ORNL Reports

Mon P-130

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M.I.T., Lexington Project		6/17/48
Attn: Prof W. Whitman		

AEC RESEARCH AND DEVELOPMENT REPORT

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MonP-130

Contract No. W-35-058, eng. 71

PHYSICS DIVISION

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REPORT FOR MONTH ENDING JUNE 30, 1946

L. W. Nordheim

[redacted] information affecting [redacted] meaning of the Espionage Act, [redacted] prohibited by law.

Date Received: July 12, 1946

Date Issued: July 15, 1946

[redacted]

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Problems connected with the new pile has continued to form a major part of the activities of the division. In the critical experiments work on pure heavy water systems has been substantially completed. The agreement with theory is good and may still be improved by refinement of the calculations. The trends of critical masses and of the temperature coefficient with concentration of uranium agree with predictions. At present a mock-up of the actually proposed heterogeneous pile is being investigated. The critical mass turned out to be considerably higher than expected. This may be due to various factors, such as a blocking effect by the disposition of the hydrogen containing paraffin in a layer around the active material, change in reflector activity and other effects. Further studies are in progress.

The characteristics of a variant of the design, namely Wigner's light water core pile, are now being studied by the theoretical group. In this pile the active portion consisting of alloy plates with ordinary water cooling channels, is concentrated without any P-9 in between, but a heavy water reflector is retained.

The production of photoneutrons in P-9 from fission products has been further investigated. A new quite strong component with half life of 2.4 seconds has been found. A theory has been developed by the theoretical group, which permits the evaluation of the (γ, n) effect in a large pile from the experiments with a small volume of P-9. It is now possible to predict the neutron background from this effect for the new unit.

Considerable work has been done on the period monitor, and on an ion-chamber design for control purposes. Special attention has been given to the background in the ion-chamber in order to develop an instrument that [redacted] be sensitive over a very large range of variation in the neutron

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flux.

The pile simulator has been completed and will be used in studying servo control systems and the behavior of the pile under reactivity fluctuations.

A long range pile study is being set up under G. Young. At present a report is being prepared on request on the economic prospects of atomic power at the present time.

A recheck on the lifetime of C^{14} has revealed some discrepancies that make the previously accepted value subject to doubt. It seems at present that the lifetime is only 6000 years. In the field of diffraction the relative phases of the nuclear scattering by Ca and C have been investigated. It has been found by the comparison of the intensity of different order reflections, that Ca and C must have the same phase.

The short lived isomer, reported in the last report, has been definitely indentified as following the disintegration of Hf^{181}. It belongs, therefore to Ta^{181}.

The pile oscillator technique has been improved by replacing the galvanometer and synchronizer circuits by an integrator circuit similar to a counting rate meter. The ease in operation has considerably improved.

A method for assaying samples with unknown uranium contents or enrichment has been developed, using the delayed neutrons after irradiation in the pile, as indicator.

In the past period Dr. Chauncey Starr from the Tennessee Eastman Company joined the Division. He will start to build up a group working on the physics of solids.

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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.	Next Per.
PX1-7	C^{14} Production	Active	2	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	$3\frac{1}{2}$	$3\frac{1}{2}$
	Neutron Decay	Active	2	2
		Total......	9	9

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

The factory ran steadily during the past month, oxygen being flooded into the box around the centrifugal pump in another attempt to see if an inward air leak has been the source of the inactive carbon. There are reports that the precipitates have been less bulky, but they have not yet been assayed, so we do not yet know if the specific activity is higher than usual.

A mistake was found in the computation for the half-life as quoted last month. The new value is 6100 years. It is hard to reconcile this with the value of 20,000 years found by Langsdorf and Purbrick, especially inasmuch as work with photographic plates by Goldhaber and by Floyd and Borst has indicated that about all of the N^{14} cross section is taken care of by the (n,p) reaction; in spite of this, we do not see anything wrong with our determination.

Determinations of the activity of the gas stream in the factory before and after passing through the extraction train have shown that less than 2% of the activity escapes entrapment.

