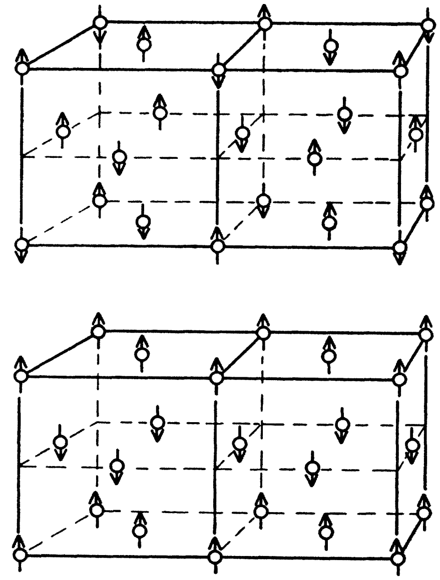

FIG. 1. Possible magnetic structures for a face-centered cubic lattice. (a) Antiferromagnetic next-nearest-neighbor ordering. (b) Antiferromagnetic nearest-neighbor ordering.

transitions can be correlated with the magnetic structures of these compounds.

Figure 1 shows two possible magnetic structures for a face-centered lattice. Case (a) illustrates the arrangement of lowest energy when the most important exchange interactions are antiferromagnetic interactions between next nearest neighbors. This magnetic structure is the one discovered by Shull[4] in his neutron diffraction experiments on the four compounds listed above. This configuration consists of four interpenetrating simple cubic lattices, each arranged antiferromagnetically within itself. Actually the neutron diffraction data does not distinguish between the magnetic structure of case (a) and one in which there is no correlation of spin directions between different sublattices. As indicated below, the x-ray diffraction data seem to favor the first arrangement.

Case (b) is a possible structure when antiferromagnetic nearest neighbor interactions are most important, and is especially favorable if there are also ferromagnetic next nearest neighbor interactions.[5] So far, this structure has not been observed experimentally.

In case (a) there is a set of (111) planes and in case (b) a set of (100) planes in which all spins in a given plane are parallel but the spins in neighboring planes are antiparallel. If our argument concerning the crystal structure transitions[3] is correct, and if we assume the existence of nearest-neighbor interactions, we should expect that at the Curie temperature the crystal would expand or contract along a direction perpendicular to these planes. Therefore, structure transitions to rhombohedral and tetragonal symmetry should occur for cases (a) and (b), respectively.

As predicted by our arguments, MnO, FeO, and NiO, which have the magnetic structure of case (a), undergo transitions to rhombohedral symmetry at the Curie temperature. Rooksby and Tombs[6] have reported that MnS undergoes a transition to rhombohedral symmetry near its Curie temperature, indicating that its magnetic structure is the same as that of the oxides. Finally, Greenwald[7] has determined that Cr_2O_3, which has the corundum structure, contracts along a [111] direction at the Curie temperature. This result suggests that its magnetic structure is the one proposed by Néel[8] in which there is a set of (111) planes with alternating spin directions.

In the case of CoO, the interpretation of the crystal structure data apparently does not agree with the observed magnetic structure. The tetragonal deformation at the Curie temperature suggests that its magnetic structure is that of case (b) with nearest-neighbor ordering, but the reported neutron diffraction work[4] indicates that the magnetic structure is actually that of case (a). We have no explanation for this discrepancy.

In order-disorder transitions in 50-50 face-centered alloys, deformations to rhombohedral and tetragonal symmetry are observed for ordering of types (a) and (b), respectively.[9] These deformations may be due to variation of ordering energy with distance, in analogy with the antiferromagnetic case.

* This work was supported in part by the ONR.
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Evidence of Long-Range Secondary Electrons Accompanying Cosmic Rays in a Proportional Counter

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THE measurement of the ionizing power of individual cosmic-ray particles has usually been undertaken with one or two proportional counters connected in coincidence with Geiger

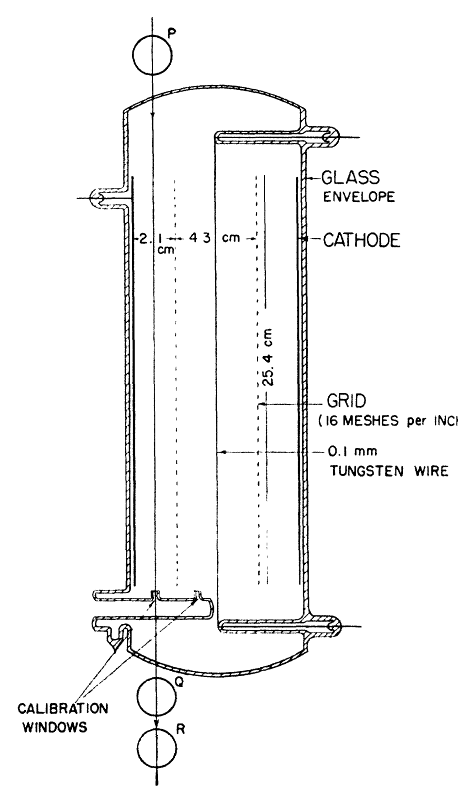

FIG. 1. The arrangement of the proportional counter.

counter telescopes.[1,2] It has, however, been found by Weisz and Swann that a cosmic ray traversing similar path lengths in two proportional counters gives pulses A and B which are unequal, A being sometimes less than and sometimes greater than B. Swann[3] has suggested, on theoretical grounds, a probable explanation for this discrepancy as being due to the statistical fluctuation in the number of high energy secondary electrons emitted within the gaseous volume of the proportional counter.

