HW-68712
COPY NO. 18 A
HAN-78113

R

HANFORD LABORATORIES OPERATION MONTHLY ACTIVITIES REPORT

FEBRUARY, 1961

MARCH 15, 1961

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

GENERAL ELECTRIC

A.E.C. - G.E. - RICHLAND, WASH.

LEGAL NOTICE

AEC-GE RICHLAND, WASH.

[redacted]

HW-68712

This document consists of 175 pages. [redacted]

HANFORD LABORATORIES OPERATION
MONTHLY ACTIVITIES REPORT
FEBRUARY, 1961

Compiled by
Operation Managers

March 15, 1961

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

[redacted]

[redacted]

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 of opinions expressed in the report are those of the author only.

Route To:	P. R. No.	Location	Route Date	Signature and Date
HDO J.E. Travis				

1229744

DISTRIBUTION

Copy Number	
1	W. E. Johnson
2	H. M. Parker
3	F. W. Albaugh
4	C. A. Bennett
5	J. L. Boyd
6	L. P. Bupp
7	F. E. Crever, GEAPD
8	W. E. Foust
9	P. F. Gast
10	A. R. Keene
11	H. A. Kornberg
12	O. E. Boston
13	F. W. Woodfield
14	W. Sale
15	I. H. Dearnley
16	H. P. Shaw - V. R. Cooper
17	R. E. Tomlinson
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

TABLE OF CONTENTS

TABLE I. HLO FORCE REPORT AND PERSONNEL STATUS CHANGES

DATE February 28, 1961

	At close of month			At beginning of month			Additions		Separations	
	Exempt	NonExempt	Total	Exempt	NonExempt	Total	Exempt	NonExempt	Exempt	NonExempt
Chemical Research and Development	127	119	246	127	120	247	1	0	1	1
Reactor & Fuels Research & Development	197	182	379	200	185	385	1	1	4	4
Physics & Instrument Research & Development	82	40	122	84	40	124	0	0	2	0
Biology Operation	34	48	82	34	48	82	0	0	0	0
Operation Res. & Syn.	16	4	20	16	4	20	0	0	0	0
Radiation Protection	38	98	136	39	98	137	1	1	2	1
Laboratory Auxiliaries	52	198	250	53	199	252	0	2	1	3
Financial	13	15	28	14	16	30	0	0	1	1
Prof. Placmt. & R. P.	72	11	83	72	11	83	5	0	5	0
Programming	15	4	19	13	4	17	2	0	0	0
General	2	4	6	2	3	5	0	1	0	0
Totals	648	723	1371	654	728	1382	10	5	16	10
Totals excluding internal transfers.	648	723	1371	654	728	1382	7	3	13	8

BUDGETS AND COSTS

February operating costs totaled $2,036,000; fiscal year-to-date costs are $16,716,000 or 64% of the $25,951,000 budget.

Hanford Laboratories research and development costs for February compared with last month and the control budget are as follows:

(Dollars in Thousands)	Cost				
	Current Month	Last Month	FY To Date	Budget	% Spent
HLO Programs					
02 Programs	$ 50	$ 32	$ 343	$ 661	52%
04 Programs	784	822	6 230	9 479	66
05 Programs	65	76	525	796	66
06 Programs	159	169	1 496	2 372	63
	1 058	1 099	8 594	13 308	65
IPD Sponsored	268	270	2 139	3 170	67
CPD Sponsored	168	183	1 339	1 854	72
Total	$1 494	$1 552	$12 072	$18 332	66%

RESEARCH AND DEVELOPMENT

1. Reactor and Fuels

The Plutonium Recycle Test Reactor Phase III-A construction is complete, with exceptions. Construction of the Maintenance and Mockup Facility, which includes the Rupture Loop Annex and Critical Facility Building, is estimated to be 50% complete over-all. Installation of gas loop auxiliaries and service piping is 95% complete. Negotiations are in progress with Bristol-Siddeley for delivery by May 15 of one main gas blower to be run at reduced operating conditions.

Additional analyses of PRTR critical test results show the radial reflector worth to be about 40 milli-k. This value is about one-half that previously calculated but is consistent with results observed elsewhere (CVTR Critical Facility). The discrepancy is ascribed largely to the void effect of the dump chamber. The negative reactivity effects due to replacement of normal fuel channels with gas loop and rupture loop components were found to be in reasonable agreement with previous estimates.

Specimens of Hastelloy R-235, Inconel, Inconel-702 and AISI-406 showed no reductions in room temperature ductility after irradiation to over 10^{20} thermal nvt in a Hanford reactor test hole in an environment of 650 C helium. These data are markedly different than commonly obtained via room temperature or 300 C irradiation of structural metals.

Using an electrically heated model, boiling burnout heat flux for the 19-rod cluster PRTR fuel element was determined to be 900,000 B/hr-sq ft or greater.

Fabrication of aluminum-plutonium spike elements for replacement use in the PRTR is approximately 50% complete. Availability of Zircaloy cladding tubes continues to be a problem.

Plutonium standards have been made to test the feasibility of monitoring the distribution of plutonium in a finished PuO_2-UO_2 fuel element by gamma spectrometry.

A four-foot long Zircaloy-clad UO_2-PuO_2 seven-rod cluster containing sintered and ground pellets has now attained an exposure of 2300 MWD/T in the ETR under simulated PRTR conditions.

Zirconium clad plutonium plates have been successfully rolled in preliminary development directed toward an economical plutonium spike element. Some difficulties were encountered at the higher ratios of plutonium to cladding.

Radiometallurgy examination of a prototype PRTR spike element indicates that no significant physical changes occurred as a result of 72 thermal cycles in the ETR loop. The corrosion rate of the Al-Ni-Pu core material of the spike element was tested in an ex-reactor loop under PRTR coolant conditions - pH 10, 300 C water - and found to be acceptably low, about 400 mils/month.

Reduction of PuO_2 to Pu_2O_3 by dry hydrogen was not found to occur below 1440 C. UO_2 and PuO_2 pellets and intermediate mixtures were sintered for 75 hours at 1500 C in hydrogen. Eight PuO_2 pellets completely vaporized while the UO_2 and the UO_2-20 weight percent PuO_2 pellets more than tripled in weight by condensation of plutonium oxides.

Addition of 10 weight percent PuO_2 to UO_2 was found to raise the melting point from 2730 for UO_2 to 2825 C for the 10 percent PuO_2 material. Fifteen weight percent material melts at 2700 C.

PuC was found to exist over the composition range of 44 to 50 a/o carbon.

Plutonia-thoria and plutonia-zirconia systems were further investigated to establish composition limits and sintering behavior.

A Mark II-C nested tubular UO_2 fuel element has been fabricated by vibrational compaction for high flux irradiation testing in the ETR 6x9 facility. The element is now at the reactor site awaiting charging.

A four-rod cluster fuel element containing recycled electrodeposited UO_2 was returned to HAPO after irradiation in the MTR. Preliminary observations show no abnormalities or dimensional changes.

Preliminary autoradiographic studies of transverse surfaces of irradiated UO_2 fuel rods reveal evidence of non-uniform fission product distribution.

Investigation of the cause of the previously reported severe corrosion and hydriding of a KER-1 Zircaloy-2 process tube has continued. The first corrosion data on rings cut from an unirradiated section of the tube indicate that the corrosion rate in 300 C, pH 10 water is erratic and much higher than that of standard specimens. Also, it is now believed that recrystallization occurred during cut-off operations and not in-reactor.

Failure to obtain a black oxide autoclave coating on beryllium-brazed Zircaloy-clad fuel elements can be eliminated by use of moderate agitation and by removing at least 1-1/2 mils of surface metal during etching.

Metal tear defects in NPR process tubes continue to plague the vendor, having affected about 50 tubes to date. Nondestructive tests are being developed at Hanford to detect these defects.

Measurement of the activation energy for creep of annealed Zr-2 at 15,000 psi have now shown an abrupt increase from 6,500 cal/mole at 281 C to 57,800 at 296 C. Additional testing will be carried out to evaluate the effect of cold work on this transition temperature.

It has been found that non-fissionable metals irradiated with neutrons exhibit remarkable similarities in the post-irradiation annealing behavior. A synthesis of irradiation data for Cu, Ni, Al, W and Mo reveals a sequence of recovery processes classified according to kinetics and falling into five temperature ranges which can be roughly normalized according to reduced melting point correlations.

Failures of Zr-2 coextrusion-clad uranium rods and tubes as a result of localized clad straining have occurred in both NaK capsules and in high temperature water. These failures may be correlated with a major variation of cladding thickness over a very short gage length. Variations in thickness of equal magnitude but occurring over a larger gage length have not caused cladding instability.

The first KER loading of enriched, single-tube, NPR-type fuel elements with brazed closures, discharged in January at an exposure of 1200 MWD/T, shows no evidence of damage. In-basin density measurements show a 1.3% increase in uranium volume. This figure correlates well with swelling data from previous testing.

U-U diffusion couples are now being irradiated for study of the mobilities of rare gas fission products in uranium. Each specimen consists of a transverse section from an extrusion which has a core of depleted uranium and a shell of enriched uranium.

Self-sustained burning in the full-scale mockup of the EGCR lattice with dummy fuel elements, graphite fuel sleeves coated with silicon carbide, and EGCR moderator graphite occurs above 675 C.

Candidate graphites for the Dragon Project high-temperature gas-cooled reactor contracted during high temperature irradiations at two to six times the CSF contraction rate. This is tentatively attributed to the relatively large fraction of non-graphitic carbon in these materials.

Work was started on heat transfer and fluid flow studies in support of the CANDU power reactor design.

2. Chemical Research and Development

Ten measurements averaged over the last two months' operation of the pilot scale reactor effluent aluminum bed decontamination facility showed the following removal percentages for principal radioisotopes: As-76, 53%; P-32, 47%; Zn-65, 62%, Mn-56, 71%.

A high temperature vapor phase chromatographic technique was developed to characterize the number and relative quantity of organic components in hydrocarbon diluents used in solvent extraction. The method can identify the number of normal paraffin, branched chain, and aromatic components after prior fractionation of the hydrocarbon mixtures into these compound classes. Normal paraffins, for instance, can be recovered co-precipitated with urea which acts as a specific carrier for straight chained organic compounds. Characterization of the common hydrocarbon diluents is reported.

Plutonium elution from previously loaded Florida pebble phosphate rock may be more difficult than last month's results indicated.

In support of the flowsheet for the Hot Semiworks recovery of strontium-90, a mini mixer-settler run was made using one liter of Purex strontium concentrate as feed. Reasonably good strontium recovery was demonstrated; however, cerium decontamination was poor. Subsequent experimental runs are expected to improve these features. Fine solids in the feed followed the aqueous stream to waste and did not carry any significant amount of strontium.

No strontium-90 was recovered from the ion exchange equipment in the High Level Radiochemistry Facility during the month because of repairs underway. Supporting laboratory work indicated that strontium purification capacity of the in-cell columns may be increased by a factor of three by simply diluting the feed. Analytical results on the composited strontium-90 product solution shows Sr-90 content and purity to be within specifications.

A second hot demonstration of the Salt Cycle Process was completed using 220 grams of irradiated UO_2 feed and the salt residue from the first run. By-product UO_2 was again cleanly separated from plutonium and fission

products. The product deposition of plutonium and uranium was better controlled in this run by an extended controlled humidity air sparge prior to electrolysis. As expected, an increased concentration of the trivalent rare earth fission products carried along with the plutonium in the co-deposition step.

In other work on Salt Cycle, there are indications that nickel-aluminum alloys may be sufficiently resistant to corrosion to form acceptable process vessels.

Laboratory results indicated that some radioactive anions may be effectively removed from solution by mineral replacement reactions. The incorporation of radio-phosphorus and radio-sulfur during the replacement of gypsum ($CaSO_4 . 2H_2O$) by barite ($BaSO_4$) in barium-containing solutions was studied.

3. Physics and Instrument Research and Development

Predictions of control rod effectiveness in the NPR were substantiated when exponential experiments gave results in good agreement with calculations. In other NPR support work, the recently completed measurements on the fuel temperature reactivity coefficients were reduced to an analytical expression useful for hazards analyses.

A larger surge tank may be needed on the NPR secondary loop according to results of an analog computer simulation of that system. Meanwhile progress toward simulation of the total NPR plant was assisted by simplification of two existing heat transfer models.

Difficult requirements for radiation, area monitoring instrumentation in the NPR building may be met by a new system which has completed six weeks of successful performance in the laboratory. Previously developed systems gave unsatisfactory performance after occasional exposures to high level radiation.

Irradiated fuel inspection and other operational activities at the NPR will be aided by newly designed improved portable periscopes, binocular underwater periscopes, and borescope cameras; and by an optical instrument now under development for measuring fuel channel distortions.

Analysis of data from the startup experiments at the PRTR has confirmed the value of improvements in calculation techniques devised since the design of PRTR and now incorporated in the MELEAGER code. Results also tend to favor the current values of U. S. measurements of the neutrons per fission of Pu-239 as against the somewhat higher "world average" value.

At the Plutonium Critical Mass Laboratory, replacement of faulty valves will be required. The vendor has agreed to supply the replacements. Meanwhile the hood chosen for the initial experiments has successfully passed performance

tests and improvements in the control system will still further reduce chances of criticality incidents occurring.

Predictions of critical mass by calculations took a step forward with application of recently developed methods to unmoderated Pu-Al alloys where good agreement was obtained with the only existing experimental data: all plutonium and half plutonium.

Remote measurement of high radiation levels in the environs of a radiation incident may be possible in the future through installation of newly developed inexpensive detectors at locations where nuclear accidents might conceivably occur.

The use of inconvenient headphones with portable radiation detection instruments may be avoidable in the future through a new development. Field acceptance of a prototype miniature plug-in resonant air column speaker has been enthusiastic.

The quality of fuel element bonds as indicated by ultrasonic tests does not correlate in many cases with heat transfer properties measured with direct thermal testing methods recently developed. These differences are being thoroughly investigated concurrently with further improvement of the thermal test equipment.

A major step forward in the automatic interpretation of electromagnetic test results was achieved with laboratory demonstration of an electronic method for time reversal of the signals, a necessary link in the interpretation process.

The operating safety of the PCTR has been re-evaluated following a recent addition of fuel channels. The effectiveness of fuel in old and new channels was compared experimentally as was the strength of control rods in various fuel loadings. The results confirmed that the safety of the PCTR was not impaired by the modifications.

Some assistance has been given to CPD in response to a request for aid in determining the causes for unsatisfactory performance of automatic contour control on recently purchased lathes.

4. Biology

Treatment of reactor effluent with aluminum turnings gave a slightly higher fish mortality than did untreated effluent.

Some difference in virulence was noted in C. columnaris organisms isolated last year from fish taken from various localities in the Columbia River. The most virulent was taken late, after river temperatures had dropped below 60 F.

Counting of Sr-90 in pigs fed 25 μc Sr-90/day indicates that skeletons of

second generation animals receive 0.5, 1.5 and 4 rads/day, respectively, at birth, weaning, and six months of age. Slight effects on growth were noted in offspring maintained on the same feeding level. The ratio of Sr-90/Ca increased between the time of birth and six months of age.

Sequential addition of different calcium nuclides to sheep serum demonstrated an irreversible binding of excess calcium. This may lead to a new concept of calcium regulation in blood.

Less than 0.1% of orally administered neptunium was absorbed in rats. Localization in bone, ovary and adrenals was noted.

Irradiation of a short section of small intestine causes as much loss of material from blood to gut as does irradiation of the entire intestine. This suggests a regulatory center in this area.

5. Programming

Machine calculations are being initiated to parameterize nuclear fuel costs (in mills/KWh) for thorium cycles variously enriched with U-233, U-235, or Pu of three alternative isotopic compositions. In other computer activities, the MELEAGER code is being generalized and improved for more rapid and economical physics calculations applicable to different methods of reactor fuel charging.

The predictability of reactor operating conditions from the isotopic compositions of recovered cesium and strontium fission products is discussed in a secret report issued during the month.

TECHNICAL AND OTHER SERVICES

There are 17 currently active projects having combined authorized funds in the amount of $19,328,000. The total estimated cost of these projects is $25,978,000. Total expenditures through December were $16,372,000. In addition, project proposals have been submitted to the Commission requesting total authorization of $540,000 on seven new projects.

The Director of the Division of Classification met with HAPO personnel February 1 to discuss the current classification restrictions on plutonium. The discussion was primarily an exchange of information on policy, practice, and the effect of the restrictions on the Plutonium Recycle Program. Declassification of the plutonium in the initial PRTR loadings was requested.

During CY-1960, Technical Publications published 117 formal reports and 25 informal reports. These reports contained 6,873 pages, of which 77% were text and 23% illustrations. Average number of days each report was in Technical Publications was 31.7.

A mathematical model for reactor front-to-rear flux profiles has been developed which simplifies computational and interpretative features.

Break strength data from several tubes of normal I and E fuel elements were used to derive a model relating break strength to fuel element power and residence time. These models may be useful in providing information about thresholds for split ruptures.

A new gamma density-dose calibration function has been derived and fitted to density-dose data. The function arises naturally from theoretical considerations and can be mathematically inverted to express dose as a function of density. These properties are not enjoyed by the gamma calibration function presently in use.

Assistance is being given in determining the post-irradiation data requirements for NPR fuel elements.

One case of minor plutonium deposition was confirmed during the month; preliminary bioassay measurements indicated the amount to be probably less than 5% of the maximum permissible body burden. The total number of plutonium deposition cases that have occurred at Hanford is 265 of which 192 are currently employed. Two contaminated minor injuries required excision to remove plutonium from the wound site. Excision reduced plutonium in the wound from about 25% of the maximum permissible body burden to less than 5%.

Exposure record cards for CY-1960 were distributed to all employees. Thirteen employees received in excess of 3 rems in 1960. The maximum penetrating dose received was 4.6 rems.

SUPPORTING FUNCTIONS

Hanford Laboratories received two special requests during the month:

Heat Transfer and Fluid Flow Studies for Canadian Cooperative program. Estimated cost for FY 1961 to be transferred to AEC is $50,000.

Evaluation studies of the Vallecitos Boiling Water Reactor control rod drive for APED. Estimated costs are $5,000.

A formal request was made of HOO-AEC to discontinue the requirement that we segregate expenses between fuel fabrication and research and development for our PRP fuels.

During the month 4240 grams of platinum scrap valued at $12,000 and of no further value to HAPO were made available to the AEC for shipment off-site. Upon receipt of shipping instructions the dollar value will be transferred to AEC.

Thirteen Ph. D. candidates visited HAPO for professional employment interviews. Three offers were extended and one previous offer accepted during the month. Current open offers total three.

One-hundred and two BS/MS applicants were considered. 51 offers were extended, 9 acceptances and 3 rejections were received. Current open offers total 71.

Three new Technical Graduates reported aboard and four were placed on permanent assignments. Current program members total 61.

Status of the summer employment program is as follows:

	Accepted	Open Offers	Probable Additional Offers to be Made
Professors	13	0	2
Students	5	13	10-15
High School Teachers	0	0	3-4

The incidence of both medical treatment injuries (53 for the month) and security violations (4) was higher than recent past experience during February.

Paul F. Gast

for Manager
Hanford Laboratories

HM Parker:PFG:mlk

1229756

REACTOR AND FUELS RESEARCH AND DEVELOPMENT OPERATION

TECHNICAL ACTIVITIES

A. FISSIONABLE MATERIALS - 2000 PROGRAM

1. METALLURGY PROGRAM

Corrosion Studies

Hydriding of Zircaloy-2 in Simulated NPR Gas. A number of Zircaloy-2 samples have been exposed to a simulated NPR gas atmosphere. Tank helium was passed through a solution of potassium acetate to give an inlet dew-point of 0°C (estimated). This gas was passed over 990 C graphite. The exit gas (non-equilibrium) contained 98.7% He, 0.5% CO, 0.7% H_2, and 0.005% H_2O. Samples exposed for 53 days and 107 days picked up little or none of the molecular hydrogen at 325 and 375 C. However, at 425 C the one sample tested picked up 645 ppm hydrogen in 107 days. It is necessary to assume that 96% of the corrosion hydrogen reacted with the metal in order to account for the hydrogen pickup. Since only 25 to 30% of the corrosion hydrogen is picked up in the absence of added hydrogen, it is concluded that a considerable amount of gaseous hydriding occurred.

The Effect of Hydrogen Pressure on the Hydriding of Zircaloy-2. In the January 1961 monthly report, experimental data were presented on vapor-blasted Zircaloy-2 coupons which were exposed at 400 C to 400 mm hydrogen gas containing one mm and five mm of water. An additional test in this series with 400 mm hydrogen and 23 mm water has been completed which shows that increasing the water pressure increases the corrosion rate and decreases both the hydrogen absorbed and the percent theoretical pickup. The increased corrosion rate is probably due to increased rate of transport of water from the water source to the samples.

Autoclave tests at 400 C on Zircaloy-2 and Zircaloy-4 in 15 psia water vapor with 1000 psia hydrogen overpressure resulted in a higher hydrogen pickup and a lower rate of oxidation than has been observed at the normal test condition of 1500 psi steam. The corrosion rate did not approach the normal value, either at low rates or when the number of samples in the autoclave was reduced, as might be expected if the reaction were limited by gas diffusion. This suggests that the hydrogen inhibits the oxidation rate. Further tests are planned.

Corrosion Evaluation of the Irradiated KER-1 Zircaloy Process Tube. The first corrosion data on rings cut from the unirradiated section of the KER-1 Zircaloy-2 process tube show that the corrosion rate in 300 C, pH 10 water is erratic and much higher than that of standard specimens. These preliminary tests suggest that regions of the KER tube may have been corrosion-prone. It is not possible at this time to tell whether corrosion of the ring samples occurred chiefly on the inner or outer surface. At the completion of the test, the rings will be sectioned in order to estimate the relative corrosion rates at each surface.

Reactor Rear Face Corrosion. Two failed rear face pigtail connectors (Parker fittings) from B-Reactor were examined. These austenitic stainless steel fittings were welded to the rear cross header. One fitting was screwed into a stainless steel temperature detector fitting and the other into a brass pigtail adaptor. These are presumed to be original reactor equipment. Metallurgical investigation of the failure indicated both had failed by intergranular cracking. Both fittings showed extensive intergranular carbide precipitation. The fitting attached to the stainless steel temperature detector had only a few localized cracks. The other fitting showed many cracks throughout the area under the brass nut. All cracks were intergranular. The brass nut showed corrosion in the threaded portion.

The preliminary examinations suggest that the fitting in the stainless steel temperature detector failed by intergranular stress corrosion due to carbide precipitation, while the fitting in contact with the brass pigtail adaptor failed by intergranular attack caused by an aggressive chemical agent such as is found in a decontaminating solution.

Etching and Autoclaving Beryllium-Brazed Fuel Elements. Until recently, FPD has had difficulty in obtaining a black autoclave coating on welded end closures of beryllium-brazed Zircaloy-clad fuel elements. A cooperative investigation has suggested that several phases of the etching process are critical in obtaining a black oxide on beryllium-brazed material. Although the end closures contain beryllium, it is still possible to obtain a black oxide coating during autoclave testing. During the investigation all of the test pieces which received moderate agitation (30 cycles per minute) during etching and that had 1-1/2 mils of surface metal removed had shiny black surfaces following the autoclave exposure. Additional rinsing or brushing of the fuel elements following the HNO_3-HF was not helpful in producing a black oxide coating on the welded ends of the fuel elements. The use of sulfuric acid rinses following the HNO_3-HF caused accelerated corrosion on the welded ends during autoclaving.

Radiometallurgy Laboratory Studies

Eight tube-in-tube coextruded elements were examined and found to have no defects other than slight bumping and 100 mils double throw warp on one of the inner tubes (RM-706).

Non-homogeniety and core cracking was found in the outer component of an unalloyed KER tubular element. Further examination will be done by electron microscopy. Samples were cut for density determinations and for burnup analysis. Results and interpretations of these examinations will be reported in more detail in connection with the development programs served (RM-569).

Basic Metallurgy Studies

Radiation Effects in Structural Materials. The effects of irradiation upon zirconium and Zircaloy-2 are being investigated. Lattice spacings of 20 specimens of zirconium irradiated to exposures from 2.9 x 10^{18} to

1.2×10^{20} nvt have been made and show that the c/a ratio of zirconium increases with increasing neutron exposure. Both the c-axis and a-axis decrease, but a decreases faster than c. The c/a increased from 1.59770 in the unirradiated state to 1.59885 at 1.2×10^{20} nvt. Line width of the 104 Cr k α_1 increased from .50° 2 θ to .70° 2 θ.

In order to augment limited data on changes in mechanical properties of structural materials resulting from radiation damage, tensile specimens of Zircaloy-2, Zircaloy-3, aluminum alloys X-8001 and M-257, magnesium alloys HK-31A-H24 and A-3XA-0 and AM-350 stainless steel were irradiated in the 105-KE magazine facility. Three charges accumulated exposures of 7×10^{19} nvt, 3.19×10^{20} nvt, and 6.25×10^{20} nvt (thermal), respectively. As a continuance of the program, the AM-350 stainless steel alloy has been tested. This alloy is one of the hardenable stainless steels which combine the formability and corrosion resistance of austenitic stainless steel with the strength of martensitic types. The pre-irradiation heat treatment given to these specimens consisted of a high temperature solution treatment followed by a low temperature quench and an intermediate temper for improving ductility. A comparison of the effects of irradiation on mechanical properties of this alloy is shown in the following table. Values are averages of two samples tested at each exposure condition.

Irradiation Exposure nvt thermal	Strength - 1000 psi .2% Yield	Ultimate	Young's Modulus 10^6 psi	Elongation % Uniform	Total
Unirradiated	171.3*	209.9	33.1	--	10
7×10^{19}	186.5	217.7	30.2	5.4	7.4
3.19×10^{20}	199.0	225.8	29.7	3.5	5.9
6.25×10^{20}	206.5	230.5	28.7	4.0	5.4

*Measured at .1% offset.

Calculations of displacement rates in zirconium and Fe in various neutron flux spectra have been carried out. The rates calculated on the assumption of a mono-energetic neutron flux have been compared to those calculated using a cascade model. Displacement rates assuming that the measured neutron flux is equivalent to a mono-energetic one Mev source are in error and lead to an underestimation of the damage sustained. An irradiation in the MTR and in the Hanford reactors for an equivalent quoted exposure of 10^{21} nvt fast flux ≥ 1 Mev does not result in the same number of displacements. Since the total fast flux component above one Mev in a Hanford reactor represents a smaller proportion of the total flux than it does in the MTR, the total number of displacements for zirconium in the Hanford reactor will be over 50% higher than in the MTR to the same quoted exposures to ≥ 1 Mev neutrons. In making estimates of the neutron exposure, therefore, the total neutron flux spectrum should be considered.

Electron and Optical Microscopy. The study of the microstructure of cladding and fuel material before and after irradiation is a direct way of detecting radiation induced damage in these materials. Irradiation of specimens in the Quicky Facility and Snout Facility have continued. Foils

of aluminum, approximately 0.003" in thickness have been thinned after an irradiation dose of 1 x 10^{19} nvt (thermal), and have been studied in the electron microscope. Both the annealed and cold worked foils disclosed the presence of a small number of dislocation loops, approximately 300 A in width. Since no such loops were detected in similar, unirradiated foils and since they resemble loops observed in aluminum quenched from high temperatures, it can be concluded that the irradiation has produced an excess concentration of vacancies which, after clustering, collapse and form the small dislocation loops. The movement of dislocation lines in the irradiated aluminum appeared to be impaired, compared to the motions observed in non-irradiated control specimens. Since the dislocations after the irradiation appear to contain a large number of jogs and frequently exist as tangles, additional energy is required for their movement. Interaction between collapsed vacancies, the small dislocation loops, and normal line dislocation has also been detected. That this actually is the case is demonstrated by a series of sequence micrographs which show several moving dislocations which become pinned at the point of intersection between the stationary, small loop and the moving dislocation. These observations provide direct experimental evidence on the effect of irradiation on the plastic deformation modes of metallic materials. X-ray diffraction line breadth studies as an additional technique for studying irradiation-induced defects are being applied. Specimens having exposures of 1 x 10^{20} and 2 x 10^{20} nvt (thermal) have been received. As soon as their radioactivity decays, they will be examined.

X-Ray Diffraction Studies. The crystalline perfection of large metal single crystals before and after neutron irradiation is being studied. Diffraction intensities from ground and polished faces of the sample crystals are measured for all available orders of reflection, placed on an absolute scale, and compared with intensities calculated from the "ideal Mosaic" model. The results can be interpreted in terms of the sizes of the "blocks," or coherently diffracting domains, and the degree of misalignment between blocks.

An aluminum crystal ground to expose a surface parallel to the 111 planes shows considerable secondary extinction and negligible primary extinction. The magnitude of the secondary extinction indicates an angular misorientation of about 2-1/2 minutes of angle; the absence of primary extinction means that the block size is less than about 1000 A. A second aluminum crystal having a 100 face exposed is being studied. Additional crystals of higher purity are being obtained for this study

Measurements of diffracted intensity from a 110 face of molybdenum crystal show strong primary extinction, from which a block size of 2.8 microns can be deduced. These measurements were made after grinding but before chemical polishing, so the surface may contain some residual cold work. These measurements will be repeated after chemical polishing.

A copper crystal ground to a 111 face has given inconclusive results, possibly due to the greater depth of the surface cold work. Crystals of nickel and zinc are being prepared for this study

X-ray diffraction is being used to study the effects of irradiation on molybdenum. Isothermal lattice parameter curves in the temperature range 100-180 C have been interpreted as resulting from two successive processes. The first is approximated by an equation of the form

$$df/dt = f \ 10^{1.3} \ e^{9,3000/kT}$$

the second by $$df/dt = f \ 10^{4.5} \ e^{16,400/kT}$$

where f is proportional to the damage (measured by lattice parameter expansion) present at time, t. The first process is believed to be related to the release of trapped interstitials and their annihilation at shallower traps, clustering or cancelling out with vacancies. The second process may be related to carbon migration. Maringer and Schwope have used internal friction to study carbon movements in Mo and find a peak at approximately 250 C representing a thermally activated process with an activation energy of 15,200 cal/mole. This is close to that for lattice parameter recovery, 16,400 cal/mole, found above. Data of D. C. Martin on cold worked molybdenum has been re-analyzed in terms of this model, and it was found that his resistivity versus time curves could be broken into two processes also.

Zirconium Alloy Studies. Melting of the 13 zirconium base alloys is nearly complete. Five alloys have been forged from 2-7/8" diameter to 3/4" and are prepared for hot rolling. One alloy is partially forged; five are ready for lathe turning preparatory to forging; and two remain to be prepared for second melting.

Forging of first melt ingots into 1-1/2" diameter electrodes has not proved successful due to the poor surface condition of the turned ingots. This condition is attributed to MgCl present in the compacted bars. During melting the high vapor pressure of the MgCl and its violent evolution create unstable arc conditions resulting in splattered metal, folds and gas holes in the ingots. These defects when forged cause oxide entrapment and further cracking of the work.

Most successful preparation for second melting has been accomplished by sawing the ingots into longitudinal quarters, welding the quarter sections together, and remelting.

Metallic Fuel Development

Fuel Irradiations. Radiometallurgical examination was continued on the KER tube/tube elements irradiated to an average 3200 MWD/T exposure in KER Loop 2. The failed inner tube was examined earlier, and work this month was concentrated on the outer tube from the same element. Two recrystallized zones were found in the fuel at the mid-length of the element. Extensive intergranular cracking has occurred in the recrystallized zones and the clad has separated from the uranium. The bond itself has not deteriorated, but the uranium adjacent to the bond has failed. A uranium-two a/o Zircaloy core outer tube from the same irradiation was also examined. In this element there were no cracks and no sign of recrystallization.

The first KER loading of enriched single tube fuel elements (KSE-3) was discharged from KER Loop 4 during January after attaining an exposure of 1200 MWD/T. These elements are 18 inches long, have Zr-Be eutectic brazed closures and are supported by iron rails attached to the fuel element surface with Zircaloy-2 studs. Operating conditions of the co-extruded tubes simulates those expected in NPR outer fuel tubes.

Examination of the discharged elements at the K and C Reactor basin facilities showed no obvious changes in the elements as a result of irradiation. The iron rails were black upon discharge, and there was no apparent dimensional instability or bumping. There was no discoloration or obvious corrosion of the brazed closure. One of the four elements was shipped to the Radiometallurgy facility and has been examined superficially. Again, there were no visible indications of fuel element misbehavior. This element will be examined in more detail during March.

The above fuel elements were weighed in water against an unirradiated standard piece for the direct determination of swelling behavior. Calculations of the irradiation-induced volume increases from the weight data for three of the four elements were in good agreement and showed a 1.3 percent increase in the uranium volume. These figures correlate well with swelling data from previous testing.

Two NPR inner elements with brazed closures, GEH-4-57, 58, which are currently being irradiated in the MTR have received more than 750 MWD/T to date. These elements are operating at 75 kw/ft with a uranium surface temperature of 180 C and a core temperature of 350 C. Exposure has been authorized for 1000 MWD/T. The closure alloy is 12 Fe + 4 Be + 84 Zry-2.

An old size NPR inner tube (KSN1) fuel element ruptured in a KER Loop after 1700 MWD/T exposure. Examination in Radiometallurgy confirmed that an end cap failure had occurred. The failure consists of a circumferential crack in the weld and in the Zircaloy-2 clad in the adjacent heat affected zone. The crack continues for at least 180° around the circumference of the cap and is approximately 0.010 inch wide at the widest point. To form the closure on this element, a flat end ring was fitted flush against the uranium in a chem-milled and machined recess and welded in place using a heliarc weld.

Failures of Zircaloy-2 clad uranium rods and tubes as a result of localized clad straining have occurred in NaK capsules and high temperature recirculating water loop irradiations. Calculation of circumferential cladding strains from the measured pre- and post-irradiation diameters of Zircaloy-2 clad rods irradiated in NaK capsules to 2000 MWD/T has been completed. Those rods with 0.020 inch cladding showed from 1.5 to 2.0 percent cladding strain and those with 0.030 inch cladding all showed less than 1.4 percent cladding strain. The 0.020 inch clad rods all suffered ductile failures or localized plastic strain (necking) in the cladding. None of the 0.030 inch clad rods showed indications of localized plastic strain; however, one rod incurred a brittle clad failure. The strain in the cladding of this latter rod is less than 0.4 percent.

Circumferential strain in 0.020 and 0.030 inch clad rods irradiated to 1100 MWD/T have the same relative values as found at the higher exposure; that is, the strain for the 0.020 inch clad rod is greater than for the 0.030 inch.

Measurement of the local cladding thickness on a striated 0.020 inch clad rod showed that local plastic deformation had occurred where the cladding thickness changed from 0.022 inch average to 0.013 inch within a 0.050 inch gage length. There were several other locations where the cladding was only 0.015-0.016 inch thick, but the thickness changes were gradual. The 0.030 inch clad was found to have equally as large thickness variations over the same gage lengths, but the percentage thickness change was considerably less than for the 0.020 inch rod. It would appear, then, that an appreciable percentage thickness change over a short gage length may be necessary to initiate local clad instability.

To further study the effects of cladding thickness variations on the susceptibility to failure, a series of NaK capsule irradiations of Zircalcy-2 clad fuel rods is planned for the Hanford reactors. Welding and assembly of the capsule parts has started. A 0.600 inch diameter Zircaloy-2 clad rod of U - two w/o Zr alloy has been coextruded. Measurements of the cladding thickness variations are now being made on this rod. Electrodes for vacuum arc melting of unalloyed uranium for additional extrusions have been machined.

The sixth in the series of in-reactor rupture tests of metallic fuel elements at the ETR is planned for March. This test will use an NPR inner tube (KSN1) which has been irradiated here at Hanford to 1660 MWD/T. The previous test used an unirradiated KSN1 element. The fuel, the basket, and the tools for assembling the experiment have all been shipped in preparation for the test.

Heat Treatment Studies. A marked columnar grain structure has been observed in some fuel element geometries after various heat treatments. In order to keep the grain structure as small and random as possible in future heat treatments, information must be obtained concerning the cause of the columnar grain structure. Toward this end, an investigation has been undertaken to determine the effect of fuel geometry, heat treatment, and the as-extruded grain structure on the resulting beta-treated grain structure. Samples of KER inner and outer tubes, NPR inner and outer tubes, and KER single tubes have been obtained. Metallography has been completed on the as-extruded samples and shows that a very large variety of as-extruded grain structures are available for study. Quenching methods used will include nitrate quench, oil quench, water quench, and air cool. Thermocouple holes have been drilled in the samples and the Visicorder is being prepared so that measurements of thermal gradients across the samples during heating and quenching can be obtained.

Fuel Component Development. Samples of iron clad, Zircaloy-2 supports are being subjected to decontamination testing. Two 8-inch long simulated fuel elements, having both 1008 steel and ingot iron clad supports are being tested. The iron and steel were charged in the "bright" and in the auto-

autoclaved condition. Coupons of each material are also being tested to determine extent of decontaminant attack. Test candidates are being subjected to one and two decontamination cycles.

Closure and Joining. An investigation is under way to determine the effect of beryllium and uranium in Zircaloy on corrosion and metallographic properties. This investigation encompasses a total of 40 alloys. The first ten alloys have beryllium contents varying from 0.35 to 4.20% Be; the next six alloys have a fixed uranium content of 250 ppm with beryllium contents from 0 to 4.80 Be; the remaining alloys are identical to the second series except the uranium content is increased in each series to 500, 750, 1500, and 2500 ppm of uranium, respectively. All of the alloys were made in the form of arc melted buttons of 100 grams each. Chemical analyses were made for beryllium and uranium in each alloy. These buttons were then cut to corrosion coupon size and etched in the standard Zircaloy bright etch. In each case the presence of beryllium caused the surface to be dulled, but not in proportion to the beryllium content. However, when uranium as low as 250 ppm was added to the alloys, the surfaces etched darker in proportion to the beryllium content. The surface in the uranium-containing alloys ranged from bright and smooth in the alloys with no beryllium to dull black above 4% Be. The beryllium additions caused only a dulling of the black autoclave film after 100 hours in 400 C and no white oxide was observed. Weight gains appeared to be constant at 0.020 mg/mm^2. However, a heavy white oxide film was observed with samples containing as low as 250 ppm of uranium at 4.8% Be, but at no lower beryllium content. The other uranium-containing samples have not yet been autoclaved. Metallographically, the beryllium tends to separate as a second phase after a 30-minute heat treatment at 900 C followed by a cold water quench, even at concentrations as low as 0.35% Be. The phase diagram indicates solid solubility up to two w/o Be at these temperatures. At 1.95% Be the basic Zircaloy structure changes to a dendritic structure in a matrix of the intermetallic compound $ZrBe_2$. At 3.26% Be, the dendritic structure gives way to the eutectic structure. Uranium is not readily observed in the structure at least up to 500 ppm. However, there appears to be an apparent increase in the tendency to form subgrains in the Zircaloy with an increase in the uranium content. Microhardness increases sharply from 200 DPH for 0.35% Be material to 380 DPH for the 4.2% Be material. Uranium additions appear to make the structure even harder and more brittle.

Two fuel elements brazed with the BeZirc brazing alloy have been subjected to more than 600 thermal cycles from 120 to 300 C over a period of the past five months. The closure on these elements still appears black with no sign of breakaway corrosion.

Autoclaving of welds made on pure Zircaloy-2 tubes by the filler metal process has shown the process to be acceptable thus far, inasmuch as no corrosion appeared on the specimens after the autoclave cycle was completed. As yet, no actual fuel element specimen has been autoclaved because the welding apparatus is not capable of making a satisfactory weld over the braze on the ID of the tube. A change in the equipment is presently being made to facilitate such a weld.

Sputter and overhang were virtually eliminated when welding on the fuel element specimen by changing the step cut design and by lowering the weld area open to the atmosphere. Four variations in the weld step design have been tried, two of which show excellent results. It is the step design that determines the amount of overhang, partially determines the amount of beryllium in the weld metal, and helps control sputter. The inert gas atmosphere is the major factor in controlling sputter. The two-step cuts that give good results on the sputter and overhang also have contributed a major reduction in the beryllium contamination of the weld.

Several Zircaloy-2 clad coextruded NPR outer tubes (2.460 inch OD by 1.850 inch ID) have been successfully hot headed for the hot headed projection welded closure. The heading difficulties encountered on this size tube due to flashing between the heading dies and the heading container were overcome by placing a 1/16 inch thick graphite ring on the end of the tube prior to heading.

The swelling of the tube OD at the junction of the heading container and the gripping device is approximately 0.025 inch and can be reduced to approximately 0.005 inch by a subsequent drawing operation.

The projection-welded resistance-brazed closure developed on Zircaloy-2 clad coextruded rods was attempted on Zircaloy-2 clad KER inner tubes using full capacity of the 100 KVA welding machine. The attempts to obtain the initial projection weld produced promising results with the ID cladding and the Zr-2 closure cap being completely welded and the OD cladding and the cap being welded in spots. These results indicate that additional power is necessary to produce a satisfactory weld at the OD. No attempts were made to resistance braze the cap to the uranium surface pending a satisfactory and reproducible projection weld.

Attachment of Zircaloy supports to Zircaloy clad fuel elements requires a high quality weld which does not damage the clad, bond, or uranium core. Previous work has shown excellent welds obtained on the 100 KVA resistance welder using 350 pounds electrode pressure. During the month a low inertia electrode holder was obtained. This is a device which spring mounts the electrode and part of the holder. The spring pressure is adjustable With this holder it is possible to make excellent welds with 150 pounds electrode pressure. This is due to the design which requires only a small part of the holder to move during the weld whereas using the standard holder requires the upper arm assembly of the welder to move. The 350 pounds electrode pressure is required mainly to overcome the inertia present in the welder. The advantage of lower electrode pressures is reduction in power required to make the weld.

Because of the uncertainties involved in non-destructively testing and comparing the quality of experimentally developed fuel element closures by use of existing ultrasonic methods, an alternate or supplementary test method was sought. A procedure based on the principle of sonic vibration damping rather than that of transmission or reflection of ultrasonic waves appears to afford a satisfactory solution to the problem. Although this

new method shares one disadvantage with the ultrasonic method; viz., that unbonded subsurface layers held intimately together under stress give an indication of a sound bond, it offers several advantages not provided by the latter:

1. A liquid couplant is not required, thus dispensing with water baths or tanks.
2. With a stylus of small diameter (< 1/16") resolution is excellent, permitting the pinpointing of subsurface defects (up to ~0.050" deep) of approximately 1/16" diameter.
3. The reading is affected far less by surface and buried interfacial irregularities than is the ultrasonic method.
4. Resolution and sensitivity increase with decreasing thickness of material intervening between the point of transducer contact and the buried flaw.
5. The equipment involved is inexpensive and rugged, thus better adapted to operation by unskilled operators.

A complete description of this device and its operation is given in HW-68653.

Several closures fabricated by the "self-brazing closure" process (formerly known as the "extrusion-closure" process) were checked with the new testing device. It was revealed that the closures were not consistently sound, but it appears that increasing the thickness of the copper plate on the cap tends toward improved bonding. Another set of sample closures is being prepared to test this proposition more thoroughly. In any event the integrity of the "self-brazed" closure appears to be at least as good as that of the products of alternate processes.

Fuel Straightening. The three-roll straightener has been used to straighten ten 17.34-inch long fuel tubes. Six tubes were N outer tubes, and four were N inner tubes. The extrusion striations on the outer tubes made accurate warp reading difficult, but, in general, the material left the straightener with approximately 0.003 to 0.005 inch double throw warp compared to 0.006 to 0.013 inch double throw warp prior to straightening. The four inner tubes were straightened to 0.003 inch double throw warp. Their pre-straightened double throw warp ranged from 0.009 to 0.033 inch. All tubes were heated prior to straightening to 580 C in an argon atmosphere.

Fuel Deformation Studies. An initial study (HW-67939) of a fuel element model which allowed for the thermal expansions and swelling of the fuel material indicated that the fuel cladding of a tubular fuel element can proportion the deformations. Since the original fuel element model did not have a material model for the cladding material which would account for the cyclic nature of the straining, the relative restraints of inner and outer fuel element cladding could not be realistically estimated. A new fuel element model allowing for no resistance to shearing stresses within the fuel material but allowing for the cyclic behavior of the cladding material has been developed. In order to obtain the physical data necessary to evaluate the property of the cladding under the proposed cyclic behavior, a testing frame, loading mechanism, and extensiometer have been designed. Fabrication of the extensiometer is under way.

2. REACTOR PROGRAM

Coolant Systems Technology

Present Reactor Decontamination. Seventeen runs were completed this month on potential decontaminants. Those tested were Sulfam-3 (Turco 4306-C) with diatomaceous earth, Sulfam-3 at high flow rates, Bisulf-5 (Wyandotte 5043), Bisulf-16 (Wyandotte 5061), Glycolic (Hydroxy-acetic) acid, nitric acid and hot water. A ten-minute flush with 150 ppm diatomaceous earth at about 10 feet/second does not increase the decontamination factor of aluminum with Sulfam-3, but does yield higher decontamination factors for stainless steel pigtails. Decontamination factors for stainless steel averaged 400 for three tests with Sulfam-3 followed by diatomaceous earth, and averaged 160 for six similar tests with Sulfam-3 alone. The candidate decontaminant Bisulf-16 at 70 C is effective with a long contact time. Bisulf-5 did not decontaminate either aluminum or s/s under any of our test conditions.

Pump Purging During Decontamination. Tests were made in the laboratory and in ELMO-7 loop to determine the water purge rate required in canned motor pumps to prevent decontaminants circulating in the loop from mixing with the motor coolant. The conclusions of the tests are:

1. A purge velocity through the shaft annulus of 3.5 fps is adequate to prevent mixing of the decontaminants and the motor coolant when the pump is operating.

2. When the pump is not operating, a velocity of 1.5 fps is adequate.

3. The intermixing of the purge and decontaminant solutions when the pump is operating is a result of mechanical mixing as well as diffusion.

4. Higher viscosity solutions require less purge than lower viscosity solutions, probably because of the decreased turbulence in the annulus. NaOH-$KMnO_4$ solutions require only about 1/4 the purge rate of HNO_3.

Film Studies - High Temperature Systems. One of two heat exchangers from the KER-1 cleanup system now at 242-B has been disassembled. Autoradiographs of the end cap, tube sheet, and portions of the header show quite clearly that there is preferential activity deposition in the machine marks and imperfections of the metal. Considerable quantities of radioactive particulate matter have also been found on both the lower side of the header and where the header meets the end cap. Sections of tubes from the tube bundle of this heat exchanger have been removed for activity exchange studies.

A section of a 2-1/2" schedule 80 pipe from KER-3 was acquired during the past month. This is being used to perfect a technique for autoradiographing inner pipe walls. Later this technique will be used to study the distribution in straight piping sections.

