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HOT WATER

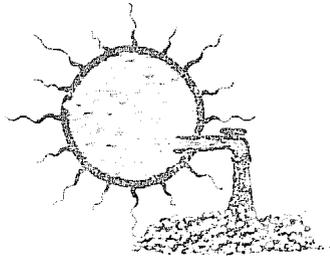
as written by

Scott & Chole Morgan

David & Susan Taylor



SOLAR WATER HEATERS *and* STACK COIL HEATING SYSTEMS



Revised Edition

1975

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Many thanks to our friends for their thoughts & criticisms.

We would appreciate any feedback to improve this pamphlet.

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Introduction

This booklet was written in an effort to combine a variety of materials from diverse sources into an easy to follow, technically complete source of information on the construction of home and farm water heating systems. The information compiled here does not represent the last word in solar and stack heating systems. It does represent research and construction of both types of water heating systems. They all work well and the variations on each will serve individual needs. After reading this manual thoroughly, you will have to decide which style best suits your needs. If, during construction, you run into a problem which you cannot solve locally, send your question along with a stamped, self-addressed envelope and we will be glad to help if we can. Have fun and be patient.

NOTE: *The drawings in this booklet are not to scale.* 

Pressure Systems

A PRESSURIZED SYSTEM is, for all practical purposes, one with five or more pounds pressure per square inch in the water line. If you are serviced by a public water system, you probably have pressurized water. The coil and straight tubing absorbers are designed for use in pressure systems. The flat plate absorber is a very efficient unit, but difficult to adapt to a pressure system. As of this writing, we do not recommend the flat plate absorber for use under pressure.

The gravity pressure equation is $\frac{1}{2}$ lb. of pressure for every 1 foot of fall.

Open & Closed Systems

An OPEN SYSTEM is one in which the water to be heated flows from the storage tank through the absorber and back to the tank.

A CLOSED SYSTEM is recommended to those who wish to keep the solar units operating during prolonged, sub-freezing weather. A liquid mixture of water and ethylene glycol* (anti-freeze) constantly recirculates through the absorber and a heat exchange tube or coil in the storage tank. As it gets warmer, it heats the water in the storage tank through a process of heat exchange. In the closed system, the absorber and the heat exchange tube are not under pressure. However, the storage tank can be under pressure to provide pressurized water from the storage tank to the use locations.

The coil and straight tubing absorbers work efficiently in both open and closed systems. The flat plate absorber is recommended for use only with a closed system.

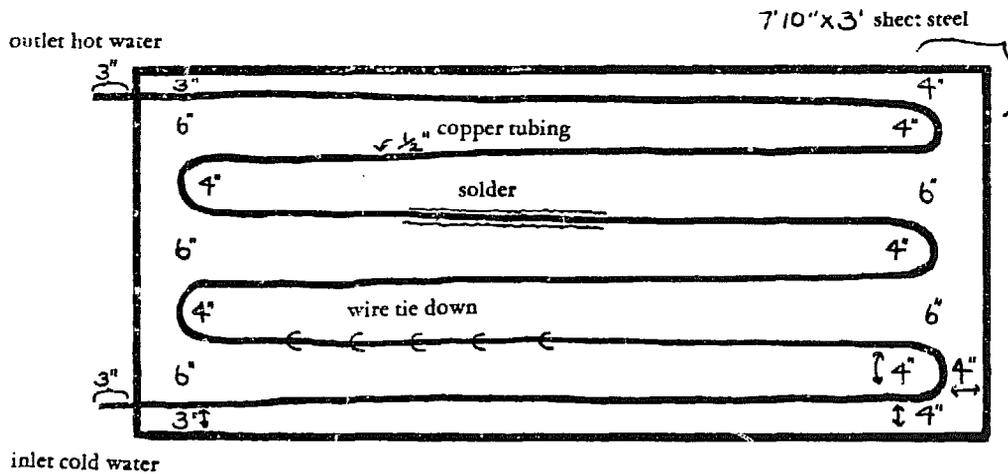
* See warning on page 22.

The SOLAR ABSORBER: Coil Tubing Type

Materials:

- 50' of 1/2" inside diameter soft copper tubing
- 3' x 7'10" piece (or pieces) of galvanized sheet metal
- 1/2" coiled wire tube bender (plumbing supply house)
- Solder and flux
- Wire for securing tubing to backing sheet
- Propane or acetylene torch for soldering
- 2 sheets medium grade sandpaper
- 1 qt. flat black paint

Diagram #1



For every square foot of absorber surface you will get 1 1/2 gallons of 140°-150°F. water on a sunny day. If you want a greater quantity of hot water you can build two or more units and run them together.

The absorber described here will produce a minimum of 30 gallons of hot water on a sunny day.

I. You will need a sheet of 20–22 gauge galvanized steel measuring 3' x 7'10". A single sheet is easier to work with; however, any number of sheets can be screwed or riveted together to equal the required panel size.

II. Mark the path of the tubing on the sheet using the measurements in DIAGRAM #1 as a guide. If you have a used sheet of steel, clean and sand a 2" swath on the path of the tubing. This is necessary for a good solder connection.

III. The absorber sheet is now ready to have the copper tubing fastened to it. Starting 3" up from the bottom left-hand corner of the sheet, extend the tubing 3" beyond the left edge of the sheet and start unrolling. Follow DIAGRAM #1 to completion of tube laying and soldering. Using the coil wire tube bender, make the bends as indicated in DIAGRAM #1. Another method for bending is to pack the tubing tightly with sand and make the bends around a 4" outside diameter pipe. This method is described in §II of WATER HEATER ADAPTATIONS FOR WOOD AND COAL BURNING UNITS (*Description of Return Bend*). Heating the tubing will facilitate bending. You might want to practice a bend first to get a feel for the procedure. If you have 50' of tubing, you have about 2 extra feet. Wire tubing to sheet every 6–8 inches or as needed. Another possibility is to purchase pre-bent 180° slip fittings at a plumbing supply house. These fittings can be soldered to the straight pieces of tubing.

IV. For maximum efficiency and heat transfer, you must run a solder bead along both sides of the entire length of the tubing.

V. Once the coil is soldered to the backing sheet, paint the entire unit with two coats of flat black paint—black being the most efficient heat-absorbing color.

VI. The coil tubing absorber can be rotated to put the outlet and inlet either on the right or the left side. The bottom connection is always the cold inlet on the absorber.

