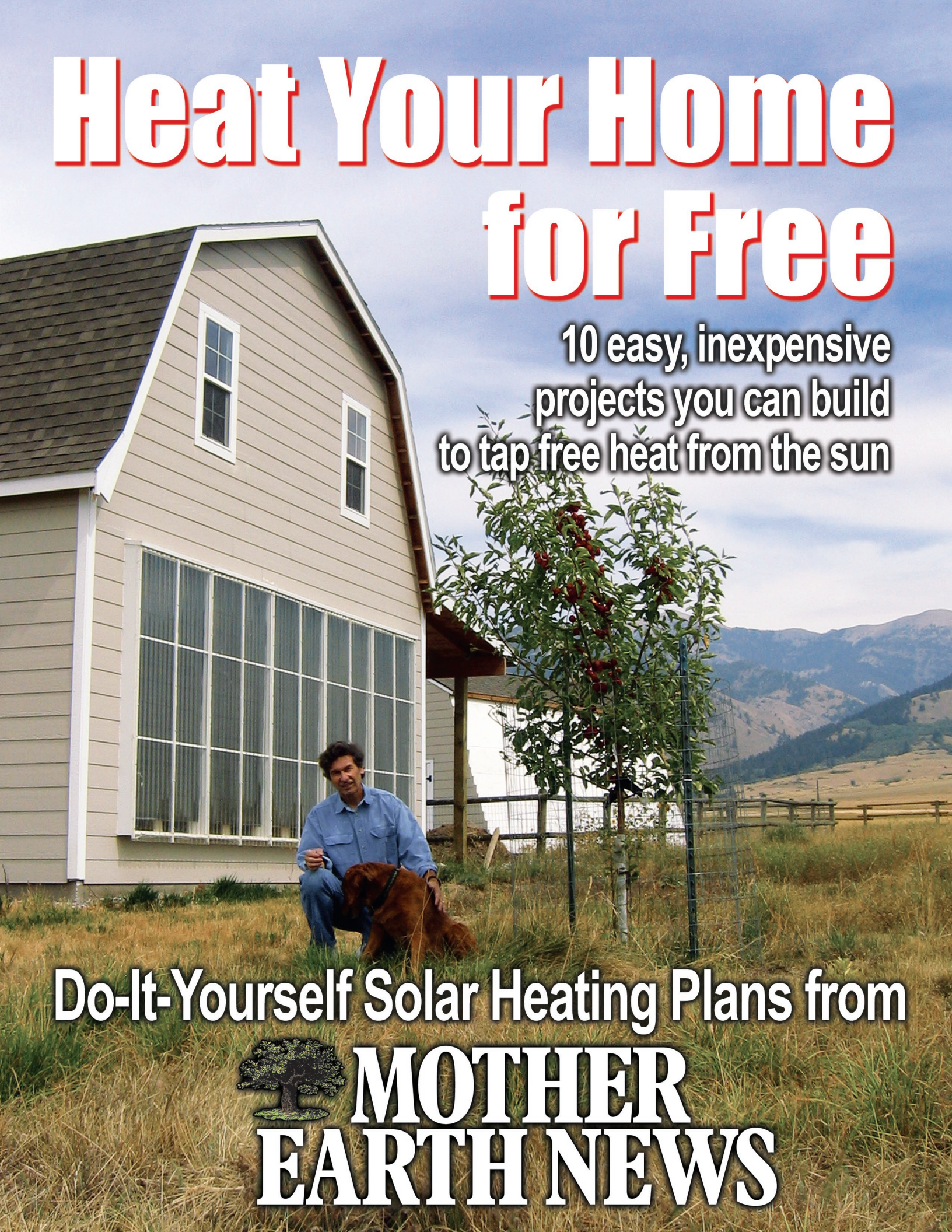
Heat Your Home for Free

10 easy, inexpensive projects you can build to tap free heat from the sun



Do-It-Yourself Solar Heating Plans from

MOTHER EARTH NEWS

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Install Solar Heat Today — and Start Saving Tomorrow!

Heat Your Home for Free is a collection of classic articles from MOTHER EARTH NEWS that shows how simple solar systems can heat your home, garage, shop, barn, commercial building — just about any structure with a south-facing wall. The heat comes from solar energy, and it's *free*. Best of all, this book shows how you can design, build and install solar heating systems *yourself!* We've compiled our best articles on do-it-yourself solar heating, from the early days of the magazine right up to the present.

Heat Your Home for Free shows you several approaches to solar heating: different materials, designs, construction methods. By the time you've read half of it, you'll be inspired to *design your own system* — and *you'll know how to do it!* These articles are by and about *real* people who built *real* solar systems that make *real heat*. They did it, and you can too! This book has loads of diagrams, photos, sketches, materials lists — everything you need to know to design, build and install your own solar heating system.

Here's what's included:

You'll meet Gary Reysa, an engineer and solar expert, who turned the *entire* south wall of his workshop into a solar heater! It produces heat equivalent to 60 gallons of propane every month. He built it for $350, and earned that money back in saved fuel in less than two years. You can adapt his simple design to just about any building with southern exposure. If it works for him, in Bozeman, Montana, *it will work for you!*

You'll read about the "Solar Heat Grabber," a simple window heater made from hand-cut insulating panels. It's a classic design, a reader favorite ever since MOTHER EARTH's staff developed it during the energy crisis of the 1970s. If you'd rather install a readymade solar heater, skip ahead to our "Buyer's Guide to Solar Heaters." It's a quick rundown on commercially available systems, and a great basic intro to how solar heating works.

Put easy, low-cost solar heat into a metal-sided building with our simple, low-profile TAPs (Thermosiphon Air Panels). No fan, no wiring, lots of warm! Or get some common framing lumber and corrugated fiberglass sheets, spend two or three hours building, and turn a south wall into a room heating system.

You'll meet a family living high in the New Mexico mountains who outfitted their old adobe home with a bare-bones-simple, effective solar booster for $25. You'll visit a church in Washingtonville, New York that installed solar collectors made of castoff aluminum cans — and cut its fuel costs by 55 percent. You'll learn how to use salvaged storm window frames to pump FREE HEAT into your home. You'll meet a father/son team from Springfield, Missouri, who spent just $30 to heat their 1,200-square-foot workshop by following four rules for super-inexpensive solar heat (Rule 4: Scrounge!). There's even instructions to build an automated control system for simple sungrabbers like these, using inexpensive, readily available parts.

For the latest on solar heating and other renewable energy news, be sure to visit:
www.MotherEarthNews.com and sign up for our free newsletter.

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BUILD A SIMPLE SOLAR HEATER

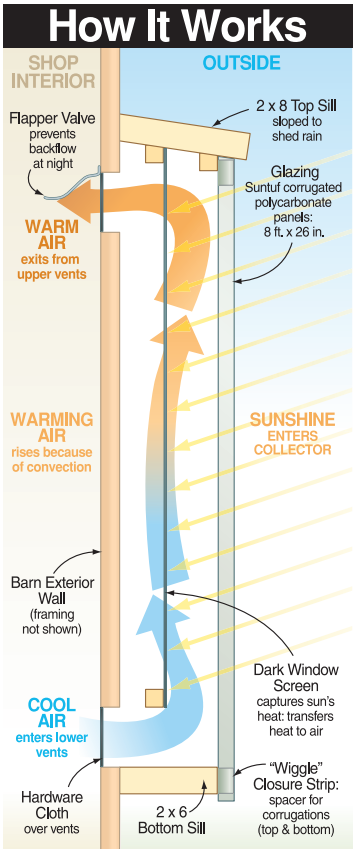
This low-cost plan lets you turn any south wall into a source of free solar heat.

By Gary Reysa

After walking into my workshop one December morning and feeling a bone-chilling 10 degrees, I decided to install a heating system. Given the rising costs of propane and my family's environmental concerns about using nonrenewable fossil fuels, a solar solution seemed fitting.

I'm a retired aircraft engineer, but you don't need a similar background to tackle this project. In fact, a solar hot-air collector built into new construction or added to an existing building can be an easy and inexpensive heating solution. Following the simple principles and plan outlined here, you can heat your workshop, barn or even your home with free heat from the sun. If it works here in Bozeman, Mont., it's bound to work wherever you are.

I reviewed many solar collector concepts and decided to install a thermosiphon air collector on the south wall of the workshop. The elegant, simple thermosiphon design uses only the buoyancy of heated air to create circulation through the collector, eliminating the cost, maintenance and power consumption of fans, sensors and controllers commonly used in other collector designs. On a sunny day, in a cold climate like ours, this simple system can produce heat equivalent to burning about $2 worth of propane (equivalent to about $3 for natural gas).



To minimize costs, I integrated the collector with the structure and used readily available materials. It cost me about $350 and took only one trip to the hardware store. I built and installed it in about three working days. Follow the suggestions below, and you may be able to do it faster!

HOW IT WORKS

The thermosiphon collector consists of clear, corrugated polycarbonate panels fastened to 2-by-6-inch studs. The clear panels admit sunlight, and an absorber suspended inside the collector captures the sun's heat energy. The air around the absorber warms, expands and rises, creating a convection current. Vents at the top and bottom of the collector allow air to circulate through it. Cool air enters the lower vents from the interior, is heated by the absorber, rises to the upper vents and returns to the interior. Air circulation continues as long as the sun shines on the collector.

At night, airflow reverses as air in the collector cools to outside temperatures. Simple flapper valves on the top vents stop this reverse circulation and keep the heat inside.

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PERFORMANCE AND ECONOMICS

On sunny winter days, the collector raises interior temperatures to between 60 and 75 degrees. In my neck of the woods, that's 25 to 35 degrees above outside temperatures. Overnight, the building typically cools to 8 to 15 degrees above the outside temperature. On heavily overcast days, the collector does little heating, but on partly cloudy days or with a thin overcast it provides useful heat. It usually takes about three hours to warm the workshop from 35 to 65 degrees — a good excuse to sleep in! If you're determined to start work early, more insulation, more thermal mass or an early morning blast from a backup heater would be in order.

Be sure to install adequate insulation and to control air infiltration. No solar collector — or any other kind of heating system — will heat a drafty, uninsulated area effectively. The walls and roof of my 700-square-foot workshop are insulated to R-19, as good as many houses.

According to my measurements, the heat output per square foot of panel compares favorably to that of most commercial panels — at less than one-tenth the cost! (See "Heat Gain: Running the Numbers," Page 5, for more details.) Our only alternative would have been to heat the workshop with propane. Although a propane heater would have cost a bit less than building the solar collector, paying $2 per gallon for propane over our five-month heating season would have cost $300 to $400 per year. The simple payback period of the collector is a year or two on materials cost. I haven't needed a backup heater, which is an additional savings.





Collector Materials

This list shows what I used and my costs, and should help you figure totals for your installation:

2" x 6" lumber (verticals, bottom sill)	68 ft.	$42
2" x 8" lumber (top sill)	22 ft.	$18
1" x 1" lumber (glazing supports)	130 ft.	$15
Suntuf 8' x 26" corrugated polycarbonate panels*	10	$160
Foam closure molding*	40 ft.	$10
Screws w/EPDM washers*	200	$10
Black metal window screen	4 x 70 ft.	$70
Paint, caulk, lag screws, hardware cloth, etc.		$25
Light plastic sheet (vent flappers)		free
Total		**$350**

*Your hardware store may need to special-order these items from the manufacturer, Palram Americas, (800) 999-9459, *www.suntuf.com.*

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SIZING THE SOLAR COLLECTOR

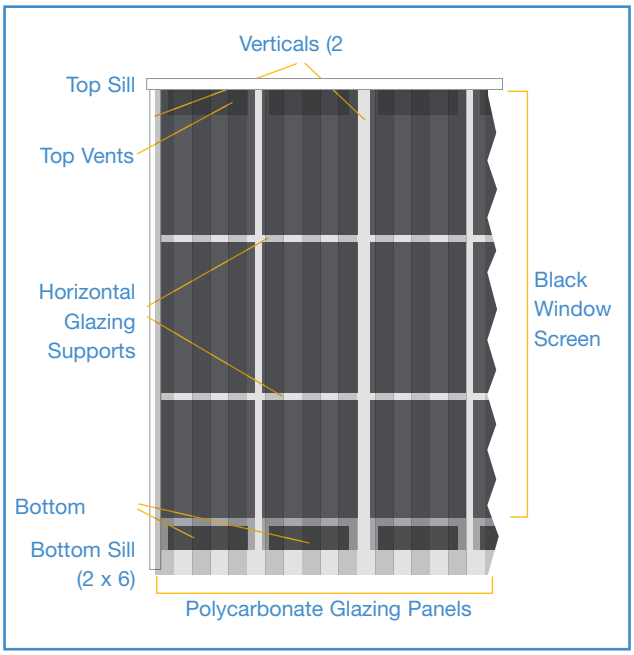
Usually, the bigger the collector, the better. Most outbuildings suffer high heat losses because of high infiltration rates and inadequate insulation, so the heat a large collector generates can be put to good use. More collector area provides some allowance for partly cloudy and thinly overcast days. With this collector design, overheating usually isn't a problem. You can easily close off upper vents or add thermal mass, such as water containers. Increased thermal mass also reduces nighttime interior temperature swings.

The added time and material cost is small to build a collector that uses the full south wall versus only part of it. Exceptions to using the full wall include locations with mild climates, well insulated and well sealed buildings, or buildings that are much longer along their east-west axis than their north-south axis. Even if the entire south wall is not available, using a portion still pays off.

NUTS & BOLTS

The collector frame is built of common dimension lumber and consists of vertical members, a bottom sill and a top sill. In mine, the six vertical 2-by-6-inch members divide the collector into five 4-foot-wide bays. The bottom sill is a 2-by-6, and a 2-by-8 is used for the top sill. The collector frame components are attached to the building with lag screws driven into them from the inside. The collector is glazed with clear Suntuf corrugated polycarbonate panels. The manufacturer applies an ultraviolet-resistant coating to the panels' sun-facing side to extend their life. I used 10 panels, each 26 inches wide by 8 feet high. Pairs of panels are overlapped and joined over a 1-by-1-inch vertical wood strip to make the 4-foot-wide panels for each bay. Two 1-by-1-inch horizontal members provide additional support for the glazing.

The absorber, a black metal window screen, is installed on battens fastened vertically to the uprights and across the top and bottom of the bays, about halfway between the glazing and siding (see photo, page 4). After measuring thermal performance with one, two and three layers of screen, I found that two layers work best. The top and bottom vents are simply holes cut through the building's sheathing and siding. Simple light plastic flapper valves prevent back flow through the upper vents at night.



In summer, the vertical orientation of the panels and the high sun angle minimize overheating, but you should block the top vent openings to prevent the collector from delivering heat. I just staple a piece of cardboard over each top vent, but you could install hinged vent doors. Shading or covering the panels also would work, but is probably unnecessary. In the spring and fall, you can close some vents and leave others open to control the heat output.

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First, measure your building's south wall to determine how you'll need to adjust the collector design. Pay particular attention to available height and to stud spacing. Next, lay out the vents. Offset them from the wall studs enough to leave room for the vertical frames to be placed away from studs and lag-screwed from inside the building. Mark the vent locations on the inside and outside of the building to ensure you have no conflicts with electrical wiring. After you're certain the layout is correct, take a deep breath and cut the vents.

Cut the top sill long enough to lap over the end verticals by at least 1 inch. Bevel the back edge of the top sill so that it slopes about 10 degrees when fitted against the siding, to shed rain. Next, cut the verticals, angling their tops to match the slope of the top sill. Line them up and cut notches for the two 1-by-1-inch horizontal glazing supports.

Next, prime and paint everything. You don't have to repaint the siding that will be behind the collector, but painting it a dark color will improve the efficiency slightly. Keep in mind that a muted version of this color will show through the collector screen, so be sure it meets your aesthetic sensibilities.

After the paint has cured, mount the verticals to the siding. I fastened them from the inside using 5 inch lag screws, with washers, through the wall sheathing and siding. If your siding is not strong enough to support the weight, align the verticals with the wall studs and drive lag screws from the outside through them and into the studs. Take care to keep everything level, plumb and straight — this will save you a lot of four-letter words later.

