METALLURGICAL LABORATORY
PROGRESS REPORT FOR DECEMBER 1943
CONTRACT #W-7401 eng-37

S. K. Allison - Director

PART I

SUMMARY

During the month of December, Mr. H. C. Vernon was appointed Assistant Director of the Metallurgical Laboratory in charge of blueprint review for the Hanford plant. This shortened considerably the average time taken for the Laboratory to approve a print. Dr. T. R. Hogness was appointed Director of the Division of Chemistry, with Dr. J. Franck as Associate Director. The change was made at the request of Dr. Franck to safeguard his health.

A remeasurement of the yield of unseparated product to be expected at Hanford showed no important error in our expectations, namely one gram per 1000 kw days. Testing of the neutron properties of graphite, water, helium, etc., to be used at Hanford continued intensively.

Several investigators from the Laboratory were temporarily stationed at X to work on the problem of the detection of failed coatings at Hanford. A mass spectrometer for the isotopic analysis of P-9 has been completed.

Intensive effort has been placed on the problem of the density of metallic 49, but the problem is not yet completed. Numerous X-ray diagrams have been obtained and interpreted but it is not certain that any of them results from 49 metal. An unambiguous result is expected soon as larger quantities of 49 are arriving. Rapid analytical procedures have been devised for the determination of fission products as a method of plant control at Hanford, and will soon be tried in actual solutions which appear in the separation process.

Rapid progress was made in setting up a laboratory for P-9 analysis at Site B.

The pilot plant for slug canning at Site B was under construction, and emphasis changed from the double jacketing technique to a single jacketing procedure. The other favored approach is the aluminum-silicon dipped coat.

In co-operation with Site X, the biological research group began the investigation of the effects of pure fission products on animals. Certain dogs have now been fed tuballoy oxide for one year with no effects, and others have inhaled oxide dust once a week for six months with no change except appearance of an unknown pigment in the urine which is under investigation.

The total expense for the month of December is $532,652.01 as compared with $539,194.98 for November, a decrease of $6,542.97. The net increase in the number of personnel reported on the project was 84 during the month of December.

PART II [redacted] DECLASSIFIED 531

NUCLEAR PHYSICS DIVISION
General Report

The theoretical section examined the current plans for Hanford and submitted numerous criticisms and suggestions. The reliability of the calculations of the multiplication constant has been improved by the development of a second order diffusion theory and an analysis of the resonance absorption data at Indiana University. The accuracy of predictions of induced racioactivities has been improved by a theoretical analysis of the data obtained at Y on the fission spectrum. Calculations have been completed on the multiplication constants for Be-U systems.

The experimental sections have continued the construction of the P-9 pile, and prepared for the erection of the W exponential test pile and the P-9 exponential lattice test pile. The metal and graphite testings have continued and corroborating evidence obtained on the multiplication constant improvement resulting from substitution of Gulf-Cleves for AGOT standard graphite. Investigation of short-lived induced radioactivities showed no differences in treated Columbia River Water and distilled water. The purified helium to be used at Hanford showed satisfyingly low induced radioactivity. A new determination of the number of neutrons per fission of U^{235} gave the value 2.14 which is in substantial agreement with earlier values. The energy release per fission was determined at 210 MEV. The amount of 49 produced was found to be but slightly less than one gram per 1000 kw days.

Plans for the Next Two Months

Work of the same scope and nature is to be continued. The P-9 heterogeneous lattice exponential experiment will be run as soon as the P-9 is obtained. The W test exponential pile will yield some preliminary data, but final results will be delayed until slugs in their final can design can be obtained.

Personnel

The total academic personnel is 62.

GENERAL PHYSICS DIVISION
General Report

Work on the water monitoring problem has continued; the use of synthetic resins as active product adsorbers shows promise and further work will be carried on at Site X. A rugged, portable and water proof radiation meter with audible and visual alarms is being developed. A new G. E. varnish used on Victoreen high resistances results in a very satisfactory resistor for use in our circuits. Work has progressed on a thermopile for use as a "neutron thermometer". The Beckman instruments are being tested by the Engineering Group with the object of making them satisfactory for use with ion chambers at W. This same group has been testing six different types of scalers with the object of preparing specifications for satisfactory use at W.

