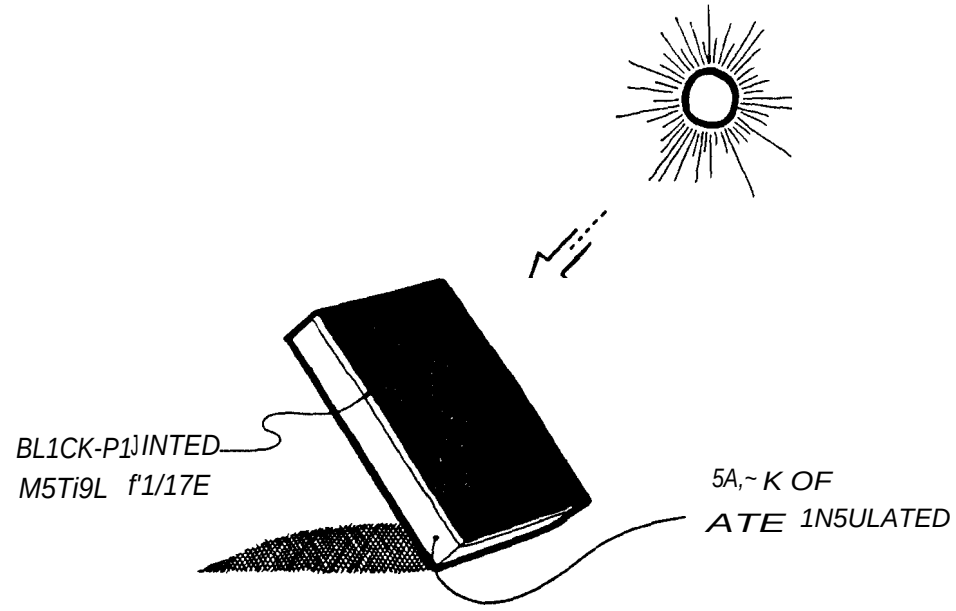
A SIMPLE SOLAR COLLECTOR 11

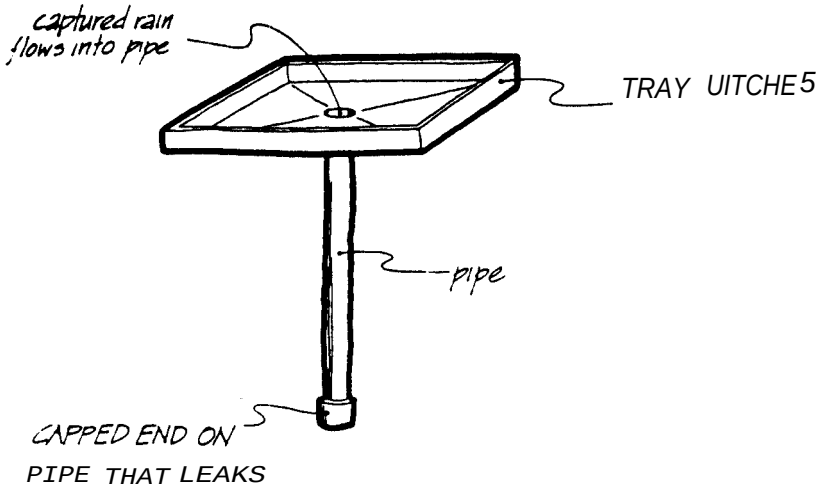
Now we need to learn what a solar collector is. The simplest kind of flat-plate solar collector is just a black-painted metal plate with a layer of insulation on the back side. It's painted black because black best absorbs solar radiation, as we discussed in Chapter 9. Since Insulators prevent heat from conducting through them, the insulation on the collector prevents heat loss from the collector's back side.

If we faced the plate toward the sun at noon, It would begin to get hot as it absorbed solar heat. How hot would It get?



A Simple Solar Collector

We can learn a lot about a solar collector by thinking of It in terms of a rainwater collector. Imagine that we are building a device to collect rainwater. As a start, we get a big tray to catch the rainwater, just as a solar collector "collects," or absorbs, solar radiation. We attach a capped pipe to the tray so that all the rain falling in the tray will flow down the pipe and be caught.