Now, attach the top and bottom sills. If desired, install sheet-metal flashing above the top sill to repel rain. Then, seal the perimeter of the collector frame with silicone caulk. Mount the battens and staple the window screen absorber onto them. Fold over the edges of the screen to fit in the bays, which are slightly less than 48 inches wide. Make your 4-by-8-foot glazing panels by joining pairs of the 26-inch-by-8-foot corrugated panels. Overlap the panels by one corrugation, applying a light bead of silicone caulk between the overlapped sheets. Reinforce the joint by fastening a 1-by-1-inch wood strip on the inside of the overlapped corrugations using screws with washers made of EPDM, a synthetic rubber that stands up to sunlight and high and low temperatures.



Install the horizontal 1-by-1-inch glazing support strips in the notches cut into the collector frame. The surface of the strips should sit flush with the surface of the frame. Do any cleanup, caulking or other work inside the collector frame now. You won't be able to reach inside after the glazing is attached.

Next, mount the glazing panels. Install foam sealing strips, which are molded to fit the contours of the corrugated panels, on the top and bottom sills. Run caulk beads on the first set of verticals and mount the first

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glazing panel section. (You'll quickly find out how square your frame is.) Fasten the panel sections to the frame using screws with EPDM washers. Install the rest of the sections in the same way. Overlap each new section over the previous one by one corrugation, using a bead of caulk in the overlap.

For the flapper valves on the inside top vents, I went high-tech and used two thicknesses of plastic garbage bag. Before adding these, attach half-inch mesh hardware cloth over each vent to keep the flappers from being sucked into the vent. Then, staple the flappers along the top edge of the vent, just above the vent opening.

COLLECTOR VARIATIONS

A couple of variations could improve the system's performance. Substituting dual-wall polycarbonate glazing for the single corrugated sheet would reduce thermal losses through the glazing (although some loss in energy absorption also will occur). This type of glazing, which consists of two sheets of polycarbonate separated by support webs, also simplifies installation, since it requires less support and doesn't have corrugated edges that require sealing. Buildings in cold climates will benefit the most from this change, which would increase the cost by about $100.

Another option is alternating collector panels and windows on the south wall. This approach would admit more light and some direct heat gain through the windows, without the glare, high losses and overheating that accompany full window walls.

You can use the same concept to heat a house or cabin. With some refinement to integrate the vents with the interior wall, the same basic design can provide daytime heat to living spaces. One caveat — the National Mechanical Code prohibits circulation of conditioned air warmer than 120 degrees in wooden stud spaces. While this may not pose a problem for outbuildings, in buildings used for human habitation, consider constructing the collector with metal, rather than wood studs. As an extra measure of safety, wood areas immediately surrounding exit vents also could be flashed with sheet metal.

In altering the collector design, make sure you don't violate these guidelines:

- The collector's depth should be at least 1/15 of its height.
- The absorber must offer low resistance to airflow.
- The vent area should be at least 50 percent of the collector's horizontal cross-sectional area.
- The air path through the collector should be as shown in the "How It Works" diagram, Page 1.

Heat Gain: Running the Numbers

In a recent test I did at midday, under typical sunny winter conditions, the collector produced a 50- to 60-degree temperature rise between the lower vent and the upper vent, and an average air velocity at the upper vent of 110 to 120 feet/minute. Peak output was 25,000 Btu/hour, and the total daily heat gain was about 130,000 Btu (38 kWh). This is equivalent to burning about 2 gallons of propane (about $4 worth) at 70 percent efficiency.

Heat gain estimates are based on measurements of the temperature rise and the vent exit velocity. Combining these with the specific heat of air and the density of air gives the collector heat output. I estimated the rate of heat gain using the following equation:

$$G = A \times V \times D \times (T_u - T_l) \times H$$

G is heat gain rate; A is vent area; V is velocity of air through the vent; D is air density at prevailing temperature and altitude (you'll have to look this up); T_u is air temperature at the upper vent; T_l is air temperature at the lower vent; and H is the specific heat of air (a measure of the heat required to raise the temperature of a pound of air one degree Fahrenheit; it varies with temperature and pressure but is about 0.24 Btu/lb-F° under everyday conditions).

I measured the temperatures with several $2 Taylor thermometers from the hardware store. The vent exit velocity was taken using a Kestrel wind meter. Although this instrumentation might not meet Sandia National Laboratories' standards, I believe it does provide a solid estimate of the collector's performance.

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OTHER WAYS TO BUILD IT

This collector could be built with less material and lower cost if it were integrated with the wall during initial construction. It also could be built on the outer surface of the wall, omitting the exterior siding behind it. This might save up to $2 per square foot. For a more finished appearance, you could install a higher grade of sheathing in the collector area.

For a more integrated approach, the wall stud cavities could be used for the collector itself. Using standard 2-by-6 studs at 24-inch spacing, inlet and exit vents could be incorporated in the inside finished wall, with the absorber screen mounted about halfway back in each stud cavity. The collector side of the inside finished wall could be lined with polyisocyanurate foam board insulation, which withstands high temperatures and provides high R-value at modest cost. The R-value of the insulated collector wall would be comparable to that of a standard wall. The glazing could be mounted on 2-by-2-inch members extending along the top and bottom of the collector, and over each of the vertical studs in the collector area.

The difference in materials cost between such a collector and a conventional wall would be close to zero! With a large collector, diagonal bracing or a shear-resistant inside wall may be required to maintain the wall's shear strength. Be sure to work out an agreement with your building department on the details.

Other approaches surely are possible. If you work out a good one, I'd love to hear about it. Meantime, here's to your warmth and comfort!

Gary Reysa worked for Boeing Aircraft. Since 2000, he has lived in Montana, where cold winters, high heating bills and ample sunlight sparked his interest in solar heating. Send your questions about this article or project to gary@BuildItSolar.com. He has posted many other DIY solar projects at his Web site, www.BuildItSolar.com.

Solar Collector Pros & Cons

PROS:

- Simple (not much to go wrong or watch over)
- Easy to build and does not require changes to the building structure
- Long life and little maintenance (so far)
- Very low initial cost (less than one-tenth the cost of most commercial panels)
- Good economic return on the initial investment
- Reduces our greenhouse gas production by about 1,800 pounds per year
- Output can be adjusted by opening and closing vents — summer output can be reduced to zero
- Does not affect use of building (I can still pile stuff against the wall, but now it's not junk — it's thermal mass)
- It's not ugly (or at least not too ugly!)

CONS:

- It hurts a bit to cut holes in the wall (but you'll get over it)
- The building might require additional thermal mass and insulation to keep inside temperatures from dropping too much at night

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2

BUYER'S GUIDE TO SOLAR HEATERS

Tap free heat from the sun with these solar hot-air collectors.
By Dan Chiras

Are you freezing in the winter to keep your fuel bill down? Or paying an arm and a leg to stay warm? Either way, it's probably time to consider installing a solar hot-air system. There are several options, and these systems are a hot commodity right now — in recent months several suppliers have reported increased consumer interest.

Solar hot-air systems capture sunlight energy and use it to heat incoming air. Heated air is then transferred into your home, often with a small electric fan. The solar energy costs what it always has cost — nothing. Solar hot-air systems can help alleviate homeowners' worries about rising fuel costs and provide years of inexpensive, maintenance-free comfort. They can heat homes, offices, workshops, garages and barns.

SOLAR SIMPLICITY

All solar hot-air systems rely on hot-air panels or collectors. Collectors are typically mounted on south-facing walls, roofs or even on the ground, if it's unshaded during the heating season.

Some commercial systems are simple thermosiphon collectors that rely entirely on convection to distribute hot air, but most use fans or blowers controlled by relatively simple electronics. A temperature sensor mounted inside the collector monitors internal temperature. When it reaches 110 degrees, it sends a signal to a thermostat mounted inside the home, which turns on the fan if room temperature is below the desired level. When the temperature inside the collector drops to 90 degrees, or the room reaches its setting, the thermostat turns the fan off.

Solar hot-air systems actively produce heat only in the daytime, but some of that heat is absorbed by the building's thermal mass: drywall, tile, framing lumber, etc. At night, the heat stored in the thermal mass radiates into the rooms. The more thermal mass, the greater the nighttime benefit.

HOT AIR VS. HOT WATER

Solar hot-air systems are far simpler and easier to install than solar heating systems that circulate water as the heat-transfer medium. They're also less expensive, and don't use potentially troublesome chemicals or require complicated electronic controls. You can even build a solar hot-air system yourself (see "Build a Simple Solar Heater," Page 1).

Solar hot-air systems also produce heat earlier and later in the day than water-based systems. As a result, they may produce more usable energy over a heating season than water-based systems of the same size, according to the U.S. Department of Energy's online publication, *Consumer Guide to Energy Efficiency and Renewable Energy*. Moreover, air systems do not freeze. Minor leaks in the collector or distribution ducts, which cause significant problems in water-based systems, also are less troublesome in hot-air systems. (Water-based heating systems do have one major advantage: They can store heat for use at night in water tanks inside the home.)

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TWO KINDS OF HEATERS

Solar hot-air systems have been around since the 1950s. Today's systems fall into two categories: open-loop and closed-loop. The difference lies in the source of air entering the system.

In open-loop systems, collectors draw in cold outdoor air, heat it and transfer the heated air into buildings. Collectors used in open-loop systems, known as transpired air collectors, incorporate a dark-colored, perforated metal facing, called the absorber plate. There's no glazing over the plate; the sides and back are insulated to reduce heat loss. Sunlight striking the absorber plate of a transpired collector heats it. Air is drawn through the plate by a blower and is piped to the interior of the building.

Closed-loop systems, the most popular option today, draw cool air from the house, heat it and return the heated air to the interior. These collectors include glass or other clear glazing over an absorber plate, typically made of dark-colored metal. Its surface is roughened to increase air turbulence so that air absorbs heat from it more effectively. The collector's back and sides are insulated.

Air from the home enters the bottom of the panel and moves up, either behind the absorber plate (back-pass collectors) or in front of it (front-pass collectors). Air moves in and out of the collector through ductwork running through the wall or roof — the shorter the better. Small registers are mounted inside on the air intake and outlet openings.

Of the two types of glazed closed-loop collectors, back-pass collectors are more common. Back-pass designs use single panes of glass; front-pass designs are double-glazed to reduce heat loss. That makes back-pass collectors somewhat less expensive to manufacture and about 50 pounds lighter than front-pass collectors and, therefore, a little easier to install.

Most systems are thermostatically controlled and include backdraft dampers on the outlets to prevent reverse convective airflow at night, which would suck heat out of a building.

HEAT OUTPUT

Closed-loop solar hot-air panels can substantially boost the temperature of air flowing through them. According to the U.S. Department of Energy, air entering a glazed collector at 70 degrees is typically warmed an additional 70 to 90 degrees. Open-loop transpired air collectors may provide considerably less heat than glazed collectors. Chuck Marken, president of AAA Solar and solar thermal editor of Home Power magazine, says transpired air collectors increase the temperature of the air flowing through them only about 20 degrees, which is probably of little value to residential structures. However, manufacturers report considerably larger temperature increases, achieved by restricting airflow through the collector.

Closed-loop residential solar hot-air systems can produce impressive results. Steve Andrews, a residential energy expert based in Denver, Colo., for example, installed a collector to heat the bottom 500 square feet of his tri-level home, which was usually 5 to 6 degrees colder than the rest of his house. He found the collector made a big difference during sunny winter days and the following evenings. "Overall, the comfort improvement was dramatic," he says.

As part of my research for this article, I tested the SolarSheat 1500G, a closed-loop collector, and found it consistently raised the temperature of 68-degree indoor air that entered it by 40 degrees

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on sunny but cold winter days. (For more information about the SolarSheat and other commercially available panels, see "Seven Solar Heaters at a Glance," Page 12.)

Marken recommends one 4-by-8-foot collector per 500 to 1,000 square feet of heated space, depending on the location and energy efficiency of your home. A 2,000-square-foot home with unobstructed southern exposure might require two to four collectors. Separate collectors may be required for each room. For larger rooms, two or more collectors may be needed, with a more powerful fan to ensure adequate air flow. If collectors are shaded during part of the day, more will be needed.



MAKING CENTS OF SOLAR HOT AIR

How much can a solar hot-air system save you? Bill Hurrle of Bay Area Home Performance, a company in Wisconsin that installs solar hot-air systems, says they're able to achieve a 25 percent to 35 percent annual reduction in heat bills, or about $200 to $270 per year, when retrofitting homes — not bad in his cold, cloudy climate.

Greater savings will be achievable in cold areas that receive more sunlight. As a rule, active solar heating systems are most cost-effective in cold climates with good solar resources, but they make sense in other locations as well. Many solar installers will help you determine the cost-effectiveness of a solar hot-air system, or you can run the numbers yourself.

One way is to calculate payback — or how long it will take to reclaim the cost of the system, plus installation, through annual fuel savings. Divide the cost of the system plus installation by the anticipated annual fuel savings. If a $2,100 system will save $300 per year in heating bills, simple payback is seven years. Manufacturers estimate paybacks of four to eight years, based on current energy prices.



To calculate payback accurately, consider rising fuel costs, interest paid on money borrowed to buy the system (or lost interest, if you withdraw money from savings to buy it), and maintenance

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costs. Fortunately, these systems have just two moving parts, a fan and a backdraft damper, and both should give many years of trouble-free service. The rest of the system should last 50 years or longer. Let's see: $300 saved per year, for 50 years, is $15,000!

When calculating payback, don't forget financial incentives from utilities and state and local governments. Federal incentives now are offered only for dual-use solar hot-air systems — that is, they also use hot air to heat water for domestic uses. To qualify for this credit, however, the panel must be certified by the Solar Rating and Certification Corporation. Currently, only one certified dual-use collector exists, the Northern Comfort, produced by Sunsiaray Manufacturing, although the SolarSheat products are currently being tested.

You also can use payback to calculate your return on investment (ROI) by dividing the payback into one. A system that pays for itself in five years has an impressive ROI of one-fifth, or 20 percent.

SHOPPER'S GUIDE

Before you buy a solar collector, make your home as energy-efficient as possible, because efficiency enables the system to meet a higher percentage of your heat requirements. Beef up insulation in ceilings and add insulation to walls, if they're uninsulated. Cover windows at night with insulating shades, and seal cracks in the building envelope with caulk and weatherstripping. Install foam gaskets in electrical outlets and light switches. Seal ducts in forced air systems.

Be sure to investigate local building codes and zoning ordinances before purchasing a solar hot-air system. You may need a building permit. Check out neighborhood or subdivision covenants as well. They may prohibit solar systems, although many homeowners have successfully challenged their neighborhood associations.

You can buy solar hot-air collectors online or through a growing list of solar suppliers, companies that also often install other solar systems such as hot water or electric systems. When shopping, watch out for too-good-to-be-true claims.

"Marketing departments can make anything look good," Hurrle says. "One panel won't heat a home, despite what some salespeople may tell you."

I personally prefer closed-loop systems — collectors with glazed panels. I think they look nicer than transpired collectors, and they produce lots more heat. Moreover, open-loop transpired collectors are designed primarily for commercial and industrial buildings and are generally not a good choice for home heating.

As energy expert Andrews notes, "Transpired air collectors appear to be very suitable for a range of commercial applications, but seem to present more challenges than opportunities in residential applications, either in existing or new-home applications." One problem in residences is that transpired collectors can pump in too much fresh air, resulting in more air changes than necessary. Some fresh air is desirable, but the loss of heat through cracks in the building envelope caused by massive fresh air influx could waste a substantial portion of the heat produced by the collector.

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Although transpired collectors usually are not suitable for homes in colder climates, they are designed to work well in barns, garages, workshops and commercial buildings that need large amounts of fresh air. John Hollick, president of Conserval Engineering, says one of the best applications for their SolarWall transpired collectors is school buildings, where building codes require a steady supply of fresh air.

INSTALLATION

Installing solar hot-air panels is not a job for a beginner. Solar energy expert Marken says a seasoned crew of two can install a solar hot-air system in a few hours, but it's more realistic to set aside a full day. "If this is your first time, plan on a weekend, even with help," he says. Because collectors are fairly heavy and measure around 4 by 7 feet, you'll need a brawny assistant or two.