The SOLAR ABSORBER

Straight Tubing Type

Materials:

- 3' x 7'10" piece (or pieces) of galvanized sheet metal
- 38' of $\frac{1}{2}$ " inside diameter flexible or rigid copper tubing
- 14' of $\frac{3}{4}$ " inside diameter flexible or rigid copper tubing
- 28— $\frac{3}{4}$ " to $\frac{1}{2}$ " copper "T"s
- 2— $\frac{3}{4}$ " to $\frac{1}{2}$ " right angle connectors
- 2 sheets medium grade sandpaper
- Solder and flux
- Propane or acetylene torch for soldering wire for securing tubing to backing sheet
- 1 qt. flat black paint

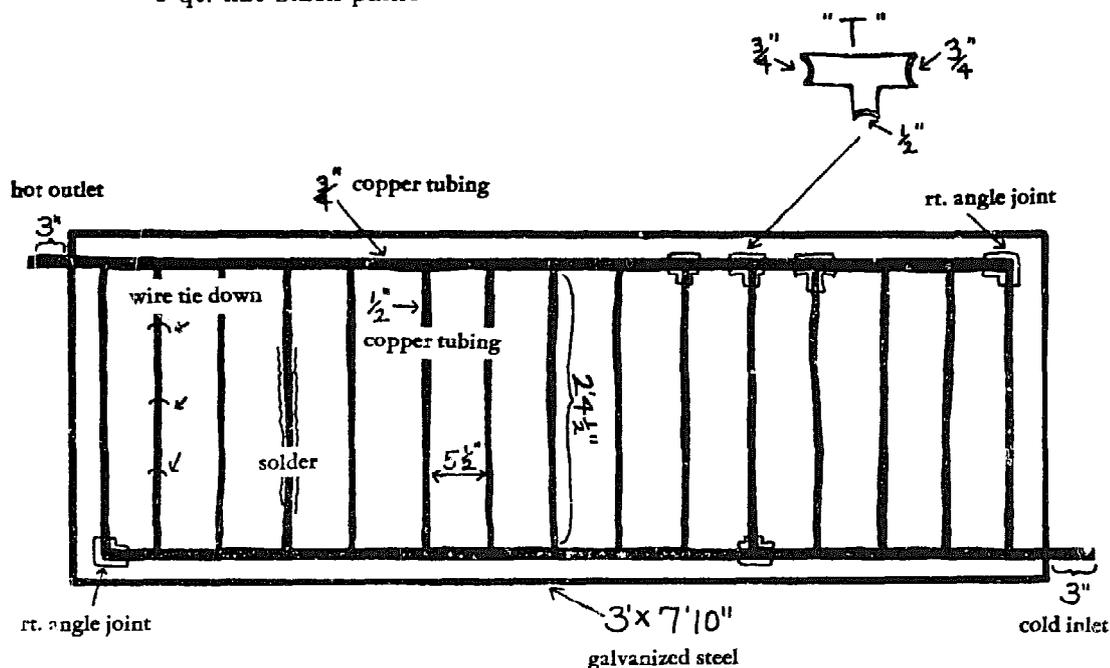


Diagram #2

This absorber is also made of copper tubing, but here you may use rigid or flexible tubing since no bending is required. This unit takes more work time and costs 10-\$15 more than the coil absorber. The difference between the two types is that this is a faster flowing absorber. It will give you a greater quantity of warm water earlier in the day,

whereas the coil type will give you smaller quantities of hotter water at the end of the same period. However, by the end of the day, the results are about the same.

I. This absorber is similar to the coil type in materials used. The sheet metal backing is the same size and weight. The $\frac{3}{4}$ " copper tubing is for the header pipes (see DIAGRAM #2). From this tubing cut 2—6" sections and 28— $5\frac{1}{2}$ " sections. From the $\frac{1}{2}$ " copper tubing cut 15— $2'4\frac{1}{2}$ " lengths. All this material, plus the copper "T"s and the right angle connectors will be soldered together to make the absorber.

II. *Reminder:* The $\frac{3}{4}$ " tubing sections comprise the header pipes. The $\frac{1}{2}$ " tubing sections are the uprights between the headers.

III. Find a flat, even surface. First you will lay out and solder the $\frac{3}{4}$ " to $\frac{1}{2}$ " copper "T"s to the $\frac{1}{2}$ " x $2'4\frac{1}{2}$ " uprights. Make certain the "T" is in the correct position so that you are soldering the $\frac{1}{2}$ " section of the "T" to the $\frac{1}{2}$ " section of the upright. Also, be sure that the $\frac{3}{4}$ " extensions of the "T" are quite flat on the work surface to assure a flat finished product. Flux all soldering surfaces before applying solder.

IV. Now the 28 header pipe sections ($5\frac{1}{2}$ " x $\frac{3}{4}$ ") are ready to be soldered to the "T"s. Start by fluxing the end of the tubing and the inside of the "T". Insert the pipe into the "T". Heat the joint until the solder will melt when it touches the joint. Run the solder all around the joint so that it will be drawn into the joint evenly. If you have never soldered before, talk to a plumber or other local talent. These people are always willing to pass on information and advice. If, after completion of this step, the "T"s won't lie flat on the backing sheet, they can be reheated and resoldered in the correct position.

V. Now solder the 2 ($\frac{3}{4}$ " to $\frac{1}{2}$ ") right angle connectors in position. (see DIAGRAM #2).

VI. Solder the 2 (6 " x $\frac{3}{4}$ ") sections on for the inlet and outlet (DIAGRAM #2).

VII. Once the absorber is complete, it should be secured and soldered to the backing sheet following the same procedure as the coil-type absorber. 

The SOLAR ABSORBER Flat Plate Type

Materials:

- 2 sheets of 3' x 7'10" galvanized or plain sheet steel (14-20 gauge)
- 2— 4" x $\frac{3}{4}$ " steel pipe nipples
- 45' of 1" angle iron or box steel
- Welding set (arc or gas)
- 1 qt. flat black paint
- 14— $\frac{1}{4}$ " steel spacers

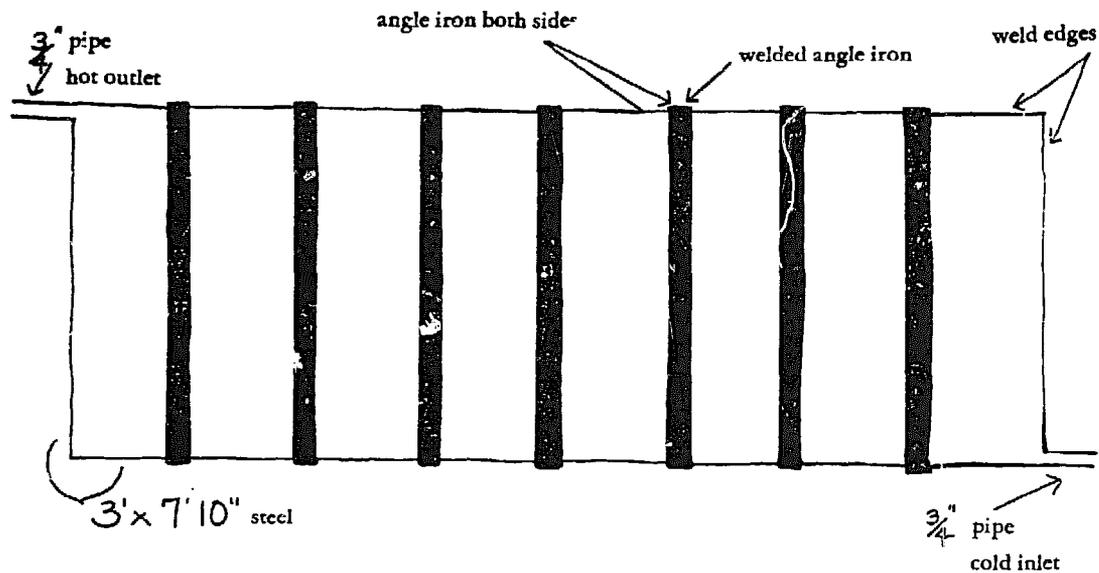


Diagram #3

This absorber is made of 2 sheets of 14-20 gauge steel welded together. It does not employ any copper tubing. The cold water flows in at the bottom and out at the top.

