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ON THE ENERGY DISTRIBUTION OF THE FISSION FRAGMENTS OF U^{235} PRODUCED BY 2.5-MEV AND 14-MEV NEUTRONS

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FISSION PHYSICS

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ON THE ENERGY DISTRIBUTION OF THE FISSION FRAGMENTS OF U^{235} PRODUCED BY 2.5-MEV AND 14-MEV NEUTRONS

INTRODUCTION

Many investigators have examined the energy distribution of the fission fragments resulting from the isotopes of uranium and thorium.[1-12] In most of the works published to date, the energy of the neutrons used to produce the fission process was confined to the thermal region. In this paper, we report on the energy distribution of the fission fragments of U^{235} for thermal neutrons, 2.5-Mev neutrons, and 14-Mev neutrons.

EXPERIMENTAL METHOD

The method used in this experiment was essentially the same as that used by other investigators, that is, to compare the ionization produced by the fission fragments to the ionization produced by alpha particles of known energy. A fission chamber designed and built by Fowler and Rosen,[1] and similar to the one described in their paper, was used. The chamber, Fig. 1, was of the electron-collection type. The screen, which shields the collecting electrode from the positive ions, was one cm from the collecting electrode and 2.2 cm from the high-voltage electrode. This was maintained at 4000 volts while the grid was at 1850 volts. The high field region between the grid and the collecting electrode was established to insure the "funnel" effect for the electrons through the grid wires. The chamber was filled to a total pressure of 162 cm of mercury of which 95% was argon and 5% was CO_2. This pressure was more than sufficient to stop the alpha particles before they reached the grid. The CO_2 was present to hasten the collection time of the ions. The gas was continuously purified by passing it over calcium metal which was heated to 180° C.

The recording equipment consisted of a Model 101 amplifier with a Model 100 preamplifier connected directly to the chamber. The clipping circuit consisted of a delay line which placed on the grid of the amplifier, after 3 μsec, the original signal which had been inverted by reflection. The amplified signal was fed into a 10-channel pulse-amplitude analyzer Model 301, in which each channel had been adjusted to accept pulses over equal range. For the amplification used, this was set either at 0.8 Mev or 2.0 Mev. By shifting the bias on the analyzer, it was possible to cover the entire energy range of the fission pulses, taking nine points at a time. The last three points of each setting corresponded to the first three points of the next setting. Because of the tendency of the 10-channel analyzer to drift, it was calibrated before and after each run. This was a period of 10 minutes for the 14-Mev data and 50 minutes for the 2.5-Mev data.

The neutron source used was the Los Alamos Cockcroft-Walton set. For the 14-Mev neutrons, the $H^3(H^2, n)He^4$ reaction was used, while for the 2.5-Mev neutrons, the $H^2(H^2, n)He^3$ reaction was used.

The foils were made by John Poevlites of Group CMR-4. The U^{235} had a foil thickness of 0.14 mg/cm^2 and a total weight of 5.42 mg.

To check the techniques required for the experiment, a thermal source of neutrons was obtained by placing a Po-Be source in a graphite pile, and the distribution of the energy of the fission fragments was obtained. The results are shown in Fig. 2 and are compared to the results of Fowler and Rosen in Table 1.

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The distribution of the energy produced by the alpha particles of U^{234} is shown in Fig. 3. The width at half-maximum serves as a measure of the resolution of the ionization chamber and is approximately 0.20 Mev, or 4.2%.

RESULTS

Figure 4 shows the energy distribution of the fission fragments of U^{235} for 2.5-Mev neutrons, and Fig. 5 shows the distribution for 14-Mev neutrons. Table 1 compares these results with results obtained with thermal neutrons.

It is interesting to note that the depth of the valley between the two energy peaks decreases with increasing energy and also that the ratio of the two peak heights approaches unity with increasing neutron energy. This is in qualitative agreement with results reported by R. W. Spence for 14-Mev neutrons using chemical analysis for the mass distribution.[13]

ACKNOWLEDGMENT

The writer wishes to thank Drs. J. H. Coon, J. L. Fowler, E. R. Graves, and Louis Rosen for their many discussions which helped to clarify the problem, also Mr. R. W. Davis for operating the Cockcroft-Walton set during this experiment.

