

ENERGY NOTES

BATCH SOLAR WATER HEATER CONSTRUCTION AND INSTALLATION MANUAL

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SYSTEM DESCRIPTION

The cost effectiveness of solar water heating in Oregon is closely tied to the initial cost of the system. With the reduction of tax credits, low cost, doityourself solar systems are emerging as a cost-effective means of heating water.

There are various types of solar water heating systems; the simplest are passive "batch" or "integral" systems. These systems preheat cold city or well water before it enters the conventional domestic water heater. Figure 1 shows the basic plumbing configuration. Because batch collectors do not require pumps and controls, they are ideal for low cost doityourself solar water heating systems. This Energy note explains how to build and install a batch solar water heater similar to one shown in Figure 2.

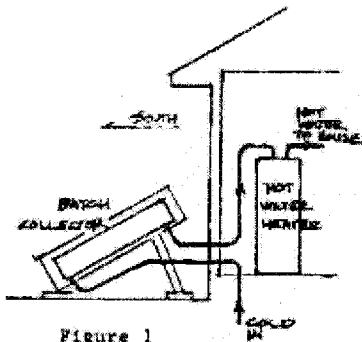


Figure 1

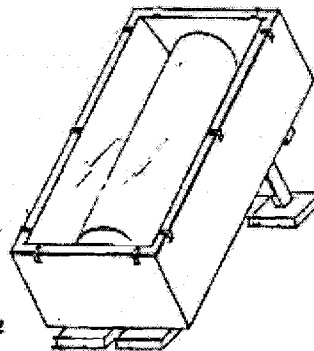


Figure 2

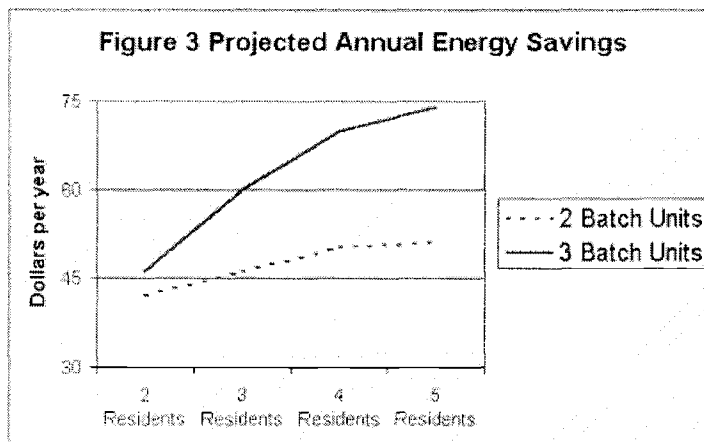
The OSU batch collector was designed to be cost effective. If second hand water heaters and patio door glass is used, each collector costs less than \$100. The collector can easily be constructed from off the shelf materials and common hand tools. An installed system with two collectors costs about \$300, but costs do vary depending on the your particular situation.

To keep the cost of the system down these collectors were designed around recycled 52 gallon electric hot water heater tanks and a single pane patio glass. These two items dictated the size of the collector. A cradle supports the tank and legs made from 2x4's. A plywood box surrounds the cradle and tank and serves to hold the insulation and glazing in place. The collector was designed to avoid wasted material, and complicated cutting and assembly operations.

A sheet of selective surface such as "Sunsponge " is recommended on the upper face of the tanks to increase the performance of the collectors. You probably have to order the selective surface through the mail.

No freeze protection was added to the system, the water mass in the tank coupled with the use of insulated polybutylene piping resulted in a freeze tolerant system. Under extreme cold conditions the polybutylene pipes between the collector and the heated portions of the house will freeze, but will not burst. When frozen pipes do occur, simple valving, shown in Figure 6 will allow bypassing the collectors until the pipes thaw. You may wish to bypass the system during December, January and February, to avoid freeze up situations using the same valving procedures.

COLLECTOR ECONOMICS



Senior OSU mechanical engineering students tested the collectors. Test results indicated a two collector system would save about 30 percent of a typical family's annual water heating energy costs. The heater provides much less of the water heating energy requirements in the winter than in the summer. Figure 3 estimates the annual dollar savings from a two or three collector

system, based on the number of people using the system. The estimates assume the weather conditions similar to the Willamette valley and the use of an electric water heater with electricity costing 4 cents per kWh. The annual savings will usually pay for the installed system in three to five years without tax credits, which is a sound investment. It is usually not cost effective to exceed three batch collectors.

LOCATING THE COLLECTORS

The following three important factors have to be considered when locating the solar collectors:

1. The distance between the batch collectors and the existing hot water heater should be kept to a minimum.
2. Collectors should have minimal shading.
3. Collectors should be optionally orientated.

Ground Mounting and Short Pipe Runs

When considering different places to locate the collector, it is important to be aware of the distance between the collectors and the existing water heater. The longer the run the more heat will be lost from piping, even if the pipes are insulated.

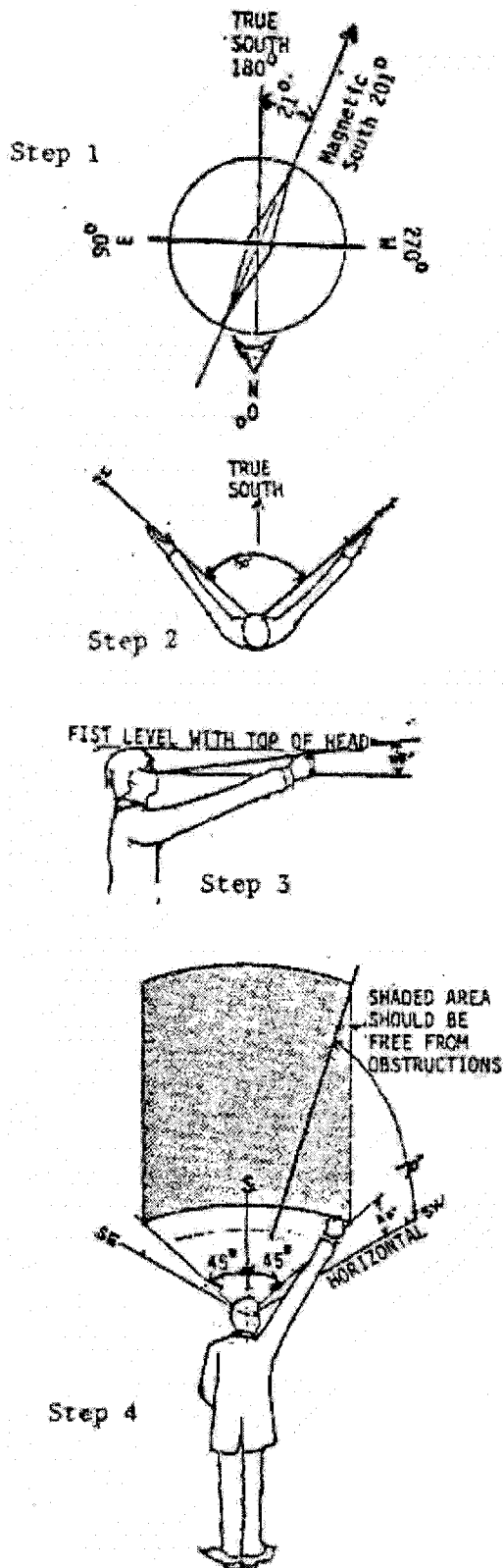
Batch collectors are heavy; the ideal situation is to have them situated on the ground near the existing water heater. A short run of pipe to the collector is then possible.

Batch collectors can be roof mounted, but care must be taken to insure that the roof structure can support the load. Roof mounting should only be considered if all ground mounting possibilities have been exhausted. A structural engineer should be consulted before mounting batch collectors on a roof.

Optimal Collector Orientation

The collector should be orientated, as near to true south as possible, and any orientation within 30 degrees of true south is suitable. Batch collectors lose more heat over night than active systems; this is especially the case in the winter. Because of this, the OSU batch collector is designed to take more advantage of the summer sun and warm conditions. The collector is sloped 30 degrees up from level, a low angle compared to most active solar collectors.

Avoid Panel Shading



Having the collectors in the sun is by far the most important siting criteria. To do a quick check on whether or not the proposed location for the collectors is shaded see Figure 4. More accurate site analysis methods are described in Energy Notes 'Plotting Skylines' and 'Easy Skyline Plotters'.

