

DETECTOR FOR TRITIUM IN WATER

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A cell containing a stack of plastic scintillator sheets measures concentrations of tritium in water down to $1 \mu\text{Ci litre}^{-1}$. The response time constant is less one than minute.

Measurement of tritium in water at concentrations equal to or less than one microcurie per litre is desirable for monitoring water streams associated with power reactors moderated or cooled by heavy water. Several detectors for tritium in water have been described previously. Muramatsu et al.¹⁾ used a folded sheet of plastic scintillator, whereas Moghissi et al.²⁾ used a thin surface layer of anthracene powder. An alternative and more sensitive detector is a cell tightly packed with anthracene; units of this type are commercially available, but the impedance to flow is high and they tend to block with prolonged use. Sannes and Banville³⁾ used a double spiral of plastic scintillator as a means of packing a large surface area of scintillator (needed because of $5 \mu\text{m}$ maximum range of the tritium betas) into a small volume. This geometry is not directly applicable to water flow and, in addition, bending and cementing the scintillator need skill if bad memory effects are to be avoided. By using a stack of flat plastic scintillator sheets, a sensitivity for tritium in water comparable to, or better than, detectors previously described can be attained with both low memory and with reproducible low flow impedance.

Detector and electronics: The detector shown in fig. 1 contains 60 sheets ($5 \times 5 \text{ cm}$) of NE102*, 0.0125 cm thick. The sheets are mounted vertically on 4 horizontal stainless steel rods, teflon spacers setting the sheets 0.075 cm apart. The rods are mounted on a removable side of a cubic lucite cell. Four sides are coated with diffuse reflector paint. Water flows in through five inlet orifices at the bottom of the cell and flows out at the top. Two photomultipliers (RCA 8675)[†] view the cell from opposing sides. The pulses from the photomultipliers are amplified (with double delay line shaping) and analysed (single channel).

Coincidences within 30 nsec between timing pulses from the single channel analysers are scaled. NIM[‡] assemblies were used for these functions. The arrangement of units is shown in fig. 2.

Performance. The sensitivity of detectors of this type for tritium in water is 24 c. min^{-1} per $\mu\text{Ci litre}^{-1}$. Background is about 40 c. min^{-1} . The sensi-

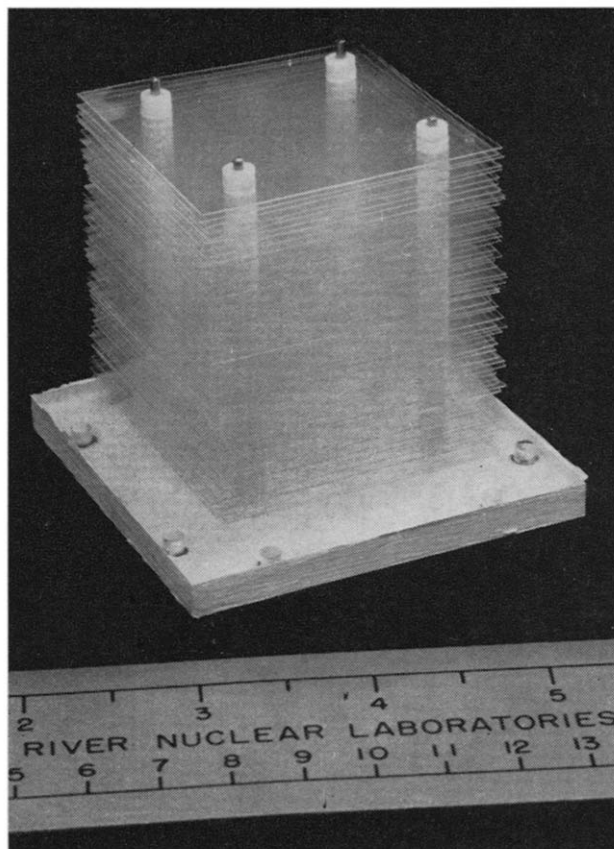


Fig. 1. Detector for tritium in water. The scintillator sheets fit into a cubic lucite cell. The lucite plate shown here, on which the sheets are mounted, forms one vertical side of the cell.

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† RCA Victor Research Laboratories, Montreal, Quebec, Canada.

‡ Nuclear Instrument Module.

