# BUILDING IN ALASKA

EEM-00456

## Warm Floors Are Essential For Comfort

Axel R. Carlson
Extension Engineer Emeritus

In Alaska, wherever we work, play or rest, our legs and feet are nearest to the floors of our buildings and, thus, are quickly affected by floor temperatures. Cold surfaces carry heat away from our bodies by conduction and radiation. Thus, a cold floor can be a health hazard to children who play upon it and a discomfort to all ages.

Stratification of air is common with a cold floor; that is, warm air rises to the ceiling and colder air settles at the floor. This results in wide temperature differentials between the floor and ceiling. In addition, condensation may occur on a cold floor, although the dampness, which often results in a formation of mildew, may be concealed under rugs.

### Unheated Space

In Alaska most houses have some floor area exposed to unheated spaces, such as garages, porches, recessed entrances, cantilevered floors, and unheated basements and crawl spaces. Modern heating plants for homes are usually so well insulated that most basements require baseboard radiation, registers or stack robbers to keep them at a comfortable temperature. Basements of electrically heated homes are usually provided with minimum insulation and, for economic reasons, are not heated. Unless basement heat is provided, floors over basements should be classified as over an unheated space.

### Open Crawl Space

An even more serious problem is that many of the newer homes in remote villages are constructed over open crawl spaces for economy of construction and to avoid melting of permafrost. Although insulation is usually provided, the floors may still be uncomfortable to lightly clothed occupants, especially small children. Often the crawl space is closed in with plywood to make the house more comfortable. In some of the older houses, basements have been excavated and the wall scribbed in with lumber and sealed with polyethylene sheets. For maximum heating comfort, the space heater is often relocated in the basement with registers cut into the floor for distribution of heat.

Alaska Cooperative Extension
UNIVERSITY OF ALASKA FAIRBANKS

417/10-82/ARC/1200 Reprinted February 1997

The University of Alaska Fairbanks Cooperative Extension Service programs are available to all, without regard to race, color, age, sex, creed, national origin, or disability and in accordance with all applicable federal laws. Provided in furtherance of Cooperative Extension work, acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, Hollis D. Hall, Director, Cooperative Extension Service, University of Alaska Fairbanks.

Contrary to the belief of many inexperienced builders, basements and closed crawl spaces may be constructed on permafrost soils of uniformly graded sand and gravel with no problems with the foundations. However, building on permafrost with high silt content may result in serious foundation problems because of melting of ice lenses (large masses of ice formed in the silt) with resultant uneven settlement of the soil.

## FIGURING SURFACE TEMPERATURES

The surface temperatures (Ts) of floors or any other interior surface may be computed by the following formula if you know the outside temperature (To), the inside temperature (Ti), the total R-value (Rt) of the particular section, and the resistance of the interior film (Ri):

$$Ts = Ti — [Ri/Rt(Ti — To)]$$

EXAMPLE: A typical floor installed over an unheated space insulated with 2 inches of fiberglass would have an R-value of 10.15 as tabulated below:

| | |
|---|---|
| Exterior Film | 0.17 |
| 2" Fiberglass | 7.40 |
| 25⁄32" Subfloor | 0.98 |
| ¾" Flooring | 0.68 |
| Interior Film (Ri) | 0.92 |
| Total R-value (Rt) | 10.15 |

Assuming an outdoor temperature (To) of -40°F and an interior temperature (Ti) of 70.0°F., the interior temperature of the floors (Ts) may be computed as follows:

$$\begin{aligned} Ts &= 70.0 - \{ 0.92/10.15 \times [70.0 - (-40\text{-}0)]\} \\ &= 70.0 - \{0.92/10.15 \times 110.0\} \\ &= 70.0 - 10.0 = 60.0°F \end{aligned}$$

A more revealing technique, but more time consuming, is to display the temperature gradients of the entire section. The temperature gradients of a typical floor section with an open crawl space based upon temperatures of 70°F indoors and -40°F outdoors may be computed in tabular form as follows:

| | Insulation | | Temperatures | |
|---|---|---|---|---|
| **Material** | **R-Value** | **Percent** | **Differential** | **Gradients** |
| Exterior Film | 0.17 | 1.16 | 1.28 | -40.00 |
| ⅜" Plywood | 0.43 | 2.93 | 3.22 | -38.72 |
| 3" Fiberglass | 11.10 | 75.76 | 83.11 | -35.50 |
| Air Space | 1.08 | 7.35 | 8.09 | 47.61 |
| ¾" Plywood | 0.94 | 6.39 | 7.03 | 55.70 |
| Tile | 0.05 | 0.35 | 0.39 | 62.73 |
| Interior Film | .92 | 6.26 | 6.88 | 63.12 |
| TOTALS | 14.69 | 100.00 | 110.00 | 70.00 |

