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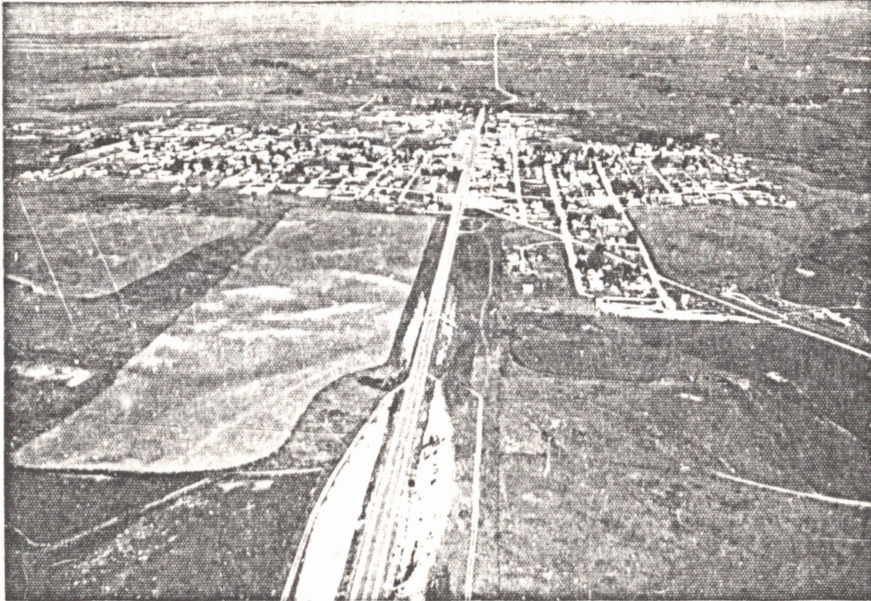
School of Architecture

Montana State University

Bozeman, Montana 59715

I am submitting this thesis book as partial fulfillment of the requirements for the degree of Bachelor of Architecture at Montana State University.

By: Richard J. Weitz



A
COMMUNITY CENTER
FOR

WHITE SULPHUR SPRINGS,

MONTANA

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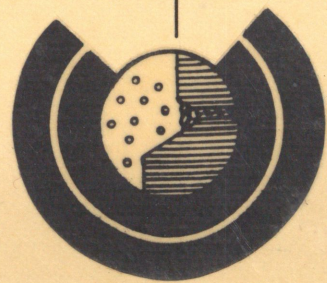
Undergraduate thesis in
architectural design

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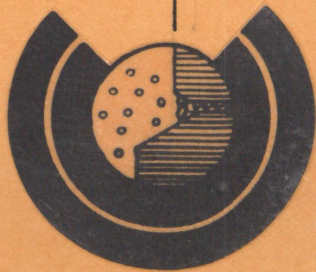
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STATEMENT of THESIS

THESIS STATEMENT

"Quality architecture which satisfies the social and recreational needs, creates an environment that stimulates a sense of community spirit."



PROPOSAL

PROPOSAL
for
THESIS IN ARCHITECTURE

WHITE SULPHUR SPRINGS
COMMUNITY CENTER

the city and recreation facilities. The city is involved with the educational and governmental activities since the community has existing facilities to accommodate these functions. This is especially true for the city and youth groups for satisfying the social and recreational needs.

This thesis was submitted by Richard J. Weitz of White Sulphur Springs. The influencing factors are:

- 1) a lack of an adequate community facility for social and recreational needs;
- 2) a need for outdoor activities in conjunction with a center;
- 3) a need for a re-evaluation of the existing city's park; and a need for a new center to provide a center for the city.

March 31, 1975

The author, Richard J. Weitz, is a graduate of the University of Utah. He has advanced in the field of architecture and is currently a graduate student at the University of Utah. He has been involved in several other projects with the city of White Sulphur Springs and is currently working on a project for the city of White Sulphur Springs.

PROPOSAL
for
THESIS IN ARCHITECTURE

THESIS STATEMENT:

"Quality architecture which satisfies the social and recreational needs, creates an environment that stimulates a sense of community spirit."

The subject of my thesis is a community center for White Sulphur Springs, Montana. A community center becomes a facility for educational, recreational, governmental, and cultural activities. This community center located in my hometown, White Sulphur Springs will basically be limited to the social and recreational aspects. I will not be involved with the educational and governmental activities since the community has existing facilities to accommodate these functions. This center will be used by adult and youth groups for satisfying the social and recreational needs.

This Thesis evolves from the existing conditions and needs of White Sulphur Springs. Some of the influencing factors are:

- 1) a lack of an adequate community facility for social and recreational needs;
- 2) a need for outdoor activities in conjunction with center;
- 3) a need for redeveloping of the existing city's park;

With these considerations, I hope to provide a solution to the needs and problems of the community and prove my Thesis statement.

My Thesis Advisor will be William Carver. We have arranged to meet at least once a week and at other times as required. I will also schedule other meetings with my resource people.

An outline of the method in reaching a "solution"

- 1) familiarization of general conditions of the community and research: history, demography, economy and resources, and characteristics of community;
- 2) selection of site
- 3) site analysis - climate, sun angles, geography, and etc.
- 4) activities analysis;
 - a) organized groups
 - b) spontaneous groups
- 5) a study analysis of the existing city park to the proposed site;
- 6) spacial schematic studies;
- 7) function-space analysis;
- 8) organize synthesis;
- 9) finalize synthesis;
- 10) introduction to design development;
 - a) use of creative imagination, in the possible alternatives in relationships of spaces to one another;
 - b) intergrating the use of indigenous materials;
 - c) locating the proposed center with other magnets of neighborhood and community life;
- 11) design development;
- 12) finalized design proposal;

Timetable of Development:

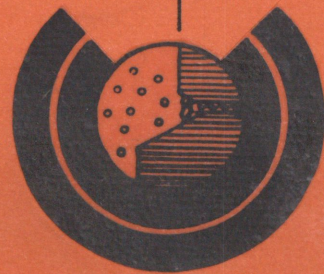
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|----------|---|---|
| March 31 | - | submission of Thesis Proposal |
| April 4 | - | meeting with Thesis Advisor and resource people; |
| April 11 | - | discussion with Advisor; gathered information concerning general conditions, selection of site and beginning site analysis; |
| April 18 | - | research of activities: <ol style="list-style-type: none">1) organized groups2) spontaneous groups |
| April 25 | - | first preliminary presentation, end of research phase and at this time discussion of activities analysis; |
| May 2 | - | beginning of analysis phase; |

Timetable cont.

- May 9 - meeting with Advisor
- May 16 - second preliminary presentation, discussion of analysis phase, and beginning of synthesis;
- May 23 - synthesis and starting final presentation;
- May 30 - organizing final presentation;
- June 6 - present;
- June 16 - beginning of summer quarter;
- June 23 - introduction to Thesis II
- June 30 - schematic studies of function-space relationships;
- July 7 - finalized function-space analysis for approval by Advisor;
- July 14 - preliminary design proposal;
- July 21 - begin final presentation;
- July 28 - preparation for final presentation and meet with Advisor;
- Aug. 3 - working on final presentation;
- Aug. 10 - final presentation completed;
- Aug. 11 - present;

The final presentation for Thesis I will be in the form of schematics diagrams, photographs, flow charts, and some other degree that can best be exploited to illustrate a solution. The progress report will be near completion by the end of the quarter, other information researched in Thesis II will complete the progress report.

Approved by: _____



COMMUNITY RESEARCH



white sulphur springs - 1872

HISTORY

The original boundaries of Meagher County were the Missouri River on the west and the Musselshell River on the east; with Chouteau and Gallatin County's forming the northern and southern borders, respectively. In 1867, this designated area gave Meagher County a total of 20,000 square miles; 2,000 were comprised of the valleys of the Judith, Musselshell, Smith, and Missouri Rivers. Meagher County has decreased in population throughout the years, but its natural boundaries have remained the same since 1920.

This tenth Montana county received its name from Thomas Francis Meagher, acting governor of Montana Territory from 1865-67. Diamond City, the first seat of government for Meagher County, was a booming mining town in 1865. Gold was the main attraction. Thousands of miners flocked to Diamond City from other diggings. But in 1880, the gold supply nearly depleted, the population had shrunk to about 80.

James Scott Brewer, founder of White Sulphur Springs, was born of German and English parents in Frederick County, Virginia. Later, in search of a new home, Brewer crossed the western plains in 1862, reaching Montana Territory in 1864. By 1866 he reached the thermal springs, and named it "Brewer Springs". It was later called "Trinity Springs".

Brewer constructed the first house in the Smith River valley. This was the only house on the east side of the

Belt Mountain range, between there and Diamond City. The Flathead Indians told him of the "Hot White Sulphur Springs" nearby, and Brewer soon moved to this area. By 1872 he had constructed a bath house with three single bath rooms and one plunge that was 12 feet by 12 feet. He charged 75¢ for a bath and the whiskey was extra. The hotel, a cluster of individual log cabins, was located a short distance to the north. A week-long Fourth of July celebration attracted hotel guests from Helena, Fort Benton, Camp Baker, and the Missouri Valley.

In 1876, James Brewer sold half of his landholdings to Dr. Parberry, who later acquired the remainder. During that same year, a postal service was established and Brewer Springs became White Sulphur Springs. In 1878, Dr. Parberry's townsite was located. After two more years, White Sulphur Springs replaced Diamond City as the county seat.

In 1890, White Sulphur Springs was growing and prospering. It had a bank, school, post office, jail, bath house, drug store, auditorium, fire house, and two hotels. The streets, of course, were dirt and the sidewalks were of wood.

In 1892, an auditorium was constructed, called the Temple of Fun, which was used for community entertainment of all types. Since this old structure was destroyed in the early 1900's by an earthquake, my thesis proposes a new community center to perform similar activities.

In the 1950's, a modern pool facility was constructed, later known as the Spa Motel, using the mineral water in a heated outdoor pool and in two steam rooms. It is still in use today, under the ownership of Merrit Smith. During early years of operation, the facilities were open to the public, but today they are used exclusively by renters. I will also be utilizing this geothermal water in the proposed center.



Community Center 1892

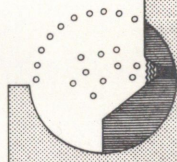
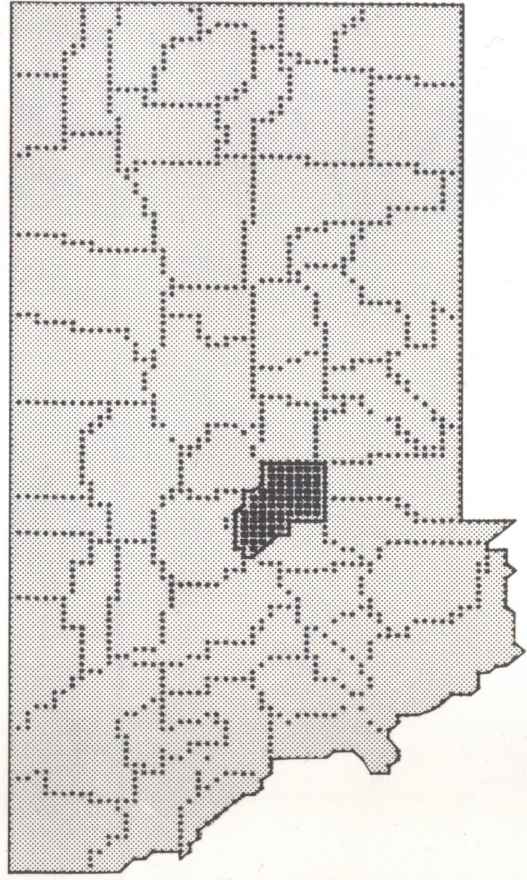
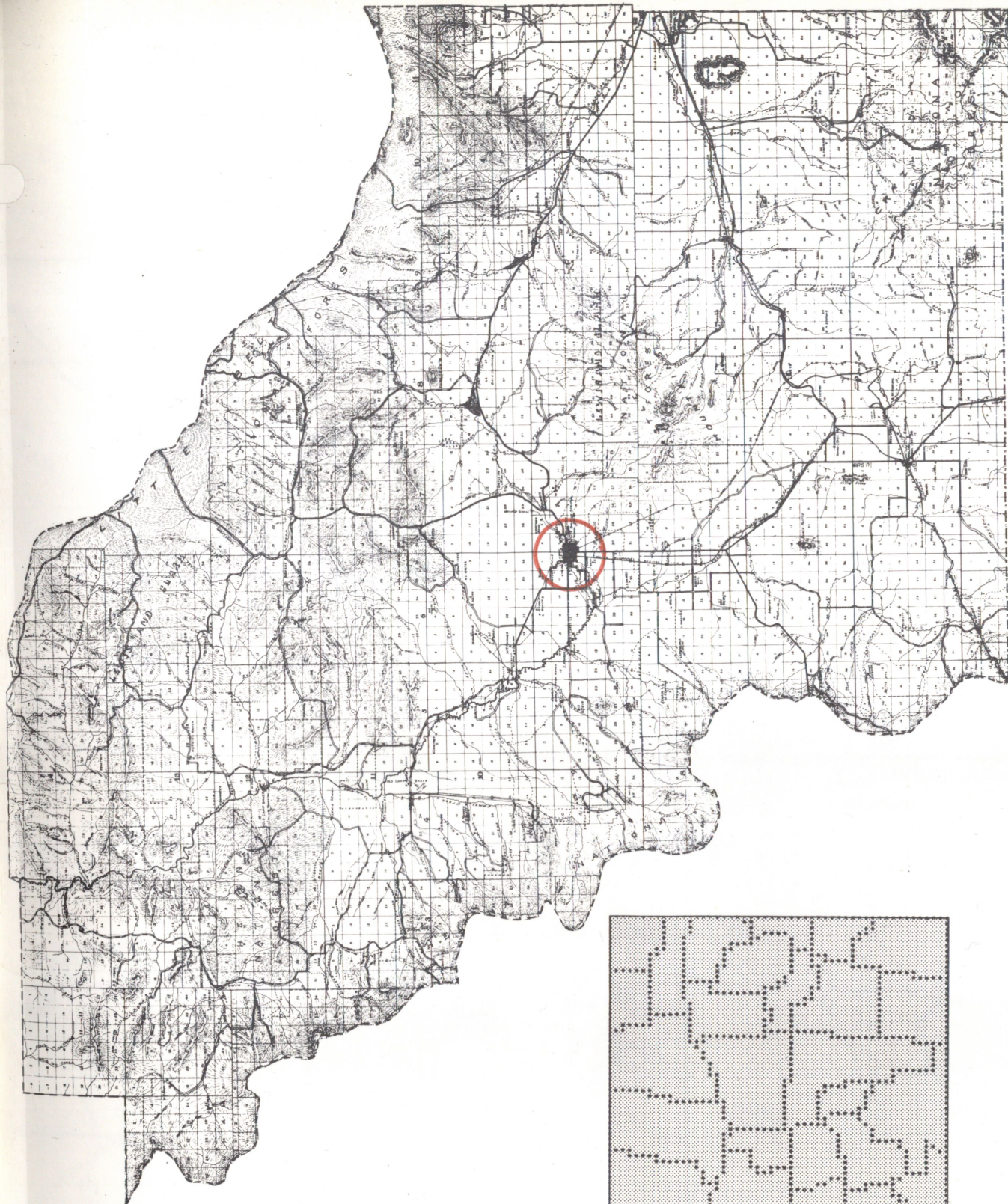
GEOGRAPHY

White Sulphur Springs is located in the central portion of Montana, in the heart of the Smith River valley. In a geologic sense, the Smith River valley is uniquely situated, for it lies in a structurally complex region between the Big Belt uplift, the Little Belt uplift, and the Castle Mountain Dome. In addition, the Smith River valley is the apparent zone of intersection of the huge central Montana arch. Two mountains, Mount Baldy and the Three Sisters, were once filled with glacial ice, which melted, forming numerous small lakes. The impressive exposures of paleozoic limestone and dolomite strata in the walls of Smith River Canyon rival America's most scenic tourist attractions.

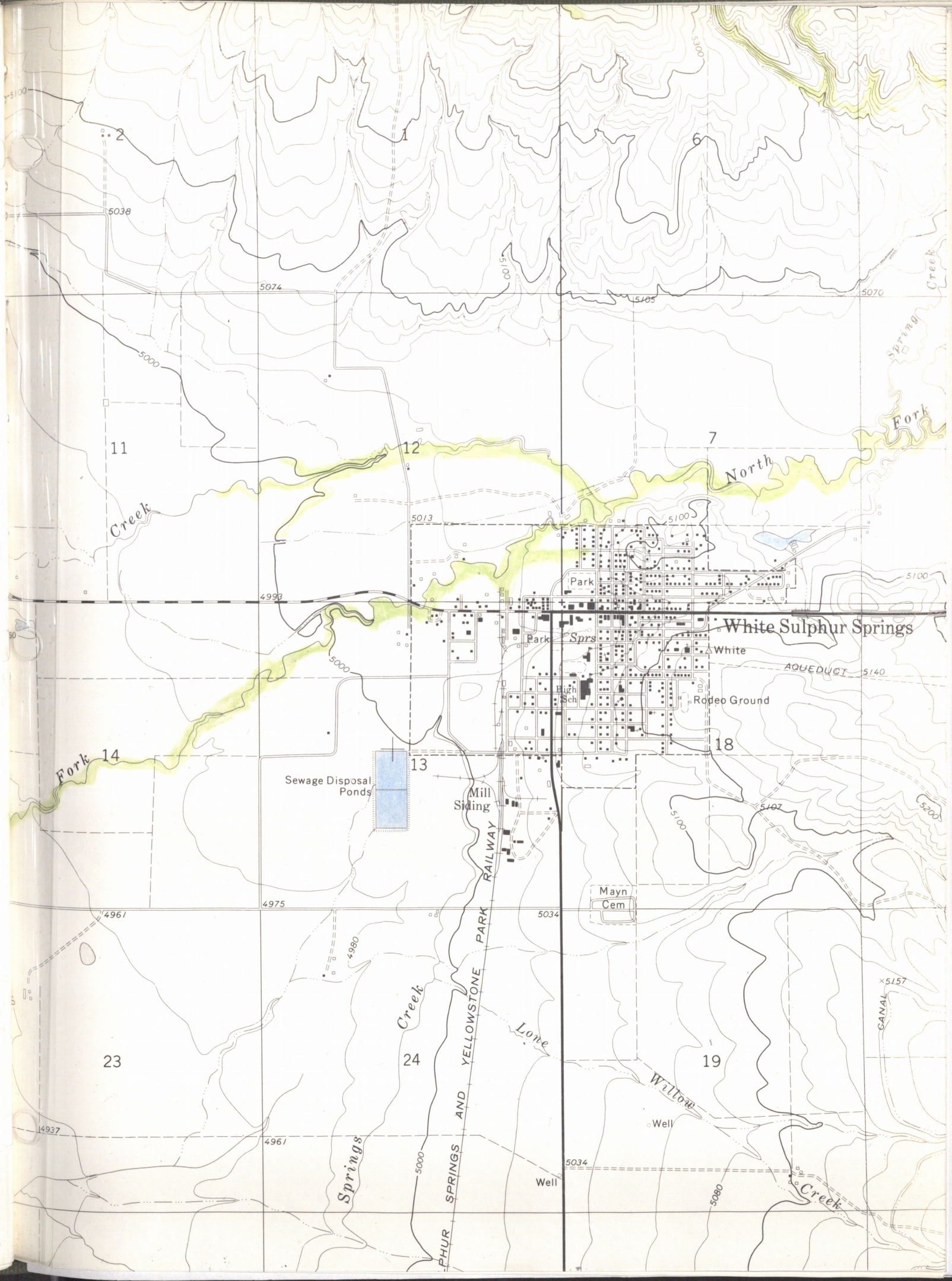
White Sulphur Springs is at the hub of transportation as it follows the layout of the Smith River valley. Interstate 12 runs west to Helena and east to Billings, and three miles on route, it intersects Highway 89 to Great Falls. County Road, leaving west from White Sulphur Springs, passes old Fort Logan and continues on to Lingshire and Milligan.

The county occupies a land area of 2,354 square miles. It is comparatively larger in size than other counties in the United States whose average area is 620 square miles. Ninety three percent of the 3,135 counties nationwide are

smaller than Meagher County. None of the land area of Meagher County is occupied by urban areas containing populations of 2,500 or more.



GEOGRAPHY



CLIMATE

The climate of Meagher County ranges from semi-arid in the intermountain areas of the Smith River valley and Musselshell River to sub-humid in the higher mountain ranges. Mountain basins are characterized by a comparatively low rainfall, with temperature extremes on a large number of sunny days. The midsummer temperatures reach a high of 95°F, with a relatively low humidity while the winter lows are -25°F. The climatic conditions in the stream and river canyons and in the mountain terrain vary with location and elevation.

The prevailing winds are normally from the north to northwest, at an average velocity of 8.7 miles per hour.

NORMAL, SEASONAL, AND MONTHLY TEMPERATURE AND PRECIPITATION

	<u>Mean</u>	<u>Absolute Maximum</u>	<u>Absolute Minimum</u>	<u>Precipitation</u>
<u>Month</u>				
December	21.6	55	-39	1.11
January	20.7	64	-42	0.95
February	24.1	78	-33	1.17
WINTER	22.1	78	-42	
March	29.2	85	-32	1.68
April	40.8	76	-7	1.40
May	50.1	96	15	2.32
SPRING	40.0	96	-32	
June	58.1	98	26	3.28
July	65.0	99	30	1.35
August	63.1	98	29	1.45
SUMMER	62.1	99	26	
September	52.4	93	16	1.38
October	42.6	79	-10	1.17
November	32.4	61	-25	1.19
FALL	<u>42.5</u>	<u>93</u>	<u>-25</u>	
TOTAL	41.7	99	-42	

Average yearly precipitation

18.46 inches

Average yearly snowfall

93.0 inches

DEMOGRAPHY

The concentration of population in and around urban centers of Meagher County is classified as a peripheral metropolitan or suburban area. The total population of Meagher County, taken from the 1970 United States census statistics, was estimated at 2,122 persons.

White Sulphur Springs has steadily declined in population since the 1960 census. The tally of the immediate vicinity was recorded at 1120 residents with 180 persons living on farms or ranches. The total population of the urban trade centers was 1,300 persons. The fact that three sawmills closed down in the early 60's has accounted for the decrease in population.

Meagher County has a population density of 0.9% persons per square mile. Age distribution varies in the county, with 28% under 14 to 11% over 65 years, establishing a medium age of 32. This is comparatively higher than the national average of 28.6 medium age.

The projected population growth for Meagher County for 1985 estimates an increase of about 350 persons.

MEAGHER COUNTY
POPULATION - 2122

TOTAL SQ. MILES - 2356

DENSITY .9% per person

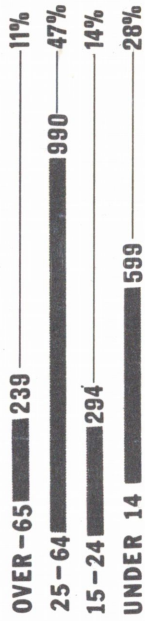
WHITE SULPHUR SPRINGS
POPULATION - 1300

CITY LIMITS - 1120

RURAL FARM - 180

MEDIUM AGE 32

AGE DISTRIBUTION



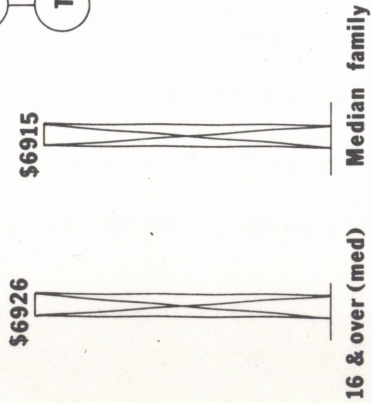
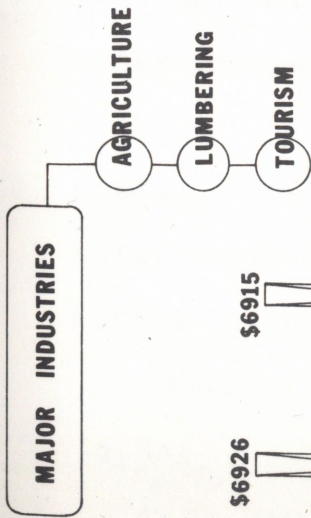
ECONOMY AND RESOURCES

Meagher County's present economic resources are agriculture, lumbering, and tourism. The most current census, taken in 1970, records agriculture as contributing 36% of the total earnings, with government earnings of 15%, and non-farm earnings at 49%.

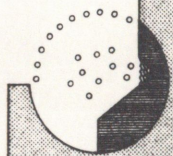
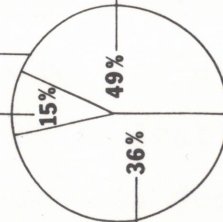
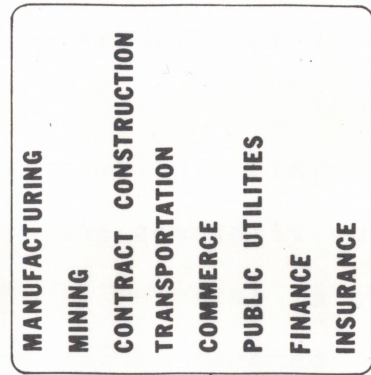
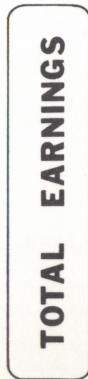
During the late 50's and in the 60's, much of the economy was in the wood product industry. At this time four sawmills were in operation. Lack of an adequate labor force two years later forced the smaller mills to shut down. Presently there is still one large sawmill in operation, which is located on the south side of town.

The community's natural hot mineral springs has added to the area's vacationland attractions, another facet of the county's economy. Tourism is, and probably will remain, one of the county's most important industries. The whole county is filled with immense recreational opportunities and the beauty of it's lakes, rivers, and the long range of mountains. The area is filled with scenic sites and historic monuments.

White Sulphur Springs is the largest trade center and dominant economic area in the county. Martindale and Ringling are two other smaller towns, with populations less than 200 people. Meagher County will always be a resourceful and resolute area by the contribution of its natural resources.



PROFESSIONAL & TECHNICAL	67
MANAGERS & ADMINISTRATORS	47
SALE WORKERS	7
CLERICAL	49
CRAFTSMEN & FOREMAN	27
OPERATIVES	104
LABORERS (NON-FARM)	68
FARMERS & FARM MANAGERS	131
FARM LABORERS & FOREMEN	150
SERVICE WORKERS	127
PRIVATE HOUSEHOLD WORKERS	27
TOTAL EMPLOYED	804



INCOME

NATURE OF THE COMMUNITY

White Sulphur Springs' history plays a dominant role in the community's social and economic behavior. Mining and lumbering were the first settling factors in the Smith River valley. This little community became the center of manufacturing and transportation to other regions of Montana. The White Sulphur Springs - Yellowstone Park Railway provides the only main line to serve the area. The Railway Express Company operates it's main headquarters in White Sulphur Springs. The sawmill and agricultural industry used the transit line for shipping lumber and raw materials. The destination is at Ringling, approximately 20 miles away. The railway stops at this point, where a commercial railway is then used for further shipment to other regions.

The community has one tax supported public library, maintained by local people, and open to the community on a year-round basis. Mountainview Memorial Hospital is the only medical facility within the county and is located under the same roof as the nursing home. The hospital has a capacity of 8 beds and the adjoining nursing addition has 6 beds. This provides medical care service for 70% of the total community population. The professional medical personnel include one physician, one surgeon, and one dentist.

Meagher County consists of seven school districts,

with the largest institutions, one high school (enrollment 135) and one elementary school (enrollment 280), located in White Sulphur Springs. These educational facilities are primarily concerned with their own interests but do promote some community interaction.

The existing space available for small and large organizations are the school lunch room, the Courthouse, above the First National Bank, individual homes, and others. These groups must pay rent for the use of these quarters. There are no other facilities within the community that provide space for social and recreational activities. The only indoor entertainment which draws community interest are the Strand Theater, the school athletic programs, guest speakers, dances, and social and recreational gatherings. Because of the geographic location, recreation evolves around outdoor activities, and neglects the nature of activities within the city limits.

