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PHYSICS DIVISION

QUARTERLY REPORT ENDING JUNE 25, 1949

A.H. SNELL, DIRECTOR
E.O. WOLLAN, ASSOCIATE DIRECTOR

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PHYSICS DIVISION

QUARTERLY REPORT ENDING JUNE 25, 1949

A. H. Snell, Director

E. O. Wollan, Associate Director

DATE ISSUED

JUL 27 1949

OAK RIDGE NATIONAL LABORATORY

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SUMMARY

Xenon 135 Cross Section. Preparations are being made to study the Xe^{135} cross section at higher energies by using a LiF crystal instead of quartz. Preliminary observations indicate also that it may be possible to obtain a rough measurement of the scattering cross section of Xe^{135}.

Neutron Absorption in Zirconium-Water Systems. Apparatus is being assembled for measurement of the resonance absorption of neutrons in Zr-H_2O systems. A Ra-Be source will be used, and indium resonance distributions will be taken in a water tank with and without an assembled array of zirconium plates.

Shielding. The large tank which has been built against the core hole in the west face of the ORNL reactor has been fitted with a device for automatic plotting of the isodose curves of the radiation as it is absorbed in water.

Neutron Absorption in Aluminum-Water System. Experimental results are being compared with neutron flux distributions derived from appropriate solution of the Boltzmann equation.

Physics of the Solid State. Annealed Cu-Be alloy is found to undergo greater changes in hardness and electrical resistivity as a result of pile irradiation than does cold-worked Cu-Be alloy.

A new set of samples of U-Al alloy has been prepared for irradiation at Hanford, and extensive pre-irradiation measurements have been completed. These samples will not be subject to mechanical constraint during their time in the reactor, as were the samples of a previous set.

Considerations of specific gravity have shown that the density changes observed in U-Al alloys as a result of pile irradiation cannot arise from formation of UAl_5.

Strain "relaxations" thought to have been observed in uranium and other metals have been found to be an instrumental effect, arising from peculiar properties of bonded wire strain gauges which come into play when the latter are used near the limit of their sensitivity.

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Large decreases in thermal conductivity of uranium-impregnated graphite have been observed to result from pile irradiation at high temperatures.

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NUCLEAR PHYSICS

Xe^{135} Cross Section as a Function of Energy (S. Bernstein, C. P. Stanford, T. E. Stephenson, J. B. Dial). A fairly complete record of the Xe^{135} measurements was given in the last Physics Division Quarterly Report, ORNL 325. During the early part of the current quarter we took measurements on three more samples (Nos. 11, 12, and 13), bringing the total number of samples used so far for spectrometer measurements to nine. A preliminary analysis of the data of these three samples shows good agreement with the results given in ORNL-325.

Members of the Mathematics and Computing Panel are at the present reconsidering very carefully the analysis of all the data taken thus far with the object of deducing the best possible values for the Breit-Wigner constants. This work is being done by A. Forbes, N. Dismuke, and R. Lewis under the direction of A. Householder and R. Coveyou.

The latter part of the current quarter's work with respect to Xe has been directed toward two objectives: (1) Extending the energy range of the transmission measurements to higher and lower energy values, and (2) investigating the feasibility of measuring directly the Xe scattering cross section.

The quartz crystal used in Xenon cross-section measurements made to date has not permitted us to work below .03 ev due to the presence of higher orders in the reflected beam. In an attempt to extend this range to lower energies, tests were made with a LiF crystal ground parallel to the (111) planes. A paper by E. Fermi [Phys. Rev. *71*, 666 (1947)] shows the second and fourth orders should be missing and the third order weak (approximately 3%). The tests consisted of measuring the cross section of a B^{10} sample at various energies and then plotting E_{ev} *ln* T *vs* E_{ev}. In the absence of higher orders a horizontal line should be observed. Instead, the line was horizontal down to about .03 ev and then dropped off rapidly for lower energies. These results suggest that the new crystal is no better for low energies than the quartz crystal. The measurements show that the LiF crystal can be used for higher energies than the quartz crystal. The counting rate is about the same, but LiF has a lower background for a given energy since one is working with a angle (farther from direct beam) due to the grating space for the (111) plane of LiF being about 1/2 that of the quartz (1,0,0) plane.

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At the present the measurement of the Xe scattering cross section seems possible but difficult. A fission chamber has been constructed to fit into the graphite stringer in the pile shielding above the sample (See Fig. I-6, ORNL 325). The background counting rate for an open capillary tube is 3 scalers per second. With the capillary tube filled with enough powdered graphite to scatter all neutrons passing through it, the counting rate is 4.1 scalers per second, an increase of more than 30%. The fraction of neutrons scattered by the Xe sample will, of course, be far less. Additional efforts are being made to further reduce the background counting rate by working with the sample outside the pile.

Resonance Escape Probability and Age Measurements for a Zirconium-Water System (J. I. Hoover).* Experiments are planned for resonance escape probability measurements and age measurements to indium resonance for a zirconium-light water system containing approximately 20% zirconium by volume. The resonance escape probability measurements will be made utilizing a Ra-α- Be source and indium foils. The age measurements will be made using a fission neutron source and indium foils.

The geometry for both measurements will be a cubic assembly of zirconium sheet (36 in. × 6 in. × 0.080 in.) stacked horizontally in layers in a tank of water, with an average spacing of 5/16 in. between successive layers. The assembly will be an approximate cube 36 in. × 36 in. × 36 in. with provisions to measure neutron intensity along the central axis perpendicular to the sheets. The neutron source will be fixed along this axis near the bottom of the cube. In the case of the resonance escape probability neutron intensity measurements as a function of the distance from the source will be made without (i.e., in water) and with the zirconium in place. The age measurements will be made only with the zirconium in place.

The zirconium metal for these measurements will be relatively pure, containin about 1% hafnium, and negligible amounts of other impurities. The thermal neutron cross section of a sample of this metal, as measured by H. S. Pomerance, is about 0.85 barn.

Working drawings for the apparatus have been turned in to the shop. The zirconium metal sheet is expected to arrive soon.

