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JULY 16th NUCLEAR EXPLOSION: NEUTRON MEASUREMENTS WITH GOLD-FOIL DETECTORS

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ABSTRACT

The number of neutrons per square centimeter per unit logarithmic energy interval was measured as a function of distance from the gadget and was measured by means of the activation cadmium-covered gold foils. The absolute sensitivity of the gold foils was measured by calibrating them in a graphite block with a known Ra-Be source

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JULY 16th NUCLEAR EXPLOSION:

NEUTRON MEASUREMENTS WITH GOLD-FOIL DETECTORS

The gold-foil detectors used at Trinity were 2-mil foils, 4 x 6.5 cm in area. They were made by clamping gold sheet in a press between an accurately ground steel block and a block of lucite and cutting around the steel block with a sharp scalpel. The foils were rolled loosely and placed inside of cylinders 1 inch in diameter and 4 cm long made of 30-mil cadmium, with an inner telescoping wall of aluminum for mechanical strength. One end of the cylinders was closed by soft-soldering on a disk of 30-mil cadmium sheet, and the other end was covered by a spun cadmium lid. The lids fitted snugly, and a strip of scotch tape was used to make the cylinders nearly dust-tight. The cadmium cylinders were placed in containers made of 3-inch lengths of 1-1/4-inch aluminum pipe with standard aluminum pipe caps on either end. These containers were sealed with a small amount of glyptal.

The aluminum containers were fastened with iron wire near the ends of 1-inch iron pipes 30 inches long which telescoped into 1-1/4-inch iron pipes, also 30 inches long, which had been driven 24 inches into the ground. The pipes were held together by means of a bolt through the common section. In each case the axis of the aluminum cylinder was perpendicular to the iron pipe and to the line from zero, and the cylinder was between the tower and the pipe. Foils were placed at a distance of 50 meters and then at even 100-meter intervals out to 1000 meters in two lines at an angle of 180° with each other.

The absolute sensitivity of the foils was determined by measuring their saturation activity as a function of the distance to the source in a graphite block with a known Ra-Be source. In every case the foils were counted on each of the 3 glass-walled Geiger counter setups in building "G". The foils were placed between sheets of 32 mil cadmium for the calibration. Counting cylinders of brass were made for each Geiger counter which held the foils close to the inside wall of the cylinder and made the

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counting geometry reproducible. Because the thickness of the foils varied by as much as 17 percent, one of the thickest and one of the thinnest were measured in the same slot of the graphite block. The saturation activity was found to be the same for the two foils. The calibration value obtained[1] was

$$\frac{nv}{\text{unit logarithmic energy interval}} = 0.0463 \left(\begin{array}{l}\text{saturation activity of} \\ \text{resonance detector in counts/min}\end{array}\right).$$

Gold foils were also exposed in the liquid-air bath to determine the source strength[2].

Initially only those foils which were recovered still fastened to the iron pipes were counted. At least one foil at each distance from 500 meters out satisfied this condition; and all such foils were counted on all 3 Geiger counters. The activities of the foils varied by a large factor, and it was impossible to count the most active ones in the geometry used for the calibration. A holder was made to hold the brass counting cylinders in a fixed geometry at as large a distance from the counter as possible, and the holder was made in such a manner that only the gammas were counted. All the foils were counted in this geometry. As a first approximation to the demultiplication for this geometry, a thin strip of the least active foil was counted in the standard geometry at three positions along the axis of each Geiger counter. Later one of the less active foils was counted in the standard geometry on each of the counters, and the demultiplication factor for each was determined accurately.

The curve of the initial activity of the foils as a function of distance from the gadget was obtained from the measurements described above. The point at 300 meters was obtained from a gold foil in the ground cellophane camera station. Part of the aluminum cylinder from a detector which had been placed at 300 meters was found, and it showed the detector had been destroyed.

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2) LA-337

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One of the containers with a foil originally at 400 meters was found about 700 yards from zero; the other was found about 800 yards from zero. These foils were counted, and the initial activities obtained differed by 12 percent. Since the average value fell on the curve, it was assumed that only the prompt neutrons were important in producing the activity at this distance. The foils found near their starting points were counted on only one of the Geiger counters, and the values obtained agreed with the curve determined previously. The activities of foils at the same distance from zero in opposite directions differed on the average by about 10 percent.

Fig. 1 gives the initial activities of the gold foils as a function of their distance from zero.

