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The Solar Survey

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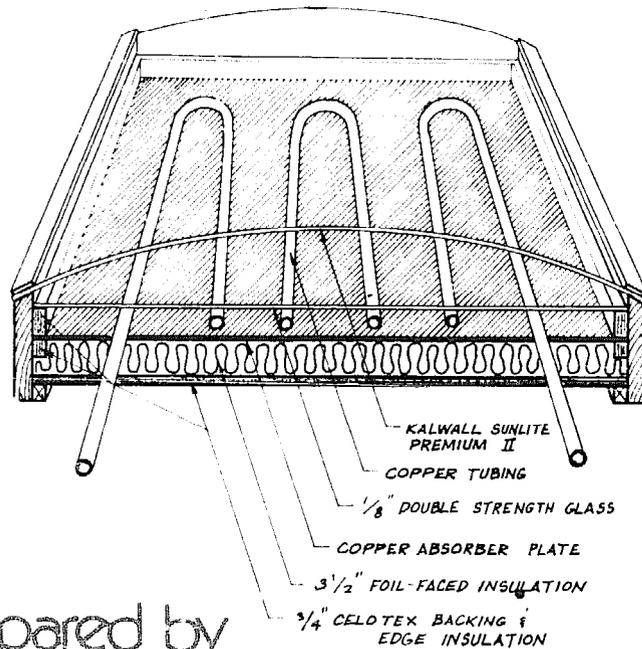
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# the Solar Survey



Prepared by  
**the National Center for  
Appropriate Technology**

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# The Solar Survey

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## The Solar Survey

Community-built and Do-it-yourself  
Solar Heating Systems

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## INTRODUCTION

This survey of solar projects was undertaken by the National Center for Appropriate Technology to compile information about low-cost, community-built (and do-it-yourself) solar collectors. Individuals and small groups are a traditional source of innovative technical research in this country; in solar energy the most significant contributions have come from this grassroots level. But many of the groups that are designing and constructing solar devices aren't aware of each other's work. Each may encounter and resolve similar problems, but they do so independently; often, the valuable experiences of these groups are communicated only in the most informal ways.

NCAT hopes that small groups will be assisted by a publication that summarizes as much of this practical, hard-won information as can be gathered from scattered sources. The survey coordinators put together a mailing list that included community action programs, solar energy associations, state agencies, colleges, and individuals who might be working on design and construction of solar collectors.

Approximately 300 survey questionnaires were sent out; more than 50 groups responded.

Many groups doing research in this field were undoubtedly overlooked in the initial mailing of questionnaires. We hope their projects can be included in future editions of the **Solar Survey**.

Nineteen organizations submitted detailed information on their collectors. These systems are described and illustrated in the survey. The names and addresses of twelve other groups that have had some experience in solar energy, along with short summaries of their activities, are also included.

NCAT doesn't endorse or guarantee the design, materials, construction or utilization of any of the collector designs reviewed in this publication. The purpose of the survey is to make these designs available to a wide audience rather than to critically evaluate their efficiency and serviceability. In many instances a responding group noted a flaw in its design that was corrected or a material that didn't perform well and was replaced; this information was included in the description of the unit. Some of the designs may have been changed since the time this information was submitted.

Although the performance of most of these collectors has not been formally tested, users have expressed satisfaction with the designs. NCAT has funded some testing of solar designs, and is developing a facility near its offices in Butte to conduct evaluations. Construction of untested solar designs provides useful experience for the participants, but the legitimization of such relatively low-cost units ultimately will depend on independent testing and monitored performance in actual installations over a period of years.

Most of the collector systems in this booklet are relatively low in cost. Survey respondents often noted that

materials had been purchased wholesale or scrounged, or listed substitutes that might further cut construction costs. A description of the Minimum Energy Building, designed by Atmospheric Sciences Research Center, is included despite the fact that it cost \$15,000 to construct. The energy conservation techniques utilized in the structure, and its combination active and passive solar system, can perhaps be applied in other, less sophisticated designs.

If you have questions about any of these collector systems, or need additional information, please direct your inquiries to the project concerned. These groups aren't affluent, so remember to enclose a self-addressed stamped envelope for the reply.

If you would like to comment on the content or format of the survey, or suggest additions or changes that might make it a more useful resource, please write to us. Several groups that weren't involved in solar work told us they had forwarded the questionnaire to a group that was. We would appreciate your efforts to help us reach all possible sources for future editions of the **Solar Survey**.

We hope to revise and update this survey annually. Those who want to be included in the next edition should send us their names and addresses so that we can add them to our questionnaire mailing list. As we gather more data and receive suggestions for changes, the survey will be improved to meet our readers' needs; this sampling of projects will develop into a continuing exchange of information on community-built solar designs.

# the Solar Survey

## GLOSSARY

**S**olar heating systems generally are classified as *active*, *passive* or a combination of the two, called *hybrid*. **ACTIVE SYSTEMS** are those that use mechanical devices (such as blowers or pumps) to move the transfer medium (usually air, water or a water-antifreeze mixture) from the place where solar heat is captured to the place where it is stored or used. **PASSIVE SYSTEMS** accomplish this heat transfer by natural means — conduction, convection and radiation. Both types of systems use thermal mass for heat storage. Other terms used in the text of the **Solar Survey** are:

**ABSORBER** or **ABSORBER PLATE:**

A sheet of material, usually copper, aluminum or steel, which absorbs solar heat and conducts it to the transfer medium. In some systems, this function is performed by the side of the building or by interior masonry elements like floors and walls.

**COATING:** Flat black paint or some other highly absorptive substance applied to the absorber plate to help soak up rather than reflect sunlight.

**COLLECTOR:** A device to trap the sun's radiation and convert it into usable heat. A well-designed building with south-facing windows may be considered a collector in the broad sense of the term. In its most common usage, *collector* refers to a panel made up of an absorber plate and glazing, surrounded by an insulated frame.

**CONDUCTION:** Heat transfer within an object or between adjacent objects; the handle of a poker gets hot when its pointed end is placed in a fire because the metal *conducts* heat. The process of conduction may transfer heat across airspaces that are too small to permit convection.

**CONVECTION:** Heat transfer by means of a moving fluid like air or water. *Gravity convection* (also called gravity circulation) is the tendency of a warm fluid to rise or a cool fluid to sink under the influence of gravity. Thus, warm air rises toward the ceiling of a room while cold air moves toward the floor.

**DRAINDOWN:** A type of active solar heating system that uses water as the transfer medium. The water is drained out of the collector on cold nights to prevent freezing.

**FRAME** or **BOX:** The structural elements that hold together the glazing, absorber and insulation of a solar collector.

**GLAZING** or **COVER:** The transparent sheet that admits sunlight to — and then inhibits the escape of heat from — a solar collector.

Commonly used glazing materials are acrylic, fiber-reinforced plastics and glass. Plastic covers are marketed under a variety of brand names, including Kalwall, Mylar, Tedlar and Filon.

**INSULATION:** A material that inhibits the transfer of heat. The best insulating materials for use in solar collectors are fiberglass and polyurethane foam.

**MECHANICAL SYSTEM:** In active solar systems, mechanical devices like pumps and fans convey the transfer medium from the collector through pipes or ductwork to storage, and from there to rooms where heat is needed.

**RADIATION:** The flow of energy, including solar energy, via electromagnetic waves.

**STORAGE:** The area utilized to retain the solar-heated transfer medium for later use. The thermal mass of water, rock and masonry is most commonly used for storage.

**THERMAL MASS:** That characteristic of a material that allows it to store heat. Water has a greater thermal mass than stone or concrete, which in turn retains more heat than wood.

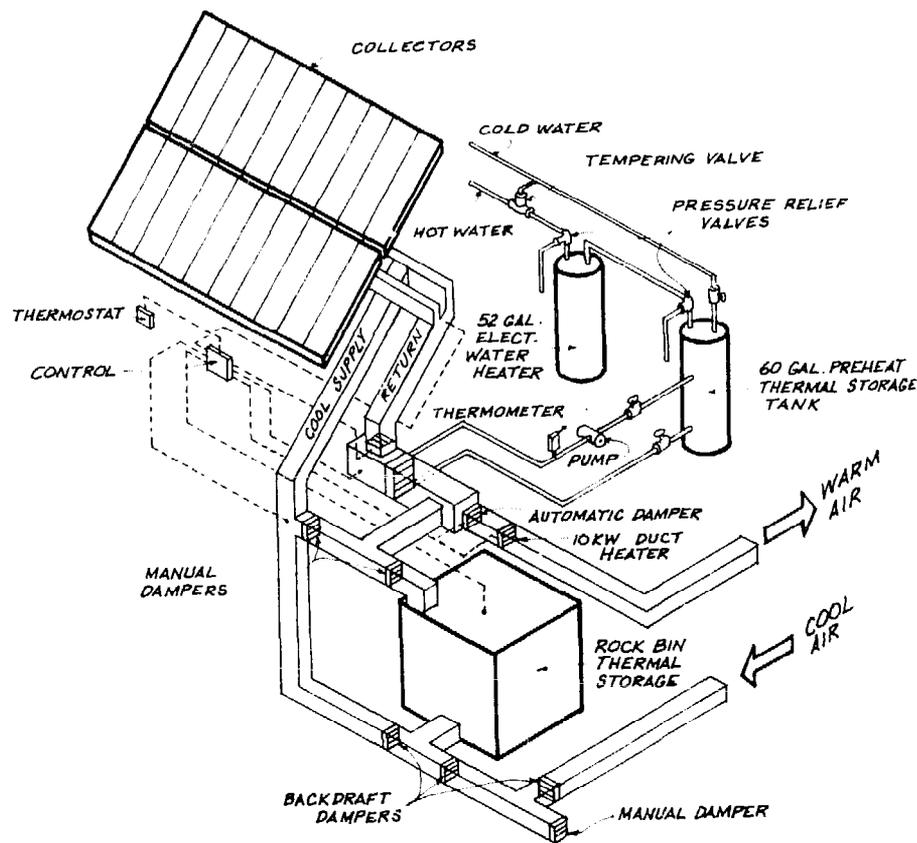
**THERMISTOR:** A type of electronic temperature sensor.

**THERMOSTAT:** An automatic control that stabilizes temperatures in a mechanical system by transferring heat within a building.

**THERMOSIPHON:** The process in which a heat transfer medium moves by gravity convection in a closed-loop system.

**TROMBE WALL:** A masonry wall located directly inside south-facing glazing. The wall functions simultaneously as a structural element of the building and as a solar collector and heat storage unit. It was named after a Frenchman, Felix Trombe, who developed it in collaboration with architect Jacques Michel.

## SRAC SYSTEM DESIGN SCHEMATIC



**Absorber:** In the original design, a thin film of Enersorb (TM), a flat black urethane resin, was applied to v-corrugated Foamglas (TM). This closed-cell glass foam insulating material is non-reactive and heat-resistant; the v-corrugations increase the surface absorption area. Foamglas, however, is brittle and subject to crazing. The designers have been experimenting with other materials, particularly black chrome, for the absorber plate.

**Frame:** Constructed of high-temperature epoxy with fiberglass reinforcement, the 22-5/8" x 70-5/8" frame is lightweight, rigid and moisture-resistant. A support flange (lip) facilitates installation in roof trusses. Aluminum stripping with rubber gaskets covers the flanges.

**Glazing:** Water white 3/16" tempered glass is used for the outer cover. Kalwall .040" Sunlite Premium fiberglass forms the inner glazing. There is a one-inch space between the two glazings.

**Insulation:** Foamglas, R=2.63. The sides are not insulated since the panel is designed to fit into the roof.

**Mechanical System:** Air is forced through the solar collectors by a separate blower (size not given). Heated air from the collectors then passes through ducts either to storage or directly into the interior of the house via a conventional forced air heating system.

**Storage:** Rock bin and 60-gallon water storage tank with preheat coil.

**Cost:** SRAC estimates that the collector can be produced and installed for approximately \$6.00 per square foot, which would make the system competitive with conventional electric heating systems in West Virginia.

**Labor and Tools:** Information not yet available.

**Performance:** Testing underway.

### Designer Comments:

(from the SRAC preliminary report)  
"Our goal is to produce and install a system that will immediately result in a 25 percent reduction in the homeowner's monthly heating cost."  
"... pretest analysis indicates that there is a potential 10 percent increase in efficiency with the two-pass system because the amount of heat loss to the outside is substantially reduced."