In our opinion, this unit is limited to use in a non-pressure or a closed system. Our attempts to "beef it up" for pressurized systems have been unsuccessful to date. The flat-plate absorber is probably the most efficient type of absorber in terms of moving greater quantities of water. Its greatest value is in sub-freezing climates as a closed

system. In a sub-freezing climate you want as much efficiency as possible plus you will probably want to use a closed system. The closed system can be pressurized at the tank, but the absorber and heat exchanger are not under pressure. These circumstances are ideal for the flat plate absorber. An ability to weld or access to someone who can weld is a prerequisite to building this unit. Another drawback to the flat plate absorber is its finished weight, approximately 200 lbs.

I. This is a 24 sq. ft. absorber. Acquire 2 sheets of 14-20 gauge steel 3' x 7'10". Mark $\frac{1}{2}$ " in along all edges of both pieces. This is the point at which you bend the steel to make the joining edges of the absorber. Bend the edges on both sheets to about 30°. One simple method for bending is to clamp a piece of heavy angle iron at the bend point and hammer along the outside edge. The sheet is lying on the ground with the straight edge underneath. Next, weld $\frac{1}{4}$ " steel spacers every foot inside one of the plates. These spacers will keep the absorber from collapsing.

II. Paint both inside surfaces with a non-toxic, rust-resistant paint. If you use galvanized metal, you don't need to paint, but you do need to weld outside since the fumes are toxic.

III. Now lay one sheet on the ground and the other on top of it. Tack weld around the absorber. Then stand it on edge and finish welding all edges.

Note: You must leave 3" unwelded on the upper left and lower right corners for the outlet and inlet pipes. A good weld is important to prevent leaks. If you can't do it, find someone who can. Labor exchange is a nice way to make friends.

IV. The inlet and outlet pipes are 2—6" x $\frac{3}{4}$ " pipes. Heat and bend the unwelded corner out, insert the pipe in about $\frac{1}{2}$ "; heat and hammer the edges back over the pipe, weld the pipe to the side and finish welding the seams. Repeat for the other side.

V. To avoid ballooning of the absorber when filled with water, weld steel reinforcement plates every foot of the entire length of both sides of the absorber. Use angle iron, "I" beam or strap (box) steel, which is the strongest. Check the salvage yards for this stuff. Weld the ends of the reinforcement bars together also.

(continued)

VI. Paint the whole absorber (both sides) with two coats of flat black paint. Then pour about a pint of non-toxic, rust-resistant paint in through a pipe and tip the absorber all around so that all welded seams are sealed on the inside. Pour out excess paint.

VII. The dimensions of these absorbers can be changed to fit your specific needs. For example, you could make your absorber 8' high and 4' wide. On the other hand, an absorber 2' high and 10' wide will not circulate adequately. You *can* increase the height and decrease the width, but you *cannot* decrease the height and increase the width. 🐛


The ABSORBER BOX

Materials:

- Enough 1" x 6" to make a snug box frame
- One 4' x 8' x 1/2" sheet of exterior grade plywood
- Insulation material
- Some 6d and 8d nails
- Enough glass to cover box (double layer in sub-freezing climate with air space between the panes)
- Tube of silicone sealant and applicator gun
- "L" brackets and screws to secure glass to box
- 1" x 1/2" wooden strips
- Felt for glass padding

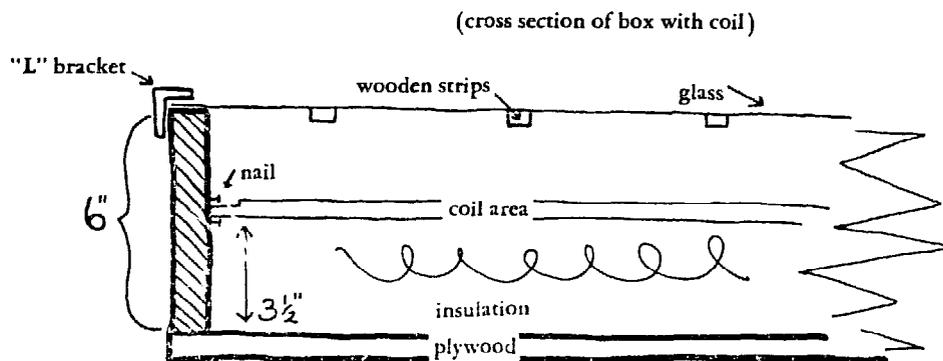


Diagram #4

This box will hold and insulate the absorber of your choice. When finished, the absorber will fit snugly into the box. The box is basically the same for any absorber.

Design the box for a snug fit, according to the dimensions of the absorber you have built.

I. Construct the box frame out of 1" x 6" wood. The bottom of the box should be no less than $\frac{1}{2}$ " plywood. Paint the entire box inside and outside with exterior wood paint.

II. Lay the insulation in the bottom of the box. The best for an absorber (especially a flat-plate) is styrofoam. It is also the most expensive. 1" of styrofoam is equivalent to $3\frac{1}{4}$ " of fiberglass. Foam carpet padding and layers of cardboard are also good insulators. If you use fiberglass or other crushable insulation, use 3"-4" and then tack 6d nails around the inside frame every 6" at the top of the insulation (see DIAGRAM #4). The nails will hold the absorber off the insulation. The flat-plate absorber will take stronger supports.

Notches must be cut in the sides of the absorber box to accommodate the outlet and inlet pipes of the absorber.

III. Place the absorber in the box. Once again, nail every 6", this time snug up to the top of the absorber to hold it in place.

IV. You are now ready to secure the glass to the top of the box. A single pane is great, but you will probably find a few smaller panes more economical. If you cover the absorber box with a single sheet of glass, it should be double strength with at least one support in the middle of the absorber. If you use two or more pieces of glass, wherever you join two panes, span the box frame with wooden strips, (1" x $\frac{1}{2}$ ") cut to fit flush to the top of the box (DIAGRAM #4). Pad the glass between the support strips and the frame with felt. Seal all edges and seams with silicone. Glass is removable by cutting the silicone bead. Secure the glass with "L" brackets. Pad between the glass and the "L" brackets with felt.

Keeping the glass clean will maintain full efficiency.

V. If you are designing your absorber for sub-freezing use, you need a double layer of glass. Here is one method for mounting the first layer of glass: nail a $\frac{1}{2}$ " x $\frac{1}{2}$ " strip of wood all the way around the inside of the absorber, $\frac{1}{2}$ " down from the top edge of the box. Make certain you have the appropriate cross-strips, as described in §IV. Secure glass in place by spotting it with silicone sealant or additional wooden strips used to frame the glass in place. Mount the second layer as described in §IV.

(continued)

VI. Completely seal all edges and seams of the glass cover with silicone to protect against loss of heat.

The absorber must have a southern exposure. The best position is at a 90° angle to the sun. You will have to adjust the position of the absorber as the position of the sun changes with the seasons. The absorber cannot operate from a flat position however, without an in-line circulation pump, so you should maintain at least a 35° angle between the flat surface and the back of the absorber box. A mirror or other reflecting surface, placed on the ground in front of the absorber at an angle which will reflect additional sunlight toward the absorber, will greatly increase its efficiency. Care should be taken to protect the tank and the absorber from prevailing winds.