The town does have two playgrounds, a community baseball field, and a privately owned tennis court which is open to the public. These areas provide activities during the summer months. Winter activities include ice skating, sleigh riding, snowmobiling, and skiing.

CONDITIONS CONSTITUTING A NEED FOR A COMMUNITY FACILITY

White Sulphur Springs is definitely in need of a different outlook on community interest. The small town is lacking a sense of citizen participation, which it had lost many years ago. Built in 1892, the old auditorium satisfied most of the community needs but was destroyed. A new structure was never built to gain back the "sense of community". The little community must regain its self identity and provide a more useful order of activity participation to generate moral.

POVERTY INDICATORS

Definition of poverty - considering the relationship of family income to family size and residence status in Meagher County, the average income cutoff distinguishing poor from non-poor stood at 2,696 in 1960 and 2,750 in 1966.

Severity of poverty - 19.3% of the families in Meagher County receive incomes below the Social Security Administrations poverty cutoff in 1970, as opposed to 22.6% of the families in the typical county. These 19.3% are considered poor according to the above definition.

Family resources - a mean family income of \$6,915 was observed in the county in the 1970 census, as compared to the national level of \$10,015.

Employment conditions - 8.1% of the labor force in the county was unemployed in 1960, as compared to a

national county average of 4.8%.

The town furnishes most of the basic essentials for consumers but because of the high transportation costs, these goods are above normal price. The cost of living is higher in this area because of the above factor.

In observing these conditions, a large percentage of the citizens in the community cannot afford alot of outside luxuries and amenities. Can we help these people?

GENERAL CONDITIONS

Educational achievement - a median age of 10.6 school years was completed by persons age 25 and over in Meagher County in 1960. 2.3% failed to complete over 4 years of schooling in the same year.

Population density - 1.2 persons per square mile was recorded in Meagher County in 1966, indicating a sparse population concentration. Among all the inhabitants of the county, the largest proportion, considering residence status, were residents of rural areas, though not living on farms. This segment of the population comprised 74.4% of all families in the county in 1960.

Farm size - county average was 5,552 acres in 1959, showing sizes larger than the average farm in the United States, 303 acres.

This indicates a widespread population, which exhibits even more so that some force is needed to bring the citizens

together.

In order to meet the community needs, questionnaires were distributed to the townspeople, to determine which activities would be of interest to them. To stimulate a "sense of community", the citizens must have the opportunity for a more useful order of their leisure time and to participate in a variety of different activities.

"The Only County in Montana with a Castle"



The Meagher County News

White Sulphur Springs, Montana 59645

Community meeting explores federal funding of numerous community projects presented

A poor turnout greeted concerned citizens trying to interest members of the community in bettering White Sulphur Springs and Meagher County by obtaining federal funds to attack some of the many problems besetting the area. Undaunted, they presented what information they had gathered and talked of another community meeting to get more people interested in the projects.

A presentation was made by Roger Sicz on a multi-purpose building to be used for recreation and community purposes of some 5,000 square feet in size. An outdoor swimming pool in conjunction with the facility was envisioned by the presentation, all to be funded by federal funds, if available. Within the building, there would be a large area to be used for physical recreation and meetings, with a locker room that could be used for the building and also for a pool complex later. Smaller rooms for other purposes would be built, including a kitchen. An outdoor pool, possibly enclosed by a "bubble" would be built adjacent to the building if sufficient funds could be obtained.

A housing and health presentation was made by Roger Ala of Bozeman who stated that documentation was needed before federal funding could be obtained. Using 1970 federal census data, he drew a dismal picture of conditions in Meagher County. In the 1960-1970 period, Meagher County lost 18.9% of its population, with a 40.9% decrease in farm population alone. Income less

than the poverty level is felt by some 23.1% of Meagher County residents. The median income is some 6,900, which is far less than enjoyed by the rest of the state. Housing is generally poor, with some 13% living in crowded housing, defined, as more than one person per room.

Health conditions in Meagher County were very depressing, with the county having a death rate twice the state average. This also holds for infant mortality, and low weight births account for some 99 percentage points higher than the state average. Our incidence of heart disease is twice as high as the state average and our diabetes incidence is the third highest in the state.

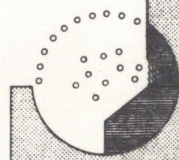
An idea for a locally controlled and operated Human Resource Development Council was presented. This would be part of a tri-county council composed of Gallatin, Park and Meagher Counties and would be used to search for and obtain federal funding for various needed projects in the county. It would be composed of one-third business and professional people, one-third low income people, and one-third public officials. A number of people volunteered to help get more interested people to the next meeting and to get just such a council off the ground and operating.

JANUARY 28, 1975

PRIMARY ORGANIZATIONS	no of members	meeting period	place of meeting	max. assembly
MEAGHER COUNTY STOCKGROWERS	100	ANNUALLY	COURTHOUSE	200
MASONIC LODGE	75	BI-WEEKLY	MASONIC LODGE	150
MEAGHER COUNTY COWBELLES	70	MONTHLY	INDIVIDUAL HOMES	140
MEAGHER COUNTY RODEO CLUB	65	MONTHLY	COURTHOUSE	130
EASTERN STAR	45	BI-WEEKLY	MASONIC LODGE	130
HOSPITAL GUILD	65	MONTHLY	HOSPITAL	130
MERCHANT ORGANIZATION	50	MONTHLY	VARIOUS RESTAURANTS	100
MEAGHER JUNIOR RODEO CLUB	45	MONTHLY	COURTHOUSE	80
SEARCH AND RESCUE COUNCIL	40	MONTHLY	INDIVIDUAL HOMES	80
JAYCEE'S	40	WEEKLY	FIRST NATIONAL BANK	80
JAYCEEN'S	40	WEEKLY	INDIVIDUAL HOMES	80
4-H CLUBS	40	MONTHLY	INDIVIDUAL HOMES	80
BRIDGE CLUBS	40	WEEKLY	INDIVIDUAL HOMES	80
BOY SCOUTS	35	WEEKLY	FOREST SERVICE	70
CLUB SCOUTS	35	WEEKLY	FOREST SERVICE	70
SENIOR CITIZEN'S	30	WEEKLY	SENIOR CITIZEN'S CENTER	60
ROTARY CLUB	30	WEEKLY	DOWNTOWNER CAFE	60

SMALL GROUPS

HOBBY CLUB	24	MONTHLY	INDIVIDUAL HOMES	48
AMERICAN LEGION AUXILIARY	24	MONTHLY	INDIVIDUAL HOMES	48
V.F.W. AUXILIARY	22	MONTHLY	V.F.W. HALL	40
MEAGHER ROD AND GUN CLUB	20	MONTHLY	COURTHOUSE	40
CAMPFIRE GIRLS (2 GROUPS)	20	WEEKLY	INDIVIDUAL HOMES	30
SQUARE DANCING CLUB	20	BI-WEEKLY	SCHOOL GYM	40
WEIGHT- WATCHERS	20	WEEKLY	SENIOR CITIZEN'S CENTER	30
HOME DEMONSTRATION CLUB	20	MONTHLY	INDIVIDUAL HOMES	30
MEAGHER COUNTY HISTORICAL SOCIETY	15	WEEKLY	INDIVIDUAL HOMES	20
BLUE BIRDS (2 GROUPS)	15	WEEKLY	INDIVIDUAL HOMES	20
CITIZEN ADVISORY COUNCIL	15	MONTHLY	FIRST NATIONAL BANK	20
WOMEN'S KNITTING CLUB	12	MONTHLY	INDIVIDUAL HOMES	20
W.S.S. FLYERS	7	MONTHLY	INDIVIDUAL HOMES	10
HUMAN RESOURCE COUNCIL	6	WEEKLY	FIRST NATIONAL BANK	10



GROUP ACTIVITIES

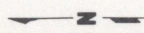
CURRENT MEETING ROOMS

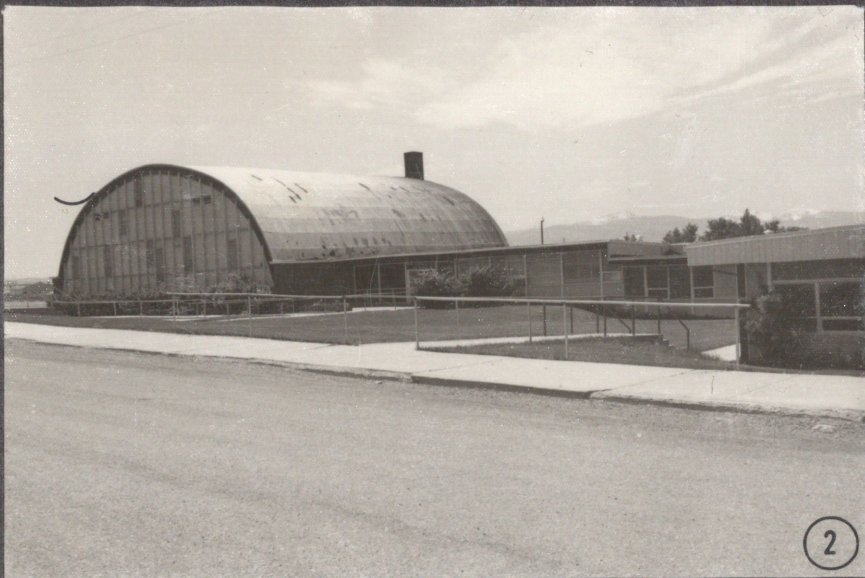
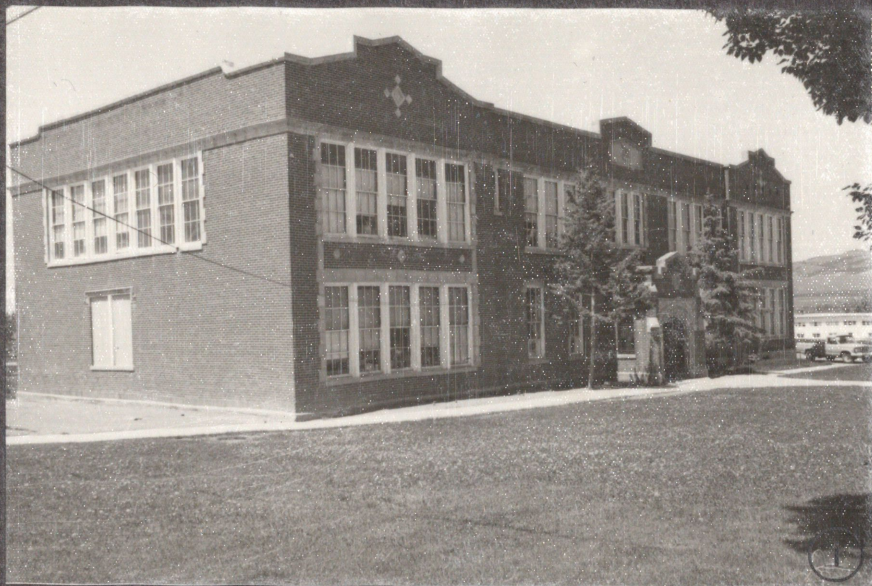
1. White Sulphur Springs Elementary School
2. White Sulphur Springs High School
3. City Hall
4. Meagher County Courthouse
5. First National Bank
6. White Sulphur Springs Ranger Station of U.S. Forest Service
7. Mountain View Memorial Hospital
8. Senior Citizen Center
9. Downtowner Restaurant
10. Truck Stop Cafe
11. Spa Motel and Restaurant
Home of the natural hot springs - swimming and steam bath
12. International Order of Odd Fellows (I.O.O.F.) Hall
13. Berg Residence
14. McDaniels Residence



Legend

- courthouse
- city hall
- senior citizen's center
- forest service
- first national bank
- elementary school
- high school
- various restaurants
- v.f.w hall
- individual homes



















SELECTION of SITE

SELECTION OF SITE

Site selection was based on the following criteria:

1. its centrality to the urban population
2. location in proximity to the mineral springs, utilization of geothermal energy for building heating, swimming pool, and bathing facilities
3. in proximity to other intensive use activities
4. the adaptability of the site, and allowable area for outdoor activities
5. located in conjunction with the city's existing park
6. situated away from main flow of traffic movement
7. a focusing magnet to residential and commercial areas
8. allotted area for usable parking
9. within walking distance from neighborhood areas

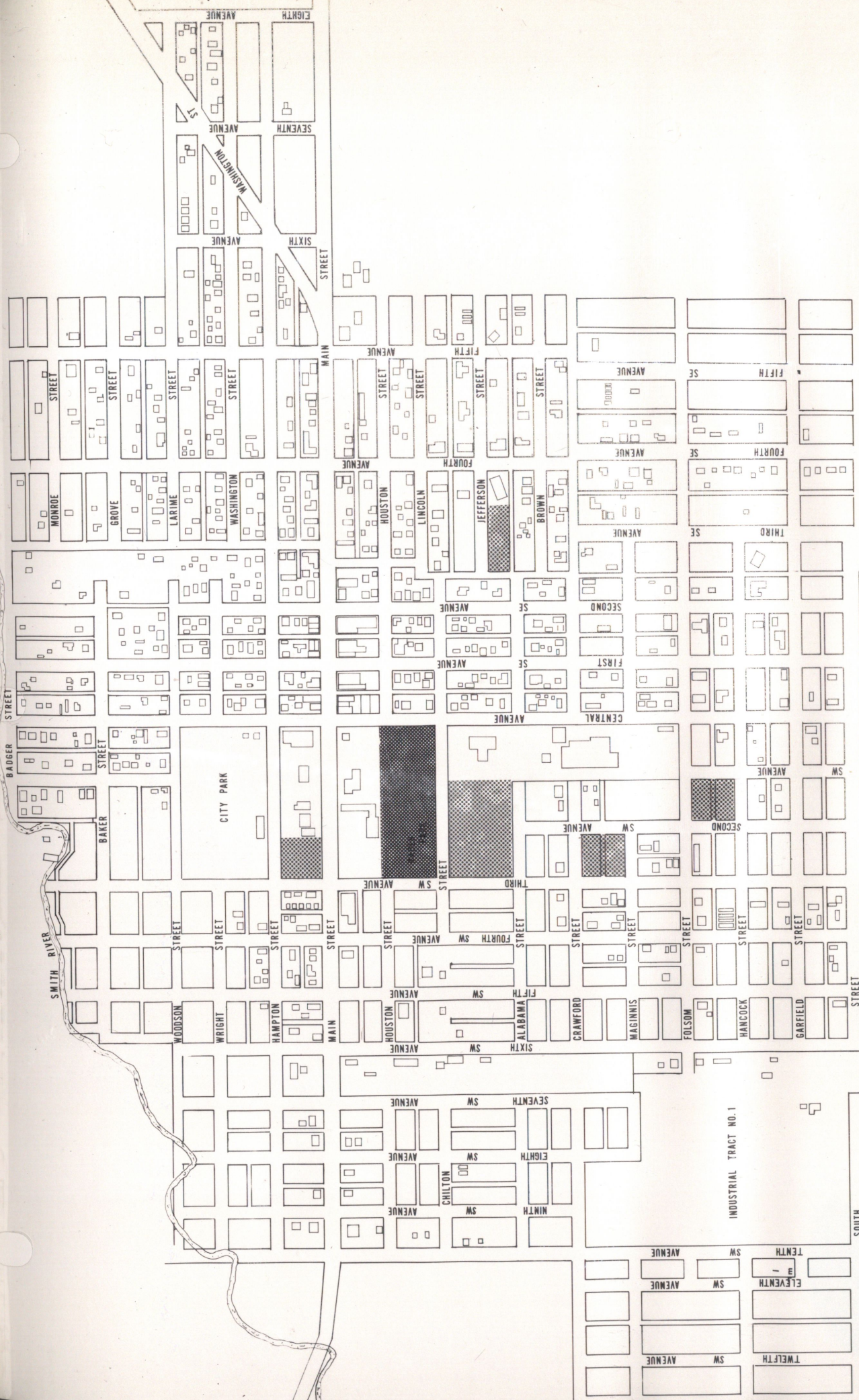
The area selected is located on the corner of Central Avenue and Chilton Street.

The major portion of my project deals with recreational activities. The site becomes optimum for creating a transitional node with the existing park activities and utilizing the hot mineral water located near the site. No other site could be more qualified or need more improvement than the site selected. Many sites could have been adapted to the requirements of the community and been used to some advantage but would not have been suitable for the activities

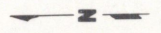
considered.

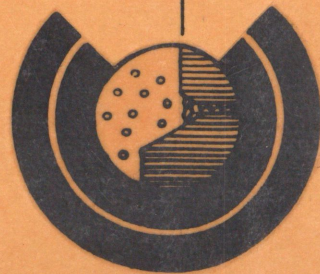
The site is relatively flat. The only change in elevation is where it slopes into the adjoining park. The proposed site, in conjunction with the existing park, is composed of half a city block. This allows enough area for expansion of outdoor activities, landscaped areas, and an allotted area for parking. To reduce any noise problems, the building will be located on the east corner of Central Avenue and Chilton Street.

The list of criteria established has been completely satisfied in the selection of this site.



PROPOSED SITE
OTHER AREAS





SITE ANALYSIS

SITE ANALYSIS

The planning area is centrally located in the downtown business district, yet still focuses toward the residential areas. Access to the site may be accomplished off of Chilton Street and Central Avenue. Ingress and egress will be primarily controlled off of Central Avenue, with pedestrian access onto the site by walks or smooth pathways.

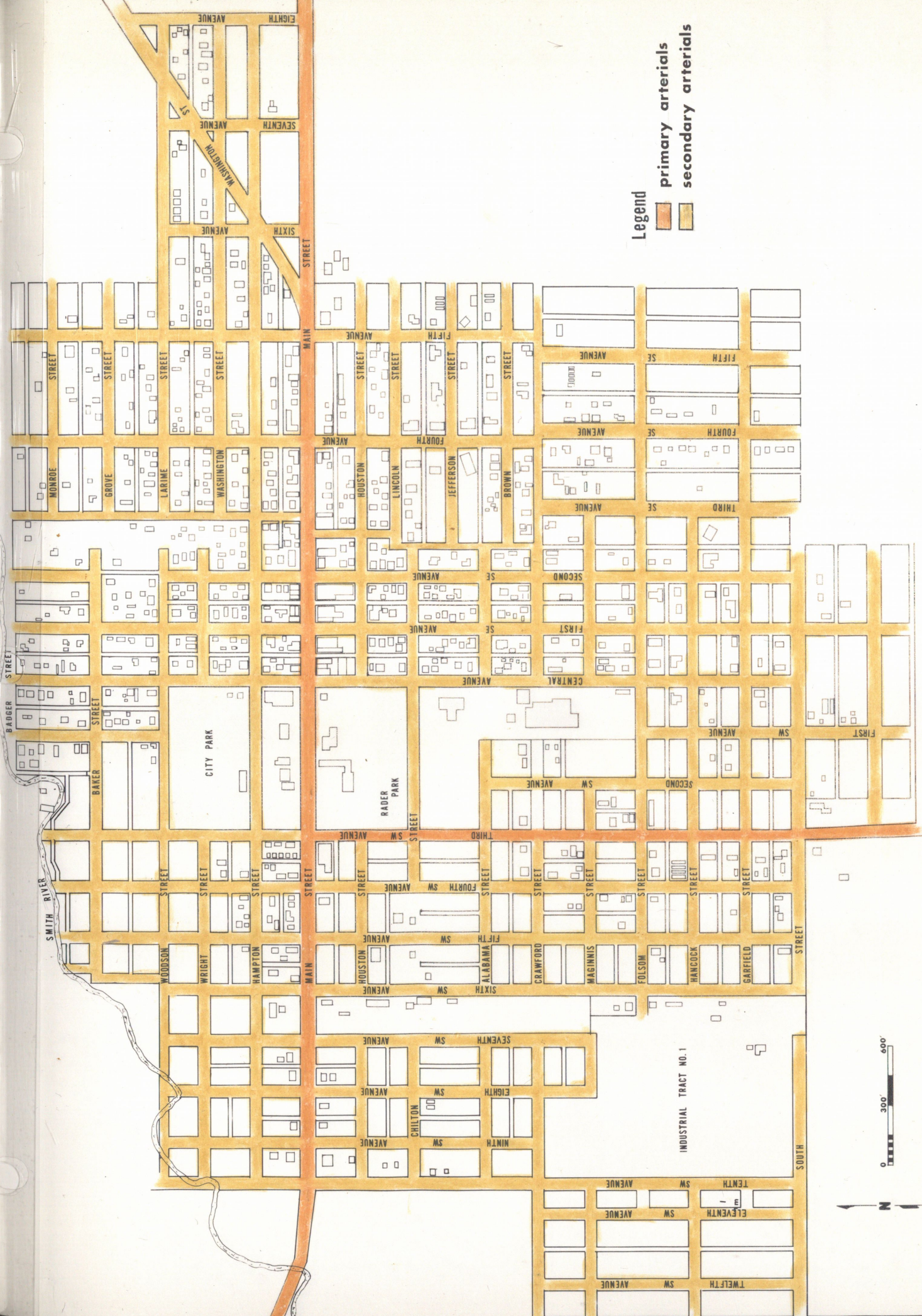
Existing buildings encompass the planning area on the north and east borders, leaving the remainder of the area open and sprawling. The Memorial Hospital and the Spa Motel on the north side are more or less new in appearance, as opposed to other buildings in the intense area.

PHYSICAL ASPECTS

The topography is basically level except for the slope of the hilger loam clay terrain near the edge of Rader's Park. Maximum relief of contour is 8 feet in elevation. The geology of the area is a combination of cheyenne gravelly loam, hilger stony loam, and teton-adel silt loams.

The most distinctive feature of this area is, of course, the geothermal energy. As previously mentioned, this water was first recognized in the early 1860's as a strong curer of diseases, and, in its natural state, for bathing facilities.





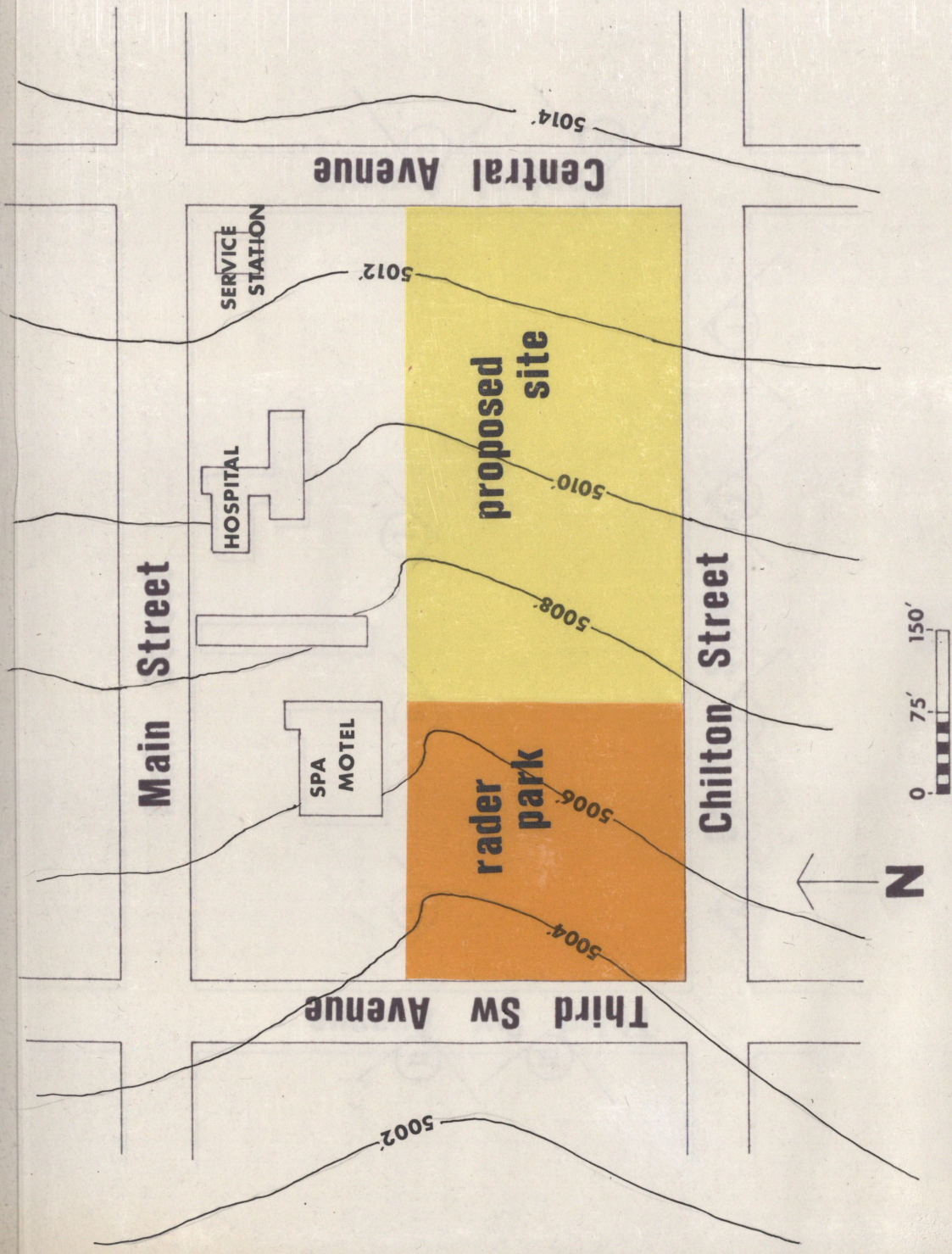
Legend
primary arterials
secondary arterials

