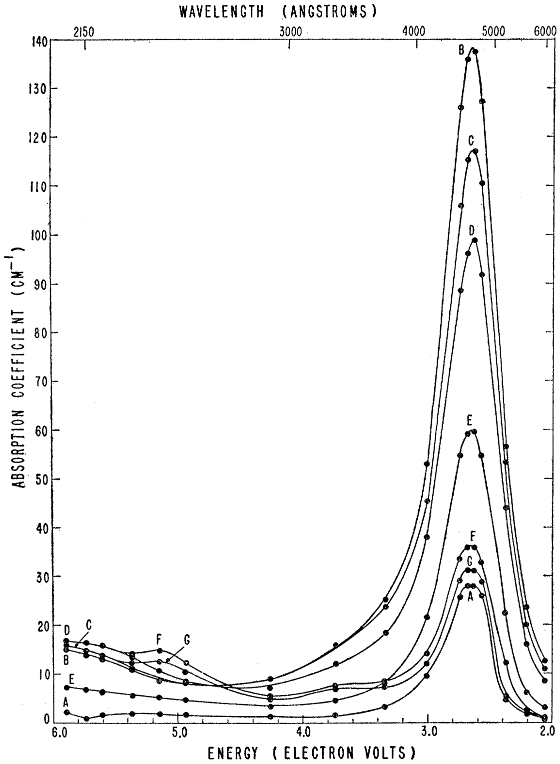

FIG. 1. Spectral absorption of x-rayed NaCl single crystals containing the following nominal mol ratios of impurities to Na in the melt: curve A: None; B: 0.005 Ca/Na; C: 0.001; D: 0.0005; E: 0.0001; F: 0.005 Cd/Na; G: 0.001.

since two Na^+ are replaced by each Ca^{++}. If the crystal is then x-rayed, the probability for the capture of holes by positive ion vacancies to form V-centers is greater than it would be in a "pure" crystal. As a result, the probability for the recombination of holes and electrons is reduced. The probability for the formation of F-centers is thereby increased since more electrons are free to be trapped by negative ion vacancies. If the F-band is enhanced, then an increase in the V-band absorption which occurs in the short wavelength ultraviolet region should also be observed. Figure 1 shows a three- to eightfold increase in the absorption in the neighborhood of 2100A for Ca^{++}-bearing crystals over that of "pure" NaCl. Irradiation into this band produces no observable emission, indicating these crystals are not radiophotoluminescent in this region. The same conditions do not exist in crystals containing Cd^{++} since the excess positive ion vacancies are bound to the Cd^{++} at room temperature and are not favorable traps for holes. Therefore, recombination of electrons and holes occurs with nearly the same probability as exists in a "pure" crystal, and the F-band is not significantly enhanced. Unfortunately NaCl containing Cd^{++} has radiophotoluminescent absorption bands at 2400A and 3400A; thus it is not possible to strengthen the explanation further by showing no enhancement of the V-band in the crystals containing Cd^{++}.

Further experiments are planned with Ca^{++} and Cd^{++} in NaCl and in other alkali halides. If the observed differences in the behavior of these ions in NaCl appear in other alkali halides, arguments[4] based on the *a priori* similarity of these ions may require modification.

The writer wishes to express his appreciation to Mr. R. D. Kirk for growing the single crystals used in this work.

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Threshold for (γ,p) Reaction in Be^9

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ALTHOUGH the (γ,n) reaction in Be^9 is well known, only one paper[1] has established the existence of the $Be^9(\gamma,p)Li^8$ in beryllium. They identified a Li^8 beta-activity and made a rough estimate of 18 ± 1 Mev for the (γ,p) threshold.

The radioactive chain for $Be^9(\gamma,p)Li^8$ is:

$$Be^9+\gamma\rightarrow p+Li^8;\quad Li^8\rightarrow\beta+Be^8;\quad Be^8\rightarrow 2\alpha.$$

The 0.88-sec half-life beta-particles from Li^8 have a maximum energy of 13 Mev. The final α-particles have about 1.5 Mev each.

Possible alternative reactions from Be^9 in a betatron beam are: $Be^9(\gamma,n)2\alpha$, $Be^9(n,\alpha)He^6$, and $Be^9(\gamma,d)Li^7$. He^6 from the (n,α) reaction has a 0.86-sec beta-activity with a 3.5-Mev maximum energy. In spite of a low ($\sim$2.6 Mev)[2] threshold, the (n,α) probability is far below the (γ,p) because the neutron flux is far lower than the γ-intensity. There was no evidence of beta-activity below 16.9 Mev.

