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SEMIANNUAL PROGRESS REPORT

FOR PERIOD ENDING MARCH 10, 1955

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PHYSICS DIVISION

SEMIANNUAL PROGRESS REPORT

for Period Ending March 10, 1955

A. H. Snell, Director

Edited by
E. P. Blizard, Associate Director

DATE ISSUED

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ORNL-1630	Period Ending September 10, 1953
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ORNL-1820	Period Ending September 10, 1954

Unclassified work for the period between November 1948 and September 10, 1954 is reported in the following reports: ORNL-325 supplement, ORNL-366, ORNL-481, ORNL-577, ORNL-694, ORNL-782, ORNL-865, ORNL-940, ORNL-1005, ORNL-1092, ORNL-1164, ORNL-1278, ORNL-1289, ORNL-1365, ORNL-1415, ORNL-1496, ORNL-1620, ORNL-1705, and ORNL-1798.

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PREFACE

Owing to a recent change in policy, the information pertaining specifically to the Aircraft Nuclear Propulsion Project will hereafter be published only in the quarterly report of that project. The secret Physics Division semiannual will contain information which is not published in a project progress report.

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J. B. Dee, "Progress of Reflector-moderated Reactor and Shield Mockup Tests at the Lid Tank Shielding Facility."

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S. Auslender, "Heat Generation from Transport of Gamma Radiation Through Slabs."

F. C. Maienschein, "Recent Experiments at Bulk Shielding Facility."

C. E. Clifford, "Experimental Progress at Tower Shielding Facility."

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Reactor Shielding Information Meeting, Cincinnati, November 15–16, 1954 (papers published in WASH-185)

F. C. Maienschein and R. W. Peelle, "An experimental Determination of the Luminescence Produced by a Nuclear-Powered Aircraft."

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C. D. Zerby, "The Penetration of Composite Slabs by Slant Incident Gamma Radiation (Monte Carlo Solution)."

C. D. Zerby, "Energy Absorption Resulting from Incident Gamma Radiation as a Function of Thickness of Materials with Slab Geometry."

Symposium on Fission Physics and Classified Nuclear Physics for Reactors and Shielding, Oak Ridge, October 13–15, 1954 [abstracts of papers published in Reactor Sci. Technol. **4**, *No. 4 (1954), TID-2015]*

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*A list of unclassified talks presented by members of the Physics Division is given in the unclassified semiannual for this period, ORNL-1879.

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J. L. Fowler, "Variation of $\nu(E)$ for U^{235} in Energy Range 0 to 14 Mev."

J. T. Thomas and J. K. Fox, "The Direct Comparison of U^{233} and U^{235} by Means of Critical Experiments."

F. G. Prohammer, "Comparison Between Theory and Experiment in Water-moderated Critical Assemblies."

H. B. Willard, J. B. Bair, and J. D. Kington, Jr., "Elastic Scattering Differential Cross Section for Li^6."

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PHYSICS DIVISION
SEMIANNUAL PROGRESS REPORT

SUMMARY

CRITICAL EXPERIMENTS

The critical parameters of aqueous U^{235}-enriched solutions in cylindrical geometry were determined in several experiments. In one experiment aluminum and stainless steel cylinders of various sizes containing various concentrations of the solution were investigated for the unreflected, half-water-reflected, and totally water-reflected assemblies. In another experiment to investigate the safety of pipe joints, a 90-deg cross was made from aluminum tubing and tested with and without a water reflector. A third experiment was designed to determine the effect of adding a latticed solid poison (steel) to a solution contained in a stainless steel cylinder; the assembly was water-reflected.

The critical parameters of aqueous U^{235}-enriched solutions contained in the annular space between two cylinders of various sizes were also studied. The experimental variations included changing the contents of the annuli and testing the assemblies with and without water reflectors.

The variation with concentration of the critical parameters of aqueous U^{235}-enriched solutions contained in spheres is being investigated. The spheres, which vary in size, are either filled or partly filled with the solution, and the experiments are performed with and without a water reflector.

The variation with concentration of the critical parameters of slightly enriched uranium solutions contained in spheres was also investigated. The assemblies were tested with and without a water reflector.

The critical height of an enriched UO_2F_2 solution contained in a 9-in.-dia cylinder was studied as a function of its distance from a concrete neutron reflector. Increasing the separation between the concrete and the cylinder resulted in an increase in the critical height, which approaches the unreflected value as a limit at a 2-ft separation.

NEUTRON-INDUCED FISSION CROSS SECTION OF U^{238} FROM THRESHOLD TO 4.0 Mev

The fission cross section of natural uranium was measured from threshold to 4.0 Mev by using protons from the ORNL 5-Mv Van de Graaff to bombard a tritium gas target, and the data were corrected for the U^{235} present in natural uranium in order to obtain a cross section for U^{238}. Uranium-238 does not show a sharply defined threshold, but there is a measurable cross section at 500 kev which increases to 0.65 barn at 4.0 Mev.

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CRITICAL EXPERIMENTS

A. D. Callihan

An extended program is in progress to measure the critical parameters of aqueous solutions of U^{235}-enriched uranium. The results will be applicable to the design of homogeneous reactors and to the specification of processing operations. These data extend those reported earlier[1,2] and, although within themselves they do not represent a completed project, are made available in this preliminary manner prior to inclusion in a topical report. Subsequent progress reports in this series will, from time to time, include similar tabulations as measurements are completed.

CRITICAL PARAMETERS OF U^{235}-ENRICHED SOLUTIONS IN CYLINDRICAL GEOMETRY

J. K. Fox L. W. Gilley
E. R. Rohrer

An experimental investigation of the critical parameters of enriched uranium aqueous solutions contained in aluminum and stainless steel cylinders was conducted previously.[1] For the present series more U^{235} and a larger variety of containers were available, and, accordingly, a number of additional critical arrays have been examined (Table 1). Most of the experiments were performed with aqueous UO_2F_2 solutions in cylinders constructed of type 2S aluminum, either unreflected or surrounded on all sides by water at least 6 in. thick; however, in two cases only half the reactor surface area was covered with water. Five measurements with an aluminum vessel 20 by 20 in. square in cross section and two measurements with stainless steel cylinders were also made.

In an earlier experiment[3] the critical mass of a slab of enriched UO_2F_2 aqueous solution was investigated as a function of the thickness of the slab. The values reported for unreflected and half-water-reflected slabs were measured, but those for completely water-reflected slabs were obtained by assuming the reflector savings to be linear with the area covered by the reflector. The more recent data presented in Table 1 from actual measurements with totally reflected reactors of large area indicated that the critical mass is depressed more by the final addition of the reflector than by the initial addition. If this is true, the derived values reported earlier[3] for the thickness and mass of a totally reflected critical slab are too large and should be applied with caution. This subject will be investigated further.

