Some Passive Solar Buildings with a Focus on Projects in New Mexico

Presentation for the Albuquerque Chapter of the AIA

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Images 3-15 were taken from “A Survey of Passive Solar Buildings”, AIA Research Corporation, 1976

Other photos and drawings by the Zomeworks Corporation staff

SUMMARY

Thirty years ago there was strong interest in passive solar in Corrales and all of New Mexico. Many houses were built with lots of south facing glass admitting sun directly into the house or onto concrete or adobe “Trombe” walls or drum walls.

There have been many significant changes in tools and materials available to builders inclined to use the sun. There has also been a notable lack of interest in direct gain or Trombe wall buildings. Driving through Corrales today I am struck by how many shades are drawn during cold winter to block the sun that might enter south facing windows. Oddly, builders have not been cursed by the disappearance of components that would allow them to repeat successful designs of 30 years ago. Just the opposite. Generally, by accident, better tools and components have appeared in the last decades that make building passively heated and cooled structures easier.

Steel drums of 30 years ago developed leaks. Now we have plastic drums that don’t leak. Black paint was about the only surface to absorb sun. Now selective surfaces are more easily available. R-2 windows were about the best one could do against heat loss. Today windows that insulate twice as well are available. Shutters to block heat gain and heat loss were hard to find or make. Now they are everywhere. (But, why don’t people operate them correctly?) measuring temperatures required thermocouples or thermometers – now we have infra red scanners.

Interest in passive solar seems to occur in waves. There was one championed by “House Beautiful” in the 1940s (my parents built a passive solar house in California in 1949). Then there was the wave of interest in the 1970s.

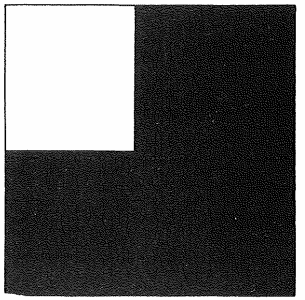
Those who sell gas, electricity, propane and oil may regard these periods of self reliance and clever designs as epidemics which weaken the demand for their power and fuels which they must combat to re-establish healthy fossil fuel appetites.

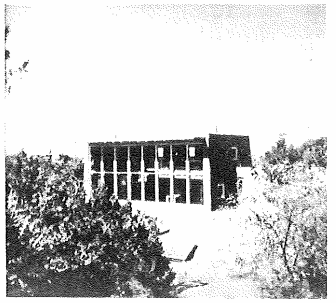
Let us hope we can begin a new epidemic of passive design. Surely the passive solar virus has mutated and the epidemic will reach larger populations, perhaps establishing itself permanently at a higher level.

Steve Baer

Sunscoop Direct Gain

David Wright Santa Fe, NM 1974

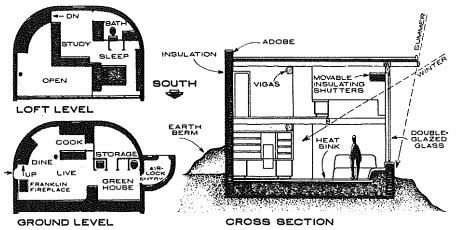




DIRECT GAIN NO. 24

The Sunscoop 1974
Santa Fe, New Mexico
David Wright, Architect

climatic 35° N
5900 heating degree days
6900 ft. altitude
11°F design winter temp.
88°F design summer temp.
1090 BTU/ft² jan. horiz. insol.
76% sun/year



building description:
This two story, one bedroom house and office is of adobe construction. The walls, 14" adobe on the 1st floor, 10" adobe on the second, have 2" of styrofoam exterior insulation and 1" of adobe cement protection. The floor is 2 ft. thick adobe. All windows are double glazed and an air lock entry is used. Earth berms have been used on the north to reduce building exposure to the climate.

solar system:
Heat is collected by direct gain through 384 sq. ft. of thermopane glass which constitutes the south wall. Heat is then stored in walls of 14" adobe and floors of 24" adobe. Several 55 gallon drums filled with water are buried beneath an adobe banco along the south wall to provide additional heat storage for up to 3 or 4 days. When the temperature drops, heat is radiated and convected throughout the open plan house (only services and a pantry are separate). Unwanted heat losses and gains are controlled by wall and floor insulation, and a shutter system of canvas and insulation. liquid collectors with a glycol/water solution (circulated by gravity convection) provide DHW preheat.

cooling techniques:
Operable east and west windows maximize cross ventilation, and high vents exhaust hot air. The massiveness of the adobe building delays daytime heat until the cooler evening hours and retains a nighttime coolness. 4 foot overhangs in addition to the insulating shutters exclude unwanted overheating from sunshine exposure.

auxiliary: Wood burning stove.

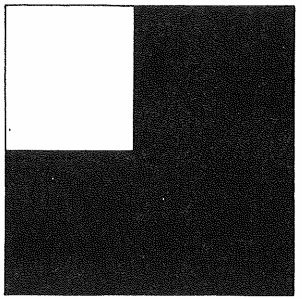
performance evaluation: Generally excellent. Warm walls and floors permit comfort at lower ambient temperatures. Daily swings (60-85°) sometimes unpleasant; occasional overheating due to lack of shade in the spring and fall.

reference: 17.) Arizona, 7.) Popular Science, correspondence with the Architect.

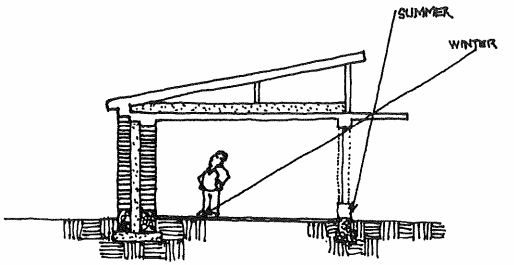
Sun Dwelling Demonstration 3 Ghost Ranch Direct Gain

Peter Van Dresser

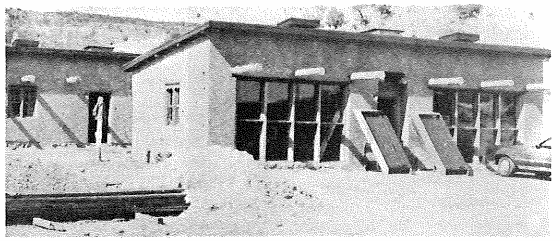
Abiquiu, NM



DIRECT GAIN NO. 21



Sundwelling Demonstration 3
Ghost Ranch, Abiquiu, New Mexico
Peter Van Dresser, Coordinator



climatic data:
35°41′ N
6350 heating degree days
10°F design winter temp.
1090 BTU/ft² jan. horiz. insol.
76% sun/year

building description:
The Sundwellings Demonstration Center consists of four adobe dormitory buildings each demonstrating one low-cost, low-technology passive solar system. The 2 bedroom and bath units cover 800 sq. ft. of floor area, and are constructed of adobe which stores heat well but is not a good insulator. The north wall has a double brick cross section with a 10-inch cavity filled with pumice insulation. The ceiling is insulated with 10 inches of natural insulation.

solar system:
The simplest of the Sundwelling models (greenhouse, trombe wall, direct gain); this unit involves a direct heat gain passive system. Solar radiation enters through large south facing windows to directly heat the rooms. Heat is stored in the massive floors and walls for radiant distribution when the temperature drops. Insulating curtains prevent heat loss at night. Deep roof overhangs prevent summer overheating by blocking out the high summer sun, but allow the wanted low winter sun to flood the rooms.

