

was better than 0.1°C, although the absolute accuracy was not this great since the thermocouple was not individually calibrated.

A step in the heating curve was observed indicating a thermal anomaly between 128.2 and 128.7°C. Essentially the same temperature limits were observed for different heating rates from 0.32°C per min to 2.8°C per min. Upon cooling, the anomaly was observed in a different temperature range, 126.5 to 127.1°C. These anomalies each occur within a much smaller temperature range than that observed by Blattner and Merz, however, they still do not give unequivocal evidence of a latent heat.

Temperature changes could be observed when an electric field was applied. When the temperature reached 130°C, an electric field of 600 v/mm was suddenly impressed. This produced an immediate temperature rise of 0.5°C. When the voltage was turned off, the temperature fell the same amount. This temperature change may be interpreted as that accompanying an adiabatic transition from the cubic to the tetragonal phase.

Upon cooling to 127.7°C the voltage was applied again for one second. This produced an irreversible temperature rise of about 0.5°C, and the usual thermal anomaly between 126.5 and 127.1°C was not observed as cooling continued. These observations indicate that the electric field in this case produced a permanent transition before the material had cooled enough for the transition to take place spontaneously. The temperature change of 0.5°C indicates that the transition has a latent heat. If this figure is multiplied by the average specific heat,<sup>2,4,5</sup>  $c_p = 0.13$  cal/g°C and by the molecular weight, a lower limit of 15 cal/mole is obtained for the latent heat of the transition.

<sup>1</sup> V. Ginsburg, *J. Phys. U.S.S.R.* **10**, 107 (1946); S. Roberts, *Phys. Rev.* **71**, 890 (1947); H. D. Megaw, *Trans. Faraday Soc.* **42A**, 224 (1946); P. W. Forsbergh, Jr., *Phys. Rev.* **76**, 1187 (1949); A. von Hippel, *Revs. Modern Phys.* **22**, 221 (1950); W. J. Merz, *Phys. Rev.* **78**, 52 (1950).

<sup>2</sup> M. G. Harwood *et al.*, *Nature* **160**, 58 (1947).

<sup>3</sup> A. F. Devonshire, *Phil. Mag.* (7) **40**, 1040 (1949); W. Kaenzig, *Phys. Rev.* **80**, 94 (1950); C. Kittel, *Phys. Rev.* **82**, 729 (1951).

<sup>4</sup> H. Blattner and W. Merz, *Helv. Phys. Acta* **21**, 210 (1948).

<sup>5</sup> S. Sawada and G. Shirane, *J. Phys. Soc. Japan* **4**, 52 (1949).

### Slow Neutron Liquid Scintillation Detector

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ASIDE from the possibility of discovering a fluorescent boron compound, the problem of detecting slow neutrons with boron at very high efficiencies ( $\sim 100$  percent) reduces to the problem of discovering a boron compound which may be introduced into a fluorescent medium without quenching the fluorescence. The series of esters: methyl, ethyl, propyl, etc.—borate when added to a standard fluorescent solution of phenylcyclohexane, terphenyl, and diphenylhexatriene—satisfies the above requirement. The only effect on the "alpha" pulse height due to the addition of these borates to the "phenyl" solution is to reduce it in proportion to the dilution of the original fluorescent solution. Even this loss of pulse height may be regained by addition of more terphenyl.

Enriched ( $B^{10}$ ) methyl borate contains the least number of extraneous atoms and has the highest density of the series. A one-to-one solution by volume of methyl borate—"phenyl" used in conjunction with a 5819 photomultiplier tube has the following properties: (1) "alpha" pulse height of  $\sim 30$  electrons at the cathode; (2) neutron lifetime in the medium of  $\sim 0.4$   $\mu$ sec.

It should be observed that with this short a lifetime, the presence of hydrogen is no obstacle to the use of such a counter for slow neutron time-of-flight velocity selection. In fact, the presence of hydrogen aids in keeping faster neutrons in the detecting medium. To use the counter in a practical way, however, it is desirable to use either liquid air cooling of the photomultiplier tube or to employ coincidences, and to bias out electrons of  $\sim 100$  kev and higher in energy.

