## LOOP DESIGN

Last week I visited a rock storage air loop collector that had some interesting features in its design. I was at first pessimistic about it, but after considering my own rules which were violated in the design I decided perhaps my rules should be modified. Last issue I went to great lengths to explain why in the storage bin the air should be introduced at the top rather than at the bottom of the rock bin. If it is introduced at the top it spreads the heat evenly throughout the bin; it if is introduced at the bottom (or so I claimed) it burns a hole through the bin and leaves without heating all the rocks. This must be qualified - the important matter is not where the air enters the bin so much as where it leaves. If the hot air enters at the bottom but cannot escape through the top then it will warm all the rock, because although it seeks out the warmest rocks to rise up through it seeks the coolest rocks to descend through. There is increased friction within the bin since the air is both rising and falling through the same cross section, but in many bins this is not a problem.

to this design where the collector goes to the top
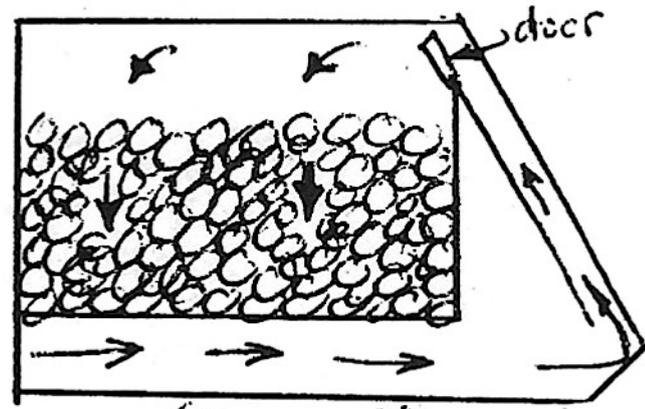
(figure 3)

is that the first design does not need a door to keep the air in at night - it will not escape out the collector because hot air rises and has no desire to flow down through the collector.

The second design needs a door at the top of the collector which is opened in the day and closed at night This is not an insuperable problem, but it is important to get a tight fitting door and then the door must be operated either manually with a rope or automatically by means of balanced freon cannisters much as the skylid works. We have tried both systems - the freon door is best since it never forgets to open or close but the problem of constructing and balancing a door as long as the collector is wide that doesn't warp as it ages or become hot is not easy or cheap to solve.

I think that in some instances the best solution is to build a system such as
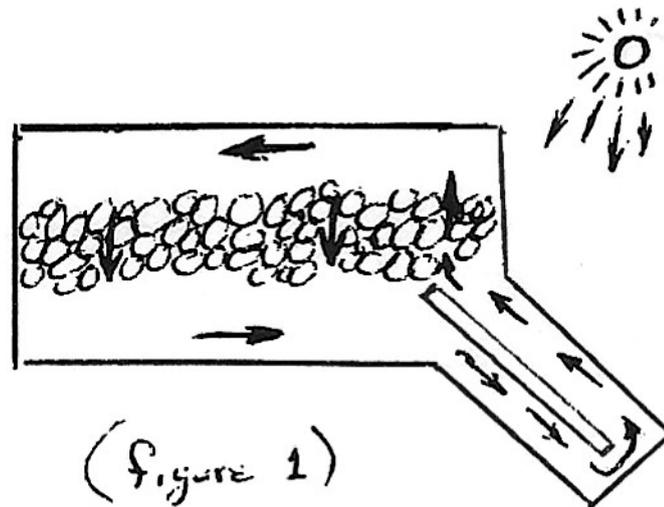
(figure 1)

(Sidelight on the evolution of design - the person constructing the solar heater had visited our neighbors' air loop rock storage heating system and evidently misunderstood how it functioned because he explained that his worked in the same way. I am looking forward to hearing how it works this winter since the difference in design may be an advantage.)