A thermosiphoning flat plate system provides domestic hot water preheat.

cooling techniques:
The hot space between the pitched (north facing) roof and the insulated ceiling heats the air in the attic. This heated air, escaping through large roof vents, draws warm air from the living space through ceiling vents. This provides a cooling breeze inside the room even when the outside air is calm. A deep roof overhang protects the living space from the high summer sun.

auxiliary: Butane room heaters.

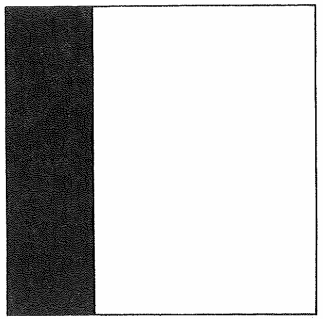
performance evaluation: 70-80% passive heating contribution. A control dwelling of identical construction but limited southern glazing will allow for precise evaluation of these passive dwelling prototypes.

reference: The designers: Ghost Ranch Design Team.

Sun Dwelling
Ghost Ranch
Trombe Wall

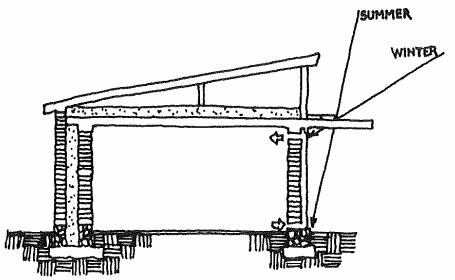
Peter Van Dresser

Abiquiu, NM



MASS TROMBE WALL NO. 8

Sundwellings I
Ghost Ranch; Abiquiu, New Mexico
Peter Van Dresser, Coordinator



climatic data:
35°40′ N
6350 heating degree days
10°F design winter temp.
1090 BTU/ft² jan. horiz. insol.
76% sun/year

building description:
The Sundwellings Demonstration Center consists of four adobe dormitory buildings each demonstrating one low-cost, low-technology passive solar system. The 2 bedroom and bath units cover 800 sq. ft. of floor area, and are constructed of adobe, which stores heat well but is not a good insulator. The north wall has a double brick section with a 10 inch cavity filled with pumice insulation. The ceiling is insulated with 10 inches of natural insulation.

solar system:
A double glazed south wall and a massive adobe wall directly behind this glazing, have been added to this Sundwelling. Air is heated in the space between the glazing and the mass wall by incoming solar radiation. The heated air rises, entering the room through the upper vents, while cooler air leaves the room through the lower vents creating a continuing circulation. The mass wall also stores heat for direct radiation into the living space.

cooling techniques:
The hot space between the pitched (north facing) roof and the insulated ceiling heats the air in the attic. This heated air, escaping through large roof vents, draws warm air from the living space to provide a continual cooling breeze inside. The large thermal capacity of the adobe walls prevent rapid temperature increases, delaying daytime heat until cooler night hours, then storing nighttime coolness for daytime relief. A deep roof overhang protects the mass storage wall from the high summer sun.

auxiliary: Butane room heaters.

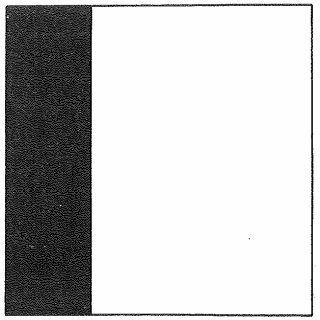
performance evaluation: 70-80% passive heating contribution. A control unit of identical construction but limited southern glazing will allow for precise evaluation of these Passive Solar Dwellings.

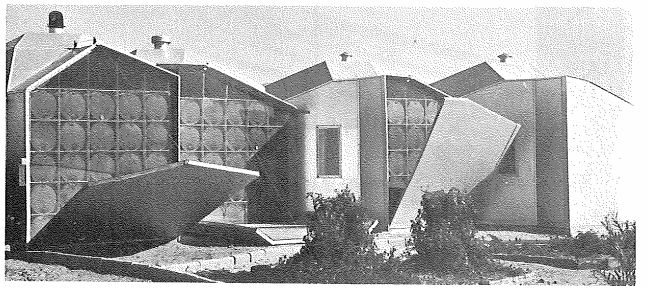
reference: The designers: Ghost Ranch Design Team.

Baer Zome

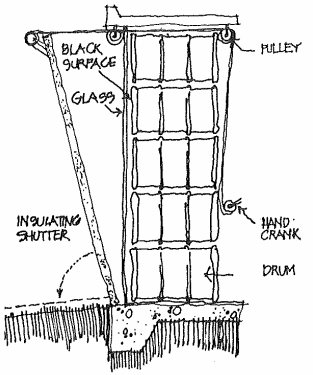
Drum Wall

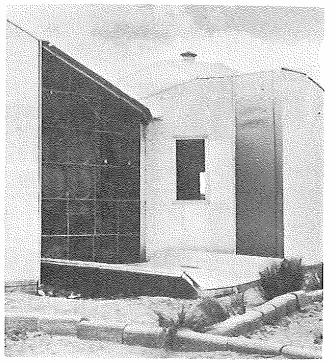
Corrales, NM
1971





WATER TROMBE WALL NO. 9





Steve Baer House—1971
Corrales, New Mexico
Steve Baer, Zomeworks, Designer

climatic data:
35° N
4348 heating degree days
23°F design winter temp.
100°F design summer temp.
1125 BTU/ft² jan. horiz. insol.
2520 BTU/ft² july horiz. insol.
76% sun/year

building description:
This 1925 sq. ft. rambling house has ten single spatial units (zomes) connected by doorways so air can circulate throughout. Many walls are of adobe, others are insulated aluminum sandwich panels. The floor is a 5 inch slab of concrete, with no basement below. Automatic 'skylids' (insulating skylights which open and close automatically) are used throughout.

