TABLE II. Abundance distribution of products. Each element has been normalized to 100 percent for the number of particles found per unit solid angle per unit radius of curvature interval. The actual number of tracks found are in brackets and are listed below the percentages in each case.

Radius of curvature interval	42–46 cm						29–32.5 cm						21–24.5 cm					
Element	Be	Al	Ni	Ag	Au	U	Be	Al	Ni	Ag	Au	U	Be	Al	Ni	Ag	Au	U
H^1	10.92	12.10	13.36	17.37	29.62	28.74	8.36	13.57	26.88	38.56	19.59	9.79	6.50	14.82	31.16	15.90	1.67	2.45
	(163)	(199)	(239)	(194)	(178)	(204)	(119)	(214)	(401)	(499)	(402)	(271)	(125)	(276)	(491)	(508)	(196)	(137)
H^2	3.62	2.43	2.63	3.40	3.16	2.26	3.94	1.97	0.87	0.15	0.09	0.33	2.08	0.65	0.19	0.06	0.14	0.25
	(54)	(40)	(47)	(38)	(19)	(16)	(56)	(31)	(13)	(2)	(2)	(9)	(40)	(12)	(3)	(2)	(16)	(14)
H^3	2.75	0.48	0.34	0.09	0.17	0.42	2.32	0.19	0.34	0.15	0.09	0.25	1.51	0.43		0.03	0.08	0.15
	(41)	(8)	(6)	(1)	(1)	(3)	(33)	(3)	(5)	(2)	(2)	(7)	(29)	(8)		(1)	(9)	(8)
He^3	2.68	1.46	1.29	1.07	1.16	1.13	4.29	1.33	1.01	0.08	0.15	0.47	2.76	0.59	0.38	0.06	0.17	0.27
	(40)	(24)	(23)	(12)	(7)	(8)	(61)	(21)	(15)	(1)	(3)	(13)	(53)	(11)	(6)	(2)	(20)	(15)
He^4	10.52	9.67	7.88	17.46	28.29	18.60	19.19	14.97	8.51	2.24	1.17	3.87	12.59	11.70	2.22	0.25	0.49	4.01
	(157)	(159)	(141)	(195)	(170)	(132)	(273)	(236)	(127)	(29)	(24)	(107)	(242)	(218)	(35)	(8)	(58)	(224)
Li^6, Be^7	0.74	0.42	0.50	0.63	1.50	1.55	0.63	1.14	0.47		0.34	0.47	0.83	0.48	0.19		0.43	0.38
	(11)	(7)	(9)	(7)	(9)	(11)	(9)	(18)	(7)		(7)	(13)	(16)	(9)	(3)		(5)	(21)
Li^7	0.33	0.48	0.34	0.27	0.83	0.28												
	(5)	(8)	(6)	(3)	(5)	(2)												
Li^8	0.07					0.14	0.28						0.16					0.02
	(1)					(1)	(4)						(3)					(1)
B^8	0.07	0.06												0.05				
	(1)	(1)												(1)				
I	0.27	0.42	0.06	0.27	0.17		0.77	1.46	0.47	0.38	0.68	0.43						
	(4)	(7)	(1)	(3)	(1)		(11)	(23)	(7)	(5)	(14)	(12)						
II	0.07	0.18	0.06	0.09	0.17	0.42	0.21	1.27	0.14	0.08	0.09	0.32						
	(1)	(3)	(1)	(1)	(1)	(3)	(3)	(20)	(2)	(1)	(2)	(9)						
III		0.12	0.06	0.18		0.71												
		(2)	(1)	(2)		(5)												
Not classified	0.13	0.61	0.22	0.81	8.15	16.91	0.07	3.30	0.14	0.23	1.27	4.05	1.35	3.60	0.32	0.18	0.31	1.36
	(2)	(10)	(4)	(9)	(49)	(120)	(1)	(52)	(2)	(3)	(26)	(112)	(26)	(67)	(5)	(6)	(37)	(76)
	I—He^6, Be^9, B^{10}, C^{11}						I—He^6, Li^7, Be^9, Be^{10}, B^{10}, B^{11},											
	II—Be^{10}, B^{11}, C^{12}, C^{13}						C^{11}, C^{12}, C^{13}											
	III—He^7, Li^9, B^{12}, C^{14}						II—He^7, Li^9, B^{12}, C^{14}											

