rence of the showers for various thicknesses of lead above the chamber at the stations indicated. The observed jumps were arbitrarily classified according to size into various groups. By using the value of 100 ion pairs per cm path for air under standard conditions as the specific ionization produced by a single ray,[2] together with the average diameter of the sphere, these groups could be expressed in terms of the number of rays passing through the chamber. No jumps representing less than 10 rays are included in the Cambridge data, and none less than 20 for the South American stations.

The results are plotted in Fig. 1 for the group of 20–30 rays. The curves all have a maximum at about 1 cm lead, though there are indications that the maximum shifts to smaller thicknesses of lead for the higher elevations. This maximum becomes increasingly pronounced with increasing elevation. The curves for the other groups, while not given, are of the same general form, and show the same variation in shape with altitude. For the group of 20–30 rays for 1.27 cm lead, on which there are the most data, the ratios of the rates of occurrence (corrected for side shielding by subtracting the value for zero lead above) are: Huancayo to Cambridge, 5.0 : 1; Cerro de Pasco to Cambridge, 11.0 : 1. Johnson,[3,4] from counter observations, gives for the same thickness of lead, the ratio 7.8 : 1 between Cerro de Pasco and Swarthmore, which is to be compared with the Cerro de Pasco to Cambridge ratio. It has been suggested[5] that the transition effect may be explained in terms of a shower-producing radiation, having a much higher equilibrium intensity in air than lead. Our data indicate this to be the case, both from the form of the curves in Fig. 1, which are of the general shape of transition curves, and from the fact that the transition difference increases with altitude in approximately the same ratio as the showers, namely: Huancayo to Cambridge, 3.9 : 1; Cerro de Pasco to Cambridge, 7.5 : 1.[1]

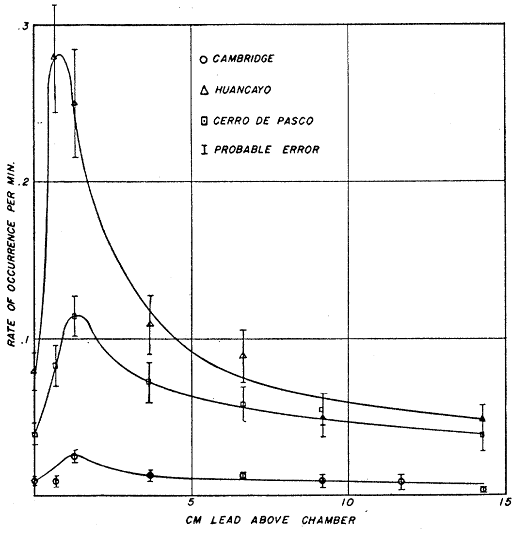

FIG. 1. Shower curves for group of 20–30 rays.

Taken in conjunction with our ionization data,[1] the showers consisting of more than 10 rays contribute approximately 2 percent to the general ionization for 1.27 cm lead at Cambridge. As seen from Table I, the rate of occurrence increases rapidly with decreasing shower size. Measurements made on a few traces indicate that this increase continues for the groups of still smaller sized showers than given in the table. (For 1.27 cm lead at Cambridge, the rate for the group of 6–9 rays is 0.40 per min.) Taking into account the increasing abundance of the smaller showers, one concludes that the shower phenomenon contributes appreciably to the general radiation. Since the showers increase more rapidly with altitude than the general radiation, this contribution is of increasing importance at higher elevation.

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Collisions of High Energy Protons in Hydrogen

Since September, 1934, some 250,000 proton (750 kv) tracks in hydrogen have been photographed and about 160 collisions observed. The protons were obtained by the apparatus of Lawrence and Livingston,[1] the apparatus being capable of producing a 1.3 MEV proton beam at a current of 10^{-9} amp. A Wilson cloud chamber and stereoscopic camera were used to make a study of intimate collisions of protons with hydrogen ions. The data, though still very meager, are sufficiently at variance with the concept of a "point-charge" proton to make a brief report of interest to theoretical physicists.

The salient features of the results are as follows:

1. All collisions technically accurately photographed show conservation of energy and momentum. Certainly no energy in excess of 20 kv is radiated in any form even for collisions of 750 kv.
2. The total number of scattered protons as a function of the energy of the incident proton does not fall off as the inverse square of the energy.
3. The angular distribution of scattered protons does not follow Mott's[2] formula, but is much too large at large angle deflection.

Table I shows the expected and the observed number of collisions in a given angular range and energy range. It must be again emphasized that such few numbers of collisions are represented as to make statistical fluctuations quite serious. Of course where identical nuclei are concerned no angle of scattering greater than 45° should appear if one always chooses the angle of deflection of the longer tine.

TABLE I. *Number of 600–750 kv collisions.*

Angle	15°–20°	20°–25°	25°–30°	30°–35°	35°–40°	40°–45°
Theoretical	8.7	3.8	2.1	1.1	0.74	0.55
Observed	10.5	5.5	0.5	1.5	3.5	5.0

If we accept these results at face value, they indicate a serious departure from Coulomb's law for two protons at distances of 5×10^{-13} cm. These deviations are much larger than those to be expected from the theory of the positron, and are not to be expected at all on the basis of classical electron theory,[3] according to which a proton should act like a point charge down to 10^{-16} cm. The present results can be accounted for by assuming a Gamow potential[4] with radius small compared to the de Broglie wavelength of the proton, but more certain and much more detailed data are needed to justify any theoretical interpretation.

The work is being continued with improved technique using a Wilson cloud chamber and in addition a new electrical counting method is being developed to avoid the inevitable paucity of data obtainable from the cloud chamber. It is hoped in the near future to submit these further results in detail to the *Physical Review.*

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