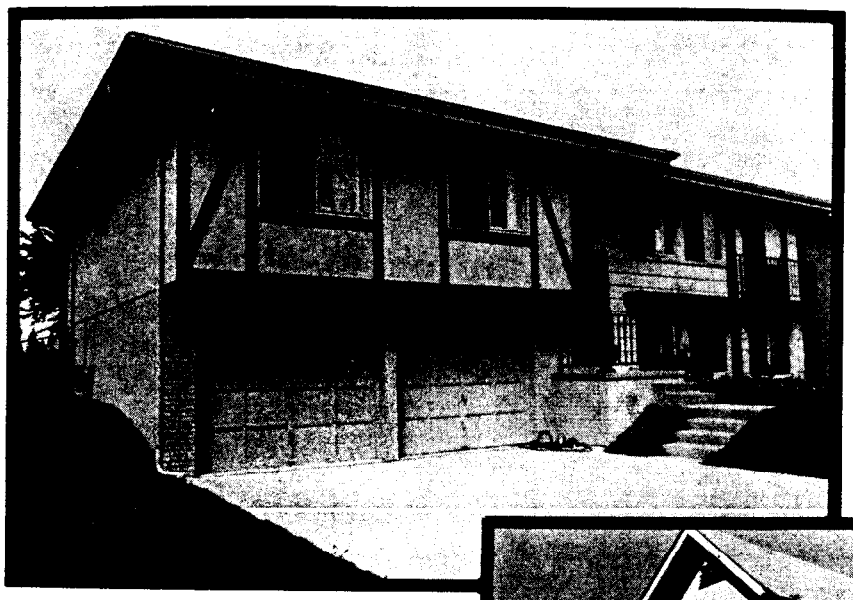
RESIDENTIAL SOLAR ARCHITECTURE

A REPRESENTATIONAL INVENTORY



STATE OF NEBRASKA

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NEBRASKA RESIDENTIAL SOLAR ARCHITECTURE

A REPRESENTATIVE INVENTORY

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OMAHA, NEBRASKA

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This book is dedicated to the modern day pioneers who are building an energy efficient future.

ACKNOWLEDGMENTS

It is not possible to undertake and complete a project like this inventory without the help of many people, and I would like to recognize and thank them.

I am grateful for the kind cooperation and the generous contributions of the homeowners who granted permission for the inclusion of their homes and the design professionals, builders, and others who provided the invaluable information that made this book possible.

The Nebraska Energy Office is cited for their support in funding this project and providing the design for the cover of this book.

I thank those who contributed the photos for this effort, particularly Robert Youngberg, Keith Pedersen, and Russ Sandstead.

Several of those who worked on the PATH TO PASSIVE made monumental contributions once again. Kevin Garey and Doug Shapland with assistance from Brian Porter are responsible for the layout, drawings, and floor plans. Debra Stangl and Allan Ziebarth have again served to edit my rather random writings.

Finally, a good portion of the body of knowledge in passive solar energy is due in great part to the labors of volunteer faculty and student support by the past and present members of the Passive Solar Research Group (PSRG). Among universities, Nebraska's is the most comprehensive passive solar test facility in the world today. Their reward, for the countless thousands of hours spent in toil and labor, is the knowledge that someday this effort may tip, even if ever so slightly, the equations which govern the future.

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PREFACE

Solar energy is TODAY and it is NOW! Those critics and self-styled experts who claim that decades of research are needed before solar energy can be practical or reliable are wrong. The projects chosen for this inventory represent a cross section -- types, cost, lifestyle, geography -- of the more than three hundred examples of energy efficient/solar homes in Nebraska. They demonstrate that not only is passive solar energy a practical and reliable source of home heating, but that there is a wide diversity of design application as well. Unfortunately, space does not permit us to present all of the fine efforts which have been undertaken during the past several years. Nonetheless, it is the sense of the tidal wave effect of the movement toward energy efficient home design which this book seeks to convey.

A century ago Nebraska's early settlers had to carve out a livelihood dictated by the harsh realities of their environment. The settlers survived the bitter winters because their homes -- "soddies", so-called because they were constructed of strips of earth, or sod -- had earth bermed on the north and west sides to keep out the winter winds and faced south to admit sunshine for light and warmth. The soddies also remained cool in summer because of the direct contact with the earth. The individuals whose homes are included in this inventory represent a rekindled spirit of independence and self-reliance of the pioneers of yesteryear. Each of the homes herein is a rousing and personal statement of energy independence.

One of the contributing homeowners to the inventory remarked that he could not understand how any home being built in Nebraska did not at least face south and incorporate minimal energy conservation techniques. With each new age emerge the "Noahs" who can observe the shifting tides of reality and take action. Therefore, it is the expressed intention of this book to provide a brief glimpse of how fifty modern day Noahs arrived at their "arks" of energy freedom.

The era of cheap, non-renewable fuels is drawing to a close. There will be many who fail to heed the warning signals -- already forgotten by many are the lessons of the 1973 Arab oil embargo, despite the fact that energy prices continue to rise. Survival is not a birthright; it is earned by vigilance, foresight, and action.

No in-depth analyses of the homes in this inventory are provided. Rather, the intention is to acquaint the reader with the wide diversity of approaches being taken by Nebraska homeowners. Similarly, there is no one single correct approach; given the opportunity to do so, many homeowners would now make some change in their design. The insights of the homeowner's experiences are shared with the reader whenever possible. It is hoped that a mosaic pattern of wisdom will be garnered by the reader as the homes are reviewed.

Solar energy fundamentals -- passive solar space heating, passive solar space cooling, active solar space heating, domestic water heating, superinsulation, earth sheltering, -- are covered in the introduction of this book. The discussion is non-technical and is intended to be introductory in nature. The reader is encouraged to obtain the companion to this book, "PATH TO PASSIVE: NEBRASKA'S PASSIVE SOLAR PRIMER", for further information on passive solar heating.

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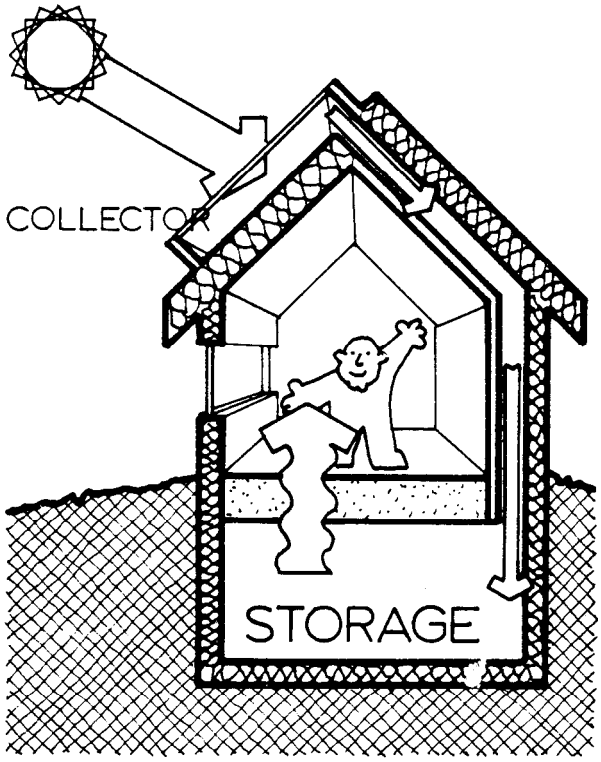
INTRODUCTION

The two principal solar heating methods for residential space heating and domestic water heating are passive solar (FIG 1) and active solar (FIG 2). Each method has its own unique characteristics and applications. Energy efficient homes frequently combine more than one solar heating technique, and these techniques are also often coupled with conservation strategies such as earth sheltering (FIG 3) and superinsulation (FIG 4).

SPACE HEATING: PASSIVE SOLAR

The passive solar space heating techniques are direct gain, Trombe wall, greenhouse, double shell, thermosiphon, and roof pond. Passive solar heated buildings are oriented so that the majority of windows face south, and the structure itself acts as a collector. Building mass such as tile floors and brick walls absorb and store the solar heat which is released when interior air temperatures drop after the sun sets.



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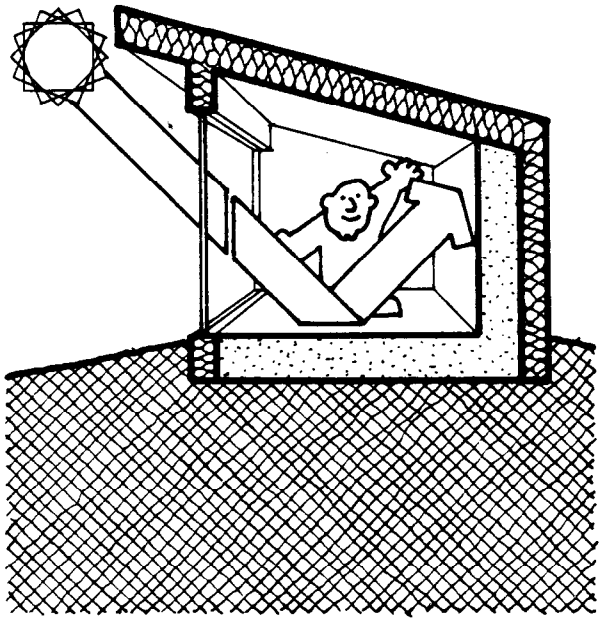

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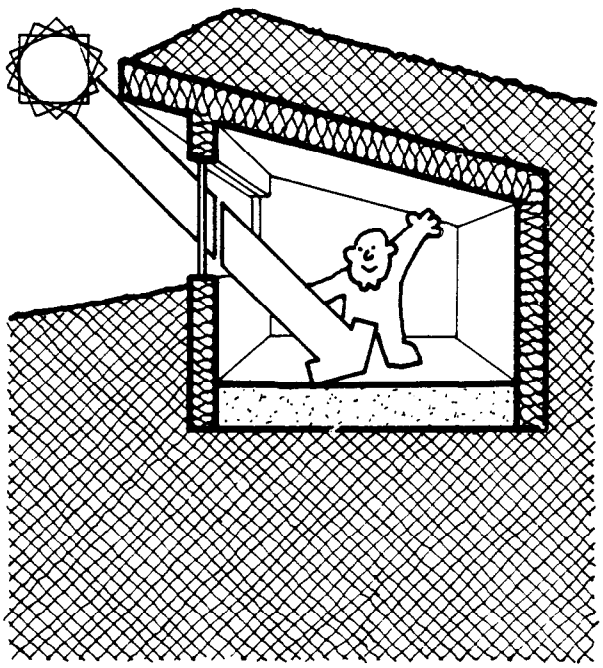

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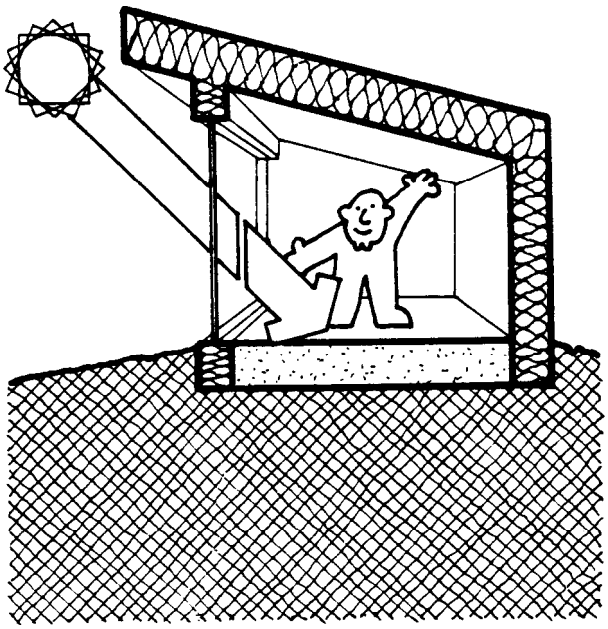

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Direct Gain

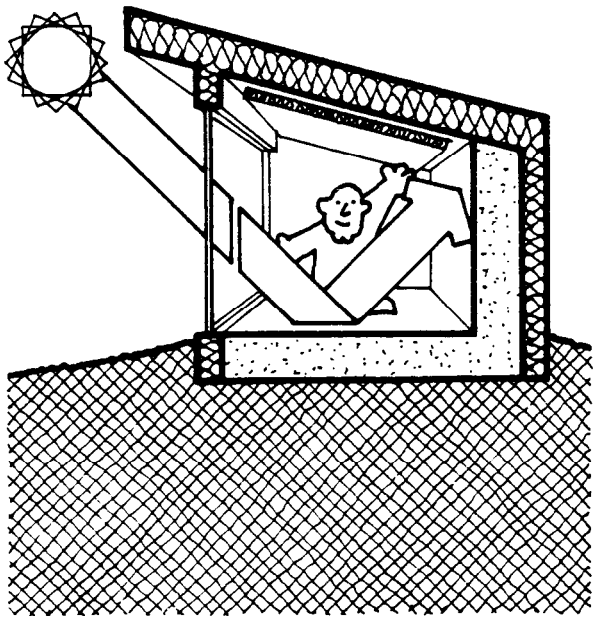
In a direct gain structure (FIG 5), sunlight shines directly into the building where walls, floors, and other mass storage are heated. When room temperatures drop after the sun sets, heat stored in the mass radiates to the living spaces. The use of night shutters is strongly recommended to help reduce heat loss to the outdoors through windows. Although direct gain systems are relatively economical and easy to build, buildings using direct gain must be carefully designed to avoid winter overheating.

Trombe Wall (Thermal Storage Wall)

The Trombe wall (FIG 6), or thermal storage wall, is a heat storage medium located directly behind south facing glass. The sun's rays are absorbed by the mass, and the heat slowly conducts through the mass and radiates to the living space. Concrete, brick, stone, and water are common Trombe wall materials. The absorbing surface of the storage system is frequently painted a dark color to better absorb sunlight. Buildings with Trombe walls tend to have stable temperatures without the extreme temperature fluctuations associated with direct gain systems.

Solar Greenhouse (Sunspace)

Solar greenhouses (FIG 7), or sunspaces, are a very popular passive solar space heating technique, particularly in retrofitting existing homes. They provide additional living space and can act as a buffer between the interior of the home and the outdoors. During sunny weather, warmed sunspace air is drawn through open windows, doors, and vents to heat the interior of the home. Thermal mass -- in the form of brick or tile floors, and walls of brick and/or water containers -- will often be included in a sunspace.



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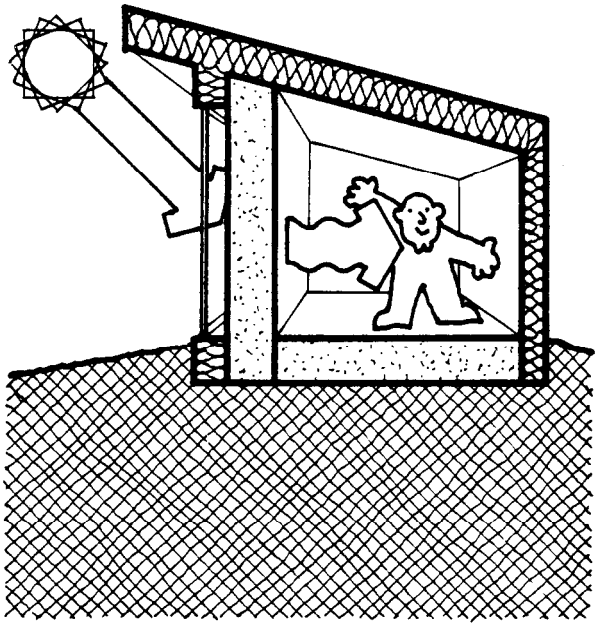
Double Shell (Continuous Thermal Envelope)

The double shell (FIG 8), or continuous thermal envelope, is essentially a house within a house, with the outer shell enclosing a sunspace. During the day, heated air from the sunspace rises into the plenum between the inner and outer walls, and the slowly migrating column of warm air circulates around the plenum chamber warming the inner walls. At night the air flow direction is reversed because the plenum air is warmed by an upward migration of heat from the earth beneath the home.



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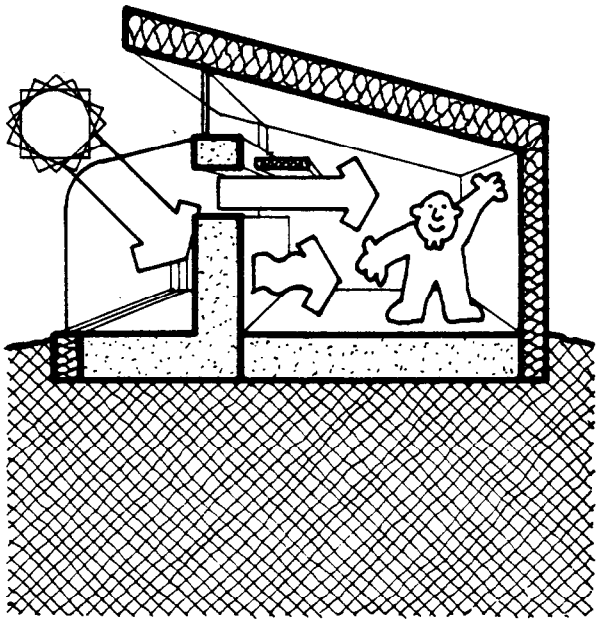

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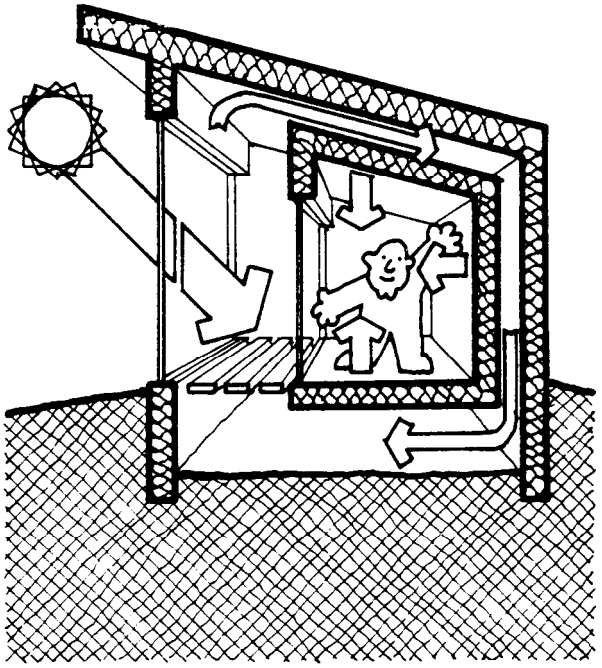

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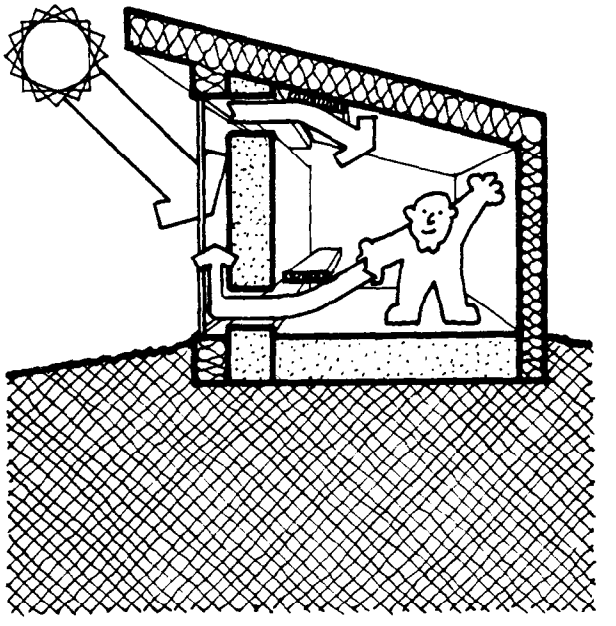
Thermosiphon

In a thermosiphon system (FIG 9), air warmed in the collector area is vented to the living space, and, as it cools and falls during its circulation, it is drawn back to and through the bottom of the collector area where the cycle is repeated. Thermosiphon systems are often used in conjunction with Trombe walls because the thermosiphon provides a faster means of getting warmth to the living space. For existing buildings, a thermosiphon collector can be site built and attached to the south wall.



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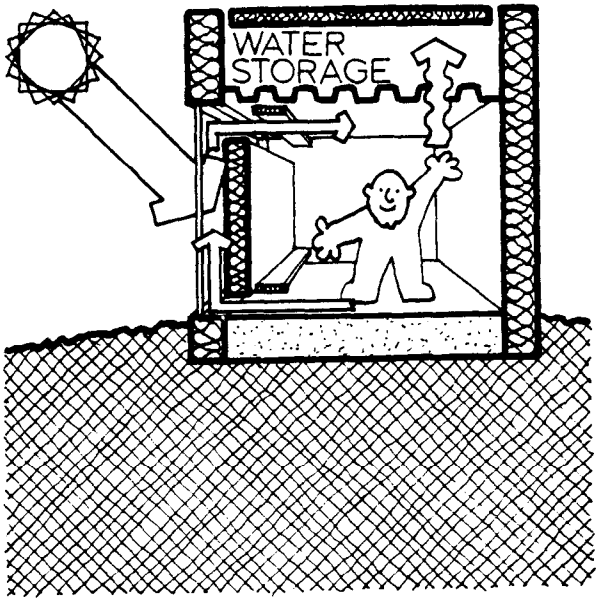
Roof Ponds

In a roof pond system, water stored in a membrane liner located above the ceiling of the structure functions as mass storage. For the heating mode in a typical roof pond, shutters above the storage are opened during the day to collect direct solar gain. At night, the heat stored in the roof pond radiates to the living space -- the shutters are closed to prevent heat loss to the night sky. In the summer cooling mode, the shutter operation procedure is reversed; the roof pond absorbs heat from the living space while the shutters are closed, and at night, the shutters are opened to allow the stored heat to radiate to the outdoors. The typical thermosiphon strategy would not be feasible in the Nebraska climate, so a modified strategy is undergoing testing by the PSRG. In the modified scheme (FIG 10), the roof pond is covered at all times, in this case,by a cover of floating, cement coated rigid insulation panels cut to fit over the mass storage. In the heating mode, heat to mass storage is provided by a thermosiphon system. In the cooling mode, a pump circulates storage water over the cover. The water loses heat through night sky radiation and evaporation and, after the water is cooled, it sinks back to storage through cracks between the insulation panels.



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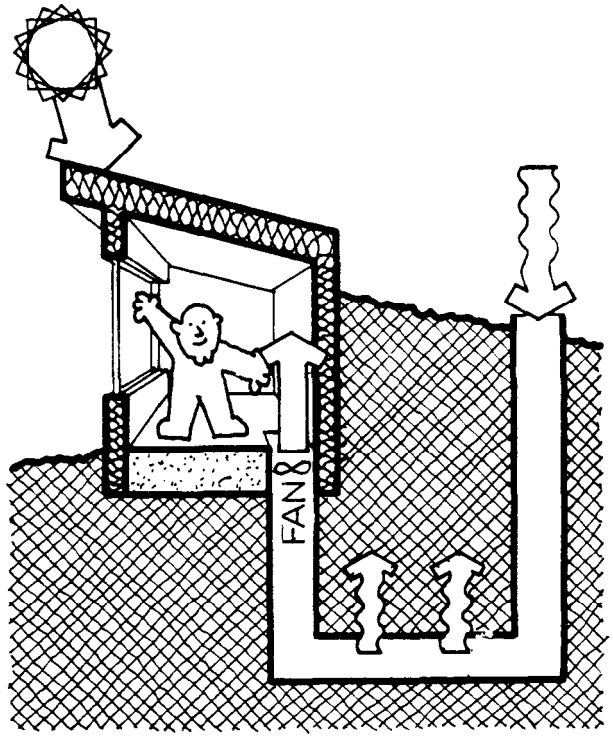
SPACE COOLING: PASSIVE SOLAR

Buried Pipe Cooling

In addition to earth sheltering and roof ponds, buried pipe cooling (FIG 11) is being utilized as a cooling technique in homes in Nebraska. The results, however, have been mixed. In this method of cooling, air drawn through an underground pipe is cooled as heat is transferred to the earth. Extreme care is required in designing cooling tube systems; cooling is a function of tube length, depth, diameter, material, fan speed, and soil conditions. Research by the (PSRG) indicates significant cooling potential in long pipes buried deep underground.

Annual Cycle Cooling

Before the widespread use of refrigerators, ice blocks cut from Lakes in winter were stored for use during the summer. This procedure, with modifications, is being given serious consideration for space cooling purposes today. In annual cycle cooling systems (FIG 12), water in storage is allowed to freeze during the winter. In summer, a heat exchanger is used to transfer heat from the living space to the frozen water storage. Because of the abundant cold furnished by Nebraska winters, annual cycle cooling holds some promise, and experiments by the PSRG are underway to determine the technical feasibility of annual cycle cooling systems.



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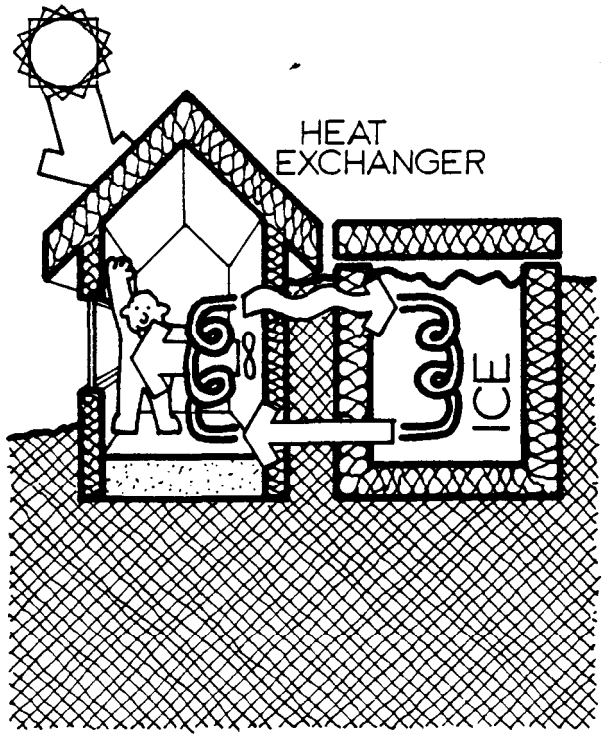

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SPACE HEATING: ACTIVE SOLAR

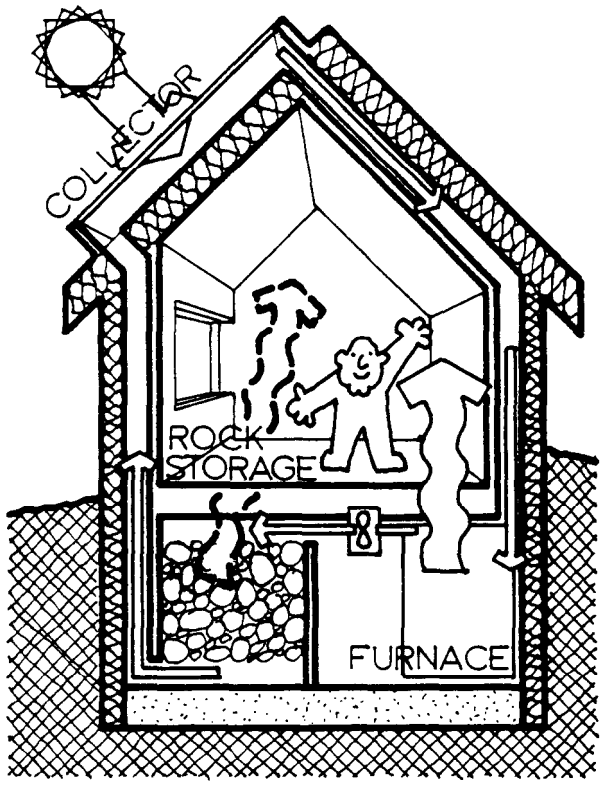
Active solar residential space heating techniques are comprised of air and liquid systems. In active solar systems, air or liquid passing through a collector -- typically consisting of glazing and an absorber plate -- is heated, and, by the operation of fans or pumps, the heated air or liquid is transported through ducting to storage.

The purpose of the storage is to provide a source of heat during the night or cloudy periods. Rock bed storage (FIG 13) is usually used with air systems, although the Colgan home in the book uses a phase change material (PCM) in place of rock as the storage thermal mass. Water -- in membrane lined storage or glass-lined steel or fiberglass tanks -- is the common storage medium for liquid systems (FIG 14). The collector fluid is usually an alcohol/water solution or a specialized oil.

A number of add-on space heating kits are available to the consumer. These kits provide a simple and sometimes economical means to provide space heating, but only while the sun is shining, since the kits do not have storage capabilities.

DOMESTIC WATER HEATING: ACTIVE SOLAR

From a cost effective standpoint, active solar systems utilizing flat plate collectors are likely to provide their highest rate of return in the production of domestic hot water. As a general rule, liquid systems are more thermally efficient than air systems for heating water. To ensure that the liquid system does not freeze, an antifreeze solution in a closed loop system (antifreeze system) is used, or the water is either drained to storage at night (draindown system) or simply drained from the system (drainback system).



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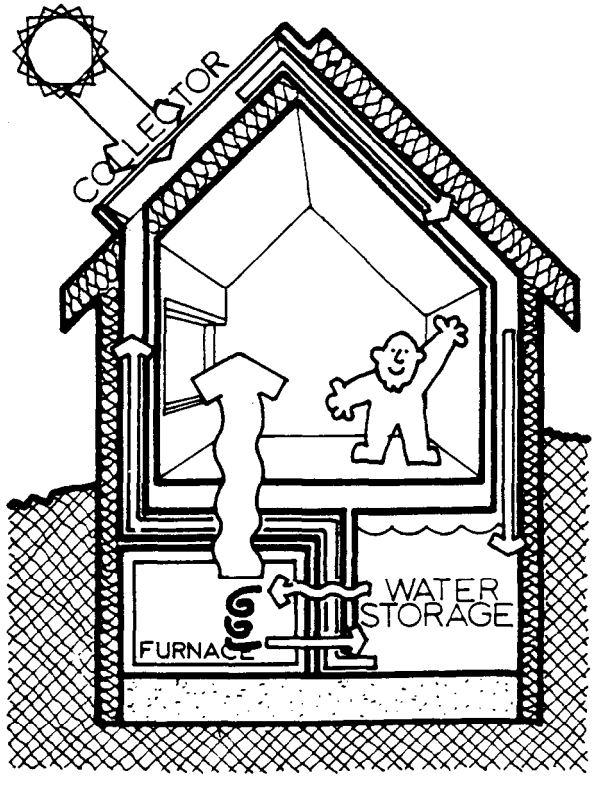

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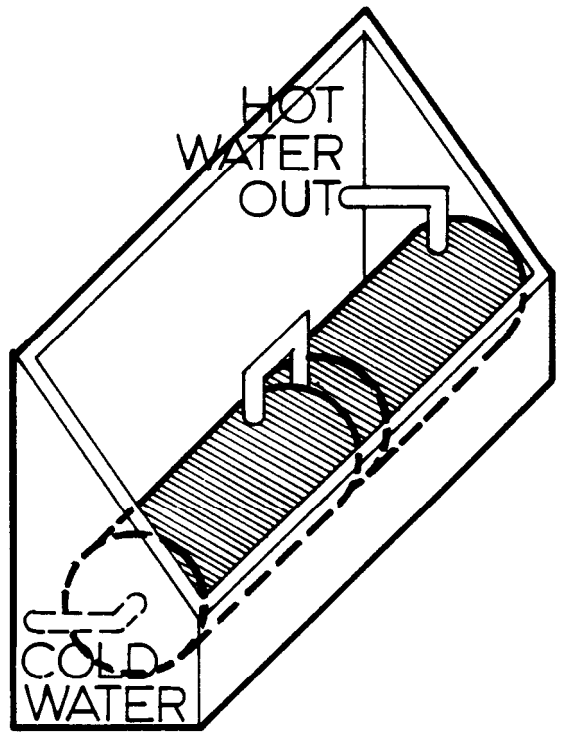
DOMESTIC WATER HEATING: PASSIVE SOLAR

The passive solar hot water heating systems are batch heaters and thermosiphon heaters. They are characterized by simplicity -- they have no moving parts or pumps -- and low cost, usually providing preheated water to a conventional hot water heater. Most of the summer domestic hot water load can be supplied by passive solar water heaters. The operation of the thermosiphon water heating system is the same as the thermosiphon space heating system except that water, rather than air, is circulated in a closed loop system. Batch water heaters (FIG 15) rely on tap water pressure and usually consist of little more than one or more black painted water tanks housed in a well-insulated, weather-tight enclosure. Sunlight shines through the glazing of the enclosure and heats the water. As with active liquid water heating systems, passive water heating systems need protection against freezing, and batch heaters are often located in attached greenhouses rather than separate enclosures.



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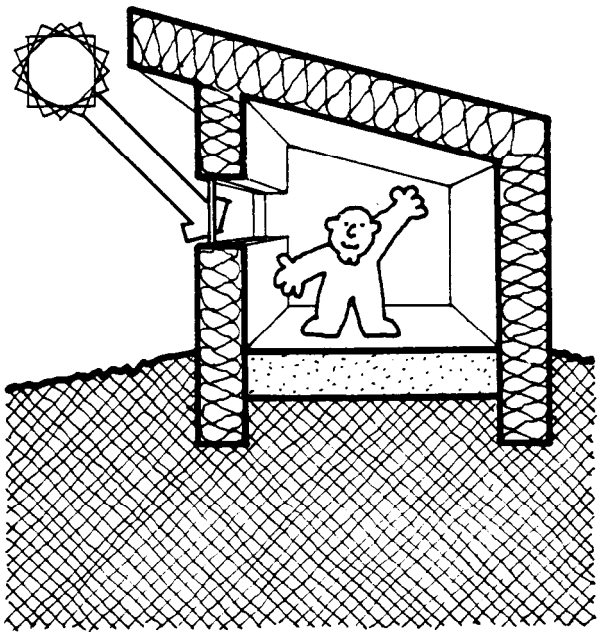
CONSERVATION STRATEGIES:

Superinsulation

Superinsulation (FIG 16) is a means of achieving thermal efficiency and is sometimes used when conditions do not permit the use of passive or active solar heating techniques. It is, as the name suggests, the placing of extra insulation in walls, roof, and below grade. Increased insulation levels limit heat loss in winter and heat gain in summer. During construction care must be taken in taping joints and installing vapor barriers. Because superinsulated structures have low air infiltration rates, the use of air-to-air heat exchangers to ensure proper ventilation should be considered.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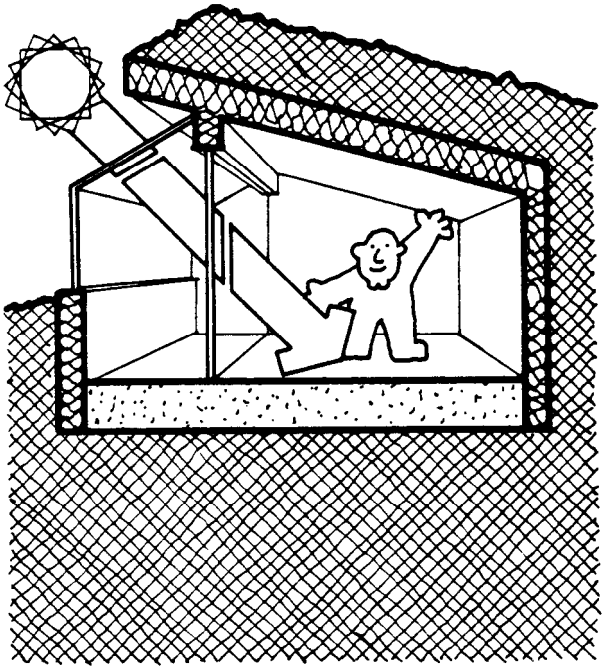

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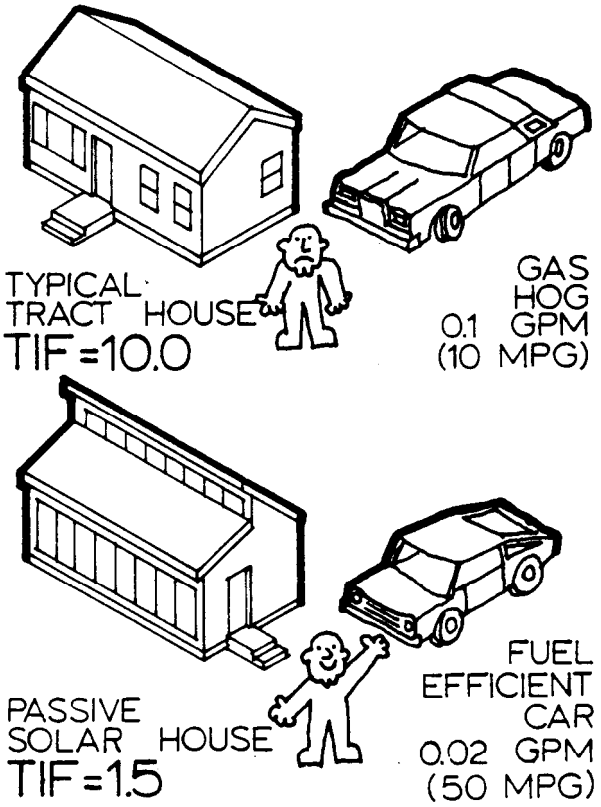

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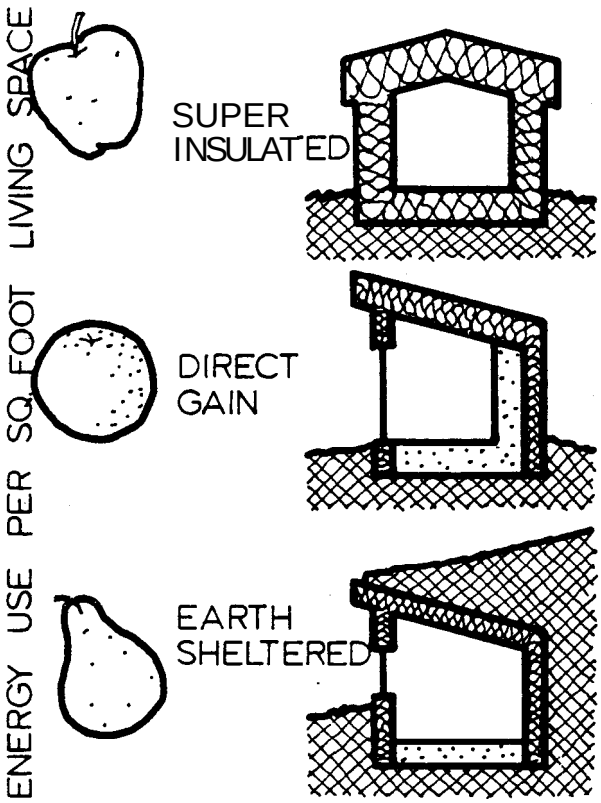
Earth Sheltering

Earth sheltering (FIG 17) has become a very popular conservation technique in Nebraska. Earth cover protects a structure against wind chill and eliminates unwanted air infiltration on the covered sides. Although the earth is not an insulator, the earth drastically reduces air temperature fluctuations so the earth sheltered building is nestled into a more temperature stable environment than above ground buildings; earth shelters are naturally warm in winter and cool in summer. In an earth shelter of concrete construction, the large thermal mass of the structure is ideal storage for passive solar heat gain. Properly designed and constructed earth shelters can be as light, open, and spacious as other energy efficient above-grade buildings; they need not be cave-like.

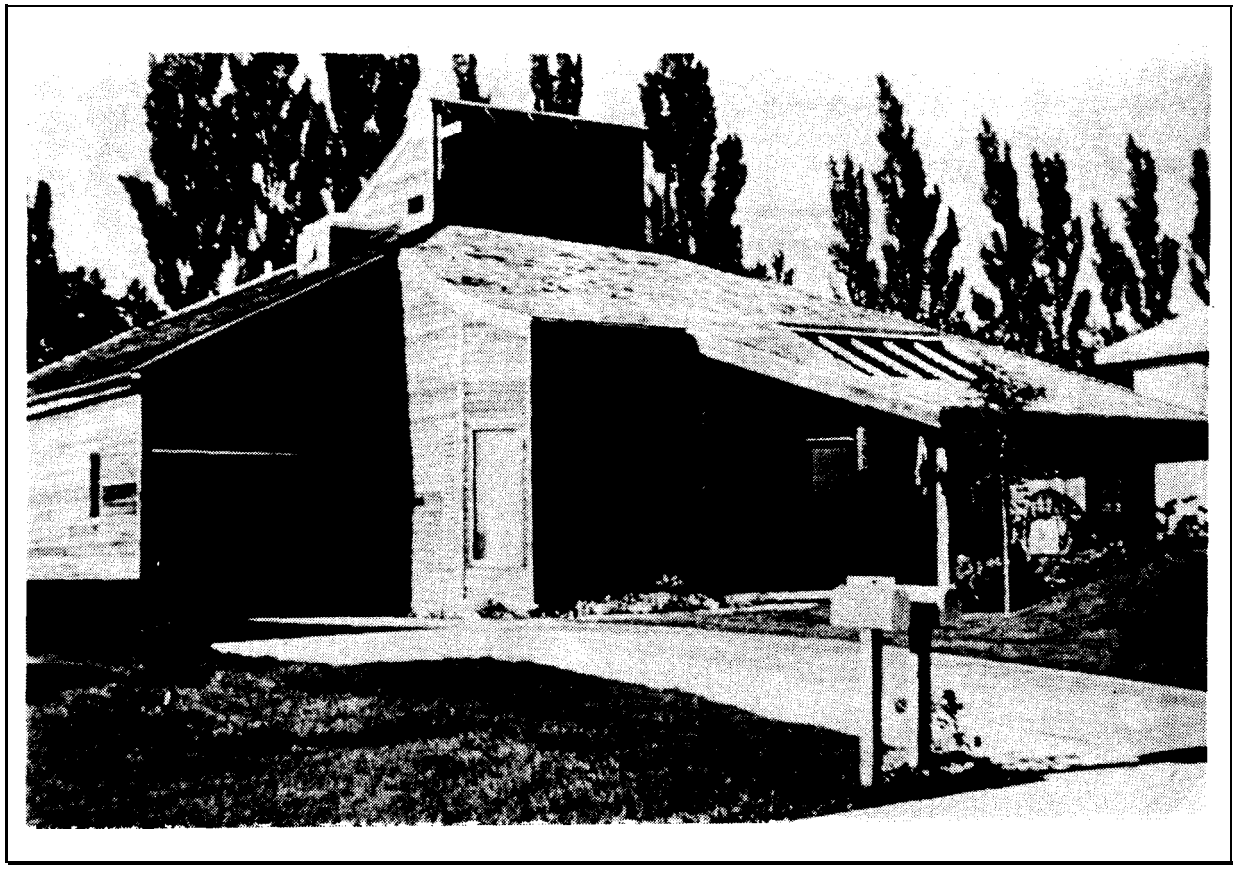
THERMAL INTEGRITY FACTOR (TIF)

Although there are a number of yardsticks which can used to judge the thermal performance of a home, the most valuable measurement is the thermal integrity factor (TIF) (FIG 18). The TIF value measures the number of Btus of auxiliary heat required per square foot of living space per degree day of heating for each year (Btu/ft^2-DD) and allows the thermal performance of solar as well as non-solar homes to be compared to each other. The lower the TIF value, the higher the efficiency. For example, a homeowner deciding among a superinsulated, direct gain, and an earth sheltered home can compare the thermal efficiency of each. Thus apples, oranges and pears can now be compared (FIG 19). Whenever possible, the TIF value is computed for the homes in the book to serve as a guide to the reader.


ENERGY USE PER SQ. FOOT LIVING SPACE
SUPER INSULATED
DIRECT GAIN
EARTH SHELTERED

19

nSINGERn

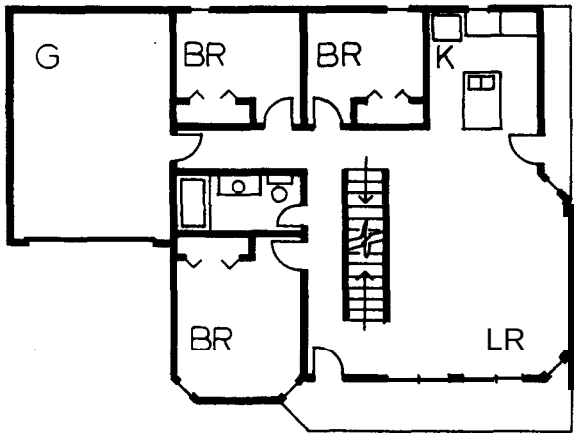


The Singer Residence is the first of three Jim Bowman (owner) Lee Schriever (architect) residential project collaborations. Each project represents an evolutionary stage in the development of an energy efficient/solar design philosophy.

Designed in 1975, the principal goal of the Singer house design was conservation; minimal use was made of then-untested passive solar techniques. For example, although the house is oriented to the south and windows are primarily located to take advantage of solar gain, the house has no thermal mass to absorb and store heat generated by the sun. Backup heat is supplied by an electric forced-air furnace.

Heating loads were reduced through a combination of reduced transmission losses -- 2x6 side wall framing allowed for higher than then-customary insulation levels -- and reduced air infiltration. Earth bermed against the north side of the house helps the building present a low profile that forces winter winds from the northwest up over the roof of the structure, a strategy designed to reduce infiltration losses resulting from wind loads.

Thoughtfully conceived ventilation strategies combined with shading techniques reduced cooling loads. The basic ventilation pattern of the house is north to south/low to high. Because windows are fixed/non-operable, air flow is enhanced by the use of screened ventilation panels (opposite right). This technique also helps reduce unwanted air infiltration in winter. Cooling by ventilation is aided by a central clerestory which functions like a chimney in drawing hot air from the home in summer. Operable shading devices protect the central clerestory from unwanted solar gain (opposite left).



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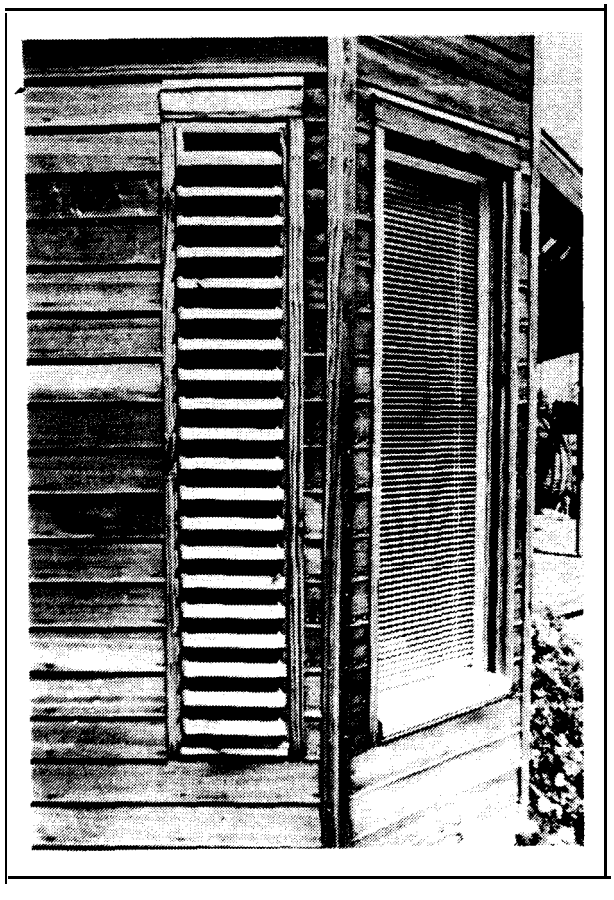

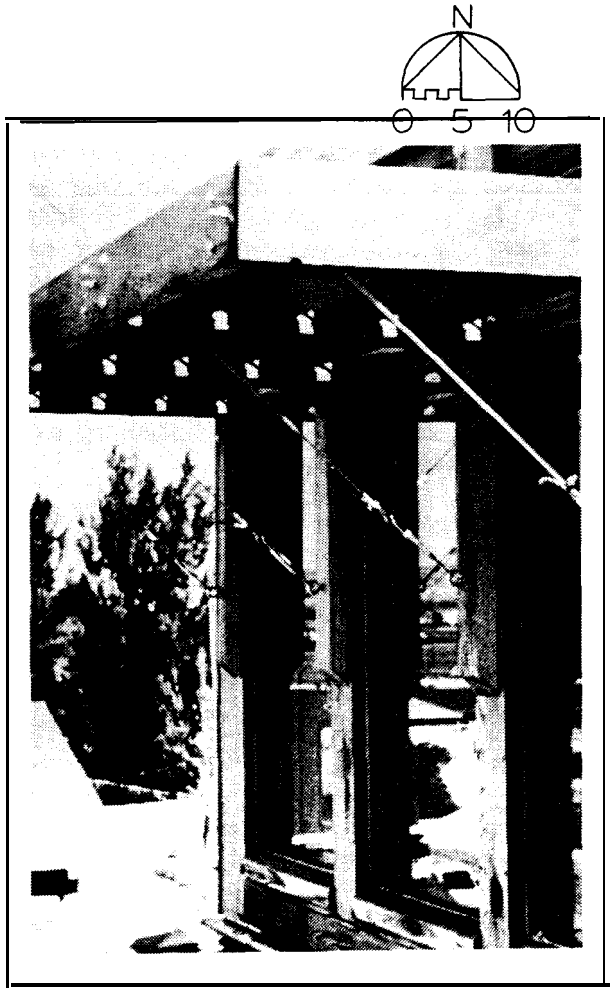

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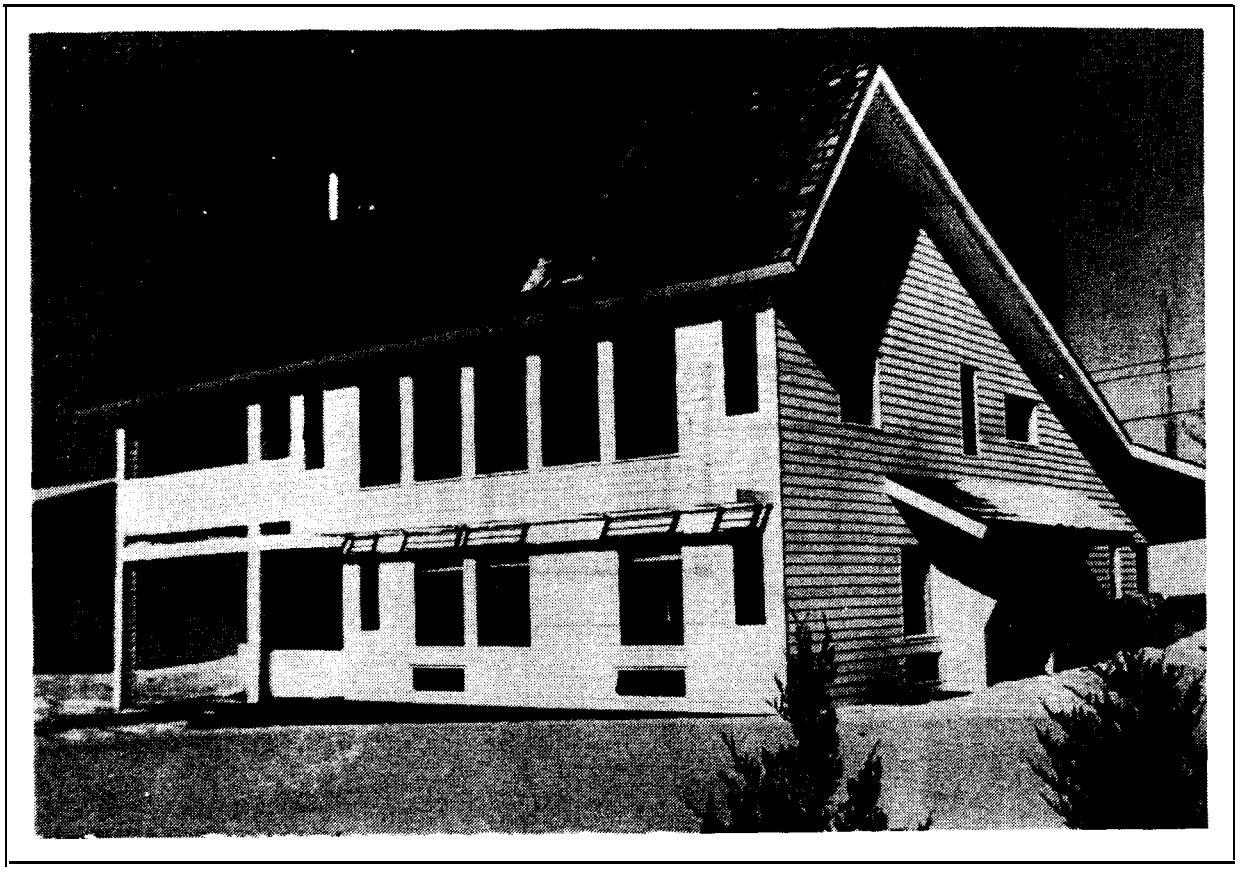


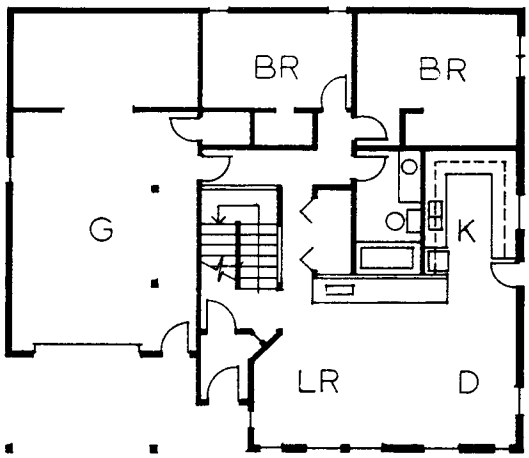
The Combs house, the second of the three Jim Bowman/Lee Schriever residential projects, repeats several energy efficiency strategies used in the Singer residence. These include earth berming, ventilation strategies, and long roof slope to the north (opposite left). In addition, direct gain passive solar techniques were incorporated.

Sunlight entering through windows in the two-story south wall brightens the living room/dining area which is open to the second floor and generates considerable direct solar gain. A unique catwalk (opposite right) was constructed along the second floor perimeter of the open living room/dining area to make upper windows more accessible for the nightly installation of shutters.

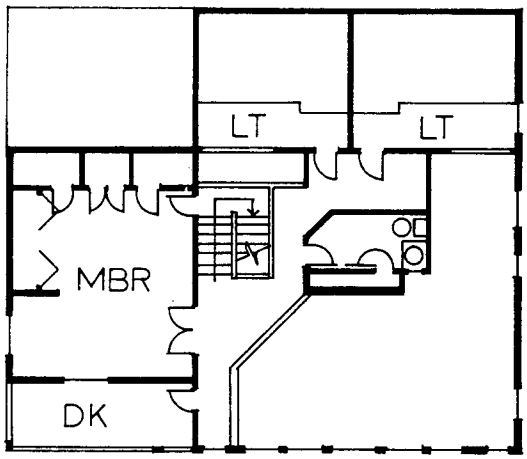
The Combs house does not have a conventional central heating system. Instead, solar heated air is distributed throughout the house as follows: the sun warmed air rises to the top of the open living room/dining area where it is drawn through duct openings in the top of a two-story, floor to ceiling rock mass wall located at the back of the room. A variable speed fan (with air filter) draws the warmed air from a central plenum and blows it under the floor slab where it is distributed to perimeter registers.

Backup heat for north bedrooms is provided by a mid-sized, air-tight, Timberline wood stove located in front of the masonry wall; baseboard heaters in the rooms have not been used. Backup heat to the bathrooms is provided by 220 volt electric baseboard heaters.

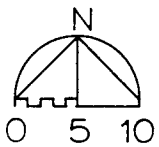
Domestic hot water is provided by an active solar air heating system. The two site-built flat plate collectors utilize an air to water heat exchanger. Bowman feels that a liquid flat plate collector system would work better than the air to water system.

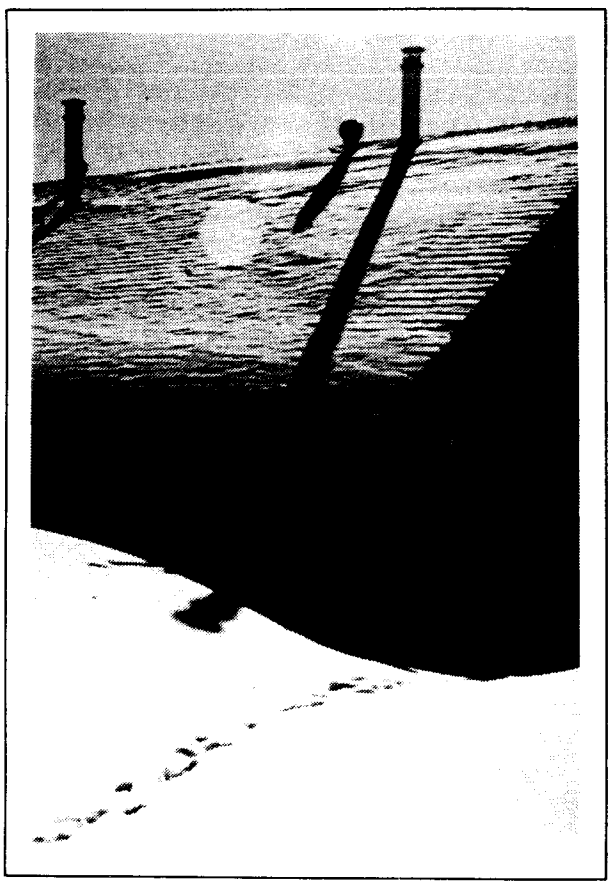


MAIN LEVEL



UPPER LEVEL





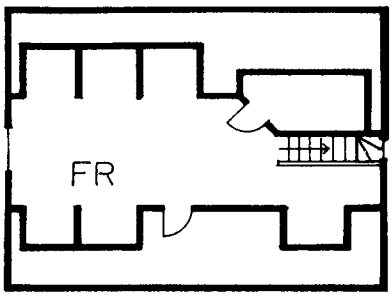
nBOWMANn

The third Jim Bowman/Lee Schriever residential project is Bowman's current hone in Lincoln. Unlike the Singer and Combs houses which were new construction, this project is the retrofit of a home built in 1896. Like the two preceding homes, however, the house utilizes energy conservation strategies and employs direct gain passive solar techniques. The pre-retrofitted home was not energy efficient, and both the interior and exterior of the building were in poor condition. However, the house was structurally sound and had good solar access.

The retrofitting process began with the gutting of the building early in 1981. Insulation was added to the roof and walls, and new double paned glass was installcd to increase the solar gain and to brighten the interior of the house. The south facing living room and dining room are the collection area of the direct gain system, and a passive solar collecting panel was added to the south wall. Solar heated air rising from the dining room, passes through a grill in the first floor ceiling (opposite left) to the bedroom spaces on the second floor. Warm air from the third floor is recirculated to lower floors through the former chimney which has been converted for this use after a new gas pulse combustion furnace was installed. The measured TIF after conversion is under 2.3.

Two site-built active liquid flat plate collectors by Morningstar were incorporated to provide domestic hot water.

A sunspace addition of 256 sq ft of heated floor space and 132 sq ft of storage is currently under construction (opposite right). Included in this addition are a second bathroom and loft. Backup heating to the addition will be provided by a small wood stove.



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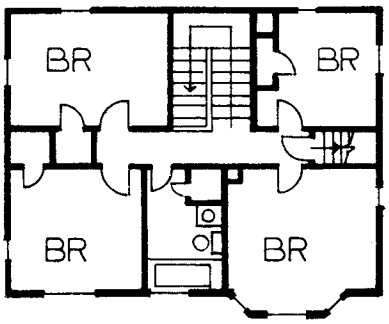
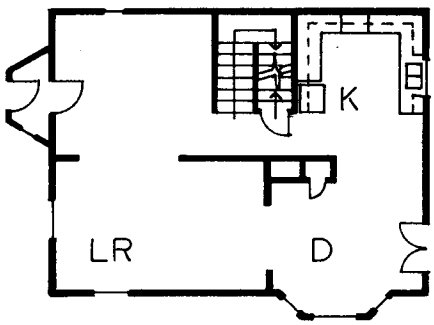
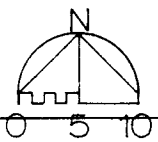
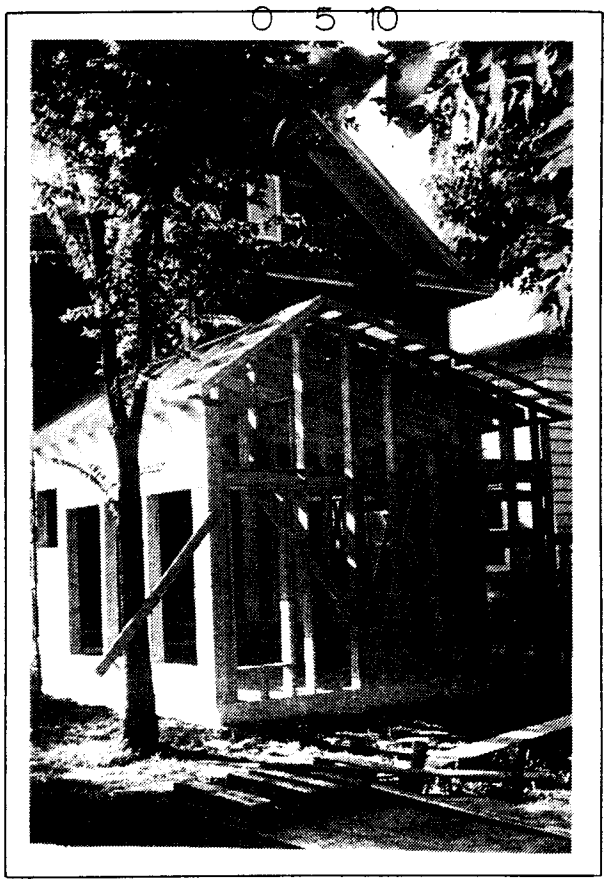


UPPER LEVEL

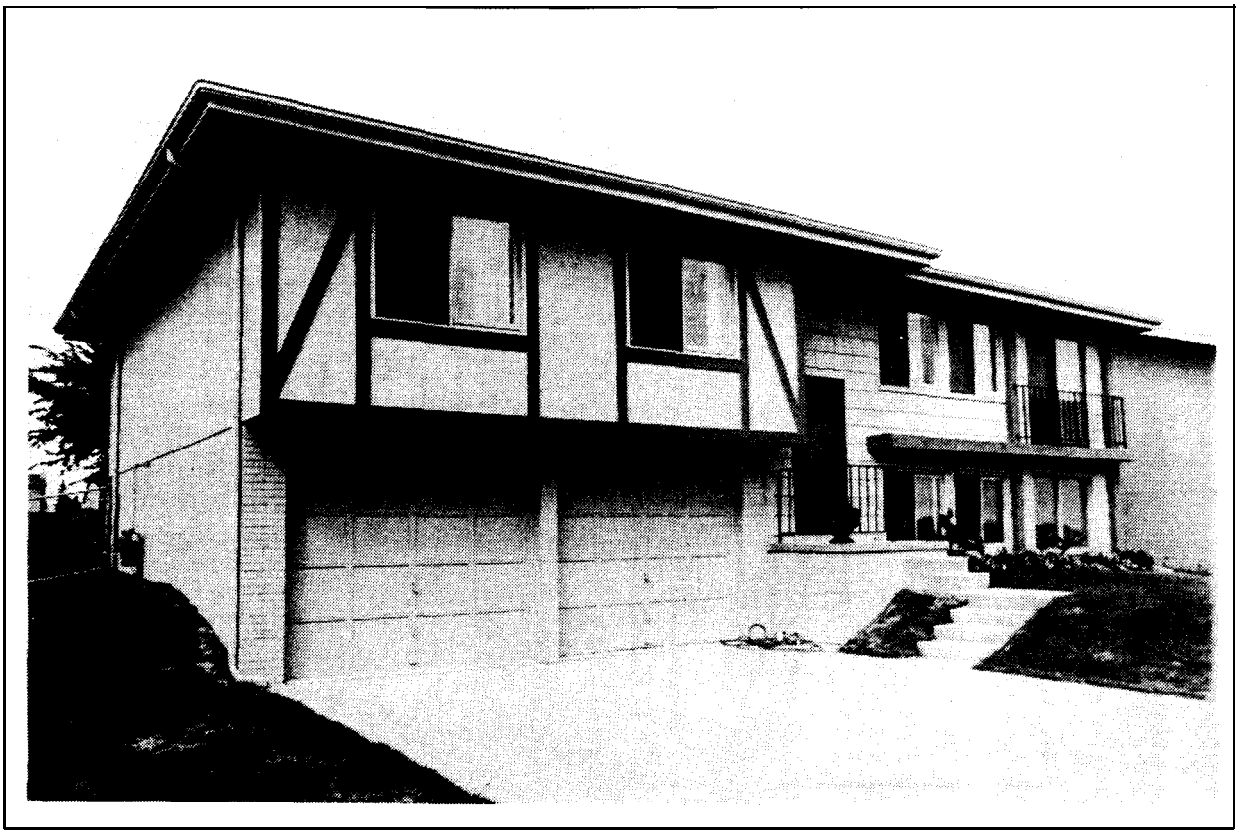


MAIN LEVEL





nBUSSEYn

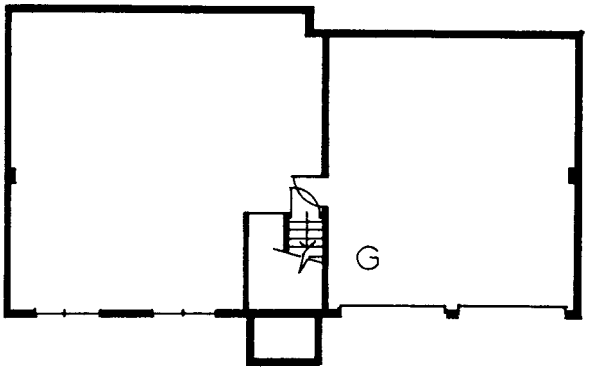


The Bussey home, like the Henley home also described in this inventory, is one of the solar models being offered by Pacesetter Homes of Omaha. The Bussey home, the Riviera model, is a three bedroom, split-level house with 1344 sq ft of living space on the main level. A two car garage and basement that can be finished to provide additional living space are on the lower level. From the outside, the Riviera model looks like a typical attractive suburban house, however, its energy conservation and passive solar features make it distinguishable from typical tract housing. For example, the standard insulation levels for this energy conscious structure are R-25 in the walls and R-36 in the ceiling.

