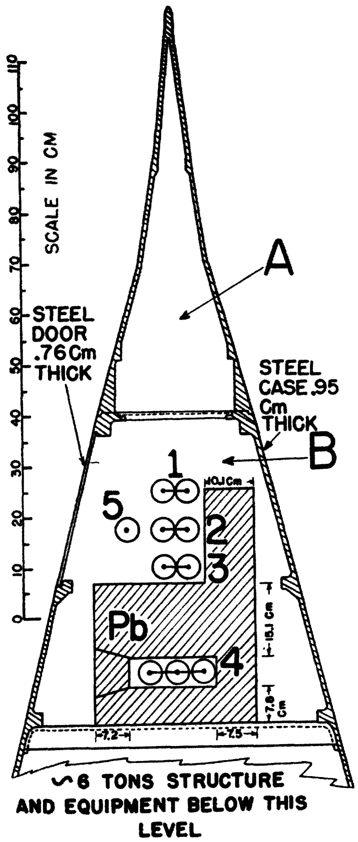

FIG. 1. Arrangement of cosmic-ray equipment as mounted in the warhead.

Figure 1 is a schematic drawing of the cosmic-ray equipment as mounted in the warhead. Chamber A above the cosmic-ray chamber had a total weight, including contents, of 100 pounds, which was almost entirely steel. If this is considered spread uniformly across the top of chamber B, it is equivalent to about 7.8 centimeters of iron. Single counts in counters 1, 5, and 4 were transmitted, as well as coincidences (1, 2, 3), (2, 3, 4), (3, 5), and (1, 3, 5). In addition, coincidence between each of these various data could be read off the record on the ground. Coincidence resolving times in the rocket were 20×10^{-6} sec., while the resolving time for inter-channel coincidences on the ground was 5×10^{-3} sec. The cosmic-ray counters were fastened in a light aluminum rack which could be removed from the lead for solid angle calibration. A series of calibration runs was made both at Washington and at White Sands, (altitude 4000 feet, geomagnetic latitude 42°N).

Considering first the data from the single counters, counters 1 showed an increase in rate above 200,000 feet over the rate on the ground of 21.3 ± 1.0 times. Counter 5 showed an increase of 20.7 ± 1.2 times. Counters 4 gave 34.9 ± 1.7 for this ratio. In a separate experiment on the ground at White Sands with a vertical telescope, it was determined that the ratio of hard count to total count was 0.651 ± 0.024. If the primary rays are all hard, then the shielded counters (4) should have a ratio of counting rate in flight to ground rate higher than that for the unshielded counters by the ratio 1 to 0.651. Reduction of the shielded counting rate by the reciprocal of this factor gives 22.7 ±1.4, which agrees with the ratios for the other counters within probable error. Probable errors are determined from statistics only. Counting rates in flight were 36.2/sec., 22.0/sec., and 39.2/sec. for counters 1, 5, and 4, respectively.

The data from the coincidence channels were as follows: (1, 2, 3) increased by a factor of 56 over the ground rate, (3, 5) by a factor of 150, and (1, 3, 5) by a factor of 420. Channel (2, 3, 4) developed an electronic defect and furnished no usable data. Of the 61 counts observed in 28.6 sec. in the shower channel (1, 3, 5) 49, or 80 percent, accompanied coincidences (1, 2, 3). The latter channel in this time had 103 counts. Thus, 49/103 or 48 percent of the counts in (1, 2, 3) were accompanied by showers. This presumably accounts for the higher increase in counting rate than the single counter results indicate.

The effect of the warhead structure as determined in the ground calibration was to increase the soft part of the count in (1, 2, 3) by a factor of 2.2 over the rate without warhead. At the same time, a shower in (1, 3, 5) was recorded for each 6.6 soft counts recorded in (1, 2, 3) with the warhead in place. The high shower to total count ratio in flight probably indicates therefore, that showers of many particles are produced at high altitudes in the structure adjacent to the counters.

Further experimental work is being undertaken for future flights. The present data are perhaps best regarded as provisional pending subsequent corroboration. In particular, whatever effect the high shower count may have had on the single counters has not been completely determined.

The writers are indebted to their colleagues in the Rocket Sonde Section, Naval Research Laboratory, and to M. Schein for suggestions concerning the problem.

Single Scattering and Annihilation of Positrons

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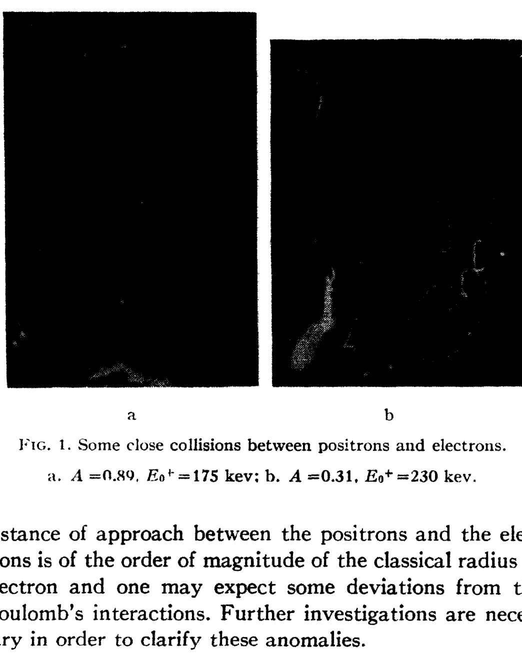
July 26, 1946

I

IN the process of collisions between electrons, it is impossible to distinguish, after the collision, between the recoil electron track and that of the incident β-particle. One cannot, therefore, separate the cases of strong energy exchange (large angle of scattering, θ) from those of weak energy exchange ($\sim\frac{1}{2}\pi-\theta$). But in the case of collisions between positrons and electrons, if one investigates them in a cloud chamber with a magnetic field, one can distinguish the particles easily according to the sense of their curvatures, which permits one to study the problem of single scattering more in detail. But until now, as we know, such kind of collision has not yet been reported.

