Chapter Five
Constructing the Roof Collector

Introduction

The MODEL-TEA roof collector has several advantages over the wall collector. One, it doesn't interfere with lighting or views from living spaces, because it usually occupies an unused space. Second, more collector area can be constructed, because the available space is usually larger on a roof than on a wall. It can be combined with direct gain passive solar heating on the south wall, and a higher solar heating fraction can be reached through the combination of the two. There will be less shading problems in the winter on a roof than on a wall. And a domestic hot water system can be built into the air-handling system, resulting in energy gains year round and a shorter pay back period.

The instructions on how to build the MODEL-TEA roof collector are meant for those persons familiar with wood frame construction -- skilled contractors, carpenters, or owner-builders. The key word is skill -- the ability to perform the tasks, based on working knowledge gained from carpentry experience. The more experience, the easier these instructions will be to follow.

This chapter, plus Chapter Seven on Constructing the Rock Bin (if there will be remote storage) and Chapter Eight on the MODEL-TEA System Control Wiring,

should be read through thoroughly. This should be done before beginning to order materials, and before beginning any stages of construction.

The experienced carpenter will have most of the tools necessary to build this collector, but may have to borrow or rent a few of the special ones. Among the tools needed are:

hammer, screwdrivers, tapes, pliers, tin snips, etc.

chalk line, caulking gun, staple gun, hand saws, circular saw, table saw, sabre saw (optional)

soldering iron (optional), paint sprayer

power screwdriver or variable speed/reversible drill

The MODEL-TEA roof collector can be built into new construction, or retrofitted into existing buildings. The instructions are directed toward new construction, with indented sections if there are additional special instructions for retrofit.

RETROFIT: The instructions for retrofit begin with the word RETROFIT, and are indented to set them apart from the normal instructions. These indented sections must be read by those who are retrofitting the MODEL-TEA, and can be skipped by those building into new construction.

Before installing the collector on the roof, certain calculations must be done and decisions must be reached. First, the system must be sized according to the heating load of the building. This should be done using the rules of thumb in Section 4.1, resulting in a square foot area for the collector.

Second, the size of the glazing must be selected to fit the square foot size of the collector and to fit on the roof. The glass comes in two standard sizes (in inches): 34 x 76 and 46 x 96. In conjunction with the CY/RO Universal Glazing System, you must

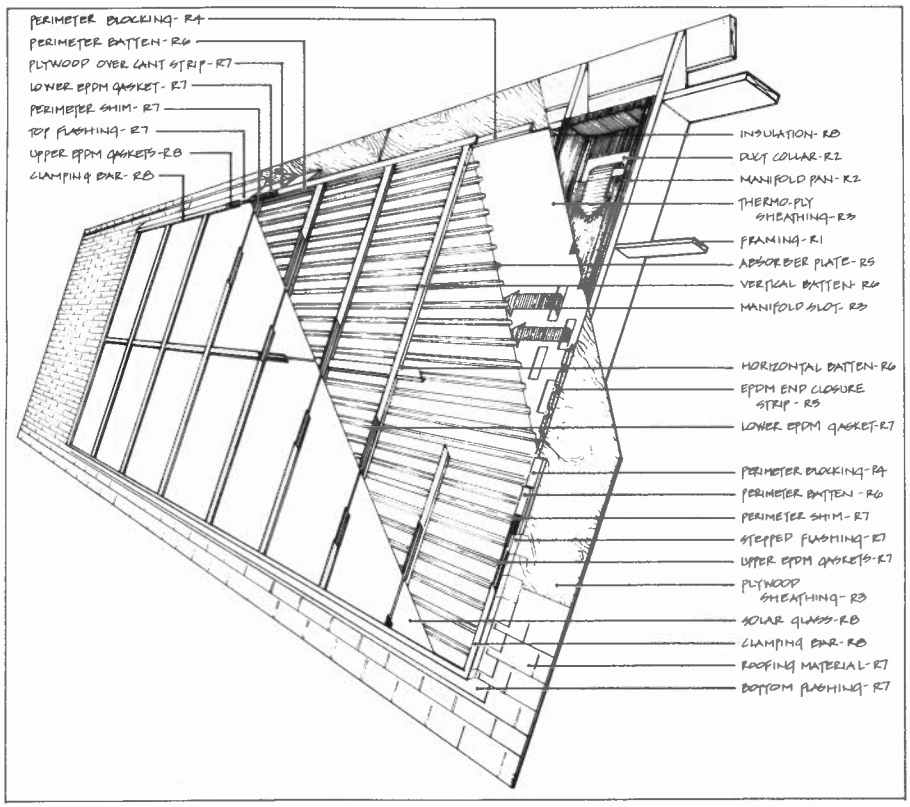


Figure 5.1 MODEL-TEA Roof Collector

allow 3/4 in. between each sheet of glass, plus an additional 3-1/4 in. for the sides (or top and bottom, not including the cant strip), plus the width or height of the glass itself. Use the following formulas to calculate the width and height of the collector:

Collector width in inches = (glass width in inches x no. of panels) +(3/4 x no. of panels) + 2-1/2 in.

Collector height in inches = (glass height in inches x no. of panels) +(3/4 x no. of panels) + 2-1/2 in.

For example, if the collector was to be glazed with eight panels of 24 in. wide glass side-by-side, the collector width would be: (34 x 8) + (3/4 x 8) + 2-1/2 = 280-1/2 in. or 23'-4½".

Compare the calculated width with the width of the roof. A minimum distance should be left between each side of the collector and the edge of the roof, to allow for the intersection of the side wall and roof. Then compare the calculated height with the height of the roof. Allow approximately 9 in. above the collector for the cant strip and flashing. The lowest the collector can extend to the bottom of the roof is where the south wall intersects the roof.

Third, determine the number of manifold pans that will be needed, and their size. In an average width collector (about 24 feet wide), there are two manifold pans built into the roof. One will supply cool air to the collector, and one will take the hot air away. The manifold pan which is closest to the remote storage or living space to be heated will be the return pan. The shorter the duct run, the less the heat loss. It is next to this pan that the temperature sensors (discussed below) will be located.

The maximum distance between the outsides of the supply and return manifold pans should be 26 feet. If the collector is wider than this, additional manifold pans must be introduced at the center-line of the collector. The two manifold pans at the sides of the collector will be the supply pans, and the two at the center of the collector will be the return pans. In this case, it is next to one of the center pans that the temperature sensors (discussed below)will be located.

Holes for the duct collars, connecting the supply and return ducts to the manifold pans, must be located in the manifold pans. If there are only two pans, the return duct collar hole is placed in the top or bottom corner of the pan (whichever is closest to storage), and the supply duct collar to the other pan in the opposite corner. For example, if the return duct is in the lower left of the collector, then the supply duct will be in the upper right (see detail 1 on Roof drawing number 2). However, if there are four manifold pans, this changes slightly. The two

return manifold pans are in the center of the collector. The two supply manifold pans are on the outside of the collector. If the return ducts are attached to the center manifolds at the top of the collector (they both must be side-by-side since they feed into the same return duct), then the supply ducts are attached at the two bottom outside corners. If the return ducts are in the bottom-center, then the supply ducts are at the top-outside.

Wherever the return duct is located, the temperature sensors (discussed below) will be located next to the manifold where it is attached.

The size of the manifold pans depend on the area of the collector. Section 4.1 discusses how to size the manifold pans. One thing that should be remembered is that the area used in the calculations to size the pans is the area located between the manifold pans. If there is one supply and one manifold pan, the area used in the calculations is the full area of the collector. If there are two supply pans and two return pans, then the area used in the calculations will be half the actual area of the collector.