### Project

Social Research Applications Corp.  
800—18th St., N. W.  
Washington, D. C. 20006

North Central West Virginia  
Community Action Agency, Inc.  
208 Adams St.  
Fairmont, West Virginia 26554

### Consult:

Joe Straub, SRAC Vice President,  
(202) 462-6130

Kenny Dean,  
(304) 363-2170

Under a contract with North Central West Virginia Community Action Agency, SRAC has designed a low-cost residential solar heating system. The collector panel is currently being tested by Desert Sunshine Exposure Testing, Inc., in Arizona. If the system is approved by

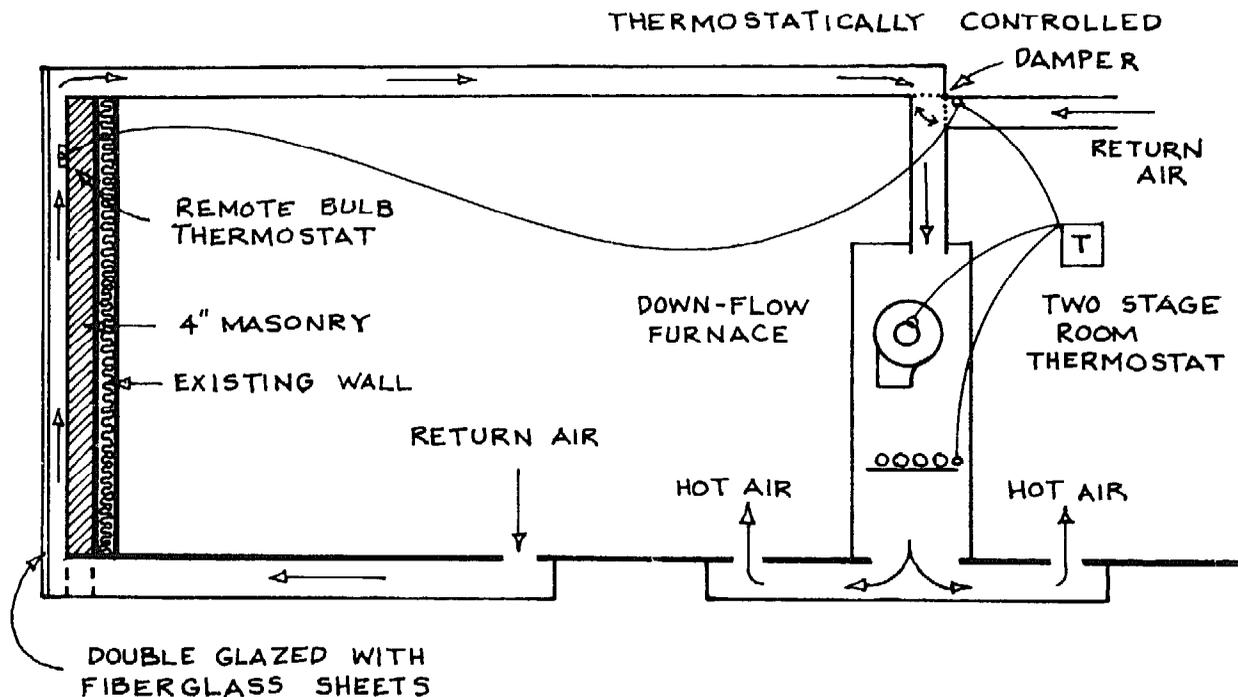
the Federal Housing Administration it will be incorporated into a test house.

NCWV CAA proposes to use this collector system in the HOMES (Housing of Mountaineer Efforts) low-income residential building program, under which FHA will finance approximately 150 houses per year in West Virginia. The solar panels for this large-scale construction program would be manufactured in the state.

### System Description

The SRAC solar collector features a two-pass air heating design: In the first pass air moves between the two glazings and in the second pass between the inner glazing and the absorber. The solar system will provide room heat and hot water pre-heat.

# the Solar Survey



## CRHDC — TROMBE WALL HYBRID SYSTEM

### Project

Colorado Rural Housing  
Development Corporation  
119 Bridge Street  
Brighton, Colorado 80601

### Consult:

Rick Reynolds, (303) 659-1044

At the time of this survey, CRHDC, with construction sub-contractors and self-help applicant families, has built 24 solar heating systems. These have been installed in new homes; project staff would like to experiment with retro-fitting the system.

### System Description

"This system could be considered a hybrid solar design. It combines the passive heating of the Trombe wall with forced-air action of a down-draft furnace."

**Absorber:** A Trombe-type wall (9' x 18') constructed of 4"-wide concrete block and coated with smooth, trowel-applied stucco and high-

temperature black paint, pre-heats air to furnace.

**Glazing:** Two layers of fiberglass spaced with 1x2" strips. Inner layer, .025" Kalwall; outer layer, .040" Kalwall.

**Insulation:** 1/2-inch of Celotex and 5 1/2 inches of fiberglass batt in stud wall behind collector. Insulation is covered with 1/2-inch gypsum drywall.

**Mechanical System:** A two-stage thermostat controls room temperature and determines when the damper will open to admit air from the collector or when the back-up heat will be activated. A second remote bulb thermostat, set at 70° F. is placed inside the collector. If air from the collector is 70° F. or above (and heat is required), the room thermostat will open the damper and solar-heated air will be used in the system.

**Storage:** "The 4-inch block wall is fully grouted and is the heat storage for the cover."

**Financing:** Community Services Administration and Colorado Division of Housing grants.

**Cost:** Not given.

**Labor:** 40 hours per system.

**Tools Required:** Not given.

**Performance:** Not yet evaluated. Agency reports that 35-50 percent heating bill reductions (compared with cost of heating) are typical.

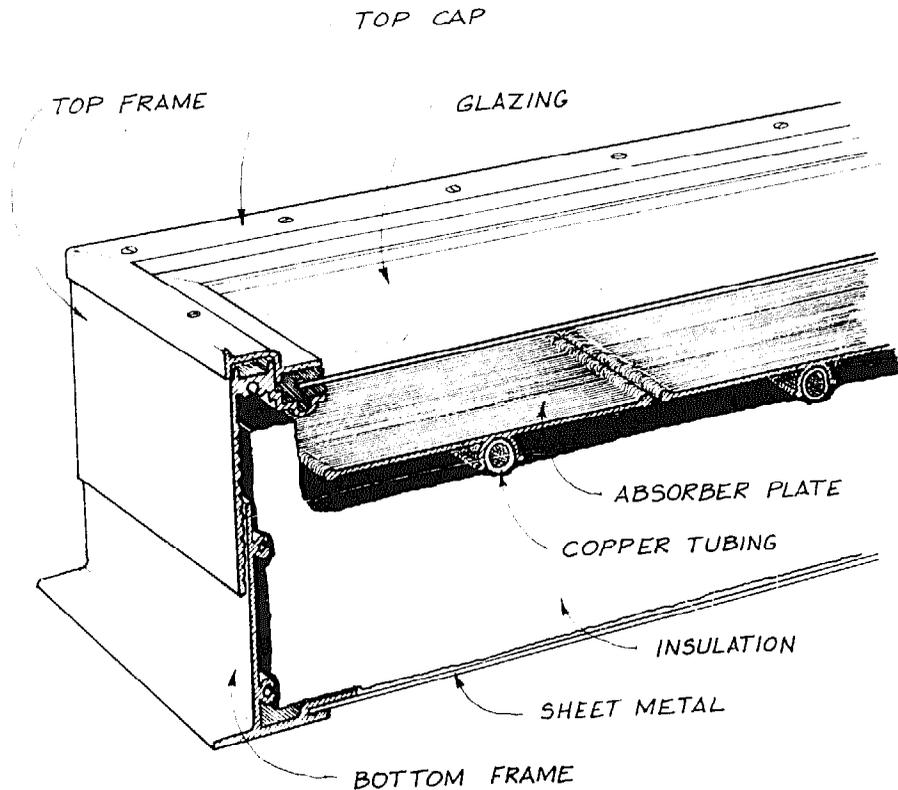
### Builder Comments:

"We are no longer applying a strucco finish to the collector wall. This was originally intended to cut down on air friction. It proved difficult to control the quality of the plastering and only added unnecessarily to building costs."

### Post-survey Note:

Five additional systems with an 8' x 36' collector wall will be built with HUD funding. These new units may provide up to 75 percent of the heating requirement for the houses.

## INSTITUTE FOR LOCAL SELF-RELIANCE — COLLECTOR CROSS-SECTION



**Glazing:** Single cover of 1/8" Plexiglas. The plexiglas is a standard pre-cut size that fits directly into a neoprene seal in the glazing frame.

**Insulation:** Rigid 2-inch urethane foam board was cut to fit the back and sides of the frame.

**Mechanical System:** A Rho Sigma controller regulates a 1/20-hp Grundfos pump. The first controller they purchased didn't work and the unit had to be re-ordered. The solenoid coils in the draindown regulator (a package from Heliotope) didn't work properly, so the system is drained down manually in winter. They plan to purchase another regulator.

**Storage:** Heated water from the collector is stored in an 82-gallon tank. There is no heat exchanger and no heating element in the tank.

**Financing:** NCAT

**Cost:** \$256.00 per 4' x 8' panel.

**Labor:** About four hours for pre-assembly; 24 hours per panel in the workshop.

**Tools Required:** Drill, screwdriver, sàhre saw, utility knife, propane torch, gloves, goggles, and caulking gun.

**Performance:** Not tested.

### Builder Comments:

We originally tried to solder copper tube to copper sheet for the absorber plate; however, we found this to be a difficult technique to use in our workshops. We thus turned to the commercially available extruded aluminum fin arrangement, in which the copper tubing can be snapped on.

The water temperature in the storage tank in summer gets to about 120° F. In winter, it reaches about 80-90° F. This lower winter temperature is acceptable because the hot water is used mostly for washing hands and for cleanup. For domestic use in the D.C. area, one collector panel could be used to preheat water for a conventional water heater. A two-panel system would probably suffice for all water heating in an average home, even in winter. David Cawley noted that New Jersey Aluminum Company has a toll-free customer assistance number: 1-800-631-5856. Their address is: P.O. Box 73, North Brunswick, New Jersey 08902.

### Project

Institute for Local Self-Reliance  
1717 19th Street, N.W.  
Washington, D.C. 20009

### Consult:

David Cawley, (202) 232-4108

The Institute for Local Self-Reliance is exploring the potential for community self-sufficiency by: utilizing decentralized energy technologies; finding new sources of credit for neighborhood enterprises; producing food in greenhouses and rooftop gardens; and developing solid waste collection and recycling systems. They have conducted several collector building workshops through Neighborhood Housing Services, a community organization that helps people in the District of Columbia area obtain mortgages and loans for home improvements.

### System Description

ILSR is the only group in our survey that chose to use primarily off-the-shelf components for their collector system. They built and installed a 4' x 8' collector panel that heats the water for their offices.

**Absorber:** Half-inch copper tubing is snapped into clips on the back of extruded aluminum fins. The pre-fabricated fins were purchased from New Jersey Aluminum Company. The tubing runs into 3/4-inch headers. David Cawley noted that the copper-to-aluminum absorber might corrode in the future, but they haven't had any problems in the first year's operation.

**Frame:** A pre-fabricated aluminum frame was ordered from New Jersey Aluminum and assembled by agency staff. The back is 20-gauge sheet metal, purchased from a local supplier.

## Project

Ecotope Group  
2332 E. Madison  
Seattle, Washington 98112

## Consult:

Ken Eklund, (206) 322-3753

Ecotope Group has done research on flat plate collectors, greenhouses and biomass. The staff conducts weekend workshops on solar energy throughout the West, emphasizing local projects that use available tools and materials and train "solar enthusiasts" who then can teach others in the region. Ecotope's motto is "Ask not what your country can do for you, do it yourself."

## System Description

Ecotope has designed a solar heating system for domestic hot water that feeds into an existing hot water heater. The solar storage/preheating tank must be placed at least one foot above the collector panels for the system to function as a thermosiphon.

**Absorber:** Corrugated steel roofing painted flat black forms the absorber plate of each 4' x 8' collector panel. Rigid copper tubing is soldered or wired to the plate. Thermal mastic will crack and separate. "In past workshops the pipes have been soldered to the absorber plate, but this is now considered time consuming and unnecessary. . . glazing materials are much more the limiting factor in performance than is the conductivity between plate and pipe."

