

HOW TO BUILD A HIGH-EFFICIENCY, AIR-TYPE SOLAR SPACE HEATING COLLECTOR

OVERVIEW

INTRODUCTION

These instructions are for a homebuilt version of Sol-Air Company's air-based SHVC™ (Solar Heating / Ventilation Cooling) Solar System; please see the description at the end).

Our commercial unit differs from the homebuilt version in its patented internal air-handler, automatic four-season mode-switching, and proprietary high-surface-area filament-matrix absorber. Selective Matrix™ Absorber Material is available for your own uses, see the contact info at the bottom of the page.

Homebuilt Solar Collector Output

Like its commercial cousin, this homebuilt unit produces more energy for the money by far than other forms of solar utilization, including PV and solar DHW systems. The output for a 20 square foot unit is approximately 5,000,000 Btu per year, equal to approx. 50 gallons of heating oil (or 50 Therms of natural gas). This output is produced primarily in the spring and fall, with a decided dead spot in the middle of a cold winter.

Mounting

The collector is mounted vertically on the outside wall (the rule that tilt = latitude is for another type—DHW collectors, which need year-round input). The lower sun angle in winter reduces the performance penalty, and the avoidance of summertime sun is an important factor in increasing system life. Another advantage gained is ease of installation.

House Connection

Air passes into and out of the collector through a manifold, which connects it to the inside of the house. Instead of using the collector to replace a window, plan to install your homebuilt collector with the manifold passing through a hole in the wall, (you can install it beneath a window, or with the manifold passing across the window sill of a slider-type of window). That way, you will have two solar devices, the collector and the window.

WINDOW COMPARISON

Gain from a solar collector, as with a window, is directly proportional to glazed area; it occurs for 5-6 hours on sunny days. Both a window and a solar collector “leak” some of the energy taken in, but there is a net gain during collecting hours on a good day. The difference between a solar collector and a window is that the window leaks energy 24 hours a day, while the solar collector leaks energy only during those 5-6 hours. People with “passive solar” homes must play an active role in reducing nighttime losses. During non-collecting hours, an active solar collector loses virtually no energy, with no manual intervention. A solar collector is a large no-loss window with a virtual window plug that self-installs, whether you're home or not.

ADVANCED AIR-BASED SOLAR COLLECTOR

Contact Sol-Air Company, kreamer@adelphia.net for free accompanying instructions

4WT48
70 cfm or
4WT47
105 cfm
Grainger
fan

2E245
"On 110/
Off 90"
Grainger
t'stat

Fan and Solar Thermostat Inlet Shroud

make shroud of aluminum house trim stock

1/4" plywood on top and bottom of manifold

Absorber Mounting-Rails

Manifold

14" square x 9" deep

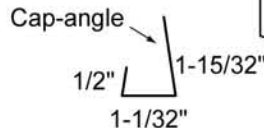
(plywood/urethane foam board construction - same method as case; bond to case w/urethane construction adhesive)

Case

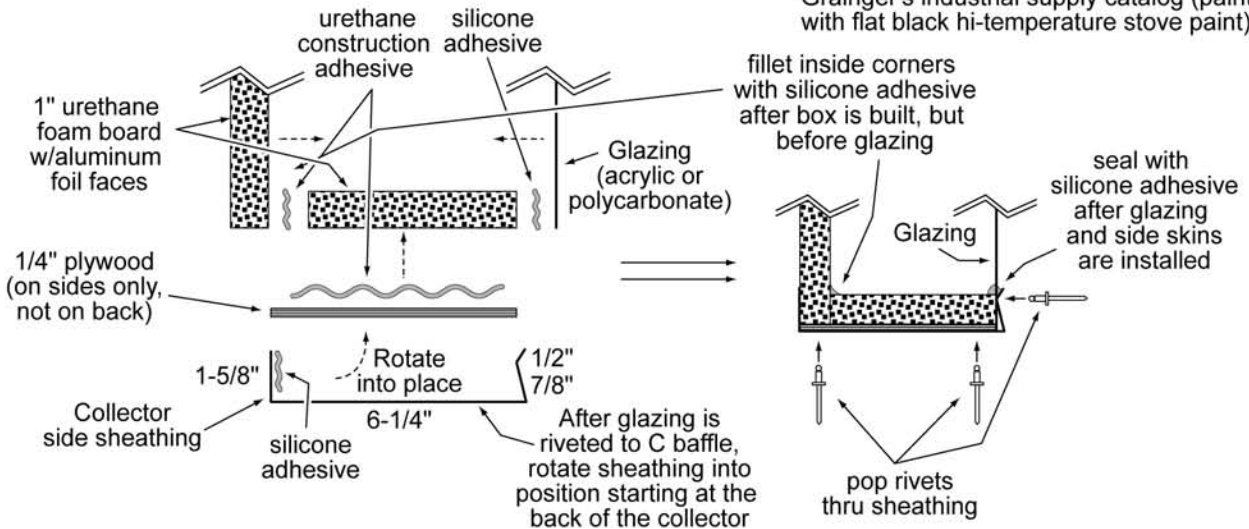
6" deep

C baffle - trim with a cap-angle of alum. flashing or house trim stock, then rivet glazing to C baffle on 8" centers

Case Construction - Side View at Bottom



Use a continuous fillet of silicone adhesive to install 1" x 1" "L" aluminum flashing mounting rails, following the diagonal orientation shown. For the solar absorber, use either black polyester felt, or item 4WZ72 filter-media from Grainger's industrial supply catalog (paint it with flat black hi-temperature stove paint).



COLLECTOR FEATURES

EFFICIENT FILAMENT-MATRIX ABSORBER

High Surface Area

The most important material characteristics for an air-cooled solar absorber are black color and extremely high surface area. One material with these properties is 1" thick furnace filter media (made of glass or polyester fiber), painted flat black with hi-temp paint. The "new collector" smell (curing silicone smells like vinegar), and the smell from hi-temp paint ends in a day or two. Black polyester felt is an even better material. It has finer fibers, higher surface area, and it needs no paint.

Furnace filter media and polyester felt present a total surface area to the airflow that is more than 50 times the absorber's planar face area. This is higher by an order of magnitude than the surface area of conventional metal absorbers, whether finned, rippled, dimpled, or screen-type. Because material with a surface area this high transfers heat quite easily to the air flowing through it, a filament-matrix absorber runs at comparatively low temperatures, about 140-160 degF.

Longevity

I have used both glass fiber and polyester fiber furnace filter media as a solar collector absorber for 18 years without observing significant material degradation. There is no more outgassing from a polyester solar absorber than from polyester wall-to-wall carpet in a sunny room. One should, as a pro-active precaution, observe the "Stagnation Caveat" stated near the end of these instructions.

Turbulent Heat Exchange

The absorber is mounted within the collector on a slight diagonal, so air must pass through it to reach the outlet. The sun shines on the fibers, which get hot. As the air passes through the filament matrix, it comes into intimate contact with the fibers. Because fluid flowing past cylindrical elements produces "vortices"—regions of spinning fluid that are periodically shed and pass downstream—the flow becomes turbulent. This turbulence disturbs and reduces the thickness of the "boundary layer" of air that naturally adheres to and effectively insulates the fibers. Heat transfer to the air is increased significantly.

Low Cost

The linear geometry of a filament provides a virtual tripling of the heat transfer surface area available within a conduction path length of one fiber diameter. Because the tripled-area path length is extremely short, non-metallic material is used without a performance penalty. This allows significant cost savings.

Light Weight

A liquid-cooled collector cannot take advantage of this type absorber construction, which is very light. The low weight of the absorber produces a cascade of weight and cost savings in the support structure of the collector.

Shortened Heat Exchange Path

The benefit of a filament-matrix absorber's mass being finely divided and dispersed is twofold: the reliance on over-long heat-transfer paths is reduced (the pathway involved in the transfer of heat from the mass of a fiber to the adjacent air stream); and the pathway from any sunlit fiber site to an adjacent shaded site on the same fiber is short (one or two fiber diameters).

In other words, a sun-lit fiber can transfer its heat via either of two mechanisms:

A filament matrix absorber can use "inside out" (outer-surface) heat exchange: most heat will transfer directly at the site at which it is generated, i.e., without involving internal conduction.

Additional surface area is available just one or two fiber diameters away in either direction along the fiber. Some heat is conducted internally to these locations for transfer.