MATERIALS AND TOOLS

After selecting the appropriate location for the collector, and dialing with the applicable building permits, you are ready to assemble tools and buy materials. See the tools and material lists on the last page for details. To save time and blisters, a variable speed electric drill with a bit to drive screws is a strongly recommended. Make sure the screw bit fits the screw head, which might be either a hex head and/or a slotted head.

Figure 4 Checking for Shading

Step 1 To check for shading, stand where you plan to locate the collectors. Find true south on a compass by setting the south end of the magnetic needle on 20 degrees, true south will be at 180 degrees on the compass (see Step 1 illustration). This procedure might be off a few degrees in some parts of Oregon, but it is close enough for siting purposes.

Step 2 Facing south, hold your arms out so they are at right angle (see

Step 2 illustration). Pick cut a reference point in line with each arm.

Step 3 Make a fist; raise the fist so that it is even with the top of your head (see Step 3 illustration).

Step 4 Keeping your fist at this angle, swing it from one reference point to the other. The area above your fist throughout this arc should be free from obstructions such as trees, buildings (including your house) or steep hills. Utility poles and wires usually do not present a shading problem. If there are obstructions, try another location.

PREPARE WATER TANK

Remove drain valve, nipples, thermostat and wiring (but not elements). Remove sheet metal shell and insulation. If a secondhand tank is being used, pressure test it for leaks. To pressure test do the following steps

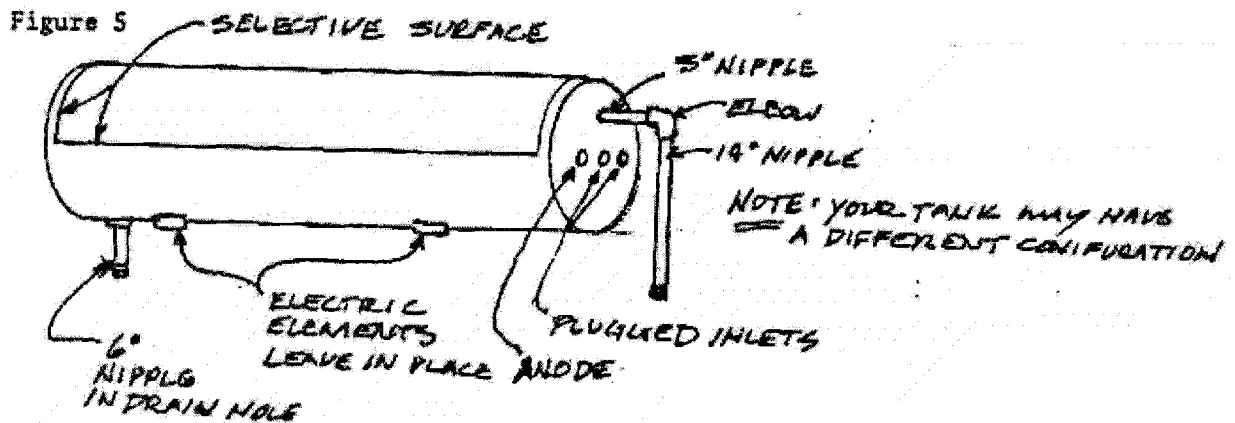
- 1) Screw a 6" galvanized nipple into the drain at the bottom of the tank. Wrap Teflon tape around pipe threads. Screw a hose bib to nipple.
- 2) Plug the entire inlet holes at the top of the tank except one with 3/4" galvanized plugs.
- 3) Connect garden hose to water supply and hose bib at the bottom of the tank. Fill tank with water until flowing out the top of the tank. Turn off water.
- 4) Plug remaining inlet hole with plug and turn water back on.
- 5) Look for leaks. Leaks around elements can sometimes be fixed with a new gasket. Leaks around the base of the unit are beyond repair. If there are no leaks drain tank and remove hose bib from drain nipple.

Unscrew anode rod at the top of the tank and check its condition, replace if necessary. Remove any rust on the tank with sandpaper. Spray tank with high temperature flat black stove paint.

Determine the inlet hole in the top of the tank. Select the inlet holes which is on the opposite side of the tank from the tank drain and screw into it a 6" galvanized nipple. Screw an elbow on the end of the nipple. Screw a 1/4" nipple into elbow and rotate until the nipple is in line with the tank's drain.

All the inlets at the top of the tank should be plugged except for the one with the nipple (See Figure 5).

Selective surface increases the collector's performance. It should be applied just before the tank is installed in the collector for the final time. This avoids damaging the selective surface while handling the tank during the construction of the collector. The selective surface should be applied to the forward facing half of the tank (See Figure 5).

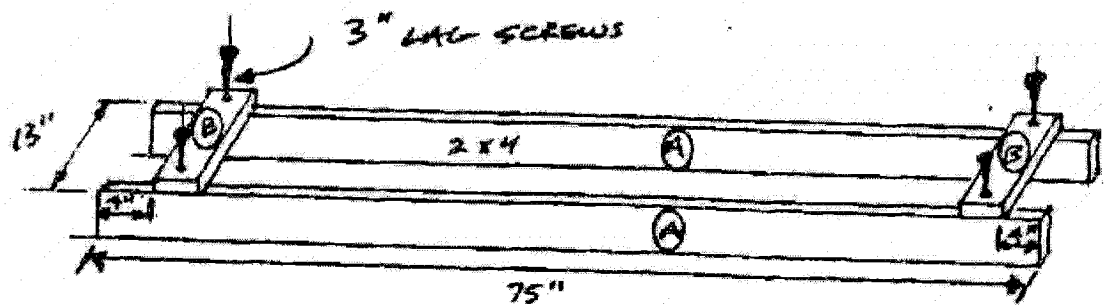


CONSTRUCTION PROCEDURES

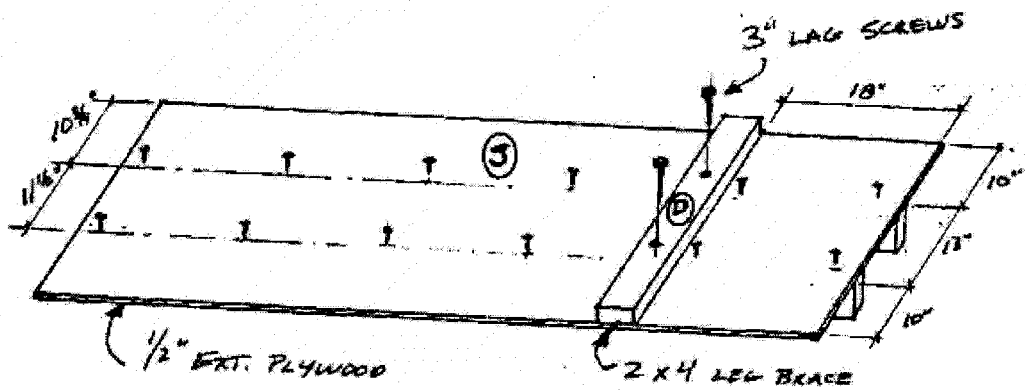
The collector construction sequence is set out in easy to follow graphical steps on the next five pages. Cross sectional drawings of the collector on page 16 and 17 should also be referred to. Building two collectors should be a weekend project. One person could build the collector, but two make things a lot easier. Installing the system takes two people. Steps 2 through 5 can be done conveniently on a bench level, but after that it is easier to set the collector base on a lower working surface, such as saw horses or boxes, between 16" and 24" high.

