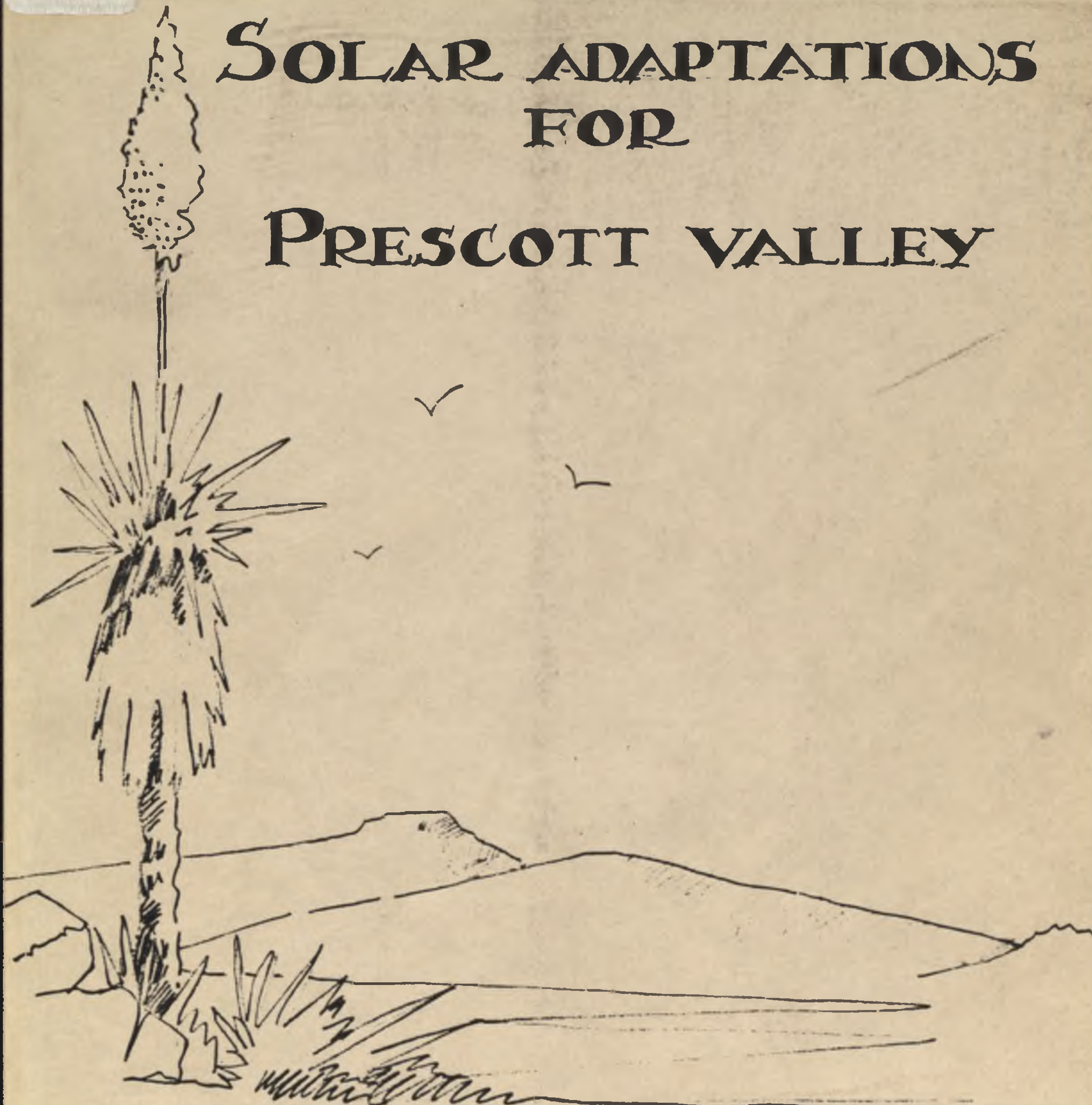
SOLAR ADAPTATIONS FOR PRESCOTT VALLEY



ALBERT S. MERKER

1983

SOLAR ADAPTATIONS

FOR

PRESCOTT VALLEY

by

Albert S. Merker

A Masters Project Submitted To The Faculty Of The

COLLEGE OF ARCHITECTURE

In Partial Fulfillment of the Requirements
For the Degree of

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THE UNIVERSITY OF ARZIONA

1982

STATEMENT BY AUTHOR

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SIGNED: Albert [signature]

APPROVAL BY MASTERS PROJECT DIRECTOR

This Masters Project has been approved on the date shown below:

Fred S. Matter — 11/29/82

FRED S. MATTER
Assistant Dean, Architecture

Date

ACKNOWLEDGMENTS

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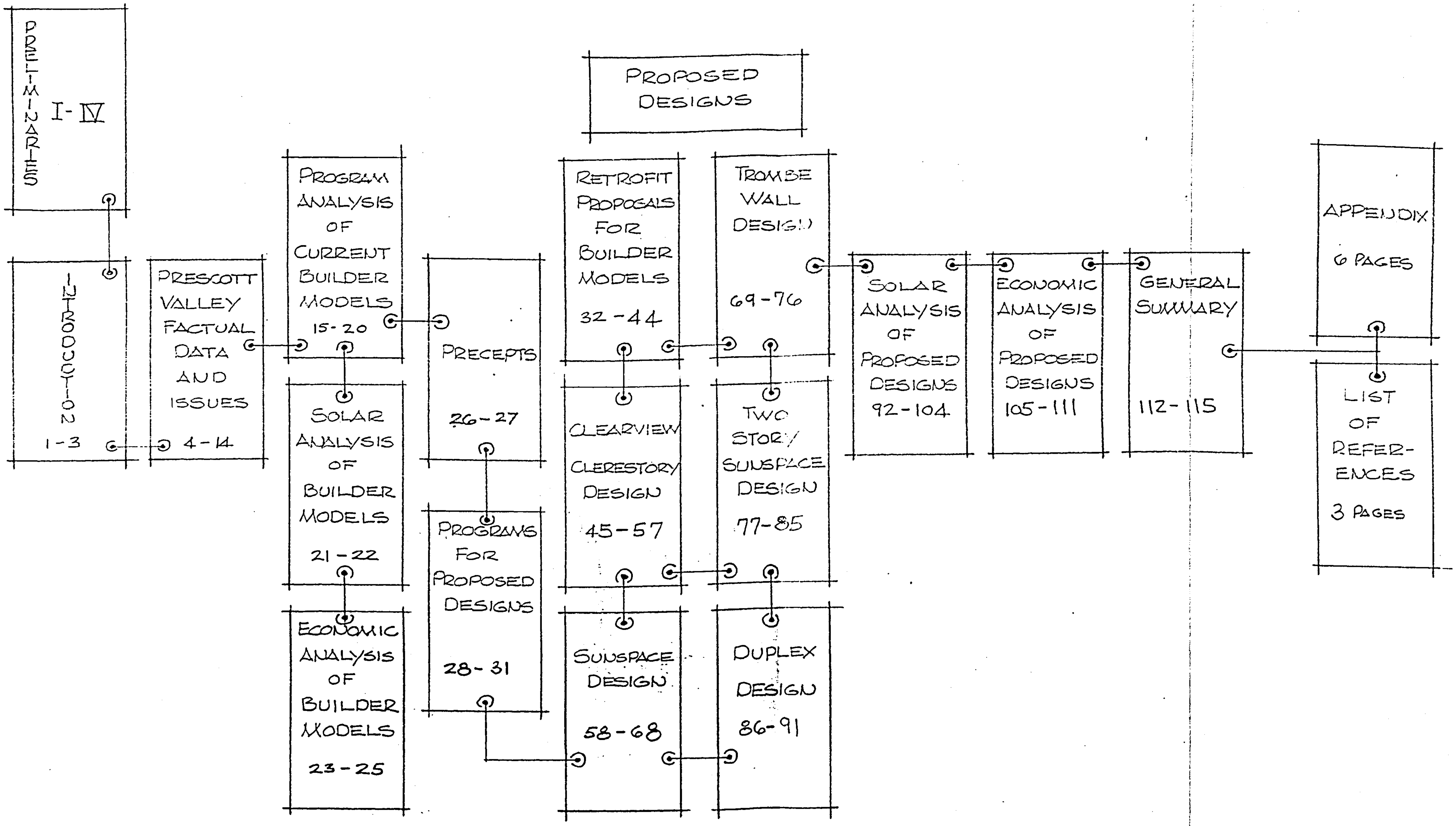
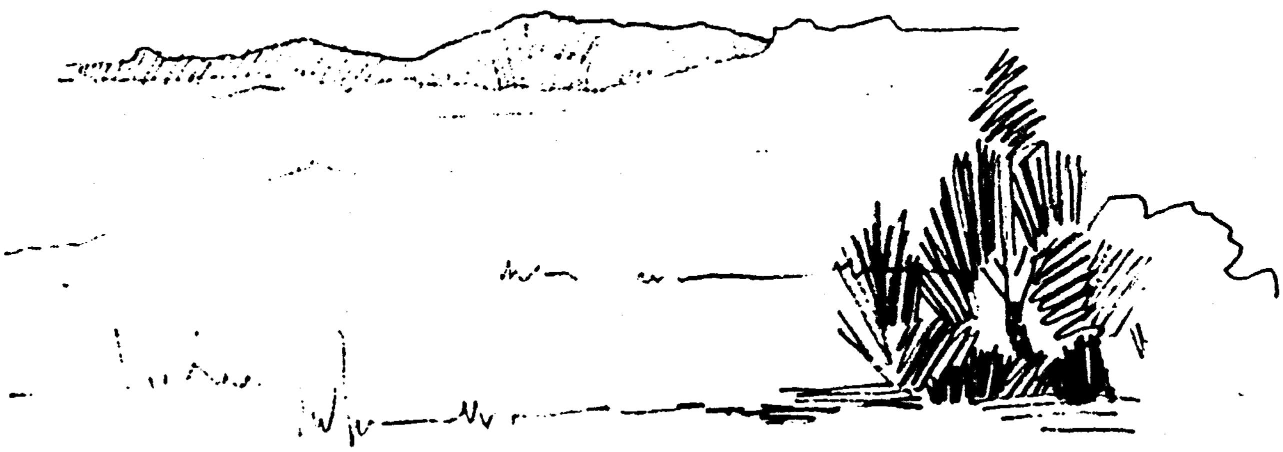
• SOLAR ADAPTATIONS FOR PRESCOTT VALLEY • PROJECT OUTLINE AND INDEX •



INTRODUCTION



A.S. Merker

INTRODUCTION

The purpose of this Masters Project is to narrow the gap between passive solar theory and the application of this theory to a specific type of project such as the existing single family suburban southwestern residential subdivision.

Research was undertaken to identify and to sort out ideas, applications and principles from the voluminous work being done all over the country by engineers, academics and experimenters. This research has been focused with regard to the subdivision application.

The second phase of this project is to suggest some specific applications of passive solar principles for use in the context of the southwest single family residential subdivision and is organized into three sections. The first is to present an analysis of builder models presently being built. The second is to present a program of requirements and to identify certain applicable precepts for a group of new design responses. The third section presents a group of design responses. This section will include an analysis and critique of the design responses. A final section includes an appendix of detailed analytic data.

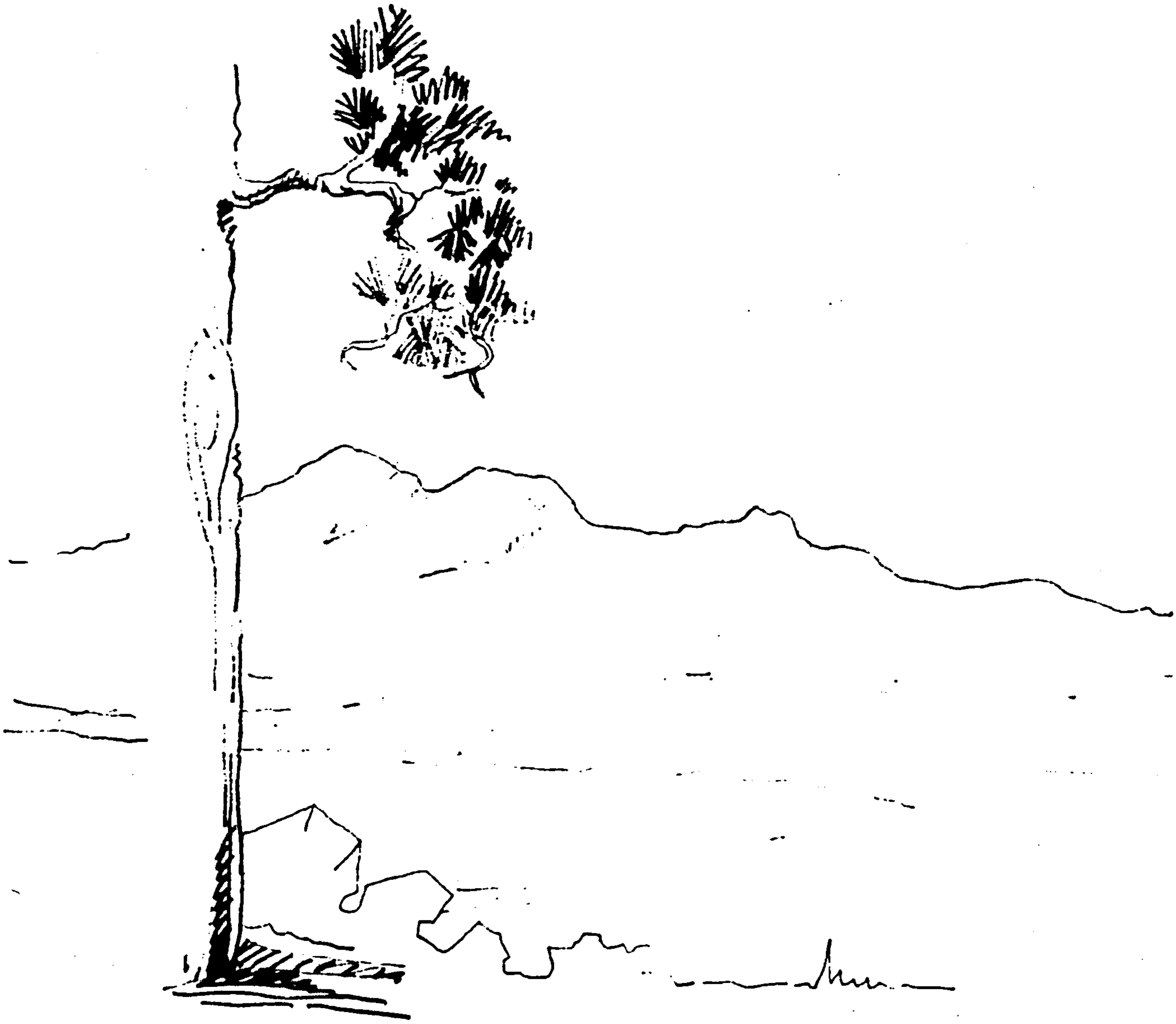
Prescott Valley has been selected as a vehicle for this study. It is a sizable land subdivision development started in 1966 and recently incorporated as one of Arizona's newest municipalities. This subdivision is typical of land planning practices of its time and is located near the community of Prescott, Arizona. It is presently supplied with electric and liquid petroleum energy sources. It is a southwestern location at 5000 feet altitude above sea level and is mostly (55%) composed of single family residences. Prescott Valley is in multiple ownership and presents a number of poorly considered lot orientations typical of many such examples of its time frame. It is at this date only 8% built upon, thus presenting the opportunity to study solutions both for new construction as well as for solar retrofit. As some 20% of the 10,500 lots are zoned for multiple family duplexes it also presents the opportunity to study the solar retrofitting of this type of unit.

The remaining portions of the subdivision are zoned for mobile units (20%), commercial (5%) and some apartment usages which are not a part of this study.

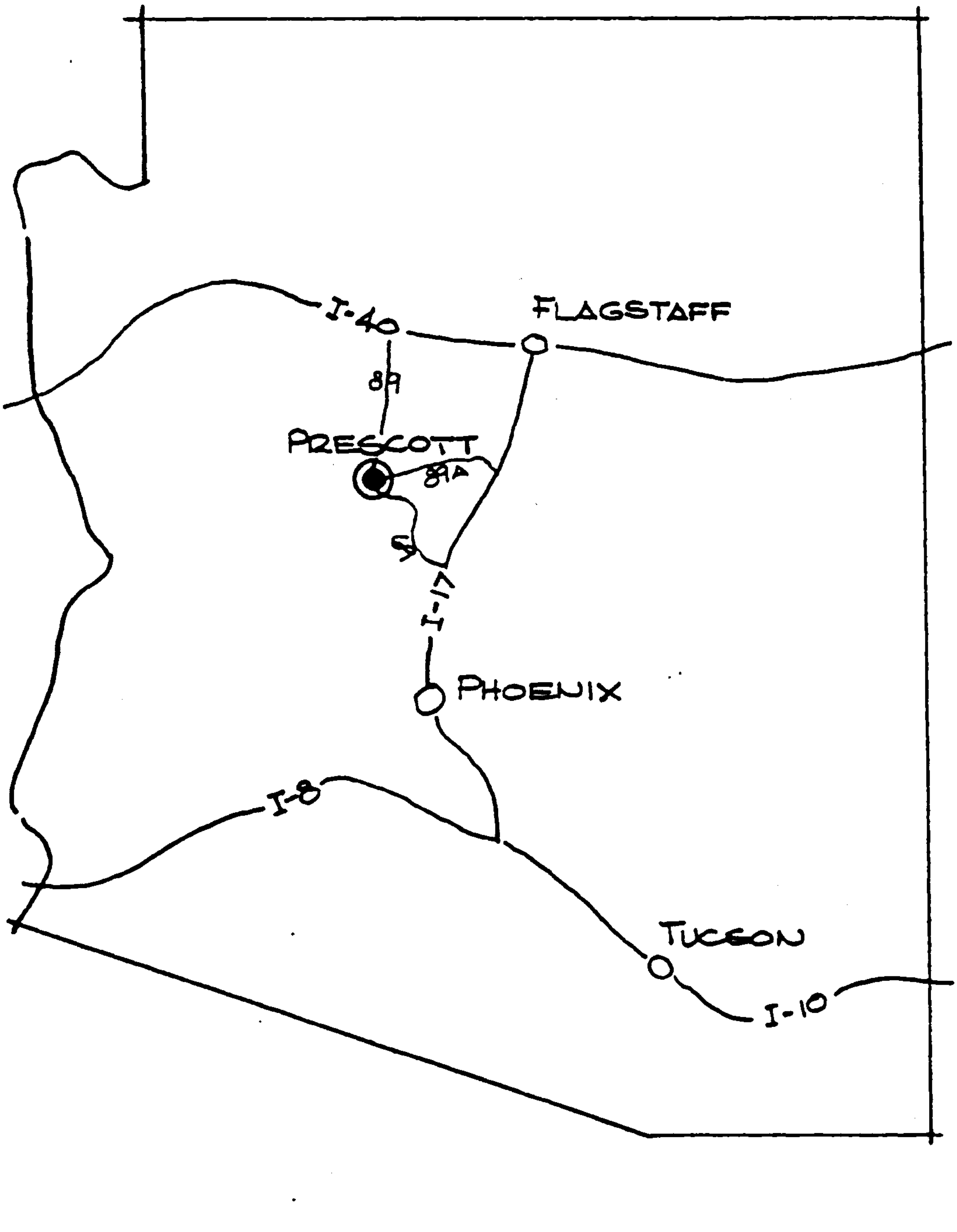
This study accepts the fact that under the current status of multiple ownership (many owners are out of state) replanning of the land areas for improved solar orientation is not feasible or economically practical. This is in consideration of the substantial existing investment in roads, utilities systems, surveying, planning and legal recording costs. In certain isolated cases where a small group of continuous owners could get together, some advantages could be gained by prudent, careful replanning of their lots. The city of Prescott Valley could make such an option legally available and relatively easy to accomplish.

PRESCOTT VALLEY

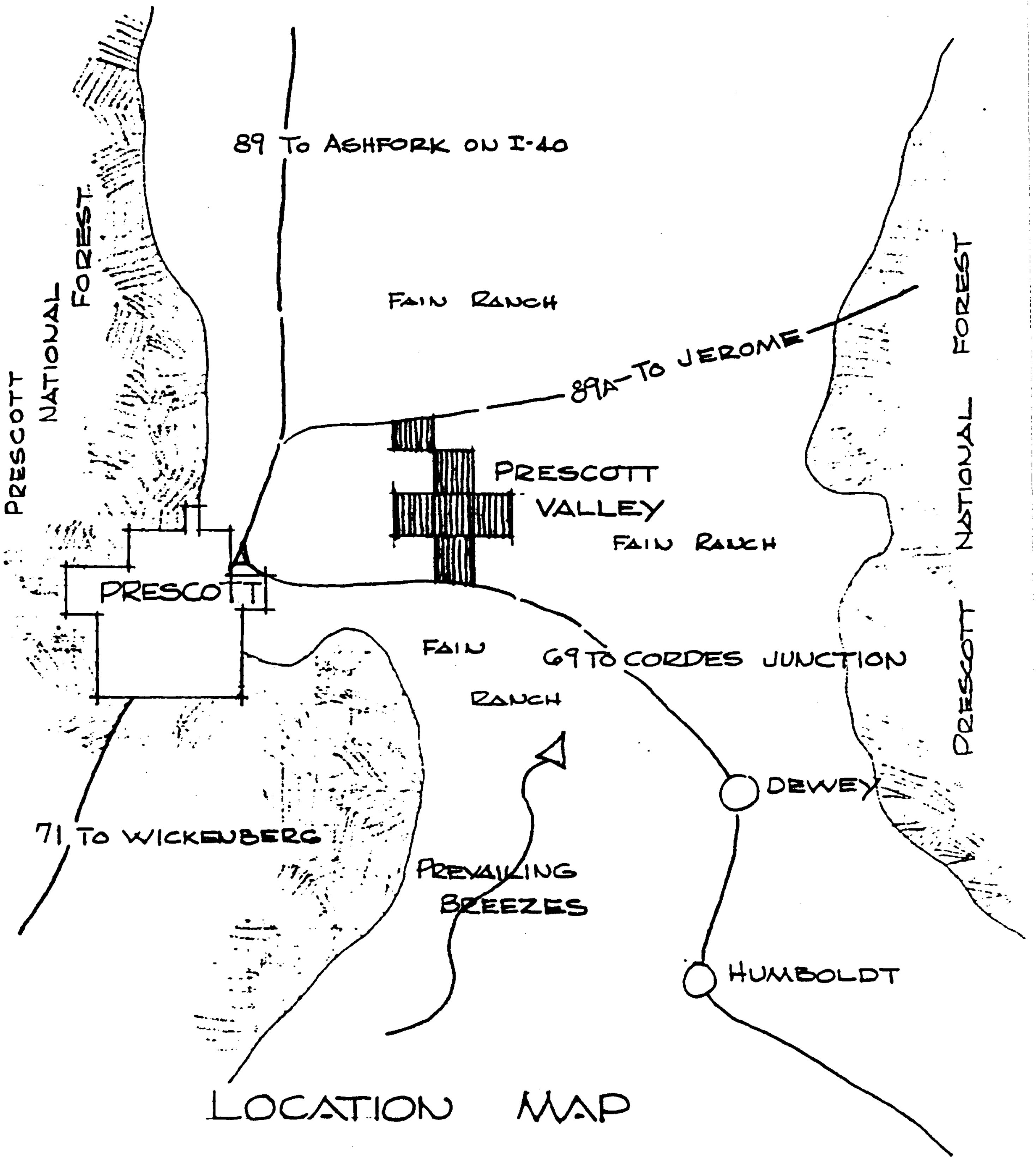
FACTUAL DATA AND ISSUES



THE STATE OF ARIZONA



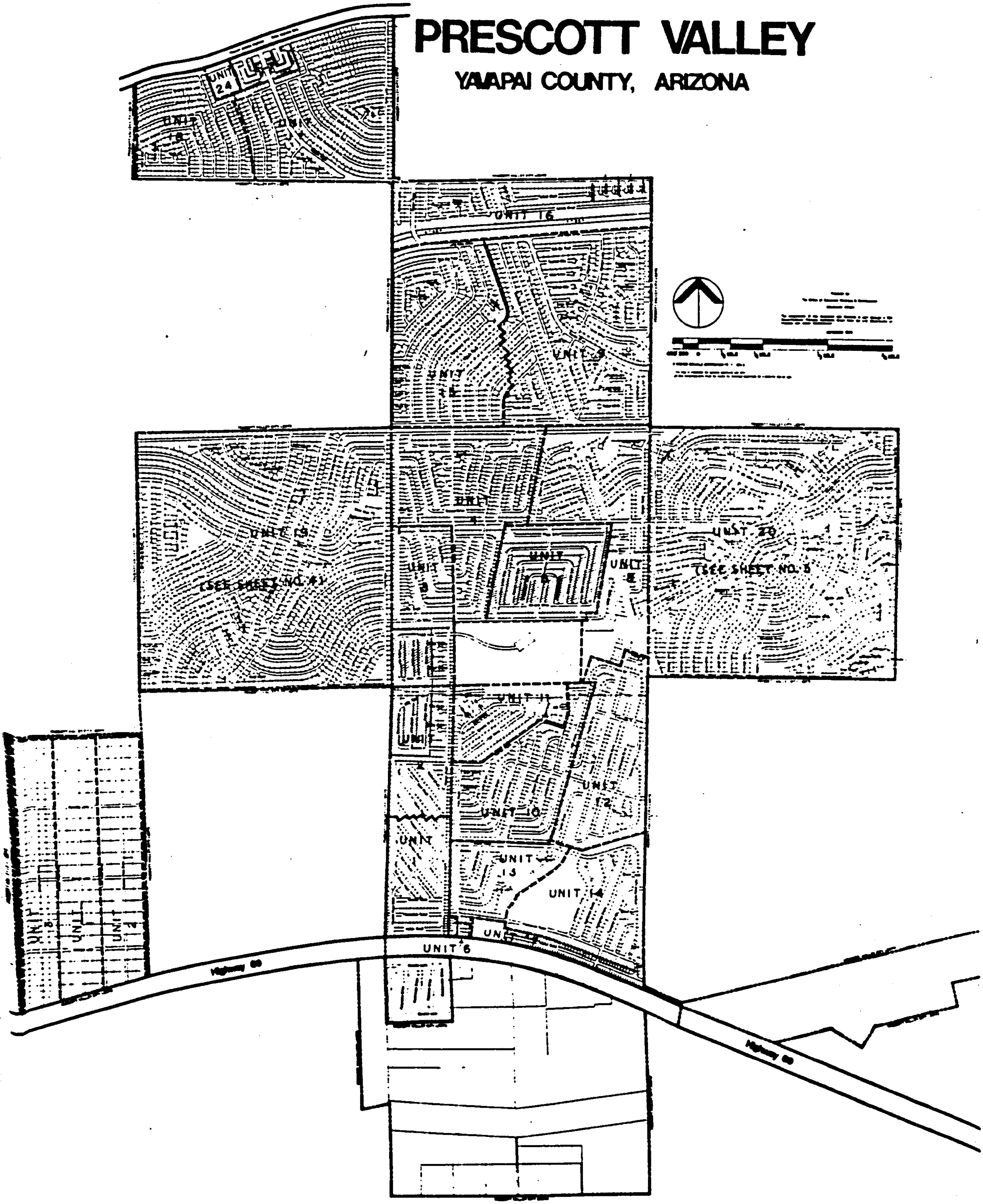
A.S. MERKER



LOCATION MAP

PRESCOTT VALLEY

YAVAPAI COUNTY, ARIZONA



PRESCOTT VALLEY STATISTICS:

Developed - 1966

3500 Acres - 10,500 Lots -	55%	Single Family
	20%	Duplexes
	20%	Mobiles
	5%	Commercial
	100%	Sold
Built to date - April 1980 -		
	450	Homes
	45	Apartments
	41	Commercial

Population (1980) - 4000±
Projected Population - 30,000±
Population doubled during last two years.
Surrounding land ownerships and uses are:
To North 89A (Fain) no expected development
To East (Fain) no projected development
To West Castle Canyon Mesa & Lynx Lake Estates
To South (Fain & others) considerable expected development in industrial-commercial (Contact Town & Country Realty - Pavlich)

Water Supply Unlimited

Energy Resources: Arizona Public Service - Electrical
Liquid Petroleum
Natural Gas - (High pressure line in the development, but no distribution system in place as yet)

Access: South - Arizona Highway 69
North - Arizona Highway 89A

PRESCOTT VALLEY

A.S. Merker

This study concerns itself with the development of solar design prototypes for the existing residential land subdivision now known as the city of Prescott Valley. This land subdivision was planned prior to the current energy crisis and the need for solar emphasis. At the time of planning and subdivision little, if any, concern was given to the idea that the sun might provide a direct source of energy for space and water heating.

Recent projections of population growth in the state indicate that these lands and others like it will come under extreme pressure for development during the next ten to twenty years, especially in the smaller municipalities of northern Arizona.

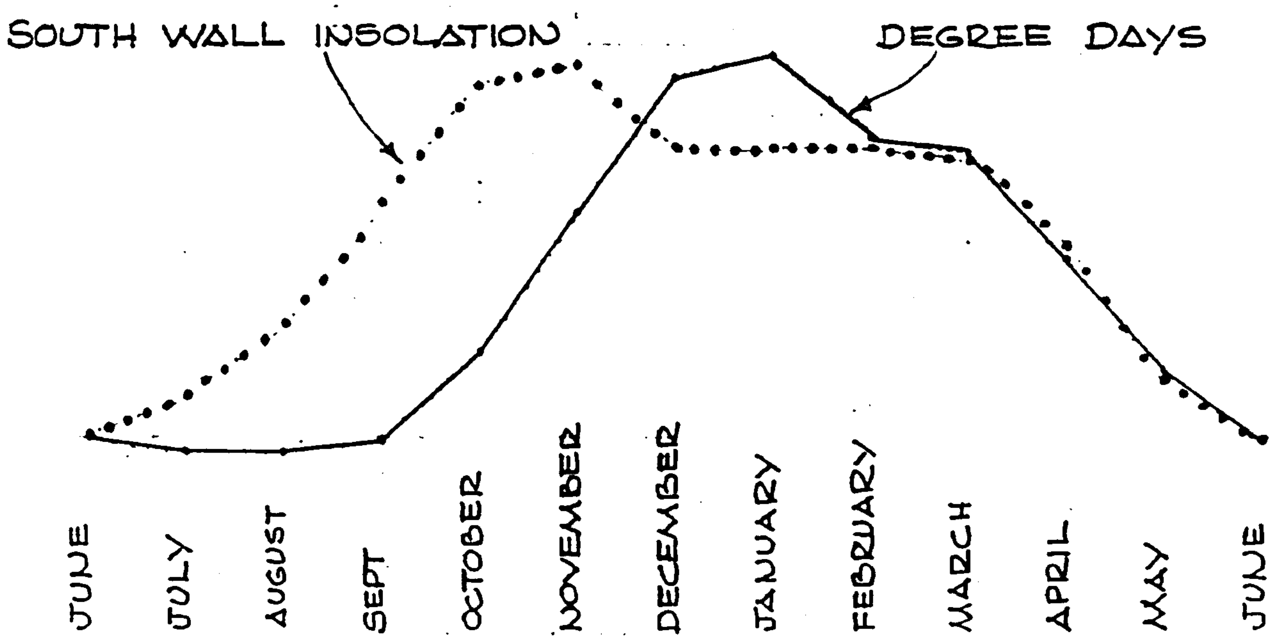
As planned, Prescott Valley is only supplied with electric and liquid petroleum energy sources. Natural gas is not now available but could become so. Current moves by government to deregulate prices in this area would likely place natural gas in the expensive, as well as depletable, category of energy source.

Prescott Valley does, however, enjoy an abundance of sunshine. Solar insolation data favors Prescott Valley with a range of 73% up to 95% or an average of 83% of possible sunshine. The solar angle of incidence varies in such a fashion during the year as to be in a favorable correlation with the heating demand as dictated by local weather patterns. Few areas of the U.S. are so blessed.

Prescott Valley winters produce upon occasion heavy snow storms which drop 8" to 20" of heavy snow. These storms do not occur often, however, roof structures and slopes should be designed for these conditions.

Prescott Valley is situated midway between the two halves of the Prescott National Forest which encompasses large portions of the surrounding mountains. This forest is comprised of chaparrel and evergreen types of growth which provides an enormous supply of fire wood.

PRESCOTT VALLEY



COMPARISON
OF
SOLAR SUPPLY & HEATING DEMAND
FOR
PRESCOTT, ARIZONA

A.S.Merker

Prescott valley is a typical, sizable land subdivision (5½ sq.mi.,10,500 lots, 3500 ac.) of the 1966 era. The planning was executed with the goal of gaining minimal utility and access costs versus maximum number of salable lots. No consideration was given to solar access. Most lots were sold out of state, sight unseen in the Midwestern U.S.

Recent commercial and light industrial development in the area to the south of Prescott Valley is creating an increased pressure for new residential construction in the area as new residents seek jobs and homes in the community.

The conditions as noted above bring with them some new problems which become issues to which this study must address itself. They are ;

A. Few prospective homeowners can afford architectural services on an individual basis.This study is an attempt to address this issue.

B. Lot orientations are difficult and troublesome for solar applications.This subject will be dealt with later in more detail as the proposed designs are developed.

C. Prospective owners bring with them preconceived traditional images of the appearance and nature of their domicile thus rejecting many contemporary solar applications.

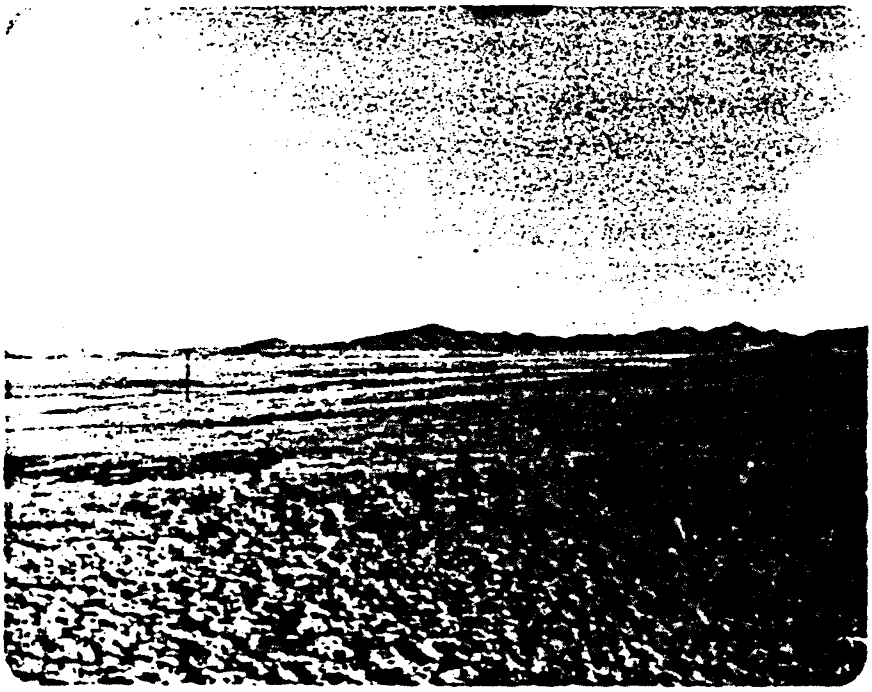
D. Builder-designers presently working in the area lack the required knowledge and expertise to adequately solve the problems involved. Most of these builders are not in a financial position to provide the required research and development to solve their customers solar needs.

A typical builder model in Prescott Valley

SITE CONDITIONS:

A. Flat or gently rolling topography prevails in most areas of the subdivision.

B. Open grassland virtually uninterupted by shrubs or other vegetation is the the natural condition.



C. Open panoramic views of distant mountains are available in all directions.

D. Water-electric power-telephone are available to each lot.

E. Unpaved street access is available to all sites.

F. The altitude above sea level is 5200 ft.

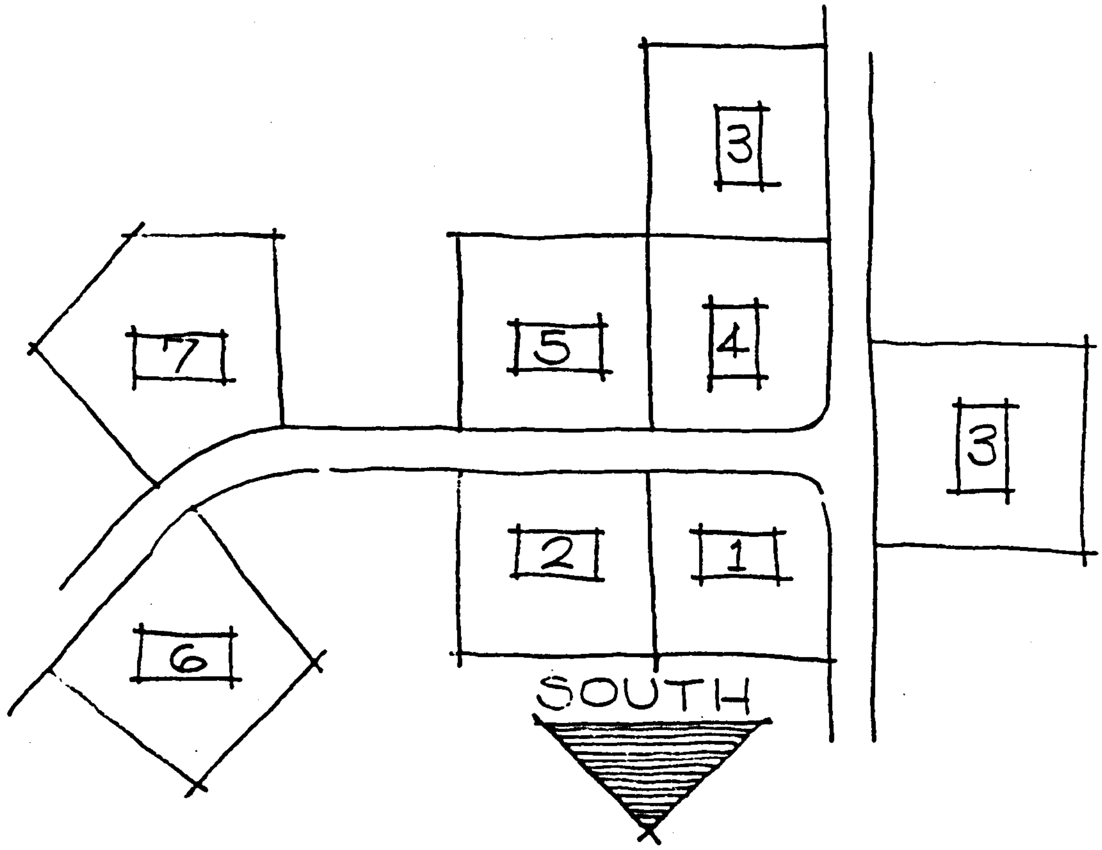
G. All sites require traveling to services. Site access is provided by Arizona Highway 69 on the south allowing travel from Prescott (approx. 10 mi.) to Phoenix (approx. 80 mi.) and also on the north by Arizona Highway 89A allowing travel to Prescott and Jerome.

