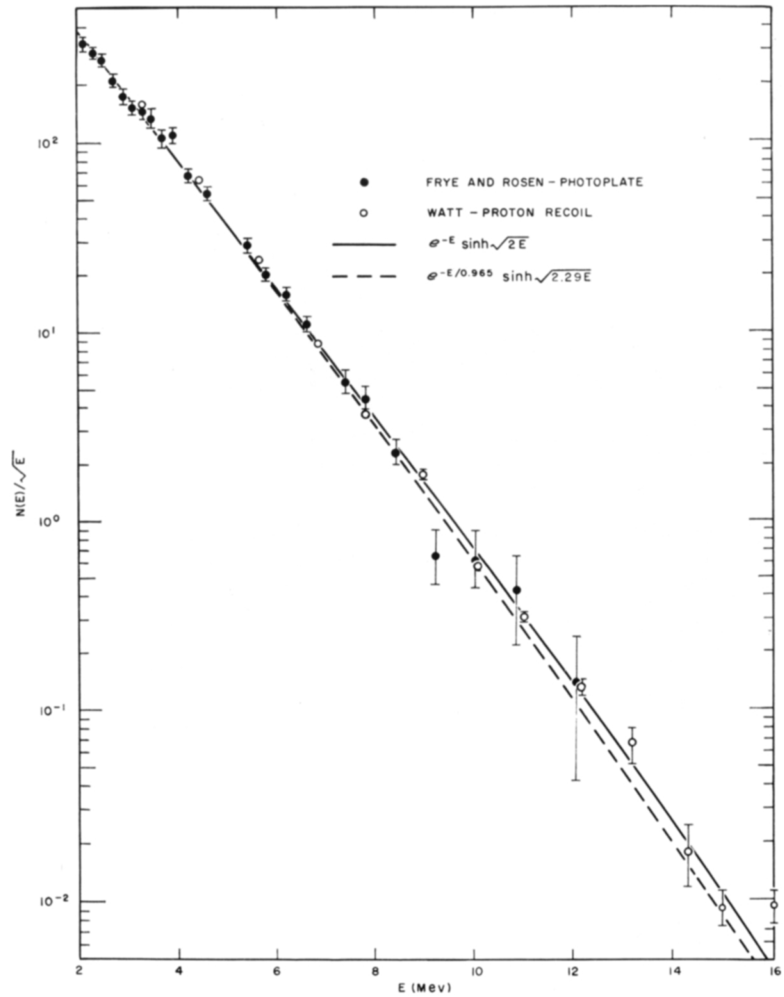


FIG. 1. Neutron spectrum from thermal fission of $U^{235}$

Neutron Spectrum of U-235." *Phys. Rev.* **103,** 662 (1956).

K. SHURE

*Bettis Atomic Power Laboratory**
*Pittsburgh, Pennsylvania*
*Received January 7, 1963*
*Revised March 1, 1963*

* Operated for the U. S. Atomic Energy Commission by Westinghouse Electric Corporation.

## Cadmium Ratios of $U^{235}$ Fission in Slightly Enriched Uranium, Light Water Moderated Lattices*

The initial conversion ratio of multiplying assemblies containing $U^{238}$ can be inferred from measurements of the ratio of epicadmium to subcadmium capture in $U^{238}$ ($\rho_{28}$), expressing the contribution of the $U^{235}$ epicadmium fission either in terms of the ratio of epicadmium to subcadmium fission in $U^{235}$ ($\delta_{25}$), or in terms of the cadmium ratio in gold ($CdR_{Au}$) (*1*).

Work performed at BNL in slightly enriched uranium, water moderated lattices (*1, 2*), has shown a discrepancy between conversion ratios deduced from $\rho_{28}$ and $CdR_{Au}$ measurements, and those deduced from $\rho_{28}$ and $\delta_{25}$ measurements. Since in ref. *2* it was stated that the gold cadmium ratios measurements were probably the most reliable ones, the values of $\delta_{25}$ seeming systematically low, some by as much as a factor of two, the cadmium ratios for $U^{235}$ fission of some of these lattices have been remeasured, using a technique similar to that tried at WAPD (*2*).

The method originally used at BNL, and described in ref. *1*, consisted of counting the fission product $\beta$ activity of high purity Al catchers, which had been irradiated, one bare and one cadmium-encased, between sections of fuel rods in miniature lattices. Miniature lattices (18 in. tall) were preferred to exponential assemblies because of their ease of operation and of the higher flux attainable, previous work having indicated that the use of a reduced size assembly does not have appreciable effects on the values of the measured parameters.

* Work supported by the U. S. Atomic Energy Commission.

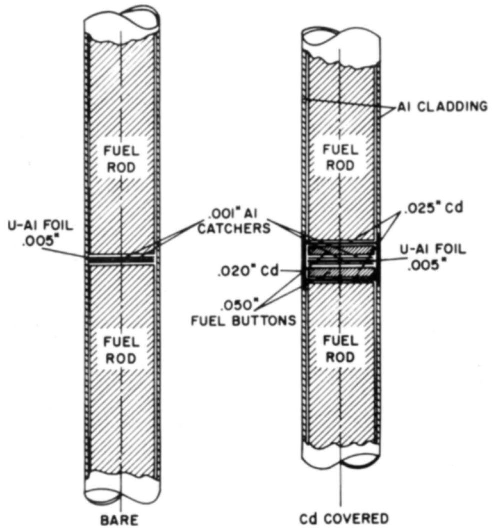


FIG. 1. Fuel rod assemblies of bare and cadmium covered foils.

