9/6/46

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PHYSICS DIVISION

REPORT FOR MONTH ENDING AUGUST 31, 1946

L. W. Nordheim, Director

Date Received: 9-6-46

Date Issued: 9-6-46

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Physics Section I

A. H. Snell, Section Chief

Total technical personnel (including supervision)..... 9

Problem Assignment Number	Subject	Status	Man-months of Effort Report Per.	Man-months of Effort Next Per.
PX1-7	C^{14} Production	Active	2	$1\frac{1}{2}$
PX6-4	Neutron Temperature in Pile	Inactive	0	0
PX8-1	Gamma Ray Spectra	Inactive	0	0
PX8-2	Photoneutron Sources	Inactive	0	0
163-X39P	Service Flux Measurements	Active	1/2	1/2
PX8-4	Gamma Energy per Beta	Active	1	1
PX5-22	Critical Experiments	Active	$3\frac{1}{2}$	2
	Neutron Decay	Active	2	1
		Total.....	9	6

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PX1-7 - C^{14} Production - (Norris, Arnette)

Further counting of mass-spectroscopically analyzed samples has supported the half-life value of about 6000 years for C^{14}. The liquid factory has continued its steady operation. An effort has been made to obtain some C^{14} of high isotopic purity by extracting the bulk of the more impure CO_2 from the gas stream before it passes over the hot copper oxide, and then extracting again from the gas stream after passage over the copper oxide. The latter sample should contain the C^{14} which came from the ammonium nitrate solution as CO, and may be quite pure $BaC^{14}O_3$ if the C^{12} in the factory does indeed come from incoming CO_2. Observations to date are that very little precipitate is forming in the second bubbler; its specific activity has not yet been measured.

PX5-22 - Critical Experiments - (Goodman, Mann, Slawson)

Tests and measurements continued on the 15 cm hexagonal lattice intended as a mock-up of the heterogeneous pile. As explained last month, the very high critical mass ($>$ 3478 g) required for the assembly in which each fuel tube was surrounded with 1 cm of paraffin was explained largely by the blocking effect of the paraffin. During the past month the UO_2F_2 has been dissolved in light water and different annuli have been used. Typical results follow:

	Air Annuli	D_2O Annuli
Critical Mass as measured	2974 g	2444 g
Corrected for control rod, various holes, etc.	2742 g	2283 g

These figures apply to the case in which the experimental recesses are present in the side reflector.

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The effect of the 4" central thimble has also been investigated. With the empty thimble replaced by a fuel tube, with D_2O annuli throughout, the "corrected" critical mass dropped from the value 2283 g quoted above to 1966 g.

Other measurements have been made upon the relative worths of the thimble, the control rod port, and the poison rods in terms of peripheral fuel. The temperature coefficient has been measured. The control rod has been calibrated in terms of peripheral fuel. Poisoning has been studied as a function of radial position, and central fuel has been evaluated in terms of peripheral fuel. Neutron distribution measurements have been made.

PX8-4 - Gamma Energy per Beta - (Barker)

Work is continuing on the FP 54 and the calibration of the volumes of the ionization chambers.

Neutron Decay - (Shrader, Saxon)

The collecting system and the electron multiplier have been set up on the north face of the pile, and preliminary counts have been taken in trying to evaluate perturbing effects. The main perturbing effects are gamma rays from the C^{14} factory nearby and from the pile. Counts taken with various gains with and without lead and boron shields interrupting the beam, and with and without accelerating voltage have indicated that there is not much left for neutron decay. However, we are still far from giving even a preliminary answer to the question of the existence of an effect.

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PHYSICS SECTION II
A.M. Weinberg, Chief

Age of Fission Neutron in Beryllium - R. Arnette and H. C. Schweinler

The age of fission neutrons in beryllium has been recomputed. The ages from variable upper energy to .03 ev (including first and last collision terms) are given in the accompanying table.

