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STATUS AND PROGRESS REPORT

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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

November, 1954

F. T. Howard

and

W. H Sullivan

Date Issued: DEC 6 1954

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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

November, 1954

This status and progress report presents material on approximately one-half the Laboratory's program, which is covered, with some exceptions, on a bimonthly schedule.

PROGRAM 2000 - SOURCE AND FISSIONABLE MATERIALS

Waste Metal Recovery - The first shipment of americium, recovered from Hanford crucible waste (ORNL-1793), contained 1.11 g of Am, 1.15 g of La, and 1.7 g of Pu. It was prepared by eluting the americium extraction product (La/Am = 300/1) with 12.8 N HCl from Dowex 50 resin, evaporating the eluate, precipitating AmF_3 to remove iron, dissolving the AmF_3, and reprecipitating it as the hydroxide. The HCl elution cannot be used for large-scale separation because the HCl would attack the metal parts in the large resin column. About 4 g of americium, to complete our commitment to UCRL at Livermore, is being eluted from a 20-liter Dowex 50 column with 0.15 M citric acid--0.10 M ammonium citrate. In small-scale tests the citrate eluent gave a better separation from lanthanum than HCl; partial separation from plutonium was also obtained.

In the Los Alamos Clementine reactor fuel-element recovery program, completed in October, 14.7 kg of plutonium and 0.2 g of americium were obtained; this is 99.9 and 60% recovery, respectively, based on losses. In the process, a modification of that used with the Hanford program, aluminum nitrate added to the feed served as the salting agent in americium extraction, in place of the calcium and magnesium nitrates present in the crucible waste solution. The plutonium elements were dissolved in 12.5 M HNO_3--0.05 M HF, and the solution was diluted with 2.0 M $Al(NO_3)_3$ to prepare the plutonium extraction cycle feed, which was 1.3 M $Al(NO_3)_3$--4.4 M HNO_3. The aqueous waste from this cycle was neutralized with NH_3 to give the americium extraction-cycle feed, 1.0 M $Al(NO_3)_3$--3.5 M NH_4NO_3. (AEC Activity 2344)

Excer Program - Studies were continued on preparation of uranium oxide pellets for use in the Excer moving-bed process. Pellets of $UO_3 \cdot xH_2O$ containing 40% $UO_2(NO_3)_2 \cdot 6H_2O$ were successfully denitrated in a vertical bed, 1/2-in. diam. and 12 in. deep, at 450°C. A nitrate content of less than 0.5% was obtained in 15 min, and an air velocity through the bed of approximately 9 cm/sec was sufficient to prevent softening or sticking of the pellets. If the decomposition gases contact pellets whose temperature is below 150°C, condensation causes severe plugging. UO_2 pellets produced by the reduction of denitrated pellets with hydrogen or anhydrous ammonia in a vertical bed were much stronger than those reduced in boats under similar conditions.

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U_3O_8 pellets prepared by heating UO_3 pellets to 700°C were as reactive to anhydrous ammonia as the UO_3. Approximately 95% reduction was obtained in 90 min at 525°C with a tenfold excess of NH_3.

The heat loss from the reactor in the denitration step was 350 Btu per lineal foot at 535°C, the average temperature anticipated, and 485 Btu per lineal foot at 665°C, the average temperature in the subsequent one-stage conversion of UO_3 hydrate to UF_4. (AEC Activity 2602)

PROGRAM 3000 - WEAPONS

RaLa Production - Run No. 58 was started as scheduled on October 18; it was completed and approximately 20,000 curies of product was shipped October 27. The run was uneventful. (AEC Activity 3702)

PROGRAM 4000 - REACTOR DEVELOPMENT

HOMOGENEOUS REACTOR PROJECT

Homogeneous Reactor Design - Final drawings for construction of the HRT cell and the electrical systems in Bldg. 7500 were completed. Flowsheets with near-final revisions are being issued for the high-pressure core and blanket systems, the steam system, and the auxiliary and emergency cooling systems. Design and experimental work for the reactor core and pressure vessel are complete except for the design of baffles to control the flow of slurry in the blanket, the testing of zirconium-to-stainless steel flanged joints and the final specification of a procedure for making the girth weld on the pressure vessel. The zirconium core tank is being fabricated at Newport News Shipbuilding and Dry Dock Company. The final layouts and detailed drawings are being prepared for the piping and equipment arrangements in the HRT low-pressure and steam systems. Studies are continuing on the layout of equipment and the analysis of piping stresses in the high-pressure systems.

Studies aimed at the conceptual design of a 450-Mw homogeneous reactor were initiated; several flowsheets are being compared. Costs data are being developed for reactor plant components and for the associated power plant; optimization studies are being made to establish the most economical operating conditions. (AEC Activity 4109.1)

Homogeneous Reactor Test - The fabrication and installation of the HRT tank and shield by the contractor are approximately 50% complete. The structural steel and concrete work in the control area are 100% complete. The base of the reactor shield tank was completed; the tank bottom and the first 4 feet of stainless-clad wall is being installed. Steel plate for the side walls was delivered to the site.

Procurement of reactor component materials is proceeding satisfactorily with the exception of welded pipe. This fabricator has had difficulty producing acceptable welds but is expected to make delivery by December 15, two months late. As a result, the fabrication of most components is also behind schedule. (AEC Activity 4109.11)

Homogeneous Reactor Analysis - The HRT has been analyzed for situations which could cause physical damage. After minor design changes, no conditions appear to exist which could damage the HRT. The pressure vessel would probably rupture at a differential of 8,000 psi, the core tank at a differential of about 1,000 psi between the core and reflector. Conservative safety limits of 200 psi differential between the core and reflector and 4,000 psi between the reflector and the atmosphere were chosen for the safety analysis of the HRT. The corresponding maximum allowable rates of reactivity increase are 0.5%/sec and 2%/sec, respectively.

An analysis of the relative effects of major process variables on the economics and characteristics of two-region thorium breeder reactors is nearing completion, and the results to date are presented in the HRP Quarterly Report, ORNL-1813. The results of calculations for over 100 reactor designs show that the net unit cost of electrical power is only slightly affected by rather large changes in process variables. For reasonable ranges of these the unit cost varies only about 0.4 mill/kwh for an average reactor temperature around 280°C. (AEC Activity 4109.2)

HR Mathematics and Computation - The lowest eigenvalues and the corresponding eigenfunctions of Gaussian kernels for a spherical multiplying region with an infinite reflector were computed on the Oracle. Calculations of effective resonance integrals and their temperature coefficients for various nuclei of interest are in progress. (AEC Activity 4109.2)

HRP Chemistry--Radiation Studies - Two additional in-pile bomb experiments were completed in the LITR for the study of the effects of reactor radiations on the corrosion of Zircaloy-2 by uranyl sulfate solutions; a third experiment is underway.

One of these experiments was designed to test the effect, upon irradiation, of excess acid on the corrosion rate. The solution was 0.16 M in UO_2SO_4, 0.02 M in $CuSO_4$, and 0.04 M in H_2SO_4. Based on oxygen consumption data, the corrosion rate was roughly 2/3 that previously observed in two similar experiments which contained no added acid. Corrosion rates based upon pin-weight loss data and solution analyses for these experiments are not yet available.

The other experiments were to determine, under irradiation, the effect of temperatures higher than 250°C on the corrosion rate. Preliminary results indicate that the corrosion rate at 280°C is about twice that at 250°C.