If the new value of the half-life is correct, it would seem that we are collecting C^{14} from the factory with rather poor efficiency - assuming the correctness of Scalettar's estimate of the yield. This conclusion seems to be supported by the records of the time required to make the two samples which were mass-spectroscopically analysed, for with these samples we can work in milligrams without involving the half-life. The obvious measurement now is to check the old solution for C^{14} content.

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The improved standardization against UX which was used for the half-life determination has resulted in the realization that we have made more C^{14} than we thought. The assayed samples total 134 millicuries.

Neutron Half-life - (Shrader, Saxon)

The collimator is nearly complete, and it is expected that the apparatus will be assembled at the pile in a few days. It should not take long to see whether or not proton counts are obtained, and to examine their dependence on the presence of slow neutrons and of accelerating voltage.

Gamma Energy per Beta - (Barker)

The new ionization chamber with polystyrene insulation seems to be working well, inasmuch as it gives intercalibrations of the high resistors in good agreement with those obtained from an external network. A preliminary curve was run on the Co^{60} gamma rays for orientation purposes.

Critical Experiments on Heterogeneous Reactor - (Branch, Goodman, Scalettar, Slawson, Snell)

The first part of the experimentation is considered complete, and is being written up. Meanwhile, the mock-up of the proposed heterogeneous pile has failed to go critical with 3500 g of U^{235}. This mock-up, however, is different in two rather minor respects from the present design of the Technical Division. In the first place, there is a little too much light hydrogen; in the second place, the light hydrogen is probably unfavorably distributed in an annulus 1 cm. thick around the enriched uranium. A foil measurement of the disadvantage factor, however, shows that the neutron density in the paraffin is only 18% higher in the paraffin than in the uranium solution. These factors are currently being studied in an effort to see why so much U^{235} is required for criticality.

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Physics Section II

A. M. Weinberg, Section Chief

Total Technical Personnel (including supervision).............. 12

<u>Diffusion and Production of Neutrons by Photon in D_2O</u> (E. Greuling, P. O. Levy, M. C. Schweinler and H. Soodak)

The neutron yield resulting from the photo-disintegration of deuterium in heavy water was calculated using the following simple approximations:

(1) Every scattered photon of energy greater than 2 Mev suffers negligible change in direction. Actually 4 Mev photons originating from a source placed at the center of a sphere of heavy water are Compton scattered by less than 30° if their resulting energy is above the γ - n threshold, 2.2. Mev.

(2) The differential cross section for scattering of photons of energy E' into the energy range between E and E + dE is independent of the lower energy E.

$$\sigma(E' \rightarrow E)\,dE \approx \frac{2\pi r_0^2 N_e}{E'^2}\,dE, \; 4.3 \leq E \leq E' \leq 8 \qquad (1)$$

where $r_0 = e^2/mc^2$, N_e = electron density and E' & E are the incident and scattered γ ray energy in mc^2 units. The maximum deviation from Equation (1) is 9% which occurs for $E' = E_0 = 8$ and $E = 4.3$.

(3) The total Compton cross section as a function of γ ray energy E is approximately given by

$$\sigma(E) = \pi r_0^2 N_e (1.6/E + .178). \qquad (2)$$

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This approximation is good to within 2% in the energy range 4.3 to 8 mc^2.

The inhomogeneous integro-differential equation describing the steady state can be solved exactly using the three above approximations.

$$\frac{\partial F(r,E)}{\partial r} + F(r,E)\cdot\sigma(E) = \int_{E}^{E_0} dE' F(r,E')\,\sigma(E'\to E) + e^{-\sigma(E_0) r}\,\sigma(E_0\to E) \quad (3)$$

Here F(r, E)dE is the number of photons of energy E to E + dE that have suffered at least one collision crossing a spherical surface of radius r outwardly.

