located in position D-8. From the 37 flux values thus measured an iso-flux pattern for the three elements C-8, D-8, and E-8 could be plotted. Such a pattern is shown in Fig. 5 for a cut 16 in. below the top of the fuel. The iso-flux lines are normalized to the highest flux measured in position E-8. The fluxes shown as greater than one were extrapolated from plots of flux across the channels.

The difficulty in choosing the proper single point at which to measure flux is obvious. If one should choose the geometric center, physically the easiest point at which to make measurements, one measures only 0.91 times the highest flux in D-8, 0.74 times the highest flux in E-8, and 0.61 times the highest flux in C-8. The situation concerning the average flux is even more uncertain. It is interesting to note the effect of the beryllium reflector. One sees that the reflection very nearly makes the *iso*-flux lines symmetric about the center line of column "8."

At this point there are several conclusions which can be drawn. The first is that, when a heavily burned element (low fuel density) is placed next to a new element (high fuel density), the flux will peak in the burned element, and will show a depression in the new element. Such a condition is not unexpected, since, in first approximation, local flux varies as the inverse of the local macroscopic absorption cross section Σ_a, and the burned element will have a lower Σ_a. For the cases measured here, the magnitude of the peak to center ratio in the new element was as high as 1.6. The second conclusion is that the placing of large water gaps such as that which exists between the fuel and the cadmium sections in the shim rod can cause large peaks in the adjacent elements. If these peaks raise the flux in a high fuel density region, high-power density or, in other words, hot spots have to be expected. The case of a new element is clear because the fuel concentration is uniform. Thus, one may infer that placing new elements next to heavily burned ones or next to water gaps should be done with care being given to the subsequent flux peaks and power density peaks. The case of burned element is more difficult. It is evident that the geometrical variation of fuel density will be a function of the prior flux history. It is also evident that the high-density regions will locally suppress the flux. However, it is conceivable that a power density peak of unexpected proportion may be found at various spots.

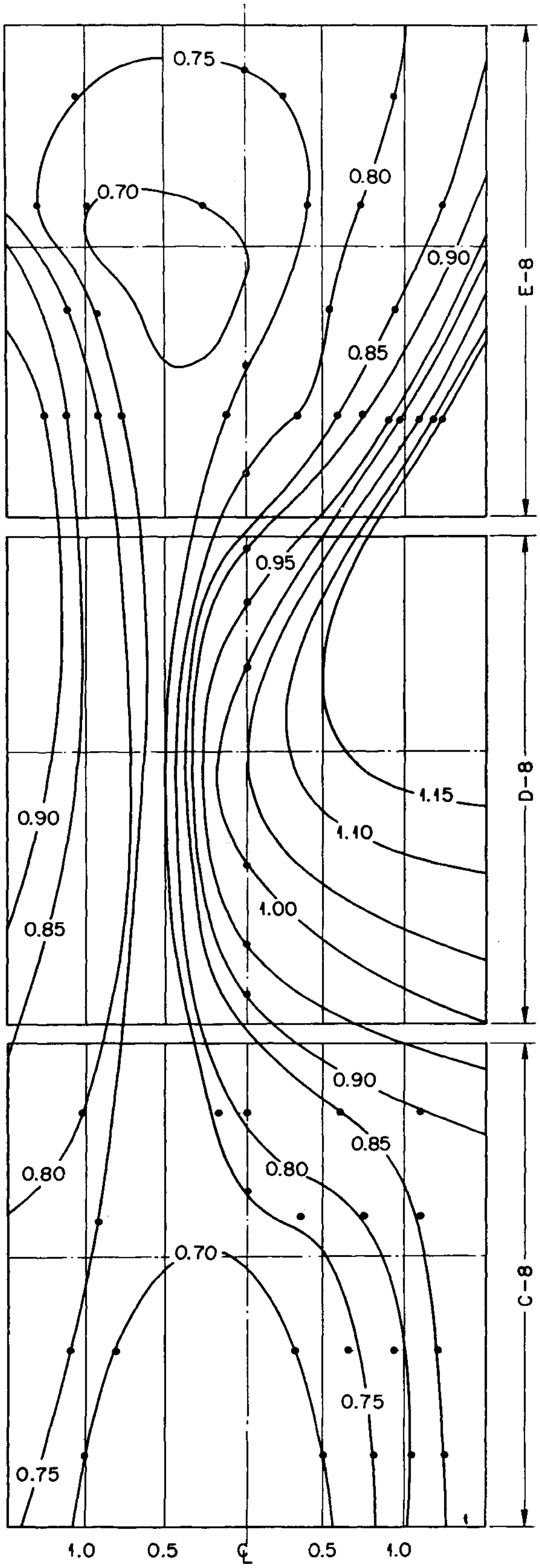

FIG. 5. Iso-flux for core positions C-8, D-8, E-8 normalized to highest measured values in E-8.