The panel should face as close to due south as possible. The most common place to mount a solar hot-air collector is a roof, where shade is least likely. Unfortunately, roof mounts are usually more complicated and more costly than wall mounts. In homes with attics, installation requires flexible insulated ducts to transport air to and from the collector. Outdoor runs of duct are protected from the elements by galvanized pipe. Much shorter duct runs suffice in homes with closed ceiling cavities and for wall mounts. Like roof mounts, ground-mounted systems require considerable ductwork, and both require much heftier fans to ensure adequate air flow.

To install a glazed collector, you'll need to cut two 5- to 7-inch holes in the wall or roof and ceiling. Transpired air collectors require only one hole, albeit a rather large one (up to 9 inches in diameter). When cutting holes in a wall or roof, be certain not to damage water pipes or electrical wires.

You'll also need to hook up the thermostat, temperature sensor and fan. Wiring diagrams can be difficult to understand for the electrically illiterate. To make life easier, two manufacturers have provided rather ingenious alternatives to wiring. Your Solar Home sells my favorite solar hot-air collector, the SolarSheat 1500 series, which comes with its own supply of electricity: a small solar electric module that powers the unit's fan. To install, simply mount the panel on the wall or roof and then attach two wires from the panel to the thermostat inside the house. It's affordable, a snap to wire and very attractive.

Cansolair provides another simplified wiring solution. Its Solar Max is a glazed collector made from 240 empty aluminum cans, painted black and arranged in 15 vertical columns. Air flows through the solar-heated cans, pulled by an indoor fan in an attractive console that plugs into a 120-volt wall outlet. The fan unit also has a washable filter that helps keep indoor air clean.
(To read about a DIY solar heater that utilized aluminum cans, see "A Solar-Heated Church" in this book.)

Solar hot-air collectors are often attached to existing walls or roofs, but DeSoto Solar sells collectors designed to be integrated into walls, reducing their profile. Such installations work especially well in new construction or when building an addition to a house, so the panel can be installed into the wall as the structure is framed.

Solar Sources

The Homeowner's Guide to Renewable Energy by Dan Chiras

"Solar Hot Air System Design" and "Solar Hot Air Systems, Part II" by Chuck Marken; *Home Power* magazine, Dec. 2003/Jan. 2004 and Feb./March 2004.

Consumer Guide to Home Energy Savings by Alex Wilson, Jennifer Thorne and John Morrill; American Council for an Energy-Efficient Economy, 2003. (*www.aceee.org/consumerguide*)

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SOLAR COMFORT

If a solar hot-air system makes sense for your home or your business, you'll be rewarded many times over. Once you've paid off your investment, you'll get free heat for the life of the system. And perhaps best of all, you'll be doing something positive to create a cleaner, healthier future.

Seven Solar Heaters at a Glance

Company	Model	Type	Estimated Peak Output (Btu/hr)	Airflow (cfm/min)	Cost	Comments
AAA Solar Supply Inc.; 2021 Zearing NW, Albuquerque, NM 87104; (800) 245-0311; www.aaasolar.com	Sun Aire (2 sizes)	closed	5,000 to 6,000	362 to 488	$864 to $1,273	Wiring hookup required; ships assembled
Cansolair Inc.; Box 100, Colliers R.H., NL, Canada A0A 1Y0; (709) 229-4387; www.cansolair.com	RA 240 SolarMax	closed	9,500	90	$1,649	Wiring hookup required; uses 240 aluminum cans in collector; washable air filter; ships assembled
ClearDome Solar Thermal; 3368 Governor Dr., 153-F, San Diego, CA 92122; (888) 227-7547 ext. 3427; www.cleardomesolar.com	Low Profile UB Solar	closed or open	2,048	100	int., $395 ext., $449	Interior model intended for use inside a large window; plugs into standard outlet; units connect in series; ships assembled
DeSoto Solar; 1410 20th St. #20, West Des Moines, IA 50265; www.iedu.com/DeSoto	on-wall (4 sizes)	closed	variable	variable	$240 to $1,280	On-wall model meant for agricultural structures, warehouses, shops, etc.; in-wall installs much like manufactured windows. No wiring required (thermosiphon, uses no fan); both types available in economy or high-efficiency models; ships assembled
	in-wall (3 sizes)	closed	variable	variable	$200 to $840	
Sunsiaray; 4414 N. Washburn Rd., Davison, MI 48423; (810) 653-3502; www.sunsiaray.com	Northern Comfort	closed	3,000 winter; 4,000 summer	237	$1,150 to $1,400	The only SRCC-certified solar hot-air panel; also heats water; dual use qualifies it for federal credit; wiring hookup required; assembly by professional installer
Your Solar Home, Inc.; 299 Applewood Crescent, Unit 4, Vaughan, ON Canada L4K 4E7; (866) 556-5504; www.yoursolarhome.com	SolarSheat 1500G, GS	closed	5,118	90	$1,655 (G); $979 (GS)	No wiring required (uses integral PV panel); ships assembled; 1500GS is an auxiliary panel
Conserval Engineering Inc.; 4242 Ridge Lea Rd. Unit 28, Buffalo, NY 14226; (716) 835-4903; www.solarwall.com	SolarWall (3 sizes)	open	7,800 to 15,600	70 to 135	$1,959 to $2,788	Wiring hookup required; several colors available; 100 percent recycled materials; ships unassembled

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3
SOLAR HEAT GRABBER

Some of the climatologists are predicting that the coming winter could well be colder than the last one. But even if that forecast comes true, you'll be a lot warmer during the clear-but-below-zero sieges ahead ... if your house or apartment has one or more un-shaded south-facing windows and if you outfit those windows with MOTHER's Heat Grabber.



Believe it or not, this simple and effective "window box" solar collector can be fabricated in just under an hour by an experienced home craftsman (or in less than two hours by the more fumble-fingered among us) for the astonishingly low price of $32.18 (see materials breakdown on next page). And once constructed, this sturdy unit should give years of dependable service.

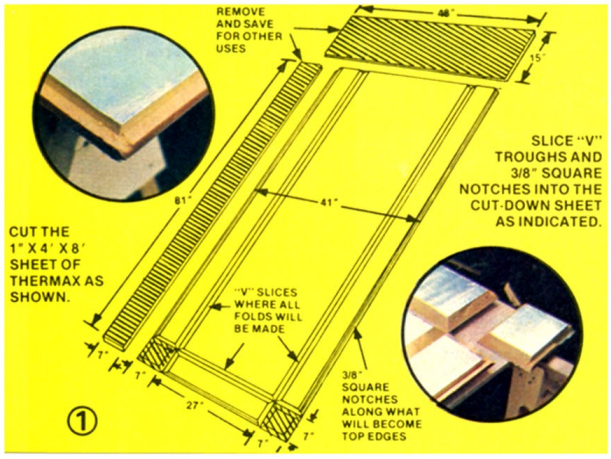
The secret of the Heat Grabber's quick assembly and low cost is a new rigid foam insulation board manufactured by Celotex. This board, trade-named "Thermax TF-610", is impregnated with glass fibers for strength, faced on both sides with heavy aluminum foil, and available in thicknesses ranging from 3/8" to 1-7/8". Celotex markets the material as a replacement for the pressed-fiber sheathing or "blackboard" now used by contractors in the construction of wood-framed houses and does not recommend it for any other purpose. Mother's researchers, however, have run heat and other tests on the insulation board and found it near-ideal for use in quick, easy, and low-cost solar collectors such as the Heat Grabber.

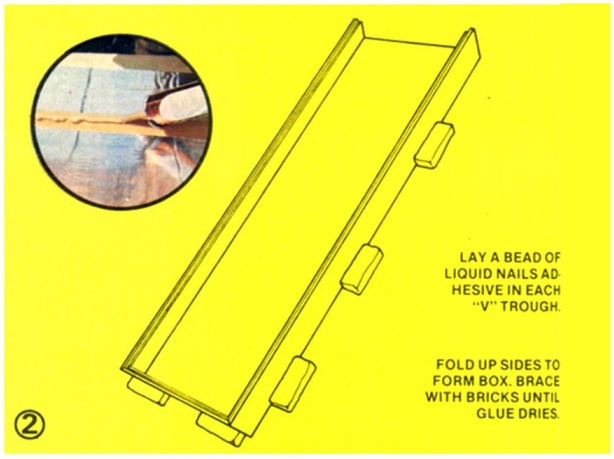
Yes, the basic Thermax TF-610 sheet does have a slight disadvantage. Its aluminum foil surfaces can be punctured relatively easily by anyone intent on doing just that. There are, however, at least two remedies for this problem: [1] Substitute Thermax-610/.019 - which is the same foam, but faced on one side with a much heavier layer of aluminum - for the Thermax-610 specified here, or [2] use the Thermax-610 called for in our plans, and protect the sides and bottom of the finished collector with a casing of scrap lumber. The second alternative will be less expensive than the first ... but, really, neither course of action should be necessary unless you live in a high-vandalism area.

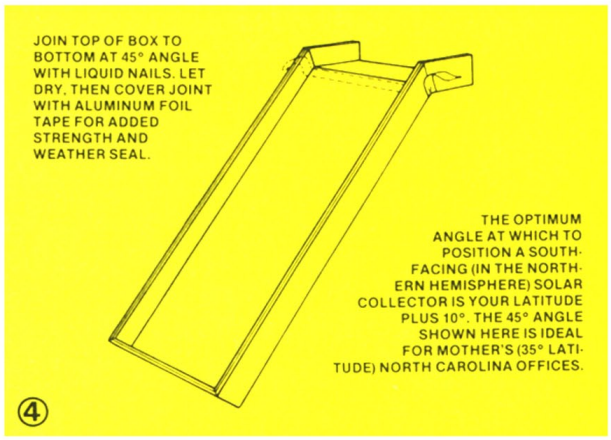
The ideal angle at which to position a south-facing solar collector (in the Northern Hemisphere) or a north-facing collector (in the Southern Hemisphere) is your latitude plus 10 degrees. This adds up to 45 degrees for MOTHER's North Carolina offices (which are situated 35 degrees north of the equator), and that's the angle shown on the following plans. Please take this into consideration when making the cuts called for in Steps 3 and 6 on the next two pages.

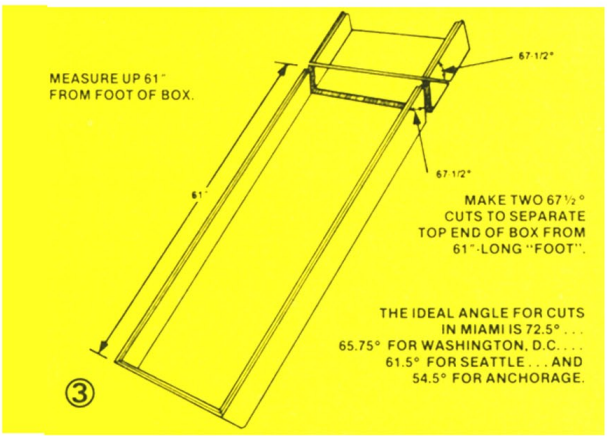
(Miami, for instance, is located about 25 degrees north, which means that collectors there should be angled up at 35 degrees to the horizon, which, in turn, means that the 67.5-degree cuts specified in the following plans should be 72.5 degrees for Miami. Likewise, the cuts should be 65.75

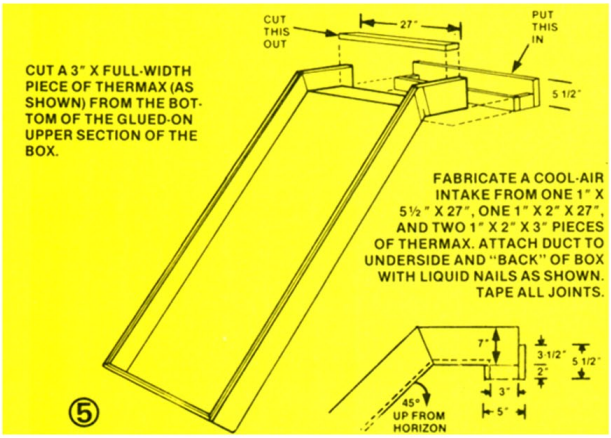
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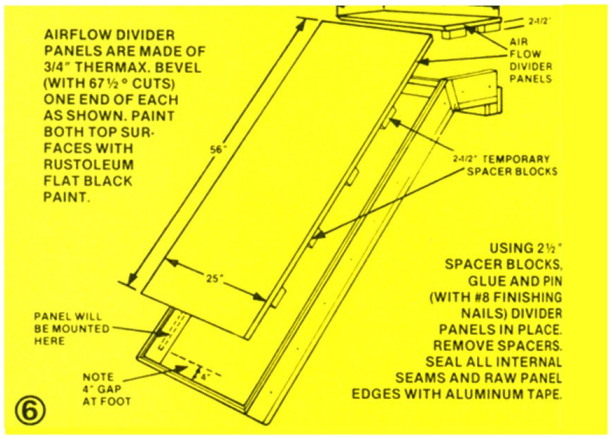


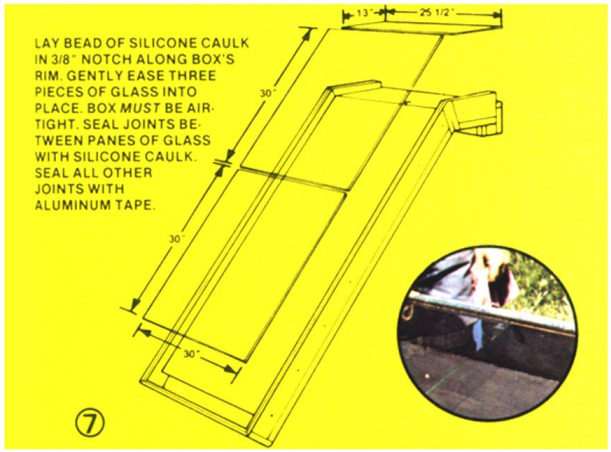


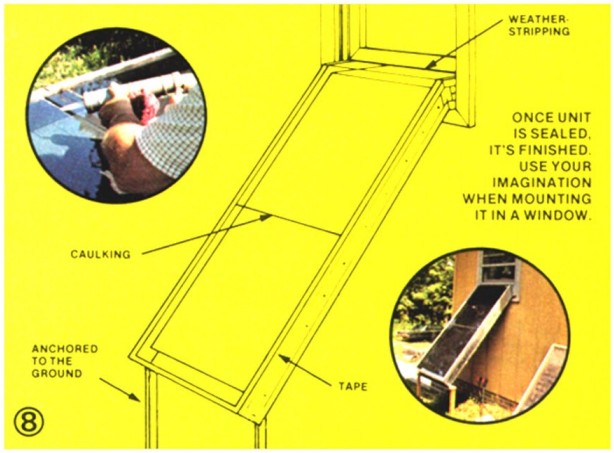








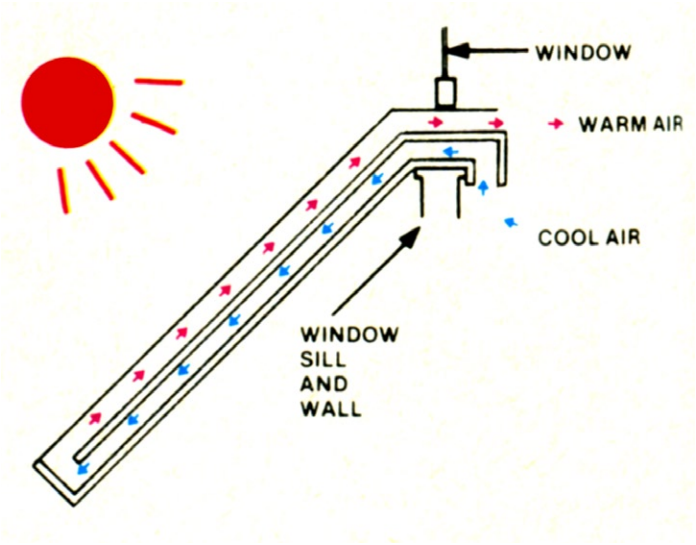




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degrees for Washington, D.C; 61.5 degrees for Seattle; and 54.5 degrees for Anchorage. You can calculate the specific angle for your own location [subtract your latitude plus 10 from 180 and divide by two] or just average it out from the figures given here. The angle is important, but not that crucial.)

