General expressions have been developed for the cross sections for electron excitation of a nucleus because of the interaction of the electron's field with the electric 2^l-pole moments of the nucleus; unambiguous expressions are obtained for these cross sections because the form of the electric 2^l-pole moment does not depend upon the nuclear interactions.[1] The intimate relation between excitation by photons and by electrons has been developed explicitly. This relation has been exploited, in particular, in a comparison of the theory of the disintegration of the deuteron by high energy electrons with the corresponding photodisintegration theory. Because of the relative precision with which an electron beam can be controlled, electrons may be useful in high energy deuteron disintegration experiments.

* Supported in part by the ONR.
† AEC Predoctoral Fellow, now AEC Postdoctoral Fellow at Cornell University, Ithaca, New York.
[1] R. G. Sachs and N. Austern, Phys. Rev. **81**, 705 (1951).

ZB2. Photodisintegration of the Deuteron.* V. E. KROHN, JR., AND E. F. SHRADER, *Case Institute of Technology*.—The angular distribution of the protons from the $d(\gamma, n)p$ reaction has been investigated for 5–13-Mev gamma-rays by means of the D_2O loaded emulsion technique with the Case betatron serving as gamma-ray source. The results have been compared to a differential cross section of the form $d\sigma = \{a + (b + c\cos\theta)\sin^2\theta\}d\Omega$ in the center-of-mass system and the isotropy found consistent with the mean values: $a/b = 0.04 \pm 0.03$ from 5 to 11 Mev and 0.24 ± 0.07 from 11 to 13 Mev. The forward asymmetry was determined for energies above 8 Mev and found to be $c/b = 0.24 \pm 0.09$. Except for the isotropy observed above 11 Mev where the theory predicts $a/b \sim 0.01$ these results are in agreement with the theoretical calculations of Marshall and Guth[1] in which the possible effects of meson exchange currents and tensor forces are neglected.

* Work supported by the AEC.
[1] J. F. Marshall and E. Guth, Phys. Rev. **78**, 738 (1950).

ZB3. High Energy Photodisintegration of the Deuteron. T. S. BENEDICT AND W. M. WOODWARD, *Cornell University*.*—The cross section for the photodisintegration of the deuteron has been measured in the energy range 80 to 150 Mev using 300-Mev synchrotron bremsstrahlung. The experimental arrangement, using a high pressure gas target and scintillation counters for detecting the protons, is essentially that used in a previous photodisintegration experiment[1] on He^4. The geometry of the present experiment has been improved by adding an internal collimator to the pressure chamber and decreasing the solid angles of the counting system. The chamber was filled with deuterium (>99.5 percent H^2) to a pressure of 120 atmospheres and protons were counted at laboratory angles of 60°, 90°, and 120°. The cross section at 80 Mev is in essential agreement with that calculated by Schiff[2] and Marshall and Guth,[3] while at higher energies it is somewhat greater than the theoretical prediction.

* Supported by the joint program of the ONR and AEC.
[1] T. S. Benedict and W. M. Woodward, Phys. Rev. **83**, 1269 (1951).
[2] L. I. Schiff, Phys. Rev. **78**, 733 (1950).
[3] J. F. Marshall and E. Guth, Phys. Rev. **78**, 738 (1950).

ZB4. Excitation Functions for Photoprotons from Carbon. A. M. PERRY AND J. C. KECK, *Cornell University*.—We have measured the yields of 60-, 100-, and 140-Mev protons from a carbon target bombarded by synchrotron γ-ray beams of maximum energy 310, 260, 215, and 180 Mev. The protons were detected by a two-crystal coincidence telescope,[1] at a mean angle of 67° with respect to the γ-rays. Proton energies were determined by copper absorbers in front of the telescope. The energy intervals were determined by discriminator bias on the output of the second crystal and by target thickness. Positive identification of the protons was by their pulse height in the first crystal. Cross sections per γ-ray for producing protons of a given energy were found to be roughly proportional to γ-ray energy above some threshold, which depends on the proton energy, and to decrease rather sharply below this threshold.