of ranges so that separation could only be made by groups in the 42–46 cm position and the 29–32.5 cm position. Carbon was the highest atomic number considered because the range-energy relations have not been verified for higher atomic number. However, higher atomic number could possibly fall into groups II and III in the 42–46 cm position and into groups I and II in the 29–32.5 cm position.

The minimum range accepted was 9 microns. All tracks that had a range greater than 9 microns but still too short to fall on a calculated locus were put in the "not classified" group. The resolution for the separation of the heavy isotopes decreases with energy so that in the 21–24.5 cm position only Li^6 and Be^7 could be separated, while all the rest fall into the "not classified" position. The 9-micron criterion eliminated very little information for the light elements, but for Au and U there were many tracks that were shorter. These doubtless included fission fragments.

The analysis of the results of this experiment are still in a preliminary stage. Similar experiments are being done with the same targets, but high energy protons and deuterons are being used as the bombarding particles. An angular distribution measurement using high energy alphas is also being made in order to separate the instantaneous emission of particles from the struck nucleus from the slow boiling off process.

The results of this experiment and reference 1 indicate that fragments of $A>4$ are emitted from nuclei with high momenta. Dr. L. Alvarez has suggested as a possible mechanism that these heavy fragments are not created in the initial bombardment but are subsequently formed by the fission of resultant nuclei left in excited states.

I am particularly indebted to Dr. W. Barkas for his aid in guiding this entire program. I wish to thank Esther Jacobson for having scanned most of the plates.

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Dysprosium 157

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AN 8.2±0.1-hour activity has been obtained by bombarding highly purified terbium oxide with 24-Mev protons in the ORNL 86-inch cyclotron.[1] Separations were made by ion exchange[2] and two radioactive species were found with the dysprosium fraction. There was an 8.2±0.1-hour activity from the $(p, 3n)$ reaction and a 134-day activity from the (p, n) reaction on Tb^{159}. The 134-day activity is Dy^{159}, as previously reported,[3] and decays by pure electron capture.

A rough excitation function was run to aid in establishing the reaction and mass assignment for the 8.2-hour activity. This was done by wrapping a number of 5-mg samples of Tb_2O_3 in thin aluminum foil and making a stack of these with aluminum absorbers interspaced to adjust the proton energy. The method proved to be sufficient to differentiate between (p, n), $(p, 2n)$, and

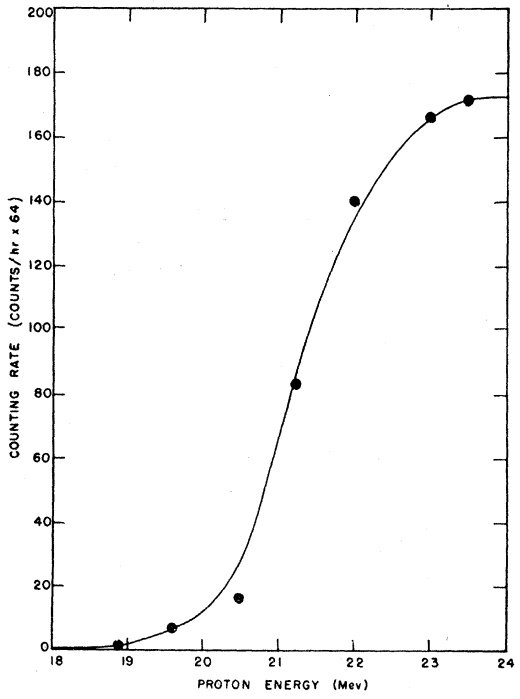

FIG. 1. Excitation function.

