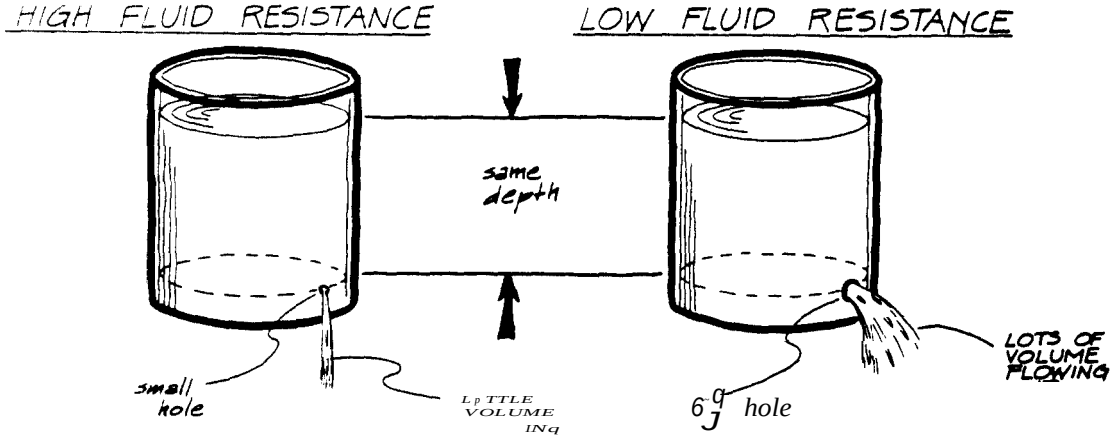
THERMAL RESISTANCE

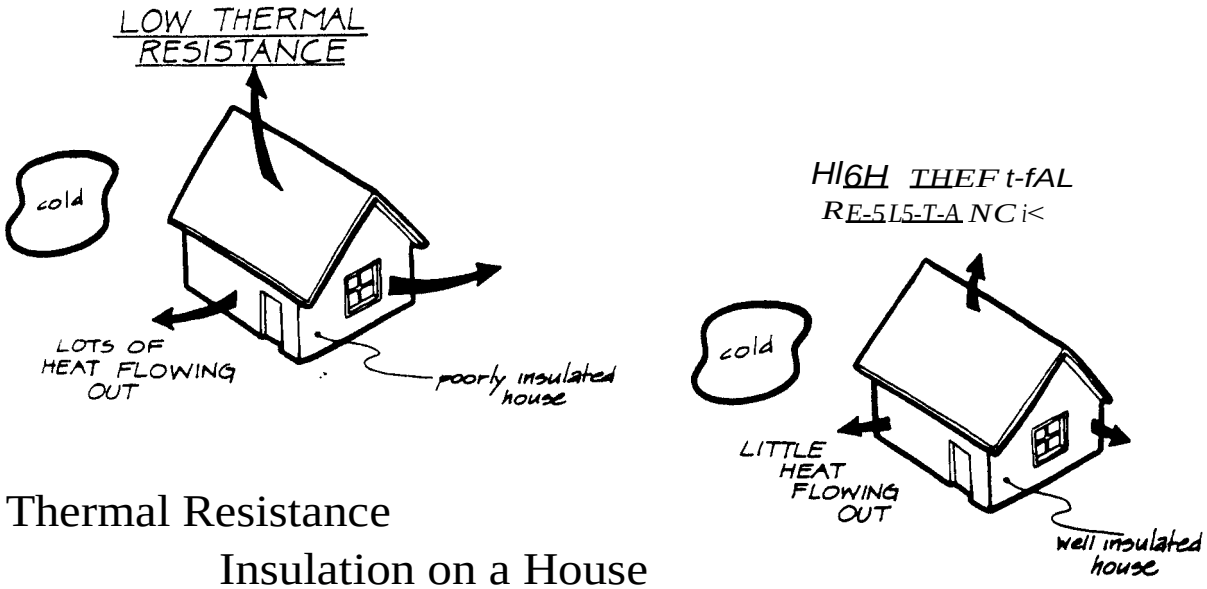
Temperature differences are what cause heat to flow: heat flows from hot things to cold things. But other factors determine how *fast* the heat will flow. These other factors, when lumped together, cause a *thermal resistance.* The bigger the thermal resistance, the harder it is for heat to flow, since the resistance to the flow of heat is increased. *Resistance is* common to other forms of flow as well: electrical resistance restricts the flow of electric current, and fluid resistance restricts the flow of volume.

Fluid resistance might be thought of in terms of the size of a hole in the side of a container: a little hole has more fluid resistance than a big hole. The little hole doesn't let much volume out, but a big hole will, even though both holes are at the same depth. The little hole "resists" the flow of volume through it more than the big hole, so it has a high resistance.

Fluid Resistance: A Hole in Can



Similarly, thermal resistance is a measure of how hard it is for heat to flow. Sometimes we say one house is better insulated than another house, and that's exactly what thermal resistance is-how well insulated something is. Since a well-insulated house has a higher thermal resistance than a poorly insulated one, the well-insulated one loses less heat than the poorly insulated one. The temperature difference may be the same for both houses (room temperature inside and cold out. doors), yet heat will leak at a slower rate from the one with high thermal resistance-the well-insulated one.