Three experiments have been performed to investigate the safety of pipe joints in processing plants. In the first experiment it was found that a 90-deg cross made from vertical and horizontal sections of 5-in.-dia aluminum tubing, each more than 4 ft long, was subcritical when filled, without reflector, with UO_2F_2 solution having a concentration of 0.35 g of U^{235} per cubic centimeter. This concentration corresponds to an $H:U^{235}$ atomic ratio of 71.5. In the second measurement the assembly was immersed in water and was critical with the solution only 7.5 in. above the intersection. In the third experiment it was shown that a similar cross 7.5 in. in diameter was subcritical when it was filled with the solution and did not have a reflector.

Some measure of the increase in the critical mass of a cylinder of enriched uranium solution caused by the addition of a latticed solid poison has been obtained in an experiment expressly designed to test the nuclear safety of a particular piece of equipment. A variable number of steel rods were positioned with plastic spacers in a 15-in.-dia stainless steel cylinder into which a 93.2% enriched U^{235} aqueous solution was pumped. The solution had a concentration of 0.338 g of U^{235} per cubic centimeter, corresponding to an $H:U^{235}$ atomic ratio of 73.0. The steel rods were $\frac{7}{8}$ in. in diameter and 8 ft long and were coated with a corrosion-resistant material. The lateral surfaces and bottom of the cylinder were surrounded by an effectively infinite water reflector. The critical height of the solution was measured as a function of the number of rods distributed approximately uniformly across the area of the vessel. The results are shown in Fig. 1, where the critical height and corresponding critical mass are plotted against the steel loading. With 47.2% of the capacity of the cylinder filled with steel, there was

[1] C. K. Beck *et al.*, *Critical Mass Studies, Part III*, K-343 (April 19, 1949).

[2] A. D. Callihan *et al.*, *Phys. Semiann. Prog. Rep. Sept. 10, 1954*, ORNL-1820, p 16.

[3] A. D. Callihan *et al.*, *Phys. Semiann. Prog. Rep. March 10, 1954*, ORNL-1715, p 12.

TABLE 1. CRITICAL PARAMETERS OF ENRICHED URANIUM AQUEOUS SOLUTIONS IN CYLINDRICAL GEOMETRY

Fissionable material: UO_2F_2 enriched to 93.2% in U^{235}

Reactor container material: (1) $\frac{1}{16}$-in.-thick type 2S aluminum coated with Heresite
(2) $\frac{1}{16}$-in.-thick stainless steel

Reactor Container and Size	Solution Concentration		Critical Values		
	$H:U^{235}$ Atomic Ratio	U^{235} (g/cc)	Height (cm)	Volume (liters)	Mass (kg of U^{235})
Totally Reflected (6 in. Water, Minimum)					
Aluminum					
6-in. dia	26.9	0.8309	90.0	16.38	13.61
10-in. dia	26.9	0.8309	13.13	6.67	5.54
15-in. dia	26.9	0.8309	8.41	9.60	7.97
20 × 20 in. square in cross section	26.9	0.8309	6.99	18.02	14.97
	71.5	0.3477	6.88	17.75	6.17
30-in. dia	26.9	0.8309	5.72	26.08	21.67
	71.5	0.3477	6.2	28.3	9.8
Stainless steel					
6-in. dia	75.3	0.329	*a*	*a*	*a*
Half-Reflected[b]					
Aluminum					
30-in. dia	71.5	0.3477	10.10	46.05	16.05
20 × 20 in. square in cross section	71.5	0.3477	11.33	29.23	10.16
Unreflected					
Aluminum					
10-in. dia	26.9	0.8309	38.53	19.60	16.27
	73.4	0.3372	33.25	16.89	5.70
15-in. dia	26.9	0.8309	18.14	20.70	17.20
	74.0	0.3300	16.44	18.76	6.19
20-in. dia	26.9	0.8309	15.44	31.28	25.99
20 × 20 in. square in cross section	26.9	0.8309	16.2[c]	41.3[c]	34.3[c]
	71.5	0.3477	13.90	35.86	12.47
30-in. dia	71.5	0.3477	13.4[d]	61.4[d]	21.3[d]
Stainless steel					
9-in. dia	75.3	0.329	57.8	23.8	7.84

[a]Estimated from subcritical volume 143.7 cm high containing 8.61 kg of U^{235}.
[b]Water reflector covered only half of reactor surface area.
[c]Estimated from subcritical volume 12.3 cm high containing 26.4 kg of U^{235}.
[d]Estimated from subcritical volume 12.2 cm high containing 19.4 kg of U^{235}.