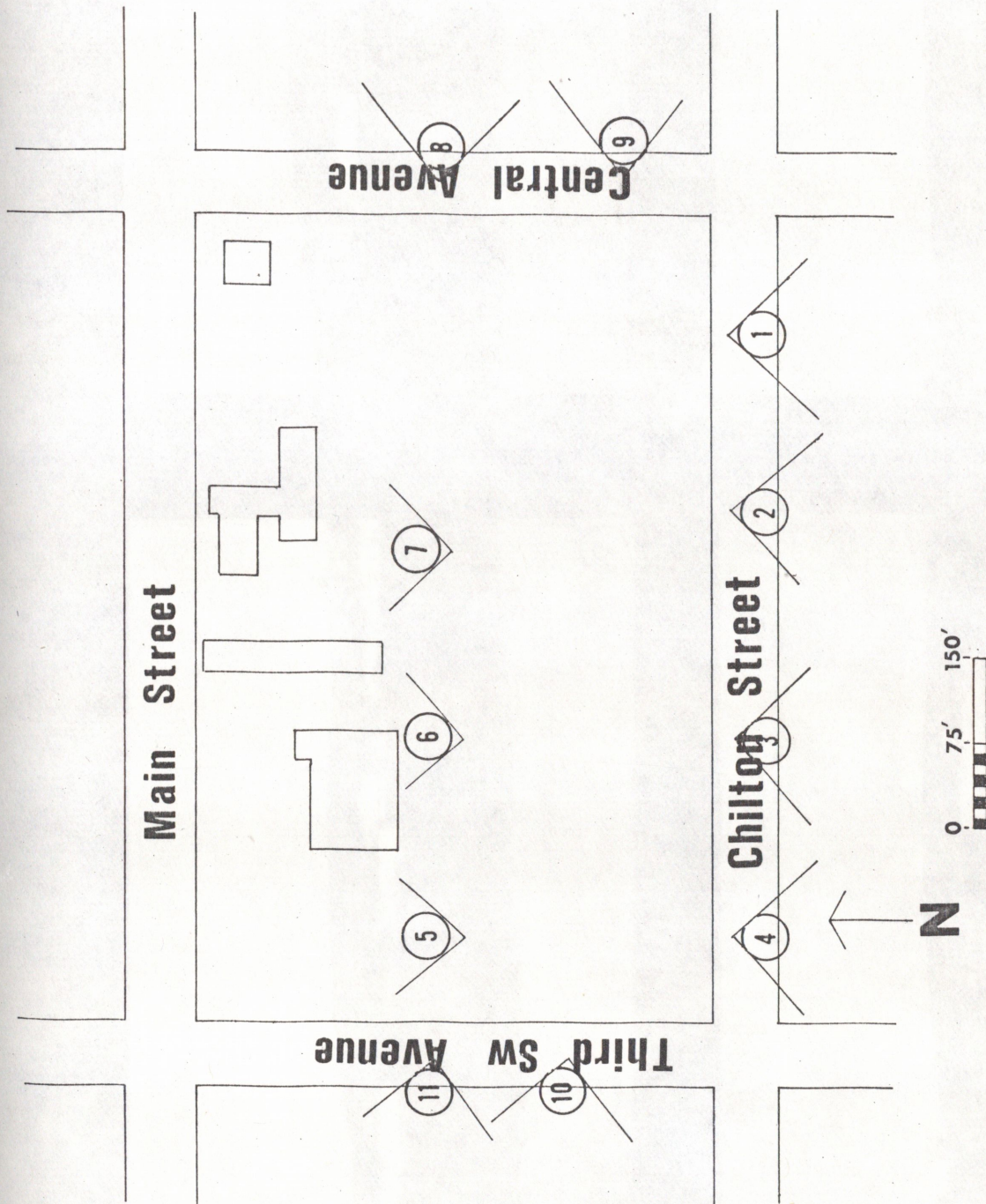
0 300 600

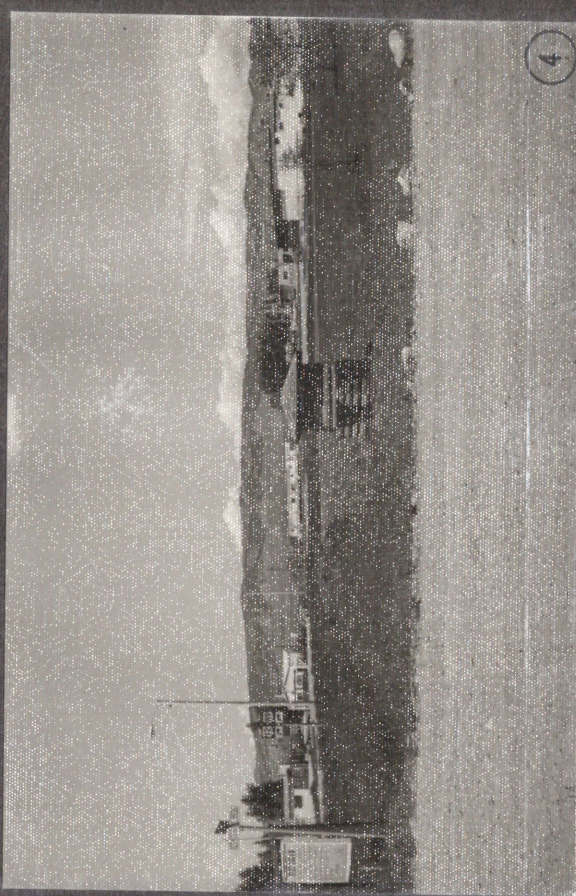
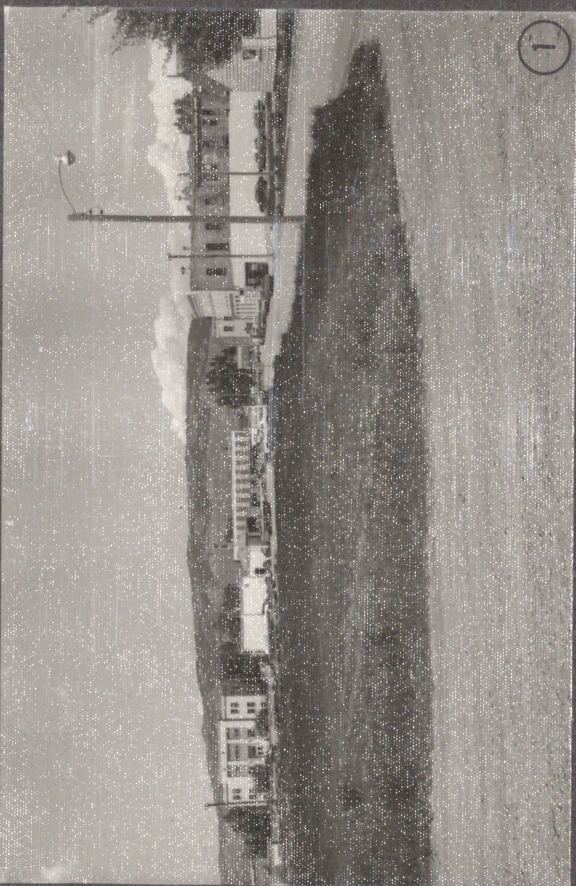




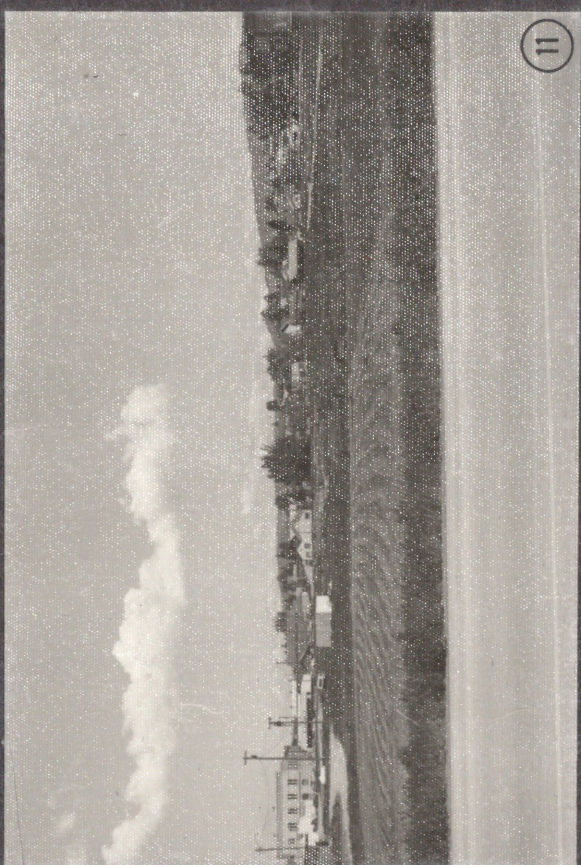
- Legend
- residential
 - commercial
 - industrial
 - schools
 - hospital
 - governmental
 - churches
 - parks and public areas









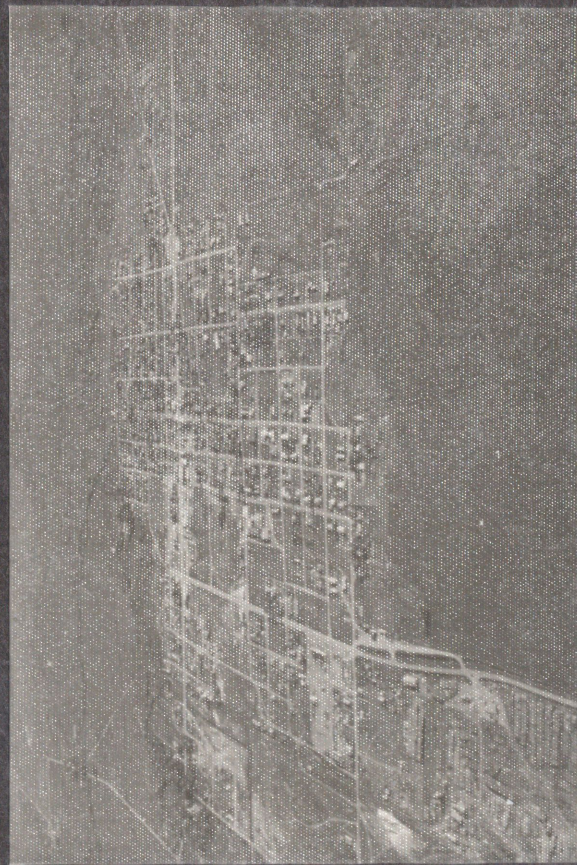




2. Looking southwest



1. Looking west



3. Aerial view



4. Looking north

GENERAL ANALYSIS OF GEOTHERMAL ENERGY

Future possibilities in the geothermal field are commencing in the community of White Sulphur Springs. The following information is the general analysis data on geothermal energy. It is incomplete at the present but will have to suffice until a more thorough investigation of the water capabilities can be conducted by research personnel. The feasibility of utilizing the hot mineral water is evident near the planning area, as the Spa Motel is making use of the water in a heated pool. The motel is not exploiting the possibility of employing the geothermal water for building heating purposes.

GEOTHERMAL ANALYSIS

General

Geothermal resources are not clearly nor comprehensively defined in a final formulation since research surveys are still in the stage of discovering and characterizing new types of this resource.

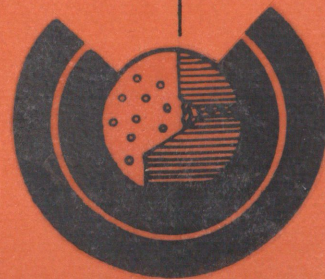
Geothermal resources are considered as to three basic factors:

- 1) The geothermal formation of the field's container
- 2) The geothermal constituents which fill the "container"
- the rocks surrounding it
- 3) The process by which the geothermal continues

generating natural heat and water recharge

The geothermal constituents include hot water, steam, minerals, gases, and chemicals mixed in the water. They also include the gases in the steam and water, minerals in the geothermal host rocks, and the energy located in compressed water.

The variety of constituents have possible uses in the characteristics of local economic, climatic, and topographic conditions. The full testing and drilling for the community is illustrated on the sample work plan. Geothermal exploration of the area will begin in August of 1975, conducted by the Montana State University Research Administration. The research committee will then begin a program which provides for full testing of everything found in the geothermal formulation, including temperature flow, the composition of the water, of the gases, rocks, and other related areas.



—THE

COMMUNITY

CENTER —

"The well-organized community center becomes a social nucleus and a place of cultural growth giving direction and stimulus to group effort. At the same time, it enables each individual in the various age groups to attain, through active participation, his full stature within the community."

Dr. Walter Gropius

INTRODUCTION

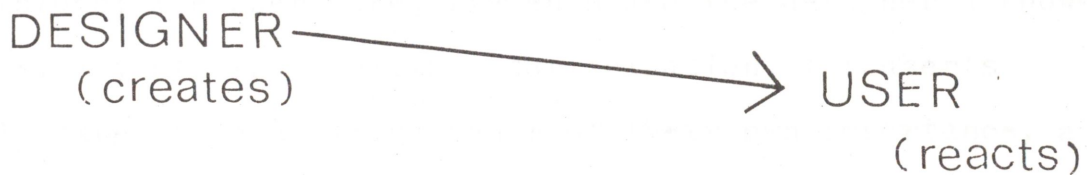
Numerous social problems finally sparked a dramatic interest in community activities in the early 1960's. Simultaneously, there had been an increasing acquaintance with the community structure and it's social obstacles. The social framework of our modern day society ignores a large portion of the population, and cuts off channels which would allow them to influence the administrative departments that decide their futures.

Recently there has been an increased effort to encourage citizen participation in the community. Smaller communities, especially in rural areas, suffer from many problems, such as a scarcity of job opportunities, a diminishing population, and / or inadequate and neglected public buildings. More than ever, these communities need some type of structured citizen participation to counteract the forces that are eating away at community spirit. Many of these communities lack any kind of organized group that could effectively deal with these problems, and quite often, the town leaders are unaware of the need's of the area's population. This would indicate that an outside force may be required to initiate a solution.

One superior implement to aid in the restoration of a sense of community is a municipal facility, designed to meet the community's social and recreational needs. The

practiced approach is to research the economic and physical characteristics of the area, develop a solution, and present it to the community leaders. It has been exhibited that the official's decisions did not reflect the opinions of the population. There was no direct feedback to any of the design decisions, which resulted in user dissatisfaction with the designed environment. There are two basic procedures, both of which are unsuccessful.

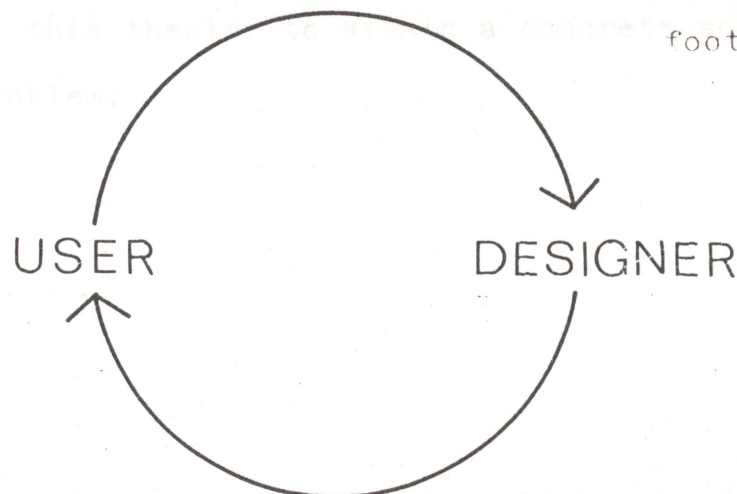
footnote 1



Lack of interaction between the two is the core of the problem.

The continuous cycle illustrated below might be a more ideal solution.

footnote 2

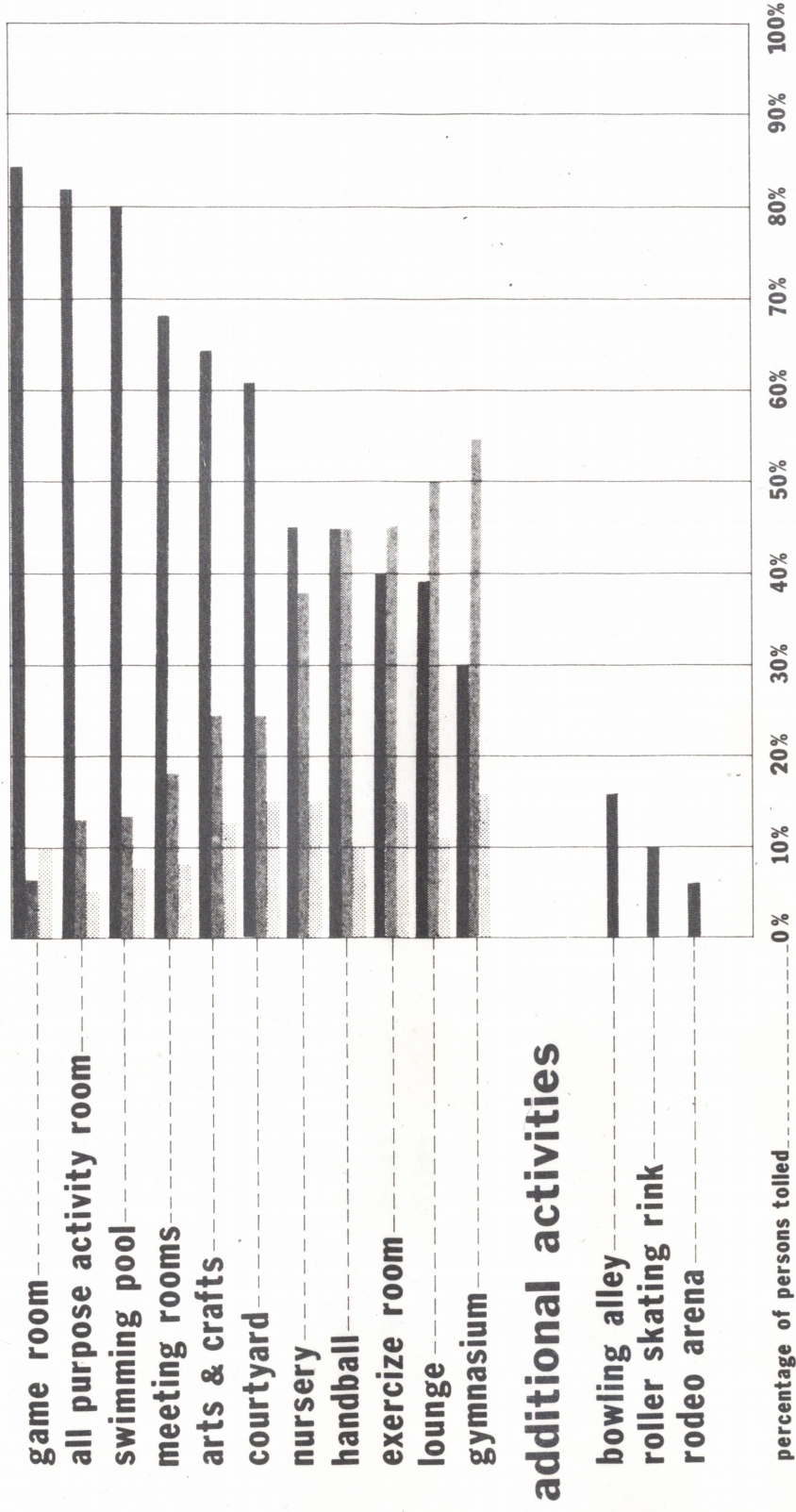


To create an environment that is satisfactory to the user's needs, the designer must allow the user to participate in the space considerations for the facility. One of the designer's options might be to solicit the user's desires for activities or types of space. Another possible mode would be to allow the user to manipulate the space to his own needs after the facility has been constructed, via partitions, furnishings, and the like. Both procedures would incorporate the possibility for a balanced input of decisions; the user's requirements and the designer's knowledge. By utilizing citizen participation, the user's would experience a strong sense of their own importance, a significant step towards community spirit. The final outcome should be a successful community facility, fully utilized and enjoyed by the citizens of the community.

This thesis will attempt to incorporate both concepts into it's program. The first method will be accomplished by circulating questionnaires throughout the community. Two different age groups were selected to achieve a better overall opinion. In this manner, I hope to include the facet of realism into this thesis, to attain a concrete solution to an actual problem.