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TABLE 1

	Position of High-Energy Peak	Position of Low-Energy Peak	Ratio of Minimum to High-Energy Peak (percent)	Ratio of Peak Energies	Ratio of High-Energy Peak to Low-Energy Peak	Foil Thickness (mg/cm^2)
U^{235} thermal neutrons						
Fowler and Rosen	93	61.8	21	1.50	1.43	0.105
Friedland	93	60.1	23	1.54	1.37	0.140
U^{235} 2.5-Mev neutrons	91.1	59.6	36	1.53	1.08	0.140
U^{235} 14-Mev neutrons	91.0	59.7	57	1.52	1.08	0.140

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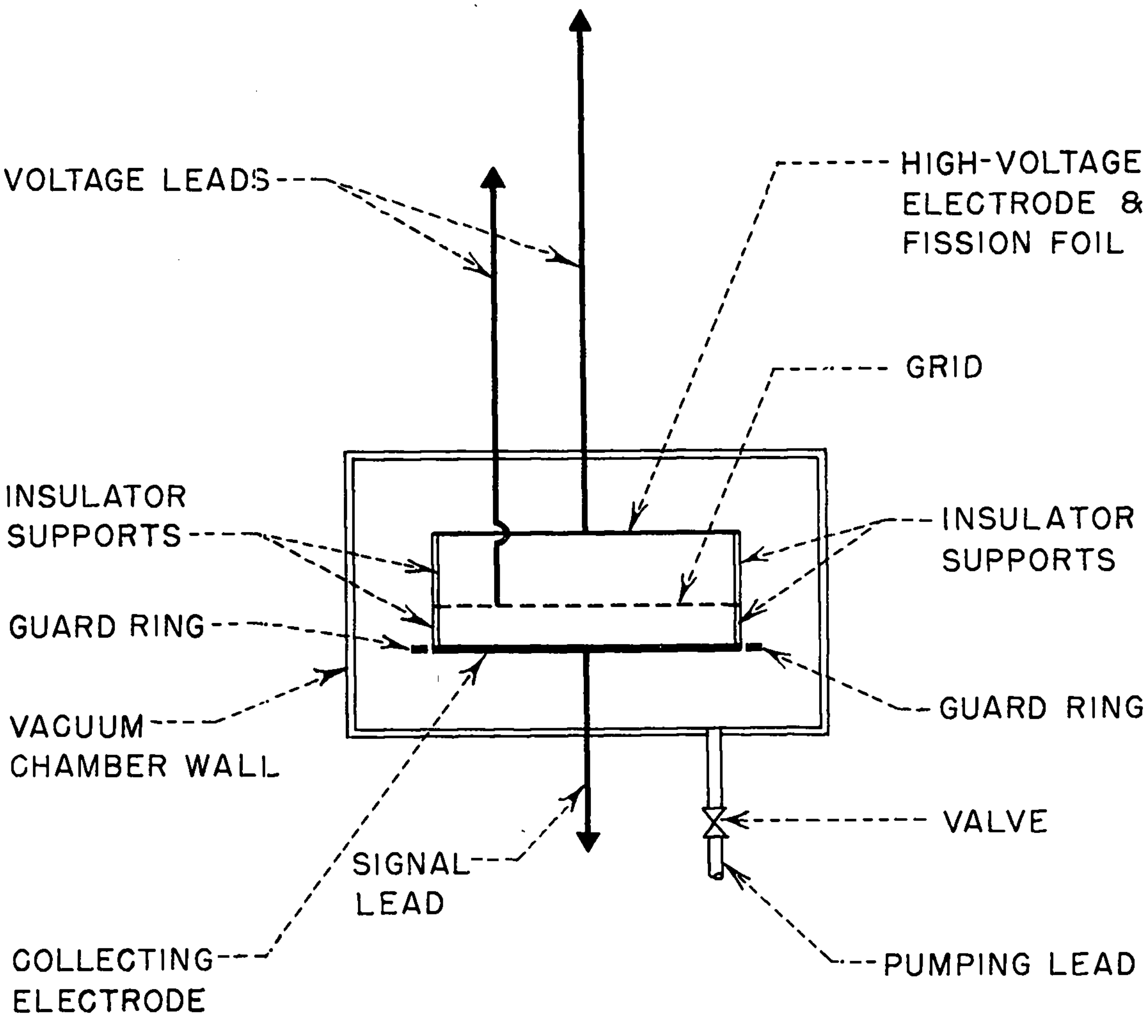

Fig. 1 Schematic diagram of fission chamber.

