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A METHOD FOR THE DETERMINATION OF TH-U CONCENTRATION RATIO

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One of the main problems in calculating the annual dose rate in pottery by thick-source α-counting (Tite and Waine, 1962) is due to the effect of sample reflectivity. Lack of information on the Th/U ratio may be another source of error, mainly in calculating β and γ contributions to annual dose-rates (Sasidharan et al., 1978). This work is intended to investigate the influence of reflectivity and to determine indicatively the Th/U ratio by a new method that needs only two single channel analyzers. The method is similar to that suggested by Pierson (1951) and Sanderson (1979), but we found it to work only by eliminating the influence of reflectivity.

Reflectivity

Huntley (1977) and Huntley and Wintle (1978) showed that reflectivity influences the height of pulses arriving to the photo-multiplier, so that a poorly reflecting sample gives pulses much smaller than a highly reflecting one. The discriminator setting adjusted so that the count rate is 85% of the zero-extrapolated count-rate of a Th sample (or 82% of U sample) could then be affected by reflectivity.

We had a number of Th and U samples with different values of reflectivity. For each of them we plotted the count-rates vs. discriminator setting. The straight lines of Figure 1 are fits of the data by the least square method (all lines are normalized to the zero-extrapolated value of count-rates). The samples are: Th-1 NBL standard n.109 (monazite sand) kindly supplied by Dr. Aitken, 100 ppm Th and 4 ppm U; Th-7 = 7540 ppm Th and 1490 ppm U obtained from Mineralogy Institute of Milano University measured by Ge(Li) spectrometry; U-1 and U-3 respectively 550 ppm U and 2074 ppm U from the Novazza Uranium mine in northern Italy (SIMUR-ENI propriety) measured by chemical analysis and Ge(Li) spectrometry; U-2 = IAEA standart S-8 (pitchblende) 1187 ppm U. U-2 and U-3 were also analyzed by neutron activation by CESNEF (Centro Studi Nucleari Enrico Fermi Politiecnico di Milano).

It can be seen from Figure 1 that the threshold value at which the count-rate is 85% or 82 % is different for different samples. After fixing a discriminator setting for a sample, the errors we found for other samples were ranging up to 5%. To eliminate the effect of reflectivity, we interposed between the sample and the ZnS(Ag) sheet, a thin (0.9 mg cm^{-1}) mylar foil covered with aluminium. As a consequence, a reduction of the effect of reflectivity was observed as can be seen in Figure 2.

Th-U ratio

On the basis of the work done using SCA and varying the discriminator setting, we used a MCA to verify whether U samples are different enough from Th ones to obtain, from the shape of the spectra, an indication of Th/U ratio in any pottery sample. As expected from the measures with SCA, the spectra are different depending on the reflectivity of each sample (Figure 3). At first sight, nothing can be said about Th/U ratio. Using again a thin mylar foil covered with aluminium, the effect of reflectivity is eliminated and the spectra of Figure 4 were obtained. All the spectra of U samples are quite similar, and the spectra of Th samples, as well, but there is an evident difference between any spectrum of a Th sample and a U one.

Figure 4 shows also that each spectrum can be divided into two different parts. The first (the shaded area in Figure 4) is quite similar in a U spectrum and in a Th one (when normalized); the second is significantly different in U and Th samples. We can write: $C_T = C_0 + C_1$, where C_0 is the shaded area and C_T is the total area (which corresponds to a well-defined percentage of counts from a Th or U sample that is no more than 85% for the former and 82% for the latter because of the presence of the mylar foil: in our case, this percentage is 44.3% for Th and 43.8% for U but it depends on the mylar thickness. Moreover, the ratio C_1/C_0 will be in a definite relation with the Th/U ratio, in Th samples being surely higher than in U ones. In Table 1 are reported the values of C_1/C_0 ratio for a set of samples whose Th/U ratio was known by γ spectrometry or neutron activation measurements. The lower value of C_1/C_0 for the U-2 sample could correspond to a non-equilibrium in U-Ra chain detected by γ-spectrometry and neutron activation.

Table 1

	Th/U	C_1/C_0
Th-1	25	1.70
Th-7	5	1.57
U-1	0	1.02
U-3	0	1.03
U-2	0	0.86

Conclusions

The possibility of having an indication of Th/U ratio by only two count-rates on the same sample seems to be promising, avoiding long measures and expensive instrumentation. As a matter of fact besides the usual instruments needed for α-counting on thick samples, this method requires only an additional SCA and an additional counter. Even if the calculated Th/U ratio obtained by this method has only a qualitative significance, it could be very useful in determining the β-contribution to the annual dose-rate of the sample and the γ dose-rate when only a small amount of soil is available. It is also useful to evaluate γ dose-rate when only an α-counting system is available.