**Frame:** Glued and nailed 2x4s with 1/2" CDX plywood back.

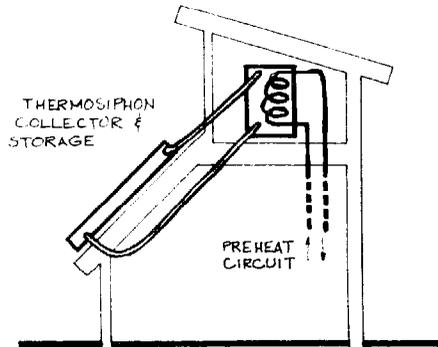
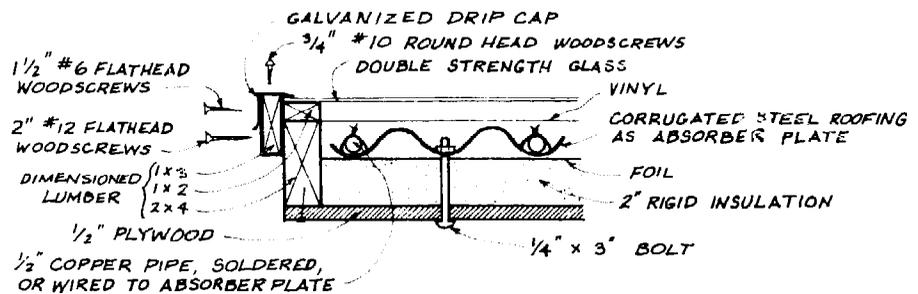
**Glazing:** Double tempered glass and vinyl sheeting with a 3/4" airspace between these two layers. "We recommend the glass/vinyl combination for best collector performance. Fiberglass (Kalwall or Filon) is recommended only if the system is to be portable or is subject to vandalism.

**Insulation:** Two-inch rigid fiberglass or foil-faced styrofoam, applied to back of collector only.

**Mechanical System:** Thermosiphon (gravity circulation).

**Storage:** One 30-to-80-gallon hot water tank with gate valves at inlet and outlet. Connect storage to distribution system, if appropriate.

## ECOTOPE — COLLECTOR CONSTRUCTION



SYSTEM SCHEMATIC

**Financing:** By owner, or through workshop fees.

**Cost of Materials:** Not given

**Labor:** Not given.

**Tools Required:** Pipe cutter, propane torches, electric drill or breast drill, wire cutters, wrenches, pliers, hammer, saws, stapler, screwdriver, utility knife, mitre box, wood chisel, pop-rivet gun, squares, sawhorses, caulking gun.

**Performance:** Not given.

## Builder Comments:

"When assembling the materials for this unit, one should try to purchase as many items as possible at wholesale outlets . . . This is especially true for the plumbing supplies which constitute a major portion of the expenses (about 1/3 to 1/2) . . . Shop around carefully for glass; wholesale prices vary widely and 'scalping' is frequent and common."

## Project

Solar Energy Association of  
Northeastern Colorado (SEANC)  
2025—5th Avenue  
Greeley, Colorado 80631  
SEANC is a non-profit solar group primarily concerned with homebuilt and low-cost energy systems. In-

dividual and family memberships are \$7.00 per year; commercial organization dues are \$15.00 per year. Membership includes a subscription to the Association's newsletter, **The Solar News Collector**.

This group has published a construction and installation manual for a 12' x 8' flat plate forced air collector.

**Schematics for the "North" Collector: Theory, Calculations, Glossary, Bibliography**, is available from SEANC at \$3.00 per copy.

## Project

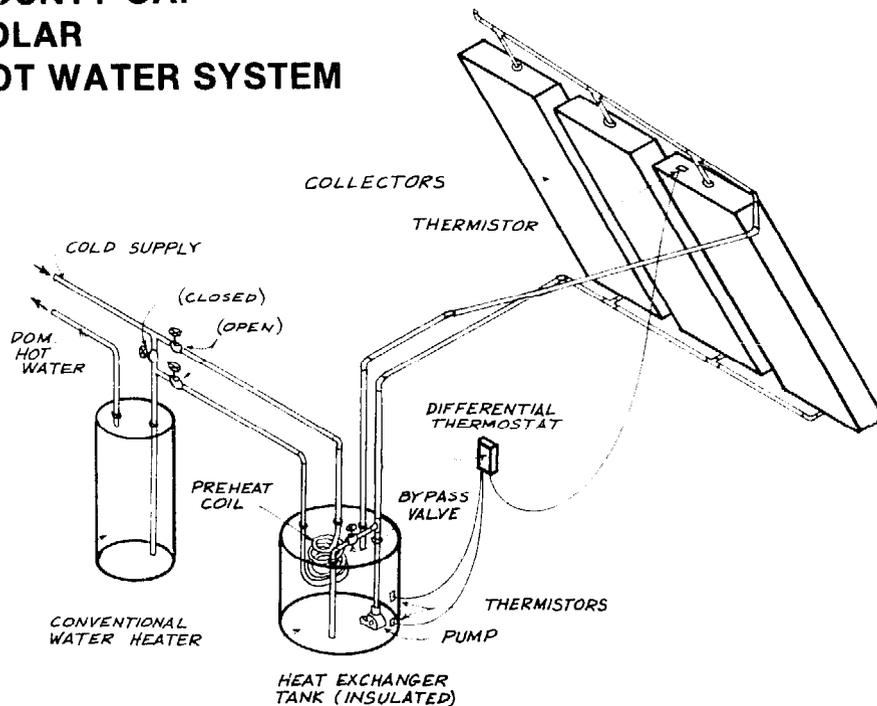
Upland Hills Ecological  
Awareness Center  
481 Lake George Road  
Oxford, Michigan 48051

## Consult:

Phillip Moore, (313) 628-5116

The Center conducts workshops on solar and wind energy applications. Over the past five years staff and workshop participants have built many solar devices, including: Thomason collectors, copper water heaters, window box heaters, beer can collectors, Fresnel lens collectors and a focusing collector. They can be contacted for the construction details of these systems.

## LANCASTER COUNTY CAP— SOLAR HOT WATER SYSTEM



with plastic pipe. A bypass valve permits adjustment of the amount of water flowing through the panels. A differential thermostat mounted near the storage tank controls the pump, shutting it off when no heat is available from the collectors, thus allowing the system to drain.

**Storage:** The storage tank must be rustproof and sturdy enough to hold about 500 pounds of water. A 60-gallon plastic garbage can, an oil drum with plastic liner, or a heavy plywood box with liner could be utilized. The tank is mounted on a concrete block base near the conventional water heater. It is insulated with six inches of fiberglass on the sides and two inches of blue styrofoam on the top and bottom and is wrapped with polyurethane film. The heat exchanger (Type L 3/4 or 5/8-inch copper tubing) is suspended in the top of the tank and is connected to a cold water line and to the water heater.

**Financing:** CETA Title VI funds.

**Cost of Materials:** Approximately \$500.00

**Labor and Tools:** Not given.

**Performance:** System is being tested by the University of Delaware.

### Builder Comments:

"The University of Delaware has suggested a larger heat exchanger coil, perhaps an additional 60 feet of 3/4-inch copper. This will increase the cost of the unit by about \$45."

### Project

Lancaster County Community Action Program  
Energy Conservation Center  
630 Rockland Street  
Lancaster, Pennsylvania 17602

### Consult:

John Young, (717) 397-6267

The Energy Conservation Center, funded by the Comprehensive Employment Training Act, provides information about solar energy and other appropriate technologies to low-income residents of Lancaster County. Outreach workers and two-building teams assist local homeowners in their efforts to conserve energy and fight rising fuel costs.

The solar water heating system described here has been installed in more than a dozen homes in the region. It was designed by Chris Fried, a consultant for the Pennsylvania State Weatherization Program. Mark Hopkins, Mike Verwey and John Young built the Lancaster County units and prepared a construction manual for the system. They recommend a three-panel system with a 60-gallon storage tank for most families.

### System Description

One or more collector panels pre-heat the water entering a conventional water heater. Water circulates through the absorber plate and enters a well-insulated storage tank, where the heat exchanger picks up the heat and transfers it to the conventional water heater.

**Absorber:** Each collector panel has a 22" x 96" Kennecott Terra-Light copper absorber plate. These plates are less expensive than other commercial plates, but are lightweight and fragile and must be handled with care.

**Frame:** The collector box is constructed from 1x6 boards; side and cross supports are cut from 1x2 furring. A 23 3/4-inch by 8-foot piece of 3/8-inch plywood is used for backing.

**Insulation:** Six-inch fiberglass batt covered with heavy-duty aluminum foil.

**Glazing:** Single layer Filon or Kalwall fiberglass secured with 1" x 1" aluminum L-molding.

**Mechanical System:** A small submersible pump (recommended, Little Giant No. 2E-38N) with a 115-volt power supply is installed in the bottom of the storage tank. The collector panels are connected to the tank

### Project

Passamaquoddy Tribe  
Pleasant Point Housing Authority  
P. O. Box 339  
Perry, Maine 04667

### Consult:

Norman Laberg, (207) 853-2790

The Tribal Council, under a government grant, has built two hot water collectors, utilizing 1/2-inch copper tubing soldered to sheet metal and a double Kalwall glazing. They noted that the units were never installed in working systems "... although fine for the home tinkerer, (the absorber plate) was not viable on a community level where wages were concerned, particularly with plates presently available such as Olin Brass supplies."

## Project

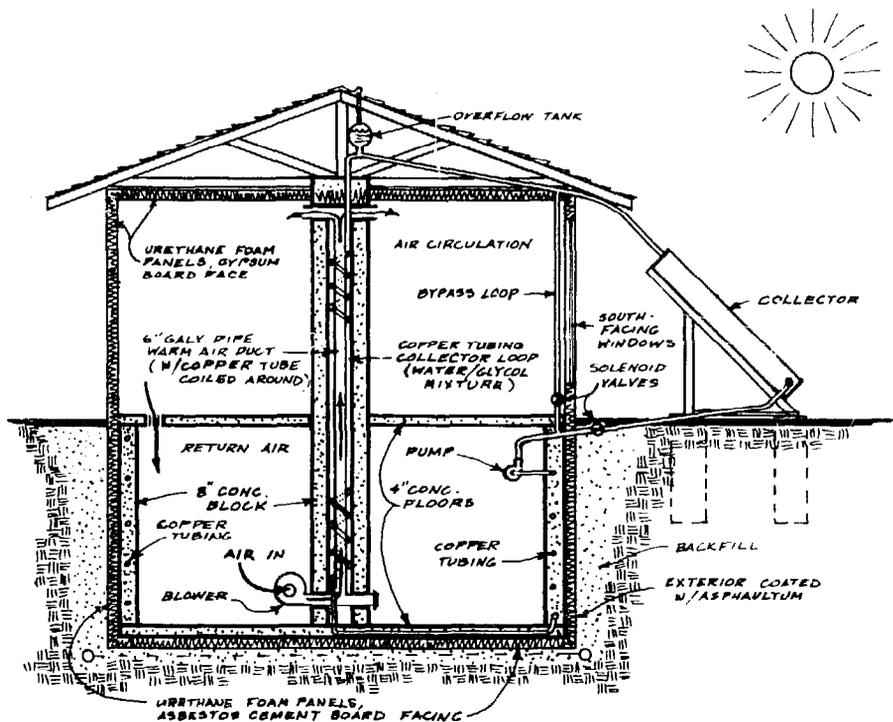
Atmospheric Sciences Research Center  
State University of New York at Albany  
1400 Washington Avenue  
Albany, New York 12222

## Consult:

Donald McClenahan (518) 457-4824

A solar-heated "Minimum Energy Building" was constructed in Schenectady County in 1975 by ASRC, in collaboration with students, volunteers from the community, and the Advance Cooler Manufacturing Company. The designers of the project wanted to show that solar energy space heating is a valid technology in cold climates, and their goal was to produce comfortable living conditions year round without using conventional fuels. The energy conservation concepts applied to the system are air-tight construction, massive insulation, structural thermal storage and efficient collectors.

## ATMOSPHERIC SCIENCES RESEARCH CENTER — MINIMUM ENERGY BUILDING



## System Description

The Minimum Energy Building has a combination active and passive solar system. The construction of the building and operation of the heating/cooling system will be outlined, and the collector design briefly summarized.

**Construction:** The building faces south so that the windows will receive full sun in winter. Its dimensions are 16' x 20', with an 8' ceiling on the ground level and a 7' ceiling in the basement. The airtight walls, roof and underslab are constructed of polyurethane panels that have a double function: They form the structural supports as well as insulate the interior. Four inches of polyurethane is sandwiched between sheets of aluminum, steel, sheetrock or asbestos cement board, the outer material depending on where the panels will be placed.

The prefabricated 4' x 8' or 4' x 16' panels are sealed together with polyurethane foam. Door and window openings are then cut out of the walls. A foam-core (with a 1/2-inch airspace) door with magnetic weatherstripping and tri- and quad-

pane windows complete the building envelope. The corrugated steel and poured concrete floor is supported by a concrete block foundation. The floor, and the sand-filled concrete blocks that form the basement walls, provide heat storage for the collector. The 79,600 pounds of masonry has a heat storage capacity of over 12,500 BTU for each degree Fahrenheit, equivalent to about 1,500 gallons of water storage.

