

DECLASSIFIED
WITH DELETIONS

By Authority of CG-PR-2

A. J. Lewis 2-23-92

James H. Webb 8-5-92

DG Kremer 8-10-92

HW--65854-Del.

T
O DE93 002500
O

ts
No.
s

76145

HANFORD LABORATORIES OPERATION
MONTHLY ACTIVITIES REPORT
JUNE, 1960

Compiled by
Operation Managers

July 15, 1960

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

PRELIMINARY REPORT

This report was prepared only for use within General Electric Company in the course of work under Atomic Energy Commission Contract AT(45-1)-1350. Any views or opinions expressed in the report are those of the author only.

Route To:	P. R. No.	Location	Route Date	Signature and Date
<u>HCC</u>				
<u>Attn: J. E. Tawari</u>				

MASTER

DISTRIBUTION RESTRICTED TO U.S. ONLY

DISTRIBUTION

Copy Number

1	W. E. Johnson
2	H. M. Parker
3	O. C. Schroeder
4	F. W. Albaugh
5	C. A. Bennett
6	J. L. Boyd
7	L. P. Bupp
8	F. E. Crever, GEAPD
9	W. E. Foust
10	P. F. Gast
11	A. R. Keene
12	H. A. Kornberg
13	T. G. Marshall
14	L. H. McEwen
15	W. Sale
16	J. W. Healy
17	H. P. Shaw - V. R. Cooper
18 - 21	Atomic Energy Commission, Hanford Operations Office, Attn: J. E. Travis
22 - 24	G. F. Quinn, Director, Division of Production, Washington 25, D. C.
25	Savannah River Operations Office, Aiken, South Carolina
26	300 Files
27	Record Center

	<u>Page</u>
Staff	iv
Force Report and Personnel Status Changes	v
General Summary	vi through xiv
Reactor and Fuels Research and Development Operation	A-1 through A-50
Physics and Instrument Research and Development Operation	B-1 through B-27
Chemical Research and Development Operation	C-1 through C-22
Biology Operation	D-1 through D-5
Operations Research and Synthesis Operation	E-1 through E-6
Programming	F-1 through F-5
Radiation Protection Operation	G-1 through G-7
Laboratory Auxiliaries Operation	H-1 through H-17
Professional Placement and Relations Practices	I-1 through I-5
Financial Operation	J-1 through J-6
Invention Report	K-1

STAFF

Manager, Hanford Laboratories H. M. Parker
 Manager, Biology H. A. Kornberg
 Manager, Chemical Research and Development L. P. Bupp
 Manager, Laboratory Auxiliaries J. L. Boyd
 Manager, Operations Research and Synthesis C. A. Bennett
 Manager, Physics and Instrument Research and
 Development P. F. Gast
 Manager, Programming L. H. McEwen
 Manager, Radiation Protection A. R. Keene
 Manager, Reactor and Fuels Research and
 Development F. W. Albaugh
 Manager, Professional Placement and Relations
 Practices T. G. Marshall
 Manager, Financial W. Sale

TABLE I. HLO FORCES REPORT AND PERSONNEL STATUS CHANGES

DATE June 30, 1960

	<u>At close of month</u>		<u>At beginning of month</u>		<u>Additions</u>		<u>Separations</u>			
	<u>Exempt</u>	<u>NonExempt</u>	<u>Exempt</u>	<u>NonExempt</u>	<u>Exempt</u>	<u>NonExempt</u>	<u>Exempt</u>	<u>NonExempt</u>		
Chemical Research and Development	133	112	245	129	105	234	4	10	0	3
Reactor & Fuels Research & Development	194	189	383	194	173	367	5	19	5	3
Physics & Instrument Research & Development	77	40	117	70	35	105	8	5	1	0
Biology Operation	41	42	83	37	43	80	5	1	1	2
Operation Res. & Syn.	16	4	20	16	4	20	0	0	0	0
Radiation Protection	34	100	134	35	101	136	0	0	1	1
Laboratory Auxiliaries	54	190	244	53	190	243	1	4	0	4
Financial	14	15	29	14	15	29	0	0	0	0
Prof. Placmt & R. P.	86	15	101	51	19	70	39	1	4	5
Programming	19	4	23	19	4	23	0	0	0	0
General Totals	<u>1</u> 669	<u>2</u> 713	<u>3</u> 1382	<u>1</u> 619	<u>2</u> 691	<u>3</u> 1310	<u>0</u> 62	<u>0</u> 40	<u>0</u> 12	<u>0</u> 18
Totals excluding internal transfers.	669	713	1382	619	691	1310	61	38	11	16

BUDGETS AND COSTS

Costs for June were \$2,916,000, an increase of \$1,013,000 from May. Fiscal year costs were 96% of the amounts currently authorized to Hanford Laboratories.

Hanford Laboratories research and development programs have the following cost-budget relationship for FY 1960.

(Dollars in Thousands)	<u>Cost</u>	<u>Budget</u>	<u>% Spent</u>
HLO Programs			
2000 Program	\$ 638	\$ 615	104%
4000 Program	7 843	8 208	96
5000 Program	608	609	100
6000 Program	2 200	2 200	100
	<u>11 289</u>	<u>11 632</u>	<u>97</u>
FPD Sponsored	10	10	100
IPD Sponsored	3 473	3 510	99
CPD Sponsored	1 762	1 909	92
	<u>\$16,534</u>	<u>\$17 061</u>	<u>97%</u>

RESEARCH AND DEVELOPMENT1. Reactor and Fuels Research and Development

The Phase III portion of PRTR construction is about 92% complete versus a scheduled 100% based on a contract completion date of June 24, 1960. Final inspection of the river pump facility was made, and the facility is expected to be accepted in July. The four PRTR primary process pumps have been returned following successful modification by the vendor. Sixteen PRTR shim control assemblies have received operational tests and are now available to the reactor contractor.

Design funds for the Fuel Element Rupture Test Facility (Project CAH-867) have been authorized by the AEC.

Preparations for PRTR startup are continuing with writing of Critical Test and Power Test descriptions and Startup Process Specifications. An independent audit of plans for startup and operation of the reactor is currently under way by an IPD team.

Very preliminary results from in-reactor defect tests show that Zircaloy-4 is less prone to hydriding than Zircaloy-2.

DECLASSIFIED

DECLASSIFIED

Cold swaged UO_2 fuel specimens have achieved an exposure of 16,500 MWD/T without failure.

Electron micrographs of UO_2 compacted to 99.4 percent of theoretical density, in the Dynapak, show that plastic deformation and particle growth occur.

Final assembly of thirty 19-rod Pu-Al fuel elements, previously delayed because of Zircaloy etching and autoclaving difficulties, is now proceeding at a steady rate. The autoclaving and etching problems associated with the startup of new facilities have been resolved.

An insulating coating, duPont J-400, applied to the outside Zircaloy cladding surface is being used to improve the density of injection cast Pu-Al rods. Equipment is being readied to produce two 19-rod Pu-Al PRTR clusters by this technique.

A Zircaloy clad 3-rod cluster of corrosion resistant Pu-Al with a 9-mil diametral gap has been successfully irradiated for 32 days at full power in the GEH-4 loop.

Essentially pure Pu_2C_3 has been prepared from Pu metal powder and carbon. Attempts to make PuC from PuO_2 and carbon have been unsuccessful.

In a fretting corrosion test of PRTR Zircaloy at 316 C, the rate of fretting attack decreased with time.

PRTR process tube monitoring techniques appear promising for the non-destructive measurement of the tube wall thickness and the gas gap with the shroud tube. In the testing of electronic components, vacuum tubes and tunnel diodes are more resistant than transistors to high gamma doses.

No measurable hydriding of Zircaloy-2 occurred in 43 days of exposure at 350 C to a simulated NPR gas atmosphere containing 0.05% H_2 . Although hydriding has previously been demonstrated at more stringent conditions, a 0.005-mil thick Cr coating, vapor deposited from dicumene chromium, reduced the rate of hydriding 1000-fold at 500 C.

Both the in-flux and out-of-flux portions of the Zircaloy-2 tube removed from KER-1 after 2-1/4 years in-reactor show substantial recrystallization; hence, this effect is not believed to have been irradiation-induced. Hydride content was less than 50 ppm.

Satisfactory straightening of NPR tubular fuel employing a three-roll straightener has been demonstrated.

The fourth deliberate rupture test (in ETR) employing a tubular element was terminated after 30 minutes at which time the loop activity was 20 r/hr.

The application of mechanical force during the brazing of NPR end caps results in an improved product employing about one-tenth the braze required using capillary techniques.

Heat transfer experiments were continued to determine the boiling burnout conditions of flows and heat generation rates for the NPR tube and tube type fuel element. Twenty-eight boiling burnout points were obtained that are applicable to the middle cooling annulus of the fuel element.

Neutron attenuation and gamma dose measurements as a function of temperature have been completed for iron-serpentine concrete with a density of 265 lb/ft³.

The EGCR graphite irradiation capsule installed in the GETR in late May operated satisfactorily through the first GETR cycle with measured graphite temperatures ranging from approximately 350 to 750 C.

The addition of two volume percent Cl₂ gas to air elevated the graphite ignition temperature over 150 C, and successfully controlled combustion when the graphite temperature exceeded 1000°.

2. Chemical Research and Development

Work has been initiated to develop an all stainless steel cartridge to replace the "zebra" cartridges of the Purex HA column scrub section and the Purex HS column. Although an all stainless steel cartridge is probably less efficient than the "zebra" cartridge, acceptable performance appears possible.

Construction of a pilot plant batch waste calciner is about 80 percent complete.

Attempts to measure nitrate decomposition under irradiation have been unsuccessful to date because of limited gamma source intensities and difficulties in estimating beta source intensities.

DECLASSIFIED

DECLASSIFIED

Two primary separation processes for isolating strontium-90 from Purex wastes have been found practical. Both involve sulfate precipitation.

Technetium-99 is absorbed strongly on Dowex-1 anion resin from synthetic Purex waste supernatants. About 20 percent of the technetium entering the Purex plant leaves with the uranium product.

The Chempump, equipped with a hydroclone to by-pass solids from the bearings, pumped an estimated 15,000 pounds of sand before excessive bearing wear was encountered. This is a solids load equivalent to 20 years of "normal" separations plant service.

Substitution of steam for air as the sparge gas in Sulfex dissolutions resulted in more uniform and more rapid dissolution rates of stainless steel.

In Salt Cycle studies one-pound lots of electrolytic UO_2 are being prepared for fuel development and evaluation. To date low melting chloride systems have not been satisfactory for producing electrolytic UO_2 . It was confirmed that uranium (IV) is needed in NaCl-KCl melts to promote reduction of the oxygen/uranium ratio while equilibrating non-stoichiometric UO_2 . Experiments have been started to study scavenging of fission products from NaCl-KCl melts.

Strontium decontamination obtained on passing aged decladding wastes through clinoptilolite exceeded that for cesium, possibly because of phosphate in the waste. Re-examination of the effects of irradiation on clinoptilolite shows that at 10^9 R the cesium equilibrium coefficient at 25 C is reduced, but at 55 C is increased. Erionite is less selective for cesium and strontium than clinoptilolite.

High level operation of the High Level Radiochemistry Facility was initiated on June 30 with the introduction of one gallon of Purex 1WW into Cell "B".

3. Physics and Instrument Research and Development

In the NPR program, the full-scale mockup of the scanning type fuel failure monitor is operating satisfactorily under simulated NPR conditions. The NPR prototype Linear Remote Area Monitor System was completed and delivered to IPD for test installation. Some cost reduction modifications to the Logarithmic System have not adversely affected

its operation during a test period just completed. An improved lighting system was devised for the NPR process tube inspection borescopes.

Calculation of control strengths in the NPR will be aided by two computer codes acquired offsite and now being adapted for this use. Meanwhile, materials are being received for exponential and PCTR measurements on the NPR lattice.

In the nuclear safety program, the Critical Mass Laboratory was accepted, with some minor exceptions, from the contractor. External contamination of the building, which resulted from activities not under HLO control, is being cleaned up and is not expected to interfere with use of the facility. The experiments on 2% enriched uranium continued and were supplemented by measurements on 2.6% enriched oxide rods. Substantial improvements were effected in the performance of the mass spectrometer for use in the plutonium critical mass program, and neutron instrumentation for the experimental assemblies was completed and is undergoing test.

In the Plutonium Recycle Program, physics parameters of a variety of light water moderated plutonium fueled lattices will be measured in the initial series of experiments in the PRCF according to plans recently drawn for startup of this facility. Development work continued on a variety of instrument problems including calibration of the rupture monitor, camera equipment for the Fuel Examination Facility, a periscope for the PRCF, in-reactor process tube diameter and gas gap measurement, and final evaluation of the controller.

An increase in the rate of examination of subjects for whole body radiation is promised in studies conducted using the present shielded room as a shadow shield. According to studies completed this month, the background radiation in such an arrangement is acceptable. This would allow establishment of a second examination station outside of the present one. Meanwhile, in the neutron dosimetry program, significant improvement in the reproducibility of precision long counters was achieved by substitution of aluminum for brass.

Work continued on the phosphorescence technique for assaying the amount of zinc sulphide tracer collected on filters during atmospheric transport and dispersion experiments with running of the "Green Glow" samples scheduled for the near future.

A meeting of the AEC Meteorology Program Leaders was held at Hanford, June 20-22.

DECLASSIFIED

DECLASSIFIED

HW-65854 DEL

Progress was made in the development of a number of radiation protection instruments and on instrumentation for biology research including the personal dose alarm, air monitoring, solid state detectors, and measurement of Pu²³⁹ in blood streams.

In the nondestructive testing program, improved interpretation of the signal in terms of structure of the test piece is the aim of combined theoretical and experimental work now under way on broadband electromagnetic testing. Efforts to improve the fuel element heating system for thermal bondtesting are also in progress.

In the area of improvement of basic knowledge, experiments are now under way to measure the effect on neutron energies produced by diffusing from hot graphite to cooler water and a companion theoretical program is studying similar effects resulting from absorption of neutrons in fuel elements and control rods. Experiments on the scattering of neutrons from water have been resumed following achievement of improved performance of the neutron spectrometer. A computer program has been written for the solution of the non-linear reactor kinetics problem.

4. Biology

Contamination of Columbia River life forms was about six times greater than those observed a year ago while contamination of terrestrial forms showed no important changes.

Local Columbia River salmon seem to be more sensitive to columnaris than salmon obtained from hatcheries elsewhere. Whether this is due to species difference or to difference in size (local fish are smaller) is not known, although resistance appears to increase with size and weight.

Recent results indicate that ten percent EDTA and Tide enhances deposition into liver of plutonium from wounds in rat skin. Urinary excretion also increased with such decontamination procedure. The net effect of the treatment on the hazard is yet to be determined and the results are yet to be confirmed.

Interesting results in GI radiation injury included the observation that tumors developed in small intestines of animals whose exteriorized tract was exposed to 1500 to 1900 r. None developed in animals whose exteriorized tracts were exposed to 900 to 1300 r.

5. Programming

A survey evaluation has been made of the several "partial decontamination", pyrochemical reprocessing methods now under development at various sites. The salt cycle process under development at Hanford appears to have many advantages over others.

The availability of large blocks of IBM-709 computer time was exploited to achieve substantial advance in the computation of reactivity effects of plutonium enrichment. More than 360 cases were analyzed.

A presentation was made to DRD personnel on progress in estimating the economic utility of plutonium as a fuel material for the advanced PWR.

A study was made to determine the practicality of a plutonium isotope separations method based on nuclear magnetic moment properties; only fissile isotopes have nuclear spin and thus exhibit magnetic moments. It appears that with magnetic deflection equipment of special design, separation of isotopes may be technically feasible.

TECHNICAL AND OTHER SERVICES

A document was issued in which the probability of operating a given reactor for a specified time period without shutdown was determined, conditional upon current rupture potential of the reactor. This was an extension of previous work which had, as a first approximation, assumed constant rupture potential, and will be useful in the scheduling of reactor outages.

Following official acceptance by the AEC of the General Electric Company bid for the necessary computing equipment, the Z-Plant Information Study is now being reactivated.

A mechanism for the Redox dissolution process has been formulated. This mechanism is based upon the cathodic reduction of nitric acid by nitrous acid as the rate determining reaction in the dissolution of uranium.

A recommendation to adopt part-by-part acceptance testing rather than a tolerance statement was prepared for review by CPD personnel.

A mathematical model of a proposed Continuous Fuel Element Measurement device was constructed and analyzed to determine the ability of the machine to detect and quantify desired information on fuel element dimensional irregularities.

DECLASSIFIED

DECLASSIFIED

Widespread particulate contamination in the 200-E Area occurred following burial of defective equipment from the Purex plant. Dense ground contamination gradually diminishing from the point of origin in the Industrial Burial Ground, extended in a band approximately 2.5 miles wide to a distance of several miles, southeast and outside of the 200-E Area. Nominal control of movements of vehicle and personnel was required. No significant exposure of personnel is believed to have occurred. Repetitive surveys indicate that ground contamination movement is slight.

There were no new cases of plutonium deposition recorded in June. The total number of deposition cases that have occurred at Hanford remained at 256 of which 187 are currently employed. One CPD employee sustained a minor injury while machining plutonium. About one maximum permissible body burden of Pu (0.04 μ c) measured in the wound at the Whole Body Counter was reduced to 0.01 μ c Pu with excision. Treatment with a chelating agent (diethylenetriaminepentaacetic acid) was started to minimize deposition from the wound site into the bone.

There are 24 currently active projects having combined authorized funds in the amount of \$24,786,500. The total estimated cost of these projects is \$29,318,000. All but two of those authorized are on or ahead of schedule and none are more than three percent behind schedule.

Building modifications at C-25, White Bluffs, for processing NPR tubes have been completed. Equipment modifications and installation is going forward but progress is slow and many items are still not available for use in testing.

Modifications to the Library and Files building were completed at month's end. The changes will provide improved working space for the technical publications group with offices for the Patent Attorney located adjacent to the area. These arrangements are made possible by the continued reduction in the clerical force.

Final acceptance of the Contractor's work on CG-731 - Critical Mass Laboratory was conducted on June 20, 1960; only minor exceptions were noted.

This project will be closed with accruals for startup and installation of the reactor components which will be done by J. A. Jones forces.

Project CGH-790, High Level Radioactive Receiving and Storage Addition - 327, is complete with exceptions. The painting of the new basin was unacceptable and rework is nearly complete.

**DECLASSIFIED
WITH DELETIONS**

xiv

W-65854 DEL

SUPPORTING FUNCTIONS

Ten Zircaloy-3 ingots in inventory were reduced to \$7.00 per pound to reflect their realistic value. This resulted in a write-off to cost of \$40,000.

As of July 5, 1960, 746 or 55.5% of the employees eligible to participate were enrolled in the new personal accident insurance plan.

HLO facilities closed out of equipment and construction work in progress during June totaled \$7.6 million.

As of June 30, 1960, the staff of the Hanford Laboratories totalled 1,382 employees, including 669 exempt and 713 nonexempt. Of the total, 573 possessed technical degrees, including 352 B.S., 117 M.S., and 104 Ph.D.

The medical treatment frequency for June was 1.55 as compared with 1.77 for May. There were no serious accidents. There was 1 security violation during June, bringing the total to 11 for the year to date.

During June a Doctor of Veterinary Medicine and a Ph.D. pharmacologist reported on the roll. Eight Ph.D. candidates visited Hanford for interviews. Two offers were extended to Ph.D.'s and two offers are currently open.

With the completion of the campus BS/MS recruiting, 83 acceptances have been received for program assignments, resulting in an acceptance rate of 43%. Thirty-nine of these new Technical Graduates reported on the roll during June, and there are 29 yet to report during the summer. At month's end there were 73 Technical Graduates on Program rolls.

Forty nonexempt vacancies were filled during the month. With the receipt of 28 new requisitions and the cancellation of 5, there are currently 20 non-exempt vacancies for which 4 are in process and 4 transfers are pending, leaving 12 candidates yet to be procured.

Paul F. Gast for

DECLASSIFIED Manager
Hanford Laboratories
WITH DELETIONS

HM Parker: PFG:mlk

DECLASSIFIED

REACTOR AND FUELS RESEARCH AND DEVELOPMENT OPERATIONTECHNICAL ACTIVITIES

DECLASSIFIED

A. FISSIONABLE MATERIALS - 2000 PROGRAM1. METALLURGY PROGRAMCorrosion Studies

Hydriding of Zircaloy-2 in Simulated NPR Stack Gas. Two groups of Zircaloy-2 coupons were exposed for 43 days in helium gas contaminated with 0.05% H₂ and 0.03% CO. This gas was prepared by passing tank helium over NPR graphite at 800 C where the traces of water in the gas were converted in part to hydrogen and carbon monoxide. The Zircaloy-2 samples were held at 350 C and 300 C while the gas flowed over them at a slow rate. Hydrogen analyses of the samples indicated no detectable hydrogen pickup in 43 days on either autoclaved or etched Zircaloy-2. From this test it is concluded that the system 0.05% H₂, 800 C graphite, and 350 C Zircaloy-2 is a much safer operating zone than the 5% H₂, 1100 C graphite, and 400 C Zircaloy-2 system which resulted in hydriding failure in 53 days in earlier experiments. It is planned to continue the experiments for several more months to establish that the system is not hydriding at a rate undetectable for short exposure, but still unacceptably fast for the designed NPR tube life.

Zircaloy-2 and Zircaloy-4 Corrosion and Hydrogen Pickup. In the past data obtained at HAPO for the corrosion of Zircaloy-2 in 400 C, 1500 psi steam have shown a lower hydrogen pickup than reported at Bettis. However, the tests at the two sites employed different lots of Zircaloy-2. To resolve this difference, a sample of Bettis-fabricated Zircaloy-2 was obtained and tested at HAPO. The corrosion rates found at Bettis and HAPO are almost identical. However, again, HAPO data for hydrogen pickup are lower than Bettis data. Even more significant is the slope of the hydrogen pickup versus time curves. At three days the hydrogen pickup was essentially the same for both HAPO and Bettis tests. However, after three days the hydrogen pickup rate was significantly slower in the HAPO experiment; resulting after 42 days in 16 percent of the theoretical hydrogen absorbed compared with 44 percent in the Bettis test with Zircaloy-2 from the same lot. The reason for this difference has not been resolved. Possibilities are: (1) error in hydrogen analysis - however, the analytical laboratory reports good checks against proved Zircaloy-2 standards; (2) autoclave operation, where real differences exist. The HAPO autoclaves are operated under refreshed conditions, whereas the Bettis autoclaves are static. This undoubtedly results in some of the corrosion product hydrogen being swept out of the HAPO autoclaves. If hydrogen overpressure is responsible for the observed difference in hydriding during corrosion, then data from a refreshed system would not be applicable to a system with a substantial hydrogen overpressure. Furthermore, it will be important

to determine whether a similar effect is seen in water systems rather than steam. There are also other differences between the HAPO and Bettis autoclaves, such as physical size and oxygen content. A program is being started to compare static versus refreshed autoclave operation.

Zirconium-Hydrogen Reactions. Zircaloy-2 reacts with hydrogen rapidly at 500 C in the absence of any protective film or oxide-forming reagents such as oxygen or water. These oxide-forming agents are not compatible with hot graphite and, therefore, a protective film which would protect the Zircaloy from hydrogen pickup would be very useful. Chromium plate applied by a vapor deposition process on Zircaloy-2 is being evaluated for this purpose. The coupon used in this test was experimentally plated by the Union Carbide Chemical Corporation, utilizing a di-cumene chromium vapor-deposition process.

In one evaluation test, the very thin (0.005-mil) coating slowed down the hydrogen absorption rate in pure dry hydrogen at 500 C approximately 1000-fold. A plated coupon exposed to 400 C steam at 1500 psi for 64 hours gained 15 mg/dm²; the coupon had a predominantly shiny yellow metallic color instead of the typical black oxide for Zircaloy-2. This coating evaluation work is continuing and will include an attempt to produce and evaluate thicker coatings, as well as study of the mechanism of protection.

Fuel Element Rupture in Steam. A coextruded Zircaloy-2 clad, uranium core rod element sample was "pinhole defected" and ruptured in steam at 300 C and 1000 psig. The rupture was viewed in the sight glass facility and time-lapse movies were made. The induction period was 51 minutes. The rupture rate attained after about one-third of the sample had corroded was 3.8 grams/minute. During this stage the core was observed to be burning with a red-orange heat estimated at about 700 C, although the inlet steam temperature was 300 C. The steam temperature was lowered until it condensed to water (about 285 C) at which time the rupture rate increased to 12 grams/minute for several minutes until the run was terminated. Rupture rates attained in water at 300 C are about 1.5 to two grams/minute, after a 50-minute induction period. The higher rates in steam (and after steam condensation to water for this experiment) are probably due to increased core temperatures caused by the heat of burning.

Radiometallurgy Laboratory Studies

Examination of the irradiated, defected rod which was used for decontamination studies in the irradiated rupture prototype facility revealed that the rupture had progressed along 40% of the rod. This element was used to simulate NPR shutdown conditions. A tube-in-tube coextruded fuel element which ruptured in KER was found to have a badly warped inner tube. Rapid corrosion of the cladding occurred at the point of contact between the concentric tubes, causing failure (RM-568). Examination of two coextruded 7-rod clusters continued this month. One sample from the area of a rupture showed the cladding to have failed in tension. Another sample showed a line on the outside of the cladding leading away from

DECLASSIFIED

DECLASSIFIED

the failure. The Zircaloy was necked down, and the uranium had cracked in the vicinity of the line. Analysis indicated a burnup of 3400 MWD/T (RM-562). Five additional enriched uranium swelling samples were removed from NaK-filled Zr-2 capsules without incident. Longitudinal cracks were found in the cladding of three samples (RM-559). Two Zr-2 specimens were examined to determine possible intergranular corrosion caused by decontamination procedures. No corrosion was found (RM-407). Three sections of the KER Loop 1 process tubing have been received and examined for internal defects located by in-reactor boroscope examination. A detailed examination of the sectioned tubes failed to reveal any of these defects with the exception of one small pit, four mils deep. Metallographic examination of the first two sections revealed partial recrystallization and a layer of large grains along the outside edge of the tube (RM-330).

Results and interpretations of these examinations will be reported in more detail in connection with the development programs served.

Basic Metallurgy Studies

Mechanical and Physical Properties of Materials. The physical properties of a zirconium-2% Nb-2% Sn alloy are being determined in order to evaluate the applicability of this material as fuel element cladding. Jominy-type end quench hardenability tests have been carried out on specimens 1/2" in diameter and 2-1/2" long. Structures and hardness found in these end quench tests depend on the temperature from which the specimens are quenched and the cooling rate obtained along the test bar. A maximum hardness of Rg 94 was obtained near the quenched end of the specimen heated to 975 C prior to quenching; a hardness of Rg 91 was attained in the specimen quenched from 950 C and Rg 85 in the specimen quenched from 850 C. The heat treatability of this alloy is attributed to the formation of a martensite upon quenching from temperatures greater than 950 C.

Electron and Optical Microscopy. The study of the microstructure of cladding and fuel material after irradiation is a direct way of detecting radiation damage in these materials. Thin films and foils suitable for electron microscopy offer advantages since radioactivity is a minimum.

Thin evaporated films of ZrO₂, Pt, Ge, Al, and SiO₂ on carbon have been irradiated in contact with UO₂ to 1×10^{16} and 2×10^{16} nvt to study fission fragment damage. Contrary to previous results, fission fragment tracks in regions free of UO₂ were observed not only in ZrO₂ but also in the case of Pt and Ge. The presence or absence of tracks appears to be dependent on film thickness. In cases where tracks were observed, the film thickness was approximately twice that of the previous experiments. Absence of tracks in Al and SiO₂ multiple films must be associated with insufficient scattering power and contrast. All films after shadowing show similar straight line irregularities which consist of discrete nodules.

Aluminum foils thinned electrolytically have been irradiated in contact with a thin evaporated layer of UO₂. Prior to irradiation to 1×10^{16} nvt,

dislocation motions were readily observed. After irradiation and fission fragment bombardment, the dislocations were not observed to move during examination in the electron microscope. This qualitative observation requires further study.

X-Ray Diffraction Studies. Growth index values and inverse pole figure data are being obtained for extruded uranium rods and tubes with various fabrication and heat treatment histories. Growth indices have been determined by two methods - the Morris ten plane and the Sturkin 31 plane. There has been some controversy here and off-site (and between Morris and Sturkin) as to which method is the better. Results of over 120 determinations in this laboratory indicate that there is essentially no difference in the final results obtained using either method; that is, the methods are equally as good in producing a number to represent growth. The Morris method is less tedious and may be preferred on that basis. Although the general method of growth indices has been successfully applied to uranium rods and plates, it is by no means certain that such methods will be adequate for predicting the behavior of extruded tubes. There are several drawbacks to the methods as applied to rods and plates. One of these is that only one to three points of a true pole figure are examined. A very strong growth orientation not coinciding with those points can be easily overlooked. It is, thus, quite possible that a texture will exist at a point where no measurements are made. Full pole figure determinations are being made to determine the extent to which this problem invalidates growth predictions made on the basis of growth indices.

Solid State Reactions. Effects of irradiation on non-fissionable materials are being studied by means of x-ray diffraction. Currently, the studies of irradiated molybdenum have been extended to include effects of annealing of high exposure material. Isochronal anneals of molybdenum irradiated to 5.0×10^{19} nvt have been carried out to 500 C, and no change in x-ray line width has been observed. Cold worked molybdenum is also being annealed for comparison and likewise shows no change in x-ray line width up to 500 C.

Metallic Fuel Development

Cluster Fuel Elements. Production Test IP-288A comprising seven, twelve-inch, 7-rod cluster elements with hot headed and projection welded end closures was examined in KE basin. After 2010 MWD/T exposure in KER, the elements appeared in near perfect condition. There was some white corrosion of the spark machined spiders. One of the elements was selected for detailed examination in Radiometallurgy.

Tubular Fuel Elements. The present KER loop process tubes are not large enough to accommodate complete NPR tubular fuel elements. However, the inner tubular components can be tested in KER loops under thermal conditions close to those proposed for the NPR. During June, fabrication of three, 16" long, NPR inner tube test elements was completed. Five additional elements were rejected during fabrication due to unbonded or thin

DECLASSIFIED

DECLASSIFIED

clad and contaminated welds. The three completed elements are scheduled for charging during the next reactor outage.

On April 24, 1960, a tube/tube KER-size fuel element failed in KER Loop 4, after 1200 MWD/T exposure. Examination of this element began in June. The failure was located on the outer surface of the inner tube of a 36" long uranium-two weight percent zirconium alloy fuel element. The inner tube had warped into an "S" curve, touching the outer tube in two places. The clad was corroded severely in the hot spot areas surrounding the points of contact. Corrosion at the downstream point of contact had penetrated the 0.020 inch Zircaloy-2 clad. Corrosion of this alloyed fuel core was not severe, and no swelling of the clad adjacent to the point of rupture could be observed. No accurate dimensions have been taken from the fuel element to date, but visual inspection shows that the severely bowed inner tube has decreased in length and increased in diameter.

Two Zircaloy-2 clad I & E elements containing natural uranium were assembled for irradiation in the GEH-4 facility at the MIR.⁽¹⁾ The elements were 1.470-inch OD, 0.400-inch ID, nine-inch over-all length, with 0.100-inch thick end caps electron beam welded. The goal exposure of the test was 1000 MWD/T to determine fuel and cladding behavior of coextruded, Zircaloy-2 clad material under conditions applicable to HAPO reactors. The test was inserted in the reactor in cycle 140, and was discharged after 11 hours of operation because of rupture indications. Average power for the two elements during this period was 110 kw/ft with the peak power 140 kw/ft. Maximum power calculated from basket water temperatures was 124 kw/ft average and 156 kw/ft peak. Examination in the basin revealed a rupture at the upper end of the upper element. The cap was bulged 1/16 to 1/18-inch above flat, and both the inner and outer welds have separated on one side. The elements have been returned to Radiometallurgy for further examination.

Irradiation test FT-IP-317A elements prepared from coextruded natural uranium tubes, 1.470-inch OD x 0.400-inch ID with nominal 0.020-inch thick inner and outer Zircaloy-2 cladding were discharged from KER Loop 3, after ten hours of operation because of rupture indications. Ten of the eleven elements were recovered and have been examined in the C Reactor viewing pit and in the KE basin. The remaining element has not been located as yet. The cap of one element, HT-10, was bulged and the inner weld appeared cracked. The activity in the loop is attributed to this failure rather than to suspected surface contamination of the elements. The ruptured element will be examined further in Radiometallurgy.

(1) HW-64281, "GEH-4-40,51 - Zircaloy-2 Clad, I & E Cooled Fuel Element Irradiation," March 11, 1960. Confidential.

Component Fabrication. The quenching rates of sections of NPR inner tube stock, 1.430-inch OD x 0.520-inch ID, were determined for additional heat treatments considered for beta heat treatment of this fuel. The treatments and midwall quenching rates are given in the following table:

<u>Heat Treatment</u>	<u>Delay Before Quench, seconds</u>	<u>Quench Rates, °C/min</u>
730 C 10 minutes NUSAL salt-quench in room temperature oil		
1	3	3275
2	10	2730
3	20	1900
4	30	730
5	40	Partially in transformation at quench. Transformation half completed at quench.
6	45	

Dimensional changes recorded indicate no change in outside diameter, 0.003-0.005 inch increase in inside diameter, and 0.010-0.014 inch increase in a three-inch length. The change in inside diameter was progressively less with lower quench rate. Comparison was made of the macro and micro grain sizes of the uranium after these treatments and previous water, salt, and air quenches. Oil quenches up to 30 seconds delay time produced slightly coarser but more uniform grain structure than 20 or 80 C water quenches. Radially columnar structures are produced at the higher quenching rates. Oil quenches with delays of 40 and 45 seconds produced coarse grains, similar to air cooled or 590 C salt quenched sections. To avoid the columnar grain structure and associated crystallographic texture developed, it appears desirable to use a quench rate of 3000 C/min or less. An 18" long NPR inner tube with brazed end closure was beta heat treated using the 730 C, ten-second delay, oil quench treatment. Dimensional changes were as predicted by the treatment of short sections, no change in OD, 0.005-inch increase in ID, and 0.062-inch increase in length. Double throw warp increased from 0.007 to 0.011 inch and remained in the same plane.

It has been proposed by the Fuel Element Design Operation that a rod type fuel element be fabricated having an outer layer of three percent enriched uranium and a core of depleted uranium. Such a combination would allow the use of rod type elements having lower operating core temperatures.

Preliminary fabrication has been started. Vacuum melted and cast components consisting of a natural uranium core piece and a natural uranium outer sleeve have been extruded with Zircaloy-2 cladding. The resulting clad rod was 0.600-inch diameter representing an area reduction ratio of 12.5:1. Approximate dimensions of the finished extrusion are as follows: Zr-2 clad - 0.020 inch, uranium sleeve - 0.026 inch, core diameter 0.508 inch.

DECLASSIFIED

DECLASSIFIED

HW-65854 DEL

Metallographic, eddy current, and ultrasonic inspections show the grain size, bonds, and clad thickness to be equal in quality to previously extruded rods. The uranium-uranium interface shows complete bonding with the grains growing across the interface.

Initial testing of the three-roll straightener indicates it is possible to straighten tubular fuel geometries within 0.013 inch double throw warp in an 18-inch length. A 30-inch long NPR outer tube having 0.140 inch double throw warp was straightened during quenching from beta heat treatment. Following the 600 C isothermal quench, the tube was rolled in the straightener during cooling to ambient temperature. This treatment decreased the double throw warp to 0.010 inch in the 30-inch length. The tube was then relaxed for two hours at 400 C in an air furnace. During relaxation the double throw warp increased to 0.025 inch in the 30-inch length. Four sections of two percent Zircaloy alloy, 1.6 percent enriched, 18 inches long KER tubing were straightened. The sections (two inner and two outer) were heated to 650 C in salt and rolled during cooling. The outer tubes were straightened from 0.028 inch and 0.021 inch to 0.013 inch and 0.013 double throw warp. The inner tubes straightened from 0.021 inch and 0.007 inch to 0.012 and 0.007 inch double throw warp. Some dimpling of the surface was noted on the KER inner tubes. This is caused by salt breaking and flaking as it freezes on the material. Decreasing unit loading force on the tube should minimize this action.

Closure and Joining. Several pieces of a coextruded, ingot uranium KER inner tube have been hot headed after having different heat treatments to show the effect of the post-extrusion heat treatments on hot heading. The different heat treatments consisted of a four-hour 650 C anneal, a 730 C beta heat treatment with a water quench, a 730 C beta heat treatment held at 590 C for five minutes and air cooled, and a 730 C beta heat treatment held at 590 C for five minutes and air cooled followed by a four hour 650 C anneal. The results show that the beta heat treated tubes, annealed or not, required approximately ten percent more force to hot head than the as-extruded tubes. No appreciable difference was noted between the air cooled and water quench beta heat treated tubes. The above tests were run at press ram speeds of 30, 40, and 50 inches per minute. The ram speeds do not appreciably affect the maximum heading force required with the only noticeable difference being a more uniform streamlined flow over the relatively square heading dies at higher ram speeds.

A preliminary test of the use of ultrasonic energy as an aid in acid milling was conducted. The test consisted of vertically suspending test specimens (KER inner coextruded fuel material) in 53 C, 3 M hydrochloric acid solution. A 60-watt, 40 kc transducer was used to supply energy to the acid solution. No significant difference in milling rate or surface characteristics was observed in the test specimens.

Pressure loading of the fuel element end cap during brazing has resulted in a much improved brazed closure. Pressure is applied manually through a push rod which bears on a graphite pressure pad. This brazing method

has several advantages over the capillary brazing method. First, the braze alloy can be placed under the cap in contact with the uranium. This simplifies the handling problems associated with beryllium containing braze alloys. Second, the amount of braze alloy required for a single braze has been reduced by a factor of ten. An NFR inner fuel element required 25 grams of braze for each closure by the capillary technique, now only 2.5 grams is required. Third, because of the reduced amount of braze alloy, the amount of beryllium containing braze alloy which must be removed by machining is practically nil. Fourth, the braze material can be in virtually any form - powder, turnings, or disks. And fifth, the number of voids along the braze line has been reduced considerably. By pressurizing the cap, there is only a thin line of braze material between the cap and the uranium. This thinner braze line has reduced the swelling of the fuel element at the cap to uranium interface. This technique, however, requires very flat uranium surfaces.

The present brazing cycle for NFR inner fuel tubes is to hold the closure for two minutes at 1035 C, and to apply an approximate pressure of 75 psi to the cap for the last 30 seconds of brazing. These appear to be the minimum conditions to obtain consistent bonding between the braze alloy and the uranium. All of the present work is being done with the 5% beryllium-95% zirconium braze alloy. Several other alloys are on order from Oregon Metallurgical Corporation and should be received next month for evaluation.

Full size test pieces have been made, heat treated, and are being autoclaved. With favorable results the first brazed production test will be started.

Development of the hot headed resistance projection welded end closure has been progressing slowly due to restricted time off-site equipment is available and local difficulties in procuring material. In an effort to obtain data which could be used in the program when equipment is installed at Hanford, end caps were prepared with three different projection designs. The projections were milled off over three-fourths of the cap surface leaving two 45 degree segments of projections. To fire these requires practically full power of the 100 KVA machine available at Hanford. These have been fired onto Zircaloy washers and the results are being studied. It appears that the amount of set down can be controlled by projection design. Also, techniques are being developed which should be transferable to fuel elements on the larger machine.

Allied Fuel Studies. The fourth ETR in-reactor rupture test was conducted Friday, June 17, 1960. The fuel element for this test consisted of an unirradiated KER tube/tube element defected on the outer surface of the outer tube. Operating conditions during the test were:

Bulk Water Temperature - 520 F (outlet)
Fuel Surface Temperature - 570 F
Specific Power (outer tube)- 53.3 kw/ft.

DECLASSIFIED

Immediately following rupturing, three to four mr of gross gamma activity was recorded in the loop. The activity remained essentially constant in the loop for the first twenty minutes. During the next ten minutes, loop activity increased at a constant rate to a level of 20 r at which time the test was terminated. The rupture behavior observed in this test compares with the behavior of laboratory defect tests but does not support the rupture behavior of the first unirradiated ETR test (7-rod cluster) in which failure did not occur during seven hours of operation.

A total of four pinhole defected irradiated fuel rods have been tested in the IRP loop facility. Some conclusions derived from these tests and post-failure examination of the test rods follows:

- a. The formation of the blister in the Zircaloy-2 clad at the defect, the manner of blister failure, and the nature of subsequent clad deformation and failure indicates that the ductility of the Zircaloy-2 has not been seriously impaired by its exposure.
- b. Irradiated fuel rods which have been beta treated and water quenched behave the same as rods which have been slow cooled. This behavior indicates that the manner of pre-irradiation beta heat treatment does not influence the irradiated failure behavior to a significant extent.
- c. The rate and the manner in which the blister developed in the clad at the site of the pinhole defect is not significantly different from that observed in unirradiated defect tests. This is interpreted to mean that the bond strength and corrosion rate of the fuel have not been altered appreciably by irradiation. The maintenance of high bond strength during irradiation has also been verified by notch-fracture tests performed on wafers of irradiated fuel material.
- d. The mechanical properties of the irradiated fuel appear to dominate the mechanics of irradiated failure behavior. Cracking of the fuel underlying the bond zone has been consistently observed. Failure of irradiated test specimens is more rapid and severe than unirradiated test specimens because of the tendency of the irradiated fuel to crack or fragment, thus exposing much more fuel surface to corrosion attack than in unirradiated specimens.

In a simulated NPR reactor shutdown procedure using material irradiated to 2400 MWD/T, corrosion was severe. In this test, 183 grams of fuel were corroded during the 38 minutes required to cool from 300 to 220 C. Initial examination indicates fuel cracking was a major factor contributing to the high corrosion rate.

Fuel element supports formed from 1010 and 1020 steels have been wear tested and have performed satisfactorily even when the contact area

between the support and autoclaved Zircaloy-2 is reduced to a point. However, in evaluating the performance of a newly designed support with flat bearing surfaces 5/8 inch long, scratching of the autoclaved Zircaloy-2 did occur. However, decreasing the radius of curvature of the bearing surface to approximately two inches eliminated all traces of autoclave film damage by the 1020 steel. Several steel supports were attached to Zircaloy-2 surfaces by spot welding a small wire through a hole in the support and upsetting the wire over the support. These were autoclaved at 300 C, 1500 psi for ten days. A small amount of white oxide appeared on two of the supports where the Zircaloy-2 and steel had alloyed together during welding. On the remaining samples no indications of corrosion could be found. Wear and corrosion evaluation of other materials, including Zircaloy-2 roll clad with steel, is continuing.

Mechanical testing of candidate NPR fuel element self-supports is continuing. Important interdependent parameters affecting support design include the allowable coolant pressure drop across supports, the load the support must hold without taking a permanent set, the elastic properties of the support, and height of the support when it is completely crushed. Typical values for an annealed Zircaloy-2 suitcase handle support made from 0.030 inch thick stock, 1/4 inch wide are: load to cause 0.001 inch permanent set, 150 pounds; buckling load, 290 pounds; and crushed height, 0.070 inch.

Supports incorporating the latest design changes are being prepared in two thickness to width ratios for flow testing by Thermal Hydraulics Operation. The results of these tests will be used in establishing the final dimensions of NPR elements.