Reflective Cavity

The absorber is fixed to mounting rails, inside a collector with reflective interior surfaces, i.e. it is a “black body” in a “reflective cavity”. The inner foil surface of the collector is not painted black, but is left reflective, so the black fibers can do all the absorbing. Any sunlight that passes through the absorber from the front direction is reflected by the inside rear surface back to the absorber for another capture attempt, effectively doubling the light-capturing ability of the absorber without adding air flow resistance.

Low Operating Temperature

The absorber's high surface area and turbulent flow produces a very low operating temperature, which reduces heat losses from re-radiation and conduction, and leads directly to high efficiency.

The collector design was tested using the ASHRAE 93-77 procedure, at Western Michigan University's Energy Learning Center (no longer operating). The result: greater than 72% maximum efficiency. This was the highest efficiency air collector they ever tested. It bettered all liquid collectors but one, which it virtually equaled. I know of no non-concentrating air collector, Conservall's SolarWall included, with higher efficiency.

Available Material

Black polyester felt, the preferred material, is available at fabric stores. Get a thickness that stops a good amount of light. Try looking at the sun through it.

If you prefer, contact me to purchase Sol-Air's Selective Matrix™ solar absorber material, which is 3/16" thick, and made of super-fine fibers.

MAKING THE SOLAR COLLECTOR

Build the Case

Use urethane construction adhesive for all joints. When the case is done, run a protective bead of silicone adhesive at the inner side of each joint that is exposed to heat (side-to-back joints; baffle-to-back joints). Hint: Both urethane adhesive and silicone adhesive use water (humidity) to cure; spray a fine mist of plain water on seam edges after you put pieces together. Wait 24 hours for the urethane in the joint to set before putting silicone on the joints. Use a spoon to smooth the silicone fillets.

For efficient use of materials, and convenient installation, use a case size of 46" x 64" or 46 x 80". The long dimension can run either horizontally or vertically. If you prefer, you can use the general construction details, and revise the collector dimensions to your requirements. The sides, top, and bottom are a pre-glued sandwich of 1/4" plywood and 1" foil-faced urethane (isocyanurate) foam board. 6" wide, they sit against and cover the edges of the 1" thick back wall (foam board-only). The depth of the case is therefore 6". The 1" thickness of the foam board back wall leaves 5" for internal air passage. (Hint: the above dimensions use a back wall measuring 43-1/2" x 61-1/2", or 43-1/2" x 77-1/2").

The 1/4" plywood sides top and bottom provide a surface that will hold screws for the collector mounting brackets. You can also use luan "underlayment" plywood—slightly lighter, thinner and cheaper—but it's a less "green" over-harvested wood. There is no plywood on the back.

Use 1/4" plywood—3/8" adds unnecessary weight. No screws are needed through the lightweight plastic glazing. They would produce an uneven point pressure at each screw. Instead let the aluminum case sheathing hold the glazing evenly all around the edge of the collector case.

Glue a sandwich of 2-foot x 8 foot pieces of 1/4" plywood and 1" foam board on the shop floor. To do this, mark the foam board with lengthwise lines spaced 6" apart. Apply wavy beads, 3" wide, of urethane adhesive between the 6"-spaced lines. Lay the 2-foot x 8 foot piece of plywood on the foam board; weight it down with books on the glue lines. The urethane adhesive cures in 24 hours.

Cut the back wall (43-1/2" x 61-1/2" or 77-1/2") out of another sheet of foam board. Cut an 11-1/2" high x 12" wide hole, centered in the upper back wall of the case; the top edge of the hole is 1-3/4" from the top edge of the back wall (it will be 3" from the outside top surface of the case when completed).

When the sandwich is cured, lay out and cut all the pieces indicated in the Plywood and Foam board Layout. Cut against a long straight edge with a circular saw, with the plywood facing up right on the shop floor. Either set the circular saw depth of cut to miss the floor by about 1/8" (run a sharp knife down each side of the saw kerf to cut the last bit of foam). Or, cut on top of sacrificial 2x4s.

Make (4) aluminum flashing angles, 1" x 1" x 5" long. Next, to receive the thickness of the top and bottom pieces, cut away 1-1/4" of the foam (leaving the plywood) from each end of the 46" long side pieces.

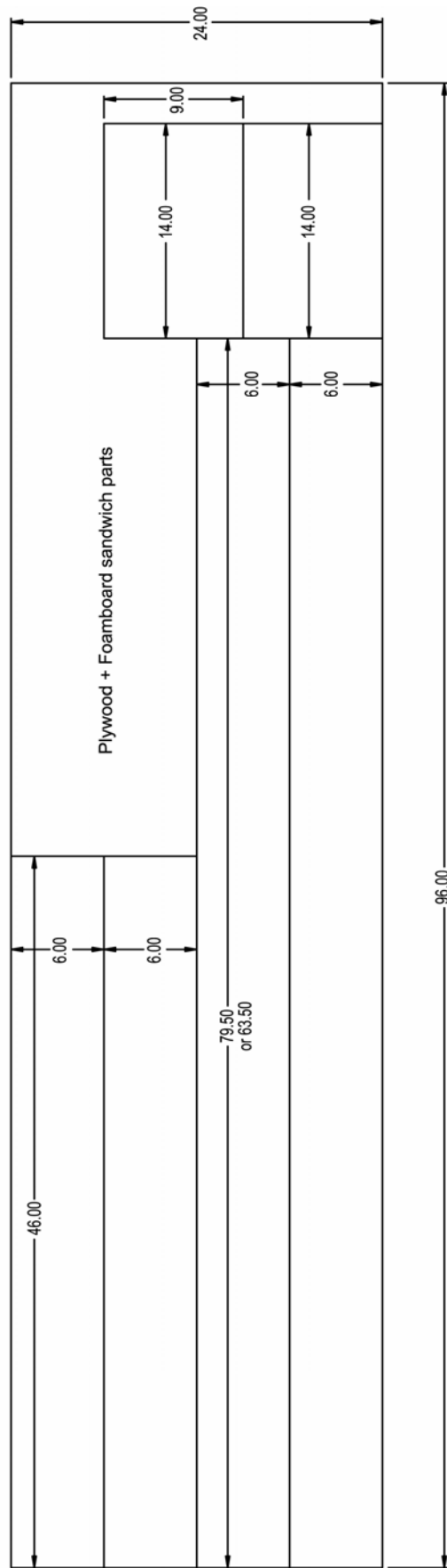
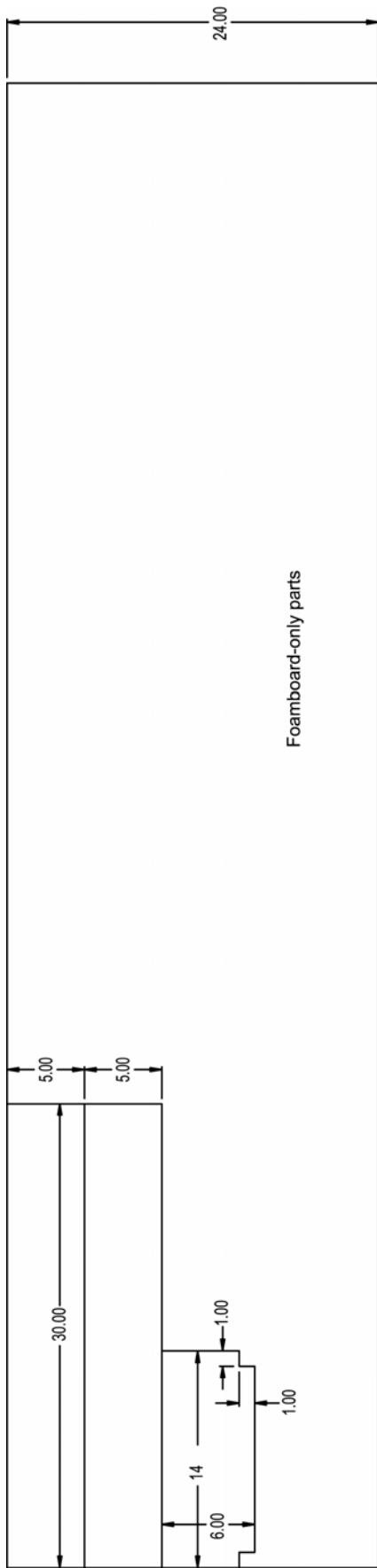
Assemble a corner joint with two generous beads of urethane adhesive. Press the bottom edges flush to the shop floor while you staple through an aluminum flashing angle. Use (3) 1/4" staples through each side of the angle. Leave the angles in place permanently. Do the three remaining joints. All the joints will be flush on the side against the floor, while the top side will not be perfectly flush, due to human error.