Installation of the new experimental facility in hole HB-5 of the LITR is essentially complete, and the equipment will be placed in operation in the near future. A new water-cooled bomb exposure assembly has been designed to permit radiation exposures at higher power densities. The design of a new facility for opening irradiated bombs is essentially complete. (AEC Activity 4109.31)

HR Laboratory Service Corrosion Tests - It was found possible to distinguish between thoria slurries prepared by different methods by observing weight changes on type-347 stainless steel pins inserted in small stainless steel toroids in which the slurry is circulated. Tests at 250°C at 26 fps with slurry concentrations of 500g Th/kg water gave corrosion rates on type-347 stainless steel pins of less than 0.3 mpy with Ames 100 mesh thorium oxide and 75 psi oxygen. Under similar conditions with Lindsay No. 7 thorium oxide, the rates varied from 1.4 to 2.2 mpy. In four tests, Lindsay No. 8 thorium oxide with 75 psi oxygen showed rates less than 0.8 mpy. In the absence of oxygen, with either a nitrogen or helium atmosphere, the results were more erratic but definitely showed increased corrosion rates; Ames thorium oxide at 500 g Th/kg water, 250°C, and 26 fps bulk slurry velocity gave rates from 1.1 to 3.4 mpy while Lindsay No. 8 under similar conditions gave the same results within the limits of the experimental error (95% confidence level).

Tests of various materials and bimetallic couples in tap water at room temperature (simulating exposure expected when the HRT tank is flooded for maintenance operations) indicate that carbon steel, aluminum, magnesium, lead, and copper are substantially attacked, while stainless steel, brass, and galvanized steel are not appreciably affected. Protection is afforded, however, by the use of sodium chromate inhibitor in the tap water; less highly colored inhibitors are being investigated.

A specimen of sintered aluminum oxide proposed for use as a canned rotor pump bearing material, is being exposed in oxygen-pressurized 0.17 molal uranyl sulfate solution at temperatures of 150, 175, 200, 225 and 250°C. After 1015 hours an average corrosion rate of 0.6 mil/year, with no evidence of any other detrimental attack, has been observed. (AEC Activity 4109.4)

HR In-Pile Loop - In the first in-pile loop corrosion experiment, Loop DD was installed in beam hole HB-4 of the LITR and operated for 465 hours with enriched uranium; the experiment followed an 85-hour out-of-pile check run with normal uranium solution. With a few minor exceptions, the performance of the loop, operating equipment, and instruments proved satisfactory in this first experiment. During the in-pile run the LITR energy output was 840 Mwh, of which 49 Mwh were liberated at pile power levels of 1 and 2 Mw during the initial portion of the experiment. The remainder were liberated at the maximum pile power of 3 Mw. The fission power developed in the loop solution, as determined by analysis, was about 525 watts at full pile power. The results of oxygen consumption measurements and analyses of samples of the loop solution indicate negligible corrosion during operation at pile powers of 1 and 2 Mw but appreciable corrosion at 3 Mw (5 mpy for the first day and 1-2 mpy for the remainder of the exposure, calculated on the assumption of uniform corrosion).

Following exposure, the loop was removed and disassembled without difficulty. The Type 347 stainless steel corrosion specimens were weighed before and after defilming. Results of these measurements, with other calculated quantities, are tabulated below. The locations of the core samples were such that the neutron flux was greatest at position A and smallest at position L. In the absence of solution, the fluxes at these two locations would differ by a factor of four. The fission power density at position A is estimated to have been 3 kw/liter in loop DD with the LITR operating at 3 Mw. More accurate values of the relative fluxes during the experiment will be obtained by measuring the induced activities of the corrosion specimens themselves. The neutron fluxes seen by the in-line specimens were negligible.

Position	Specimen	Velocity at leading edge, fps	Wt. change as removed from loop, mg.	Wt. change after defilming, mg.	Corrosive Penetration, mils
Core	A	10	-115.8	-119.9	1.95
	B	11	- 90.0	- 93.9	1.53
	C	14	- 85.6	- 89.0	1.45
	D	17	- 77.5	- 79.8	1.30
	E	23	- 65.0	- 67.8	1.10
	F	36	- 55.6	- 59.0	0.96
	G	42	- 34.5	- 37.9	0.62
	H	51	- 14.9	- 19.3	0.31
	I	28	- 2.3	- 11.6	0.19
	J	20	+ 7.5	- 7.7	0.13
	K	15	+ 10.2	- 6.6	0.11
	L	12	+ 10.6	- 5.2	0.085

Position	Specimen	Velocity at leading edge, fps	Wt. change as removed from loop, mg.	Wt. change after defilming, mg.	Corrosive Penetration, mils
In-Line	A	9	+ 8.3	- 3.0	0.049
	B	11	+ 9.4	- 3.5	0.057
	C	13	+ 9.9	- 6.7	0.109
	D	17	+ 14.9	- 1.9	0.031
	E	22	+ 10.5	- 4.2	0.068
	F	35	+ 9.7	- 6.5	0.106
	G	40	+ 8.0	- 5.4	0.088
	H	49	+ 8.7	- 2.8	0.046
	I	27	+ 8.1	- 2.9	0.047
	J	19	+ 4.8	- 5.8	0.094
	K	15	+ 5.8	- 4.2	0.068
	L	12	+ 6.2	- 5.3	0.086

It is apparent that the greatest corrosion during exposure was in the regions of the core holder exposed to the greatest neutron flux. The corrosion of specimens in the in-line holder was not significantly greater than that which would have been anticipated in the absence of radiation. Further examination of the corrosion specimens from this loop is in progress. (AEC Activity 4109.4)

HR Metallurgy - A number of weld design combinations, proposed for the final girth closure weld on the carbon steel pressure vessel (clad with 347 stainless steel) for the HRT, were tested on a comparable clad plate. Those combinations which contained a barrier insert of low carbon steel in contact with, but not fused to, the stainless steel weld did not meet radiographic standards. However, composite welds, in which the transition from the stainless steel weld metal to the carbon steel weld metal was made by using an integrally fused layer of type-308L, 347, or 310 stainless steel or of ingot iron, showed little or no porosity upon radiographic examination. These welds have now been sectioned for mechanical testing and metallurgical examination.

Pieces of 1/4" type-347 stainless steel base plate were successfully joined by the Heliarc method by using a specially prepared heat of filler metal of composition "H", a fully austenitic type-347 material modified by additions of nickel and manganese in excess of the standard composition. These welds are being made into specimens for corrosion, mechanical, and metallurgical testing.

Stress corrosion tests, in boiling concentrated magnesium chloride solutions, were made on simulated tube-to-tube sheet assemblies, in which the degree of tube expansion by rolling was varied. These tests indicated that very light expansions were associated with substantially less susceptibility to stress-corrosion failure than were heavier expansions.

Elevated temperature tensile tests on Zircaloy-2 specimens cut from a forged block, emphasized the anisotropy which is to be expected in the use of shapes made from heavy forged sections. (AEC Activity 4109.4)

HR Radiation Damage - A beam-hole experiment was prepared, shipped to the MTR, and accepted for insertion. It includes impact and tensile specimens of the following: normalized, quenched and tempered, and spheroidized A-212B pressure vessel carbon steel; high purity iron annealed both subcritically and supercritically; 8-1/2% nickel and 5% Cr - 1/2% Mo steels in recommended commercial heat-treated condition; and Ti-75A and Zircaloy-2, both in the vacuum-annealed state. (AEC Activity 4109.4)

HR Instrumentation - Specifications for approximately 70% of the instrumentation of the HRT have now been formulated. The status of the present committed expenditure for these components is $65,000, or approximately 35% of the total estimate. (AEC Activity 4109.6)

AIRCRAFT NUCLEAR PROPULSION PROJECT

Aircraft Reactor Experiment - The ARE was operated successfully for more than 100 Mw-hr and a preliminary analysis of the operating data has now been made. The maximum outlet fuel temperature was 1580°F, and the maximum power level was 2.5 Mw. The temperature coefficient of reactivity 2 min after introduction of a cooling perturbation was $-5.5 \times 10^{-5}\% \Delta k/°F$, and the instantaneous temperature coefficients were considerably larger. As a result, the reactor was extremely stable while operating at full power, and there were no control problems.

