makes it possible to force the beam entirely past the target in times of the order of two microseconds. The computed values for the 300-Mev M.I.T. machine are: ejection capacitor $2.7\mu f$; capacitor voltage 12,000 v; time for total γ-ray pulse 2μ sec.; and peak current in the ejection coil 1400 amp.

The effect on the electrons in the beam is such that the equilibrium orbit is larger on one side of the magnet and smaller on the other side. The equilibrium orbit varies as $\Delta R/R = -\Delta B/[B(1-n)]$ where $\Delta B/B$ is the impressed fractional variation in the field at the orbit and n the usual exponent of radial dependence of the field. For $n \cong \frac{3}{4}$, the natural period of the radial oscillation is twice the period of rotation in the orbit. Thus, the forced radial oscillations in the beam are similar to those developed in a linear harmonic oscillator driven by a square wave at twice the resonant frequency. Since the build-up time of the driving force is long compared with one period, only equilibrium oscillations need be considered. The resulting radial oscillation amplitude, A, is to the first order,

$$A/R = 4\Delta B/\pi n B.$$

Direct integration of the electron's equations of motion gives the same result.

Thus, if $n \cong \frac{3}{4}$, a one percent change in B produces oscillations of amplitude equal to 1.7 percent of the radius. These oscillations are 180° out of phase with the driving displacement and of the same frequency regardless of the value of n. The electrons reach maximum radius all at the same place, a fact which facilitates ejection of the entire beam.

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The Relative Probability of the (d, p) and the (d, n) Reactions in Bombarded Bismuth

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The bombardment of bismuth (209) with high energy deuterons leads to the formation of both radium E and radium F (polonium). The latter is an alpha-emitter of half-life 140 days, while radium E emits beta-radiation with a half-life of 5 days, thereby converting into radium F. By noting the building-up of the alpha-emission from the target following bombardment, it is possible to determine the total number of each of the product atoms formed. Radium E (bismuth (210)) is formed by a (d, p) reaction while the formation of radium F follows from a (d, n) process. It is thus possible to observe the relative probability for the two competing processes.

Earlier investigations[1] have been made of this effect up to about 9.5 Mev. These results indicated that in this energy range the (d, p) reaction is much more probable. The ratio of the two yields was found to change from a value greater than 10 at 7 Mev down to about 5, at 9.5 Mev. This apparent anomaly that the proton can escape more easily than a neutron from an excited nucleus was reconciled by consideration of the Oppenheimer-Phillips process, according to which the deuteron need not enter the nucleus but dissociates outside into a scattered proton and a neutron that proceeds on into the nucleus. At higher energies it would appear reasonable to expect that the OP effect should greatly diminish and the above ratio fall to a value of one or even less.

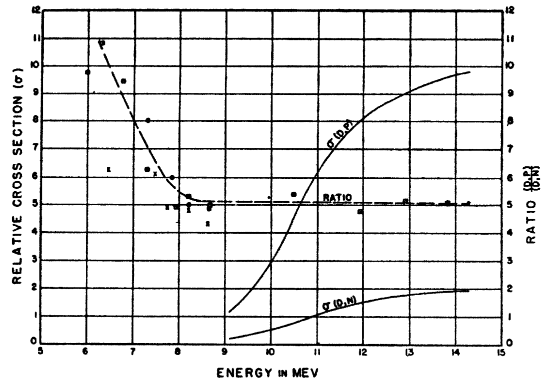

Fig. 1. Excitation curves and ratios obtained in this and other experiments.

Through the courtesy of Professor R. D. Evans and the kind assistance of Dr. Eric Clarke this phenomenon was studied up to 14.5 Mev by bombardment with the MIT cyclotron. Two types of bombardment were made. In one, a series of identical targets were exposed singly in turn to equal bombardments, each succeeding target being covered with an increasing thickness of aluminum foil so as to reduce the bombarding energy by the desired amount.

In another bombardment a stack of thin bismuth foils each of about 40 mg per cm^2 was exposed to a single bombardment. By using an alpha-counter with a thin window the growth of activity in each target was followed for many days, as in the previous investigations. From the growth curve the number of atoms of each kind produced could be readily determined. Since the exposure of each of the foils in the stack is identical it is possible to indicate an excitation curve for each process.

These excitation curves at the high energy together with the ratios obtained in this and previous experiments are shown in Fig. 1. The excitation curves seem to indicate an approach to saturation. The absolute cross sections can be determined only approximately since the effective geometry of the counter cannot be accurately determined. Within this limit the ordinate 10 may be regarded as 25×10^{-28} cm^2. The relative yields have no such uncertainty.

It is apparent that the ratio does not drop at higher energies to a value of one or less as had been expected but seems to remain within the experimental limit, at a value close to five.

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[1] J. M. Cork, J. Halpern, and H. Tatel, Phys. Rev. **57**, 371 (1940); D. Hurst, R. Latham, and W. Lewis, Proc. Roy. Soc. **A174**, 126 (1940); H. Tatel and J. M. Cork, in press.