The advantage of this design where the collector ends at the bottom of the bin
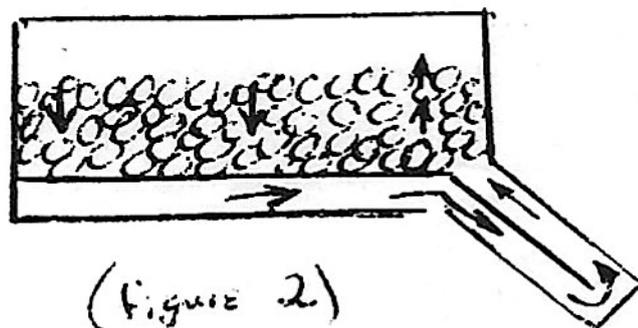
(figure 2)
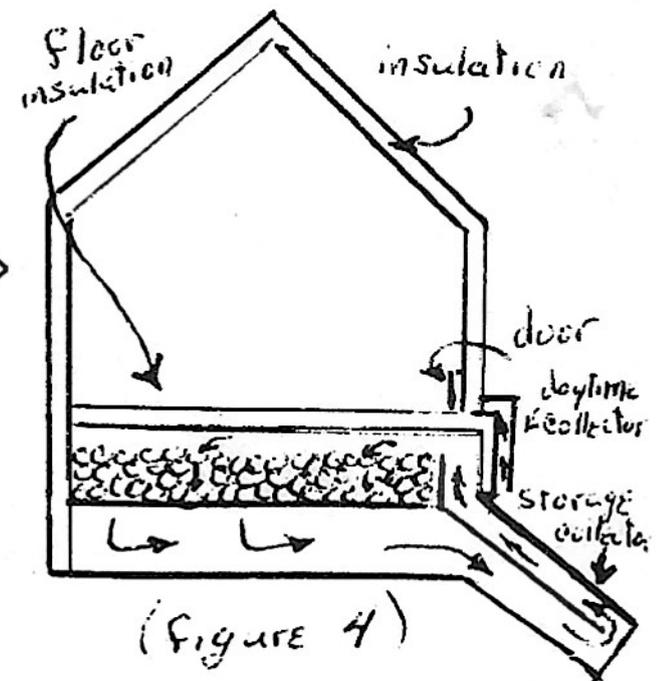
(figure 4)

in which the collector ends at the bottom of the rock bin where it releases the air to flow up inside the insulated wall and then back down through the rocks.

Then rather than leave the south facing wall of the bin blank a second perpendicular collector can be built over the wall and fed directly into the house with small doors with which it can be shut off. It can heat outside air or be fed return air from the house or rock bin via ducts.

The advantage of this design is that you need no doors or control mechanisms. The system works by itself automatically adding heat to the storage whenever it is sunny.

SIZING COMPONENTS

How big a collector? How big a storage bin?

A large rock bin coupled to a small collector will warm only slightly during a day of collecting.

A small rock bin coupled to a large house with great heat loss will cool considerably when supplying heat during the night.

What kind of relationship should there be between the size of the house, the size of the collector and the size of the storage bin? The most essential part of the construction of a solar heated house is to make the house tight and well insulated so that it does not require a great deal of heat. In New Mexico the roof should have 6 to 9 inches of fiber-glass insulation, the walls should have 6 inches, the footings should have perimeter insulation. The windows should be double glazed.

We will take two box shaped houses and calculate the heat loss through the walls and ceiling assuming there are insulated walls and ceiling with 6'' of fiberglass insulation giving a total resistance to heat loss of 20 or equivalently that 1/20th of a BTU flows through each square foot of wall each hour for each degree difference in temperature there is between one side and the other.

Box # 1
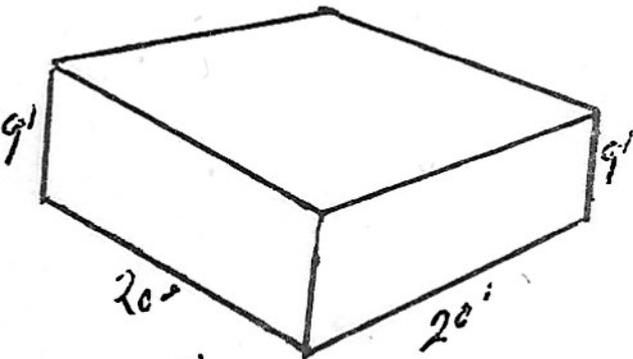
(figure 5)

total surface, walls and ceiling = 400 + 4 (180) = 1120 sq. ft.
heat loss = 1120 sq. ft. x 1/20 BTUs/ sq. ft. hr. ° F. x 24 hrs. x = 1344 BTUs/day ° F. Perimeter heat loss (assuming perimeter insulation)
4 (20) ft. x ½ BTU/ft. hr. ° F x 24 = 960 BTUs/day ° F.

