msec^{-1}. The experimentally measured "asymptotic decay constant" for this assembly at 273°K is 6.4 ± 0.2 msec^{-1} (7). Even for this larger assembly, at the lower temperature, the contribution of the trapped neutrons to the decay is not observed.

In conclusion, it must be said that the trap effect does not appreciably affect the measurements of absorption cross sections and diffusion constants by the pulsed-neutron-source method, at least at room temperature and above, since these parameters can be obtained from measurements on large assemblies for which the over-all leakage probability is smaller than the energy transfer probability out of the trap. In these assemblies a true equilibrium energy distribution is established and an asymptotic decay constant may be measured.

However, the determination of the diffusion cooling constant and of terms proportional to B^6 or B^8 must rely on measurements of the asymptotic decay constants in small assemblies. For small assemblies the over-all leakage probability is comparable to the inelastic scattering probability out of the trap, and the instantaneous decay constant keeps decreasing almost until the last neutron has left the assembly. Under these conditions, the asymptotic decay constant is not a measurable quantity and the diffusion cooling constant is not a very useful concept.

The "measured" asymptotic decay constant of a small assembly is a function of the intensity of the pulsed-neutron source available, of the practical limitation imposed by the background conditions, and of the data evaluation scheme. It also depends to a lesser extent on the energy of the pulsed-neutron source, the duration of the pulses, and the geometry of the experiment, as such factors determine the ratio of the number of neutrons trapped to the total number of neutrons at the initial time. Therefore, it does not appear too surprising that as the precision of the measurements increases the discrepancy between the "asymptotic decay constants" obtained for the same assembly but under different experimental conditions also increases.

Finally, it must be noted that the trap effect is not taken properly into account by the usual diffusion cooling calculations. Indeed, because of mathematical difficulties, these calculations always assume a smooth variation of the transport cross section (E^α-law or incoherent approximation) and an equilibrium neutron spectrum that can be expressed as a Maxwellian, or a Maxwellian multiplied by a finite number of terms of a power expansion, or a Wigner-Wilkins spectrum (8–10), whereas the equilibrium spectrum of the trapped neutrons is better approximated by an energy δ-function.

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The Resonance Integral For Uranium Metal and Oxide

Smith, et al. (1) have made a careful study of the relative epicadmium absorption in uranium metal and oxide. Their measurements yield a larger ratio of metal to oxide resonance absorption than was calculated from the formulas obtained earlier at our laboratory (2). As our measuring technique has much improved since the old experiments, a minor set of new measurements has been performed.

The method of measurement was similar to the one used for the study of thorium metal (3). Thus the calibration in barns was obtained by means of the dilute resonance integral for gold and the thermal cross sections for gold and uranium (for the old measurements (2) the dilute resonance integral for uranium was used). The arrangement for the irradiations is illustrated in Fig. 1. The neutron flux was monitored with gold foils. They were placed about 12 cm above the samples to avoid screening effects from the uranium resonances. The diameters of the samples were 28 and 10 mm for the metal, and 17 and 12.5 mm, respectively, for the oxide.

The measurements for the metal yield values about 4.5% larger than those calculated from the formula given in (2). For the oxide rods, however, the resonance integrals obtained agreed to within 0.5% with the earlier results. The old formula for the oxide, $RI = 4.15 + 26.6\sqrt{S/M}$, may therefore still be used. For the metal the following new expression should be recommended