The dimensions arrived at in Section 4.1 will be the inside dimensions of the pans. Allow for the thickness of the pan material itself when determining the actual "manifold pan width" used so often later on.

Fourth, decide whether the system will have remote storage or not, and if it will have a domestic hot water (DHW) pre-heating system. If the collector is connected directly to the living space, without using remote storage, it is called a "Daytime System." These systems will have a relatively small collector area (less than 200 square feet), and the domestic hot water pre-heating mode will probably not be included because it wouldn't be cost effective.

If the system does have the DHW mode, there will be three temperature sensors connected to the collector. One is for the normal winter operation of the collector. The second is for the summer power venting operation, and the third is for the DHW mode. If there is no DHW mode, only the last one can be elimi-

nated. These sensors will be located near the return duct collar connection to the return manifold pan.

It is very important to remember (while the pieces of the collector are going together) that unless the pieces are put together very carefully, the glass panels will not fit into the spaces allotted for them. There is a 1/4 in. gap (shown on the drawings and called for in the instructions) around each pane of glass. This is vital to allow space for the glass to expand. If it is not there, the glass will crack. Therefore, be absolutely sure that all the dimensions are correct, and that all the blocking is square. Check and double check each dimension carefully.

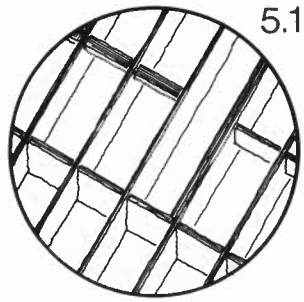
Go through the drawings step-by-step with the instructions, until everything is clear. The drawings are not meant to be used without the instructions, nor are the instructions meant to be used without the drawings. Make notes on the drawings of those things that depend on site-conditions. Write in the actual dimensions found above. Determine how much of each material needs to be ordered, and order through the manufacturers found in Appendix A.2, and in the sequence described in Section 4.5, Purchasing Materials and Scheduling Construction. Read through all the descriptions in Appendix A.1 to become familiar with the materials. Such things as which type of caulk should be used with which type of joint are discussed there.

The following step-by-step instructions are keyed to the construction drawings at the end of the chapter. Each construction step has a key number, and a corresponding key sketch in the margin where the step begins. Each construction step also has a corresponding drawing with the same key number, and the same key sketch in the upper right hand drawing of the page.

As you read each section, you will be asked to refer to details on the construction drawings. For example, you might see (3-R6) at the end of a sentence. This would mean, refer to Detail 3, on Roof Collector drawing number 6. Turn to Roof Collector drawing number 6, and you will see a number 6 in the upper right hand corner with the word "ROOF" below it. The key sketch is there, as well as the title of the

page and the step: BATTENS. As you refer back and forth from instructions to drawings, look for these four things: the drawing number, the word ROOF, the key sketch, and the title of the page. It is important that the instructions and the drawings are used together.

5.1 Framing



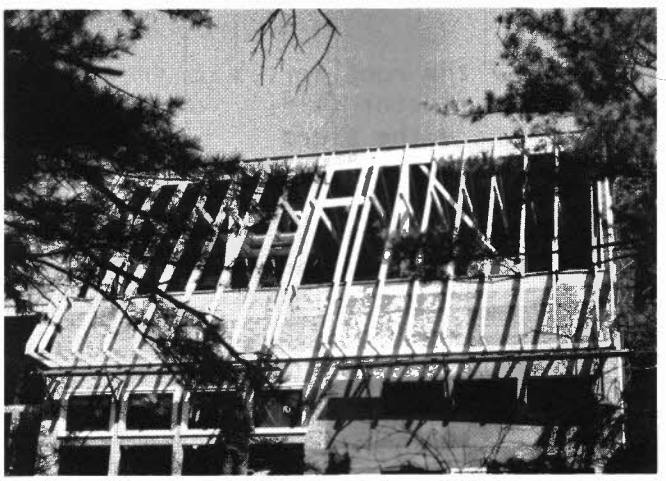
The framing of the roof serves as the base of the MODEL-TEA roof collector (1-R1). The outer manifold rafters mark where the sides of the collector will be attached, and the top and bottom blocking mark where the upper and lower limits of the collector will be. It is important that the rafters be parallel with each other, and that the horizontal runs of blocking be parallel with each other and perpendicular to the rafters.

The manifold bays will house the manifold pan (1,2-R1), so be sure they are a little wider than the outside manifold pan dimension.

RAFTERS: Frame the roof with 2x nominal rafters spaced at 24 in. on center (1-R1). The depth of the rafters will depend on their actual span/design load. The collector itself will increase the dead load on the rafters by approximately seven pounds per square foot. It is assumed in the drawings that the center-line of one rafter will lie along the center-line of the roof. If a rafter is not centered on the roof, it only means that the collector will not be centered on the roof. This will not affect the collector performance. It is essential, however, that the center-line of one rafter (the "center-rafter") will lie along the center-line of the collector.

The outermost rafters under the side edges of the collector are the "outer manifold rafters" (1-R1). To locate these two rafters, divide the total width of the collector in half, subtract 3/4 inches, and measure out this distance to each side of the center-line of the center-rafter. Frame the center-lines of the two outer manifold rafters at these two points.

The rafters framed just inside the outer manifold rafters will be the "inner manifold rafters." Add 3 in. to the manifold pan width (determined in Section 4.1) and measure in this distance from each outer manifold rafter. Frame the center-lines of the inner manifold rafters here. The space between the outer and inner manifold rafters is the manifold bay.



Framing the Collector

If the manifold bay (pan) width plus 1-1/2 in. is greater than 24 in. on center, double both the inner and outer manifold rafters. Frame one rafter to the inside of the outer manifold rafter, and one to the side of the inner manifold rafter outside the manifold bay. If the collector width is great enough to warrant inner manifold pans (greater than 26 ft.), frame these manifold bays to each side of the center rafter, in the same way the outer manifold bays were framed. If this manifold bay width is greater than 24 in. on center, triple the center rafter, and double the outer manifold rafters outside the manifold bays.

When fastening the collar ties, fasten them to the outside of the rafters at the manifold bays (not inside the manifold bays) so they won't interfere with the manifold pans.

RETROFIT: First, if there are any

electrical wires in the roof, turn off the electricity. Remove the shingles in the general area where the collector will be. Lay out the perimeter lines of the collector on the sheathing, checking the diagonals between corners to make sure the lines are square. The width and height will be the full collector width and height. Snap the lines with a chalk line. Mark the center line of the collector on the sheathing at a point 4 in. above and below the perimeter lines.

Measure in the width of the manifold pan plus 5-1/4 in. from the side lines. Snap two vertical chalk lines at these points, parallel with the side lines. Set a circular saw to the depth of the sheathing, cut down these four sidelines, and then cut across the manifold width at the top and bottom (between each pair of sidelines). Remove any rafters or blocking within these spaces, as well as any insulation or electrical wires, and move any collar ties to the outside of the space.

If the rafters have been framed at 16 in. on center, frame the manifold rafters as called for above, but remove any rafters or collar ties that fall in the manifold bays. Double up on the manifold rafters as done above, if the manifold bay plus 3 in. is greater than 24 inches. Then use the rafter to the inside of the manifold rafter as your manifold blocking.

Examine the rafters. Their depth and spacing must structurally be able to carry an additional seven pounds per square foot of dead load. Books on wood frame construction have tables listing how much live and dead load a rafter can hold, given certain sizes and spacings. If there are any doubts, consult a structural engineer.