solar system:
The chain of rooms are organized in a U-shape, with the longer arm facing south. The walls of the 4 southernmost zomes are vertical and single glazed (10 ft. × 10 ft. panes). Behind each window is a stack of 56-gallon steel barrels, 95% water filled, 90 barrels in total with 4800 gallons of water. Stacked 4 to 5 feet high in metal support frames, the ends of the barrels are painted non-selective black and face south. Heat is collected from direct heat gain through the glass and stored in the water. Heat is distributed from the barrels by radiation and convection. Skylids allow direct radiation to penetrate the other zome units, with the 5 inch concrete floor and adobe walls providing solar storage. An exterior aluminum faced shutter swings down to act as a crude mirror directing additional radiation to the window. Inside, curtains control flow of warm air from the barrels to the room. Domestic hot water is supplied by a flat plate thermosiphoning system.

cooling techniques:
The large aluminum faced shutters are insulated to prevent heat loss in winter as well as unwanted heat gain in summer. Closed during the summer day to keep the barrels cool, the shutters are open at night to cool the barrels by radiation to the cool night sky. This cooled down water will absorb indoor heat to provide comfortable summer temperatures.

auxiliary: Wood-burning stoves.

performance evaluation: The passive system contributes 85% of the total space heating requirement.

reference: 17.) Arizona, 5.) House and Garden, 16.) Shurcliff.

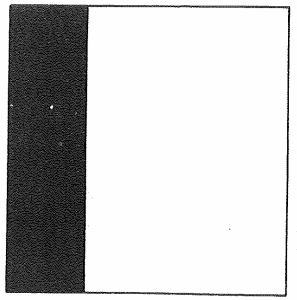
Benedictine Monastery

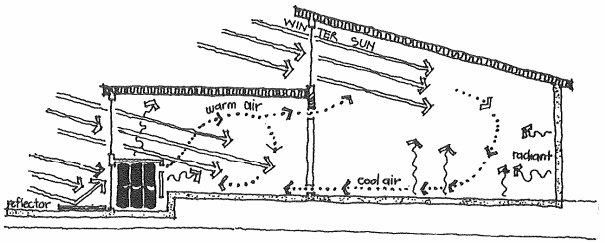
Drum Wall & Clerestory

Steve Baer, Zomeworks

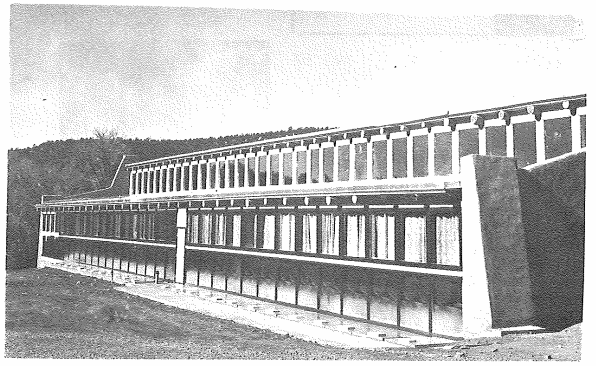
Pecos, NM

1978





WATER TROMBE WALL NO. 11



Benedictine Monastery—1976
Pecos, New Mexico
Steve Baer, Zomeworks, Designer

climatic data:
35½° N
4383 heating degree days
10°F design winter temp.
100°F design summer temp.
1120 BTU/ft² jan. horiz. insol.
76% sun/year

building description:
This building is 1-story with 7000 sq. ft. of space. It has no attic or basement. The floor is 4 in. concrete slab. The typical wall is 8 in. concrete block with 2 in. beadboard on the inside, R-12. The roof is insulated with 6 in. fiberglass, R-20. Window areas on east, north, and west sides are small (10 sq. ft. in all) and are single glazed. The building faces south, with 3 bands of thermopane windows, 140 ft. long by 4 ft., 5 ft., and 4 ft. high. Offices occupy the south portion of the building, and the north portion is a warehouse.

solar system:
Heat is collected when sun passes through the south facing low band of windows and strikes 140 55 gal. steel drums filled with water. A corrosion inhibitor is used. The lower row of drums rests in a 4 ft. wide, 1½ ft. deep depression; tops of upper row drums are 3 ft. above floor level. The drums are in operable housing that have 4-6 in. fiberglass insulation. Heat stored in the drums is radiated to the living space as interior temperature drops. Through the intermediate band of windows the sun's rays strike the concrete floor slab deep into the space and east-west partition wall. Heat is stored in these masses and later radiated to the space. Radiation entering through the highest band of windows lights and warms the north portion of the building. External insulating shutters may be used at night in winter at the lower window band, to contain heat from drums inside the building.

cooling techniques:
In summer, the external insulating shutters remain closed to exclude radiation and reduce conductive heat in-flow at the lowest window area. Uppermost windows are opened to allow venting of hot air. Thermal capacities of water-filled drums and of floor, partition, etc., reduce temperature rise.

auxiliary: Electric

performance evaluation: The passive system supplies 95% of the actual space heating requirement.

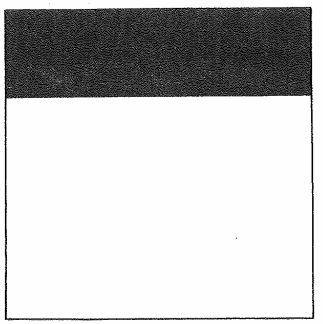
reference: 16.) Shurcliff

Close-up of Monastery south wall showing drums on their sides and reflector/shades flat on the ground (winter mode).

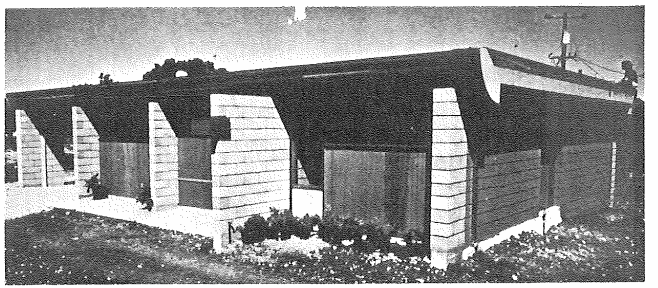
Skytherm Roof Pond

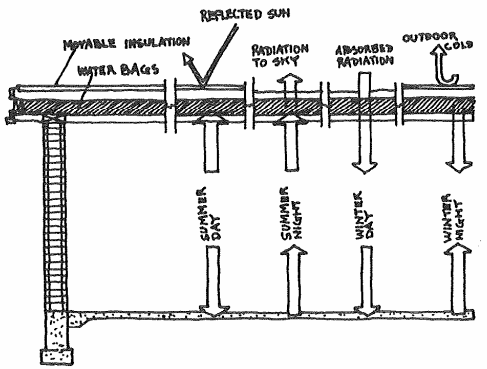
Harold Hay,Inventor J.Edminster and K. Haggard. Arch.