Scaling of Heat Exchanger Surfaces. Four sections of the KER-1 cleanup heat exchanger tubing (schedule 80, 3/4" carbon steel pipe) were descaled and examined for localized corrosion. The tubing was in good condition on the side exposed to the primary water, but numerous pits up to 1/16" in depth were found on the raw Columbia River water side. Before descaling, the side exposed to the raw water was covered with a very thick coating of rust, tubercules, and mud which had nearly completely blocked the water flow. A large amount of the coating was lost in obtaining the sections, but weighing of four samples in the moist condition resulted in an average weight of about five grams/inch of rust formation on the four samples. The average corrosion on the four samples, assuming all the attack was uniform and no pitting was present, was 15 mils. The heat exchanger had been in service since early in 1958.

KER-1 Loop Coolant. The in-reactor section of KER-1 was decontaminated December 8, 1960, using a single-pass Phos-1 process. Special coolant samples were drawn following reactor startup to evaluate the effects of decontamination on water purity. The phosphate concentration after decontamination was as high as 1.5 ppm. This has decreased slowly and approximately linearly with time to about 0.10 ppm. Since the normal phosphate concentration is less than 0.02 ppm, some phosphate is still being removed from the piping film.

The total solids concentration immediately following startup was as high as 22 ppm. This value decreased to the normal level of approximately 10 ppm early in January. These tests suggest that loosened film particles are removed, and/or the corrosion rate is increased for a few weeks following the decontamination. The iron, chromium, and calcium concentrations were also considerably higher than normal during the first few days after startup; these concentrations returned to normal by early January.

Structural Materials Development

NPR Process Tubes. The fluorescent penetrant tests at Harvey Aluminum and at Hanford are now in good agreement. Both sites are using the same black light source. Use of the water base developer has been discontinued. This eliminates the heavy deposits of developer remaining from uneven drying of the developer film. These deposits were the source of many of the spurious readings in the black light borescope examination. Harvey is applying the developer by drawing a swab soaked in the alcohol base developer through the tube. This dries immediately leaving a thin uniform film. Hanford develops the inside of the tubes by blowing a dry powder type developer through the bore. With this method a uniform film is formed free from concentrations of developer. This provides an excellent background against which to read the fluorescent indications.

The previously reported metal tear defect in NPR process tubes continues to plague the vendor, having affected about 50 tubes to date. Sectioning by Harvey has shown the tear to be accompanied by an underlying laminar-type defect that can be more than 1/2 inch long. It is suspected that the laminar-type defect can exist without tearing through to the surface to reveal itself visually. Attempts are being made to detect such a defect nondestructively.

An innocuous defect is present in some of the tubes in the form of a shallow smoothly rounded "groove" in the inner tube wall. These grooves, which may be up to 3/8" wide by 0.010" deep by an inch to several feet long, produce a "lost signal" on the Vidigage instrument. However, they are not considered cause for rejection if the wall thickness and inside diameter of the tube are within specifications at that point. About 40 tubes have been delivered that showed a momentary "lost signal" on the Vidigage but were shown to have acceptable dimensions.

It is suspected that a hidden laminar-type defect in the tube wall may cause a loss of Vidigage signal in a manner similar to that of the "groove" defect. Some of the tubes reported to have "lost signal" areas on the vendor's Vidigage have been checked on the same type instrument at Hanford. In most cases it has been possible to confirm the results of the vendor's test. Reflectoscope, Immerscope, and radiographic tests have confirmed the presence of a "groove" type defect in these areas. No laminar-type defects have been discovered.

Chase Brass and Copper Company has seven tubes that have been accepted by G.E. inspectors toward their quota of 15 tubes due on March 10. An additional 14 were submitted for inspection this week. Corrosion tests have been completed and accepted on all these tubes.

Stress Rupture Facility - Project CGH-896. Bids for constructing the facility were opened on 2/2/61. Of the 10 bids submitted the low price was $69,400. This bid was under the fair cost estimate but exceeded the funds available. A project revision for an additional $10,000 was prepared and has now been approved. Construction should begin in March.

Nonmetallic Materials Development

Graphite Burnout Monitoring. Monitoring samples were discharged from 3580-F after 447 operating days. The average percent weight loss per 1000 operating days determined from five samples in upstream, center, and downstream positions of the channel were respectively 0.48 ± 0.05, 5.2 ± 21.7, and 0.04 ± 0.00. These samples, which were all cut from the same graphite bar, were previously exposed in 3580-F in the same relative positions as this test. For comparison, the previous average rates were 0.85, 0.78, and 0.04. As can be seen from the latest data, the scatter of rate values for the center boat is very great. A likely explanation is that water, loaded with minerals from the rusty piping, splattered onto some of the samples during charging. Upon evaluation of the water in the reactor, the iron catalyst remained on the graphite samples, resulting in a wide range of burnout rates during the test.

Graphite Compatibility with Helium Containing 0.1 mm of Water Vapor. Lower oxidation rates than those reported previously have now been obtained as a result of eliminating back diffusion of air into the system. At a temperature of 830 ± 3 C and a flow of helium of ~2.0 cfh, the following rates have been obtained:

Condition	Specific Rate (g/g-hr)	Relative Rates
Dry Helium	6.0×10^{-7}	1.0
Wet Helium (150 ppm H_2O)	3.3×10^{-6}	5.5
Wet Helium + 3% CO	1.5×10^{-6}	2.2

Experiments are planned in which hydrogen as well as carbon monoxide is added to the gas system.

NPR Graphite Evaluation. The compressive strength has been determined on four bars of TSX (NPR core) graphite. Maximum, minimum, and average values are 4489, 4061, and 4186 psi, respectively. The measurements were made by loading the 6" x 6" face of 6" x 6" x 5" samples. These values are somewhat higher than the compressive strength of 3390 psi measured on AGOT-LS (NPR reflector) graphite. The difference in strength could be attributed in part to the difference in sample sizes, since the AGOT-LS was loaded on the 4" x 4" face of a 4" x 4" x 5" sample.

The modulus of rupture has been determined for several bars of TSX graphite. One group of six samples had a maximum modulus of 3496 psi and a minimum of 2694 psi. Another group of four had a maximum modulus of 3576 psi and a minimum of 1864 psi. The results are scattered and the low results appear to be due to internal defects in the individual bars not visible before testing.

Irradiation of TSX (NPR Core) Graphite. Samples of TSX graphite have been irradiated to 1257 MWD/AT in a Hanford hot test hole. The percent length change per 1000 days on the TSX samples and on samples of CSF included as controls are as follows: TSX ($\perp$), 0.011; CSF ($\perp$), 0.007; TSX ($\parallel$), 0.009; CSF ($\parallel$), 0.002. The greater initial expansions indicate an improved stability towards contraction at higher exposures.

The GEH-13-5 graphite irradiation capsule containing NPR reflector graphite is scheduled for removal from the ETR during the first week in March. The samples at that time will have been irradiated for four cycles to a total estimated exposure of 1.4×10^{21} nvt ($E > .18$ Mev) at about 700 C. Thermocouple #4 failed during the current cycle; heaters #3 and #4 are both on manual control for the remainder of the irradiation.

Radiometallurgy Laboratory Studies

Further examination of the KER Loop I tubing revealed that recrystallization previously reported apparently was caused by the cut-off operation. Four more tubing rings were crushed at 300 C and no significant differences were observed among these samples (RM-330). Results and interpretations of these examinations will be reported in more detail in connection with the development programs served.

Thermal Hydraulic Studies

Boiling Burnout Conditions for Eccentric Annuli. The program to investigate the effect on heat transfer conditions of the non-coaxial positioning of fuel elements within a coolant tube was continued. During the past month collection of data applicable to I&E fuel elements in a K Reactor process tube was completed for the case of 90% eccentricity. (Percent eccentricity is the fraction of the normal annulus thickness that the fuel element is displaced from a coaxial position toward the wall of the coolant tube.)

The test section used was a 24-inch long electrically heated rod, 1.457-inch in diameter, placed within a 1.681-inch ID tube. Data were obtained for two flow conditions of cooling water through the annulus. These were 40 gpm at 107 psig and 23 gpm at 53 psig, which represent conditions in the flow annulus for I&E fuel elements in the central and fringe tubes at a K Reactor. The temperature of the water at the inlet of the test section was held constant during each approach to boiling burnout but was varied during the investigation to obtain data at bulk outlet temperatures between 21 and 226 F below the boiling temperature. During each run, while the heat generation rate was gradually increased, temperature measurements were made of the heated surface and cooling water at selected points around the annulus of the test section. Each run was terminated when film boiling was encountered as detected by a large temperature excursion at some point on the surface of the heated rod. The data indicated that the boiling burnout heat flux for the 90% eccentric annulus was nearly constant for different values of bulk outlet water temperature. For the conditions of 40 gpm and 107 psig the burnout heat flux varied only between 250,000 and 305,000 B/hr-sq ft over the range of water temperatures investigated. Similarly, for 23 gpm and 53 psig the burnout heat flux varied between 171,000 and 220,000 B/hr-sq ft. These burnout heat fluxes are considerably less than those which were found for cases of lesser eccentricities. For example, for the case of 50% eccentricity at a low rate of 40 gpm, heat fluxes ranging from 1,150,000 to 1,450,000 B/hr-sq ft were found for outlet water temperatures between 60 and 130 F below the boiling temperatures at 107 psig.

During this experimental investigation it was noticed that the burnout heat flux was dependent upon the size of steps with which the heat generation rate was increased. When the heat generation rate was increased by large steps, boiling burnout was encountered at a lower heat flux than when the heat generation rate was increased very slowly. Since most of the data were obtained by slowly increasing heat flux, the results are probably non-conservative for application to reactor power surges.

Fuel Element Temperatures Following an Inlet Fitting Failure at a BDF Type Reactor. A laboratory program was started to study the effects of a sudden failure of an inlet hydraulic fitting on a BDF reactor process tube during reactor operation. The objective of this program was to determine under what conditions would the reverse flow from the rear headers be insufficient to prevent fuel element melting. Such information is of value in updating the reactor hazards evaluations.

Experiments were performed using a full scale electrically heated mockup of I&E fuel elements in BDF type process tube. With the test section operating under normal conditions, the inlet hydraulic line was opened suddenly at atmosphere and the rear header pressure was maintained at a constant pressure. After approximately three seconds the heat generation rate in the test section was decreased at a rate simulating a 500 in-hour scram of the reactor. The experiment was continued until all thermocouples in the heated test section had reached a maximum value and then started to decrease as the test section was cooled by the reverse flow from the rear header.

Data were obtained relating the fuel element temperatures to be expected following such an incident for various rear header pressures and an initial tube power of 800 KW. These preliminary data at this low tube power compare quite well with results of similar studies performed for the K Reactors (reported in HW-68214). In general, the data indicate it is marginal whether the water flowing from the rear header following an inlet piping rupture would be sufficient to prevent melting of the fuel cladding.

Heat Transfer Experiments Pertaining to the NPR. The studies to determine the boiling burnout conditions for the NPR tube-in-tube fuel element were continued. Experimental data were obtained in the heat transfer laboratory which are applicable to the outer flow annulus of the fuel element. The test section used consisted of a 24-inch long Hastelloy tube having an OD of 2.390 inches placed inside a 2.70-inch ID process tube. The Hastelloy tube was electrically heated and the heat generated was transferred to water flowing through the annulus. Thermocouples attached to the inside walls of the heated tube were used to detect the temperature excursions associated with boiling burnout conditions.

Nine boiling burnout points were obtained at 1500 psi for flow rates between 1 x 10^6 and 4 x 10^6 lb/hr-sq ft. During the increase in heat flux toward the tenth point the test section failed when a weld to the copper electrical lead parted. The test section was repaired and five additional burnout points were determined before a hole was melted in the test section. The film boiling in these runs always started at the bottom of the heated rod in this horizontal test section. This is opposite to the experience with flow inside of tubes where the boiling burnout always starts at the top of the water passage. The data reported here will be combined with results from previous and future experiments to verify the fuel element design conditions and establish the maximum operating limits for the reactor.

Calculated Time Before Melting of an Uncooled Hanford Reactor Fuel Element. During reactor fuel discharge operations the possibility exists of a fuel element becoming lodged in the rear face piping or other obstruction and not falling into the discharge basin where it is cooled by water. A computer program was written and calculations performed to predict fuel element temperatures as related to time after reactor shutdown and time after discharge of fuel from the reactor. Calculations were performed for tube

powers ranging from 1200 to 2000 KW and for times after discharge between one second and 100 hours.

A sample result is as follows. If a fuel element from a tube initially at 1600 KW became lodged in the rear piping of a K Reactor that had been shut down for 20 hours, it would be approximately 55 minutes before the aluminum jacket would melt.

These data will be reported in HW-67747 REV and used by IPD personnel in evaluating hazard and establishing procedures for instances where discharged fuel elements inadvertently do not enter the water storage basin.

Hydraulics. Ten CG-558 venturis, nominally 0.283 inch in diameter, were calibrated in the hydraulics laboratory. These venturis will be installed in the coolant lines of the H Reactor biological shield to determine if the flow is sufficient to meet process standards.

Shielding Studies

Shielding Instruments. A time-of-flight measurement has verified the existence of the unexplained peaks found previously with the Perlow neutron spectrometer when investigating the Be(d,n) reaction. New Be targets are being made to eliminate the possibility of carbon contamination, which could account for the observed peaks. A complete maintenance checkout of the spectrometer and associated electronics is under way.

Attenuation Studies. The first problem in calculating the neutron flux distribution throughout a reactor shield is to find a suitable source term for the multigroup equations. Three methods have been programmed and are being checked against the experimental results obtained in the DR Reactor bulk shield facility for several types of concrete. Using ORNL effective removal cross sections, the fast neutron flux was underestimated by a factor of about two. Using the removal cross sections suggested by A. E. Avery (AERE-R-3216), the fast neutron flux was underestimated by a factor of ten. The third method utilizes the Avery cross sections with the addition of a linear buildup factor. In this case the fast neutron flux was overestimated by a factor of about two, yielding a conservative approximation to the experimental data. This treatment appears to offer promise as a suitable source term for neutron attenuation calculations. The program for calculating resonance and thermal flux is now being debugged.

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 PROGRAM

1. PLUTONIUM RECYCLE PROGRAM

Plutonium Fuels Development

PRTR Fuel Fabrication. Fabrication has begun on the 30 replacement spike fuel elements for sustained operation of the PRTR. These elements will be the same Mark I-H design as the first loading, i.e., 19-rod cluster, Al, 1.8 Pu, 2 Ni alloy core and 35-mil wall Zircaloy-4 sheath tubing. Four hundred of the 600 tubes needed have been received from on-site inspection. All 400 tubes have been gaged, machined, and the first end cap welded. Two hundred have been loaded with cores, and 50 have been etched.

Considerable time has been spent between fabrications making improvements in the process equipment. Parts of the process in which rates of fabrication are expected to double are core fabrication, welding, loading, leak checking, and autoclaving. Pointing of the rods prior to drawing is now done by notching and applying a tensile stress so as to neck down the rod and cause a rupture at the notch. This is faster than the previous method of using a specially designed cutting tool, and it does not generate Al-Pu chips. Modification of the vacuum pumping system has decreased the pump down-time on the welding chamber by a factor of four, and weld closures have increased from 54 to 108 final welds in an eight-hour day.

Fabrication Development. Four capsules have been prepared for Nucleonics Instrument Operation. These include a straight PuO_2, a straight UO_2, a 0.466 w/o PuO_2-UO_2, and a 0.446 w/o PuO_2-UO_2 with a defect built into it. This defect is an area of about one-tenth of an inch which has a PuO_2 concentration double that of the rest of the capsule. These will be used in testing the application of a gamma spectrometer for a nondestructive testing device of UO_2-PuO_2 fuel rods. If this approach works, it will provide a method of testing for gross longitudinal fuel variation.

No method superior to autoradiography has been developed up to this time for the testing of microsegregation. A physical mixture of UO_2-PuO_2 (0.446 w/o) was prepared, and analytical samples were taken following the blending period. These samples were comprised of: (a) samples from various locations in the blend to detect possible segregation or layering, (b) a cut 10% sample of the blend to verify blend analysis, and (c) a sample from the walls of the blender to detect any retention of the PuO_2. Seven tubes have been loaded with the oxide mixture and are currently being swaged to full length elements. The loading method utilized a bottle and hose unit which was connected to the tube. The tube end, with loading unit attached, was sealed within a double bag and detached from the hood. The loading was then completed in the open room, using a shaking table to obtain the desired tap densities. Samples will be taken from the swaged rod for autoradiographic studies.

An alternative to using preswaged ends in fabricating UO_2-PuO_2 elements by cold swaging is the use of swagable end caps. Three designs were used in swage compacting dummy elements containing UO_2. The welds, which were variations of the head weld joint, all appeared satisfactory after swaging. Slight wall thinning was observed from two of the designs. Use of swagable end caps would eliminate the need for preswaging and possibly, the MgO end plugs. This would allow more uniform densities along the full length of the rod, and the larger tube opening would facilitate loading and decontamination.

The recovery of plutonium-uranium oxides from reject swaged rods has been a problem for some time. Normal methods of vibrating, shaking, etc., have not proved satisfactory in removing this tightly packed material from swaged tubes. In the best present technique an operator cuts the rods into short sections, squeezes them between the platens of a press until the tubing ruptures. He then beats the section against the side of a bucket until the material falls out. This is a very tedious operation which spreads oxide powder everywhere. The associated losses and spread of activity cannot be tolerated when plutonium or enriched uranium is involved.

In order to effect this recovery in a clean, inexpensive manner a simple piece of equipment was designed. This makes use of the differences between the elastic properties of the metallic cladding and the ceramic core. It was theorized that all of the conventional methods of emptying the tubes failed because no space was provided into which the oxide could move and "unkey" itself. It was thought that if the tube could be elastically deformed, the oxide would not behave in a similar manner but would, rather, fracture or unblock particles into the void area caused by the deformation of the tube. At first, air vibrators and hammers were tried for this job. Since they work on an impact rather than a pressure principle, they were not satisfactory. Next, a compression riveter, Gardner-Denver Model 10DCH-B-4½, was tried. The valving on this machine was altered slightly so that it would operate continuously as long as the control pedal was depressed. The riveter was mounted on its side so that the work could be fed through it vertically. The end of a scrap rod was cut off with a tubing cutter and a plastic bottle taped over the open end. When the riveter was set to compress the tubing about 0.060-inch, the oxide dropped out readily. It was necessary to turn the tube as it was fed through the dies. The feed rate could be increased by speeding up the riveter and also by setting up vibrations in the tube. A Martin BD-16 pneumatic vibrator was found to be very effective. Not only does this technique recover the oxide without splitting the tubing, but it catches the powder as it falls out.

Eight rods swaged to 90% theoretical density were thermally cycled in an autoclave under argon pressure for 60 cycles. The cycle conditions for this test were from 120 C to 350 C at a constant pressure of 1200 psi and required four hours per cycle. The average total length change for the 60 cycles was -0.0014 in/in or six mils over the 42-inch test length. The average diameter change was too small to measure accurately, being less than plus one mil on the 0.570-inch diameter.

Four Zr-Pu-Zr sandwiches were rolled into plates. The steel jackets were removed, and no contamination occurred on the plates. Qualitative stripping tests indicated the Pu-Zr bond to be weaker than the Zr-Zr bond. The Pu-Zr bond was similar to Al-Zr bonds previously obtained. Radiographs of the plates showed the plutonium to be distributed uniformly throughout the fuel length of the plate in a reticular structure. The four plates each contained a one-gram plutonium wafer. An attempt to roll three sandwiches each containing a four-gram plutonium wafer was unsuccessful when the steel jacket ruptured, spreading plutonium contamination into the room. Two things apparently occurred which had not previously occurred: (1) the plutonium was forced out of the Zr sandwich, and (2) forced out of the mild steel sandwich either at a cracked weld or through reaction with the steel. Three alternative solutions in order to prevent future occurrences are possible: (1) preweld the Zr sandwich, (2) lengthen intermediate heating times between roll passes to permit greater diffusion, and (3) use a higher melting Pu alloy for core material.

Zirconium scrap nibbled to approximately one-fourth-inch cubes was extruded to a solid rod. A section of the rod was exposed to the standard steam-autoclave corrosion test. Results of the test were well within the acceptable limits of zirconium specification. The rod was made by a 95% reduction extrusion at 850 C. Other chemical and mechanical properties of the extruded scrap are being analyzed.

Fuel Evaluation. The four-foot long Zircaloy-clad UO_2-PuO_2 7-rod cluster containing sintered and ground pellets has now received 68 days of exposure in the ETR 3x3 loop, or about 2300 MWD/T. The element is operating with a calculated maximum core temperature of 1850 C with an associated surface heat flux of 346,000 Btu/hr-ft^2.

The proposed prototypical PRTR 7-rod cluster rupture experiment which was sent to the ETR for testing has been rejected by the MTR-ETR Reactor Safeguards Committee. The reluctance on the part of the committee was primarily based on apprehensions related to the handling of plutonium ruptures. The committee raised seven points in question which are being answered or corrected in an effort to get the test approved at a later date. It is highly unlikely, however, in view of their decision, that the experiment will be performed prior to PRTR power tests.

All the capsules for the Phoenix irradiation experiment have been completed and a rough draft of the irradiation proposal has been prepared. The reactivity of the samples will now be measured in the PCTR prior to shipment to the MTR.

Radiometallurgical examination of the 42-inch long Zircaloy-clad 7-rod cluster which was subjected to about 72 thermal cycles in the ETR loop is continuing. Length measurements on individual rods taken over a 36-inch length were essentially unchanged. Also, end gap measurements taken on the center rod and one rod in the 6-rod ring were unchanged, indicating that the cores had not moved relative to the cladding. Examination of the element to date indicates that no physical changes have occurred as a result of its in-reactor cycling treatment.

The two capsules (GEH-14-27, 28) fabricated with Al - 2.1 w/o Pu - 2 w/o Ni alloy cores by injection casting are at the MTR. Recent analytical results show that the plutonium content was not 1.9 weight percent as reported earlier but was 2.1 w/o, and it was determined that a supplemental irradiation test document would be required before the specimens could be charged. The document (HW-68434) has been written and is being prepared for distribution.

UO_2 Fuels Development

Irradiation of Defected Fuel Elements. Irradiation of the second purposely defected UO_2 fuel element (HD-2) in a Hanford reactor began February 25, 1961. To date, no gamma activity has been detected in the effluent coolant even though the reactor was power cycled once (from ~ 1/4 full power to zero power then to full power) during startup. The 12-inch long, 4-rod cluster element contains sintered and crushed, natural UO_2 swaged to a bulk density of 90% T.D. Two rods are clad in Zircaloy-2 and two are clad in Zircaloy-4. One each of the Zr-2 and Zr-4 clad rods are defected with a 0.006" diameter hole near the center of the rod. This element will be irradiated at full power for approximately three weeks, after which additional elements will be similarly irradiated at increasingly higher power levels.

PRTR Fuel Elements. One modified Mark I PRTR fuel element was assembled for use in several power tests. The element comprises 13 standard fuel rods and six thermocoupled fuel rods, three in each ring. The thermocouples, swaged into the center of the UO_2, will indicate fuel temperatures during irradiation. A nickel-phosphorous high temperature brazing alloy was used for brazing the cladding of the thermocouples to the end caps of the fuel rods. An oxy-acetylene flame was used to heat the wire and the end cap to 1925 F, where the braze metal flowed readily. Porosity in the braze was revealed by radiographic inspection; it was eliminated by remelting the joints. A junction box was assembled for installation in the PRTR upper access space. Chromel-alumel extension wires lead from the junction box into the instrument cell.

High Energy Impact Forming of UO_2. High density UO_2 was prepared for a vibrationally compacted nested tubular fuel element to be irradiated in the ETR. The UO_2, which was previously pressed and sintered to the unsatisfactorily low density of approximately 90%, was ball milled to -200 mesh powder and compacted by high energy impact in stainless steel containers at 1100 C. Initial experiments using a conventional impact punch, capable of exerting pressures of approximately 200,000 psi, yielded compacted UO_2 having a bulk density of 93% T.D. The density of this material was increased to the required 95% T.D. by sintering for 10 hours in hydrogen at 1700 C. The UO_2 was cooled in helium from 1600 C, crushed, and screened to the particle size distribution required for vibrational compaction. The O/U ratio of the UO_2 was 2.005.

The UO_2 loaded in the center rod of the nested tubular fuel element was compacted by high energy impact using apparatus capable of exerting a pressure of 500,000 psi or greater upon the UO_2. The average particle

density was 97% T.D. This fuel was not given a sintering treatment after compaction, although it was heated to 800 C for six hours in hydrogen to make certain of an acceptable O/U ratio (less than 2.010).

Nested Tubular Fuel Element (Test GEH-12-22). A Mark II-C, nested tubular fuel element was fabricated by vibrational compaction for irradiation testing in the ETR 6x9 facility. This test (GEH-12-22) will provide pertinent data on a second generation PRTR fuel element geometry. The fuel element is 44 inches in over-all length and contains 33 inches of fuel vibrated to a bulk density of 85% of theoretical, (the particle density of the fuel was 95-97% T.D.). The fuel is contained in 0.060-inch wall Zircaloy-2 cladding having spacer ribs which were integrally formed on the tubes during extrusion. End caps were welded to the tubular cladding by a seam weld followed by a fusion weld. All components of the element passed a leak test, a weld radiograph test and autoclaving for 24 hours in 400 C, 1500 psi steam.

High Frequency Resistance Welding. It was demonstrated that the narrow line of gray corrosion product sometimes observed in the weld area of resistance welded ribs was due to a slight contamination by the atmosphere during welding. The difficulty has been eliminated by improving the inert atmosphere shielding during welding and by a light vapor blasting after welding. All major problems for producing an acceptable weld between spacer ribs (0.075" x 0.135") and Zircaloy-2 tubing (9/16" OD x 0.030" wall) now appear to have been surmounted. Ribs welded to loaded or empty fuel rods consistently have high weld strength and corrosion resistance and they are within dimensional limits. The over-all efficiency of the process still is low. This is being improved by redesigning several components of the machine to make it more dependable and to simplify operating procedures.

Coolant Systems Development

Fretting Corrosion. A Zircaloy-2 fretting test at 316 C and a pH of 10.0 was terminated after 494 hours in CEP-2. A carbon steel rod containing three carbon steel ribs was suspended vertically in a Zr-2 tube. At a flow of 30 fps a penetration of two mils on the Zr-2 tube was observed with only the normal loop vibration. The addition of three cps supplemental vibration resulted in a penetration of four to eight mils at the same coolant flow. These penetrations represent no improvement over results using Zr-2 supports. However, the carbon steel supports themselves suffered little penetration.

Corrosion and Decontamination of Pu-Al-Ni Fuel Cores. The corrosion rate of a ie-clad section of an irradiated PRTR Pu-Al-Ni fuel element was estimated from the increase in activity in the Irradiated Rupture Prototype Loop. A corrosion rate of approximately 400 mils/month was measured at 300 C in pH 10 demineralized water at a fluid velocity of about 16 feet/second. The rate of activity buildup was linear after the first two hours.

At the end of 15½ hours the corrosion test was concluded and the sample was dissolved by increasing the pH to 12. The loop and metal test coupons were decontaminated using a 10% nitric acid solution at 60 C followed by the APACE process. The beta-gamma and alpha activity of stainless steel and Inconel-X coupons indicated that a good decontamination was obtained. The Zr-2 coupons were not appreciably affected by the decontamination. The loop itself, especially the heater and filter, did not decontaminate as well as the coupons. The test section was the only point that was less than 10 mr/hr at the end. A second APACE resulted in only a slight reduction in activity. Since an aluminum oxide compound was suspected as remaining in the loop, a NaOH-$KMnO_4$ solution was circulated for about four hours and allowed to remain in the loop overnight. This step, followed with Turco 4518, resulted in a clean loop; all readings were less than 10 mr/hr.

Structural Materials Development

Process Tube Monitoring. Analysis of insulating gas gap measurements made after the 48-hour hot test of the PRTR primary coolant system in December indicated a decreased gas annulus of 80 mils from a nominal annulus of 270 mils on one side of tube 1857. After disconnecting the inlet and outlet jumpers the minimum annulus increased to 100 mils. Measurement of the process tube revealed a maximum bow of about 45 mils. Mechanical measurements after removing the tube showed only 24 mils bow. With the process tube removed, optical measurement of the shroud tube indicated about 85 mils bow. The process tube was reinstalled with the indicated bows in the same direction and the gas annulus remeasured, this time giving a minimum annulus of about 105 mils.

Tests were made at Lerma Engineering at Northampton, Mass., to determine the feasibility of using a closed circuit television camera-borescope combination to visually inspect irradiated PRTR process tubes. The combination appears feasible if high intensity diffused lighting and a high resolution TV camera are used. Further tests to determine the approximate lighting levels required are being made on-site. The housing and optics of the rented camera used for previous visual examination of the PRTR process tubes are being redesigned and waterproofed to permit use of the camera until the final visual inspection system is obtained.

Development of a PRTR process tube wall thickness probe using a commercially available Vidigage ultrasonic tester has continued. The voltage output from the recorder adaptor supplied by the vendor was found to be too low to actuate the Visicorder multichannel recorder used for the other PRTR monitoring instruments. The vendor has supplied an auxiliary voltage amplifier which furnishes an acceptable voltage. The amplifier is being repackaged to fit into the existing instrument chassis. A problem has been encountered in obtaining a single stable signal from the transducer crystals. Increasing the contact area and providing larger crystals to give higher energy signals are being investigated as possible solutions to the problem. The sensitivity of wall thickness crystals mounted on a fiberglass base with Hysol expoxy dropped to one-third the original value after 5×10^8 total gamma irradiation. The crystals

should still be usable at the sensitivity obtained, however. No reduction in sensitivity had been noted after irradiation to 1 x 10^8 R.

Zircaloy-4 Sheath Tubing. The number of sheath tubes rejected for fluorescent penetrant indications has increased during the past month. A selected sampling of these reject tubes is being examined to detect the source of the defects. To date, all indications have been of the same type. Metallography reveals what appear to be small impressed particles of zirconium. The elongated nature of the particles indicates that they have their origin early in the processing history. Two possible sources have been proposed: small shavings or burrs from cutting operations or the speck-like plateaus of zirconium that are frequently left on the surface by the uneven action of the etching solution used to strip the copper from the extrusion. As more data are developed they will be discussed with the fabricator in an effort to eliminate this defect.

It has been postulated that a substantial improvement in the quality of Zircaloy-2 sheath tubing and a decrease in price could be achieved through the use of ultra fine grained extrusions as a starting material prior to cold finishing operations. Experiments have been initiated to describe processing variables that influence the grain size. Ultra fine extrusions have been produced by the use of the warm extrusion method at temperatures of less than 1000 F; however, extrusion ratios are severely limited at this temperature by the strength of die materials. An equally fine grain size was produced by extruding at 1150 F. At this temperature extrusions ratios are double those attainable at 1000 F. Sample tubes extruded at 1150 to 1200 F are being prepared for subsequent coil forming by commercial fabricators.

Radiometallurgy Laboratory Studies

A 19-rod swaged UO_2 element which had ruptured was examined and disassembled. Rod Number 18 from the outer ring had ruptured at approximately the midpoint of the rod. The Zircaloy cladding split open for a length of about one and one-half inches (RM-615).

A 4-rod cluster containing recycled UO_2 was examined, disassembled, and each rod measured. The rod which contained sintered pellets had about 85 mils of warp, but the other three rods had practically no warp. There were no significant diameter changes in any of the rods (RM-625). Results and interpretations of these examinations will be reported in more detail in connection with the development programs served.

Thermal Hydraulics Studies

Boiling Burnout Studies for the PRTR Mark I Fuel Element. An effort was made to determine boiling conditions for the 19-rod cluster Mark I fuel element for the PRTR. The test section consisted of 19 thin wall (approximately 0.009 inch) Inconel tubes electrically heated by DC resistance heating. The tubes were each 0.564 inch in diameter, 16 inches long, and were supported on the inside by steel rods coated with a

ceramic insulation. The 19 rods were wire wrapped for flow mixing and spacing in the same manner as the reactor fuel elements. Thermocouples were installed in most of the rods between the Inconel tube and its steel cores to measure temperatures of the heated surfaces. The test section was placed in a 3.25-inch ID pressure tube.

Burnout conditions were approached at 1050 psig and a flow of 123 gpm (measured at 478 F) by gradually increasing the heat generation rate while holding the inlet water temperature constant at 480 F. The test section failed when the heat flux was increased to 900,000 B/hr-sq ft. While a temperature excursion was noted, it was not definitely determined that boiling burnout was encountered. Three of the rods had melted places at the downstream end but also many of the rods showed melting near the inlet end. The DC power supply holds constant power at any one setting so when melting of one rod takes place the other rods, in turn, see an increase in power. For that reason it is difficult to determine if the test section failed due to mechanical reasons or to boiling burnout.

Two-Phase Pressure Drops Across PRTR Discharge Piping. A detailed analysis of the two-phase pressure drop across the PRTR discharge piping components was started. The over-all pressure drops at PRTR operating conditions have been used to define the hydraulic demand characteristics of a PRTR process tube. The pressure drops so obtained were greater than would have been calculated using an equivalent length to account for the presence of the various fittings and other components of the piping system. The present analysis is being conducted to identify those components which contribute to the higher pressure drop and to attempt to define the magnitude of the error, in general terms, in techniques which are available to calculate these pressure drops. The effort so far has been to convert the raw data into useful numbers, to identify the heat losses from the test section and to separate the static head pressure drop from the frictional pressure drops.

PRTR Project Management and Design

Phase III-A construction is complete, with exceptions, at month's end. Remaining PRTR construction items include the fuel element examination facility equipment installation, some painting and insulation, and cleanup of exception items on systems transferred to operations.

Construction of the Maintenance and Mockup Facility (including the PRTR Rupture Loop Annex and PRP Critical Facility buildings) is estimated at 50% completed versus 59% scheduled predicted to March 1, 1961. The contractor has poured basement walls and approximately one-half of the -14-foot floor slab in the M&M Building which is 44% complete versus 47% scheduled. Helium storage facility work was completed. The chilled water reserve tank installation was completed without exceptions.

The new exhaust fan for the PRTR stack filter arrived on site and was installed. Exhaust filter work is complete except for pneumatic seal installation and testing.

A gasoline-driven generator unit and battery is being installed on the load-out facility shipping trailer in order to insure a reliable source of electricity for the coolant pump motor and fan.

The Fuel Element Examination Facility equipment installation package has been given to Minor Construction. They will install the viewers, manipulator and make minor modifications to the piping and electrical systems. The manipulator installation will be delayed about two months. The vendor has found that he will have to replace the spline shafts used to operate the chucks before the manipulator can be shipped.

Modification of the pressurizer inlet nozzle was completed and accepted by the third party inspector as meeting ASME code. The new configuration, which permitted additional flexibility, resulted in combined stresses within the allowable code limits. In the critical area of nozzle wall thickness near the bimetallic weld, the completed nozzle was checked by ultrasonic techniques to insure that the wall thickness was within the specified range.

The support structure for HX-1 is being re-evaluated taking into consideration the method of support, strength of bolts used, condition of grout, and the results of the earthquake analysis by Electric Boat Division of General Dynamics.

The helium system is physically completed and all compressors have been operated. Piping vibration at the low pressure compressors has been corrected. Vibration of the compressors has been reduced to an acceptable level by reinforcing the supporting framework. Hydrostatic testing and air blowing of the system is complete.

A gasometer vacuum breaker seal pot has been fabricated and installed on the gasometer-gas balance compressor line to limit possible vacuum in the system to two inches D_2O. The breaker incorporates vacuum alarm instrumentation. Interlocks are being installed to prevent operation of the low pressure helium compressors at low gasometer level. These measures are all designed to prevent inadvertent increases in moderator level from operation of the helium system.

Hydrostatic testing and preliminary functional testing of the secondary system is complete. All boiler feed pumps have operated satisfactorily.

The fuel element rupture monitoring electronics system was received and installed. The system is ready for initial operation. Formal design testing is not expected to take place until later in March

The piping interconnections with the primary coolant and helium systems were completed. Final leak testing has not yet been completed, but preliminary checks for leaks have disclosed only a few.

Calibration and alignment of the reactor automatic controller was completed and Design Test 44 partially completed. All control equipment checked out as expected except that the dead band in the B-1 compensating

loop was higher than the design value. This problem is currently being investigated to determine whether the Btu controller is operating within specifications.

Paint in the storage basin and water pit has been removed and replaced where it had come loose. The affected area included most of the water pit, the storage basin floor, and portions of the storage basin wall. Cracks discovered in the storage basin wall were repaired. Painting and insulation in "A" Cell is scheduled to be concluded at month's end.

PRTR Design and Component Testing

PR-10 - Primary Loop Mockup. The spare primary pump operated 554 hours during the month for a total of 4503 hours. The present leak rate is 0.06 gallon per hour.

The prototype pump with self-adjusting seal assembly operated 713 hours during the month for a total of 6049 hours. The leak rate increased from 0.5 to 0.8 gallon per hour.

The seal test stand operated an additional 125 hours and 17 starts for a total of 530 hours and 71 starts with the two prototype primary pump mechanical seal assemblies.

The Aldrich injection pump operated 491 hours for a total of 842 hours on the present test run with R/M Vee-Flex packing. Leak rates are presently 1000, 300, and 1500 ml/hour on the individual packing glands.

Flexure Loop. The three-clamp Grayloc transition union completed 248 hours and 31 cycles operation at 2000 psi and 200-600 F before the loop's pump started leaking excessively. The leak was found to be in the static neoprene U-cup seal in the mechanical seal assembly.

Shroud Tube Replacement. Bids for the borescope have been received and are being reviewed. A mockup of the upper plenum plate was set up to devise some means of removal and replacement of shroud tubes in the bellows.

Scope design has been completed on tools to hold the hydraulic cylinder that collapses the tube and a feeler gauge to check for out of roundness of shroud tube before it is removed through the bellows.

Plutonium Recycle Critical Facility (CAH-842)

Project Management and Design. Construction of the Critical Facility building is about 59% versus 99% scheduled.

The bid due date on the instrumentation package, consisting of the control console and valve control panel, was extended from February 24 to March 3. Orders have been placed for the thimble coolant pump and the reactor pumps.

The vendor constructing the reactor assembly submitted a revised heat treating procedure, which was reviewed and approved. Construction is under way.

The moderator storage tank vendor expects to complete fabrication and testing for shipment during March.

The fuel transfer lock was received on February 16, 1961. In order to meet this date, the vendor was unable to finish the painting and testing. In addition, minor modifications are required to the operating mechanism for the cell door, and the compression seals still have to be delivered and installed. This work will be done during installation of the lock.

Prototype Mockup and Component Testing. The synchro transmitter-receiver position indicating systems for the weir and control rods have not yet been placed on order. Rebids were required by AEC purchasing and were scheduled for resolution on February 21. Difficulty with a low bid of questionable conformance has been the cause of delay.

The source positioner is being fabricated in Tech Shops. A nitrile rubber rolling diaphragm was irradiated and failed to endure an exposure of 10^9 r. New materials will be tested and evaluated; however, materials are available which will endure at least 100 hours of service. 10^9 r exposure would require about 10,000 hours of operation with irradiated fuel elements.

Control rod and safety rod detail design has been completed but has not been checked for final approval. Position readout meters for the safety rods were scoped, and procurement specifications are being prepared.

Thimble material procurement is under way, and fabrication is expected to proceed on schedule.

The weir was designed to control the level of the moderator in the critical facility. Minor design changes were made. These consisted of replacing the quad-ring seal with an inorganic packing, adding limit switches, and revising some dimensions. The weir is in a radiation zone of approximately 5×10^4 r/hr. Elastomers selected for possible use in this location are urethane or natural or polyacrylic rubber.

Tests of fuel element hanger seals were completed.

Long term tests show that available weight will seat O-rings with very little pressure loss. Recommended hardnesses and sizes have been determined.

Procurement specifications for all major instrumentation items except the moderator temperature recorder were completed and put out for bids. Bids are expected to be opened early in March. Work is nearing completion on interconnection and installation drawings. The moderator temperature monitoring system specifications are being revised. Components will be ordered for evaluation and testing early in March.

Fuel Element Rupture Test Facility (Project CAH-867)

Project Management and Design. Construction of the annex building is approximately 86% complete versus 76% scheduled.

Shop fabrication of the in-reactor test section has begun. Nearly all material for this work has now arrived.

Construction drawings and the specification for the annex equipment installation have been issued for approval. Final design review has been completed on the "B" Cell installation drawings and the in-reactor drawings. Preparation of fair cost estimates for equipment installation in "B" Cell and the annex is being made. Consideration is being given to requesting Minor Construction to do the entire job rather than splitting it between Minor Construction (B Cell) and a fixed price contractor (Annex) as had been previously planned. Special conditions have been prepared under the assumption the annex work will be by a fixed price contractor.

Consideration was given to enlarging the water plant to supplement the 300 Area supply. Arrangements could not, however, be accomplished in sufficient time to meet the water plant schedule. The elimination of non-essential items from the water plant as well as a reduced size plant are being reviewed to permit a reduction in the current estimated project cost which is excessive.

Procurement specifications and requisitions for the instrumentation package electrical gear, control valves, and makeup system pumps were issued. It is expected that orders will be placed for these items during March.

Montgomery Brothers, who are providing the immersion heaters, were contacted regarding the lack of adequate design calculations for the flat vessel bottom plates and requested to provide a baffle plate at the top connection for one heater vessel. The latter is desirable to avoid erosion of the heater tubes in the one vessel whose inlet connection is at the top.

The Zr-2 process tube components have been fabricated by Chase Brass and Copper Co. There was no loss of tubes during the extrusion process, making it more probable that five assemblies will be furnished under the contracted price of $24,800 which was for three to five tubes. The first tube assembly is scheduled to arrive at HAPO on March 17.

Prototype Mockup and Component Testing. Minor design changes to the in-reactor section were made during approval of the tracings.

Shop drawings are being prepared for fabrication of assemblies for proof testing the component seals and bellows.

Design Analysis

PRTR Critical Tests. The Critical Test phase of the PRTR startup has been completed, and reduction and refinement of the raw data are nearing completion. Several preliminary results have been obtained in addition to those previously reported.

Boron poisoning of the moderator was successfully accomplished with no detectable boron remaining after cleanup. A total of 222 grams of boron were added (0.0193 gm/liter), which increased the critical moderator level from 61.04 to 93.11 inches. Analysis of this experiment to obtain reactor parameters is under way.

Draining the radial reflector tank was found to result in a reactivity loss of about 40 milli-k with the moderator level initially at 61 inches. This is not in agreement with a two-dimensional calculation which was carried out for the moderator level at 108 inches and which yielded about 100 milli-k. The discrepancy is believed to be due largely to the dump chamber and is a measure of the change in radial reflector savings with moderator level. The results are consistent with reports of measurements made in the CVTR Critical Facility.

Substitution of the gas loop test section for the process tube, coolant, and UO_2 fuel in location 1542 resulted in a reactivity loss of six mk. This is in good agreement with the calculated value of five mk. Substitution of the rupture loop assembly in this location with a natural uranium metallic fuel element resulted in a reactivity loss of 0.8 mk dry and 2.8 mk with H_2O coolant. Although the calculations were carried out for slightly enriched uranium rather than for a natural uranium fuel element, the experimental values obtained were about as expected.

A period and reactivity computer code (PARCODE) is being used in the analysis of Critical Test data. The code performs a least squares analysis on count rate data to yield a reactor period. Periods obtained from several instruments in each measurement are averaged. The code then uses these average periods to calculate the corresponding reactivity values. The final step is to determine the critical moderator level from each series of reactivity measurements. These calculations are nearly complete for all of the Critical Tests.

Power Test Preparations. Foil holders for the Shielding Adequacy Power Test have been fabricated. These holders will be used to position foils at the process tube annuli, flux monitor tubes, calandria access tubes, and shim control tubes. Neutron streaming measurements through these shield penetrations will be made as part of the power testing program.

Several PRTR Process Specifications have been modified and one new specification has been written. These changes reflect knowledge gained during the Design and Critical Testing performed to date. All specifications required for Power Testing have been reviewed and approved by the PRTR Startup Council at month's end.

PRP Reactor Physics Calculations. The FLUX-WEIGHT one dimensional, three-group reactor code has been utilized to provide a reactivity, power, flux, and perturbation description of 62 core, reflector and cell configurations in the PRTR during critical testing. Analysis is not complete, but substantial agreement with results of substitution experiments has been obtained. A study is under way to redetermine the effective parameters representing the Pu-Al elements. It is expected that the Pu-Al parameter modifications determined recently will lead to more successful loading calculations in the PRTR and increased confidence in subsequent loading and substitution calculations for the Critical Facility.

Evaluation of the moderator level coefficient in this recent work is improved to approximate previous two dimensional calculations by a simple revision of the assumed reactor model. An earlier model specified the core and side reflector by a constant, radially homogenized set of parameters and the analysis was carried out in the axial direction, varying the moderator level. That treatment determines well the axial buckling which, however, can be determined with fair consistency from inspection of the axial geometry and the near-cosine flux distribution expected in that direction. The solution in the radial direction is not known well by any such simple prescriptions and is not constant throughout level variation. It is essential that analysis be performed in the radial direction.

PRTR Operations

With PRTR construction reaching its final phase, and following completion of critical testing, PRTRO efforts during February were concentrated on design testing and startup of various equipment and systems. Extensive startup work was performed on the following systems during the month: moderator and reflector coolant systems; gas balance system, including liquid level instability tests; top and bottom shield coolant system; fueling vehicle; helium systems; the primary coolant system; and the secondary water system.

Primary coolant system work included deuterizing the ion exchanger, volume calibration and filling of the system with heavy water, fixing numerous leaks, balancing pumps, tie-in of rupture detection and helium systems, check-out of tube data equipment, tube examination, including measurement of tube bowing, and extensive testing of all instrumentation and control equipment.

Some of the problems which slowed startup preparations were as follows: moderator pump maintenance problems continued with a bearing failure on Pump #2 and a seal failure on Pump #1. All moderator pump motor bearings have been replaced.

Two containment solenoid valves burned out during the month. Several tube flow monitors had plugged impulse lines. The pressurizer pressure instrument was inoperable until a new impulse line was provided separate from the level instrument. The pressurizer level instrument was placed

in service without its density compensation after continued failure of the computing relay to function.

A faulty level transmitter for the ring header was replaced D_2O filling was delayed while equalizing valves were eliminated from all level transmitters.

Difficulty in arming the dump valves continued; this trouble is yet to be corrected. Injection pump oil pressure instruments do not function as yet.

