of the recombination theory, whereas the beta-ray range theory would predict no effect at either pressure.

Further support of the recombination theory of the limited ionization at high pressures comes from the observation that when nitrogen is used, the ionization remains proportional to the pressure up to pressures much higher than is the case with air. We have observed this to be the case using gamma-rays, and Broxon informs us that he finds the same difference with cosmic rays. The interpretation of this difference between nitrogen and air is apparently the fact that the energy lost by an electron per collision is much less in nitrogen than in air. Thus an electron ejected by a passing beta-particle should move farther from its parent positive ion in nitrogen than in air before losing its initial energy. This would make recombination less likely in nitrogen.

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September 23, 1931.

The Constancy of Cosmic Rays

In the preceding letter to the Physical Review we have called attention to the fact that the ionization of air traversed by gamma-rays from radium is a function of the pressure, and that this dependence upon the pressure is greater when the pressure is high. There have been from time to time important and careful experiments which have indicated a variation in the intensity of cosmic rays with the time of day. Those of Millikan have, for example, shown a maximum intensity in the afternoon and a minimum at night. This is the type of apparent variation that one should expect if the apparatus is not kept at a uniform temperature. Other observers have noted that the apparent variation in cosmic ray intensity is greater for the softer component of the cosmic rays. These softer components, however, can only be studied in very high altitudes where the temperature variation between day and night becomes relatively large. We, therefore, determined to study the variations in the intensity of cosmic rays in a high altitude in such a way that possible temperature variations would not influence our results.

The ionization chamber used in these experiments was a hollow steel sphere, 4 inches in diameter, filled with dry air at thirty atmospheres pressure. (The ionization was measured by means of a Lindemann electrometer. Hourly readings were taken of the ratio of the intensity of the cosmic ray entering this chamber when shielded with two inches of lead to the intensity of the gamma-rays from a milligram of radium placed in a fixed position about 30 centimeters from the chamber.) Any temperature variations should, under these conditions, affect equally the ionization produced by the cosmic rays and the gamma-rays.

This apparatus was taken to Summit Lake, near the top of Mount Evans, Colorado, at an altitude of 12,680 feet. A series of hourly readings taken for 240 consecutive hours showed no variations in the intensity greater than the variations to be expected from purely statistical considerations. (The probable error of the intensity for a four hour period was about 0.15 percent.) This series of readings appears to be as thorough a test of the diurnal variations of cosmic ray intensity as has yet been made, and since it shows no intensity changes, it would appear that probably some of the previous changes that have been recorded may be due merely to variations in the temperature of the apparatus employed.

The long, continuous series of readings necessary to make this test of diurnal variations could not have been completed without the cooperation of Messrs. V. J. Andrew, F. P. Longman, V. L. Ridenour, and A. A. Compton of Chicago; and W. J. Overbeck, P. M. Barth, and J. A. Headberg of Denver.

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Thermionic Emission from a Plane Electrode

Being convinced of the importance of space charge in any theory of the thermionic work function, as Waterman and I have pointed out, I have sought explanations of the differences between experimental results and theoretical calculations along this line. In addi-