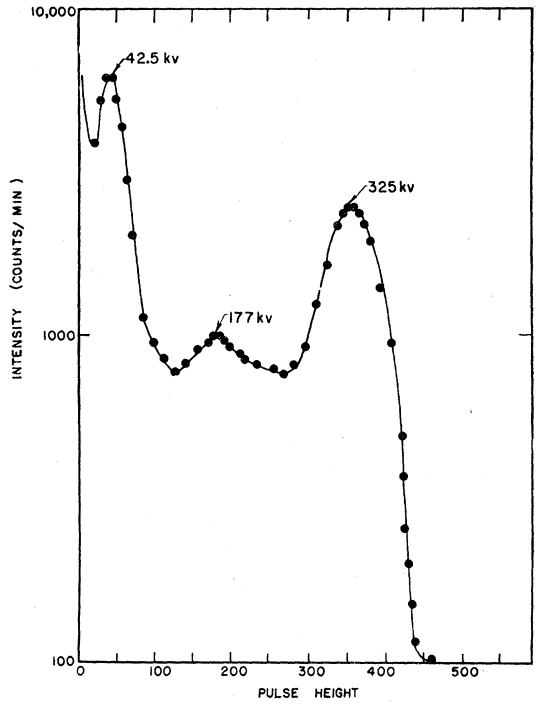

FIG. 2. Gamma-spectrum of Dy^{157}.

$(p, 3n)$ reactions. From Fig. 1 the high threshold of 19 ± 1 Mev indicates a $(p, 3n)$ reaction, thus assigning the 8.2-hour activity to Dy^{157}. The ratio of Dy^{157} to Dy^{159} activity is approximately 700, if one assumes equal counting efficiencies. This indicates a cross-section ratio of about 1.8, which agrees reasonably with what might be expected from the $(p, 3n)$ and (p, n) reactions. It completely excludes the possibility that the 8.2-hour activity might be due to an impurity or any reaction other than (p, n), $(p, 2n)$, or $(p, 3n)$.

The gamma-spectrum of Dy^{157}, Fig. 2, shows a photopeak and a Compton scattering peak of a 325-kev gamma-ray and a 42.5-kev peak corresponding to Tb or Dy x-rays. Decay of these peaks was followed. The 325- and 177-kev peaks decayed with an 8.2-hour half-life while the 42.5-kev peak decayed into two components, 8.2-hour activity and 134-day activity, Dy^{159}. No betas or electrons were detected on running a beta-spectrum.

The Dy^{157} 8.2-hour activity was allowed to decay and another spectrum obtained, showing the presence of only the Tb x-rays of Dy^{159}. Decay of this long-lived activity, followed for 120 days, has a slope corresponding to a 134-day half-life of Dy^{159}.

One radioactive species was found with the Tb fraction from the ion exchange separation; this was identified as 74-day Tb^{160}, formed by (n, γ) on Tb^{159}. Previous experiments have shown that a neutron flux adequate for this reaction is readily obtained from proton bombardment of the metal foils in which the Tb_2O_3 was wrapped. Decay of this species has also been followed for 120 days. If the half-life of Tb^{157} is 4.7 days as previously reported,[4] its decay would have been observed. Also the 1.4-Mev gamma associated with the reported 4.7-day activity was not observed. The half-life of Tb^{157}, daughter of Dy^{157}, is either short, <30 minutes, or greater than 100 years. If it is assumed that Tb^{157} is in equilibrium with Dy^{157} when the separation is begun, calculations show that an upper limit of 30 minutes may be placed on Tb^{157}. The Dy^{157} 8.2-hour activity of the order of 10^7 cpm was allowed to decay and another separation was made by ion exchange. From counting rates obtained for the Tb and Dy fractions, a lower limit of 100 years can be placed on the half-life of Tb^{157}.

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