

THE CRYSTAL CITY SOLAR COLLECTOR

a community-based approach to
solar utilities



Crystal City, Texas
in collaboration with the
Center for Maximum Potential Building Systems
8604 FM Road 969, Austin, Texas 78724 • 512-928-4786

Fisk, 1975

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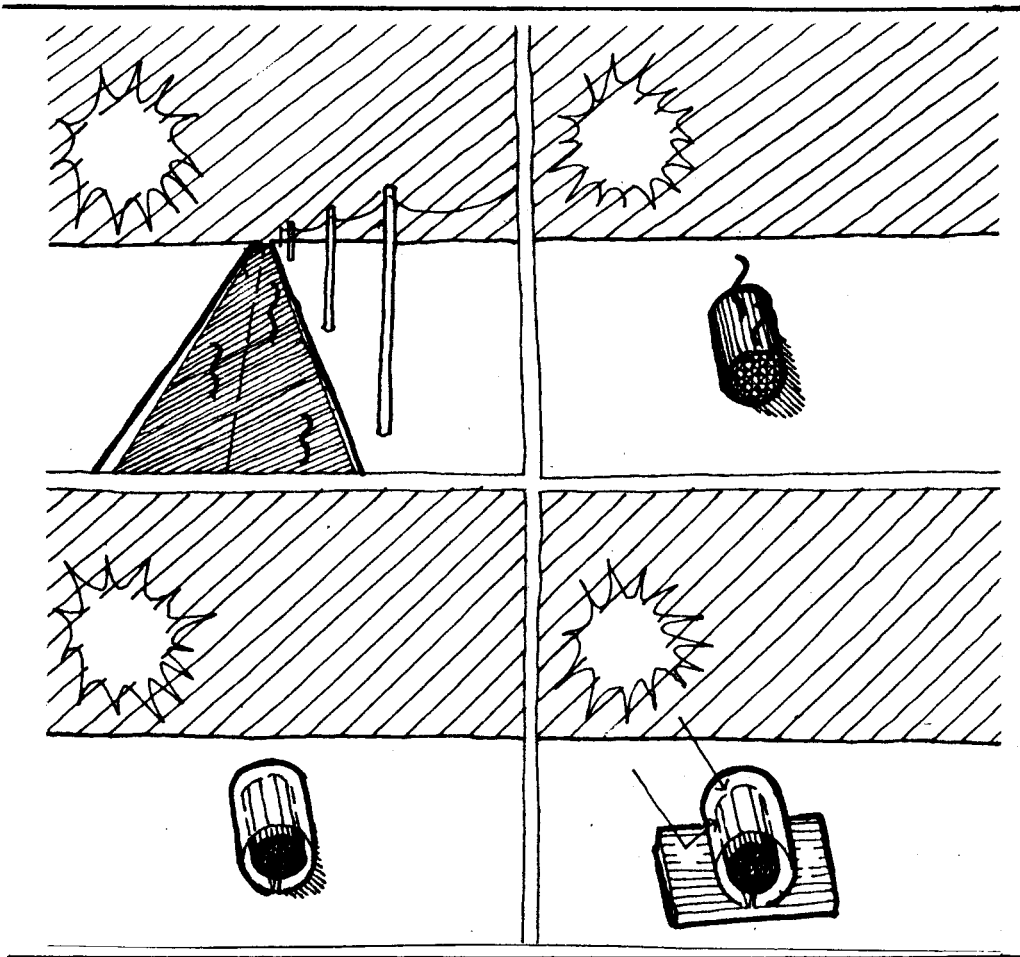
How much hot water is given : how much needed?

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What you already have is all you might get.

INTRODUCTION

What does solar energy mean to your town?

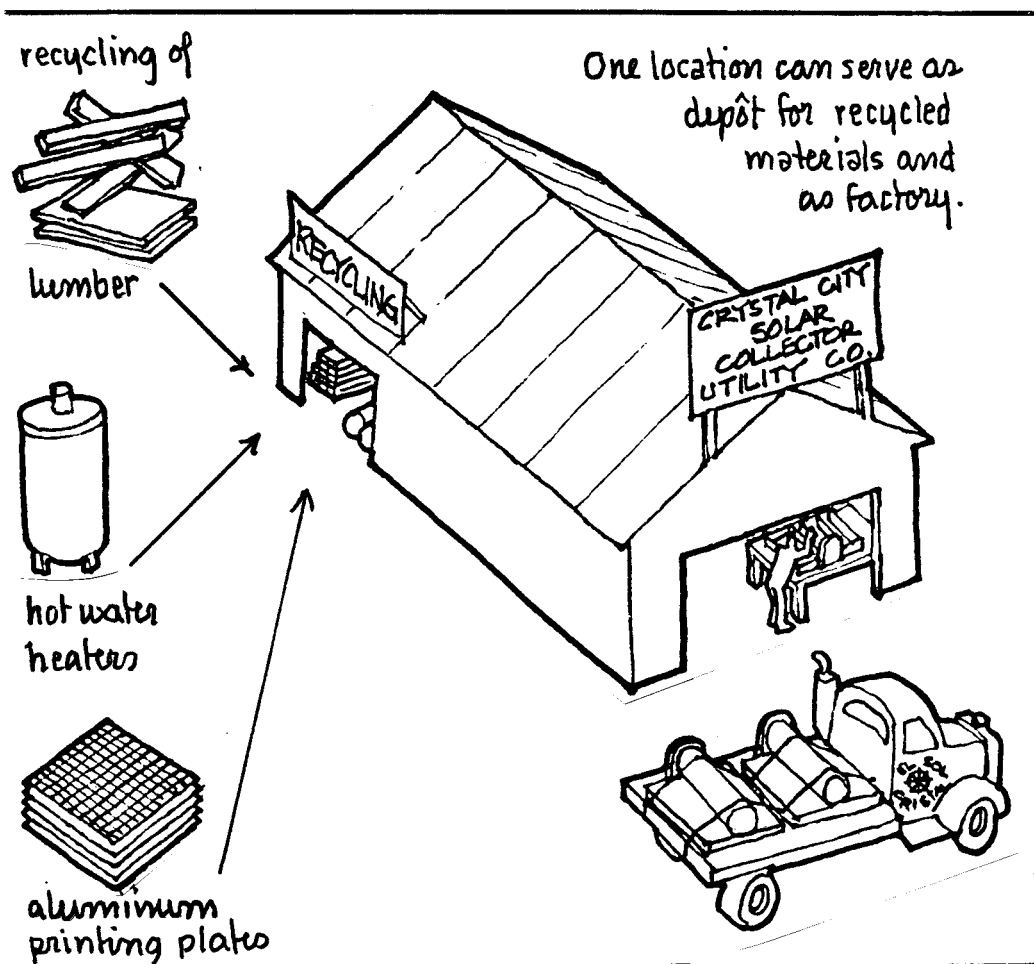


This pamphlet describes the technology for constructing a simple solar hot water heater, and it also shows how to organize a community to obtain hot water from the sun. A solar hot water heater is a household appliance that works in a similar way as a number of familiar things in nature around us. If you look carefully at a dark road surface on a hot, sunny day, for example, you will see heat waves rising off the road. This happens because the

road has turned the sun's light into heat that we can see as waves or a mirage in the air above the road. The same thing happens with a hot water tank painted black. If you place glass over the road or tank, you keep the heat waves from escaping. Since the heat is trapped, the temperature builds up further than if the glass were not used; and the tank gets hotter and hotter as the sun continues to shine through the glass. When water is placed in such a tank,

it remains hot even after the sun goes down because the water is able to store the heat. This idea was first used in the early 1800's well before the first gasoline engine was invented, and the idea is used in various parts of the world for such applications as hot water heaters and food dryers since that time.

The introduction of solar energy to the city and its citizens is important to your own development of permanent



energy sources. Several distinct advantages can come from thinking of the solar collector project as a municipal utility. The city will not be dependent on a gas distributor or an electric co-op for its energy. Since the sun is the energy source, the local citizenry will have control of their solar utility; and they will receive the revenue from the production and installation of collectors. The cost of the solar hot water heaters to those who receive

them will be much less than an equivalent amount of gas or electric equipment, and the money purchasing the collectors can support the construction of more solar collectors for neighbors' homes.

The grant supporting the collector project may be seen as the federal government's gift which ends with the construction and installation of 120 solar water heaters, or it may be seen as a starting point in the city's

organization of a sustainable energy future. The solar collector project is an opportunity to keep money, jobs, and energy resources in the local community where they will most benefit its citizens. By investing money and effort in one's own community instead of a company whose owners live far away, a stronger and more stable life-style can be developed. In a few years, other towns in the United States will be faced with problems similar

to those that you are in the process of solving now. This solar collector program is a small beginning and is unable to address all energy needs. What is important to realize, however, is that community-based approaches like this project can lead to the development of other renewable resource utilities, such as methane gas from sewage, electricity from wind, and fuel alcohol from grain.

The collector factory presented in the next section is designed so that it can be managed by local people and is organized so that skills and jobs can be rotated. In that way, more and more people can learn how the solar collector works and how to construct and install one. Then they will be able to communicate this process to friends and neighbors in the community.

