sensitivity, reproducibility, cost, size, and calibration difficulties. Gold-cobalt versus copper thermocouples give sufficient sensitivity, but inhomogeneities lead to non-reproducibility and deviations from established calibration tables. Copper-constantan thermocouples are extremely reproducible but not sensitive enough below 40 K (68). Platinum thermometers are not sensitive enough at lower temperatures and are too bulky when properly mounted (68,69). Carbon resistors had all the attributes necessary for low temperature measurements, including an equation that fit their temperature resistance characteristics (70,71,72) so that complete calibration over all ranges was not necessary. These were used for preliminary runs and calibrated while running against a germanium thermometer which was mounted in the baseplates.

However, with the base heater on, a small negative temperature gradient sometimes existed in the crystal so that both carbon thermometers were not at the same temperature during calibration. Thus, the calibrated values were incorrect. Further, upon cooling, the thermal resistance between the crystal and base sometimes changed, which rendered any corrections for the negative gradient invalid. This was later traced to partial fracture of the crystal at the base. These difficulties were circumvented when another germanium thermometer became available so the temperature gradient was measured with the two germanium thermometers. These thermometers have all the advantages of the carbon thermometers except size and price and the fact that there is not yet an equation which gives a good fit to their data over the entire range of sensitivity. They have the advantage, further, of being extremely reproducible so that once calibrated they need no recalibration for long periods of time (70,73,74).