While the corner joints are still uncured, assemble the back wall to the sides. Work on the floor with the flush side down, as before. Level the ends; wedge any low corner as needed (level the ends only; ignore the top and bottom). Make needed wedges of flat stock, and extend them several inches to the inside.

Cut (6) small blocks of foam, 5" long. Place them inside the case, one at each corner and one at the middle of the top and bottom. Place the blocks on top of any wedges you used.

Cut a bevel 1/8" wide x 1/4"-to-1/2" deep bevel in the foam, all the way around the upper edge of the case sides. This will permit you to start the back wall down into the sides more easily. The back wall will keep the case square while the joints cure.

Put the back wall down into the sides, so it rests on the blocks. If the back wall is bowed, face the bow outward (upward). Fill the joint with urethane adhesive. Smooth the adhesive with a flexible tool (credit card). Add weights if necessary to keep the back wall down.

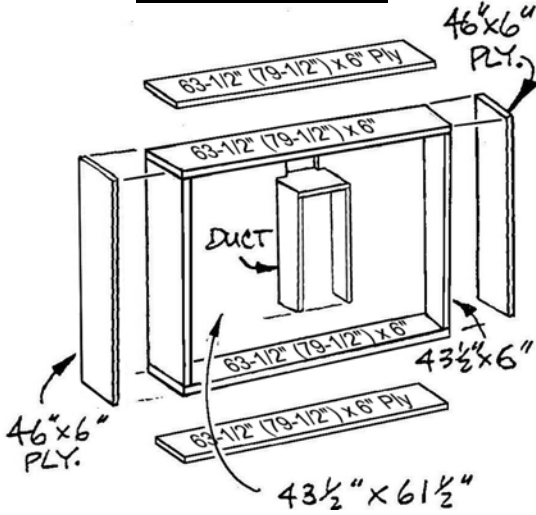


Plywood and Foam Board Layout

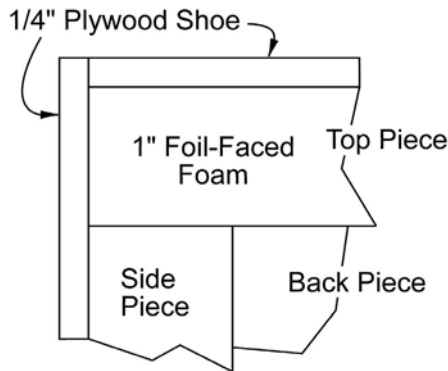
Steps

1. Cut the case parts per the drawing and assemble.

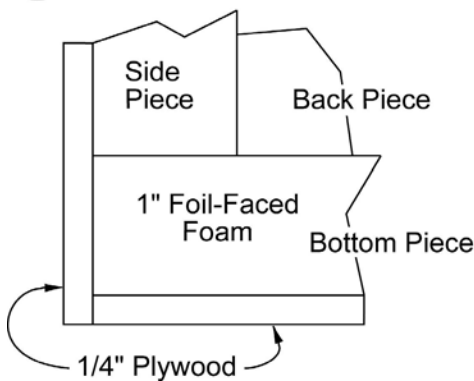
Layout Diagram



1 Top Corner (full scale)



2 Bottom Corner (full scale)

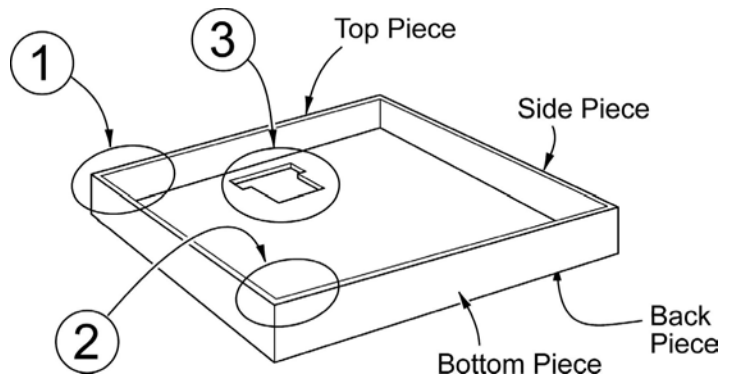


Notes

Pre-assembly hint: laminate together 2' by 8' pieces of plywood and foam, let cure, then cut the indicated case and manifold pieces per the layout diagram.

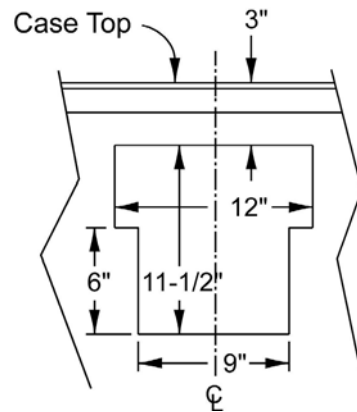
Painting Note: Spray both sides at a 45° angle to the surface. Use almost 1/2 can per side, saving some for final touch up.

Case View Key



*Thermax, Tuff-R, Celotex, R-Max, etc, foil-faced urethane (polyisocyanurate) foam

3 Case Hole



Make a Jig for the C-Baffle

Wait for the case to cure. You will install the C-Baffle next, but first make a jig to hold the baffle pieces straight and square to the back wall while the urethane adhesive sets.

Make the jig base of plywood, 11-1/2" x 24". Along each long edge, hot glue a 24" long piece of 1x6 wood, on edge, and overhanging 1/4", so that measured outside, the jig is 12" wide. Set the collector face up on the floor, place the jig on the centerline below the hole in the case and lightly clamp the baffle pieces to it. If you have a long clamp, one clamp is sufficient.

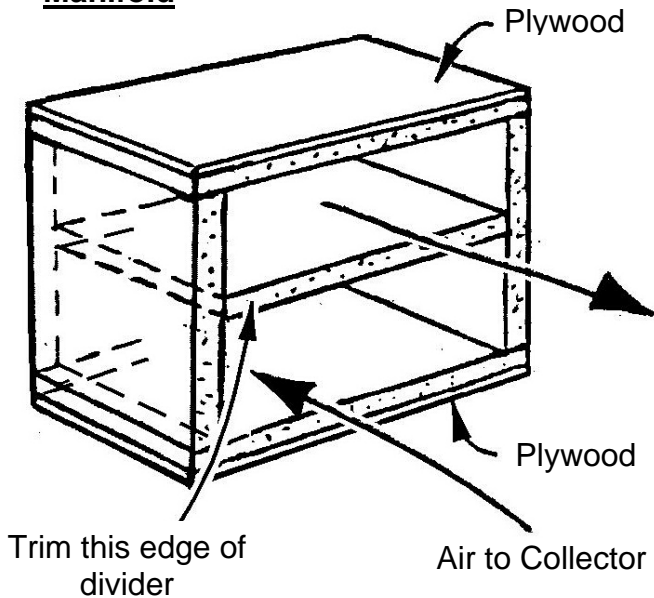
Install the C-Baffle

Use the jig to glue the C-baffle pieces inside the case with urethane adhesive. The horizontal piece crosses the hole in the back wall of the case. The dimension between the vertical pieces is 12". There is a gap of 5" from the bottom of the baffle down to the inside wall at the bottom of the case. Below the horizontal piece, the vertical dimension of the hole measures 6"; the portion above measures 4-1/2". When you install the manifold later, its horizontal divider will coincide with the horizontal piece of the baffle.

Protect the Joints with Silicone Adhesive

When the case is done, wait 24 hours for the urethane in the joints to set. Then add a protective layer of silicone adhesive to the inner side of any joint that is exposed to heat (side-to-back joints; baffle-to-back joints, including all around the C-baffle members). Use a spoon to make smooth silicone fillets.