The absorber box or boxes can be located in any convenient place as long as they have the correct southern exposure. Flat roofs, slanted roofs, sides of buildings, on the ground, anywhere you can figure out a way to mount them. 

The Hot Water STORAGE TANK Pressure Tank

Materials:

- Insulation to wrap all exposed pipes
- 30-50 gallon tank (old water heater is most available)
- $\frac{3}{4}$ " or $\frac{1}{2}$ " "T" connector
- Pressure regulator or bleeder cap
- Several feet of reinforced rubber hose
- Automotive-type hose clamps
- Nipples for outlets and inlets
- $\frac{3}{4}$ " steel pipe (length determined by distance between the storage tank and the absorber)
- One temperature/pressure relief valve

If you are running a pressure system you must use a storage tank built to operate under pressure. An oil drum and similar units do *not* qualify. They will deform and burst under pressure greater than 10 psi. An old hot water heater works well and is adaptable to a closed system. Another option you have, using a hot water tank for storage is to build an open system, drain it in the winter and switch over to gas during the sub-freezing months. It should be noted that you could consider com-

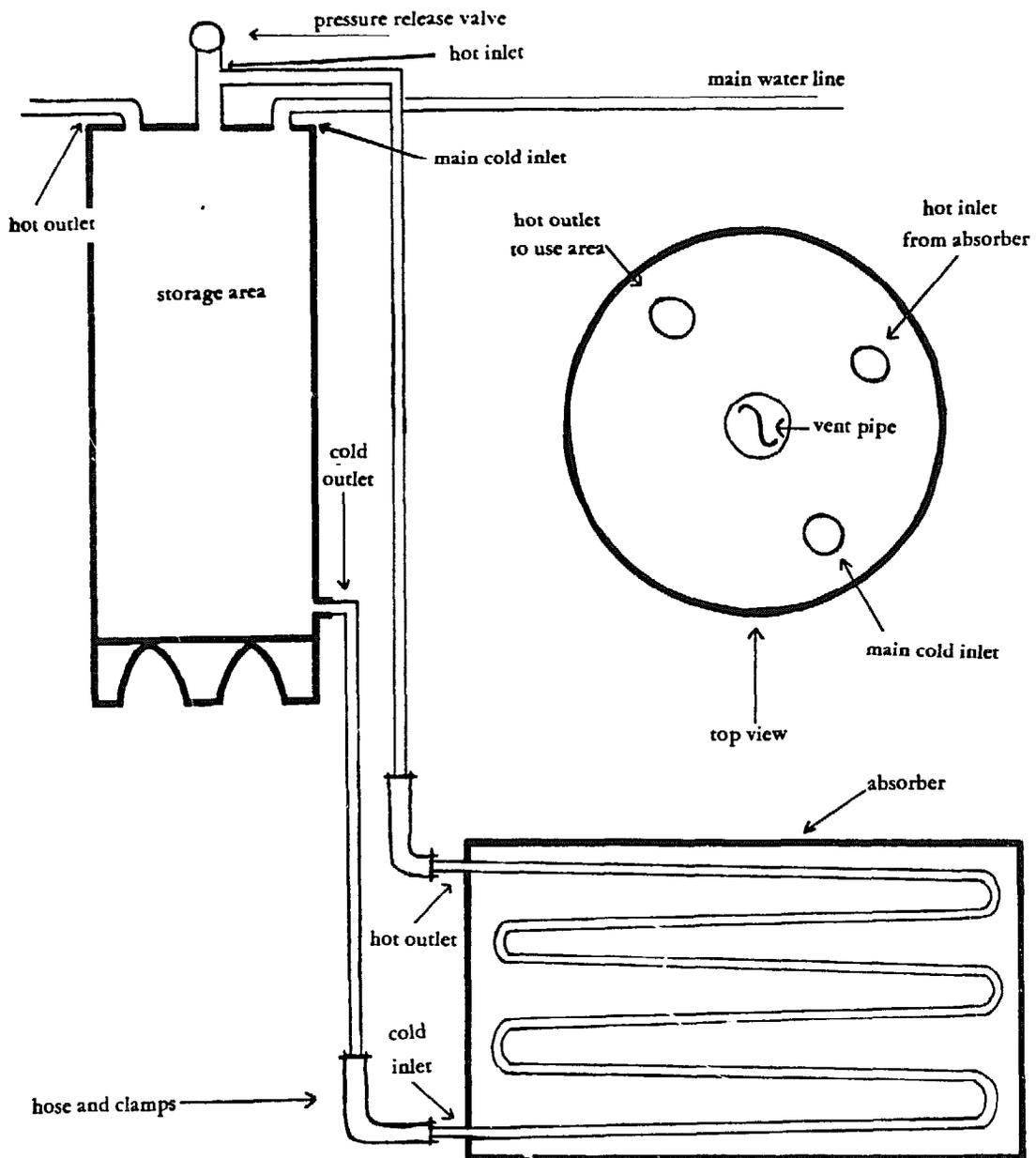


Diagram #5

binning the solar (open or closed) and stack heating units to avoid entirely the burning of fossil fuels.

I. Check **DIAGRAM #5** closely. If you have 3 or more connections on the top of the tank, the cold inlet and the hot inlet are used in the conventional way. These connections are usually labeled. It is imperative that you use these connections correctly or you will end up with a lot of luke-warm water. The hot water outlet from the absorber is piped into

(continued)

the third connection at the top of the tank. The third connection is often hidden under the tank cover. One of the connections will have a metal rod inside. This is a mineral collector. You can throw it away or cut it off and put it on the bottom of the tank.

II. Remove the drain faucet at the bottom of the heater. Clean out any mineral deposits which might clog the opening. This becomes the cold water outlet to the absorber (see DIAGRAM #5).

III. At the hot water inlet on the storage tank, mount a "T" connector (DIAGRAM #5). If you will be set up for gas as well as solar heat, you need a temperature/pressure relief valve at the top of the "T". If the set-up is for solar only, cap the "T" and use it as a bleeder valve when air becomes trapped in the system and blocks water circulation. If air blockage occurs, remove the cap to release the air and when water flow returns secure the cap. The pressure relief valve can also act as an air bleeder valve.

IV. How you make the connections from absorber to storage tank depends upon the distance between the two. If only a few feet, you might want to use all reinforced rubber tubing. With more than a few feet, it is best to use steel pipe for all but the last foot. The connections from the copper tubing to steel pipe are much easier if spanned with reinforced rubber hose. All pipe or tubing from the absorber to the tank should be $\frac{3}{4}$ " to reduce resistance and aid maximum flow. 