The solution of Equation (3) obtained by Laplace transform methods is:

$$F(r,E) = \sigma(E_0\to E)\, e^{-\sigma(E_0) r}\, r\, F[1-\alpha; 2; -(\sigma(E)-\sigma(E_0)) r] \quad (4)$$

Here $F(a; b; x) = \sum_{n=0}^{\infty} \frac{\Gamma(a+n)}{\Gamma(b+n)} \frac{\Gamma(b)}{\Gamma(a)} \frac{x^n}{n!}$ is the confluent hypergeometric series or the so-called modified Kummer function. The constant α is determined by the approximate equations (1) and (2).

$$\alpha = \sigma(E'\to E) \Big/ \left| \frac{d\sigma(E')}{dE'} \right| = 1.25 \quad (5)$$

The number of neutrons appearing per second inside a sphere of radius R per unit γ ray source strength was obtained by adding to the first collision yield, $\sigma_{\gamma n}(E_0)\left(\frac{1-e^{-\sigma(E_0) R}}{\sigma(E_0)}\right)$ the number of neutrons produced by second and higher collisions.

$$\int_{E_1}^{E_0} \sigma_{\gamma n}(E) \int_0^R F(r,E)\, dr\, dE \quad (6)$$

Dropping terms beyond the third in the series expression for $F[1-\alpha, 2, -(\sigma(E)-\sigma(E_0)) r]$ introduced an error of less than 0.2%.

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The numerical results are summarized in the following table:

D_2O Sphere Radius	Neutron Yield From 1st Coll.	Neutron Yield From 2nd and Higher Coll.
25 cm	.183%	.014%
∞	.336%	.078%

These results have been used by Preston and Bernstein to correct their observed photoneutron yield in a sphere of D_2O to the yield in an infinite medium.

Pile Poisoning by Xe and Sm (H. C. Schweinler and P. O. Levy)

The effect of Xe and Sm upon the operation of a spherical pile having k_o = 1.61, L^2 = 67 cm^2, and τ = 85 cm^2 has been computed. (The constants are those of the proposed high-flux pile). In this calculation the central flux was assumed to be 4 x 10^{14}, and the depletion of 25 was neglected. The poisoning of Xe and Sm at equilibrium produces an average $\delta k_{eff}/k_o$ of -.045. Of this the Xe and Sm contributions are -.037 and -.008 respectively.

The $\delta k_{eff}/k_o$ from Xe and Sm poisoning has also been computed for several times after shut down. Simple statistical weight theory was used in making these calculations, hence they are slightly optimistic. The results are

Time after shutdown	0	20	40	80 min.
$\delta k_{eff}/k_o$	-.045	-.089	-.124	-.182

The Sm contribution is practically constant at -.008 over this short time interval.

The maximum amount of Sm which can grow in after shut down would produce a local $\delta k_{eff}/k_o$ of -.036. Since this is almost

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The increasing percentage difference as one goes to lower concentration is an effect of the lattice structure and will be partially eliminated when this correction is applied.

The contributions to the temperature coefficient of the η - effect and the Doppler effect are completely negligible in these lattices. The most important contributions arise from the 1/v law and the expansion coefficient of the D_2O, the former being greater at low concentrations and the two being equal at 10 gms./liter. The calculations are based on a bare pile theory which has been shown to give results in good agreement with the more rigorous perturbation calculation. The change in reflector effectiveness is taken into account by considering the change in the pile Laplacian necessitated by a given change in reflector constants (on a thermal theory). These considerations lead to the following expression for the temperature coefficient of the pile: -

$$\alpha \equiv \frac{\delta \frac{\Delta k}{k}}{\delta T} = -\left\{ \frac{1}{2T}\frac{\mu^2}{\mu^2+\kappa_s^2} + \left(\frac{\mu^2}{\mu^2+\kappa_t^2} + \frac{\mu^2}{\mu^2+\kappa_s^2}\right) 2\beta \right\}$$

$$- A_{ref} \left\{ \frac{\mu^2}{\mu^2+\kappa_t^2} + \frac{\mu^2}{\mu^2+\kappa_s^2} \right\} \left(\frac{1}{2T} + 2\beta \right)$$

$$A_{ref} = \frac{K_s R\left[\operatorname{ctnh} K_s t - K_s t \operatorname{csch}^2 K_s t\right]}{\mu^2 R^2 + (1 + K_s R \operatorname{ctnh} K_s t) K_s R \operatorname{ctnh} K_s t}$$

where β is the average expansion coefficient for water in the range 20 - 80°C, T is the average absolute temperature in this range, R is the pile radius (assumed spherical for ease of calculation), t the reflector thickness, and all other constants are as usual (the constant K_s occurring in A_{ref} refers to the reflector). The calculated and experimental coefficients are given in the following table:

