of the traps changes appreciably. Somewhat later the shallow traps empty ($\tau \sim 10^{-2}$ sec), and this occurs before the occupancy of the deep traps changes appreciably. Finally, the deep traps empty ($\tau \sim 260$ sec). Each set of traps gives a long decay time because the average electron is trapped many times before it recombines. The photoconductivity associated with trapping comes from the additional free holes in the valence band which, due to space charge neutrality, are exactly equal in number to the number of trapped electrons.

It can be shown that the final decay time τ is related to τ_r, τ_g (the mean time an electron spends in a trap for a single trapping event), and τ_t, the mean free time an electron spends in the conduction band before trapping when most of the traps are empty. Approximately, $\tau = \tau_r\tau_g/\tau_t$. Because the time constants are so well separated, it can be shown that this formula applies to each set of traps independently.

For the shallow traps $\tau = 10^{-2}$ sec, $\tau_g = 50$ μsec, and since $\tau_r = 20$ μsec, $\tau_t = 1\times 10^{-7}$ sec. For the deep traps τ_g cannot be measured independently, but it can be estimated from the agreement between the theory of the multiple trapping process and experiment. Thus for the deep traps, $\tau = 260$ sec, $\tau_g \simeq 1$ sec, $\tau_t \simeq 1\times 10^{-7}$ sec. The concentration of normally empty trapping sites N can be obtained from the amplitudes of the conductivity changes. For the shallow traps $N_1 = 2\times 10^{12}$ cm^{-3}, for the deep traps $N_2 = 9\times 10^{12}$ cm^{-3}. If we may write $1/\tau_t = N\sigma v$, where σ is the trapping cross section and v is thermal velocity, then $\sigma_1 = 4\times 10^{-13}$ cm^2 and $\sigma_2 \simeq 1\times 10^{-13}$ cm^2.

From the ratios $(\tau_g/\tau_t) = (\tau/\tau_r)$, the energy ϵ of the traps below the bottom of the conduction band may be computed by using the principle of detailed balance which relates σ and τ_g. We find $\epsilon_1 = 0.57$ and $\epsilon_2 = 0.79$ ev. The Fermi level for this specimen, $\epsilon_F = 0.72$ ev.

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[2] Trapping effects have also been observed in n-type silicon at room temperature.

The Magnetoresistance Effect in InSb

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WELKER[1] has recently shown that the compound indium antimonide is a semiconducting material with properties akin to the fourth column elements germanium and silicon and that it has unusually high electron and hole mobilities. This letter describes the preparation of the compound in a highly purified form as well as the results of magnetoresistance measurements which verify the high electron mobility. Analysis of the data indicates that the energy surfaces in InSb are spherical in nature as contrasted with the more complicated structure proposed for germanium.

The compound was prepared by melting together stoichiometric amounts of indium and antimony metals. InSb crystallizes in the zincblende lattice[2] and melts at 523°C.[1] The starting materials and the resulting compound were purified by extensive zone-refining.[3] In this manner polycrystalline specimens of 0.03-ohm cm resistivity were obtained. The primary impurity in the final material is arsenic in concentrations of approximately 0.01 percent. By spectrographic analysis all other impurities were shown to be below 0.005 percent. The compound is stoichiometric to within 0.2 percent of antimony which is the reliability of chemical analysis. All material prepared to date has been n type at room temperature and shows a reversal to p type near 175°K.

Samples suitable for making magnetoresistance measurements were prepared as previously described.[4] With **H** perpendicular to **I**, it was found that at room temperature $\Delta\rho/\rho = 8\times 10^{-9}H^2$ over the entire range of measurement from 0 to 13 000 gauss. For this alignment simple theory[5] predicts that

$$\mu^2 = 2.6\times 10^{16}H^{-2}\Delta\rho/\rho,$$

where μ is the electron mobility in cm^2/volt-sec. Substitution of the experimentally determined value of $H^{-2}\,\Delta\rho/\rho$ gives an electron mobility of 15 000 cm^2/volt-sec at room temperature. Hall measurements[6] on the same sample gave a value of 23 000 cm^2/volt-sec. Welker has reported[1] Hall mobilities as high as 25 000 cm^2/volt-sec. As the temperature is lowered and the magnetic field held constant, $\Delta\rho/\rho$ reaches a maximum at 270°K and then decreases.

Figure 1 is a plot of $\Delta\rho/\rho$ for the InSb sample as a function of the angle θ between the applied field **H** and the current **I** at a fixed magnetic field of 13 000 gauss. It is seen that the effect is maxi-

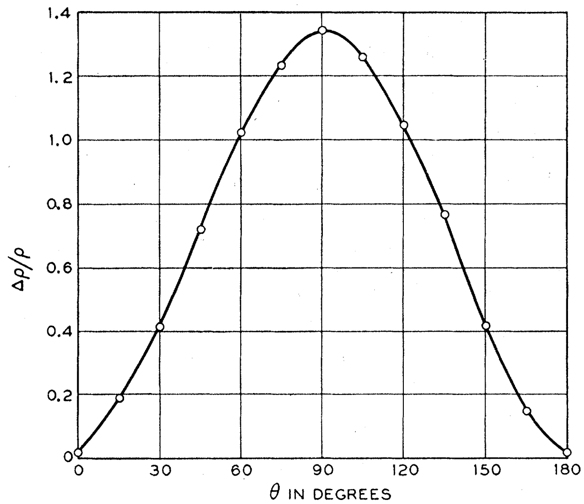

FIG. 1. Variation of $\Delta\rho/\rho$ in InSb as H is rotated through an angle θ from 0 to 180 degrees. H is 13 000 gauss and T is 300°K

mum for **H** perpendicular to **I** and approaches zero for **H** parallel to **I**. This behavior is in agreement with simple theory[5] which assumes spherical energy surfaces and is in contrast with the measurements on n-type germanium[4] where nonspherical energy surfaces have been proposed by Shockley[7] to explain the results.

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[6] These measurements were performed by F. J. Morin and J. P. Maita and will be reported in detail at a later date.
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The Continuous Layer Formation in the Atmosphere under the Influence of Solar Radiation*

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THE ionized layer formation in the atmosphere under the influence of a quiet sun and under the influence of a disturbed sun has been investigated. It has been found that a continuous layer formation in the ionosphere for both cases can be obtained, if account is taken of the variation with height of dissociation of molecular constituents and of the variation with height of ionization of the different constituents present at the various altitudes. By "continuous layer formation" we refer to continuous increase and decrease of the electron density with height, throughout the entire ionosphere.