derivatives to volume derivatives the value, $\kappa=1.67\times10^{-6}$ per atm, calculated from the elastic constants,[22] was used for the compressibility of lead. The derivatives of the Debye temperature for lead, θ_D, are computed from the work of Dheer and Surange.[23]

These experimental data may be used in the formulas of the BCS theory to determine the pressure variation of V, the BCS interaction parameter. However, in making such a calculation it must be recognized that Pb is a special case among the superconducting elements for which the original BCS treatment of the cutoff frequency is probably incorrect. For this reason it is preferable to work from the BCS theoretical expression valid at $T=0°$K instead of Eq. (1).[24] Although Eq. (1) expresses the same result at T_c, it implies a law of corresponding states between superconducting elements which is known experimentally to be invalid for Pb.[12]

From BCS's Eq. (2.42) we write

$$H_0^2/8\pi\simeq 2N(0)(\hbar\omega)^2\exp[-2/N(0)V]. \quad (17)$$

Differentiating and replacing $[d\ln N(0)/dP]$ by $(d\ln\gamma^*/dP)$ we obtain

$$\frac{d\ln V}{dP}=N(0)V\left[\frac{d\ln H_0}{dP}-0.5\frac{d\ln\gamma^*}{dP}-\frac{d\ln\theta_D}{dP}\right]-\frac{d\ln\gamma^*}{dP}. \quad (18)$$

Evaluating (18) from the experimental data [and, for reasons discussed below, using $N(0)V=0.66$] we obtain $d\ln V/dP=3.4\times10^{-6}$ per atm (or $d\ln V/d\ln v=-2.04$). With the same value of $N(0)V$, an analogous calculation proceeding from Eq. (1) gives the result $d\ln V/dP=2.8\times10^{-6}$ per atom which is not significantly different from the result of (18).

It is difficult to place limits on the precision of our calculated value of $(d\ln V/dP)$. Because of the present inadequacy of the theoretical understanding of Pb, there is doubt regarding a suitable value for $N(0)V$. The value $N(0)V=0.41$, obtained by solving Eq. (1) using experimental values of T_c and θ_D, implies a cutoff frequency corresponding to $0.75\theta_D$. For the case of Pb, estimates based on lifetime effects[25] indicate that the cutoff frequency may be of the order of $\theta_D/3$ or even less. In evaluating (18) we have used Morel's calculation[20] for Pb, $N(0)V=0.66$, which corresponds to a cutoff frequency of $0.3\theta_D$. A value of $N(0)V$ greater than unity is required to reverse the sign of $(d\ln V/dP)$, the positive sense of which is a noteworthy feature of the present results.

The BCS criterion for superconductivity requires that V be positive, and the application of pressure increases V. An increase in V, if acting alone, favors superconductivity, and so would shift T_c to higher temperatures. However, the change in $N(0)$ must over-ride the changes associated with V and θ_D to produce a net decrease in T_c if the theory is to be in accord with experiment.

Morel has described detailed calculations of the pressure effect[26] based on the BCS theory via Eq. (1). His theoretical expressions are not in good agreement with the results described above. In addition to predicting a negative value of $(d\ln V/dP)$, Morel's results are very sensitive to the value $(d\ln\gamma^*/dp)$ employed in the calculation. For Pb he uses a value of about 1.2×10^{-6} per atm deduced from earlier results,[20] but this is considerably smaller than the value of the present work. Revising his calculations using the experimental values listed above does not improve the agreement with experiment. Such revision increases his calculated value of $(d\ln T_c/dP)$ from about half the observed value to a new result which is 3.8 times larger than the observed value.

A theoretical estimate of the experimental constant, B, is possible from BCS's Eq. (3.39) which is valid at 0°K, and according to which

$$H_0^2\propto N(0)\epsilon_0^2, \quad (19)$$

where ϵ_0 is the energy gap at 0°K. Despite the abnormally large value of ϵ_0 characteristic of Pb ($4.1kT_c$[27] vs $3.5kT_c$ for the BCS theory), it seems likely that ϵ_0/T_c is independent of pressure; particularly so in view of the observed geometrical similarity expressed by (10). If it is assumed that ϵ_0/T_c is independent of pressure, (19) gives

$$H_0^2\propto\gamma^*T_c^2. \quad (20)$$

[The same relation follows by eliminating common factors between Eqs. (1) and (17) since they implicitly contain the assumption, $\epsilon_0T_c=\text{const}$. However, this approach is less fundamental than (19)]. Differentiation of (20) leads to the following expression

$$B=\frac{d\ln T_c/dP}{d\ln H_0/dP}=1-(0.5)\frac{d\ln\gamma^*/dP}{d\ln H_0/dP}. \quad (21)$$

Substituting experimental values in (21) gives B(calc) $=0.58$ which is in very good agreement with the directly measured value, $B(\exp)=0.562$.

We turn now to the effect of pressure upon γ^*. In general[28]

$$\gamma^*=\tfrac{2}{3}\pi^2k^2N(0), \quad (22)$$

where k is Boltzmann's constant. From Eq. (22) {which was the basis for the replacement of $[d\ln N(0)/dP]$ by

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