H. Climate is temperate-dry- requiring heating from November first through June. Little cooling is required other than natural ventilation (2-4 weeks, 90°)

J. Multiple lot orientations with respect to south are the rule.

They can be reduced to the seven typical conditions illustrated here.

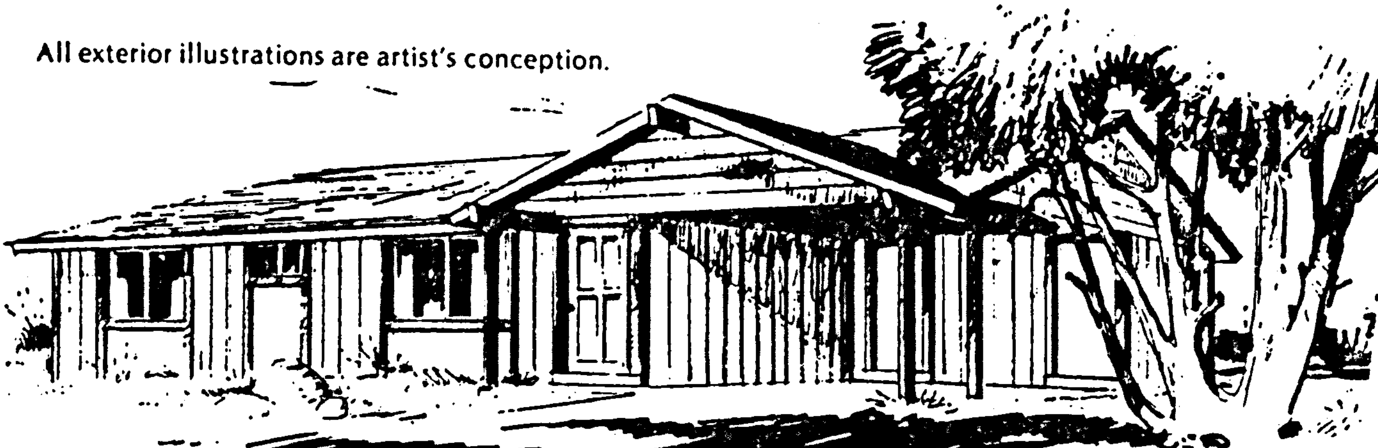
This diagram also serves to illustrate the conflict between the solar south and traditional street facing orientations usually expected for houses.

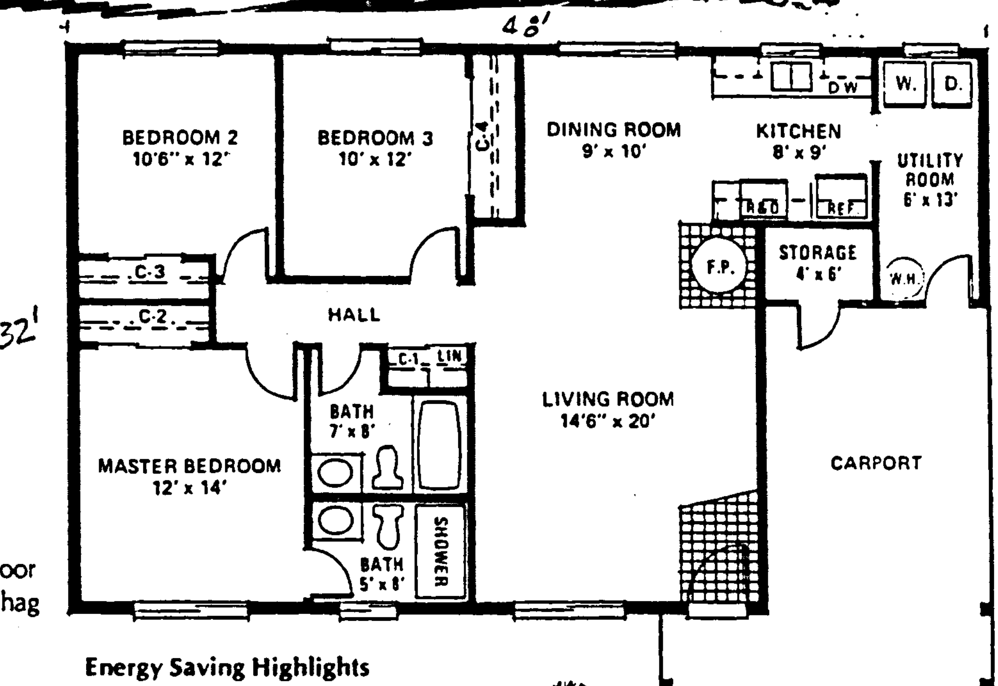


PROGRAMATIC ANALYSIS OF CURRENT BUILDER MODELS

Plan 1176

All exterior illustrations are artist's conception.





Standard Features of Your New Home

General Highlights

★ 3 Bedroom
★ 2 Bath
★ Carport with storage
★ Concrete driveway & patio
★ Ceramic entry & fireplace area
★ Ceramic over bathtub
★ Spacious utility room with tiled floor
★ Fully carpeted with sculptured shag
★ Shower with glass door

Kitchen Highlights

★ Built-in Range & Oven
★ Built-in Dishwasher & Disposal
★ Recessed Luminous Lighting
★ Kitchen Carpet
★ Formica Counter Tops
★ Stainless Steel Sink

Energy Saving Highlights

★ Efficient "Spin-A-Fire" fireplace
★ Bronze Dual Pane Windows
★ R-30 Blown Insulation in ceiling
★ Full thick fiberglass batts in the exterior walls
★ Individual heat control in each room
★ Weatherstripped exterior doors

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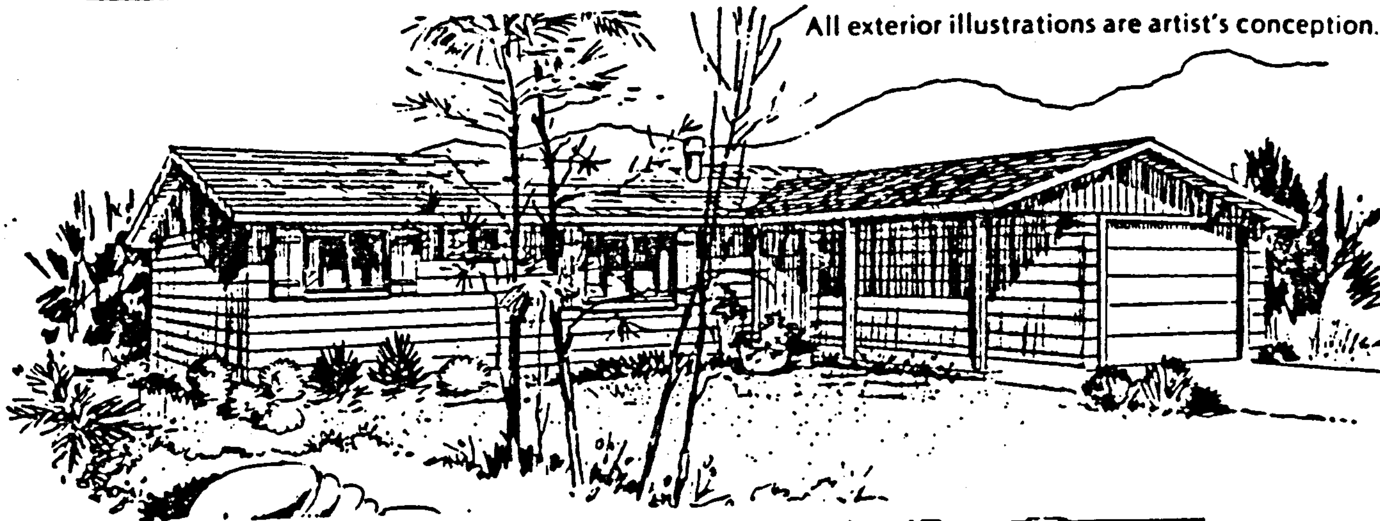
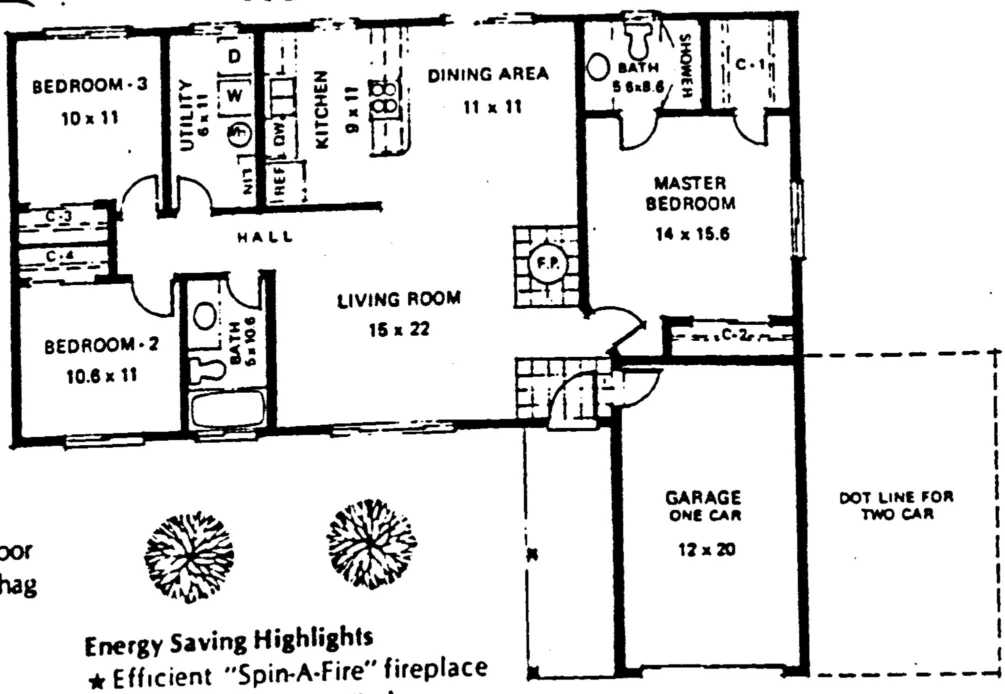
Plan 1250

All exterior illustrations are artist's conception.





Standard Features of Your New Home

General Highlights
- ★ 3 Bedroom
- ★ 2 Bath
- ★ Garage
- ★ Concrete driveway & patio
- ★ Ceramic entry & fireplace area
- ★ Ceramic over bathtub
- ★ Spacious utility room with tiled floor
- ★ Fully carpeted with sculptured shag
- ★ Shower with glass door

Kitchen Highlights
- ★ Built-in Range & Oven
- ★ Built-in Dishwasher & Disposal
- ★ Recessed Luminous Lighting
- ★ Kitchen Carpet
- ★ Formica Counter Tops
- ★ Stainless Steel Sink

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- ★ Efficient "Spin-A-Fire" fireplace
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Continuing a policy of constant research and improvement, we reserve the right of price, product, or design change [illegible]

PROGRAMMATIC ANALYSIS OF CURRENT BUILDER MODELS:

Two examples of local builder models are selected as typical. These models by the Neal Klein Construction Corp. are analyzed here in order to establish a basis for proposed new designs. Other options are available which include different features not illustrated by the two included. Most builders offer a selection of six to eight, or more, designs which are carefully selected. They offer as wide a variety of plan layouts as possible for prospective buyers.

Some 20-30% of the housing built in Prescott Valley is designed and built by do-it-yourselfers. They develop programs considerably different than these builder models in detail, although, the overall size is very similar. Proposed designs should attempt to offer something for this group as well.

1. The plan shapes are simple, clean, rectangles for economy reasons. The carport or garage is the only exception to this rule.

2. Living rooms-dining areas and kitchen are open spaces which flow together creating the illusion of larger spaces. Kitchens usually turn around a corner or are only half open to the dining-living space, thus creating an illusion of separation. These elements are usually located in the center of the plan and toward the street, or direction of exterior access, as they usually include the front entry.

3. Utility-storage-garage are to one side of the open living area while bedrooms and baths are clustered together and placed at the other side of the open living area. This usually results in the open living area becoming an open corridor or passage way. This is not altogether a good feature but is accepted in lieu of added cost for the separated passage.

4. No less than two bedrooms are included and usually not more than three bedrooms will be observed. One bathroom may be observed in the two bedroom models. The three bedroom models usually have two baths. In this case it is frequent that one bath will be exclusively associated with a master bedroom. Clothes closets are included with each bedroom which are adequate but not overly generous.

5. Kitchens include the expected appliances (sinks Dishwasher-Refrigerator-Cooking range and hood). Upper and lower cabinets for storage are adequate but not overly generous.

6. A utility room for clothes washing- storage- water heater and some work space is a frequent feature but is not always included.

7. A minimum of extra storage is provided for linens-coats etc. This is usually a weak feature.

8. A fireplace or other space heating device is observed more frequently now than in the past. This unit is quite apt to be of the closed opening controlled draft type for more efficient use of wood.

9. A garage for one or two cars will be included. The carport option is not built very often in Prescott Valley due to the more severe winter weather.

10. The total square footage of heated area is kept as compact and as low as possible as this one feature is the most important regarding cost.

11. The following are typical size allocations:

A.	Living room	290-330 sf
B.	Dining room	90-120 sf
C.	Kitchen	75-100 sf
D.	Master Bedroom	170-220 sf
E.	Bedroom 2	120-130 sf
F.	Bedroom 3	110-120 sf
G.	Baths	40- 60 sf
H.	Utility	70- 80 sf
I.	Garage	240-480 sf

The builder models with simple rectangular plan shapes are ideal for the purpose of minimizing the thermal heat load per square footage of floor area. They also are almost ideal in shape for solar exposure when they are oriented with the longer dimension facing south. This places bedrooms and garages to the east and west which are less favorable from a solar exposure point of view. The configuration then becomes a favorable feature, as bedrooms and garage can be cooler in winter and not suffer too badly. The real problem arises when this plan is turned 90° with the longer dimension facing east and west and the garage facing the solar south.

The open living- dining area is frequently the space that is left over when all other spaces have been included. This is a somewhat less than desirable feature.

Roofs are generally pitched with the gable across the short dimension. This is done so that trussed rafters can be used which are less expensive to construct and provide attic space for insulation and positive drainage of the roof exterior. Shingle roofs are also less expensive to build, and provide good life expectancy as well as low maintenance costs.

Batt insulated stud frame construction is used for walls, providing economy in construction as well as superior thermal resistance.

Exterior wall surfaces are generally treated wood or other similar siding which provides a neat appearance and are economical to construct.

SOLAR ANALYSIS OF CURRENT BUILDER MODELS

SOLAR ANALYSIS OF CURRENT BUILDER MODELS

THE TOTAL HEATING LOAD CALCULATED WITHOUT ANY SOUTH WINDOW AREA FOR SOLAR GAIN IS

1250 MODEL	- 116,000 BTU
1176 MODEL	- 122,000 BTU

SOLAR ANALYSIS :

1250 MODEL

$$BLC = \frac{116{,}000^{BTU}}{1250^{\square'}(32^{\circ})} = 2.9$$

$$LCR = \frac{1250^{\square'}(2.9)}{60^{\square'}_{COLLECTOR}} = 60.42 \quad \text{THEREFORE}$$

SOLAR FRACTION = 43 %

1176 MODEL

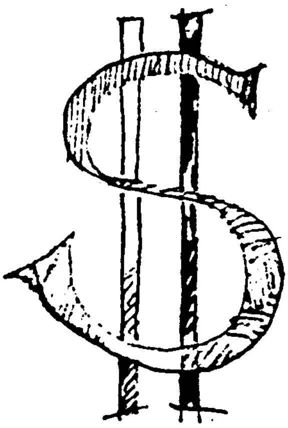
$$BLC = \frac{122{,}000^{BTU}}{1176^{\square'}(32^{\circ})} = 3.24$$

$$LCR = \frac{1176^{\square'}(3.24)}{54^{\square'}_{WINDOW}} = 70.6 \quad \text{THEREFORE}$$

SOLAR FRACTION = 41 %

FOR DETAILS OF SOLAR ANALYSIS PROCEDURES PLEASE CONSULT THE APPENDIX AND THE SECTION TITLED "SOLAR ANALYSIS OF PROPOSED DESIGNS" THESE TWO EXAMPLES ARE COMPUTED WITH ONE LONG DIMENSION FACING SOUTH.

ECONOMIC ANALYSIS
OF
CURRENT BUILDER
MODELS



The cost analysis used for these models is identical to that used for the proposed designs included in this project. All estimates are exclusive of land. See economic analysis of proposed designs for methods of cost estimating.

COST ESTIMATING PROGRAM BY KIP MERKER

BLDR MODEL 1176 COST ESTIMATE DATA MAY 10,1982

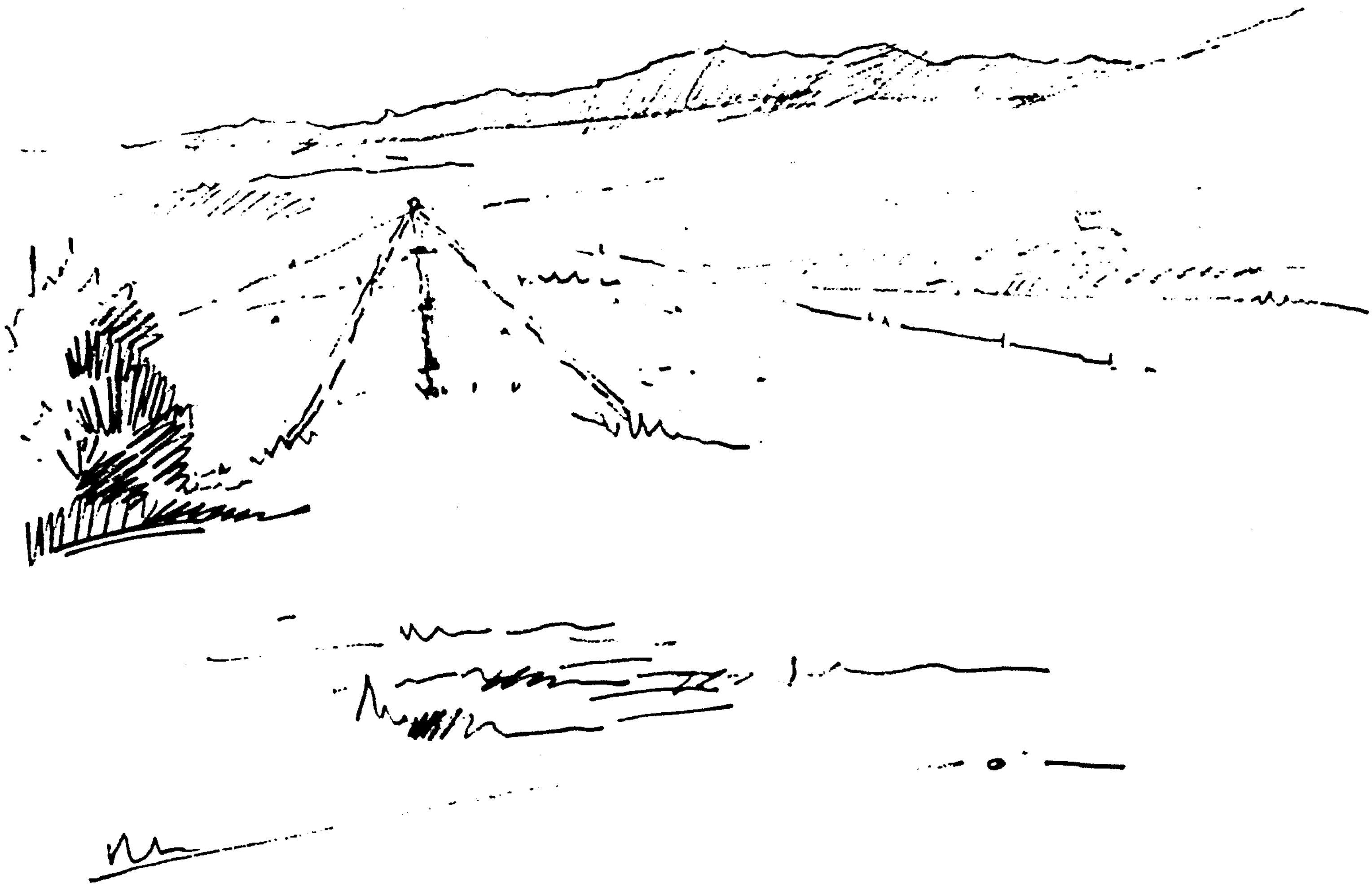
CATEGORY	UNIT COST	DIF NO	AREA	TOTAL COST
EXCAVATION	0.45	1	1200	540
FOUNDATION	0.8	2	1176	941
FRAME	0.44	1	1176	517
FLOOR STRUCTURE	2	2	1176	2352
FLOOR COVER	0	0	0	0
CARPET	1.55	2	1000	1550
VINYL SHEET	1.45	2	284	412
0	0	0	0	0
CEILINGS	0	0	0	0
ACOUSTIC DRYWALL	1	1	1176	1176
0	0	0	0	0
0	0	0	0	0
INTERIOR CONSTRUCTION	5.86	2	1176	6891
PLUMBING	2.13	2	1176	2505
SPRINKLERS	0	0	1176	0
HEATING-COOLING	1.29	2	1176	1517
ELECTRICAL	1.6	2	1176	1882
EXTERIOR WALL	0	0	0	0
6" STUD/WOOD SIDING	5.39	2	1392	7503
0	0	0	0	0
0	0	0	0	0
ROOF STRUCTURE	2.75	2	1542	4241
ROOF COVER	0.55	2	1542	848
0	0	0	0	0
GARAGE	16.92	1	300	5076
CL FACTOR = 1.17	37.76			44403
	COST/S.F.			TOTAL COST

COST ESTIMATING PROGRAM BY KIP MERKER

BLDR MODEL 1250 COST ESTIMATE DATA MAY 10,1982

CATEGORY	UNIT COST	DIF NO	AREA	TOTAL COST
EXCAVATION	0.45	1	1300	585
FOUNDATION	0.8	2	1250	1000
FRAME	0.44	1	1250	550
FLOOR STRUCTURE	2.2	2	1250	2750
FLOOR COVER	0	0	0	0
CARPET	1.55	2	1060	1643
VINYL SHEET	1.45	2	236	342
0	0	0	0	0
CEILINGS	0	0	0	0
ACOUSTIC DRYWALL	1	1	1250	1250
0	0	0	0	0
0	0	0	0	0
INTERIOR CONSTRUCTION	5.86	2	1250	7325
PLUMBING	2.13	2	1250	2663
SPRINKLERS	0	0	1250	0
HEATING-COOLING	1.29	2	1250	1613
ELECTRICAL	1.6	2	1250	2000
EXTERIOR WALL	0	0	0	0
6" STUD/WOOD SIDING	5.39	2	1404	7568
0	0	0	0	0
0	0	0	0	0
ROOF STRUCTURE	2.75	2	1772	4873
ROOF COVER	0.55	2	1772	975
0	0	0	0	0
GARAGE	16.92	1	336	5685
CL FACTOR = 1.17	38.21			47762
	COST/S.F.			TOTAL COST

PRECEPTS



PRECEPTS

A. Adopt a passive solar strategy for design.

B. There is a type of passive design best suited to each lot orientation.

C. Cooling is not required under these conditions.

D. Lot orientations are fixed and cannot be replanned.

E. The inherent nature and quality of the subdivision context dictates life styles and budget constraints within a narrow range. See builder models analysis.

F. The existing traditional exterior image of domicile should be reflected in the proposed designs.

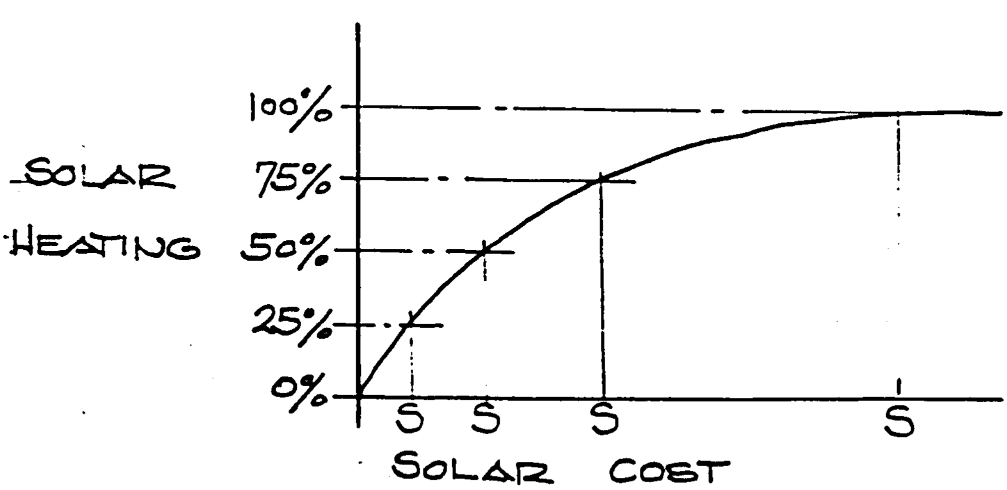
G. Plan shapes and configurations should be simple and compact, in order to meet budget restraints, to reduce heat losses and to stay within the buildable lot area.

H. Auto storage is in enclosed garage in order to meet winter conditions.

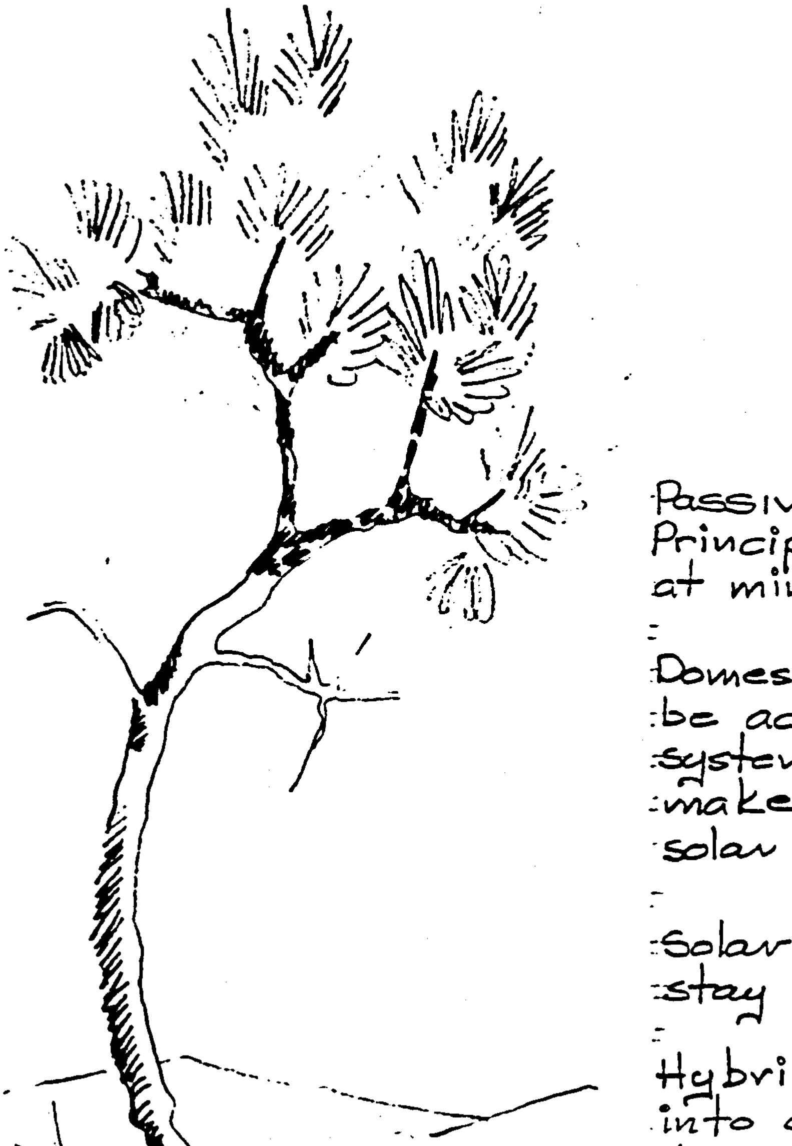
I. Roofs should be sloped in order to meet winter drainage and snow conditions.

J. Wood burning stoves (not Fireplaces) should be accomodated in the designs as backup for solar heating. Wood supplies in the area are plentiful and do not appear to be in danger of depletion.

K. Careful attention should be payed to the law of diminishing returns with regard to the percent of solar heating achieved versus the cost of attaining that percentage.



PROGRAMS
FOR
PROPOSED DESIGNS



Passive Solar Design Principles can be incorporated at minimal cost.

Domestic water heating can be achieved with active systems and simultaneously make maximum use of solar tax credits.

Solar tax credits will not stay in force much longer.

Hybrid solar systems come into conflict with the law of diminishing returns for this type of project.

PROGRAMS FOR PROPOSED DESIGNS:

This study will propose a family of solar heated designs which could be used by builders and do-it-yourself owners in Prescott Valley. This category requires that the designs be programmed to satisfy a certain budget range and that it incorporate a certain range of elements which the market will demand. The following is an enumeration of those certain basic requirements:

A. Budget or cost range for 1300 to 1600 sq. ft.

B. Due to existing zoning by the city of Prescott Valley there should be two general types, the single family residence and the duplex unit.

C. The designs should include the following space functions:

1.	Living area	270-360 sf
2.	Kitchen with storage & appliances	100-220 sf
3.	Dining area	112-180 sf
4.	Sleeping areas for 2-4 providing privacy and study-recreation	100-200 sf
5.	Bathrooms, 1 to 2	50-90 sf
6.	Clothes storage associated with bedrooms.	
7.	Utility for washer-dryer & mech.	35-80 sf
8.	Entrances with vestibule air lock.	minimal sf
9.	General storage areas.	maximize
10.	Wood burning space heating backup stoves.	
11.	Passive solar design - storage - distribution control.	
12.	Enclosed type of auto storage.	280-320 sf

D. Research and experience with the area indicates that this is a middle income class of clientele with quite traditional attitudes toward their domiciles. Exterior appearance and the major elements and symbolisms should not conflict with these traditional notions in any major way such as to elicit the reactions of "Farout", "Exotic", "Modern" or "Different". This notion has been noted and used in a successful solar subdivision in Columbus Ohio by Joe Kawecki of Kawecki Arch. Solartherm Builders when he expressed the point that "Most people who are serious about reducing energy consumption want to live in a home that looks like a typical home. It might have a little more glass, that's all. This is the market I think most architects are failing to communicate with. The house has to be subtle, and I think that's the hardest type of design - to mix solar in with good contemporary design". This attitude can also be seen in the Davis California Group.

The following examples of local builder models from Prescott Valley serve to illustrate the point.

E. Active solar heating systems are not considered as viable alternatives in this study because original investment costs are too high for this budget group. To attempt to use $10,000 out of a $60,000 budget for solar heating alone would not be accepted in the market place, not to mention the added cost of maintenance. The philosophy has to be that "The less equipment and the fewer gadgets, the less the cost, the fewer the breakdowns-repairs and maintenance costs."

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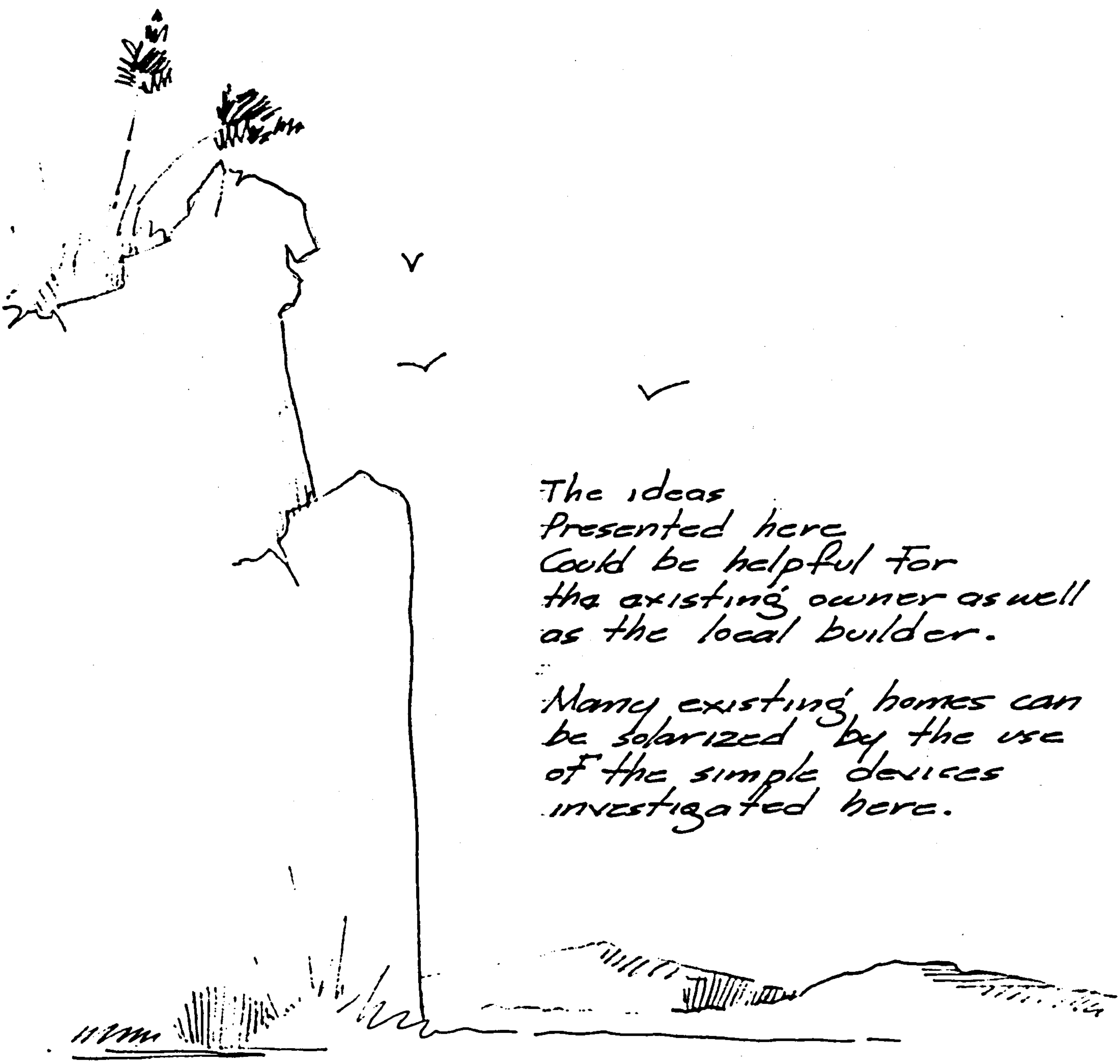
One change will be incorporated. Added insulation to provide an R-19 for walls, R-30 for roofs, which will add to the cost of construction of approximately $600. Double glazing of windows and the solar collector areas will add about an additional $600. The assumption, in this instance, is that $1200 will save $171 per year in the cost of electric fuel costs.

1.9×1400 sf $\times 4362$ D.D. $\div 3413$ = KWH/Yr saved

At $0.05 per kwh x 3399 = $170.00/Yr. saved. At this rate it would take seven years to pay for the $1200 cost.

As will be shown by this study this is a better investment than the solar improvements.

RETROFIT
PROPOSALS



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A.S. Merker

RETROFIT OF BUILDER DESIGNS 1176 & 1250

These retrofit designs illustrate what can be achieved by the addition of a solar porch and a clearview collector on the south side of an existing residence. Approximately 66% of the total annual heating load can be provided by these simple additions.

The solar porch provides added living spaces which can be used as a sitting area, as a space for plants, and as an air lock vestibule in winter. At least two windows or doors should be provided which will open to the exterior in order to present overheating in the fall and spring and on warm winter days. This space functions as a porch in summer when the glazing panels are removed or replaced by screens.

Control of heating is provided by the opening and closing of doors and windows to the house proper. The venetian blind in the clearview collector can be turned over (black side out for heating, and the white side out for no heating. See the details for this collector.)

A backup source of heating is suggested for the months of December-January-February to supply the remaining 34% of the annual heating load. Most of this 34% will be required during the three winter months mentioned above depending upon weather conditions. The methods of winter back-up heating are suggested as electric and wood burning stoves. Wood fuel is in plentiful supply in the Prescott National Forest.

These designs will not adapt to lots where street facings are to the East and West.

Plan shapes are simple compact rectangles. They expose the longer sides to the North and South, and the shorter sides to the less desirable East and West. These exposures have little or no solar gain in winter and too much gain in the summer. An attempt has been made to minimize the glass and wall areas to these exposures.