The Hot Water STORAGE TANK Drum Type

Materials:

- 30-55 gallon drum
- Insulation to wrap all exposed pipes
- $\frac{3}{4}$ " or $\frac{1}{2}$ " "T" connector
- Bleeder cap
- Several feet of reinforced rubber hose
- Automotive-type hose clamps
- Nipples for outlets and inlets
- $\frac{3}{4}$ " steel pipe (length determined by distance between storage tank and absorber)
- Acetylene torch or power hack-saw to cut opening in drum
- Pipe cutter

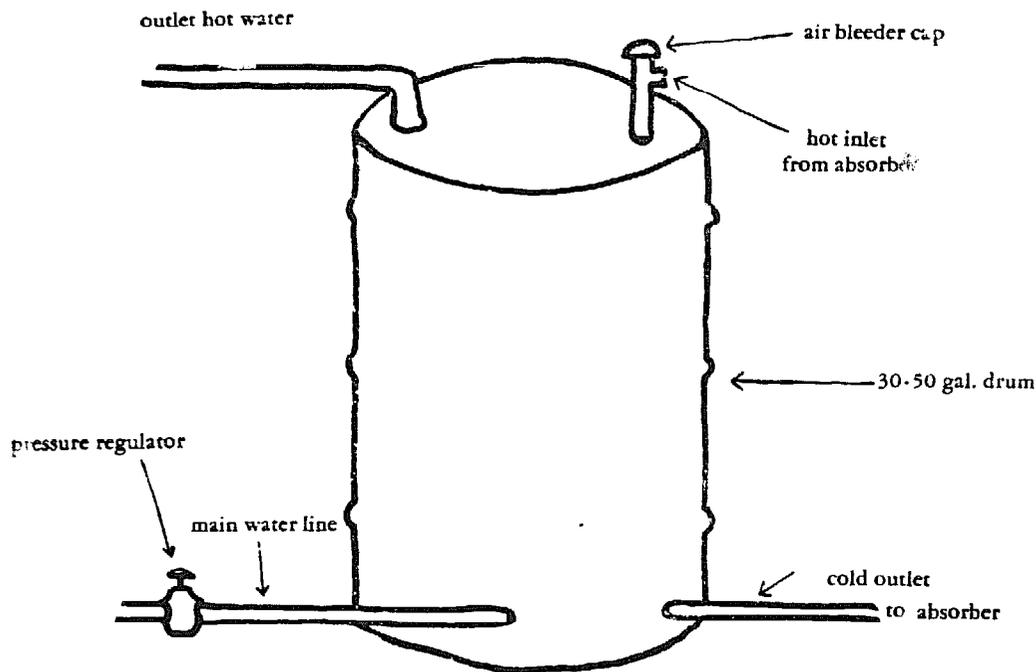


Diagram #6

A clean, 30–55 gallon drum will serve as a hot water storage tank for a non-pressure system.

I. Find a drum. Clean it by the “slosh” method using a solvent to cut the oil and then soap and water. (Or, use an organic, non-toxic heavy duty cleaner). Air it well.

II. The drum will have two openings on top: one large, one small. Install a “T” connector on the large opening to accommodate the hot water inlet from the absorber and the air bleeder valve (DIAGRAM #6). The smaller opening is used as the hot water outlet to the supply area. If your drum has no openings, they will have to be cut and welded in at the proper places.

III. You will need 2 connections at the bottom of the drum (DIAGRAM #6). One is for the main cold water inlet, the other is for the cold outlet from the tank to the cold inlet to the absorber. These connections will have to be cut and welded in.

IV. Pour about 1 qt. of non-toxic, rust-resistant paint into the drum and cap it. Paint the inside of the tank by the “slosh-and-roll” method. Pour out excess.

V. The procedure for pipe connections from absorber to storage tank are the same as those described in the last section. 

The Storage Tank INSULATION BOX

Materials:

Wood for frame (2" x 2" is adequate)
Plywood or panelling or sheet metal for siding
Insulation
Tools for cutting pipe holes

It is always a good idea to insulate the storage tank, whether inside or outside. Even a water heater has very poor insulation. If the tank is under cover, simply wrap insulation around it. If the tank is outside, you should wrap insulation around it and then build a weather-proof box around it. Holes must be cut for all pipe connections. Also, don't forget to insulate all exposed pipes and tubing. ♣

More on Closed Systems

A definition for a closed system has already been given. DIAGRAM #7 depicts a type of closed system.

As mentioned before, the liquid in the absorber is a mixture of water and anti-freeze. You mix it as you would for a car radiator, the ratio of water to anti-freeze depends on local weather conditions.

The water and anti-freeze mixture flows through the coil into the tank where it heats the water around it. As the mixture cools, it sinks in the heat exchanger, goes back out and is reheated in the absorber.

This system loses about 10% efficiency as compared to the open coil unit, because this is a heat transfer process rather than a direct heating one. However, the direct heat or open system becomes useless in sub-freezing weather. You do not necessarily need *warm* weather to get hot water—*sunshine* is the key ingredient. Cold, sunny winter days will also produce hot water.

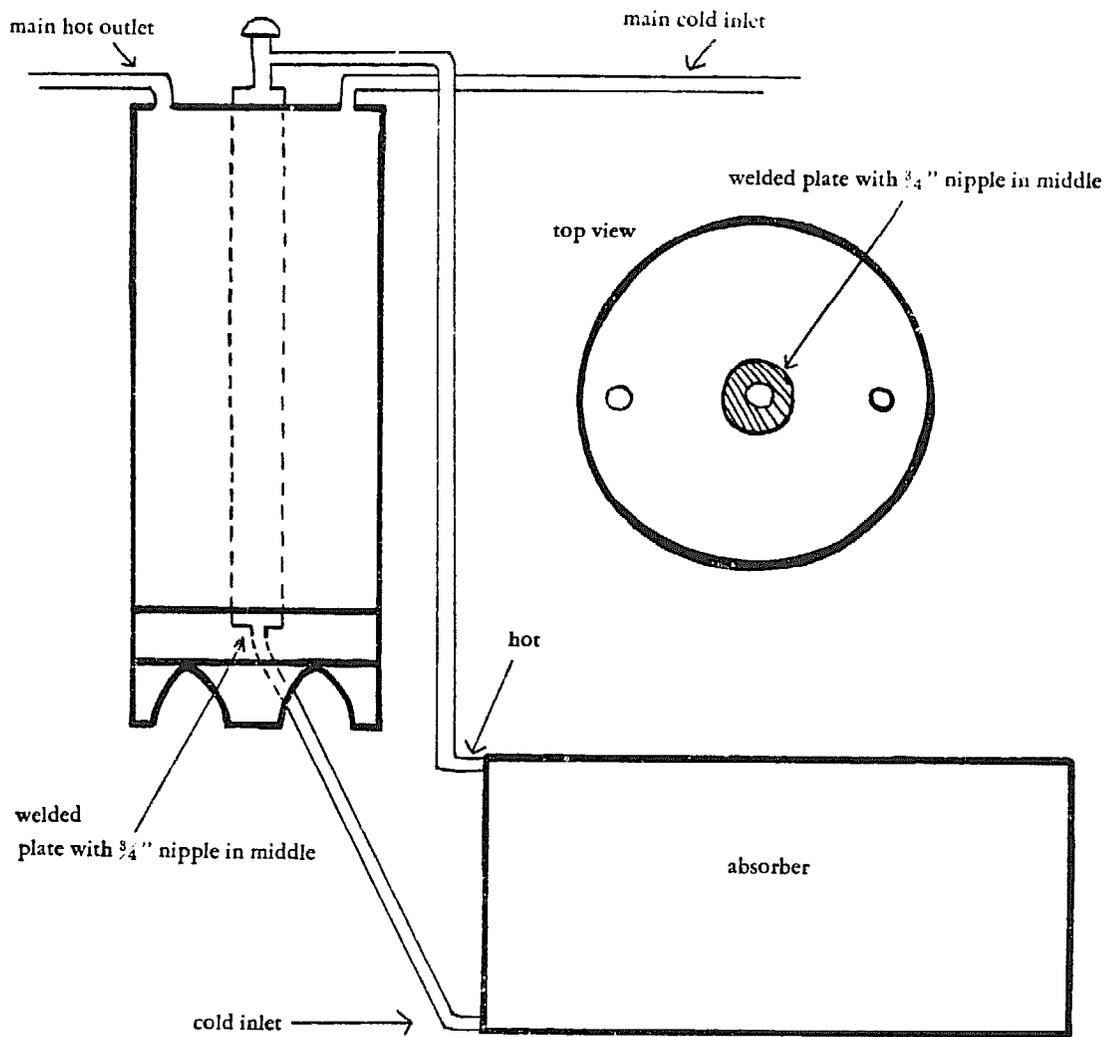


Diagram #7

This is a low pressure system. Thus, the flat-plate absorber, which is more difficult to construct for high-pressure use, becomes a real possibility in this situation.