Manifold

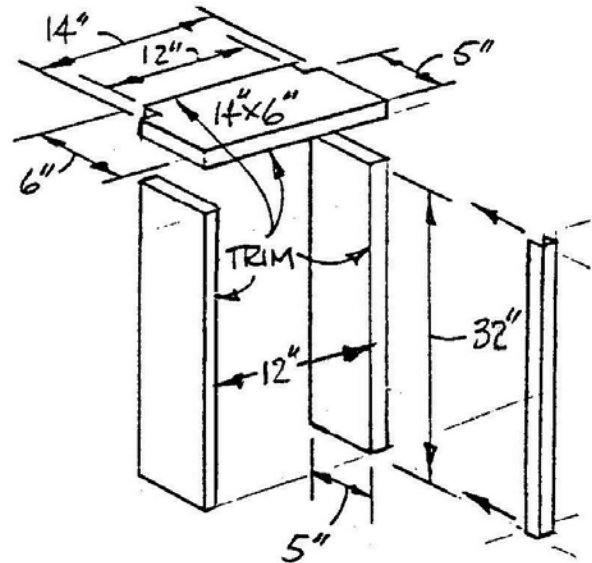


The Manifold

The collector connects to the house via a manifold box made using the same construction materials and gluing method you used for the case—a urethane foam board box with an outer layer of plywood around the sides. It also has a sheathing of aluminum flashing, made from a 9" x 1-1/2" angle, 60" long (this allows an overlap). The 14" square, 9" long, two-way, over-and-under manifold connects to the house through the wall or across the window sill. You can use plywood on just the top and bottom, or on all four sides of the manifold. The manifold is divided by a foam board "center divider" into a lower intake and an upper exhaust passage (back to the house). The lower passage is 6" high, the top is 4-1/2" high.

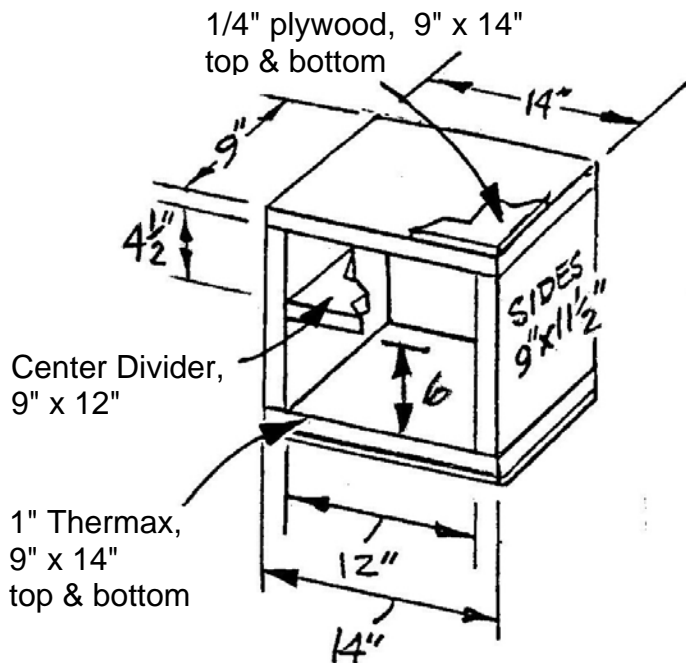
Cut an 11-1/2" square piece of furnace filter media to use for an inlet/outlet filter. On the upper surface inside the upper passage, 1" away from the front face, install an 11" length of 1" x 1" flashing angle. Use hot glue dots and silicone adhesive. Face the angle legs away from the front face. This will act as a stop and support for the edge of the inlet/outlet filter. Do the same at the lower surface inside the lower passage. The filter will span the center divider of the manifold, and rest against the 1" x 1" stops.

C-Baffle Assembly



Manifold Dimensions

Notes



If you install the collector with the manifold passing across a window sill, seal the spaces at the sides of the manifold with Thermax foam board edged with aluminum foil tape.

Aluminum Case Trim

An outside aluminum skin (case trim) makes the collector case weather resistant. You can choose to make the case trim and the "cap angles" (see below) from either of two materials: pre-painted aluminum house trim material ("coil-stock"), available at lumber yards in 50-foot rolls); or plain aluminum flashing. Coil stock is preferred, but is too thick to bend by hand. I recommend you take the sketches (on the next page) to your local vinyl-siding contractor, and have them bend the required pieces.

However, you may want to make them yourself. Work with 25" long pieces of regular aluminum flashing material, which can be bent by hand over the edge of the shop bench or a piece of plywood. Overlap the 25" long pieces to obtain required lengths.

Either way, have the aluminum case trim pieces on hand before you apply silicone adhesive under the edge of the glazing, so that you can immediately install the trim, which clamps the glazing in position while the silicone cures.

Aluminum flashing needs a finish coating to prevent unsightly oxidation. It can be painted, but be sure to scuff the aluminum thoroughly with an abrasive pad, and use a paint specifically recommended for aluminum. For a bright finish, use car wax.

General instructions For Forming Aluminum Flashing

If you're going to form the required pieces yourself, using aluminum flashing, work with 25" long sections. Cut two "clamping blocks" of straight 2x4 material, 30" long, to help you bend the flashing. Rip one to 1-1/32" thickness (x 3-1/2" wide). Rip the other to 7/8" thick (x 3-1/2" wide). Then cut a straight 2x4 piece, 25" long, to use as a "bending block". Clamp each end of the clamping block to the table on top of the 25" long aluminum flashing piece, exposing the desired leg length past the edge of the table. Use the bending block to press the leg downward as nearly to 90 degrees as you can. To get a bend to be slightly more than 90 degrees, clamp 1/2" back from the edge, and press and slide your gloved hand along the bend.

Bending the Case Trim (If You Have Chosen to Bend Your Own)

Set the 7/8" thick clamping block on edge at the edge of your worktable, on top of a 25" length of aluminum. Start by making the bend that is 1-3/8" (1/2" + 7/8") from the edge. Bend to 90 degrees.

Then, reverse the material (follow the drawing!), expose 1/2" of that same leg, and make a 35 degree bend. Last, make a 90 degree bend 1-5/8" from the opposite edge. Finish with the gloved-hand trick.

Bending the C-Baffle Cap Angle (If You Have Chosen to Bend Your Own)

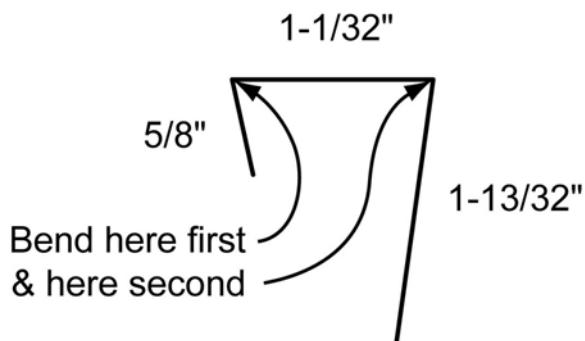
The edge of the C-baffle that supports the glazing is covered by a 1/2" x 1" x 1-1/2" "cap angle" of aluminum. Make the cap angle from (7) 25" long pieces of aluminum flashing or coil stock, 3" wide.

Working as before, but with the 1/1/32" thick backup block, set it on edge at the edge of your worktable, on top of a 25" length of 3" wide aluminum flashing. Clamp each end of the clamping block to the table, exposing the aluminum past the edge of the table by 1/2". Use the bending block to press the full length of the exposed edge downward.

Turn the aluminum piece so the 1/2" leg points up. Clamp it tightly in the corner just made, and expose a 1-15/32" leg over the edge of the table. This time, make the bend upward.

Invariably, one cap angle will be slightly wider than another, so they can be overlapped to form the required longer lengths. Bend the aluminum as far as you can clamped, then unclamp it and bend a bit more.

Baffle Trim Profile (approx. full scale)



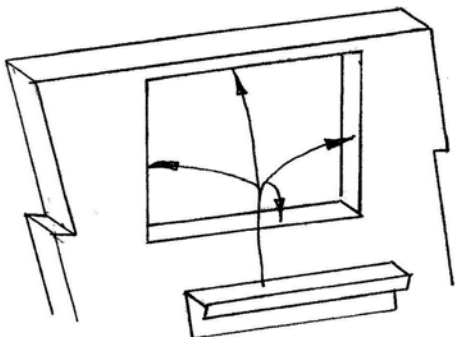
Mat'l: Alum. flashing, 2-3/4" wide; or

Notes: Make (7) 25" L. pieces

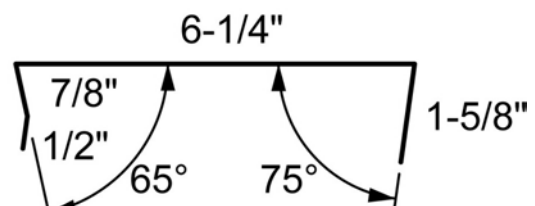
Cover the exposed edges of the C baffle and the edges of the case hole.