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EXCAVATION	0.45	1	1300	585
FOUNDATION	0.8	2	1284	1027
FRAME	0.44	1	1284	565
FLOOR STRUCTURE	2	2	1284	2568
FLOOR COVER	0	0	0	0
CARPET	1.55	2	1000	1550
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CEILINGS	0	0	0	0
ACOUSTIC DRYWALL	1	1	1284	1284
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INTERIOR CONSTRUCTION	5.86	2	1284	7524
PLUMBING	2.13	2	1284	2735
SPRINKLERS	0	0	1284	0
HEATING-COOLING	1.29	2	1284	1656
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EXTERIOR WALL	0	0	0	0
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0	0	0	0	0
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GARAGE	16.92	1	300	5076
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	COST/S.F.			TOTAL COST

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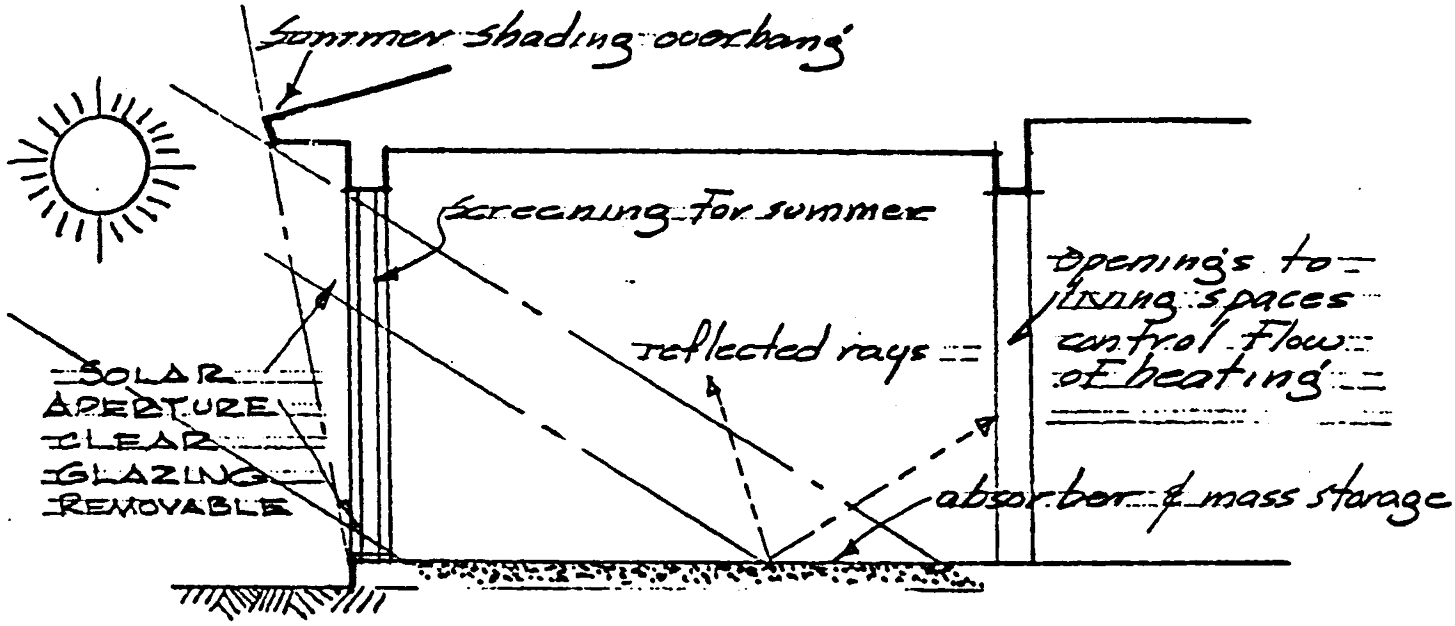

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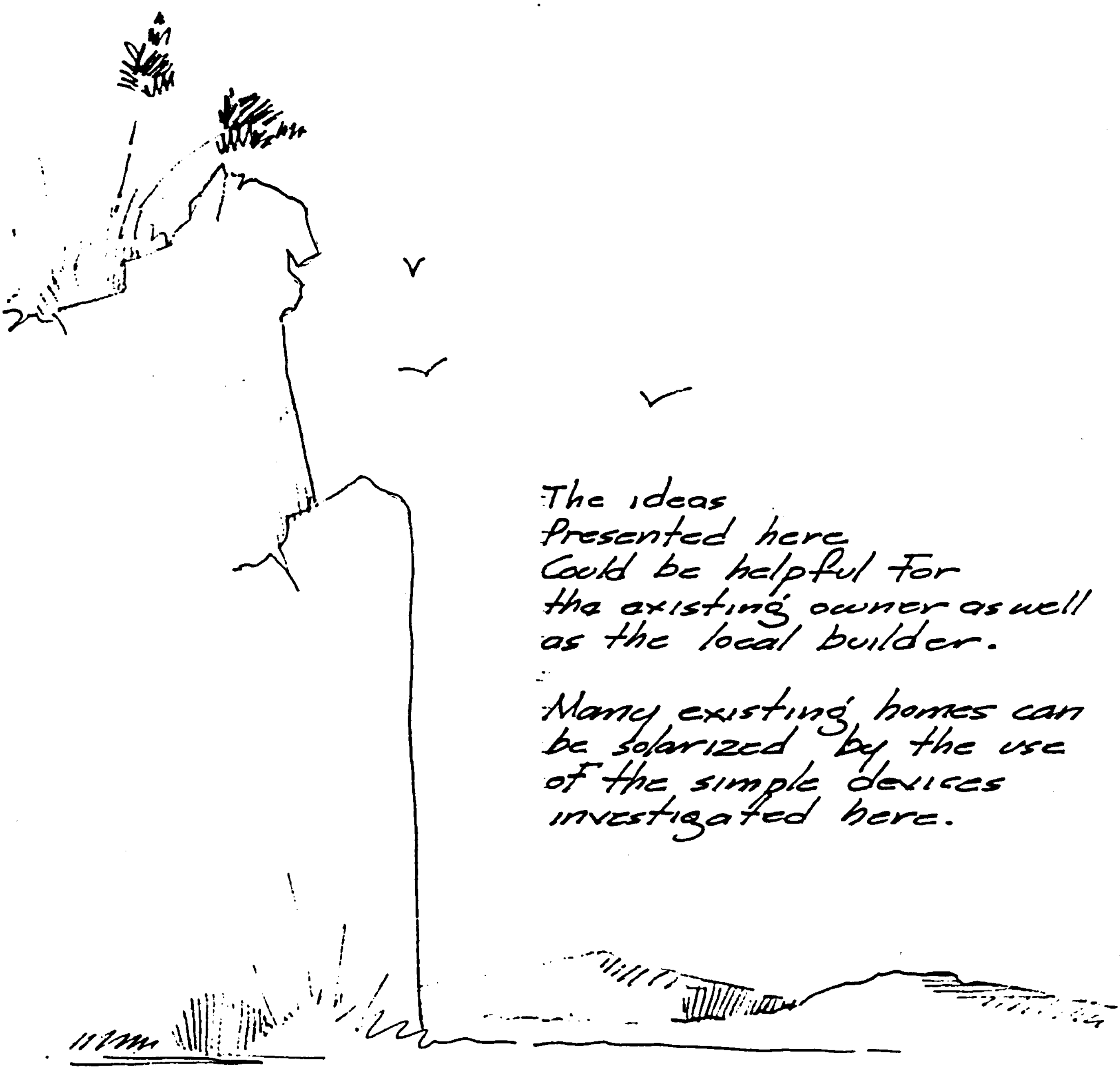

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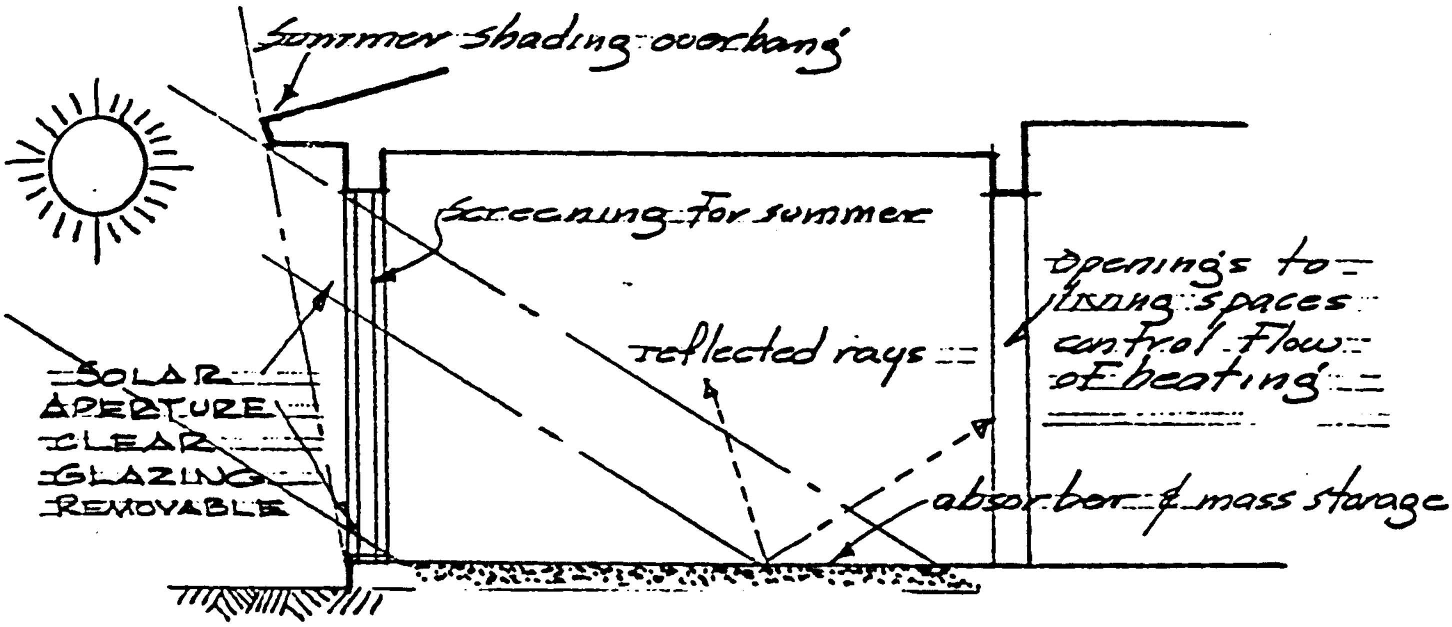

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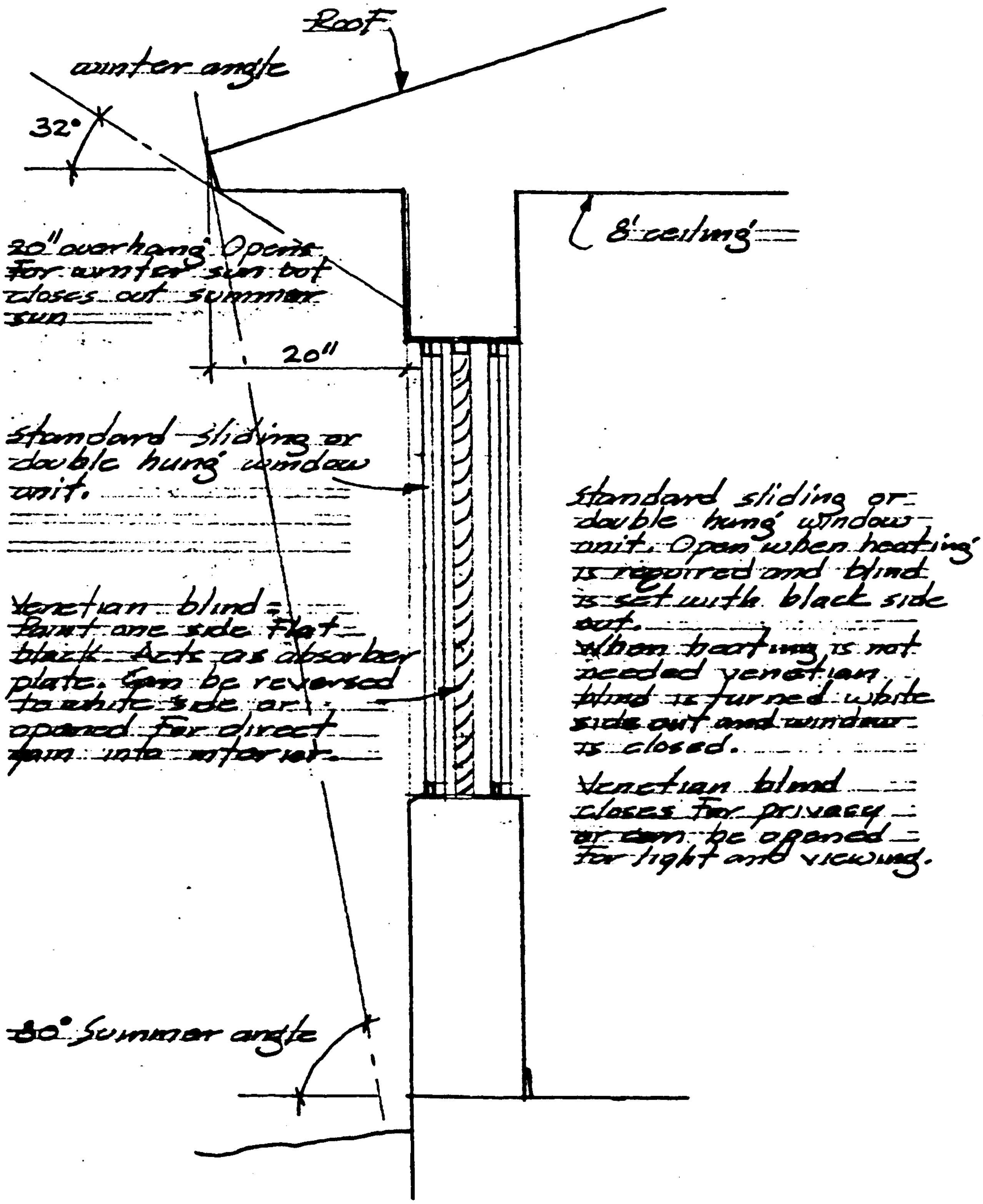
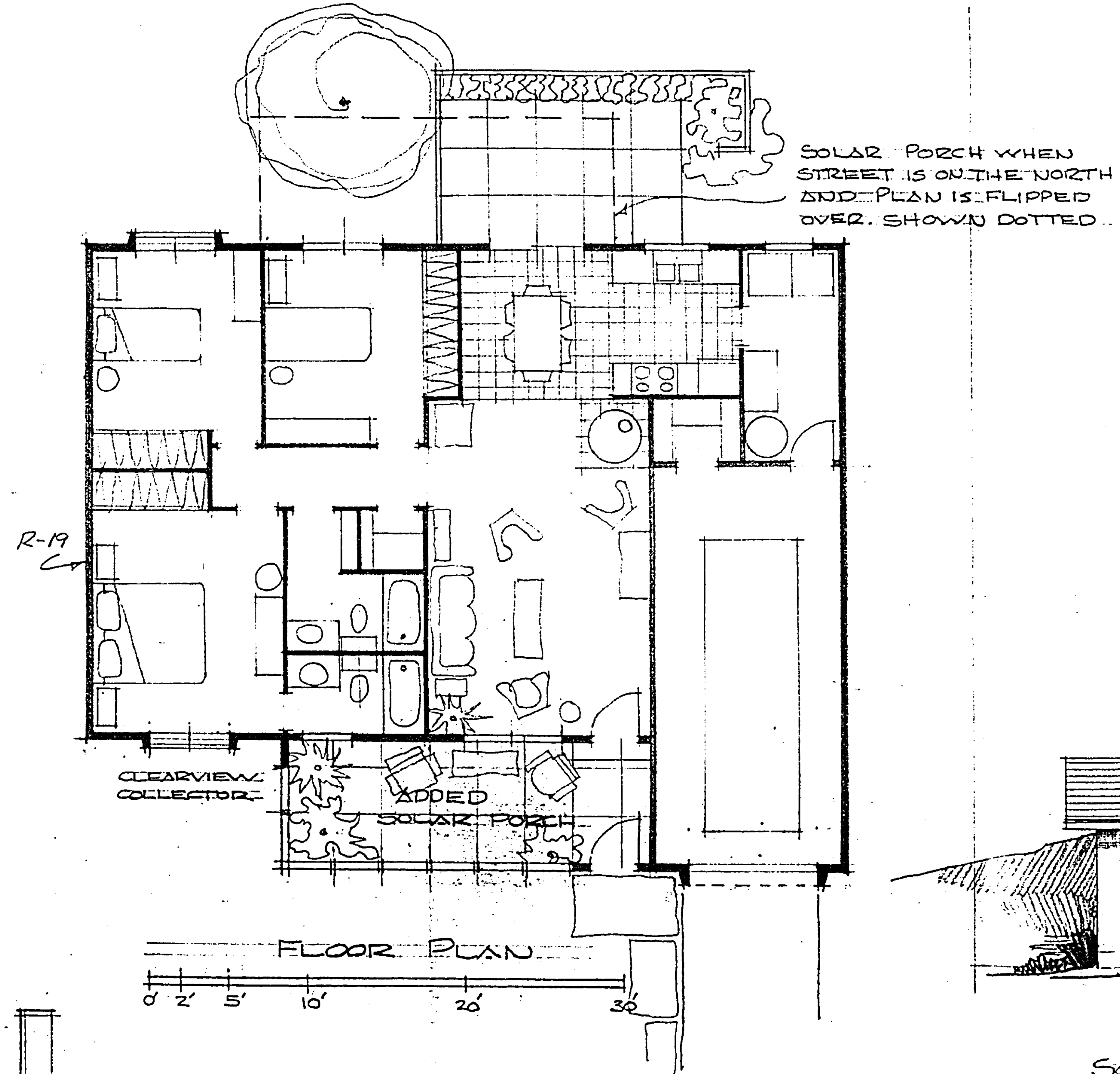


A CLEARVIEW COLLECTOR

PRESCOTT VALLEY

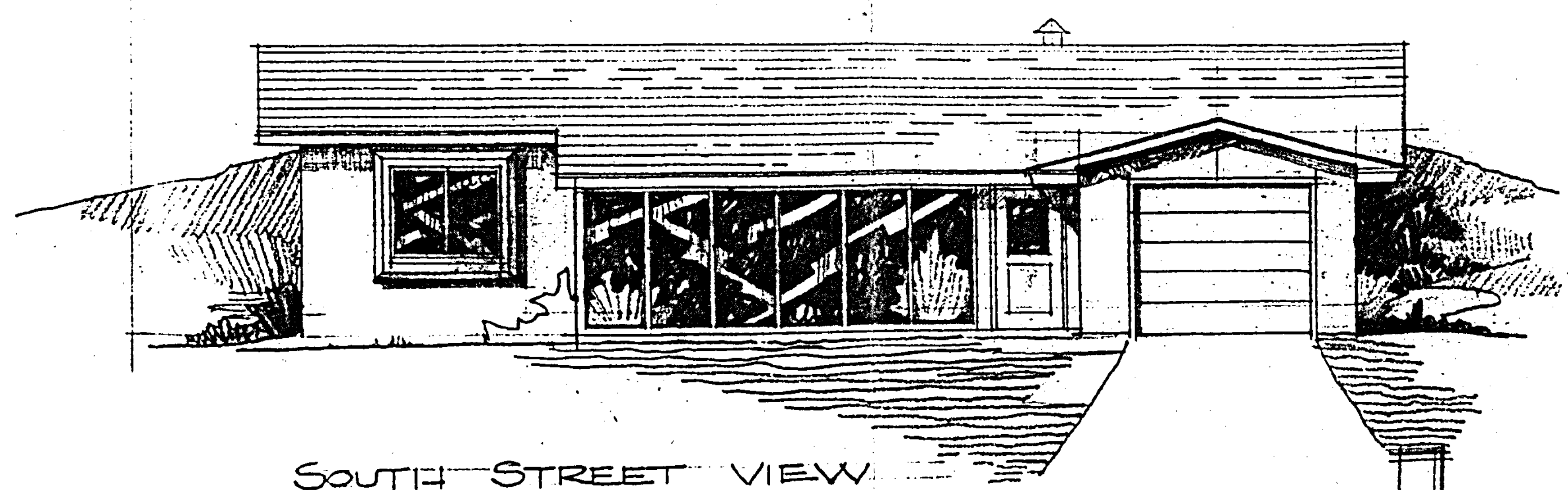
A.S. MERKER



HEATED FLOOR AREA 1284 SF
SOLAR PORCH AREA 184 SF
COLLECTOR AREA 156 SF
SOLAR PORCH 136 SF
CLEARVIEW COLL 20 SF
TOTAL COLL. A. 156 SF

$LCR = \frac{1284\ (3.0)}{156} = 24.5\ \%$

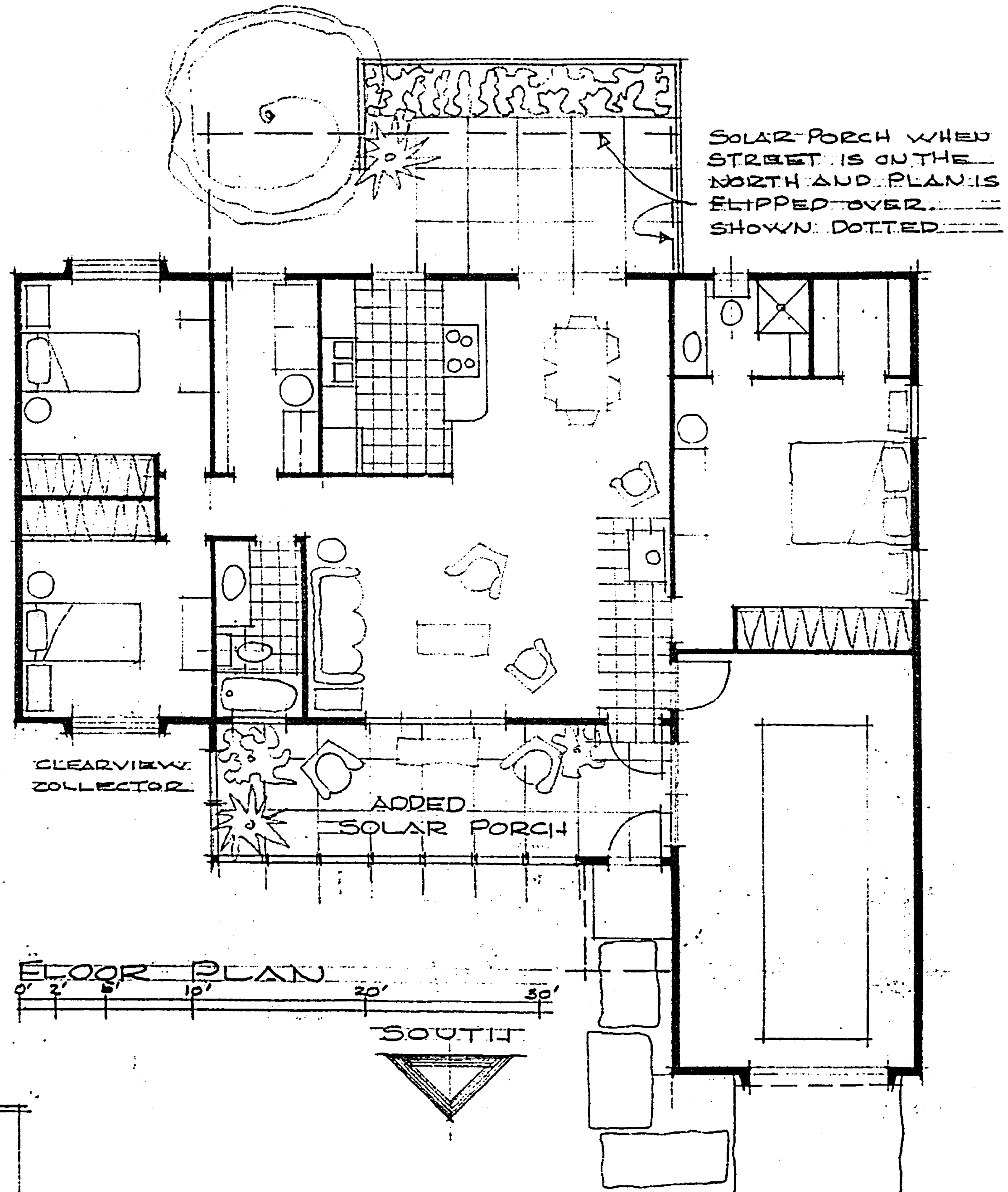
PERCENT SOLAR = 66%



BUILDER DESIGN SOLAR RETROFIT 1176

PRESCOTT VALLEY

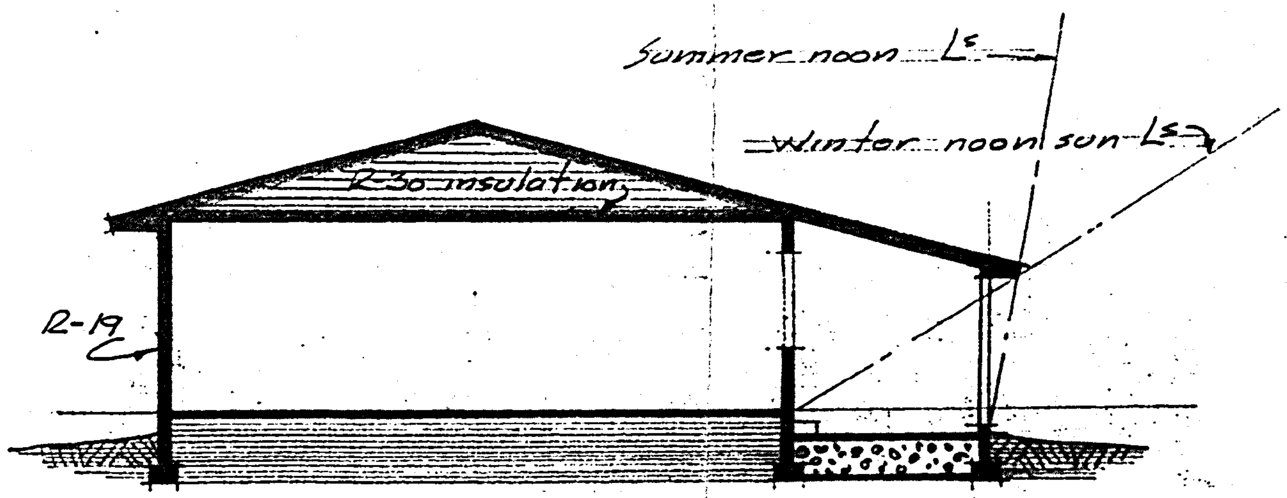
A.S. MERKER



HEATED FLOOR AREA		1296 SF
SOLAR PORCH AREA		197 SF
COLLECTOR AREA 8 * 2.67' * 6.2'	PORCH	132 SF
	CLEARVIEW COLL.	20 SF
	TOTAL COLLECTOR AREA	152 SF

$$LCR = \frac{1296(2.8)}{152} = 24$$

PERCENT SOLAR = 66%



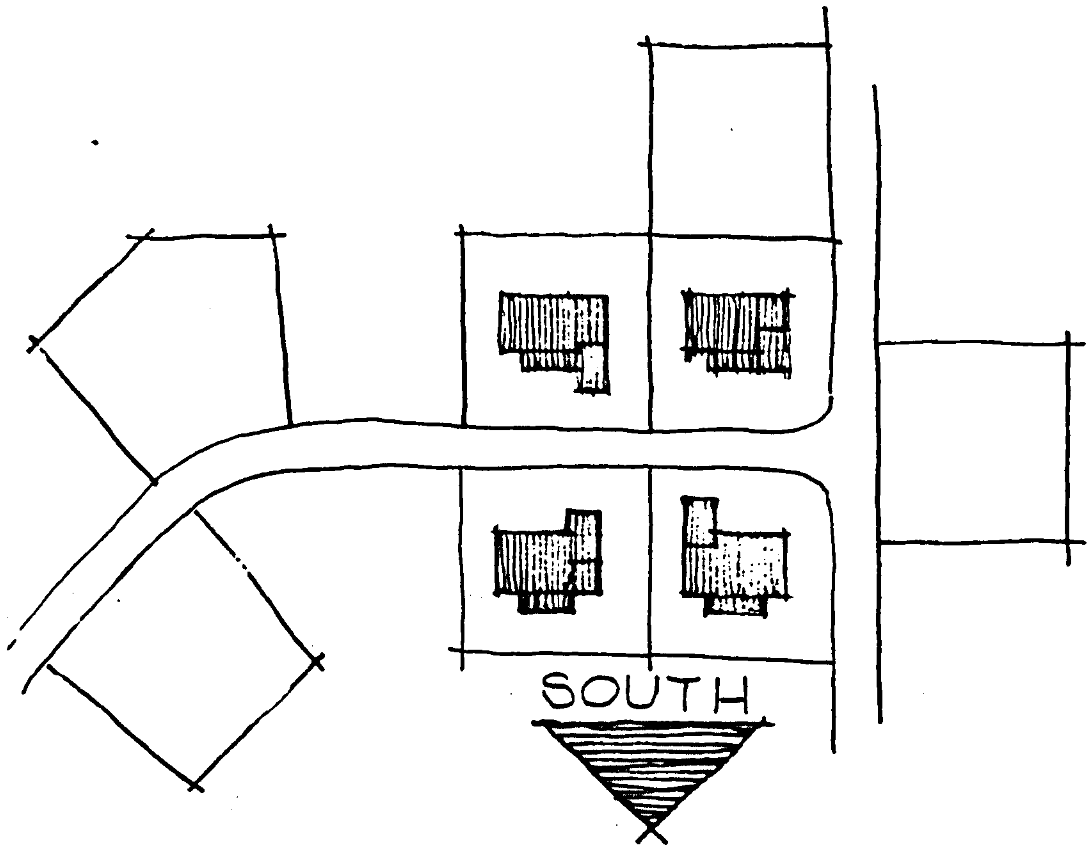
SECTION VIEW

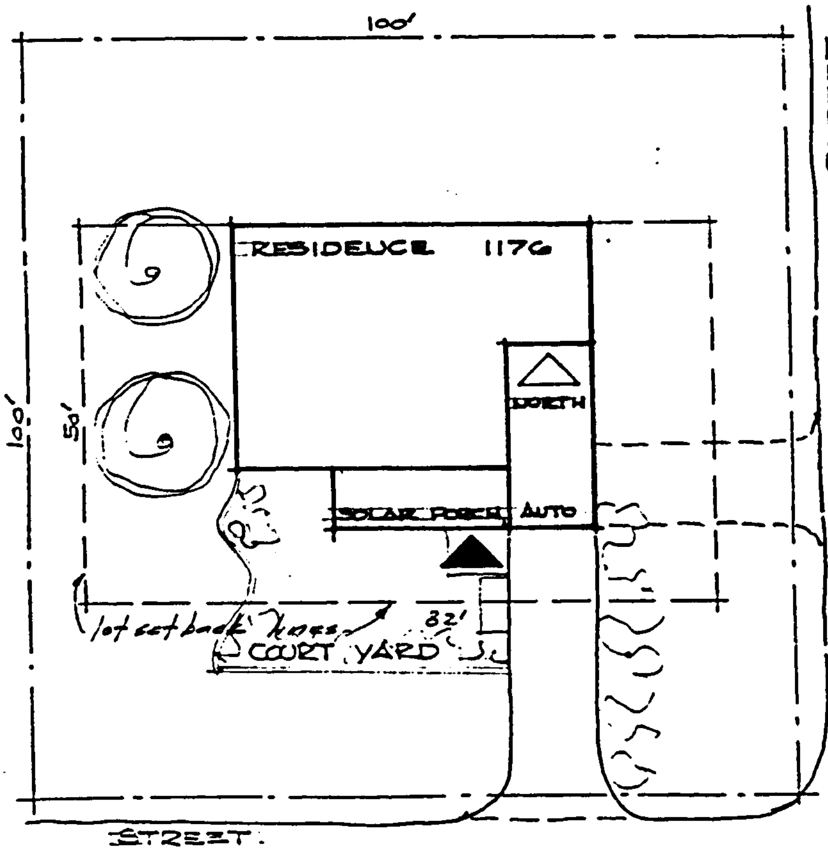
BUILDER DESIGN SOLAR RETROFIT 1250

A.S.Merker

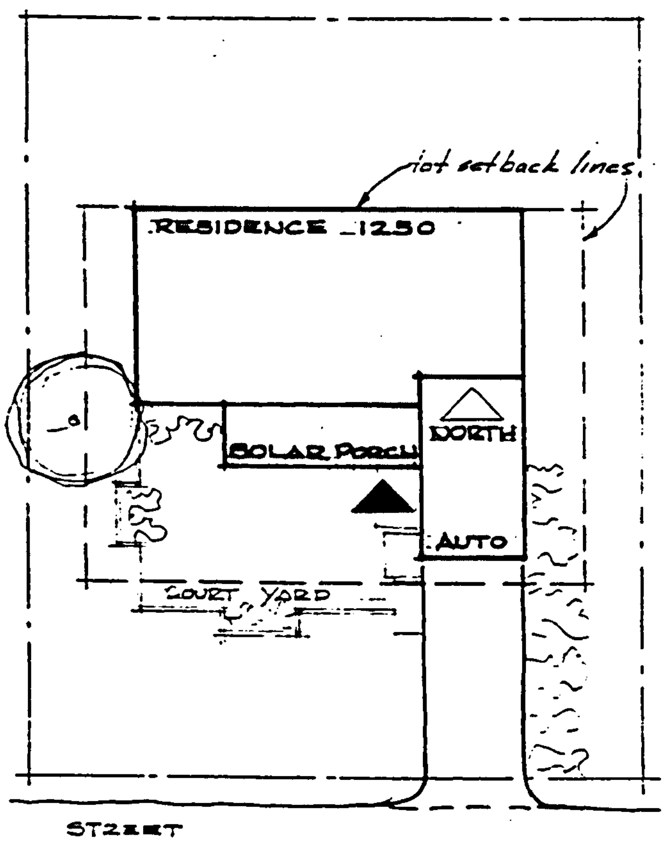
RETROFIT SITING POSSIBILITIES:

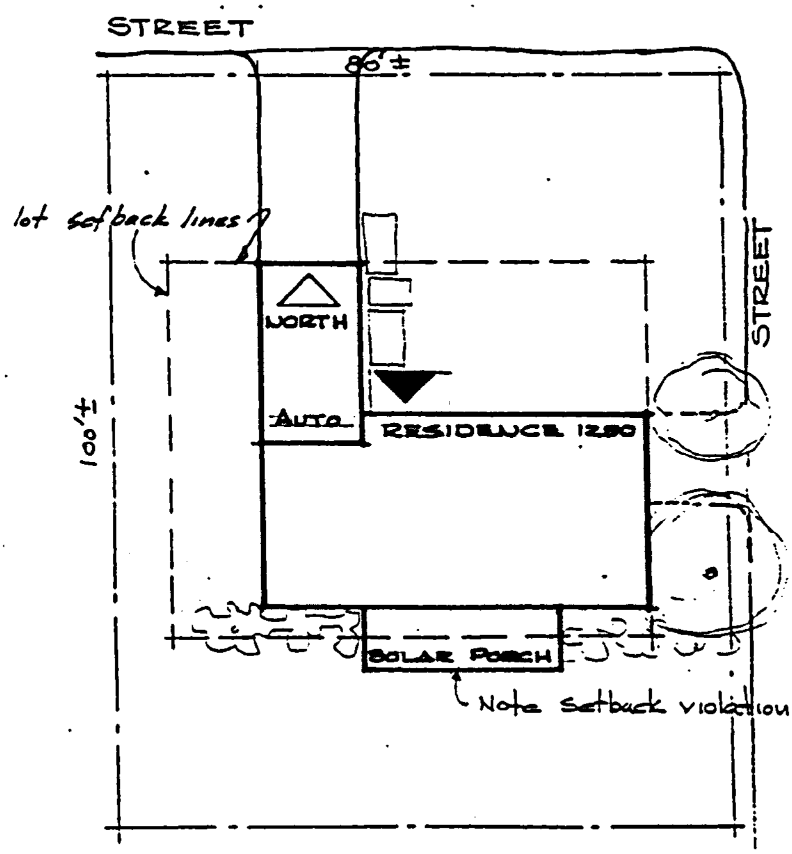
The following siting diagrams serve to illustrate in more detail how the problems of siting can be handled.



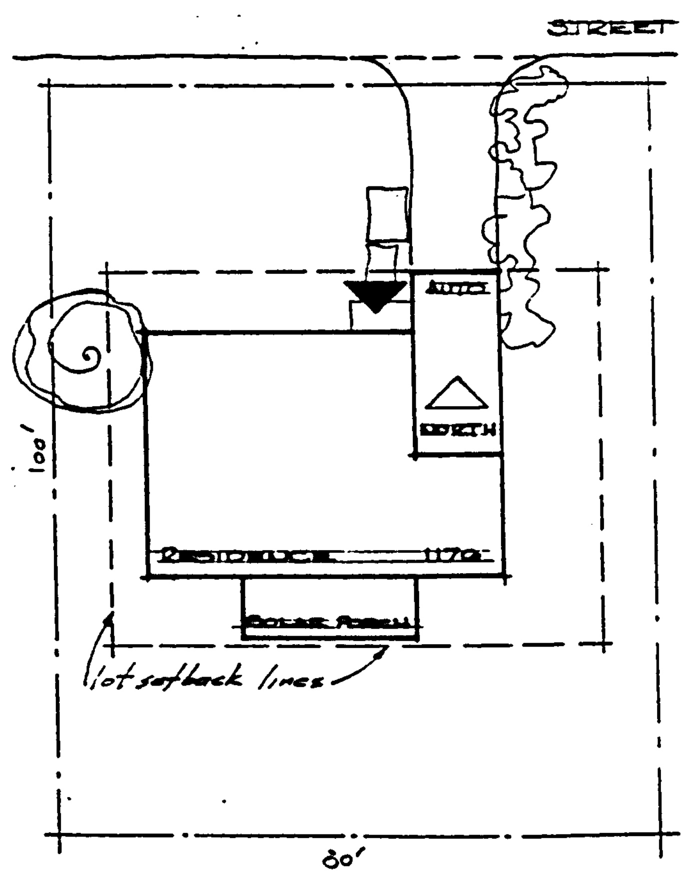


These examples illustrate the condition where the street is on the south side of a lot. Locating the house as far to the north setback line allows for the development of a court yard around the solar porch. Shading by the garage is not a serious problem as the sun rises to the south during heating season and is not effective before 10:00 A.M. in any event.





The two examples here illustrate the condition where the street is on the north side of the lot. This places the solar porch on the rear of the house. The city of Prescott Valley could arrange to allow some setback line exceptions which would allow much more extensive solar adaptations.



CLEARVIEW CLERESTORY DESIGN

The clearview collector system provides a maximum of heating control at least cost.

CLEARVIEW - CLERESTORY DESIGN

A new element is introduced into the design, the clerestory. The purpose is to place solar radiation area and direct solar gain to the rear elements of the floor plan. The validity of the reasoning for placing collection area directly where needed may be somewhat questionable. The gravity flow principle would eventually distribute heat to this area without the clerestory. This would, however, require more time to accomplish. Americans have become so used to instantaneous response systems with automatic thermostat control that an adaptation to natural functioning solar systems may well require some time.

The somewhat larger floor plan area provides more livability and grace at a somewhat increased cost. This is in comparison to the builder models analyzed earlier in this study.

The 62% annual solar fraction comes at a relatively low cost of 5% of the total budget. This compares favorably with the Trombe Wall Design which will be presented later in this study.

The clearview collector introduces a new dimension in control into passive solar heating design. This is most important, as the one real problem with most passive heating systems becomes one of how to control overheating when the design has been sized for the worst average condition during winter. The venetian blind incorporated into the clearview collector provides this control by allowing the resident to open or close the collector as heating is required. The collector area can now be oversized somewhat in order to provide sufficient heat for a cold winter day. If this amount of heat is not required on another warm fall day, it is a simple matter to close the collector down.