proposed activities

circulation 100 response 82



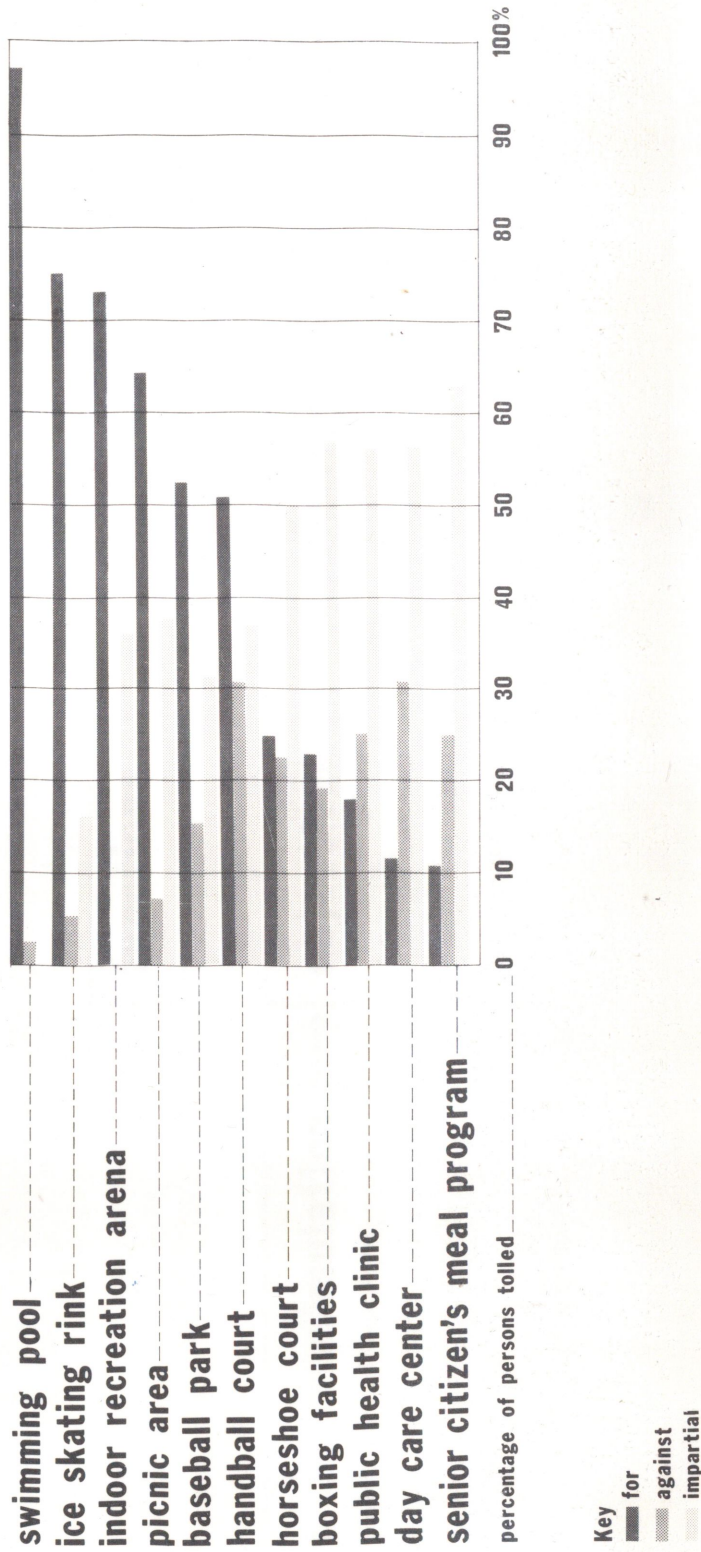
additional activities

Key

- for
- against
- impartial

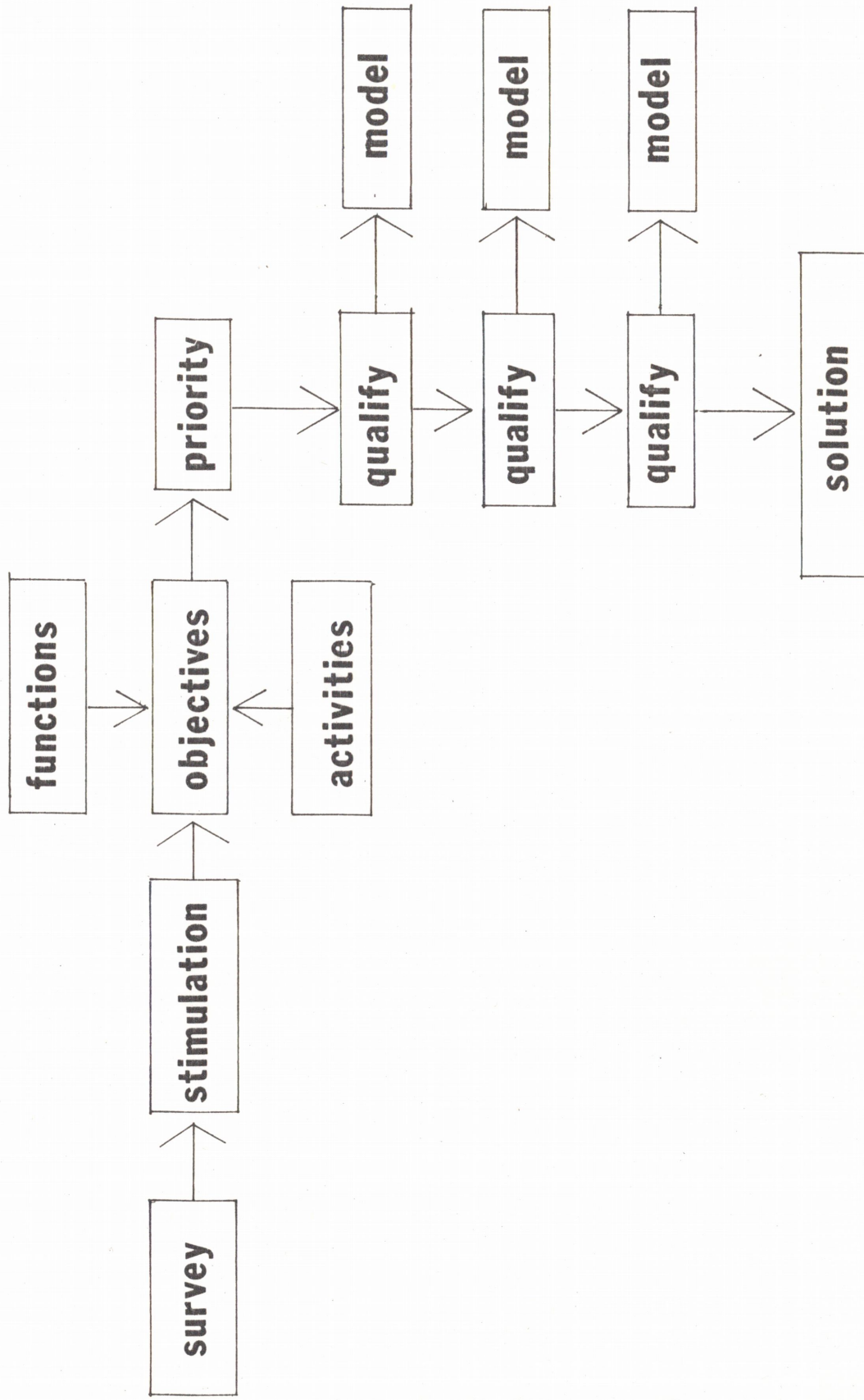
older age group

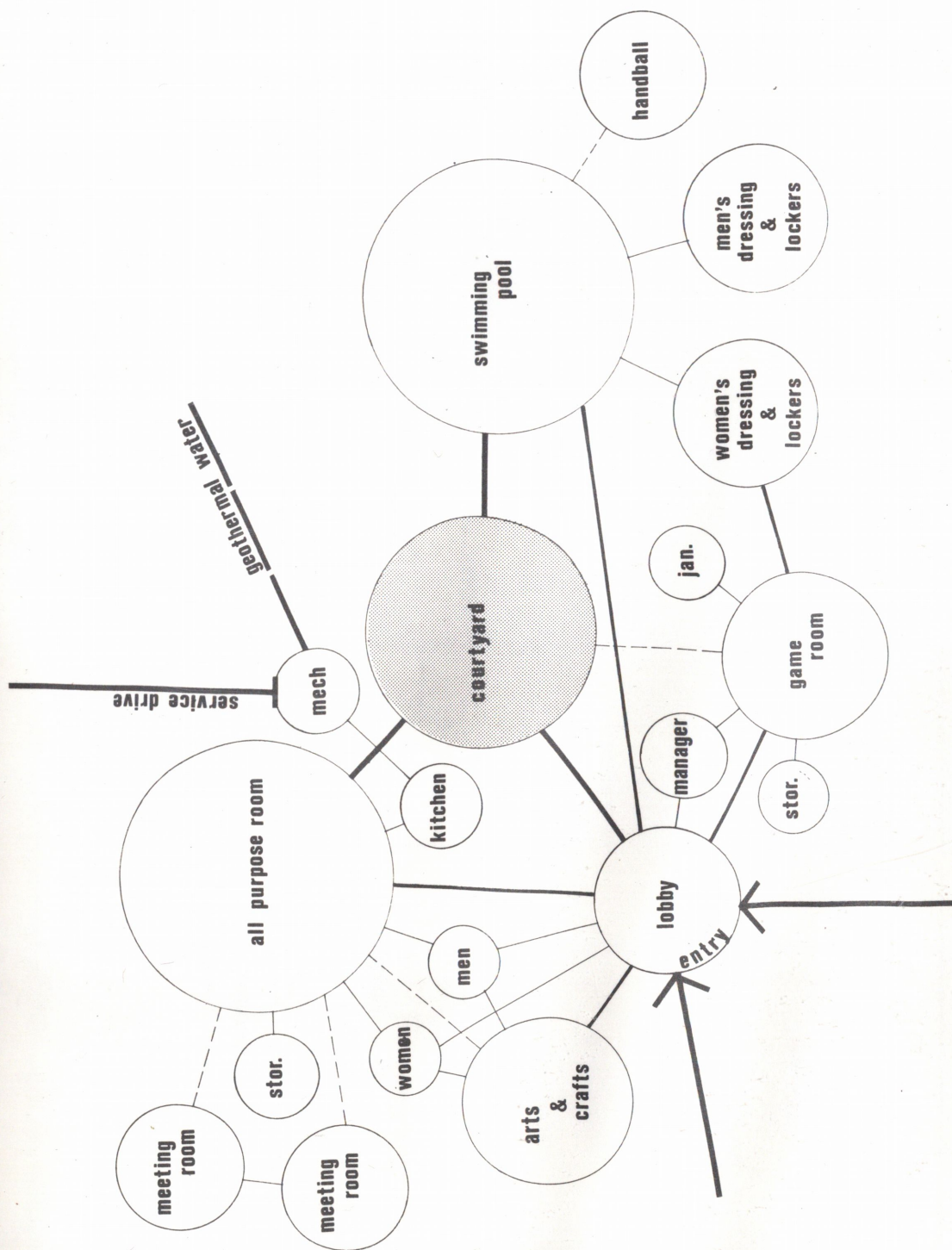
proposed activities



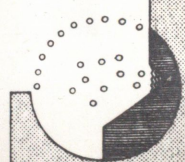
younger age group

community development process



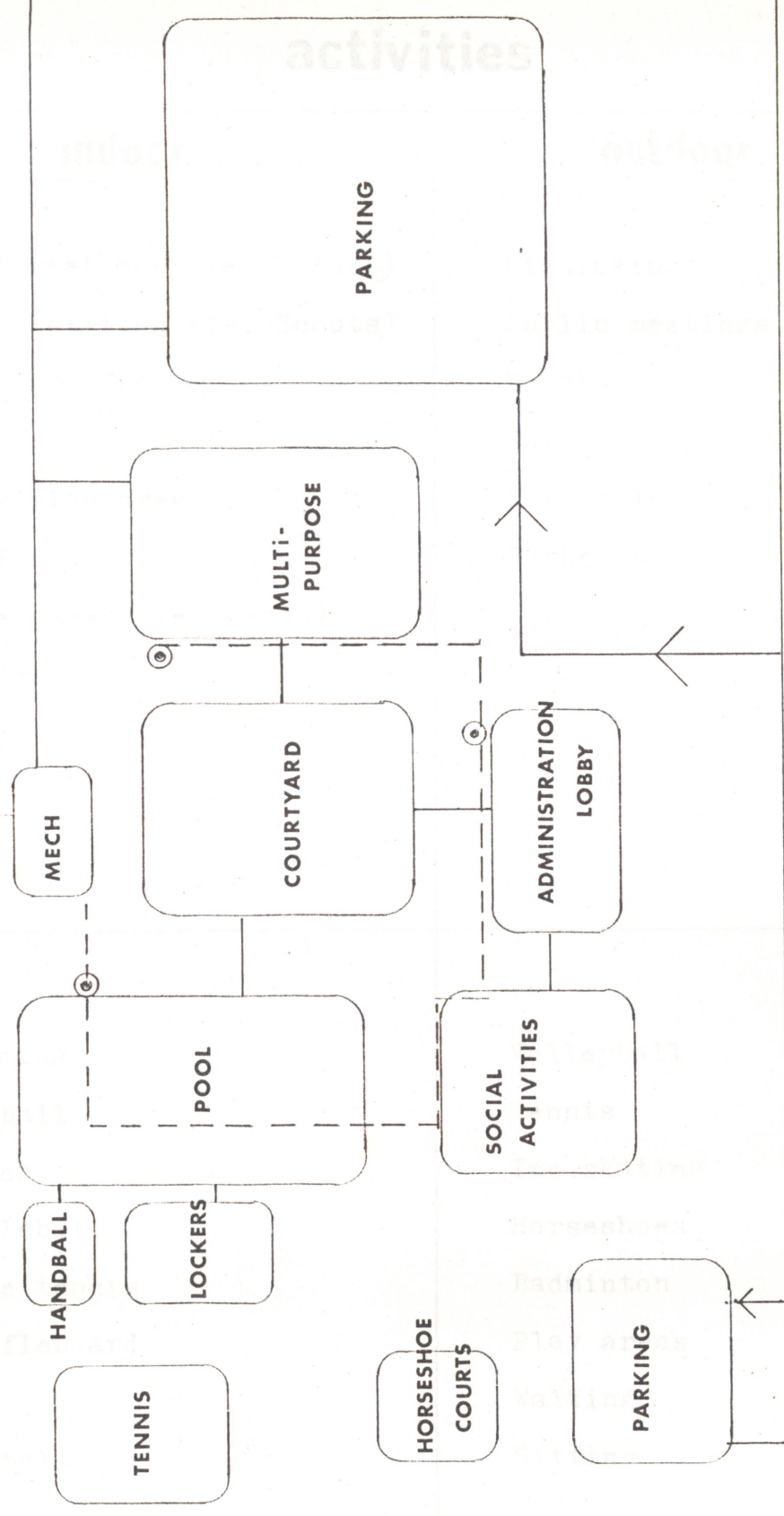


SPATIAL SCHEME

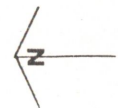


GEO THERMAL SOURCE

PARK



PARK



Development plan

activities

	indoor	outdoor
social recreation	Adult meetings (ie. Rotary) Youth meetings (ie. Scouts) Arts & Crafts Music Television area Reading Table games (ie. cards) Bazaars Dances	Picnicking Public meetings Dances Fairs Carnivals Barbeques
physical recreation	Swimming Handball Squash Paddleball Table tennis Shuffleboard Pool Foosball	Volleyball Tennis Ice skating Horseshoes Badminton Play areas Walking Sitting

AESTHETIC GOALS

This architectural expression will provide, through visible texture of materials, logic of space relationships, and language of cultural style, a pleasing, comfortable, and workable atmosphere for social and recreational activities of the people of the community.

Choice and Utilization of Native Materials

Wood

Readily available supply of this material in the community.

Stone

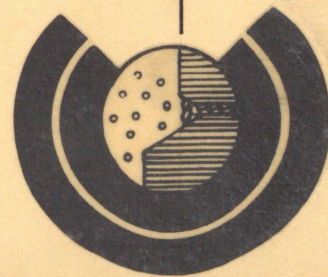
Nearby mountains can supply the necessary quantities from a number of useable quarries.

Brick

Masonry plant at Lewistown, MT can manufacture the amount of this material in the necessary quantities.

Construction of Materials

Aesthetic Pleasure - Joining of these building elements in proportional, rhythmic relationships with a harmony of texture and color, to create an expressive architectural statement that is compatible with the community.



SPATIAL REQUIREMENTS

MULTI-PURPOSE ROOM

This large area will accomodate a gathering of up to 150 people for activities such as banquets, lectures, movies, and dances. The related spaces are accessible to each divided area when the large room is partitioned. There is a kitchen for catered affairs and storage rooms for such things as chairs, tables, and movie projectors. Entry and exit will be provided into each meeting area from a circulation corridor. There is a minimum ceiling height of 18 feet. This is a minimum requirement for acoustic and ventilation purposes. The area will be planned in direct relationship with the courtyard.

SWIMMING POOL

It will be Olympic size of the multi-purpose type, including six swimming lanes. A diving tank will also be included in connection to the main pool. The pool area will be directly related to the exterior courtyard so swimmers may have availability to the sunlight, lounging areas, and direct access to outdoor activities. The east side will be planned so these extra outdoor relations can be provided. Movable glass doors will be installed for this purpose. Deck area will be immediately surrounding the pool and should be constructed of concrete. Seating will be provided around the perimeter of the pool. A

balcony will be planned on the west side of the pool for observation and sitting. Furniture will include: benches, lounge chairs, drinking fountains, towel racks, and seat walls.

Pool Use:

- instruction
- water safety and lifesaving
- competitive swimming
- recreational swimming
- special events
- water games

Equipment and Storage

Located next to the pool, for storage of ropes, life saving equipment, balls, paddle boards, shelving, and cabinet space. The space will also be used for first aid station equipment and supplies.

LOCKER AREA

Each space is planned to accomodate 50 swimmers, and include 50 lockers. A major consideration will be location and accessibility to the pool area. Related spaces will include: dressing area, drying area, showers, steam room, and sauna, with the appropriate plumbing facilities.

Locker Requirements

14 sq/ft per person

Showers

10 showers per 30 persons

1 shower for @ additional 4 persons

Fixtures

Toilets

1 - 30 women - 3

1 - 50 men - 2

Urinals

1 - 25 men - 2

Lavatories

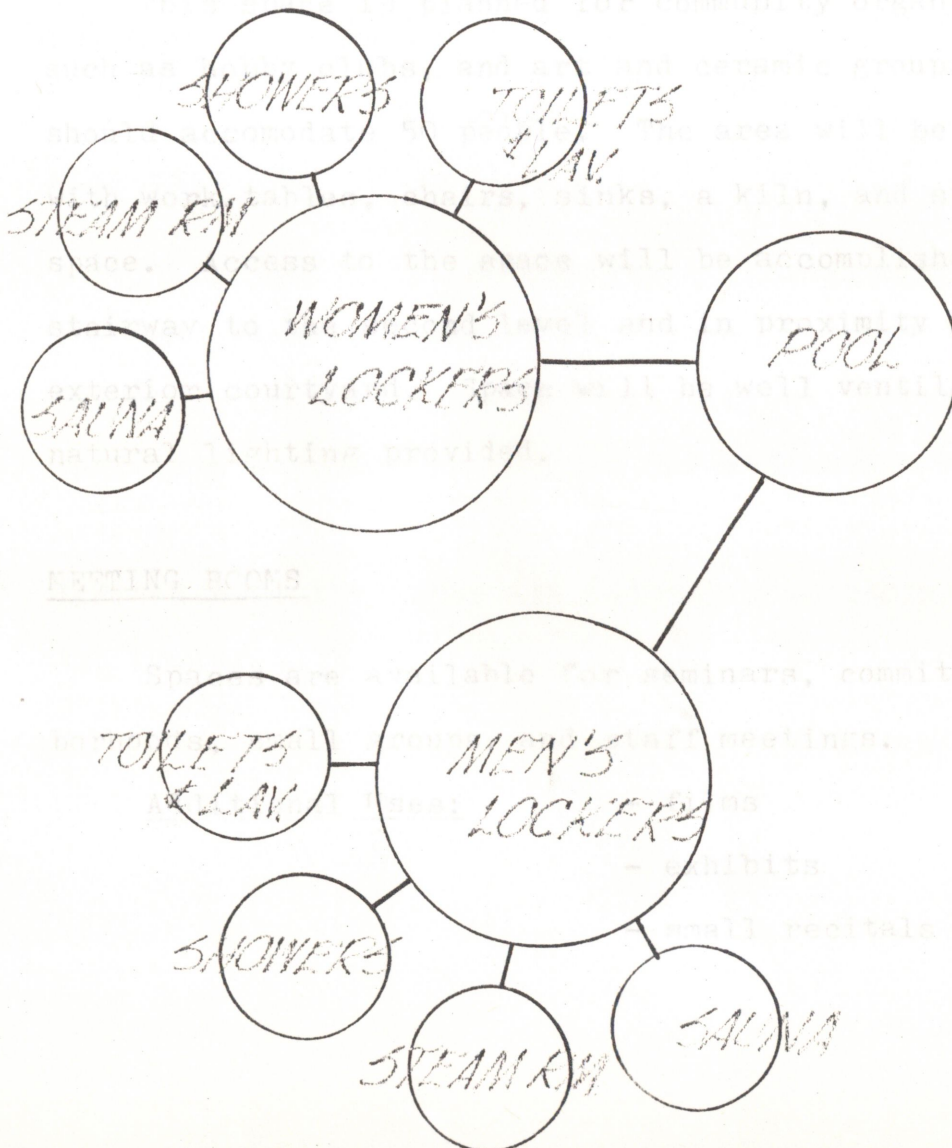
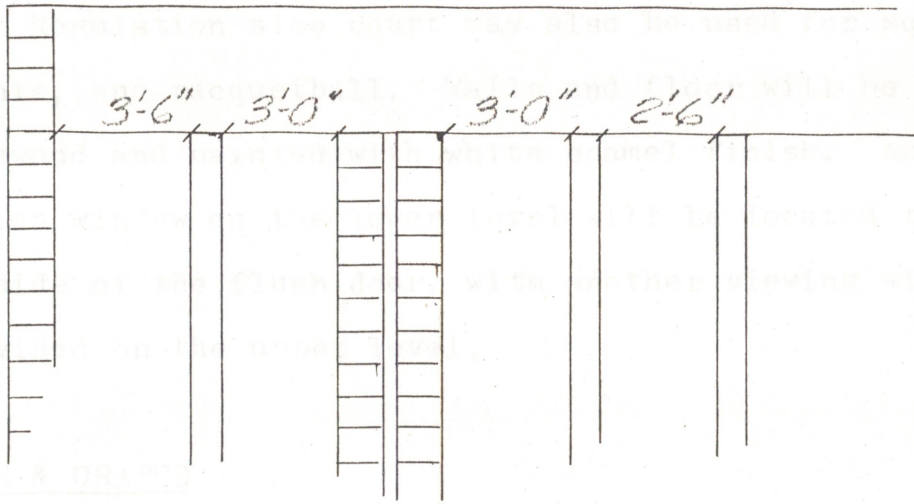
1 - 20 women - 3

1 - 20 men - 3

Locker room facilities will include:

- stationary benches
- mirrors for men, full length mirrors for women
- drinking fountain
- bulletin board
- lighting located adequately for aisles and passages
- windows located with regard to height arrangement
of lockers
- adequate ventilation

LOCKER ROOM MIN. DIMENSIONS



HANDBALL COURT

Regulation size court may also be used for squash, tennis, and racquetball. Walls and floor will be of a hardwood and painted with white enamel finish. An observation window on the lower level will be located to the outside of the flush door, with another viewing window provided on the upper level.

ARTS & CRAFTS

This space is planned for community organizations, such as hobby clubs, and art and ceramic groups, and should accomodate 50 people. The area will be provided with work tables, chairs, sinks, a kiln, and storage space. Access to the space will be accomplished by a stairway to the second level and in proximity to the exterior courtyard. Space will be well ventilated and natural lighting provided.

MEETING ROOMS

Spaces are available for seminars, committees, neighborhoods, small groups, and staff meetings.

Additional Uses:

- films
- exhibits
- small recitals

GAME ROOM

This room will be planned to accomodate youth groups and adults. A variety of games can be played: table-tennis, foozball, shuffle board, pool, and card games. Natural lighting would be provided. Access will be available from the main lobby space and visible from the courtyard. Exit / entry is also necessary to outside activities, horseshoe courts, and tennis courts. Storage space will be provided for game maintenance equipment. This space should be located near the administration area for checking out game equipment.

MANAGER'S STATION

This space will accomodate all management activities for the community center, including publicity, public relations, information, and exhibitions. Space will include a secretarial station for filing and bookkeeping, manager's office, and storage room. This area will be located near the lobby and becomes a welcoming space into the center.

MEN and WOMEN TOILETS

The restrooms will be located near the lobby area and in proximity to the all-purpose activity room. Circulation is planned for access from both sides of these rooms.

Men's room will include two sinks, two water closets, and two urinals. Women's room will be provided with two sinks and three water closets. Spaces are to be lighted and ventilated.

COURTYARD

This space may be defined as the central gathering point in the facility. The area expresses a feeling of openness and an atmosphere of total freedom. Walkways will be provided for transition between social areas and places for relaxation. This space is primarily for circulation and for access to all activities in the center. The promenade will open onto the courtyard and walkway's through the plaza will be directional with the use of planters and benches. A fountain may be the central focus of the courtyard. The elements used should be durable and an expression of pattern and texture may be combined to encounter a pleasing feeling, blended with warm, exciting colors. Public restrooms will be located in

proximity. Geothermal water will be located underneath the walkways and gathering areas to remove snow and moisture during the cold months, so the courtyard may be utilized year round.

JANITOR CLOSETS

To be located near the all-purpose room and in nearness to the administration area. A second closet will be located on the second floor. Spaces will include one sink, shelves for storage, lighted and ventilated.

MECHANICAL ROOM

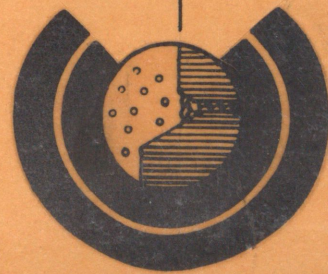
Space provided for boilers, heat exchangers, air cooling units, humidifiers, exhaust fans, and mechanical ducts. The heating and cooling system will be a dual duct air system circulating hot and cold air from the heat exchanger units. This conventional heating system will be used as the main source of heat with the geothermal energy as a secondary resource. The heating system will be located on the perimeter of the building and underneath circulation areas. Space also includes a pump room for transmission of geothermal water and an area provided for the required equipment.

PARK AREAS

These will serve to link all areas of the surrounding property together. They are areas for informal activities, such as picnicking, sunbathing, games, or just sitting. The walkways connecting the areas may also be just for strolling. They will be landscaped.

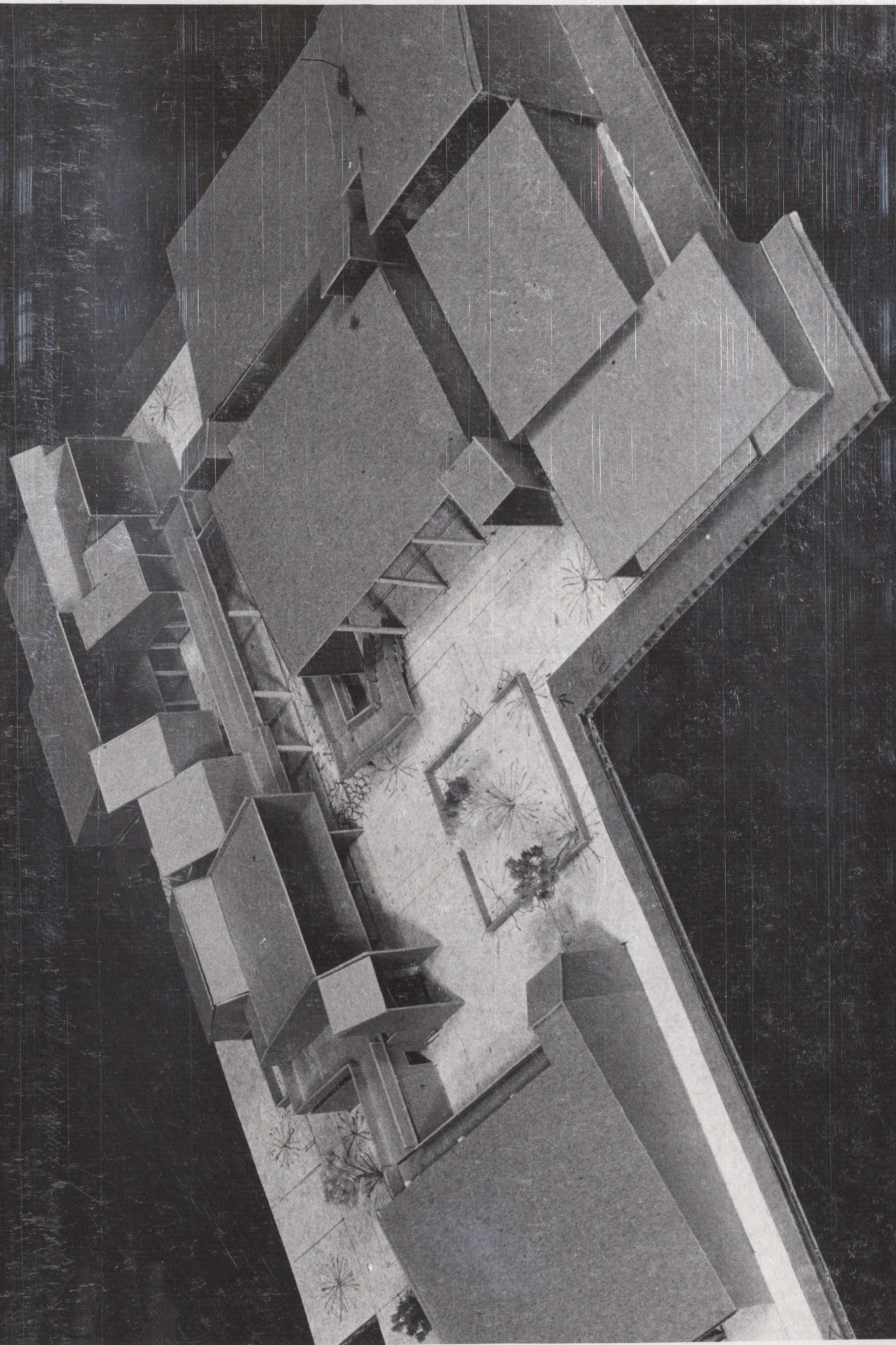
PARK SHELTER

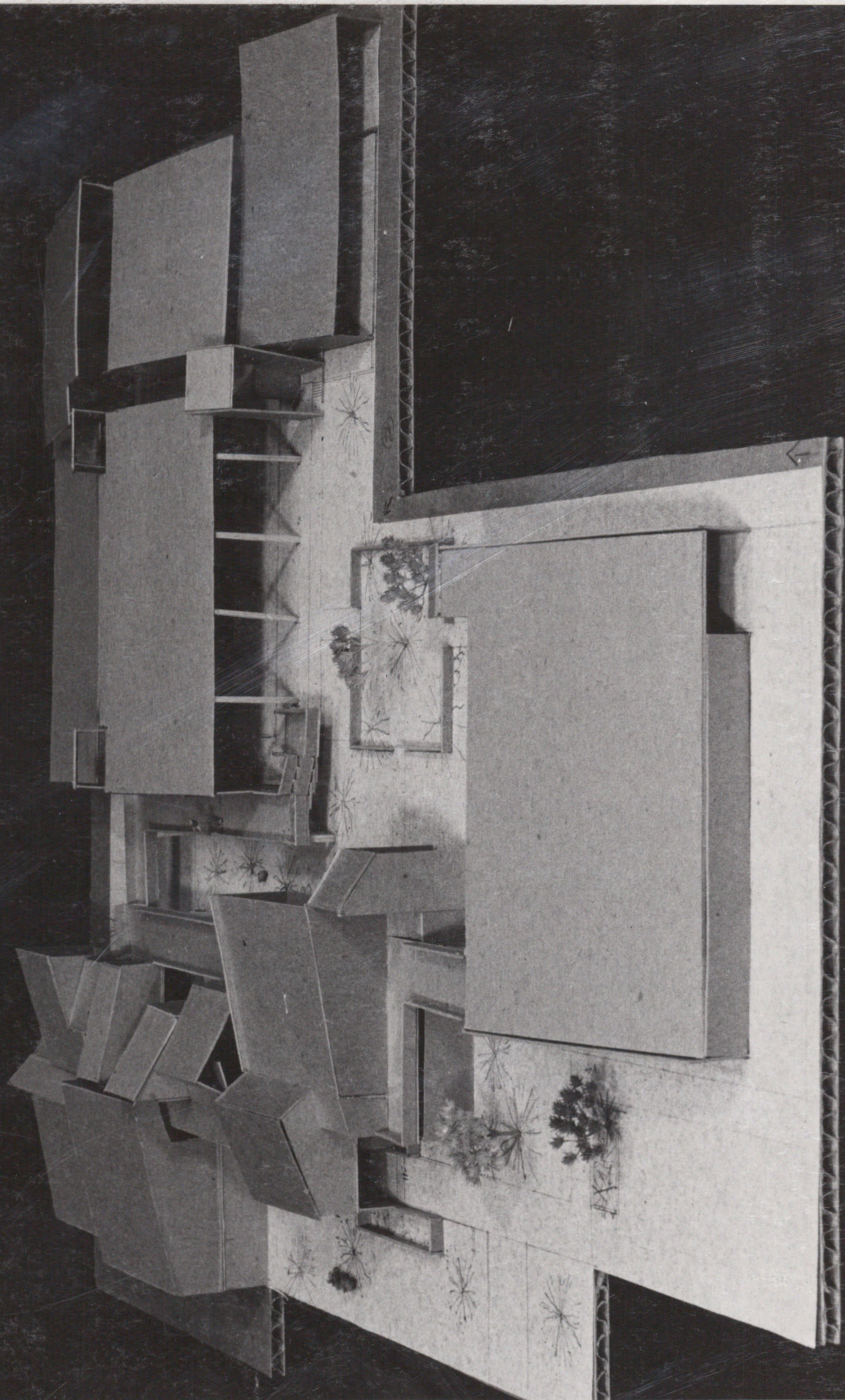
There will be a few park shelters, consisting of a roofed space which will include tables underneath. These may be used for picnicking in inclement weather, or sitting under to get out of the sun.