Make a clamping block from a 30" long 2x4 ripped to 1-1/32" thickness.

Trim the Edges of the Case Hole



Case Trim Profile (approx. 1/3 scale)



Mat'l: Alum. flashing, 9-1/4" wide.

Note: See the clamping block note at left.

Make (10) pcs. 25" L. Overlap them, (3) on top, (3) on the bottom, and (2) on each side. First install the side pieces, starting at the bottom, and overlapping as you go up.

Let the sides extend past the corners, and cover them with the top and bottom pieces.

Prepare the Absorber Pieces

With the exception of the fan intake area, the entire forward-facing back wall of the collector is covered with absorber material. It is glued to sidewall-mounted rails that hold it spaced away from the back wall on a slight diagonal. In preparation for installing the absorber, cut the pieces you will need to size. Cut (1) 12" x 33-1/2", and (2) 24" x 44-1/2" solar absorber elements. If you are using non-black furnace filter instead of black felt, paint them.

Paint the material from both sides with hi-temp stove paint, holding the spray can at a 45 degree angle to the face of the material. Work quickly, covering the back first, then the front, and favoring the front with the most paint. Use nearly the entire spray can, leaving enough to paint the fan shroud. At the very end, just before you put on the glazing, you can use the last of the paint to touch up where needed.

Install the C-Baffle Cap Angles

When the adhesive is cured, use a straight edge and a sharp knife to trim the C-baffle edges flush with the plane of the case sides.

Then run a 3/8" diameter bead of urethane construction adhesive inside the cap-angle pieces, and install them on the raw edges of the baffle, including on the bottom edges of the descending legs.

Lastly, use aluminum foil tape to cover the exposed foam at the two upper corners of the C-baffle.

Bend the Mounting Rails

Last, make twenty aluminum flashing mounting-rail pieces, 1"x1" x 2 feet long, legs at a 90 degree angle.

Absorber Mounting-Rails

The absorber sits on mounting rails aligned on a diagonal to the air flow. Air enters the collector between the absorber and the glazing. As it moves through the collector toward the outlet, the diagonal absorber placement forces air to pass through the absorber to the back side, away from the glazing. The diagonal progression starts with the absorber near to the back wall at the inlet, and moves near to the glazing at the outlet; the progression continues all along the air flow path. This keeps the hottest air away from the glazing, reduces conductive heat loss, and increases efficiency.

Install the 1"x1" aluminum flashing mounting rails that you bent up earlier. Use dots of hot glue a foot or so apart to hold the rails in place temporarily. Install each piece so the leg touching the collector is oriented toward the back wall. Run a continuous fillet of silicone adhesive along the joint between the rails and the collector wall.

Install the Mounting Rails

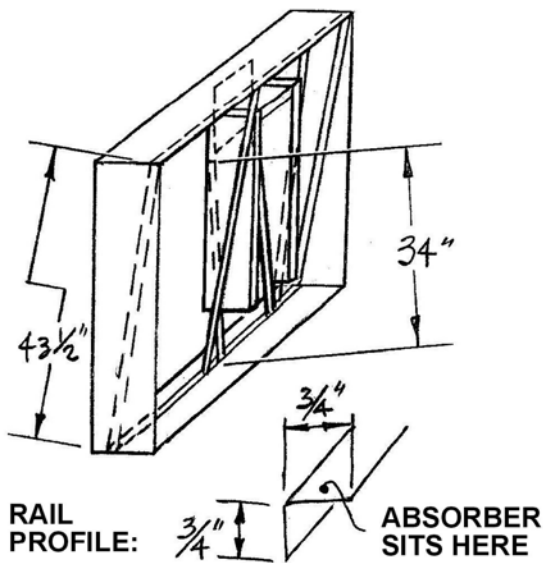
Install horizontal mounting rails at the top and bottom inside surfaces of the collector. Use two or four pre-bent angles pieces, overlapped by an inch, to make up the required lengths. Stop the rails 3/8" short of the adjoining surfaces. The top mounting rail has its absorber-mounting-surface spaced 1-1/2" from the glazing plane. The bottom mounting rail has its absorber-mounting-surface spaced 2" from the back wall (3" from the glazing plane).

Install diagonal vertical rails. Begin with the center section, inside each C-baffle leg, starting below the fan. At this end, the mounting surface of the rails should touch the back wall of the collector; to accomplish this you'll have to snip away some of the rail leg that sits against the C-baffle. The rails run in a straight line to overlap the rail at the bottom of the collector; that is, they run at a slight angle away from the back wall down each C-baffle leg, continuing past the bottoms of the C-baffle legs to overlap the bottom rail. Snip a small piece from the back leg of the angles so they can overlap the bottom rail.

Moving to the side bays, install diagonal mounting rails at the sides of each bay, so the rails make a continuous straight line from the bottom rail to the top rail. As before, snip a small piece from the back leg of the angles so they can overlap the bottom and top rails.

Where the four central rails of the collector cross open space, snip the back leg of each rail near the C-baffle and fold the rail flat. This allows air to travel unimpeded between the center bay and the side bays.

Absorber Rails



Notes

One leg of the absorber rail is glued to the inside wall of the collector; the other is the mounting surface for the absorber.

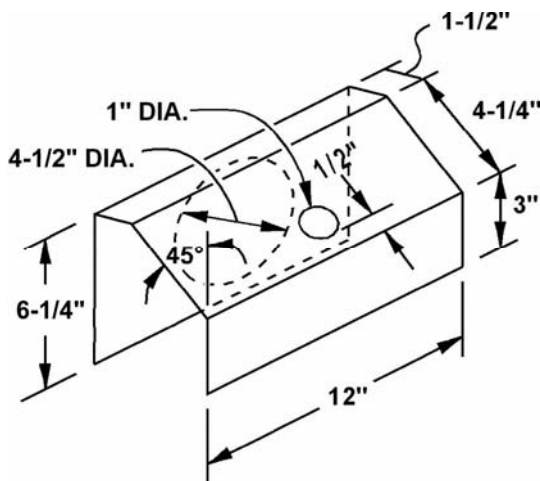
The bottoms of the rails in both side bays and center bay sit on the bottom rail, which is spaced 3/4" from the back wall.

The rails in the side bays lean forward at the top, and meet the top rail. The top rail is spaced 1 1/2" away from the glazing when using 1" furnace filter, or 5/8" away when using 1/8" felt for the absorber.

The rails in the center bay lean backward. At the top they allow the absorber to touch and make a seal against the back wall of the collector, just below the inlet. To allow this, trim away the collector-wall leg of the rails on a long taper towards the top.

Fan Shroud

Stock – .024 Wh. Aluminum,
or Alum. flashing
Dimension. – 12" x 15"



Pop-riquet the fan to the fan shroud, then apply silicone around the edges.

Crimp a ring terminal onto 6" of power cord lead and pop-riquet the ring terminal to the shroud. Connect the green ground lead of the power cord to this.

Pop-riquet the sensor into the 1" dia. hole. Paint the fan shroud and sensor nose hi-temp black.

Locate top of center-section absorber against the collector back wall, at the height of the bottom of the fan shroud. The center-section absorber leans out at the bottom, coming to rest at the rail that runs along the bottom of the collector case.

The side-bay absorbers lean in the opposite direction, out at the top.