Atascadero, CA 1973



ROOF POND NO. 1





Atascadero Skytherm–1973
Atascadero, California
John Edminster, Kenneth Haggard, Architects
Harold Hay, Inventor and Consultant
Phil Niles, Solar Engineer

climatic data:
35° N
315 feet altitude
2970 degree day
45°F design winter temp.
77°F design summer temp.
970 BTU/ft² jan. horiz. insol.
2510 BTU/ft² july horiz. insol.

building description:
This one story, 1140 sq. ft. home is constructed of hollow-core concrete blocks filled with sand to improve the heat storage capacity of the building mass. The roof is constructed of steel panels horizontally arranged. The continuous steel roof ties together the concrete block walls to offer rigid resistance to earthquakes. Overhangs on all faces provide summer shading.

solar system:
Four 8 ft. wide, 38 ft. long water filled plastic bags are placed in thermal contact with the steel roof deck. This provides a 10 inch depth of water storage. A movable insulation cover is opened on winter days to collect solar heat for direct radiation through the steel ceiling to the living space. Excess radiant ceiling heat is absorbed in the massive floors and walls to balance the temperature swings and control overheating. The insulating panels are opened and closed automatically depending on the indoor temperature, the storage water temperature, and the sol-air temperature. Two layers of transparent plastic film filled with nitrogen gas over the water bags provide subsidiary insulation against daytime heat loss. The Skytherm™ roof pond system seen in this Atascadero house has been patented by the designer Harold Hay.

cooling techniques:
In the summer, the insulated roof panels are opened at night to expose water bags to the cool night air. During the day, the cool water in the ceiling draws heat from the living space and its occupants. The steel roof deck can also be flooded to allow evaporative cooling during the summer.

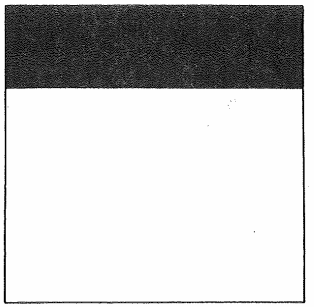
auxiliary: 230 volt electric baseboards are provided but have not been used.

performance evaluation: 100% passive contribution provides constant comfort conditions at acceptable levels. Improvements were suggested in terms of the system's operation and cost.

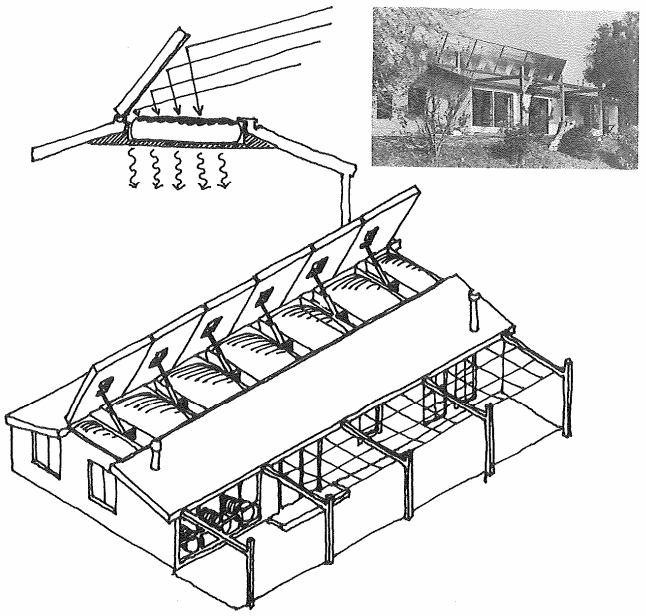
reference: 17.) Solar Oriented Architecture, and correspondence with the architect.

Hammond House
Living Systems Design
Jonathon Hammond

1975
Winters, CA



ROOF POND NO. 3



Hammond House—1975
Winters, California
Jonathon Hammond,
Living Systems, Designers

climatic data:
38° N
1525 heating degree days
40°F average winter temp.
75°F average summer temp.
977 BTU/ft² jan. horiz. insol.
70% sun/year

building description:
This single family house is built with 2" × 6" wood frame construction, is heavily insulated in both the walls and roof, has a concrete slab floor on grade, and incorporates 1800 sq. ft. of space. 2 inch thick shutters or sliding panels filled with insulation can be closed over all windows.

solar system:
A solar collector covers ⅓ of the roof surface. It consists of six 6 × 8 foot galvanized metal pans running the length of the flattened roof peak. Each of the tar-lined pans is filled with water in a bag one foot deep. Movable, insulated reflector panels cover them. When panels are raised, the water is exposed to the sun and panels act as reflectors. The panels are built on a wood framework with a sheet aluminum top, and plywood bottom with fiberglass insulation sandwiched in between. An electric motor powers the hydraulic rams that raise the panels on sunny winter days. At night, panels are lowered to contain heat in the house. The underside of the water pan rests on roof joists and is exposed to the house interior. The open floor plan allows radiating heat to reach every room. The exposed concrete floor slab assists in absorbing and re-radiating heat to the space. Several 30 gal. steel drums painted black act as additional heat sinks; collecting heat radiated from the roof pans and from sunlight passing through the south-facing windows and then releasing it at night.

cooling techniques:
In summer, the panels are raised at night. The water pans absorb the warmth collected inside during the day and transmit it to the cool night sky, by radiation and convection. During the night, windows in the north and south walls are opened to let cooling breezes pass through the house.

auxiliary: Franklin stove (gas heater required for bank loan has never been used). Domestic hot water is heated with a flat plate solar collector with thermosiphon distribution.

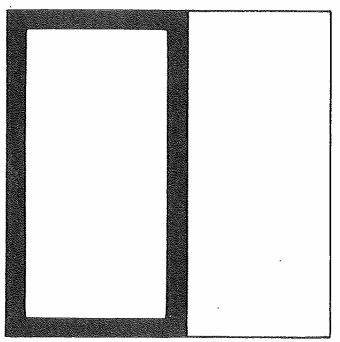
performance evaluation: 100% passive cooling contribution and 90% passive heating is provided. The client was from Alaska and expressed a preference for colder comfort zones. During three days of 112°F weather, interior temperature reached 76°F.

