Introducing the density of states per unit energy interval,

$$\nu(\varepsilon_F) = Vp_F^2/2\pi^2 v_F$$

and using formulas (2) and (3), we express F in the form

$$F = \frac{1}{2(4\pi)^2}\frac{N_0}{Ms^2\nu(\varepsilon_F)}$$

In this formula it is convenient to go over from the speed of sound s to the Debye temperature $\omega_D = \pi s/a$, where a is the lattice constant equal to $(V/N_0)^{1/3}$; then the expression for T_k can be rewritten in the form

$$T_k = 1.14\omega_D \exp\left\{-\left(\frac{N_0}{V}\right)^{2/3}\frac{N_0}{32\nu(\varepsilon_F)M\omega_D^2}\right\}^{-1}, \quad (4)$$

whence

$$\frac{\partial T_k}{\partial P} = T_k\varkappa\left\{\gamma_p\left(1-\frac{2}{F}\right)+\frac{\gamma_e}{F}+\frac{2}{3F}\right\}, \quad (5)$$

where we have introduced the notation

$$\varkappa\gamma_p = \frac{1}{\omega_D}\frac{\partial\omega_D}{\partial P},$$

$$\varkappa\gamma_e = -\frac{1}{\nu(\varepsilon_F)}\frac{\partial}{\partial P}\nu(\varepsilon_F), \quad \varkappa = -\frac{1}{V}\frac{\partial}{\partial P}V. \quad (5')$$

The quantities γ_p and γ_e are the Grüneisen constants for the lattice and for the electrons and κ is the compressibility.

Assuming that formula (5) is correct not only for a quadratic dispersion law, but also for an arbitrary law $\epsilon(p)$, we compare the theory and experiment.

The experimental values of the quantities γ_p and γ_e and κ known at present are presented in the Table for a number of metals. Using these values it is easy to calculate $T_{k,P}$ from formula (5). It can be seen from the Table that the experimentally observed values of $T_{k,P}$ and those calculated according to formula (5) are generally in good agreement.

In those instances in which the Grüneisen constant γ_e for electrons is not known, we assumed that $\gamma_e = 1.5$ (this corresponds approximately to the average of the known values). The average value of γ_e yields the correct sign of the derivative of the temperature of the superconducting transition with respect to the pressure.

The calculated values of $T_{k,P}$ for all metals differ nevertheless from the experimentally found values of $T_{k,P}$. In principle this could be related to the fact that the constant γ_e has not been determined sufficiently well, for an error in γ_e (or γ_p) of 10—20 per cent leads to an error of 50—100 per cent in the calculated value of $T_{k,P}$ because of the presence of the large parameter F^{-1}.

Analyzing the data presented in the Table (the seventh and eighth column) one can assume that the Grüneisen constant γ_e for the metals In, Hg, Zn, Cd, Zr, Mo, and La_β can differ from $\gamma_e = 1.5$ by no more than ±(0.1—0.2).

3. The value of the critical magnetic field in the superconductor at temperatures T much smaller than T_k is connected with the superconducting transition temperature by the relation

$$H_k(0) = 1.75[4\pi\nu(\varepsilon_F)/V]^{1/2}T_k. \quad (6)$$

Differentiating this expression with respect to the pressure, one can express the derivative $H_{k,P} \equiv \partial H_{k,}(0)/\partial P$, as was done for $T_{k,P}$, in terms of the Grüneisen constants γ_e and γ_p and the compressibility κ:

$$\frac{\partial H_k}{\partial P} = \varkappa H_k\left\{\left(1-\frac{2}{F}\right)\left(\gamma_p-\frac{1}{2}\gamma_e\right)+\frac{2}{3}\frac{1}{F}+\frac{1}{2}\right\}. \quad (7)$$

On the basis of this formula one can calculate the magnitude and the sign of $H_{k,P}$ for various metals and compare it with the experimentally found values of $H_{k,P}$ (see the Table). As can be seen from the Table, the agreement for $H_{k,P}$, just as for $T_{k,P}$, between the calculated and experimentally determined values is not bad.

The values of $T_{k,P}$ and $H_{k,P}$ are determined for 19 pure metals. For Ga, Re, Ru, Th, and Ti γ_e and γ_p have not been determined and therefore a comparison with the theory is difficult.

For Tl, if we assume $\gamma_e \approx 1.5$, then according to the theory $T_{k,P} = -5 \times 10^{-5}$ deg/atm; the experimentally determined value $T_{k,P}$ is -1.4×10^{-5} deg/atm at 20,000—28,000 atm. The thallium anomalies in the pressure range up to 6000 atm are apparently connected with features of the energy spectrum of the conduction electrons.[14,15]

The authors thank B. G. Lazarev for a discussion of the work.

[1] N. B. Brandt and N. I. Ginzburg, UFN 85, 485 (1965), Soviet Phys. Uspekhi 8, 224 (1965).

[2] J. Bardeen, L. Cooper, and J. Schrieffer, Phys. Rev. 108, 1175 (1957).

[3] H. Bethe and A. Sommerfeld, The Electron Theory of Metals (Russ. Transl.) ONTI, 1938.

[4] V. I. Bonch-Bruevich, DAN SSSR 124, 1233 (1959), Soviet Phys. Doklady 4, 172 (1959).

[5] V. L. Bonch-Bruevich and S. V. Tyablikov, Metod funktsiĭ Grina v statisticheskoĭ mekhanike (The Green's Function Method in Statistical Mechanics), Fizmatgiz, 1961.

[6] P. W. Bridgman, The Physics of High Pressure, Bell, London, 1949.