Note Added in Proof: Recent detailed analysis of the multigroup diffusion calculations indicates that the good agreement between calculation and experiment is partly fortuitous. The effect of the diffusion approximation as applied to the D_2O is to underestimate both the ratio of U^{238} fissions to thermal fissions and the resonance escape probability. Further study of these effects is continuing.

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Corrosion of Irradiated Uranium Alloys

The effect of nuclear radiation on some corrosion-resistant uranium alloys has been described in previous papers (*1, 2*). Essentially, we learned that small radiation dosages effectively destroyed the corrosion resistance of metastable uranium alloys heat-treated for corrosion resistance.

Accordingly, the fuel for the EBWR, U-5% Zr-1½% Nb, was heat-treated for dimensional stability under irradiation. This treatment comprised heating at 825°C, quenching at 640°C, holding at 640°C for 23 hr, and air cooling. In this condition the fuel material has a corrosion rate[1] at 260°C in initially pure water of 9470 mg/cm²/day. For comparison, the corrosion rate for unalloyed uranium under the same conditions is about 64,000 mg/cm²/day.

At a scheduled shutdown of the EBWR a subassembly was removed and sections taken from one of the plates for corrosion testing. Burnup varied with position in the plate and was determined by radiochemical analysis. The sections were exposed to initially pure water at 260°C–270°C for aproximately one day. Results are summarized in Table I.

The results are interesting and surprising. Because of the nature of the work, the results reported here (as well as most of those in previous studies) are necessarily based on one or two samples at each level of burn-up. However, the trend observed appears to be definite enough to warrant publication. At the present time we have no explanation for the improvement in corrosion resistance or the apparent minimum in corrosion rate as a function of burn-up.

TABLE I
CORROSION OF IRRADIATED U-5% ZR-1½% NB AT 260°–270°C AS A FUNCTION OF BURNUP

Sample No.	Burnup, Total a/o	Corrosion Rate, mg/cm²/day
	0.000	9470
1	0.005	2500
15	0.009	2780
13	0.017	2310
12	0.024	1880
10	0.088	1890
6	0.140	5160

This study is continuing and results will be published as they become available.

The samples and burnup data were furnished by C. F. Reinke of the Metallurgy Division.

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[1] The rates discussed in this letter are based on original exposed area. True rates would therefore be higher but the quoted rates are valid for purposes of comparison.

[2] Operated for United States Atomic Energy Commission by the University of Chicago.

Measurements of the Transport Mean Free Path of Thermal Neutrons in Beryllium as a Function of Temperature

In order to calculate temperature effects on reactors it is important to know the variation of the transport mean free path of thermal neutrons with temperature. K. S. Singwi and L. S. Kothari (*1*) have calculated this variation for different crystalline materials. In an attempt to confirm these calculations experimentally, we investigated the variation with temperature of the transport mean free path, λ_{tr}, of thermal neutrons in beryllium using the pulsed-neutron technique (*2*). The decay constant, λ, of the fundamental mode of the thermal neutron density in a beryllium assembly 20 by 20⅛ by 20⅛ in. (buckling, $B^2 = 1.05 \times 10^{-2}$ cm^{-2}) was measured for 10 different temperatures of the beryllium, ranging from −46° to +511°C.

The reciprocal thermal-neutron lifetime, $\lambda_a = 288 \pm 60$ sec^{-1}, and the room-temperature diffusion cooling constant, $C = 1.1 \pm 1$ cm², for this beryllium had been previously measured (*3*). The relation between the decay constant λ

TABLE I

DECAY OF THERMAL NEUTRON DENSITY IN A 20 BY 20⅛ BY 20⅛ IN. BERYLLIUM ASSEMBLY AS A FUNCTION OF TEMPERATURE[a]

T, Temperature °C	T, Temperature °K	λ (10^3 sec^{-1})	λ_{tr} (cm)
		($\times 10^3$	
−46	227	1.482	1.58
27	300	1.560	1.47
50	323	1.593	1.45
100	373	1.665	1.43
146	419	1.720	1.40
220	493	1.815	1.38
233	506	1.850	1.39
292	565	1.922	1.37
335	608	1.992	1.38
511	784	2.220	1.38

[a] These reported temperatures were determined to $\pm 5°$ and the decay constants to ± 2 per cent; ρ, density of beryllium, = 1.85 gm/cm^3, B^2, buckling, = 1.05×10^{-2} cm^{-2}.

