

FIG. 2. Neutron capture γ -ray spectrum of carbon tetrachloride. The resolution curve shown is estimated for 8.5-Mev γ -rays; for lower energy γ -rays the resolution is better.

γ -rays below 4 Mev or to detect the $N^{14}(n-p)C^{14}$ reaction. The calibration in this case was made by measuring the saturation characteristics of both counters, and making use of the calibration of the first counter. The way the γ -ray curves overlap in the case of chlorine gives a gratifying justification of this procedure. The overlap for the cadmium spectrum is not so gratifying.

Figures 1 to 3 present the relative intensities of γ -rays of various energies; corrections have been applied to the pulse-height distribution curves for wall effect¹ and for the variation of the photo-disintegration cross section with energy. The statistical standard deviations are not given for each point, but are shown alongside the curves for clarity. The cadmium spectrum is the shape one would expect from the statistics of a many level nucleus. Even here, however, there are distinct signs of a peaked distribution, probably caused by a grouping of levels rather than by single γ -ray transitions. It is not certain, with the low statistics available, whether the slight peak at 8.7 Mev, indicating a direct transition to the ground state, is genuine or not. The chlorine spectrum shows definite signs of level structure. The background ($n-p$) reaction prevents data being obtained in the energy region shown.

The end points of the spectra can be identified with mass differences and are $Cd \sim 8.5 \pm 0.5$ Mev, $Cl \sim 10.5 \pm 0.3$ Mev. These figures may be compared with the results of Kubitshek and Dancoff.³

The capture in carbon was much smaller, and to avoid background a different arrangement was necessary. The first counter

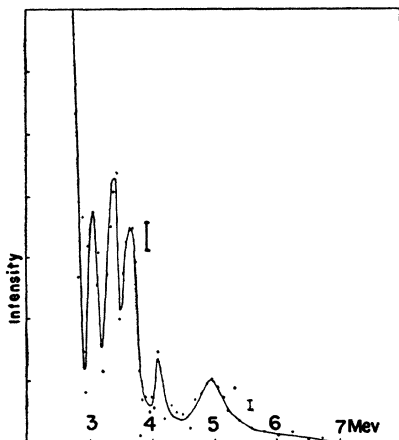


FIG. 3. Neutron capture γ -ray spectrum from graphite.

was surrounded with boron to absorb slow neutrons which would otherwise cause an ($n-p$) reaction, and placed to one side of the neutron beam, shielded from the direct radiation from the pile by the pile wall of cadmium and lead. Large blocks of graphite were placed in the beam, of such a size that the mean free path for Compton scattering of γ -rays in the carbon was approximately the dimensions of the block. The background was measured as before by blocking the beam with a boron lithium shutter. The arrangement was such that appreciable capture could have occurred in surrounding materials, particularly the lead wall of the pile; it is therefore not certain whether the spectrum shown is due to neutron capture in carbon alone, or also to capture in impurities and surroundings. Calibration of the counter was made from the $N^{14}(n-p)C^{14}$ reaction as before. The spectrum shown is corrected as before for wall effect and for variation of photo-disintegration cross section with energy.

Gamma-ray peaks were found at 3.05, 3.4, 3.65, 4.1, and 4.95 ± 0.05 Mev. The last appears to be a transition direct to the ground state of C^{13} , and agrees well with the value 4.951 Mev found by Kinsey,⁴ whose work was published after these measurements were completed. The 4.1-Mev γ -ray is probably a transition⁵ to the 0.8-Mev metastable state of C^{13} , and the 3.05-Mev γ -ray may be a transition from the 3.1-Mev excited level to the ground state. The 3.4- and 3.6-Mev γ -rays may come from levels not previously reported, or from impurity capture. The statistics, however, are not good.

No γ -ray of 8 Mev corresponding to capture in C^{13} was found, and it seems probable that 80 percent of the capture in carbon is due to C^{13} .

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A Standard Substance for Precise Electron Diffraction Measurements

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DURING the course of some work dealing with the variation of the lattice constants of very small crystals with crystal size, it was necessary to look into the question of a standard reference substance for precision electron diffraction measurements. The conditions to be met are as follows: (1) The recorded pattern should consist of several very sharp rings so that a good average value of the constant to be found can be obtained. (2) When prepared, the material should remain chemically stable and without physical change, such as growth in crystal size, over a period of several days. (3) The lattice constant and crystal structure must be known and be independent of the method of preparation.

Gold has been used as a standard material by several workers. However, Lu and Malmberg¹ have reported thin gold foil to have a lattice constant less than the usual x-ray value, and our results on evaporated gold films corroborate this result. Thin films of alkali halides are unsuitable since, in most cases, the crystals grow on exposure to air. ZnO has been suggested as a standard material. However, both Finch and Wilman² and Cosslett³ have reported that in some cases the lattice constant of ZnO as determined by electron diffraction differs from the x-ray value, and varies with the age of the specimen.

A vacuum-evaporated film of TlCl about 300Å thick, deposited on a thin Formvar or collodion substrate was found to provide a satisfactory standard material. A typical transmission electron diffraction pattern is shown in Fig. 1. The angular half-width of

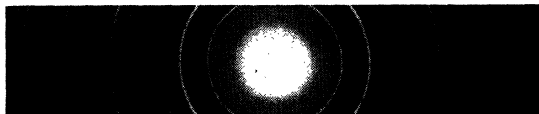


Fig. 1. A typical electron diffraction pattern of an evaporated TlCl film.

the rings (neglecting those which are overexposed) is about 3×10^{-4} radian, and this is thought to be entirely due to an instrumental factor and to the finite sizes of the diffracting crystals. The diameters of these rings can be measured readily with an accuracy of one part in 5000 by means of an optical comparator. No change has been detected in such a specimen left exposed to the air for a number of weeks.

