# THE DROP CITY CONVECTIVE ROCK LOOP HEATER

The rocks from the river were placed in an insulated reinforced box - tied together with cross wires to prevent its bursting. The hot air rises in the solar chimney collector and then discharges into an air space above the bin filled with rocks - the pressure of the warm air in the chimney behind it pushes the air down through the rocks. The hotter the rocks get and the deeper in the box they are warmed, the slower the air circulates - for the head of warm air on the storage side of the loop begins to balance the head of warm air in the collector. Of course, as soon as the circulation is slowed the air in the collector is super heated as it lingers next to the hot metal - which gives it more bouyancy and extends the will of the system to circulate.
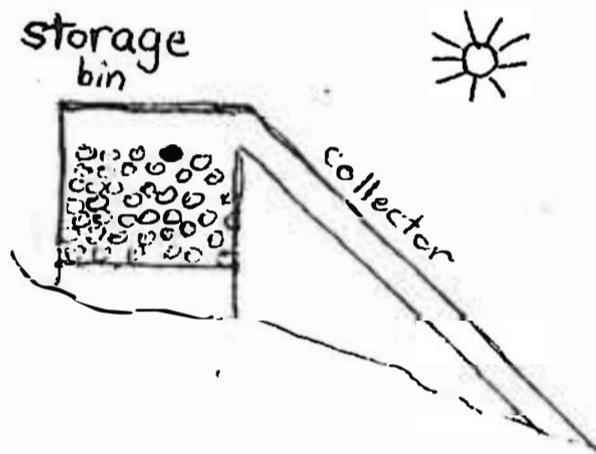
In order for the heat to be distributed among the rocks the hot air must enter at the top rather than at the bottom. If the hot air entered at the bottom it would not heat the rocks equally, but would instead burn a chimney through the bin of rocks. This must be qualified: If the box were left alone long enough with hot air entering the bottom all the rocks would be heated since means of heat transfer - convection, conduction and radiation - would finally spread the heat throughout the box. The will of the system is to find the easiest way from the bottom to the top and once it succeeds in warming a path to the top this becomes a warm chimney which the air prefers since it remains warm and bouyant on this path - whereas if it departs and attempts a circuit through the neighboring cold rocks it will be cooled - will become more dense and thus be discouraged from rising through the bin.

This is a very poor arrangement to take the heat from a stream of air since the system's will is at cross purposes to the designer's. All these problems are solved if the hot air is introduced at the top of the bin and forced down through the rocks. Then the air, instead of following the warmest path through the rocks, follows the coldest path because the cooler the air is the more dense it is and the easier it is to descend through the rocks. Hot air entering at the bottom becomes addicted to a pathway and does not want to depart from it.

Hot air entering at the top fowls its own pathways by warming them and thus continues to hunt about the bin for cool rocks where it may descend more easily.

In the construction of a rock storage bin the rocks should be distributed in a pancake rather than a column - a broad shallow container is far preferable for the transfer of heat to the rocks than a tall thin container. The reason for this is the resistance to flow presented by the rocks. A filter which is tall and narrow. If there is a great deal of resistance the convection loop can't operate efficiently because it moves so slowly that the air overheats and this, as always, reduces the efficiency.

The disadvantage to shallow broad heat storage bins is that they take up more space than a compact deep one and if they are built outside of the house they suffer a great deal more heat loss.

For instance a container of volume 64 cubic yards can be shaped
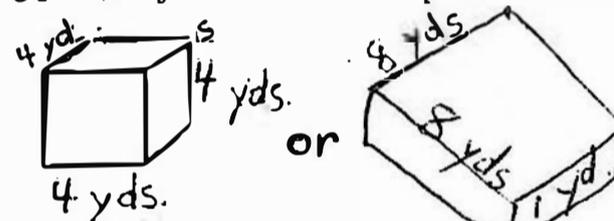
The broad shallow container is preferable for the flow of air, but is a poor place to hold heat because its large surface area loses heat rapidly.