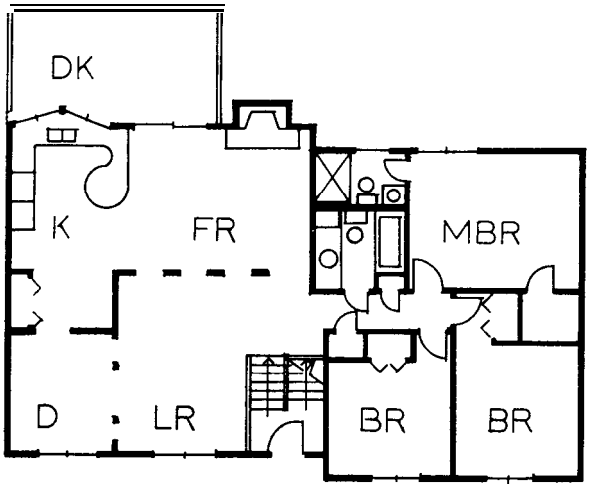
The Riviera model is a simple direct gain passive solar heated building designed so that the front of the structure faces south, with the option of reversing the floor plan (compare the photo above with the floor plan opposite). There are no east or west windows and all north facing windows are triple glazed. Two of the bedroums and the living and dining areas all have southern exposures (opposite); to optimize solar gain in the dining room, south facing patio doors are used in place of conventional windows.

There is little thermal mass in the upper floor, and no night shutters are used in the Bussey home. Initial calculations from actual energy consumed show the Riviera, as inhabited by the Bussey's, to have a TIF value of approximately 4.2.

Pacesetter Homes has begun a complete solar subdivision in Omaha, and solar envelopes are being developed to show where buildings can be built and vegetation can be grown on each of the lots in the subdivision so as not to shade the solar collecting surfaces of houses within the subdivision.

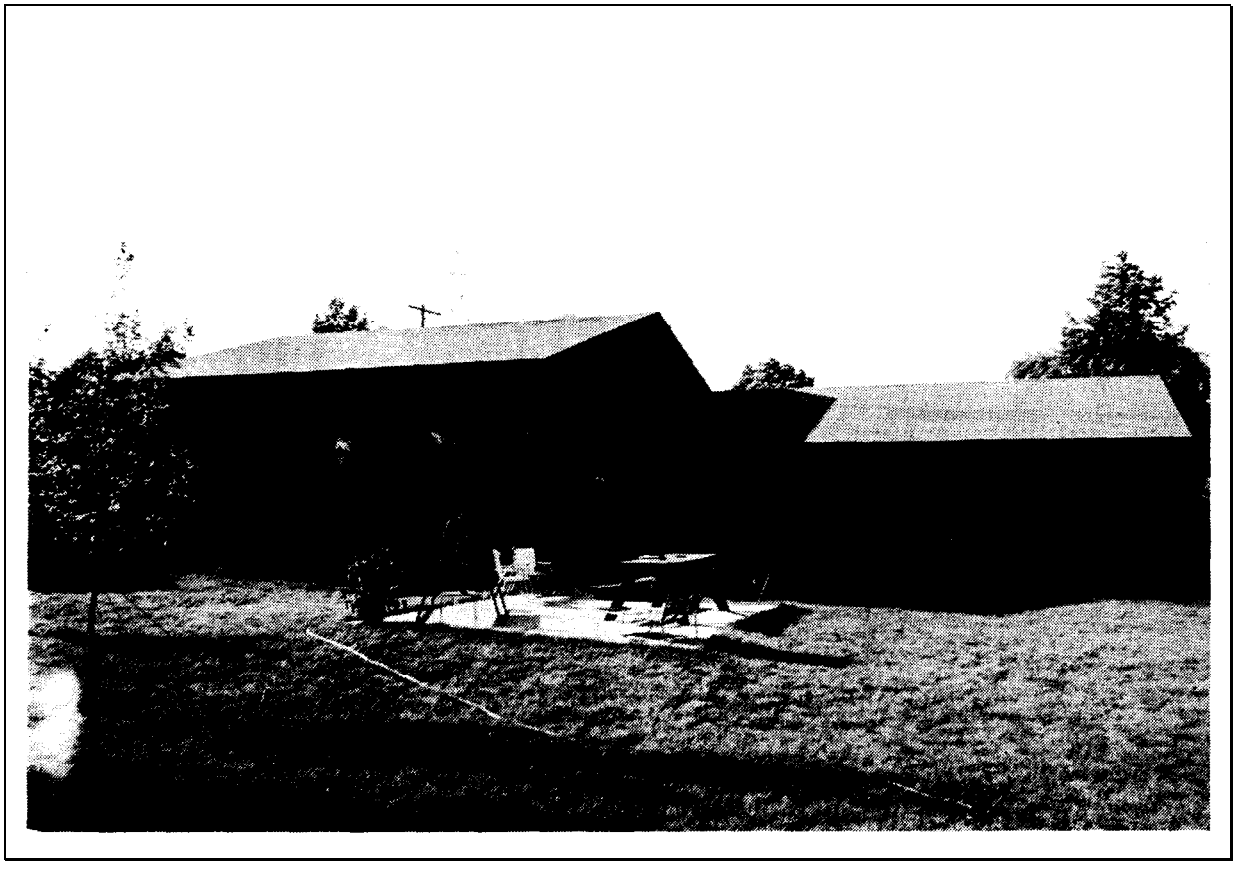


LOWER LEVEL



MAIN LEVEL

nR. DAYn

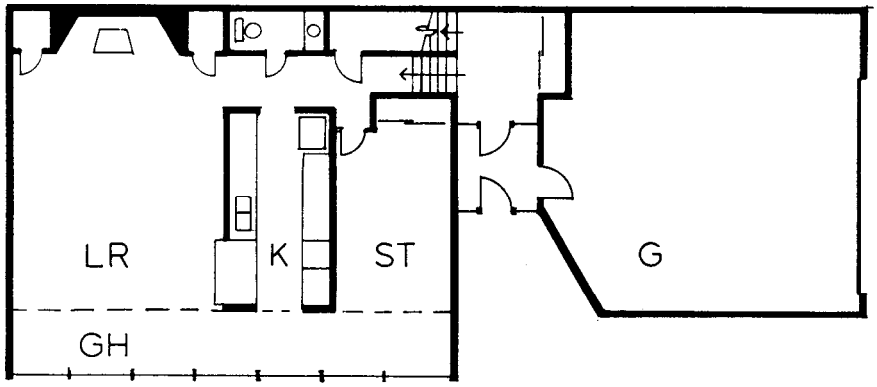


The Day home is an energy conserving two-story home with direct gain passive solar heating features. On the north side of the house (opposite left), unwanted air infiltration is eliminated and heat loss is reduced by the earth that is bermed above the main level. The two north facing thermal paned windows provide lighting and aid in cross ventilation.

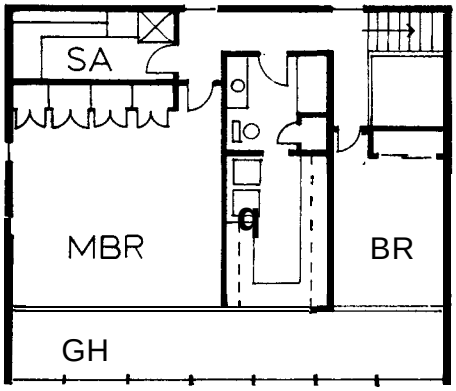
The south wall of the Day home is almost entirely glass, and the 375 sq ft of vertical glazing significantly expands the 1900 sq ft of living space. The two bedrooms on the upper level have views to the living space below. Quarry tile floors and brick walls serve as storage mass and store heat during the day. Air ducts at the top of the living space permit solar heated air to be drawn into the house mechanical system, thereby providing excellent distribution of heat during sunny periods in winter. The backup heating system is a gas-fired furnace with pilotless ignition, the type particularly recommended for all homes with minimum levels of air infiltration using natural gas for backup heating.

"Window Quilts", one of a number of commercially available night insulation products for windows, are used on the south glazing (opposite right) to reduce heat loss at night. The use of night insulation schemes in direct gain buildings is crucial as thermal performance without night insulation is seriously degraded.

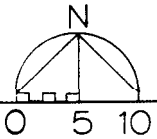
The overhangs which shade the south glazing (opposite right) prevent unwanted direct gain in summer. Summertime cooling loads are minimized by opening the operable windows at the bottom of the south wall glazing (opposite right) to help create cross ventilation.

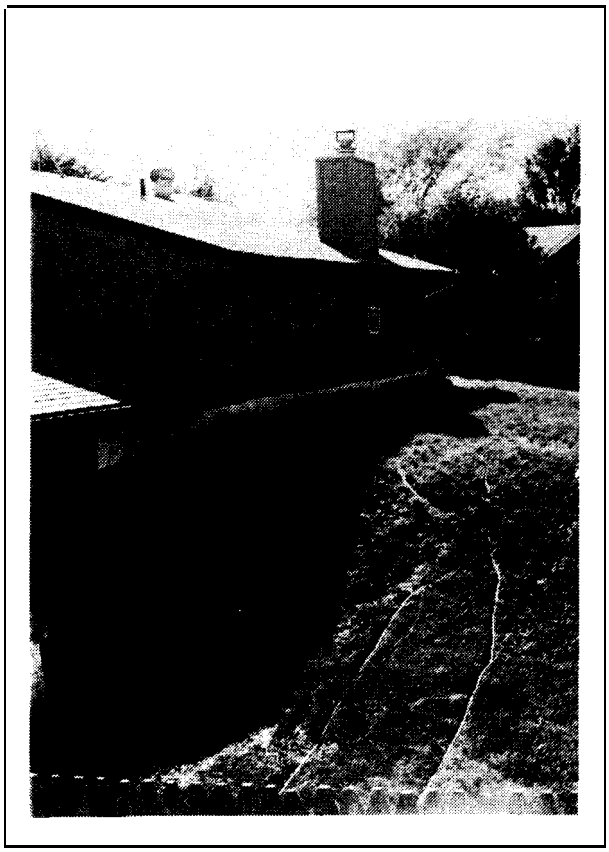


MAIN LEVEL

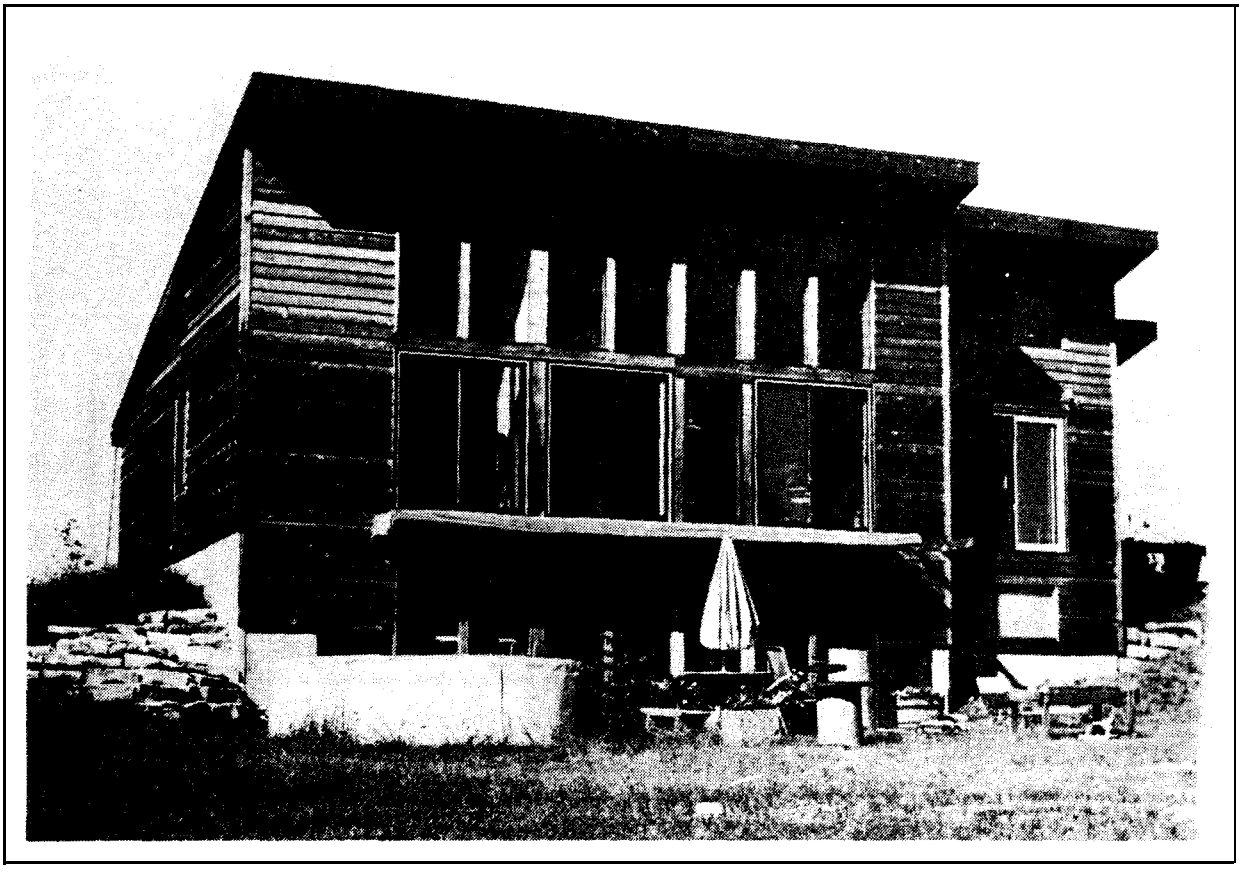


UPPER LEVEL





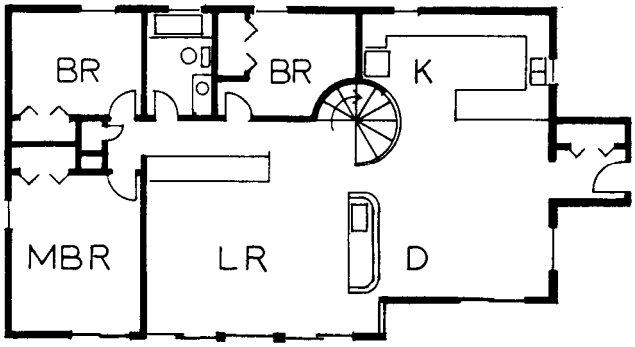
nJAKSHAn



The 1320 sq ft Jaksha home is an energy conserving -- R-28 side walls and R-32 roof -- direct gain passive solar house with some mass storage. The owner-designed and owner-contracted house is basically a single story dwelling with a walk-out basement that contains a family room, office, laundry, and storage -- both thermal and conventional.

Considerable sunlight penetrates through the 420 south facing vertical double paned glazing to provide light and heat. Some of that heat, in 250 gallons of water mass storage located in the basement, supplies backup heating. The water in storage is heated by solar warmed air drawn, by a fan located in the basement, through the unfilled cores of an 8' high concrete block wall in the living room. When the water storage is incapable of providing sufficient heat to the living spaces, a woodburning stove, located between the living room and dining room, provides backup heating. The stove is on the living room side of a waist high, semi-circular brick mass wall (opposite right).

Nighttime heat loss through the dining room windows is minimized by the use of movable insulation on the inside of the windows (opposite left). In this case, the movable insulation is an owner-designed innovation that is also available commercially. The "INSULIDER" window shutter is 3/4" thermax backed with nylon/herculon upholstery fabric. The shutter rolls not unlike a conventional shade and, when not in use, stores in a compact housing unit that is located above the window. The shutter, which slides in its own side tracks, ctn be operated manually or, uith the appropriate mechanical modifications, automatically. The Insulider, with a maximum width of almost nine feet and a maximum length (or height) of twenty feet, is available in a number of sizes.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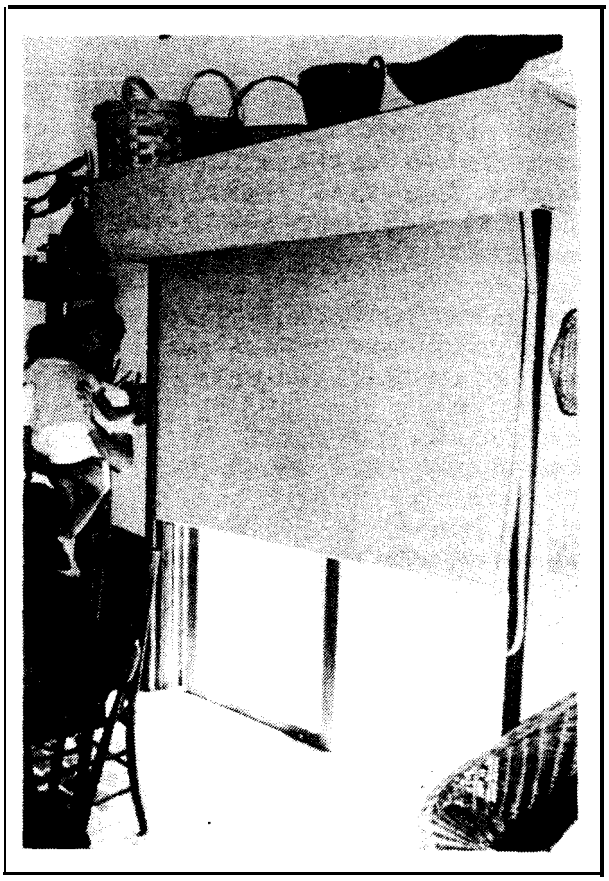

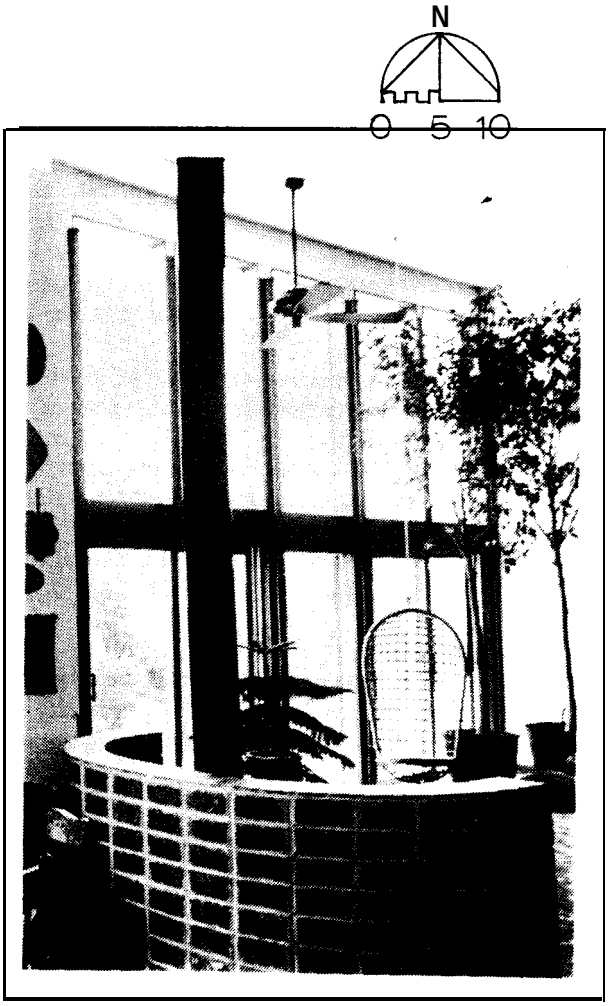
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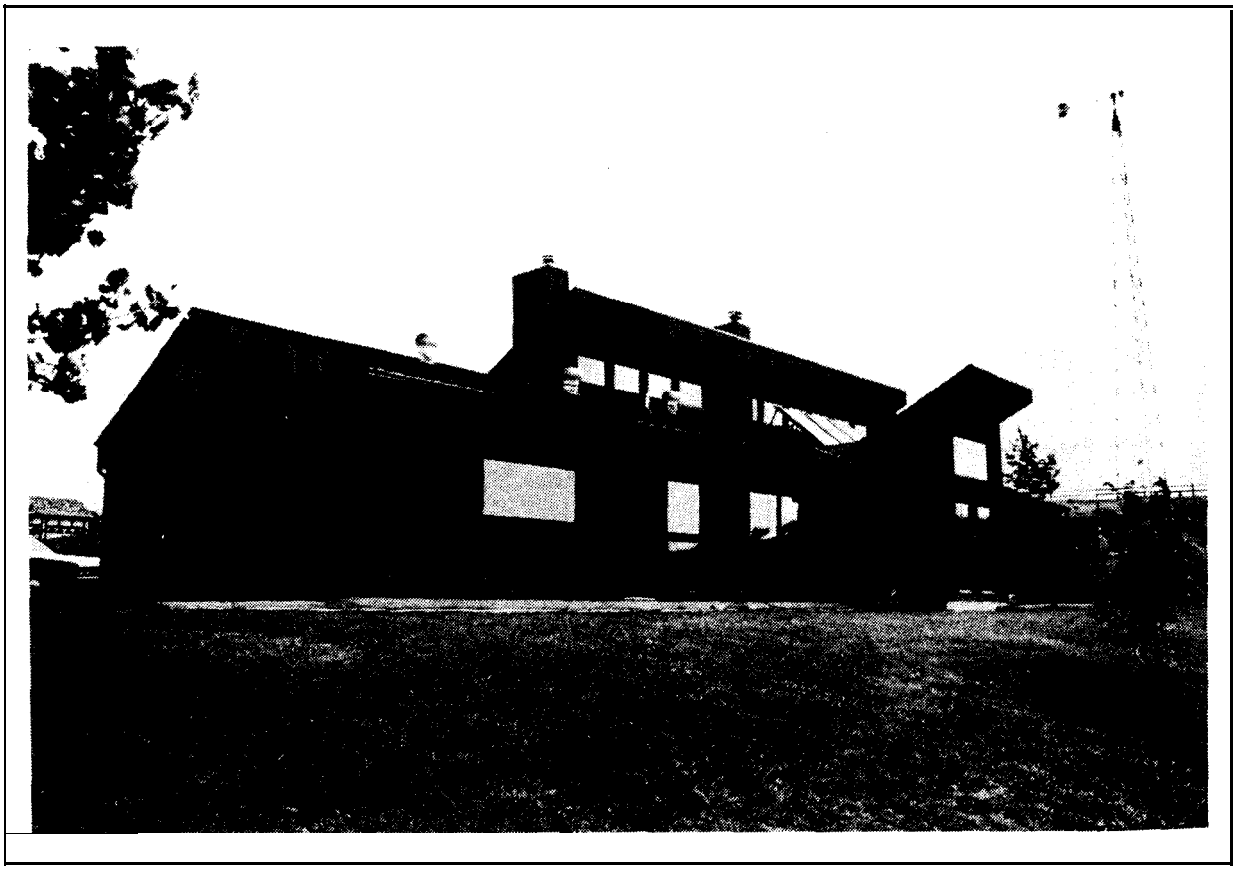
nMILLERn

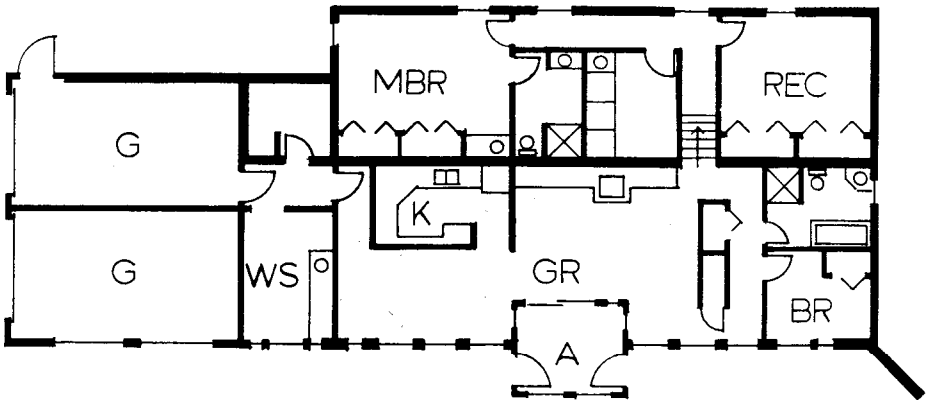


The super energy efficient Miller home effectively combines energy conservation strategies with passive solar energy, active domestic water heating, and wind generation in its scenic location just outside Kearney. The owner-designed home feels more spacious than its 1640 sq ft plus of floor space because rooms tend to be partitioned rather than completely walled off. There is a loft over the kitchen, and other lofts are located in the bedrooms.

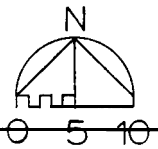
The home is primarily a direct gain passive solar structure with 260 sq ft of glazing, and backup heating is supplied by a wood stove (opposite left). Heat is circulated throughout the house by an internal convective loop system in the following manner: warm air rises to the elevated north rooms in the bi-level structure and is drawn through ducts in these rooms and returned beneath them to the front rooms. Air circulation aided by ceiling fans helps circulate warm air in winter and cool air in summer. considerable thermal mass in the floors (opposite right) and walls helps to keep temperatures stable. The house also has double door entries.

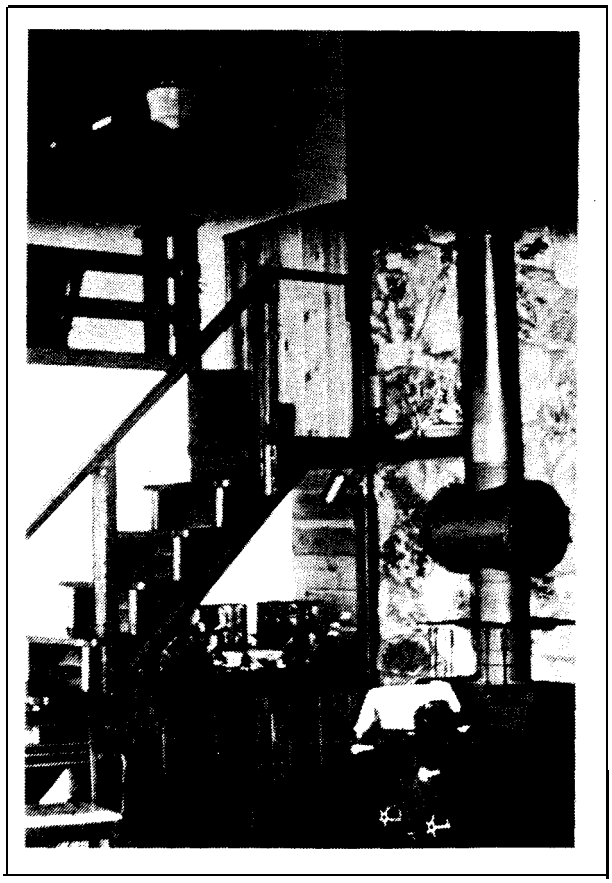
Approximately three cords of wood have been burned each of the past three winters to supply backup heat. Electricity is supplied by the wind generator, and electric bills have averaged under $38 per month for the three years the Millers have lived in their house. If night shutters are used,the predicted TIF for the Miller home is under 1.0, making it one of the most thermally efficient homes in the state.

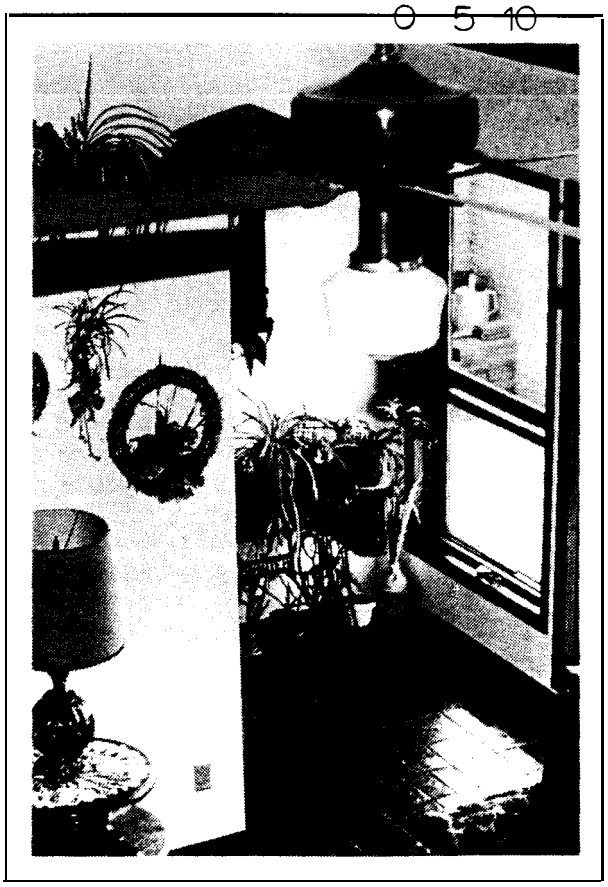
An active collector panel by A.O. Smith heats water needed for domestic use. The Millers estimate that nearly 70% of the total family hot water heating requirements are supplied by the system.



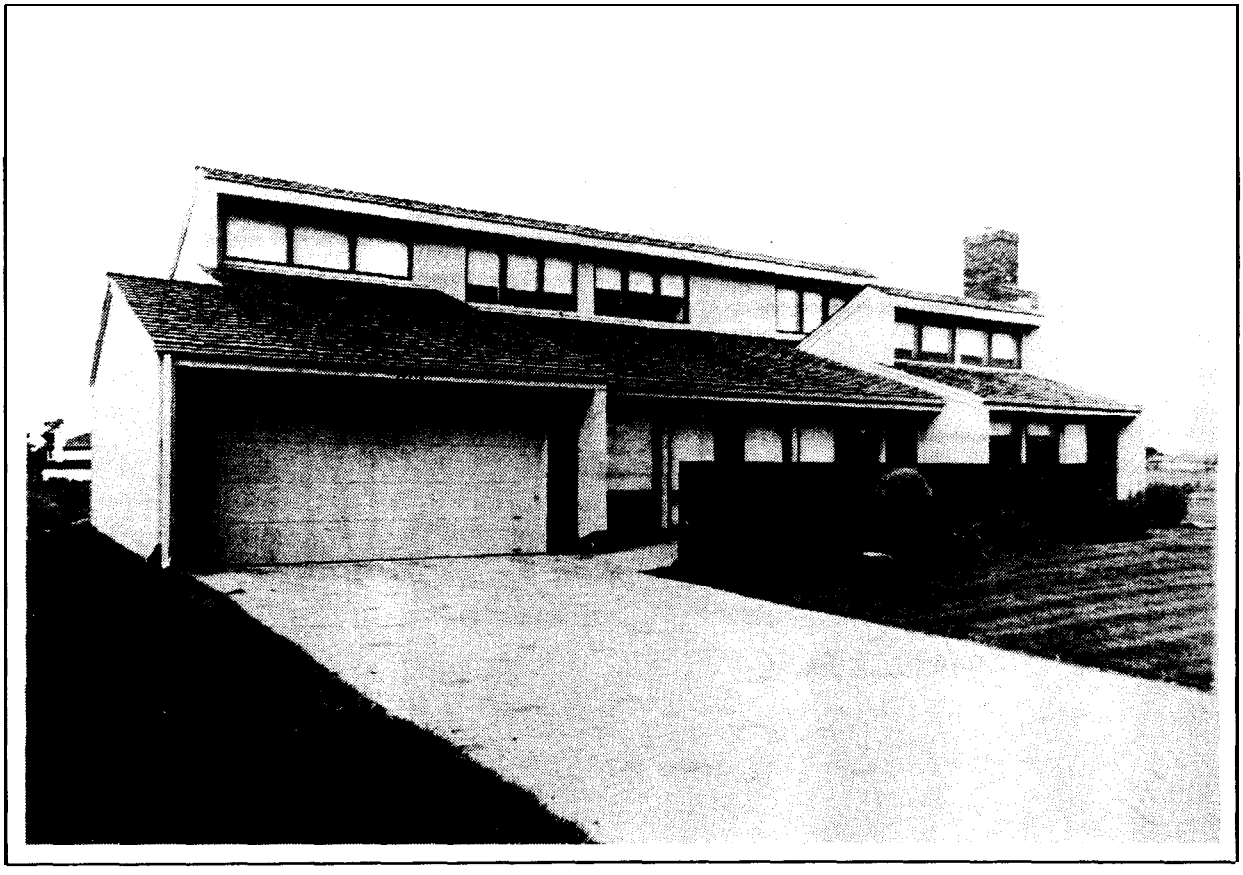
MAIN LEVEL







nC. NELSONn

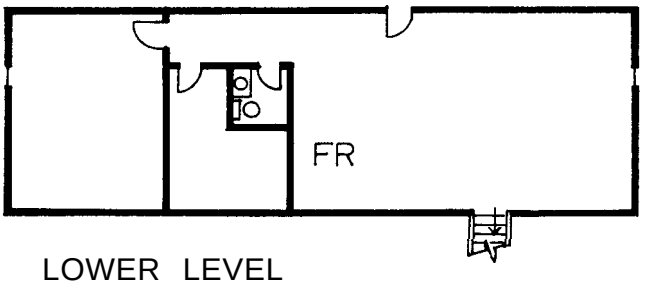


The Nelson residence is the California Sun house, a solar and all gas -- heat and appliances -- demonstration home built by Marquis Quality Construction of Omaha. The exterior walls of the approximately 2400 sq ft house are 2x6 framing stud walls with an insulation level of R-29. The ceiling insulation level is R-38.

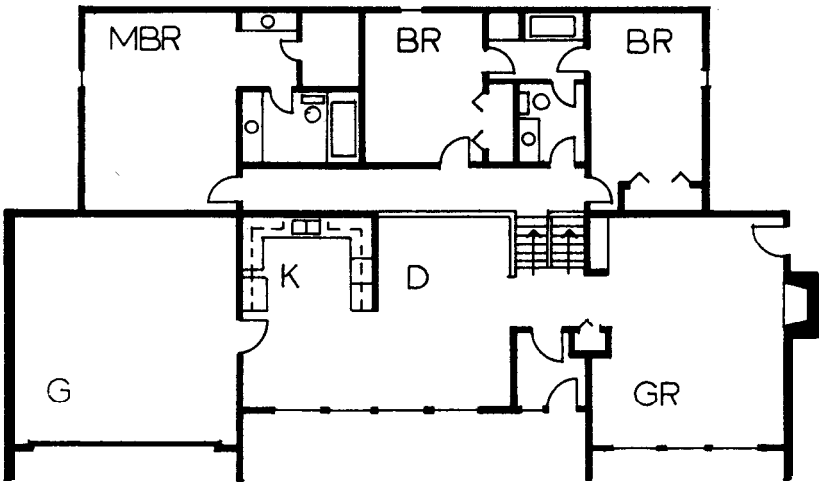
The primary passive solar heating strategy is direct gain, with most of the south wall glazed (opposite left). Clerestory windows allow sunlight to penetrate and heat the bedrooms located to the back (north) of the house. Warm air, mostly solar heated, is also collected in an exposed duct at the peak of the house (opposite right) to be circulated throughout the house.

The home has considerable thermal mass, and, therefore, is not as likely to overheat as most direct gain houses. In fact, it is one of the few direct gain structures in Nebraska that was designed with sufficient thermal mass to reduce the temperature swings normally associated with direct gain buildings, and the owner confirms that the house functions as designed in this regard.

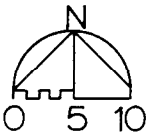
The Nelsons moved into the home in September of 1982, and, since then, their largest utility bill has been approximately $100. The owners believe that the energy performance of the home will improve with some modification to conservation strategies and/or operations. For example, some of the solar quilts (opposite right) that are used for night insulation were mismeasured and consequently did not fit properly. Property fitting quitts have been installed for the next heating season, and the Nelsons expect and additional 20% decrease in their energy use. The owners also feel that using the fireplace, which has never been used for heating purposes, will decrease reliance on the conventional backup heating system.

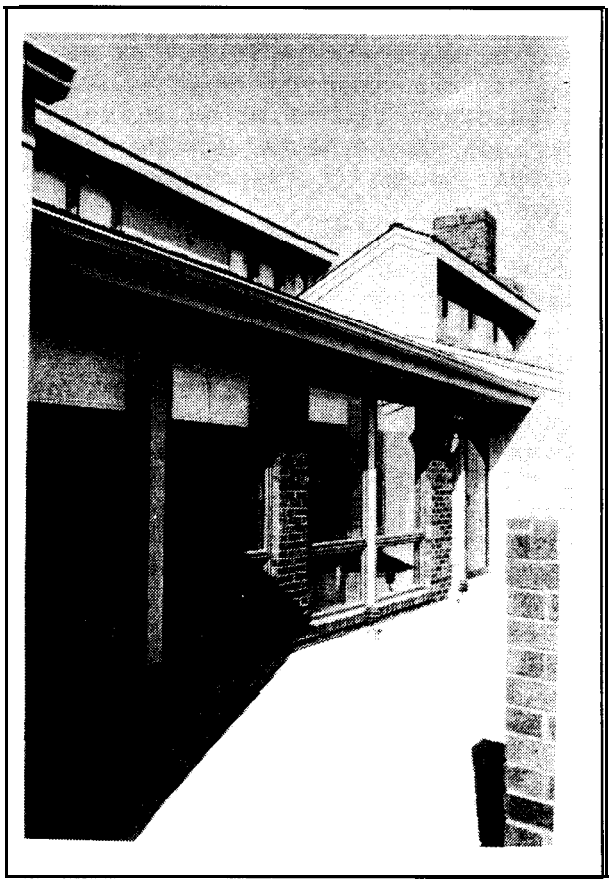


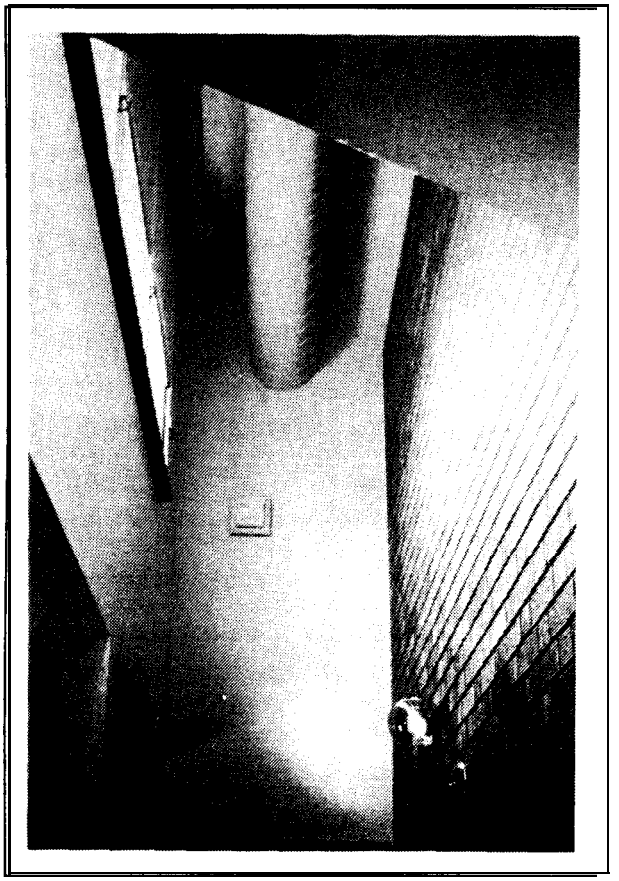
LOWER LEVEL



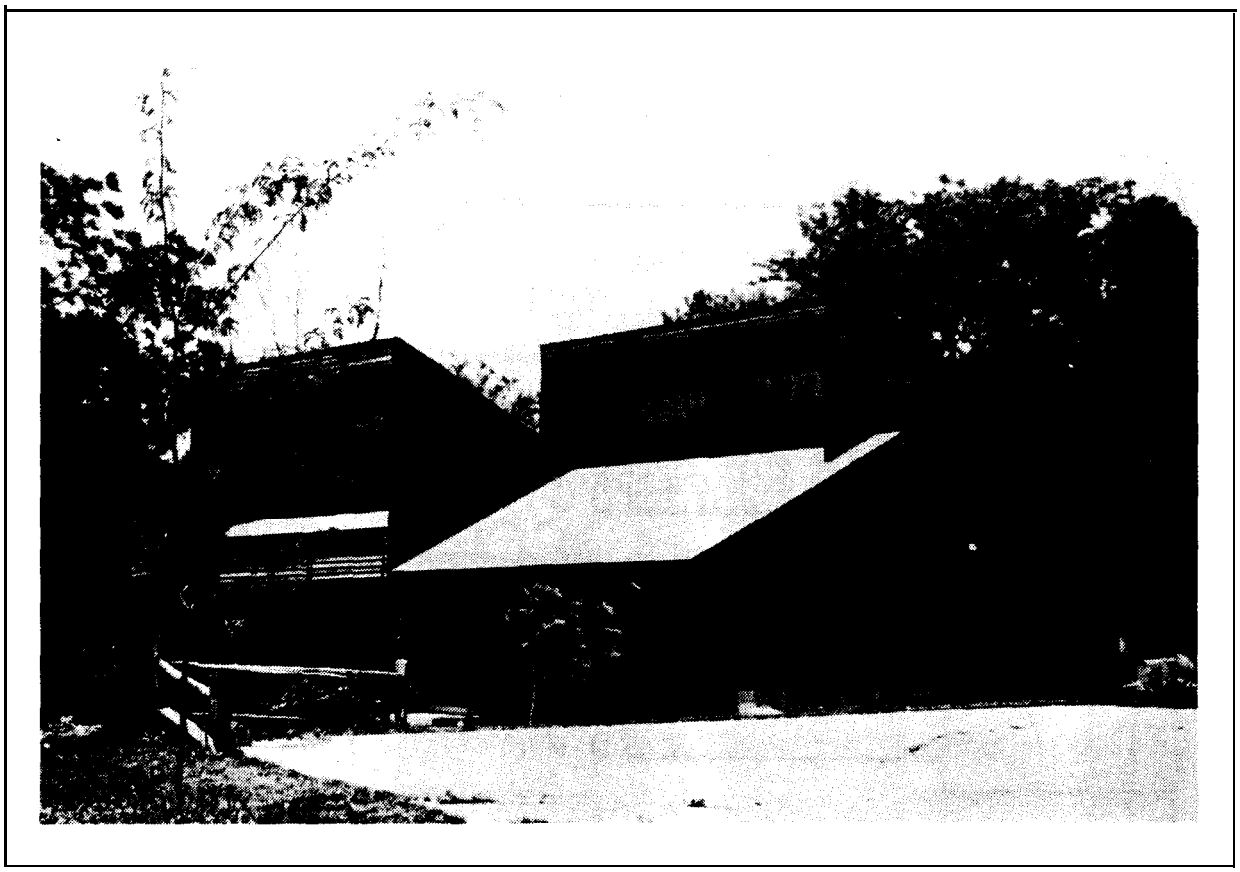
MAIN LEVEL







nPETERSONn

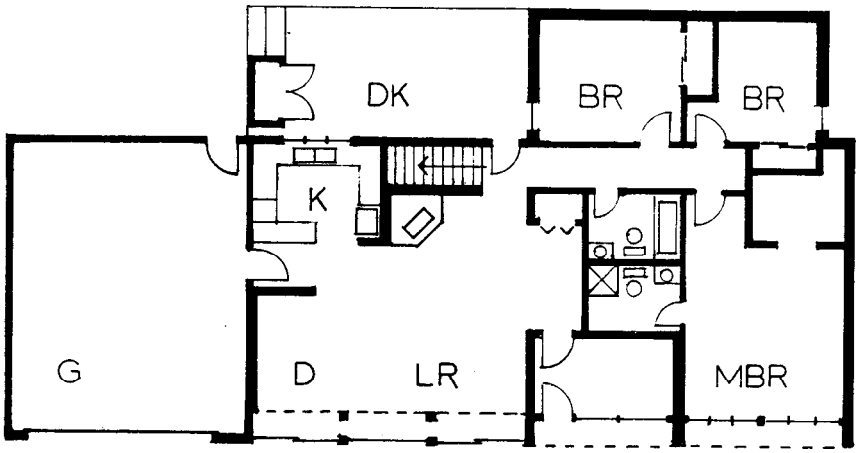


The Peterson home was one of the first solar houses built by Peterson Construction of Lincoln. This design, the creation of Charlie Thomsen -- then of the Clark Enersen Partners, also of Lincoln -- was a HUD Cycle V solar design award winner. The 1600 sq ft house has 2x6 framing in the side walls with insulation levels of R-19. The sloped ceilings have insulation levels equating to R-32.

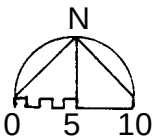
For solar heating, the house relies primarily on direct solar gain through the south glass and clerestory windows. The house also has water wall mass storage, and a modest greenhouse functions as a vestibule/entry. The clerestory glazing is a translucent Kalwall material. The upper portion of the south walls in the bedrooms is glazing, so sunlight penetrating the clerestory windows reaches the north walls of the bedrooms. Brick walls in the north bedrooms absorb solar heat, and the incoming light provides daylighting to the normally dark north rooms. Warm air is collected at the peak of the house and returned through a cold air return to be circulated throughout the house. A wood burning stove is used for supplemental heating.

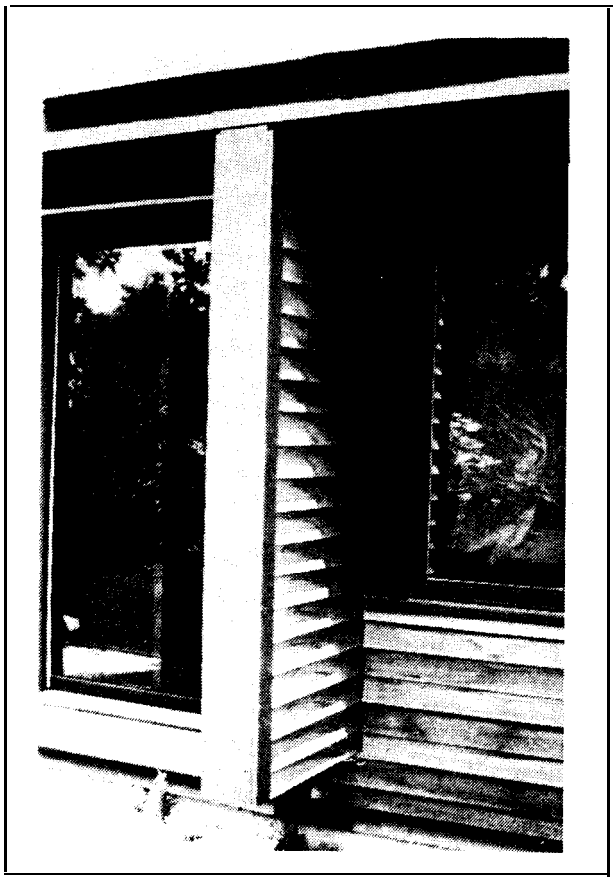
Solar shading and control devices are important cooling strategies in the Peterson house. For example, the clerestory windows are recessed to prevent unwanted summer sun penetration. Vertical wingwalls (opposite left) are used to eliminate unwanted solar gain in the late afternoon. Attached overhangs also provide shading to non-clerestory windows (opposite right).

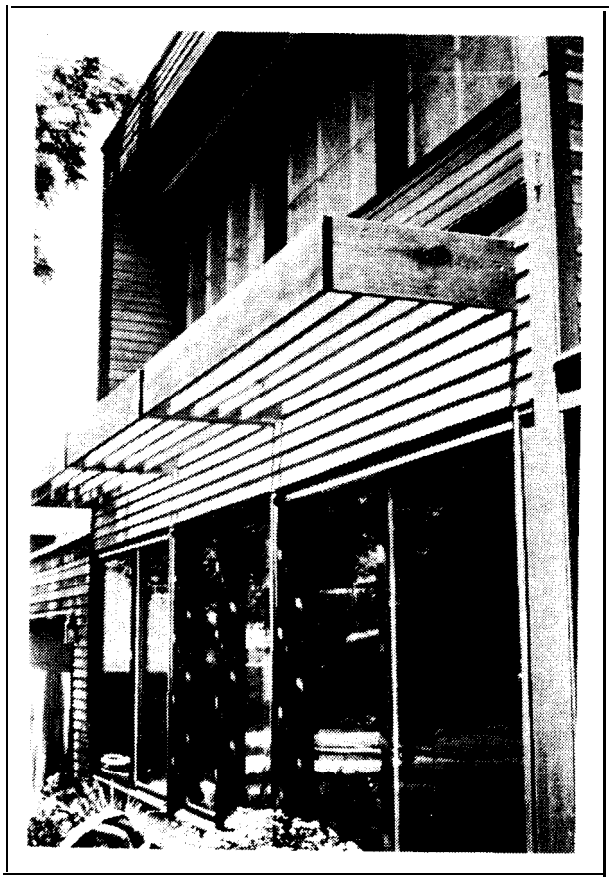
Two different movable insulation systems -- one automatic and motorized, the other manually operated -- are used on the south windows. The multi-layered shutters create air pockets when unrolled and provide an insulation value of approximately R-13.



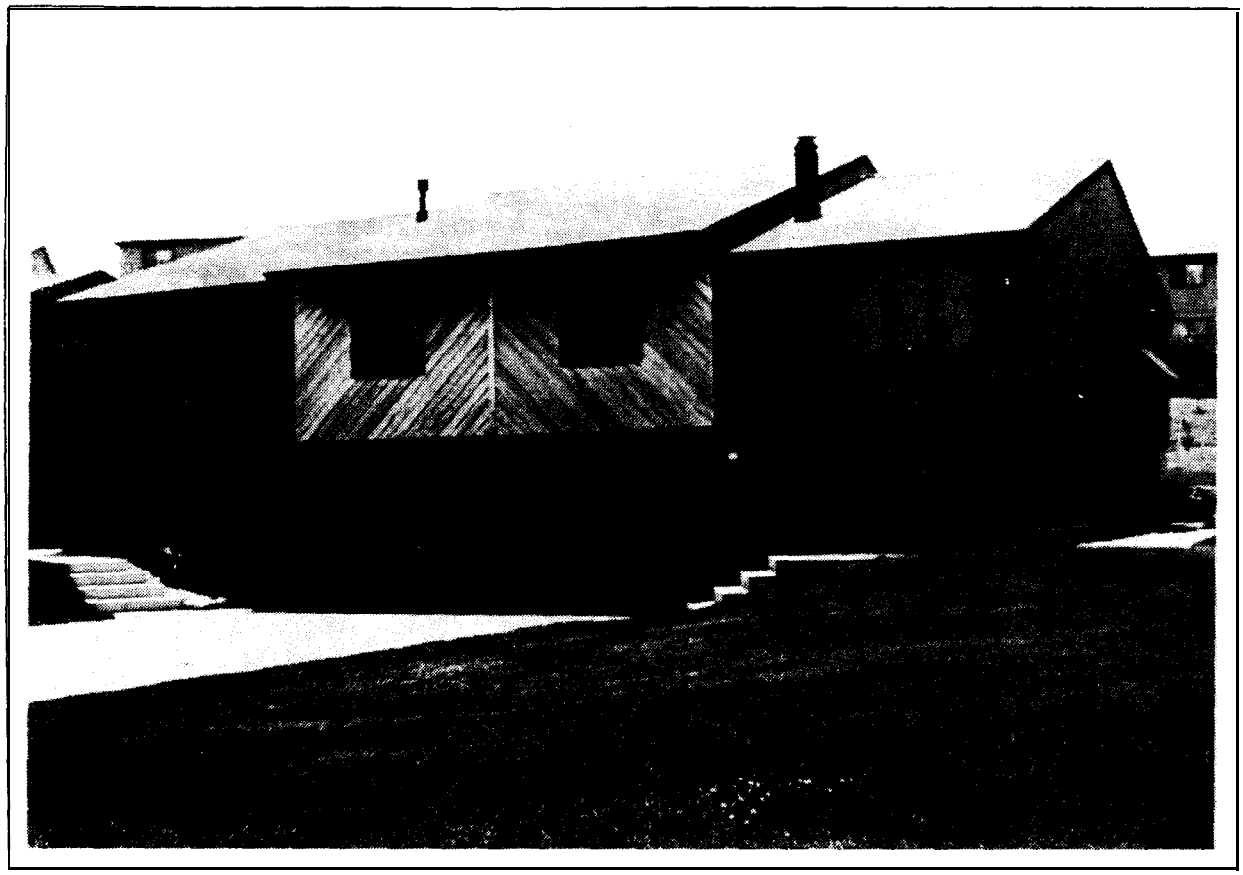
MAIN LEVEL







TOWNHOMES

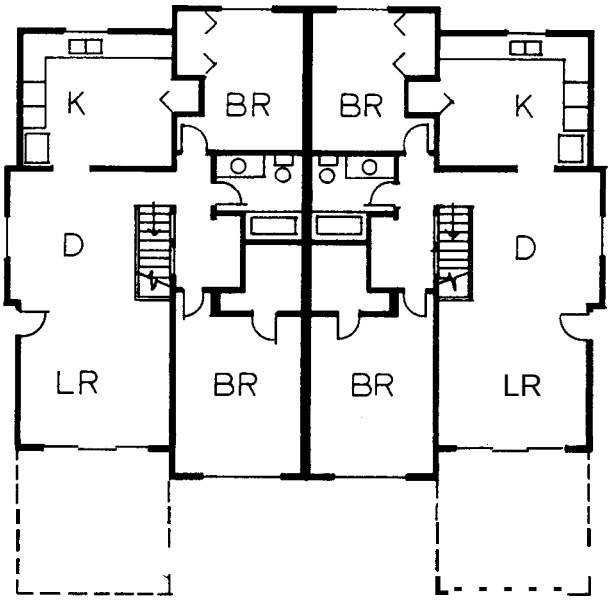


Energy efficiency and passive solar design strategies are available to Lincoln residents choosing townhouse living thanks to the foresight and commitment of Bob Peterson of Peterson Construction.

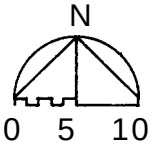
The townhouses are intended to have wide appeal and are offered in a number of different models and designs. They range in size from 860 sq ft for a one story home to 1200 sq ft for a three bedroom home on two levels. Inner units of the townhomes are 16' wide and outer units are 24' wide. Purchasers also have the choice of one or two car garages. In some models, the garage is situated to function as a wind break, thereby reducing heat loss resulting from wind load air infiltration.

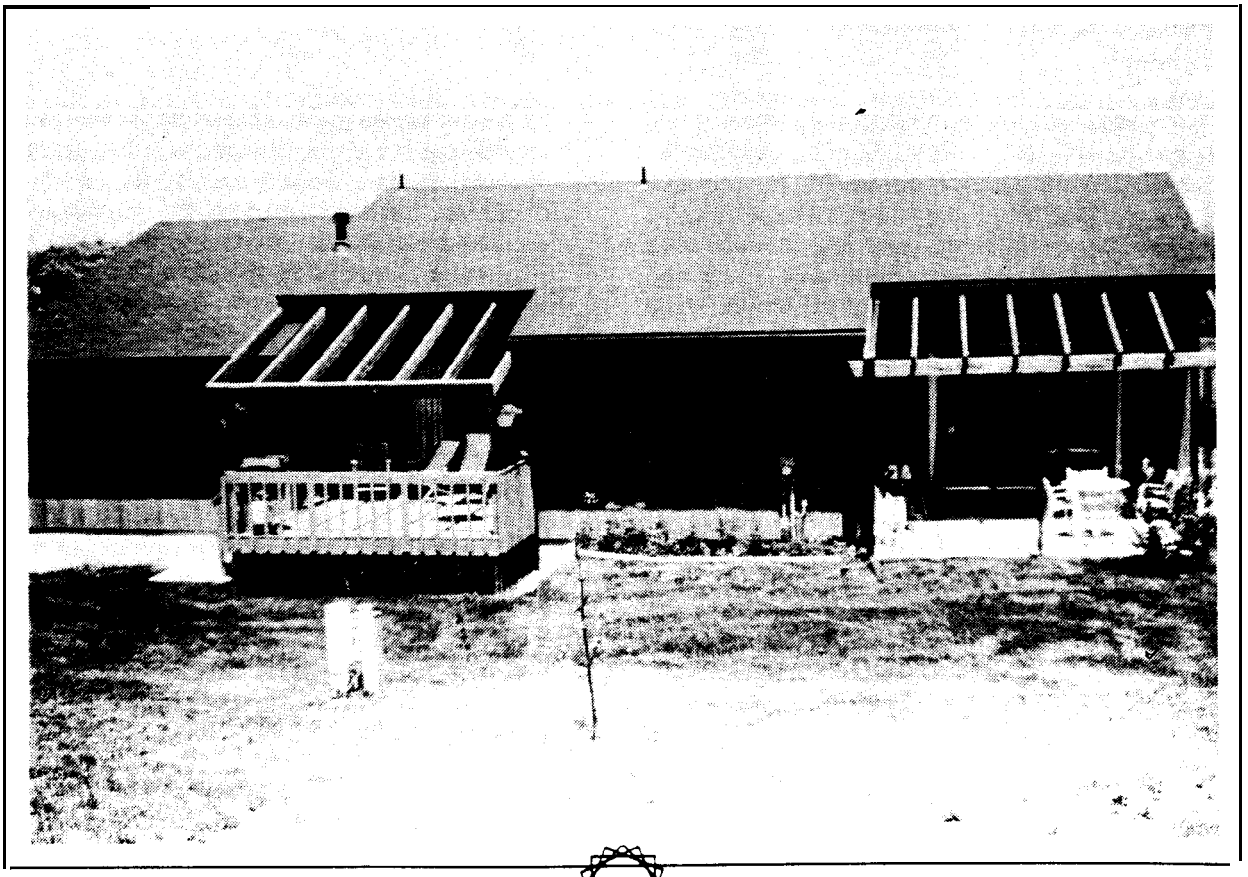
Common wall construction, typical in townhouse design, can have a major impact on energy consumption; common walls result in less surface area of the structure exposed to outside temperature extremes and consequently have lower heat losses. In the Peterson townhomes, common walls have double stud wall framing. Insulation levels are R-21 in the exposed walls, R-30 in the cathedral ceiling roofs, and R-38 in the other roofs; below grade walls are insulated with 2" of rigid insulation. Metal doors have an insulation value of R-14. Backup heating is supplied by electric furnaces or heat pumps, at the option of the owner.

The south glazing in the units varies from approximately 55 sq ft to 90 sq ft, and all windows are double glazed casement windows. The townhouses are a simple direct gain system, although owners of certain units with the back facing south have an option to replace the deck (opposite) with a greenhouse.



MAIN LEVEL





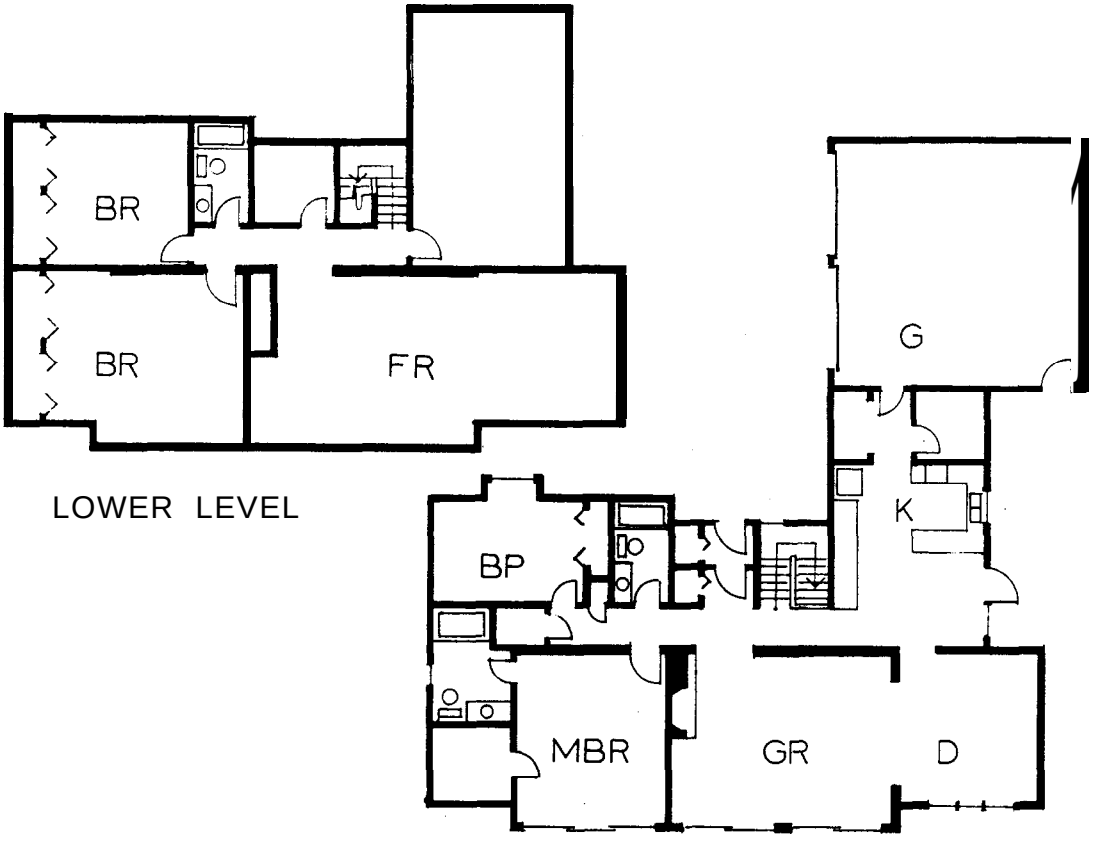
nSYBOUTSn

The Sybouts moved into their direct gain passive solar home in April of 1983. The owner, influenced by THE PATH TO PASSIVE: NEBRASKA'S PASSIVE SOLAR ENERGY PRIMER and other resource materials, designed the house, and the floor plan reflects the lifestyle of a couple with grown children -- the master bedroom is located on the 1500 sq ft main level.