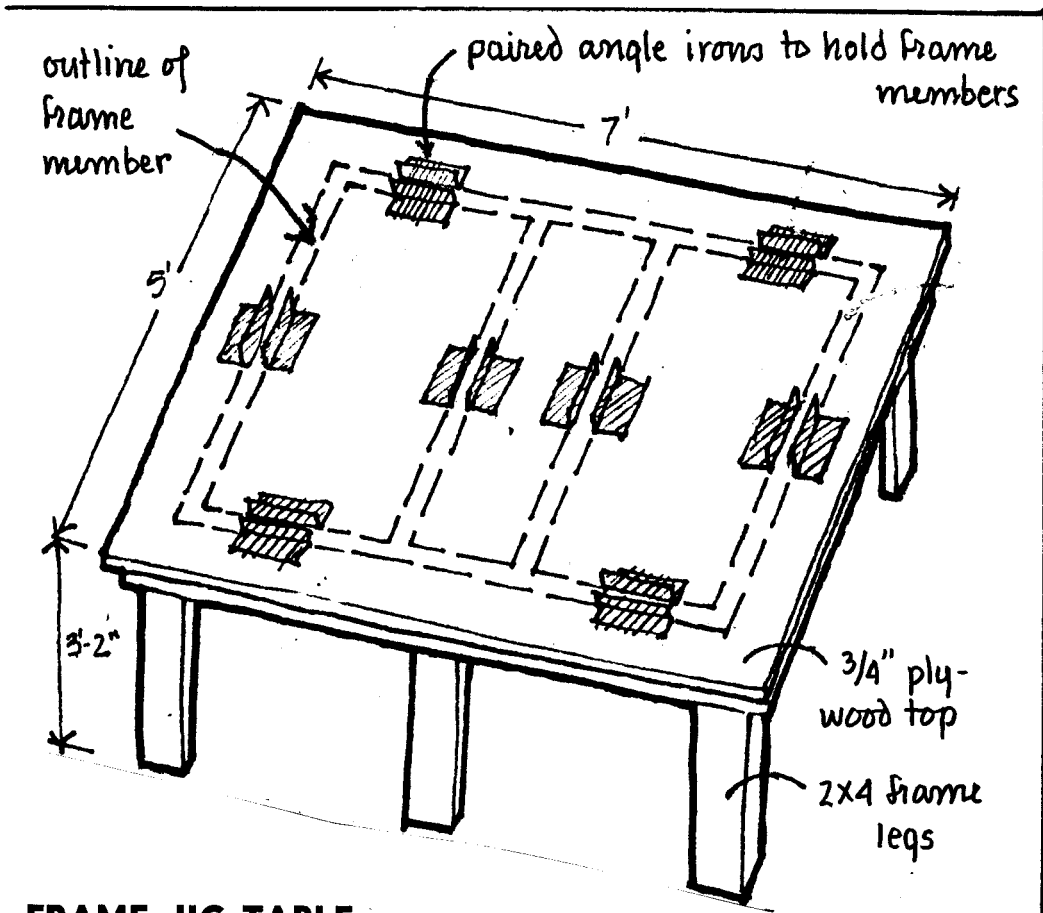
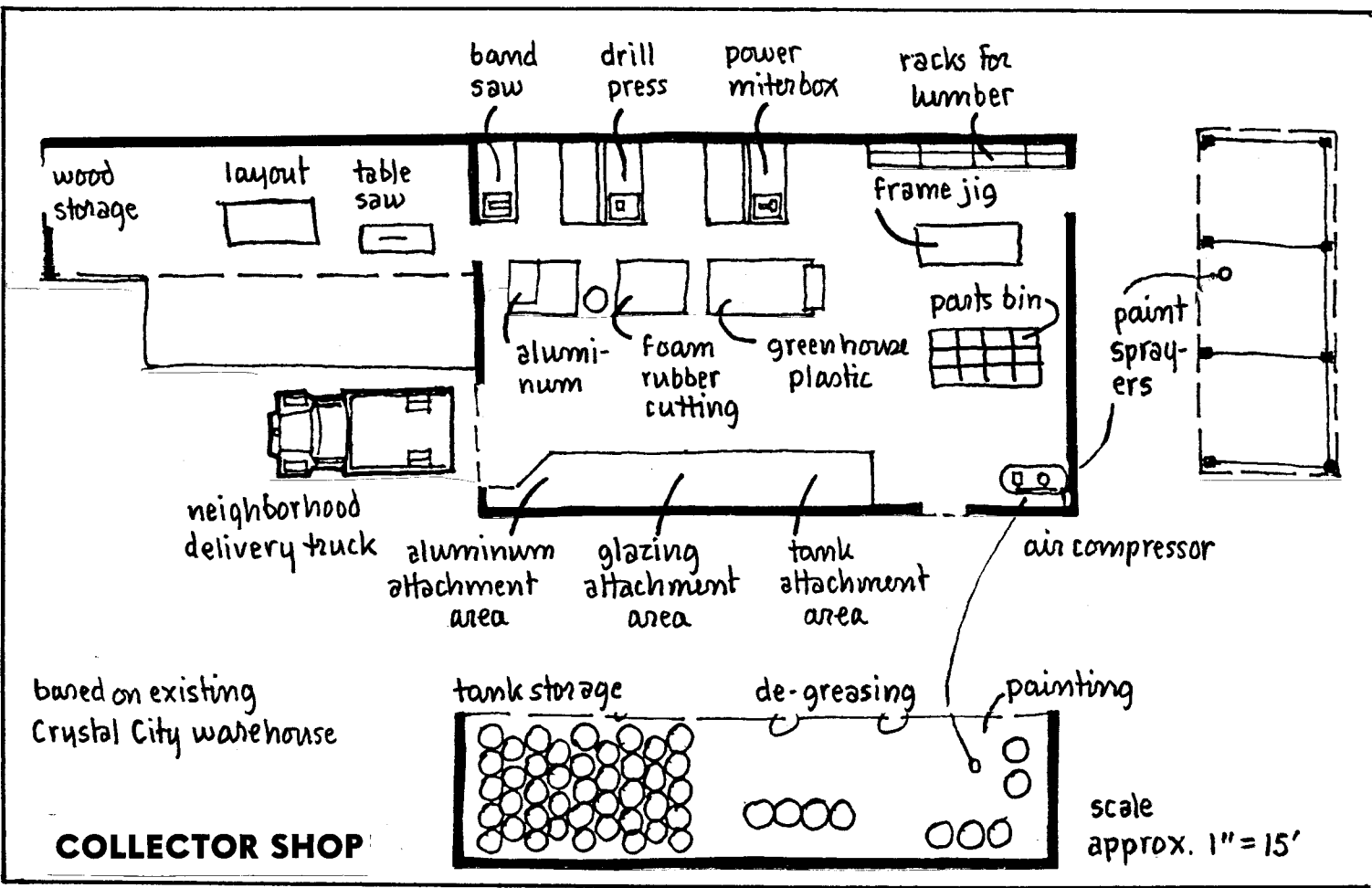
The Chicano culture has a rich tradition of

working together to exchange skills and resources for mutual benefit. The collector project continues this heritage through a process of developing resources that will build community in a humane and lasting way, a way respectful of the natural processes around us. Finally, the project as an effort in working together may serve as a means of survival in difficult economic times ahead.

Solar collectors could be your own utility.

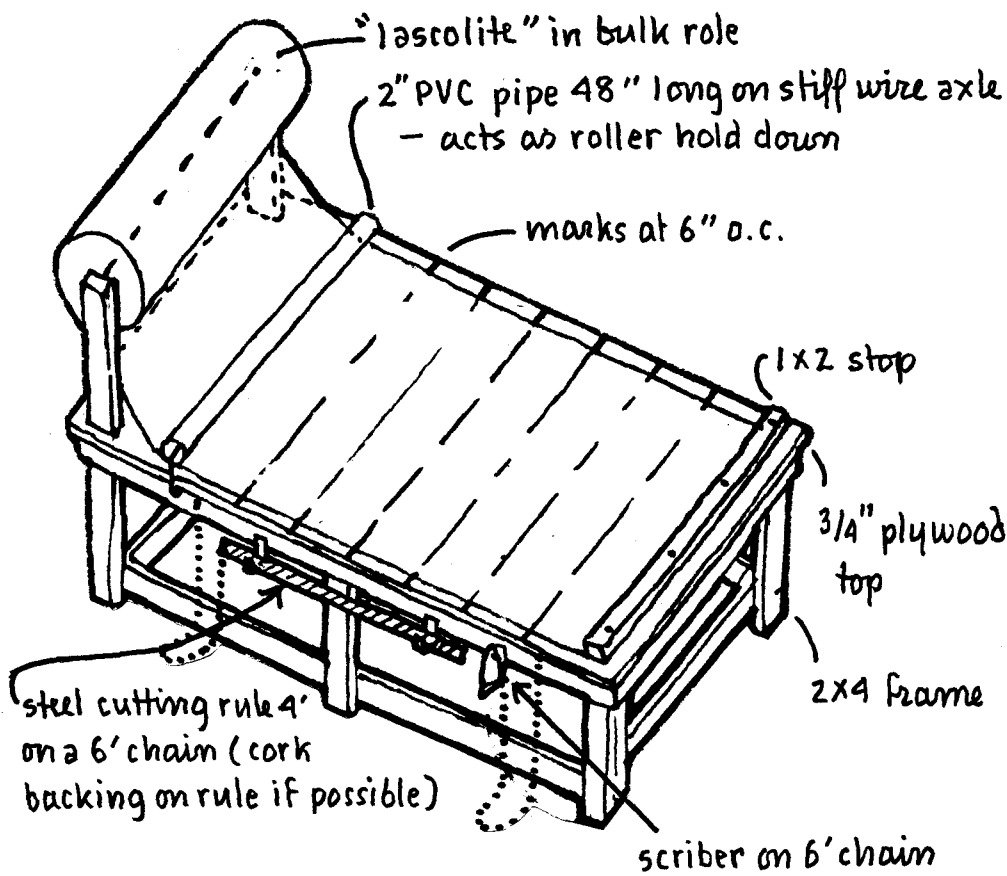
A building already owned by the city has been converted into a small solar collector factory with a capability of producing about four or five collectors a day. The facility is designed for an assembly process using different skills such as carpentry, sheet metal working, plumbing, and painting. Different task areas have been color coded, and a task list has been compiled so that each job can be understood in relation to the tasks before and after it. This

list is given at the end of this chapter. The equipment required has been selected from readily available shop machinery whose cost totals about \$ 2500, excluding the cost of the building. The building size is approximately 2400 square feet. This is a good size for adequate job safety and efficiency.



