Technical methods

Assay of diagnostic radioisotopes in large liquid volumes with a well-type crystal in the end-on position

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A large number of instruments have been constructed to assay volumes of radioactive liquids of the order of a few hundred millilitres and include the multi-Geiger tube ring counter (Veall and Vetter, 1952), variations of the Marinelli beaker (Hill, Hine, and Marinelli, 1950) with a solid sodium iodide crystal (Dratz, 1957), and plastic well-type scintillation counters (Warner and Oliver, 1962; Cook and Valberg, 1963).

In a small laboratory equipped with a well-type sodium iodide crystal type counter carrying out a small number of diagnostic radioisotope tests the assay of large liquid volumes, including homogenized faeces, is generally carried out by assaying 5 ml of the sample and relating the counting rate to the total volume, since the justification for the capital outlay on an additional

counter similar to the above instruments may be difficult.

This article illustrates the performance which may be obtained from a sodium iodide well-type counter, used in the end-on position for direct counting of six diagnostically useful radioisotopes in large liquid volumes and is compared with that obtained from a six-Geiger tube counter.

METHOD

A 5 ml well-type NaI crystal, of outside diameter 5 cm housed in a counter type N664 (Ekco Electronics, England) with an opened lid, was surrounded by an additional cylindrical lead shield with walls 3.2 cm thick. The shield of length 10 cm projected 3.5 cm above the top of the crystal and supported a small Perspex platform on which the samples to be counted were placed. The liquid volumes used were contained in a glass jar of diameter 9 cm and overall height 14.5 cm which had a screw cap and rubber ring to prevent leakage. With this arrangement the base of the jar was 10 cm from the top of the crystal in an attempt to reduce the change in counting rate with increasing volume without a large loss in the counting rate due to the inverse square law effects.

One microcurie (μCi) of ^{131}I was dissolved in 100 ml deionized water and added to the jar which was placed

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FIG. 1. Variation of the counts per microcurie per second with increasing liquid volumes for the two systems.

TABLE I

SUMMARY OF RESULTS FOR 600 ML VOLUMES COUNTED WITH THE TWO SYSTEMS

Radioisotope	Main γ-ray Energy (MeV)	Well-type Crystal		6-GM Tube Counter	
		Background (c/sec)	$\frac{S^2}{B}$	Background (c/sec)	$\frac{S^2}{B}$
¹²⁵ I	0.03	19	12	14	—
⁵⁷ Co	0.12	18	1,028	14	275
⁵¹ Cr	0.32	17	7	14	7
¹³¹ I	0.36	17	738	14	672
⁵⁸ Co	0.81	16	930	14	773
⁵⁹ Fe	1.1 and 1.3	13	596	14	592

on the Perspex platform. Using the minimum discriminator bias on an associated scaler the high voltage (HV) to the photomultiplier tube viewing the crystal was adjusted to give the maximum $\frac{S^2}{B}$ value (Loevinger and Berman, 1951) for this integral counting mode, where S is the sample count and B the associated background count.

The jar containing the 100 ml ¹³¹I solution was then placed in the centre of a multi-Geiger ring counter similar to that described by Veall and Vetter (1952), incorporating six Geiger tubes type G26Pb (20th Century Electronics, England), the counting rate determined, and corrections were applied for dead time. Another 100 ml of deionized water was added to the jar and the counting rates were determined again with the sodium iodide crystal and the Geiger tube counter. This procedure was continued with additional 100 ml volumes of deionized water up to a total volume of 600 ml.

Five other radioisotopes, ¹²⁵I, ⁵⁷Co, ⁵¹Cr, ⁵⁸Co and ⁵⁹Fe, covering a range of gamma ray energies from 0.03 to 1.3 MeV, were also counted similarly with both counters.

RESULTS

Figure 1 shows the counts per microcurie per second plotted against increasing volume of solution in the jar for the two systems. It can be seen that there is little variation in counting rate in the Geiger counter over the range 100 to 600 ml while the counting rate in the end-on position of the well-type crystal falls by about a factor of

two with the exception of ¹²⁵I. The factor is greater for this isotope because of considerable self absorption effects in addition to the inverse square law effects. However it will be noted that no counts are obtained from ¹²⁵I in the Geiger tube counter due to penetration difficulties encountered by the low energy gamma and x rays emitted by this isotope.

Table I summarizes the results for the largest volumes measured and compares the counting rates obtained from the two systems in association with the background counts. Using the well-type crystal the background counts fall for increasing gamma ray energy at the optimum HV settings for the isotopes considered. A comparable or higher $\frac{S^2}{B}$ figure is obtained for volumes up to 600 ml using the well-type sodium iodide crystal in the end-on position under these geometrical conditions, and consequently a comparable or better performance than the multi-Geiger counter.

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