Remember that all the dimensions given in the plans are for a collector specifically tailored to fit the windows in one particular house. If your windows are wider or not as wide, feel free to build your Heat Grabber(s) accordingly. And don't get unnecessarily hung up on trying to keep the upper and lower air chambers in the collector exactly as deep as shown here either. A half-inch or more variation is fine. As a matter of fact, it's awfully hard to keep this little Btu-grabber from working, as long as its passages are deep enough for air to circulate through them at all.



One final caution: Although the single-strength glass used to cover the prototype Heat Grabber is neither more nor less safe than the single-strength glass currently in use in millions of storm doors and windows throughout the continent. It can break and possibly will cut you or a child if either of you falls into it. Take any measures you deem necessary to prevent such an accident.

HOW IT WORKS

MOTHER's Heat Grabber is nothing but a weather-tight box that's insulated on the bottom and sides and topped with glass. An insulated divider is positioned inside this box and brought out its top to form an open "lip" at the box's upper end. This lip is designed to hook over a windowsill, so that the window can be pulled down snugly onto the glass covering the top of the Heat Grabber ... leaving the main body of the solar collector "leaning against" the south side of the house at a 45-degree-or-better angle.

The operation of the unit is just as simple. When the sun shines, its rays pass through the glass on top of the Heat Grabber, striking the upper surface of the divider (which is painted black), and warming the aluminum foil covering on that divider. As the foil heats up, it warms the air next to it. And that air, as might be expected, rises up the face of the divider and begins to pour out the opening at the Heat Grabber's top.

But, of course, that hot air can't move up the face of the divider unless it pulls cool air around the divider's foot to take its place. This pulls even more cool air in through the lower opening at the collector's top (the only place that cool air can enter the otherwise airtight unit) and down under the central divider.

What we have, then, is a "convective loop" solar room heater that operates automatically on nothing but the sun's energy. Whenever the sun shines, this clever little unit (which, as near as we can

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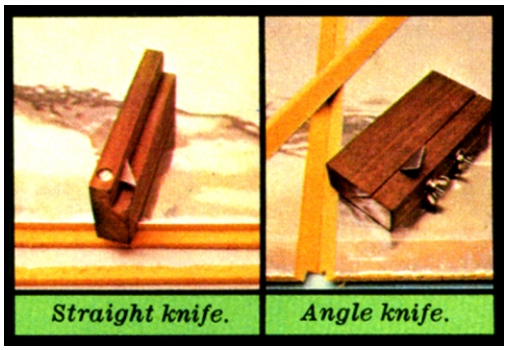
tell, seems to be an old Steve Baer design, modified by William A. Shurcliff, and further refined by some of MOTHER's research staff) just sits there happily pumping thousands of Btu's of heat into the house. And when the sun quits shining? The air in the box cools and tries to sink to the collector's foot, which "shuts off" the whole convective loop. (The Heat Grabber, in other words, will spew heat into the room when the sun shines ... but it won't pull heat from the room when the sun doesn't shine.)

TOOLS

Thermax is so easy to work with that you won't need any saws, hammers, or other "conventional" carpentry tools to build this solar collector. MOTHER's Heat Grabber, in fact, was constructed with little more than a protractor, tape measure, paintbrush, and the two little "we built 'em ourselves" knives you see here.

These knives are nothing but blocks of 1" X 2-1/2" hardwood, cut to fit the hand comfortably. The pieces of wood were then slotted and rigged with 10-32 bolts and wing nuts to grip Stanley 1992-5 utility knife blades at either a 45-degree (for V cuts) or a 90-degree (square cuts) angle to the blocks' faces.

All cuts on the Thermax used in the collector were made straight and accurate by sliding one of the two knives along a board or other straightedge that had been clamped to the rigid sheets of foam. For V cuts, the blade in the 45-degree knife was set to slice only to within about 1/32" of the aluminum facing on the far side of the sheet (not all the way through either the facing or the foam). Since the foam varies slightly in thickness, this setting - for the most part - kept the blade from cutting too deeply. Two such cuts, with the straightedge reset between them, were necessary for the completion of each "V".



And what if you don't want to make "V" cuts and fold up the box of your solar collector? Then just build your "heat grabber" from separate pieces of Thermax, all made with right angle cuts ... peel back the aluminum skin from the butted face of each joint ... and glue the sections - foam to foam - together.

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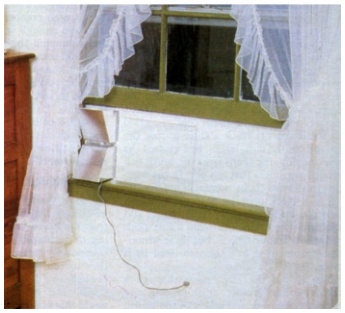
STORM WINDOW SOLAR HEATING PANELS

They're designed to keep the cold out, but you can use 'em to bring the warm in too!









Over the years, Mother's staff tinkerers have come up with a variety of solar devices, most of which have been designed for those who want to harness the power of the sun without incurring a lot of expense. But then - after all of our past efforts - whenever we tried to come up with some original solar projects, we were stumped for ideas. (Was there really nothing more new under the sun?)

But all of a sudden, MOM's researchers hit upon the idea of using salvaged aluminum storm window frames as the basis of a low-cost, weather-resistant, simple-to-assemble hotair collector ..and a promising - economical - approach to backyard solar technology was born. After all, the triple-trackers seem almost custom-suited to the application, since they're [1] preformed in perfect shallow "collector shape", [2] made of lightweight, durable, heat-resistant material (a stagnant wooden collector can, over time, start to smolder), [3] already equipped with precut, tight-fitting glass, and [4] commercially fabricated, giving them a finished "marketplace" appearance.

On top of all this, secondhand frames—at least the ones appropriate for this project—can often be obtained for a few bucks apiece. Many people are upgrading their windows' weatherization with new or color-coordinated storm fixtures ... meaning that plenty of old-but-sound frames are finding their way into the trash or to salvage houses. Even sashes that are missing a pane can be recycled. In fact, a shrewd buyer could probably pick up such "worthless" castoffs for next to nothing and replace the damaged glass with cannibalized sheets from other junk windows!

However you acquire the materials for a storm window solar panel, all that matters is that you locate two frames of the same size and come up with enough glazing to seal one of them tightly. Remember, though, that it's to your advantage to search for large units (they don't have to fit your own home's windows), since they'll naturally offer more absorber surface area.

Once you've latched on to one or more pairs of equal-sized storm sashes, you'll need only to come up with a few more items—which we've specified in our list of materials—to make your solar project a success. The back of the collector and its absorber is a single sheet of 1" foil-faced rigid foam insulation board. The inlet and outlet ducts consist of 4" holes cut in that board at opposite ends. A thermostatically controlled box fan draws air through the collector and exhausts it into the room. And a couple of clothes-dryer fittings, some flexible hose, and a channel made from sections of insulation

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board complete the connection between the air ducts in the collector and those in the living area.

To attach your solar storm window as effortlessly as possible, you'll probably want to use an installation similar to the one shown in our photographs. The collector mount is an adjustable board assembly, designed to fit in the tracks of any partially open double-hung window. Once the sash is closed tightly against this insert (foam stripping at the joint will assure a weather-tight seal), it's sturdy enough to support the weight of the solar panel on the two brackets extending from its outside face. To help give the aluminum collector walls some structural support, a tubular framework is fastened to the edges of the panel "sandwich" ... and to hold the unit at an optimal angle to the sun, a pair of rubber-tipped legs stretch between the frame and the house's exterior.

Begin construction of the collector by laying a screenless and windowless aluminum frame mounting face-up on a flat surface. Measure the width and height of the sash opening (where the framed glass panes normally go), and then cut your foil-covered insulation board to those dimensions, using a utility knife.

Next, cut a 4"-diameter opening in one corner of the board (be sure to leave at least an inch or so margin from the edges), then remove a 4" -square plug from the sheet's diagonally opposite corner. By slicing three long, narrow strips (two, 2" wide and one, 6" wide) from your leftover insulation material and, using aluminum foil tape to join those pieces together, you can then make a simple heat-retaining passageway between what will be the collector's lower (intake) duct and a point about three inches from its upper one. (We found that the easiest way to do this was to first determine the tunnel's necessary length. Next, cut the strips to fit, join them in a three-sided channel, and then tape the entire assembly to the surface of the board after that insulation sheet had been installed within its aluminum frame.)

Before you do that, though, it'd be a good idea to put the square-to-round dryer-duct fitting you purchased in place over its upper-corner opening and secure it with some silicone sealant. Then, you can coat the front side of the absorber surface with high-temperature flat black paint and complete the installation, again using a continuous bead of silicone sealant as a bond. With that done, it's a simple matter to secure the insulated channel—making sure the lower duct is covered—and trim out some end caps that'll fasten neatly over the tube's open tips. (A strip of foil tape placed over each 4" duct's cut edge will protect the foam insulation from the long-term effects of heat.)

The dryer-vent kit you bought should contain about 10" of sheet-aluminum pipe. Cut several inches from it and install it in the upper end of the channel. The remaining piece of pipe can be cut in half and used later on.

At this point, you can join the glass face to the collector frame. First, check to make certain the panes are locked securely in their slots, then seal all of the joints—including the one between the windows—with silicone. Run a bead of caulk (or lay sections of weather stripping) along the frame's faces, then fasten the halves together at the top and bottom flanges with some bolts or self-tapping screws. Take care to orient the glass so the upper pane overlaps the lower, and thus sheds rainwater rather than catching it.

The tubular framework that helps hold the collector at the correct sun-catching angle is constructed of appropriate lengths of 1/2" electrical metallic tubing (E.M.T.). Five-foot-long side rails fit the 36" X 62" frames we were working on. With those bolted through the right and left edges of the

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storm fixtures, so that about 2" of E.M.T. protruded above both top sides of the collector, it was easy to determine the length of conduit necessary to connect those two stubs. The joints were secured by cutting the heads from two 1/4" bolts and bending hooks in their shanks. These "claws" could then be slipped into holes drilled in the cross pipe, and their threaded ends could be passed through openings bored in the side rails and secured with nuts.

At the lower ends of the two side rails, wing nuts, slipped inside each tube, served as a "catch" for the 1/4" X 3/4" bolts that hold the lower support legs in place. Those 1/2" E.M.T. props are offset at one end so they'll crisscross—and bolt together—in the middle for added stability. (Naturally, the dimensions of this "X" brace will depend upon the size of your completed collector and your home's latitude. Just remember that the ideal winter angle for your sun grabber's surface is that latitude plus 10 degrees.)

Congratulations! The collector itself is now complete. Now it's time to move on to the insert that fits in the grooves of your home's window. This wooden "plug" supports the collector from the top and houses the blower fan, along with the air supply and return ducts. To make it, simply cut a section of 1/2" plywood to 12" X 20" and 12" X 26" dimensions, then fasten a 1" X 1" X 20" piece of 16-gauge angle iron to each edge of the longer board—flush with one end—so the other slab can slide snugly into the track you've created. Bolster the outer ends of each board with 1/2" spacers (the long one will take a 3/4 "-wide strip, and the short one a hunk about 3" wide) tacked in place on sides opposite each other.

Next, using your two remaining dryer duct pipes as templates, trace and cut out openings in the longer piece of plywood that are 2-1/2 inches apart and at least 2 inches from the window-frame end of the board. Seal and tack the metal collars into these holes so they extend to the home's outside (away from the angle iron tracks), then bolt a shelf-and-pole bracket to each of the sliding boards. (Fasten one to the 1/2" X 3" X 12" spacer, and the other about 2 inches to the inside of the ducts.) A No. 6 X 3/4" roundhead wood screw threaded through the interior panel and forced into the exterior one will keep the sliding insert from slipping once it's placed within the window tracks.

The way you utilize your blower fan is a matter of preference. If it has limited delivery (under 100 cubic feet per minute), it can be mounted to the upper insert duct and connected, with dryer hose, to the fitting on the collector's air channel. This will draw air in from the middle of the room, feed it to the bottom of the collector, allow it to flow upward along the absorber face, exit it out the corner duct, and return it to the house via the dryer hose connected to the lower window vent. Alternatively, if your fan has more than enough capacity, it can be fastened over the lower window duct and used to suck air through the system, with the supply and return tubes reversed. This will slow down the flow—and further heat the air—but be forewarned that you'll sacrifice some efficiency by doing so.

Either way the fan is mounted, its thermostatic control should be wired in (as shown in our diagram) and that unit should be fed through the corner duct tube and allowed to rest on the absorber surface. Some protective housings—bent from sheet aluminum like those shown in the photo—can be used to cover the window vents if you want to avoid the expense of purchasing louvered grilles ... and homemade foam-rubber plugs will keep those openings from leaking cold air in the evenings. (If you live in a particularly cold climate, you'll also want to insulate the dryer hoses by wrapping batts or foam around them and covering that with duct tape. You could also seal the joints between the insert and the window with weather stripping ... and you might even want to glue scraps of insulation board to the surface of the plywood.)

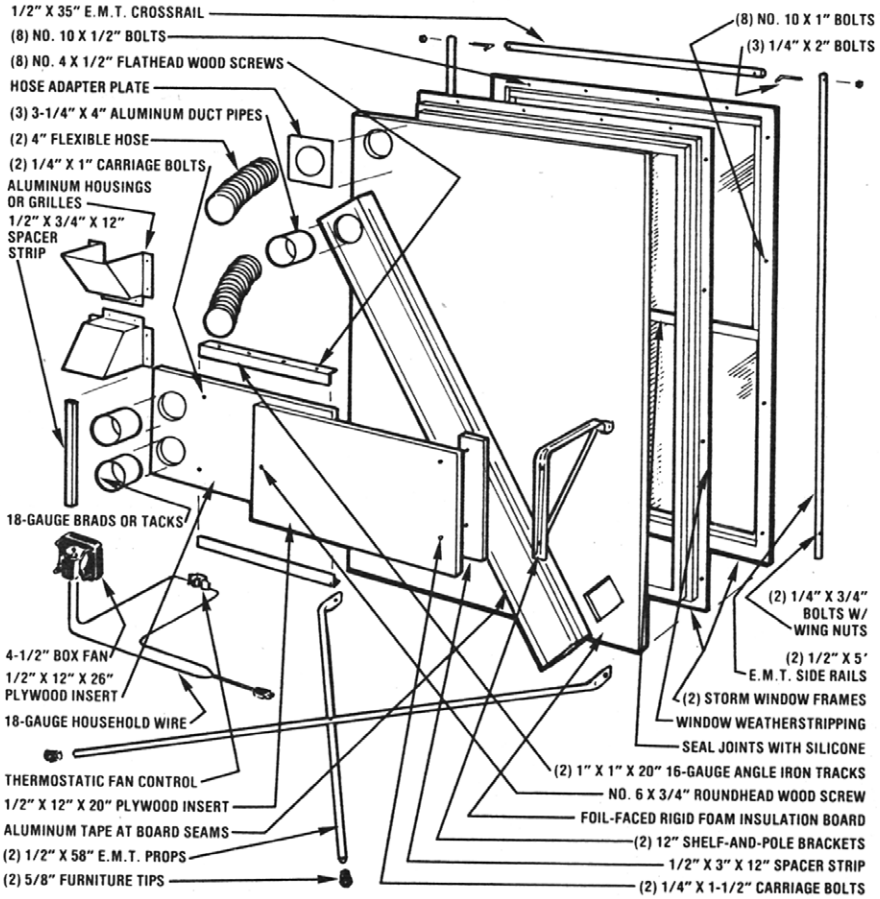
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Are the storm window sun catchers worth building? You'll have to answer that question for yourself. Each of the three units we completed cost us, on the average, under $50 to build, with all new materials, except for the windows. We expect the heaters to last for at least five years. And our initial tests indicate that on a clear or partly cloudy day, they're capable of delivering 120-degree air to the house for up to six hours.

We're not about to tell you that storm window collectors are super-efficient ... but they definitely do work and are among the simplest-to-make collectors you could ever build. Yes sir, for the value of time and materials that you'll put into them, these "Btu bargains" just might be among the nicest introductions to bootstrap solar technology that you'll run across!

