or so. Surprisingly enough, however, water power accounts for only 1.8 per cent of all existing power sources. Even in the vast Tennessee Valley Authority system embracing some twenty-five dams, the installed generating capacity of about 12 million kilowatts is only 34 per cent hydroelectric, the bulk (66 per cent) being generated in coal-burning steam power plants. Grand Coulee power plant on the Columbia River is the world's largest power plant, and its 1,974,000 kilowatts are all hydroelectric. Undoubtedly there are still many undiscovered possibilities in the field of hydroelectric power, and the dwindling of fossil fuel reserves makes it quite imperative to exploit "white coal" more than ever before. (1:p.11)

Tidal Energy

Although the energy of the tides is enormous, few of the experts specializing in new power sources have devoted serious attention to harnessing it. The tidal level at the mouths of the world's rivers varies in height, attaining a maximum height of 53 feet. There is an astonishing amount of kinetic energy in the rise and fall of tides. France is presently working on a huge tidal project, calling for the construction of a high-capacity power plant in Brittany. The first phase of the project will consist of a pilot plant capable of furnishing 700 million kilowatthours annually. If this works out as expected, the entire Bay of St. Michel will be utilized as a power source. Here the peak level of high tide is about 43 feet, which means that tidal energy would supply 17 billion kilowatthours a year--enough to satisfy 30 per cent of the total power requirements of East and West Germany. Unfortunately, however, tidal energy for Germany has not as much promise as in other countries; for example, the difference in level of the North Sea and Baltic Sea between high and low tide is much less than it is on the French coast. (1:p.11)

The well-known English scientist J. B. S. Haldane has voiced an odd warning about the use of tidal energy. In his opinion, the unlimited exploitation of tidal energy will slow the rise and fall of the tides, which in turn will seriously affect the earth's rotation. As a result, the days would become longer, the moon would approach closer to the earth, and the end result would be the cataclysmic destruction of our planet. Haldane figures that it will take about 36 million years for the earth to be destroyed in this way, so that we have a free hand for at least the next five or ten thousand years. (1:p.12)

Professor Haldane's unusual theory has been challenged on scientific grounds. A slowing down of the earth's rotation because of tidal friction would, it is argued, cause the moon to move farther away from the earth instead of approaching it because the torque of the earth-moon system remains a constant. The moon would continue to recede from us until the periods of the earth's rotation and the moon's revolution were again of equal magnitude. (1:p.12)

Nuclear Power

Estimates as to how long the current "atomic age" will last have changed basically during the past decade. Whereas the early opinions were that there was a shortage of uranium deposits which would limit the atomic age to a few decades (according to authoritative United States experts), today the consensus is that the world supply of uranium and thorium, as well as other atomic raw materials, will last for roughly 2,000 years. This is the figure given by the contemporary British physicist Sir Charles G. Darwin. (1:p.12)

Nuclear power, or atomic energy, today enables us to create wholly new and versatile industrial complexes and to open up power sources of practically unlimited capacity. Atomic energy is the most important supplement to the traditional types of power. But we must be soberly realistic about what we can reasonably expect in this field. Experience has shown that a nuclear power plant designed for an output of 50,000 kilowatts requires about the same capital investment as one that can deliver from three to ten times as much power. Consequently only large plants are feasible. (1:p.12)

The effect of nuclear power on industry will be in every sense as dramatic as the effect of the steam engine or electric motor. Nevertheless, only the highly industrialized countries can meet the high cost of investment. Thus an equalization between the economically highly developed and underdeveloped areas cannot be expected at the outset. (1:p.12)

Given the governmental and social context of the crisis, it seems clear that no technical solution can begin to reverse this worsening situation for two to three decades.

The most optimistic projection for such new, abundant and nonpolluting sources--fusion and solar energy, especially--look to the mid-1980's for solar plant prototypes, and to the mid-1990's for fusion, if the technical problems can be overcome. The actual shift from fossil fuel to these other sources will take many years more.

It is fine and well to advocate pushing ahead the cut-off point for fossil fuels or, in contrast, advocate moving back the pickup point for fusion or solar generation. Either argument leads us back to the point where we must question our energy demands, even scrutinize them--back to the point where we must ask ourselves what is necessary, what is desirable. This is particularly so when one faces up to the consequences of unbridled increases in energy production, be it fossil (as some say it should be) or fusion (as some say it should be). (2:p.40)

In the perspectus of energy usage and conservation, other valuable resources are being depleted more rapidly than the earth can replenish them.

Aluminum, at the present rate of use, would (according to this source) last 100 years more; and, at an exponential rate of use, just 31 years. Copper, at the present rate, would last 36 years; and, with the exponential increase, 21 years. If we assume that five times the known supply were discovered, copper would last another 48 years. The figures for gold are 11, 9, and 29 years. The figures for iron are 240, 93, and 173. Lead weighs out at 26, 21 and 64; mercury at 13, 13 and 41; silver at 16, 13 and 42; tin at 17, 15 and 61; tungsten (used in high-grade steels) at 40, 28 and 72; and zinc at 23, 18 and 50. (2:p.39)

After analyzing the energy situation the world over, one can plainly see that at the present rate poeple will run out of fuels or pollute themselves to death in the very near future. Solar power seems to be a partial answer to many problems.

FOOTNOTES

1. Hans Rau, Solar Energy (New York: The MacMillan Company, 1964).

2. Richard G. Stein, "Architecture and Energy," The Architectural Forum (July/August, 1973).

3. "Richard Stein on Lighting and Energy Use," AS (Architectural Student) (Summer, 1973).

# TABLES

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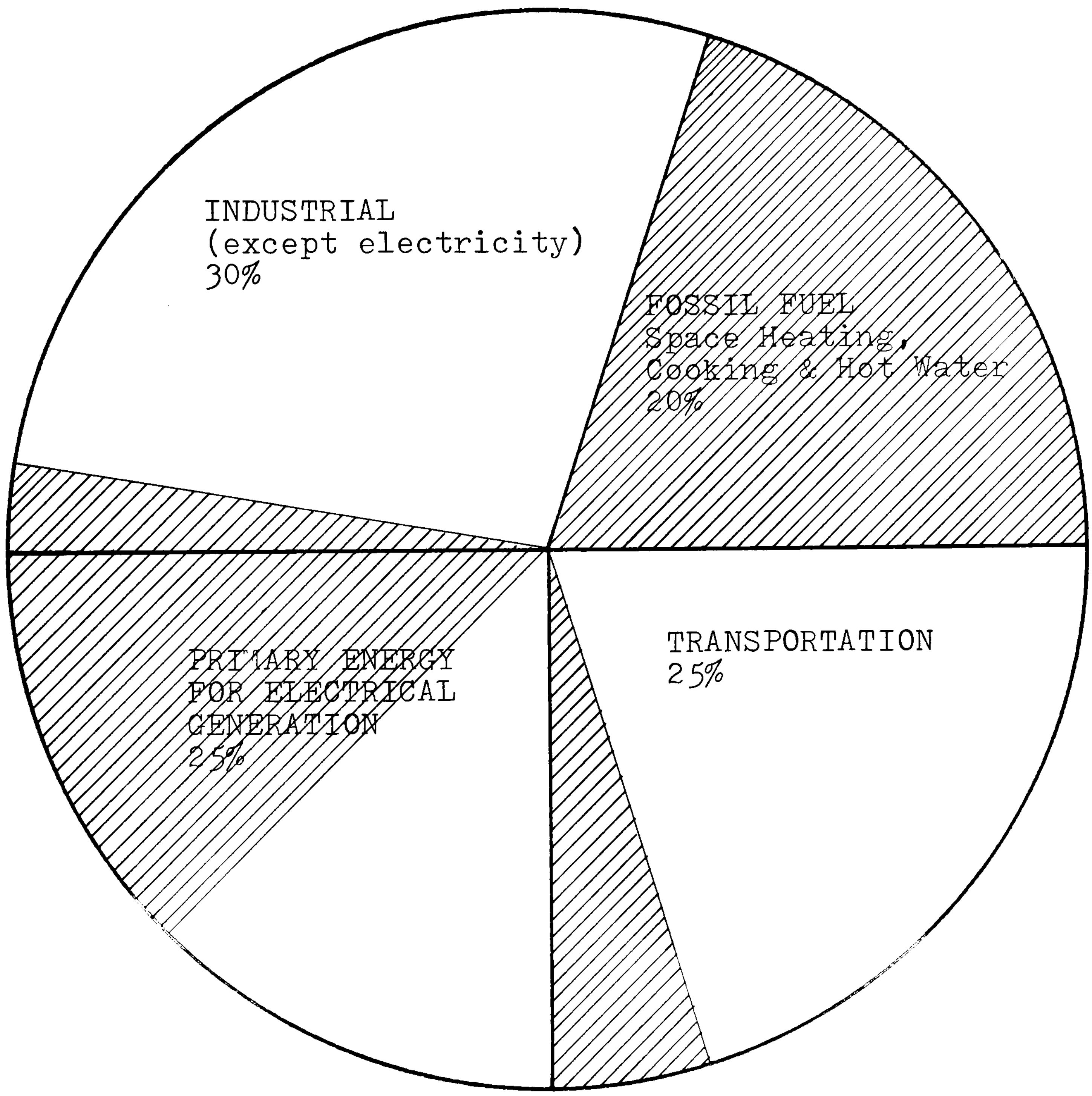
# FIGURES




# U.S. energy usage

SHADED AREAS AFFECTED BY
ARCHITECTURAL DECISIONS

SOURCE: The Architectural Forum
(July-August 1973) p. 44

Figure 1

| Countries | Million Btu per capita |
|---|---|
| United States | 300.00 |
| Sweden | 165.00 |
| USSR | 120.00 |
| Finland | 102.00 |
| France | 101.00 |
| Japan | 81.00 |
| New Zealand | 76.00 |
| India | 5.50 |
| El Salvador | 4.50 |
| Pakistan | 2.13 |
| Ethiopia | .67 |

**U.S. vs. World**

SOURCE: The Architectural Forum
(July-August 1973) p. 43

Table 1

| Continent or Country | Per cent of World Power Consumption |
|---|---|
| North America | 44.2 |
| Africa | 1.0 |
| South America | 7.1 |
| Asia | 10.7 |
| Europe | 24.5 |
| Soviet Union | 11.5 |
| Oceania | 0.9 |

**power consumption**

SOURCE: Rau's Solar Energy (1964) p. 8

Table 2

| Country or Continent | Coal | Oil | Natural Gas | Hydraulic Power | Power per capita 1,000 kwh |
|---|---|---|---|---|---|
| Africa | 614 | | | 1.5 | 10 |
| North America | 12,406 | 50 | 66 | | 75 |
| Central America | 26 | 3 | | | 2 |
| South America | 139 | 18 | | | 4 |
| Asia | 3,191 | 132 | | 1.0 | 3 |
| Europe | 5,107 | 2 | 3 | | 14 |
| Soviet Union | 10,447 | 16 | 10 | | 53 |
| Oceania | 240 | | | | 21 |

# POWER RESERVES in bil. k.w.h.

SOURCE: Rau's Solar Energy (1964) p. 7

Table 3

# PROPOSAL

PROPOSAL

Many individuals and some public institutions are every day undertaking the ever increasing struggle to harness some of the sun's energy. These people work under various circumstances, from an energy laboratory in Wisconsin to a deserted field in New Mexico. To do research and to study the problems of solar energy, one must exhaust every means possible to seek out both large and small discoveries which for the most part go unrecorded and unrecognized by others who may find these discoveries useful and in some cases improve on them. While doing my own research on solar energy, I found it very difficult to gain ground on the subject. Everyone seemed to be approaching the problem in an entirely different manner and most of the time almost in opposition to each other. I therefore felt that a common facility for all these various directions and ideas was desperately needed.

