$1s\sigma 2s\sigma^3\Sigma_g \rightarrow 1s\sigma 2p\sigma^3\Sigma_u$ transition, with atomic lines also visible. Decay of the molecular spectrum is so rapid that it cannot be photographed within the 10–15-μsec resolution of our shutter. The light at times from 0–600 μsec is continuous in character, having a maximum at about 4250A and cutting off at about 3400A; and is thus not identifiable with the molecular continuum. Changes in spectral distribution and absolute intensity are observed in passing from quartz to Pyrex containers.

Estimates to within a factor of 2 or 3 (by means of a calibrated 1P28 photo-tube) of the absolute energy lying in the band of the 1P28 per disappearing electron lead to results which (a) are less than 1/500 of the available energy (ionization potential) per recombining electron, and (b) vary widely with time instead of remaining constant. These and other results lead to the conclusion that the light associated with the hydrogen afterglow arises from the container walls, and that nonradiatiative volume recombination accounts for the removal of electrons. A possible mechanism is

$$H_2^+ + e \rightarrow H + H + \text{K.E.},$$

with the $1s\sigma 2p\sigma^3\Sigma_u$ or similar state as the final state of the molecule.

* This research was supported in part by the ONR.
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Californium Isotopes from Bombardment of Uranium with Carbon Ions*

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November 8, 1950

THE recent production and identification[1] of isotopes of elements with atomic numbers up to six higher than the target element through bombardment with approximately 120-Mev carbon (+6) ions made it seem worth while to apply this technique to the transuranium region.

Accordingly, small pieces of natural uranium metal (about 0.5 mil thick and 2.5 cm by 0.6 cm area) were irradiated in the internal carbon ion beam in the Berkeley 60-inch cyclotron. Following the irradiations, the uranium was dissolved in dilute hydrochloric acid containing hydrogen peroxide and a transplutonium fraction was isolated through the use of lanthanum fluoride and lanthanum hydroxide precipitation steps followed by the ion exchange adsorption column procedure, in which concentrated hydrochloric acid is used to separate the tripositive actinide elements from the rare earth elements.[2]

The transplutonium fractions in hydrochloric acid were evaporated as weightless films on platinum plates which were placed in the ionization chamber of the 48-channel pulse analyzer apparatus in order to measure the yield and energies of any alpha-particles which might be present. In the best experiment at about one hour after the end of the 90-min bombardment, some 50 disintegrations per minute of the distinctive 7.15±0.05-Mev alpha-particles[3] of Cf^{244} were observed to be present and to decay with the 45-min half-life. The Cf^{244} was presumably formed by the reaction $U^{238}(C^{12}, 6n)$.

After the decay of the alpha-particles due to Cf^{244}, about five disintegrations per minute of alpha-particles with 6.75±0.05-Mev energy were observed and this alpha-radioactivity decayed with a half-life of about 35 hours. In subsequent experiments involving the use of an ion exchange method[4] to separate the individual actinides from each other, both the ~45-min and ~35-hour activities were found together in the chemical fraction corresponding to the new element californium. A consideration of the systematics of alpha-radioactivity[5] leads us to the view that this 35-hour period is due to the new isotope Cf^{246} formed by the reaction $U^{238}(C^{12}, 4n)$. The measured half-life agrees with the expected alpha half-life for the observed energy for an even-even isotope of the element with atomic number 98.

It is not possible at this time to obtain a good estimate of the intensity of the carbon ion beam. Therefore, the cross sections for the reactions given above cannot be calculated. However, it is interesting to note that the indicated yields for the (C, $6n$) and (C, $4n$) reactions are comparable.

If the mass assignment of the new 35-hour activity to Cf^{246} is correct, these new data give a better idea as to the slope of the alpha-energy *vs* mass number line for californium, which in turn makes it possible to make better predictions of the radioactive properties of the nuclides in this region.

We wish to express our appreciation to Professor J. G. Hamilton, J. F. Miller, G. B. Rossi, T. M. Putnam, Jr., M. T. Webb, and the operating crew of the 60-inch cyclotron in the Crocker Laboratory for their help in the carbon ion bombardments. We would also like to thank Mr. E. K. Hulet for his help in the chemical separations.

* This work was performed under the auspices of the U. S. AEC.
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Thresholds of Photo-Neutron Reactions*

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November 6, 1950

NEUTRON yields as functions of the maximum energy of the bremsstrahlung output of the University of Pennsylvania betatron have been measured for several substances in the energy region from threshold to 22 Mev. The samples, of the order of 50 grams of high purity materials, were inserted in a block of paraffin 9 in×9 in×20 in, in which was also placed a $B^{10}F_3$ counter (Fig. 1). Shielding against background neutrons was obtained by surrounding the apparatus with sheet cadmium, then with about 4 inches of paraffin mixed with B_4C, then with about 1 foot of additional paraffin. The samples were $\frac{3}{4}$-in diameter cylinders. The collimated x-ray beam was about $\frac{5}{8}$ in diameter and irradiated the samples axially. The distance from sample to betatron target was 8.5 feet. The counter was parallel to the beam and about one inch away.

In order to avoid counting pile-up due to the x-ray pulse, and also to avoid being bothered by transient effects on the counting system due to the x-ray burst and auxiliary betatron pulses, only those neutrons were counted which, having been delayed in the paraffin, entered the counter some time after each burst of x-rays. This was done by constructing an electronic gate signal which was delayed from each x-ray burst by about 30 μsec, and whose dura-

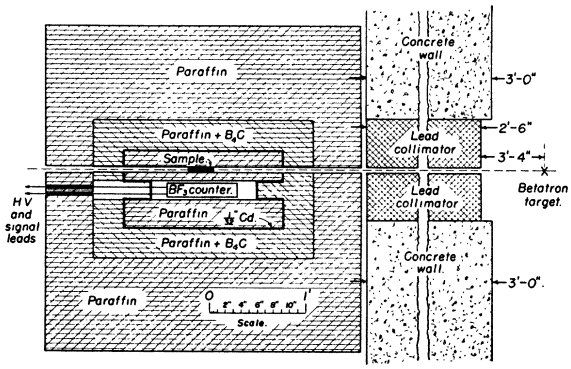

FIG. 1. Schematic diagram of the experimental arrangement (side view).