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The investigation of thermal conductivity of air layers is of importance not only from a theoretical point of view but also because of its practical implications. Air Layers (or Air Barriers) are used to insulate thermally spaces of temperatures higher or lower than room temperature. The determination of thermal conductivity of air layers of different thicknesses is therefore of interest.

The thermal properties of solid insulators, like cork, wall board, etc. are not blurred by convectional currents in the insulators, and to a certain extent, we can assume that materials like foam glass, rock wool, or balsa wool blankets will act like other solid insulators. However, when we consider air barriers, as used in double windows, or sandwich glass (Thermopane), or air layers used in refrigerated display cases we will observe that the transfer of heat is not a pure result of conduction. Convectional currents will develop in the air layers, and therefore the transfer of heat will be increased between the confining plates of the air layers.

This investigation deals with air layers confined between two glass plates (3 mm thick and of an effective diameter of 78.2 mm). The air layer was formed by placing Masonite spacers, of ring shape between the glass plates. Each spacer constituted an air layer thickness of approximately 4.8 mm. By piling up a number of spacers, layers were formed varying from 4.8 mm to 44.1 mm. The air used in the layers had a dew point of less than 0 °C (between —0.5°C to —2°C) to avoid condensation of moisture within the air layer.

To determine the thermal conductivity of the air layers Fitch's Thermal Conductivity Apparatus * was used, with some modifications, e.g. the transmitter was adapted to other positions of the sample than horizontal by adding an inversed funnel on the top of the transmitter. To detect small changes of temperature differences between transmitter and receiver the thermocouple of the receiver was not connected with the thermocouple of the transmitter but with a reference junction inserted in a container filled with water of room temperature. This arrangement permits the use of highly sensitive galvanometers because in the initial stages of the measurement the thermo electromotive force is rather small.

After assuring that the dew point of the air in the room was less than 0°C and the room temperature itself was 20°C, the follow-

* A. L. Fitch, Am. Phys. Teacher, vol. 3, 135 (1935).

ing procedure was adopted for the investigation: the air layer (glass,—spacer,—or spacers,—glass) was placed upon the receiver and the transmitter set on the air layer. Of course, the transmitter was filled with a mixture of ice and water and its temperature kept at 0°C before being placed upon the air layer. The readings of the galvanometer were recorded not before the receiver temperature was 19°C or 1°C less than room temperature. This temperature drop was due to the loss of heat of the receiver to the cold transmitter, having a temperature of 0°C. As the measurements progressed the temperature of the receiver dropped. A series of readings were taken in intervals of 0.3°C and recorded against the time. To effectuate this, the galvanometer scale was calibrated in degrees C rather than μV. The readings were discontinued when the receiver temperature was 16°C (or was 4°C less than room temperature). This practice avoided an extensive loss of heat of the receiver to the surrounding insulation, as well as established a good calibration of the galvanometer, considering the fact that Copper-Constantan thermocouples were used.

There were made two series of measurements: one placing the air layers in a horizontal position, and one series placing the air layers in a vertical position. The results were tabulated and evaluated with respect to the (relative) thermal conductivity (k) by using the formula Fitch suggested:

$$k = \frac{-2.303 \,.\, 1.\, M.c.\, (\log i - \log i_0)}{A.\, t}$$

where 1 = the thickness of the air layer

M.c = the thermal capacity of the receiver

i and i_0 = two consecutive readings on the galvanometer in A or μA

A = the area of the receiver exposed to the transmitter

t = the time that elapsed between the two readings i and i_0

This conductivity (k) indicates the heat transfer per unit of length.

The other evaluation involved the actual amount of heat transferred through the air layers, in calories per cm^2, second, and degree C. As the thermal capacity of the receiver was known, and the temperature increase of it also, as well as the time during which the temperature increase took place, the calculation was possible. The values of (k) and the actual amount of heat transferred (c) have been plotted against the thickness of the air layers (see graph).

As it was expected, the total amount of heat transferred (c) decreases with the thickness of the air layer. But it is interesting to notice that the conductivity per length of the layer (per cm) (k) has a high value at small thicknesses, decreases to a minimum at approx. 1.5 cm, and then increases again, when the thickness of the air layer increases. This dip in the conductivity graph (k) was observed with layers in horizontal as well as vertical positions.

However, the dip of the conductivity of the vertical layers is shifted to the smaller thickness of the layers.

The dip in the conductivity graph (k) seems to indicate that air layers less than a certain thickness reduce the formation of convectional currents. If this critical thickness is transgressed, convectional currents are formed, and the conductivity (k) increases.

From a practical point of view, however, the actual amount of heat transferred is of importance (c). Since the actual amount of heat transferred (c), as seen in the graph, decreases with the thickness of the air layer, the increase of heat insulation will be performed by increasing the thickness of the air layer.

Measurements are in progress dealing with the conductivity (k) and total amount of heat transferred (c) of air layers having different inclinations to the horizontal. Also air layers of different volumes are under investigation, as well as air layers exposed to greater temperature gradients. The preliminary measurements seem to indicate that thicker air layers, being exposed to greater temperature gradients, display a greater conductivity, as well as total amount of heat transferred, especially when the volume of the air layers is large when a second dip is observed.