# A SOLAR ENERGIES COMMISSION BUILDING

proposed site:

LAKE HAVASU CITY, ARIZONA

# SOLAR

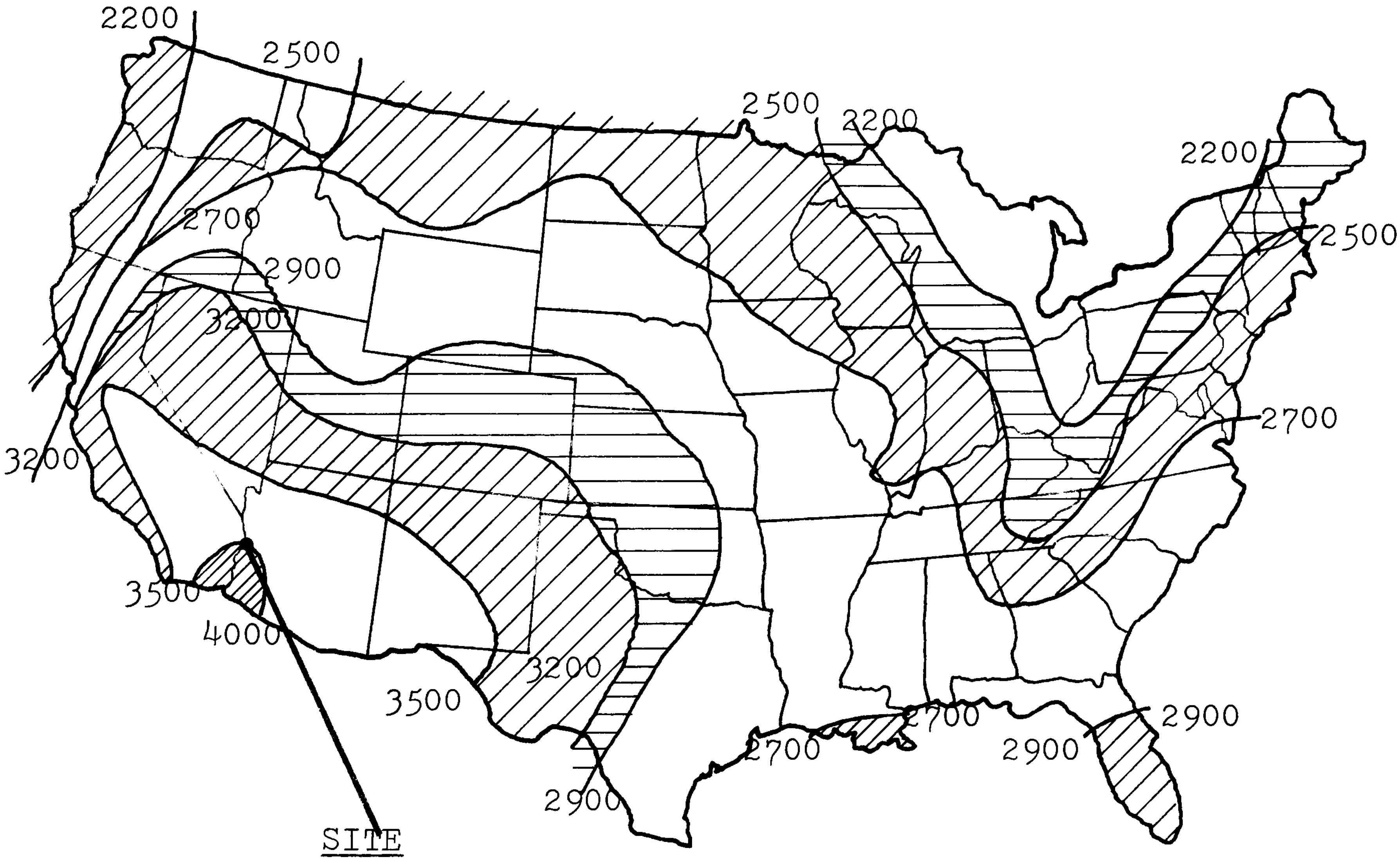
# SITE

SITE: (General)

The site location, Lake Havasu City, Arizona, was picked with a number of considerations in mind:

1. Use of solar energy is not practical in all locations or in all climates. Northern locations where winters are dark and where areas have very cloudy climates are not appropriate for the use of solar energy. The length of sunlight periods, the frequency and predictability of cloudy weather, and the height of the sun in the sky are all factors which must be considered. (See Figure 2) A record of the total number of hours of the day when a man can see his shadow, combined with data on the latitude and weather reports from a nearby station, could be used to determine the feasibility of installing solar devices in a given location. A simplified instrument for recording solar radiation on a normal surface as well as on a horizontal surface is also needed.
2. The McCulloch Corporation is a major land developer throughout the United States. Most of their development is in the form of new cities, and the majority of them are in the southwest portion of the country. Lake Havasu City, Arizona, is one of their newer ventures. Since this proposal is a new type of activity, Lake Havasu City was picked as a probable location.

3. Although solar radiation is a rather constant ratio, the atmospheric conditions at Lake Havasu City merit the proposal even more. There are 3,500 hours of sunshine in an average year, and therefore research could be a more continuous process than one where the seasons changed and weather conditions varied. (See Figure 2)




# U.S. sunshine hours per year

SOURCE: Visher's Climatic Atlas of the United States (1954) p. 177

Figure 2

<u>SITES</u>: (Specific)

After analyzing the Lake Havasu City area and studying the specific land use regulations that have been established, I have generally settled on seven preliminary site locations. (Refer to Figure 4 - Foldout)

SITE SELECTIONS

| Site | Zoning | Area (SF) Approx. | Frontage | Access | Comments |
|---|---|---|---|---|---|
| 1 | Recreation and Public Facilities | 500,000 | South | Industrial Boulevard | * |
| 2 | Industrial | 500,000 | South | Industrial Boulevard Havasu Ave. | * * |
| 3 | Commercial | 320,000 | Northeast | State Hwy. | * |
| 4 | Commercial | 320,000 | Northeast | State Hwy. | * |
| 5 | Industrial | 600,000 | North | Kiowa Blvd. | * * |
| 6 | Commercial | 320,000 | Northeast | State Hwy. | * |
| 7 | Industrial | 400,000 | West | State Hwy. Havasu Ave. | * * |

*Zone change required if site is selected

**No zone change required if site is selected

Site #1

This site has been selected as my first choice of location. The site is rather large, but the proposed facility may not utilize all the space and would therefore propose uses for the unused portion. The site is bound on the north and east by industrial zoning and bound on the west by Lake Havasu and its beaches. The southern boundry is recreation and public facilities. The site is approximately one and one-half miles from the airport, and access to and from the site is excellent on major boulevards and expressways. If this site is selected, a zone change from public recreation to industrial would be required.

Site #2

The second selected site requires no zone change and is zoned for industrial uses. The site is approximately the same square footage as chosen in Site #1 and may not be used in its entirety, thus proposals would be made for the unused portion. The site is bound on the north by industry, on the east by a major state highway, on the south by commercial zoning, and on the west by industrial zoning and Lake Havasu and its beaches. Access to and from the site is the same as Site #1.

Site #3, 4, & 6

These sites have been selected because (1) the frontage is on a major state highway that connects the industrial park, the airport, and all major commercial establishments throughout the city; and (2) the southern and western boundries are on Lake Havasu and its beaches and would therefore provide a scenic backdrop and natural landscaping to the site. If any one of these sites is selected, it would require a zone change from commercial zoning to industrial zoning but would in no way disturb the character of the surrounding businesses.

Site #5

This site was chosen in the industrial park area and requires no zone change. It fronts on the north by Kiowa Boulevard and a larger industrial park. The eastern boundry is also an industrial park. The southern boundry is light manufacturing, and the western boundry is a future state highway and light manufacturing. Access to and from the site is excellent on a major boulevard and state highway. It is well located in respect to airport travel, major thoroughfares, and businessmen coming and going to the other industrial sites in the area.

Site #7

Site #7 was chosen with the same respect given to travel as Site #5. It fronts on the west by a state highway, on the north by light manufacturing, on the east by light manufacturing, and on the south by commercial zoning.

Site selections were made in respect to the Declaration of Reservations established by the Architectural Review Board of Lake Havasu City. (See Appendix 2) Specific land use areas were laid out in the town for industrial purposes. The proposed facility falls into an industrial zoned area due to the use of chemicals and laboratories. Permission to change zones would be granted by the Review Board if the situation merits a change.

In respect to topography, the whole Lake Havasu basin is in a desert valley. There are mountains to the north, east, south and southwest. They are far enough in distance not to disturb the general topography of the land. (See Figure 5) All the sites are flat and on an average of 22 feet above sea level.

Rain, wind, and other natural climatic conditions have not been investigated because they do not affect the general proposal as it stands at present. The sun has been investigated as mentioned earlier and is one of the prime reasons Lake Havasu City was chosen as the location for the solar research building.

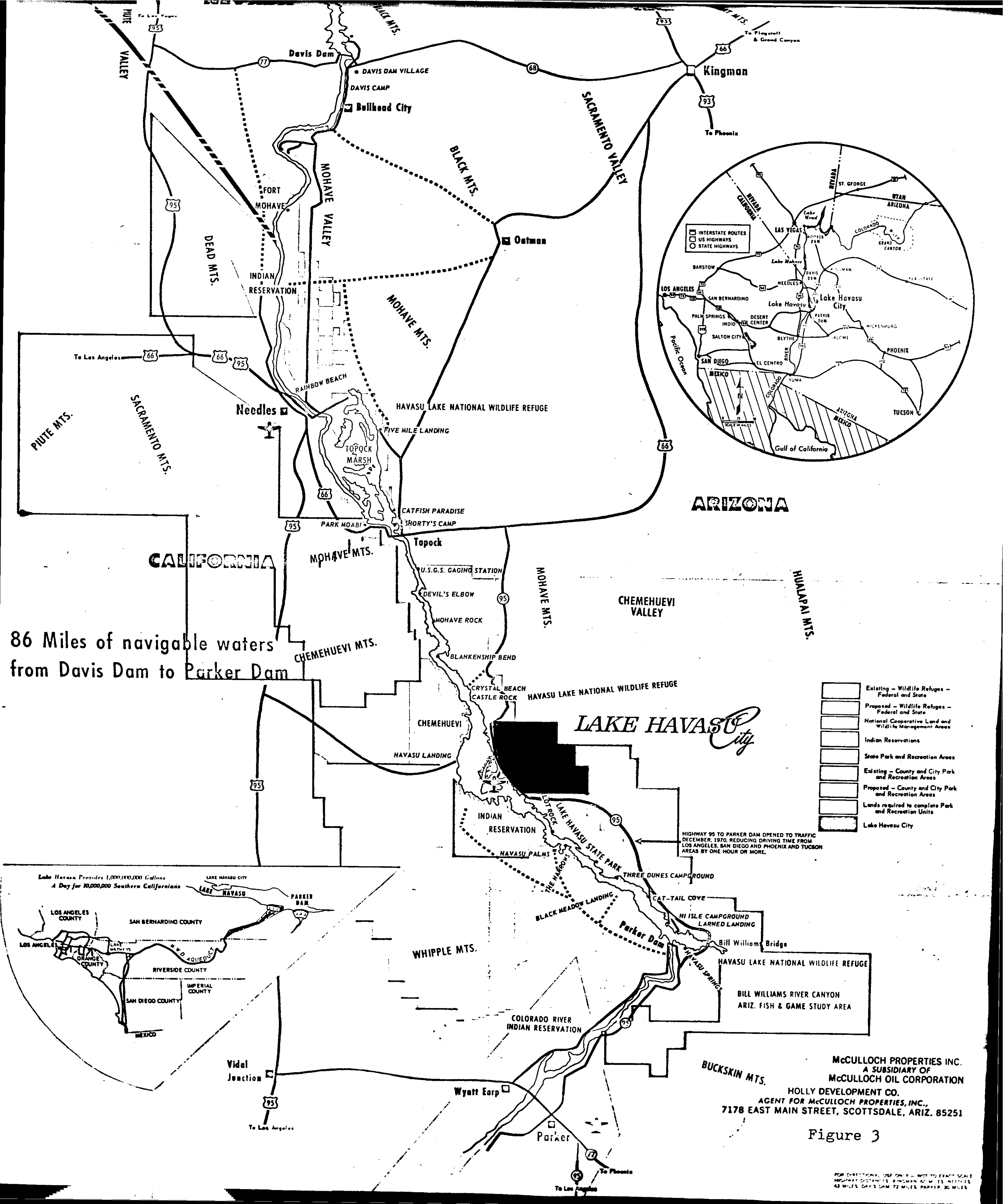
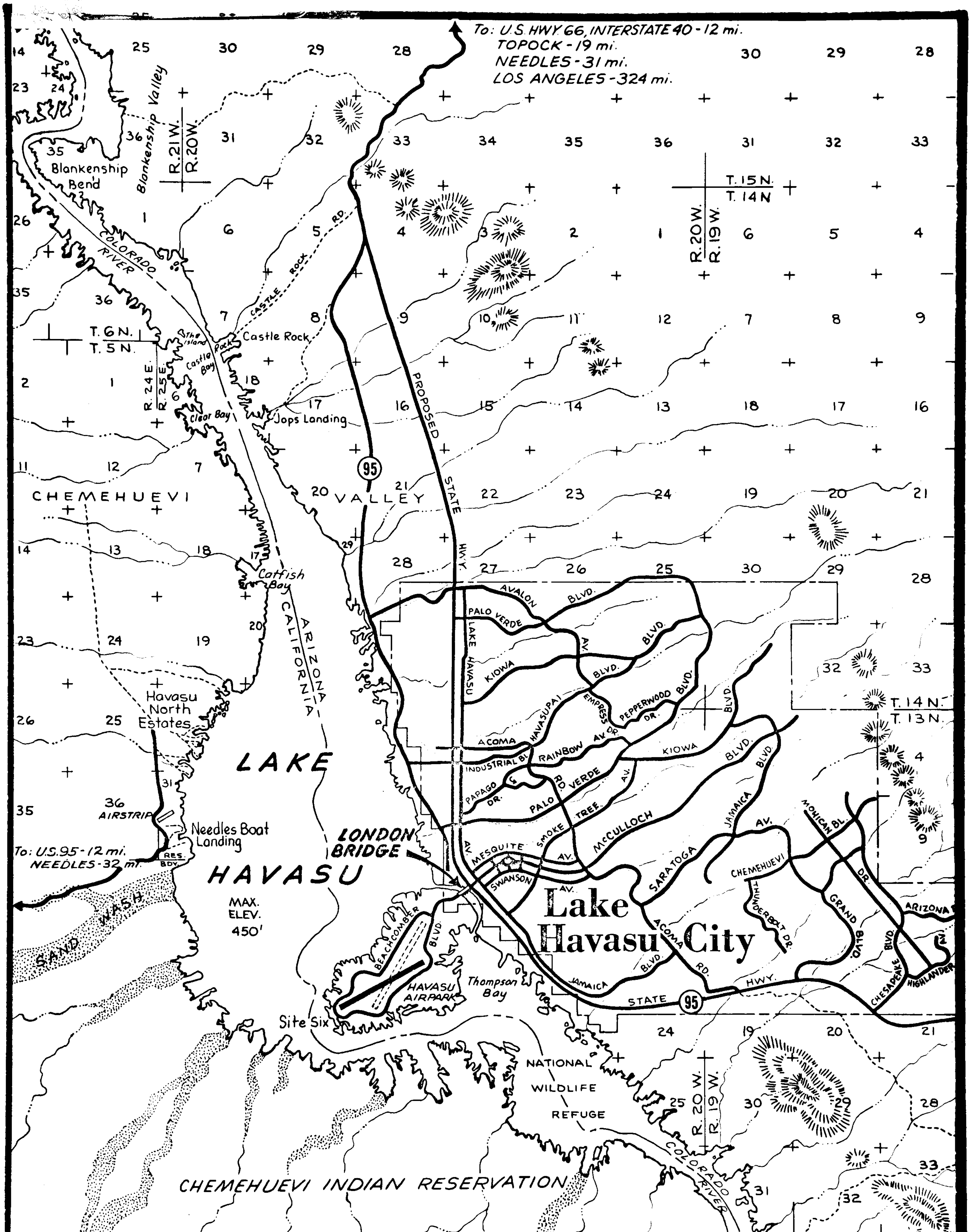