The storage tank can be pressurized without affecting the absorber. This is why we recommend a high pressure tank for storage in a closed system where pressurized water is available.

You may not want to run a solar water heater in the winter. You could then go to a stack system in cold weather, saving the solar unit for warmer months. If your area does have many clear winter days, both units would be nice to have.

(continued)

I. It is quite simple to make a closed system with a gas-type hot water heater. When finished, the system will not convert to gas again because the vent pipe becomes the heat exchanger (DIAGRAM #7).

II. Cut two circular pieces of steel to fit the outside edge of the vent pipe at the top and bottom of the storage tank. The metal should be the same gauge as the vent pipe.

III. Cut a $\frac{3}{4}$ " hole in the center of each piece and weld in $\frac{3}{4}$ " nipples. Weld the plates on the vent openings. You will have to remove the gas burner to get to the bottom opening.

IV. Connect the bottom outlet to the cold inlet on the absorber and the top one to the hot outlet from the absorber. All other connections match those of the open system.

V. As the fluid mixture in the closed system heats up it will expand. In order to make room for this expansion and avoid leaks, you must construct an air expansion chamber. Install a $\frac{3}{4}$ " "T" on the hot water inlet at the storage tank. At the top of the "T" mount a $\frac{3}{4}$ " nipple. Then mount a $\frac{3}{4}$ " to 2" bell expander. Mount a 6" piece of 2" water pipe to the bell expander. Reduce back down to $\frac{3}{4}$ " and install a temperature/pressure relief valve. When filling the closed system with fluid, leave about $\frac{3}{4}$ of this chamber empty to allow for expansion. This precaution will eliminate the possibility of breakage in your closed system.

VI. WARNING: *A leak in the heat transfer tube in the storage tank of your closed system will cause the ethylene glycol to mix with the hot water to be used. Even though the chance of leakage is small, we would not recommend drinking water manufactured in a closed system.*

If you do not wish to use anti-freeze, you can substitute undenatured ethyl alcohol. This will require about 10% more alcohol (by volume) than anti-freeze to achieve the same results. A leak between the heat exchange tube and the water storage tank could be detected by mounting a pressure gauge on the closed system. If the gauge constantly reads the same as your line pressure, then there is a leak.

WATER HEATER ADAPTATIONS For Wood & Coal-Burning Units

Materials:

- 30-50 gallon storage tank
- 25' of $\frac{1}{2}$ " inside diameter flexible copper tubing
- 3" outside diameter steel pipe 6' long
- 5 lbs. of very dry plaster sand
- Roll of tape
- Tube cutter
- "C" clamp
- One temperature/pressure release valve
- 5' section of $\frac{3}{4}$ " galvanized steel water pipe

This is a neat system which gives double use every time you light a fire...you get warm and you get hot water too. You can adapt any wood or coal burning unit to include a water heating device.

Essentially, this is a coil system. A tightly coiled copper tube is inserted into the chimney stack or stove pipe. The water feeds through the coil and into a storage tank.

I. The minimum size combination of stove pipe and copper tubing to be used is 5" pipe and $\frac{1}{2}$ " inside diameter copper tubing. A smaller pipe would require smaller tubing which risks boiling water in the coil, this creating an air lock which blocks circulation. Using a 5" stove pipe and 25' of $\frac{1}{2}$ " copper tubing, you will get approximately 30 gallons of 150°F. water in 1½ hours. If you have an 8" or larger stove pipe or chimney stack, use 35' of $\frac{3}{4}$ " copper tubing and you will get 40-45 gallons of 150°-170°F. water in 1½ hours.

The coil we describe will function inside a 5" stove pipe. However, a 6" pipe is preferable. It will require less cleaning and work more efficiently. A good formula, except for the 5" stack, is to make the outside diameter of the coil 2" less than the diameter of the stove pipe.

These figures represent a moderate fire. If you stoke-up the fire, the water will get hotter, faster. You should experiment for speed and temperature to meet your requirements.

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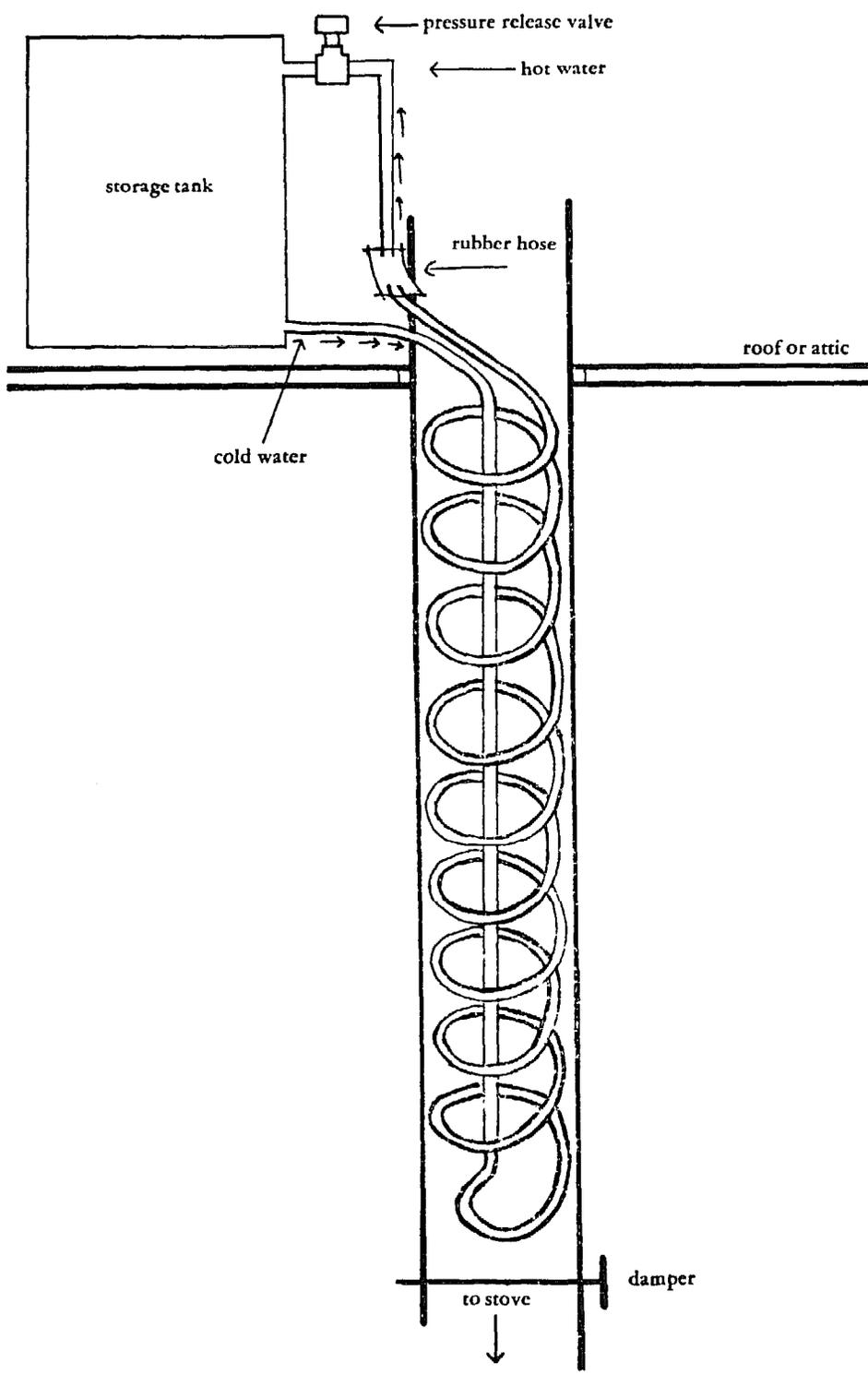