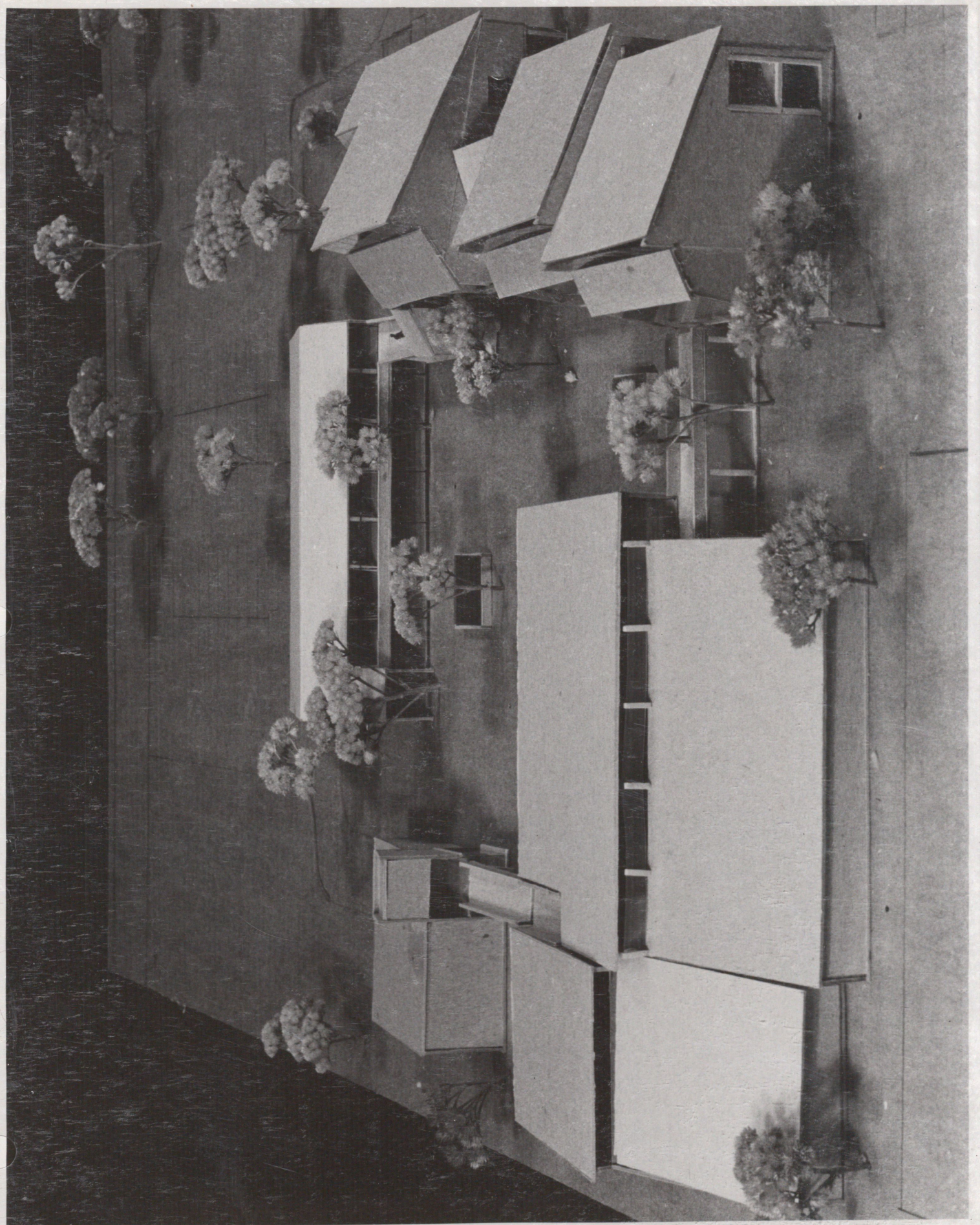


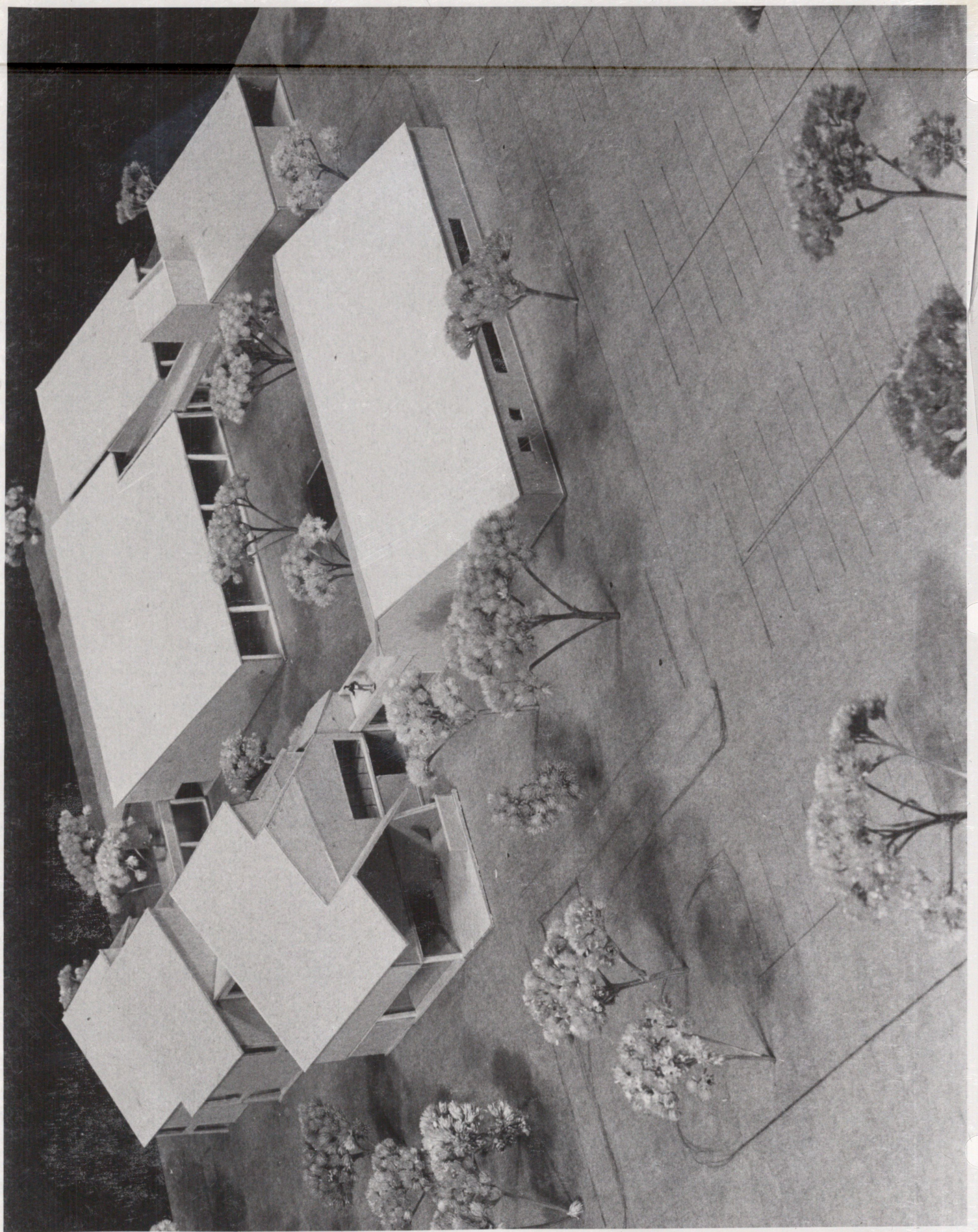
— **DESIGN** —

CONCEPT —





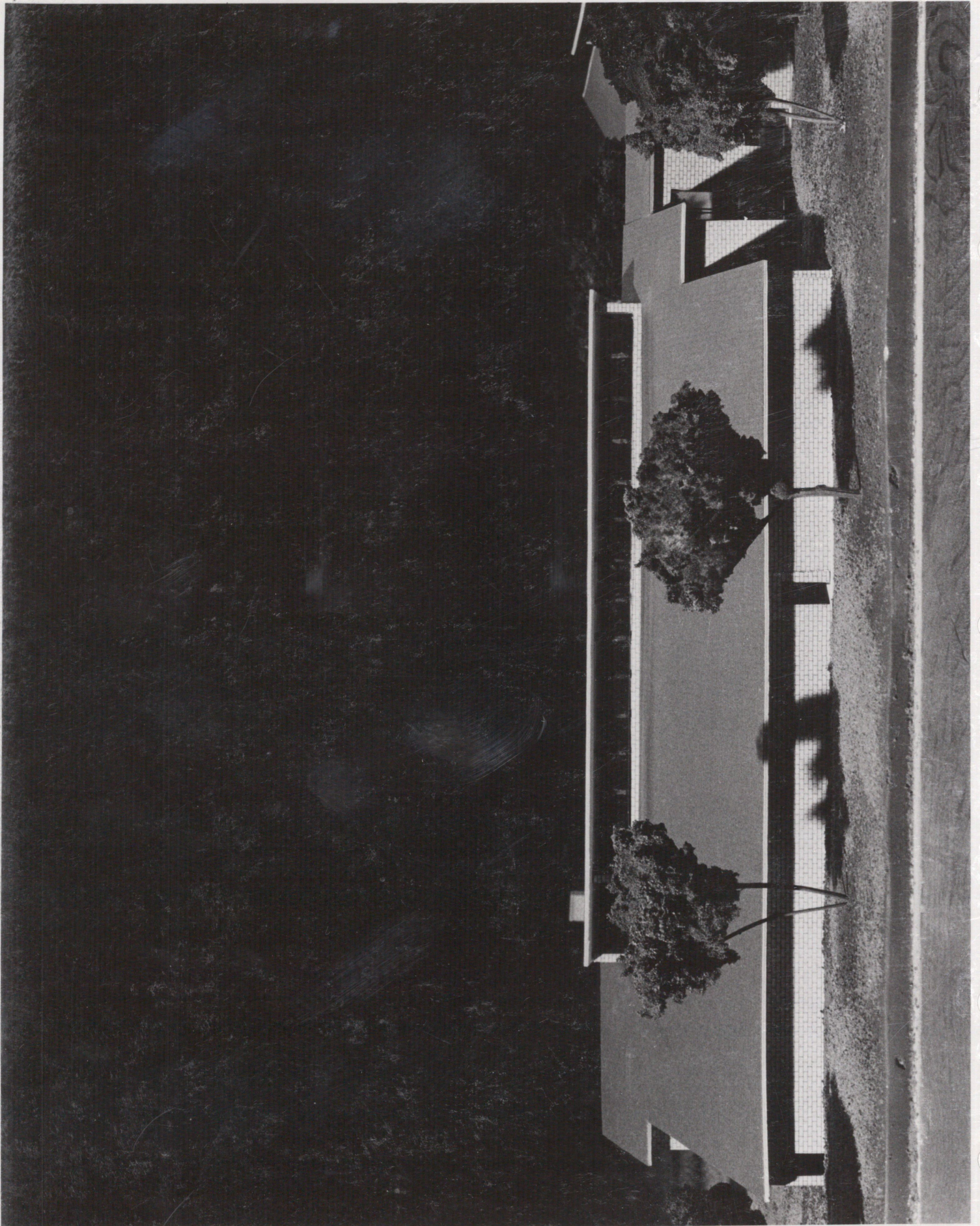






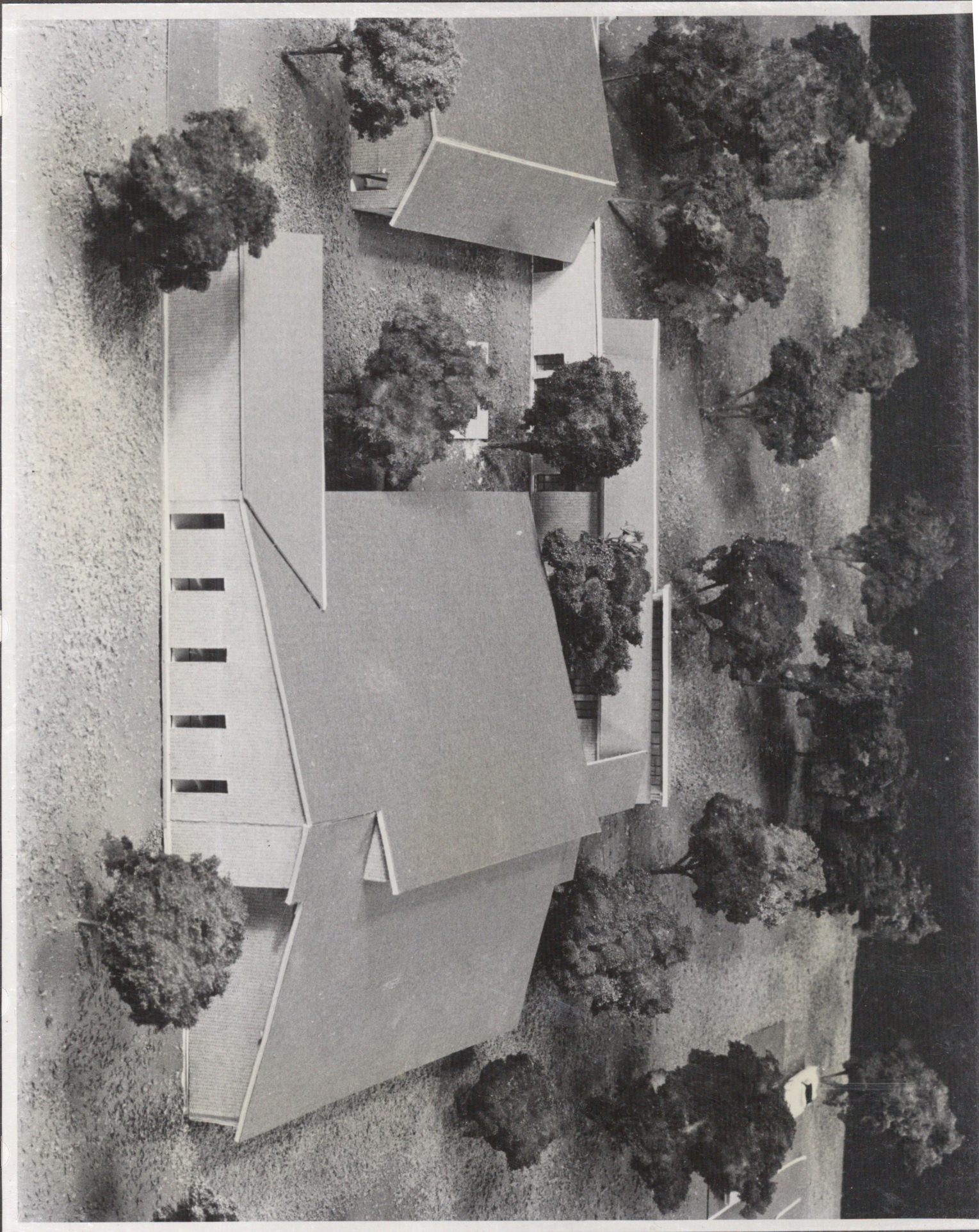




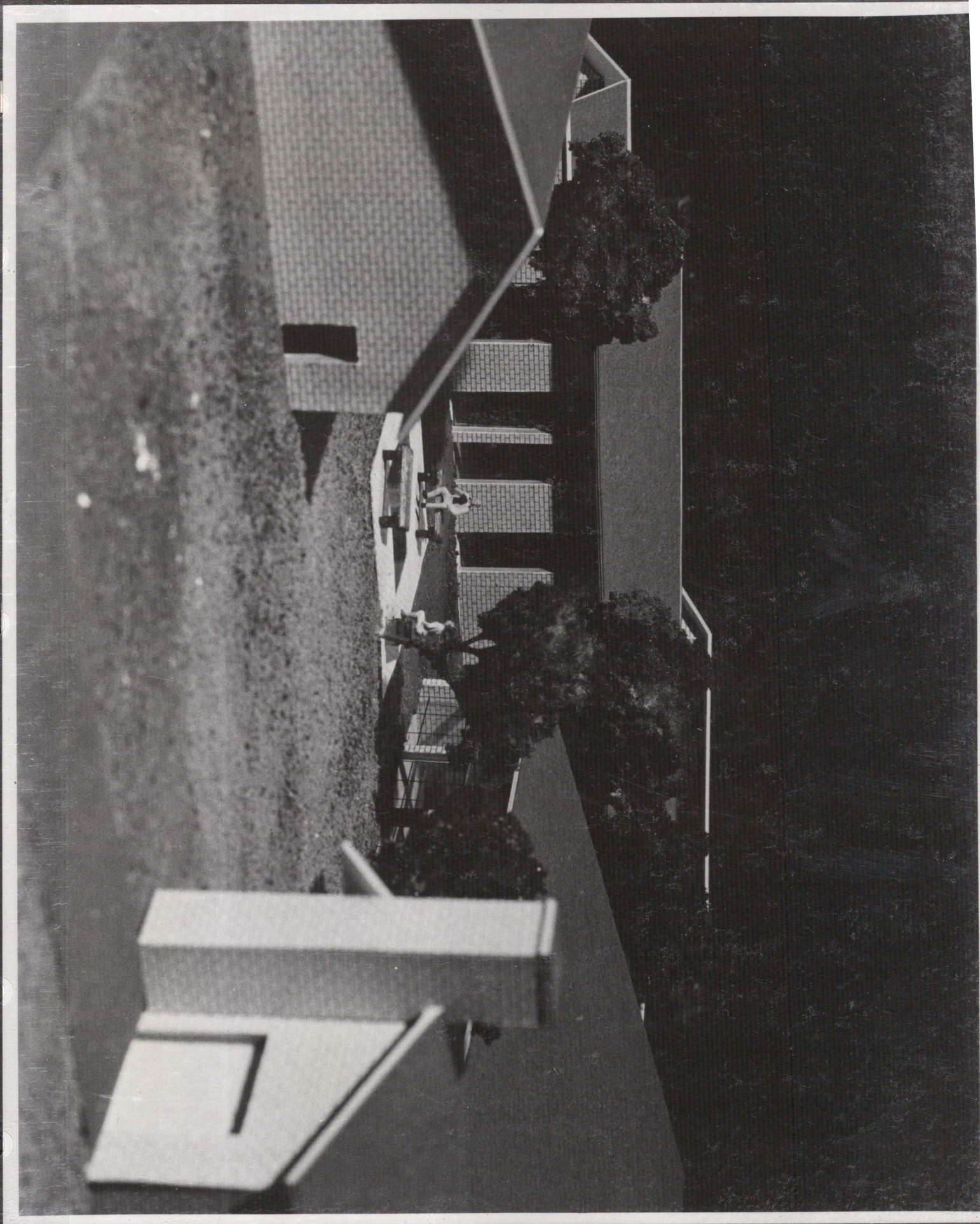




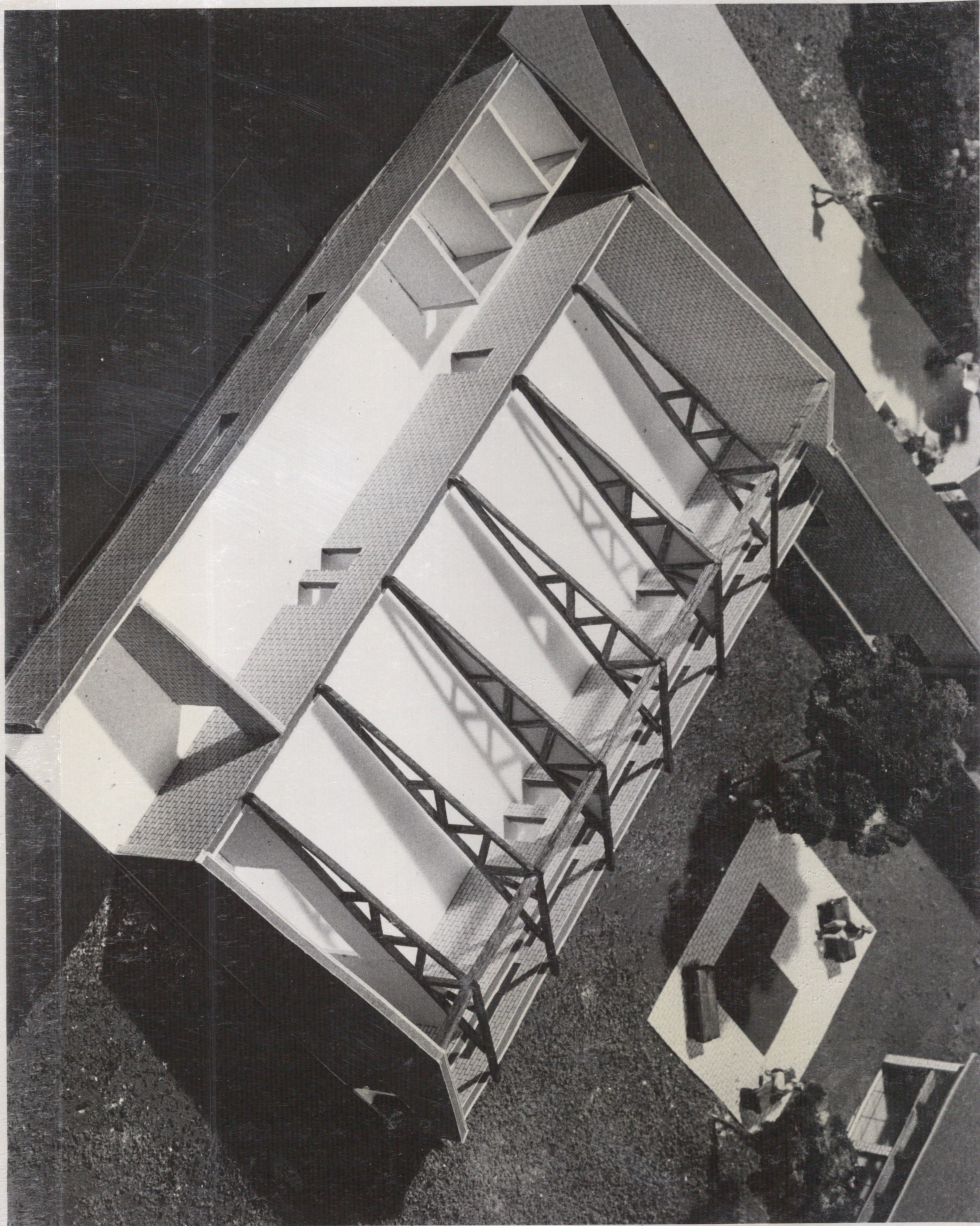


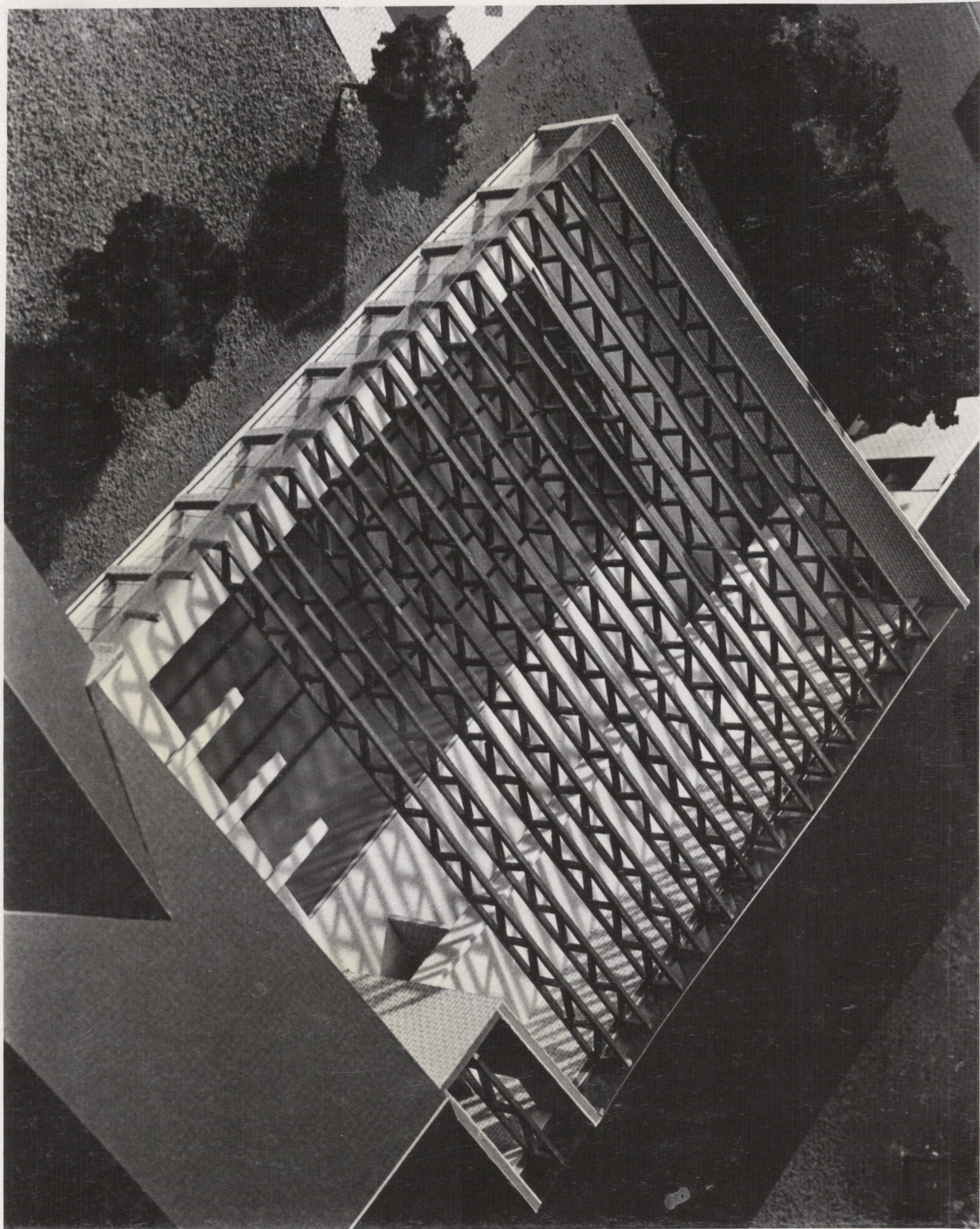


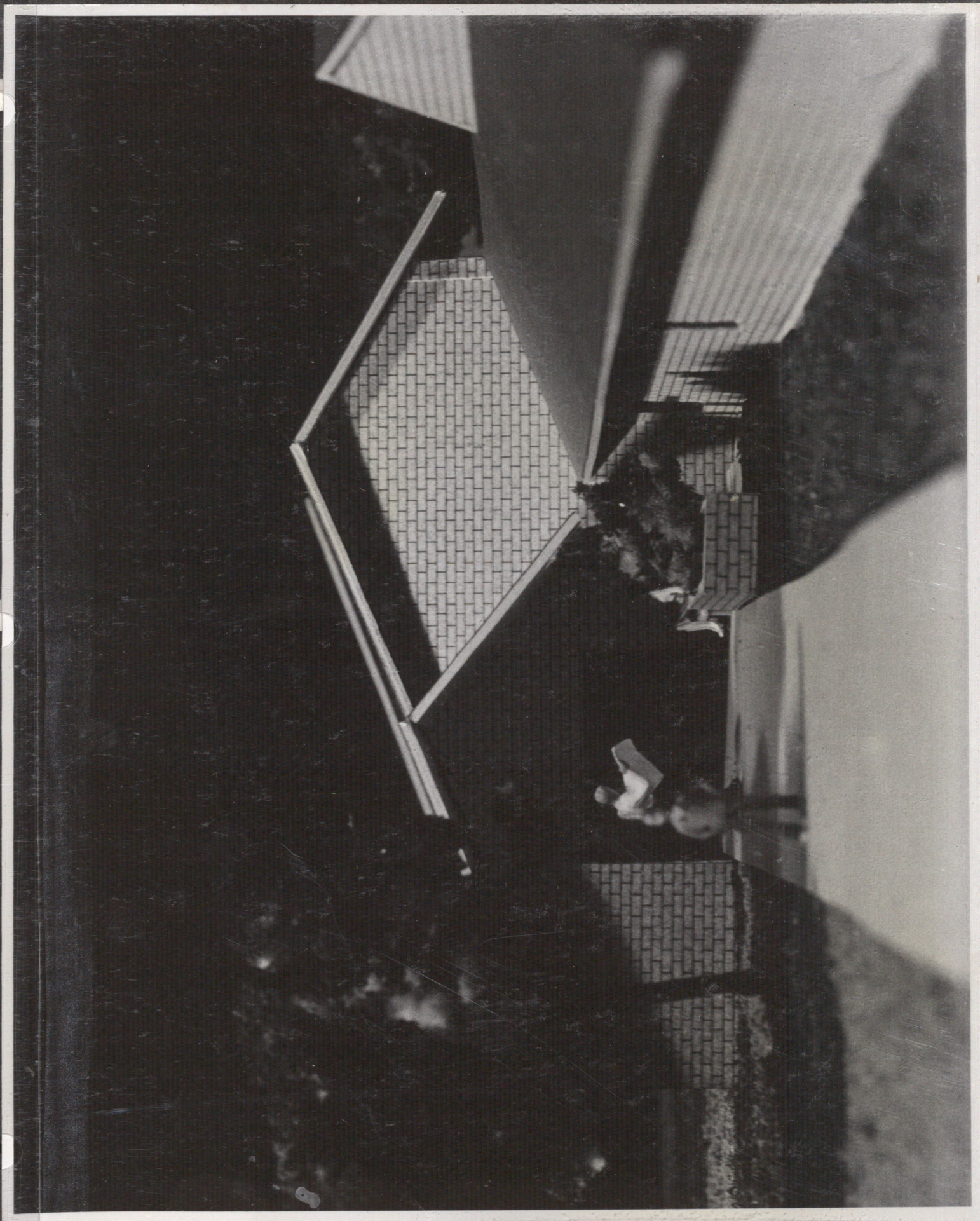


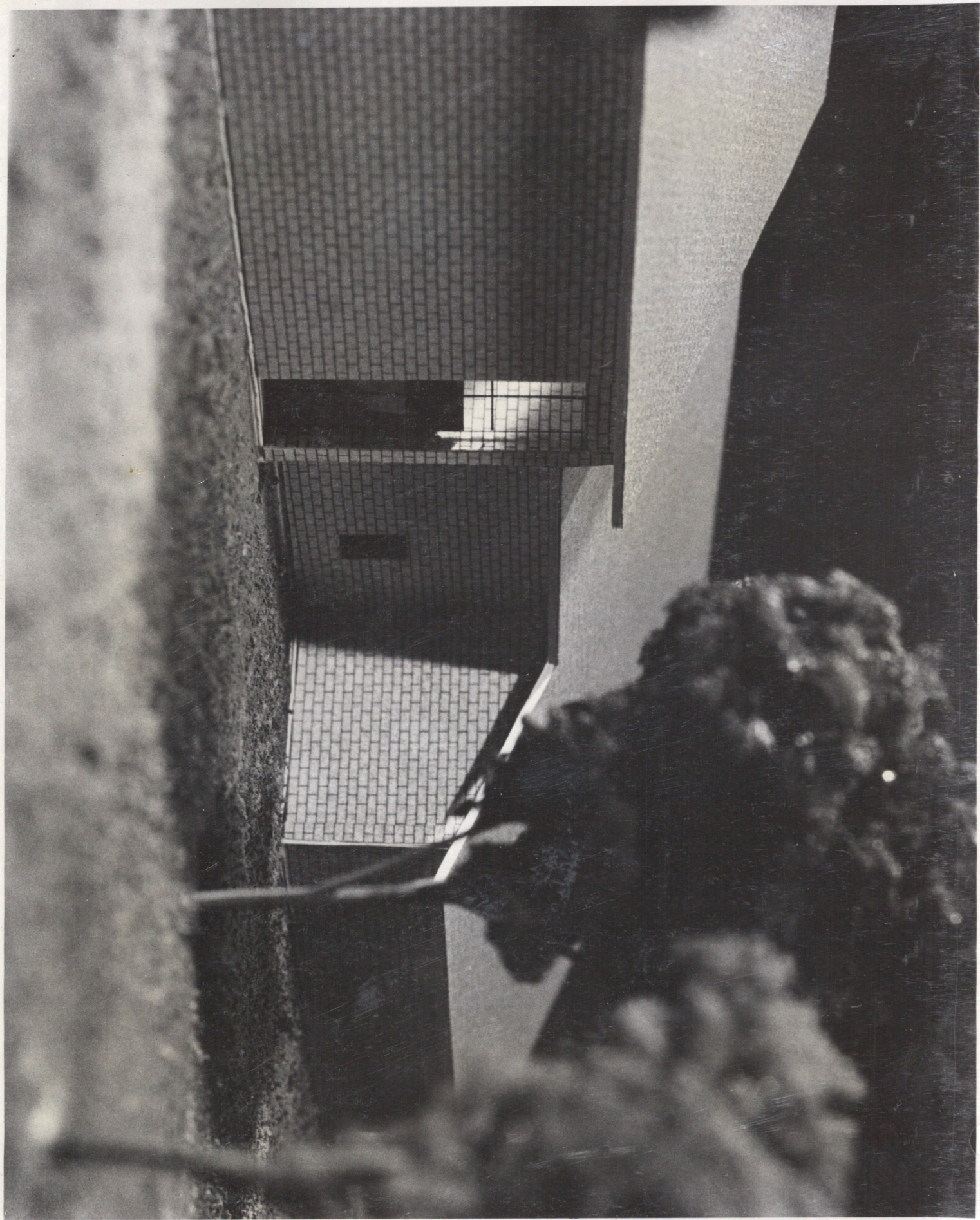


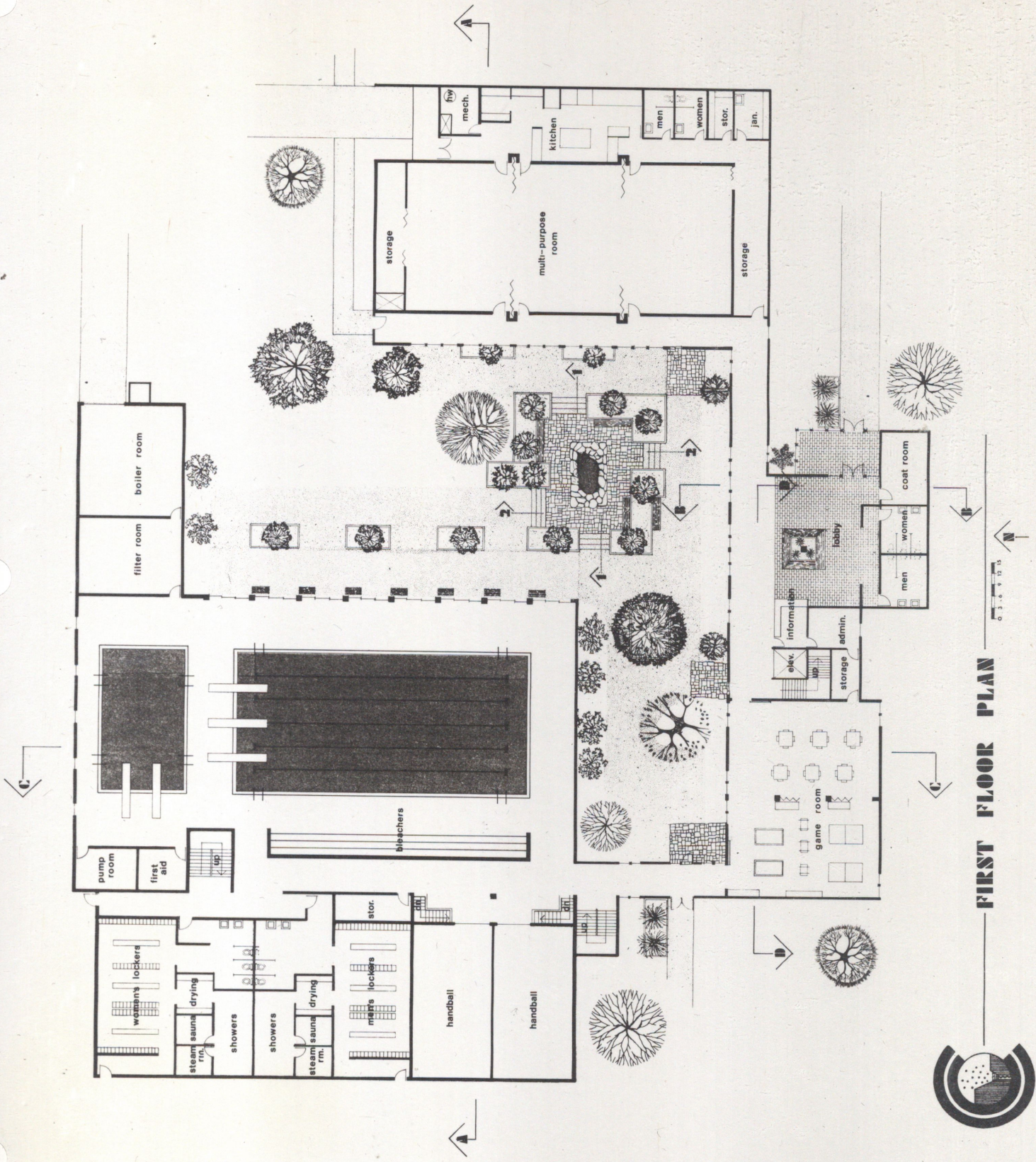






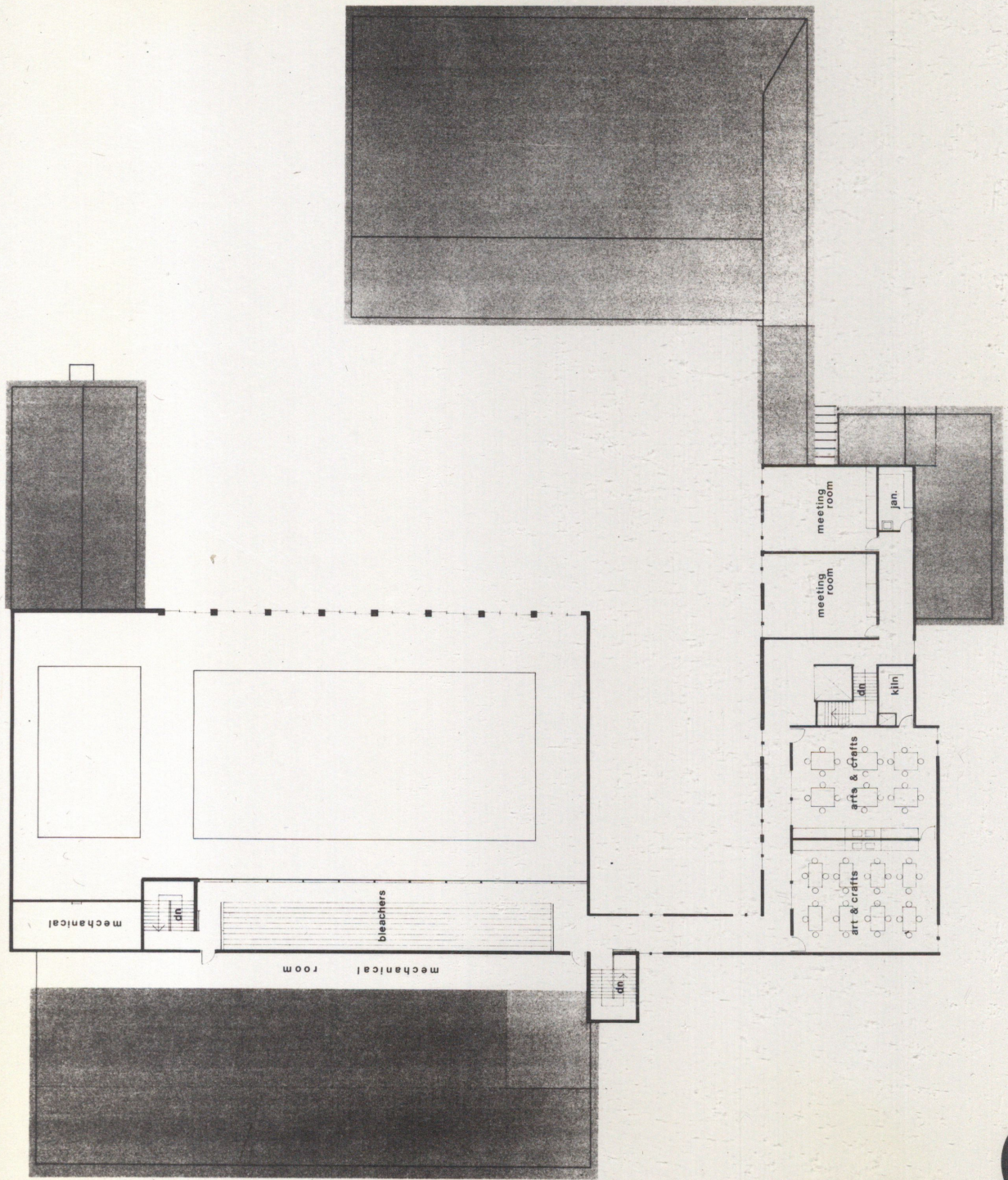






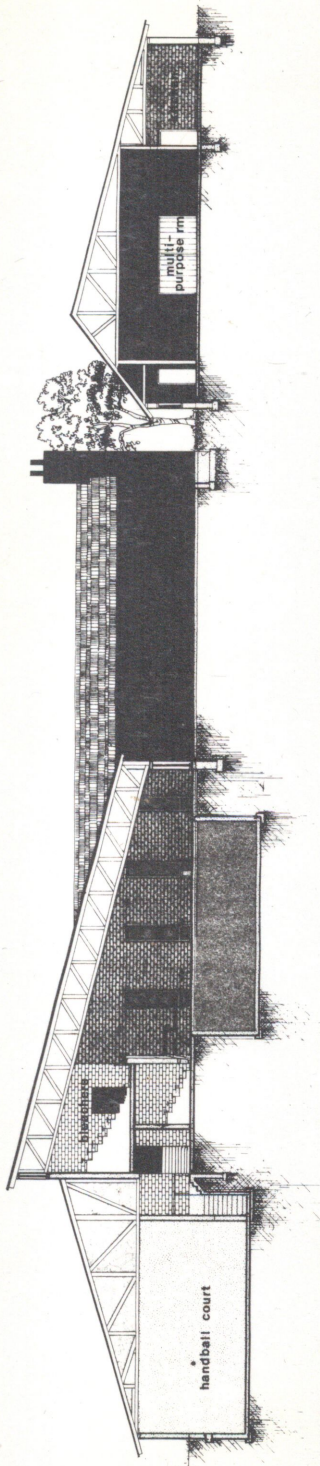
FIRST FLOOR PLAN



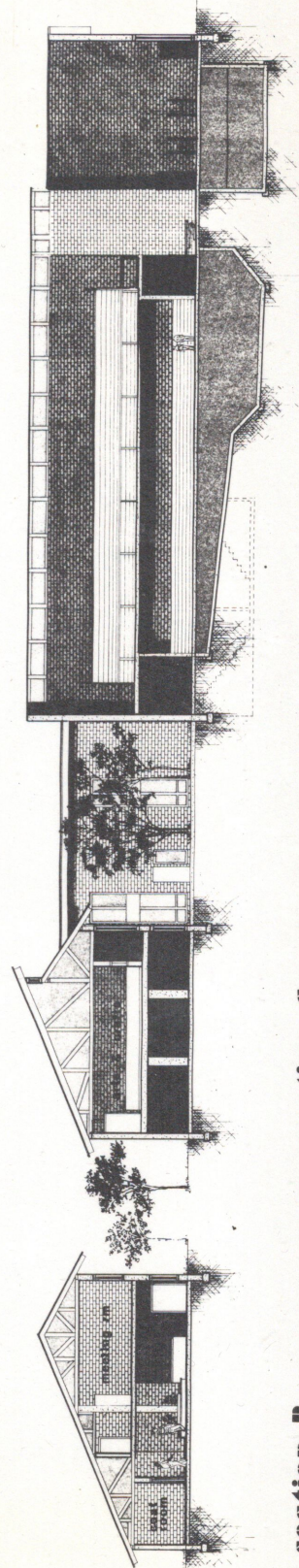


SECOND FLOOR PLAN



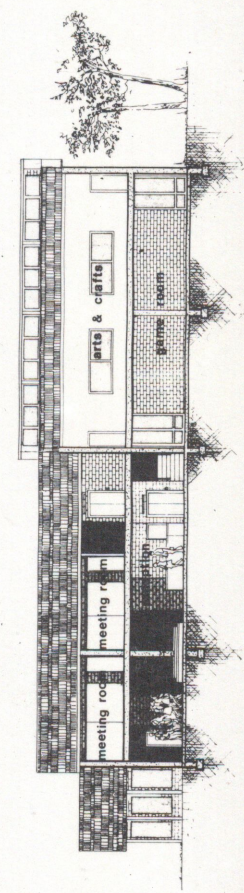


section A



section B

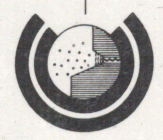
section C



section D

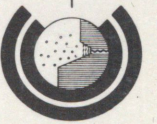
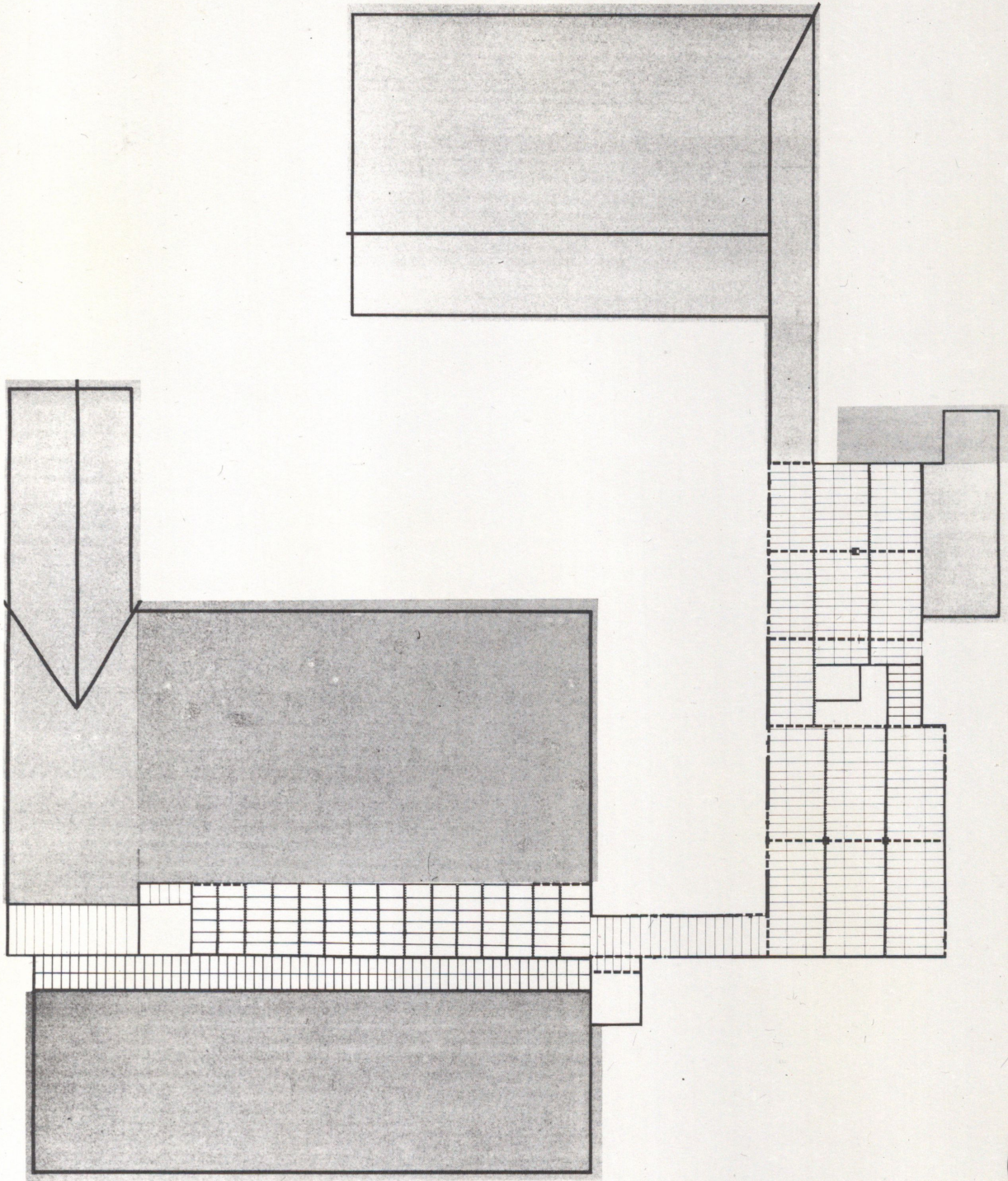


section 1
section 2
court fountain



SECTIONS



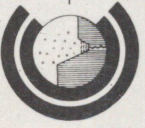
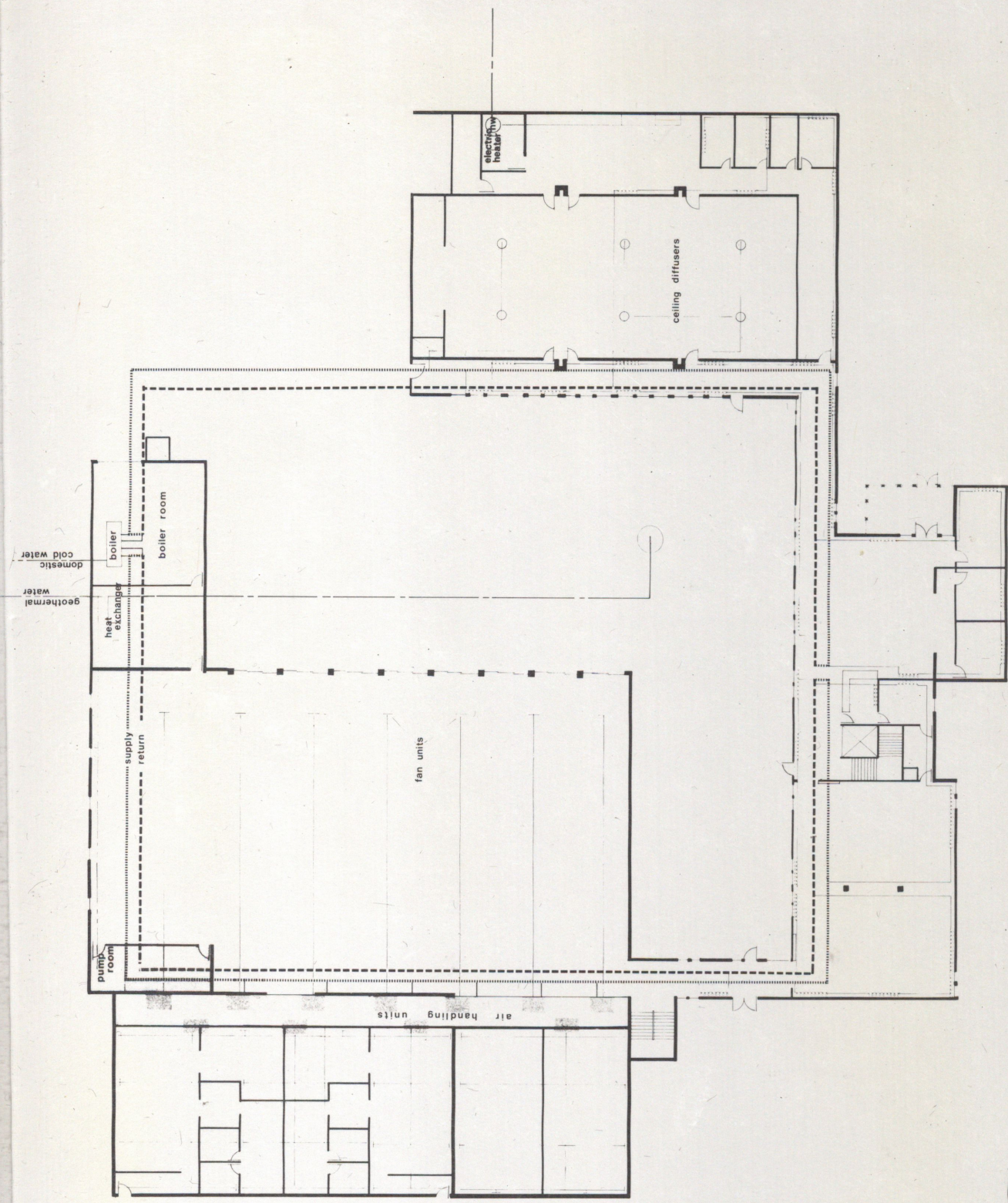


SECOND FLOOR FRAMING PLAN

0 1 2 3 4 5 6

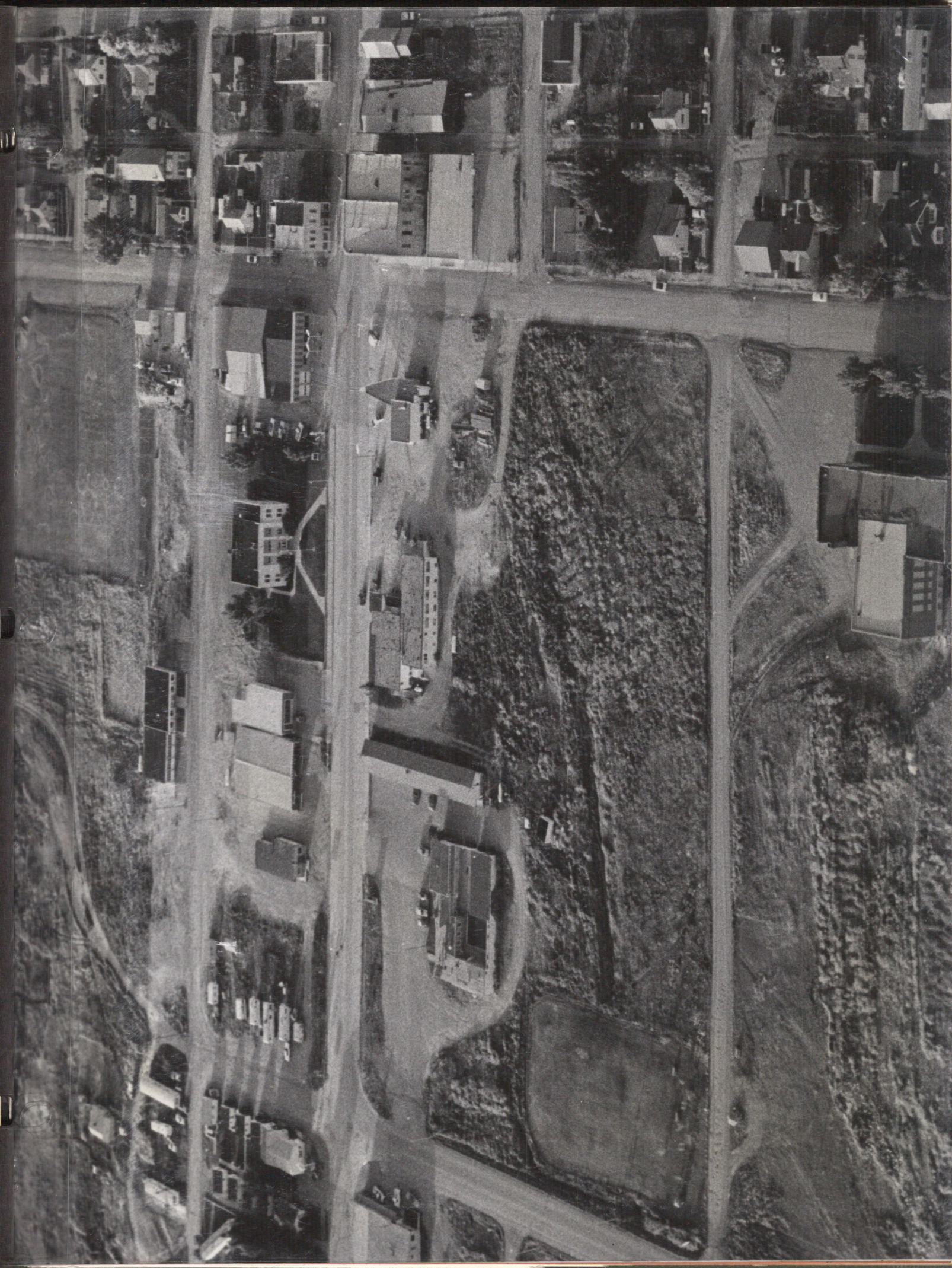






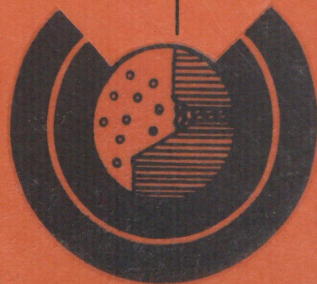
MECHANICAL PLAN

0 3 6 9 12 15





CONCLUSION



CONCLUSION

Being a native of White Sulphur Springs, my own growth process has made me increasingly aware of the lack of community spirit in the town. My thesis was inspired by my concern for White Sulphur Springs and its future. Thus the project has merit and could be valid when and if the community decides to build such a facility. The project was based on a realistic need, dealing with practical problems, and capable of providing a tangible solution, rather than a theoretical problem with a hypothetical solution. I felt that this fact made my thesis a more enriching experience, one that will be an advantage to me as I pursue my career in architecture. It seemed more of a beginning to my practical training, rather than a final process in my formal education.

