The scintillation pulse distributions from cosmic rays, from a Co[60] source, and from the radioactive contamination of the aircraft are shown in Fig. 1. A Co[60] calibration curve was taken after each data run; and all pulse heights are referred to the peak of the differentiated Co[60] curve which corresponds to a Compton electron energy of $\sim$1.0 Mev. Over a limited range, therefore, the scale for pulse height on Fig. 1 may be used as energy in Mev.

The total pulse distribution, obtained during a flight at 2000 feet, was assumed to be due to the contamination of the aircraft and was used to correct the data. This was justified on the basis of G-M tube data regarding the total cosmic-ray intensity (ionizing and gamma) at 2000 feet and introduces an error of less than 10 percent in the evaluation of the contamination.

The relatively short airborne time and low counting rate yielded a small number of counts with resultant poor statistics, as shown by the extensions of the data points in Fig. 1. These extensions are based solely on the probable error due to statistical variations.

Very brief investigation with a G-M tube guard ring around the scintillation detector indicated that pulses due to the ionizing component were in the region above 0.8 units of pulse height (0.8 Mev), whereas the region for energies below $\sim$0.8 Mev probably consists primarily of pulses due to gamma-rays created in the atmospheric cascade process. Since the pulse distribution for a mono-energetic source (Co[60]) rises much more slowly at small pulse heights than does the cosmic-ray distribution, it is concluded that many cosmic gamma-rays are spread over a broad energy range in the vicinity of 0.5 Mev.

The shape of the distribution above slit position 0.8 (0.8 Mev) is probably a result of nonlinear crystal response[2] in combination with an ionizing particle energy spectrum obeying an inverse power law. There is some indication that the curve has a peak in the region above 1.7 units. Most of the pulses above 0.8 Mev are due to cosmic-ray electrons which, it is estimated,[3] constitute 80 percent of the total ionizing intensity at 30,000 feet and 50° geomagnetic latitude. These electrons give up energy to the anthracene by ionization and the formation of bremsstrahlung.

Using the formula of Bloch,[4] it may be shown that electrons with energies above 5 Mev will lose about 2 Mev by ionization in 0.5 inch of anthracene. This energy loss is almost independent of the incident energy and would account for a peak in the distribution above 1.7 units.

For very high energies, the bremsstrahlung process would become increasingly important, and partial capture of the resultant radiation would contribute to pulses above 2 units. There is, of course, no reason to expect a linear relation between pulse height and incident electron energy once bremsstrahlung becomes important (even if the electron is stopped in the crystal), unless the crystal is large enough to capture all of the secondary gamma-rays.

Investigations are being continued in an effort to obtain more information about the cosmic-ray background and the various processes contributing to the scintillation spectrum.

* This work was done under contract with the United States Department of the Air Force.
[1] To be described elsewhere.
[2] The linearity of the pulse height versus energy curve for low energies in anthracene has been studied by J. I. Hopkins, Phys. Rev. 78, 643 (1950).
[3] Montgomery, Cosmic Ray Physics (1949), p. 131.
[4] W. Heitler, Quantum Theory of Radiation (1944), pp. 217 ff.

Radiations from Zr[89]

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THE Zr[89], produced by Y(d, 2n) in the M.I.T. cyclotron, decays with a half-life of 79.3 hours. Figure 1 shows the momentum distribution of the particles emitted from Zr[89] as
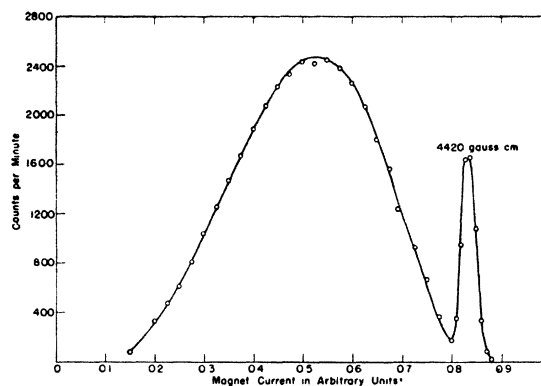

FIG. 1. Momentum spectrum of Zr[89] particles.

measured with a thin lens magnetic beta-ray spectrometer. The conversion line has an energy of 910 kev, whereas the continuum of positrons has an end point of 905 kev on a conventional Fermi plot. No beta-gamma coincidences nor x-gamma coincidences have been found. No gamma-gamma coincidences except those due to annihilation radiation have been found. The conversion coefficient has been estimated as 0.5 percent.

From the results of this research, the level emitting the conversion electrons has a lifetime considerably greater than the resolving time of the coincidence circuit used (10^{-7} sec). This is in agreement with the high conversion coefficient found. It is not known whether the conversion takes place in Zr or Y.

Cross Sections and Q-Values for the $C^{13} + D^2$ Reactions*

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THE energy of the reaction products from the disintegration of C^{13} by deuterons has been analyzed with the 16" double-focusing magnetic spectrometer. The emitted particles, identified by their mv/Ze value and pulse size in the scintillation proportional counter, correspond to the reactions (1) $C^{13}(d, \alpha)B^{11}$, (2) $C^{13}(d, p)C^{14}$, and (3) $C^{13}(d, t)C^{12}$.

The targets were prepared by depositing C^{13} on thin tantalum strips by heating the tantalum in an atmosphere of CH_3I vapor, enriched to 61 percent C^{13}. The thickness of the targets, estimated from the energy spread of the outgoing particles, was approximately 50 kev for the incident deuterons. The deuteron beam of 1006±1 kev from the van de graaff generator was controlled with an electrostatic analyzer calibrated against the $Al^{27}(p, \gamma)Si^{28}$ resonance at 993.3±1 kev.[1]

The calibration of the magnetic spectrometer with Po alpha-particles and the experimental procedure has been described previously.[2] No correction for surface contamination layers has been made, since a magnetic analysis of the elastically scattered deuterons showed these layers to be negligibly small. Appropriate relativistic corrections have been made. Our results are $Q_1 = 5.164$ ±0.006 Mev; $Q_2 = 5.940 \pm 0.004$ Mev; and $Q_3 = 1.310 \pm 0.003$ Mev. The probable errors include statistical errors as well as all known systematic errors, the most significant being the uncertainty in the angle of observation, 89.3±0.2 degrees. These values are in good agreement with those obtained recently by Buechner and his collaborators:[3] $Q_1 = 5.160 \pm 0.010$ Mev; $Q_2 = 5.948 \pm 0.008$ Mev; and $Q_3 = 1.310 \pm 0.006$ Mev. The agreement between independent