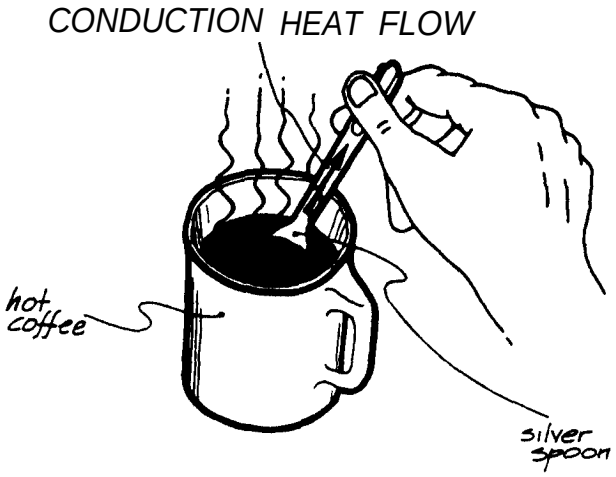
Thermal Resistance
Insulation on a House

The extent of thermal resistance is caused by several factors, depending on the way heat moves from place to place. There are four important types of thermal resistance, corresponding to each of the four important ways in which heat moves in solar heating systems. They are:

1. conduction
2. convection
3. radiation
4. transport

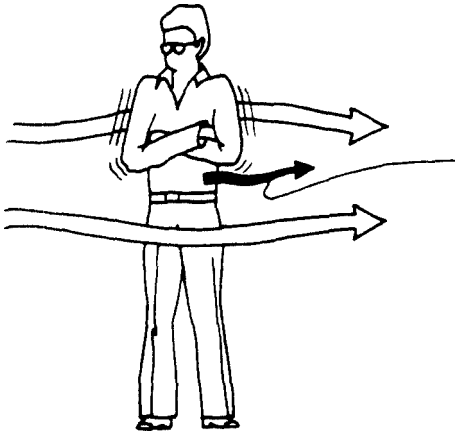
Before we look at each of these types of heat flow in detail, first let's see how they differ generally. As we have learned, heat is like water in that it flows from place to place. If it flows through material that isn't moving, the heat flows by

means of *conduction* heat transfer. For instance, a silver spoon is hot when you've been stirring coffee because heat flows easily through the silver from the hot coffee to your fingers. The silver itself doesn't move, but heat flows through it. When we show conduction we'll always use a straight arrow to distinguish it from the other ways in which heat flows.



Conduction Heat Flow

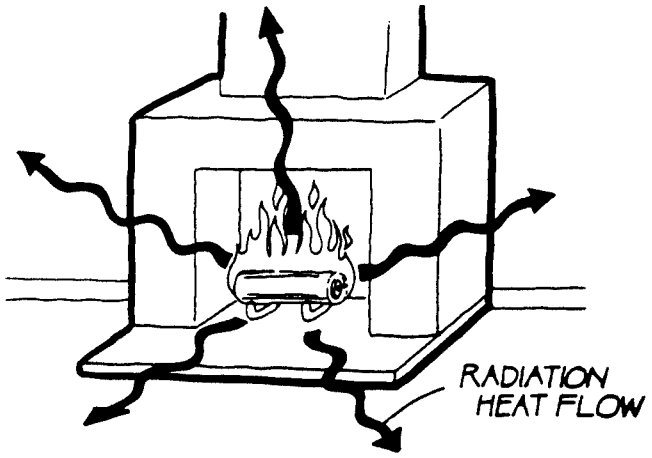
In *convection heat flow,* a surface heats a liquid or gas near it, and the heat is carried away by the liquid or gas. For example, you feel cold on a windy day because the wind carries heat away from your skin by convection heat transfer. We'll use a curved arrow (= ") to show convection heat flow.



Convection Heat Flow

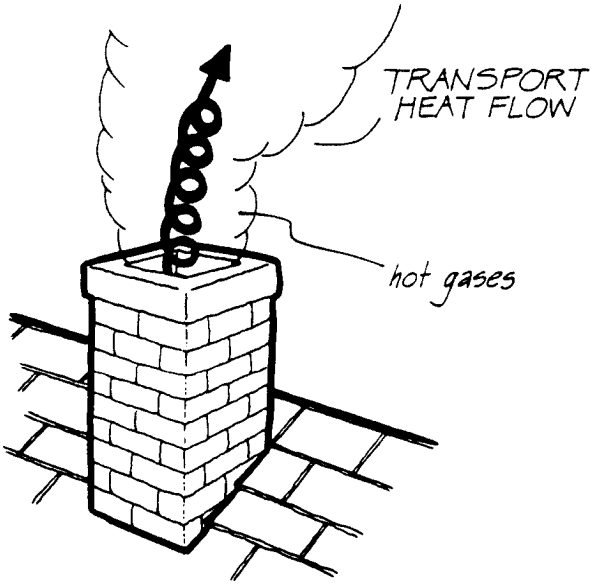
Radiation heat flow is a special kind of energy that travels like radio waves through air--and even through a vacuum. You feel warm in front of a fireplace mostly because the flames and

hot coals move heat to your skin by radiation. Wavy arrows will be used to show heat flowing by means of radiation.



Radiation
Heat Flow

Transport heat flow is similar to convection in that it involves the transport of a heated liquid or gas. But instead of a surface heating the liquid or gas, previously heated liquid or gas is transported, or moved, from one place to another. Hot gases rising out of a chimney is a form of transport heat flow. We'll use a curlicue arrow (OMa*) to indicate transport heat flow.



Transport
Heat Flow

Now that you have an idea of the ways heat flows in general, let's take a more detailed look at each way.