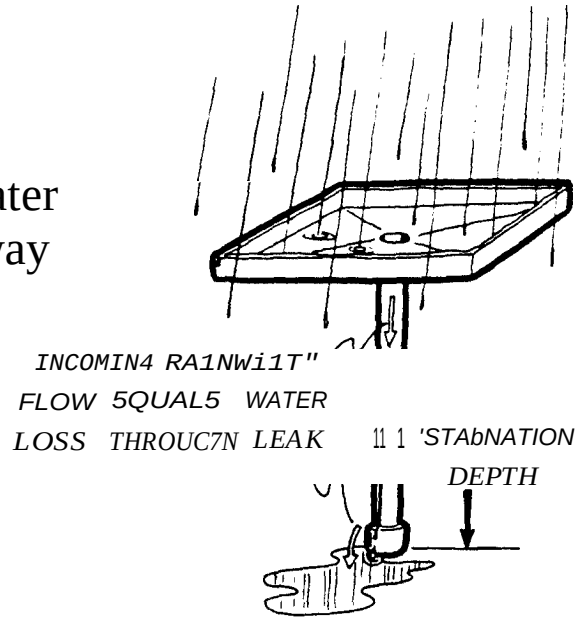


A Rainwater Collector with a Leaky Pipe

Suppose the only capped pipe we can find is one that leaks. As the tray collects rain, the pipe fills; but rainwater flows out through the leak. The deeper the water gets,in the pipe, the more water leaks out. At some point the depth gets so high that the flow out the leak balances the incoming flow of rainwater. Once this point is reached, the water gets no deeper. When the incoming rainwater exactly balances the outgoing water loss through the leak, the depth of water in the pipe Is at Its *stagnation* depth.

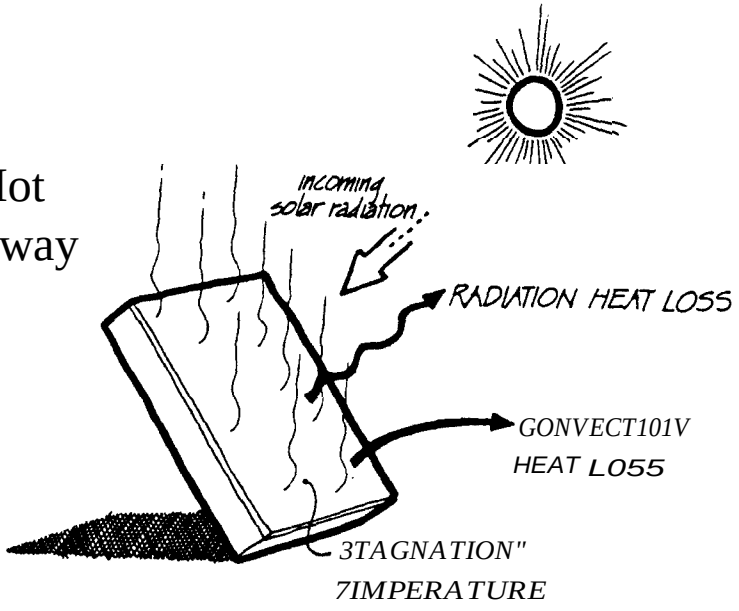
Similarly, the stagnation temperature Is how hot a collector gets when the Incoming solar radiation exactly balances the heat losses that take place by radiation and convection. To continue our analogy, the tray captures rainwater as the solar collector captures solar radiation. Just as the water in the pipe gets deeper and deeper, so does the temperature of the plate become hotter and hotter. And just as more water flows out through the leak as the water In the pipe gets deeper, so more

Pipe Fills
as Rainwater
Leaks Away



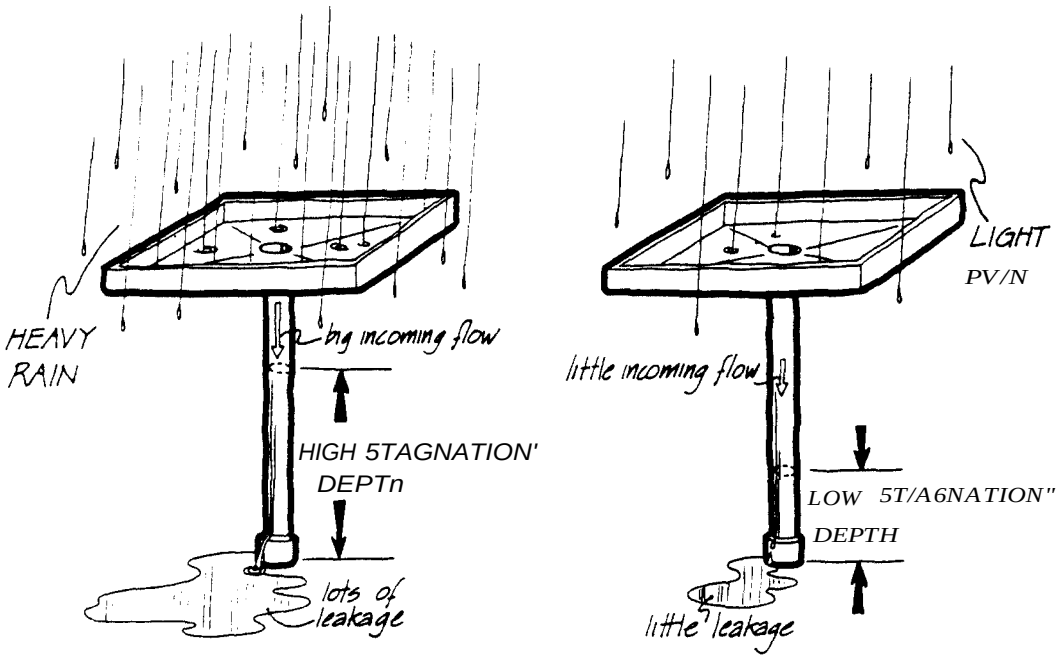
heat leaks off the front of the solar collector by radiation and convection as the plate gets hotter. At some point the plate gets so hot that the heat losses exactly balance the Incoming solar radiation. Once this point is reached, the plate gets no hotter.