Diagram #8

II. How to coil the copper tubing:

For a 5" diameter stove pipe, get a 3" outside diameter piece of steel pipe. You will bend the tubing around this pipe to make the coil. Get 25 *continuous* feet of flexible copper tubing. Uncoil the tubing. Seal one end tightly with tape and fill the tubing completely with *very dry* plaster sand. Make sure the sand reaches the sealed end and tap the tubing as you fill to get a tight pack. Seal the open end. The sand keeps the tubing from deforming during the coiling process. The easiest way to get the sand into the tubing is to carefully uncoil the tubing and have one person on a roof slowly filling the tubing with sand, allowing the air inside the tubing to escape. Another person will be tapping up and down the tubing to pack the sand.

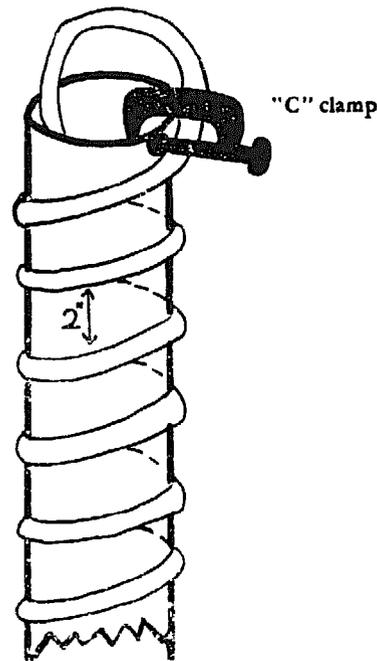


Diagram #9

Keep filling and tapping until the tubing is completely filled and *very* tightly packed. Now seal the open end. *This step is all important.* We have ruined many feet of expensive tubing because of rushing this simple step. As mentioned in an earlier section, the sand and tubing have to be perfectly dry. Purchase a few extra feet of tubing, pack a one foot section with sand as directed and practice the return bend before you do the real thing. You may get some small ripple crimps on the inside of the tubing. This is natural. By packing tightly, you will avoid

the big crimps or extreme flattening which will ruin the whole coil.

Recoil the tubing in about 2' diameter circles, leaving about 6' uncoiled.

One problem in the coiling process is securing the pipe so that the tubing can be wrapped around it without slipping. There are several possibilities. The best method we have found is to mount a bench vise on a 6" x 6" and place it on the ground. Secure the pipe vertically in the vise and prepare to coil. You could secure the pipe in a vise mounted on a workbench, but since part of the procedure requires walking around the pipe, this might be rather awkward. You could dig a one foot hole in the ground, cement the pipe in and coil the next day. Or, you could dig a hole in the ground, place the pipe in it and have someone secure the pipe at ground level with a large pipe wrench.

Once you have filled, packed and recoiled the tubing, it is time to make the return bend. This is the hardest bend, so stay mellow, it gets easier.

Measure in 5' from the straight end of the tubing. This will be the center point of the "U" bend. Tie the tubing horizontally to the 3" pipe, making sure that the 5' mark will be the center point of the return bend. Tie it *very* tightly in a criss-cross pattern with wire which will not stretch (baling wire, for example). Slowly bend the tubing around the pipe to make a slightly closed "U" bend. If it begins to crimp or flatten badly, either the sand is not packed tightly enough or the tubing is not secure enough on the pipe.

Using the return bend as a hook, hang it down inside the 3" pipe. Clamp a "C" clamp at the top of the pipe. This acts as a stop, preventing the tubing from simply rotating with you as you walk around the pipe trying to coil. Do not clamp the tubing to the pipe. It will crimp badly. As you make the first bend, the tubing will hit the "C" clamp. Start slowly, bending the tubing around the pipe with approximately 2" spaces between the coils (inside measurement). Leave about 2' at the end uncoiled for the hot outlet connection.

III. The cold water inlet is the straight piece of tubing running down the center of the coil. Go down 12" from the beginning of the cold water inlet. Measure from that point to the beginning of the return bend. Take the 5' section of $\frac{3}{4}$ " galvanized steel water pipe and cut it to that length. Now slide the pipe down over the cold water inlet. The one foot section sticking out past the pipe will be bent to bring it out of the stack to make the connection to the storage tank.

This pipe is necessary to insulate the cold water inlet and thus insure correct waterflow when you fire up the stack. After you have used the stack coil system a few times, it carbonizes somewhat. Without the galvanized pipe insulation on the cold inlet, the water will heat too fast, reverse flow and greatly impair the efficiency of the coil. You can omit this step if you build the stack coil unit shown in DIAGRAM #11. Before removing the sand, make certain that the coil will fit inside the stack and make all bends for pipe connections. If the coil doesn't fit, make the necessary adjustments while the sand is still inside the coil.

Shake and rotate the finished coil until all sand is removed. The procedure is identical for $\frac{3}{4}$ " copper tubing.

IV. There is a general rule about the height of the storage tank in relation to the height of the collector, or in this case, the hot water outlet from the stack coil. For good flow, the bottom of the tank should be at or slightly above the top of the hot water outlet. To stop circulation at night, the tank should be at least 2' above the hot water outlet. Night circulation cools the hot water gained during the day. If raising the tank is a problem and you have electricity, you can install an electric shut-off valve on the cold inlet to stop circulation.

You do not need a pump to move water from the absorber to the storage tank. Hot water rises and cold water falls. Thus, the hot water will move from the absorber to the storage tank naturally without any aid.

V. The storage tank options for this system are the same as those for the solar units. The only situation faced here, not met in the solar units, is the procedure for inserting the outlet and inlet stems through the stack, stove-pipe, chimney or what have you. If you are adapting to a stove pipe, cut a slit on one side at a seam, large enough to accommodate both inlet and outlet stems, then close the stove pipe section. You should have a fairly tight fit. In order to seal completely, solder or cover with a non-flammable material.