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FIG. 1

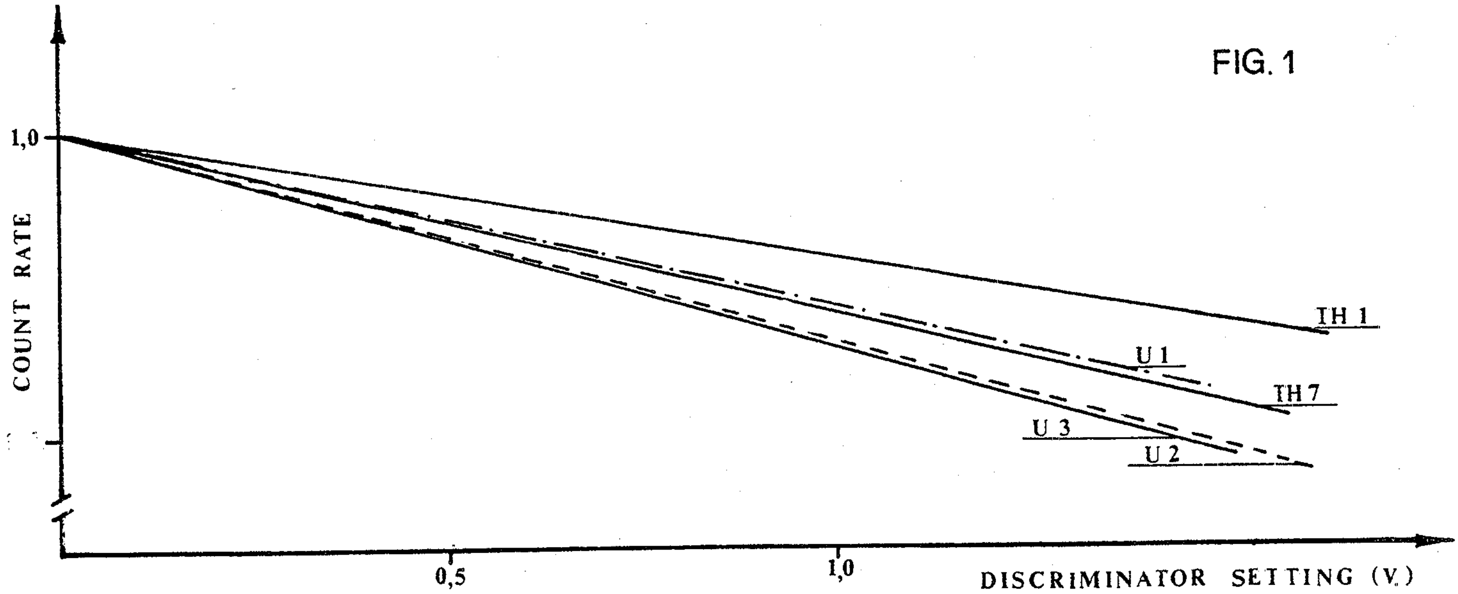
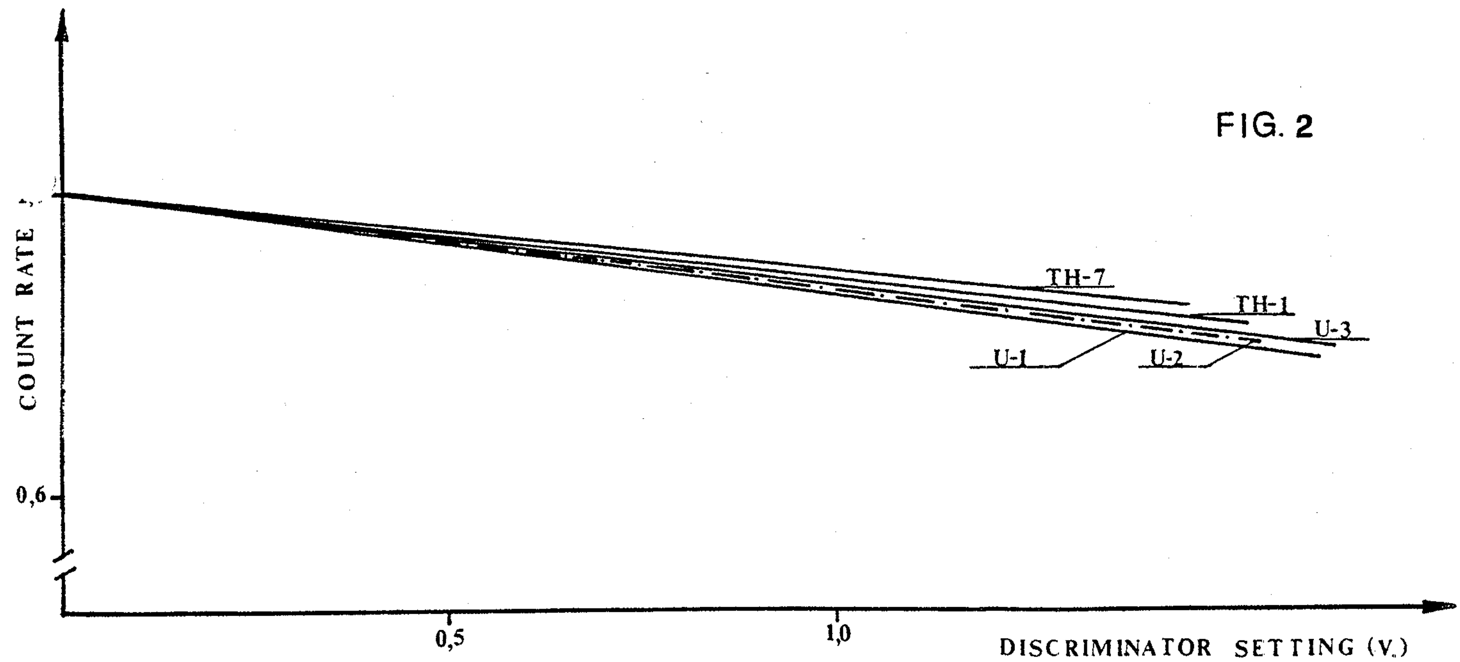