If the sheathing is uneven and disjointed, remove all of it within the collector perimeter lines. An uneven surface

could cause the Thermo-ply to buckle and later cause problems with the air flow through the collector.

If the collector is wide enough to have center manifolds, snap a chalk line down the center-line of the collector, and one line to each side of it at a distance of the manifold pan width plus 4-1/2 inches. Cut out this entire area, between the top and the bottom perimeter lines.

Frame new rafters with their center-lines vertically along the edges where the sheathing was cut out. Frame the outer manifold rafter and the manifold blocking (see below) to the inside of these rafters. At the center manifolds, triple up on the center rafter. Double up on the outer manifold rafters, with the center-line of the outer rafter under the edge of the plywood.

COLLECTOR BLOCKING: Lay out the collector height on one of the rafters. Check the highest and lowest points with a piece of blocking the depth of the rafters, to be sure the ridge pole, soffit or south wall will not interfere with the collector. If it does, shift the collector height up or down on the roof. If there is still interference, a new glazing height for the collector will have to be found. Return to the Introduction and refigure. Mark the center-line of the collector on the rafter. Divide the collector height in half, subtract 2 in. and mark this distance above and below the center-line. Fasten the center-line of the 2 x nominal "collector blocking" at these points. The depth of the blocking should equal the depth of the rafters. The blocking will ld be in a continuous straight line from one outer l manifold rafter to the other. Since the blocking joints will not be staggered, toe-nail the blockingng at one end. Make sure that the top 1-1/2 in. face of the blocking is flush with the top of the rafters (3-R1).

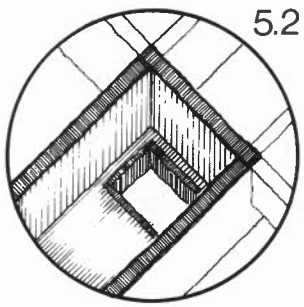
MANIFOLD BLOCKING: Fasten 2x4 (nominal) blocking to the inside of the outer manifold rafters, and to both sides of the center rafter (if there are to be inner manifolds). This blocking is parallel to,

and flush with the top of the rafters (2-R1). It is continuous from the top to the bottom collector blocking.

If the manifold rafters were doubled up because the width of the manifold pans was greater than 24 inches, the extra rafter is the manifold blocking, and will be called the "manifold blocking" (2-R1).

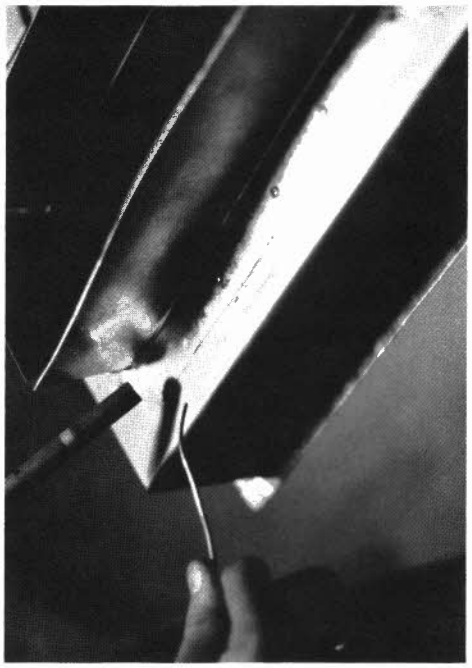
SHEATHING BLOCKING: Measuring down from the center-line of the top collector blocking, fasten 2x4 (nominal) horizontal blocking across the roof at 4'-0" on center (1-R1). This blocking is continuous across the roof, with its 3-1/2 in. face flush with the face of the rafters (3-R1). Do not stagger this blocking, but toe-nail at one end. Do not install this blocking in the manifold bays, because it would interfere with the manifold pans. Do install it outside the manifold bays, with its 1-1/2 in. face flush with the face of the rafters, including it along the same center-line as the collector blocking.

5.2 Manifold Pans



The purpose of the manifold pans is to distribute air the full height of the collector. The supply and return ducts are connected to the manifold pans. The air from the supply duct flows through the duct collar (3-R2) and fills the manifold pan, supplying the air to the full height of the collector. At the return manifold side, the hot air from behind the absorber plate will first fill the return manifold pan, and then will be drawn away by the duct collar at the bottom of the pan. The duct collars must be connected to the manifold pans with an air-tight seal, or leakage will occur, and performance will be lost.

Prefabricate the manifold pans and duct collar inserts to the dimensions determined in Section 4.1. The dimensions found in Section 4.1 are the interior dimensions of the pan. Have them made of 30 gauge galvanized sheet metal, with 1-1/2 in. nailing flanges. Overlap the horizontal corners over the vertical corners. Solder all joints and all overlaps (2-R2).



Soldering the Duct Collar to the Manifold Pan

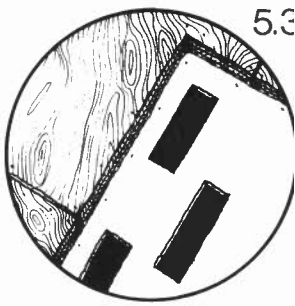
Arrange the duct openings in the manifold pans according to the Introduction to Chapter Five. The duct openings should have the same cross-sectional area as the manifold pan (its width times its depth).

There are two ways to fasten the duct collar inserts to the manifold pans. One is to drop the inserts into the pans, and solder the insert to the pan. The other is to lay a 1/4 in. continuous bead of urethane caulk around the duct connection openings inside the manifold pans, and drop the duct collar inserts into the openings (2, 3-R2). Fasten with #6x 1/4 in. Phillips pan head sheet metal screws at 6 in. on center. Drop the manifold pans into place in the manifold bays, with the nailing flanges over the supports. Fasten the pans with 1 in. galvanized roofing nails at 6 in. on center around the nailing flanges. (See Appendix A for urethane caulk recommendations.)

RETROFIT: If the room behind the collector is finished, the piece of rigid fiber-

glass insulation that will fit behind the manifold pan must be placed in the manifold bay before the pan is (2-R8). Cut the piece just big enough that it will fit snugly in the bay. Wedge it into the bottom of the bay, and then drop the manifold pan in on top of it.

5.3 Sheathing



The air from the supply manifold pan flows through the slots cut in the collector sheathing (1-R3). The air flows across the face of the collector, between the sheathing and the absorber plate. Therefore, the seams in the sheathing must be air-tight to keep the air from leaking through the back of the collector. For the same reason, the edge of the collector sheathing and the roof sheathing must be air-tight. This is accomplished with caulk, but also with support from rafters and horizontal blocking. Caulk is also applied around the nailing flanges of the manifold pans so that air cannot leak between the pans and the sheathing.

THERMO-PLY COLLECTOR SHEATHING: Thermo-ply super strength (blue) sheathing (an 1/8 in. foil-faced structural/insulative sheathing), is shown as the collector sheathing on the drawings. (See Appendix A)

It is important that the four edges of the sheathing be supported by either blocking or the rafters, horizontally and vertically. This is for structural reasons and to minimize air leakage between the sheets of sheathing and the back of the collector.

Beginning at the center-line of the collector, lay sheathing horizontally across the collector, running a continuous bead of urethane caulk along the edge of one before butting to the edge of the next. Cut the perimeter sheets to fit (1-R3).

Fasten the Thermo-ply with 1 in. galvanized roofing nails or 7/16 in. crown divergent staples at 4 in. on center around the panel edges, and 8 in. on center

at the intermediate supports. Cover the entire collector from the center-line of one outer manifold blocking to the other, and from the center-line of the top to the center-line of the bottom collector blocking.