86 Miles of navigable waters
from Davis Dam to Parker Dam
ARIZONA
CALIFORNIA
LAKE HAVASU City
Davis Dam
DAVIS DAM VILLAGE
DAVIS CAMP
Bullhead City
Kingman
To Flagstaff & Grand Canyon
To Phoenix
SACRAMENTO VALLEY
BLACK MTS.
Oatman
MOHAVE VALLEY
MOHAVE MTS.
FORT MOHAVE
INDIAN RESERVATION
DEAD MTS.
PIUTE VALLEY
To Las Vegas
To Los Angeles
Needles
RAINBOW BEACH
PIUTE MTS.
SACRAMENTO MTS.
HAVASU LAKE NATIONAL WILDLIFE REFUGE
FIVE MILE LANDING
TOPOCK MARSH
CATFISH PARADISE
SHORTY'S CAMP
PARK MOABI
Topock
MOHAVE MTS.
U.S.G.S. GAGING STATION
DEVIL'S ELBOW
MOHAVE ROCK
BLANKENSHIP BEND
CRYSTAL BEACH
CASTLE ROCK
CHEMEHUEVI MTS.
CHEMEHUEVI VALLEY
HUALAPAI MTS.
CHEMEHUEVI
HAVASU LANDING
INDIAN RESERVATION
HAVASU PALMS
LOT ROCK
LAKE HAVASU STATE PARK
THE NARROWS
THREE DUNES CAMPGROUND
BLACK MEADOW LANDING
CAT-TAIL COVE
HI ISLE CAMPGROUND
LARNED LANDING
Parker Dam
Bill Williams Bridge
HAVASU SPRINGS
HAVASU LAKE NATIONAL WILDLIFE REFUGE
BILL WILLIAMS RIVER CANYON
ARIZ. FISH & GAME STUDY AREA
WHIPPLE MTS.
COLORADO RIVER INDIAN RESERVATION
BUCKSKIN MTS.
Vidal Junction
Wyatt Earp
Parker
To Phoenix
HIGHWAY 95 TO PARKER DAM OPENED TO TRAFFIC DECEMBER, 1970, REDUCING DRIVING TIME FROM LOS ANGELES, SAN DIEGO AND PHOENIX AND TUCSON AREAS BY ONE HOUR OR MORE.
Existing – Wildlife Refuges – Federal and State
Proposed – Wildlife Refuges – Federal and State
National Cooperative Land and Wildlife Management Areas
Indian Reservations
State Park and Recreation Areas
Existing – County and City Park and Recreation Areas
Proposed – County and City Park and Recreation Areas
Lands required to complete Park and Recreation Units
Lake Havasu City
INTERSTATE ROUTES
US HIGHWAYS
STATE HIGHWAYS
ST. GEORGE
UTAH
ARIZONA
NEVADA
CALIFORNIA
LAS VEGAS
HOOVER DAM
BARSTOW
LOS ANGELES
SAN BERNARDINO
NEEDLES
DAVIS DAM
Lake Havasu City
PARKER DAM
PALM SPRINGS
INDIO
DESERT CENTER
SALTON CITY
BLYTHE
SAN DIEGO
EL CENTRO
MEXICO
YUMA
PHOENIX
TUCSON
Pacific Ocean
Gulf of California
Lake Havasu Provides 1,000,000,000 Gallons A Day for 10,000,000 Southern Californians
LAKE HAVASU CITY
LAKE HAVASU
PARKER DAM
LOS ANGELES COUNTY
SAN BERNARDINO COUNTY
LOS ANGELES
ORANGE COUNTY
RIVERSIDE COUNTY
IMPERIAL COUNTY
SAN DIEGO COUNTY
MEXICO
M W D AQUEDUCT
McCULLOCH PROPERTIES INC.
A SUBSIDIARY OF
McCULLOCH OIL CORPORATION
HOLLY DEVELOPMENT CO.
AGENT FOR McCULLOCH PROPERTIES, INC.,
7178 EAST MAIN STREET, SCOTTSDALE, ARIZ. 85251

Figure 3


To: U.S. HWY. 66, INTERSTATE 40 - 12 mi.
TOPOCK - 19 mi.
NEEDLES - 31 mi.
LOS ANGELES - 324 mi.
Blankenship Valley
Blankenship Bend
R. 21 W.
R. 20 W.
T. 15 N.
T. 14 N.
R. 20 W.
R. 19 W.
COLORADO RIVER
CASTLE ROCK RD.
T. 6 N.
T. 5 N.
The Island
Castle Rock
Castle Bay
Castle Rock
R. 24 E.
R. 25 E.
Clear Bay
Jops Landing
PROPOSED STATE HWY.
95
CHEMEHUEVI VALLEY
Catfish Bay
ARIZONA
CALIFORNIA
Havasu North Estates
LAKE HAVASU
MAX. ELEV. 450'
AIRSTRIP
Needles Boat Landing
To: U.S. 95 - 12 mi.
NEEDLES - 32 mi.
RES. BDY.
SAND WASH
LONDON BRIDGE
AVALON BLVD.
PALO VERDE BLVD.
LAKE HAVASU AV.
KIOWA BLVD.
EMPRESS DR.
PEPPERWOOD DR.
HAVASUPAI BLVD.
ACOMA
INDUSTRIAL BL.
RAINBOW AV.
KIOWA BLVD.
PAPAGO DR.
PALO VERDE
SMOKE TREE AV.
McCULLOCH BLVD.
JAMAICA BLVD.
SARATOGA AV.
MESQUITE AV.
SWANSON AV.
MOHICAN BL.
CHEMEHUEVI DR.
THUNDERBOLT DR.
GRAND BLVD.
ARIZONA
ACOMA BLVD.
JAMAICA
STATE HWY. 95
CHESAPEAKE BLVD.
HIGHLANDER
BEACHCOMBER BLVD
T. 14 N.
T. 13 N.
Lake Havasu City
HAVASU AIRPARK
Thompson Bay
Site Six
NATIONAL WILDLIFE REFUGE
R. 20 W.
R. 19 W.
COLORADO RIVER
CHEMEHUEVI INDIAN RESERVATION
Pilot Rock
Whipple Pt.
Beaver Pt.
Roads End
Havasu Palms
LANDING STRIP
SAN BERN
Res. Bdy.
T. 4 N.
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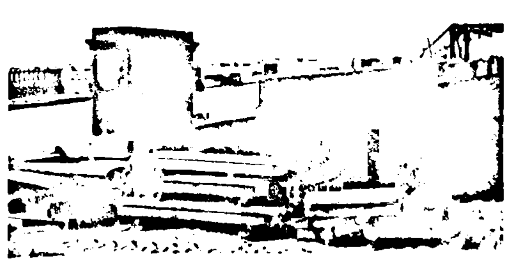

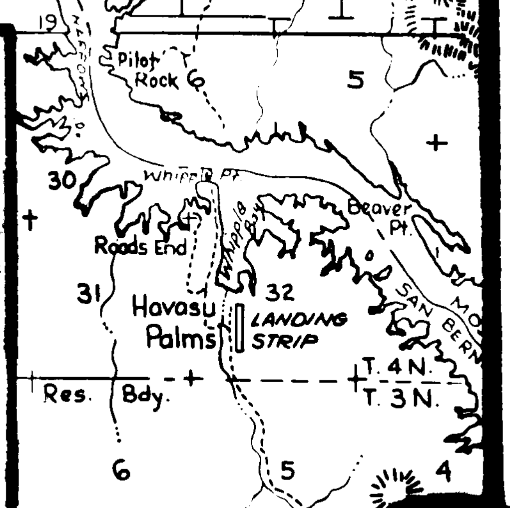

# SOLAR

# FACILITY

FACILITY (General Concept Part 1)

The Solar Energies Commission Building itself must not be a tribute to the pioneers of solar research but rather an example of various kinds of application of the use of the sun's energy: potential uses that can have the capacity to change with technology. The following outline and description called "Facility" is the conceptual stage of the physical function relation.

A. Administration
   1. Board of Directors
   2. President
   3. Staff
   4. Research Personnel
   5. General Labor Force

B. Spaces
   1. Offices
   2. Lounges
   3. Conversation

C. Laboratory Facilities
   1. Heating - Research
   2. Cooling - Research
   3. Chemical Laboratory
   4. Mechanical Laboratory
   5. Different Scales of Application of Principles

D. Research
   1. Library
   2. Communications
   3. Grants
   4. Computer
   5. Research Area to Public Information

E. Exhibits
   1. Building Itself
   2. Public
   3. Researchers
   4. Public Relations

F. Education
   1. Public Assemblies
   2. Seminars
   3. Lectures and Presentations

A. Administration

1. Board of Directors

McCulloch Corporation, as principal financier, would make up part of the Board of Directors; the rest of the members would be comprised of architects, engineers, scientists, chemists and people deeply involved with solar research. They would function primarily as consultants and promoters of projects to utilize the commission's findings in actual application.

2. President

The president would be appointed by the Board. His qualifications would be left to the Board but obviously would be sold on solar energy. He would run the commission on a business level, including hiring and firing of personnel and appropriating money for projects; and he would act generally as a laison between the commission, agencies and the general public.

3. Staff

The staff required to operate the commission would generally come from many specific fields of study throughout the United States and any foreign country striving for achievement in the Solar Energy field. The chief research personnel in the different fields would be paid a salary, and they in turn would be responsible for the hiring of staff personnel for their specific research. Many of the personnel working through the commission could possibly be students at the many universities and colleges throughout the country.

4. Research Personnel

   Research personnel would vary from time to time in accordance with the specific research being done at any time. I can foresee a need for mechanical engineers, architects, and scientists from other fields doing research on projects that are sometimes different and at other times very much related or the same.

5. Labor Force

   As mentioned previously, many of the general labor force could and probably should be comprised of students from the world over. When student help is not available, other sources of labor would have to be drawn on for a labor force. With as much interest being generated concerning solar energy, there will be no problem of an interested labor force.

B. Spaces

1. Offices

   Since the Commission is established and set up on the corporate level, offices for management must be a part of the unity of the project. Space must be provided for visiting researchers, who may come for any period of time (1 day--1 year).

2. Lounges

   Areas and spaces will be allotted for relaxation and breaks from the research. Such areas will probably connect various functional parts that will aid in a relaxed atmosphere for study and research.

3. Conversation Spaces

   These areas are probably identical to lounges and relaxation spaces. People may meet here and freely discuss things privately or publicly.

The design of this category called Spaces will be a key factor in the successfulness of the unity of the facility.

   a. Offices may each demonstrate a unique use of Solar Energy in an office environment

   b. These spaces will tend to give first impressions of Solar Energy potential to the public visitors

   c. The spaces as related to other work areas may be a use of Solar Energy without structure or mechanics

   d. These spaces should show formal and informal usage.

C. Laboratory Facilities

Laboratory facilities in the Commission Building will be the primary element for the application of Solar Energy. To gain a general feeling of the type of research that will be done in the various laboratories, see Appendix 1.

Types of Laboratories:

1. Heating
   a. direct use of sun rays
   b. storage of heated air
   c. storage of heated water and chemicals
   d. storage of heated water
   e. storage of heated chemicals
   f. storage of heat by other means, rock, sand, earth, etc.

   Designing areas must encompass the following:

   (1) area must be provided for storage
   (2) area must be provided for outside study--this will be the main type of facility
   (3) area must be provided for application of discoveries and exhibits
   (4) area must be provided for safety reasons due to certain application
   (5) area must be located as to use other laboratory areas to overlap research
   (6) area must be safe for public tours

2. Cooling

For the solar experiments concerning the cooling research, the same factors apply as those that apply to heating. Perhaps the nature of these two in relationship with each other suggests they should be in the same area or at least have the overlapping of facilities although some of the research involving heating would not necessarily involve cooling and vice-versa.

3. Chemical Laboratory

The chemical lab will study the direct application of solar energy when chemicals are used.

a. storage of energy by the use of chemicals
b. study of chemicals
c. safe storage
d. study of possible harm to other materials
e. study of possible building code changes to allow solar storage with chemicals

Designing areas must encompass the following:

(1) area must be located in relationship to actual usage in studies
(2) area must have chemical analysis facilities
(3) area must be safe in relationship to other areas
(4) area must have storage facilities

4. Mechanical Laboratory

The mechanical lab will primarily build all projects research is being done on. They will study direct application on the building level.

a. use of solar energy in systems

b. use of solar energy with building materials

c. structural feasibility

d. life expectancy of system, etc.

