Neutron Measurements with Boron-Trifluoride Counters

We have been studying the behavior of boron-trifluoride counters for use in the measurement of slow neutron intensities. Copper cylinders, ranging from seven to 40 cm in length and one to seven cm in diameter, have been used in glass envelopes with three-mil tungsten central wires. Before filling, they were washed with dilute nitric acid and heated with a flame during evacuation. Pressures of BF_3 from two to 20 cm have been tried. Operating voltages were lowered and behavior improved by the addition of about one cm of argon in each case.

We define the threshold of a counter as that voltage at which it will break down into a continuous discharge if no quenching resistance is used. Below this threshold voltage, the ions formed in the tube are swept by the field to the central wire without starting a self-perpetuating discharge. The average number of ions so swept will be proportional to the number produced in the counter by the passage of the ionizing ray. As the ions travel toward the wire, they produce additional ions by collision, and the number of additional ions will be a function of the voltage. In most counters, such as those filled with argon or air, there is a small voltage range, generally less than five volts below the threshold, within which pulses greater than 0.01 volt are produced on the wire. The boron-trifluoride counters have the property of producing large pulses over a considerably greater voltage range.

A slow neutron entering a counter filled with boron trifluoride produces an alpha-particle by disintegration of the boron nucleus. This alpha-particle will produce a large amount of ionization in the counter, as compared to that produced by cosmic-ray particles or gamma-ray secondaries. By setting the recording amplifier to record only the larger pulses, it is possible to count the alpha-particles to the exclusion of beta- or gamma-counts.

The alpha-particle pulses produced by such counters can be as large as several tenths of a volt when the counter is operated at some 200 volts below the point where gamma-ray pulses of similar size are produced. No high quenching resistance is needed. The counter wire may be connected directly to the grid of the tube and a grid resistor of the order of one megohm is satisfactory.

In Fig. 1 is presented the counting rate of such a counter as a function of the applied voltage, when a radium-beryllium neutron source was nearby. As the voltage applied to the counter increases, the average pulse size increases. The counting rate of the recorder, therefore,

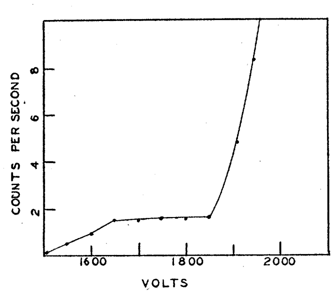

FIG. 1. Counting rate near a beryllium source as voltage applied to the counter is increased.

rises with voltage until even the smallest pulse produced by the alpha-rays is large enough to record. Further increase of voltage results in no change in the counting rate until that voltage is reached at which the largest of the gamma-ray pulses becomes large enough to operate the recorder. The threshold of this particular counter (11 cm pressure, cylinder 20 cm long, 1.8 cm diameter) was 2080 volts.

The limiting neutron intensity which may be measured is that which is small compared to the natural background due to alpha-rays arising from contamination of the cylinder of the counter.

The efficiency of the counters was calculated from the boron cross section to be about 0.3 percent for the counters filled to 11 cm pressure. The order of magnitude of this figure was verified experimentally by comparing the counting rate of a BF_3 counter with that arising from induced radioactivity in a silver (argon-filled) counter.

These counters have been used for about six months, in measuring the neutron intensity in the cosmic radiation in the stratosphere, as well as that due to sources in the laboratory. Stratosphere flights using automatic radio transmission of data with these counters indicate an increase of the neutron counting rate with elevation which is more rapid than the increase in the total radiation. At an elevation of three meters of water equivalent below the top of the atmosphere, the neutron intensity in the cosmic radiation is of the order of 100 times the sea level neutron intensity.

The work on these counters has been partly supported by the Carnegie Institution of Washington. The authors are indebted to M. D. Whitaker of New York University for the loan of the neutron source, and to W. F. G. Swann, T. H. Johnson, C. G. Montgomery and R. D. Fowler for helpful advice and assistance.

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Bartol Research Foundation,
The Franklin Institute,
Swarthmore, Pennsylvania,
April 27, 1939.

The Detonation of Nitrogen Iodide by Nuclear Fission

Small samples of nitrogen iodide mixed with black uranium oxide were exposed to a 200-mg Ra-Be neutron source surrounded by six cm of paraffin. About half of the exposed samples exploded during exposure after periods of irradiation ranging from one minute to several hours. Unexposed control samples gave times for spontaneous detonation greater than the average time under exposure by a factor of 20 or more. Samples of pure nitrogen iodide were unaffected by exposure to the source. Altogether 32 detonations occurred during irradiation among the *samples* containing uranium oxide. Several detonations occurred with two cm of lead between the source and the sample, other conditions remaining the same.

It seems reasonable to conclude that nuclear fission (the splitting of the uranium nucleus into two approximately equal parts) set off nearly all of the detonations observed among the irradiated samples. An effect of this type is not