In the course of the writer's study on the β^+-spectrum of ${}_{25}Mn^{52}$, a great number of such collisions (single scattering) have been observed, which allowed her to make a first comparison with the theory.[1] The experimental conditions are as follows: Cloud chamber was filled with air at an initial pressure of about 1.9 atmos. and the magnetic field was about 900 gauss. The source, ${}_{25}Mn^{52}$ prepared by the reaction of ${}_{26}Fe^{54}(d, \alpha){}_{25}Mn^{52}$, was mounted in the center of the chamber. The trajectories were photographed stereoscopically. Measurements were carried out by means of the same objectives as in the original photography; by such arrangement, a natural size image of the track in space was produced at a position corresponding to that in the cloud chamber. Of a total length of 240-m trajectories (reduced to normal conditions) from 2774 positrons (the energy of which extends from 25 to 800 kev with maximum intensity at about 200 kev), 178 single scatterings with energy exchange $A \geq 10$ percent have been observed ($A = E^-/E_0^+$, where E_0^+ and E^- are the energy of the initial positron and that of the recoil electron, respectively). Some of such collisions are shown in Fig. 1. Within the limit of experimental error, it seems that the principle of conservation of energy holds in the collisions of positrons with electrons.

A comparison of the experimental results on the frequency of single scatterings with the theory, which was developed independently by Bhabha[2] and Bothe is shown in Fig. 2. In the first approximation, there is a general agreement between the theoretical and the experimental curves. But it is noticeable, that, in the case of strong energy exchange ($A > 0.5$) where the experimental accuracies are much higher, the experimental values are much higher then the theoretical ones. Just in such cases, the distance of approach between the positrons and the electrons is of the order of magnitude of the classical radius of electron and one may expect some deviations from the Coulomb's interactions. Further investigations are necessary in order to clarify these anomalies.



a b

FIG. 1. Some close collisions between positrons and electrons.
a. $A = 0.89$, $E_0^+ = 175$ kev; b. $A = 0.31$, $E_0^+ = 230$ kev.

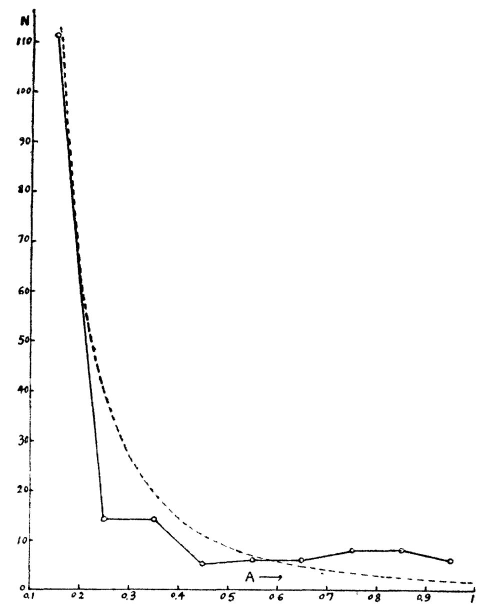


FIG. 2. Comparison of theory and experiment on frequency of single scattering. N is the number of single scatterings; A is E^-/E_0^+. The circles indicate experimental results. The dotted curve is from theory.

II

There have been many experimental works which gave sufficient evidence for the existence of annihilation of fast positrons, but it seems, as we know, there is still no direct proof (for example, by means of cloud chamber). In the course of the present experiment, from 240 meters of β^+-trajectories, 3 annihilations of positron still in motion were observed, i.e., the trajectories stopped suddenly in the illuminated part of the cloud chamber. (By means of the stereoscopical photographs, we can identify them without doubt.) Their energies are 92, 245, and 352 kev, respectively. According to Bethe's calculation,[3] based on Dirac's theory of positron, the expected value of annihilation for a total length of 240-m trajectories of positrons with the corresponding energy range is 2.8. The agreement between the theory and the experiment may be considered as satisfactory.

[1] Ho Zah-wei, Comptes rendus **222**, 1168 (1946). One of such close collision photographs has been projected in the cosmic-rays conference held at Bristol, England, Sept. 1945, as reported in Nature **156**, 543 (1945).
[2] H. J. Bhabha, Proc. Roy. Soc. **154**, 195 (1936).
[3] H. A. Bethe, Proc. Roy. Soc. **150**, 129 (1935).

A Thermodynamic Criterion for the Fracture of Metals—A Criticism

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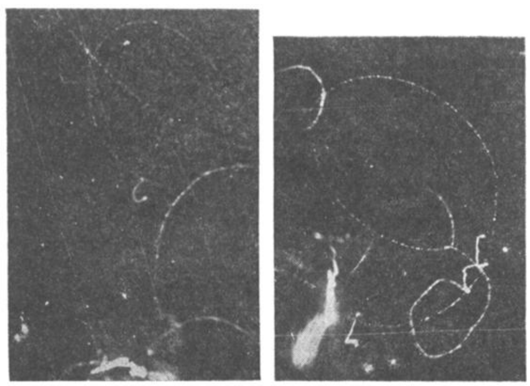
A THERMODYNAMICAL criterion for the fracture of metals has recently been proposed.[1] The purpose of this letter is to point out that this proposed criterion is



a b

FIG. 1. Some close collisions between positrons and electrons.

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