The main source of error in this technique was ascribed to the magnitude of the correction for the contribution of the $U^{238}$ fast fission to the cadmium-clad foil activity.

To avoid this inconvenience, in the present measurement the Al catchers were replaced by highly enriched U–Al foils (14% uranium–93% $U^{235}$–and 86% high purity aluminium by weight). The foil arrangement is shown in Fig. 1: the purpose of the fuel buttons contained in the cadmium pillbox is that of minimizing the effect of streaming of neutrons through the cadmium end pieces, thus ensuring that the resonance spectrum impinging on the cadmium-clad foil is typical of that entering the bare foil. The thickness of the cadmium pillbox corresponds to a cadmium cutoff of about 0.45 ev. The miniature lattices and the high flux facility used were the same as those described in ref. *1*.

The fission product gamma activity of the foils above 410 kev was detected by a 1 × 1.5 in. NaI (Tl) scintillation counter. The induced activities were normalized by measuring the natural gamma activity of the foils (above 130 kev) before irradiation. Statistical counting errors were about 0.5%. The effect of $U^{238}$ fast fission, as well as the correction for the $U^{235}$ natural activity above 410 kev, were negligible. Use of the above technique implies that the fission product yield is the same for subcadmium and epicadmium fissions. This seems to be a reasonable assumption, since the bulk of the epicadmium fissions of $U^{235}$ occurs just above the cadmium cutoff. The assumption has been further supported by the experimental evidence that the decay curves of the bare and the cadmium-clad foils are identical.

Table I lists the results of the $\delta_{25}$ measurements for 0.600 in. and 0.250 in. diam, 1% enriched uranium-water moderated lattices (water to uranium ratios of 1:1, 1.5:1, 2:1, 3:1, and 4:1), together with the previous values. Table II lists the corresponding conversion ratios inferred from the values of $\rho_{28}$ reported in refs. *1* and *2*; expressing the epithermal $U^{235}$ fission in terms of the new measurements of $\delta_{25}$ ($ICR_{25}$) and, alternatively, in terms of the measurements of $\delta_{25}$ ($ICR_{25}$ *(1, 2)*) and of $CdR_{Au}$ ($ICR_{Au}$ *(1, 2)*) reported in refs. *1* and *2*. The equations used to calculate ICR from the measured quantities were those derived in ref. *1*. The satisfactory agreement between the values of the conversion ratios obtained from the $CdR_{Au}$ and the new $\delta_{25}$ measurements is considered to resolve the discrepancy which originated this work and supports the hypothesis that the previous $\delta_{25}$ values were incorrect.

TABLE 1

RATIOS OF EPICADMIUM TO SUBCADMIUM FISSION RATES OF $U^{235}$ IN 1% ENRICHED URANIUM, LIGHT WATER MODERATED LATTICES

| Rod diameter | $\frac{W}{U}$ | $\delta_{25}$ Present measurement[a] | $\delta_{25}$ Previous measurements *(1, 2)* |
|---|---|---|---|
| 0.600 in. | 1 | 0.190 ± 0.0007 | 0.168 |
| | 1.5 | 0.133 ± 0.0007 | 0.131 |
| | 2 | 0.099 ± 0.0004 | 0.085 |
| | 3 | 0.0702 ± 0.0007 | 0.047 |
| | 4 | 0.0543 ± 0.0001 | 0.033 |
| 0.250 in. | 1 | — | — |
| | 1.5 | 0.1461 ± 0.0017 | 0.140 |
| | 2 | 0.1103 ± 0.0003 | 0.095 |
| | 3 | 0.0726 ± 0.001 | 0.056 |
| | 4 | 0.0538 ± 0.0005 | 0.050 |

[a] The errors quoted are the standard deviations of the mean of a series of 3 to 5 measurements.

TABLE II

CONVERSION RATIOS OF 1% ENRICHED URANIUM, LIGHT WATER MODERATED LATTICES

| Rod diameter | $\frac{W}{U}$ | $ICR_{25}$ | $ICR_{Au}$ (1, 2) | $ICR_{25}$ (1, 2) |
|---|---|---|---|---|
| 0.600 in. | 1 | 0.965 | 0.965 | 1.012 |
| | 1.5 | 0.750 | 0.747 | — |
| | 2 | 0.709 | 0.703 | 0.730 |
| | 3 | 0.651 | 0.649 | 0.674 |
| | 4 | 0.592 | 0.587 | 0.610 |
| 0.250 in. | 1 | — | — | |
| | 1.5 | 1.14 | — | |
| | 2 | 1.06 | 1.05 | |
| | 3 | 0.83 | 0.82 | |
| | 4 | 0.75 | 0.75 | |

REFERENCES

*1.* H. KOUTS AND R. SHER, BNL 486 (T-111) (1957).
*2.* H. KOUTS *et al.*, *Proc. Intern. Conf. Peaceful Uses Atomic Energy, 1958*, P/1841. UN, New York.

S. TASSAN*

*Brookhaven National Laboratory*
*Upton, New York*
*Received March 13, 1963*
*Revised March 26, 1963*

* *Present address:* Euratom, CCR Ispra, Ispra (Varese), Italy.