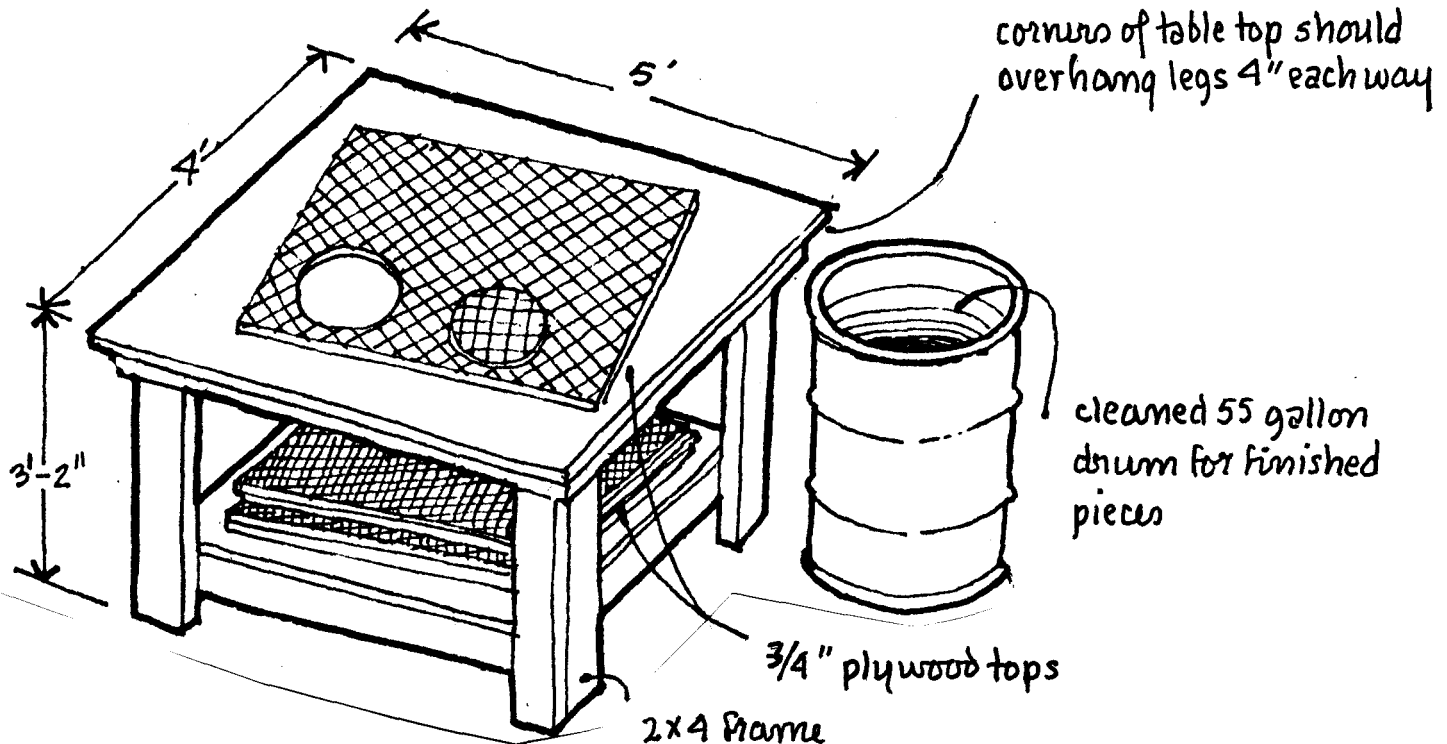
FRAME JIG TABLE

Various jig tables and cutting surfaces have been designed with the Crystal City collector in mind. They are made to enable maximum production in minimum time and are sized so that labor efficiency and tasks per worker are coordinated. A task-time chart based on actual production experience is available.

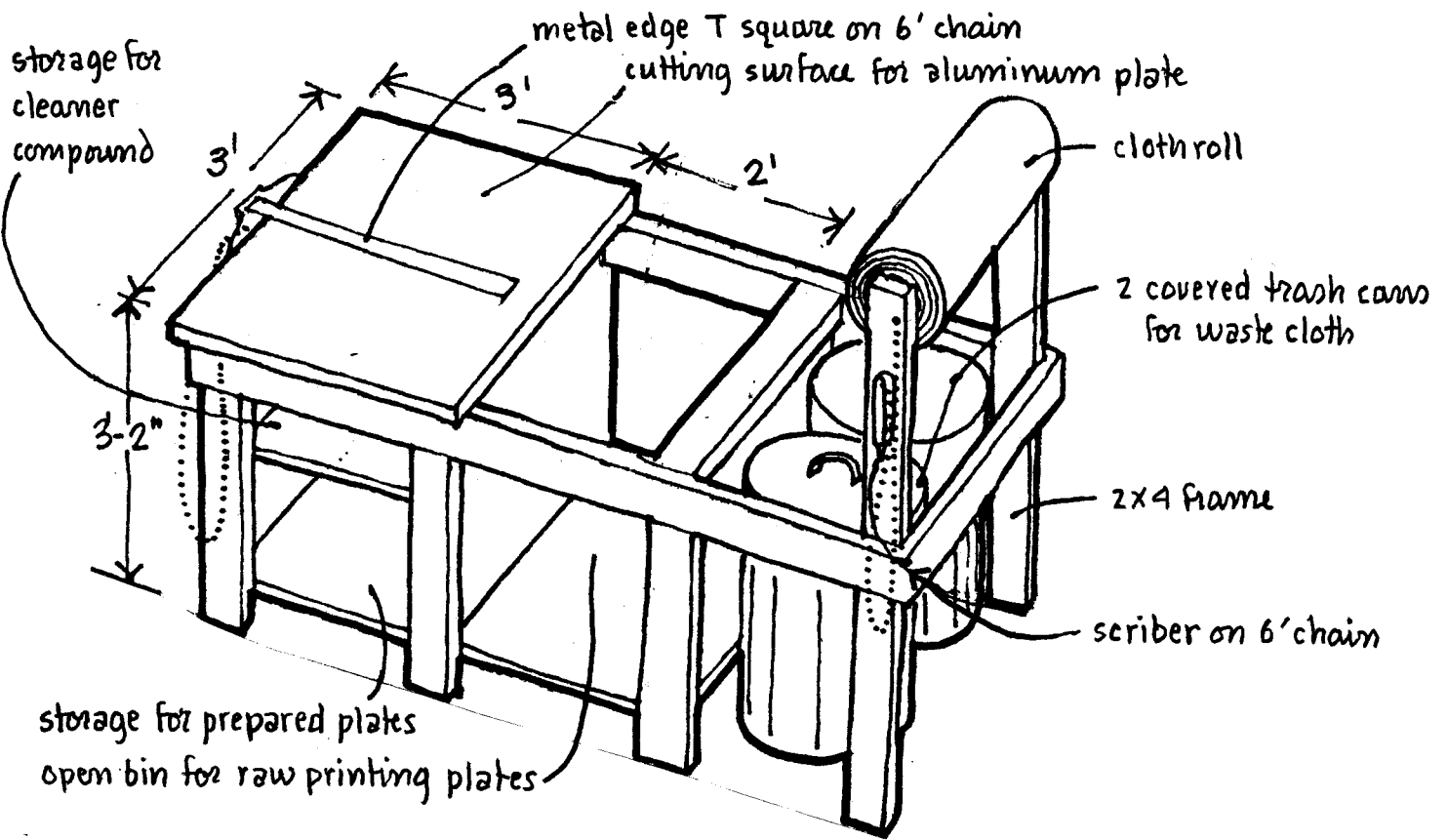


PLASTIC CUTTING TABLE

The factory warehouse area also serves as a recycling station for used lumber, plywood, discarded hot water heater tanks, and aluminum printing plates. All these materials are used in the production of the solar collector frame and hot water tank. The aluminum printing plates from an area newspaper printer are used for the reflector panels on the collector.



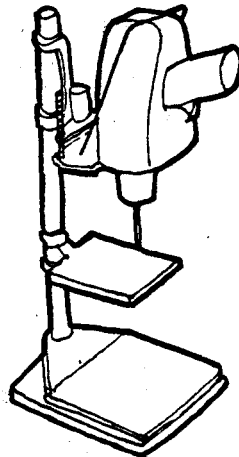
FOAM RUBBER INSULATION CUTTING TABLE



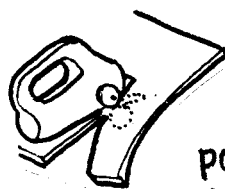
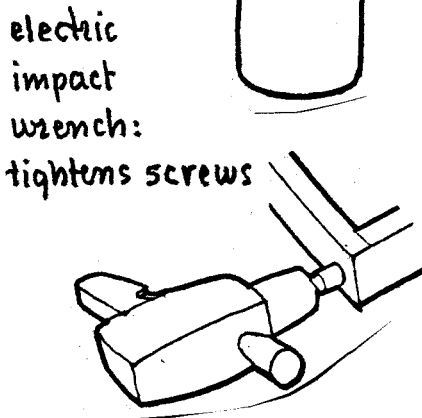
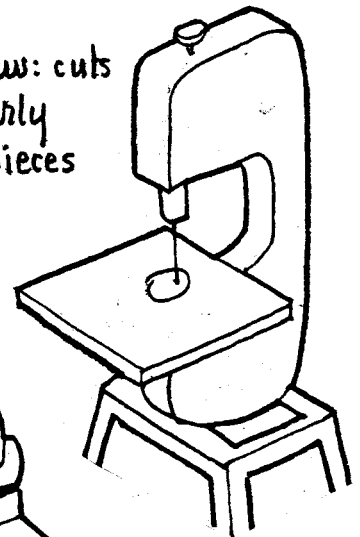
ALUMINUM REFLECTOR CUTTING TABLE



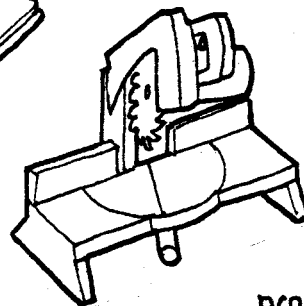
hand drill press: cuts pipe and screw holes in plywood and screw holes in 2x lumber



band saw: cuts irregularly shaped pieces of wood



power sheet cutter: cuts sheet aluminum, foam rubber, plastic glazing, etc.

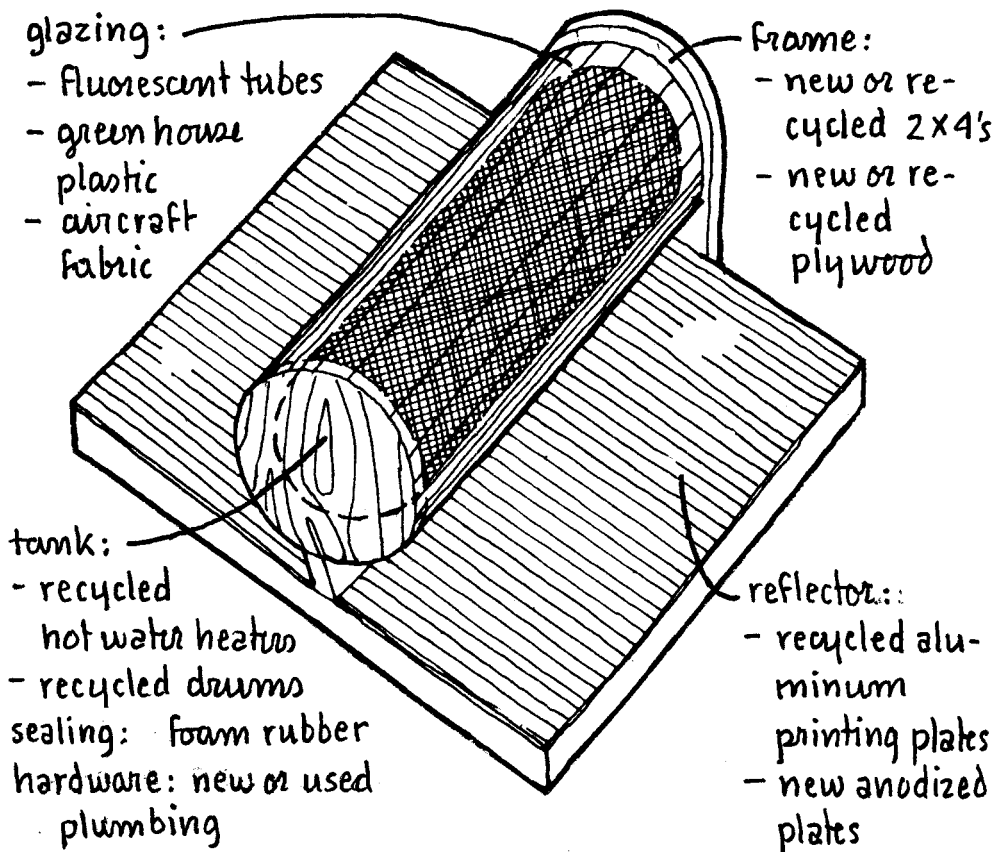


power miter box: cuts accurate ends of lumber, plastic pipe, trim, etc.