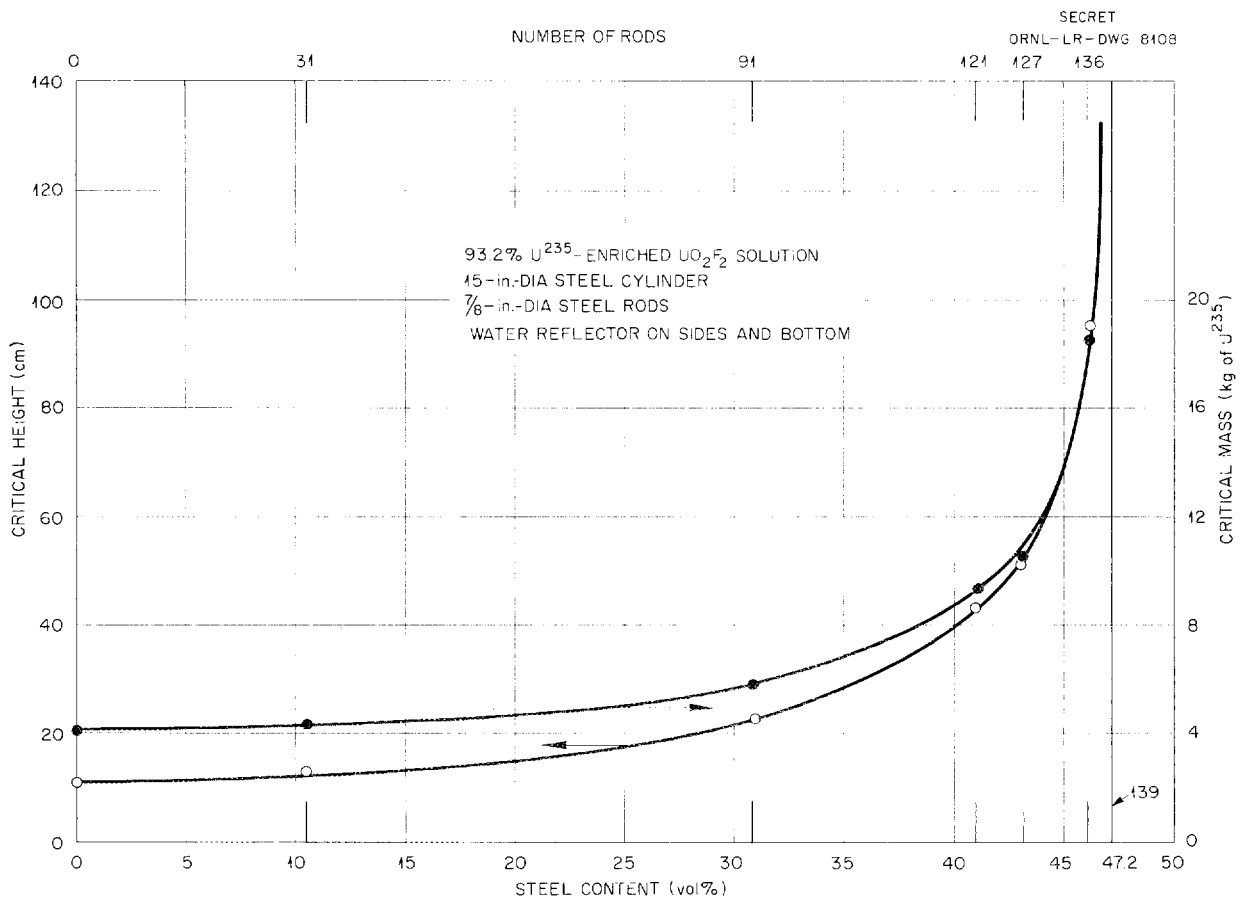

Fig. 1. Effect of Steel Content of Reactor Core on Critical Height and Critical Mass of U^{235} Solution.

no apparent source-neutron multiplication, and, presumably, the assembly could not be made critical in this condition. It is pointed out, however, that the displacement of the UO_2F_2 solution by the rods, in addition to the neutron absorption by the steel, contributes significantly to the loss in reactivity. This result is not inconsistent with that of work reported previously.[4]

CRITICAL PARAMETERS OF U^{235}-ENRICHED SOLUTIONS IN CYLINDRICAL ANNULAR GEOMETRY

L. W. Gilley J. K. Fox
V. G. Harness

The possibility of more economically storing fissionable solutions in annular cylindrical vessels rather than in ordinary cylinders has been considered in a few experiments. Cylinders of several diameters were fabricated from type 2S aluminum tubing so that any two could be combined, thus allowing variations in the thickness of the annulus. The annuli were filled with an aqueous solution of 93.2% U^{235}-enriched UO_2F_2, which had a U^{235} concentration of 0.338 g per cubic centimeter, corresponding to an $H:U^{235}$ atomic ratio of 73.3. Further variations of the experimental conditions were effected by altering the contents of the inner cylinders of the assemblies. The variations included: (1) leaving the inner cylinder empty, (2) filling it with water, (3) lining it with a sheet of cadmium 0.02 in. thick, or (4) both lining it with cadmium and filling it with water. In the experiments performed thus far, assemblies have been tested with and without a water reflector on the sides and bottom; no reflector was used above the solution. The data are presented in Table 2.

[4] A. D. Callihan *et al.*, *Critical Mass Studies, Part V*, K-643 (June 30, 1950).

TABLE 2. CRITICAL PARAMETERS OF ENRICHED URANIUM AQUEOUS SOLUTION IN CYLINDRICAL ANNULAR GEOMETRY

Fissionable material: UO_2F_2 enriched to 93.2% in U^{235}
Container material: type 25 aluminum coated with Heresite
Solution concentration:* 0.256 g of U per gram of solution; 0.338 g of U^{235} per cubic centimeter; $H:U^{235}$ = 73.3
Solution specific gravity: 1.42 g/cc

Outside Diameter of Assembly (in.)	Inside Diameter of Assembly (in.)	Contents of Inside Cylinder	Critical Values		
			Height (cm)	Volume (liters)	Mass (kg of U^{235})
		Annulus Surrounded by Effectively Infinite Water Reflector			
8	0		23.97	7.79	2.63
	2	H_2O	27.10	8.26	2.79
	4	H_2O	50.04	13.76	4.65
10	0		17.35	8.81	2.98
	2	H_2O	18.10	8.83	2.98
		H_2O + Cd	20.51	10.00	3.38
		Cd	20.40	9.95	3.36
		Air	20.65	10.10	3.41
	4	H_2O	23.75	10.14	3.43
		H_2O + Cd	45.43	19.40	6.55
		Cd	31.90	13.62	4.60
		Air	27.56	11.77	3.98
	6	H_2O	64.13	20.91	7.06
		H_2O + Cd	**	**	**
		Cd	**	**	**
		Air	76.80	25.00	8.45
15	0		12.66	14.44	4.88
	2	H_2O	12.85	14.41	4.87
		Air	13.34	14.95	5.05
	4	H_2O	13.87	14.70	4.97
	6	Air	17.51	16.79	5.67
		H_2O	16.00	15.34	5.18
	8	H_2O	21.00	17.14	5.79
	10	H_2O	41.60	26.33	8.89
20	0		11.28	22.87	7.73
	2	H_2O	11.35	22.78	7.70
	6	H_2O	12.60	23.25	7.85
	10	H_2O	16.35	24.84	8.39
	15	H_2O	44.30	39.25	13.26
		No Reflector			
10	0		34.13	17.35	5.86
	2	Cd	70.00	34.14	11.53
		H_2O + Cd	138.20	67.40	22.77
		Air	49.60	24.19	8.17
	4	H_2O + Cd	**	**	**
		H_2O	**	**	**

TABLE 2 (continued)

Outside Diameter of Assembly (in.)	Inside Diameter of Assembly (in.)	Contents of Inside Cylinder	Critical Values		
			Height (cm)	Volume (liters)	Mass (kg of U^{235})
15	0		16.43	18.73	6.33
	2	Cd	18.00	20.18	6.82
		H_2O + Cd	18.20	20.40	6.89
		H_2O	17.05	19.11	6.46
		Air	17.55	19.67	6.64
	6	H_2O + Cd	54.20	51.98	17.56
		H_2O	25.15	24.12	8.15
		Air	29.90	28.67	9.68

*These values varied by as much as ±2.5% during the experiments.

**These volumes were not critical at heights of 122 cm or greater, and the source-neutron multiplication curves indicated they could not be made critical.

CRITICAL PARAMETERS OF U^{235}-ENRICHED SOLUTIONS IN SPHERICAL GEOMETRY

J. T. Thomas

Different sized spherical vessels made of type 2S aluminum are being used to investigate several nuclear parameters of 93.2% U^{235}-enriched UO_2F_2 aqueous solutions over a wide range of concentrations. The experiments are performed with and without a water reflector. Parameters being investigated include the variation of the critical mass and critical volume with concentration, along with a determination of their minimal values. The neutron flux and the fission rate distribution as a function of the concentration are also being measured. Some of the critical spheres are only partly filled.

The flux distribution measurements are made with indium foils. Since the use of the oxyfluoride solution necessarily requires that the detectors remain free of contamination by the solution, the indium foils (with and without cadmium covers) are sealed in pockets of Teflon tape which are then attached to a small-diameter stainless steel stringer placed directly in the solution.