The critical mass was 31.5 lb of U^{235}, which was in reasonable agreement with the calculated value of 30 lb. It was found that most of the fission gases escaped from the liquid fuel; in a 25-hr period, it was determined that no more than 1 part in 30 of the xenon poison remained in the fuel. (AEC Activity 4401.1)

Circulating-Fuel Reactor Experiment (CFRE) - Analytical studies, layout work, and detail design proceeded on both the reactor assembly and the installation for the CFRE. A layout showing the CFRE installed in a 25-ft-dia double-walled tank placed in a 60-ft extension of the present ARE building was completed and the proportions of the principal items of equipment worked out.

Specifications were completed for radiators to be used as heat dumps in laboratory-scale heat exchanger tests. It is expected that these specifications can also be used in procurement of the radiators for the CFRE heat dumps and that these laboratory tests will establish the reliability of the product of at least one vendor.

Recent work on the expansion tank-pump xenon-removal system indicates that the central expansion tank between the two fuel pumps gives a fundamentally sound configuration. The sensitivity of the system to clearances is now being investigated. (AEC Activity 4401.1)

ANP Experimental Engineering--Basic Developments - A high-turbulence, high-temperature-difference, test loop constructed of Inconel tubing has circulated a fluoride mixture for more than 175 hr of a scheduled 1000 hr at design conditions: maximum temperature, 1500°F; minimum temperature, 1300°F; Reynolds number, 10,000. This and similar loops now being constructed will provide information on the mass transfer of Inconel when exposed to a turbulent, high-temperature fused-fluoride salt flowing in a system with a high temperature differential.

The third sodium-beryllium-Inconel mass-transfer test was terminated, as scheduled, after 1000 hr of operation under the following conditions: maximum temperature (beryllium section), 1300°F; minimum temperature, less than 1000°F; Reynolds number at beryllium surface, greater than 175,000. The beryllium section and samples of the Inconel tubing were submitted for metallographic examination. A fourth test unit, now operating, duplicates the third unit except for the shape of the beryllium section.

The large-scale isothermal loop for testing ARE components has now operated dependably and satisfactorily for over 3000 hours. The gas nozzle of the pump has not plugged since an antiplugging device was installed over 1000 hours ago. Operation of the loop is being continued as a life test of the pump. (AEC Activity 4401.1)

ANP Experimental Engineering--In-Pile Loop Components - Water tests at room temperature on the plastic model of the proposed regenerative turbine-type pump for in-pile use were completed. When the impeller side clearances were 0.040 in. or less the pump primed, filled, and degassed satisfactorily. With the greater clearances required for hot operation, however, priming was erratic. Therefore, the proved methods for positively priming and filling hot pump loops are being simplified for application to this pump loop.

An in-pile fuel-to-gas heat exchanger was tested with a simulated fused-salt fuel and with air as coolant. The air pressure drop was too large, which indicated that helium should be used as the cooling gas. A fuel-to-helium heat exchanger is being designed. (AEC Activity 4401.1)

ANP Math and Computation - The critical mass calculated for the three-region critical assembly by using the Eyewash code did not agree well with the experimental value, that is, 7.2 kg of U^{235} computed vs 4.35 kg of U^{235} experimental. Foil activations for flux and power traverses were calculated and are to be compared with experimental data now being obtained.

The Oracle three-group, three-region code was used to calculate fluxes during startup of the ARE. The results explained the unexpected shape of the fission chamber startup curves as being due to changes in the space form of the flux with increasing enrichments of the carrier. (AEC Activity 4401.2)

ANP Reactor Chemistry - A modified quenching technique that permits the quenching of 20 samples of a single composition at one time and covers a range of about 50°C was developed and applied to the study of $NaF-ZrF_4-UF_4$ and $Na_7Zr_6F_{31}$ form a complete series of solid solutions without a maximum or minimum.

Equilibration of Fe with UF_4 (15 wt %) using NaF-LiF-KF (11.5-46.5-42.0 mole %) as solvent yielded filtrates containing 690 ppm of Fe at 600°C and 480 ppm at 800°C. A higher Fe content was also observed at 600°C with $NaF \cdot ZrF_4$ as a solvent. Similar studies with chromium in the alkali fluoride gave chromium concentrations of 1090 and 2700 ppm at 600° and 800°C, respectively. The value at 800°C is comparable to that measured in $NaF-ZrF_4$, but the value at 600°C is much lower than observed for $NaF-ZrF_4$. The addition of UF_3 decreases the chromium content very markedly in both solvents.

A semi-quantitative evaluation of the efficiency for electrolytic purification (Fe, Cr, etc. impurities) of $NaF-ZrF_4$-containing mixtures with and without UF_4 was obtained. In the absence of UF_4 about 0.32 equivalent of reduction per Faraday was achieved. In a comparable system containing 6.5 mole % UF_4, the initial efficiency was only 0.03 equivalent per Faraday; this value decreased steadily as the purification progressed and reached 0.005 at the end. (AEC Activity 4401.5)

ANP Corrosion Research - A thermal-convection loop constructed of Hastelloy-B in which sodium was being circulated at 1500°F plugged in 1010 hr. The plug consisted of a ball of dendritic nickel crystals. A duplicate loop was operated for 1000 hr and the sodium was drained while the loop was at operating temperature. This loop showed hair-like crystals on the wall, but a larger mass could have been washed out in the sodium. Additional Hastelloy-B loops, which were subjected to a special cleaning step, are now being operated.

Another group of Inconel thermal-convection loops with beryllium inserts was operated. After both 500 and 1000 hr, macroscopic roughness was visible on both the inside and the outside of the beryllium. Only preliminary metallographic results are available, but they show no difference between the rough and smooth areas. The roughening seems to be independent of temperature and is not what would be expected from a flow pattern. A likely possibility is that it is caused by differences in the surface as a result of machining. The beryllium insert from the third high-velocity pump loop was also removed and examined visually. The velocity of the sodium on the inside of this piece was many times greater than that in the thermal loops, and yet no visible roughness was found.

In the study of mass transfer of material in contact with liquid lead, it has been hypothesized that if there is a tendency toward intermetallic compound formation in an alloy, there is an increase in resistance to mass transfer in liquid lead. The only exception occurred with a 50% Cr-50% Fe alloy. It is believed that this exception can be explained by the very friable nature of the alloy resulting from its extreme brittleness. (AEC Activity 4401.5)

ANP Metallurgy--Fabrication - In a continued search for new and better container materials, several alloys were vacuum-melted and extruded to produce tubing blanks. The alloys included commercially-available Hastelloy-B; vacuum-melted Hastelloy-B; and 80% Ni-20% Mo base composition with additions of 3, 5, 7, and 10% chromium; Hastelloy-C; 78% Ni-20% Mo-2% Zr; 99% Mo-1% Ti; and columbium. It was found that the difficulties in the extrusion of Hastelloy-B could be overcome by dropping the extrusion temperature from 2100° to 2000°F. When this was done both rod and tubing could be prepared with excellent surfaces. (AEC Activity 4401.5)

ANP Metallurgy--Welding and Brazing - Two Hastelloy-B heat-exchanger test specimens were prepared for evaluation under cyclic conditions at 1500°F in an oxidizing atmosphere. The fabrication of each of these heat exchangers involved the machine welding of 20 tube-to-header welds which, along with about 40 type-310 stainless steel-clad copper fins welds, were back-brazed with Coast Metals 52 alloy. The tubing was 3/16 in. OD and 0.020-in. wall. The two manifolds on each exchanger were completed by manual welding that involved longitudinal welds and end-cap welds on 1/16-in.-thick Hastelloy-B sheet. The experience accumulated in this fabrication indicates that construction of Hastelloy-B radiators can be accomplished by using the techniques developed for Inconel.