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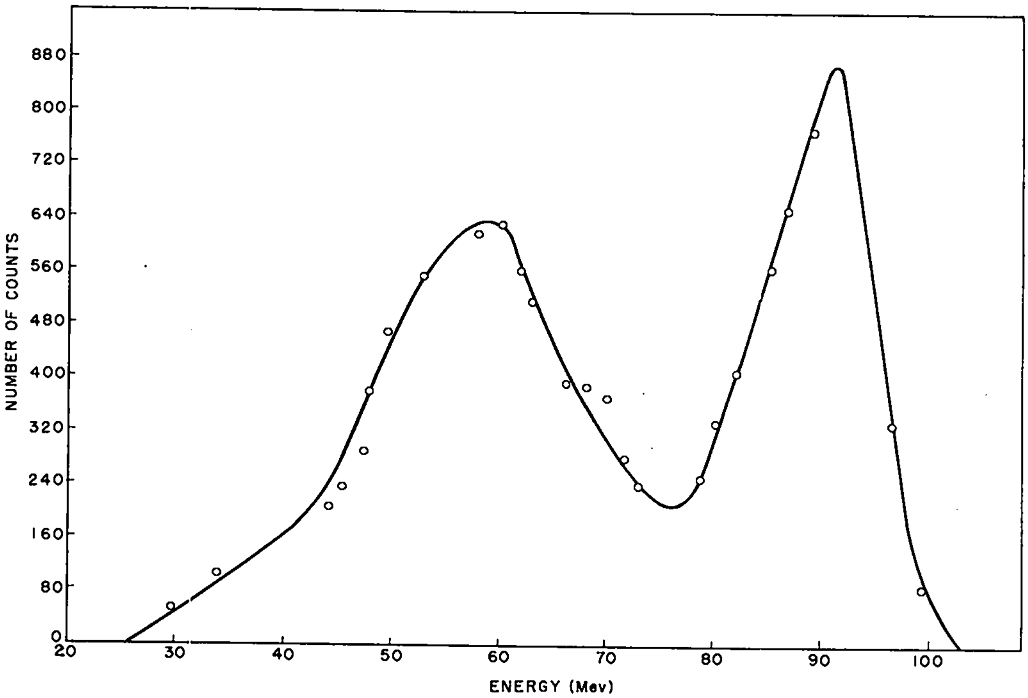

Fig. 2 Energy distribution of U^{235} fission fragments for thermal neutrons.

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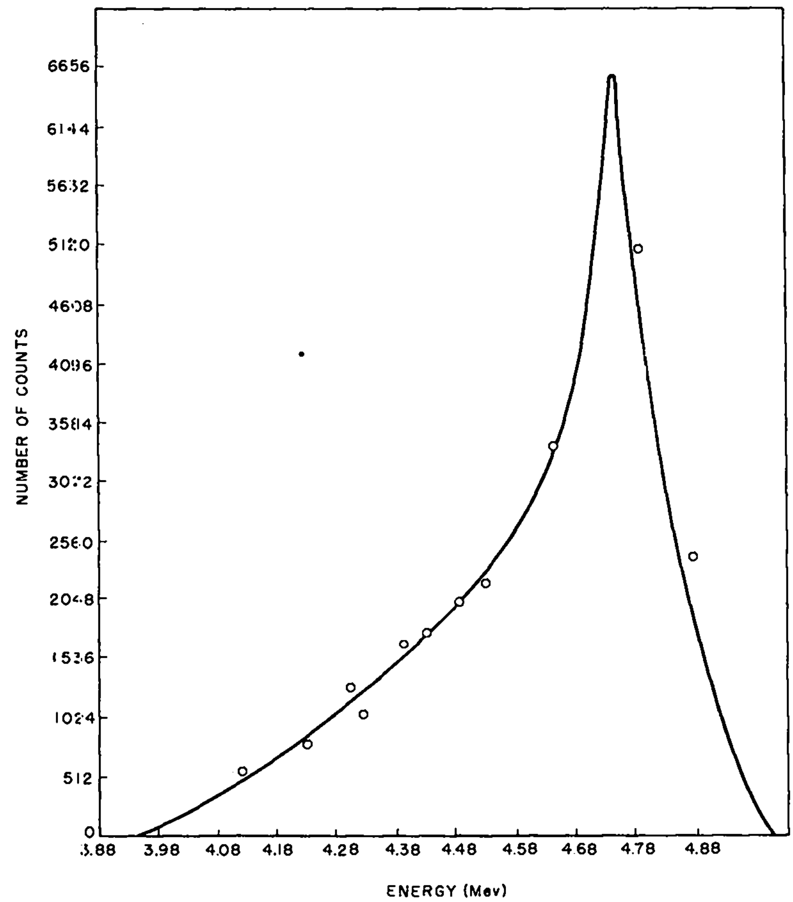

Fig. 3 Energy distribution of U^{234} alpha particles.