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exactly the steady-state Xe loss, the excess reactivity built into the pile for starting up after brief shutdowns will certainly be enough to overcome the Sm poisoning.

Analysis of Critical Experiments on Enriched U^{235} - D_2O Systems (R. Scalettar)

We compare below the theoretical with the experimental characteristics of the heterogeneous enriched U^{235} - D_2O systems which have been under investigation as a preliminary to the construction of the new pile. The experimental units consist of $U^{235} O_2 F_2$ solutions in Al tubes distributed on a square lattice of varying spacing; the active part of the lattice is roughly cylindrical in shape, is D_2O moderated, and is surrounded completely by D_2O reflectors of various thicknesses. The lattice structure induces only a few per cent change in the Laplacian at the lowest concentration and no correction has as yet been applied to the results (quoted below) for this effect. The theoretical investigations have been made on the basis of a corrected two group theory which essentially assumes a Gaussian slowing down for neutrons of intermediate energy.

The comparison of the experimental and theoretical critical masses for the various concentrations investigated is given in the following table:

$c(\frac{\text{gms.}}{\text{liter}})$	$M_{exp.}$(gms.)	$M_{theor.}$(gms.)
2.6	1320	1140
5.2	930	850
10.4	869	830

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c ($\frac{gms.}{Liter}$)	α_{exp} ($^{o}c^{-1}$)	theor. ($^{o}c^{-1}$)
2.6	-0.76×10^{-3}	-0.738×10^{-3}
5.2	-0.674	-0.681
10.4	-0.669	-0.639

The trend of decreasing temperature coefficient with increasing concentration is understandable on the basis of the fact that the ratio of fast to thermal flux increases making the pile somewhat less sensitive to 1/v law changes in the thermal cross-section.

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Physics Section III

E. O. Wollan, Section Chief

S. DeBenedetti, Associate Section Chief

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

Problem Assignment Number	Subject	Status	Man-Months of Effort Report Per.	Next Per.
PX6-1	Pile Oscillator	Active	2	1
PX10-8	Neutron Diffraction	Active	½	½
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	1½	1½
	Ranges of Delayed Neutron Emitters	Active	1½	2
	Supervision and Report Writing	Active	1	1
			9	8

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PX10-8 Neutron Diffraction - E. O. Wollan

I. Diffraction by Powdered CaC_2 and the Relative Phase of Scattering from Calcium and Carbon

There has been some disagreement on the question of whether carbon scatters neutrons with the same or a different phase from that of several other elements which have been shown here and at the Argonne to scatter with the same phase.

We have made measurements of the diffraction of neutrons by a number of crystals both as single crystals and in the powdered form. Previous measurements made here of the diffraction by Ca O, Mg O, Na Cl and K Cl showed that Ca, O and Mg scatter with the same phase. An analysis of the intensity of reflection from even and odd order from Na Cl indicated that the two chlorine isotopes scatter with opposite phase.

To check the point about the relative phase of scattering from calcium and carbon, measurements have been made of the diffraction from various planes in powdered Ca C_2. Although the measurements have not yet been made to high statistical accuracy the effect of a change of phase in scattering by carbon is so great that there cannot be much doubt about the results.

The following table gives the measured relative intensities and the calculated intensities for the case of carbon and calcium scattering with the same and opposite phase.

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TABLE 1.

Miller Indice of Reflecting Planes	Relative Intensities		
	Measured	Calculated	
		Same Phase	Opposite Phase
C11 and 002	3000	2300	2300
110	6000	6000	437
200	2400	3120	230

Undoubtedly, carbon scatters with the same phase as calcium.