U = l/R = 1.0/14.69 = 0.068 BTU/Hr/°F/SF

*Figure 1. Uninsulated floor with closed crawl space*

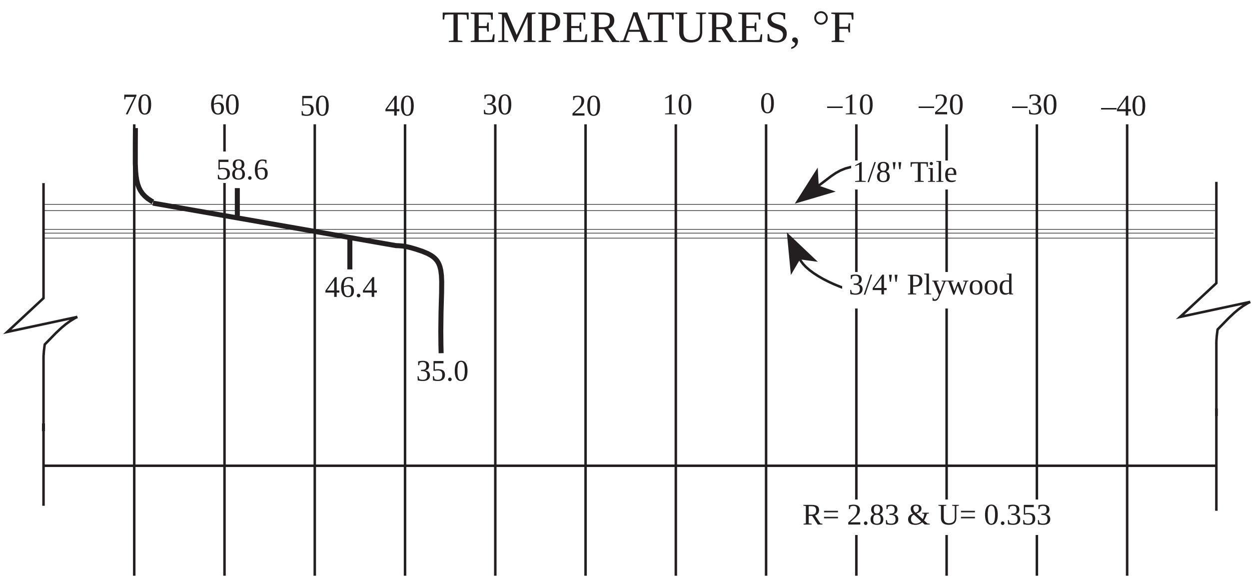



*Figure 2. Insulated floor with open crawl space*