For the shim rods, a second round of major repair work was started and is in progress. Also, at month's end, one high pressure helium compressor has a ruptured diaphragm; an over-heating problem with Primary Pump #3 is being investigated; and the emergency diesel well pump, after failure to start, is still disassembled for troubleshooting and redesign of its lubrication system.

PRTRO assumed responsibility for several items of project work during the month, including the following:

A revised control system for four containment valves is being installed to correct failure of these valves to reset.

Extended testing and troubleshooting of the water softeners was performed to correct control problems and capacity deficiencies.

The chilled water system was refilled after construction revisions in the experimental cell, service building piping changes by the M&M contractor, Phase III-A changes to the pumps, and complete rewiring of the chiller units.

In addition, a major reweld job to relieve pipe stresses at the pressurizer inlet, started in January, was performed by FPD Maintenance forces.

A major D_2O spill occurred on February 7, when a temporary hose fitting failed during design test work on the reflector system. The leakage was stopped promptly, limiting the spill to 1850 pounds. Essentially all of this was recovered, but it was diluted with light water to an extent requiring return to SRP for reconcentration.

A fire in the containment vessel occurred on February 23. Sparks from a grinder ignited a dust filter in one of the reactor hall ventilation units. No damage resulted.

On completion of critical testing, all Pu-Al fuel elements were removed from the PRTR core. During the month, all Pu-Al fuel was returned to the Plutonium Metallurgy Operation. The top hangers in the six Class I elements will be modified and returned to PRTR for use during Power Tests. All Pu-Al elements for Power Tests will be brought to the 309 Building next month.

D_2O level instrumentation problems continue to cause concern. The reflector level sensing line was repaired by using a high-temperature plastic sealer. The line could not be welded because of the location of the leak. The leak existed when the system was transferred to PRTRO. Pressurizer level instrumentation does not yet function as designed. To expedite performance of Design Tests, the specific gravity transmitter and the pneumatic computing relay were removed from service and a standard level transmitter-to-recorder arrangement utilized. Work on the specific gravity transmitter and computing relay continues. Moderator level instrumentation provided for Critical Tests will be retained since it has proven to provide satisfactory level readout.

Numerous equalizing valves have been removed from transmitters and in-line shutoff valves installed. Since it is difficult to keep instrument lines filled water, fill taps have been installed to speed troubleshooting efforts.

Data system problems uncovered and presently being corrected include: flow readout in the Control Room does not agree with flow monitor indications in C Cell; three RTD leads out of six give poor response (apparently will have to be replaced); total primary flow does not yet agree with summation of tube flow; and punched tape readout of flow and temperature has not functioned reliably as yet.

Calibration of helium and secondary system, plus miscellaneous instrumentation continues.

Shim rod connectors were corroded when water dripped on them from the fueling vehicle during tube mapping and during attempts to remove the air from the primary system. This, in addition to internal problems in the shims, necessitated a second major repair program on the shim rods.

A PRTR dump valve actuator was removed and returned to the factory for modification. All other actuators must be returned to the factory, one at a time, to undergo modification. Several control valves have been dismantled to clean valve seats in an attempt to reduce leakage when the valves are closed. Included are the pressurizer over-pressure control valve, main heat exchanger vent valve, pressurizer bleed solenoid valve, and a pressurizer relief valve.

A study of the Gas Loop spare parts requirements was begun and is now 50% complete. Procurement will begin in early March. Initial rough drafts of the Gas Loop Operating Procedures were completed. These will be extensively reviewed by PRTRO and NMDO personnel and refined as necessary. Construction liaison continued.

Drawings of the Rupture Loop In-Reactor Test Section were reviewed and approved, as were the drawings and specifications for the PRP Critical Facility Instrumentation System. At month-end, the Rupture Loop Mechanical Equipment Specifications and Instrumentation, Electrical and Piping Drawings are being reviewed.

2. PLUTONIUM CERAMICS RESEARCH

Plutonium Dioxide-Uranium Dioxide

Experiments on the structural stability of PuO_2 in hydrogen have continued. A series of PuO_2 pellets and powders which had been produced by calcining plutonium oxalate at 300 and 600 C in air were heated to 910, 1050, 1250, 1440, and 1550 C in dry hydrogen, (less than 75 ppm H_2O). Densities increased with temperature and at each temperature 300 C calcined PuO_2 showed higher densities than the material calcined at 600 C which might be expected from surface area considerations. The weight loss of the powders due to liberation of surface adsorbed gases was independent of temperature and nearly constant at about 3.5 w/o. X-ray diffraction showed for all samples the usual lattice parameter of 5.396 A for the cubic PuO_2 phase. Reduction to alpha Pu_2O_3 was seen only in the samples heated to 1440 and 1550 C. In addition, the strong 2θ = 31 degree line which previously has been attributed to beta Pu_2O_3 was seen on these pieces. Weight gain data for determination of O/Pu atom ratio is presently being obtained.

To determine the stability of PuO_2 in the presence of UO_2 when sintering in hydrogen, eight UO_2-PuO_2 compositions were heated to 1500 C in dry hydrogen. X-ray examination on the pellet surfaces showed solid solution formation to be incomplete. On oxidizing at 650 C in air, all of the pellets except pure PuO_2 crumbled due to U_3O_8 formation. The O/Pu ratio of the PuO_2 specimen was 1.921, indicating a "slightly reduced" condition.

The UO_2-PuO_2 pellets sintered for 75 hours at 1500 C which, as previously reported, resulted in a flow of the UO_2-PuO_2 and a disappearance of the PuO_2 have finally been examined. Eight PuO_2 pellets, which had been sitting behind the UO_2 in the hot zone, presumably vaporized and condensed on the UO_2 and UO_2-20 w/o PuO_2 pellets as evidenced by both lattice parameter and the pellet weight gain. The data obtained are summarized below:

LONG TIME SINTERED DATA

Nominal w/o PuO_2	Orig. Wt.	Final Wt.	% TD	FCC a_o	w/o PuO_2 based on a_o	Pu_2O_3/ PuO_2
UO_2	5.8 g	21.4	91.0	5.431	52.0	0.45
UO_2-20 PuO_2	5.9	15.3	90.5	5.440	39.5	0.35
-40 PuO_2	6.0	5.8	84.5	5.452	23.0	0.33
-60 PuO_2	6.1	5.7	83.3	5.428	56.0	0.40
-80 PuO_2	6.0	5.6	89.3	5.417	71.5	0.50
PuO_2	48.0*	0.0	-	-	-	-

*Eight pellets.

The w/o PuO_2 based on lattice parameter, is that in the fluorite phase. In all cases alpha Pu_2O_3 was seen together with the fluorite UO_2-PuO_2 phase and the quantity of Pu_2O_3 is based on the relative intensities of the type C (222) and the fluorite (111). The lattice parameters of the Pu_2O_3 phase

fit well to the plot presented last month, again indicating that Pu_2O_3 is a defect phase with a variable number of oxygen atoms. The compositions of the last three samples would appear to indicate that PuO_2 may be preferentially lost from UO_2-PuO_2 mixtures and could conceivably result in a relocation of plutonium atoms during in-reactor operation of the fuel element. Chemical and metallographic analyses of this experiment will be carried out.

The work begun last December on melting points of UO_2 containing small additions of PuO_2 has been detailed. The results confirm those of ceramic fuels on irradiated UO_2 and KAPL on UO_2-PuO_2, in that there exists a rise in melting point with slight additions of a second constituent, in this case PuO_2. For example, the melting point varies from 2730 to 2825 to 2700 C for UO_2, UO_2-10 and UO_2-15 w/o PuO_2, respectively. This had not been seen earlier since the liquidus was determined beginning at a UO_2-15 w/o PuO_2 composition.

On the eleven UO_2-PuO_2 irradiated capsules which are to be sent back to the MTR for additional exposure, it was decided to issue a supplement to the original test proposal and request that the specimens be placed in higher flux positions. The test supplement is being prepared, and an attempt will be made to have the specimens operate at or above the initial specific power values (19 kw/ft for high density pieces, 12 kw/ft for low density).

Plutonium Carbides

Plutonium carbide possesses the NaCl type structure and is a defect phase in that it can exist over a range of carbon contents. During the past month it has been attempted to determine the composition limits by noting the lattice parameter versus carbon relation. A series of nine PuC alloys was prepared via arc-melting. The button interiors were ground with a diamond wheel under trichlorethylene and the claimed powder was set in a back reflection integrating camera together with a platinum standard. Unfiltered copper radiation was used with nearly perfect focusing to examine the PuC (620) line ($2\theta \approx 160^0$) and Pt (422) line ($2\theta \approx 150^0$). Temperature was held to 26.2 ± 0.5 C. The lattice parameters found for the PuC phase varied nearly linearly for 44 to 50 a/o C, indicating a wide composition range. Further experiments to pinpoint the limits of this phase will be performed. The accuracy of this technique is amazing in view of the single line examined. Calculations based on both the PuC and Pt doublet enable four values of the lattice parameter to be determined. On all the samples the a_c of Pt was also determined, and it was always within ± 0.0005 A of the accepted value. Substituting both gold and silver for the PuC unknown gave lattice constants within ± 0.0002 A of NBS values.

Plutonium Oxide-Thorium Oxide System

Investigations into the solid phase relations in the PuO_2-ThO_2 system have continued. Previously it had been found that PuO_2-ThO_2 formed a continuous series of cubic solid solutions after sintering for 12 hours at 1500 C in tank hydrogen. In recent experiments it has been found that solid solution formation after the above thermal treatment in dry hydrogen

is incomplete due to the reduction of PuO_2 to Pu_2O_3. Further, after ten hours at 1550 C in wet helium, PuO_2 goes into ThO_2 as a solid solution, but there remains unreacted or second-phase ThO_2. The density-composition curves for this system show a gradual decrease in density with increasing ThO_2, reaching a minima at about 50 w/o ThO_2 and gradually increasing to a maximum at pure ThO_2.

Plutonium Oxide-Zirconium Oxide System

The past reporting period was spent investigating the high temperature equilibria. Emphasis was placed upon the compositions containing greater than 60 w/o ZrO_2. Sintered pellets were contained in tantalum crucibles, heated in vacua to temperatures ranging from 1000 to 1335 C, and furnace quenched. Quench rates during the first 30 seconds varied from 200 C/minute to 570 C/minute. The transformation from the high temperature F.C.C. structure to the two-phase monoclinic plus F.C.C. solid solution structure appears to be strongly dependent upon quench rate. A specimen containing 79.3 w/o ZrO_2 was quenched at 300 C/minute from 1100 C. X-ray diffraction data indicate that only the face of the pellet away from the tantalum crucible retained the high temperature F.C.C. structure. The quench rate of the surface next to the crucible was probably not as great as the exposed face. The high temperature structure was also retained on the surface of the 89.5 w/o ZrO_2 specimen. It was quenched from 1300 C at a quench rate of 380 C/minute. This evidence demonstrates the need for higher quench rates in order to determine the lower temperature transformation points. Further experiments are being conducted utilizing a means to accomplish this higher quench rate.

3. UO_2 FUELS RESEARCH

Irradiation of Recycled UO_2

The four-rod cluster fuel element (GEH-4-59) containing recycled electrodeposited UO_2 was returned to HAPO after irradiation in the MTR. It is now undergoing post-irradiation examination. Preliminary observations show no abnormalities or dimensional changes in the rods containing electrodeposited UO_2. However, the rod containing sintered pellets warped during irradiation. The maximum warp, ~0.084 inch, occurred approximately five inches from one end. Fission gas release data and metallography samples for the four rods in this cluster are being obtained.

Zircaloy Hydriding Studies

Six capsules were fabricated for use in simulating reactor conditions in the vicinity of a fuel rod defect. These capsules are four-inch segments of a PRTR swaged UO_2 fuel rod, having an 1/8" diameter central, axial hole to accommodate a tungsten resistance heater. The capsules were each defected by drilling a hole through the claddings at a position two inches from either end. The defects are 0.005, 0.010, and 0.020 inch in diameter. The rods are surrounded by a jacket to provide a 1/8 inch coolant annulus. Coolant flow through the jacket can be varied from 0-2 gpm. Coolant

entrance and exit temperatures are measured by iron-constantan thermocouples. The tungsten rod (1/8" diameter x 18" long) can be heated to 2800 C to provide a heat flux of about 300,000 Btu/hr-ft^2 at the fuel rod outer surface. The system is contained in an evacuable stainless steel enclosure.

Fission Product Distribution in UO_2

Preliminary results of autoradiographic studies of cut transverse surfaces of irradiated UO_2 fuel rods reveal evidence of non-uniform fission product distribution. The technique for obtaining autoradiographs in glass is being developed in conjunction with RML personnel.

Fused UO_2 Crystal Characterization

Electron and optical microscopy studies of fused UO_2 single crystals continued. Polished and etched surfaces and natural cleavage faces of specimens were examined, principally to determine the size, shape, and distribution of inclusions and etch pits.

UO_2 Thermal and Electrical Conductivity

Four non-irradiated UO_2 specimens were shipped to BMI for conductivity measurements. Included were two isostatically pressed and sintered discs and one large single crystal for electrical and thermal conductivity studies, and one electrodeposited specimen for electrical conductivity determination. Measurements on an irradiated specimen continued at BMI.

Electron Microscopy - Methods and Instruments Development

Development of techniques and instruments for special applications of the JEM electron microscope are in progress. Initial evaluation of the reflection technique is encouraging, but magnification and detail study have been limited by the low image intensity inherent in the method and the low sensitivity photographic plates used. From comparative evaluation of six types of photographic plates and four photographic developers, all commercially available, it was discovered that a film speed increase of 7 to 10 times can be achieved by proper selection of conditions and materials.

A modified technique for replication of glass-smooth surfaces such as those of UO_2 single crystals is being developed. The method combines SiO (for strength) and carbon (for greater visibility and handling ease) as replicating materials and may result in relatively large stable replicas.

A preliminary design was completed for an internal electron detector for use as an exposure photometer. The device is expected to result in increased sensitivity and accuracy of image intensity measurements and permit better control of the photographic process. Construction of components for testing the design was started.

Work was begun on improved high temperature stage for the electron microscope with a goal of achieving a temperature of 1800-2000 C. Efficient utilization of energy input is being emphasized to permit high temperatures at the specimen without distortion or damage to the microscope components.

4. BASIC SWELLING PROGRAM

Irradiation Program

Capsule No. 8 containing three, hollow, split, uranium cylinders was successfully bench tested and shipped to the reactor to await charging for irradiation. This capsule joined Capsule No. 7, which also is awaiting charging. The previous three capsules are in Radiometallurgy; they are scheduled for opening shortly for post-irradiation examination of the specimens. Laboratory capsules have been machined for ex-reactor tests on specimens identical to those in the irradiated capsules. The specimens in the ex-reactor capsules will be subjected to the same thermal history as their irradiated counterparts, and a comparison of the irradiated and non-irradiated specimens will be made with respect to density, geometrical, and microstructural changes.

Pore Size and Distribution

Optical and electron microscopy are being used as a direct means of determining the size and distribution of pores in irradiated uranium. Such information is needed in order to understand how gas atoms migrate, coalesce, and grow into large pores. Replicas of uranium with burnups of 0.29 a/o and 0.41 a/o annealed at various times and temperatures are being analyzed by quantitative metallographic techniques, and the changes in pore frequency distributions as a function of thermal treatment are being ascertained. Specimens cut from Zircaloy-2 clad rods of uranium with burnups of 0.29 a/o and 0.41 a/o, respectively, were declad and have been annealed for times of one hour and 100 hours at temperatures of 400, 500, 600, 650, 700, and 880 C. The low annealing temperatures have been included because changes in the original pore distributions at the higher temperatures were very large. For example, a one-hour anneal at 880 C of a specimen having a burnup of 0.29 a/o resulted in a change in density from 18.56 (as irradiated) to 12.77 g/cc (after the anneal). The original cylindrical specimens had bulged in all directions assuming a barrel shape. The final maximum diameter was 0.676", whereas the initial diameter was only 0.577". A one-hour anneal at 500 C, on the other hand, showed essentially no change in dimensions, and the density had decreased only slightly, 18.41 to 18.26 g/cc.

New higher resolution pore size distribution curves have been constructed for uranium specimens having a burnup of 0.29 a/o and one-hour, post-irradiation anneals at 600, 650, and 700 C. Comparison of this distribution data, obtained with the Zeiss Particle Size Analyzer, shows that: (1) an increase in annealing temperature from 600 to 650 C causes an increase in the number of small pores and also large pores, (2) a further increase in annealing temperature from 650 to 700 C causes a decrease in the number of small pores and an increase in the number of large pores. Since small pores may combine with one another or larger pores, and since such agglomeration would depend on the actual frequency distributions in the specimen, it is imperative that the distribution curves obtained be sufficiently accurate to permit subtractions and comparisons. Statistical analysis of the high resolution data is, therefore, being made.

Distinct and consistent differences in the pore frequency and pore volume fraction distributions were obtained from measurements of pores in the center of the specimen and its edge. For these two regions the data indicate that the total volume of pores in the edge region is higher than that in the center region, whereas the total number of pores in the edge is less than that in the center. This applies to the three annealing temperatures, 600, 650, and 700 C. If the pore volume fraction is divided by the pore density, the resultant average volume of a pore in the edge region is found to be twice as large as the average volume of a pore in the center. This relationship again applies to all three annealing temperatures. The difference between the pore distributions in the center and edge regions of a specimen is presumably related to the fact that during irradiation the temperature was higher in the center regions of the specimen and/or the fission gas generation rate was lower.

Various pore growth mechanisms which may account for the observed changes in the pore distribution curves caused by post-irradiation annealing are being postulated and evaluated.

Fission Product Mobility

A knowledge of the mobility of rare gas fission products in uranium is important to the understanding of the basic mechanisms underlying the swelling phenomenon. Uranium specimens are being examined that have had inert gas introduced into the surface by "glow" discharge and U-U diffusion couples are being examined that have had an appreciable amount of fissioning occurring in one-half of the couple, but very little in the other half. Two NaK filled capsules have been sent to the MTR for irradiation of U-U diffusion couples. Each capsule contains a single specimen which consists of a slice from an extrusion which has a core of depleted uranium and a shell of enriched uranium. One surface of each specimen was metallographically polished, cathodic vacuum etched, hardness impressions made, and the surface replicated.

Continued study of the gas release characteristics of the flow discharge system previously reported has indicated that the system itself may have contributed significantly to the krypton gas evolution that was monitored. The uranium specimen was removed, the system re-evacuated, and then heated. Krypton was observed to be evolved when the formerly highest temperature was exceeded. This could have come from the glass walls, the uranium that had evaporated into the walls, or the tungsten cathode on which the uranium had rested. A second vacuum annealing system is being constructed so that the specimen can be heated to above its melting point in a system that previously has had no krypton in it. This will allow a better evaluation of the amount of krypton actually in the specimen.

Restrained Irradiations

Zircaloy-2 clad uranium fuel rods with selected uranium temperatures, cladding thicknesses, and exposure are being irradiated in NaK filled, temperature monitored capsules. Three swelling capsules, GEH 14-94, 95, and 99 are presently being irradiated in the MTR to various goal

exposures. Exposures and average center uranium temperatures for the fuel rods in these capsules are respectively 0.14, 0.23, 0.36 a/o and 575, 500, and 540 C. Seven capsules have now been discharged from these MTR tests and will be examined in Radiometallurgy during the succeeding months. Density measurements were completed on 12 enriched declad uranium rods. R values ranged from 7.5 to 39.5 for a volume average temperature range of 375-430 C and from 15 to 53 for a volume average temperature of 450-530 C. The extreme R values were from rods on which the cladding had failed. Most of the rods have random cracks large enough to entrap air but perhaps not large enough to be wetted by the density measuring fluid. This would result in erroneously large density changes and, hence, erroneously large R values.

Radiometallurgy Laboratory Studies

Four replicas were prepared for electron microscopy after annealing at 400, 500, and 800 C. Density determinations are being made on these same samples (RM-265). Results and interpretations of these examinations will be reported in more detail in connection with the development programs served.

5. IN-REACTOR MEASUREMENT OF MECHANICAL PROPERTIES

In-Reactor Creep Measurements

One of the second generation creep capsules has been tested in the laboratory by thermal cycling to duplicate the thermocouple failures experienced in the reactor. In the laboratory a rapid reduction of temperature resulted in the failure of one thermocouple in the capsule after the first cycle. Subsequent cycles caused further failures. The thermocouple failures, resulting from a rapid reduction of temperature, have occurred both in the reactor and in the laboratory, demonstrating that the problem is independent of radiation damage. Consequently, the three remaining capsules have been returned to the vendor for modifications. The capsule in the reactor is being used to check out the automatic control and data recording system. When the system is performing satisfactory, the capsule will be used for a stress-to-rupture test of the Zircaloy-2 annealed specimen, utilizing the remaining two thermocouples for temperature measurement.

Capsule and Instrument Development

An order has been placed for the construction of six third generation creep capsules. Expected delivery is near the end of June. Specifications for the third series of capsules call for simplification in the construction of the capsule while retaining the reliability and accuracy of proven methods and techniques used in the first two capsules.

Calibration and performance checks of various types of extensometers suitable for in-reactor measurements are being carried out in the laboratory. Calibration of a linear potentiometer constructed for in-reactor use has been completed.

Pre-irradiation Material Characteristics

Measurement of the activation energy for creep of Zircaloy-2 scheduled for in-reactor testing has continued. Creep tests giving data for the calculation of activation energies are being conducted in annealed Zircaloy-2 at 15,000, 20,000, and 25,000 psi and on 20% cold worked Zircaloy-2 at 35,000 psi. The activation energies for creep of Zircaloy-2 determined in the past month have shown that a transition occurs between 250 C and 300 C (from low temperature glide controlled creep, characterized by an activation energy near 2000 cal/mole, to high temperature diffusion controlled creep, characterized by an activation energy of 61,500 cal/mole).

The activation energy for creep of the 20% cold worked material was found to be a small positive value between zero and 3000 cal/mole in the temperature range 200-250 C. The activation energy gradually increases to 36,500 cal/mole at 257 C and to 49,700 at 272 C. It is expected a value of 61,500 cal/mole will be attained as the test temperature is increased further.

Annealed Zircaloy-2 being tested at 15,000 psi has shown somewhat different behavior. The creep activation energy reported previously as low in the range 200 to 272 C is actually a small positive value between zero and 3000 cal/mole. The present experimental procedure does not allow determination of activation energies lower than 3000 cal/mole; creep processes characterized by activation energies lower than 3000 cal/mole change in rate so little that in a temperature interval of 15 C differences cannot be resolved. In the past month it was shown the activation energy for creep of annealed Zircaloy-2 at 15,000 psi increased abruptly from 6500 cal/mole at 281 C to 57,800 at 296 C. A value of 58,100 cal/mole was determined at 308 C. The temperatures at which the governing creep process in Zircaloy-2 changes from glide to climb appear to depend on degree of cold work. Additional testing will be carried out to evaluate the effect of cold work on this transition temperature.

Irradiation and Environmental Effects in Structural Materials

As reactors are being built to operate at increasingly higher power levels and consequently at higher temperatures, a knowledge of the combined effects of elevated temperature, environment, and neutron bombardment on the mechanical properties of structural materials becomes imperative. Flat Zircaloy-2 tensile specimens, cut from rolled plate of various cold work levels in the transverse and rolling directions, are being machined and prepared for long-term irradiations in the ETR. Seven-hundred completed specimens are presently on hand, of which 432 will be inserted as the first charge in a 30-inch capsule in the C6x9G7 loop. Capsule design is complete and construction is in progress. The ETR 6x9 loop is presently being modified for the purpose of this program. Operating temperature will be approximately 280 C and proposed exposures vary from 3.8×10^{20} nvt to 1.6×10^{22} nvt. As the tensile specimens reach their desired exposure, they will be discharged and the vacated space filled with notched Zircaloy-2 tensile specimens. Low temperature irradiations of 150 tensile specimens and 30 notched tensile specimens will be carried out in the G6 or G9 positions for three high exposures and in the ETR reflector for two low exposures.

6. GAS-GRAPHITE STUDIES

Physical Properties of Graphite

To prevent cracking of silicon carbide coatings on graphite, it is necessary that the thermal expansion be relatively isotropic and that the thermal expansion coefficient of the graphite match that of the coating. Thermal expansion determinations have been completed on Speer graphites considered for use in the EGCR fuel sleeves. Average values taken from three samples of each orientation are given below:

Extrusion Size	Impregnation	Orientation	Average Thermal Expansion from 25 - 425 C x 10^6	Ratio $\perp/\parallel$
3" x 8"	Single(Type 901S)	Transverse in 3" direction	5.75 C^{-1}	1.38
3" x 8"	Single(Type 901S)	Transverse in 8" direction	4.90	1.18
3" x 8"	Single(Type 901S)	Parallel	4.16	--
3" x 8"	Double(Type 901T)	Transverse in 3" direction	5.35	1.29
3" x 8"	Double(Type 901T)	Transverse in 8" direction	4.88	1.18
3" x 8"	Double(Type 901T)	Parallel	4.15	--
4" round	?	Transverse	4.90	1.30
4" round	?	Parallel	3.77	--

It is interesting to note the second pitch impregnation had the most effect on the transverse 3" sample in which the c axis of the grains is most highly oriented transverse to the direction of extrusion.

EGCR Irradiations

The H-3-2 experiment has now completed four cycles in the GETR, two of which were non-operating cycles. Thermocouple #9 failed just prior to the last shutdown.

Calculations of the integrated fast flux received by the samples in the H-3-1 irradiation capsule have been completed. The results from the nickel monitors ($Ni^{58}(n,p)Co^{58}$) were corrected using a thermal absorption

cross-section for Co^{58} of 3750 barns as determined from the nickel wire irradiated during Cycle 15. These corrected results were only seven percent lower than the results from the PDQ calculations made by the GETR physicists. Calculations of the flux as measured by the iron monitors ($Fe^{54}(n,p)Mn^{54}$) gave results which were 20 percent higher than the PDQ calculations. However, upon analysis, these supposedly pure monitors were found to contain only 72 percent iron so that the impurities, largely nickel, may have contributed to the activity. Consequently, it is felt that the nickel monitors are more reliable, and therefore the doses based on computer calculations reported last month are essentially correct.

EGCR Runaway Oxidation Evaluation

Tests have been conducted in the EGCR burning rig with a full scale radial mockup of an EGCR lattice unit, including dummy fuel elements, graphite fuel sleeves coated with silicon carbide, and EGCR moderator graphite. Runaway oxidation occurred in the rig when moderator temperatures exceeded 675 C at 186 lbs/hr air flow. The coated sleeves afforded some protection during the six-hour test at temperatures ranging from 600 to 1100 C. Examination of the coated sleeves after the oxidation runs showed them to be very badly attacked at the uncoated ends and at breaks in the coatings. The attack at the ends is particularly important, since this widens the gap between sleeves and permits air to leak from the fuel channel to the burning annulus region.

Sixteen uncoated graphite samples removed from different locations in the EGCR burning rig were sectioned perpendicular to the oxidized surface and examined with the stereo-microscope. Color photographs were taken to reveal ash particles adhering to the surface. Pitting was more severe on outer surfaces of the sleeve than around holes which contained heater elements. A region up to one-tenth of an inch in depth was severely oxidized on the outer surface of the sleeve.

Pyrolytic Graphite Studies

Additional samples of pyrolytic graphite from GERL have been prepared for irradiation. These samples are intended to test the effect of irradiation on graphite with near-theoretical density. Also included were samples of pyrolytic material which were heat treated at 2500 C or higher while under tensile stress in the parallel direction. Deformation at such temperatures results in a material with a considerably higher degree of alignment of the graphite planes than the starting pyrolytic material.

Surface Complex Studies

Studies of the sorption of CO_2, CO and O_2 on graphite are continuing. The effect of graphite impurities and surface area on the rate of oxidation and total amount adsorbed is indicated in the table below. These results are independent of the type of gas considered.

Sample	Specific Surface Area m^2/gram	Metal Impurities ppm	Oxidation Rates (in 2 cfh air at 600 C)	Relative Wt. Gained
SP-7	0.25	21	0.43×10^{-2} g/g-hr	1.00
SP-24	0.32	48	0.90×10^{-2}	1.17

The oxidation rates, which are proportional to the number of active sites, seem to correlate with the impurity content of the graphite. On the other hand, the amount of gas adsorbed on the surface is not in proportion to the oxidation rates or to the number of active sites.

Irradiations of Special Graphites

Dragon Project and Armour Research Foundation graphites were irradiated in four non-instrumented capsules in the MTR at temperatures estimated between 550 and 700 C. The exposure ranged from 6,000 to 11,000 MWD/AT (Hanford equivalent). Since temperatures and exposure varied with each capsule, comparisons in the table below are made only within a given capsule. The relative amount of contraction is given in terms of the observed contraction rate of CSF ($\perp$) and ($/\!/$) samples in the same capsule.

RELATIVE GRAPHITE CONTRACTION $\left(\frac{\%\,\Delta L}{\%\,\Delta L\ CSF}\right)$

Graphite Type		Orientation ($\perp$)	Orientation ($/\!/$)
Dragon-	(HX-10	1.9	1.4
	(HX-12	2.6	1.9
	(EY-X-60	6.1	2.8
ARF	-(3-2 (furfuryl alcohol binder)	--	0.72, 0.82
	(2-4 (pitch Binder)	--	0.41, 0.88
TSF	-(Same as CSF, but Texas Coke)	--	0.75, 0.97

The high contraction rates of the Dragon graphite are probably due to the relatively large fraction of non-graphitic carbon in the samples. The ARF graphites 3-2 and 2-4 are both fine grain, Texas Coke, 2900 C graphites. The ARF 3-2 graphite is bonded with furfuryl alcohol and 2-4 with pitch.

Gas Loop Project Management and Design (Project CAH-822)

The Head Mechanical work (auxiliaries and service piping, J. A. Jones Subcontract JAJ-73) has been stopped at 95% completion pending installation of the Struthers-Wells ex-reactor package by Minor Construction. All Struthers-Wells packages have been moved into "B" Cell.

The NaK electrical preheater has been removed from the "D" package and stored in the PRTR warehouse. This unit will be replaced with a heater having less or no NaK in order to reduce to within design value the total predicted reactor containment pressure in the event of the worst creditable incident.

Due to continuing difficulties with the main blowers, Bristol-Siddeley has agreed to provide one blower capable of continuous running at conditions less than design but sufficient for initial loop operation. Bristol-Siddeley is providing one technician for the installation of the blower, now scheduled to be received on or about May 15. Delivery and return of the blower will be at vendor's expense. Terms and conditions of the original order remain unchanged.

Prototype Mockup and Component Testing

The PRTR gas loop test section and heater were repaired and installed in the mockup. The heater mounting and guides were revised so that power leads entered at the bottom of the test section to eliminate problems of differential thermal expansion causing potential grounds at the nozzle. On the first test run the heater failed at a test section temperature of 1100 F, extensively damaging the heater and test section inner tube. Cause of the failure was shorting of the heater to the inner tube at the lower end of the test section, where clearance between the heater and tube is less than in the main section. The guide cage apparently did not contribute to initiating the short.

Test section reapir is under way, but only part of the heater can be salvaged. Rebuilding of the heater to a shorter length will be continued so that an abbreviated test will be possible, but a new heater design will be required in order to perform full scale tests. Alternate designs, including low voltage and single phase heaters, are being evaluated for possible use. Effect on the test program is also being assessed.

Arrowhead Products has experienced another bellows failure in the compensator and are changing to a completely redesigned bellows. An alternate arrangement of a bellows sealed slip-joint will be provided in view of the difficulties with the vendor's compensator.

7. GRAPHITE IRRADIATION DAMAGE STUDIES

National Carbon Company Research and Development Contract

Samples of anthracite based, pitch bonded graphite were received. Four hot capsules containing samples of the anthracite graphite and 1400 C lampblack graphite have been shipped for irradiation in the ETR.

Samples of hot worked, lampblack, graphitized coke, and natural flake graphite were discharged after an exposure of 1257 MWD/AT at Hanford and post-irradiation measurements are under way. This completes the initial series of irradiations of experimental graphite supplied under this contract.

Metallography Studies

A replica from an unetched sample of graphitized coke was examined with the electron microscope. The surface was very similar to that observed on a chemically etched sample which suggests the chemical etch was not effective in enhancing structural detail. Small closely-spaced and aligned pits were observed. Areas of interest were referenced for further study after a cathodic vacuum etch.

8. SPECIFIC FUEL CYCLE ANALYSIS PROGRAM

Conceptual Design - Fuel Element Fabrication Plant

A second draft of Part I, Preliminary Computations and Basic Assumptions, of the Fuel Cycle Economics Process Study was prepared and issued for final comment. A manuscript draft of Part II is substantially complete. Manuscript listings of estimated time in each Fuel Element Fabrication and Jacketing (FEFJ) process step, process loss and recycle factors, and process capacity of FEFJ process steps were prepared for use in "debugging" runs on the FEFJ code presently being developed for the IBM-7090 computer.

9. SUPERCRITICAL PRESSURE WATER REACTOR STUDY

The economic evaluation of a 300 MWe Supercritical Pressure Power Reactor continued with studies directed toward defining the power cycle, moderator type, containment features, and fuel element design.

The power cycle selected for the Supercritical Pressure Power Reactor maintains a turbine throttle pressure of 3,515 psia with initial steam temperature of 1050 F and two 1000 F reheats to increase the plant thermal efficiency and to reduce the moisture content of the steam at exhaust. The turbine generator will be a cross compound unit condensing at 1.5" Hg. The cycle pressure and temperatures were selected after review of present conventional supercritical power plants. It is believed that exploiting higher pressures and temperatures than those selected, while producing some gains in thermal efficiency, would be offset by increased cost of high temperature, high pressure materials and possibly by decreased reliability of these components. Preliminary plant heat balance indicates a gross thermal efficiency of about 45 to 46%.

The present flow cycle utilizes the condensate as the reactor moderator, then uses the heated moderator as "boiler" feedwater. The outlet temperature of the moderator is 200 F. Additional heating with turbine bleed steam raises the fluid temperature to about 270 F in the deaerator. The fluid is pumped to a discharge pressure of 4,500 psia by a turbine-driven feed pump, then further heated to a feedwater temperature of 545 F in four heaters with turbine steam bleeds. In the reactor the fluid makes two passes through the reactor with a resultant supercritical water temperature of 1050 F. The fluid is split into two streams for regenerative heating of the steam exhausted from the high pressure and the first reheat turbine. This regenerative heating is accomplished in high pressure heat exchangers. The supercritical fluid is returned to the reactor for heating to 1050 F a second time prior to entering the turbine.

The feedwater pump location necessitates four high pressure feedwater heaters. The possibility of locating the main pump after heating the feedwater to 545 F was considered. However, several disadvantages were apparent including:

1. The pump suction pressure must be maintained at at leeast 1000 psia to prevent cavitation, thus requiring a second feed pump in series.

2. Pump operation at 454 F would be less reliable than at 300 F.

3. The fluid volume increase from 300 F to 545 F would require a larger pump.

The main boiler feed pump will be turbine-driven using steam extraction from the main turbine at about 100 psia and 750 F. An electrical-driven pump of lesser capacity will be parallelled to provide coolant to the reactor during startup and during emergencies which require stopping the main turbines.

On the basis of preliminary studies, a light water moderated reactor utilizing "inverted cluster" type fuel elements appears to be most economically attractive for SPPR application. Graphite and beryllium (or beryllia) moderators were considered but rejected because of lesser economic advantages - beryllium because of its high acquisition cost and graphite because of lowered thermal utilization in a reactor of this size, with resulting higher fuel costs. The use of heavy water would afford significant nuclear advantages, but the inventory cost of D_2O for this reactor cannot be justified in comparison to a light water moderated reactor.

The possibilities of pressure vessel reactors for supercritical applications were investigated for comparison purposes. However, the problems of constructing a vessel for SPPR operating temperatures and pressures, combined with the poor moderating qualities of low density supercritical water, make this approach most unattractive, if not infeasible.

Fuel elements of the "inverted cluster" type appear to be the outstanding candidates for use in SPPR. In one such design, a block of UO_2 is surrounded by ZrO_2 thermal insulation, with an outer cladding of zirconium or aluminum. The element would be suspended directly into a moderator tank. The UO_2 fuel within the element is pierced by a number of small diameter U-tubes which carry the primary coolant. Thus, only the small coolant tubes need be exposed to the high pressure coolant.

Studies are continuing toward optimizing fuel element design. The element "most likely to be selected" at present is hexagonal in cross section, about two inches on a side, arranged in a triangular lattice with lattice spacing of about 4.5 inches. The active zone of the element would be about eight feet. The elements would be clustered and piped together in bundles of seven, and such a bundle would be handled as an entity in charge-discharge operations. Approximately 100 such bundles will be required for the reactor.

Control of the SPPR would likely be by a relatively large number of "gray" control rods, possibly in conjunction with separate safety rods. Such an arrangement appears necessary to afford adequate control of outlet temperature in each of three (series) passes the coolant will make through the reactor. Control requirements will be about 100 m, not including fast safety.

Moderator level control was considered, both for reactor control and "scram" functions, but did not provide sufficient control over reactivity with light water moderation in this reactor design.

Sketches have been prepared of the site layout and reactor building. The building consists of a 220-foot diameter steel hemispherical shell sealed to a 24-foot high cylindrical concrete wall. A gas tight concrete floor slab on which all equipment is mounted completes the structure. The building is designed to withstand about three psig internal pressure, a vapor suppression system being utilized to limit the pressure and temperature within the facility. Essentially all plant components are housed in the one structure, including the reactor, turbine generator, control room, and other service facilities. Only the river pump and waste disposal facilities are located outside. The size of the building is determined by the free area required to service the turbine generator units with a gantry type crane. Rough estimates indicate the structure would cost approximately $2,000,000.

10. ALUMINUM CORROSION AND ALLOY DEVELOPMENT STUDIES

Metal Growth During Corrosion

In corrosion tests of long duration it has been observed that aluminum samples grow appreciably in length and width due to compressive stresses developed in the corrosion product oxide. The first results on 0.002 inch X-8001 foil have shown an approximately linear relationship between weight gain and metal growth after two days of exposure to 360 C deionized water. On additional exposure the dimensional growth rate begins to fall off. When X-8001 samples of a greater cross-section (1/16 inch) were employed, no dimensional changes were observed during five days of exposure, presumably because the compressive stresses in the oxide were insufficient to strain the metal.

By using varying thicknesses of metal, the stresses developed in the oxide may be estimated from these tests. Corrosion of foil samples, in particular, will be carefully observed to see if stress relief of the oxide affects the corrosion rate. Similar tests of zirconium alloys are under way

Heat Treatment of Alloys

An aluminum alloy containing 0.25% Ni and 0.37% Fe with superior corrosion resistance in 360 C water was heat treated at 350 C for one month and tested in 360 C water. The samples were destroyed in 10 days. The iron-nickel ratio of this alloy is the same as that used for the 1.2% Ni, 1.8% Fe alloy which withstood six months of heat treatment without a reduction in corrosion resistance. The low Ni-Fe alloy will be fabricated with Ti or Zr additions to determine if these additions will improve the resistance to heat treatment

D. RADIATION EFFECTS ON METALS - 5000 PROGRAM

Radiation damage recovery is being studied for a number of metals, namely, copper, nickel, titanium, zirconium, iron, and type 347 stainless steel. Isothermal annealing of zirconium, iron, nickel, and copper was continued during the month. Accurate calculations of reaction kinetics cannot be made, however, until complete recovery has occurred. One general observation is that the reaction rates for recovery in zirconium are much greater than in iron, nickel, or copper.

Isochronal annealing of irradiated iron specimens with various exposures and impurity contents has disclosed several interesting facts: (1) the magnitude and temperature of maximum recovery rate are altered for all stages in specimens of equal exposure but different purity; (2) at exposures of less than 3×10^{18} nvt, the recovery stage at 175 C is absent, and (3) at exposures less than 1×10^{18} nvt, the stage at 325-375 is absent. This provides an illuminating correlation with tensile tests on irradiated iron: continuous yielding was observed at 1×10^{17} nvt, but yield points occurred for all specimens with exposures greater than 2×10^{18} nvt. Apparently, point defects or extended defects have interacted with existing dislocations at the higher exposures to effectively pin these dislocations and "harden" dislocation sources. Yielding should require a high stress to activate the hardened sources, and the flow stress would be correspondingly higher due to the frictional resistance of the pinned "debris". The increase in flow stress on going from 1×10^{17} to 2×10^{18} nvt was 36% for ingot 3 (low purity), 60% for ingot 2 (intermediate purity), and 87% for ingot 1 (high purity). This indicates that a portion of the radiation-induced defects have become entrapped at the small impurity atoms, and the higher the concentration of impurity atoms the more defects are trapped. Consequently, fewer defects are available for interaction with dislocations and dislocation sources. The observed upper yield stresses at an exposure of 2×10^{18} nvt are in agreement with the conclusions, being 37,600 psi for ingot 3; 38,000 psi for ingot 2; and 40,200 psi for ingot 1. The observed flow stresses also concur, being 35,000, 36,000 and 39,250 psi for ingots 3, 2 and 1, respectively. It would be interesting to test this theory with a study of irradiated iron with prior cold work.

Repeated yielding tests have been performed on "A" nickel. A specimen with an exposure of 3.6×10^{18} nvt exhibited a yield point, with a yield decrement of 3650 psi. After yielding, a limited amount of easy glide occurred, followed by rather rapid work hardening. Upon unloading and immediate reloading, the specimen again exhibited a yield point which was 850 psi greater than the stress upon unloading. The yield decrement was 250 psi. After yielding, another region of easy glide was observed, this time to a greater extent than during the initial test. An unirradiated specimen yielded continuously.

It has been found that metals irradiated with neutrons exhibit remarkable similarities in the post-irradiation annealing behavior. A synthesis of irradiation data for Cu, Ni, Al, Au, W and Mo reveals a sequence of recovery processes classified according to kinetics and falling into temperature ranges which can be roughly normalized according to reduced melting point correlations

These stages are for irradiations $< 10^{19}$ nvt: I, 0 - 0.03 T_m; II, 0.03 - 0.17 T_m; III, 0.17 - 0.28 T_m; IV, 0.28 - 0.42 T_m; S V, > 0.42 T_m.

It appears that stage III recovery may be broken into two substages, where one (approximately 0.17 to 0.22) is closely associated with divacancy movements. It has also been found that stage IV recovery is absent in pure metals irradiated with electrons. It appears in neutron irradiated metals and the kinetics are usually complex with high apparent reaction orders. Neutron hardening persists in this temperature range (Cu, Pt, Al, Mo). There is reason to believe this stage is related to the break-up of defect clusters formed during irradiation and with the release of trapped defects. This break-up appears to occur through dislocation and vacancy movements.

E. CUSTOMER WORK

Radiometallurgy Service

The inner spire of an I&E failure from 3476-KE was blocked for a distance of approximately four inches. There was no "mud flat" cracking on the core. The point of initial water entry has not yet been found (RM-417).

A "hot spot" was noted during examination of one of the nickel-plated fuel elements and was probably caused by misalignment in the process tube. No corrosion of the aluminum or sloughing of the nickel plate was associated with this "hot spot". Metallography revealed that the nickel-aluminum bond was good (RM-414).

Examination of an elliptical fuel element was completed this month. The fuel grew away from the spire over a three-inch length and produced a maximum ellipticity of 37 mils; there were gaps of 30 mils between the AlSi and the fuel. Grain growth in the fuel material adjacent to the gap probably was the result of local heating near the unbonded area (RM-416).

Examination of three elements with high weight losses revealed that the cladding had been uniformly removed over about three-fourths of the circumference. Minimum canwall thickness was 23 mils (RM-418).

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

Metallography Service

An investigation was made to determine the cause of the failure of a 100-K Area pump impeller seal ring which failed in service resulting in considerable damage to the pump. The seal ring was fabricated from type 410 stainless steel with a 3/16 inch thick overlay of Stellite #6 on the outer surface. The failure was determined to be one of fatigue initiating from a crack present in the seal ring either prior to installation or one which developed after startup of the pump.

Electron microscopy during the month included the examination of autoclaved zirconium surfaces, UO_2 fracture surfaces, zirconium thin films by transmission, deposits formed on a graphite capsule during irradiation, polished sections of graphite and coke, and air-borne particles captured in millipore filters when uranium was heated in air. A series of micrographs showing dislocation movement in a single crystal of cubic ZrO_2 was obtained.

A technique to thin zirconium metal, which will permit transmission electron microscopy, is being developed. An attempt was made to remove the worked surface layer, which remains after mechanical thinning, by the use of cathodic vacuum etching. However, the thin foil was converted to a blue oxide during the etching process and the specimen was no longer usable. Work is continuing on a chemical etching technique that has proved partially successful on previous attempts. Work is also in progress to develop a thinning technique for the examination and identification of the oxide or oxides formed during the autoclaving of zirconium.

Samples Processed During the Month:

Total Samples	1,227
Total Replicas	39

Photographs:

Micrographs	730
Macrographs	84
Electron Micrographs	193
	1,007

NPR Charging Machine

Installation of the rail sections in 314 Building was completed except for installation of the racks. The racks and pinions were received and modified as required.

Assembly of the truck frames was completed. Fabrication of components for the cross travel drive sub-assembly is 85% complete. Assembly of the cross travel drive sub-assembly is 75% complete. The main frame has been moved into the 314 Building. Fabrication of the transfer arm sub-assemblies was started and is 30% complete. The hydraulic power package was received.

Scope drawings of the magazine support are 80% complete. Four comment drawings were issued. Tests to determine optimum angle and material to stop free piston travel in the magazine continued and are estimated to be 30% complete.

NPR Bellows Test

Bellows from Associated Piping, Solar, and Uniflex have been cycled. Results to date: the Solar bellows suffered a hole in a convolute from galling on the shroud after 798 cycles; the Uniflex bellows parted completely after 637 cycles; and the Associated Piping bellows is still intact after 1435 cycles. Conditions

of cycling are: 500 F, plus and minus 7/8 inch travel for 4000 cycles, then 500 F, plus and minus one inch travel for 1000 cycles. Vibration tests to date have resulted in the destruction of one Uniflex bellows.

Heat Transfer Studies for the USAEC-AECL Cooperative Program

Bids were called for materials to build 19-rod boiling burnout test sections with rod spacings of 0.050, 0.035, 0.025 and 0.015 inch. All of these test sections will be run in a 3.25-inch ID pressure tube to determine the effects on heat transfer of different spacing between rods.

Installation of the 19-rod electrically heated test section used for full scale studies of the PRTR Mark I fuel element was started with the pressure tube situated in a horizontal position. This test section has an active length of seven feet, four inches and can generate over 2000 KW. It will be run under boiling conditions to determine the effects of stratification of the steam and water on rod temperatures.