- 1 CUT 2X4'S AND 2X2'S
SEE CUTTING DIAGRAM PAGE 18
CUT PLYWOOD (IF YOU DID NOT HAVE THE
PLYWOOD CUT AT THE PLACE OF PURCHASE)
SEE CUTTING DIAGRAM PAGE 19

- 2 ASSEMBLE CRADLE AND
COVER WITH ALUMINUM TAPE



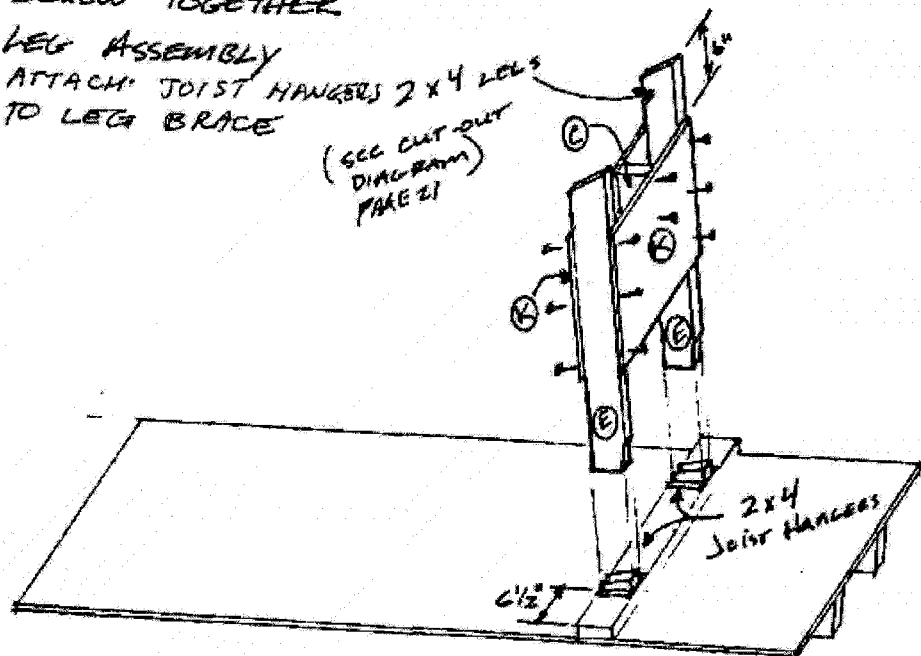
3 SCREW BACK AND
LEG BRACE TO
CRADLE



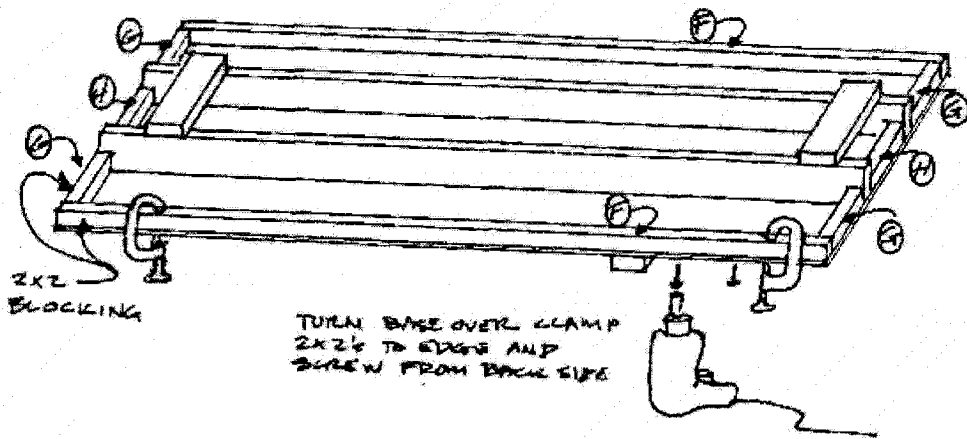
4 SCREW TOGETHER

LEG ASSEMBLY
ATTACH JOIST HANGERS 2 X 4 LEGS
TO LEG BRACE

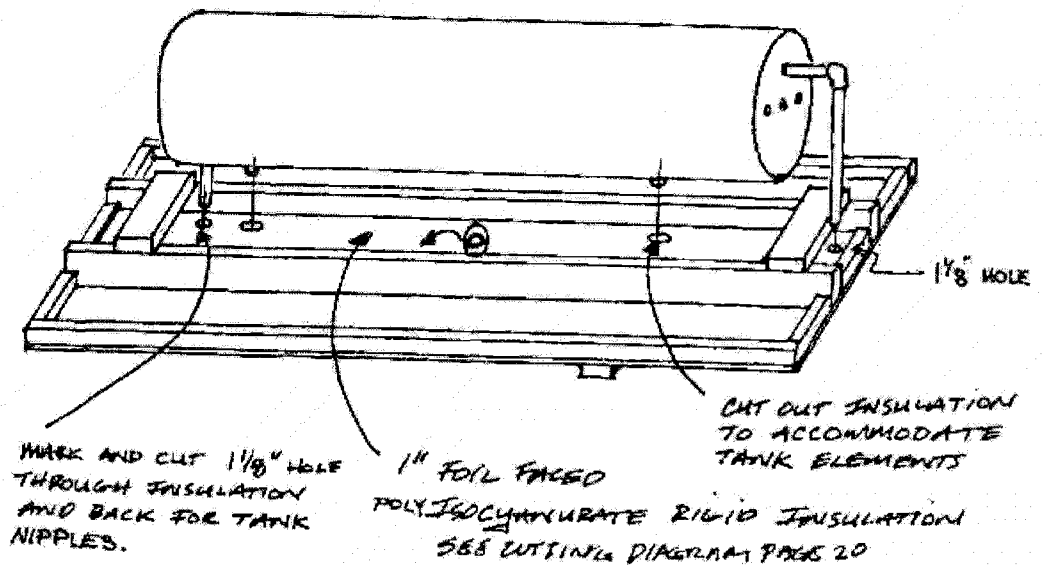
(SEE CUT-OUT
DIAGRAM)
PAGE 21



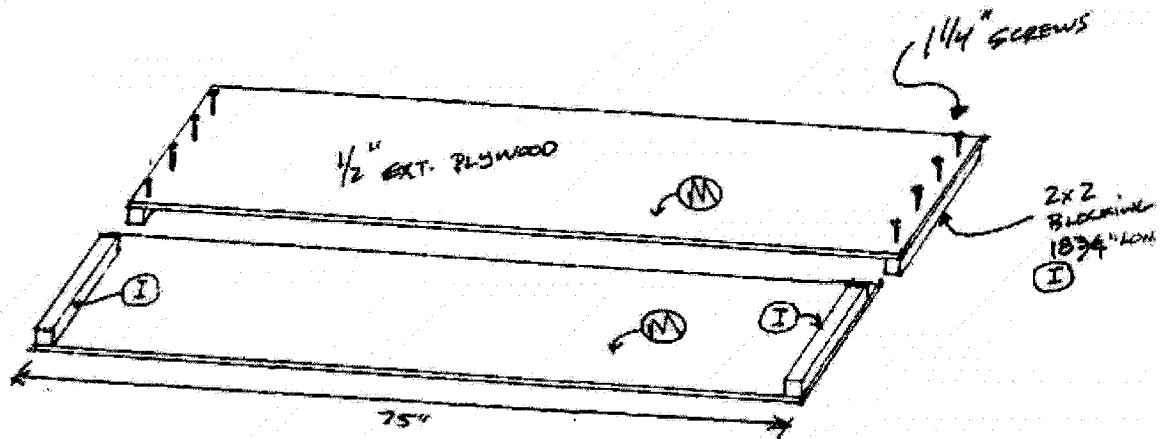
5 SCREW PERIMETER BLOCKING TO BASE



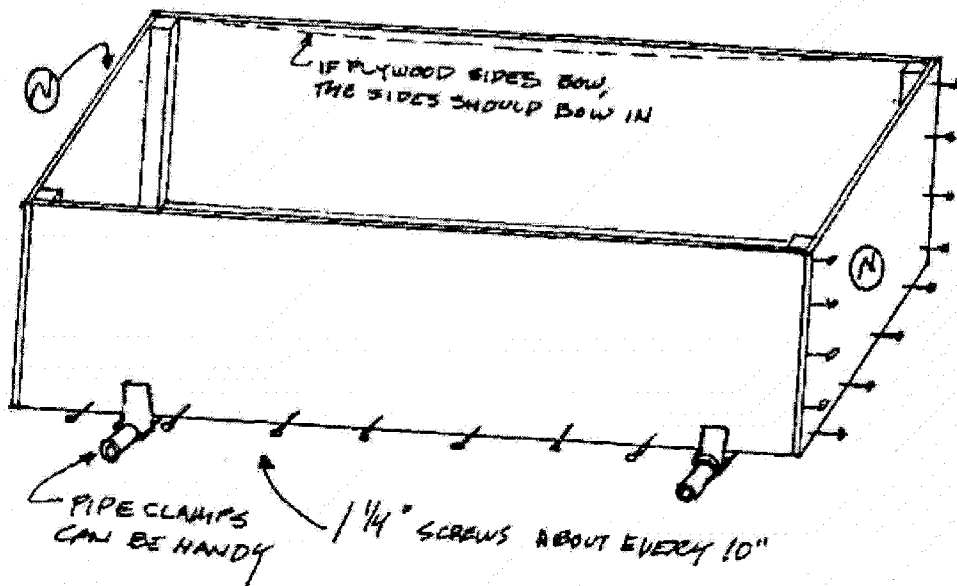
6 INSTALL CRADLE INSULATION



7 ASSEMBLE SIDES