Having completed my project, I am satisfied with the results. Much of what I have done was based on the hope that, through a 3-dimensional and graphic presentation, I might be able to stimulate the community towards some action in a positive direction. It is all too easy to verbally admit that the community is lacking a bond to keep it together; yet it is quite a different matter to come to a definite solution. In my point of view, a social and recreational center is the architectural answer to this problem. It is my hope that the community of White Sulphur Springs might arrive at this same conclusion, with the direct aid of this thesis.



APPENDIX

Geothermal district heating

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1. Introduction

The optimum ambient temperature for human comfort is in the range of $+15-22^{\circ}\text{C}$, depending on physical effort and to a certain degree on environmental factors such as relative humidity, air movement, exposure to radiation etc. The temperature of the natural environment in the inhabited parts of the earth varies, however, within the wide range of say -35 to $+45^{\circ}\text{C}$. Few parts of the earth offer the optimum temperature except for a relatively short span of the yearly cycle.

Clothing, houses and other shelters give protection against exposure to extreme cold and heat, but are insufficient for full comfort, unless the confined spaces are heated or cooled to the desired temperature. Artificial heating or cooling of houses requires expenditure of energy, which is supplied primarily by fossil fuels.

However fuels are costly, the reserves (while enormous) will ultimately be depleted, and their use pollutes the environment on a scale that is now becoming a real concern in many towns and metropolitan areas of the world.

An alternative source of energy that is eminently suited for this purpose is the geothermal energy which has been receiving increased attention in a number of countries in recent years.

Prospecting for geothermal energy is still only beginning, and accordingly estimates of the global reserves are bound to be uncertain.

The known reserves are nevertheless tremendous and growing every year as prospecting is continued. This is perhaps best illustrated by random examples.