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PHYSICS OF SOLID STATE

Effects of Irradiation on Metals (D. S. Billington, R. H. Kernohan**).* Studies of the effects of pile irradiation on the precipitation hardening alloy, Cu - 2% Be, have been continued. Specimens were prepared for measuring the properties of hardness and electrical resistance. Hardness specimens were small discs 3/8 in. in diameter and $\frac{1}{4}$ in. thick, and resistance specimens were 1/8 in. diameter rods 2 $\frac{1}{2}$ in. in length. Eighty hardness and 64 resistance specimens were prepared, measured, irradiated for three weeks in Hole 1768 in the X-10 pile, and re-measured approximately six weeks after removal from the pile.

Half of the number of each type of specimen were in the α-quenched plus cold-worked condition (55% reduction of area), while the other half were soft, or α-quenched, having been held at 770° C for 20 minutes and water quenched.

The average of the results are tabulated below:

TREATMENT	HARDNESS		ELEC. RESISTIVITY		Δ R PERCENT CHANGE
	Before Irradiation	After Irradiation	Before Irradiation	After Irradiation	
α-quenched cold-worked	81.5	87.1	10.81	10.93	1.11
swaged 55% reduction	(244)	(270.5)			
annealed	11.4	48.2	10.05	10.93	8.75
swaged and α-quenched (20 min at 770° C)	(109)	(158)			

Explanation: Hardness numbers are Rockwell G.
Numbers in parenthesis are corresponding Vickers hardness numbers.
Resistivity in microhm-cm, corrected to 20° C.

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A second phase of the Be-Cu work is the investigation of the effect of irradiation on the process of subsequent precipitation hardening. It appears from some experiments now being performed that the increased hardness and resistance due to irradiation can be annealed out by a very short (30 sec) treatment at 300°C. Figure 1 shows the behavior of the electrical resistance as a function of time of heat treatment at 300° C. Experiments are being continued to study this annealing effect as a function of temperature.

Hardness and resistance specimens of copper-base alloys have been prepared and measured and are now being irradiated in the pile. These specimens are oxygen-free, high conductivity copper-zinc, copper-aluminum, and copper-silicon.

The extensometer adapter for the hot lab tensile testing machine has been finished, installed, and found to operate satisfactorily by remote control.

In connection with the work on creep under irradiation, a visit was made to the National Bureau of Standards at Washington May 17-19 concerning spring type resistance strain gages. The advantages and practicality of the gages which are still in the developmental stage were discussed with Dr. W. A. Wildhack of the Bureau of Standards.

Uranium-Aluminum Alloys. Preparation and Pre-Irradiation Measurements of New Series (*S. E. Dismuke, L. C. Templeton, R. W. Coyle,** R. H. Kernohan,** W. E. Johnson**). Increases in size, and decreases in density had been observed in U-Al alloys containing 5, 15 and 30 weight percent of U when subjected to radiation in the Hanford Pile (see preceding quarterly report, ORNL 325, p.75). Because of the importance of these observations in regard to the behavior of reactor of reactor fuel elements, a new set of tests was initiated in which the samples are not subject to any mechanical constraint such as the previous samples had been.

The present samples fall into 4 groups of alloy composition:

1. Approximately 14 weight percent U, 93% enriched in U^{235}.
2. Approximately 30 weight percent U, 38% enriched in U^{235}.
3. Approximately 30 weight percent U, natural U.
4. Approximately 14 weight percent U, natural U.

For protection against corrosion by the cooling water of the Hanford pile these alloys were aluminum-clad by rolling a plug of the alloy within an aluminum

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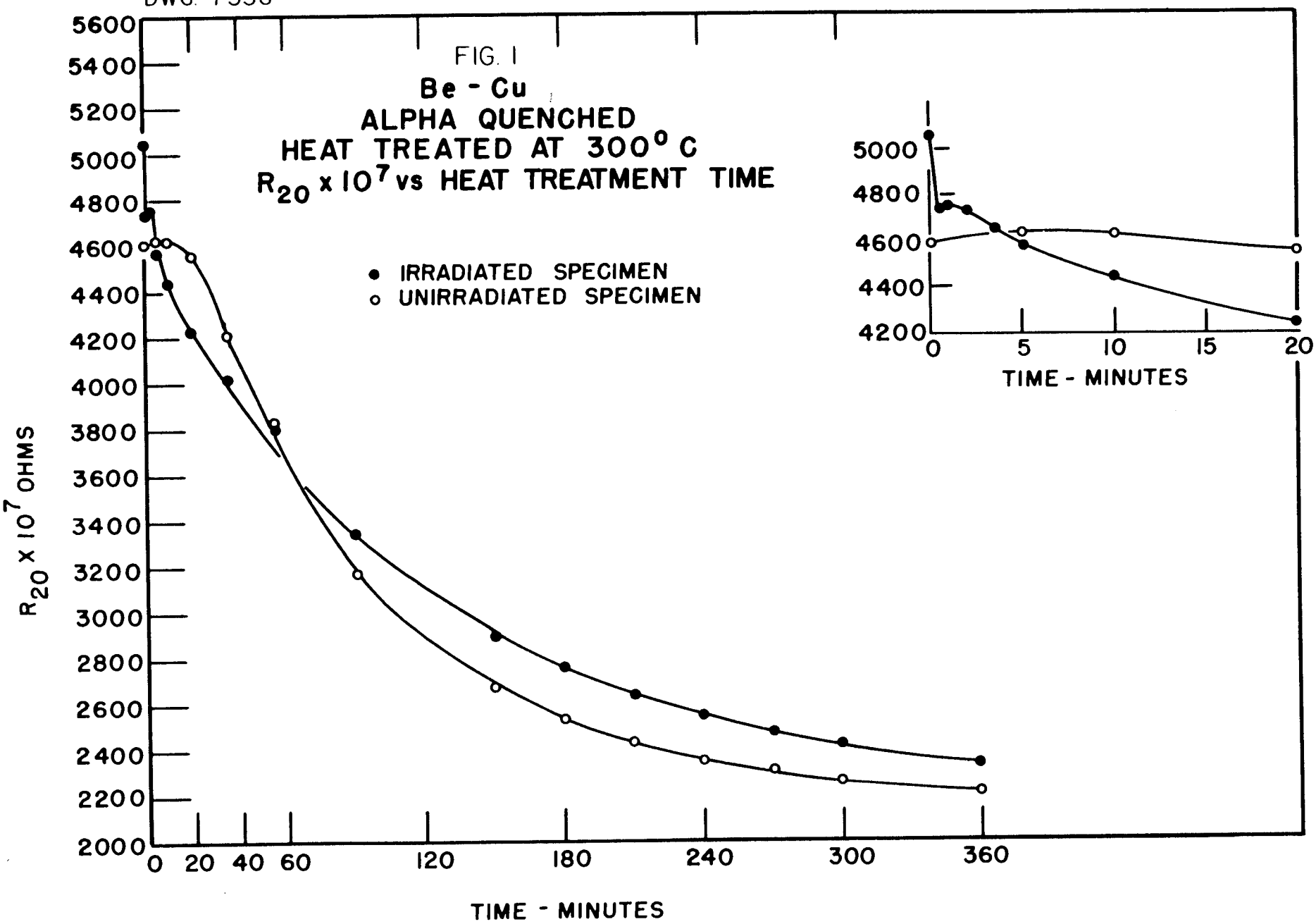

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"picture frame" and front and back sheets of aluminum. (Metallurgy Division, ORNL).