The Sybouts house, which from the street (opposite left) gives no indication that it is a passive solar design, incorporates a number of energy conservation features. For example, the house has an airlock entry,it has only 23 sq ft of gLazing on the north side of the house and only 6 sq ft of glazing on the west, and it has 9"of batt insulation in the sloped roof and 12" of batt insulation in the flat roof.

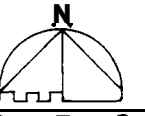
Solar gain is through 240 sq ft of south facing glazing which includes the clerestory windows. Heat is stored in the brick mass walls (opposite right) in the great room, and ceiling fans (opposite right) circulate sun warmed air. Motorized "Insulider" night shutters (opposite right) are used on all south facing windows to reduce the significant heat losses that can occur through windows with relatively low R values. Although the house has a high efficiency gas furnace, backup heat is primarily supplied by a Lincoln woodburning stove (Papa Bear model) that is located in the basement and is connected to the ductwork of the mechanical system.

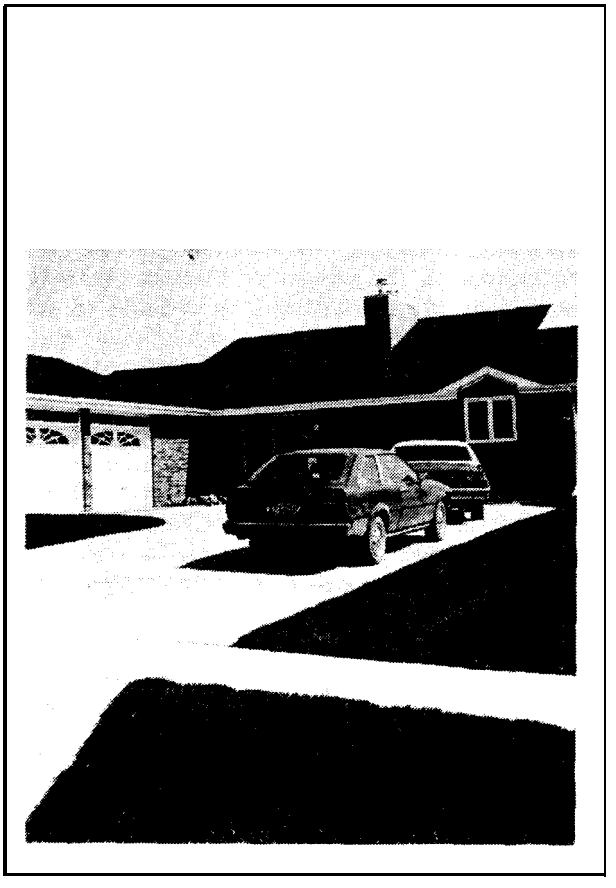
To reduce air conditioning loads during the cooling season, the owner lowers the motorized night shutters during the day to block direct gain, and, after the sun sets and outdoor temperatures fall, the operable windows in the clerestory are opened to allow warm air at the peak of the house to vent.

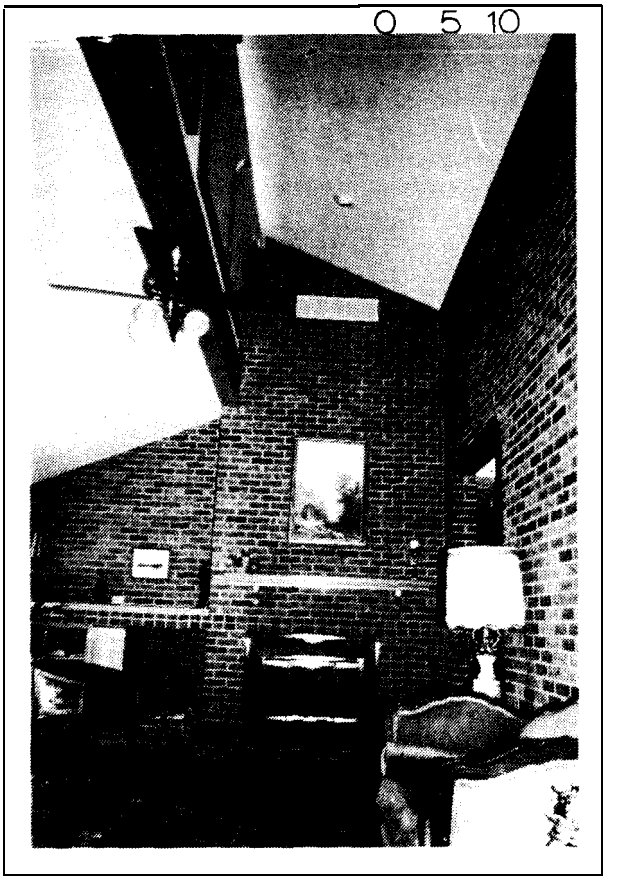


LOWER LEVEL

MAIN LEVEL





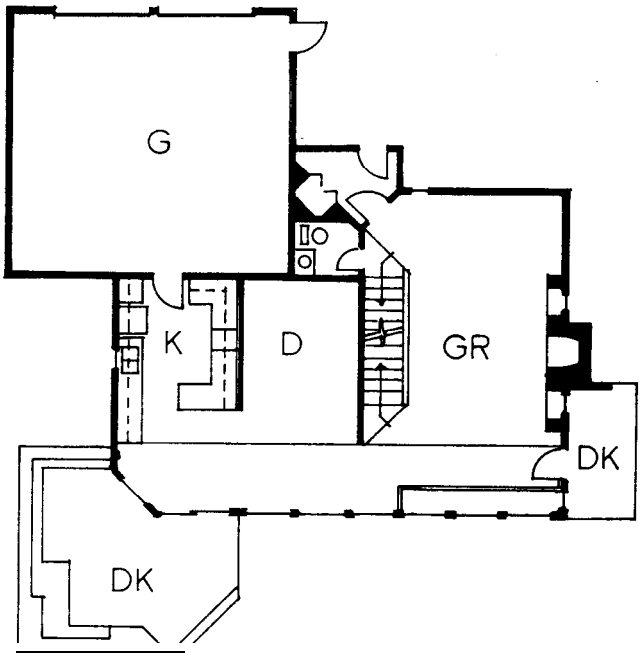


WRAITH

The Wraith home, Solar 1, is an American Wood Council "Idea House" built in conjunction with the Metropolitan Omaha Builders Association. This direct gain passive solar design demonstration home features a basement foundation of treated wood. The house was designed and engineered by Ionic Solar and built by Grace-Cizek Construction, both of Omaha. The home has 3400 sq ft of living space divided between two levels.

The passive solar heating strategy used is direct gain with vertical glazing. Sun heated air is drawn to the east wall by a squirrel cage fan and redistributed to the rest of the house. The primary source of backup heat is a Lennox gas pulse combustion furnace. The house also has a fireplace,and there is a wood burning stove in the basement.

The most unique feature of the house is the bead wall window insulation system which is used in the windows of the first floor and some of the windows of the second floor (opposite left and right). Basically, a bead wall window insulation system functions like any other window insulation system; the windows are left uninsulated when the sun is shining, and they are insulated when the sun goes down. A beadwall window insulation system is unique, however, in that the insulation is applied to neither the exterior nor the interior of the window. Rather, Styrofoam beads are blown from a storage compartment into the cavity of each specially constructed fixed-pane oversized window when insulation or shading is desired, or sucked from between the windows when sunlight in the rooms is wanted. Static electricity can sometimes prevent the removal of the beads.



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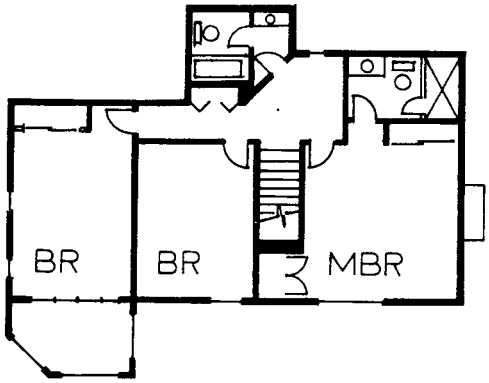
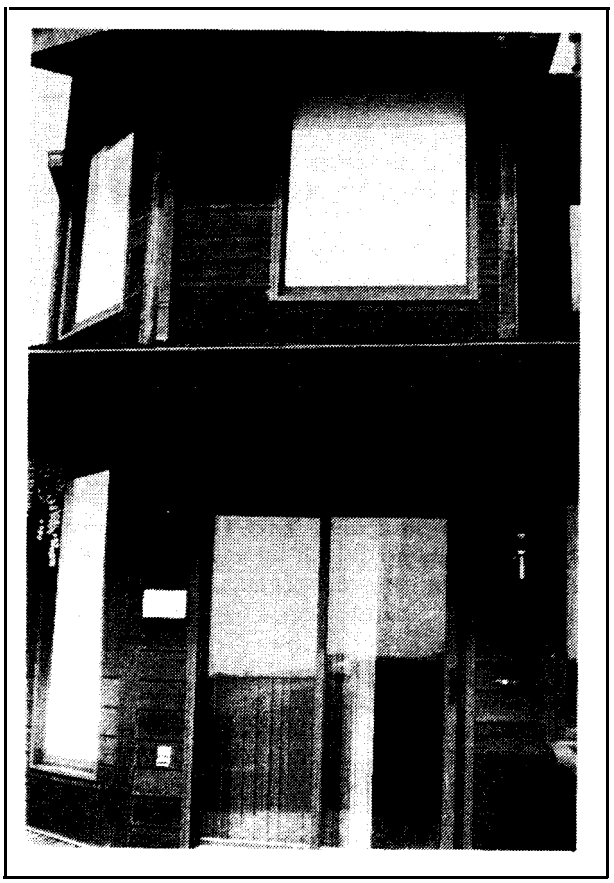
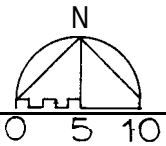
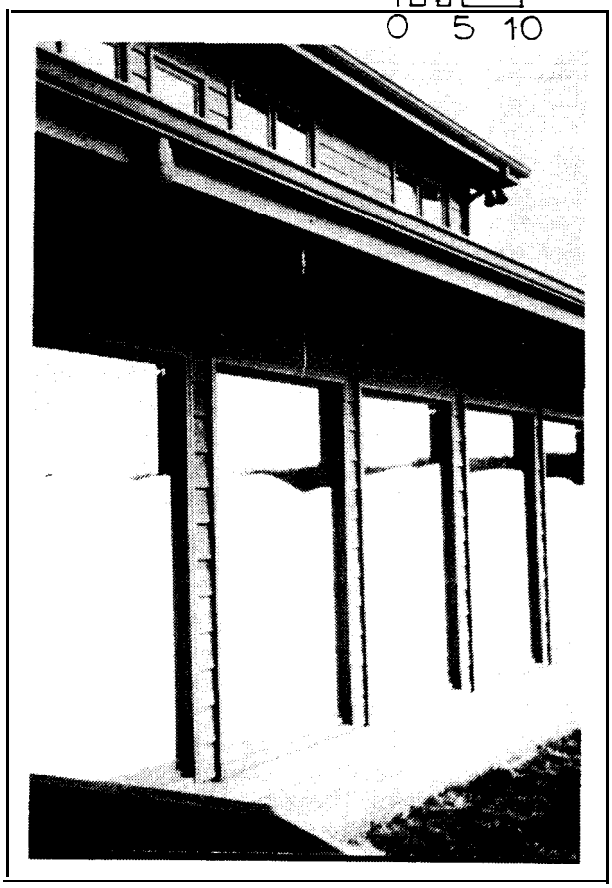


UPPER LEVEL







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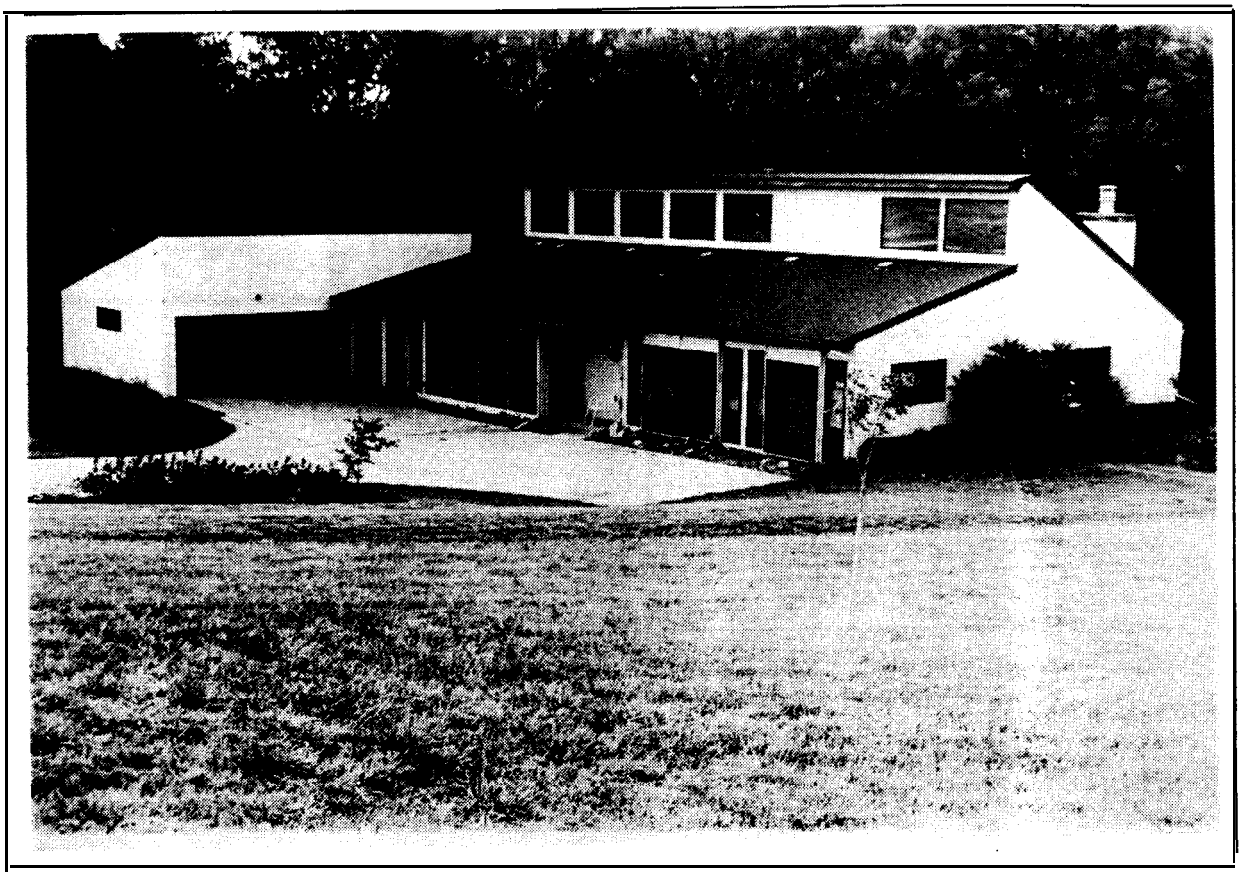
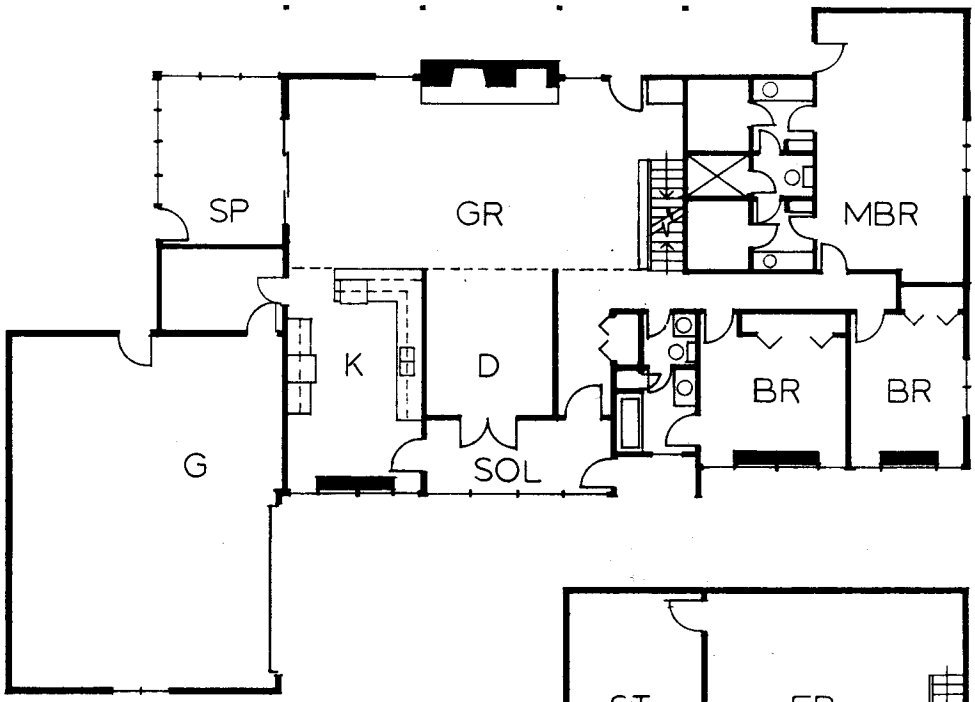
MIXED PASSIVE



The Frisk home, designed by Solar Energy Associates of Omaha, is an interesting combination of conservation strategies and direct gain, trombe wall and greenhouse passive solar heating techniques. A particularly nice feature of the Frisk home is the loft (opposite left) located above the bathroom area and overlooking the great room. The empty vertical spaces typically found in rooms with clerestory windows and high ceilings can be ideal for lofts which can be used as a study, family room, spare bedroom, children's play area, etc.

An earth berm protects the northeast corner of the house from winter winds. Mature trees to the north of the house serve as a windbreak during the winter, and those to the west shade the house from the afternoon sun in summer. Another conservation feature of the home is the airlock entry which functions as useable space. The main entrance is an airlock entry that is also a solarium/sunspace (opposite right). The other airlock entry, between the garage and the kitchen, is the location for the laundry and pantry.

Sunlight reaches north rooms through clerestory windows, and, in the great room, a massive fireplace located along the north wall absorbs and stores direct solar gain. The Trombe wall is located in the breakfast area and two of the bedrooms. Trombe walls are inherently efficient and temperature stable, and the owner is very pleased with the "toasty" atmosphere of the Trombe wall spaces. No night shutters are used in the house, and backup heating is provided by a heat pump.



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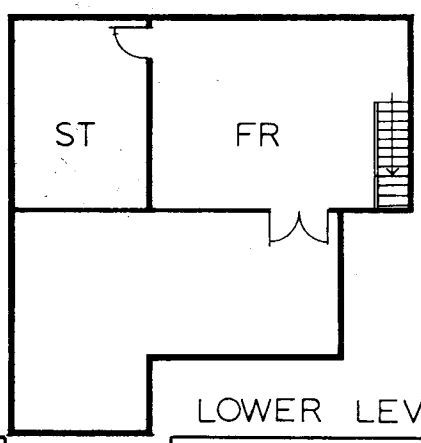
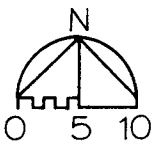
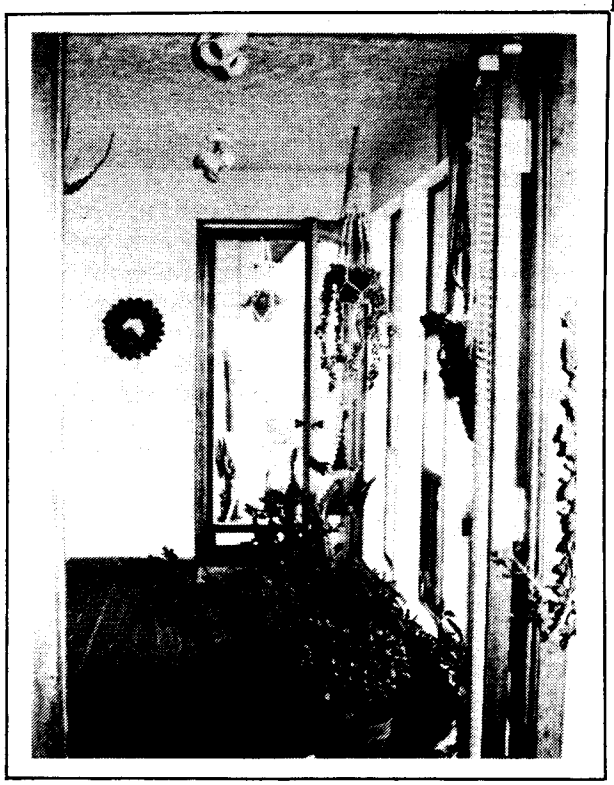
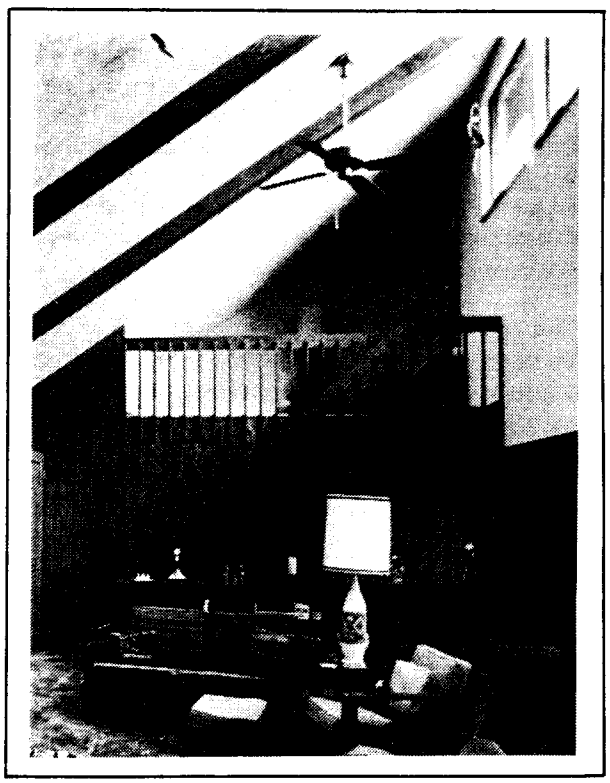


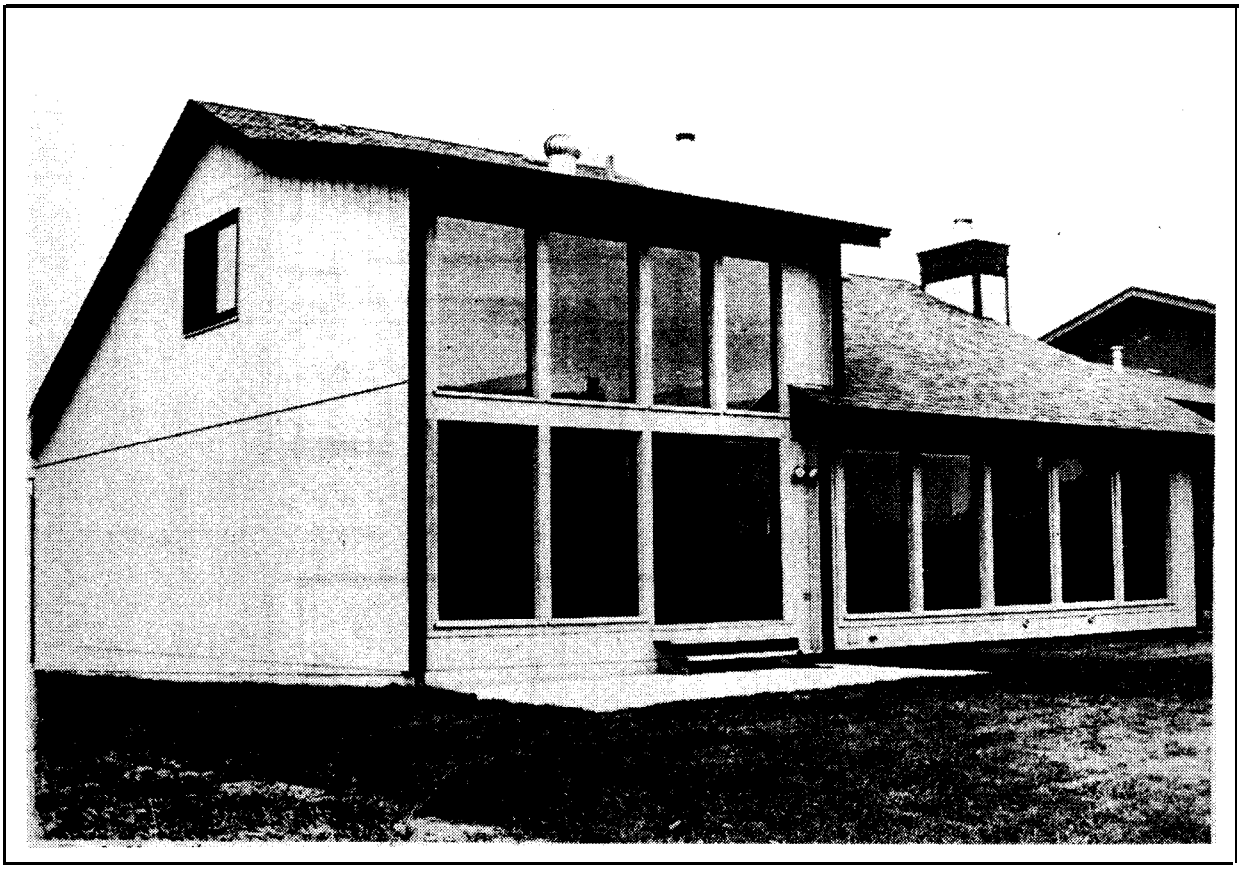
LOWER LEVEL







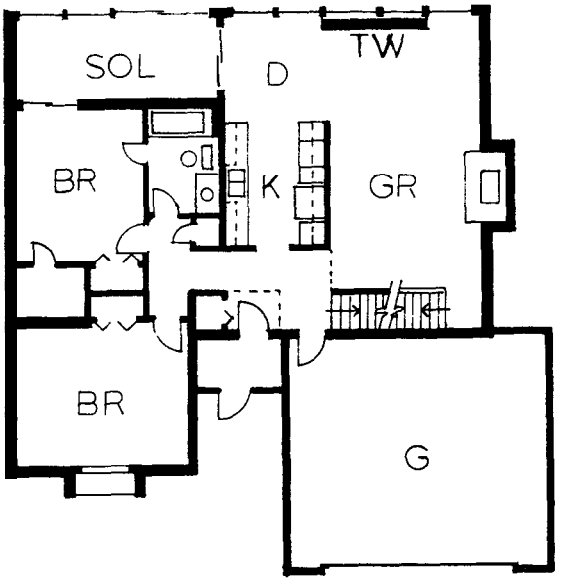
nHENLEYn



The decision made by Pacesetter Homes several years ago to upgrade the energy efficiency of their houses, has resulted in their emergence as the leader in constructing energy conscious/solar tract housing in Omaha. Their homes are affordable and well designed. They are also attractive in appearance without overstating their energy conservation and solar aspects.

The Henley residence is Pacesetter's Solarstar model. The base design has slightly more than 1300 sq ft of floor space on the main level. The conservation features include an air lock main entry (vestibule) on the streetside of the house (opposite), a 6 mil vapor barrier on all exterior walls and ceilings, a clock operated thermostat for the automatic setting back of temperatures at night, and a furnace with an energy efficiency rating of 53%. Insulation levels are R-25 in the exterior walls, R-40 in the flat ceiling areas, and R-36 in the sloped ceilings. In addition, 3" of rigid insulation are installed below grade.

Like the Bussey home, the other Pacesetter solar model described previously in this inventory, the Solarstar is primarily a direct gain structure. Unlike the Riviera model, however, the Solarstar is designed so that the back of the house faces south, and it utilizes more than just direct gain passive solar strategies. In addition to the considerable main level direct gain glazing, there is a two story sunspace, a 12" Trombe wall, and masonry floors in the solarium and dining room to absorb solar heat. Warm air from the solarium can be circulated to the north bedrooms, bath and loft in winter, and it can be vented to the outside in summer.



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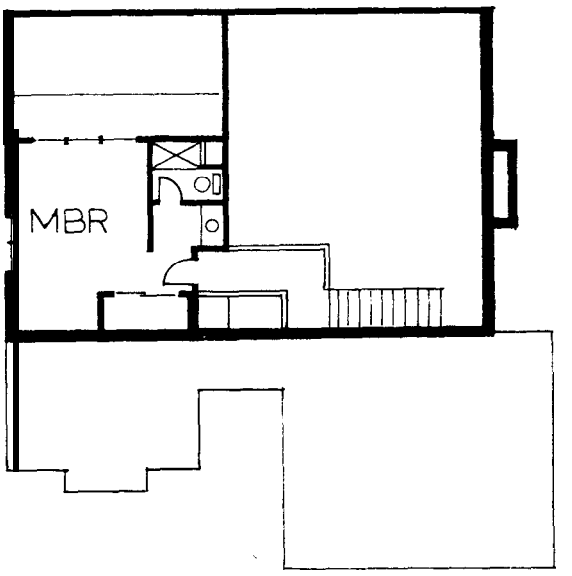

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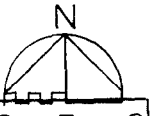
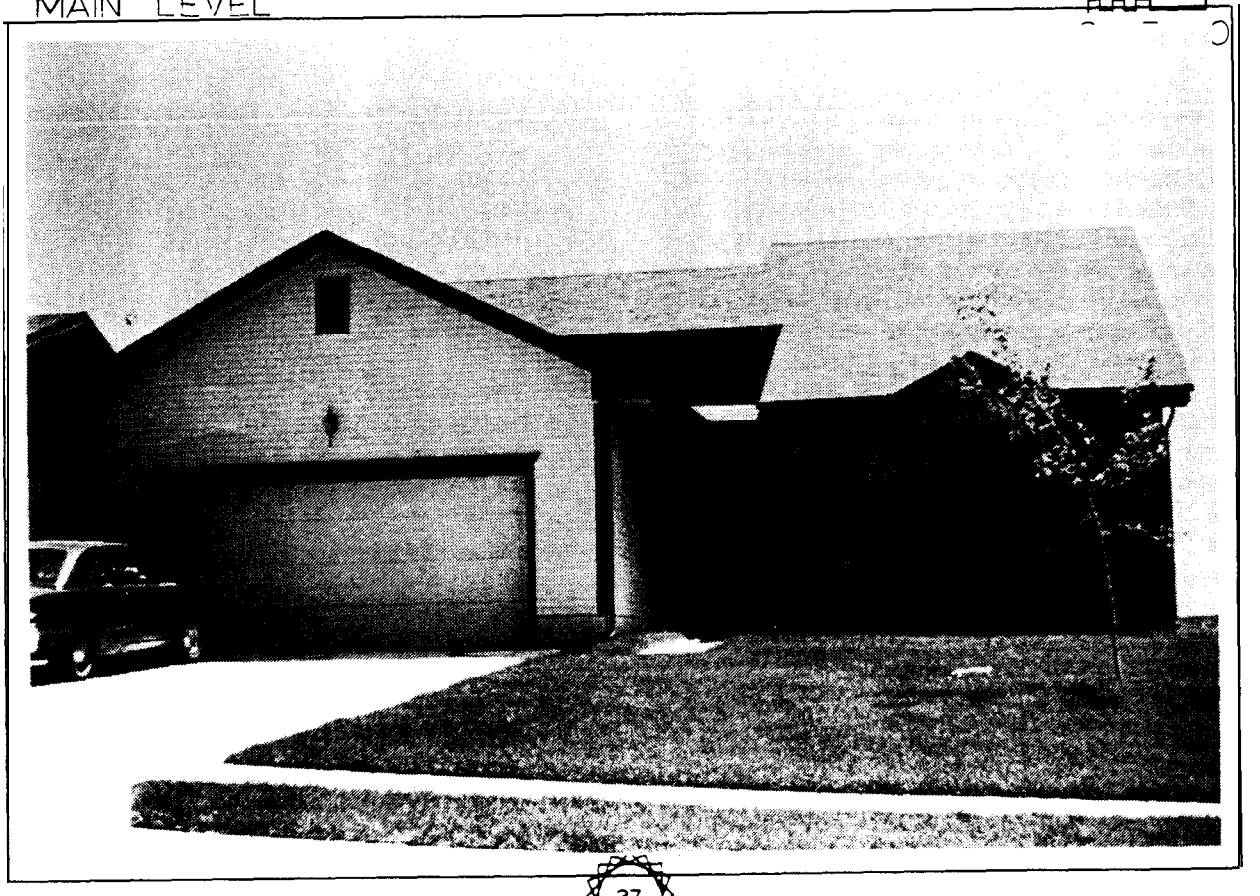
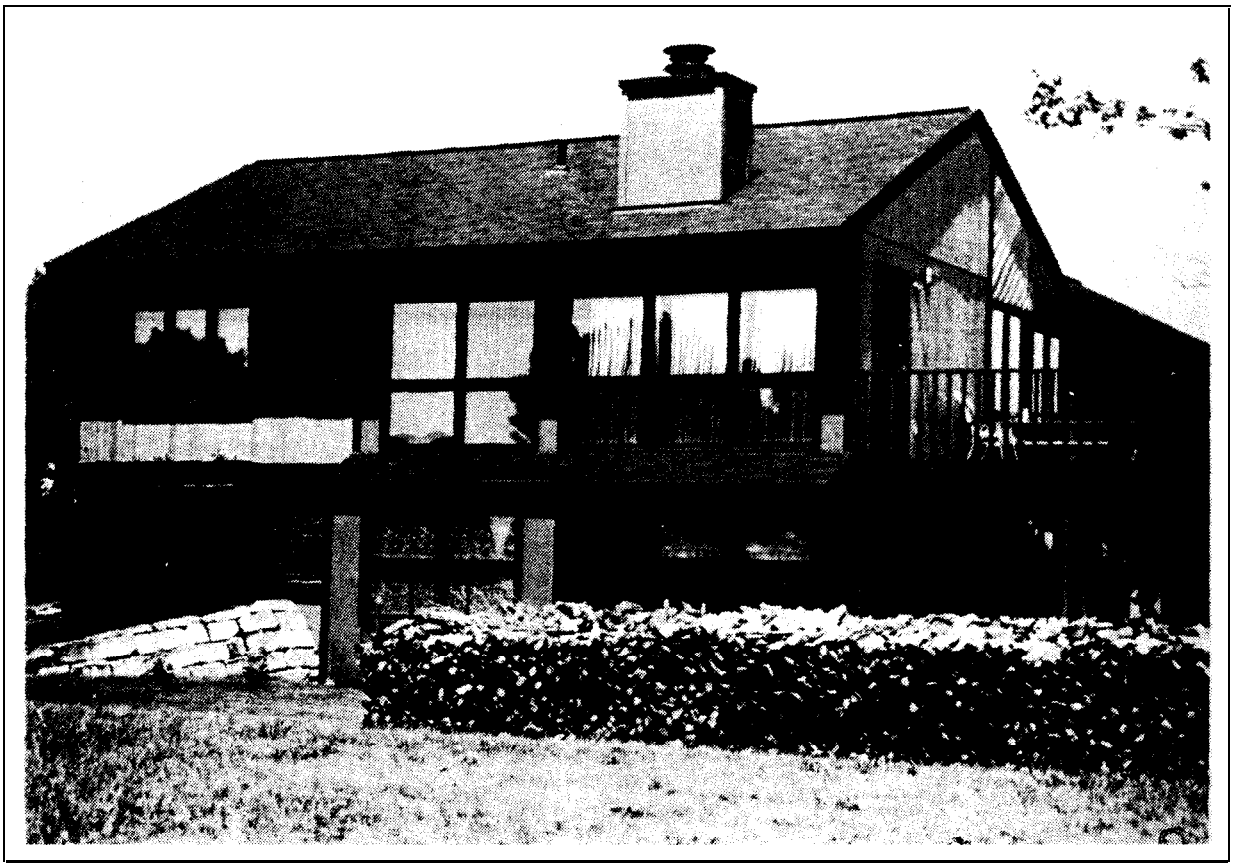




nBATESn



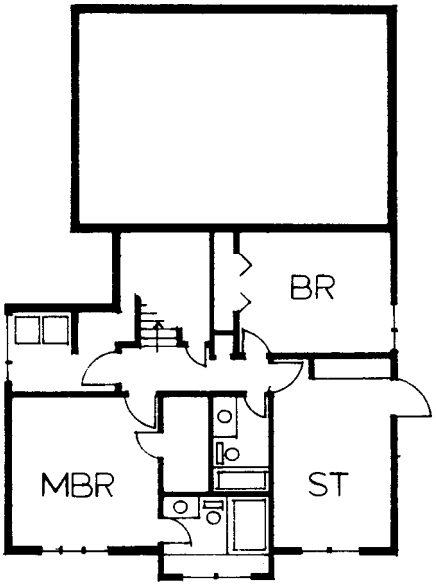
The Bates home is the Golden Anniversary, a direct gain and Trombe wall passive solar model home offered by Peterson Construction of Lincoln. This model has 1950 sq ft of floor space with an optional loft that can be located over the strategically placed garage. Located on the north side of the house, the garage functions as a buffer to protect the house against cold north winds.

This solar home has nearly 30O sq ft of vertical south glass. The Trombe wall, located in the great room, contains a fireplace. A ceiling fan near the ceiling peak is used to help circulate air and reduce air stratification. The bedrooms in the Golden Anniversary are located on the lower level where the rooms have ceilings of conventional height. These rooms are warmer than rooms with vaulted ceilings because heat tends to stratify in the rooms with vaulted ceilings in passive solar buildings.

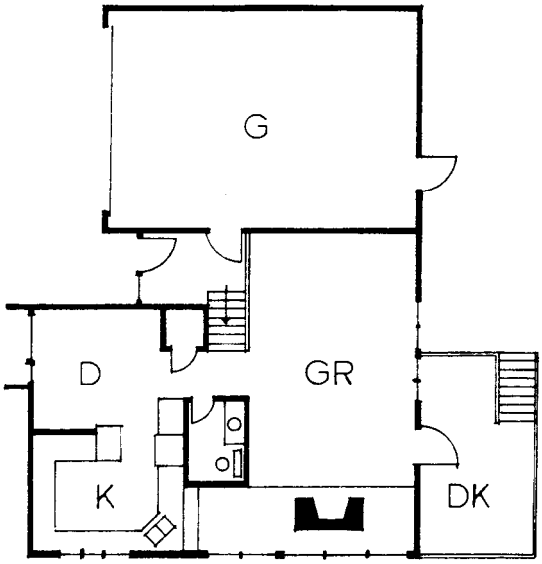
Combustion air for the furnace is ducted from the outside. The incoming combustion air is preheated by being drawn through a ground tube, the intake opening of which is cleverly disguised under a wooden seat (opposite right) located near the main entrance to the house.

The owner has indicated that thermal performance of the building could be improved if movable insulation were to be installed on the windows in the bathroom located on the lower level off the master bedroom; without night insulation, the bathroom can become quite cold.

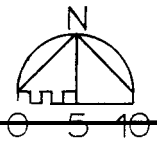
Energy efficiency finished second to aesthetics in the choice of window coverings for the south facing glass in the great room. The interior decorator unfortunately chose a vertical blind (opposite left) with a mirrored surface that has a negligible insulation value.

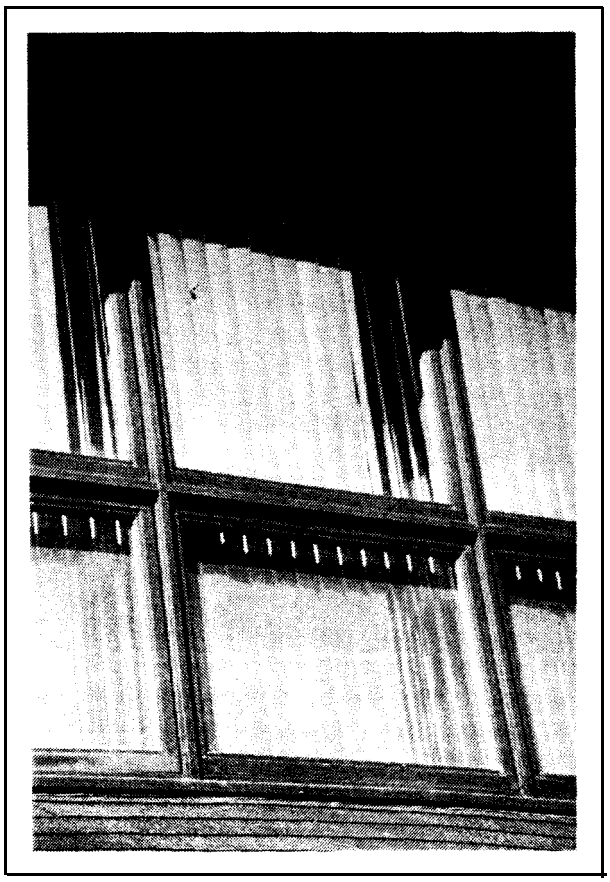


LOWER LEVEL



MAIN LEVEL





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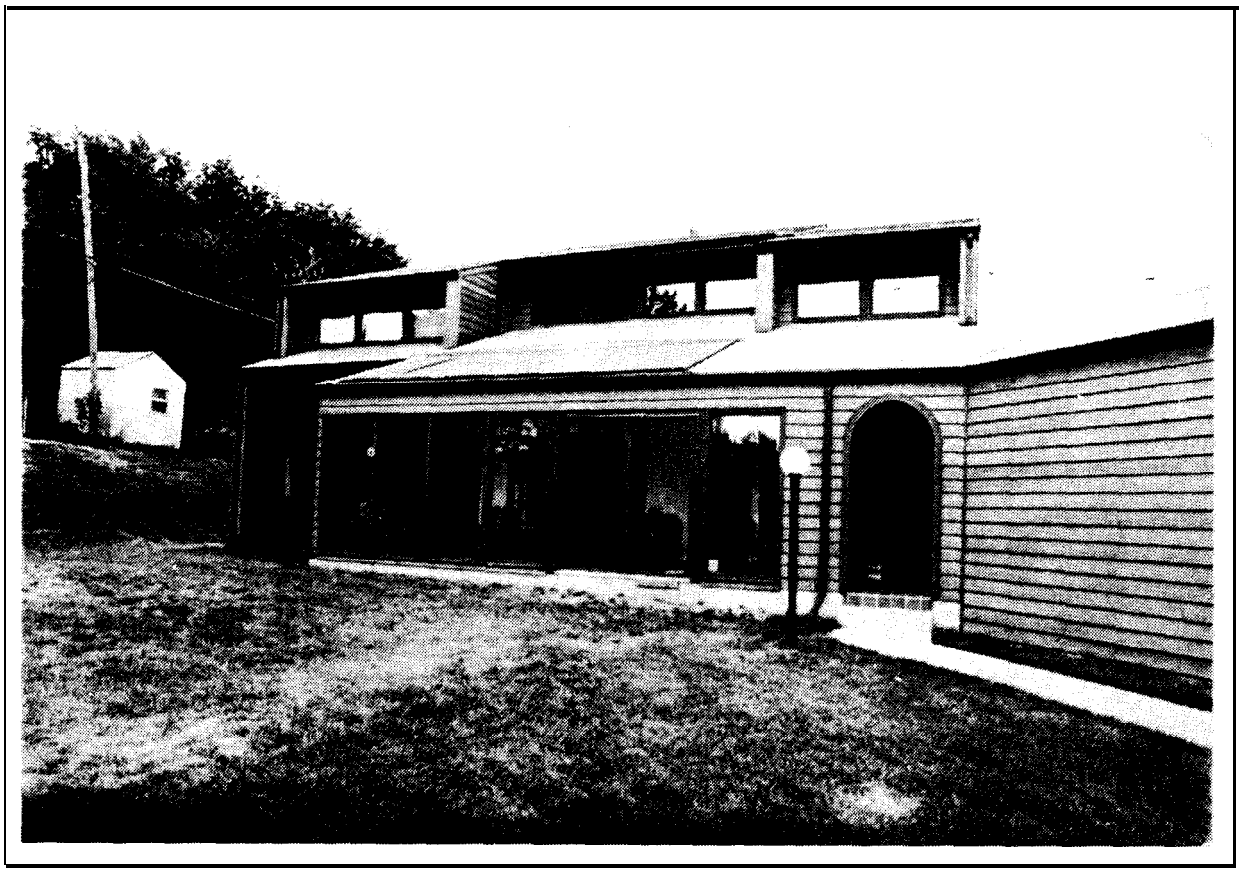
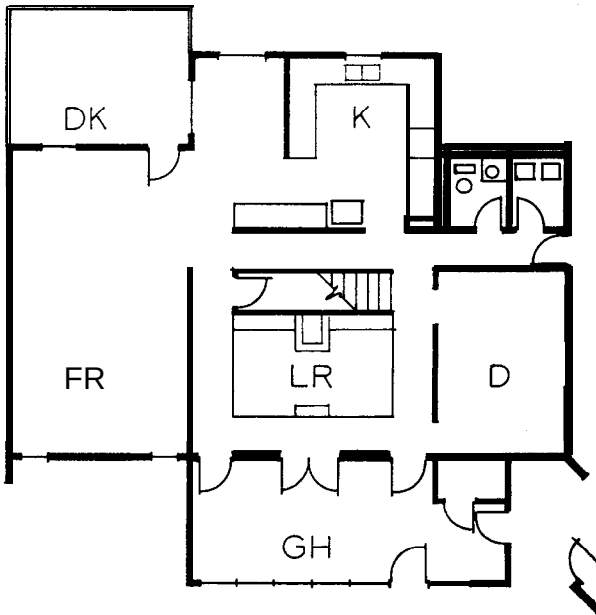


The Coren residence was designed by Robert Youngberg, director of the University of Nebraska-Lincoln Solar Resource Development Office. The four bedroom, two-story frame house with basement has 2800 sq ft of living space.It is primarily a direct gain and greenhouse design, although it also utilizes a Trombe wall. Backup heat is supplied by a groundwater source heat pump.

The 90 sq ft of direct gain glazing in the Coren house includes the clerestory windows which provide light to the upper level bedrooms as well as to the hallway that is open to the living room below. The living room also receives sunlight through the glazing that separates the greenhouse from the Living room. Another 90 sq ft of glazing is located in front of a vented Trombe wall in the family room (opposite left).

The majority of solar glazing -- a total of 200 sq ft of vertical and sloped glazing -- is in the attached sunspace/greenhouse which is connected directly to a vestibule that functions as an airlock entry (opposite right). A thermostatically controlled fan charges a rockbed beneath the sunspace with solar warmed air. Unfortunately, when it is extremely cold outdoors, heat losses from the sunspace are substantial. Heat stored in the rockbed is lost to the sunspace, and, therefore,is unable to be used for heating the house.

The Coren home was monitored under a special program by the Solar Energy Research Institute (SERI) which is headquartered in Golden, Colorado. For a test period from 1981 to 1982, the calculated passive solar contribution ranged from 10% to 41%. The building is, however, very tightly constructed -- the air infiltration rate was measured to be 0.39 air changes per hour. Based on SERI data, the TIF for the Coren house is calculated to be slightly over 2.0.



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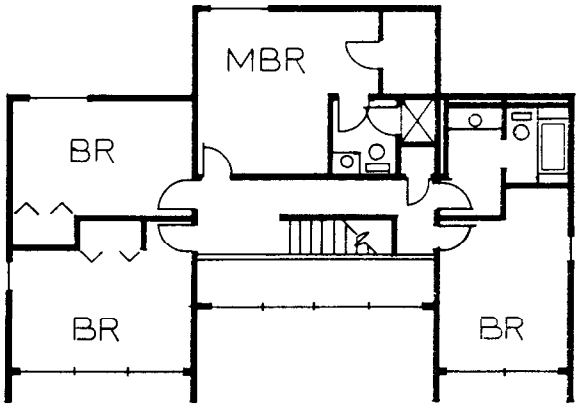

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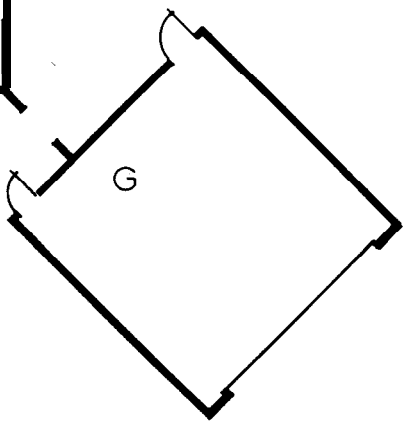
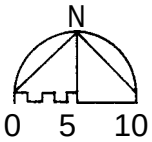
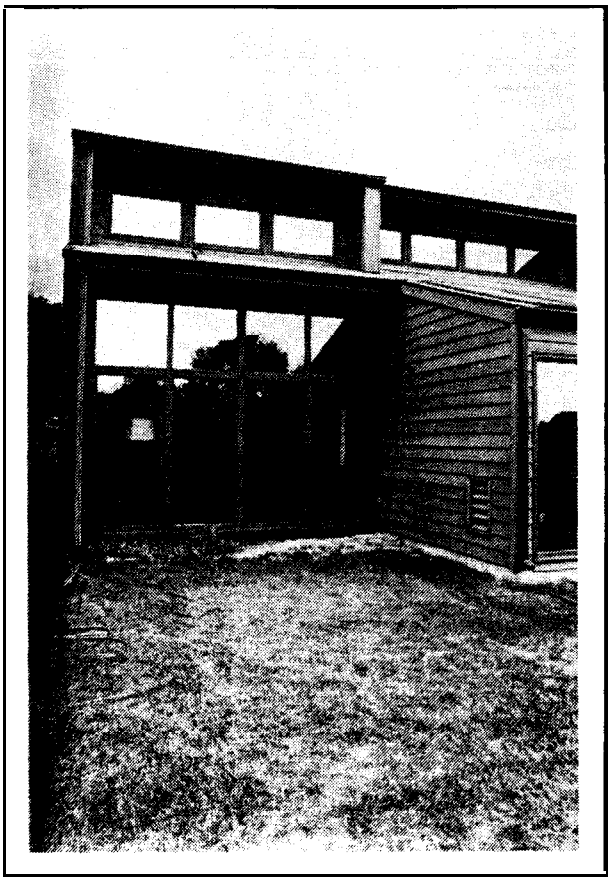
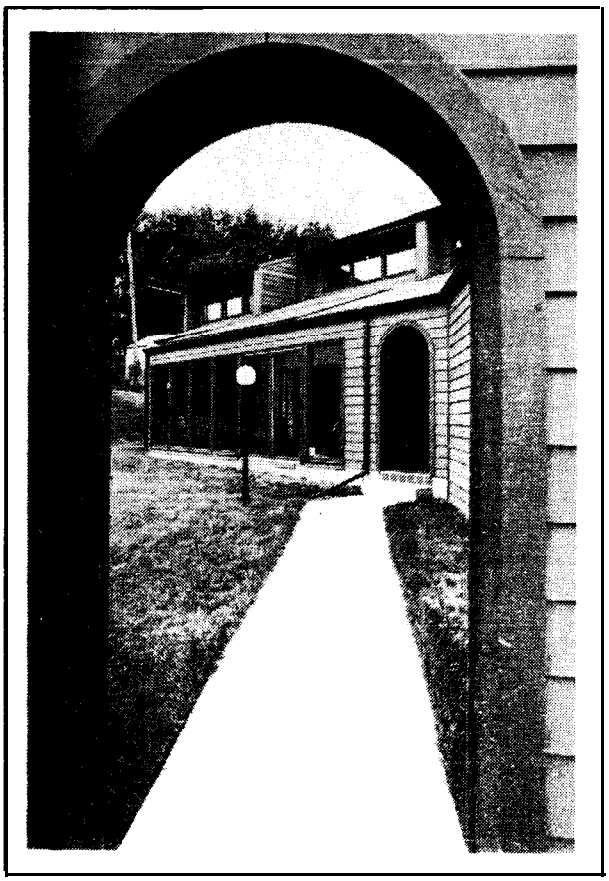
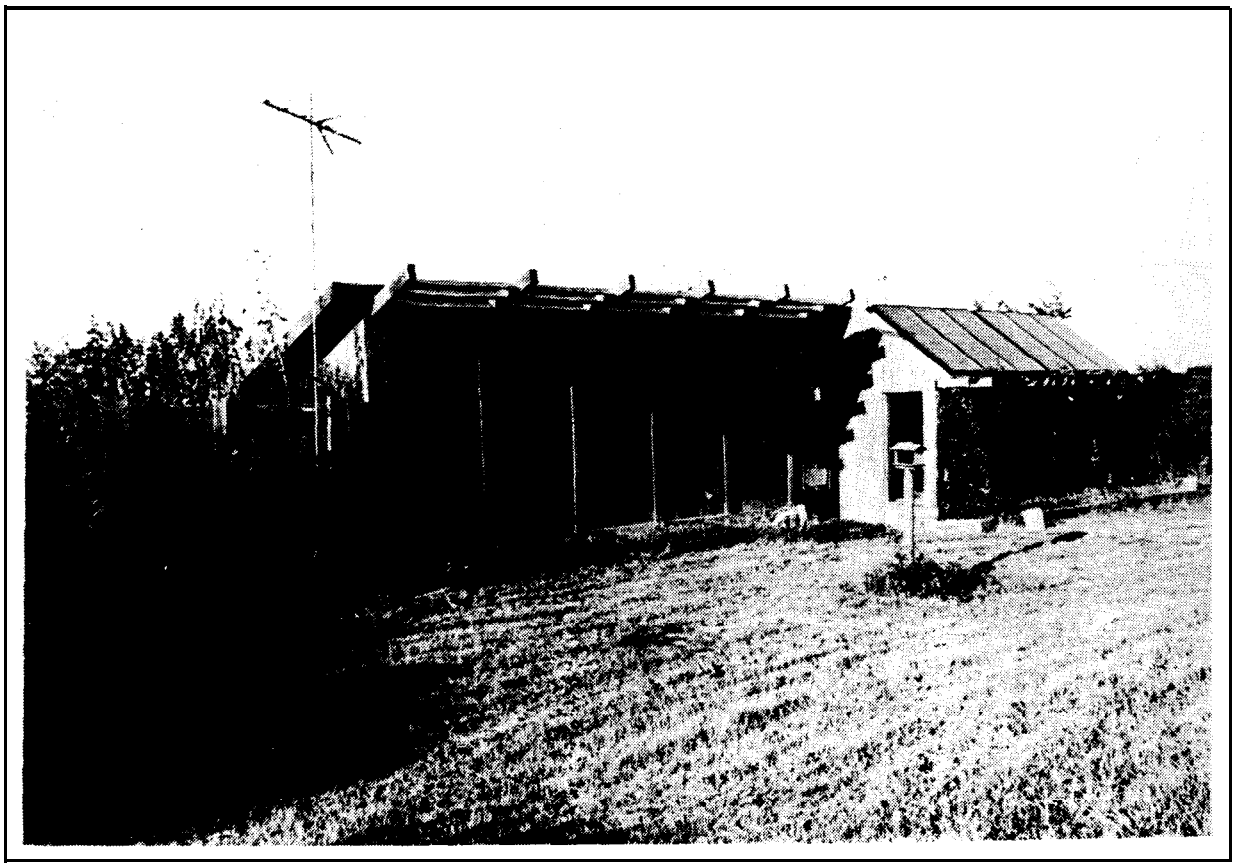










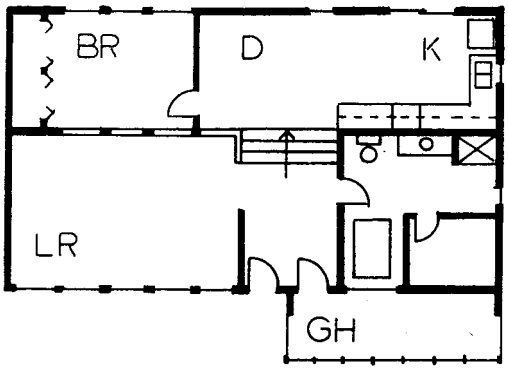
The Johnson home, designed and built by the owner in 1979, is a compact dwelling with slightly less than 1100 sq ft of floor space. The house combines energy conservation strategies with direct gain and greenhouse passive solar approaches so effectively that the only backup heating system, a Vermont Castings wood burning stove (opposite left) is only needed occasionally during the winter.

Energy conservation strategies in the Johnson house include earth bermed against three sides of the house, an airlock entry, R-27 east and north walls, an R-31 west wall, and 5" of Thermax rigid insulation in the roof.

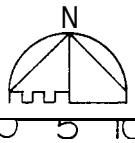
160 sq ft of Andersen triple glazed windows in the living room admit for direct solar gain. Solar heat is absorbed by the brick living room floor. Warm air from the room is used to heat a rock bin containing 40 tons of thermal mass. Unfortunately, the rock bin storage is not working to the owner's satisfaction. Warm air within the house is prevented from escaping through windows by the use of Window Quilts in the winter. During the summer, warm air is vented through the operable windows above the fixed glazing in the living room (opposite left).

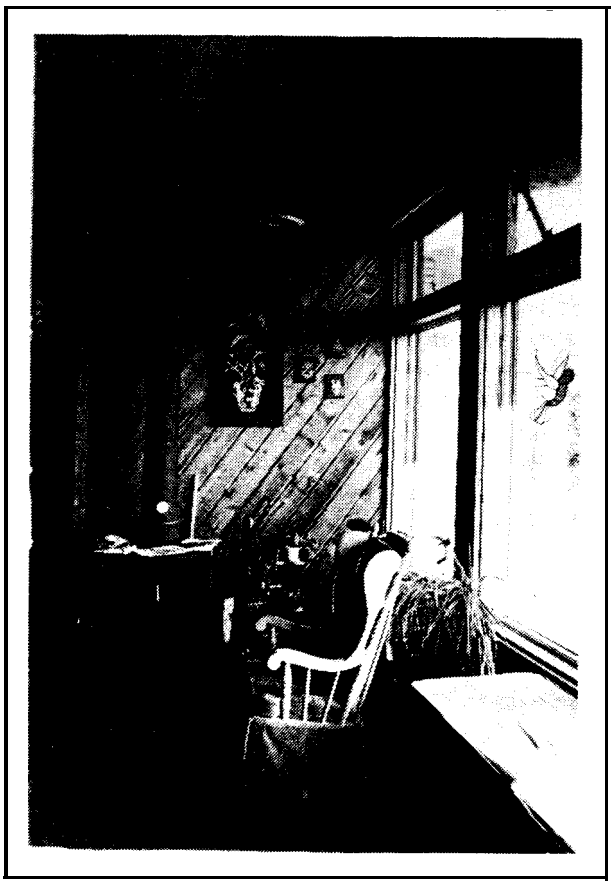
The greenhouse, the other major passive solar heating system in the Johnson house, provides the owner with fresh vegetables throughout the year. The greenhouse is insulated to a level of R-35, although night insulation is not used on the 130 sq ft of quadruple paned glass. Overhangs and hanging plants (opposite right), like Passion Flower, as used for summer sun control.

A Sunworks active solar water heating system over the greenhouse (opposite right) provides hot water for domestic use as well as to a hot tub located just behind the greenhouse. The closed loop antifreeze system is pump-driven.