Apply a 1/4 in. continuous bead of urethane caulk around the inside edge of the nailing flanges of the manifold pans just before laying a sheet of Thermo-ply over them (1-R3). It is vital not to apply this caulk until you are ready to lay a sheet of sheathing over it. The caulk will skim over quickly, especially on hot sunny days, and must be replaced if it hardens before the sheathing goes on. (See Appendix A for urethane caulk recommendations.)

If the collector has center manifolds, snap a chalk-line down the center-line of the collector on the face of the Thermo-ply.

PLYWOOD ROOF SHEATHING: Finish sheathing the rest of the roof with 1/2 in. CDX plywood. Run a 1/4 in. continuous bead of caulk along the edge of the Thermo-ply before butting a sheet of plywood against it (3, 4-R3). Fasten the plywood with 8d common nails at 6 in. on center around the panel edges and 1'-0" on center at intermediate supports.

Mark the center-line of the collector on the plywood, at a point 4 in. above and below the Thermo-ply perimeter. These marks will be very important as reference points.

RETROFIT: Sheath with Thermo-ply, as instructed above, fastening the Thermo-ply to the existing roof sheathing. This will leave a vertical gap of 2-1/2 in. to each side of the collector, and a 2 in. horizontal gap above and below the collector. Cut 1/2 in. CDX plywood to these widths and fill in these gaps, caulking each side edge of the plywood as it goes in. Be sure each edge of the plywood is being supported by the rafters or blocking. (These gaps were predetermined, so that the rest of the framing for the collector will be in the same levels as new construction framing.)

MANIFOLD SLOTS: Slots are cut in the Thermo-ply to allow the air to pass out of the manifold pans and behind the absorber plate ribs. They are cut in the following pattern so that every rib in the absorber plate will be fed air from the manifold pan. Snap a chalk-line 3 in. to the inside of the edge of the plywood sheathing at the sides of the collector, parallel to the rafter and extending the full height of the collector. Snap three more lines, parallel to the first and space 3 in. apart, toward the inside of the collector. Repeat the process at the other outer manifold rafter (1,2-R3). If there are center manifold pans, repeat this process to each side of the collector center-line.

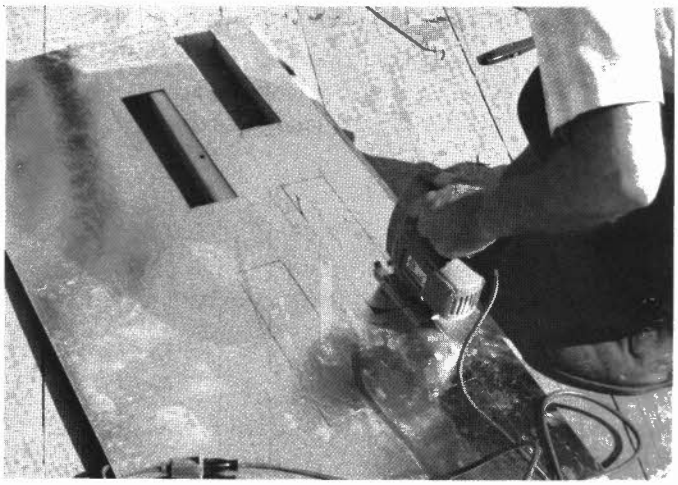
Beginning at the edge of the top sheet of Thermo-ply, mark the following lines between the chalk-lines closest to the side edge of the Thermo-ply (or center-line of the collector): 2-1/2 inches, 9 inches, 8 inches, 9 inches, 8 inches, 9 inches, 2-1/2 inches. Repeat this process up each sheet of Thermo-ply between all the pairs of chalk-lines closest to the side of the collector. If the bottom sheet is an irregular size, end the last hole a minimum of 2-1/2 in. above the bottom seam (1, 2-R3).

Between the pairs of chalk-lines furthest from the sides (or the center-line of the collector) mark the following lines perpendicular to the chalk-lines: 11 inches, 9 inches, 8 inches, 9 inches, 11 inches. Repeat this process up each sheet of Thermo-ply between all the pairs of chalk-lines furthest from the rafters. Again, if the bottom sheet is an irregular size, end the last hole a minimum of 2-1/2 in. above the bottom seam (1, 2-R3).

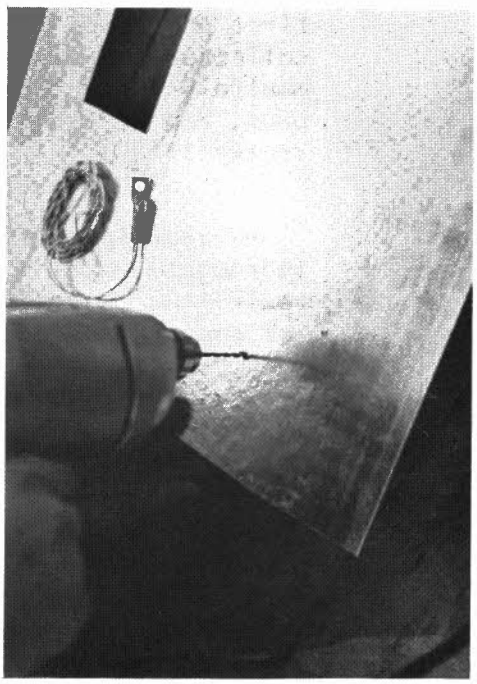
With a sabre saw or utility knife, carefully cut out all the rectangles that measure 9 in. by 3 in. The only rectangles of different dimensions that should be cut would be the lowest rectangles on the collector, ending 2-1/2 in. away from the bottom edge of the Thermo-ply. Remove all pieces of Thermo-ply from manifold pans.

Drill one 1/8 in. diameter hole in the Thermo-ply for every temperature sensor to be used (see Temperature Sensor, Section 5.5), near the return manifold duct connection. These holes will be lined up with the inner manifold slots, beginning with the bottom slot,

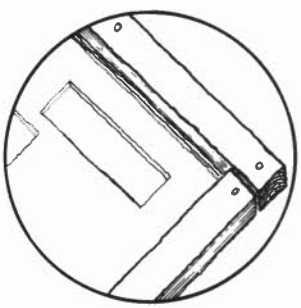
one hole per slot. They should be located horizontally at a distance in from the side of the collector (or from the center-line of the collector center-line if the return manifolds are in the center of the collector) equal to the manifold pan plus 4 inches. These holes are for the wires attached to the temperature sensors that will be connected to the back of the absorber plate.



Cutting the Manifold Slots



Drilling the Hole for the Temperature Sensor Wire



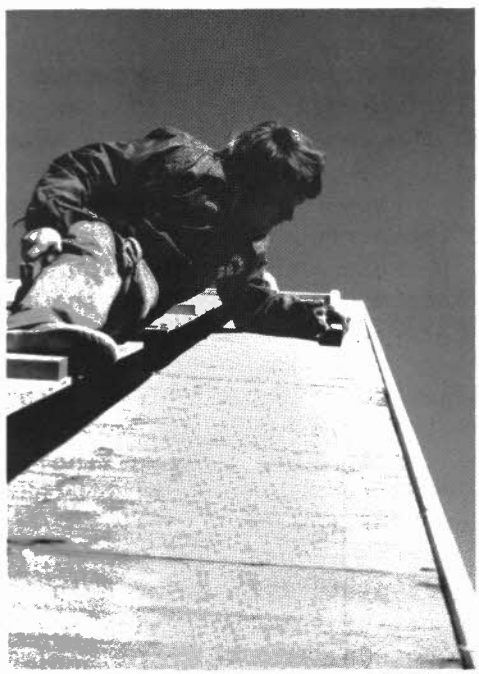
5.4 Perimeter Blocking

The perimeter blocking not only sets the boundaries for the absorber plate to be fastened within, but it also the beginning of the framework for the glazing. It is vital that these pieces be square with each other -- and be fastened to the exact dimensions called for. Therefore, follow the

sequence of laying out and checking diagonals carefully. Check the dimensions several times to be sure they are correct. Any miscalculation now could mean the glass won't fit later.