The thermocouple test element in KER Loop 1 continued to operate satisfactorily. The temperatures measured during the entire operating period show that there has been no deposition of crud film on the fuel element surface.

Radiometallurgy examination of five 1.6 percent enriched uranium fuel rods irradiated in NaK capsules at D Reactor was started. These rods are in addition to the four similar fuel rods reported last month. Two of the rods operated at volume average uranium temperatures in the range 440-515 C to exposures of 2000 MWD/T, and three of the rods operated to similar exposures at volume average temperatures of 390-425 C. Extensive splitting of the clad on four of the five rods occurred during irradiation. From initial observations in the examination cell, the failures appear similar to the ductile cladding failure that was observed in one of the four rods examined last month, and metallographic examinations are planned to determine whether or not these cladding failures are also the result of severe localized deformation of the clad.

A series of Dynapak extrusions of mild steel were made with instrumentation to record punch pressure during extrusion. Billet temperature, impact energy, and reduction ratio were varied in these tests. An unexpected result of this investigation was an apparent extrusion velocity limit. The average extrusion velocity, as determined from the punch

DECLASSIFIED

DECLASSIFIED

pressure-time curve and the extrusion length was, in each test, 3000 inches/second. Detailed results of this work are presented in HW-65606.

Facilities and Equipment. Two major pieces of equipment located in the 306 Building (Project CA-744) have been tested and accepted. They are the 14" x 14" two high four high rolling mill and the synchrodrive tube and rod straightener. Both have met all performance requirements. A third major item, the stretch straightener, has been tested. It, however, does not perform as it should. The low pressure control system is decidedly lacking in sensitivity. The nine roll leveler has been tested and is acceptable. Formal acceptance of this item should be made before the end of the month.

2. REACTOR PROGRAM

Coolant Systems Development

Nickel-Plated Production Reactor Fuel Elements. Improved nickel-plated aluminum-clad fuel elements have been under test at 120 C (for 1½ weeks) and 165 C (for three days) in the Single Pass Mockup Facilities. The nickel coatings were pre-defected in various degrees (dents, scratches, or file marks), some ranging up to areas 1/4 inch by four inches. The elements will be examined after two weeks of exposure to evaluate corrosion effects at the defected points. Elements removed from previous tests at 120 C and 165 C show excellent resistance and low film formation. Defected spots were not enlarged, and the aluminum jacket underneath was not pitted.

Corrosion on Single-Pass Decontamination. Corrosion measurements are being obtained on aluminum, stainless steel, carbon steel, and Zr-2 samples subjected to repetitive decontamination cycles. Each cycle consists of 156 hours of exposure in 130 C process water at 35 gpm, and a 30-minute "decontamination" with one of three selected chemical mixtures. Two cycles have been completed using inhibited sulfuric-oxalic (0.3 molar sulfuric acid, 0.1 molar oxalic acid, and 1½ grams/gallon of 1-phenyl-2-thiourea). This process appears promising for cleaning the aluminum, stainless steel, and Zr-2 coupons without severe metal loss. However, significant yellow-green film is deposited on the carbon steel coupons. Total penetrations due to the decontamination solution are less than 0.05 mil per cycle for carbon steel, and less than 0.8 mil per cycle for aluminum. Penetrations of stainless steel and Zr-2 are too small to be measured. One cycle has been completed using the proprietary mixture Turco-4518 (3 oz/gallon solution). This process also cleaned aluminum, stainless steel and Zr-2 in this first cycle. The carbon steel sample was covered with dark brown film.

Cyclic Decontamination Studies Employing Alkaline Permanganate, Oxalic Acid. The CEP-1 loop completed three weekly decontamination cycles during the month, for a total of five cycles completed out of eight scheduled. The test is proceeding with a minimum of loop down time.

The installation of a purge system for the pump bearings appears to be very helpful in decreasing the hours of down time. The carbon steel coupons are covered with an adherent black film which is not the characteristic magnetite film normally formed under high pH, high temperature operating conditions. This black film is covered with a thin film of mixed ferrous and ferric oxalates which is removed by wiping. The oxalate film was found on all metals tested. The black film is not completely removed after treating the coupons in the standard inhibited hydrochloric acid cleaning process for carbon steel. It appears to be characteristic only of the carbon steel as it has not been observed on the other metallic surfaces. At the completion of four cycles, the uniform corrosion rates of carbon steel, stainless steel, Zircaloy-2, and Graphitar were very low. The carbon steel mechanically coupled to stainless steel exhibited the highest corrosion rate, about 0.05 mil/cycle. The stellite samples have not been examined metallographically, but it is very probable that they have undergone excessive penetrations as a result of dendritic attack. Stress-crevice coupons of type 304 stainless steel, Zr-2, A-212 carbon steel and Sheffield steel have been discharged after two and four weeks of exposure in CEP-1. There have not been any indications of non-uniform corrosion on the type 304 stainless steel and Zr-2 coupons. However, some pitting up to five mils deep has been found in the crevice areas of the carbon steel coupons. Weld samples of etched Zr-2 tube have shown good corrosion resistance in this process. No signs of white corrosion have been found at the weld areas.

Alkaline Permanganate, Phosphoric Acid. The system completed three weekly decontamination cycles in CEP-4 during the month to bring the total to five completed cycles out of eight scheduled cycles. The loop has been operating with a minimum of down time. A purge system for the main loop recirculating pump has aided greatly in decreasing the loop down time. After the third cycle, the uniform corrosion rates for Zircaloy-2, Zircaloy coupled with stainless steel, 304 stainless steel sensitized and non-sensitized, A-212 Grade B carbon steel and A-212 Grade B carbon steel coupled by an 18-8 stainless steel screw were about equivalent to those for the alkaline permanganate, oxalic acid cycles described above. None of the stress-crevice coupons discharged to date have shown any stress cracking, crevice attack or pitting. The stellite-6 and -12 had corroded 0.5 mil and 0.07 mil, respectively, but the surfaces were pitted in the characteristic fashion of the alkaline permanganate solutions. The A-212 Grade B carbon steel - 304 stainless steel welded specimen discharged after the fourth cycle exhibited 0.83 mil uniform corrosion on the carbon steel portion. However, the carbon steel portion was extensively pitted in general, with gross pitting between five and 10 mils deep in several areas adjacent to the weld bead.

All of the coupons were defilmed during the loop decontamination cycle. However, they were coated with a phosphate conversion coating caused by the Turco-4512, inhibited phosphoric acid. This coating was easily removed by the standard hydrochloric acid cleaning process.

DECLASSIFIED

DECLASSIFIED

ELMO-10 Decontamination Studies. Twenty-nine scanning studies have been completed in ELMO-10 during the past month to develop information for designing further modifications of certain promising compounds for decontamination. The tests consisted of exposing active stainless steel samples and inactive samples of carbon steel, sensitized stainless steel, and non-sensitized stainless steel to decontaminating solutions. The solutions tested were variations of alkaline permanganate (including Turco 4502 and Wyandotte 1112) and different acidic solutions suggested as film removing solutions (Turco 55-8A, Turco-3291, Turco-4512, Turco-4518, Wyandotte-1112, Wyandotte-75, Oakite 84A, Oakite 84M, Oakite 88, Wedac, oxalic acid, oxalic acid with EDTA, oxalic acid with sodium oxalate, and ammonium citrate). The uniform corrosion rates for stainless steel were all low. The uniform corrosion rates for carbon steel were all satisfactory except for Oakite 84A (1.5 mils/hr), Wedac (1.2 mils/hr), and ammonium citrate (1.0 mil/hr).

pH Control. The pH control characteristics of IRC-50 (a weakly acidic, cation exchange resin) have been evaluated. The resin has been tested in the lithium, sodium, potassium, and ammonium forms using deionized water as the influent. The resin has performed exceptionally well in producing high pH effluent water. The results indicate that pH control at 9.5 to 10.0 is possible using ammonium form resin and 10.0 to 10.5 using resin in the other forms. These resins had processed approximately 3000 bed volumes of water and were still performing well when the tests were discontinued.

Oxygen Scavenging Studies. Equipment modifications were completed and several tests were performed using activated carbon to accelerate the reaction between aqueous hydrazine and dissolved oxygen. The results of the dynamic tests at 70 F and a hydrazine-to-oxygen ratio of two, show that the scavenging efficiency is time dependent during the initial period of operation, increasing from 10 percent O₂ removal at 10 minutes to 95 percent removal at 150 minutes, at a flow rate of 50 gpm/ft². These data indicate that it may be necessary to concentrate an appreciable quantity of hydrazine in the activated carbon bed before any significant amount of reaction is obtained.

KER Water Quality. A chemical addition system for feed and bleed operation of the KER loops has been installed. The system was checked out and was used on KER-3 and KER-4 for a short time. The loops were operated at pH 10 during this period, and operation was quite satisfactory.

Several KER hot crud samples were taken to determine the particulate solids concentration in the coolant. Samples were taken from KER-1, KER-2, and KER-3 during operation at pH 10. Samples were taken from KER-1 during the first week of operation following startup. These samples indicated an average crud concentration of 80 ppb. After three weeks of operation the concentration had increased to 130 ppb. A previous sample taken after six weeks of operation indicated a concentration of 250 ppb. Samples taken after six weeks of operation in KER-2 and

KER-3 (stainless steel systems) indicated crud concentrations of five to ten ppb.

Rupture of Irradiated Rod with Programmed Shutdown. A fourth rupture test was made using a rod from the third ETR rupture test element. It was a beta heat-treated, air cooled piece which had been previously exposed to 2400 MWD/T in KW Reactor at relatively low temperature. After the first rupture indications, an NPR cool-down rate was followed down to 220 C. At this point (total elapsed time, 38 min), a rapid cool-down was necessary because of high loop activity readings. The fuel element had ruptured severely over about one-half of the area. In one place, only a small section of the cladding held the two ends together. There was a weight loss of 183 grams out of approximately 700 grams starting weight. Breaking apart of the uranium was evidenced by the spread of uncorroded metallic uranium throughout the loop.

Heated Slug Rupture Prototype. Two more programmed cool-down runs were made with KER size inner tubes. The tubes were coextruded uranium-Zircaloy-2 in the isothermal heat treated condition. The elements were run at 300 C, 1650 psi, and 16 fps until the rupture was detected by the hydrogen detector. At this time the loop water was cooled at the NPR cool-down rate. Both tubes were defected on the outside surface with a 0.025 inch pinhole. After the respective runs both tubes were similar in appearance: each lost five grams of uranium and exhibited a ruptured area about 0.7" x 0.35" and extending above the surface a maximum of 0.15".

Hydrogen Detector. A test run operated with the instrument at 300 C has given very satisfactory results. Hydrogen was added to the loop and calibrations were made on the detector and recorder. Full-scale deflection of the recorder occurred with a hydrogen concentration in the water of 100 cc/liter. A linear calibration was obtained with hydrogen concentrations ranging between nine to 80 cc/liter. The system came to 95% of equilibrium within seven minutes. One interesting feature is that when a change in hydrogen content is made in the loop, the detector makes 50% of its ultimate change in the first minute. This indicates that the palladium diffusion is dependent on the driving force between the hydrogen concentration in the water and in the palladium wire. Additional tests will be made at other temperatures and other water conditions.

Structural Materials Development

NPR Zircaloy Process Tubes. Harvey Aluminum Company has made 26 extrusions for the pilot order of NPR tubes and is now making good progress on this pilot order, as well as in the procurement of sponge and setting up of a production organization for the 800-tube order. A viewing box has been devised which facilitates the visual inspection of Zircaloy corrosion test coupons. The use of the box, which incorporates built-in illumination and lighting control as well as a magnifying lens, has been demonstrated to tubing vendors.

DECLASSIFIED

DECLASSIFIED

Ribless Zircaloy Replacement Tubing. Current orders for a total of 200 C² Reactor size tubes will be completed in July, including approximately four to six tubes being made an extra five feet long for installation in one or more of the six KE Reactor once-through water studies process tube channels.

Trials of new fabrication techniques for ribless Zircaloy replacement tubes are being started by three vendors, with initial metal reductions scheduled for completion in July.

Examination of KER Loop 1 Zircaloy Tube. Samples cut from three different locations along this tube have been examined metallographically. All three samples exhibited substantial recrystallization, including one from the low-flux shield region which leads to the tentative conclusion that this recrystallization was not irradiation-induced. Hydriding was estimated at less than 50 ppm.

The pit defects reported from in-pile borescope examination were not found and it appears that localized deposits of crud were mistakenly identified as pits and protrusions. However, one small pit approximately 10 mils in diameter and three mils deep was found which had not been previously reported.

Nonmetallic Materials Development

Properties of NPR Reflector Graphite. Crystallite dimensions and room temperature thermal conductivity values determined on samples of the graphite being used in the NPR reflector are given below:

Vendor	Graphite Type	Thermal Conductivity (cal/cm ² /°C/sec)		C _o (Å)	L _c (Å)	A _o (Å)	L _a (Å)
		Transverse	Parallel				
National Carbon	AGOT-LS	0.270	0.627	6.721	650	2.463	52
Great Lakes Carbon	GLC	0.303	0.577	6.729	600	2.463	48

The highest degree of preferred orientation yet observed in a production lot of reactor grade graphite as determined by coefficient of thermal expansion (CTE) measurements is indicated by preliminary results on the Great Lakes graphite being supplied for the NPR reflector. Data are as follows:

Sample Location and Orientation With Respect to Extrusion Axis	CTE* Over Indicated Temp Range		Ratio of Transverse to Parallel CTE's	
	25 to 100 C	25 to 425 C	25 to 100 C	25 to 425 C
Center of Bar Transverse	3.00	4.48	8.3	5.1
Center of Bar Parallel	0.36	0.88		
Edge of Bar Transverse	2.83	3.90	6.0	4.7
Edge of Bar Parallel	0.47	0.83		

(*Multiply values by 10^{-6} to obtain units of in/(in)(°C).

The highest ratio previously observed was in KC graphite with a ratio of 4.05 for samples cut from the center of the bar measured between 25 and 425 C. Similar tests on AGOT-LS are in progress.

NPR Reflector Graphite Irradiation at ETR. Samples of NPR reflector graphite have been prepared and measured for the GEH-13-5 controlled temperature experimental capsule to be installed in the N-5 corner of the ETR. The capsule is designed for a sample temperature of 550 C and a fast neutron flux ($E > 1$ Mev) which varies by a factor of three along the length of the capsule. The experiment will consist of four sample positions with three wafer samples per position. Each sample cup will have two NPR graphite samples and one CSF graphite standard.

Hanford Irradiations. Eleven sample boats have been prepared for charging in a hot test hole (500 to 600 C) at C Reactor at the outage of July 11. Previously irradiated samples being recharged include: (a) reactor grade graphites which have accumulated 7600 MWD/AT, (b) a temperature of graphitization series, (c) samples formed by pressure-baking, (d) NPR candidate graphites, and (e) samples in which iron oxide has been added to improve final density.

Samples of TSGBF, KC, and CSF graphite previously irradiated at 30 C and then annealed at 700 to 750 C for one hour are included to determine the effect of low temperature damage on high temperature contraction rates.

Explosively compacted graphite obtained from duPont, and pyrolytic graphite from GERL are also included in the charge.

Annealing of Unirradiated Graphite. Unirradiated graphite which is annealed at temperatures above about 700 C undergoes some small growth. This length change is not associated with the much larger growth observed during relief of compression set and may be related to the "freeing" of a graphite sample from a large bar. However, the mechanism of growth is not certain, and if full size bars also slightly expand, this might explain the observed initial growth of graphite in reactors, such as C and K which have always run hot.

DECLASSIFIED

DECLASSIFIED

Cubes, 4" x 4" x 3½", of CSF and GL-10 (needle-coke) graphite were heated in a hydrogen furnace to 900 C and held for two hours. The length changes measured varied from +0.005 to +0.01 percent and are believed to be the maximum effect attributable to annealing. Consequently, it is not now concluded that thermally-induced expansion is important in initial reactor growth. A quantitative discussion of this experiment is found in HW-65815, "Thermally Induced Length Changes of Graphite Cubes."

Water Uptake Studies. As part of a study to determine possible effects of water on graphite dimensional stability, transpiration rates of water from soaked samples were observed at room temperature and pressure by means of an automatic recording balance. In contrast to the uptake curves which showed saturation only after 1500 hours, the transpiration curves showed essentially complete evaporation in about two hours.

Effects of Acid on Graphite. Dichromate-sulfuric acid solutions have been used to clean various aluminum reactor components. There has been recent interest in possible effects of this solution on graphite in connection with the cleaning of the Pneumatic and General Purpose Facilities.

Four graphite samples were soaked in a weak dichromate-sulfuric acid solution for one hour, then baked for one hour at 150 C and one hour at 250 C. X-ray examination showed a 0.1 to 0.2 percent increase in C_0 for the four samples. It is concluded that there should be no serious consequences if a small amount of this mixture is spilled into the graphite.

Flux Monitoring. Ni and Co flux monitors were discharged from the 2 C test hole in KW Reactor. Thirty pairs of wires were arranged axially along the 22½-inch sample boat, and thus the axial variation in the fast and gross thermal flux was obtained. For the fast flux the average integrated fast flux was found to be 6.9×10^{16} nvt (1 Mev)/(MWD/AT). This is to be compared with the value of 6.1×10^{16} derived solely from the GNU-II calculations. The previously observed value for C Reactor was 5.0×10^{16} which gives close agreement with the calculated ratio of 1.3 relating the integrated fast flux per MWD/AT at K and C. Along the axis of the test hole, the fast flux was found to peak near the process tubes and to drop midway between them giving a maximum difference of 15 percent between the maximum and minimum values over one reactor lattice unit.

The gross integrated thermal flux was 2×10^{17} nvt/MWD/AT and was flat to within seven percent. Since an attempt to obtain a cadmium ratio was unsuccessful, the net thermal flux could not be calculated. However, this number is in any case significantly lower than the value for the net thermal flux of 2.6×10^{17} per MWD/AT obtained from the fissioning rate.

Thermal Hydraulic Studies

Heat Transfer Experiments Pertaining to Present Production Reactors. Experiments were conducted in the Heat Transfer Laboratory to determine the course of events when a sudden reduction in front header pressure is imposed on a prototypical K Reactor (single) process channel. These transient type experiments simulate such conditions as sudden "loss" of a high lift pump(s) and flywheel, "loss" of a pump-to-riser connector line, or "loss" of an entire riser whereby the front header pressure would be sustained at some new lower value by the remaining pumps and piping. Such a pressure loss would result in an immediate scram and initiation of power level decay. However, there is a period when the power level has not decayed to as low an equivalent heating value as the flow rate - hence, a period of inadequate cooling will result. The objective of the experiments was to determine the magnitude of front header pressure reductions which could occur without resulting in fuel element and process tube meltdown during the inadequate cooling period of the flow reduction-power decay transients. For added confidence in the reactor application of these experiments, data were obtained for two different programmed power decay characteristics - one which allowed only for the nuclear heat generation and the other which allowed for nuclear heat plus five percent of the original power level for sensible heat removal from the graphite stack.

Although the experiments were not completed, preliminary analysis of the available data indicates the following (with a rear header pressure of 20 psig and an initial outlet water temperature of 125 C):

1. For an initial tube power of 1000 KW, excessive heater rod temperatures were not evident, and complete recovery of adequate cooling was attained with a sudden reduction in front header pressure to values of 40 psig or greater with a heat decay curve which allowed five percent of original power for graphite sensible heat in addition to the nuclear heat generation.
2. For an initial tube power of 1500 KW, 80 psig front header pressure was required with the high heat input decay curve and 60 psig front header pressure was required with the low heat input decay curve to prevent excessive temperatures.
3. For 2000 KW initial tube power, the front header pressure requirements were 150 psig and 135 psig for the high heat input and low heat input decay curves, respectively.

A very brief determination of the effects of increased rear header pressure and different initial outlet water temperatures is yet to be made.

DECLASSIFIED

DECLASSIFIED

Hydraulic Studies. Modifications to the Hydraulics Laboratory were nearly completed to enable a study of flow splits and the pressure drop characteristics of support pieces for the coaxial, tube-in-tube NPR fuel element.

A 12-foot test section, equivalent in length to six fuel elements, was installed on the 189-D Building mezzanine. Test section sizes are as follows: (1) inner element - 0.520 ID x 1.430 OD, (2) outer element - 1.850 ID x 2.460 OD, (3) process tube - 2.700 ID.

Heated water, approximately 150 F, supplied from the head tank, will be pumped to the test section at flow rates of 300 to 350 gpm with and without the fuel supports installed. Comparison of the two cases will permit determination of the effect of the fuel supports on pressure drop. Standard methods for obtaining channel flow splits will be employed.

Pressure drop, flow measurements were made on three orifices for D Reactor to determine the effects of non-uniformity of length and surface finish. Three different orifices were examined, all being 0.239 inch ID with a 15 degree upstream taper:

1. An orifice of length L, and 32_{μ} surface finish.
2. An orifice of length L, and 63_{μ} surface finish.
3. An orifice of length L + 0.040" and 63_{μ} surface finish.

No differences between cases (2) and (3) were noted, showing little effect of the additional 0.040" length. Case (1), however, exhibited a slightly lower pressure drop for an equivalent flow than (2) and (3), indicating surface finish does affect the calibration.

Boiling Burnout Conditions for NPR Fuel Elements. Laboratory heat transfer experiments were continued to determine the boiling burnout conditions of flows and heat generation rates for the NPR tube-and-tube fuel element. Twenty-eight boiling burnout points were obtained that are applicable to the middle cooling annulus of the fuel element.

The test section consisted of a 32-inch long Inconel tube with flow on the inside and having a hydraulic diameter equal to the hydraulic diameter of the middle flow annulus in the NPR fuel element. Boiling burnout was determined over ranges of flows between 1,000,000 and 4,760,000 lb/hr-sq ft, heat fluxes between 560,000 and 2,000,000 B/hr-sq ft, and fluid outlet conditions between 17.5 percent steam quality and 54 F subcooled.

Boiling burnout for this test section was detected in most cases by noting a sharp increase in temperature of the heated surface for a small increase in heat flux. However, for the runs at the lower flow rates, the increase in surface temperature was less distinct and on further increases in heat flux the surface temperature fluctuated with a random frequency. For these cases a plot of heat flux versus temperature difference between the surface and the liquid indicated a distinct decrease in slope at the point where the temperature fluctuations started, indicating a definite

departure from nucleate boiling. It is suspected that phase stratification is occurring in such cases and is accompanied with somewhat of a shift in heat flux from the top to the sides and bottom of the horizontal test section.

Critical Flow Experiments. The experimental study into the so-called "two-step critical" behavior of flashing of an initially subcooled fluid through short tube orifices was continued by investigating this phenomenon in two 0.50" diameter sharp-edge entrance nozzles possessing lengths of 0.5 inch and 2.0 inches. The behavior observed was consistent with that reported in the previous monthly report. In order to determine the possibility of the existence of this phenomenon in reactor geometries, a test section was constructed consisting of a 10-inch long section of 0.550" ID tubing, preceded and terminated by a BDF outlet nozzle Parker fitting and header Parker fitting, respectively. Ten and thirty degree Centigrade subcooled water initially at 100 psig was passed through the assembly, and flow rates, various pressures, and temperatures were monitored. A trace of the "two-step critical" phenomenon observed with the short tubes was evident at both temperatures. Subsequent experimentation indicated that this phenomenon was occurring in the header fitting notwithstanding the high velocity of approach of the coolant. The difference between the flow rates between the unstable entrance and exit criticals was, however, quite small. At 140 C, it amounted to only one gpm and at 160 C, 2.5 gpm. This suggests that this phenomenon need not be of great concern as applied to these reactor fittings.

Plans have been made to visually observe the flow during the existence of this phenomenon in order to gain a better insight into its mechanism. Glass test sections have been designed and are under construction at the Optical Shop.

Shielding Studies

Attenuation Measurements. The Perlow Spectrometer, 100-channel analyzer, and associated electronic components have been moved to the positive ion accelerator laboratory for the spectrometer calibration. After the move, the analyzer required only 10 minutes warmup with no adjustment before it was ready for pulse analysis. Preliminary results using a chamber pressure of 13.0 cm of methane indicate that the spectrometer is linear to $\pm 1/2$ channel on the 100-channel analyzer, with each channel representing approximately 9.2 KEV. The resolution was about eight percent for a neutron energy of 889 KEV.

The 265 lb/ft³ iron-serpentine concrete was tested after being baked at 320 C. The measured fast neutron removal cross sections are as follows:

<u>Bake Temp.</u>	<u>Removal Cross Section (Σ_R)</u>
As-Cured	0.128 cm ⁻¹
As-Cured	0.126 cm ⁻¹
100 C	0.113 cm ⁻¹
320 C	0.112 cm ⁻¹

DECLASSIFIED

DECLASSIFIED

The gamma dose rate increased by a factor of three after baking this concrete at 320 C as compared to the as-cured condition. The gamma dose rate through 48 inches of the lighter iron-serpentine concrete (210 lb/ft³) changed by a factor of only about 1.2 due to baking at 320 C.

Design and Component Testing

NPR Charging Machine. Fabrication of the transfer arm assembly, idler roll assembly, and power roll assembly was completed. Design of the magazine positioner was completed, and a cost estimate is being made. Design of the nozzle adapter was started.

An estimate for a reduced size charging machine containing all the critical facilities was made. The estimate amounted to \$50,000 as compared to \$80,000 for the complete machine. A new prototype evaluation is being made.

B. WEAPONS - 3000 PROGRAM

Research and development in the field of plutonium metallurgy continued in support of the Hanford 234-5 Building Operations and weapons development programs of the University of California Lawrence Radiation Laboratory (Project Whitney). Details of these activities are reported separately via distribution lists appropriate to weapons development work.

C. REACTOR DEVELOPMENT - 4000 PROGRAM1. PLUTONIUM RECYCLE PROGRAMPlutonium Fuels Development

PRTR Fuel Fabrication. Several Mark I-G PRTR fuel element clusters have been assembled and finally inspected. These are part of a group of 36 plutonium spike elements to be used in the PRTR for criticality tests. The problems associated with etching and autoclaving Zircaloy-2 clad Al-Pu elements have been solved by modification of the autoclaves to provide a method for blowdown during startup. The blowdown system eliminates the boiling off stage where any impurity in the water is concentrated. Boiler scaling of the finished rods was eliminated.

The etching problem was apparently a matter of insufficient neutralization in the stop etch tank. Higher bath temperature and vigorous agitation of the work piece eliminated the acid staining problem. It is now possible to provide a steady output of rods for assembly. Six of the 36 elements will be of the Mark I-H design using tubing with a 35-mil wall thickness. The fabrication of these elements has been delayed awaiting the Zircaloy tubing shipment.

All welding and autoclaving has been completed on the Mark I-G end brackets for the first PRTR loading. No white or grey corrosion product was found on the autoclaved brackets indicating the welding atmosphere was satisfactory.

The design has been completed and approved on a special Pu-Al monitor fuel element for use in PRTR critical testing. This element is of the Mark I-G type and will have three special rods containing monitoring foils (Dwgs. H-3-13332 and H-3-13333).

Fabrication Development. The silicon content in Al - 1.8 w/o Pu - 1.3 w/o Ni - 1.0 w/o Si alloy cores has caused difficulties in solvent extraction reprocessing testing. Accordingly, an alternative corrosion-resistant alloy, Al - 2 w/o Ni - 1.8 w/o Pu, has been investigated, with and without the addition of 0.1 w/o Ti. Twenty-four extrusion billets were cast with the casting and mold temperatures varied over the range which would be normal practice for billet casting. A total of 72 samples of extruded and straightened rods from these billets were corrosion tested at 350 C. in a static autoclave containing deionized water at a neutral pH. Visual examination showed corrosion resistance as good as the alloy containing 1.3% silicon. Samples of both alloys were also tested in deionized water adjusted to pH 10 with lithium hydroxide. Exposures at 350 C for 24 hours revealed only negligible increase in visible inspection, although the oxide coating appeared darker in color.

Five, 89-inch long, 1/2-inch diameter, injection castings were made with aluminum - 2 w/o Ni alloy in Zircaloy tubing. The average density of the five castings was 95% of theoretical with a maximum of 97%. The improved density was obtained by adding an additional heating cartridge to increase the preheat temperature of the fitting at the junction of the dip tube and fuel tube, and by applying an insulating protective coating, duPont J-400, to the outside of the Zr fuel tubing. The additional heat at the dip tube fitting resulted in a steeper temperature gradient in the castings and permitted better feeding of the solidification shrinkage at the lower end. The protective enamel used on the fuel tubes is one that was developed for heat treating titanium alloys. At its firing temperature of 700 C, it forms a vitreous coating which prevents oxidation of the Zircaloy. This coating which is later removed with caustic should simplify decontamination of Pu-Al fuel elements as well as preventing oxidation of the tubing.

The castings can be vented through a 0.070-inch diameter hole in the top end cap, and this will make it possible to weld one end cap in place before casting. The small vent hole will be closed by spot welding after casting and will save one counterboring and decontamination operation. Two 95% density castings were made with vented end caps which proved quite satisfactory.

Lucite panels were installed on the bottom glove box of the injection casting equipment, and the panel to the top glove box will be installed as soon as a sheet metal safety shield is ready. Preliminary tests will be made with the equipment with the gloves in place, and it is planned to start fabrication of two 19-rod clusters of Pu-Al fuel elements in July.

Fuel Evaluation. An eleven-inch long, Zircaloy clad, Pu-Al, 3-rod cluster which has as much as nine mils diametral gap between the core and cladding has successfully completed its irradiation in the GEH-4 loop in the MTR. It was irradiated 32 days at full power at a maximum heat flux of 576,000 BTU/hr-ft² for a maximum burnup of about 40 percent of the Pu atoms. The core in this element is a corrosion resistant alloy and initially contained 3.2 w/o Pu. The element is now being returned to Hanford for examination.

Metallographic examination of rods from an irradiated, four feet long, Zircaloy clad, 19-rod cluster showed that large aluminum grains had formed near the surface of the core whereas the rest of the Pu-Al cross-section consisted of smaller ones. The large grains near the surface were also observed on a pre-irradiation sample of the same material. Large grains, however, were also present in the center of the pre-irradiated sample, and there was a zone between the center and edge which consisted of the smaller sized grains.

Self-Shielded and Phoenix Fuel Element Experiments. Irradiation experiments to investigate the self-shielded and Phoenix fuel element concepts are being formulated. The feasibility of conducting reactivity change experiments with these fuel concepts in the Reactivity Measuring

Facility (RMF) at the MTR in conjunction with the irradiation testing is being explored and the possibility that useful information can be obtained appears promising. The rate and manner in which the reactivity and power generation of a given fuel concept changes as a function of exposure can be obtained with this type of experiment.

As presently conceived, the self-shielded element consists of a 70% T.D. core of pure PuO₂ about 3/32-inch diameter surrounded by MgO which is in turn clad in 0.030-inch Zircaloy with an OD of 0.565 inch. Physics calculations indicate that complete self-shielding occurs in a PuO₂ core which is between 1/16 and 3/32-inch diameter. A 70% dense PuO₂ core, 3/32-inch diameter, will generate about 17 kw/ft in a thermal flux of 1×10^{14} nv. Heat transfer calculations will now be made to determine the core temperature for this case of non-uniform power generation. Samples containing various amounts of plutonium are also being fabricated for testing in the RMF to determine the optimum quantity of plutonium which yields the most reliable data from the facility.

Calculations are also being made for irradiation specimens of the Phoenix fuel concept. Supplies of plutonium containing 6, 13, and 29 percent of the isotope Pu-240 are available for these experiments. The irradiation specimens for plutonium which contains about six percent Pu-240 will consist of an alloy which contains 2.84 w/o total Pu in aluminum. The total Pu content will be correspondingly higher for samples which contain plutonium richer in the higher isotopes in order to obtain the same power generation. The specimens will generate about 30 kw/ft in an unperturbed flux of 2×10^{14} nv with a calculated surface heat flux of 693,000 BTU/hr-ft². Physics and heat transfer calculations are being made to determine the total plutonium content of alloys containing plutonium rich in the higher isotopes so that all specimens will generate the same initial power in the same flux.

UO₂ Fuel Development

PRTR Fuel Elements. One dummy 19-rod cluster fuel element, in which a lead-cadmium mixture is substituted for UO₂, has been swaged. After assembly, this element will be used for PRTR physics tests.

Three dummy, 19-rod cluster, fuel elements are under fabrication for PRTR charge-discharge tests. Lead was swaged in Zircaloy-2 cladding to simulate fuel. The finished elements will be dimensionally identical to the UO₂-containing, 19-rod PRTR fuel elements.

A vibrationally compacted, nested tubular fuel element having Mark II-A cladding dimensions is being fabricated. This and other prototype ETR test elements will provide developmental information for future fabrication of PRTR elements having Mark II-C geometries.

Fabrication Development. Modifications made to the hot swaging equipment resulted in improved response time of the induction heater, better temperature control, and smoother surfaced swaged rods. These modifications

included the following:

1. Three coils of the saturable reactor of the induction heater were biased. This resulted in elimination of the severe temperature overshoots that had been experienced. Heating rates, however, were decreased.
2. Edges of the blades of the swaging dies were relieved 1/32 inch. Subsequently swaged rods exhibited less longitudinal marking than was noticed previously.
3. The feeding device was anchored to the floor to eliminate side-to-side movement. Such movement causes loss of feeding alignment and results in crooked swaged rods.

High speed motion pictures (16,000 frames per second) have been used to optimize conditions for magnetic force butt welding fuel rod closure. The film revealed that the fuel rod cladding heated and upset during the first half cycle and the cap during the second half cycle on application of the 60-cycle/sec alternating current. Macrosections of the initial welds showed that excessive heat was generated in the cladding without obtaining sufficient heat in the cap. From interpretation of the film and the macrosections, it was determined that less welding current should be used in the first half cycle and additional current used in the second half cycle. A superior weld was produced by making the indicated changes.

High speed motion pictures were also employed to investigate the performance of the high frequency continuous rib (thermatool) welder. Films revealed an erratic movement of the Zircaloy tube and rib wire beneath the welding electrodes. The machine was designed to allow the draw bench to attain full speed before engaging the parts. The engaging cushion causes the parts to make a bouncing start, with rapid acceleration followed by deceleration - slowing almost to a stop - and another rapid speed up for approximately 2/3 of a second (eight inches of travel) before the constant speed of 60 feet per minute is attained. A positive connecting link will be provided to assure constant velocity.

The film also revealed the formation of the beads at the edge of the welded rib. These beads are caused by intermittent arcing between the parts as the rib approaches the tube beneath the pressure roll. The arc produces excessive heat, resulting in overheated metal being squeezed out of the weld area adjacent to the rib. A means of controlling this arcing must be obtained.

Attempts will be made to use an impeder to force continual arcing, thereby making a virtue of it. Controlled arcing can produce the necessary heating, with much less power than that associated with the originally anticipated resistance heating. With controlled arcing, and lower power, it is anticipated that smaller cross-section ribs can be attached to tubes.

Rolling contacts were attempted for electrical connection to the rib and the tube. It was believed that less galling would occur with the rolling contact than with the sliding contact. However, intermittent arcing occurred between the rollers and the work in the same manner that arcing occurs between the rib and tube. This experience indicates that the sliding contact is more desirable and care must be taken to minimize the electrode contact width and assure that the parts and the contact do not approach each other at a slight angle. Both the heel and toe of the electrode must make good contact with the part and approach the part at a 90 degree angle.

Corrosion Studies

Rupture of Aluminum Core Fuel Element. An aluminum core, Zircaloy-2 clad fuel element sample is being rupture tested in the sight glass facility at 300 C and 1500 psig in pH 10 (LiOH) water. The 0.5 inch diameter, 1100 aluminum core was slipped into the Zircaloy tubing with five mils diameter clearance. End caps were welded on, resulting in a sample 2.5 inches long. A 20-mil slot defect, 1.5 inches long, was milled through the clad. The corrosion rates of 1100 aluminum and the Pu-Al core material for PFR are approximately the same. After eight hours of exposure, the sample showed no appreciable visible signs of core corrosion.

Steam Corrosion of Aluminum Alloys. Aluminum alloys corrosion tested in 500 C, 1000 psi steam have exhibited either very low corrosion penetrations or catastrophic destruction. There have been indications that increasing the iron content of the alloy increases its resistance to failure. The British have reported a correlation between catastrophic attack and hydrogen pressure in the autoclave. In a recent test, eight samples containing 2.0% Fe, 0.64% Ni, which had been autoclaved in steam for 300 hours without failure, were put in a static autoclave in 500 C, 1000 psi steam along with eight samples each of a 2.5% Fe, 0.64% Ni, and 3.0% Fe, 0.64% Ni alloy for 24 hours. All the samples in the test were destroyed or severely attacked except for the 3.0% Fe, 0.64% Ni alloy. Since hydrogen builds up in the static autoclave as samples are corroded, this test tends to confirm both of the above observations.

Autoclave Testing of Aluminum Alloys. Four low-silicon aluminum alloys have now completed six months of exposure in the 360 C water autoclave with no measurable increase in penetration after the first ten days. These alloys are 1.0% Ni, 0.5% Fe, 0.1% Ti fabricated at ANL; and 1.5% Fe, 1.5% Ni; 1.8% Fe, 1.2% Ni; and 2.1% Fe, 0.64% Ni all fabricated at Hanford.

Fretting Corrosion of Zircaloy. The Zircaloy fretting corrosion test at 316 C, pH 10.0 is being continued. Periodic visual examinations of the specimens indicate the fretting rate of penetration is decreasing with increasing exposure.

Structural Materials Development

Process Tube Monitoring - Mark I Prototype Monitor. Design of the mechanical equipment for inspecting the PRTR process tubes before startup or at low radiation levels has been completed, and fabrication of all major components is scheduled to be completed by the middle of July. The ID measurement equipment has been tested and found to conform with design specifications. Final assembly and calibration is awaiting completion of the linear transformer housing, scheduled for early in July.

Investigations to establish the most satisfactory optical and lighting system have continued. A borescope type viewing head with integral lighting modified to fit the standard television lens mount has been ordered and is scheduled for delivery the last week in June. This head will permit both 360 degree and 90 degree viewing for better inspection of particular areas of interest.

A purchase requisition for a recorder to give a permanent film record of the television inspection of the tubes was issued with bid returns set for July 11.

Mark II Prototype Monitor Development. Design and testing has continued on the equipment for inspecting the irradiated PRTR tubes. A preliminary specification for a TV camera to be used in a high gamma radiation environment was issued. Several manufacturers have been visited to obtain comments and to discuss foreseeable problems before the final specifications are issued.

Irradiation testing of television camera components has continued.

Transistors have been shown to be sufficiently unstable after 10^8 R total gamma irradiation to make them unacceptable for use. Vacuum tube, tunnel diode, and ceramic tube characteristics have remained relatively unchanged after 10^9 R total gamma. All tests conducted to date have been by measuring characteristics before and after irradiation but with no operating load applied. Plans are now being made to make tests on duplicate components which have at least a partial operating load applied to determine effects on life and characteristics.

Irradiation tests to 2.2×10^7 R total gamma of various glasses and plastics for possible lens and lighting use have shown ordinary Vycor, Crown and Flint glasses to be unacceptable with at least 50% transmission loss over the visible spectrum. Radiation protected Crown and Flint glasses still have 95% transmission, ordinary quartz a minimum of 87%, Corning purified fused quartz a minimum of 95%, and Styron 690 (a polystyrene produced by Dow Chemical Corp.) a minimum range of 5% at shorter wavelengths and up to 90% at higher wavelengths.

Work on the gas gap measurement instrument by Instrument Research and Development Operation was concentrated on fabricating various shaped coils with ferrite powder and laminated and nonlaminated steel cores

for testing. Apparatus has been built for measuring the effects of probe spacing with variable gas gap to determine the best spacing and coil design.

Determination of the wall thickness from the internal surface using water for ultrasound coupling with a standard Vidigage crystal shaped to fit the tube ID has been successfully demonstrated. Determination of the accuracy obtained by this method is continuing. Preliminary results indicate accuracy to at least one mil. Straight vertical movement of the probe gave more easily interpreted results than a 360° oscillating scan.

Irradiation tests of quartz, lithium sulfate, and a special synthetic crystal similar to barium titanate have accumulated 10^9 R total gamma irradiation. No irradiation effects after 5×10^8 total gamma were observed. Measurements above this level are not completed.

Sheath Tubing. The first lot of 0.495 ID Zircaloy-2 tubing has arrived. The fabrication procedure on this lot of tubes was changed in an attempt to produce a higher percentage of crack-free tubes than in the past. The total reduction in diameter from the extrusion to the finished tube was reduced from 54 to 18 percent, resulting in more working of the tube wall and less reduction of the diameter.

Physical Properties of Zircaloy-2. Twelve longitudinal tensile samples from KER and PRTR type tubes were tested at 300 C. Following is a table of the results listing the percent cold work and tensile strength of each sample compared with the results obtained from rolled strip and burst tests of tubing sections.

<u>% Cold Work</u>	<u>Longitudinal Tensile Strength (psi)</u>	<u>Tubing Hoop Strength (psi)</u>	<u>Strip Tensile Strength (psi)</u>
40	*69,800	68,400 (one test)	64,000
60	*75,800		
70	*84,700		
40 and annealed	*35,600	45,200 (avg. of 3)	28,000 to 45,000

*Each figure an average of three tests.

Three burst tests are being run on each of the 40, 60, and 70 percent cold worked KER tubes to provide data to compare with the longitudinal tensile tests.

Radiometallurgy Laboratory Studies

Metallographic examination of a Zr-2 clad, swaged UO₂ capsule revealed extensive cracking around the outside of the capsule (RM-607).

Examination of the third defected UO₂, Zr-4 clad element revealed no effects of the defect on fuel or cladding. A high flux at the midpoint

of the rod was shown by the axial void in the UO₂ as compared with sections two inches from the end, where no sintering occurred (RM-608). An enriched uranium dioxide pre-defected element was examined after a two-hour irradiation. No hydride gradient was found and the maximum hydride concentration was 50 ppm (RM-605). Work continued on the set-up and installation of equipment for UO₂ refabrication experiments. A manipulator, a shielding window, and part of the lead shielding were installed.

Examination of two PuO₂-UO₂ elements showed that the requested heat flux was not obtained. One element contained 7.45 w/o PuO₂ and the other 5.46 w/o PuO₂ (RM-654).

Six uranium swelling samples were annealed. Densities before annealing were 18.62 g/cc for the 0.41 a/o burnup and 18.74 g/cc for the 0.29 a/o burnup samples. Post-annealing densities will be reported next month (RM-265).

Results and conclusions from these examinations will be reported in more detail in connection with the development programs served.

Thermal Hydraulic Studies

Heat Transfer Characteristics of the Mark I Fuel Element. Experiments were run with a full size but foreshortened, electrically heated model of the Mark I, 19-rod fuel element to determine boiling burnout conditions. The experimentation was interrupted due to leak problems, but several interesting conditions of non-boiling burnout were first obtained as shown in the following table.

<u>Flow (gpm)</u>	<u>Exit Quality (Weight %)</u>	<u>Heat Flux (B/hr-sq ft)</u>	<u>Flow (% of normal)</u>	<u>Heat Flux (% of normal)</u>
121.4	2.5	442,000	98.7	172.6
80.5	6.1	443,000	65.4	173.0
60.2	10.0	452,000	48.9	176.6
44.4	14.9	445,000	36.1	173.8
123.8	3.2	551,000	100.6	215.2
121.5	3.8	676,000	98.8	264.0

As may be seen, the test section was operated at a heat flux of 676,000 B/hr-sq ft, a flow rate of 121.5 gpm, and an outlet steam quality of 3.8 percent without any indication of excessive temperatures.