E	0.1	0.5	1.0	1.5	2.0	3.0	4.0	5.0	6.0	7.0	8.0	Mev.
(E → .03ev)	60.0	72.0	80.6	87.5	93.9	105.8	117.6	129.7	141.8	153.8	165.4	cm^2

(The cross-sections used in these calculations are those of MUC - HHG-7, with the following interpolated or extrapolated values:

E	$10-10^2$	$10^2 - 10^3$	$10^3 - 10^4$	5.10^6	6.10^6	7.10^6	8.10^6	ev
σ	5.9	5.7	5.4	1.50	1.37	1.27	1.20	b)

Upon averaging with respect to the fission spectrum of LA - 84, the age of fission neutrons is found to be 96.5 cm^2. This agrees well with an earlier calculation of M L Goldberger (CF - 3403, p. 43 ff.), which gave $\tau = 98\ cm^2$

Interpretation of Critical Experiments - A.M. Weinberg

There has been a gross discrepancy between calculated and observed critical masses in the light water - heavy water systems now being studied by Mr. Goodman's group, the previously calculated critical masses being about 1 kg. too low.

A recalculation of these systems has been carried out, and the origin of a major part of the error has been found. It consists in the fact that the diffusion area L^2, had been erroneously calculated as though the pile were homogeneous. Actually the piles are heterogeneous, and it is necessary

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to take account of the disadvantage factor in order to compute L^2.

New cell calculations for the 4.8 gm/li. system (which has been measured) give a value of $L^2 = 95\ cm^2$ instead of the old value $L^2 = 58\ cm^2$. The Laplacian for the system is therefore $-2.83 \times 10^{-3}.\ cm^{-2}$ instead of -3.52×10^{-3}. Calculations of the reflector saving are now underway to check whether the new Δ is sufficiently small to account for the 1900 gm. critical mass which was observed.

A further discrepancy which had been noticed previously was the increasing trend of the ratio observed critical mass: calculated critical mass as the lattice spacing increases in the pure P-9 systems. Again we believe the use of the homogeneous approximation is responsible for this. As the lattice spacing increases the heterogeneous L^2 becomes increasingly larger than the homogeneous; this is in the direction to remove the discrepancy between calculation and observation.

Slowing down in heavy-light water mixture - M. E. Rose

Consideration has been given to the problem of calculating the slowing down length in heavy water-light water mixtures. The method used is that of the transport theory and the energy dependence of mean free paths is represented by a power series in which a suitable number of adjustable constants can be inserted. These calculations have been carried out for an arbitrary mixture. Numerical application remains to be carried out.

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Critical Mass Calculations - E. Greuling

Two group calculations of the neutron densities and critical dimensions of the following cylindrical cored piles were made:

(A) Core : 25 - Aluminum Alloy plus H_2O

30.8 gms. of 25 per liter of core.

Volume of Al/ Volume of H_2O = 1.03

$L^2 = 4.69\ cm^2$, $\tau = 76.7\ cm^2$, R = 1.56

Finite Loaded Reflector:

(25 - Al - H_2O) Lattice in P-9

3.0 gm of 25 per liter of reflector

Volume of H_2O / Volume of D_2O = 0.07

$L^2 = 100\ cm^2$, $\tau = 85\ cm^2$, k= 1.52

(B) Core : Same as (A)

Infinite P - 9 Reflector:

$L^2 = 10^4\ cm^2$, $\tau = 120\ cm^2$

(C) Core: Same as (A) and (B)

Finite P-9 Reflector:

Outer radius = 70 cm.

For all three cases the height of the pile was taken to be one meter with no reflector at top or bottom.

Below is tabulated the core radius, a, critical mass μ_{25}, reflector thickness, and the ratio of maximum thermal neutron density in the reflector to the density at the center of the core, n max / n_o.

Pile	a in cm.	μ_{25} in Kg	Reflector Thickness	n max / n_o
A	11.4	1.26(core)+ 1.20 (Ref.)	26.1	1.13
B	13.0	1.63	∞	1.76
C [redacted]	13.3	1.71	56.7	1.69

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Physics Section III

E. O. Wollan, Section Chief
S. De Benedetti, Associate Section Chief

Total Technical Personnel(including supervision).....9

Problem Assignment Number	Subject	Status	Man-Months of Effort Report Per.	Man-Months of Effort Next Per.
PX6-1	Pile Oscillator	Active	½	1
PX10-8	Neutron Diffraction	Active	½	1
PX10-16	Characteristics of Fission Products and Neutron Induced Activities	Active	1	1
PX10-19	Capture Gamma Energies	Active	1½	1
PX10-22	Short Lived Isomers	Active	1	1
	Ranges of Delayed Neutron Emitters	Active	1½	1
	Studies of Prompt Fission Neutron Emission	Active	1½	1
	Supervision and Report Writing	Active	1	1
		Total.....	9	8

