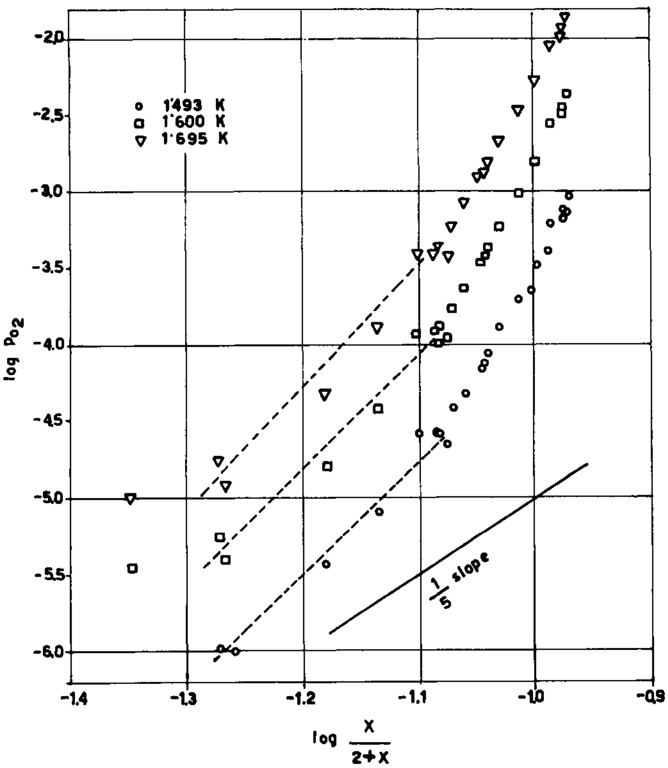

Fig. 1. Log $x/(2+x)$ vs log p_{O_2} plot.

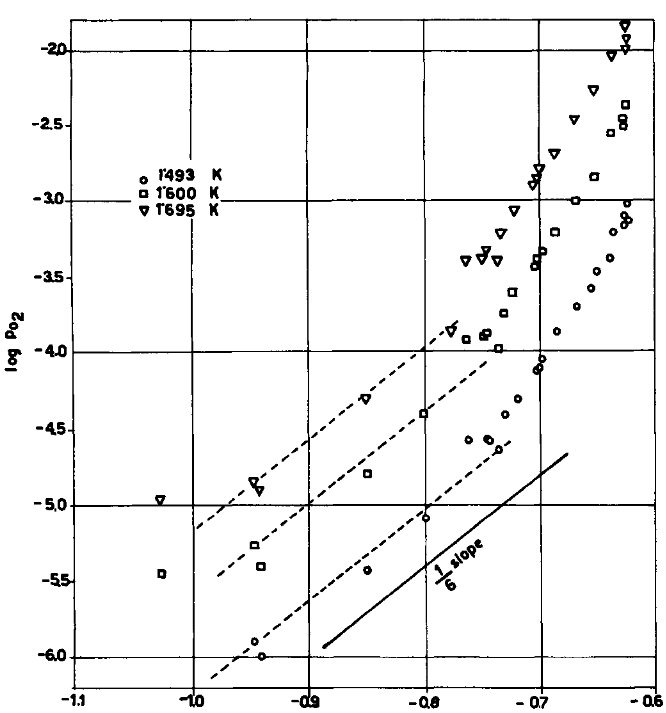

Fig. 2. Log x vs log p_{O_2} plot.

Data taken from the work of Roberts & Walter[7] are shown in Fig. 1 and 2. One sees that eq. (1) is not likely to hold anywhere. Eq. (2) may be made to hold between, say, x = 0.10 (log x = -1) and x = 0.16 (log x = ~-0.8), so that the interstitial picture would be favored. Below x = 0.10, the thermal contribution to the defect concentration might become important, and above x = 0.16 the material structure might perhaps be no longer represented as that of a normal UO_2 lattice containing equivalent oxygen interstitials and the electronic structure should undergo radical changes. (Young *et al.* suggest that there exist two non-stoichiometric oxides, namely UO_{2+x} and U_4O_{9-y}; their breaking point comes also very close to x = 0.16).

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The Infinite Dilute Resonance Integral of Thorium

Previous measurements of the infinite dilute resonance integral of thorium show wide discrepancies. Values between 67 barns[1] and 106 barns[2] have been reported. Therefore, and due to the importance of the resonance integral as a check for resonance parameters, a redetermination of this quantity was performed.