The fission rate measurements are made by exposing, in the solution, capsules containing U^{235}. Each capsule consists of a ⅜-in.-OD by ¼-in. cylindrical Lucite tube filled with 25 to 50 mg of 93% U^{235}-enriched UO_2F_2. These capsules (with and without cadmium covers) are closely fitted in a thin-walled Lucite tube which, in turn, is inserted into another Lucite tube (½-in. OD) and immersed in the solution. After exposure, the gamma activity of the U^{235} fission products in each capsule is counted.

Thus far, measurements have been made with a water-reflected 12.6-in.-dia aluminum sphere. The sphere was critical when filled with 17.00 liters of solution having a concentration of 0.0494 g of U^{235} per cubic centimeter ($H:U^{235}$ = 524). The total U^{235} content was 841 g. The sphere was also critical when filled to 51% of its capacity with 8.74 liters of a solution containing 0.644 g of U^{235} per cubic centimeter ($H:U^{235}$ = 35.8), the total U^{235} content being 5.63 kg.

Several measurements of the flux and fission rate in both the filled and the partially filled sphere are shown in Figs. 2, 3, and 4. The total radial fission rate and neutron flux distributions obtained with UO_2F_2 capsules and indium foils in the full sphere are shown in Fig. 2 to be the same, within the precision of the measurements. The results with cadmium-covered UO_2F_2 capsules indicate that about 93% of the fissions are produced by low-energy neutrons. The corresponding data taken along a vertical diameter in the partly filled sphere are plotted in Figs. 3 and 4. The bare indium foil traverse (Fig. 3), which was extended into the reflector water above the sphere, has a maximum at approximately the geometric center of the fuel, remains almost constant across the void, and has typical but somewhat diminished peaks in the reflector. The distribution of neutrons producing

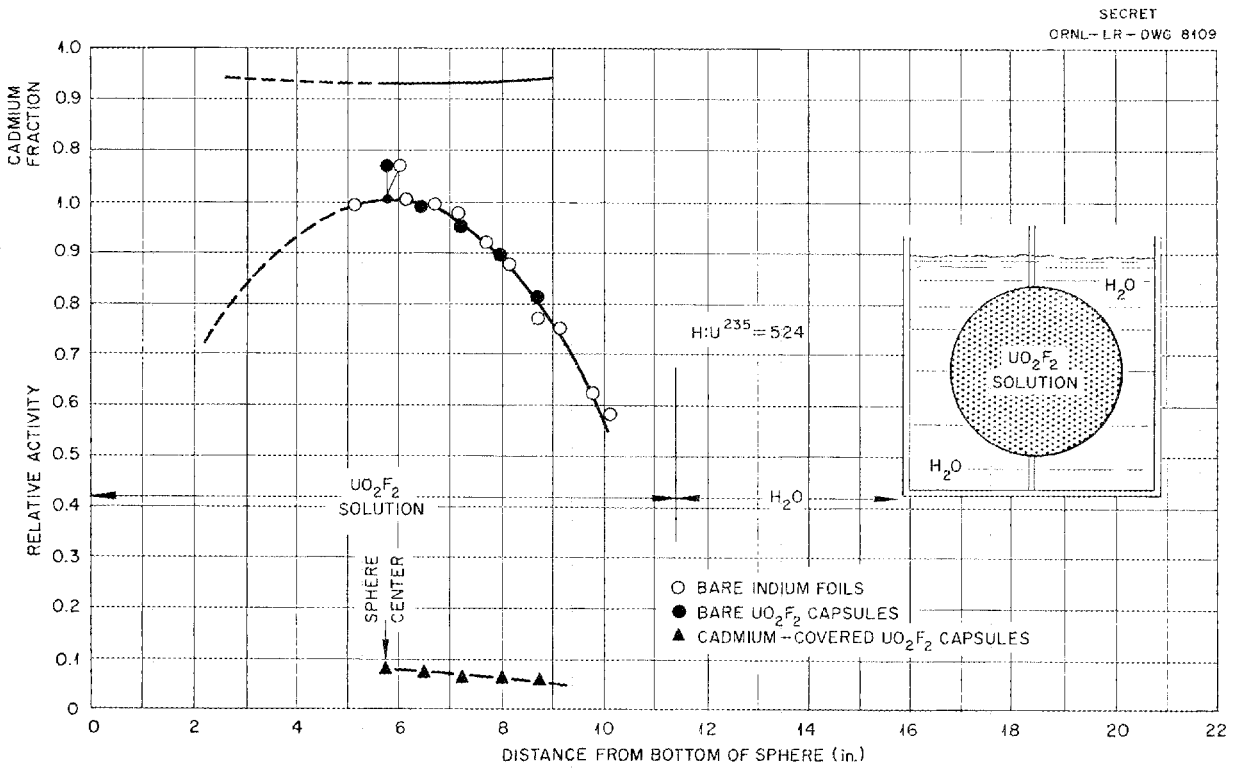

Fig. 2. Neutron Flux and Fission Rate Distribution in a Critical, Filled, Water-reflected, 12.6-in.-dia Sphere.

fissions in the bare UO_2F_2 capsules also peaks near the geometric center of the solution (Fig. 4), has a minimum near the surface, and apparently rises again in the void. The reason for the difference between the results of the UO_2F_2 capsules and those of the indium detectors in the void is not clear. The high apparent fission rate in the void may be due to an interaction between the fuel-filled capsules. The measurements with cadmium-covered UO_2F_2 detectors show that about 62% of the fissions in the hemisphere are produced by neutrons of energy below the cadmium cutoff, a result to be expected, since the relative hydrogen content in the hemisphere is significantly less than that in the full critical sphere.

CRITICAL PARAMETERS OF SLIGHTLY ENRICHED URANIUM SOLUTIONS IN SPHERICAL GEOMETRY

D. F. Cronin J. T. Thomas

A series of experiments, with the use of a 27.3-in.-dia aluminum sphere, has been performed on uranium enriched to 4.89% in U^{235}. Uranyl fluoride solution was used at two concentrations in order that the sphere would be critical, when essentially filled, with and without an effectively infinite water reflector. The reflected assembly contained 0.2934 g of uranium per gram of solution, while the unreflected assembly contained 0.3161 g of uranium per gram of solution. Sufficient excess reactivity was then available so that various detectors could be introduced for relative thermal-neutron flux and fission rate distribution measurements. It was also found that the higher concentration became critical when the reflected sphere was filled to 83% of its capacity. The data are given in Table 3.