LIST OF MATERIALS

- (2) matching aluminum storm window frames (one with unbroken glass)
- 4′ X 8′ sheet of foil-faced rigid foam insulation board (polyisocyanurate)
- clothes-dryer vent kit, which should contain the following parts:
  - 4″-diameter flexible hose
  - 4″ X 10″ sheet-aluminum duct pipe
  - hose adapter plate
- (3) 1/2″ X 10′ E.M.T.
- (2) 5/8″ rubber furniture tips
- 4-1/2″ box or muffin fan (110-volt AC) with a 65–110 CFM flow
- 6-amp warm-air differential fan control (White-Rogers Part No. 757-1)
- 10′ 18-gauge household wire w/plug and wire nuts
- 1/2″ X 12″ X 46″ plywood sheet
- 1″ X 1″ X 40″ 16-gauge angle iron
- 1/2″ X 3/4″ X 12″ wooden spacer strip
- 1/2″ X 3″ X 12″ wooden spacer strip
- (2) 12″ shelf-and-pole brackets
- (8) No. 10 X 1/2″ bolts or self-tapping screws
- (8) No. 10 X 1″ bolts
- (3) 1/4″ X 2″ bolts
- (2) 1/4″ X 3/4″ bolts w/wing nuts
- (2) 1/4″ X 1″ carriage bolts
- (2) 1/4″ X 1-1/2″ carriage bolts
- (8) No. 4 X 1/2″ flathead wood screws
- No. 6 X 3/4″ roundhead wood screw
- 18-gauge brads or tacks
- high-temperature flat black paint
- silicone sealant
- rubber door and window weatherstripping
- aluminum foil tape



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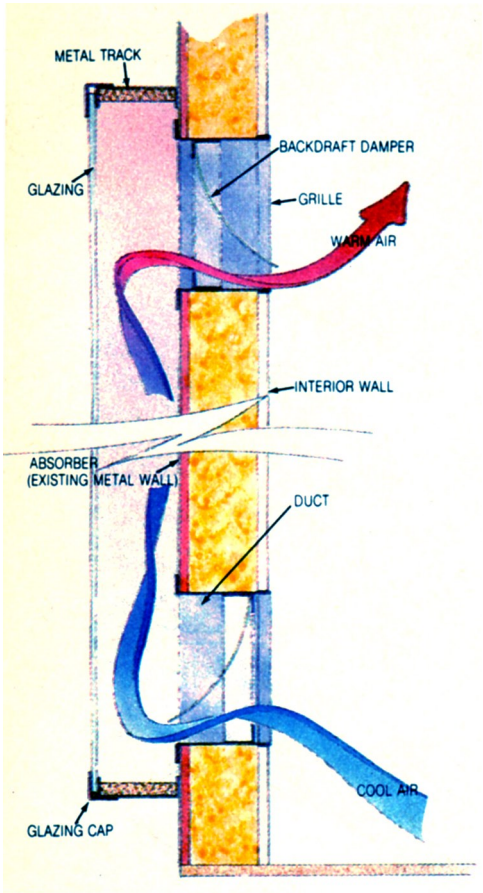
5

TAP THE SUN WITH A THERMOSIPHON AIR PANEL

Looking for an easy, low-cost way to add solar heat to your mobile home for metal outbuilding?

By Luke Elliott

The integrated thermosiphon air panel (TAP, for short) is a fresh approach to solar air heating—one that's perfectly suited to the 10 million or so folks who live in mobile homes and to owners of the countless metal-sided storage, industrial, and commercial buildings around the world. By making use of the building itself as a part of the collector, the TAP keeps material costs down, simplifies construction, and maintains a low visual profile. And, because it relies on thermosiphoning to move air past the absorber, the TAP avoids the complexity and cost of an electrically driven fan.



Steven McCarney—the developer of the TAP—says the idea evolved after he'd installed several standard collectors on metal-sided buildings. In his words, "It seemed redundant to put a collector with a separate absorber and an insulated back on a building that already had those elements." Hence, Steve decided to use the building's own insulated wall as the collector's absorber. Now, longtime readers may recall that the integrated collector idea goes back a little ways (remember the Waterman solar setup in MOTHER NO. 48?). But, regardless of the origin, McCarney and his co-workers can take credit for researching and refining the scheme to the point where just about anybody can build a durable TAP that will pay back his or her investment in only a few years.

WHAT IT TAKES

What do you need to build your own TAP? The critical element, of course, is sunlight: You need a metal-sided wall that faces within 25 degrees of south and that isn't shaded in the crucial winter months. You'll also need some hand tools, such as a drill, metal snips, screwdrivers, a caulking gun, a 1/4" nut driver, and maybe a circular saw. Add to these items less than $100 worth of materials and a weekend's work, and you'll have solar heat flowing into your home.

HOW BIG?

A rule of thumb for solar air heaters is to allow 1 square foot of collector for every 10 square feet of floor area you wish to heat. (The room should first be caulked, weather-stripped, and at least moderately insulated. Always take care of such energy-conserving fundamentals before adding solar

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heat.) Thus, a 180-square-foot room suggests an 18-square-foot collector. This, however, is only a rough estimate. The available wall space for mounting the collector and the limitation of standard tempered glass sizes (28", 34", or 46" X 76"; 34" or 46" X 90") will determine the actual dimensions of your collector.



Because the TAP relies on passive airflow to distribute the heat collected on its absorber, you'll get the best results by sizing the collector to warm the room directly adjacent to the wall on which it's mounted. Though heat will eventually be transferred to other rooms, over sizing the TAP to try to heat more than one room will make the first room too warm.

PLANNING FOR AVAILABLE MATERIALS

The collector frame is made of 25-gauge, 4" or 6" metal track available from a drywall supplier or contractor. To ensure that air moves through the collector without restriction, use the 4" material for any TAP that's less than 80" high and the 6" track for taller units.



Air moves into and out of the collector through metal grilles that run all the way across the top and bottom of the unit, and these too must be large enough to prevent restriction. The height of the grilles should be equal to twice the metal track size: 4" track requires 8"-high grilles.

Because wall studs will be in the way, however, you'll probably have to use several grilles to cover the intake and exhaust areas. Unfortunately, when you shop for grilles, you may find that the perfect sizes simply aren't available. If you run into this problem, compromise by using the next larger size; you don't want to take a chance of restricting free movement of air through the collector.

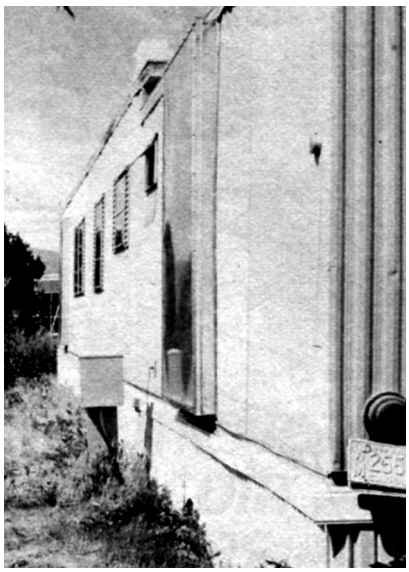
PLAN AND CUT

Many metal structures have horizontal supports called purlins, as opposed to (or in addition to) vertical studs. It's desirable from a structural viewpoint to secure the collector to these members at the top, bottom, or both, if possible. You can find the purlins by looking for horizontal rows of screws that penetrate the exterior metal siding.

Once you've found a likely spot, check inside and out for electrical outlets or other services that might be in the way of the intake or exhaust registers. When you feel certain that you've located an obstruction-free place for your collector, clean the siding in the general area, and mark out the dimensions for the device with masking tape. (Add 1/2" to the vertical and horizontal dimensions of the glass to allow for the frame. Thus, the size of a collector with 34" X 76" glass will be 34-1/2" X

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76-1/2".) Inside this area, mark the duct locations with chalk lines, but be sure to leave about 1-3/4" between the frame and ducts to allow for mounting the frame and attaching the 1" tabs from the ducts.



For safety's sake, turn off all power before cutting into either the exterior or interior wall. Use a hammer and an old screwdriver to punch through the building's exterior skin within the area where each duct will be located, and then carefully trim out each opening with aviation snips. (Be mindful of razor-sharp metal edges while you're cutting.)

Next, remove the insulation from the duct area, and use a nail or drill to precisely transfer the corners of the duct openings through the interior wall. After double-checking your measurements, trim out the interior drywall or paneling with a razor knife or keyhole saw.

Now paint the exterior wall within the taped area with high-temperature, flat black paint. Spraying is easier than brushing and will give you a more effective absorber surface, but be sure to follow the instructions on the can's label.

DUCTS AND DAMPERS

You'll use sheet-metal ducts to fit through the openings you've just cut out. If you're competent with metal shears and have a brake for bending the sheets, you can make the ducts yourself, according to the dimensions we've provided. But if you'd prefer, just take the drawing to a sheet-metal shop and have them fold up the ducts for you.

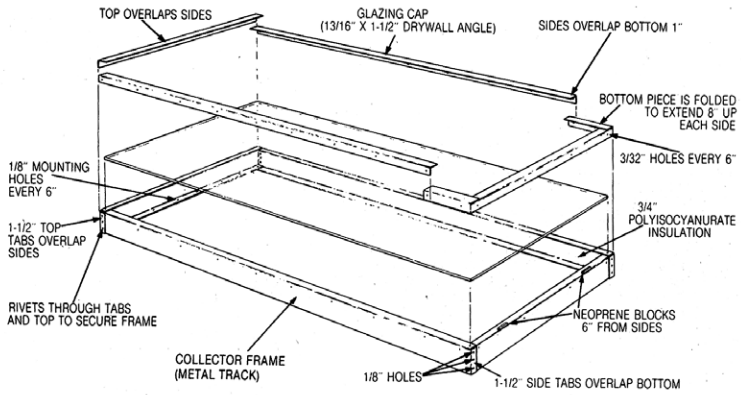
When the ducts are completed, soak them in vinegar (overnight is best) to etch the surfaces. Paint doesn't adhere well to galvanized metal surfaces, so don't overlook this important step! After the vinegar bath, rinse the ducts, dry the surfaces, and paint them. Once they're dry, fit the ducts through the openings and attach their metal tabs to the siding with rivets and to the studs or purlins with No. 8 X 1/2" screws. (Always wear safety glasses when riveting, since a stem will occasionally fly out with enough force to cause injury.) Caulk the seams in the ducts, the joint where they fit to the building, and all rivets and screws.

Assemble the damper frames from drywall angle (not corner bead!) to the dimensions shown (make them 1/8" smaller than the ducts overall), and trim 1/2" hardware cloth to fit over the finished frames. Attach these screen pieces to the damper frames by first drilling 1/8" holes about every 6" around each frame and then riveting (with 3/4" washers) the hardware cloth to the frames. Treat the metal dampers with vinegar, rinse them, and apply paint when they're dry. Now cut pieces from a dry-cleaner bag (or other very thin plastic) to fit within the frames. Use duct tape to attach these to the top inside of each frame, and apply a thin layer of silicone caulk around the tape, to prevent it from peeling away.

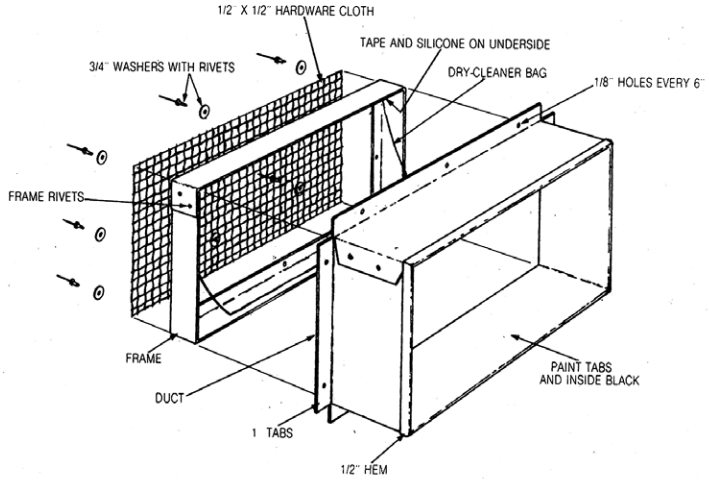
The finished dampers may now be "friction fitted" into the ducts, as shown in the drawing on page 24. The upper damper must be positioned so that it will open when air attempts to exit from the

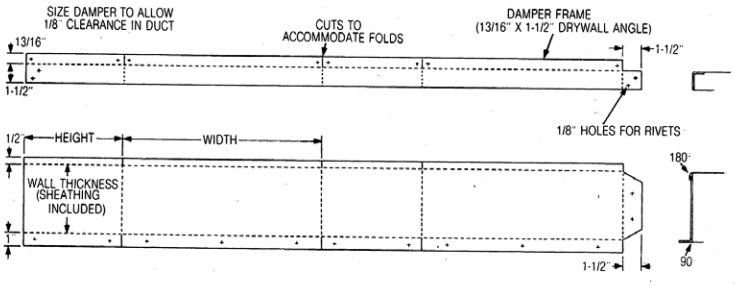
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COLLECTOR FRAME



BACKDRAFT DAMPER AND DUCT





DAMPER AND DUCT PATTERNS

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collector, and the lower one must be set in the opposite direction. A fine bead of silicone where the dampers meet the ducts will ensure an airtight seal, but be careful to avoid getting any fresh caulk on the damper flaps. Secure the dampers to the ducts with a 1/2" sheet metal screw through each side.

The slightest breath of air in the desired direction should open the plastic flaps in the dampers, but any reverse action (air flowing through the collector in the opposite direction at night and thus becoming cooled) should be stopped.

FRAME IT

The collector sides, top, and bottom should be cut from the metal track to the proper size with aviation snips, drilled for assembly and mounting, and squared and riveted together as shown. Although it's not mandatory, you may want to paint the outside of your collector frame to match the color of your building, but don't forget to prepare the surface first. Be sure to caulk all joints—inside and out—with silicone.

ATTACH AND INSULATE

Enlist the help of a friend for the final few steps of assembly: You'll need an extra pair of hands to hold things in place while you affix the collector to the wall. Lay the collector frame on the ground with its glazing side down, and apply a layer of silicone caulk all around the edge where the frame will contact the wall. Then quickly (before the caulk dries) position the assembly on the wall. Plumb and level the frame, and, while your friend holds it tightly against the wall, drill 3/32" pilot holes through the guides in the frame and into the purlins. Attach the collector to the wall with No. 10 X 1-1/2" screws.

Using the remaining mounting holes as guides, drill 1/8" holes through the siding, and rivet the collector frame to the siding. Finally, caulk the perimeter of the frame carefully, filling all gaps.

To isolate your system thermally, cut rigid insulation to fit snugly into the top, bottom, and sides of the collector. Place a small amount of silicone on the inside of the track, press the insulation in place, and caulk all edges to create an effective seal.

BILL OF MATERIALS (34" X 76" collector)

QUANTITY	ITEM	UNIT COST	TOTAL COST
4	air grilles	$ 4.34	$17.36
4	ducts	2.00	8.00
1 can	flat black, high-temp paint	2.77	2.77
3 tubes	100% silicone caulk (not sill seal)	4.84	14.52
36 feet	13/16" X 1-1/2 25-gauge drywall angle (from a drywall contractor or supplier; don't use corner bead)	.10	3.60
4 sq. ft.	½" X 1/2" hardware cloth	.38	1.52
2 yards	duct tape	.11	.22
1	plastic dry-cleaner bag	--	--
20 feet	4" 25-gauge metal track (pick up w/ drywall angle)	.22	4.40
1 sheet	34" X 76" single-pane tempered glass (don't use annealed or nontempered; substitute fiberglass-reinforced polyester if weight or vandalism is a concern)	24.37	24.37
2	¼" X 1/4" X 2' neoprene blocks (from glass supplier).	.10	.20
6 sq. ft.	3/4 polyisocyanurate, foil-faced, rigid-foam insulation	.25	1.50
100	1/8" X 1/4" steel rivets	.01	1.00
25	No. 8 X ½" hexhead (1/4") sheet metal screws	.03	.75
15	No. 10 X 1-1/2" hexhead sheet metal screws	.05	.75
40	No. 8 X ¾" hexhead (1/4") sheet metal screws	.03	1.20
40	bonded (gasketed) washers for No. 8 X 3/4" sheet metal screws	.03	1.20
2 quarts	household vinegar	.70	1.40
COLLECTOR COST PER SQUARE FOOT = $4.72		TOTAL COST = $84.76	

FINAL TOUCHES

The tempered glass sheet mounts to the collector frame on a 1/2" bead of silicone caulk (with neoprene blocks at the bottom edge for extra security) and is secured with a glazing cap made from drywall, angle trimmed

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to the dimensions shown. Once you've cut the four lengths of cap, mark and drill 3/32" holes every 6" along the short side of the angle, and treat and paint them. Then glue the neoprene blocks to the collector frame as shown.