Equipment was gathered and initial fabrication started to mockup the PRTR hydraulic piping of one process tube between the top of the fuel element and the ring header. This mockup, which will be placed in the high pressure heat transfer apparatus, is being built to obtain values of two-phase pressure drop through the outlet piping. This experimental information is needed because it is felt that analytical methods of calculating two-phase pressure drop are not sufficiently precise to allow a realistic hazards evaluation of the reactor for certain events.

PRTR Project Management and Design

Phase III PRTR Contract. The Phase III contractor is estimated to be about 92% complete as of July 1, 1960, versus a scheduled 100% based on contract completion date of June 24, 1960.

The second river pump was tested and run-in for the six-hour period required by the contract ATP. Final inspection of the river pump and condenser facilities was made. The contractor is currently completing or connecting items on the check list. It appears that the facility will be turned over to the AEC in early July.

Installation of the ion exchange resin in the zeolite water softening units was started and is expected to be complete by the end of the month at which time ATP's will be started on these units.

Flushing and testing of the chilled water system within the containment vessel was completed.

The alignment of the calandria and the top and bottom primary shields was checked and found satisfactory. The shot filling operation was completed on the top primary shield, and the top shield to side "B" shield gas shield was installed.

Considerable grinding was done on the rotating and stationary secondary shields to provide adequate clearance between the rotating members.

The helium storage tanks were received and installed. The only item of equipment not yet available for installation in the helium system is the blower for the reactor dry gas system. This is a contractor procured item.

Tracing revisions were completed during the month to provide (1) an independent emergency cooling water tube-bundle spray system for heat removal in the event of pipe ruptures causing loss of shellside water in the steam generator, (2) a second light water injection system for emergency fuel element cooling, (3) automatic continuous oxygen analysis for boiler feedwater, and (4) piping revisions for primary pump seal temperature monitoring, seal water cooling, and seal gas elimination.

Requisitions were prepared for (1) pump governor valve for the boiler spray system, (2) a tubeside gas vent valve for the steam generator, and (3) an emergency diesel-operated D₂O-H₂O injector pump for use in maintaining liquid inventory and pressure in the primary system during total power outage. Bids on the vent valve were received for engineer review at month-end.

Outlet ring header piping is complete and being prepared for hydrostatic and leak testing. Most inlet jumper flange welds have been rejected. The jumpers are now being repaired.

Grouting of rails for the fueling vehicle was completed. Installation of controls and piping for the fuel transfer system is in progress.

A number of exceptions had previously been noted to the PRTR control room panels as delivered. Discussions were held with the vendor's representative, and arrangements are under way whereby the vendor will correct the panel components to meet specifications.

The vendor who is furnishing the electronics portion of the fuel element rupture monitor system has now agreed to furnish a printing wheel on the activity recorders for positive point identification. All questions on this system have now been resolved with the exception of acceptance test procedures.

Fabrication of the mechanical portion of the fuel element rupture monitor system has been assigned to plant forces since satisfactory bids could not be obtained off-site. This work will be coordinated by Technical Shops. Currently, shielding and sample cask racks are nearing completion and orders have been placed for all materials and system components not already on hand.

Maintenance and Mockup Facility. The bid assembly for the maintenance and mockup facility including the critical facility building was mailed to prospective bidders on June 28, 1960. The tentative bid opening date is July 28, 1960. This may be extended when the rupture loop building and exhaust filter drawings and specifications are included in the bid assembly by addendum around the middle of July.

PRTR Exhaust Air Filter and Filter Vault. The scope description and design was completed and approved. The \$35,000 (estimated cost) project will be included as an addendum to the M&M facility "lump-sum" contract. CE&U personnel are now detail designing the facility.

Fuel Element Examination Facility. The primary manipulator vendor has started sub-assembly work on the manipulator carriages and the gear box. The main frame has been metallized and is undergoing machining for installation of the carriage ways prior to final finishing. Completion of fabrication is scheduled for the week of July 24, 1960 with testing to be completed the week of August 14, 1960.

Load-Out Cask. Construction of the cask is continuing. The cask is scheduled to be shipped the week of July 17, 1960.

PRP Critical Facility (Project CAH-842). The bid package for the building was issued as part of the maintenance and mockup facility bid package. Bids for the fuel transfer lock have been received. Henry Pratt & Company is the apparent low bidder.

Development work on the adjustable weir, the control and safety rods, the thimble tubes, and the source positioner was continued.

Purchase requisitions for the required electrical drives were prepared and approved. Preparation of an instrumentation purchase specification is under way. Drawings required for the specifications are nearing completion.

Authorization was given CE&U for the design of in-cell components and preparation of instrument and electrical interties.

Fuel Element Rupture Test Facility (Project CAH-867). Approval has been granted for design funds (\$130,000) for the Fuel Element Rupture Test Facility, Project CAH-867.

The text of the design criteria has been approved and is being duplicated; all scope drawings are complete and are being routed for approval. It is expected that the design criteria will be ready for publication July 1. Detail design on the loop system will be started immediately after issuance of the design criteria.

In addition to the starting of detail design, plans are being made for early procurement of the coolant circulating pumps, regenerative heat exchanger, and electric immersion heaters to determine the degree of cost control necessary for completion of the project within allocated funds. It is also planned to start procurement of Zircaloy and Hastelloy tubing for the test section assemblies so that tests can be conducted during the PRTR critical tests. Tubing purchase specifications for all tubes for the test sections are written and ready for bid submittal.

Three bids were received on a 2100 psig, 600 F, bellows for the inlet of Test Section "B". One or possibly two will be purchased for evaluation testing at HAPO. One vendor has submitted a design for a 2100 psig, 600 F butterfly valve which would be installed in the inlet end of the test section main tube. However, high pressure drop across the valve (at 200 gpm) will limit its use to Test Section "B". Fuel handling procedures can be based on keeping water in the test section by (1) coolant freezing with Test Section "A" and (2) use of a valve on Test Section "B".

Other major project items scheduled for early completion are the preparation of an addendum bid package for inclusion in the maintenance and mockup contract and preparation of a design-construct bid package for the water plant and effluent storage tank.

Work on transient analysis of control characteristics continued; it is expected that this work will be completed by July 1, 1960.

Design and Component Testing

PRTR Fueling Vehicle. The spare discharge hoist control unit was received during the month.

PR-10 - Primary Loop Mockup. All four of the PRTR primary process pumps have been returned from the factory following flywheel enlargement,

impeller trimming, and balancing while operating to less than one mil vibration. The four 350 h.p. drive motors have been rebalanced off-site to within 1/2 oz-in dynamic imbalance and returned. An order has been placed for four new full sized (18" dia.) impellers.

The spare pump has been operated for two test runs since the above changes were completed. The first test of 105 hours resulted in heat checking of the rotating face. Initial vibration, when cold, was three mils, decreasing to approximately one mil when hot. The extra vibration is assumed to be the result of hydraulic forces not present during the factory tests. The stationary graphite face used had a 70% balance and a raised face of 0.063". The second run was not attempted until the vibration was improved to approximately 0.75 mil when running cold. The graphite face used has a 65% balance and an 0.018" raised face. The seal faces were excellent when inspected after both 25 hours and 152 hours of operation. Pump power consumption and seal graphite temperature appear normal after more than 250 hours of operation. The seal has two leak rates, one very low rate of 0.01 to 0.02 gallon per hour when the pump has been started at low pressure and the thrust remains down, and a leak rate of one to two gallons per hour following a high pressure startup when the thrust goes through a reversal. The reason for this is not known, but the leak change has occurred three times, once before each of the previous two inspections and without apparent detrimental effects. Byron Jackson calculations have shown the pump to be operating with only 200 to 300 pounds down thrust under operating conditions in the Primary Loop Mockup. PRTR conditions (about 10 psi higher pump head) will increase the down thrust considerably.

The small Byron-Jackson prototype pump has operated a total of 932 hours as of June 24, 1960, without incident using the B.J. self-adjusting seal assembly. The leak rate has decreased to a low of 0.7 gallon per hour.

Testing of the R/M Vee-Flex Packing rings in the prototype injection pump was discontinued on June 20, 1960, when the leak rate on one of the three plungers glands was found to have increased to 4500 ml/hr. The leak rate of the other plungers glands was still only 150 ml/hr. The two sets of packing still looked good, and the plungers were not badly scored, while the fabric had broken down on the failed set of packing. This life of 1080 hours represents about twice the useful life of previous packings tested.

Chesterton Superlon square braided packing has been installed for further testing.

Process Tube No. 586-6063 has operated 640 hours and 15 thermal cycles during the past month. A TV camera inspection of the tube was made on May 25, with no indication of tube damage. This process tube has now operated for 2900 hours at reactor conditions.

Process Tube Seal Experience. The new gasket without shim in the nozzle-to-process tube (NTP) connection on the Single Tube Prototype has operated 640 hours and through 15 thermal cycles with an average leakage of about 0.1 milliliter per hour.

With the special NTP test piece, 475 hours and 53 thermal cycles of operation have also been made. Two gaskets tested without shims have leaked less than 0.1 ml/hr. Two gaskets have also been tested while using shims. The first of these had a leakage rate of only 0.2 ml/hr; however, upon disassembly it was discovered that the gasket had absorbed almost all the bolt torque preventing solid metal-to-metal contact on the shim. The second gasket with shim after 135 hours and 15 thermal cycles is operating with a leakage rate of about 0.5 ml/hr.

The modified outlet nozzle cap plug has been operated with four gasket seals during the past month. This modified design uses a slightly wider gasket. Average leakage with these four gasket seals, three operated in the Single Tube Prototype and one in the Flexure Loop, has been quite satisfactory with leakage averaging about 0.1 ml/hr in 750 hours and 26 thermal cycles of operation.

PR-40 - Shim Control Mockup. Sixteen PRTR shim control assemblies have received operational tests at Hanford and are now available to the reactor contractor. The remaining eight drives are at GE-APED, San Jose, awaiting acceptable gear motors. Four prototype gear motors from another vendor are due June 25. A letter has been issued designating the proper reactor location for each assembly.

PR-80 - Air Cooling Duct Test. The transition piece from the wall to the air duct is 70 percent designed. Final clearance measurements are based on current information received from the vendor. An opening in the transition piece will mate with a spring tensioned door on the wall bracket to permit movement over the hook.

Special Tools. The cut-off saw and core saw prints have been checked and are ready for approval. Design of the load-out cask gate wrench has been completed and fabrication has started.

Material for new and stronger push rod springs for the Fuel Element Extractor has been received. Design of a push rod uncoupler has been started.

Final design of the PRTR Unit Motion equipment has been completed.

PRTR Process Instruments. Special infrared responsive lenses were received for possible use in the temperature probe for the Fuel Examination Facility. The resistance to gamma radiation of these lenses, with and without coatings, will be compared to the lens already procured in order to extend the service life of this temperature probe.

Material for a temperature probe was received from the vendor for an in-reactor temperature detector planned for use in the PRTR Gas Loop. The instrument is intended to detect lateral movement of the process tube. An in-pile test has been scheduled to evaluate its performance in a nuclear radiation environment.

Final evaluation of the long (six-foot) probe for measuring rate of moderator dump has been completed. Continuous timing of the fall of the moderator level from approximately full to within six inches of empty was obtained on the calandria mockup at 189-D. Times were measured after release of the electric solenoid valves. Total times for a fall of about eight feet using various numbers of dump valves were as follows:

<u>No. of Dump Valves</u>	<u>Time Required (seconds)</u>
4	5.8
3	6.0
2	6.4
1	7.6

Design Analysis

PRTR Process Specifications. Approximately 95 percent of the Startup Process Specifications have been written in first draft form and given initial review by the PRTR Startup Council. With one exception, first drafts of the remainder are being written currently. The exception, "Required Actions Following a Primary Coolant Leak," will require further studies and calculations. Sixty-five percent of the process specifications have been approved by the Startup Council. Thirty percent have been issued in approved form.

PRTR Process Tube Ruptures. Recent transient flow calculations indicate that for a certain range of leak sizes, fuel temperatures in excess of the Pu-Al melting point may be attained. These calculations assume failure of the 450 psi light water injection system, i.e., emergency light water cooling is not available until the system has blowdown to a pressure of 100 psia. Analyses to better define the problem are continuing, and several possible solutions are being studied.

PRTR Startup Preparations. Review of both critical and power tests is continuing in conjunction with the respective Startup Sub-Councils. An addition to Critical Test 10 has been written to provide for overflowing the moderator into the gas header and observing the reactivity effect as the weir is depressed and gas is allowed to bubble up through the moderator. A test description of the shielding Adequacy Power Test has been written.

PRTR Startup Audit. An independent audit of the plans for startup and operation of the PRTR is currently being performed by an eight-man team from IPD. A two-day orientation session was conducted for the group to

acquaint them with design features of the reactor and with current startup and operating plans. The audit is expected to require about two months for completion.

PRP Critical Facility. Two-group, diffusion theory calculations have been carried out to determine the reactivity worth of safety rods in the Critical Facility. Rods considered to date are composed of boron carbide. The results of this work indicate that a total safety rod worth of -100 mk is effected by the full insertion of three, 3.5 cm radius rods on the periphery of the UO₂ buffer region. The IBM-709 Code RECON was utilized for these calculations.

The change in reactivity as a function of moderator height has been calculated for the Critical Facility with respect to several typical loadings. The three-group, diffusion theory reactor code FLUX-WEIGHT was employed.

Shielding calculations to date indicate that the amount of heavy aggregate concrete shielding can be reduced slightly from the present design.

PRP Physics Analysis. Three-group cross sections for the constituents of PRTR have been calculated for use in the 709 ANGIE Two-Dimensional Reactor Code. The first two dimensional multi-group calculation of the PRTR core has been performed with this code. The preliminary analysis of the output indicates that previous one dimensional calculations performed with VALPROD are essentially in agreement with the two dimensional results. This first reactor case incorporated full moderator level, 34 Pu-Al fuel elements, 51 UO₂ elements, and the geometry of the calandria weir and dump chamber. Further studies at different moderator levels are presently being pursued.

The first draft of the Reactor Physics Chapter of the PRTR Technical Manual is essentially complete. A document summarizing PRTR physics calculations to date is also being prepared.

At the request of Plutonium Metallurgy Operation, a study of a seven-rod depleted UO₂ cluster fuel element with stainless steel cladding was performed. Figures for the relative heat generation in the outer ring of rods and the inner fuel rod were computed with the S4 Code. A value of 0.735 was obtained for the ratio of inner to outer rod heat generation.

Reactor Control. The maximum rate of reactivity insertion in the PRTR at low moderator levels was reduced by adding a fifth valve in the moderator gas balance system. The effect of this valve on reactor control was studied by Minneapolis-Honeywell on a consulting contract. A report on this study recommended several minor changes which are being incorporated in the equipment.

Plutonium Fabrication Pilot Plant

The project is estimated to be 99% complete.

Installation of the 20" rolling mill was completed during the month. A complete checkout and adjustment of the amplidyne control system was made by a General Electric service engineer.

Installation of the Group 5 Equipment has been completed and the equipment placed in operation.

Painting of the second floor corridor was completed; additional floor painting is scheduled for early July.

PRTR Operations Planning

Pre-Startup Activities. The writing of the PRTR Operating Standards was started. At month-end ten were completed and an equal number substantially finished. The first rough draft of all the standards is planned for completion in early August.

Testing of production run RTD's and RTD cables has been completed. Preliminary evaluation of results show satisfactory performance. A formal report will be issued.

Arrangements have been started to obtain the services of the W. D. Betz Company boiler plant water treatment specialist starting in August 1960.

Bid reviews have been made on about half of the SAR's placed covering high priority spare parts. Repair parts for the French helium compressors appears to present no problem. Delivery on parts for the German helium compressors is not yet firm; however, the most-needed items for the latter machines should be available in Erie, Pa., at the plant of the American vendor.

Operating requirements have been prepared covering an industrial-type TV system and a second communication system for the PRTR.

A precision-servo manometer for accurate determination of moderator height has been received. Installation will be made after completion of construction.

A proposal was prepared at the request of PRTR by the Design Test Sub-Council for submittal to the Phase III contractor for the performance of a 48-hour hot test of the primary coolant system during the performance of his ATP's. Work continued on the integration of Design and Critical Tests along with the preparation and scheduling of the final drafts of Design Tests.

Procurement of equipment for Design Tests continued.

Descriptions of the approved PRTR Critical Tests (HW-61900-B) were prepared and ready for distribution at month-end.

The Power Test Sub-Council reviewed six additional rough drafts of the anticipated 33 power tests. The tests reviewed are: Vibration, Expansion, and Noise Monitoring; Ventilation System Testing; Light Water Quality Monitoring; Corrosion Monitoring; Rupture Monitor Calibration; and Emergency Procedures. A new outline of the scope of the tests was submitted to the PRTR Startup Council for review and approval.

The remainder of the PRTR Technicians and Engineering Assistants, in addition to five Shift Engineers, have completed the second written test on the automatic controller system, the reactor safety system, and other operational features of the reactor.

Training continues with a number of personnel on special assignments and training sessions centered around the following phases -- safety, control room panels, published operating procedures, and review of annunciators.

2. PLUTONIUM CERAMICS RESEARCH

Two runs were made in an attempt to obtain pure PuC and pure Pu₂C₃. The first of these was conducted in the melting point furnace using small amounts of PuO₂ and graphite in stoichiometric proportions for PuC formation. The temperature was carefully controlled at 1600 C and a high vacuum maintained. Even though held for 7.5 hours at this temperature, no clear carbide lines were detected by the x-ray analysis. This experiment will be repeated in the thermal analysis furnace with a larger sample.

The induction furnace was used to successfully make pure Pu₂C₃. Ball milled Pu powder was mixed with 7.0 w/o C and the mixture heated for two hours at 1550 C. X-ray analysis showed only Pu₂C₃ lines. This material will be used for dilatometric studies and thermal conductivity measurements.

Seven trial runs were performed with the thermal conductivity device during this period. Severe outgassing problems invalidated the first six runs. The data taken on the seventh run showed an uneven temperature distribution across parallel planes in the test assembly. This is caused by several factors, the principal one being concerned with the molybdenum balls between the parallel thermocouples which act as small reflectors and tend to establish a uniform temperature zone. If the placement of these balls is not uniform, it is possible to have an uneven temperature distribution.

The properties of Norton and Spencer fused oxides have been investigated for use in swage or vibratory compacted UO₂-PuO₂ fuels. Oxygen and uranium analyses were made, and both materials showed an O/U ratio of 2.02. The departure from stoichiometry may be due to the fact that these samples have been on the shelf for three to four months since pulverizing. Metallographic analysis of the samples showed both to have isolated gas bubbles with the Spencer material having a slightly higher concentration. The Norton material shows a fine Widmanstatten structure

in about 50% of the grains after etching which is attributed to the presence of U_4O_9 . The Spencer oxide showed a small amount of this material but of a coarser variety.

Evaluation of the MTR, VH-4 rabbit facility for in-pile sintering studies is under way. The most important problem involving the use of the rabbit facility is the low burnout heat flux under static conditions. Because of this limitation, several techniques will be proposed which will give a surface heat flux sufficiently high enough to obtain center temperatures of 1800 C but will not present film boiling problems.

3. URANIUM DIOXIDE FUELS RESEARCH

Fuel Evaluation. A Zircaloy-4 clad, 2.42 w/o enriched, swaged UO_2 rod in which UO_2 density is 86.5 percent of theoretical has been fabricated and delivered to Vallecitos Atomic Laboratory. This will replace one rod of the Zircaloy-2 clad, 9-rod bundle which has been irradiated to approximately 3000 MWD/T. The fuel bundle with the replaced rod will be re-inserted in the VBWR for a second year of irradiation.

The concentration of hydrogen in the Zircaloy-4 cladding of a defected, swaged UO_2 fuel rod did not increase during irradiation in the MTR. The rod was irradiated for 60 minutes, 22 minutes of which were at 685,000 BTU/hr/ft². An identical defected fuel rod, but clad in Zircaloy-2, was irradiated for 45 minutes at 685,000 BTU/hr/ft². The hydrogen concentration in the Zircaloy-2 increased approximately 200 ppm.

Swaged UO_2 capsules attained an estimated exposure of approximately 16,500 MWD/T in the MTR and ETR. No failure of swaged UO_2 fuel elements have occurred during irradiation.

Basic Studies. Fabrication methods for UO_2 specimens for fundamental studies include high energy impact forming, using a Dynapak machine. Electron micrographs of UO_2 compacted at high temperature 99.4 percent T.D. in the Dynapak machine revealed that plastic deformation and particle growth had occurred. The average particle size was approximately twice as large as that found in material prepared from the same micronized UO_2 powder at pressure and temperatures resulting in compacted densities of 95 percent T.D.

Apparatus for resistance heating of UO_2 in metal capsules in the Dynapak die was designed, fabricated, and tested. Capsules can be rapidly heated to the melting point of stainless steel. This equipment permits compaction of a heated capsule in less than two seconds after it is heated.

Sintered, 94% dense UO_2 pellets (0.190" dia. x 0.200" long) were compacted in the ultra-high pressure and temperature press at the General Electric Research Laboratories. The pellets were pressed at 40 and 80 kilo-atmospheres at temperatures ranging from 600 C to 2000 C. During compaction the pellets had fractured with no other visual change, except for

the pellets compacted at 2000 C. These had changed to a black, non-pyrophoric powder. Evaluation of the specimens has started.

Uranium dioxide irradiated to 84,000 and 64,000 MWD/T was received from BAPD (Bettis), Westinghouse. This material will be examined with high temperature microscopy equipment to determine the melting point and other high temperature physical characteristics.

Thermal Conductivity. The thermal conductivity apparatus at Battelle Memorial Institute has been reactivated, and measurements are in progress on the second HLO irradiated specimen. Measurements are expected to be completed about June 30. An unirradiated specimen for study of effects of fabrication methods on thermal conductivity has been shipped from HLO. BMI will ultrasonically drill 0.043-inch diameter thermocouple holes in this UO₂ specimen (a 7/8" x 3" diameter disc prepared by pressing PWR grade material in the 300-ton press and sintering to 96.5 percent theoretical density). Additional specimens by other fabrication methods are being prepared or planned.

The UO₂ thermal conductivity specimens irradiated in the Hanford reactors for the past two years were removed from the capsule without incident. The UO₂ rods (1/4" x 3" long) were relatively easy to remove from the aluminum holder and showed no immediate evidence of swelling or distortion. Of the five unbroken pieces, three will be sent to BMI for thermal conductivity measurements. Two of the three broken rods will be used for metallographic and other examinations at HLO.

High Temperature Microscopy. Assumptions that small amounts of oxygen in the helium employed in the filament furnace might increase the volatility of the UO₂ were checked. It was determined that small quantities of oxygen had no effect upon the optically observed high temperature properties of the UO₂. A comparison of melting points and of vaporization and deposition rates of UO₂ in the temperature range 200 C to 2800 C, revealed no difference in properties of specimens viewed under helium atmospheres containing a 0.18% O₂ and 0.67% N₂, in one case, and containing no detectable O₂ (less than 0.01%) and 0.02% N₂ in the second case.

Apparatus for high temperature optical examination of irradiated UO₂ was modified to permit sampling of the effluent helium gas stream. Data from gas samples obtained at several temperatures from UO₂ specimens having various in-reactor exposures will be correlated with optical and electron microscopy studies.

4. BASIC SWELLING STUDIES

Irradiation Program. Fabrication of components for ten additional general uranium swelling capsules and ten additional metallographic specimen capsules is continuing. General swelling capsule #5 was shipped to the reactor in April and is still awaiting authority for charging. General swelling capsule #4 has been under irradiation for four months at a temperature of 550 C. The capsule components still indicate their initial

integrity except for one thermocouple which is behaving erratically. There are indications that water entry into the thermocouple connector at the face of the reactor may have recently occurred. Repairs cannot safely be made, however, without endangering the integrity of the other three thermocouples.

Unfortunately, the instrumentation is not behaving as well as the capsule. To date, there have been a total of nine apparent temperature excursions varying from 10 C to as high as 90 C. Of these nine excursions, five may be attributed to controller malfunctions, two may have been due to a defective temperature recorder, and two cannot be explained because the periodic temperature and power readings being taken by the operating personnel did not coincide with the recorded temperature excursions.

The precise cause of the failure of the control system is not known, but faulty potentiometers and vacuum tubes in the controller may have been responsible. Improved potentiometers have been received from the manufacturer and installed in the controllers and the vacuum tubes are being replaced with premium pre-aged tubes. The heater supply circuit at the reactor site is being revised to allow a complete replacement of instrumentation during irradiation without disturbing the capsule.

Two new metallographic specimen swelling capsules are being assembled at this time. Modifications were necessary at the internal heater connector to eliminate the heater to connector shorting that took place in the three previously assembled capsules. The specimen and specimen holder have also been slightly modified to assure correct specimen orientation during irradiation and to allow easier capsule assembly. The hole that was originally drilled in the specimen for thermocouple insertion and specimen retention has been eliminated to provide a symmetrical right cylinder.

Pore Size and Distribution. Optical and electron microscopy are being used as a direct means for determining the size and distribution of pores in irradiated uranium. Various applications of microscopy to uranium are, therefore, being investigated.

A precharacterized specimen of uranium contained in capsule GEH-14-35 which had received a burnup of approximately 0.07 a/o at a temperature less than 200 C is being processed. Swelling as a function of post-irradiation annealing in specimens with a burnup of 0.29 w/o and 0.41 a/o is continuing. Density, hardness, and metallographic measurements are being utilized.

A large number of pores in uranium which had been subjected to various post-irradiation anneals have been measured, and the data have been subjected to statistical analyses. Curves of frequency versus pore size distribution have been plotted. Such curves, coupled with the pore void fraction and pore density values are being compared to establish the effects of post-irradiation annealing on swelling in uranium.

The examination of standard synthetic specimens containing pores of known diameters of 0.56, 0.81, and 1.17 microns, respectively, has permitted assessment of the type and degree of distortion which arises during the mechanical stripping of a replica from a surface with exposed pores. Replication of pores cut below their centers is apparently faithful, but when pores are cut appreciably above their centers, the replication indicates the shape of the pore to be a truncated cone with a spherical cap instead of a simple sphere. The statistical analyses of pores in uranium is being adjusted to include these findings.

Since the bonding of "cold" uranium to irradiated uranium and subsequent annealing would permit simple experiments on fission gas mobility, preliminary attempts have been made to bond uranium to uranium. The two techniques thus far examined are: (1) allow a molten drop of uranium to fall onto a clean, cold uranium surface in a high vacuum, and (2) butt weld 1/2" diameter disks together in a resistance welder. These studies have indicated that (1) an oxide film prevents diffusion at interface temperatures (as determined from the structure of the uranium adjacent to the interface) below 660 C during short term spot welding with a discharge duration as high as 1/20th second, (2) diffusion and the absence of an interface occurs if the interface temperature is higher than 660 C during spot welding, and (3) solidification of a molten droplet on a cold uranium surface does not, as yet, yield a satisfactorily bonded, sharp interface. These techniques are being investigated further.

5. IN-REACTOR MEASUREMENTS OF MECHANICAL PROPERTIES

This program has been initiated to determine the mechanical properties of structural materials during irradiation. Currently, the study of in-reactor creep properties of Zircaloy-2 is in progress. A test is being conducted in a prototypical capsule in a reactor. At the same time a duplicate specimen is being tested in the laboratory to provide a direct comparison with the in-reactor test. The instrumentation used to monitor the radiation resistant variable permeance transducers was specially designed for the capsule, and after several months of operation, output readings began to drift. The cause was determined to be an unstable local oscillator circuit that was drifting in frequency. The frequency changes would heterodyne with 60-cycle harmonics to give an indication of random change in the output readings. The condition was corrected, and operation has continued satisfactorily for the past 36 days.

A second set of creep data has been obtained at 550 F and is tabulated below and compared to the original rates measured at 500 F with 95 percent confidence intervals in parenthesis:

At 500 F:

In-reactor - Sensor 1: 1.50×10^{-6} ($\pm 0.52 \times 10^{-6}$) in/in/hr
Sensor 2: 1.88×10^{-6} ($\pm 0.80 \times 10^{-6}$) in/in/hr
Average: 1.69×10^{-6} ($\pm 0.52 \times 10^{-6}$) in/in/hr
Ex-reactor: 1.50×10^{-7} ($\pm 0.10 \times 10^{-7}$) in/in/hr

At 550 F:

In-reactor - Sensor 1: 3.98×10^{-6} ($\pm 0.43 \times 10^{-6}$) in/in/hr
Sensor 2: 4.08×10^{-6} ($\pm 0.43 \times 10^{-6}$) in/in/hr
Average: 4.03×10^{-6} ($\pm 0.43 \times 10^{-6}$) in/in/hr
Ex-reactor: 1.93×10^{-7} ($\pm 0.10 \times 10^{-7}$) in/in/hr

At 500 F the difference in the creep rates between in-reactor and ex-reactor specimens varies between factors of ten and sixteen using the extremes of the data, and at 550 F the rate in-reactor is at least seventeen times that of the control specimen. Each test is based on 36 days of test data (864 hours) which, from ex-reactor creep studies, may not always be sufficient time to establish the minimum rate. Consequently, the test at 550 F conditions will continue to verify the minimum creep rates. The rates being measured, both in-reactor and ex-reactor, are at the extreme limit of range of the transducers and instrumentation. The next test will be at a sufficiently high creep rate so the transducers will be operating nearer the middle of their capability.

The specimen in the prototype capsule was originally assumed to be annealed Zircaloy-2, however, the low creep rates observed on the specimen indicated a behavior more typical of a 15 to 25 percent cold worked Zircaloy-2. This indication led to the determination of the tensile properties, hardness properties, metallography, and annealing studies on standby specimens and on the bar stock from which the specimens were machined.

The tensile tests revealed a yield strength of 74,300 psi for the Zircaloy-2 which could be reduced to 36,600 by annealing. The hardness was reduced from 83.2 R_B to 79.6 R_B by the same anneal. Consequently, the specimen in the in-reactor test must be assumed to contain at least 15-25 percent cold work. The next four capsules will contain both annealed and 20 percent cold worked Zircaloy-2 specimens which have been properly checked and identified before installing in the capsules. Studies on the correlation of creep behavior of Zircaloy-2 have shown that annealed Zircaloy does not present self-consistent rates nor does it display the creep resistance of cold worked Zircaloy-2. Very few tests will be made on annealed Zircaloy-2 specimens in the reactor as they cannot be correlated nor compared with

ex-reactor tests nor with the results on cold worked Zircaloy-2. It is felt, however, that two annealed specimens should be run to determine the in-reactor creep of Zircaloy-2 in its poorest condition. Most tests will be made with specimens containing reasonable and technically useful amounts of cold work.

Work in progress includes the design of a capsule capable of operating in a vertical position in the Engineering Test Reactor at Arco, Idaho. This capsule will be similar to the HAPO capsule. The main difference is the smaller size of the test tube in the ETR as compared to Hanford. Smaller diameter bellows and transducers will be required. A small diameter transducer of the same type as in the present HAPO capsule is being fabricated by Physical Sciences Corporation, and acceptance tests will be run on these transducers before their actual use. Calibration and evaluation of a Schaevitz DRS-100 Type R lineal differential transformer system is also being performed. Preliminary results indicate that the readout system is quite sensitive to core motion in any direction. In the actual use of the system some means of eliminating core motion, perpendicular to the axis, will be necessary. The investigation also indicates that the initial alignment of the system is a relatively complex procedure. A visit was made to the vendor's plant to observe the performance check out on four additional capsules being constructed for further in-reactor creep tests on Zircaloy-2. These capsules are expected to be more reliable and accurate than the prototype now in use. The capsules contain both a mechanical and electrical transducer. The mechanical transducer contains a micrometer-type screw which moves an electrical contact as the screw is rotated. The tests at the vendor's plant indicate sensitivity of approximately 1×10^{-5} inches. The electrical transducers are of the low impedance variable permeance type used in the prototype capsule now being irradiated. The transducers are of multiple range, however, to give increased sensitivity. The first range is 0.080" for the highest sensitivity, the middle range is 0.120", and the third range is 0.600" to measure total elongation. The capsules are completed and are being held at the vendor's plant for the check out of digital readout equipment installed on the instrumentation. Heat transfer calculations are being performed to assure that the irradiation of the creep capsules will not interfere with the safe operation of the reactor.

Deformation mechanisms of Zircaloy-2 are being determined by the use of annealed, 15, 25, and 45 percent cold worked specimens. The current series of tests are being carried out in a static helium atmosphere at 800 F (425 C). Metallographic examination under polarized light revealed that grain tilting had occurred, and that deformation bands had formed during the creep of the 45 percent cold worked specimen. An annealed specimen revealed no microstructural changes during creep.

6. GAS-GRAPHITE STUDIES

EGCR Graphite Irradiation. The experimental capsule, H-3, containing EGCR prototype graphite was successfully irradiated in the General Electric Test Reactor during cycle 13. All nine thermocouples operated satisfactorily during the cycle. Average sample temperatures along the capsule are: 350, 500, 650, 750, 650 C.

EGCR Graphite Oxidation Prototype Unit. Fabrication and installation of the unit have been approximately 80 percent completed. Completion of construction is expected by July 7. A packed gas adsorption column has been designed and fabricated to permit safe testing of gas phase graphite oxidation inhibitors.

Graphite Combustion Experiments. Experiments have been conducted on laboratory scale samples (cylinders up to eight inches long and 7/8 inch in diameter) to test the model proposed to evaluate graphite combustion conditions. Agreement between observed and calculated temperatures has been good (± 20 C). These tests will continue on several types of graphite to determine the effect of graphite reactivity on the ignition temperature.

Chlorine has proven very effective in control of runaway graphite oxidation. The addition of two percent (by volume) chlorine has elevated the graphite ignition temperature over 150 C and successfully controlled combustion when the graphite temperature exceeded 1000 C.

Gas-Graphite Systems. Two quartz capsules containing CO₂ and graphite which were irradiated for 274 days at 500 to 700 C have been opened with resulting data as shown below:

<u>Original Weight</u>	<u>Weight Change</u>	<u>Original Moles of Gas</u>	<u>Change in Moles of Gas*</u>	<u>Initial Pressure (Psia)</u>	<u>Final (Psia)</u>
5.0669	-0.2912%	8.788×10^{-3}	+ 7.63%	589	653
4.8003	-0.2229%	5.654×10^{-3}	+ 5.66%	424	463

*The increase in number of moles of gas and the gas composition are corrected values, necessitated by the diffusion of 2.9% helium from the pile gas.

Gas Composition* (Mole Percent)

<u>CO₂</u>	<u>CO**</u>	<u>H₂</u>	<u>Total</u>
93.16	6.73	.10	99.99
92.92	7.08	-	100.00

*The increase in number of moles of gas and the gas composition are corrected values, necessitated by the diffusion of 2.9% helium from the pile gas.

**Mass number 28 (CO or N₂).

There is a direct proportionality between charging pressure, percent increase in gas, and percent decrease of graphite sample weight, i.e., the ratio of charging pressures is 1.39 and the ratio of $\Delta n = 1.35$. The Δ weight ratio = 1.31. This is interpreted as evidence that equilibrium between the CO₂ and graphite was probably reached.

Capsules from ex-pile experiments held at 550 and 650 C for 27 days to 150 days showed no reaction. The pressures were in the range 300 to 500 psi. From these preliminary results, radiation appears to accelerate the attainment of equilibrium at high pressures.

Two boats (one loaded with ten C-CO₂ capsules and the other loaded with five C-CO, two C-CO₂, and one C-H₂ capsules) are awaiting charging into Y test hole at C Reactor. Capsules from the first boat will be removed and analyzed periodically to determine the rate of the C-CO₂ reaction under irradiation.

Gas Analysis for PRTR CO₂ Loop. A Consolidated Electrodynamics Model 21-620-A mass spectrometer is being calibrated and tested prior to installation on the PRTR Gas Loop. The instrument will continuously monitor the level of impurities in the main carbon dioxide coolant stream. The volume of gas removed from the loop through a capillary tube and molecular leak will be four liters per day or approximately 0.4 percent of the main loop value. A peak selector was installed on the mass spectrometer to scan six mass numbers on a repetitive basis. Reproducibility of analyses for six selected mass numbers was better than one percent for a 24-hour run. Gas mixing equipment is being assembled for determining sensitivity coefficients and component spectra for impurities expected in the loop gas stream.

A gas chromatograph which has been adapted for use on the PRTR gas loop was received. The analyzer records oxygen, nitrogen, carbon monoxide, and hydrogen concentration on a pre-set cycle.

Coatings Evaluation Studies. Several siliconized - SiC samples irradiated at 500 C to an exposure of several thousand MWD/AT are being tested. The samples are heated to 960 to 1000 C in flowing air until loss of weight indicates failure of the coating and attack of the graphite substrate. Two samples tested showed no attack.

Thermal Cycling Studies on Coatings. Three graphite rods coated with siliconized-SiC have been thermal cycled over a temperature range of 200 C to 1000 C in flowing air at six cycles per hour. Another rod was cycled three times per hour between 200 C and 1200 C. Coatings applied to selected graphites such as Great Lakes Carbon Company's "A" grade showed no significant change. Coatings on usual reactor grade graphite developed severe circumferential cracks with a resultant high weight loss in the graphite substrate.

Materials for PRTR Loop. Nickel-base alloys are being considered for use as in-reactor structural materials for the gas-cooled loop in the PRTR. Tensile specimens of Inconel, Inconel-702, Hastelloy-X, and Hastelloy R-235 scheduled for three months of irradiation will be discharged at the end of the month. Tensile specimens of modified Ferral (an iron base aluminum-chromium alloy); and AISI 406, 304 L, and 316 L stainless steels will be inserted in the reactor for irradiation at that time. Thin washer samples of several candidate alloys exposed for 30 days to reactor atmosphere and neutrons are being measured for weight gain and hardness change.

Gas Loop Project Management and Design (Project CAH-842). The Phase "A" package remains at approximately 95% complete. Progress payment to this extent has been requested by Struthers-Wells and will be accomplished by month-end. The Hastelloy-X tubes for the electrical heater, the main delaying item, have been re-ordered from a new supplier after a history of rejected tubes from Carpenter Steel.

After experiencing repeated unsuccessful test runs of the Blowers⁽¹⁾, Bristol-Siddeley reports the first blower has now been running at 6000 rpm at 250 psi and 250 C. These results are the most encouraging since last April and have been achieved by silver plating the shaft ends and hand-lapping while installed in the journal bearings. A problem of field strength balance exists around the rotor at startup. No new delivery date has been quoted.

Gas Loop Component Testing. Fabrication of the first in-reactor section prototype is approximately 85% complete with the remainder scheduled for completion by June 30. Drawings for the prototype test mockup have been completed, and all component parts are on order. The two Roots Connersville helium blowers have been shipped from Warren following a successful fit-up in the Phase "A" package. One of these blowers will be used for the test.

The comments on the graphite sample cask have been returned and final design started. Initial tests of the extension handle have shown the 1/8-inch diameter pickup hook does not have sufficient strength. A new hook has been designed and will be tested.

Testing of the gimbal joints was interrupted due to a cracked pressure inlet tube. The tube was repaired and will be placed back in service. One gimbal joint has been received from Solar Aircraft.

The dome seal has again been modified to incorporate a free floating seal ring which is pinned to the seal body.

Gas Loop Design Analysis. Temperature transients for a series of operating conditions were reproduced by the Berkeley EASE. The setup was based on a series of heat transfer equations provided by J. Muraoka. Results will be reported separately.

(1) Harty, H., Report of Visit to Bristol-Siddeley Engines, Ltd., HW-65793, June 22, 1960.

7. GRAPHITE HIGH TEMPERATURE IRRADIATION DAMAGE STUDIES

Graphite Metallography. Graphite or coke is normally vacuum impregnated with a resin for the preparation of metallographic specimens. The resin fills voids and strengthens the structure preventing its alternation during polishing. This technique cannot be used when a given specimen is to be examined before and after irradiation or heat treatment. Experiments have shown that by impregnating with water and subsequent freezing, a specimen may be successfully taken through the grinding and lapping steps which precede the final Synttron vibratory lapping. A modification of the Synttron sample holding pan is being designed to permit the use of liquid nitrogen as a polishing medium during final lapping. If final polishing is successful, the ice will be melted and the sample dried by placing it in a vacuum. Samples prepared in this manner will be useful in studies of structure changes during baking, graphitization, and irradiation.

X-Ray Studies. The computation of the Fourier coefficients of the x-ray diffraction lines from natural flake and reactor grade graphites has been completed for two series of anneals. These samples had been irradiated at 400 to 500 C and annealed at various temperatures to 2000 C. Although the analytical techniques are still being evaluated, the results were in agreement with previous analyses in indicating an increase in apparent crystallite size upon annealing. A further observation was that the inhomogeneous strain in the irradiated graphite was substantially reduced during annealing.

D. RADIATION EFFECTS ON METALS - 5000 PROGRAM

Radiation damage recovery is being studied for a number of metals, namely, copper, nickel, titanium, zirconium, iron, molybdenum, and type 347 stainless steel. Tensile properties, microhardness, electrical resistance, and x-ray diffraction spectra are being studied to determine the characteristics of recovery mechanisms.

One hour isochronal annealing treatments at 25 C increments were extended from 675 to 775 C for molybdenum, from 300 to 450 C for titanium, and from 300 to 400 C for iron. Isochronal annealing has been completed for copper, zirconium, and nickel. The highest recovery zones measured to date occurred at the following fractions of the melting point (T_m): iron - 0.30 to 0.36 T_m , nickel - 0.43 to 0.48 T_m , zirconium - 0.36 to 0.43 T_m , and titanium - 0.33 to 0.34 T_m . The approximate temperature for self-diffusion in metals is 0.45 T_m . The maximum release of stored energy in cold worked nickel occurs near 0.49 T_m , which indicates that the irradiation damage in nickel associated with the final recovery point probably involves dislocations.

A special annealing fixture was fabricated during the month which will permit sharp end points in the temperature-time records for the isothermal anneals. This fixture was evaluated and the first series of isothermal anneals started during the month.

DECLASSIFIEDE. CUSTOMER WORKRadiometallurgical Examinations

Routine examination of four standard HAPU fuel elements revealed groove pitting on the inside spire surface of two elements (403-9 and 10), voids in the braze layer of one (403-11), and slight bumping on the other (403-12). (RM-403).

Comparison of the canwall bonding on the self-supported elements irradiated at different power levels showed no significant difference in the extent of cracking or AlSi deterioration (RM-404).

Compression testing of irradiated concrete from the dome of storage tank 241-A-103 (200 E Area) was completed with wide scatter in results. Non-uniform material and poor bonding of cement to aggregate were evident (RM-332).

Metallography Laboratories

Samples of AlSi braze material have been annealed at temperatures of 250 C to 404 C for periods of from one day to thirty days. These samples are now awaiting evaluation. Other samples are being annealed for periods up to 100 days.