Final outside dimensions were 0.064 in. × 0.84 in. × 4.0 in. with the alloy plug dimensions, inside the cladding, approximating 0.020 in. × 0.45 in. × 3.5 in.

Three specimens from each alloy group, or a total of 36, are being exposed at Hanford for one, three, and six months. One sample from each alloy composition and exposure time group was selected to go through the same brazing cycle that the reactor fuel elements will go through, that is the samples were fluxed, heated and cleaned in the same way. (Metallurgy Division, ORNL).

For a check on the bonding of the cladding, photomicrographs of a section along one of the long narrow sides of these specimens were taken. (R. J. Gray, Metallurgy Division, ORNL).

The pre-irradiation measurements taken on all the samples included (1) dimensions, (2) weight and density, (3) electrical resistance (through longitudinal section), (4) surface profile, (5) radiographs.

Sample holders are employed for irradiation at Hanford that allow the cooling water to pass directly over the specimens.

<u>X-Ray Diffraction Examination.</u> *(M. A. Bredig, F. A. Sherrill).* A number of sample of UAl alloys ranging in composition from 5 to 42 weight percent U revealed the presence of UAl_3 in all specimens but one (24%). While the unexpected occurrence, in major proportions, of this compound UAl_3 in the 5% and 10% specimens requires further investigation, its presence in the range of hypereutectic compositions, i.e., above ca. 13% U, may be attributed to incompleteness of the peritectic reaction $UAl_3 + 2\ Al = UAl_5$.

<u>Specific Gravity of UAl_5.</u> *(M. A. Bredig, L. C. Templeton).* It appeared possible that irradiation conditions in the Hanford pile had caused the peritectic reaction to go to completion, and that possible volume changes in this reaction were responsible for the dimensional changes reported previously. A check of the density of UAl_5 as compared with that of $UAl_3 + 2\ Al$ therefore suggested itself.

A determination of the density of the 24% UAl sample, for which an X-ray pattern had shown the presence of UAl_5 and Al and the absence of UAl_3, yielded 3.359 g/cm^3, or 5.620 g/cm^3 for the specific gravity of UAl_5. Specific volume figures for UAl_5 and ($UAl_3 + 2\ Al$), calculated from the specific gravities of

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UAl_5, UAl_3 and Al, then, compare as 0.1780 cc/g and 0.1785 cc/g, respectively. They prove that no volume effect of any consequence is involved in this reaction, and therefore cannot be responsible for the density changes observed on irradiation.

Order - Disorder Reaction in Ni_3Mn (L. C. Templeton, S. Siegel).* Electric resistivity (voltage - current) measurements on Ni_3Mn were made as a function of radiation dosage. A specimen, annealed at 420° C for 100 hours to produce the ordered structure was irradiated in the doughnut hole #1867 of the X-10 pile. A gradual increase of resistance up to 11.5% was observed which is ascribed to increasing disorder in the structure of this alloy under the influence of fast neutron irradiation. No saturation of the effect had yet been observed when insulation break-down of the lead wires occurred at an integrated flux of 9×10^{18}.

*Irradiation of 25-28 Alloy in Hanford (R. W. Coyle**).* Finished samples of normal, 2½% enriched, and 7½% enriched material have been transferred from Metallurgy to this group. These samples were rolled from cast billets to 3/8 in. diameter rods with frequent anneals to prevent rolling cracks. From 3/8 in. diameter, the samples were swaged to approximately 1/8 in. diameter and finally drawn through a series of special square section wire drawing dies to final cross-sectional dimension of .117 in. × .117 in. Final lapping of the samples for parallelism is under way.

With the above treatment, the final structure shows a preferred orientation in the direction of working and it is felt that this condition will accentuate any dimensional instability introduced through irradiation. Control work on the specimens will include electrical resistivity, thermal conductivity, dimensional stability, macro-hardness (Rockwell) and micro-hardness (Tukon) to determine changes in micro constituents, metallographic structure, profile, and tensile strength.

*Equipment for "Hot" Laboratory (R. W. Coyle**).* Considerable time was spent on questions of design and procurement of remote control apparatus. The design of adaptations, for remote control operation, of the micro-hardness tester known as the "Tukon" tester for determining Knoop Hardness numbers has been completed. A special apparatus suitable for *remotely polishing* of metallog-

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raphic specimens is being worked out. Preliminary designs are almost complete. This will permit micro-examinations of the many specimens previously irradiated but now unsuitable for metallurgical microscopy.

The *remote control microscope* was received from the shops and put in working order. Additions were made to adapt it for use as a *surface profile analyser*. It was used in determining profiles in pre-irradiation measurements of the aluminum-clad UAl and zirconium-clad UZr alloys, described elsewhere in this report.

A trip was made to Tinius Olsen Testing Company to discuss the design of an *impact testing machine* suitable for remote operation. The RCA laboratories were visited to discuss the feasibility of installing *television cameras* in the ceiling of the new "hot" lab to observe motions not visible from the windows. RCA has been doing work along the lines of our needs. Tests have been made with television equipment exposed to 1300 R and no interference noted.

New Physics of Solids Laboratory (D. S. Billington, E. P. Epler).* Perliminary drawings for the structural, architectural and other features outside the cells proper have been reviewed and returned to the Cleveland office of the Austin Company. Design work has been started by the Austin Company on doors, windows and barriers in the hot cells. A one-cell "mock up" of the hot lab has been designed and approved and will be constructed in the 101 Building in the very near future.

Studies of experimental equipment in relation to the use of the cells have been initiated in cooperation with the Special Equipment Design Engineering group (Frank Ring, Jr., head). This group is maintaining control with the Argonne design group with respect to the hot cells windows.