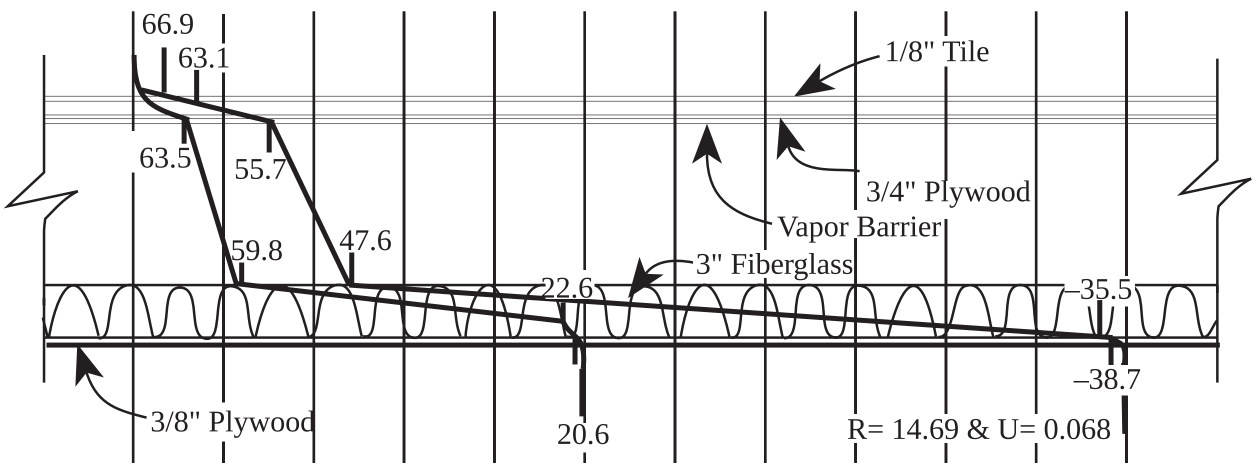



*Figure 3. Insulated floor with open crawl space and heated cavity*

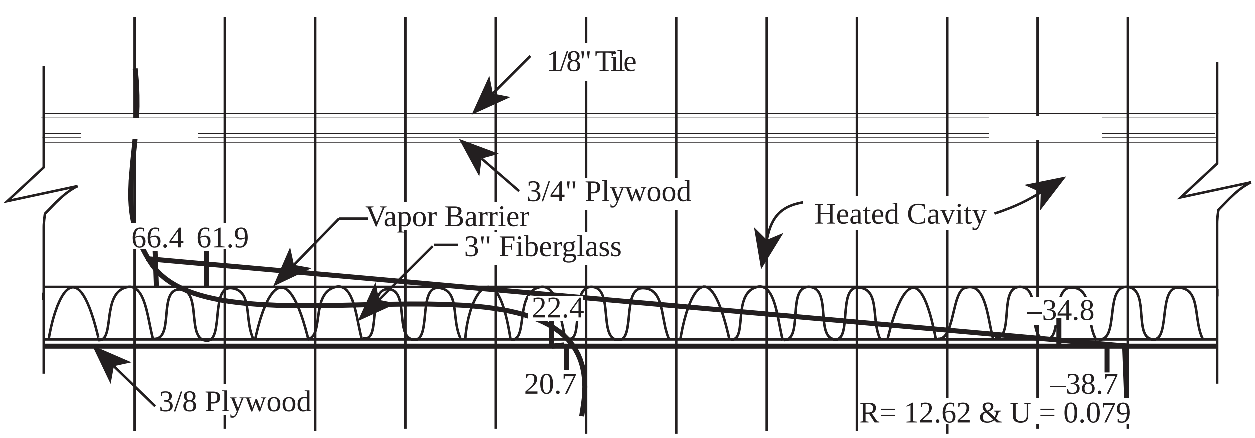
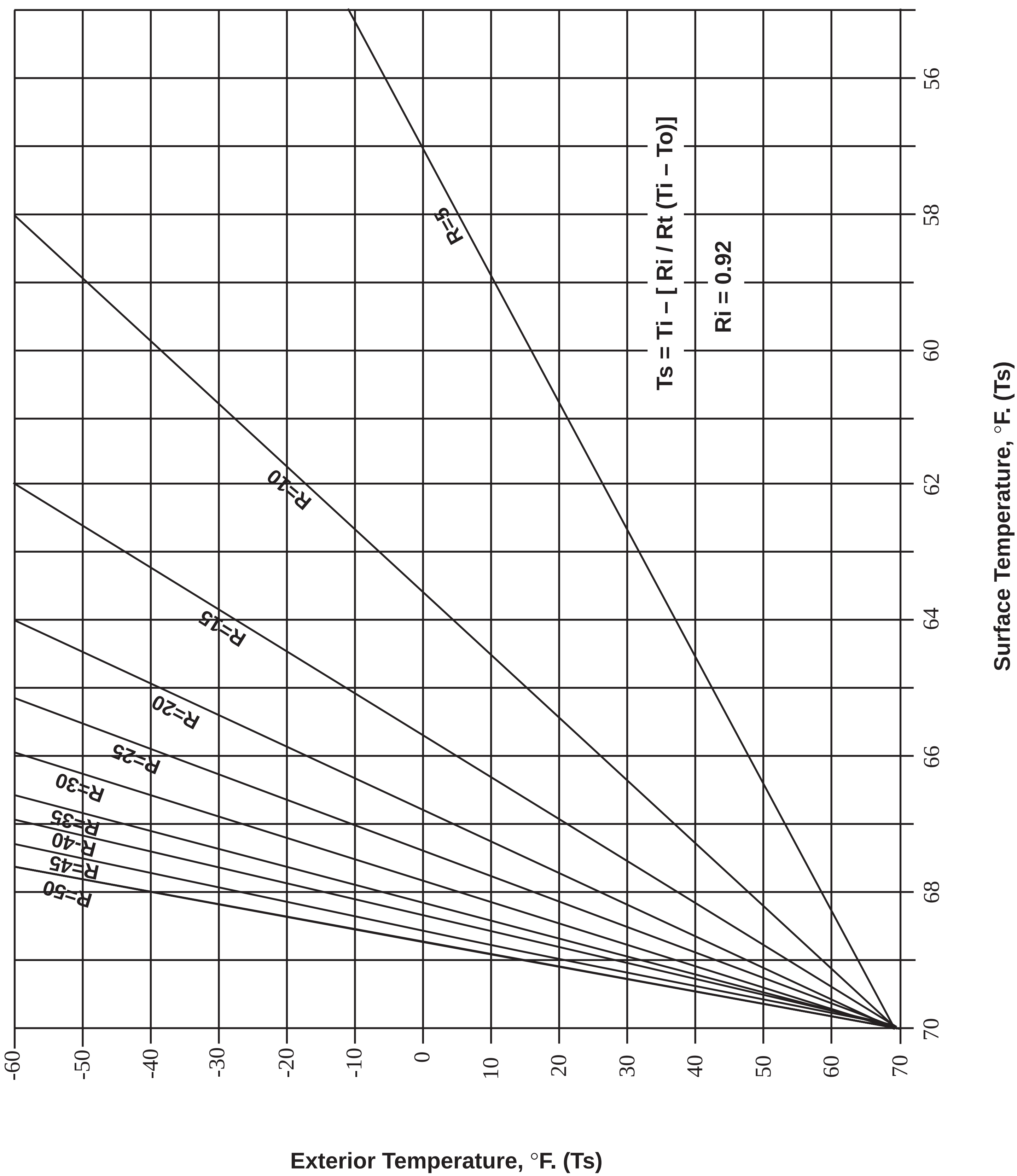


