14

CHAPTER 3.B

(Continued from last week)

HEAT EXCHANGERS

7 & 8 LIQUID- LIQUID

Here are a bundle of steel pipes which once passed through a tank of liquid. The pipes themselves had liquid pumped through them to heat or cool the liquid in the tank. In solar heating water the problem of water freezing in flat plate collectors necessitates liquid to liquid heat exchangers. A flat plate collector as shown in Photo 10 has anti-freeze flowing through it during the day. The hot anti-freeze passes through a liquid to liquid heat exchanger where it heats water. At night the flow of anti-freeze stops, since convection ceases, and although the flat plate collector may reach temperatures below freezing the pipes are safe from damage. Photo #11 shows a very simple liquid to liquid heat exchanger - a conventional hot water tank placed within a 55-gallon drum which is connected to the heat collectors - the anti-freeze flows in the drum and outside the hot water tank.

Photo #7

Another radiator amid engine blocks and other junk.

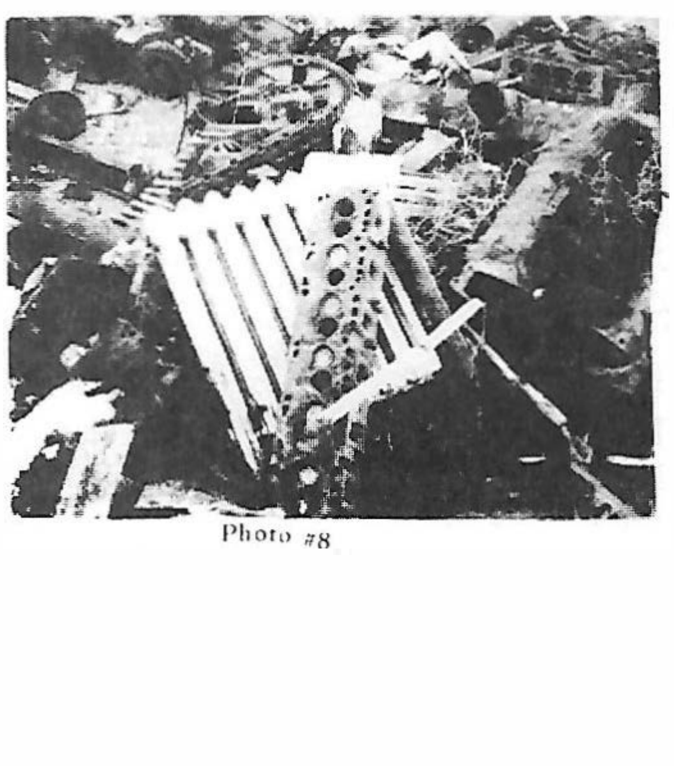
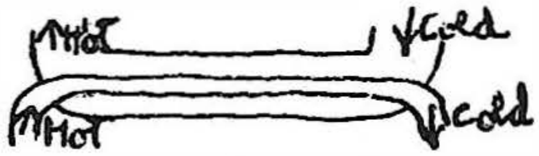


Photo #8

This is a section through a liquid to liquid heat exchanger - the two tubes are copper and the space between has a toothed plastic strip spiraling to increase turbulence.

The two liquids in this heat exchanger - which I picked up a couple of years ago at the Zia junkyard at Los Alamos probably flowed in different directions making what is called a counterflow heat exchanger.



At one end a hot liquid enters and another liquid, almost as hot, leaves. At the other end a cold liquid enters and the other almost as cold leaves. The longer the counterflow heat exchanger the closer the temperatures of the two liquids flowing past each other are to being the same.

Some birds have counterflow heat exchangers in their legs. Their legs are long and naked and have no protection against the cold and yet they must expose their legs all night long while they roost. The bird could not afford to throw away heat through its naked legs all night. There are counterflow heat exchangers in their legs which warm up the cold blood on its way back from the legs towards the heart and thus cools the warm blood before it even reaches the bird's foot. Some fish have similar mechanisms to protect them from the cold water through which they must swim.

9, 10, & 11 RADIANT- LIQUID

A close-up of a heat collector for heating hot water. Anti-freeze circulates through these tubes, where it is heated by the sun, and then through a heat exchanger where it heats the water. The small tubes are ½" and the large heads 1". They are copper as is the .020" thick sheet they are soldered to. The tubes are spaced 6" apart. The tubes are large because the liquid is moved through them by convection which provides only a slight head. The advantage of using convection is that it saves the cost of a pump and it shuts itself off at night.