**Operation:** The collector heats a water/glycol solution that is pump-circulated through 422 feet of half-inch copper tubing embedded in the masonry. The collector loop is controlled by a standard differential thermostat. Heating and cooling thermostats on the ground floor activate a small fan that transfers heated or cool air through a central column to the living area. A switch on the control panel determines heating or cooling mode.

**Collector:** The 5' x 10' solar collector is pivot-mounted so that it can be set at a favorable angle for either heating or cooling. A tube-and-fin evaporator coil (the type commonly used in air conditioners) is the absorbing plate. The wood frame has a

building-panel back and is insulated with 4-inch polyurethane panels, the same as those used in the building. In the heating mode, the front of the collector is covered with a single layer of Kalwall fiberglass and the back with insulated doors. For cooling, the glazing is removed and the doors are opened so that the collector can reject heat by radiation and convection.

**Financing:** A grant from the New York State Legislature.

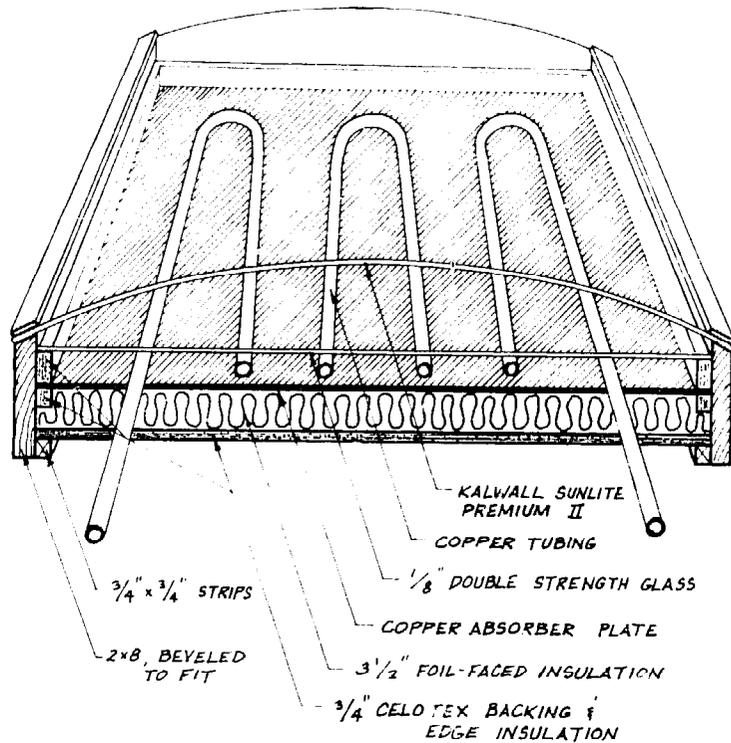
**Cost:** Approximately \$15,000 for the entire building. The cost of the collector was estimated to be \$225, excluding donated materials.

**Hours:** Not given.

**Tools:** Not given.

**Performance:** Winter weather in this part of New York is generally cloudy, with only 40 per cent of possible sunshine, and seasonal heating loads total almost 7,000 degree-days. Over the first winter's operation (1975/76) the average building temperature was 66° F., occasionally dropping as low as 58° F. The designers believe that a larger collector will narrow the temperature range.

# the Solar Survey



**NORTHEAST CARRY — COLLECTOR CONSTRUCTION DETAIL**

## Project

Northeast Carry Trading Company  
110 Water Street  
P. O. Box 187  
Hallowell, Maine 04347

## Consult:

Ron Poitras, (207) 623-1667

Northeast Carry is a non-profit organization offering goods and services "that strengthen . . . farm and household economy, that are energy efficient, long lasting and resource conserving." The yearly membership fee of \$6.00 entitles the member to a catalog of merchandise, design information and workshops on energy-related projects, and a book rental service. The store is open to the public.

## System Description

Northeast Carry has published a clear, concise construction guide for a solar water heating system. The size of the flat plate water-circulating collector (approximately 3' x 8') was determined by the cheapest, most readily available copper sheet. The collector, which weighs about 300 pounds, can be installed on a sloping roof or on a ground support.

**Absorber:** Type M 3/4-inch copper tubing is connected to 180° copper return bends with 95-5 solder (lead and tin) to form a continuous coil. This tubing grid is soldered to 16-ounce copper sheet. The absorber is coated with high-temperature flat black paint. In a pumped system, 1/2-inch continuous-coil flexible copper tubing could be used.

**Frame:** The collector box can be constructed from galvanized sheet metal, fiberglass, construction grade lumber, or treated exterior marine plywood. The material shown in the construction guide is 2x8 pine boards, caulked with silicone and fastened with wood screws.

**Glazing:** A double cover is placed on the collector only after it has been installed (particularly if it is roof-mounted). The inner glazing is 1/8-inch double-strength glass, which rests on 3/4-inch Celotex strips. A minimum of 1/8-inch must be allowed for thermal expansion of the glass panes. The top glazing is Kalwall Premium Sunlite II, secured with sheet metal or aluminum angle.

**Insulation:** 3 1/2-inch foilfaced fiberglass insulation is stapled to the inside of the frame. The guide advises the builder **not** to use styrofoam or urethane, which aren't

resistant to high temperatures, or cellulose, which has a tendency to absorb moisture.

**Mechanical System:** This collector can be used in a thermosiphon system (gravity circulation) or with a pump, if the collector is located above the storage tank. A drain-down system requires a 1/3-hp pump; a 1/20-hp pump is adequate for a closed system.

**Storage:** An 80-gallon hot water tank is the typical size used with this system.

**Financing:** Owner.

**Cost of Materials:** Approximately \$175 for one collector. Total cost of the system, including storage, is about \$350 to \$400.

**Labor:** Twenty hours per unit.

**Tools Required:** Not listed.

**Performance:** "Calculated efficiency averaged 58 percent."

## Builder Comments:

"The more you learn about solar energy the more you realize how variable . . . it can be. Any solar heating system, whether commercial or owner built, is not likely to be carefree and 'automatic' — it will require your involvement and attention."

## Project

Santa Cruz Alternate Energy  
Cooperative  
P. O. Box 66959  
Scotts Valley, California 95066

## Consult:

Brian Williams, (408) 475-6868

The Cooperative has developed two collector designs, one for people who want to build their own collector, but have no access to welding technology, and the other for people who want to manufacture collectors. Through workshops in the community, they have assisted in the construction and installation of several collector systems.

## System Description

The following specifications are for a build-it-yourself flat plate water-circulating collector.

**Absorber:** Copper tubing is soldered to .015" copper sheet; the risers are 1/2" pipe, the headers are 1" pipe. The five risers are each about 5' 9" long and are spaced about 6" apart. The risers are joined to the headers with reducing T's and each header is a total of 40" long. The soldered panel is then coated with a heat-resistant black paint.

**Frame:** The box can be constructed of either wood or light gauge galvanized steel. If wood is chosen, the cooperative can provide plans for getting a box out of one 4" x 8' sheet of 1/2" or 3/4" exterior plywood. The sides are five inches high and three 3 3/4" ribs are spaced 18 inches apart inside the box to provide additional structural strength and support for the insulation.

**Glazing:** Glass is the preferred cover, although special fiberglass and plastic glazings, which are lower in cost and easily applied, are acceptable. "Usually only one cover is used . . . in our climate, but . . . combinations of glass and plastic are possible."

**Insulation:** Recommended material is 3 1/2" fiberglass applied to the back sides of the collector.

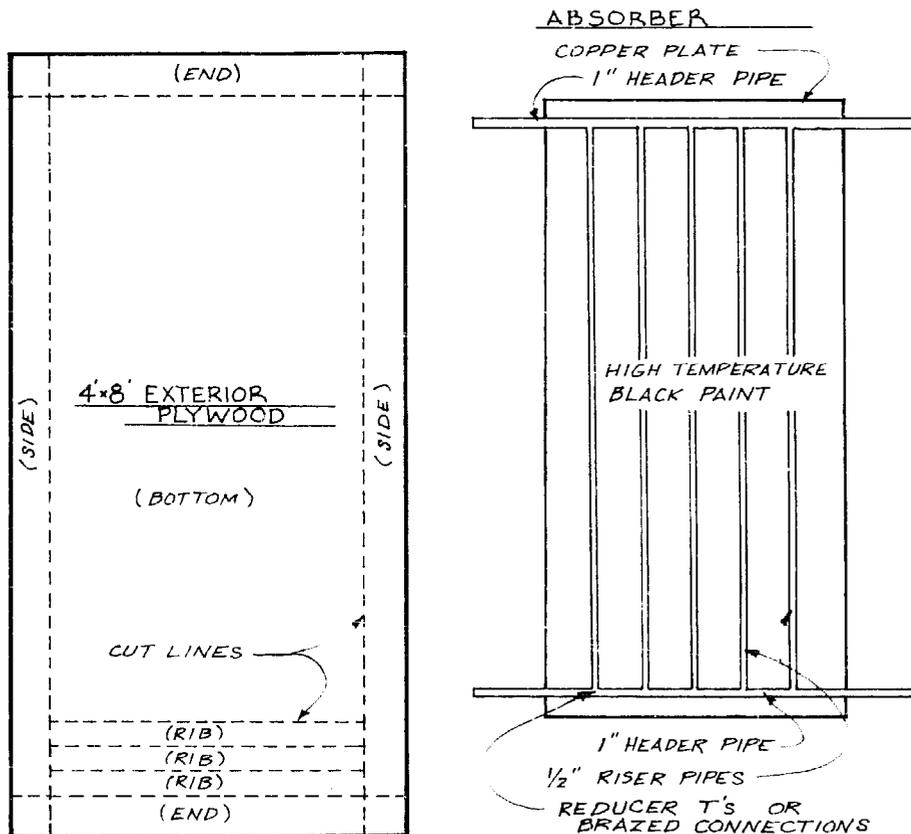
**Mechanical System:** Collector is designed to be used in conjunction with a liquid medium transfer system.

**Financing:** Owner/user.

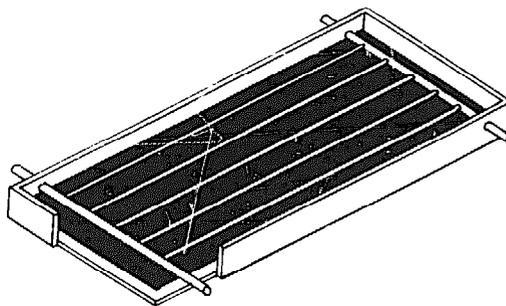
**Cost of Materials:** Approximately \$100, or \$6.50 per square foot.

**Labor:** 20 hours per collector panel.

## SANTA CRUZ— ABSORBER CONSTRUCTION DETAILS



## COLLECTOR BEFORE GLAZING



**Tools Required:** Metal shears, propane torch, and tube cutter.

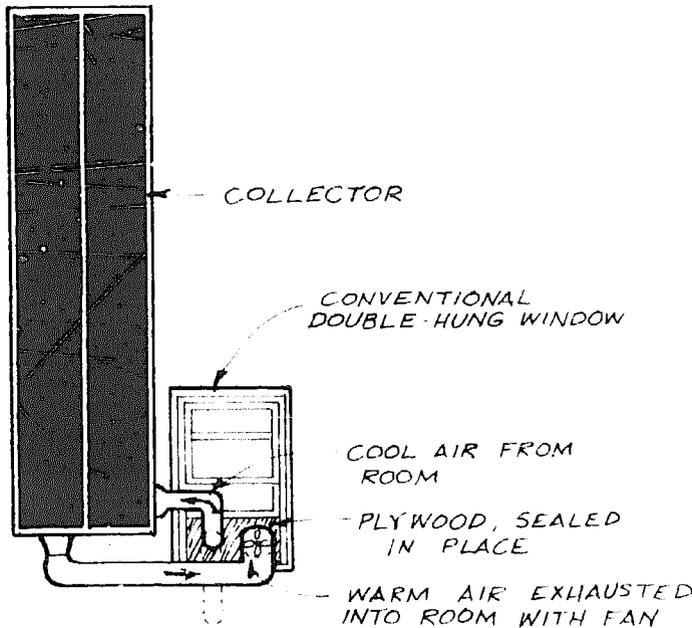
**Performance:** Not tested.