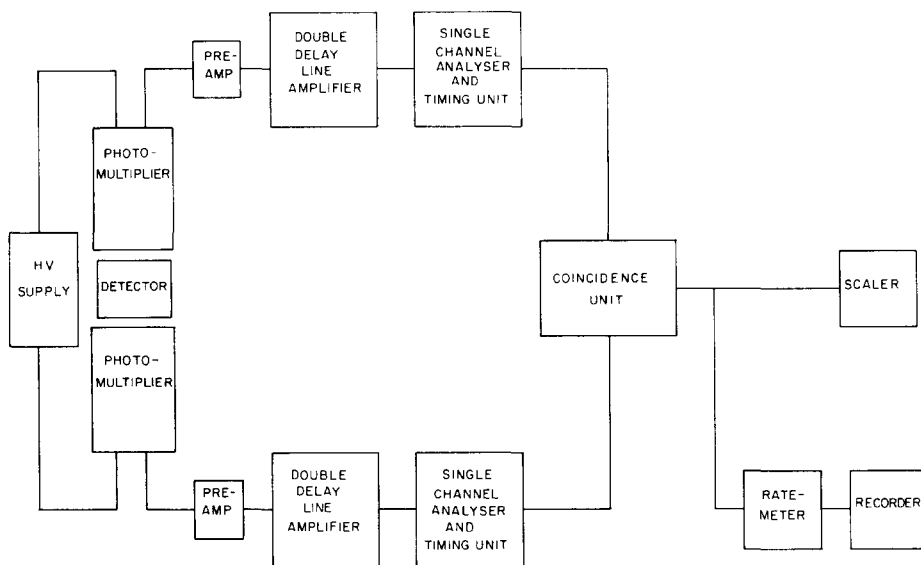


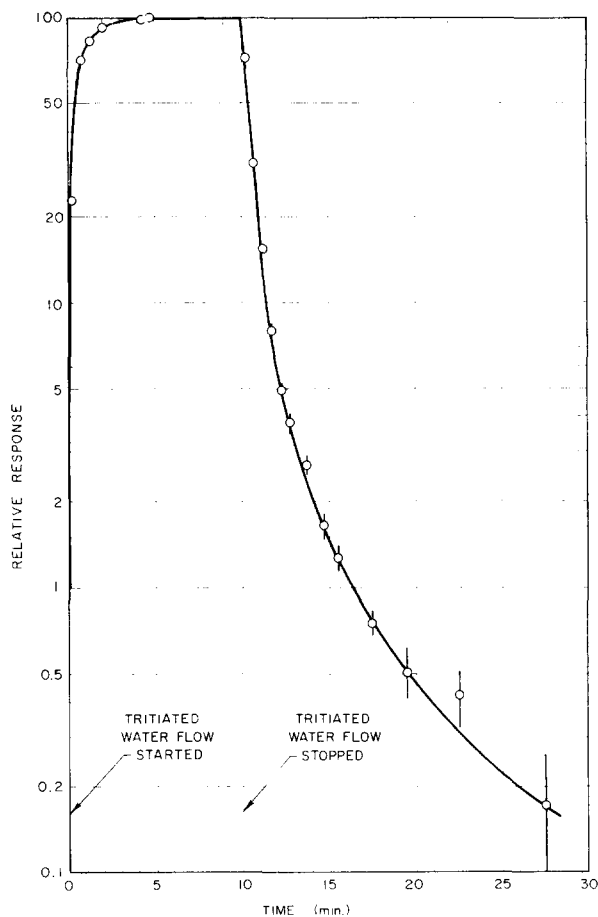
Fig. 2. Outline of the electronics used with the detector. Units were hv supply-fluke 412A; pre-amplifiers, DDL amplifiers, SCA/timing units and the coincidence unit were Canberra 1405, 1411, 1435 and 1441 respectively.

tivity to gamma radiation is $160 \text{ c. min}^{-1} \text{ per mR h}^{-1}$ with 10 cm of lead shielding around the detector. The output from the detector reaches 90% of its final steady reading 1.2 min after a step input of tritiated water with a flow rate of $550 \text{ cm}^3 \text{ min}^{-1}$. Clearance is at a similar rate as shown in fig. 3. Retention of activity in the cell is low, less than 1% remaining after 6 min. The pressure drop across the detector at this flow rate is 2.7 kN m^{-2} ($\sim 20 \text{ mm mercury}$). The performance characteristics have been within 10%

TABLE 1

Detector	Background (B) c. min ⁻¹	Sensitivity (S) c. min ⁻¹ per $\mu\text{Ci litre}^{-1}$	S^2/B
Plastic (NE102) ¹⁾	—	1	—
Anthracene powder in surface layer ²⁾	30	10	3.3
Plastic (NE102), this paper	40	24	14.4
Cell packed with anthracene crystals	35	40	46

Fig. 3. Response of detector to tritiated water. A flow of non-tritiated water at $550 \text{ cm}^3 \text{ min}^{-1}$ was changed to tritiated water at the same flow rate for 10 min. Error bars in the lower two decades indicate ± 1 standard deviation for the scaler counts in each interval.