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Correlation of Delayed Neutron Emitters from U^{235} with Fission Fragment Range (Wollan, Burgy, Rose)

A run has been made on the range of the fission fragment (reported by Snell as I^{137}) responsible for the 22 second delayed neutron activity. With this activity, which is the easiest to observe, the range can be determined with considerable accuracy ($\sim$1%). The observed activity was reduced by a factor of 2 with a change in pressure inside the rabbit from about 29.8 to 30.2 cm Hg. The distance from source to receiver being 2-1/16" and the temperature being ca.25° C, one obtains a mean range in air at 76.0 cm, 15° C, of 1.98 cm. From the data of Finkle, Hoagland, Katcoff and Sugarman, CC-2076, relating range to mass number of fission fragments, it is possible to obtain the mass number corresponding to the 22 second delayed neutron activity. The value obtained is 133 which is not in agreement with Snell's value, 137. The work of Finkle et al was done with aluminum absorbers and the range in Al converted to air on the assumption that the relative stopping power of Al is the same for fission fragments and α particles. A difference of 3% would account for the discrepancy between Snell's and our results. To clear up this point, we plan to make observations with Al absorbers. We have modified our technique so that we can observe at a shorter time after bombardment and hope to get data on the range of the fission fragment responsible for the 4.5 second delayed neutron activity, and also that for the 56 second activity.

PX10-22 Search for Short Lived Isomers (De Benedetti, McGowan)

The origin of the delayed coincidences previously reported in connection with W^{187} source was studied. It was found that these correspond to a metastable state of half-life around one microsecond. Special tests were made to insure that the observed effect was not due to delays introduced

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by the Geiger counters. For this purpose we used a beam of β rays which traversed both counters giving about 1000 immediate coincidences per minute; when the shortest electronic delay was introduced ($\sim 2\ 10^{-6}$ sec), the coincidences due to the β beam were no more recorded, and only the random coincidences were counted.

Absorption experiments are under way in order to study the energy of the new metastable transition and its connection with the other radiations from W^{187}.

Mechanism of Emission of Prompt Fission Neutrons (De Benedetti, Francis)

The electonic circuit for this experiment is being studied. Two pulse height selectors and a fast ($\sim 2\ 10^{-7}$ sec) coincidence circuit have been assembled and seem to work satisfactorily.

PX10-16 Characteristics of Fission Products and Neutron Induced Activities (P. W. Levy)

2.7 Day Au^{198}

The 180° β ray Spectrometer, which was recently equipped with a new thin window of 1.3 mg/cm^2, has been used to again determine the shape and end point of the β ray spectrum of 2.7 Day Au^{198}. In order that back scattering and absorption in the source be made as small as possible the source was prepared by irradiating a gold foil .2 mg/cm^2 in the Clinton Pile and then supporting it in the spectrometer on a film of Zapon $<<$ .1 mg/cm^2.

Comparison of the Kurie plots calculated for this new data and for data obtained with a source 20 mg/cm^2 reported some time ago indicate that the effect of the thick source is to cause an apparent increase in the intensity at low energies. Also, the Kurie plot for the improved source is linear over a larger region than the plot obtained from the old data.

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Kurie Plots derived from both sets of data give an end point of .97 Mev. The end point determined by inspection of a plot of intensity divided by $H\rho$ against $H\rho$ would indicate that the end point is .91 Mev. Since the purpose of the Kurie Plot is to enable one to avoid the necessity of making the end point determination by inspection the value of .97 Mev is probably the correct one.

Superimposed on the continuous spectrum is the K, L, and M conversion lines of a γ ray of .41 Mev. There is also an indication of a conversion line at $H\rho \approx 1400$ in the data obtained only from the thin source. Work is planned to definitely ascertain if this conversion line accompanies the 2.7 day activity.

Neutron "Age" Measurements (Wollan, Hill, Roberts)

A program is being started to measure some of the important constants of pile moderator materials. We are planning first to make measurements of neutron "age" in Be, BeO, water, and graphite, the latter being included primarily as a check on the other measurements. Before these measurements can be started it appears that it will be necessary to rebuild the thermal column.

PX10-19 Energies of Capture Gamma Rays (Moak, Burgy)

The stabalizer for the magnetic field current has proved unsatisfactory and new circuits are now being built.

