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Rapid Thick Source Alpha Counting

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A difficulty often experienced when measuring dose rates of sedimentary samples is that low activities can be encountered. Thick source α counting using a 13.85 cm^2 screen is a common way of determining the uranium and thorium decay series contributions, however for low activity samples the time taken to achieve reasonable counting statistics may be very long, and discrimination between the series of pair counting would take even longer. To overcome this difficulty a simple inexpensive device can be constructed which increases the volume of material actually counted. Fig. 1 is a block diagram of the equipment used in our laboratory; Fig. 2 shows the counter head assembly in more detail.

The perspex sample holder is similar in design to the small ones supplied by ELSEC. As commercial α phosphorescent screens are expensive and have a high background we make our own. A sheet of Fascal 710 transparent adhesive is stretched over an aluminium ring and trimmed to size. Levy West G345 ZnS(Ag) is sprinkled uniformly over this and the excess is shaken off.

When counting a background the spacers are placed directly on the screen and the sealed sample holders are left for two days before counting to enable the short-lived daughters of radon already on the screen, and the ZnS(Ag) phosphorescence to decay. Before counting a sample it too should be left for 2 days after sealing, although it is preferable to leave it for a month so that ^{222}Rn will be in secular equilibrium with ^{226}Ra. Radon emanation can be corrected for later. To overcome problems of sample inhomogeneity common with many sediments, about 70g should be homogenized in a seed mill, and the required counting sample then be extracted from this. By comparing derived activities for crushed and uncrushed samples it has been possible to clearly demonstrate that for many aeolian sediments the radioactive nuclides are concentrated in crusts coating the matrix grains.

The sample is placed over the mouth of a plastic conical funnel which has its inner wall painted with white high gloss enamel paint to reflect the light pulses from the screen down to the photomultiplier tube (PMT) base. Using a pulser and a timer, a gating pulse of 0.4 sec. duration, but with a random delay of up to 20 msec., is used with a scaler to record the pair pulses. Another scaler records the total number of pulses.

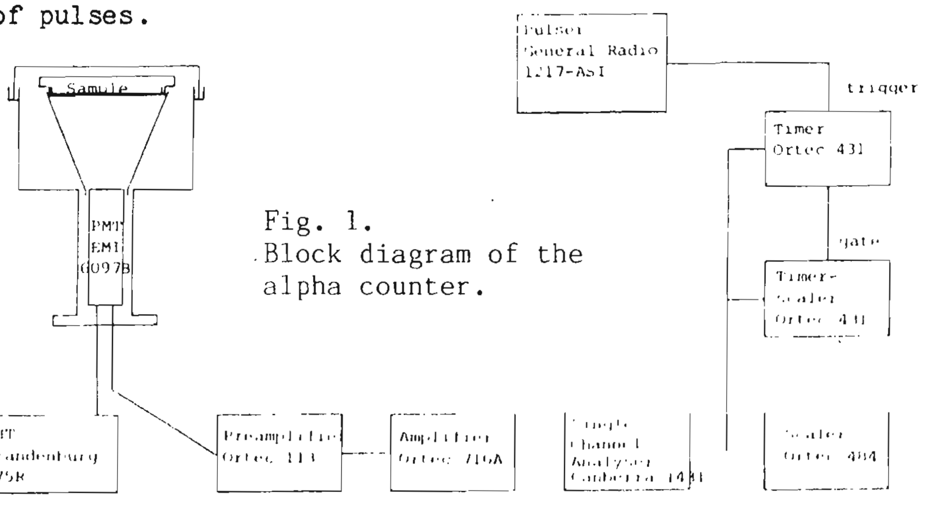
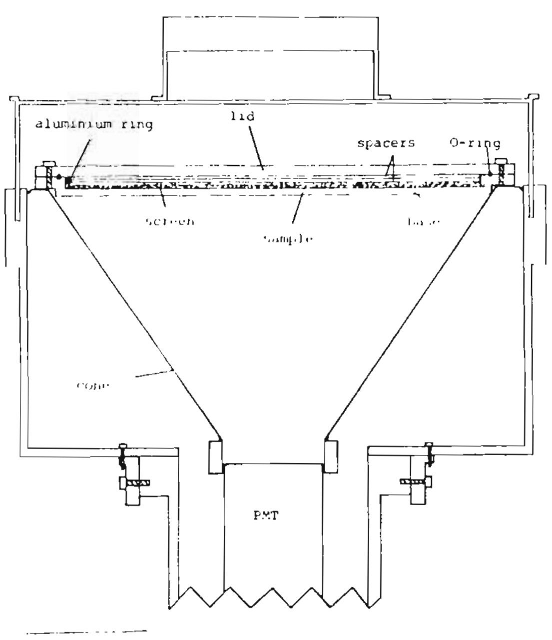


Fig. 1.
Block diagram of the alpha counter.

As the light pulses from the screen generally suffer many reflections before reaching the photocathode, they are of weak intensity and so the PMT pulses have to be greatly amplified to raise them above the electronic noise background. For our combination of EHT and gain the background is typically 7.5 counts/hr total and 0.03

Fig. 2.
Cross-section through the alpha counter head assembly.



pair counts/hr, of which the electronic noise contributes less than a third. As a comparison, a sample containing average ^{232}Th and ^{238}U decay series activities of 4.3 and 3.6 Bq/kg, respectively (equivalent to 1.1 ppm Th and 0.29 ppm U), yields 82.7 and 1.9 true total and pair counts/hr. At our operating efficiency of 85% for ^{232}Th decay series particles, less than 0.02% of β particles and 5 x 10^{-6}% of γ rays are detected.

The counting efficiency is less at the edges of the screen than in the centre, so calibration requires that a sample of known activity covers the whole screen. For this purpose $Th(NO_3)_4.6H_2O$, which was refined in 1906 and hence is now in secular equilibrium, can be obtained from the Radiochemical Centre, Amersham, U.K., and can be diluted with silica and homogenized in a seed mill. The activity of the silica must be taken into account. When calibrating the counter it is generally easier to set the modules' parameters and then determine the relative efficiency rather than set the counter to record 85% of ^{232}Th decay series particles. The equations needed for conversion of count rates to specific activities can be obtained from the author.

Acknowledgements

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References

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Editorial comment (MJA)

In response to the comment that use of sealed samples would accentuate error due to overcounting (such as reported in various articles of PACT 9) the author replied as follows:

> Pair counting has shown that Rn-220 is largely responsible for the radon emanation observed with alpha counting; this is due to Th-232 and Th-228 being distributed on the crusts of grains. This inhomogeneity leads to much of the observed overcounting but very fine crushing of samples, as is done when preparing XRF pellets largely eliminates the problem.