MAIN LEVEL





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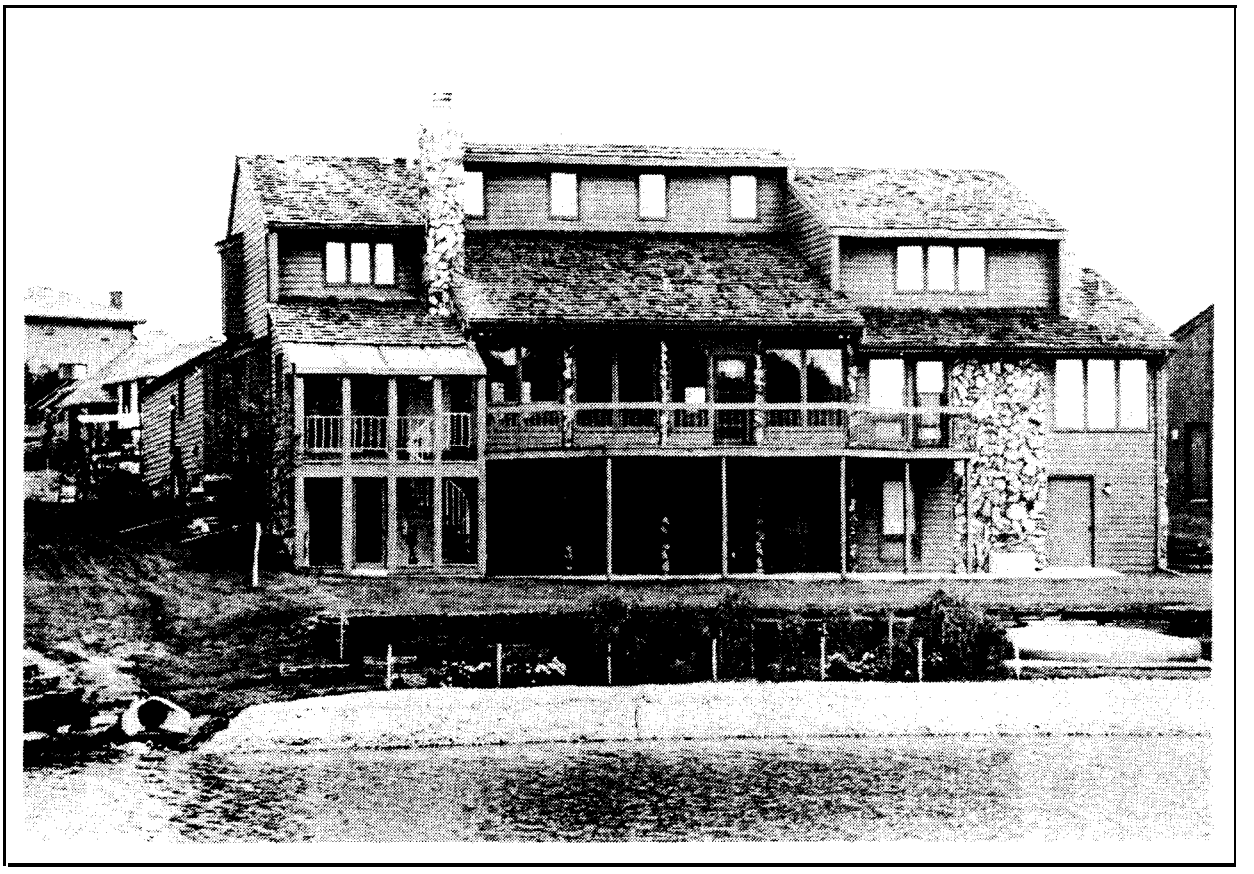
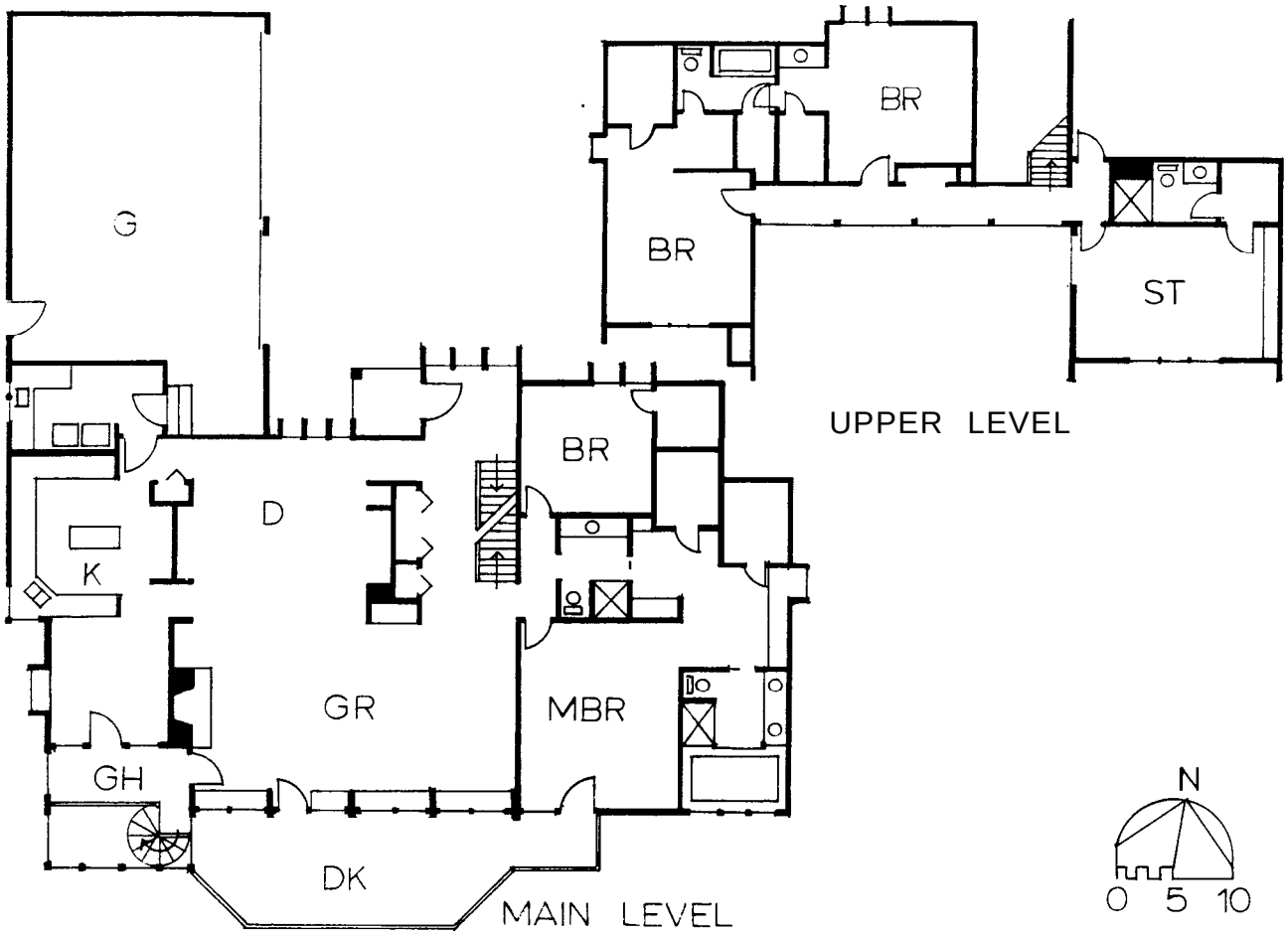


The O'Donohues have lived in their spacious 5300 sq ft home overlooking west Omaha's Lake Candlewood to the south since September of 1982. The five bedroom two-story house, with a family room and storage located in the basement, was designed by Norm Reece of Design Associates of Omaha. Solar consulting was provided by Solar Energy Associates, also of Omaha.

The O'Donohue house combines direct gain and greenhouse passive solar heating strategies. The house has approximately 500 sq ft of Pella windows -- mostly vertical and facing south to provide direct gain passive solar heating. The clerestory windows (opposite right) allow sunlight to reach the upper level rooms as well as the hallway which, open to the great room below, provides an excellent view of the massive stone fireplace along the west wall. Ceiling fans located throughout the house are used to circulate air and prevent air stratification in the high ceilinged rooms.

A two-story attached sunspace with vertical and sloped glazing is located just off the kitchen area. The sloped glazing makes it necessary to vent the space in summer. A spiral staircase located in the greenhouse connects the kitchen area to the lower level and provides access to the outdoors. A deck with a beautiful view of the lake (opposite left) is accessible from the greenhouse as well as the great room.

Two heat pumps and two gas furnaces provide for supplemental heating and cooling. Despite the absence of night insulation for the direct gain windows which would improve thermal performance, this large home has a computed TIF of just over 3.0.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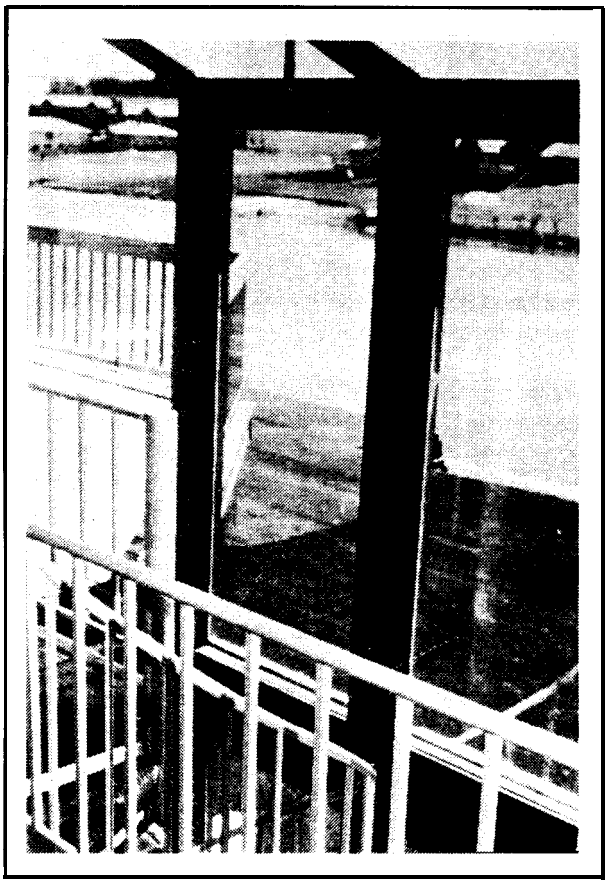
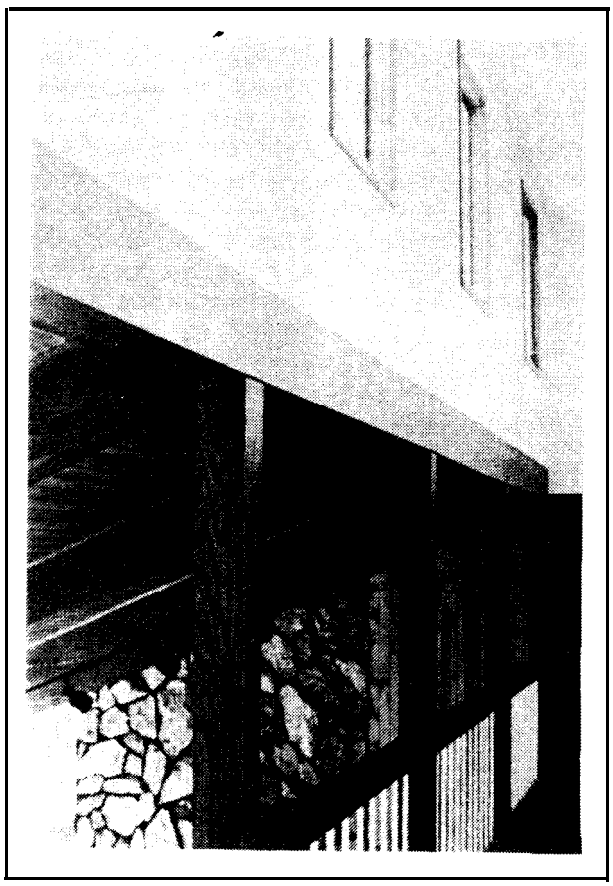
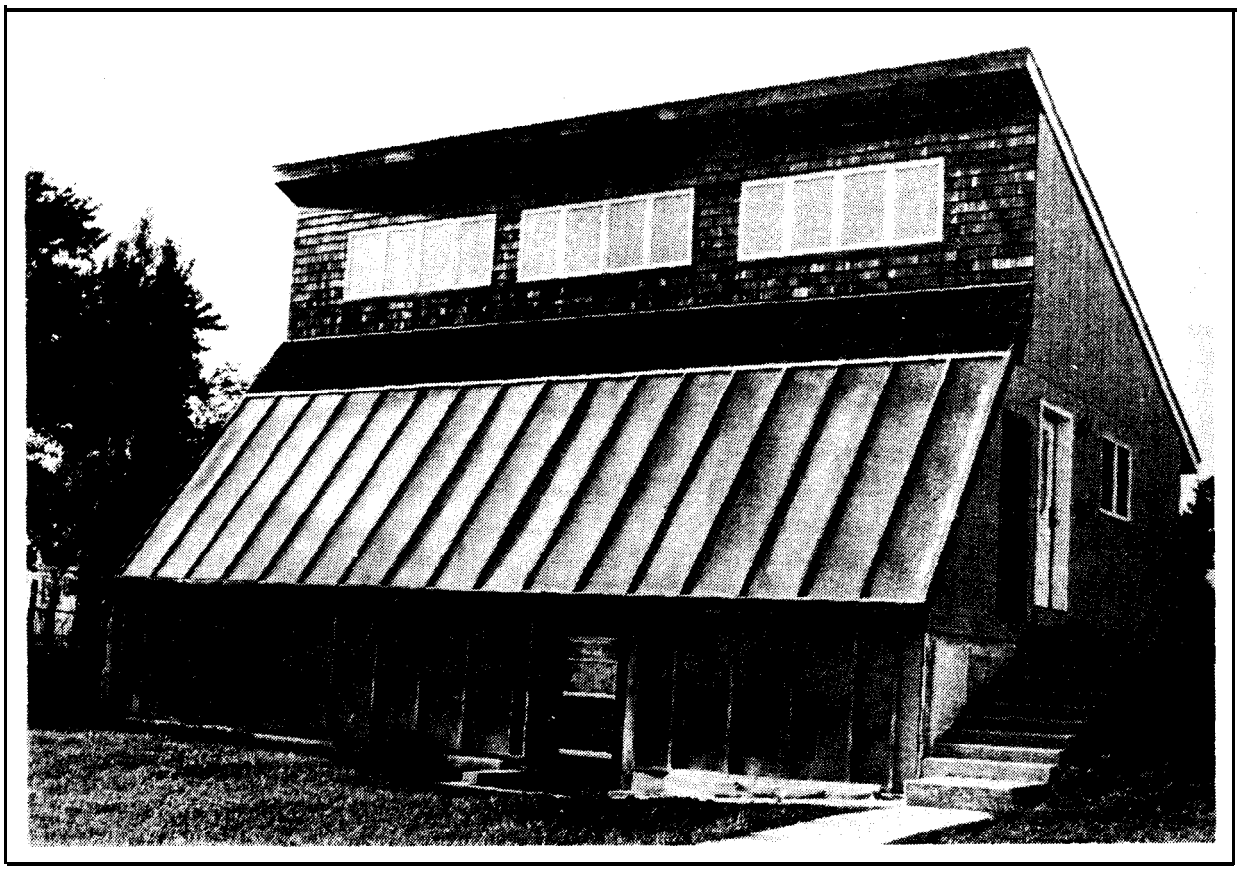




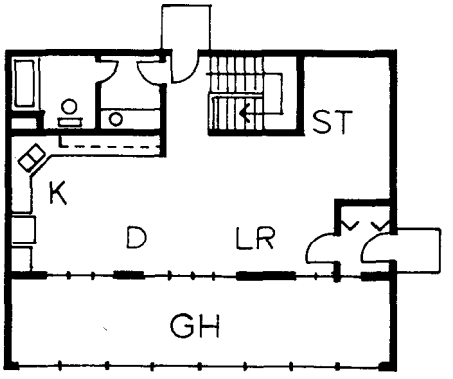
nMORANn



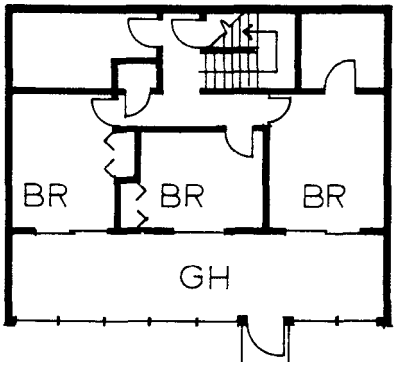
The Moran home, designed by the owner -- with solar consulting assistance provided by Solar Energy Associates of Omaha -- and built by the owner, is an energy conserving home that relies on a combination of direct gain and greenhouse passive solar space heating techniques. It is also an excellent example of economic space design. In fact,a delegation of solar experts from the Peoples Republic of China touring solar projects in Nebraska felt that,of the houses they visited, the Moran house most clearly exemplified their ethic of using resources and space wisely.

The three bedroom house has 1100 sq ft of living space divided between a main level for daytime activities and a lower level for sleeping. Although the house is compact, the main level seems spacious because of its open floor plan -- which includes a loft in the vertical space above the kitchen (opposite left), because of its vaulted ceilings, and because considerable light is admitted through the clerestory windows and the windows to the greenhouse. As recommended in passive solar houses with rooms with vaulted ceilings, the bedrooms are located in the lower level where minimal air stratification will occur because the rooms have ceilings of conventional height.

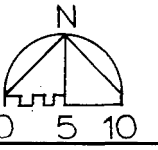
Energy conserving features such as a double door main entry and no windows on the north side of the house help minimize the heating loads. Although some solar heat is generated through the direct gain clerestory windows, most of the solar heat is provided by the greenhouse with its 320 sq ft of economical translucent filon glazing. Because the greenhouse is accessible from the bedrooms (opposite right), sun warmed air from the two-story, 239 sq ft sunspace that spans the entire front of the house can be used to heat the lower level.

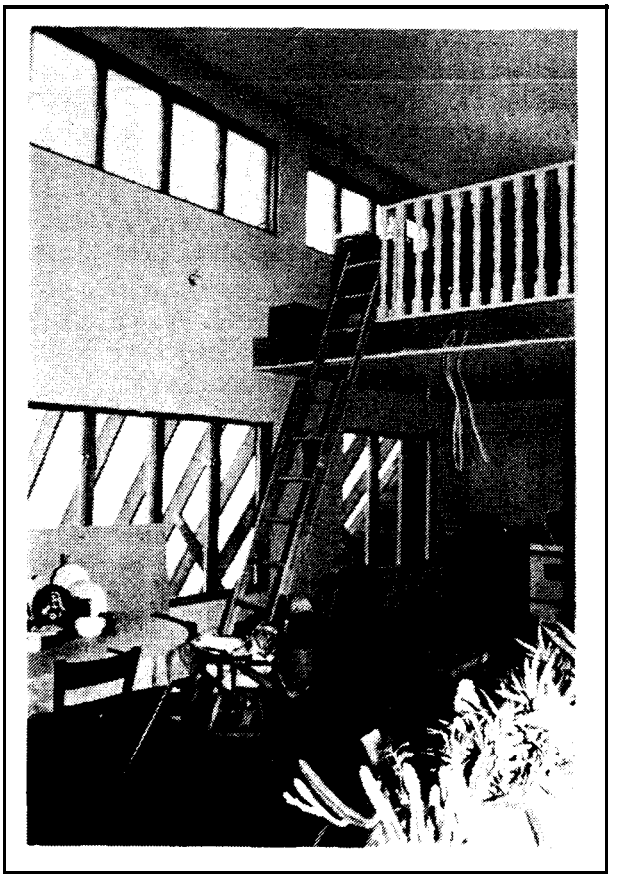


MAIN LEVEL

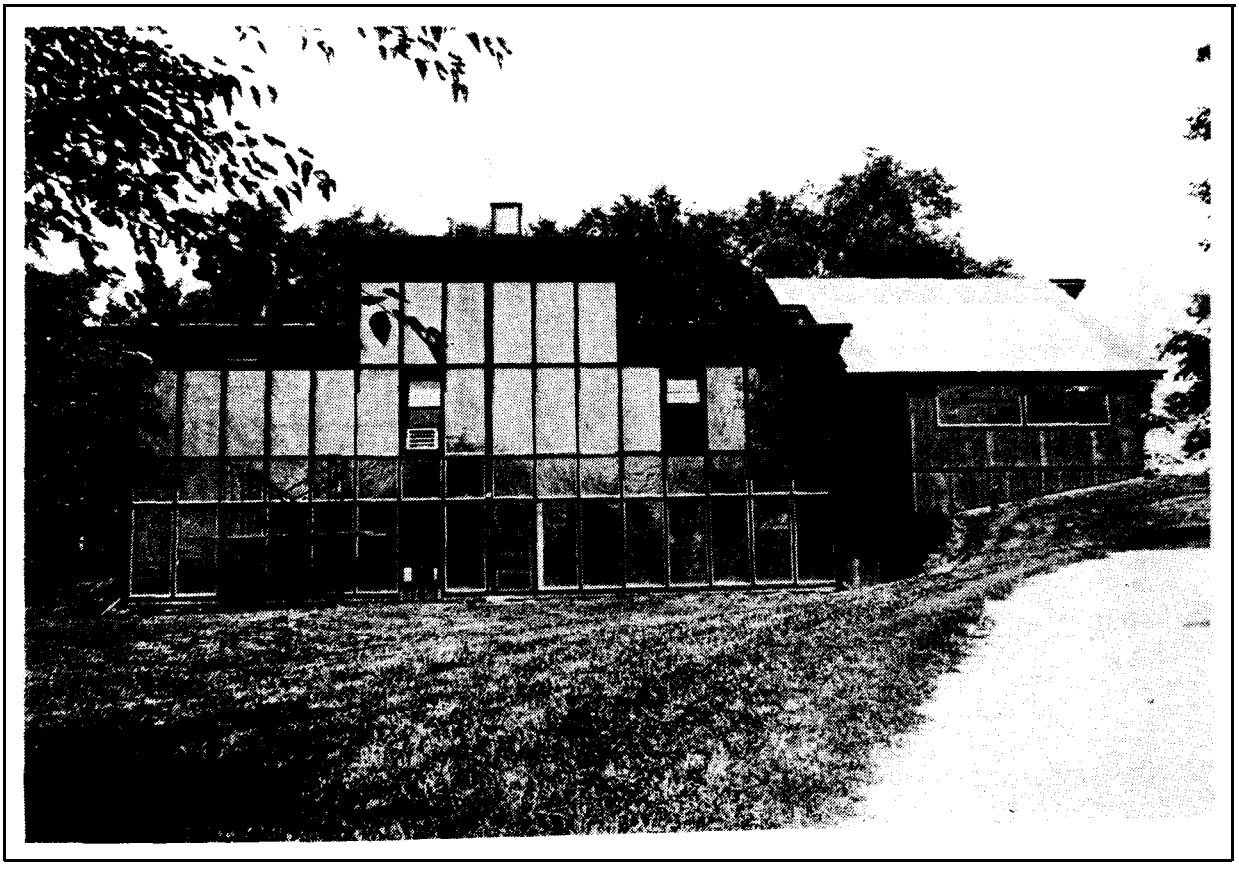


LOWER LEVEL





EURICH

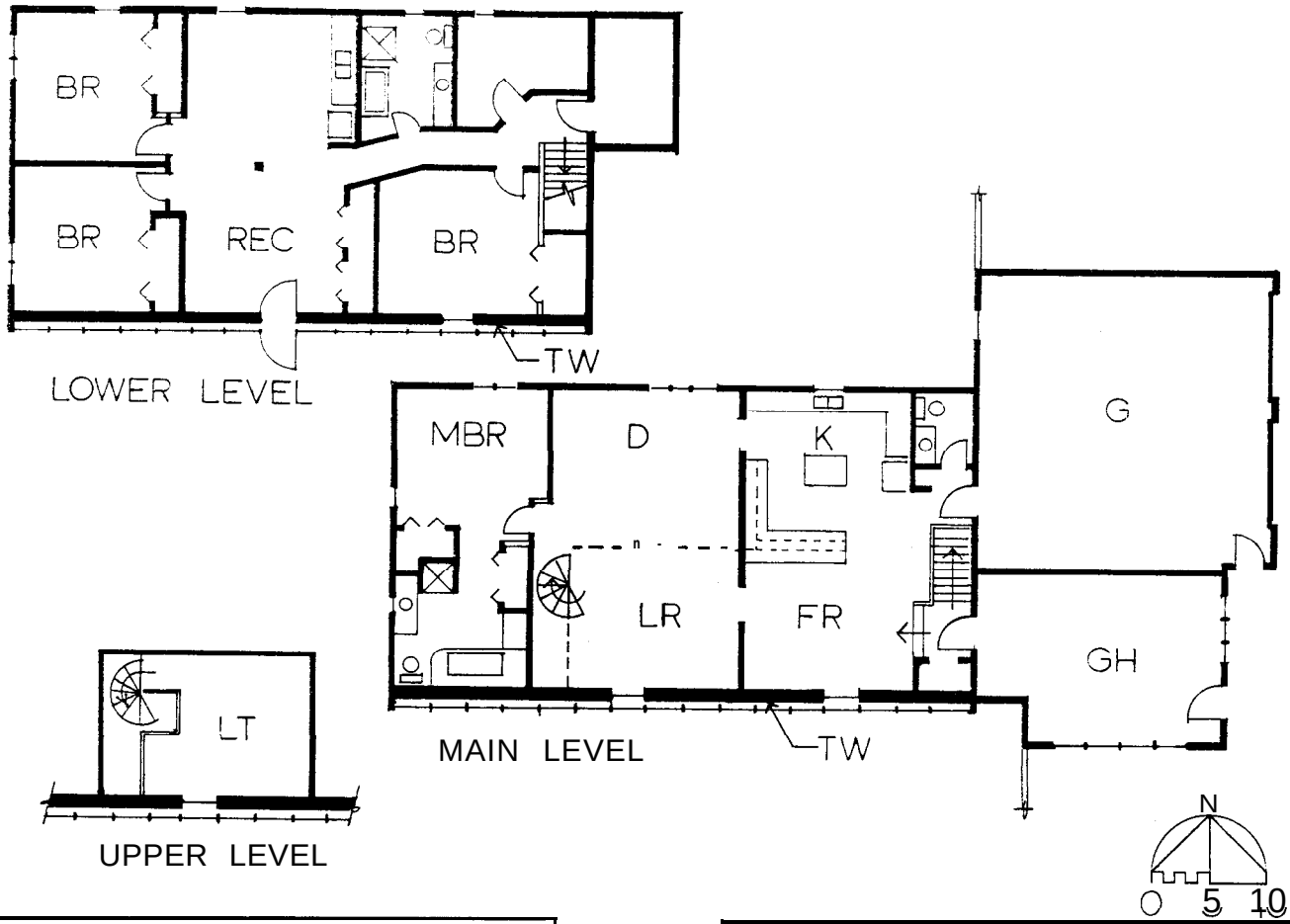


The Eurich home has 2900 sq ft of living space divided equally between two levels with an additional 12' x 14' loft area located above the living room. A 20' x 16' greenhouse/airlock entry creates a light, warm, and spacious entrance to the house (opposite left).

Although a full height, two-story 12" filled concrete block Trombe wall is the major passive solar heating system, the Eurich house functions not unlike a double shell with mass -- the Trombe wall and a 6" thick concrete basement floor slab; sun warmed air rises along the Trombe wall and moves by convection through the upper living spaces to a north wall plenum, then through an air passageway comprised of concrete blocks laid under the basement floor stab and back to the bottom of the Trombe wall where the process is repeated

Dick Eurich has developed a unique multiple-layer glazing system (opposite right) with nearly the same solar transmission value as double pane glass but with a higher net solar radiation gain. The multiple glazing system consists of an outer glazing of l/8" tempered glass and four inner glazings of clear teflon. The multiple glazings also serve as an insulation barrier, and, because the system has a lower heat loss than conventional triple pane windows, night shutters are not needed.

The summertime cooling strategy utilizes a cool tube system comprised of two tubes 65' and 45' long buried between 4' and 4.5' deep. Air is drawn through the tubes into the building on its north side and circulated through the air passageway beneath the basement floor slab to the Trombe wall and exhausted out the roof. The less than ideal performance of the cool tube system the owner has experienced could be enhanced by burying the tubes between 8' and 12' underground.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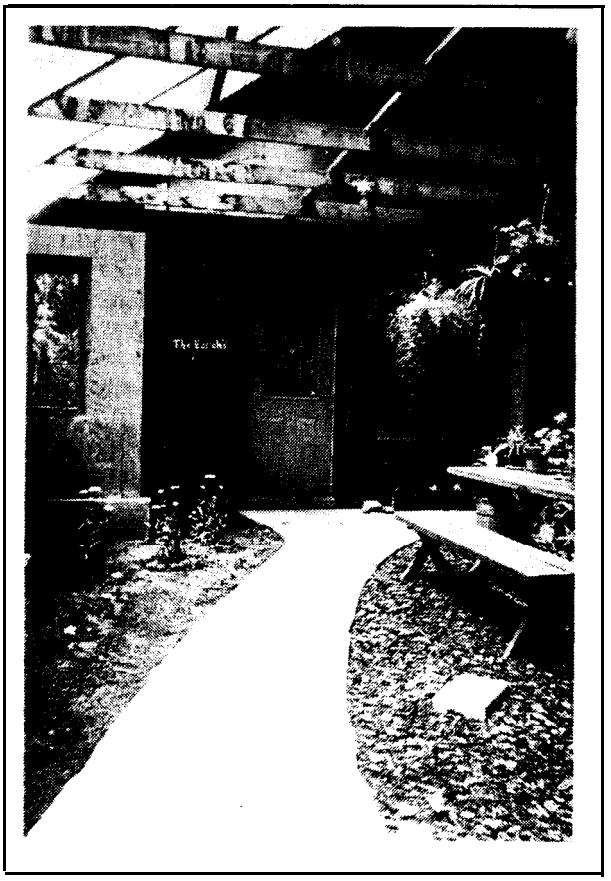
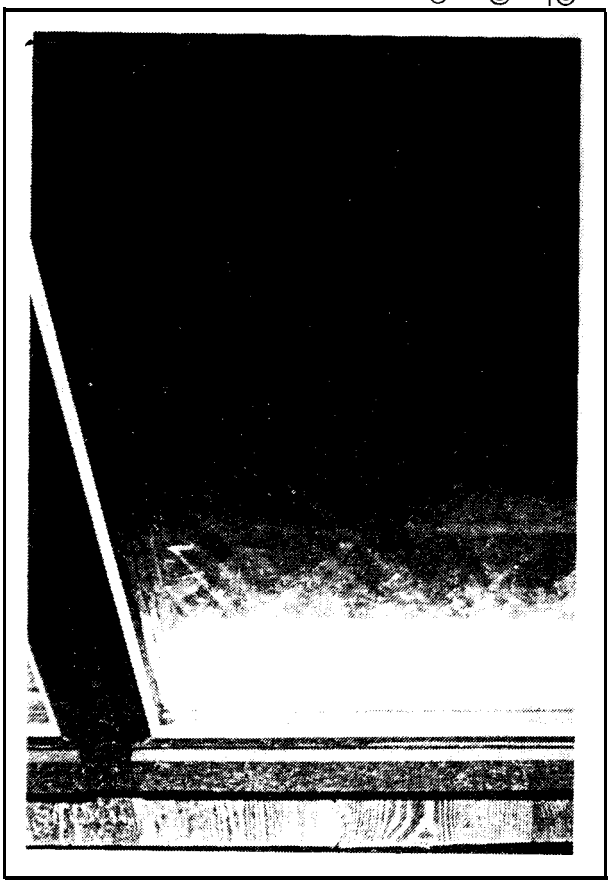
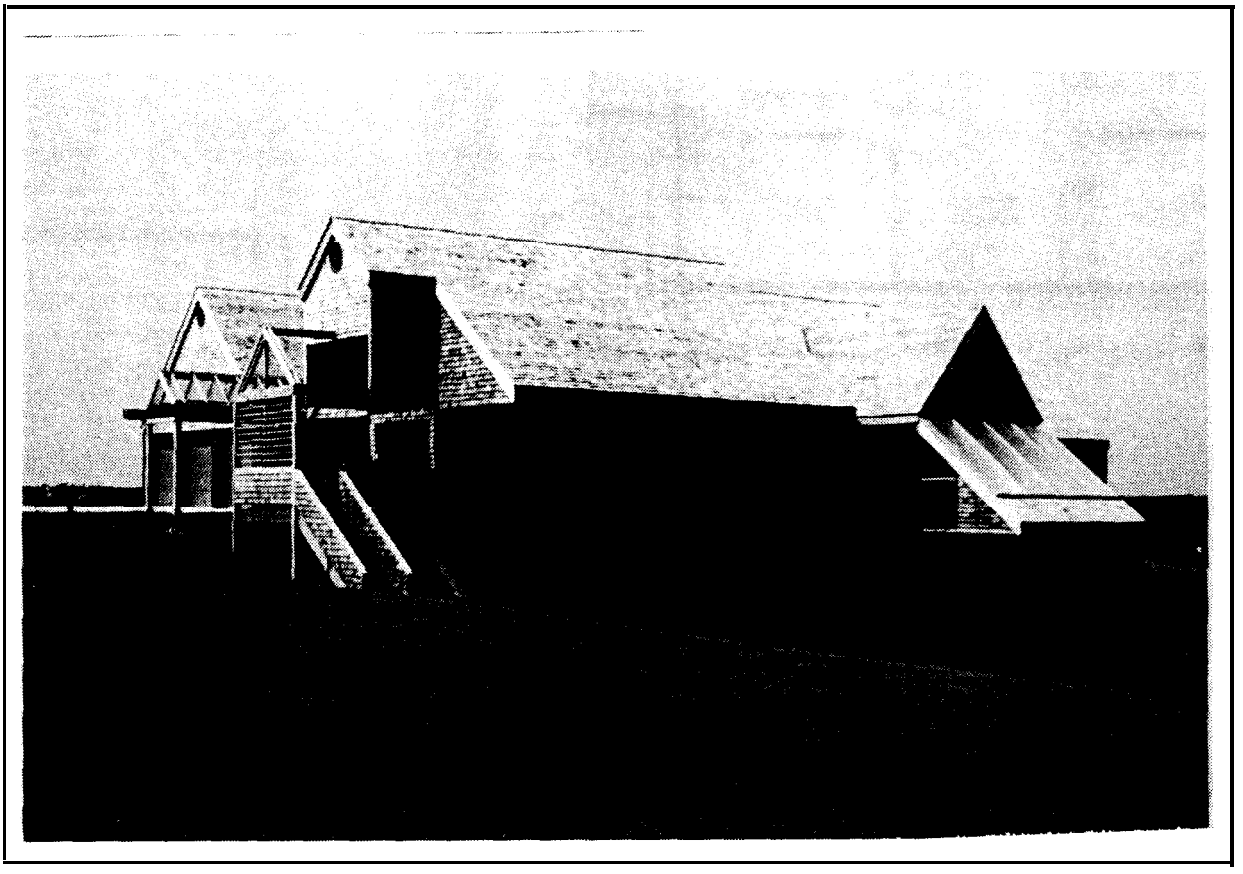




nSCHWABn

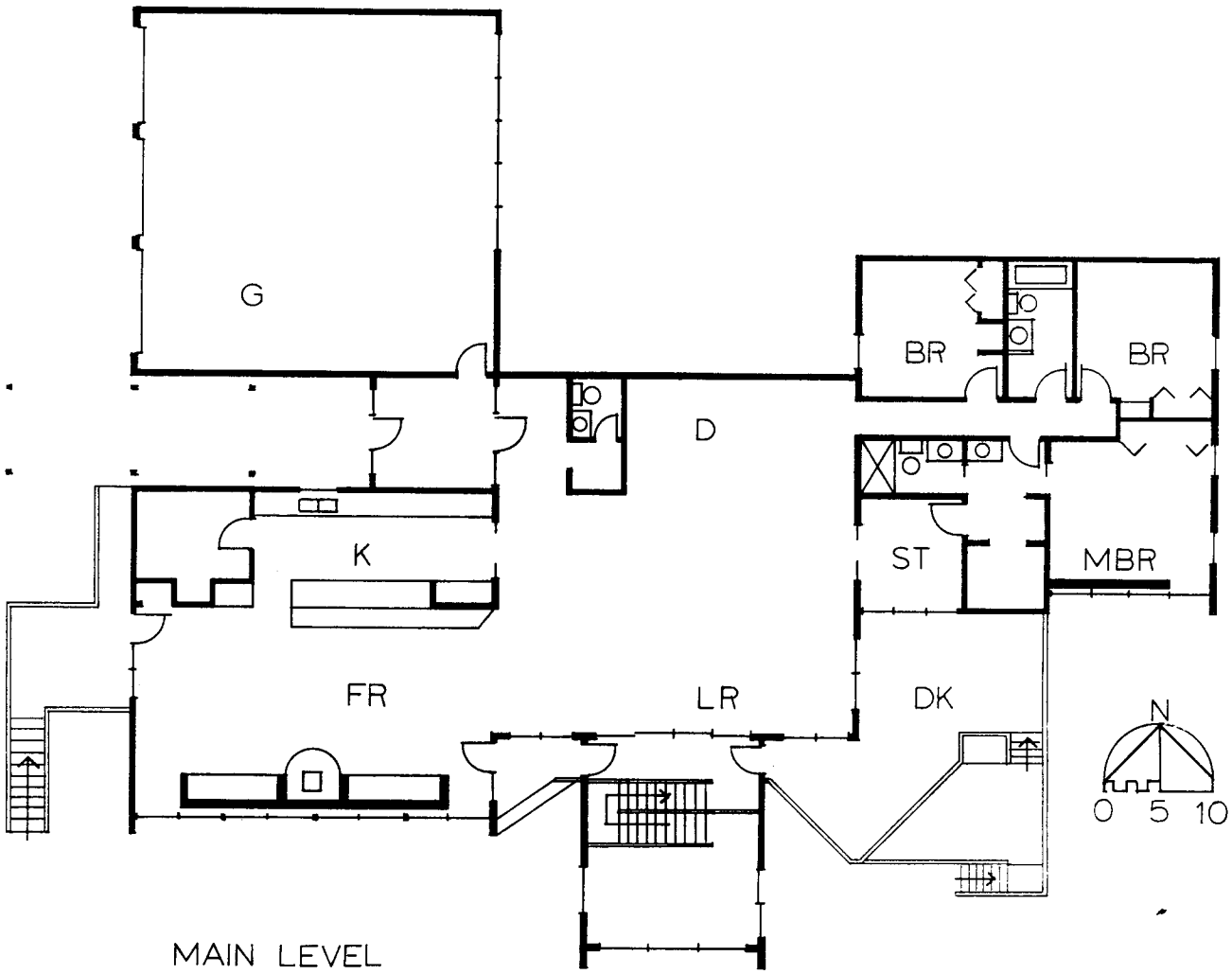


The Schwab home, designed by Bob Alfieri of Lincoln, is both architecturally stunning and energy efficient. The home has 3850 sq ft of living space on each of two floors, and rooms with vaulted ceilings in the open floor plan are bathed in light from the south glass or the overhead skylight in the bedroom wing.

The house primarily relies on Trombe wall passive solar heating, although some direct gain and greenhouse strategies are also used. The Trombe wall is floor to ceiling height in the basement, but it is only half-wall height (opposite left and right) in the family room on the main level to permit an essentially unrestricted view to the south. The 52" Trombe wall is of solid brick which has been grouted to eliminate air voids, and, thereby, improve thermal conductance. The Trombe wall totals 400 sq ft of wall surface area, and the Trombe wall glazing area is 600 sq ft.

The Schwab house also has 132 sq ft of direct gain glazing, and 220 sq ft of greenhouse glazing in the two-story attached sunspace. The greenhouse, which is adjacent to the living room, has an exterior meshed fiberglass screen for summer shade control. Four ceiling fans circulate warm air during the winter, and backup heat is supplied by two Tetco groundwater to air heat pumps, which are in turn backed by an electric resistance heating system.

Windows on both the main and lower levels have night insulation shades (opposite left and right) with an R value of 13. The movable insulation, by Thermal Technology, operates automatically in response to outside temperature sensors. The automatic system also has a manual overide.



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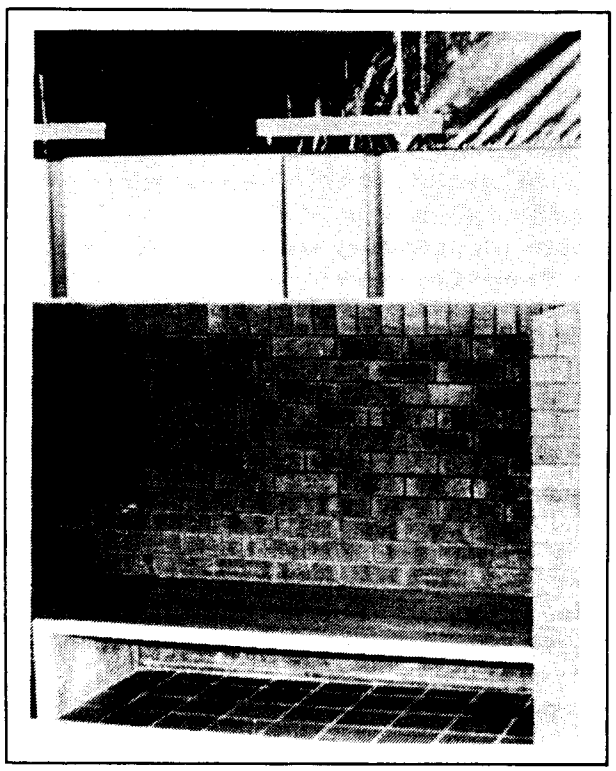
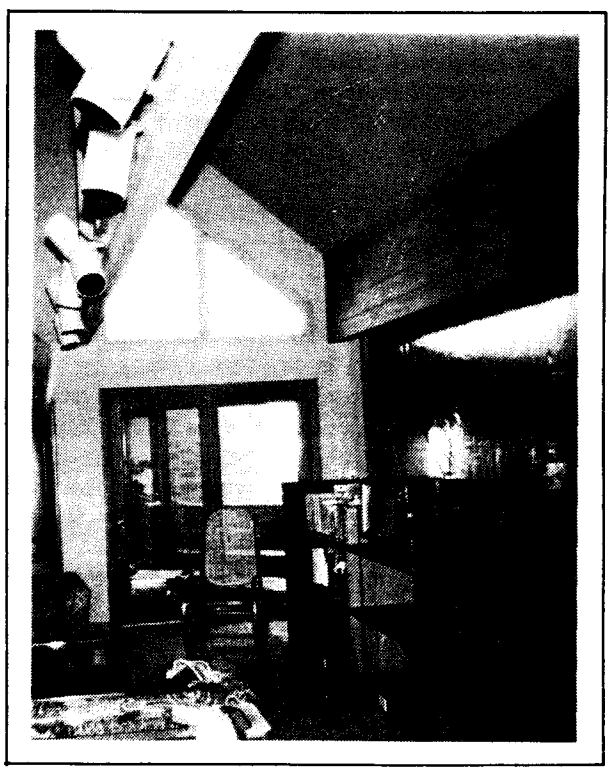
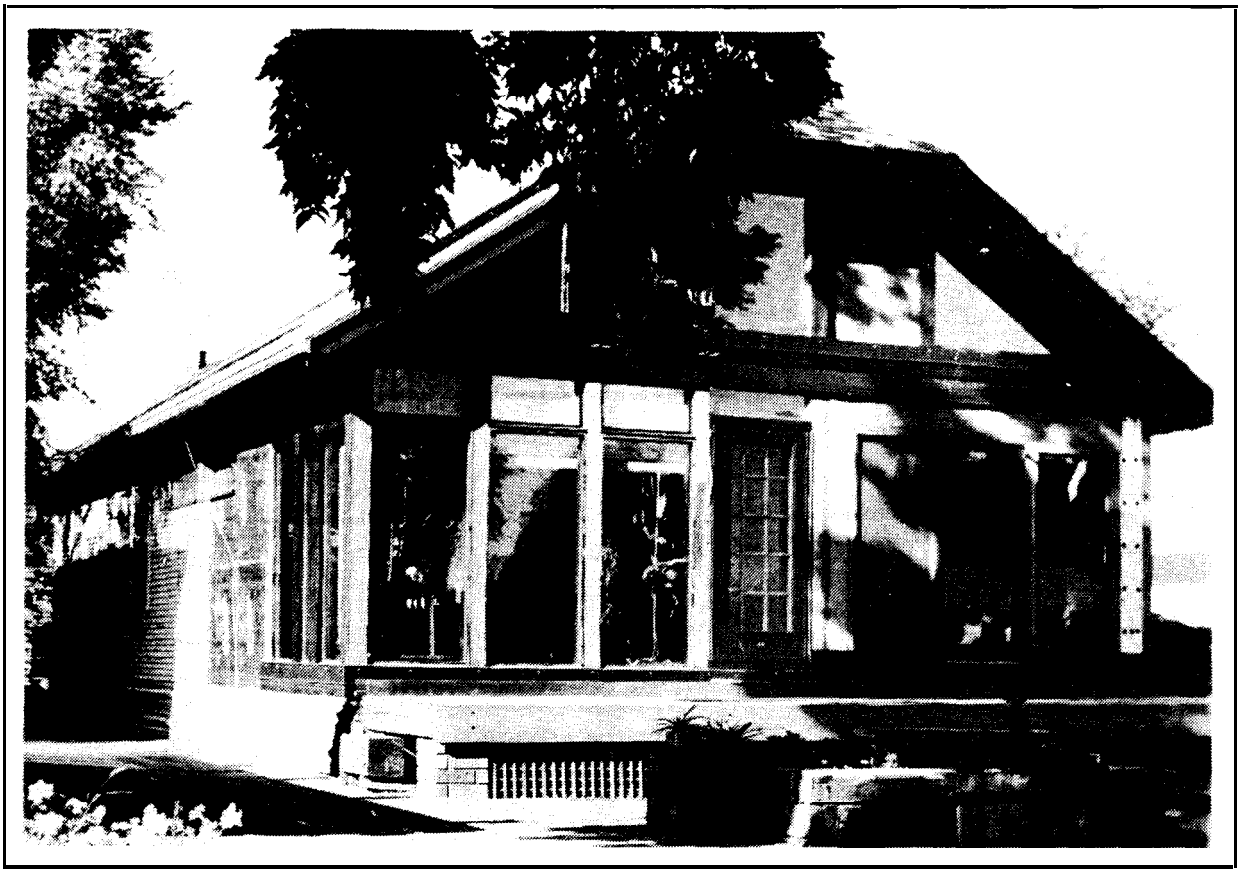




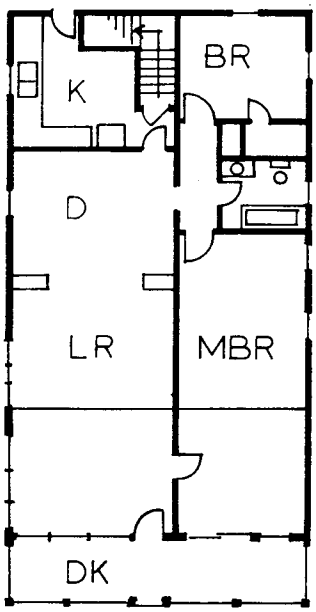


The Bond passive solar retrofit, the result of the Bond's desire to improve energy efficiency in their 60+ year old home (opposite is a photograph of a bungalow that closely resembled the pre-retrofitted Bond house), is a good example of how an existing home can be converted to a direct gain retrofit.

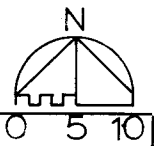
The Bond retrofit involved increasing the floor space of the home, increasing the insulation levels in the home, and increasing the direct gain glazing in the home. The floor space of the existing house was expanded by enclosing the porch at the southwest corner of the house. In what was formerly the attic of this enclosure, a loft overlooking the living area was also added. 2x4 studs were added to the inside of the existing house framing to create space for new batt insulation.

The new direct gain front wall of the Bond house is almost entirely glass, and the 165 sq ft of double pane glazing admits large amounts of sunlight. Because the original home contained virtually no thermal mass, 3.5" brick pavers were laid in the floor of the retrofit expansion to absorb some of the solar energy. A hot air redistribution system circulates solar heated air for space heating purposes. Excess heat is exhausted in summer. Currently, no night shutters are used to cover the new south glazing, and as a result heat loss may be severe.

The owner has had no leakage problems -- frequently associated with sloped glazing and commercial skylights -- with the non-operable, 48"x76" skylight he designed. He has also designed a condensate gutter for the skylight to prevent moisture condensing on the windows from rotting the skylight frame or dripping onto the floor.



MAIN LEVEL



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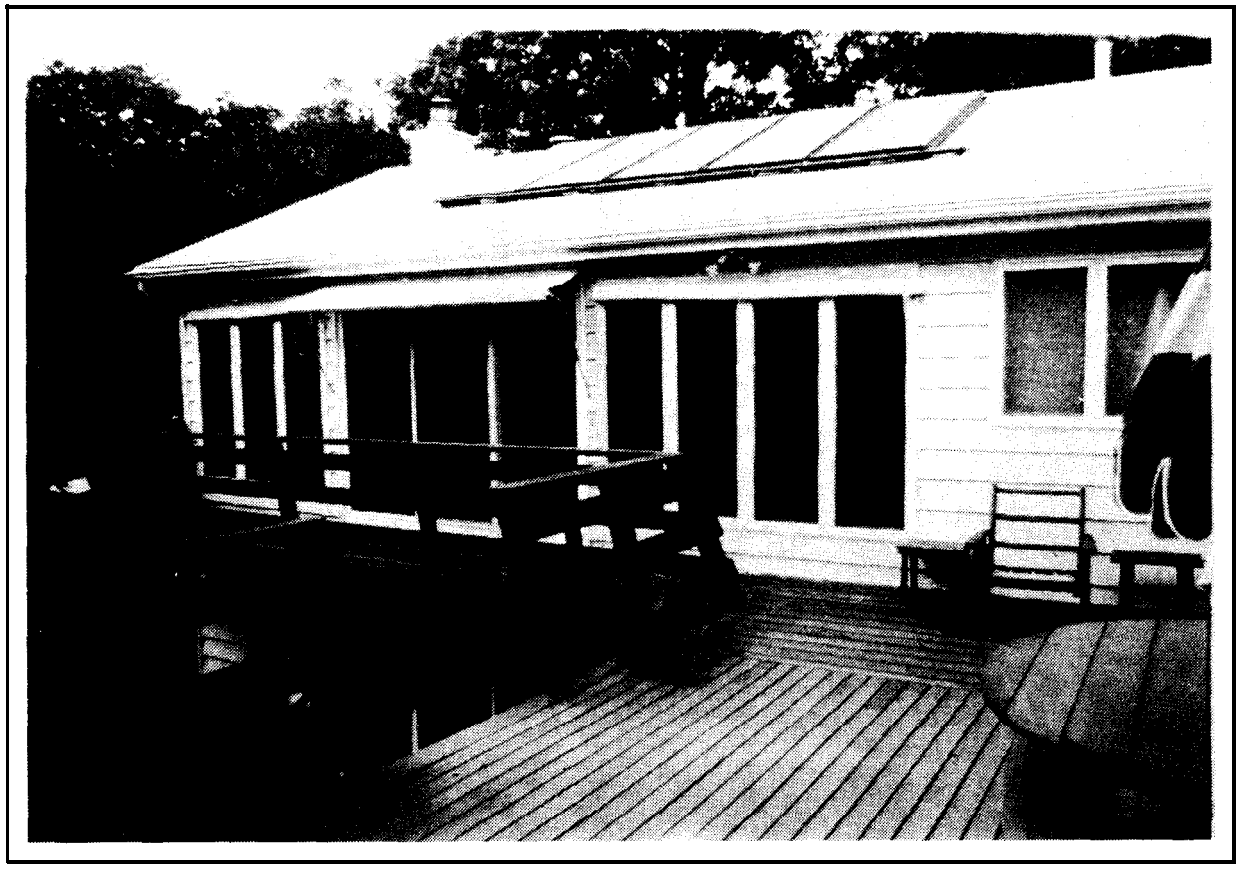


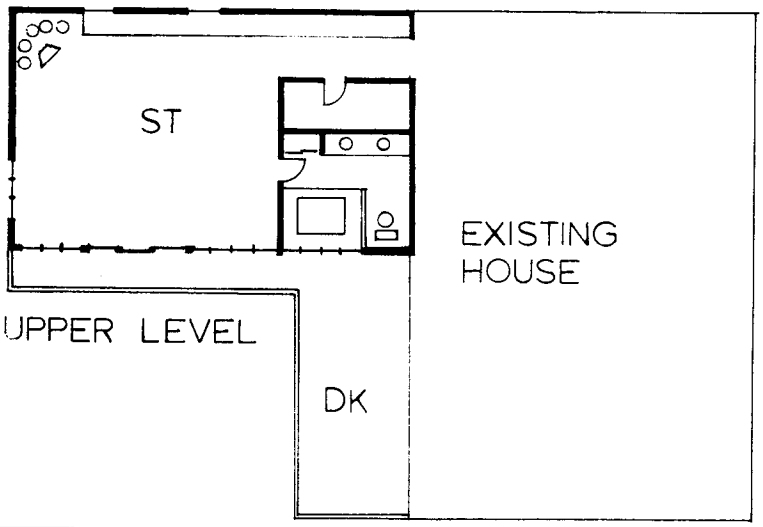
The need for study and studio space coupled with a desire to reduce energy consumption forced the Ratzlaffs to choose between building a new house and constructing an addition to their existing home in 1981. Their decision was to add a two-story passive solar retrofit and upper level deck to the kitchen and basement of the existing home.

The addition, designed by Solar Energy Associates of Omaha, has 700 sq ft of floor space on each level. The upper level, which serves as an office and study for Dr. Ratzlaff, is also the location for a family-sized jacuzzi. The lower level is an art studio for Mrs. Ratzlaff.

The passive solar heating strategy chosen for the addition was a direct gain system with water wall storage -- Civil Defense water barrels which have been painted black to increase solar absorption (opposite right) -- on both levels. Backup heating to the addition is provided by a Morso wood burning stove on each level, and the owner is quite pleased with their performance.

Triple paned Andersen windows were chosen for the direct gain glazing of the retrofit. The windows are insulated with Window Quilts during the heating season. During the summer, the windows on the lower level are shaded by a deck accessible from the upper level, and the windows and sliding patio doors of the upper level are shaded by awnings. The owner reports that there have been some problems with water condensing inside one of the panes of the windows.

An active liquid flat plate collector system, installed by Arens Solar of Omaha, preheats water used in the bathroom and jacuzzi. The solar heated water is stored in a 120 gallon tank located in the basement and supplied as needed to a conventional 50 gallon gas water heater.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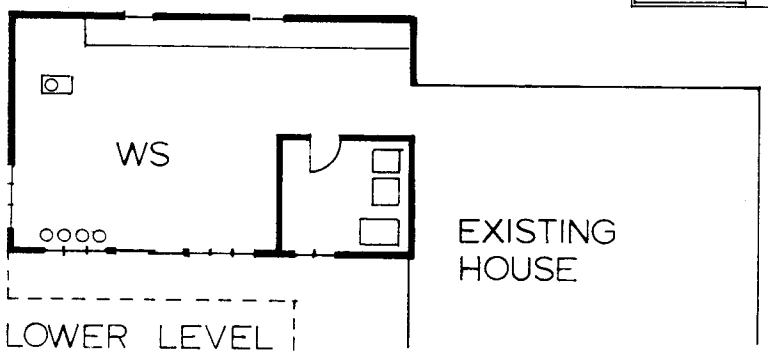
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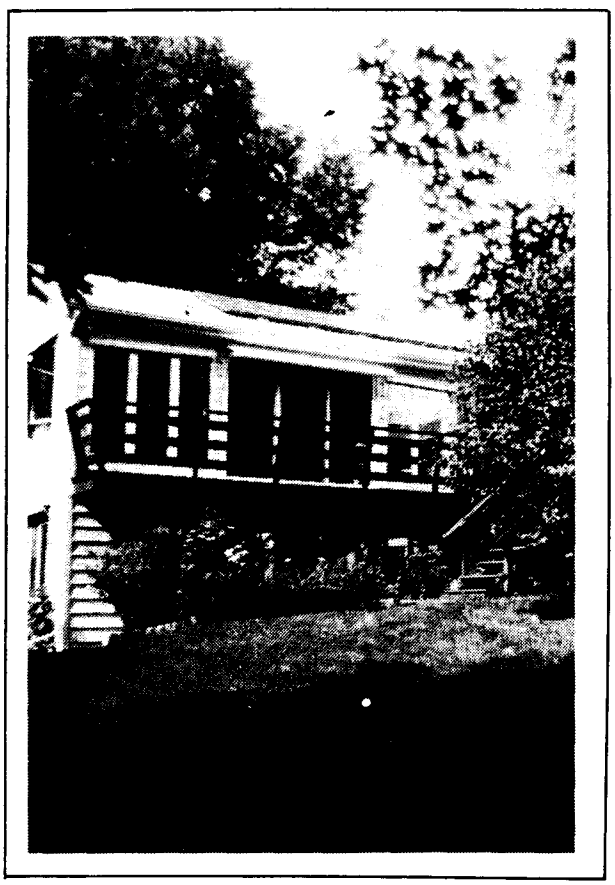

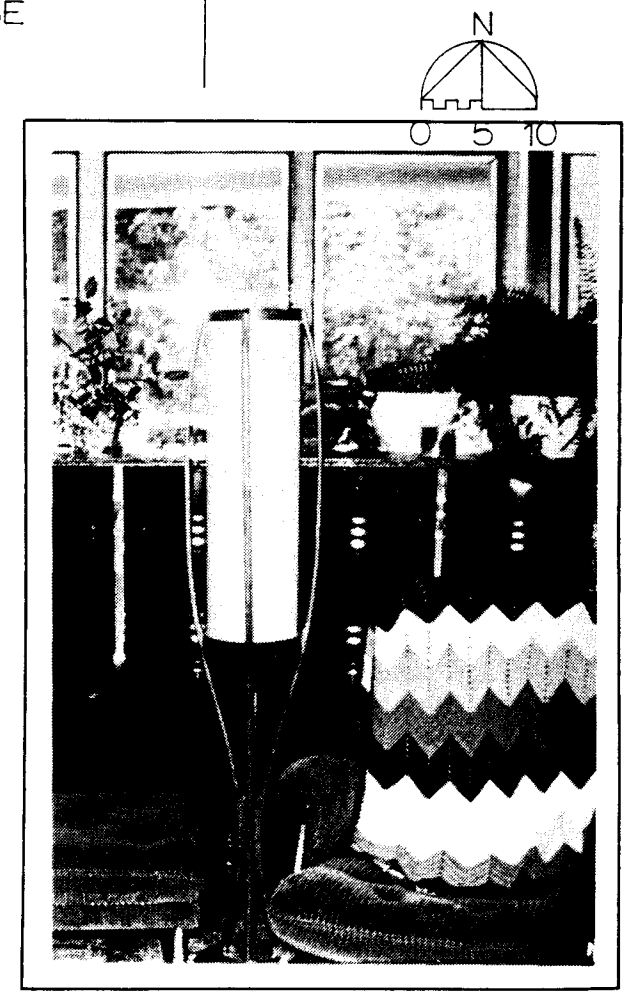
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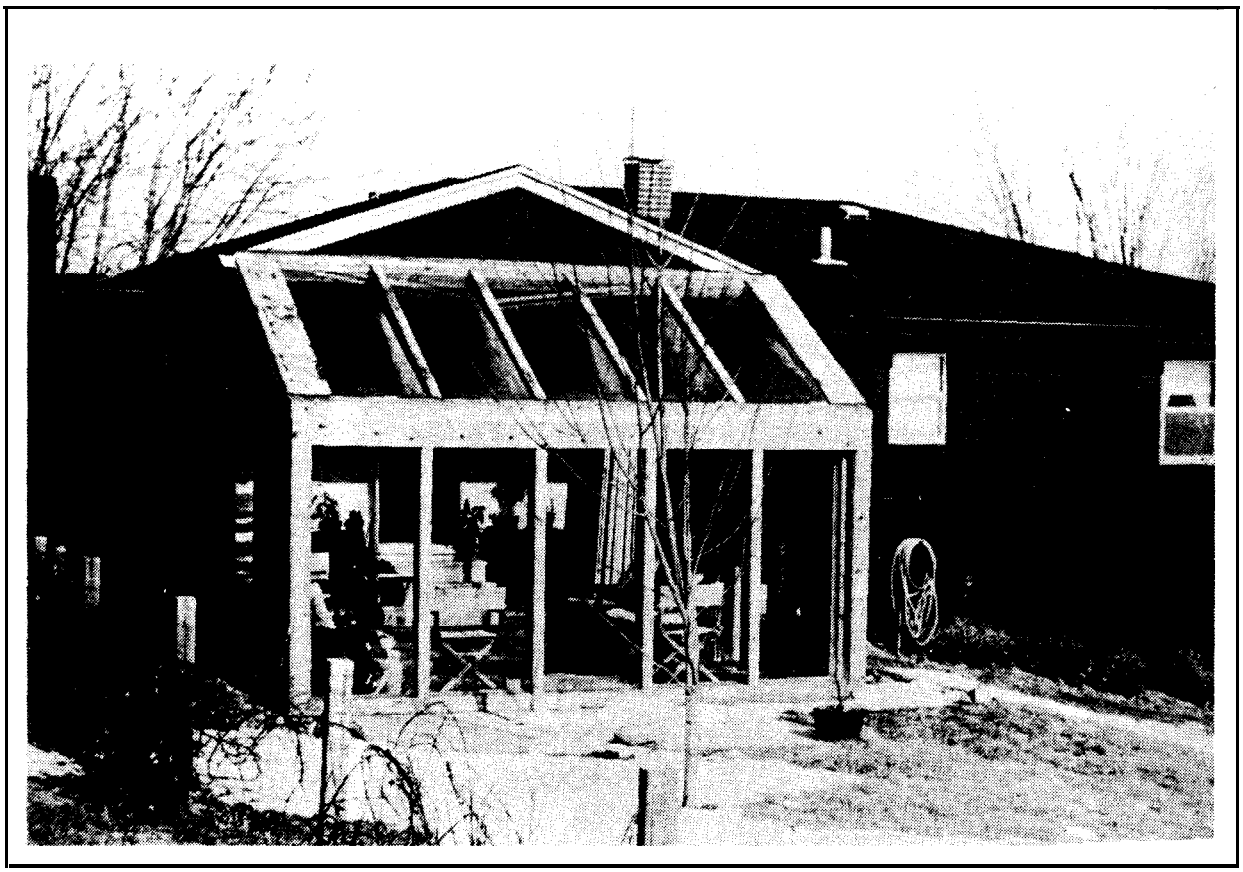
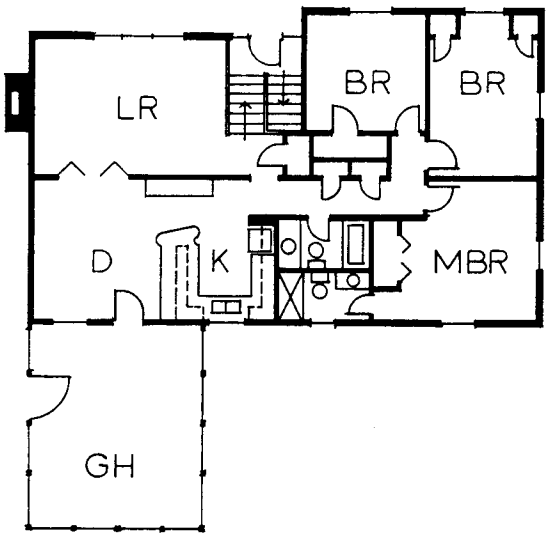


From calculations based on energy consumption records meticulously kept by the owner, it is obvious that the Shult sunspace retrofit has been the major improvement in a continuing effort to increase energy efficiency in the Shult home.

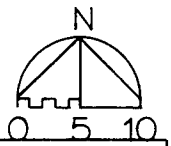
This effort began in 1974 when Shult lowered the thermostat setting for the gas furnace. As a result, the TIF for the house improved from approximately 6.5 to 5.6. In 1977, Shult installed a duct to provide outside combustion air to the furnace, and the TIF dropped to 5.0. The use of a fireplace added in 1978 to provide backup heating lowered the TIF value to 4.4. In 1981, the house was caulked and the attic insulation level was increased from R-19 to R-38. This reduced the TIF to 3.6.

The major impact on energy consumption occurred in 1982, however, when a step-down solarium was added to the south side of the house off the dining room. The use of solar heated air -- drawn through an opened window and door into the house from the greenhouse for space heating -- during the 1982-83 heating season lowered the TIF of the Shult house to its current level of 2.3.