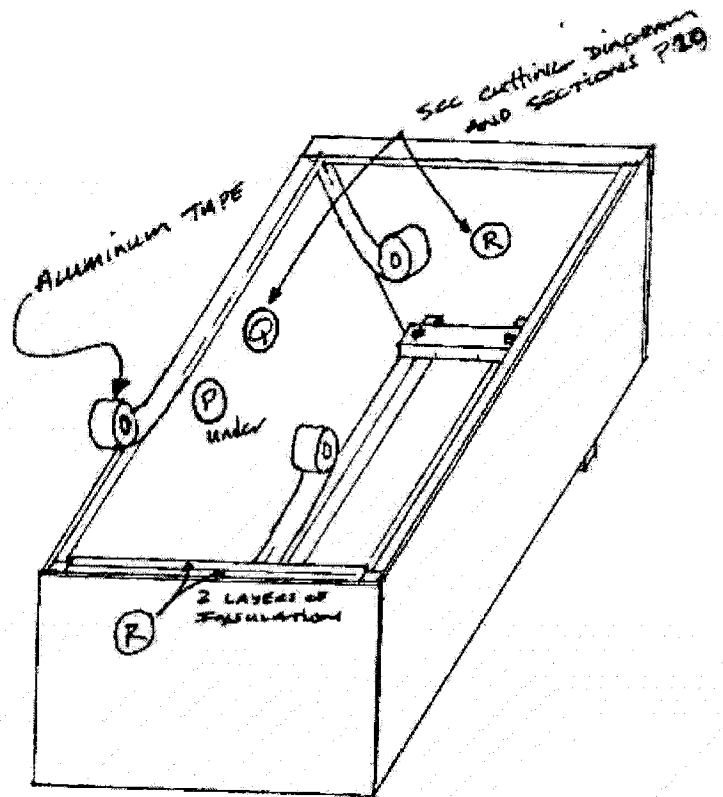


8 SCREW SIDES TO BACK SCREW END TO SIDES AND BACK

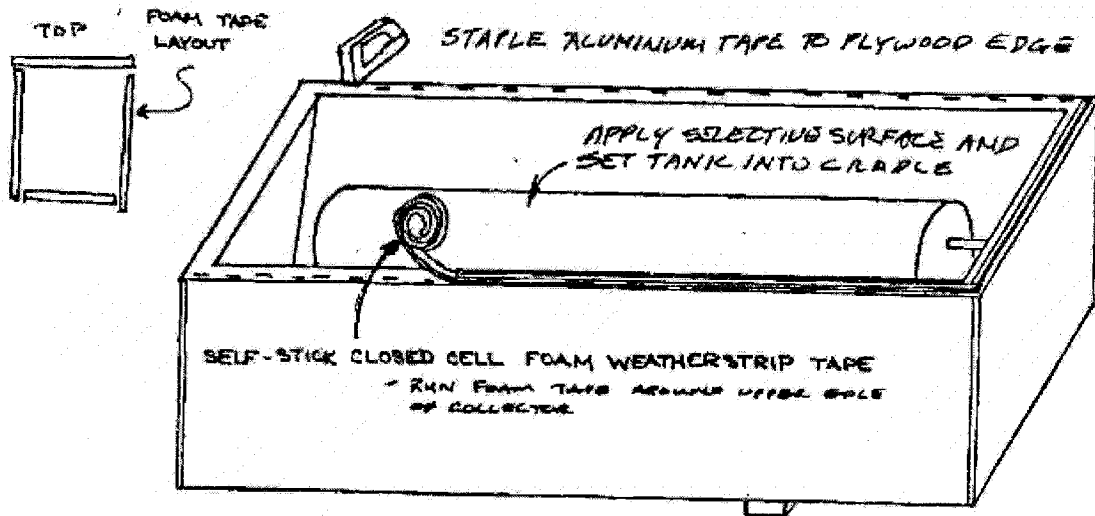


9 INSULATE SIDES AND END OF BOX

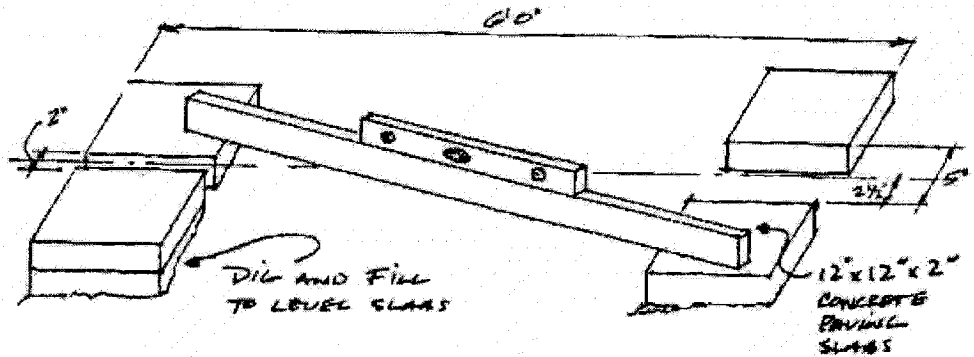
TAPE EDGES AND CORNERS



10 STAPLE EDGES
APPLY FOAM TAPE GLAZING GASKET

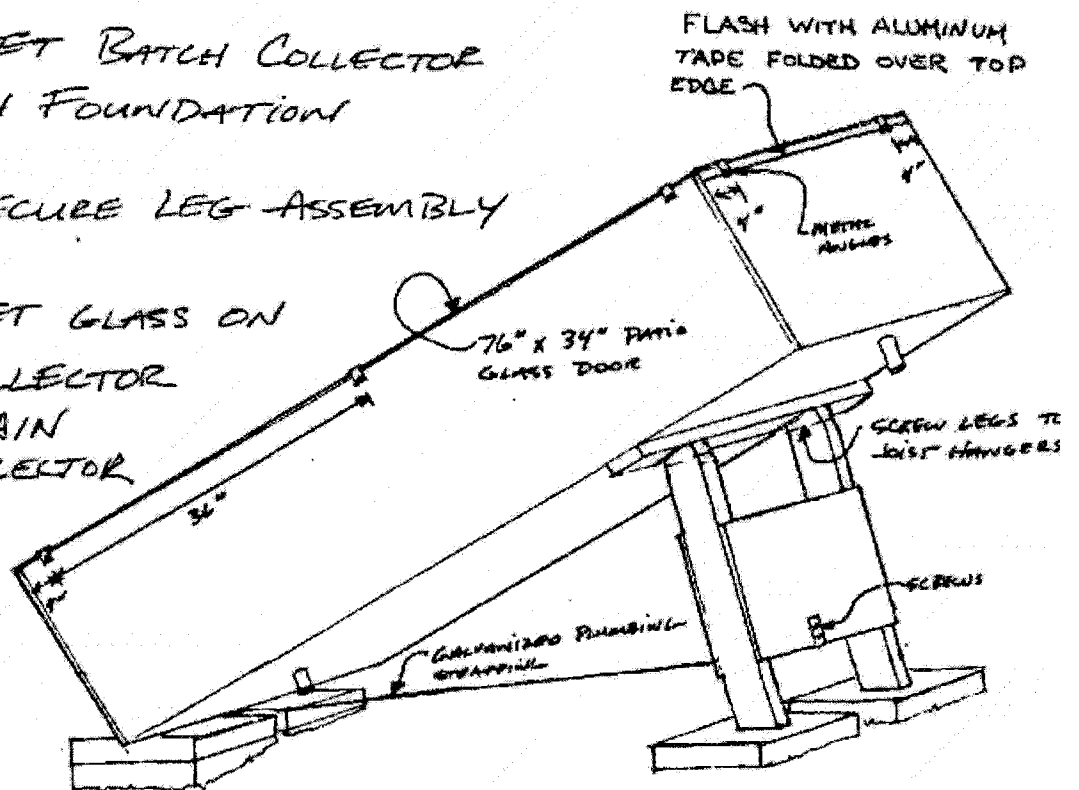


11 PREPARE FOUNDATION FOR COLLECTOR



12 * SET BATCH COLLECTOR ON FOUNDATION

- * SECURE LEG ASSEMBLY
- * SET GLASS ON COLLECTOR
- * STAIN COLLECTOR



PLUMBING

With the major components in place, the collector and hot water heater, you can now begin plumbing them together. The tools required are listed on page 22.