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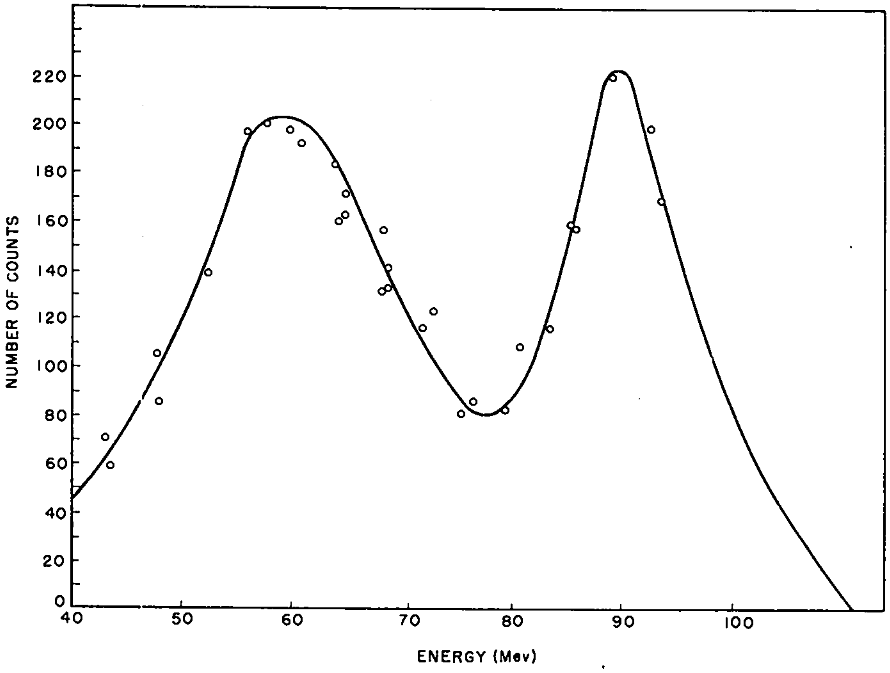

Fig. 4 **Energy distribution of fission fragments of U^{235} for 2.5-Mev neutrons.**

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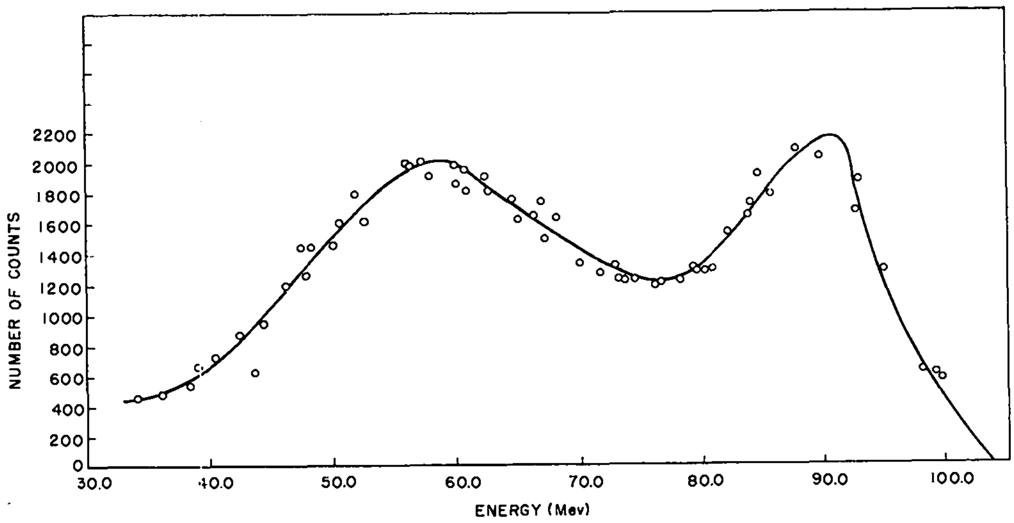

Fig. 5 Energy distributions of fission fragments of U^{235} for 14-Mev neutrons.

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