If we assume the absorption is by the free holes, then by dividing the absorption coefficient $(4\pi k/\lambda)$ by the number of free carriers we can compute a cross section for capture of photons. At 3.4 microns this cross section for holes is $1.5A^2$, while for electrons it is only $0.13A^2$. These are both much larger than the cross section calculated from classical theory, which is of the order of $10^{-3}A^2$ for mobilities of the order of 1500 cm^2/volt sec such as are found in these samples. Similar discrepancies with classical theory have previously been pointed out for *n*-type germanium[2] and *p*-type silicon.[2,3]

[1] R. C. Lord, Phys. Rev. **85**, 140 (1952).
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The Double Compton Effect

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AN effect was predicted by Heitler and Nordheim[1] in which, in addition to the normal scattered quantum in the Compton process, one or more further quanta were produced, with decreasing order of probability. For two scattered quanta having comparable energies, and for incident quantum energies $\gg m_0c^2$, the ratio of the cross section to that of the normal Compton process $\sim 1/137$.

Co^{60} γ-rays from a 200-mC source were defined by a horizontal collimator designed to minimize scattering, secondary electrons being removed by a magnetic field. Effects due to coincident γ-rays from the source were negligible. The γ-rays fell on a foil placed perpendicular to the beam, scattered quanta being detected by two NaI(Tl) crystals $2\frac{3}{4}$ in. in diameter and just under 1 in. thick placed symmetrically in a plane just below, so that they were not struck by the incident beam. They accepted quanta with scattering angles between 45° and 145°, subtended a solid angle at the scatterer of ~ 4 percent sphere, and were shielded from each other by 20 g/cm^2 lead to eliminate cross-scattering.

From a preliminary experiment, in which the scatterer was a 170-mg/cm^2 naphthalene-anthracene crystal, it was found that all coincidences between the quantum counters due to the source were accompanied by the ejection of an electron from the scatterer.

The ratio of the quantum-quantum coincidence rate to the sum of the single quantum rates should be constant and independent of scatterer thickness for coincidences produced by a primary process. In addition to those from the double Compton effect, coincidences may also be produced by a normal Compton process in which the scattered electron suffers an inelastic nuclear collision in the material of the scatterer, resulting in a bremsstrahlung. The coincidence rate due to this secondary process is proportional to the square of the scatterer thickness, if this is fairly small compared with the electron range, and gives rise to a component in the coincidence rate per recorded quantum which varies linearly with scatterer thickness. The magnitude of the component depends on the atomic number of the scatterer.

Scatterers of thickness varying from 40–400 mg/cm^2 of Be, Al, Cu, and Ag were used. In each case, below $\sim$200 mg/cm^2, the variation of coincidence rate per recorded quantum with thickness can be represented by the sum of a constant term, and a term varying linearly with thickness, as shown in Fig. 1. The magnitude of the constant term is independent of the atomic number of the scatterer, as it should be for an effect depending only on scattering from free electrons. The coefficient of the linear term $\propto Z^{2.24}$; the increase in the value of the exponent over that appropriate to bremsstrahlung production, $\propto Z^2$, being due possibly to the increased path length of electrons brought about by scattering.

To obtain a rough estimate of the relative cross sections for double and single Compton scattering, it will be assumed that one

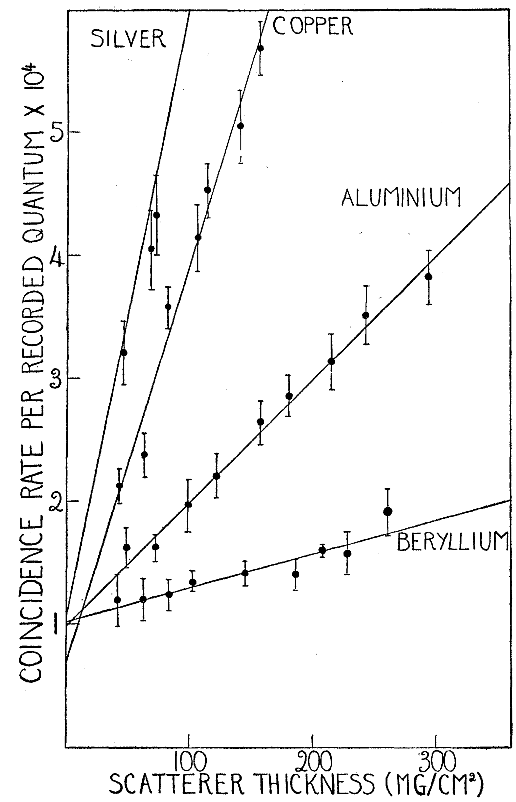

FIG. 1. Coincidence rate per recorded quantum *versus* scatterer thickness.

quantum has the normal distribution and the other is isotropically emitted and detected with 100 percent efficiency. This gives the double Compton cross section, integrated over the energy range 80–530 kev, to be 3×10^{-3} of the single Compton cross section. Mandl and Skyrme[2] have used the Feynman method to calculate the differential cross section where the two quanta are scattered at right angles to each other and to an incident quantum of energy 1 Mev, a case which approximates to the experimental one. Integrating over the energy range accepted by the discriminators and assuming 100 percent detection efficiency, a value for the coincidence rate per recorded quantum of 0.4×10^{-4} results. This is to be compared with the experimental value of 1.0×10^{-4}.

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Mobility of Electrons in Germanium

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IN the past, measurements of the Hall coefficient and conductivity of *n*-type germanium have yielded mobility values which, although increasing with time and presumably better crystals, were consistently lower than the drift mobility.[1] Measurements have now been made, at room temperature, on a number of new samples in various conductivity ranges which have yielded higher mobilities than any previously found. In the range of resistivity for which drift mobility values are available, these new values substantially agree with the drift mobility values measured