Install the Absorber

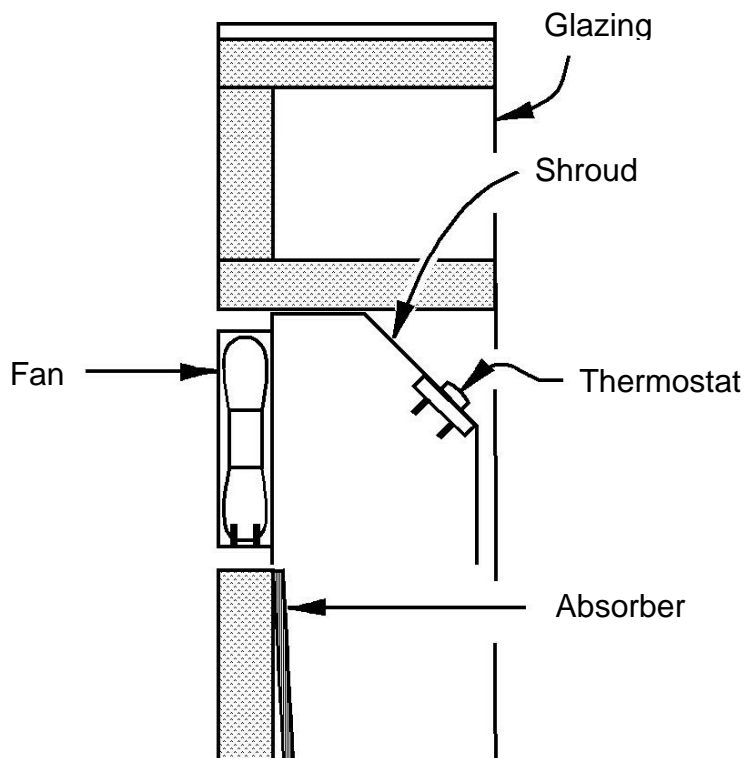
Working one foot at a time, glue the absorber to the mounting rails in a continuous bead of silicone adhesive, again using occasional dots of hot glue as a temporary aid.

Install the Fan

Install your collector fan (Grainger, 4WT48 70 cfm, or 4WT47 105 cfm) and a pre-set snap-disc cooling thermostat (Grainger 2E245, close at 110 degF, open at 90 degF) in a shroud of aluminum flashing or house trim. Make a one-piece fan-and-solar-thermostat inlet shroud, or you can use a two-piece shroud. One piece, to mount the fan, is an 11-7/8" x 6" pan with 1" flanges on top and bottom (make from 11-7/8" x 8" material); it has a 4-3/4" hole at its center and a 3/8" hole at one side to pass the thermostat leads out from the collector. Mount the fan over the hole with 1/8" x 1/4" pop rivets and a fillet of silicone adhesive, and bond the assembly in place with silicone adhesive vertically in the intake, at the back wall of the collector. Make sure the fan's air-direction arrow points into the collector.

The other shroud piece is also mounted with silicone adhesive. It has a 1" horizontal leg, a 4" 45 degree surface to mount the thermostat facing the sun and to redirect the incoming air downward, and a descending 3" leg. Mount the thermostat through a hole the size of a quarter, and fasten it with pop rivets. Bond the thermostat shroud in place so the vertical leg is spaced 1/2" away from the plane of the glazing. Pass the thermostat leads through the 3/8" hole in the fan mounting plate. Wire the fan and the thermostat in series—tie one lead from the fan to one lead from the thermostat with a #14 wiring nut, and finish with an 8" length of electrical tape. Seal the thermostat wire hole with silicone adhesive. The remaining unattached leads, one from the fan and one from the thermostat, will be wired to the power cord leads at final installation.

Fan Installation



Touch-Up

Use the rest of your spray paint to paint the inlet shroud (paint the nose of the thermostat) and touch up the absorber.

Install the Glazing

The glazing can be Plexiglas (acrylic), which does well in this application because of the vertical angle and the efficient (low) temperature at which this collector runs, or another material of your choice (Kalwall). Polycarbonate (TwinWall, etc.) is strong, but may yellow. Cut the glazing to size, 45-1/2" x 63-1/2" (or 79-1/2"), to match the inside line of the plywood. Install the glazing with 1/8" pop rivets (1/4" grip range), spaced every 8" along the baffles.

Install pop rivets through the glazing every 8" along the C-baffle. Put four rivets across the center of the C-baffle.

Lift the glazing edge slightly and put a 5/16" bead of silicone adhesive around the collector sides where the glazing will sit. Place the silicone adhesive bead near the inside edge of the surface, so that as you allow the glazing to rest on it, the adhesive squeeze-out just reaches the inside of the collector.

Install the Aluminum Case Trim

Press the aluminum case trim in place using an aid made from two 2-foot-long 1 x 1-1/2's glued together to make a 90 degree angle. As you do, install 1/8" pop rivets through the case trim into the plywood, all around the sides of the collector, located 1" from the front edge, and every 8".

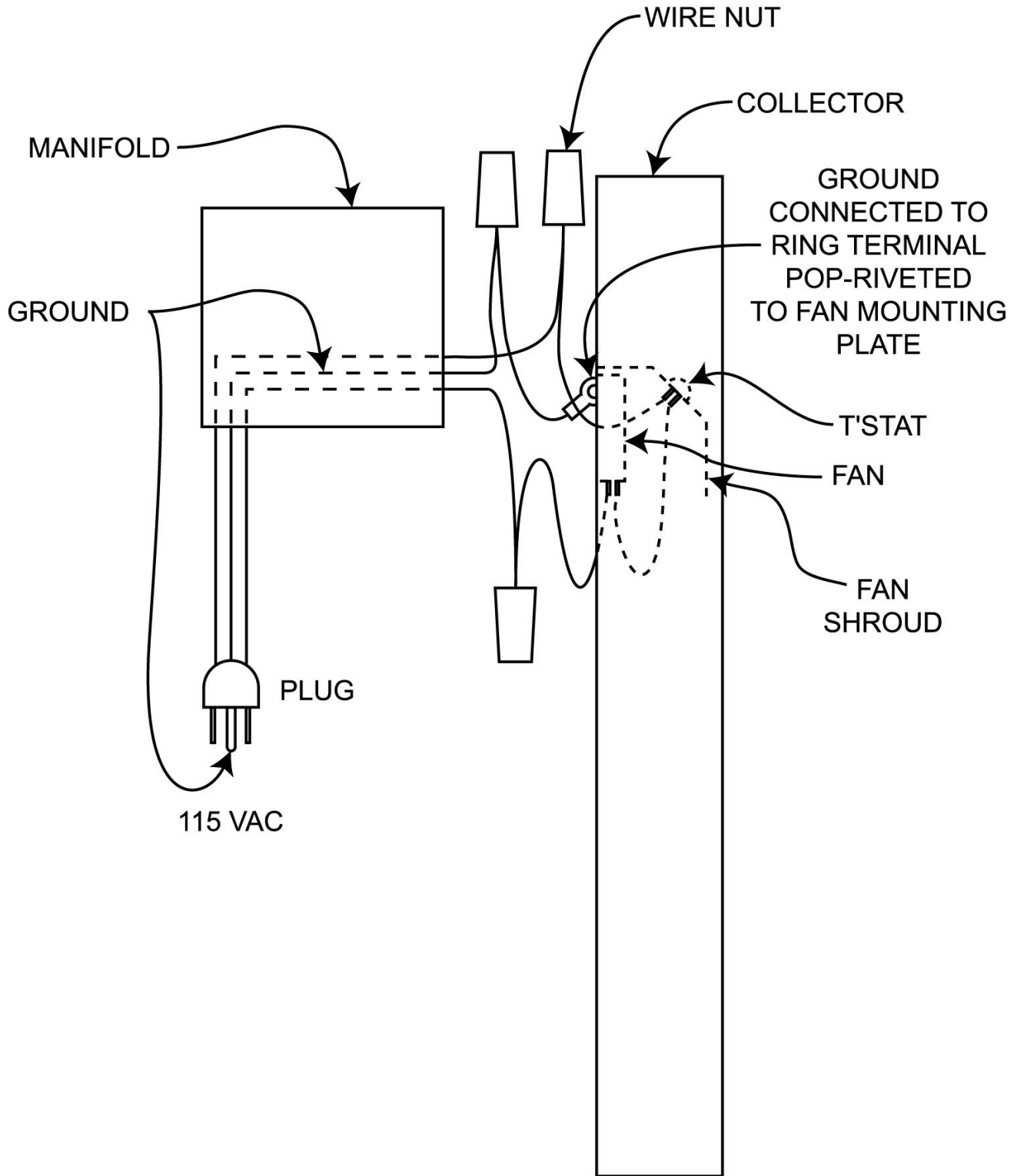
Then install the 90° case trim angle all around the rear edge of the collector with 1/8" pop rivets into the plywood spaced, located 1" from the rear edge, every 8".