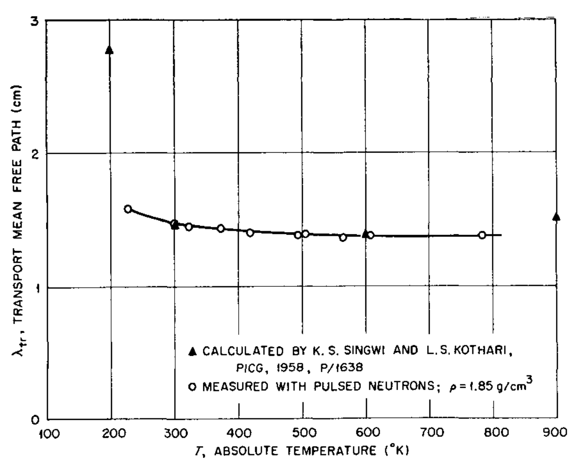

FIG. 1. Transport mean free path of thermal neutrons in beryllium at various temperatures.

and the transport mean free path was assumed to be

$$\lambda = \lambda_a + (1/3)\lambda_{tr} v B^2(1 - CB^2) \qquad (1)$$

where $v = (8kT/\pi m)^{1/2}$ is the average neutron velocity; k is the Boltzmann constant; m, the mass of the neutron; and T, the absolute temperature of the beryllium. For the determination of λ_{tr} from Eq. (1), $B^2(1 - CB^2)$ was taken as temperature-independent; this is justified in this case since $CB^2 \ll 1$ and the extrapolation length is only about 4 per cent of the linear dimensions of the beryllium assembly.

The measured decay constants and the corresponding values of the transport mean free path are given in Table I. Figure 1 shows the experimentally determined variation of λ_{tr} with temperature and also four values of λ_{tr} calculated by K. S. Singwi and L. S. Kothari (*1*) (corrected to a density of 1.85 gm/cm^3). It is seen from Fig. 1 that the agreement between the experiment and the calculations of Singwi and Kothari is good.

These measurements will be extended toward lower temperatures as soon as the necessary experimental equipment is completed. An investigation of the variation of the diffusion cooling constant C with temperature is also in progress now and will be described in a later paper.

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A New Approximate Treatment of the Energy-Dependent Boltzmann Equation

For a constant cross section, nonabsorbing medium, the one-dimensional Boltzmann equation can be written (*1*)

$$\mu\phi' + \phi = \frac{1}{2\pi}\int_0^u du' \int_{-1}^1 d\mu' \int_0^{2\pi} d\varphi'\phi(x, u'\, \mu')f(\mu_0, u - u') + S(x, u, \mu)$$

where distance is expressed in terms of the scattering length.

Let us consider a unit isotropic plane source,

$$S(x, u, \mu) = \delta(x)\delta(u)$$

If we now take the Laplace transform with respect to lethargy we get

$$\mu\bar{\phi}' + \bar{\phi} = \frac{1}{2\pi}\int_{-1}^1 d\mu' \int_0^{2\pi} d\varphi'\bar{\phi}(x, s, \mu')\bar{f}(s, \mu_0) + \delta(x)$$

By expanding $\bar{f}(\mu_0, s)$ in a Legendre series

$$\bar{f}(\mu_0, s) = \sum_{l=0}^{\infty} \frac{2l+1}{2}\bar{f}_l(s)P_l(\mu_0)$$

and approximating $\bar{\phi}(x, s, u)$ as[1]

$$\bar{\phi}(x, s, \mu) = \tfrac{1}{2}\bar{\phi}_0(x, s)P_0(\mu) + \tfrac{3}{2}\bar{\phi}_1(x, s)P_1(\mu)$$

one easily gets

[1] This is the P_1 approximation.