### Relative Probabilities of Diverse Photonuclear Reactions from $Zn^{64}$ and $Fe^{54}$

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BY the use of a high energy x-ray beam from the Iowa State College synchrotron with the maximum energy adjustable up to 67 Mev, measurements have been made leading to relative cross sections as a function of quantum energy for  $(\gamma, n)$ ,  $(\gamma, pn)$ , and  $(\gamma, 2np)$  reactions<sup>1</sup> on the same parent isotope  $Zn^{64}$  or  $Fe^{54}$ . The curves obtained are shown in Figs. 1 and 2.

The values for the integrated cross sections are evaluated and listed in Table I. The values for zinc agree well with the values reported by Strauch<sup>2</sup> from transition curves in lead for 330-Mev bremsstrahlung. The relative values for  $\sigma_{\gamma, 2n}$  and  $\sigma_{\gamma, pn}$  also agree well with those given by Ghoshal,<sup>3</sup> who produced the compound nucleus  $Zn^{64}$  by  $Ni + \alpha$  and  $Cu + p$  reactions. In addition, the shapes

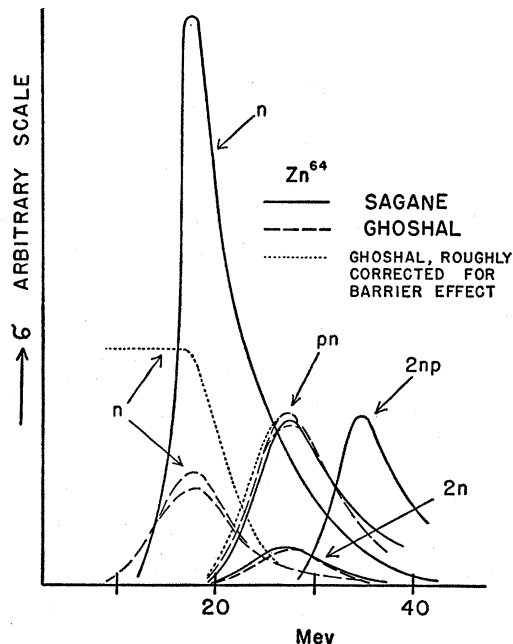


FIG. 1. Relative cross sections vs  $E_{\gamma}$  for  $(\gamma, n)$ ,  $(\gamma, pn)$ ,  $(\gamma, 2n)$ , and  $(\gamma, 2np)$  reactions on  $Zn^{64}$ . Excitation functions for  $n$ ,  $pn$ , and  $2n$  emission from the same compound nucleus,  $Zn^{64*}$ , as reported by Ghoshal are also given.

of these cross section curves vs energy agree with the shapes of Ghoshal's curves. Since he showed that his results are in good accord with the statistical theory of the compound nucleus excited to an energy of the order of 30 Mev, this agreement with the present data shows that competition in the excited nucleus can satisfactorily explain the results for  $(\gamma, 2n)$  and  $(\gamma, pn)$  processes. It is also to be noted, however, that the  $(\gamma, n)$  cross section reported here is relatively seven times higher than that obtained by Ghoshal. Since the processes of excitation are different and it is known that the cross section for excitation to 18 Mev by charged particles will be lower than that for excitation to 30 Mev (by a factor of 1.5 to 2, because of the potential barrier which is particularly significant for incoming particles with large  $l$  values), this difference in  $\sigma_{\gamma, n}/(\sigma_{\gamma, 2n} + \sigma_{\gamma, pn})$  must indicate that the cross section for gamma-ray absorption is several times larger at 18 Mev than at 30 Mev. In addition, it is to be noted that, for  $Zn^{64}$ ,  $\sigma_{\gamma, p}$  is probably at least as large as  $\sigma_{\gamma, n}$  in the region of 18 Mev.<sup>4</sup> It seems