TOOLS FOR C. C. C. SHOP

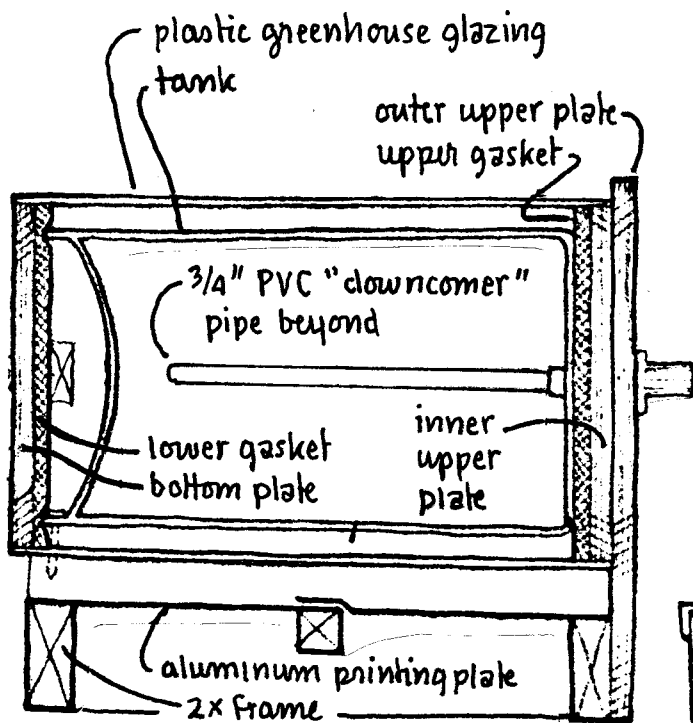
FABRICATION

Four collectors a day built at a cost of \$ 2500.

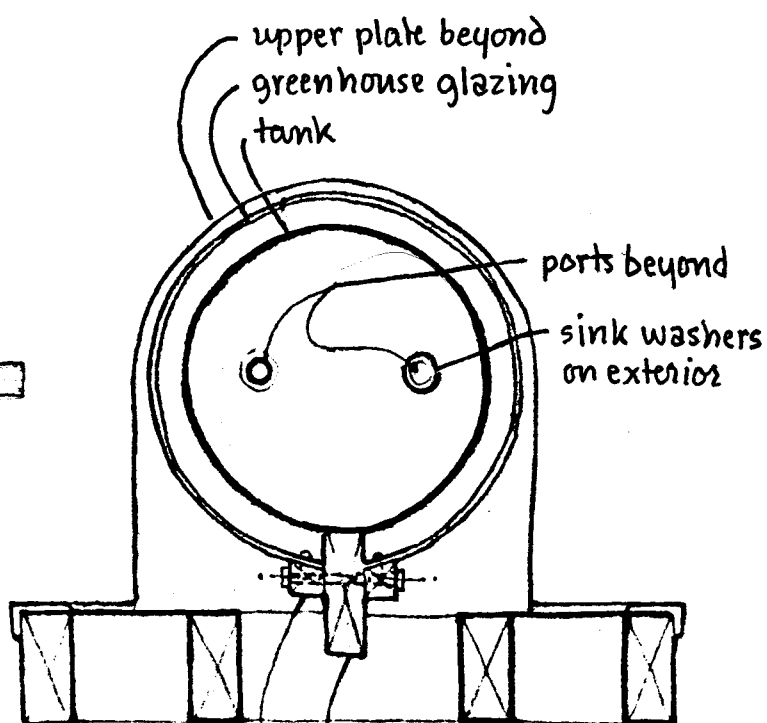


COLLECTOR MATERIALS OPTIONS

This collector is a batch type passive solar hot water heater developed by The Center for Maximum Potential Building Systems. It differs from a flat plate solar collector in that it has no separate storage tank: the tank itself is the solar collecting area. In this way the system is less difficult to build and costs less, while supplying an amount of hot water equal to collectors with separate tanks.



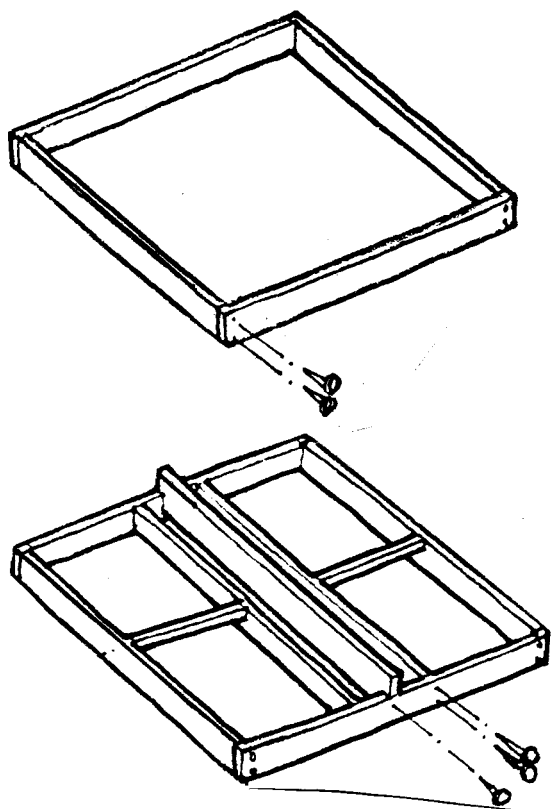
longitudinal



transverse

2x6 center rail
2x2 glazing ships

COLLECTOR SECTIONS - PLASTIC "GREENHOUSE" GLAZING

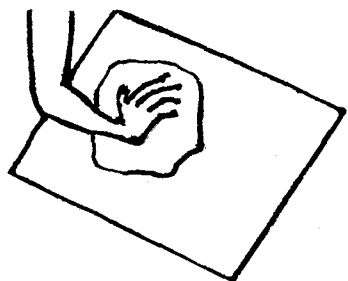


CONSTRUCTION SEQUENCE

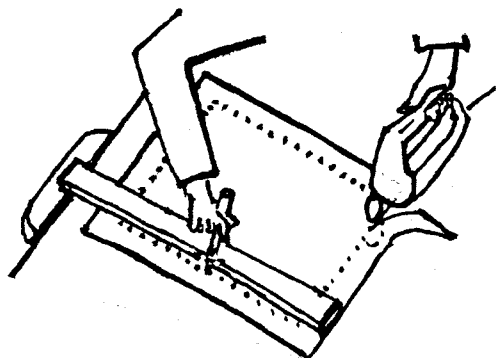
1. affix outer side rails to top and bottom rails using lag screws or 16d nails and glue.

2. affix inner side rails and center rail with lag screws, attach 2x2 joint supports for reflectors with nails.

The fabrication sequence is straightforward and has been grasped by some construction crews in only a few hours. A frame is constructed out of 2x4's. This frame acts as a weight distributor of the water tank on the roof surface and as a morning and afternoon reflector for sun light onto the collector tank. The second major component is the tank attached to the frame. This is done primarily by a plywood end plate attached to the top of the frame. The normal pipe connections attach the tank to this plate and

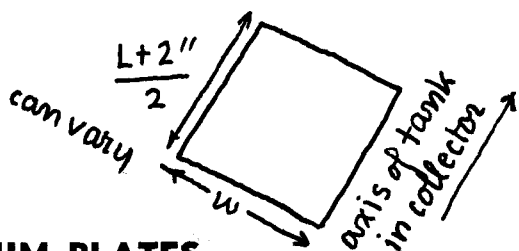


1. clean off ink and dirt from good side of printing plate, using turpentine, kerosine, white gas or ink solvent.



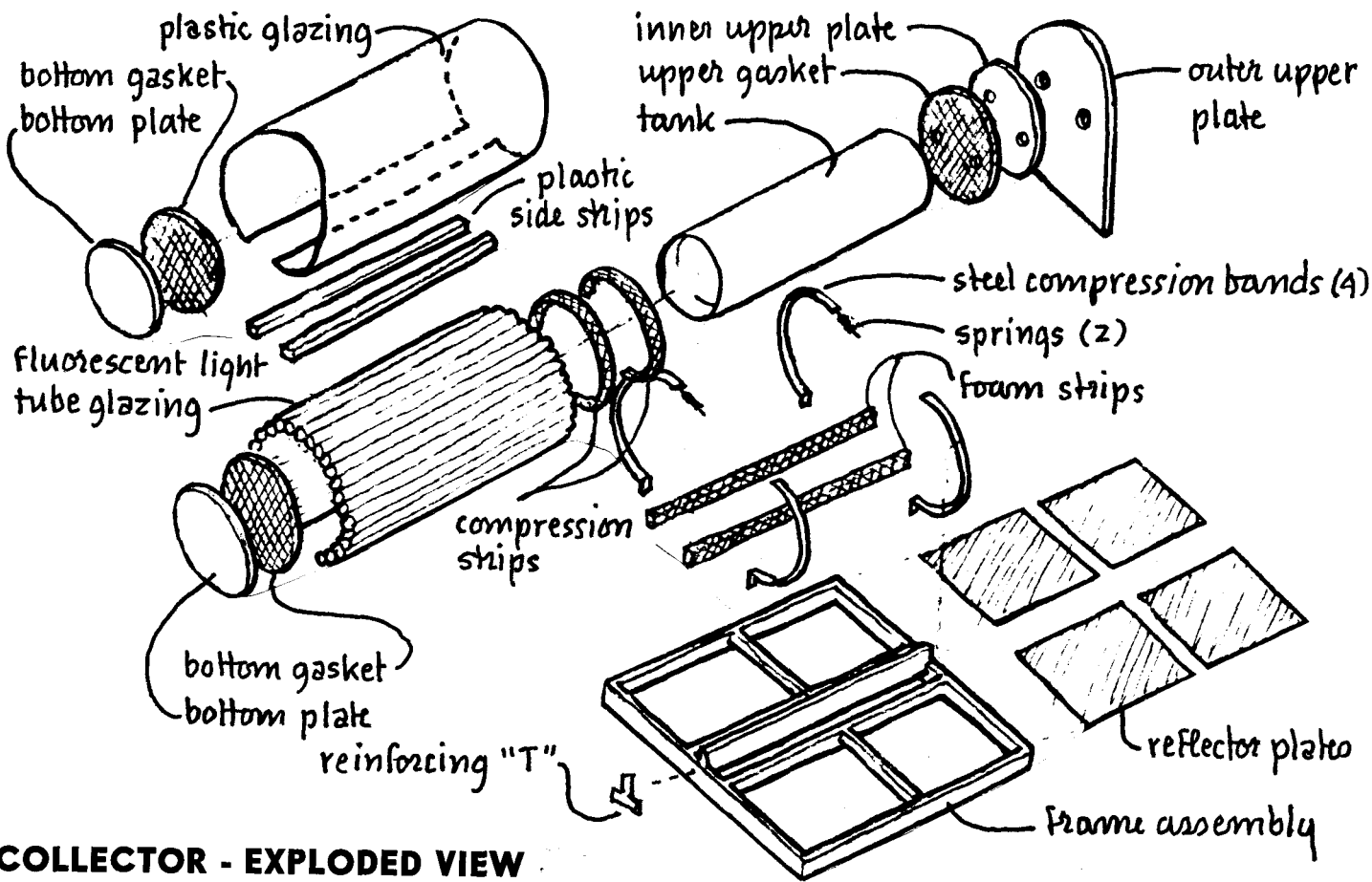
2. mark plate to size and square using pen and metal straight edge. cut with special tool.

