Photoelectric Effect in Self-Quenching Geiger-Mueller Counters*

M. V. Scherb
Bartol Research Foundation of the Franklin Institute
Swarthmore, Pennsylvania
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A METHOD has been discovered for treatment of a Geiger-Mueller counter which produces a marked change in its photoelectric properties. By means of a discharge treatment at liquid-air temperatures, the results shown in Figs. 1 and 2 were obtained with the following experimental set-up.

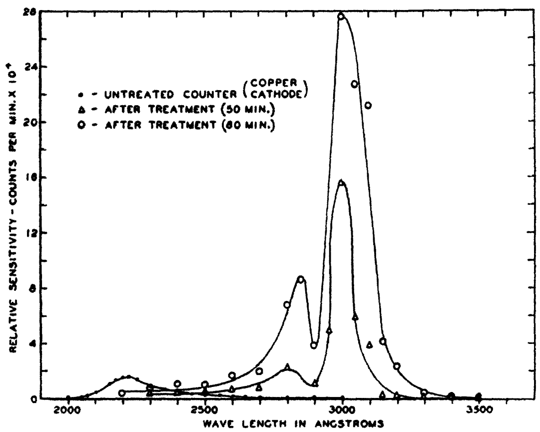

Fig. 1. Spectral distribution curves showing the effect produced by a prolonged discharge of a self-quenching Geiger-Mueller counter at liquid-air temperatures.

A glass wall counter, having a copper cathode 3 cm in length and 1 cm in diameter, was used. Light was transmitted along the counter axis through a Nonex glass bubble window, 0.01 mm thick, at one end of the tube. The counter was chemically washed, rinsed in distilled water, and vacuum baked at 420°C for 2 hours before a 12-cm Hg argon-butane filling was made. The discharge treatment

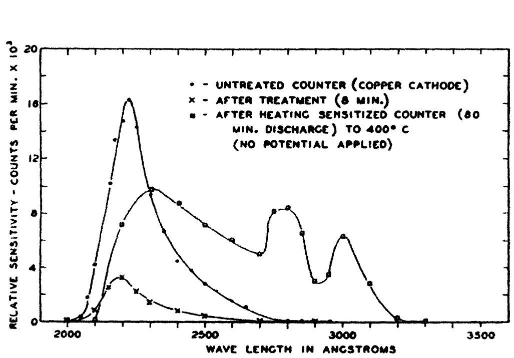

Fig. 2. Spectral distribution curves showing the effect produced by the initial discharge and by heating the sensitized counter.

was carried on by immersing the counter in liquid air and connecting to it a suitable voltage supply. To determine the spectral response, the discharge was terminated and the counter allowed to return to room temperature.

Spectral response curves were obtained by the use of a quartz monochromatic illuminator, a suitable radiation source, a quartz condensing lens, a slit system, a scale of 256, and a mechanical recorder. In this preliminary investigation, no corrections were made for counter losses, scaling circuit losses, or stray light effects in the illuminator.

The spectral response curve of the counter before treatment is plotted in Fig. 1, and to an enlarged scale in Fig. 2. It can be seen that the peak response is at 2250A, and the photoelectric threshold is roughly at 2900A which is in agreement with published results[1] considering the possible contamination of the cathode surface by the quenching gas. After discharging the counter for 8 minutes, the spectral response curve obtained (Fig. 2) indicated a sharp drop in the peak sensitivity. Response curves taken after 50- and 80-minute treatments are shown in Fig. 1.

These results indicate that the prolonged discharge (1) shifted the spectral distribution curve toward the longer wave-lengths, and (2) increased the sensitivity of the counter by a factor of 15 at the peak response. No decrease in sensitivity was observed 24 hours after treatment. Changes in Geiger-counter properties such as useful life, background, pulse shape, starting voltage, and plateau characteristics have not been observed. A counter treated in this manner 8 months ago has shown no long-term photoelectric fatigue to date.

A similar photoelectric effect has been observed for the argon-butane mixture using cathodes of nickel, silver, and Aquadag. Preliminary results obtained with an argon-ether mixture indicate that sensitivities many times greater than previously mentioned can be obtained in the same spectral range.

