TABLE I.

NEUTRON-REACTION	MAXIMUM NEUTRON-ENERGY	URANIUM		THORIUM	
		NO Cd	WITH Cd	NO Cd	WITH Cd
	Mev				
Li+D	13.5	100	70	100	100
D+D	2.5	100	70	100	100
C+D	0.5	100	10	0	0

With the amplifier feeding a cathode-ray oscillograph the usual alpha-particle pulses were observed when a layer of uranium oxide was placed on the disk. On exposure to neutron-radiation from (Li+D) at 1000 kv two additional groups of pulses were observed. The first group corresponded to the "neutron-recoils" from the air in the chamber, as previously measured with the same amplifier gain and without the uranium. These neutron-recoils gave pulses about four times the size of the alpha-particle pulses. The second additional group was 20 to 40 times larger than the largest "recoil"-pulse, thus corresponding to energies of 75 to 150 Mev released in the chamber, or 150 to 300 Mev total energy for each individual process. With paraffin surrounding source and chamber the yield was roughly 30 counts per min. per μA of 1000-kv deuterons, which is a neutron-intensity corresponding to about 10,000 millicuries of radon-beryllium. The yield from thorium was of the same order of magnitude.

No effect was observed from bismuth, lead, thallium, mercury, gold, platinum, tungsten, tin or silver with as much as 1/1000 the intensity of that from uranium and thorium.

No effect was observed with either uranium or thorium produced by the gamma-rays from 3 μA of 1000-kv protons on lithium or on fluorine.

To determine roughly the energy-range of the neutrons involved in the fission-process, observations were made with the neutrons from several reactions, both with and without cadmium surrounding the ionization-chamber to filter out the thermal neutrons produced in the surrounding paraffin. Bearing in mind that the ratio of the counts with cadmium and without cadmium depends to a large extent on the amount of paraffin surrounding the source and chamber, the results of these tests may be deduced from Table I in which the relative number of "fissions" is given, with the total yield for uranium and thorium with high energy neutrons, being approximately equal, taken as 100 on an arbitrary scale.

From these comparisons it appears that the uranium fissions are produced by different processes for fast and slow neutrons, the fast-neutron process requiring more than 0.5 Mev but less than 2.5 Mev for effective operation. For thorium, on the other hand, only the fast-neutron process is effective, but somewhat surprisingly it also appears to require between 0.5 and 2.5 Mev.

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Heavily Ionizing Particles from Uranium

After reading in local papers of Hahn's discovery of the splitting of uranium into heavy elements, we wired Professor Gamow for further details. He answered that Tuve had observed the heavily ionizing particles in a differential linear amplifier chamber. We have confirmed this by using a thin ionization chamber, one of whose plates was covered with U, or U_3O_8. With a certain gain, the U natural alphas gave two-mm kicks on an oscilloscope, Po alphas passing parallel to the plates gave eight-mm pulses, and the Hahn-Tuve particles gave deflections of four cm. The energy released in a path length of less than 0.5 mm was about 10 Mev, so the particles must carry several charges, and therefore be "heavy." Check runs on Pb, Cu, Zn, W and Th showed no such bursts. After confirming the existence of these particles, we investigated the type of reaction responsible. A thin Cd covering around the chamber reduced the counting rate to less than five percent. This is unexpected in view of the fact that about half of the "transuranic" activity is due to resonance neutrons which could penetrate Cd. This result shows that Hahn's effect is due largely to thermal neutrons. By the use of a modulated beam of neutrons, we have looked for a time delay in the emission of heavy particles, after the neutron irradiation. The time delay is less than 3×10^{-3} sec. Our thanks are due Professor E. O. Lawrence for his interest in this experiment, and the Research Corporation for financial support.

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Intensely Ionizing Particles Produced by Neutron Bombardment of Uranium and Thorium

We have bombarded uranium nitrate and also thorium oxide with deuteron-deuteron neutrons in a three-millimeter brass ionization chamber and found particles producing an intense ionization. We attribute the results to extremely high energy particles of roughly half the mass of the bombarded nucleus, and believe that they confirm the recent work of Hahn and Strassmann[1] and of Frisch and Meitner[2] on uranium, and also establish a similar effect with thorium.

The substance was bombarded in the form of a layer (about 0.5 gram) stuck with collodion on a paper disk three centimeters in diameter and placed in contact with a mesh-covered opening into the ionization chamber. The gain of the oscilloscope was set so that the kicks resulting from the natural alpha-radiation were about one centimeter high. During neutron bombardment kicks of height greater than five centimeters (peak outside the field of vision) were observed. These were counted visually. Counts were made at various deuteron beam intensities with the chamber directly under the neutron source and also about a meter away, with paraffin and without paraffin