Working on one side at a time, tip the collector up on the side you are working on, on a flat work table, to help ensure the sheathing edge is straight and not slipping toward the side. Install 1/8" pop rivets, through the bend line where the sheathing touches the glazing (drill these holes through both sheathing and glazing). Rivet around the collector face on the contact line using a 12" spacing.

Dress and Fill the Glazing Joint

Use a gentle leather-glove touch to adjust the gap where the edge of the aluminum sheathing "returns" away from the glazing. The gap should be at least 1/4". Completely fill the gap with silicone, and finish it the joint with a spoon. Allow the fillet to extend 1/4" out onto the face of the glazing. Don't try to clean up until the silicone cures.

This seal design is tough and won't be broken by shock or expansion from temperature change.



PICTORIAL ELECTRICAL SCHEMATIC

Power Cord

Install a Grainger 2W050 three-wire power cord up through a 3/8" hole in the bottom front edge of the manifold; make an overhand strain relief knot. Crimp a closed-ring terminal on the green ground wire. When you install the manifold, pop rivet the ring terminal to the fan shroud with a 3/16" rivet. Note: You could install an additional room temperature thermostat (open on temperature rise) in the inlet to disable the fan on rising room temperature; this would partially limit warm weather output.

Grilles

The grilles for the manifold should be split, to eliminate heat cross-over. Don't choose moveable-louver grilles. You could use perforated metal. The best and cheapest pre-made grilles are white painted steel, available from Hart and Cooley through your local HVAC supplier. Order one #672-steel-white, 12 x 4 for the upper air passage, and one #672-steel-white, 12 x 6 for the lower passage. These are approximately 13-3/4" long, and 5-3/4" high for the 12 x 4, 7-3/4" high for the 12 x 6.

There are two mounting holes in the grilles (one at each side). Glue four blocks of wood into the foam board with urethane adhesive, at the mounting hole locations, to accept wood screws. Install the grilles with the bottom louvers angled down, and the top louvers angled up, to prevent air from crossing over from outlet to inlet (short-circuiting). The hot outlet air tends to segregate itself by rising away.

INSTALLATION

PLAN

Overall Concept

My preferred installation method is to cut a 14-3/8" square hole through the wall between studs (assuming a 14" square manifold). Or, if you choose, a sliding window installation is an option.

Pre-Mount The Manifold

Two days beforehand, bond the manifold to the collector with urethane adhesive. Lay the collector face down on a soft surface. Dispense a 3/8" bead of urethane adhesive at the center of the five mating edges of the manifold, i.e., around the four sides, and across the center divider. Make sure the urethane adhesive bead is continuous and unbroken. Position the manifold on the back of the collector so the center divider of the manifold aligns with the horizontal piece of the center divider. Press into place and check the alignment. Give the adhesive a full 48 hours to cure. When the urethane adhesive has cured, add a protective fillet of silicone adhesive around the outside and inside of the joints.

Prepare

In preparation for installation, make (4) brackets of 1/8" x 3/4" flat aluminum bar, 9" long, bent to give a 6" and a 3" leg. Use a 3/16" drill for #10 stainless pan head screws. Drill (3) holes in the 6" leg, (2) holes in the 3" leg. Put (3) #10 x 3/4" stainless screws through the 6" leg into the collector, and (2) #10 x 1-1/2" stainless screws through the 3" leg into the building. Use one bracket near each corner of the collector.

BEGIN

Sliding Window installation:

As described above, pre-mount the manifold to the collector with urethane adhesive two days before. Give the adhesive a full 48 hours to cure.

Prop the collector in place with the manifold resting on the window sill. If you have a storm sash, deal with that one first. Shut the storm sash on the manifold and block off the gaps with 1" urethane foam-board—the same foam-board used to make the collector. Trim the foam-board edges with aluminum foil tape. Next do the same to the inside sash. Caulk only the joints at the bottom and sides of the foam-board. Use peel-and-stick foam strips on the underside of the sliding sashes so you can open them when needed. Install a security catch on the inside sash if desired.

Wall installation:

Make a small hole in the center of where you think you'd like the hole to be. Probe with a coat hanger to locate the studs. Measure the manifold and mark lines for a hole 3/8" bigger than the manifold dimensions. Cut the inside wall board with a utility knife. Stuff the insulation from the hole into the wall cavity. Square from the edges of the inside hole over to the outside wall, and drill holes at the corners to the outside. From the outside mark the lines, check the dimensions, and make them plumb and square. Use a saw to cut the hole.

Flash the Hole (Wall Installation)

Next, line the hole with a piece of aluminum flashing. This will be flush with the inside wall surface, with 3" wide ears bent to sit against the outside wall. To make this, cut a piece of flashing 60" long, and 3" wider than the wall thickness. Make a 90 degree, 3" wide bend down the length of the piece. Make cuts through the 3" leg, to allow you to wrap it around the outside of your 14" square manifold, making 90 degree bends at the four manifold corners. Set the manifold aside to attach to the collector later, from inside the house. Staple the pre-bent flashing into place in the hole, putting some staples inside the hole and at least four in each outside ear. Caulk under the ears (don't neglect the corners) with silicone adhesive.

Pre-Mount the Upper Brackets

Mount the upper two mounting brackets to the collector (use (3) #10 x 3/4" stainless screws). Take care to locate the brackets so the collector will be spaced about 9/16" away from the wall (or from the clapboard bottom edges, if you have clapboards; and locate the brackets so they fall just under a clapboard edge).

Before you place the collector against the wall, press sticky-back foam seal strips (3/16" thick x 1-1/2" wide, the type used to mount camper caps onto pickup trucks) to the back of the collector around the 11-1/2" square manifold hole. Space the foam strips 1-3/4" away from the hole edge. Build up three layers of the strips, so the seal is 9/16" thick.

Prop the Collector In Position

Now use short pieces of 2x6, on edge, as braces under the collector to raise it to the right height on the wall (so the foam seal rests on the flashing ears). Use a long 2x4 as a brace to keep the top brackets of the collector against the house. Use a level to get the collector plumb. Now take the manifold inside the house. To check whether the collector is aligned with the hole, insert the manifold into the hole and check that the center divider lines up with the C-baffle in the collector case. Readjust everything until it's plumb and aligned.

Outside, fasten the upper collector brackets first, then install the lower ones (keep the collector vertical, viewed from both ways. From the inside, with the manifold removed, use silicone adhesive to caulk around the perimeter of the hole against the foam seal. Completely fill the space between the collector and the flashing.

Install the Manifold (Wall Installation)

To install the manifold, lay a generous 1/2" bead of urethane adhesive around the manifold rear edges and across the center divider. Place it in the hole, and press it onto the collector. It should stay there by itself, or you can wedge it in position to cure overnight. You can immediately caulk the gap around the manifold at the inside wall with siliconized latex caulk. For a finished look, trim with quarter-round or picture frame molding.

STAGNATION CAVEAT

As stated earlier, DO NOT impede the air flow without covering the collector, as this may allow high temperatures to build up and damage the unit. To stop the unit from producing heat in summer (by thermosyphoning even with the fan unplugged) without damaging the unit, you must cover it, not simply close, or stop up, the manifold openings.

Collector Cover (for Summer)

For the cover, use white canvas or poly-tarp material, with a 1/8" braided nylon cord sewn into a wide hem. No need to make it into a box shape—just make it rectangular, 12" larger than the collector in both directions. Lop each corner off at a 45 degree angle. Cut on line connecting points 12" in each direction from each corner. Fold a hem on each side on a line 3" from the edge. Sew the 1/8" cord into the hems all around in a continuous length, and leave some extra cord length for tying a knot. Tie a small loop in one end of the cord.

To hold the cover in place, drive two screws (aluminum, round head, #8 x 3/4") into the case near each corner. Locate them 3-1/4" back from the front edge and 1" from the corner edge. Let the heads protrude 3/16". Put the cover on with the "good" side out, so the hems are hidden. Run the nylon cord behind the screws at each corner. Thread the bitter end through the loop end, pull tight, and tie a secure knot.

LARGER ARRAYS

In scaling up, keep these points in mind:

1. The geometry shown in the accompanying illustration permits daytime thermosyphoning, and discourages nighttime thermosyphoning (the descending and rising legs of the flow circuit are both at outside temperature at night, and are of nearly equal height). If you change to a different flow layout, you may need an anti-backdraft damper.

