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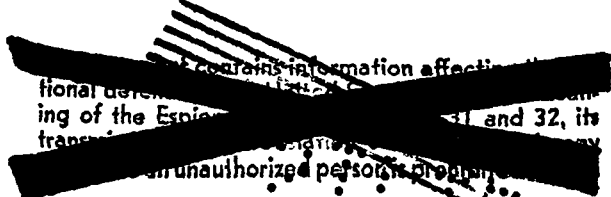
PENETRATION OF A RADIATION WAVE INTO URANIUM

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For ~~ALDR(TID-1400-52) Sent-Oct. 1974~~

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PENETRATION OF A RADIATION WAVE INTO URANIUMAbstract

We consider a plate of cold uranium whose surface is suddenly heated to and then maintained at a temperature T in the neighborhood of 2 Kev. A radiation wave will penetrate into the uranium as:

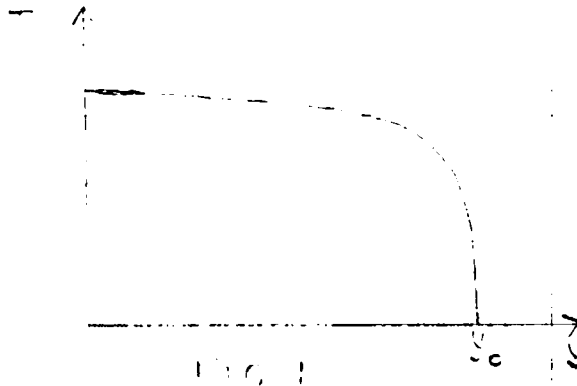
$$(d/cm) = .1 (T/Kev)^3 (t/\mu\text{sec})^{1/2}$$

If we assume the opacity of uranium to go as T^{-3} the diffusion of radiation is described by the following differential equation*.

$$\frac{\partial T}{\partial t} = D \frac{\partial^2 T}{\partial x^2} \quad (1)$$

We can find a similarity solution for (1) if we set: $y = X/t^{1/2}$ and $T = T(y)$. If we make this transformation we obtain the ordinary differential equation:

$$-\frac{1}{2}y \frac{dT}{dy} = D \frac{d^2 T}{dy^2} \quad (2)$$



Equation (2) has solutions of a character represented in Figure 1 with a head at $y = y_0$. One sees easily that near the head the solution must have the form

* See LA-322.

$$T = A \left(1 - \frac{y}{y_0}\right)^{1/6} \quad (3)$$

with

$$A^6 = \frac{3}{7} \frac{y_0^2}{D} \quad (4)$$

Instead of actually solving (2) we find an approximate T so that it:

- 1) agrees with (3) and (4) near the head
- 2) satisfies the integrated Equation (2)

$$\frac{1}{2} \int_0^{y_0} T dy = -D \left(\frac{d}{dy} T^7 \right)_{y=0} \quad (5)$$

which is merely an expression of the law of conservation of energy. We try to achieve this by setting $T = A \xi^{1/6} (1 + \alpha \xi)^{1/7}$ ($\xi = 1 - \frac{y}{y_0}$) and find that $\alpha = -\frac{13}{163}$. This leads to a surface temperature of

$$T_0 = A \left(1 - \frac{13}{163}\right)^{1/7} \quad (6)$$

We can now express $\int T dy$ in terms of T_0 as

$$\int T dy \approx 1.31 \sqrt{D} T_0^4 \quad (7)$$

If we transform back to X and t we obtain simply $\int T dX = t^{1/2} \int T dy$.

We can define a depth of penetration $d = \int T dX / T_0$ which is given by:

$$d = 1.31 \sqrt{D} T_0^3 t^{1/2} \quad (8)$$

From equation (5) of LA-322 we find:

$$D = \frac{(\gamma - 1) M}{N \kappa} \frac{ac}{3 \rho^2} \frac{4}{7 \kappa T^3} \quad (9)$$

In the 2 Kev region the heat capacity of uranium is* 200 eV per atom 238 and per eV. Therefore we can write $(\gamma - 1)M = 238/200 = 1.19$ gm/mole. The opacity can be represented by the law**

$$\kappa = 3.76 \times 10^{11} (T/\text{eV})^{-3} \text{ cm}^2/\text{gm}$$

and we obtain:

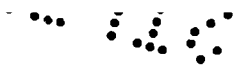
$$D = 6.75 \times 10^{-15} \text{ cm}^2/\text{eV}^6 \text{ sec} \quad (10)$$

We substitute (10) into (8) and obtain:

$$d/\text{cm} = .107 (T_0/\text{Kev})^3 (t/\mu \text{sec})^{1/2} \quad (11)$$

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