Neutron Converter (R. P. Metcalf). Shop work on the neutron converter is essentially complete, and assembly and installation are under way. The converter should be in operation by the end of June.

Cryostat for Pile Irradiations (R. P. Metcalf). Improvement of the design of the cryostat is progressing. Following discussions with representatives of Arthur D. Little, Inc., a decision has been reached to cool the cryostat with

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helium gas, circulated in a closed system. The helium will be cooled by liquid nitrogen. Consideration is being given to having the helium refrigerator designed and built by Arthur D. Little, Inc.

X-Ray Diffraction (M. A. Bredig, F. A. Sherrill). Besides determining the quality and orientation of large single crystals and identifying constituents in UAl alloys as reported above, there was comparatively little activity in this field, due largely to preoccupation with other duties. A new vacuum connection for the high temperature heating chamber of the spectrometer was installed. Attention was given to the problem of "hot" X-ray diffraction methods. It was found, in agreement with recent reports from manufacturers of X-ray diffraction equipment, that a thin bent mica crystal, when used in transmission as required by the geometry of the apparatus, does not diffract copper $K\alpha$, X-ray radiation with sufficient intensity to make its use appear suitable. Other materials such as LiF will have to be tried.

Relaxation of Strains in Uranium (M. R. Goodman). A very careful and detailed analysis of the results obtained due to the thermal cycling of uranium and other metals, as mentioned in the previous quarterly report, appears to indicate that the relaxations observed are characteristic of the attached strain gages rather than the specimens. It thus became necessary to shift temporarily the emphasis to an investigation of the properties of the Sr-4 strain gages used. This would insure against obtaining misleading information in subsequent employment of such gages in the investigation of inhomogeneity, coefficient of expansion, permanent growth or contraction due to thermal cycling, creep, and of pile irradiation effects in various materials.

Those who contemplate use of bonded wire resistance strain gages for work of a similar nature to that performed here are cautioned against using them for measurements of strains in the range 0.100×10^{-6} in/in, for temperatures greater than 60° C, and for long time creep measurements of very small magnitude unless satisfactory behavior of the gages themselves has been ascertained under these conditions. A report is now being prepared which will describe in detail some of the many and peculiar properties of SR-4 strain gages. The findings of an exhaustive literature research will also be discussed.

Irradiation Creep Experiment (C. L. Segaser, C. E. Stilson**, J. G. Morgan**).* The apparatus for determining creep of aluminum under irradiation[1,2]

[1] ORNL 171, E. B. Ashcraft, *Power Pile Division Quarterly Report for June, July, and August, 1948*, September 10, 1948.

[2] Description and drawings in ORNL 66, H. Etherington, *Power Pile Division Quarterly Report for March, April and May, 1948*, June 8, 1948, p. 38.

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is being assembled and calibrated. Methods for annealing the aluminum specimens and fastening thermocouples to them have been developed. The heat input required to raise the samples to the desired temperature has been determined. A preliminary measurement of the mean effective area of the bellows was made, and the area was found to agree within the experimental error (2%) with the manufacturer's specifications. An electrically heated model which will serve as a control is being assembled. Equipment for charging the apparatus into the pile has been constructed and partially installed. The model which will be used to perform creep tests on wires[3] is now being fabricated.

Circuits have been designed to record the following on a 6 point Brown Electronik Strip Chart Recorder: the emf's of the three aluminum-constantan specimen thermocouples, the elongation as measured by a linear variable differential transformer, and the pressure measured on a Baldwin-Southwork Division SR-4 pressure cell. The circuit for measuring the elongation has been tested and found to work satisfactorily. The exciting voltage for the differential transformer is obtained from an audio-oscillator supplying 5 volts at 3000 cps. The output is fed to an amplifier stabilized by the use of well regulated power supplies, cathode degeneration, and negative voltage feedback. A cathode follower stage is used to give a low impedance output which is fed to a vacuum thermocouple and then to the Brown recorder. Three elongation ranges 0.05, 0.1, and 0.2 inches, are provided by changing the feedback.

Linear Variable Differential Transformer Tests (C. E. Stilson**).* A Schaevitz Engineering type 18-LCT linear variable differential transformer was tested in the X-10 pile by a method similar to that used previously for the Peters transformer[4]. The Schaevitz transformer operated satisfactorily for five months. During the sixth month a circuit fault occurred in the transformer or in the inaccessible connecting leads within the fuel channel. A detailed examination cannot be made because of the high level of induced radioactivity.

Physical Changes in Uranium-Bearing Materials (R. G. Berggren, H. E. Robertson, J. M. Kincaid).* Two irradiations of uranium-bearing graphite in the thermal conductivity apparatus were continued into the present quarter. The

[3] ANL 4259, H. Etherington, *The Naval Reactor Division Report for the Period, December 8, 1948 to February 28, 1949,* March 15, 1949, p. 83.

[4] ORNL 66, H. Etherington, *Power Pile Division Quarterly Report for March, April and May, 1948,* June 8, 1948, p. 53.

* Sponsored by the Argonne National Laboratory. L. P. Hunter, consultant, from Westinghouse Electric Corporation. Progress was last reported in ANL-4259. A recent summary report by L. P. Hunter 'Thermal Conductivity of Uranium-bearing materials under Irradiation at High Temperatures' appears in TID-66.

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first was a sample molded of a mixture of petroleum coke flour, pitch and U_3O_8 fired to 2500° C and containing 7.72 g uranium oxide in 22 g graphite. During pile operation this sample maintained a temperature of 750-790° C. The differential thermocouples gave erratic emf readings initially. The readings then steadied for a period of time and rose to a value which indicated a 38 fold decrease in thermal conductivity at 43 KWH of fission energy dissipated per cm^3 of sample. At this time the thermocouples failed.

The second sample was a UNH-impregnated sample which was then pitch impregnated and graphitized at 2500° C (graphite density 1.61; 4.96 g uranium oxide per 23.9 g graphite). During pile operation this sample maintained a temperature of 675-750° C. The initial differential thermocouple readings were about 10 times larger than experienced in previous samples. These readings did not change appreciably during the irradiation which was conducted until thermocouple failure occurred at 24.3 KWH of fission energy dissipated per cm^3 of sample. Pitch impregnation might be expected to decrease the damage effect in graphite because the graphite is shielded from fission fragments by the carbon formed from the pitch. However, the high initial differential thermocouple reading may indicate a defective sample.