Aluminum bronze can be used successfully as a high-conductivity fin material against Inconel tubing, if it is brazed in a dry hydrogen atmosphere after the following pretreatment. First, the fins are plated with 0.0005 in. of chromium; second, they are plated with 0.0015 to 0.002 in. of nickel; and, finally, they are brazed with Coast Metals 52 alloy. Apparently the chromium acts as a diffusion barrier to aluminum and prevents the contamination of the nickel plate which heretofore resulted in poor wetting.

Room-temperature bend tests have been completed on Hastelloy-B with specimens aged at 1500°F for periods up to 300 hr. A comparison was made between specimens which were aged in the as-received condition and those aged after an "overaging" heat treatment proposed by the Haynes Stellite Company. This "overaging" treatment is a solution anneal at 2150°F for 2 hr followed by a 30-hr hold at 1950°F. The data collected to date show an improvement in ductility, gained by the "overaging", up to 300 hr, at which time, the as-received specimen shows approximately the same ductility as the overaged one. It appears that little advantage is gained from "overaging" after the first 300 hr. (AEC Activity 4401.5)

ANP Design Physics - An analytical expression for the neutron diffusion in a fairly realistic model of a reflector-moderated reactor was developed. In an attempt to understand the discrepancy between observed and computed critical mass of reflector-moderated reactors, the "Janvier" method of treating boundary conditions between very different media is being investigated. Machine calculations on various configurations of the reflector-moderator reactor and of the approach to criticality of the ARE were preformed. The physics problems of the CFRE hazards report, such as the expected activity of the off-gases and possible power, temperature, and pressure excursions, are under active consideration. (AEC Activity 4401.7)

ANP Shielding Analysis - Calculations were made which indicate that the fractional dose due to thermal neutrons inside the hydrogenous crew compartment of a divided shield will be considerably greater than with a unit shield. Investigations are currently being carried out to determine whether boron will be adequate to suppress this component or whether the boron-capture gamma rays will be significant contributor to the total divided-shield dose. In the latter case, lithium will have to be used as a thermal-neutron suppressor, since it has no capture gamma rays. Therefore, a lithium-containing alloy, 80-20 wt % Mg-Li, is being developed by the Metallurgy Division. (AEC Activity 4401.7)

ANP Shielding--Lid Tank Shielding Facility (LTSF) - The measurements of neutron transmission through a system of 35 GE-ANP helical air ducts (3-in.-ID, 46.4-in. projected length, 5-in. between duct centerlines) were continued. The array was surrounded by a gamma shield medium of steel Raschig rings (35 vol %) and borated water (1% by volume) contained in a 4-ft long iron tank (5/8-in.-thick walls). The tank had 1/4-in.-thick iron windows in each end; they were 29 in. in diameter and were slighly larger than and concentric with the LTSF source plate. The presence of the ducts in the medium increased the thermal-neutron flux by a factor of approximately 3000, and neutron streaming appears to be more important than the inevitable reduced-density effect. The gamma-ray dose rate was increased by a factor of approximately 160. (AEC Activity 4401.7)

ANP Shielding--Bulk Shielding Facility (BSF) - A series of experiments to determine the effect of beam holes on the reactivity of the BSF reactor were performed at the BSF. The beam holes used were similar to those designed for the Oak Ridge Research Reactor (ORR). The purpose of the experiment was to obtain data with which the ORR reactivity requirements introduced by the beam holes can be predicted. The data have not yet been analyzed. The BSF was modified recently to permit the use of demineralized water in the reactor pool in order to eliminate corrosion of the reactor fuel elements. The pool was cleaned and painted and all steel was either removed or sprayed with a stainless steel protective layer. A by-pass demineralizer is being installed to maintain the water purity.

Several BSF staff members participated in a program to discover any short-period isomeric gamma-ray transitions which might be present in K^{39}, Rb^{85}, Rb^{87}, and Zr^{90}. Measurements were made at the ORNL graphite reactor, and no previously unknown short-period isomers were found in K^{39}, Rb^{85}, or Rb^{87}. Zr^{90} yielded a 2.30 $\pm$ 0.03-Mev gamma ray with a half-life of about 0.83 $\pm$ 0.03 sec. This may be of importance in design considerations for a circulating-fuel reactor. (AEC Activity 4401.7)

ANP Shielding--Tower Shielding Facility (TSF) - Gamma-ray dose rate measurements were made in the TSF detector tank located 64 ft from the GE-ANP R-1 reactor shield at an elevation of 195 ft. A 5-in. thickness of lead was placed in the detector tank 1 ft from the rear (reactor side). The gamma-ray relaxation length at the rear of the tank is $\sim$17 cm and at the front of the tank it is $\sim$13 cm. The capture gamma-ray intensity in the detector tank was calculated on the basis of earlier thermal-neutron flux measurements. It is estimated that at 30 cm from the side walls the dosage due to capture gammas is of the order of 10% of the total measured gamma dose. Fast-neutron dose rate measurements are now being made in the tank.

Analyses of both the differential and the GE shield experiments have now confirmed (previously predicted in ORNL-1793) that a single-scattering theory which includes the anisotropies of the sources fits the thermal-neutron flux measurements. The contribution of the ground-scattered neutrons to the total scattered intensity at the maximum altitude (195 ft) was calculated as 1% in the differential experiments and 5% in the GE experiments. (AEC Activity 4401.7)

ANP Fuel Recovery - Excess fluorine is required in the fluorination step of the fused salt fluoride-volatility process for uranium recovery because of the stable UF_6-NaF complex in the molten salt. The corrosion rate of nickel in this step is approximately 0.1 mil/hr. Kinetic data indicate that much less than a tenfold excess of fluorine will be needed. Use of less fluorine will probably result in better decontamination and a lower corrosion rate.

The most important, volatile, fission-product contaminant in long-cooled irradiated uranium is ruthenium. Although an over-all gross beta decontamination factor of 2×10^4 was obtained when the volatilized UF_6 was scrubbed with molten NaF-ZrF_4 (ORNL-1793), the ruthenium decontamination factor in the scrub step alone was only about 5. Passing the UF_6 through a NaF absorbent bed at 650°C gave a gross beta decontamination factor of $> 10^4$ and a ruthenium decontamination factor of 3000 to 5000.

A long-range survey (ORNL-1803) indicated that fused salt-volatility techniques will be feasible for chemical processing of ARE-type reactor fuels and certain types of heterogeneous reactor fuel elements. Radioactive waste volumes should be much lower than those from aqueous processes; operation should be simpler; processing costs, including disposal of excess fluorine, should be lower; and equipment should be less expensive, even though nickel

will be required as construction material. Total chemical costs, which are approximately 10% of operating costs, have been estimated at 20 cents per gram of U^{235}. (AEC Activity 4401.81)

GENERAL REACTOR RESEARCH

General Reactor Math - Two general but elementary two-dimensional one-group reactor problems were coded and run on the Oracle. The first problem computes the fundamental eigenvalue and the eigenfunction on a two-dimensional square mesh. This is a one-region or bare-reactor type calculation. Although various shaped objects, such as L's, T's, crosses, and square doughnuts, were involved in the calculations, the main objective was to investigate the question of the appropriate mesh size and the methods of speeding up the convergence processes. The second problem is a two-region or core-reflector type calculation of the simplest type. This problem is set up in a fashion so that it may be easily generalized to multigroup calculations.