A large ($1\frac{1}{2}$ in.$\times$1 in.) NaI crystal was mounted in contact with a 5819 photomultiplier as shown in Fig. 1. The gate was off during the complete acceleration cycle of the betatron so that spurious γ-counts from the beam and the injection gun were avoided. The discriminator was set for the best ratio between background and true counts. The background remained high even during the dead time of the γ-beam, probably because iron, aluminum, and copper are all beta-active under γ-radiation of this energy.

Threshold determinations from seven sets of data for the (γ,p) reaction give 16.93 ± 0.15 Mev. An accurate mass difference calculation gives a theoretical value of 16.872 ± 0.008 Mev.[3] Graphical extrapolation of the seven curves agreed with calculations of the $N=k(E-E_0)^m$ type.

As a check against confusion of other beta-activities, the half-life was measured at 0.89 sec, and the beta-particles penetrated 0.39 in. of aluminum, indicating an energy above 6 Mev.

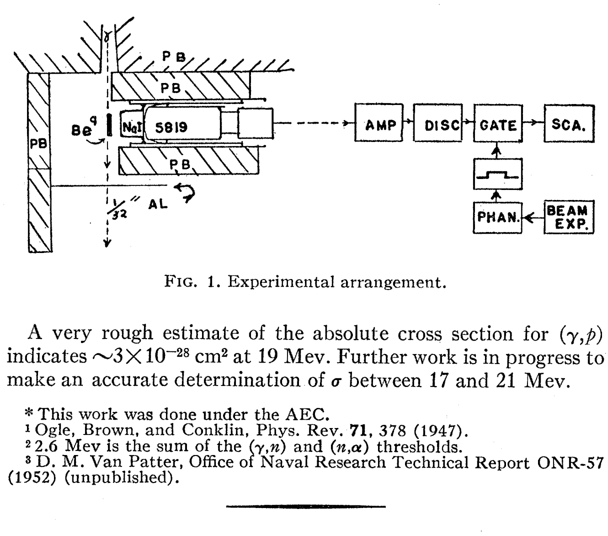

FIG. 1. Experimental arrangement.

A very rough estimate of the absolute cross section for (γ,p) indicates $\sim3\times10^{-28}$ cm² at 19 Mev. Further work is in progress to make an accurate determination of σ between 17 and 21 Mev.

* This work was done under the AEC.
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[3] D. M. Van Patter, Office of Naval Research Technical Report ONR-57 (1952) (unpublished).

Neutron Total Cross Section for Lead Between 37 and 156 Mev

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IN the course of an investigation into the variation of neutron total cross sections with energy for a number of elements, a dip has been found in the lead cross section at about 60 Mev. The neutrons used in this experiment were produced by proton bom-

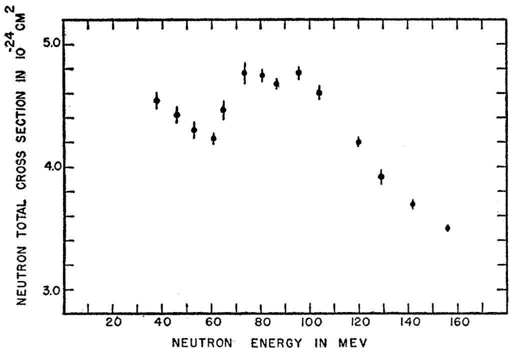

FIG. 1. The variation with energy of the neutron total cross section for lead. The cross sections have been corrected for forward scattering, and the errors shown are standard deviations based upon total counts.

bardment of internal targets in the 110-inch Harwell cyclotron, and were collimated by small diameter holes in the concrete shielding. The apparatus, neutron attenuators and geometrical layout were similar to those used in earlier measurements at this laboratory.[1] A triple coincidence proportional counter telescope was used to detect the protons recoiling from a polyethylene disk placed in the collimated neutron beam. By putting absorbers between the counters a lower energy limit was set for the detected recoil protons, and hence there was a lower energy limit to the neutrons used in the determination. The upper energy limit was governed by the position of the target in the cyclotron, the value of the magnetic field, and the threshold energy for production of neutrons by protons. It was therefore possible to use a small band of neutron energies in any measurement. Further, since the majority of the neutrons were detected as recoil protons coming from the hydrogen content of the polyethylene disk, the effective neutron energy could be calculated with an error dependent upon the accuracy of a range-energy relation. This error was estimated to be about 1 Mev at the lowest energies and about 3 Mev at the highest. The band of energies used varied from about 10 Mev at the lowest energy measured to about 20 Mev at the highest.