reference: 10.) Sunset, 6.) Mother Earth

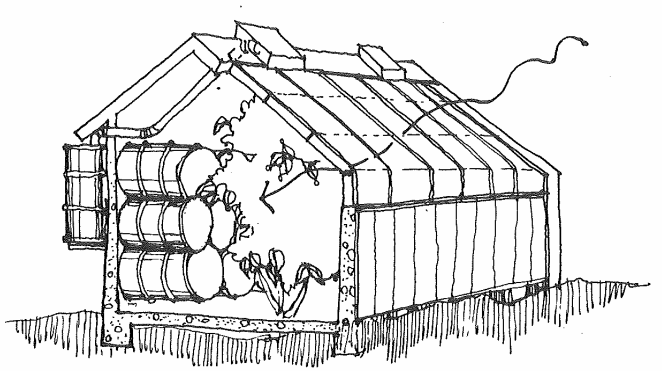
Monte Vista School Greenhouse

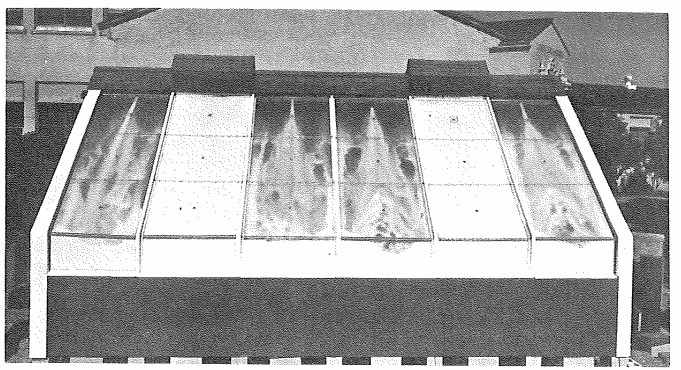
Dave Harrison, Zomeworks, Designer

Albuquerque, NM 1973



SUNSPACE NO. 15





Monte Vista School—1973
Albuquerque, New Mexico
David Harrison, Zomeworks, Designer

climatic data:
35° N
5310 ft. altitude
4348 heating degree days
17°F design winter temp.
92°F design summer temp.
1125 BTU/ft² jan. horiz. insol.
2520 BTU/ft² july horiz. insol.

building description:
This project incorporates 240 sq. ft. of greenhouse attached to a school building. The south face is thus glazed, and insulated, to optimize passive solar heating.

solar system:
Heat is collected by direct heat gain through south facing, plastic double glazing with a 3 inch air space. The sun hits 37°F gallon drums filled with water, painted black to absorb incident solar radiation. The heat is distributed by radiation and convection, from the 38 water drums. Styrofoam insulation beads are blown into the 3 inch air space on winter nights to prevent heat loss, and summer days to prevent unwanted heat gain.

cooling techniques:
The use of beadwall glazing on the south provides both shading from direct radiation, and insulation against summer heat gain.

auxiliary: None used.

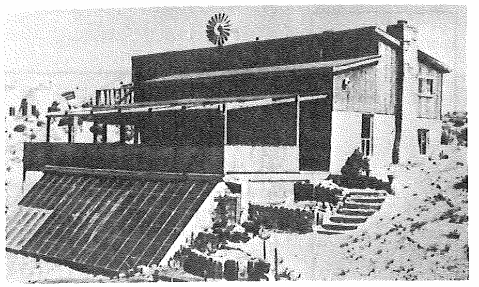
performance evaluation:

reference: 17.) Arizona

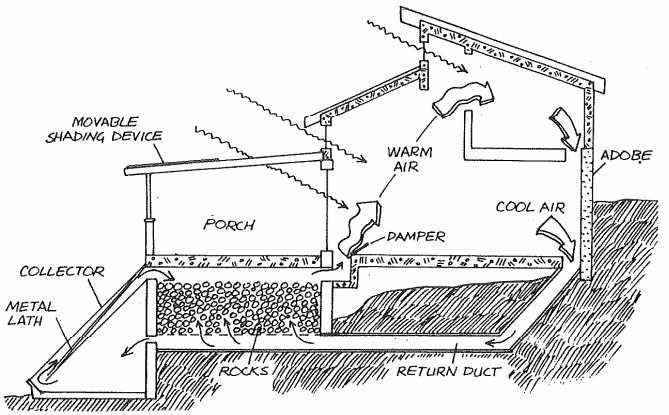
Paul Davis House
Air Loop Rock Storage

Paul Davis, Designer
Steve Baer, Zomeworks, Solar Engineer

Corrales, NM
1972



THERMOSIPHON NO. 4



P. Davis House—1972
Albuquerque, New Mexico
Paul Davis, Designer
Steve Baer, Zomeworks, Solar Engineer

climatic data:
35° N
4348 degree days
0°F design winter temp.
100°F design summer temp.

building description:
This one story wood frame house has 1000 sq. ft. of space arranged in an open interior plan with a loft. Insulation has been added throughout with a wall of books used to maximize the north wall section. Adobe end walls add to the thermal mass of the building.

solar system:
420 sq. ft. of air collectors—single glazed with a block finished aluminum absorber panel—are located on the sloping ground in front of the house. Air is heated by direct gain and circulates through the collector by natural convection. The heated air rises to 45 tons of rock storage which supports the floor of the south facing porch. From here heat is distributed through the house by radiation and natural convection. The heat supply is controlled by dampers which open and close the air ducts adjoining the living space.

Domestic hot water preheat is provided by a thermosiphoning system with 80 sq. ft. of collector.

cooling techniques:
The south porch provides shading for the southern face, with overhangs to protect the clerestory windows. Cross ventilation is provided by the high clerestory windows.