PX10-8 Neutron Diffraction (Shull, Wollan)

We are investigating the possibility of making reliable measurements of the absolute integrated intensity from powdered crystals. The problem is made difficult by the low intensities available in the diffracted beam and hence the need for long BF^3 counters.

PX6-1 Pile Oscillator (Pomerance)

The work on the pile oscillator is now being taken over by Herbert S. Pomerance.

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Physics Section IV

L. B. Borst, Section Chief

S. Bernstein, Associate Section Chief

Total technical personnel (including supervision)..... 8

Problem Assignment Number	Subject	Status	Man-months of Effort Report Per.	Man-months of Effort Next Per.
PX10-17	Fissionability Studies	Active	3	2
PX10-8	Neutron Diffraction	Active	2	1
PX10-15	Photoneutrons from Fission Products Plus P-9	Active	2	1
	Plutonium Project Record	Active	1	1
		Total.....	8	5

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PX10-17 - Fissionability Studies

Thermal Fission of U^{238} - (Osborne)

Cooperative research has been carried out with members of the staff of K-25 in an attempt to evaluate the isotopic ratios in what are known as "Q" and "Super-Q" materials. The method of photographic exposure has proved satisfactory in evaluating "Q" material at a concentration of one part U^{235} in thirty thousand parts of U^{238}. A sample of "Super-Q" has been studied and measurements indicate an extremely small concentration of U^{235}. Estimates based on other considerations indicate that the concentration is likely to be in the region of one part in two hundred thousand. Since the concentration is not known with any accuracy and will be difficult to evaluate, the tracks observed may be due to either fission of U^{235} remaining in the sample, or due to thermal fission of U^{238}. Assuming that all tracks are attributed to U^{238}, the cross section for thermal neutrons cannot be larger than 1 millibarn ($10^{-27}/cm^2$).

Fissionability of UX_1 - (Osborne and Ceveyou)

A sample of highly purified UX_1 has been prepared by members of Mr. Stoughton's group in the Chemistry Division. The sample contained .05 of a microgram of UX_1 (Th^{234}). Exposures were made against fission plates at various times during the past two months. The data obtained indicate no observable cross section in UX_1 since no tracks were observed within a few hours of the chemical separation. A rapid growth in a fissionable specie appears to occur during the first day. The number of

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fissions for a given exposure goes through a maximum at two days and slowly diminishes with an apparent half-life of a few months. The latter part of this curve is interpreted to imply that U^{234} has a real fission cross section, and that the short-lived fissionable material is decaying with the 24-day period of UX_1. Two intermediates between UX_1 and U^{234} are UX_2 of 1 minute life and UZ, an isomer, having a branching ratio of about .1%, which has a half-life of about seven hours. The growth curve would imply that the fissionable specie is not UX_2 but is in some manner associated with UZ.

Two samples have since been prepared consisting of approximately 1 microgram of UX_1 and a chemically separated protoactinium sample which should contain the UZ in equilibrium with the UX_1 sample. Preliminary data only are available at present. The UZ sample appears to go through a maximum which would imply that the fissionable specie is a second generation product. A beta ray curve is being obtained on the UZ fraction. The counting rate increases for the first nine hours and then eventually decays with a period of approximately eight hours. This evidence would indicate that the fissionable specie is a second generation product of the protoactinium fraction.

The UX sample has not been studied in sufficient detail to determine the growth and decay curves.

<u>Fissionability of Pu^{240}</u> - (Schofield)

Difficulties with the mass spectrograph have prevented progress on this problem. Since Mr. Schofield will not be able to complete the

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work before leaving the project, the problem is being temporarily suspended.

PX10-8 - Neutron Diffraction

Xe^{135} - (Hasbrouck)

The chemical difficulties associated with the separation of an appropriate sample of Xe^{135} in I^{135} are thought to have been solved. In this process a uranium slug is dissolved in HCl with carrier iodine. The uranium is oxidized to uranyl with sodium bichromate. In this step the iodide is oxidized to iodine and is distilled from the uranium by steam. The iodine is carried over with steam to a solution of the paladium chloride saturated with sulphur dioxide. The iodine is reduced to iodide but paladium iodide does not precipitate well in the presence of excess SO_2. It has been found possible to achieve good precipitating conditions by sweeping out the excess SO_2 with an air stream. With this procedure excellent precipitates have been obtained, containing as much as 90% of the tracer iodine used in preliminary runs. An attempt will be made to separate tracer amounts of I^{135} - Xe^{135} from a slightly active slug. At the conclusion of this run an attempt will be made to make the full scale experiment.