To check the indications that the photoelectric effect was a cathode-surface phenomena, the sensitized counter was heated to 400°C and allowed to cool to room temperature. The resultant spectral response curve (Fig. 2) shows that most of the assumed cathode deposit had been driven off although the peaks at 2850A and 3000A still persist. With further heating, it is expected that the response curve would revert to the original. The dip in the curve at 2900A may be due to absorption by some gaseous component after treatment.[2]

Spatz[3] and Bergstrand[4] have reported on the photosensitivity of argon-alcohol counters after long use. Similar effects, particularly after high speed counting, have been observed at this laboratory for various hydrocarbon quenching mixtures. The decomposition of the hydrocarbons in the discharge quenching mechanism is accompanied by the deposit of polymers on the cathode surface.[5,6] After being built up through counter use, it is likely that this deposited layer is responsible for the observed photo-sensitivity. Discharging a Geiger-Mueller counter at liquid-air temperatures would seem to be a similar process[7] although the layer deposited and the gas disintegration products may very well be different.

While photon counters have been compared favorably with certain types of photo-multipliers, they have had few applications because of lack of reliability or limited spectral response.[8] A reliable photon counter of high surface quantum efficiency in the near ultraviolet or visible light region could find important uses in spectroscopy, as a Čerenkov radiation detector,[9] and possibly as an alpha-particle and low energy β-ray detector without thin-window techniques by the use of suitable phosphors.

Work is proceeding on the investigation of the reported photoelectric effect for various gases and cathode materials.

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Cosmic-Ray Bursts in the Upper Atmosphere*

H. E. TATEL** AND J. A. VAN ALLEN
Applied Physics Laboratory, Johns Hopkins University, Silver Spring, Maryland

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ON July 29 a successful V-2 rocket carried a bundle of four automatically calibrated pulse ionization chambers mounted in the rocket nose (Fig. 1) to an altitude of 100 miles. During the flight there were recorded 150 seconds of good quality telemetered data above 180,000 ft.

The ionization chambers were similar to those used by Bridge and Rossi,[1] 20 in. long and 3 in. in diameter filled with 5 atmospheres of purified argon. Calibration was achieved by periodically sliding tubes internal to the chambers by means of external solenoids, thereby uncovering fairly thin polonium sources. There were 11 Po α-particle pulses per second during calibrations compared to a high altitude cosmic-ray counting rate of 4 per second (mostly smaller pulses). The pulses of 10-μsec. duration were amplified by a feed-back type pulse amplifier with 2-μsec. rise time. These pulses were shaped by an artificial line, amplified, lengthened by an integrating circuit, and then transmitted to the ground by the 23-channel radio telemetering system of the Naval Research Laboratory. Before firing, an artificial pulser was used to establish the amplitude calibration of the over-all amplifier, telemetering, and recording system. The system was linear and the scale and reliability were assured by the six Po-α-calibration periods of two-second length each at 27-second intervals during flight.

The results of three of the chambers are concordant and yield the distribution of pulse height shown in Fig. 2. The

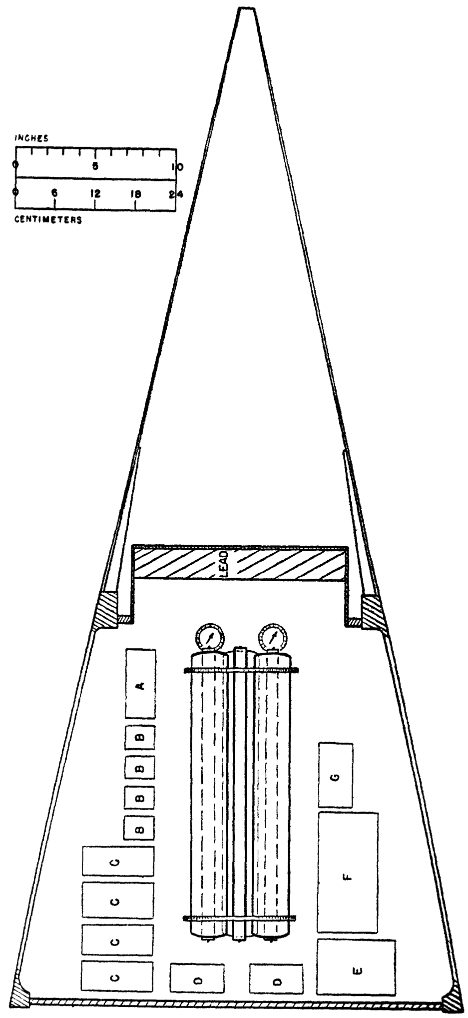

FIG. 1. Schematic diagram of ionization chambers in V-2 instrument cone. *A*, *B*, *C*, etc. represent electronic chasses. Remainder of rocket extends 40′ below.

data from the fourth chamber are in disagreement with these three, and by examining the distribution, we have deduced that there were 24 spurious large pulses, and so we have not used the data from this chamber although the distribution of smaller pulses is in complete agreement with the group of three.

Selecting the pulses with amplitude greater than 1.5 and 2.5 times the extrapolated integral pulse amplitude of a