3. reflector dimensions (4)

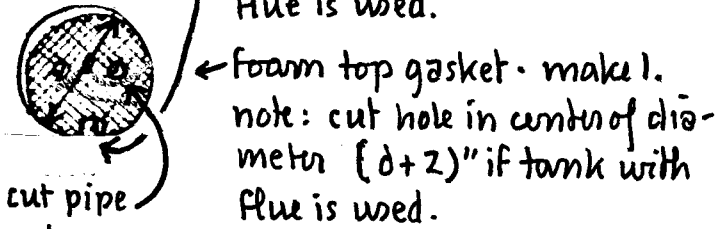
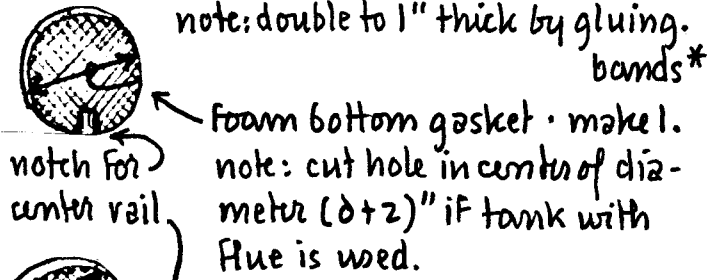
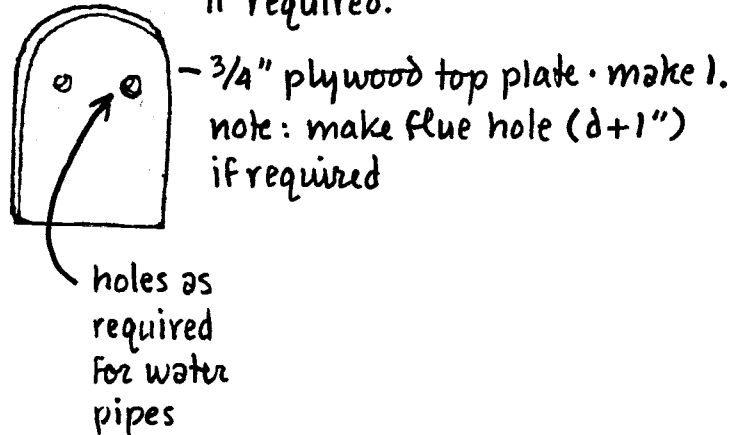
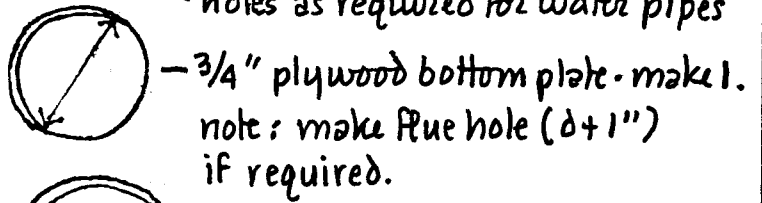
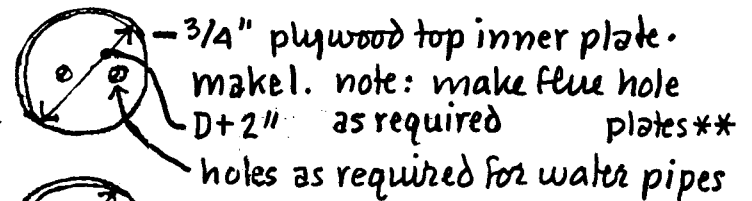
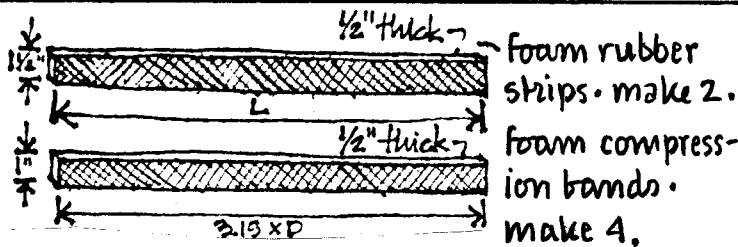


RECYCLING OF ALUMINUM PLATES

at the same time serve as hot and cold water pipes, like a gas or electric water heaters. The opposite end or bottom of the tank is held to a 2x6 by a simple "S" hook connection. The tank therefore stays supported on its center rail in a structurally stable way.



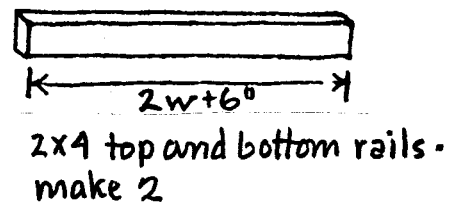
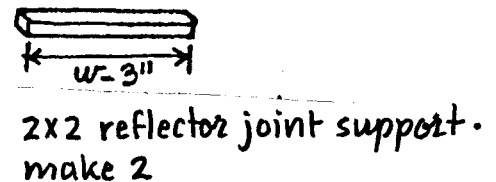
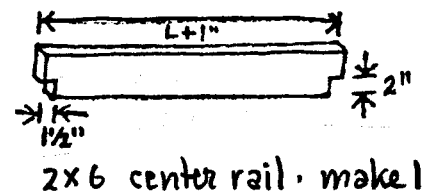
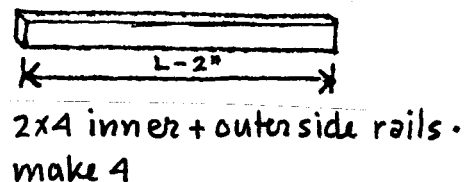
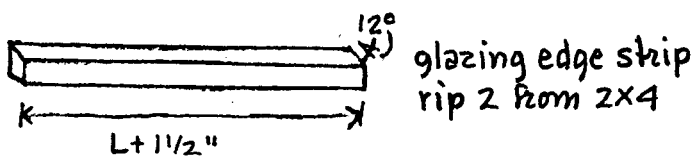
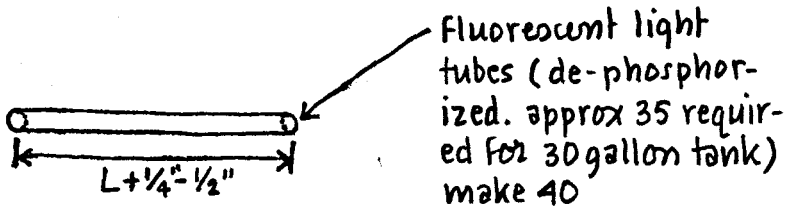
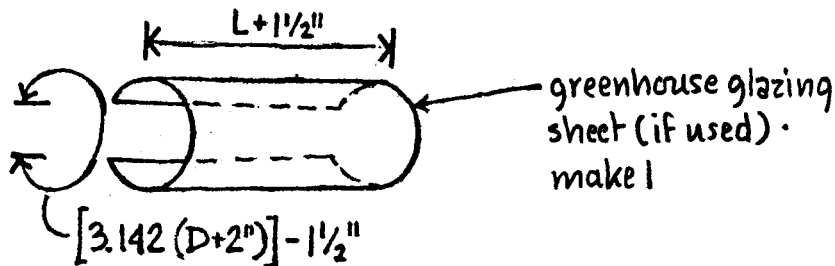
COLLECTOR - EXPLODED VIEW



* used with fluorescent tube glazing

** used with greenhouse plastic glazing

FOAM RUBBER AND PLYWOOD COMPONENTS



GLAZING AND BOARD LUMBER COMPONENTS

- 2 couplers
 - 2 sink washers
 - 2 3/4" nipples 2 1/2" long
- "down-come" plastic pipe attached to inlet nipple

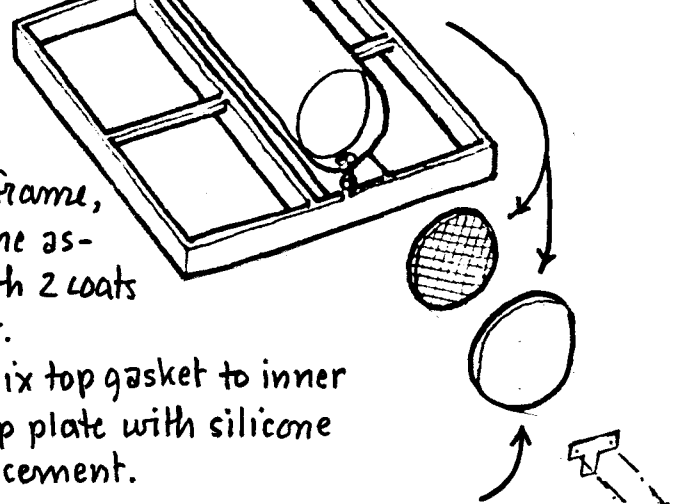
3. affix top inner plate and attach assembly to frame, paint frame assembly with 2 coats of paint.

5. bore 5/16" hole in bottom rim of tank at 90° to axis of inlet / outlet holes. affix nipples to tank with teflon tape affix tank to frame with pipe couplers and washers. draw tight. lag screw tank to center rail.

CONSTRUCTION SEQUENCE

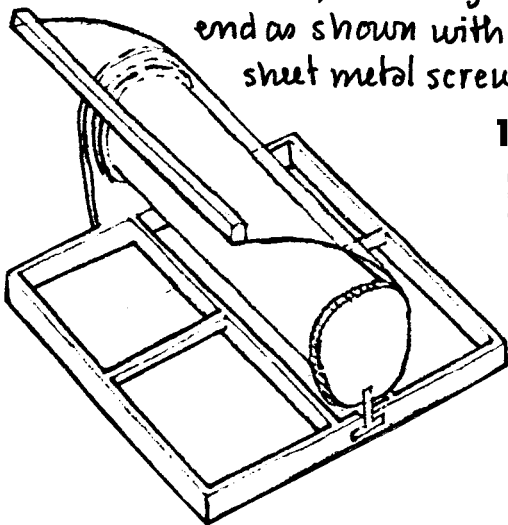
to center rail.

