Electron Lenses

We wish to amend a statement which appears over our names in an abstract in the Physical Review for August 1, 1931.[1] It is there stated, as a result of calculation, that the distorted electrostatic field about a circular hole in a charged conducting plate (a vacuum tube electrode) has for electrons, or other charged particles, the properties of a spherical lens of focal length $f=2V/(G_2-G_1)$, where V represents the kinetic energy of the particles in equivalent volts, and (G_2-G_1) represents the difference between the potential gradients on the emergence and incidence sides of the plate. The part of this statement which requires amendment is the formula for the focal length, which should read: $f=4V/(G_2-G_1)$.

The original formula, with 2 as the numerical factor, is correct for the other case mentioned in the abstract, that of a rectangular slit. The field about such a slit acts as a cylindrical lens; it was with lenses of this type only that tests had been made at the time the abstract was written. More recently we have made observations on the lens action of the fields about circular holes, and have obtained results in agreement with the corrected formula given above. We hope to have a report of these investigations ready for publication within the next few months.

C. J. Davisson
C. J. Calbick

Bell Telephone Laboratories,
New York City,
October 13, 1932.

[1] Davisson and Calbick, Phys. Rev. (2) **38**, 585 (1931).

On the Secondary Emission from Collectors in Neon Discharge

There are known some deviations from Langmuir's theory for currents to a collector in a neon discharge.[1] In order to investigate the causes of such deviations a number of experiments was carried out by us in 1931–32. The experiments were made with cylindrical tubes of different diameters from 3 to 5 cm (pressure $p=1-2$ mm) with movable collectors of various geometrical shapes. These tubes were made with heated as well as with cold cathodes. The collectors were made of iron, nickel and molybdenum. Before filling the tubes neon was purified in the usual way. The discharge tube could be illuminated by an outside neon source. This illumination caused a corresponding change of the collector current.

When collector potentials approached the anode potential the volt-ampere curves obtained with probe electrode placed in the positive column differ somewhat from those given by Found and Langmuir.[2]

The shifting of the movable collector across the tube permitted the study of the secondary emission from the probe electrode on the axis of the discharge and also its changes when the collector approached the wall of the tube. Close to the wall the shape of the collector's characteristic in the ion part approached the shape of ordinary curves (e.g., mercury vapor) in absence of secondary emission from the collector. Again when the electrode was placed on the axis of the positive column or beyond it at high negative potentials the curves had a shape analogous to that given by Found and Langmuir. It is known that a considerable increase of the ion current can be explained by the ionization in the sheath by electrons escaping from the probe electrode. It should be noted that the conditions in some of our measurements were such that only a slight part of the positive column radiation could pass the anode and reach the collector behind it. In other cases in order to study the influence of the radiation on the secondary emission, special tubes with a "transparent" anode (grid-anode) were used. With the increase of illumination intensity, from the emission tube the corresponding decrease of ion current to the collector in the discharge tube was observed. At probe electrode potentials near the space potential the collector current depends only slightly on the intensity of illumination. Ion currents to the collector placed near the wall do not depend on the magnitude of the discharge current up to certain limits. Thus the changes of the collector current due to illumination also do not depend on the discharge current. When the

[1] W. Uyterhoeven, Proc. Nat. Acad. Sci. **15**, 32 (1929).

[2] C. G. Found and I. Langmuir, Phys. Rev. **39**, 237 (1932), (Fig. 9.)