Measurements of terrestrial heat flow in Hungary were carried out in 1954 and led to the discovery of reserves of $4,000\text{ km}^3$ of hot water ($60-200^{\circ}\text{C}$) stored under the Hungarian plains. The recoverable heat has been estimated by Boldizar (1970) at 2.3×10^{19} cal which is about 50% of the calorific value of the known petroleum reserves of the world. Important discoveries have been made in recent years in other parts of the world. It is thus claimed by

Tikhonov *et al.* (1970) that thermal waters available for economic exploitation are found at depth in 50-60% of the territories of the U.S.S.R. Enormous hyperthermal areas are known in regions of recent or active volcanism in Europe, Africa and a number of countries surrounding the Pacific Ocean. The potential of the hydrothermal systems represents only a fraction of the energy reserves stored in the deep-lying rock formations of the earth's crust, provided that a suitable technology of extraction could be developed.

The utilization of geothermal energy presents as a rule minimal pollution problems, much less than those inherent to the use of fossil fuels. Most important, however, is the fact that the production cost per unit of energy is lower for geothermal energy than that of most if not all other available sources of energy.

Where geothermal energy is abundant it is in fact sufficiently economical that artificial microclimate can be created in relatively large sheltered spaces, say over scores or hundreds of hectares. This is of greatest importance for agriculture in countries with cold climates. But another obvious use for geothermal energy is the heating of houses in cold climates and cooling of houses in hot climates for increased human comfort.

The present paper will report on developments that have taken place in utilizing geothermal energy for house heating in various parts of the world, describe the technology employed and discuss some pertinent economic aspects.

2. Historical notes

(a) ICELAND

The use of geothermal energy for large-scale heating of houses was pioneered in Iceland, which is natural in as much as the country has a cold temperate climate requiring the heating of houses for about 330-340 days of a year. No fossil fuel sources are available in the country except limited reserves of peat and lignite. Hyperthermal areas

are however abundant, as manifested by a multitude of hot springs and a number of major geothermal steam fields.

The first attempts at heating single farm houses were made in the beginning of the 20th century, and around 1925 hot spring water was used for the first hot houses for vegetables (Bodvarsson *et al.*, 1964; Zoëga *et al.*, 1970).

A major step forward was made when the first boreholes for hot water were drilled in the vicinity of Reykjavik in 1928, yielding 14 l/sec of 87 °C hot water. A 3 km long pipeline to the city was constructed, feeding a pilot district heating scheme comprising 70 houses; an enclosed swimming pool, an open-air swimming pool, and a public school house (Sigurdsson, 1964).

This venture was quite successful, and as a consequence more extensive drilling for hot water was started in 1933 at the Reykir thermal spring area some 18 km outside the city. This yielded about 200 l/sec of 86 °C hot water, and in the years 1939-1943 a new district heating system was constructed, serving 2,300 houses with about 30,000 people and all public buildings of the town. The system included an 18 km long transmission pipeline, pumping stations, 8,000 m³ water storage tanks and underground distribution network in the streets of the town. This system was commissioned on 1 December 1943 and is still operating quite satisfactorily.

An extension of the system was built in 1949-50 after additional drilling had been carried out 3 km north of Reykir. A total of 72 boreholes were drilled in these two spring areas, producing a total of 330 l/sec of 86 °C water. The boreholes vary in depth from about 300 m to 770 m.

The Reykir fields have now been producing continuously for about 35 years, and the total production over this period is of the order of 300 million m³ of water without any drop in temperature or decrease of the production rate.

A geoscientific survey of the area within the limits of the city of Reykjavik was resumed in 1954 (Bodvarsson and Palmason, 1964) and delineated a thermal area where deep drilling (700-2,200 m) was started in 1958. The steady yield of his field is now 300 l/sec of 128 °C water, and another thermal area more recently discovered and developed on the eastern periphery of the city yields about 165 l/sec water at 105 °C (Zoëga *et al.*, 1970).

The district heating system has been greatly expanded on the basis of these new thermal sources and 8,700 houses with 72,000 inhabitants were connected to the system by the end of 1969. This represents about 87% of the houses in the city, and the goal of connecting new residential quarters to the heating system as soon as they are built is nearing realization.

The city of Reykjavik has developed, owned and operated the systems from the very beginning. It has been highly successful, technically and economically, and is perhaps more highly regarded by the inhabitants than any other public service. This has contributed to the general concept in Iceland that, where thermal resources are available, a district heating system is a necessary and normal

public service, just as much as a cold water supply, an electricity supply or a sewer system.

Developments in other parts of Iceland have been somewhat slower than in the capital, mostly because of lack of suitable financing resources for the rather capital-intensive geothermal installations.

The town of Olafsfjörður in northern Iceland with 1,000 inhabitants built its first district heating system in 1944 using hot water of only 48 °C produced by drilling in a thermal area about 3 km away. Deep drilling in 1961 yielded additional water at 56 °C. The system comprises all the houses of the town, and it has been quite successful.

The town of Selfoss (2,200 inhabitants) in southern Iceland has a district heating system which was built and operated by a local cooperative society from 1948 until 1969, when it was sold to the township. It heats the whole town comprising 154,000 m³ of flats and 75,000 m³ of public, commercial or industrial buildings. The water is supplied from boreholes, 1.5 km outside the town and the production is 80 l/sec water at 80 °C.

The village of Hveragerði in southern Iceland with 820 inhabitants and a balneo-therapeutic institution for 140 patients, is one of the main hot house centres for growing flowers and vegetables. A district heating system serving all houses in the village and supplying heat to 30,000 m² of hot houses has been in operation since 1953. This is the only district heating system in Iceland that uses a high-temperature field (180 °C).

The town of Saudárkrúkur in northern Iceland (2,000 inhabitants) has operated a district heating system for about 15 years, utilizing water at 70 °C from boreholes in the vicinity.

Since about 1930 elementary and secondary boarding schools in the rural areas of Iceland have whenever possible been sited at locations where geothermal energy is available. In these centres the school buildings and living quarters for the pupils and staff are geothermally heated. They are also as a rule equipped with a swimming pool, and are self-supplying with vegetables (tomatoes, cucumbers, cauliflower, etc.) grown in their own hot houses. There are now many such schools in various parts of the country, and quite often they are used as tourist hotels during the summer holidays. Quite often these centres have formed the nuclei of new service communities in the rural areas.

Several new district heating schemes have been studied, and some are now under construction. A scheme for supplying the satellite towns of Reykjavik with geothermal heat from the neighbouring high-temperature areas has been studied. Feasibility studies have been made for district heating systems for Akureyri (10,000 inhabitants), Siglufjörður (2,500 inhabitants), Akranes (4,500 inhabitants), Húsavík (2,000 inhabitants), Keflavík International Airport and the neighbouring communities of Njardvík and Keflavík (about 10,000 inhabitants), Dalvík (1,000 inhabitants), Hrísey (300 inhabitants), Egilstaðir (800 in-

habitants), Reynihlid at Lake Myvatn (200 inhabitants and some tourist hotels). Several of these projects are already being executed or are being seriously considered.

At the end of 1969 a total of almost 80,000 people, or 40% of the population of Iceland (200,000), lived in houses heated with geothermal energy. On the basis of the

present geographical distribution, the author has estimated elsewhere that 60-70% of the population could be supplied with direct geothermal heating for their homes. Figure 1 shows the gross production of geothermal energy in Iceland since 1960 with a forecast of the growth until 1975 (Palmason and Zoëga, 1970).

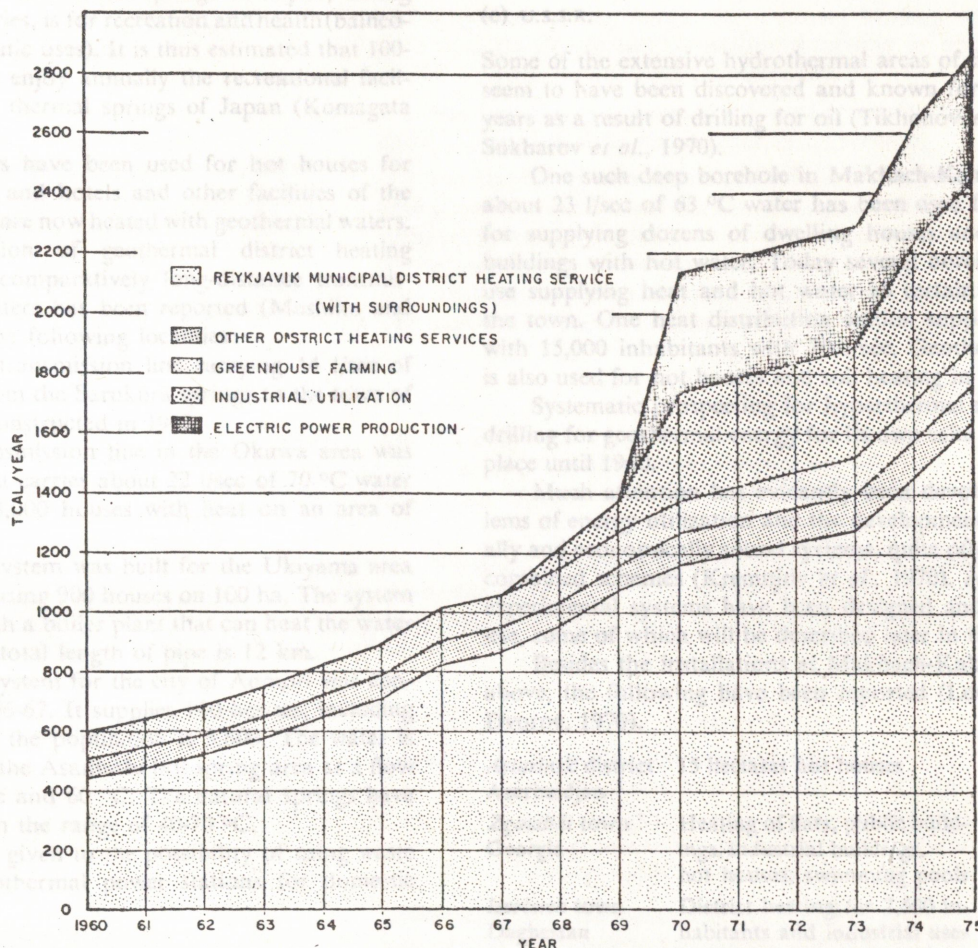


FIG. 1. Gross production of geothermal energy in Iceland (above 40 °C).

(b) HUNGARY

Following the discovery of the vast geothermal reserves of Hungary about 15 years ago, considerable interest was aroused for utilizing the energy for domestic heating. Plans were studied for constructing a geothermal district heating system for the city of Szeged around 1962. However, the drilling for hot water for this project led to the discovery of Hungary's richest oil and gas field, which resulted in the heating system being converted from geothermal energy to gas. Subsequent utilization of geothermal energy in Hungary has concentrated on agricultural applications

(hot houses and animal husbandry), which have expanded extremely rapidly (400,000 m² hot houses by the end of 1969, expected to be doubled in 1970) (Boldizsar, 1970).

The total volume of buildings heated with geothermal energy by mid 1969 is reported as follows (Boldizsar: private communication):

Szeged 1,200 flats	120,000 m ³
Szeged University clinics	106,000 "
Hódmezővásárhely factory	160,000 "
Hódmezővásárhely Hospital	12,000 "
Makó Hospital	80,000 "
Total	478,000 m³

The thermal waters of Hungary produced by drilling to a depth of about 2,000 m have a temperature of about 90 °C and the yield per well is of the order of 15-30 l/sec on the average.

(c) JAPAN

The traditional use of thermal springs in Japan, dating back through centuries, is for recreation and health (balneological and therapeutic uses). It is thus estimated that 100-150 million visitors enjoy annually the recreational facilities offered by the thermal springs of Japan (Komagata *et al.*, 1970).

Thermal waters have been used for hot houses for flowers since 1916, and hotels and other facilities of the recreational centres are now heated with geothermal waters.

The construction of geothermal district heating schemes involving comparatively long-distance transmission of thermal waters has been reported (Mashiko and Hirano, 1970) in the following localities:

An 11.5 km long transmission line carrying 14 l/sec of 70 °C water from the Sarukura springs to the town of Towata, was constructed in 1963.

A 12 km long transmission line in the Okawa area was built in 1963. It carries about 22 l/sec of 70 °C water and supplies 3,000 houses with heat on an area of 260 hectares.

A district heating system was built for the Ukiyama area in 1965, comprising 900 houses on 100 ha. The system is equipped with a boiler plant that can heat the water to 55 °C. The total length of pipe is 12 km.

A district heating system for the city of Aomori was constructed in 1966-67. It supplies 140 houses, including 34 hotels, and the population is 3,600. The water is supplied from the Asamushi hot spring area at a flow rate of 22 l/sec and 60 °C. The natural springs have temperatures in the range of 40-70 °C.

Attention has been given to the possibility of using waste heat from geothermal power stations for domestic heating.

(d) NEW ZEALAND

Considerable use of geothermal energy for domestic heating has been reported in the town of Rotorua (20,000 inhabitants), a tourist centre with balneo-therapeutic institutions (Kerr *et al.*, 1964; Burrows, 1970; Cooke, 1970).

The town is situated on a high-temperature area and a very large number (about 1,000) of boreholes issuing a mixture of water and steam have been drilled within the city limits. The individual boreholes are connected to single houses, groups of houses or to public building complexes, hospitals, etc., but an integrated district heating system for the whole town has not been organized. This leads apparently to rather wasteful use of the energy, and creates certain disposal problems for the excess hot water. The use of geothermal heating in Rotorua was started about 30 years ago.

A remarkable development is the recent construction of a 100-room tourist hotel in Rotorua that is not only heated with geothermal energy, but also cooled during the hot season by the use of a lithium bromide absorption unit powered with geothermal heat. This installation was commissioned in 1968 (Reynolds, 1970).

(e) U.S.S.R.

Some of the extensive hydrothermal areas of the U.S.S.R. seem to have been discovered and known for very many years as a result of drilling for oil (Tikhonov *et al.*, 1970; Sukharov *et al.*, 1970).

One such deep borehole in Makhach-Kala producing about 23 l/sec of 63 °C water has been used for 22 years for supplying dozens of dwelling houses and industrial buildings with hot water. Today several boreholes are in use supplying heat and hot water to certain districts of the town. One heat distribution station supplies districts with 15,000 inhabitants with 70 l/sec. Geothermal water is also used for hot houses and soil heating in this area.

Systematic prospecting for hyperthermal reserves and drilling for geothermal energy for its own sake did not take place until 1960.

Much attention has evidently been devoted to problems of energy utilization and the development of technically and economically sound systems, quite often involving combined schemes (Kremnjov *et al.*, 1970). A number of experimental systems have been designed and taken into use, some of which will be described later in this paper.

Besides the installations at Makhach-Kala mentioned above, the following have been reported (Lockchine and Dvorov, 1970).

Astarinsk district Azerbaijan	15 hectares hot houses	46.5 Gcal/h
Zgoudidi town Georgia	Heating of flats, public buildings, industrial buildings, hot houses, swimming pools	50 Gcal/h
Iserbach town Daghestan	District heating for 7,500 inhabitants and industrial uses	6 Gcal/h
Caspilsk town Daghestan	District heating for 5,000 inhabitants and hot water supply	5.0 Gcal/h
Massalinski district	15 hectares hot houses	46.5 Gcal/h
Mendji Georgia	Heating of meteorologic station and agricultural uses	2.0 Gcal/h
Paratounka Kamchatka	Heating of 3 apartment houses with 48 apartments each	0.55 Gcal/h
Ternahir Kamchatka	5 hectares hot houses and soil heating of 5 hectares	19.5 Gcal/h
Zaichi Georgia	Heating of meteorologic station, hot houses and baths	2.1 Gcal/h
Cherkesk Stavropol	District heating for 18,200 inhabitants, industrial uses, hot houses	22 Gcal/h
Total		200.2 Gcal/h

3. Technical aspects

The general technology of house heating, comfort cooling and district heating using conventional sources of energy, such as fossil fuels or electricity, is well known and need not be elaborated here.

Geothermal energy, however, has certain inherent characteristics that have to be taken into account whenever a geothermal system is planned and designed.

1. The thermal fluids have a fixed temperature in each thermal area.
2. Each borehole has as a rule a constant output.
3. The unit cost of the energy produced and/or delivered to the ultimate consumer is predominantly capital costs (depreciation, return on capital, etc., similar to hydro-power).
4. The chemistry of the thermal fluid must be observed.
5. The transportability of the thermal fluids is limited.
6. The unit cost of the energy produced and delivered is dependent on the capacity of the system (scale effect).

Every district heating project must be tailored to the climate of the site. The most significant characteristic of the climate in this respect is the variation of the daily mean outside temperature over the year. Due attention must also be given to the diurnal variation of the outside temperature, and the effect of such factors as wind velocity and solar radiation.

Figure 2 shows qualitatively a typical duration curve for the mean daily temperature over the year.

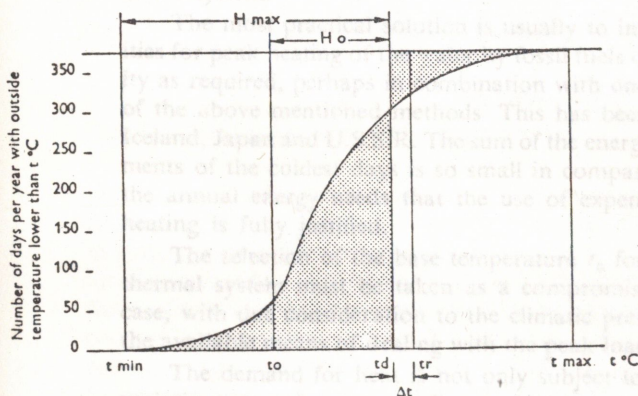


FIG. 2. Typical duration curve for the mean daily temperature over the year.

The objective is to maintain a constant optimum room temperature t_r in the heated buildings, for instance 20-22 °C for apartments. The building receives, in addition to the heat supplied by the system, a certain amount of 'free heat', i.e. heat lost by the occupants, electric lighting and appliances, solar radiation, etc. The free heat increases the room temperature by Δt °C, and accordingly the design room temperature is:

$$t_d = t_r - \Delta t \text{ °C}$$

The power required for heating is directly proportional to the differences between the inside design temperature and the outside temperature:

$$H = k(t_d - t) \text{ kcal/h}$$

where t is the outside temperature (°C).

The shaded area in Figure 2 for $t < t_d$ represents the annual number of degreedays G_h requiring heating, and for $t > t_d$ the degreedays G_c requiring cooling in order to maintain the desired room temperature.

The annual energy demand for heating (or cooling) is directly proportional to the number of degreedays.

The unit energy cost is, as stated before, predominantly capital costs. A geothermal district heating system that has sufficient power to maintain the desired room temperature on the coldest day of the year would have a very low annual load factor, and consequently high unit energy costs. The annual load factor for heating can be defined as:

$$\eta_{\min} = \frac{G_h}{365(t_d - t_{\min})}$$

where G_h = degreedays for heating above $t_{\min}$,

t_d = the design room temperature °C,

$t_{\min}$ = the mean temperature of the coldest day of the year.

If the geothermal system were designed to maintain the desired temperature to a minimum outside temperature of t_0 only, where $t_0 > t_{\min}$, the annual load factor would be:

$$\eta_0 = \frac{G'_h}{365(t_d - t_0)}$$

where G'_h = degreedays for heating above t_0 ,

t_0 = the so-called base temperature, °C, i.e. the mean temperature of the coldest day at which the geothermal system can still maintain the desired room temperature.

Reference to Figure 2 shows that this would greatly improve the annual load factor, and reduce the unit cost of the geothermal system correspondingly. The power of the geothermal system would be reduced in the proportion $H_0/H_{\max}$ (Fig. 2), and in the first approximation the unit geothermal energy costs would be reduced in the proportion:

$$\frac{e_0}{e_{\max}} = \frac{\eta_{\min}}{\eta_0} F \frac{(H_0)}{(H_{\max})}$$

where e_0 = unit energy cost for geothermal system with base temperature t_0 ,

$e_{\max}$ = unit energy cost for geothermal system with base temperature $t_{\min}$,

$F \frac{(H_0)}{(H_{\max})}$ is a function that defines the variation of the capital investment for the system in relation to the ratio of installed power ($H_0/H_{\max}$).

The remaining problem is how to handle the heating demand of the relatively few days of the year that have outside temperature $t < t_0$, and days with high wind velocity at which the system may only be able to handle the load at $t > t_0$.

This problem is aggravated by the fact that the water of the geothermal system has constant temperature, and accordingly the efficiency of heat utilization in radiators decreases with increased load.

The simplest solution is to expect the consumers to accept a lowering of the room temperature on the relatively few days of the year with $t < t_0$. This can be tolerated if the cold spells are of short duration and the houses have some heat storage capacity (masonry or concrete construction), but it is not popular with the consumers.

Thermal aquifers, where the temperature allows installation of deep well pumps in the boreholes (150-180 °C or less) can sometimes yield increased production for a limited time by pumping at a considerable draw-down of the water level. This method has been used in Reykjavik, Iceland, for several years (Zoëga *et al.*, 1970).

Heat pumps utilising the heat of the waste water leaving the house systems are being used in Paratounka, Kamchatka, U.S.S.R., to supply additional heat (Lokchine *et al.*, 1970).

It has been suggested (Bodvarsson *et al.*, 1964) to store surplus hot water by injecting it into underground permeable formations if such are available in the vicinity of the system.

The most practical solution is usually to install facilities for peak heating of the water by fossil fuels or electricity as required, perhaps in combination with one or more of the above mentioned methods. This has been done in Iceland, Japan and U.S.S.R. The sum of the energy requirements of the coldest days is so small in comparison with the annual energy needs that the use of expensive peak heating is fully justified.

The selection of the base temperature t_0 for the geothermal system must be taken as a compromise in each case, with due consideration to the climatic premises and the available means of dealing with the peak load.

The demand for heat is not only subject to seasonal variation over the year as discussed above, but also to diurnal variation. Figure 3 shows the variation of the load over 24 hours on two consecutive days in one of the sub-stations of the Reykjavik District Heating System. This comprises the demand for heating and for hot tap water. The general shape of the curve (b) is typical for most days of the year; however, it is of interest to note the difference between the demand of the two days, which shows the influence of 'free heat' due to a few hours of sunshine (a).

In as much as the unit cost of energy in geothermal district heating systems is primarily capital cost, attention should be given to all available possibilities of either reducing the investment or increasing the annual load factor.

At the present state of the art, geothermal power stations operating in geothermal fields with two phase flow

have a very low factor of energy utilization, which means that they supply enormous amounts of waste energy. Wherever possibilities permit this should be used for district heating, agricultural or industrial purposes. Combined schemes allowing the use of excess water for heating hot houses and especially for soil heating are practical measures for improving the annual load factor.

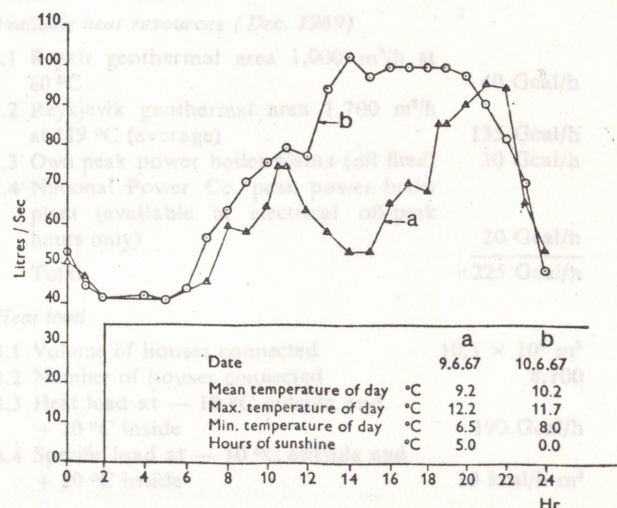


FIG. 3. Variation of the heat load over 24 hours on two consecutive days in one of the sub-stations of the Reykjavik District Heating System.

The above discussions have been concerned primarily with problems associated with the heating of homes and other buildings.

In certain climates, the cooling of premises is required for comfort. The use of absorption equipment for cooling opens up new perspectives for the utilization of geothermal energy (Reynolds, 1970).

The shaded area above for $t > t_d$ in Figure 2 represents the number of degree days G_c requiring cooling. If the energy requirements for cooling were supplied by the district heating system, its annual load factor would be:

$$\eta_0 = \frac{G'_h + xG_c}{365(t_d - t_0)}$$

where G'_h is the number of degree days for heating above base temperature t_0 .

G_c is the number of degree days for cooling above the design temperature t_d .

x is the ratio of the energy requirements for each degree day of cooling and heating respectively.

The load factor is thus obviously improved.

Figure 4 shows in a similar way to Figure 2 the main characteristics of three types of climate. Figure 4a shows a subarctic insular climate like that of Iceland, Figure 4b a cold temperate continental climate, and Figure 4c a tropical climate. The last two figures are qualitative but they indicate, as stated above, that there should be an oppor-

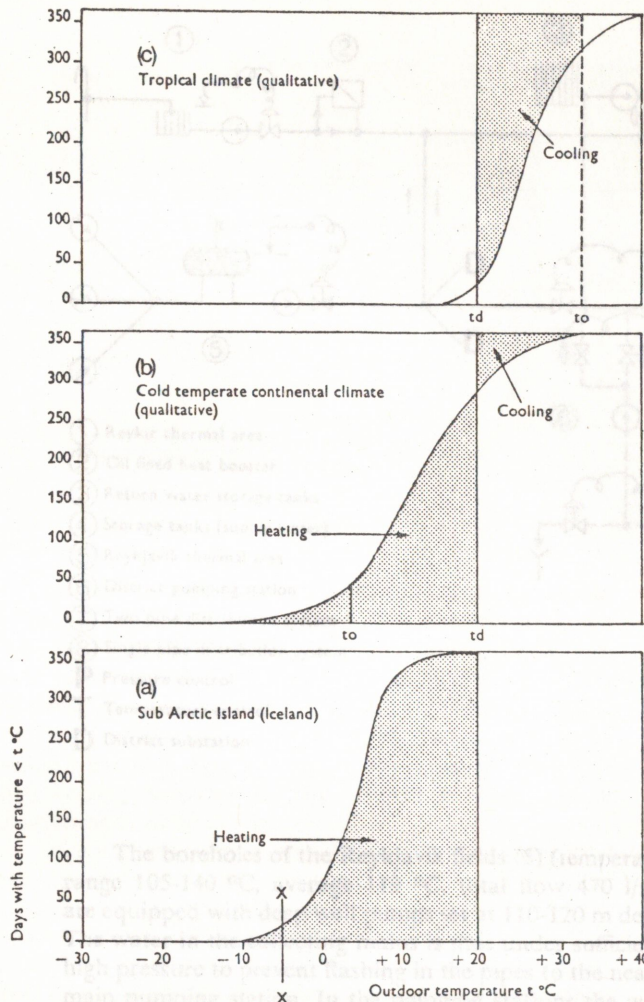


FIG. 4. Main characteristics of three types of climate.

tunity of improving the annual load factor in continental climates by the introduction of comfort cooling, and they raise the question whether an economic basis can be found for district comfort cooling systems in the tropical parts of the world. The tropical countries have an urgent need for cooling in connexion with food processing and storage, and other industrial uses for cooling and heating might be found and developed, comparable with the use of geothermal energy for soil heating and hot houses in colder climates. Combined comfort cooling and industrial schemes might therefore be feasible in the tropics.

4. Description of some geothermal district heating systems

(a) REYKJAVIK DISTRICT HEATING SYSTEM

This is the oldest and still the largest geothermal district heating system in the world.

The principal physical data of the system are summarized in the following tabulation, which is based on published data (Zoëga and Kristinsson, 1970).

