largely by the nature of the surface and the temperature difference between the boundary surfaces of the air space. Conduction and convection are controlled largely by the width and shape of the air space and the roughness of the boundary surfaces. The thermal resistances of air spaces bounded by extended parallel surfaces perpendicular to the direction of heat flow and at different mean temperatures have been determined for average building materials at the University of Minnesota in a cooperative research program with the Society.

The values given in Table 1 show the results of this study and apply to air spaces bounded by such materials as paper, wood, plaster, etc., having emissivity coefficients of from 0.9 to 0.95. The conductivity coefficients decrease with air space width until a width of about ¾ in. has been reached, after which the width has but very little effect. In these

Table 1. Conductances of Air Spaces[a] at Various Mean Temperatures

Mean Temp Deg Fahr	Conductances of Air Spaces for Various Widths in Inches						
	0.128	0.250	0.364	0.493	0.713	1.00	1.500
20	2.300	1.370	1.180	1.100	1.040	1.030	1.022
30	2.385	1.425	1.234	1.148	1.080	1.070	1.065
40	2.470	1.480	1.288	1.193	1.125	1.112	1.105
50	2.560	1.535	1.340	1.242	1.168	1.152	1.149
60	2.650	1.590	1.390	1.295	1.210	1.195	1.188
70	2.730	1.648	1.440	1.340	1.250	1.240	1.228
80	2.819	1.702	1.492	1.390	1.295	1.280	1.270
90	2.908	1.757	1.547	1.433	1.340	1.320	1.310
100	2.990	1.813	1.600	1.486	1.380	1.362	1.350
110	3.078	1.870	1.650	1.534	1.425	1.402	1.392
120	3.167	1.928	1.700	1.580	1.467	1.445	1.435
130	3.250	1.980	1.750	1.630	1.510	1.485	1.475
140	3.340	2.035	1.800	1.680	1.550	1.530	1.519
150	3.425	2.090	1.852	1.728	1.592	1.569	1.559

[a]Thermal Resistance of Air Spaces by F. B. Rowley and A. B. Algren (A.S.H.V.E. Transactions, Vol. 35, 1929).

coefficients radiation is a large factor, and if surfaces with low emissivity coefficients are substituted for ordinary building materials the total amount of radiant heat will be reduced. The reduction in radiant heat caused by the low emissivity surface is independent of width of air space. Values of air spaces lined with bright foil on one or both sides for widths of ⅜ in. and ¾ in. are shown in Table 2 of conductivities. In assigning these values to a practical condition one must be certain that the surfaces of the material will be maintained in a polished condition and not allowed to tarnish and become coated with dust or moisture. The low emissivity coefficient is entirely a surface characteristic and if the surface is covered with any foreign material it will not reflect the heat any more than a mirror so covered would reflect light.

In comparing the conductance coefficients for air spaces with and without bright metallic surface lining it should be noted that the reduction in heat transfer is substantially as great when one surface is lined as it is when both surfaces are lined. The reason for this is that practically 95 per cent of the total radiant heat is intercepted by one surface lining

and there is but a small amount left to be stopped by the second surface lining. The effect of any low emissivity surface in stopping the transmission of radiant heat is the same regardless of whether it is on the high or low temperature side of the air space. For materials such as aluminum or bronze paint which stop only a small percentage of radiant heat there is a greater percentage of gain by addition of a second surface lining.

PRACTICAL COEFFICIENTS

For practical purposes it is necessary to have average coefficients that may be applied to various materials and types of construction without the necessity of making tests on the individual material or combination of materials. In Table 2 coefficients are given for a group of materials which have been selected from various sources. Wherever possible the properties of material and conditions of tests are given. However, in selecting and applying these values to any construction a reasonable amount of caution is necessary; variations will be found in the coefficients for the same materials, which may be partly due to different test methods used, but which are largely due to variations in materials. The recommended coefficients which have been used for the calculation of over-all coefficients as given in Tables 3 to 12 are marked by an asterisk.

It should be recognized in these tables of calculated coefficients that space limitations will not permit the inclusion of all the combinations of materials that are used in building construction and the varied applications of insulating materials to these constructions. Typical examples are given of combinations frequently used, but any special construction not given in Tables 3 to 12 can generally be computed by using the conductivity values given in Table 2 and the fundamental heat transfer formulae. For example, the tabulation of all of the values for multiple layers of insulating materials would present extensive and detailed problems of calculations for the varied application combinations, but the engineer having the fundamental conductivity values can quickly obtain the proper coefficients.

Attention is called to the fact that the conductivity values per inch of thickness do not afford a true basis for comparison between insulating materials as applied, although they are frequently used for that purpose. The value of an insulating material is measured in terms of its heat resistance, which not only depends upon the thermal conductivity coefficient per inch but also upon the thickness as installed and the manner of installation. For instance the material having a coefficient of 0.50 and 1 in. thick is equal in value to a material having a coefficient of 0.25 and a thickness of ½ in. Certain types of blanket installations are designed to be installed between the studs of a frame building in such manner as to give two air spaces. In order to get the full value of such materials they should be so installed that each air space is approximately 1 in. or more in thickness and the air spaces should be sealed at the top and bottom to prevent the circulation of air from one space to the other. Another common error in installing such a material is to nail the blanket on the outside of the studs underneath the sheathing, in which case one air space is lost and also the thickness of the insulating material is materially reduced at the studs. There are certain other types of insulation which are very porous, allowing air circulation within the material if not