An attempt is being made to develop thermocouples which will permit a study of the later phases of the thermal conductivity changes during high temperature irradiation of uranium bearing graphite. Apparatus is being constructed which will permit studies at lower temperatures. Apparatus is also being constructed to measure dimensional changes during the irradiation of uranium bearing samples.

Thermal Conductivity of Graphite (J. G. Morgan**).* The effect on the thermal conductivity of several treatments used in preparing impregnated cylindrical graphite samples was studied. The apparatus used was similar to the one described previously[5,6], modified by discarding the insulating material used before and placing cylindrical Dewar over the sample and copper bar. The thermal conductivity of the copper checked that given in the literature within

[5] MonN-442, J. Butler and R. G. Berggren, Appendix 3, *Progress on High Temperature Thermal Conductivity Measurements*, December 16, 1947, p. 4.

[6] ORNL 66, R. G. Berggren and H. E. Robertson, *Power Pile Division Quarterly Report for March, April and May, 1948*, June 8, 1948, p. 20

* Sponsored by the Argonne National Laboratory. L. P. Hunter, consultant from Westinghouse Electric Corporation. Progress was last reported in ANL-4259.

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10%. The values of individual graphite samples when compared with the copper standard reproduced each other within 3%. Two of the graphite samples showed no change in thermal conductivity as a result of firing to 800° C; a third decreased by 7%. Impregnation produced much greater changes, 10-30%, sometimes positive, and sometimes negative. However, these changes are small compared to the changes observed on irradiation.

The Specific Heat of Uranyl Nitrate Hydrate Melts (J. C. Carpenter).* To assist the interpretation of the drying process in the impregnation of graphite with UNH, the specific heat of UNH hydrate melts was studied. A sample was heated to the desired temperature in a small flask, and was then plunged into water contained in a calorimeter at the desired temperature. The calorimeter consisted of a liter Dewar flask fitted with a stirrer. Temperature rises were measured on a Beckman thermometer. Only a partial correction was made for heat losses. There was some variation in composition of the UNH crystals used. Two samples which were analyzed yielded the results $UO_2(NO_3)_2 \cdot 6.2\ H_2O$ and $UO_2(NO_3)_2 \cdot 5.7\ H_2O$.[7] Determinations were made with UNH melt at 99, 89, and 79° C. An average specific heat of 0.31 ± .02 cal/gm deg C was obtained for the melt in the range 65-100° C. Some more careful calorimetric work is being done on material of known composition to determine the specific heat more accurately.

[7]Analysis by E. V. Kazlauskis, Analytical Group, Chemistry Division, Oak Ridge National Laboratory.

* Sponsored by the Argonne National Laboratory. L. P. Hunter, consultant from Westinghouse Electric Corporation. Progress was last reported in ANL 4259.

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SHIELDING

Reporting of Tungsten, Boron, Hydrogen Attenuation Measurements. C. E. Clifford, of the ORNL Technical Division, and W. K. Ergen, of NEPA, finished a series of memos on the bulk shielding test carried out last year by ORNL and NEPA, which involved B_4C, WC and hydrogenous material. These NEPA memos are listed below and will be summarized in the report ORNL 253, *Neutron and Gamma Attenuation through Boron Carbide and Tungsten Carbide*, by W. K. Ergen and C. E. Clifford. Work on this report is in progress. Participating personnel in the tests were: T. I. Arnette, ORNL; E. P. Blizard, ORNL; J. M. Cassidy, ORNL; M. S. Johnson, NEPA; J. G. Puckett, NEPA; J. C. Sellers, NEPA; H. P. Sleeper, General Electric; G. Thornton, NEPA; W. E. White, NEPA;

LIST OF NEPA MEMOS

STRM-18 - *Neutron Attenuation through Alternating Layers of WC and B_4C - (NEPA Run 7)*

STRM-19 - *Attenuation of Fast and Slow Neutrons through Boron Carbide - (NEPA Run 10)*

STRM-20 - *Neutron Attenuation through B_4C, Followed by WC - (NEPA Run 1, Gold Foil Data)*

STRM-22 - *Neutron Attenuation through Paraffin - (NEPA Run 8)*

STRM-23 - *Neutron Attenuation through B_4C without Hydrogenous Material - (NEPA Run 4)*

STRM-24 - *Neutron Attenuation through Alternating Layers of B_4C and Hydrogenous Material (Paraffin) - (NEPA Run 6)*

STRM-25 - *Neutron Attenuation through Alternating Layers of Hydrogenous Material and B_4C - (NEPA Run 3)*

STRM-26 - *Neutron Attenuation through WC - (NEPA Run 5, Tungsten and Gold Foils)*

STRM-27 - *Neutron Attenuation through WC - (NEPA Run 5, Threshold Detectors)*

STRM-28 - *Neutron Attenuation through WC followed by B_4C - (NEPA Run 2)*

STRM-31 - *Gamma Attenuation through WC and B_4C - (NEPA Runs 1, 2, 5, and 9)*

Design of Shield-Testing Facility for Materials Testing Reactor (W. K. Ergen, E. P. Blizard). A memo to M. M. Mann, *Shielding Facility at the Materials Test Pile*, was written by W. K. Ergen and E. P. Blizard on April 25, 1949, and was supplemented on May 16 by a memo to Mann from Ergen, entitled *Comments on Preliminary Layout of Experimental Shielding Facilities of Materials Testing Reactor by*

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C. L. Segaser. These studies demonstrate the feasibility of equipping the Materials Testing Reactor with a shield-testing facility. Conclusions are that the facility will require several features to be incorporated in the original reactor design, including a water tank access hole, hot sample storage in the building, and a movable cooled plate of fissionable material.

Core Hole Water Tank (C. Clifford, V. L. DiRito, J. G. Puckett). The external "lid" water tank for large scale attenuation measurements is now installed; instruments are in place.

A method has been developed which allows automatic mapping of gamma intensity in a given Z plane of the water tank. A graphite-walled air-filled ion chamber is moved about in the X, Y plane by means of two motors. The vertical motor drives continuously in one direction. The horizontal motor is a Brown balancing motor and is actuated by a signal from a null electrometer in parallel with a high impedance input Brown amplifier and motor control. This system causes the chamber to oscillate about a region where the signal is nulled. The recorder and part of the chamber carriage are shown in the accompanying photograph, Fig. 2.