Designing areas must encompass the following:

(1) storage area for materials

(2) loading and unloading of materials

(3) possibly in connection with seminar areas or exhibition space to demonstrate the how

(4) area must relate to the other labs for flow (overlap)

(5) most projects will be constructed outside

(6) area must be safe for public tours

5. Different Scales of Application of Principles

The utilization of Solar Energy at different scales will be one of the primary functions of the research compiled at the Commission.

a. Laboratory Relationship

Discoveries made in each lab must be analyzed on the real scale. They must be scrutinized as to their relationship with the environment: Will it add heat? Will it create waste?, etc.

b. Economic Relationship

If solar energy is to relieve pressure in the energy crisis, then the projects must be somewhat economically feasible or they will themselves create problems as great as already known. For example, certain applications of solar energy involving expensive mirrors have already been proven, as technology knows today, uneconomical.

c. Application Relationship

i.e. One proposal by the Optical Science Laboratory in Tucson, Arizona, mentions a one square acre solar collector bed at a cost of $4 million. Before such a project is undertaken, many experiments must be run to prove the feasibility, economically, and results to area relationship.

This part of the facility is a research area of its own but must work in coordination with the other laboratories. The results in the other labs will be analyzed by the department and due to the nature of this research will be enclosed in the building itself.

D. <u>Research</u>

The research area encompasses the laboratory facilities, but the area I am calling research is a slightly different environment. The research area will be primarily theory research.

1. Library

   The library area will contain all documents on solar energy and any material needed for research of solar energy.

2. Communications

   There should be some type of communications network connecting all other labs throughout the world. This system would keep labs posted on current work being done and would keep facilities from overlapping too much in their own research. This may be in the form of a magazine, teletype, or tele-communication network.

3. Grants

   This department would survey grants, loans, and foundation money for research.

4. Computer

   A computer will be necessary for the many problems in doing this research. The computer would be available to all persons at the commission and to the network of labs and schools throughout the world.

5. The research department would also operate as a public information service. They would schedule lectures, seminars and demonstrations.

Designing areas must encompass the following:

a. must relate physically to all lab facilities

b. must relate physically to education

c. must be accessible to the public and other people doing projects or research in solar energy

d. area should be a learning experience in itself for solar energy as an interior space(s)

E. Exhibits

1. Buildings

As stated earlier, the buildings will be an application of various kinds of solar energy. The capacity of the buildings to change as progress is made in research is one demand that must be designed into the facility. Exhibition space will be provided but will be utilized according to the scale of the project. The lab areas (outside) and work areas (outside) will be used as display areas for larger projects. A smaller area will be provided for smaller projects such as solar cells, batteries, and photo cells.

2. Public

The facility must be open to the public as the research is done for the public. Public spaces must accommodate tours and visitors at most any time of the day.

3. Researchers

Anyone, i.e. builders, architects, engineers, etc., will be classified as researchers. The facility will be open to public information where individuals may go into the research area and do research. Individuals not belonging to the Commission will be able to place their projects on display in exhibit spaces for certain lengths of time.

4. Public Relations

By utilization of the exhibit spaces, public relations and acceptance should result. An extremely aggresive program must be established to inform not only builders, contractors, and architects about the new advances in solar energy but to inform the general public about the progress being made and to help them understand what can be done to help.

Commercial, industrial, and professional groups may come to lectures, seminars and workshops. They must then inform others and utilize new techniques and technology. These groups with as much influence as they have will be greatly needed to enforce the stability of successful advancements.

Political action groups may be sponsored to attain action from governments as political action would greatly enhance the economics of future projects.

F. Education

1. Public Assemblies

   Lecture areas will be provided for public information dissemination points. Conferences may be held in the building industry fields, for example, to let people know of the various uses of solar energy. These areas must be in connection with exhibition space and laboratory areas for demonstration. When designing, these spaces will probably be multi-use areas overlapping other spaces and in conjunction with necessary facilities.

2. Seminars

   Seminar areas will be provided for small informal discussions and presentations. When designing, as stated above, many of these described spaces will overlap and serve as multi-use areas.

3. Lectures and Presentations

   Lectures and presentations will be an integral part of the total operations by functions of the facility. Public presentations, by students and other people doing solar energy projects, may be presented to the Commission. The Commission will also present its findings for others to use.

The spaces needed for Education overlap with many phases of the other areas. These areas must in a design sense show solar energy uses in areas where the function of the space is rather removed from solar energy studies--applied knowledge to a public area.

PERSONNEL REQUIREMENTS (Facility Part II)

When evaluating the personnel requirements needed to operate the Solar Energy Commissions Building, one must observe a scale that would not only make the function a smooth operation but would genuinely create interest in many others in varying degrees of solar projects. Therefore, selecting specific numbers has been a rather difficult task.

I based my assumptions of personnel requirements on the premise that there will be three mechanical laboratories operating at the same time on three separate projects of a large scale.

A. Administration

1. Board of Directors

The Board of Directors will consist of eleven members. Five will come from outside solar energy fields for financing and six will be employed at the Commissions Building and thus will have office space with each having a secretary. A conference space will be provided, for the Board will seat approximately 33 people. The function of the Board of Directors has been previously discussed and will be discussed later in this section.

2. President

There will be a president or director for the solar energy commission as previously described, and he will need an office space and a space for one secretary. His function has also been described earlier.

3. Staff

   The staff required to operate the Commission will be broken up into a team concept. Three separate projects will be in process at the same time with the general staff broken up into four members per team for the three projects. The general staff or the team leaders will consist of architects, engineers, and other people involved with solar energy research. They would have at their disposal two members each from the labor force to carry out their work in physical solutions. Each of the general staff will need an office space and will share a secretary for a total of twelve offices and three secretaries. Their function has been described earlier.

4. Research Personnel

   Research personnel will consist of the general staff and any visiting interested researchers. There will be a provision for three office spaces for visiting researchers. Their function has been described earlier.

5. General Labor Force

   The general labor force will consist of two members each assigned to one member of the general staff for a total of 24 general laborers. Their function has been described earlier.

B. Spaces

1. Offices

A total of 31 office spaces will be provided for the staff members and others, and there will be a need for a total of 17 secretaries.

2. Lounges

Lounge space for visiting researchers and employees will be provided for, with a total seating capacity of approximately 100 people. This space will be the same as, or in conjunction with, conversation areas to allow intimate discussion in a relaxed atmosphere.

C. Laboratory Facilities

1. Mechanical Laboratory

Three areas called mechanical laboratories are provided for the construction and installation of solar devices. This allows three projects to continue at the same time. Approximately twelve people will be working in each of these mechanical labs on one project at any given time. The function of mechanical laboratories has been established earlier. As the present concept has been developed, part of the mechanical labs will be enclosed; but probably the majority will be in an external environment. Therefore when the general space requirements are reviewed, the mechanical labs may be a little larger than needed.

2. Chemical Laboratory

   A chemical laboratory will be provided for research in the uses of chemicals in solar energy. Approximately nine people will be working in the chemical lab at any one time, and there will be three chemists with two assistants assigned to each.

3. Heating and cooling laboratories will be provided for the specific work. Approximately nine people will be working in this laboratory at any given time, three of whom will be heating and cooling engineers with two assistants assigned to each.

4. Economic Relationship

   Office space for three economists in one area will be provided. They will be studying feasibility and economics at different scales of application.

D. Research

1. Library

   A research library will contain all documents and publications specifically related to solar energy and any other publications that would be necessary or helpful. One librarian will take care of the library files and incoming and loaned out publications.

2. Communications

   A communications network will be established to connect any other labs throughout the world doing solar energy research. Three key punch operators and one operator-programmer will maintain the communications network.

3. Grants

   Grants were previously discussed and will not be discussed here, other than to mention the people working to attain grants, loans, and funds will be the Board of Directors and the president. They will work out of their office space and therefore will not be provided any other office space.

4. Computer

   A computer operation has been provided for. The personnel involved was mentioned in No. 2 Communications.

5. Public Information Service

   Research areas for the general public have been described earlier. The librarian and public relations people will maintain this department for the general public's use.

E. Exhibits

1. Buildings

   The buildings, as mentioned previously, will be an example of solar energy uses and application. A preliminary estimated square footage allotment for enclosed spaces is approximately 52,000 square feet. As the design phase continues, this number will probably change.

2. Public

   The public will be able to utilize the research facilities as previously mentioned. They will be considered researchers when working on solar energy projects whether at the Commission itself or some other place. Public relations will establish vigorous programs to enlighten people on advances in solar energy.

The Board of Directors will in many ways act in a public relations capacity, and therefore a public relations director and one secretary will be provided to maintain an updated public relations program.

F. Education

1. Assemblies, Seminars, and Lectures

Public assemblies will be organized through the public relations office and will hold lectures and seminars on solar energy problems and solutions. There will be two lecture halls provided for each with a seating capacity of 100 and three smaller seminar rooms each with a seating capacity of 25. Guest lecturers will be invited to hold lectures and seminars in these spaces.

Custodians will be utilized as necessary to clean office space and public assembly spaces. Three janitors will be needed unless Lake Havasu City has a custodial service. Then perhaps that service could be utilized.

GENERAL SPACE REQUIREMENTS

The following spatial requirements have been established for the major spaces in the facility. Circulation, expansion, unassigned and versatility factors have been used but are only estimates.

| Spaces | SF |
|---|---|
| Mechanical Laboratory (3)<br>12 people on one project per lab @ 200 SF per person | 7,200 |
| Chemical Laboratory<br>9 people working @ 100 SF per person | 900 |
| Heating and Cooling Laboratory<br>9 people working @ 200 SF per person | 1,800 |
| Office Spaces (28) | |
| 28 @ 100 SF per person | 2,800 |
| 17 secretaries @ 50 SF per person | 850 |
| Conference space for 33 @ 15 SF per person | 495 |
| 2 Lecture Spaces - seating capacity 100 @ 20 SF per person | 4,000 |
| 3 Seminar Areas - seating capacity 25 @ 20 SF per person | 1,500 |
| Lounges - seating 100 @ 10 SF per person | 1,000 |
| Research - computer space | 2,500 |
| Library for 30 @ 30 SF per person | 900 |
| | 23,945 |
| Spaces not assigned i.e. rest rooms, janitor space, etc. (20%) | 4,789 |
| Circulation space for the public (50%) | 11,973 |
| Versatility and Change Factor (30%) | 7,184 |
| Storage Space i.e. chemicals, rocks, building material, etc. (20%) | 4,789 |
| APPROXIMATE TOTAL | 52,680 |

# APPENDIX 1 & 2

## APPENDIX 1

It is obvious from all surveys and reports that we are using our fossil fuels at a tremendous and ever increasing rate so that in the not too distant future these supplies of energy, so vital to our present growth of civilization, will be depleted. For this reason it is of utmost importance that we look for other more permanent sources of energy and learn to use them before the dire need arises. Solar energy is readily available, well distributed, inexhaustible for all practical purposes, and has no pollution effects upon the environment when converted and utilized.

Our present usage of energy can be compared to a family or group living off their savings, stored in a bank, and being steadily depleted. This process cannot go on very long unless some "income" is added to the savings.

In the field of energy the most abundant "income" is solar energy. This incoming energy was, usually in very inefficient processes and over millions of years, converted into fossil fuels. With these savings rapidly disappearing we will have to learn to use this income, in the form of radiant energy, directly by converting it into the forms of energy needed.

This conversion from solar energy into the desired forms should be done in the fewest possible steps and along the most direct route. This procedure will insure the most efficient way of doing this and will keep the equipment necessary simplest.

Solar energy has certain characteristics. It is intermittent, only available during the day on a particular location on the surface of the earth. In spectral character it approximates a black body source of about 10,000F, modified by gaseous layers of both the sun and the earth atmosphere.

It arrives on the surface of the earth both as direct radiation and diffuse radiation. The former portion can be concentrated if desirable.

A knowledge of the specific properties of materials under solar irradiation will then allow the collection and, or concentration and absorption of this energy.

If night time operation or operation during bad weather conditions is necessary or desirable the storage has to be provided. For many applications this is not necessary. The energy could be stored in conventional manner as potential energy (pumped water, etc.) as heat in hot water storage tanks or rock bins, as chemical energy utilizing chemical processes, the latent heat or heat of fusion, etc.

In other words the technology has been developed to convert and utilize solar energy, the economics and sociological acceptance has still to be worked out in many cases. These problems vary from region to region and there take on a local character to be worked out by the potential users.

To be most effective, local materials should be used in fabricating by local methods and labor fitting the economics and habits of the local civilization.

Solar Water Heating

One type of solar water heating uses five different flat plate collectors. They consist of a box with glass or plastic covers (one or more) with a metallic absorber element inside, which contains the water. This water is circulated to the small water storage tanks. These absorbers can be compared with each other when exposed to the sun under identical conditions and for the same length of time.

Some of the absorbers have copper plates with copper tubes soldered into them, others are two flat plates riveted, crimped or welded together. The most efficient unit found consisted of two thin flat copper plates fastened together on the edges and providing a water space of about 1/4 inch, with one glass cover and one inch of styraform insulation behind the plates. No plastic materials were found to be as good as glass since none of them had the characteristics of glass, namely letting through the short wave radiation but not the long wave radiation. This characteristic of glass allows it to be used in the design of a solar trap.

A typical Florida Solar Water Heater consists of a sheet metal box, 4 feet by 12 feet, covered by a layer of glass. Inside the box is a copper sheet with copper tubes soldered to it in sinusoidal configuration and connected to an 80 gal. water storage tank. This system, rather common, is found satisfactory for a typical American family of four with automatic washing machine, etc. Under the copper sheet is one inch of styraform insulation. For satisfactory operation the bottom of the hot water storage tank must be above the top of the absorber to provide circulation without a pump.

