Case A. When $r_1^2a^2$ is small compared with br_1^2 we have the full space-charge condition and (13) reduces to

$$V|_1^2=b^{\frac{1}{2}}\int_{r_1}^{r_2}\frac{(r^2-r_1^2)^{\frac{1}{2}}}{r}dr. \tag{15}$$

Peirce[2] Eq. (131) gives

$$V|_1^2=b^{\frac{1}{2}}([r_2^2-r_1^2]^{\frac{1}{2}}-r_1\cos^{-1}[r_1/r_2]). \tag{16}$$

Case B. When $r_1^2a^2$ is large compared with br_1^2 we have a transition equation from the full space-charge condition to no space charge. Here (13) reduces to

$$V|_1^2=b^{\frac{1}{2}}\int_{r_1}^{r_2}\frac{(r^2+r_1^2a/b)^{\frac{1}{2}}}{r}dr. \tag{17}$$

Peirce[2] Eq. (130) gives

$$V|_1^2=(r_1^2a^2+br_2^2)^{\frac{1}{2}}-(r_1^2a^2+br_1^2)^{\frac{1}{2}}+r_1a\log_\epsilon\frac{r_2}{r_1}\frac{r_1a+(r_1^2a^2+br_1^2)^{\frac{1}{2}}}{r_1a+(r_1^2a^2+br_2^2)^{\frac{1}{2}}}. \tag{18}$$

Case C. When $r_1^2a^2$ is large compared with both br_1^2 and br_2^2. In this case the current is limited by back diffusion only and Eq. (18) reduces to

$$V|_1^2=r_1a\log_\epsilon r_2/r_1. \tag{19}$$

As previously stated, the above equations are all in c.g.s. electrostatic units. For calculation we will want to use cm, gram, second, volts, amperes per cm, length, and mobility in cm/sec./volt/cm. In that case a remains

$$a=\frac{c}{(6\pi)^{\frac{1}{2}}\mu}\left(\frac{i}{I-i}\right), \tag{20}$$

and b becomes

$$b=0.903\times10^{12}\,2i/\mu. \tag{21}$$

It was interesting to find experimentally that these equations which are based on a constant mobility gave a good fit to the experimental volt-ampere characteristics, under a wide variety of conditions, for both electron and lithium positive ion emitters in air at atmospheric pressure.

[1] J. J. Thomson, *Conduction of Electricity through Gases* (The Cambridge University Press, New York), second edition, p. 267.
[2] B. O. Peirce, *A Short Table of Integrals* (Ginn and Company, New York).

Note on Thickness of Quartz Wafers for Observed Surface Phenomena

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THE writer and his co-workers have reported some effects occurring on thin crystals.[1-3] In this work the critical thickness has been given as 25–30 microns. These figures for thickness do not take into account the depth of the etch pits developed on the surface. Examination of the cross sections of some of the plates, and more recent work with smoother surfaces indicate that the thickness is ~10 microns.

[1] D. D'Eustachio and S. B. Brody, Phys. Rev. **69**, 256 (1946).
[2] D. D'Eustachio, Paper presented at the Cambridge Meeting of the Am. Phys. Soc., April, 1946.
[3] D. D'Eustachio and S. Greenwald, Phys. Rev. **69**, 532 (1946).

Spontaneous Emission of Neutrons from Uranium*

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FLEROV and Petrzhak[1] have established the existence of spontaneous fission in uranium by recording the heavy fission fragments with a uranium-coated ionization chamber. The partial decay constant of the "average uranium atom" calculated from their data lies between 2×10^{-25} and 2×10^{-24} sec.$^{-1}$ for this process. It seemed possible that the mechanism of spontaneous fission might be different from that of induced fission, in particular that no neutrons might be split off in the former process. Libby[2] had previously made an unsuccessful attempt to find spontaneous fission neutrons with the help of a boron counter. His results indicated an upper limit for the partial disintegration constant of 2×10^{-22} sec.$^{-1}$ for spontaneous fission with neutron emission. We have now carried out an experiment with a more sensitive calibrated arrangement, using a hydrogen-filled ionization chamber which allowed us to record neutrons of an energy higher than about 100 kev.[3] Spontaneous emission of neutrons from uranium was observed. Several sources of error were excluded by check experiments and simple considerations. From the number of counts obtained we estimate the partial decay constant for spontaneous fission for the "average uranium atom" to be of the order of 7×10^{-24} sec.$^{-1}$ under the assumption that one neutron is emitted per fission. Neutrons with energies up to 800 kev have been observed.

* This paper was received for publication on the date indicated, but was voluntarily withheld from publication until the end of the war.
[1] G. N. Flerov and K. A. Petrzhak, J. Phys. U.S.S.R. **3**, 275 (1940).
[2] W. F. Libby, Phys. Rev. **55**, 1269 (1939).
[3] G. S. Klaiber and G. Scharff-Goldhaber, Phys. Rev. **61**, 733 (A) (1942).

On the Production of Penetrating Ionizing Particles by the Non-Ionizing Component of Cosmic Radiation

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EXPERIMENTS of the type using a vertical coincidence set of two or more counter tubes, in which an absorber is placed either above the whole system, or between the two top counters, have been reported by various authors.[1-6] All these experiments are in agreement in that they give an increased coincidence rate with the absorber in the first position as compared to that with the absorber in between the counters.

In all these experiments, except those of Froman and Stearns,[5] the material shifted during the experiment was either iron or lead, and the increase in counting rate was found to be relatively small. Rossi *et al.*,[7] using the anti-coincidence method, have shown conclusively that the