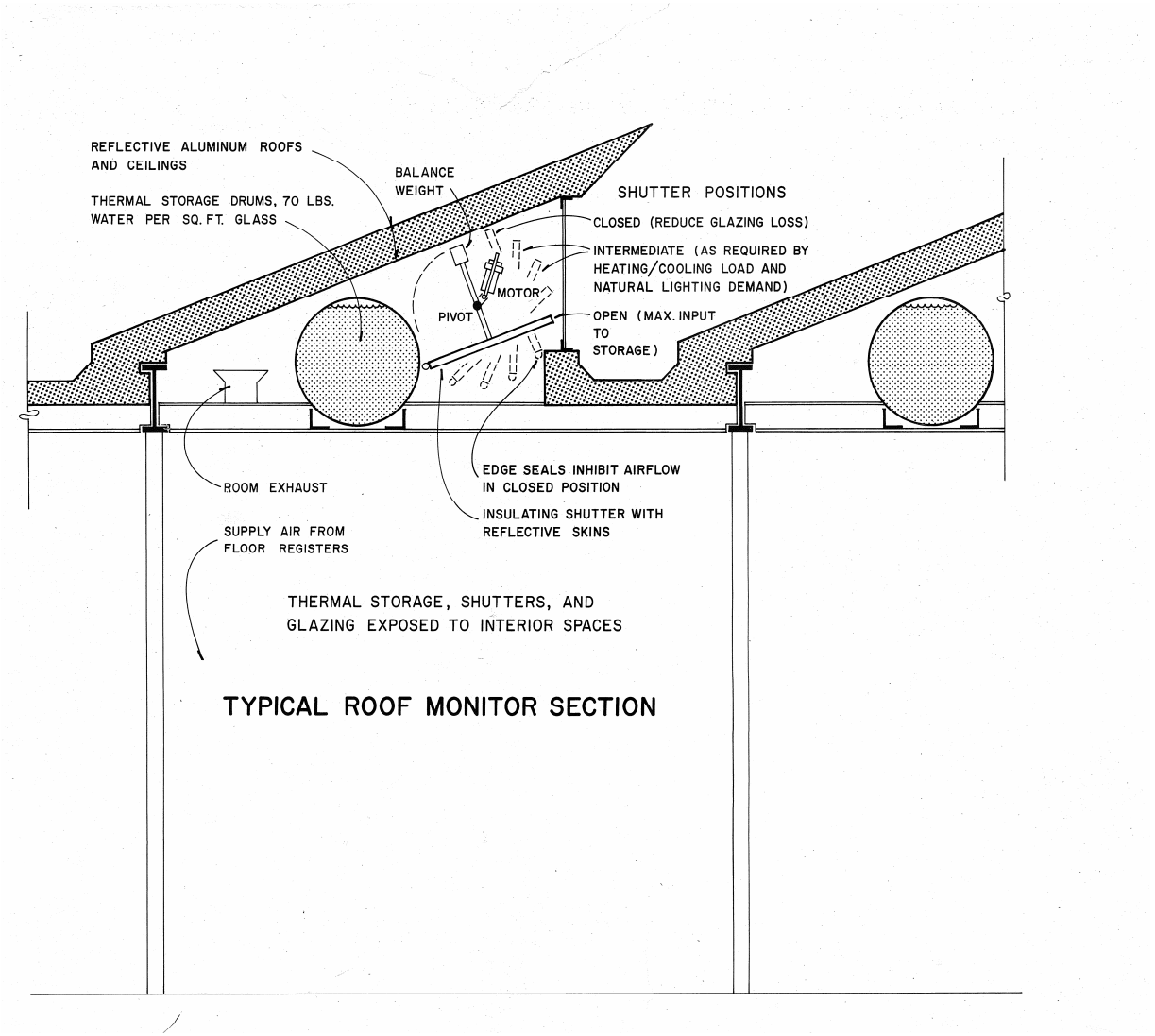
auxiliary: Electric heaters and a fireplace with heatilator recycle serve as auxiliary.

performance evaluation: 75% passive heating contribution.

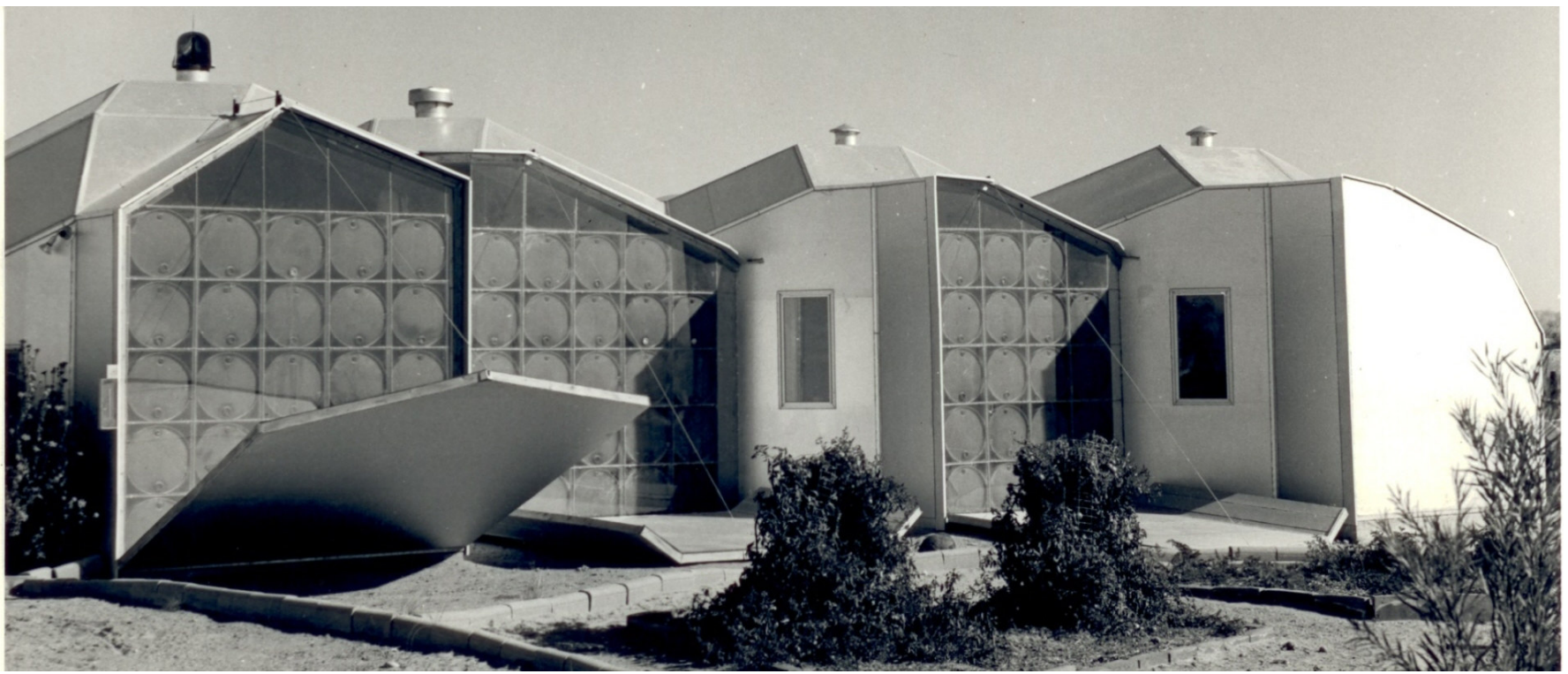
reference: 1.) AIA Journal

State of New Mexico Office Building
Taos, New Mexico
William Mingenbach AIA, The Architects, Taos, NM

June 1976 Job No. 7507



Insulated reflector/shades in front of four banks of south facing 55-gallon steel drums behind single glazing.
Baer Zome Cluster, Corrales, NM 1972



The heavy drum doors were raised and lowered using a winch mounted inside the house.