6. affix bottom gasket to bottom plate with RTV silicone cement.



7. center bottom plate on tank axis (plate should project 1" all around) affix plate to frame with a "T" connector.

8. cut plastic to size (length = $L+2"$, width = $3.142(D+2") - 1 1/2"$, attach glazing strips to each end as shown with silicon cement and sheet metal screws.

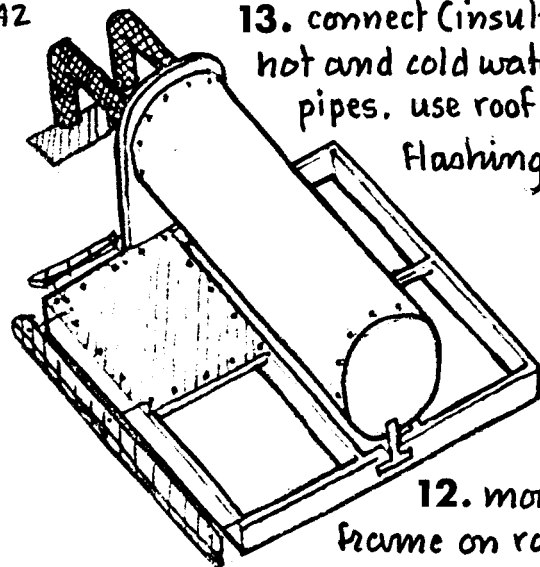


11. affix aluminum printing plates to frame with sheet metal screws. trim edges.

10. unscrew one side of glazing, run a bead of silicone cement around top and bottom plates. re-connect side of glazing to center rail with lag screws. screw glazing to top and bottom plates with sheet metal screws.

CONSTRUCTION - PLASTIC OPTION

13. connect (insulated) hot and cold water pipes. use roof flashing.



12. mount frame on roof.

9. using lag bolts, screw one 2x2 to side of center rail so that plastic is 1" from tank. wrap plastic around top and bottom plates. screw 2x2 to other side and bore holes radially in top and bottom plates for # 6 sheet metal screws at 4" o.c..

TASK LIST

This person-by-person task list goes through each step of small factory production. The list is keyed into the physical positions of the factory layout. This plan is tailored to the conditions of the Crystal City shop and should not be considered the only feasible plan. The basic process sequence, however, should be applicable to a 20-25 collector per week production line anywhere.

- Person 1.
- unloading new wood supplies
 - de-nailing old wood
 - wood stockpiling and inventory
 - helping person 2. mark and cut wood on a table saw.

- Person 2.
- measure plywood for plates
 - table saw cutting of basic dimensions
 - band saw final cutting of two top plates and one bottom plate

- Person 3.
- gluing top plywood plate to inner full circle plywood disk
 - clamping two top plates
 - using drill press to cut top two holes in glued plates.
 - cutting 2x4 and 2x6 members
 - cutting 2x2's
 - placing frame members on rack

- Person 4.
- placing wood frame members in jig
 - drilling holes for lag bolts
 - using heavy duty drill with socket end to screw lag bolts in
 - screwing 2x2 mid brace onto frame

- Person 5.
- taking frames to racks to prepare for painting
 - degreasing tanks
 - painting frames
 - painting tanks

e. delivering tanks and frames to fabrication areas when needed

Person 6. a. cutting and storing foam rubber insulation

b. cutting and storing plastic

c. cleaning aluminum

d. cutting and storing aluminum

Persons 7. a. placing and gluing insulation

and 8. b. placing and attaching tank

c. connecting plastic to frame

d. placing rubber weatherstrip

e. screwing on aluminum

f. nailing finishing nails and attaching plastic trim

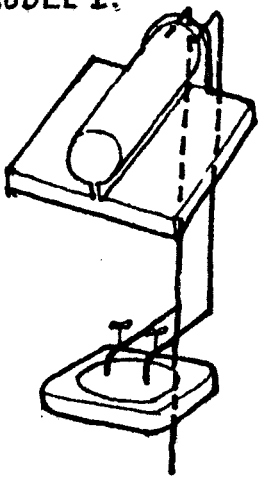
g. placing finished collector in storage

INSTALLATION

How much hot water is given: how much is needed?

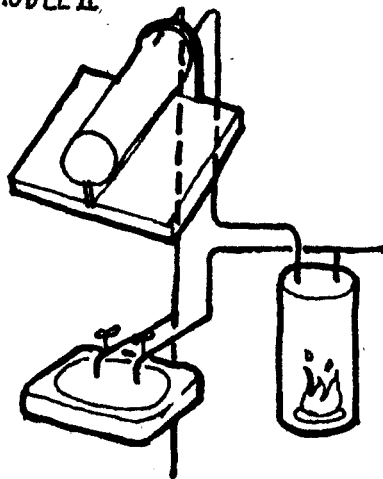
Three models under this grant are designed for three home situations: 1.) those homes with neither wood stoves nor hot water heaters, 2.) homes with a water heater for back up on cloudy days, and 3.) homes with a wood stove connected to an extra tank as back up on cloudy days.

MODEL I.



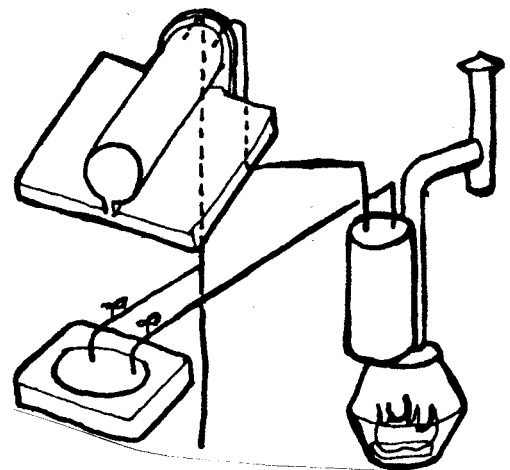
C.C. Collector used as the only hot water source

MODEL II.



C.C. collector used as pre-heat for conventional hot water heater

MODEL III.

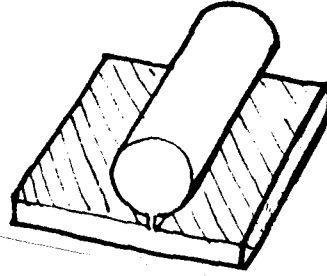


C.C. collector with wood heat exchange as back up

A useful approximation of hot water use is 15-30 gallons per person per day. A conservation-minded user may reduce this to 13 gallons per person per day or less.*



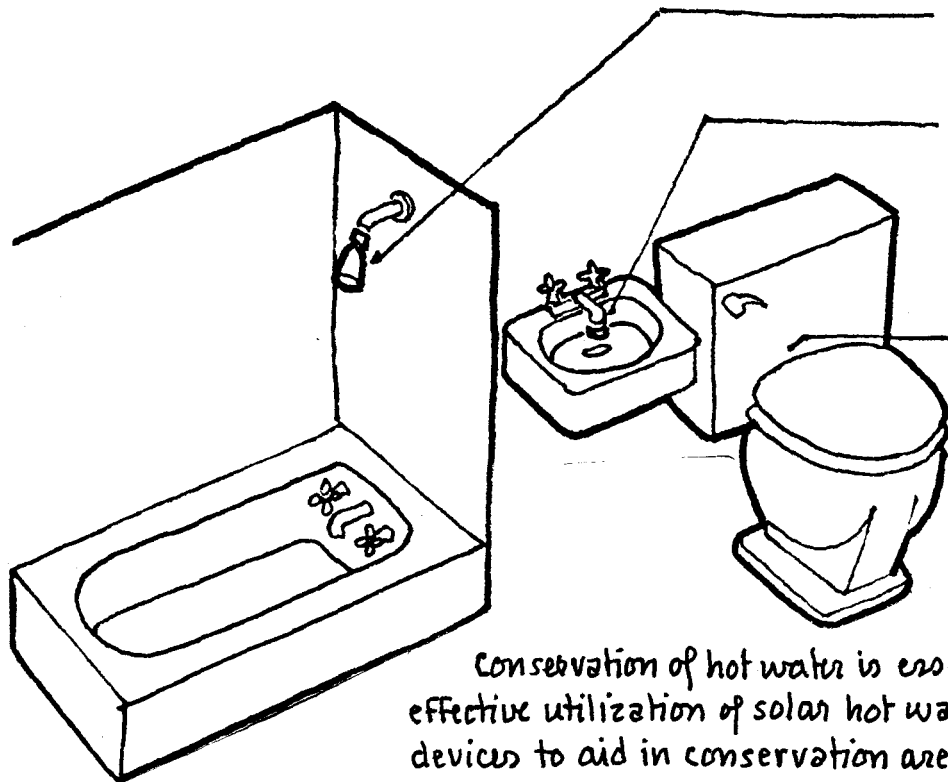
A Crystal City Collector can produce 1 1/2 to 1 2/3 times its 30 gallon capacity in 105° F hot water on a sunny day in the San Antonio area. This will decrease in colder climates or on days with less than full sun. Back up systems will have to come into operation, therefore, if usage is not reduced by conservation.



Each system is also supplied with water conservation devices on each faucet that uses hot water. This accomplishes two things: 1.) it reduces your water bill with no inconvenience to the user, and 2.) it reduces the amount of hot water needed so that the solar collector can meet this need.

* "Solar Systems in British Columbia" by B.C. Hydro

DEMAND VERSUS SUPPLY OF HOT WATER



- "water gate" flow-limiting shower head # 0812 cost \$4.95
- "water gate" flow-limiting aerator # 0810 cost \$1.98
- recommended optional water conserving device for toilet tank:
- "water gate" toilet tank saver # 0808 cost \$4.95
- or
- "gold ring" water saving device from Jegco Inc., 2016 Sunset Dr., Pacific Grove, CA 93950

Conservation of hot water is essential for effective utilization of solar hot water. Low-cost devices to aid in conservation are shown above.

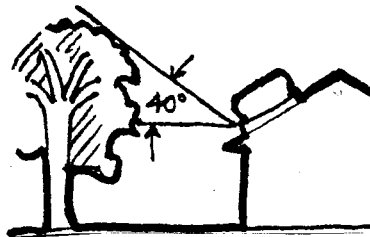
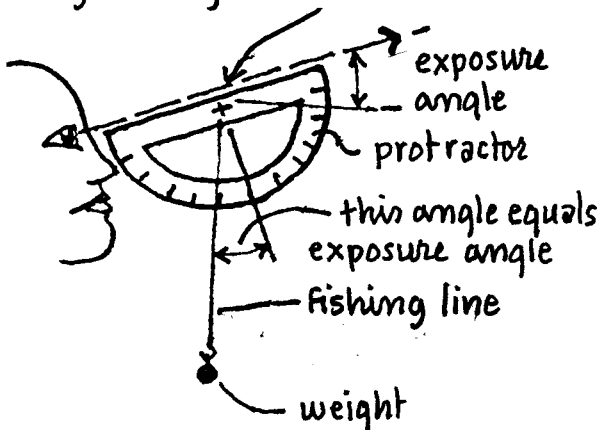
WATER CONSERVATION

HOW MUCH HOT WATER DO YOU GET?

