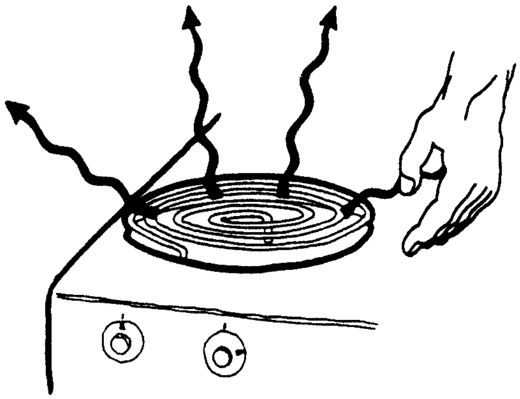
RADIATION AND TRANSPORT t~

Radiation heat flow is very similar to convection heat flow in many ways. Radiation heat flows from surfaces, as does convection heat flow. Radiation is also similar to convection in another basic way: the bigger the surface is, the more heat flows from the surface. Most surfaces lose heat by both radiation and convection, and it's sometimes hard to separate the two kinds of heat *flow*. For instance, the example used to illustrate convection-a cooling bowl and a cooling mug of soup-applies equally to radiation. The bowl loses heat quickly by both convection and radiation because the bowl has a bigger surface area. Some *of* the heat flow from both the bowl and the mug takes place by means of convection, and some by radiation.

However, radiation differs significantly from convection, especially with regard to solar energy. One big difference is that convection depends on a liquid or gas flowing by the surface. With radiation heat flow, the heat leaves the surface even if there is no gas or liquid around. In the vacuum of space, where no gas or liquid exists, heat flows from a space satellite only by radiation. Radiation heat flow is often called *infrared* radiation. Infrared film, for example, is sensitive to radiation heat flow; it is used to photograph heat leaving objects by radiation. We'll learn more about radiation heat flow when we discuss solar radiation-a kind of radiation heat flow that comes from the sun.

A second important difference between radiation and convection is that radiation heat flows from a surface in straight lines. If you put your hand to the side of a heating coil on an electric range, you would feel the warmth of the radiation heat flow. But if you put a book or even a piece of paper between the coil and your hand, it would block the radiation heat flow. Likewise, if you're sitting in front of a fire, the radiation heat flow from the embers is blocked if someone sits in front of you.



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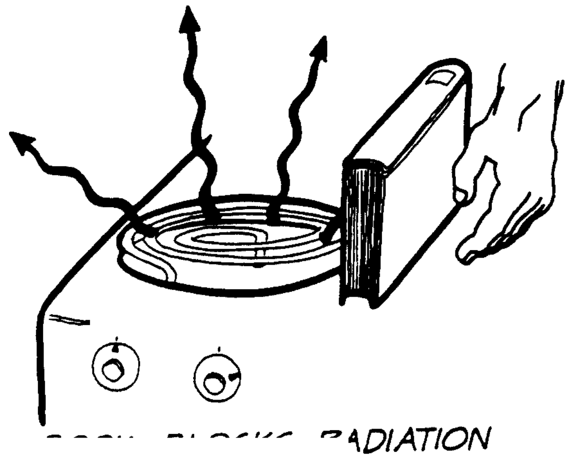


FROM COIL -

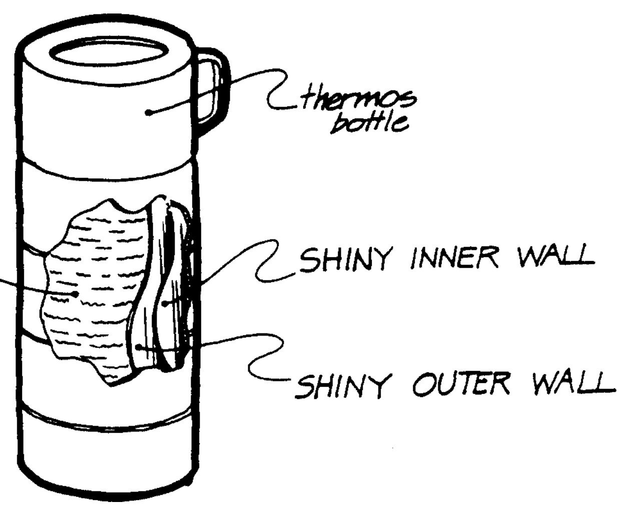
Radiation Heat Flow is Easily Blocked

As with all heat flow, radiation heat flow depends on temperature difference. The important temperature difference is that which the surface sees. In the case of the bowl, the soup's surface sees the temperature of its surroundings (the room), so the important temperature difference is that between the soup and the room. In the case of the hand, the skin's surface "sees" the coil, so the important temperature difference is that between the skin and the coil.