Another advantage to the clearview is that ultraviolet degredation can be minimized while still collecting heat. This collector can be hybridized by adding small fans to force flow the collector; or the system can be allowed to operate on gravity flow.

The floor plan places elements needing less heating to the north side such as bedrooms and bath. The living areas on the south begin to heat up during the morning hours when they come into use by the occupants. Bedrooms have heated up during the day and are comfortable during the hours of use before retiring at night.

The solar porch provides additional heat which can be opened or closed, as needed during the day. An air lock vestibule is provided in this porch which helps considerably during cold winter periods to reduce the heat loss of the building.

The garage on the east or west helps to shield the house from the less favorable exposures. The lack of windows to the east or west also helps in this respect and is an added advantage in subdivision areas where side lot setbacks are small and privacy from neighbors is minimal.

The collector areas are not so large as to cause problems with a conventional appearance. Most people would not suspect that this was a solar house.

The first attempt at this design included rockbed storage with ducts and fans. This was found to have run into the law of diminishing returns as to the small additional annual solar fraction increase, compared to the cost of the storage. When removed this design became one of the most efficient of the group in this study.

The garage was planned in such a way as to be easily converted to additional living space at some future date.

CLEARVIEW - CLERESTORY DESIGN

SOME SUBJECTIVE THOUGHTS CONCERNING LIFESTYLE:

Changes in lifestyle in this case should be minimal and will revolve around the clearview collector and clerestory.

The clerestory will increase light levels in the bedroom-bath-corridor areas of this design. This increase in light levels during daytime hours could be exciting and exhilerating for some individuals or threatening for others. This is a variable response depending upon the individual psyche.

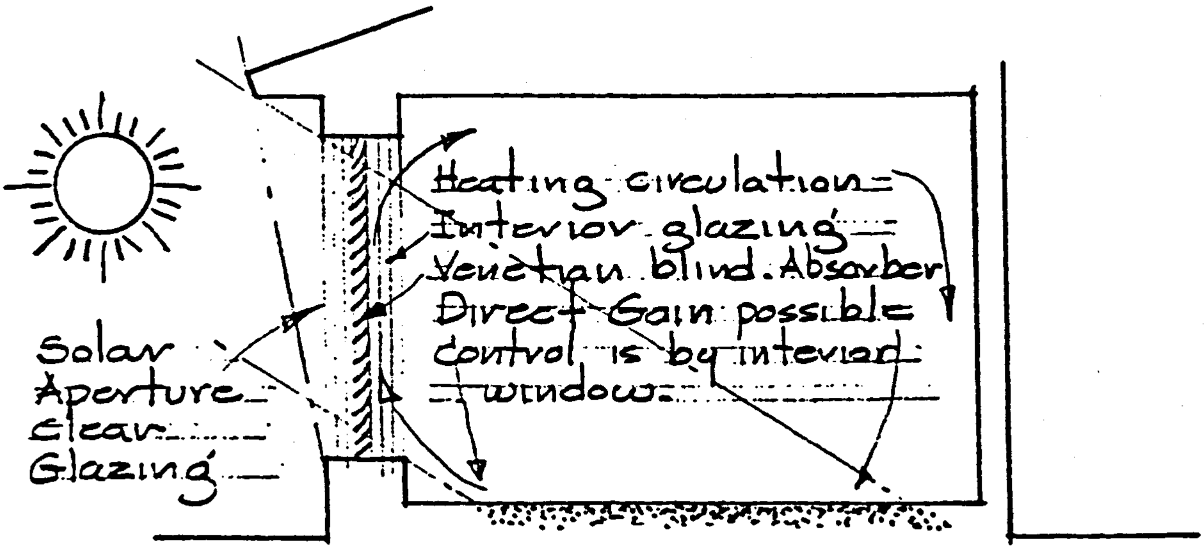
The clearview collector should be received much the same as a conventional window with venetian-blind. That the venetian blind is down and closed during periods of heat collection should provide the occupant with a sense of protection from exterior visual intrusion. For those who close drapes on windows for privacy these would be a welcome characteristic.

That heat can be collected by direct gain if the venetian blind is raised, should be a welcome variation for those who like to look to the outside and who do not have a great concern for privacy.

The most noticeable difference upon lifestyle from this design could well be that more frequent adjustment of the collector would be necessary if the maximum heat gain is to be achieved. For those who like to tinker with a new toy this could be fun.

That the fun wears off and the tinkering ends, could cause some degree of inefficiency of operation to develop. The result would be that the automatic backup heating system would be called upon to supply an increased percentage of the heat loss.

A.S. Merker



CLEARVIEW... COLLECTOR.

COLLECTOR efficiency is high. Double glazing stops heat losses and makes night insulation unnecessary. Venetian blind absorber allows direct gain and glare control. Convection allows distribution and control.

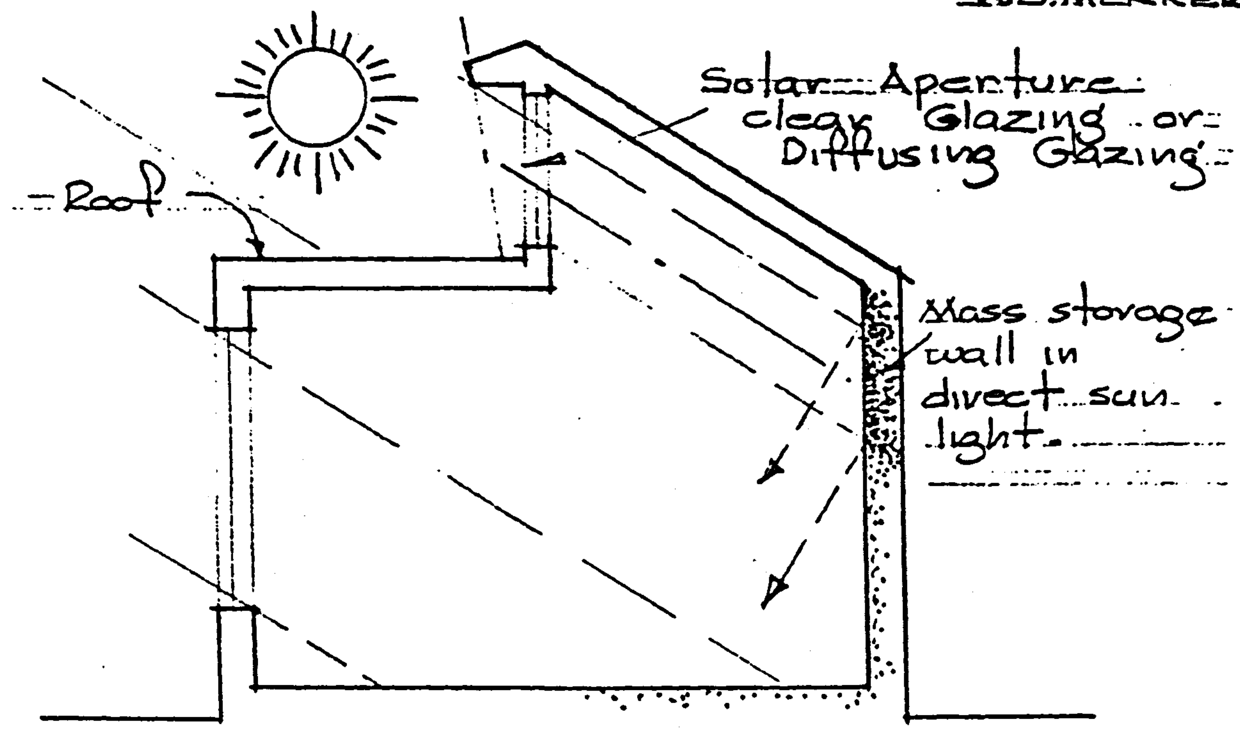
STORAGE Excess heat can be ducted to storage or allowed to pass through living space. Storage costs increase, as well as comfort levels and cloudy day carryover.

DISTRIBUTION is improved by convective flow and/or by small forced draft fans. Multiple modes of operation are possible to control comfort level. Evaporative cooling can be used exhausting through the collector.

CONTROL is multiple and for a passive system is good. Venetian blind absorber is adjustable for heat collection as well as glare control.

ADVANTAGES Improved control and distribution. Glare control is important. A more conventional appearance interior and exterior. Cooling option is desirable. Ventilation through collector is possible.

DISADVANTAGES Required collector access.



DIRECT GAIN CLERESTORIES

COLLECTOR Collection efficiency is high as little radiation is lost back out through the collector. Collection efficiency can be increased up to 100% by adding a reflector on the lower roof surface, equal in size, or larger than the solar apertuee. Use clear glazing for water storage and diffused glazing for masonry storage.

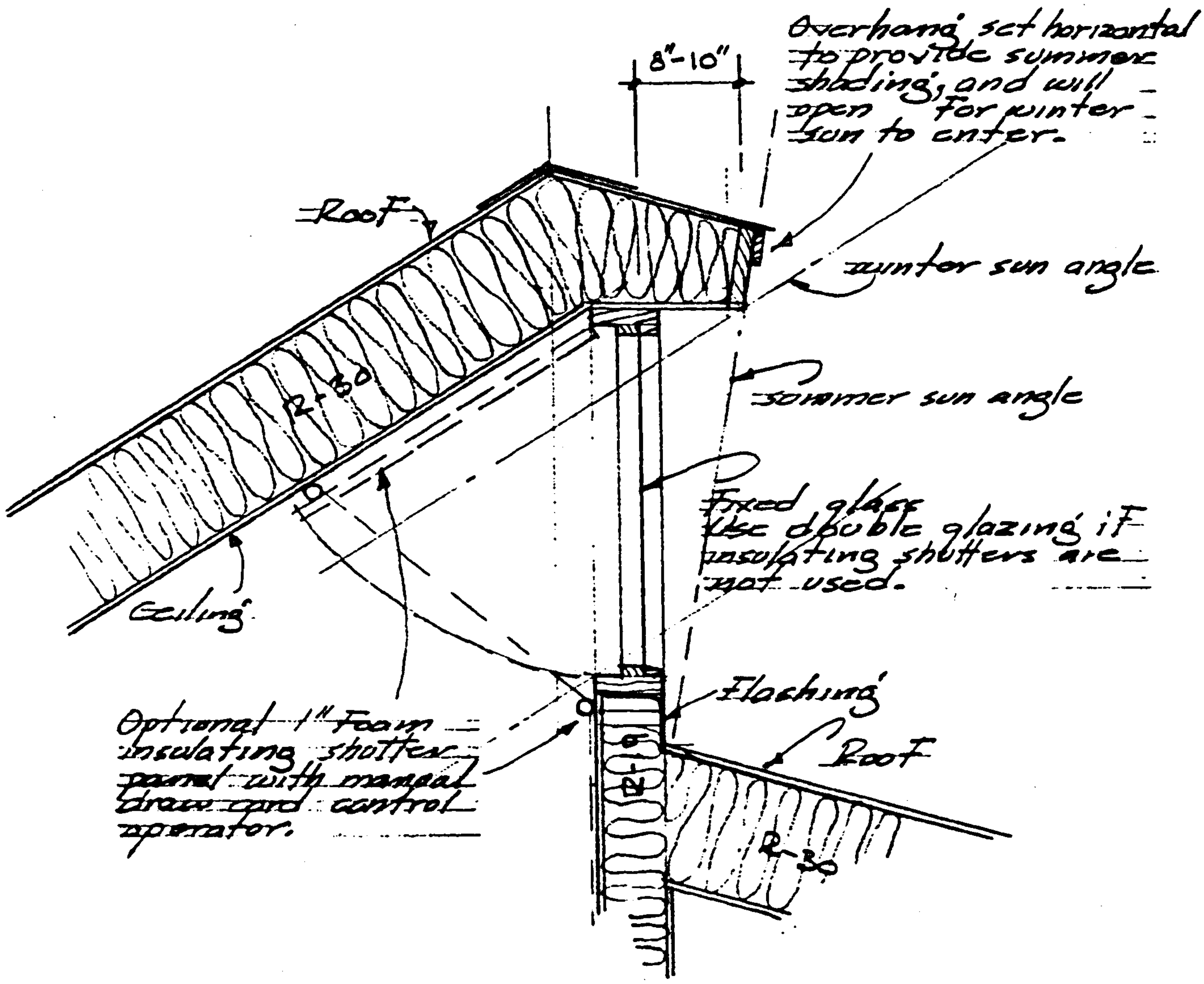
STORAGE Provide masonry storage 3 sq.ft. for each one sq.ft. of solar aperture and increase proportionately for reflectors. Colors should be dark for heat absorbing areas. Paint ceilings white to reflect rays.

DISTRIBUTION is passive to all interior areas.

CONTROL is minimal requiring careful sizing to prevent over- underheating.

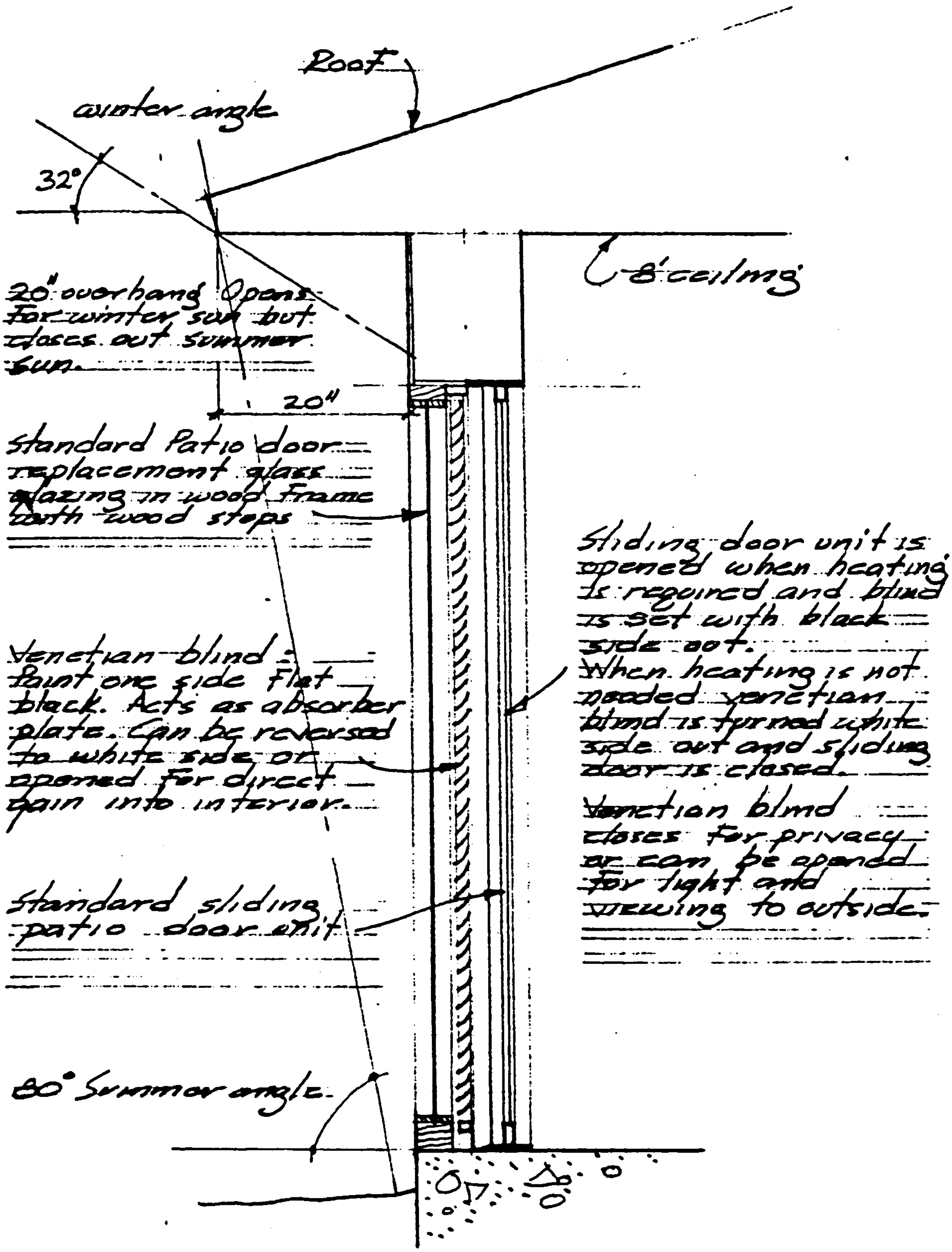
ADVANTAGES Simple construction, a relative low cost factor. Provides natural lighting. Provides heat to areas along the north side of a house, thus helping in distibution. Diffusing glazing would scatter rays and aid in heat distribution.

DISADVANTAGES Summer shading must be provided.



• CLERESTORY DETAIL •

A.S. MERKER



A SIMPLE CLEARVIEW COLLECTOR

COST ESTIMATING PROGRAM BY KIP MERKER

CLEARVIEW-CLERESTORY COST ESTIMATE DATA MAY 10,1982

CATEGORY	UNIT COST	DIF NO	AREA	TOTAL COST
EXCAVATION	0.45	1	1500	675
FOUNDATION	0.8	2	1487	1190
FRAME	0.44	1	1487	654
FLOOR STRUCTURE	2	2	1487	2974
FLOOR COVER	0	0	0	0
CARPET	1.55	2	1180	1829
VINYL SHEET	1.45	2	307	445
0	0	0	0	0
CEILINGS	0	0	0	0
ACOUSTIC DRYWALL	1	1	1487	1487
CLERESTORY	10.5	2	43	452
0	0	0	0	0
INTERIOR CONSTRUCTION	5.86	2	1487	8714
PLUMBING	2.13	2	1487	3167
SPRINKLERS	0	0	1487	0
HEATING-COOLING	1.29	2	1487	1918
ELECTRICAL	1.6	2	1487	2379
EXTERIOR WALL	0	0	0	0
6" STUD/WOOD SIDING	5.39	2	1312	7072
0	0	0	0	0
0	0	0	0	0
ROOF STRUCTURE	2.75	2	1957	5382
ROOF COVER	0.55	2	1957	1076
SOLAR PORCH	16.28	1	102	1661
GARAGE	16.92	1	375	6345
CL FACTOR = 1.17	37.31			55481
	COST/S.F.			TOTAL COST

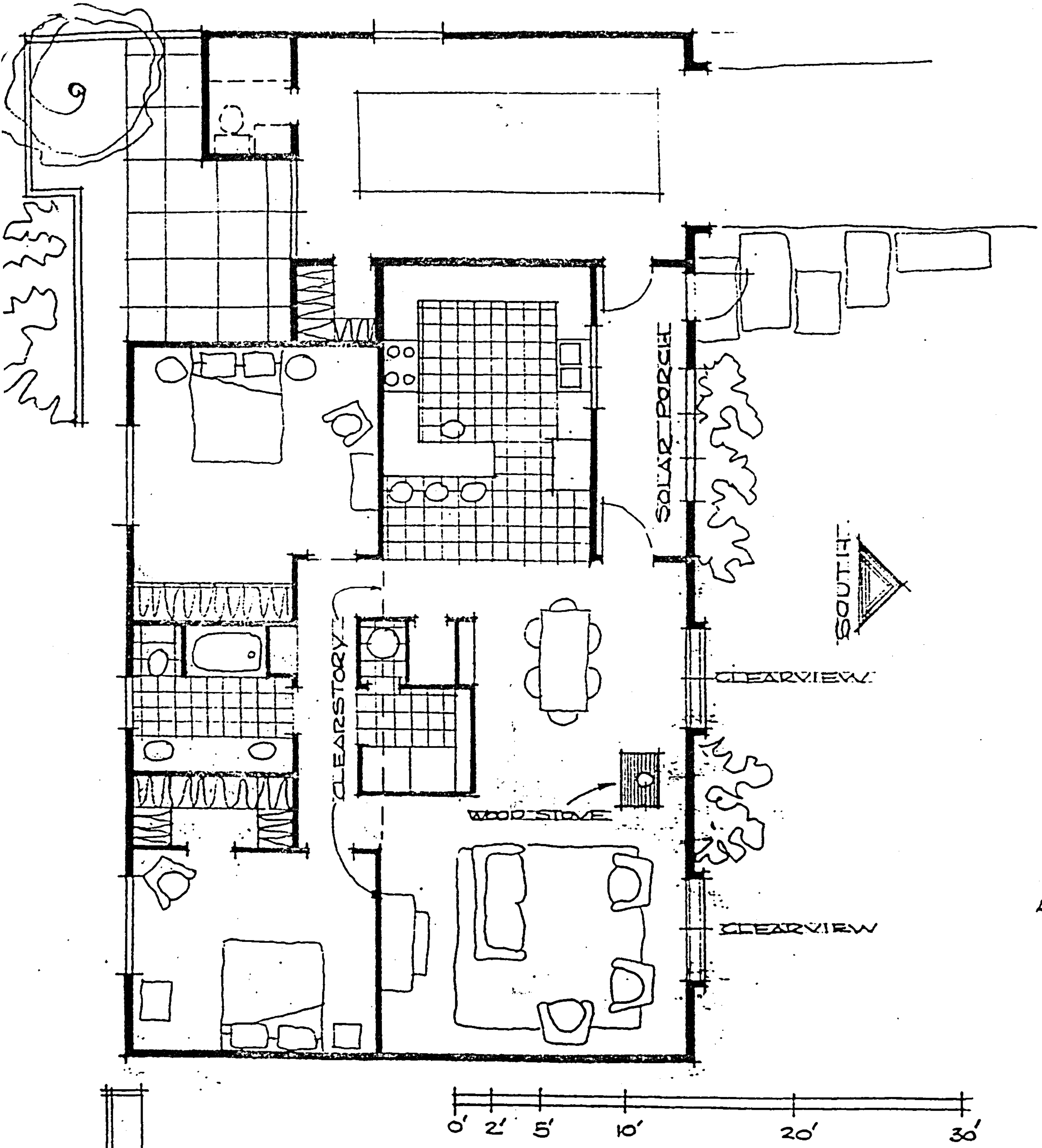
PRESCOTT VALLEY

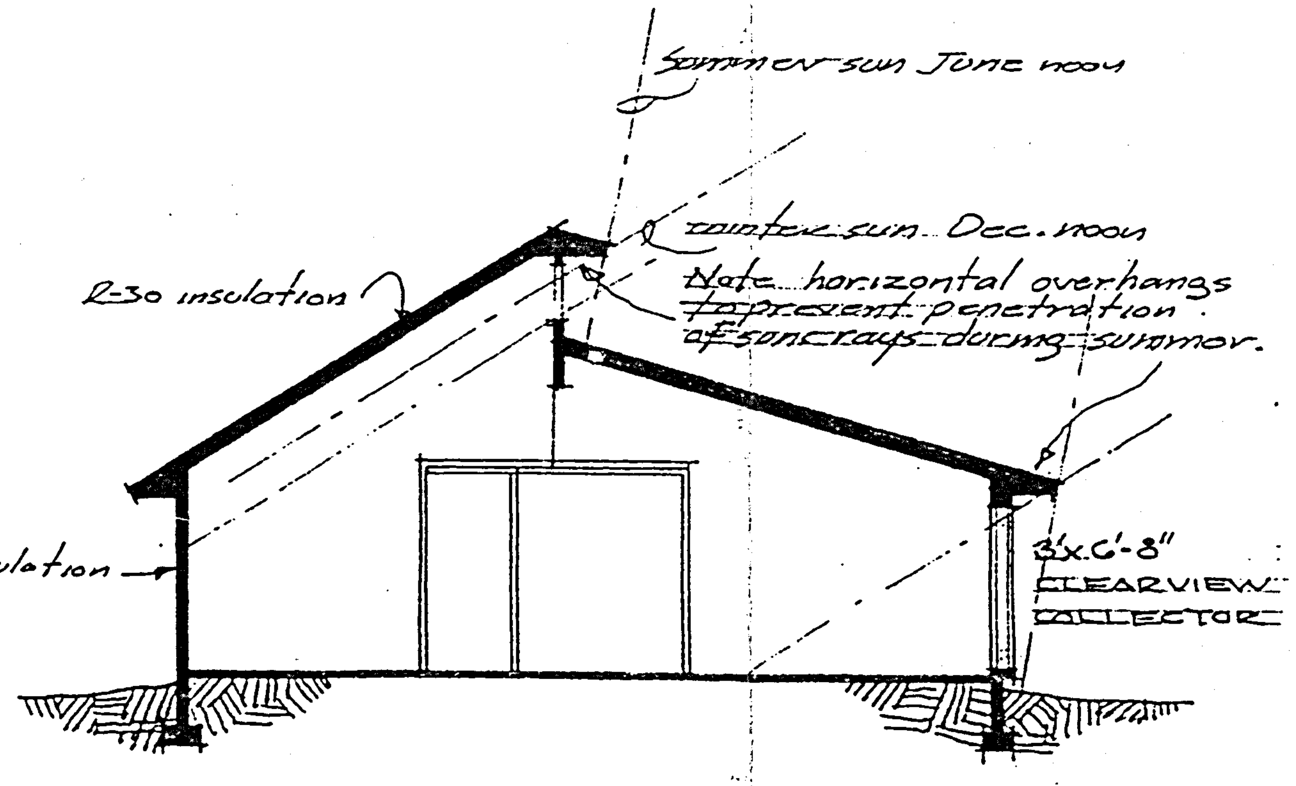
A.S. MERKER

HEATED AREA		1487 SF
COLLECTOR AREA		182 SF
Clerestory	78 SF	
Clearviews	68 SF	
Solar Porch	36 SF Extra	

$$LCR = \frac{1487(3.6)}{182} = 29$$

SOLAR FRACTION = 62%



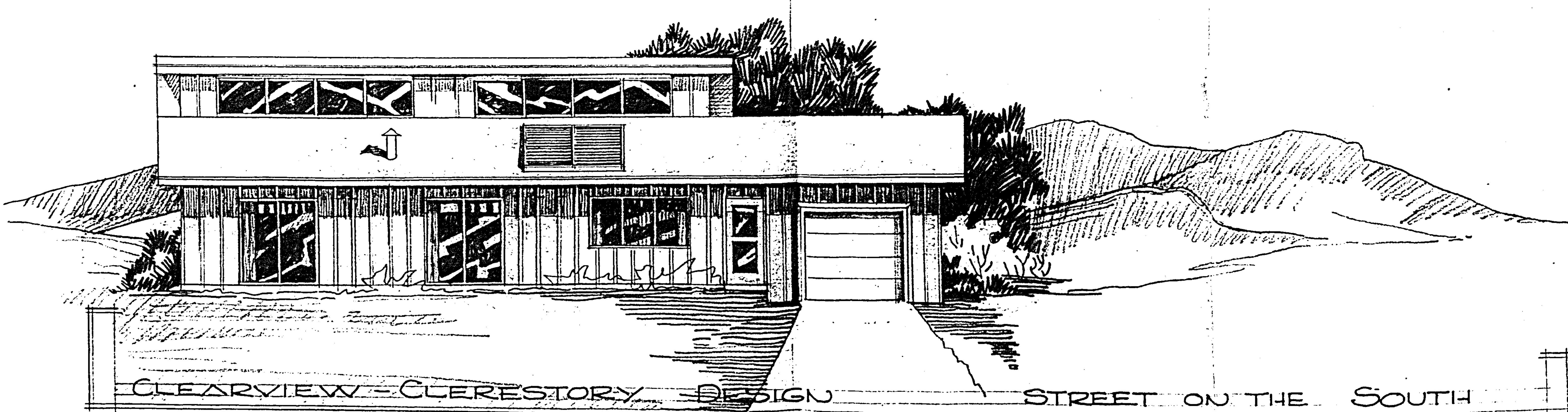


SECTION VIEW

CLEARVIEW - CLERESTORY DESIGN

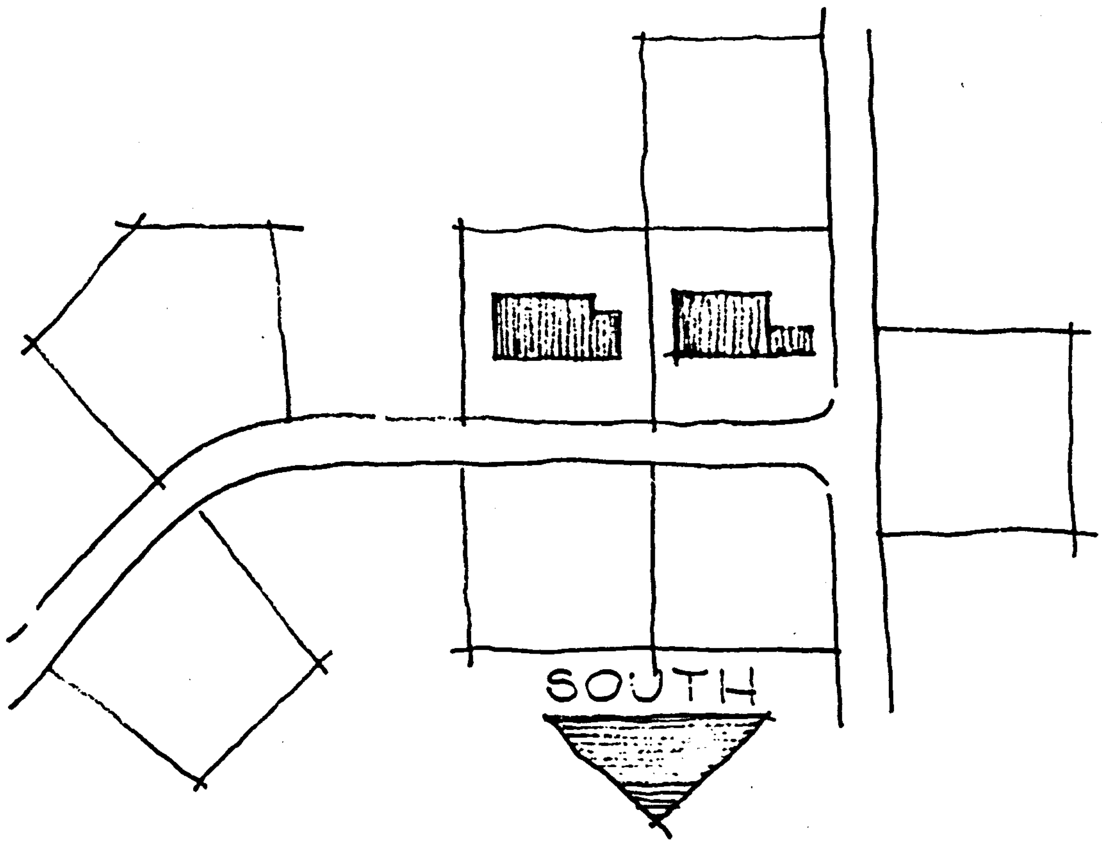
PRESCOTT VALLEY

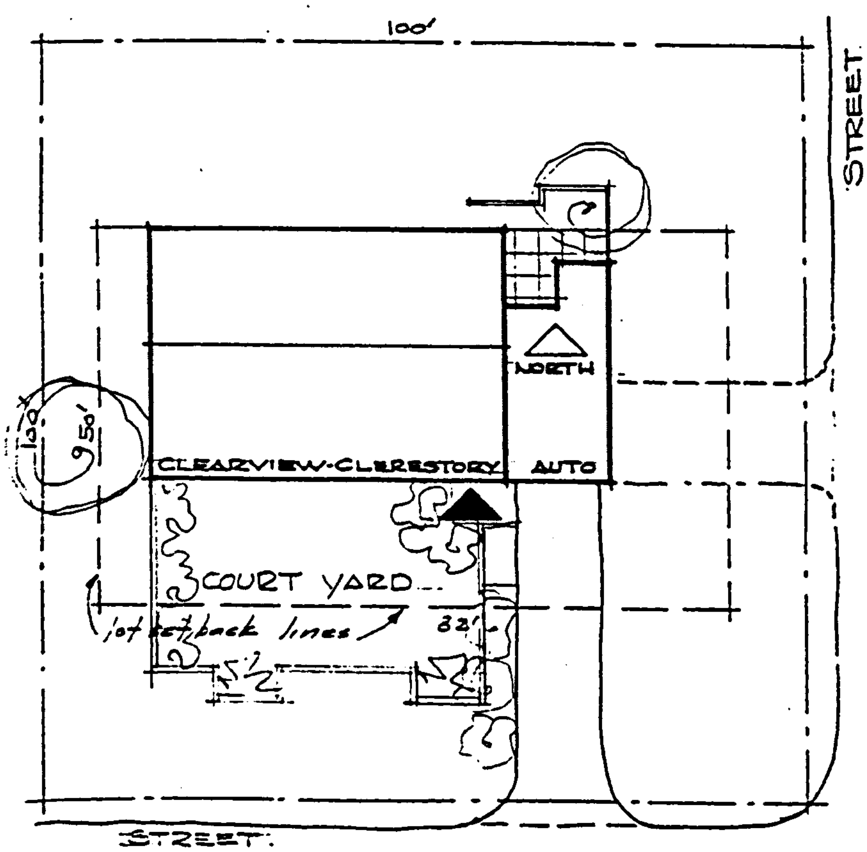
AS MERKER



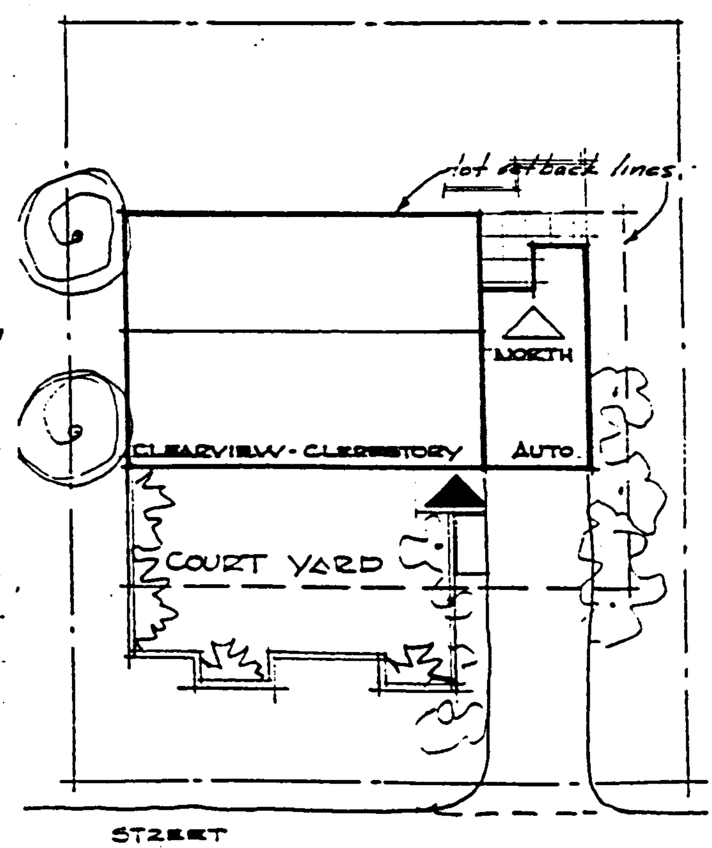
CLEARVIEW-CLEARSTORY SITING SITUATIONS

The following two diagrams will illustrate the siting problems involved and suggest some possible alternatives.

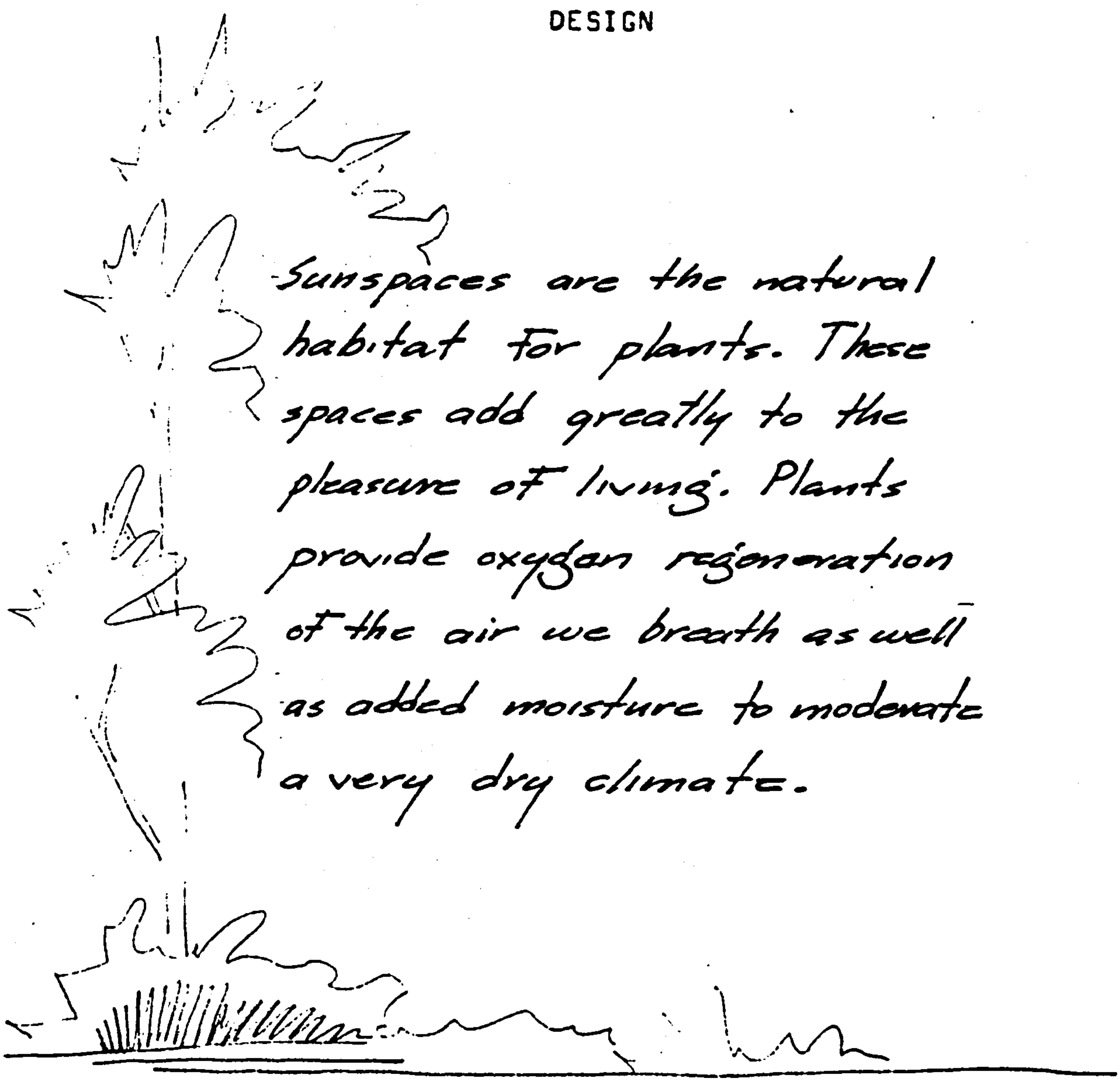




The clearview-clerestory design in this particular plan form adapts well for lots on the north side of the street. Placement of the house as far north as possible will allow for the option of a court yard around the larger south facing glass areas.