The Deuterium mass spectrometer has been put into condition to be used as a routine analytical instrument. Instrument development includes a neutron survey meter, a pocket sized electrometer survey meter and a thimble chamber for neutron measurement. The current plans for Hanford have been examined and numerous calculations, criticisms and suggestions made.

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GENERAL PHYSICS DIVISION
General Report (Con't)

A large amount of cyclotron time has been used by other sections. Investigation of the N^{16} activity in neutron irradiated water has shown that the resulting γ energy is about 4 MEV and one γ per β. Bi and Xe^{133} activities are being followed with new samples. The β-ray spectrometers are now vacuum tight and will soon be in operation.

Although no product metal sample has yet proved satisfactory, x-ray diffraction studies have been made of UF_4, $BiPO_4$, product fluoride, rhenium metal (density is 20.99 ± 0.01), $UO_4 \times H_2O$, and UO_2, ThO_2. The discovery of a new crystalline form of $BiPO_4$ in addition to the hexagonal form is of importance.

The mass spectroscopy section has made good progress on the mass spectrometer with electrical pick-up to measure light element impurities in the final product and has practically completed the new instrument for analytical work in the decontamination and purification processes.

Experiments on extrusion of uranium and drawing of Al tubing of special forms have been continued. Thermal transfer through an annular gas-filled space between concentric graphite and brass cylinders has been measured and has been shown to be due to conduction only. Thermal conductivity measurements for uranium are nearly completed. Several methods of testing jacketed slugs for leaks have been investigated and an analysis of all contemplated methods has been made.

Plans for the Next Two Months

The present programs will continue with little change.

Personnel

Academic personnel 83.

CHEMISTRY DIVISION
General Report

One extraction, one product and one by-product precipitation on W concentration (including Pu) gave a yield of ~95% using 0.5 cc of solution. Various reducing agents are being investigated to determine effect on decontamination, cross-over cycles, and concentration steps; preliminary results are encouraging. High percentages of Pu in $BiPO_4$ have shown lattice expansions indicating that the Pu carrying involves incorporation into the crystal lattice. Dissolving rate of plutonous peroxide has been checked and indicates that the data used heretofore for flow sheets are satisfactory.

Alternates

The use of H_3PO_4 to elute Sr and Cb selectively from Amberlite IR-1 gives a decontamination factor and 500 for Cb and 1700 for Zr. Titanium Leolite in one cycle after extraction results in a β decontamination factor of > 400. $LaPO_4$ carries tracer amounts of Pu quantitatively. $LaPO_4$ plus cupferron does not seem promising. Uranous hypophosphate precipitated from $La(NO_3)_3$ has possibilities.

Work on the separation of Np and Pu by the thorium molybdate method is being deferred in view of erratic results. The half life of Pu is recalculated as 24,000 years and this may effect the fission cross section value. Considerable work has done without definite results, in preparing metal for x-ray determinations of density. Using thorium as a stand-in, work is progressing on purification by solvent extraction.

Several reagents are regarded as promising for Pu purification from work done on thorium and these will be checked as soon as Pu is available. Work on volatile compounds is progressing but must await Pu for conclusive results. Apparatus to determine hardness and melting point of Pu is on hand and will be used as soon as milligrams are available. Work on determination of oxygen and carbon is progressing. Atomic Fluorine investigation, atomic hydrogen for reduction, refractory crucible, $BiPO_4$ process precipitates solution of HCl and determination of oxygen by the bromine method, are all topics receiving some attention.