A manifolded array could use collectors 4 feet wide (any height), divided into left and right bays (rising and descending legs) by a vertical baffle, with the bays interconnected at top or bottom by a gap in the baffle, with the absorber mounted on rails in each half, on one long diagonal from inlet to outlet.

2. With more than 25 square feet (one good-size collector) per room, room overheating becomes a concern in warm or hot weather. Make sure the collector temperatures do not climb too high. You should cover the collectors in summer, and you may also want large sized automatic or manual collector vents at the bottom and top of each collector. This overheating concern is what gave rise to Sol-Air's AutoVent control, which makes possible a four season SHVC (Solar Heating and Ventilation Cooling) system.
3. A large array manifolded with a single fan should be segmented into areas (separate collectors) with a parallel-flow circuit. You might need to restrict the higher-flow collectors to get the array balanced.
4. You could use "in-at-the-bottom, out-at-the-bottom" collectors manifolded in parallel. These could be served by a split over-and-under manifold duct located at floor level on the inside wall, that might not be too intrusive. It might be three to four inches thick out from the wall, by two feet in height. The bottom 12 inches would be the intake manifold, with an intake grille located at one side of the room; the lower part would be divided from the top 12 inches, the outlet manifold, with a grille at the other side of the room. Or, there could be small outlet grilles located all along the top of the outlet duct and small intake grilles located all along the intake duct.

In this scheme, the entry and exit connections to the collector are all located low in the collector. This arrangement tends to thermosyphon at night, in either direction unpredictably; it will need a positive manual damper, or a timed electro-mechanical damper, that prevents nighttime flow in either direction.

5. An alternative scheme that needs no damper is to place the over-and-under manifold duct near the ceiling, serving "in-at-the-top, out-at-the-top" collectors manifolded in parallel. There would be an auxiliary inlet duct connecting to the inlet half of the split over-and-under manifold. It would descend to the floor at one side of the room. There would be an auxiliary outlet duct connecting to the outlet half of the manifold, descending to the floor at the other side of the room (i.e. one descending duct at the left side and one descending duct at the right side of the room, at the corners against the outside

wall). The reason for the descending ducts inside the room is to receive the coolest inlet air and distribute heated air low in the room.

In this scheme, the entry and exit connections to the collector are located high in the collector. So, the descending and rising outside legs of the flow circuit are both at outside temperature at night, the inside descending and rising legs are at inside temperature, and all are of nearly equal height, so you don't need any damper.

SOL-AIR COMPANY'S PRODUCT – THE SHVC

Sol-Air Company's SHVC™ (Solar Heating and Ventilation Cooling) solar system—the world's only modular year-round solar comfort system—offers a realistic payback and a 20-year+ working life. The SHVC solar system provides energy, comfort and safety, automatically and efficiently, all year.

The SHVC employs Sol-Air's Transorber™ Selective Matrix™ Solar Absorber, a new material that has a surface area more than fifty times that of a flat plate. A big improvement over earlier absorbers for air-heating solar systems, it is both efficient and inexpensive. As a result the SHVC solar system provides better efficiency at lower cost than either photovoltaic (PV) or domestic hot water solar systems (SDHW).

The system is packaged as a single wall-mounted module, for easy installation. It provides space-heating in cold weather, ventilation cooling in warm weather, and both cool-air conservation and system safety in hot weather, all automatically. The SHVC system's year-round capability distinguishes it from the seasonal "air panel" or "hot air collector". A patented room-temperature-responsive control transitions the system between four operating modes, hands-off, year-round.

Although they are the most cost-effective form of solar utilization, overheating in conventional air systems gave rise to Sol-Air's AutoVent control, which makes the four-season SHVC system possible. The system has four ports—an inlet port and an outlet port are located at both the interior and the exterior. The AutoVent™ Adaptive Air Handler comprises separate three-way valves, one for the inlet ports, and the other for the outlet ports. The valves and their non-electric phase-change actuators are integrated into a drop-in control, the AutoVent™ Adaptive Air Handling Control. The AutoVent control is available separately for use in kits and homebuilt systems.

As the room temperature rises in warm weather, the control initiates room ventilation. In hot weather, it seals the inside ports while continuing to move outside air through the collector to prevent overheating. The SHVC solar system thus conserves cool inside air, and allows conventional A/C to operate normally. You don't need cover the system manually to prevent overheating, or uncover it to resume heating. The system returns to the solar heating mode automatically on room temperature demand, maximizing yearly heat production.

Please contact us!

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Parts List - Solar Air Space Heating Collector

	PART #	Mfr. PART#	SUPPLIER	ORDER QUANTITY	ORDER PRICE	O.Q.'s. PER COLLECTOR	UNITS	PRICE	No. PER COLLECTOR	COST PER COLLECTOR
Axial Fan, 4-11/16" Square, 105 (70) CFM, 2900 (2000) RPM, 18 (15) watts	100	4WT47 (4WT48)	Dayton/Grainger	1	20.91 (21.19)	1.000	pcs	\$20.91	1	\$20.91
24 inch Axial Fan Cord	101	4YD79	Dayton/Grainger	1	\$1.18	1.000	pcs	\$1.18	1	\$1.18
Absorber – polyester felt at least 1/16" thick; 19 square feet, 24" w. x 9.5' l.	102		fabric store	1 sq. yd.	\$4.50	2.111	sq. yd.	\$4.50	2.111	\$9.50
Snap-Disc T'stat – 110 on / 90 off	103	2E+245	Dayton/Grainger	1	\$8.42	1.000		\$8.53	1	\$8.53
Power cord	104	2W050	Dayton/Grainger	1 @ \$ 3.14	\$3.14	1.000	pcs	\$3.14	1	\$3.14
Closed-end connector	105	4X839	Dayton/Grainger	Box (50) \$ 8.73	\$8.73	0.060	pcs	\$0.17	3	\$0.51
Female spade connector 1/4	106	5X424	Dayton/Grainger	Box (100)	\$15.74	0.020	pcs	\$0.31	2	\$0.62
Ring terminal, 22-18, .330 OD x #10	107	4X304	Dayton/Grainger	100	\$10.76	0.010	pcs	\$0.11	1	\$0.11
Aluminum foil tape; 50 yd roll	108	2W500	Dayton/Grainger	1	\$10.79	0.060	ft	\$0.20	3	\$0.60
Plexiglas (acrylic), .060 in. 45.5" x 63.5"	109		EBS	1			pcs	\$55.00	1	\$55.00
Grille, upper, Hart & Cooley	110	672, 12 x 4	Redlon & Johnson	1	\$2.30	2.000	pcs	\$2.30	1	\$2.30
Grille, lower, Hart & Cooley	111	672, 12 x 6	Redlon & Johnson	1	\$1.95	2.000	pcs	\$1.95	1	\$1.95
Aluminum coil stock, .019 x 12", Br & Wh	114		EBS	50	\$40.00	0.460	ft	\$0.80	23	\$18.40
Aluminum flashing, .015", 12" wide	115		EBS	50	\$12.75	0.200	ft	\$0.26	10	\$2.60
Adhesive, urethane	116	PL-400	EBS	1	\$5.00	1.000	tube	\$5.00	1	\$5.00
Adhesive, GE silicone, 10.5 oz.	117	GE	EBS	1	\$4.00	2.000	tube	\$4.00	2	\$8.00
1/4" Plywood or equivalent	118		EBS	1	\$14.00	1.000	sheets	\$14.00	1	\$14.00
Aluminum Flat Bar, 1/8" x 3/4" x 72"	119		EBS	1	\$8.00	0.500	ft	\$8.00	0.5	\$4.00
Foil/foam board, 1"	120		EBS	1	\$13.00	2.000	sheets	\$13.00	2	\$26.00
Aluminum rivet, 1/8" x 1/8"	121	4X641	Dayton/Grainger	500	\$10.38	0.100	pcs	\$0.02	50	\$1.00
Aluminum rivet, 1/8" x 1/4"	122	5X520	Dayton/Grainger	500	\$10.98	0.020	pcs	\$0.02	10	\$0.20
Aluminum rivet 3/16" x 1/8"	123	4X581	Dayton/Grainger	250	\$9.31	0.064	pcs	\$0.04	16	\$0.64
SS deck screw, #10 x 2"	125		EBS	1	\$0.04	8.000	pcs	\$0.04	8	\$0.32
									Total:	\$184.51