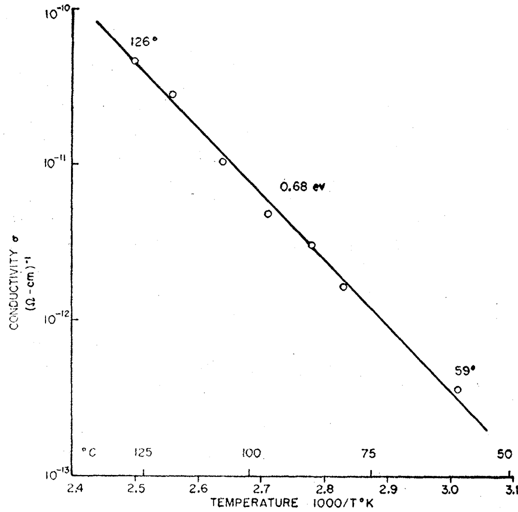

FIG. 1. The dc conductivity as a function of temperature.

dielectric constant can be fitted by a Curie-Weiss law curve, $\epsilon' = C/(T-\theta)$, with $C = 8.5\times 10^4$, $\theta = 17°K$. However, at $-160°C$, this curve gives a value of $\epsilon' = 880$, compared to a measured value of 815, thus indicating, in agreement with Hulm's results on

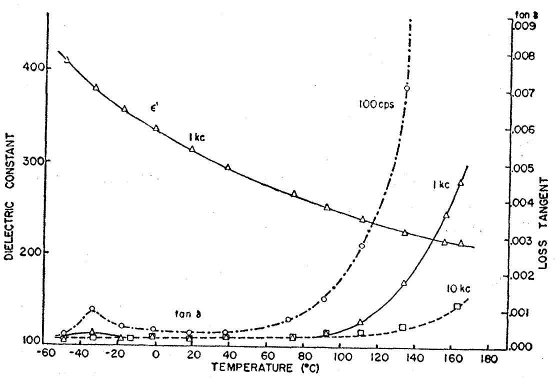

FIG. 2. The dielectric constant ϵ' and the loss tangent $\tan\delta$ as functions of temperature at various frequencies.

sintered strontium titanate,[3] that a Curie-Weiss law curve based on high-temperature data should not be used to predict a ferroelectric Curie point for this material. It should be noted that the value of the dielectric constant for a single crystal was found

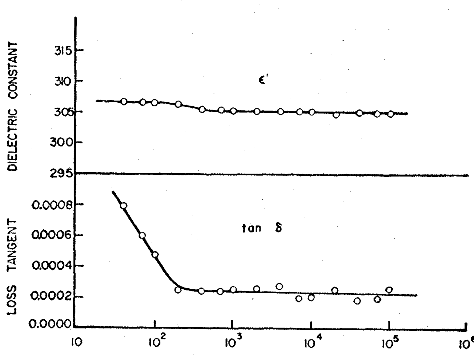

FIG. 3. The dielectric constant and loss tangent as functions of frequency at 25°C.

to be twenty percent higher than values found by Hulm and others[4] for sintered specimens, although the latter values were corrected for porosity. The increase in loss tangent with temperature is presumably the result of the increase in conductivity of the crystal, but the cause of the peak at $-30°C$ is not known.

The dielectric constant and loss tangent as functions of frequency at 25°C are shown in Fig. 3. The loss tangent appears to consist of a polarization loss, $\tan\delta = 0.00025$, substantially independent of frequency over the range studied, and a conductivity loss approximately inversely proportional to the frequency. The situation is complicated by space-charge effects in the crystal and at the boundaries where diffused silver ions from the electrodes form low-lying electron traps. A more detailed investigation is in progress.

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Evaporation of Copper from Germanium

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BECAUSE of the interest in "thermal" acceptors introduced into germanium by heat treatment[1,2] and because of the fact that these acceptors may be due, at least in part, to copper as an impurity,[3,4] the following results are believed to be significant. It has been found that if germanium is heat treated in a vacuum, the number of acceptors introduced at a given temperature and a given quench time is less than that corresponding to heat treatment in an atmosphere of helium (see Fig. 1).

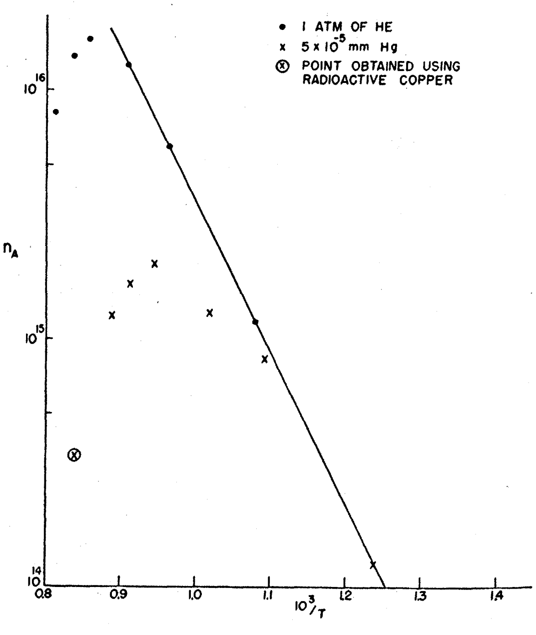

FIG. 1. Number of acceptors introduced as a function of the reciprocal of the heat-treatment temperature for two residual gas pressures.

