by the solid disks D of '400' Supra-mica, a glass-bonded mica material. Axial heat flow in the outer cylinders C or C' is not a problem but moulding compound rings E of Dow Corning 301 moulding compound, a low-conductivity substance, are used.

The two gas layer thicknesses are determined for each outer cylinder C or C' by the three set screws J on each end. Each piece is marked to ensure reassembly in exactly the same position.

Other Designs

Cells for measuring the thermal conductivity of gases at high pressures have followed three designs with several modifications of each. These are the hot-wire design based on the early Schleiermacher (1889) design, the horizontal flat-plates design and the concentric-cylinders design.

In the hot-wire design the heat from an electrical resistance wire flows radially through a surrounding layer of gas. This design was used by Vargaftik (1937) and by Stolyarov, Ipatiev and Teodorovitch (1950). The thermal conductivity is determined by observing the temperature difference across the gas layer, the rate of heat generation in the wire and the thickness of the gas layer. Corrections must be made for heat conducted out along the ends of the wire. A serious problem arises when this design is used at high pressures. The clearance between the wire and the wall of the surrounding tube must be made so small to avoid convection, that it is almost impossible to centre the wire properly and measure the thickness of the gas layer with the required precision.

The horizontal flat-plate type consists of two flat plates with the gas in the space between them. The thickness of the gas layer is carefully determined by spacers. The upper plate is the hotter and heat flows downward so that the more dense gas is on the bottom as a precaution against convection. Heat flow at the edges of the gas space must be taken into account. This is done in the cell described by Michels and Botzen (1952) by using three different thicknesses of spacers and calculating the cell constants. The three measurements also permit an allowance to be made for heat transfer between the plates by direct radiation. Borovik (1947) used a horizontal plate-type cell. Uhlir (1952) points out that Borovik found evidence of convection in his cell despite the desirable arrangement with the heat flowing downward. This arrangement alone does not ensure that convection will not be present and reliance must be placed on a layer which is sufficiently thin. In a cell of this type at the U.S. Bureau of Standards capacitance measurements were made to determine the cell constants by analogy between the heat flow and electric system.

Several variations of employing concentric cylinders have been used. Keyes (1951), Keyes and Sandell (1949) employed an electrically heated vertical inner cylinder and the heat flows out radially through a gas layer about 0·025 inch thick. Temperatures are measured on both sides of the gap and the electrical input, corrected for end losses, permits direct calculation of the thermal conductivity. This layer was thick enough to permit separation of the two components of a mixture by thermal diffusion (1954). Uhlir (1952) used a vertical cylinder with a gas layer thickness of 0·010 inch and a helium gas thermometer on both sides of the layer. Electric current was switched from an external heater to a heater in the cylinder during a measurement and the power, temperature difference, and cell dimension are used to calculate the thermal conductivity of argon. In the cell described by Lenoir and Comings (1951), horizontal concentric cylinders are used. The gas layer thickness is 0·006 inch and is thin enough to preclude convection in most circumstances. Heat flows inward radially from circulating water or oil (Leng 1957) in the jacket and is removed by circulating water or oil in a central tube. A second layer 0·030 inch thick containing a standard gas is used outside the test gas layer and no heat measurements are required. The cell is calibrated at atmospheric pressure with several gases of known thermal conductivity and temperatures only at three positions need be measured to calculate the thermal conductivity. This design is cumbersome and is probably not suited for measurements above a few hundred atmospheres since the walls of the gas layer are pressure-retaining walls and the gas layer is subject to distortion.

FEATURES OF CELL DESIGN

The elements of cell design and operation which are important when operating at pressures up to a few thousand atmospheres and temperatures to 400 deg. F. with gas mixtures in regions including the critical region are:

(1) cell geometry including symmetry, and end effects;
(2) gas layer thickness and position with respect to avoiding convection and thermal diffusion effects;
(3) pressure distortion effects;
(4) thermal expansion effects;
(5) radiation effects;
(6) the heating and temperature measuring system;
(7) the method of determining the cell constants whether by direct measurement, by calibration, or by analogue measurements.

The horizontal cylindrical type offers a symmetrical arrangement and provision can readily be made to minimize end effects or to correct for them. Very thin layers of gas combined with small temperature gradients offer the least possibility of convection and with these in a horizontal position no difficulty should be encountered from thermal diffusion. No appreciable error results from small eccentricity. Pressure distortion is eliminated if the cell is contained in the cavity of a pressure vessel and is immersed in the gas being tested. This arrangement requires a large gas sample and is thus not suited to measurements on rare or expensive gases. The cell constants are determined by calibration at atmospheric pressure against gases of known thermal conductivity at each