Thoroughly clean both sides of the glazing, and collect all the materials and tools you'll need for this last but crucial step. You'll need your electric drill with 3/32" bit, a fistful of No. 8 X 3/4" hex head sheet metal screws with bonded washers, a 1/4" nut driver (or, better yet, an attachment for your drill), and silicone caulk.

Place the 1/2" bead of silicone on the frame, and lift the glass into place. (Remember, always carry glass on edge—never flat.) While your companion holds the glass, drill 3/32" starter holes in the collector frame, using the holes in the glazing caps as guides. Install the bottom cap first, and follow with the sides and top to give a shingled effect that will shed water. (The power screwdriver is a lifesaver at this stage.) For the best results, push the glazing cap firmly against the glass while you're placing the screws.

IT WORKS!

You can expect to save 15 to 20 percent on your fuel bill in an area served by a TAP. Specifically, computer analysis has shown that the system should pay back your investment in three to seven years—depending on how much you have to pay for conventional heating.

10 Tips for Top-Notch Caulking

1. Read the label before you purchase. Be sure the caulk you're about to buy is compatible with the materials you're using. And don't skimp—use only 100% silicone and beware of cheaper brands.
2. Clean and dry. Thoroughly remove all dust, dirt and moisture before you caulk.
3. Keep your cool. Hot surfaces make silicone difficult to apply. Don't caulk during the heat of the day.
4. Work fast! Silicone caulk skins over (dries) quickly. Once materials (such as glazing) are embedded in the caulk, they shouldn't be moved. An ineffective seal can result. Be sure you have everything at hand and positioned before the caulk leave the tube.
5. A 1/8-inch opening in the tube's nozzle will dispense enough silicone for most jobs.
6. Slick the beads. Caulking wouldn't be half as messy but for this: Run your finger (rubber gloves work great) over the bead immediately after you caulk a joint or seam. This action forces the silicone into any gaps and ensures a good seal.
7. A plentiful supply of rags or towels to wipe your hands will save pant legs and shirt sleeves.
8. Paint doesn't adhere to silicone caulk, so coat everything before you caulk.
9. Disengage the caulk gun after each use to avoid wasting the globs that inevitably ooze out under sustained pressure.
10. Push a large nail into the nozzle to save a partially used tube.

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6

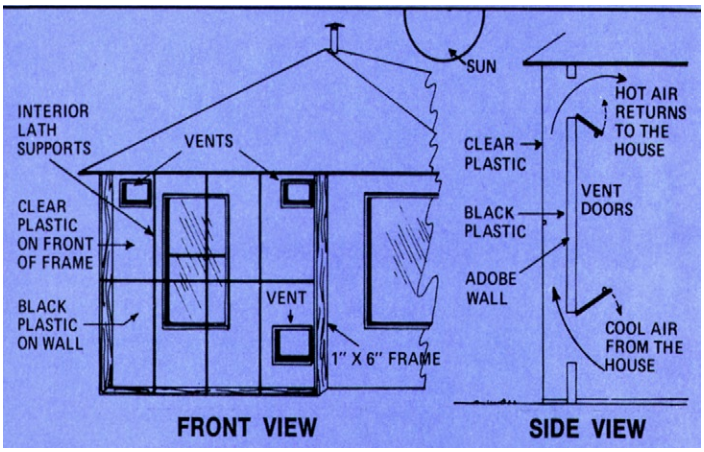
ULTRA-SIMPLE SOLAR HOT-AIR WALL HEATER

By Diane A. Gilman

Contrary to what you might think, solar heating installations don't have to be complicated and expensive in order to do the job. We proved this to ourselves not long ago when we outfitted a home—an old adobe dwelling located high (8,000 feet) in the mountains of northern New Mexico—with a bare-bones simple, yet highly effective, $25 solar heating system.

When we took it over, the house was nothing but a drafty, unfinished, 750-square-foot adobe lodge that featured lots of window area and walls with an equivalent insulation value of less than an inch of fiberglass. Not exactly what you'd call a cozy shelter in which to brave minus-19-degree New Mexican winters!

Fortunately, the building's roof was insulated with a full 6 inches of fiberglass ... but the floor—like the walls—had no insulation. We were told that during the winter before our arrival, the house's occupants had spent $60 per month for propane to keep the place warm.



That was all the incentive we needed to begin looking for a way to improve the dwelling's heating efficiency. So we pondered the situation for a while, and ultimately decided to [1] put in a wood-burning stove and [2] rig up a large solar collector for the south wall of the structure. (Because we were renting, not buying, the place, we felt it wouldn't be feasible for us to go to the expense of insulating the entire building, even though that would've solved the better part of the heating problem.)

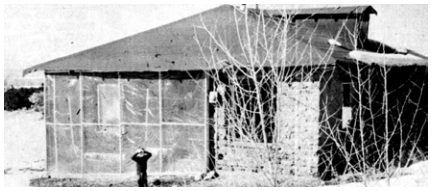
Building the collector was a cinch. All we did was [A] tack up a sheet of black plastic to the outside of the south wall, [B] construct a 9' X 14' framework of 1" X 6" boards, [C] cover the outside face of this framework with see-through 4-mil plastic (we put a few lath reinforcements between the one-by-sixes to help the plastic withstand the strong mountain winds), and [D] mount this stud-wall-like frame to the side of the house, right over the black plastic.

As you can see from the accompanying diagram, we also cut two 12" X 15" vent holes in the wall near the ceiling and a 24" square opening in the wall near the floor, and placed doors over all three openings. (These holes vent the collector to the house, but not to the outside.)

Thus, whenever Ole Sol shines down on our humble abode and we need some extra room heat, all we have to do is throw open the hatches, sit back, and let the collector (aided by natural con-

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vection) do its work. Cool house air enters the collector through the 24" opening at the bottom of the wall ... rises as it's warmed by the sun's rays ... and exits back into the house through either of the two top vents (which are located in two different rooms) with enough force to flutter a few ribbons. TA DA! Passive solar heat!



The beauty of this design is that it's simple (no expensive pumps, differential thermostats, copper tubing, etc.), and yet it works. The setup's only drawback is that it doesn't keep us warm for very long ... because at night, the heat passes right through our adobe walls. (The only remedy for this, of course, is insulation.) Still, we're proud to report that our solar heater now provides us with one third of all the Btu's we consume in space heating, which—in terms of propane—translates out to about $20 a month. Hence, you can figure the pay-back time on our whole system at around five weeks ... a far cry from the five to ten years it takes most solar heating installations to pay for themselves.

It's true that we could have increased the collector's efficiency and durability by using glass in place of plastic ... but this would've been—for our budget—much too expensive. Plastic works fine for us (and when it does need replacing, a new sheet should cost only about $5.00).

We found this a fun and rewarding experiment — to ourselves and to the planet. So much so, that we're already at work constructing a solar heated house of our own!

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ALUMINUM CAN SOLAR HOT-AIR HEATER

An inspired leader and a willing congregation reaped unexpected benefits when they created...
A SOLAR-HEATED CHURCH
By Luke Elliott

Inexpensive solar heaters (made with sliced-in-half beer and soda cans) have cut the Washingtonville, New York First Presbyterian Church's fuel costs by 55 percent!

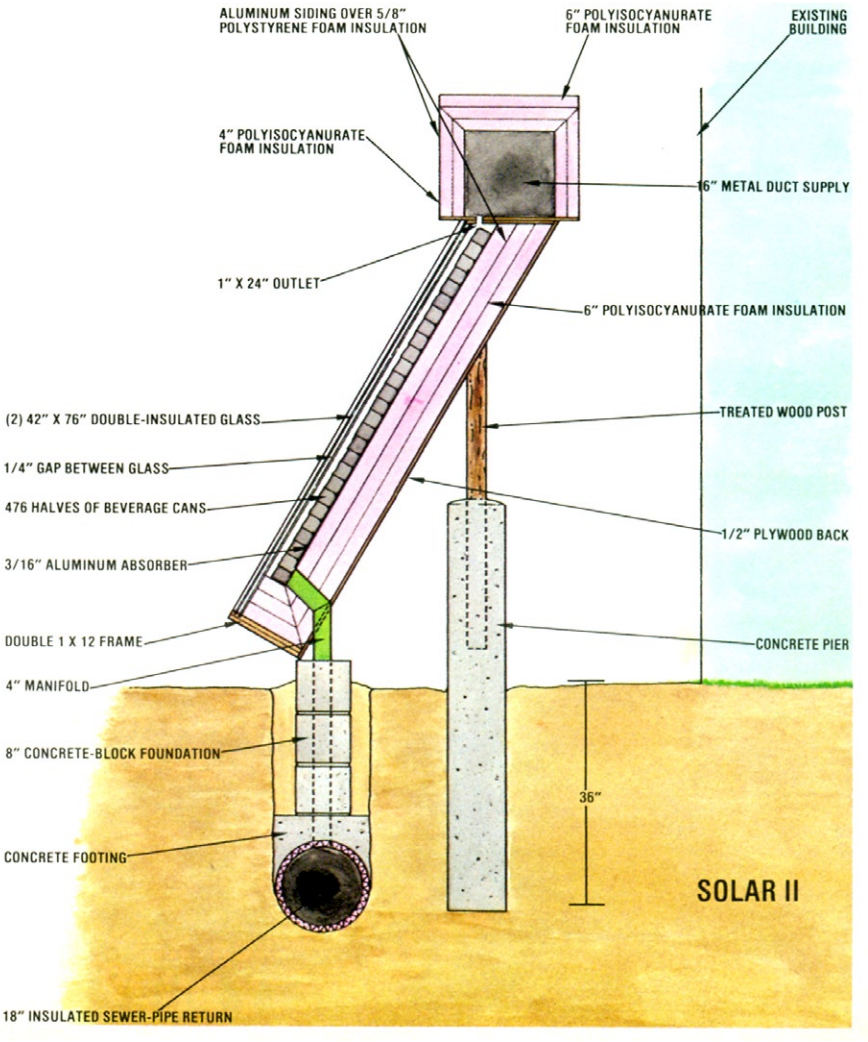
The project got under way in the fall of 1978, when the Reverend Lee H. Poole, a longtime solar advocate, convinced the church's council to put up $110 to build a collector. He drew up the plans himself, and the first unit was constructed over the course of a single weekend, in a member's back yard.

"We tested our creation on a sunny October afternoon," the minister recalled, "and the temperature inside the collector reached 203 degrees. So we knew then that my design would work, and, as a result, the council agreed to fund two more units."

FINAL TOUCHES

The Reverend's system was hooked into the church's Sunday school building by air ducts and a fan that drew cool air in from the basement, passed it through the collectors, and back into the building again. It reduced the church's fuel oil costs by more than $650 that first winter ... almost exactly what it cost to construct and install the complete solar-heating system.

The church then offered to "spread the word" by sending information about the solar heater design to anyone who'd mail in $1.00. A few months later, The New York Times and some other newspapers, as well as a number of church



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magazines, publicized their offer ... and that attention brought in more than 13,000 letters, from all 50 states and 29 foreign countries.

"During the peak of our mail-answering period," the pastor noted, "we were printing plans in lots of 2,000, and we had five youngsters and three mothers sending them out and taking money to the bank."

After taking care of the printing and postage costs, the church found that it had made a profit of $7,000, which was then used to build a much more elaborate eight-unit system, dubbed "Solar II". These collectors were put into operation in October 1980.

While installing the enlarged setup, Lee and his helpers decided that they needed some professional assistance ... primarily to help installing the ducts and fans and tackling the necessary electrical work. The fee for that labor came to $2,400, and brought the total price of Solar II to about $6,700, but as the following figures show, the system has already proved to be a bargain.

You see, during the winter of 1975-76, the church used 4,572 gallons of oil to heat its 96,800 cubic feet of volume. However, after aluminum siding was installed on the buildings, the fuel-oil requirements dropped to 3,810 gallons in the winter of 1976-77 and to 3,738 gallons in 1977-78. Then, during the winter of 1978-79, when the initial three-unit heater was installed, usage dropped to 2,869 gallons, and, once Solar II was in place, oil usage dropped to approximately 1,700 gallons. The Reverend estimates that the collective conservation efforts have resulted in a present savings of about $3,500 a year for the congregation!

BUILD YOUR OWN

Folks hoping to duplicate the church's collectors should know that the dimensions of the original units each of which required two glass panels separated by a 1/4" air space - were determined by the size of the panes that volunteers were able to obtain. By accepting a local dealer's offer of secondhand 42" X 76" sheets of tempered Thermopane (commonly used for sliding glass doors), the church was able to spend only $10 per pane, as compared with a typical retail cost of about $90.

Next, a rectangular frame - made from commonly available 1 X 12 lumber - was built around each double pane, with notches in the wood to hold the glass securely at the front of the box. Then, a second frame was built around the first and attached to it, so the completed "border" is actually more than 1- 1/2 " thick.

A piece of 1/2" plywood serves as the back of the box (or the underside of the frame). However - since that material can deteriorate under high temperatures - the pastor says that, if he had to do it over again, he'd likely use metal instead of the plywood, and would also prefer a steel frame.

At this stage, 6" of polyisocyanurate foam insulation (with an R-value of almost 50) was placed on top of the bottom (plywood) sheet and formed into an inner lining around all four sides of the unit. (The importance of effective insulation, the preacher says, can't be overemphasized.) Then a 3/16"-thick aluminum sheet-painted flat black to absorb the sun's rays-was put above the insulation, and the aluminum beer and soda cans (each cut in half around the circumference and painted black) were placed on the aluminum sheet with their open ends facing the sun. (A space of about 1/2" was left between the top of the cans and the inside sheet of glass.) Each of the church's units required

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476 half-cans. The containers could have been held in position with aluminum nails, but, because they tilted upward and fit snugly against each other, the church workers found that this wasn't necessary.

The Reverend believes that it's generally better to have collectors rest on the ground, rather than on a roof, simply because the lower location allows easy removal of snow and/or ice. (Also, additional energy would be required to pump hot air down from a roof-mounted unit, and heat would be lost during the journey.) Therefore, the rectangular collectors were placed at ground level in back of the church, and angled due south at 60 degrees from horizontal ... or more or less perpendicular to the sun's rays in February, the coldest but sunniest winter month in the area. (This angle should, of course, be increased at locations north of latitude 42 and decreased farther south.) The units are held in position by 2 X 4s or 4 X 4s, which are either embedded in concrete or set in 8" concrete blocks.

FROM COLLECTORS TO CHURCH

After the actual heat gatherers were set up, the next step involved placing a 16" diameter, insulated sewer pipe 3 feet deep (which is below the frost line) and directly under the row of collectors. The pipe is connected to the Sunday school building's basement ... and from there, it draws cool air, which enters the base of each heater by way of two 4"-diameter, insulated ducts.

Additionally, a 16"-square air duct (it's also well insulated, with 4" of polyisocyanurate foam on each side and 6" above) was built along the top of the row of heating units, to receive the hot air that flows from two 4"-diameter ducts leading from the top of each collector. The wood framing of the ducts and collectors was then covered with aluminum siding (placed over 5/8" polystyrene insulation) to match that on the exterior of the buildings.



One end of the 16" -square duct leads into the church sanctuary, and the other outlet goes into the Sunday school annex. At each end, a blower, having a capacity of about 1,700 cubic feet per minute, is housed inside an aluminum container. Each fan pulls heated air from the collectors and pushes it through the buildings' metal ducts and air vents.

A key component in the system is a thermocouple, located inside the middle of the 16"-square duct atop the heaters. This turns on the Sunday school fan when enough heat is present inside the duct ... usually around 9:00 a.m. on a sunny day. Then, when that building is warmed to the desired level, a thermostat in the annex cuts off that fan, and the second blower draws heat into the church.