Shiny surfaces play a role in radiation heat flow because they reflect radiation. For example, a thermos bottle is "silvered" to reflect back any heat that the hot soup inside might

Shiny Surface Reflects Radiation Heat Flow

hot --cup

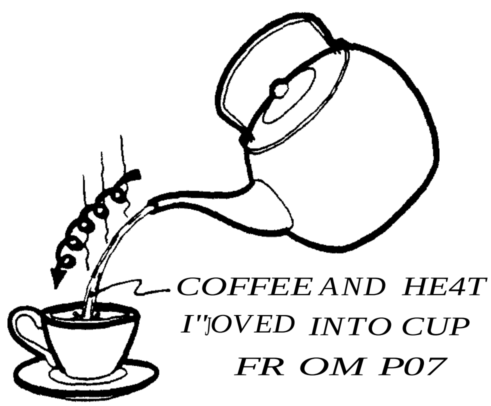


lose by radiation. This trick keeps the soup hot longer. Fiberglass batting used to insulate houses also has a shiny reflecting surface to keep heat in.

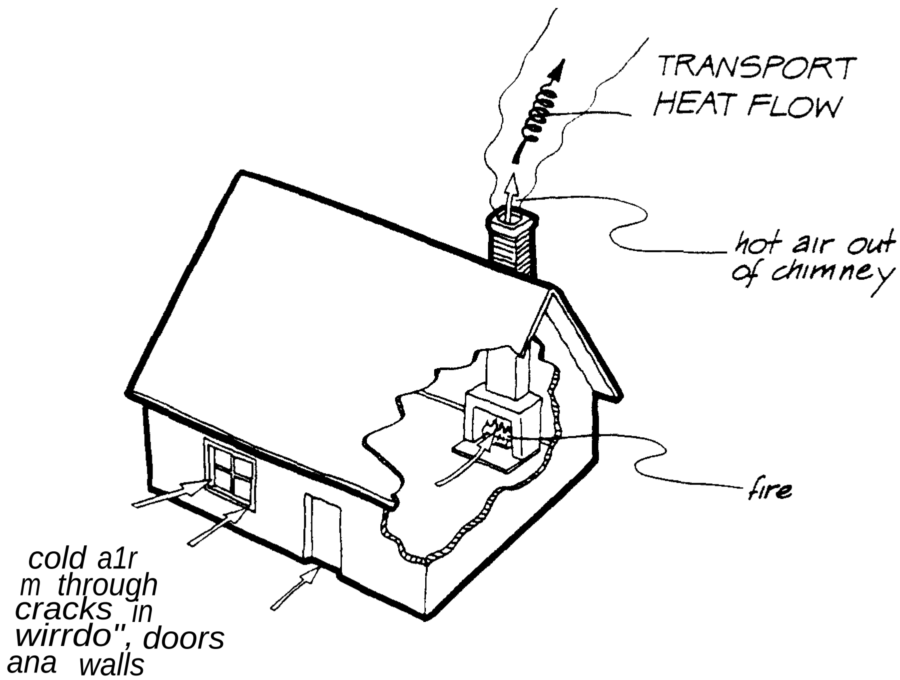
Radiation heat flow, then, is much like convection in one way: heat flows from surfaces at a rate depending on the size of the surface. But unlike convection, radiation heat flow travels in straight lines and can be very easily blocked from flowing. In addition, radiation heat flow can be affected by how shiny the surface is, whereas convection cannot.