Two auxiliary codes were also prepared. One of these codes calculates the fundamental eigenvalue by using the associated variational definition. The other code obtains the curves of constant values from the values of a function which are given on mesh points. (AEC Activity 4510)

PROGRAM 5000 - PHYSICAL RESEARCH

Reactor Operations - An automatic reactor-power controller was installed to actuate the No. 5 shim rod on the graphite reactor. The controller performed very well and it will be continued as a permanent feature. This is in line with plans to eventually bring the control instruments for all three reactors --graphite, LITR, and ORR--into the ORR control room.

The newly-installed demineralization equipment for the LITR cooling water is very effective; the resistivity of the water increased from 200,000 to 550,000 ohms and the radioactivity was reduced by a factor of ten. By using the old exchangers filled with cation resin in series with the mixed-bed unit, 90% of the radioactivity is removed before it reaches the radiation-sensitive anion resin in the mixed-bed unit.

The Oak Ridge Research Reactor (ORR) - Preliminary drawings and specifications have essentially been completed on all phases of the work to be done under the lump-sum-bid contract. These drawings are currently being reviewed by the AEC, ORNL, and The McPherson Company and necessary changes and corrections are being made.

ISOTOPE PRODUCTION

Radioisotope Production - Routine operation of the new I^{131} plant is now established. Yields have improved; only 75% of the irradiated uranium formerly required is being used to meet radioiodine requirements. One difficulty experienced was leakage of dissolver "A"; dissolver "B" was promptly started and the leaking dissolver was decontaminated and removed. Since the dissolvers, as well as other strategic pieces of equipment, are isolated in separate cells, this work was quickly and easily done, thus proving the merit of this type of design.

The loading of Co^{60} teletherapy units proceeded on schedule, although the new high-level manipulator cell will not be finished until February 1955. During the period, about 7000 curies of Co^{60} were loaded into various types of units. (AEC Activity 5111)

Radioisotopes, Process Development - The directive for the design and construction of the Fission Product Pilot Plant was received and design work was started. The architectural design will be done by an outside firm; the rest of the working design will be done by the ORNL Engineering Department. Quantitative flow sheets, based on Purex waste-type feed material, were completed. The principal method used throughout is precipitation; studies were made to establish design criteria for precipitators, crystallizers and centrifuges. The design is scheduled for completion May 30, 1955.

Further improvements were made in technetium processing. Solubility curves were made for tetra-phenyl arsonium nitrate in water and in $NaNO_3$ solution of various strengths. Because of the great difference in the solubility of the compound in pure water and in salt solution, recycle steps could be devised to recycle the expensive phenyl arsonium nitrate precipitating agent, thereby greatly reducing the processing costs.

The long-term, carefully-monitored irradiation of Eu_2O_3 to produce $Eu^{152-154}$ has proceeded far enough to establish that some of the published neutron cross sections for nuclides in this complex system are in error by perhaps a factor of two. Empirical data are now being obtained to determine the practical production rate.

Concentrates of activity thought to be Al^{26} were made from Mg target wastes, resulting from Na^{22} separations. The concentrates were sent to interested research people at Carnegie Tech.

It was determined that the average contamination of fission-product Eu^{155} with Eu^{154} is about 20%. The Eu^{154} is produced by neutron capture by stable fission-product Eu^{153}. Eu^{155} is a 2-year 85-kev gamma emitter and contamination by 1.2-Mev Eu^{154} is undesirable when Eu^{155} is used for portable X-ray units. (AEC Activity 5112)

PHYSICS

Heavy Ion Physics - Measurements of charge exchange cross sections for hydrogen ions passing through gases were extended to the energy region 3 to 30 kev. The present experiment determines the fraction of the hydrogen beam in each charge state (+1, 0, -1) after passage through a "thick" gas target, i.e., sufficient gas for equilibrium to be established between competing electron capture and loss reactions. Also a determination is made of the cross section for a neutral atom to gain or lose an electron, i.e., to become a positive or negative ion. The target gases used were hydrogen, helium, nitrogen, oxygen, neon, and argon. The present results join smoothly the curves previously reported at higher energies. At low energies, the average charge of the hydrogen beam is different for the various gases. In helium it is nearly +1, but approaches 0 in the more easily ionized gases. This behavior is equivalent to that observed for the heavier ions (e.g. A^+) at much higher energies. (AEC Activity 5200)

High Voltage Program - The total neutron cross section of fluorine was measured for neutron energies between 0.5 and 4.5 Mev. A tritium gas target, utilizing the $T(p,n)He^3$ reaction, was used as a neutron source; protons were supplied from the 5-Mev Van de Graaff generator. Measurements were made with a neutron energy resolution of 70 kev and of 20 kev. Teflon cylinders, 1 in. and 2 in. long, were used as scatterers. Graphite cylinders containing the same number of carbon nuclei as the teflon cylinders were used alternately as scatterers to eliminate the carbon nuclei from consideration. The scatterers were selected so that the neutron transmission of the fluorine would be between 50 and 70%. The observed cross sections were not in serious disagreement with cross sections previously measured. Several small resonances, not previously reported, were observed, however.

The yield of recoil protons from 17.9 $\pm$ 0.1-Mev neutrons was measured every 5 deg. from 0 to 45 deg. in the laboratory system. Neutrons were produced by bombarding a tritium gas target with 1.70-Mev deuterons from an electrostatic generator. Proton recoils from a thin CH_2 radiator were counted by a triple coincidence spectrometer consisting of two argon-CO_2 proportional counters followed by a NaI(Tl) crystal which was thick enough to stop the protons. The coincidence spectrum of proton energies in the crystal was measured at each of the above angles. Spectrum widths were kept under 25% by using progressively thinner radiators as the angle of observation was increased. Part of the width is introduced by the angular resolution, which was $\pm 3^{\circ}$. The statistical accuracy of the measurements varied from 2% to 3%. The ratio

of neutron scattering cross sections at 180 deg and 90 deg in the CM system is 1.08 $\pm$ 0.03. Corrections on the proton spectra will be made for Coulomb scattering effects in the radiator, the argon-CO_2, the walls of the proportional counters, and the angle-defining slit over the NaI crystal. (AEC Activity 5200)

Theoretical Physics - Previously reported work on the calculation of proton orbits in the fixed-frequency Thomas cyclotron was continued and a large number of interesting results obtained. It was established that no real limit exists to the proton energy obtainable, save that set by cost. Sufficient information was obtained on orbit sizes and magnetic field variation to allow reasonable estimates to be made of the machine size required for specified performance. Further work is aimed at setting accuracy specifications for the magnet design. (AEC Activity 5200)

CHEMISTRY

Chemical Separation of Isotopes - In work on the isotopic fractionation of uranium isotopes by use of an ion exchange resin a single-stage fractionation factor was obtained for the reaction

$$U^{238}O_2^{++} \text{ (in aq. versenate sol.)} + U^{235}O_2R_2 \rightleftharpoons$$
$$U^{235}O_2^{++} \text{ (in aq. versenate sol.)} + U^{238}O_2R_2$$

by means of a multi-stage batch experiment in which both resin and aqueous phases were followed. The resin used was Dowex 50-X8. A solution of magnesium ammonium versenate was used to elute the uranium from the resin. The fractionation factor was found to be approximately 1.00006.