Photo #9

View of a hot water heater being installed. The 55-gallon drum on the right has a 42-gallon water tank inside of it. The water tank within the drum is connected to the 80-gallon water tank on the left. There is storage for 122 gallons of hot water. The heat collectors have anti-freeze flowing through them by convection. They both connect to the 55-gallon drum. The heat collectors can be tipped back in the summer to catch the overhead sun and leaned forward in the winter to get the low winter sun.

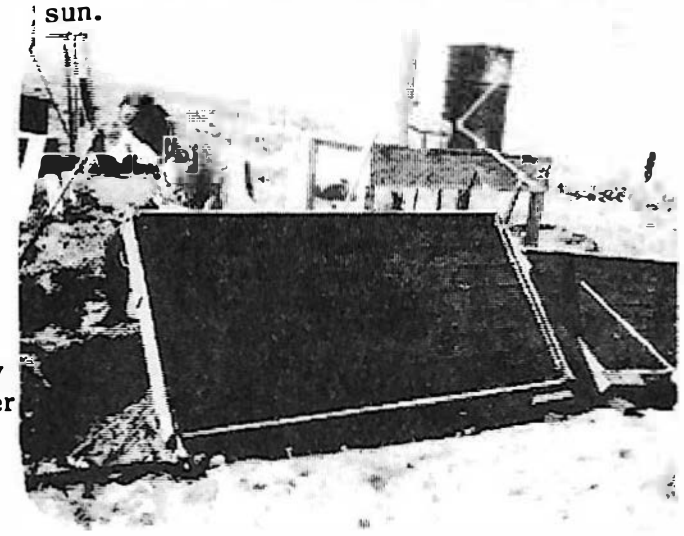


Photo #10

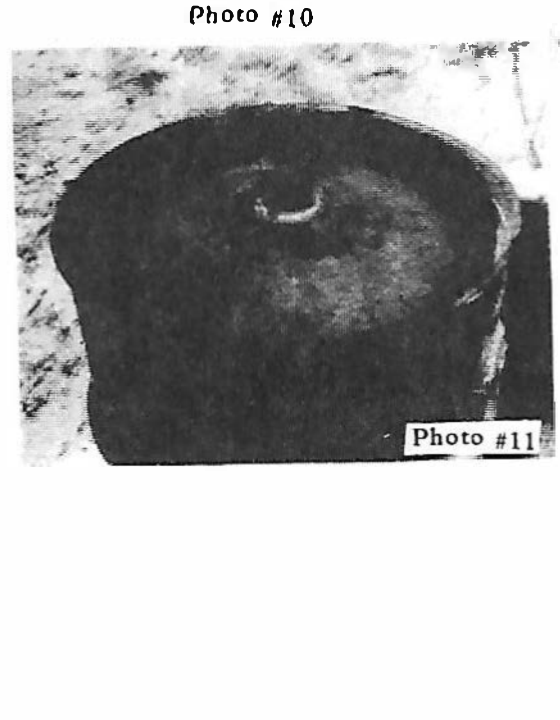


Photo #11

Closeup of the water tank within the drum. The hot water is taken off the top of the tank - as hot water leaves, cold water replaces it at the bottom. The pipe that delivers the hot anti-freeze to the drum is just visible on the right.

12 RADIANT - AIR

This is a mat of expanded aluminum foil. Metal lath works equally well. It is placed behind glass and heats air which flows through it. The best arrangement for heating air is to have cool air enter from the top and be heated as it flows from top to bottom. In this configuration the outer layers of the mat are coolest and do not radiate so much heat to the protecting glass as they would if the air passed the other way.

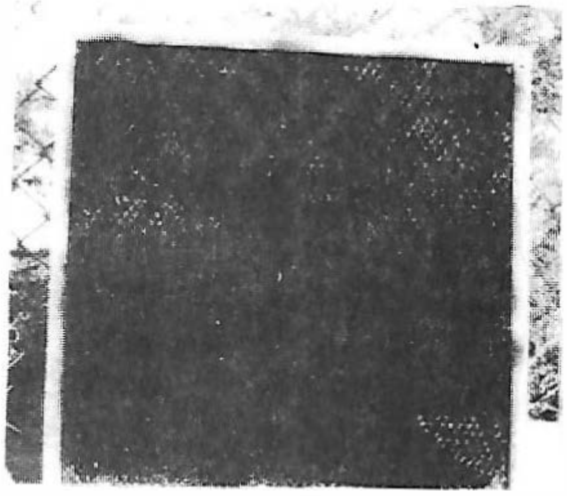


Photo #12

This concludes Chapter Three.