Cut 1x (nominal) #2 select fir or spruce (do not use pine, it is not a suitable wood to use anywhere between the collector sheathing and the glazing) planks into 2-1/4 in. and 2 in. widths. Tack the 2 in. width across the top and bottom of the collector, with the 3/4 in. face flush with the edge of the plywood (3-R4). Tack the 2-1/4 in. width down the sides of the collector, with the 3/4 in. face flush with edge of the plywood (2-R4). Maintain the straightness of the blocking over long distances.

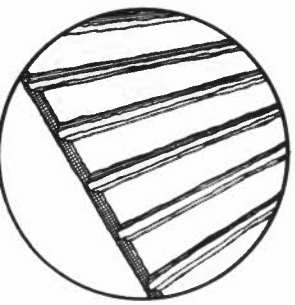
It is very important at this point to check the diagonals to be sure the perimeter blocking will be square. Check the diagonals from the outside corners



Tacking the Perimeter Blocking

of the blocking. Adjust the blocking until the diagonals are equal (within 1/4 in. of each other). If the blocking is not square, each step from here on will magnify the error, with the result that the glass will not fit.

When the blocking is square, fasten it with 3 in. drywall screws at 1'-0" on center.



5.5 Absorber Plate

The air from the supply manifold pan passes through the manifold slots in the Thermo-ply into the ribs of the absorber plate. It flows between the back surface of the absorber plate's ribs and the face of the Thermo-ply, carrying away the heat from the surfaces as it passes by. It is then pulled through the slots into the return manifold pan. The absorber plate is painted black to absorb more of the sun's light, and reflect less back to the outside.

It is very important that every edge of the absorber plate, including the overlaps, be air-tight. Leakage through the absorber plate can mean the difference between a good collector and a poor one. Therefore, be generous with the urethane caulk. And don't skimp on the screws. The number called for will help keep the aluminum's expansion to a minimum. The less the plate moves, the longer the seal of the caulk will hold.

Don't forget to attach the temperature sensors now, or to pass the wires through the Thermo-ply. It could save some costly (and embarrassing) tearing apart later. Identify which is which with a felt marker on the back of the Thermo-ply.

The absorber plate is made of 8 in. ribbed aluminum industrial siding sheets (49-3/4 in. actual width, 48 in. coverage, .032 in. thick aluminum with the mill finish). (See Appendix A for manufacturer recommendations.) Note that the siding will be applied to the roof with the 1-3/8 in. rib valley fastened flush with the Thermo-ply. The 5-5/8 in. rib will be one inch above the Thermo-ply (3-R5).

Enough sheets will be needed to cover the face of the Thermo-ply (1-R5). Use the following two equations to determine the number of sheets to order, and their lengths:

No. of sheets (round off to next highest whole number) = (collector height in inches - 4 in.)/48 inches

Sheet length (round off to next highest 6 in.)= (collector width in inches - 4-1/2 in.)

For example, if the collector were the same one used as an example in the introduction to this chapter (23' - 4-1/2'wide x 16'-4" high), the number of sheets ordered would be: (16'-4" - 4 in.)/4 ft. = four sheets. The actual sheet length would be: (23'-4½") - (5 in.) = 22'-11½". But the sheets must be ordered in 6 in. increments, so they would be 23 ft. long sheet sheets.

The sheets only come in standard lengths up to 30 feet, in increments of 6 inches. If the collector is longer than 26 feet, and has inner manifolds, divide the collector width in half and use two sheets to cover the width. The sheets will butt together at the center-line of the collector, between the two inner manifold pans.

At the ends of each sheet there will be a EPDM end closure strip. Order enough "inside" end closure strips by the linear foot to close off all ends of the sheets. For example, if the collector is one sheet wide, order two times the height of the collector. If it is two sheets wide, order four times the height. There will be two sets of EPDM end closure strips at the center-line of the collector, between the two inner manifolds.

The sheets will probably have to be cut both horizontally and vertically. Horizontal and vertical cuts can be made using a hand held circular saw (with a carbide blade). Cuts across the rib can also be made with a pair of tin snips. Cuts along the rib or rib valley can be scored with a utility knife, and the siding is then bent back and forth until the metal breaks clean. When using the circular saw, wear eye

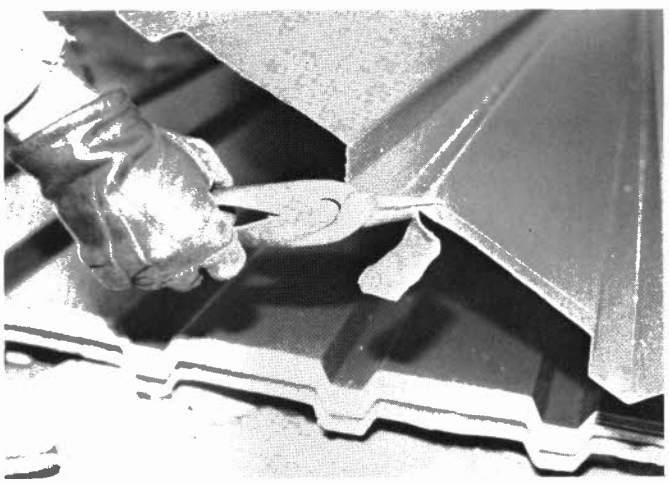
Aluminum Industrial Siding and EPDM End Closure Strips

and ear protection while cutting, and a respiration mask. Cutting the sheet may raise or bend the edge slightly. Remove the raised areas with a file or utility knife, and straighten the edge with a pair of pliers.

Cut the sheets to the width required to fit horizontally across the collector (e.g., 22'-11½"). Save a 49-5/8 in. long piece of ribbed scrap, cut from the end of the sheet, to be used later. Cut 5/8 in. horizontally from the top of the rib valley of the top sheet (3-R5), leaving 3/4 in. left as the valley width. The bottom sheet will be cut after all the other sheets are in place on the roof and an actual measurement can be taken.

SHEET PREPARATION: To remove the thin film of oil that will be found on the sheets and prepare them for painting, sponge down the outside of the sheets with a solution of TSP powder (tri-sodium-phosphate)

Cutting the Absorber Plate Sheets



dissolved in water. Rinse the sheets with water. Next, etch the sheets with muriatic acid according to its manufacturer's instructions. The TSP powder and muriatic acid are both available at hardware or building supply stores.

The temperature sensors will be located on the back of the sheets of siding located over the holes drilled in the Thermo-ply for the sensor wires. Before mounting those sheets on the roof, see TEMPERATURE SENSOR below.