Examine the Existing Water Heating System

Before starting, become familiar with your existing hot water heater. There will probably be at least three pipes connected to the water heater.

Look on the top of the heater for "hot" and "cold" labels where pipes enter the heater. Find the hot water pipe, which connects the hot water heater to the various hot water faucets in your house. The pipe draws water from the top of the tank where the water is hottest.

Find the pressure relief pipe coming out of the tank. It is located either at the top of the tank or on the side of the tank near the top. This pipe is usually very short. Screwed on the end of this is a pressure relief valve. This valve is the safety mechanism that prevents the tank from exploding if too much pressure builds up. There might be a pipe attached to the relief valve designed to carry off the steam or superheated water in the event of the pressure valve releasing.

Find the cold water supply pipe. Follow this cold water pipe away from the tank, there should be a gate valve (valve #6, Figure 6, page 13) before the pipe disappears into a wall or under the house. Closing this valve shuts off the incoming city water and relieves the entire hot water system of the city water pressure. This valve needs to be closed before any plumbing work starts. (Note: Always turn off the electricity or gas to the hot water heater whenever working on it.)

It is the cold water supply pipe that will be tapped into when installing this batch collector. Some hot water heaters have only the hot and cold inlets, the relief valve being placed in the hot water line leading to the house. A solar hookup can be done equally well with either system.

Tapping into the cold water supply line

For ease of installation and freeze tolerance, all of the new plumbing should be done with 3/4 inch polybutylene pipe. Before making final plumbing connections between the various components in the system, it is strongly recommended that all the pipes and fitting be assembled to ensure proper fit BEFORE they are connected up.

Refer to Figure 6 as the new plumbing requirements are explained. Between gate valve #6 which shuts off the city water pressure, and the cold entry opening to the water heater, two T fittings and three new gate valves (Nos. 1, 2, & 3) as shown on Figure 6 must be installed. Valves #2 and #3 will normally be open. Valve #1 will be closed. Closing valve #2 and #3 and opening valve #1 will isolate the entire solar system from the city pressure, but allow the existing hot water system to function.

Plumbing to the Batch Collector

Cold City water will go directly to the collector. The cold water supply pipe going to the collector should start at valve #2 and run to the inlet nipple at the lower end of the first collector. The return pipe run between the batch collector and the existing water heater starts from the nipple coming out of the high end of the last batch collector and ends at valve #3. Valve #3 will normally be open.

A pressure/temperature relief valve should be placed near valve #3 on the collector side of the valve. If more than one collector is used, they should be plumbed in series. The upper outlet of the first collector should be connected to the lower inlet of the next collector (see Figure 6).

There should be a drain valve (#5) at the end of the inlet nipple on each collector. Their valves are used to drain the collectors. Valves #4 should be opened when draining the tanks to let air into the system.

A thermometer for monitoring the performance of the system can be installed. It should be placed in the return line before it enters the hot water heater. Thermometers usually come with a 1/2" male screw fitting that allows easy connection at a T fitting in the plumbing.

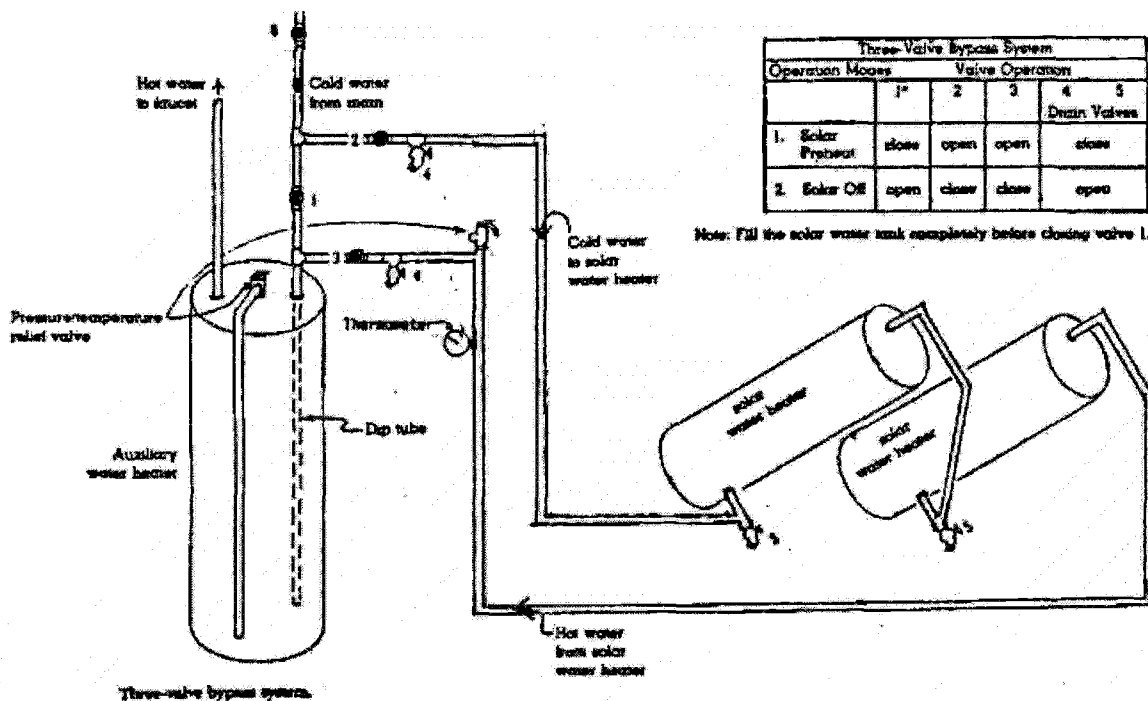


Figure 6
Plumbing Layout

INSULATION

The performance of a solar hot water system is adversely affected by poorly insulated pipes and storage tanks. This is particularly true when pipe runs are long and water heaters sit in unheated areas.

Insulating Pipes

All plumbing between the solar collector and water heater must be insulated. It is especially important that all outdoor piping be insulated. In the Willamette Valley, R3.5 is the minimum R value recommended. For Central and Eastern Oregon sites, a minimum of R7 should be used. To extend system performances into the cold December and January months, consider adding a layer of R11 fiberglass batt insulation to the pipe insulation listed below. Burying insulated pipe below the frost line can also reduce pipe freezing and improve the looks of the installation especially if the collectors are not adjacent to the house. A waterproof cover, such as flexible black plastic drainpipe, should be used to cover fiberglass insulation or buried pipes.

There are several types of pipe insulation available. The insulation will be made either to slide over the pipe or to clamp around it. In either case, the insulation is available for various pipe diameters. Pipe insulation exposed to the weather must be protected. The following table is a guide to several locally available pipe insulations:

Type	Brand Name	R value/Inch	Wall Thickness	Weather Protection
Rigid Fiberglass	Microlok 650	3.0	1"	needs PVC or metal jacket
Elastomer	Armaflex Rubstax	3.5	3/4"	needs latex paint or PVC or metal jacket
Polyethylene (closed cell)	Zipcote Imcoaflex	4.1	3/4"	needs latex paint or PVC or metal jacket
Urethane	Solar 7 Insultec	7.0	1"	comes with PVC Jacket

Elastomers.

Elastomer insulation comes without slits and should be put on the pipes as the plumbing is done. Cut the insulation tube slightly longer than the pipe to be insulated. Slide onto the pipe and join by butting, Use vise-grips to hold back the insulation while soldering. Use the manufacturer's recommended adhesive to seal the joints. Elastomer insulations will have to be double-layered to get the recommended R4 insulation values. When layering the insulation is sure to stagger the points. Elastomer will deteriorate rapidly when exposed to weather or soil. They must be protected. If paint is used it should not be oil base and it should be reapplied every 35 years.

Fiberglass, Urethane and Isocyanurate.

These types of insulation can be bought in preformed halves. They must be protected from the weather by a watertight PVC or metallic jacket. The slits in the jacket should be positioned on the downward side of the pipes and taped over with water-proof, weather-resistant tape. Pressure test the plumbing before insulating.