$$RI = 2.95 + 25.8\sqrt{S/M}$$

Taking into account the uncertainties in the spectrum corrections (compare (3)) and in the cross sections used for the absolute calibration, the standard deviations for the
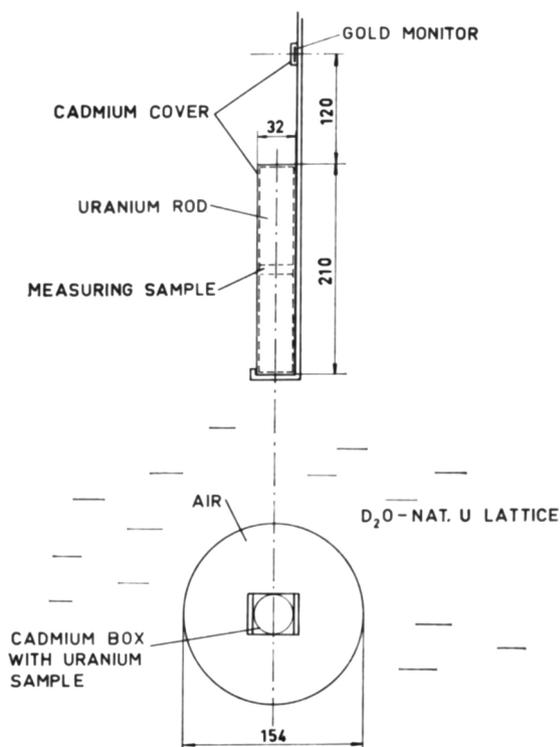
FIG. 1. Arrangement for the irradiations (all units in mm). D$_2$O–natural uranium lattice: hexagonal lattice, pitch 145 mm, rod diameter 29 mm, central rod missing.

resonance integrals calculated from the two formulas are ±5%.

This new result for metal gives a ratio of oxide to metal resonance integrals which is in better agreement with the value obtained by Smith *et al.* Unfortunately, a direct comparison of the two results is not possible because of the large difference in neutron energy distribution at the sample position for the two measurements.

The old measurements were less accurate than the new ones, and part of the discrepancy for the metal is explained by the common margin of errors. In addition, a minor systematic error has been discovered for the measurements described in (*2*). During the metal irradiations, one of the uranium rods in the inner ring of the reactor lattice had been removed by the reactor operators. This caused a slight decrease of the high energy tail of the neutron spectrum, which decreased the resonance absorption for the lumped uranium relative to that for the infinitely thin uranium standard. This effect is certainly small and it can hardly amount to more than about 1%. Finally, it may be pointed out that the use of different cross section standards for the two measurements makes it difficult to say if the old measured activities for the metal were too low or those for the oxide too high.

It has been argued against the method of measurement that the cadmium box (diam 30 mm, length 200 mm, Cd-thickness 0.8 mm) depresses the fission sources nearest to the samples and thus causes a depletion of high energy neutrons around the samples. To investigate the magnitude of this effect, threshold detectors (phosphor, sulphur, and aluminium) were successively irradiated inside the large

cadmium box and inside a small one (diam 30 mm, length 10 mm). Gold was used as a flux monitor. The normalized activities from the detectors inside the small box were about 1% larger than those from the large box. Thus, the depression of the very high energy flux (above 1–2 Mev) is quite small and there is no reason to believe that it should be considerably larger at lower energies.

More details about the experiments described and some additional ones concerning the epithermal absorption in samples, being part of a noncadmium covered rod, will be given in a company report, AE-64.

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The Temperature Dependence of the Viscosity of Liquid Metals

A knowledge of the thermophysical properties of liquid metals is essential to the effective use of these elements as working fluids or as high-temperature coolants in nuclear power plants. In this connection, viscosity is an important property because of its relation to pumping power requirements and heat transfer characteristics of the system (*1*). Experimental difficulties are so great that direct measurements of viscosity have been made on only a fraction of the metals of the Periodic Table, and methods to estimate unknown viscosities from measurement of simpler more basic properties are desirable both for preliminary assessment of practical applicability and for improving our understanding of the liquid metallic state. Although attempts have been made to correlate viscosities and their temperature coefficients with other properties of the elements (*2-16*), no completely satisfactory viscosity–temperature relation for liquid metals has been formulated. However, Andrade's equation for the estimation of viscosities of liquid metals at their melting temperatures (*14*)[1] gives values which are generally in reasonably good agreement with those determined experimentally, this being especially true for metals whose structures do not deviate greatly from cubic close packing (*14*). If a temperature dependence factor could be incorporated into Andrade's expression for η_m, the resulting equation would offer a means to estimate viscosities as a function of temperature for liquid metals for which experimental data are not available. Among the more promising equations proposed for the calculation of temperature coefficients are those of Eyring (*3, 7*), Fürth (*5*), and Hrbek (*9*). While each of those equations (*3, 5, 9*) has

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[1] This equation is: $\eta_m = 0.57 \ (MT_m)^{1/2}V_m^{-2/3}$, where η_m is the viscosity, in millipoises, at the Kelvin melting temperature, T_m, M is the atomic weight, and V_m is the atomic volume at T_m.