SOME SINGULARITIES OF THE BEHAVIOR OF THE SUPERCONDUCTING TRANSITION TEMPERATURE OF THALLIUM UNDER PRESSURE

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The shift of the superconducting transition temperature in annealed single-crystal samples of pure thallium ($R_{4.2°K}/R_c \approx 2 \times 10^{-4}$) was measured in detail at various pressures up to 1730 kg/cm^2. A complex dependence of ΔT_c on p was found for this pressure range. The effect of small electron groups was estimated by taking into account the differences in the electron-phonon interaction constant.

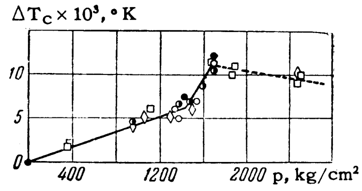
AN increase of the superconducting transition temperature of thallium at pressures up to 1730 kg/cm^2 has been reported earlier. [1] So far this is the only elemental superconductor (pure metal) for which the derivative dT_c/dp is positive in this range of pressures. Other workers have confirmed this behavior of thallium and have shown that on further increase of pressure dT_c/dp reverses sign. [2,3] The present communication reports the results of detailed measurements of the shift of the superconducting transition temperature in annealed single-crystal samples of thallium ($R_{4.2K}/R_c \approx 2\times10^{-4}$) at pressures up to 1730 kg/cm^2.

The pressures of 1370 and 1730 kg/cm^2 were obtained by the "ice" technique, the intermediate pressures—by means of water—alcohol solutions. [4] The pressure in the bomb was checked with a tin or indium manometer. The differential method was used in measurements: one thallium sample was inside the bomb, another outside. The results of the present measurements and those reported by other workers are given in the figure.

The figure indicates that in the 0—1500 kg/cm^2 pressure range the transition temperature T_c rises linearly with p at the rate of $dT_c/dp \approx (0.4 \pm 0.1) \times 10^{-5}$ deg/atm. Between 1500 and 1730 kg/cm^2 the value of T_c increases rapidly; on further increase of pressure T_c decreases. [2,3]

Thus for thallium at pressures of 1500—1730 kg/cm^2, as for tin near 800 kg/cm^2, [5] we observe a strong variation of T_c with pressure, while, for example, for indium at all pressures up to 1730 kg/cm^2 the dependence of T_c on p is linear. [5]

Considering these results one might suggest that this complex dependence of T_c on p for thal-



Dependence of the shift of the superconducting transition temperature of thallium on pressure: □—results of [2]; ◇—results of [3]; o, •, o—results of the present work for different samples.

lium (and tin) may be due to transitions in the energy spectrum of conduction electrons, for example due to a change in the Fermi surface topology, caused by the disappearance of a group of electrons with low limiting Fermi energy. [6]

In fact a metal has electron groups with various densities of states $\partial N/\partial \epsilon$ at the Fermi surface boundary and the lower values of $\partial N/\partial \epsilon$ obviously correspond to the higher values of the electron-phonon interaction constant $g \sim m^{-2}$, [7] where m is the effective electron mass. The superconducting transition temperature in the case of two conduction-electron bands is governed by the ratio of the parameters $\rho = g^2 \partial N/\partial \epsilon$ for each of the bands. [8]

For the quadratic dispersion law we have $\rho_1/\rho_2 = m_1/m_2$, where m_1 and m_2 are the effective masses of conduction electrons corresponding to the small and large groups, respectively. From measurements of the de Haas—van Alphen effect and cyclotron resonance it follows that for most of the metals the ratio $m_1/m_2 = 0.1$—0.01, ie., ρ_1 corresponding to the group with low limiting energy may represent a considerable fraction (about 10%) of the value of ρ_2 corresponding to the main group.

It is probable that simultaneous studies of the effect of impurities and pressure on the superconducting transition temperature and on the magnetic properties of the metal may make it possible to give a clearer interpretation of the results obtained. Such studies are being carried out at present.

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