Reduction of NaI Background

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To develop 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 this type of low-level counting is useful in many fields, we're reporting some of our experiences in detail.

Main Shield

To shield both instrument and subject from the gamma activity emitted by ordinary building materials, we built an 8- × 8- × 6-ft room with 8-in. steel walls. See Fig. 1.

This type of construction has several advantages, most prominent being low cost, ease of assembly and the possibility of recovering most of the material in it should its use be discontinued.

The gamma-ray background of a 1½- × 1-in. NaI(Tl) crystal was examined within this room as the steel plates were being laid on the frame. Differential pulse-height spectra, covering the range from 0.2 to 2.5 Mev, were obtained with 0, ¾, 1½, 3, 6 and 8 in. of steel in place. Figure 2 shows the spectra with and without a 6-in. 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 additional lead and triple-distilled-Hg shielding around the crystal. The data are summarized in Table 1.

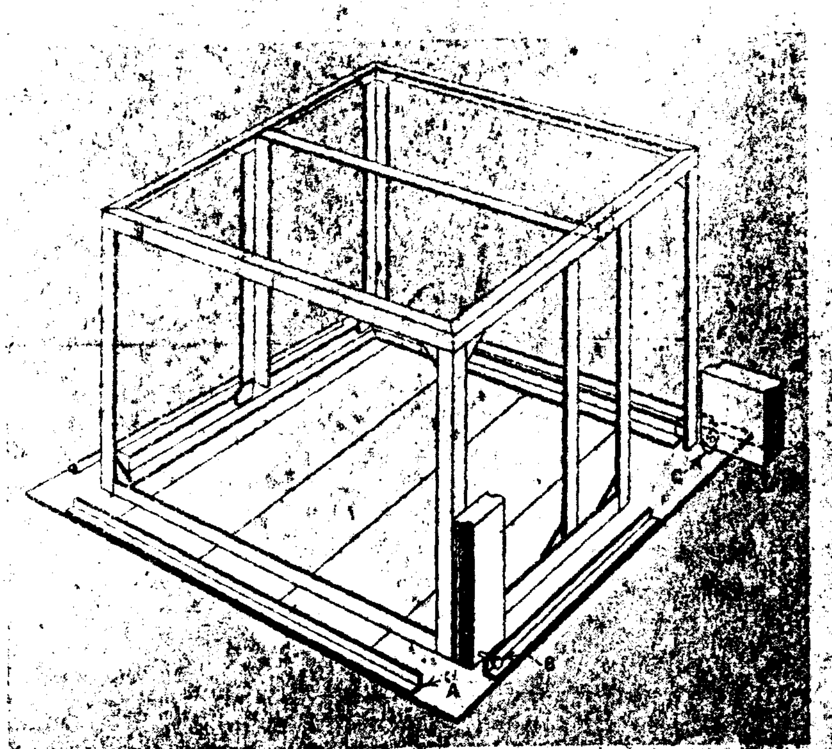

FIG. 1. Main shield consists of a bolted frame of 3½-in. angle beams upon which steel plates of 12-, 24- and 26-in. width were placed in staggered sequence on all sides to avoid continuous cracks. Two men handling up to 160 lb can assemble any thickness of wall desired. Floor and ceiling plates were simply laid in place; side plates were clamped together between frame and appropriately placed angle irons, *A*, by lag bolts, *B*. Access to room is by door swinging on roller bearings *C* and consisting of a welded steel box 6¾ in. × 2 ft × 6½ ft made and filled with ½-in. plates. Although weighing 1 ton, door can be opened with only slight effort. The room weighs 52 tons and can be assembled by four men in two days

TABLE 1—Effect of Shielding on Gamma-Ray Background

Shielding (in. steel)	Integral background (cpm) 0.2–2.5 Mev	70 kev–2.5 Mev
None	576.4	
¾	312.2	
1½	173.2	
3	84.2	
6	43.6	
8	41	62
8 + 2 in. Pb	29.5	41
8 + 1 in. Hg	26	35
8 + 2 in. Pb + 1 in. Hg	25	32.8

Note that the gross background (from 70 kev to 2.5 Mev) was never sensibly reduced regardless of the amount of shielding added beyond a thickness of 8 in. steel plus 1 in. of Hg. These thicknesses are sufficient to effectively eliminate the influence of local activity.

An estimate of the contribution from cosmic rays was made by placing a bank of cosmic-ray-sensitive G-M counters around the Hg shield and by measuring the coincidence rate between them and the crystal. The result, 7 cpm, is consistent with the cross-sectional area of the crystal and the primary cosmic ray flux at sea level.

Attempts were made to determine the sources of the remaining 25 cpm which were assumed to be inherent to the detector. Since placing another 5819 photomultiplier in front of the crystal added 7–10 cpm to the background, discarded phototubes were crushed and placed on the crystal. Activity, due to K^{40}, was found in the glass envelope and in the ceramic base. In fact, photomultipliers are one of the principal sources of residual radioactivity and will be discussed further later.

The 25 ppm by weight of K in the NaI crystal (1) contributed 4 cpm more. Subtraction of these identified activities, about 17 cpm, leave 14 cpm or 0.14 cpm/gm of NaI unexplained.

It was not considered practical to