Guided by the thermostat, the two fans switch on and off during the day, keeping the Sunday school building at the desired temperature. Thanks to the drop in heating costs, the building is now used an average of six days a week, as opposed to the pre-solar three days a week. The church, usually unoccupied except on Sundays, gets all of the "extra" heat, generally beginning to warm up around 11 a.m. on a sunny day, even in February.

Note: The plans for this unit are no longer available. The church tore out the unit a few years ago as obsolete.

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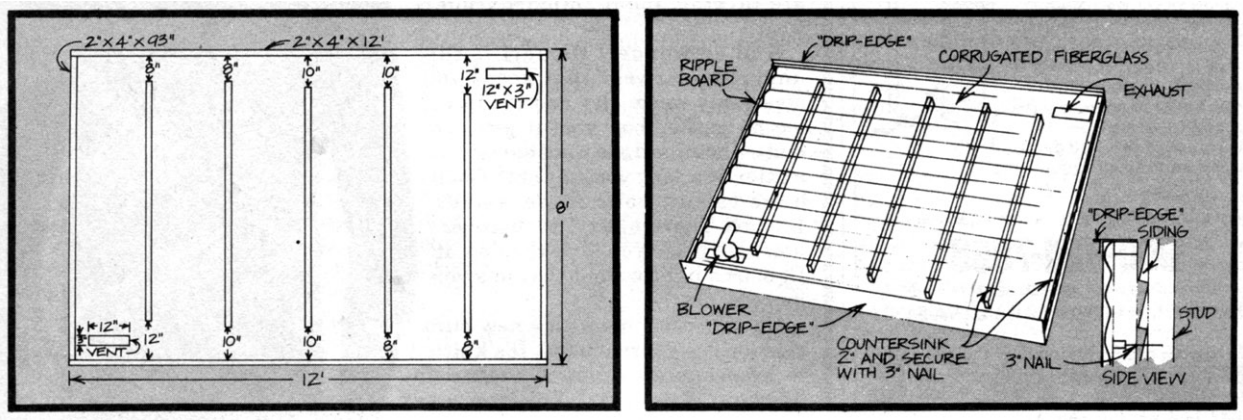
8

SUPER EASY, SUPER LOW-COST SOLAR HOT AIR CORRUGATED COLLECTOR

There are some real advantages to using solar energy to heat your home's air, rather than depending upon the transfer of the sun's heat to the air by a thermal mass. Not only do such "direct" solar systems circulate and humidify your dwelling's atmosphere, but many are also surprisingly easy to build. In fact, you can have MOTHER's convective collector (which gets an "active" boost from a small blower) ready to nail to any south-facing wall on your house in a couple of hours!

Start the construction of your sun powered heater by locating the studs inside your frame wall and scouting for any plumbing or wiring that might get in the way of the collector's intake or exhaust vents. Once you've mapped out a suitable 8' X 12' location, just countersink holes every two feet in the 2 X 4s, which will be the collector's frame. Make the holes about two inches deep (as indicated in the illustrated side view). Then fasten the parts to your wall with 3-inch nails.

Next, you can add the collector's internal baffles by countersinking and nailing these 2 X 4s to the wall, just as you did the frame pieces. The spacing shown in the diagram is critical ... it maintains the correct airflow through the system. (The baffle boards should—by virtue of their 24-inch separation—connect with the studs below them.)



Now that the frame is complete, cut the 3" X 12" vent holes in your wall, line them with Thermax-brand insulating board, and seal the cracks with silicone caulking. If you trim a standard-sized sheet of the insulator carefully, there should be enough material left to completely cover the rest of the exposed wall space inside the frame. Make sure that the Thermax fits tightly around the boards, and seal every junction with a liberal amount of caulking. With that done, brush a coat of flat, black paint on the inside of the collector.

Once the paint is dry, lay each piece of ripple board on an appropriate frame member, and secure the "wobble wood" with three nails per section. The translucent corrugated fiberglass fits right over the wood, and—after you've drilled a hole that's three sizes smaller than the diameter of the rub-

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ber-sealed roofing nails (which secure the covering) through every third bump in both the wood and the glass—you can caulk the surfaces and affix the light-admitting material.

Finally, tack and carefully apply silicone-seal to a 12-foot strip of "dripedge" along the top and bottom of the collector to seal the fiberglass and protect the wood from rain. Then cut a 2" X 8" vent in the vertical 2 X 4 next to the exhaust duct, to allow the collector to breathe during extremely warm spells. (Of course, this hole should be plugged when you're using the solar heater.) In addition, if you live in a very windy climate, you may wish to add an extra layer of glazing for insulation. (We've found the 3M Company's Flexigard plastic, in 3-mil thickness, to be an excellent substance for this purpose.)

To start your solar "heater" up, just insert a blower (about one cubic-foot-per-minute capacity for each square foot of collector) in the intake duct, and let the sunshine warm your home. In moderate climates, two of these devices can heat your entire abode for less than $300 total cost (including the blowers). At that rate, the materials should return your investment in less than a year.

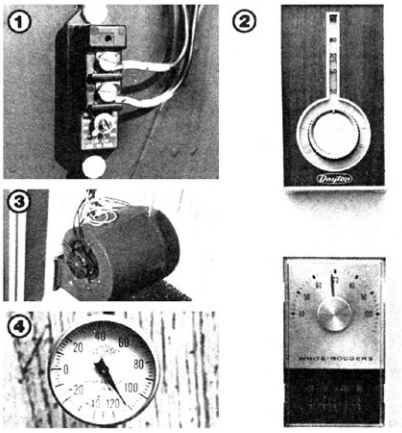
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9

AUTOMATIC COLLECTOR CONTROL

SOLAR ON A SHOESTRING

The preceding, "Solar on a Shoestring" article, page 32, featured an incredibly inexpensive solar collector, which could be built from lumberyard materials. Well, that project proved to be so successful that a member of our research team has put in a few extra hours developing an automatic control system for the "Corrugated Collector" (or most any passive sun-grabber)... so you can take advantage of 19,000 Btu per hour without lifting a finger.



One of MOTHER'S solar researchers, Dennis Burkholder, was so enthusiastic about the low-cost collector, that he took a day off recently to build one of the sun catchers on the side of his own home. And - not surprisingly-Dennis couldn't resist doing a little additional design-as-you-go engineering with the basic corrugated collector concept.

First of all, the fearless fabricator decided to cover the whole south-facing side of his house with collector ... including the windows. Though the view is now a bit blurry through the rippled fiberglass, neither of the affected bedrooms has suffered any significant loss of natural light. In addition - since he was about to put roughly 200 square feet of "solar furnace" into action - Dennis increased the vent size to 6" X 12" and ran a 10" duct through his attic - to drop the warm air into the center of his home. With these modifications, he was able to use a blower with a flow rate of 400 cubic feet per minute.

Well, our researcher did such a good job of reworking the collector that he soon found out his house would overheat during the middle of the day if he didn't shut the "fan" off. So the obvious next step was to set up the solar heater to work on demand. The solution is simple and inexpensive, and you can wire up one of "Dennis's brainstorms" for your own collector in about an hour or so.

The control system works by placing one temperature sensor in the living area of the house and another inside the collector, then wiring the two sensors and the blower into a series circuit. Thus there must be both a need for heat and sufficient warmth on hand in the collector before the blower will switch on.

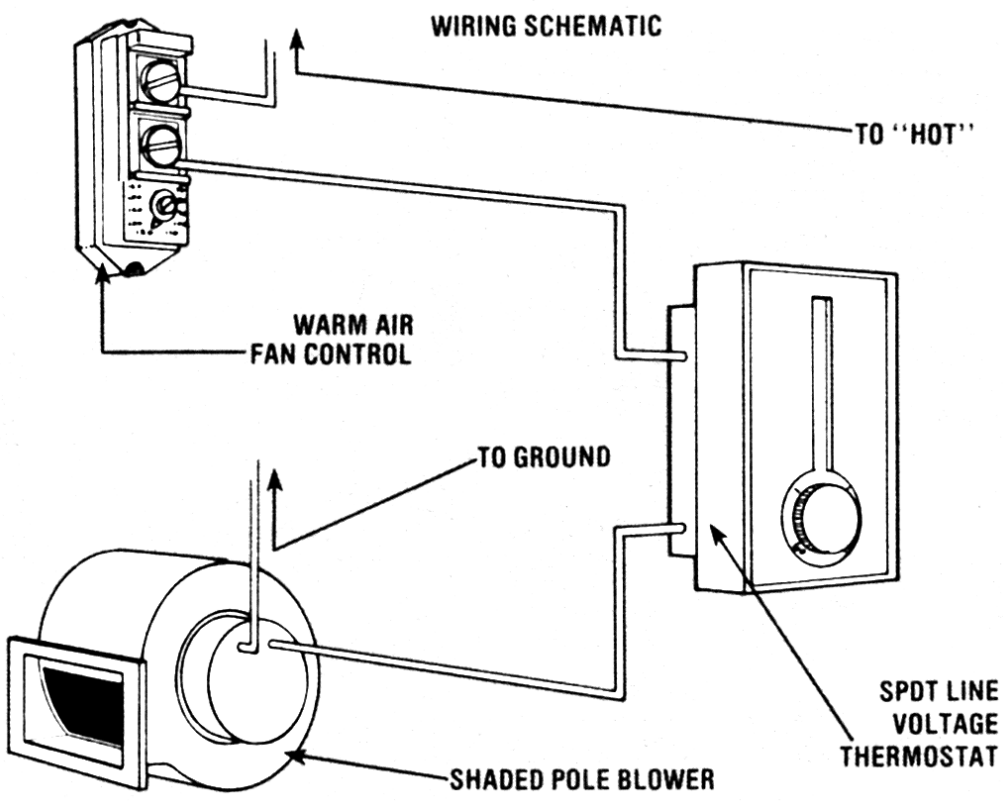
You can start the installation by lifting the upper panel of corrugated fiberglass (if you've already built your corrugated collector) to expose a point about a foot from the top, and two "channels" over from the air intake. Drill a 1/2" hole through the Thermax insulating board and the wall, and run two wires through the opening. Then use screws to fasten a 70-160-degree warm-air fan control to the collector surface, and attach each of the wires to a pole on the control. The positive wire will go to a power source inside the house, and the neutral wire will connect to one terminal on a 115V thermostat located near the main thermostat for your heating system. (WARNING: Before you make the "hot"

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connection to your home's electrical system, BE SURE TO SHUT OFF THE CIRCUIT BREAKER FOR THAT SECTION OF YOUR HOME'S WIRING TO AVOID SHOCK.)

Once the hot-wire/control/thermostat circuit is complete, you can set the temperature scale on the collector's sensor to about 120-130 degrees and close the corrugated fiberglass again. Next, run a wire from the remaining lug on the interior thermostat to the positive pole on the blower, and then connect the ground post on the fan to any available ground in your house's wiring.

Now you can flip the circuit breaker back on again and set the interior thermostat to a temperature a few degrees higher than your main furnace control. As long as there's heat in the collector, your energy-consuming traditional heating system will be taking a moneysaving rest. As a matter of fact, Dennis has found that on a clear, crisp winter day, the blower will kick in as soon as 20 minutes after sunrise and keep his home warm all day long. And best of all, his heating bills have already dropped from $90 per month to a little under $40!



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INEXPENSIVE SOLAR HOT AIR COLLECTOR

THIS $30 SOLAR SETUP HEATS A 30X40 WORKSHOP FOR FIVE HOURS OR MORE EVERY SUNNY WINTER DAY.

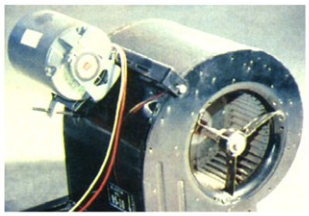
"For a super-simple and super-inexpensive solar heating system that really works," say Don R. and George Waterman of Springfield, Missouri, "you only have to follow four rules. [1] glaze with low-cost plastic film instead of glass or Plexiglas [2] use a structure's existing south-facing wall for the back of your collector [3] forget about trying to store the heat you collect and,[4] scrounge!"



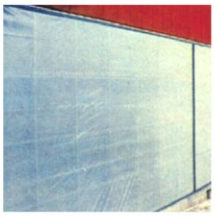
The unglazed collector: 500 feet of 3/4-inch wood strips on trapezoidal spacer blocks.



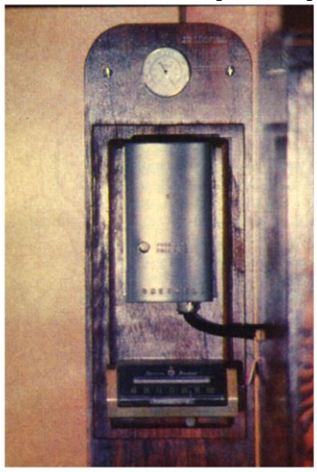
One of two corner inlets through which cold shop air enters the solar collector.



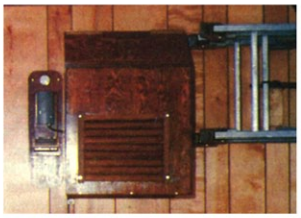
Blower motor and squirrel cage fan.



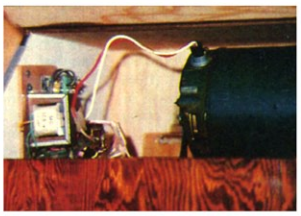
One layer of plastic.



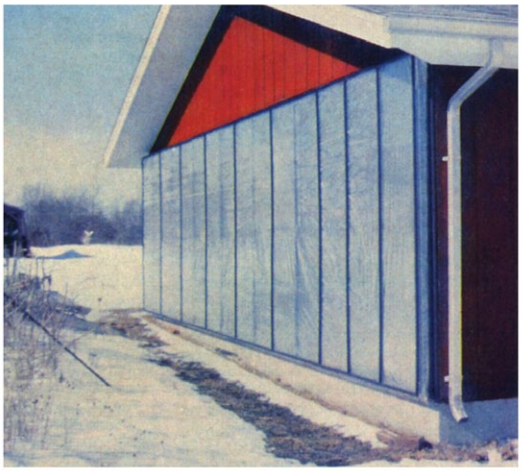
The automatic controller thermostats



The blower housing and controller.



Note transformer in blower housing.



240 - square foot, $30 solar collector. Simple....and effective!

If you really want to put solar energy to work for you right now on a minimum-cash-investment basis, you can. I know, because last winter my father, George Waterman, and I supplied a 30 X 40 insulated workshop with almost all of the heat needed to keep the building's interior comfortable

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throughout near-zero days ... and we did it with a solar heating setup that cost us a total, out-of-pocket, of only $30.

We accomplished this feat with a fourfold secret of low-cost construction: [1] We glazed our 8' X 30' solar collector with inexpensive plastic film instead of glass or Plexiglas, [2] we used our workshop's existing south-facing wall for the back of the collector, [3] we did not build any heat storage into our design, and [4] we scrounged a great deal of the material that went into the solar heating system.