In addition, radioactive copper was deposited on the surface of several samples of germanium by dipping the germanium in a solution of radioactive copper nitrate. This copper was then diffused into the germanium to within one percent of equilibrium by heating in one atmosphere of helium at 918°C. One of these samples was then etched to remove any excess copper from the surface and heated for three hours at 918°C at a residual gas pressure of 5×10^{-5} mm mercury. It was found that during the vacuum heating radioactive copper was collected on a cold finger in the vacuum system indicating that copper had evaporated from the germanium. From the change in sample surface count before and after the vacuum heating and from the amount of copper collected on the cold finger, it is estimated that at least 96 percent of the copper was evaporated from the germanium during the vacuum heating. Hall measurements made on the sample show that after the initial heat treatment in helium, the density of added acceptors was $n_A=1.43\times10^{16}/\text{cm}^3$, and after the vacuum heat treatment the remaining density of acceptors was $n_A=3.4\times10^{14}/\text{cm}^3$.

The evaporation of copper during the vacuum heating corresponds within experimental error to the loss of acceptors as given by Hall measurements.

The author wishes to thank Dr. George Morrison for the work with radioactive tracers and Dr. S. Mayburg and Dr. E. N. Clarke for much helpful discussion.

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Diode Characteristic of a Hollow Cathode*

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If a current is drawn from an aperture of a hollow cathode, the inside surface of which is coated with Ba—Sr oxide emitting material, a diode characteristic is obtained which does not resemble the typical Child-Langmuir characteristic.

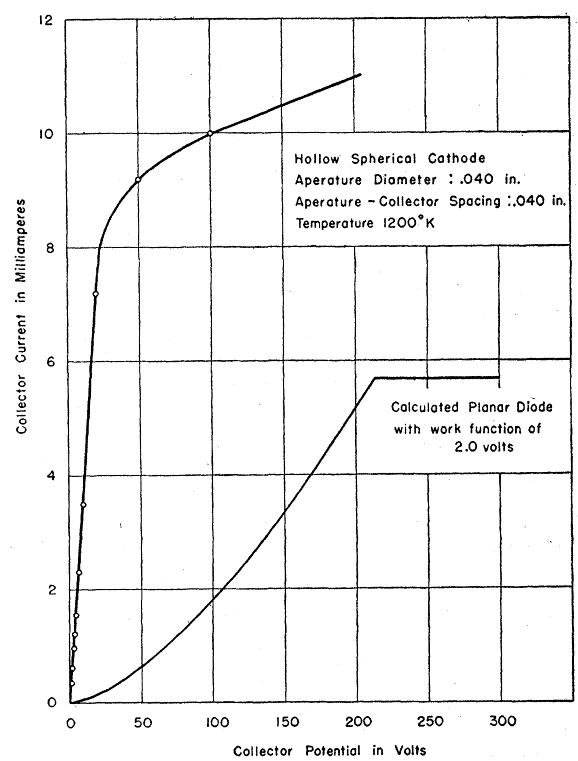

Fig. 1. Comparison of the measured current-voltage characteristic obtained through the aperture of a hollow cathode with the computed characteristic of a planar diode with a cathode area equal to the aperture area.

In Fig. 1 the diode characteristic is plotted for a hollow cathode arrangement in which the current from an aperture of one millimeter diameter is collected by an anode spaced one millimeter distant. This is compared with the curve one would expect from an equivalent planar diode, i.e., one with the same emitting material, with a cathode area equal to the aperture area, and with the same cathode-anode spacing.

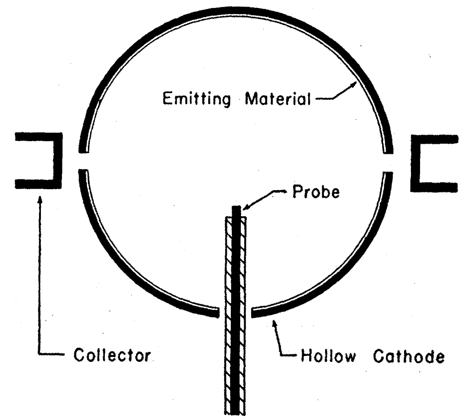

Fig. 2. Schematic diagram of the experimental arrangement used for the study of the characteristic of a spherical hollow cathode.

Three typical features of this characteristic are of particular interest:

(1) The rapid increase of current even if small positive potentials are applied to the collector electrode.

(2) Over the entire potential range higher currents were obtained than are to be expected from the equivalent planar diode.

(3) At potentials above which the planar diode exhibits saturation, the current in this structure continues to increase at a considerable rate.

Figure 2 shows schematically the experimental arrangement being used in these studies. The spherical hollow cathode is heated uniformly and indirectly by a larger concentric heater sphere (not shown in Fig. 2). For purposes of comparison two apertures with their corresponding collector electrodes are provided. Since particular care was taken to avoid spurious effects of any kind, the collector electrodes are water-cooled to eliminate the possibility of thermionic currents in the inverse direction. The inverse impedance under operating conditions is found to be very large indeed; it is of the order of 3×10^8 ohms.

A probe which can be inserted or withdrawn during operation allows the study of the conditions inside of the sphere.

These experiments are a phase of a general study of electron gases in equilibrium[1,2] and will be reported in greater detail in a later article.

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A Tentative Theory of Metallic Whisker Growth*

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Peach's[1] very pretty explanation of the formation of metallic whiskers[2] seems to be ruled out by the observation[3] that they grow at the root. The growth seems to be influenced[4] by the atmosphere over the surface. The energy required to form a