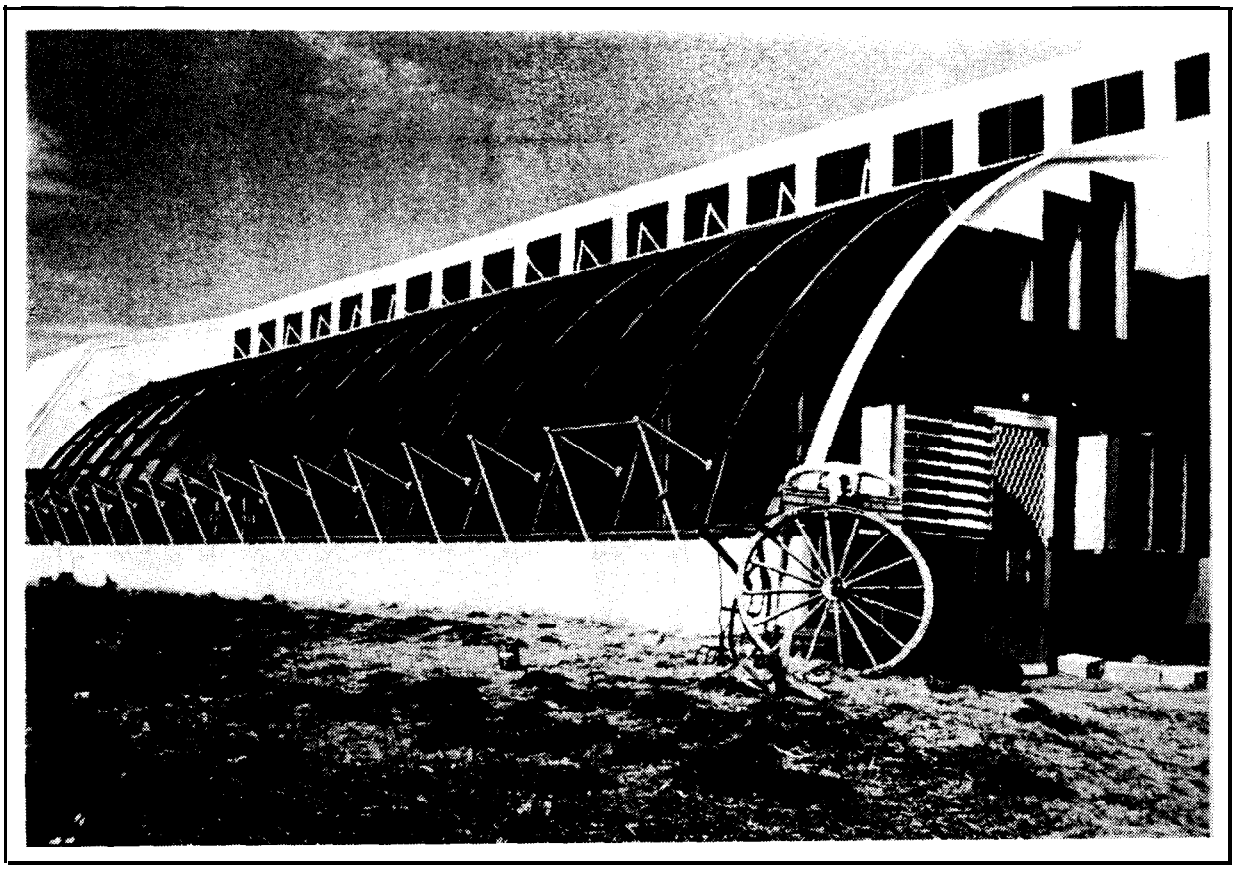
Both vertical glazing and sloped glazing -- which must be shaded in summer -- are included in the greenhouse retrofit (opposite). Tile on the sunspace floor and water barrel mass storage are used as solar heat storage in the addition. Night insulating shutters which are attached and secured manually on the inside of the greenhouse glazing are needed during the winter because greenhouse temperature fluctuations can be severe. For example, in February 1983, when the mean outdoor temperature was 31°F with a low of 1°F above zero, the temperature inside the greenhouse ranged from 34°F to 99°F with a mean temperature of 57°F.



MAIN LEVEL



nCOLSONn

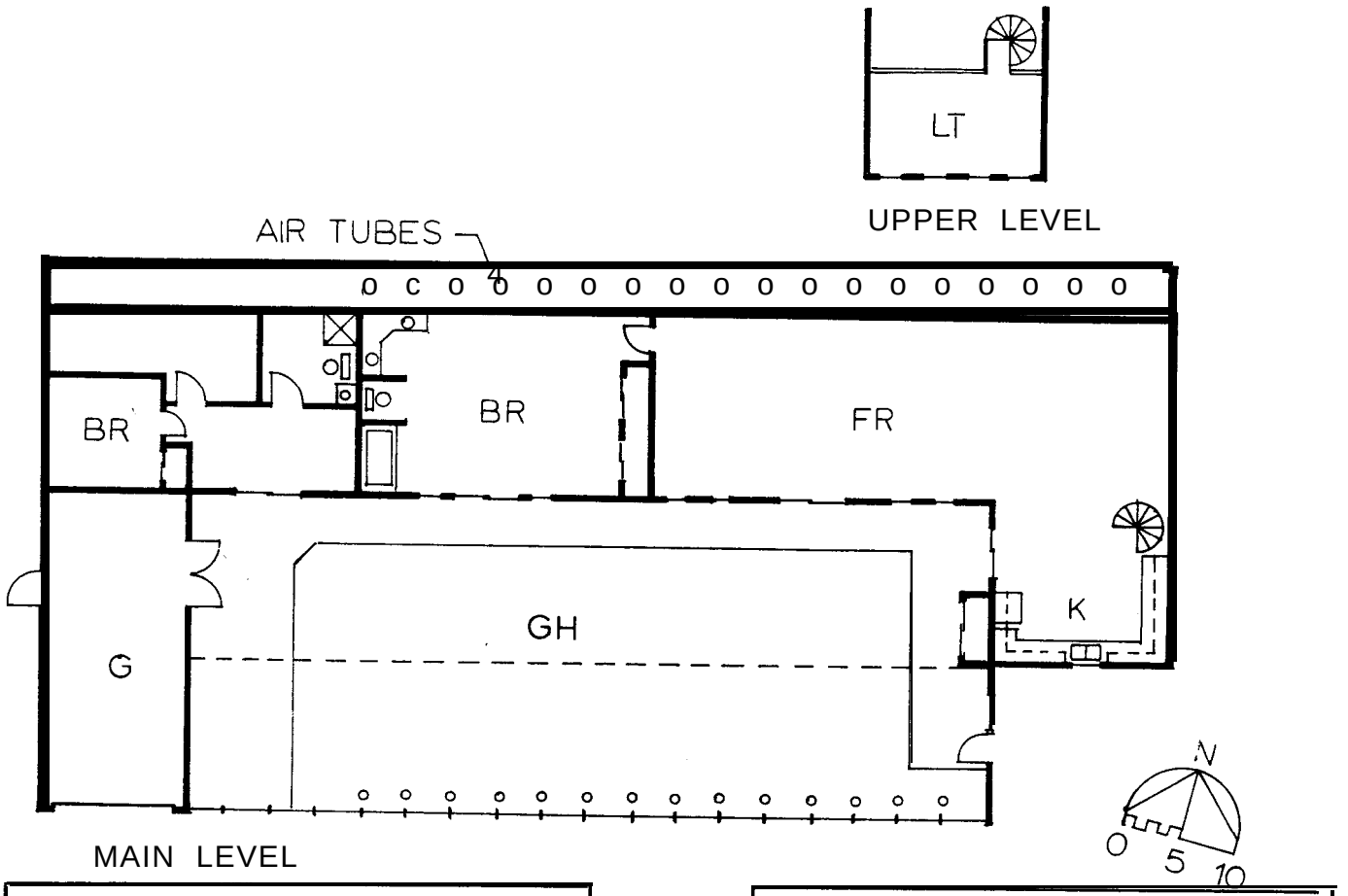


The Colson home, built by the owner in August 1981 for the exceedingly low cost of under 815 per square foot (not including his labor), is an innovative low-cost double shell residence that is also used as a church.

The airflow in the roof plenum in the Colson home is through the cavity of the roof truss system that supports a 26-gauge steel roof which is used in place of conventional residential roof decking and shingles. The truss system, also used in the floor, was designed by Components Inc. of North Platte. 2x6 stringers were placed between the truss and roof (opposite left) to create sufficient space for the installation of 6" batt insulation.

The high, vaulted ceiling of the Colson house and its expansive greenhouse space of over 2000 sq ft create an outdoors feeling indoors. Although the greenhouse glazing appears to be curved, closer inspection reveals that, in reality, the illusion is the result of flat panes of glass installed in an arc (opposite right). Unfortunately, intense temperatures and exposure to direct sunlight have caused the wood in the window framing to dry out and split, resulting in a weakened frame system. During the summer, a swimming pool cover is placed over the curved greenhouse glazing to reduce unwanted solar heat gain.

In the Colson house, the plenum chamber typically located under the floor of most double shells has been replaced by a series of underground air tubes, 2 feet on center, which connect the north wall plenum to the south greenhouse wall. Air flow through the air tubes is not fan assisted, and, despite the fact that no auxiliary heat is supplied to the greenhouse, no freezing has occurred. Three portable 1500 watt electric heaters supply backup heat to living spaces.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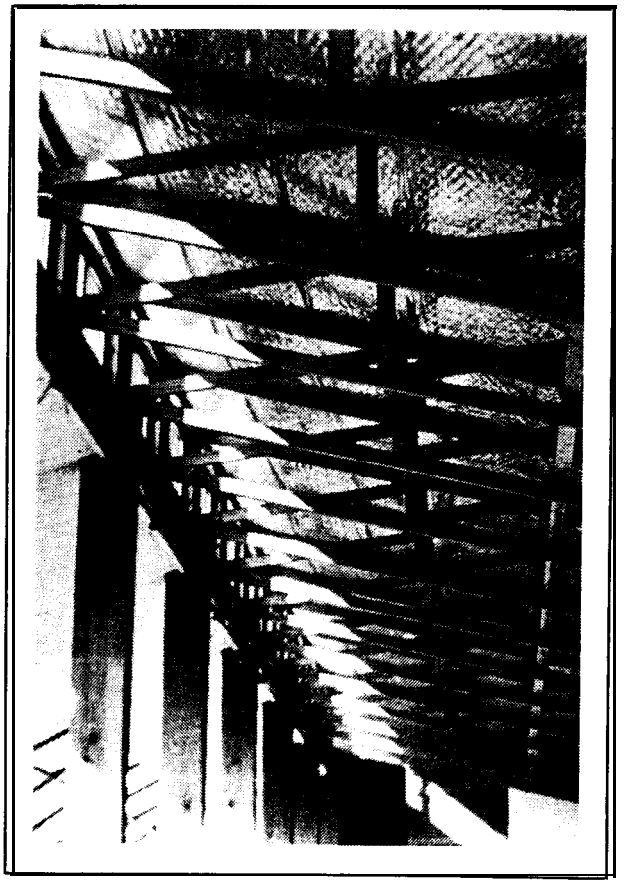

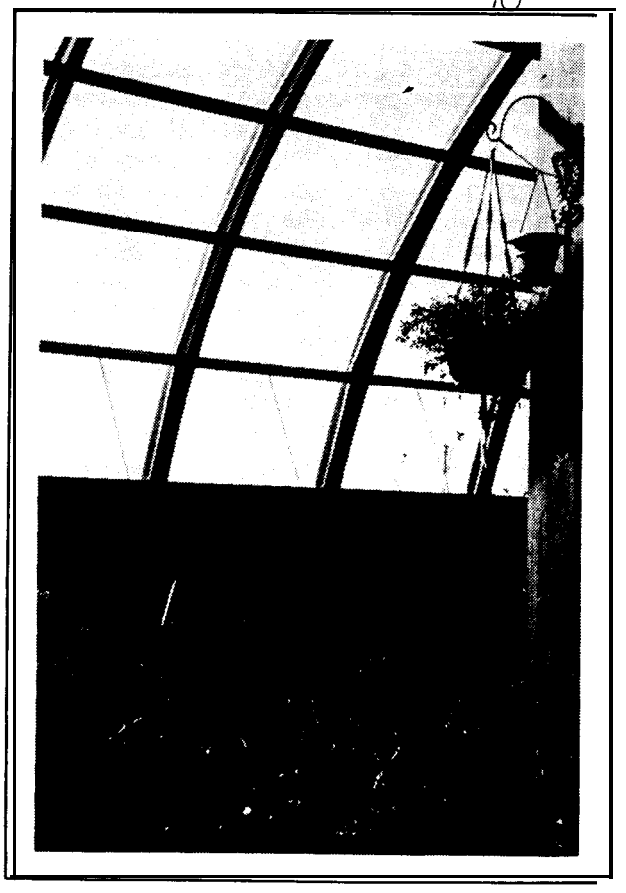

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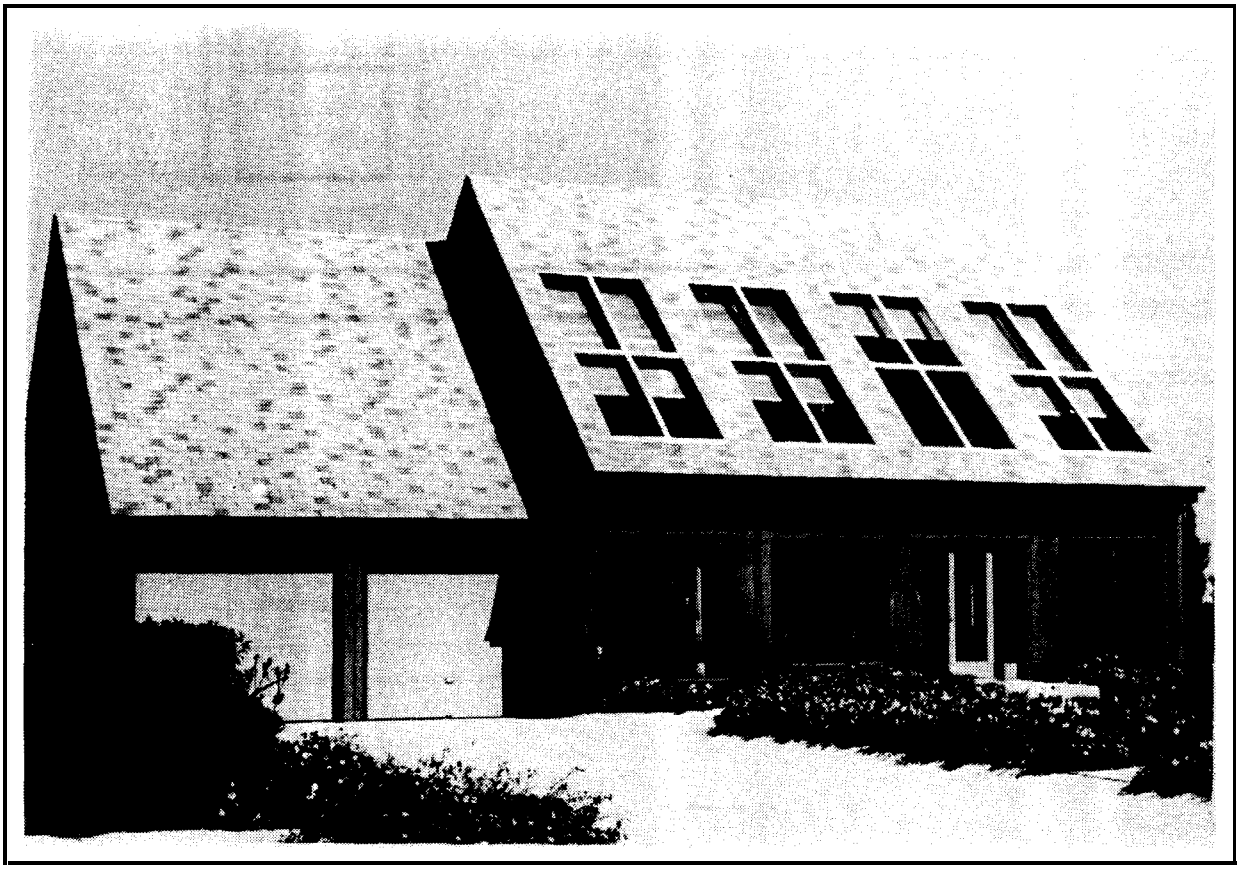


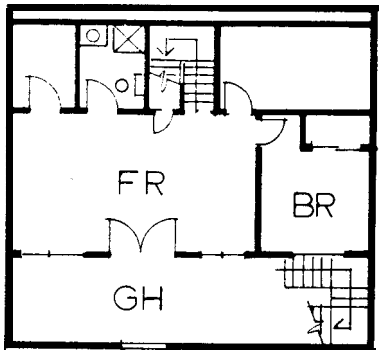
Heating bills that have averaged less than $20 per year attest to the energy efficiency of the Demmel home which, when built in 1979, was one of the first double shell homes constructed in Nebraska. The three-story Demmel home has a number of interesting features: fans to duct air directly into the home, a unique shutter system for the sloped glazing, a thermosiphon domestic hot water heater, and sill pans for window condensation.

A very low rate of convective airflow in the Demmel house air plenum resulted in lower than desired interior temperatures. To improve thermal performance, a fan was installed in the attic, and, when sunspace air temperatures are high enough, warm air is blown directly into the home.

The shutters for the sloped glazing slide in a garage door track and are raised and lowered by means of a pulley system. The control ropes for operating the shutters (opposite left) are accessible from the balcony on the upper level.

A thermosiphon collector panel in the sloped glazing opening above the main entrance heats water that is stored in a tank located (opposite right) in the open plenum above the bedrooms.

High humidity levels in the house, and moisture condensing on windows were initial problems in the home. Humidity levels were reduced by placing a vapor barrier over the earth in the crawlspace beneath the lower level. Specially fabricated metal pans, attached to each window sill to collect water condensing on the south glass and emptied to the floor through a network of thin plastic tubes, collected nearly one gallon of water at the dewpoint temperature before humidity levels were reduced.



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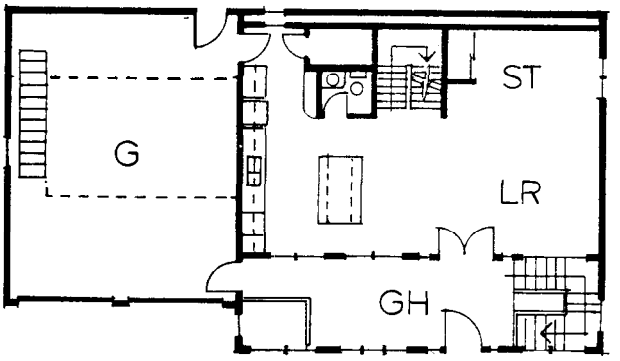
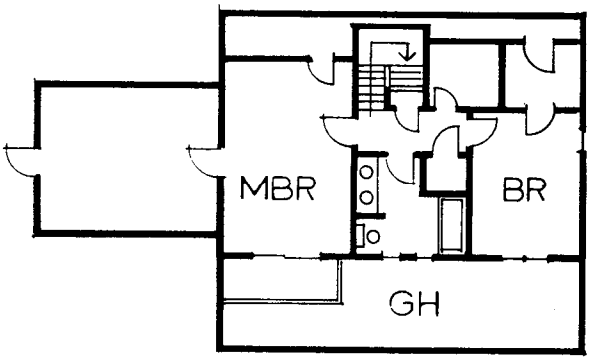


MAIN LEVEL



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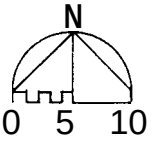
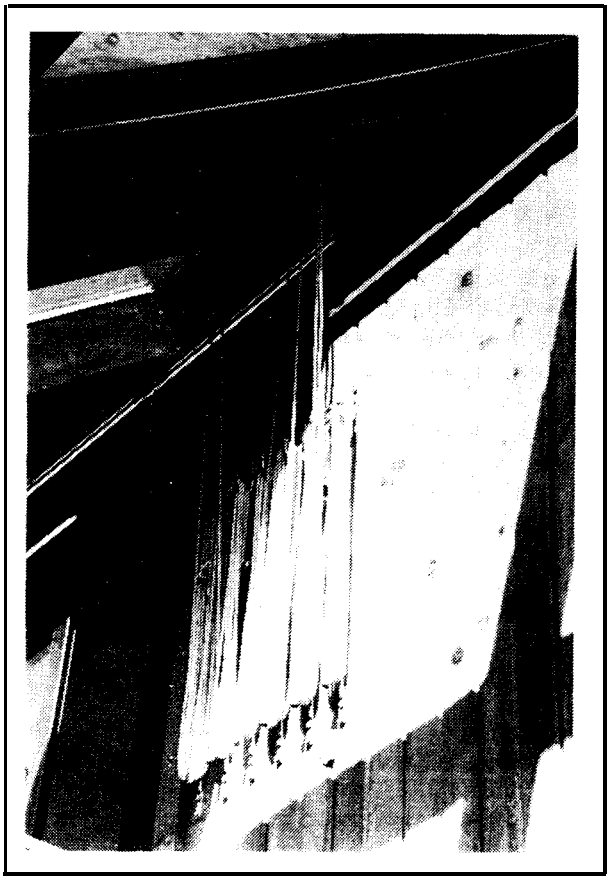
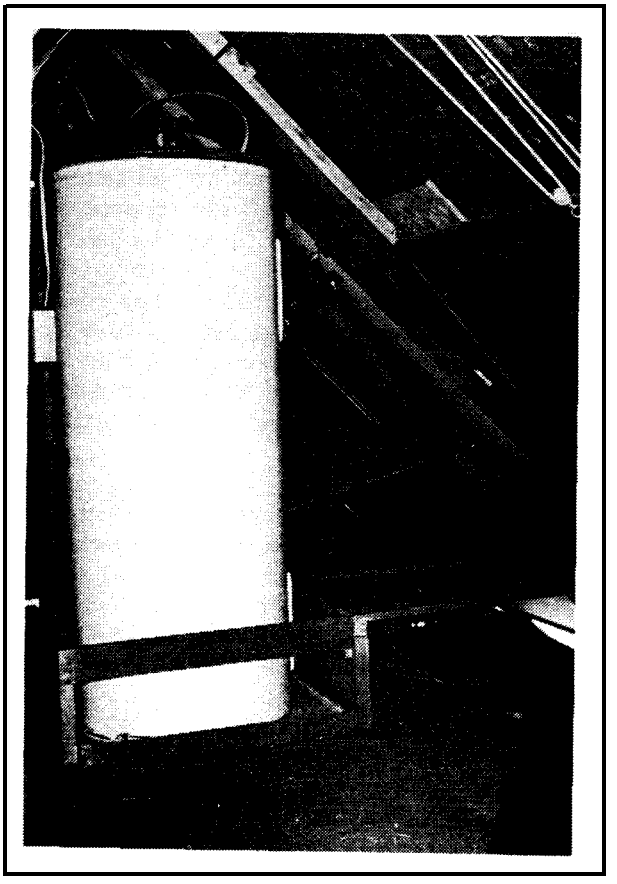




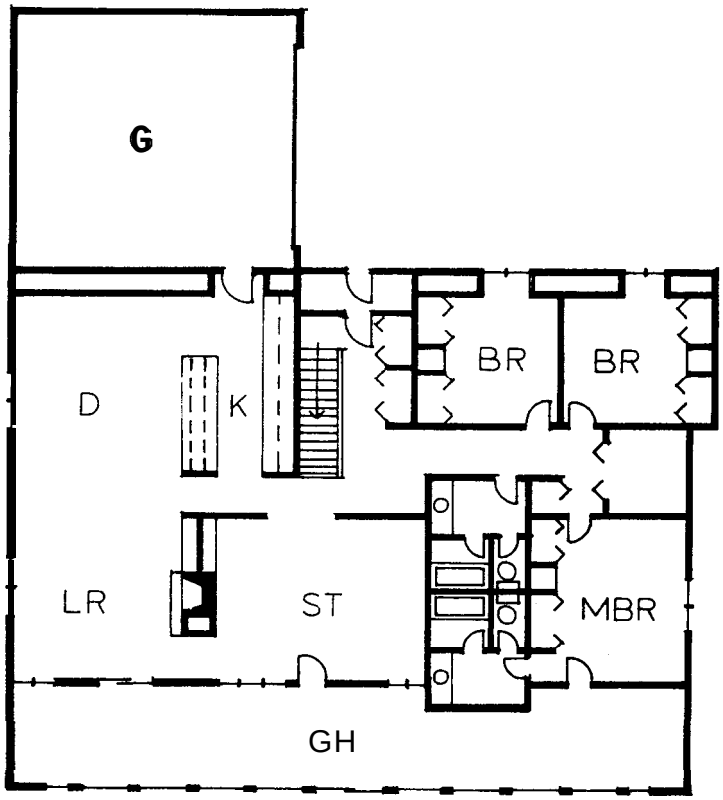


nDORWARTn

The 2700 sq ft Dorwart home, which, like the Empson house also in this inventory, was built by Sandstead Custom Solar Homes of Alliance, is different from most other double shell houses in that it has no sloped glazing. The usual sloped glazing collecting area is replaced in the Dorwart house by a greenhouse -- with 311 sq ft of vertical glazing -- that spans the entire front of the house like a corridor (opposite right and left).

According to the builder the performance of the double shell design during the heating season has been satisfactory, undoubtedly due in part to high insulation levels. The walls are insulated to R-26, the ceiling (R-19) and the roof (R-30) have a combined insulation level of R-49, and all doors are R-12 or better. The only backup heat used in the house is provided by a Defiance woodburning stove (Masters Choice model). During the 1982-83 winter, the one cord of cottonwood that was burned was sufficient to keep the home at 68°F.

The builder has indicated that high humidity levels in the house have been a problem. In fact, the use of a dehumidifier may be required year round. In the summer, however, this creates another problem, because the operation of the dehumidifier adds heat to the cooling loads. The current cooling strategy involves drawing cool air from the basement directly into living space in the following manner: fresh outside air, drawn into the plenum through the greenhouse, is cooled by earth contact as it passes through the crawl space plenum, and then is fan forced into the basement where it is drawn up the stairwell to the main floor. The use of a small air conditioning unit to decrease humidity and help cool the inner shell is being considered for the future.



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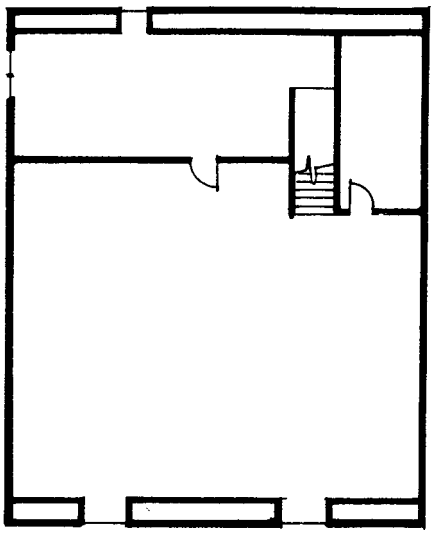

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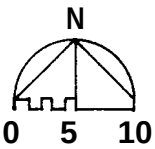
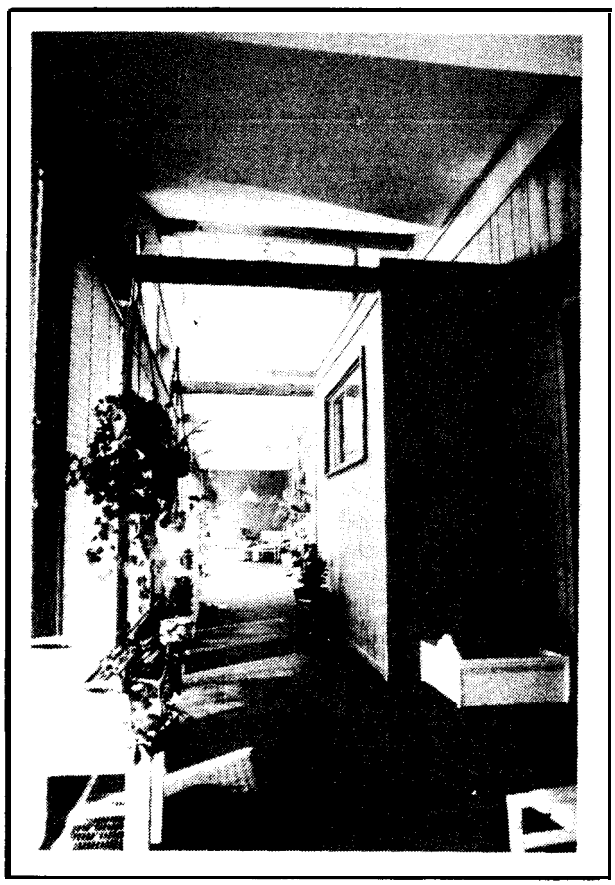
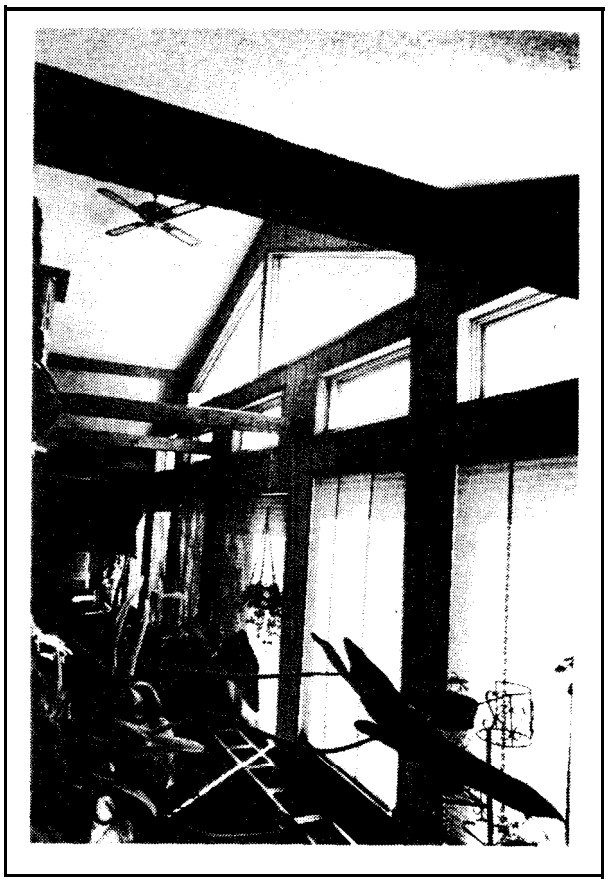
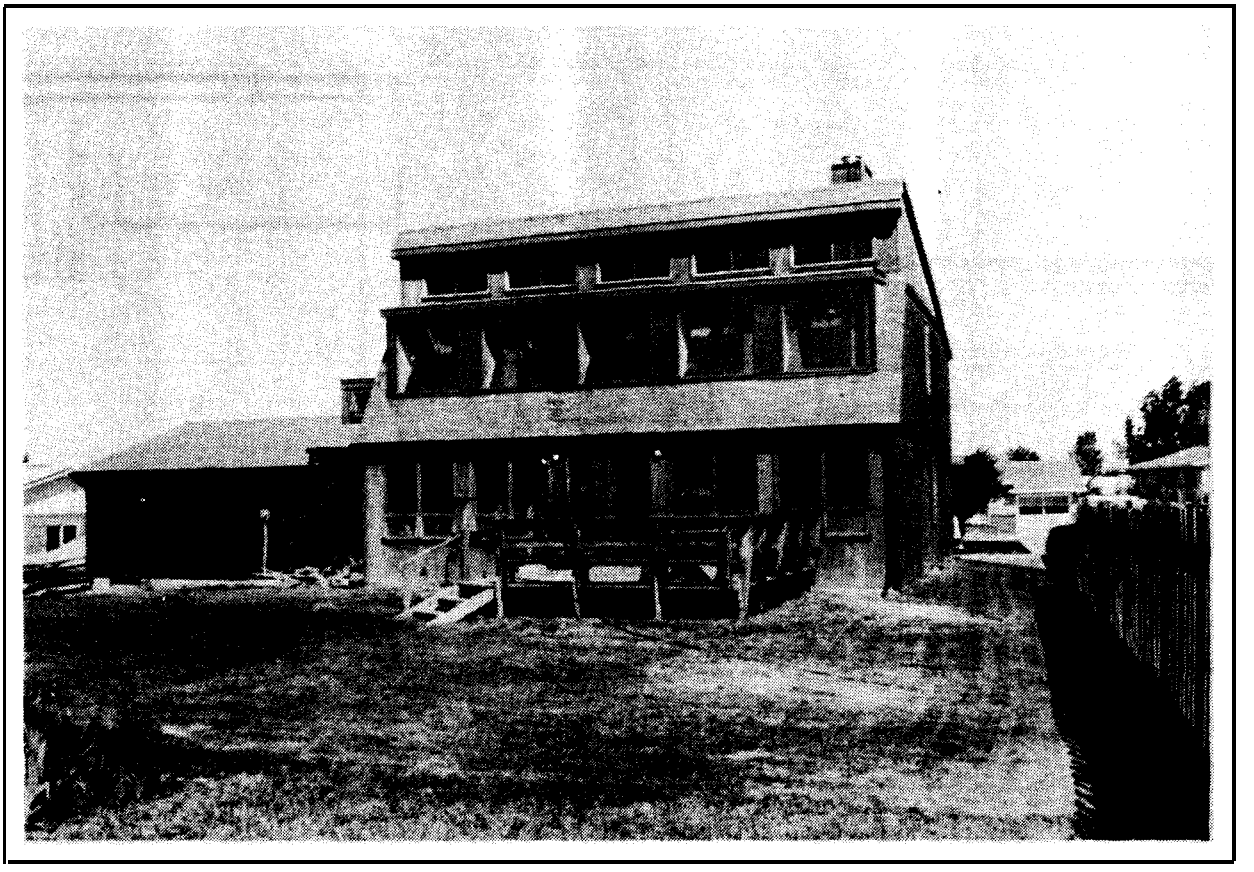






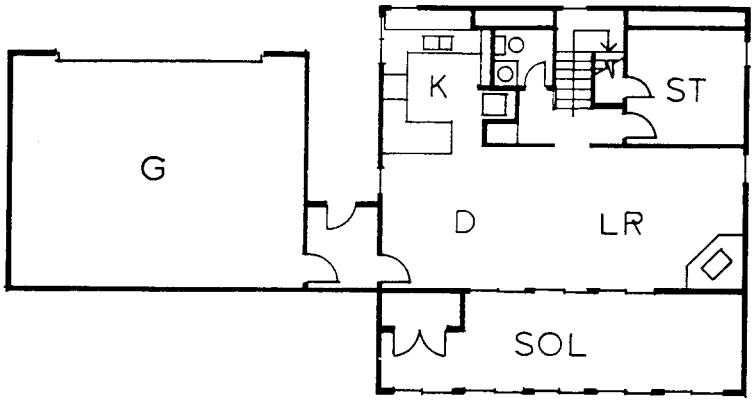
nEMPSONn



The Empson home, like the Dorwart house, is a double shell passive solar house built by Sandstead Custom Solar Homes of Alliance. Unlike the Dorwart house, however, the Empson home is a double shell design of the classic style as developed by Tom Smith of Positive Technologies, Lake Tahoe, California, with one exception: the Empson house also has vertical glazing -- slightly more than 300 sq ft -- rather than sloped glazing, although sloped glazing was incorporated in the design when it was built in 1981. However, after problems with overheating (the major reason why sloped glazing is no longer recommended for double shell designs) and leaks, the builder retrofitted the structure by replacing the sloped glazing with the vertical glazing currently in place.

Like the Dorwart house, the performance of the Empson house during the heating season has been satisfactory, again undoubtedly due in part to high insulation levels -- inner walls (R-11) and outer walls (R-19) combine for an R-30 value, and ceiling (R-19) and roof (R-30) combine for an R-49 value -- and conservation features like an airlock entrance (opposite left). A Defiance woodburning stove is the only backup heating system used in the 1500 sq ft house with a 380 sq ft sunspace (opposite right). In the severe northwestern climate of Chadron a total of 3/4 cord of hardwood was burned during the 1981-82 winter period. The calculated TIF for the home was under 1.

During summer months, hot air from the house is vented directly outdoors and is replaced by cool air that is drawn up the stairway from the basement, which in the Empson house functions as the belowgrade plenum -- there is no crawlspace.



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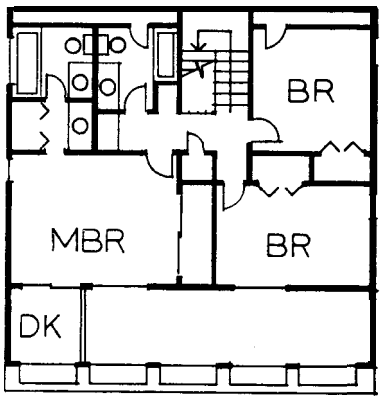

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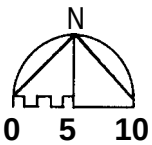
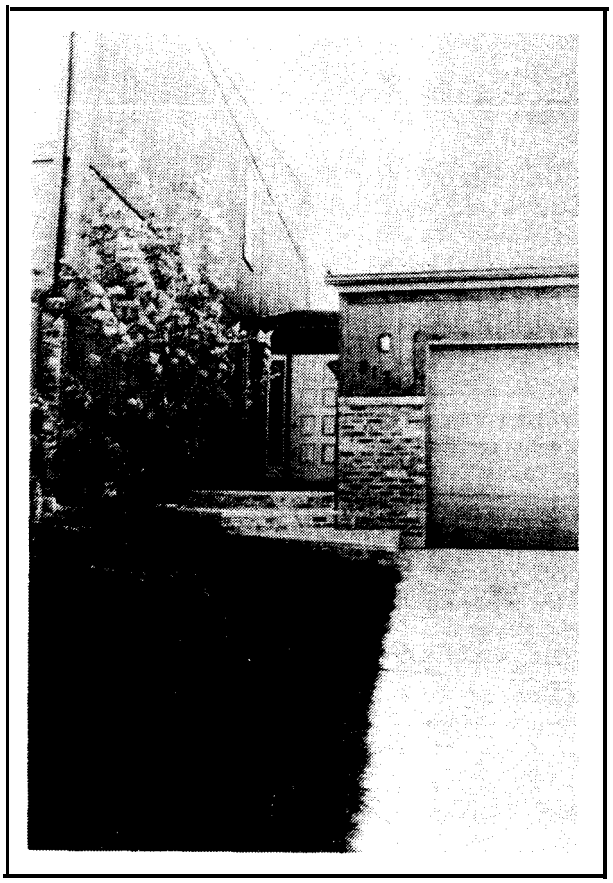
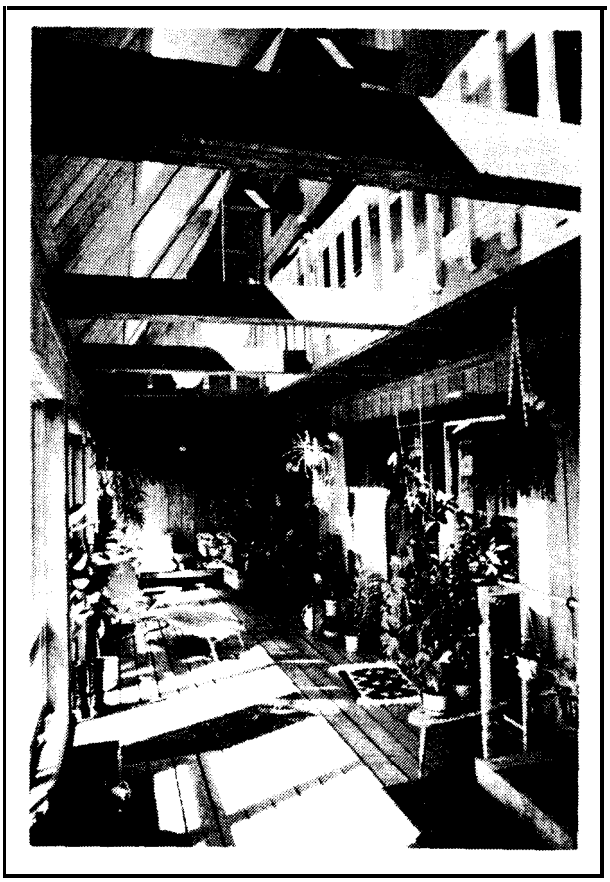
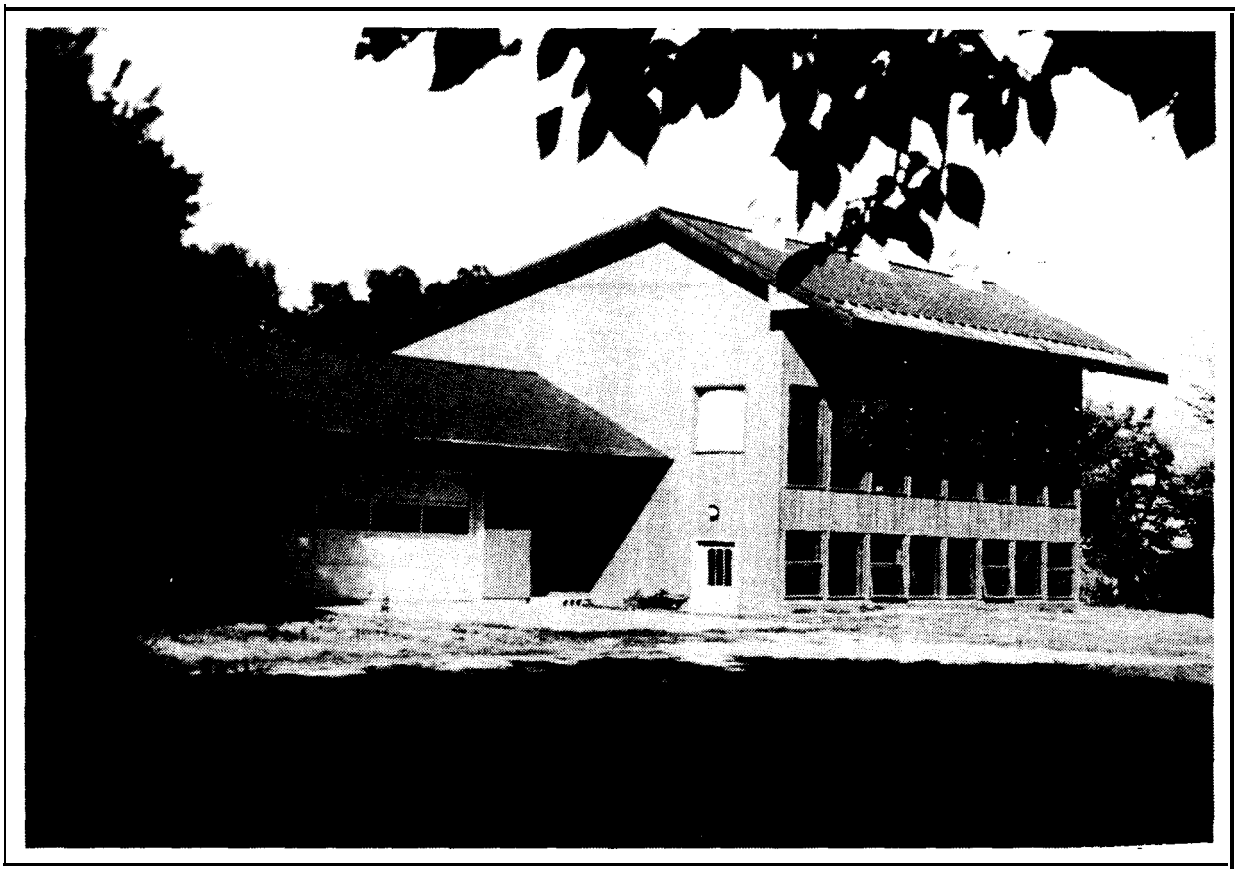






nKUCERAn



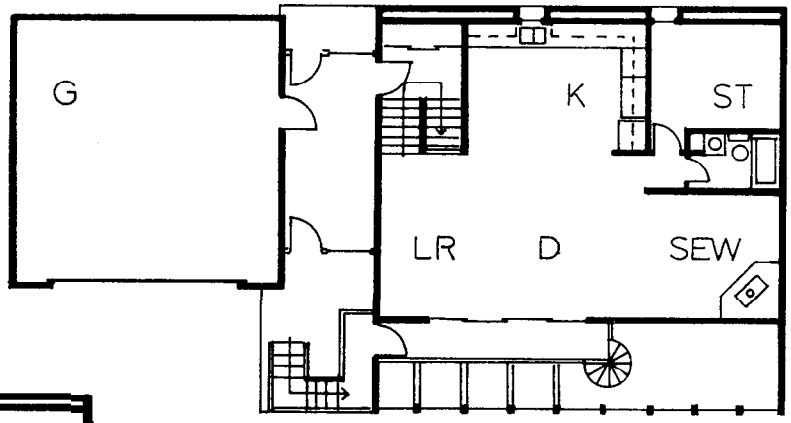
The Kucera double shell passive solar home, designed by Solar Energy Associates of Omaha, is a two-story 1900 sq ft building that is fronted by a two-story 300 sq ft greenhouse (opposite left) with balcony. As recommended for passive solar buildings with vaulted ceilings, bedrooms are located on the lower level.

The Kucera house is well insulated as the insulation level in the east and west walls is R-27, and it is R-19 in the south wall. Both the living space ceiling and the roof are insulated to R-18, giving a combined insulation level of R-36+ counting the airspace.

Considerable solar heat can be generated by sunlight entering the greenhouse through approximately 500 sq ft of vertical south facing exterior glass. A woodburning stove, located in the greenhouse rather than in the living space, provides backup heating.

The cooling of the house during summer is achieved through a combination of strategies. Overhangs (opposite right) shade the glazing from unwanted solar gain. A small window air conditioner, vented to the sunspace, is used to help cool the living space. Roof turbines, a modification to the original design undertaken by the owner as a less expensive cooling alternative to north facing clerestory windows, vent heat from the sunspace. Operable windows (opposite right) at the bottom of the south facing glazing can be opened for ventilation as well.

One rather unique and functional feature of the home, the root cellar located just under the breezeway, provides excellent storage for vegetables and serves as a shelter during violent weather.



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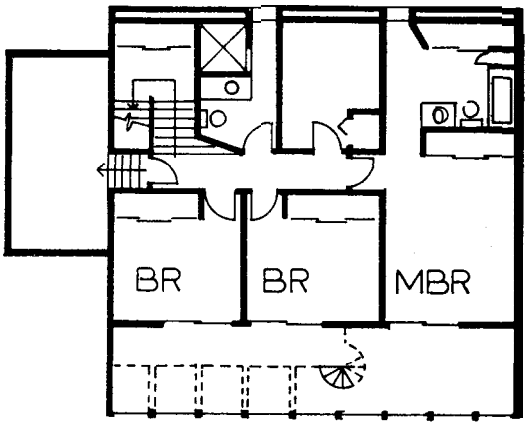

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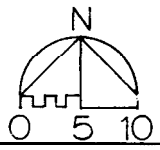
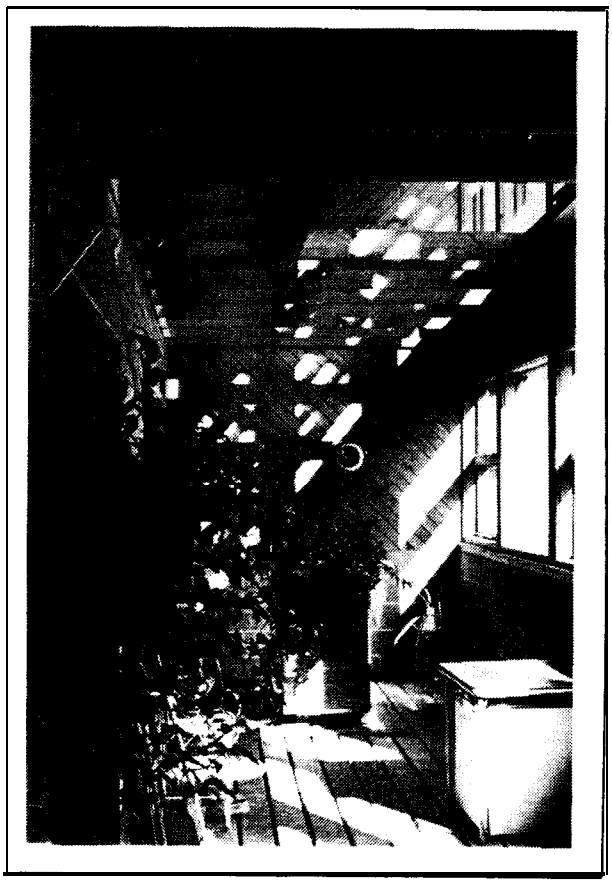
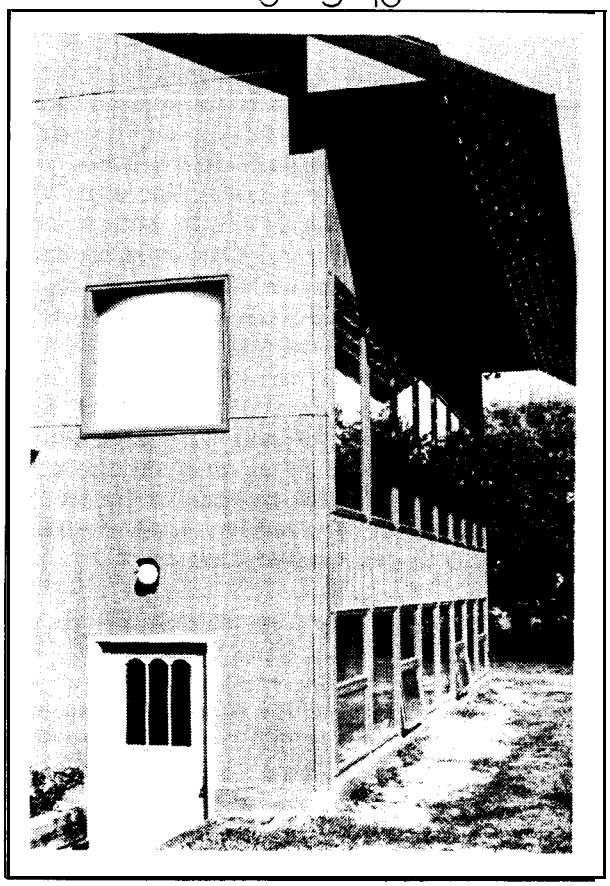




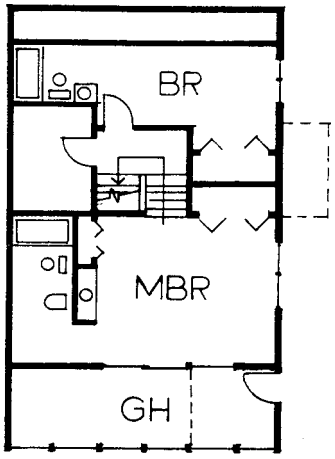


nNYHOLMn

The luxurious and contemporary styled Nyholm double shell home was designed by the owner after considerable research. The research included a trip to Lake Tahoe to visit the home of Tom Smith whose double shell house was the first one built in the United States. Slightly less than 1400 sq ft of ftoor space is divided among the multiple levels of the house, and each level is open to the three-story sunspace (looking up, opposite right) across the front of the house. The greenhouse is combined with an open floor plan -- with few walls or partitions -- to allow excellent views from everywhere in the house (opposite left).

Almost the entire south wall of the Nyholm house is glazing -- over 800 sq ft of double paned glass -- which might be considered excessive for a house of this size. However, the glazing is needed to let in light and solar energy because the house is located on a lot in a heavily wooded area overlooking a park and shading is a problem, even in winter. Although normally only leaves present shading problems, the branches of some deciduous trees can also cast thick shadow patterns. Obviously, trees are desirable for shading, but their preferred location is west or east of south as opposed to due south.

Despite any shading problems, the thermal performance of the Nyholm double shell has been good. Backup heating to the Nyholm house is provided by a natural gas furnace. For 1981, the total heating bill was under $119 for the entire winter. The total non-electric utility bill for the 12 month period from January through December of 1982 was $342. This bill covered the cost of gas used for space heating, the cost of gas used for heating water for domestic purposes -- including the hot tub located off the master bedroom on the lower level, and the cost of water used for all purposes.



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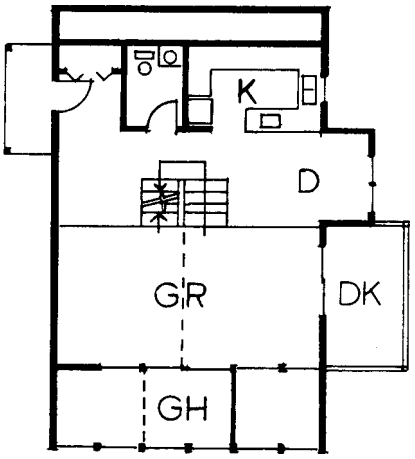

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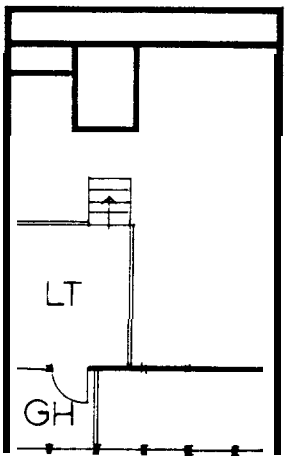

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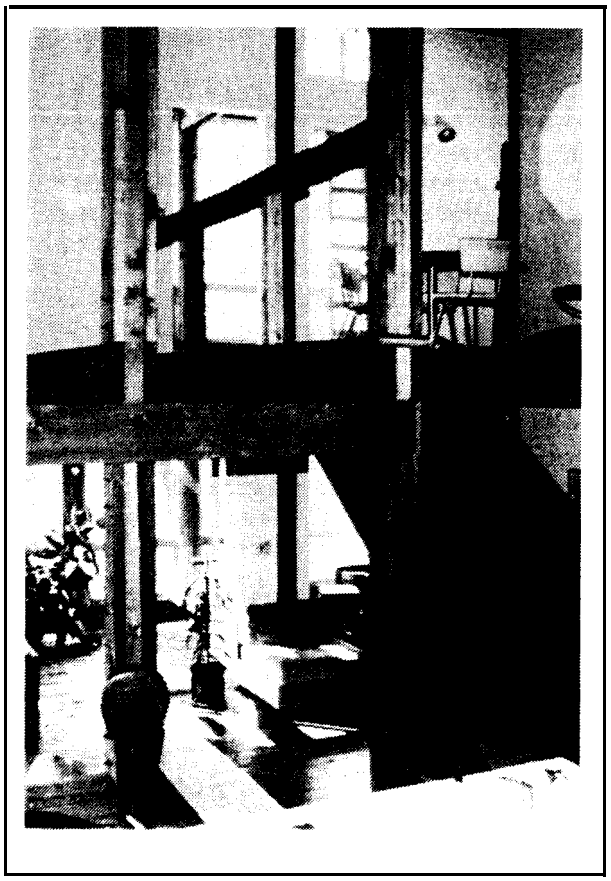
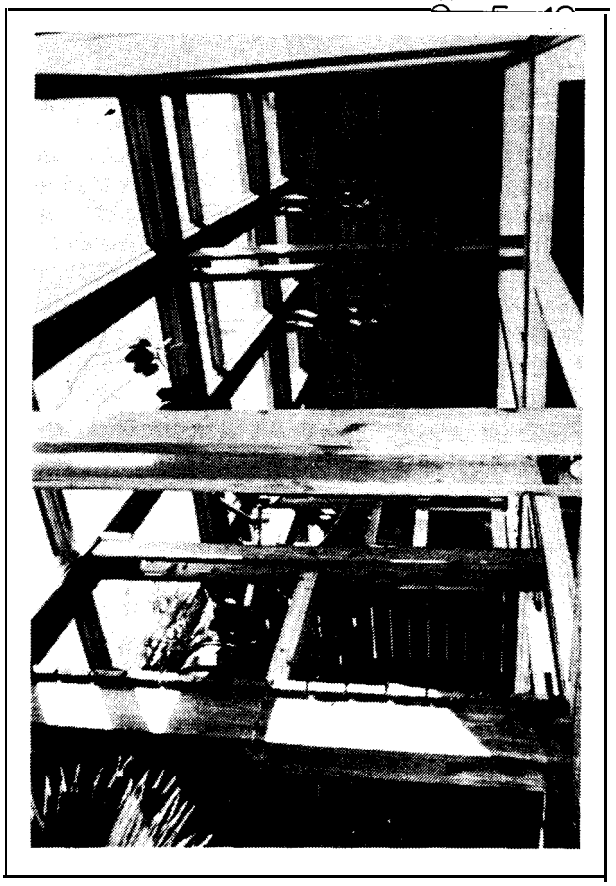




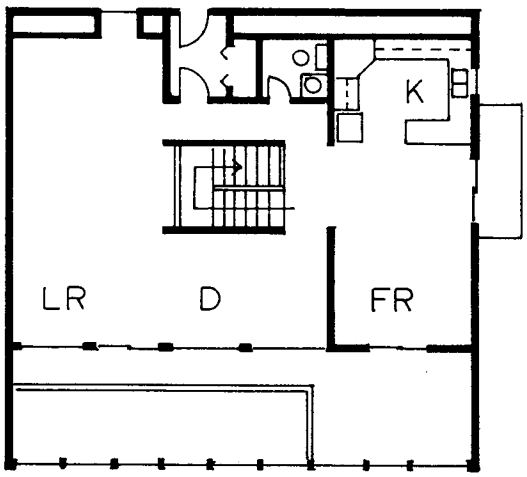
nSEBERGn

The Seberg double shell home, completed at the end of 1982, is significantly different from other double shell houses. In the Seberg double shell, the central flow of air through the roof plenum chamber is interrupted by a cupola (opposite left) which is located over a central stairwell. Light, admitted through the clerestory windows in the cupola, floods the main level -- with open floor plan and high ceilings (opposite right) -- and also reaches to the lower level.

The two-story Seberg house has 2200 sq ft of floor area, and the 360 sq ft greenhouse has a walkout from the lower level. The interior wall of the north plenum has 2x4 framing, and the exterior wall has 2x6 framing. Combined, their insulation level exceeds R-27. The roof consists of a 2x6 ceiling and a 2x6 roof.

All glazing in the Seberg double shell is vertical including the entire south wall and consists of nearly 500 sq ft of tempered glass panels of the type usually used in sliding glass doors. On sunny winter days,the greenhouse temperature rises to over 100°F, and the main 1evel living space temperature easily reaches the high 70's with no backup heat. Ceiling fans are used to circulate the warm air. Backup heat to the main level is provided by a centrally located wood stove (opposite right), and the bedrooms are heated, as needed, with a small. quartz space heater. A forced air propane furnace, available for backup heating, is not needed or used.

Cooling the structure is a little more difficult than heating it, as shading is lacking for the most part -- the roof is the only overhang and shade trees to the south of the house have not yet matured. Hot air is vented from the structure through windows and a 3 ton air conditioning system is also used.



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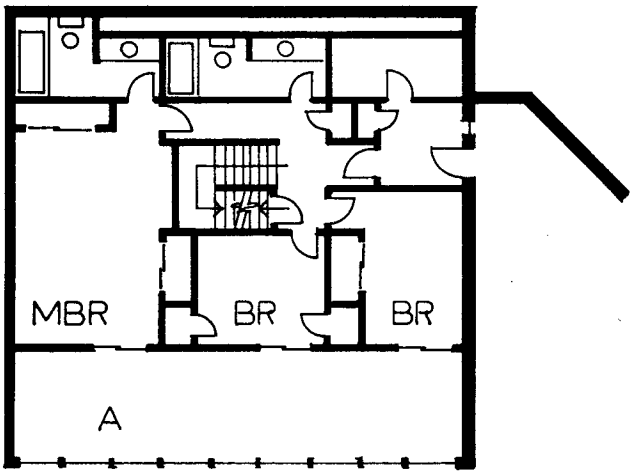

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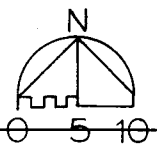
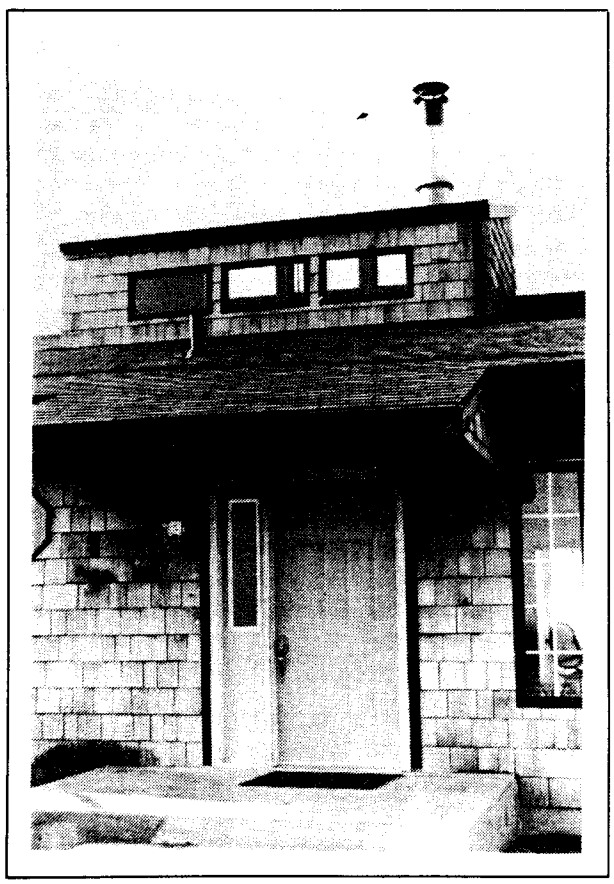
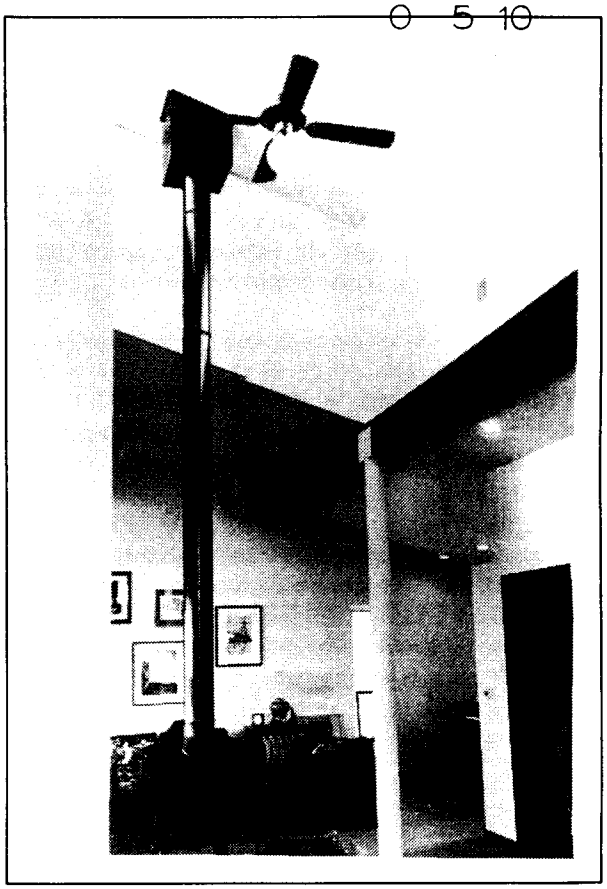
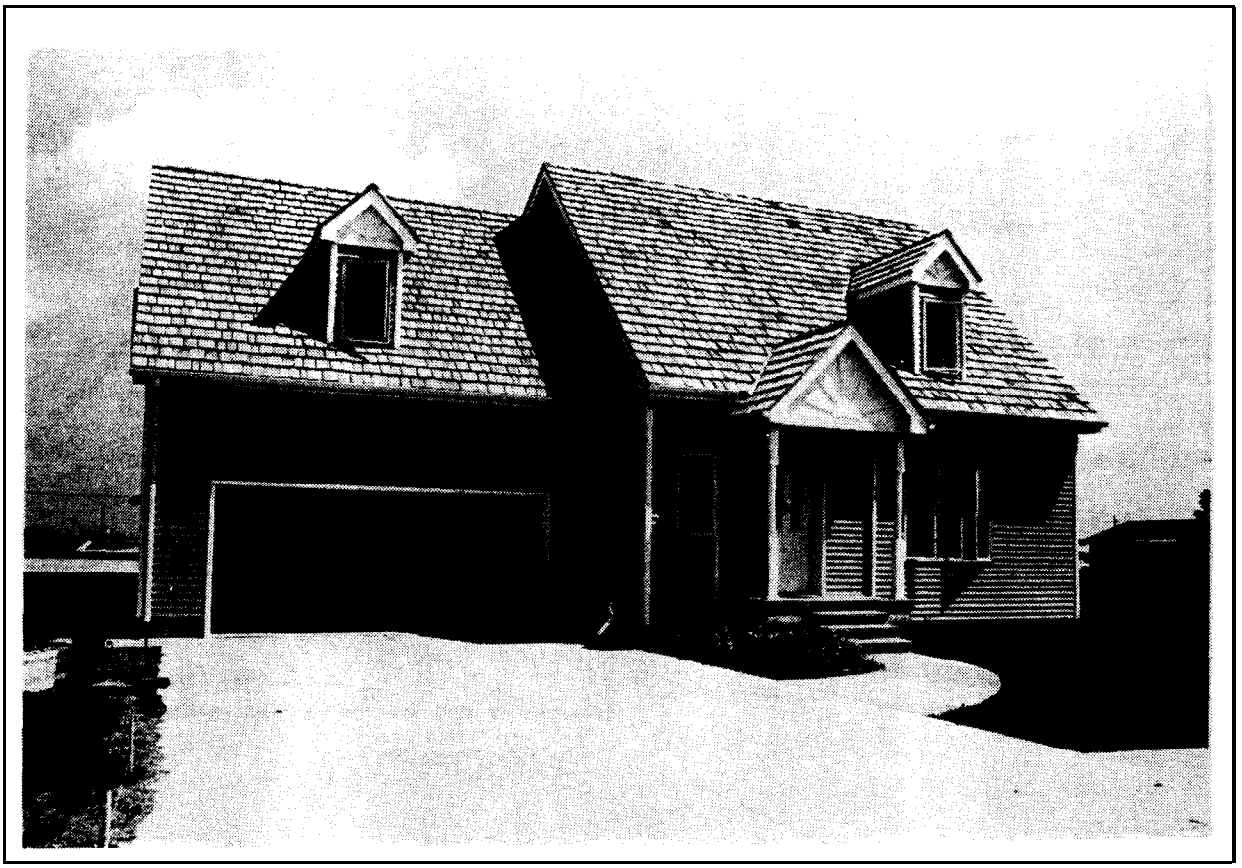






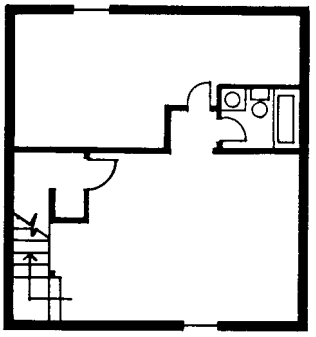


The Jeffrey home, a 2500 sq ft two-story superinsulated design with some direct gain passive solar features, marks a departure from the earth sheltered and passive solar heated homes for which Sunshine Construction of Kearney has become known.