The position of the chamber is recorded by means of a two way Brown recorder. Thus, for a given intensity, a gamma "isodose" curve can be plotted. As the chamber does not move within 18 in. of the bottom of the tank a complete curve is not obtained, but it has been assumed that the gamma flux is symmetrical about the source. Therefore only the isodose plots above the horizontal center line of the source are utilized. Measurements of the gamma intensity have been taken over the entire area of the tank at various distances to allow attenuation measurements through 14 ft of water (inner and outer tank full). From the isodose map for distances at 10 cm (Fig. 3) and other similar plots, the areas enclosed by the line drawn through the center of oscillation and the horizontal center line were obtained. These areas were then plotted versus the corresponding intensities (normalized to a constant pile power) for each distance. The resulting curves are shown in Fig. 4. A graphical integration under each curve should represent $\frac{1}{2}$ the total flux for a given plane.

Gamma background in the tank due to sources other than the radiation transmitted through the water-filled core hole was measured with a 2 in. Pb slab over the outside end of the core hole. This reduced the gamma intensity along the center line by approximately a factor of 10. By mapping the tank again and taking the difference between the 2 integrals for each plane (Fig. 5, Z = 60 cms) the effect of the background was eliminated.

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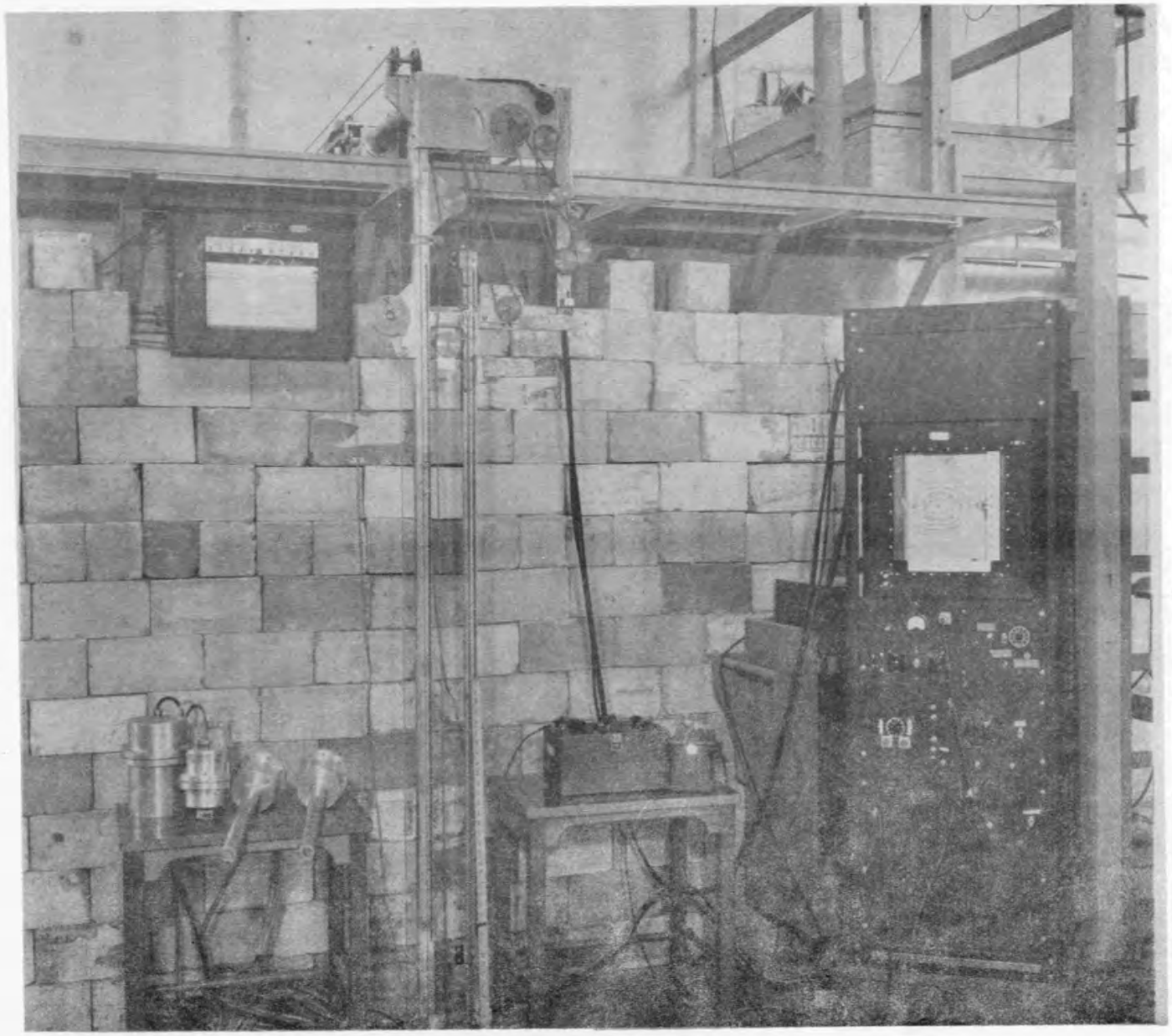