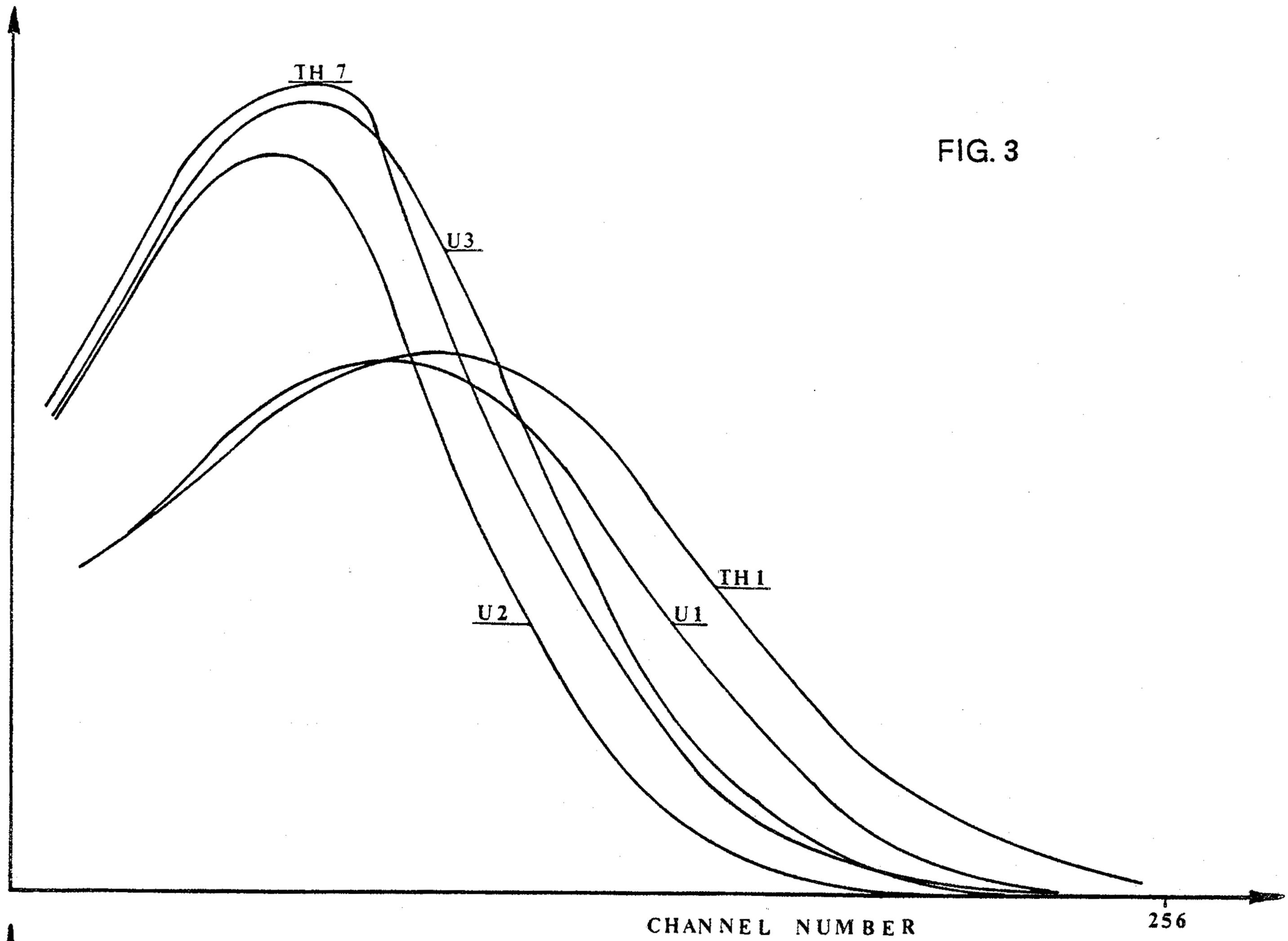

1,0
COUNT RATE
TH 1
U 1
TH 7
U 3
U 2
0,5
1,0
DISCRIMINATOR SETTING (V.)