At first glance, there are few clues to indicate that this home is anything other than a typical, attractive suburban house. A closer examination reveals, however, that this is not any ordinary home. The relatively few windows are strategically located -- most of the windows face south or east -- only two windows face north (opposite). In addition, these triple-glazed windows are set in walls which are nearly one foot thick. The double 2x6 framed stud walls allow for insulation values of R-40 minimum.

The Jeffrey home is all electric. A water source heat pump is the principal auxiliary heat source, and the average monthly electric bill during the heating season, including the heat pump, lights, and appliances, was under $50.

Among the problems associated with tightly sealed buildings, including superinsulated houses, are clinging odors and water condensation. The Jefferys, however, have not experienced either of these problems. In fact, the Jefferys have indicated they are so pleased with the design and performance of the house that were they to start over they would not change anything.



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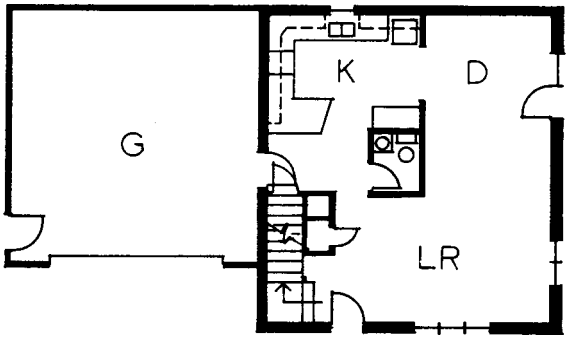

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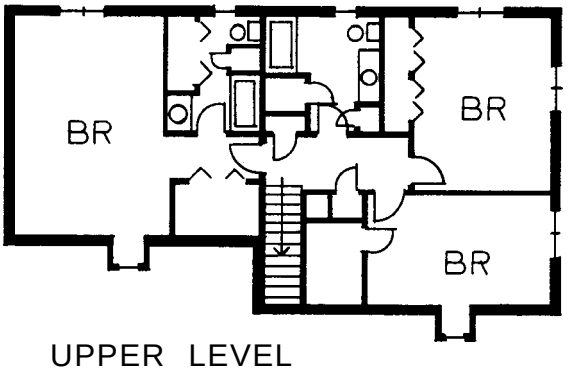

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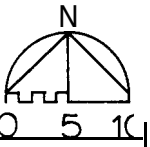
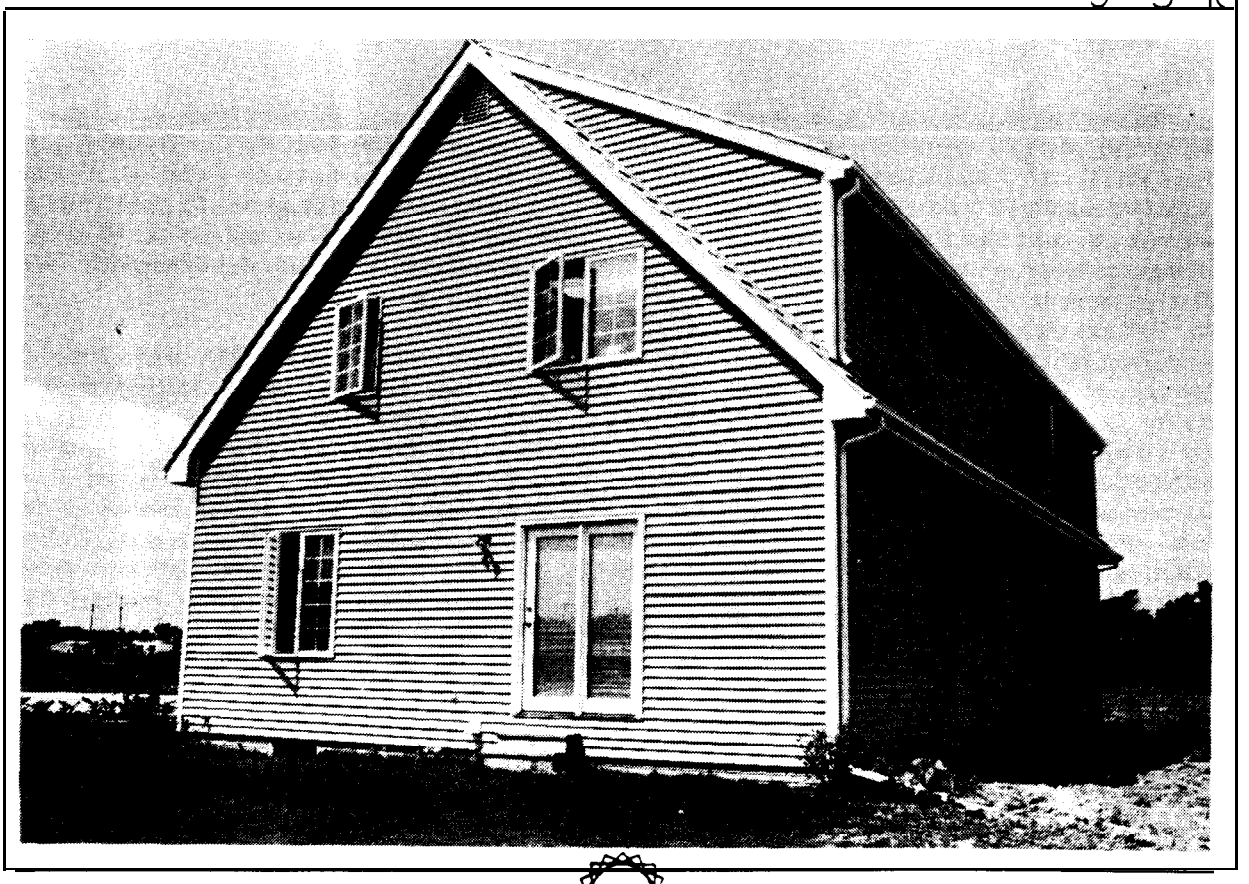
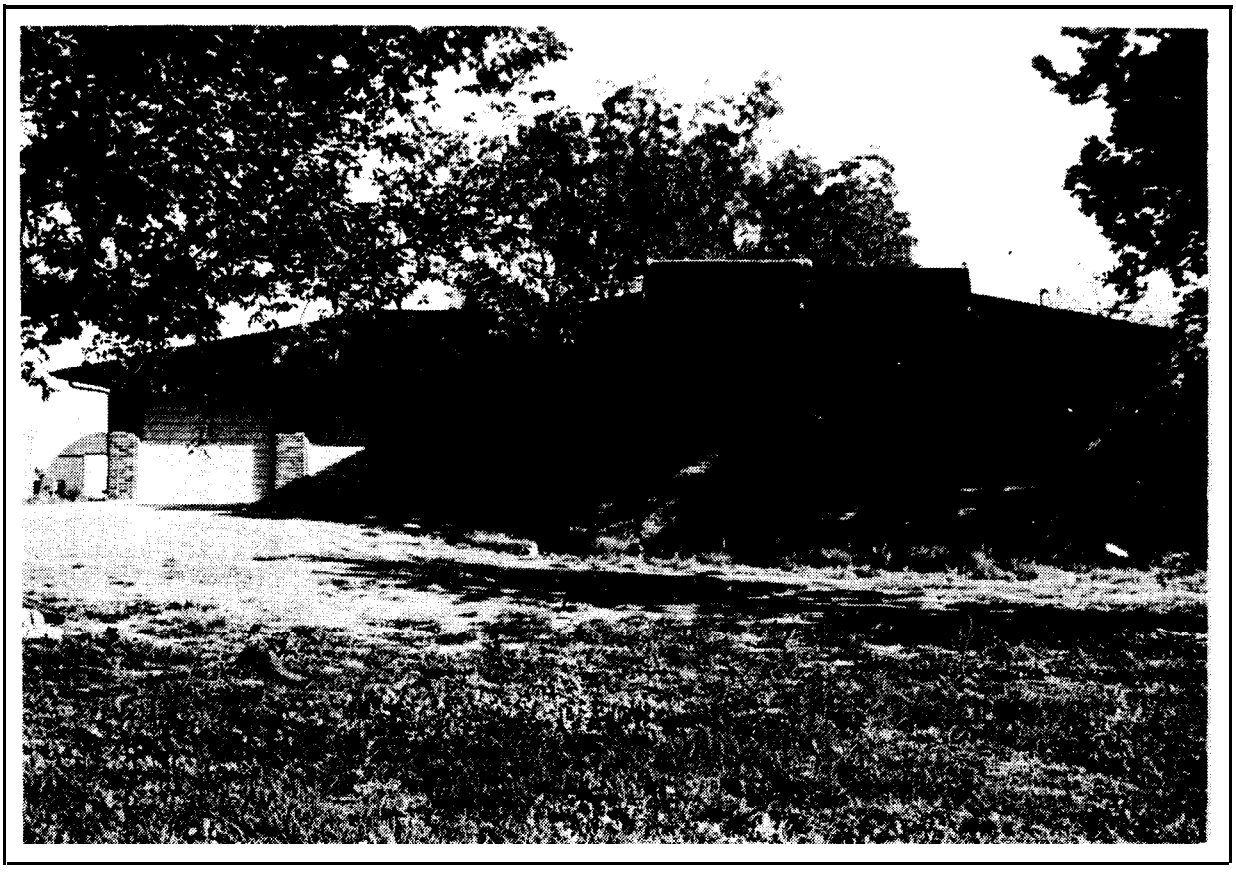




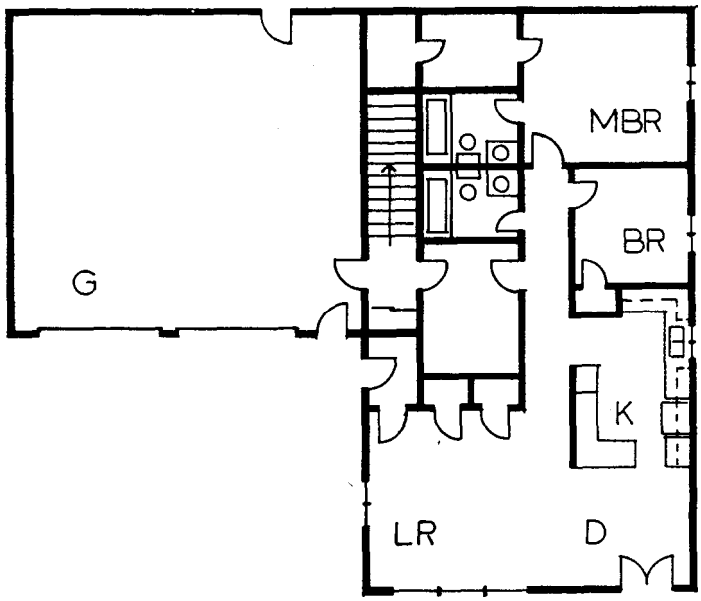
nKRAMERn



The superinsulated Kramer home was designed by the owner who relied on THE PATH TO PASSIVE: NEBRASKA's PASSIVE SOLAR PRIMER and other resource materials for ideas and guidance. Energy conservation features of the recently completed 1345 sq ft all brick dwelling include air lock entries,no windows on the north side, the garage positioned to block winter winds from the northwest, and a Van-EE, model R-200 air-to-air heat exchanger (opposite left) located in the basement. A superinsulation level of R-43 in the side walls is possible because the side wall framing is double 2x4 stud walls. At least 10" of blown insulation in the roof, gives it an insulation value of R-45.

Hot water for domestic use is provided by a site-built, two panel active solar collector liquid draindown system. The owner built the system after having attended active solar domestic hot water workshops to gather information.

Some of the minimal heating load in the Kramer house is supplied by solar heat generated through approximately 60 sq ft of south facing direct gain glazing (opposite right). Warm air is circulated within the house by ceiling fans (opposite right), and the owners rely on an electric forced air furnace for backup heat. Energy performance should improve with the use of window insulation to reduce heat loss at night.



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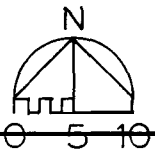
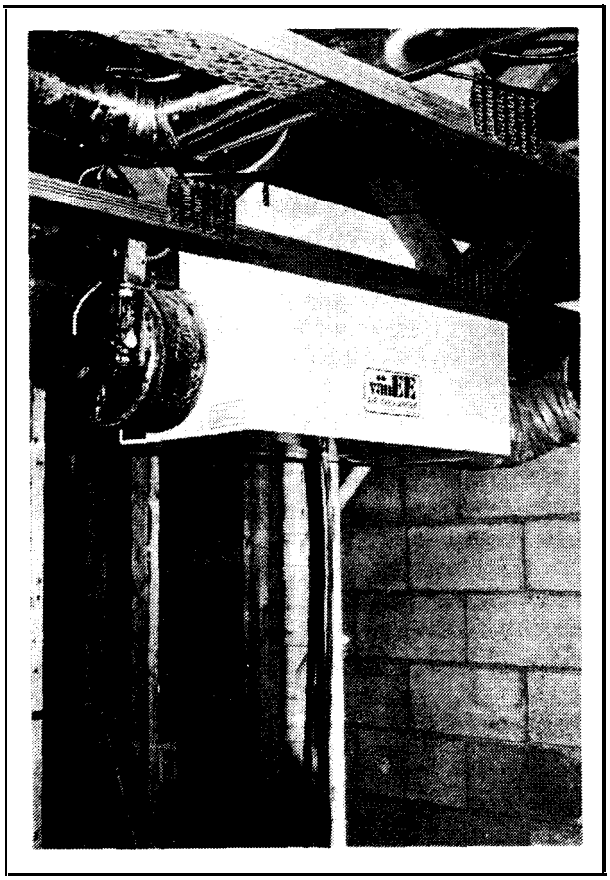
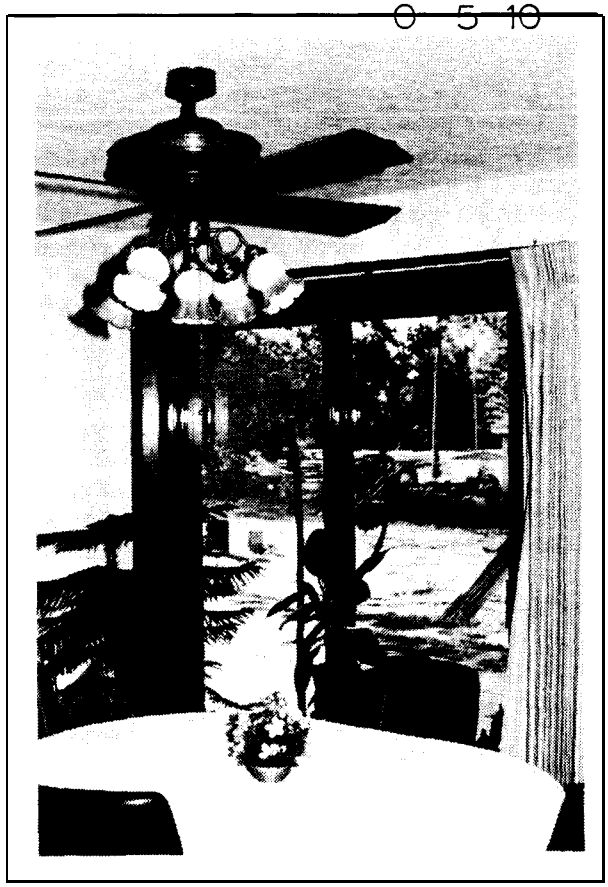
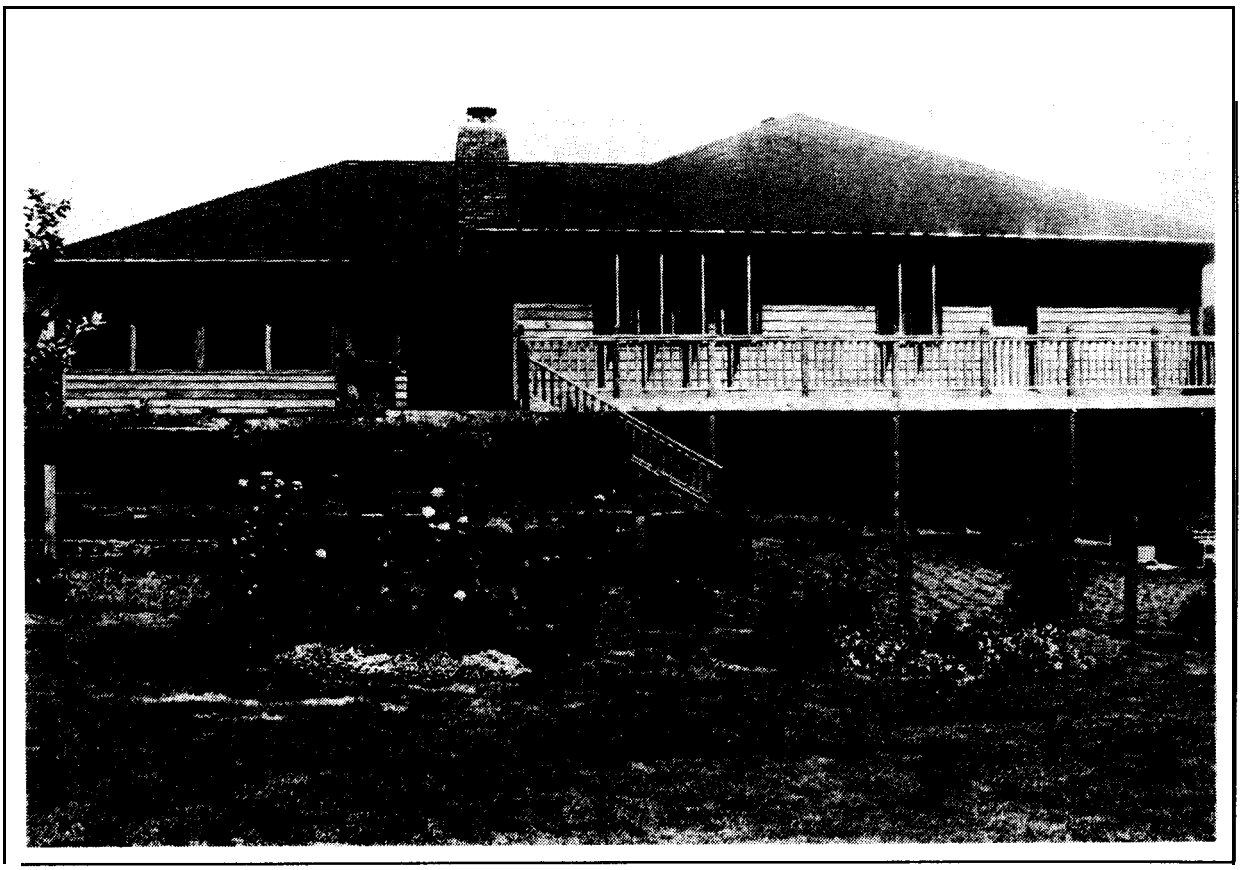




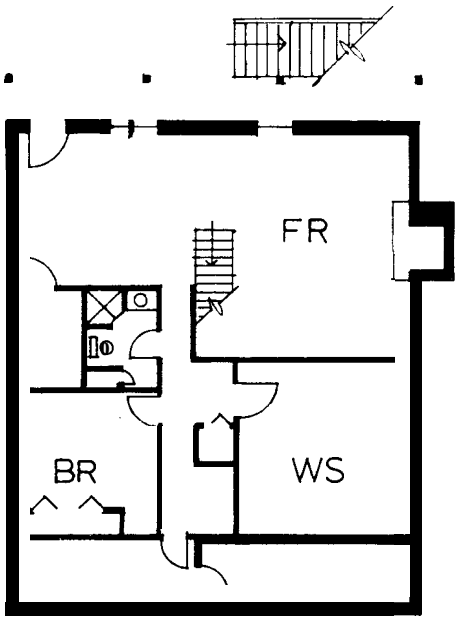




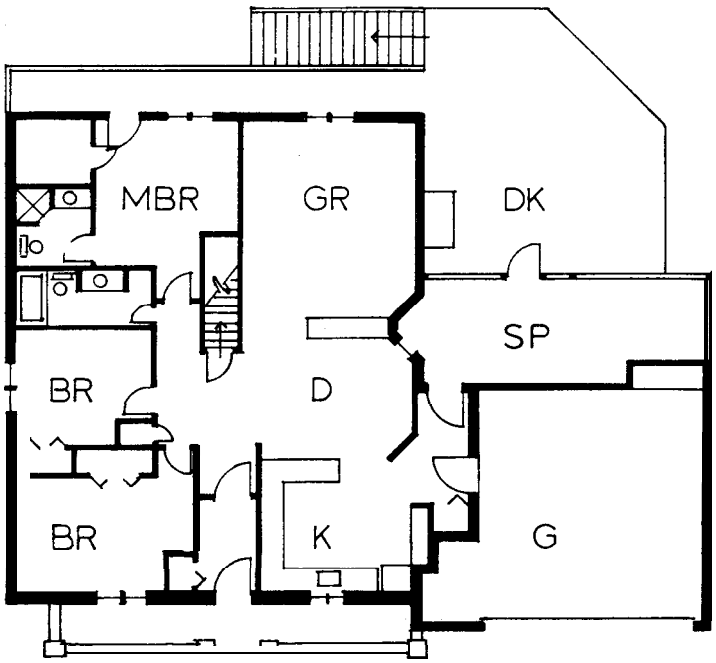
The MacFerrins moved into their superinsulated home in February of 1983. The owner, influenced by William Shurcliff's book on superinsulated design as well as periodicals such as Solar Age and New Shelter, designed the house and served as the general contractor during construction.

The MacFerrin house, which from the street (opposite) gives no indication of its energy efficiency, has 1550 sq ft of living space on the main level and approximately 1500 sq ft on the lower level. The superinsulation of the house is achieved by side walls with double 2x4 stud framing to create a 9" deep cavity for insulation and an attic with an insulation level of R-63. Although the principal heat source in the house is a Lennox heat pump, some direct gain solar heat is generated through the south facing Pella casement windows. A whole house ceiling fan helps ventilate the house during the cooling season.

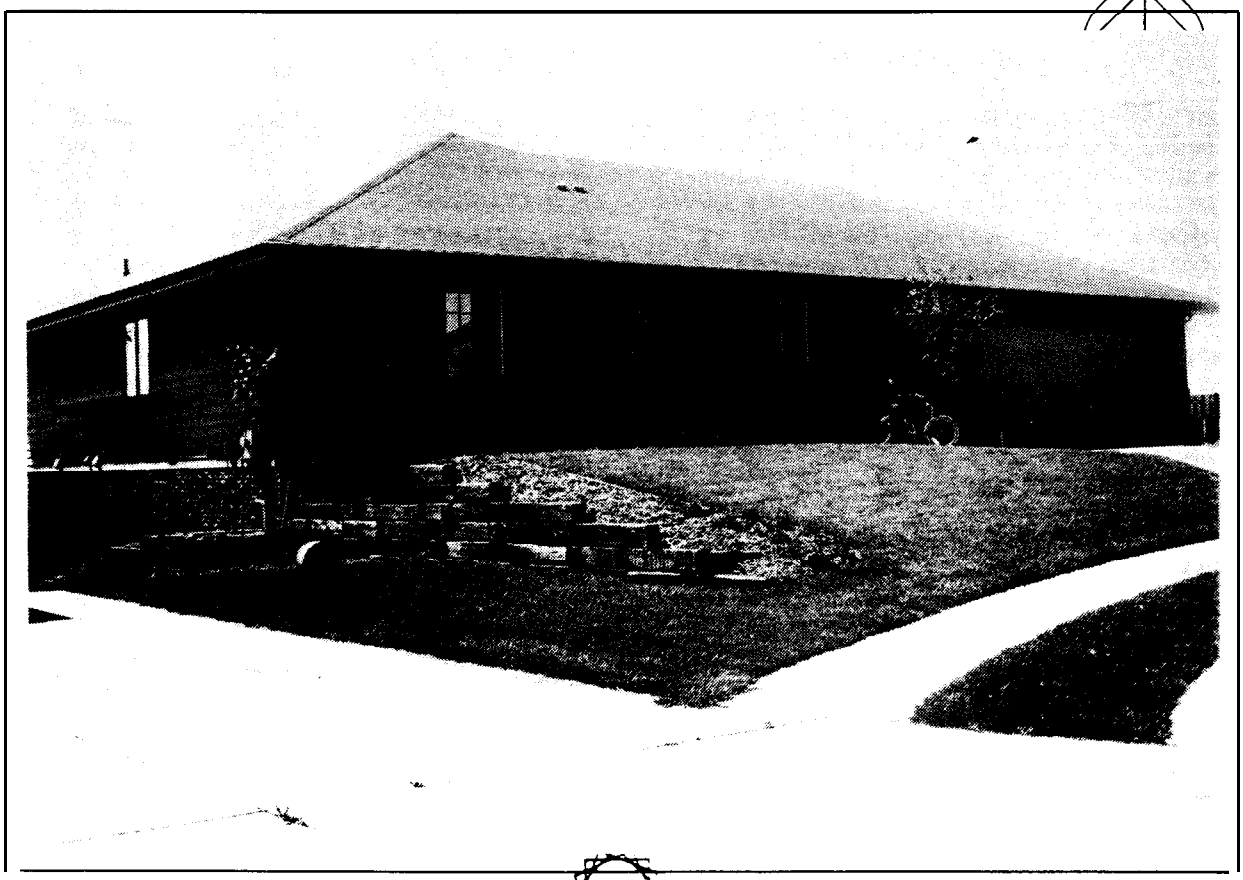
Superinsulated houses are energy efficient not only because they are heavily insulated, but also because they have very low air infiltration rates, largely the result of a properly installed vapor barrier. Resulting stale air may require the use of an air-to-air exchanger, which, as the name suggests, exchanges stale air from the house for fresh air from the outdoors. The air-to-air exchanger also transfers heat from the outgoing air to the incoming air to make the process relatively thermal efficient. In the MacFerrin house, a Van-EE, model R-200 air-to-air heat exchanger is located in a closet near the central hallway to exhaust stale air drawn from the kitchen and bathrooms.



LOWER LEVEL

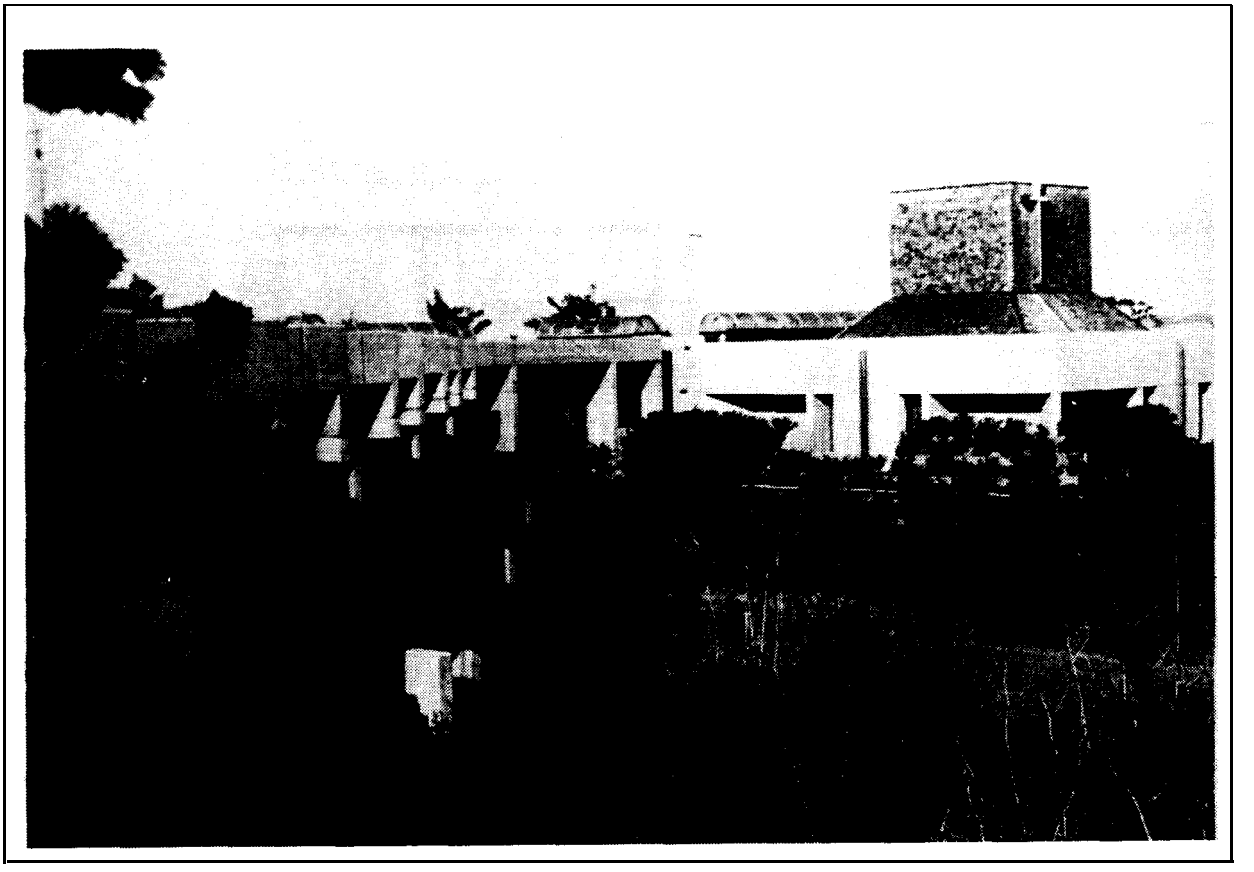


MAIN LEVEL



BENEDICTINE MISSION

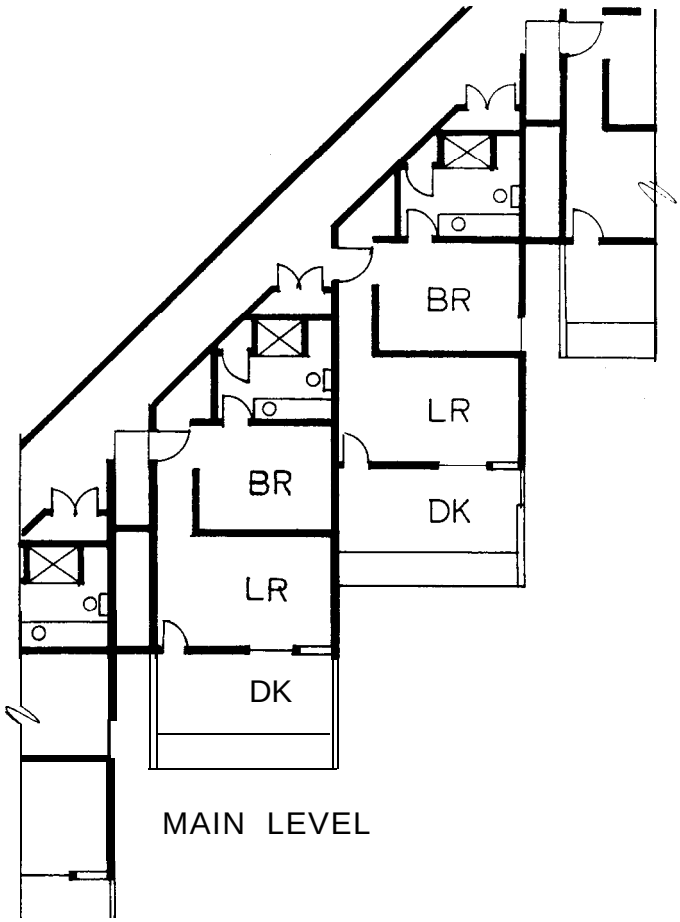
SCHUYLER EARTH SHELTERED-DIRECT GAIN



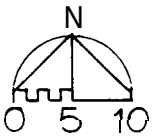
The earth covered Benedictine Mission House, designed by Astle, Ericson and Associates of Omaha, is a support center for other missions of the order throughout the world. The 40,000 sq ft building is roughly "Y" shaped: the right arm is guest quarters, the left arm is living quarters for the occupants (floor plan opposite), the shaft is the office/work area which includes a full-size printing press, and the hub is the commons and gallery/chapel (opposite right).

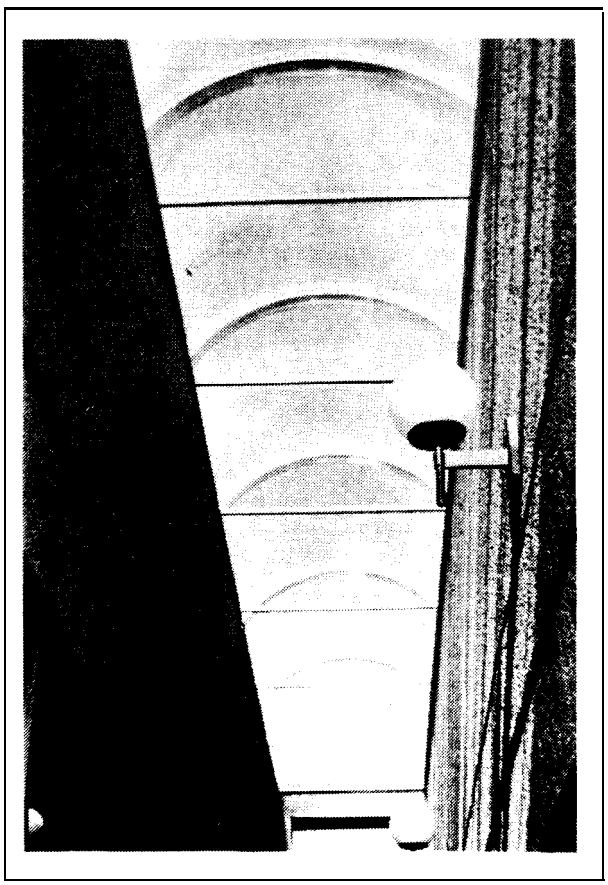
The north, west, and east sides of the monastery are bermed except for a small entry on the north. The building is lightly insulated with 2" of rigid insulation on the roof, perimeter wall, and below grade. The combination of earth cover, earth berm, and the considerable thermal mass of the all concrete building combine to create a structure with fairly constant temperatures, required for the paper storage. The energy conscious occupants contribute to the energy efficiency of the building, and the architect has indicated that the mechanical system in the monastery is smaller by one third than the mechanical system required in a comparable above grade structure. Skylights (opposite left) are distributed throughout the building to provide daylighting, thereby eliminating some of the need for artificial lighting and the energy it uses. Direct passive solar gain is gathered through glazing in the office/work areas and the living quarters. No night shutters are used on the glazing.

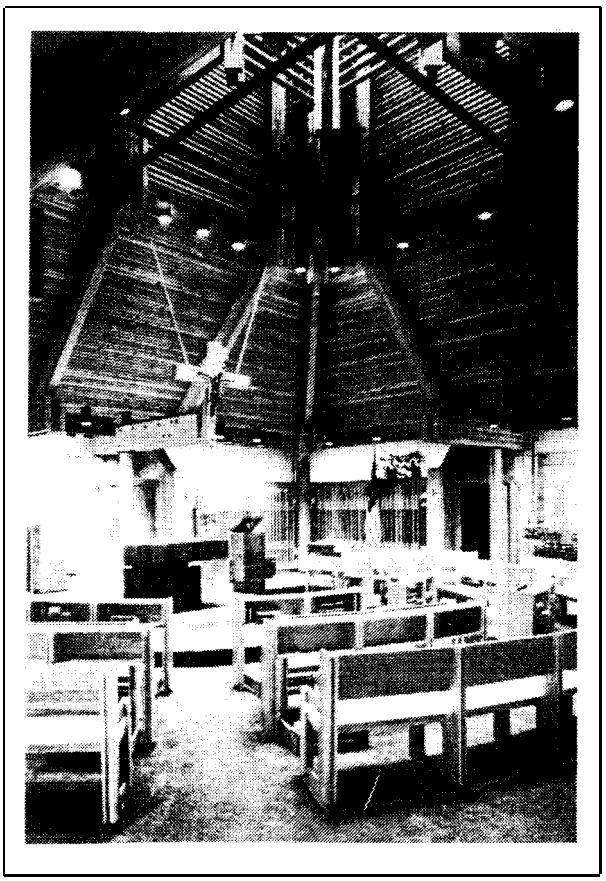
The earth contact aspect of the monastery helps minimize cooling requirements, and the main cooling strategy is nighttime natural ventilation through ventilation panels -- the windows are fixed/non-operable. A conventional backup chiller unit is available for emergency use.



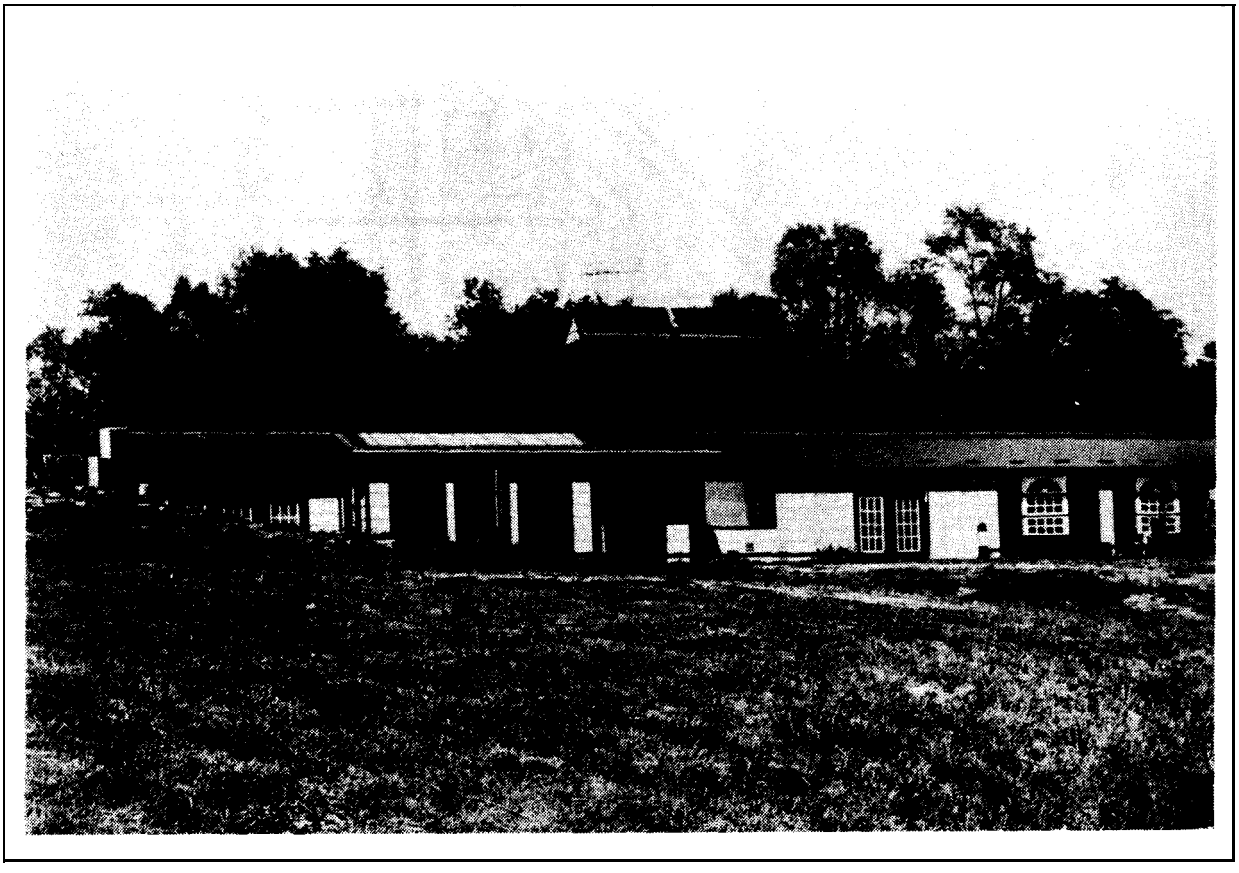
MAIN LEVEL







nGUSTAFSONn

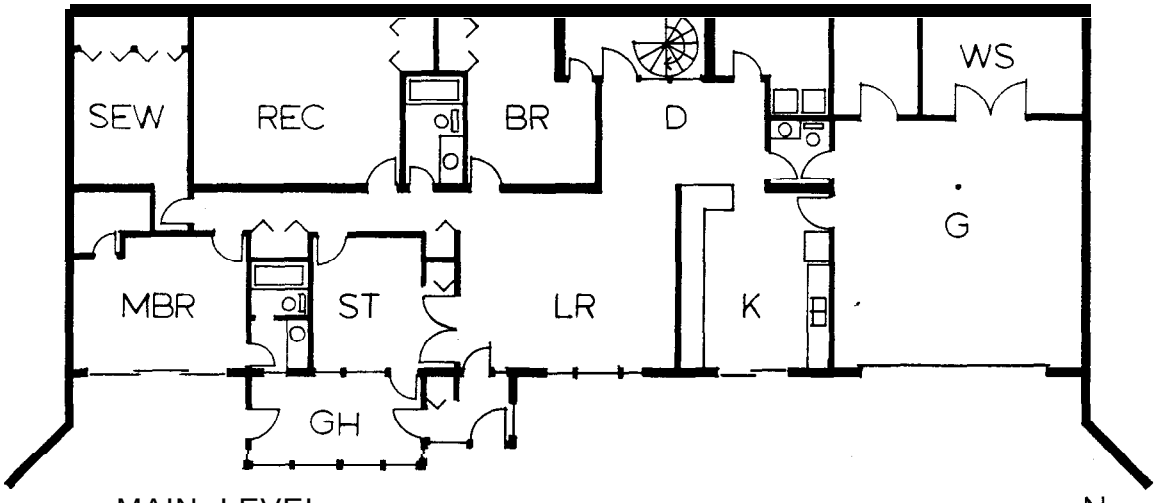


The earth covered Gustafson home was one of the first earth sheltered houses built by Sunshine Construction of Kearney which also built the Nelson earth sheltered residence described later in this inventory. In addition to the inherent energy efficiencies of earth sheltered construction, the house incorporates direct gain and greenhouse passive solar heating techniques.

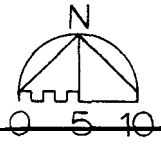
Skylights are frequently used in earth sheltered houses to bring daylighting to back rooms. Unfortunately, they are the source of heat loss in winter and unwanted heat gain in summer, and they often leak. For these reasons, vertical skylights -- skylights with vertical glazing -- are the recommended design choice in an earth sheltered dwelling. Perhaps the most unique feature of the Gustafson house is the vertical skytight/lightwell. In addition to admitting tight to back rooms, the lightwell in the Gustafson house can also serve as an exit -- a circular stairway (opposite right) connects the main level of the house with the roof. In fact, such an exit from a back bedroom may be a requirement of certain building codes. Although the lightwell is adjacent to the dining room, they are separated by a glass wall to minimize heat loss. During the summer, the door from the dining room and the operable windows in the skylight can be opened (opposite left) to permit natural ventilation and cooling.

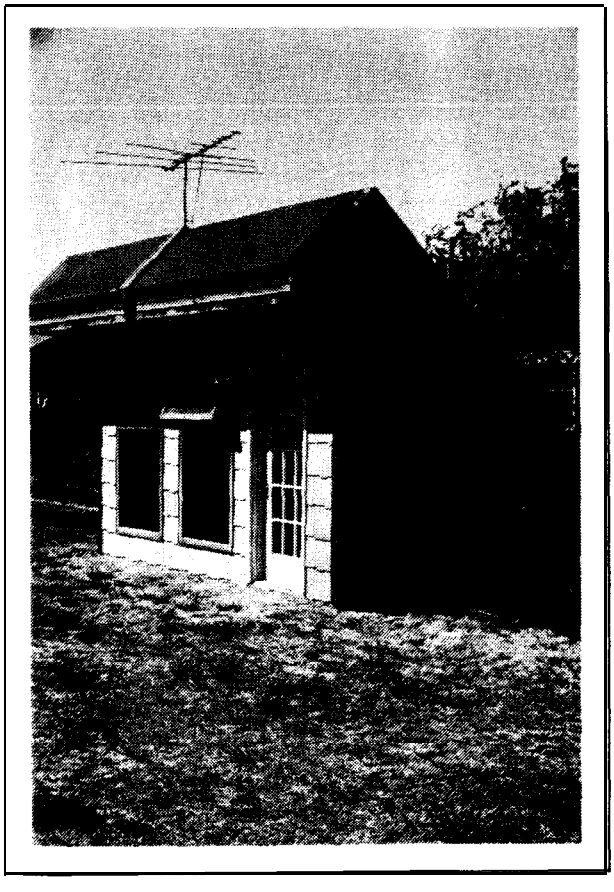
An active two plate collector system with freon refrigerant circulating liquid was installed for water heating and is mounted over the roof of the lightwell (opposite left). The performance of the system proved to be unsatisfactory to the owner, however, as he felt that the high cost of operating the active solar system pumps exceeded the cost of using a conventional natural gas water heater, and the system was disconnected.

UPPER LEVEL



MAIN LEVEL

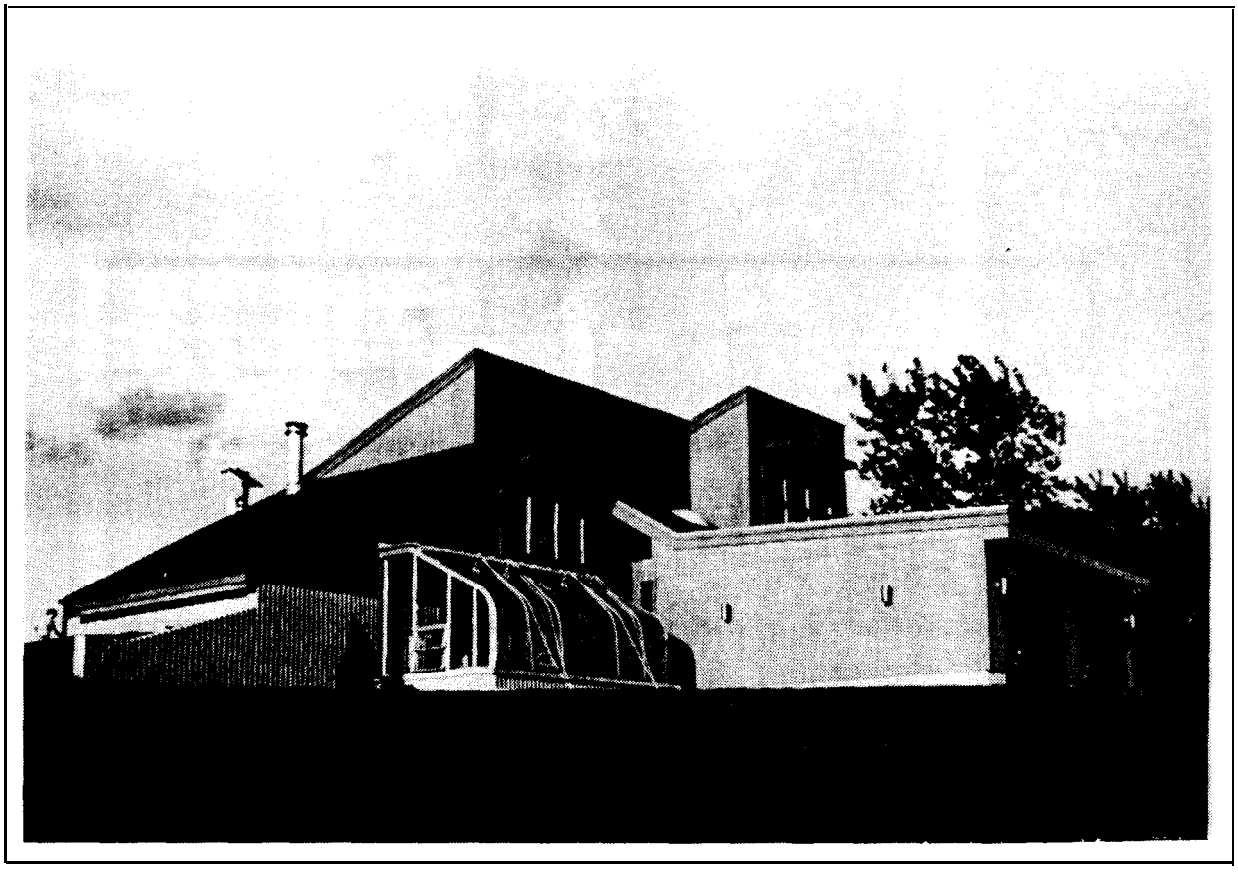




HOSCHIET

FREMONT

EARTH BERMED-PASSIVE

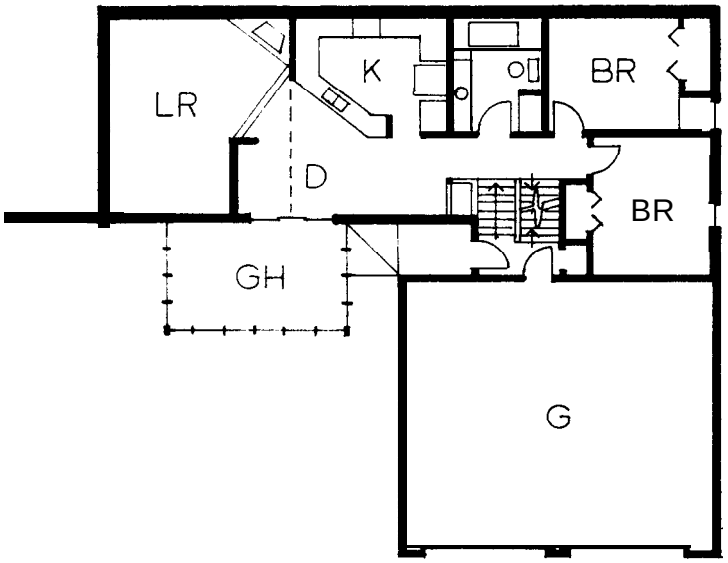


The 2075 sq ft Hoschiet home, earth bermed and contemporary in appearance, was designed and built by the owner who utilized the knowledge and experience he gained assisting during the construction of the earth sheltered Lively house which is also featured in this inventory.

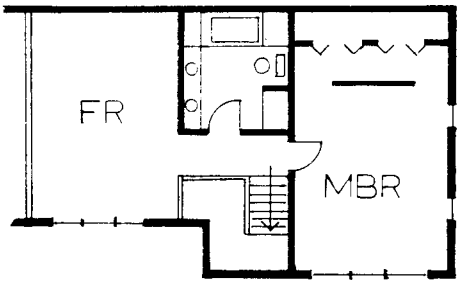
Earth is bermed against a 17' high by 54' long poured concrete wall on the north side of the building. The base of this wall, upon which floor joists are placed, is 1' wide. Above the base, the poured wall is 10" thick. The bottom portion of the poured concrete wall, the basement level, is uninsulated. The upper portion of the wall, the main level of the house, is 2x4 framed and insulated to R-11. The exposed walls in the house are insulated to R-25 and the roof to R-38.

Direct gain and sunspace passive solar heating strategies are present in this home. An attached, 10' x 16', Lord and Burnham commercial add-on greenhouse (opposite left and right) is adjacent to the dining room at the southwest corner of the residence. A family room overlooks the dining room/greenhouse and living room area.

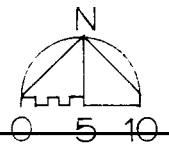
The energy conservation strategies at work in the Hoschiet house resulted in a heating bill of only $146.87 for the period from October 1982 to March 1983. Backup heat is provided by a 3 ton York water-to-air heat pump, that utilizes two wells -- one for the heat source and the other for a return. A 15kw electric strip heater is an additional backup. One cooling benefit of the earth contact was the air conditioning requirements of the Hoschiet house did not exceed $31 per month in all of 1982 and averaged approximately $18 per month for the summer of 1982. The overall success of the earth berming and passive solar combination is evidenced by the computed TIF value of just under 2.0.

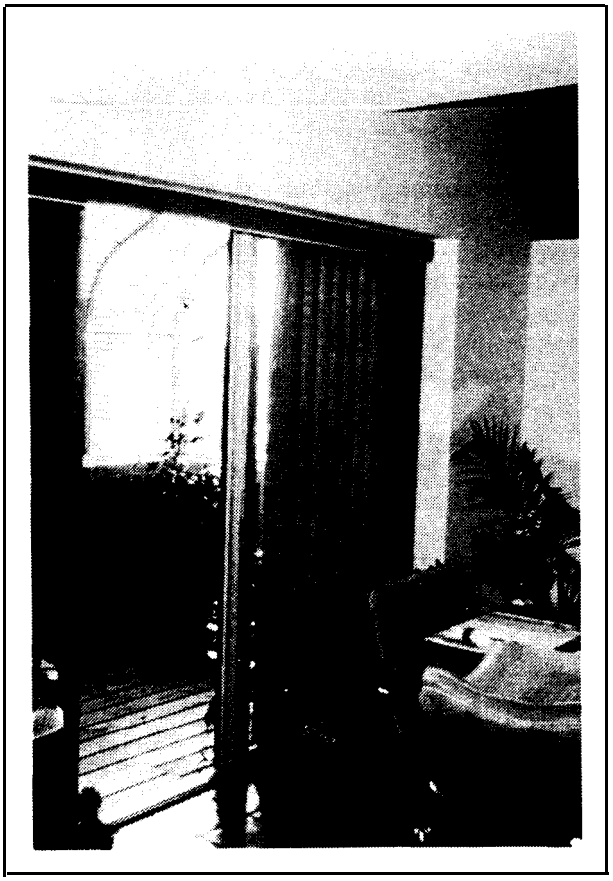


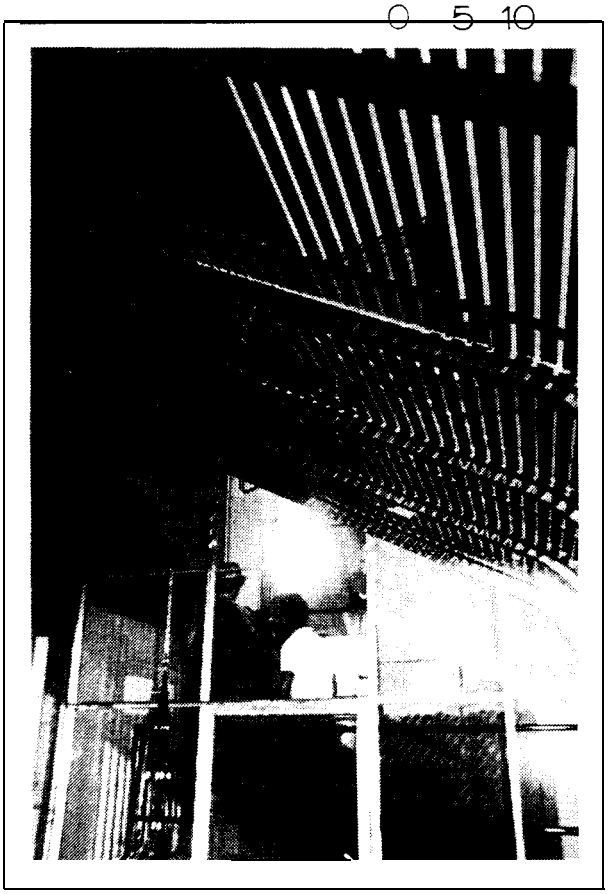
MAIN LEVEL



UPPER LEVEL







nD. JOHNSONn

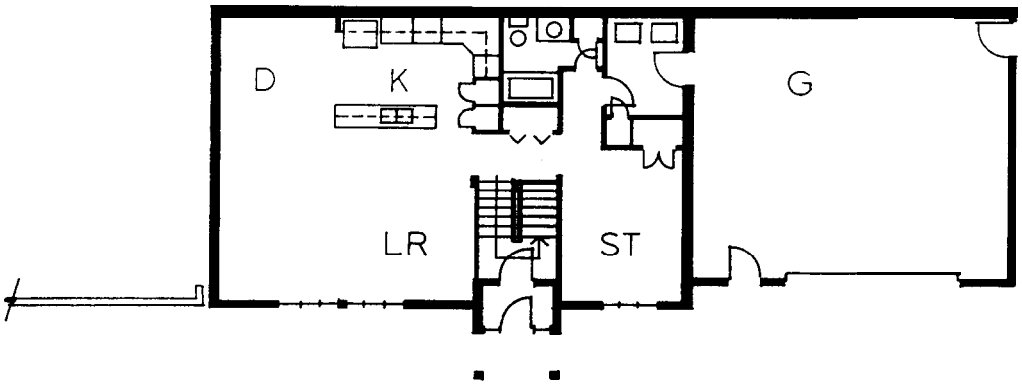
The two-story earth sheltered Johnson home, built by HM Smith & Son of Omaha, combines the inherent energy efficiency of a properly designed, situated, and constructed earth shelter with direct gain passive solar strategies. The house is earth bermed on the north and west walls -- as well as to the lower level window sills on the south, earth covered on the roof, and protected from northeast winter winds by the garage (with conventional roof).

The house has an open floor plan with a clearspan of over 25'. The north and west walls are 12" poured concrete with steel reinforcing. The roof, which supports an earth cover of approximately 18", is comprised of 10" hollow core concrete slabs with grouted joints. The slab is supported in front by a beam and columns conceated in the 2x6 wood framed wall (opposite left).

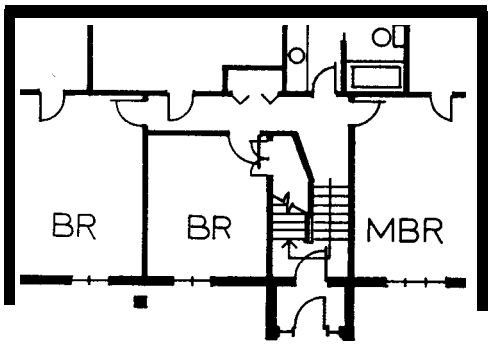
HLM waterproofing is used on the vertical earth contact walls. An elastomeric membrane was installed on the roof after HLM on the horizontal surface proved unsatisfactory.

6" styrofoam insulation is used on the roof and the first 4' down the earth contact walls. 4” styrofoam is placed the second 4', and the remainder of the wall is uninsulated. The front earth contact walls are insulated with 2" styrofoam. The exposed wall has 5.5” of batt insulation and 3/4" high R sheathing. A woodburning stove provides backup heating to solar gain, and the all electric house has a forced air resistance furnace. Active solar stubbing is also in place.

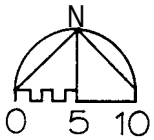
The wood deck between the 1150 sq ft main level and the 1050 sq ft lower level is cantilevered to provide shading to the bedroom windows (opposite right). No air conditioning is used, and the owner reports that although the main level gets a little warm, the lower level always remains cool and comfortable.