Collector Gets Hot
as Heat Leaks Away



The stagnation temperature of a surface-the hottest a surface exposed to the sun can get-depends on how much solar radiation is absorbed. The amount of radiation absorbed depends on the color of the surface, the angle of the sun's rays striking the collector, and how much sunlight actually strikes it. The best setup to use to absorb solar radiation is the one just described: a black surface squarely facing the sun on a clear day. A light-colored surface, a surface not directly facing the sun, or an overcast day will reduce the amount of solar radiation absorbed by the surface.

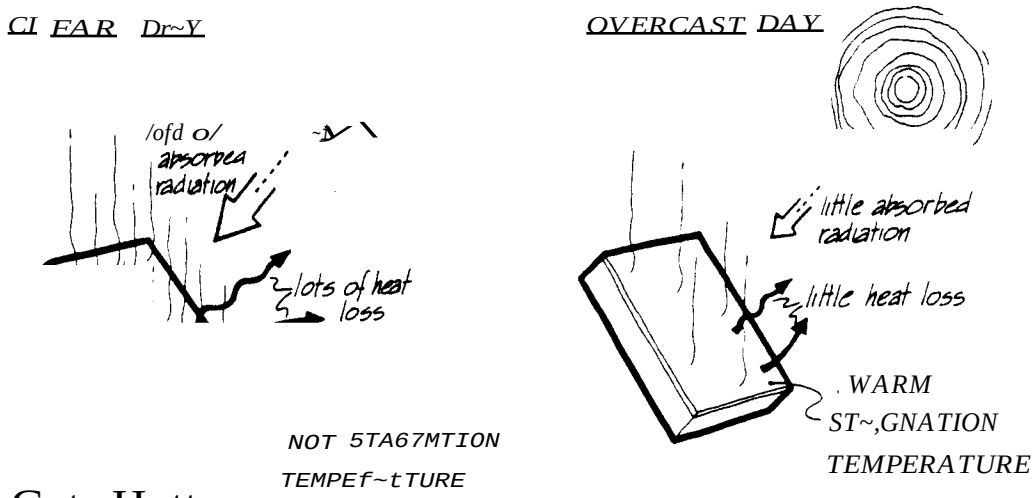
How will less absorbed radiation affect the stagnation temperature? Let's use the analogy of the rainwater collector again to understand what happens. Suppose a light rain is fal li ng on the tray rather than a heavy rain-that's comparable to l ess solar radiation striking the solar collector. With less rain falling, the tray collects less and the incoming rainwater flow is l ess. Recall that when we discussed house heating, we found that a lower water depth in the bucket resulted in less flow out through the bucket's holes: high depths are associated with high leakage; low depths, with low leakage. Thus, if less rain-water is flowing down the pipe, the depth needn't be as high to force all of the incoming water out through the holes. The water i n the pipe wouldn't be as deep before the flow out through the



Pipe Fills Higher with Heavy Rain

holes balanced the Incoming rainwater flow. We can conclude from this that if the incoming rainwater is less, the stagnation depth also goes down.

How can we apply this analogy to the solar collector? We would expect the stagnation temperature to be less if the absorbed solar radiation was less (since the stagnation depth was less when the rainfall was less). When less solar radiation is absorbed, our simple solar collector starts to get hot. It will lose more and more heat as It gets hotter. Eventually the heat losses will equal the amount of solar radiation absorbed. But since the solar radiation absorbed Is less, the collector won't be very hot when the losses balance the absorbed radiation.



Collector Gets Hotter with More Sun

How hot our simple solar collector gets depends on how much solar radiation it absorbs. We've gotten the plate hot, but we haven't gotten any heat from it yet-the plate may be collect ing solar radiation, but it's not doing us any good. You can't pay your heating bills with a hot black plate. We want heat from a solar heating system, not temperature.