A possible method of attaching a Zircaloy cap to coextruded Zircaloy-canned uranium is pressure bonding with heat. FPD personnel have been investigating this method and have produced good bonds in a vacuum furnace assembly using 10,000 psi and a temperature of 600 C. The work piece is heated to 600 C under pressure and cooled immediately. Diffusion bonding is produced between the cap and the uranium with no appreciable growth of the canwall-uranium diffusion layer. Testing along this line is continuing.

Results and interpretations of these and other metallographic examinations and electron microscopy work will be reported in more detail in connection with the respective development programs served.

Samples Processed During the Month:

Total samples	385
Carbon replicas	82
	<u>467</u>

Photographs:

Micrographs	538
Macrographs	139
Electron micrographs	104
	<u>781</u>

Special Fabrications

To date, 864 fuel rods have been shipped to the Savannah River Laboratory. The coextruded rods contain Al-7.35 w/o Pu alloy and are clad with aluminum (X-8001 alloy). At the present time there are 344 pieces in the process stream, and they are distributed as follows: 86 cast fuel cores, 204 extruded and/or straightened rods, 42 rods ready for final etching and inspection, and 12 rods ready for shipment.

Increased fabrication rates were required to meet scheduled shipments of 144 rods on May 31, 192 rods on June 13, and 240 rods on June 27. During the inspection of rods for the June 27 shipment, the greatest single cause for rejection of a rod was a fold of overlapping metal which could be lifted with a knife blade. The depression left in the rod was quite deep, certainly deeper than 0.010 inch.

Four-hundred-ninety-two Pu billets were cast for coextrusion cladding and 58 billets were remelted after rejection for gas pockets. Three-hundred and twenty-six rods were extruded from these billets during the month to give the highest processing rate achieved to date.

Body exposure rates throughout the process have become excessive due to the large quantity of material being handled. Rates have been decreased in the core cleaning and assembly steps by using light spun lead glass aprons. These cut radiation by 50% from the unclad cores but shield less than 10% of the radiation from the extruded clad rods.

An I & E rod was coextruded to a 72-inch length using a floating mandrel and a streamlined die with a 90 degree entrance angle. The element was clad in 8001 Al with a 2% Ni-Al alloy configured core as a substitute for Pu-Al. The nominal OD was 1.115 inches and the ID 0.588 inch. Surface finish was good. Evaluation is continuing.

J. W. Albaugh

Manager, Reactor and Fuels Research
and Development

FW Albaugh:kb

DECLASSIFIED

DECLASSIFIED

PHYSICS AND INSTRUMENT RESEARCH AND DEVELOPMENT OPERATIONSMONTHLY REPORTJUNE 1960FISSIONABLE MATERIALS - 2000 PROGRAMFUELSNuclear Safety in FPD

The nuclear safety of a proposed storage array for 0.95% enriched uranium billets, which is to be used in the NPR fuel element fabrication, was evaluated and found to be nuclearly safe. These billets are of two sizes: 5.6" O.D. x 1.2" I.D. x 20" long and 7.0" O.D. x 2.7" I.D. x 20" long.

They are to be packaged six billets to a box in a close packed lattice. The storage array will be five boxes high, two boxes deep, and of an unlimited number of boxes wide. The nuclear safety evaluation shows that such an array will be safe both dry, i.e., partially moderated with wood, and flooded. The extrapolation of criticality data, for the dry case, shows that the material buckling is negative for the rod sizes in question; in the flooded case, the array will be essentially a series of safe slabs.

Nuclear Safety in Special Uranium Shipment

Recommendations concerning the nuclear safety of a special uranium shipment to Oak Ridge were submitted to the Nuclear Materials Operation. (Letter from C. L. Brown to F. J. Zelle, "Nuclear Safety Limitations for Special Enriched Uranium Shipment", June 8, 1960.) The shipment was made up of 500 Kg of uranium metal and solutions containing 7.9 Kg of U^{235} . At optimum conditions the materials in the shipment would comprise about 1.7 critical masses. To ship this amount of uranium in one railway car, it was recommended that the material be divided into two lots, to have a separation of at least ten feet. The basis for dividing the uranium was given in the referenced letter.

STUDIES RELATED TO PRESENT PRODUCTION REACTORSNeutron Temperature Studies

The calculations of quantities which are used in an analysis of a lutetium activity ratio have continued using the program ACE. The g factors for Lu-176 and Lu-175 have been calculated with the revised cross sections for 17 temperatures between 200 K and 900 K. The calculations show that the g factor for Lu-175 changes by ~4% between these temperatures. However, the experimental curve of the ratios of g (176) to g (175) fits the calculated curve for g (176) much better than the calculated curve for the ratio of g (176) to g (175). It is believed that this is due to the inadequacy of the description of the Lu-175 cross section. This fact is corroborated by the experimental value of g (175) which was shown to be constant and equal to 1.

Epithermal-subcadmium resonance integrals for Lu-175, Lu-176, and Pu-239 are being calculated also. The calculations assume a slowing down distribution that is $1/E$ with a sharp-cutoff at thermal energies. The calculations were done for cutoff energies which are appropriate for the temperatures at which g factors were calculated. The calculations were repeated for a $1/E$ cutoff which has the form $\left[1 + \left(\frac{\mu kt}{E}\right)^{16}\right]^{-1}$ and also for one which has the form calculated by Hurwitz for a heavy gaseous moderator.

In preparation for the latter calculation a subprogram has been added to ACE which will calculate the Hurwitz spectrum of slowing down neutrons. This subprogram utilizes a ninth-order polynomial which describes the spectrum for $\frac{E}{kT} < 8$ and the asymptotic series presented by Hurwitz, et al, for values of $\frac{E}{kT} > 8$. This subprogram has been checked and it does reproduce the Hurwitz spectrum.

The data from a lutetium traverse in the reflector of the TTR has been analyzed assuming a $1/E$ slowing down distribution with a sharp cutoff. As a result of this analysis the spectral index near the edge of the fuel and water ring was calculated as 355 K. At greater distances from the fuel the spectral index decreased and finally at 18" from the fuel the index was 325°K.

The beta particle energy distribution data which was obtained from the Lu-176m source is being analyzed using the programs FERMI plot and LLESQS. The initial analysis indicates that a Na-24 contamination might have been present. Sufficient data was not obtained to accurately subtract this contamination. If the 256 channel analyzer had been available when the source was being analyzed the contamination would have been readily observed and extra data could have been taken. The intensity of the Na-24 was estimated and an analysis conducted using this estimate. The analysis resulted in a beta component with a maximum energy of 1.07 Mev (in agreement with the value reported earlier). A component with a slightly higher maximum energy was indicated also. However, the result cannot be considered very reliable because of the Na-24 subtraction. The high energy region of the spectrum will be analyzed in more detail after a new source has been prepared.

The data for the L and M electron lines from the internal conversion process have been analyzed. The energy of the electrons corresponds to a gamma-ray transition in Hf-176 of 88.8 kev. The intensity of the L electrons to that of the M electrons is 3.4. From this information it will be possible to determine the type of transition and thus to deduce possible spin states for the levels in Hf-176.

Effect of Absorber on Neutron Energy Spectrum

The investigation of the effect of an absorbing cylinder on the thermal neutron flux spectrum in the surrounding nonabsorbing moderator, begun about one year ago, has been renewed. In the earlier investigation $1/v$ absorption was assumed, and the effect of this absorption on the boundary condition at the absorber-moderator interface was described by a reciprocal blackness empirically found to vary linearly with $E^{1/2}$. For mathematical simplicity in evaluating coefficients in the infinite series solution, this linear dependence with $E^{1/2}$ was approximated by a linear dependence with E , according to a recipe which was

DECLASSIFIED

DECLASSIFIED

HW-09054 DEL

developed. Results of these earlier calculations have been described previously.

In the current investigation, a more realistic Breit-Wigner resonance absorption in the cylinder has been assumed. In this case, the energy dependence of the reciprocal blackness contains a resonance term in addition to the linear variation in $E^{-1/2}$. The evaluation of the coefficients is now more difficult, because the approximation of linear dependence with E is no longer justifiable. The analytic part of this evaluation is now being done, and the solution for $1/v$ absorption (neglecting the resonance term) is nearly complete. Completion of this $1/v$ case, which conveniently occurs as part of the Breit-Wigner case, will allow a desirable check to be made on the results of the earlier investigation.

Experimental Work on Neutron Rethermalization in Water and Graphite

The experimental investigation of the space-energy distribution of neutrons in moderating media with temperature discontinuities has been extended to a water-graphite system. Discontinuities in the physical temperatures were established at the water-graphite interface and at a graphite-graphite interface as in previous all graphite experiments. Four experiments were completed. The temperature conditions in the concentric cylindrical regions are tabulated below.

EXPERIMENTAL PHYSICAL TEMPERATURES REGIONS

Exp. 865	Water °K	Heated Graphite °K	Unheated Graphite °K	Fuel - Reflector °K
A	294	300	300	300
B	315	410	300	300
C	294	600	300	300
D	312	703	325	300

The geometry of the system was identically the same as that used in the graphite-graphite experiments except for the introduction of a 3.25 inch O.D.-2.7 inch I.D. zirconium water tube along the axis of the FCIR. Activity traverses of bare and cadmium covered Cu foil were taken in the water. Activity traverses of Cu, Au, Lu were taken in the heated and unheated graphite regions. All of the activated detectors have been counted. The raw counting data is being prepared for processing on the IBM code APDAC I. The processed data will yield traverses of the thermal activity of a $1/v$ detector in all regions, the spatial variation of the slowing down flux at thermal and the spatial distribution of neutron temperatures. The thermal and slowing down activity data will be analyzed with IBM code FIT-I to yield the rethermalization cross section of water.

Digital Computer Codes for Reactor Analysis

Work has begun on adapting the ANP multigroup, multiregion diffusion theory code F-N to HAPC use. This code can handle up to 20-energy groups in systems containing up to 50 regions, with transfer cross sections permitted between each pair of groups. Either cylindrical or slab geometry can be used. The bulk of the original program was written in FORTRAN and may be simply recompiled for 709 use. The input routine, however, must be replaced by a FORTRAN version. Design of this input is underway and coding should begin within the next month.

A code, QUAD-1, has been written to evaluate the slowing down density as a function of position inside a ring of $N(\approx 100)$ symmetrically placed line sources. Fermi age theory is used, and the reflector outside the ring is assumed to be infinite. The code requires 900 memory locations, exclusive of library subroutines. Running time is less than one minute per case.

Experience is being acquired in the use and relative advantages of the diffusion theory codes AIM-5 and F-3. Both are one-dimensional multigroup codes, improved versions of which are expected to be adapted to our use in a few months. There are several differences between the codes which suggest that each may have a range of problem types more particularly suited to its method of solution of the diffusion equation. At the present time, input data are being assembled for each of them to calculate the control rod worth in the NPR lattice. Some snares have already been encountered in getting the proper data into AIM-5 for this case. The test case has not yet been attempted on F-3.

A digital computer code has been written for calculating the thermal flux spectrum in an infinite moderator with arbitrary energy dependence of the absorption cross sections. The code also computes average cross sections using the following weights: 1) the calculated flux, 2) the maxwellian for the temperature of the moderator, and 3) the maxwellian for the temperature of the peak of the calculated flux. This code is based upon the combination of two General Atomics codes, one evaluating scattering kernels for a moderator in the heavy gas approximation and the other calculating the thermal spectrum resulting when this moderator is combined with nonmoderating absorbers. The code is in use in some investigations described elsewhere.

The data on the nuclear data tape are being improved. During the past month, revisions have been made in the thermal absorption and fission cross sections of Pu-239 and U-235 and in the transport cross sections of a number of elements.

Instrumentation and Systems Studies

At the request of the Office Procedures Operation, an estimate was compiled of the cost of development and fabrication of a Panellit readout system. The device is to translate Heise and Panellit pressure gage readings into a digital code for printing and punching onto paper tape.

The study of reactor transients due to lithium loss was prepared and programmed for the EASE computer. Analog simulation of this problem should be completed early in July.

The transient response to a reactor transfer function was requested by IPD and solved on the PACE TR-10 desk top analog computer.

STUDIES RELATED TO FUTURE PRODUCTION REACTORS

Exponential Pile Measurements of Large Diameter Fuel Elements

Material buckling measurements in an 8 x 8 foot exponential pile using tube-in-tube fuel elements (2.5" O.D. by 2.0" I.D. and 1.66" O.D. by 1.1" I.D.) at a lattice spacing of 8-3/8 inches have been completed. The coolant used was H₂O. The final results are shown in Table I.

DECLASSIFIED

DECLASSIFIED

TABLE I

<u>Buckling</u> <u>10 cm</u>	<u>λ(side-side)</u> <u>inches</u>	<u>λ(front-rear)</u> <u>inches</u>	<u>Source</u> <u>Position</u>
-63 \pm 2	2.0	2.0	clustered
-88 \pm 3	0.8	1.0	split

λ is the measured extrapolation length. The errors quoted on the buckling are due to the uncertainty in the "least squares" fit. The sources are placed at $(\pm \frac{a}{4}, 0)$ and $(0, \pm \frac{b}{4})$ for the split source case, and $\pm 1-1/16$ inches for the clustered source case. The buckling measured for the clustered source case agrees quite well with the value of $-64 \times 10^{-6} \text{cm}^{-2}$ determined in the 4' pile. No explanation has been found for the relatively large discrepancy in the split source measurement. The extrapolation length shows the same type of variation with source placement, that was found in previous results in a 6 x 8 foot exponential pile with the same lattice spacing and fuel element.

As an aid to further understanding of the variations in extrapolation length, a 9-1/2 x 8 foot exponential pile has been built using the same tube-in-tube fuel elements mentioned above at a lattice spacing of 14-9/16 inches. Measurements have started with the sources split as defined above. The extrapolation length has been measured with two different thicknesses of graphite at the outer edge of the pile. The analysis of the data is not yet complete. A preliminary buckling value of $-126 \times 10^{-6} \text{cm}^{-2}$ using an assumed λ of 1.0 inches shows good agreement with the value of $-127 \times 10^{-6} \text{cm}^{-2}$ measured in a 4 foot pile.

PCTR Measurements of Large Diameter Fuel Elements

An experiment is in progress in the PCTR to measure k_{∞} , f , p , and ϵ of a 10-1/2 inch graphite lattice with a 2.5 inch diameter natural uranium fuel element. The measurements with air coolant have been completed and preparations are being made to continue with water coolant.

Lutetium foils have been irradiated at the fuel center, in the coolant annulus, and two positions in the moderator to investigate the variation of the neutron temperature index through the cell.

Exponential Pile Measurements for N Reactor

The graphite for building the N-Reactor mockup exponential stack has been shipped by the manufacturer. The smaller diameter tubes for the tube-in-tube fuel element have arrived. The larger tubes should arrive in July. The enrichment on these elements is .94%.

PCTR Measurements of Lattice Parameters of Large Diameter Fuel Elements

The graphite for the mockup and condensed lattice for the N-reactor measurements has been assembled. Two bars have been machined to the proper size for Δh measurements in the Hanford Test Pile.

Instrumentation and Systems Studies

The wheel portion of the mockup prototype NPR Scanning-Type Fuel Element Rupture Detection System is now in operation using known Cs¹³⁷ test sources. The 102 Cs¹³⁷ sources were calculated to be approximately equivalent to actual operating conditions for the NPR. The fast-scan detector and amplifier are in operation and signal-to-background ratios were as expected. A single source of twice the strength of the other 101 sources gives a 2:1 signal-to-background ratio. This effect of linearity was tested with a source known to be 60 times the strength of the other 101 sources; the resulting signal-to-background ratio was, by measurement, 60:1. No saturation effects were noted. The magnetically activated indexing or gating switches were installed and tested. Operation was satisfactory. The display panel, patch panel, and other fast-scan circuitry are now being fabricated. The locally designed and fabricated slip-ring assembly continues to perform in a satisfactory manner. The commercial slip rings are to be delivered in July. The necessary instrumentation for the slow-scan (gamma energy analysis) portion is rack-mounted and is ready to test.

The NPR prototype Linear Scintillation Remote Area Monitor was completed, tested, calibrated, and delivered to IPD for further testing. The system was used in a comparison test, using test operating conditions, with an HM chamber system. The NPR prototype system performed quite satisfactorily in all tests, and it proved to be more stable than the HM chamber-Beckman system. The NPR prototype is a two-level, two-probe, 0-200 mr/hr and 0-2 r/hr, selectable level, alarming monitor.

The prototype Logarithmic Scintillation Area Monitor (5 mr/hr to 5 r/hr) was modified using a new (our design) inexpensive high-voltage supply and an RCA 6655-A phototube. The modified system worked in a satisfactory manner for two weeks, thus far, of continuous operation. If the modification proves successful, the cost of the monitor will be reduced by \$350.

Fabrication started on the bench-tested transistorized circuitry for the NPR prototype Scintillation Beta-Gamma Air Monitor. All design-development work is completed, all circuitry has been tested, and only fabrication remains to be completed. The lead-shielded detector head is now being tested.

The analog computer transient analysis of the primary loop in the NPR has been started. At present, necessary equations and constants are being obtained from interested groups. All studies for the various groups concerned will be coordinated. A special prepatch board for the EASE computer has been ordered so that this problem can be left wired for a long period of time. It is expected that initial analog studies will be started sometime in July.

A set of equations similar to the reactor kinetics equations with sinusoidal reactivity excitation were programmed on the PACE TR-10 computer. These equations are to be used to determine the accuracy of the computer simulation since their solutions are known. The TR-10 was used to obtain information as to the nature of the solutions. The problem has been programmed for the GEDA computer and will be run as soon as the computer is available.

DECLASSIFIED

DECLASSIFIED

Investigations are continuing on concepts leading to reactor control systems. Information is being gathered on the representation of large reactors where multiple control regions are required. This involves the determination of coupling equations in addition to the familiar kinetic equations.

Assistance was given to IPD on some questions of reliability. One was with the task force on panellit pressure monitor circuit revision. The questions here were more of a general nature on reliability attainment and the interpretation of some panellit failure data. Another was to help the Electrical Development Operation locate sources of component failure-rate data. The study of the NPR emergency cooling system has reached the point of analyzing the instrumentation circuits to see if redundancy is being used to best advantage.

The study for CBOU reported last month reached the stage of finding a method for computing the probability of simultaneous failures in two parts of a redundant circuit. This question comes up frequently. A simple, approximate method exists for answering this question; OROs has undertaken to develop a more accurate method.

On the reactor kinetic study, OROs has obtained a 709 program for solving the equations. Also, an iterative procedure for determining the characteristic exponents of the solution has been worked out. Which of these will be the most satisfactory for our purpose will be determined before starting on the 709.

Mechanism of Graphite Damage

The manufacturer was not able to supply the beam sweep high voltage set promised for delivery early in June. To prevent a delay in the program the beam sweep equipment was redesigned to make use of a high voltage set that was available for immediate delivery.

Control cables were installed between the new energy loss calorimeter and the Van de Graaff control room.

STUDIES RELATED TO THE SEPARATIONS PLANTS

Plutonium Critical Mass Laboratory

The Plutonium Critical Mass Laboratory was contaminated with fission products as a result of burial operations on Friday, June 10, which spread fission products throughout a section of the 200-E Area. There was some contamination on the exterior surfaces of the building; the parking lot and access roadway were also contaminated. The parking lot and access roadway have not been fully decontaminated. Further decontamination has been planned and no lasting effects on the facility operation are expected.

The facility was accepted by HLO from the fixed price contractor on June 23. Some minor exceptions and items are yet to be completed by the contractor. The total project has been closed out by the Construction Engineering Operation as of June 30 with exceptions. Work orders have been written covering the work remaining. This includes completion of the in-hood reactor components, their installation by Minor Construction, some alterations and additional work on the facility (paving the access road and enclosing the covered walkway between

buildings); a work order has also been written to Plant Forces to cover startup costs.

The major work during the month was directed towards completion of sealing the reactor room and to performing the acceptance test for containment and minimum allowable leakage. After correcting some unsealed conduits, progress was slow in locating and correcting successively smaller leaks. The largest difficulty was encountered in obtaining effective seals in conduits relatively full of wires. It was difficult to get the silicone rubber to completely seal around each wire. The difficulty expected in sealing the large shielding door did not materialize--no leaks were detected. The final test, on the basis of which the room was accepted, resulted in a leakage of 2.8 volume percent in six hours at the design internal pressure of 4.5 psig.

The inhood reactor components are ready to undergo acceptance tests at the manufacturer's plant, and if no difficulties are encountered, delivery is expected the second week of July.

A third reactor vessel has been received. This vessel has a 12-inch diameter sphere. A fourth vessel, also spherical, 13 inches in diameter, was to be shipped on June 30.

The period and level measuring instrument has been completed and adjusted. This instrument consists of a stable voltage source, a divider circuit that provides steps of "e" in voltage, an electronic null indicator to compare this with that generated by an ion chamber current, and a circuit to provide an output pulse as the null indicator passes through a null. This pulse will control an external timer to make automatic measurements of the period. Tests performed to date relate to the voltage source and divider string. The source is stable to better than 0.1% over a reasonable range in voltage and temperature. The divider string factors are also better than 0.1%. Additional tests will be made to determine long-term drifts and errors in measuring fast periods.

Critical Hazards Specifications

Nuclear Safety in HLO

The nuclear safety of the six slab tanks to be used in the Critical Mass Facility was reviewed. These tanks are 2.5 inches thick, but vary in height from 2-4 feet and in length from 3-14 feet. The mixing tank, acid storage tank, and waste storage tank are shielded with several inches of polyethylene with a 0.03 inch thick cadmium sheet and a 2-inch thick styrafoam layer interposed between each tank and the polyethylene. The two dump tanks and the waste hold-up tank are imbedded in concrete with a 0.03 inch thick cadmium sheet interposed between the tanks and the concrete. The styrafoam is essentially a nuclear void, i.e., the safe slab thickness may be increased due to an increase in neutron leakage brought about by the styrafoam layer. The cadmium sheet results in the tanks being safe for the case of a nominal reflector (≤ 1 inch of water), i.e., the safe slab thickness may be increased because of the reduction in the reflector savings brought about by the cadmium sheet. To provide a lower limit on the critical mass, the styrafoam layer and the cadmium liner were neglected in the calculations. Considering the masses and concentrations to be used in the operation, the calculations show that even without cadmium the tanks have a reasonably large margin of safety. The results of the calculations are given in the following table:

DECLASSIFIED

DECLASSIFIED

<u>Tank Size and Designation</u>	<u>No. of Tanks</u>	<u>Minimum Critical Mass (Kg Pu)</u>	<u>Minimum Critical Concentrations (g Pu/l)</u>
Dump Tank (2.5" x 24" x 35.5")	2	17	490
Mixing Tank (2.5" x 24" x 71.5")	1	17	250
Waste Hold-up Tank (2.5" x 48" x 96")	1	11	74
Acid Storage Tank (2.5" x 24" x 150")	1	21	140
Waste Storage Tank (2.5" x 24" x 170")	1	23	140

Two birdcage designs were reviewed for the Plutonium Metallurgy Operation and were found to be nuclearly safe. One design consisted of a 4-inch I.D. x 62-inch long pipe centered inside a 16" x 16" x 65" metal frame. This birdcage will be used to ship Al-7.35 w/o Pu fuel elements off-site. The other design consisted of an 8-inch I.D. x 18-inch long pipe centered inside a 20" x 20" x 20" metal frame. This birdcage will be used for storing and transporting Al - 7.35 w/o Pu billets in the 308 Building.

Critical Studies in Support of Processing Power Reactor Fuels

a. Critical Approach and Exponential Measurements with 2-Percent Enriched Uranium Rods

Critical mass studies, in support of processing power reactor fuels, were continued with the 2-percent enriched uranium rods. Critical approach and exponential measurements were carried out with the 0.925-inch diameter - 32 inches in length fuel rods. The fuel rods were encased in thin walled (1/32") lucite tubes for insertion in the lattice assemblies which were fully water reflected; a hexagonal pattern was used for the lattice. The results of the measurement completed in June are given in Table II.

The critical number of rods was determined by a least squares fit to the neutron multiplication data between 85 and 96 percent of the estimated critical number of rods. The extrapolation lengths were obtained by equating the bucklings from the critical approaches and the exponential measurements.

The minimum critical mass for the 0.925 inch fuel rods of 2 percent enrichment is ~700 lbs. of U which occurs at an H₂O/U volume ratio of ~2.8. This compares very favorably with the value of ~690 lbs. U reported last month for the 16 inches in length rods with identical fuel.

b. Exponential Measurements with 2.6 Percent UO₂ Rods

A series of exponential experiments were begun for determining the minimum

TABLE II

CRITICAL MASS DATA FOR 2.00 PERCENT U-235, 0.925-INCH DIAMETER RODS

Lattice Spacing (Inches)	Critical Approach Data			Exponential Meas. Data			Calculated		Critical Material Buckling (10^{-6} cm^{-2})
	H ₂ O/U (Volume Ratio)	Critical No. of 3/2-in. Rods (Cyl. Geom.)	Critical Mass (Cyl. Geometry)	Effective Radius of Assembly (cm)	Relaxation Length (cm)	Extrapolation Length (cm)	Critical Mass (Spherical Geometry)		
1.50	1.89	82.4	1211 lbs U	14.84	22.02	6.46	831 lbs U	10,656	
1.60	2.29	72.5	1066	14.94	21.50	5.94	723	11,088	
1.70	2.72	68.5	1007	14.87	19.59	6.20	698	10,461	
1.80	3.17	68.2	1003	15.74	20.54	6.07	714	9,754	
1.95	3.89	74.4	1094	18.20* 19.29	24.01 37.45	5.44	819	8,610	

R-10

HW-65854 DEL

* The relaxation length was determined for two assemblies at a lattice spacing of 1.95 inches. The assemblies differed in that one assembly contained 49 rods and the other contained 55 rods.

DECLASSIFIED

DECLASSIFIED

critical mass for 2.6 percent enriched UO_2 rods in water. These fuel rods which were hollow were of the following dimensions: 0.325 inch I.D., 0.705 inch O.D., and 32.25 inches in length. The UO_2 density of the rods was $\sim 10.8 \text{ gm/cm}^3$.

The lattices were hexagonal and the lattice spacings were 1.0, 1.2, and 1.4 inches. Six fuel-to-water volume ratios were obtained by determining the relaxation length of the above lattice spacings with and without a lucite rod inserted down the center of the hollow fuel rods. The water-to- UO_2 volume ratios obtained by this method were 1.54, 1.81, 2.78, 3.04, 4.24, and 4.50.

Data Correlation - Development of Nuclear Codes for Criticality Calculations

The work on the HISMC code (Homogeneous Infinite System by Monte Carlo) was continued. The first trial at making a data tape from the Up-Date code was successful. Debugging of the code can now proceed.

Kinetics with Time Dependent Reactivity

Program HAIREK has been used in reactor kinetics calculations for the hazards report currently being prepared for the Critical Mass Laboratory. Adapting the code to these calculations required the writing of two subroutines and the modification of the main integration subroutine for HAIREK. One of these subroutines calculates the reactivity, which includes the effects of control and safety rod motions, bubble formation, and changing geometrical buckling. The other subroutine controls the size of the time interval used in tracing the peak of an excursion. Thus far the survey has concentrated on homogeneous cylindrical systems at various H/Pu ratios. Data are being compiled for similar calculations in spherical geometries.

Mass Spectrometry

The mass spectrometer for this program was used primarily during the month to study several sources of possible operating difficulties. In addition, four plutonium samples were analyzed for Critical Mass Physics programs. The spectrometer continued to operate satisfactorily at the reduced accelerating voltage of about 7000 volts in routine analysis. Excessive current leakage was encountered in the electron multiplier detector socket which was apparently correlated with increased humidity in the laboratory. The addition of a drying agent in an enclosure surrounding the multiplier reduced the leakage to an operating level.

The ion beam of the spectrometer was refocused by adjusting the magnet and the theoretically expected beam shape was again attained.

An ion focusing control was added to the spectrometer to allow steering of the ion beam in the direction of the magnetic field lines. It was found that the addition of this control significantly improved the performance of the spectrometer by allowing the focusing of individual samples. Increases of ion intensity as high as a factor of forty were obtained for some sample loadings.

Studies were also made of the possibility of increasing sample ion yield and life time by prolonged heating in the spectrometer. Optimum conditions have not yet been determined but significant repeatable increases in sample life time have been obtained.

The addition of the new ion focusing controls, beam refocusing, trough shaped filaments and sample baking in situ have combined to give a greatly improved performance of this spectrometer in the past few weeks. With present techniques a plutonium sample of 0.25 microgram would be expected to yield a usable ion beam intensity for a period of several hours.

NEUTRON CROSS SECTION PROGRAM

Monochromator Crystal Studies

Three attempts to grow large single crystal aluminum ingots by modified techniques were all unsuccessful. Three commercial single crystals were procured. An aluminum crystal and a copper crystal each of modest dimensions appear to be visually unsatisfactory showing distinct grain boundaries and broad optical reflections. Neither crystal has been subjected to investigation by neutron diffraction. A commercial zinc single crystal ingot appears to be very promising, showing no grain boundaries and giving sharp, bright optical reflections.

Slow Neutron Scattering from Water

The three axis spectrometer has been set up to continue studies of the energy distributions of initially monoenergetic neutrons scattered from water. The experimental arrangement is similar to that previously used in the measurements which were concluded about a year ago. The primary difference is the use of a pair of aluminum crystals for a monochromator in the analyzing spectrometer. The use of the aluminum (200) reflection and double collimation on the analyzer gives an energy resolution of the analyzing spectrometer which is about twice as good as was used in the earlier measurements. The detectable scattered intensity is approximately equal to that previously attained.

Measurements of the energy distributions of neutrons of initial energy of 0.147 eV have been made at scattering angles of 3, 10, 20, 30, 40, 50, and 84 degrees. A room temperature water sample which scatters about 30 percent of the incident beam has been used in all measurements. The results obtained to date have shown that the earlier measurements suffered from extreme resolution effects and that consequently some of the shapes obtained for energy distributions were badly distorted. The analysis of the bound elastic scattering component has been started. It appears at present that the broadening with increasing scattering angle of the energy distribution of this bound scattering component has been observed with sufficient precision to evaluate the width of the Lorentz function which presumably governs the distribution. The analysis of the angular distribution of this component is in progress and the distribution appears to differ from the description given by Brockhouse as was also interpreted from the earlier measurements. The quantitative description of this component will, however, require further analysis.

Subthreshold Fission

Measurements of the low neutron energy fission of the target nuclide Pa^{231} have been completed. The 0.75 eV resonance data have been evaluated to give a fission width of 1×10^{-6} eV for this resonance. This result is consistent with the values of 0.2×10^{-5} eV and 0.9×10^{-6} eV obtained for the fission widths of the 0.4 eV and 0.5 eV resonances. The evaluation of the fission data in the region of the 1.24 eV resonance has not been completed.

DECLASSIFIED

DECLASSIFIED

HW-65654

DEL

The analysis of the fission cross section measurements on U-238 has been completed. The upper limits to the fission widths of the resonances at 6.7 ev and 10.2 ev were determined to be 0.2×10^{-6} ev and 11×10^{-3} ev, respectively.

Fast Neutron Cross Sections

The shells of the slit boxes for the Van de Graaff beam locating system have been assembled. Finish machining is in progress. Installation of the components of the new analyzing magnet chamber and associated beam tubes in the Van de Graaff is now scheduled for September.

Development work is in progress on the equipment for evaporating thick lithium targets in situ.

Preparation of specifications and cost estimates for samples to be used in total and scattering cross section measurements has been made.

Two new photomultipliers were tested for rise time and maximum saturated current in connection with the fast neutron time-of-flight program. They were compared with the RCA 6810A. The 56AVP, an imported tube, is superior to the 6810A on both counts. The CBS CL 1004 had markedly slower rise time and lower current.

The design concept for a 1,000 channel slow neutron time-of-flight analyzer was greatly expanded to allow more flexible use as a pulse-height analyzer, or a three dimensional time pulse-height analyzer.

REACTOR DEVELOPMENT - 4000 PROGRAM

PLUTONIUM RECYCLE PROGRAM

Low Exposure Plutonium Lattices

Revision of the scheme of analysis used to compute k_{∞} for the 8-3/8 and 10-1/2-inch lattice measurements has led to revision of the values reported last month. The corrected results are presented below.

8-3/8-inch lattice	$k_{\infty} = 1.525$	$f = 0.875$
10-1/2-inch lattice	$k_{\infty} = 1.465$	$f = 0.846$

Plans are being made to do some additional measurements in the PCTR with these lattices to verify some activity ratios using Pu foils and to gather some data which are desired but not previously obtained.

Critical Facility of the PRP

The experiments which will be done initially in the Critical Facility with H₂O moderator were outlined as a guide to the evaluation of safeguard procedures. These experiments will comprise exponential, approach-to-critical, and critical experiments which utilize plutonium fuels of various isotopic concentrations. The objective of these experiments is to obtain parameters for the loadings in order to further the technology of H₂O moderated reactors for recycling plutonium. The initial studies will be conducted with 1.8 w/o and 5 w/o Pu-Al fuel elements.

As fuel elements of other Pu concentrations become available, they will also be used in the studies. The experiments will be conducted with individual rods as well as clusters. In some cases the loading will be only two feet long and in others the full length (7'4") of the PRTR fuel rods will be used.

Eventually, "full-length" and "partial-length" reactors would be assembled for reactivity measurements. However, these loadings are not contemplated for immediate use.

The possibility of an irradiation study with plutonium fuels at the RMF at Idaho Falls was discussed with personnel from Plutonium Metallurgy.

The Procurement Specifications for the Reactor Instrumentation System of the FRP-CF have been reviewed along with the personnel of Nucleonic Instrumentation and Experimental Reactors Operation.

It has also been proposed that a design criteria change be made so that the source be injected from the base of the reactor. This change is desirable since the facility has been modified to allow moderator level changes.

Multichannel Analyzer

The RCL 256-channel analyzer was received last month and assembled during that month. After a few initial adjustments the analyzer operated properly. Two systems, which use a 2" and a 3" NaI (TL) crystal, have been assembled and are available for use with the analyzer. Eventually it is planned to have a 5" crystal available, also.

Instrumentation and Systems Studies

Calculations were performed concerning the sensitivity and saturation levels for the PRTR Fuel Element Rupture Detection System. With proper channel settings on the included pulse-height analyzer, the system should be able to detect about 2×10^{-6} $\mu\text{c/cc}$ of I^{131} or equivalent. With the use of judicious channeling, the upper limit--before saturation occurs--should be about 3×10^{-3} $\mu\text{c/cc}$ of I^{131} or equivalent. These figures represent gas contamination levels.

Camera equipment has been designed, fabricated and mounted on the PRTR Profilometer. The equipment consists of a Polaroid "Picture a Minute" film holder with a focal plane shutter from a U. S. Army aircraft camera type K-24. Physical Measurements Memorandum 60-14 provides the most recent instructions for the installation of the Profilometer.

Installation instructions for the PRTR Wide Angle Viewer were reviewed. Physical Measurements Memorandum 60-1 gives adequate instructions, but sketches of the required lifting bales and centering clamps have been prepared and are now being detailed on numbered drawings.

Design drawings for the FRP Critical Facility periscope have been completed and approved.

The final portion of the PRTR controller evaluation program was started this month. This consists of checking the period control characteristics of the controller. If possible, this work is to be performed on site at the PRTR control

DECLASSIFIED

method of analyzing the output signal in the time domain, although giving promising results in the measurement of jacket thickness and jacket-to-core gap thickness in an unbonded fuel element, becomes impractical when additional parameters are to be measured.

Increased effort is being made to further resolve basic questions concerning the broadband test. Studies are in progress to determine mathematical and electric circuit models which approximate the behavior of broadband testing probe and test metal combinations. It has been shown that if the metal can be properly represented by an inductance-resistance network of a given configuration, the information necessary for determining the parameters of the network is contained in its input impedance or response to known driving functions.

The nature of the diffusion of currents, resulting from probe coil current, into the metal is being examined to obtain a more accurate picture of its effect on response functions. The first approach has been to consider diffusion in the metal as analogous to the diffusion of current through the conductance along a transmission line having distributed series inductance and shunt conductance, but no capacitance. The impedance of a coil coupled to such a line has been shown to display single-frequency impedance character changes due to changes in conductance or coupling which are very similar to those for a probe coil near metal. The operational impedance for this model is irrational, but the step function response of the long line (corresponding to the thick metal) has been determined. The impedance has also been determined for the layer-metal analogue.

Application of the principles of the geometry of orthogonal spaces will be made in an attempt to describe the broadband output test signal with a minimum number of numbers. An orthonormal filter will be used to obtain an expression representing the broadband signal in matrix form. The matrix will then be monitored to determine the effect of various test sample parameters on the signal.

In the thermal bond testing study, experiments to evaluate applicability of a Radiation Electronics Corporation model TA-2 ultra low noise preamplifier in conjunction with the present infrared radiometer have been completed. The signal-to-noise ratio was 4 for a signal generated with the radiometer focused on an autoclaved X8001 aluminum surface at 37°C. An identical experiment, using a cascade amplifier employing a type ECC-88 low noise tube, yielded a signal-to-noise ratio of only 3. Laboratory measurements of the noise equivalent resistance at the input of the FA-2 indicated that it was at least 17 ohms. Literature included with the instrument specifies that it should only be approximately 6 ohms. A request for further clarification of the manufacturer's specifications has been sent to their Seattle representative.

An attempt to use the present radiometer in conjunction with a 50 KW, 10 KC/S induction heater for bond testing showed that magnetic shielding of the equipment would be necessary. The strong magnetic field from the work coil induces a large spurious signal in the output of the instrument. Shielding only the detector with "netic" and "conetic" magnetic shielding material did not eliminate this stray pickup.

The 50 KW, 10 KC/S induction heater used with the tests thus far has been cumbersome because of its size and high audible noise level. Since higher frequency units can be more efficiently coupled into the load from a single turn work coil,

DECLASSIFIED

DECLASSIFIED

DEL

it was believed that a smaller, higher frequency induction heater might be used. For this reason, two high frequency units were tested with one turn work coils. The first was a Lepel 455 KC/S, 7-1/2 KW unit. It was possible to couple 0.45 KW into an aluminum dummy fuel element. The second was a Lepel 5 MC/S, 2-1/2 KW unit. Only about 0.1 KW could be induced in the aluminum from a single turn coil with this unit. However, by using four closely spaced turns two layers deep, 0.5 KW could be coupled into the dummy.

This machine was used with the four turn coil in conjunction with the prototype radiometer in an attempt to detect a one-half inch diameter artificial void 0.030 inch under the aluminum dummy. A very slight indication of the void was recorded with the induction heater at full power. The power density using the fourturn coil is apparently not high enough since the same void gave a strong indication when the 50 KW, 10 KC/S induction heater was used with a commercial radiometer in previous experiments. About 1/2 KW was induced in the sample from a single turn work coil in these experiments.

Several preamplifiers are being evaluated for possible use with the General Radio Impedance Comparator. When this instrument is being utilized as part of an inductive thermometry device, the requirements for the input stage are somewhat stringent. Specifically, a preamp is required which will detect a low impedance signal of approximately 0.25 microvolt amplitude at 100 KC with a bandwidth of 10 to 20 KC.

GAS COOLED REACTOR PROGRAM

Lattice Parameter Measurements

Error analysis of the data taken during the EGCR stainless steel loop experiment has been completed. In addition, a re-analysis of absorptions in the copper poison has resulted in slightly different values of k_{∞} from those reported last month. The results are:

- 1) stainless steel tube empty $k_{\infty} = 1.037 \pm 0.010$
- 2) 2.6 w/o fuel element in ss tube $k_{\infty} = 1.076 \pm 0.004$

Analysis of data from the EGCR, 2.6 w/o enrichment experiments has been completed except for an error analysis. The preliminary results are:

EGCR LATTICE - 2.6 W/O ENRICHMENT

$$k_{\infty} = 1.267$$

$$f = 0.850$$

The error analysis has been delayed pending a further study of the effects of axial flux and adjoint mismatches on the error in k_{∞} .

In addition to the data required for determination of k_{∞} and f , the stainless steel spiders and end caps were replaced by graphite in the central cell and end buffers. This was intended to serve as a mockup for beryllium. A flux traverse was taken along the axis of both the center and outer rods to deter-

mine the flux peaking in the graphite end caps and spiders. With the flux normalized to the same value at the center line in both cases, the data indicates the average $1/v$ flux in the graphite is 20% higher than in the stainless steel.

The depleted uranium foils which were irradiated in the PCTR in the moderator graphite of the EGCR lattice cell are being analyzed for uranium isotopic abundance. The foils were irradiated to obtain information about the fast flux above the U-238 fission threshold, and it is necessary to correct the fission product activity in the depleted foil for the activity resulting from U-235 fission.

A customer report on the PCTR measurement of the EGCR control rod worth is partially completed.

Variation of Doppler Coefficient with S/M Ratio

Preparations for measuring k_{eff} , f , p , and ϵ for the 0.925-inch-diameter natural uranium have been completed. The 6-1/2-inch graphite lattice was prestacked in the mock-cavity framework in the 305-B building to assure compatibility of components when the lattice is assembled in the cavity of the PCTR. A layout for machining grooves in specific graphite bars was made while the lattice was stacked. These grooves will accommodate thermocouples for the fuel temperature coefficient measurement. Prior machining eliminates the time lost in having the grooves cut as the lattice is being stacked in the test cavity.

Difficulty in analyzing the results of the 1.92 inch diameter fuel temperature coefficient measurements due to heat leakage into the pile moderator has caused a design change in the heating apparatus for the 0.926-inch experiments. A nichrome heater on the fuel element surface will be used, and the reactivity effects observed while heating. The assembly will be enclosed in a quartz vacuum envelope as before.

Consideration is being given to removing the excess heat from the reactors by flowing helium past the vacuum envelope and through a heat exchanger. It is now believed that some apparatus of this nature will be necessary if useful data are to be obtained at temperatures exceeding 700-800 C.

BIOLOGY AND MEDICINE - 6000 PROGRAM

ENVIRONMENTAL SCIENCES

Atmospheric Physics

The Hanford Laboratories and HOO-AEC were host to the AEC Meteorology Program Leaders at Hanford on June 20, 21, and 22, 1960. Although the meeting was under the auspices of the Fallout Studies Branch, Division of Biology and Medicine, all AEC-sponsored Meteorological Research programs were reviewed. Representatives of the Air Force, Army Chemical Corps, Army Signal Corps, U. S. Weather Bureau, U. S. Public Health Service, Atomic Energy Commission, and British Meteorological Office were in attendance. Many outstanding individuals in the field of atmospheric turbulence and diffusion were brought together for a free exchange of information and ideas. Two specific topics dominated the discussion sessions: 1) The mechanism of deposition of airborne materials from the diffusing cloud on

DECLASSIFIED

DECLASSIFIED

the ground and other surfaces. 2) The utilization of the method of moving averages in determining diffusive characteristics of the atmosphere.

Calibration work on the phosphorescence technique for assaying the amount of zinc sulfide tracer collected on membrane filters during the atmospheric transport and dispersion studies continued. The analytical procedure, developed by Radiological Chemistry, is based on electronically counting the individual phosphorescence photons following light-excitation. The basic data required for mass calibration of the scintillation counting equipment were obtained from prepared dilutions containing known masses of zinc sulfide. Four second degree polynomials were required to adequately construct the calibration curve over the mass range of 10^{-8} to 3×10^{-3} grams. The phosphorescence method of assaying provides the standard curves from which the Rankin counters can be calibrated for use with clean filters. Statistical analysis of the data for determination of the mass calibration curves for the Rankin counters was in progress at month end.