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Received August 23, 1960

Natural Abundances of Er^{172} and Yb^{167}

Since the inception of the program for separating isotopes electromagnetically at Oak Ridge National Laboratory in

1945,[1] receiver pockets have occasionally been located at positions where collection of product material might provide evidence of the natural existence of previously undetected isotopes. But regardless of whether or not new isotopes are "discovered," the mass distribution data for any collected material can be used to assign more positive upper limits to the existence of particular isotopes.

During recent electromagnetic collections of erbium and ytterbium isotopes at Oak Ridge National Laboratory, collector pockets were inserted at the "Er^{172}" and "Yb^{167}" positions to check for the possible natural existence of those isotopes. Mass spectrometric analyses of the purified product, performed at Knolls Atomic Power Laboratory,[2] showed new limits of < 0.000008 and < 0.00001 atom %, respectively (*1*, *2*). Assuming, conservatively, at least a tenfold enrichment of the isotopes during the separation, the limits of natural abundance would be <0.0000008 and < 0.000001 atom % for Er^{172} and Yb^{167}, respectively.

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[1] Operated for the U. S. Atomic Energy Commission by Union Carbide Nuclear Company.

[2] Operated for the U. S. Atomic Energy Commission by General Electric Company.

Precision Measurements of the Slow Neutron Absorption Cross Sections of Normal Boron Standards

The thermal neutron cross section of natural boron is widely used as a standard for measurement of other cross sections and in boron loading specifications for reactors and in reactor physics calculations. Mass spectrometer measurements have indicated that the ratio of the two isotopes B^{10} and B^{11} in natural boron may have as much as a 3% geographic variation (*1*). In the past, the uncertainty due to such variations have been circumvented by mixing a large batch of a boron compound and using this material as a standard. Increasing demands for samples of these standards have, in instances, either exhausted the available supply or required laboratories to have their own standard batch of natural boron. Recent improvements in the reliability of mass spectrometric determinations of the boron isotopic abundance and the high degree of precision that has been obtained for neutron transmission measurements in the thermal region now make possible a precise intercomparison of the thermal neutron cross sections and the isotopic abundance for different samples of natural boron which are available for neutron standardization.

TABLE I

THE NEUTRON ABSORPTION CROSS SECTIONS AND THE ISOTOPIC PURITY OF THE NATURAL BORON SAMPLES

Sample	Atomic % B^{10}	σ_a (2200 m/sec) barns	$E^{+\frac{1}{2}}\sigma_a$ (barns-ev$^{\frac{1}{2}}$)
Argonne–Brookhaven standard boron	$19.8 \pm 0.2\%$	764 ± 3	121.5 ± 0.5
New Argonne standard boron	$19.7 \pm 0.17\%$	761 ± 3	121.0 ± 0.5
Westinghouse Bettis sample of normal boron	$19.7 \pm 0.15\%$	764 ± 3	121.6 ± 0.5
Am. Chem. Soc. reagent grade H_3BO_3	No measurement	762 ± 3	121.2 ± 0.5

In the present experiment the total neutron cross section for four different samples of normal boron has been measured at neutron energies between 0.00291 ev and 0.1 ev with the Columbia University Crystal Spectrometer. The absorption cross section was obtained by subtracting the relatively small known scattering cross section. In addition, the B^{10} content has been measured for three of the four samples with a mass spectrometer.[1] The samples which are compared are Argonne-Brookhaven standard boron, a new Argonne Laboratory standard boron, a sample of natural boron from Westinghouse Bettis Atomic Power Laboratory, and a sample of A.C.S. Reagent grade H_3BO_3.

For the neutron cross-section measurements, each of the four samples was converted to $NaBO_2$ dissolved in D_2O and was contained in a quartz cell of known thickness. A separate cell of identical thickness contained Na_2SO_4 in D_2O solution. This cell was used to determine the effective transmission of elements other than boron in the cell containing the $NaBO_2$. The concentrations of the $NaBO_2$ and Na_2SO_4 were adjusted such that a BO_2^- ion is compared with $\frac{1}{2}SO_4^{--}$ and the number of Na^+ ions per cc was the same for the two cells. When the ratio of the transmissions of the two cells is taken, the effects of Na^+ cancel, as do the effects of the D_2O except for a small D_2O off-balance, for which a small measured correction of 2% was made for the slightly different volume occupied by the BO_2^- and the $\frac{1}{2}SO_4^{--}$ ions in solution. Another small correction of 1% has been made for the effective cross sections of BO_2^- and $\frac{1}{2}SO_4^{--}$ ions including interference effects in the coherent scattering cross sections of these ions. Spectrochemical analysis showed chemical impurities were small, giving rise to 0.1% correction. The details of the sample preparation (*2*) and of the neutron crystal spectrometer and associated techniques (*3*) have been described previously in the literature.

The results are summarized in Table I. The values of $E^{\frac{1}{2}}\sigma_a$ were obtained from a weighted-least-squares fit to a straight line for thirteen measured points between 0.00291 and 0.1 ev for each sample. The errors quoted are

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[1] The authors wish to express their gratitude to Dr. T. L. Collins, Jr. of Knolls Atomic Power Laboratory for the mass spectrometric measurements of the boron samples.