Insulating Storage Tanks

The water heater tanks should be insulated to at least R11. Check manufacturer literature to see if the tank is already insulated to this level. If not, it is necessary to add an insulating jacket. R11 fiberglass batts, wrapped around the tank and secured with duct tape, work well. Many Oregon utilities provide free water heater wrap services.

OPERATION AND MAINTENANCE

Batch collectors store a large quantity of solar heated water in the collector itself. Performance of the batch system is improved if hot water is used during or at the end of the day. Morning hot water usage is the worst situation; much of the solar heat is lost during the night.

The entire solar hot water system should be inspected at least once a year. If a thermometer has been installed to record solar collector output temperatures, periodic checks are suggested. If temperatures seem low, inspection of the system is advised.

Collectors

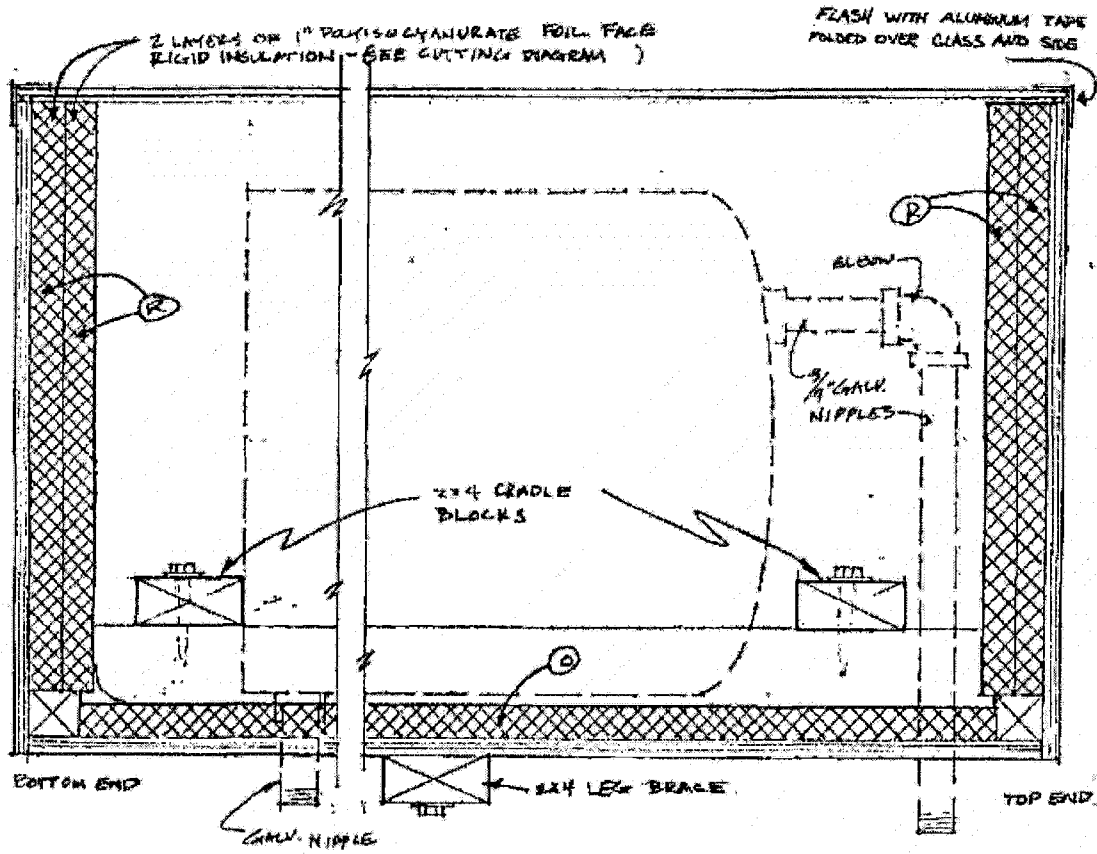
The glazing of the collector panels should be cleansed regularly. All exposed wood surfaces should be inspected and repainted or repaired as needed.

Plumbing

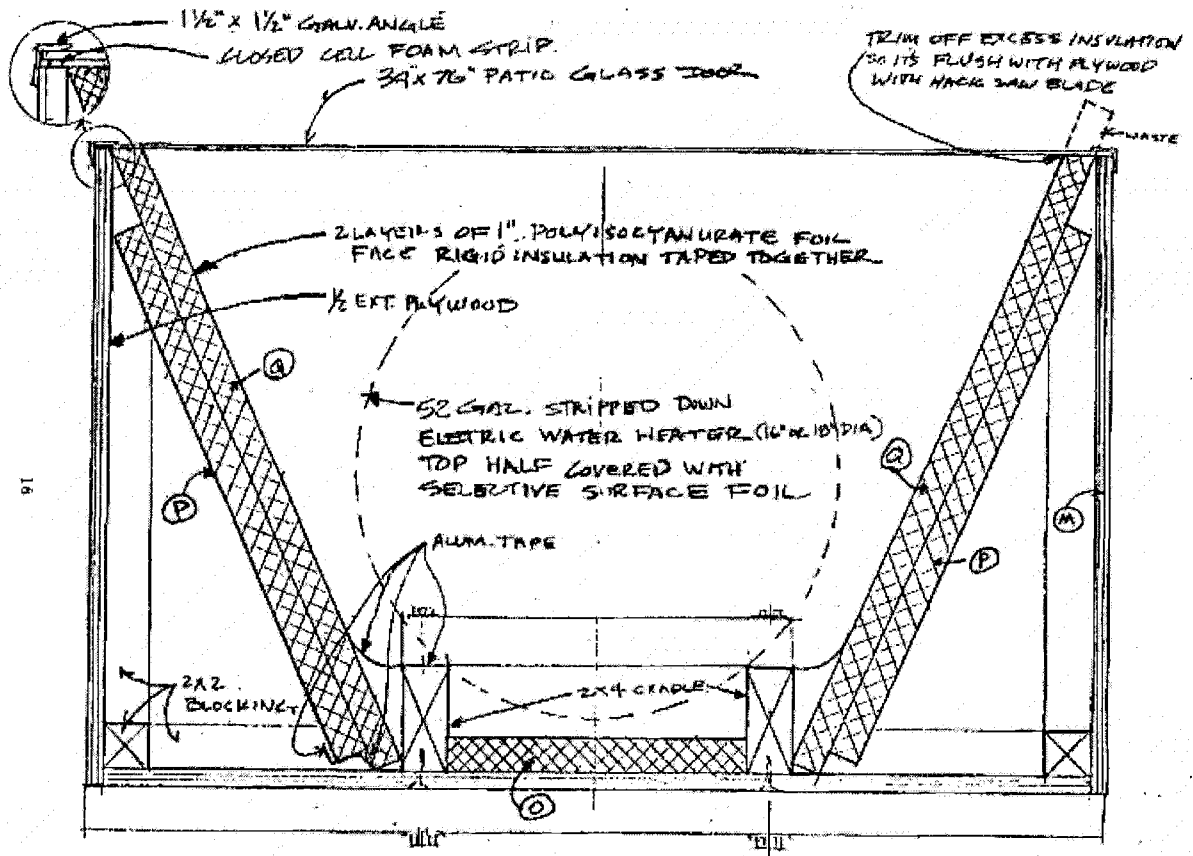
Check for leaks around valves and fittings. Check pipe insulation to make sure it is tight and has not deteriorated.

Tanks

Drain and flush tanks once a year. Check tank insulation for tight fit.



