known calibration curves. However, they have a very small emf output and are subject to contamination problems unless carefully used. The thermocouples and axial crystal heater were insulated from the sample by Degussit[8] alumina tubing because it is a very pure ceramic, and is available in very small diameters. It does contain a small amount of iron and silicon, i.e., about 300 ppm. The radiation shields were made from platinum -40% rhodium. These served to keep heat losses from the end of the sample low. They also served as vapor barriers for germanium and silicon vapor coming from the sample. The external heater winding was made in three sections so that both the temperature gradient along the axis of the apparatus near the ends of the sample and the average temperature of the sample could both be controlled. A ground sheath was placed under the external heater to reduce stray electrical leakage currents. The ceramic end plugs were installed to hold the electrical wires in place and to reduce axial heat conduction by the gas. They also helped to protect the thermocouple wires in the temperature gradient from the silicon and germanium vapors.

The electrical heater power to the sample was furnished by either dc or ac. Direct current was used below about 750°K and ac was used (about 435 cycles/sec) at higher temperatures. Due to the lower electrical resistance of the Si, the Ge, and the Al_2O_3 at high temperatures, a small leakage voltage from the crystal heater always appeared in the thermocouples above about 850°K. This leakage was rendered harmless by use of ac since any small 435-cycle ac voltage was not recorded by the thermocouple galvanometer. To insure that the temperature gradient was measured accurately, a few

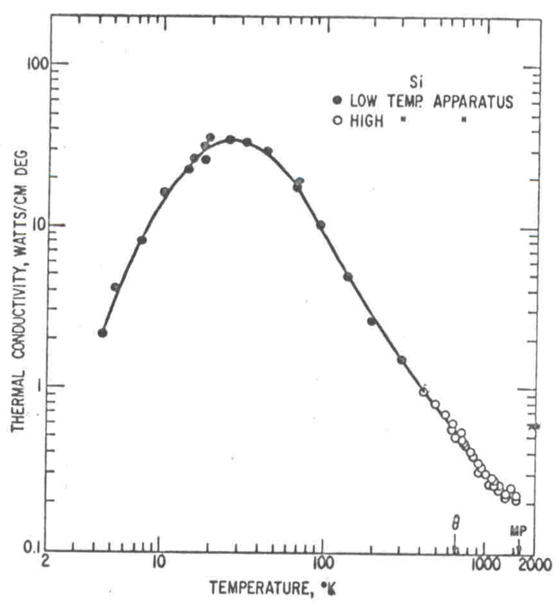

FIG. 4. The low- and high-temperature K versus T results for Si.

[8] Degussit A123, Liasson Company, New York, New York.

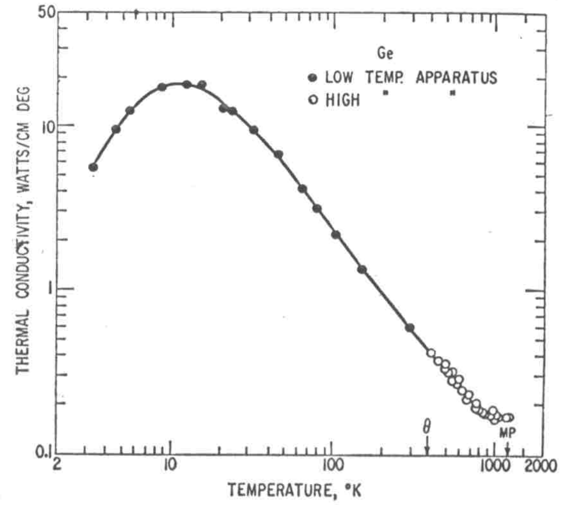

FIG. 5. The low- and high-temperature K versus T results for Ge.

special measuring techniques were employed. Since no two thermocouples are exactly alike, two of the three thermocouples inside the sample were always calibrated in terms of the third when the sample was in an isothermal condition. Checks on the presence of possible thermocouple contamination were made in two ways. First the high-temperature K data points were always followed by a reconfirmation of lower temperature K points at about 400°K. Secondly, variations in the axial temperature gradients in the apparatus at and beyond the radiation shields were intentionally produced by the end windings on the external heater. These variations should not affect the measured K. Any apparent effect meant contaminated thermocouples. Discrepancies of these types resulted in rejection of the high-temperature data, and a reassembly of the entire apparatus with new thermocouples. The final results for both Si and Ge each involved several such reassemblies.

Under steady-state operating conditions between 30 and 50 W of electrical power was furnished to the crystal heater. This is equivalent to about 4 W/cm of sample length. The average temperature differences between the center and surface of the sample ran between 1 and 3°K. The heater wire temperature usually operated between 50 and 100°K above the sample temperature.

RESULTS

The results of the present investigation of the high-temperature K of Si and Ge are shown in Figs. 2 and 3. The composite results for single crystal Si are shown in Fig. 4. Notice that the low-temperature results (solid circles) join on smoothly to the high-temperature results (open circles). Both sets of data were obtained in their respective apparatuses as absolute thermal conductivity values, and neither set of data has been adjusted to match the other. The actual data points in the low-temperature set span the temperature range from 4.3 to 304°K, while the high-temperature points cover the