**Figure 4. Interior floor surface temperature at various insulation R-values and outdoor temperatures**



## Typical Floors

The temperature gradients of typical floor sections are illustrated in Figures 1-3. An uninsulated floor over a closed crawl space, as shown in Figure 1, has a floor surface temperature of 58.6°F at a crawl space temperature of 35.0°F. A floor over an open crawl space insulated with 3 inches of fiberglass (Figure 2) has a surface temperature of 66.9°F at 20.0°F outdoors and 63.1°F at -40.0°F outdoors. The effect of heating the crawl space is illustrated in Figure 3, where in the cold surfaces of 64.4°F and 61.9°F, respectively, are dropped to the surface of the insulation.

More detailed discussion of the effect of surface temperature on human comfort and how to correct some of these problems follows. The interior surface temperatures of other floors of various insulation R-values and various exterior temperatures, based upon an indoor ambient temperature of 70.0°F and an interior surface coefficient of 0.92, may be predicted from curves developed in Figure 4.

An uninsulated floor over an unheated space would result in excessive heat conduction and radiation from your body, if lightly clothed, even though heating requirements of the house might be relatively low. A typical uninsulated floor with an R-value of approximately 3.5 would have an interior surface temperature of 60.8°F at a crawl space temperature of 35.0°F. Thus, a person sitting at a table would eventually begin to suffer chilling of the legs and feet. A child playing on the floor would become thoroughly chilled unless dressed in warm clothing. A child moved from the floor to the crib would undergo radical temperature change of 9.2°F due to stratification of air. At the top of a bunkbed, the temperature would be nearly 80.0°F.

Hence, a floor over a closed crawl space should be insulated with at least 2 inches of fiberglass for a total R-Value of 10.15. At a crawl space temperature of 35.0°F., a floor surface temperature of 66.6°F is predicted. Only minor discomfort might be expected while sitting with legs under a table. A carpet and pad would increase the total R-value to 12.33.

A floor constructed over an open crawl space, even with the 2 inches of insulation, would become uncomfortable as outdoor temperatures approach zero. At zero outdoors, the floor surface temperature would drop to 63.6°F., at -40.0°F a surface temperature of 60.1°F would occur, while at -60.0°F a surface temperature of 58.3°F would occur.

Even providing the equivalent of 3 inches of fiberglass insulation for a total R-value of 13.85 would be inadequate for arctic conditions, as a surface temperature of 65.3°F would occur at zero outdoors. Therefore, a minimum of 6 inches of fiberglass insulation is recommended for floors constructed over open crawl spaces, which gives a total R-Value of 24.95, including the subfloor and finished floor. At zero outdoors, the 6 inches of insulation would result in a surface temperature of 67.4°F at -40.0°F outdoors, an interior surface temperature of 65.9°F would occur; while at -60.0°F a surface temperature of 65.2°F would occur.