Air change heat loss - assuming we change the air in the house every 4 hours.

400 sq. ft. x 9 ft. x 1/15 lbs./sq. ft. x ¼ specific heat air x 6 changes/day x = 360 BTUs/day °F.

In calculations for the box we are omitting losses through windows - which can be very great if they are located on the north side of the house - or can be balanced out by the sun which shines through them on the south side of the house.

Omitting windows then we find that the box loses 1344 + 960 + 360 = 2664 BTUs/ day ° F.

So that if we take a cold winter day in Albuquerque where over the 24 hours the temperature averages 20°F then if the box is kept at 65 degrees it will lose 2664 (65-20) = 119,880 BTUs/day.

How big a collector do we need to capture this much heat? A good air loop collector can capture and store about 800 BTUs/ day sq. ft. during clear winter weather.

$$\frac{119,880}{800} = 150 \text{ sq. ft. of collector.}$$

But we would like to have some heat left over after this cold day in case it's cloudy the next day - so let's size the collector for this 400 sq. ft. box at 200 sq. ft.

How much storage do we need? Let's say we want enough so that if we have our rocks at 110 degrees F they can take us through 2 days as cold as the one we have described. The rocks are useful until they fall to about 75 degrees F. One pound of rock stores 1/5 of a BTU for one degree F.

(119,880) x 2 = X lbs. x 1/5 (sp. ht. rock) x (110-75)   239,760 = X (7)
x = 34,251 lbs. rocks

Rocks take up about 100 lbs./cubic foot So we need about 340 cubic feet of rocks to store heat or a layer a little less than one foot deep under the entire floor.

Box # 2
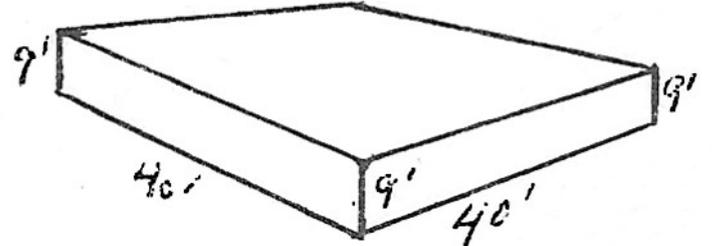
(figure 6)

Total surface walls and ceiling   1600 + 4 (360) = 3040
Heat loss = 3040 sq. ft. x 1/20 BTU./sq. ft. hr. x 24 hrs x   = 3648 BTUs/day ° F.
Perimeter: 4(40) ½ BTU/ft ht. F x 24 = 1920 BTUs/day°F.

Air change: 1600 sq. ft. x 9 ft. x 1/15 lbs./ cubic ft. x ¼ sp. ht. air x 6 changes/day = 1440 BTUs/day ° F.

3648 + 1920 + 1440 = 7008 BTUs/day ° F.
(7008) (65-20) = 315,360 BTUs/day
315,360/800 = 394 sq. ft. collector + fudge factor = 500 sq. ft..collector
(315,360) (2) = x lbs x 1/5 x (110-75)
630,720 = 7X
X = 90,102 lbs. rock =
900 cubic feet rocks

900/1600 = .5625 ft. = 6 ¾'' of rocks under entire floor.

Are these sensible assumptions to make about houses? Few houses are as well insulated as the two boxes I have described, but there is no reason they cannot be. There would be additional heat loss through the perimeter from the storage bin which would need extra thick insulation to protect the above 100 degree temperature.

The house should be insulated from the storage bin by at least 6'' of insulation below the floor. The ground directly below the storage bin should perhaps be insulated.