A brick chimney presents more of a challenge. First, you can't have a 2' hot water outlet stem on the coil because it won't fit down the chimney. If you are installing in a chimney, bend for the hot water outlet, but leave only enough to get 2"-3" through the opening in the side of the chimney. In any case, choose the point at which you want to locate the top of the coil. Take out a brick. Using a rope, drop the coil down through the top of the chimney to the desired point. Reach

in, bring out the stems, make connections and reseal the hole with a half brick and cement.

DIAGRAM #10 is self-explanatory. This is an alternate stack coil system which allows you to close off the coil completely when you want heat, but don't need hot water. To heat water, open damper "B" and close "A". To stop heating water, close "B" and open "A". Damper "C" is only for damping the stove.

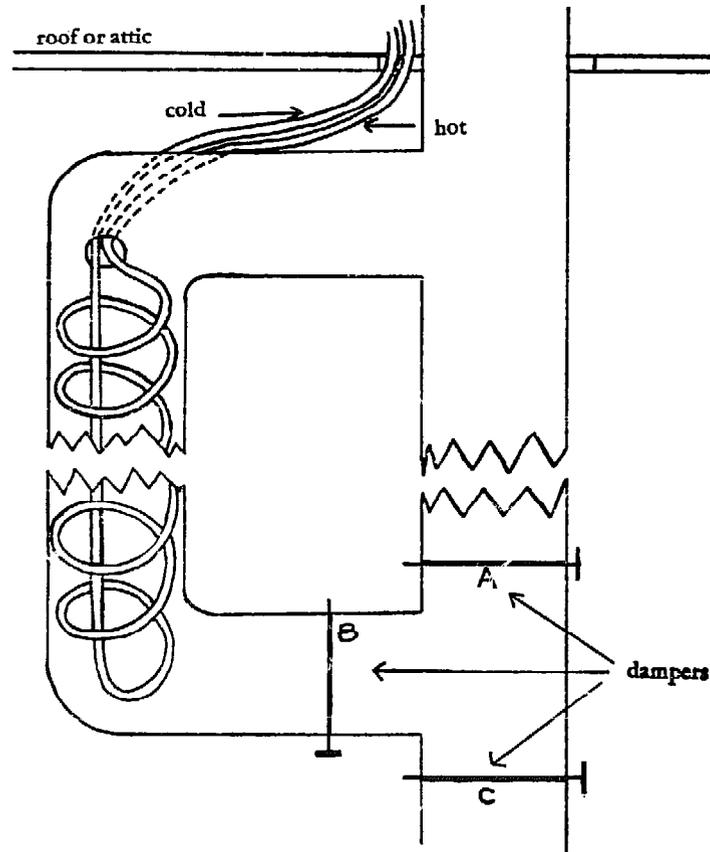


Diagram #10

If you leave hot water stored in the tank for any length of time and it is still being heated in the coil, it is possible to boil the water in the coil. If this occurs, you run the risk of explosion. To avoid this you *must* put a pressure/heat relief valve on the hot water outlet from the coil. This is an important safe-guard against explosion. You will find a relief valve on most modern water-heating systems. 

Running Two or More Absorbers Simultaneously

Solar absorbers can easily be set up to run several in a series. Set the absorbers side by side and run two 1" (minimum) header pipes. One will be above the absorbers and will carry the hot water to the storage tank. One will be below the absorbers and carry the cold water to the absorbers. Put a "T" connection on the headers at each outlet and inlet. Hook up to the stems from the absorbers and you are ready to heat water for the chickens and cows too.

Pumps

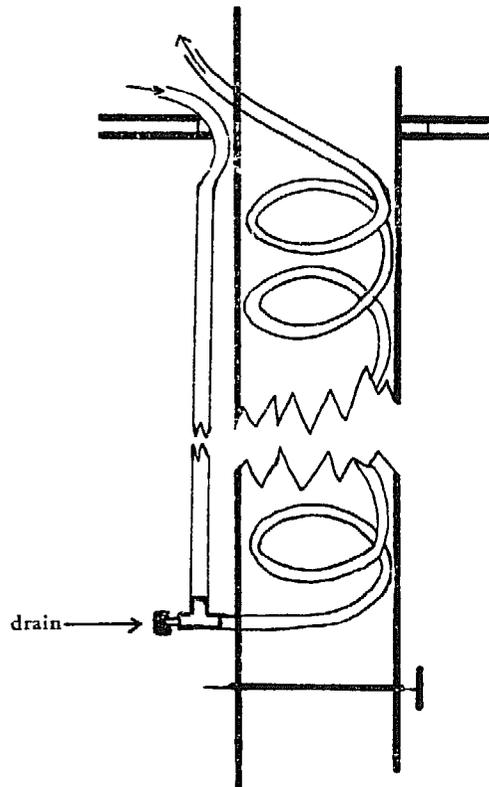
If the absorber must be above the storage tank, an in-line circulation pump must be installed on the cold water inlet to assure proper flow.

Drains

In cold climates, all open systems, including the stack coil system, are subject to freezing. The stack coil system will be alright unless you leave the house for a number of days, then, as with all pipes and tanks in a cold house, you have a potential freezing and breakage problem.

DIAGRAM #11 shows a stack system set up for easy drainage. It should be clear that in this unit, the cold water inlet runs outside the stack rather than inside the coil. Install a drain tap at the lowest point on the cold water inlet and you are ready to drain the system. With the solar units, simply disconnect the cold water inlet at the absorber and it will drain. You must remove the coil from the stack if it is not hooked up with water in it and circulating to a tank. If you operate your stove or fireplace with an empty coil, the heat will damage the coil. 

Diagram #11



Where To Get It

The cost of any of these systems depends on where you get your materials. If you buy everything at retail outlets, the solar units could cost over \$150.

There are ways, however, to keep your costs within the \$30-\$50 range. Auto-wrecking, salvage yards and dumps are a few of the places available for free or almost free materials. The copper tubing can be retrieved from junked commercial freezers. Sheet metal and insulation are also standard freezer parts.

A hatchet is handy for cutting sheet metal. Sheet metal is also an option for the absorber box. All rubber hose and clamps can be found on heaters and radiators of junked cars. Auto-wrecking and salvage yards are also great places to find drums, water pipe, pressure tanks and old hot water heaters. Be sure to test for leaks. Most dealers will be happy to exchange.

Plumbing outfits usually have shorter pieces of copper tubing left over from big jobs which they may sell at their cost. They also have used water heaters, solder and flux. Buy the tube benders and pipe cutters at plumbing supply outlets, or better yet, borrow them.

Water heaters, glass and wood, nails, insulation and many other things can be salvaged from old houses and buildings that are being torn down.

More information on the uses of solar energy is available at public and university libraries. Use them—they're your books.

Use your own imagination and ingenuity. You will probably come up with many other possibilities for free materials. You may also feel free to question and improve upon our designs. Anyway, the sun will probably last longer than the fossil fuels. At least you will have hot water when the energy runs out.

Please write us if you have any ideas or information which would improve this booklet. 

Includes information on:

Solar Absorbers
Hot Water Storage & Insulation
Stack Coil Systems
Wood & Coal-Burner Adaptations
Pressure Systems
Open & Closed Systems
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