## Builder Comments:

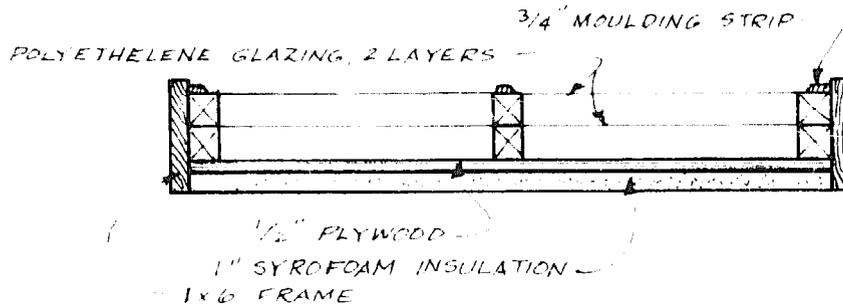
"We specifically recommend that people not build this collector to sell

because . . . the sweat soldered joints are not that reliable at the high temperatures the collector can theoretically get up to. For potential manufacturers, we suggest they invest in learning how to braze, and that the water channels be brazed together with silver solder . . ."

## ALTERNATIVE SOURCES OF ENERGY — "SUN SUCKER"



### COLLECTOR CONSTRUCTION — END-VIEW SECTION



**Mechanical System:** The cold-air intake pipe and the 8-inch exhaust duct enter the house through holes cut in a piece of plywood that was installed in a partially opened double-hung window. The ducting was insulated with 3½" fiberglass and covered with a protective polyethelene tent. Heated air from the collector is circulated by a 300 CFM, 10-inch inline fan. The intake pipe can be removed and a piece of styrofoam inserted to seal off the opening at night and on cloudy days.

**Financing:** CETA Title VI funds.

**Cost:** All new materials were purchased for a total cost of \$93.13.

**Labor:** Approximately 40 hours.

**Tools:** Standard carpentry tools.

**Performance:** The unit produced an 8,000 to 16,000 BTU/hour heat gain during a six-hour operating day.

**Note:** Specifications and graphics were obtained from Eric Larson's article "How to Build Your Very Own Sun Sucker!" **Alternative Sources of Energy**, Issue No. 32, June 1978, pp. 14-15.

### Project

Adams-Brown Community Action Program  
P. O. Box 78  
Decatur, Ohio 45114

### Consult:

Mrs. Nancy Darby, (513) 378-6041

### Project

Alternative Sources of Energy  
Route 2, Box 90A  
Milaca, Minnesota 56353

### Consult:

Donald Marier, (612) 983-6892

The primary activity of this non-profit group is the publication of the magazine **Alternative Sources of Energy**. In February 1978 they built a hot air collector and installed it on the south wall of the two-story frame building that houses their offices.

### System Description

ASE wanted a simple, inexpensive supplemental heating unit. They chose a design by Darryl Thayer of St. Paul, Minnesota, in which heated air from a 4' x 16' vertical wall-

mounted collector is blown directly into the interior of the building.

**Frame:** Two sheets of ½-inch CDX plywood were butted end to end to form a 4' x 16' back. Caulked and nailed 2x2's were used for the sides of the box. The exterior frame of 1x6 lumber was added after the glazing was in place.

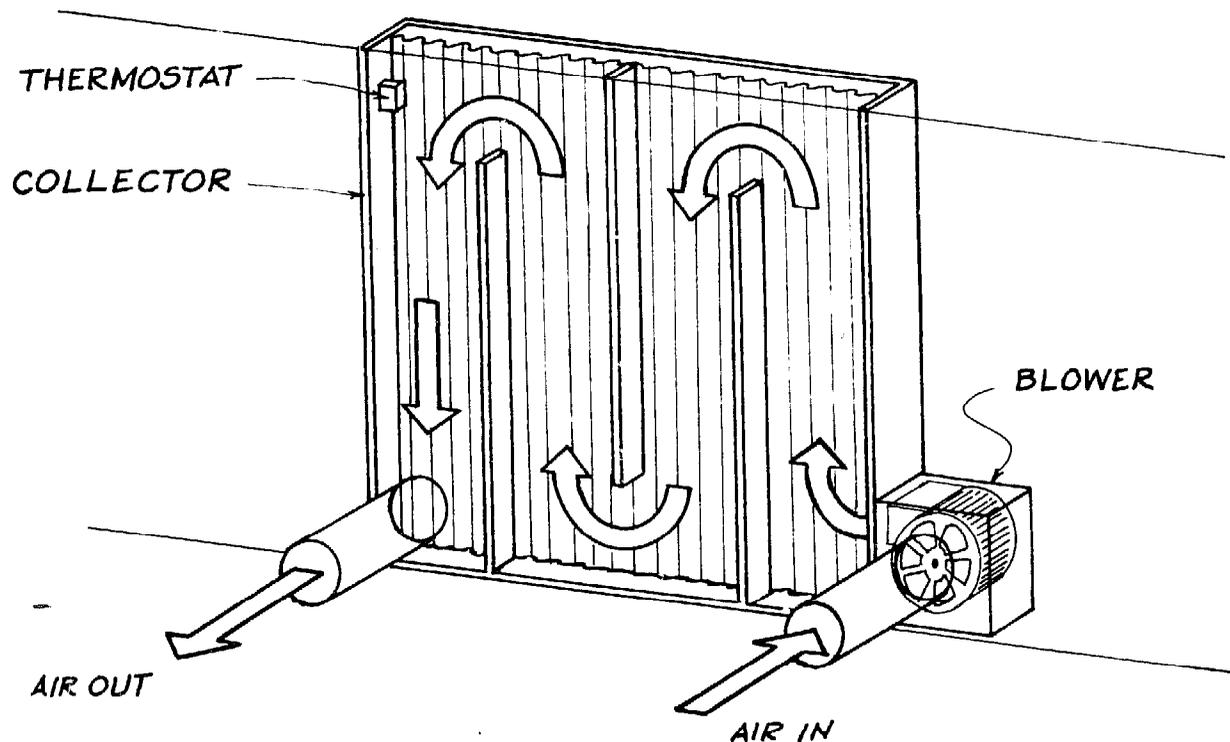
**Glazing:** Polyethelene film was chosen for the glazing material because it is relatively inexpensive. Two layers of film were stapled and caulked to the sides of the frame. The first layer was secured with 2x2 lumber; the top layer was anchored to the 2x2's with a 3/8" x 1" molding strip.

**Absorber:** The interior of the collector box, painted black, acts as the absorber in this design.

**Insulation:** One-inch styrofoam was glued to the back of the frame.

In June, 1974, this agency constructed a small solar-heated house near Sardinia, Ohio, using a design that could be appropriate for low-income families. An air thermosiphon system with integral storage furnishes room heat. A wood frame collector/storage box holds 1,000 plastic (gallon) jugs filled with water and supported in several tiers on 2 x 2 studding. The jugs and the interior of the collector are painted flat black. Salvaged plate glass windows were used for glazing. This collector cost approximately \$500 and required 360 hours of labor.

Mrs. Darby commented, "This type of construction was highly controversial at the time and not well received in this rural conservative community." She noted, however, that attitudes are changing and the community might now be more receptive to solar heating systems.



**WEST CENTRAL MISSOURI—SYSTEM OPERATION**

## Project

West Central Missouri Rural  
Development Corporation  
P. O. Box 125  
Appleton City, Missouri 64724

## Consult:

G. Herbert Gill, Solar Engineer,  
(816) 476-2185

This Community Action Agency has built and installed many solar collectors (10 at time of survey) in its nine-county region. The collector is free of charge to homeowners over age 60 who meet low-income guidelines.

## System Description

The WCMRDC solar collector is a low-cost, vertical forced air unit that is mounted on the south wall of a house. The collector design was developed by Domestic Technology Institute. Mr. Gill, however, modified the layout of the system after evaluating the first units the agency installed. He emphasizes the importance of taking air from and returning it to the living area rather than using an outside, crawl space or basement air intake.

Most of the collector panels are 4' x 8' or 8' x 8', although it is possible to make other sizes as needed. It is

estimated that each unit will collect between 18 percent and 28 percent of the solar energy falling on it, amounting to 18,000 to 30,000 BTU/day for the 8' x 8' panel. This is 50 percent to 100 percent of the heat for a room eight to ten times the area of the collector.

**Absorber:** Small-pitch (1 1/2") corrugated iron, painted flat black.

**Frame:** 1x6 lumber, nailed and glued. Back is 3/8" or 1/2" exterior grade plywood. All joints sealed with butyl, neoprene, or silicone caulk.

**Glazing:** A layer of any one of these materials may be used: 'Ice Clear' fiberglass, 'Lexan', 'Plexiglas', 'Tedlar', 'Mylar', heavy vinyl, or butyl. Do not use polyethylene film—it will melt.

**Insulation:** 3/4" or 1" styrofoam beadboard, preferably aluminum foil-faced, on back of collector only.

**Mechanical System:** A 265-Dayton blower is mounted next to the intake duct to push air through the collector. A thermostat (fan or duct control type used in standard heating systems) is positioned at the top of the last warm air passage, diagonally opposite the blower. The thermostat should have a 25° differential and should be set at 110° F.

Mr. Gill particularly stresses that a squirrel cage blower is designed to blow, not suck air. It is very inefficient in pulling a vacuum, and if it has to suck hot, low-density air at the collector outlet, there will be less air flow. He therefore strongly recommends the blower placement noted above.

**Storage:** None. Heated air moves directly into the house.

**Financing:** Grant from the Model Projects in Aging Program, Department of Health, Education and Welfare.

**Cost of Materials:** An average of \$250 for an 8' x 8' collector.

**Labor:** About 25 hours on an 8' x 8' unit.

**Tools Required:** Miter box, sabre saw, 10" radial saw, 10" table saw, 6" planer, hand drills and hand tools.

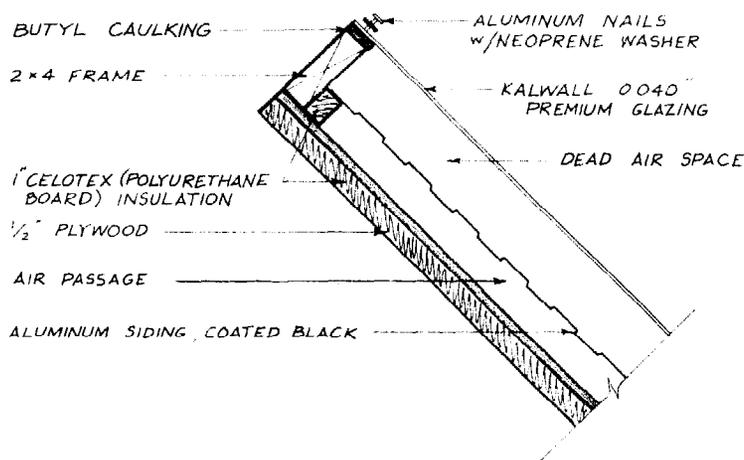
**Performance:** Testing underway.

## Builder Comments:

"To reduce heat loss we may have to insulate the sides of the collector as well as the back.

"As to re-entry into the crawl space, what is the point of using half or more of the energy to heat the ground and foundation walls?"

## SIMPSON— COLLECTOR CROSS-SECTION



### Project

Andrew M. Simpson  
c/o WAMY Community Action, Inc.  
Boone, North Carolina 98607  
(704) 264-2421

Although Mr. Simpson works for WAMY, this is not an agency project. The collector system was built by Mr. Simpson and his father-in-law, Sigmund Orłowski.

### System Description

Ten 4' x 8' collectors (320 sq. ft.) were mounted directly on the roof of an existing two-story house to provide a hot air heating system. The solar system does not interface with the electric baseboard heating system, and so has its own thermostats, relay, fans (one for the collector loop and another for the storage-to-house loop) and differential controller.

**Absorber:** Aluminum siding painted first with zinc chromate primer and then with a layer of Kalwall's absorber coating (one gallon covered about 225 sq. ft.) Heated air circulates behind the absorber.

**Insulation:** One-inch Celotex (polyurethane board), R-8.

**Frame:** Sides constructed with 2x4 lumber, the back with 1/2-inch plywood.

**Glazing:** Kalwall .040" premium fiberglass.

**Mechanical System:** A differential controller for the collector loop, two thermostats connected to each other, a 12-volt relay unit, and a

variable speed switch. The system turns on only when the thermostat at the rock pit reads 80° F. or more and the thermostat in the bedroom reads 70° or less.

**Storage:** An above-ground storage box was added on to the house and filled with ten tons of clean, rounded river rock (\$20 per ton). The box was constructed with standard concrete blocks and insulated with Celotex boards.

**Financing:** Bank.

**Cost of Materials:** Estimated total, \$2000. Collector panels-\$600, storage-\$600, ductwork-\$400, controls and fans-\$300.

**Labor:** "God knows, I don't! 1000?!"

**Tools:** Table saw, hammer, paint-rollers, T-square, caulking gun. Building the storage system also requires a reciprocating saw, a wheel barrow and a trowel.