Luckily the bin of rocks can sometimes be placed within the house itself or directly under it.
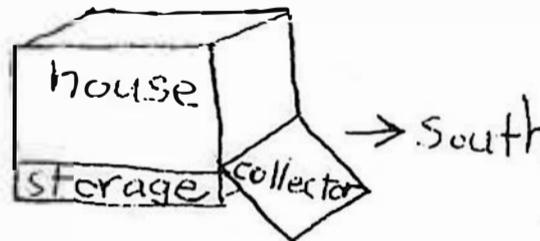
One discouraging aspect of the kind of rock storage bins I have been describing is that the air must flow past the rocks even when it has no useful business with them. Our whole reason for running the air through the rocks is to transfer the heat from the air to the rocks. We place a great deal of resistance in the way of the flowing air to accomplish this. It is a shame, then, after the rocks have already received heat from the air, to have to continue pushing air past them - this takes work, for the pathway is tortuous

and resistant. The only zone where something useful happens is where there is a marked difference in temperature between the air and the rocks.

This is perhaps somewhat too specialized a discussion of a not very serious problem in heat storage, but one answer that would eliminate the unnecessary friction is interesting to consider.

A storage bin with the air entering at the top could have by-passes (open passage ways) with little friction - the air would follow these to a depth where the rocks became cold and then seep out through the cold rocks where it could lose bouyancy and easily descend.

space. If spherical rocks remained in a checkerboard pattern, each touching only six neighbors, they would occupy

$$\frac{\frac{4}{3}\pi R^3}{(2R)^3} = .5236$$

of the volume.

This is not the case - the rocks shift to a closer packing which can be seen in any pile of oranges in a market and the void space shrinks to about 26%. Then everywhere that we slice through our rock storage bin we are going to find somewhere in the neighborhood of 25% of the area of the cut to be void, and thus a passageway for air. All of the passageways interconnect and although some become pinched at places, the general flow of air is not badly discouraged by constrictions.

We never want to ask the air to flow rapidly through the rocks. This would require considerable pressure and means installing fans or having a very fine collecting site with a long steep south slope for a solar chimney. What do we mean by fast? In a solar chimney

SURFACE AREA IN A CUBIC YARD OF ROCK

If we assume that rocks are round and join each other in a checkboard grid we find that a cubic yard of rocks of diameter----- has the following surface area:

DIAMETER	No. of ROCKS	SURFACE/ROCK	TOTAL SURFACE
1" =	36^3 = 46656	$4\pi(\frac{1}{2}")^2$ = 3.142 sq."	113 sq. yds.
2" =	18^3 = 5832	$4\pi(1")^2$ = 12.5664 sq."	56 sq. yds
3" =	12^3 = 1728	$4\pi(1\frac{1}{2}")^2$ = 28.27 sq."	37.7 sq. yds.
4" =	9^3 = 729	$4\pi(2)^2$ = 50.256 sq."	28.3 sq. yds.
6" =	6^3 = 216	$4\pi(3)^2$ = 113.09 sq."	18.85 sq. yds.
9" =	4^3 = 64	$4\pi(4.5)^2$ = 254.5 sq."	12.56 sq. yds.

These enormous surface areas account for the rapid transfer of heat from the air stream to the rocks.

What flow channel exists through the rocks? This depends on the percentage of void that is left between the rocks. You can easily tell by filling a 5 gallon can with a sample of the rocks and then seeing how much water can be poured in among the rocks. The more nearly uniform in size the rocks are the greater the void space. When the rocks are big and small the small rocks fit in the voids between the big rocks and, although the small rocks in turn have voids between themselves as they pack the larger voids, they have already largely occupied the possible void

it is easy to get the air to flow over 100 ft/min which comes out to be a little over 1 mph. In one long chimney I built I frequently got air speeds above 400 ft/min.

It's very exciting to build a solar chimney in the wintertime and stick your face at the exit and feel the warm air blowing out. The mechanism, consisting only of black insulation and clear plastic or glass and the air inside and the sun seems magic in its ability to create both warmth and a breeze.