During prolonged periods of subzero temperatures and continuous winds, a more effective and perhaps more economical method of providing a warm floor would be to force warm air into the floor cavity. Forcing warm air into the floor cavity would increase the structural heat loss through the floor slightly due to the turbulence of air movement. Normally, a surface coefficient of 0.92 would be expected; however, with increased turbulence a surface film of about 0.17 is expected which is equivalent to the exterior film with a 5-mile-per-hour wind. Compared with the total R-value of 24.95 for the floor insulated with 6 inches, reducing the surface film from 0.92 to 0.17 would result in an insignificant increase in structural heat loss through the floor.

### Heated Floors

Heating the floor cavity with warm air is not a new concept, as it has been used in mobile homes, in houses with crawl spaces, and for wood floors constructed over concrete basement floors. In a mobile home, a metal duct is often used for distributing heat to floor registers, while sufficient air is bled into the floor cavity to raise the floor surface temperature to a desirable level. However, it is rather difficult to provide an adequate vapor barrier in conventional floor framing systems. Hence, you can only depend upon the warm air that is bled into the floor cavity to remove any moisture that may condense in the insulation during colder outdoor temperatures. If the space between the joists is used as a duct, the resistance to air flow necessitates higher air velocities and temperatures to deliver adequate heat. The higher floor temperatures may even constitute a fire hazard if the floor joists are used as ducts without a metal liner. Also, the floor may become overheated and uncomfortable due to excessive radiant heat.

The effect of the cold surface of a concrete basement floor may be lessened by installing a wood floor over the concrete. The space between the two floors may be used as a plenum for distribution of warm air to floor registers, or a $\frac{1}{8}$-inch continuous slot around the perimeter of the floor may be installed. The floor nailers are set on metal chains leaving sufficient space between the floors for circulation of warm air. A down-draft furnace is commonly used for this type of hot-air heating system.

In a home with an open crawl space, a double floor with a 16- to 48-inch space between the two floors would be desirable. The space provides a convenient area for the installation and servicing of water and sewer piping and other mechanical equipment. The insulation and vapor barrier may be installed in the lower floor. The lower floor may be constructed of 2 x 6 joists and a $\frac{3}{8}$-inch plywood floor, while the upper floor may be constructed of 2 x 10 joists and a $\frac{5}{8}$-inch subfloor with a finished floor as desired. The space between floors may be used as a plenum for a down-draft furnace with registers, or a $\frac{1}{8}$-inch continuous slot may be installed around the perimeter. Metal ducts may be used for distributing heat to floor registers with a heat outlet in the cavity to heat the upper floor to the desired temperature. Also hot-water baseboard radiation maybe used for heating the main floor with thermostatically controlled unit heaters or baseboard radiation to heat the floor cavity.

A double floor would be more expensive to construct than a single floor. However, it is possible to reduce the framing costs somewhat by the use of lumber-plywood I-beams spaced at 4-, 6-, 8- or 12-feet centers, depending upon the span. The I-beams may be constructed of 2 x 4 or 2 x 6 flanges nailed to both sides of $\frac{1}{2}$- or $\frac{5}{8}$-inch plywood webs, depending upon the span and spacing. Then 2 x 4 purlins are placed between the I-beams to support the top and bottom floor. The insulation and vapor barrier may be installed between the lower flanges so that it is adequately sealed against moisture migration. The cost of the lumber plywood I-beam floor framing system could be reduced further by supporting the house on

2 rows of posts and beams instead of the usual 3 or 4 rows of post beams of conventional floor joists. Space does not permit a more detailed discussion of the design of the lumber-plywood I-beams.

With proper heat distribution, a 24' x 24' home with limited interior partitions could be adequately heated by a single, centrally located space heater. Using a double floor, a small circulating fan mounted in a vertical duct could pickup warm air at the ceiling and force it into the plenum between floors to floor registers; or a ⅛-inch continuous slot may be cut into the perimeter of the upper floor (Figure 5). A similar system was developed by the USDA for heating low-cost housing with an insulated crawl space.

In summary, we have suggested that it is possible to verify surface temperature of floors or other interior surfaces with modern portable temperature-sensing devices. It is possible also to measure the insulation R-values of any section of unknown internal construction by simultaneous measurement of: (1) the interior ambient temperature, (2) the exterior temperature, and (3) interior surface temperature of the section in question and inserting the values in the formula discussed in a previous paragraph. However, you must be careful in adjusting the exterior film to appropriate wind conditions or an erroneous R-value may be obtained, particularly with sections of low-insulation values.