Radiation effects

An Aluminum and W water flow system has been exposed to radiation and results indicate that what small effect there is, is confined to the surface and will not have an appreciable effect on overall rate. Difference in effect of radiation in various grades of graphite can be explained on basis of crystal size. Glass exposed to β radiation suffers a few per cent change in breakage modulus. Effect of γ radiation is uncertain. No consistent results have been obtained on the effect of radiation on the reduction and extraction steps of the $BiPO_4$ process. Primary effects on aliphatic and aromatic hydrocarbons caused by radiation are under study. Eders solution used as a radiation actinometer gives visible change with 25 r. Cupferron will be stable in contact with hot W test solutions for ca 0.6 hours.

Fission Product Chemistry

Although there is no evidence that it will become dangerous in W operations, it is to be noted that an insoluble form of $BiPO_4$ has been found and is being studied. Decontamination of Pu may vary between 10 and 200 depending on completeness of reduction of the Pu. A 7-day U has been found in X pile material amounting to ca 0.2% of product yield. The solubility product for LaF_3 is 2×10^{-18}. Analysis of minor fission products not found in cyclotron material, a comprehensive study of long lived α and β emitters in pile material, the half lives of fission gases, the electrostatic α ray spectrograph, redetermination of Ba yield and MEV per fission of Argonne material, fission yields of 2.3 h Br, 86 m Ba, 6.6 h I, 22 h I, 8 d I and 33 h Ce, and determination of capture to fission ratio of X pile material are all subjects under study.

Analytical

The determination of phosphorous, the recovery of Li and Be by cupferron, determination of sulfide have been developed for small samples. Various spectrographic sensitivities have been determined by the copper spark method. Samples of $Pu(NO_3)_4$ and $Pu(OH)_4$ have been spectrographically analyzed for Al, Be, Bi, Ca, Cr, Fe, La, Li, Mg, Mn, Na, Pt, Si, Th, W, and Y and their sum found to be $< 7\%$ in the nitrate and $< 1\%$ in the hydroxide. The samples were small, hence these upper limits.

Work has started on preparation of purification and analysis of special chemicals for research.

Preferential elutriation of fission and Pu and IR-1 resin by oxalic acid gives reproducible results of a satisfactory nature. Control methods for W are being worked out. Samples for various project groups have been analyzed both chemically and spectroscopically.

P-9

Analytical apparatus has been assembled and tested. Work has started on density determination of pure P-9 which includes isotopic repurification of our best material. A stable non-settling UO_3 slurry has been prepared for research, and is being studied. Slurry drift studies are being made.

Plans for the Next Two months

Work will continue along the previous lines with a few exceptions. Conference with Clinton Laboratory led to agreement that Clinton would work on problems centering around X and Chicago on problems centering around W. The group working on extraction, decontamination, concentration and isolation is being split into three parts to study problems centering around respectively Y, W, and fundamentals. An understanding with Y has been developed to avoid duplication of effort. Plans are being made to move twelve men from here to join six men from du Pont to W for development of analytical procedures and techniques. A new study of fission product distribution and analysis in process solutions will get under way working closely with Clinton.

Personnel

Personnel - 177

TECHNICAL DIVISION
General Report

. The effort of the Technical Division and associated groups for the month of December has been largely on development of jackets for the tubealloy slugs, and in the associated problems concerning corrosion of aluminum and heat transfer between aluminum jacketed slugs and water.

It became evident during the month that double jacketing with Zn-Sn solder does not provide the extra factor of corrosion safety that had been hoped for, and it has been abandoned in favor of a single heavy jacket. This arrangement is much simpler to handle and should yield an excellent product. Manufacturing details are being worked out, and unless unexpected difficulties arise it is anticipated that the Pilot Plant at Site B will be in production by February 1.

The aluminum-silicon bond in development at Grasselli still offers the best resistance to corrosion, and it is expected that the mechanical problems remaining can be solved within perhaps the next two months. In the meantime both approaches will be pressed.

The test for bond discontinuities as developed at M. I. T. (induction heating with temperature indicating slug coatings) has proved to be adequately sensitive. A unit will be ready in Chicago by about February 1.

TECHNICAL DIVISION
General Report (Con't)

Corrosion testing in Hanford geometry has been at a standstill during the month with efforts aimed at duplicating the heavy films on slug surfaces as found in the CMX tests at Hanford. Recently films similar in appearance and yielding similar increases in pressure drop in flowing water have been laid down.