From the calibration of the foils we have the followed expression for the steady state conditions in the graphite block:

$$\frac{nv}{\text{unit logarithmic energy interval}} = .0463 \left(\begin{array}{l}\text{saturation activity of gold}\\ \text{foil in counts/minute}\end{array}\right)$$

The factor .0463 relates the rate of disintegration of the active gold atoms present immediately after an infinite irradiation to the number of neutrons/sq. cm./sec. passing through the foil. For a burst of neutrons whose duration is short compared to the half-life of the active atoms formed, as was the case at Trinity, this same factor relates the initial (in this case also total) number of active gold atoms (the time integral of the rate of disintegration of the active atoms) to the total number of neutrons which had passed through the foil. For this case we have the following expression:

$$\frac{\int_0^\infty nv\,dt}{\text{unit logarithmic energy interval}} = .0463 \int_0^\infty \left(\begin{array}{l}\text{initial activity of gold}\\ \text{foil in counts/minute}\end{array}\right) e^{-\lambda t}\,dt$$

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$$\int_0^\infty nvdt = (.0463/\lambda)\ \text{(initial activity of gold foil)}$$

$$\lambda \text{ for gold } = .0001783/\text{minute}$$

$$\int_0^\infty nvdt = 260\ \text{(initial activity of gold foil)}$$

Fig. 2 gives the values of $\int_0^\infty nvdt$ as a function of the distance from zero.

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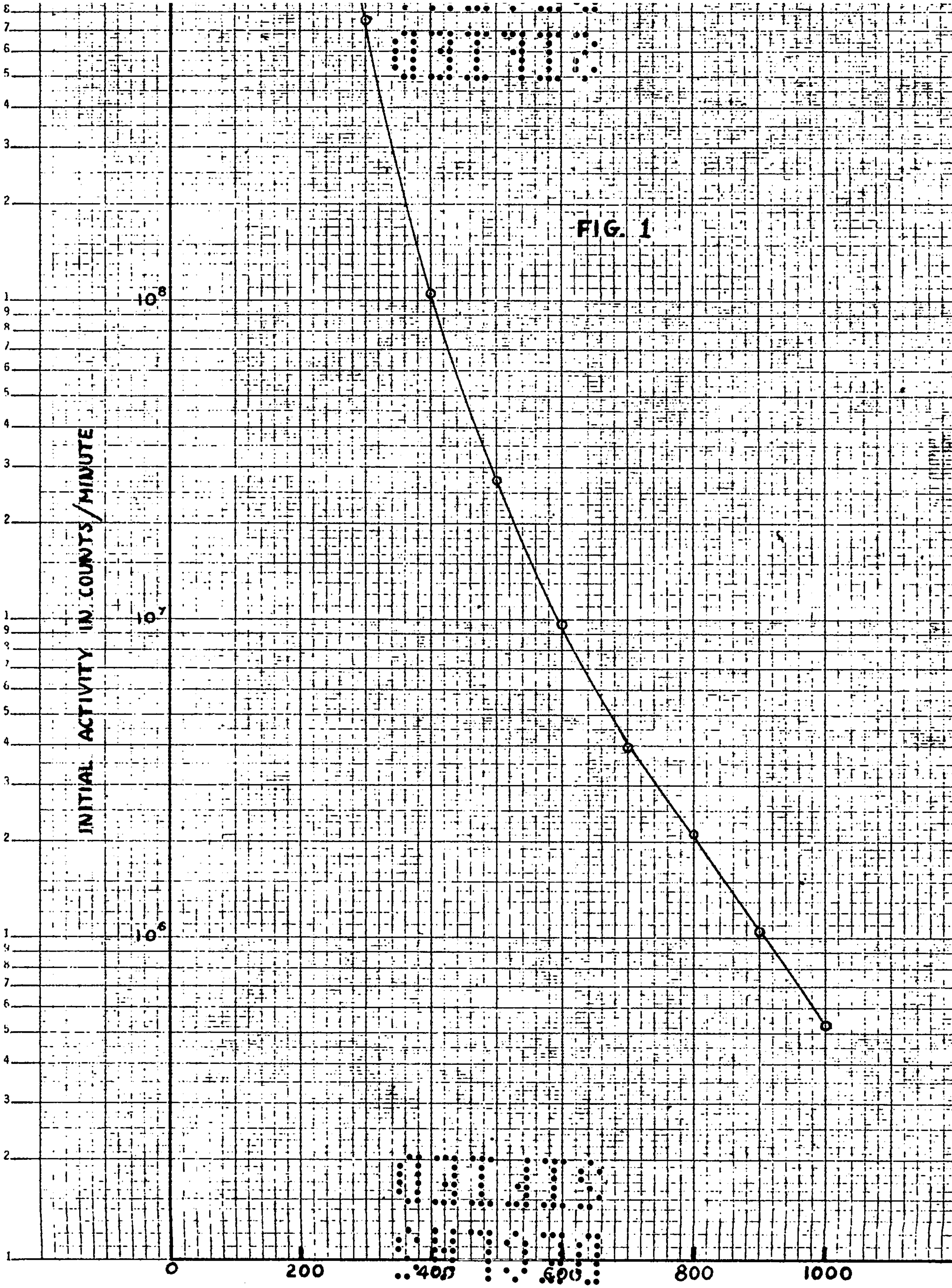

