

### Mass Assignment of 2.6 h Ni<sup>65</sup> \*

J. A. SWARTOUT AND G. E. BOYD  
Clinton Engineer Works, Monsanto Chemical Company,  
Clinton Laboratories, Oak Ridge, Tennessee

AND  
A. E. CAMERON, C. P. KEIM, AND C. E. LARSON  
Clinton Engineer Works, Tennessee Eastman Corporation,  
Oak Ridge, Tennessee  
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THE assignment of the 2.6 h Ni activity to a definite mass number was complicated in the past by the ambiguity of reactions by which it was produced. Assignment to a mass of 63 was made primarily on the basis of the higher yield obtained by bombardment of nickel in a field of fast neutrons than in a field of slow neutrons which was interpreted to be indicative of its formation by an (*n*, 2*n*) reaction on Ni<sup>64</sup>.<sup>1-4</sup> The availability of enriched copper isotopes in the Manhattan Project has now made possible a positive assignment of the 2.6 h Ni isotope to a mass number of 65. This reassignment brings the stability characteristics of this radioactive isotope into agreement with predictions based upon the Bohr-Wheeler theory.

Approximately 100 mg of each of two copper samples enriched in Cu<sup>65</sup> and in Cu<sup>63</sup> by the calutron were obtained from the magnetic separation plant operated by the Tennessee Eastman Corporation. The enriched samples were purified chemically by three electrolyses from a H<sub>2</sub>SO<sub>4</sub>-HNO<sub>3</sub> electrolyte using platinum electrodes and then dissolved in purified nitric acid and conductivity water. Mass-spectrographic analyses indicated the following isotopic abundances in the samples:

Sample 1: 93.1±0.5 percent Cu<sup>65</sup>, 6.9±0.5 percent Cu<sup>63</sup>,  
Sample 2: 3±1 percent Cu<sup>65</sup>, 97±1 percent Cu<sup>63</sup>.

In order to establish the mass of the 2.6 h Ni isotope, comparisons were made of intensities of the nickel activity obtained from (*n*, *p*) reactions on each of the enriched copper samples placed in the neutron field of the chain-reacting uranium pile. Because of the low activation cross section expected for the (*n*, *p*) reaction compared with that for an (*n*, *γ*) reaction, it was necessary to eliminate the possibility of traces of nickel impurity in the copper. Assurance of freedom from nickel contamination was obtained by repeated bombardments in the pile at constant neutron flux of the same copper samples followed by chemical isolation of nickel after each bombardment. Attainment of a constant specific activity of the 2.6 h Ni isotope was considered to be evidence for its production only by an (*n*, *p*) reaction with copper.

TABLE I. Evidence for the production of 2.6 h Ni by the reaction:  
Cu<sup>65</sup> (*n*, *p*) Ni<sup>65</sup>.

	Sample 1	Sample 2
Weight of enriched Cu sample bombarded (mg)	48.8	27.4
Weight of Cu <sup>65</sup> —(based on mass-spectrograph analysis)	45.2 to 45.7 mg	0.55 to 1.1 mg
Total 2.6 h beta-activity—(c/m at 100% geom.)	1.5 × 10 <sup>6</sup>	1.7 × 10 <sup>4</sup>
Specific activity—(c/m/mg Cu <sup>65</sup> at 100% geom.)	3.4 to 3.3 × 10 <sup>4</sup>	3.1 to 1.5 × 10 <sup>4</sup>

The chemical separation of nickel from the bombarded copper samples consisted of a copper sulfide precipitation from 0.5*N* HCl solution in the absence of nickel carrier (this precipitate was then converted to copper oxide for rebombardment in the pile), two copper sulfide precipitations in the presence of nickel carrier, addition of cobalt carrier and precipitation with α-nitroso-β-naphthol to remove any cobalt activity produced by an (*n*, *γ*) reaction on cobalt impurity or by (*n*, *α*) on copper, and finally three or four nickel dimethylglyoxime precipitations.

The apparent specific beta-activities of the 2.6 h Ni obtained from the first one or two bombardments were erratic, due probably to nickel impurity in the copper and to the presence of longer lived beta-activities, believed to be from Pt<sup>197</sup>, which resulted in complex decay and absorption curves. However, in the nickel fractions from subsequent bombardments, the amount of the 2.6 h Ni beta-activity was proportional to the amount of Cu<sup>65</sup> bombarded, as is illustrated by data from one bombardment of enriched Cu<sup>63</sup> and enriched Cu<sup>65</sup>. (Table I.)

The characteristics of the beta-activity agreed with those previously reported<sup>2</sup> in that the half-life was within the limits of 2.5 to 2.7 h, and the energy as determined by Feather analysis was 1.9 to 2.0 Mev.

The possibility of a mix-up in the two enriched copper samples prior to or during these experiments was eliminated by the following precautions: (1) the mass-spectrographic analyses were confirmed within limits of experimental error by radiochemical methods based upon the relative amounts of 12.8 h Cu<sup>64</sup> and 5 m Cu<sup>66</sup> produced by neutron bombardment; (2) the weights of the two copper samples which were bombarded were sufficiently different in magnitude to permit detection of any change in the subsequent bombardment; (3) the relative activities of the two copper sulfide precipitates measured three days after the final bombardment when essentially all of the activity would be caused by the 12.8 h Cu<sup>64</sup> agreed with the relative amounts of Cu<sup>63</sup> present in the samples; and (4) the identity of the enriched Cu<sup>65</sup> sample was confirmed after the last bombardment by mass-spectrographic analysis.

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<sup>1</sup> E. A. Oeser and J. L. Tuck, *Nature* **139**, 1110 (1937).

<sup>2</sup> F. A. Heyn, *Physica* **4**, 1224 (1937).

<sup>3</sup> J. J. Livingood and G. T. Seaborg, *Phys. Rev.* **53**, 765 (1938).

<sup>4</sup> M. E. Nelson, M. L. Pool, and J. D. Kurbatov, *Phys. Rev.* **61**, 428 (1942).

### Properties of Radar Echoes from Shell Splashes

HERBERT GOLDSTEIN\*

Department of Physics, Harvard University, Cambridge, Massachusetts  
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BACK scattering from spray drops has frequently been proposed as the explanation of phenomenon of sea echo on microwave radar. Although many of the characteristics of the echo are in accord with this hypothesis, measurements on the frequency dependence are in violent disagreement with the theoretical prediction.<sup>1</sup> It has been suggested that the study of the echo from a target known