A column run was made to measure the total separation obtained by passing an eleven inch band of uranium through 64 inches of Dowex 50-X8 in the copper form. The uranyl ion was eluted from the resin with a 0.005 M solution of magnesium ammonium versenate of pH 6.5. The column was operated at room temperature for about 180 hours. The ends of the band were samples in increments and a number of samples were combined to give sufficient material for mass analysis. The ratio of the ratios of U^{235}/U^{238} in the leading and trailing edges was found to be 1.0008 $\pm$ .0009 (95% C.I.). (AEC Activity 5300)

Hot Laboratory Research - A sample consisting of approximately one gram of $KTc^{99}O_4$ was irradiated for one year in a reflector position in the MTR for the purpose of establishing the extent of burn-up and hence the absorption cross section of Tc^{99}. Neutron absorption initiates the following reactions:

$$Tc^{99}(10^5y)\ n,\gamma \longrightarrow Tc^{100}\ (15\ sec)\beta^- \longrightarrow Ru^{100}\ (stable)$$

After irradiation, the previously white crystals had become completely black and contained a portion of solid material which was identified as metallic ruthenium.

Three methods were used to check the amount of depletion of technetium. These were: determination of specific beta activity of the $KTcO_4$, ultra violet spectrophotometric analysis for TcO_4^-, and weight of tetraphenyl arsonium pertechnetate. Two methods were used to determine the amount of ruthenium formed; the direct weighing of ruthenium metal and a colorimetric analysis which was found to suffer Tc interference. The limits of error in the analyses involving technetium were almost equal to the amount of burn-up (1-1/2 - 2-1/2%) but a low cross section of 1-2 barns is definitely indicated. The direct weighing of Ru metal gave a consistent value of about 2 barns. (AEC Activity 5300)

Chemistry of Corrosion - In view of the surprising dissimilarity of the pertechnetate and the perrhenate ions with respect to the inhibition of corrosion, experiments were made to determine whether the inhibitory properties of technetium might be ascribable to its radioactivity. Irradiated potassium perrhenate, containing initially activities due to 12.4h K^{42}, 91h Re^{186} and 17h Re^{188}, was used in corrosion tests with carbon steel at 100°C. In these experiments at a perrhenate concentration of 5×10^{-4} f or 1×10^{-3} f different levels of total activity were used. In one case the activity was due almost exclusively to Re^{186} and was approximately equal to that from 50 ppm of technetium. In the other experiments the counting rates were 18 and 80 times higher, respectively. In no case was inhibition observed. (AEC Activity 5300)

Hope Project - Two asphalts being evaluated as membrane material for waste storage basin linings, Micro-wax 4H54 (softening point 253°F) and a P_2O_5-blown asphalt (softening point 190°F), resisted nonradioactive acid and neutralized Hope-type wastes at temperatures between 72° and 170°F but deteriorated at 200°F. Surprisingly, in water at 125°, 170°, and 200°F they separated from the surface to which they were attached and became about 10% harder. A Micro-wax membrane submerged in 3 M NaOH--3 M $NaAlO_2$ at 93°C for 14 days formed no gas and remained black, smooth, and adherent. A thin, fragile crust of white solid, which was deposited from the solution, covered the sample. A sample kept in water under the same conditions became brown, loose, and covered with gas bubbles, but the water was not discolored. Gamma irradiation, 5×10^8 r, in a nitrogen atmosphere damaged both materials extensively; gas was evolved, resulting in honeycombing and expansion.

A new type hopper, from which slugs are pushed by a plunger, was designed for use with a continuous dissolver. Slugs may be stacked in this hopper at random, and even the bent ones are transferred.

An automatic mechanical "dejacketer" for aluminum-jacketed irradiated natural uranium slugs was designed to operate under water. The slug is pushed through

a guide sleeve containing knife edges and then through dies which strip the jacket from the body. The slug is then passed through a channel in which a spring-operated device presses the ends against knife edges in such a way that the softer end caps, which vary in thickness, are sheared from the harder uranium core with no loss of uranium. The dies are similar to those used in the manually operated dejacketer at KAPL (KAPL-1139).

Simulated contaminated water from an underwater Hope-type facility was decontaminated by gross β and γ factors of $\sim$1500 and 450, respectively, by passage through cation and anion exchange media (Dowex 50 and Dowex 2) followed by scavenging with $Fe(OH)_3$, 0.01 g/liter. The decontamination obtained by ion exchange alone was 500 for β's and 220 for γ's. (AEC Activity 5300)

Ion Exchange Technology - The Higgins 6-in.-dia continuous ion exchange column (Permutit SK-20 resin) operated successfully in a 16-hr test for the recovery of uranium from synthetic sulfuric acid ore-pulp leach. The pulp contained 1 g of uranium per liter and 10 wt % bentonite and was fed at a rate of 2.5 gpm, equivalent to 9 tons of ore per day. The uranium loss was high (2%), partly as a result of uranium adsorption on the bentonite. There was no plugging. The eluant was 1 $\underline{M}$ NH_4NO_3.

Fixed-bed studies showed that vanadium in the ore-pulp leach can be recovered along with the uranium when the vanadium in the feed is oxidized with manganese dioxide. The capacity of resin for vanadium under these conditions was about 4 g per liter of resin. Being less strongly held on the resin than uranium, vanadium could be eluted separately. (AEC Activity 5300)

Criticality Studies - Criticality studies are being made on problems associated with the proposed caustic flowsheet for chemical processing of U^{235} at Savannah River. Tentative approval was obtained for the use of a centrifuge 4 in. high and 42 in. diameter, with a capacity of at least 10 kg of U^{235} in 8 hr, for separating the solid uranium dissolution product from the supernatant. Studies with slab-type processing and storage tanks indicate that such tanks may be 4 in. thick, outside to outside, if kept 2 ft from walls and 10 ft from and parallel to similar parallel adjacent uranium-containing tanks. Slab tanks give greater building volume efficiency than banks of 8-in.-dia cylindrical tanks spaced 2 ft side to side in banks with 4 ft between banks. (AEC Activity 5300)

Feed Materials - Two specimens of thorium metal, 9 and 18 g, were produced by the Metallex process. The quality of the metal was good, considering the small size of the samples. The metal density was 11.4 $\pm$ 0.1 g/cc; Vickers hardness, 140; the carbon content was 0.32%; oxygen, 0.22%; and mercury, 4 ppm.

A 1% thorium quasi-amalgam was produced by reducing a solution of $ThCl_4$ in propylenediamine with sodium amalgam. The quasi-amalgam was concentrated to 9% thorium ("cheese") by filtration, and to 15% thorium (solid amalgam) by

cold die-pressing at 60,000 psi. The solid amalgam was decomposed, the mercury removed, and the thorium metal formed by heating in a vacuum induction furnace to the melting point (1800°C) of thorium.

Anhydrous thorium chloride was prepared, by direct chlorination with chlorine gas at 500°C, from thorium nitrate tetrahydrate which had been intimately mixed with lampblack. It was also prepared by chlorination of a suspension of an active thorium oxide with phosgene in a melt of 50 mole % each of sodium and potassium chlorides at 700°C. The active thorium oxide was prepared by adding thorium nitrate tetra hydrate to the salt melt at 700°C so that it was dehydrated and denitrated just previous to the chlorination. Thorium tetrachloride is soluble in the melt to at least 9 mole %. From 60 to 90% of the thorium was leached out of the salt as $ThCl_4$ by propylenediamine. (AEC Activity 5300)

Analytical Research - A coulometric determination of Cr(VI) that employs the use of electrolytically generated Fe(II) was developed to determine chromium in uranyl sulfate solutions. It was found that 10 μg of Cr(VI) can be determined in the presence of 40 mg of uranium (as UO_2SO_4) and 2.5 mg of Cu with a relative standard deviation of 1.0%. This will be useful as a second method for determining chromium in homogeneous reactor fuel solutions in cases where it is desirable to confirm the results of the colorimetric method.