II. Measurements with Powdered Li H

Preliminary measurements of the scattering of neutrons by powdered Li H have failed to give diffraction effects. The background scattering indicates that much of the hydrogen scattering must be incoherent.

PX10-19 Capture Gamma Rays - H. B. Willard and M. Burgy

Work with the cloud chamber has been delayed due to a breakdown in the insulation of the windings in the Helmholtz coils. The insulation has been repaired. Observations on capture gamma ray energies are being resumed.

PX10-22 Short-Lived Isomer - S. De Benedetti and F. K. McGowan

Experiments with a sample of Hf (85% pure) proved that the half-life of 25 microseconds (originally found with Zr sources) follows the disintegration of Hf^{181}. The metastable state is therefore

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an isomer of Ta^{181}. Absorption curves of immediate and delayed rays seem to prove that all (or nearly all) the β rays from Hf^{181} lead to the new metastable level. The β rays from Hf^{181} have an end point of about 0.6 Mev. The radiation from the metastable state consists of electrons of about 0.11 Mev and of more penetrating rays. If the electrons of 0.11 Mev are K conversion electrons the excitation energy of the metastable state should be 0.18 Mev. The change in nuclear angular momemtum involved in the disintegration of this metastable state is probably 3 units.

We plan to use the β ray spectrograph to study more accurately the energies of the radiations from Hf^{181} and from Ta^{181*}.

A few more isotopes were investigated for delayed coincidences with negative result.

PX10-16 Characteristics of Fission Product and Neutron Induced Activities - P. W. Levy

For more accurate work on low energy β spectra and to make more detailed analysis of continuous spectra it was desirable to reduce the thickness of the counter window of the 180° Beta-ray Spectrometer. The old window was 4 mg/cm^2 and we are now trying to install a window of approximately 1 gm/cm^2.

It was also found that hysteresis effects introduced small perturbations in the manner in which the magnetic field followed changes in the exciting current due to the necessity of changing some of the adjustments of the power supply in steps. A special switching device has been installed to enable the exciting current to be changed in a continuous manner.

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PX6-1 The Clinton Pile Oscillator - C. Moak and J. Strong

A new measuring technique has been developed for the pile oscillator. The swinging galvanometer and synchronizing circuits for keeping reciprocator and galvanometer in step have been replaced by an integrator circuit of long time constant similar in principle to the counting rate meter. By interupting the signal every other half cycle and feeding the result into an RC circuit a resultant charge is built up on the condenser proportional to the size of the signal from the pile oscillator. This charging rate is read by means of a vacuum tube voltmeter of very low drain. Statistical noise, being as often negative as positive for a given half cycle, balances out giving accuracy comparable with the resonance galvanometer method. Although no increase in the accuracy of measurements is expected, considerable ease in operation has been gained.

Some attempt has been made to determine the factors which cause the "noise" in the pile oscillator signals coming from the detecting chamber. It has been proved that none of this noise arises in the amplifier itself. This was proved by introducing "fake chambers" and "fake signals" into the circuit. One anomaly found in the experiments was that increasing the size and currents of the chamber did not increase the signal to noise ratio. Thus far no way is known of decreasing this pile noise.

Some attempts have been made to measure samples of Be but it has been found that the size of our carrier channel is too small to allow such measurements with any degree of accuracy. As soon as possible the channel will be widened to accomodate larger samples. Due to the high slowing down power of Be no absolute cross sections

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can be determined. However, comparisons of different samples of Be should give the amount of impurity of one as compared to another.

An Attempt to Correlate Fission Fragment Ranges with Delayed Neutron Emission - E. O. Wollan, D. G. Rose, and M. Burgy

Preliminary tests on the working of the 'rabbit' have shown some changes in its design to be necessary. These changes are being made at the present. The rest of the equipment has been assembled. In order to increase the efficiency of the neutron detection, BF_3 counters using enriched boron have been obtained.

