of $0.6 \pm 0.1\mu$. This spacing is in good agreement with the spacing 0.4μ, quoted above. Thus this experiment gives independent support for assumptions 2 and 3(b). The work is being continued in an effort to get deeper into the crystal and to find out whether the spacing depends upon conditions of preparation.

I wish to express my thanks to Professor A. F. Kovarik for supplying the polonium; to Dr. E. C. Pollard for his many helpful suggestions; and to Dr. D. Cooksey for the use of the amplifier used with the Geiger counter.

ALFRED B. FOCKE*

Sloane Physics Laboratory,
Yale University,
January 3, 1934.

* National Research Fellow.

The Emission of Protons and Neutrons from Various Targets Bombarded by Three Million Volt Deutons

Continuing experiments reported in these columns,[1, 2] we have found that many substances under bombardment by 3 million volt deutons emit large numbers of neutrons and protons. We had found earlier[2] in confirmation of the observations of Lauritsen, Crane and Soltan,[3] that with 1.3 million volt deutons the yield of neutrons from Be and Li was far greater than that from other elements: for example, a hundred times as many from Be as from NH_4NO_3. Although at 3 million volts the neutron yields are higher for the lighter elements, the variation with atomic number is now very much less. Thus the observed yields from various targets on a relative scale are roughly:

Be—100	NH_4NO_3—10
Li—62	Al—10
B_2O_3—34	$Ca(OH)_2$—8
CaF_2—18	Pt—1

In the case of Be we counted about 5000 recoil protons per minute, corresponding presumably, as estimated from the geometry of the apparatus, to the emission of about 10^7 neutrons per second. Even the neutron emission from Pt, the least of all, was great enough to produce 40 observable recoil protons in the ionization chamber per minute. These very high neutron yields obtained with a deuton current of only $3(10^{-8})$ amp. indicate that it is quite possible to produce neutron radiation in the laboratory with an intensity comparable with that of x-rays.

We have observed also from these targets the emission of protons in large numbers. In most cases the majority of the protons have a continuous distribution in range extending to about 40 centimeters air equivalent.*

The proton yields from the various targets were found to be roughly proportional to the neutron yields, suggesting that the neutrons and protons were involved in the same nuclear reaction. Again it seems that the process is the disintegration of the deuton itself. The observed ranges of the protons agree well with this hypothesis, if the mass of the neutron is about unity.

We have obtained evidence of groups of protons of definite range from some of the substances bombarded. Al, for example, emits, in addition to protons that we ascribe to deuton disintegration, a group having a range of about 68 cm. These might well be the result of the reaction of the deutons with Al nuclei wherein neutrons are added to the Al nuclei and protons are emitted.

Oliphant, Kinsey and Rutherford[4] have shown that alpha-particles distributed in range continuously to 8.3 cm are emitted from Li under deuton bombardment. They attribute them to the reaction of the deuton with Li^7 to form two alpha-particles and a neutron. We investigated the possibility that an appreciable portion of the neutrons observed from Li in the present experiments resulted from this reaction, by comparing the number of recoil protons (produced by the neutrons) with the number of long range alpha-particles. We observed 1/6 as many recoil protons as long range alphas, a ratio so large as, it would seem, to rule out this reaction as accountable for the neutrons observed.

This investigation has been aided by a grant from the Josiah Macy, Jr., Foundation. We wish to thank also Professor G. N. Lewis for furnishing deuterium and Commander T. Lucci for his invaluable assistance.

ERNEST O. LAWRENCE
M. STANLEY LIVINGSTON

Radiation Laboratory,
Department of Physics,
University of California,
January 3, 1934.

[1] Lawrence, Livingston and Lewis, Phys. Rev. **44**, 56 (1933).

[2] Livingston, Henderson and Lawrence, Phys. Rev. **44**, 782 (1933).

[3] Lauritsen, Crane and Soltan, Comptes Rendus **197**, 639 (1933).

* In the earlier communication we reported protons with ranges of 33 cm, but with higher bombarding currents we find that the continuous range distribution extends somewhat beyond this value.

[4] Oliphant, Kinsey and Rutherford, Proc. Roy. Soc. **A141**, 722 (1933).

A High-Intensity Mass-Spectrometer

For the last eight years experiments have been going on in this laboratory to perfect a magnetic lens by which all positive ions of one mass emitted from a source of large area can be brought to a focus on a narrow slit. In 1932 a satisfactory lens of this type was completed. In this arrangement the parallel beam of ions, previously accelerated in an electric field and having a cross section 6 mm wide and 20 cm long, passes through the uniform