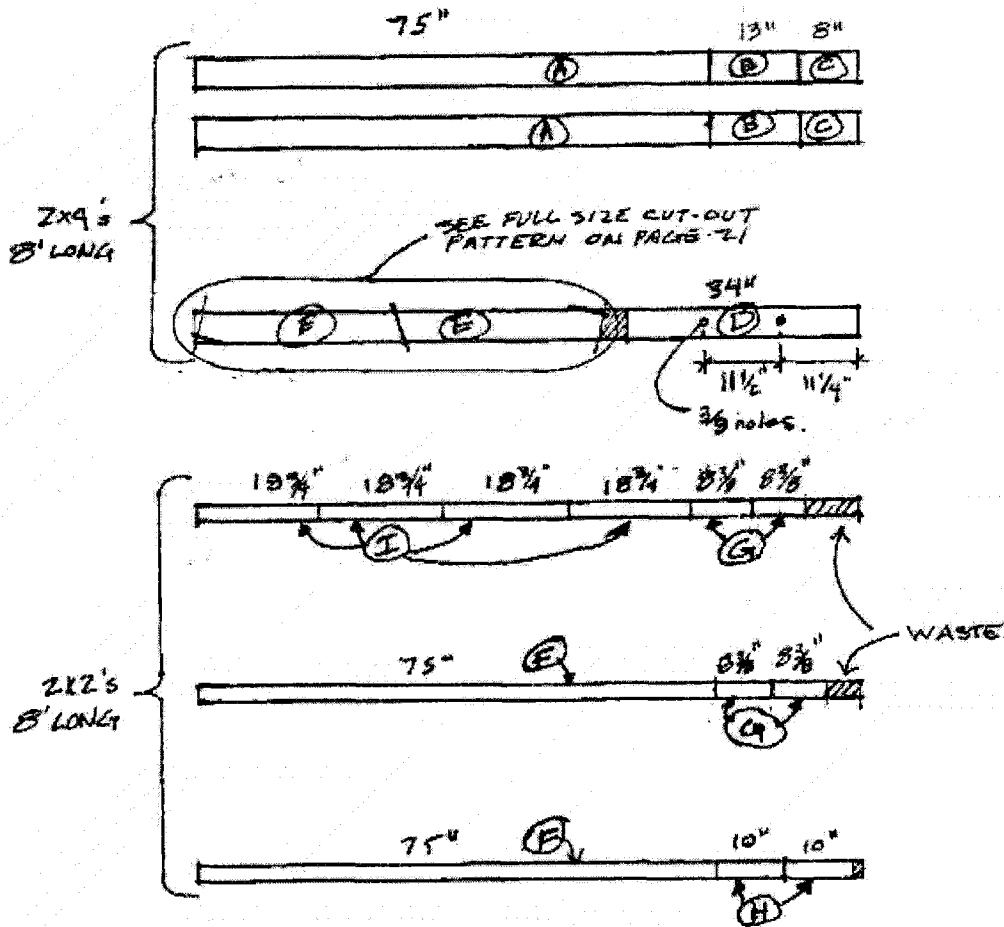
SECTION 3" = 1'0"

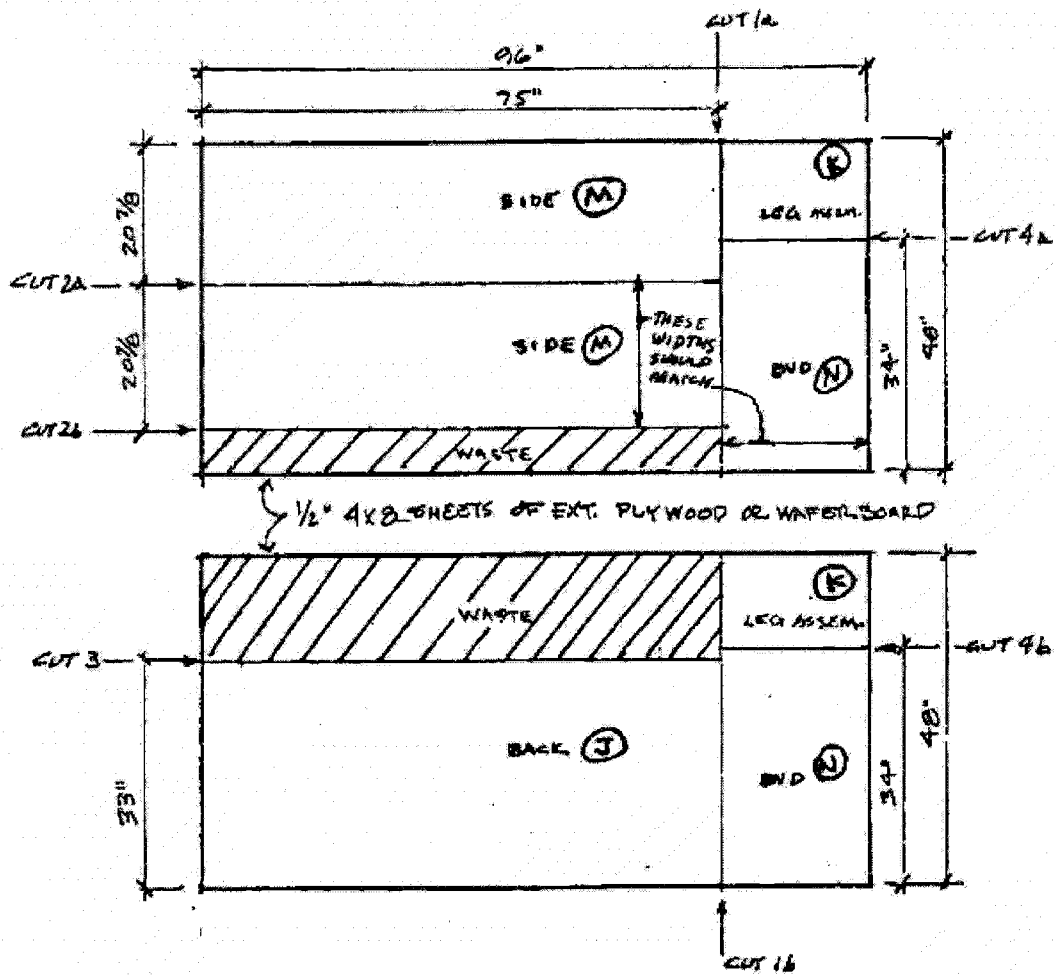


SECTION 3" = 1'0"

MATERIAL CUTTING DIAGRAMS

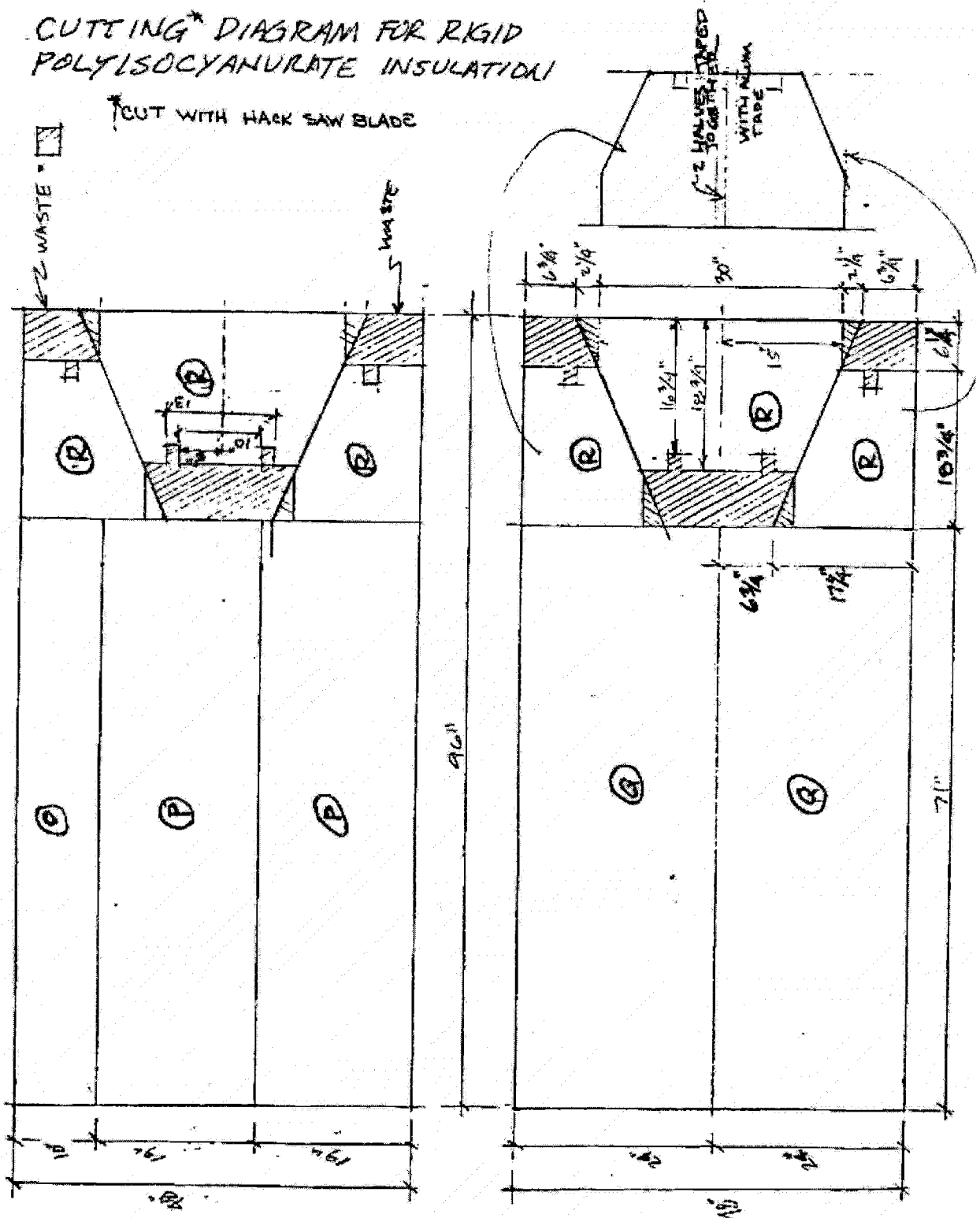
USE THE DIAGRAMS ON THE FOLLOWING PAGES AS REFERENCE WHEN CUTTING AND ASSEMBLING WOOD AND INSULATION MATERIALS.