Efforts continued toward determination of the loss in counting efficiency from dust or other impurities in the samples assayed. Definition of a correction factor to be applied directly to the mass rather than the counting rate greatly simplified this problem.

Evaluation of the complete assaying system indicated that a practical limit had been reached in its development, and analysis of the filters collected during the "Green Glow" experiments should proceed. At month end, reassay of the dirty filters obtained at distances of 8 and 16 miles from the source was 60 percent completed.

DOSIMETRY

A mockup of a full size shadow shield counter for counting people was built. The arrangement was as though the roof of the present iron room were used as the shadow shield. The background of this counter was indistinguishable from that of the counter in the iron room at the high energies. At the lowest energies we now use it was only 12% higher.

Changes in the efficiency of the whole body counter multichannel analyzer in its low numbered channels were identified as the source of many of the variations in background that have been observed. When data from the low numbered channels were disregarded, background variations were reduced and were brought into agreement with what might be expected from changes in atmospheric radon due to changes in weather conditions.

Three items were received and are awaiting installation on the multichannel analyzer. These items are a paper punch that will make the data from the analyzer immediately available to the IBM machine, a magnetic tape device for spectrum analysis and a key punch for hand entry of data into the analyzer.

Following disagreement on the measurement of the plutonium activity in a sliver removed from a wound last month, two other slivers were counted by both X-ray and alpha particle counting. The alpha particle counting was preceded by dissolution of the slivers while the X-ray counts were made directly on the slivers. The alpha particle counts indicated 6 to 8 times the activity obtained by the X-ray counts. The difference is due to self-absorption of the X-rays in the

slivers.

For plutonium in very shallow wounds both the 6 kev M X-rays and the 17 kev L X-rays can be observed. It was found that the ratio of the M to the L X-rays can be used as a measurement of the depth of the source for depths to 2 mm. At this depth correction for absorption of the L X-rays is small.

An artificial dead-time circuit was built for use with plutonium X-ray counters. The object is to eliminate small after-pulses that follow very large pulses and are of just the height to be mistaken for X-ray pulses. Tests indicate that this method of discrimination is only partially successful. Attempts were also made to discriminate against these after-pulses on the basis of their much faster rise time. The space charge saturation method can be used for this purpose but only at voltages much higher than ordinarily used for X-ray counting.

Aluminum was substituted for brass in parts of the precision long counters that are being tested. The variation in counter response was reduced from 3% down to 0.1% by this substitution.

A Perlow spectrometer for neutron energy measurements was put into operation and calibrations begun. A resolution of 8% for 886 kev neutrons was achieved. This is as good as has been achieved with such a device. A study of the B^{10} reaction was begun with a spectrometer.

The positive ion Van de Graaff was in good working condition during the month. Development of a helium ion source for the Van de Graaff continued with emphasis on measurement of the parameters of interest. Another antimony-beryllium neutron source was activated. No contamination was found on the source so it is available for experiments. A commercially made BF_3 tube of high quality was finally developed for use in the double moderator.

The seventh year of teaching Radiology-485 at the University of Washington was completed. An ad hoc committee established at the University (and of which the Manager, Radiological Physics was a member) completed its study of their Health Physics training program. A Radiological Sciences Council was established as part of the graduate school to supervise an MS degree program in this field. The Manager, Radiological Physics, was asked to serve on this council. A graduate student of the University was hired as a temporary employee to work on an experimental problem of mutual interest. He will use the results of his work for his MS thesis.

INSTRUMENTATION

Gamma energy analysis data were obtained at 105-H and 234-5 using the 200 channel analyzer. A number of locations in each of the two sites were carefully examined and all data were reduced to graph paper charts. Thus, typical background conditions have been effectively established at both locations.

Experiments were made concerning detection of Pu^{239} in blood samples. It is desired to develop an instrument for biology investigations to measure the Pu^{239} in animal blood streams. Using a 10-milliliter dried blood sample and scintillation detector, a concentration of 1×10^{-5} $\mu\text{c}/\text{cc}$ of Pu^{239} was easily detected.

DECLASSIFIED

DECLASSIFIED

DEL

A method of using a relay and photocell circuit was suggested to Biology Operations personnel to check and count the activities of mice in confined quarters. In addition, development work started on a special monitor for Biology to measure the fish uptake of Ca^{45} in a water solution. In this case, the water solution will be passed through the fish gills and then through a special scintillation counter at a rate of four ml/min. The design of the special detector head is nearly complete. At the same time, addenda equipment will be used to measure the temperature to 0.1°C accuracy of the water surrounding the fish.

The suspension device for supporting the eight-inch diameter NaI crystal for the Biology Total Body Monitor was designed. The design is such to permit a vertical five-foot detector movement, to permit a horizontal arc swing across the shielding pipe, and to permit rotation to face-up or face-down positions.

An instrument was designed to investigate an Atmospheric Physics Operation problem of counting airborne zinc sulfide particles. The unit employed a high-volume vacuum pump which caused impingement of the particles directly on the photocathode face of a phototube. The zinc sulfide, being triboluminescent, scintillated upon impact. The scintillations were amplified and recorded. Operation was satisfactory except for a need of sensitivity improvement for field use.

Further experiments were carried out on a different type of CdS cell for use in the personally-carried personnel dose alarming monitor. The sensitive relays were received for the alarming monitor and are being tested. The originally tested CdS cell type (CL-403) has consistently performed better than any other tested. The new sensitive relays performed correctly in the initial tests. With the development work now nearly complete, only the packaging remains. Similar work continues on the alternate dose alarm device which uses a miniature GM tube as a detector with a modified watch being used to give the accumulated dose readout. Again, the principal work remaining is that of miniaturization of component circuitry and appropriate packaging.

Further investigative work was carried out concerning the transistorized coincident-counting technique alpha air monitor. The instrument has expanded into a combined (separate indication) alpha and beta-gamma air monitor. The principal work now is to develop a digital, rather than analog, method of readout for airborne alpha contamination for the much better inherent accuracy of digital readout as opposed to the present analog methods.

Work continues concerning the silicon surface barrier diodes. Three diodes were successfully fabricated and tested during the month and ten more diodes have been partially fabricated. The three completed diodes are 0.75 inch in diameter and produce a gross alpha geometry, with a covering of 50 micrograms/cm² of gold, of better than 20% for gross alpha monitoring. A circuit (transistorized) was developed to work with the detector diodes. The circuit plus diode can be easily assembled into a miniature alpha monitor (headphone indication) of one-inch diameter by five-inch long tube (excluding the phones). The remaining ten diodes, now partially completed, vary in detector area size from 5 cm² to 1 cm². The smaller ones will be used for alpha energy analysis work. Two special low-noise preamplifiers are being fabricated for this work.

Studies continued concerning high-level dose radiation damage to tubes (both glass and ceramic), transistors, and tunnel diodes. At an accumulated dose

level of 10^8 r, the glass vacuum tubes showed no change in characteristics, the transistors exhibited a decrease in beta, and several silicon 952 transistors failed completely. The ceramic vacuum tubes exhibited a marked increased value of ϵ_m .

Since the as-built electromechanical drawings are now completed for the prototype scintillation transistorized alpha-beta-gamma hand and shoe counter, the instrument was rechecked, tested, and is now ready to be returned to demonstration service.

Development progress continues on the dosimeters employing thermoluminescent material ($\text{CaF}_2:\text{Mn}$). The work on this method of measuring accumulated dose is aimed towards applications in finger ring and wrist-type dosimetry. Such devices should perform markedly better than the present miniature film packets considering simplicity of use, nondestruction of the detector, and an inherent sensitivity of two to three mr minimum to 10^4 r maximum. Inductive heating experiments are now being carried out with the dosimeters, and packaging techniques are being investigated with the requirement of extreme miniaturization. The thermoluminescent material is now being contained in the void between two miniature watch glasses sealed against the atmosphere. Difficulties have been experienced in obtaining a properly working phosphor due to oxidation effects. Experiments will continue on low-vacuum firing to alleviate this problem.

Transistor circuitry experimental work continues with two new Schmitt-type trigger circuits designed and tested satisfactorily.

Advice and consultation were rendered to Instrumentation Design, CECUO, concerning proper instrumentation for Project CGI-791, Reactor Confinement or Detection of I^{131} in Exhaust Air. A method of instrumentation use was presented using two gamma energy analyzers, two count-rate meters plus a difference count-rate meter to permit successful monitoring of I^{131} in the presence of large concentrations of A^{41} and other high-energy gamma emitters. Mockup tests were performed and the chart-recorded information indicates that the method will work. The proposed instrumentation is now planned to be installed in all reactor areas.

A hard-tube sweep circuit was designed and tested for the Van de Graaff electron beam deflection system. The sweep circuit operated at 3 Kv. A triode (809) was used. By comparison of characteristics, it was decided that a type 811 tube could be used to obtain a six to eight Kv peak sawtooth voltage. This circuit is a backup design and will be incorporated in the system only if the 8 Kv thyatrons fail to perform correctly.

Information was received from the Massachusetts Institute of Technology concerning a simplified method of recording gamma energy spectrum data on magnetic tape. Experiments are scheduled to be performed, as soon as time is available, using this method in conjunction with the Total Body Monitor.

Experimental progress was made during the month on various sized and shaped plastic-housing alpha scintillation detector probes. Angular changes in the handle mounting were made and tested to permit better ease of use of the probes. These are the nongamma sensitive alpha probes.

Work was resumed on the position computation system for the robot monitor.

DECLASSIFIED

DECLASSIFIED

HW-65854 DEL

The keyboard circuits and decimal counting unit modifications for the keyboard entry into the multichannel analyzer are being made. Modification work is to be performed at the body monitor site.

WASHINGTON DESIGNATED PROGRAM

Isotopic Analysis Research and Development

The mass spectrometer for this program operated routinely throughout the month with no time lost from operational difficulty.

A procedure was instituted to alpha count in standard geometry the loaded sample filaments before loading into the spectrometer in order to assure that the sample was actually loaded. One instance in which the sample had not deposited on the filament was discovered in this manner.

A number of factors concerning the improved operation of this spectrometer were studied using the 2000 program mass spectrometer. The results of these studies of additional ion beam focusing, of sample filament preparation, and others are discussed in that section of this report.

TEST REACTOR OPERATIONS

Operation of the PCTR continued routinely during the month with three unscheduled shutdowns caused by electronic failure.

The first part of the safety ball burnout experiment was completed during the month.

The hot graphite-cold H₂O neutron rethermalization experiment was also completed.

The 2-1/2-inch diameter natural uranium wet and dry in 10-1/2-inch graphite lattice experiment for k_{∞} , f , p , ϵ was started and will continue into July.

CUSTOMER WORK

Weather Forecasting and Meteorology Service

<u>Type of Forecast</u>	<u>Number Made</u>	<u>% Reliability</u>
8-Hour Production	90	85.6
24-Hour General	60	80.8
Special	120	90.8

June was a month with near-normal temperature, but with much-greater-than normal sunshine. Solar radiation averaging 698 langley's per day was an 8-year record high for June while sunrise-to-sunset sky cover averaging only 31% was a 14-year record low for the month. Rain occurred on only two days and on one of those the amount was too small to measure. The monthly total of 0.14 inch was only about 20% of normal.

Instrument Development

A special transistorized monitor using a shielded GM tube detector was completed, tested, and delivered to the Coolant Systems Development Operation of HLO. The unit will be used for coolant system pigtail monitoring after a rupture run is completed.

The prototype conveyor portion of the Laundry Monitor designed for the Laundry Operation was completely assembled in Room 7-C of the 329 Building. The mechanical tests to date have been satisfactory.

Fabrication was completed on the circuitry portion of the specially-designed in-cell beta-gamma monitor and fabrication continues on a special air filter monitor instrument for cell filter use by the Chemical Research Operation, HLO.

Fabrication continues on ten linear 0-200 mr/hr 614 Building Monitors at the 328 Building Shop. These use a more reliable and much less expensive high-voltage supply than was used in the original ten units.

Work continued on a Pu²³⁹ wound monitor probe assembly for Records and Standards Operation, HLO. The probe will use X-ray detection techniques for the monitoring of imbedded Pu²³⁹ in human wounds.

Testing continued on three logarithmic scintillation beta-gamma area monitors (5 mr/hr to 5 r/hr) for IPD.

A design proposal was made, including cost estimate, to IPD concerning a simplified gamma scintillation scanning system for use in fuel element rupture monitoring at the D-reactor. Initial design experiments were satisfactorily completed.

A design proposal was made, including cost estimate, to the Chemical Research Operation, HLO, for an alpha-beta-gamma exhaust air monitor (behind the filters) for use in the high-level facility, 325 Building. The design utilizes a fixed filter, two detectors, and appropriate transistorized circuitry plus alarming features.

Work continued on development of a system for calibrating transducers intended for use in in-reactor metallurgy creep measurements. Some delay was encountered when a large quartz piece nearing completion broke during machining. A new piece has been made. The displacement amplifier (differential rollers) has been mocked up and tested at reduced magnification factors, and appears to be capable of the predicted frictionless and backlash-free magnification for which it was designed. This device, and a cathetometer, will be thoroughly tested and calibrated at the Meteorology Laboratory, 200-W, before being incorporated into the calibration system.

A problem consisting of a determination of the characteristics of a baffled dis-solver was received from the Chemical Research and Development Operation. This work has been started and will be completed early in July.

Process Engineering Operation, FPD, requested assistance in the selection of instrumentation for the nickel plating process pilot plant temperature control. Dynamic analysis of the process was considered unnecessary at this time but sug-

DECLASSIFIED

DECLASSIFIED

gestions were made to alter the method of controlling the nickel plating process heat exchanger temperature.

Purchase specifications for the zone temperature monitor for NPR have been completed in assistance to Instrumentation Design, CEoJO. Additional specifications on the portable beta-gamma air monitor will be started in the near future.

Process Control Development Operation has requested assistance in the analysis of the temperature control systems on the 224-U Building calciners. The process equations developed by PCDO will be used to simulate the process on an analog computer. The dynamic response of the process, with and without automatic controls, will then be investigated.

An estimate of the cost of development of an automatic data readout system for PCTR was made and forwarded to Reactor Lattice Physics Operation.

Optics

Pyrometer Telescope - A fourth pyrometer telescope has been designed for Ceramic Fuels Operation. This design permits simultaneous viewing of an upright image while the temperature sensing cell is being irradiated. The completed unit is used as the sensing head for a temperature controller. It is a form of brightness pyrometer and is sensitive to emissivity changes. It should not be confused with the radiation-ratio pyrometers under development.

Borescope Lighting - A lighting system has been designed for use with the M-2 borescope in inspection of NPR process tubes. The lighting system is designed to eliminate specular reflections from the field of view thus facilitating the detection of areas of diffuse reflectance which indicate lack of uniformity in the surface treatment of the tubes.

LVDT Calibrator - The design of the differential rollers to be used in amplifying small displacements was tested in two mockups giving 12X and 40X amplification. The roller design has been improved with respect to ease of fabrication, ruggedness and compensation for temperature variation. A change of 1°C in room temperature would result in a 13 micro-inch change in reading using quartz rollers and "Invar" strips. An aluminum roller with Zircaloy-2 strips has been shown by calculation to have no temperature variation in reading if the design parameters are adjusted to the correct values. Fabrication of the quartz pieces has been completed.

Radiation Ratio Pyrometers - This work combines the development of pyrometers for Physical Metallurgy in HLO, Materials Engineering in FPD, and temperature measurement development for IPD. A laboratory mockup has been tested. The mockup incorporated design changes which greatly reduce the size of the instrument from that first developed for Physical Metallurgy. The reduction in size will permit mounting the sensing head directly onto the hot stage of the metallograph.

A total of 488 man-hours of work was performed during the five-week period (May 29-July 3). Of this, 87-1/2% was for HLO, 5% for IPD, and 1% for FPD. The work included:

1. Repair of a Unitron Metallograph.
2. Fabrication of thermal fluorescence discs.
3. Fabrication of quartz pieces for the LVDT calibrator.
4. Fabrication of a pyrometer for Ceramic Fuels.
5. Fabrication of four glass bearings for CPD.
6. Collimation of two pair of binoculars for Biology Operation.
7. Fabrication of an underwater lighting unit for 105-C FEF.
8. Polishing quartz sample cells for John Morrey.
9. Fabrication of an illuminated magnifier for Ray Aungst.
10. Fabrication of a camera mount for PRTR Profilometer.
11. Preparation of 8 micron apertures in glass discs for H. J. Anderson.
12. Evaporation of gold junction on silicon diodes for Radiological Instruments.

Analog Computer Facility Operations

The major problems on the analog computers this month include the PRTR gas loop analysis, and the reactor lithium loss study. A problem for IPD was completed on the TR-10, a transistorized analog computer which was borrowed for evaluation.

Circuits are being investigated to determine the open loop gain and the output capabilities of the operational amplifiers for the two computers. If satisfactory tests can be devised, a test unit will be fabricated to permit routine testing of amplifiers by the maintenance personnel.

The GEDA operated 16 hours and was down 152 hours (scheduled) for extensive revisions. The EASE operated 159 hours, and was down for 9 hours of unscheduled down time.

Instrument Evaluation

1. Acceptance tests were completed on 19 Scintran Model I A-C Operated Alpha Poppy Monitors and on 50 Victoreen O-200 mr self-reading pencil dosimeters.
2. Acceptance tests were started on 20 TP and 65 CP dose-rate meters, on two Model II Scintran Alpha Monitors, and on a new inexpensive high-voltage supply for area monitor use.
3. Run-in tests continued on three 614 Building O-200 mr/hr linear scintillation area monitors.
4. Acceptance tests continued on three Logarithmic Scintillation Area Monitors (5 mr/hr to 5 r/hr) for IPD.
5. Calibration and adjustment procedures were written for the portable transistorized scintillation gamma energy analyzer and the adjustment procedures were demonstrated to maintenance personnel.

DECLASSIFIED

DECLASSIFIED

6. Field tests were successfully completed on the portable, self-illumination transistorized neutron instrument at 100-B. Performance was judged to be excellent.

Paul F. Gast

Manager
PHYSICS AND INSTRUMENT RESEARCH
AND DEVELOPMENT
HANFORD LABORATORIES OPERATION

PF Gast:mcs

Chemical Research & Development

RESEARCH AND ENGINEERING

FISSIONABLE MATERIALS - 2000 PROGRAM

IRRADIATION PROCESSES

Decontamination of Reactor Components

Additional corrosion testing with the sulfuric acid - oxalic acid mixture recommended for decontamination of present HAPC reactors was completed. With one gram per liter phenyl thiourea present as a corrosion inhibitor, the attack rate at 60 C was less than 0.05 and 0.003 mil per hour for carbon and stainless (304-L) steels, respectively. Attack rates were a factor of at least 15 greater without the inhibitor. With the inhibitor present, general attack rates at 90 C for carbon and 304-L steels were about 0.3 and 0.03 mil per hour, respectively. However, at this temperature both steels showed severe pitting attack even with the inhibitor present.

In decontamination studies pertinent to the NPR, modifications of the APACE process in which less expensive acids were substituted for citric acid in the Step II solution were tried. Removal of activated corrosion products from contaminated coupons was less effective by factors of five to ten when lactic acid and acetic acid were used instead of citric acid.

NPR Effluents

Experiments were conducted to evaluate the influence of permanganate ion concentration and precipitate settling time on the scavenging of radioisotopes from proposed NPR decontamination solutions. The cleaning solutions tested represented the mixture resulting from a two-step process, an alkaline permanganate solution followed by Wyandotte 1112 cleaner. It was found that dilutions resulting in permanganate ion concentrations of 0.013 M gave scavenging results essentially equivalent to those achieved in undiluted systems. The dilution is equivalent to one volume of 0.25 M permanganate cleaning solution mixed with one volume of the Wyandotte cleaner and 18 volumes of rinse water. Previous scavenging experiments were performed by centrifuging the mixtures. It was found that natural settling for periods of 4 to 14 days gave consistent scavenging results that were about half of those obtained by centrifuging. Experiments involving longer settling periods were started.

Reactor Effluents Treatment

The tank for pilot scale testing of aluminum turnings beds for reactor effluent decontamination was delivered to the site. Footings were placed and pumps reconditioned. Aluminum bar stock is being planed to provide the several tons of chips needed to make up the bed. Planing procedures and cutting tool shapes were developed to provide faster production of the turnings. Although greatly increased production was achieved, this operation, nevertheless, appears to be the most time-limiting one.

Effluent Monitor Development

A control chassis to be used with an improved experimental monitor being developed to record Np^{239} present in reactor effluent water was designed, wired, tested and

DECLASSIFIED

DECLASSIFIED

found to perform satisfactorily. A printer was modified for compatibility with the control chassis and a transistorized glow tube counter. In concept the Np²³⁹ monitor will extract Np²³⁹ into TTA which will then be viewed with a scintillation crystal and phototube through an appropriate collimator.

Uranium Oxidation and Fission Product Volatilization Studies

One fission product release test was made using uranium irradiated to 2.4×10^{17} nvt, approximately 1000 times greater than the value for the low level tests. Comparison of the releases at 10^{14} , 10^{16} and 10^{17} nvt showed that the release of iodine, tellurium, cesium and xenon is related to the irradiation level. The increase in the percent released in air at similar conditions of time and temperature (24 minutes at 1215 C) was as follows: iodine, 71-85 percent; tellurium, 50-63 percent; cesium, 18-31 percent; and xenon, 80-93 percent. This trend was not noticeable for strontium, barium, ruthenium or zirconium.

Two tests were made at low irradiation levels to determine the efficiencies of "absolute" filters and a one-inch thick charcoal bed for removing airborne fission products. The filters were 35 percent efficient and the charcoal about 70 percent efficient in removing iodine. Tellurium was removed by the filter at about 99 percent and by the charcoal at about 40 percent efficiency.

Analysis of 0.001 Percent Sulfur in Graphite

Document HW-65522 will describe development of the analytical method. It is being applied to NPR work. Previous methods worked only when sulfur was above 0.1 percent.

SEPARATION PROCESSES

Feed Preparation - NPR Fuels

Rates of attack of Zirflex decladding solutions on uranium-two percent zirconium alloy were determined for initial, mid-point and terminal solutions. The tests were made in the absence of dissolving Zircaloy; consequently, pH values were minimum. Attack on the two percent zirconium alloy was high ranging from two g/hr-sq.cm. in the initial solution to about 0.3 g/hr-sq.cm. in the terminal solution. For comparison, the rate of attack on ingot uranium ranged from about one g/hr-sq.cm. in the initial solution to 0.04 g/hr-sq.cm. in the terminal solution. These are all instantaneous rates based on short (two minute) exposures. It is expected the average rates for longer exposures would be less due to precipitation of uranium(IV) fluoride on the surface of the test piece.

Solvent Extraction

Purex 3B Column Studies - Investigations of this column were concluded with studies on a cartridge composed of ten percent free area stainless steel nozzle plates with 1/8-in. diameter holes in the bottom six feet and 23 percent free area nozzle plates, 3/16-in. holes in the remainder. All nozzle plates were spaced four inches apart with the 0.04-in. deep nozzles pointing up. Linear polyethylene plates with 3/16-in. holes, 23 percent free area, were inserted in the nozzle plate cartridge at one-foot intervals, starting about four feet above the bottom of the cartridge and ending six inches below the top. The interface was maintained at the top. This cartridge appears satisfactory for the proposed application.

Purex Scrub Column Studies - At the present time there is considerable interest in replacing the part-plastic cartridges in the HA column scrub section and the HS column with all-stainless steel cartridges. Brief results of tests with nozzle plate cartridges were reported in February.

Results obtained this month indicate that either six or ten percent free area nozzle plates should be satisfactory for scrub service in the present dual-diameter HA or in the HS column, and that a 23 percent free area cartridge should be suitable for a uni-diameter HA column. The efficiencies of these cartridges are undoubtedly lower than those for the Zebra cartridge; however, the aqueous phase is generally well, but loosely, dispersed in the organic phase at frequencies as low as 60 or 70 percent of the flooding frequency. Operation at such frequencies would be required in the dual-diameter column because of extraction section flooding characteristics.

WASTE TREATMENT

Semiworks Waste Calciner Prototype

Operation of the prototype waste calciner has continued using a feed of simulated high-acid Purex waste at rates from 15 to 18.5 liters/hr. Super-heated steam was successfully tested as the atomizing media and the fluidizing media in separate runs. Performance of the modified ANL feed nozzle continues to be good with respect to particle size control and agglomerate formation.

The use of steam as the atomizing media resulted in deleterious effects on calciner operability. Particle size control and minimal agglomerate formation were comparable to previous runs made with air atomization under like conditions.

Employing steam as fluidization media in two runs resulted in approximately a 15 percent improvement in heat transfer from heaters to bed and a three to ten percent decrease in product bulk density when compared to near similar operating conditions using air fluidization. The net effect of the steam, however, is obscured by a slightly higher fluidization velocity when using steam than when using air.

The obvious advantage, of course, of using steam versus air for fluidizing and/or atomizing media is the higher ratio of condensables to non-condensables in the off-gases. Both higher de-entrainment factors across the condenser and lower-capacity equipment requirements downstream from the condenser should result. Measured solids removal across the condenser while using steam fluidization is about 75 percent of the input rate. Solids removal under comparable conditions employing air fluidization is about 50 percent.

Semiworks Batch Waste Calciner

The construction of a pilot-scale unit to study the calcination of simulated high-level radioactive wastes by the batch process is about 80 percent complete. The heart of the installation is a calciner-reactor in a furnace. The rectangular furnace will be heated by silicon carbide elements and can handle four-foot tall pot reactors up to fourteen inches in diameter. The furnace height can be increased later to accommodate taller pots. The off-gas system consists of a condenser, a wet scrubber and an off-gas jet. The unit will be initially used to establish permissible feed rates and time cycles, and to study volume reduction and melt formation characteristics for various wastes. Studies of control systems and off-gas treatment will be carried out at a later date.

DECLASSIFIED

DECLASSIFIED

Radiation Damage Studies

The problems of radiolytic decomposition of Purex waste, both during interim storage and after calcination, are being investigated using gamma radiation from the 325 Building cobalt source and the electron beam from a Van de Graaff generator. In an attempt to determine the degree of decomposition of nitric acid in Purex LWW during interim storage, an acidic (not formaldehyde treated) synthetic LWW was irradiated in the cobalt source for 260 hours, to a total dose of 2.6×10^8 rads. Samples were irradiated both at 40 C and under reflux at 105 C. In neither case did chemical analysis show significant loss of nitrate. Longer irradiation or higher source intensity will be required to give meaningful results.

Equipment for rotating and translating a sample in the Van de Graaff beam (to give uniform exposure) was completed and a trial run made with sodium nitrate. The volume of nitrogen produced corresponded to a G value of only 0.1 on the basis of estimated dosage of 10^9 rads. This low value indicates that the true dosage must be much lower and that dosimetry measurements will be required.

Waste Characteristics

In an experiment on the recovery of technetium-99, it was observed that the sludge filtered from the 103-A supernate tended to float. This may imply that some of the solid matter in the storage tanks will not settle out but will remain in suspension, a factor which may be of significance in waste management. It is also found that not all of the sludge can be dissolved in nitric acid.

Observation Wells

Well drilling began during the month on Project CAH-885 and part of Project CAC-840, by the Hatch Drilling Co. of Half Moon Bay, California. Drilling by drive barrel methods began promptly following installation of starter pipe.

The elevation of water level in selected wells was determined to provide data for preparing a ground-water contour map. Few changes were found except those attributed to normal seasonal fluctuations. Small changes were evident in the vicinity of the 200 East Area as a result of some changes in the distribution of flow to the two Purex swamps.

Further comparisons were made of well cutting samples obtained with a drive barrel and those obtained by churn drilling. The cation exchange capacities of the samples were measured and compared. Considerable variation was evident when single samples from a specific horizon were compared because of the intermingling of material from different levels in the churn drilled samples. When composited samples were compared, however, the difference in exchange capacity was only about eight percent, well within the statistical precision of the analysis. Thus, the many samples that are available from churn drilling operations should be satisfactory for soil column tests, except in those cases in which drilling mud was used during well construction.

There were no significant changes in ground water contamination patterns in the vicinity of the 200 Areas over the past month.

Two wells, E28-2 and E28-3, located near the center of 200 East Area, were sampled at various depths to compare current radioisotope concentrations with those noted

in 1956-57. These latest results were in good agreement with earlier data which showed concentrations of radioactive material near the bottom of well E28-2 (about 43 feet below the surface of the ground water) to be in the 10^{-4} ucB/cc range. Samples from shallower depths were in the 10^{-6} - 10^{-7} ucB/cc range. A less prominent trend toward higher concentrations of radioisotopes at increased depths was noted in well E28-3 located 900 feet south of well E28-2; however, this well bottoms at only 35 feet below the ground water surface.

Disposal to Ground

Recommendations relative to the crib disposal of in-building and vehicle decontamination wastes from T-Plant were forwarded to the Chemical Processing Department. The preferred routing of these wastes is to the 216-T-28 (formerly 216-TY-3) crib, with by-passing of the 110-111-112T cascade tanks. It was also recommended that a replacement crib be constructed to receive the vehicle decontamination waste due to the uncertain remaining life of the T-28 facility.

TRANSURANIC ELEMENT AND FISSION PRODUCT RECOVERY

Strontium Recovery and Packaging

A flowsheet has been firmed up, based on tracer-level experiments, for the isolation of a strontium-90 concentrate from Purex waste and the process is now ready for full-level testing and demonstration in the Hot Cells, or for plant test. Two primary separation processes have been found practical, and there is little to choose between them. The first scheme uses a high sulfate concentration to precipitate strontium with the cerium-rare earth double sulfates (tartrate complexing being used to prevent ferric sulfate precipitation and improve decontamination from zirconium-niobium) while the other uses lead sulfate carrier. Both are operable and fully compatible with cerium and promethium recovery. The strontium is next separated from the rare earths by digestion at 90 C with oxalic acid at pH 0.6 to 1.0. The rare earths and lead are precipitated by this treatment while strontium stays in solution. The strontium is then precipitated (as oxalate) for load-out by raising the pH of the supernate to nine to ten and digesting at low temperature (< 50 C). Further purification and decontamination would doubtless be required prior to encapsulation. Work is proceeding on these operations.

As-yet-unresolved difficulties have been encountered with the wet-chemical process for making strontium titanate. The process, which involves oxalate precipitation from a strontium nitrate-titanous sulfate solution, worked well as long as a commercial reagent titanous sulfate which had been in stock for several years was employed. When this was used up and a new supply (from the same manufacturer) substituted, satisfactory pellets could not be produced. The density was low (only about 60 percent), and the pellets were misshapen and off-color. The cause of this strange behavior is still being sought.

Technetium Recovery

It was reported last month that the readily accessible alkaline supernate in the Purex 103-A storage tank contains almost 0.1 gram of technetium-99 per gallon. It has also been found that about 20 percent of the technetium currently entering the Purex plant leaves the plant with the uranium product. Experiments were performed this month aimed at demonstrating a practical, economic process for

DECLASSIFIED

DECLASSIFIED

recovering technetium from the stored supernate as well as tracing the path of current technetium through the UO_3 plant. Highlights of the new findings are as follows.

Following tracer experiments with synthetic 103-A supernate (2.6 M $NaNO_3$, 4.2 M $NaNO_2$, 1.0 M Na_2CO_3) which showed strong technetium-99 absorption on Dowex-1 anion resin, a micro pilot plant-scale run was performed with 100 ml of full-level 103-A supernate. The waste was filtered to remove suspended sludge and fed at 1.4 ml/cm²/min. to a nitrate form Dowex 1, X-4 column. After passage of 50 column volumes (all of the feed), 98.5 percent of the technetium had been absorbed and the instantaneous loss was still less than ten percent of the feed concentration. The column was then washed with 0.1 M HNO_3 to remove carbonate and eluted with 8 M HNO_3 . The bulk of the technetium was readily eluted in about five column volumes with a peak concentration of over 2 grams/gallon. It is estimated that about 40 kilograms of technetium could be recovered in this manner from 103-A using, for instance, the ion-exchange column installed in the waste cell in the Purex plant. Analysis of the 101-A tank supernate shows that it, too, is rich in technetium (60 mg/gal), and it may be presumed that this is true of the other Purex waste tanks as well.

Technetium analyses were obtained during the most recent Purex run period on all batches of uranyl nitrate shipped to the UO_3 plant, on all UO_3 produced from this feed, and on various pertinent UO_3 plant process streams and wastes. The results showed that, during this period, approximately 20 percent of the technetium entering Purex continued to appear in the 60 percent UNH product solution and that almost all of this leaves Hanford in the UO_3 . It was also found that over 80 percent of the technetium in the product UNH could be recovered by diluting five-fold to Purex 2EU uranium concentration and passing through a Dowex-1 column. Approximately 20 kilograms of technetium could be recovered per year by simply ion exchanging the Purex 2EU prior to concentration.

Other experiments showed that technetium can be recovered from Purex supernate in 80 to 90 percent yield by a precipitation process employing hydrazine reduction and ferric hydroxide precipitation. Disadvantages are contamination with other fission products (particularly ruthenium) and a two-fold increase in waste volume.

Fission Product Packaging

Brine Drying - The induction-heated rotary dryer equipped with a long, knife-edge scraper (to cut away salt cake as it accumulated on the tube wall) was operated for a two-day run. Salt brine containing a total of 8100 grams of NaCl was fed to the dryer. Approximately half the NaCl was recovered as dry product. The remainder accumulated on the tube wall in a cake so hard and dense that the rigid scraper was deflected by 1/4 inch.

Studies on the rotary dryer are being temporarily discontinued and emphasis is being transferred to an agitated pot dryer currently being installed in the 321-A Building.

Calcination - In support of the fission product packaging program, a qualitative study of the calcination of strontium nitrate and cerium nitrate was made. Water or nitric acid solutions of the salts were evaporated to dryness and calcined in stainless steel beakers. Strontium nitrate melted in the range 626-630 C as measured (Handbook M.P. = 570 C). Major denitration occurred between 690 and 700 C.

Conversion to oxide was complete at 750 C. Final temperature reached was 870 C. Weight of residue was within four percent that expected for conversion of strontium nitrate to strontium oxide.

A solution of cerous nitrate in 4 M HNO_3 was evaporated to dryness and calcined. Maximum temperature reached was 400 C. Evaporation and ignition went smoothly and without excessive foaming. Oxides of nitrogen were evolved in the temperature range 230-360 C. Residue weight was within five percent of that expected for conversion to CeO_2 .

ANALYTICAL & INSTRUMENTAL CHEMISTRY

Determination of Nitrate by Controlled Potential Coulometry

The method was developed and was applied generally. Nitrate was titrated with U^{+++} generated at a mercury cathode 1.10 volt below the calomel reference electrode. Precision was 0.5 percent with 0.1 mg to 0.5 mg of nitrate. Plutonium, iron, chloride, and moderate sulfate did not interfere, although anions that complex uranium did interfere. The electrolyte was 1.5 M sodium perchlorate and 0.0002 M uranium.

Measurement of Dilute Uranium in Stainless Steel Dissolvent

Fluorimetric uranium analysis was found to need preliminary hydroxide separation of uranium. After taking up the hydroxide in nitric acid, HAX extraction separated uranium from steel metals. HAX would not extract uranium directly from the steel dissolvent because its 3-8 M sulfate caused too much uranium complexing. Ion exchange, also, would not break the complex. Direct analysis of uranium in dissolvent is impossible because steel metals quench uranium fluorescence.

EQUIPMENT AND MATERIALS

Z Plant Centrifuge Test

The six inch continuous Z plant centrifuge has been installed in the 321 Building for operational testing. The machine was originally installed on a light angle-iron framework similar to that contemplated for the Z Plant installation. However, with the light mounting vibration was severe. Attempts are being made to reduce the vibration by adding weight and rigidity to the base. If necessary, after consultation with the manufacturer, the dynamic balance of the rotating parts will be investigated.

Canned Motor Pump Development

A 1-1/2 inch diameter, six inch long hydroclone was installed on the bearing solution feed stream of a tapered bearing Chempump and the assembly was put in service pumping an agitated sand-water slurry. After approximately 75 hours operation (20 gpm; 35 ft. discharge head) pumping an estimated 15,000 lb. of sand the graphite bearings had worn sufficiently to permit excessive pump vibration and the test was discontinued. During the test period the pump had handled the abrasive solid load which would be encountered in roughly 20 years of "normal" separations plant service. On the basis of these encouraging test results, two hydroclone-equipped Chempumps are being fabricated for installation in Z Plant. In addition,

DECLASSIFIED

DECLASSIFIED

a similar all-stainless Chempump (pile graphite tapered bearings, glass insulated motor windings) is being procured for modification and submerged testing in "highly radioactive" separations plant solutions.

Column Pulsar for the Plutonium Reclamation Facility

Studies have begun in the 321 Building on a prototype piston pulsar for the proposed new Plutonium Reclamation Facility. The pulsar contains an expanding ring, carbon ring-sealed piston and similar type rod seals. Two pulsar concepts will be tested during operation of the unit: (1) a long-shaft pulsar, in which radioactive solution piston leakage is eliminated by pressurizing the top of the piston with a column of liquid contained in an upper pulse leg, and (2) a short-shaft pulsar, where piston leakage outward is prevented by pressurizing the piston rod seal. For most effective use of the short-shaft arrangement a "cold" stream should be introduced directly below the piston.

234-5 Incinerator Scrubber

Laboratory tests have been initiated to determine operating conditions and efficiencies for the scrubber to be installed in the off-gas handling system of the 234-5 incinerator. Five scrub solutions have been tested to determine their relative effectiveness in scrubbing NO_2 from hot air. On the basis of these tests dilute caustic permanganate solution has been chosen as the scrub solution.

Corrosion of Metallic Materials

304-L Stainless Steel in Alkaline Purex 1WW - Samples of 304-L stainless steel exposed to vapor and liquid phase of synthetic Purex 1WW wastes at pH 10.5 show corrosion rates less than 0.01 mil/mo after 1850 exposure hours. Apparent pits noted in a previous report are actually small blisters. Their behavior in continuing exposure will be followed photographically.

304-L in Acidified 100 Percent UNH - Samples of 304-L stainless steel were exposed to boiling 100 percent UNH to which 70 percent nitric acid had been added to give concentrations of 6, 16, 26 and 36 g/l HNO_3 . Corrosion rates based on two exposure periods of one week each indicate the rate of attack increases linearly with HNO_3 content and ranges from 0.7 to four mils/mo for the concentrations studied. Accelerated attack at the vapor-liquid interface was observed in all four cases. The data are desired in connection with current high acid feeds to the calcination plant.

Flash Butt-Welded A-55 Titanium-to-304-L Joints - Coupons containing welds made by flash butt-welding A-55 titanium to 304-L stainless were exposed for 600 hours to boiling 65 percent HNO_3 . In all cases, perforation of the coupons at the weld occurred during this exposure. Evidence from metallographic studies in progress indicates a separate phase in the weld fusion zone.

A-55 Titanium in HNO_3 -HF-ANN Solutions - Samples of A-55 titanium are being exposed to boiling 4 M HNO_3 solutions containing (a) 0.025 M HF-0.05 M $\text{Al}(\text{NO}_3)_2$, (b) 0.05 M HF-0.1 M $\text{Al}(\text{NO}_3)_3$ and (c) 0.1 M HF-0.2 M $\text{Al}(\text{NO}_3)_3$. The purpose is to determine the effect corrosionwise of inadvertent admission of ion exchange column flush into the titanium product concentrator at Purex. Data from two exposure periods totalling 96 hours indicate general corrosion rates in all three solutions of less than 0.5 mil/mo. So far there is no indication of accelerated attack at the interface or in the vapor phase.

Non-Metallic Materials

HW-65497 was issued; this document summarizes non-metallic materials evaluation studies for the first three months of 1960.

PROCESS CONTROL DEVELOPMENT

1C Column Facility and Studies

Shakedown operation of the pulse column facility continued during the month. Techniques were established for maintaining steady state conditions over prolonged periods of time and minor operating difficulties were corrected. A hand-operated cable winch was installed adjacent to the column to move the mid-column photometer from one sample port to another. The photometer operated smoothly following this installation.

The column density monitor developed a faulty isolating diaphragm on the lower pressure transducer. Subsequent to the repair of this transducer and recalibration of the density monitor, the effects of LCX flow, LCF flow, pulsing frequency and column operating temperature on the indicated density were studied. While the density of the solution between the two pressure transducers is the major variable measured, the system is so sensitive to other variables that a more appropriate designation of the instrument seems to be a "cartridge differential pressure monitor" rather than a "density monitor."

The Data Scanning Programmer was modified to increase the scanning speed. The time per scan, now less than five minutes, is solely limited by the balancing time of the digital voltmeter and the time constant incorporated in the Keithley micro-microammeter. The latter is necessary to damp out interference from organic bubbles in the mid-column photometer.

Data from three preliminary C-Column runs have been processed using the Data Reduction Code on the IBM 709. Approximately 15 engineering manhours per run is estimated to have been saved through processing the data in this way.

Redox 3BP Plutonium Summation System

The plutonium summation system is now installed in the plant and working satisfactorily. A means of eliminating the manual flow meter setting is being developed. This will make this system completely automatic and improve the accuracy of the results, as the time delay involved in manually changing the flow setting will be eliminated.

In-Tank Boron Monitors

HW-65531, "Information for Application of In-Tank Boron Monitors," was issued June 10, 1960.

Purex pH Probe Standardization

A sample cup and valve with drain piping has been designed and fabricated for installation in the Purex E-3 Gilmont sampler. This new assembly uses industrial type electrodes, and minimizes exposure to the operator during the manual standardization.

DECLASSIFIED

DECLASSIFIED

Calciner Furnace Control System

Three differential equations have been derived which relate calciner furnace temperature, outside shell temperature and inside shell temperature to the input power. A single differential equation was also derived for outside shell temperature as a function of input power. Two analog computer programming diagrams were developed. One diagram solves the first three equations simultaneously to yield all three temperatures as a function of power input. The other diagram solves the single differential equation for calciner outside shell temperature versus input power. The HLO Analog Computer Group will program the heat transfer differential equations on an analog computer. The computer solutions will be used to check the two sets of equations with actual test data. The calculated system constants will be varied on the computer to obtain an accurate analog of the calciner furnace. Present plans are to study the calciner furnace response to different system inputs and disturbances while using various simulated controller mode settings. The optimum control system will then be verified by actual tests on the calciner.

NON-PRODUCTION FUELS REPROCESSING

Mechanical Processing

Shear Studies - Operation of a HAPO designed, 40-ton hydraulic shear equipped with a male Vee moving blade and semicircular stationary blade was continued, primarily to study blade life under varying conditions. Basically, the studies have shown little difference in the "wear rate" of shear blades operated at high and low velocities (within the range of experimental conditions). However, the greater effective capacity of the high velocity shear, as compared to the low velocity shear was confirmed. In addition, the tests showed: (a) the blade life of the male Vee blade is approximately the same as that of a male straight blade, (b) the more shock resistant S-4 (silicon-manganese) tool steel will outwear D-2 (chrome alloy) tool steel; and (c) the "shape" of the fuel, i.e., properties which govern the deformation of a fuel assembly under the shear knife, will significantly affect shear forces.

Unless design confirmation studies are required, shear studies will be concluded during the next quarter. Remaining studies include life testing of a Stellite shear blade and studies of the energy relationships existing during various phases of high and low speed shearing.