Frank's House Beadwall Closed, David Harrison Designer
Placitas, New Mexico
1980

Frank’s House Beadwall Open, David Harrison Designer

Placitas, New Mexico
1980

Frank's House Beadwall Filling, David Harrison Designer

Placitas, New Mexico
1980

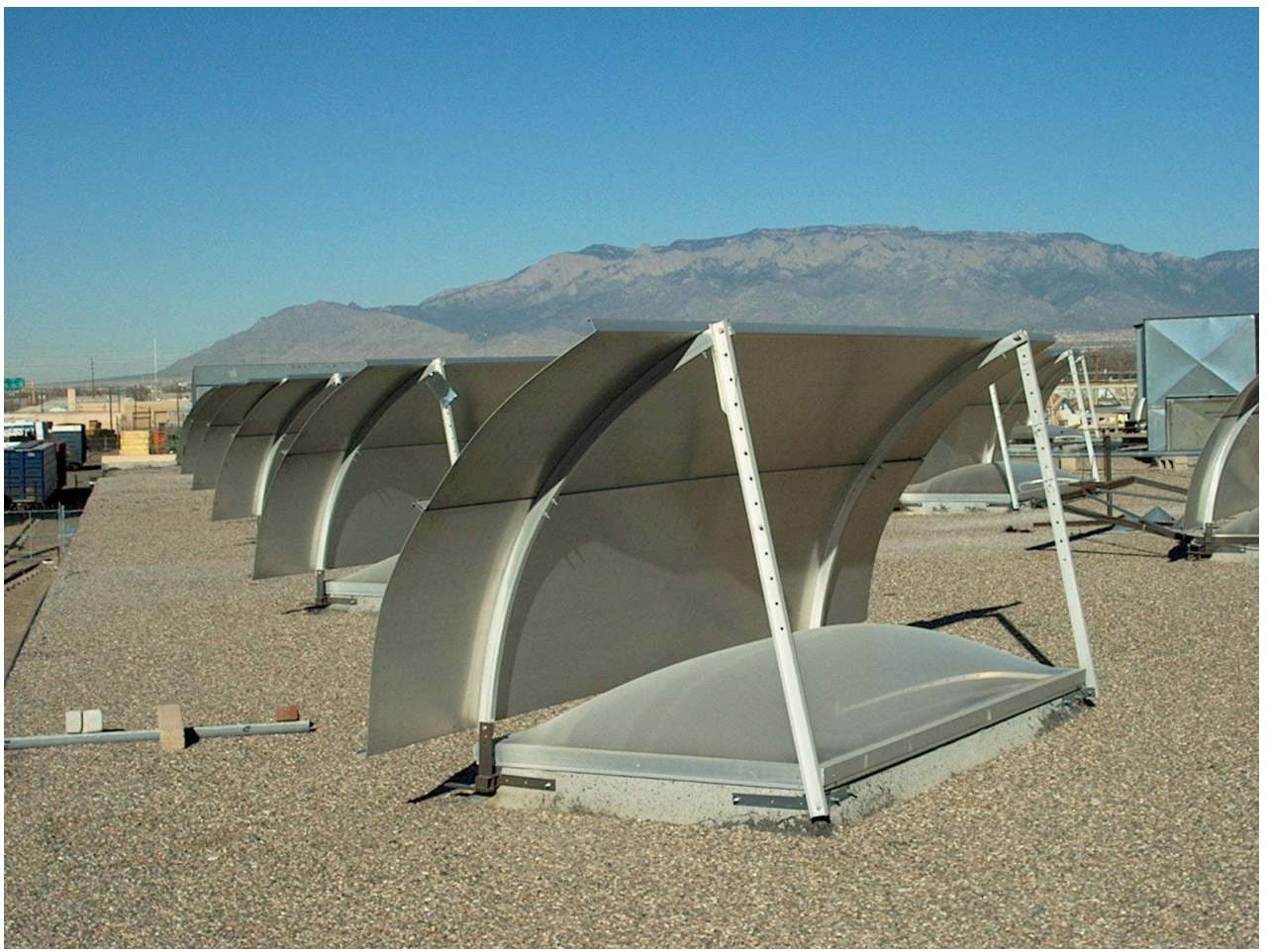
Baer Zome Skylid® Insulated Louvers Open and Close in Response to Sun. In Summer Kept Tied Mostly Closed to Allow Some Light.(1973)

Passive solar house with low drum doors in summer position (outside painted tan to blend with wood siding and plaster)
Mike Elliston c.1980

In 1991 the steel drums were replaced with plastic barrels stacked upright and the reflector/shade doors were replaced with seasonally adjusted aluminum sheet panels that can be pushed up in summer and held with light-weight poles.

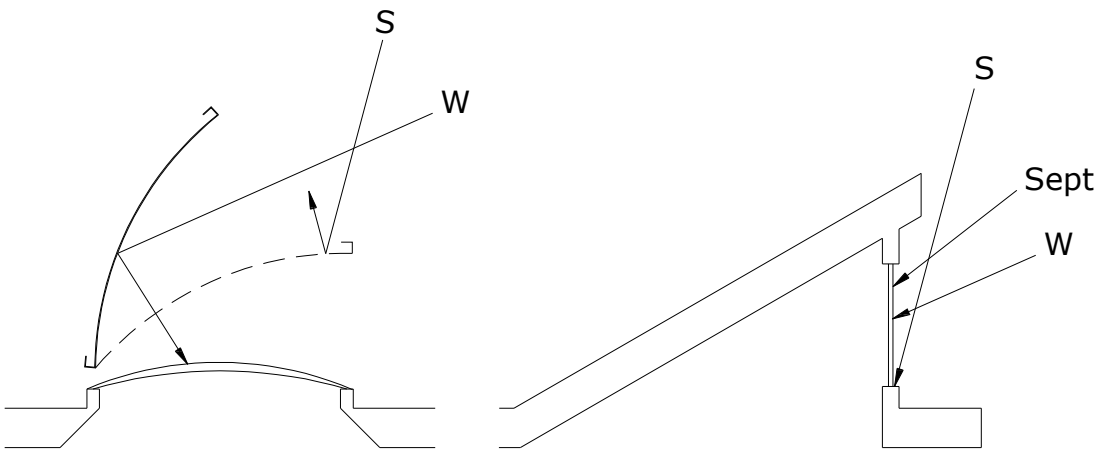
Bruce Davis Sunbenders® in Summer Position Provide Shade and Allow Light into House From About April 30 to October 30 (1990s) Albuquerque, NM

Sunbender® Reflector/Shades over Skylights in Winter Position to Light and Heat Shop at Zomeworks (1988)