Some measurements have been made of the fission rate distributions along a vertical diameter of the filled sphere by using the capsules of enriched uranium solution described in the previous section. The data obtained with bare and cadmium-covered detectors in both the reflected and unreflected sphere are given in Fig. 5. The distributions apparently peak somewhat below the center

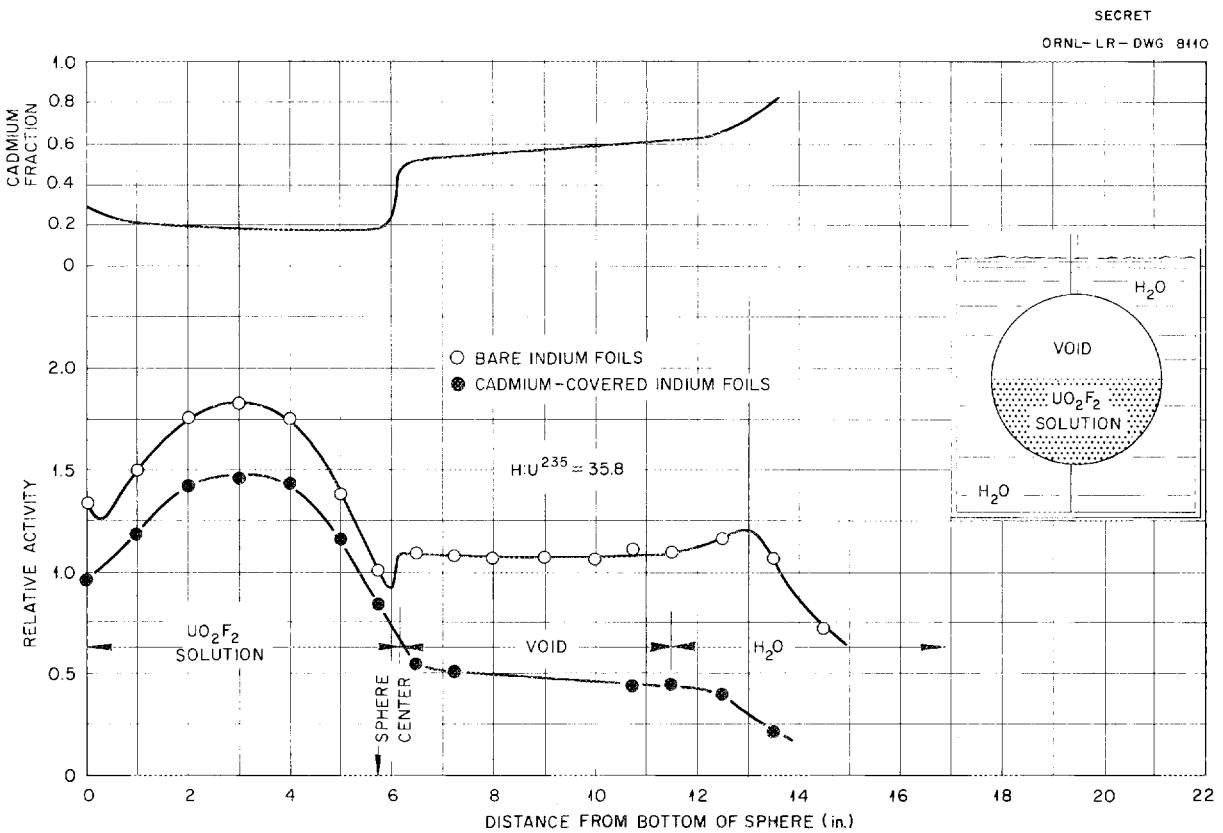

Fig. 3. Neutron Flux in a Critical, Partially Filled, Water-reflected, 12.6-in.-dia Sphere.

of the sphere, possibly owing to the effect of the solution in the 3-in.-dia filling pipe at the bottom of the sphere. (Three points measured in the reflector water along the extension of a nonvertical diameter have been plotted as a part of the vertical traverse. One of these is the lower of the two at the interface.) The fission rate in the unreflected sphere follows a sine distribution within the limits of accuracy of the data. The fuel cadmium fraction, that is, the fraction of all the fissions which are produced by neutrons having energies below that of the cadmium cutoff, is also plotted as a function of distance from the center along the radius. The value in the central region of the sphere is constant at 94% and is independent of the reflector; there is considerable uncertainty in the results near the periphery of the sphere.

EFFECT OF CONCRETE AS A NEUTRON REFLECTOR

L. W. Gilley

In one experiment a measurement has been made of the effect of concrete as a neutron reflector. A 9-in.-dia aluminum cylinder was so arranged that it could be made critical when containing enriched UO_2F_2 solution with no reflector, with an effectively infinite water reflector, or when located at various distances from a concrete slab. This slab was $4 \times 4 \times \frac{1}{2}$ ft thick and consisted of blocks of shielding concrete having a density of 2.14 g/cc. The solution had a concentration corresponding to an $H:U^{235}$ atomic ratio of 74, and its critical height was the parameter sensitive to the several experimental arrangements. It was found, for

