Transitions were observed by an a.c. induction method in which the superconductor was mounted as the core of a secondary coil of a mutual inductance, the primary of which was actuated at 1000 cycles/sec. by a current sufficient to produce an a.c. field at the core of 1.5 oersteds or less. Webber, Reynolds, and McGuire,[7] who described the method in detail, observed that magnetic transitions obtained in this way for a single crystal of tin yielded critical fields in agreement with those obtained by other methods.

The measurements on pure columbium were made on a sample that had been annealed in an induction furnace for five hours at 1000°C in a vacuum of $10^{-6}$ mm. The results, shown in Fig. 1, were taken in five different experiments extending over a period of several weeks. Comparison measurements on the high tantalum sample yielded higher critical field values before the sample was annealed, but after a three-hour annealing at 1000°C in a vacuum of $10^{-5}$ mm the values came into agreement with those of the purer material. Two additional samples of the pure material which were less carefully annealed also agreed with the lower curve in Fig. 1.

The zero field transition of the purer columbium occurred at 8.98°K in the first run after annealing, but thereafter the half-normal value was observed repeatedly at 8.55°K with a mean deviation of 0.01°K. The transition was 0.15° wide, the normal state being fully restored at 8.65°K, which was within 0.06° of the zero field transition temperature determined by least squares fit of the curve from magnetic transitions.

The best parabolic fit to the latter curve was given by substituting $H_0=8050$ oersteds and $T_0=8.71$°K into the empirical relation, $H=H_0(1-T^2/T_0^2)$. With the aid of the usual thermodynamic equations, the difference of specific heats in the normal and superconducting states was calculated. The electronic specific heat term in the normal state was found to be 0.0352 $T$ cal./mole-deg., and the Debye $\Theta$ in the superconducting state was estimated to be 69°K. The extremely high value of the electronic specific heat is a consequence of the large initial slope of the $H-T$ curve, 1840 oersteds/deg., which is larger than that for any other superconductor so far observed except vanadium,[7] which has an initial slope of 4100 oersteds/deg.

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## Beta-Gamma-Angular Correlation*

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IN continuation of the angular correlation work reported earlier,[1] 2.8-day $Sb^{122}$, and 60-day $Sb^{124}$ have been investigated with a coincidence counting arrangement using scintillation counters and a coincidence circuit of 0.1-$\mu$sec. resolution, consisting of blocking oscillator pulse shapers, and a pentode mixing stage. The geometrical arrangement used is shown in Fig. 1, a 30-mil aluminum absorber for the betas (not shown), and a beta-collimator having been added for $Sb^{124}$. The 1P21 photo-multipliers were dry-ice cooled. The gamma-counter was made insensitive to betas by a $\frac{1}{8}$-in. aluminum absorber. Counts were taken at 90° and 180°, the gamma-counter being moved, and the coincidence rate was normalized by the single counting rate in each channel to compensate for solid angle variation and slight drifts in counter efficiency.

The vacuum chamber was made large and lined with plastic to minimize scattering effects. Sources of the isotope in question with betas shielded at the source by $\frac{1}{8}$-in. brass were counted to evaluate the effects of gamma-scattering from one counter to the other,

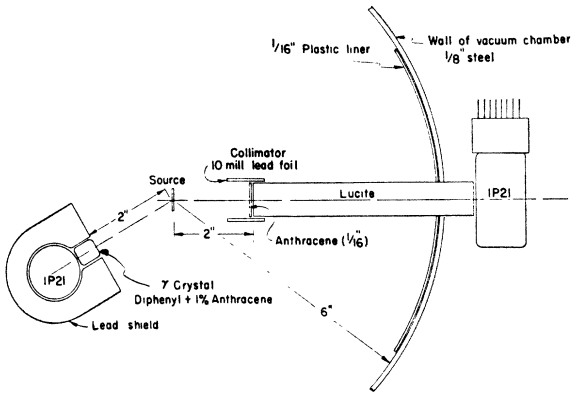


FIG. 1. Geometrical arrangement.

and of any gamma-gamma-correlations for those nuclides that had gamma-rays in coincidence. The gamma-gamma-coincidence rate was largest in $Sb^{124}$, amounting to 20 percent of the beta-gamma-rate, but showed no angular correlation. Pure beta-emitters $Tl^{204}$ and $P^{32}$ were used to show the absence of beta-scattering from one counter to the other.

The sources were prepared from Oak Ridge irradiated units on 0.1 to 0.2 mg/cm$^2$ collodion backings. $Au^{198}$ was prepared by the precipitation of a mirror of gold from a chloride solution with oxalic acid, $Rb^{86}$ and $Sb^{122}$ by the evaporation of a solution of a salt to dryness, and $Sb^{124}$ by evaporation of the metal from an electroplated platinum filament in high vacuum. This last method gave a source with no observable irregularities under a 10-power microscope.

Assuming a correlation function $(1+b\cos^2\theta)$, the results are given in Table I. The result for $Au^{198}$ is in agreement with other

TABLE I. Angular correlation function.

| Nucleus | Source thickness mg/cm$^2$ | $b$ | Standard deviation |
|---|---|---|---|
| $Au^{198}$ | 0.02–0.02 | +0.004 | 0.015 |
| $Rb^{86}$ | 1.0 | +0.019 | 0.014 |
| $Sb^{122}$ | 0.2 | +0.011 | 0.013 |
| $Sb^{124}$ | <0.2 | −0.168 | 0.025 |

work,[2,3] that for $Rb^{86}$ agrees with that of Novey,[4] in which the correlation is taken averaged over the whole beta-spectrum as in this work, but is considerably less than the correlations observed by Franckel,[3] and by Deutsch[5] who selected the upper end point of the beta-spectrum. This low result may be due to the chemically deposited source having local thicknesses much greater than the average thickness, which has been experienced with this type of source in beta-spectroscopy. According to the work at Indiana,[6–8] $Sb^{124}$ has five beta-groups, 2.37 (21 percent), 1.62 (8 percent), 1.00 (9 percent), 0.65 (44 percent) and 0.48 (18 percent). It is believed that this correlation should be ascribed to the most energetic transition, and it is consistent with a first- or second-forbidden tensor interaction.[9] A re-analysis of the beta-spectrum data using forbidden shapes might reduce the number of beta-groups necessary to fit the spectrum data, which is not unreasonable in light of the coincidence data not showing the 1.00 and 1.62 groups.[7]

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