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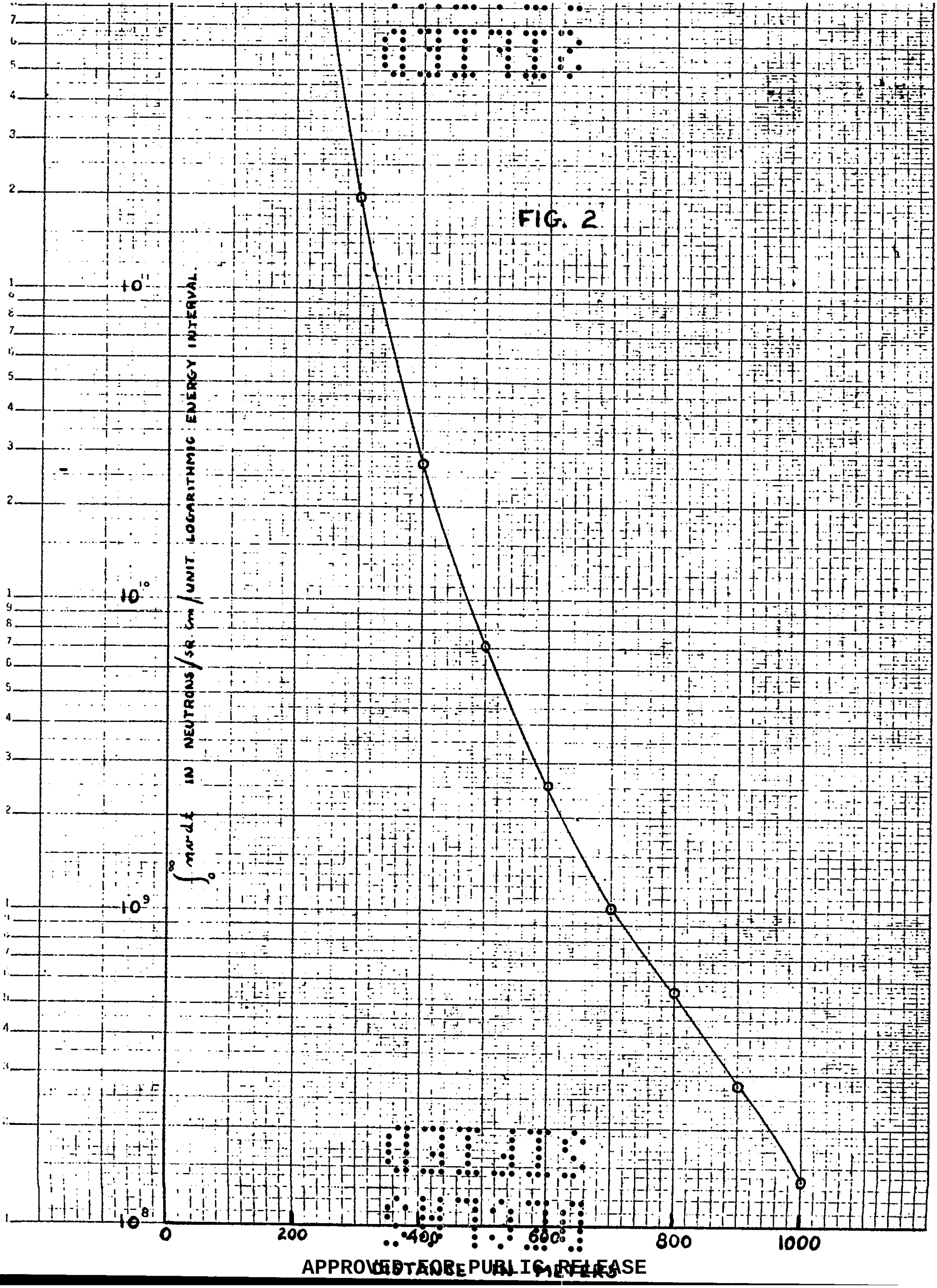
FIG. 2
$\int_0^\infty nv\,dt$ IN NEUTRONS/SR cm/UNIT LOGARITHMIC ENERGY INTERVAL
10^{11}
10^{10}
10^{9}
10^{8}
0
200
400
600
800
1000
DISTANCE IN METERS