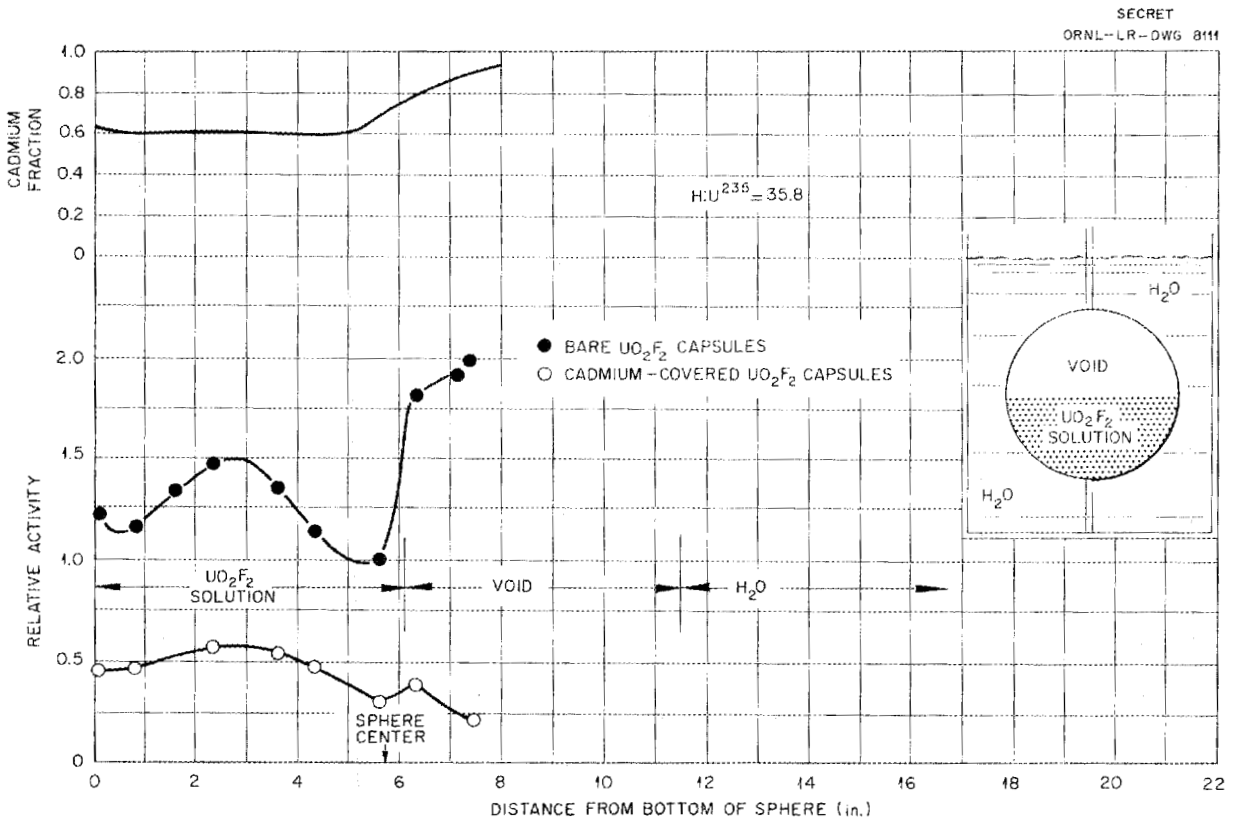

Fig. 4. Fission Rate Distribution in a Critical, Partially Filled, Water-reflected, 12.6-in.-dia Sphere.

TABLE 3. CRITICAL PARAMETERS OF SLIGHTLY ENRICHED URANIUM AQUEOUS SOLUTIONS IN SPHERICAL GEOMETRY

Fissionable material: UO_2F_2 enriched to 4.89% in U^{235}
Container: 27.3-in.-dia aluminum sphere

	Unreflected, 0.3161 g of U per gram of Solution	Water Reflected	
		0.3161 g of U per gram of Solution	0.2983 g of U per gram of Solution
$H:U^{235}$ atomic ratio	1012	1012	1113
Specific gravity of solution	1.56	1.56	1.52
Fraction of sphere capacity filled, %	98.9	83.4	98.3
Critical volume, liters	172	145	171
Critical mass of uranium, kg	85.0	71.7	77.3
Critical mass of U^{235}, kg	4.16	3.51	3.78

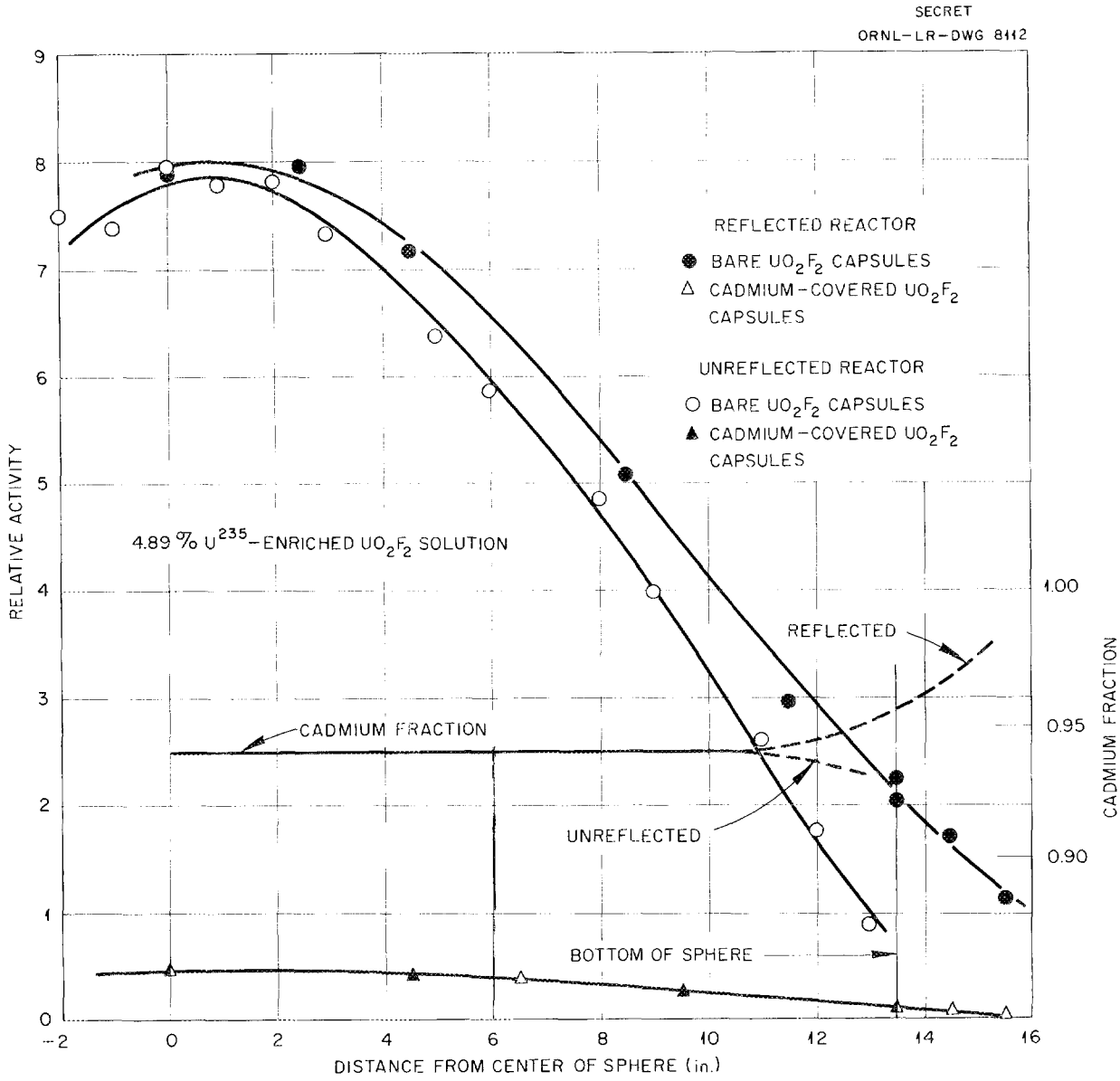

Fig. 5. Fission Rate Distribution in a Critical, Filled, 27.3-in.-dia Sphere, Water-reflected and Unreflected.

example, that the height with a thick lateral water reflector was 7.68 in., and with no reflector it was 22.75 in. With the concrete tangent to the cylinder and with no water reflector, the critical height was 15.80 in. Increasing the separation between the concrete and the cylinder resulted in an increase in the critical height shown in Fig. 6; the critical height approaches, as a limit, the unreflected value at a separation of about 2 ft. A single test of the effect of increasing the slab thickness was made by rearranging the blocks into a 3.5 × 3.5 × 1 ft slab in contact with the cylinder. Under these conditions the critical height was 15.35 in., 3% lower than the value with the 1-ft-thick slab. In another experiment, with the 6-in.-thick slab tangent to the cylinder, the array was flooded with water and the critical height was found to be essentially the same as that with the water reflector alone.