Early in our work on this problem, we wished to determine the amount of U^{235} on a foil of unknown enrichment. It occurred to us to compare the delayed neutron count from the foil with that from a weighed amount of uranium. Later, Dr. C. D. Goodman pointed out that our method of 'weighing' U^{235} could be a rapid method of uranium ore analysis. He has procured for us a number of ore samples, which have been assayed, and which we shall use to prove our method. The method consists simply of weighing a portion of the ore, putting it in a 'rabbit', bombarding it in the pile, then bringing it out and counting it over a definite time interval. A similar count on a weighed amount of uranium, bombarded for the same time with the pile at the same power, would permit the proportion of uranium in the ore to be calculated.

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Physics Section IV

L. B. Borst, Section Chief

S. Bernstein, Associate Section Chief

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

Problem Assignment Number	Subject	Status	Man-Months of Effort Report Per.	Next Per.
PX10-8	Neutron Diffraction	Active	2	2
PX10-10	Deuterium Gamma Ray Spectrometer	Inactive	0	0
PX10-15	Photo-neutrons from Fission Products	Active	3	3
PX10-17	Fissionability Studies	Active	2	2
PX4-5	Heat Evolution from Pa^{233}	Active	1	0
	Plutonium Project Record	Active	1	1
			9	8

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PX10-8 Neutron Diffraction - (Dial, Hasbrouck)

Measurements are now being taken on the transmission of a sample of dysprosium and a sample of yttrium in the region from 0.1 to 10 e.v.

The test-runs on the collection of a sample of Xe for cross-section study continue to give trouble. A really successful test run has not yet been achieved.

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

The photoneutron studies have been extended to include the region of periods less than 30 seconds. A period of 2.4 seconds half-life of quite large amplitude has been found. This new activity in addition to those mentioned in the last monthly report (MonP-113) are included in the following table.

Photoneutron Periods & Yields

$T_{\frac{1}{2}}$	A_{∞}
53 h	.0167 x 10^{-2}
4.4 h	.0529
1.65 h	.338
27.3 m	.342
7.7 m	.546
110 s	1.81
32.6 s	2.93
2.4 s	10.00
	$\sum$ = 0.161

[redacted]

The first column gives the half-life. The second column gives the saturated photoneutron activity as a fraction of the saturated total delayed neutron activity. The results given in the Table are for an infinite amount of P-9. They were obtained from the data for the 10 inch radius sphere on the assumption that a single Comption collision scatters the photon below the γ-n threshold.

The results shown in the Table may be increased further to take account of two effects:

(1) The γ-n contribution of Compton scattered photons which stay above the γ-n threshold after one or more collisions - Mr. Soodak and Mr. Greuling are calculating the magnitude of this correction.

(2) Absorption of neutrons in the P-9. Although this correction is a small one if the P-9 is really 99.7% pure, we plan to measure during the coming month the number of neutrons actually capture by the sphere of P-9.

PX10-17 Fissionability Studies (Osborne, Schofield)

A sample of UX_1 has been received from Mr. J. Halperin of the Chemistry Division for the study of fission cross-section by the photographic plate method. Exposures of the sample against a photographic plate have been made in a slow neutron flux and also to fission spectrum neutrons. The plates have not yet been examined for numbers of fission tracks.

A sample of thorium has also been exposed in the fission spectrum neutron source.

Dr. McRae of K-25 has sent over several samples which have been exposed to slow neutrons. The purpose of these exposures is to develop a method of measuring enrichments using the fission photographic film technique.

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Work is progressing on the mass spectrometer program as outlined last month. The shop-work on the ion source furnace is scheduled to be completed within two weeks.

PX4-5 Heat Evolution from Pa^{233} (Ulrich)

This work has been interrupted by the departure of Mr. Ulrich.