HW-63854, "Confinement and Collection of UO₂ Fines from a Shearing Operation," is currently being issued.

Transient Shear Measurements - Transient blade velocity, blade position and cylinder pressure measurements are necessary on the shear to determine energy variations during a cutting cycle. A system using a tachometer generator as a velocity transducer and a high frequency response strain gage pressure transducer has been set up and calibrated for this purpose. A high gain operational amplifier will be used to integrate the velocity signal and thereby obtain blade position versus time. All variables will be plotted on a high speed Sanborn recorder.

NaK Disposal and Fume Abatement - Studies on methods of safely handling NaK containing fuel elements in the Hanford NPF mechanical cell are currently being completed. In recent hacksaw tests, steel capsules containing uranium-molybdenum alloy and reservoirs containing eight grams of NaK were successfully deactivated in a shallow pool of water covered by a gas blanket. The U-Mo fuel did not ignite or react noticeably when the NaK reacted violently with the bath water.

Samples of the generated off-gases (hydrogen, steam, NaK fumes) showed no detectable uranium particles generated in the NaK destruction process. The tests also showed that the method of cutting least likely to produce vigorous underwater NaK-water reactions involves cutting through a row of elements slowly (less than 20 strokes/min) leaving the hacksaw blade in the cut on the backstroke. Under the most reactive test conditions (capsules of NaK opened as quickly as possible) no detectable damage was noted on the 0.035 in. tube wall, the hacksaw blade, or the shock absorbing submerged hood (used to trap and complete the NaK water reaction underwater).

The tests to date indicate that the submerged hood contains essentially all the NaK fume generated. Consequently, serious consideration could be given to eliminating the special fume scrubbers included in the original mechanical cell design. The tests also indicate that up to 30 grams of NaK (the maximum to be released during hacksaw operation) could be instantaneously released in the cell-hood system safely. A vigorous reaction occurs but the equipment can be simply provided to withstand and dissipate the reaction energy.

Feed Preparation

Zirflex Process - A study of Zircaloy-2 dissolution rates in Zirflex decladding solutions as a function of pH and "free fluoride" concentration has been completed. Data obtained permit construction of a family of curves showing dependence of dissolution rate on pH for six different solution compositions that will occur during the Zirflex decladding process. Range of pH covered (as measured in boiling solutions) was from six to about 7.5. Dissolution rate dependence on hydrogen ion concentration was the same for each of the solution compositions studied - dissolution rate proportional to $(H^+)^{0.5}$. Least squares treatment of the data at pH 7 indicate the dissolution rate to be dependent on the (free fluoride)^{1.9}.

Further laboratory-scale experiments were made to compare uranium waste losses to Zirflex decladding solutions for steam and air sparge removal of ammonia. Small Zircaloy-2 clad UO_2 fuel pieces, with and without oxide coating on the Zircaloy were declad with 5.5 M NH_4F -0.5 M NH_4NO_3 . Terminal decladding solutions were diluted to 0.6 M zirconium, cooled to room temperature and held for 24 hours. Uranium remaining in solution represented about 0.13 percent loss (plant scale) when steam sparging was used for ammonia removal and about 0.35 percent loss with air sparging. The presence or absence of an oxide coating had little effect on the ultimate uranium loss.

Electrical Conductivity-Zirflex Solutions - Recent development studies have shown that the electrical conductivity of Zirflex solutions is a measure of dissolved zirconium, or calculated free fluoride. The method appears to give a zirconium or free fluoride concentration to within 10-20 percent during the course of the dissolution.

Sulfex Process - Seven Sulfex decladdings of sintered UO_2 cores clad in type 304-L stainless steel and two Sulfex partial dissolutions of stainless steel pipe were performed in the recirculating dissolver pilot scale facility. One nitric acid core dissolution of swaged UO_2 was made. The UO_2 cores from the other six decladding runs (4 pellets, 1 split cylinder, 1 swaged) were recovered intact and transferred to Ceramic Fuels Development Operation

DECLASSIFIED

DECLASSIFIED

In every case where steam was substituted for air as a sparge gas a marked increase in reaction rate was observed, as indicated by the hydrogen evolution rates. As a consequence, the acid concentrations or reaction times necessary to effect rapid and complete decladdings can be reduced whenever steam is used in place of air. This also results in lowered uranium losses (0.03 percent versus 0.07 percent) and reduced corrosion of the Hastelloy F dissolver vessel (about 0.5 versus 1.5 lb. metal removed per declad run).

The variations in reaction rates between different batches of sulfuric acid which are observed when air is used for sparging are absent or greatly diminished when steam is used.

The accumulated corrosion from the Niflex, Zirflex, and Sulfex studies conducted in the recirculating tube dissolver vessel became quite apparent during this series of runs. The bail on the fuel charge basket failed at a highly "worked" point due to stress corrosion. A hole also appeared in the bulk metal of the dissolver. This hole was behind a small bracket which had been installed in such a manner that a stagnant pocket was formed. Accelerated corrosion took place in this pocket possibly through a concentration cell mechanism. Slight pitting of the heat affected metal immediately adjacent to the welds and general etching of the dissolver inner surfaces are apparent.

Materials of Construction

Corrosion testing of the second (and last) series of 12 experimental alloys prepared at Battelle Memorial Institute is nearing completion. Test solutions have included Zirflex, Sulfex and Niflex type solutions as well as nitric acid and nitric acid-ferric nitrate. In this series, the principal composition variables were chromium and molybdenum. Cobalt replaced half of the nickel content in three of the alloys. Five alloys--those containing cobalt and two with high (9 w/o) molybdenum content--showed severe intergranular attack in boiling 65 w/o HNO_3 when sensitized. Two heats having low (1.5 w/o) molybdenum content (copper absent) had poor corrosion resistance in Sulfex solutions. Four of the heats appear superior to either Nionel or vacuum-melted Hastelloy F for use in the HAPO non-production fuels dissolver (for Zirflex and Sulfex). Fifty-pound heats of the four most promising alloys prepared by BMI in this program have been requested. These will allow further testing under conditions more nearly simulating actual operating conditions.

HIGH LEVEL RADIOCHEMISTRY FACILITY

A four place sampler has been fabricated for use in cell "A". The device is syringe controlled using the Model 8 manipulators. The sampling technique has been tested and was satisfactory.

A micro pipet device has been fabricated and installed in cell "B". The controls are on the exterior of the cell. A quick-release technique is used to hold the pipet in place; the device is easily operated with the Model 8 manipulators.

One gallon of LWV was received from Purex on June 20. The material was transferred to cell "B" on June 30. The High Level Radiochemistry Facility was placed on a "hot" status at that time and is now being operated on an approved Building Operating Procedure.

REACTOR DEVELOPMENT - 4000 PROGRAMPLUTONIUM RECYCLE PROGRAMReprocessing PRTR Spike Fuel Elements

Dissolution rate studies this month have sought a better understanding of the effect of various parameters (HNO_3 , $\text{Al}(\text{NO}_3)_3$, $\text{UO}_2(\text{NO}_3)_2$ concentrations) on the dissolution of alloys proposed for PRTR spike fuels. Most work was done with an alloy having the composition (in weight percent) 1.8 to 2.2 Ni - 1.8 Pu - 0.4 (max) Fe - 0.17 (max) Si - 0.1 to 0.2 Ti - remainder Al. It was found that this alloy, as well as a similar alloy containing ca. one percent silicon (on which dissolution studies were reported previously) must be in an active state to dissolve rapidly in HNO_3 - $\text{Hg}(\text{NO}_3)_2$ solutions. In the active state the alloy is coated with a grayish material; inactive it is shiny and metallic. Activation may occur in the dissolver solution; an induction period whose magnitude depends on the solution composition is required. At sufficiently high nitric acid concentration ($\geq 6 \text{ M}$) activation does not occur, and rapid dissolution is not obtained. In some solution compositions, actively dissolving pieces will deactivate and rapid dissolution ceases. Activation can be induced by simply immersing the alloy in $1 \text{ M HNO}_3 - 0.002 \text{ M Hg}(\text{NO}_3)_2$ for a few minutes. An induction period is then not required when the activated metal is placed in the dissolver solution. The studies have sought to determine the interrelations of these various phenomena to arrive at an optimum procedure for dissolving aluminum alloys in the Redox plant. It is anticipated that the data obtained will be useful for other processing needs also such as removal of aluminum binding from NPR fuels.

Preliminary data indicate considerable less hydrogen evolution during rapid dissolution of the two percent nickel alloy than was found previously in dissolving the ca. one percent nickel - one percent silicon alloy. Equipment for more adequate sampling of the off-gas stream has been assembled for rechecking hydrogen evolution during dissolution of both alloys.

Experiments are in progress to determine the attack of Zirflex decladding solutions on PRTR spike fuel alloys. A non-clad wafer of the Al-Pu-Ni alloy was present during an entire simulated Zirflex decladding cycle in which the initial decladding solution contained $2 \text{ M NH}_4\text{F} - 0.17 \text{ M NH}_4\text{NO}_3$. A total of 28.2 grams of Zircaloy-2 was dissolved per liter of solution. Total time was 17 hours; Zircaloy-2 was dissolving during 11 hours. Total penetration of the Al-Pu-Ni alloy was about eight mils. This represents the removal of about six percent from a one-half inch diameter rod. Roughly two-thirds of the penetration occurred during the six hours when zirconium was not dissolving. The core exposure in this experiment was far in excess of that expected in an actual decladding operation.

Salt Cycle Process

Polarography in Molten Salts - Obtaining reproducible polarograms in the NaCl-KCl melt continues to prove difficult, largely through deterioration of the insulators used on the microelectrode and consequent contamination of the melt. Successful polarograms have been obtained for the Cu(I) reduction and for Ag(I) reduction. The silver wave was fitted by the Kolthoff-Lingane equation, the copper wave by the Heyrovsky-Ilkovic equation.

DECLASSIFIED

DECLASSIFIED

The use of commercial high density, high purity alumina as an insulator for the platinum micro-electrode improved the situation in that lower blank currents were obtained. However, there were peaks on the blank polarogram at potentials which would prohibit the use of such a system for conducting polarographic studies of dilute solutions of the materials of interest.

Attempts to remove these peaks by in situ reduction of the melt with a macro-electrode only worsened the situation. However, the residual currents with the macro-electrode were surprisingly low and indicated that controlled potential coulometric titration might be a useful tool for studying Redox reactions in this melt.

Preparation of Electrolytic UO₂ - A program has been initiated to prepare one-pound lots of electrolytic UO₂ under a variety of electrolysis conditions. Studies by personnel of the Ceramic Fuels Development Operation of the compaction behavior of these powders should provide information as to the desirability and manner of altering the deposition process to improve the fabrication properties of the UO₂ powder.

The apparatus employed for these preparations yields about 0.5 pound in each deposition so two successive electrolyses are required to obtain the desired one-pound lot. To date, one such lot has been prepared, depositing the UO₂ on platinum cathodes at 700 C and at a current of 20 amperes. Analysis of the two samples which were composited into a one-pound lot showed oxygen/uranium ratios of 2.012 and 2.015.

Two problems of the "nuisance" category have been encountered in this work. A platinum-clad rectangular electrode has been used in part of the work. This electrode developed a decided warp in its first use and the bowing has progressed in each successive use. Annealing in air at 800 C has only partially corrected the warp. Other than this, however, this electrode has held up fairly well, weight losses generally running on the order of 0.05 to 0.1 grams per run.

A more serious problem has been recently encountered. Throughout all the work to date with platinum electrodes an attempt has been made to inhibit passage of chlorine from the graphite anode to the platinum cathode by surrounding the anode with a Vycor sleeve. Unfortunately the sleeve became plugged by salt which crystallized on it above the surface of the melt, eventually forcing the chlorine to exit out the bottom of the tube. In an effort to avoid this the shroud tube was used to enclose the cathode in a run in which a 0.02 in. x 2 in. x 14 in. pure platinum cathode was used. In this run a rapid rise in voltage was noted after about 1.5 hours of electrolysis and a post-mortem disclosed that about half the submerged portion of the platinum sheet had disintegrated and the remainder had become quite brittle. The cause of this catastrophic attack on the platinum is currently being investigated.

Preparation of Pilot Quantities of Electrolytic UO₂ - Fabrication of the apparatus for making 100 pounds of electrolytic UO₂ has been completed. The caustic scrubber which consists of a submerged sparge ring in an unpacked vessel has been tested and removes two liters of chlorine/minute with no chlorine detected in the off-gas. Transite off-gas piping was satisfactory even while chlorinating a melt at 800 C. The large quantity of air in-leakage lowered the transite temperature appreciably.

Electrolysis of a fused salt solution made by dissolving $\text{UO}_2\text{Cl}_2 \cdot \text{H}_2\text{O}$ in equimolar NaCl-KCl and chlorinating for four hours to remove water gave a product with an oxygen to uranium ratio of 2.18.

Electrodeposition of UO_2 from Low Melting Chlorides - The problems of finding materials to contain the $\text{NaCl-KCl-UO}_2\text{Cl}_2$ system at 700 to 800 C and the proven thermal instability of UO_2Cl_2 in such systems provide substantial incentive for developing a lower-melting chloride system from which to electrodeposit UO_2 . Unfortunately, brief scouting experiments conducted to date have not turned up a suitable substitute for the equimolar NaCl-KCl melt. Both UO_3 and U_3O_8 were only slowly dissolved by chlorine into equimolar $\text{ZnCl}_2\text{-KCl}$ at 500 C.

Although UO_2Cl_2 is quite soluble in pyridinium hydrochloride, electrolysis of such a solution at 150 C was not markedly successful. Shortly after applying a potential the solution turned dark and the temperature increased. A small shiny black adherent deposit was obtained on the cathode. (Behavior somewhat reminiscent of reduction of UO_2Cl_2 by hydrogen.)

Electrolysis of a concentrated solution of UO_2Cl_2 in KCl-AlCl_3 at 340 C yielded a poorly adherent UO_2 deposit and resulted in substantial attack on the graphite anode. It is expected that some of the difficulties encountered in this electrolysis stemmed from residual water left in the HCl -dried uranyl chloride monohydrate which was used to prepare the melt and that electrolytic deposition of UO_2 could probably be successfully contrived out of this melt.

Aging of Non-Stoichiometric UO_2 in NaCl-KCl - It has been previously reported that equilibrating non-stoichiometric UO_2 in NaCl-KCl-UCl_4 results in reduction of the oxygen/uranium ratio in the UO_2 . In order to confirm that this effect was indeed due to the presence of uranium(IV) in the melt, an experiment was performed in which UO_2 was simply equilibrated with NaCl-KCl (pretreated as in the earlier experiments). A three-hour equilibration resulted in no solubilization of the UO_2 and no change in the oxygen/uranium ratio of the UO_2 . Measured values of this ratio were 2.255 in the initial " UO_2 " and 2.256 after the equilibration. By comparison, equilibration of this " UO_2 " with a melt containing uranium(IV) had previously resulted in solubilization of at least 30 percent of the powder and reduction of the oxygen/uranium ratio to about 2.04 in the residual powder.

Measurements of Oxygen to Uranium Ratios - A precision of 0.04 percent is indicated for O/U calculated from coulometric measurements of uranium and hexavalent uranium, mentioned in recent months. Accuracy would be affected should some kind of uranium oxide be included in phosphoric acid insolubles which occasionally have appeared. In general, the coulometric method is being used for non-routine samples and the ignition method, for controlling experimental fuel element fabrication. The ignition method, capable of 0.1 percent precision, is subject to interferences such as the presence of graphite.

Fission Product Scavenging - In conceptual Salt Cycle flowsheets, repetitive use of the NaCl-KCl eutectic salt melt has been proposed. To regulate the steady state concentration of fission products under such a plan, a fraction of the salt would be discarded in each processing cycle. An alternate method for accomplishing the same effect would be to scavenge the fission products from the molten salt. Initial experiments with less than one weight percent of zinc sulfide added to molten NaCl-KCl eutectic resulted in removal of about 95 percent of tracer ruthenium-106 from the melt. Because of the nature of the system, it is believed

DECLASSIFIED

DECLASSIFIED

that a variety of chemical compounds, including sulfides and oxides, may be useful for the scavenging of fission products. Extension to the scavenging of salt "dissolver solutions" is also a possibility.

Non-Metallic Materials - Screening studies have continued on ceramic materials to be used in a sodium-potassium chloride melt (equal mol percentages) containing 10 weight percent uranyl chloride. The melt was maintained at 750 C and sufficient chlorine was bubbled through the melt to keep the uranium in solution. Results of the studies are summarized below:

<u>Material Tested</u>	<u>Duration of Test</u>	<u>Observations</u>
Silicon Carbide Rod	6 days	No dimensional change. Excellent resistance. Sample weight increased 0.008 gram to 2.531 grams.
Zirconia Crucible (Zirconium Corporation of America)	6 days	No apparent change. Crucible weight increased 0.10 grams to 36.08 grams.
Alumina Crucible (Morganite Triangle XN100)	40 days	Crucible was being used for testing small pieces of ceramic materials. Melt percolated through crucible. No significant weight change or apparent damage. Top portion of crucible found to be a factor of two more porous than the bottom.

Continuous Ion Exchange Contactor Development

MABIE Contactor - In analyzing the mass transfer efficiency of the MABIE contactor, the assumption has been that each stage acts as a separate, perfectly mixed vessel. There was some question, however, as to validity of this assumption. If the mixing characteristics of the contactor are unpredictable and are limiting the overall efficiency, any data from a pilot-plant contactor are of doubtful utility in designing a full-scale unit. On the other hand, if the mixing characteristics are predictable and the mass transfer is the controlling factor, the mixing can be taken into consideration in designing a full-scale unit.

In analyzing the mixing characteristics of the MABIE contactor, a mathematical model expressing the concentration-time relationship for a perfectly mixed vessel has been expanded to apply for a contactor containing many stages in which no reaction of mass transfer is taking place. The theoretical behavior of a three-stage contactor was calculated and compared with the measured data obtained from a run in the experimental three-stage contactor. The stage void volume, flow rate, and solute concentration was the same for both the experimental run and the calculated curve. At an aqueous flow rate of 290 gal/hr-sq.ft., the experimental curve was of identical shape to the calculated curve and displaced by an amount equivalent to the quantity of solute taken up by internal solution in the resin. This indicates the validity of the mathematical model and allows its use for quick and quantitative analysis of actual agitated bed performance.

The dual-column system consisting of a 6-inch diameter by 11-foot long compound column with seven adsorption stages and three scrub stages and a 6-inch diameter by 12-foot long elution section with six stages has been fabricated and is ready for "shakedown" studies.

Jiggler Contactor - A new intermediate section between the absorption and elution columns has been installed and tested. The section is four inches in diameter and thus provides a completely open transfer channel. A screen near the bottom of the new section provides exit for the raffinate and, as before, restricts the pulse effect to the absorption column only.

Initial tests show that the non-fluidized resin in the intermediate section has a great enough force to prevent visible expansion of the resin in the absorption column at flow rates up to one liter/min. The pressure drop across the section is practically zero.

Tests also indicated that the use of air or a combination of air-water to recycle the resin may not be adequate for controlling the flow rate or for effecting sufficient separation of resin from slip liquid at flow sheet requirements of about 200 cc of resin per minute. As the resin rate is increased, the quantity of slip acid increased. Attempts to introduce water to assist the air have increased the quantity of resin recycled, but have not in initial experiments sufficiently reduced the strength of the 7 M HNO_3 slip liquid which is carried into the elution column with the resin. Experiments are now being readied to test resin pumping as a more positive means of control.

Thorium Adsorption Studies - In preliminary studies of the adsorption of thorium on Permutit SK 20 to 50 mesh resin from 7 M HNO_3 solutions at 60 C, diffusion coefficients of 11×10^{-9} and 7×10^{-9} cm^2/sec were obtained at loadings 30 and 50 percent of equilibrium respectively. The variations of the diffusivity with loading is greater than with plutonium; however, the values are of the same magnitude and thorium transfer data should provide a good measure of contactor efficiency. Pending additional data, a value of 10^{-8} will be used for the diffusion coefficient, corresponding to a resin loading of about 30 percent.

Measurement of Boron in PRTR Moderator

A flame photometric method was adapted. Before flaming, boron was separated from interferences by ion exchange. A 50-50 mixture of IRA-400 and XE-77 retained nearly a kilogram of potassium metaborate per cubic foot of resin. One-hundred column volumes of simulated PRTR feed caused no breakthrough.

RADIOACTIVE RESIDUE PROCESSING DEVELOPMENT

Radiant-Heat Spray Calcination

Eighteen runs were made during the month to complete capacity studies prior to writing a comprehensive summary report (HW-65806). Most significant new findings were as follows:

1. One hundred seventy to 200 grams/liter of sugar is optimum for calcination of acidic Purex waste, based on powder characteristics and extent of calcination. Weight loss on subsequent heating to 900 C (a measure of sulfate

DECLASSIFIED

DECLASSIFIED

decomposition) is reduced from a value of 23 percent at 50 grams/liter sugar to less than one percent at 200 grams/liter. Cost of sugar is only about \$1.40/TU if added at rate of 200 grams/liter.

2. The free-flowing character of the powder increases with extent of calcination, but bulk density decreases. However, all powders sintered to a density of about 2.35 g/cc on heating to 900 C.
3. With adequate sugar addition, spray calciner capacity appears to be even higher than the 4 gal/hr (11.4 gal/hr.sq.ft.) limit set by the capacity of the system auxiliaries.
4. A successful run was made with neutralized Zirflex waste slurry (0.5 M Na_2ZrF_6 , 0.9 M NaF, 0.1 M NaNO_3 , 2.5 M NH_4OH , pH 10).
5. Thermal conductivity measurements were obtained over the range 450 to 1650 F for a massive phosphate glass prepared from spray calciner runs with Purex waste. The conductivity decreased from values of about 0.8 BTU/hr. ft. F at 450 degrees to 0.2 units at 1650 degrees (in the molten region). The very low conductivity of the melt implies that thermal conductivity in the melt, rather than in the surrounding solid, may be limiting in storage.
6. The juncture between a stainless steel thermocouple well and the Inconel column failed during the month. Inspection showed that corrosion of the heated Inconel center section - following 18 months operation - was only nominal, but that corrosion in the region of the weld (probably electrolytic corrosion) was considerable.

Mineral Reactions

Aged decladding waste was passed through two 60 cm beds of clinoptilolite in series at a flow rate of 47 gal/ft²/hr. and the breakthrough of radiocesium and radiostrontium was measured. A strontium decontamination factor of about 100 was obtained fairly consistently for about 1000 column volumes. At that time radiocesium had achieved a C/C_0 of about 0.8. This anomalous removal of strontium may have resulted from a calcite-phosphate reaction involving impurities in the mineral. The history of the waste is not well known and it may have been mixed with some bismuth phosphate process waste, introducing the necessary phosphate ion. The presence of 0.03 M chromate ion in the waste lends support to this explanation.

The cesium breakthrough curves were obtained for the first 60 cm bed and for both 60 cm beds considered as a 120 cm bed. The slope of the Cs breakthrough curve for the 120 cm bed was greater than that for the 60 cm bed. The capacity for cesium from this waste appears to be about 800 column volumes. A cesium breakthrough of $C/C_0 = 0.6$ was attained in the first 60 cm bed before 0.1 MPC ($C/C_0 = 7 \times 10^{-6}$) was reached in the effluent from the second 60 cm bed. This suggests that if three of these 60 cm beds were in series the mineral in the first bed would be essentially saturated before Cs^{137} reached 0.1 MPC in the effluent from the last.

The effect of irradiation on clinoptilolite was re-examined by means of equilibrium experiments with cesium solutions. Concentrations of 10^{-4} M cesium were used to provide increased sensitivity over that previously obtained with 10^{-2} M cesium. The experiments revealed a 25 percent reduction in the equilibrium distribution

coefficient at 25 C after the mineral is irradiated to 10^9 R. At an equilibration temperature of 55 C, the mineral irradiated to 10^9 R showed a K_d 29 percent higher than that of the unirradiated. Samples are being treated to reveal the effect of intermediate and higher levels of irradiation in an effort to explain the results.

Condensate Streams

Studies on the decontamination of Purex Tank Farm condensate in the 271-CR building Micro Pilot Plant were continued. During Run 5 columns 1 and 2 contained activated carbon with a particle size of 0.6 to 2.4 mm and each having a bed height of about 36 inches and bed diameter of 1 inch. Column 3 contained clinoptilolite having a particle size of 0.7 to 0.8 mm, a bed height of about 33 inches and a bed diameter of 1 inch.

During Phase I, the waste was routed downflow through the two activated carbon columns followed by the clinoptilolite column. The temperature was maintained at 25 C. At a flow rate of about 0.2 gpm/cu.ft. strontium was removed with a decontamination factor of about 20 and as the flow rate was increased to about 2 gpm/cu.ft. the DF was reduced to about 10. At 0.2 gpm/cu.ft. cesium was removed with a DF greater than 1000, but as the flow rate increased to about 1 gpm/cu.ft. the DF decreased to a minimum of about 450 and as the flow was increased further to 2 gpm/cu.ft. the DF increased to about 650.

During Phase II, the temperature of the clinoptilolite column was maintained at 45 C. Based on incomplete analytical results, DF's for both cesium and strontium removal were comparable to those found in Phase I.

During Phase III, the activated carbon columns were by-passed and the waste passed directly through the clinoptilolite at 25 C. The strontium removal was comparable to that measured in the first two phases. Cesium was removed with a DF of about 1000 at 0.2 gpm/cu.ft. and as the flow increased to about 0.8 gpm/cu.ft. the DF decreased to about 300 and remained at that level as the flow was increased to about 2 gpm/cu.ft.

BIOLOGY AND MEDICINE - 6000 PROGRAM

Sample Concentration by Electrodialysis

Improvements were made in the electrodialysis apparatus so that five hours of operation are sufficient to isolate the radioisotopes formerly requiring 24 hours. The technique was successfully applied to 11-gallon samples of reactor effluent water and Columbia River water to separate 90, 82 and 77 percent of Na^{24} , Zn^{65} and Np^{239} , respectively. Cr^{51} was separated from the river water into the cation chamber, whereas in the case of reactor effluent water about equal quantities were found in the cation and anion chambers. This substantiates other data which indicate that in reactor effluent water Cr^{51} is present as both anionic and cationic species. Only the cationic form is present in the river water as a result of the reducing action of some material in the river.

Reactor Effluent Radioisotope Studies

Slow to fast neutron flux ratios were determined in test positions in the reactor graphite reflector in order to characterize these various fluxes for use in

DECLASSIFIED

DECLASSIFIED

determining the reactions responsible for the formation of some of the reactor effluent radioisotopes, and hence to identify the parent isotopes. The Al^{27} (n, α) Na^{24} , Fe^{54} (n, p) Mn^{54} , and Fe^{58} (n, γ) Fe^{59} reactions were used in the study. The graphite reflector will serve effectively as a thermal column giving a slow to fast ratio of 200:1.

Protection Indices

Determinations of the equilibrium and rate constants for interconversions between the various forms of erioglaucine present in aqueous solution were completed for 25 C and 0.5 M ionic strength. It was concluded that erioglaucine in solution is present in two colored forms and three colorless forms which differ in the extent of hydrolysis at the central carbon atom and protonation at the amino groups. With these data it is now possible to determine which of the various forms of this dye react most rapidly with free radicals and to adjust conditions for measuring the protection indices of other compounds relative to this dye in non-neutral solutions.

Geology and Hydrology

The U.S. Geological Survey, Tacoma office, reports that the potentiometric level in well 15/28-35P1, penetrating several hundred feet into the basalts on the east end of Wahluke Slope, has risen about 30 feet in three years. This rise and level are comparable to those in Lake Linda, north of the Saddle Mountains near Othello, and in the Scooteney Lake area. The water level in at least one well farther west on Wahluke Slope, penetrating the same aquifers in the basalt, stands much lower and has shown no significant rise according to U.S.G.S. records. This rise evidently is the result of irrigation north and east in the Columbia Basin Irrigation Project. Water flow is either through the Saddle Mountain structure from the Lake Linda area about three miles north, or more likely along permeable horizons in the basalts from the Scooteney Lake area seven miles east, where such horizons probably are exposed in the Ringold Coulee walls. A mechanism is thus suggested by which unconfined ground water can enter and move rapidly through the basalts. Changes of this magnitude in water levels east of the Columbia River are expected to affect at least locally the water levels in wells tapping the same confined aquifers in the Hanford Works area, with resulting changes in water flow patterns there.

Research continued to obtain data for correlating basalt flows. One method examined was the possibility of age dating the material by means of its uranium to lead ratio. However, spectrographic analyses of basalt samples revealed a natural lead content too high to permit dating by this method.

A laboratory flow model was used to perform experiments for measuring the rate of sinking of high density solutions. Radioactive iodine was used as a tracer material and the flow patterns mapped by means of a scintillation detector in a collimating shield. Experiments were completed using solutions having densities of 1.05, 1.07, and 1.10, respectively. Highly significant rates of sinking were observed with each of these solutions. Attempts to derive a formula for generalizing these data have not yet been successful.

A numerical method for describing the pattern of water flow beneath a ground water mound was developed and tested further. The method involves the application of difference equations. Extending the method to analysis of a three-dimensional flow

problem gave results that appeared consistent with the boundary conditions of the problem. Using the technique, two hypothetical situations were examined involving identical conditions except that in one case flow directly beneath the mound was assumed and in the other case no such flow was assumed. The results of these test cases were gratifyingly consistent with similar patterns developed by other methods. It should be possible to solve the flow patterns beneath actual Hanford mounds with this technique using generalized conditions.

Computational studies of water flow in porous media at partial saturation was extended from the draining cycle to the imbibition cycle, i.e., the movement of water into initially dry soil. Some difficulties were experienced in applying the computer program established for the draining cycle. This program cannot handle negative values of potential since such negative values were utilized in the boundary indexing system of the draining cycle program, and negative values frequently occur in the imbibition cycle. Furthermore, the values of capillary conductivity for dry soils are so small that they may become lost in the computational process. Methods of adjusting the computer program to avoid both of these difficulties were found and will be incorporated into a revised program.

Ground Waste Investigations

The soil beneath the experimental crib is draining although neutron moisture probe readings indicated no measurable change from the spatial distribution of moisture as determined early in May.

Another unsaturated soil column experiment was completed. The radiostrontium breakthrough curve had a lesser slope than usual and indicated quite rapid breakthrough. The breakthrough data are somewhat scattered, making interpretation uncertain. Identical soil columns were used to perform saturated ion exchange experiments. Additional results must be obtained to permit reliable comparison between the saturated and unsaturated case. The saturated experiments performed to date indicate that the 50 percent breakthrough point is achieved with the passage of a smaller volume of solution than is needed to achieve 50 percent breakthrough in unsaturated experiments.

A soil column experiment was performed with synthetic Redox high-level waste spiked with Sr^{90} and Cs^{137} . No breakthrough of cesium or strontium was obtained in 30 column volumes of effluent but the Y^{90} daughter of Sr^{90} appeared in the effluent after passage of only about one column volume. The pH of the influent solution was near that found to be optimum for rare earth radiocolloid formation (about pH 11). The yttrium is thus probably moving through the soil as a peptized colloid.

Soil Chemistry and Geochemistry

Two hundred pounds of mineral containing the natural zeolite erionite ($\text{CaO} \cdot \text{Al}_2\text{O}_3 \cdot 6\text{SiO}_2 \cdot 5\text{H}_2\text{O}$) were received from the Nevada Bureau of Mines for experimental purposes. The material is approximately 85 percent erionite. According to the literature, erionite should have a selective adsorption capacity for calcium. Preliminary experiments were performed to determine the effect of various cations on the adsorption of Ca^{45} . The work indicated that erionite is actually selective for adsorbing strontium. To a lesser degree it also selectively adsorbs cesium. The selectivity of erionite for the ions examined was not nearly as marked as that of clinoptilolite for cesium.

DECLASSIFIED

DECLASSIFIED

OEL

Recent laboratory studies of the uptake of rare earth radioisotopes by soils were extended to include experiments with actual waste solutions. Samples of Purex process condensate and steam condensate wastes were spiked with Ce^{144} , Pm^{147} and Eu^{152} and equilibrated with portions of calcareous sub-soil. The results were in general agreement with the rare earth adsorption data previously obtained. The uptake of all of the isotopes examined was greater than 95 percent complete in the pH range 6.25 to 7.8 for both wastes starting with samples of unneutralized waste having pH of about 1.7. This was raised to between 6 and 8 when the calcareous soil was added. When samples of process waste neutralized with lime bed were used, a somewhat lower rare earth removal by soil was obtained (87-94 percent) although the final pH of the equilibrium system was in the same range. The reason for this behavior is not known.

When equilibrium systems of unneutralized waste and soil were adjusted to pH 1.2 with HCl, the uptake of rare earth isotopes was reduced to 17.5 percent. The uptake of rare earths was about 94 percent in the case of equilibrium soil systems adjusted to pH 12.3 with NaOH.

Field Apparatus Development

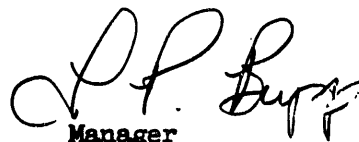
Seven units of a multiple depth well sampler were constructed locally and tested. The units feature quick disconnect couplings with electrical connections for transmitting the operating signal. The seven units in tandem array with five-foot spacing intervals were successfully tested by sampling at an average depth of 500 feet below the water table in a project well (65-50). All seven samples were brought to the surface without mishap. Some water leakage into the interconnecting tubing was noted but can easily be corrected if found troublesome. The sampler received its first practical use in testing several wells in 200 East Area for contamination stratification.

The thermistor flow meter earlier described was incorporated into an experimental instrument for measuring vertical motion of water in wells. Tests in wells at the Gable Mountain test site showed vertical flow in one well of four to eight feet per day. These flows are of significance in the evaluation of piezometric head differences resulting from differing permeabilities in successive formations or the influence of water mounds.

Micromeritics

The deposition rates of lycopodium spores in a one-inch diameter aluminum pipe were measured in the Reynolds number range from 3000 to 8350. The density of the lycopodium spores was calculated to be 0.67 grams/cm³ taking the number per gram to be 1.06×10^8 and the effective spherical diameter to be 30 microns. The deposition velocities obtained are consistent with the data for 30u glass beads ($P = 2.37$) when reduced by the general correlation function previously determined. This indicates, at least for the present data, that the particle density term has been entered to the proper power in the correlation function.

LP Bupp:cf

Manager
Chemical Research & Development

BIOLOGY OPERATION

A. ORGANIZATION AND PERSONNEL

Dr. W. J. Clarke started his post-doctoral study at Washington State University on a 20-month leave of absence. Dr. Roger McClellan joined the Experimental Animal Farm.

B. TECHNICAL ACTIVITIES

FISSIONABLE MATERIALS - 2000 PROGRAM

BIOLOGICAL MONITORING

Radiiodine Contamination

Concentrations of I^{131} in the thyroid glands of jack rabbits were slightly lower than those observed one year ago. Values follow:

<u>Location</u>	<u>µc/g Wet Thyroid</u>		<u>Trend Factor</u>
	<u>Average</u>	<u>Maximum</u>	
4 mi. SW Redox	2×10^{-4}	3×10^{-4}	-
Prosser Barricade	2×10^{-4}	3×10^{-4}	-
Wahluke Slope	1×10^{-4}	3×10^{-4}	-

Columbia River Contamination

Concentrations of gross beta emitters in Columbia River organisms collected at Hanford were approximately six times greater than those observed one year ago.

<u>Location</u>	<u>Organisms</u>	<u>µc/g Wet Weight</u>		<u>Trend Factor</u>
		<u>Average</u>	<u>Maximum</u>	
Hanford	Minnows (entire)	6×10^{-3}	6×10^{-3}	+3

Fallout Contamination

Fission products occurred in rabbits from the Hanford Reservation in the following amounts:

<u>Sample Type</u>	<u>Total Beta Avg. µc/g Wet Material</u>	<u>Trend Factor</u>
Bone	5×10^{-5}	+ 5
Feces	1×10^{-5}	- 3
Liver	9×10^{-6}	-
Muscle	1×10^{-5}	+ 2

Effect of Reactor Effluent on Aquatic Organisms

A test designed to determine the effect of reactor effluent on young chinook salmon of migratory size was terminated at the end of the month. The young salmon had been exposed for approximately three months to concentrations of effluent typical of those which occur in the Columbia River at this season and at concentrations anticipated for the future. No adverse effect on mortality or growth rate was evident at either of these concentrations. A third group of fish was exposed to a concentration twice that predicted for the future. A slight adverse effect which appeared in this group could be attributed to physical characteristics of the experiment rather than to chemical toxicity.

The degree of resistance of salmon to lethal effects of columnaris appears to be related to strain differences. The local Columbia River stock is killed off more readily than fish obtained from the White Salmon Hatchery and the most resistant salmon so far tested were obtained from the University of Washington. It is possible that the apparent differences in sensitivity may be in part due to size differences between the fish tested from the various hatcheries. There is an increased resistance to columnaris with increase in size and age. This has been observed both in salmon and trout.

BIOLOGY AND MEDICINE - 6000 PROGRAMMETABOLISM, TOXICITY, AND TRANSFER OF RADIOACTIVE MATERIALSStrontium

After 17 weeks of oral administration of Sr^{90} - Y^{90} there is a strong indication that trout receiving 0.5 uc per gram of body weight per day are suffering radiation damage. Survival of the control fish is slightly better than any of the fish administered the isotope and the growth rate of the high level fish (0.5 uc/day) is slackening although the difference is not yet statistically significant.

The concentrations of Sr^{90} in the skeletons of fetuses from sows fed daily amounts of Sr^{90} are nearly comparable to those in newborn swine. Weaned pigs (6 weeks old) contain approximately 2.5 times more Sr^{90} per gram of skeletal ash as the newborn, and the only six-months-old pig raised on Sr^{90} that has been sacrificed contained about three times more Sr^{90} per gram of skeleton as the weanlings. These differences are probably due primarily to the differing food sources (e.g., Sr^{90} concentration) for the various age groups. Ninety per cent of the pigs' skeletal growth (determined from skeletal ash) occurred after weaning.

The skeletons of the sacrificed swine are at present being sub-divided for radioanalysis. On the basis of only three swine, it appears that the concentration of Sr^{90} per gram of ash in the teeth is indicative of the average concentration in the total body.

These observations are being further investigated, especially the factor of age dependence.

Comparative Toxicity of Sr⁹⁰, Ra²²⁶ and Pu²³⁹

The hematological response of miniature swine three months following the intravenous injection of estimated biological equivalent doses of Sr⁹⁰ (6.4 μ c/Kg), Ra²²⁶ (6.4 μ c/Kg) and Pu²³⁹ (1.3 μ c/Kg) appeared to be relatively independent of their age at the time of injection. The response of the bone marrow as revealed by the percentage drop in the neutrophil component appeared similar in all age groups. A slight depression in lymphocyte numbers, which seemed most pronounced following radium administration, was observed in animals six months old at the time of injection.

At seven months following administration of plutonium to six-week-old miniature swine no significant hematological changes were observed. This may be due to the pattern of deposition of plutonium in young growing animals as well as to the energy of the radionuclide. (Proper evaluation will require observation over a longer period of time.)

Plutonium

Twenty-four intradermal injections of plutonium nitrate in doses varying from 0.0016 μ c to 5 μ c per site were made in a white miniature pig. Seven areas served as control sites. The intensity of the response was related to dose with erythema, swelling and foci of necrosis evidenced in twenty-four hours. Scabbing was evidenced within a week. Some of the control areas injected with 0.2 N nitric acid showed a slight scabbing and resembled the sites injected with 0.0016 μ c of plutonium nitrate. (The areas are being monitored with a scintillation probe. Difficulties in using this probe were noted, however, due to what appeared to be a magnetic field effect.)

Some preliminary results have been obtained from experiments to study the effect of EDTA applied to plutonium contaminated wounds. Results are presently available from only six animals and there is considerable variation between animals. There is a rather consistent indication, however, that as compared with water, decontamination of the wound with a 10 per cent EDTA--"Tide" solution, results in an enhanced deposition of plutonium in liver and bone by perhaps a factor of 2. Excretion of plutonium in the urine was enhanced by a factor of 5 during the two days following treatment. The EDTA "Tide" treatment appeared to be only slightly more effective than water in affecting decontamination of the wound. These conclusions are based upon very limited data and additional experiments are in progress to more clearly define the situation.

Radioactive Particles

All single exposures of dogs to Pu²³⁹O₂ aerosols for study of the translocation to tracheobronchial lymph nodes have been completed. The dogs will be killed two years post-exposure for radiochemical analysis of the tissues. Additional experiments on the factors influencing deposition of particles in the respiratory tract were completed and equipment is being assembled for the controlled inhalation of radioactive aerosols by rats and dogs.

Gastrointestinal Radiation Injury

Rats retained for duration of life following various types of irradiation of the intestine have been screened for the appearance of intestinal tumors. Tumors of the small intestine developed in 5 of 18 animals whose exteriorized intestine was exposed to doses ranging from 1500 to 1900 r. Tumors of the small intestine developed in 2 of 12 animals whose intestine was exposed in situ to radiation in this same dosage range. None of the 25 control animals, and none of 21 animals exposed in the dosage range 900-1300 r developed intestinal tumors. No tumors of the large intestine were observed in any of the animals.

Microbiological Studies

Irradiation of yeast cells has been studied for its effect on mercury binding to the cell surface. The cells bind less mercury than do irradiated controls at high doses of radiation. Furthermore, the mercury which is bound to irradiated cells is more easily lost to a suspending medium composed either of distilled water or distilled water containing cysteine. From the known specificity of mercury for SH groups, it appears that the radiation is modifying these SH groups so that they are less available for mercury uptake.

Project Chariot

Limnological and terrestrial invertebrates field studies were initiated at the Project Chariot site. Samples were collected to determine the ecological structure of three ponds, Ogotoruk Creek and the invertebrates fauna associated with four of the dominant terrestrial plant community type.

HA Kornberg
BIOLOGY OPERATION

HA Kornberg:es

C. Lectures

a. Papers Presented at Meetings

R. F. Palmer, "Deposition in rats of reactor effluent radioisotopes," June 16-17, Northwest Regional Meeting of the American Chemical Society, Richland, Washington.

M. P. Fujihara, "Antibiotic resistance and dose-mutation response in Chondrococcus columnaris," Tenth Annual Meeting of the Canadian Society of Microbiologists, Vancouver, B.C., June 13-16.

J. F. Cline, "Cesium toxicity in bean plants," June 15, Western Division of the AAAS meeting, Eugene, Oregon.

J. J. Davis, "Accumulation of radioactive contaminants by aquatic insects," 6/28/60, Pacific Branch Entomological Society 44th Annual Meeting, Davenport Hotel, Spokane, Washington.

R. C. Thompson, "An evaluation of the hazards of internally deposited zinc-65," June 29 - July 1, Fifth Annual Meeting of the Health Physics Society, Boston, Mass.