Besides the major efforts indicated above it should be noted that the chemical semi-works in the West Stands, though not entirely complete, has been operating in conjunction with the Chemistry Division in dissolving active metal to provide solution for chemical work, and in carrying on studies in the concentration step and in the improvement of the "main line" process. Active work is going on with Clinton on optical devices for use in the new Hot Laboratory, in the development of a boroscope for inspecting the inside of pile tubes, and in other optical devices. Some assistance has been given to Clinton in connection with increase in pile output. Design studies concerning adsorption processes have been going on at Chicago but will now be discontinued since Clinton is in a position to handle the work.

Plans for the Next Two Months

Unless unexpected difficulties arise research on canning should become less urgent and emphasis shift to the pilot plant. Corrosion tests under more nearly Hanford conditions should get under way.

Personnel

The academic personnel of this division is now: Chicago 116*, outside Chicago 56**.

HEALTH DIVISION
General Report

A. Clinical Medicine and Medical Research

During the month, the Liaison Committee made 33 special surveys. As a result of these surveys, 7 individuals were referred to the Clinics of Billings Hospital. Mr. Cunningham's group has been working almost exclusively with active materials during the past month. One of this group showed a diminished white blood count which was felt to be due to radiation. Removal from exposure resulted in prompt return to normal. 162 pre-employment examinations were done. Site B shop was re-surveyed. Recommendations for increased ventilation were made because of the tubealloy dust hazard. Ingestion experiments with T_3O_8, TF_4, TcL_4, TO_2F_2, and TNO_3 are continuing. No abnormal findings have been found except a mild depression of weight in the TNO_3 and To_2F_2groups. Injection experiments with TNO_3 show that the 50% lethal dose is 10 to 20 milligrams per kilo. Dogs injected with 5 milligrams per kilo of TNO_3 have shown weight loss, weakness and increase in the red blood cell protoporphyrin. Dogs who have been fed oxide for one year have shown no change. Dogs who have inhaled

*A considerable fraction are du Pont men in training for Hanford.
**Estimated.

oxide of Tubealloy once a week for 6 months have shown no change except the appearance of an unknown pigment in the urine. This is being studied. One human has been given 150 total r body radiation. The most marked change has been a fall in the lymphocytes from 1800 to 500 in the period of approximately one week. A temporary increase in urorosein excretion was also noted. Blood and urine pigment studies on Metallurgical personnel have begun. Dr. Barron has organized a group and is starting to study the effect of radiation on proteins.

B. Meteorology

Because the main stacks at Site W have not been completed, an auxiliary stack is being constructed to determine what conditions may be expected during the winter, the season of maximum intensity, duration and frequency of inversion. Meteorological observations of the various elements continue to be taken and a supplementary forecasting division has been established. Improved meteorographs have been completed.

C. Biological Research

The histological work with rabbits shows a marked damage to lymphatic tissue in the appendix within a few hours after an 800 r x-ray exposure. The cytological damage in the duodenum appears somewhat later. Experiments with Sr^{89} indicate that mice and goldfish can survive rather large bone irradiation as compared with the whole body radiation by x-ray or injected Na^{24}. Goldfish have been found to accumulate Sr^{89} to about 100 times the concentration of the medium in a week.

D. Radiation Measurements

A laboratory technician was added to the group to help with expanding routine radiation measurements. Measurements of contamination on hands have been started. Studies of the relative amounts of the biological dose contributed by gammas and by betas from UX indicate that gammas contribute approximately 0.1% of the dose when absorption in the intervening medium is small. Indications are that neutron survey meters will be available soon.

Plans for the Next Two Months

The most important work for the coming month is that on Sr^{89} and Ba^{140} from X. The program for the complete section includes the use of the isotopes on mice, rats and goldfish for: metabolism, radiotoxicity, histological and haematological investigations.