VBWR Control Rod Review

A technical review of the Vallecitos Boiling Water Reactor control rods has been undertaken at the request of the APED. The review centers around the possibility, probability and circumstances which could lead to a "rod shoot-out incident" which would permit a significant step-wise increase in reactivity. A step-by-step analysis of possible component failures and operating errors is being made. The study will be completed in early March.

Pebble Bed Reactor Study

A special study group has been assembled which will direct its efforts towards developing answers to the specific questions cited in the Commission's inquiry on this reactor type. The study has been broken down into five study areas. A brief description of each of these areas is as follows:

Physics. Initial conversion ratio and anticipated conversion ratio after extended operation, power distribution, control characteristics including over-all reactivity coefficient and critical mass requirement.

Fuel. Cost of fabrication, expected integrity of balls at design exposure and in-reactor environment, migration through shell of fission product and fissile material, transport of coating material, and reaction with coolant and coolant impurities. In consideration of these items, it appears an estimate is required as to the amount, direction, and expected results of an R&D program.

Graphite. Cost of graphite moderator-reflector, life of moderator-reflector considering irradiation damage and reaction with coolant impurities, what knowledge of physical properties is required, and possibility of graphite transport to other parts of system. As with fuels, most of these considerations may be summarized by a proposed R&D program

Heat Transfer. Feasibility of natural convection cooling as proposed, heat balances on water side and gas side of system with reactor operating and shutdown, pressure drop on primary system, analysis of reported temperature gradients and heat transfer coefficients, estimates of any unusually high transient temperatures that may occur, and over-all net thermal efficiency.

Costs. Analysis of costs presented for the 330 MWe reactor. Development of estimated capital cost for the 330 MWe reactor including power generating equipment. Develop PBRE capital cost and costs for other R&D work required. Development of a cost review for the 330 MWe based on accepted Commission methods to show unit cost electrical energy produced and compare with unit cost presented.

FW Albaugh/kb

Manager, Reactor and Fuels Research
and Development

FW Albaugh:kb

PHYSICS AND INSTRUMENT RESEARCH AND DEVELOPMENT OPERATION

MONTHLY REPORT

FEBRUARY 1961

FISSIONABLE MATERIALS - 2000 PROGRAM

FUELS

Nuclear Safety in FPD

The nuclear safety of the storage array proposed for NPR tube-in-tube fuel elements in the fuel cladding facility (333 Building) was evaluated for the Engineering Operation. The evaluation shows that if the fuel elements are stored in the pallet on 4-3/4-inch centers (Drawing H-3-18827), the pallets may be stacked three high, with no limit in the horizontal directions.

REACTOR

Exponential Measurements for N Reactor

Measurements of the change in buckling upon insertion of boron control rods have continued in the N-reactor mockup. The fuel elements were 0.946% enriched uranium with H_2O coolant. The results are given in Table I.

TABLE I

Buckling ($10^{-6}cm^{-2}$)	Δ Buckling ($10^{-6}cm^{-2}$)	Number of Rods	Rod Configuration
116	0	No rods	Wet NPR lattice
-106	222	6 rods wet	N-reactor control rod spacing
-118	234	6 rods wet inside only	N-reactor control rod spacing
59	57	1 rod wet	18" left of pile center
8	108	2 rods wet	18" left and right of center
95	21	1 rod wet	left rear corner
74	42	2 rods wet	left rear and right front corner

The wet control rods had water both inside and outside the boron region. Extrapolation lengths used were 1.7 inches side-to-side and 1.4 inches front-to-rear. The bucklings assume no change in radial leakage. Thus it is assumed that the flux distribution is the same as the flux in an infinite medium with rods, weighted by the cosine distribution of the fundamental mode.

A subroutine has been written for use with a generalized least squares fitting program. The subroutine is intended to fit horizontal traverse data taken with control rods in the NPR mockup.

PCTR Measurements for N-Reactor

Measurements of the NPR mockup lattice parameters in the PCTR have been completed. The multiplication factor has been measured at effective water densities of .795 and .445.

$\rho_{eff}(H_2O)$:	1.0	0.795	0.445	0.0
k	1.075 ± .002	1.065 ± .003	1.043 ± .003	1.015 ± .002
f	0.879 ± .003	0.893 ± .003	0.914 ± .003	0.941 ± .003
p*	0.829 ± .007			0.717 ± .011
ϵ	1.050 ± .002			1.076 ± .003
η (derived)	1.406			1.396

* Using uranium catcher foils.

Depleted uranium foils were irradiated using either aluminum catchers or depleted uranium catchers to determine the effect of resonance neutron leakage through the aluminum for the dry lattice on the recent measurements of p. The experiment indicates that resonance neutrons do leak through the aluminum catchers. The leakage causes additional "surface" activation of the depleted foil with aluminum catchers relative to the foil with depleted uranium catchers. Comparison of the normalized foil activities confirmed the suspicion that the "window" did exist for the outer tube but did not exist for the inner tube which is already shielded from the resonance flux. The value for p using aluminum catcher foils is 0.701 ± .014. The value for p in the wet lattice (0.820 using aluminum catchers) has been raised to correct for the excess surface activation.

NPR Fuel Temperature Coefficient

The data from the experiments described last month have been fitted over the range from 20°C to 650°C with two expressions:

$$\rho_i = \rho_o + \beta (T_i^n - T_o^n) \qquad (1)$$

$$\rho_i = \rho_o + C_1 T_i + C_2 T_i^2 \qquad (2)$$

The data from each of three runs were fitted separately with Equation 2. The average value C_1 and C_2 was computed by weighting each value by its reciprocal variance. The resulting expression, which represents the data in the temperature range 20 to 650°C, is

$$\rho_i = \rho_o - (8.96 \pm 0.38) \times 10^{-3} T_i + (2.18 \pm 0.35) \times 10^{-6} T_i^2$$

with ρ in cents, T_i in degrees Kelvin. The temperature coefficient of k_∞ due to the fuel temperature can be expressed by

$$1/k_\infty \, dk_\infty/dT = - (1 \pm 0.07) \left[(2.35 \pm 0.1) \times 10^{-5} - (1.1^\circ \pm 0.18) \times 10^{-8} \, T(^\circ K) \right]$$

The factor (1 ± 0.07) is the maximized error due to spectrum and adjoint mismatches.

The data obtained for fuel temperatures greater than 650°C were complicated by several factors. Localized heating of the graphite in the PCTR core caused a reactivity loss. The change in the effective resonance integral of the fuel due to a volume expansion upon passing through the $\alpha \longrightarrow \beta$ and $\beta \longrightarrow \gamma$ phase changes in uranium metal caused a reactivity loss. These losses are not due to the true doppler effect and must be removed from the data before attempting to fit all of the data with a single functional relation. The effect due to passing through both phase changes can be expressed in terms of an effective fuel temperature increase of about 4%. Work toward establishing the rest of the appropriate corrections is continuing.

Exponential Measurements of Large Diameter Fuel Elements

The series of measurements on 2.5" diameter I and E and tube-and-rod fuel has been completed. Final material buckling values are given in Table I.

TABLE I

Material Buckling Values for the 12-3/8" Lattice

Fuel Element	Buckling 10^{-6} cm^{-2}	Lattice Spacing (in)	λ (s-s) (inches)	λ (f-r) (inches)	Source Configuration
2.5 x 1.6 dry	113 ± 3	12 3/8	0.9	1.0	Split
2.5 x 1.6 dry	113 ± 3	12 3/8	2.4	1.0	Clustered
2.5 x 1.6 wet with 1.17	-17 ± 2	12 3/8	2.2	1.0	Clustered
2.5 x 1.6 dry with 1.17	131 ± 3	12 3/8	2.4	1.0	Clustered

λ (s-s) and λ (f-r) are side-to-side and front-to-rear extrapolation lengths, respectively. The uncertainties in the buckligs do not include uncertainties in extrapolation lengths.

Several horizontal traverses analyzed previously using harmonic corrections based upon thermal source theory have been analyzed with harmonics based upon fast source theory. The results are listed in Table II.

TABLE II

Extrapolation Length Comparisons

Lattice Spacing (in)	λ (s-s) Thermal Source	λ (s-s) Fast Source	Pile Width
8 3/8	1.6 ± 0.2 inches	0.8 ± 0.1 inches	6 feet
14 9/16	3.7 ± 0.4	1.7 ± 0.2	10 feet with 8 in. added
14 9/16	4.3 ± 0.6	1.8 ± 0.3	10 feet with 12 in. added
14 9/16	5.5 ± 0.7	2.0 ± 0.3	10 feet with 20 3/8 in. added

Optimization of Retubed C-Pile Lattice

All components needed for a C-pile exponential mockup pile are either received or on order. An 8' exponential will be constructed for control rod measurements with both standard and overbored fuel.

Status of Components

Graphite: Collected from stock-machining started.

New I and E fuel (natural and enriched): On order, some natural fuel received.

Old I and E fuel: Canned rejects saved by FPD.

New I and E cans: Components on order, FPD will do canning and install bumpers.

New process tubes: Al tubes ordered and received by IPD (Zr not available).

Old process tubes: Received from stores.

Control rods: To be supplied by C-maintenance, 6 sections are reserved for our temporary, non-destructive use.

Polyethylene (to mockup flooding around tube block): Order has been received.

Exponential pile base: From stock, to be assembled where 12 3/8" lattice stood.

All data were taken in exponential piles loaded with 2.5" x 2.0" with 1.66" x 1.1" tube-and-tube natural uranium. The neutron sources were clustered about the pile centerline in all cases. The 14 9/16 lattice had varying amounts of graphite

added to the sides of the pile. Early exponential piles had varying amounts of graphite at the edge of the piles. The use of fast source harmonics yields more reasonable results in all cases analyzed at this time. In fact, it now appears that most of the discrepancy between recent measured extrapolation distances and early measurements can be attributed to the use of clustered sources without the fast source analysis which is more nearly correct. The difference is seen primarily for large lattice spacings for which the extrapolation distance was not measured in the early studies.

A general format has been prepared for an IBM card system to file exponential data. Identification will be printed on the cards between rows of punches and the data will then be punched in and printed at the top of the card.

Control Rod Burnout Measurements

The measurement of Cd^{113} burnout in two samples of a cadmium control rod from 105-C reactor was completed. Monoenergetic neutron transmission measurements were made of these samples using the single crystal neutron diffraction spectrometer. The remaining Cd^{113} content was assayed from the known Cd^{113} neutron total cross section by comparison with unirradiated cadmium standards. The results of measurements on one of these samples showed that it was almost completely burned out of Cd^{113}. An upper limit of 0.016 percent of the Cd^{113} content of natural cadmium was established. This sample was apparently the outer layer of the cadmium sandwich of the control rod. Measurements on the other sample (inner layer) gave a Cd^{113} content which was 35.6 ± 0.5 percent of the Cd^{113} content of natural cadmium. The errors quoted do not consider any possible difference in thickness between the radioactive irradiated cadmium samples and the standard cadmium samples with which they were compared. The results of these measurements are being reported to Operational Physics for comparison with burnout calculations.

Digital Computer Programs for Reactor Analysis

Development of HFN, the Hanford version of multigroup neutron diffusion theory code, FN, is continuing. A criticality search procedure was incorporated. This procedure varies a single diffusion parameter in an attempt to make the calculated multiplication factor equal to some input value. Neither this option, nor those mentioned last month, have been debugged, due to the press of other business.

Instrumentation

Final comments and corrections were made on the mechanical specifications and drawings for the NPR Fuel Failure Monitor. Preliminary information for the slow-scan scintillation portion of the monitor was supplied to Instrumentation Design, CE&UO.

Experimental work continues on the Scintillation Fast and Slow Scanning-Type Fuel Failure Monitor. A solid state DC amplifier was successfully tested with the fast scan simulator signal. A new readout, identification, and memory circuit was completed and tested. The circuit uses current-biased magnetic reed switches, driven by the voltage comparators, with closure times of 1.5 millisecond. The performance of the circuit is superior to that obtained with solid-state switches and the cost is reduced by 50 percent.

The experimental scintillation, chopper-input, transistorized combination multi-range linear and quasi-logarithmic beta-gamma area monitor (1 mr/hr to 50 r/hr) continues to show excellent operation in breadboard form after six continuous weeks of operation. No general drift errors have been observed, and day-to-day reading values have varied by less than ± 10 percent on the most sensitive (0-10 mr/hr) range for the six weeks. Two final prototypes are being fabricated and should be completed within two weeks. Complete evaluation tests will then be made.

The NPR nuclear instrumentation bids to IPD Specification HWS-6510 were reviewed and recommendations were made concerning certain vendor exceptions. Technical recommendations also were made to IPD regarding the Intermediate Range Period Monitors and the Subcritical Monitor Improvement Program. These recommendations were based on work previously done within IPD by an engineer recently transferred to HLO.

Work continued on a pyrometer for reading and recording reactor moderator temperatures with equipment completely external to the reactor. Temperatures are determined by analyzing the thermal radiation emitted through a sighting channel terminating at the surface whose temperature is to be measured. The radiation pyrometer cannot compete with the thermocouple in those applications where the thermocouple operates reliably now, but the radiation pyrometer offers the possibility of eliminating some of the costly and difficult thermocouple replacement work and may provide temperature data where previously thermocouples could only provide data during the first few days of operation. Fabrication of the electronic cabinet has been completed by the Electronic Shop. Assembly of the mechanical parts has been delayed to permit completion of other customer work in the Optical Shop.

Systems Studies

The NPR primary loop problem has been left patched on a problem board for the EASE computer. A new stability analysis will be made using this model sometime in March. A firm decision has not yet been made on what particular runs to make.

Further study is being made into design of a whole plant simulator for the NPR. The approach being taken is: (1) determine the detail needed in the simulation based on results of detailed studies of the individual components, (2) design simplified models of the individual reactor components and compare against the detailed studies, (3) determine what additional equipment will be necessary, (4) simplify simulation where possible so the plant can be studied with existing analog computers, and (5) simulate entire plant. GEL's five-node heat transfer model for the heat exchanger has been reduced to a one-node model. IPD's four-node reactor bulk primary heat transfer equations have been reduced to one-node equations. The computer program for these two parts of the NPR plant simulation has been designed, and will be checked out on the EASE soon.

An analog model of the NPR secondary loop has been designed and constructed. This system is presently being studied on the GEDA computer. The secondary system consists of the exterior reactor loops from the secondary side of the heat exchanger to the turbines and includes a surge tank, pressurizer and other loop operation. The data obtained from the study seems to indicate the surge tank, as previously designed off-plant, is too small. Additional studies will provide further insight into the effect of design proposals on reactor operation.

An approximate transfer function relating reactor coolant water outlet temperature changes to control rod movements was determined from experimental data obtained earlier at 100-D reactor. This transfer function will be used as part of a two-zone reactor control simulation now being prepared for the analog computer. The reactor transfer function to be used on the computer will be divided into three blocks: (1) a one delayed-group kinetics simulation, (2) a heat transfer simulation and (3) a temperature measurement simulation. A rough estimate of the transient response of a process to a step function input can be expressed in terms of a pure time delay and a single "equivalent" time constant element. Applying this approximation to the derived transfer function yields a pure delay of one second an an equivalent single time constant of five seconds. This approximation is stated for purposes of general comparison only; the computer simulation uses the three blocks mentioned above in each reactor section. The computer simulation of the control system will include some of the effects of moving a half-rod. The two simulated sections will represent two sections of the reactor in which the ends of a half-rod are located. Addition of reactivity into one section will, in general, result in a decrease in reactivity in the other section. The effects of various ratios of the reactivity effects at both ends of the rod will be studied.

SEPARATIONS

Plutonium Critical Mass Facility

The pre-startup checkout of the Facility and equipment preparatory to the critical mass experiments was continued.

The hood to be used for containment about the solution critical experiments was checked for leaks and accepted. When under a negative pressure of three inches of water, the leakage rate was five cubic feet per hour. This hood will normally be operated under a negative pressure of one inch of water.

A chain hoist was installed in the top of the hood, with a swinging boom support to provide for more versatile movement.

Further difficulties were encountered with the operation of the stainless steel valves in the suction header in the mixing hood; the stainless steel threads of these valves were found to be galling. The manufacturer of the valves was notified of the difficulty and has agreed to replace the fourteen stem and bonnet assemblies of the valves. Shipment of the replacement parts was to be made on March 6. The difficulties with these valves have prevented further tests being made on the solution system, which are necessary before the criticality experiments can be undertaken.

Adjustments were made in the air balance system of the mixing room to give a negative pressure of 0.1 inch of water when the doors are closed; the mixing hood will be operated under a negative pressure of one inch of water.

The security alarm system for the mixing room and the reactor room was checked out and is now operable, but this system will not be placed into routine operation until plutonium is brought into the building.

Delivery of the two transtackers for the Facility was requested and these were received. The battery charger for the transtackers was installed in the corridor near the entrance to the reactor room. Charging leads were run to the reactor room for charging the batteries of the transtacker in that area.

New stainless steel control rods were received for the criticality experiments with Pu solutions. Calculations had shown that the rods designed originally would very likely have had a worth in excess of one dollar and more transparent rods were needed.

Design drawings were reviewed for the split half machine which will be used for the conduct of criticality experiments with PuO_2-plastic mixtures to obtain data relevant to precipitates of Pu and PuO_2 slurries. The Technical Shops have estimated about two months' time will be required to complete and assemble the mechanical components for the split-half machine.

Work was begun on the development of a canning process for the PuO_2-plastic fuels for use with the split half machine. The results of recent tests indicate the problem of gas evolution in PuO_2-plastic mixtures will be eliminated if PuO_2-polystyrene mixtures are used. The prior experiments on the coating of the PuO_2 particles to prevent excessive gas evolution have attracted the interest of people interested in oxide fuels with enhanced heat conductivity.

Data Correlation - Development of Nuclear Codes for Criticality Calculations

The Monte Carlo Code HISMC, as originally designed for homogeneous infinite systems, has been made operable on the 7090 computer. However, it was evident that the accuracy of the code could be greatly increased with two modifications: 1) by conversion of the cross section scheme from a group averaged to point values and, 2) by adapting an integral inversion technique for selection of the scattering cosine for elastic scattering events. Both modifications have been incorporated in the program with only the final debugging to be completed. A new data tape was constructed containing the point cross section values. The selection of a cross section value for a particular energy is accomplished by the following simple interpolation scheme:

For a neutron having an energy E, such that, $E_{i-1} < E \leq E_i$

$$\sigma(E) = \sigma(E_i) - \left[\sigma(E_i) - \sigma(E_{i-1})\right] (E - E_i)/(E_{i-1} - E_i).$$

$\sigma(E_i)$ and $\sigma(E_{i-1})$ denote, respectively, the cross section values at energies E_i and E_{i-1}.

The cosine of the scattering angle, μ, is determined from the equation

$$\int_{\mu}^{1} \sigma(\mu', E)\, d\mu' = R$$

where R is the random number lying between 0 and 1. The partial integrals have been inverted(1) for the following eight elements: oxygen, nitrogen, boron,

(1) J. R. Lamarsh, A. I. Lieberman, M. C. Vassell "Selected Nuclear Data for Monte Carlo Calculations", NP-8216.

carbon, aluminum, iron, lead and uranium. It has been assumed for HISMC that the differential elastic scattering cross section for the plutonium isotopes 239, 240, and 241, as well as the uranium isotopes 233 and 235, behave similarly to that for uranium. The partial integrals have been tabulated and stored in a binary card library for use in HISMC. The scattering cosines are then determined by simple interpolation from the $\mu(R,E)$ tables.

A symbolic copy of the AIM-6 multi-group diffusion code has been received from Atomics International. This code has the two following advantages over the 9-Zoom code: 1) a criticality search option and, 2) the code was written in Fortran, which makes modifications simpler. It was found that several subroutines were missing when the code arrived; these have been requested from Atomics International. The code is presently being modified so that the cross section dependency on plutonium concentration, i.e., thermal spectrum shift and resonance self shielding, will be computed within the code.

It was also noted that the AIM-6 code did not contain the SNG restart dump option that was initially in AIM-5; this is due to the memory limitation of the IBM-7090. We propose to surmount this difficulty by carrying out the execution of the two codes in sequence without a re-entry of the input data into the computer.

Quantities of interest in the fabrication and handling of Pu-Al alloy fuel elements are the critical masses for the Pu-Al alloy under moderated and unmoderated conditions. Experimental data obtained at Hanford are available from which to obtain critical mass estimates for the fabricated fuel elements when immersed in water. To provide better estimates than currently available for the critical mass of the unmoderated system, the eighteen group diffusion code (9-Zoom) was used to calculate the critical mass for the Pu-Al alloys. The high energy transport cross sections of plutonium were adjusted to provide approximate agreement with the critical mass of α-phase Pu at full density. The results of these calculations are presented below.

CRITICAL MASS FOR UNREFLECTED Pu-Al ALLOY SPHERES

Volume Fraction of Pu	Alloy Density, gm/cc	Critical Radius (cm)	Critical Mass Kg-Pu-239	Critical Mass (Measured)
0.99	19.44	4.88	9.44	9.9(1)
0.9	17.91	5.43	11.83	
0.8	16.32	6.02	14.33	
0.7	14.53	6.78	17.92	
0.6	12.84	7.73	22.76	
0.5	11.15	9.01	30.03	31(2)
0.4	9.46	10.82	41.61	
0.3	7.77	13.61	62.09	
0.2	6.08	18.44	103.0	
0.1	4.39	29.75	216.2	
0.01	2.87	120.3	1429	

(1) H. C. Paxton, "Critical Data for Nuclear Safety Guidance", LAMS-2415, May 16, 1960.

(2) D.P. Wood, et al., "Critical Masses of Cylinders of Plutonium Diluted with Other Metals", Nuclear Science and Engineering, 8, 578-580 (1960). (The number given is an estimated value which has been corrected slightly to conform with the system calculated.)

Interaction of Subcritical Systems

Efforts to improve the trial functions in a variational principle calculation of the interaction of subcritical systems have been described in recent months. These efforts have met with only limited success. An alternative approach is now being tried, namely, to use the constant trial function expressions for relative rather than absolute calculations of criticality. The quantity now calculated by the variational expression is k'/k'_o, where k' is the k-infinity which each of the (identical) interacting systems must have for criticality of the assembly and k'_o is the k-infinity which would be needed to make one of the systems critical by itself. This ratio is now being calculated for two interacting slabs, in which case the "exact" answer can be found with the multigroup code, HFN. A code has been written for evaluation of the variational expression in slab, cylindrical, and spherical geometries. Up to 25 interacting systems may be used. This code has been used to calculate k'/k'_o as a function of separation for two interacting slabs. The HFN solutions for comparison have not been completed.

Criticality Hazards Specifications

Nuclear Safety in HLO

a) One nuclear safety specification was issued in HLO. The specification was for Critical Mass Physics to cover experimental measurements in the PCTR with plutonium nitrate solutions; the specification number is C-11, Experimental Determination of Limiting Concentration of Plutonium Nitrate Solution.

b) A criticality display, which is to be used for nuclear safety education throughout HAPO, was completed this month. This display consists of twenty different models which show the "just critical" dimensions of fissile material in different geometries and conditions of neutron reflection. The models include bare and reflected spheres, cylinders and slabs; the materials represented are plutonium (metal and solution), highly enriched uranium (metal and solution), and slightly enriched uranium in the form of a water moderated lattice of uranium rods.

Evaluation for Nuclear Materials Operation

The nuclear safety of a special Mound car shipment to Oak Ridge, Tennessee, was received and approved.(1) The Mound car, which is normally used for shipping isotopes from HAPO to Oak Ridge, is AEC escorted, and therefore may contain larger quantities of fissile materials than common carrier vehicles. The approved shipment consisted of "J" and "C" fuel elements, UNH powder, and slightly enriched UO_2 pellets.

Nuclear Safety of Off-Site Shipment

At the request of the AEC, the nuclear safety specification for the Redwood railway car was revised and brought up to date to conform with the fissile material

(1) Letter P. F. Gast to F. J. Zelley, "Nuclear Safety - Special Mound Car Shipment", February 13, 1961.

currently being shipped.[2,3] In addition certain non-fissile materials were approved for shipment with the fissile material such as D_2O, etc.

Miscellaneous Experiments for Nuclear Safety Specifications

The experimental work on the measurement in the PCTR of the limiting (just critical) concentration of U-235 in an aqueous solution was completed this month. The results of this measurement will be compared with those reported by ORNL and will serve as a cross check between the two laboratories. In addition the measurement will provide another "known value" for checking the PCTR method.

The concentrations of the 93% enriched UO_2F_2 solutions used in the experiments were 13 gm U/l for the buffer tank, and 11, 13, and 15 gm U/l for the three core tanks, respectively. Despite difficulties with leaking tanks (five of the original six tanks eventually leaked), the tanks were finally filled and sent to the PCTR for the measurements.

On the completion of the measurements, when the tanks were being emptied, it was noted that a reaction between the UO_2F_2 solution and the aluminum of the tanks had taken place. A layer of some insoluble uranium compound was deposited on the tank wall, thereby lowering the concentrations of the solutions. Each tank was re-sampled while being emptied; these samples are now being analyzed to determine the solution concentrations in the tanks after the buildup of the uranium compound on the tank walls. It is not understood why the UO_2F_2 solution reacted with the aluminum in the tanks, since a test piece of aluminum immersed in the UO_2F_2 solution prior to the experiments showed no significant reaction.

Final preparations for the measurement of the limiting concentration (the concentration for which $k_\infty = 1$) for a plutonium nitrate solution were completed during the latter part of this month. The stainless steel experimental vessels were completed and sent to the 234-5 Building where they were filled with the proper plutonium nitrate solutions by CPD personnel. The buffer tanks were filled with solution at a concentration of approximately 11.4 gm Pu/l, and the three core tanks were filled with solutions with concentrations of 10.4, 11.4, and 12.5 gm Pu/l. The filled tanks have been sent to the 305-B Building and will be installed in the PCTR as soon as the experiment presently being conducted there is completed.

The experiment to determine the limiting critical concentration of an aqueous Pu solution was originally undertaken in April and May of 1960. When the experiment was in the final stages of completion, a contamination incident occurred and it became necessary to stop further measurements at that time. The current measurements will complete the experiment, and also serve as a check on the preliminary results obtained earlier.

---

(2) A. T. Gifford, Nuclear Safety Specification - Redwood Car, HAN-7756g, January 27, 1961.

(3) P. F. Gast, Nuclear Safety Specification - Redwood Car, HW-68452, February 10, 1961.

Mass Spectrometry

Previous studies carried out with the mass spectrometer for this program have shown that the energy distributions of ions arriving at the detector are not homogeneous as they should be. The effects which have been observed are relatively small in magnitude and have a negligible effect on routine analyses. Experimental studies are in progress which have isolated the source of the inhomogeneities to the ion optical system of the ion source. A new source electrode structure has been fabricated which was designed to lessen the influence of the steering electrodes which were ascertained to be the contributing factor to the observed effects.

Studies on the effect of filament shape on sample life in the spectrometer are also in progress. A configuration of filament has been found which has increased the apparent sample life by an order of magnitude over the life obtained with a simple single filament. The configuration of filament under study possesses some of the general features of a double filament ion source. These studies are very important since sample life determines the minimum sample size which can be processed. Particularly for plutonium samples, the ability to use a very small sample is important in controlling contamination both in the analyses (spectrometer) and in the laboratory. With the filament configuration under study a 0.10 μgm plutonium sample was isotopically analyzed to a statistical precision of 0.5 percent in the 240 to 239 ratio using the metallic ions.

Seven analyses of product plutonium were performed as a service for Analytical Laboratories during the month using the three filament mass spectrometer of the Isotopic Analysis Program. One of the analyses which was also performed on the single filament mass spectrometer agreed with the analysis of the 240/239 ratio obtained with the three filament spectrometer to within the precision of the measurement (0.5 percent). The results obtained on analyses performed on duplicate samples with the mass spectrometer of Analytical Laboratories were consistently different from the results obtained in our laboratory by three to five percent in the 240 content. As a result of this discrepancy work is in progress to attempt to eliminate some of the apparent malfunctions of and evaluate the performance of the Analytical Laboratories mass spectrometer.

Instrumentation and Control

Help was requested by CPD in putting into satisfactory operation some recently purchased lathes with automatic contour following control. These controls cannot be adjusted to give the required accuracy without jittering. The vendor made an attempt to fix them, without success, and has discontinued his efforts on the basis that the machines allegedly met specifications in factory tests and were accepted.

A two-prong attack on the problem is under way. Since no instruction book or descriptions exist, and circuit diagrams are meager, the vendor has been requested to furnish design data so that a detailed analysis of the system can be made. In the meantime, tests have been set up to measure the response of the system to various stimuli. This work is under way and has not yet yielded definite results--except for an indication that the system is highly nonlinear.

The problem was discussed with experts from the Control Systems Steering Group, with two results: Concurrence that the two-prong attack is correct, and statements that usual industrial applications do not have nearly as great an accuracy requirement.

NEUTRON CROSS SECTION PROGRAM

Slow Neutron Scattering Cross Sections

A series of measurements of the differential scattering of incident 0.20 ev energy neutrons from room temperature water has been started. Energy analyses have been measured at scattering angles of 10 and 50 degrees. Measurements have been made of the angular distribution of the scattered intensity of neutrons of final energies of 0.075, 0.10, 0.15, 0.20, 0.279, and 0.30 ev.

INELASCAT, the code which processes inelastic scattering data from the three-axis neutron spectrometer, has produced satisfactory results on several test cases. It is now in the process of revision to allow for computation of several additional quantities, as well as polishing of output. Input data forms have been designed and are being drawn.

A liquid nitrogen cryostat for cooling a vanadium scattering sample during scattering measurements is under construction.

Fast Neutron Cross Sections

The positive ion Van de Graaff accelerator was used for a one-week period to study the background and intensity problems to be encountered in pulsed beam, time-of-flight total cross section measurements. The general indications from the background study were moderately encouraging. Be(d,n) neutrons were successfully observed 5.5 meters from the target with a signal to background counting ratio greater than two without detector shielding. The pulse shape discrimination circuit which was previously successfully bench tested exhibited radio frequency pickup in the accelerator building, and complicated the detector operation during the measurements.

Instrumentation

A new time mark generator was built for use with the vernier chronotron. The vernier chronotron measures very short time intervals, and is used in the fast neutron time-of-flight program. The time mark generator provides a pulse to indicate when the burst of neutrons was formed. The bursts are actually formed by sweeping the ion beam across a slit by a strong RF field. The time mark generator produces a five-nanosecond-wide pulse each RF cycle. The new unit has a built-in oscillator so the vernier chronotron may be checked without the necessity of operating the RF sweep. Also, a 360-degree phase shift control has been added so the chronotron display may be shifted as desired. The circuit is transistorized, except that one EFP60 is required as an output tube to get a large enough pulse to drive the chronotron. Installation and system testing will begin in March.

REACTOR DEVELOPMENT - 4000 PROGRAM

PLUTONIUM RECYCLE

PRTR Critical Tests

A summary of test results was submitted for the June American Nuclear Society meeting. Interpretation of results by means of reactor codes made good progress. Nearly all of the earlier discrepancy between theory and experiment appeared to be removed by two changes: reduction of Pu-239 neutrons per fission from 2.91 to 2.84, and adoption of the plutonium cross section data and resonance self-shielding techniques used in the MELEAGER code. Preliminary analysis using the FLUXWEIGHT code appears now to agree very well with the experimental results for critical loading as well as level coefficient and reflector savings.

Analyses of the results of the startup experiments were undertaken at the end of the tests. A total of 259 multiplication numbers and 186 period numbers were obtained for experiments during the tests. Each multiplication number corresponds to an approach-to-critical experiment for a different reactor configuration and each period number to a different measurement of a period. In addition, there are data from gold foils irradiated during 14 experiments. Approximately 95% of the analyses have been completed.

The moderator level at which criticality occurs for a particular reactor configuration has been predicted from both multiplication data and period data. The worth of the moderator at various levels has been determined from the period measurements which were made during the second series of tests. The data from all the gold foils have been analyzed. Preliminary analyses of data which were obtained from a vertical string of BF_3 counters have been completed also. The final analyses of the counter data will not be made until final normalization factors are obtained for the counters.

The remaining 5% of the analyses comprise the determination of the worth of the moderator as a function of height for the first series of tests, the tabulation of the results from all the experiments, and the plotting of final radial and vertical flux data.

In addition to the analyses of data, summaries of the experiments have been prepared for reproduction. These summaries relate various Critical Test numbers, multiplication numbers, period numbers, and fuel loadings to each other. Diagrams which show the positions of the fuel elements in the reactor have been prepared also.

The Critical Facility of the PRP

The use of 5086-type aluminum for the reactor vessel rather than 6061-type aluminum was studied to determine their relative effects on the experimental program. It has been decided to use the 5086 aluminum for the vessel and the 6061 aluminum for parts which appear inside the reactor. Although the former aluminum is not the purer one, it does have several advantages. It is easier to fabricate and structurally would make a better vessel. Also, the impurities which would be activated (principally manganese) decay rapidly enough that for times greater than 24 hours after shut down the dose rates from the 5086 aluminum would be less than from 6061 aluminum. This is only of importance when

work is to be done on the empty reactor since earlier access to the loaded reactor would be limited by the fission product radiations which would be emitted by the fuel. The 6061 aluminum has ~20% lower absorption cross section and so it was felt advisable to limit "in-reactor" components to this type of aluminum.

Specifications were set for procurement of the D_2O which is to be used as the moderator during the first experiments. The D_2O which Savannah River usually supplies to its customers has properties which are adequate for use in the Critical Facility. Its tritium content is a principal objection. However, the concentration is not large enough to be considered hazardous and procurement is simplified if standard D_2O is requested.

A rough draft of a description of the MTR-RMF experiment was reviewed. The description is to serve two purposes. It is to inform people of the experiment and also serve as a "Test Description" for the personnel who will perform the experiment at Idaho Falls.

By the time the RMF measurements will be made the Advanced Reactivity Measuring Facility (ARMF) may be in operation. The latter facility is to be more sensitive than the RMF for measurements of reactivity changes. For this reason, the proper forms have been initiated for AEC authority to use the new facility if it seems advisable at the time of the measurements. In order to obtain this authority the start of the experiment may be delayed, about one month, until April. This delay may allow time for measurements of the samples in the PCTR. Such a measurement would be a third check on the method of analysis. The other two checks would be obtained from the measurements in the RMF (or ARMF) and in the PRP-CF.

Code Development

RBU

The Basic Library Editor code was completely written and ready for compilation at the end of the month. A portion of the Output code (Output Editor) is being revised to permit more convenient selection of output information, and several errors in the treatment of inelastic scattering transfer coefficients and computation of diffusion coefficients for regions containing voids were corrected.

MELEAGER

Several additional options were incorporated into the code, including a provision for automatic spectrum interaction (pseudo-homogeneous reactor core), for automatic determinations of temperature coefficients at the beginning and end of each cycle, for multiple reactivity end-point iterations, and for direct modification of the cross section library. These changes are also described in the final draft of the report, which is essentially ready for publication except for the inclusion of a code listing and sample problem.

LOLA

The final report has been submitted for publication.

C-6

Most of the subroutines for the Hanford version of C-6, the ANP slowing down spectrum code, have been compiled and debugging of the code will start soon. The initial phases of debugging will involve checking the method of obtaining data from the 100 point data tape.

Analysis of Finite Heterogeneous Lattices

A revision was made in the code POWER, which solves the matrix equation $A x = \lambda x$ for the maximum eigenvalue λ and the associated eigenvector x, to reduce the number of iterations for convergence. The code was made available to the Fortran Program Library. Some revisions were made in the code HET, which performs the heterogeneous lattice calculations, in order to utilize memory more efficiently. This is needed to permit expansion of the limits on some indices and to include other calculations which now must be done by hand.

Machine Calculation of the Hurwitz H-function

To evaluate a general approach for obtaining infinite medium spectra by integrating the defining differential equation, the Hurwitz H-function has been calculated using Runga-Kutta integration. The H-function has also been calculated from its defining power and asymptotic series in order to determine the error in the integration approach. Four figure agreement is obtainable with a reasonably large integration mesh.

The Hurwitz H-function has general application, since it represents the deviation from a thermal spectrum of the infinite medium spectrum of a weak v^{-1} absorber. Consequently, the power series representation of the H-function has been coded as a 7090 subroutine for general use. This subroutine is currently being incorporated into ACE, a generalized integration routine.

Neutron Rethermalization in Graphite and Water

During the past month the activity traverses of lutetium 176 across a temperature discontinuity, have been fit to within 5-10% for four different experiments. Lutetium 176 has a non-1/v cross section in the thermal energy region. The calculations were based upon the two thermal group model. The rethermalization cross sections used in the calculations were those derived previously from the "1/v" activity traverses. These fits show the general validity of the two thermal group model and suggest that absorption rates in other non-1/v absorbers, such as plutonium 239, samarium 149, or xenon 135 can be adequately calculated.

The comparisons of the calculated and experimental traverses are dependent upon the model of the energy distribution of the epithermal neutrons. A Westcott model (AECL 1101) yielded the agreement quoted. This agreement was improved by a factor two through the use of the "Hurwitz model" (NSE 1, 280-312, 1956).

The values of resonance integrals which have been measured and calculated for the lutetium isotopes have been compiled for inclusion in the January, February, and March issue of the Nuclear Physics Research Quarterly Report.

A final draft of a report which is entitled "ACE - An IBM 709 Program for the Convolution, Evaluation, and Integration of Various Functions" has been prepared and will be distributed.

Pu-240 Effective Resonance Integral

A different method has been formulated for measuring the effective resonance integral of Pu-240 than the one which was discussed last month. The new method is also a relative measurement, and the standard would be the Pu-240 dilute resonance integral. The reactivity effect of the Pu-239 is not a problem in the new scheme, because the reactivity measurements are compared only between samples with the same Pu-239 content, but with differing Pu-240 concentrations. Preliminary plans for this experiment are almost complete, and nothing has been found so far to indicate that the experiment is not feasible. The earlier method was discarded because the reactivity effects of the Pu-239 would not be a linear function of the Pu-239 concentration.

Analysis of Fuel Temperature Coefficient Data

In HW-63766 the temperature coefficient of the resonance integral, $1/\Sigma\ d\Sigma/dT$, was first expressed as a quadratic function of the fuel temperature, T. The quantity $1/\Sigma\ d\Sigma/dT$ was then evaluated at 50-degree intervals for temperatures from 50 through 500°C. These results were plotted as a function of Kelvin temperature on a log log scale. From this plot the expression

$$1/\Sigma\ \ d\Sigma/dT\ \ =\ \ 2.90 \times 10^{-3} T^{-0.480} (^{\circ}K)$$

was obtained by fitting a straight line to the data. No error was attached to either the coefficient or exponent of T because the errors which were calculated by the fit were too small and not representative of the uncertainty in the experimental measurements.

A discussion with an HLO statistician indicated that an error evaluation more representative of the experimental uncertainty would be a formidable task if not impossible. It thus seemed advisable to start again with the raw data and attempt to fit it directly with the general form, AT^n, instead of the quadratic form originally used. Two different approaches have been tried and each one has its difficulties.

One method requires using about 90 percent of the original data points twice which, besides being somewhat objectionable in itself, considerably complicates the error analysis. This complication arises because the use of the same data points twice must be taken into account. The second method, which uses a generalized least squares program, was successful in fitting the experimental data to the desired functional form. However, the errors which this program generates for the coefficient, A, and exponent, n, are now such that when a value of $1/\Sigma\ d\Sigma/dT$ is calculated by using the fitted equation the error on this value is a factor of three larger than the experimental uncertainty. The method which is used by the program to evaluate the errors is being checked in an attempt to resolve the difficulty.

Pebble Bed Reactor Studies

At the request of the AEC, a proposed pebble bed reactor design is being evaluated. The physics portion of this study is being conducted by Theoretical Physics personnel.

The proposed reactor is fully reflected by graphite. U^{235} fuel is dispersed in graphite spheres which also contain Th^{232}. These spheres are simply loaded into the reflector structure which is in the form of a right circular cylinder with the ends closed.

Instrumentation and Systems Studies

The PRPCF Instrumentation Specifications (HWS-7813) were reviewed, and a number of important changes were suggested in the interests of useful performance, safety, and general operability.

Investigations continued concerning spectral measurements of fuel rods containing UO_2 and PuO_2 to determine the possibility of locating improper concentrations of PuO_2 in the elements. Collimated scintillation detector scanning was used with channeling at 380 Kev. One element was tested which, supposedly, contained a PuO_2 concentration "imperfection" about 0.25 inch long with two times the normal amount of PuO_2 at the point of imperfection. A number of scans were made using different speeds, collimator slit widths, etc.; however, the imperfection could not be located via the scintillation scanning method. Future tests will use fuel elements with imperfection concentrations six and 20 times normal to determine the detectability limits of the scanning method.

Two experimental PRPCF "last ditch" safety fuse units were assembled using different thermostats and with electric heaters to simulate the proposed operation which will employ enriched uranium. Laboratory tests indicate reliable triggering is possible at flux levels of 3×10^9 nv. and that the trigger level is easily controlled by thermostat selection. Final tests will be held when the 93 percent enriched uranium on order is obtained and installed.

The scintillation fuel element rupture monitor system for PRTR was received and is being installed. Discussions were held to determine testing procedures to be used with the system.

Two of the radiation-resistant variable differential transformers for PRTR process tube inside diameter measurement were calibrated. They were then exposed to 1×10^8 R gamma and rechecked. Thorough testing has revealed no electrical or physical damage. The devices were calibrated on a range of sensitivity which produces full-scale meter deflection for displacement of ± 0.010 inch. The same two transducers are to receive a further exposure of 1×10^9 R.

The probe for measuring the PRTR Gas Annulus was tested in 200°F water and appreciable distortion in the nylon based phenolic (of which the major portions are fabricated) was observed. Further testing indicated the upper temperature range for the probe will be approximately 160°F, since above this the phenolic distorts and the coil holders have a tendency to stick. However, this should be satisfactory since the maximum temperature expected during the actual inspection was set at 150°F.

Work is continuing on the wall thickness measurement of the PRTR process tubes. In an effort to improve the acoustic coupling between the ultrasonic transducers and the tube walls, the probe is being redesigned to accommodate a crystal having a contacting surface area of 1.0 x 0.5 inch. Although the accuracy and reliability will be greatly improved, an accompanying reduction in resolution will result from the increase in transducer size.

A magnetic tape recording of PRTR neutron flux signals was made using the new ionization chamber described in the January report. This chamber had been filled with BF_3 at a pressure of one atmosphere (the maximum available locally) in an attempt to increase chamber efficiency. It was found that the increase in efficiency obtained, however, was not sufficient to clearly indicate the location of the frequency "break" due to neutron lifetime. The effects of the delayed neutrons on the frequency response were shown although a detailed analysis of this portion of the frequency spectrum was not attempted. It was apparent that a higher chamber efficiency was required for measurement of the prompt neutron lifetime. A new chamber, 3/4-inch in diameter and 30 inches long was then constructed. It uses a 1/4-inch diameter center electrode and one atmosphere of 96 percent enriched BF_3 gas. In addition, a new preamplifier was designed and built. The design is such that the d-c component of the ionization chamber current can be biased out with a control box located in the control room during reactor operation. The input circuit was also changed to be more compatible with the new chamber. The new chamber and preamplifier were tested at the TTR and used to measure the TTR prompt neutron lifetime. A well defined break in the resulting frequency response curve established the ratio β/ℓ, for the TTR, at a value of 27.6. Using a β of 0.00755, this ratio yields a value of 0.366 milliseconds for the effective prompt neutron lifetime.

The PRTR Gas Balance System simulation has been started. This work consists of the simulation of the gas loop, gas storage tank, the gasometer, and the control system. The Gas Loop System alone has previously been simulated. In practice, it has been found that a shock excitation to the system can produce sustained oscillations in the moderator level. The gasometer was designed to prevent this occurrence, but does not operate satisfactorily in this respect. The purpose of the present study is to determine the necessary system parameters to eliminate the possibility of moderator level oscillation. The study involves the derivation of the system equations, including those representing the gasometer and the orifice coupling to the gas loop proper.

NONDESTRUCTIVE TESTING RESEARCH

A segmented time reversal scheme using transmission lines has been conceived for use in the analysis of the broadband eddy current test signals, and the operation of a crude prototype signal reverser was successfully demonstrated. The time reversal device will be used just ahead of the orthogonal filters in the analyzing equipment, and its function will be to segmentally reverse the broadband signal. Heretofore workers in this field of signal analysis have recorded the signals on a magnetic tape and obtained the time reversed function by reading the tape in reverse direction. The tape method leaves much to be desired for handling signals having high frequency components and in meeting the requirements presented in continuously analyzing the signals in an instrument as proposed for the broadband eddy current test.

The new time reversal device consists of two electric transmission lines with diode gates between the lines connecting corresponding points of each line. The lines are terminated in their characteristic impedances to minimize reflections. The signal to be reversed is applied to the first line. When this signal is all on the line the diode gates are energized for a very short period. This action establishes two waves traveling in opposite directions on the second line. The wave traveling in the reverse direction develops a signal across the line terminating resistance which is reversed in time.

The waves traveling in the forward direction on both lines are dissipated in the corresponding line terminating resistors. Successive signals fed to the near end of the first line can be continuously reversed by this method.

The prototype device consists of two artificial transmission lines each having six sections with delay time of about 11 microseconds per section and cutoff frequency of 30 kilocycles. A blocking oscillator provides gating pulses of about 1 microsecond duration. The time reversal effect in elementary signals was clearly observed with this relatively crude device.

An improved device will be constructed using transmission lines having 50 or 100 sections with correspondingly higher cutoff frequencies.

The new method is presently limited to use at higher frequencies as contrasted to magnetic tape recording which is most practical at lower frequencies. Effectiveness of the new method will be limited by time delay to rise time ratios of the transmission lines.

Comparison of heat transfer test maps and ultrasonic maps of fuel element bonds indicates there is no definite correlation between the size of bond defects in fuel elements, as indicated on the ultrasonic maps, and the magnitude of impedance to heat flow. Heat transfer defects were detected in both rejected and non-rejected production fuel elements. Sixty-three aluminum clad natural uranium Hanford production fuel elements which had been ultrasonically rejected and 60 which had passed ultrasonic tests were heat transfer tested using a 10 KC, 15 KW induction heater and a Physical Measurements Operation Model III heat transfer testing radiometer. This equipment will detect bond heat transfer discontinuities due to circular voids 3/8 inch or larger in diameter.

Discontinuities in heat transfer were detected in the bonds of only 17 of the 63 production ultrasonic rejects. Comparison of ultrasonic maps of 12 of these rejects with the heat transfer maps showed that large areas of ultrasonic discontinuity do not necessarily indicate large heat transfer discontinuities. On the other hand, distinct indications of bond heat transfer discontinuities were found in four of the fuel elements which had passed the production ultrasonic tests. The largest of these discontinuities produced a surface temperature increase similar to that produced by a circular 3/8-inch-diameter void. Further ultrasonic characterization of these fuel elements is under way.

