The isothermal runs were made by raising the hot seal temperature to a fixed value and maintaining it. Pressure was then cycled between several kilobars and 35 kbar. Several cycles were generally made at each temperature. During the course of these cycles the cold seal would continue to heat up slightly thus changing the magnitude of the pressurized temperature interval. This change was typically less than 2% however.

Both isobaric and isothermal excursions were made in a few runs. Most runs were limited however to one type of cycle due to mechanical failure of the wires. Runs generally lasted from 5 to 10 h. The scatter associated with cycling many times, performing both types of cycles on the same wires, holding at the extreme pressure and temperature for up to 15 min, and exposing the thermoelements to up to 10 h of cycling all appears in the final data.

Pressure was determined by monitoring the oil pressure in the piston ram with a Heise Bourdon tube gauge. In the runs where pressure excursions were made, hysteresis loops relating single-wire emf to ram oil pressure were plotted. The centers of these loops were taken as indicating the effective pressure. Corrections determined from these runs were applied to the indicated pressure of temperature cycles.

Strangely, in some cases the hysteresis loops seemed to show higher pressure on compression than that indicated by the Heise gauge and lower pressure on decompression. This is the reverse of that expected and has never been encountered in any prior measurements in this laboratory. Similar results in a solid medium single-wire experiment have been reported by Freud and La Mori.[8] We tentatively attribute this effect to lack of completely hydrostatic pressure on the test wires, but do not have a clear understanding of the phenomenon. The strength of the normal pressure medium was greatly reduced by replacing the talc and boron nitride with silver chloride without significant effect on the shape of the hysteresis loops nor on the magnitude of the single-wire emf. Test wire geometry was varied from the usual longitudinal orientation to a helical configuration in one silver chloride run, again with similar results.

Corrections to the pressure indicated by the Heise gauge were everywhere less than 1 kbar, positive on compression. Pressures determined in this manner differed from those calculated from the center of piston displacement hysteresis loops by as much as 3 kbar, around 10 kbar. The pressure gradient in the talc surrounding the test wire region was determined from Bi I–II transition studies. It corresponds to a maximum 3-kbar pressure drop along the wires at the highest pressures and room temperature. Guided by these quantities, the pressure uncertainty is estimated as ±3 kbar over the entire pressure range.

It is crucial in these measurements to show that the pressure gradient at both the high-temperature seal and the low-temperature seal take place over a region of essentially uniform temperature. Therefore, in one experiment the temperature distribution along the axis of the cell was explored by five fixed thermocouples and is shown in Fig. 4. The temperature gradient across the hot seal amounted to only 2% of the maximum temperature reached and the gradient across the cold seal amounted to no more than 4%. Accuracy in the determination of the pressurized temperature interval $T_J - T_S$ is ±5%.

RESULTS

The experimental data are presented in Figs. 5–10. In Fig. 5 we present the data taken at 12, 23, and 33 kbar for platinum. Results are plotted in terms of the observed single-wire voltage versus temperature difference between the hot seal and the cold seal. Similar data for Pt10Rh are shown in Fig. 6; data for Chromel are shown in Fig. 7; and data for Alumel are shown in Fig. 8. Data in these four figures were taken on isobaric excursions, i.e., the pressure was held constant and the temperature was varied. In Figs. 9 and 10 we show typical data for Pt, Pt10Rh, Chromel, and Alumel with the temperature held constant and the pressure varied. Fig. 9 for Pt and Pt10Rh shows reversed hysteresis loops of the type we have discussed. Figure 10 for Chromel and Alumel illustrates data where one hysteresis loop is normal and the other reversed. Solid curves shown in these six figures do not necessarily represent the best fit to the data in each figure. There are curves taken from the smooth surface constructed to fit all our available data as discussed in a subsequent portion of this paper.

The single-wire emf for Pt varies linearly with either pressure or temperature, but for Pt10Rh it is slightly concave toward the voltage axis in both cases. The

FIG. 5. Single-wire voltage for platinum.