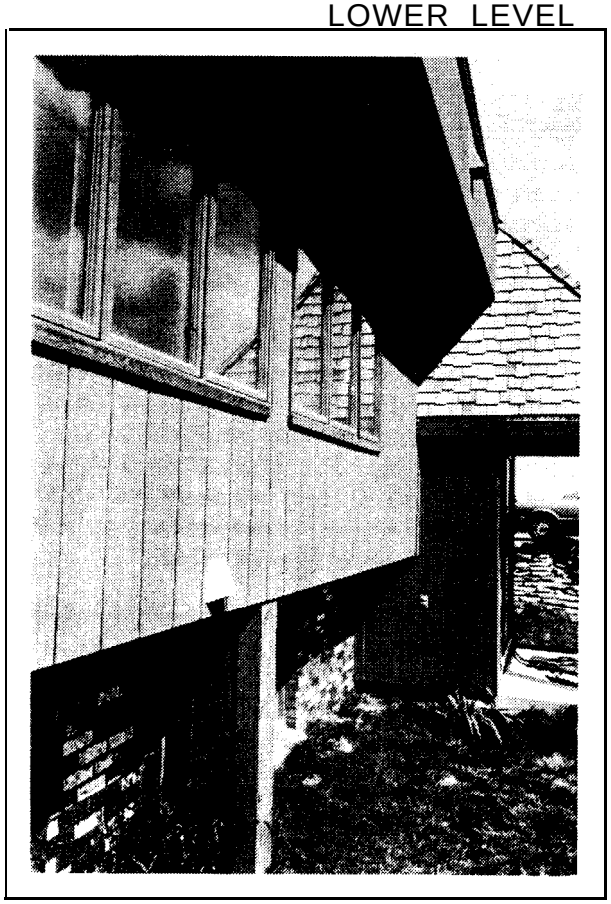


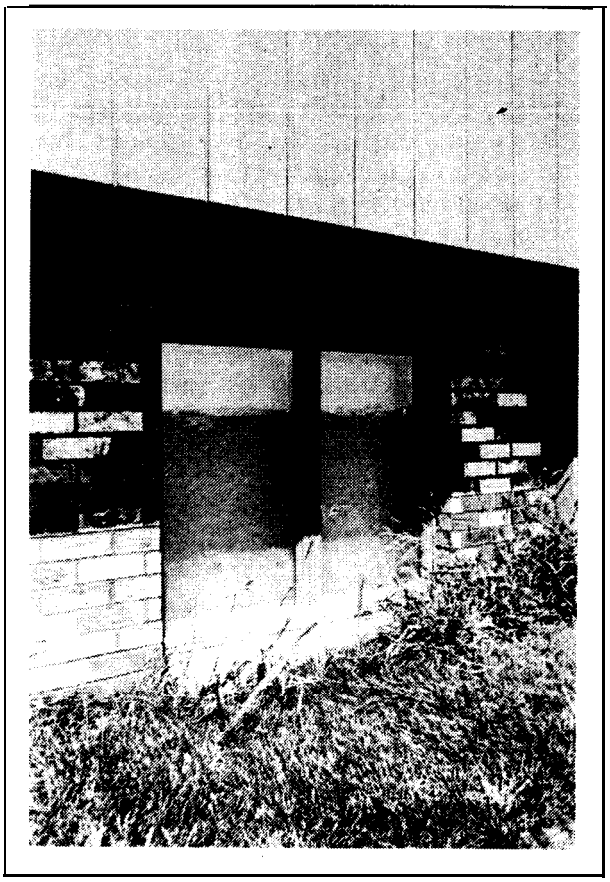
MAIN LEVEL



LOWER LEVEL







nLIVELYn

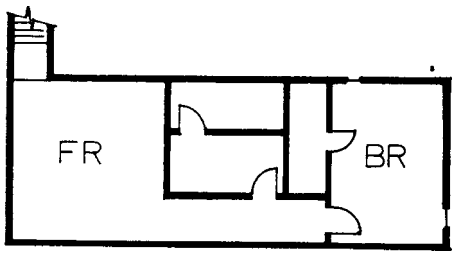
The earth bermed Lively home, begun in October of 1978 and completed in June of the following year, was designed and contracted by the owner. The house is a carefully planned design that would require few changes if started anew today -- something which cannot be said of all early solar efforts in Nebraska.

Vaulted ceilings on the main level of the 1800 sq ft house allow winter sunlight to penetrate to the north walls because the kitchen level actually has a lower elevation than the south portion of the house which includes the living room and master bedroom. Several small windows at the top of the bermed north wall (opposite left) also admit light to the north rooms. An overhang prevents unwanted gain through south facing glass in summer.

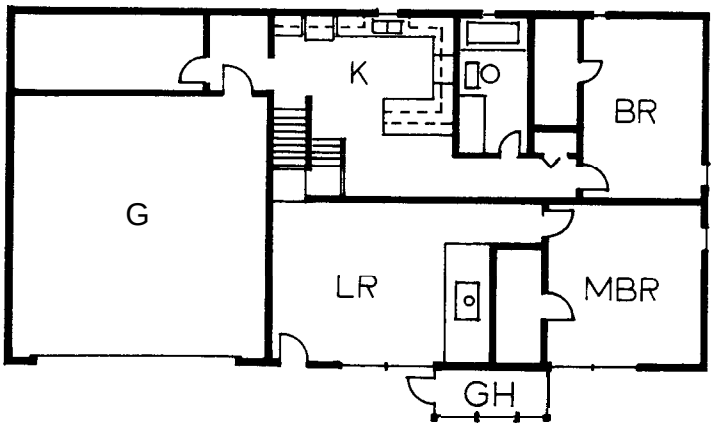
The earth contact portions of the house are insulated with 4" of rigid insulation from the footings to the window sills. The exposed walls are double 2x6 framed stud walls, and the conventional roof has 12" of cellulose insulation.

Solar heated air is ducted from the attached greenhouse (opposite right), the main purpose of which is for the generation of solar heat for space heating, although it can also be used for winter sunbathing and relaxing. Commercial grade filon was chosen as the glazing for the modest 10'xl0' glazing area. Night insulation is not used on the greenhouse glazing.

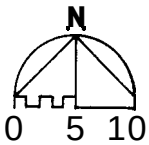
A woodburning stove located in the living room supplements solar heat generated by the direct gain and greenhouse systems. 1.25 cords of ash was burned in the period from October 1982 through April 1983. A 2 ton General Electric heat pump system is also available for backup.

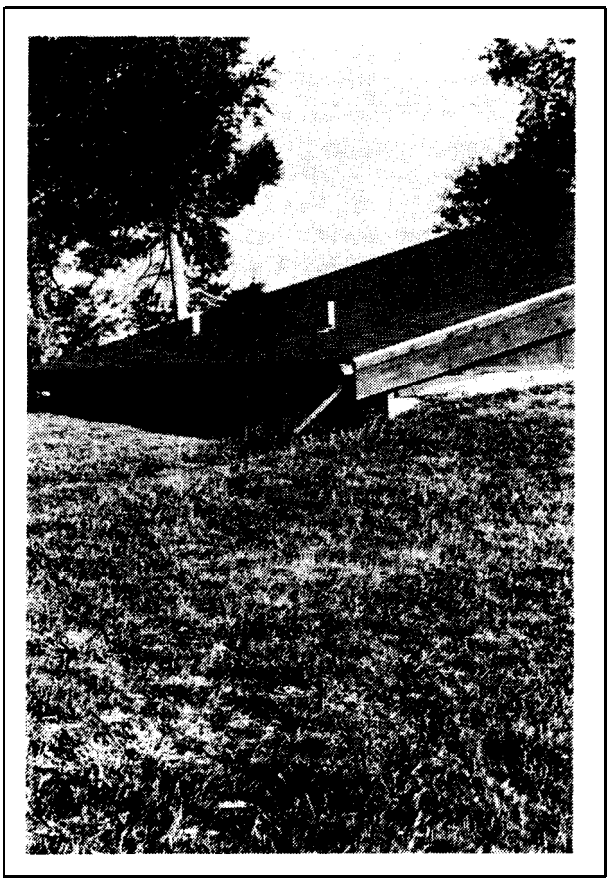


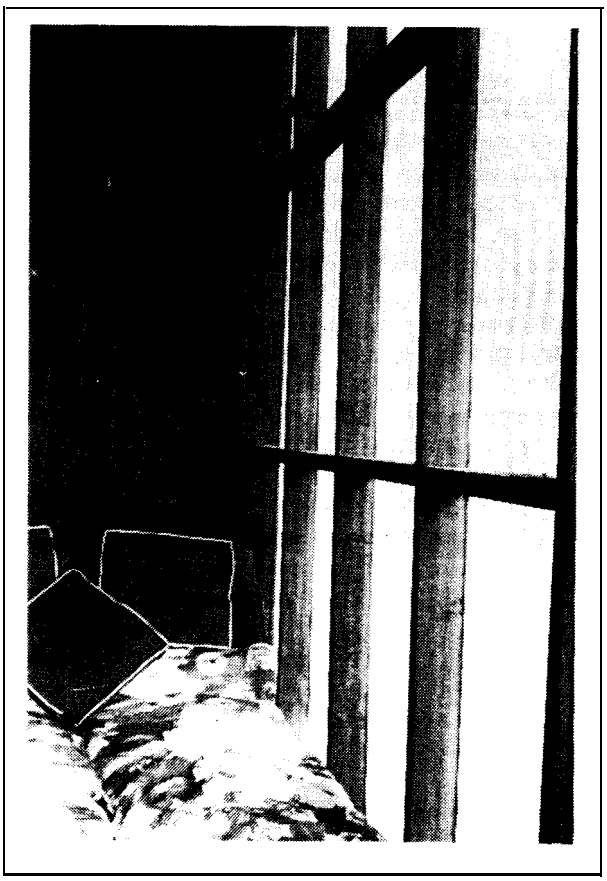
LOWER LEVEL

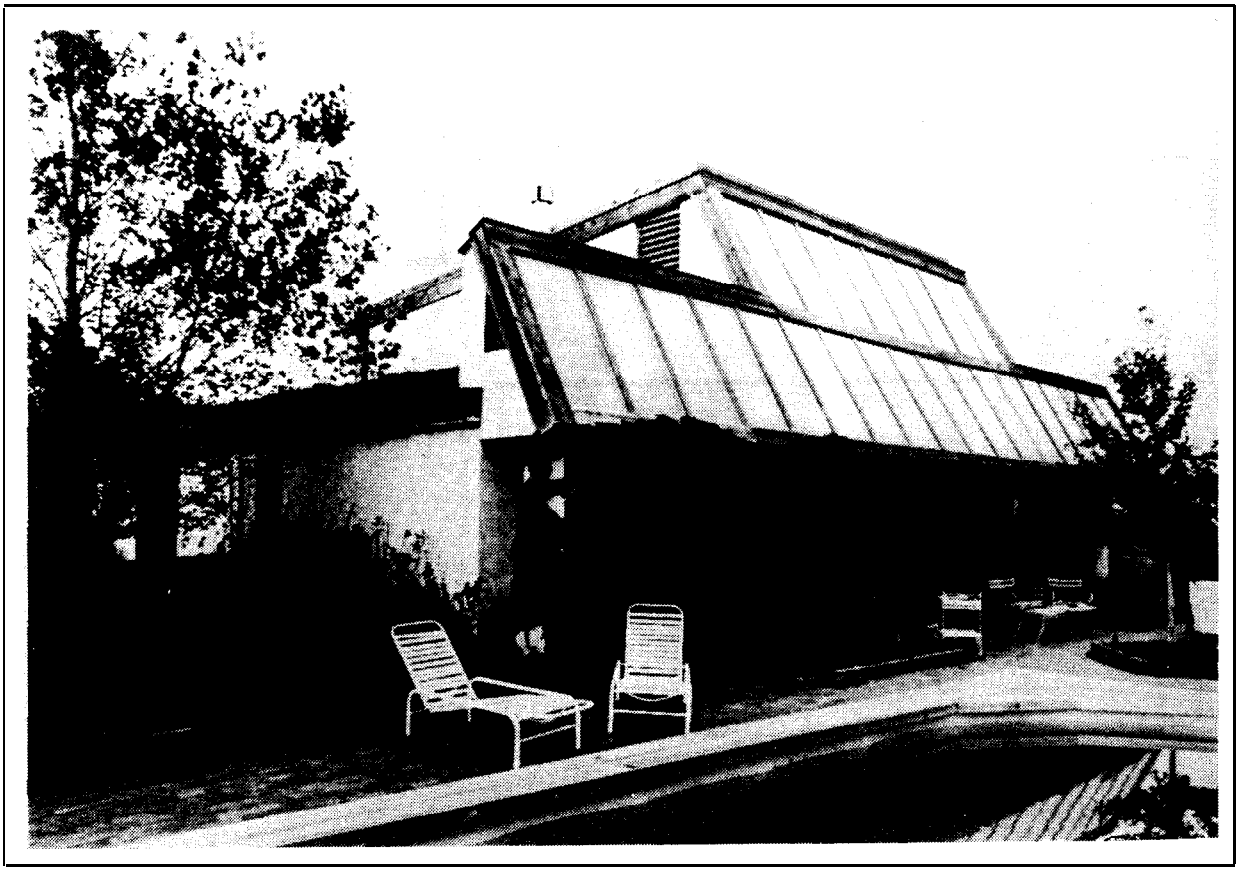


MAIN LEVEL









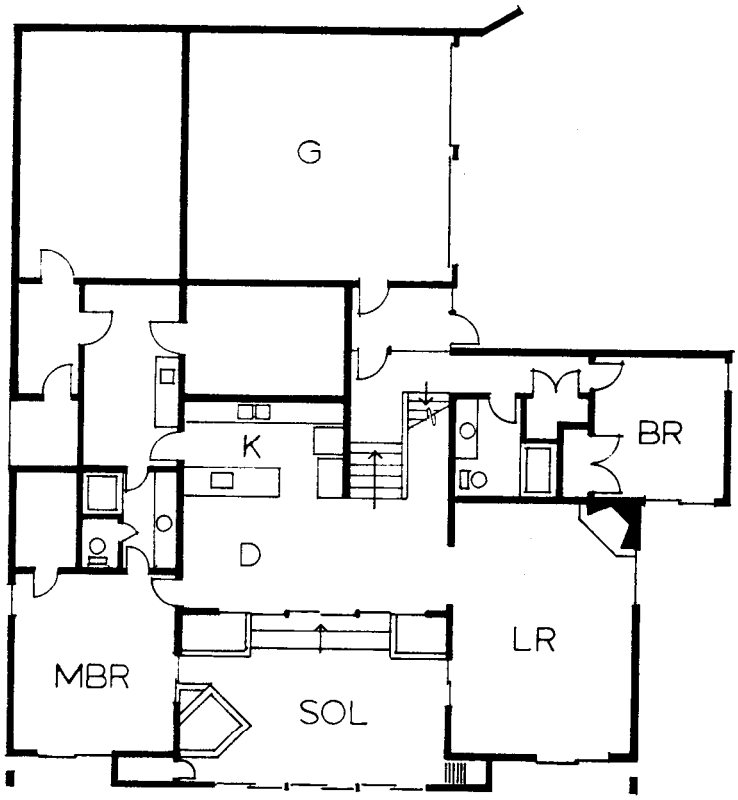
The Morton home, "Maka-Ina" which is Sioux for "Mother Earth", is an exquisite earth covered design, complete with a swimming pool that graces the south terrace of the house and cools southerly breezes during the summer. The owner, an architect in Omaha, designed and built the structure, and the attention that he paid to detail -- like the use of wood throughout the house to give the concrete warmth -- makes this house exceptional.

The 8" concrete roof, waterproofed with a membrane liner and insulated with 4" of rigid insulation, supports 14" of earth over 2" of gravel used for drainage. A drought resistant grass is planted on the roof (opposite left). The earth contact walls are 8" concrete block walls with sand fitted cores and 3" of rigid insulation.

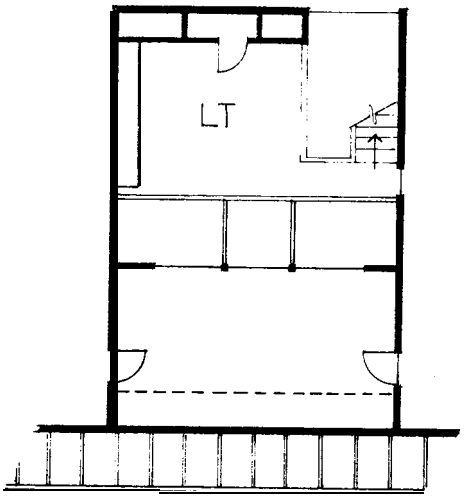
The house relies on both passive and active solar heating strategies. The master bedroom and living room are direct solar gain rooms. Sliding door night shutters are used as insulation on the direct gain glazing of these rooms. The focal point of the house, the two-story solarium (opposite right), around which all rooms are arranged, functions as a greenhouse. The solarium has 126 sq ft of glazing, and the clerestory windows have 168 sq ft of direct gain glazing.

Across the front of the house -- above the vertical glazing and below the clerestory windows -- is a bank of flat plate collector panels which were intended to provide solar heated air to a pebble bed storage. Unfortunately, the system has not worked as the owner hoped.

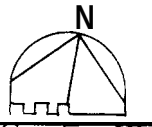
Although a heat pump is used as the main backup system, a Morso woodburning stove, strategically located in the informal dining area, provides heat and is used primarily to take the chill out of the air.

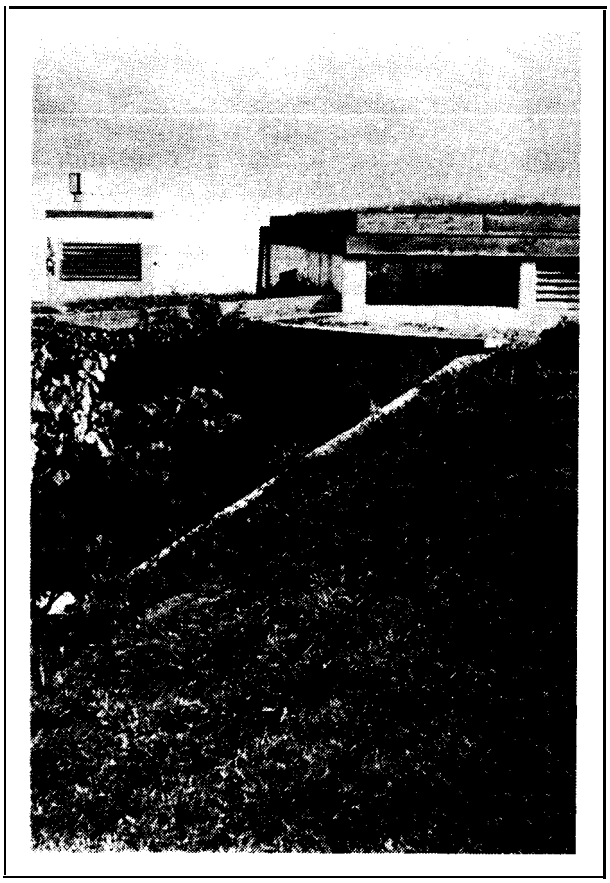


MAIN LEVEL

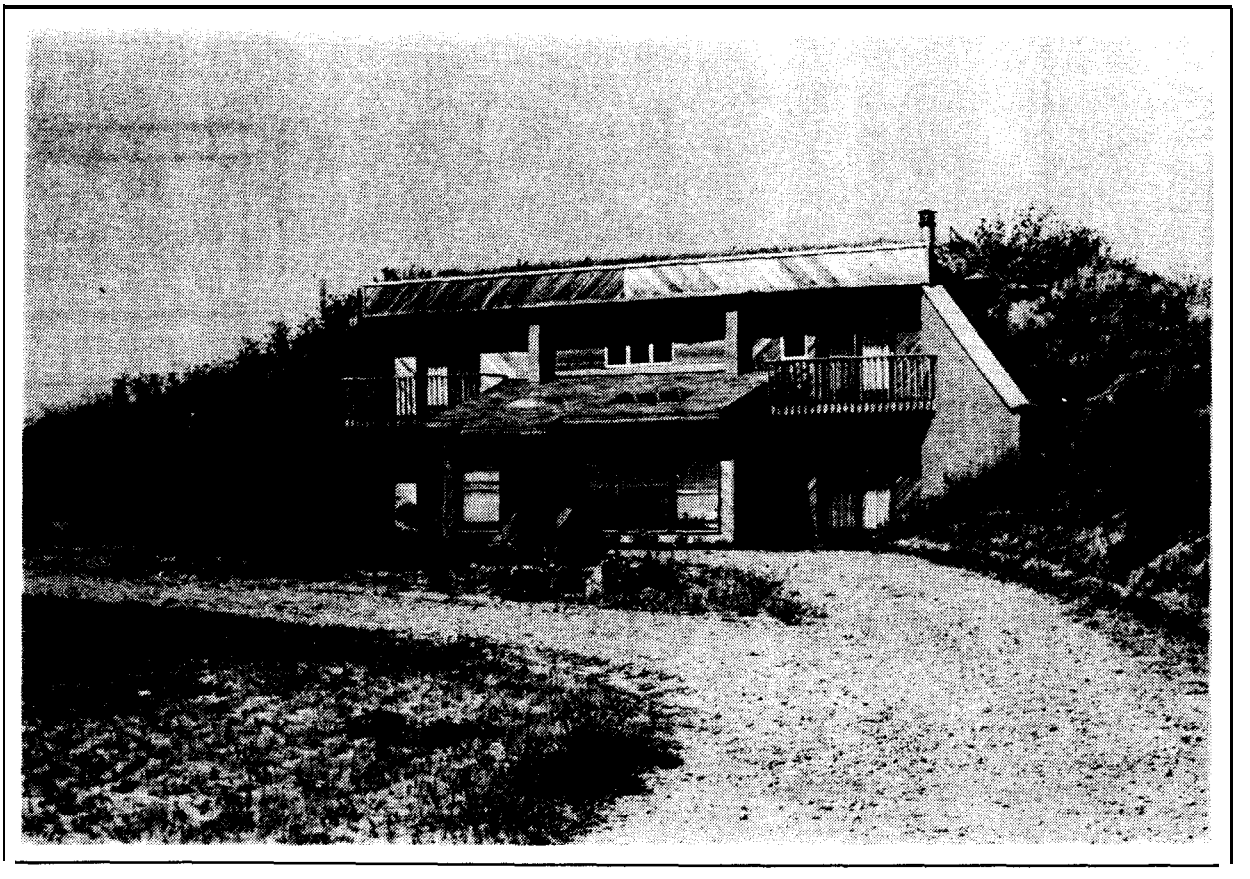


UPPER LEVEL





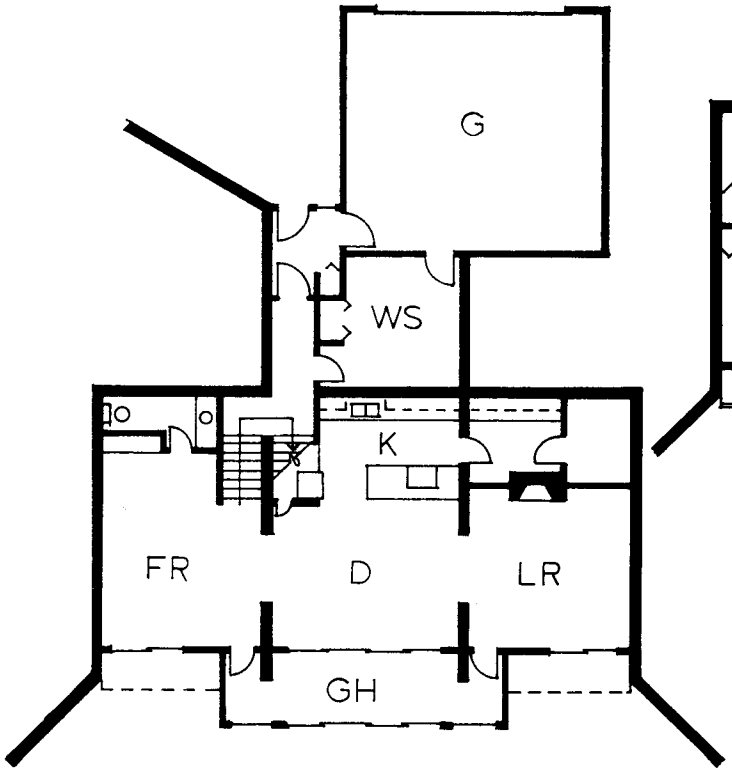
J. NELSON



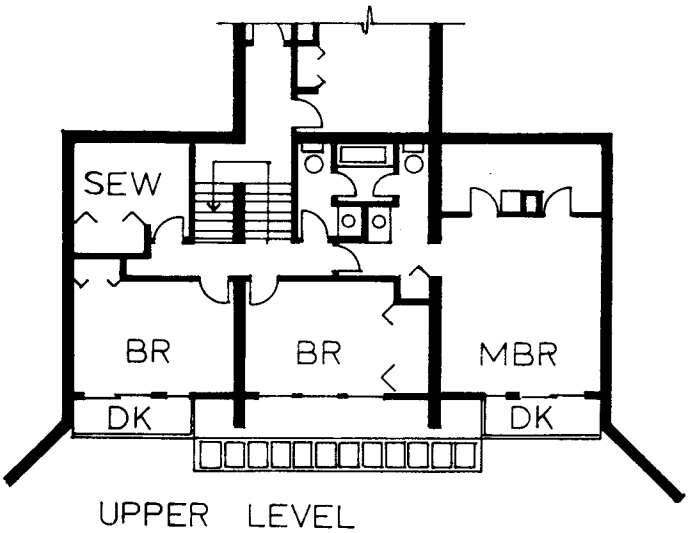
The Nelson residence, like the earth sheltered Gustafson house also in this book, was built by Sunshine Construction of Kearney. Unlike the Gustafson residence, however, the Nelson earth shelter is a two-story earth covered dwelling rather than a single story structure. Although the exterior of the house is certainly contemporary in appearance, the interior is traditionally styled with wood columns, a beautiful candlelabra in the dining room, a comfortable mantle over the fireplace, and a number of pieces of antique furniture.

The main entrance to the house is located on the north side. Although this entrance is an airlock entry (opposite right), the owner has had difficulty with unwanted air infiltration in winter, as apparently a vapor barrier to the outside was broken during construction. Steps to eliminate the problem, including new double insulated doors and better sealing, are planned. Off the entry is a stairwell that connects the 1310 sq ft main level with the 903 sq ft upper level. A skylight at the top of the stairuell provides excellent daylighting to this back area of the house.

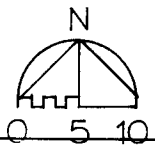
The roof of the Nelson house is insulated to a level of R-36, and the south wall is insulated to a level of R-27. Passive solar space heating is provided by 150 sq ft of direct glazing and 130 sq ft of glazing in the 175 sq ft greenhouse (opposite left). Although the greenhouse has a tile floor for storage mass, it has no night insulation, and heat loss can be severe. Humidity levels -- in the range of 70% -- have been uncomfortably high.

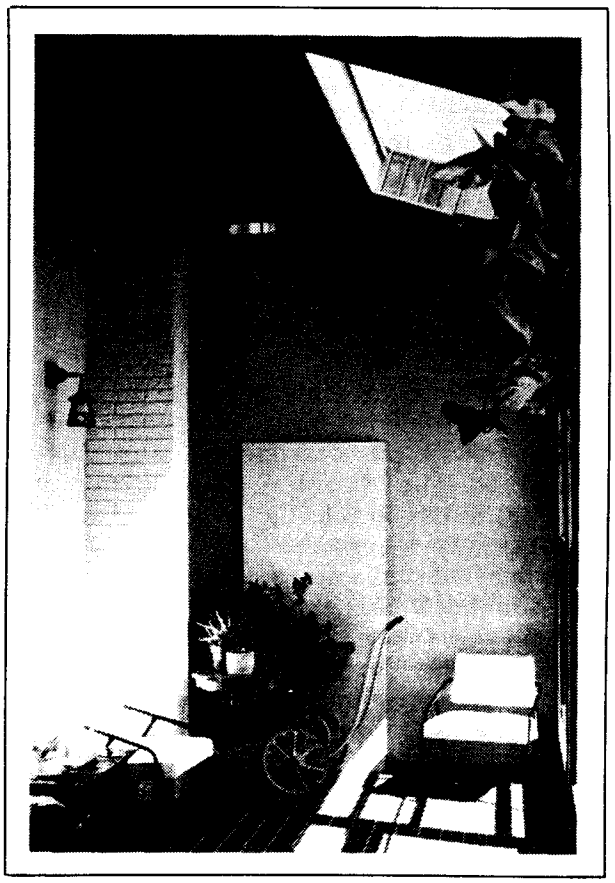


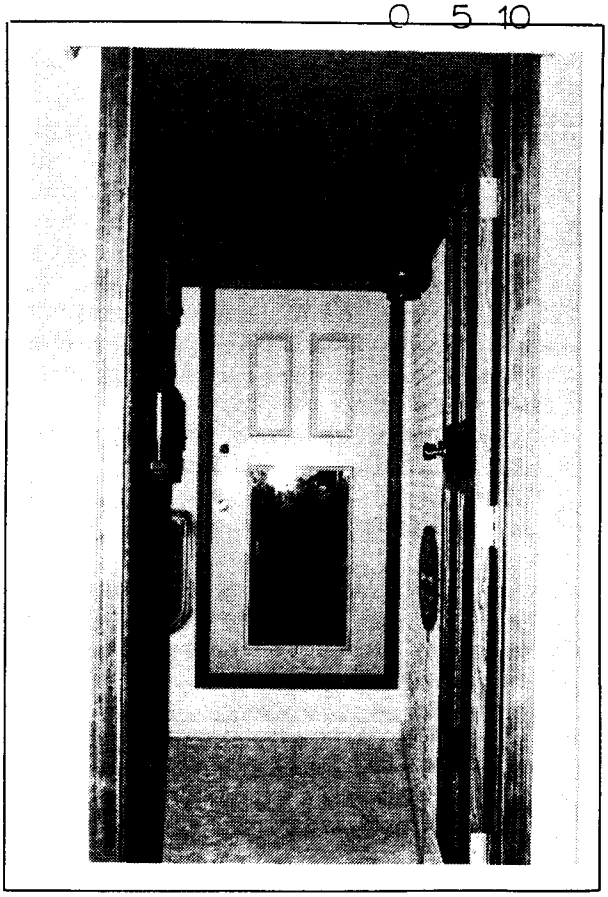
MAIN LEVEL



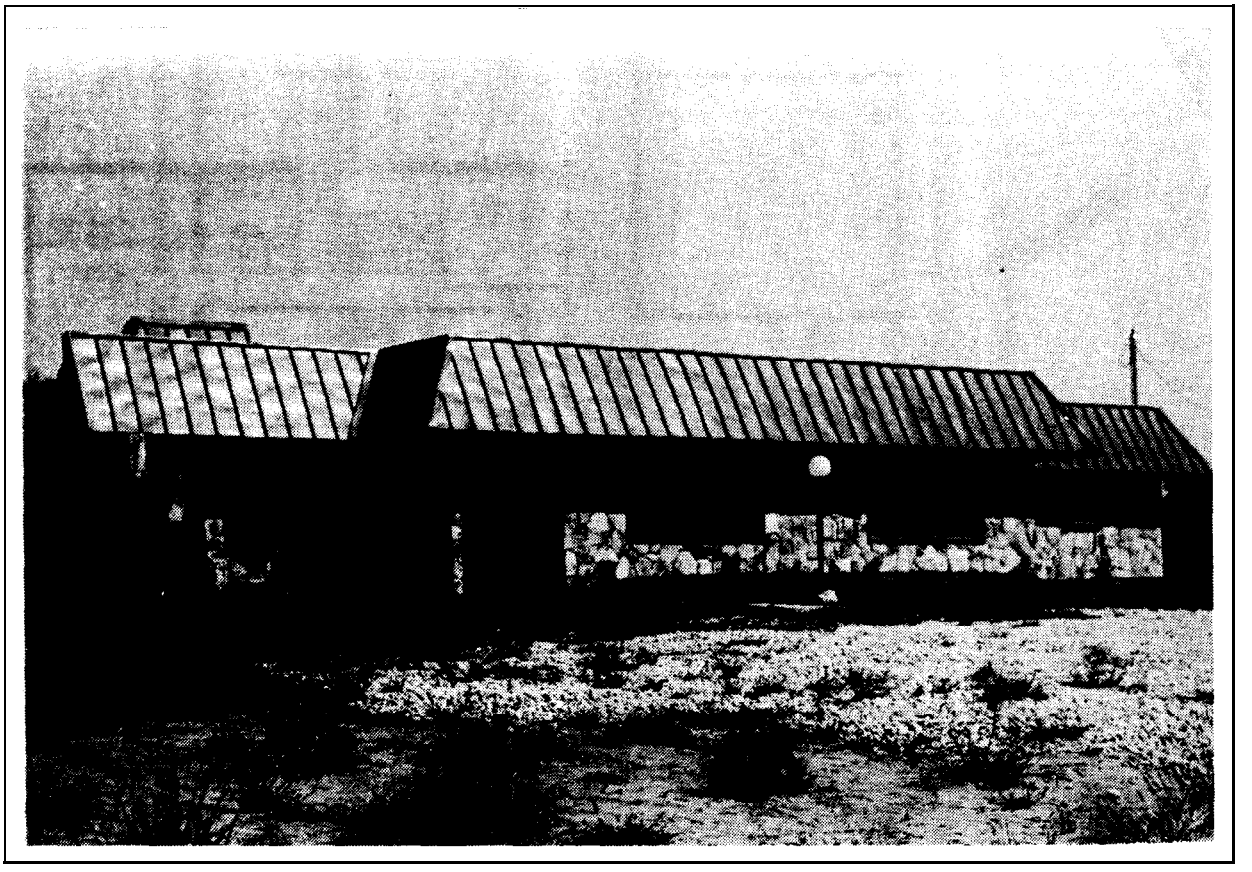
UPPER LEVEL







nREINERTSONn



The 2800 sq ft earth covered Reinertson home is unique among earth sheltered houses in Nebraska because it utilizes all wood construction -- even below grade. Under good building conditions, the all wood structure -- including floor system, walls, and roof -- can be erected in approximately two weeks. In comparison with earth shelters of concrete construction, the all wood construction system reduces the construction period by 45 days, according to the builder, Pioneer Energy Systems of Kearney.

2x10 treated wood side walls filled with 9” of batt insulation rest on footings of impacted crushed limestone 12" deep and 24" to 30" wide. A 3/4" treated shiplap plywood roof deck is supported by 12" microlaminated beams placed 1' on center, and additional roof support is provided by load bearing interior walls. The 12" cavity created by the roof beams is filled with insulation.

The treated wood structure is waterproofed with spray-on bentonite waterproofing. Plastic sheets are draped over the sprayed building for additional moisture protection, and 9" of gravel backfill are used for drainage.

Beneath the wood floor joists in the Reinertson house is a cavity that is utilized as a plenum space. Direct gain solar heated air, collected at the ceiling of the house and fan forced to the floor plenum, rises through strategically placed floor registers to warm the living spaces. The underfloor plenum space works well with downdraft electric furnaces used to provide backup heating. In addition to overhangs (opposite right) that prevent unwanted solar gain in summer, the house is cooled by earth contact plenum air. Another feature of the home is an outside air intake (opposite left) that operates to prevent a vacuum when fans in the utility room or bathroom are used.

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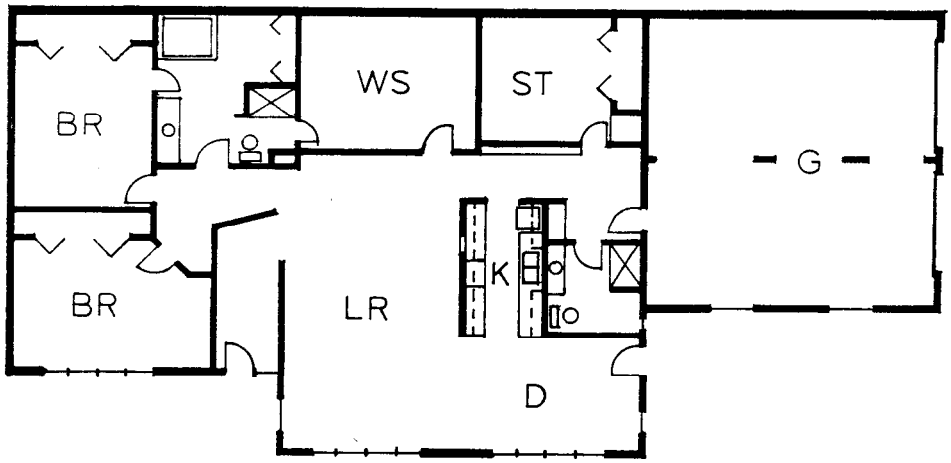
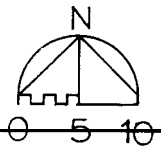
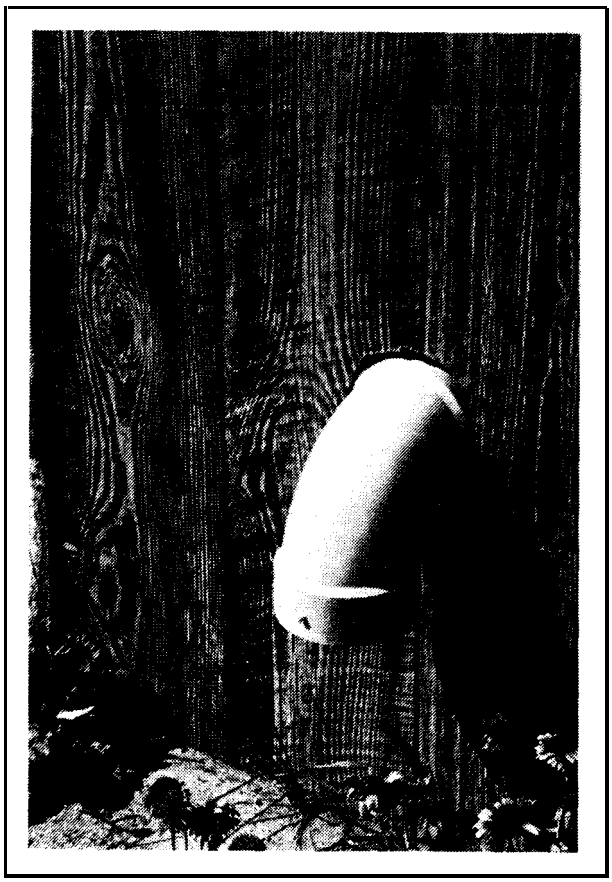
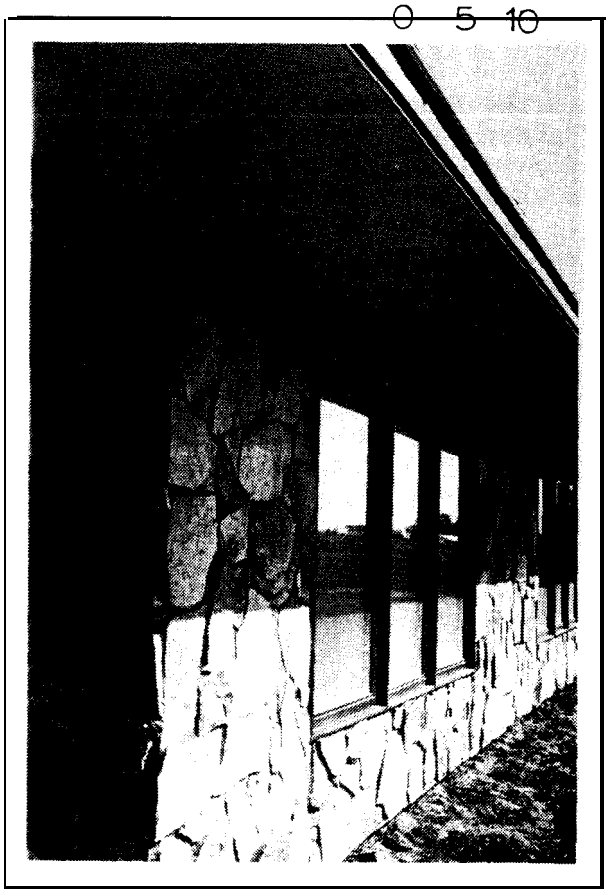


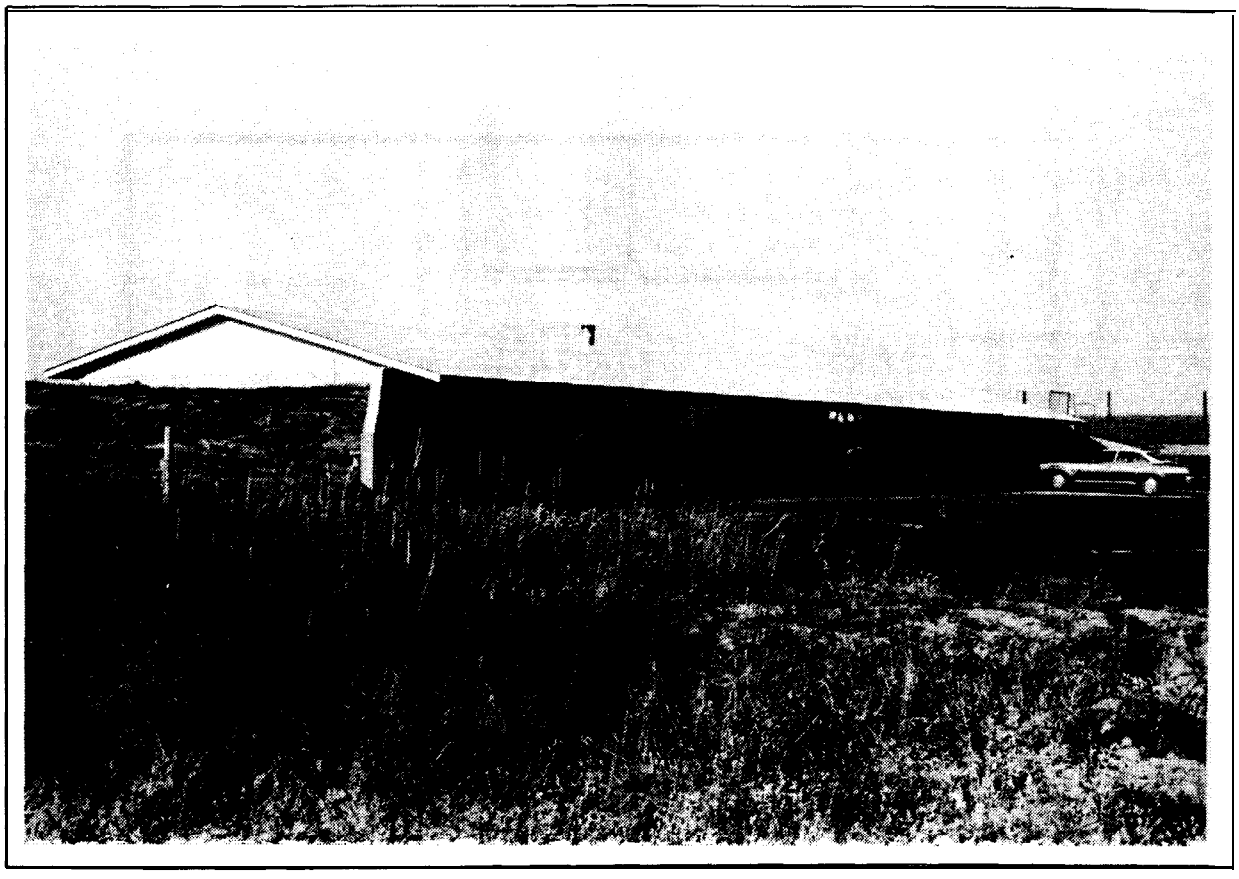
MAIN LEVEL







nRHODEN n

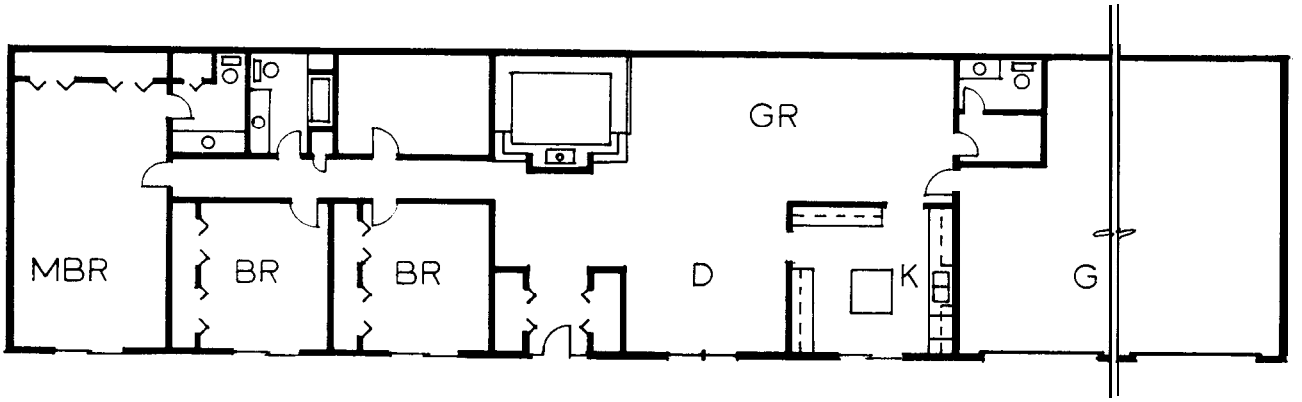


The Rhodens moved into their owner-designed and owner-built earth bermed home in December of 1982. The total cost of construction for the 2300 sq ft dwelling, which is now over 90% complete, is under $30,000 including land and well.

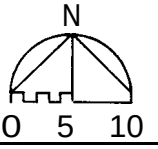
The conventional roof has a 4:12 pitch and is supported by roof trusses which rest, in the back of the 28' deep house, on 8' high concrete walls that are 8" thick. The owner experienced some difficulty placing the insulation in the eaves, and indicated that were he to do it over, he would pour a 9' wall in the back and drop the truss one foot on the inside.

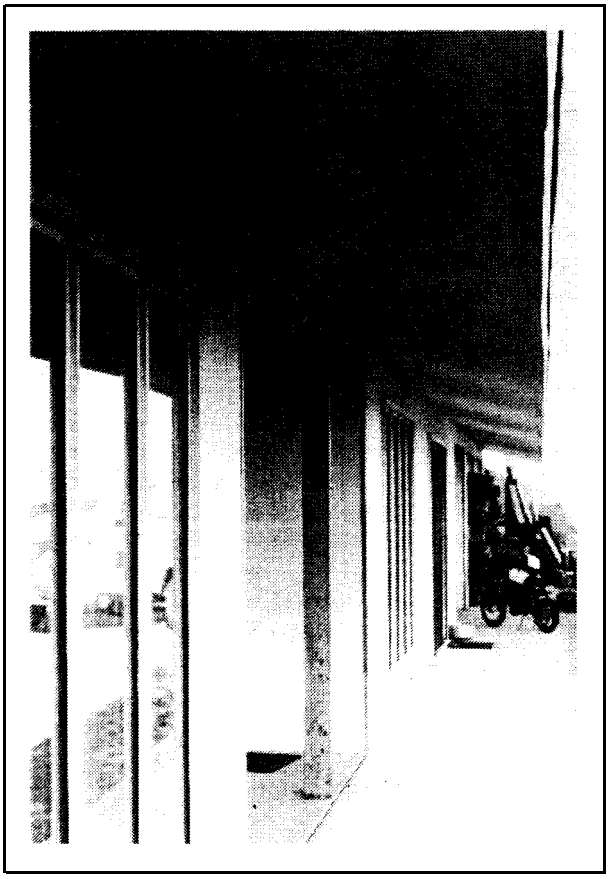
The house is liberally insulated as the ceiling has an insulation level of R-40, the walls have 6" of batt insulation and 3/4" celotex, and even the interior walls have 3" of fiberglass insulation. Although a 55,000 btuh electric furnace -- designed for use in mobile homes -- is available for backup heating, 100% of the backup heating has been provided by a special owner-designed wood-burning stove (opposite right). Heat from the stove is allowed to migrate down the hallway to the bedrooms or it can be distributed through the ductwork of the backup furnace to which it is connected.

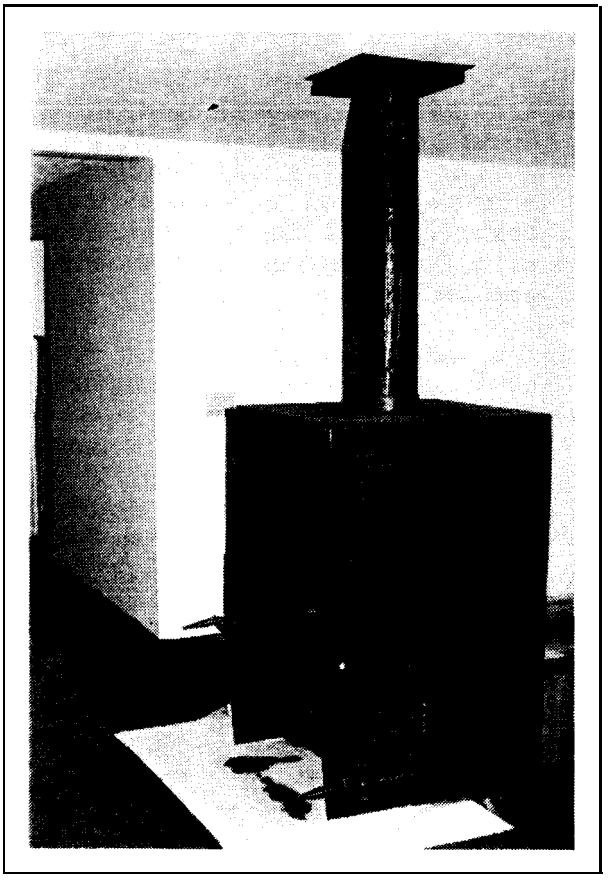
The Rhoden house stays remarkably cool during the summer. Overhangs (opposite left) prevent unwanted solar gain through the vertical south glazing, and despite the high outdoor temperatures of the summer of 1983, the owner states that the house was comfortable -- indoor temperatures never exceeded 80°F. In addition, there were no humidity or dampness problems, most likely the result of a long curing period for the concrete which was exposed for a number of months before the house was framed.



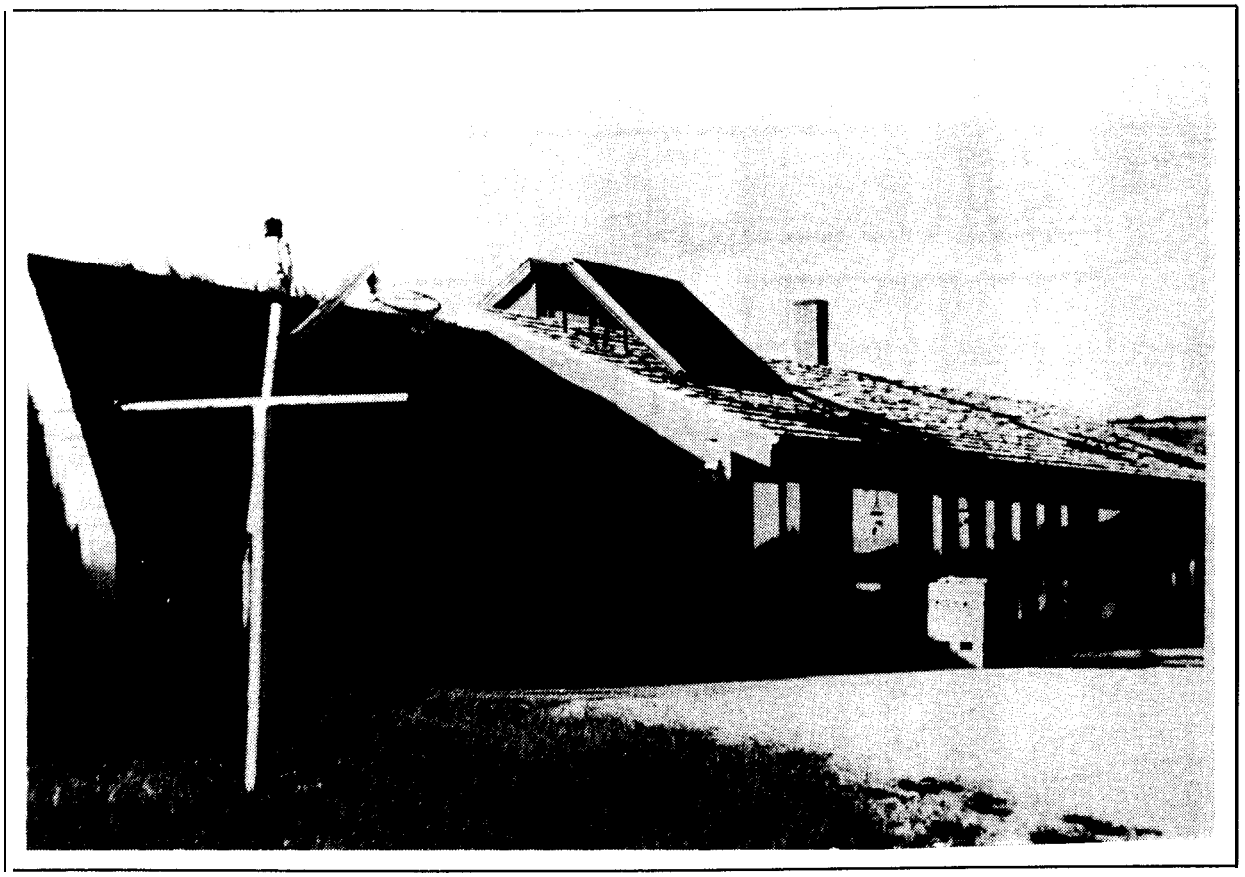
MAIN LEVEL







n WIGINGTON n



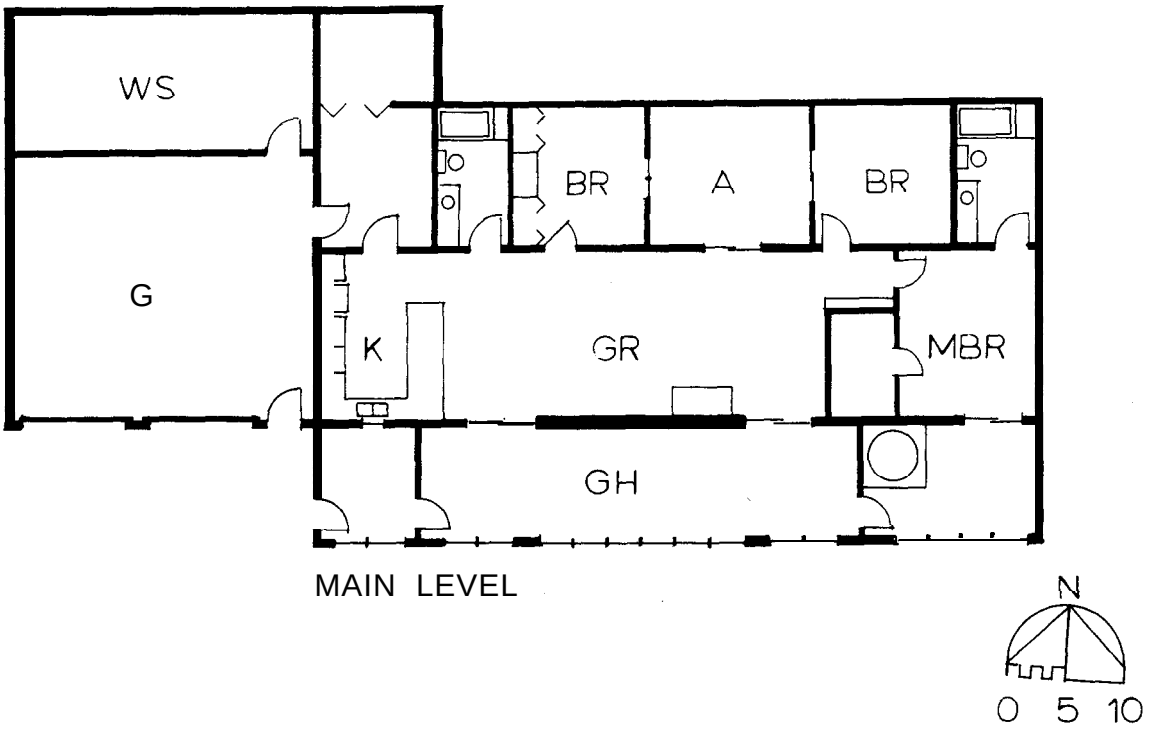
The Wigington home is located on a 14 acre nature preserve containing over 50 varieties of trees and shrubs and an artificially created pond. Fuel from the wood, as well as water and fish from the pond, lend an air of self sufficiency to the Wigington homestead.

The owner-designed earth sheltered home has 1764 sq ft of living space. It is all earth covered except over the greenhouse and the atrium. The concrete shell, a monolithic pour structure with 8" thick roof and walls, is waterproofed with bentonite. 4" drain tile with gravel backfill is used around the footings to drain water away from the foundation.

Insulation levels in the house are more than adequate as belowgrade walls are insulated to R-20, the earth covered roof to R-30, and the conventional roof on over the greenhouse to R-20. Another feature contributing to the energy efficiency of the house is the airlock entry. The only backup heating source that is used in the house is a woodburning stove,and, during the winter of 1982-83, only one cord of wood was used.

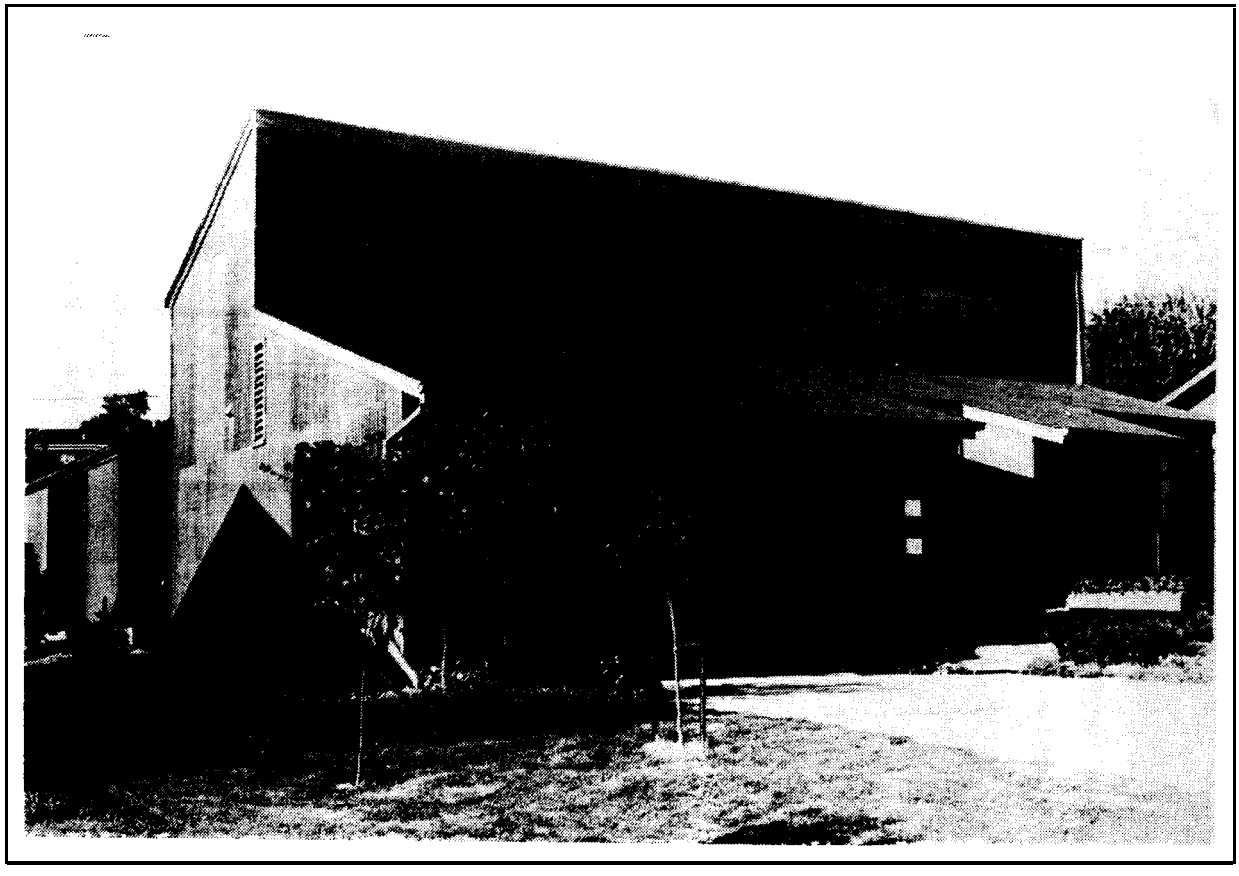
The 669 sq ft greenhouse (opposite), which fronts the entire south wall of the house, is the central passive solar heating system. The greenhouse has 270 sq ft of vertical glazing, and skylights in the greenhouse roof provide an additional 27 sq ft of solar gain glass. The greenhouse is sectioned at the master bedroom for privacy -- the separated portion contains a hot tub.

There is an active two collector system which provides domestic hot water to the Wigingtons.



MAIN LEVEL

nARMKNECHTn

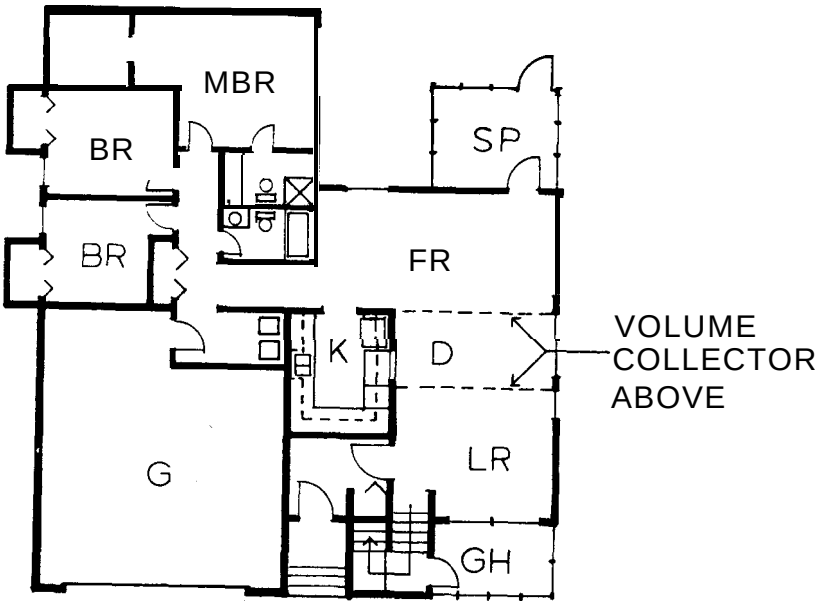


The Armknecht home is a solar house that utilizes a volume collector with brickbed mass storage. The owner, an architect, was told that, because the lot faced south, he would be unable to design a solar house -- it would face the street. He successfully overcame the supposed obstacle. In addition, he used a hill behind his home to his advantage by planting windbreak vegetation (opposite right).

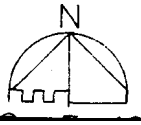
The volume collector is located in the attic space directly above the dining room. The collector surface has approximately 160 sq ft of vertical south facing glass. Ventilation panels (opposite left) on the side of the volume collector space permit ventilation of the collector area during the summer. During the heating season, hot air is ducted from the volume collector to a mass storage room in the basement. The 5 x 7 x 8 foot storage room is filled with 1oosely stacked factory reject bricks. The air return of the mechanical system in the house is routed through the brickbed to preheat air to the gas furnace.

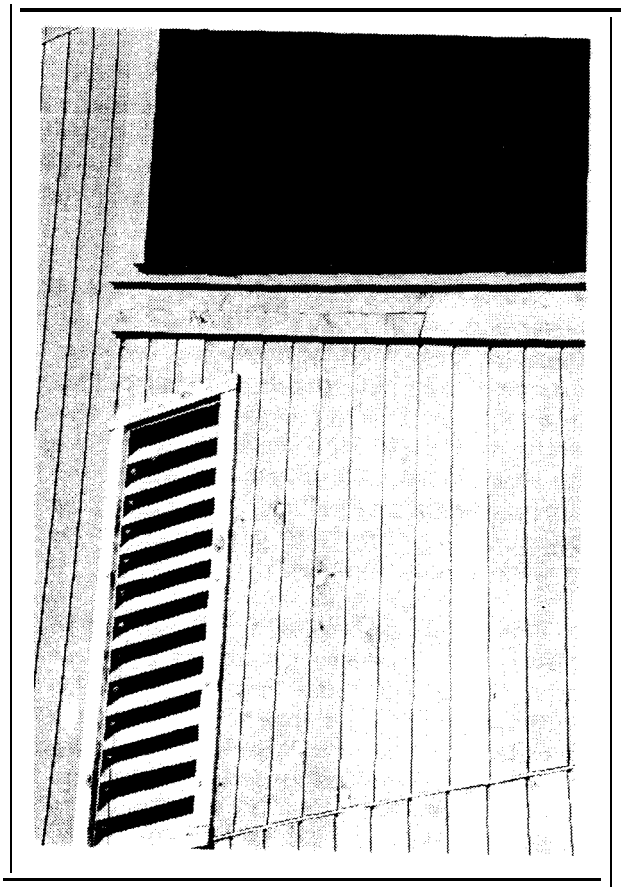
The owner has had problems with the volume collector system. For example, air leaks in the passageway between the volume collector and storage have caused heat loss. The owner also feels that the house has more mass than necessary because there are too many bricks in the brickbed storage. At the time of construction, however, there were few guides available to assist in sizing rockbeds/brickbeds. At present, access to the volume collector is limited by the location of a folding stair which makes the volume collector area unusable space, a situation the owner would correct were he to design it over. Despite problems, however, the TIF value for the Armknecht home, calculated from performance data, is 3.2.