A method was developed for the spectrochemical analysis of thorium for trace elements, especially the rare earths; it employs a preliminary separation of thorium from the impurities by TTA extraction. The resulting aqueous solution can be concentrated to a small volume and analyzed by the porous-cup technique or by arc methods with almost complete freedom from interference from the very complex thorium spectrum. Although large quantities of TTA are required, its use is not uneconomical, since the extractant can be recovered and reused on successive samples without introducing cross contamination.

OTHER PHYSICAL RESEARCH PROJECTS

Instrumentation and Control Development - A decade-type scaler with a resolving time of 0.5 microsecond was designed. A Burroughs beam-switching tube is used as the input decade, and the succeeding two stages use type GC-10/4B glow transfer tubes, with their respective 12AU7 drivers. The maximum repetition rate at the input is 20,000 pules per second, limited only by the mechanical register. The instrument will accept pulses of either positive or negative polarity and is capable of remote operation in conjunction with data-taking equipment.

The instrumentation for the Metallurgy Division's Liquid Metal Creep Testing Laboratory was recently completed. The installation provides temperature control and recording of 28 creep-test units. The Leeds and Northrup recording controllers will control to ± 1°C in the range from 500 to 1100°C.

Protection against amplifier or thermocouple failure is provided and the annunciator in the system indicates temperature deviations over 10°C with visual and audible alarms. Multi-point recorders are available for the determination of temperature gradients on any specimen or for additional temperature checks. A 100-point Leeds and Northrup precision indicator is used to check all thermocouples, recorders, and controllers. The precision indicator is periodically compared with a laboratory standard potentiometer, thus insuring precise control and indication. The installation requires a total of 40 feet of control panel length. (AEC Activity 5400)

Oracle - During the months of October and November, regular two-shift operation of the Oracle was continued, with a third shift available on a voluntary basis. A total of 641 hours of computing time was scheduled for problem solution, of which 20 hours was lost due to machine breakdown; thus, an operating efficiency of 97% was realized.

Construction and installation of the control for the auxiliary memory system is nearing completion. The system is composed of 4 magnetic tape transports operating as a non-volatile memory for subroutine information storage in the Oracle. Access time of the magnetic tape memory in this system is from 14 milliseconds to approximately 5 minutes. Starting time of the tape from rest to full speed, 47 inches per second, is 5 milliseconds, 1/8 inch of tape being required for acceleration. Deceleration from full speed to rest position requires 2 milliseconds and 1/16 inch of tape. Storage capacity is 3×10^6 machine words (each word contains 40 binary bits) or 750,000 words per unit, with a packing density of 100 words per inch.

The type of tape used is red-oxide impregnated plastic, two inches in width and 1200 feet in length per unit. Each tape contains 42 recording channels with 40 channels used to store the 40-bit machine word, one channel for word counting, and the remaining channel for parity checking.

A parity check (odd-even type) was installed in the Oracle. With this system, all information entering or leaving the machine is constantly checked for misrepresentation of numbers. The check consists of an electronic method of storing a binary bit along with each Oracle word, and subsequently comparing the sum of the digits in the word with the bit each time the word is used. When an error is indicated, a signal is produced that stops the computer and warns the operator. (AEC Activity 5511)

BIOLOGY

Cytogenetics - The experimental work on the problem of how oxygen causes an increase in chromosomal aberration yield for the same dose of X-rays is nearly completed. The number of aberrations seen is the product of the number of primary breaks times the fraction of those that fail to fuse back in their original condition. Thus oxygen could increase aberrations by increasing breakage, decreasing fusion, or both. Three independent methods of estimating fusion were developed and applied to oxygen-nitrogen experiments in which aberrations and fusion were simultaneously measured; this permits solving for the third factor, breakage. The results, for *Tradescantia* chromatid types of aberrations, show that: (1) oxygen increases both kinds of primary breaks, chromatid and isochromatid, equally; (2) the fusion of isochromatid breaks is the same in nitrogen as in air; and (3) fusion of chromatid breaks is only half as much in nitrogen as in air, i.e., twice as many chromatid deletions result for an equal number of breaks in nitrogen as in air. This last result is the exact opposite of one hypothesis that has been expounded to explain the oxygen chromosomal effect. The data from the fusion experiments made it possible to quantitatively account for the air/nitrogen ratios for all types of chromatid aberrations from oxygen-nitrogen experiments reported in the literature.

It has been established that somatic elimination of an unstable ring-X chromosome of *Drosophila melanogaster* is more frequent among the late than among the early progeny of females carrying this chromosome. This age effect is maintained as was shown by the elimination frequency among the F_2 produced by early, as compared with late, F_1 ring-bearing females. The frequency of ring elimination and viability of ring-bearing zygotes appear to be inversely related; the age effect was also shown to exist in the case of ring zygote viability. Age experiments with unstable ring-X males have not yet provided conclusive results. This information is desired in order to determine whether the age effect operates directly on the ring chromosome or through the egg cytoplasm.

In the wasp *Habrobracon*, the unfertilized eggs develop normally to become haploid males; the fertilized eggs into diploid females. By first generation analysis of dominant and recessive lethal mutations and second generation analysis of recessive lethal mutations induced in eggs by X rays, it has become apparent that two classes of dominant lethal mutation exist. One class, comprising 60% of all dominant lethal mutations kills the eggs in a specific developmental stage whether or not the embryo is haploid or diploid. The other class, conditionally delayed dominant lethal mutations, results in death of diploid embryos at a later stage of development than those induced in the haploid embryo. The present data show that the hypothesis presented in the previous bimonthly report, ORNL-1793, (reversion of gene mutation), is no longer tenable. (AEC Activity 6400)

Microbiology - Purification of the two principal enzyme fractions concerned with succinyl-CoA decarboxylation is reported here. The decarboxylase is isolated from Propionibacterium and converts succinyl-CoA to propionyl-CoA and a one-carbon complex; the latter is transformed into CO_2 by the "CO_2 producing enzyme", isolated from Veillonella.

The two enzymes were isolated by starch electrophoresis; they were resolved to the extent that when the purified fractions are combined, no CO_2 is formed. However, upon the addition of a third component (heat stable, and present in boiled Propionibacterium extract), CO_2 is produced. The particle fraction from Veillonella (obtained by ultracentrifugation) also contains the CO_2 producing enzyme, but when mixed with the decarboxylase fraction it is not stimulated by addition of boiled extract.

Since purification of the enzymes by starch electrophoresis did not result in high-specific-activity material, it was necessary to "pre-purify" the bacterial extracts. In addition to dialysis, it was helpful to carry out a calcium phosphate gel treatment, which removes much foreign protein. (AEC Activity 6400)

Radiation Protection - During the past two months an extensive study was made of the effects of protective chemicals (β-mercaptoethanol, cysteamine) on the X-ray-induced reversion rate of several mutant strains of E. coli (adenineless, phenylalanineless, tyrosineless, methionineless, and threonineless). These studies permit the tentative conclusion that there exists a definite quantitative relation between the reduction in mutation rate and the increase in survival produced by the protective action of these compounds, and suggest that both effects are produced through the same protective mechanism. Further studies on these strains bear out this relationship in the case of oxygen displacement by nitrogen, as has been previously observed for the adenineless strain and for the tyrosineless and prolineless strains.