Variations in cladding surface emissivity is one of the main factors limiting the sensitivity of the present heat transfer testing equipment. These emissivity variations cause spurious variations in radiometer indications of the surface temperature which mask temperature changes due to small heat transfer discontinuities.

Increasing surface heating power density during testing would increase the magnitude of temperature changes over discontinuities, but an ultimate limit would be imposed at the point where metallurgical changes would occur in the cladding due to high surface temperatures. For this reason, it is necessary to eliminate the effect of emissivity variations.

An invention report describing a possible new type of emissivity-independent infrared radiometer being developed for application in heat transfer testing has been issued (HW-68574). The theory upon which this instrument is based has been extended to include the case of large temperature variations.

A Zircaloy-clad uranium fuel element having suspected bond discontinuities was heat transfer tested in the same equipment used with the aluminum clad elements. Although apparent bond heat transfer discontinuities were indicated, large diameter variations in the test piece made it impossible to determine whether they were real, since much higher power densities are generated in areas that protrude nearer the induction heating coil.

Previous tests with plasma-arc heating indicate it is much less position-dependent than induction heating. Preliminary experiments have indicated high sensitivity can be obtained in the heat transfer tests with a plasma-arc heat source. Arrangements have been made with Ceramic Fuels Operation to continue using their unit on a part time basis during further evaluation of this heating method for applications in heat transfer testing.

NEUTRON FLUX MONITORS

Investigative work now includes detector location considerations in the reactor such as in the process tube, in moderator near the tubes, and in regions between the process tube and the moderator. Sets of parameters for the three possible locations have now been obtained and these new parameters are being used to determine appropriate detector compositions. The scope of material considerations now includes U^{235} and U^{236} in addition to previously considered U^{238}, Pu^{239}, Pu^{240}, and Pu^{241}. Information concerning procurement of depleted uranium and various plutonium isotopes was received. Tentative arrangements have been made for on-site experimental fabrication of several prototype detectors and experiments have been planned for detector testing. If feasible, tests will be made both in the Hanford production reactors and in the ETR at Idaho.

Prints and radiographs of various types of in-core chambers were obtained to guide the structural design of the proposed fissile material detectors.

PHYSICAL RESEARCH - 3000 PROGRAM

Mechanism of Graphite Damage

Tests were carried out of a technique for compensating for beam heating during irradiation of graphite samples with the electron Van de Graaff. The results were good. It was possible to reduce temperature drifts to negligible values for temperatures as low as that of dry ice to up above room temperature.

BIOLOGY AND MEDICINE - 60CO PROGRAM

ENVIRONMENTAL SCIENCES

Atmospheric Physics

The IBM 7090 program for processing the dosage data obtained during atmospheric diffusion experiments was modified and expanded to increase its versatility and include calculation of some dispersion parameters. The program is now sufficiently flexible to accept experimental data from almost any grid of sampling arcs. In addition to the mass values obtained for each sampler location, the program includes calculation of the first four moments of the arcwise mass distribution, the modal value along the arc, and the position of the mode. Debugging of the program was completed in preparation for processing data collected during the 1960 field test series.

Four additional diffusion experiments were attempted during the month, with three successes. Two experiments were conducted using an elevated source located at 200 feet height with dosages measured at 1.5 meters height to a distance of one mile. One experiment was conducted using a ground source with dosage measurements on both the vertical and horizontal grids to a distance of two miles. Meteorological conditions were unstable in the three experiments. The fourth experiment was attempted during a steady rain, but failed when the wind direction shifted off the sampling grid.

Refurbishing of the Rankin counters for assaying the amount of zinc sulfide tracer material collected on membrane filters during the atmospheric diffusion experiments progressed. Three units that were previously contaminated by flaking of plutonium from the alpha particle source were decontaminated. New alpha particle sources of Americium 241 were installed in two of the units. The signal-to-noise ratios for counters using the americium sources was about 50% better than with any of the previously used plutonium sources, even though the alpha flux was nearly identical. However, the americium sources also flake off slightly, and Analytical Laboratories have been requested to seek methods to provide better adherence of the source material. One counter, utilizing a source of plutonium electrodeposited on platinum, has not deteriorated in nearly two years of use.

Attempts to calibrate the rain-droplet sampler for use in precipitation scavenging studies continued. Droplets of distilled water of nearly uniform size are generated with a modified hypodermic syringe at the top of a vertical tube 42 feet in length and are sampled at the bottom, having reached terminal velocity in the tube. Droplets are collected on the Diazo paper of the droplet sampler and on an oil surface. Droplets collected on the oil are sized under a microscope and their diameters compared with the spot size on the Diazo paper. Large drops are collected and weighed. Calibration data have been obtained in the dropsize range 0.75 to 4.6 mm diameter, which embraces the rain droplet sizes that intercept the zinc sulfide tracer.

Over-all precision of the calibration is expected to be approximately ten percent.

[redacted]

DOSIMETRY

The Zn-65 calibration is continuing. The result continues to change with time and is approaching the calibration value now in use.

The last modification necessary to permit use of the paper punch for preparation of whole body counter data for the IBM machine was completed. Routine use of the paper punch will begin March 1. Its use will eliminate the need for hand punching of cards.

The air filters for the iron room were changed. The old filters were found to contain Ce-144, Ru-106 and Cs-137 but the amounts were lower by an order of magnitude than those found on previous occasions.

A study was begun of the rate of elimination of Co-60 from an individual found to be contaminated with that isotope. Zr-Nb-95 that was initially present was rapidly excreted. The rate of excretion of the Co-60 is very low.

Our past practice for locating Pu in wounds was to cover the wound with a thin lead sheet containing a small hole. The plutonium was located by finding the position of the hole that would permit the counter to detect the X-rays. We have found it to be simpler and faster to use just a small piece of lead and find the position of that piece which will keep the X-rays from being counted.

A circuit was developed that permits discrimination against very short scintillation counter pulses. This circuit may be useful in reduction of noise in plutonium X-ray counters. The circuit works by requiring a coincidence between a counter pulse and the same counter pulse delayed.

The positive ion Van de Graaff operated satisfactorily during the month. Timers were installed on each of the mercury diffusion pumps that will turn the pumps off if not reset within twenty-four hours. These will protect the system if for any reason the pumps are not serviced with dry ice every day. Plans were prepared for a deuterium gas target. The work with the Perlow spectrometer was completed and it and the 100 channel analyzer were removed from the building. A Li-6 spectrometer and a 400 channel analyzer were moved into the building.

We understand that our precision long counter has been adopted as a neutron standardizing device for the International Radiation Standards Laboratory being set up by the International Bureau of Weights and Measures. We also understand that our double moderator device has been adopted by the Mound Laboratory for use in checking the Pu-Be sources that they produce. They are the maker of such sources for the United States.

The measurement accuracy achieved with the precision long counter brought to light that the neutron emission from Pu-Be sources changes on the order of half a percent per year. The change appears to be due to the growth of daughters of the plutonium isotopes in the source and therefore depends on the isotopic composition of the plutonium. Mound Laboratory is seeking ways to establish the composition of the sources they have already produced and to measure it for future sources.

A precision long counter was fabricated for intercomparison of neutron standards in different laboratories. An antimony-beryllium neutron source previously prepared was successfully decontaminated and used in precision long counter measurements. The study of the effects of large doses of gamma rays on the BF_3 counters is continuing.

One of the results of the work with the Perlow spectrometer was the discovery of deuterium contamination in most of our tritium targets. This was confirmed by measurements with the double moderator. This is important to our laboratory work because it means we cannot produce neutrons of energy above 5.4 Mev that are not seriously contaminated with neutrons of lower energy.

The system for filling tissue equivalent chambers with tissue equivalent gas was completed and tested. It worked satisfactorily.

Through correspondence with the National Bureau of Standards our results for the calorimetric determination of their Co-60 source was combined with their free air chamber measurements of the same source. The result was a precision determination of the average energy to form an ion pair in air. This should be one of the better determinations of this fundamental constant.

INSTRUMENTATION

The experimental "pocket" alarming dosimeter using a modified pencil ionization chamber detector was modified to use a miniature low-current lamp which will remain energized instead of being pulsed on. This will permit reliable use of the unit, which has a selectable level alarming range from 10 mr to 200 mr, in fields to 10 r/hr. Controlled size slit widths from 0.01 to 0.0005 inches were devised using photographic means, and the various slits were tested to determine the optimum width for proper operation with the CdS cell. The optimum width was 0.002 inches for use with the miniature 603AL cell. The method devised for slit production is directly applicable to volume fabrication of the dosimeters. Necessary circuit development was started to provide chopper, amplifier, and oscillator gate circuits for the unit. The amplifier holds off the oscillator until the preselected dose is attained or the batteries fail. The oscillator will drive a resonant air column "speaker" to provide the audible alarm.

Experimental work continued on another type of miniature alarming dosimeter. A circuit was successfully completed to "read" the ion chamber dosimeter charge. By amplification, the obtained signal will gate an oscillator which will drive a transistor scaler to provide a readout proportional to the charge remaining on the chamber. The reading circuit uses tunnel diode quantizing gate techniques.

Investigation, using cross-correlation techniques, continued concerning low gamma energy (1 to 25 Kev) analysis methods in an effort to reduce the noise problems and improve the ability to detect a source. The development work concerned transistor circuits driving dual log count-rate meters. A metered ratio is obtained of the two signals which are noise-plus-background; and noise, background, and source. Some improvements have been obtained over the conventional analysis methods.

Development and design work was completed, and one prototype unit was fabricated, for a stable DC amplifier needed to drive standard one milliampere chart recorders full scale in about 0.5 seconds. The unit is driven by the previously-developed, in general HAPO use, 100 microampere transistorized count-rate meter. The prototype amplifier, using silicon transistors, is substantially improved over the original breadboard unit. The output current errors are minus 2 percent at 0°F and plus 5 percent at 150°F. The principal use for the unit will be in radiation monitoring work from airplanes, boats, and automobiles where fast chart recorder response is required.

Experiments started on a reliable, small, inexpensive, high level dose-rate detection method for use in reactor buildings, high level facilities, and other locations where situations may occur which result in continued high dose rates such as the recent Arco incident. The resultant prototype detector measures only one inch long and one-half inch in diameter and is contained in a cylindrical package 50 percent larger with plastic foam shock material included. The unit can drive several hundred feet of simple two-wire cable and is gamma energy independent from about 80 Kev to 5 Mev. Only the probe, which is composed of a rugged photocell and a terphenyl-in-polyvinyltoluene organic detector, is located in the hot area. The power supply and measuring instrument are located in a safe zone. The power can be 60 to 150 VDC or VAC (whichever is available) with a necessary current required of only two to three milliamperes maximum. The output can be read with a simple millivoltmeter or microammeter with a meter-relay for alarming purposes if desired. Dose rate levels from about 50 r/hr to 5×10^6 r/hr are easily read. Reading errors caused by radiation damage are expected to be negligible below 10^7 or 10^8 r integrated dose. Tests to date have been satisfactory with more high level tests scheduled. The probe is inexpensive, as the organic detector costs only $4 and the photocell, $3.

Final prototype fabrication continues on an experimental scintillation alpha air monitor using coincident-count techniques. All development work was completed last month. The original breadboard unit continues in successful operation, and repeated tests have shown the unit to be easily capable of alarming on equivalent continuous Pu^{239} air contamination levels of 2×10^{-11} μc/cc in about one hour even when the unit is operating in high radon-thoron air concentrations.

Twenty-five 1100 ohm-cm silicon wafers were lapped and are ready to etch for use as silicon surface barrier alpha and neutron solid state detectors. The miniature prototype "palm-size" gross alpha monitor using a silicon diode detector, transistorized circuitry, and a resonant air column "speaker" was used throughout the month with excellent results and strong interest by monitoring personnel. Experiments were conducted with a boron-coated silicon surface barrier diode used as a slow neutron detector. Results were somewhat disappointing due to lack of sensitivity as a result of the very small detector area. Further tests are scheduled with both boron and lithium coatings on the diodes.

A prototype transistorized amplifying annunciator was completed during the month. This unit, packaged in a 3 x 3 x 2 inch container and self-powered, can be "plugged into" any HAPO count-rate type portable radiation monitoring instrument via the phone jack. The unit eliminates the necessity of wearing headphones during monitoring. The resonant air column "speaker" incorporated produces a gated 3 Kc/s note for each input pulse at low count rates, a modulated 3 Kc tone at medium rates, and a continous 3 Kc sound at high count rates.

The unit has excellent audibility characteristics and was enthusiastically received by monitoring personnel.

Extensive development work continued on the circuitry for readout, scanning, and control portions of the automatic film-dosimeter densitometer at the request of Radiation Protection Operation, HLO. Redesign was found to be necessary on the relay decoding "tree" and on the film spot identification circuitry and detectors. These items had to be redesigned before development and design work could be started on the readout, scanning, and control portions. The associated IBM type 026 Card Punch was operating incorrectly when received, and it required repair. Development work completed to date includes a preamplifier, printing circuits, and some master control circuits. Extensive work remains.

Design modification work continued on the experimental zinc sulphide particle counters in use by the Atmospheric Physics Operation, HLO. Two new americium hydroxide activator sources were installed, tested, and the units were placed in field use. Difficulties are still being encountered with minor source flaking and subsequent filter contamination. Another source fabrication technique will be tried.

The two transistorized scintillation portable dose-rate meters were finally completed in experimental form and initial tests proved satisfactory. The full scale first range can be one mr/hr or five mr/hr as desired with four total decaded ranges available. Further tests will be accelerated.

Experimental prototype fabrication continued on a transistorized beta-gamma combined area monitor, hand and shoe counter employing background suppression circuitry, and cable-connected clothing and object probes. The unit will be termed a Check Out Station Monitor.

Experimental work continues on the thermoluminescent dosimeters. The gamma energy response curve for a constant 100 mr dose was obtained for the packaged dosimeter from 8 Kev to 1 Mev. Four prototype units were calibrated, to accuracies of ± 10 percent, from accumulated doses of 20 mr to 10 r. Tests were conducted to determine the effects of mechanical vibration on an irradiated dosimeter, and no effects of such vibration were found for doses from 20 mr to 1 r; that is, the readout was the same whether vibrated or not. Experiments are in progress to fabricate an experimental 4π dosimeter as an improved step from the present 2π design. Various glass thicknesses with inclusions, such as lead, will be tried for the packaging material. Demonstrations of the prototype units were conducted for members of the Biology Operation.

Components were ordered for developing the equipment to store and analyze pulse-height spectra in the whole body counter. At the present, it is planned to use a ferrite memory and parallel arithmetic. The logic for the current address and index registers has been developed.

An analog computer study was made regarding the distribution of I^{131} in the human body following a one-shot administration into the lungs. Specifically, it was required to determine the various biological decay constants necessary to meet certain specified maximum concentrations of I^{131} in the thyroid gland at specified times. This constitutes a curve-matching process. It is necessary to generate a solution and note the maximum value of the variable, and the time of maximum value. Then changes in the parameters are made and the effect noted

on the solution. The obvious ideal method consists of generating solutions fast enough so that an oscilloscope can be used to visually observe the effect of parameter variations. The problem was completed using the repetitive mode of operation on the EASE computer, and a 17-inch linear oscilloscope for displaying the solution.

Studies are under way concerning the feasibility of using "noise" techniques, similar to those being applied to the measurement of neutron lifetimes, for the analysis of meteorological data. It appears that analog methods can be used to obtain the various correlation coefficients required and that these techniques would be much more simple than digital techniques for the high frequency components of the signal. A combination of analog and digital techniques may be advisable for low frequency components. The basic instrumentation requirement at the present time is a means of recording the data continuously in a form which can be easily analyzed. A multiple-track FM tape recording system is under consideration. Assistance is being given to Atmospheric Physics Operation personnel in determining specifications for a recording system compatible with the available analog computing equipment.

WASHINGTON DESIGNATED PROGRAM

Isotopic Analysis

The mass spectrometer for this program provided isotopic analyses of the program samples received this month. The program sample load processed was again about 200 percent of the goal. In addition, seven analyses were provided for Analytical Laboratories on product plutonium samples. The results of sixty-nine analyses of thirteen different uranium standards were compiled and reported.

TEST REACTOR OPERATIONS

Operation of the PCTR continued routinely during the month. There were two unscheduled shutdowns both due to faulty by-passing technique.

The experiment to determine the limiting concentration of 93 percent enriched UO_2F_2 in H_2O was completed during the month.

The experiment to determine the burnout in ball 3X materials was completed during the month.

The calibration of the PCTR continued. In all determinations the test cavity contained solid graphite. The worth of a fuel rod, a control rod, a safety disk, and also the neutron lifetime for four fuel loadings have been determined. The neutron lifetime data are being processed and are not included in the table of data as follows:

Reactor Properties

Square Fuel Loading	30 x 30	37½ x 37½	45 x 45	52½ x 52½
Fuel Rods at Critical	22	32	46	73
Driver Worth	108.1¢	84.4¢	54.2¢	34.4¢
Control Rod Worth	44.1	56.0	51.2	44.8
Safety Disk B	--	--	$2.78	--
Safety Disk C	$2.52	--	$3.38	$3.40
Safety Disks B and C	--	--	$5.66	--

Au foils were irradiated in the TTR in order to normalize them for PRTR experiments. Instruments to measure neutron lifetimes by noise analysis methods were tested by Systems Research Operation personnel in the TTR.

Data necessary to determine the neutron lifetime by observing the neutron flux decay after rapid insertion of poison were taken and are being analyzed.

A method of rapidly injecting poison into the reactor by forcing a piston containing the poison down a cylinder by air pressure has been utilized to measure the neutron lifetime in the PCTR with different core loadings. Incomplete data indicate that the neutron lifetime may vary from 0.82 m sec to 2.0 m sec for the various core loadings. Tests were also made on the TTR and are being analyzed.

The poison comes to rest in the reactor within 30 m sec after pressure is applied to the piston. The piston travels about 6 feet during this time.

CUSTOMER WORK

Weather Forecasting and Meteorology Service

Meteorological Services, viz., weather forecasts, observations and climatological services, were provided to plant operations and management personnel on a routine basis.

Weather Summary

Type of Forecast	Number Made	% Reliability
8-Hour Production	84	78.9
24-Hour General	56	78.8
Special	158	86.7

February was warm, wet, and windy. Temperatures were above normal throughout the month and averaged 43.7, a mark which has been exceeded in February only twice in 49 years of record. Precipitation, all in the form of rain, was largely confined to the first 10 days when 1.91 inches occurred. Subsequent rains raised the monthly total to 2.10 inches, the second greatest February amount in 49 years of record.

Wind speeds averaged only 3.0 mph during the heavy-rainfall period from the 1st to the 10th. However, many windy periods during the last 18 days raised the over-all monthly average to 9.4 mph, the highest for February in 17 years of record.

Instrumentation and Systems Studies

Fabrication continued on an experimental beta-gamma (mixed fission product) air monitor for the 327 Building using a moving-tape filter head, and on an alpha-beta-gamma air stack monitor for use by Chemical Research Operation, HLO, in the 325 Building. Due to the extensive backlog of work in the Electronics Shop, fabrication completions will be delayed.

Design work was just started on a specialized very sensitive portable beta-gamma "field use" monitor using our previously developed, and now standardized, transistor circuits. The instrument will be used by the Biology Operation.

Modification work and advice was completed and rendered concerning the scintillation transistorized shoe and clothing monitor for the 325-A Building. The newly installed shoe probes work satisfactorily and only minor circuit adjustments remain.

Calibration of the micro-displacement readout systems, to be used by Physical Metallurgy for in-reactor creep measurements, has continued during February. Calibration of the Schaevitz DRS-100 readout system is 20 percent complete. This includes the room temperature drift checks for all scales, and the 20°, 100°, and 200° C calibration runs on the 0-0.3 inch scale. It was found that the DRS-100 is quite sensitive to the transient electric and magnetic fields which occur within the furnace as the various heating elements are turned on and off. In an effort to reduce this adverse effect, a large copper shield, which completely surrounds the LVDT, is being installed. This should effectively ground the unwanted transients, and also improve the temperature profile throughout the length of the furnace. An additional thermocouple is being mounted on the transducer clamp which will continuously monitor the temperature of the transducer. Early indications are that the temperature variations in the laboratory may produce appreciable calibration error when the required accuracy is of the order of a few micro-inches. At present, no obvious solution to this problem exists, but an attempt will be made to determine the magnitude of this environmental error.

The feasibility of using gamma spectroscopy to detect fission product mobility was studied at the request of Radiometallurgy and Ceramic Fuels. The mobility of certain fission products may possibly be measured by a finely collimated scan of the gamma radiation from wafers cut from irradiated UO_2 fuel elements. Study assumptions and recommendations were recorded in a memorandum report.

The bids for the 333 Building autoclave hydrogen detection system have been received and evaluated. The low bidder was $3,000 below our estimated $10,000 figure. Some additional tests will be required before the 306 Building mockup instrument is acceptable.

The Chemical Dissolver problem for Chemical Research and Development Operation has been programmed and is ready to go as soon as analog computer time is available. A plug-flow dissolver is represented mathematically by a partial differential equation. Since this cannot be simulated exactly, an approximation is employed. In this case, the dissolver was considered to be equivalent to eight consecutive, identical dissolvers. In each section, the characteristics were assumed to be a function of time only. The mathematical model then consists of eight ordinary differential equations, solved simultaneously. The recirculating reservoir is simulated by a transport lag.

Solid-state circuits were developed and fabricated for timing and synchronizing the scanning of transducer inputs into a digital voltmeter-printer combination. The system is being used by Chemical Development Operation to print automatically the data from 35 points of measurement in an experimental chemical separations process.

Development started on the Panellit-Heise pressure gage readout device for 105-DR. Originally the device was to consist of one hand-held gage readout box in back, for Heise gage, and one in the front of the panel for the Panellit readings. Information was to be punched on a tape and typed by an electric typewriter. Requirements have been changed and the present device will consist of three hand-held gage readout boxes in the front of the panel, one for each panel. The Heise gage information will, as before, be transmitted to the front of the panel by telephone. An adding machine tape punch will provide a base computation feature by subtracting the Panellit reading from the Heise reading. Disadvantages of this system include a long, hard-to-handle adding machine tape readout. Had more money been available, the data could have been typed on a large sheet of paper by a billing machine. Insufficient funds have also prevented the use of an automatic Heise gage readout from a pressure transducer. The device will probably not save any time in the actual gage readout procedure, but it will save time between the control room and the 7090 data processor. It should eliminate the card punching procedure at the 7090 and the manual typing in the control room. The adding machine tape punch, the equipment cabinet, three shaft encoders and some small parts have been ordered. Development of the logic circuitry should start next month.

Optics

High pressure mercury vapor lighting is being incorporated in equipment being designed to permit vertical illumination of objects through the Ceramic Fuels' long-working-distance microscope. A special microscope eyepiece adapter also has been designed to permit simultaneous viewing, photographing, and monitoring of light level.

A camera designed to be used on the latest model 1-3/4-inch-diameter Lenox borescope for photographing reactor process tubes has been completed and tested. The camera employs a Polaroid back, permitting examination of the photograph within minutes after exposure. A right angle eyepiece has been added to the camera to permit visual use of the borescope without disconnecting the camera.

Design sketches have been prepared showing the optical and mechanical construction of portable periscopes and binocular underwater periscopes for the NPR project. The portable periscopes are generally used for viewing the rear face of the reactor through holes in the biological shield. The design sketches provide for improved mechanical construction over previous models and also specify the optical components more completely. The binocular underwater periscope sketches modify the design used for K Area, providing improvements in optical and mechanical construction. Arrangements have been made to get complete engineering drawings. Studies are in progress to further improve design.

An optical traversing mechanism is being developed for use with a borescope to determine the distortion in reactor process tubes and other channels. It will be particularly useful in the many cases at both the old reactors and at the NPR where the mercury manometer and surveying type measurements are not applicable. Preliminary calculations indicate the required sensitivity will be readily obtained.

A total of 463 manhours' shop work was performed during the four-week period (January 29 to February 26) included in this report. Of this, 8% was for an offsite order code 0777, 21% for code 1300, 7% for IPD, 37% for GPL, 21% for HLO, 5% for FPD, and 2% for CEO.

The work included:

1. Fabrication of two glass cylinders for GEL, Schenectady.
2. Modification of a camera flash attachment for Photography.
3. Fabrication of three solar cell pyrometers for Facilities Engineering, FPD.
4. Fabrication of 20 glass bearings for CPD.
5. Modification of a borescope for Facilities Engineering, CPD.
6. Fabrication of camera adapters for Radiometallurgy.
7. Fabrication of three-way split-beam eyepieces for Ceramic Fuels, HLO.
8. Fabrication of parts for a borescope camera for Irradiation Testing, IPD.
9. Repair of one crane periscope head for Redox.

Analog Computer Facility Operation

The major analog computer problems considered this month include:

1. NPR Primary Loop Analysis.
2. NPR Plant Simulator.
3. NPR Secondary Loop Analysis.
4. Thyroid I^{131} Activity.
5. Plug-Flow Dissolver Study.

Computer operation was as follows:

GEDA		EASE	
138	hours up	116	hours up
30	hours scheduled downtime	36	hours scheduled downtime
8	hours unscheduled downtime	4	hours unscheduled downtime
0	hours idle	20	hours idle
176	hours total	176	hours total

Instrument Evaluation

Successful demonstrations and field testing continued with the two prototype Model II Scintran instruments. Thirty units have been ordered from off-site (General Electric Company, APED, San Jose, California).

Nine of the ordered 12 Sentinel portable alarming dose-rate meters have been tested and are now in field service. Three will require a phototube change to permit first range operation of 0-400 mr/hr in place of the 0-1 r/hr first range originally requested. Future units will use the higher gain RCA 6655-A phototubes in place of the RCA 6199 tubes. The general mechanical fabrication and layout work on the units, purchased to our circuit-only specifications, from Technical Associates, Inc., were not satisfactory.

Field testing and demonstration work was carried out on the new "palm-size", transistorized alpha monitor using a solid-state detector and a resonant air column speaker. In addition, field tests were conducted on the new transistorized "plug-in" package circuit, also using a resonant air column speaker, for headphone elimination for all HAPO portable count-rate type radiation detection instruments. Tests on both units have been completely successful and field personnel acceptance most gratifying.

Investigation tests continued concerning general drift problems with Dumont 6363 phototubes. They are far more subject to gain variation with time than are comparable RCA tubes.

General instrument problem discussions and demonstrations were held with a number of analysts and supervisory personnel at various CPD and IPD locations.

Paul F. Gast

Manager
PHYSICS AND INSTRUMENT RESEARCH
AND DEVELOPMENT
HANFORD LABORATORIES OPERATION

PF Gast:mcs

CHEMICAL RESEARCH AND DEVELOPMENT OPERATION

RESEARCH AND ENGINEERING

FISSIONABLE MATERIALS - 2000 PROGRAM

IRRADIATION PROCESSES

Uranium Oxidation and Fission Product Volatilization Studies

Rear face single fuel-element "burning" incidents were simulated using unirradiated 4" solid and 8" I&E aluminum-clad elements. Induction heating was substituted for the fission product decay heat which would be generated within a discharged element which might be intercepted and exposed to air on the rear face of a reactor. Six tests were conducted in an air atmosphere with inductive heating rates varying from 80 - 680 C/min. Each test resulted in different oxidation and melting characteristics due to variations in the integrity of a uranium-aluminum alloy coating formed at the surface. Essentially no uranium was oxidized when the alloy coating was continuous--even at temperatures above the uranium melting point. When the coating was disrupted rapid and extensive oxidation resulted. The integrity of the coating was dependent on the heating rate, cladding defects and length of the heating period. Uranium temperatures attained in the tests ranged from 1085 C for an unoxidized specimen, to an estimated 1700 - 1800 C for a free-flowing specimen that exhibited a rapid exothermic reaction.

These tests indicate that a single fuel element which failed to drop clear into the storage basin during discharge could reach temperatures exceeding the melting point but would not necessarily oxidize extensively. Fission product release could vary from a very low to a very high percent of the fission product inventory, depending upon the integrity of the jacket-uranium alloy sheath formed.

Analytical results from two fission product release tests using small specimens irradiated to 10^{14} - 10^{15} nvt indicated that 30 percent and 40 percent of the I-131 released at oxidation temperatures of 1200 and 1300 C, respectively, were retained on a Millipore filter downstream of the oxidation tube. An electrostatic precipitator collected 10 percent of the I-131 passing through the filter. The Millipore filter was slightly more effective in retaining Zr-95 (55 percent removal). Tests such as these constitute the preliminary work leading to a better understanding of the physical nature of certain radionuclides and their possible modes of transport to the environs when released from overheated fuels.

NPR Effluents

Soil column experiments were conducted to determine the utility of ground discharge for disposal of phosphoric acid decontamination solution proposed for NPR. When the waste solution was initially neutralized with caustic the soil removed more than 90 percent of the radionuclides of zinc, iron, strontium, cerium, chromium, and cesium. Similar experiments with initially unneutralized phosphoric acid waste resulted in much poorer retention of these radioisotopes by the soil. Isotopes of ruthenium, zirconium, and cobalt were poorly removed by soil in all experiments. Radiosilver was the only isotope removed by soil more efficiently from acid than neutralized waste solutions.

It might be possible to release the phosphoric acid waste to a crib at a judiciously chosen location without an initial scavenging treatment, depending on the soil to provide necessary decontamination. The research results indicate the advisability of neutralizing the waste before ground disposal. The disposal of the entire slurry from a scavenging operation to a crib would be preferred to direct release of the supernatant solution to the river.

Wells 699-69-45 and 699-67-51, a mile to a mile and a half north of Gable Mountain were completed at depths of 300 and 250 feet, respectively. Altitudes of the well collars are being carefully determined so that accurate representation of the water table configuration will be possible. These wells were drilled to better define ground water altitudes in a location which may prove suitable for NPR effluent ground disposal.

Reactor Effluent Treatment

The pilot scale reactor effluent aluminum bed decontamination facility was operated at reduced flow because of increasing pressure drop across the first few feet of the bed. The increase in resistance is due in large measure to debris settled out in the 107-D basin which enters the pilot facility feed line from the bottom of the basin. Material reductions in pressure drop would likely be realized if reactor effluent could be drawn directly from the basin inlet rather than from the basin crib drain.

Analytical results made available for two recent months of operation permitted the decontamination efficiency of the aluminum bed to be more firmly established than previously. Over the two months the average percent removal as determined in ten measurements was as follows:

As-76	- 53%
P-32	- 47
Mn-56	- 71
Cu-64	- 68
Zn-65	- 62
Np-239	- 19
Cr-51	- 8

The adsorption of trace concentrations of As-76 from tap water at 80 C by a bed of freshly crushed olivine, $(Mg, Fe)_2 SiO_4$, was studied in a flow system providing a residence time of 2.93 min. The mineral was found to have a capacity of 35 bed volumes for adsorbing arsenic under these conditions. The solution used in these experiments also contained Zn-65 in trace concentrations. The zinc was removed from solution by olivine more efficiently than was the arsenic, reaching only 10 percent breakthrough when the breakthrough of arsenic was complete. The mineral became coated with a reddish-brown ferric hydroxide film during the experiment, which probably plays an important part in the adsorption.

Water Treatment Processes

Several water treatment modifications were tested on a laboratory-scale plant. Phosphate removal through the use of combined ferric hydroxide-manganese dioxide floc was found to be comparable to the results previously found for arsenate removal.

Separan filter aid is useful in this process. The phosphate removal efficiency was 96 percent if 20 ppb Separan were used and 86 percent if 10 ppb were used. Substitution of manganous ion for the ferrous ion as reductant of the $KMnO_4$ gave a manganese dioxide precipitate with very little ability to remove phosphate. The efficiency of aluminum nitrate as a flocculating agent for removing phosphate from high turbidity water was tested. Phosphate removal was equal to or greater than with the same agent in low turbidity water.

Reactor Film Studies

Studies are in progress on the adsorption of trace ions from near-boiling water onto aluminum surfaces containing corrosion oxide formed while in contact with water of various salt contents. The amount of a trace ion adsorbed by a column should be a direct indication of the amount of radioisotope formation which would occur under similar conditions in a reactor provided a steady state film exists. Some preliminary findings are: aluminum surfaces exposed to distilled water have a higher affinity for zinc, sulfate, arsenate and phosphate ions than surfaces exposed to tap water; addition of 50 ppm magnesium reduces the adsorption of anions; carbonate and sulfate reduce the adsorption and increase the desorption rates of anions, but increase the uptake of zinc.

SEPARATION PROCESSES

Diluent Studies

A new high temperature ("Apiezon" coated diatomaceous earth) column for the vapor phase chromatograph has been very useful in characterizing hydrocarbon diluents with respect to the number and relative quantity of their components. A further aid to characterization of these diluents is the highly specific precipitation of normal paraffins with urea. Through the use of these procedures the following information has been developed concerning several kerosene type diluents:

1. Shell E-2342 contains over 36 distinct components. It contains less than 50 percent normal paraffins.

2. Shell Code 82 is quite similar to Shell E-2342 but contains relatively more normal paraffins. The inference is that Shell E-2342 may have been chemically treated to remove branched chain and cyclic species.

3. Soltrol 170 consists of fewer components than E-2342 but contains almost no normal paraffins. It is, by test, however, considered to be a superior solvent to the Shell product. The inference is that branched species per se may not be harmful, but that perhaps a small fraction of a particular component is responsible for poor performance.

4. Amsco 125-90W diluent consists of only about five major components (about nine are detectable) and is very low in normal paraffin content.

5. Amsco D-95E-1 contained perhaps 20 to 50 percent of aromatics, and was similar to Penola 100.

6. Boyol D and Ultracine were similar to the Shell products but were intermediate in n-paraffin content.

7. Degradation of E-2342 with boiling 4M HNO_3 containing added nitrite for three hours followed by washing with 20 percent NaOH and reduction by zinc yielded a product of almost identical composition as the starting material. With more aggressive degradation (about 25 percent destroyed) the non-straight chain portion was removed in greater amount, resulting in a product relatively richer in n-paraffins.

Observation Wells

Radiocontaminants present in low concentrations in the ground water five miles southeast of 200 East Area have migrated further southeastward to appear in well 299-20-20 which is 6.5 miles from 200 East Area. The last three samples from this well contained concentrations of beta emitters just slightly greater than the routine detection limit of 8×10^{-8} uc B/cc. The additional 1.5 miles of movement occurred over a relatively long period (ca. 2.5 years) compared to the 1.5 to 2 years taken to migrate the first five miles. The reduced movement rate is in accord with hydrological and geological conditions in the area of concern. Isotopic analysis shows that Ru-106 - Rh-106 are the only radionuclides in the ground water in this region.

The decayed animal material taken from a well monitoring the Purex A-6 steam condensate crib was identified by Biology Operation as the remains of a cottontail rabbit. Considering the volume of water in the well and typical Sr-90 body burdens of rabbits near 200 East Area, the decayed animal can account for the low Sr-90 concentration, about 1×10^{-7} uc/cc, recently detected in samples from the well. Initial results from a dilution test in progress indicate the water in the well is stagnant which lends support to the conclusion that the animal was the source of the Sr-90.

Waste Tank Leak Investigations

Runs were completed in the application of a computer program to the solution of a three-dimensional unsaturated flow model, with an immediate objective of evaluating the behavior of wastes leaking from underground storage tanks. The program results are expected to assist with the evaluation of possible leak monitoring systems for boiling waste tanks. Current knowledge assures that lateral spread will permit leaks to be detected in simple vertical wells adjacent (10 feet) to the tanks before the waste reaches the water table. The additional computations will permit comparison of the amount of liquid that may be lost before detection with vertical monitoring wells, and with lateral monitoring tubes extending under the tank from a caisson. The calculations are kept conservative by utilizing soil parameters for the most porous of the Hanford soil samples on which appropriate measurements were made, and by assuming the material beneath the tank to be homogeneous.

Disposal to Ground

Laboratory research to study the possible application of Florida pebble phosphate rock for plutonium recovery from D-6 sump wastes from the 234-5 Building was continued. It was found that upon standing the plutonium removed by the mineral gradually becomes unavailable for elution, apparently by means of solid-state diffusion along crystal interfaces. Freshly leached phosphate rock may be eluted with a solution of sodium carbonate, which replaces the outer layer of phosphate mineral with calcite, thus releasing the plutonium remaining near the grain surface. When not eluted, the phosphate mineral automatically recovers plutonium adsorption capacity upon standing.

A bed of pebble phosphate was cycled three times through a loading, eluting, and recharging cycle in laboratory experiments with D-2 sump waste. The capacity of the bed to 10 percent plutonium breakthrough increased with each cycle, being 210 bed volumes for the first, 425 bed volumes for the second, and 600 bed volumes for the third. Prompt elution after the first cycle recovered 95 percent of the plutonium. The bed was permitted to stand for two days before elution after the second and third loading cycles and as a result elution recovered only about 10 percent of the plutonium on the bed. Elution was performed with five bed volumes of 1 M sodium carbonate solution. The mineral was then recharged with five bed volumes of 0.2 M trisodium phosphate solution.

Similar experiments were performed with Canadian apatite mineral which has the same composition but a different crystal structure. This mineral was found to have a much lower plutonium capacity than the Florida pebble phosphate with no improvement in elution performance. For complete recovery of plutonium, the pebble phosphate mineral may be dissolved in five bed volumes of 6 M nitric acid with the exception of about 2.5 percent insoluble silica.

Zirflex Decladding of NPR Elements

The Zirflex dissolution of oxidized Zircaloy cladding from tube-in-tube type uranium fuel elements was investigated in two pilot unit tests. The possibility of gas blanketing or poor diffusion in the annuli was specifically studied by placing the fuel elements in a horizontal position. Prototypical fuel elements with the following dimensions were used in the tests: Outer tube - 1.825 in. O.D., 1.460 in. I.D., 22 mil clad, 200 mil end plugs, and 14 in. length; Inner tube - 1.049 in. O.D., 0.498 in. I.D., 22 mil clad, 200 mil end plugs, and 14 in. length.

Initial dissolvent concentrations for both runs were 5.5 M NH_4F - 0.5 M NH_4NO_3 and the F/Zr mole charge ratios for the two runs were from 6.0 to 7.0, and 6.7 to 7.7, respectively; the uncertainty is due to difficulty in cladding weight estimation. Constant boil up rates of 0.61 and 0.82 g mol/min/ft^2 were maintained in the first and second runs, respectively. Condensate was removed to a separate receiver and replaced by continuous water addition.

The first run was stopped after 2.8 hours to observe the initial dissolution pattern. Preferential attack on areas of maximum abrasion and random attack on undisturbed surfaces were noted. Approximately 60 percent of the cladding had been removed. In the second run greater than 90 percent of the cladding was removed in 6.5 hours; that remaining was in a random distribution. No gas blanketing or adverse diffusion effects were apparent. Dissolution occurred essentially as predicted from earlier studies on fuels of different geometry.

Photochemical Production of Uranium(IV)

Some further studies have been made on the production of uranium(IV) in nitrate solution by irradiation of UNH-formaldehyde solutions with ultraviolet light. An ultraviolet lamp (GE UA-11) made especially for use in chemical process industries was used in these studies. The lamp is about two feet long and one inch in diameter. It operates at about 1.5 kilowatts electrical input. Preliminary data indicate that one such lamp is capable of producing about 15 pounds of uranium(IV) per day under optimum usage of the radiation.

Continuous Dissolver - Reclamation Facility

The cold pilot plant Recuplex dissolver terminal report is being issued under the title "Continuous Slag and Crucible Dissolver," HW-68630.

Purex C Column Water Studies

A series of runs using the experimental C column were carried out in an attempt to establish a relationship between the performance of the test facility and the source of the water used for the 1CX stream. The tests were conducted by varying the pulsing frequency under a fixed set of conditions until a reproducible degree of instability was observed. Building 321 steam condensate water, Purex sanitary water, water passed through the Purex cation demineralizer and water passed through both the Purex cation and anion demineralizers were used as extractant in the tests.

The following instability thresholds were observed under the test conditions: (Runs were carried out chronologically in the order listed.)

Source 1CX Water	Instability Threshold Cycles/Min.	Remarks
321 Steam Condensate	76	Final run prior to using Purex water.
Demineralized Water	42	Mixture from both demineralizers.
321 Steam Condensate	67	Run subsequent to use of above Purex water.
321 Steam Condensate	72	Run subsequent to carbonate-acid flush of column.
Purex Sanitary Water	63	---
Demineralized Water	52	Cation and anion removal in #1 unit.
Demineralized Water	61	Cation removal only in #2 unit.
Demineralized Water	40	Cation and anion removal in #2 unit.

WASTE TREATMENT

Batch Calcination

Nine bench-scale runs were made with simulated Purex high-level wastes to study factors affecting melt formation of the batch calcine. An annular pot, 6-inch O.D. and 15-inches high, heated by electromagnetic induction was used in one run. The induction heating exhibited short heat-up times and short response times to changes in energy input. No operational problems were encountered that could be attributed to the annular pot geometry or to the method of heating.

The effects of permanganate and manganese dioxide on calcine melting were studied briefly. In two similar runs with a high sodium to metal ion ratio, the waste with potassium permanganate did not form a meltable calcine, whereas the solution without the permanganate did. The presence of manganese dioxide in the waste solution produced no noticeable effect on melt formation.

A synergistic effect on melt formation was found to exist between iron and aluminum. A simulated waste solution with a sodium to metal ion (iron plus aluminum) ratio of 7.5 and a sulfate to salt nitrate ratio of 1.4 yielded a calcine that formed a fluid melt. However, for three runs in which the metal ion was only iron, aluminum or chromium, partial melting occurred. These latter runs had the conditions necessary for the generation of internal pressure; namely, partial melting and the sulfate concentration in excess of the stoichiometric sodium equivalent. The generation of internal pressures during the calcination step was evident in all three runs.

Storage Studies

Studies of the temperature effects of radiolytic heat generation in calcined high-level wastes are continuing.

The temperature distributions in a proposed annular storage vessel have been estimated for the case of air cooling by natural convection only and for the case of air cooling by natural convection combined with radiation cooling. The first case approximates the situation of annuli standing in close mutual proximity. The second case approximates the situation where a vessel "sees" only cool surfaces, e.g., canyon walls, during transit to a storage vault. Within an annular vessel having containment radii of 11 and 24 inches, 0.25 inch thick stainless steel walls, and containing a solid which has a thermal conductivity of 0.6 Btu/sq.ft./hr.(F/ft.) and is generating 2940 Btu/cu.ft./hr., the maximum temperature is 1700 F when heat dissipation is through natural convection from both bounding surfaces to air at 80 F. The wall temperatures at the central cooling channel and the outer surface are, respectively, 1050 F and 915 F. Within a like vessel the maximum temperature is 1460 F when heat dissipation is accomplished by natural convection to 80 F air in the central flow channel and by combined natural convection and radiation to 80 F air and 80 F black body equivalent surfaces from the outer surface. The wall temperature at the central cooling channel is 955 F and that of the outer surface is only 550 F.

Underground Waste Sludge Sampler

Development and design on the waste sludge sampler and handling cask has been completed. The sampler is designed to withdraw a 1/2-inch diameter, 36-inch long sludge core. Initial use is proposed for the Purex tank 241-A-103. Tests with a tool steel knife edge noze cone have shown that 10,000 pounds force is sufficient to penetrate plaster of paris and a simulated Redox waste sludge. A force of 13,000 pounds (the maximum force allowable for the sampler tube) caused the noze cone to penetrate approximately 3/16-inch into mild steel plate. With a rounded edge noze cone the penetration into steel was reduced to less than 1/16-inch with no appreciable change in pressure required to enter the simulated sludge.

TRANSURANIC ELEMENT AND FISSION PRODUCT RECOVERY

Strontium-90 Program

Laboratory Solvent Extraction Studies - One liter of Purex Plant "crude cut" solution was brought into the 222-S Building cubicle for use in mini-mixer-settler runs testing flowsheets for solvent extraction recovery of strontium. The solution, as received, was at pH 1.2 and contained a small amount of finely divided white solid. Acidification to 1.17 M HNO_3 and digestion at 60-70 C for three hours did not dissolve this solid.

The crude cut solution, after being butted to feed composition, was used in a mini-mixer-settler run simulating 1A column conditions in Study Flowsheet No. 2. Seven extraction and five scrub stages were used in this run. Product from this run (1AP) was diluted with an equal volume of non-radioactive 1AP prepared in another mini-mixer-settler. The diluted material was then used as feed in a mini run simulating the second column (1B) of Flowsheet No. 2. Five mini stages were used in this run.

Analytical data so far obtained for these runs show considerable scatter. Best estimates which can be made at present place overall strontium recovery at about 87 percent; about 10 percent was lost in the first column and 2-3 percent in the second. Gamma-scan data obtained to define decontamination performance are limited in sensitivity due to the high background from strontium. Cerium decontamination in the 1A column was less than two. About six was obtained in a previous run at trace level using the same flowsheet. Zirconium-niobium and ruthenium were not detected by gamma scan in the 1AP.

Gamma scans of the second column product (1BP) showed no peaks for gamma emitters. A cerium decontamination factor of about nine was estimated from gamma scan data on 1BF and 1BW. This estimate agrees with the cerium decontamination obtained in miniature pulse column runs at tracer level and under Flowsheet No. 2 conditions.

Hydraulic performance of the mini-mixer-settler was excellent during these runs. There was no tendency toward flooding in either the 1A or 1B run. The fine solids present caused no difficulty, they followed the aqueous stream to the 1A waste. The composition of these solids has not been determined. They apparently did not carry a significant part of the strontium. Some precipitation of ethylene diamine tetraacetic acid occurred in the 1A waste because of the relatively low pH (3.5) of this stream. Batch contact studies at tracer level indicate that the cerium in feed prepared from the crude cut solution is in the same oxidation state (III), as tracer cerium used in prior laboratory studies.

Further runs anticipated for the immediate future will be 1A column runs at 10-20 percent full activity level. These will be aimed at improving cerium decontamination. One such run has been made but analytical data are not yet available. A second liter of crude cut solution has been brought into the cubicle. This material is very similar in appearance to the first liter although the pH is somewhat higher (2.5).

Pilot Plant Solvent Extraction Studies - "Cold" development studies for the HSW strontium-90 recovery program were completed with the satisfactory confirmation of the HSW Study Flowsheet No. 2. Strontium waste losses for the solvent extraction portion of this flowsheet were 3 percent in the 1A column and 2 percent in the 1B column, using feeds ranging in pH from 3.8 to 4.7. The sodium DF in the 1A scrub section ranged from about 10 with the low pH feed to 3 with the high pH feed. The corresponding 1BP pH's ranged from 1.7 to 2.1 (2.4 is the maximum tolerable).