FIG. 2
LID TANK RECORDER AND CARRIAGE
EXTERNAL VIEW

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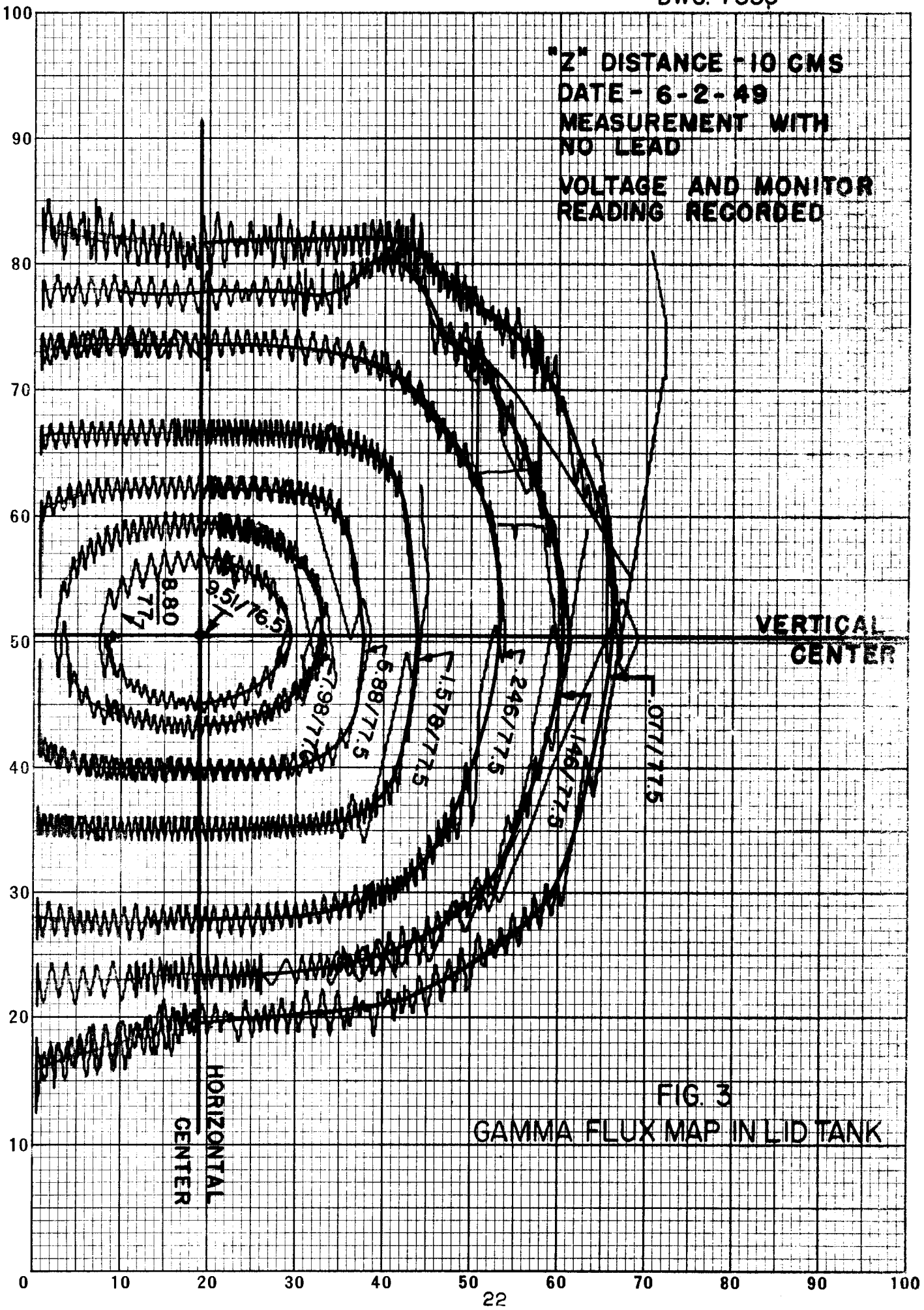

FIG. 3
GAMMA FLUX MAP IN LID TANK

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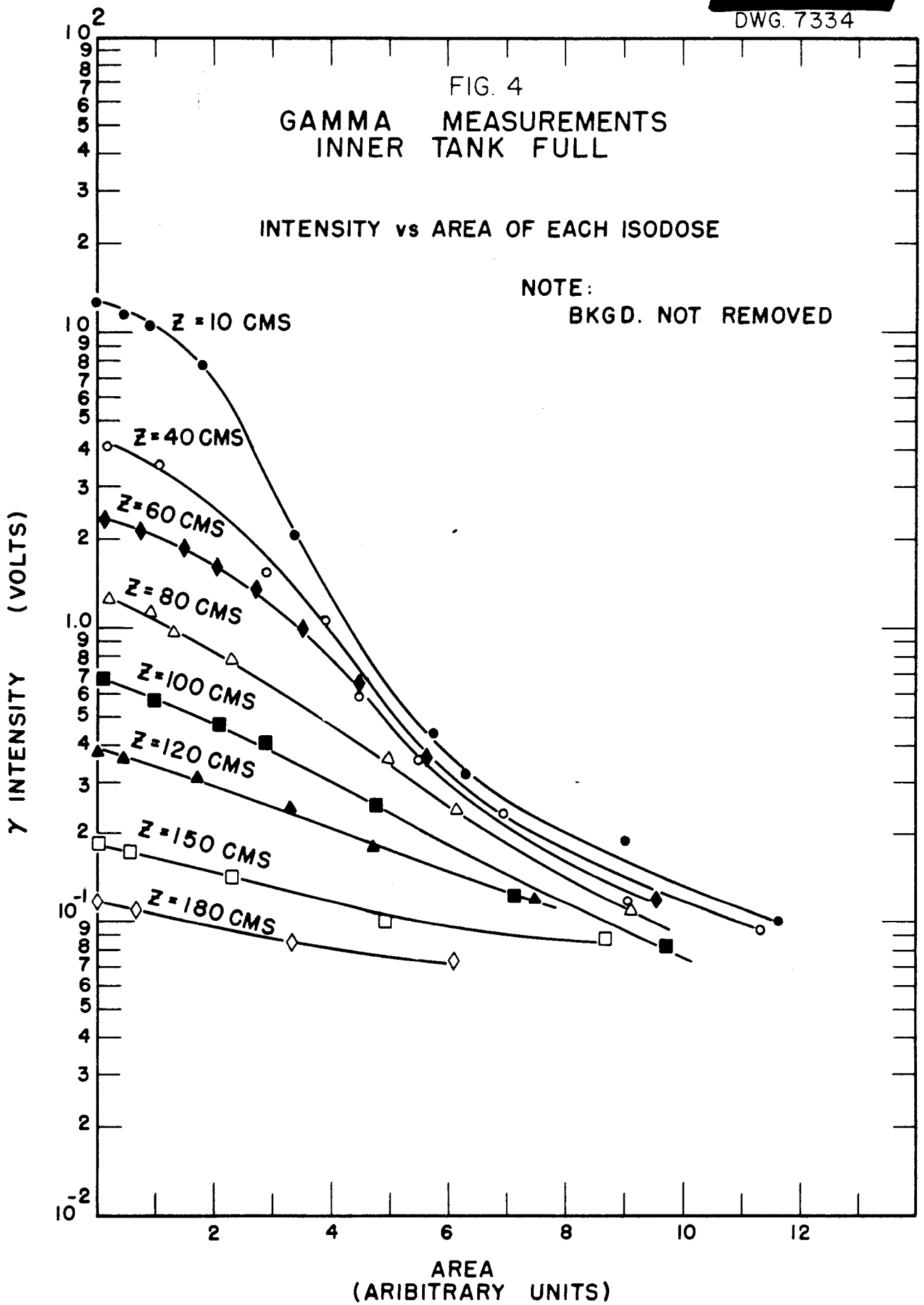

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The difference was taken point by point between the two integrations as shown in Fig. 5. An effort was made to estimate a boundary correction. Since several points appear to lie on a straight line in the log plot of intensity vs area, this curve was assumed to be exponential to infinity. In most cases the correction from the last measured point to infinity was less than one per cent of the total integration. Line A in Fig. 5 indicates the point at which the curve was assumed to become exponential.