It has been previously shown that cysteamine-protected cells have the ability, under certain conditions, to recover markedly from the lethal effects of X irradiation. An attempt to determine the effect of the postirradiation recovery process on the production of reversions by X ray is in progress. Comparisons of strains which have little ability to recover on minimal media with those which have marked ability suggest a definite quantitative relation between the recovery of irradiated cells and the decrease in the mutation rate. These studies tentatively suggest that the phenomenon of radiation-induced mutagenesis is indirect and related to the mechanism of killing of cells by irradiation. (AEC Activity 6400)

Biochemistry - The final identification of the nucleotide a and b isomers as nucleoside-2'- and -3'-phosphates, respectively, was accomplished by the identification of the ribose and ribitol phosphates associated with each nucleotide. Initially, this was made on the basis of the borate complexing of the ribose-3-phosphate and the presence of optical rotation in the ribitol-

2-phosphate. It has now been demonstrated that hydrogen bonding is also a factor which can be exploited for the separation as well as the identification of sugar phosphates even in the absence of borate complexing. Accordingly, α- and β-glycerophosphates were separated by simple anion exchange in the pH range of 4 to 8, the β compound being the stronger acid and thus appearing last. Periodate oxidation has also been studied as a means of identification or the ribitol phosphates. Ribitol-2-phosphate consumes 2 moles of periodate; ribitol-3-phosphate and both ribose-2- and -3-phosphate take up 6 moles (ribose-5-phosphate consumes 3). All these are in accord with theory and serve further to establish the identity of the ribose phosphates.

The structure of the natural anticoagulant heparin has not been completely determined because of its resistance to both chemical and enzymatic degradation. Partial chemical hydrolysis products have been isolated but no attempts to quantitate this information have been recorded. Enzymatic approaches, with one exception (liver "heparinase" which inactivates heparin), have been uniformly unsuccessful. However, a possible source of degradative enzymes, bacteria, has been completely overlooked. An attempt was made to isolate, by "elective-culture" techniques, microorganisms which will bring about heparin decomposition. To date, seventy-three organisms have been isolated from soil on heparin containing media, forty of which can use heparin as a source of carbon, nitrogen, or sulfur. These forty appear to belong to a wide spectrum of genera and fall into four easily differentiated classes with respect to their heparin-utlizing abilities: (1) those that can use heparin as a sulfur source (presumably by desulfation); (2) those that can use heparin as a sulfur and nitrogen source (desulfation followed by deamination); (3) those that can use heparin as a source of carbon, nitrogen, and sulfur; and (4) those that can use heparin only as a carbon source. As no organisms were found that could use the nitrogen without also using the sulfur, it is inferred that perhaps all of the nitrogen in heparin is sulfated. Similarly, as organisms are found that can use the carbon in heparin but not the nitrogen or sulfur, there may exist units in heparin that contain only carbon, hydrogen, and oxygen. (AEC Activity 6400)

Plant Biochemistry - A survey was completed on the distribution in barley plants of a major unidentified phosphorus compound. The compound is detected by labeling it with P^{32} and its quantitative distribution is determined by paper chromatographic analysis. In the last semiannual report (ORNL-1766), the transport of this compound in the normal green plant was reported as a major compound moving from the roots to the leaves of plants. The present survey indicates that the compound is made in the roots or seed, where it accumulates in large amounts. It is then transported to the leaf, where it is used in metabolism and consequently does not accumulate. In plants grown from seed in total darkness, the compound is transported upward from the root and accumulates in the leaf; in the dark the leaf cannot utilize all of this unidentified phosphate. These biochemical characteristics are similar to those found for the amides, glutamine, and asparagine. The unidentified

phosphate compound thus appears to be one of major importance in phosphorus transport and normal metabolism. (AEC Activity 6400)

Biophysics - Growing *Tradescantia* pollen tubes irradiated with ultraviolet of 2650 A wave-length and subsequently irradiated with light of the wave-length range 4000-6000 A showed no photoreactivation of the ultraviolet-induced damage. A small temperature effect was found when dry *Tradescantia* pollen is irradiated with 200 r of X rays at the temperatures of 9-1/2°, 19-1/2°, and 29-1/2°C. This temperature dependence is considerably less than that determined for microspores as reported by other investigators. These results give further evidence of the relative insensitivity of irradiated dry pollen to various modifying factors, such as intensity and effect of infrared, when compared with the effect of these agents on radiation-induced aberrations in microspores.

Work has continued on an experiment in which the metamorphosis of a salamander (*Gyrinophilus palleucus*) is being attempted by means of thyroxin and by TSH injection. This salamander is normally known only in the larval form. Some success in inducing metamorphosis has been achieved. A cytological technique for preparation of tail-tip material from this salamander for chromosome study was worked out, and the suitability of the material for irradiation studies is to be examined. (AEC Activity 6400)

Physiology - Work on high-resolution differential centrifugation was continued with the development of more refined methods for producing continuous gradients and for fractionating the gradient after it has been centrifuged. A new gradient engine was designed and built which provides uniform and reproducible gradients at the rate of about one every 100 minutes. Sector-shaped centrifuge tubes of glass were designed and blown in a suitable graphite mold. A new device for recovering material fractionated in the gradient was designed which utilizes a sliding plate system similar to that used in Tiselius electrophoresis cells. Application of these techniques to the fractionation of liver cells is continuing. Complete quantitative separation of nuclei and whole cells, mitochondria, microsomes, and soluble phase was achieved. (AEC Activity 6400)

Enzyme Chemistry - Sporadic reports have appeared indicating that protection from X-irradiation effects in mammals can be observed if sublethal doses of cyanide are administered just prior to the irradiation. It is possible that some of this effect is caused by the inhibition of iron-containing oxidative enzymes (cytochromes) which provides protection by some mechanism unrelated to the dose-reduction effect manifest by lowered production of radicals in a hypoxic tissue. When the microorganism *Pseudomonas aeruginosa* is grown on an Fe-deficient medium a fluorescent dye replaces the usual cytochrome system. The radiation sensitivity of this organism with and without the cytochrome system, and in the presence and absence of oxygen, was determined. The results obtained indicate that the presence of the cytochrome system does not alter the sensitivity of this organism to radiation. (AEC Activity 6400)

RADIOISOTOPE SALES AND COSTS

Type of Transaction	October	FY to Date
Domestic Sales	$ 128,783	$ 376,651
Foreign Sales	7,335	21,640
Project-Cash Sales	34,301	50,521
Project-Transfer Credits	12	1,447
Technical Cooperation Program Credits	-0-	1,510
Plant Credits	7,103	14,605
Civilian Defense Credits	105	105
Cancer Program Credits	15,979	79,077
*Miscellaneous	-3	55
	$ 193,637	$ 545,611
**Income-No production costs incurred Subtract from total income	50,151	55,944
	$ 143,486	$ 489,667
Radioisotope Costs	$ 89,897	$ 318,301
Radioisotope Shipments	987	3,968

*Miscellaneous Income - D_2O, Freight, Missing Parts
**Income from H^3, He^3, B^{10}, and miscellaneous items in excess of handling costs.

GROSS OPERATING COSTS

	Cost for October	FY 1955 Cost to Date
Programmatic Operating Cost - Net	$ 1,900,102	$ 9,775,212
Plant and Equipment Cost	267,710	965,830
Construction Program "H"	18,582	34,242
Work for Other Parties - Transfers	56,382	137,319
Inventory Changes	44,934	44,857
Reimbursable Work for Other Parties	216,068	656,820
Deferred Charges	4,438	1,066
Total Laboratory Cost - Net	$ 2,508,216	$ 11,615,346
Estimated Cost for Next Month - Net	$ 3,100,000	$ 14,715,346

[redacted]

PERSONNEL SUMMARY

	Number of Employees November, 1954	New Hires November	Terminations November
Administration	62	0	0
Operations*	121	0	0
Engineering, Shops and Mechanical	750	0	72
Laboratory and Research	1876	22	12
Protection	147	0	0
Service	370	2	4
	3324	24	88

*Includes Electrical Distribution and Steam Plant as well as the Operations Division.

A total of 749 Laboratory personnel are located in the Y-12 Area.

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March 1954	ORNL-1703
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August 1954	ORNL-1781
September 1954	ORNL-1793
October 1954	ORNL-1805

[redacted]