TABLE I. *Number of counts per minute of heavily ionizing particles from the bombardment of uranium and thorium with deuteron-deuteron neutrons for deuteron currents of 0.5 and 1.0 ma at 250 kv.*

	No paraffin		Paraffin	
	$i=1.0$ MA	0.5 MA	$i=1.0$ MA	0.5 MA
U	35	—	69	38
Th	21	11	20	—

around the chamber. Also background counts were made with no uranium or thorium and ran consistently zero over five-minute periods.

Results are given in Table I. The numbers represent counts per minute and are the means of five to ten observations for each case. The paraffin effects in the table were obtained with paraffin around chamber but not between chamber and neutron source. Placing paraffin between source and chamber reduced the counts for uranium to 34 per minute.

The ionization due to nitrogen and oxygen ions produced by neutrons was approximately the same as that due to the natural uranium alpha-particles. Our linear amplifier did not possess a calibrated gain variable over sufficiently wide limits to enable us to determine accurately the ionization produced by the heavy particles. However, on removing one stage of amplification, we were still able to observe the kicks due to heavy particles, and therefore we believe the ionization due to the heavy particles is at least one hundred times that produced by the alphas or recoil ions.

Thus the effect is obtained with 2.4-Mev neutrons for both thorium and uranium. Paraffin doubles the yield for uranium but has no effect on that for thorium. The reality of the effect is confirmed by its proportionality to the intensity of the deuteron beam.

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[1] Hahn and Strassmann, Naturwiss. January, 1939.
[2] Frisch and Meitner, Private Communication from Dr. M. A. Tuve. We are informed by Dr. Tuve that Frisch and Meitner have also observed this effect with thorium on or about January 16, 1939.

Cleavage of the Uranium Nucleus

We have been studying what seemed to be L x-rays from the seventy-two-hour "transuranic" element. These have now been shown by critical absorption measurements to be iodine K x-rays. The seventy-two-hour period is definitely due to tellurium as shown by chemical test, and its daughter substance of two-and-a-half-hour half-life is separated quantitatively as iodine. This seems to be an unambiguous and independent proof of Hahn's hypothesis of the cleavage of the uranium nucleus.

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Resonance in Uranium and Thorium Disintegrations and the Phenomenon of Nuclear Fission

The study of the nuclear transmutations by neutron bombardment in uranium and thorium, initiated by Fermi and his collaborators, and followed up by Meitner, Hahn and Strassmann, and by Curie and Savitch, has brought to light a number of most interesting phenomena. Above all, as pointed out by Meitner and Frisch,[1] the recent discovery of Hahn and Strassmann of the appearance of a radioactive barium isotope as the product of such transmutations offers evidence of a new type of nuclear reaction in which the nucleus divides into two nuclei of smaller charges and masses with release of an energy of more than a hundred million electron volts. The direct proof of the occurrence of this so-called nuclear fission was given by Frisch[2] for thorium as well as for uranium by the observation of the very intense ionization produced in a gas by the high speed nuclear fragments.

In a recent note[3] commenting on the ingenious suggestions put forward for the explanation of the fission phenomenon by Meitner and Frisch, the writer has stressed that the course of the new type of reactions, just as that of ordinary nuclear reactions, may be assumed to take place in two well-separated stages. The first of these is the formation of a compound nucleus, in which the energy is stored in a way resembling that of the heat motion of a liquid or solid body; the second consists either in the release of this energy in the form of radiation or in its conversion into a form suited to produce the disintegration of the compound nucleus. In the case of ordinary reactions, resulting in the emission of a proton, neutron or α-particle from this nucleus, we have to do with a concentration of a considerable part of the excitation energy on some particle at the nuclear surface, sufficient for its escape, which resembles the evaporation of a molecule from a liquid drop. In the case of the fission phenomena, the energy has to be largely converted into some special type of motion of the whole nucleus causing a deformation of the nuclear surface sufficiently large to lead to a rupture of the nucleus comparable to the division of a liquid drop into two droplets. From considerations of statistical mechanics analogous to those applied to the evaporation-like nuclear disintegrations, it follows indeed that the probability of occurrence of fission becomes comparable to that of ordinary nuclear reactions when, with increasing nuclear charge, the deformation energy concerned has decreased to values of the same order of magnitude as that demanded for the escape of a single particle.

Here I should like to show how such considerations would seem to offer a simple interpretation of the peculiar variation with neutron velocity of the cross sections of the different transmutation processes of uranium and thorium observed by Meitner, Hahn and Strassmann.[4] In the light of the new discoveries, the great variety of processes obtained, which could not be disentangled on the ordinary ideas of nuclear disintegrations, would seem, according to Meitner and Frisch, to be reduced to only two types of transmutations. Of these the one consists in an ordinary radiative capture of the incident neutron, resulting in the