[1] J. C. Keck, Cornell thesis (1951); to be published in Phys. Rev.

ZB5. Gamma-Rays from Sodium Bombarded by Protons.* P. H. STELSON, W. M. PRESTON, AND CLARK GOODMAN, *M.I.T.*—The gamma-ray yield from sodium was measured as a function of proton bombarding energy over the range 1.0 to 2.6 Mev using resolutions of 1.5 to 10 kev. Thin targets of metallic sodium were prepared by evaporation in vacuum. Gamma-rays were detected with a NaI(Tl) scintillation counter. Thirty-seven resonances were found, giving an average level spacing of 40 kev at an average excitation energy of 13.5 Mev in the compound nucleus, Mg^{24}. The present results are in general agreement with the earlier work of Burling.[1] The resonances vary in natural width from less than 1.5 kev to 70 kev. The energy spectrum of the gamma-rays from a number of the resonances was investigated with a single crystal NaI(Tl) scintillation spectrometer. Only the very sharp resonance at $E_p = 1.415$ Mev gave appreciable proton capture radiation. The spectra of the other resonances consist mainly of two gamma-rays with energies of 0.45 ± 0.01 and 1.63 ± 0.02 Mev. These are interpreted as resulting from transitions from the first excited states of the residual nuclei formed by the reactions: $Na^{23}(p, p')^*Na^{23}$ and $Na^{23}(p, \alpha)^*Ne^{20}$, respectively.

* Work jointly supported by ONR and BuShips.
[1] R. L. Burling, Phys. Rev. **60**, 340 (1941).

ZB6. Angular Distributions of Photoprotons.* M. A. ROTHMAN, A. K. MANN, AND J. HALPERN, *University of Pennsylvania*.—Targets of Co, Ni, and Cu have been bombarded with bremsstrahlung of maximum energy 23 Mev. The angular distributions of all the emitted protons from each target have been measured with ZnS scintillation counters.[1] Preliminary data indicate that within the precision of the measurements, approximately ±5 percent, protons are emitted isotropically from Ni. The distribution from Cu appears to be peaked in the forward direction with a ratio of 1.17 between the number of protons observed at 45 and at 150 degrees. The distribution from Co is similar to that from Cu. Departures from the assumptions of the statistical theory which might account for the observed angular distributions will be discussed.

* Supported in part by a contract with the Air Force.
[1] A. K. Mann and J. Halpern, Phys. Rev. **82**, 733 (1951).

ZB7. (p, n) Yields from the Light Elements. HARVEY B. WILLARD AND JOE KEAGY BAIR, *Oak Ridge National Laboratory*.—The yields of neutrons from the proton bombardment of T, Li^7, Be^9, B^{11}, and F^{19} have been extended with 0.1 percent resolution to 5.3 Mev. The neutrons produced in the forward direction were measured with a conventional "long" counter and monitored by a beam current integrator. T exhibits a gradual increase up to 4.22 Mev, where it rises more rapidly as though approaching a very broad resonance. New maxima were observed in the yield from Li^7 at 4.90 Mev (broad), from Be^9 at 4.72 Mev (broad), and from B^{11} at 3.17, 3.75, 4.14, and 4.67 Mev (all broad). The $F^{19}(p, n)Ne^{19}$ threshold was determined to be 4.253 ± 0.005 Mev and narrow maxima occur at 4.29, 4.46, 4.49, 4.57, 4.62, 4.71, 4.78, 4.99, 5.07, and 5.20 Mev.

ZB8. Disintegration of Helium by 90-Mev Neutrons. P. TANNENWALD, *University of California, Berkeley*.—90-Mev neutrons produced by stripping 190-Mev deuterons in the 184-inch cyclotron were collimated and sent through a 22-inch Wilson cloud chamber filled with helium gas to a total pressure of 81 cm Hg. The chamber was operated in a pulsed magnetic