Ion Exchange Separations Studies - A small (1 cm x 62 cm) ion exchange column is being used to study ion exchange treatment of the 1B column product stream for further purification of strontium. Bicrad Dowex 50 W - X12 resin is used. From a feed solution containing 0.0625 M SR - 0.0075 M Ca - 1.0 M citrate, loadings of 34.5 and 37.8 g Sr/l were obtained for flow rates of 5.0 and 2.5 ml/min - sq.cm., respectively, at 10 percent breakthrough of strontium. Elution with 3.0 M $NaNO_3$ removed 85 percent of the strontium at an average concentration of 0.098 M; elution with 0.5 M Na_4EDTA removed 86 percent at 0.179 M. Batch contact studies are in

progress to aid in selection of an effective wash solution for improving cerium decontamination. On the basis of relative strontium and cerium distribution coefficients, citric acid and citric acid-EDTA solutions show promise. The data indicate close pH control will be required for effective cerium removal without excessive loss of strontium.

Strontium Peroxide Intermediate - Filtration studies on SrO_2 as an intermediate to SrO continued. Contrary to early results with pure strontium nitrate solutions, excessively fine grain SrO_2 was precipitated from feeds containing sodium and calcium in the ratios expected in Hot Semiworks strontium product solution. Studies are continuing.

Strontium Carbonate Filter Cask - Design was completed on a full scale filter simulating the strontium carbonate filter to be employed for Hot Semiworks product. The completed unit will be available for testing at Hot Semiworks in April.

Solid Strontium Product - The following procedures have been investigated as means for preparing strontium titanate:

1. Calcination of SrO-TiO_2 mixtures (200 to 1000 C).
2. Simultaneous precipitation of peroxides of titanium and strontium followed by calcination.
3. Simultaneous precipitation of strontium and titanium from solution by increasing the pH and adding carbonate followed by calcination at 1200 C.
4. Calcination of mixtures of titanic acid and strontium peroxide or oxide.

Methods (1) and (2) have not been successful. Methods (3) and (4) show promise; diffraction pattern data are not yet available on the products.

Hot Cell Operation - On completion of the second strontium purification run late last month, failure of several equipment items necessitated shutdown for repairs. Thus, leaks had developed in the rubber-impregnated asbestos gaskets at the bottom of the ion exchange columns, the in-cell Lapp pump had failed, a Durco valve in the feed line had developed a leak, and several Hoke needle valves had been damaged. Two weeks of equipment flushing and cell washdown reduced the radiation levels to tolerable values and permitted entry for contact maintenance, with reasonable working times. The columns and pump have been re-gasketed with linear polyethylene (which should prove much more resistant both to radiation and to chemical attack), offending valves have been replaced or repaired, and piping changes have been made to minimize cell wall penetrations and eliminate the danger of solution back-up to the outside. Modifications were complete at month's end with a run scheduled for early March.

Ion Exchange Capacity and Feed Preparation Studies - The capacity exhibited by the hot cell equipment in the two full-level purification runs with Purex strontium concentrate was disappointly low, as compared to the cold and tracer-level shakedown runs. Breakthrough was obtained in both cases after loading only about three grams of strontium per liter of resin. Experiments were accordingly carried out in the laboratory and in small columns installed for this purpose in the hot cell complex to determine the cause and cure of this condition. It was found that the low capacity was due to the high concentration of ammonium and sodium ions in the column feed.

The sodium (9 g/l) was present in the as-received concentrate and the ammonium ion came from the ammonia which was added to neutralize the acid required to dissolve the solids present in the crude. Laboratory runs with synthetic feed duplicated the observed capacity of 3 g Sr/l. It was found that simple dilution gave an almost proportionate increase in capacity. Two-fold dilution increased the loading to 6.4 g/l and four-fold dilution to 11.7 g/l. Behavior of actual concentrate in small scale ion exchange equipment was much more complex, and not yet fully understood. The solids apparently contain components in addition to ferric hydroxide, and these affect the dissolution and stability of the feed. Thus, a feed brought into solution by addition of nitric acid and HEDTA (followed by adjustment to pH 4 with ammonia), although stable under these conditions, re-precipitated on modest dilution. It is believed, however, that an empirical recipe has been found which will assure a clear feed and a reduced ammonia concentration for the next run. This involves addition of HEDTA and ammonia, little or no nitric acid, and no dilution. A column run with this feed went very well, but analytical data are not yet available. It appears each batch of Purex concentrate must be considered as a separate problem and feed makeup and loading procedures piloted on a small scale prior to full-scale operation.

Hot Cell Analytical Support - Analysis of the pooled product from Runs 1 and 2 has been completed; except for uncertainty in the barium value, where widely varying results (0 to 53 grams) were obtained. A comparison with the Martin specifications follows:

Purity of Runs 1 and 2 Combined Product

Component	Product	Specification
Sr-90 Content	36.9 - 47.2 Percent*	35.5 Percent by Weight (Min.)
Ce-144 Content	<0.03 curies/gram Sr-90	0.15 c/g Sr-90
Zr-Nb-95 Content	<0.03 curies/gram Sr-90	
Cs-137 Content	<0.03 curies/gram Sr-90	
Ru-106 Content	<0.03 curies/gram Sr-90	

* Reflects range of reported barium values.

Major impurities, other than barium, were copper and calcium at 18.4 and 11.2 grams per 160 grams of strontium, respectively. It might be noted that if all of the barium in the feed appeared in the product, the amount could not exceed 25 grams. The decontamination factors for cerium and zirconium-niobium across the ion exchange process (based on the above detection limits) are $>5 \times 10^4$ and >1000, respectively. Cesium and ruthenium were not detected in the feed.

In other work, the decontamination from rare earths in the ion exchange analytical method for strontium (which is used by the HAPO laboratories) was improved by a factor of ten by substituting ammonium form resin for hydrogen form. Measured decontamination factors of 10^4 from cerium-144 are obtained.

The Sr-89/Sr-90 ratios determined by Analytical Laboratories Operation and Purex Laboratories have shown marked disagreement. After further extensive work, using

both mass spectrometric and radiochemical methods, it was concluded that the values obtained by ALO are correct. Referee samples and counting standards are being exchanged in an attempt to find the source of the Purex difficulty.

Strontium Shipment on Cerium-Cask Decalso Insert - Most of the work previously reported on the absorption of strontium on Decalso was tailored to proposed shipment of Purex strontium crude in Oak Ridge STT's (which accommodate over 400 gallons of Decalso). Decision to ship the purified 325-A product in a special 10 gallon Decalso insert for the Cerium Filter Cask necessitated additional experiments to define a loading procedure. Decalso loading and elution experiments were run with a solution simulating the 10 gallons of combined Run 1 and 2 product (4.5 g Sr/l in 2 M HNO_3 with previously indicated Cu, Ca, and Ba). The results showed:

1. Absorption from acidic solution is not satisfactory due to low capacity, irreversible absorption, degradation of the Decalso, and contamination of eluted strontium with dissolved Decalso.

2. Neutralization and dilution gave the best results. Neutralization with caustic followed by four-to-ten-fold dilution will reduce the loading losses to less than one percent. Water washing will result in an additional loss of as much as five or six percent.

3. Caustic neutralization gave better absorption and higher capacity than did ammonia. However, achieving the desired neutral or slightly acidic pH is somewhat more difficult with caustic.

4. Four column volumes of 4 M NH_4NO_3 elutes most of the absorbed strontium. Fraction of the initial strontium readily recoverable at the destination (allowing for loading, washing, and elution losses) will range from 70 to 95 percent.

Multi-Fission Product Recovery Flowsheet

A study flowsheet for the recovery in Hot Semiworks of strontium, cerium and promethium - rare earth fractions from Purex 1WW (following the current lead sulfate scavenging step) was issued. The presently preferred modification of this flowsheet would have the following features:

1. The 1WW crude is neutralized to pH 3.5 to 4 in a buffered system with HEDTA present to complex iron and lead.

2. Strontium, calcium and rare earths are extracted with 0.4 M D2EHPA in the 1A column.

3. The extract phase enters the midpoint of a 1B column where the strontium is stripped at a controlled pH with citric acid. An organic scrub stream prevents the stripping of Ca and rare earths.

4. The rare earths are stripped in a 1C column with 1 M HNO_3. Hopefully some yttrium DF may be accomplished at this point.

5. The rare earths from the 1C column are oxidized with $KMnO_4$ to produce the highly extractable cerium(IV). This should be very effectively extracted in the 2D column, using 1 to 2 M HNO_3 to prevent extraction of the other rare earths. The aqueous waste contains essentially only calcium, manganese and all of the rare earths but cerium (and possibly yttrium).

6. The cerium is removed from the solvent in the 2E column by stripping with 1 M HNO_3 containing H_2O_2 (or hydroxylamine sulfate).

Limited demonstration of the above flowsheet indicated that 90 percent of the cerium could be extracted from an EDTA-complexed feed at pH's from 3.1 to 3.8 and that the extracted cerium could be quantitatively stripped with 1 M HNO_3 at a flow ratio (A/O) of 0.2.

Attempts to oxidize and extract cerium(IV) met with mixed success. In the first run with 0.007 M Ce and 0.012 M $KMnO_4$ in the 1 M HNO_3 feed, only about 40 percent of the cerium extracted. This was effectively stripped with 1 M HNO_3 containing 0.1 M hydroxylamine sulfate.

Virtually the same performance was obtained using 0.1 M sodium dichromate as the oxidant. A disadvantage of this oxidant was the extraction of dichromate into the solvent followed by the formation of a highly extractable green chromium species. Limited laboratory studies failed to identify this green species. Its color and properties differ considerably from the chromium(III) and chromium(VI) species which normally extract into D2EHPA and DBP.

A third oxidant, persulfate ion, was used very successfully in laboratory studies to form the extractable cerium(IV) ion but a pilot plant run with persulfate-oxidized feed was unsuccessful, apparently because of an impurity in the system which reduced the cerium(IV) to cerium(III). Unlike dichromate or permanganate, oxidation with persulfate is slow and requires several minutes digestion at high temperature.

Fission Product Packaging - Cannister Calcination

Strontium nitrate solution has been evaporated and calcined in small cylindrical vessels that could be used for shipping containers. A 1-1/2 inch pipe cannister nine inches long was heated in a furnace while strontium nitrate solution (250 g/l) was intermittently added and boiled to dryness. Ten hours were required to evaporate two liters of solution without splashing or boiling over. The 500 grams of salt made a dense cake 2-3/4 inches deep. The temperature was then raised to the calcining point, and the heating rate was controlled to prevent slugging and foaming over of the calcining melt. Six hours were required for completion of the reaction. The product formed a dense mass about one inch deep in the bottom of the pot.

In a similar cannister of two inch pipe, the calcining time was reduced to two hours as the reacting melt showed reduced tendency to "slug." In both cannister sizes, the foam volume was about twice the salt cake volume and about five times the final product volume. The calcined cake was dense, hard and very difficult to remove.

ANALYTICAL AND INSTRUMENTAL CHEMISTRY

Determination of Thorium in Uranium Ores

R. Ko presented the subject paper at the Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy. The formal report, HW-66220, was issued December 1, 1960.

Determination of Gases in Metal by Emission Spectrography

Fabrication of characteristic (Fassel) equipment is progressing after a feasibility study promised significant Hanford usefulness. Principal item needed is a source capable of evacuation so that inert gas may be admitted to permit oxygen analysis.

Determination of Cs-137 for Burnup Measurements

The tetraphenylborate (TBP) extraction method for the determination of Cs-137 for burnup measurements was found to be 2-1/2 times as precise and over twice as economical as the standard perchlorate method. Replicate analyses of a burnup sample gave deviations at the 95 percent C.L. of 4 percent and 10 percent for the TBP and perchlorate methods, respectively. The TBP procedure consisted of diluting the sample aliquot with 10 ml of water, neutralizing to the bromcresol purple endpoint with sodium hydroxide, extracting cesium into 10 ml of 0.05 M sodium tetraphenylborate in amylacetate, and transferring 4 ml of the organic phase to a 10 ml tube for counting in a 3 inch NaI well crystal with the 256-channel energy analyzer. Cesium-137 disintegration rates were obtained by counting a Cs-137 standard under identical conditions.

EQUIPMENT AND MATERIALS

Continuous Centrifuge

The six-inch continuous centrifuge for Z plant was modified on the recommendations of the manufacturer's representative by boring out the baffles inside the case to provide 30 mils diametral clearance (previously 17 mils) between the rotating bowl and the case. The machine has subsequently been taken down, reassembled, and operated several times without mechanical difficulty or bothersome vibration. The centrifuge has been removed from the one-ton concrete mounting block and mounted on a vendor-recommended, 840 pound steel base, resting on fiberglas vibration isolators. The arrangement is entirely satisfactory.

Process testing with a feed slurry of freshly precipitated cerium oxalate (stand-in for plutonium oxalate) has been resumed. The solids product is very wet (greater than 50 percent liquid compared to 35 percent moisture in previous runs). Product characteristics were insensitive to new feed solutions, carefully controlled strike conditions, and reduced speed of the solids-unloading conveyor.

Microscopic comparison of the feed slurry to the solids product showed evidence of mechanical degradation of the crystals by the solids conveyor. The feed contained very few particles smaller than 10 microns with the majority larger than 20 microns. In contrast, particles in the product slurry were largely in the 2 to 5 micron range. Further development will be directed toward reduction of particle attrition.

Pulse Generators

Operation of an air driven pulse generator at the Idaho Chemical Processing Plant was observed. CPD personnel have proposed that the Recuplex H-1 column be converted to this system of pulsation on a prototype basis.

Two 316 stainless steel bellows were received for replacement of Recuplex Teflon bellows on the next failure of the latter. Stainless steel bellows of this type have been operated for 3×10^7 cycles, without change in spring rate, at pressures and frequencies in excess of those developed in Recuplex pulse generators.

PROCESS CONTROL DEVELOPMENT

C Column Data Processing

The latest version of the Data Reduction Code, which will accommodate the output data from the absorptiometer Data Logger, was debugged this month. Some revisions

were necessary in the code as originally written because upon compilation of this new version it was discovered that the 32K memory capacity of the IBM 7090 had been exceeded by the code. The library subroutines, which are available in the FORTRAN-MONITOR processing system, are now included with the binary program deck of the Data Reduction Code, because the time being spent by the MONITOR system in searching magnetic tape for these routines was amounting to approximately 1/3 of the total processing time for one run.

The design of a generalized computer code which will be used to process the reduced data that is punched out by the Data Reduction Code for the C column runs, has been started. From the reduced data this code will generate the coefficients of any mathematical model of the C column which has been arrived at theoretically. In the future this code will be referred to as the Modeling Code. Since a great deal of data handling by magnetic tape is anticipated in this code, the Electronic Data Processing Operation has agreed to write special sub-routines compatible with FORTRAN, which will allow computation and magnetic tape operations to proceed simultaneously. This feature is not normally available in FORTRAN programs.

C Column Instrumentation

Construction of the Absorptiometer Data Logger was completed this month. The Logger was debugged and several statistical tests were run on the unit to determine uranium analysis reproducibility with various methods of sample handling.

The high speed scanning circuitry (0.4 sec. per data point) which will eventually be incorporated in the C Column Data Scanning Programmer has been tested out with a laboratory mockup of the Programmer. Installation and testing of the circuitry in the actual Programmer is now proceeding. It is anticipated that when this system is operable, the time to log the data pertinent to a single sample port in the column will be reduced from the present value of 12 minutes to approximately 1.5 minutes or less.

Analytical Expression for Equilibrium Diagrams

Development of mathematical equations to fit the curves of equilibrium diagrams has resulted in a set of simple equations which relates organic uranium concentration to aqueous uranium concentration for constant aqueous acid parameters of 0.00, 0.05, 0.10, 0.20, and 0.30 molar.

From previous studies on fitting equations to the equilibrium curves, it was concluded that a polynomial form of equation should be developed. To be useful in later calculations this polynomial function was limited to the form: $y = ax^2 + bx + c$. It was necessary, therefore, to represent each of the constant acid equilibrium curves by two second order polynomials, breaking the curves at their inflection points.

The coefficients for these sets of polynomials have been calculated using the method of Least Squares. The error in approximating the data by a polynomial fit has been calculated for each equation and expressed as a standard deviation. A report is being written which will present the developed equations.

Control System Development for Recuplex

A chain hydrometer type density monitor for in-line use in the new Plutonium Reclamation Facility was tested this month. Hysteresis, flow and temperature

induced errors were observed to be less than one percent of range. The output signal is linear over the mid-portion of the density range used (1.0 to 1.5) but errors as large as ±3 percent were observed at the extreme ends of the span. With the flow controlled to ±500 ml/min and the temperature to ±10 C of the calibration point a measured error in density of less than one percent is obtained over the range 1.08 to 1.42 density units.

The strain gauge column density monitor now under test has performed satisfactorily. Long term stability and reproducibility appear to be good. Tests are continuing and comparisons with pneumatic transducers are planned.

Electrolytic Conductivity Cell

A drawing (H-2-57888) of the electrolytic conductivity cell for installation in the Purex 1BP sampler has been completed. The drawings, prototype cell and a diagram of bridge resistance values for a Foxboro Resistance Dynalog Controller for this application have been turned over to CPD Facilities Engineering personnel.

REACTOR DEVELOPMENT - 4000 PROGRAM

PLUTONIUM RECYCLE PROGRAM

Salt Cycle Process

Hot Cell Experiments - A second hot run removed the single major uncertainty as to plutonium behavior which remained after the first hot run, viz., the ability to induce plutonium to "co-deposit" with uranium as a mixed oxide in the product deposition step. In the first hot run this was achieved only on the second attempt.

The second run employed the same salt melt used in the first run. An additional batch of about 220 grams of irradiated UO_2 was dissolved into this melt and a by-product deposition and a product deposition conducted in sequence. Procedures and results in the dissolution and by-product deposition essentially duplicated those of the first run. The by-product UO_2 was again cleanly separated from plutonium and fission products, decontamination factors being about 200 for plutonium, 430 for cerium, and 2000 for other rare earths. The product deposition was preceded by a two hour controlled humidity air sparge of the melt vice only a half-hour sparge in the first run. This sufficed to permit PuO_2 and UO_2 to be "co-deposited." The plutonium/uranium ratios found in two samples of the mixed oxide product were, respectively, 6 percent and 19 percent greater than the ratio which existed in the molten salt solution prior to the air sparge. Thus, it appears readily possible by this simple two step sequence to increase the plutonium/uranium ratio in fuel to be recycled by a factor of $1/(1-x)$ where x is the fraction of the total charged uranium which is "discarded" in the by-product deposition. The quantity x can be varied at will (at least up to a demonstrated value of 0.4) so sufficient flexibility exists to accommodate any reasonable "self-sustaining" plutonium recycle scheme.

Fission product behavior in this run was consistent with that of the first run. Rare earth decontamination factors (from salt solution to product deposit) were about 1.2 for cerium and about 6 for the other rare earths. Ability of cerium to follow plutonium almost exactly was therefore again demonstrated. This causes little concern in that cerium contributes only a minor poisoning effect and can therefore be recycled to the reactor without significant penalty. However, the other rare earths constitute the most prominent fission product poisons and their recycle to the reactor would entail some economic penalty.

The projected Salt Cycle processing approach for such a self-sustaining plutonium recycle scheme entails use of the same salt bath for prolonged periods during which by-product UO_2 powder (free of plutonium) would be removed as the sole waste stream and mixed UO_2-PuO_2 powder removed as the sole product stream. With rare earth decontamination factors as observed in these first runs (2000 in the by-product deposition and 6 to 8 in the product deposition) prolonged re-use of the salt melt would simply result in accumulation of rare earths in the melt until their concentrations reached levels on the order of 6 to 8 times their levels in the feed after which the rare earths would exit in the product deposit at about the same level at which they existed in the entering feed. There is thus substantial incentive for "destroying" the present large rare earth decontamination factors in the by-product deposition in order to provide the rare earths with an outlet from the process via this step.

Deliberate destruction of the decontamination potential of a chemical process step has a refreshing element of novelty and several possibilities for accomplishing this will be pursued in projected future work.

Electrode Processes - Studies have been initiated with non-radioactive lanthanum and cerium. Only preliminary results are available as yet but these are encouraging. "Co-deposition" of lanthanum with UO_2 is much less pronounced when the electrolysis is conducted under anhydrous conditions. Since co-deposition of plutonium with UO_2 does occur with reasonable efficiency under a dry air atmosphere this may afford a means of increasing rare earth decontamination factors in the product deposition step.

Studies with cerium confirm the analogous performance of plutonium and cerium observed in the hot cell experiments. Cerium "enrichment" (cerium/uranium ratio in deposit divided by cerium/uranium ratio in initial salt solution) were 0.39, 0.45, and 1.67 for "product depositions" conducted under dry air, building air, and water-saturated (at 0 C) air, respectively. It is especially interesting that the highest enrichment was obtained under conditions where a visible precipitate was present in the melt and contained virtually all the cerium and a substantial amount of uranium.

Further studies of the polarization effects in electrodeposition of UO_2 from molten NaCl-KCl show an effective depolarization effect by chlorine. Electrolysis at a fixed superficial current density of 0.15 amps/cm^2 can be carried to substantial depletion of the melt uranium without developing any substantial cathode over voltage (other than the unavoidable IR drop). However, enclosing the anode in a shroud tube and thereby restricting access of chlorine to the cathode region allows only about half as much uranium to be plated at this current density before a substantial overvoltage is seen on the cathode.

Studies of UO_2 Crystal Growth - Continued study of the influence of deposition conditions on the crystal habit of electrodeposited UO_2 has produced some illuminating information. To date, the most important variable determining the nature of the UO_2 deposit formed is the composition of the atmosphere over the melt. Essentially two extreme cases are seen. If the NaCl-KCl melt is thoroughly dried and electrolysis initiated under a dry helium atmosphere by "driving" a microcathode (a platinum wire shielded by a quartz sleeve except at the tip) at a potential of one volt negative with respect to a Ag/AgCl reference electrode the electrolysis current increases rapidly to a maximum value and then decreases to a small but steady current of ca. 50 milliamperes. The UO_2 deposit which forms under this strongly polarized condition is a smooth, dense polycrystalline sphere. One sphere grown in this manner measured about one centimeter in diameter, had a highly polished "glazed" appearance, and a measured bulk density of 10.76 g/cm^3.

By contrast, when an electrodeposition is conducted in the same equipment but under an oxygen-bearing atmosphere, the current which flows is greater by a factor of 20 to 60 and "rampant" growth of UO_2 occurs, resulting in a "mace" of radially oriented, loosely packed single crystals of UO_2, each of which may be as much as 8 mm in length.

Studies of $KCl-PbCl_2$ Systems - In sharp contrast to the NaCl-KCl system, the atmosphere over the equimolar $KCl-PbCl_2$ salt mixture had little effect on either the physical appearance or measurable properties of UO_2 cathode deposits. Granular UO_2 deposits essentially identical in appearance, of essentially identical oxygen/uranium ratio and chemical purity were prepared by electrolysis under helium, chlorine, dry air, and moist air atmospheres. Under each atmosphere, a decreased oxygen/uranium ratio was observed as the current density was increased, however.

Measurements of the reduction potential of uranyl ion in ten mole percent solutions of UO_2Cl_2 in KCl-PbCl gave results from which strong complexation of uranyl can be inferred in these systems. The measured deposition potentials of uranyl (relative to the Ag/AgCl reference cell) at 600 C were +0.578, +0.481, +0.393, and +0.350 volts, respectively, as the $KCl/PbCl_2$ ratio was varied from 1 to 1.5 to 2 to 2.5. In the absence of uranium deposition potentials of lead in these systems were -0.281, -0.345, -0.400, and -0.445 volts relative to the Ag/AgCl reference cell. Quite apparently, the activity of the reducible uranium species can be decreased by a factor of about 400 by increasing the $KCl/PbCl_2$ ratio from 1.0 to 2.5.

Process Studies - Calculations have been made to determine the distribution of fission product elements and their relative poisoning effects in the Plutonium Recycle Test Reactor at steady state with plutonium-natural uranium mixed oxide fuel. Complete fission product removal after each cycle and a burnup of 10,000 MWD/T at a flux of 5×10^{13} $n/cm^2/sec$ were assumed. The total estimated fission product poisoning during one cycle is 6.4 gram equivalent weights of neutrons per ton uranium. Fission product removal would have little effect on 55 percent of these poisons, which have cross sections greater than 10^4 barns, because they are in secular equilibrium with the fissioning nuclides. The remaining poisons are distributed as follows: 59.1 percent rare earths, 9.8 percent inert gases, 7.0 percent alkali metals, 0.80 percent halides, 0.19 percent alkaline earths, 11.6 percent Rh, 4.0 percent Tc, 3.3 percent Ag, and 4.0 percent other elements. Cerium, which is expected to be difficult to remove by the Salt Cycle Process, accounts for only 0.14 percent of the removable poisons.

Alloy Development - Samples of 11 experimental alloys prepared by Battelle Memorial Institute have been exposed to HCl sparged equimolar NaCl-KCl melt at 800 C for six hour periods. One of these (85 percent Ni - 15 percent Al) corroded at less than 10 mils/mo. Four samples - three modifications of Alnico 3-B, and one of Hastelloy B - corroded at rates about 20 mils/mo. The remainder corroded at rates in the 200-900 mils/mo range. Battelle is preparing other alloys of the Al-Ni system in hopes of finding a composition combining forgability with good corrosion resistance. A sample of the 85 Ni-15 Al alloy was exposed as above with alternate water vapor-saturated air and HCl sparges. During three such cycles totaling 72 hours exposure the sample corroded at 0.8 mil/mo, an exceptionally low rate for this system.

Non-Metallic Materials - An alumina crucible, grade Triangle RR manufactured by Morganite, Inc., failed after 1470 hours at 700 to 800 C containing an equimolar solution of sodium chloride and potassium chloride. The solution was saturated with chlorine for at least half of the test. The crucible was judged to have

failed when a detectable amount of the solution had percolated through the walls and bottom.

A second crucible from the same batch failed after 262 hours test without chlorine. Failure was by the same mechanism as the first crucible. There was no significant change in weight of either vessel.

Continuous Ion Exchange Contactor Development - Jiggler Contactor

Three four-hour thorium-traced adsorption-elution runs have shown that when the effective hydraulic length of the elution column is shorter than the adsorption-scrub column the elution medium cannot be held low enough in acidity to permit effective thorium removal from the resin in the thorium-nitric acid anion exchange system. Increasing the length of the elution column by two feet and introducing a 0.5 M HNO_3 wash stream at the bottom of the A column were sufficient to maintain the desired low acidity in the C column. This change in apparatus, however, made resin movement control through the air lift more difficult than before.

Possible designs for a unidirectional resin flow device are being investigated. Brief experiments with tapered orifices indicate that at a low frequency pulse the 20-50 mesh resin in nitric acid tends to behave as a liquid. Under alternating equal pressures in a U tube arrangement in which equal columns of resin were separated by a 3-inch x 1/2-inch disc with a 3/4-inch to 1/4-inch tapered orifice, a net flow of resin was observed from the larger diameter side of the orifice. Frequencies greater than 6 cyc/min appear to nullify this effect. Apparently as the frequency is raised the voidage of the resin bed decreases, resulting in a rapidly increasing pressure drop.

An increase in length of the C column and the use of the new tapered orifice in place of the thin 1-1/4-inch orifice previously used make it possible to recycle the resin without use of the air lift. The propulsion of resin is effected by the hydraulic pressure of the pulser during the compression stroke. The elimination of the air lift promotes greater operational stability and may allow the use of cocurrent flow in the C column because of a reduction in C column slip acid. The most promising adsorption-elution performance to date has been a four-hour thorium-traced run with a 4-inch column at 3 cyc/min and a 2-inch amplitude. Both the liquid and resin flow rates were about 200 ml/min.

RADIOACTIVE RESIDUE FIXATION

Kinetics of Ruthenium Tetroxide Decomposition

Substantial quantities of ruthenium tetroxide will be evolved in any scheme of radioactive waste calcination and will require removal from the off-gases. This can be done readily and effectively by absorption on silica gel or similar materials provided there is no decomposition to sub-micron sized ruthenium dioxide, which would be very difficult to filter out. Since data are not available on the rate and extent of decomposition of RuO_4 at the temperatures and dilute gas phase compositions which will be involved, an experimental program has been initiated to determine these quantities. The reaction will be carried out in a glass system and followed analytically by infrared spectrometry. Preliminary experiments indicate that common stopcock greases cannot be used (because of rapid reduction of tetroxide) but that polyphosphoric acid will probably be satisfactory. Although there was some dissolution of ruthenium tetroxide in the polyphosphate, as evidenced by a yellow color, there was no apparent decomposition. The equipment is accordingly being fabricated with stopcocks and ground joints.

Radiant Heat Spray Calciner

Several runs were made during the month in the demonstration spray calciner to evaluate the suitability of a proposed feed composition (mixed underground stored waste and 1WW) and for further testing of the effectiveness of ceramic cloth filters and of the new jack-leg filter section which would be used in the proposed hot cell unit. The feed is one which Chemical Development has found (after drying and calcining) barely meltable at 900 to 925 C. The spray calciner run was accordingly made with the melt pot operated at 930 C. An excellent compact sinter with density of 2.7-2.8 g/cc was formed even though the powder was being added continuously to the pot. A volume reduction factor of 20 (from feed to melt pot) was achieved. An Eco gear pump, rather than feed pot pressurization, was used successfully in this run to pump the feed to the two-fluid nozzle. It is planned to use a similar gear pump (but with stainless steel rather than Teflon-glass gears) in the hot cell, an intrinsically safer operation than pressurizing the feed tank.

The jack-leg filter arrangement continued to perform well, with only a slight coating of powder accumulating on the bottom of the jack-leg section. A prolonged test of ceramic cloth filters in the filter section showed no significant increase in pressure drop during the runs. A sodium balance from feed to condensate indicated a decontamination factor of 1725 for the cloth filter plus the condenser (but excluding the scrubber).

In other experiments, it was found that the filter cake which slowly builds up on solid filters (ceramic or stainless steel) and is not removed by blow-back can be readily removed by back-washing with a small volume of water. Use of only five liters of water per square foot restored the filters to their original condition.

Mineral Reactions

A procedure was devised and tested for preparing pelletized clinoptilolite from the powdered mineral by extrusion using a sodium silicate binder. The resulting product was mechanically stable and was not affected by cold water, acids or caustic solutions. However, the pellets distintegrated in water at 90 C. Cesium adsorption by a bed of the pellets was inefficient compared with a bed of crushed clinoptilolite.

The effect of increased temperature on the adsorption of cesium from synthetic high level waste was found to be similar to that reported for other systems. The cesium capacity of a bed of the mineral at 80 C was about one-third of that at 20 C. The mineral was found to adsorb strontium more readily at 80 C than at 20 C and exhibited a much sharper breakthrough at the higher temperature. This behavior is consistent with the hypothesis that the calcite impurity in the bed is largely responsible for removal of strontium.

The elution of strontium and cesium from clinoptilolite with a 5 N solution of ammonium acetate was found to proceed at about one-fourth the rate obtained with 5 N ammonium nitrate. Adjusting the pH of the solutions had little effect on the elution. Conductivity measurements indicate that the elution efficiencies of various ammonium salts is determined by the degree of ionization.

Laboratory research was initiated to compare a commercial phenolic resin known to have a high specificity for cesium with clinoptilolite. The resin has a particularly good specific cesium capacity at very high pH. A column of the resin was charged with the supernatant solution of a synthetic coating waste traced with Cs-137. The 50 percent breakthrough capacity of the resin for undiluted waste was 200 column volumes. This is greater than previously determined for clinoptilolite.

Clinoptilolite was found to have a cesium capacity greater than ten times that for a sulfonated polystyrene resin in laboratory column experiments with acidified, carbon filtered, Purex tank farm condensate waste. A column of clinoptilolite received 10,000 column volumes of waste before 50 percent breakthrough was reached. Because of the low amount of dissolved salts normally present in this waste a higher cesium capacity was expected for the resin. The cesium capacity of the resin may have been depressed somewhat by salts leached out of the activated carbon or by residual cleaning agents in the tank truck used to transport the waste.

A bed of activated carbon removed suspended organic material from about 1500 bed volumes of acidified Purex tank farm condensate before breakthrough of suspended organic material was observed in the effluent from the bed. Breakthrough of Ru-106 and Zn-95, Nb-95 from this same bed was also detected at this point. Little more than half of the Ru-106 and Zn-95, Nb-95 was being removed prior to breakthrough.

Condensate Streams

Micro Pilot Plant Run 12 was conducted to evaluate the effectiveness of activated carbon, calcite and clinoptilolite columns in removing organic and radiocontaminants from Purex Tank Farm condensate waste. Treatment with carbon reduced butyl phosphate concentrations to <0.1 ppm and hydrocarbon diluent concentrations to 1 - 3 ppm. Reducing the flow rate from 1.3 to 0.5 gpm/ft^2 improved the removal efficiency for hydrocarbon diluent. The addition of sodium hydroxide to increase the pH and tri-sodium phosphate to promote the calcite-phosphate rearrangement reaction did not measurably alter the efficiency of the mineral beds for removing Cs-137. However, the Cs-137 capacity of the beds, based on an effluent breakthrough concentration of 2×10^{-4} uc Cs-137/cc, was reduced about 20 percent from the 7200 column volumes obtained in Run 11 in which only phosphate was added during part of the run.

Strontium decontamination factors varied from 4 - 10 across the carbon column and from 10-15 across the mineral columns when no chemicals or when only NaOH was added. A maximum mineral column Sr-90 decontamination factor of 20 was realized when the phosphate ion concentration was 100 ppm. At this time the overall Sr-90 decontamination factor for the three columns was 100.

BIOLOGY AND MEDICINE - 6000 PROGRAM

Geology and Hydrology

The fanglomerate (piedmont or alluvial fan deposit) directly overlying basalt beneath the Separations Plants areas was tentatively correlated with comparable fanglomerates locally exposed on the flanks of Gable Mountain and Umtanum Ridge. These exposed fanglomerates are largely basalt sand and gravel in contrast to the Ringold gravels which are characteristically quartz-rich, exotic rock types derived from areas upstream on the Columbia River. Westward along Umtanum Ridge the exposed fanglomerates grade into and form part of the tuff beds that some persons have referred to as the lower Ellensburg formation. The exposed fanglomerate is overlain by basalt flows emitted to the west and referred to by some persons as Wenas basalt.

The fanglomerate beneath the Hanford Works is comparable in grain size and in composition to the exposed fanglomerates. The mineralogy of the silt and clay fractions is more nearly that of the interbasalt beds than later Ringold. These, together with the structural form of the bed, appear to validate the correlation.

The absence of basalt flows above the fanglomerate beneath the Hanford Works indicates either that the flows were once present and locally were eroded, or were never present there. If in part eroded they might occur eastward. Unconfined ground waters moving eastward thus might have a ready path for their entry into the basalt series. If the flows originally terminated on the west side of the Hanford Works area, those ground waters, moving eastward, will remain in the sediments that lie above the latest basalt flow there.

Study of the fanglomerates where exposed will help determine the potential of ground water and waste movement through it at depth in either case.

Methods of solving three-dimensional flow problems were compared. The dependence on symmetry to simplify such problems to two-dimensions is often not justified. The solution of the non-linear partial differential equation representing three-dimensional flow by an iteration method is prohibitive except through the use of a large digital computer. The possibility of reducing the labor of solving such problems through the combined use of the finite sine integral transform and an iteration process was studied. For the test case examined for comparison the combined process required only one-fifth the computation needed for direct iteration.

Additional computer calculations were performed using a model and computer program developed for solving three-dimensional unsaturated flow problems. The problem considered was the movement of water from a point of entry in a soil medium. Definition of the lateral extent of movement under unsaturated flow will assist in optimum placing of wells for monitoring the movement of wastes from a release point.

Soil Chemistry and Geochemistry

Laboratory research was performed to study the removal of radioanions from solution by mineral replacement reactions. It was found that trace concentrations of radioanions could be removed from solution during cation replacement reactions in much the same way that radiocations are removed during anion replacement reactions. The removal of P-32 (as the phosphate) and S-35 (as the sulfate) during a gypsum-barium replacement reaction was utilized in the study. It was found that as a solution of barium was passed through a bed of crushed gypsum ($CaSO_4 \cdot 2H_2O$) the mineral is gradually replaced with barite ($BaSO_4$). During the replacement process accompanying radiosulfur was removed from solution with decontamination factors of 10^2 to 10^4. Similar experiments with solutions containing radiophosphorus resulted in decontamination factors somewhat lower than those for sulfur but having approximately the same range. Factors significantly affecting the radioanion incorporation in the mineral were column flow rate, mineral grain size, influent pH, Ba^{+2} concentration, and temperature.

Laboratory studies to investigate the reaction mechanisms by which sulfide minerals remove radioactive ions from solution utilized galena (PbS) and arsenopyrite ($FeS_2 \cdot FeAs_2$). Experiments were performed on the removal of phosphate ion from solution to statistically evaluate system variables. It was found that pH and residence time are important system variables, while temperature, oxygen concentration, and electrolyte concentration are not significant within the limits studied. Apparently, then, the mechanism is not associated with oxidation of the mineral bed, and is unlike ion exchange in that the competitive ion concentration has no effect.

Field Apparatus Development

A Lynes packer was received. This in-well tool consists of two heavy rubber inflatable packing elements and a control element. The control element allows inflating of the packing members separately, opening the column pipe to the well fluid above, between, or below the packing members separately. With this tool and a hydraulic pump recently acquired, in-well measurement of piezometric head and formation permeabilities may be initiated.

The "H" model thermistor flow meter was tested for downscale response. Orienting in a horizontal position eliminated down scale readings noted earlier. There still remains the inexplicable anomaly of a different calibration for "up" flow than for "down" flow. Effort to improve the symmetry of the thermistor used did not improve the agreement between the two calibrations.

A linear motion transducer operated from direct current was tested for use with an orifice type in-well vertical current meter. A novel feature of the device will be a pressure-sensing diaphragm which contains the orifice across which the pressure drop is to be measured. Simplicity and good sensitivity with flow direction indication are anticipated.

L. P. Bupp

Manager
Chemical Research and Development

LP Bupp:cf

A. ORGANIZATION AND PERSONNEL

No significant changes occurred in organization during February 1961.

B. TECHNICAL ACTIVITIES

FISSIONABLE MATERIALS - 2000 PROGRAM

BIOLOGICAL MONITORING

Columbia River Contamination

Fish

Concentrations of total beta emitters in all species of fish collected from the Columbia River continued to decrease during the month. The average concentrations in flesh of whitefish from Ringold, where highest values were found, was approximately three times the mean value of the three fish sampled from the same location during January, 1960.

Specific values for fish at all sampling locations follow:

Sample Type	Location	Collection Date	No.	μc/g Wet Weight Average	Maximum	Trend Factor
Whitefish muscle	Priest Rapids	Jan 31-Feb 2	8	2×10^{-5}	7×10^{-5}	-5
	Hanford	Feb 3	10	3×10^{-4}	1×10^{-3}	--
	Ringold	Jan 25-26	11	1×10^{-3}	5×10^{-3}	--
	Richland	Jan 19-24	7	3×10^{-4}	5×10^{-4}	-2
	McNary	Feb 9	1	7×10^{-5}	7×10^{-5}	--
	Burbank	Jan 17	1	2×10^{-4}	2×10^{-4}	--
Channel Catfish muscle	Burbank	Jan 17	2	2×10^{-5}	3×10^{-5}	--
Carp	Richland	Jan 19	1	2×10^{-4}	2×10^{-4}	--
	Burbank	Jan 17	4	4×10^{-5}	5×10^{-5}	--
Chiselmouth muscle	Priest Rapids	Feb 1-2	3	4×10^{-5}	5×10^{-5}	--
	Burbank	Jan 17	5	2×10^{-4}	3×10^{-4}	--
Crappie muscle	Burbank	Jan 17-18	5	2×10^{-5}	3×10^{-5}	--
Yellow Perch muscle	Ringold	Jan 26	1	8×10^{-5}	8×10^{-5}	--
	Burbank	Jan 17	5	1×10^{-5}	3×10^{-5}	--

(Continued)

Sample Type	Location	Collection Date	No.	μc/g Wet Weight Average	μc/g Wet Weight Maximum	Trend Factor
Squawfish muscle	Priest Rapids	Feb 1-2	5	4×10^{-5}	7×10^{-5}	--
	Ringold	Jan 26-27	4	5×10^{-5}	7×10^{-5}	--
	Richland	Jan 19	5	3×10^{-5}	6×10^{-5}	--
	McNary	Feb 9	2	3×10^{-5}	3×10^{-5}	--
Coarse-scaled sucker muscle	Priest Rapids	Feb 1-2	1	4×10^{-5}	4×10^{-5}	--
	Ringold	Jan 26	5	6×10^{-4}	9×10^{-4}	--
	Richland	Jan 19	5	1×10^{-4}	4×10^{-4}	--
	McNary	Feb 7-9	5	1×10^{-4}	1×10^{-4}	--
	Burbank	Jan 17	5	1×10^{-4}	3×10^{-4}	--
Fine-scaled sucker muscle	Priest Rapids	Feb 2	1	2×10^{-5}	2×10^{-5}	--
	Ringold	Jan 26-27	3	9×10^{-4}	1×10^{-3}	--
	Richland	Jan 19-25	2	4×10^{-4}	6×10^{-4}	-8
	McNary	Feb 9	4	4×10^{-4}	1×10^{-3}	--
	Burbank	Jan 17	5	6×10^{-4}	2×10^{-3}	--
Rainbow trout muscle	Ringold	Jan 27	1	6×10^{-4}	6×10^{-4}	--
Minnows entire	Hanford	Feb 3	7	3×10^{-3}	3×10^{-3}	--
	Richland	Feb 18	6	3×10^{-3}	3×10^{-3}	--

Waterfowl

Concentrations of total beta emitters, predominantly P^{32}, in flesh of game species of waterfowl collected from the Columbia River within the Hanford Reservation were two times greater than those obtained last month and approximately twice those of one year ago. Average concentrations in flesh of various species follow:

Sample Type	Collection Date	No. of Samples	μc/g Wet Weight Average	μc/g Wet Weight Maximum	Trend Factor
Diving ducks	Jan 11	1	5×10^{-3}	5×10^{-3}	+3
River ducks	Jan 11-25	4	4×10^{-4}	1×10^{-3}	--
Mergansers	Jan 11-27	3	2×10^{-3}	3×10^{-3}	+2
Coot	Jan 10	1	3×10^{-4}	3×10^{-4}	-8

Swamp Contamination

Waterfowl collected at the 200 West swamps contained approximately the same concentrations of total beta emitters, principally Cs^{137}, as observed last month and one year ago. Average concentrations in flesh were as follows:

Sample Type	Collection Date	No. of Samples	μc/g Wet Weight Average	μc/g Wet Weight Maximum	Trend Factor
River ducks	Jan 12-13	5	2×10^{-4}	3×10^{-4}	--
Diving ducks	Jan 13	2	5×10^{-5}	9×10^{-5}	--

Effect of Reactor Effluent on Aquatic Organisms

Effluent monitoring was continued at the 1706-KE laboratory with the exposure of young salmon to dilute untreated effluent and to like concentrations of effluent passed through a bed of aluminum turnings. A slight increased mortality has appeared in fish exposed to the effluent passed through the aluminum (4 per cent strength) over those of the control and untreated effluent, but any significance is still questionable.

C. columnaris

Columnaris strains obtained during the summer of 1960 from various locations in the Columbia River were tested for comparative virulence in killing small salmon. Organisms had been held in lyophilized form during the intervening time.

Of the nine strains tested so far, eight were clearly less virulent and one equal in virulence to the test strain used previously in standard test procedures. The most virulent strain was obtained late in the fall after river temperatures were below 60°.

BIOLOGY AND MEDICINE - 6000 PROGRAM

METABOLISM, TOXICITY, AND TRANSFER OF RADIOACTIVE MATERIALS

Strontium and Calcium

Three lots of eggs spawned from a stock female were fertilized with ripe control, and low and medium treatment males (6 months after the termination of feeding of Sr^{90}-Y^{90} at a rate of 0.005 and 0.05 μc/g of body weight per day). No additional spawn was taken in February. None of the four surviving medium treatment females appears ripe and it is questionable whether they will mature this season. Spawn taken in late January from a low-treatment female indicated very poor fertilization (as measured by initial pick-off data) when they were compared to the control lots.

Exploratory work on single oral administration of Sr^{85} to trout is being pursued in order to study the distribution of the isotope in various tissues and organs with time. Most of the effort in February for this study was expended in technique and analysis problems. Some measurements of the various sources of variations were obtained.

The body weights of year-old miniature swine offspring at the 25 μc Sr^{90}/day level are significantly less than those of animals on the 1 μc Sr^{90}/day level.

Preliminary data were evaluated on the skeletal uptake of Sr^{90} in first and second generation offspring miniature swine which received Sr^{90} through fetal life and up to one year of age. The skeletal concentrations of Sr^{90} at birth and weaning were slightly greater in the second than in first generation offspring. (Variation in Sr^{90} concentration between the bones from any one animal was slight.) Deposition in teeth was about 70 per cent of the average skeletal concentration. On the basis of present estimates, skeletal tissues of offspring on the 25 μc Sr^{90}/day level will receive about 0.5 rads/day at birth, 1.5 rads/day by weaning and about

4 rads/day at six months of age and older. The skeletons of the offspring obtained during fetal development and at birth contained a Sr^{90}/g calcium ratio approximately 4 per cent of that in the dams' ration, as compared to 13 per cent for swine sacrificed at weaning. Swine sacrificed at six months of age or older contained a Sr^{90}/g calcium ratio about 25 per cent of that in their diets.

Evidence was obtained indicating that in sheep irreversible binding of calcium in circulating blood may be an important factor in maintaining ionic calcium level. In serum from ewes containing between 9 and 13 mg Ca/100 ml, calcium in excess of 7 mg/100 ml appeared to be irreversibly bound and, therefore, not exchangeable with in vitro-added Ca^{45} or Sr^{90}. This evidence is in contrast to work by other investigators who have assumed that all blood calcium is in dynamic equilibrium with blood protein. That the irreversible binding of calcium may occur in the circulatory system was suggested by a second study. In this latter study, with in vitro additions of up to 10 mg of Ca^{40} to 100 ml of sheep's plasma, calcium in excess of 6 mg/100 ml appeared to be irreversibly bound and, therefore, not exchangeable with in vitro-added Ca^{45}. If these observations can be confirmed for other species of animals, simpler explanations than previously possible may be provided concerning calcium transport and concentrating mechanisms (e.g., at the gastrointestinal tract and kidney level).

Neptunium

Approximately 30 per cent of intravenously injected neptunium was retained by a rat after 178 days. Highest concentrations were present in bone. Autoradiographs showed quite specific localization in certain soft tissues, notably ovary and adrenal glands. Gastrointestinal absorption of neptunium based on tissue retention after chronic feeding appears to be less than 0.1 per cent. This is comparable to plutonium and lower than was previously indicated by urinary excretion data.