Thanks in large part to the four points listed above, our sun-powered heater was also quite simple in design and went together very rapidly. We put the whole system up with only about a week's worth of work (spread out, due to bad weather, over nearly two weeks). Compare our total time and cash investment to the $1,500, $2,000, or more that 240 square feet of commercially manufactured collectors would have cost (before installation, of course, and before tacking on another ridiculous

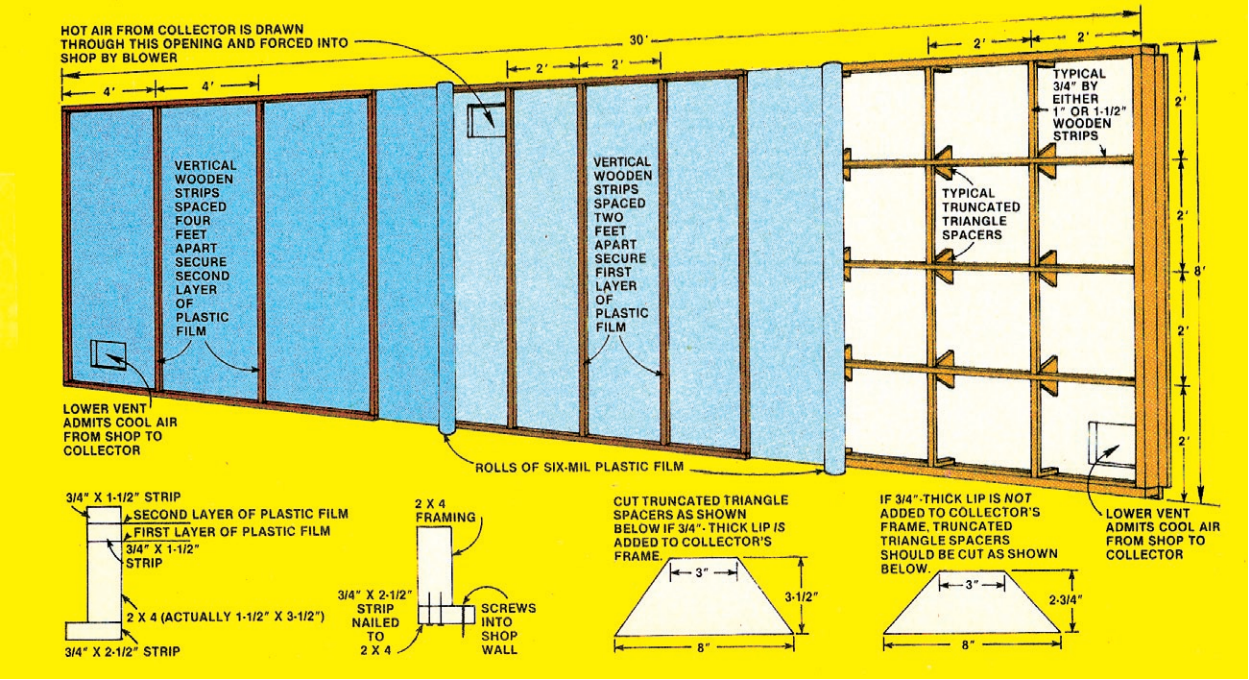


figure for blowers, ducting, etc.) ... and I think you'll agree that our initial investment was quite reasonable.

Nor will upkeep (which should mainly involve the replacement of our collector's double layer of plastic film) be the continuing expense that you might think. We figure on replacing our film no more frequently than once every two years (it's already been through one winter and looks good for another). But even if we have to change both layers of the plastic every year, it's quite inexpensive (a roll of six-mil polyethylene measuring 8' X 100' cost us only $17). At that price, it'll take 34.5 years worth of annual replacements to add up to the cost ($400) of one original double set of glass collector covers ... and 69 years of annual replacements to equal the cost ($800) of duo Plexiglas glazing. We think we've got the trade-off working in our favor.

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We started our collector by outlining its 8' X 30' area with four 15'-long and two 7'9"-long 2 X 4s. (Since our plastic was just eight feet wide, we used 7'9" uprights on the ends of the unit which, when capped top and bottom by 1-1/2"-thick 2 X 4s, added up exactly to the plastic's eight-foot width.) These 2 X 4s could have been just toenailed (on edge) to the south wall of the shop, but we took the time to mount them in a somewhat more sophisticated (and we think better) way. What we did was first nail 3/4" X 2-1/2" strips of lumber flat against the edges of the 2 X 4s (see detail I sketch on the drawing which accompanies this article). Since the so-called 2 X 4s sold today actually measure only 1-1/2" by 3-1/2", this means that the strips formed a lip measuring 3/4" deep and a full one inch wide completely around the 8' X 30' perimeter of the collector frame. And that made it awfully easy to attach the frame (right through the lip) to the shop's wall with wood screws.

We made the seal between the 2 X 4 frame and the tongue-and-groove siding on the workshop wall as airtight as possible by stuffing small amounts of fiberglass insulation and old cardboard into every crack we could find. A good bead of caulking compound, run completely around the outside of the collector-to-wall joint, finished off that part of the job.

As soon as we had our collector framed in, we cut three holes into the part of the shop's wall that was enclosed by the framing: one in the top center and one each in the lower corners. These openings, of course, were made so that cool air from the workshop could enter the collector (through the two lower holes), where it would be heated before exhausting back into the shop (through the top, center vent) to warm the building.

The size of the upper hole was determined by the dimensions of the case around the intake on the blower we later mounted inside the shop and over the opening. (See "THE BLOWER" section of this article for more details about that part of our installation.) The two cool-air inlets, however, were pretty much calculated on a by-guess-and-by-gosh basis.

Which would you rather do? Move a little bit of air through your collector and heat it a lot, or allow a great deal of air to flow through and warm up only moderately? The size of your inlet vents can decide that question one way or the other. In general, though, you're better off making those openings too large rather than too small, since severely restricted intakes will "starve" the blower in the top hole, making it labor excessively, causing it to wear out faster. You'll also find that a greater volume of air, freely circulated through the collector and then back into the area that is being warmed, pays off (especially in larger buildings) in more uniform temperatures throughout the space being heated.

The 42 truncated triangles (triangles with one tip cut off), which we used as spacers inside our collector were cut from leftover two-foot-long lengths of 2 X 12 that we picked up free at a local lumberyard.

If we had not added the 3/4"-thick lip to our collector's frame, these truncated triangles would have been cut 2-3/4" high. Since we did add the lip to the frame, though, we made the triangles 3-1/2" tall. (The whole idea, of course, is to cut these spacers so that when they're topped by the 3/4"-thick strips, which make up the framing for the collector's front ... the outside [front] surfaces of the strips will come out just flush with the outside [front] surfaces of the 2 X 4s that form the collector's perimeter.)

I should point out, too (no matter which height spacer you use when building one of these collectors), that you don't really have to make the blocks in the shape of truncated triangles. The

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"ears" on such triangles are awfully handy when it comes to nailing or screwing them to a wall, but squared-off, rectangular blocks about 3" long and either 2-3/4" or 3-1/2" high will work just as well, if you don't mind toenailing them in place.

The truncated triangle spacers were spiked into position in three evenly spaced horizontal rows, so that they were two-feet apart, center-to-center, both horizontally and vertically. Once they were in place we slapped a good, thick coat of black wood stain on the triangles, all the wall area bounded by the collector's main frame, and the inside and outside surfaces of the frame itself. (As you know, dark colors—especially black—tend to absorb the sun's heat, whereas lighter colors reflect the sun's rays away ... and we wanted our collector to absorb.)

This is a good place to mention that you should not coat the inside of one of these collectors with a paint that contains lead or any other toxic compound. The relatively high temperatures sometimes generated inside the unit can release noxious elements as gases, which will then mix with the air drawn through the collector and spew into the living or working area that the solar setup heats. Even the wood stain we used emitted a rather disagreeable (though harmless) odor during the first few weeks our sun-powered heater was in operation. And that was bad enough. So take a tip from someone who knows: Paint the inside of your collector only with a high-temperature, flat black paint or stain that contains absolutely no toxic compounds and that — if at all possible — will emit no odors when heated to as much as 200 degrees or more by the sun.

HOW WE FRAMED & PAINTED OUR COLLECTOR'S SIDES & INNARDS

Once you've framed in and painted the inside of your collector - and before you add the facing strips and plastic film to its front - you'll probably find it convenient to install the blower on your heater's exhaust (top) vent. (Although this blower is installed inside the shop or room that is to be heated - not inside the collector itself - you may very well find it convenient to put the fan in position with one man or woman working inside and a second on the outside of the building. After the plastic film is in place, of course, that will no longer be possible.)

We salvaged our blower from an old, unused gas furnace that was gathering dust in my father's basement. The "squirrel cage" fan was ideal for distributing warm air throughout the 30' X 40' area we wanted to heat (as well it should be, since that's exactly the kind of job it was designed to do).

If you don't just happen to have an old blower on hand, the way we did, ask around at your local furnace sales and supply houses. For every new central heating unit that goes into an already-built house, there's usually an old one that comes out. One dealer, in fact, told my father that he sometimes accumulates so many replaced furnaces that he has to cart them—lock, stock, and blowers—off to the dump. Which is why he's always happy to remove some of the fans and sell them for a price. His price? Usually about $3.00 for a blower with a working motor ... although we talked him out of four of the fans with motors and two without for a grand total of eight bucks. Bargain a little.

And if bargaining doesn't turn up a "real" blower or two, you can always use an old window fan instead. Sure, such a fan will probably take up more space than one of the compact squirrel cage blowers, and you'll most likely have to cut a bigger hole in the wall where it mounts in order to get a proper transfer of air, but that's neither here nor there. The important point to remember is that you have a great deal of latitude when it comes to scrounging up a blower for this solar heating system. Almost anything that will pull hot air out of the collector and push it into the area where you want it

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is probably going to be just fine.

And here's yet another possibility: If you're thinking about adding one of these sun-powered heating setups to a cabin or other building that happens to be located out beyond the power lines somewhere ... well, it can be done. Just scrounge up a 12-volt automobile heater blower and a few batteries from some junked cars, and you're in business. Especially if you have a waterwheel or a wind plant out there "back of beyond" to keep the batteries charged!

We built a housing for our squirrel cage blower out of scrounged pieces of plywood and sheet metal ... and we didn't put a whole lot of scientific study into the design. We just made sure that the hole in the wall through which the fan would draw warm air from the collector was at least as big as the blower's outlet. Then we mounted the fan over that hole and boxed in around it. A rectangular opening that just fit around the blower's exhaust was left in the side of the casing that faced into the shop.

At first, since we all know that hot air tends to rise, we put a set of louvers in this outlet hole on the housing and positioned the flow guides so they'd direct the stream of hot air down toward the floor. That didn't work so well, though, because the concrete immediately under the blower tended to soak up most of the heat, and what was left of the air's circulation never seemed able to make it past various benches, equipment, and other objects in the shop to the building's other side. So we took the louvers out and immediately noticed a much more even temperature throughout the whole 30' X 40' workshop.

As you wind up your blower installation, remember that the job won't be complete until you've put a furnace filter screen over each of the cool air inlets in the collector's bottom corners. You don't want dirt, sawdust, and other fine debris to float into the collector, cling to its plastic cover, and thereby reduce the amount of sunlight (heat energy) that the unit absorbs. For the same reason, it's a good idea to frame in all three of the holes cut through the wall ... to keep any dust, insulation particles, etc., that might be inside the partition from floating into the collector.

THE BLOWER

There are approximately 500 linear feet of 3/4" by either 1" or 1-1/2" facing strips on the front of our collector and we scrounged 'em all from old boxing lumber. It's possible to get four or five lengths of these strips from even split boards that are virtually useless for any other purpose. Remember, too, that a great many of these facing pieces can be as short as two feet long and still work.

Nail your longest strips to the tops of the triangles so that you form three horizontal rows that extend the full length of the collector. Then cut short pieces that fit between the horizontal rows to make vertical rows of the stripping. When you've finished, you'll have a very neat grid work of two-foot squares completely covering the face of the whole 8' X 30' unit. This grid work (which you'll probably want to paint) will provide excellent support for the plastic film you're about to apply and will keep the flexible covering from being drawn against the back of the collector when the solar heating system's blower is pulling air from the unit.

Check around and take a look at the various types of plastic sheeting available in your area before you buy. In general, the clearer the covering on your collector, the better the unit will work ... and you'll find a considerable range of transparency, even in the least expensive plastic films. Either

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4- or 6-mil-thick sheeting should be all right, but the 6-mil (even though it transmits slightly less light) is somewhat more durable and, therefore, to be preferred. We covered our collector with 6-mil polyethylene that we bought in an 8' X 100' roll (for $17) from Sears.

Before you begin to apply the plastic film (especially if you do the job in cold weather), make sure that it has warmed to at least room temperature. If you don't, you'll find it impossible to stretch the covering tightly enough to compensate for the plastic's expansion, once the collector begins to heat up. And that's not good. Besides looking bad, a loose, floppy covering will also wear out a great deal faster than a taut one.

We tacked our plastic on with a few staples to hold it in place until we could really anchor it every two feet with predrilled vertical 3/4"-thick by 1"-wide by 8'-long strips of wood. These strips were attached with screws, which we think are almost a must for easy replacement of the plastic covering.

A second layer of the film was then put on, right over the strips holding the first (which, of course, automatically created a 3/4"-thick insulating air space). This second plastic covering was also stretched as tightly as possible and anchored with strips and screws. This time, however, the vertical strips were spaced four feet apart.

FACING STRIPS AND PLASTIC FILM

We wondered just how much better our collector would work with two layers of plastic on its front instead of only one. So we operated the solar heating system with its collector enclosed by a single sheet of film for about a week before we applied the second. Surprisingly enough, the "double glazing" of plastic raised the temperature inside the collector by only about ten degrees, which wasn't nearly as much as we had anticipated. There was, however, relatively little wind during the test of the single layer (although it was quite cold: 5 to 10 degrees above zero), and this undoubtedly made some difference. The single sheet would almost certainly lose far more heat on windy days than the double layer of film.

We were also surprised to learn that temperatures inside our collector did not directly reflect the differences in outside air temperature. In the middle of the winter, with the blower turned off, it didn't seem to matter much whether it was five or 40 degrees above zero outside. The temperature inside the double glazed collector usually hit 140 degrees by about 10:00 a.m., rose to 150 or 160 somewhere between 11:30 a.m. and 1:30 p.m., and then fell back to 140 by 4:00 p.m.. With the blower running, these figures all dropped about 30 degrees right across the board. (Remember, too, that our collector is set up in Springfield, Missouri. Readings will be somewhat different for any unit you build if you live at a different latitude, your area experiences more or less cloud cover, etc.)

From our observations, then, we have concluded that the outside air temperature makes practically no difference in the performance of our vertically mounted collector. The angle of the sun, however, makes a great deal of difference in the unit's output ... and, interestingly enough, these variations in output work entirely to our advantage.

That is: During the coldest months of winter (outside air temperatures of 5 to 40 degrees), when the sun is lowest in the sky, our collector—as we've already stated—hits a maximum internal

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temperature (blower off) of 150 to 160 degrees. In May, though (outside air temperature of 80 degrees), with the sun much higher in the sky, the collector warms up inside (blower off) to only about 120 degrees!

A vertically mounted collector, then, works just the way we'd all like a solar-energy trap to work. It catches a lot of the sun's rays in the winter (exactly when we want it to), and absorbs increasingly fewer of those rays as Ole Sol rises higher in the sky and the weather warms (which is precisely the time that we don't want a solar or any other kind of heating system to work well at all).

THE BOTTOM LINE

Despite our enthusiasm for the solar heating system we've added to my father's workshop, we do want to be painfully honest and say that our 8' X 30' collector has proven slightly too small to completely heat the whole 30' X 40' building as much as we'd like. If the insulated structure had only been turned the other way (so that one of its 40' sides faced south), however, the solar heater would probably be just big enough to supply all the warmth we'd ever want on almost any winter day that we'd care to work in the shop.

This is not to say that the solar furnace doesn't do a bang-up job. It most certainly does. With no supplemental heat at all, the sun-powered system will bring the workshop up to a very comfortable temperature for at least five hours per day ... from 1:00 in the afternoon to 6:00 that evening. And if a small propane burner is turned on for 45 minutes just once about mid-morning to warm the shop to 55 or 60 degrees, the solar heating system will then maintain and gain on that temperature throughout the rest of the day, topping out right at 70 degrees about 4:30 in the afternoon. (The building's insulation then keeps the shop's inside temperature from dropping below 35 or 40 degrees during the following night. The lower figure doesn't concern us, though, since we only use the shop during the day.)

We think that's pretty good performance for a total installation cost of $30. As a matter of fact, it'd still be darned good performance if we'd have bought everything new and spent, perhaps, $100 on the solar heating system. The bottom line, then, is that for very little cash outlay we're tapping a meaningful amount of the sun's energy for use in our family workshop.

The question I'd like to ask you is: Are you sure you don't have a workshop, playroom, or other enclosed area that you need heated only during the day ... for which this very simple, low-cost, non-storage sun-powered system that can be largely constructed from scrounged materials - would be ideal?

Once it's up, you know, all you have to do to keep this solar furnace working for years is [A] supply its blower with a small amount of electricity, and [B] replace that plastic every two years. That's a pretty inexpensive way to heat in this day and age!

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We hope you've enjoyed reading Heat Your Home for Free. There's a lot more great, inspiring information where it came from. Check out MOTHER EARTH NEWS magazine and our associated Web sites!

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