SUNSPACE DESIGN



Sunspaces are the natural habitat for plants. These spaces add greatly to the pleasure of living. Plants provide oxygen regeneration of the air we breath as well as added moisture to moderate a very dry climate.

SUNSPACES DESIGN:

The sunspace and atrium in this design provides areas of solar collection and, at the same time, provides spaces for plants and for sitting, play, etc. This dual use is paramount to making the cost of solar heating less than just an added cost for heat.

The clerestory over the atrium opens the north central portion of the house to direct sunlight and heat gain. The optional insulating night time shutters would minimize the heat loss at night. They do, however, require opening and closing which to some people is not automatic enough. The omission of these shutters would not be too severe a penalty.

The inclusion of venetian blinds or drapes on glazed areas in the living room and bedroom, which are adjacent to the south sunspace, would be a necessary element to provide control of heat gain during spring and fall days, when heat losses are not as high as winter. This would reduce the effect of ultraviolet degredation of interior furnishings.

The plan layout is zoned for solar with the major living spaces to the south, while less used areas are placed on the north. The openness of the plan between kitchen and living areas will provide good circulation of heat from the south living space.

The atrium graces the major living spaces while providing a shield from the more private areas of the house. This feature should add considerably to the livability of the design while providing heating and, at the same time, not increasing cost too heavily.

The garage is convertible to added living space at some future date and can achieve its own solar heating. This feature has been incorporated into several of this design series as a desirable feature, which is not often found in builder examples.

Again, this original version of this design, incorporated rockbed storage and ducts and fans. The increased annual solar heating fraction did not justify the added cost.

An important feature of the sunspace, sunporch, greenhouse is that heat can be rejected during fall and spring days when a lesser degree of heating is required than would be needed for a cold winter day. This points to one of the problems encountered when dealing with passive solar designs. Once built the house is not as easily adjusted or changed to accommodate fluctuating weather conditions outside. All passive designs must incorporate some device, or system of control, wherein the amount of heating can be rejected at times when the demand is less. The sunspace, sunporch, greenhouse provides this opportunity because it can be closed off from the house proper. By using drapes or blinds the direct sun radiation can be excluded and heat gain can be adjusted to the need for a warm fall day and yet can be opened when a cold storm comes in and drops exterior temperatures. There may be little sun during the storm. However, as is so often the case in the southwest the day after the storm a cold front leaves clear skies and very cold exterior temperatures for several days. It is during these several cold days that a solar system can be opened up and work well.

This design was created for the lost orientation where the street is on the north. The large glazed areas present themselves to the rear yard and, thus, are not the dominating factor regarding image. The north elevation presents to the street side a very conventional appearing house.

This design seems to meet all of the stated precepts quite well. The original design incorporated rockbed heat storage with ducts and fans and was found to have run into the law of diminishing returns. The elimination of these elements substantially reduced the solar cost without a heavy reduction in the annual solar fraction.

The cost of the sunspace raised the solar cost to 9% of the total budget, however, this space adds considerably to the livability of the house. This space can be used in so many ways to add to the quality of life. This choice should be given careful consideration by a prospective owner.

A.S. Merker

SUNSPACE DESIGN:

SOME SUBJECTIVE THOUGHTS CONCERNING LIFESTYLE:

The solar elements introduced in this design are the sunspaces. In this instance these spaces are intended as habitats for plants as well as heat collectors.

For those individuals who do not care for plants these spaces would require some adaptive use. As plant habitats they would introduce a noticeable increase in the oxygen and humidity levels. Although this is generally considered more healthy, it would cause condensation upon any cold glass surfaces such as windows. Double glazing would be required.

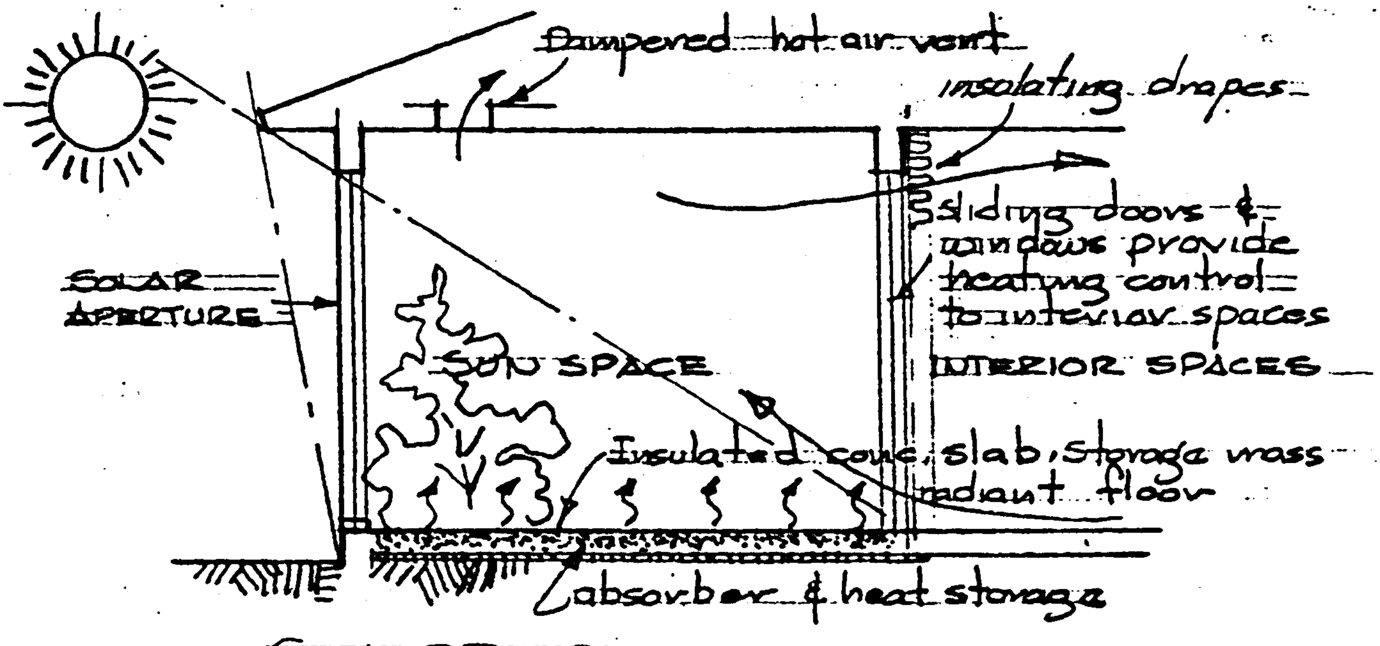
These spaces would also introduce light. This increased lighting level could be exciting for some and threatening to others.

The spaces are also rather tightly integrated with the living spaces and would tend to give the impression that all spaces are larger.

The impression could tend to become one, that a person was living within an interior garden. This could be an asset or liability depending upon individual tastes and preferences.

The only frequent manipulation of solar associated equipment would be the sliding doors and drapes. This could lead to tinkering with the system if a person were so inclined, and to some occasional discomfort if ignored. Severe overheating should not be very frequent due to the reduced sizing of the collector areas. This was done deliberately so as to avoid the heavy intrusion upon lifestyle.

These spaces can double for other occasional uses which should add to the pleasurable experience of living in these spaces.



SUNSPACE

COLLECTOR	the sunspace (greenhouse) serves as collector and absorber. Masonry walls, concrete floors, and water can be used for heat storage. Convection or fan forced air flow can distribute heat to interior spaces and to rock storage. Venting is required to control overheating.
STORAGE	can be direct in water and masonry to temper night losses. Diurnal temperature swings can be moderated and some carry-over had for cloudy days. The sunspace can drop to lower temperatures at night thus buffering interior spaces.
DISTRIBUTION	can be by natural convection or small forced draft fans. This configuration is improved over direct gain systems for distribution.
CONTROL	is improved over direct gain. Overheating can be isolated to the sunspace. Diurnal swings are controlled by air flow from storage.
ADVANTAGES	Sunspace is usable for plants, dining, living, etc. Improved control and distribution, reduced glare and ultraviolet degredation. Humid air with more oxygen from plants is more healthful. Sunspace doubles as an entry air lock.
DISADVANTAGES	Overheating in sunspace. Viewing to exterior is not direct.

COST ESTIMATING PROGRAM BY KIP MERKER

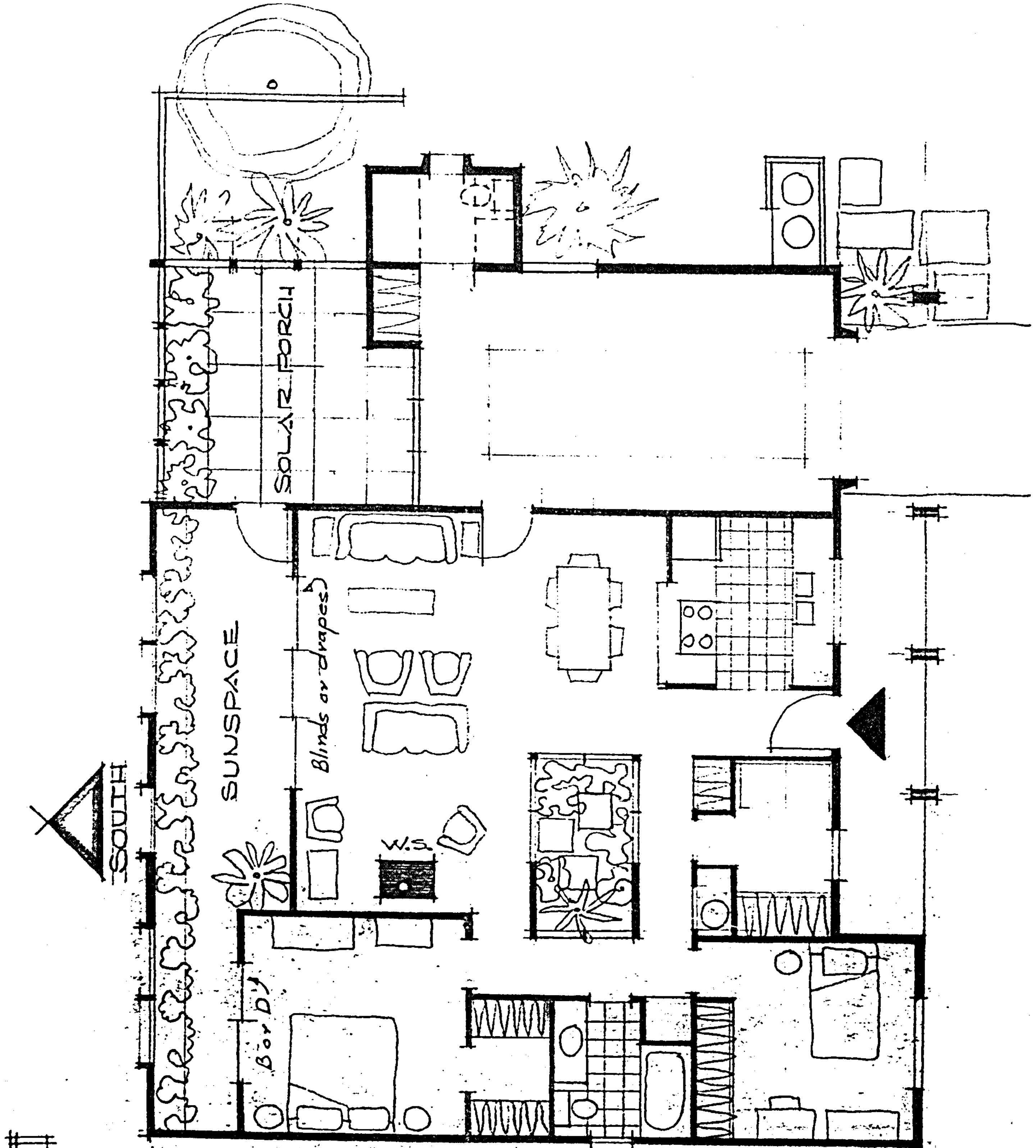
SUNSPACES COST ESTIMATE DATA MAY 10,1982

CATEGORY	UNIT COST	DIF NO	AREA	TOTAL COST
EXCAVATION	0.45	1	1404	632
FOUNDATION	0.8	2	1404	1123
FRAME	0.44	1	1404	618
FLOOR STRUCTURE	2	2	1404	2808
FLOOR COVER	0	0	0	0
CARPET	1.55	2	1126	1745
VINYL SHEET	1.45	2	278	403
0	0	0	0	0
CEILINGS	0	0	0	0
ACOUSTIC DRYWALL	1	1	1404	1404
0	0	0	0	0
0	0	0	0	0
INTERIOR CONSTRUCTION	5.86	2	1404	8227
PLUMBING	2.13	2	1404	2991
SPRINKLERS	0	0	1404	0
HEATING-COOLING	1.29	2	1404	1811
ELECTRICAL	1.6	2	1404	2246
EXTERIOR WALL	0	0	0	0
6" STUD/WOOD SIDING	5.39	2	1244	6705
CLERESTORY	10.5	2	24	252
0	0	0	0	0
ROOF STRUCTURE	2.75	2	1887	5189
ROOF COVER	0.55	2	1887	1038
SUNSPACE	16.28	1	310	5047
GARAGE	16.92	1	395	6683
CL FACTOR = 1.17	40.77			57239
	COST/S.F.			TOTAL COST

HEATED FLOOR AREA 1464 SF
SUNSPACES AREA 353 SF

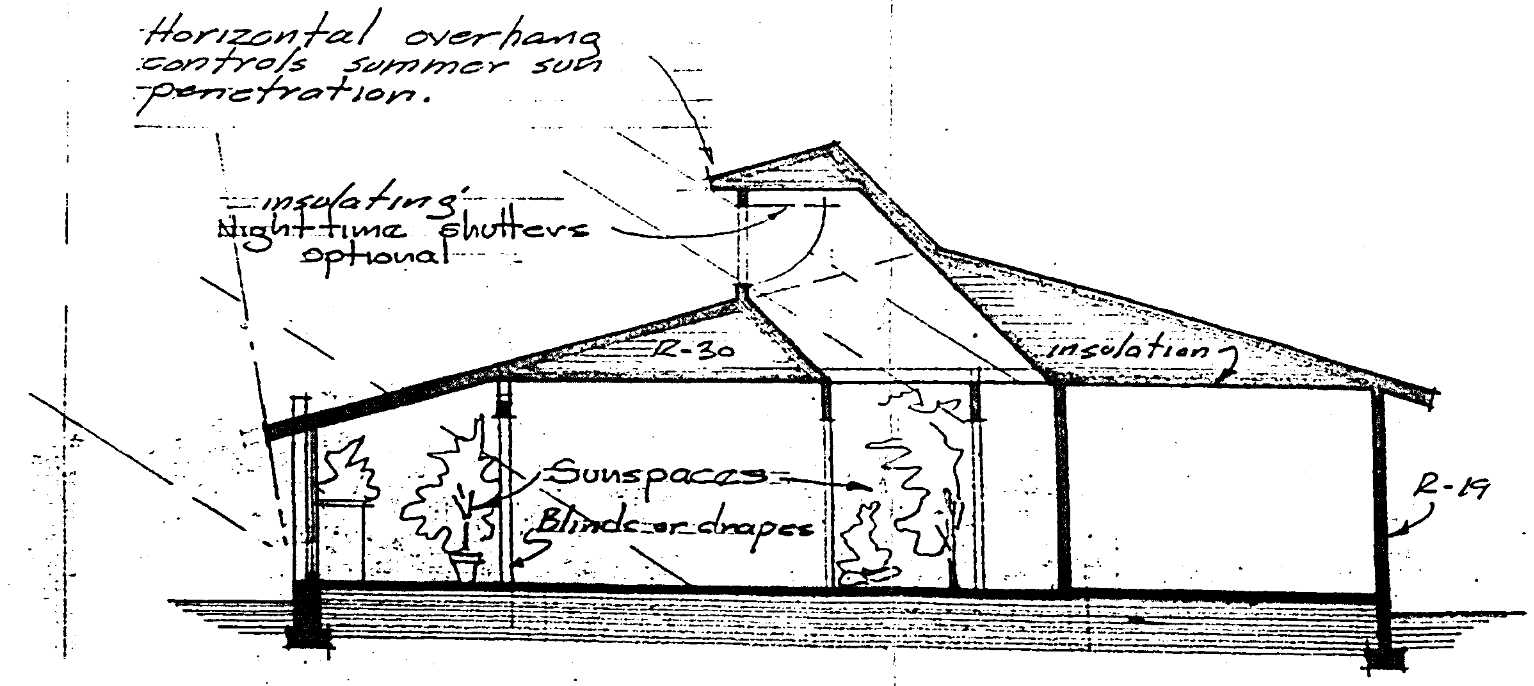
collector provided
Greenhouse 120-144 SF,
Clerestory 3*9 = 27 SF 140-171 SF

LCR = 1464 (3.5) / 171 = 30 % SOLAR = 62%



FLOOR PLAN

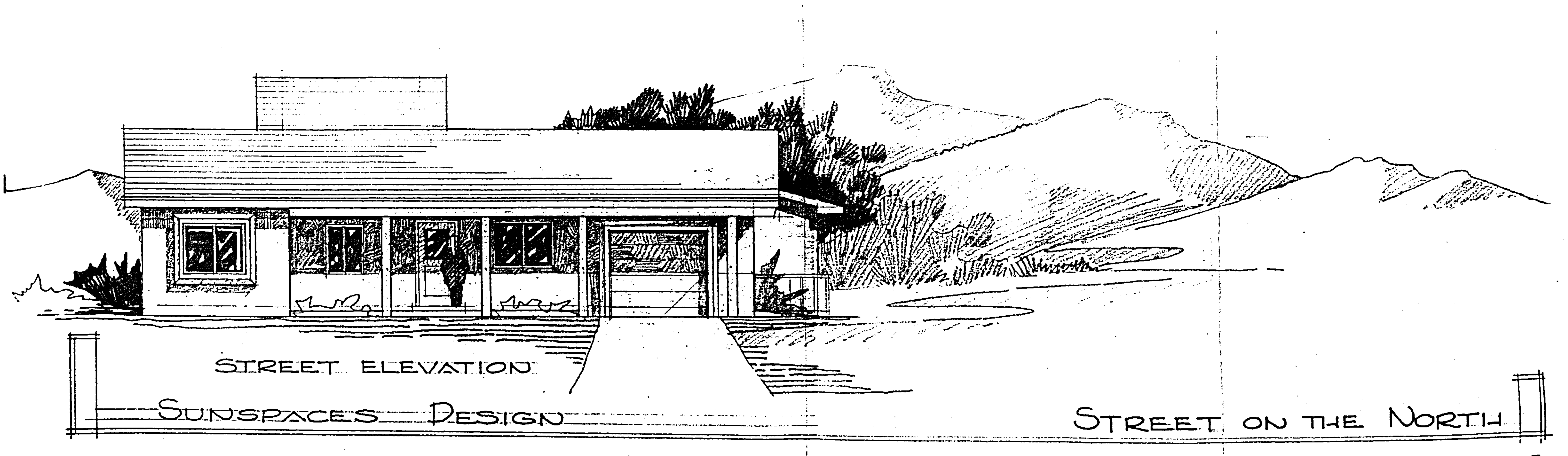
0' 2 5 10 20 30'



SECTION VIEW

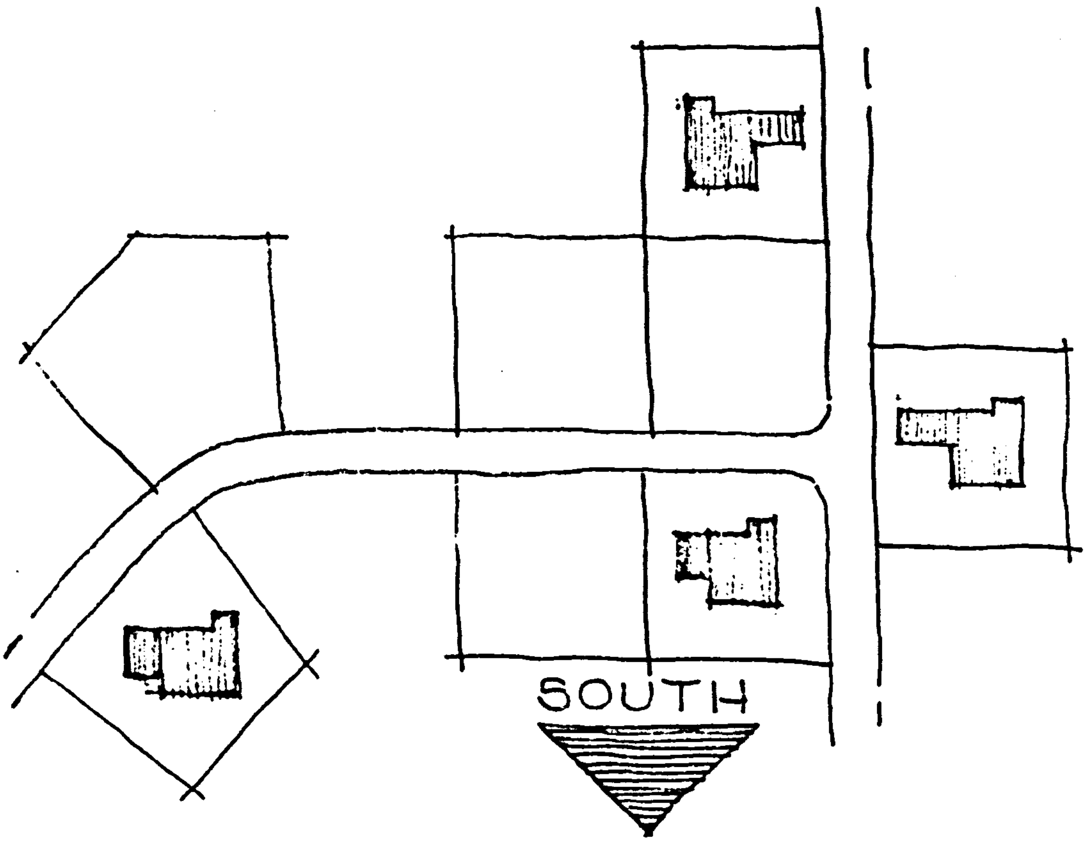
SUNSPACES DESIGN

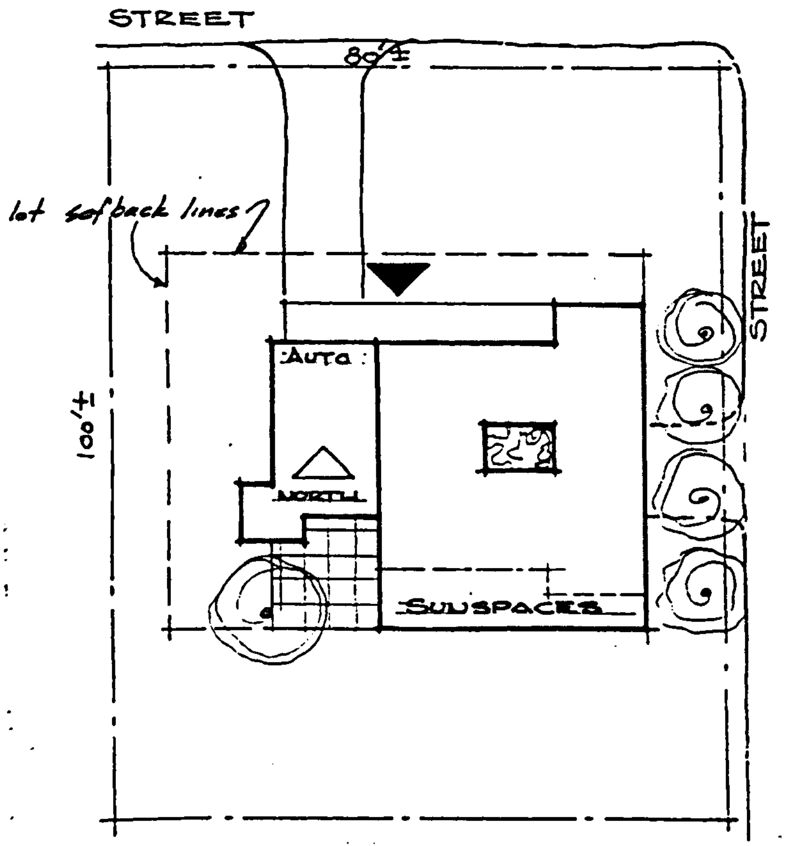
STREET ON THE NORTH


STREET ELEVATION
SUNSPACES DESIGN
STREET ON THE NORTH

SUNSPACE DESIGN SITING POSSIBILITIES

The following diagrams illustrate the site orientations which this design will accomodate.

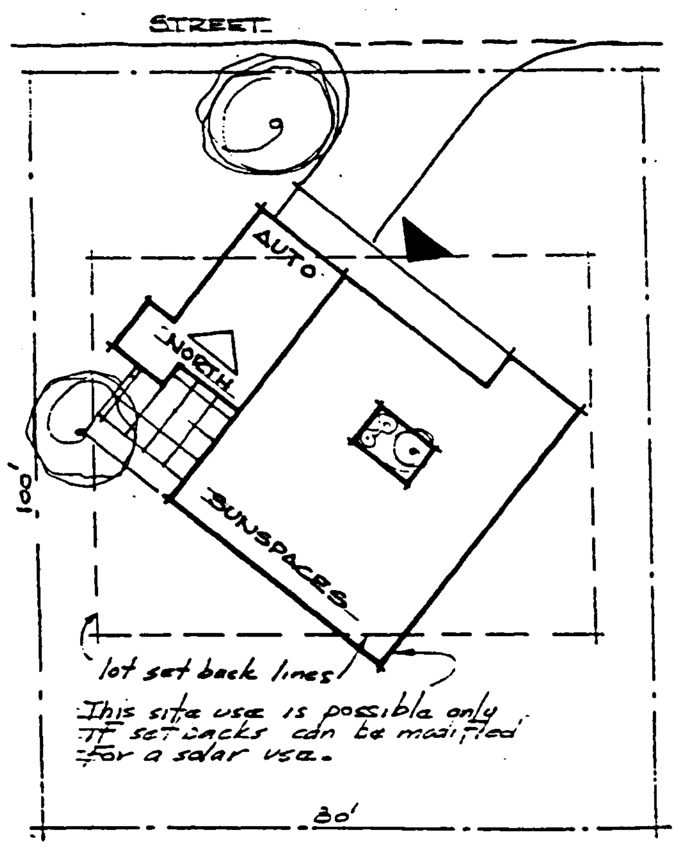


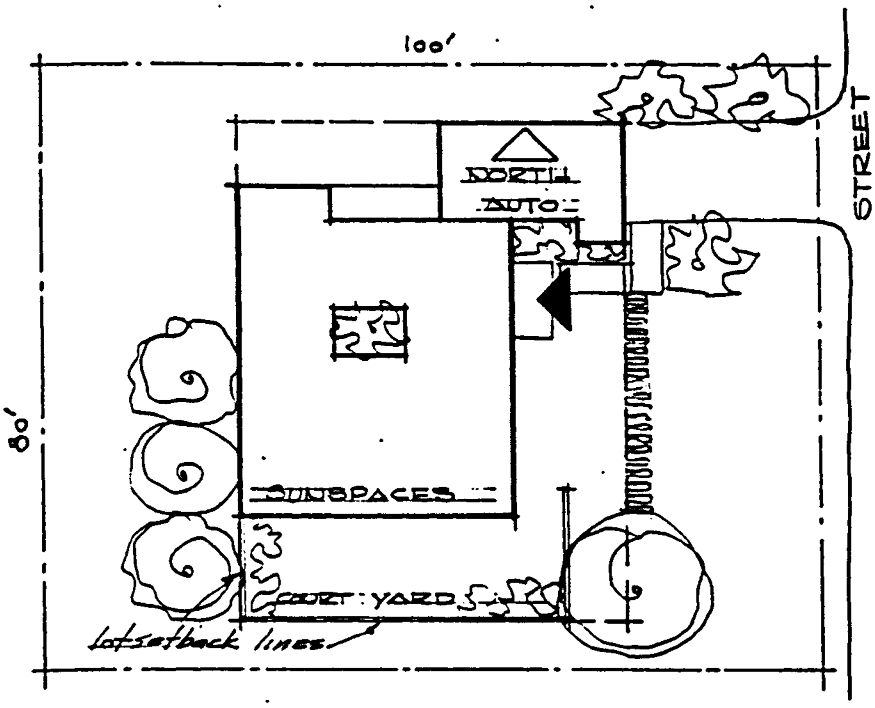


This design will adapt well to the siting situations where streets are on the north or north west.

When the sunspace is used as a greenhouse with plants the view to the rear yard will not be too critical.

This rear yard view may not always be desirable hence care should be exercised for any specific lot.





The lots which face on streets running north and south have presented the greatest challenge. The sunspace faces south into a neighbors side yard. In this case the courtyard, functioning as "buffer and" protection of the view out from the sunspace is most important. Designs in which the garage can be easily relocated are most adaptable so that set back lines are not violated. This plan flips over for the condition where the street is on the west side of the lot.

TROMBE WALL DESIGN

The Trombe wall system offers a simple compact combination of collector absorber and storage mass all combined. The owner must accept the notion that some manual adjusting of the dampers is necessary as the seasons change. Movable night insulation would be cost effective provided the owner would be willing to open & close it each day.

TROMBE WALL DESIGN

The plan shape is well adapted to those lots which require an angled orientation relative to the lot lines. The plan shape is quite compact presenting a minimum of exterior wall area to the elements. Reduced heat loss will result from this feature. The compact plan shape is adaptable for more lot types, as less ground coverage is required. The open plan configuration results in a free flow of air throughout. Heat distribution should be no problem.

The large continuous collector glazing does present a less than desirable feature. The result is a storefront appearance.

There is a relative lack of control over heat gain. This is an inherent feature which must be accepted as a part of the trombe wall design.

The 68% solar fraction is quite good when compared with the builder retrofit examples in the 6% solar cost as a percentage of the total construction cost. The total cost of construction looks very favorable as compared with the two builder design costs.

An attractive feature is the 65 float temperature that can be achieved on a severe winter day. If such conditions were to last only 24 hours, it is conceivable that no backup would be required during the winter months.

The problem of devising a simple system for framing the roof would present a challenge. Most builders would have little prior experience with this type of framing configuration.

Few openings present themselves to the east-west. All are compromised to a partial north orientation. This would not be unreasonable in Prescott Valley. Here summer heat buildup is not the problem that it is in more southerly locales of Arizona.

A.S. Merker

TROMBE WALL DESIGN

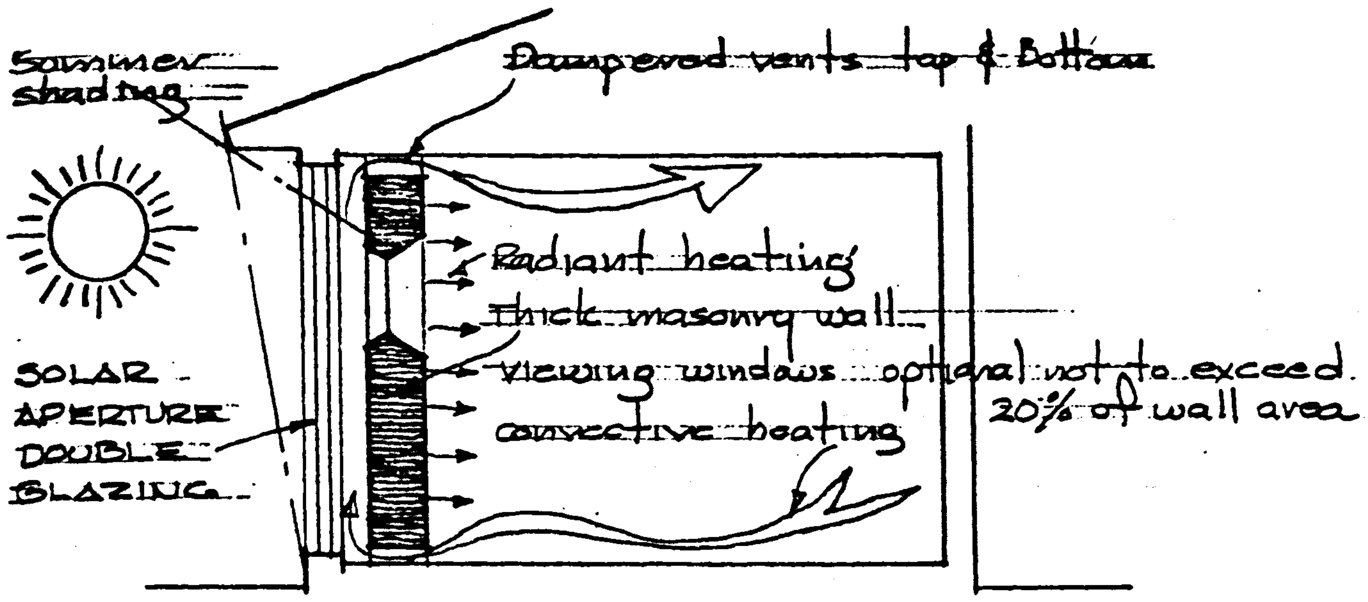
SOME SUBJECTIVE THOUGHTS CONCERNING LIFESTYLE:

The principle solar feature of this design is the Trombe Wall. As a warm surface it should be a comforting reassuring element to live around.

Much of the effect upon lifestyle should be dependent upon the viewing openings in this wall. Small areas and few openings could produce a dimly Light space which could be dark and depressing for some individuals or to others could seem private, secure and protected. This feature should be compromised rather carefully in a speculative built model as it could become a feature which only a certain few buyers would purchase.

With the usual proportioning of window area to room area it should appear to be little different from the interior, than a conventional livingroom.

The manual operation of the vents to control heating could lead to some tinkering if one were so inclined. If set seasonally the manual tinkering could be minimized, for those who do not care to be bothered. This feature if ignored would cause the automatic backup systems to function more. This would reduce the overall efficiency of the solar design somewhat.



INDIRECT GAIN • TROMBE • MASONRY WALL

COLLECTOR Collection efficiency is reduced as some radiation is lost back out through the collector. Night insulation is more effective than with direct gain systems.

STORAGE Use 12" to 18" of masonry painted dark on the collector side. Viewing windows should not be so large as to reduce the masonry storage area. They will provide some direct gain. Dampered vents are the important control feature. Provide excess masonry thickness rather than too little, as this mass moderates the day to night diurnal temperature variations. Summer shading by overhang must be provided to prevent overheating.

DISTRIBUTION is radiant from the masonry wall and by convective air. Vents are sized to be 1 sq. ft. for each 100 sq. ft. of wall area.

CONTROL is easily provided by dampers in the vents. Manual operation is sufficient.

ADVANTAGES Ultraviolet degredation of furnishings is reduced. Collection to storage is direct allowing the control feature. Los Alamos Scientific Laboratory studies by Balcomb indicate improved performance over direct gain systems.

DISADVANTAGES Night insulation is a must. Heat storage is concentrated near the largest night loss area, and distribution becomes more of a problem. Cost of construction is increased by the storage masonry wall.