The value which we have taken for the lattice constant of TlCl is the previous x-ray value given by Jevins and Karlsons.⁴ This value was determined assuming the wave-length of the $\text{Cu } K\alpha_1$ -radiation to be 1.5374Å. The lattice constant of TlCl is then 3.834Å at 20°C.

We have also found MgO smoke to be useful as a secondary standard. This pattern has the defect that only two recorded rings are sufficiently sharp to allow precise measurement. The specimens were prepared by holding a Formvar-covered wire mesh about 10 in. above a short strip of burning magnesium ribbon. It was found that the lattice constant of MgO smoke did not vary from specimen to specimen. In terms of the TlCl standard mentioned above we found the lattice constant of MgO smoke to be 4.202Å. This value is in agreement with the best x-ray determinations for MgO powder.

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Pulses in Argon Counters

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THE building-up of the discharge in argon counters is due to photons, as pointed out by several authors.¹ The photons generated near the wire during the initial avalanche cause the cathode or the gas to send out a number of photo-electrons which, as soon as they get near the wire, build up a new avalanche, and so on.

No definite results have been obtained from experimental work recently carried out for the purpose of discriminating between the process on the cathode and the photo-ionization in the gas, as both processes seem to lead to results which are quantitatively possible.²

Here we give a few experimental observations on this subject.

We have studied α - and β -particle pulses in cylindrical counters of the usual type, filled with argon (previously purified with hot calcium) operating in the proportional and Geiger zones. The brass cathodes range from 60 to 90 mm in diameter; the tungsten wires are 0.2 mm in diameter, and the argon pressure employed ranges from 15 to 100 cm Hg.

A thin layer of uranium has been placed inside the counter.

The circuit consists of a cathode follower, an amplifier mod. 100 (with a rise time of 0.6 $\mu\text{sec.}$) and a synchroscope-delay line-

oscillograph system to observe and photograph the pulses. Different time constants have been employed in the amplification chain and sometimes directly on the counter, in order to differentiate the pulses in a suitable way.

Figure 1 shows the multiplication curves obtained with one of the counters for α - and β -particle pulses, and with two different time constants. Figure 2 shows the pulse forms for increasing voltages.

The interpretation of the curves and of the pulse shapes is as follows. $N(V)$ being the multiplication factor at voltage V due to the ionization process by electron collision (Townsend α -process), and A_0 the number of ion pairs generated by a primary ionizing particle, the first avalanche built up by this particle will contain $Q_0 = NA_0$ electrons.

In the multiplication process photons are produced also; if f is the number of photo-electrons extracted from the cathode for each electron of the primary avalanche, the number of electrons extracted from the cathode and which reach the wire will be NA_0f . Here f depends on the nature of the gas, its pressure, the photoelectric efficiency of the cathode for the photons involved, the average solid angle under which the cathode can be seen from the wire, and the wire-to-cathode distance.

After a transit time τ , these photo-electrons reach the high field region in the neighborhood of the wire and are multiplied N times, producing an avalanche containing $Q_1 = fN^2A_0$ electrons, viz. $Q_1 = fNQ_0$.

The following avalanches will be subject to the formula $Q_k = (fN)^k Q_0$.

The foregoing holds good provided $fN < 1$, as in this case the convergence of the pulse succession is ensured, and when it is possible to disregard the decrease of N produced by the positive ions which, after a few transit times τ , are still very close to the wire. The succession of photo-electronic pulses originating from every α - or β -particle has been observed by the oscilloscope,

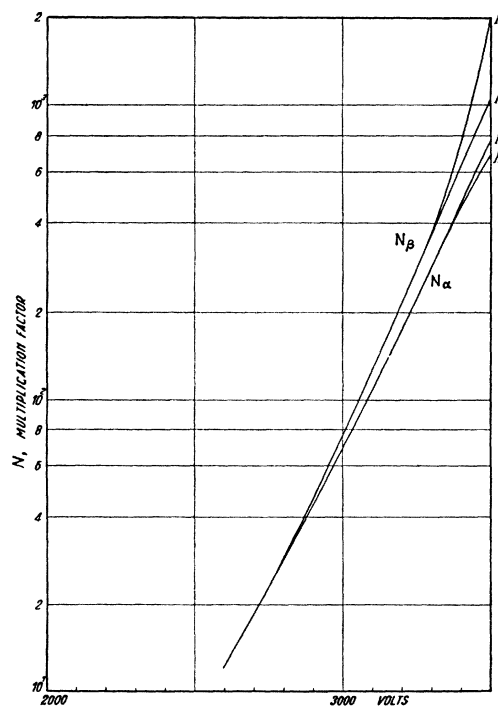


Fig. 1. Multiplication curves. Counter diameter: 90 mm; argon pressure: 76 cm Hg; I. β -particles $RC = 1.5 \mu\text{sec.}$; II. β -particles $RC = 250 \mu\text{sec.}$; III. α -particles $RC = 1.5 \mu\text{sec.}$; IV. α -particles $RC = 250 \mu\text{sec.}$; at $N = 30$ the space-charge distortion of the multiplication begins for α -particles; at $N = 400$ photo-electronic pulses are detectable. The Geiger threshold is at $N_\beta = 1000$.

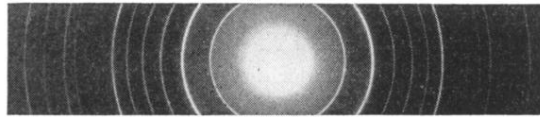


FIG. 1. A typical electron diffraction pattern of an evaporated TiCl film.