It is clear that the relation between reduced gap and temperature varies with pressure; increasing pressure moves this relation closer to the universal BCS curve for a weak-coupling superconductor. From Fig. 2 one can determine the relative shift of $\Delta(T)/kT_c$ with pressure at constant reduced temperature. It is found that this shift is independent of reduced temperature, within the accuracy of the experiment, and given by $d\ln[\Delta(T)/kT_c]/dP = -(5.6\pm0.6)\times10^{-6}$/bar, $t>0.55$. As mentioned, we also determined the gap at $T=2.0$°K, i.e., $t \simeq 0.28$. The relative shift of $\Delta(T)/kT_c$ with pressure at this temperature was obtained from the shift in the extremum of d^2i/dv^2; we found a slightly smaller value, $d\ln(\Delta(T)/kT_c)/dP = -(4.8\pm0.5)\times10^{-6}$/bar. At present, we do not believe that the difference between the values in the two temperature ranges is significant and therefore base the following discussion on an average value given by

$$\{d\ln[\Delta(T)/kT_c]/dP\}_{t=\mathrm{const}} = -(5.2\pm0.6)\times10^{-6}/\mathrm{bar}. \quad (1)$$

The pressure dependence of T_c observed in this experiment was

$$d\ln T_c/dP = -(4.9\pm0.2)\times10^{-6}/\mathrm{bar}, \quad (2)$$

in good agreement with determinations on bulk material.[3,4] From this it follows that

$$[d\ln\Delta(T)/dP]_{t=\mathrm{const}} = -(10.1\pm0.8)\times10^{-6}/\mathrm{bar}, \quad (3)$$

$$[d\ln\Delta(T)/d\ln T_c]_{t=\mathrm{const}} = 2.06\pm0.3. \quad (4)$$

It was further found that the reduced gap-temperature relation for Pb, Fig. 2, can be obtained from the BCS relation by scaling with a constant factor; remaining deviations are of the order 3%. One can therefore, in good approximation, describe the temperature-dependent energy gap of Pb by a BCS relation, but assuming an empirical gap ratio $2\Delta_0/kT_c$ deviating from 3.53. In the present experiment, we find for this parameter $2\Delta_0/kT_c = 4.47$ ($P=0$) and 4.41 ($P=2730$ bar).

Hodder and Briscoe[5] recently reported a study of Pb-insulator-Pb junctions that were mechanically strained at liquid-helium temperatures. They observed a reduction of the energy gap with strain. Unfortunately, the volume reduction achieved in these experiments does not seem to be very well known, so that a comparison with our results is not possible. No information on the strain dependence of T_c is given, in fact this is calculated assuming a constant gap ratio.

The main result of these experiments is that the coupling strength in Pb, as measured approximately by the gap ratio, decreases with increasing pressure (i.e., decreasing volume). This effect was also observed as a reduction in the phonon-induced anomalies in the tunneling characteristics. We believe that the coupling strength is reduced due to the combined effect of a reduction with pressure of $N(0)$, the single-particle density of states at the Fermi surface (Ref. 3), and to the increase in phonon frequencies with pressure. The effect can probably be understood in terms of the present strong-coupling theory[6,7] along the lines indicated, e.g., by Wu.[8] Similar effects have been reported for Pb-based alloys by Adler, Jackson, and Will[9] and by Claeson.[10] In these experiments the coupling strength was reduced by changing the density of states through alloying.

From Eq. (4) it follows that in Pb the energy gap is proportional to the square of the transition temperature. We do not know of any reason for this particular exponent, but expect that this dependence goes over into the familiar linear dependence at sufficiently high pressures.

The present results can be combined with published data on the pressure dependence of the condensation energy at 0°K. Wada[11] has shown that, in general,

$$H_0^2/8\pi = N(0)I,$$

where H_0 is the critical field at 0°K and I is a function of the renormalization factor and of the complex gap function. In the weak-coupling limit the function I goes properly over into $I=\frac{1}{2}\Delta_0^2$ to yield the BCS result. One can then introduce the ratio $I/\frac{1}{2}\Delta_0^2$ and use this as an approximate measure of the coupling strength, similar to the use of the gap ratio $2\Delta_0/kT_c$. For Pb, $I/\frac{1}{2}\Delta_0^2 = 0.83$,[6] i.e., the condensation energy is smaller then given by the BCS expres-