Plutonium

Studies were continued on the therapeutic effect of DTPA administered at short intervals following combined X-irradiation and plutonium administration. The acute lethality can be sharply reduced in DTPA treatment when DTPA is given within one hour following plutonium and X ray. The treatment has little effect when delayed for as little as three hours. Whether this effect of treatment time is due to the difference in amount of plutonium removed or the difference in length of time that the plutonium remains in the animal, remains to be clarified.

Radioactive Particles

In dogs the processes of deposition, pulmonary clearance, and translocation favored the pulmonary retention of plutonium inhaled as particles with a mass median diameter of 4.3 μ, compared with 3 and 1.7 μ particles. These experiments with 48 dogs suggest a correlation between the amount of plutonium translocated from lungs to other tissues (some of which was excreted in urine) and the particle size distribution of the aerosol.

Four experiments of a series planned to study the inhalation of $Ce^{144}O_2$ aerosols were completed. The half-life for retention of Ce^{144} in lungs is greater than 30 days. Translocation to liver is considerably less than was reported by other authors using $Ce^{144}O_2$ fumes.

Effects of Irradiation

Further studies on the leakage of I^{131}-labeled polyvinylpyrrolidone (PVP) as influenced by irradiation of the intestine indicate that the effect of irradiation is confined principally to the upper small intestine. Irradiation of a 10 cm segment of the upper small intestine results in as great a leakage of PVP as occurs when the total body or entire exteriorized intestine is irradiated.

Project Chariot

Sorting of quantitative samples of invertebrates associated with dominant plant communities from Cape Thompson was completed. Sorting of benthonic samples from ponds and streams and taxonomic analyses of planktonic crustaceans was initiated.

FP Hungate

Acting Manager
BIOLOGY LABORATORY

FP Hungate:es

C. Lectures

a. Papers Presented at Meetings

J. J. Davis, "Project Chariot," Am. Inst. Chem. Eng., Richland, Wash., February 9, 1961.

b. Off-Site Seminars and Local Seminars

W. C. Hanson, "Project Chariot," Carmichael Jr. High Science Classes, Richland, Washington, February 3, 1961.
W. C. Hanson, "Project Chariot," Central United Protestant Church Scout Group, Richland, Washington, February 6, 1961.
M. F. Sullivan and E. M. Uyeki, "Ameliorating and potentiating agents and radiomimetics," Radiation Biology Seminar and In-Service Institute of Radiation Biology, University of Washington, Seattle, Washington, February 8 and 9, 1960.
R. A. Hennacy, "Radiation carcinogenesis," Radiation Biology Seminar, University of Washington, Seattle, February 17, 1961.
L. K. Bustad, "Radiation carcinogenesis," Radiation Biology Seminar, University of Washington, Seattle, February 17, 1961.
L. K. Bustad, "Physiological effects of irradiation," In-Service Institute, University of Washington, Seattle, February 16, 1961.
L. K. Bustad, "Effects of Atomic Energy on Agriculture," Parent-student meeting of FFA at Chief Joseph auditorium, Richland, Washington, February 23, 1961.
L. K. Bustad, "Effects of Atomic Energy on Agriculture," U. S. Department of Agriculture group, Pasco, Washington, February 24, 1961.
L. A. George, "Radiation biology at Hanford," I.P.D. Safety Meeting - 100-B Area, February 22, 1961.

c. Biology Seminars

Dr. L. B. Kirschner, Department of Zoology, Washington State University, Pullman, Washington, "Calcium Movement Across the Molluscan Mantle," February 8, 1961.

W. J. Bair, "Plutonium Inhalation Studies," February 22, 1961.

D. Publications

a. HW Publications

Bair, W. J., D. L. Willard and L. A. Temple, "The behavior of inhaled $Ru^{106}O_2$ particles," Document HW-64139, November 15, 1960.

b. Open Literature

Marks, S., and M. F. Sullivan, "Tumours of the small intestine in rats after intestinal X-irradiation," Nature 188, 953 (December 10, 1960).

Schiffman, R.H., "A perfusion study of the movement of strontium across the gills of Rainbow Trout (Salmo gairdneri)," Biol. Bull. 120 (1961)

OPERATIONS RESEARCH AND SYNTHESIS OPERATION
MONTHLY REPORT - FEBRUARY, 1961

ORGANIZATION AND PERSONNEL

There was no change in organization or personnel during the month of February.

OPERATIONS RESEARCH PROGRAMS

Inventory of Models

Work continued on the inventory of business models at HAPO with some evaluation of their use in different local environments. Information concerning a series of supporting models is being compiled currently.

OPERATIONS ANALYSIS STUDIES

Fuel Element Performance

Considerable assistance was given in preparing for the major re-run of the complete file of Quality Certification data, scheduled for the first part of March. Several changes have been made in the program, and additional calculations, notably the calculation of uniform corrosion rates, are being incorporated. Data from this re-run will be used to establish improved relationships between fuel element performance and reactor variables, and will form the basis for the issuance of routine monthly reports starting sometime in the next few months. Pre-irradiation data will be included.

Break strength data from several tubes of normal I and E fuel elements were used to derive a model relating break strength to fuel element power and residence time. The empirical models chosen fit the data very well. It is hoped that these models may be useful in providing information about thresholds for split ruptures.

Process Tube Leak Detection and Replacement

Assistance is being provided in connection with simulating the process tube leak detection system with the primary intent being to train operators in becoming more efficient in detecting leaks.

Z-Plant Information Systems Study

Final compilation of the computer program is now in process. A paper tape of the program will be made so that final debugging can be performed on-line. It is hoped that debugging can start March 16th.

A design error in the weight balance circuitry has been discovered. Design change and implementation is now in process in 234-5 Building.

The memory capacity of the computer has been changed from 16,000 to 19,072 words. Engineering and reinstallation of the drum at Hanford should be finished by the first part of April.

Radiation Protection Study - Development of Badge Calibration Curve

An equation of the general form

$$\gamma = a + \gamma_{\infty} (1 - e^{-bD})$$

was used for the density-dose calibration function. Here, γ = density, D = dose in mr., γ_{∞} = limiting density for large doses, and a and b are constants. In the range 30 to 1000 mr. the fit of the equation to density-dose data is insensitive to changes in γ_{∞}, so it can be fixed and not re-estimated with each developer batch. In the range 30 to 5000 mr. γ_{∞} is a critical parameter and must be estimated by an iterative procedure. For both cases (1/density variance) weighting improves the precision of the fitted function.

Inventory Studies

A discussion was held with personnel of General Stores and Excess Property Operation for the purpose of exploring the feasibility and approximate cost of implementing a pilot experiment to test the mathematical model of spare parts and general inventory control.

STATISTICAL AND MATHEMATICAL ACTIVITIES FOR OTHER HAPO COMPONENTS

Fuels Preparation Department

Tolerance statements were provided for dimensions of the OVIN (overbored) fuel element.

Total count data were analyzed from a pilot plant test designed to evaluate the effects on quality of the bonding layer of vacuum outgassing to remove hydrogen after the beta heat treating step.

A cuboctahedron design was used to design an experiment involving optimization of the canning cycle for nickel-plated fuel elements. The resulting data have been analyzed, and an optimum cycle was selected.

Load requirements necessary to bend a section of co-extruded fuel element a given amount were determined based on available data. This was in connection with the straightening of such fuel elements to meet specifications.

Additional curves were prepared giving sample size requirements for evaluating rupture performance. Specifically, this was in connection with proposed evaluation of nickel-plated fuel elements.

Further assistance was provided in setting up acceptance testing procedures for aluminum components with respect to wettability properties.

Irradiation Processing Department

Data were analyzed from the test previously designed to evaluate the effects on reactor front face radiation exposure of removing front face cap inserts. These inserts were used at one time to support zinc wafers which were corrosion inhibitors.

Assistance is being given in determining the post-irradiation data requirements for NPR fuel elements. The possibility of representing the fuel element profiles by polynomial expressions is being considered.

Most reactor front-to-rear flux profiles can be described by a three-term trigonometric series. A method has been developed which simplifies the computational and interpretative features of the model.

An expression has been found to use in connection with calculating certain heat transfer values in smooth bore process tubes. This is a greatly simplified approximation to a theoretically valid result.

Chemical Processing Department

Considerable assistance was given in connection with possible revised specifications for the final product. Attention was directed towards determining what conditions must prevail, (process and measurement parameter values) in order for the specifications to be met with given probability.

A special standard sample program was inaugurated to resolve a possible misallocation of total observed variation to measurement and process variation. This is in connection with the determination of final product purity.

Assistance of a scoping nature is being given in connection with a cost control study which may be conducted in Purex.

An IBM-7090 program for computing detailed contour descriptions, calculating and correcting for specific errors inherent in machine tool design, and generating the design specification for cams which control these machine tools is in the process of being written. Following a recommendation of the Numerical Control Sub-Committee of the Committee on Super Accuracy, the Hanford routine will be compared with different methods being investigated by other AEC installations.

Relations Operation

Curves of the form $y = a + bx + cx^2 + dx^3$ where y = monthly salary and x = years since graduation were developed for data from two off-site sources as well as HAPO. These curves facilitated comparison of data from different sites although the smaller amount of data limited its usefulness at values of x beyond 15-20 years.

STATISTICAL AND MATHEMATICAL ACTIVITIES WITHIN HLO

2000 Program

Pulse Column Test Facility

Discussions were held with personnel of Process Development Operation concerning the precision of instrumentation to be used on the pulse column test facility study. As a result of the analysis of pilot study data from the mid column photometer, a method of collecting and analyzing read filter-standard filter ratios was suggested which guarantees uniform precision for all samples. An experimental plan was discussed for the calibration of a gamma absorptiometer to be used for the analysis of pulse column feed concentrations.

4000 Program

Plutonium Recycle Program

A fluorescent penetrant nondestructive test is used to detect surface defects on zirconium tubes contemplated for use as PRTR fuel element cladding. To date the reliability of the fluorescent penetrant method is unknown. An experiment was designed to investigate this reliability as a function of several preparation variables: Time in penetrant oil bath, time in emulsification bath, and developer drying time. The form of the experiment allows for the estimation of absolute reliability and operator effects in addition to the relative effects and interaction of the preparation variables.

Swelling Studies

A meeting with program personnel was held to discuss current ideas on mechanisms of swelling and possible approaches to the analysis of photomicrographs of uranium samples to determine the effect on pore size distributions of burnup and annealing variables. Analysis was initiated of pore size distributions for .09 and .29 a/o irradiated uranium samples annealed at either 650° or 850° C for one hour. To familiarize experimental statistics personnel with the status of quantitative metallography, particularly as it applies to the estimation of three-dimensional properties from two-dimensional sections, W. L. Nicholson attended a symposium on quantitative metallography sponsored by the Metallurgical Research Laboratory of the University of Florida, Gainesville, Florida, February 1-3, 1961.

Aluminum Corrosion

Several standard procedures are used by Corrosion and Coatings Operation to measure aluminum corrosion from autoclave experiments. The most precise method of measuring corrosion penetration uses the stripping of samples in a methanol iodine solution to give a direct measure of metal weight loss, which can be converted to milli-inches penetration. A less precise, but simpler, method of calculating penetration is based on the assumption that the penetration/weight gain ratio depends only on autoclave ambient variables. Standard samples are used to estimate the penetration/weight gain ratio, and this ratio is used as a factor to convert all sample weight gain data for the particular autoclave run into penetration data. Since the chemical stripping and the film weighing process is by far the most involved part of a corrosion experiment, the second method is preferable if, in fact, it is valid. Data from several recent experiments have been re-evaluated in order to determine the effect of sample preparation variables on the penetration/weight gain ratio. The degree of this dependence will be useful information in deciding the amount of stripping necessary in future experiments.

6000 Program

Biology

Work continued on the statistical analysis of data from an experiment to determine the effects of varying amounts of radiation on various population parameters of Ephestia kuehniella Zeller (Mediterranean flour moth). Significance tests were conducted on the sex ratio and the results reported to interested personnel of the Biology Operation.

General

Instrumentation

Additional data analysis was done for Instrument Research and Development Operation in connection with the calibration of an RST #4 potentiometer.

Work Sampling Studies

Statistical analysis continued of data from the work sampling study recently completed by Analytical Laboratories Operation. Summary statistics are being computed to estimate over-all work efficiency and variation of this efficiency with time of day and day of the week.

Division of Research Programs

Work continued on a report of a statistical study to determine the best method of estimating background for a high energy anticoincident type gas sample counting instrument. A statistical method was devised and flow charted for computer coding for the estimation of the death rate and initial population size of a pure death process convoluted with a Poisson process of unknown intensity. Discussions were held jointly with Chemical Instrumentation and Data Processing concerning the setting up of a magnetic tape master file of program sample data.

Other

Work continued on additional features of a mathematical problem associated with ion exchange phenomena reported in January. A random walk model was constructed, and the diffusion equation associated with the continuous generalization of the model was derived.

W. L. Nicholson

for Carl A. Bennett, Manager
Operations Research & Synthesis

WL Nicholson:kss

PROGRAMMING OPERATION
FEBRUARY 1961

A. REACTOR DEVELOPMENT - 4000 PROGRAM

1. PLUTONIUM RECYCLE PROGRAM

Computer Code Development. Microscopic debugging of the fuel cost portions of the PUCK code is nearing completion. At the same time, debugging of the reactor physics portion (GPR) was completed to the point that small fuel exposures are computed accurately and the code fixes the fuel geometry, SDPV (Slowing Down Power Volume Ratio), rather than fixing the spectral index for a given case. The final step to attain a fully updated working recycle code (PUCK) is the masterminding routine, Rx, which selects equilibrium and near-equilibrium plutonium batches for analysis. Rx is now being rescoped and will be ready for final programming and debugging in a few weeks.

The IDIOT code (a transport theory physics code) was used to obtain the physics parameters necessary to communicate with the PUCK code for a large number of inverted clusters with H_2O and D_2O coolants. (The inverted cluster fuel element is one with multiple internal cooling channels composed of relatively thin-walled tubes.) The Holey Element code (which determines the temperature distribution in inverted clusters) was used to give information which aided in determining the maximum specific power.

The physical size of an idealized cylindrical reactor was computed by using the lattice spacings assumed in the IDIOT runs, fuel specific power, and the requirement of generating 750 thermal megawatts, and was used with the fermi age and the diffusion length (also from IDIOT code) to calculate a total non-leakage probability. This, with allowances for: xenon and samarium absorption, reactor temperature coefficients, and control, allows selection of K_∞ values for the PUCK input.

More exact comparisons will be made for this study on a smaller number of cases using MELEAGER (a physics burnup code) which will solve for both batch and graded irradiation cases. These more refined calculations are important because some of the schemes for fueling supercritical reactors are not suitable for graded use.

The stainless steel cladding comparison study was amended to include data with which one can estimate the penalty for operating a reactor at fuel exposures less than the exposure at minimum cost. Cases included cover a large number of reactor physics and economic conditions.

Assistance was provided Reactor Engineering Development Operation in the preliminary phase of the Supercritical Reactor Study making use of the relative fuel costs for graded U-235 enriched machines generated by the PUCK code.

One member of Programming attended a two-week short course at UCLA entitled "Nuclear Reactor Research and Design - Utilization of Digital Computers".

2. SPECIFIC FUEL CYCLE ANALYSES

A computer program to generalize the MELEAGER burnup calculations was begun during February. The basic code (i.e., first working deck) will convert batch irradiation data to uninteracted graded data and will provide "shutoff" data at any desired final reactivity. Thus, a single MELEAGER physics calculation represents both batch and uninteracted graded cases at any number of final K_{∞} values which constitutes a gross saving of computer time. The uninteracted graded case is representative of a reactor in which the excess neutrons from a fresh fuel channel are available to other fuel channels but the neutron spectrums of each channel are independent of the other channels. This is in contrast to fully interacted graded in which the neutron spectrum of all fuel channels is the same and is determined by weighing all the isotopes in the reactor on a population density basis. Currently, fully interacted cases are being solved by iteration of the MELEAGER code, but a higher speed method is being programmed. Most power reactor graded cycles actually represent a combination of the two methods, although there is only a small difference in the results except for fully-enriched plutonium cycles.

This program will represent the isotopic concentrations as calculated by MELEAGER under batch irradiation conditions with a combination polynomial-expoential fit. The uninteracted graded data will be obtained by normalizing the time intervals to a constant flux. Different specific powers can be obtained by varying the time intervals, since the isotopic decays are ignored. Separate polynomial fits are made as a function of K_{∞} to determine the end-point conditions.

Thorium Fuel Cycles. Some preliminary physics calculation runs have been made with the MELEAGER code on thorium fueling systems with Pu, U-233, and U-235 enrichment. Some physics calculations were made previous to the development of QUICK code economics for thorium systems, but the total fuel cost values in the table below were obtained after development of a thorium cost code. Although only minor changes were required in the QUICK code, a set of consistent logic had to be developed to handle these systems. In general, the logic was to fix the value of U-233, and calculate the remaining uranium values from the price schedule. The plutonium isotopes were handled in the usual manner by making total fuel costs (T.F.C.) a function of Pu value.

THORIUM-232 FUEL CYCLE COST RESULTS (NOT MINIMIZED)

Basis: APWR Physics; TID-8602 for Graded Fuel Cases; TID-8502 for Batch Cases.

Enrichment Material	Fueling Method	MWD/Ton	Percent Fissile Enrichment	T.F.C.** Mils/KWh
Pu I*	Graded	11,480	2.29	3.43
Pu II*	Graded	40,040	3.75	2.15
Pu III*	Graded	44,020	4.77	2.21
U-233	Graded	37,700	3.25	1.40
U-235	Graded	52,395	4.38	2.23
Pu I*	Batch	5,360	2.29	5.17
Pu II*	Batch	16,950	3.75	3.26
Pu III*	Batch	18,290	4.77	3.24

Notes:

*Atomic fraction of each isotope:

	Pu-239	Pu-240	Pu-241	Pu-242
Pu I	0.950	.0.5		
Pu II	0.752	0.195	0.049	0.003
Pu III	0.529	0.301	.0.143	0.026

**With U-233 and fissile Pu valued at $15/gram.

Interesting comparisons can be made in the above table between Batch and Graded Cases at the same enrichment, showing a reduction in fuel cost using graded irradiation. However, these graded calculations do not include "startup" and "shutdown" charges, which would increase the graded costs somewhat.

Comparison of fuel costs for different enrichment materials is not valid, because the costs are not minimized. Thus, some cases may be near minimum while others are far away, giving the erroneous impression of a high fuel cost. Comparisons between the Batch and Graded Cases at the same enrichment are still considered at least qualitatively valid, however.

The next step planned in the thorium evaluation is to calculate minimum fuel costs with different enrichment materials. The calculations made to

date will be used as a guide to the relative enrichment necessary to obtain these fuel cost minimizations. In addition, thorium cycles will also be investigated in the broad spectrum of thermal reactors that have been analyzed with plutonium-U-238 cycles.

B. OTHER ACTIVITIES

Sixty-six Form 189 Research and Development Program Proposals were reviewed, including eleven which were written by Programming. Also, the budget assumptions for FY-1963, 06 Program, Division of Biology and Medicine, were composited and prepared for transmittal to the AEC, and DBM programs at Hanford were reviewed with Dr. Allen Lough and Mr. James Turner (of AEC-DBM) who visited Hanford Laboratories to familiarize themselves with these research programs, particularly in the area of radiological physics.

Hanford assignments which were taken on at the meeting of the Panel on Disposal of Radioactive Wastes into Fresh Waters were completed and forwarded to the IAEA headquarters in Vienna. In addition, comments on a draft report were provided and appropriate reference materials were forwarded.

The meeting of the Division of Biology and Medicine Program Directors was attended at the Donner Laboratories, Berkeley, California by one member of Programming. Most of the meeting was devoted to a review of the progress of research programs at the University of California and to discussions of the recent SL-1 reactor accident at Idaho Falls.

Two new, long-range proposals for research and development were prepared for submittal to the AEC. One is concerned with the study of distinctive physical chemical properties of isotopes; the other proposes the study of unconventional isotope separations processes. Preparation of these was encouraged by the earlier success of Hanford Laboratories personnel in separating mercury-204 by the monochromatic photochemical sensitization process - an unconventional isotope separations process which is based on a distinctive physical chemical property.

A secret report discussing the isotopic compositions of recovered cesium and strontium fission products and the implications of what such compositions may disclose concerning reactor operating conditions was issued. (HW-68315, "Fission Product Security Problem - Preliminary Evaluation" by R. W. McKee, dated February 20, 1961.) Additional details on this study were being refined.

Dr. Gerald W. Johnson, Director, Plowshare Program, has agreed to be the Hanford Science Colloquium speaker for April 18, 1961.

Assistance was provided in arranging for visits and tours by 356 visitors during the month. This number included 26 visitors on 15 official business visits, and 330 students, teachers, and other lay personnel on six separate tours.

J. W. Woodfield

Acting Manager,
Programming

FW Woodfield:rd

RADIATION PROTECTION OPERATION
REPORT FOR THE MONTH OF FEBRUARY, 1961

A. ORGANIZATION AND PERSONNEL

Effective 2-1-61, V. M. Milligan transferred from the Calibrations Operation to IPD and L. L. Crawford transferred from the Radiation Monitoring Operation to the Reactor & Fuels Research & Development Section. On 2-15-61, P. C. Friend was hired as a Specialist, Radiation Monitoring, and assigned to the Radiation Monitoring Operation.

B. ACTIVITIES

One case of minor plutonium deposition was confirmed during the month. Based on preliminary bioassay measurements, body deposition will probably be less than 5% of the maximum permissible body burden (mpbb). The total number of plutonium deposition cases that have occurred at Hanford is 265 of which 192 are currently employed.

Six minor injuries potentially contaminated with plutonium were examined in the Whole Body Counter. Two of these cases showed no measurable contamination in the wound. Two cases showed detectable, but minor, plutonium contamination and two cases required excision of small amounts of tissue to remove plutonium at the wound site. In the excision cases, about 10 nc was the maximum amount measured in the wound (one nanocurie = 1 nc = 10^{-3} uc; mpbb = 40 nc). Excision reduced the plutonium remaining at the wound site to about 1 nc.

Fission product air contamination occurred in the 221-T Building in conjunction with pumping out fluid in the tank with air pressure. Examination of involved employees in the Whole Body Counter showed a maximum of about 0.1% of the maximum permissible body burden for Zr^{95} and Ce^{144}. Faulty ventilation at a cut-off saw in the 333 Building resulted in a transient body burden of 5 - 10 mg of uranium in a Fuels Preparation Department employee.

An Irradiation Processing Department employee entered an abnormally high radiation field (1 r to 100 r/hour) in the 105-B Building. He was in the supply air duct; a radiation zone most of which has a normal dose rate of 1 to 3 mr/hour. He strayed from this location in the course of performing housekeeping and was exposed to a dose rate of 1 - 100 r/hour, for an estimated three minutes. The source of this dose rate was discharged metal in the discharge area pickup chutes. The supply air duct in which the man was working in this location is in the vicinity of the discharge area pickup chutes. His film dosimeter indicated he received a whole body dose of 170 mr.

Prompt action by employees minimized the consequences of a spread of plutonium contamination which resulted from a rupture of a Pu-Al billet at the 308 Building rolling mill. Microcuries amounts of plutonium were detected on the floor.

A sudden change in containment vessel pressure caused an unplanned incremental rise in the moderator level of the PRTR during critical testing. The circumstances associated with this incident were investigated because of the potential for operating difficulties if the reactor were operating at full power level. Appropriate action was planned to prevent a recurrence of this condition.

A study conducted to determine if the mask checking equipment in the 2724-W Building was sufficiently sensitive, indicated that the mask checking equipment is at least as sensitive to contaminated materials potentially trapped in air passages of assault masks as the conventional GM meter check.

One employee who was contaminated during the grinding of a contaminated pipe in January still had a measurable, though small, quantity of Co^{60} in his lungs. While the lung burden is only about 0.1% of the maximum permissible body burden, repetitive examinations in the Whole Body Counter indicate that the excretion rate is extremely low.

The air filters for the air supply to the iron room in the Whole Body Counter were changed after fifteen months of operation. The total activity for the four removed filters was: 6×10^3 d/m of Cs^{137}, 1.3×10^4 d/m of Ru^{106} and 7.2×10^3 d/m Ce^{144}. Radon daughter activity was also measured in the filters immediately after they were removed.

In using the Whole Body Counter probe for locating plutonium contaminants in superficial wounds, it was found that use of a small (1 mm^2) piece of lead as an absorber over the wound site was more effective in locating the contaminants than the previously used small collimator.

The exposure record cards for employees were prepared and distributed through supervision. The annual radiation exposure report for 1960, required by AEC Manual Chapter 0523, was prepared and forwarded to AEC-HOO.

Fifty extra-high range CP-TP's were ordered for emergency monitoring purposes. These instruments provide the capability of measuring gamma dose rates up to 5000 r/hour. The ionization chamber of these instruments is to be constructed of 1/8 inch aluminum to minimize beta radiation sensitivity.

The automatic Columbia River Monitoring Station was reactivated on February 8 following repair of the pump which had suffered excessive wear of the impeller shaft and temporary repair of the amplifiers. Overheating, excessive maintenance, and lack of dependability resulted in the ordering of replacement transistorized amplifiers.

Equipment and supplies for transfer of the Biological Monitoring function to the Radiation Protection Operation were ordered. One boat, outboard motor, trailer and associated hunting and fishing equipment were transferred from the Biology Operation to the Environmental Monitoring Operation. Necessary game collector permits were also obtained.

Modification of the existing aerial monitoring equipment to provide faster and variable time responses was completed. Design of improved aerial monitoring equipment by Nucleonic Instrumentation personnel proceeded on schedule. Modification and calibration of the Redox Plant 50 ft. stack sampling equipment approached completion. The design and fabrication of an isokinetic sampling probe for the critical mass facility exhaust was completed with the assistance of Chemical Effluents Technology personnel. Development activities leading to uniformly acceptable stack monitoring systems for use on Hanford stacks were initiated. Generally, the approach will be to mate commercially available components with Hanford designed components.

Radiological Design consultation was provided for the Fuel Recycle Pilot Plant. The preparation of the complete radiological design criteria for this facility was started.

The X-ray energies obtained with the use of various K-fluorescent targets and filtered X-rays were analyzed with a portable energy analyzer. The study indicated that the 23.7, 52, and 100 Kev energies were the best monoenergetic sources available with the present calibration equipment. Several discrepancies in established energy values were noted. Additional work was planned to improve the calibrations made with the X-ray and K-fluorescent source.

The design for the new Hanford personnel dosimeter approached completion. A number of solid state devices was obtained for evaluation as fast neutron dosimeters. The contract with the Battelle Memorial Institute was completed and the BMI silicon diode neutron dosimeters were received. Studies on correlating forward resistance changes with neutron dose will be initiated when operating time on the positive ion-accelerator is available.

A 9-inch double-moderator criticality dosimeter was evaluated for neutron response in the energy range from 54 Kev to 6 Mev. Initial studies showed the response in this range to be better than $\pm$ 20%. Activation of the indium foils in this dosimeter amounted to about 8 counts/minute/mrem neutrons. One disadvantage of the double-moderator approach to criticality level dose measurement is that the energy distribution of neutrons is not determined.

The exposed fluorods which were sent to Los Alamos for comparison with our fluorod dosimeter system were interpreted by Los Alamos to within $\pm$ 10% of the actual doses delivered to these devices at Hanford. A copper foil exposed to 1 rad of 230 Kev neutrons resulted in a disintegration rate of 210 dpm/gm, indicating sufficient sensitivity for use as a component in a criticality personnel dosimeter.

P. E. Bramson attended the 2nd Annual Conference on Microdosimetry sponsored by the Bausch & Lomb Company at Rochester, New York. He presented a paper describing the Hanford application of fluorod dosimeters. Technical consultation on the proposed Washington State Bill (SB 427) was provided by AR Keene to the Senate Committee on Natural Resources at Olympia, Washington.

The hazard analysis , analyzing the radiological consequences of loss of control during shipment of kilocurie amounts of Ce^{137} and Sr^{90}, neared completion.

C. EMPLOYEE RELATIONS

One suggestion was submitted by personnel of the Radiation Protection Operation. Three suggestions submitted by Radiation Protection personnel are pending evaluation.

There were six medical treatment injuries during the month for a frequency of 2.81. No security violations occurred during February.

Radiation Protection training included: Training and refresher sessions were presented to two groups of Fire Protection employees, Radiographic Testing Operation, and Design personnel; orientation programs for Security Patrol were formulated; a training program including tours was organized for two newly assigned exempt personnel; training courses were planned for 90 members in engineering and drafting assignments in the 700 Area; a one-hour training talk was presented to Nuclear Physics Research personnel; and three one-half hour training sessions on use of Exposure Estimate Cards were held with Plutonium Metallurgy personnel.

D. SIGNIFICANT REPORTS

HW-68204 "Neutron Damage to Semiconductor Devices" by D. R. Haffner.

HW-68471 "Analysis of Radiological Data for the Month of January, 1961" by E. C. Watson.

HW-68706 "Monthly Report - February, 1961, Radiation Monitoring Operation" by A. J. Stevens.

ENVIRONMENTAL MONITORING - RESULTS - (Mid-January 1961 - Mid-February 1961)

Sample Type and Location	Activity Type	Monthly Average	Units
Drinking Water			
100-F Area	Isotopic	0.9	% MPC_w-GI*
Separations Areas	Gross Beta	1.9×10^{-7}	µc/cc
Pasco	Isotopic	7.6	% MPC_w-GI**
Kennewick	Isotopic	< 1.2	% MPC_w-GI**
Richland	Gross Beta	$< 3.0 \times 10^{-8}$	µc/cc
Columbia River Water			
Above 100-B Area	Gross Beta	1.7×10^{-8}***	µc/cc
100-F Area	Isotopic	2.9	% MPC_w-GI*
Hanford	Isotopic	3.2	% MPC_w-GI*
Pasco	Isotopic	22	% MPC_w-GI**
McNary Dam	Gross Beta	No sample	µc/cc
Vancouver, Washington	Isotopic	0.6	% MPC_w-GI**
Atmosphere			
I^{131} Separations Areas	I^{131}	9.8×10^{-14}	µc/cc
I^{131} Separations Stacks	I^{131}	0.5	Combined curies/d
Active Particles - Project	--	2.9	ptle/100 m^3
Active Particles - Environs	--	0.2	ptle/100 m^3
Vegetation (Control limit for vegetation is 10^{-5} µc I^{131}/g)			
Separations Areas	I^{131}	2.6×10^{-6}	µc/g
Residential	I^{131}	$< 1.5 \times 10^{-6}$	µc/g
Eastern Washington and Oregon	I^{131}	$< 1.5 \times 10^{-6}$	µc/g
Fission Products less I^{131} - Wash. and Ore.	Gamma Emitters	$< 1.0 \times 10^{-5}$	µc/g

* The % MPC_w 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_w-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.

EXPOSURE EVALUATION AND RECORDS

Exposure Incidents above Permissible Limits

	Whole Body	Localized
February	0	0
1961 to Date	0	2

Gamma Pencils

	Pencils Processed	Paired Readings 100-280 mr	Paired Readings Over 280 mr	Lost Readings
February	4,440	71	7	0
1961 to Date	9,418	146	10	0

Beta-Gamma Film Badges

	Badges Processed	Readings 100-300 mrads	Readings 300-500 mrads	Readings Over 500 mrads	Lost Readings	Average Dose Per Film Packet mrad(ow)	mr(s)
February	8,745	965	65	31	32	11.08	23.15
1961 to Date	19,375	1,677	130	35	48	8.54	18.58

Neutron Film Badges

	Film Processed	Readings 50-100 mrem	Readings 100-300 mrem	Readings Over 300 mrem	Lost Readings
Slow Neutron					
February	832	0	0	0	6
1961 to Date	2,912	0	0	0	15
Fast Neutron					
February	263	31	0	0	6
1961 to Date	819	139	43	0	15

Whole Body Counter

	Male	Female	February	1961 to Date
GE Employees				
Routine	55	4	59	105
Special	9	0	9	17
Terminal	1	0	1	1
Nonemployees	1	1	2	6
Pre-employment	0	0	0	0
Total	66	5	71	129

Bioassay

	February	1961 to Date
Confirmed Plutonium Deposition Cases	1	2*
Plutonium: Samples Assayed	874	1,415
Results above 2.2×10^{-8} μc/sample	20	35
Fission Product: Samples Assayed	891	1,485
Results above 3.1×10^{-5} μc FP/samples	1	2
Uranium: Samples Assayed	308	571

*Bringing the total number of plutonium deposition cases which have occurred at Hanford to 265.

Uranium Analyses

Sample Description	Following Exposure Units of 10^{-9} µc U/cc Maximum	Average	Number Samples	Following Period of No Exposu Units of 10^{-9} µc U/cc Maximum	Average	Number Samples
Fuels Preparation	60.8	4.2	76	13.7	2.5	62
Fuels Preparation*	0	0	0	0	0	0
Hanford Laboratories	30.5	6.1	40	9.4	3.0	33
Hanford Laboratories*	0	0	0	0	0	0
Chemical Processing	59.9	6.2	37	36.8	4.6	43
Chemical Processing*	18.9	12.7	2	20.8	20.8	1
Special Incidents	164.0	55.7	12	0	0	0
Random	1.5	1.1	2	0	0	0

*Samples taken prior to and after a specific job during work week.

	February	1961 to Date
Thyroid Checks		
Checks Taken	0	0
Checks Above Detection Limit	0	0
Hand Checks		
Checks Taken - Alpha	35,574	56,657
- Beta-gamma	45,235	97,030
Skin Contamination		
Plutonium	28	34
Fission Products	40	83
Uranium	1	23

CALIBRATIONS

	Number of Units Calibrated February	1961 to Date
Portable Instruments		
CP Meter	998	1,858
Juno	260	483
GM	594	1,349
Other	181	337
Audits	110	213
Total	2,143	4,240
Personnel Meters		
Badge Film	1,620	2,640
Pencils	-	-
Other	603	889
Total	2,223	3,529
Miscellaneous Special Services	305	961
Total Number of Calibrations	4,671	8,730

1229885

AR Keene:jmb

AR Keene
Manager
Radiation Protection

LABORATORY AUXILIARIES OPERATION
MONTHLY REPORT - FEBRUARY, 1961

GENERAL

There was one security violation charged to the Operation.

There were no major injuries; the minor injury frequency rate was 3.49, which is considered about average experience.

TECHNICAL SHOPS OPERATION

Total productive time for the period was 23,280 hours. This includes 17,716 hours performed in the Technical Shops, 4,299 hours assigned to Minor Construction, 42 hours assigned to other project shops and 1,223 hours assigned to off-site vendors. Total shop backlog is 23,350 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 1,208.7 hours.

Distribution of time was as follows:

	Man-Hours	% of Total
Fuels Preparation Department	5,011	21.5%
Irradiation Processing Department	546	2.3%
Chemical Processing Department	576	2.5%
Hanford Laboratories Operation	16,639	71.5%
Construction Engineering & Utilities	58	0.3%
Miscellaneous	450	1.9%

Requests for emergency service increased slightly, requiring an overtime rate of 5.4%, compared to 4.5% the previous month.

At the close of the reporting period, there were four open requisitions for Journeyman Machinists and one for a qualified Instrument Technician.

A check of government owned surplus equipment disclosed a deep hole drilling machine available to the Technical Shops for the cost of freight and installation. As a new machine of this type was planned for the Shops, a savings of approximately $20,000 will be realized.

RADIOGRAPHIC TESTING OPERATION

General

A total of 7,984 tests were made, of which 728 were radiographic (including x-ray and gamma-ray) and 7,256 were supplementary tests. Out of a total of 3,359 man-hours, 546 (16.2%) were used in connection with radiographic tests, and 2,813 (83.8%) were used on supplementary tests. The supplementary test work included: autoclaving; borescoping; dimensional measurements (microscopic and air-gage); eddy current; magnetic particle; penetrant (contrast and fluorescent O.D. and I.D.); leak detection; surface treatment (pickling, steam detergent cleaning, and vapor degreasing); and ultrasonic (core integrity, bond tests, flaw detection, and thickness measurement).

The number of pieces handled this month totaled 5,276 items. The feet of material represented by these items amounted to 56,800 feet. Work on tubular components continued to account for a large percentage of the footage of material tested; the tubular component work includes both fuel element sheath tubes and reactor process tubes.

Production testing and treatment of the NPR process tubes is proceeding routinely. The backlog of tubes requiring fluorescent penetrant testing is now being successfully worked off. Problems involving artifacts have been mainly solved by the use of a dry developer technique and by white light borescope checks of fluorescent penetrant indications that may be arising from surface marring. The backlog of development order tubes is also being worked off in order to obtain more in-process storage space.

Some question has arisen regarding the internal integrity of the process tubes. Investigation of voluntary rejects by the vendor has disclosed a condition that may be serious in that present methods of testing do not assure detection. A metal separation in the plane paralled to the tube surface has been assumed by the vendor to be breaking out to the inside wall surface with its subsequent detection by fluorescent penetrant testing. However, in the investigation of some of these discontinuities evidence has been found of cases where the lamination may not open up completely to the surface. Loss of ultrasonic measurement signals has been pointed out as a possible corollary. Such a loss could also be accounted for by localized conditioning resulting in a very small area of reduced wall thickness. Both the problem of a localized conditioning and the detection of purely internal discontinuities is currently under investigation.

The field operation has been unusually active on a wide variety of jobs for a large number of customers as evidenced by the supplementary test performed and the large number of components represented. Some of the work has been of an emergency nature involving either reactor outages or extremely critical construction work. Some of the construction work involves both

PRTR and NPR work. An unusual job encountered at PRTR involved a pressurizer for the reactor system. A heavy nozzle weld (4" thick) in a restricted location required the use of Cobalt 60 for a gamma radiograph. Considerable fluorescent penetrant work was done in the field on the over-bore nozzle program for B, D, F, and H Area. A new 140 KV portable x-ray unit has been obtained to give additional flexibility to the field operation.

The 300 Area laboratory work continued on a routine basis with primary effort being devoted to testing of sheath tubes and plutonium metallurgy fuel element examination. The new ultrasonic flaw detection test tank in the 314 Building was put into operation for preliminary evaluation of the equipment. The ultrasonic cleaning equipment has been obtained and the scanning bridge for the ultrasonic cleaning tank is 50% complete.

Testing Statistics

Component	No. of Tests	Ft. of Weld or Material	No. of Pieces
CPD	2,003	15	19
FPD	25	36	9
HLO	4,986	32,008	4,005
JA Jones	163	100	11
Kaiser Engr.	44	18	7
IPD	2,766	24,638	1,244
Total	7,984	56,800	5,276

CONSTRUCTION OPERATION

There were 63 existing J. A. Jones Company orders at the beginning of the month with a total unexpended balance of $141,998. Ninety new orders, 4 supplements and adjustments for underruns amounted to $67,334. Expenditures during the month on HLO work were $108,589. Total J. A. Jones backlog at month's end was $110,743.

Summary

	HL		CE&UO	
	No.	Unexpended Balance	No.	Unexpended Balance
Orders outstanding beginning of month	63	$ 137,200	1	$ 4,798
Issued during the Month (Inc.Sup. & Adj.)	93	67,334	1	10,000
J.A. Jones Expenditures during month (Inc. C.O. Costs)		98,296		10,293
Balance at month's end	64	106,238	1	4,505
Orders closed during month	89	94,582*		0*

* Face Value of Orders Closed

FACILITIES ENGINEERING OPERATION

There were 13 authorized projects at month's end with total authorized funds of $2,673,500. The total estimated cost of these projects is $9,488,000. The difference between expenditures at 1-31-61 and estimated cost is $2,910,000.

Project CGH-874, Consolidation of Plutonium Metallurgy Facilities, 231-Z Building was returned without approval by the Commission.

The following summarizes the status of FEO project activity:

Number of authorized projects at month's end 13

Number of new projects authorized during the month: 1
CAH-916 - Fuels Recycle Pilot Plant

Projects completed during the month: 1
CAH-885 - Geological & Hydrological Wells - FY-60

New project proposals submitted to AEC during month 2

New projects awaiting AEC approval:
CGH-902 Uranium Scrap Burning Facility
CAH-917 Field Service Center
CGH-918 Second Whole Body Counter Cell Addition - 747 Building
CGH-919 314 Building Ventilation System
CAH-921 Geological & Hydrological Wells - FY-1961
CGH-923 Spectroscopy Laboratory - 325 Building
CGH-924 200 KW Induction Heating System - 306 Building

Note - Proposals complete or nearing completion are as follows:
Burst Test Facility for Irradiated Zirconium Tubes
271-CR Waste Treatment Facility

Engineering Services

Engineering work performed during the month included the following listed major items as well as scope engineering for project proposals. The availability of capital work order funds have increased the work load.

Title	Status
Pressure Vessel and Piping Systems Engineering & Inspection Service	This is a continuing work program on HLO vessels, pressure systems and related safety devices. The work includes not only periodic inspection and engineering evaluations of plant pressure systems but engineering service during design, fabrication, installation, and operation to R & D components having process devices subjected to high pressures and temperatures. Code compliance work is being performed on 1) PRTR Systems; 2) Irradiation Studies Loop; 3) Breakaway Corrosion Loop; and 4) HLO PAC & Equipment Projects.
"Split-half" Machine for Critical Mass Studies	Design of machine is essentially complete. Fabrication cost is being estimated.
Horizontal Control Rod and Drive for Tamper Tank (Critical Mass)	Design work is nearing completion. Materials are on order.
Beryllium Dust Filters - 306 Bldg.	Design complete. Fabrication and installation work is 80% complete.
Electrical Modifications - 3702 Building	Material is on hand and field work is in progress.
Filter Changer - CWS	Drawings are being prepared of proposed design.
327 Water Basin - Clean-up System	A study is being made of a recirculating filter system for removing radioactive contaminates from storage basin water.
Material Handling System for Heat Treating Equipment - 328 Bldg.	Engineering work has started.
Motorized Door Opening Device - 327 Building	Design complete. Installation work is in progress.
Arrange space and install utilities for business machines - 3760 Bldg.	Design work in progress.

Title	Status
Source Positioner - 3745 Bldg.	Design complete. Material on order.
Special Air Conditioning - Laboratory in 222-U Bldg.	Design complete. Installation work is in progress.
Animal Pens and Ground Improvement - 100-F	Steam and water has been installed in dog kennels. Also, an evaporative cooler is being installed. Asphalt parking area and animal pad is being placed.

Drafting and Design Services

Work load in 3706 Building drafting room is constant with some overtime work required. Branch offices in 306 and 308 Buildings have steady work loads with backlog in 308 office. The equivalent of 155 design drawings were completed this month.

Major design and drafting work in progress includes the following:

1. Physical and Mechanical Properties Test Cell - 327 Bldg. - Special equipment design - complete.
2. Structural Materials Irradiation Test Facility - design - 36 dwgs. required - 75% complete.
3. Strontium Purification Project - Work complete.
4. Thermal Precipitator - 5 dwgs. required - 40% complete.
5. Critical Facility - approx. 20 dwgs. required - 95% complete.
6. Ultrasonic Transducer - Bridge & Track - 4 dwgs. - essentially complete.
7. Special Air Operated Chuck for vibratory compactor - 6 dwgs. 70% complete.
8. Oxide Press - Hood Enclosure - 75% complete.
9. Process Calciner - 25 dwgs estimated - 40% complete.
10. Special Air Filter for 325-A Cells - 9 dwgs. - complete.
11. Transfer Cask - 327 Bldg. - 7 dwgs. - 75% complete.

Plant Maintenance and Operation

January costs were $158,779, which is 97.6% of forecasted expenditures.

Analysis of Costs

The cumulative expenditures are 2.4% below forecast. Of this $21,000, $17,000 is attributable to less maintenance work than planned. For the month of January the costs were within $2000 of the predicted amount. During this month the work forecast was reviewed in the light of the limited work force available for building and machinery maintenance. The steam predictions were likewise revised because of the mild winter. As a consequence, $200,000, was released. The result was a 27% reduction in current monthly liquidations (rent) in HLO buildings.

Improvement Maintenance

Item	January
Relocation & Alteration	$ 7,301
Repainting	2,763
Reroofing	9,419
Electrical modifications	743
Piping modifications	37
H&V modifications	215
	$20,478

Waste Disposal and Decontamination Service

The improvements provided by Project CGH-819 to the 340 Building loadout stations, trailer shelter, and increased storage capacity has improved working conditions and decreased loadout time. During the construction of this project, some interference with operation was anticipated and some overtime was used to accumulate wastes.

The decontamination work continues primarily on laboratory radiation handling equipment. High level waste disposal by concrete drum process has increased in volume primarily because of wastes generated in the 325-A cells.

Plant Engineering and Miscellaneous

Approximately 26,000 square feet of prints were reproduced during the month.

The total estimated value of the 12 requisitions issued during the month was $4,000. The majority of this procurement activity is for approved HLO projects.

Painting was continued in 325 building.

Interior painting was started in 3707-C building.

Painting of certain rooms in 231-Z was started.

A contingency maintenance request for the replacement, rerouting and shielding of the crib waste line in 327 building has been approved by the Commission. J. A. Jones Construction forces are doing the work.

Laboratory furniture for 325 building has been ordered.

A canopy has been designed and is being built for 747 building.

Improvements to 50 ton refrigerant compressor in 325 building are being made.

Design has been made for procurement of improved laboratory hoods in 329 building.

A new type of sump pump is being installed in basement of 326 building to solve flooding problem.

Safety switches are being installed in control circuitry - 326 building.

Electrical load studies are being made on 325 and 3760 buildings.

Plans made for a new drafting room location in 306 have been delayed pending building occupants approval.

A new product assembly room has been completed on the mezzanine of 325 building basement.

The crane in 314 building was inspected. The crane is out of service until repairs are made. Material is on order.

TECHNICAL INFORMATION OPERATION

Volume I, No. 1, of a new Technical Information publication -- the Plutonium Information Bulletin -- was distributed during the month to HAPO personnel concerned with plutonium technology and to a limited number of off-site AEC contractors actively engaged in plutonium research and development. Intent of the Bulletin is to present a current-awareness service to HAPO and off-site AEC contractors of new and significant plutonium information from world-wide sources. Comments on the first issue have been solicited.

B. B. Lane has edited and issued a revised "Glossary of Hanford Technology", HW-68206, updating an earlier glossary published in 1954 as HW-32464. The new edition revises and supersedes the former and adds about 150 new words and abbreviations. Entries consist of Hanford jargon (words and abbreviations which have special and unique meanings at Hanford) as it is found in written reports or personal conversations.