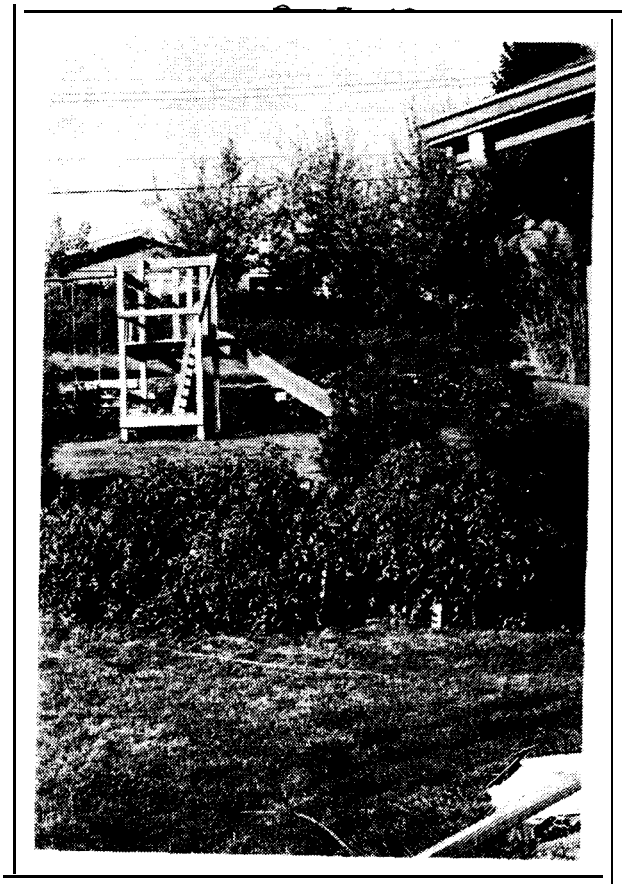
A step down greenhouse to be located in front of the existing living room is planned for future construction.

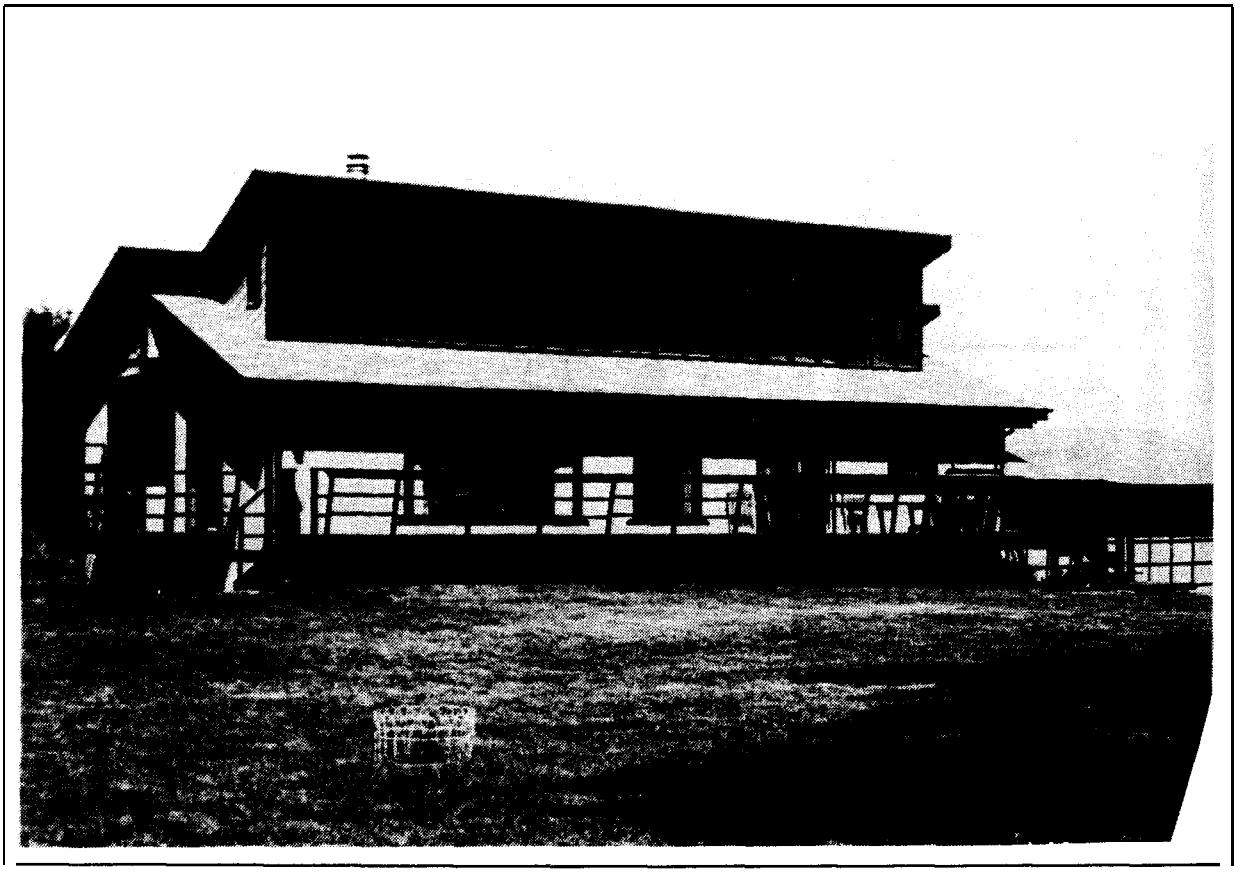


MAIN LEVEL







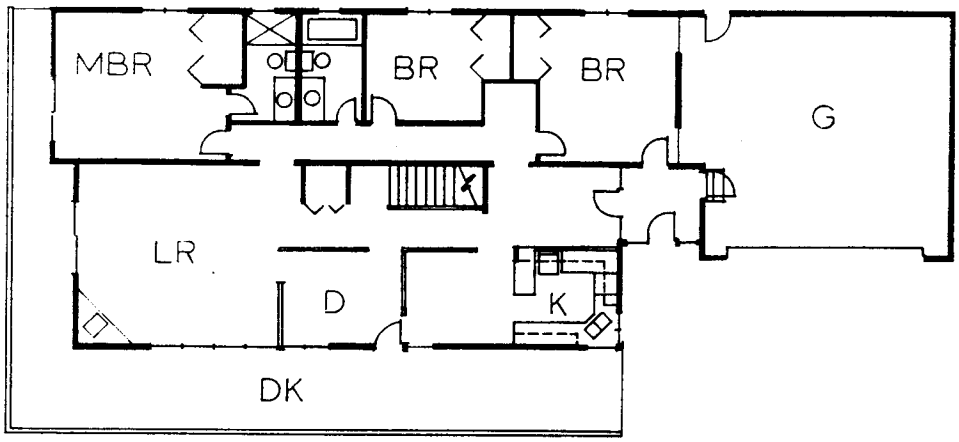


Construction on the Buhl solar home -- with an active collector and water mass storage -- was begun in 1979 and completed in 1980. The volume collector (opposite left), located in the attic, has over 360 sq ft of vertical filon glazing. Water, in two truck radiators (opposite right) located in the volume collector, is heated by sun warmed air and circulated to a large, vinyl clad, cast concrete storage tank under the basement. The storage tank measures 12' wide by 54' long and 5' deep, and holds between 18,000 and 20,000 gallons of water.

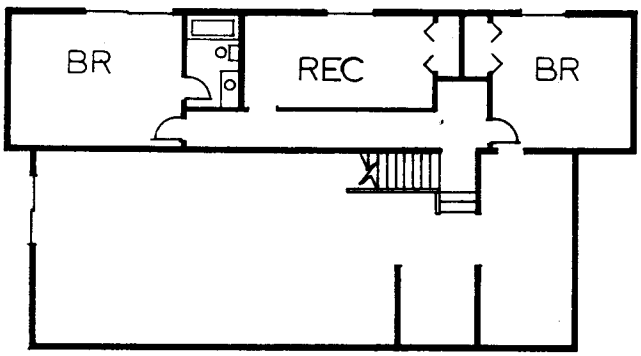
When the temperature of the water in storage is above 97°F, the heated water can be routed directly to the furnace, and the furnace fancoil unit taps heat from the water directly to heat the house. However, the water storage system has more mass than is needed, and, therefore, the temperature of the water in storage does not often reach 97°F. As a result, a backup 5 ton Solar King water-to-air heat pump provides heat to the house using the water mass storage as its heat source, so the system operates not unlike an ordinary water source heat pump system.

An alternative operational strategy that would utilize the water mass storage better and reduce the use of the heat pump would be to fully insulate the living space from the storage and then operate the volume collector at maximum capacity during the summer months to charge the storage for use during winter -- like an annual cycle system.

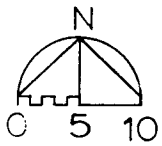
Problems associated with the design forced the owner to change the contractor before the house could be completed. The owner was also dissatisfied with the heat pump manufacturer who was unresponsive to inquiries about the system. As a result, the owner has had to acquire considerable knowledge concerning the mechanics of the heating system.

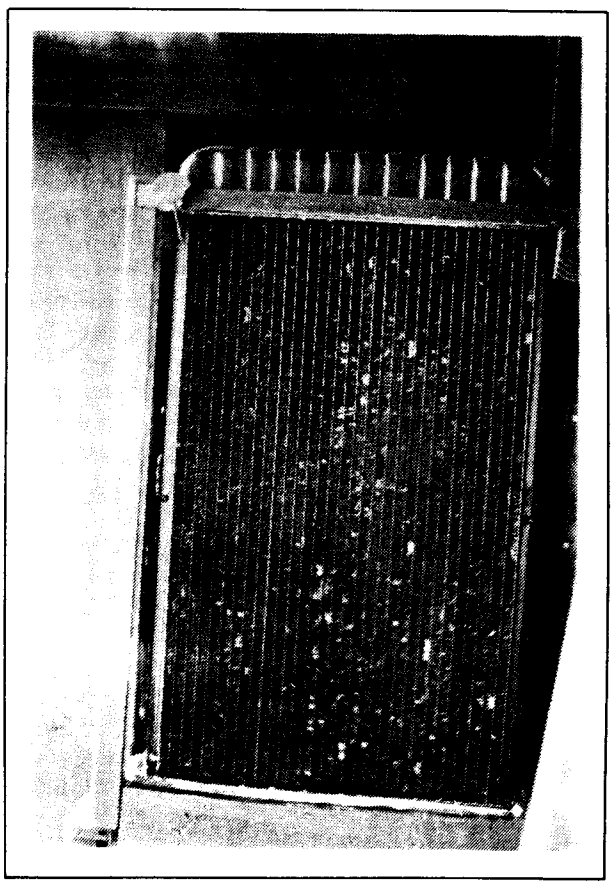


MAIN LEVEL

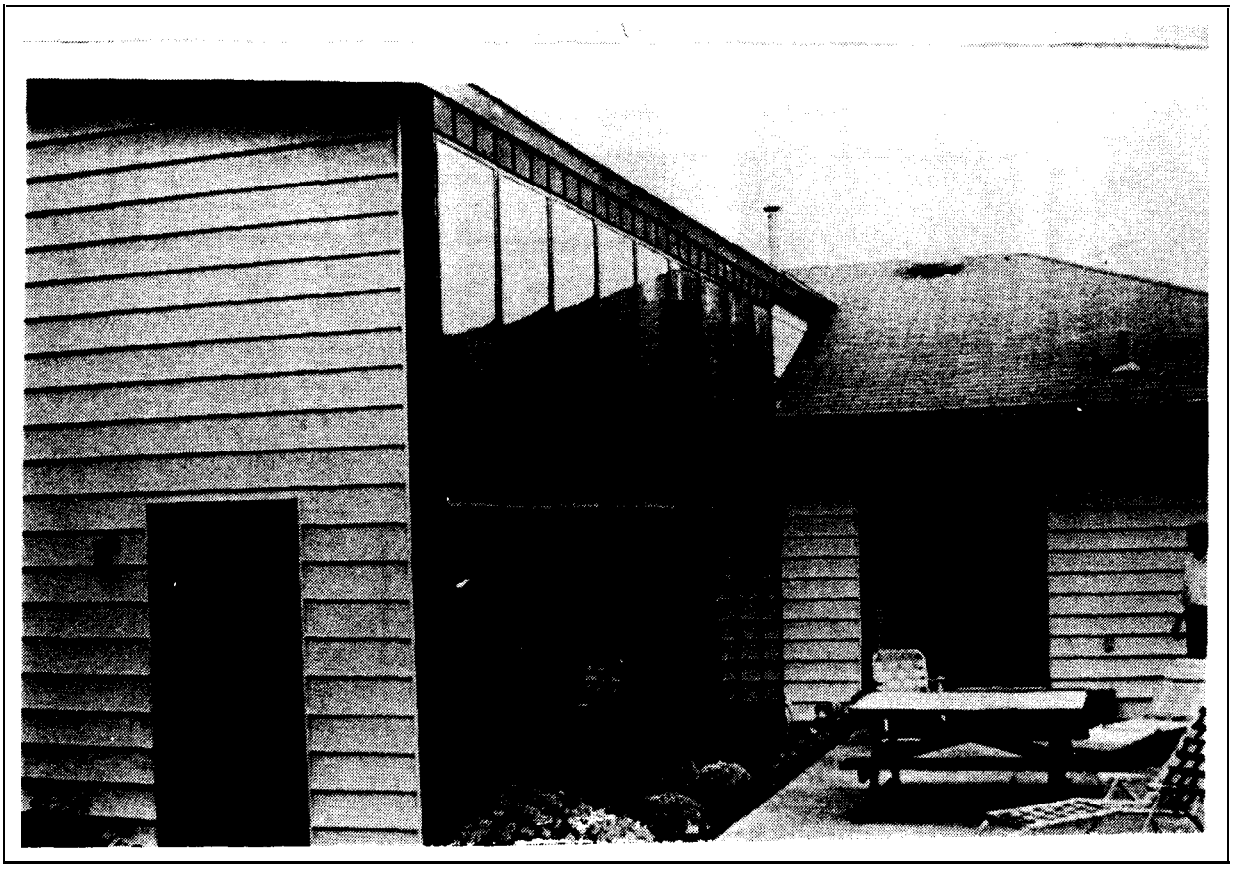


LOWER LEVEL





nCOLGANn

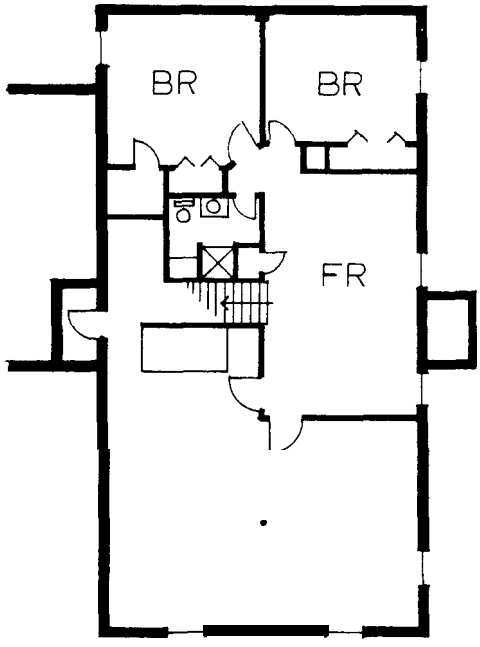


The active solar system in the Colgan ranch style house (opposite right) -- with 1683 sq ft on the main level -- is an active air flat plate collector with phase change material (PCM) storage. Installed in 1978, the 18 Solar Aire collectors (no longer available from the manufacturer who was in Mead, Nebraska) are arranged vertically along the garage wall. Each double glazed panel measures 3'x6', so the total collection area is greater than 300 sq ft. Sun heated air is moved to storage by an 850 cubic feet per minute (cfm) squirrel cage fan.

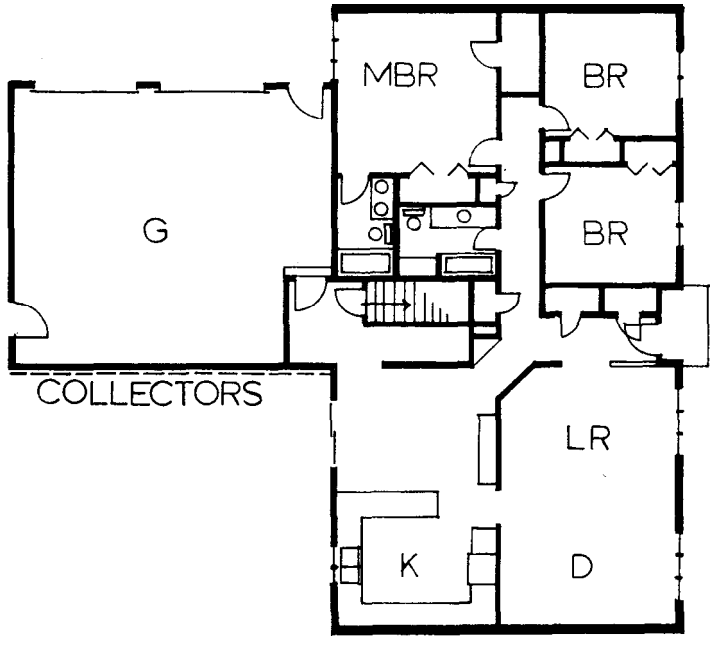
The storage (opposite left) consists of 65 plastic rods -- each 6' long and 3.5" in diameter -- containing calcium chloride hexahydrate from Dow Chemical. The original storage system -- salt storage trays from Solar Inc. of Mead -- leaked and was replaced by the plastic rods despite the fact that the rods do not transfer heat as readily.

According to the owner's calculations, between 250,000 to 270,000 Btus are collected daily during the winter -- enough to provide between 50% and 60% of the building heating load despite indications that there are air leakage losses. During the coldest weather a natural gas backup unit is used to supplement the solar system, and, in January, the backup unit runs daily.

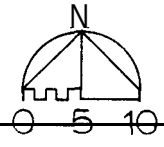
The owner would make certain changes were he to start over. First, ductwork would have straight runs, and any joints would be taped tightly. Second, the commercial air handling unit would be replaced by a smaller system of separate components. Third, modern motorized dampers would be used in the air handling unit to reduce air leaks. Despite all the desired changes in the system, the TIF for the Colgan house is 1.6.

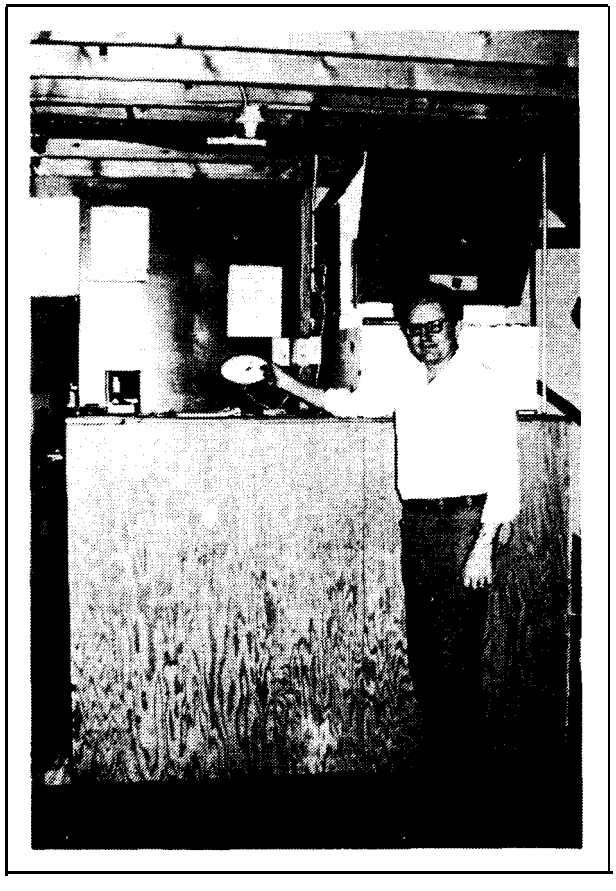


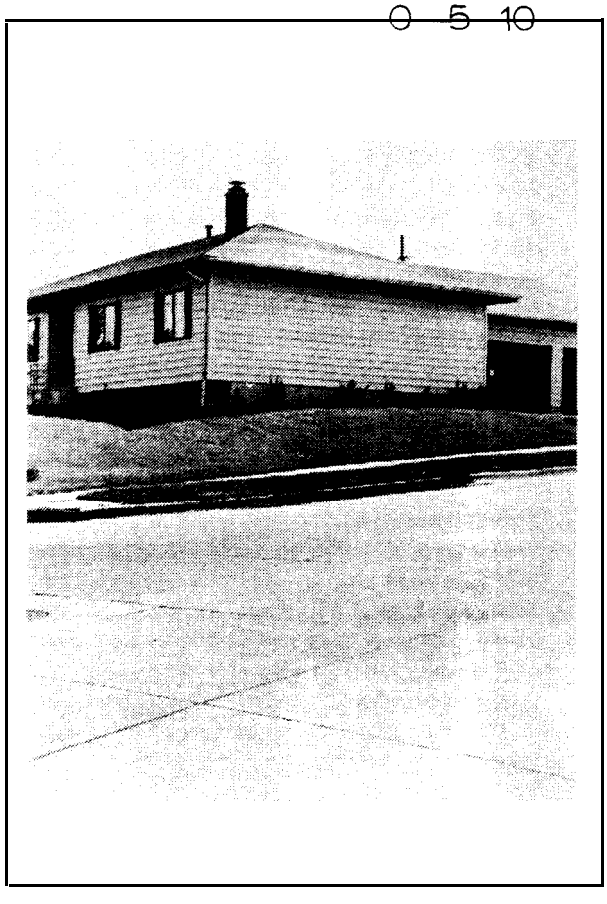
LOWER LEVEL



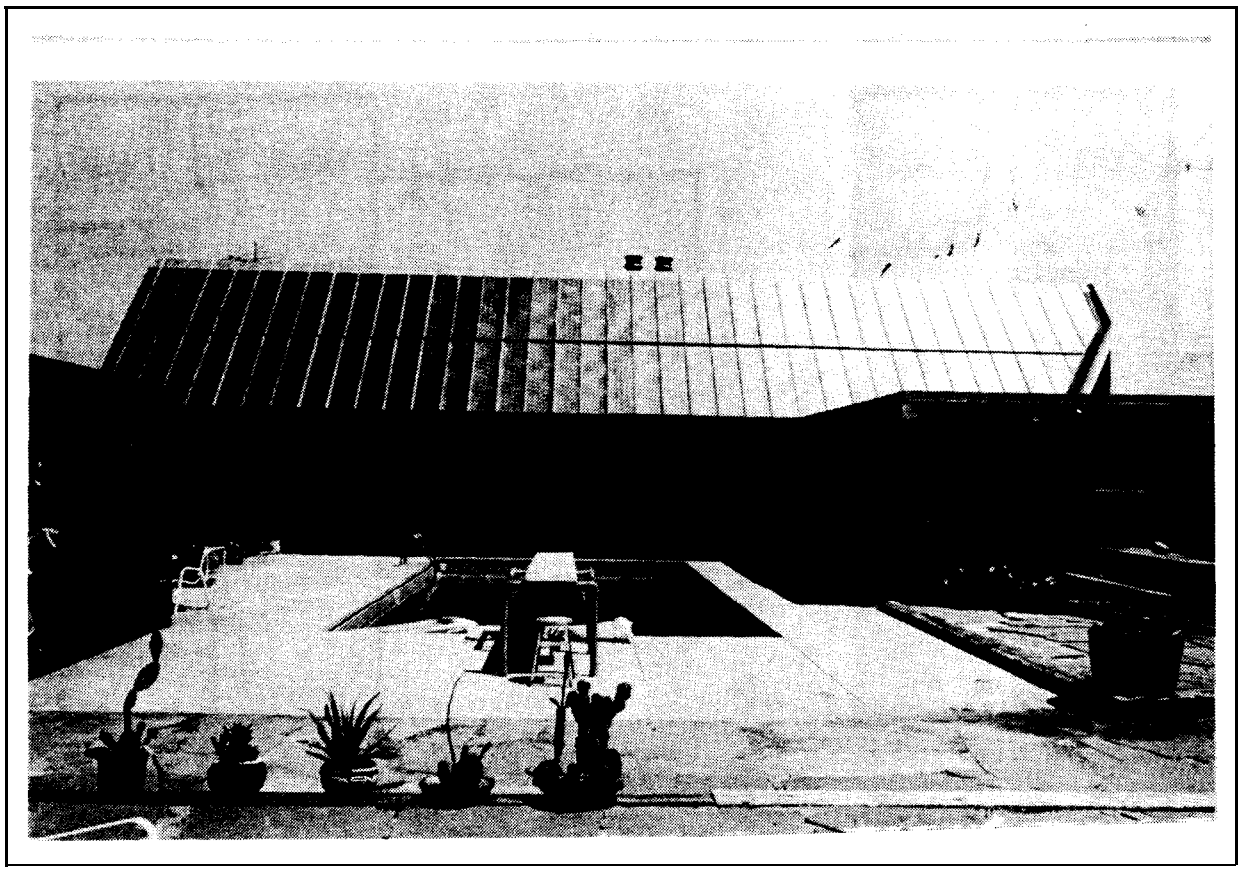
MAIN LEVEL



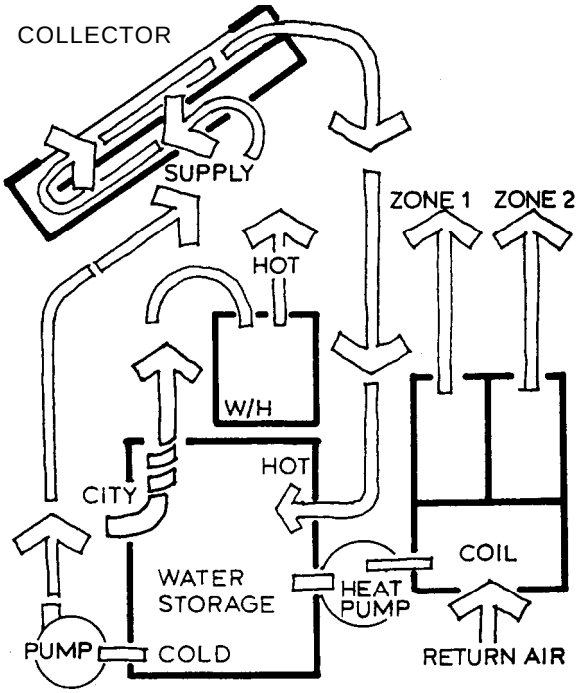


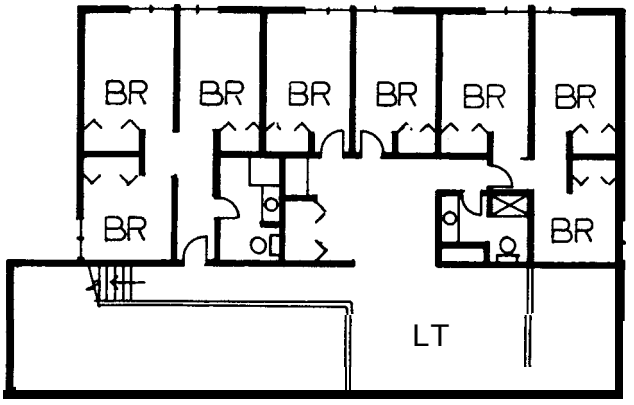


nD. DAYn

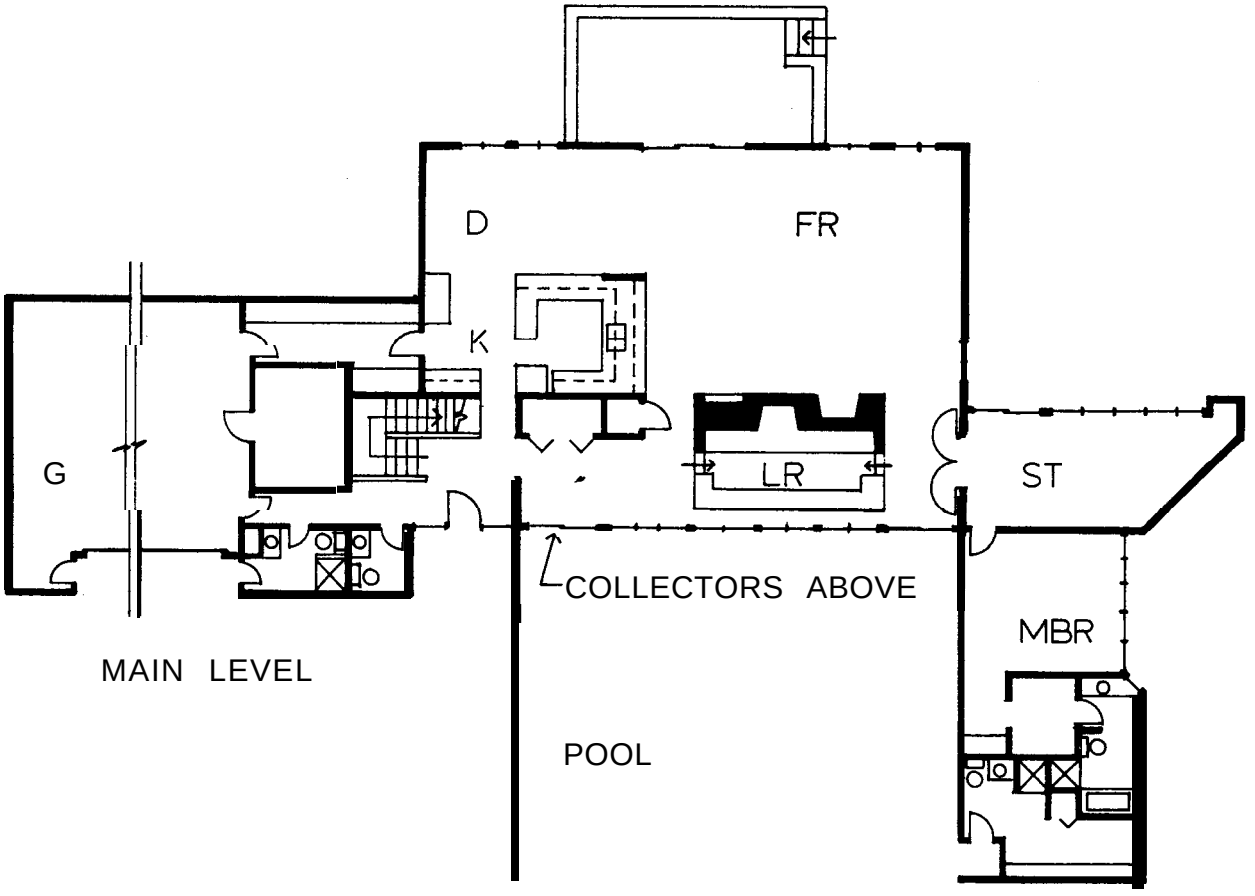


The 4000 sq ft Dick Day residence is one of the pioneering efforts in active solar space heating in the state of Nebraska. The flat plate collector system with water storage was engineered by Dick Bourne, formerly of Lincoln, now of Davis, California, In the solar assisted heat pump system (near right) water heated in the collectors is stored in a primary storage tank. A water to air source heat pump draws heat from the hot storage water via a fancoil unit, and this heated air is distributed through a conventional ducting system for space heating purposes. The house is so large that two York water source heat pumps are used in the system. The storage tank also serves to preheat water for domestic purposes, and, during the summer, provides hot water to heat a 30,000 gallon swimming pool.

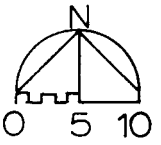




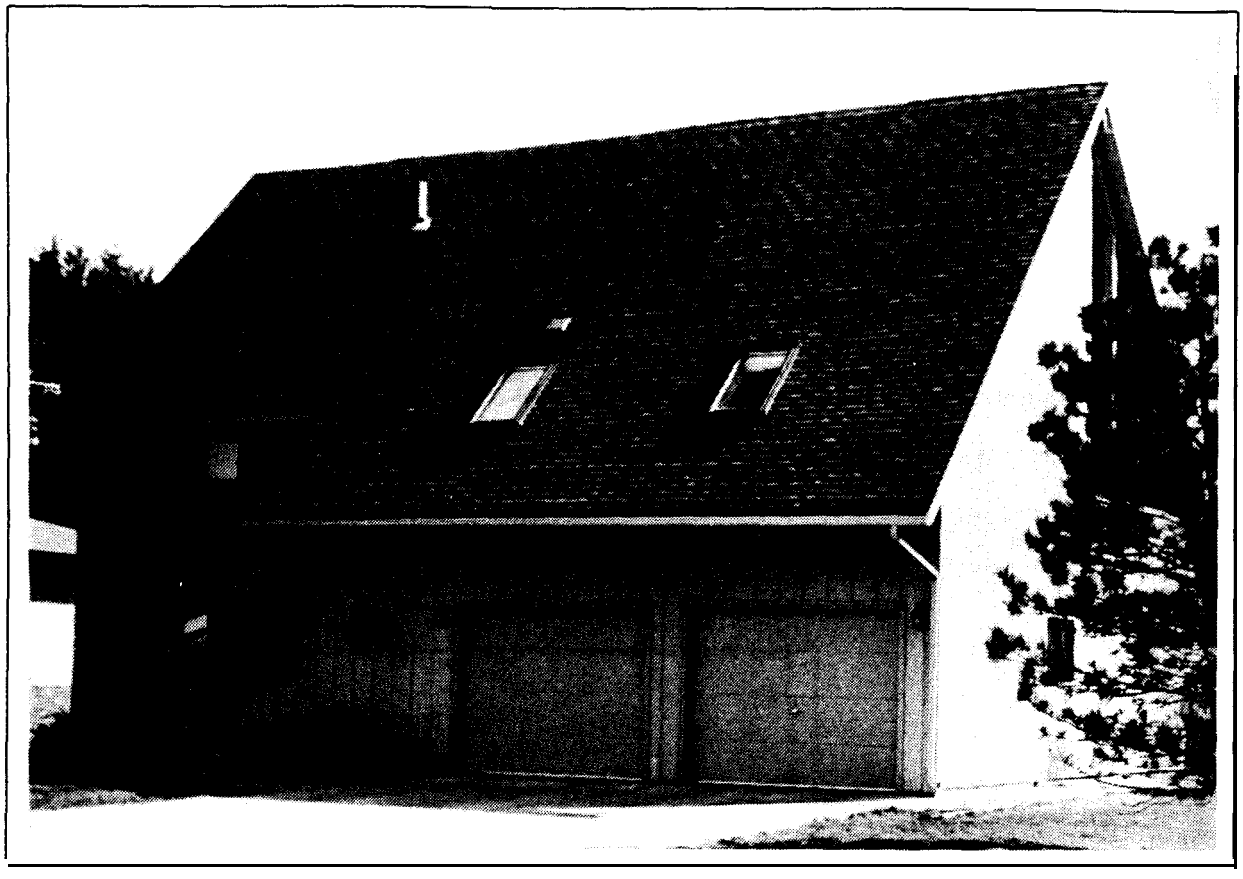
UPPER LEVEL



MAIN LEVEL



nJOHANSEN n

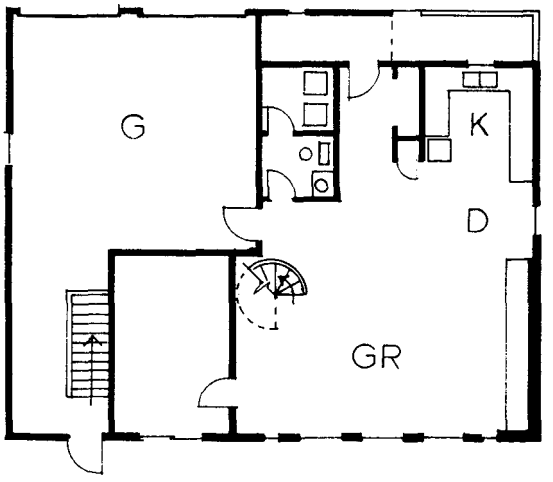


The Johansen solar home is the home of a builder who specializes in the construction of solar houses. His house, a 2100 sq ft structure with a basement that is used as a preschool, has an insulation level of R-24 in the walls and R-27 in the ceiling. The primary heat supply system used in the house is an active liquid system with water storage, although passive direct gain strategies are also incorporated.

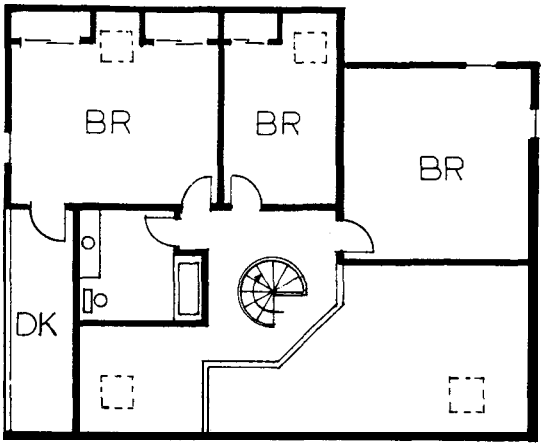
Approximately 260 sq ft of SOLAROLL -- a material the builder now feels is not thick enough for the purpose it serves-- was used as the absorber in the site built liquid collector (opposite right) which is located over the kitchen. The collector is covered with Filon glazing, and two 250 gallon insulated tanks are used for storage. Hot water from the tank storage is circulated to a "Chill Chaser" -- which acts like an add-on radiator -- to warm the room used as the preschool.

A Greenbriar woodburning stove located in the spacious great room is also used to supply heat. The water line to the Chill Chaser runs through the woodburning stove to be heated by exhausting heat. As a result the stove also burns cooler. Backup heating is supplied by electric resistance heating.

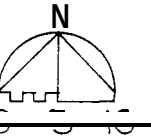
120 sq ft of south glazing provides direct gain passive solar heat to the great room where an interior brick wall -- which also absorbs heat from the woodburning stove -- and tile on the floor are used as mass storage. Solar heated air is also circulated to the bedrooms because the great room is open to the upper level (opposite left). The direct gain windows are insulated at night with Window Quilt night shutters.

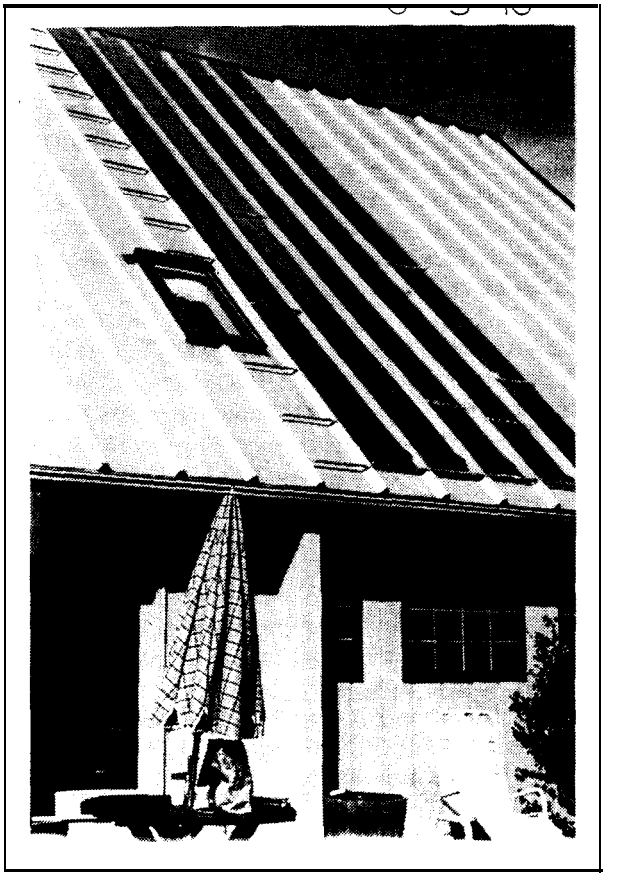


MAIN LEVEL

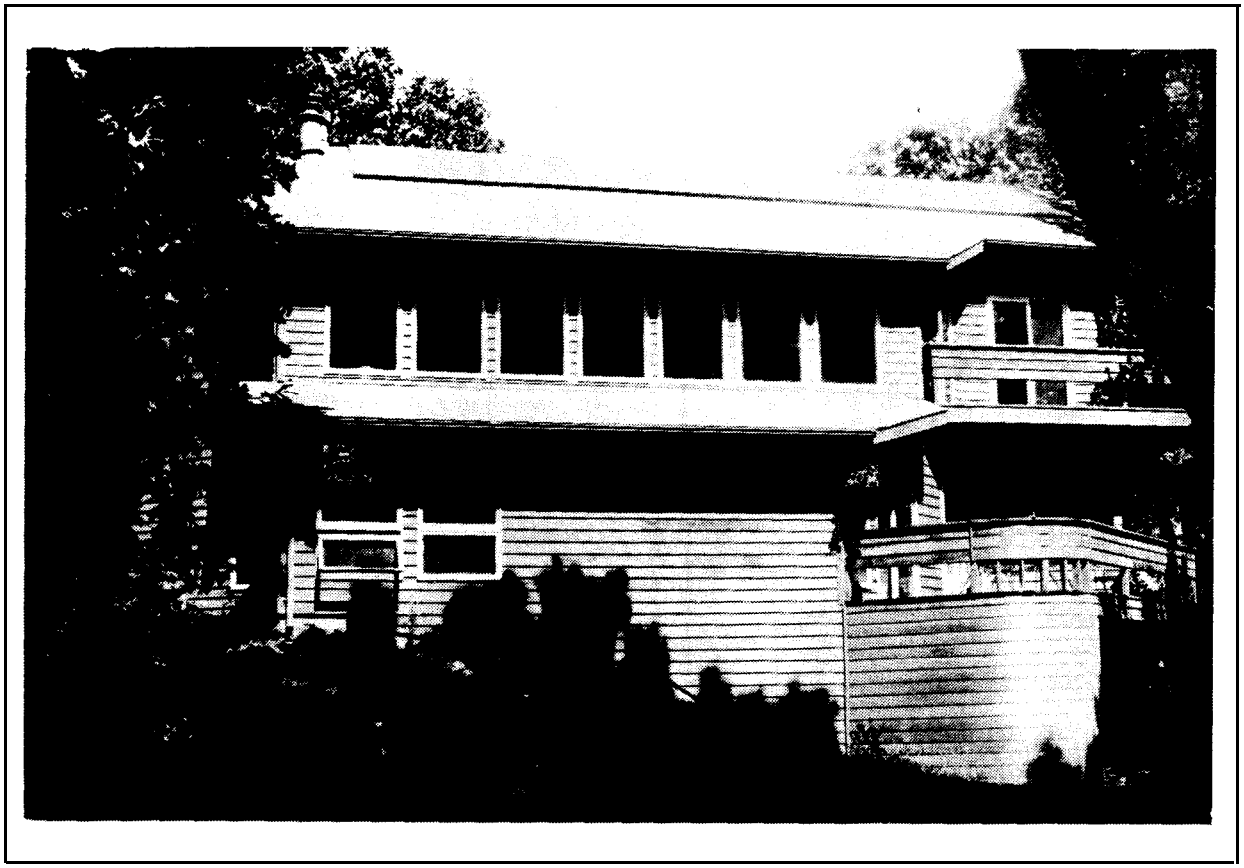


UPPER LEVEL





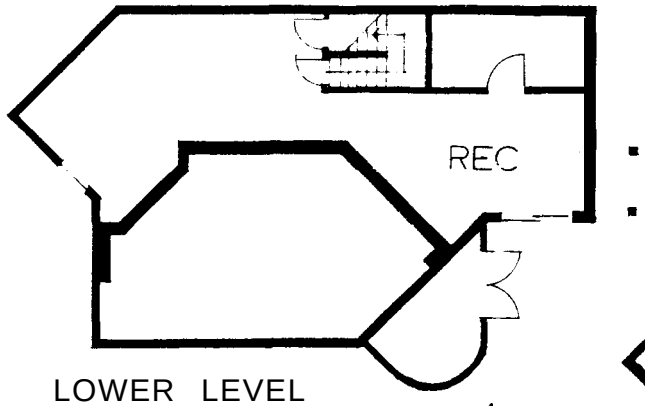
McGOWAN



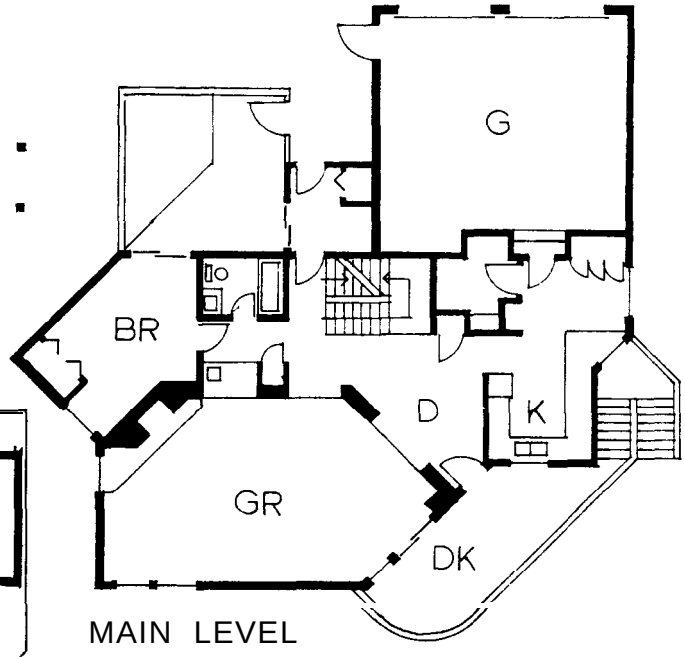
The three-story McGowan home, designed by Ionic Solar formerly of Omaha, is heated primarily by a liquid active solar system with water storage. The contemporary (opposite left) 2300 sq ft house also has 300 sq ft of vertical south facing glazing for direct solar gain.

The active solar system is used to preheat water for domestic use and for storage for a heat pump which is used as a backup space heating system. Ten active liquid collector panels, mounted on the roof, circulate propylene glycol to a 500 gallon tank which acts as mass storage. The owner estimates that at least 50% of the space heating needs are supplied by the active system. Unfortunately, the heat pump system has not been without problems including pump burnout as a result of poor water quality at the site, according to the architect.

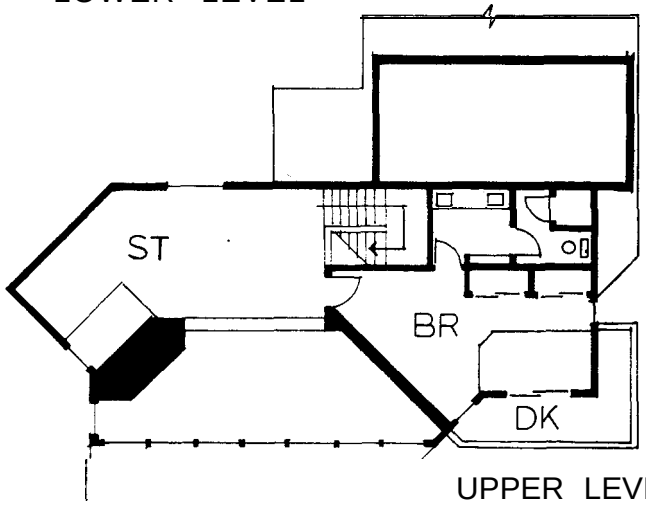
The house has some mass storage in the masonry fireplace wall (opposite right) for the direct gain system. The home, however, does not quite face true south and, therefore, loses some potential gain. Solar heated air, collected at the ceiling, is fan forced to a rockbed located beneath the great room. Because of unsatisfactory thermal performance, the owner feels he has had to accommodate his lifestyle to the house. The windows are collecting dust on the inside of the panes, and there have been fogging problems as well. In the winter, the high windows in the great room have caused a cascade of cold air to fall in a column near the windows at night, and the furniture had to be moved away from the windows. As a result, the great room is not used in the winter. Instead, time is spent upstairs in the study. The reverse holds true in the summer when the study area becomes too warm.



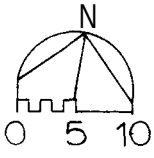
LOWER LEVEL

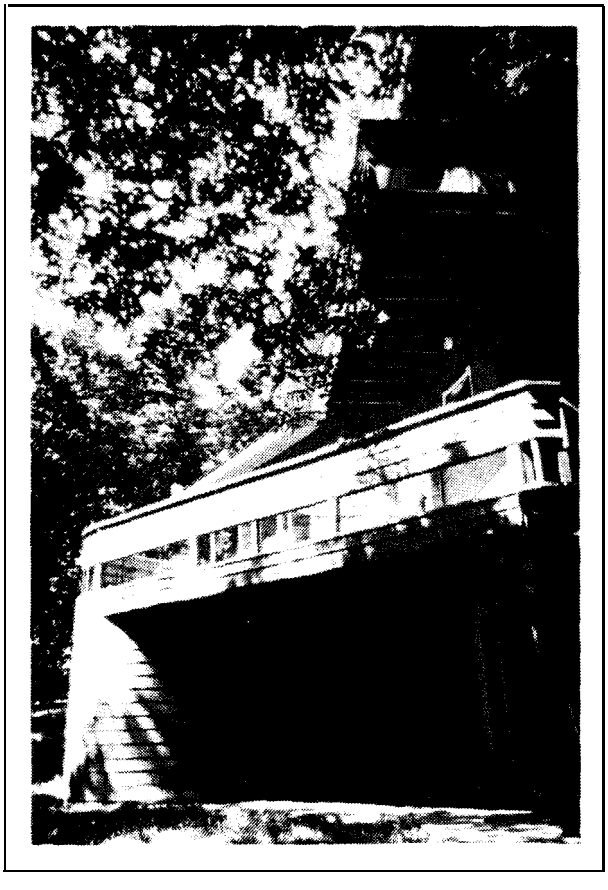


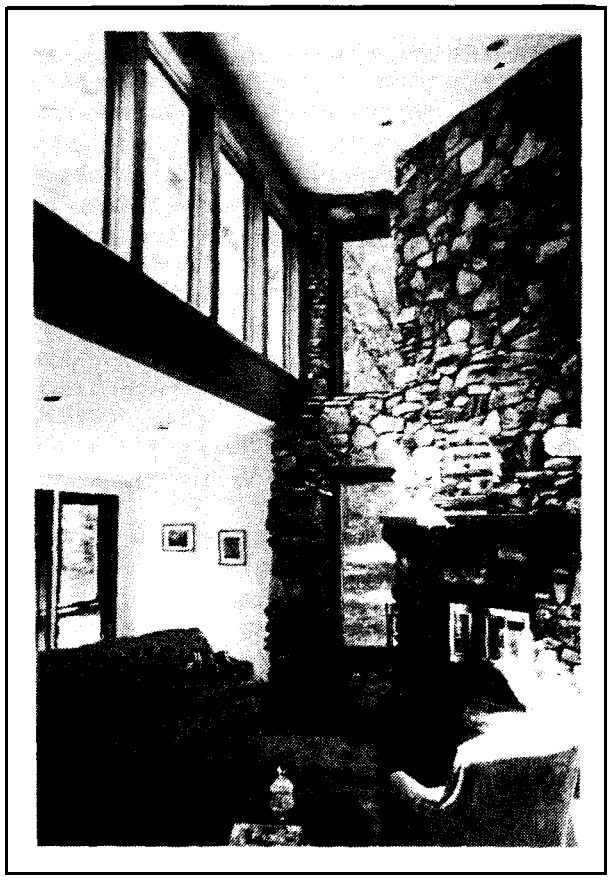
MAIN LEVEL

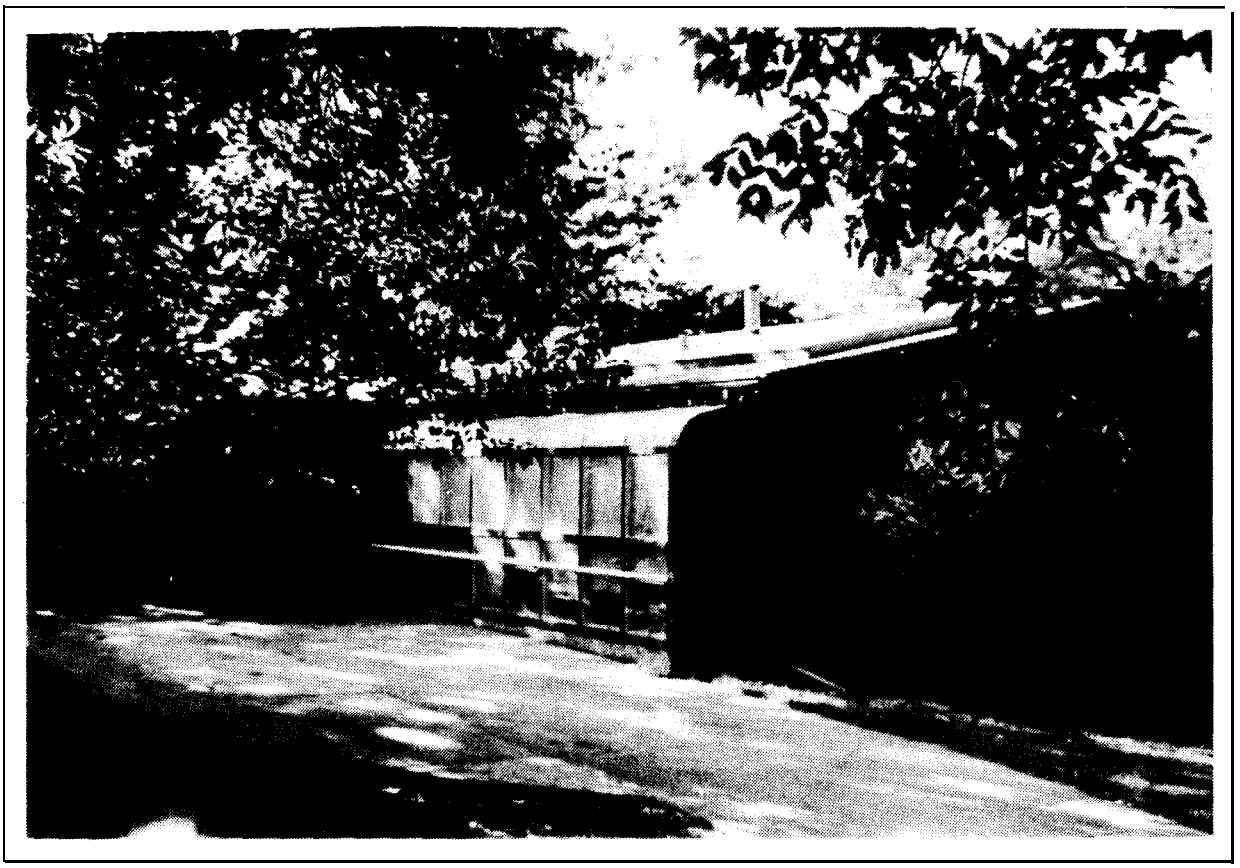


UPPER LEVEL









An active air solar collector system with water storage was the first of three major energy conservation and solar changes made to the Spurlock home which resulted in a reduction in gas consumption by at least 60%. The changes to the residence -- which, with 3000 sq ft on two floors, is fairly typical of the houses in the neighborhood -- were made by the previous owner, Charlie Thomsen, formerly a senior partner in the architectural and engineering firm the Clark Enersen Partners, and formerly of Lincoln, now of Albuquerque.

A site built active two pass air collector was added to the roof in 1975. The collector is 56' long and 12' wide with a gross area of 672 sq ft. An inadequate roof tilt angle was remedied by a V-shaped corrugated ptate placed between the roof and collectors. A brick storage bin measuring 5'x9'x7' and containing 5 tons of brick is located in the basement, and a water tank used for domestic hot water preheating is buried at the top of the storage bin. The collector fan circulates at 900 cfm and blows sun warmed air to storage (opposite left), and five motorized dampers are used to control a complex array of air flow alternatives. The active system provides 72% of the space heating and 63% of the hot water for the home.

The second change occurred in 1977 when 10" of rock wool insulation was added to the 3.5" of existing batt which had been in place above the ceiling since the house was built.

Finally, in 1978, a passive solar greenhouse was added (opposite right). Solar heat is stored in bricks, sand, and water -- the water storage consisting of 5 gallon plastic pickle barrels from a local fast food chain.

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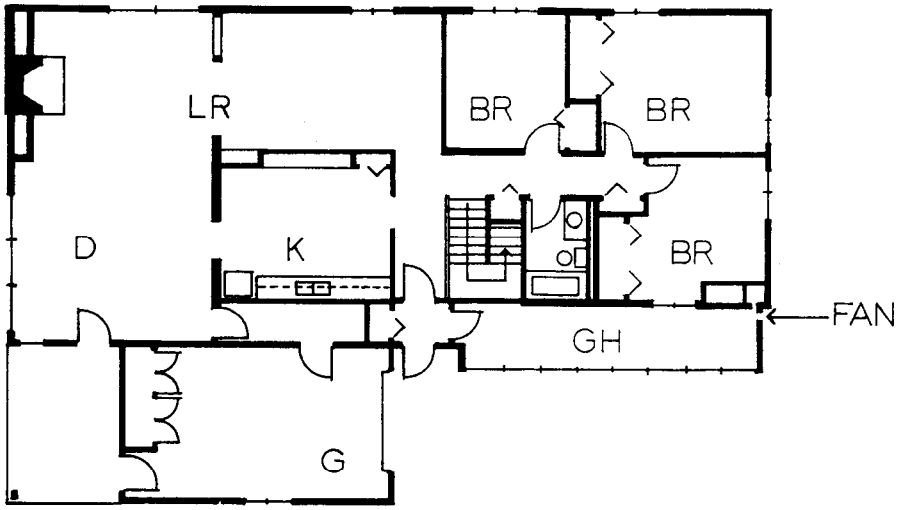
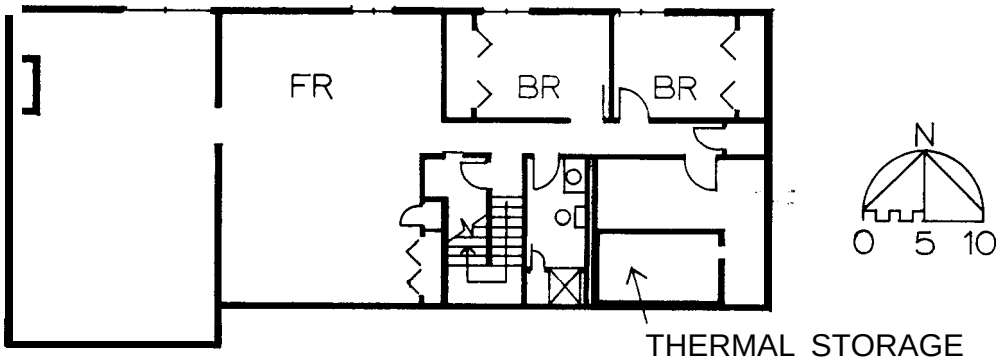
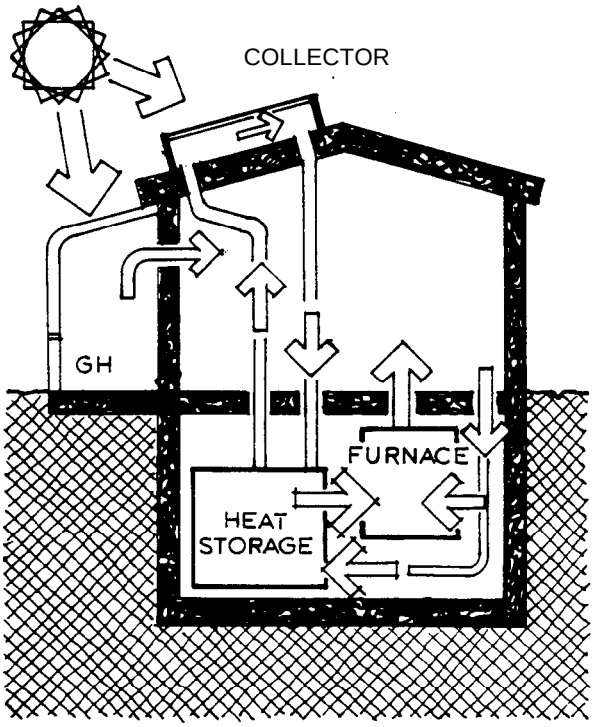


MAIN LEVEL

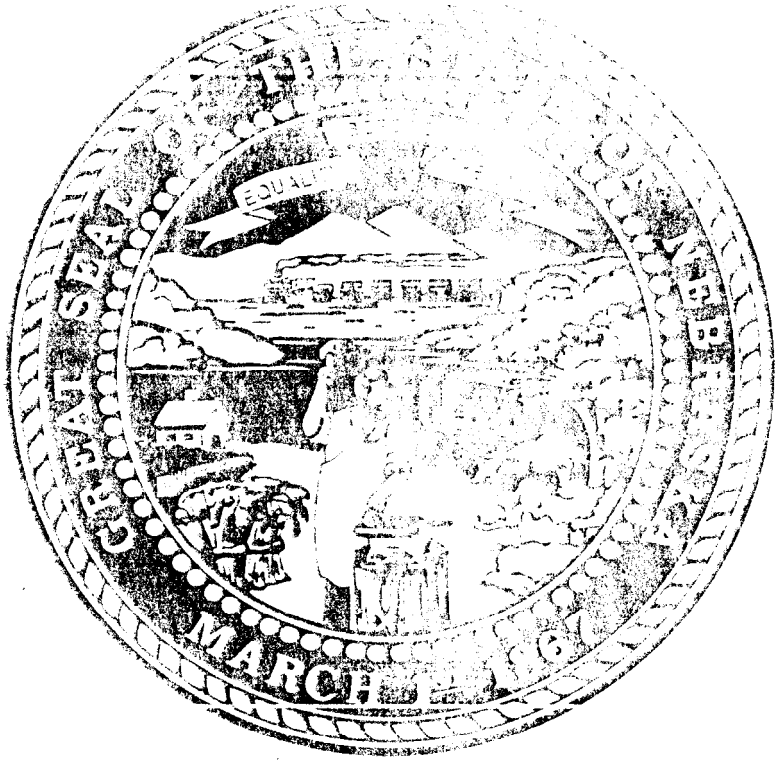


LOWER LEVEL



ABBREVIATIONS

A	ATRIUM
BR	BEDROOM
D	DINING
DK	DECK
FR	FAMILY ROOM
G	GARAGE
GH	GREENHOUSE
GR	GREAT ROOM
K	KITCHEN
LR	LIVING ROOM
LT	LOFT
MBR	MASTER BEDROOM
N	NORTH
REC	RECREATION
SA	SAUNA
SEW	SEWING ROOM
SOL	SOLARIUM
SP	SCREENED PORCH
ST	STUDY
TW	TROMBE WALL
WS	WORKSHOP



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