D. H. Willard - "Plutonium dioxide aerosol metabolism," June 29, 1960, Health Physics Society, Boston, Mass.

b. Off-Site Seminars

None

c. Seminars (Biology)

V. G. Horstman, "¹³¹I - Uptake Dependence on Age, Species, Temperature, etc.," June 15, 1960.

R. C. Thompson, "An Evaluation of the Hazards of Internally Deposited Zinc-65", June 15, 1960.

R. H. Schiffman, "Report on NASA's Biological Experiments in Space Environment Meeting held in Washington, D.C.," June 28, 1960.

d. Seminars (local)

F. P. Hungate, "Genetic effects of ionizing radiation," June 20, Radiological Physics Fellows, 300 Area.

D. Publications

a. HW Publications

Temple, L.A., S. Marks, and W. J. Bair, "Tumors in mice after pulmonary deposition of radioactive particles," HW 64337 (Unclassified) March 15, 1960.

b. Open Literature

Temple, L. A., S. Marks, and W. J. Bair, "Tumors in mice after pulmonary deposition of radioactive particles," Int. J. of Radiation Biology 2: 143-156(1960).

OPERATIONS RESEARCH AND SYNTHESIS OPERATION
MONTHLY REPORT - JUNE, 1960

DECLASSIFIED

ORGANIZATION AND PERSONNEL

There were no changes in personnel during the month of June.

OPERATIONS ANALYSIS STUDIES

Quality Certification Program

Post-irradiation data from the initial 48 tubes discharged under this program have been processed on the IEM-709. Statistical analyses of these data are in progress.

Optimization of Reactor Operations

A document was issued in which the probability of operating a given reactor for a specified time period without shutdown was determined, conditional upon current rupture potential of the reactor. This was an extension of previous work which had, as a first approximation, assumed constant rupture potential, and will be useful in the scheduling of reactor outages.

Preliminary work was done in connection with determining an optimum number of supplemental crew personnel. Work thus far has been restricted to balancing changes in overtime required against changes in the cost of maintaining different crew sizes. Additional work will be done to include possible savings due to reduced outage time as the crew size increases.

Simplified models were devised to demonstrate that the maximization of "net return" subject to a throughput restriction will in general imply a different mode of reactor operation than that obtained by maximizing the "net return" equation at a "price" for which the throughput restriction is automatically satisfied. Further investigations are planned to examine these two concepts.

Process Tube Leaks

A selection was made of tubes to probolog during the June 20 outage at F reactor.

Preliminary attention has been directed towards the general problem of determining the effect on future process leaks of different tube replacement rates. A start has been made in formulating a model to describe this situation, but it appears at this time that existing data are not of the type which can be used in estimating the parameters of the model. A more empirical type approach may have to be used.

Z-Plant Information Study

Following official acceptance by the AEC of the General Electric bid for the necessary computing equipment, this study is now being reactivated. Two people - one from Operations Research & Synthesis and one from Procedures and Computing - spent approximately ten days at the General Electric Computing

Department obtaining information on installation and programming. Because of delays in equipment procurement, the functional definition of the process originally designed to serve as the system's foundation is now invalid in many respects. The study group will now have to re-establish this definition for the proposed process and this will be followed by the translation of the process description into a computer program. A tentative estimate to re-define the information system and develop the corresponding computer program, assuming full team and consultant support, is five and one-half months. An additional six week (maximum) period will be required for on-line testing and program debugging. The tentative on-line operational date is January 1, 1961.

Reliability Studies

Work continued on the reliability and equipment failure study of the KW reactor. A reliability function was programmed for digital computation, and an expression for mean time to failure was obtained.

Work continued on the evaluation and comparison of the reliabilities of existing and proposed panellit systems for the NPR.

Further work was done on mathematical and probabilistic expressions for reliability of a control system. A solution was obtained to the problem of determining the probability law of the stochastic process associated with the simultaneous occurrence of two independent events, where two events are defined to be simultaneous if they occur within some preassigned small time interval.

Inventory Studies

The physical inventory of Spare Parts and Standby materials was taken on May 27 according to previously established sampling procedures. Results from the inventory sample were used to calculate an estimate of the total difference between physical inventory and that recorded by Electronic Data Processing reports. Further breakdown of the difference was made to allow allocation to the different departments. Calculations showed that there was a 99% probability that the estimate was within \$9000 of the true difference in the four million dollar inventory.

Redox Dissolver Study

A mechanism for the dissolution of uranium in nitric acid has been formulated. The mechanism is based upon the cathodic reduction of nitric acid by nitrous acid as the rate determining reaction in the dissolution of uranium. A report is being prepared covering this work and will be issued in the near future. The formulation of a mathematical model based on this mechanism will not be attempted at the present time, since operating data are not available currently for testing of the model with appropriate statistical routines.

Work has continued on an alternative model that can be tested with currently available redox data. This model is almost completed as a set of simultaneous differential equations which express the instantaneous interactions among the various materials in the dissolver as a function of time.

DECLASSIFIED

DECLASSIFIEDSTATISTICAL AND MATHEMATICAL ACTIVITIES FOR OTHER HAPO COMPONENTSFuels Preparation Department

A recent study concerned with the effects of varying quench conditions on dimensional distortion due to heat treating co-extruded tubes was extended by relating these observed changes to actual cooling rates. The cooling rates were computed as a function of the quench conditions (delay time before quenching and quench temperature).

Assistance was provided in setting up various control charts for NPR fuel elements. These are to control the clad thicknesses from tube to tube and the amount of nonuniformity within a tube.

Discussions were held with personnel engaged in the design of two production tests. One test has as its primary purpose an evaluation of the limitations of the ALSi canning process. The other is concerned with evaluating fuel elements produced by hot press bonding techniques.

An experiment was designed to evaluate the amount of uncertainty associated with grain size measurements as determined by the Heyn line intercept method.

Mathematical assistance was provided in analyzing the characteristics and behavior of the solution to a problem on wave transmission in a medium at ultrasonic frequencies.

Irradiation Processing Department

Analyses of data from two production tests have been completed and reports will be issued during July. One was concerned with evaluating the SORT test (Sonic Orientation Resonance Tester) with respect to its ability to predict in-reactor fuel element distortion. The other compared ingot and dingot fuel elements.

A report was written evaluating existing procedures for sampling coal. In addition to a general evaluation of the procedures, data were used to estimate the various error components of interest.

Mathematical analysis has been completed and an IBM-709 program is being written to carry out the computations on a study to determine the number of coolant pressure gauges which can be bypassed and tripped simultaneously without invalidating any normal scram signal. The study was initiated to aid in determining the feasibility of a proposed revision to reactor safety circuits.

Chemical Processing Department

A recommendation to adopt part-by-part acceptance testing rather than a tolerance statement was prepared for review by CPD personnel.

An AEC-wide information meeting was attended at which discussions were held on methods of contour description, mathematical and computer programs for contour completion, and contour data transmission and error detection. Mathematical assistance to CPD in this area is continuing.

Contract and Accounting

At the request of SS Measurements personnel, a memo was written discussing the reasoning behind the use of the cumulative model used in tank calibrations.

The analysis and evaluation of the technical data processing system and the routine data processing scheduling problem were completed. A group meeting with EDPO management and supervision was held to explain the results of both phases of the work.

STATISTICAL AND MATHEMATICAL ACTIVITIES WITHIN HLO

2000 Program

Reactor Studies

Analysis of the character of the solutions to the three-parameter reactor kinetics equation continued.

Chemical Development

Mathematical aid was provided in obtaining the solutions to a generic set of simultaneous, ordinary, linear differential equations. The problem arose in studying the concentrations in a cascade of dissolver tanks.

A regression analysis was initiated of zirflex process pilot study data for the Chemical Development Operation. Zirconium dissolution rate is being correlated with solution pH and fluoride ion concentration over the range of these variables which would be of interest to the reclamation of spent power fuel elements.

Corrosion Studies

Several discussions were held with personnel of Corrosion and Coating Operation concerning the design of a proposed experiment to investigate the corrosion properties of aluminum alloys as a function of iron and nickel content and silicon impurities. An experimental design was suggested which makes possible the orthogonal testing of current theories for the influence on corrosion rate of the total combined iron and nickel content, the ratio of iron to nickel content, and the ratio of silicon impurities to iron content.

Fuel Element Measurement

A mathematical model of a proposed Continuous Fuel Element Measurement device was constructed and analyzed to determine the ability of the machine to detect and quantify desired information on fuel element dimensional irregularities.

DECLASSIFIED

DECLASSIFIED

4000 ProgramSwelling Studies

Formulas for void fraction and density estimates for uranium samples using electron micrograph data have been reviewed and simplified in accordance with the new generalized model. A standardized method of reading apparent pore diameters on the micrographs has been devised. Mathematical formulas have been worked out for the gain in precision of calculating void density and void fraction from true interface diameter instead of observed diameter. Evaluation of this increase in precision with respect to additional work involved in measuring not only observed diameters but also shadow lengths should indicate whether or not true diameters or observed diameters should be used on a routine basis.

Plutonium Recycle

For SS Accountability purposes, a very precise inventory of moderator and coolant D_2O must be maintained during the operation of the PRTR. At the present time Plutonium Recycle Test Reactor Operation is considering the problem of the initial calibration of the various D_2O systems prior to startup and of inventorying D_2O on a routine basis.² At their request a review of the relationships among weight, density, temperature and purity of D_2O has been done which resulted in the definition of a formula for determining D_2O inventory based on available data. This formula assumes that D_2O temperature is constant or based on a suitably determined average; methods of calculating this average during reactor operation when the temperature gradient is extreme are now being considered. Work continues in this area. Methods are being considered for empirically calibrating the portions of the D_2O coolant system which are inaccessible to mathematical volume calculations.

Further consulting was done with personnel of Programming Operation in connection with the use of statistical methods for determining a maximum of a function defined over a multidimensional space for application with HLO's Meleager Physics code to optimize plutonium reactor fuel as a function of initial plutonium isotopic composition.

6000 ProgramAtmospheric Diffusion Studies

Routine statistical consultation with Atmospheric Physics Operation personnel continued in connection with the calibration of zinc sulfide particle detectors to be used to analyze the sample filters used in last summer's diffusion and deposition study.

GeneralInstrumentation

Work continued on a statistical method for constructing joint confidence region estimates for the peak heights of multiple peak gamma energy

spectra. Sample confidence regions using the method have been calculated for several two-component gamma energy spectra which illustrate the importance of conditioning of the equations on the confidence regions. This material is currently being compiled as a formal Hanford report and will be issued in the near future.

Radiation Protection

Data comparing the maximum permissible penetrating radiation dose limit with actual doses received by Hanford personnel were examined. Further analysis is contemplated to establish a relationship between age and total dose for various job functions and for Hanford as a whole.

Division of Research Programs

Statistical studies continued to determine the best method of estimating background for a high energy anti-coincident type gas sample counting instrument. An IBM program is being written to calculate the running correlation matrix for an arbitrary set of variables which will be used for the analysis of data for this background problem. Work continued on the precision and accuracy of several methods of analyzing surface ionization mass spectroscopy data.

Carl A. Bennett

Carl A. Bennett, Manager
OPERATIONS RESEARCH & SYNTHESIS

CAB:kss

DECLASSIFIED

PROGRAMMING OPERATION
JUNE 1960

A. REACTOR DEVELOPMENT - 4000 PROGRAM

1. PLUTONIUM RECYCLE PROGRAM

Cycle Analysis

Computer Code Development. The FUCK code is now workable but will not be widely applied until the reactor physics section is updated to correspond to the Meleager code in concept and to utilize the same plutonium cross-sections. The physics section of the FUCK code can compute the reactivity lifetimes and isotopes population densities for U²³⁵ enriched - 100 per cent plutonium sale, and for self-sustaining plutonium recycle with any per cent of plutonium sale but cannot handle plutonium purchases as does the Meleager reactor physics code. While the FUCK code is limited in this respect, the code takes advantage of this specialization to rapidly consider different cases and thus is particularly useful as a survey tool. While the plutonium compositions under study are those associated with equilibrium plutonium recycle the strategies that can be considered actually increases its generality beyond simple self-sustaining plutonium recycle.

In the interval while the FUCK reactor physics is being upgraded, calculations were made to determine the impact on plutonium value of the economics model employed in the FUCK code. It is most difficult to formulate an economics model that adequately approximates the various power reactor economic climates of the U.S. itself much less those of other countries. It is important then to know the possible biases introduced by the approximations in the FUCK code. Most of these approximations have to do with the capitalizations of fuel charges and fuel rental. Consequently, tests were run varying the reactor specific power, duty factor, interest rates, fuel capitalization, etc. Generally speaking, as fuel capitalization increases, total fuel costs go up and the value of plutonium goes down. Thus, in comparing plutonium values calculated by various models it will be necessary to carefully examine the relative capitalization structures.

In view of the outright dollar cost and possible technical problems, alternatives to zirconium jacketing in thermal reactors are being considered. There is considerable interest in stainless steels and other ferrous base alloys which if used in equivalent thickness to zirconium introduce a heavy reactivity penalty that often results in less favorable economics. The technology of stainless steel is such that wall thicknesses thinner than zirconium can be considered. As a consequence, an analysis scheme is needed to permit evaluation of variable jacketing thicknesses and variable jacket compositions. The major affect of these changes is to alter the thermal utilizations, f , and to a much lesser degree the resonance escape probability, p . Calculations were made with various fuel geometries and moderators to demonstrate that the following assumptions can be made to reduce the number of computations:

1. The effect of increasing the jacket thickness is equivalent to multiplying the cross-section of the cladding material by the ratio of the thicknesses.
2. The various cladding materials can be represented by their thermal absorption cross-sections and average values used for their other properties.

Approximately three-fourths of the RBU input code was debugged during the month. The remainder of the RBU code is completely debugged except for two minor modifications introduced during the month, and two or three more which will be introduced shortly. The cross-section library was checked for keypunch errors, and a method for detection of other library errors was set up.

The first-order analysis (Yates) portion of the LOLA code was completed and is in successful operation. The second-order analysis (Box-Wilson) has been programmed for the IBM-709 and is awaiting key punch. A rough draft copy of a report on the LOLA optimization code was written.

Fuel Cycle Analysis. Sufficient IBM-709 time was available to permit running a large section of a study on the value of plutonium as a fuel enrichment. Cases completed in previous months included once-thru cycles both graded and batch irradiation with f_0 (thermal utilization referred to natural uranium) at 0.85 and SDFV (slowing-down power of moderator per unit fuel volume) at 1.28, 2.56, 3.84, and 6.4. These cases were for five concentrations of U-235 in U-238 and for five separate compositions of plutonium mixed with depleted uranium to form the same five enrichments (% fissile) as for the U-235 cases. Completed during this month were 120 runs covering batch and graded cases with f_0 at 0.775 and with the previously used SDFV values and concentration compositions. An additional 240 batch irradiation cases with f_0 at 0.7 and 0.925 were also completed.

Work was begun on a revision of the Westcott s-factor tables, which describe the epithermal absorption and fission cross-section of uranium, plutonium, and other isotopes in a compact fashion. These tables are used widely throughout the reactor industry for approximate calculations, survey codes, etc. The neutron spectrum to be used in the new calculations is a closer approximation to the Wilkins spectrum than the one used by C. H. Westcott, and is expected to give better results for plutonium isotopes, in particular. The new method also serves to determine an effective neutron temperature in an unambiguous fashion.

An analysis of plutonium values as affected by premium canning cost, fuel enrichment levels, uranium prices, and blending materials was completed. Within the limits assumed it appears that when plutonium is blended with uranium the value of plutonium increases as the enrichment of the fuel mixture increases. When a premium is paid for canning plutonium bearing fuel elements, the value of plutonium passes through a maximum which is dependent upon the fissile content of the uranium with which the plutonium is blended. This maximum shifts towards the lower fissile content of the blending material as the premium canning costs increase. A report is currently being prepared describing the results of this analysis.

Plutonium value as influenced by separations cost, uranium price schedule, and spike in inert vs. fertile (U-238) diluents were examined. Plutonium value is tied directly to the uranium price schedule and indirectly to separations cost. It appears generally that when enriching reactors with plutonium, a fertile diluent such as U-238 is economically better than an inert diluent. The fertile diluent supplies fissile material for sale or recycle and also increases the heat and reactivity lifetimes. For maximum reactivity boost or simple flux flattening or with Phoenix action fuels inert diluents may be valuable but require specific analysis.

Other Activities

To establish, for study purposes, the basis for near future enriched uranium prices, concentrate costs and processing costs for conversion to diffusion plant feed were reviewed. Using total 1959 AEC costs for uranium from all sources and the price supposedly paid Allied Chemical for conversion of concentrates to pure UF₆, the cost of natural UF₆ would be about 75% of the present published price for this material. It would be expected, however, that the Allied plant is not capable of converting all available concentrates and that higher cost facilities at Paducah and Oak Ridge still must be used which may partly justify the higher price.

The first composite draft of the Plutonium Recycle Program Annual Report was completed.

The magnetic properties of atomic nuclei were studied to determine the possibilities of separating isotopes on the basis of nuclear magnetic behavior. The existence of nuclear magnetic moments and their magnitude are both isotopic characteristics. In fact, it is interesting to note that among the nuclei of the uranium and plutonium isotopes, only the fissionable isotopes have nuclear spin and thus exhibit nuclear magnetic moments. In many elements the high cross section isotopes have nuclear spin while the others do not. In other cases, like hydrogen and deuterium, all the isotopes exhibit nuclear magnetism but their magnetic moments differ by factors of two or three. The magnetic moments of many nuclei have been determined by deflection from molecular beams in strong, inhomogeneous magnetic fields. The deflections are small, on the order of 0.1 mm/100 cm path, but nevertheless, they are greater than the widths of the molecular beams used in the measurement. With novel design of specialized magnetic deflection equipment for isotope separation rather than physical measurement of magnetic moments, practical separations may be possible. For example, the use of small jets of gaseous molecules instead of molecular beams would greatly increase throughput. Molecular collisions in the jets, undesirable in precise work, might be tolerable if sufficient stages were used.

Inquiries have revealed that time is available in MIR - Reactivity Measuring Facility for collecting reactivity data on fuel materials of interest to HLO. Relating experiments performed in this facility to planned PRCF experiments should significantly extend the scope of the PRCF experimental program.

2. SPECIFIC FUEL CYCLE ANALYSIS

Work continued on the study covering plutonium enriched fuel cycles in the Advanced Pressurized Water Reactor (APWR) study. A previously reported difference in reactivity peaking between the results quoted in the APWR study and those run at Hanford was resolved. The APWR study uses no epithermal cross-sections for the plutonium isotopes and also uses a lower (as compared with ours) Pu-239 thermal cross-section. Further calculations will be carried forward based on the APWR study results for p and f, but based on what are considered to be better estimates of the plutonium cross-sections.

B. BIOLOGY AND MEDICINE - 6000 PROGRAM

1. RADIOLOGICAL CONSULTATION

Hearings of the Congressional Committee on Radiation Protection Standards were attended on June 1, 2, and 3. Assistance was given in preparing a glossary of terms for submission to the Subcommittee on Radiation.

Meetings of the AEC meteorologists and an advisory committee on geology were attended and a brief talk summarizing Hanford's programs in areas other than those of direct interest to the group was given to each. A lecture on Dose Measurements and Definitions was given to the Summer Institute on Radiation Biology at the University of Washington.

Arrangements were made for the visit of Dr. G. Dunstan, Head of Sanitary Engineering at Washington State University, and two members of his staff on July 13. A program for preparing monthly summary reports to the Division of Biology and Medicine was set up. A proposal for elimination of the Quarterly Report of Radiological Sciences work with substitution of the monthly summary and annual reports was submitted to the AEC.

C. OTHER ACTIVITIES

A section, as requested by the editors, was written on Hanford fuel elements for the revised, classified AEC Reactor Handbook, to be published. The I&E production fuel element, the NPR fuel element and the PRTR fuel elements are all described and dimensional details given. A table of reactor and fuel operating parameters is also included.

Arrangements were made for a preview showing of filmed lectures on space technology for Hanford personnel. If sufficient interest is demonstrated the possibility of showing the complete series will be further investigated.

Of the eight uranium ore mill feed samples received, all are low in natural thorium (less than the average Th-232 content of rocks of the earth's crust, 11 ppm). Five of these are sufficiently low that assuming equilibrium of the uranium with its daughters in the ore and at least equal extractability

of the natural thorium and thorium-230 contents, thorium fractions rich in thorium-230 (several per cent) should be obtainable from certain, as yet unidentified, uranium ore mill process streams. However, it is believed that extractability is distinctly different and will favor the realization of higher thorium-230 concentrations. These data on the very low, natural thorium content of U.S. ores establish a firm basis for further efforts in a program for thorium-230 recovery and utilization.

Assistance was rendered in arranging 17 tours (involving 166 people) through ELO and HAPO facilities.



Manager, Programming

LH McEwen:dl

RADIATION PROTECTION OPERATION
MONTHLY REPORT - JUNE 1960

A. ORGANIZATION AND PERSONNEL

The reassignment of L. C. Rouse from Specialist - Radiation Monitoring to Specialist - Exposure Analysis was made effective June 15, 1960. Helen C. Peart and I. Holtzman terminated on June 24 and 10, respectively. J. R. Bovington (Technical Graduate) began a three-months rotation with the Radiation Monitoring Operation.

B. ACTIVITIES

Widespread particulate contamination in the 200-E Area occurred following burial of defective equipment from the Purex plant. The spread of contamination resulted from a collapse of the burial box which contained two steam coils from a Purex waste concentrator. Fourteen railroad cars had to be used as spacers between the engine cab and the burial box to reduce the radiation dose rate to workable levels in the engine cab. A dose rate of 50 mr/hr was measured at 850 feet from the box outside the Purex railroad tunnel. The particulate contamination from the burial extended in a band about two and one-half miles wide from the Industrial Burial Ground through the Hot-semi Works and the Critical Mass area through the Purex area and towards the Southeast corner of the 200-E Area. The shoulders of the main road outside of the 200-E Area had particulate contamination up to about 10 particles per 100 square feet. About 30 acres Southwest of the burial trench were generally contaminated to a level of about 25 mrad/hr measured at a distance of six inches from the ground. An additional 50 acres were generally contaminated to about 6 mrad/hr at six inches. Remedial action taken by Purex personnel included eliminating the source of the contamination by additional covering at the burial site and wetting down the densely contaminated area. Control of vehicle movements and personnel was required. Nominal shoe contamination and vehicle contamination occurred. No significant exposure of personnel is believed to have occurred. Repetitive surveys since the incident indicate movement of the particles on the ground is slight. Gamma spectrometer measurements of collected particulates showed that Ce^{144} and Pr^{144} were the principal radionuclides present.

There were no new cases of plutonium deposition recorded in June. The total number of deposition cases that have occurred at Hanford remained at 256 of which 187 are currently employed. One CPD employee, who had previously received minor body deposition of plutonium, sustained a minor injury while machining plutonium. About one maximum permissible body burden of Pu ($0.04 \mu\text{c}$) measured in the wound at the Whole Body Counter was reduced to $0.01 \mu\text{c}$ Pu with excision. Treatment with a chelating agent (diethylenetriaminepentaacetic acid) was started to minimize deposition from the wound site into the bone.

A total of 59 persons was counted at the Whole Body Counter (WBC) bringing the year-to-date total to 572. Unusual maintenance and equipment modification was the cause for the WBC being in operation for only half of the total available operating time.

A radiation source containing two grams of Ra-Be was dropped during removal from a water tank assembly in the 326 Building. Survey results indicated no leakage from the source holder. Internal re-examination of the four capsules was scheduled upon completion of the current experiment.

A total of 129 Government sedans and pickups, 51 buses located in the outer areas, and 40 private vehicles was surveyed as part of the routine program, exclusive of the industrial burial ground incident in 200-E Area. Five Government sedans and pickups were contaminated with particulates; the maximum being about 100,000 c/m in an inaccessible part of the under gear. No contamination was detected on the private vehicles or buses.

A mockup of a full-size shadow shield counter for possible future use in additional Whole Body Counter cells was constructed for evaluation by Radiological Physics personnel. The arrangement was as though the roof of the present iron room was used as the shadow shield. Preliminary measurements indicated that the background of this mockup counter was indistinguishable from that of the current WBC at high gamma energies. In the extremely low energy range, the background count was only about 12 per cent higher than the present iron cell shield.

Following disagreement on the measurement activity in a plutonium sliver removed from a wound last month, two other plutonium slivers were counted by both X-ray and alpha particle counting. The alpha particle counting was preceded by dissolution of the slivers while the X-ray counts were made directly on the slivers. The radiochemical analysis by alpha particle counting indicated that six to eight times more activity was actually present than indicated by the X-ray counts; the difference being due to self-absorption of the X-rays in the slivers. This underestimation of the total plutonium shown in a plutonium sliver by X-ray emission is relatively unimportant since the remedial action in both cases would be the same, namely, minor excision of the affected area. For plutonium in very shallow wounds, both the 6 keV M X-rays and the 17 keV L X-rays can be observed. It was determined by Radiological Physics personnel that the ratio of the M to L X-rays is useful as a measurement of the depth of the sources of the plutonium contamination for depths to about two millimeters.

Data on waste disposal to ground in the 200 Areas was compiled and transmitted to CPD Production Operation at their request. A cumulative inventory to ground by year and a cumulative inventory to ground by year corrected for radioactive decay was estimated for total curies of beta, cesium, and strontium. Historical data on the detection of cobalt and concentrations of isotopes in the ground water were included.

Preliminary field tests were made on the prototype ionization finger dosimeters. Studies were started on the comparison between the performance of this hand dosimeter under field conditions and currently used film finger rings.

The preliminary design was completed for a new film badge dosimeter. In this new dosimeter under consideration, there is provided space for two solid state neutron dosimeter devices and small glass rod dosimeters for high-level gamma

doses. Studies of plastic materials suitable for fabrication are underway from a new material called "cycolac" which provides more strength and rigidity than the Tenite II from which the present badges are fabricated.

Performance studies of the Oak Ridge Criticality Threshold Dosimeter System continued. Evaluation of the neutron dose received by plutonium foils indicated that dose evaluations made within four hours after exposure were in error by not more than eight per cent (8%). The accuracy of this evaluation should increase as higher doses are received. Studies on the silver glass dosimeter rods contained in the Oak Ridge system showed a linear response for this dosimeter between the range of 20 r and 3000 r. Doses as low as 2.5 r have been detected with the present equipment, however, the dose response curve is nonlinear below 20 r. Studies of luminescence during the first few hours after exposure indicate that most of the glass rods increase in luminescence during the first few hours. The magnitude of this effect is not great. Estimation of the gamma dose can be made with the probable error of less than $\pm 10\%$ at any time during the first two weeks after exposure.

Two 40 liter ionization chambers were procured and attached to a Keithly electrometer. This system is capable of measuring background dose rates of a few $\mu\text{r/hr}$. This device is reasonably portable and is useful to measure instantaneously the background dose rate at various environmental test locations.

The charcoal iodine air monitoring system operated satisfactorily throughout this period. Specifications for the purchase of equipment of this type were prepared.

A. R. Keene attended the annual meeting of the AEC Health Physics Fellowship Advisors held in Boston, Massachusetts in conjunction with the Health Physics meeting.

C. EMPLOYEE RELATIONS

Captain W. D. Slightam, United States Air Force Reserve, was assigned to the Radiation Protection Operation for one year's training in bioassay and whole body counter techniques. Captain Burvie Sheets, United States Air Force, joined the AEC Radiological Physics Fellowship class for training in health physics work.

Two suggestions were submitted by RPO personnel during the month bringing the year-to-date total to 21. Six suggestions submitted by RPO personnel are pending evaluation.

There were three medical treatment injuries during the month for a frequency of 1.45. One security violation occurred during June.

Radiation protection training included: Summer program for the AEC Radiological Physics Fellowship students; two 2-hour orientation talks to Plutonium Metallurgy and Biology Research personnel; a 30-minute talk on "Hazards of Plutonium Work and Design Criteria for Gloveboxes" to 35 employees in Design Engineering, CE & UO; three lectures on the PRTR and PFPF to members of the Radiation Protection Operation exempt staff.

Four members of the Radiation Protection Operation attended the Health Physics Society annual meeting in Boston, Massachusetts, on June 29 - July 1, 1960. Two papers were presented at the meeting, namely, "Comparison of the Externally Received Radiation with the Current Maximum Permissible Accumulated Dose, Hanford, 1944-1959" by A. R. Keene and "Some Studies of Film Dosimeter Variables" by W. V. Baumgartner.

D. SIGNIFICANT REPORTS

- HW-65613 "Analysis of Radiological Data for the Month of May, 1960" by R. L. Junkins.
- HW-65763 "Report of Trip to the Nevada Test Site to Attend the Emergency Radiation Monitoring Team Training Session" by L. C. Rouse and L. G. Faust.
- HW-65946 "Monthly Report - June, 1960, Radiation Monitoring Operation" by A. J. Stevens.

EXPOSURE EVALUATION AND RECORDSExposure Incidents above Permissible Limits

	<u>Whole Body</u>	<u>Localized</u>
June	0	0
1960 to Date	1	3

Gamma Pencils

	<u>Pencils Processed</u>	<u>Paired Readings 100-280 mr</u>	<u>Paired Readings Over 280 mr</u>	<u>Lost Readings</u>
June	12,240	199	2	0
1960 to Date	101,528	1,319	19	7

Beta-Gamma Film Badges

	<u>Badges Processed</u>	<u>Readings 100-300 mrad</u>	<u>Readings 300-500 mrad</u>	<u>Readings Over 500 mrad</u>	<u>Lost Readings</u>	<u>Average Dose Per Film Packet</u>	
						<u>mrad(ow)</u>	<u>mr(s)</u>
June	10,839	905	112	28	63	9.60	17.57
1960 to Date	69,452	5,512	997	248	275	10.45	18.57

Neutron Film Badges

	<u>Film Processed</u>	<u>Readings 50-100 mrem</u>	<u>Readings 100-300 mrem</u>	<u>Readings Over 300 mrem</u>	<u>Lost Readings</u>
<u>Slow Neutron</u>					
June	1,184	1	0	0	1
1960 to Date	6,745	2	0	0	26
<u>Fast Neutron</u>					
June	129	2	4	0	1
1960 to Date	1,074	73	29	0	21

Bioassay

		<u>June</u>	<u>1960 to Date</u>
Plutonium: Samples Assayed		695	4,305
Results above 2.2×10^{-8} $\mu\text{c/sample}$		59	257
Fission Products: Samples Assayed		671	4,175
Results above 3.1×10^{-5} $\mu\text{c FF/sample}$		0	3
Uranium: Samples Assayed		201	1,770
Confirmed Plutonium Deposition Cases		0	12*

Whole Body Counter

	<u>Male</u>	<u>Female</u>	<u>June</u>	<u>1960 to Date</u>
<u>GE Employees</u>				
Routine	53	1	54	533
Special	1	0	1	14
Terminal	0	0	0	1
<u>Nonemployees</u>				
	3	0	3	19
<u>Pre-employment</u>				
	1	0	1	5
Total	58	1	59	574

*This brings the total number of plutonium deposition cases which have occurred at Hanford to 256.

ENVIRONMENTAL MONITORING - RESULTS - (Mid-May 1960 - Mid-June 1960)

<u>Sample Type and Location</u>	<u>Activity Type</u>	<u>Monthly Average</u>	<u>Units</u>
<u>Drinking Water</u>			
100-F Area	Isotopic	0.2	% MPC _{GI} *
Separations Areas	Gross Beta	5.6×10^{-8}	μc/cc
Pasco	Isotopic	2.6	% MPC _{GI} **
Kennewick	Isotopic	1.0	% MPC _{GI} **
Richland	Gross Beta	$< 3.0 \times 10^{-8}$	μc/cc
<u>Columbia River Water</u>			
Above 100-B Area	Gross Beta	7.0×10^{-9} ***	μc/cc
100-F Area	Isotopic	1.2	% MPC _{GI} *
Hanford	Isotopic	1.2	% MPC _{GI} *
Pasco	Isotopic	9.0	% MPC _{GI} **
McNary Dam	Gross Beta	1.4×10^{-6}	μc/cc
Vancouver, Washington	Isotopic	0.5	% MPC _{GI} **
<u>Atmosphere</u>			
I ¹³¹ Separations Areas	I ¹³¹	1.2×10^{-13}	μc/cc
I ¹³¹ Separations Stacks	I ¹³¹	0.5	Combined curies/day
Active Particles - Project	--	0.4	ptle/100 m ³
Active Particles - Environs	--	2.0	ptle/100 m ³
<u>Vegetation (Control limit for vegetation is 10^{-5} μc I¹³¹/g)</u>			
Separations Areas	I ¹³¹	2.3×10^{-6}	μc/gm
Residential	I ¹³¹	$< 1.5 \times 10^{-6}$	μc/gm
Eastern Washington and Oregon	I ¹³¹	$< 1.5 \times 10^{-6}$	μc/gm
Fission Products less I ¹³¹ - Wash. and Ore.	Gamma Emitters	$< 1.0 \times 10^{-5}$	μc/gm

*The % MPC_{GI} is the percent of the maximum permissible limit for occupational exposure to the gastrointestinal tract calculated from drinking water limits contained in NBS Handbook 69.

**The % MPC_{GI} is the percent of the maximum permissible concentrations for persons in the neighborhood of controlled areas for continuous exposure to the gastrointestinal tract calculated from drinking water limits contained in NBS Handbook 69.

***This location is now sampled quarterly. The most recent result is tabled.

Uranium Analyses

<u>Sample Description</u>	<u>Following Exposure</u>			<u>Following Period of No Exposure</u>		
	<u>Units of 10^{-9} μc U/cc</u>			<u>Units of 10^{-9} μc U/cc</u>		
	<u>Maximum</u>	<u>Average</u>	<u>Number Samples</u>	<u>Maximum</u>	<u>Average</u>	<u>Number Samples</u>
Fuels Preparation	22	4.9	64	21	4.2	58
Fuels Preparation*	0	0.0	0	0	0	0
Hanford Laboratories	19	6.9	27	16	4.7	29
Hanford Laboratories*	0	0.0	0	0	0	0
Chemical Processing	0	0.0	0	0	0	0
Chemical Processing*	64	17	9	100	34	4
Special Incidents	0	0	0	0	0	0
Random	1.4	1.0	10	0	0	0

*Samples taken prior to and after a specific job during work week.

<u>Thyroid Checks</u>	<u>June</u>	<u>1960 to Date</u>
Checks Taken	9	160
Checks above Detection Limit	0	3

<u>Hand Checks</u>	<u>June</u>	<u>1960 to Date</u>
Checks Taken - Alpha	29,058	188,121
Beta-gamma	43,138	269,478

<u>Skin Contamination</u>	<u>June</u>	<u>1960 to Date</u>
Plutonium	12	127
Fission Products	19	231
Uranium	7	31

CALIBRATIONS

	<u>Number of Units Calibrated</u>	
	<u>June</u>	<u>1960 to Date</u>
<u>Portable Instruments</u>		
CP Meter	936	5,449
Juno	327	1,840
GM	865	4,735
Other	193	1,112
Total	2,321	13,136
<u>Personnel Meters</u>		
Badge Film	1,548	8,150
Pencils	-	1,912
Other	495	2,544
Total	2,043	12,606
Miscellaneous Special Services	795	2,782
Total Number of Calibrations	5,159	28,524

AR Keene
 Manager
 Radiation Protection

AR Keene:kc

LABORATORY AUXILIARIES OPERATION
MONTHLY REPORT - JUNE, 1960

GENERAL

Security performance for the Operation was satisfactory with no violations during the month.

Safety performance of the Operation was considered satisfactory. There were no major injuries; the minor injury frequency rate was 2.03 which is below average experience.

TECHNICAL SHOPS OPERATION

Total productive time for the period was 23,026 hours. This includes 16,688 hours performed in the Technical Shops, 4,569 assigned to Minor Construction, 842 hours assigned to other project shops, and 927 hours assigned to off-site vendors. Total shop backlog is 20,683 hours of which 60% is required in the current month with the remainder distributed over a three-month period. Overtime hours worked during the month was 10% (1,691.7 hours) of the total available hours.

Distribution of time was as follows:

	<u>Man-Hours</u>	<u>% of Total</u>
Fuels Preparation Department	2,329	10.1
Irradiation Processing Department	931	4.1
Chemical Processing Department	883	3.8
Hanford Laboratories Operation	18,364	79.8
Construction Engineering & Utilities	488	2.1
Miscellaneous	31	.1

Requests for emergency and priority work through the month of June continued to rise above the higher than average level of May, 1960. To assist in meeting customer requirements an overtime rate of 10% was used in addition to continued assignment of work to outside shops and vendors. Less work was assigned to the Technical Shops during this report period by the amount of approximately 958 man-hours.

Items of capital equipment received include two lathes, one of which has been installed in the 326 Building shop, the other is in temporary storage in 3719 Building pending the opening of passage into 306 Building.

The Buffalo Sliding Head Drill Press has been received in 328 Building and is temporarily set up to determine damage occurring during shipment.

The Electro-Discharge Machine has been received and is at Receiving to be shipped to 328 Building. These items cover those expected before July 1.

RADIOGRAPHIC TESTING OPERATION

A total of 1,971 tests were made of which 941 were radiographic (including x-ray and gamma-ray) and 1,030 were supplementary tests. Out of a total of 2,260 man-hours, 706 (31.2%) were in connection with radiographic tests, and 1,554 (68.8%) were used on supplementary tests. The supplementary test work included: eddy current; penetrant (fluorescent O.D. and I.D.); surface treatment (alkaline cleaning, steam detergent cleaning, vapor degreasing, and vapor blasting); and ultrasonic (flaw detection, core integrity, bond testing, and thickness measurement).

The number of pieces handled this month totaled 2,325 items. The feet of material represented by these items amounted to 31,159 feet. Work on tubular components continued to account for a large percentage of the footage of material tested.

Work was done for 16 different organizational components representing most of the operating departments and service organizations. A total of 46 reports were issued detailing test findings with conclusions and recommended action. Radiographic Testing Operation was consulted on 26 different occasions for advise and information on general testing theory and applications for other than the jobs tabulated in Part II - Testing Statistics.

Building modifications at C-25, White Bluffs, for processing NPR tubes have been completed. Equipment modifications and installation is going forward but progress is slow and many items are still not available for use in testing.

Considerable effort is being expended in the field unit on strain gage installations and stress measurement work. An extensive job is being undertaken for 105-DR and will be implemented at the next reactor shutdown. Instrumentation is also being prepared for a similar job at the F-reactor on cross-header analysis. Construction of the x-ray exposure room has been completed and meets all expectations from a radiation protection standpoint.

In the 300 Area, radiographic and ultrasonic work on TPU fuel rods continued at the same level as last month. The fuel element sheath tube program is developing very rapidly. A problem not fully anticipated is the cleaning of the tubes prior to and after testing. It has been found desirable to steam detergent clean and vapor degrease to obtain maximum cleanliness prior to penetrant testing. It also appears that to successfully remove all traces of the penetrant testing solutions a hot alkaline treatment with ultrasonic cleaning is desirable. These steps are presently being done in facilities in the 325 building and 308 building. It is hoped that some consolidation can be achieved by installation of the necessary tanks in the 314 building where the

penetrant testing is now being done. The high through-put and extensive testing being requested on the sheath tubes is creating a manpower problem in that this work was planned originally to extend over a considerably greater period of time. The manpower problem will be partially solved by reassignment of personnel from the tube shop and some overtime work.

Testing Statistics

<u>Component</u>	<u>No. of Tests</u>	<u>Ft. of Weld or Material</u>	<u>No. of Pieces</u>	<u>Description</u>
CE&U	349	175	359	Film interpretation of radiographs by Weld-X Corp of California at the PRTR site.
CPD	68	54	5	Radiograph welds of H-4 vessel; Radiograph three RS-6 pressure vessels - Cast s/s 7" O.D. x 12-1/2" high; Radiograph weld on extension No. 8 of high specimen.
HLO	1,369	27,493	1,904	Thermocouples inbedded in aluminum pot; .594" O.D. swaged zr-2 tube; zr-2 clad UO ₂ canned in aluminum; 8" long zr-2 clad UO ₂ fuel samples; Radiograph two zr-4 clad swaged UO ₂ fuel rods; Radiograph thermocouples in iron oxide - Thermocouples approx. 3' long 6" dia. and 8" high; Radiograph weld-ends of fuel element; Radiograph inconel heat treat salt pots (18" dia. x 14' long); NaK sample heating coils; Tantalum tip thermocouples; TPU unfinished fuel rods; TPU finished fuel rods; 406 s/s scan welded tube; Radiograph two jumper-fillet welds; Palm fabrication and development program.
IPD	185	3,437	57	Radiograph two carbon steel pipe butt weld specimens; Radiograph 6 welds in 1706 KER; Radiograph Elmo-8 heat exchanger weld; Radiograph 1-1/2" Sch 80 pipe; Three welds Ball 3X - 105-KE; Radiograph pipe-to-bar welds 3/4" I.D. pipe to 1" bar; NPR zirconium tubes.
Total	1,971	31,159	2,325	

CONSTRUCTION OPERATION

There were 50 existing J. A. Jones Company orders at the beginning of the month with a total unexpended balance of \$150,160. 93 new orders, 11 supplements and adjustments for underruns amounted to \$268,708. Expenditures during the month on HLO work were \$232,209 (Includes C.O. Cost). Total J. A. Jones backlog at month's end was \$186,659.

Summary

	<u>HL</u>		<u>CE&U</u>	
	<u>No.</u>	<u>Unexpended Balance</u>	<u>No.</u>	<u>Unexpended Balance</u>
Orders outstanding beginning of month	50	\$ 139,097	3	\$ 11,063
Issued during the month (Inc.Sup.& Adj.)	93	250,233	0	18,475
J.A. Jones Expenditures during month (Inc.C.O. Costs)		215,920		16,289
Balance at month's end	54	173,410	2	13,249
Orders closed during month	89	125,443	1	4,000

FACILITIES ENGINEERING OPERATIONProjects

There were 16 authorized projects at month's end with total authorized funds of \$5,071,265. The total estimated cost of these projects is \$7,037,765. There was one new project authorized, two completed and two submitted to the Commission for approval this month.

The following summarizes the status of HLO project activity:

Number of authorized projects at month's end:	16
Number of new projects authorized during month:	1
CGH-896, Stress-Rupture Testing Facility	
Projects completed during the month:	2
CG-731, Critical Mass Laboratory	
CGH-790, High Level Radioactive Receiving & Storage Addition	
New projects proposals submitted to AEC during month:	2
CAH-901, Structural Material Irradiation Test Equipment	
CGH-902, Uranium Scrap Burning Facility	

New projects awaiting AEC approval:

4

CGH-832, Full Scale Physical Constants Testing Reactor
CGH-874, Consolidation of Plutonium Metallurgy
Facilities
CAH-901, Structural Material Irradiation Test
Equipment
CGH-902, Uranium Scrap Burning Facility

The attached project report details the status of individual projects.

Engineering Services

Engineering work performed during the month included the following listed major items as well as scope engineering for project proposals.

<u>Title</u>	<u>Status</u>
329 Building Ventilation Mod.	Scheduled completion is being delayed due to receipt of damaged equipment.
Electric Hoist - Graphite Shop 3730-C Building	Field work is essentially complete.
Pressure Vessel and Code Piping- Engineering & Inspection Service	This is a continuing work program for HLO vessels, pressure systems and related safety devices.
Coaxial Cable Between 325 and 329 Buildings	Field work in progress.
Additional Improvements to Air Supply - Rooms 204 and 206 - 3706 Building	Installation work is nearly complete.
Laboratory Furnace Installation Room 39-B, 326 Building	Engineering complete. Materials on order.
Glove Boxes, 325 Building	Fabrication is essentially complete.
Equipment for Critical Mass Studies	Materials on order. Detail design is about 60% complete.
Study Potable and Process Water System - 325 and 329 Buildings	Work complete.
Fire Detection System - 314 Building	Installation work 30% complete.
Criticality Alarm - 300 Area	Installation work about 50% complete.