These standard units may be damaged if used in freezing temperatures and for this reason a dual circulation system was developed which eliminates this problem. It consists of two tanks one inside the other, the outer tank being connected to the collector and this system is filled with an antifreeze solution. The heat is then transferred from this solution through the wall of the inner tank to the water to be used. Since in this system the primary curcuit operates at atmospheric conditions (the outer tank can just have a lid on it) the collector can be constructed much cheaper and lighter, for example patterned after the most efficient design mentioned earlier. Insulation covers the outside tanks.

House Heating

If the objective is to heat a house rather than water it can be done by hot water circulated through baseboard pipes in a conventional hot water heating system. Frequently it is, however, more convenient or desirable to heat a building by hot air. One type of house heating is an air heater made up of overlapping aluminum plates, painted black on the portion exposed to the sun. About 1/3 of each plate is showing the other 2/3 shaded by the plate above. They are put into a glass covered box. The air will enter this unit on the bottom and then streaming between the hot plates will pick up the heat and leave on top as hot air. The circulation can be produced either by free or natural circulation or by a fan.

All the above mentioned collectors are ideally facing South and inclined with the horizontal at an angle equal to the local geographic latitude plus 10 degrees. This gives a little higher collection efficiency during the winter when the days are shorter.

The air heater could be designed forming the wall of a building, let us say the East wall where it could produce hot air the first thing in the morning to take the chill out of the building the first part of the day.

## Solar Distillation

One of the major problems in many parts of the world is fresh water. Solar energy can with very simple equipment convert salt or brackish water into fresh and pure water. One type of solar still is a metal box with slanting glass facing South. Inside the box is a pan on short legs, painted black and holding the bad water. The sun shining into this pan heats the water in the pan and vaporized it. The vapor or steam then will, when coming in contact with the cold surfaces of the box, both the glass and the metal, condense forming the fresh which runs down the sides in the form of droplets. This fresh water can then be collected for future use. About 1/2 lb. of water can be produced at an average per square foot per day.

Another larger still is a pan covered by glass at about 45 degrees which forms most of the condensing surface. Glass is much better than plastic since it forms film condensation letting the solar energy through without much difficulty. Plastics in general produce dropwise condensation, each droplet forming a little crystal which reflects much of the incident solar energy. This larger still is also designed to be able to collect rain water and in some areas such as Florida this can double the output of the still.

The best orientation of the still depends somewhat upon the angles of the glass but is generally East-West or somewhat NE-SW.

## Solar Refrigeration and A/C

Another phase in the use of solar energy is that for solar refrigeration and air-conditioning. At a number of international meetings it was pointed out that famine could be prevented in much of the world if the food which is raised during certain parts of the year could be preserved from spoilage, and thus preserved for use during the rest of the year. This requires refrigeration and for remote areas, or areas without electricity, solar refrigeration may well be the answer.

Some of the early work along these lines was to heat oil to rather high temperatures by concentrating solar energy and then circulating the hot oil around the generator of an ammonia absorption refrigeration system. It is believed that solar refrigeration without concentration holds much more promise since nonconcentrating devices can also utilize the diffuse portion of solar radiation, thus function even on cloudy days.

A number of small units have been built and then a five ton unit. Flat plate collectors heat water which is then circulated to drive out the ammonia from the water in the generator of the system. This ammonia vapor is condensed and then expanded, providing the cooling effect by evaporation. After having done its work the ammonia vapor is reabsorbed in the ammonia absorber of the system into the water to repeat the cycle.

There is a smaller version of such a system with some improvements. The main one, of combining the solar collector and the ammonia generator into one unit, thus eliminating the primary fluid and reducing the heat losses by providing a more direct path for the solar heat to get into the system and do its work. This small 4 x 4 foot unit can produce 80 lb. of ice on a good day.

It should be pointed out again that all the applications mentioned so far did not require concentration of solar energy, and therefore could utilize the diffuse portion of solar energy and even work on cloudy days.

The solar air-conditioning or refrigeration systems have an added advantage, that the demand and supply are in phase. When the sun shines hottest the need for refrigeration and air-conditioning is greatest.

Solar Energy Concentration

For some uses, however, higher temperatures than can be obtained with flat plate, non concentrating collectors, are needed. If this is the case, then concentration is called for. Many different methods can be used for concentration, the simplest ones stationary in design but not as good, and the better ones requiring methods which allow them to follow the sun. A simple high temperature absorber consists of a number of parabolic troughs oriented horizontally and with a pipe running down the focal line of the parabolas. The system of parabolic troughs is inclined at about the local latitude. Depending upon the diameter of the pipe adjustment may or may not be needed during the year. The solar energy is reflected by the parabolic surfaces upon the focal pipe which painted with a good absorbing paint (flat black) absorbs this energy and transmits it to the fluid inside the pipe. This device can easily produce hot water, steam or hot oil.

Some energy is lost during the early morning and the late afternoon hours with the above method of converting solar energy to heat because of shading, but the simplicity and stationary design have considerable advantages, both economically and do not need much attention.

Solar Power Plant

If better efficiency is desired, then cylindrical parabolas can be used which are allowed to follow the sun. In the simplest form they can be made of a single parabola with a pipe at the focal line. This particular absorber is used to produce steam to operate a small steam engine, which in turn drives a small generator and lights up a light bulb, thus demonstrating what a solar power plant could look like. The 2 x 5 foot absorber is the equivalent of 500 watts of electrical heat.

There is a large cylindrical parabolic absorber with dimensions of 6 x 8 feet with a glass covered focal tube. The glass cover reduces the losses from the heated tube. Depending upon the needs, different diameter tubes can be used. Copper has been found best, again painted with a good absorbing high temperature paint. This absorber is mounted on a rotating axis parallel to the earth axis. It is adjusted to face East in the morning and then, by an electrically driven worm gear reduction unit is made to follow the sun all day. Where electricity is not available, a heavy weight with a clock work timing unit can be used as well. The construction of such a large device must be rather rigid since wind loads, in windy areas, may make it difficult to keep the unit directly facing the sun and to keep it from oscillating.

This unit has been used to produce steam for the operation of a fractional horsepower steam engine, to provide 800F oil to operate a solar refrigerator, etc.

Other methods of concentrating solar energy are lenses both of glass and other materials (including liquid lenses), but they are not widely used because of their cost in large sizes and their weight. However, Fresnel lenses, specially made from plastic sheets with groves cut or embossed so as to fucus the rays, can be produced rather inexpensively are unbreakable and can be of large size and light weight. The lense can produce temperature of 2000 F.

A very effective way of concentrating solar energy is to take flat pieces of reflecting materials (for better results they can even be slightly curved) such as mirrors or reflecting metal surfaces, and oriented in such a manner as to reflect the solar radiation on one spot. Front surface reflecting mirrors are giving better performance than, for instance, back silvered mirrors where some of the energy is absorbed in the glass. Very large concentrators of this type have been built with thousands of these mirrors used in some of the large solar furnaces in the world.

<u>Solar Furnace</u>

The solar furnace, with a 5 foot diameter mirror, can produce concentration ratios of almost 25,000 and temperatures of up to 7000F.

Solar furnaces can be used for research where high temperatures and extremely pure, uncontaminated heat is needed. Materials can be enclosed in glass containers or plastic containers, surrounded by vacuum or any desired atmosphere and heated under very closely controlled conditions. Since the solar energy can be concentrated onto a very small region it is not necessary for the support of the sample to be able to withstand very high temperatures nor is it necessary for the glass or plastic container to be high temperature resistent since the energy as it goes through this material is not yet concentrated to a high degree.

The furnace has been used to produce extremely high purity materials, to grow crystals of high temperature materials, crystals non-existing in nature, to extract water from rocks and moisture containing soils, (work which may be of great importance when a Lunar station is going to be set up since many experts believe that the solar furnace will be an important tool on the moon), and it may be possible to produce materials on location instead of hauling them from the earth to the moon.

Solar Pump

There is a solar pump model, in this case made out of glass so that its operation can be observed. It only has two check valves and otherwise no moving parts. A boiler is connected by a straight and a U shaped tube to a chamber with check valves at the inlet and outlet. The liquid in the boiler is vaporized pushing liquid out of the system and when the vapor reaches the bottom of the U tube it suddenly streams into the other chamber filled with cold liquid where the steam rapidly condenses. While the steam is produced the top check valve is open and liquid is pushed out. When the vapor condenses the top check valve closes due to the vacuum produced and the bottom check valve opens letting in more new liquid to be transported. This pulsating action can be smoothed into steady flow if an air chamber is provided past the top check valve.

## Solar Turbine

Another method of converting solar energy into mechanical energy is by means of a turbine. A vertical chamber with a turbine wheel in it is filled with a volatile liquid to just above the turbine wheel. The collecting surface has a cover with a small hole in the bottom of the chamber. The liquid will drain through this hole into the space below, will come in contact with the hot surface below and vaporize. The vapor will stream upward forming a jet which in turn drives the turbine wheel. When leaving the turbine wheel it will come in contact with the cold surfaces of the upper part of the vertical chamber and condense running down the walls and repeating the cycle.

For some applications it is more convenient to separate the steam generator from the turbine and the condenser.

## Conversion to Electricity

If electricity is desired as the form of energy to be used it can be produced by converting solar energy into mechanical energy and then driving a conventional electric generator.

More conveniently the solar energy can be converted directly into electricity by one of the many solid state devices normally referred to as solar cells. Through the space program great strides have been made in the photogalvanic conversion field utilizing Silicon as the most common material.

Sewage Treatment

Another project of interest is application of solar energy to sewage treatment. One phase of this work provided solar heating for sewage digesters. By heating these digesters and controlling the temperature for optimum efficiency considerably more sewage can be handled by a given size plant. Many plants buy very expensive covers and collect the sewage gas and then burn it to heat the fluid in the digesters. Many of these plants even buy fuel and all this becomes a very expensive operation. Solar heating of these digesters proved relatively inexpensive by being able to use plastic sheets glued together to form an air mattress type cover floated on top of the digester. This in many cases provided enough of a solar trap to keep the digester at good operating temperatures in our region. As a matter of fact one winter with rather severe and prolonged freezes all the bacteria in the unheated digesters died and action stopped completely until they were restocked. During this same period the solarly heated digesters survived and the bacterial action, even though slowed down during the extreme cold spells, picked right up again when the temperature of the digesters increased.

If the digester is designed more like a solar still in addition to the digestion fresh water can be produced by distillation and the remaining sludge used for fertilization.

When solar energy utilization is contemplated its availability and amount of supply, the requirements, the availability of materials and labor, as well as the economic considerations should be analyzed on a regional or local basis since large variations can occur from place to place on a global scale. The devices discussed here may have different degrees of applicability in different areas.

> In closing I would like to say that solar energy, its conversion and utilization will not solve all our problems, but it will be a great step in the right direction, by supplying needed energy wherever it can, without having adverse effects upon the environment and at the same time conserving our fossil fuels which can do much more for us than provide heat. The chemicals they contain can be used as preservatives, in medication, etc., so that the indiscriminate use of these resources for energy is unwise and a loss to future generations. -- Dr. Erich A. Farber, Professor & Research Professor of Mechanical Engineering, Director, Solar Energy & Energy Conversion Laboratory, University of Florida

This information came from <u>Solar Energy Conversion Research and Development at the University of Florida</u> Solar Energy and Energy Conversion Laboratory, by Dr. Erich A. Farber, Professor of Mechanical Engineering (Brooklyn, N.Y.: Presstech Design, Inc., 1972).

APPENDIX 2

Declaration of Reservations - Specific requirements of Lake Havasu City, Arizona

A. Improvement Standards:

1. No building, fence, patio, or other structure shall be erected, altered, added to, placed, or permitted to remain on said lots or any of them or any part of any such lot until and unless the plans showing floor areas, external design structural details and the ground location of the intended structure along with a plot plan have been first delivered to and approved in writing by the Committee. The Committee may require a reasonable fee prior to checking or appraising said plans. Notwithstanding other requirements imposed, unless more restrictive minimums are set forth under the Conditions in the preceding paragraph of the Declaration of Reservations, the Committee shall require not less than twelve hundred square feet (1,200) of floor area for any single family residence INCLUDING carport, garage, covered porches, covered contiguous patios, etc., with a minimum floor area of eight hundred square feet (800) for living area in the dwelling portion of the structure. On commercial structures submitted for approval, this Committee may require changes, deletions, or revisions in order that the architectural

and general appearance of all such commercial buildings and grounds be in keeping with the architecture of the neighborhood and such as not to be detrimental to the public health, safety, general welfare of the community in which such use or uses are to be located. All residential, commercial and industrial structures shall conform to the requirements of the Uniform Building Code as published by the International Conference of Building Officials, current edition, and the requirements of the National Electrical Code, as published by the National Fire Protection Association, current edition, as a guide to sound construction and electrical installation practices.

2. Notwithstanding any other provisions of this Declaration of Reservations, it shall remain the prerogative and in the jurisdiction of the Committee to review applications and grant approvals for exceptions to this Declaration. Variations from these requirements and, in general, other forms of deviations from these restrictions imposed by this Declaration may be made when and only when such exceptions, variances and deviations do not in any way, detract from the appearance of the premises, and are not in any way detrimental to the public welfare or to the property of other persons located in the vicinity thereof, all in the sole opinion of the Committee.

3. The designated maximum building height and minimum yard requirements may be waived by the Committee, when in their opinion, such structures relate to sound architectural planning and conform to the overall design and pattern of the development.
4. Said Committee shall adopt reasonable rules and regulations for the conduct of its proceedings and may fix the time and place for its regular meetings and for such extraordinary meetings as may be necessary, and shall keep written minutes of its meetings, which shall be open for inspection to any lot owner upon the consent of any one of the members of said Committee. Said Committee shall by a majority vote elect one of its members as chairman and one of its members as secretary, and the duties of such chairman and secretary shall be such as usually appertain to such offices. Any and all rules or regulations adopted by said Committee regulating its procedure may be changed by said Committee from time to time by majority vote and none of said rules or regulations shall be deemed to be any part or portion of said Covenants.