If you've missed any installments so far, all back issues of the Tribal Messenger are on file at Zimmerman Library, UNM, as well as on microfilm in fifty-six other libraries. Check your local library.

Proceed to Chapter Four on facing page.

Chapter 4 HEAT COLLECTORS & HOUSES

In the winter of '67-'68 we built a convective solar chimney in Placitas. The hot air rose up the heat collectors and then circulated between drums filled with water underneath the floor. We never insulated the dome properly - the dome was made of car tops and the heat loss through the metal was very rapid. The dome was very cold. Berry Hickman lived in the dome and gave an informative definition of solar heating:

You turn off all conventional heating means and then the house is solar heated- that's all there is left.

Every house that is exposed to the sun is partially solar heated. The earth itself is solar heated.

When you first start playing with heat collectors you are often impressed with the qualities of the heat collector which turn out to be its faults rather than its strong points. When something gets very hot it impresses you - later, when you are capturing heat and moving it somewhere or storing it you will continually strive to keep the collector temperatures as low as possible, while still having the heat be useful. High temperatures mean high heat losses.

A heat collector contrives to make the easiest pathway for the sun's heat to some substance where the heat is useful to you. The dirt that the sun strikes in the morning is an excellent heat collector, but the heat is given to the soil, itself, and the air in contact with it. We are so used to this and the resulting daily swing in temperature from the before dawn low to the afternoon high that we don't even think about it. What are the losses? Some of the light is reflected immediately back out into space, and the earth, itself, radiates heat into space. The rise and fall of temperature during the day is a good indication of the relative magnitude of the losses of the earth itself floating in space, and of the gains from the sun.

Generally the highest temperature during the day is recorded in the afternoon, but always the temperature begins to drop before the sun sets. The sun, when it drops below a certain angle, is unable to sustain the temperature. Evidently, the rate at which heat is arriving is not so great as its rate of loss.

Clouds act as blankets to retain heat. Clouds also act as reflectors to keep heat out. Cloudy days and clear night drop earth temperatures rapidly.

THE BEST HEAT COLLECTOR IS A WINDOW OR A SKYLIGHT

A window or skylight opening directly into a room and oriented south with the appropriate tilt is a very excellent heat collector.

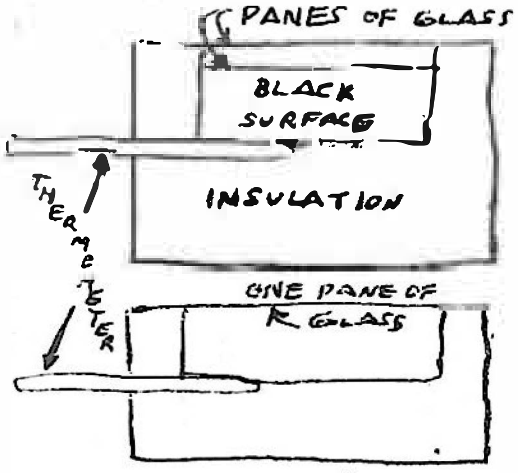
The efficiency of a heat collector is judged by the percentage of the available energy that the heat collector absorbs. The losses, the percentage that is not captured, consists of the radiation that is reflected from the outside glass or the inside collecting surface back through the clear cover. The other main loss is the heat given off by the warm front glass or plastic (glazing). There are also losses from the back and the sides of the collector These losses are decreased by adding insulation to these surfaces.

You can judge a heat collector by seeing if there is a great deal of glare coming back out through the glazing and whether or not the front glazing is warm or cool. An efficient collector is dark and its outer glazing is cool. These are the only tests you need to make on a non-focusing collector. Your eye or a light meter can be used to measure the reflection, and, by touching, you can distinguish between the warmer of two exterior glazings if you are testing different collector designs by racing them side by side. This is often the easiest way to test heat collectors - race them.

