point to a similarity between the acceptor centers in zinc-doped germanium and the lattice defects found in heat-treated material.

In the second set of experiments, zinc has been deposited on single crystals of n-type germanium by heating the germanium with a small amount of radioactive zinc (of the order 1–3 micrograms). The diffusion rate has been measured from the location of the $p-n$ junction formed by the penetration of the zinc.[3] These results show that zinc diffuses much more rapidly than indium, gallium, or aluminum. The diffusion coefficient at 900°C is about 1×10^{-11} cm^2/sec, the activation energy for diffusion about 2.5 ev.

Additional evidence for the electrical activity of zinc can be obtained by determining the amount of diffusing impurity required to effect the formation of the $p-n$ junction at the depths observed. This amount is orders of magnitude greater than the impurity present and is roughly equal to the amount of zinc actually used.

I wish to thank F. C. Kelley and R. N. Hall for furnishing samples of zinc-doped germanium, and W. DeSorbo for help in the low temperature measurements.

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[1] H. C. Torrey and C. A. Whitmer, *Crystal Rectifiers* (McGraw-Hill Book Company, Inc., New York, 1948), p. 364.

[2] W. DeSorbo and W. C. Dunlap, Jr., Phys. Rev. **83**, 879 (1951). (See also erratum on p. 869.)

[3] The diffusion experiments referred to are being reported in detail elsewhere.

Proton Bombardment of Lithium

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LITHIUM of normal isotopic ratio has been bombarded with monoenergetic protons of energies between 1.8 and 5.3 Mev. The yield of neutrons in the forward direction was measured using a conventional "long" counter at a distance of one meter from the rotating target. Gamma-rays of energy greater than roughly 10 Mev were detected using a large sodium iodide crystal as a scintillation detector.

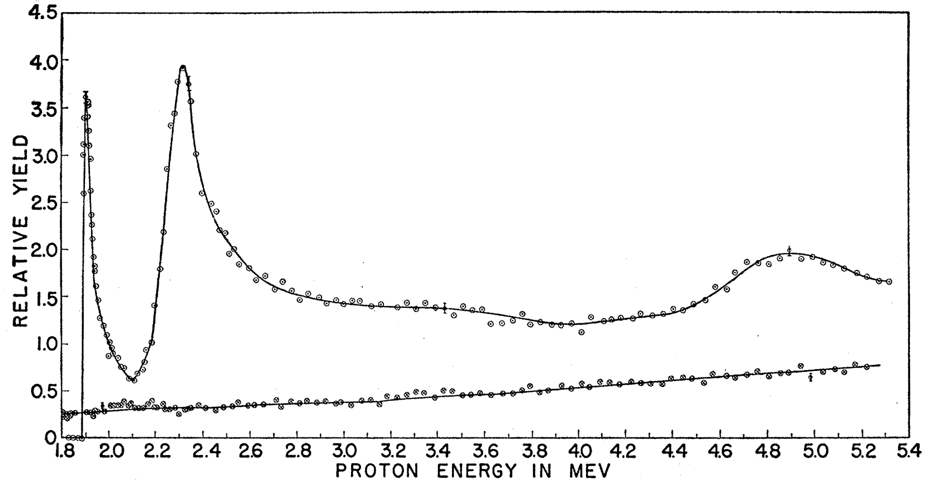

FIG. 1. Yields from the proton bombardment of lithium. Upper curve: neutrons in the forward direction. Lower curve: gamma-rays of energy greater than approximately 10 Mev.

Protons beams, of from one to three microamperes, from the electrostatic generator were obtained after 105° deflection in the analyzer magnet. The beam energy was controlled by varying the corona current in accord with the error signal obtained from slits placed at the 105° beam exit port. The energy calibration was made by correlating magnet current with beam energy by observing the known[1] gamma-ray resonances of fluorine below 1.5 Mev with mass-one, mass-two, and mass-three beams. With careful magnet recycling, repeated runs indicate that the energy determination is accurate to ±0.2 percent relative to the 1.882 $\mathrm{Li}^7(p,n)\mathrm{Be}^7$ threshold. The fluorine measurements indicate a spread in beam energy of 0.1 percent or less.[2]

The curve of Fig. 1 shows a typical neutron yield in the forward direction for proton energies between 1.8 and 5.3 Mev. Background was negligible. Target thickness was approximately 18 kev at the threshold. In addition to the geometrical peak and the well-known[3] peak at 2.30 Mev, another maximum in the yield occurs at a bombarding energy of about 4.89 Mev corresponding to an excited state in Be^8 in the vicinity of 21.5 Mev. Full width at half-maximum of the resonance at 4.89 Mev is approximately 0.4 Mev.

The lower curve of Fig. 1 shows a typical yield of gamma-rays with energy greater than about 10 Mev. Operation of the counter was checked by observing the 440-kev resonance with the mass-three beam. Target thickness was 15 kev. Background was negligible. The intensity is essentially constant over the region studied. A level with 3 percent of the intensity of the 440-kev resonance would have been easily observed.

The high radiative capture cross section of iodine together with the copious yield of neutrons gave sufficient "background" count in the NaI crystal to effectively prevent the obtaining of a low energy gamma-ray yield curve with the techniques immediately available.

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