COST ESTIMATING PROGRAM BY KIP MERKER

TROMBE WALL — COST ESTIMATE DATA — MAY 10,1982

CATEGORY	UNIT COST	DIF NO	AREA	TOTAL COST
EXCAVATION	0.45	1	1400	630
FOUNDATION	0.8	2	1388	1110
FRAME	0.44	1	1388	611
FLOOR STRUCTURE	2	2	1388	2776
FLOOR COVER	0	0	0	0
CARPET	1.55	2	1036	1606
VINYL SHEET	1.45	2	352	510
0	0	0	0	0
CEILINGS	0	0	0	0
ACOUSTIC DRYWALL	1	1	1388	1388
0	0	0	0	0
0	0	0	0	0
INTERIOR CONSTRUCTION	5.86	2	1388	8134
PLUMBING	2.13	2	1388	2956
SPRINKLERS	0	0	1388	0
HEATING-COOLING	1.29	2	1388	1791
ELECTRICAL	1.6	2	1388	2221
EXTERIOR WALL	0	0	0	0
6" STUD/WOOD SIDING	5.39	2	1900	10241
12"MASONRY HEAT STORAGE	7.12	2	163	1161
0	0	0	0	0
ROOF STRUCTURE	2.75	2	1724	4741
ROOF COVER	0.55	2	1724	948
GARAGE	16.92	1	344	5820
0	0	0	0	0
CL FACTOR = 1.17	39.32			54573
	COST/S.F.			TOTAL COST

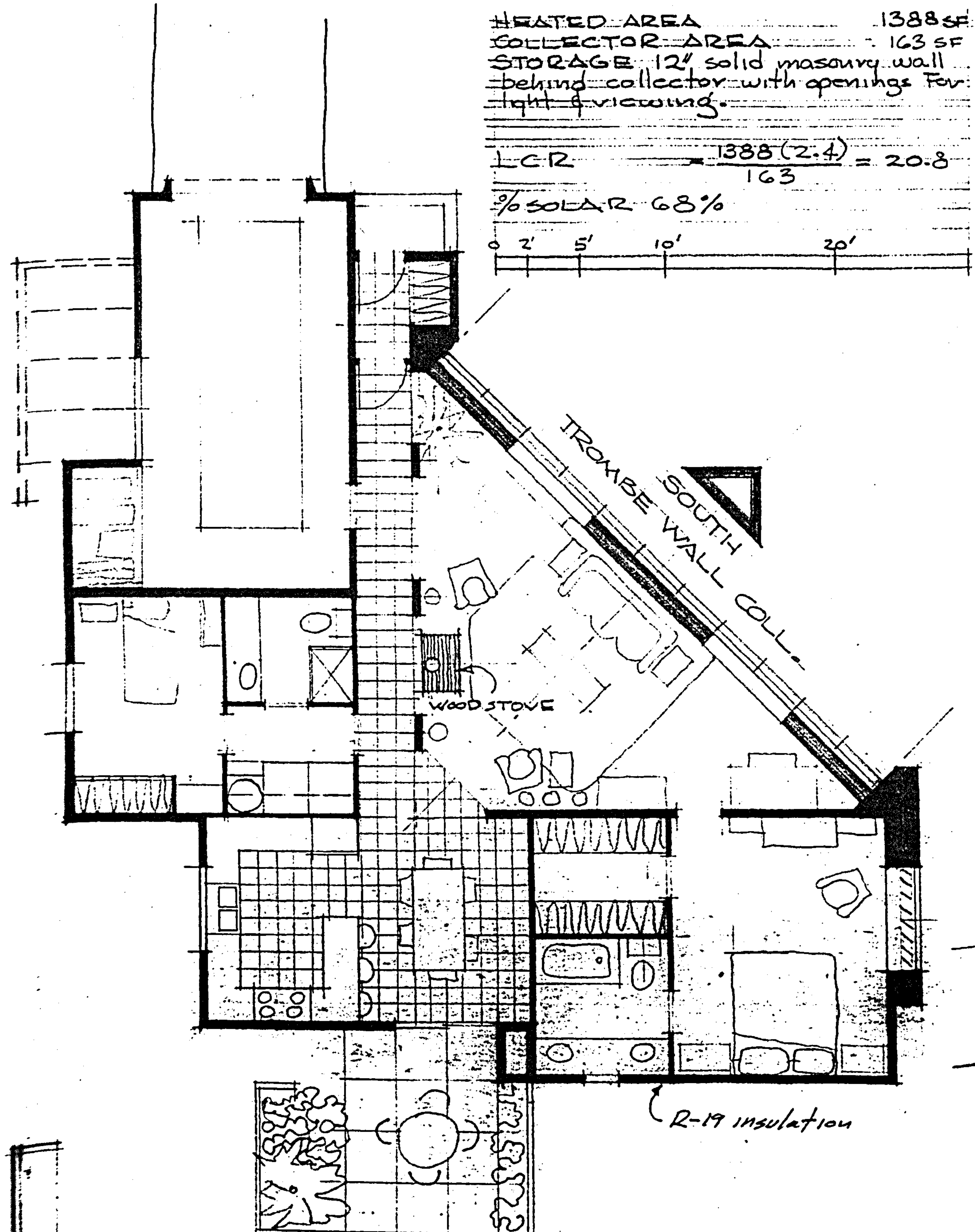
PRESCOTT VALLEY

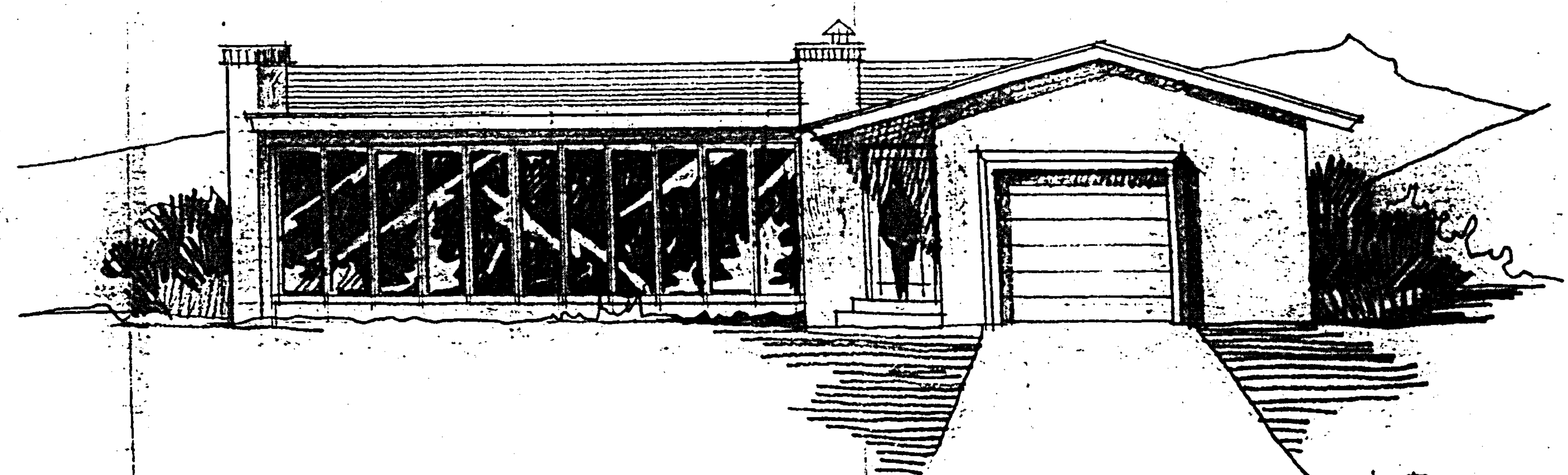
A.S. MERKER

HEATED AREA 1388 SF
COLLECTOR AREA 163 SF
STORAGE 12" solid masonry wall behind collector with openings for light & viewing.

LCR = 1388 (2.4) / 163 = 20.8

% SOLAR 68%

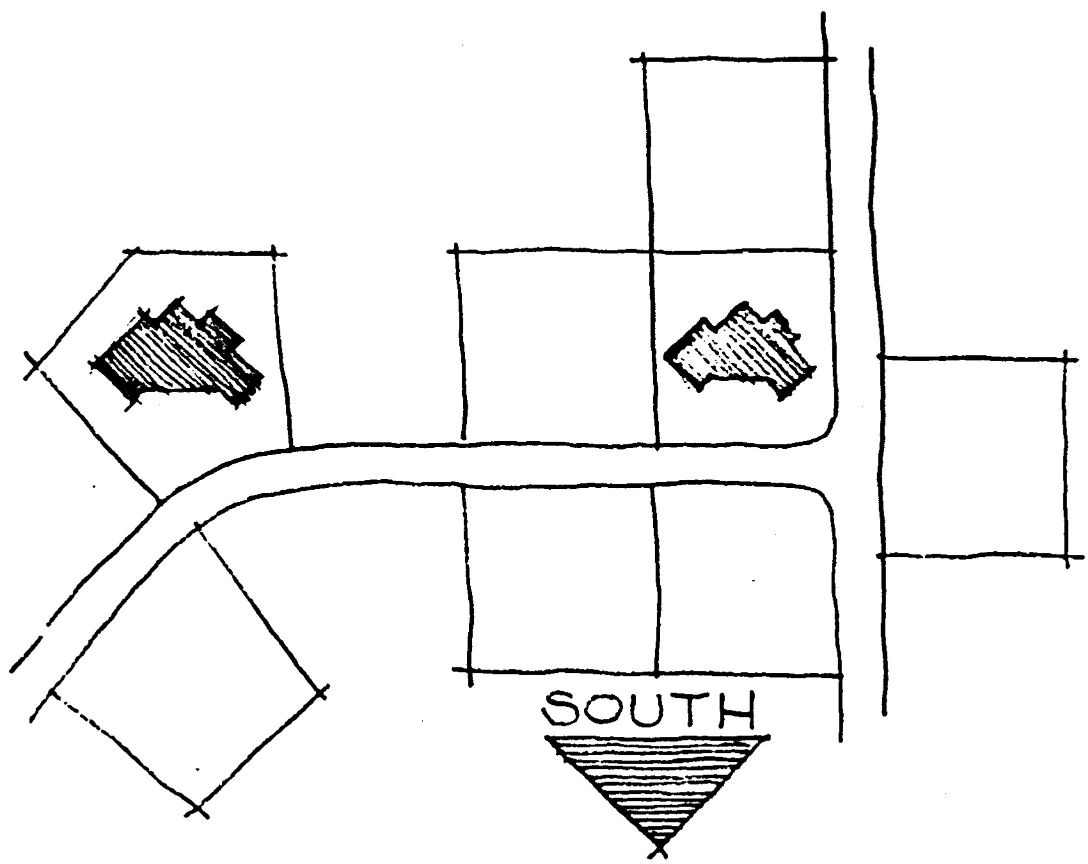


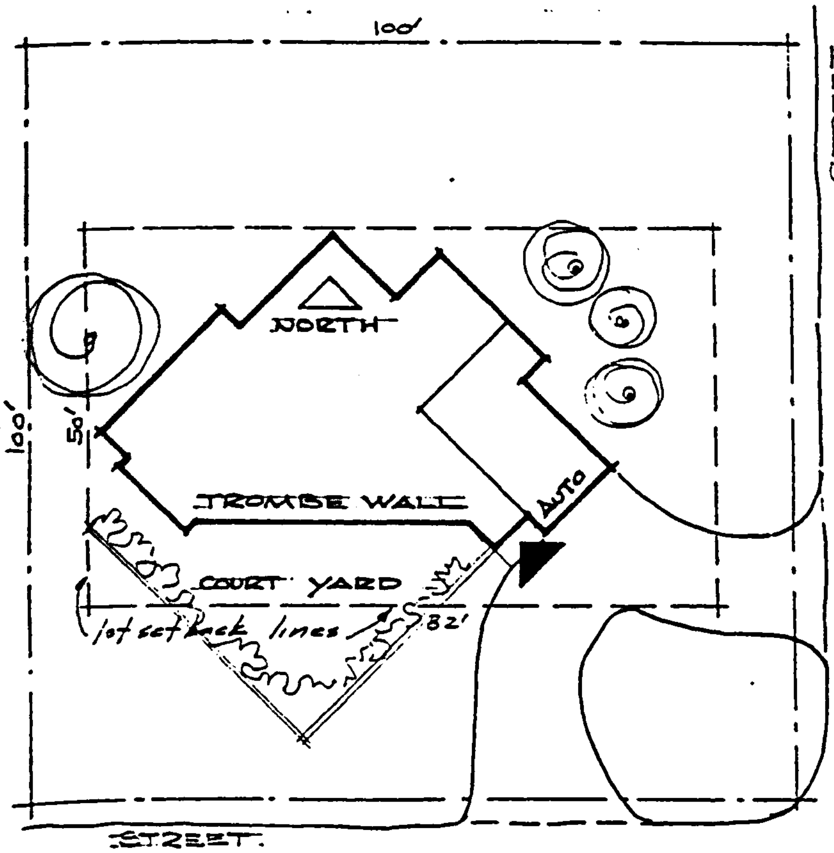


TROMBE WALL DESIGN FOR AN ANGLED LOT • STREET ON THE SOUTHEAST

TROMBE WALL DESIGN SITING ALTERNATIVES

The trombe wall design presents a good solution for the following lot orientations.

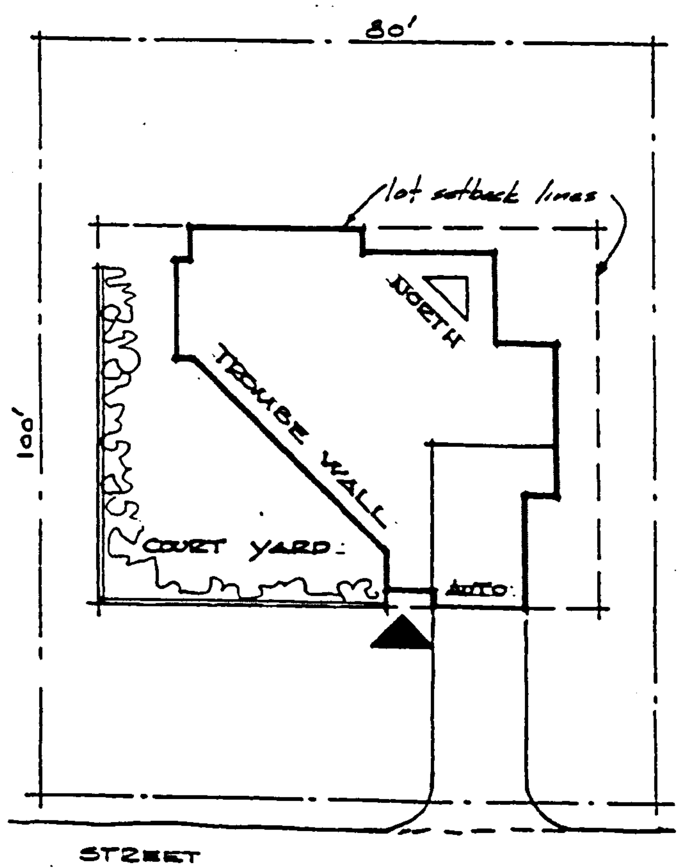




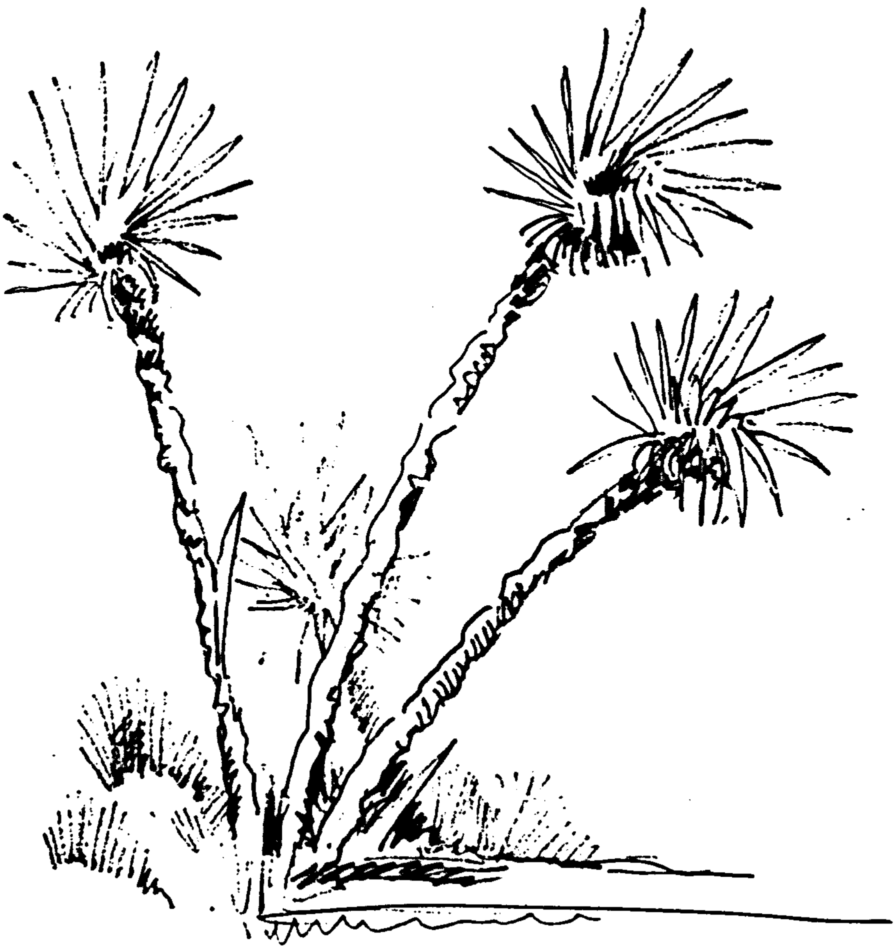
This trombe wall design was done with the angled lot in mind. It works well for this siting problem.

There is little reason why the trombe wall could not be replaced with clearview collectors or a sun porch.

The 45° angled wall can be sited up to 15° off of due south and still work well. If angled to the east of south heating will start early in the morning.



TWO STORY SUNSPACE DESIGN



TWO STORY SUNSPACE DESIGN

This design would be a better solution for a different climate. It is included in this study to demonstrate somethings that should not be done.

The compact two story plan is excellent for reducing heat loss and east-west exposures are minimized.

This plan also allows more flexibility for site adaptations as the out to out plan dimensions are shorter and the total area for ground coverage is reduced. The garage can be turned 90° allowing even more site adaptation flexibility.

The two story plan necessitates more circulation space, thus increasing the total square footage of 1600 sq. ft. to a maximum for all the designs. This house is the largest and also, perhaps the most livable. A two story living space is provided. More separation of zones results in increased privacy. The larger more spacious feeling should be more fun to live in. More, in the way of choices regarding lifestyles, is provided by this design. This is perhaps its most appealing feature.

The two story sunspace provides a way of achieving a very large collector area. Without the rockbed storage and shutters for control this house would overheat severely in Prescott Valley climate. It is a better design for a much more severe climate. The direct gain into the first floor living areas would result in glare, ultraviolet degredation and overheating. A solution would be to provide venetian blinds in the sunspace at openings to the bedroom and livingroom. Heat could still be collected in the sunspace and put into storage but could be blocked from the interior. In Prescott Valley the collector area and attendant cost could be reduced to about 50% and still work well.

This design seems to meet all precepts except the one regarding cost and diminishing returns.

The large collector area on the exterior would become more acceptable if reduced as regards exterior appearance. If broken up, this facade would be less storefront in character. Since this facade would most likely be to the rear of the house it is not a major problem. The significance of this facade would become evident when the houses were placed on a corner lot.

A.S. Merker

TWO STORY SUNSPACE DESIGN

SOME SUBJECTIVE THOUGHTS CONCERNING LIFESTYLE:

This design confirms the closest to the expected notion of what a solar design consists of.

The large two story sunspace and the rock storage including the fans and ducts to supply storage are the solar features which could contribute to an effect upon lifestyle.

The sunspace could become a solar porch or could also be used as a habitat for plants. If used for plants this space could produce increased humidity which would improve health conditions for some but not for others. Condensation on windows could become an annoying problem unless double glazing is used for all windows. This space would demand a considerable degree of control tinkering in the fans of opening and closing of the openings and drapes associated therewith, to the interior spaces. This comes to pass as a result of the expected overheating problem and would require daily attention during the heating season.

Unless the storage fans are provided with automatic controls, this feature would also require considerable manual tinkering to make the system operate successfully. All of this frequent adjusting and opening and closing would have a definite impact upon lifestyle and probably should not be attempted except by those who are willing to accept such features.

The open two story living space comes as a by product of the two story solar sunspace and is a feature which could be an asset to the individuals who like this kind of space.

The solar sunspace can have the effect of making the adjoining spaces seem larger. It could also appear to provide more diverse usages which could effect the perceived lifestyle of the occupants.

COST ESTIMATING PROGRAM BY KIP MERKER

2STR SUN SPACES COST ESTIMATE DATA MAY 10,1982

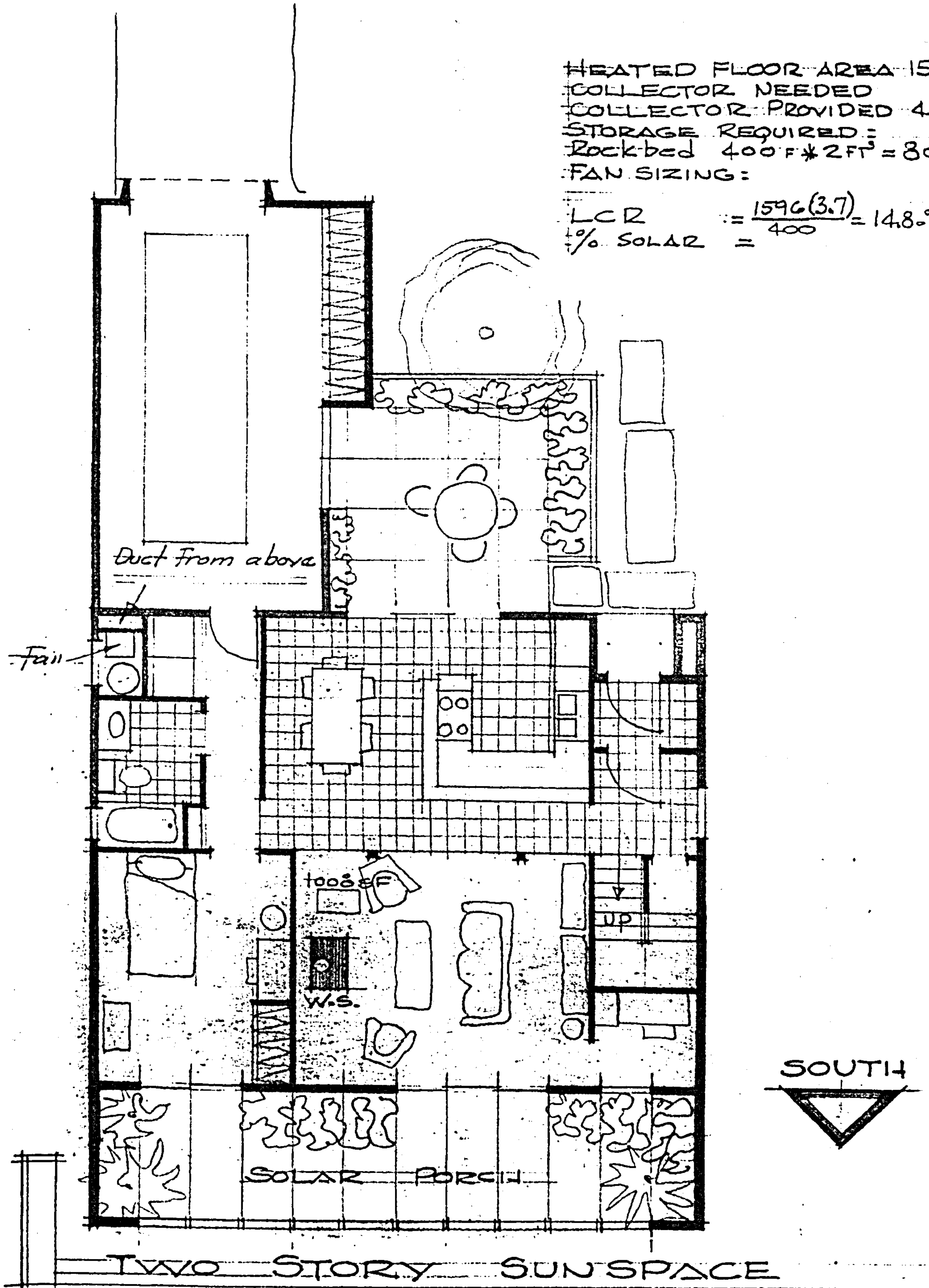
CATEGORY	UNIT COST	DIF NO	AREA	TOTAL COST
EXCAVATION	0.45	1	1600	720
FOUNDATION	0.8	2	1596	1277
FRAME	0.44	1	1596	702
FLOOR STRUCTURE	2	2	1596	3192
FLOOR COVER	0	0	0	0
CARPET	1.55	2	1074	1665
VINYL SHEET	1.45	2	522	757
ROCKBED HEAT STORAGE	3.3	1	1008	3326
CEILINGS	0	0	0	0
ACOUSTIC DRYWALL	1	2	1596	1596
0	0	0	0	0
0	0	0	0	0
INTERIOR CONSTRUCTION	5.86	2	1596	9353
PLUMBING	2.13	2	1596	3399
SPRINKLERS	0	0	1596	0
HEATING-COOLING	1.29	2	1596	2059
ELECTRICAL	1.6	2	1596	2554
EXTERIOR WALL	0	0	0	0
6" SUD/WOOD SIDING	5.39	2	2176	11729
0	0	0	0	0
0	0	0	0	0
ROOF STRUCTURE	2.75	2	1440	3960
ROOF COVER	0.55	2	1440	792
SOLAR PORCH	16.28	1	468	7619
GARAGE	16.92	1	366	6193
CL FACTOR = 1.17	44.64			71245
	COST/S.F.			TOTAL COST

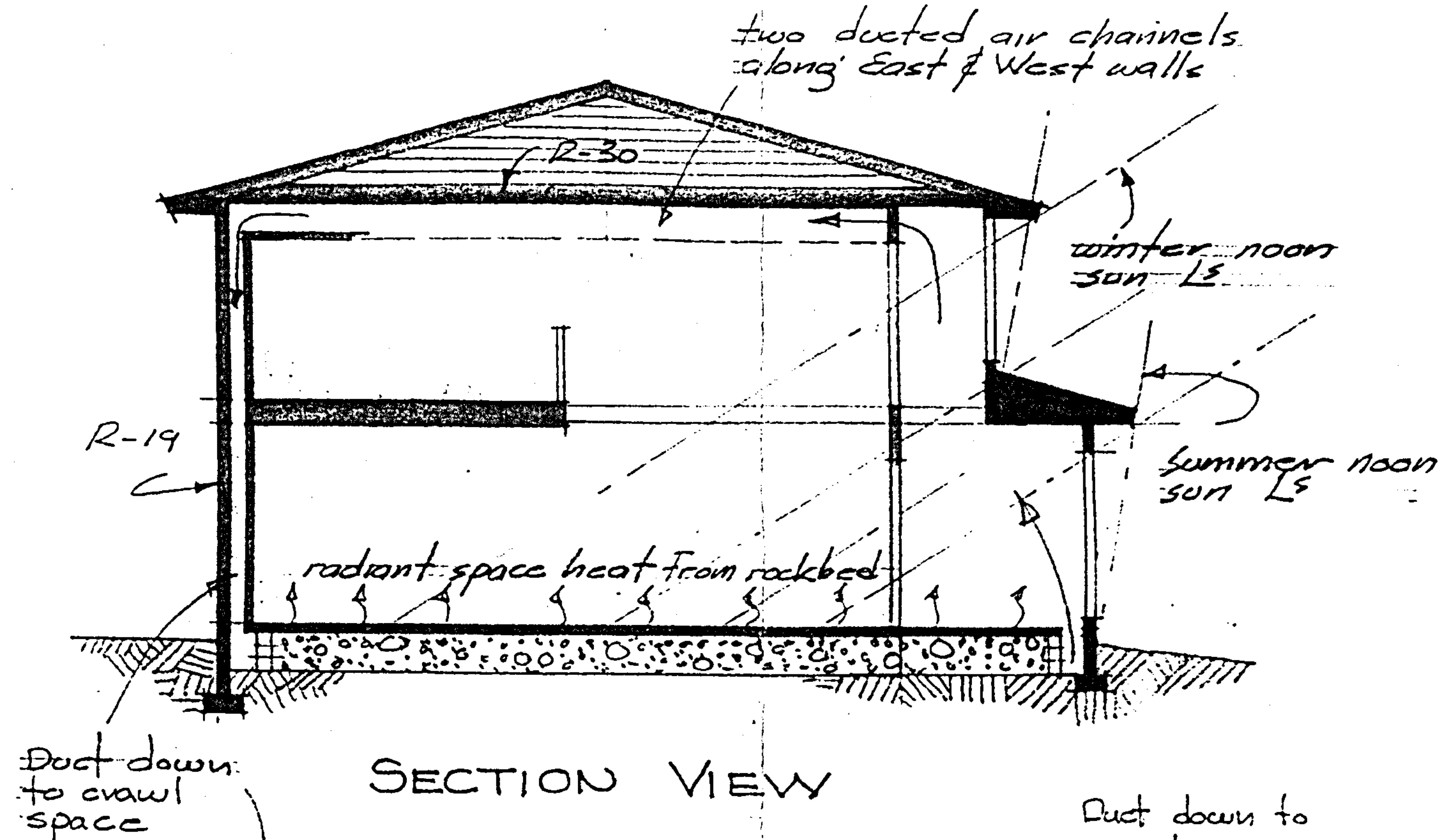
PRESCOTT VALLEY

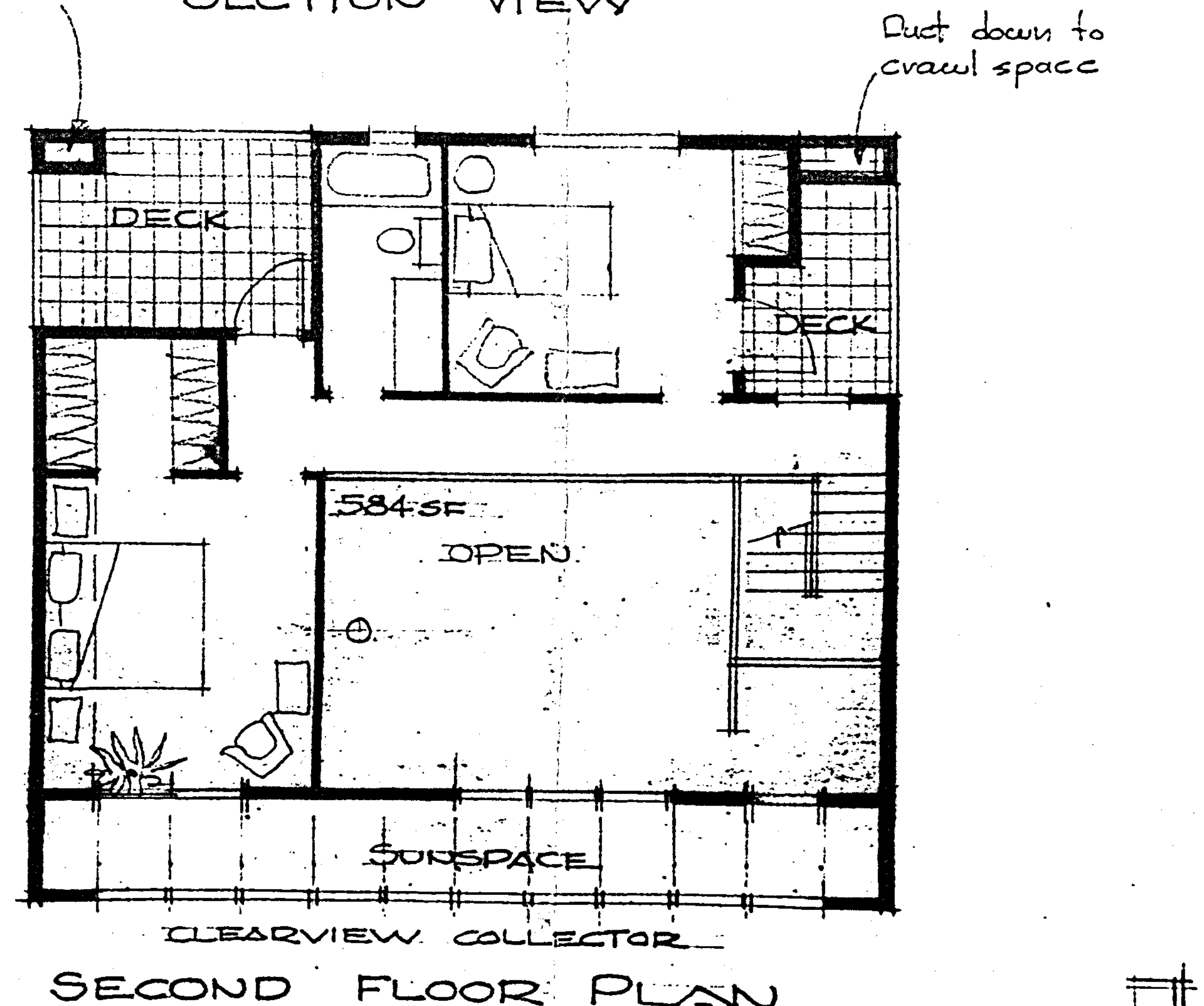
A.S. MERKER

HEATED FLOOR AREA 1596 SF
COLLECTOR NEEDED
COLLECTOR PROVIDED 400 SF
STORAGE REQUIRED:
Rock-bed 400 F * 2 FT³ = 800 FT³
FAN SIZING:

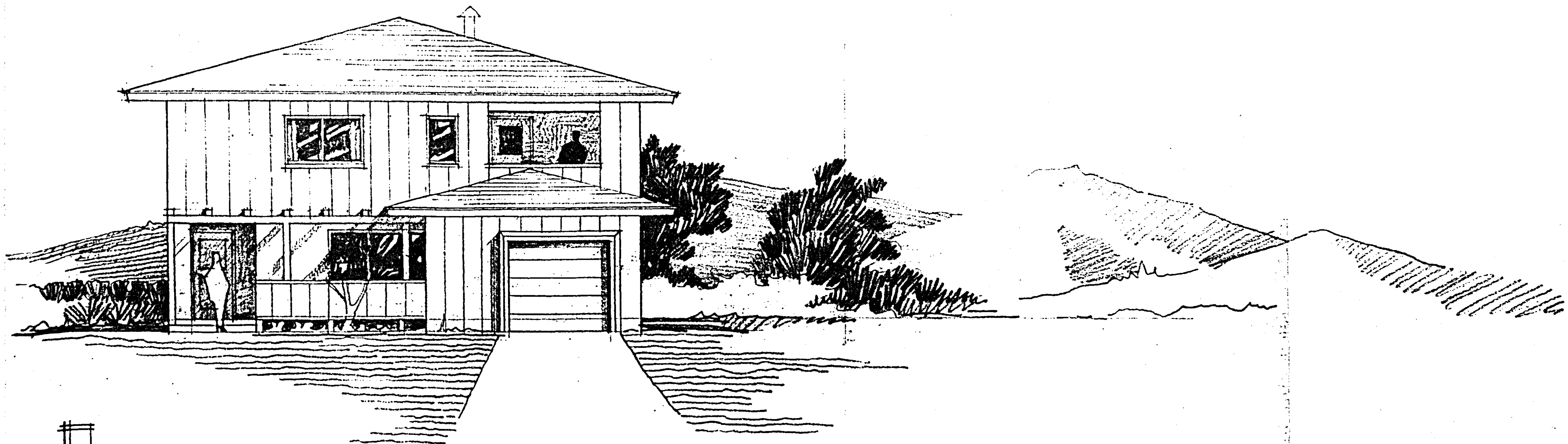
LCR = 1596(3.7) / 400 = 14.8
% SOLAR = 73%







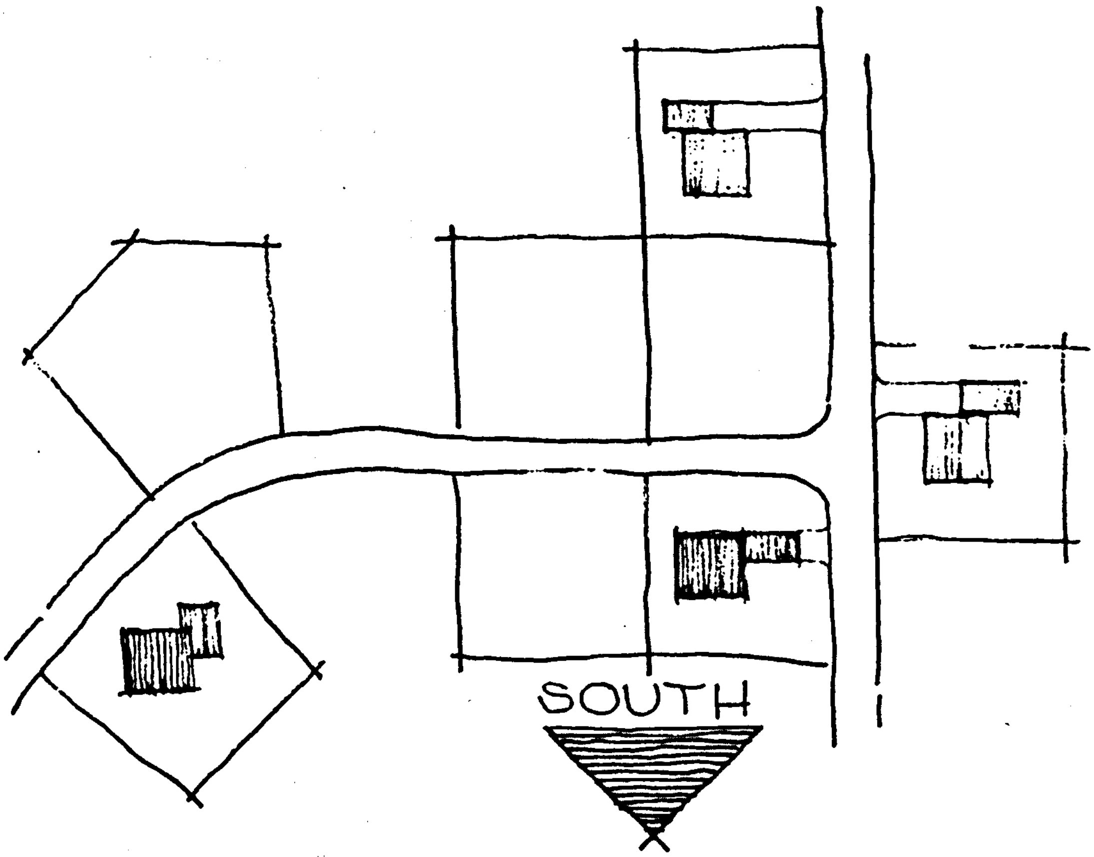
A.S. MERKER

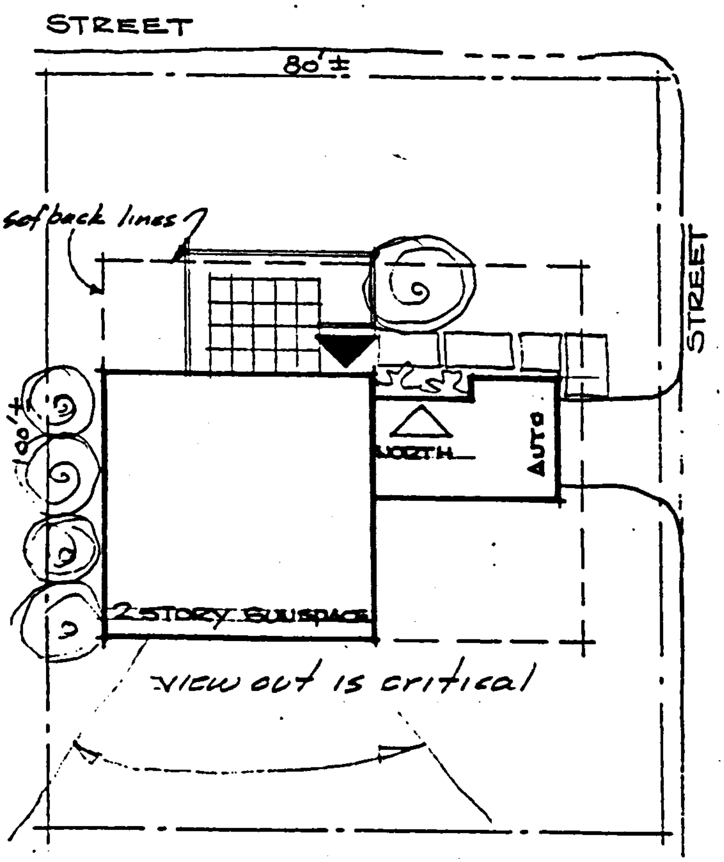


TWO STORY SUNSPACE

TWO STORY SUNSPACE DESIGN SITING ALTERNATIVES

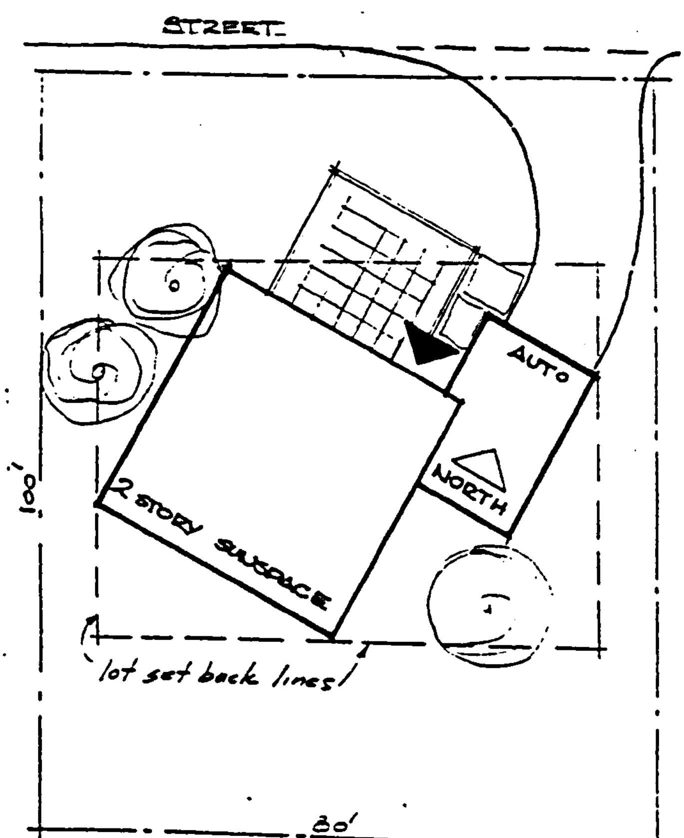
The following site diagrams serve to illustrate how this design can be used in the Prescott Valley context.