STATIC TEST

In a static test you do not take the heat away from a collector that is, you do not store it in a large body of water or stone and you do not pipe it off in hot water or hot air. You let the heat build up in the collector and measure the temperature with a thermometer. This shows how hot the absorbing surface of the collector will get before the losses through the back and the sides of the collector and the front glass equal the incoming sunlight. Never expect the part of the collector you can touch to get any hotter than other objects in the sun around it. Because they are all doing the same thing - warming in the sun until they reach equilibrium - giving off heat as fast as they take it in.

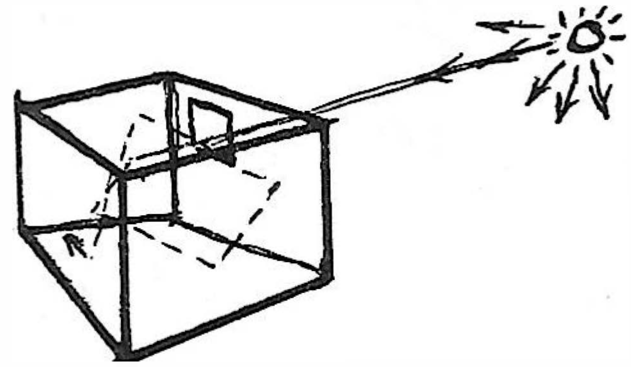
A non focusing collector is hot on the inside, never on the outside.



FIGS. 1-A AND 1-B

If two such collectors are put in a static est - facing the sun side by side in the same orientation, the double glass collector vill reach a higher temperature than the single pane. This is because the two layers of glass provide a better front insulation han one layer of glass. However, if you expose the two collectors at the same time you will notice that at first the single pane collector will be warmer than the double pane. And, only later, at higher temperatures will the double pane pass the single pane. The single pane is at first warmer because it admits more sunlight than the double pane, since the second pane reflects about 10% of the sunlight that passes through the first pane.

Why is a window or a skylight such a good heat collector? It is very difficult for a ray of light after it has come through a window to find its way by reflection back out the window.



Of course, if the entire side of the room is glass then the geometry of the room is like that of a collector as in Fig. 1, and if part of a ray reflects from the first surface then it will likely escape back through the glass. A room in which you wish to collect heat need not be painted dark colors in order to act as a very efficient absorber for the sunshine entering through relatively small windows. A succession of reflections where ½ of the light is lost each time soon absorbs almost all of the light.

The other method by which heat can escape directly out the front is by direct losses through the glass. This effect is very slight in the case of a window since its own temperature is likely to be below room temperature.

IF YOU USE WINDOWS OR SKYLIGHTS FOR HEAT COLLECTION WHERE WILL YOU PUT ALL THE HEAT???

Fifty square feet of south facing window in a 200 sq. ft. room made of frame and stucco with a wood floor will soon become intolerably hot. On a sunny day, the window may be admitting 10,000 BTUs/hr. and this flood of heat will soon warm up the walls, the floors and the furniture to an uncomfortable level. A large south window for such a conventionally constructed room as the one described does not make much sense. It is difficult to keep the room in a comfortable range because it changes temperature so quickly. If, instead, the room has a brick or slab floor and adobe or brick walls, its temperature is slow to change. A 200 sq. ft. concrete slab warmed 10 degrees Fahrenheit to a depth of 4" holds about 18,660 BTUs.

$$\left(\frac{140\ \text{lbs.}}{\text{ft}^3}\right)\left(\frac{1}{3}\ \text{ft}\right)\left(\frac{1}{5}\ \frac{\text{BTUs}}{\text{lb F}^\circ}\right)\left(10^\circ\text{F}\right)\left(200\ \text{ft}^2\right) = 18{,}660\ \text{BTUs}$$

And, if the walls are also masonry or adobe, they will have a similar capacity to hold heat. If the room is 10' x 20' and the walls are 10' high, after subtracting the 50 sq. ft. of south window, there are 500 sq. ft. of wall. If each square foot can store about 100 BTUs with a temperature rise of 10 degrees F. (as the floor) we find that we do have the capacity to store the energy coming through the south window by warming the walls and floor.

It is obvious that this scheme of utilizing solar energy coming through windows depends on a temperature swing between morning and evening. The larger the mass within the house, the smaller the temperature swing required to absorb incoming heat.

Next issue - more on houses and solar heating - how do you insulate windows at night.