The survival curves of rats, guinea pigs and chicks for single dose x-rays will be largely completed. Fast n exposures will be continued. The collection and correlations of weight changes following irradiation of rabbits, rats and mice will be brought up to date. The investigations of the effects of repeated doses of x- rays will be continued.

Histological survey of effects of 800 r and 400 r single dose x-ray for rabbits will be largely completed. Similar survey for rats and mice will be continued. Cytological study of chicks and newts after single dose of x-rays will continue.

HEALTH DIVISION
Plans for the Next Two Months (Con't)

Haematology studies at low level single dose of x-ray and the blood picture after injection of radioactive isotopes will be emphasized.

Protective action of enzyme procursors will be studied. The effect of radiation on enzyme and protein solution will be continued. Tissue enzyme inactivation studies will be continued.

The Xe133 model generator should be tested at X and work on I, Ru and radio-dusts will continue.

Personnel

Academic personnel: 40½

MISCELLANEOUS
Hanford Engineer Works

Regular weekly visits of representatives of the du Pont operating personnel have proved of value in expediting our understanding of intents as well as designs. This has resulted in more rapid approvals. Written comments and criticism have been placed on file and stem from essentially all parts of the Laboratory. During the month 73 drawings were received and 73 drawings approved and returned.

Special Materials

Procedures have been instituted for handling and accounting for both "Special Materials" and "Products".

(Signed) Samuel K. Allison

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PART III

1. Estimated cost of operations for December and budget estimates for January and February, 1944:

	January	February
Salaries	$390,955.88*	$376,542.00**
Overhead	107,817.00	108,217.00
General Expense & Equip.	187,800.00	190,000.00
Totals	$686,572.88	$674,759.00

2. Estimated status of project at 31 December 1943:

Salaries			
Appropriations		$2,200,000.00	
Payroll to 30 Nov.	$1,309,767.80		
December payroll	266,884.41		
Total		1,576,652.21	
Balance			$623,347.79
Overhead			
Appropriations		$800,000.00	
Overhead to 30 Nov.	486,336.32		
Dec. overhead	106,941.59		
Total		593,277.91	
Balance			206,722.09
General Expense & Equipment			
Appropriations		$2,750,000.00	
Expense to 30 Nov.	$1,200,702.38		
December Expense	158,826.01		
Total		1,359,528.39	
Balance			1,390,471.61
Total Balances			$2,220,541.49
Total Appropriations		$5,750,000.00	
Total Expenditures		3,529,458.51	
Balance		$2,220,541.49	

3. Personnel employed on 31 December 1943:

Academic	422
Non-Academic	766
Total	1,188

*Includes $121,455.88 salaries of loaned employees, which should be paid in January.

**Includes $106,000.00 estimated billing for loaned employees. These bills should be received in late January and paid in February.

(Signed) W. M. Munnecke

APPROVED_____
ARTHUR V. PETERSON
Major, C. E.

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OUTSTANDING OBLIGATIONS AT 31 DECEMBER 1943

Salaries:			
Estimated payroll for January		$269,000.00	
Salaries to be billed by the University		3,250.00	
Salaries of Loaned employees			
du Pont			
1 May 1943 to 31 July 1943	$121,455.88		
1 August 1943 to 31 Oct. 1943	106,000.00		
Estimated amount for November December and January	105,000.00		
	$332,455.88		
Other	2,958.33	335,414.21	
Total salary obligations			$607,664.21
Overhead:			
Overhead applicable to January payroll			108,900.00
General Expense and Equipment:			
Orders on University departments for materials and supplies		$636,000.00	
Sub-contracts		69,926.00	
Travel, moving and return moves		42,000.00	
Telephone and telegraph		18,500.00	
Building alterations		13,300.00	
Insurance		12,000.00	
Direct purchases		6,600.00	
Building repairs and moving departments		6,000.00	
Rental of radium		4,550.00	
Utilities		3,350.00	
Consultants' fees and traveling expense		1,300.00	
Repairs to equipment		1,100.00	
Miscellaneous		800.00	
Total obligations for general exp. & equip.			815,426.00
Total obligations at 31 December 1943			$1,531,990.21

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