**Performance:** The system has been partially tested. All controls on the collector loop function perfectly. At first there seemed to be excessive heat loss through the ductwork, but the sensor was being influenced by outside air and its location was changed. The system produces 140-150° of usable heat out of the ducts, with a 15-20 percent heat loss in the ductwork between the collector and the rock storage.

### Builder Comments:

"A retrofit system for hot air would have been immeasurably simpler if the house had already had a hot air central heat system!"

### Project

Big Five Community Services, Inc.  
215 North 16th Street  
P. O. Box 371  
Durant, Oklahoma 74701

### Consult:

Hub Wood, Jr., (405) 924-1021

In 1977 this CAP Agency built a window thermosiphon collector for a total cost of \$15.00. They used aluminum tubes formed from newsprint masters for the absorber. (Newsprint masters are aluminum offset printing plates that are often discarded or sold inexpensively by printing companies.) The tubes were painted flat black and inserted into aluminum manifolds. Corrugated plastic was used for glazing. Performance of the unit hasn't been evaluated.

### Project

Southeast Nebraska Community  
Action Council  
730 1/2 Third St.  
Humboldt, Nebraska 68376

### Consult:

Dan Noll, (402) 862-2411

In 1977 this agency built four vertical forced air collectors, using the plans from Design Technology Institute (see entry for West Central Missouri Rural Development Corporation). High school shop students put together the solar panels; CAA staff installed the units. The cost of materials for an 8' x 8' panel was \$150.00. Performance has not been evaluated.

### Project

Mid-Nebraska Community Action  
Program  
Box 1040  
Kearney, Nebraska 68847

### Consult:

Steve O'Driscoll, (308) 234-2591

In 1977 agency staff built and installed a 2' x 8' air collector. This vertical wall unit has a wooden frame and a thin roofing metal and wire mesh absorber. There is no mechanical system or storage. The cost of materials was approximately \$50. "User said it works great, would like another one. Warmer room."

## Project

West Central Wisconsin Community Action Agency (WEST CAP)  
525 Second Street  
Glenwood City, Wisconsin 54013

## Consult:

David Hewitt or Stephen Scoll;  
(715) 265-4271

WEST CAP staff members, with community assistance, have designed and built several collector systems. A forced air system with furnace backup and an 800-square foot collector heats the renovated church in which the agency is housed. WEST CAP now has a contract to install 20 air collectors for heating hot water in their seven-county area. They will use a modified version of the collector design used in the church system.

## System Description

The agency wanted a low-cost collector that could be constructed from readily available components. They chose an air system rather than a water system because it is less expensive and also easier to build and maintain. The large collector that was installed on the south-facing roof of the church (45° slope) is **not** composed of individual panels. The design, however, has been modified for an 8' x 16' collector, and this unit is referred to several times below.

**Absorber:** An aluminum screening material is crimped into an accordion pleat and stapled to the foil surface of a one-inch sheet of rigid fiberglass. The screen and foil are spray-painted black. The crimped screen increases the surface area of the absorber.

**Frame:** 2" x 6" metal studs on outside edges (next to manifold) with 2" x 4" metal stud lattice inside. Back is 7/16" Aspenite.

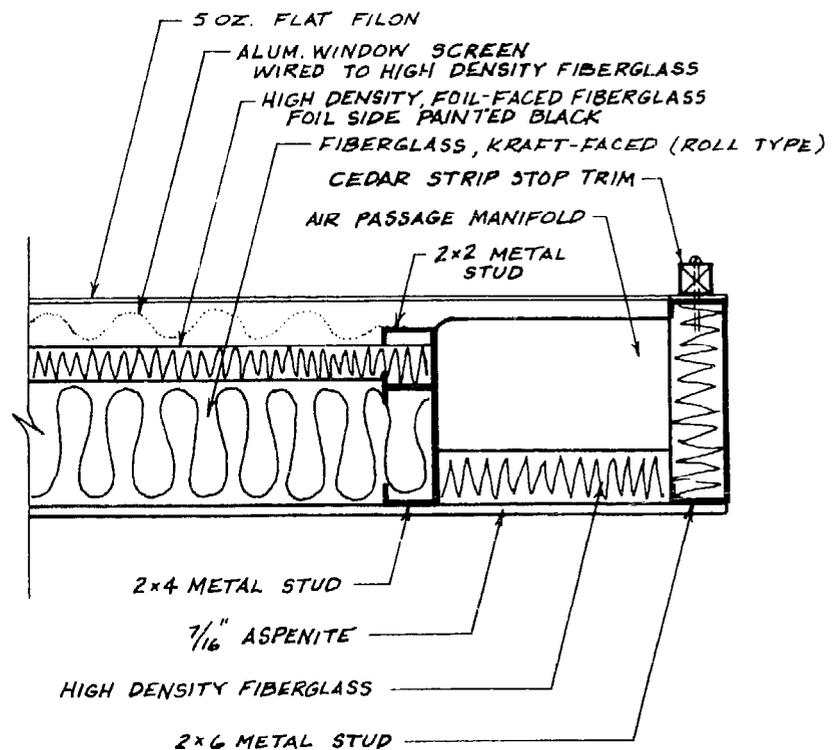
**Glazing:** Single layer of 5-oz. flat Filon fiberglass.

**Insulation:** A fiberglass blanket 3½ inches thick plus two-inch, high-density fiberglass on the sides of the collector.

**Mechanical System:** A blower rated at 1350 cu. ft./min. at .02 static pressure forces heated air through insulation ductwork.

**Storage:** In the church system, a large box filled with 10 cubic yards

## WEST CAP— COLLECTOR END DETAIL



of 1-1½-inch diameter stones provides storage. The aggregate rests on bond beam blocks covered with heavy metal lath. There are two inches of styrene insulation on the top and sides of the tank and one inch on the bottom.

**Financing:** Government grant.

**Cost of Materials:** Approximately \$250 for an 8' x 16' collector (not including support lumber or connecting ducts).

**Labor:** 12 hours (plus or minus 5 hours) for an 8' x 16' collector. (Making the absorber can be a time-consuming process without a screen crimper.)

**Tools Required:** Metal shears, screwdriver, drill, chalkline, pliers, sprayers, utility knife, hammer, pop riveter, sabre saw, tape measure, and screen crimper.

**Performance:** Measured by airflow and temperature rise figures and time on/off. Church system: 50,000

BTU/hr. at 40° F. air in, 130° F. air out, 0° F. ambient, on maximum blower output.

## Builder Comments:

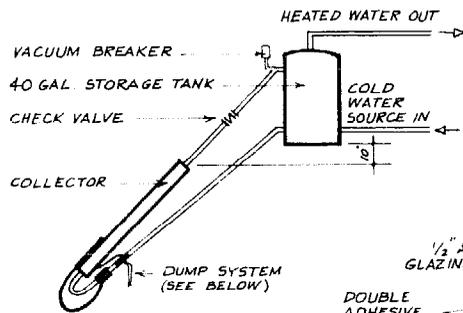
The system first used in the collectors had a tendency to melt and has been replaced with 3½ inch fiberglass. Air leaks in the church system at present lower efficiency an estimated 30-35 percent.

"Every time we build a collector system there are new problems, challenges and design alterations to deal with. This is an excellent situation for development which is lacking in commercially available systems."

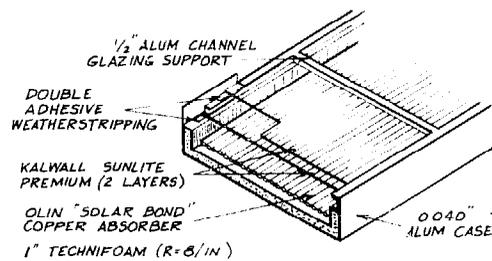
Note: A set of plans outlining the construction of this collector for use in a hot water heating system is available from WEST CAP. They are charging \$2.00 to cover publication costs.

## SCAT —

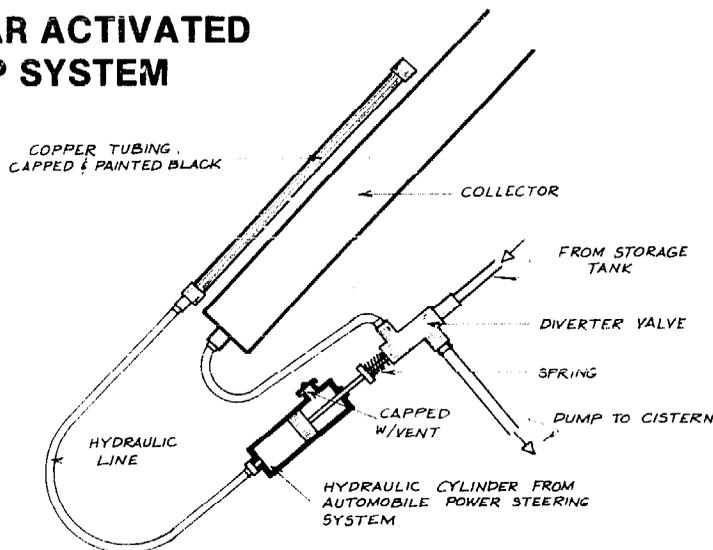
### SYSTEM SCHEMATIC



### COLLECTOR DETAIL



## SOLAR ACTIVATED DUMP SYSTEM



**Financing:** Sandusky Center for Appropriate Technology.

**Cost of Materials:** \$214.34 for collector, \$11.89 for dump system (several parts of the SADS were scrounged).

**Labor:** Six hours for collector, two for SADS.

**Tools Required:** Tin snips, rivet gun, squaring clamps, caulking gun, utility knife, screwdriver, hammer, and electric drill.

**Performance:** Testing underway.

### Builder Comments:

We are currently testing this system and intend to use this design in a demonstration project if all works out. The cost of the collector is rather high but well worth the investment. I have seen this absorber produce 135° F. water on cloudy days with the ambient air temperature at 15° F."

### Project

Solar Survival  
Cherry Hill Road  
Harrisville, New Hampshire 03450

### Consult:

Leandre Poisson, (603) 827-3797

This solar research group encourages "small scale solutions based on . . . regional needs and implemented with existing materials and renewable resources." They consider food production, preservation and processing to be their most important research priority and are using French intensive gardening methods and solar pods (cold frames) to grow vegetables during the long New Hampshire winters. Poisson, an architect by training, has developed plans for a solar food dehydrator, a small greenhouse called Solar Frame (TM), insulated shutters, and passive solar buildings. Solar Survival is attempting to remain small and decentralized; in keeping with this aim they have turned down two grant offers. "If you've got something viable, there's somebody out there who needs it. We don't need the government to pretend something is viable." Plans for the solar devices mentioned above are for sale. If you write to request information please enclose enough money to cover postage for the reply.

### Project

Sandusky Center for Appropriate Technology (SCAT)  
4620 Hayes Avenue  
Sandusky, Ohio 4870

### Consult:

V. Joseph Baker

SCAT is a community appropriate technology group. They note that their collector system for hot water heating was built for test purposes only.

### System Description

The primary components of this simple thermosiphon system are a 34" x 96" collector, a check valve, the Solar Activated Dump System (SADS), and a storage tank.

**Absorber:** Olin "Solar Bond" copper-tube-in-plate is used to heat the water.

**Frame:** .040-inch aluminum case.

**Glazing:** Two layers of Kalwall Sunlite Premium fiberglass.

**Insulation:** 1-inch 'Technifoam' (R=8 per inch).

**SADS Description:** The sun heats black copper pipe that is half-filled with oiled freon. The freon evaporates, causing pressure in the tube and forcing the hydraulic valve out. This opens the diverter valve and allows water to fill the system. After sundown, or in bad weather, the freon condenses, thus causing a spring to close the diverter valve and dump water. The lines can then fill up with air, preventing system freeze-up in cold temperatures.

## Project

Alternative Energy Resources  
Organization (AERO)  
435 Stapleton Building  
Billings, Montana 59101

## Consult:

Jim Baerg, (406) 259-1958

AERO's traveling exhibit, the New Western Energy Show, has introduced many people in Montana and on the West Coast to renewable energy sources. As part of the Energy Show, AERO staff conducts workshops on how to build a solar hot water heater. The collector design comes from Ecotope Group in Seattle.