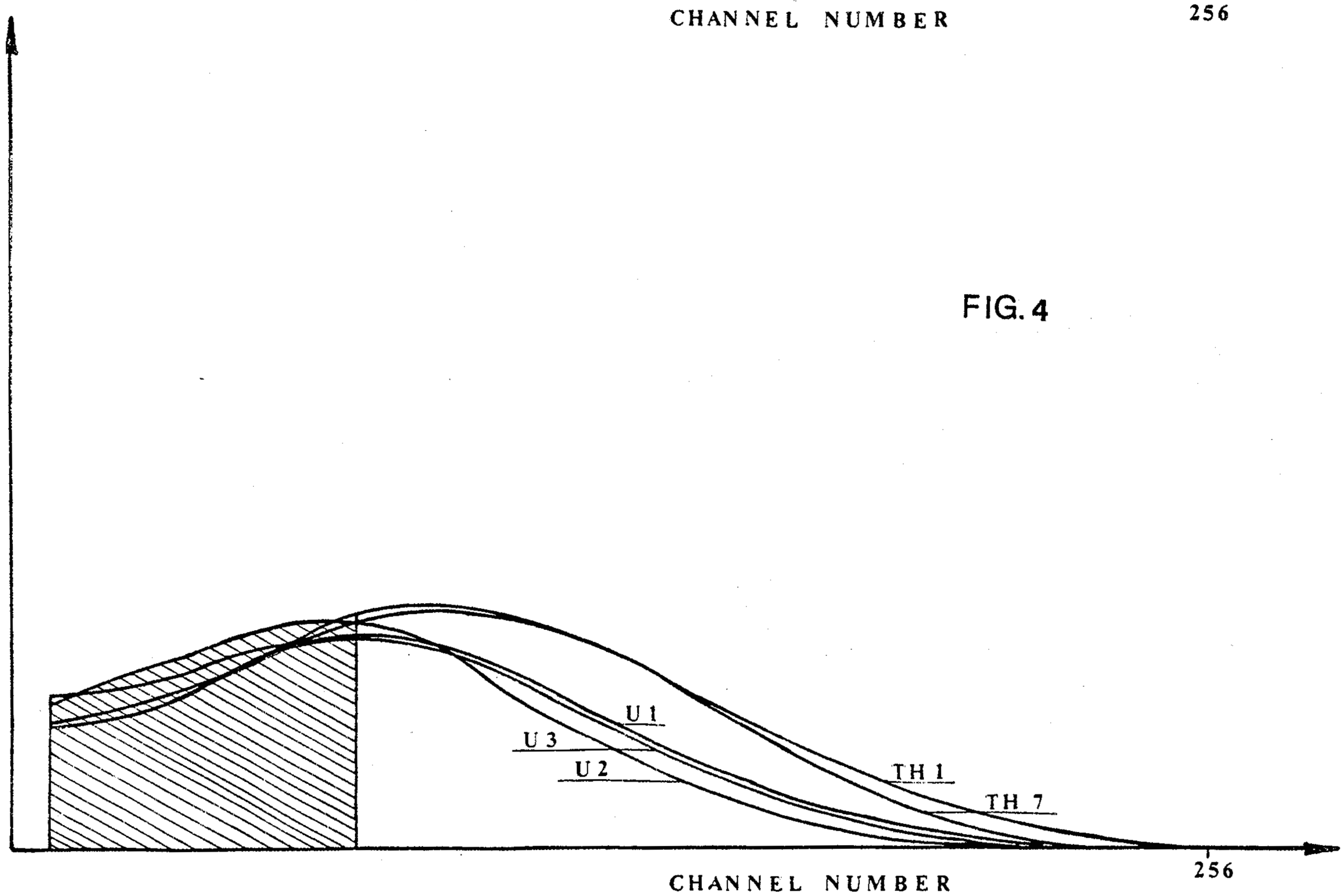
FIG. 2


COUNT RATE
TH-7
TH-1
U-3
U-1
U-2
0,6
0,5
1,0
DISCRIMINATOR SETTING (V.)



TH 7
U3
TH 1
U 2
U 1
CHANNEL NUMBER
256

FIG. 3



U 1
U 3
U 2
TH 1
TH 7
CHANNEL NUMBER
256

FIG. 4