thermocouple is then

$$\Delta E = \int_{T_S}^{T_J} (\sigma_a - \sigma_a')\,dT - \int_{T_S}^{T_J} (\sigma_b - \sigma_b')\,dT, \quad (5)$$

where σ_a' and σ_b' are the pressure-modified absolute Seebeck coefficients. Thus we see that the change in emf of a pressurized thermocouple is just the difference of the changes in each leg separately.

Measurement of the pressure effect on each leg of a thermocouple separately is experimentally easier than measurement of the effect on the thermocouple itself.

In order to make these measurements, a homogeneous wire is subjected to a pressure and temperature distribution as shown in Fig. 2. The wire is thereby subjected to two temperature gradients, one at high pressure and the other at 1 atm. Because the temperature gradients are opposed, the observed emf is just the difference in the emf's generated in each gradient.

$$E_{SW} = \int_{T_S}^{T_J} (\sigma_a - \sigma_a')\,dT. \quad (6)$$

We refer to this as the single-wire voltage because it involves only one thermoelement. The difference of two single-wire voltages gives the correction for a thermocouple with a hot junction at T_J and a pressure seal at T_S as in Eq. (5).

PREVIOUS WORK

An experiment for directly observing the pressure effect on the emf of a thermocouple was performed by Birch.[3] His technique was that of holding a pressurized thermocouple at a known temperature and observing its apparent temperature. His experiments showed a decrease in the emf of Pt–Pt10Rh amounting to several degrees at 1000°C and 4 kbar. He found essentially no effect on Chromel–Alumel to 600°C and 4 kbar. Because he failed to record seal temperatures, Birch's measurements are applicable only to his particular apparatus.

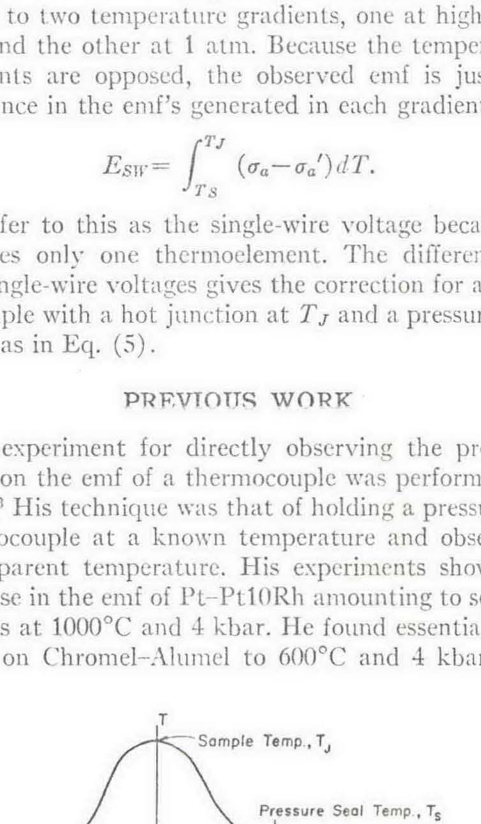

FIG. 1. Schematic view of typical high-pressure cell showing temperature and pressure distribution.

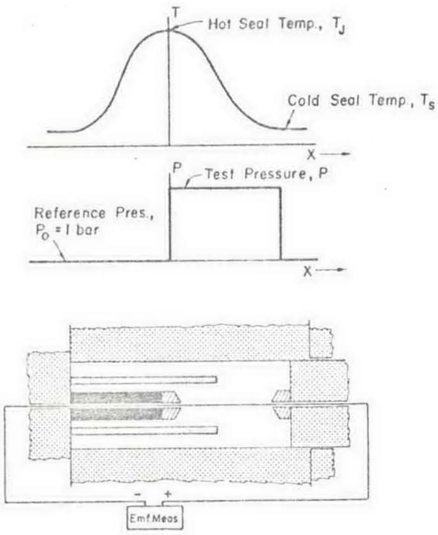

FIG. 2. Schematic view of single-wire experiment cell showing temperature and pressure distribution.

Measurements on a single wire were first made by Wagner[4] to 100°C and 300 kg/cm². Bridgman[5] extended the experimental range to 1200 kg/cm². Unfortunately, Bridgman's work did not include any of the more commonly used thermoelement pairs. Thus his results have not proved useful in determining the pressure corrections to be made to measurements of temperature at high pressure.

Bundy[6] extended the measurements to 100 kbar and 100°C. He presented data on many of the commonly used thermoelements and his results and the current results agree well within the uncertainties where the ranges investigated overlap.

Bell *et al.*[7] reported corrections for Pt–Pt10Rh and Chromel–Alumel to 5 kbar and 500°C. Freud and La Mori[8] have presented some preliminary data to 40 kbar and 400°C for the same two thermocouples. Their results are in substantial agreement with this work. They also have presented results to a few kbar at cryogenic temperatures for Chromel–Alumel and copper–constantan. Some of the data presented in this paper have been previously presented in summary fashion by Getting and Kennedy.[9]

Experiments designed to measure the difference in pressure effect on two different thermocouples have been carried out to considerably higher temperatures and pressures than have absolute measurements. Thus, a pair of thermocouples may be taken to the same temperature and pressure, and the apparent differences in temperature they record can be measured. This will, of course, yield the difference in the effect of pressure on the two thermocouples. Bundy[6] reported results of a relative pressure experiment intercomparing the