An Analysis of the Background Radiation Detected by NaI Crystals*

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Summary—**The 0.07-2 5 mev scintillation pulse height spectra of several NaI crystals, heavily shielded by Fe and Hg, have been analyzed in coincidence and anticoincidence with cosmic ray counters surrounding the crystals. The residual spectra have been analyzed further and the following sources have been identified: 1) Ra^{226} in Al casing, 2) K^{40} in phototube, crystal, and canning window, and 3) low pulse height spectrum due to the ionizing components of cosmic rays.**

The above sources still leave 0.05 c/m/g of NaI unexplained. Activities in stainless steel, quartz, and MO reflectors are too low to account for the bulk activity. Moreover, activation analysis of crystal fragments has eliminated the presence of Rb^{87} as a natural contaminant, and decay studies in neutron free caves preclude the presence of I^{126} from cosmic ray neutron activation.

A possible source of contamination, consistent with the none too well defined shape of the residual spectrum, is Cs^{137}, a fission product, in weight concentrations of about 5×10^{-16}. Studies aimed at proving or disproving its existence are currently being pursued.

Introduction

DURING THE development of an apparatus capable of measuring the natural gamma radioactivity of the human body, our group has spent considerable effort in reducing the background counting rate of several scintillation crystals. Since attainment of low level counting with instruments of this type is likely to prove useful in other fields of endeavor, it was thought worthwhile to report in detail some of our experiences on the subject.

The Main Shield

Necessary to our objectives was the construction of a large enclosure designed to shield both instrument and test object from the gamma activity emitted by ordinary building materials. For this purpose a room with 8-inch steel walls was constructed, having inside dimensions of $8 \times 8 \times 6$ feet. Its construction details are sketched in Fig. 1. It consists essentially of a bolted frame of 3-1/2-inch angle beams upon which 1/4-inch plates of 12, 24, and 26-inch width were placed in staggered sequence on all sides to avoid continuous cracks in the walls. With this arrangement it was possible to assemble any thickness of wall desired with the help of only two men, handling a maximum weight of 160 pounds. Whereas the upper and lower layer of plates were simply laid on the top of the frame and on the floor, the side plates were held in place by simply clamping them together between the frame and

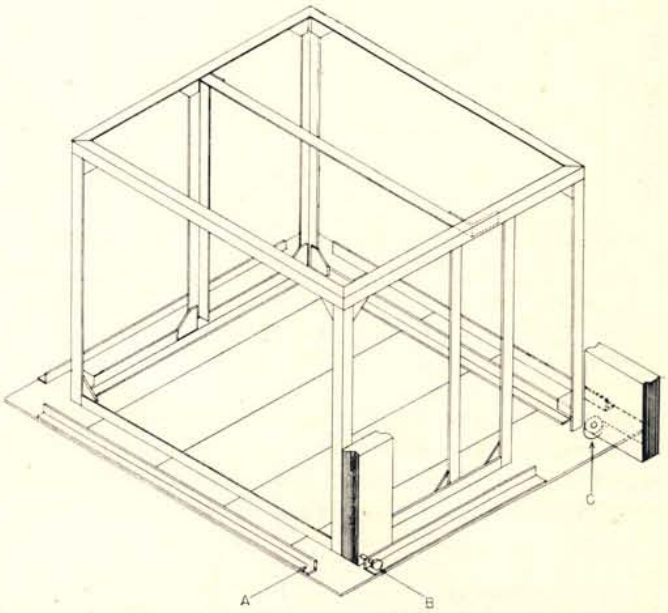

Fig. 1—Construction details of steel room. (a) Angle iron used to clamp walls to frame with (b) Log bolts. (c) lower roller bearings which support steel door.

appropriately placed angle irons A parallel to it by means of lag bolts B.

Access to the room is provided by means of a door swinging on roller bearings (C) and consisting of a welded steel box 6-3/4 inches $\times$ 2 feet $\times$ 6-1/2 feet made of, and filled with, 1/4-inch plate; although weighing over 1 ton, this door can be opened with a couple of pounds pressure. This type of construction has several advantages, most prominent being its low cost, its ease of assembly and the possibility of recovering most of the raw material invested in it, should its use be discontinued. The room weighs a total of 52 tons and can be assembled or disassembled by 4 men in 2 days time.

Shielding Experiments

The gamma ray background of a 1-1/2 $\times$ 1-inch NaI(Tl) crystal was examined within this room as the steel plates were being laid on the frame. Differential pulse height spectra, covering the energy range from 200 kev to 2.5 mev, were obtained with 0, 3/4, 1-1/2, 3, 6 and 8 inches of steel in place. Fig. 2 shows these spectra for zero and 6-inch iron shield. After the room was completed, the analyzer was recalibrated to cover the energy range from 70 kev to 2.5 mev, and runs were made inside the room with the additional shielding of 1/4-inch lead,

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