B. Definitions

1. Accessory Use :

   A use naturally and normally incidental to, subordinate to and devoted exclusively to the main use of the premises.

2. <u>Accessory Building</u>:

A detached subordinate building or structure, the use of which is accessory to the main use of the lot or to the main building which is located on the same lot.

3. <u>Alley</u>:

A public way permanently reserved as a secondary means of access to abutting property.

4. <u>Architectural Committee</u>:

DECLARANT shall appoint a Committee of Architecture hereinafter sometimes called "Committee" consisting of five (5) persons. Declarant shall have the further power to create and fill vacancies on the Committee.

IT shall be the general purpose of this Committee to provide for the maintenance of a high standard of architecture and construction in such manner as to enhance the aesthetic properties and structural soundness of the developed subdivision.

THE COMMITTEE shall be guided by and, except when in their sole discretion good planning would dictate to the contrary, controlled by this Declaration of Reservations to any and all lot owners upon request.

THE COMMITTEE shall determine whether the Conditions contained in this Declaration are being complied with.

THE COMMITTEE may adopt reasonable rules and regulations in order to carry out its duties.

SAID CONDITIONS ARE AS FOLLOWS:

THAT all of the lots within this subdivision shall be designated as One-Family Area Lots and shall be improved, used, and occupied under the conditions set forth under R-1 LAND USE REGULATIONS.

THAT the Committee of Architecture shall require not less than THIRTEEN HUNDRED FIFTY (1350) square feet of floor area for any single family residence including carport, garage, covered porches, covered contiguous patios, etc., with a minimum floor area of NINE HUNDRED FIFTY (950) square feet for living area in the dwelling portion of the structure. These minimum restrictions supersede any other minimum restrictions established for this tract.

ALL definitions and designations of Land Use Regulations refer to those contained in the Declaration of Reservations recorded with this Tract and are not to be confused with any Land Use Regulations contained in any of the sections of Ordinance of the County of Mohave provided, however, IN THE EVENT THAT ANY OF THE PROVISIONS OF THIS DECLARATION CONFLICT WITH ANY OF THE SECTIONS OF ORDINANCE 306 COUNTY OF

MOHAVE, AS APPLICABLE TO THIS SUBDIVISION, THE MORE RESTRICTIVE OF THE TWO SHALL GOVERN.

5. Building:

Any structure having a roof supported by columns or walls for the housing or enclosure of persons, animals, chattels or property of any kind.

6. Building--Condominium Project: The principal structure or structures erected or to be erected upon the land described in a Declaration to a Horizontal Property Regime.

7. Building Height:

The vertical distance from the average finished ground level of the site to the highest point of the structure directly above said ground level. On sloping sites, variances may be granted by the Committee.

8. Building Site:

The ground area of a building or group of buildings together with all open spaces as required by this Covenant.

9. Garage: A building or portion of a building designed for the purpose of parking and sheltering automobiles, whether attached, partially attached or detached from the dwelling.

10. Grade (Ground Level):

The average of the finished ground level at the center of all walls of a building. In case walls are parallel to and within five (5) feet of a sidewalk, said ground level shall be measured at the sidewalk.

11. Horizontal Property Regime:

Creation of a Condominium Project in which co-owners own fee interests in units together with fractional interests in general common elements as provided for in Arizona Revised Statutes Section 33.552, which determines the use to be made of the improved land whether or not such improvement is composed of one or more separate buildings of one or more floors or stories.

12. Industrial Waste Disposal:

Any liquid or matter that does not commonly occur in sewage from residential sources.

13. Lot:

A parcel of real property as shown with a separate and distinct number or letter on a plot recorded or filed with the Recorder of Mohave County, Arizona.

14. Lot Area:

The total horizontal area within the lot lines of a lot.

15. Lot, Corner:

A lot situated at the intersection of two (2) or more streets having an angle of intersection of not more than one hundred thirty-five (135) degrees.

16. Lot, Interior:

A lot other than a corner lot.

17. Lot, Reversed Corner:

A corner lot, the side street line of which is substantially a continuation of the front lot line of the first lot to its rear.

18. Lot, Through:

A lot having frontage on two (2) parallel or approximately parallel streets.

19. Lot Line, Front:

The property line dividing a lot from a street. On a corner lot only one (1) street shall be considered as a front line and the shorter street frontage shall be considered the front lot line.

20. Lot Line, Rear:

The line opposite the front line.

21. Lot Line, Side:

Any lot lines other than front lot lines or rear lot lines.

22. Person:

An individual, firm, company, co-partnership, joint adventure, association, club, fraternal organization, corporation, estate, trust, receiver, organization, syndicate, city, county, municipality, district or other political subdivision, or any other group or combination acting as a unit.

23. Story:

That portion of a building included between the surface of any floor and the surface of the floor next above; or, if there is no floor above, the space between the floor and the ceiling next above. A basement shall not be counted as a story.

24. Story, Half:

A space under a sloping roof which has the line of intersection of roof decking and wall not more than three (3) feet above the top floor level, and in which space not more than sixty per cent (60%) of the floor area is completed for principal or accessory use.

25. Street:

A public thoroughfare which affords the principal means of access to abutting property.

26. Structure:

Anything constructed or erected, which requires location on the ground or attached to something having a location on the ground, but not including fences or walls used as; fencing either of which is six (6) feet or less in height.

27. Use:

The purpose for which land or building is designed, arranged or intended, or for which either is or may be occupied or maintained.

28. Yard, Front:

A yard extending across the full width of the lot, the depth of which is the minimum horizontal distance between the front lot line and a line parallel thereto on the lot.

29. Yard, Rear:

A yard extending across the full width of the lot between the most rear main building and the rear lot line. The depth of the required rear yard shall be measured horizontally from the nearest part of a main building toward the nearest point of the rear lot line.

30. Yard, Side:

A yard between the main building and the side lot line extending from the rear line of the required front yard or the front lot line where no front yard is required, to the rear yard the width of which side yard shall be measured horizontally from, and at right angles to, the nearest point of a side lot line towards the nearest part of a main building.

C. LAND USE AREAS -- GENERAL

The following provisions shall be applicable to all property regardless of classification:

1. <u>Advertising</u>:

No sign, advertisement, billboard or advertising structure of any kind shall be erected or allowed on any of the unimproved lots, and no signs shall be erected or allowed to remain on any lots improved or otherwise except as expressly provided in the Uses Permitted paragraph of the particular type of land use area, provided, however, that a temporary permit for signs for structures to be sold or exhibited may be first obtained by application to the Architectural Committee. The Architectural Committee may approve the location of these signs within the front setback of the lot.

2. <u>Air Conditioning Units</u>:

No air conditioning unit, evaporative cooler, or other object other than a television or radio antenna shall be placed upon or above the roof of any dwelling or other building except and unless the same is architecturally concealed from view in plans submitted to and approved by the Committee of Architecture, and then only where to the full and sole satisfaction of the Committee of Architecture the same is not aesthetically objectionable and is otherwise in conformity with the overall development of the Community.

3. <u>Building Exterior</u>:

The exterior portions of all buildings shall be painted or stained immediately upon completion or shall have color mixed in the final structural application, so that all such materials shall have a finished appearance.

4. <u>Easements</u>:

Easements for installation and maintenance of utilities and drainage facilities are reserved as shown on the recorded plat. Within these easements, no structure, planting or other material shall be placed or permitted to remain which may damage or interfere with the installation and maintenance of utilities, or which may change the direction of flow of drainage channels in the easements, or which may obstruct or retard the flow of water through drainage channels in the easements. The easement area of each lot and all improvements in it shall be maintained continuously by the owner of the lot, except for those improvements for which a public authority or utility company is responsible.

5. <u>Electrical Power</u>:

No source of electrical energy shall be brought to the property or used upon the property until the Committee of Architecture has approved plans and specifications for the erection of approved improvements upon any lot.

6. <u>Nuisances</u>:

No noxious or offensive activities shall be carried on upon any lot, nor shall anything be done thereon which may be or may become an annoyance or nuisance to the neighborhood.

7. <u>Occupancy of Structures</u>:

No structure shall be occupied or used for the purpose for which it is designed or built until the same shall have been substantially completed and a certificate to the effect shall have been issued by the Committee of Architecture.

8. <u>Plumbing</u>:

All structures shall have complete and approved plumbing installations before occupancy. Such plumbing shall conform to the requirements of the Uniform Plumbing Code as published by the Western Plumbing Association, current edition, as a guide to sound plumbing practices.

9. <u>Storage of Materials</u>:

In any building project, during construction and sixty (60) days thereafter, a lot may be used for the storage of materials used in the construction of the individual buildings in the project and for the contractor's temporary offices, including chemical toilets. Said construction period shall not exceed one hundred twenty (120) days, unless specifically approved by the Committee of Architecture.

10. <u>Storage of Tools and Trash</u>:

The storage of tools, landscaping instruments, household effects, machinery or machinery parts, boats, trailers, empty or filled containers, boxes or bags, trash, materials, or other items that shall in appearance, detract from the aesthetic values of the property, shall be so placed and stored to be concealed from view from the public right of way. Trash for collection may be placed at the street right of way line on regular collection days for a period not to exceed twelve hours, prior to pick up.

11. <u>Temporary Buildings</u>:

No temporary buildings, including tents, shacks, shanties or otherwise shall be erected or placed upon any lot and no temporary buildings including basements, cellars, tents, shacks, shanties, garages, barns or other temporary outbuildings or other similar structures shall at any time be used for human habitation. Notwithstanding the foregoing, a trailer may be used as a residence of the owner and his family or a contractor during construction by or for such owner of a permanent residence, but only after a certificate in writing has been issued by the Committee of Architecture for such use and then only after the said Committee of Architecture shall have approved plans and specifications for the erection of said permanent residence. In no event, shall such trailer be allowed to be on any such lot for longer than 180 days.

12. Unnatural Drainage:

Under no circumstances shall any owner of any lot or parcel of land be permitted to deliberately alter the topographic conditions of his lot or parcel of land in any way that would permit additional quantities of water from any source, other than what nature originally intended, to flow from his property onto any adjoining property or public right of way.

13. Use of Premises:

A person shall not use any premises in any land use area, which is designed arranged or intended to be occupied or used for any purpose other than expressly permitted in this Declaration.

M-1-P LAND USE REGULATIONS - INDUSTRIAL PARK.

The following Regulations are intended to provide for a planned industrial district which would not in any way depreciate the character of the resort community. Uses are to be confined to those administrative, wholesaling, warehousing and light manufacturing activities that can be carried on in an unobtrusive manner and to certain accessory commercial facilities that are necessary to serve the employees of the zone.

No industrial use shall be permitted by the Committee, which, by reason of emission of odor, dust, gas, fumes, smoke, glare, liquids, wastes, noise, vibration and disturbances, or by the nature of its development or operation, will in the opinion of the Committee adversely affect the resort-residential environment in the City.

1. Uses Permitted:

Manufacturing.

(a) Electronics
Electrical & related parts
Electrical appliances
Electrical devices
Motors
Radio, television & phonograph

(b) Instruments
Electronic
Medical & dental tools
Precision
Timing & Measuring

(c) Office & Related Machinery
Audio machinery
Computers-electrical
Computers-manual
Visual machinery

(d) Pharmaceutics
Cosmetics
Drugs
Perfumes
Soap
Toiletries

(e) Laboratories
Chemical
Dental
Electrical
Optical
Mechanical
Medical

(f) Manufacturing, fabrication, & assembly of metal products where in the opinion of the Committee such operation will not adversely affect the resort-residential environment of the City.

(g) Bottling plants except those liquids that are offensive or obnoxious by reason of odor, or are hazardous.

(h) Manufacture & maintenance of electrical & neon signs. Novelties & holiday paraphernalia. Rubber & metal stamps
Furniture upholstering
Candy

(i) Manufacturing, compounding, assembly or treatment of articles or merchandise from the following previously prepared materials.
Canvas
Cellophane
Cloth
Cork

Felt
Fibre
Glass
Leather
Paper (no milling)
Precious or Semi-precious stones or metals
Plaster
Plastics
Shells
Textiles
Tobacco
Wood
Yarns

(j) Fabrication and assembly of products made from finished rubber.

(k) Wholesaling & Warehousing

(l) <u>Services</u>:
Banks & financial institutions
Blueprinting & photocopying
Business & research offices related to the administration & operation of the permitted industrial uses
Newspaper Publishing
Offices, business & professional
Off-street parking
Printing, lithographing, publishing
Radio & television broadcasting
Restaurants

(m) <u>Processing</u>:
Carpet & rug cleaning
Cleaning & dyeing
Laundry

2. SIMILAR USES PERMITTED BY COMMITTEE DETERMINATION

The Committee may permit any other uses which it may determine to be similar to those listed above, in conformity with the intent and purpose of this Regulation, and not more obnoxious or detrimental to the public health, safety, and welfare, or to other uses permitted in this Regulation.

3. BUILDING HEIGHT:

Buildings and structure shall have a height not greater than thirty feet (30').

4. YARDS:

(a) Where the M-1-P Zone fronts, sides or rears on a street which is a boundary with a residential zone, there shall be a yard abutting said street of not less than fifty feet (50'). The ten feet (10') nearest the street shall be landscaped and maintained.