<u>Title</u>	<u>Status</u>
Reactor Effluent Filter - Pilot Test Facility - 100-D	Field and shop work in progress.
Improvement to Animal Waste Disposal System	Engineering work in progress.
Electrified Fenced Animal Pens and Pasture	Field work about 95% complete.
Air Conditioner - Room 40-C, 326 Building	Existing unit is not adequate to maintain conditions. Recommendations are being prepared.
Space Alteration - 3760 Building	Work in progress.

Drafting and Design Services

Work load is constant with heavy backlog. Branch offices in 306 and 308 Buildings are busy with steady work loads. The central drafting room has been performing an increasing amount of work for the recycle program.

Major design and drafting work in progress includes the following:

1. High Level Utility Cell - 327 Building - Special Tools (30% complete).
2. PRTR Fuel Element Rupture Facility - Special piping and control design.
3. PRP Critical Facility - Detail of in-cell piping, ventilation, instrumentation and electrical work (22 drawings required).
4. Ultrasonic Test Tank - (8 drawings required - 100% complete).
5. Physical and Mechanical Properties Test Cell - 327 Building - Special equipment design.
6. Extrusion Tools for 700 Ton Press (8 drawings required - 90% completed).
7. Design for Pyro-Chemical Test Facility (100% complete).
8. Irradiation Studies Test Loop - "C" or "K" Reactor (12 drawings required - 95% complete).
9. Remote T.V. Inspection of Process Tubes (8 drawings required - 90% complete).
10. Periscope Viewer - Reactor & Fuels (4 drawings - 90% complete).
11. Structural Materials Irradiation Test Facility - Scope design - (15 drawings required - 20% complete).

In addition to the above work, miscellaneous small design-drafting jobs are in progress.

Approximately 175 drawings including sketches, work sheets, and formal drawings were completed during the month of June.

HLO Plant Maintenance and Operation

Costs: April	\$	107,505
May	\$	68,656
FY Total thru May	\$	1,389,134

Analysis of Costs

The total costs for May include a \$30,000 rebate for overliquidated steam costs during the year. The plant maintenance and operation costs for FY-1960 is estimated to underrun the budgeted amount by about \$20,000.

TECHNICAL INFORMATION OPERATION

The HAPO proposal for new procedures which would govern the access to classified documents in the Classified Files was reviewed in a meeting with HOO. HOO expressed "general" agreement with the HAPO proposal and asked that HAPO prepare detailed procedures for putting the proposal into effect as soon as practical.

With the exception of two topics, HAPO has been authorized to use the "Proposed Guide to Atomic Weapon Data at Hanford", HW-63726, for classification guidance. However, approval to use the guide for weapon data identification has not been received. Distribution to the field is being withheld until all approvals are received.

A revised "Classification Guide for Use in the Civilian Application Program", OC-DOC-54, has been received from the Commission. This guide sets forth the unclassified fields of research and is reproduced in its entirety as Section 700 of the Hanford Classification Guide. In addition, the subject index to the Hanford Guide was revised during the month.

Until recently the Access List which is used by Classified Files to determine an individual's "need-to-know" has been in the form of a printed list. It is now available in card form. This arrangement is proving to be very convenient. Special notations and insertions and deletions can be made much more easily.

The annual report to the AEC on reprint purchases and page cost payments was prepared. An increase over FY-1959 activity was noted for both areas.

Technical Information personnel met with Frieden and IBM representatives to discuss equipment for possible use in automating certain Classified Files office routines. A modified IBM Card-a-type system appears promising and will be studied further. Estimates for the cost of adding an arithmetic unit have been requested. This unit would make the system capable of handling other HLO work on a two-shift operation, with little additional monthly rental. Work is continuing on the design of forms, work flow and systems logic.

Modifications to the Library and Files building were completed at month's end. The changes will provide improved working space for the technical publications group with offices for the Patent Attorney located adjacent to the area. These arrangements are made possible by the continued reduction in the clerical force.

Work Volume Statistics

	<u>May</u>	<u>June</u>
<u>Document Distribution and Files</u>		
Documents routed and discharged (copies)	18,365	15,361
Documents issued (copies)	12,764	9,272
Documents sent offsite (copies)	3,000	3,776
Document reserves filled (copies)	615	736
Documents picked up and delivered	21,768	18,423

Document Accountability

Holders of classified documents whose files were inventoried	304	438
Documents inventoried in Files (copies)	15,206	0
Documents destroyed or retired (copies)	1,439	3,340
Documents revised (copies)	2,171	1,407
Documents pulled and documents filed (copies)	11,707	11,697
Documents reclassified	285	428
Accountable copies of SECRET and DOCUMENTED CONFIDENTIAL documents onsite	211,157	214,393

Reference and Publication

Books cataloged (new titles)	101	113
Books added to the collection (volumes)	212	164
Ready reference questions answered by professional staff	140	80
Literature searches by professional staff	99	81
Reports abstracted (titles)	248	272
Formal reports prepared (titles)	14	7
Offsite requests for HAPO reports (copies)	388	499
Reports released to CAP (titles)	68	56

Library Acquisitions and Circulation

Books ordered (volumes)	426	251
Periodicals ordered	286	91
Books circulated (volumes)	1,891	2,240
Periodicals circulated (issues)	3,052	3,607
Inter-Library loans	167	173
Films borrowed or rented	20	8
Industrial film showings	62	78
Bound periodicals added to the collection	292	1,468

UNCLASSIFIED

H-9

HW-65854

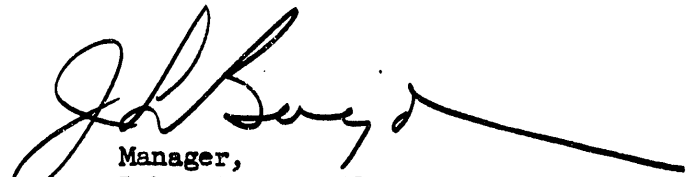
DEL

Library Collection:

	<u>Main Library</u>	<u>W-10 Library</u>	<u>108-F Library</u>	<u>Ind. Med.</u>	<u>Total</u>
No. of books	29,556	8,398	1,614	2,015	41,583
No. of bound periodicals	13,903	1	1,431	96	15,431
	<u>43,459</u>	<u>8,399</u>	<u>3,045</u>	<u>2,111</u>	<u>57,014</u>

Classification and Declassification

	<u>May</u>	<u>June</u>
Documents, including drawings and photographs reviewed for downgrading or declassification	61	8
Documents and papers (intended for oral presentation or publication) reviewed for appropriate classification	24	39
Documents submitted to Declassification Branch, Oak Ridge	1	5


Manager,
Laboratory Auxiliaries

UNCLASSIFIED

H-10

PROJECT NUMBER	TITLE	MONTHLY PROJECT REPORT										HW - 65854	
		EST. TOTAL PROJECT COST		INFORMATION AMOUNT		PROJECT PROGRESS IN PERCENT		STARTING DATE		DIRECTIVE COMP. DATE		ESTIMATED OR ACTUAL COMP. DATE	
		DESIGN	ACTUAL	DESIGN	ACTUAL	DESIGN	CONST.	DESIGN	CONST.	DESIGN	CONST.	DESIGN	CONST.
CG-731	Critical Mass Laboratory	\$980,000	\$1,000,000	100	100	100	100	5-22-58	---	6-30-60	---	6-24-59	6-20-60*
REMARKS:		<p>The fixed price contractor completed his work on June 20, 1960. The facility was accepted on June 23, 1960.</p> <p>* The reactor assemblies and reactor control system will not arrive until mid July. These will be installed by J. A. Jones Company construction forces. Funds were accrued on the project to cover the cost of this and other work not included in the Fixed Price Contract. In addition, a work order was issued to General Electric Company plant forces to cover project start-up costs.</p>											
CA-744	Metallurgical Development Facility - 306 Building	\$2,650,000	\$2,685,000	100	100	*	*	6-30-58	---	9-1-60	---	9-30-59	9-1-60***
REMARKS:		<p>The contractor schedule indicates completion by 7-8-60, however, 7-15-60, is more realistic. Equipment installation by J.A. Jones is progressing satisfactorily. The four chemical processing tanks lined with Kel-F did not pass inspection and required repairs at the vendors plant. The delivery to the contractor may be delayed until July 11th or thereabouts. Office equipment may be installed in offices now and equipment may be used in the building after July 10th.</p> <p>* Total Project 91%; Jensen-Rasmussen 100%; J.A. Jones 80%; Frank Lohse 90%; Government Scheduled Material 100%</p> <p>** Total Project 93%; Jensen-Rasmussen 99%; J.A. Jones 90%; Frank Lohse 68%; Government Scheduled Material 80%</p> <p>*** Completion of office portion 7-11-60.</p>											
CGH-790	High Level Radioactive Receiving and Storage Addition - 327 Building	\$345,000	\$345,000	100	100	100	100	6-23-58	---	6-1-60	---	12-31-58	6-1-60*
REMARKS:		<p>CPFF forces have completed painting new basin. Work progressing very slowly on clean-up.</p>											
* With exceptions													

BUDGET CLASSIFICATION		MONTHLY PROJECT REPORT										HW - 65854 H MONTH June, 1960		DEL	
General Plant Projects - FY 1959		HANFORD LABORATORIES OPERATION													
PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION		PROJECT PROGRESS IN PERCENT			STARTING DATE	DESIGN	CONST.	DIRECTIVE COMP. DATE	DESIGN	CONST.	ESTIMATED OR ACTUAL COMP. DATE	
			AMOUNT	DATE	SCHED.	SCHED.	ACTUAL								
CAH-837	Animal Pens, Isolation and Examination Facilities	\$77,000	\$80,000	3-17-59	100	100	100	3-30-59					6-5-59		
	USING COMPONENT	Biology			100	100		7-10-59					4-1-60		
REMARKS:		J. T. Lloyd													

All work has been completed. Physical completion notice was issued on June 16, 1960.

General Plant Projects - FY 1960

CGH-819	Increased Laboratory Waste Facilities 300 Area	\$ 193,000	\$193,765	2-19-60	100	100	NS	2-5-60*					5-1-60	
	USING COMPONENT	Chemical R & D			100			6-15-60					5-31-61	
REMARKS:		J. J. Peterson												

Plant forces are preparing tanks for removal from 200 West to 300 Area. CPFF forces have sent out bid package for fixed price portion of work with bid opening scheduled for July 7, 1960.

* Design started on revised scope.

CGH-860	Access for PRTR Fuel Elements - 327 Building	\$81,000	\$81,000	10-8-59	100	100	78	10-19-59					4-1-60	
	USING COMPONENT	Reactor & Fuels R & D			100		70	1-4-60					8-1-60	
REMARKS:		J. J. Peterson												

Fixed price contractor has completed plastering and electricians are pulling wire and installing electrical equipment. Rails for cask cart are being installed. CPFF forces painted crane rails and are fabricating carbon filter assembly.

UNCLASSIFIED

H-12

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST		AUTHORIZATION INFORMATION		MONTHLY PROJECT REPORT				HANFORD LABORATORIES OPERATION		STARTING DATE		DIRECTIVE COMP. DATE		ESTIMATED OR ACTUAL COMP. DATE		
		AMOUNT	DATE	SCHED.	ACTUAL	SCHED.	ACTUAL	DESIGN	CONST.	DESIGN	CONST.	DESIGN	CONST.	DESIGN	CONST.	DESIGN	CONST.	
CAH-864	Shielded Animal Monitoring Station - 100 F	\$52,000	4-18-60	100	100	42		10-22-59	---	7-24-60	---	2-4-60						
USING COMPONENT		Biology																
REMARKS:		Concrete walls and floor slab have been poured and forms stripped. The base plate and monitoring cell is in place.																

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST		AUTHORIZATION INFORMATION		MONTHLY PROJECT REPORT				HANFORD LABORATORIES OPERATION		STARTING DATE		DIRECTIVE COMP. DATE		ESTIMATED OR ACTUAL COMP. DATE		
		AMOUNT	DATE	SCHED.	ACTUAL	SCHED.	ACTUAL	DESIGN	CONST.	DESIGN	CONST.	DESIGN	CONST.	DESIGN	CONST.	DESIGN	CONST.	
CAH-874	Consolidation of Plutonium Metallurgical Facilities	\$285,000	None	0	0	0		1*	---	5*								
USING COMPONENT		None																
REMARKS:		Reactor & Fuels R & D J. T. Lloyd																

The A. E. C. has presented no comments as to the status of the proposal held since October 8, 1959.

* Months after authorization.

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST		AUTHORIZATION INFORMATION		MONTHLY PROJECT REPORT				HANFORD LABORATORIES OPERATION		STARTING DATE		DIRECTIVE COMP. DATE		ESTIMATED OR ACTUAL COMP. DATE		
		AMOUNT	DATE	SCHED.	ACTUAL	SCHED.	ACTUAL	DESIGN	CONST.	DESIGN	CONST.	DESIGN	CONST.	DESIGN	CONST.	DESIGN	CONST.	
CGH-877	Pyrochemical Test Facility - 321-A Building	\$70,000	11-17-59	100	100	65		12-8-59	---	9-30-60	---	4-17-60						
USING COMPONENT		Chemical R & D																
REMARKS:		R. C. Ingersoll																

The hood vendor changed the promised shipping date from 6-20-60 to 7-8-60. J. A. Jones accumulated man days 62 (fabrication of Mg still hood). Estimated cost plus commitments as of 7-1-60 \$38,000.

* Design changes in the exhaust and filter system have delayed field work. All anticipated changes have been completed and it is expected that construction will be back on schedule in the near future. It is anticipated that the project completion date will be met.

UNCLASSIFIED

H-13

BUDGET CLASSIFICATION		MONTHLY PROJECT REPORT										HW - 65854 . DEL	
General Plant Projects - FY 1960		HANFORD LABORATORIES OPERATION										MONTH June, 1960	
PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION		PROJECT PROGRESS IN PERCENT				STARTING DATE	DIRECTIVE COMP. DATE	ESTIMATED OR ACTUAL COMP. DATE		
			AMOUNT	DATE	DESIGN SCHED.	ACTUAL	CONST.	DESIGN				CONST.	
CAH-878	Additional Facilities for Isotope Study on Animals - 141 C Building Addition.	\$66,000	\$66,000	4-19-59	100	100	27	27	12-7-59	---	4-17-60		
		\$66,000	4-19-59		100	100	30	30	5-5-60	7-24-60	8-31-60		
USING COMPONENT		BIOLOGY											
J. T. Lloyd													
REMARKS: The prefabricated building is scheduled for delivery on July 5, 1960, and erection completed by July 15th. The project will be complete about August 31, 1960.													
CAH-885	Geological & Hydrological Wells - FY-1960	\$69,000	\$69,000	2-5-60	100	100	3	3	2-15-60	---	4-1-60		
		\$69,000	2-5-60		100	100	NS*	NS*	6-8-60	11-15-60	2-15-61		
USING COMPONENT		Chemical R & D											
H. E. Ralph													
REMARKS: Contractor brought first drilling rig on site June 8, 1960 and started unloading well casing from railroad cars. Second drilling rig arrived June 20, 1960. Drilling started at wells W-22-22 and 15-15 on June 22, 1960. Contractor is 33 days behind schedule based on submittal of performance bonds on May 18, 1960. (Progress by Projects CAH-885 - 3%; CAC-843 - 2%; CGI-791 - 0%).													
* Construction schedule submitted by Contractor was rejected by AEC. Revised schedule being prepared.													
CGH-896	Stress - Rupture Testing Facility	\$80,000	\$7,500	6-14-60	0	0	0	0	7-18-60*	---	10-21-60		
		\$80,000	6-14-60		0	0	0	0	12-12-60*	---	6-15-61		
USING COMPONENT		Reactor & Fuels R & D											
R. K. Waldman													
REMARKS: This project was authorized on June 14, 1960 to proceed with design. Design work will start about July 18, 1960.													
* Starting dates are estimated.													

AM-7300-019 (4-60)

UNCLASSIFIED

UNCLASSIFIED

H-14

UNCLASSIFIED		MONTHLY PROJECT REPORT		HANFORD LABORATORIES OPERATION		HW - 65854 [DEL] June, 1960	
BUDGET CLASSIFICATION		PROJECT PROGRESS IN PERCENT		STARTING DATE		DIRECTIVE COMP. DATE	
General Plant Projects - FY 1960		DESIGN SCHED. ACTUAL		DESIGN CONST.		DESIGN CONST.	
PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT DATE	DESIGN SCHED.	ACTUAL	DESIGN CONST.	ESTIMATED OR ACTUAL COMP. DATE
CGH-902	Uranium Scrap Burning Facility	\$36,000	None	0	0	2*	8*
			None	0	0	6*	38*
REMARKS:		USING COMPONENT Reactor & Fuels R & D R. K. Waldman FEO ENGINEER					
This project was submitted to the H00-AEC on June 16, 1960.							
* Weeks after authorization.							
Improvements to Production and Supporting Facilities - 60-a-1							
CGH-866	Shielded Analytical Laboratory 325 Building	\$750,000	\$60,000	1	0	6-27-60	NS
			5-31-60	1	0	---	---
REMARKS:		USING COMPONENT Chemical R & D R. W. Dascenzo FEO ENGINEER					
B. D. Bohna & Co., Inc. received a contract from AEC on June 27, 1960, to perform the design on this project. Mr. Lloyd Gallagher visited the site on June 27th and 28th to obtain more information for design work. General Electric Company received Work Authority No. CAH-866(1) authorizing the performance of scoping and preliminary design, related management services and technical direction of the AEC, and to incur costs in the amount of \$15,000. This work authority changed the project from G. E. to AEC managed and performance of design from G. E. to an off-site architect-engineer. Contract negotiations took place on June 10, 1960, with Mr. E. D. Arndt of B. D. Bohna Co., Inc. and the AEC.							
CAH-870	Facilities for Recovery of Radioactive Materials - 325-A Building	\$486,000	\$486,000	100	7	9-18-59	---
			3-22-60	100	7	6-1-60	6-1-61
REMARKS:		USING COMPONENT Chemical R & D R. W. Dascenzo FEO ENGINEER					
Severe trouble was encountered at the 387' elevation on the N. E. corner of the building with a cemented gravel strata approximately 6' deep. A diesel-driven pile driver and jig solved the problem and the remainder of the piles for the building and the well house were driven successfully. 3. The basement area of the 325-A building was hand excavated, formed and the basement floor and concrete ramp poured. 4. A contractor and AEC office, electricians shed, carpenters tool shed and saw were moved in and set up. 5. An existing power pole was moved outside the excavation area for the vault structure, service restored, and temporary construction service installed. 6. Two sets of existing outside concrete steps were demolished and openings broken into the 325-A building basement wall for a door and air conditioning ducts.							

AM-7300-019 (4-60)

UNCLASSIFIED

PROJECT NUMBER	TITLE	MONTHLY PROJECT REPORT				HANFORD LABORATORIES OPERATION		STARTING DATE		DIRECTIVE COMP. DATE	ESTIMATED OR ACTUAL COMP. DATE
		EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION AMOUNT DATE	DESIGN SCHED.	ACTUAL SCHED.	DESIGN	CONST.	MONTH	DATE		
CAH-870											
<p>REMARKS: 7. An abandoned 8" C.I. line was removed from the vault area and excavation made for the building area. Footings for the building were hand excavated, and forming started. 8. A casting yard has been set up for forecasting the cover slabs for the vault. Casting well starts next week. 9. A source of stainless steel sheet for the vault and trench lines was located in the N.W. and mill procurement will not be required. 10. Plant forces have completed decontamination of the six transferred tanks. The two 9 x 9 tanks were not completely decontaminated on the inside. J.A. Jones will complete modification and alterations to these tanks by July 8th and they will be ready for contractor installation.</p>											
<p>Installation for Support of Bio-Medical Research - 60-h-1</p>											
CGH-888	Biology Laboratory Improvements	\$345,000	\$30,000	NS	---	---	---	5-3-60*	---	---	12-1-60
		USING COMPONENT	5-3-60	Des.I-100	---	---	---	FEO ENGINEER	---	---	NS
		Biology	J. T. Lloyd								
<p>REMARKS:</p> <p>Architect-Engineers are being considered for the performance of design work. The design criteria has been completed and submitted to AEC for approval. This project will include a third floor to the planned 108-F building addition. * Scope design.</p>											
<p>Improvements to Production and Supporting Facilities - 61-a-1</p>											
CGH-832	Full Scale Constants Testing Reactor	\$915,000	None	0	0	0	0	---	---	---	---
		USING COMPONENT	None	0	0	0	0	FEO ENGINEER	---	---	---
		Physics & Instruments R & D	R. W. Dascenzo								
<p>REMARKS:</p> <p>No approval has been received from HOO-AEC on the preliminary project proposal requesting preliminary engineering funds.</p>											

PROJECT NUMBER	TITLE	EST. TOTAL PROJECT COST		AUTHORIZATION INFORMATION		PROJECT PROGRESS IN PERCENT		MONTHLY PROJECT REPORT		STARTING DATE	DIRECTIVE COMP. DATE	ESTIMATED OR ACTUAL COMP. DATE
		AMOUNT	DATE	SCHED.	ACTUAL	DESIGN	CONST.	DESIGN	CONST.			
CG-785	In-Reactor Studies Equipment - 105 KW Building	\$325,000*	\$276,000 12-8-58	100	99	57**	57**	1-5-59	3-22-60	12-31-60	9-1-60*	2-28-61*
USING COMPONENT		Reactor & Fuels R & D						FEO ENGINEER		H. Radow		
<p>REMARKS: The instrument panels, valve rack, saturable reactors, and a substantial amount of large conduit runs have been installed and the recent progress has been very favorable. Progress on the capsule removal facility fabrication has also been good. The hydraulic pumping unit has been shipped and BAFO representatives visited vendor's site to witness test of capsule cutter. It operated very satisfactorily and has been shipped. The project proposal, Rev. 2, has been submitted.</p> <p>* Estimated total cost and completion dates based on cost-to-complete estimate and work included in revision No. 2 of project proposal.</p> <p>**Per construction status schedule which has been submitted to the Commission for approval.</p>												
CGH-805	High Temperature Tensile Testing Cell- 327 Building	\$170,000	\$150,000 2-25-59	100	100	0	0	8-26-58	8-20-60	3-1-60	6-15-59	3-1-61
USING COMPONENT		Reactor & Fuels R & D						FEO ENGINEER		R. W. Descenzo		
<p>REMARKS: The revised project proposal requesting additional time and funds has not been approved by HOO-AEC. The procurement of viewing and solid plugs has been completed. Other procurement is continuing. Corning Glass Works requested relaxations on the viewing window frame for the fourth time and about half were permitted. This window is six months behind schedule. Washington Iron Works has had trouble with porosity in the Meehanite castings for the cell structure. One casting had to be recast.</p> <p>Equipment Procurement and Fabrication</p> <p>Orders placed 98% of value Orders delivered 40% of value</p>												
CGH-834	Modifications & Additions to the High Pressure Heat Transfer Apparatus - 189-D Building	\$700,000	\$700,000 4-8-59	100	99	78	78	4-20-59	4-22-59	10-15-60	7-1-60	10-15-60
USING COMPONENT		Reactor & Fuels R & D						FEO ENGINEER		H. Radow		
<p>REMARKS: All work that can be profitably accomplished with received equipment and material has been essentially completed. Field work will, therefore, be stopped for an interim period, pending receipt of enough of the remaining procurement items to permit resumption of field work. This is estimated to be about September 1, 1960.</p>												

PROJECT NUMBER	TITLE	MONTHLY PROJECT REPORT HANFORD LABORATORIES OPERATION										ESTIMATED OR ACTUAL COMP. DATE
		EST. TOTAL PROJECT COST	AUTHORIZATION INFORMATION	PROJECT PROGRESS IN PER CENT		STARTING DATE	COMP. DATE		DESIGN		CONST.	
		AMOUNT	DATE	SCHED.	ACTUAL	DESIGN	CONST.	DESIGN	CONST.	DESIGN	CONST.	
CGE-857	Physical and Mechanical Properties Testing Cell - 327 Building	\$500,000	\$75,000	10-1-59	11	0	10-20-59	NS	NS	12-1-60	7-1-63	
	USING COMPONENT											
	Reactor & Fuels R & D											
REMARKS	<p>Directive No. HW-498, Mod. #1, dated June 14, 1960, changed the "Methods By Which Work Will be Performed" permitting G. E. to perform the design of the cell equipment instead of the vendor, wherever practical. The Budd Co. furnished information concerning the fatigue testers, but it was incomplete and additional information has been requested.</p> <p>Equipment design is progressing slowly as drafting help was not available on a full-time basis. Detail design of the cell structure was started June 16, 1960 and is about 10% complete.</p>											
CGE-858	High Level Utility Cell - 327 Building	\$500,000	\$70,000	10-1-59	18	0	10-20-59	N.S.	N.S.	11-1-60	11-1-61	
	USING COMPONENT											
	Reactor & Fuels R & D											
REMARKS	<p>CE&UO started design of the cell structure on June 16, 1960. Design is continuing on the special lathe and mill to be housed in this cell.</p>											
CAE-901	Structural Material Irradiation Test Equipment - "ETR"	\$125,000	None		0	0	8-15-60*	4-1-61*	4-1-61*	2-1-61*	9-15-61*	
	USING COMPONENT											
	Reactor & Fuels R & D											
REMARKS	<p>The project proposal requesting authorization of this project was submitted to the Commission on June 10, 1960.</p>											
	<p>* Based on AEC authorization by August 1, 1960.</p>											

PROFESSIONAL PLACEMENT AND
RELATIONS PRACTICES OPERATION

MONTHLY REPORT

GENERAL

As of June 30, 1960, the staff of the Hanford Laboratories totalled 1382 employees, including 669 exempt and 713 nonexempt. Of the total, 573 possessed technical degrees, including 352 B.S., 117 M.S., and 104 Ph.D.

HEALTH, SAFETY AND SECURITY

The medical treatment frequency for June was 1.55 as compared with 1.77 for May. There were no disabling injuries or serious accidents during the month. There was 1 security violation, bringing the total for the year to date to 11, as compared with 22 during the same period in 1959.

There was a failure of a high pressure bellows apparatus in the Fuels Development Operation. Although personnel safety was jeopardized, no injuries resulted.

PROFESSIONAL PLACEMENT

Eight Ph.D. candidates visited during the month for Richland interviews. Two offers were extended, 3 offers were rejected, and there are currently 2 open offers.

During June a Doctor of Veterinary Medicine and a Ph.D. pharmacologist reported on HLO rolls.

The campus recruiting of BS/MS candidates was completed during the month. Eighty-three acceptances were received during the recruiting year, resulting in an acceptance rate of 43%. During June, 39 of these graduates reported on the payroll, and there are 29 yet to report during the summer.

Four Technical Graduates and 4 Technician Trainees accepted permanent assignment during June. At month's end there were 73 Technical Graduates, including 8 members of the Engineering and Science Program and 1 Technician Trainee on program rolls.

COMPENSATION

Sign-up for the new Personal Accident Insurance by Hanford Laboratories employees is currently 55.5% of our force.

EMPLOYMENT

Forty nonexempt vacancies were filled during the month.

UNCLASSIFIED

I-2

HW-65854

DEL

TRAINING

The third class of nonexempt employees to take Applied Creativity completed the thirteen weeks course.

Whinnwright
for
Manager
Professional Placement
and Relations Practices

TG Marshall:lmh

UNCLASSIFIED

TABLE II NONEXEMPT EMPLOYMENT

<u>Nonexempt Employment Status</u>	<u>May</u>	<u>June</u>	<u>Nonexempt Transfer Request</u>	<u>May</u>	<u>June</u>
Requisitions			Transfers		
At end of month	37	20	Active cases at end of mo.	73	76
Cancelled	4	5	Cancelled	3	1
Received	33	28	New	4	7
Filled	20	40	Effected	2	3

DEL

HW-65854

TABLE III. PROFESSIONAL PERSONNEL PLACEMENT

A. Technical Recruiting Activity - HAPO - September 1, 1959 to Date

Cases	<u>Visits to Richland</u>			<u>Offers*</u>	<u>To Visit</u>	<u>Extended</u>	<u>Accepted</u>	<u>Open</u>	<u>On the Roll**</u>
	<u>Considered</u>	<u>Invited</u>	<u>Visited</u>						
Ph.D.	643	151	55	15	26	8	2	5	5
Exp. BS/MS	429	107	78	3	93	55	3	3	58
Prog. BS/MS	487	-	-	-	195	83	5	5	49

*Offer totals include offers open on 9/1/59

Ph.D. 3
Exp. BS/MS 6

**On the Roll totals include 1958/59 Carryover acceptances and one 1957/58 Ph.D. Carryover.

I-4

B. Technical Recruiting Activity - HAO - September 1, 1959 to Date

Cases	<u>Visits to Richland</u>			<u>Offers*</u>	<u>To Visit</u>	<u>Extended</u>	<u>Accepted</u>	<u>Open</u>	<u>On the Roll**</u>
	<u>Considered</u>	<u>Invited</u>	<u>Visited</u>						
Ph.D.	643	151	55	15	22	7	2	5	5
Exp. BS/MS	253	35	20	2	19	15	-	1	15

*Offer totals include offers open on 9/1/59

Ph.D. 3
Exp. BS/MS 3

**On the Roll totals include 1958/59 Carryover acceptances and one 1957/58 Ph.D. Carryover.

In addition to the above activity, 16 exempt employees have transferred into HAO from other HAPO departments and 21 technical graduates have accepted Off-Program placement in HAO to date.

UNCLASSIFIED

UNCLASSIFIED

C - Technical Graduate and Technician Training Program
Month ending June 30, 1960

	<u>TG Program</u>	<u>TT Program</u>
Number of Personnel on Assignment	73	1
(HAPO Tech Grad Program 65		
(Western District E. P. 8	-----	-----
 Distribution of Assignments by Departments		
HLO	26	0
CE&UO	3	0
FPD	11	0
IPD	28	1
CPD	5	0
 Distribution of Assignments by Function		
R&D or Engineering	41	1
Other	32	0

FINANCIAL OPERATION MONTHLY REPORT
JUNE 1960

Personnel

There were no personnel changes during June.

Activities

GENERAL ACCOUNTING

The continuity of service accrual rate for FY 1961 has been established at 12.5% to coincide with the budgeted level. Results of accruing at this rate will be examined later in the year to determine if an adjustment is necessary.

Administrative work in connection with Hanford Laboratories - Assistance to Hanford Program was unusually heavy during the month of June in anticipation of the fiscal year end closing. Other Company components doing work for the Laboratories provided estimates of year-end costs for accrual purposes. A number of authorizations expiring at June 30, 1960 were either closed or, as appropriate, renewed. Only one authorization required AEC approval which was secured in sufficient time to authorize continuance of the work beginning July 1, 1960.

Travel costs in FY 1960 amounted to \$375,000 compared with \$345,000 in FY 1959. The total number of trips started in FY 1959 was 1,384; in FY 1960, 1,392 were started.

The current estimate of equipment expenditures for FY 1960 by Program is shown below:

(Dollar amounts in thousands)

<u>Program</u>	<u>Allocation</u>	<u>Expenditures</u>	(Over) <u>Underrun</u>
2000	\$ 1 620	\$1 516	\$ 104
3000	85	113	(28)
4000	600	568	32
5000	51	37	14
6000	98	98	-
Totals	<u>\$2 454</u>	<u>\$2 332</u>	<u>122</u>

* Overrun in the 3000 Program is attributable to capitalizing installation charges for a 5,000 ton press and accruing for the press which was transferred to us on a permanent basis. CPD is aware of these charges and will cover our overrun.

Our year end accrual for equipment received - not billed and equipment shipped by 6-30-60 with term, f.o.b. Vendor's plant totaled \$355,019. This accrual by Program is as follows:

2000 Program	\$161 245
3000 Program	14 025
4000 Program	171 454
5000 Program	3 334
6000 Program	4 961

Transfers from EWIP during FY 1960 totaled \$3,660,807 as compared to a total of \$1,550,215 for FY 1959 for an increase of 136%.

Reconciliation of the physical inventory of movable cataloged equipment in custody of Reactor and Fuels R&D and Chemical R&D nears completion. Both inventories will be submitted to C&AO by July 15, 1960 for their review and completion of the reconciliation.

Approximately 38 478 KGs (170 barrels) of Heavy Water were received from Savannah River during the month and subsequently transferred to the AEC for Project AEC-167, PRTR. This entire shipment valued at \$1,991,730 (Fund \$1,182,530 - Non-Fund \$809,200) is required for the initial loading of the PRTR.

Year-end accruals were prepared for 27,000 pounds of Heavy Water received from Savannah River in June valued at \$631,124 (\$376,828 Fund and \$254,296 Non-Fund). This material will remain in the inventory account for replacement of material in any one of the PRTR loops. Accruals were also made on zirconium purchase orders in the amount of \$65,388.

Due to the limited value of ten Zr-3 ingots received at HAPO in 1956 and to obtain a more realistic price all of the ingots were reduced in value to \$7.00 per pound. This resulted in a charge to Cost during the month of \$40,310.

AEC formally approved our request to transfer the Hot Semi-Works from Condition II, Plant and Equipment Held for Future Use to Condition IV, Plant and Equipment Not Used and Currently Not Useful. This change in classification will enable us to utilize some of the equipment for other purposes. Transferred to the new account classification was \$1,053,786 representing buildings and other structures. The balance of the Held for Future Use Account, \$3,323,063 representing installed and uninstalled equipment will be transferred at a later date, after determination has been made which equipment can be used now or in the near future.

The first PRTR warehouse, 3718-B Building was made available to Financial on a limited basis for additional storage space in connection with the Laboratory Equipment Pool Operation. This building is being used jointly by Plutonium Recycle Test Reactor Operation and Financial for a short period. We should have complete utilization of this building in approximately 5 months and also partial use of building 3718-A.

Approval was obtained from the AEC to add to record eleven pieces of Electronic Pulse Counting equipment valued at \$6,300 by use of the P&E Non-Fund Adjustment account. This equipment was used on the Fission Cross-Section Measurement Program which was KAPL funded and released by them for HAPO use.

Billings to Plant during the month of June totaled \$7,643,753, representing closings from EWIP, CWIP and Plant to Plant transfers from the AEC, as detailed below:

Equipment Work in Progress

Project CGH-879	High Temperature High Pressure Autoclave Facility	\$ 45 633	
Purchase Orders and Work Orders		<u>234 590</u>	\$ 280 223

Construction Work in Progress

Work Orders		\$ 16 128	
Project CGH-840	Sheet Metal Shop Annex	35 373	
Project CG- 731	Critical Mass Laboratory	990 953	
Project CGH-790	High Level Laboratories Material Receiving and Storage - 327 Building	<u>344 948</u>	\$1 387 402

Transfers from AEC

Project CA-681	Hanford Equipment, ETR	\$1 028 708*	
Project CA-747	Plutonium Fabrication Pilot Plant	3 872 531*	
Project CA-749	High Level Radiochemistry Cell	910 222	
Project CAH-827	Automatic Columbia River Monitoring Station	34 857	
Project CAH-837	Animal Pens, Isolation and Examination Facilities	77 638	
Project CAH-848	Geological and Hydrological Wells, FY-59	<u>52 172</u>	<u>5 976 128</u>
			\$7 643 753

*Partial billing enabling HLO to start depreciation July 1, 1960.

Nineteen items valued at \$11,261 were received at the Laboratory Equipment Pool Building during the month of June. Four items valued at \$2,947 were loaned to the Portland State College to be returned in August. This loan of equipment was approved by the Commission. Two items valued at \$1,430 were transferred on a loan basis and one item valued at \$255 was permanently transferred. Three transfers were made in lieu of placement of requisitions. Two hundred and sixty-nine individually controlled pieces of zirconium were received at the storage facility valued at \$60,000 for storage and reissue. The following represents the dollar value of equipment and material currently located in the storage area.

Equipment	\$ 151 633
Items stored for convenience of others	15 174
Zirconium (est.)	<u>60 000</u>
	\$ <u>226 807</u>

Total value of equipment placed in lieu of purchase since the inception of the equipment pool is \$13,208.

COST ACCOUNTING

The Hanford Laboratories operating cost control budget for June reporting was adjusted as indicated on the following page:

(Dollars in Thousands)

	<u>Increase</u> <u>(Decrease)</u>
(1) IPD Research and Development	
Metallurgy I	(8)
Metallurgy II	(13)
Reactor II	(9)
NFR	<u>(65)</u>
Total	<u>(95)</u>
(2) 4000 Program Research and Development	
Specific Fuel Cycle Analysis	30
Plutonium Recycle Program	(12)
GCPR - Reactor Physics	<u>(18)</u>
Total	<u>-0-</u>

The HLO FY 1961 Revised Budget submission has been recast to a "controllable budget basis" in conjunction with the other HAPO components. A system of reporting costs to top management has been developed HAPO-wide which will facilitate cost analysis and control. This reporting media will be used starting with July 1960 business.

A pocket size booklet containing summary data of the HLO Budget for FY 1962 and Revision of Budget for FY 1961 was issued to HLO management. Comparisons and trends covering five fiscal years (1958 - 1962) were presented for all major areas of the budget submission.

Through the efforts of Accounting Operations and HLO Finance, considerable progress has been made in mechanizing the cost accounting for Hanford Laboratories. Progress to date includes the design of a time distribution report form which will be the labor distribution input media for the data processing machine. Defining the information and the reports required has also been completed and the actual programming has been initiated. It is anticipated that programming will be completed in time to begin processing TDR's with September business.

As a by-product of machine accounting an assigned manpower report will be available which will be a great improvement in personnel data and reporting. Currently manpower assignments to programs and functions are not available except through lengthy calculations based on liquidated manpower. The new report will give positive assignments to programs and functions on a weekly basis.

Action as indicated occurred on the following projects during the month:

New Funds Authorized HLO

CAH-866	Shielded Analytical Laboratory	\$ 5 000
CAH-867	Fuel Element Rupture Test Facility	95 000
CGH-896	Stress-Rupture Testing Facility	7 500

Physical Completion Notices Issued

CG- 731 Critical Mass Laboratory
 CGH-790 High Level Radioactive Material Receiving and Storage Addition,
 326 Building
 CAH-827 Automatic Columbia River Monitoring Station*
 CAH-837 Animal Pens, Isolation and Examination Facilities**
 CAH-848 Geological and Hydrological Wells - FY 1959 **

*Physical Completion Notice for AEM Services issued in April 1960.

**Physical Completion Notice for AEM Services issued in June 1960.

Construction Completion and Cost Closing Statements Issued

CA- 749 High Level Radiochemistry Facility (AEM Services only)
 CGH-879 High Temperature, High Pressure Autoclave Facility - 306 Bldg.

Costs incurred to date on Projects CA-681 Equipment in the ETR (\$1,028,708) and CA-747 Plutonium Fabrication Pilot Plant (\$3,872,531) were transferred to Plant in Service.

There were 93 new authorizations for \$211,144 (includes \$85,600 on Project CGH-819) and 11 supplements for \$57,564 issued to J. A. Jones Construction Company during the month. Work was physically completed on 90 authorizations and 54 authorizations amounting to \$186,659 were still open at month end.

GENERAL

As of July 5, 1960, 746 or 55.5% of the employees eligible to participate enrolled in the new Personal Accident Insurance plan. The following is a breakdown of the coverage requested by the employees enrolled:

<u>Coverage</u>	<u>Number of Employees</u>	<u>% to Total Enrolled</u>
\$ 10 000	272	36.4%
20 000	160	21.4
30 000	102	13.7
40 000	17	2.3
50 000	127	17.0
60 000	6	.9
70 000	2	.3
80 000	-	-
90 000	-	-
100 000	60	8.0
	<u>746</u>	<u>100.0</u>

A further breakdown by coverage by exempt and salaried classification will be furnished as soon as all cards have been received and tabulated by Data Processing.

W Sale:bk
 7-15-60

L. H. Kelly
 for Manager Finance

Payroll StatisticsNumber of HLO EmployeesChanges During Month

	<u>Total</u>	<u>Exempt</u>	<u>Non-Exempt</u>
Employees on Payroll at Beginning of Month	1 307	618	689
Additions and Transfers In	103	62	41
Removals and Transfers Out	28	11	17
Employees on Payroll at End of Month	<u>1 382</u>	<u>669</u>	<u>713</u>

Overtime Payments During Month

	<u>June</u>	<u>July</u>
Exempt	\$ 4 893	\$ 4 122
Nonexempt	22 424	14 344
Total	<u>\$27 317</u>	<u>\$18 466</u>

Gross Payroll Paid During Month

Exempt	\$545 550	\$528 733
Nonexempt	437 310	342 092
Total	<u>\$982 860</u>	<u>\$870 825</u>

Participation in Employee BenefitPlans at Month End

	<u>June</u>		<u>May</u>	
	<u>Number</u>	<u>Percent</u>	<u>Number</u>	<u>Percent</u>
Pension Plan	1 187	99.4	1 152	99.5
Insurance Plan				
Personal Coverage	1 339	99.8	1 297	99.8
Dependent Coverage	959		922	
U.S. Savings Bonds				
Stock Bonus Plan	79	40.3	80	40.4
Saving Plan	90	6.5	91	9.0
Savings & Security Plan	1 045	84.2	1 023	87.9

Insurance Claims

	<u>June</u>		<u>May</u>	
	<u>Number</u>	<u>Amount</u>	<u>Number</u>	<u>Amount</u>
Employee Benefits				
Life Insurance	2	\$10 758	0	0
Weekly Sickness and Accident	20	1 129	25	3 352
Comprehensive Medical	33	2 689	34	2 017
Dependent Benefits				
Comprehensive Medical	76	5 989	178	18 076
Total	<u>131</u>	<u>\$20 565</u>	<u>237</u>	<u>\$23 446</u>

Good Neighbor Fund

	<u>June</u>	<u>May</u>
Number Participating	940	916
Percent Participating	68.0	70.1

CEL

INVENTIONS OR DISCOVERIES

All persons engaged in work that might reasonably be expected to result in inventions or discoveries advise that, to the best of their knowledge and belief, no inventions or discoveries were made in the course of their work during the period covered by this report except as listed below. Such persons further advise that, for the period therein covered by this report, notebook records, if any, kept in the course of their work have been examined for possible inventions or discoveries.

INVENTOR

TITLE OF INVENTION OR DISCOVERY

R. S. Paul	A Dual Scanning System for Reactor Fuel Failure Detection
M. O. Rankin	An Alarming Pocket Radiation Dosimeter
C. Metelmann	Seismograph Based on Piezoelectric Effect
A. M. Platt	Process for UF ₆ to UO ₂ Conversion
V. P. Kelly	A Method of Transferring Energy to a Fluid by Pumping, Agitating, Pulsing or Other Means Without Leakage of the Fluid
C. R. Cooley	Improved Bearing Design for Canned Motor Pumps
J. Dunn	
G. B. Hatcher	Automatic & Precise Control of Fluid Levels
G. B. Hatcher	Automatic Unit for Compacting Granular, Irregular Shaped Particles, or Powders, into a Solid Within a Cylinder or Tube
J. W. Sadler	Drafting Aids

Paul F. Gast

**DATE
FILMED
01/08/93**