A solar hot water heater is not magic. The collector described here will produce 50 gallons of hot water at 105° F a day in Texas, (or 100 gallons at 90° F). This is roughly half of the amount of hot water presently used by an average Crystal City residence in a day. Two collectors could almost produce all of the present demands of a typical family. In other words, water conservation is going to be part

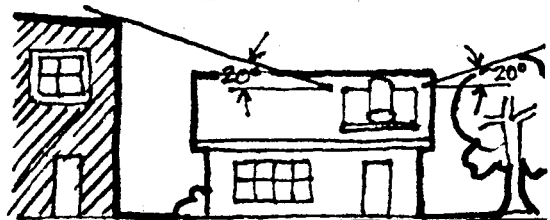
of the freedom from gas or electric bills that a solar hot water heater will bring. With water conservation devices on each faucet in the home, you can cut your hot water use by 40%! Water conservation thus nearly doubles the amount of available hot water and makes the solar hot water heater practical for you.

hang fishing line from hole



clear exposure to the south

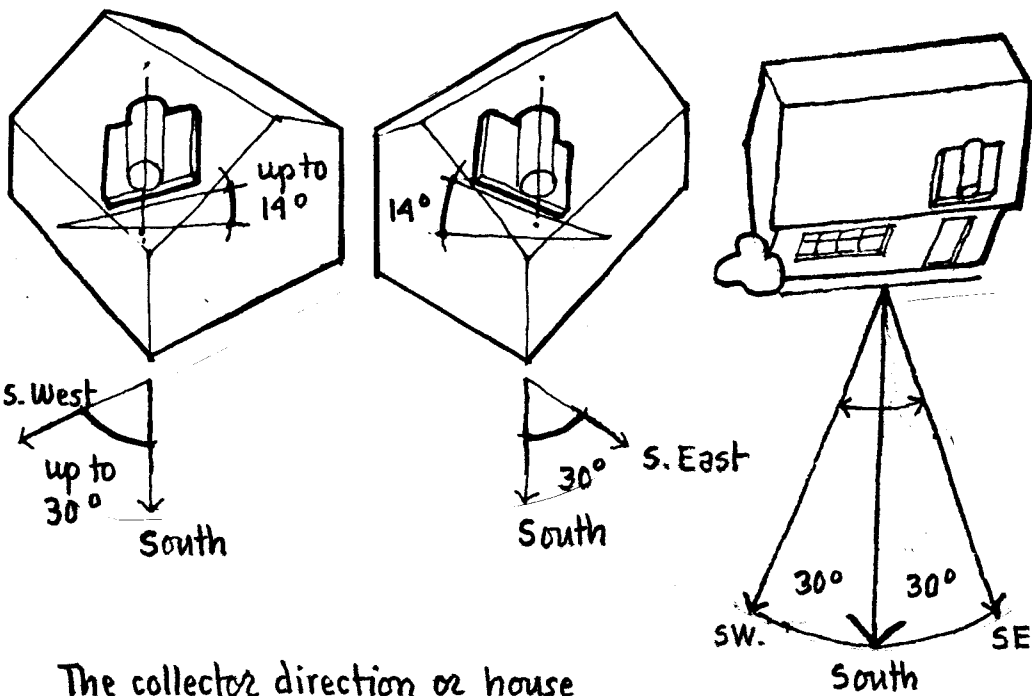
The angles shown here are for Crystal City, Texas. Other latitudes will vary.



clear exposure to east and west

"SOLAR ENVELOPE" FOR CRYSTAL CITY COLLECTOR

Care must be taken not to install the solar collector in any area that is shaded during the winter morning and afternoon from about 9:30 am to 2:30 pm.. You may determine whether a tree or building will block sunlight by sitting from the trial place on the roof toward the tree or building with a protractor. If a tree or building is in the way, choose another place on the roof and test it with protractor siting.



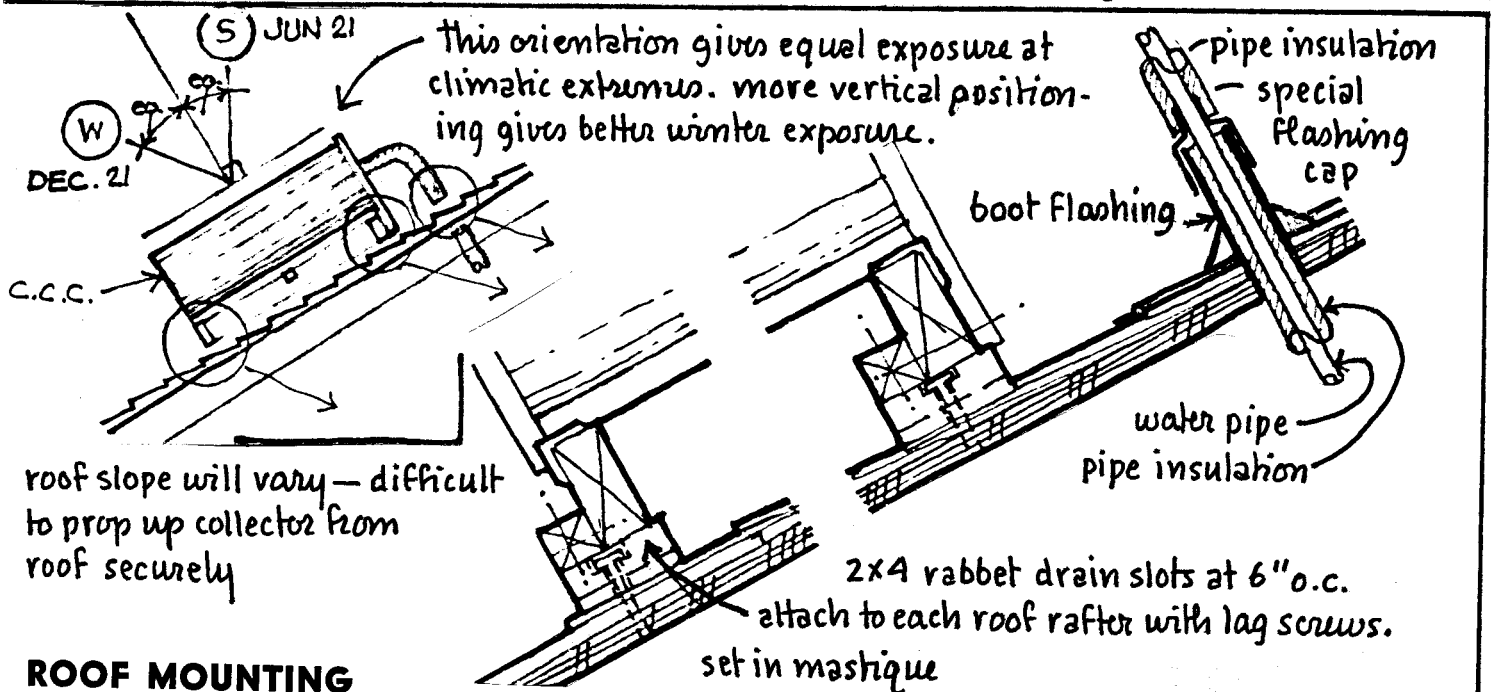
The collector direction or house direction may vary 30° from true South, so long as the collector axis points south.

INSTALLATION

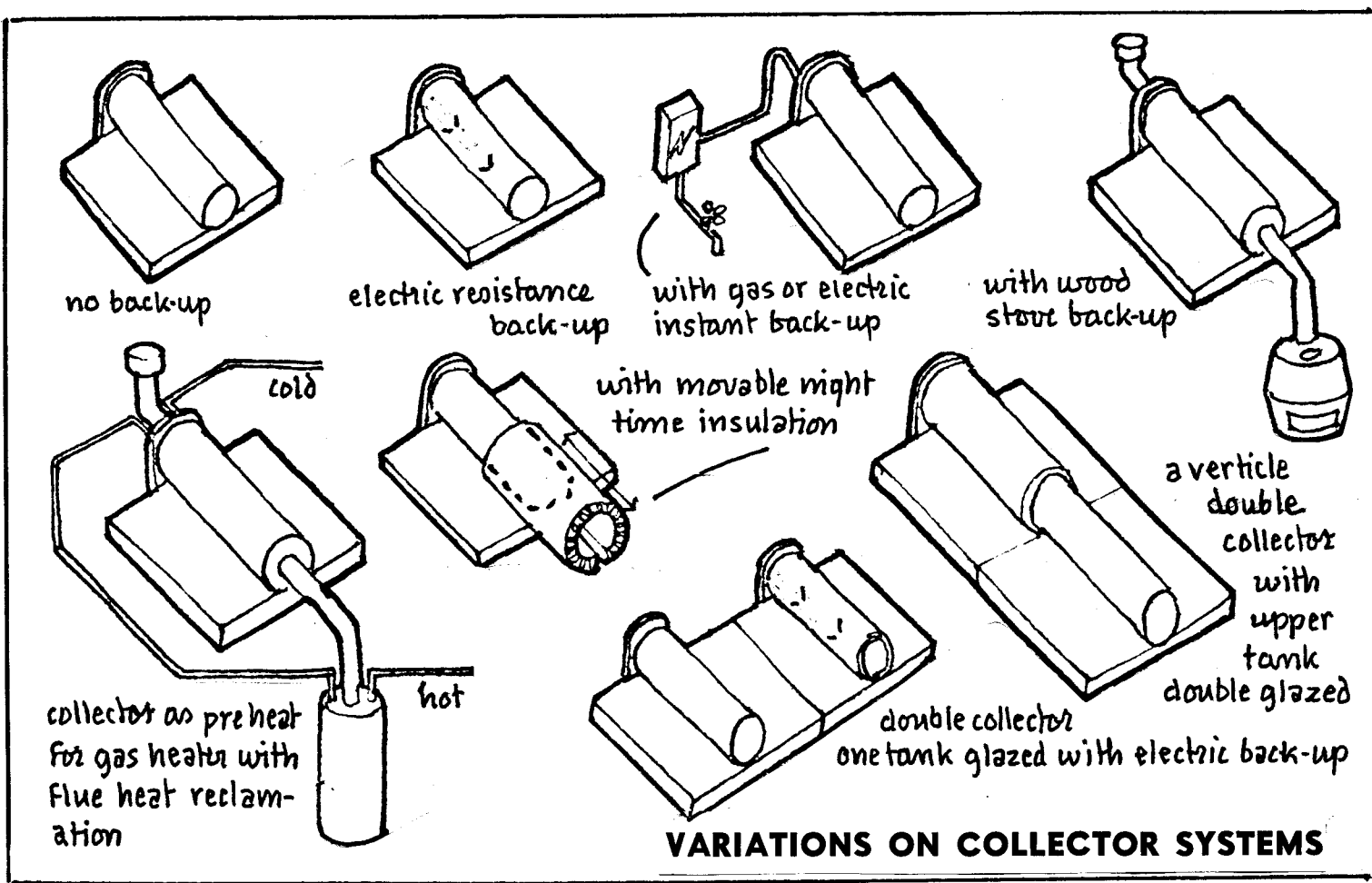
If the collector angle must be changed, a brace must be built. However, this is rarely necessary because this collector can receive effective sunlight from so many angles: so long as the axis end of the collector faces south, it may be installed on a roof that faces up to 30° SE or SW.

