Mass Dependence of the Superconducting Transition Temperature of Mercury*

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In a recent communication,[1] Herzfeld, Maxwell, and Scott fitted the available data on the superconducting transition temperatures (T_c) of mercury isotopes of different mass (M), to a formula of the type $M^{\alpha}T_c=$const. by the method of least squares. The best fit to the[2] data was given by $\alpha=0.378$, whereas in an earlier communication,[3] we had proposed $\alpha=\frac{1}{2}$.

At the time of our communication, we did not feel that the accuracy of the data warranted a close scrutiny of the kind given to it by Herzfeld and co-authors; and the exponent $\frac{1}{2}$ was proposed as giving a good fit within the accuracy of the experimental values for the transition temperatures. The poor quality of the data is evident from the appreciable deviations of the experimental points from the relation, $M^{0.378}T_c=$const., derived by least squares.

Since our communication, the detailed theories of superconductivity of Bardeen[4] and Fröhlich[5] give the value $\frac{1}{2}$ for α.

Because of the importance of determining an accurate experimental value of α, in view of these theories, we have been engaged in an extensive investigation of the transition temperatures of mercury samples of different isotopic constitutions. We have found that the temperature spread of the transition from the superconducting to the normal state (and thus the accuracy with which the zero-field transition can be determined by extrapolation) is very sensitive to the way in which the samples are cooled to liquid air temperature, and also to the way in which liquid helium is admitted to the flask. The procedure finally adopted was to place a small amount of liquid air in the outer shield flask. The system was allowed to stand for about an hour, and then small amounts of liquid air were added over the course of another hour. It was possible to get an accurate idea of the temperature of the samples during cooling by measuring the change in resistance of pick-up coils surrounding them; and thus to bring the samples slowly through the freezing point of mercury. We found it equally important never to permit the initial blow-off of warm helium gas from the transfer tube to hit the samples; thus, we waited until liquid helium poured out of the transfer tube before placing the tube in the helium flask. This method of cooling clearly produces the minimum amount of strain in the samples.

Our most reliable data for our original samples and for a new set of three samples[6] of slightly different isotopic constitution (making a total of seven samples) are shown in Fig. 1, where $\log_{10}M$ is plotted *vs.* $\log_{10}T_c$. The measuring technique was the same as that described earlier,[7] except that the frequency of the alternating field was reduced to 20 c.p.s. The transition temperature for the sample of natural mercury is in good agreement with the value, 4.167°K, given by Misener.[8]

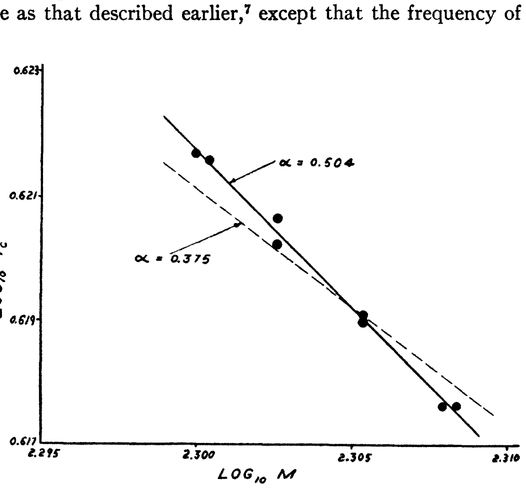

Fig. 1. Transition temperature as a function of the mass number.

The slope of the line as drawn in Fig. 1 is 0.504. For purposes of comparison a line of slope 0.375 is also drawn.

On the basis of these measurements, we feel that it is definitely established that in mercury, at least, the exponent α is certainly much closer to $\frac{1}{2}$ than to any other value having a simple physical interpretation. This result is in agreement with the predictions of the theories[4,5] mentioned above.

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[1] Herzfeld, Maxwell, and Scott, Phys. Rev. **79**, 911 (1950).
[2] Herzfeld *et al.* conclude that the true value is $\alpha=3/8$, corresponding to constant thermal energy of the lattice.
[3] Serin, Reynolds, and Nesbitt, Phys. Rev. **78**, 813 (1950).
[4] J. Bardeen, Phys. Rev. **79**, 167 (1950).
[5] H. Fröhlich, Proc. Phys. Soc. London **63**, 778 (1950); Phys. Rev. **79**, 845 (1950).
[6] The isotopes were produced by Carbide and Carbon Chemical Division, Oak Ridge National Laboratory, Y-12 Area, Oak Ridge, Tennessee, and were obtained on allocation.
[7] Reynolds, Serin, Wright, and Nesbitt, Phys. Rev. **78**, 487 (1950).
[8] A. D. Misener, Proc. Roy. Soc. **174**, A, 262 (1940).

Temperature Effect in Geiger-Müller Counters

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The temperature effect on the rate of spurious discharges in G-M counters (hard glass sealed-off type with out-gassed cathode of 2 cm diam. and 5 cm long) was observed when they were heated and cooled at constant rates. As is shown in Fig. 1, on

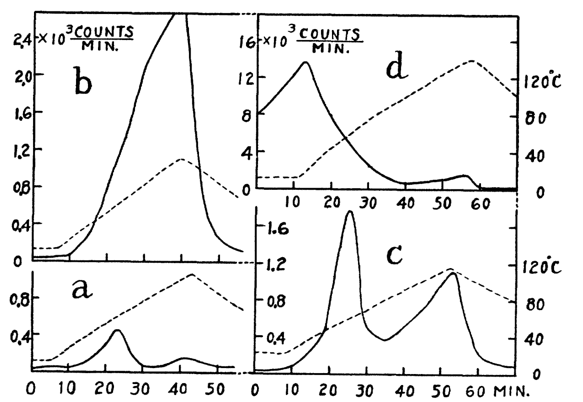

Fig. 1. Temperature effects on the rate of spontaneous discharges of the G-M counters. Full line: counts per min. The broken line gives the temperature. (a): A 76 mm, ethyl ether 9 mm. (b): A 95 mm, alcohol 10 mm. (c): A 98 mm, ethylene 10 mm. (d): A 90 mm, alcohol 10 mm, under visible light irradiation. All with Fe cathode and 0.1-mm W wire.

the heating stage the rate of natural counts increased in various manners which depended on the filling gases and less markedly on the cathode material; it decreased rapidly on the cooling stage without exception. It was verified that these discharges were due to "Spontanentladung" and the occurrence of double or triple discharges ("Nachentladung") was very rare. The plateau curves were taken with a gamma-ray source and also without any source before and after each experiment, and we could not find marked changes in them, though those with natural counts were generally better after heating. The plateau lengths were generally between 150 and 500 v, with the slopes of 0.6 to 10 percent per 100 v. We observed the increases in spurious counts also when the counter voltage was applied intermittently, that is, for 20 sec. once every 3 min. The increased counting rate began to decrease again when the temperature rise was stopped and the counter was kept at a certain constant temperature near 100°C. The decrease was an almost exponential function of the time measured from the