(b) Where the M-1-P Zone fronts, sides or rears on a street which is not a boundary with a residential zone, there shall be a yard abutting said street of not less than twenty-five feet (25'). The ten feet (10') nearest the street shall be landscaped and maintained.

(c) Where the M-1-P Zone sides or rears directly on property in a residential zone, there shall be a yard of not less than fifty feet (50'). Said yard may be used for parking provided screen landscaping not less than six feet (6') in height plus a fence six feet (6') in height of chain link, or other material shall be installed adjacent to the property line.

(d) Where the M-1-P Zone sides or rears directly on property in a commercial or manufacturing zone, there shall be a yard of not less than twenty feet (20'). Said yard may be used for parking, loading, or storage.

(e) Where the M-1-P Zone sides or rears on an alley which is a boundary with a residential zone, there shall be a yard of not less than fifty feet (50') measured from the side of the alley opposite the subject property. Said yard may be used for parking or storage.

5. MAXIMUM AREA OF BUILDING:

Lot area coverage by buildings or structures shall not exceed sixty per cent (60%) of the total lot area.

6. OFF-STREET PARKING - OFF-STREET LOADING:

(a) OFF-STREET PARKING:

There shall be at least one (1) off-street parking space provided for each five hundred (500) square feet of floor space constructed.

(b) OFF-STREET LOADING:

There shall be provided adequate loading space on private property for standing and for loading and unloading service for any commercial use involving the receipt or distribution by vehicles of materials or merchandise. Such loading space shall be of such size, and so located and designed as to avoid undue interference with the use of public streets and alleys, and shall be graded and surfaced to provide proper drainage and prevent dust arising therefrom.

7. STORAGE OF MATERIALS:

The storage of supplies and equipment, boxes, refuse, trash, materials, machinery or machinery parts, or other items that shall in appearance detract from the aesthetic values of the property, shall be so placed and stored to be concealed from view from the public right of way.

8. INDUSTRIAL WASTE DISPOSAL:

No industry shall be permitted to discharge industrial waste into the domestic sewer system UNLESS SPECIFICALLY APPROVED BY THE LAKE HAVASU SANITARY DISTRICT.

9. SUBDIVISION OF LOTS:

No lot or parcel of land shall be divided into smaller lots or parcels whether for lease, sale or rental purposes, provided that variations may be granted by the Committee of Architecture in accordance with provision of A-2, of this Declaration of Reservations.

# BIBLIOGRAPHY

BIBLIOGRAPHY

Text Books

Ayres, Eugene. Energy Sources--The Wealth of the World. New York, Toronto, London: McGraw-Hill Book Co., Inc., 1952.

Daniels, Farrington. Direct Use of the Suns Energy. New Haven and London: Yale University Press, 1964.

Daniels, Farrington; Furnas, C. C.; Lukes, George D.; Brooks, F. A.; Miller, W.; Dietz, Albert G. H.; Hottel, H. C.; Erway, Duane D.; Jordan, Richard C.; Chapin, D. M.; Calvert, Jack G.; Kastens, Merritt L.; Lof, George O. G.; Howe, Everett D.; Menetrey, Walter. Introduction to the Utilization of Solar Energy. New York, San Francisco, Toronto, London: McGraw-Hill Book Company, Inc., 1963.

Daniels, Farrington. Solar Energy. Madison: University of Wisconsin Press, 1955.

Guyol, Nathaniel B. Energy in the Perspective of Geography. New Jersey: Prentice-Hall, Inc., 1971.

Halacy, Daniel S. Solar Energy, The Coming Age. New York: Harper & Row, 1973.

Organization for Economic Cooperation and Development. Statistics of Energy. Paris: Basic Statistics O.E.C.D., 1972.

Putnam, Palmer C. Energy in the Future. Toronto, New York, London: D. Van Nostrand Company, Inc., 1953.

Rau, Hans. Solar Energy. New York: The MacMillan Co., 1964.

Thirring, Hans. Energy For Man. Bloomington: Indiana University Press, 1958.

Periodicals

Glaser, P. E. "Future of Power from the Sun." Abstract Engineering (September 13, 1968): 385.

Glaser, P. E. "Power from the Sun." Mechanical Engineer (March 1969): 20-24.

Glaser, P. E. "Power from the Sun." Science (November 22, 1968): 857-61.

Hammond, A. L. "Solar Energy, A Feasible Source of Power?" Science (May 14, 1971): 660.

Hubbert, M. K. "Energy Resources of the Earth." Scientific American (September, 1971): 60-70.

Meinel, A. B., Meinel, M. "Solar Plant." IEEE Spectrum (June, 1971): 8-84.

Staff Product Engineer. "Solar Power." Product Engineer (August 31, 1970): 1032-7.

Stein, Richard G. "Architecture and Energy." The Architectural Forum (July/August, 1973): 38-58.

Van Cleave, D. "Satellites to Relay Solar Energy for Earth Needs." Product Engineer (August 25, 1969): 13-14.

Yellott, J. I. "Solar Energy, Where It Will Shine in the 70's." Chemical Engineer (June 29, 1970): 85-89.

Special Publications

Farber, Dr. Erich A. "Solar Energy: Conversion and Utilization." Solar Energy Conversion Research and Development at the University of Florida (June, 1972): 1-9.

"Richard Stein on Lighting and Energy Use." AS (Architectural Student) (Summer, 1973): 1-31.

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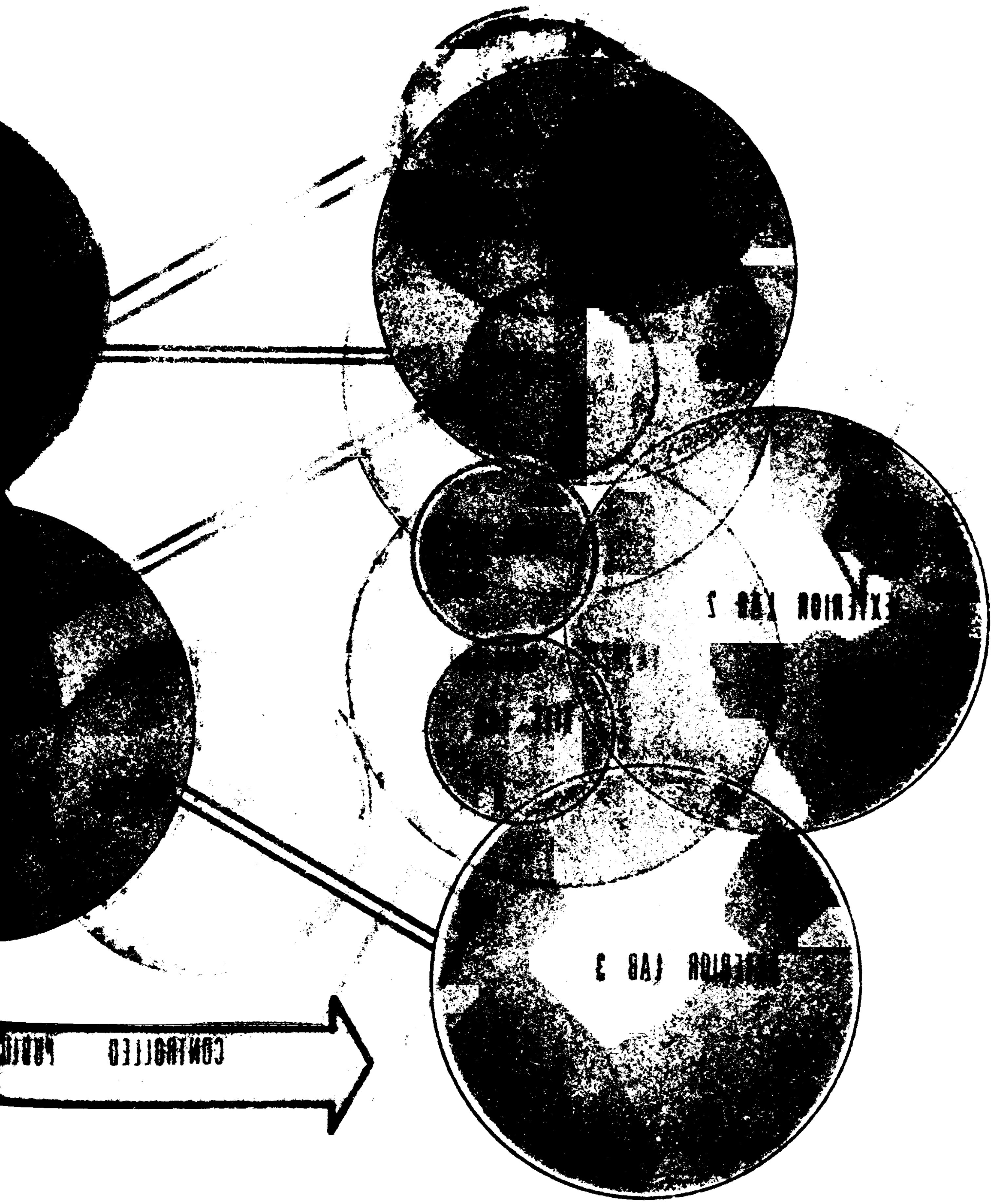
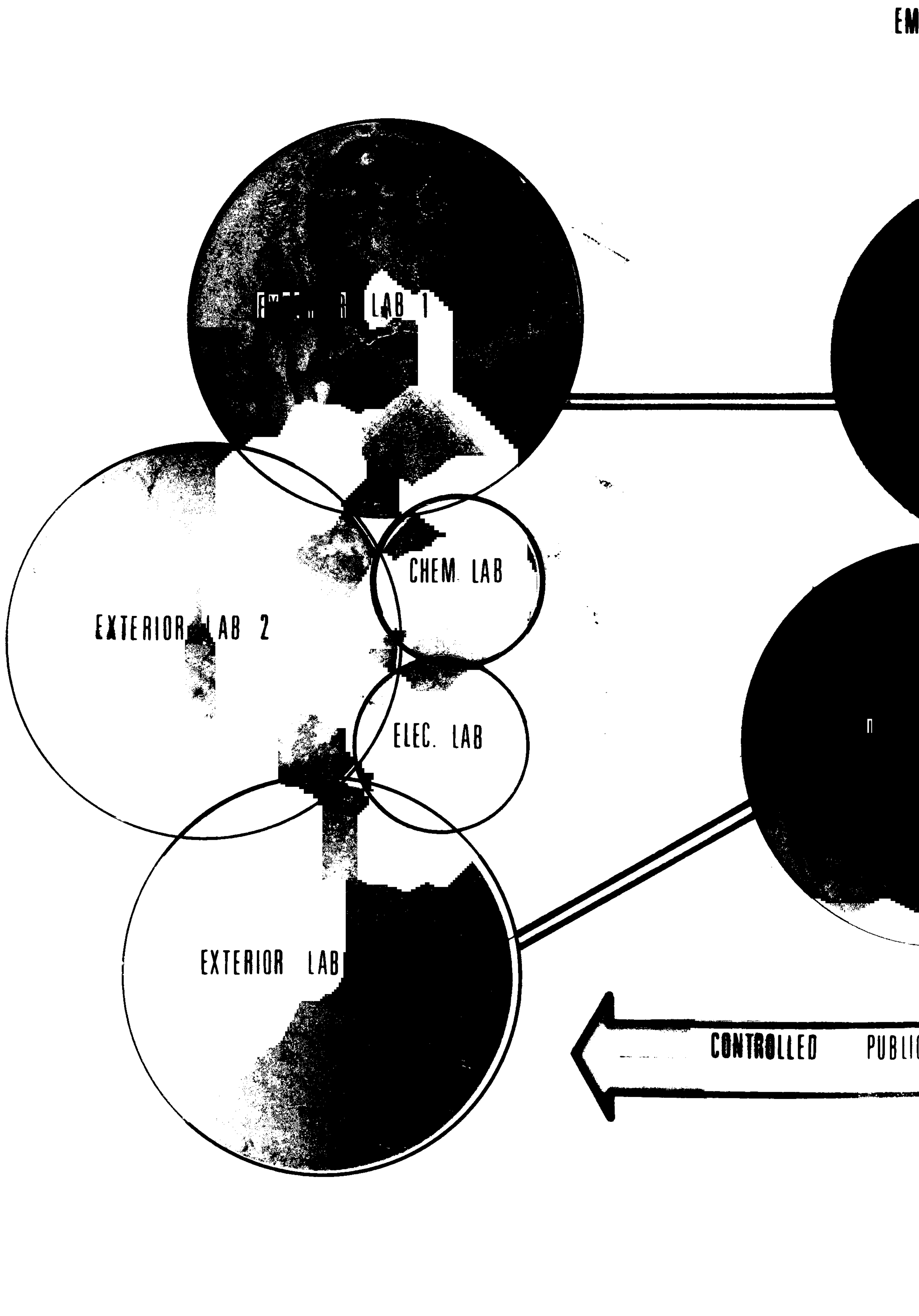
# DESIGN SOLUTION RELATIONSHIPS



