Note on the Theory of Multiplicative Showers.

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§1. Introduction.

An elegant theory of the cosmic ray shower as brought about by the succession of the emission of radiation and the pair production was developed by Carlson and Oppenheimer[1] and by Bhabha and Heitler[2] and was able to account for experimental results, on the whole, so well that it was accepted as the correct interpretation of the main part, at least, of the shower. As already recognized by these authors, there are, however, showers which do not seem to belong to the same category as the multiplicative shower. For example, an strong evidence for the existence of the production possibility of showers which was produced by a single elementary act was obtained by Watase[3], who showed that the Rossi transition curve for quintuple coincidence of the counters was linear rose linearly with thickness, while those for triple and quadruple coincidences rose quadratically. In order to compare this result with the consequence of the multiplication theory more accurately, we tried to determine the shape of the theoretical curves for the probability of appearance of a fixed number of electrons and positrons under a thin absorber layer of matter. The calculations can be performed as a special case of the general theory of the above authors and can not claim little as novel. It will not be useless altogether to give a brief account of the calculation, although it can claim little as novel, being a special case of the general theory of the above cited.

1) Carlson and Oppenheimer, Phys.Rev. 51, 220, 1937.

2) Bhabha and Heitler, Proc. Roy. Soc. A. 159, 432, 1937.

3) Watase, Nature 139, 671, 1937; Proc. Phys.-Math. Soc. Japan, 19, 749, 1937.

§2. Probable Number of Particles produced by 2n-th Order Process.

According to Bhabha and Heitler[4], the probable number of positive and negative electrons, which appear under a thickness l of absorber, when a high speed electron with energy E_0 passes perpendicular to it, is given by

(1)

where $y = \log E_0/E$, $l = b$ and $= 0.6$ and

$$W(L,y) = \frac{e^{-y} y^{l-1}}{} dy$$

$E_0 b^{-1}$ is the length depending on the atomic number of the absorber, whcich is 0.4 cm for Pb and 1.4 cm for Fe, 7.8 cm for Al, 34 cm for watwr and 275 m for air. (in (1)) the term y^{l-1} has the physical meaning, that (1) can be transformed into the form by a partial intgration

in which the first term vanishes and we have