The Director of the Division of Classification met with HAPO personnel February 1 to discuss the current classification restrictions on plutonium. The discussion was primarily an exchange of information on policy, practice, and the affect of the restrictions on the Plutonium Recycle Program. Declassification of the plutonium in the intial PRTR loadings was requested.

During CY-1960, Technical Publications published 117 formal reports and 25 informal reports. These reports contained 6,873 pages, of which 77% were text and 23% illustrations. Average number of days each report was in Technical Publications was 31.7.

The Speech and Article Clearance Activity Report for 1960 has been completely automated. It is now presented in tabular form from an IBM 407 print-out of cards generated during the year by Technical Information's keypunch unit.

There were 374 items processed for clearance. Copies of the report were sent to Level 2 Managers of HAPO, and in addition to Level 3 Managers in HLO, where most of the submittals originated.

The Specialist, Technical Information Procedures, has been spending considerable time in preparing procedures for the forthcoming automation of the Classified Files. One of the principal problems concerns the reports catalog, its role in the total literature searching spectrum, what cards should be filed into it, and so on. A clear policy in these items will be needed before Files automation is completed.

The program to replace older off-site-originated documents by microcards from the AEC has been slow. An order for 2100 microcards has been sent to OTIE and, as a result of overtime by two clerks, another 900 microcards will be ordered. There still remains a large part of the document collection to be checked.

Mechanical handling of the Library's periodical subscriptions has now been completed, and it appears that no further debugging will be necessary. The machines are now routinely updating the tape for any changes in the periodical subscription activity, and providing reports on periodical traffic.

Work Volume Statistics

	January	February
Document Distribution and Files		
Documents routed and discharged (copies)	18,701	22,215
Documents issued (copies)	18,181	14,361
Documents sent off-site (copies)	10,489	8,182
Document reserves filled (copies)	640	617
Documents picked up and delivered	21,015	20,827
Document Accountability		
Holders of classified documents whose files were inventoried	640	284
Documents inventoried in Files (copies)	10,196	--
Documents destroyed or retired (copies)	9,220	15,344
Documents revised (copies)	1,300	1,196
Documents pulled and documents filed (copies)	16,960	21,465
Documents reclassified	823	651
Accountable copies of SECRET and DOCUMENTED CONFIDENTIAL documents on-site	209,751	207,343
Reference and Publication		
Books cataloged (new titles)	124	146
Books added to the collection (volumes)	236	327
Ready reference questions answered by professional staff	210	200
Literature searches by professional staff	88	90
Reports abstracted (titles)	288	261
Formal reports prepared (titles)	21	16
Off-site requests for HAPO reports (copies)	279	231
Reports released to CAP (titles)	31	48

Library Acquisitions and Circulation	January	February
Books ordered (volumes)	645	470
Periodicals ordered	124	172
Books circulated (volumes)	1,512	1,935
Periodicals circulated (issues)	2,749	3,201
Inter-Library loans	74	83
Films borrowed or rented	13	20
Industrial film showings	50	77
Bound periodicals added to the collection	144	133
Bound periodicals discarded		35

Library Collection:

	Main Library	W-10 Library	108-F Library	Ind. Med.	Total
No. of books	30,953	8,593	1,739	2,037	43,322
No. of bound periodicals	14,276	10	1,869	3	16,123
	45,229	8,603	3,608	2,040	59,445

Classification and Declassification	January	February
Documents, including drawings and photographs reviewed for downgrading or declassification	440	246
Documents and papers (intended for oral presentation or publication) reviewed for appropriate classification	33	45
Documents submitted to Declassification Branch, Oak Ridge	81	57

J L Boyd

Manager,
Laboratory Auxiliaries

JL Boyd:jw

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 68712-

DATE 2/28/61

PROJ.NO.	TITLE	FUNDING
CG-785	In-Reactor Studies Equipment - 105 KW	0290

AUTHORIZED FUNDS				
$ 325,000	DESIGN $ 47,000	AEC $	COST & COMM. TO 2-12-61	$ 279,974
	CONST. $ 278,000	GE $ 325,000	ESTIMATED TOTAL COST	$ 305,000

STARTING DATES			EST'D. COMPL. DATES		
DESIGN 1-5-59	DATE AUTHORIZED 9-9-60		DESIGN 12-30-60		
CONST. 3-22-60	DIR. COMP. DATE 3-1-61		CONST. 3-1-61		

ENGINEER

FEO - H. Radow

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES	2	1200
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION	0	710
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTU
DESIGN	100	100	10
TITLE I			
GE-TIT. II		100	10
AE-TIT. II			
CONST.	100	100	10
PF	100	100	10
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project provides a research and development facility to permit instantaneous measurement of physical properties of materials under dynamic in-reactor and simultane ex-reactor conditions.

Physical completion, with a few exceptions, will be attained as of March 1, 1961. The exceptions include the completion of the helium modification, the delivery and checking out of the capsule removal equipment, and any start-up type corrections that may be required.

PROJ. NO.	TITLE	FUNDING
CGH-805	High Temperature Tensile Testing Cell - 327 Building	0290

AUTHORIZED FUNDS				
$ 170,000	DESIGN $ 20,400	AEC $ ---	COST & COMM. TO 2-12-61	$ 158,496
	CONST. $ 149,600	GE $ 170,000	ESTIMATED TOTAL COST	$ 170,000

STARTING DATES			EST'D. COMPL. DATES		
DESIGN 8-26-58	DATE AUTHORIZED 9-9-60		DESIGN 6-15-59		
CONST. 9-14-60	DIR. COMP. DATE 4-1-61		CONST. 4-1-61		

ENGINEER

FEO - KA Clark

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE	2	740
PLANT FORCES		
ARCHITECT - ENGINEER		
DESIGN ENGINEERING OPERATION		285
GE FIELD ENGINEERING	.5	44

PERCENT COMPLETE	WT'D.	SCHED.	ACTU
DESIGN	100	100	100
TITLE I		100	100
GE-TIT. II		100	100
AE-TIT. II			
CONST.	100	99	98
PF	2	30	---
CPFF	35	100	99
FP			
Mat'l	63	100	97

SCOPE, PURPOSE, STATUS & PROGRESS This project provides equipment for performing room and high temperature tensile tests on highly irradiated materials and involves the installation of a cell in the 327 Building.

The manipulator has not been received but the majority of all other equipment has been installed.

Acceptance testing is in progress.

Fabrication of the tray around the furnace is posing special problems which will require more time than originally planned to resolve. Completion of the project to the satisfaction of the customer is expected within the scheduled period.

1229896

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 68712-A

DATE 2/28/61

PROJ.NO.	TITLE	FUNDING
CAH-822	Pressurized Gas Cooled Facility	4141-Operating

AUTHORIZED FUNDS					
$ 995,000	DESIGN $ 40,000*	AEC $	COST & COMM. TO 2-12-61	$ 807,714
	CONST. $ 955,000	GE $ 995,000	ESTIMATED TOTAL COST	$ 1,120,000

STARTING DATES		DATE AUTHORIZED	EST'D. COMPL. DATES	
	DESIGN 8-19-59			DESIGN 4-29-60
	CONST. 10-17-60	DIR. COMP. DATE 6-30-61		CONST. 9-30-61

ENGINEER

HLO - WF Hildebrand

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	100
TITLE I			
GE-TIT. II	100	100	100
AE-TIT. II			
CONST.	100	65	64
PF			
CPFF	92	63	63
FP	8	93	80

SCOPE, PURPOSE, STATUS & PROGRESS

Work Authority CAH-822(5) dated 2/10/61, authorizing additional $125,000 making new total of $1,120,000 has been received.
Prefabricated piping sections have been moved into B-Cell. J. A. Jones in process of removing NaK heater from Section D and re-locating sections from 9" to 18" from wall of B Cell.

* Does not include design performed by Struthers-Wells.

PROJ. NO.	TITLE	FUNDING
CGH-834	Modifications & Additions to High Pressure Heat Transfer Apparatus - 189-D Building	0290

AUTHORIZED FUNDS					
$ 700,000	DESIGN $ 66,000	AEC $	COST & COMM. TO 2-12-61	$ 675,697
	CONST. $ 634,000	GE $ 700,000	ESTIMATED TOTAL COST	$ 700,000

STARTING DATES		DATE AUTHORIZED	EST'D. COMPL. DATES	
	DESIGN 4-20-59	4-8-59		DESIGN 2-15-61
	CONST. 4-22-59	DIR. COMP. DATE 4-1-61		CONST. 4-1-61

ENGINEER

FEO - H. Radow

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE	15	3500
PLANT FORCES		
ARCHITECT - ENGINEER		
DESIGN ENGINEERING OPERATION	0	960
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	100
TITLE I			
GE-TIT. II	100	100	100
AE-TIT. II			
CONST.	100	96*	95
PF			
CPFF	100	96*	95
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project provides necessary modifications to existing equipment to simulate more severe in-reactor operating conditions in out-of-reactor facilities for research and development studies.

All of the remaining vessels have been received and installation is now underway. The high-speed valve order is now progressing favorably and it is anticipated that the assembly will be ready for witness testing in late March.

* Per revised construction schedule submitted to the Commission for approval.

1229897

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 68712

DATE 2/28/61

PROJ.NO.	TITLE	FUNDING
CAH-842	Critical Reactivity Measuring Facility	58-e-15

AUTHORIZED FUNDS					
$ 360,000	DESIGN $ 45,000	AEC $ 148,000	COST & COMM. TO 2-12-61	$ 110,575
	CONST. $ 315,000	GE $ 212,000	ESTIMATED TOTAL COST	$ 360,000

STARTING DATES		DATE AUTHORIZED	EST'D. COMPL. DATES	
	DESIGN 11-17-59		DESIGN 2-1-61	
	CONST. 10-3-60	DIR. COMP. DATE 4-30-61	CONST. 4-30-61	

ENGINEER

HLO - WS Kelly

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE Geo. Grant Co., Inc.		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACT
DESIGN	100	100	1
TITLE I			
GE-TIT.II			
AE-TIT.II			
CONST.	100	NS	
PF			
CPFF	80	99	
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

The fuel transfer lock has been shipped by Henry Pratt Co. Final painting and testing will be performed after the lock is installed.

PROJ. NO.	TITLE	FUNDING
CGH-857	Physical & Mechanical Properties Testing Cell - 327 Bldg.	0290

AUTHORIZED FUNDS				
$ 75,500	DESIGN $ 75,000	AEC $	COST & COMM. TO 2-12-61	$ 74,940
	CONST. $	GE $ 75,000	ESTIMATED TOTAL COST	$ 500,000

STARTING DATES		DATE AUTHORIZED	EST'D. COMPL. DATES	
	DESIGN 10-29-59	10-1-59	DESIGN 3-1-61	
	CONST. 9-1-62*	DIR. COMP. DATE	CONST. 7-1-63*	

ENGINEER

FEO - RW Dascenzo

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT - ENGINEER	1	
DESIGN ENGINEERING OPERATION	2	
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTU
DESIGN	100	100	99
TITLE I			
GE-TIT.II	100	100	99
AE-TIT.II			
CONST.	100	NS	
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS This project will provide facilities for determining physica and mechanical properties of irradiated materials, and involves the installation of a cell in 327 Building.

All of the design will be complete by March 1, 1961, with the possible exception of incorporation of the comments on the Dilatometer Machine and the Rotating Beam Fatigue Tester.

It is not planned to ask for procurement and construction funds at this time.

* Based upon AEC authorization of total project funds by 2-1-62.

1229898

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 68712-

DATE 2/28/61

PROJ.NO.	TITLE	FUNDING
CGH-858	High Level Utility Cell - 327 Building	0290

AUTHORIZED FUNDS	DESIGN $	AEC $	COST & COMM TO 2-12-61	$
$ 70,000	DESIGN $ 70,000	AEC $	COST & COMM TO 2-12-61	$ 70,000
	CONST. $	GE $ 70,000	ESTIMATED TOTAL COST	$ 500,000

STARTING DATES		DATE AUTHORIZED	EST'D. COMPL. DATES	
	DESIGN 10-29-59	DATE AUTHORIZED 10-1-59		DESIGN 3-1-61
	CONST. 8-1-61*	DIR. COMP. DATE		CONST. 2-1-62*

ENGINEER

FEO - RW Dascenzo

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER	2	
DESIGN ENGINEERING OPERATION	4	
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	100
TITLE I			
GE-TIT. II	95	100	100
AE-TIT. II			
Vendor	5	100	99
CONST.	100	NS	
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS This prlject will provide facilities to prepare specimens from irradiated materials for use in determining their physical and mechanical properties and involves the installation of a cell in 327 Building.
The project design will be complete on March 1, 1961, providing that Western Gear completes the corrections to their Decladder design and with the exception of comments on the Round Tensile Sample Former Machine.
A revised project proposal for total construction funds is being routed in HLO for approval.

* Based on AEC authorization of construction funds by 4-1-61.

PROJ. NO.	TITLE	FUNDING
CAH-866	Shielded Analytical Laboratory - 325-B Building	61-a-1

AUTHORIZED FUNDS	DESIGN $	AEC $	COST & COMM. TO 2-12-61	$
$ 60,000	DESIGN $ 60,000	AEC $ 45,000	COST & COMM. TO 2-12-61	$ 15,000(GE)
	CONST. $	GE $ 15,000	ESTIMATED TOTAL COST	$ 700,000

STARTING DATES		DATE AUTHORIZED	EST'D. COMPL. DATES	
	DESIGN 9-5-59	DATE AUTHORIZED 5-31-60		DESIGN 11-14-60
	CONST.	DIR. COMP. DATE		CONST. 3-1-62

ENGINEER

FEO - RW Dascenzo

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT - ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	100
TITLE I			
GE-TIT. II	10	100	100
AE-TIT. II	90	100	100
CONST.	100	NS	
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS This project will allow greater capacity for analytical work involving today's more highly radioactive solutions and consists of adding a shielded laboratory to the 325 Building.
This project was approved by the local AEC Board of Review on 2/3/61, and sent to Washington for further approval.
A letter from Washington AEC has requested a further site study for this facility with consideration being given to the influence of future waste effluent and fission product work on the chosen location.

1229899

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 68712-

DATE 2/28/61

PROJ.NO.	TITLE	FUNDING
CAH-867	Fuel Element Rupture Test Loop	58-e-15

AUTHORIZED FUNDS					
$ 1,500,000	DESIGN $ 130,000	AEC $ 770,000	COST & COMM. TO 2-12-61	$ 371,314
	CONST. $ 1,370,000	GE $ 730,000	ESTIMATED TOTAL COST	$ 1,500,000

STARTING DATES			ESTD. COMPL. DATES	
DESIGN	8-1-60*	DATE AUTHORIZED	DESIGN	2-15-61
CONST.	11-2-60	DIR. COMP. DATE 10-31-61	CONST.	10-31-61

ENGINEER

HLO - PC Walkup

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTU
DESIGN	100	100	9
TITLE I			
GE-TIT. II	91	100	9
AE-TIT. II	9	100	10
CONST.	100	8	
PF	2		
CPFF	24		
FP (1)	10	77	7
(2)	33		
(3)	31		

SCOPE, PURPOSE, STATUS & PROGRESS

(1) G. A. Grant Co.

All design drawings and construction specifications being routed for approval at month end.

* Detail Design. Scope design started 11/2/59 and completed 3/15/60.

PROJ. NO.	TITLE	FUNDING
CAH-870	Facility for Recovery of Radioactive Materials-325 Bldg.	60-a-1

AUTHORIZED FUNDS				
$ 486,000	DESIGN $ 46,000	AEC $ 446,000	COST & COMM. TO 2-12-61	$ 39,147 (GE)
	CONST. $ 440,000	GE $ 40,000	ESTIMATED TOTAL COST	$ 486,000

STARTING DATES			ESTD. COMPL. DATES	
DESIGN	11-20-59	DATE AUTHORIZED 3-22-60	DESIGN	3-1-60
CONST.	5-6-60	DIR. COMP. DATE 6-1-61	CONST.	6-1-61

ENGINEER

FEO - RW Dascenzo

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE	14	2938
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT - ENGINEER		
DESIGN ENGINEERING OPERATION	2	
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTU
DESIGN	100	100	100
TITLE I			
GE-TIT. II	10	100	100
AE-TIT. II	90	100	100
CONST.	100	93	95
PF	1	100	100
CPFF			
FP	99	91	95

SCOPE, PURPOSE, STATUS & PROGRESS This project will provide a facility for recovery of specific radioisotopes from wastes, and involves an addition to the 325 Building. Work completed the last two weeks is as follows:

1. Vault "A" wall and bottom of cover slabs prepared for painting. Vault "B" walls painted.
2. Pipe testing continuing and also installation of some lines.
3. One-half of top 2" layer of concrete floor slab poured and ventilation duct openings in walls grouted in.
4. Electrical work continuing in vaults and started in the basement.
5. Insulation of pipe lines is continuing.

1229900

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 68712

DATE 2/28/61

PROJ. NO.	TITLE	FUNDING
CAH-888	Biology Laboratory Improvements	60-h-1

AUTHORIZED FUNDS					
$ 40,000	DESIGN $ 40,000	AEC $30,000	COST & COMM. TO 2-12-61	$ 9,998
	CONST. $	GE $10,000	ESTIMATED TOTAL COST	$ 420,000

STARTING DATES				EST'D. COMPL. DATES		PERCENT COMPLETE			
	DESIGN 8-8-60	DATE AUTHORIZED 9-2-60		DESIGN 3-15-61			WT'D.	SCHED.	ACTUAL
	CONST. 5-15-61	DIR. COMP. DATE		CONST. 6-15-61		DESIGN	100	NS	95
ENGINEER						TITLE I			
FEO - JT Lloyd						GE-TIT. II	17	NS	100
MANPOWER		AVERAGE	ACCUM MANDAYS			AE-TIT. II	83	NS	92
FIXED PRICE									
COST PLUS FIXED FEE						CONST.	100		
PLANT FORCES						PF			
ARCHITECT-ENGINEER						CPFF			
DESIGN ENGINEERING OPERATION						FP			
GE FIELD ENGINEERING									

SCOPE, PURPOSE, STATUS & PROGRESS This project provides additional space for biological research supporting services, and involves an addition to the 108-F Building.
38 Title I reproducibles and 15 specifications were received on 2/7/61, from B. D. Bohna & Co. for 90% review. Prints were made and review is underway. Two additional reproducibles and one specification was received on 2/21/61. Prints were made and review of the entire set is in its final stage.

PROJ. NO.	TITLE	FUNDING
CAH-896	Stress Rupture Test Facility	60-1

AUTHORIZED FUNDS					
$ 80,000	DESIGN $ 7,500	AEC $ 69,000	COST & COMM. TO 2-12-61	$ 7,486
	CONST. $	GE $ 11,000	ESTIMATED TOTAL COST	$ 90,000

STARTING DATES				EST'D. COMPL. DATES		PERCENT COMPLETE			
	DESIGN 7-29-60	DATE AUTHORIZED 10-20-60		DESIGN 12-1-60			WT'D.	SCHED.	ACTUAL
	CONST. 3-6-61	DIR. COMP. DATE 10-15-61		CONST 10-15-61		DESIGN	100	100	100
ENGINEER						TITLE I			
FEO - RK Waldman						GE-TIT. II	100	100	100
MANPOWER		AVERAGE	ACCUM MANDAYS			AE-TIT. II			
FIXED PRICE									
COST PLUS FIXED FEE						CONST.	100		
PLANT FORCES						PF			
ARCHITECT - ENGINEER						CPFF			
DESIGN ENGINEERING OPERATION						FP			
GE FIELD ENGINEERING									

SCOPE, PURPOSE, STATUS & PROGRESS

This project involves a facility for deliberately rupturing tubing to establish service conditions.
Bid opening was held 2/2/61.
Ten bids were received on a single contract combining this project with a sand filter job for FPD. The low bid was by George Grant Co. The construction for this project was set at $69,400 which exceeds currently authorized funds. Project proposal revision was prepared requesting additional money so the work can proceed. Approval from Washington of additional funds has been received.

1229901

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 68712

DATE 2/28/61

PROJ.NO.	TITLE	FUNDING
CAH-901	Structural Materials Irradiation Test Equipment - ETR	0290

AUTHORIZED FUNDS				
$ 125,000	DESIGN $ 15,000	AEC $21,000	COST & COMM. TO 2-12-61	$ 51,323
	CONST. $ 110,000	GE $104,000	ESTIMATED TOTAL COST	$ 125,000

STARTING DATES		DATE AUTHORIZED	EST'D. COMPL. DATES	
	DESIGN 9-15-60	9-2-60	DESIGN 4-1-61	
	CONST. 4-15-60	DIR. COMP. DATE 10-15-61	CONST. 10-15-61	

ENGINEER

FEO - KA Clark

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION	1	135
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTU
DESIGN	100	100	85
TITLE I			
GE-TIT. II	100	100	85
AE-TIT. II			
CONST.	100		
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project provides for the installation of equipment at the ETR for which changes in the physical properties of reactor structural materials subjected to in-reactor conditions can be determined.

Installation of sub-pile piping is expected to be started during the month of February. Instrumentation design is incomplete because of a manpower shortage for this particular portion of the work.

PROJ. NO.	TITLE	FUNDING
CGH-902	Uranium Scrap Burning Facility	61-j

AUTHORIZED FUNDS				
$ 36,000	DESIGN $	AEC $	COST & COMM. TO	$
	CONST. $	GE $	ESTIMATED TOTAL COST	$ 36,000

STARTING DATES		DATE AUTHORIZED	EST'D. COMPL. DATES	
	DESIGN 3-2-61		DESIGN 4-14-61	
	CONST. 4-14-61	DIR. COMP. DATE	CONST.	

ENGINEER

FEO - RK Waldman

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT - ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUA
DESIGN	100		
TITLE I			
GE-TIT. II			
AE-TIT. II			
CONST.	100		
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project provides a means of making uranium scrap material safer for storage and off-plant shipment by converting this scrap to a stable uranium oxide. The facility will be adjacent to the 333 Building.

Directive and work authority has been received but no work was started until review by General Electric Company has been made regarding AEC's proposed changed of Method of Performing Work.

1229902

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 68712-

DATE 2/28/61

PROJ. NO.	TITLE	FUNDING
CGH-907	Strontium-90 Interim Program	75% Operating 25% 0490

AUTHORIZED FUNDS					
$ 420,000	DESIGN $ 35,000	AEC $	COST & COMM. TO 2-12-61	$ 400,638
	CONST. $ 385,000	GE $ 420,000	ESTIMATED TOTAL COST	$ 420,000

STARTING DATES			ESTD. COMPL. DATES		PERCENT COMPLETE			
	DESIGN 9-8-60	DATE AUTHORIZED 9-6-60		DESIGN 3-1-61		WT'D.	SCHED.	ACTUAL
	CONST. 9-8-60	DIR. COMP. DATE 3-1-61		CONST. 3-1-61	DESIGN	100	100	100
					TITLE I			
					GE-TIT. II		100	100
					AE-TIT. II			
					CONST.	100	100	100
					PF	11	100	100
					CPFF	89	100	100
					FP			

ENGINEER

FEO - H. Radow

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		3600
PLANT FORCES		150
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

SCOPE, PURPOSE, STATUS & PROGRESS

This project will allow the separation of Strontium-90 material from Separations Plant waste streams on an interim basis, and involves the conversion of the Hot Semi-Works Plant for this purpose.

"B" Cell has been accepted and physical completion, with a few exceptions, will be attained as of March 1, 1961. The exceptions include the remaining phases of the outside lines and the loadout station, some punch list items, and correction of deficiencies disclosed by cold runs.

PROJ. NO.	TITLE	FUNDING
CAH-914	Rattlesnake Springs Radioecology Facility	61-j

AUTHORIZED FUNDS					
$ 72,000	DESIGN $ 3,400*	AEC $ 53,700	COST & COMM. TO 2-12-61	$ 100
	CONST. $ 68,600	GE $ 18,300	ESTIMATED TOTAL COST	$ 72,000

STARTING DATES			ESTD. COMPL. DATES		PERCENT COMPLETE			
	DESIGN 3-1-61	DATE AUTHORIZED 12-22-60		DESIGN 6-1-61		WT'D.	SCHED.	ACTUAL
	CONST. 7-15-61	DIR. COMP. DATE 10-31-61		CONST. 12-1-61	DESIGN	100		
					TITLE I			
					GE-TIT. II			
					AE-TIT. II	100	NS	
					CONST.	100		
					PF			
					CPFF			
					FP			

ENGINEER

FEO - OM Lyso

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT - ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

SCOPE, PURPOSE, STATUS & PROGRESS

This project will allow performance of radioecological studies under local environmental conditions. It consists of constructing field facilities for this purpose.

The field survey work is in progress by G. E.

AEC has negotiated for Bovay Engineers, A-E to handle the design of this project.

*Bovay Engineers.

1229903

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 68712-

DATE 2/28/61

PROJ.NO.	TITLE	FUNDING
CAH-916	Fuels Recycle Pilot Plant	Funds Avail. to Comm.

AUTHORIZED FUNDS	DESIGN $	AEC $	COST & COMM. TO $
$ 50,000	CONST. $	GE $	ESTIMATED TOTAL COST $ 5,000,000

STARTING DATES		DATE AUTHORIZED	2-9-61	EST'D. COMPL. DATES		PERCENT COMPLETE	WT'D.	SCHED.	ACTU
	DESIGN 3-1-61				DESIGN 3-1-62	DESIGN	100	NS	0
	CONST.	DIR. COMP. DATE			CONST. 2-1-63	TITLE I			
ENGINEER						GE-TIT. II			
FEO - RW Dascenzo						AE-TIT. II			
MANPOWER		AVERAGE	ACCUM MANDAYS						
FIXED PRICE						CONST.	100		
COST PLUS FIXED FEE						PF			
PLANT FORCES						CPFF			
ARCHITECT-ENGINEER						FP			
DESIGN ENGINEERING OPERATION									
GE FIELD ENGINEERING									

SCOPE, PURPOSE, STATUS & PROGRESS

This project is to provide a facility to perform a full scope of engineering tests and pilot plant studies associated with fuel reprocessing concepts.

AEC Directive No. AEC-187, dated 2/9/61, and on AEC Work Authority, No. CAH-916(1) dated 2/17/61, was issued to General Electric Company to perform scoping and design work, and related management services.

PROJ. NO.	TITLE	FUNDING
CAH-917	Field Service Center - Atmospheric Physics	61-j

AUTHORIZED FUNDS	DESIGN $	AEC $	COST & COMM. TO $
$	CONST. $	GE $	ESTIMATED TOTAL COST $ 154,000

STARTING DATES		DATE AUTHORIZED	EST'D. COMPL. DATES		PERCENT COMPLETE	WT'D.	SCHED.	ACTU
	DESIGN 5-1-61*			DESIGN 9-1-61*	DESIGN	100		
	CONST. 10-1-61*	DIR. COMP. DATE		CONST. 2-1-62*	TITLE I			
ENGINEER					GE-TIT. II			
FEO - JT Lloyd					AE-TIT. II			
MANPOWER		AVERAGE	ACCUM MANDAYS					
FIXED PRICE					CONST.	100		
COST PLUS FIXED FEE					PF			
PLANT FORCES					CPFF			
ARCHITECT - ENGINEER					FP			
DESIGN ENGINEERING OPERATION								
GE FIELD ENGINEERING								

SCOPE, PURPOSE, STATUS & PROGRESS

This project will provide facilities necessary to conduct atmospheric physics research and development programs.

The revised project proposal was transmitted to the AEC on 1/23/61. The proposal is being reviewed by individual members of the Review Board.

* Based on AEC authorization by 4/1/61.

1229904

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 68712

DATE 2/28/61

PROJ. NO.	TITLE	FUNDING
CGH-918	Second Whole Body Counter - Cell Addition - 747 Bldg.	61-j

AUTHORIZED FUNDS $	DESIGN $	AEC $	COST & COMM. TO $	
	CONST. $	GE $	ESTIMATED TOTAL COST $	110,000

STARTING DATES		DATE AUTHORIZED	EST'D. COMPL. DATES	
DESIGN	4-1-61*		DESIGN	7-1-61*
CONST.	11-1-61*	DIR. COMP. DATE	CONST.	6-1-62*

ENGINEER

FEO - KA Clark

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100		
TITLE I			
GE-TIT. II			
AE-TIT. II			
CONST.	100		
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project will provide a second whole body monitoring cell in the 747-A Building to increase the capacity of the Whole Body Counter Facility to meet projected needs.

The project proposal is being studied by the AEC.

* Assuming AEC authorization by 3-1-61.

PROJ. NO.	TITLE	FUNDING
CGH-919	Air Conditioning - 314 Building	61-j

AUTHORIZED FUNDS $	DESIGN $	AEC $	COST & COMM. TO $	
	CONST. $	GE $	ESTIMATED TOTAL COST $	35,000

STARTING DATES		DATE AUTHORIZED	EST'D. COMPL. DATES	
DESIGN	3-2-61		DESIGN	5-5-61
CONST.	4-14-61	DIR. COMP. DATE	CONST.	6-30-61

ENGINEER

FEO - RK Waldman

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT - ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100		
TITLE I			
GE-TIT. II			
AE-TIT. II			
CONST.	100		
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project will supplement existing cooling units, thus providing cooling air supply commensurate with heat load and outdoor temperatures.

The project proposal was submitted to HOO-AEC 12-21-60.

Heat load calculations were made by CE&UO Design Group to substantiate test results.

1229905

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 68712-

DATE 2/28/61

PROJ.NO.	TITLE	FUNDING
CAH-921	Geological & Hydrological Wells - FY-61	61-j

AUTHORIZED FUNDS $ — DESIGN $ — CONST. $ — AEC $ — GE $

COST & COMM. TO $

ESTIMATED TOTAL COST $ 79,000

STARTING DATES: DESIGN 3-1-61* / CONST. 5-1-61*

DATE AUTHORIZED

DIR. COMP. DATE

EST'D. COMPL. DATES: DESIGN 4-15-61* / CONST. 3-15-62*

ENGINEER

FEO - HE Ralph

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACT
DESIGN	100		
TITLE I			
GE-TIT. II			
AE-TIT. II			
CONST.	100		
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project involves the continued drilling of exploratory-type wells used in determing the conditions of water tables within Hanford Works.

Project Proposal submitted to AEC 1/24/61.

Scheduled for AEC Review Board action on 2/23/61.

* Based on AEC authorization by 2/23/61.

PROJ. NO.	TITLE	FUNDING
CGH-923	Spectroscopy Laboratory	0290

AUTHORIZED FUNDS $ — DESIGN $ 4,500 — CONST.$ 90,500 — AEC $ — GE $ 95,000

COST & COMM. TO $

ESTIMATED TOTAL COST $ 95,000

STARTING DATES: DESIGN 4-1-61* / CONST. 6-1-61*

DATE AUTHORIZED

DIR. COMP. DATE

EST'D. COMPL. DATES: DESIGN 6-1-61* / CONST. 10-1-61*

ENGINEER

FEO - RC Ingersoll

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT - ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTU
DESIGN	100		
TITLE I			
GE-TIT. II			
AE-TIT. II			
CONST.	100		
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project will provide a facility for specialized spectrometry work.

The project proposal was submitted to the Commission 2/21/61.

*Based on AEC authorization by 3/1/61.

1229906

SEMI-MONTHLY PROJECT STATUS REPORT

GENERAL ELECTRIC CO. — Hanford Laboratories

HW- 68712-

DATE 2/28/61

PROJ. NO.	TITLE	FUNDING
CGH-924	200 KW Induction Heating System - 306 Building	0290

AUTHORIZED FUNDS $	DESIGN $ 3,700	CONST. $ 27,300	AEC $	GE $	COST & COMM. TO $	ESTIMATED TOTAL COST $ 31,000

STARTING DATES	DESIGN 4-1-61*	CONST. 5-1-61*	DATE AUTHORIZED	DIR. COMP. DATE	EST'D. COMPL. DATES	DESIGN 6-1-61*	CONST. 8-1-61*

ENGINEER

FEO - RC Ingersoll

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100		
TITLE I			
GE-TIT. II			
AE-TIT. II			
CONST.	100		
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project will provide a source of power for induction heating for R & D work in the 306 Building.

The project proposal was submitted to the Commission 2/21/61.

*Based on AEC authorization by 3/1/61.

PROJ. NO.	TITLE	FUNDING

AUTHORIZED FUNDS $	DESIGN $	CONST. $	AEC $	GE $	COST & COMM. TO $	ESTIMATED TOTAL COST $

STARTING DATES	DESIGN	CONST.	DATE AUTHORIZED	DIR. COMP. DATE	EST'D. COMPL. DATES	DESIGN	CONST.

ENGINEER

MANPOWER	AVERAGE	ACCUM MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT - ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEERING		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100		
TITLE I			
GE-TIT. II			
AE-TIT. II			
CONST.	100		
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

1229907

PROFESSIONAL PLACEMENT AND RELATIONS PRACTICES OPERATION

MONTHLY REPORT

COMMUNICATIONS

Prepared press release on visit of two French physicists to Hanford Laboratories.

EMPLOYMENT (Professional)

Advanced Degree - Thirteen Ph.D. candidates visited HAPO for professional employment interviews. Three offers were extended and one previous offer accepted during the month. Current open offers total three. Recruiting trips to two universities occurred.

BS/MS - 102 applicants were considered, 51 offers were extended, 9 acceptances and 3 rejections were received. Current open offers total 71.

Technical Graduate Program - Three new Technical Graduates reported aboard and four were placed on permanent assignments. Current program members total 61.

Achievement on the summer employment program is current as follows:

	Accepted	Open Offers	Probable Additional Offers to be Made
Professors	13	0	2
Students	5	13	10-15
High School Teachers	0	0	3-4

EMPLOYMENT (Non-Professional)

Five additions occurred during the month. There are currently eleven open requisitions.

SALARY ADMINISTRATION

Non-Exempt - Nineteen job audits were conducted.

O. E. Boston, Manager
Professional Placement
and Relations Practices

OEB:lmh

1229908

TABLE II NONEXEMPT EMPLOYMENT

Nonexempt Employment Status	Jan.	Feb.
Requisitions		
Active at end of month	17	11
Cancelled	2	1
Received	10	9
Filled	14	5
Hold	0	9

Nonexempt Transfer Request	Jan	Feb.
Transfers		
Active cases at end of mo.	74	75
Cancelled	3	2
New	2	4
Effected	6	1

TABLE III. PROFESSIONAL PERSONNEL PLACEMENT

A. Technical Recruiting Activity - HAPO - September 1, 1960 to date

	Visits to Richland				Offers			
	Cases Considered	Invited	Visited	To Visit	Extended	Accepted	Open	On the Roll
PhD	437	126	31	46	17	4	3	2
Exp. BS/MS	291	44	25	-	28	14	8	5
Prog. BS/MS	205	-	-	-	93	16	71	4

B. Technical Recruiting Activity - HLO - September 1, 1960 to date

	Visits to Richland				Offers			
	Cases Considered	Invited	Visited	To Visit	Extended	Accepted	Open	On the Roll
PhD	437	126	31	46	12	3	3	2
Exp. BS/MS	-	18	11	-	11	6	-	-

In addition to the above activity, 8 exempt employees have transferred into HLO from other HAPO departments and 7 technical graduates have accepted off-program placement in HLO to date.

C - Technical Graduate Program
Month ending February 28, 1961

Number Personnel on Assignment	61
(HAPO Tech Grad Program 54	
(Engineering & Science Program 7	
Distribution of Assignments by Departments	
IPD	25
HL	23
FPD	9
CPD	1
CE&UO	2
C&AO	1
Distribution of Assignments by Function	
Research & Development or Engineering	42
Other	19

FINANCIAL OPERATION MONTHLY REPORT
FEBRUARY 1961

Personnel

One non-exempt clerk was transferred to CE&UO. Arrangements were completed to transfer J. G. Rake, Specialist - Auditing and Procedures to Light Military Electronics Department, Utica, New York, effective March 1, 1961.

Activities

GENERAL ACCOUNTING

Travel by HLO personnel continues at essentially the same level as in FY 1960. Through February of 1960, 800 trips were started compared with 829 through February 1961.

Following is a schedule of approval letters in the hands of the Commission or which have been submitted to them and the current status of each letter:

Number	Title	Status
AT- 97	Cooperative Program for Evaluation of Decontamination Agents	A new letter has been prepared and will be resubmitted.
AT-105	Symposium on the Biology of the Transuranic Elements	Letter supplemental to original letter has been prepared and forwarded to the AEC.
AT-127	Exchange of Senior Staff Members With Other Laboratories	Approved February 17, 1961.
AT-129	National Committee on Radiation Protection and Measurements	Approved February 28, 1961.
AT-133	Transfer Expenses for Key Employee	Approved February 28, 1961.
AT-136	Transfer Expenses for Key Employee	Approved February 20, 1961.

Several meetings were held with CAO and CE&UO personnel pertaining to project unitization and reporting in connection with the new criteria established by CAO for the mechanization of fixed assets. This resulted in a substantial alteration to our present method of unitization reporting and requires the preparation of Data Processing input data sheets to establish unit of property in the fixed asset accounts. In addition close working relationship will be required with CE&UO personnel on projects being unitized by them to insure consistency in unitization.

Project unitization reports were issued during the month on the following projects:

CAH-790	High Level Radioactive Material Recovery and Storage Addition, 327 Building	$344,948
CAH-860	PRTR Fuel Element Access, 327 Building	80,533
CG- 731	Critical Mass Laboratory - 290-E Building	993,763

Project unitization is progressing on the following projects:

CAH-864	Shielded Animal Monitoring Station - 100-F
CGH-877	Piro Chemical Test Facility - 321-A Building
CAH-878	Additional Facilities for Isotope Study on Animals, 141-C Building
CAH-885	Geological and Hydrological Wells - FY 1960

Assistance is currently being provided CE&UO on the unitization of projects AEC-167, Plutonium Recycle Test Reactor and CAH-747, Plutonium Fabrication Pilot Plant in establishing units of property and tagging movable equipment. This assistance will continue until unitization reports are issued.

Nuclear Materials Accounting advised us of the forthcoming Survey 18, Part 3, which will consist of a verification of HAPO inventories of depleted uranium and BIRCH as of the end of January 1961. All material custodians were advised of the survey and requested to submit inventory information to enable us to prepare and submit a physical inventory schedule for HLO.

Preparations were completed for the physical inventory of movable cataloged equipment in the custody of Reactor and Fuels R&D Operation tc begin March 13, 1961, and continue through June 1961.

Reconciliation by CAO of the physical inventory of the Hot Semi-Works facility was completed this month. This inventory, which began September 20, 1960, included fixed property (buildings, other structures, installed equipment and utility systems) valued at $4,252,743. One item valued at $373 was not physically located during the count and one unrecorded item valued at $250 was found during the count. This facility is currently being prepared for use as the Sr-90 Interim Facility.

Twenty-six items valued at $12,960 were received at the Laboratory Equipment Pool during the month of February. Five items valued at $3,021 were withdrawn by custodians and 23 items valued at $14,852 were disbursed in lieu of placement of requisitions. There are currently 561 items valued at $217,414 located in the Equipment Pool.

The following Reactor and Other Special Materials were on hand at month end:

Beryllium	63 gr.	$ 36
Gold	2,202 gr.	2,952
Palladium	1,378 gr.	1,571
Platinum	6,853 gr.	19,943
Silver	1,913 gr.	77
Zirconium		
Inventory Stock	3,010 lb.	66,123
R&D Stock	624 lb.	9,369
Scrap	9,333 lb.	000
		$100,071

During the month 4,240 grams of platinum scrap valued at $12,338 and of no further value to HAPO were made available to the AEC for shipment off-site. Upon receipt of shipping instructions the dollar value will be transferred to the AEC.

The idea of providing, by establishing the Laboratory Equipment and Special Materials Pool, a routine and uniform method for the orderly disposition of HLC equipment and material has proven to be sound. As of January 31, 1961, after being in operation less than fourteen months, the value of equipment redirected to useful purposes within Laboratories, thereby avoiding the purchase of new equipment, exceeds the costs of the building plus all operating and maintenance costs.

A physical inventory of Cold Semi-Works, 321 Facilities is currently in progress. The count will include all fixed property including buildings, installed equipment and utilities. The physical count of fixed assets is being taken by C&AC personnel assisted by HLO Financial and custodial personnel. The purpose of this inventory is to prepare detail records in a manner which will contribute to mechanization.

COST ACCOUNTING

Effective March 1, 1961, two exempt specialists and one cost clerk were transferred from the Cost Accounting Operation to other functions within the Financial Operation. The Specialist - Project Accounting and one cost clerk were transferred to General Accounting and the Specialist - Financial Representative was transferred to the Technical Administration function.

The Hanford Laboratories operating cost control budget was adjusted in February to include amounts proposed in the January review with the AEC Division of Reactor Development and for internal adjustments within Reactor and Fuels R&D Operation. These adjustments are as follow:

(Dollars in Thousands)	Previous Control	Change	New Control
Plutonium Recycle Program			
Plutonium Fuels Development	$1 482	$ -82	$1 400
Uranium Fuels Development	413	+112	525
Fuels Reprocessing Development	826	- 26	800
Physics and Instrumentation	603	+ 22	625
Design Development	158	- 3	155
Reactor Engineering Development	615	--	615
Materials Development	389	+ 61	450
Test Reactor Operation	1 275	+ 25	1 300
Cycle Analysis	224	- 24	200
Procurement of HX Plutonium	135	- 35	100
Total PRP	6 120	+ 50	6 170
Gas-Cooled Power Reactor			
Physics Measurements	5	+ 1	6
Experimental Gas-Cooled Reactor	230	- 1	229
Project Gas-Cooled Loop	349	+ 71	420
Other Gas-Cooled Reactor	294	- 71	223
Total Gas-Cooled Power	878	-0-	878
Specific Fuel Cycle Analyses	190	+ 60	250
Swelling Studies	200	- 50	150
In-Reactor Measurements of Mechanical Properties	450	- 25	425
UO_2 Fuels Research	800	- 50	750

In addition to the above changes, CPD sponsored research and development was adjusted as follows to conform with the current program controls maintained by CPD.

Separations	$1 124	$+ 25	$1 149
Separations - NPF	166	- 25	141
234-5 Weapons	230	+ 5	235

Preparation of the Budget for FY 1963 and Revision of Budget for FY 1962 continues as scheduled. Progress through February includes the following:

1. Personnel requirements approved by the General Manager - HAPO.
2. Service Assessment budget submitted to Contract Accounting.
3. Schedules of budgeted charges between departments.
4. Personnel assignments for determining Service Assessment distribution for FY 1963.
5. Special equipment submissions to budgeting department.
6. Research and Development Proposals:
   a. Received all proposals in draft form from HLO Sections.
   b. 02, 04 and 05 programs typed on duplimats.
   c. 02, 05 and 06 programs to Manager - Hanford Laboratories for review.
   d. 04 programs duplicated in preliminary form and submitted to the General Manager - HAPO for review.

Special requests received during the month were as follow:

.LJ - Heat Transfer and Fluid Flow Studies for Canadian Co. - operative program. The estimated cost for FY 1961 is $50,000. Costs will be transferred monthly to HCO-AEC.

.2S - Evaluation studies of the Vallecitos Boiling Water Reactor control rod drives for APED. Estimated costs are $5,000.

Special analyses and consultations were provided Hanford Laboratories components during the month concerning the cost-budget status of several research and development programs.

The major complications encountered in estimating the portion of Plutonium Recycle Program expenditures applicable to "fuel fabrication" as distinguished from "research and development" were outlined and transmitted to HOO-AEC Budget Division at their informal request. It appears this segregation of costs will be discontinued on budget presentations and on cost-budget reports after approval by WASH-AEC.

An AEC policy, effective January 1, 1961, requires excess construction equipment and materials to be transferred to the excess yard fully reserved without credit to the project. This equipment and material will be free issue to another construction project, but will be released to operations at full value or a negotiated price. Material or equipment released to construction from operations excess will be priced at full value or a negotiated price. CE&UO is issuing a memorandum clarifying the AEC instructions relative to handling and pricing construction excess.

Action as indicated occurred on the following projects during the month:

New Funds Authorized HLO

CAH-822	Pressurized Gas Cooled Loop Facility	$125 000
CAH-901	Structural Materials Irradiation Test Equipment-ETR	21 000
CAH-916	Fuels Recycle Pilot Plant	50 000

Physical Completion Notices Issued

CAH-744	Metallurgical Development Facility, 306 Building Addition
CGH-819	Increased Laboratory Waste Facilities, 300 Area
CAH-878	Additional Facilities for Isotope Study on Animals, 141-C Building

Construction Completion and Cost Closing Statements Issued

CAH-747	Plutonium Fabrication Pilot Plant (AEM Services Only)

Payroll Statistics

Number of HLO Employees Changes During Month	Total	Exempt	Non-Exempt
Employees on Payroll at Beginning of Month	1 382	654	728
Additions and Transfers In	10	7	3
Removals and Transfers Out	21	13	8
Employees on Payroll at End of Month	1 371	648	723

1229916

Overtime Payments During Month	February	January
Exempt	$ 7 108	$ 9 034
Nonexempt	14 748	15 868
Total	$21 856	$24 902

Gross Payroll Paid During Month		
Exempt	$567 105	$573 461
Nonexempt	367 505	367 638
Total	$934 610	$941 099

Participation in Employee Benefit Plans at Month End	February Number	February Percent	January Number	January Percent
Pension Plan	1 217	99.3%	1 225	99.4%
Insurance Plan				
Personal Coverage	383	99.8	1 374	99.5
Dependent Coverage	981		988	
U. S. Savings Bonds				
Stock Bonus Plan	68	34.5	71	35.9
Savings Plan	83	6.1	82	5.9
Savings and Security Plan	*1 051	*89.5	1 060	*89.6
Accident Insurance	797	58.2	801	58.0

Insurance Claims	February Number	February Amount	January Number	January Amount
Employee Benefits				
Life Insurance	0	$ 0	0	$ 0
Weekly Sickness and Accident	21	1 974	18	1 140
Comprehensive Medical	91	6 256	87	2 300
Dependent Benefits				
Comprehensive Medical	190	9 958	151	13 205
Total	302	$18 188	256	$16 645

Good Neighbor Fund	February	January
Number Participating	933	940
Percent Participating	68.1%	68.1%

*The original refusals of the S&S Program are no longer eligible. January % has been changed accordingly.

W. Sale:bk
March 14, 1961

1229917

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
D. R. Green	Infrared Radiometer with Automatic Self-Compensation for Variations in Emissivity of Viewed Surface
J. P. Pilger	A Device for Crimping Bearing Surfaces onto Fuel Element Supports
L. L. Ames, Jr. A. E. Reisenauer	Removal and Recovery of Plutonium from Acidic Wastes
G. Jansen, Jr. A. M. Platt G. L. Richardson	Process for Recovery of Strontium-90 from Radioactive Waste Solutions

W. Dale for Hay Parker