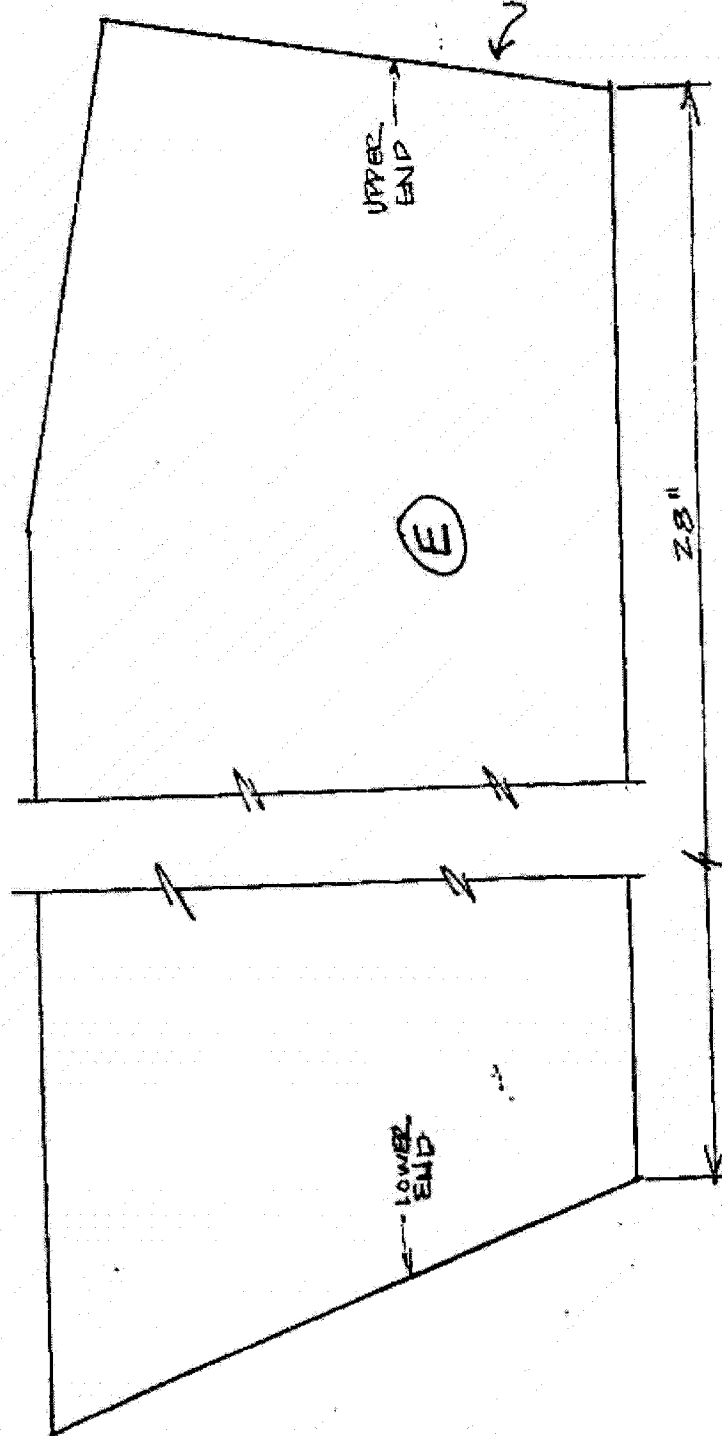
CUTTING PLYWOOD SHEETS - LUMBER YARDS WILL OFTEN CUT SHEET MATERIAL FOR LITTLE OR NO COST - A CONVENIENCE WORTH CONSIDERING.

CUTTING* DIAGRAM FOR RIGID
POLYISOCYANURATE INSULATION



FULL SIZE CUT-OUT PATTERN FOR
2x4 LEGS

THIS EDGE FITS INTO JOINT
HANGER ON LEG BRACE



MATERIAL LIST FOR ONE BATCH COLLECTOR

- 3, 2 x 2's 8' long.
- 2, 2 x 4's, 8' long
- 2 sheets, 1/2" Exterior plywood or 7/16" wafer board 4'x 8'
(Recommend cutting it according to cutting diagram at place of purchase)
- 2 sheets, 1" Foil Laced rigid polyisocyanurate insulation ("Thermax") 4'x 8'
- 4 (min), 12"x 12"x 2" Concrete paving slabs (sloped sites require more)
- 1, 34"x 76" Tempered patio door glass (Used or seconds are OK and cheaper)
- 1 roll, Aluminum duct board tape (widths between 2" and 4" OK)
- 20', 3/8"x3/16" Self stick closed cell foam weatherstrip tape (17' rolls)
- 10, 1 1/2"x 1 1/2" Galvanized corner angles.
- 2, Joist hangers for 2 x 4's 6, 3" x 3/8" Lag screws with washers
- 1 box (100), 1 1/4" #8 or #10 Zinc plated hex head sheet metal screws
- 1 box 1/4" staples
- 1 roll, Plumbers Tape (perforated galvanized metal strapping)
- 1 gallon, Water repellent wood stain (enough for two collectors)
- 1 tube, Paintable caulk
- 1 can, Flat black high temperature stove paint
- 1 New or used water heater (52 gallon preferred 16" or 18" diameter)
- Selective surface (enough to cover front half of tank, about 2'x 5')
- Plumbing fittings, 3, 3/4" galv. pipe nipples 5", 6" and 14; 3
- 3/4" galv. male plugs (nipples and plugs may vary depending on tank)
- 3/4" galv. elbow;
- 3/4" hose bib; roll of teflon plumbing tape

TOOLS LIST

- Hack saw
- Utility knife
- Screw drivers
- Tin snips
- Tape measure
- Caulking gun
- Hammer
- Shovel
- Paint brush

- 3" 'C' clamps
- Scissors
- Surform
- Magnetic compass
- Hand staple gun
- Pliers
- Sandpaper
- Saw (circular preferred)
- Variable speed elec. drill
- Drill bits 3/16", 3/8", and 1 1/8"
- Screw bit for electric drill
- Pipe clamp over 40" (not mandatory)
- Level (24" or over)
- Extension cord
- Garden Hose (for tank testing)

Selective Black Foil Products

Product	Availability	Width	Cost per Sq. Ft.	Absorptance (100% = Ideal)	Emittance (0%=Ideal)
Sunsponge	Berry Solar Products 2850 Woodbridge Ave. Edison, NJ 08837 (201) 549-0700	24"	\$2.20, 25 sqft min.	0.95	0.10
Maxorb	Novamet 681 Lawlins Rd. Wyckoff, NJ 07481 (201) 891-7976	6"	\$2.00	0.97	0.10
Solar-L-Foil	Solar Components Corp Box 237 Manchester,	24"	10 ft roll=\$2.50/sqft 25 ft roll=\$2.40/sqft	0.95	0.11

	NH 03105 (603) 668-8136				
ECP-2000	Energy Controls Products 3M Branch Sales Ctr. 3130 Lexington Ave S. Egan, MN 55121 (612) 733-5024	12"	100 ft roll=\$0.80/sqft	0.94	0.20

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