The collector should not be resting directly on the roof, as this will rot the frame. The collector should rest on 2x4 blocks lagbolted onto the roof joists.

The pipes to and from the tank go directly through the roof in order to minimize heat loss from the pipe and also to prevent freezing. All pipes should be insulated. Care should be taken to place the cold water connection on the down corner inlet side of the collector. This insures that the cold water goes to the bottom of the tank as mentioned in the fabrication section. The hottest water will rise to the top of the tank ready for use. All roof contacting material must be tarred.



ROOF MOUNTING



TECHNICAL DATA

dimensions
 total weight full
 weight / sq. ft. of roof area
 wood
 tank size
 tank material

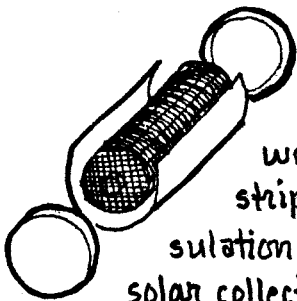
6' x 4' x 2' high
 250 lbs.
 10 lbs.
 wolmanized 2x4 ext. B.C. plywood
 30 gallons
 glass-lined shell, with magnesium
 rod for de-mineralization

BTU / year in Texas
 average BTU / day
 gallon / day average
 highest stagnation temper-
 ature on sunny summer
 day at 96° F ambient temp.
 highest stagnation temper-
 ature on sunny winter
 day at 20° F ambient temp.
 collector tank freezing

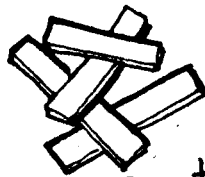
3 million
 8-10,000
 50 gals. at 105° F from 75° F water
 150° F
 120° F
 never in Texas. Montana data
 forthcoming.

RECYCLING

What you already have is all you might get.



old hot water tanks stripped of insulation can be the solar collector tank.



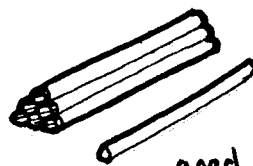
2x4's and 2x5's are made into the collector frame.



3/4" plywood in pieces as small as 2'x2' are used as end plates in the collector.



used aluminum printing plates are good for making the reflector surface.



carefully cut and cleaned fluorescent light tubes are excellent glazing.

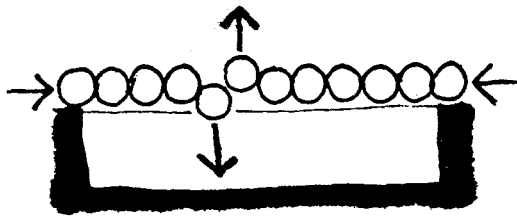
This solar collector has been designed to take advantage of available recycled materials. Using recycled materials cuts costs and reduces dependence on government grants for construction of hot water heaters. Therefore, recycling is one approach to energy self-sufficiency for the city.

Recycling is a form of exchange of materials rather than money. As we noted in the Introduction, exchange is in

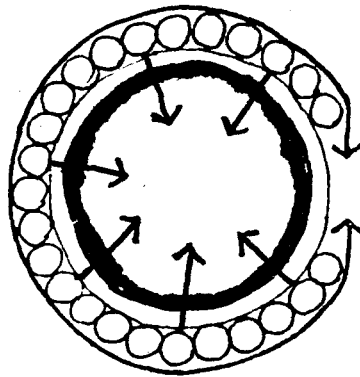
Chicano tradition. It is important that those making solar collectors are aware that they are helping another family in this exchange, otherwise that family would never receive water heated by the sun. Also they set an important example to the city, demonstrating that the community is willing and able to work together.

Forty of these collectors have already been produced and installed for families in south Texas at an average cost of

\$ 85 each, when using high quality recycled materials. These drawings show how this type of collector is built. If you are interested in how to clean and recycle fluorescent light tubes, ask Crystal City or the Center for Maximum Potential Building Systems. When there are enough people interested, we will put together a special training session on how to do this.



light tubes tend to "pop out" of alignment when pressed against each other in a plane;...



... but in a cylindrical shape, tubes seal very well against each other.

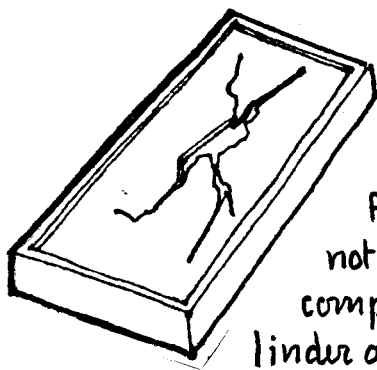
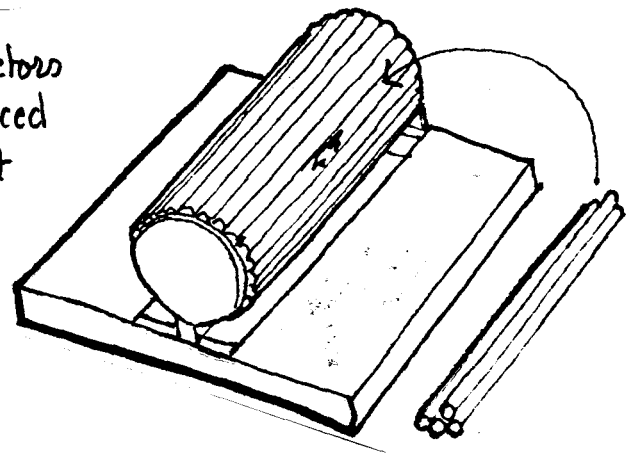
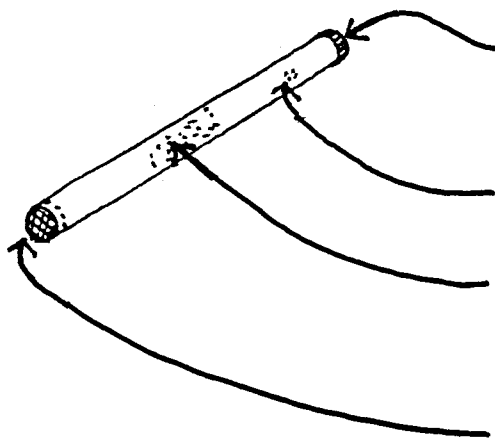


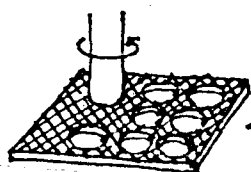
plate glass on flat collectors must be entirely replaced if broken by hail, etc.; but fluorescent light tubes are not fragile when placed in compression around a cylinder and are easily replaced.



TUBE SEALING CONFIGURATION AND BREAKAGE



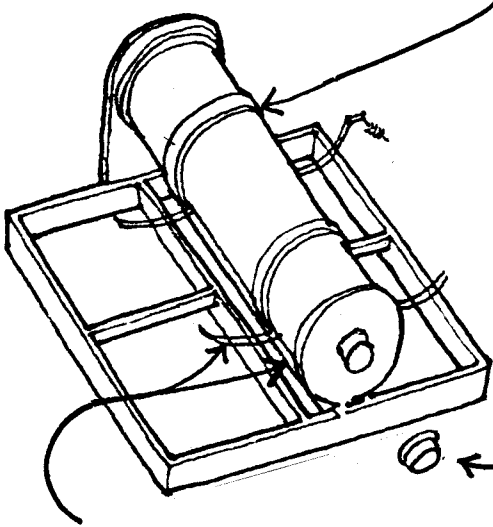
1. electrode ends of the tube must be removed
 - a. twist off with pliers
 - b. cut off with saw blade and special jig
2. remove and recycle mercury in tube (approx 50 mg.: store safely!)*
3. remove phosphors from the tube by
 - a. sulfuric acid bath
 - b. "cotton swab" technique using special machine
4. glue foam rubber end plugs in tube using silicone cement. (plugs can be cut from foam rubber sheet with a 1/4" cork borer plumbing pipe)
5. store the cleaned tubes in original box with baffles.



* contact The Center for Maximum Potential Building Systems, Austin, Texas

RECYCLING FLUORESCENT TUBES

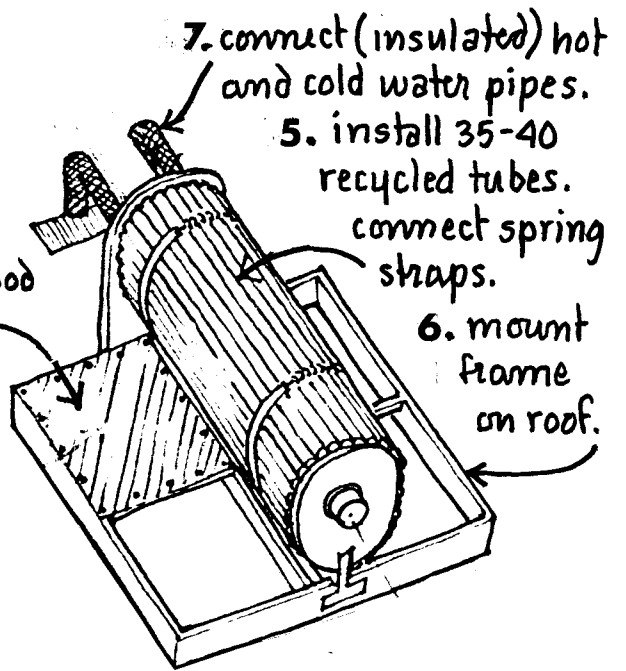
1. install 1" thick foam compression rings around tank with RTV silicone cement.



4. affix aluminum plates to frame with oval head wood screws.

3. install sheet metal retainer around flue inlet to hold bottom plate flat to bottom of tank.

2. install 1" wide foam rubber strip to sides of center rail where tubes will touch. install metal straps + springs below rubber on rail, aligned with rings.



7. connect (insulated) hot and cold water pipes.

5. install 35-40 recycled tubes. connect spring straps.

6. mount frame on roof.

CONSTRUCTION SEQUENCE