Using the scrap piece of siding as a guide, and a 1/4 in. continuous bead of urethane caulk as the "adhesive," lay out and stick the end closure strips for the first sheet of ribbed siding to the roof (2-R5). The caulk must still be "wet" to act like a glue, so don't let it skim over before pushing the closure strips into it. Fit the ribs of the closure

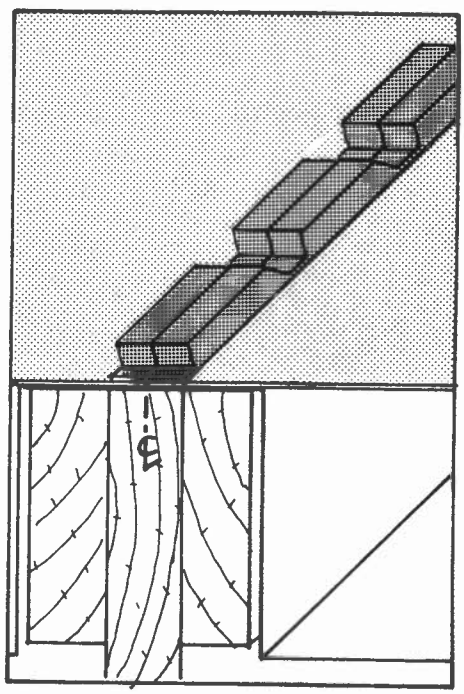


Figure 5.2 Center-line EPDM End Closure Strips

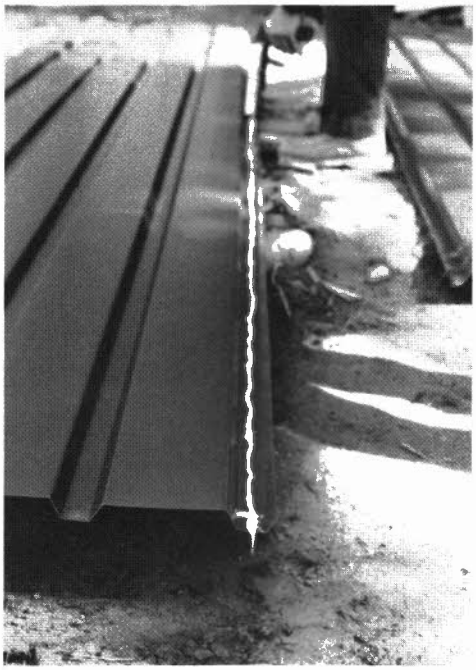
strip into the ribs in the scrap piece. Following the form of the siding will keep the closure strip from becoming stretched out as it is stuck in the caulk. Begin at the top perimeter seam between the Thermo-ply and the plywood, and line the strips up with the side seams between the two sheathings.

If the collector has center manifolds, run one strip down each side of the collector center-line snapped in the Thermo-ply (see Figure 5.2). Do not let the caulk skim over before covering it with the siding. If it does, remove it and caulk again. (See Appendix A for urethane caulk recommendations.)

Just before the first sheet is ready to be taken up to the roof, run a 1/4 in. continuous bead of caulk over the inside top edge of the EPDM end closure strips. Run the same size continuous bead across the top of the collector, along the top perimeter seam. Butt the top edge of the first sheet against the edge of the plywood at the perimeter, laying the sheet carefully over the end closure strips (3-R5). Make sure the end closure strips fit snugly into the ribs.

Fasten the sheet across the top edge with #12x 1-1/4 in. Phillips pan head aluminum or 18-8 stainless steel sheet metal screws at 6 in. on center. Fasten vertically through every rib valley at the ends of the sheet, and through every other rib valley at every rafter. Do not fasten through the air channels. The rafters can be found by noticing where the nails or staples are in the Thermo-ply. Do not fasten across the bottom of the sheet yet.

Lay out and caulk the EPDM end closure strips for the next sheet. Apply extra caulk where these strips butt against those already on the roof. Run a 1/4 in. continuous bead of caulk across the top edge of the overlap strip (3-R5). Lift the bottom of the first sheet, and place the top rib valley of the second sheet below it. Position the second sheet over the end closure strips. Lower the first sheet onto the second. Wipe off any caulk that has been forced out, before it skims over. Follow the same fastening schedule as on the first sheet (3-R5). Continue this process for all sheets except the bottom sheet.

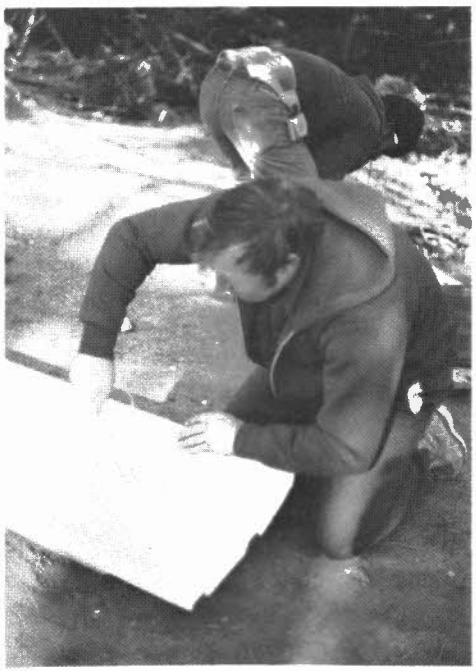


Caulking the EPDM End Closure Strip and Sheet Overlap

TEMPERATURE SENSORS: There are three temperature sensors that will be located near the return manifold pan. The first two are mandatory: one is for winter operation of the collector, and the other is for summer power venting. The third sensor, which operates the domestic hot water mode, should be mounted only if there is to be a DHW pre-heating system. It is likely that these sensors will be too thick to fit between the top of the rib of the absorber plate and the Thermo-ply. Therefore, they should be located over the manifold slots, allowing them to extend beyond the Thermo-ply if necessary. Attach each one to the back of a rib, located over each inner manifold slot that has a hole drilled next to it for the sensor wires (Section 5.3 and detail 1-R3). Each sensor should be fastened according to its manufacturer's instructions. Attach wires to the sensors if they are not already attached. Check with the manufacturer for the type of wire, because some sensors require shielded wire. Fasten the top edge of the absorber plate sheet to the roof. Tie a knot in each wire, and position it over its respective 1/8 in. diameter hole in the Thermo-ply (3-R5). This will keep the wires from being pulled out of the sensors, after the wires are fed through the holes. Feed the wires through each hole, and then caulk the holes in the Thermo-ply and the absorber. Write with a felt marker on the back side of the Thermo-ply which sensor is which (e.g., "T_c" for normal winter collector operation, "T_{col}" for summer venting, and "T_{chw}" for DHW control). Finish attaching the absorber plate sheets.

After the next to last sheet is on, measure from the top edge of the last rib valley to the bottom perimeter seam between the Thermo-ply and the plywood (3-R5). This distance, plus a 1/2 in. allowance for the overlap strip, will be the width to cut the last sheet. If the bottom of the last sheet is cut across a rib valley, follow the layout of the end closure strips and the same fastening schedule as the other sheets. Run a 1/4 in. continuous bead of caulk along the bottom edge of the Thermo-ply. Lay the ribbed siding over it and fasten at 6 in. on center (3-R5).