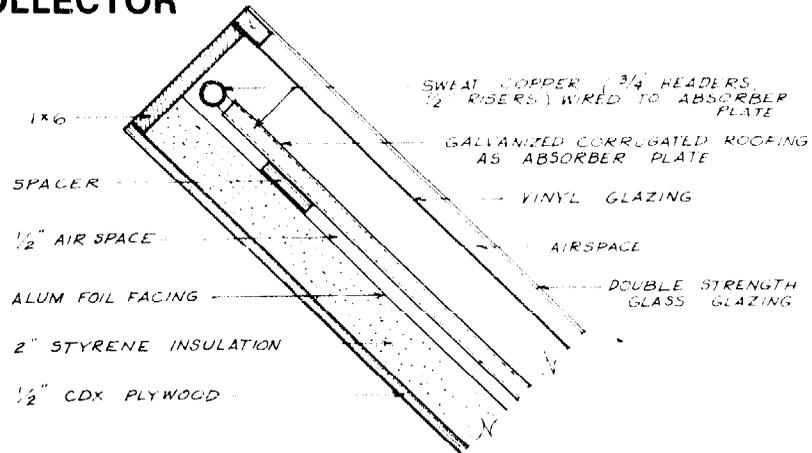
## System Description

"System design was left up to user, depending on application. Basic differences between thermosiphon and pumped, closed and draindown explained."

**Absorber:** Rigid copper tubing is wired to galvanized corrugated roofing material. Water circulates through the tubing.

**Insulation:** Two inches of styrene on back of collector only.

## AERO— CROSS-SECTION OF COLLECTOR



**Frame:** Nailed and glued 1x6's.

**Glazing:** A layer of vinyl and a layer of double strength glass with an air-space between the two layers.

**Mechanical System:** Thermosiphon.

**Financing:** User pays for all materials.

**Cost:** Not given.

**Labor:** Approximately 60 hours to complete two 4' x 8' panels.

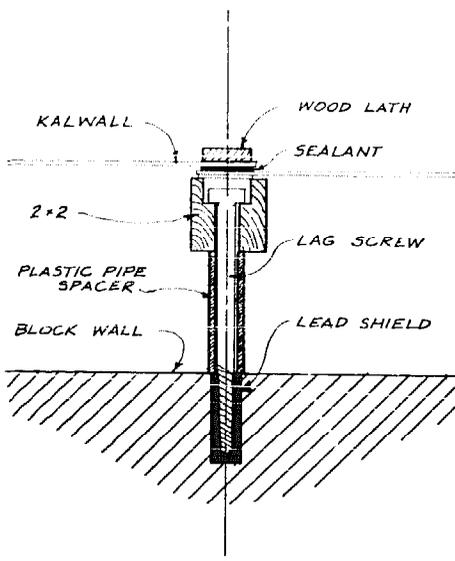
**Tools Required:** See list of tools under entry for Ecotope Group.

**Performance:** Not evaluated.

## Builder Comments:

"Little effort was made towards installation or followup on problems. I do know that nine of ten systems from the first summer (workshops) are operational."

## NORWESCAP — TROMBE WALL ATTACHMENT DETAIL



## Project

Northwest Jersey Community  
Action Program  
Old Fifth School  
Phillipsburg, New Jersey 08865

## Consult:

Charles Copcoran, (201) 454-7000

Several of NORWESCAP's low-income home renovation projects have utilized alternative energy sources. In Fall 1977, agency staff and household members installed a passive solar heating system in a large two-story house. The building had previously been insulated and weatherized and was heated with wood stoves.

## System Description

An existing 560-square-foot concrete block wall on the first story of the house was converted into a combination radiant and convective solar collector of the 'Trombe wall' type. This south-southeast-facing wall was

painted flat black. Concrete blocks were removed to create top and bottom vents.

The glazing chosen was a single layer of Kalwall fiberglass. It was framed out by using inexpensive 2x2 lumber attached to the wall with lag screws. The 3-inch spacers are cut from plastic pipe; the lag screws are anchored in lead shields. The 2x2's are run vertically on 30-inch centers and covered with the Kalwall.

Sunlight passes through the glazing and is absorbed by the concrete wall. This stored heat radiates through the wall to the interior living space. In addition, cool air is drawn through the bottom vents, absorbs heat from the wall, and rises naturally by convection currents to the top vents and into the house.

**Financing:** CSA grant.

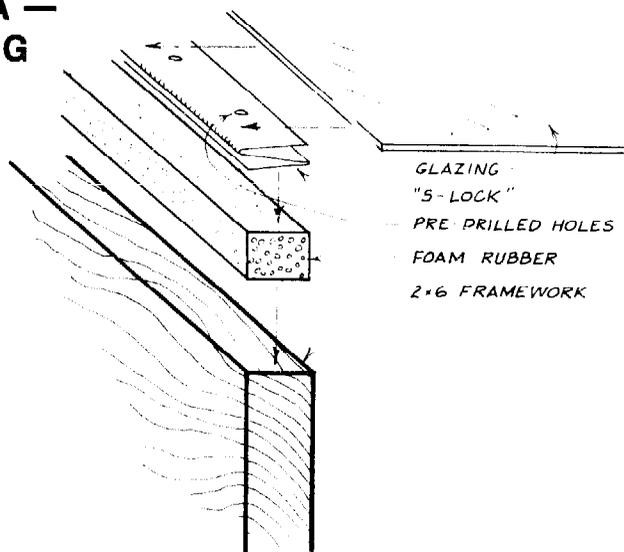
**Cost:** 90¢ per square foot, approximately \$450 total, not including labor.

**Labor:** Not given.

**Tools Required:** Common carpentry tools.

**Performance:** Not yet evaluated.

## NORTHWEST NEBRASKA CAA — S-LOCK GLAZING ATTACHMENT



### Project

Greater Omaha Community  
Action Inc.  
1805 Harney St.  
Omaha, Nebraska 68102

and

Metropolitan Technical  
Community College  
P. O. Box 37210  
Omaha, Nebraska 68137

### Consult:

Jim Termaat, (402) 341-8060

An impressive range of solar programs is being developed in the Omaha area by the combined energy education staff of Greater Omaha Community Action and Metropolitan Technical Community College.

1. In the solar training technicians program 12 fulltime CETA trainees are using CSA materials to develop alternative energy systems. By the end of their first year they will have constructed more than 400 solar systems, most of which will be installed on previously weatherized houses. The efficiency of the various designs and combinations of materials is being monitored with custom-built equipment.
2. Youth Economic Development (YEDPA) is a 20-hour per week course in alternative energy technologies for high school drop-outs, age 16-19, taught in combination with an academic equivalency program. The students design, build and install solar collectors; the use of recycled and locally available materials is particularly emphasized.

3. A \$50,000 energy education grant from CSA has enabled Jim Termaat and Gary Wright to begin work on an energy conservation curriculum for all age levels. The curriculum will include audio-visual materials and an energy conservation manual that will feature many of the low cost designs developed in the programs listed above.

Solar collectors of myriad shapes and sizes — cylinders, cones, and wedges, as well as flat plate — have been built under this program. The energy conservation manual is not yet in print, but it will undoubtedly be of great assistance to individuals and community groups.

### Project

Northwest Nebraska Community  
Action Agency  
P. O. Box 591  
Chadron, Nebraska 69337

### Consult:

Fred Schlikbernd, (308) 432-3393

Agency Weatherization Program workers, along with other CAA staff and individuals from the community, have built and installed more than a dozen solar collectors.

### System Description

The 8' x 8' forced-air collector is mounted on the south side of a home. The air intake is located inside the house. Two absorbing surfaces superheat the air; internal baffles help to slow air circulation and further improve heat gain.

**Absorber:** The absorber directly beneath the glazing is 28-gauge flat sheet metal. Air is circulated through a 4-inch space between it and a second absorber of 28-gauge corrugated sheet metal. Both surfaces are painted flat black.

**Glazing:** Single layer of Filon fiberglass.

**Frame:** The sides are constructed of 2x6 lumber. The back is 3/4-inch foil-faced Celotex. The glazing is attached to the frame with S-lock, a 28-gauge sheet metal strip folded into an S-shape. The fiberglass is inserted into the S-lock; the corners of the metal are pop-riveted; the top

edge is crimped into the glazing with a hammer or rubber mallet; the S-lock strip then is screwed onto the frame.

**Insulation:** The Celotex back provides insulation.

**Mechanical System:** Dayton Shaded Pole blower (size not indicated) forces heated air through 6-inch ductwork into the house.

**Financing:** Community Services Administration.

**Cost:** \$172 for an 8' x 8' collector.

**Labor:** 24 hours per unit.

**Tools Required:** Hammer, drill, metal shears, screwdrivers, paint brushes, staple gun and caulking gun.

**Maintenance:** CAA weatherization crew.

**Performance:** Test results not yet available.

### Builder Comments:

The S-lock strip was made at a local sheetmetal shop. Mr. Schlikbernd noted that because it provides a tight seal and allows easy removal of the fiberglass cover for cleaning and repairing, the custom manufacturing of the S-lock was a justifiable expense.

**Note:** This 8' x 8' collector is a modified version of the Domestic Technology Institute's design. It is similar to the units built by West Central Missouri Rural Development Corporation. Please see that entry for a diagram of the system.

## Project

Florida Department of Offender Rehabilitation  
1311 Winewood Alvd.  
Tallahassee, Florida 32301

## Consult:

Dave Wooliverton, information Specialist, (904) 488-5021

Inmates at the Union Correctional Institution in Raiford, Florida, built the collectors in a factory that normally produces metal furniture. Inmates installed the system in a renovated two-story building in the Tampa Community Correctional Center. The use of solar energy for space and hot water heating will save an estimated \$8,300 per year.

## System Description

A total of 166 flat plate collectors, each 4' x 8', are now being used in the Tampa Center. The collector design was obtained from State Report 1A in Solar Energy Utilization from the University of Florida.

**Absorber:** 18-20 gauge steel plate to which half-inch copper tubing is fastened in a serpentine pattern.

**Insulation:** One-inch polyurethane (Thermax TF-400) coated on both sides with tar waterproofing.

**Frame:** Light-gauge metal bottom plate with 16-gauge steel ends and sides.

**Glazing:** Single layer Kalwall fiberglass.

**Mechanical System:** Two ½-hp Bell and Gossett pumps supply 31 gallons per minute at 25 ft. of heat to 126 rooftop collectors when energized by differential controller. The 40 vertical panels (wall-mounted) are supplied by a ⅓-hp pump supplying 18 gpm at 24 ft. of head.

**Storage:** Two 7500-gallon tanks lined with 2½ inches of polyurethane insulation on tank, two inches on piping.

**Heat Delivery:** Hot water circulates through fan-coil units in each room at a rate of three gallons per minute.

**Financing:** State government agencies.

**Cost:** Cost of materials for one 4' x 8' collector panel: \$95.56. Cost of system estimated at \$60-65,000.

**Labor:** Unknown.

**Tools Required:** Unknown.

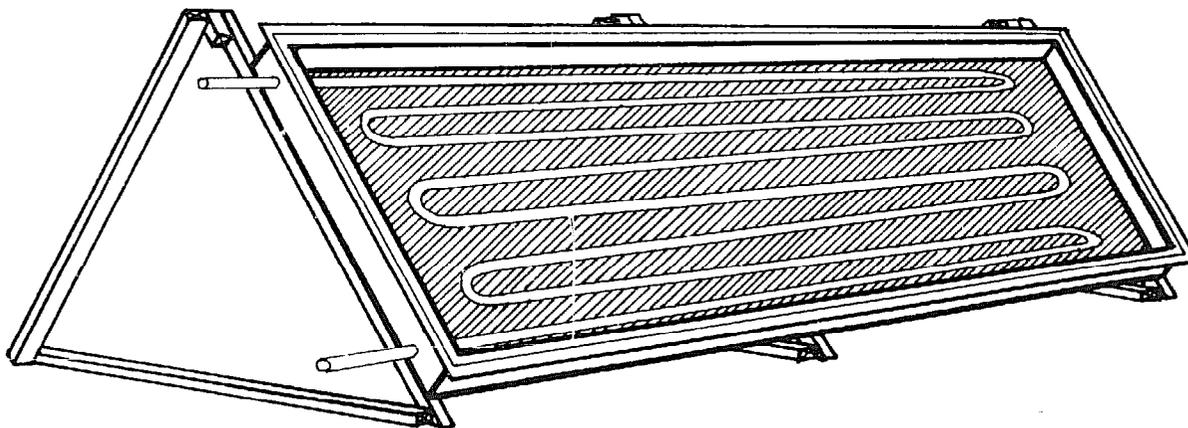
**Performance:** Designed to provide 70 percent of a calculated 87,000 BTU heating load and 85 percent of domestic hot water needs; the system has exceeded expectations since start-up in June 1977.

## Builder Comments:

The project has been very successful. Similar collector systems to heat other Florida institutions are being built.

