Using (4), it is readily shown that

$$\frac{d\delta_l(\epsilon)}{d\epsilon}=-\int_0^\infty \left(\frac{dv_\epsilon}{d\epsilon}\right)(G_{l\epsilon}^2+F_{l\epsilon}^2)dx. \quad (8)$$

But

$$\frac{dv_\epsilon}{d\epsilon}=\frac{\gamma}{\epsilon^2}\int_{x/\epsilon}^\infty \rho x dx. \quad (9)$$

Therefore

$$\delta_l<0, \quad (10)$$

providing ρ is positive everywhere. Rewriting (8) with the aid of (9),

$$\frac{d\delta_l(\epsilon)}{d\epsilon}=-(\gamma/\epsilon^2)\int_0^\infty \rho(x')x'\left\{\int_0^{x'}[G_{l\epsilon}^2(x)+F_{l\epsilon}^2(x)]dx\right\}dx'. \quad (11)$$

From this it seems plausible that the phase shifts tend monotonically toward zero with increasing l, since the inner integral probably decreases with increasing l (fixed x').

In conclusion, we should point out the actual source of error in Elton's paper. He estimates the phase shifts (for large l) by the approximation

$$\delta_l\cong-\int_0^\infty (V_l/\alpha)G_l^2 dx, \quad (12)$$

where

$$V_l=(v_E-v_P)(2-v_E-v_P)+x^{-1}(l+1)[(\alpha_P'/\alpha_P)-(\alpha_E'/\alpha_E)] +\tfrac{3}{4}[(\alpha_E'/\alpha_E)^2-(\alpha_P'/\alpha_P)^2]-\tfrac{1}{2}[(\alpha_E''/\alpha_E)-(\alpha_P''/\alpha_P)], \quad (13)$$

$$\alpha=1-v.$$

The subscript P refers to the point charge and E to the extended charge. Elton considers the term in $(l+1)$ to be dominant for large l, leading to $\delta_l\rightarrow+0$. The fallacy in the argument lies in neglecting the fact that G_l depends on l. This can be seen by carrying out an integration by parts in the term involving the second derivatives of α_E and α_P. The result is a contribution which cancels the term which Elton considered to be dominant.

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[1] L. R. B. Elton, Proc. Phys. Soc. (London) **A65**, 481 (1952). In a private communication, Dr. Elton concurs that his paper is in error.

[2] L. R. B. Elton, Proc. Phys. Soc. (London) **A66**, 806 (1953). In deriving (4), Elton takes one of the two potentials to be the Coulomb potential, but the proof is also valid for any two potentials so long as the integral converges.

Further Production of Transcurium Nuclides by Neutron Irradiation

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IN a continuation of the work previously reported,[1] we have succeeded in producing and chemically identifying an isotope of the element with atomic number 100 through neutron irradiation of the heavy californium isotopes in the Materials Testing Reactor. The method of chemical isolation consisted of precipitation and ion exchange procedures,[1] and the atomic number identification depends on the position in the elution sequence in the ion exchange adsorption-elution method of separation of the actinide elements.[2]

Alpha particles of roughly 7.2-Mev energy and about 3-hour half-life were found in the ion exchange column fraction corresponding to the eka-erbium position immediately preceding the 6.6-Mev alpha particles[1] due to element 99 which eluted in the eka-holmium position immediately preceding the californium alpha activity.[1] Although the amount of activity was small, the identification of atomic number is regarded as definite.

The isotope of element 100 emitting the approximately 7.2-Mev alpha particles is tentatively assigned[3] as 100^{254}, and a possible reaction sequence leading to its production might be the following:

$$Cf^{252}(n,\gamma)\,Cf^{253}\xrightarrow{\beta^-}99^{253}(n,\gamma)99^{254}\xrightarrow{\beta^-}100^{254}.$$

Because of the existence of unpublished information on element 100 the question of its first preparation should not be prejudged on the basis of this paper.

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[1] Thompson, Ghiorso, Harvey, and Choppin, Phys. Rev. (to be published).

[2] See, e.g., G. T. Seaborg, *Transuranium Elements: Survey*, edited by G. T. Seaborg and J. J. Katz (McGraw-Hill Book Company, Inc., New York, 1954), National Nuclear Energy Series, Plutonium Project Record, Vol. 14A, Div. IV, Chap. 17 (to be published).

[3] G. T. Seaborg, University of California Radiation Laboratory Report UCRL-1942, March, 1952 (unpublished). (Ohio State University Third Annual Phi Lambda Upsilon Lecture Series.)

Total Cross Sections of 135-Mev to 250-Mev Negative Pions in Hydrogen*

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TRANSMISSION measurements yielding the total cross section for the interaction of negative pions with protons have been reported by Anderson *et al.*[1] at Chicago and by Yuan and Lindenbaum[2] at Brookhaven. The Chicago measurements showed a rapid increase of the cross section above 80 Mev with a leveling off or perhaps a maximum at 66±6 millibarns in the region of 150 to 200 Mev. The Brookhaven measurements above 265 Mev gave values well below the maximum Chicago value, thus confirming the existence of a maximum in the cross section in the energy range of the Chicago experiments. The work reported here with the 450-Mev Carnegie Institute of Technology cyclotron covers the energy range from below to above the maximum with the same technique and with somewhat better accuracy than before. This permits the location of the maximum of the cross section within rather narrow limits.

Up to 220 Mev, the experiments have been made with quite intense and well-collimated beams of negative pions with intensities from 300 to 500 particles/cm² sec. At the highest energy, 260 Mev, the beam is reduced to about 3 particles/cm² sec, but this is readily usable for transmission measurements. The pions emerge from channels in the 8-foot magnetite concrete shielding, pass through a double-focusing deflecting magnet which bends them through 45°, and enter a monitoring telescope which determines the number of particles incident. The monitor telescope consists of three stilbene crystals, 4 cm in diameter and ½ cm thick, with a total separation of 115 cm. The beam next traverses the absorber, a

TABLE I. Total cross sections of negative pions in hydrogen.

Energy Mev	Cross section 10^{-27} cm²	Error (10^{-27} cm²) Statistical	Total
133±7	46.9	±1.3	±2.4
157±8	62.9	±1.0	±2.4
179±8	65.9	±1.2	±2.5
194±7	64.6	±1.2	±2.5
195±7	63.1	±1.3	±2.5
215±8	55.5	±1.0	±2.2
236±7	46.1	±1.7	±2.4
240±7	43.5	±1.6	±2.3
258±9	38.2	±3.0	±3.4