If the bottom edge of the last sheet is cut across a rib, follow the layout of the end closure strips and the same fastening schedule as the last sheets. Cut a continuous piece of 1 in. by 1 in. fir

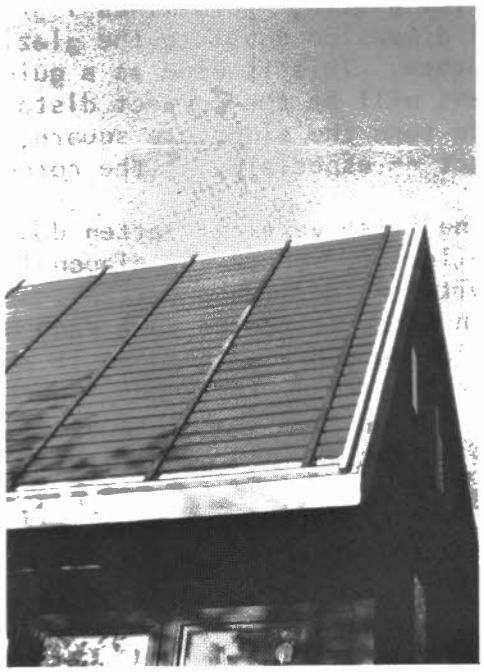


Fastening the Temperature Sensor to the Back of the Rib

or spruce blocking. Run a 1/4 in. continuous bead of caulk along the bottom edge of the Thermo-ply. Lay the continuous blocking in the caulk, and butt its length against the side of the plywood edge, and against the end closure strips at its end. Caulk again along the top edge of the blocking and lay the edge of the last sheet over it. Fasten with # 12x 2-1/2 in. Phillips pan head aluminum or 18-8 stainless steel sheet metal screws at 6 in. on center (see 3-R5). Check the four corners of the collector. The end closure strips may raise the ends of the top and bottom edges slightly, which will cause leaks. If necessary, loosen the screws, add more caulk, then tighten and add more screws.

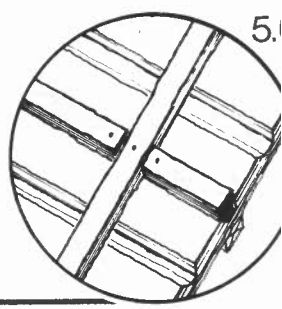
PRIMING AND PAINTING: Prime and paint the absorber plate with one coat of primer and one coat of paint. (See Appendix A for manufacturer recommendations.) Paint the inside surfaces of any wood exposed around the perimeter of the plate with one

coat also. Allow the paint to dry completely, a minimum of two full days. Standard enamel paints dry by solvent evaporation, a process which should be allowed to finish before the glazing goes on. If there is not enough time to allow for this, an epoxy paint must be used. Once the absorber plate is painted, be careful not to scratch it. Precautions, such as wrapping ladder legs with rags, should be taken. Touch up any scratches with paint before the glazing is installed.



1x3 Fir or Spruce Battens

5.6 Battens



The battens are those vertical members that the glazing system is attached to, so they must be securely fastened to the absorber plate or the perimeter blocking. They must be parallel with each other, and

square with those they run perpendicular to, or the glass will not fit. Check each dimension and diagonal carefully. Then check them again.

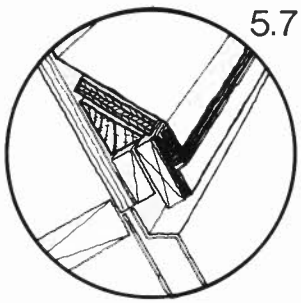
Cut 1x3 (nominal) fir or spruce (not pine) battens (1-R6). Paint with two coats of flat black paint. (See Appendix A for paint manufacturer recommendations.) Tack the battens around the perimeter of the collector first, making sure the outside edge is flush with the outside edge of the perimeter blocking. Check the diagonals before fastening with 3 in. drywall screws at 1'-0" on center (1-R6).

Cut a piece of plywood with a horizontal dimension equal to the glazing width minus 1-3/4 inches, and a vertical dimension equal to the glazing height minus 1-3/4 inches. This is used as a guide to make sure the battens will be the correct distance from each other. Be sure the sides are square, and the dimensions exact -- especially at the corners.

Fasten the first vertical batten down the center line of the collector. Check the diagonals to be sure it is square with the perimeter battens. Lay out the battens to each side, fastening down each batten as the plywood guide is run down between it and the preceding one that is already fastened. Fasten with #14x 1-1/2 in. aluminum or 18-8 stainless steel Phillips flat head wood screws at 1'-0" on center. By the time the last one is laid out, the plywood guide should fit between this batten and the preceding one, and between itself and the one fastened to the perimeter blocking (2-R6).

The horizontal battens should be laid out the same way, spaced vertically with the plywood guide. If the horizontal battens fall across a rib, 1x3 (nominal) fir or spruce is fastened with #14x1-1/2 in. aluminum or 18-8 stainless steel Phillips flat head wood screws at 1'-0" on center, with a minimum of three screws per batten. A 1x3 (nominal) fir or spruce (not pine) batten on top of 1x2 (nominal) fir or spruce (do not use pine) batten is used if the batten falls over a rib valley (3-R6). In this case, fasten with #14x3 in. aluminum or 18-8 stainless steel Phillips flat head wood screws at 1'-0" on center, with a minimum of three screws per batten.

5.7 Glazing Preparation



Preparing the collector for the glazing process consists of several important steps. The first is preparing the bed which the glazing will lie on. It is an EPDM extrusion stapled to all the battens, and will cushion the glass against wind and live loads from snow.

The second step is weatherproofing the perimeter of the collector with flashing. This will keep water from leaking in through the edges of the collector. The canted (sloped) blocking across the top of the collector will allow for good drainage.

The last step, the smoke test, is vital to the performance of the collector. The collector must be thoroughly checked for leaks. As will be seen on the first test, no matter how well the collector was caulked, there will still be spots that were missed. But don't get discouraged -- the leaks are not difficult to seal. More than one test, however, will surely be needed to find and seal them all.

The glass will rest on EPDM lower gaskets, one part of the Universal Glazing System (U.G.S.) by CY/RO Industries. Order enough linear feet of the 4 piece system as you have linear feet of battens. (See Appendix A.) The lower-gasket has two parallel ridges running up its center.

INTERIOR GASKETS: Center the gasket on each of the vertical interior battens (not the perimeter battens) cutting each the length from inside edge to inside edge of the perimeter battens plus 1/4 inch. Do not splice sections of the gasket together. Staple the battens with 7/16 in. crown divergent staples at 3'-0" on center overlapping the ends 1/8 in. onto the perimeter battens (1, 2-R7). Center the gasket on each of the horizontal interior battens (not the perimeter battens), cutting each the length from vertical gasket to vertical gasket. Staple with 7/16 in. crown divergent staples, with a minimum of three

per gasket (1, 3-R7).

CANT STRIP: Using 2x4's (nominal), cut continuous cant strips the length of the collector. The angle of the cut along the 3-1/2 in. side will equal the angle of the roof pitch minus ten degrees. For example, if the roof slope is 60°, cut the cant strip at 50°. Tack the cant strip above the collector with its 1-1/2 in. side flush with the perimeter of the collector, and its 3-1/2 in. side against the plywood (3-R7). Measure from the perimeter batten, vertically across the cant strip, to the plywood on the roof. Cut continuous strips of 1/2 in. CDX plywood this width, and fasten it continuously across the cant strip with 10d common nails at 1'-0" on center.

SHIMS: Cut enough 3/16 in. x 3/4 in. (actual) wood shims to equal the distance around the outside perimeter edge of the perimeter battens. Lay the lower-gasket around the perimeter battens, lining up the exterior edge with the exterior edge of the batten. Miter the gasket at the four corners of the collectors. Do not splice pieces together on any length, but cut continuous pieces. Lay each of the lengths along the edges, with its corresponding shim lined up with the same edge. Staple through both with 7/16 in. crown divergent staples at 3'-0" on center (1, 2, 3-R7). Caulk at all the intersections between horizontal and vertical battens, and at all four mitered corners. (See Appendix A for silicone manufacturer recommendations.)