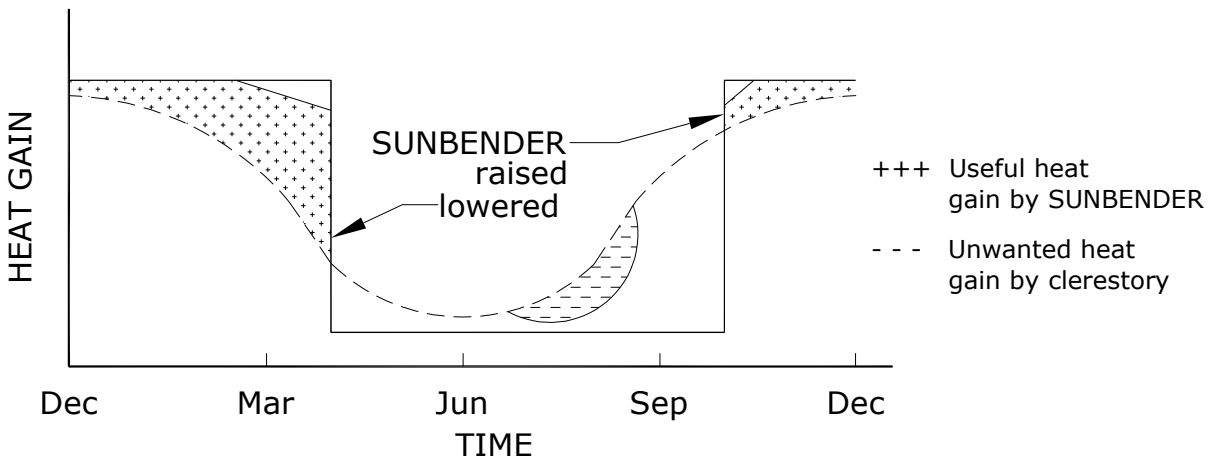


Two views of mirrored Sunbender® reflector/shades:
Fountain Valley School, winter mode, Alfred von Bachmayr, Architect 1979 (l) and a private residence in Albuquerque's north valley, summer mode, Don Felts, Architect 1985 (r).

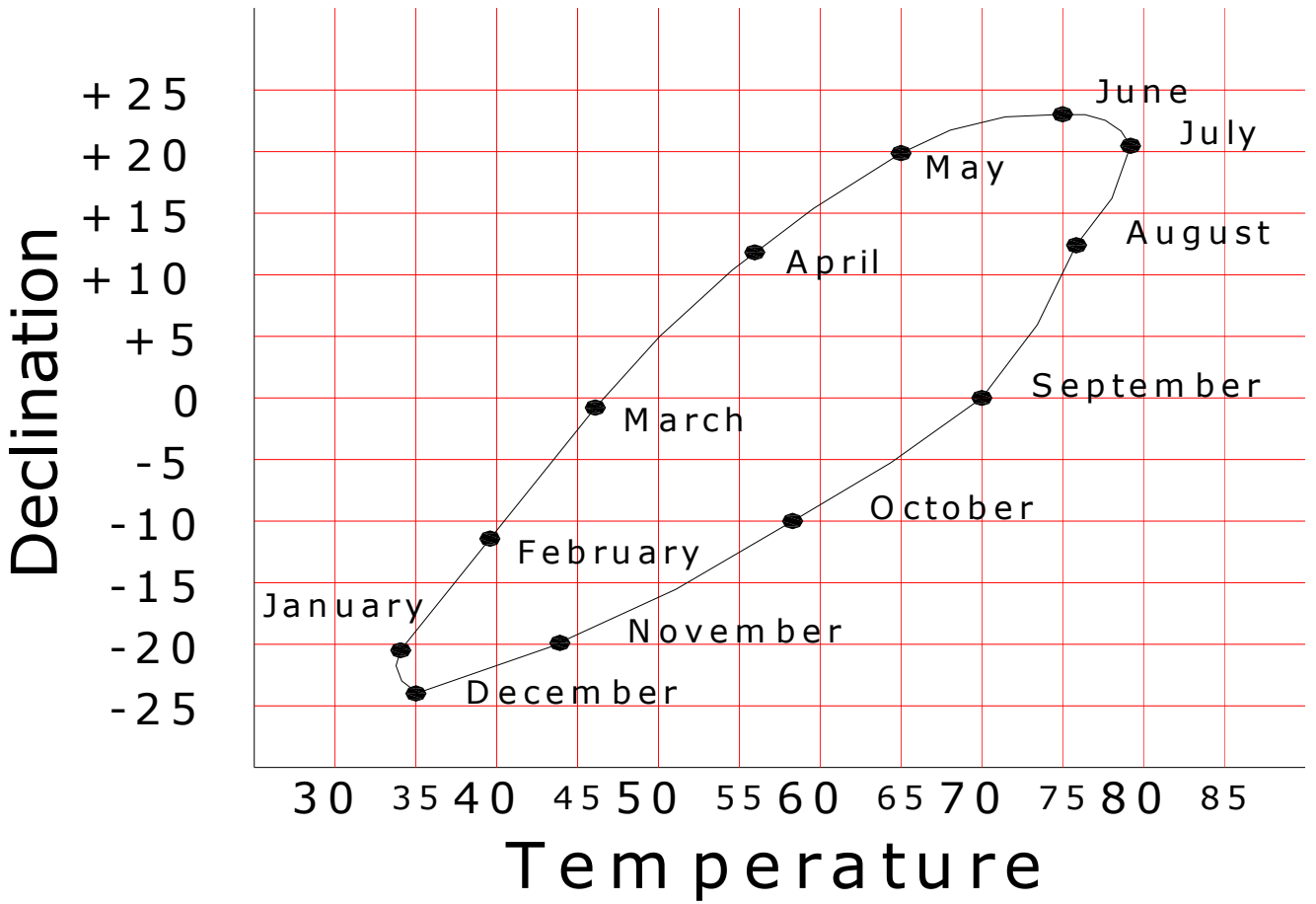
Sunbender vs: Clerestory



Sunbender® Performance (12 Months) in Albuquerque, New Mexico



Graph demonstrating the differences in temperatures at the equinoxes in Albuquerque, NM



Skylight Glass Open - Warm Air Flows Out. A House Benefits from as much as 2 cfm/sq.ft. Thermal Mass. Over-center Lever Makes Opening and Closing Vents Fast and Easy.

Andy Shack* – Heated and Cooled by Unglazed Skymats™ in Zomeworks Yard, Albuquerque, NM

*(Test Building for experiments 1988 - Present)

Andy Shack Louvers Open - 8” Thin Wall PVC Irrigation Pipes on 12” Centers are Visible.

Inside Andy Shack Reflective Thin Gauge Aluminum Louvers Closed to Prevent Heat Transfer Down. Allows Storage of Much Heat in Pipes Above.

Double Play™ System using Skymats™ to Cool Studio for Bruce Davis, Architect, Albuquerque, NM (2004)

Water Wall Storage of Heat and Coolness, Davis Studio

Double Play™ Radiator/Absorber
Zomeworks Roof, Albuquerque NM (2005)

Double Play™ Heat Storage Zomeworks Office Stores Coolness from Summer Nights and Heat from Winter Days

Double Play System / Dave House North
Zomeworks Corporation
Albuquerque, NM
2009

Dave House North
Ceiling Louvers Open

Dave House North
January 20, 2008
Albuquerque, NM

Sun Dog

Light From Sun Dog
in Sandra's Office, Zomeworks -1

Light from Sun Dog in Sandra's Office (2)

Sun Shelf Lighting Double Play Building

Light From Sun Shelf in Zomeworks Shop

Plus…The Once Ubiquitous Passive Solar Dryer, Now Seldom Seen, Clothesline