1. Climatic data

1.1 Mean temperature of the year	+ 5 °C
1.2 Mean temperature of the warmest month (July)	+ 11.2 °C
1.3 Mean temperature of the coldest month (Jan.)	— 0.4 °C

2. Available heat resources (Dec. 1969)

2.1 Reykir geothermal area 1,000 m ³ /h at 80 °C	40 Gcal/h
2.2 Reykjavik geothermal area 1,700 m ³ /h at 119 °C (average)	135 Gcal/h
2.3 Own peak power boiler plants (oil fired)	30 Gcal/h
2.4 National Power Co. peak power boiler plant (available at electrical off-peak hours only)	20 Gcal/h
Total	225 Gcal/h

3. Heat load

3.1 Volume of houses connected	10.3 × 10 ⁶ m ³
3.2 Number of houses connected	8,700
3.3 Heat load at — 10 °C outside and + 20 °C inside	190 Gcal/h
3.4 Specific load at — 10 °C outside and + 20 °C inside	19 kcal/h m ³

4. System data

4.1 Installed horsepower in pumping plants	5,115 hp.
4.2 Area served by distribution system	11.2 km ²
4.3 Length of pipe lines	
4.3.1 Collecting mains	14.2 km
4.3.2 Supply mains	29.1 km
4.3.3 Street mains	125.2 km
4.3.4 House connections	120.2 km
4.4 Average density of population	643 inhabitants/km ²
4.5 Average load density	17 Gcal/h km ²

5. Yearly heat production

5.1 Geothermal energy (1968)	960 Tcal/year
5.2 Peak power stations (1968)	80 Tcal/year
Total	1,040 Tcal/year

The development of the geothermal areas feeding the system has been described earlier in this paper.

Figure 5 shows the present system in principle. The water from the boreholes in the Reykir fields (86° C, 280 l/sec) flows by gravity into collecting tanks (1) from which it is pumped through a 15.3 km long pipeline (two 350 mm diameter pipes) to storage tanks (4), capacity 8,000 m³, on a hill within the city. The pumps are governed by air operated valves on the discharge side operated by level control in the collecting tanks. An oil-fired peak heating plant (2) can raise the temperature of the water on cold days. The water temperature in the main storage tanks is maintained at about 90 °C.

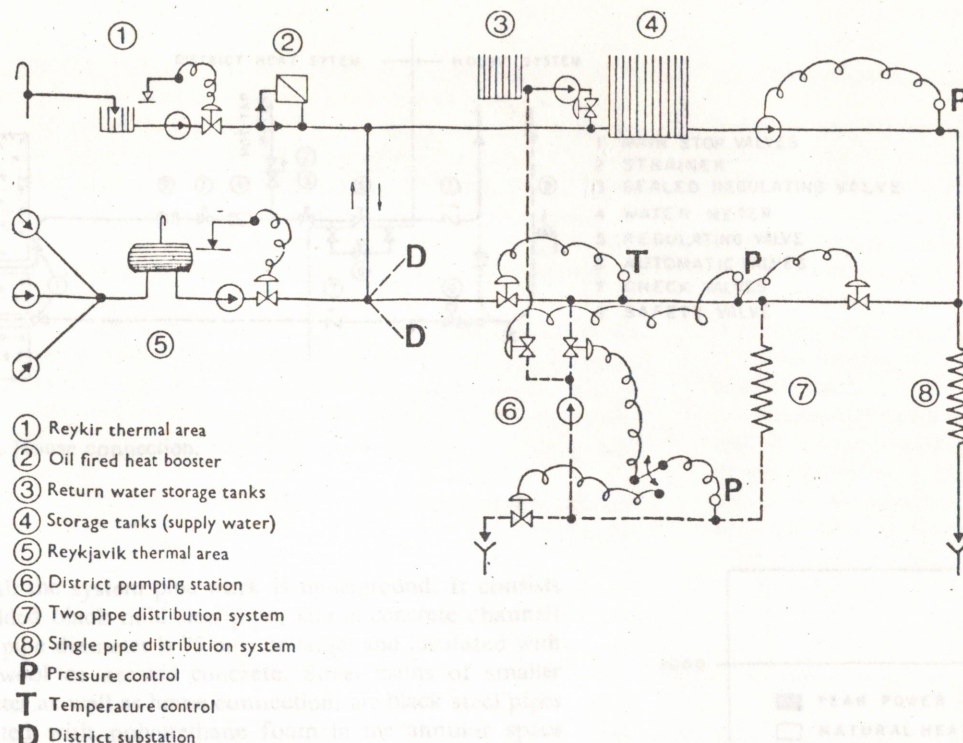


FIG. 5. Schematic diagram of system.

system has recently been commissioned (1969) for remote supervision, data logging and certain control operations (starting and stopping of pumps) from a central control room, for all pumping stations and borehole pumps.

The boreholes of the Reykjavik fields (5) (temperature range 105-140 °C, average 119 °C, total flow 470 l/sec), are equipped with deep well pumps set at 110-120 m depth. The water in the collecting mains is thus under sufficiently high pressure to prevent flashing in the pipes to the nearest main pumping station. In the pumping stations the water passes through deaerators where controlled flashing occurs in order to remove gases (primarily nitrogen) from the water. The pumps are governed by air actuated valves controlled by the water level in the deaerators.

The temperature of the water supplied to the houses (for heating or hot tap water) is maintained at about 80 °C. In the original system based on the Reykir fields, the water was pumped from the main storage tanks (4) by pumps regulated by the pressure at a suitable point on the system through a single pipe system (8) and the water was wasted to the sewer, after passing through the house system. This system is still in use.

With the advent of the water from the Reykjavik field (temperature 100 °C) it was necessary to adopt two pipe systems (7) whereby a sufficient quantity of return water from the houses was collected in order to cool the high-temperature water (by mixing) to the desired distribution temperature. A number of sub-stations have been built which are fed with high-temperature water and serve combinations of single- and two-pipe systems (6), (7) and (8).

All pumping stations except the deep well pumps are fully automatic. An electronic controlling and monitoring

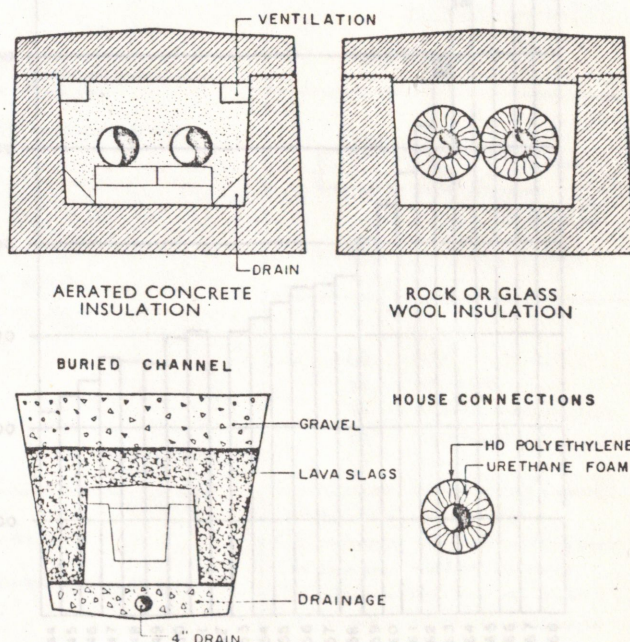


FIG. 6. Street main channels.

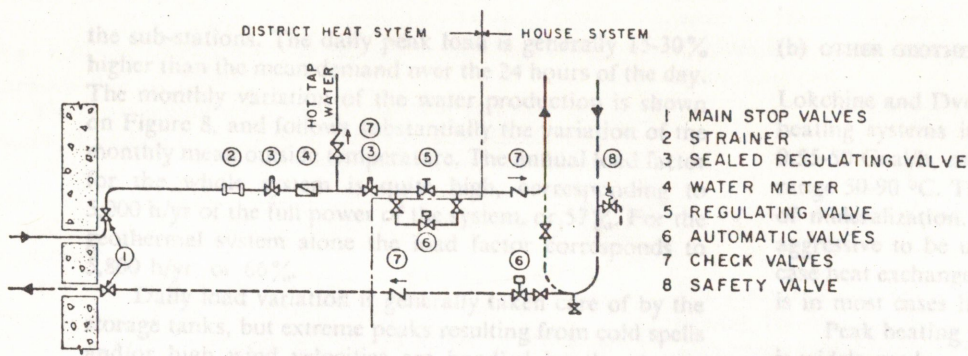


FIG. 7. House connection.

All the system pipe work is underground. It consists of welded black mild steel pipe, laid in concrete channels if the pipe diameter is 75 mm or larger and insulated with rock wool or aerated concrete. Street mains of smaller diameter as well as house connections are black steel pipes insulated with polyurethane foam in the annular space between the steel pipe and an outside protective jacket of high density polyethylene pipe. Figure 6 shows typical cross-sections of the pipes.

Figure 7 shows the standard house connections for a two-pipe system. It should be noted that the geothermal water is used directly as hot tap water. The house connection includes a sealed maximum flow regulator, (3), and an integrating water meter (4) measuring the consumption. The solenoid supply valve (6) is controlled by a room thermostat, and a high limit temperature switch controls the solenoid valve (6) in the return pipe from the radiators.

Figure 8 shows the diurnal load variation in one of

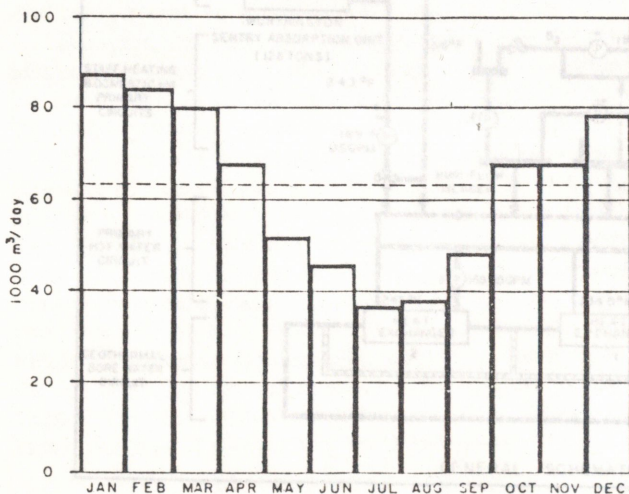


FIG. 8. Monthly water production, 1968.

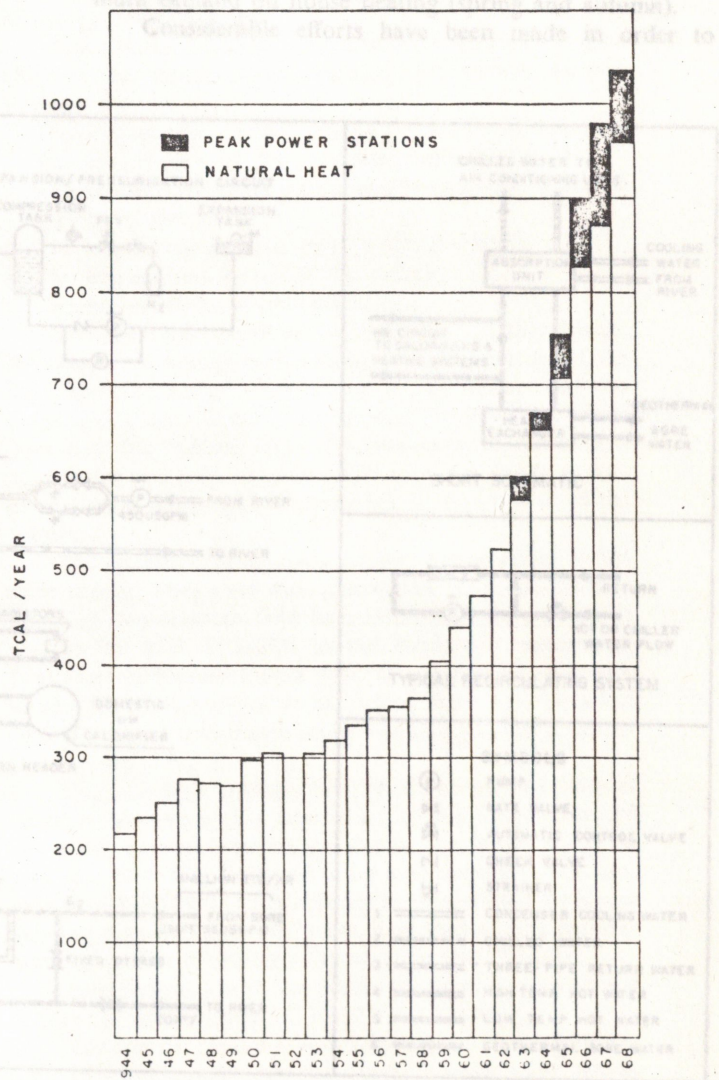


FIG. 9. Yearly heat production.

the sub-stations. The daily peak load is generally 15-30% higher than the mean demand over the 24 hours of the day. The monthly variation of the water production is shown on Figure 8, and follows substantially the variation of the monthly mean outside temperature. The annual load factor for the whole system is quite high, corresponding to 5,000 h/yr of the full power of the system, or 57%. For the geothermal system alone the load factor corresponds to 5,800 h/yr, or 66%.

Daily load variation is generally taken care of by the storage tanks, but extreme peaks resulting from cold spells and/or high wind velocities are handled by the storage tanks in combination with peak heating by oil, and intensified pumping from Reykjavik field by the deep well pumps.

Figure 9 shows the growth of the annual heat production 1944-69, and also the portion of energy supplied by the peak heating boilers.

(b) OTHER GEOTHERMAL DISTRICT HEATING SYSTEMS

Lokchine and Dvorov (1970) describe a number of district heating systems in the U.S.S.R. ranging in power from 0.55-50 Gcal/h, using geothermal water in the temperature range 50-90 °C. The thermal waters have different degrees of mineralization. They may therefore sometimes be too aggressive to be used directly for the radiators, in which case heat exchangers are used. Apparently the hot tap water is in most cases heated indirectly by heat exchangers.

Peak heating with fossil fuel fired boilers or electricity is widely used.

Frequently hot houses and/or soil heating is combined with the district heating systems, as well as other industrial or agricultural uses of heat. In this way the annual load factor can be significantly improved especially with seasonal soil heating, which falls outside the periods of maximum demand on house heating (spring and autumn).

Considerable efforts have been made in order to

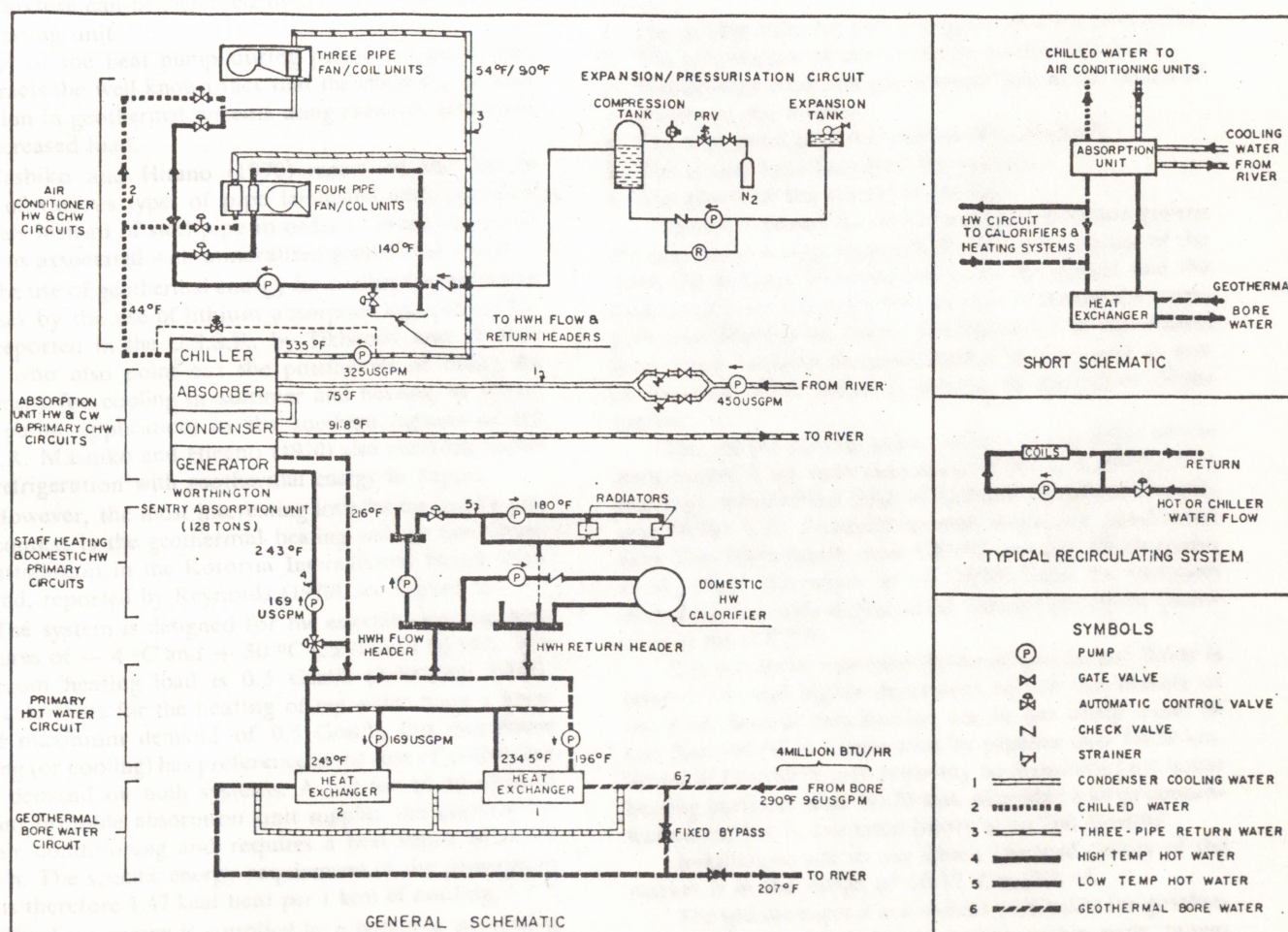


FIG. 10. Scheme of the geothermal heating and air conditioning installation in the Rotorua International Hotel, New Zealand.

increase the efficiency of energy utilization by lowering the temperature of the waste water, for instance by using two-stage heat exchangers for hot tap water, and by using two-stage heating of air.

The most interesting system is perhaps that of Paratounka, Kamchatka, (Lokchine and Dvorov, 1970). The scheme comprises three apartment houses with 48 apartments each (load 0.55 Gcal/h). Geothermal water of 80 °C is used for heating hot tap water and for heating the apartments.

The tap water is heated from + 5 °C in a heat exchanger, cooling the geothermal water to 10 °C.

The apartment houses are heated either by using a central heating system with radiators or by pipes embedded in the concrete of the floors and ceilings (radiant heating). The heating systems are designed for a temperature drop from 80 to 40 °C.

By use of a heat pump, part of the return water of 40 °C can be reheated to 60 °C by extracting heat from the remainder of the return water, which is in turn cooled to 10 °C before being wasted. The 60 °C water is mixed with the geothermal supply water of 80 °C, and the temperature of the mixture can be increased by the use of an electrical peak heating unit.

Use of the heat pump during periods of peak load counteracts the well known fact that the efficiency of heat utilization in geothermal systems using radiators decreases with increased load.

Mashiko and Hirano (1970) report on the use in Japan of various types of pipe laminated with synthetic materials instead of steel pipe in order to avoid corrosion problems associated with mineralized geothermal water.

The use of geothermal energy for cooling for industrial purposes by the use of lithium absorption equipment has been reported in the U.S.S.R. by Tikhonov and Dvorov (1970) who also point out the possibilities of using the equipment for cooling in summer and heating in winter (heat pump application) in the southern regions of the U.S.S.R. Mashiko and Hirano (1970) also mention industrial refrigeration with geothermal energy in Japan.

However, the most interesting installation in the present context is the geothermal heating and air conditioning installation in the Rotorua International Hotel, New Zealand, reported by Reynolds (1970), see Figure 10.

The system is designed for the extreme climatic temperatures of - 4 °C and + 30 °C (25 °F and 85 °F). The maximum heating load is 0.5 Gcal/h (2,000,000 BTU). Two calorifiers for the heating of tap water have a combined maximum demand of 0.5 Gcal/h, but the house heating (or cooling) has preference in the case of coincident peak demand on both systems. A 130 ton (0.39 Gcal/h) lithium bromide absorption unit supplies the cooling for the air conditioning and requires a heat input of 0.575 Gcal/h. The specific energy requirement of the absorption unit is therefore 1.47 kcal heat per 1 kcal of cooling.

The heat energy is supplied by a borehole producing at temperatures above 150 °C and a pressure of about

6 atg. The heat is transferred by heat exchanger to fresh water in closed circuits which is heated to 120 °C, and supplies heat to the radiators, tap water heaters and the absorption unit.

5. Some economic aspects

The economic feasibility of using geothermal energy for heating (or cooling) depends on whether it can compete with other available sources of energy such as fossil fuels, electricity, etc.

Such comparison should be based on the total cost to the ultimate user per unit of net energy utilized. This means comparing costs of entire systems, taking into account the desired return on invested capital of all plant used, direct operating costs, annual load factors, efficiency of energy utilization, etc.

The principal factors that affect the economic feasibility of geothermal district heating systems are the following:

1. The drilling costs per unit energy production (\$/Gcal/h).
2. The temperature of the available geothermal fluids.
3. The distance from the geothermal field to the centre of gravity of the market.
4. The load density of the market (Gcal/h/km²).
5. The annual load factor of the system.
6. The power of the system (Gcal/h).

The drilling costs per unit of energy production govern the cost of the energy ex borehole. The temperature of the fluid, the distance of transmission to the market and the load density are the main factors that influence the transport and distribution costs. The influence of the annual load factor has been discussed earlier in this paper as well as the scale effect which is related to the power of the system.

The specific drilling costs (\$/Gcal/h) can differ within wide ranges. They were thus about 2,100 U.S. \$/Gcal/h in one high temperature field in Iceland (Southern Hengill) and 16,700 U.S. \$/Gcal/h in the Reykjavik geothermal field (low temperature area 120 °C average) (Bodvarsson *et al.*, 1964). Kremnjov *et al.* (1970) show the variation of drilling cost with depth under various geological conditions in the U.S.S.R.

The economic transportability of geothermal fluids is relative low and highly dependent on the temperature of the fluid. Several installations are in use where water of less than 100 °C is transported by pipeline over 10-20 km. Water of 150-180 °C can probably be transmitted for house heating purposes over 50-75 km, provided a large concentration market is available (more than 200 Gcal/h).

Installations are in use where the load density of the market is in the range of 10-17 Gcal/h/km².

The specific capital investment (\$/Gcal/h) for geothermal district heating systems varies within wide ranges

depending on local conditions. Zoëga *et al.*, (1970) report the average costs for the Reykjavik system, based on present day methods and equipment as follows:

Heat production	29,400 U.S. \$/Gcal/h
Distribution system	58,000 "
Total	87,400 U.S. \$/Gcal/h

and estimate that the replacement value of the present system (225 Gcal/h) is of the order of U.S. \$17 million.

The energy price paid by the customers is 0.16 \$/m³ of water at 80 °C. Based on average utilization, this corresponds to 3.80 \$/Gcal and is broken down as follows (Palmason *et al.*, 1970):

Drilling	0.73 \$/Gcal
Main pipelines	0.42 "
Storage	0.15 "
Distribution	2.50 "
Total	3.80 \$/Gcal

The savings in oil by the use of geothermal energy depend on the annual load factors. The following figures are reported:

Cherkest (U.S.S.R.)	680 tons oil/Gcal year
Reykjavik (Iceland)	870 "
Paratounka (U.S.S.R.)	1,090 "
Caspilok (U.S.S.R.)	1,440 "

The Reykjavik district heating system thus saves about 150,000 tons of oil annually that would have had to be imported, and the annual cost of heating for the customers is only 60% of the cost of heating with oil.

Acknowledgement

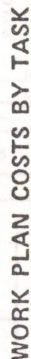
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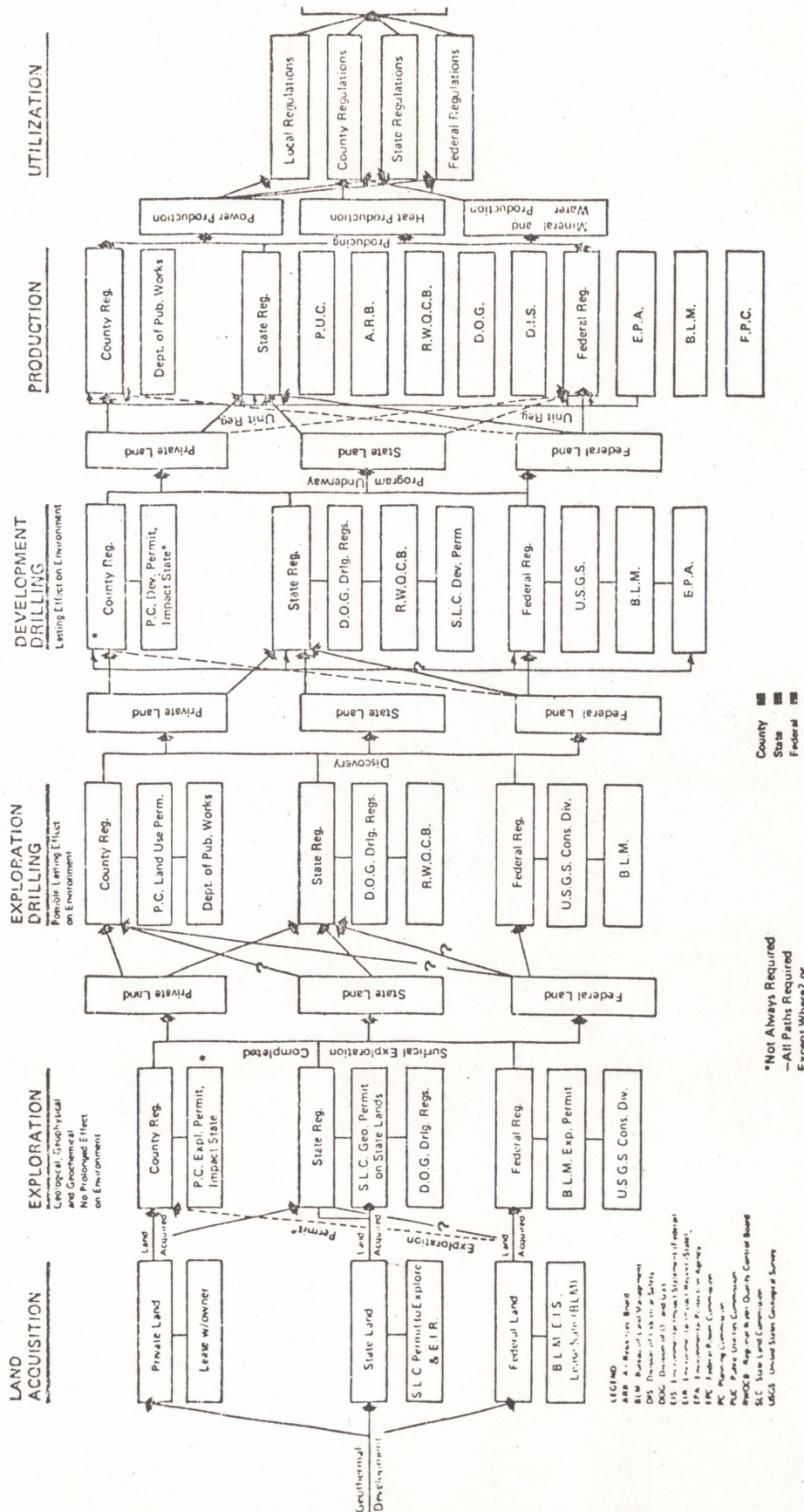
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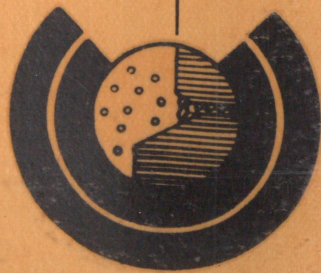
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*Includes administrative and management costs.

FLOW CHART OF CRITICAL PATH IN GEOTHERMAL EXPLORATION





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