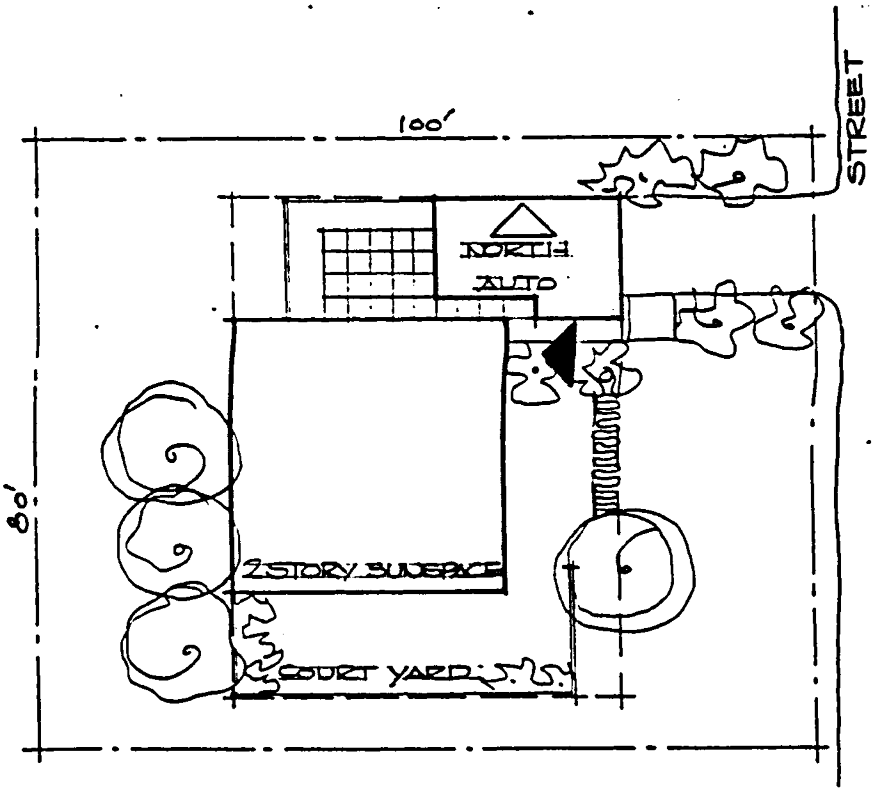




The fact that the garage can be located in different places relative to the house makes this design very flexable for many siting situations.

Care should be exercised with regard to the view from the large glass areas of the two story sunspace. A poor exterior view from inside would be devastating.





The lots which face on streets running north and south have presented the greatest challenge. The 2 story sunspace faces south into a neighbors sideyard. In this instance the courtyard, functioning as buffer and protection of the view out from the sunspace is most important. Designs in which the garage can be easily relocated are most adaptable such that set back lines are not violated. This plan flips over for the condition where the street is on the west side of the lot.

DUPLEX SUNPORCH
DESIGN

A.S. Merker

DUPLEX SUNPORCH:

Prescott Valley includes a fair percentage of lots zoned for duplex type of housing. Many owners have found that it is a very good situation for them to live in one side while renting the other. This provides a supplement to their retirement income and helps to pay for the cost of construction.

The proposed design incorporates features of flexibility which will allow it to be accommodated to as many sites as possible. In fact, all orientations except the east-west pair along streets running north-south are accommodated by this design.

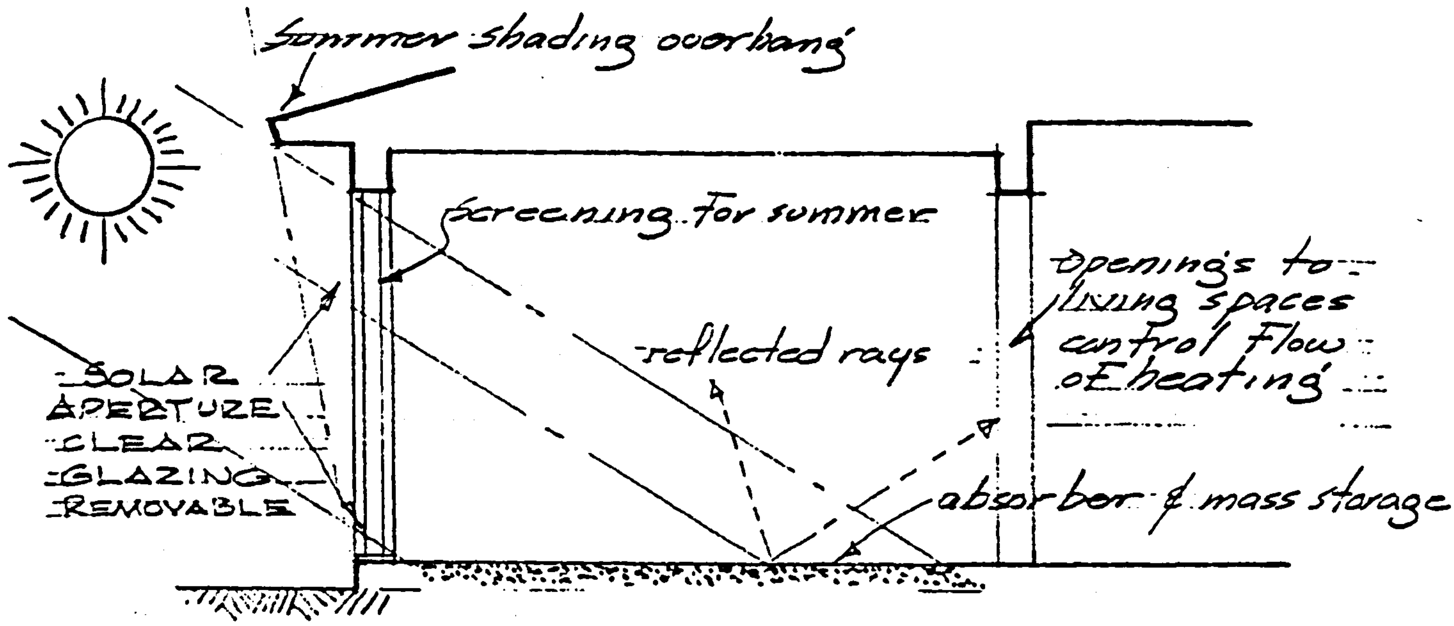
The plan includes two bedrooms which can be easily reduced to a one bedroom unit by a very simple change in the floor plan.

The solar feature is the solar porch on the south as a collection space. This space doubles in several ways for multiple use, at the same time providing the important feature of control and heating. Interior spaces can be closed off at times when less heating is required. When left full open 68% of the annual heating load will be provided by solar. This means that the wood stove backup heat source would be needed to some degree during the months of December-January-February. Except for short periods during spring and fall storms the solar system will provide all of the heating needed.

When sited on the north side of a street this unit should be moved to the rear as far as possible making it possible to provide a courtyard on the front or street side. This will open the solar porch to the courtyard creating an outdoor living space as well as supplementing the livability of the porch itself.

The 68% solar fraction is achieved by oversizing the solar porch. This is possible as a result of the fact that solar gain can be controlled by closing the porch when heating is not needed. In turn this allows the solar gain to cover more of the cold winter periods.

This design meets all of the precepts rather well. The design was changed eliminating the rockbed storage and ducts-fans etc. to reduce the cost of solar as the point of diminishing returns had been reached. The solar fraction was not increased enough to balance the increased costs.



DIRECT GAIN SOLAR PORCH

COLLECTOR Collection efficiency is high, as little radiaton is lost back out through the collector.

STORAGE is most effective where direct sunlight falls and less effective in other areas. Adequate storage mass is required to prevent excessive diurnal temperature swings. Provide 4" of brick or 6" of concrete block or 6" of concrete for floors and north wall. Use scatter rugs but not carpeting. Wall and floor colors should be dark or a medium natural color to enhance absorption. Ceilings should be painted white for reflectance. Attempt to provide 6 sq. ft. of mass storage surface for each one sq. ft. of solar aperture.

DISTRIBUTION CONTROL is passive to all interior areas. Natural convection principles provide horizontal flow of air which is controlled by openings to the interior spaces of the residence.

ADVANTAGES are simple construction relative low cost factor. Provides natural lighting.

DISADVANTAGES are higher day to night temperature swings. Ultraviolet degradation of furnishings. Some overheating during fall and late spring months. Summer roof overhang shading must be provided. Excessive light and glare on winter days.

COST ESTIMATING PROGRAM BY KIP MERKER

DUPLEX SOLAR PORCH   COST ESTIMATE DATA   MAY 10,1982

CATEGORY	UNIT COST	DIF NO	AREA	TOTAL COST
EXCAVATION	0.45	1	900	405
FOUNDATION	0.8	2	884	707
FRAME	0.44	1	884	389
FLOOR STRUCTURE	2	2	884	1768
FLOOR COVER	0	0	0	0
CARPET	1.55	2	684	1060
VINYL SHEET	1.45	2	200	290
0	0	0	0	0
CEILINGS	0	0	0	0
ACOUSTIC DRYWALL	1	2	884	884
0	0	0	0	0
0	0	0	0	0
INTERIOR CONSTRUCTION	5.86	2	884	5180
PLUMBING	2.13	2	884	1883
SPRINKLERS	0	0	884	0
HEATING-COOLING	1.29	2	884	1140
ELECTRICAL	1.6	2	884	1414
EXTERIOR WALL	0	0	0	0
6" STUD/WOOD SIDING	5.39	2	992	5347
0	0	0	0	0
0	0	0	0	0
ROOF STRUCTURE	2.75	2	1275	3506
ROOF COVER	0.55	2	1275	701
SOLAR PORCH	16.28	1	192	3126
GARAGE	16.92	1	378	6396
CL FACTOR = 1.17	45.26			40009
	COST/S.F.			TOTAL COST

PRESCOTT VALLEY

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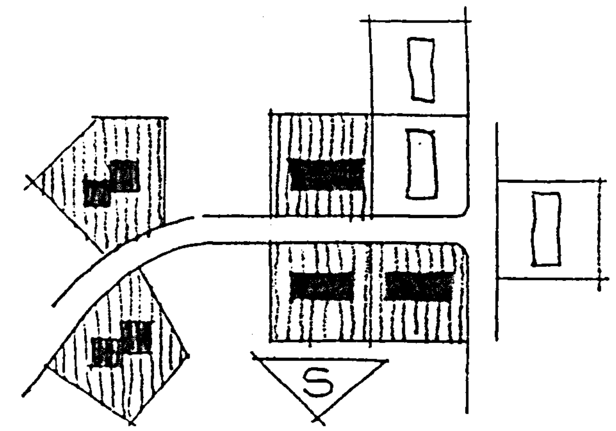
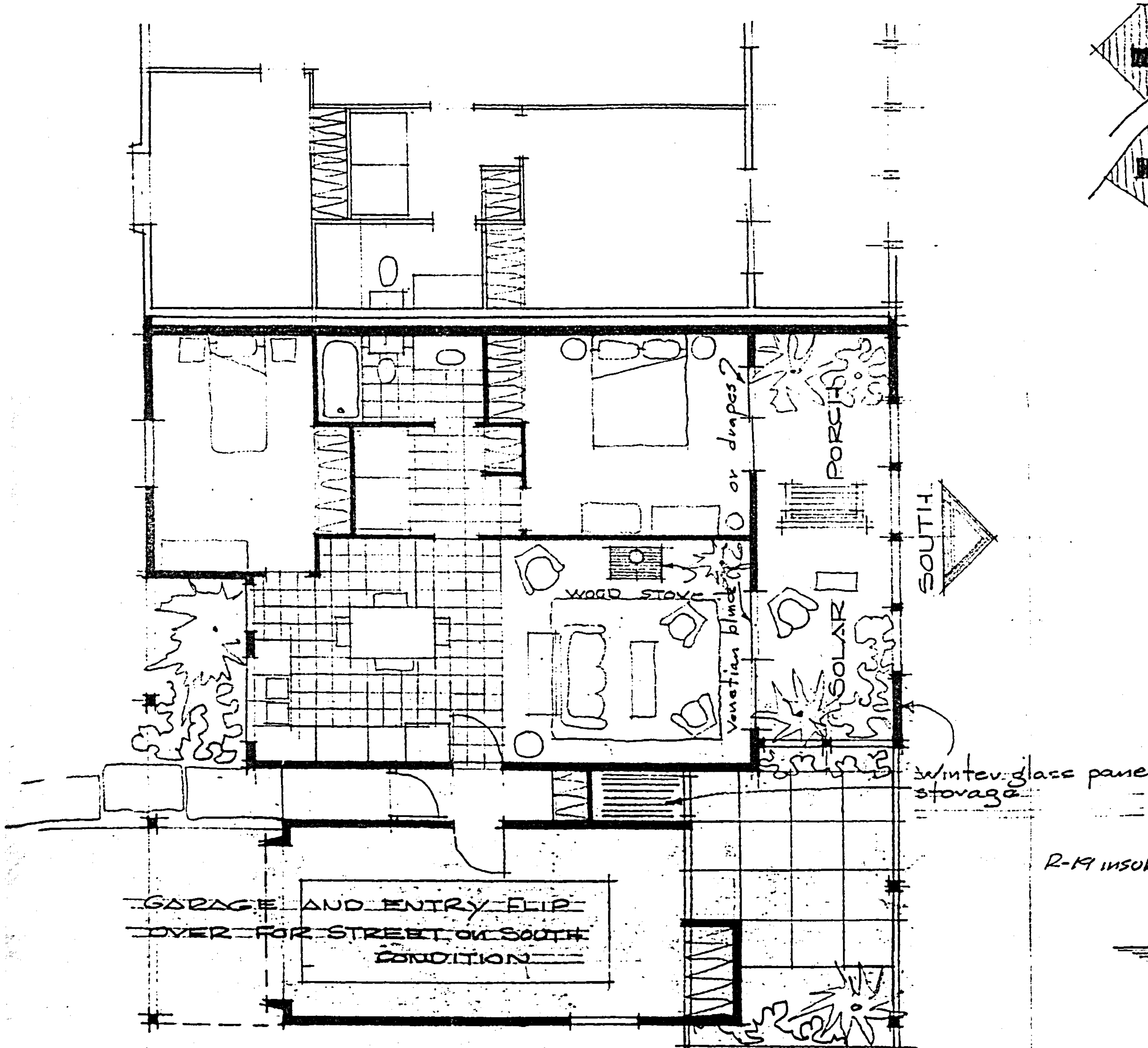
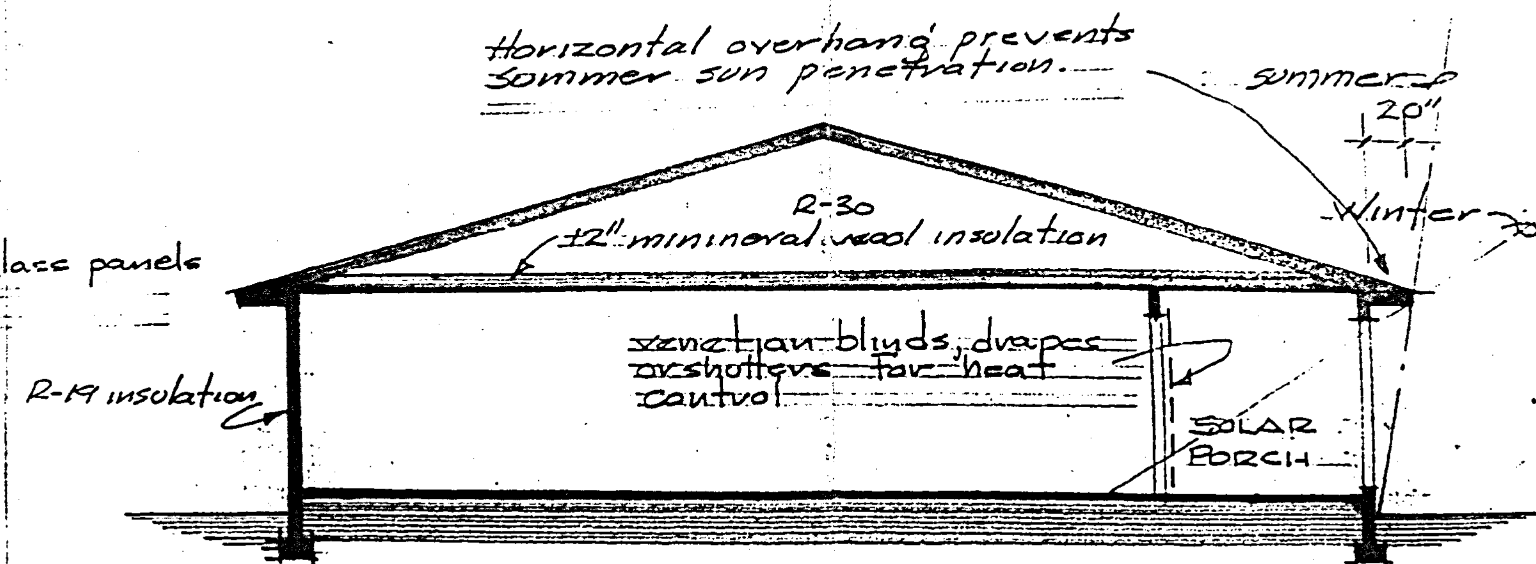




FLOOR PLAN

HEATED FLOOR AREA	884 SF
SOLAR PORCH AREA	192 SF
COLLECTOR AREA	96 SF
LCR	$= \frac{884\,(2.4)}{96} = 22$ ∴
SOLAR PERCENTAGE =	68 %



SECTION VIEW

SUNPORCH DIRECT GAIN DUPLEX DESIGN — STREET ON THE NORTH

PRESCOTT VALLEY

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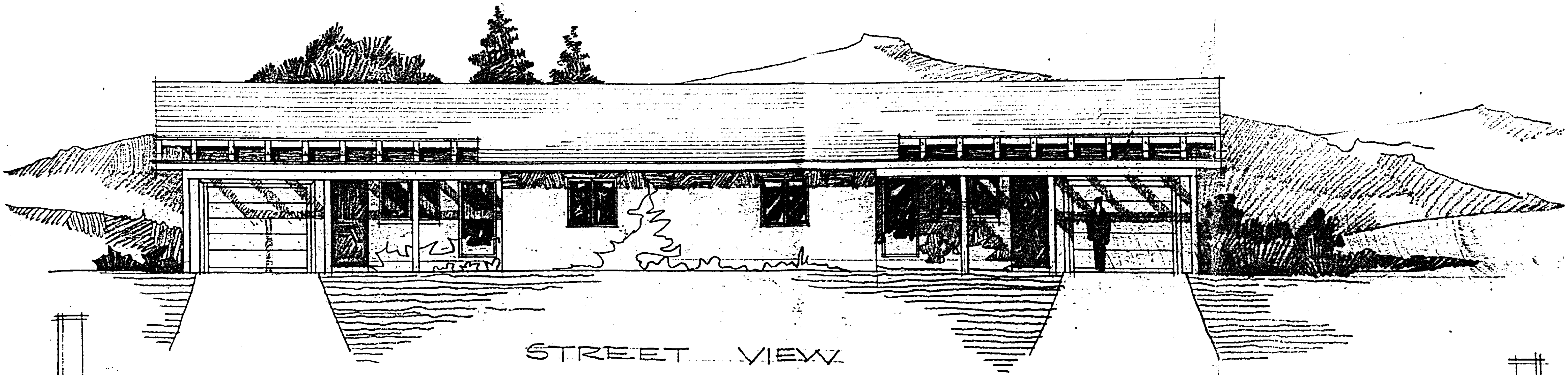
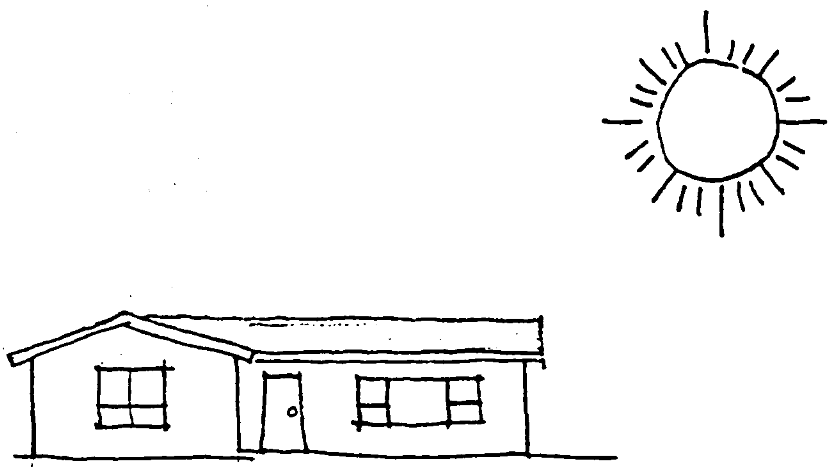


STREET VIEW

SUNPORCH DIRECT GAIN DUPLEX DESIGN STREET ON THE NORTH

SOLAR ANALYSIS
OF
PROPOSED
DESIGNS



HEAT LOSS

HEAT GAIN

FLOAT TEMPERATURE

I- PASS

LCR

BLC

ANNUAL %

A.S. Merker

SOLAR ANALYSIS METHODS AND PROCEDURES

We are all aware, in a general way, of the seasonal changes of the sun. Many are not, however, aware of the detailed nature of the changing sun angles relative to a building. The following diagrams and explanation will outline the major points involved and their meaning in the design of a solar home.

The high summer sun angle results in charging horizontal surfaces of the earth with heat stored in the earth's mass of earth, rock, and water. This charging of the earth's mass with heat results in a time delay of the seasons, making fall warmer for a longer period of time.

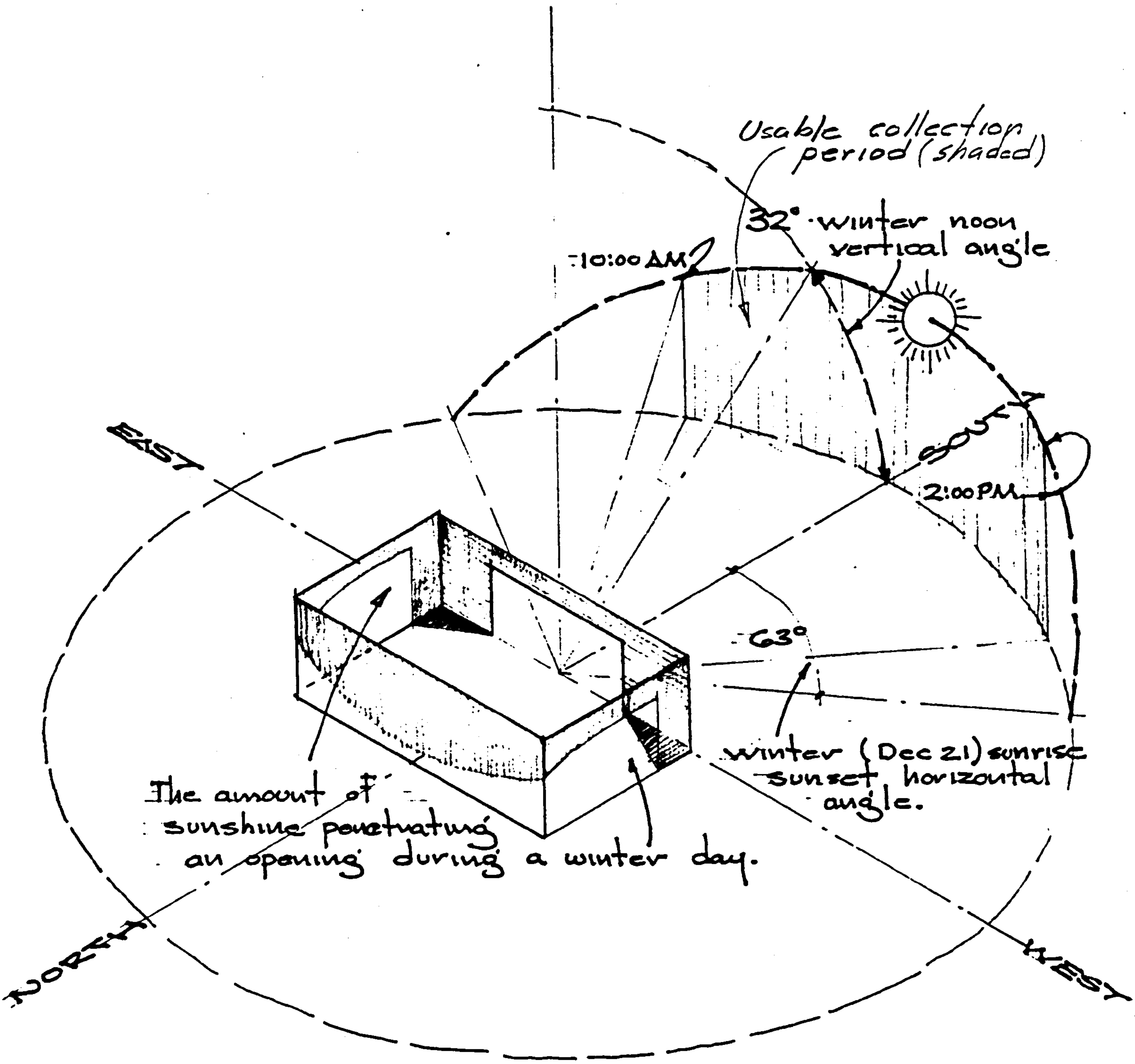
The relative low winter sun angles result in less warming of the earth's mass and cooler winter and spring weather. Vertical walls of a building can take advantage of the sun's habits to result in a heat gain during winter and the rejection of the sun's warming effect in summer.

The accompanying diagrams help to illustrate these phenomena in a more detailed fashion.

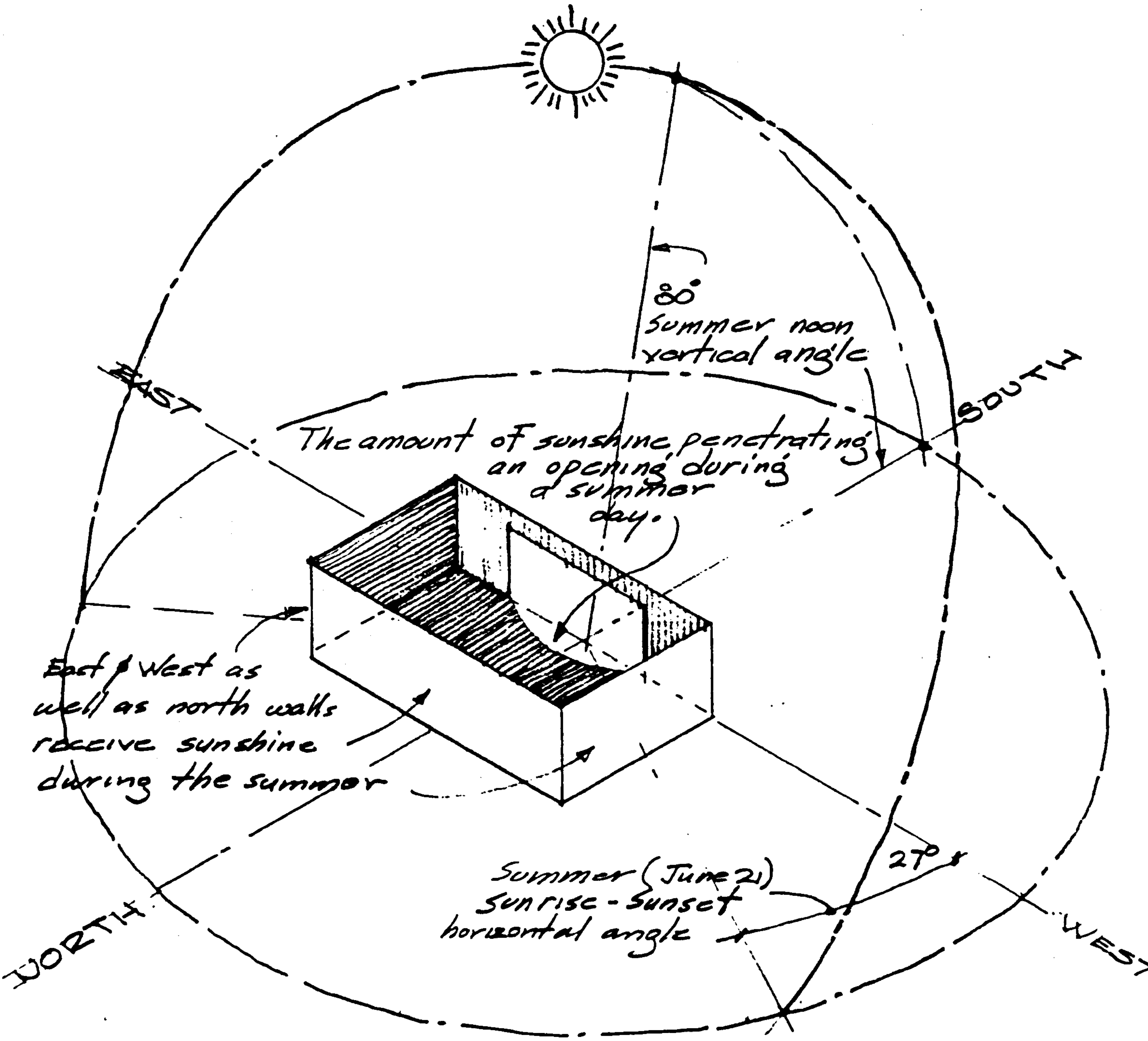
The objective of a passive solar design then would be to admit, through properly sized glazed openings, as much of the sun's heat as possible during the winter heating season and to reject as much as possible during summer when heating is not required. The diagrams illustrate the idea that south facing vertical openings allow a lot of sunlight to enter, while overhangs of the proper length will shade the high summer sun. Openings facing east and west, however, tend to admit too much sunlight during the longer summer mornings and afternoon, and do not help much during the winter midday sun period.

It should be noted that the early morning and afternoon angles of the sun during winter are so low that the sun's radiation must pass through a lot more of the earth's atmosphere, hence, reducing its effect.

For this reason the effective winter heating season is reduced to approximately 10:00 A.M. to 2:00 P.M. As previously noted the heating demand is less during fall months and greater during the spring months. Unfortunately, however, the sun angles are the same for both seasons, hence, a design that would collect sufficient heat from the sun for the spring periods would overheat a house during the fall.



THE WINTER SUN PATH



THE SUMMER SUN PATH

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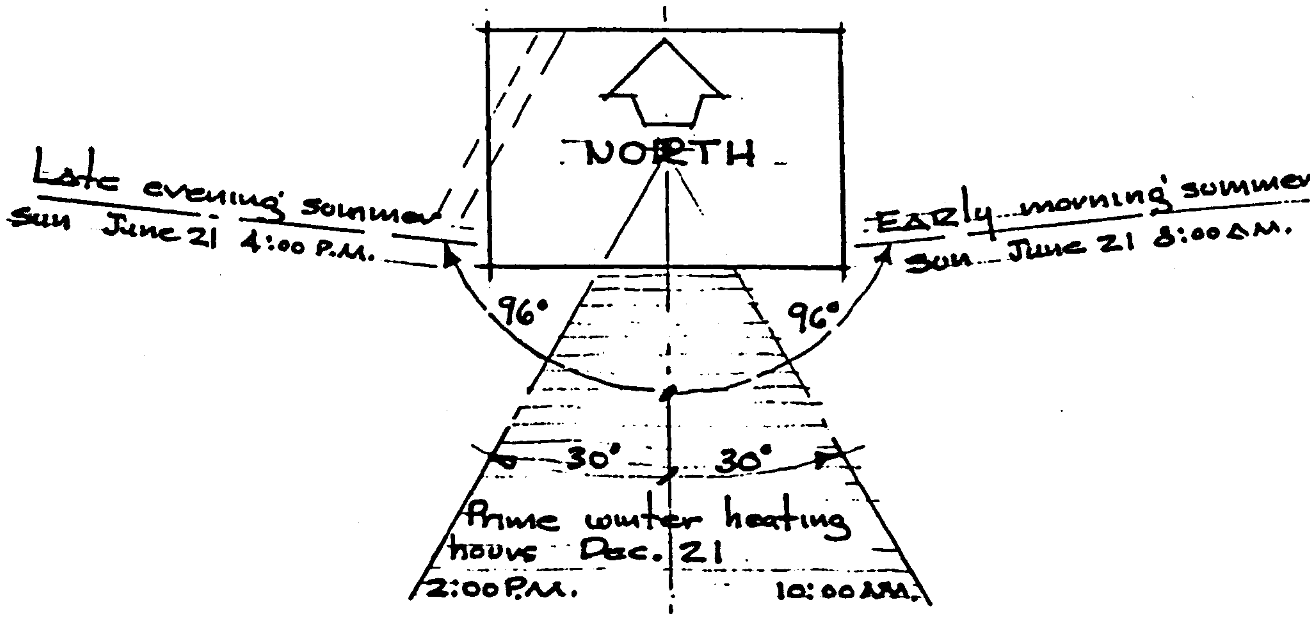


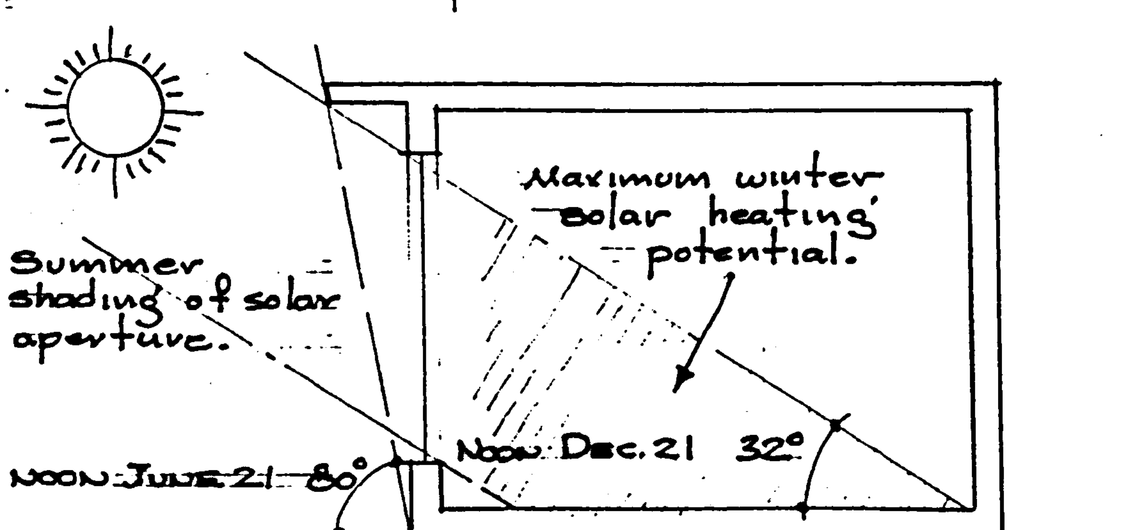
THE SUN PATH

HORIZONTAL ANGLES Summer & Winter

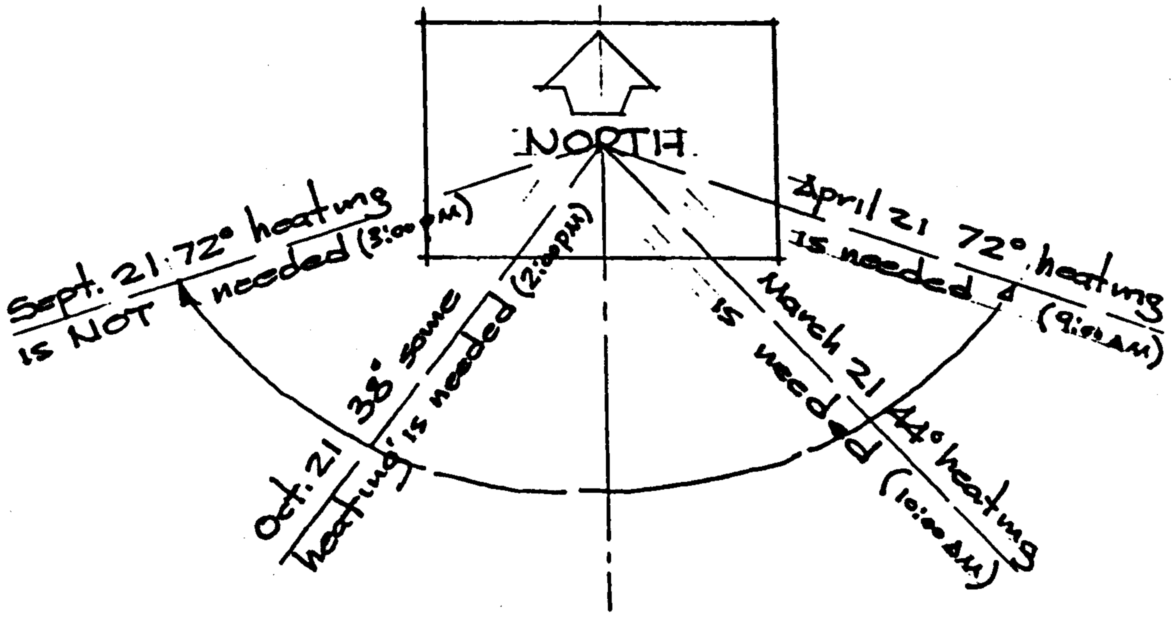
The extended horizontal angles of the summer sun produce undesirable glare and heat gains in the early morning and late afternoons.

These exposures should be designed so as to minimize the effect of the low summer sun to the east & west.