**Note:** Detailed construction plans (State of Florida Project No. 1, Flat Plate Collector Design) are available.

## STATE OF FLORIDA — FLAT PLATE COLLECTOR DESIGN



## Project

Dane County Community Action Commission  
55 North Dickenson  
Madison, Wisconsin 53703

## Consult:

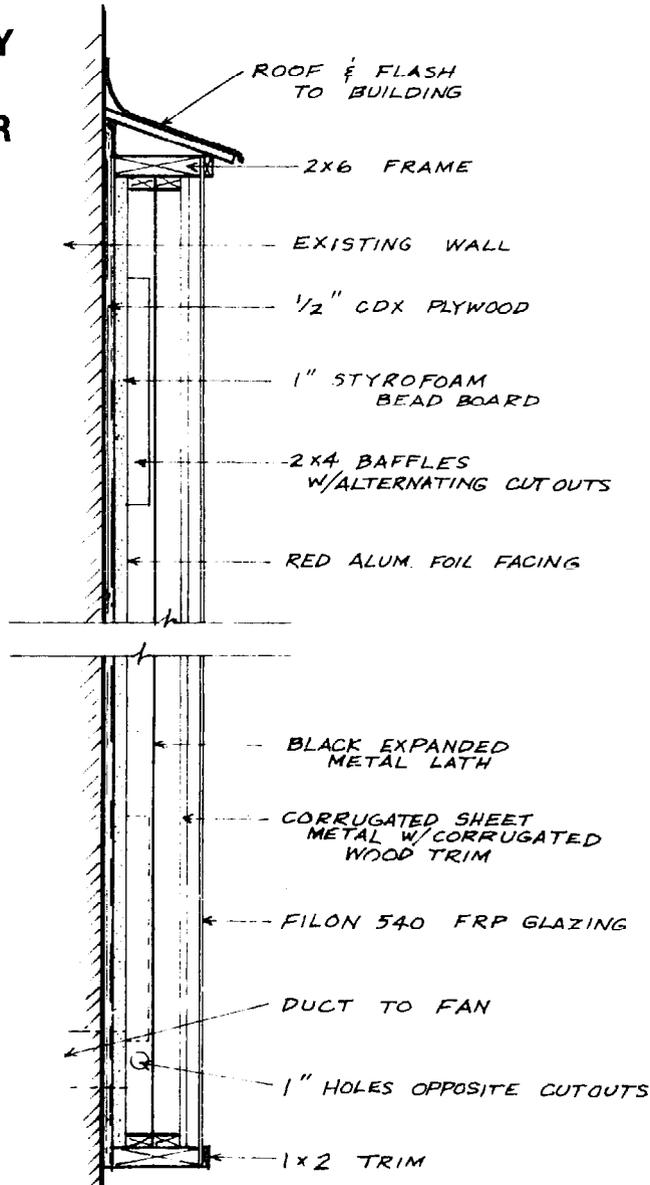
Jay Vercauteren, (608) 266-9791

This CAP Agency recently installed a research and demonstration solar forced air heating system in an existing one-story house. Thirteen 3'

x 5' collector panels were mounted between add-on, south-facing roof trusses, at a 60° angle to the horizontal. The panels have a corrugated metal frame sprayed with urethane foam insulation. The absorber was formed from six layers of extruded aluminum matrix (the material used in washable furnace filters) painted flat black. The glazing chosen was one layer of Kalwall premium fiberglass. Aluminum flashings and silicone caulk were

used to seal the glazing; project workers had some difficulty obtaining a watertight seal. The agency sub-contracted the construction of the heat exchanger, which is similar to the Suncell design. The system has two blowers, four dampers and rock storage. Mr. Vercauteren noted that the total cost of the system — approximately \$4,000 — was higher than anticipated, primarily due to the delays entailed in on-site construction.

## MID-IOWA COMMUNITY ACTION — COLLECTOR CROSS- SECTION



**Cost of Materials:** Approximately \$200 per collector.

**Labor:** Approximately 50 hours per collector.

**Tools:** Hand tools only.

**Performance:** Users are monitoring. No data is available yet.

### Builder Comments:

"I feel the project was and is an effective test of low-cost low-skill solar potential for Iowa."

### Project

Upper Des Moines Opportunity, Inc.  
P. O. Box 98  
Emmetsburg, Iowa 50536

### Consult:

Tom Millea, (717) 852-3866

With CSA funding, this agency built four demonstration collectors in March 1977, using a modification of Domestic Technology Institute's design. The 8' x 8' forced air collectors have a wood frame with plywood backing, an aluminum absorber plate, wood baffles (2x4s), and a Filon fiberglass cover. The collectors aren't insulated. Mr. Millea commented that if they were building the units now they would certainly add insulation. The agency shows the collectors to community groups in an eight-county area and would like to do more work in solar.

### Project

Inter Local Community Action  
Program  
1933 South 18th Street  
P. O. Box 644  
New Castle, Indiana 47362

### Consult:

Mike Taylor, (317) 529-6249

The Agency's CETA Weatherization Crew built two small air thermosiphon window collectors in February 1978. One unit was constructed using 3/4-inch Thermomax insulation; the aluminum foil facing acts as the absorber. The glazing was made from glued plexiglass scraps. The other unit has a black sheet metal absorber and a double glazing of plexiglass. The total cost of each collector was approximately \$30.00. The two units are placed on the south wall of the CAP workshop in winter and removed in summer.

### Project

Mid-Iowa Community Action, Inc.  
30 S. First Avenue, Room 209  
Marshalltown, Iowa 50158

### Consult:

Jacob Kvinlaug, Energy Coordinator,  
(515) 752-7162

In 1977 MICA built five solar collectors for installation on low-income homes.

### System Description

The collector design from Domestic Technology Institute, Evergreen, Colorado, was modified for use in this project. The 8' x 8' collectors were installed in the vertical position on the south side of the houses, with one collector for each hot air system.

**Absorber:** 1 1/4-inch corrugated galvanized steel, primed and painted flat black.

**Insulation:** 1-inch styrofoam bead-board, faced with red aluminum foil, covers the back of the collector.

**Frame:** Constructed of nailed and glued 2" x 6" lumber, with a 1/2-inch CDX plywood back. Frame is lined with red aluminum foil.

**Glazing:** Filon 540 fiberglass.

**Mechanical System:** A Dayton 265-c.f./min. blower with a Dayton single-pole, double-throw differential controller.

**Storage:** None. Heated air (90°F) from the collector moves through the duct to the fan and is blown directly into the house.

**Financing:** CSA weatherization grant.

## Project

Solar Research Center  
University of Oregon  
Eugene, Oregon: 97403

## Consult:

David K. McDaniels, (503) 686-4765

The solar house built by H. Mather of Coos Bay, Oregon, was the first to incorporate a large reflector into a flat plate collector system. After monitoring the performance of this solar house, the Solar Research Center decided to make a theoretical study of a reflector-collector system.

## System Description

The Solar Research Center has developed a water-medium solar collector that utilizes a reflector to increase the incident radiation and thus the overall efficiency of the collector. In the closed-system configuration for testing, a reflector-collector and a standard collector (identical to the test unit but without a reflector) are mounted on a support frame for direct comparison of their performance.

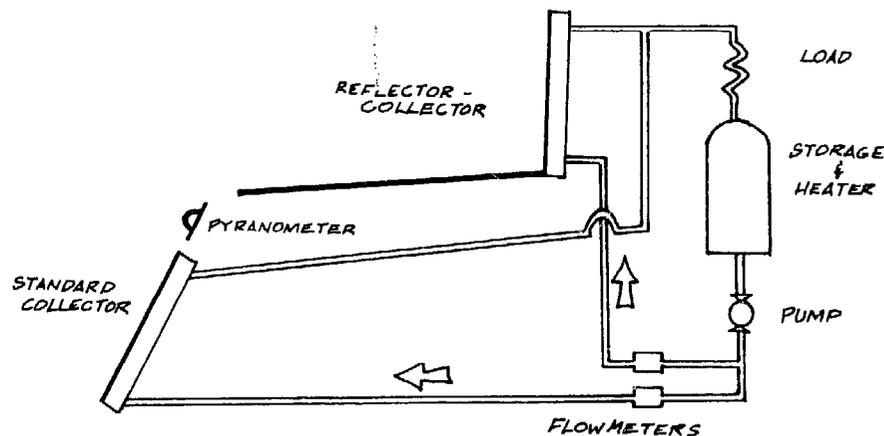
**Absorber:** Half-inch copper tubing is silver-soldered and then fastened to the back of a copper absorber plate with lead/tin solder. The plate is secured to the wood frame with steel fishing line and screws. The front of the absorber is sprayed with black paint.

**Frame:** The 32½" x 80½" frame is constructed of Douglas fir 2x6's. A 2x2 strut is placed in the middle of each of the side beams to give additional rigidity. The frame is extensively treated to protect against moisture: a wood sealer is first applied, dowelled corner joints are filled with high-temperature caulking, paint caulking is applied over the joints for improved paint adhesion, and finally, the outside is painted with two coats of enamel.

**Glazing:** The collector was originally double glazed with 1/8" clear Herculite tempered glass with a 3/8" space between layers. The Center is now using aluminized Mylar for the two glazings.

**Insulation:** "Thermal-12" insulation bricks support the collector plate ends. Because the low-density bricks are fragile, a 50/50 solution of sodium silicate and water is used to harden the outer surface of the

## UNIVERSITY OF OREGON— TESTING SYSTEM SCHEMATIC



bricks. A 3½-inch layer of fiberglass applied over a one-inch layer of Technifoam insulates the back of the collector.

**Support Structure:** The collectors weigh about 220 pounds apiece, so a strong 12-gauge galvanized strip steel system called Unistrut was chosen for the support frame. The Unistrut beams do not have to be welded. They are connected with spring-loaded nuts inserted at any point into a channel slot. The collectors are attached to this structure with right-angle fittings and 1" lag bolts that do not penetrate the wooden casing of the collector.

**Reflector:** The reflector is made of individual foot-square glass mirror tiles. The tiles are sealed with silicone for moisture protection.

**Mechanical System and Storage:** Water is driven by a circulation pump (size not given) through independently controlled and monitored pipelines to the two collectors; it is heated by thermal conduction. After temperature is measured by platinum Resistance Temperature Detectors (RTDs) the water from both collectors is mixed and the acquired heat is radiated away through an artificial heat load: A pair of parallel-connected car heaters. The water returns to a storage tank where it is reheated if necessary to maintain a constant inlet temperature to the collectors. The entire system is closed.

**Financing:** Government grant.

**Cost of Materials and Labor:** Information not given.

**Performance:** "The key conclusion . . . is that the useful output of the reflector system averaged over an entire heating season is typically about 40-50 percent greater than that obtained with a standard flat plate collector combination."\*

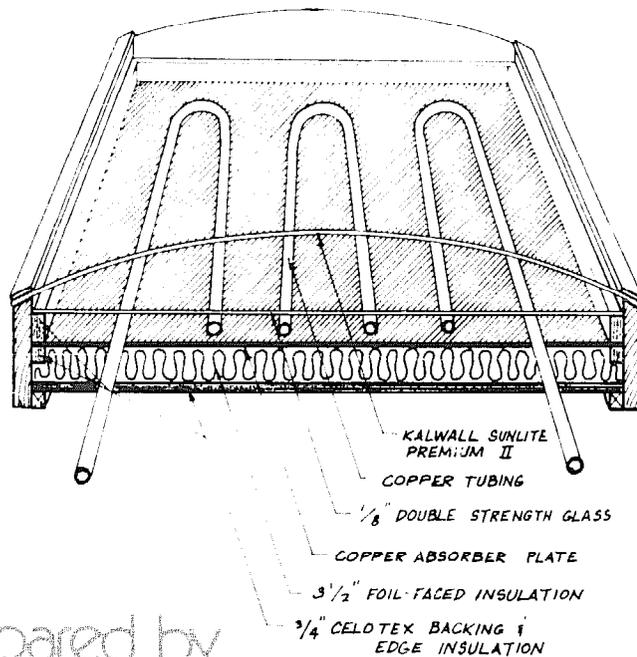
The system was designed to conform to the National Bureau of Standards' specifications for flat-plate collector testing. The reference collector is mounted 60° to the horizontal plane; the collector for the reflector system was oriented at 85° to the horizontal plane.

## Builder Comments:

This system is notably cost effective because the size of the collector can be reduced with the additions of a relatively inexpensive reflector. It is particularly advantageous for hot water heating.

\*"Experimental Evaluation of the Reflector-Collector System," H. D. Kaehn, M. Geyer, D. Fong, F. Vignola and D. K. McDaniels, **Proceedings of the 1978 Annual Meeting of the American Section of the International Solar Energy Society, Inc.**, Vol. 2, 1, pp 654-659.

# the Solar Survey



Prepared by  
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Appropriate Technology