The values of the total cross section for lead at the various energies are presented in Fig. 1. The difference between the value at 81 Mev and the minimum value at 61 Mev is 10 times the standard deviation on either point.

A similar dip has been found in cadmium and in copper at lower energies.

The results for the whole investigation will be reported more fully elsewhere.

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[1] Taylor, Pickavance, Cassels, and Randle, Phil. Mag. **42**, 20 (1951); **42**, 328 (1951); **42**, 751 (1951); **42**, 1336 (1951).

Size Effects in the Superconductivity of Cadmium

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As part of a program to study electrical and magnetic properties of matter below 1°K, we have investigated the critical magnetic fields of various sized particles of superconducting cadmium. The experimental arrangement used for these measurements was similar to that of Daunt and Heer[1] except that we used a lead wire (0.025 cm in diameter and 50-cm long) as the heat switch. With such a switch it took from 40–60 minutes for the system to warm up from 0.1° to 1.2°K. To date we have obtained results for two different sizes of cadmium. Both specimens consisted of spheres of cadmium made by stirring the molten metal with a high boiling silicone oil.[2] The cadmium used for the preparation was spectroscopically pure material obtained from Johnson-Matthey. The pills were pressed into cylindrical form (diameter 1.75 cm, length about 2.2 cm) from a mixture of chromium potassium alum and the cadmium particles. Specifications are given below:

Pill No.	Cadmium particle size (radius in cm)	Wt. of cadmium (grams)	Wt. of salt (grams)
1	$2.2–3.1\times10^{-3}$	2.2	6.7
2	$6–12\times10^{-2}$	1.2	7.0

The critical fields, obtained from the warm up curves, are shown in Fig. 1. The dashed curve shows the results obtained by

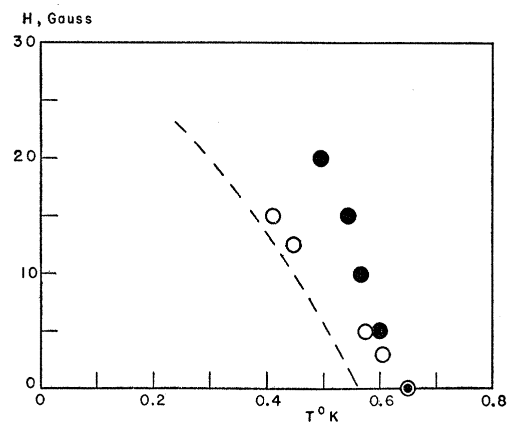

FIG. 1. Magnetic threshold for Cd as a function of temperature. ●—Pill No. 1; ○—Pill No. 2. Dashed curve shows data of Goodman and Mendoza.

Goodman and Mendoza[3] using another method and bulk cadmium. We obtained a zero field transition temperature of 0.65±0.02°K for both specimens. This is somewhat higher than the value 0.56°K reported by the Cambridge workers. Since our experiments with superconducting zinc and ruthenium gave transition temperature in good agreement with other workers, we believe that this difference in T_c for cadmium is a real one. It may be associated in some way with our method of preparing the spheres. Aside from that factor the data reveals a definite increase in the critical fields for the smaller particles. If this is interpreted in light of the particle size becoming comparable to λ the penetration depth, one can estimate that $\lambda_0 \sim 10^{-4}$ cm for cadmium. This value is a factor of ten larger than penetration depths for such elements as indium, tin and lead.[4] It may be significant to note that the suggested large value of λ_0 for cadmium is qualitatively consistent with the empirical observation that λ_0 increases as T_c decreases.[4]

A detailed account of the work reported above, as well as experiments in progress at this date, will be given in subsequent publications.

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[3] B. B. Goodman and E. Mendoza, Phil. Mag. **42**, 594 (1951).
[4] J. M. Lock, Proc. Roy. Soc. (London) **A208**, 391 (1951).