In order to test the validity of this hypothesis an experimental arrangement, schematically depicted in Fig. 1, was set up. The path of the cosmic ray was defined by three small Geiger counters P, Q, and R, using the usual coincidence circuit method and kept confined between grid and cathode of the proportional counter. The grid was maintained at a negative potential (approximately 90 volts) relative to the cathode, so that no negative ions produced in the region between grid and cathode could get to the wire. However, long-range secondary electrons emitted by the primary can pass through the grid and produce avalanches near the wire by an appropriate adjustment of the potential difference between grid and wire.

The pulse from the proportional counter was fed to a two-stage linear amplifier followed by a biased multivibrator and a Rossi tube. The latter was connected in coincidence with another similar circuit which was fed by the triple coincidence pulse from the Geiger counters after suitable modification. The triple and quadruple coincidences were recorded separately by an Esterline Angus pen-recorder.

Figure 2 shows two typical curves, obtained at two different sensitivities of the multivibrator, where the ratio of the quadruple to triple coincidences in percent has been plotted as a function of the voltage on the proportional counter. The nature of the curves most probably results from a combination of two phenomena:

(a) The increase to a maximum in the primary phenomenon under investigation, *viz*, the detection of the secondary electron, and

(b) superposition of the phenomenon resulting from the sucking of ions through the screen from the region outside, which would presumably mount at increasing rate with increase of "sucking-in" field. It is proposed to investigate more fully the phenomenon of leakage of ions by utilizing a grid having a smaller mesh of thinner wires and also by adopting two grids instead of one, the potentials being suitably adjusted.

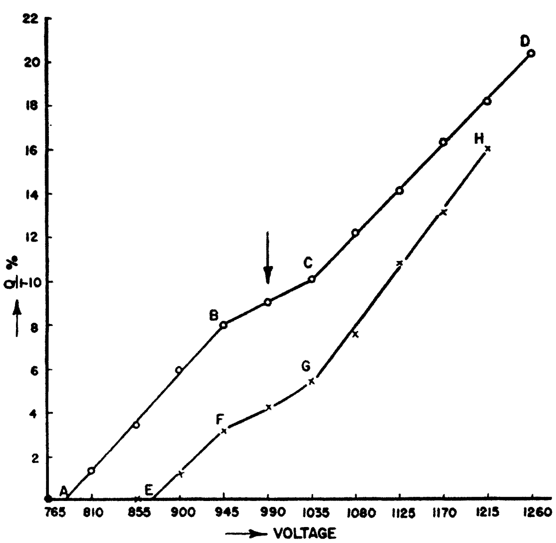

FIG. 2. The ratio of quadruple to triple coincidences in percent *vs* voltage on the proportional counter.

It may be seen, however, that the curve $ABCD$, obtained with the multivibrator operating at its maximum sensitivity, shows a point of inflection at about 9 percent. This represents probably the most acceptable value of the percentage of secondaries obtained under these experimental conditions.

It is interesting to compare this value with that deduced theoretically according to Swann's[3] method. The fraction P of the N secondaries, with energy $Q>Q_0$ is given by

$$P=Q_m/Q_0, \tag{1}$$

where Q_m is the lowest limit of Q ($\sim$10 ev), and Q_0 is the lowest energy of a secondary detectable under our experimental conditions.

Assuming that the secondaries are ejected at right angles to the path of the cosmic ray, like delta-rays accompanying swift β-particles,[4] it may be seen that the secondaries have to traverse an average length of approximately 1 cm in the gaseous mixture (5 cm of argon+15 cm of methane) before entering the sensitive volume of the proportional counter. This path length is equivalent to a range of approximately 0.2 cm in air at N.T.P. and necessitates a dissipation of approximately 3 kev on the part of the electron.[5] Moreover, the path length of 25.4 cm traversed by the primary through the gaseous volume of the counter gives about 130 primary ionizing events (N).

Therefore, the average number of cases where $Q>Q_0$ in the passage of a primary through the counter along the path designated is

$$PN=130\times 3.3\times 10^{-3}=0.43.$$

Now if, as a first approximation, we assume that the number of secondaries for $Q>Q_0$ shows fluctuations in accordance with Poisson's law, the fraction F of the primary rays which give n secondaries is represented by

$$F=x^n e^{-x}/n! \tag{2}$$

In this case x, the average number of secondaries per particle, is 0.43. The values of F for $n=0$, 1, 2, respectively, are 0.65, 0.28, 0.06. Thus, in only 34 percent of the cases, the primary ray is accompanied by secondaries above 3 kev, which are ejected in all directions perpendicular to the path of the former. On account of the geometry and dimensions of the cathode and grid, however, it can be shown that only 33 percent of these secondaries can penetrate through the grid into the active volume of the proportional counter. Therefore, the calculated percentage of long-range secondaries which can be detected in the present set up is about eleven, which compares favorably with our experimental finding.

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* National Research Laboratories Post-Doctorate Fellow.

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Measurement of Isomeric Transition Energies with a Scintillation Spectrometer

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AN accurate determination of isomeric transition energies is necessary for a comparison between theoretical and experimental gamma-ray lifetimes and plays, therefore, an important role in any systematic investigation of isomers. The gamma-ray scintillation spectrometer[1] is particularly suited for the determination of isomeric transition energies whenever one or more of the following conditions are fulfilled: the isomeric transition is not too highly converted, the specific activity is low, and the lifetime is short. Under such circumstances the use of the scintillation