In the measurements the cadmium-ratio technique was used, comparing the activation of thin circular thorium and gold foils. To eliminate self-shielding effects, foils containing only 50 $\mu g/cm^2$ thorium were prepared by alloying thorium and aluminum. The gold foils were about 700 $\mu g/cm^2$ and therefore show some self-shielding; this was, however, corrected by using previous experimental results (see below). The irradiations were performed in the pool of the Munich research reactor at a core distance of about 20 cm, where the epithermal neutrons follow a $1/E$ spectrum. Bare and Cd-covered Au and Th foils (Cd thickness 1 mm) were irradiated simultaneously by placing them on a rotating Plexiglas turntable. Thus the average neutron flux was the same for all

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[2]R. B. TATTERSALL, TNCC (UK)-53.

foils. The activity of the foils was counted with single-channel γ spectrometers using the Hg^{198} 412-keV line in the case of gold and the 105-keV Pa^{233} line in the case of thorium.

The results of the measurements were evaluated by the well-known equation

$$\left(\frac{I}{\sigma_{eff}}\right)^{Th} = \left(\frac{I}{\sigma_{eff}}\right)^{Au} \frac{R_{cd}^{Au} - 1}{R_{cd}^{Th} - 1}$$

where

I is the resonance integral

σ_{eff} the effective thermal cross section.

R_{cd} the cadmium ratio.

We found

$$R_{cd}^{Au} = 8.40 \pm 0.05$$

$$R_{cd}^{Th} = 10.80 \pm 0.05$$

and thus

$$\left(\frac{I}{\sigma_{eff}}\right)^{Th} = \left(\frac{I}{\sigma_{eff}}\right)^{Au} \left[0.7543 \pm 0.0066\right].$$

Using $I = 1461.8$ barn and $\sigma_{eff} = 99.3$ barn for gold foils[3] and $\sigma_{eff} = 7.45 \pm 0.15$ barn for thorium[4], we get

$$I^{Th} = 82.7 \pm 1.8 \text{ barn}$$

for the infinite dilute resonance integral of thorium under 1 mm cadmium. This value is in good agreement with that obtained by Johnston[5]. From the resonance parameters published in BNL - 325, one calculates 96 barn for this quantity (including a correction of 3.89 barn for unresolved s-resonances and 2.86 barn for the $1/v$ part).

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[4]E. HELLSTRAND and J. WEITMANN, "The Resonance Integral of Thorium Metal Rods," *Nucl. Sci. Eng.* **9**, 507-518 (1961).

[5]F. J. JOHNSTON *et al.*, "The Thermal Neutron Absorption Cross-section of Th^{233} and the Resonance Integrals of Th^{232}, Th^{233} and Co^{59}," *J. Nucl. Energy, Part A: Reactor Sci.* **11**, 95-100 (1960).

Age to 1.44 eV for (*D,D*) Neutrons in Concrete

Concrete is by far the material most commonly used for shielding. Fast neutrons are slowed down to thermal energies and are absorbed in the concrete. Gamma rays are emitted during the absorption process and the production of gamma rays will be proportional to the flux of thermal neutrons. The distribution of gamma-ray sources can be calculated assuming the results of age theory[1], and calculated values for the age of fission neutrons to thermal energies in a number of different concretes are reported[1].

All concretes contain hydrogen and it is indeed this element that is mostly responsible for the slowing down of neutrons. Age theory will therefore be a poor approximation and, if used, may result in big discrepancies between calculated and measured values of the age. No measurements of neutron age in concrete are reported in Reference 1, and we have found no other references to such measurements. We therefore decided to carry out such a measurement, the result of which is reported here. For practical reasons it was necessary to work with a (D, D) neutron source and to measure the age to the indium resonance at 1.44 eV.

Deuterons were accelerated in a SAMES J accelerator to an energy of 150 keV. The target consisted of a foil of zirconium in which deuterium was absorbed. Thus a true deuterium target was formed. It was circular with a diameter of 2 cm and the source strength was about $5 \cdot 10^7$ neutrons/sec.

Bricks of concrete with dimensions (50×25×10) cm^3 were used to build a block as shown in Figure 1. The concrete block was situated on the floor below the target. This was itself enclosed in concrete as far as possible.

Indium foils, 2 cm × 2 cm and 90 mg/cm^2 thick, were enclosed in boxes of 0.5-mm-thick cadmium plates and placed in small cavities along the axis of the block. The distance from the target to the nearest cavity was 9.3 cm. Otherwise the positions of the cavities were as indicated in Figures 1 and 2. Four or five foils were irradiated simultaneously, one of them being always at the 9.3-cm position. The activity at any point was thus always determined relative to the activity at the 9.3 cm position. Between 8 and 10 different measurements were made for each point. All irradiations lasted for $2\frac{1}{2}$ hours.

[1]A. ARONSON and C. N. KLAHR, Neutron Attenuation, Chapter 9 in *Reactor Handbook, Vol. III, Part B.* Editors: E. P. BLIZARD and L. S. ABBOTT, Interscience Publishers, New York (1962).