**relationship diagram**

**fig. 6**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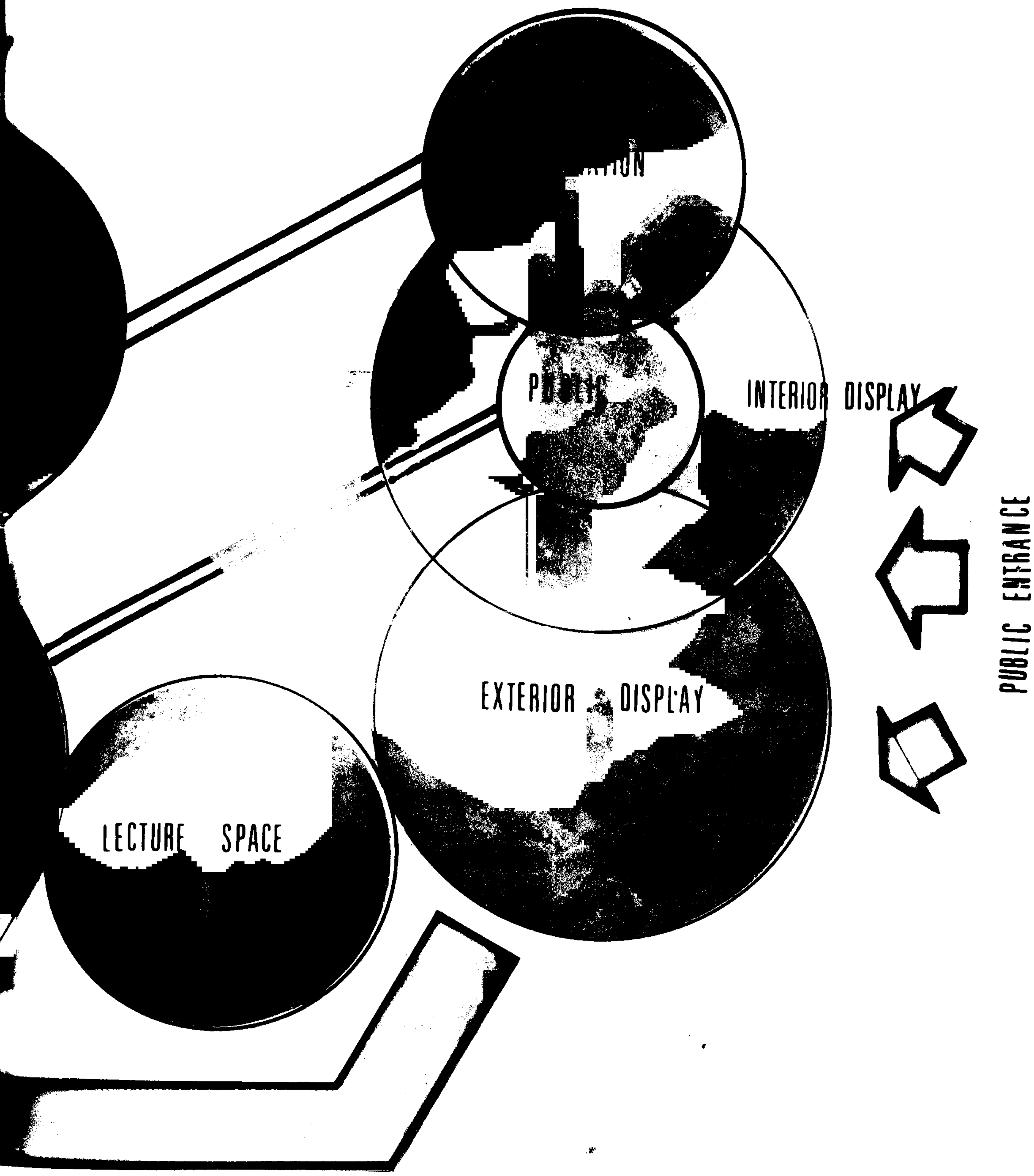


**relationship diagram**
**fig. 6**

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**relationship diagram**

The following outline includes alterations and clarifications of the written program. This outline provides a framework for commentary of the physical design process, solutions and decisions that were made. This outline refers directly to the relationship diagram fig. 6, page 34.

I. Reassess Validity of Written Program

A. Procedure

1. Assumptions about specific aspects were altered and refined.

B. Facility Organizations

1. Administration

<u>RELATIONSHIP</u> -- Direct public access, public relations personnel to the public, office space, direct relationship with secretarial pool, and the conducting of facility business, tours, seminars and lectures

<u>SPECIFICS</u> -- Waiting areas, exposure to solar devices, isolated from experimental working conditions, and flexibility of spatial arrangements

2. Research Personnel

<u>RELATIONSHIP</u> -- 24 researchers, direct access to five secretaries in a pool concept, and direct linkage with computer facility

<u>SPECIFICS</u>

a. Two chemists, two electrical specialists, work space in enclosed laboratories, directly related with exterior labs, and office space not required

b. 20 researchers, open plan concept for the 20 office spaces provided, private entry, somewhat isolated from public circulation, and experimental solar devices utilized

3. Spaces -- Includes lounges, lunch room, break areas, conversation spaces, circulation spaces, and quiet study areas

<u>RELATIONSHIP</u> -- Conversation areas directly related with office spaces, circulation spaces as quiet spaces related to the function of the areas, break areas isolated from all work space, and good circulation to and from all of these areas for employees and public visitors

<u>SPECIFICS</u> -- Well designed furnishings allowing flexibility, areas utilizing solar devices, and some areas secluded

C. Laboratory Organization

1. External Laboratories

<u>RELATIONSHIP</u> -- Direct access for research personnel and general labor force, direct access to all storage areas, controlled public circulation areas, and encompassing all safety requirements

<u>SPECIFICS</u> -- The three general areas tier down as specified in the program and are secured by an 18 foot sloped retainer wall.

2. Internal Laboratories -- Electronic and Chemical

   RELATIONSHIP -- Directly related vertically with researcher office spaces, directly related horizontally with external labs for experiment coordination, and directly related with all storage areas

   SPECIFICS -- Must utilize solar devices, must be somewhat isolated from public areas, egress and ingress to external lab areas, good circulation to office spaces but direct relationship not necessarily important.

D. Research -- Research areas to include library and computer

   RELATIONSHIP -- Access to the library should be open to the general public and directly related horizontally and vertically with all research areas to include office spaces. The computer is not open to the general public but must be directly linked with research spaces and office spaces horizontally.

   SPECIFICS -- Both research areas should utilize solar devices to as great an extent as possible even though the computer area is fairly well regimented in environmental controls.

E. Exhibits -- The building, public exhibits, and facility exhibits

   RELATIONSHIP -- The public exhibition space, also utilized by the facility for exhibition space, should be in the public area with good circulation from entry and exit points. Exterior display spaces should relate directly with entry and exit points and with interior display areas.

F. Education -- Public Assemblies and Seminars

RELATIONSHIP -- Public assemblies as discussed in the program take place in one lecture hall. After re-evaluation of lecture hall needs, the two allotted in the program have been reduced to one, seating approximately 90 people. This space relates directly with interior and exterior public displays. Seminar spaces are generally utilized by the research personnel but may be utilized by the general public, so circulation by the public must be considered.

SPECIFICS -- Solar devices should be used to as great an extent as possible in both of these spaces although from early design decisions the public lecture hall is fairly well isolated and insulated. Comfortable furnishings will be furnished for seminar spaces with flexibility of arrangement. Continental seating will be used in the lecture hall.

G. Spaces not covered in the written program include parking lots and large open display spaces around the site.

1. Entry to and from the visitor parking areas should be interesting and should emphasize the form and design concept of the building as much as possible.

2. Parking has been provided for the research personnel with a private entry so as not to mingle with the public.
3. A large display space has been dedicated on the south side of the building for displays too large to show in the preceding display spaces.

# Design Concept

Site

1. After analyzing the function relationships and facility diagrams, the site previously selected was determined to be about twice as much area as would be required. The plotted tract has therefore been divided in half, and the western half of the site is being utilized.

2. As discussed in the program, the external labs will be directly exposed to the sunlight as much as possible so orientation of these labs are to the west, southwest, south, and southeast.

3. Public entry onto the site will be from the south off Industrial Boulevard. Employee entry onto the site will be from the west off of a future avenue.

4. See map page 34 and copy of site analysis, page 108.

**TRICO WESTERN CORPORATION**
P.O. DRAWER 628 · LAKE HAVASU CITY · ARIZONA 86403
(602) 855-2551
Russell W. Thiele, P.E.
Gordon F. Freudig, P.E.

April 10, 1974

Mr. Gary L. Townsend
4822 - 52nd Street
Lubbock, Texas 79414

Dear Gary:

Charlie Thompson forwarded your letter to our office for the information requested.

1. Topography of sites. All sites, as indicated on the amp, have topography that is level to gentle roll. All areas have been graded.

2. Soil conditions in general for Lake Havasu City are silty, sandy, rocky soil with sparse desert vegetation.

3. Wind velocity is from 0 to 65 M.P.H., the average being 15 to 20 M.P.H., wind direction is Northerly in the winter and Southerly in the summer.

4. Average rain fall per year is five (5") inches.

I am returning your map of the site locations, per your request.

If I can be of any further assistance in this matter, please contact me.

Sincerely,

TRICO WESTERN CORPORATION

Patricia A. Duncan

Patricia A. Duncan
Vice President

PAD:jgm

Enclosure

Facility

1. After studying all the various solar systems being explored and experimented with today, a design decision was reached. Solar systems used in this facility must be real to the extent that they are somewhat proven systems. Systems that work only in theory will be studied and then perhaps used to modify chosen systems in the future.

2. The systems chosen for design purposes in this facility are as follows:

a. A hydrogen collector system is utilized to power a turbine generator set to provide electric power and to run gas absorption air conditioning equipment. This device is a proven system but slightly dangerous. The hydrogen collector must be kept away from public circulation areas, water and chemicals, and anything that could rupture any of the input or output lines. Therefore, this entire system should be located on the roof of the structure. Since there are no real proven methods for calculating the exact amount of hydrogen gas or surface area of collector space, the majority of the roof area will be assumed enough collector.

b. Flatplate collectors utilizing water systems, water and chemical systems, and chemical systems will be the majority of the collector areas used. These collectors under certain conditions can power heating and air conditioning equipment but will mainly be used to demonstrate uses. These systems need a very large storage area. Storage will be accomplished by steel drums insulated with salt brine. These storage areas should not be exposed to outside environmental factors but should have good circulation patterns for maintenance and visiting personnel.

c. The bead wall system will be utilized in all areas where natural lighting would be of major importance such as office spaces, interior labs, seminar spaces, and dissemination points. This system also provides a very good heating source for smaller areas such as seminar spaces. A U factor of .1 can be obtained with a three inch styrofoam bead wall. The level of the beads in the wall can be either thermostatically or manually controlled. Storage for the styrofoam beads can be exposed. These storage units can be utilized to separate one area from another instead of building partitions or floor-to-ceiling walls.

3. After careful volumetric studies of the areas and relationship of activities, a multilevel (3) facility is proposed. The Declaration of Reservations written by the Architectural Review Board of Lake Havasu City established a 30 foot maximum building height. This tends to force one level below grade. After careful consideration of the function of activities that require a high ceiling height due to gross areas calculations, it has been determined that the first level of the facility will be 15 feet below grade. These areas will be lecture hall, interior display court, library, and the two interior laboratory spaces.

4. With the relationships established in the outline, the interior form began to evolve. The form the solar panels

began to take on was directly derived from plotting all sun angles through a year and averaging them. This calculation led me to believe that on an average a $54^{\circ}$ curvature would optimize solar angles every day of the year. A curved panel would work best in a fixed position because the pipe connections would be an inflexible joint. Another factor that creates the curve of the panel is the buckskin mountain range located approximately 40 miles east southeast of Lake Havasu City. This mountain range curves upward from the desert floor to a flat plateau on top.

5. Preliminary designs were experimented with by using suspended cable structures, but the weight of the panels soon gave way to a rigid structure.

6. To maximize solar panel surface areas and minimize material waste, a 4' x 10' panel section was established. Working from this module, interior proportions began to be derived. To minimize structure depth and maximize spans, an open column space of a 20' module was established. This module was also directly proportioned to interior office spaces established by the scale of a man and the area he needs to work in.

7. To conserve energy and minimize internal environmental fixtures, a concrete structure and concrete wall system were chosen due to their unique insulating qualities. Exterior walls exposed to sunlight will either be bead wall systems to allow heating and natural lighting or solar glass to minimize heat gain and maximize natural lighting. Exterior walls not exposed to direct sunlight should be of concrete construction

except in areas where there is natural lighting in which case bead walls will be used.

8. Internal areas of the building with a large amount of circulation will utilize a resilient floor covering that will minimize maintenance. Other areas such as office space, seminar rooms, etc., due to their function will be carpeted.

## SPECIFIC SPACE REQUIREMENTS

The following spatial requirements have been established for the major spaces in the facility. Circulation, expansion, unassigned and versatility factors have been used.

| Major Spaces | SF |
|---|---|
| Mechanical Laboratory (3) | |
| 12 people on one project per lab @ 200 SF per person | 7,200 |
| Chemical Laboratory | |
| 9 people working @ 100 SF per person | 900 |
| Heating and Cooling Laboratory | |
| 9 people working @ 100 SF per person | 900 |
| Office Spaces (31) | |
| 31 @ 100 SF per person | 3,100 |
| 12 secretaries @ 50 SF per person | 600 |
| Conference space for 24 @ 25 SF per person | 600 |
| 1 Lecture Space - seating capacity 90 @ 18 SF per person | 1,600 |
| 2 Seminar Areas - seating capacity 14 @ 44 SF per person | 1,200 |
| Lounges - seating 60 @ 20 SF per person | 1,200 |
| Research - Computer Space | 2,500 |
| Library for 30 @ 60 SF per person | 1,800 |
| | 21,600 |
| Factors | |
| Spaces not assigned, i.e. rest rooms, janitor space, etc. (20%) | 4,320 |
| Circulation space for the public (50%) | 10,800 |
| Versatility and Change Factor (30%) | 6,480 |
| Storage Space, i.e. chemicals, rocks, building material, etc. (9%) | 1,944 |
| APPROXIMATE TOTAL | 45,144 |