Finally, let's discuss transport heat flow. Heat flow via a flowing gas or liquid is somewhat different from conduction, convection, and radiation. Suppose you wanted to heat up a cup of coffee by adding more hot coffee to it. When you add the coffee you're also adding heat, since the hot coffee has heat stored in it. Heat is physically transported from the pot to the cup by transferring a certain amount of hot coffee from the pot to the cup.

Heat Flowing by Transport



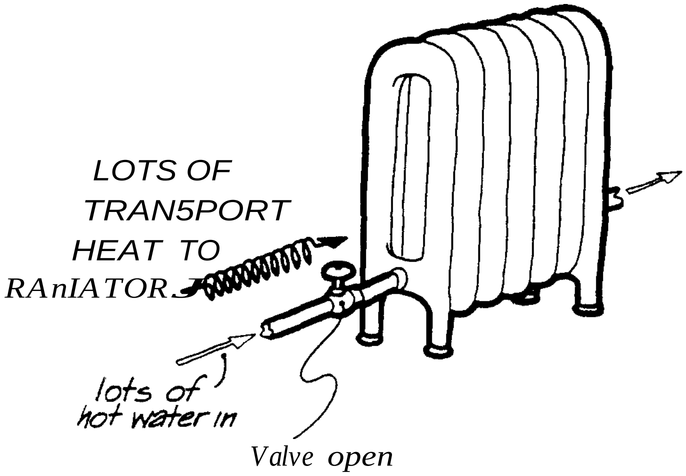
In most transport heat flow, the flowing gas or liquid moves continuously, not just for a short time, as in the example of the coffee and cup. To understand this, think again of the example of a house losing heat through its chimney. In this case, the flowing medium which transports the heat is a gas-mostly hot air. But for as much hot airthat goes up the chimney, there must be as much cold air that comes In from outside to replace it. The cold air isn't so obvious because it leaks in through cracks in the walls, windows, and doors. Nevertheless, as much cold air leaks in as hot air leaves. The air, then, moves continuously: it enters in through the cracks, is heated by the

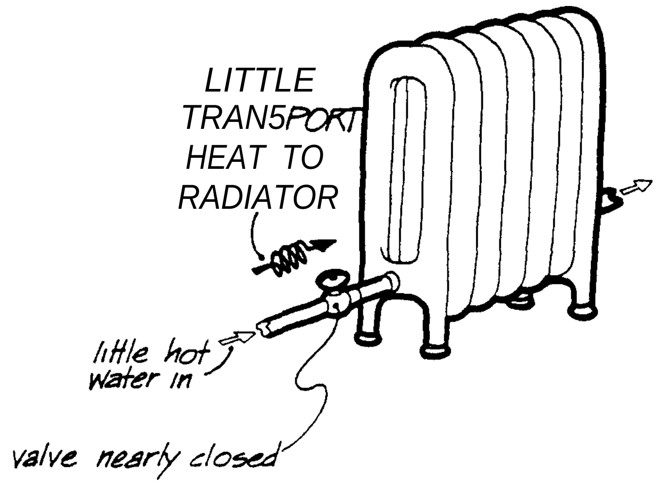


Transport Heat Flow up a Chimney

fire, and flows out through the chimney. As in conduction, convection, and radiation, the amount of heat flow depends on the temperature difference. In this case, the important temperature difference is that between the incoming airflow and the outgoing airflow-the temperature of the hot air going out the chimney minus that of the cold air leaking in through the cracks in the house.

Transport heat flow depends on two other factors besides temperature difference. One is how fast the gas or liquid is flowing, and the other is what the flowing medium is. To better understand the first factor, suppose your house were heated by hot-water radiators. Hot water flows in one end and out the other end; how fast it flows depends on how wide you open the valve. To get lots of heat out of the radiator, you open the valve so that lots of hot water will flow through the radiator. If you don't want much heat, you close the valve so that little hot water will flow into the radiator; It, in turn, will add little heat to the room.





More Transport With Fast Flow

The second factor in transport heat flow is the flowing medium itself. Air and water are the two most important *heat transfer* mediums used in solar heating systems today. The key difference is the volume needed. In this respect, water is a much better heat transfer medium than air. More than a thousand times more air than water is needed to transport the same amount of heat. Fans are often used to transport heated air, while heated water is generally moved by pumps.