Difficulties in mapping the background were encountered due to the small size of the Pb slab which allowed streaming around the edges. This produced a peak at each edge of the slab as well as the middle. A new background measurement will be obtained using larger Pb slabs (56 $\frac{1}{2}$ in. x 66 $\frac{1}{2}$ in.) ten of which are now under construction to be used in later Pb and water experiments. An integrated attenuation curve is not presented pending completion of background measurement.

X-10 Reactor Studies. N. F. Lansing has been temporarily assigned to assist Dr. A. M. Weinberg in making a study of the feasibility of various methods for increasing the central flux of the X-10 reactor.

Calculations of Flux Distributions in Al-H_2O Mixtures (F. H. Murray). The analytical methods of ORNL 218 were applied to calculations of flux distributions which had been measured by Hill and Roberts at this Laboratory.

The Boltzmann equation is set up and solved with the following assumptions:

1) The oxygen cross section is equal to one barn in the high energy part of the spectrum (above 6 Mev).

2) The macroscopic cross section for hydrogen in pure water was assumed given by 0.492/E.

3) In part of the high energy region, neutrons are assumed to make only grazing collisions with hydrogen, losing energy but with negligible angular deflection; at lower energies the slowing down process is considered to be ordinary aging.

Computations were made for the quantity z^2nv at energies somewhat above thermal energies; representing this quantity in the form C exp(-kz) where k varies slowly with z, it was found that for pure water, the calculated average of k between 60 and 90 cm was about 16% too small. For one volume of Al and two volumes of H_2O, k was nearly 5% too small; for equal volumes of Al and H_2O the error in k was inappreciable. It is necessary to observe that certain approximations made in the calculations of some definite integrals introduced errors which can be corrected by more lengthy numerical calculation. The formula for

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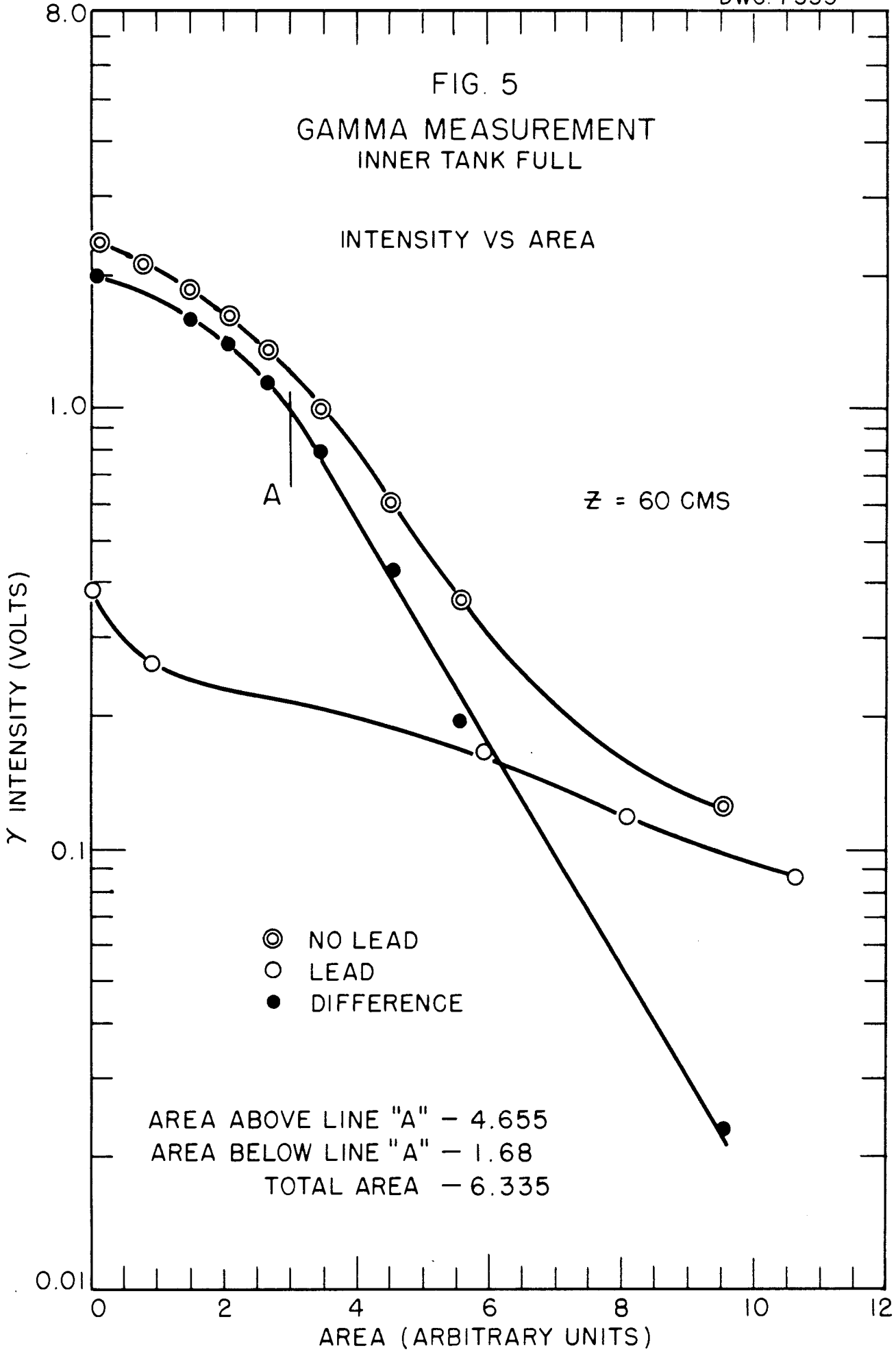

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the fission spectrum was the best available when the original calculations were started, but differs somewhat from more recent results.

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