ROOFING/FLASHING: Roof with chosen material across the bottom of the collector. Bend ten-inch wide 0.019 in. aluminum flashing over the shim, so the flashing edge is flush with the inside edge of the shim (2-R7), down the side of the batten blocking and onto the roof, continuously from side to side of the collector. Fasten to the batten, and to the roof, with 1 in. galvanized roofing nails at 1'-0" on center. Cut and bend the flashing around the side corners of the collector. Begin roofing up the sides of the collector, slipping sheets of the same thickness flashing between the roofing. Bend the flashing over, fastening it to the batten and roof in the same manner used across the bottom of the collector. Bend the flashing up and over the cant strip when the top corners are reached, and fasten to the

cant strip top and sides. Flash across the cant strip, over the shim across the top of the collector, and fasten with 1 in. galvanized roofing nails at 1'-0" on center. Bend over the sides at the corners of the collector and fasten. Complete the roofing across the roof above the collector (1, 2, 3-R7).

SMOKE TEST: Before installing the glazing, it is necessary to check for leaks in the system. This is important, since even small leaks reduce the efficiency of the collector dramatically. One method of checking for leaks is a smoke test. This can be done using a metal paint can and a smoke bomb. (See Appendix A for smoke bomb recommendations.) Follow manufacturer's warnings on the smoke bombs.

It is helpful at this point to have the supply and return ducts attached to the manifold pans, to check for leaks at the connections.

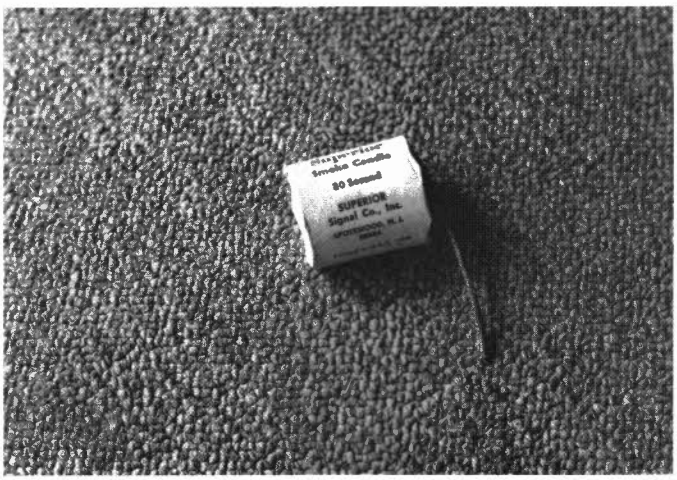
Seal off the duct connection to one manifold or duct using polyethylene film (or cardboard) and duct tape. Leave a hole at the other manifold or duct to insert the paint can.

Place the smoke bomb in the paint can, ignite it and place it up into the duct or slightly into the manifold. Carefully check the collector for leaks, and seal all leaks with caulk.

It will not be unusual for the collector to leak slightly around the edges of the absorber plate and at the overlaps, and these leaks must be completely sealed. Adding clear silicone caulk and more screws at these seams will help stop these leaks. Paint over the new screws and any scratches on the plate. (See Appendix A for silicone caulk recommendations.)

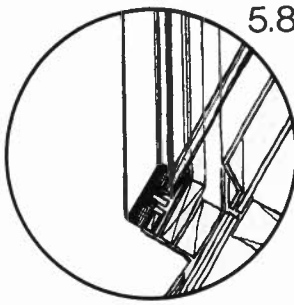
Also check the back of the collector for leaks at the manifolds, ducts, or those made by any fasteners that punctured the Thermo-ply. Caulk all the leaks with silicone.

Several tests may be required before all the leaks are sealed. This is an important step in the construction process, so conduct it carefully.



Smoke Testing the collector before the glazing is Fastened

5.8 Glazing and Finishing



The panes of glass allow the sun's light to pass through and hit the absorber plate, but slow the transfer of the resulting heat back to the outside. The glass must be able to expand and contract freely with the extreme temperature changes, therefore the 1/4 in. gap allowed around each pane of glass is vital to the survival of the glass.

The aluminum clamping bars with built-in gaskets provide support, along with an almost caulk-free weatherproof seal. The only place caulk is needed is at the intersections of the clamping bars, where water could leak in under the bars and, through freezing and thawing, shorten the life of the lower EPDM gaskets.

GLAZING: The rest of the glazing process requires mounting sheets of 3/16 in. thick glass to the collector using the remaining parts of the CY/RO U.G.S. system. (See Appendix A for glass recommendations.) The last pieces of the U.G.S. system are the aluminum clamping bar and the two upper EPDM gaskets.

Lay out the clamping bars and cut to the same lengths as the lower-gaskets were cut (Section 5.7). Miter the corners of the clamping bars at the four corners of the collector battens. The long horizontal sides may have to be done in sections, since the clamping bars come in stock 25 ft. lengths. Try to keep the splices to a minimum. Pre-drill the clamping bars at 8 in. on center along the center-line of the bars, with holes no more than 1/2 in. from the ends of the bars. Feed the upper-gaskets into the channels extruded into the underside of the bars. Run the gaskets continuously through any splices of the clamping bars.

Center the clamping bar over the lower-gasket, horizontally across the bottom of the collector. Fasten with #12x2 aluminum or 18-8 stainless steel Phillips pan head sheet metal screws, with neoprene washers. Fasten all the screws part way in, leaving enough room between the bar and the gasket to fit the

glass. Repeat this process up one side of the collector.

Starting at this same corner of the collector, center the first pane of glass within the boundaries set by the two clamping bars and the ribs on the lower neoprene gasket. Re-center the lower-gaskets on the battens if they were moved as the glass was centered. Tighten the screws on the two clamping bars already in place. Center the other vertical clamping bar over the side lower-gasket, and partially fasten the screws, to a point 16 inches below the top of the piece of glass in place. Partially fasten the horizontal clamping bar above the glass. Center the next pane of glass above the first, and reposition the lower-gaskets on the battens if they were moved. Tighten the screws across the horizontal clamping bar and the vertical clamping bar at the perimeter. Continue partially fastening the other side clamping bar to the top of this piece of glass.

Repeat this process until the top of the collector is reached. Do not fasten the horizontal top clamping bar at this time. Caulk between any intersections of the fully fastened clamping bars, including the splices. (See Appendix A for silicone caulk recommendations.) This caulk will keep water from leaking through the intersections and under the glazing bars.

Return to the bottom of the collector, and continue the glazing from bottom to top, of the side of the set just completed. Once a clamping bar has glass on two sides of it, fasten the screws all the way into the wood. Once an intersection is completed, caulk it.

Repeat this process across the collector until the last vertical clamping bar is fastened up the opposite side. Fasten the horizontal top bar, and caulk all remaining intersections.

INTERIOR FINISHING: Cut rigid fiberglass insulation the width and length necessary to fit behind the manifold pans, from manifold rafter to manifold rafter and from top to bottom collector blocking. Make the insulation as thick as will fit without protruding beyond the rafters. Locate the sensor wires that were fed through the Thermo-ply. Attach more wire

(shielded wire if manufacturer calls for it) and run to the air handling control panel (See Figure 8.17 and 8.18, or 8.24 and 8.25). It is important to tag the wires so that they don't become confused with each other. Insulate between the rafters behind the collector with fiberglass batt, the full depth of the rafters. If the space behind the collectors is unheated, insulate to a point at least 6 in. beyond the perimeter of the collector. If the space behind the collector is heated, insulate from east to west wall. Staple a 6 mil polyethylene vapor barrier to the rafters, overlapping the sheets and taping the edges together. Finish the interior surfaces as desired.