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Physics Section V

H. Newson, Section Chief

Total Technical Personnel (including supervision)................6

Pile Power Control - H. A. Straus

The pile simulator circuit has been completed and preliminary tests show that in most respects it behaves qualitatively like a real pile. The chief point of difference is the lack of stability over a long range of neutron intensity. An actual pile will run steadily at a neutron flux 10^{10} times the source, while the simulator has a range of only 10^4. At the present time, the voltage which simulates the spontaneous neutrons is disturbed by noise to such an extent that the range is restricted to 10^2 in start-up problems where the ratio of spontaneous to total neutrons is important. However, for other problems it seems satisfactory. A mock Servo system to control the simulator is being designed and should be ready for the shop soon. This system will be disturbed by mock bubbles to determine the maximum fluctuation which may occur in k without making the pile uncontrolled.

Electronic Design - W. H. Jordan and P. R. Bell

The design and layout of a fast linear amplifier and pulse height selector have been completed. The high frequency response of the amplifier can be adjusted by means of a three position switch to give

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rise times of approximately 0.1, 1 and 10 microseconds. A ganged switch will vary the "clipping time" of a differentiating circuit to match the rise time. The gain is stabalized by inverse feedback.

Considerable experimenting was done to achieve a satisfactory pulse height selector (PHS). The resulting circuit is easily triggered by 1/4 μsec pulses, works well with long pulses and high duty cycle. It will measure pulses from about 1 volt up to 100 volts, the full output of the amplifier. It recovers in 0.15 μsec, even when set to count very small pulses in the presence of large pulses. The accuracy of the measurement of pulse height varies from 1/4 volt for the lowest pulses to 1 volt for the highest pulses.

The amplifier and PHS are each built on a well shielded subchassis and bolted to a larger chassis containing the power supply. Since the two units are mounted adjacent to each other, the speed of response is not impaired by the use of long connecting cables and associated capacity. The PHS is designed to give a four volt pulse, 0.3 μsec long, into a terminated line for working into a fast scaler.

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Layout and assembly has been completed on the "d log n" circuit. This is an amplifier designed to convert the neutron flux signal from the pile ion chamber into an output proportional to the time derivative of the logarithm of the flux. Testing of the circuit as first assembled indicated the need for certain changes, principally a phase shifting device. These changes have been made and the circuit is ready for further test.

Study of ion chamber design has been continuing. It is desirable to increase the ion current to neutron flux ratio and also to maintain

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the lowest possible β and γ activation of the chamber itself. Some increase in the neutron sensitivity can be achieved by use of boron enriched in B^{10} and also it is hoped by experimenting with coating procedures. Chamber activation seems to be due mainly to the 110 minute argon activity (σ = 1.24), the 2.59 hour manganese activity (σ = 11.5) in the steel, and the 5.3 year cobalt activity (σ = 22.5) in the Kover. It is proposed that an experimental chamber be filled with nitrogen instead of argon, made of low manganese steel. Other possible improvements may result from the use of a cadmium mask over the Kovar, and lead tin solder instead of the silver and copper solders. Nitrogen is being tried at the present in a standard G. E. differential chamber but no results are ready now.

Calculation with the photoneutron data of Bernstein and Preston shows that the gamma activity of the new (heterogeneous) pile will maintain the neutron flux in the pile at a sufficiently high level after shutdown so that even after 48 hours the flux will have dropped to no less than about 5 x 10^{-6} of the operating flux. Since we are faced with the problem of keeping sight of the pile flux at all times when we wish to start up rapidly, this lower limit of neutron flux must be known and must be readily detectable. The neutron ion chamber must be capable of detecting neutron fluxes over a range of 2 x 10^5 without having its lower limit readings made uncertain by the beta and gamma ionization due to the chamber itself. This requirement is responsible for the attention given to suppressing chamber activation (see previous paragraph). Actual tests were run on the G. E. differential ion chamber in the X pile. With the pile shut down and with the chamber completely removed from the concrete shield, it was determined 45 minutes after shutdown that the fluctuations in the ionization

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were small enough that the actual expectable range between ion current at pile operating level and ion current fluctuations at shutdown is 8×10^5. This factor of 4 over the required range is considered not ample, but possibly satisfactory. Further data will be taken on the rate of decay of the background of the chamber. An increase of range of as much as a factor of 10 may be found after the argon and manganese activities have decayed.

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