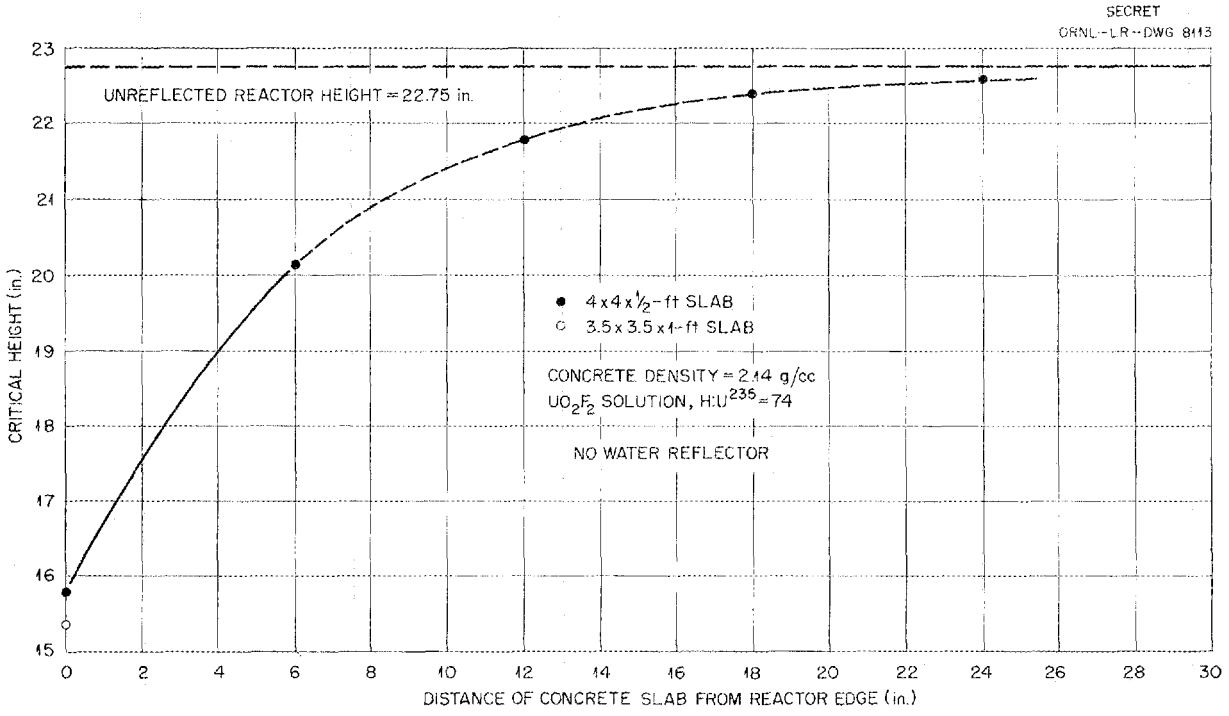

Fig. 6. Critical Height of a 9-in.-dia Cylinder as a Function of Distance from a Concrete-Slab Reflector.

NEUTRON-INDUCED FISSION CROSS SECTION OF U^{238} FROM THRESHOLD TO 4.0 Mev

R. W. Lamphere

The fission cross section of natural uranium has been measured from threshold to a 4.0-Mev neutron energy by using protons from the ORNL 5-Mv Van de Graaff to bombard a tritium gas target. The neutron energy spread varied from 60 to 100 kev for most points. The data were corrected for the U^{235} present in natural uranium in order to obtain the cross section of U^{238}. A simple comparison type of experiment was performed in which the cross section of natural uranium was found as a ratio to that of U^{235}. The U^{235} cross section had been determined[1] by comparison with the (n,p) scattering cross section over the energy range of 400 kev to 1.6 Mev and had been extended to higher energies by means of the long-counter method.[2] These results were used to calculate the U^{238} cross section from the experiment.

With the energy spread present in the neutron beam, no minima were found, but there are a few features worthy of note. Uranium-238 does not show a sharply defined threshold. There is a measurable cross section at a neutron energy as low as 500 kev, which gradually rises to 17 millibarns at 950 kev, remains constant to 1.05 Mev, rises to 40 millibarns at 1.16 Mev, remains constant to 1.23 Mev, and then rises in a normal manner to 0.54 barn at 2.0 Mev and to 0.58 barn at 3.0 Mev. At about 3 Mev the increase in cross section with

[1] B. C. Diven *et al.*, *The Fission Cross Section of U^{235} from 0.4 to 1.6 Mev*, LA-1336 (Feb. 3, 1953).

[2] R. L. Henkel, *Fission Excitation Curves for U^{233}, U^{235}, U^{236}, U^{238}, and Np^{237}*, LA-1495 (Nov. 21, 1952).

energy becomes more rapid, the cross section reaching 0.65 barn at 4.0 Mev.

The results shown in Figs. 7, 8, and 9 are believed to be accurate to within 4%. For purposes of comparison, Fig. 7 includes U^{236} and U^{234} fission cross sections previously measured.[3] Figure 9 gives the fission cross section of U^{235} used to calculate the U^{238} cross section.[4]

[3] R. W. Lamphere and R. E. Greene, "The Neutron-Induced Fission Cross Sections of U^{234} and U^{236}," *Phys. Rev.* (to be published).

[4] H. H. Barschall and R. L. Henkel, *Summary of Fast Fission Cross Sections*, LA-1714 (August 1954).