PX10-15 - Photoneutrons from Fission Products Plus P-9 - (Bernstein, Slattery)

A project report of the results obtained on 25 plus P-9 has been prepared.

A considerable fraction of the time during the past month has been spent in replacing our troublesome 30 μ sec. resolving time amplifier with a new 3 μ sec. amplifier.

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We have accumulated data on 23 fission products plus P-9 with our 143 mg sample of 23. This data is now being analyzed.

Mr. Simon of the Power Pile Division is looking after the drafting and shopwork in connection with repeating the experiment for the system 25 plus Be.

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Physics Section V

H. W. Newson, Section Chief

Total Technical Personnel (including supervision)..... 8

Introduction (H. W. Newson)

Reports on the stage of development of various instruments are given below. In addition to this work considerable time of the section has been devoted to general considerations of control problems and pile construction features. A report now in preparation will discuss the problem of control in highly enriched piles.

Ionization Chamber Development (F. C. Armistead)

Attention has been given chiefly to the "d log r" or "period" circuit (mentioned in previous reports). This device has been adjusted to a satisfactory balance and is going under test in conjunction with the pile simulator, using simulator output as "period" circuit input signal.

Model Servo System (H. A. Straus)

The amplifier for the 6 channel recorder mentioned in last month's report has been completed and is now under test. The D.C. amplifier for use in the model servo system is now under construction. The gear train for the model servo is under construction. Mathematical study of the model servo system continues.

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Linear Amplifier (W. H. Jordan)

The first of 12 linear amplifiers has been completed and is now being tested. The performance seems to be as expected in nearly all respects. Minor troubles with pickup from the heaters was encountered but can be reduced to an acceptable level by shielding and filtering.

Scalers (W. H. Jordan)

Fairly extensive tests have been made on a commercially obtainable scaler which uses the Higgenbotham circuit. It seems to perform very well and should be reliable. It has a resolving time of about 3 microseconds so that fairly high counting rates can be attained by connecting two scalers in series. For very high counting rates another commercial scaler will soon be available, this one having a resolving time of 0.1 microseconds.

Electronic Pile Simulator (P. R. Bell)

The basic electronic pile simulator has been operating for some time. Changes have been made to simplify the design and to increase its stability. A Brown electronic recorder has been converted to read the output of the instrument giving a satisfactory record of all but the very fast part of the transient when δk effective is changed.

The computer for the Xenon effect will contain both the Iodine and Xenon periods. The circuit is partly constructed and the individual units have been tested. The condenser and amplifier to be used shows an internal leak giving a period of about 100 hours which will satisfactorily reproduce the required periods. This part of the pile will probably be finished before September 1.

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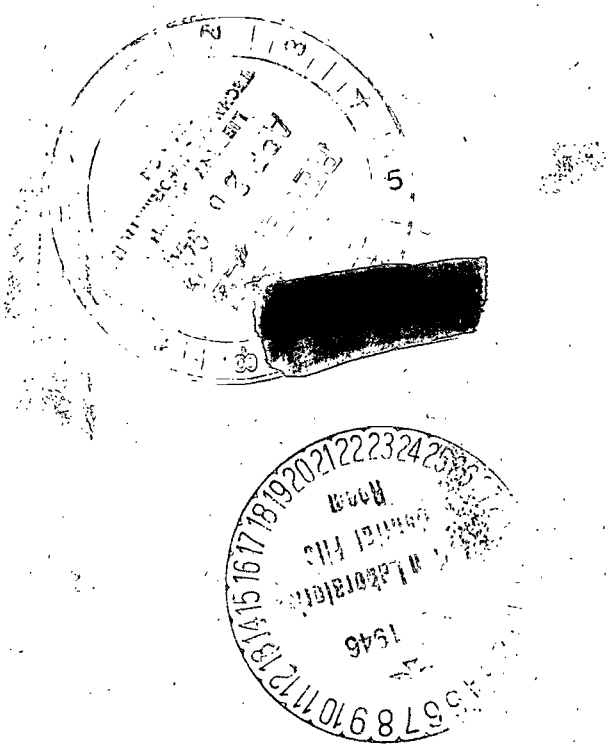
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