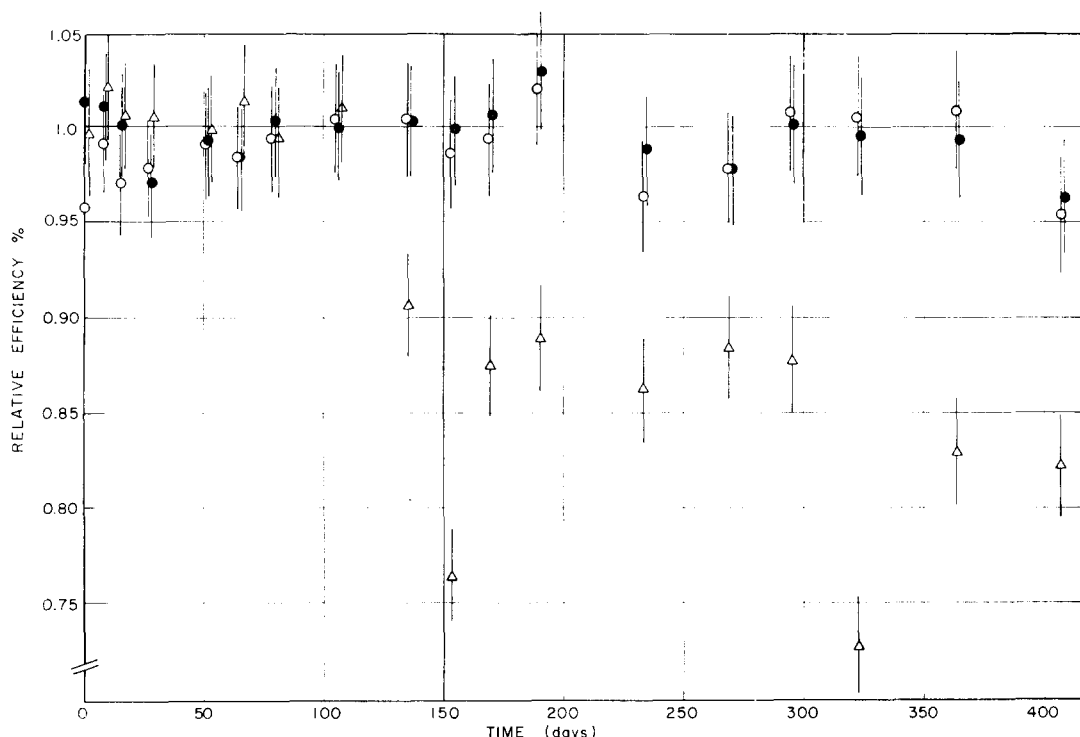


Fig. 4. Effect on efficiency for tritium detection of prolonged immersion of NE102 in distilled water (○), process water (●) and 0.1 M hydrochloric acid (△).

of the above for the three detectors made to this design.

The scintillator will withstand prolonged exposure to water without any appreciable loss in counting efficiency. The counting efficiencies of NE102 continuously immersed in water and decimolar hydrochloric acid (HCl) for over a year are shown in fig. 4. No significant change is observed in the counting efficiency (relative to NE102 kept in air) for water immersed samples. Immersion in HCl caused deterioration after 130 days.

The performance of the detector described here is compared with other detectors in table 1. A "figure of merit" taken as $(\text{sensitivity})^2/\text{background}$ is shown in column 4.

Tritium in air may also be measured with this

detector. The sensitivity is 150 c. min^{-1} per $\mu\text{Ci m}^{-3}$ and the background counting rate is 30 c. min^{-1} . Gamma sensitivity of the air filled detector is 80 c. min^{-1} per mR h^{-1} . Hence the response to 1 (MPC)_a tritiated water vapour ($= 5 \mu\text{Ci m}^{-3}$) is approximately equal to that from 10 mR h^{-1} .

Mr. N. W. Tepley and Mrs. J. Sterling assisted in assembling and testing the tritium detector and associated equipment.

References

- 1) M. Muramatsu, A. Koyano and N. Tokunaga, Nucl. Instr. and Meth. **54** (1967) 325.
- 2) A. A. Moghissi, H. L. Kelley, C. R. Phillips and J. E. Regnier, Nucl. Instr. and Meth. **68** (1969) 159.
- 3) F. Sannes and B. Banville, AECL-2283 (1965).