The radiation experienced on the north is not as damaging in Prescott as is the case in more southerly warm desert locations.



VERTICAL ANGLES Summer & Winter

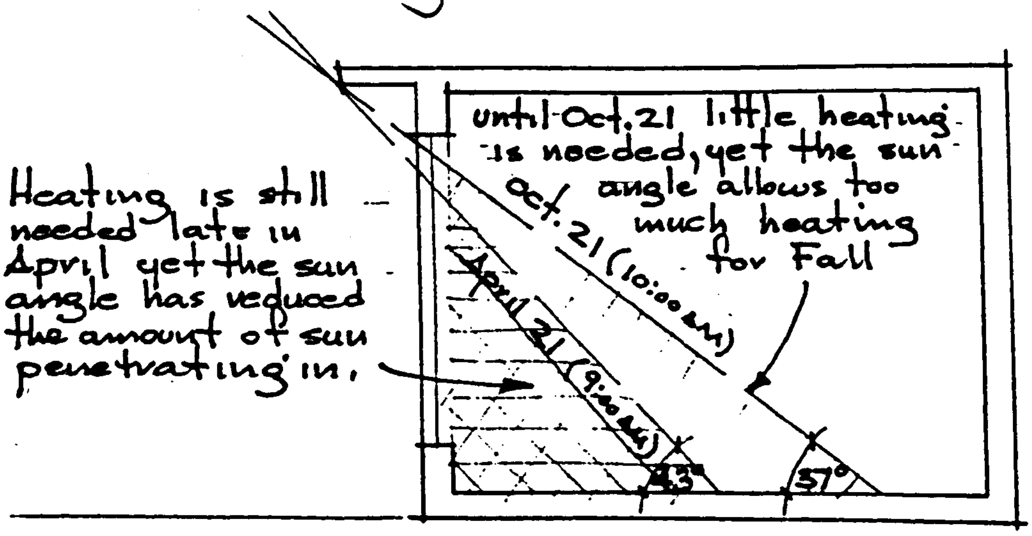


SPRING – FALL HORIZONTAL ANGLES

The warming effects of the low sun angles in the spring months are welcome.

The same warming effects of the low sun angles in the fall months are not welcome at all in the afternoon.

Landscaping or other such devices can be very helpful on the west when temperatures are higher. The early morning sun is often welcome during fall months in Prescott Valley.



VERTICAL ANGLES

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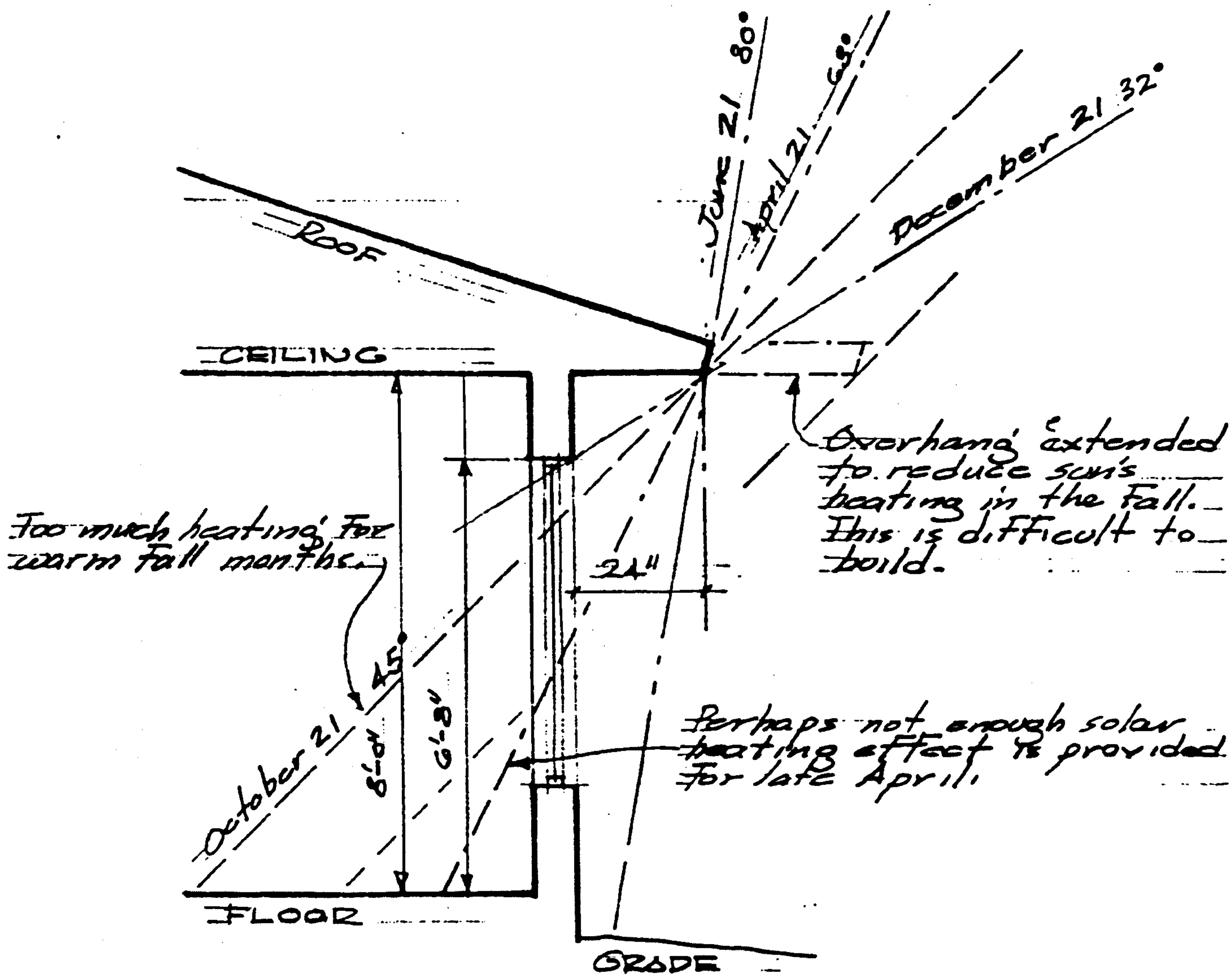


BUILDING SECTION SHOWING OVERHANG

The ideal design would be an adjustable overhang which could be extended in the Fall to reduce the solar gain when not needed and retracted in the spring when heating is required. This has been achieved but at such cost as to be prohibitive in this type of market.
Drapes & blinds would be a reasonable solution which would require that the occupant adjust same.

A.S. MERKER

I. Abundant solar insolation is available.

SOLAR DESIGN DATA

Prescott Arizona Latitude 34° 39′ North

Heating Degree Days:

July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	Total
0	0	27	245	579	797	865	711	605	360	158	15	4362

Average Daily Temperature

July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	Total
76	73	68	57	46	39	37	41	44	52	60	69	

South wall insolation BTU/SF-DAY

July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	Total
551	739	1156	1468	1506	1283	1399	1395	1273	948	614	458	

Percentage of Possible Sunshine

July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	Total
73	73	84	86	88	84	78	81	79	85	95	93	83

Sun Angles

	8AM	10AM	Noon	2PM	4PM
Oct. 21	63°/17°	38°/37°	0°/45°	38°/37°	63°/17°
Dec 21	53°/9°	30°/26°	0°/32°	30°/26°	53°/9°
Mar 21	72°/23°	44°/46°	0°/55°	44°/46°	72°/23°
June 21	96°/37°	76°/62°	0°/80°	76°/62°	96°/37°

Horizontal Angle

Vertical Angle

QUANTITATIVE SOLAR ANALYSIS

The heat loss-gain for the various designs have been determined gy using the ERLAB_REAGAN method for the TI-59 programmable calculator with printer.

The percent of solar is the percentage of heat loss for a total year which is made up by the heat gain from the solar collector areas. This figure has been determined by the "Semi- Empiricle" method developed by Wray-Balcomb-McFarland of L.A.S.L. The LCR (load collector ratio) is determined by

$$LCR = \frac{\text{BLC (building loss coeff.) in BTU/DD/SF of FLR. AREA}}{\text{SOLAR COLLECTION AREA in Sq. Ft.}}$$

$$BLC = \frac{\text{TOTAL HEAT LOSS in BTU/day}}{\text{FLOOR AREA} \times \Delta T \text{ in degrees F}}$$

The total heat loss can be obtained from the TI-59 tape sum for the 72° interior temperature and with no south collector glazing. Once BLC is determined then LCR can be calculated and read in the appropriate table supplied by the LASL method. One can interpolate and read directly the solar fraction which is then noted in the percentage form.

Four runs were made for each design on the TI-59

1. At 40° as the average winter day for Prescott Valley without any south glazing. This determines the total heat loss needed for BLC.

2. As designed using the total south collection area determined in the design process. Usually this would indicate an over heating situation of some magnitude noted on the TI-59 tape by I PASS temperature + the 40° assumed for Prscott Valley.

3. Optimum: This third run was made to determine what collector area would produce the desired 72° interior float temperature. By this process cut & try it was finally determined that by using CYPNL * (32) * (0.67) would produce a south collection area which wuold not over-heat the house. (32° is a standard 4'x8' collector)

4. Cold winter day: This run on the TI-59 was made by using 25° as the average outside temp. A few TETD's had to be changed also to reflect the new 25° temperature. This run produced a

new I PASS which, when added to 25°, produced the minimum temperature which could be expected dueing a severe winter storm condition.

This explanation is provided such that anyone who wishes to know how this part of the work was accomplished can do so.

For most readers, however, all that is important is to undrstand the results.

The No. 1. run on the TI-59 calculator gives an idea of what the inside temperature would be on an average winter day without any solar gain. This temperature falls in the 50°s for all designs. Also the designer can now determine the proper or optimum collector area for maintaining an inside temperatuer of 72° during this average winter day.

The No.2. run on the calculator indicates to the designer how far off the mark he was with the design rule of thumb sizings for required collector area. Decisions can now be made as to whether collector area should be reduced to prevent overheating, or whether additional mass storage area should be incorporated inorder to moderate the overheating and store heat for the night time or cloudy days. This will result in increasing the percentage of annual solar participation.

The No.3. run uses the reduced or increased collection area thought to be optimum and if I PASS + 40°= 72° then the optimum is close at hand.

The NO.4. run indicates that a severe winter day would put inside temperatures into the 55°-66° range and would necessitate the use of a backup heating system if thie were too cold.

Data for these calculations for each of the designs is tabulated in a table form for the purposes of direct comparison.

PRESCOTT VALLEY

SOLAR FRACTION CALCULATIONS

CLEARVIEW CLERESTORY:

Heat Loss = 170,280 BTU/day $\Delta T = 32°$

$$BLC = \frac{170,280}{1487(32)} = 3.57 \quad LCR = \frac{(1487)(3.57)}{182} = 29.2$$

SOLAR FRACTION = 62 %

TROMBE WALL:

Heat Loss = 108,450 BTU/day $\Delta T = 32°$

$$BLC = \frac{108,450}{1388(32)} = 2.44 \quad LCR = \frac{1388(2.44)}{163} = 20.77$$

SOLAR FRACTION = 68 %

TWO STORY SUNSPACE:

Heat Loss = 190,041 BTU/day $\Delta T = 32°$

$$BLC = \frac{190,041}{1596(32)} = 3.7 \quad LCR = \frac{1596(3.7)}{400} = 14.8$$

SOLAR FRACTION = 73 %

BUILDER RETROFIT 1250:

Heat Loss = 116,000 BTU/day $\Delta T = 32°$

$$BLC = \frac{116,000}{1250(32)} = 2.79 \quad LCR = \frac{1250(2.8)}{152} = 24$$

SOLAR FRACTION = 66 %

BUILDER RETROFIT 1176:

Heat Loss = 122,333 BTU/day $\Delta T = 32°$

$$BLC = \frac{122,333}{1176(32)} = 2.97 \quad LCR = \frac{1176(2.97)}{156} = 24.5$$

SOLAR FRACTION = 66%

PRESCOTT VALLEY

SUNSPACES :

Heat Loss = 161,955 BTU/day $\Delta T = 32°$

$BLC = \frac{161{,}955}{1464(32°)} = 3.45$ $LCR = \frac{1464(3.45)}{171} = 29.5$

SOLAR FRACTION = 62 %

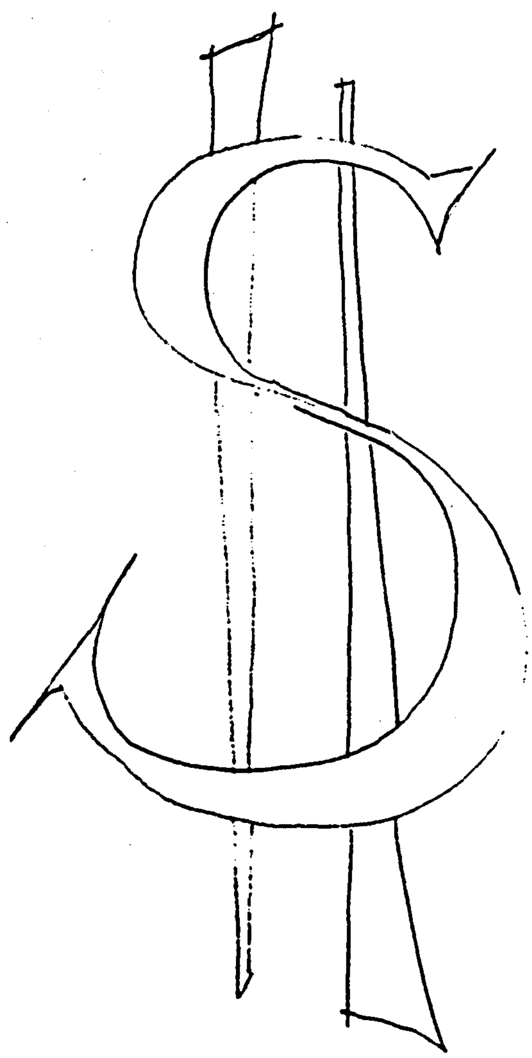
DUPLEX SUNPORCH :

Heat Loss = 66,349 BTU/day $\Delta T = 32°$

$BLC = \frac{66{,}349}{884(32°)} = 2.35$ $LCR = \frac{884(2.35)}{96} = 21.6$

SOLAR FRACTION = 68% (62% @ 70SF collector)

ECONOMIC ANALYSIS
OF
PROPOSED DESIGNS



A.S. Merker

ECONOMIC ANALYSIS PROCEDURE:

The estimates of cost were prepared using the Marshall-Stevens Valuation Service which the author has used with excellent results for some 15 years. This service provides a monthly update of costs and a correction factor for location. The author wrote a computer program which accepts input data then calculates all values and provides the printed data summary sheet.

Costs, not including land, have been determined as of May 1982 for each design including separate cost factors for elements of the design which would be considered solar. These two figures provide a means of determining the percentage of cost attributable to solar.

This percentage of cost attributable to solar reveals that the more intricate designs of the hybrid type using fans-ducts and rockbed storage provide some increase in the annual solar percentage at a rapidly increasing rate of cost. In general, it would appear that to achieve 65% solar contribution would cost about 6% of the total construction budget. Beyond this point the law of diminishing returns comes into play in a serious way. Attempts to increase the collection area of glazing begins to cause overheating which must then be moderated by taking some heat into rockbin storage for use at night and on cloudy days. An increase of 10% above the 65% solar contribution about doubles the cost of solar installation.

The solar savings of the annual heating cost is determined by calculating the total annual heating load then calculating the percentage attributable to solar by using the previously determined percent of solar. This figure was then converted to kilowatt hours and priced by using the current rate in Prescott Valley for electric power which is $0.05/kwh.

The total cost for installing the solar features was then divided by the solar saving of heating cost to arrive at the number of years required to pay for the cost of installation.

It could be argued that this is a much too simplistic method, however, the formulas used by economists and others which account for interest, inflation, operating and maintenance costs require that considerable speculation be done in order to arrive at rates for these factors. Most guesses at these figures are arrived at by extrapolating past figures into the future. No one knows what inflation and interest rates will be 10, 20 or 30 years from now. It is just as accurate to assume now, that for the future, interest will be cancelled out by inflation.

For these reasons the simple direct method used here was chosen in order to appraise the relative effectiveness of the solar application.

COST ESTIMATING PROGRAM BY KIP MERKER

SOLAR PORCH — COST ESTIMATE DATA — MAY 10, 1982

CATEGORY	UNIT COST	DIF NO	AREA	TOTAL COST
EXCAVATION	0.45	1	184	83
FOUNDATION	0.64	1	184	118
FRAME	0	0	184	0
FLOOR STRUCTURE	1.52	1	184	280
FLOOR COVER	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
CEILINGS	1	1	184	184
	0	0	0	0
	0	0	0	0
	0	0	0	0
INTERIOR CONSTRUCTION	0	0	184	0
PLUMBING	0	0	184	0
SPRINKLERS	0	0	184	0
HEATING-COOLING	0	0	184	0
ELECTRICAL	0.5	1	184	92
EXTERIOR WALL	6.16	1	248	1528
	0	0	0	0
	0	0	0	0
	0	0	0	0
ROOF STRUCTURE	2.4	1	246	590
ROOF COVER	0.49	1	246	121
0	0	0	0	0
0	0	0	0	0
CL FACTOR = 1	16.28			2996
	COST/S.F.			TOTAL COST

COST ESTIMATING PROGRAM BY KIP MERKER

GARAGE — COST ESTIMATE DATA — MAY 10, 1982

CATEGORY	UNIT COST	DIF NO	AREA	TOTAL COST
EXCAVATION	0.45	1	300	135
FOUNDATION	0.64	1	300	192
FRAME	0	0	300	0
FLOOR STRUCTURE	1.52	1	300	456
FLOOR COVER	0	0	300	0
	0	0	0	0
	0	0	0	0
	0	0	0	0
CEILINGS	0	0	300	0
	0	0	0	0
	0	0	0	0
	0	0	0	0
INTERIOR CONSTRUCTION	0.98	1	300	294
PLUMBING	0	0	300	0
SPRINKLERS	0	0	300	0
HEATING-COOLING	0	0	300	0
ELECTRICAL	0.5	1	300	150
EXTERIOR WALL	0	0	0	0
6" STUD/WOOD SIDING	4.78	1	360	1721
0	0	0	0	0
0	0	0	0	0
ROOF STRUCTURE	2.4	1	390	936
ROOF COVER	0.49	1	390	191
ELECTRIC DOOR	1000	1	1	1000
0	0	0	0	0
CL FACTOR = 1	16.92			5075
	COST/S.F.			TOTAL COST

ESTIMATES OF SOLAR COSTS - 1

BUILDER DESIGN SOLAR RETROFIT 1284:

SOLAR PORCH	$2996.00
CLEARVIEW COLLECTOR 20SF (cost in addition to standard window)	104.00
	$3100.00

BUILDER DESIGN SOLAR RETROFIT 12968

SOLAR PORCH	3207.00
CLEARVIEW COLLECTOR 20SF (cost in addition to standard window)	100.00
	$3300.00

TROMBE WALL DESIGN:

COLLECTOR GLAZING 163SF @ 10.00	= 1630.00
TROMBE MASONRY STORAGE WALL 163SF @ 8.00	= 1304.00
	2934.00

TWO STORY SUNSPACE DESIGN:

SOLAR PORCH & SUNSPACE	= 7619.00
DUCT RUNS HORIZ. & VERT. 86 LF of Furred channel @ 2.00	= 180.00
ROCK BED 1000SF @ 3.3	= 3326.00
FANS (w/ thermostat controls 2 @ 150.00	= 300.00
	$11425.00

ESTIMATES OF SOLAR COSTS - 2

CLEARVIEW-CLERESTORY "A" DESIGN:

% SOLAR WITH STORAGE 62%	SOLAR PORCH (see computer estimate)	= $1661.00
	CLEARSTORY	= 452.00
	ROCK BED STORAGE 672 SF @ 3.3	= ~~2210.00~~ DEL
	CLEARVIEW COLLECTORS 80 SF @ 10.5	= 714.00
	DUCTWORK (underfloor) 36 LF @ 3.00	= ~~108.00~~ DEL
	FAN (with controls installed) 1 @ 150.00	= ~~150.00~~ DEL
		$2827.00 ✓

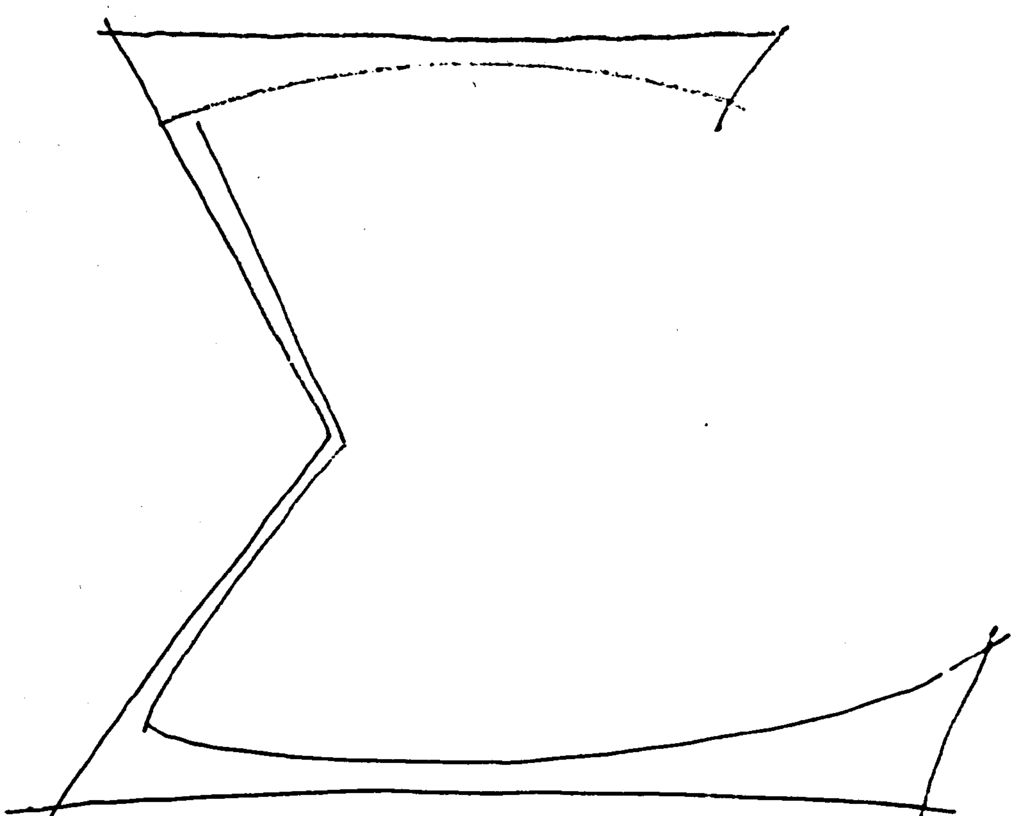
SUN PORCH DUPLEX DESIGN:

% SOLAR WITH STORAGE 68%	SOLAR PORCH	= $3126.00
	ROCKBED STORAGE 486 @ 3.3	= ~~1604.00~~ DEL.
	DUCTWORK UNDERFLOOR 2 @ 20' = 40 LF @ 3.00	= ~~120.00~~ DEL.
	FANS (with controls installed) 2 @ 150.00	= ~~300.00~~ DEL.
	ATTIC DUCTWORK 36 LF (Furred channel insulated) @ 2.00	= ~~72.00~~ DEL.
		$3126.00 ✓

SUNSPACES DESIGN:

% SOLAR WITH STORAGE 62%	SUNSPACE (see computer estimate)	= $5047.00 ✓
	CLEARSTORY 24 SF @ 10.5	= 252.00 ✓
	ROCKBED HEAT STORAGE (see computer estimate)	= ~~1901.00~~ DEL.
	DUCTWORK UNDERFLOOR 2 @ 20' = 40 LF @ 3.00	= ~~120.00~~ DEL.
	FANS (with controls installed) 2 @ 150.00	= 300.00 DEL.
		$5299.00 ✓

GENERAL SUMMARY



GENERAL SUMMARY:

The general rules of thumb as suggested by Mazria for the sizing of collector areas appear to be too generous for the Prescott Valley area. The collector area had to be reduced for all designs as the TI-59 calculation revealed a severe overheating problem. No storage except the mass of the house itself was incorporated into the designs except for the two story sun space design. The collector area was not reduced for this design.

This master's project has revealed that a solar design can be developed and quantified without the use of computers and other expensive equipment and methods. The TI-59 calculator and program were helpful but are not crucial to the process. The heat loss for a particular house can be determined by the long hand method and applied. It would not be too difficult to determine the float temperature by working backwards through the heat loss formula.

$$\text{Heat Loss} = U \times A \times (Ti-To)$$

When factors of cost comparison are introduced the problem becomes much more complicated, and one is reduced to the old methods of design and change until a satisfactory design is arrived at. Some important guidelines can be established however, from the experience with this project.

1. The simpler the idea and its execution the more effective it will be in terms of cost.

2. For Prescott Valley a total south collector area of 12% of the heated floor area will result in a relatively effective design which will produce approximately 65% solar fraction.

3. A well insulated envelope is the first and most effective step.

4. An air tight, or as close thereto, and well constructed building will provide an envelope which will be a most cost effective step.

5. The type of solar design should be selected which will provide the greatest degree of control for the resident. Control in passive solar design is not automatic (i.e. thremostat) The new owner will have to be educated in the ways and means of how to control overheating and underheating.

6. Difficult siting problems such as those encountered in Prescott Valley are not sufficient reason to abandon solad design.

7. Passive solar design is cost effective when compared to electric in the mild climates of the plateau areas of the southwestern United States.

8. For low cost subdivision housing it is probably not cost effective to attempt to incorporate rockbeds or other heat storage devices.

COMPARATIVE SOLAR AND COST DATA FOR PROPOSED DESIGNS

TWO STORY SUN SPACE	DUPLEX SUN PORCH	BUILDER RETROFIT 1176	BUILDER RETROFIT 1250	TROMBE WALL DESIGN	SUN SPACES DESIGN	CLEAR VIEW CLERE STORY	
1596 SF	884 SF	1176 SF	1250 SF	1388 SF	1464 SF	1487 SF	FLOOR AREA
$71245	$40009	$44463	$47762	$54573	$57239	$55481	TOTAL COST
$11430	$3120	$3300	$3300	$2930	$5300	$2827	SOLAR COST
16%	8%	6%	6%	5%	9%	5%	SOLAR COST AS % OF TOTAL COST
73%	68%	66%	66%	68%	62%	62%	PERCENT SOLAR
CLOSE OFF SUNSPACE	CLOSE OFF PORCH	CLOSE OFF PORCH	CLOSE OFF PORCH	NONE	CLOSE OFF SUNSPACES	VENETIAN BLIND	CONTROL
	SPRING FALL	SPRING FALL	SPRING FALL	FALL	SPRING FALL	SPRING FALL	OVERHEATING
190,000	66,300	122,000	116,000	108,500	162,000	170,300	HEAT LOSS @ 40° OUTSIDE TEMP. BTU/DAY
85°	76°	75°	75°	72°	72°	72°	FLOAT TEMP @ 40° AVG. WINTER DAY
66°	57°	60°	60°	62°	55°	57°	FLOAT TEMP @ 25° COLD WINTER DAY
400 SF	96 SF	156 SF	152 SF	163 SF	171 SF	182 SF	COLLECTOR AREA
800 FT³ ROCKBED	NONE	NONE	NONE	163 SF of 12" MAS. WALL	NONE	NONE	STORAGE
.25	.11	.12	.12	.12	.12	.12	COLLECTOR AREA / FLOOR AREA
$573.00/YR	$102.00	$180.00	$170.00	$167.00	$225.00	$222.00/YR	SOLAR SAVING OF ANNUAL HEATING COST
20	30.7	17.2	19.4	17.5	23.6	12.7	YEARS REQUIRED TO PAY FOR SOLAR COST

APPENDIX

A.S. Merker

A GLOSSARY OF TERMS:

1. ABSORBER: That portion of a solar system which is struck by the sun's rays and which in turn converts the rays into infrared radiation or heat.

2. ACTIVE: Performed with supplemental motive power such as fans, pumps, furnaces, boilers.

3. CLEARVIEW: A solar collector consisting of glass, an air space with a venetian blind suspended in the air space, and another layer of glass on the interior. This system was developed by the Environmental Research Laboratory of the University of Arizona.

4. CLERESTORY: That part of a roof which rises above the other parts and has glazed openings to admit the sun.

5. COLLECTOR: The part of a solar system which collects the sun's rays.

6. CONVECTION: Transference of heat by moving masses of matter such as air.

7. DEGREE-DAY: A unit representing one degree of inclination from a given point (as 65) in the mean outdoor temperature for one day.

8. DIFFUSING GLAZING: A type of material which is transparent to the sun's rays but which in turn converts the rays into infrared radiation or heat.

9. DIURNAL: Cyclic, from day to night.

10. ENVELOPE: The walls, floor, roof, etc. which encloses the building. A particular type of passive solar design wherein the envelope is used to receive and store heat.

11. FLOAT TEMPERATURE: The temperature that will result inside a building if losses and gains are allowed to come into balance.

12. HYBRID: A cross between different varieties. Partly active and partly passive.

13. INSULATION: Solar radiation received by the surface of the earth.

14. NIGHT INSULATION: Panels, drapes, shutters, etc. which are removable during sun light hours, but which can be put in place at night in order to prevent heat loss.

15. OVERHANG: An extended roof eave or other projection which shades the wall or opening below from the direct rays of the sun.

16. PASSIVE: Inactive. Performed without motive power.

17. RADIATION: The process by which energy is emitted from molecules and atoms owing to internal changes. The heat felt from a warm surface.

18. REFLECTORS: Surfaces which have been made metallic or shiny so as to bounce the sun's rays off of the surface and on to another.

19. SOLAR: Of or pertaining to the sun. Heating provided by the sun.

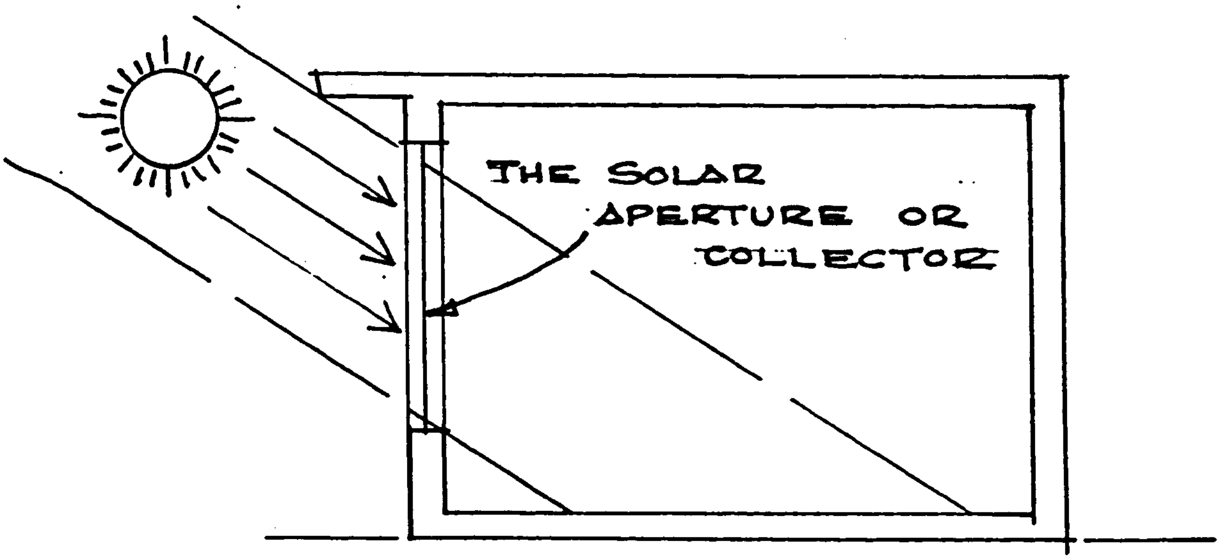
20. SOLAR APERATURE: A wall, clerestory, or roof opening which admits the sun's rays.

21. SOLAR CONTRIBUTION: The amount of the total heat loss of a building for one year, which is made up by solar heat gain. Usually expressed as a percentage of the total heat loss.

22. TROMBE: A solar heating system consisting of glass, an air space, and a masonry wall. This system was invented by a Frenchman named Trombe.

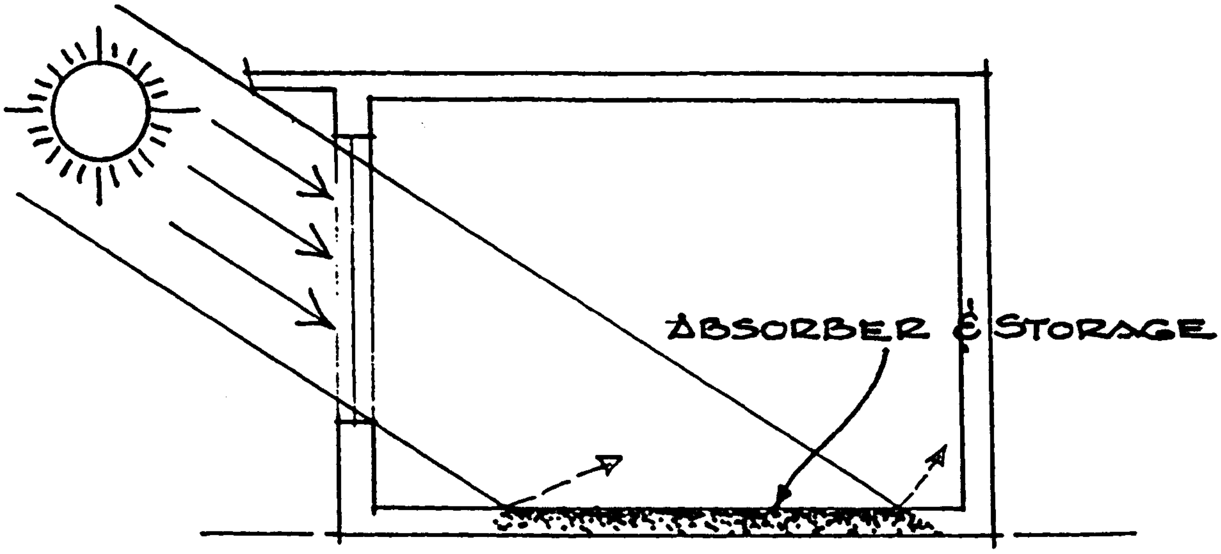
23. ULTRAVIOLET DEGRADATION: The deterioration of materials, surfaces, colors as a result of the sun's rays caused by the ultraviolet frequency spectrum.

-A.S. MERKER



THE SOLAR APERTURE OR COLLECTOR

The purpose of the collector is to admit the sun's radiation into the space to be heated. Solar radiation upon striking a solid surface is either absorbed or reflected. Fortunately, one exception to this phenomenon is a family of materials such as glass which allows solar radiation to pass through relatively unchanged. Solar radiation which is absorbed is converted in frequency into the infrared range. This infrared frequency range is what we know as heat. Fortunately again the (infrared) heat frequency range does not as readily pass back out through the glazing surface. Thus heat is trapped inside the space resulting in what is known as the "Greenhouse effect".



THE ABSORBER AND STORAGE

In many passive solar designs the absorber surface and heat sink or storage are combined in the same material. This combination allows simpler and less expensive systems to be built. When diffusing glazing is used the sun's radiation is scattered and hence is spread over a larger area of the absorber storage surface. The same amount of heat is spread over a larger area, thus enhancing distribution and lowering storage temperatures. Several advantages accrue from this happening. Glare is reduced within the space, lower storage temperatures ultimately result in lower heat losses back out through the building envelope, and the spreading effect results in more even distribution of heat throughout the living space.

A.S. Marker

STORAGE

In general the heavier a material is the better it functions as storage for heat. Masonry and concrete store more heat than wood. Water stores more heat per unit of volume than concrete. It also gains and loses heat faster than concrete. Rocks are good for storing heat. There are on the market today new materials for heat storage which involve phase changes (liquid to a solid), however, costs are still relatively high.

These simple phenomena and systems, however, do not allow as much control over how much heat is gathered where. It is stored, and when the heat is made available the result is often too much heat during the day and too little during sunless hours such as night time. Hence, from this point on we make different and more complicated configurations in an attempt to gain control over when we want heat and where we want it. This situation is further complicated by exterior weather phenomenon which produces fluctuating temperatures, relative humidity and wind, resulting in human discomfort. The effort to design enclosures which balance the effects of these complications, natural phenomenon, with even steady human comfort as the result is known as solar design. To do this without mechanical energy using devices is passive solar design. Perhaps the intelligent compromise is to use a minimum of mechanical devices in order to gain optimum distribution and timing control. These systems are called hybrid designs. The other extreme end of this situation is commonly known as active solar design. This study will concern itself with passive and hybrid systems in an effort to produce the optimum situation of comfort and, at the same time, the lowest first cost as well as reduced operational costs.

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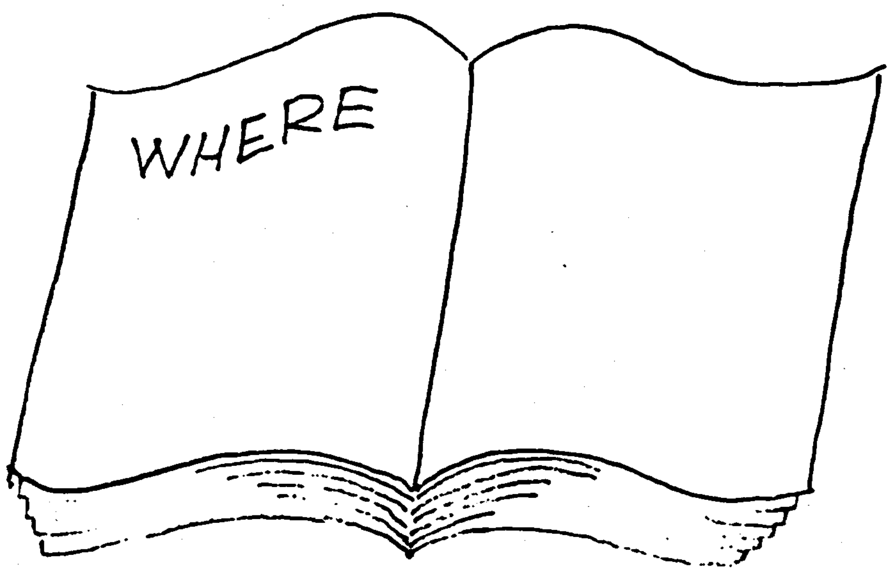

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