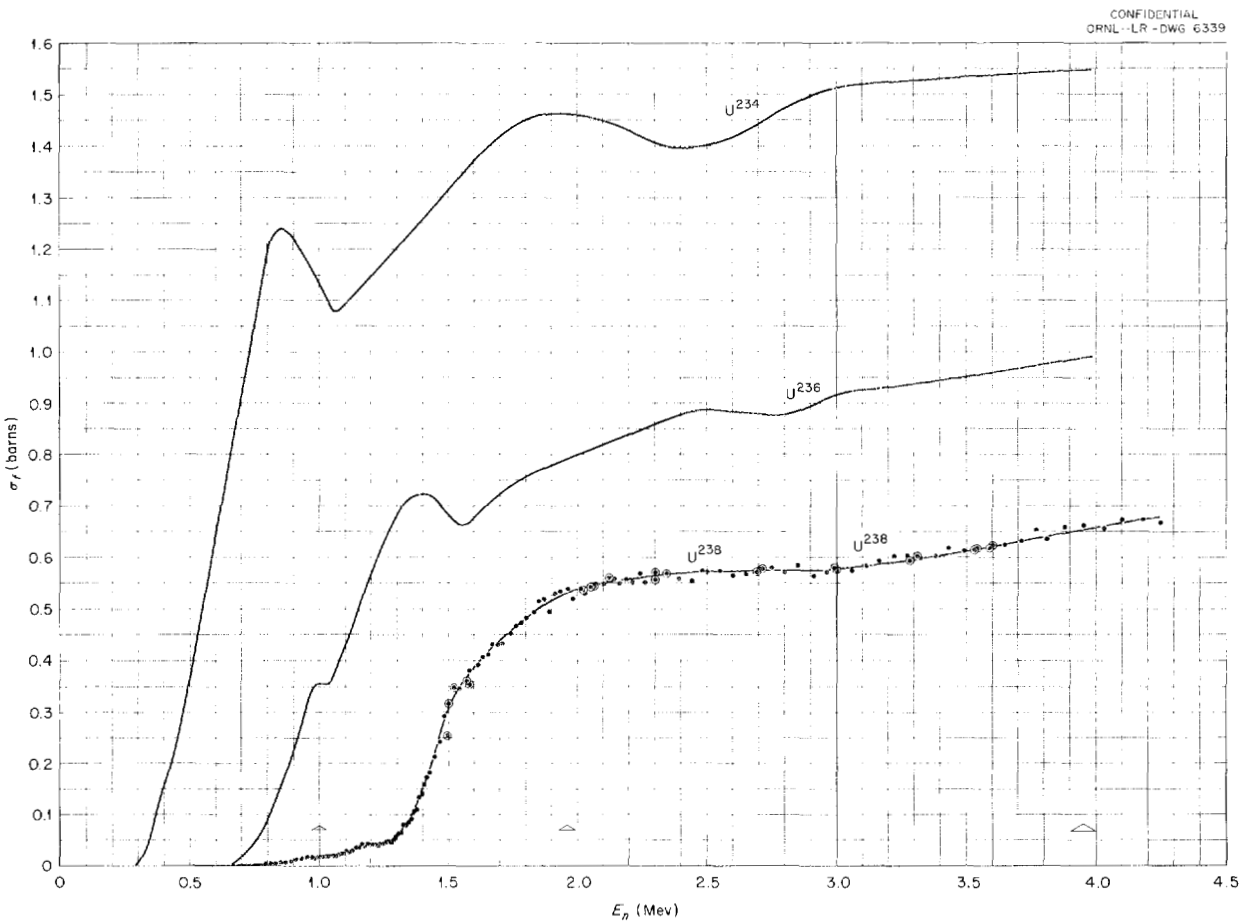

Fig. 7. Fission Cross Sections of U^{238}, U^{236}, and U^{234}.

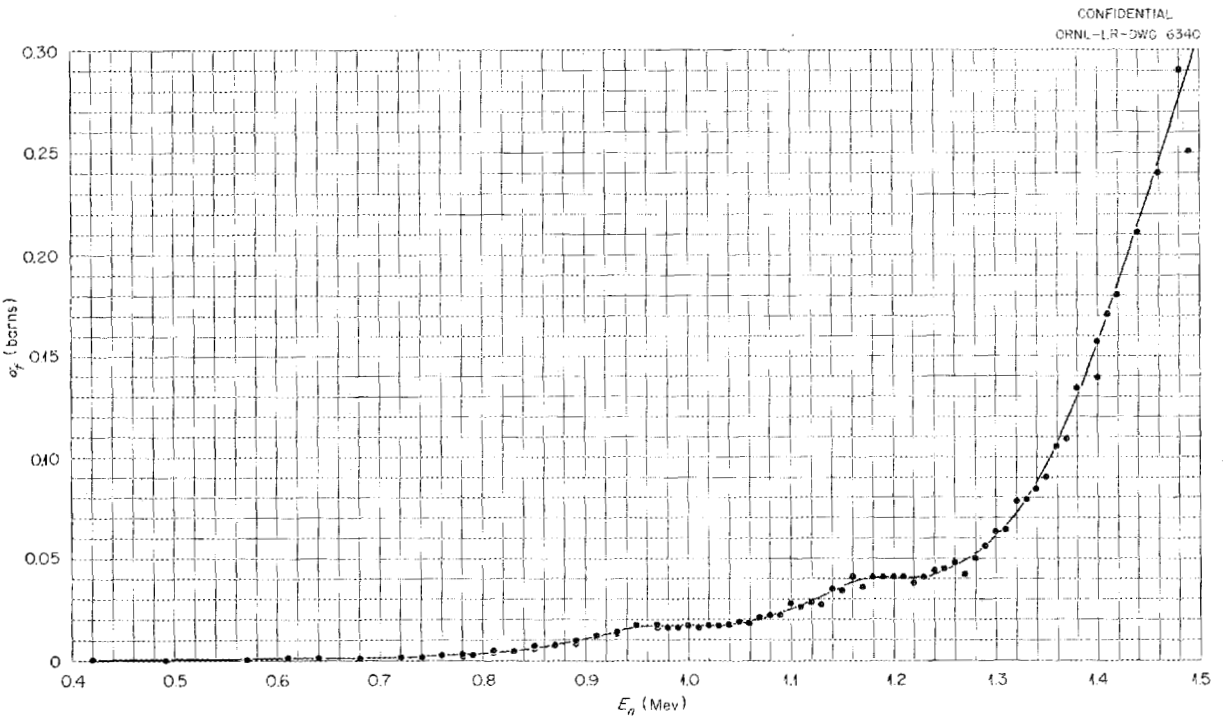

Fig. 8. Fission Cross Section of U^{238} from 500 to 1500 kev.

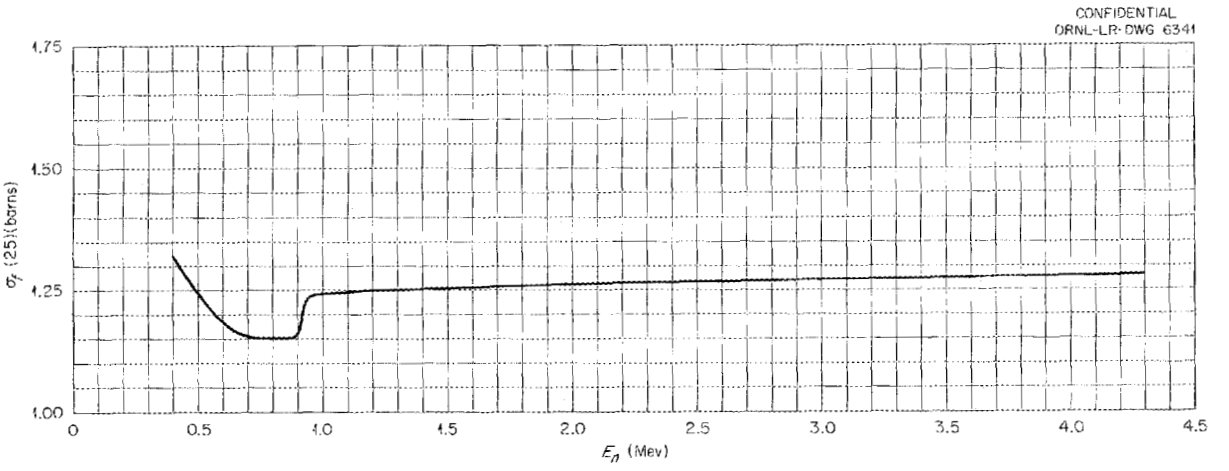

Fig. 9. Fission Cross Section of U^{235} Used to Calculate Cross Section of U^{238} by Comparison Method.