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OAK RIDGE NATIONAL LABORATORY
STATUS AND PROGRESS REPORT

JUNE 1954

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OAK RIDGE NATIONAL LABORATORY
STATUS AND PROGRESS REPORT

June, 1954

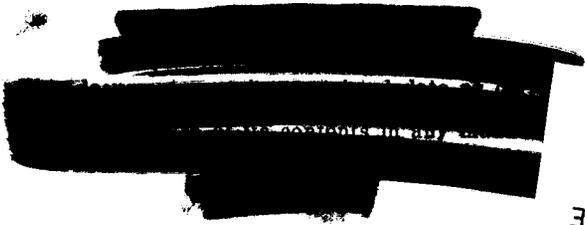
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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

June, 1954

The subject material of this report represents approximately half of the Laboratory's program, which is covered with some exceptions on a bimonthly schedule.

PROGRAM 2000 - SOURCE AND FISSIONABLE MATERIALS

25 Processing - The 5.5-in.-dia. "trickle" dissolver with Hanford-type cast 7.5% uranium--92.5% aluminum alloy slugs had a maximum dissolution rate, using 6 M nitric acid, of 6.6 kg of uranium per day with a product aluminum concentration of 1.7 M, approaching the 1.8 M specified for the ORNL flowsheet. The previously reported (ORNL-1719) dissolution rate of 12 kg/day was obtained with a product aluminum concentration of only 1.2 M, the concentration required for the Idaho Chemical Processing Plant.

In studies on the 1-in.-dia. continuous dissolver using miniature Savannah River-type extruded slugs (5% uranium--95% aluminum), the dissolution rates, as extrapolated to a 5.5-in.-dia. column, were 15 and 25 kg of uranium per day using 6.3 M and 8.4 M HNO₃, respectively, as the dissolvent. The aluminum concentration in the product stream (~2.8 M) did not vary with feed flow rate (42 to 100 ml/min) at column heights of 12 or 21 in. but dropped to 1.65 M with a 6-in. height (same flow rate), with a corresponding increase in product acidity.

In an initial run on the proposed first-cycle solvent-extraction flowsheet, a gross beta decontamination factor of 10³ (about 100-fold less than expected) was obtained in 3/4-in.-dia. glass pulse columns. The relatively poor decontamination was attributed to solvent impurities, excessive buildup of interfacial material in the extraction and stripping columns, and inefficient scrubbing caused by equipment failure. The uranium recovery was greater than 99%. (AEC Activity 2560)

PROGRAM 3000 - WEAPONS

Special Electromagnetic Separations - A third Calutron run for the separation of plutonium isotopes was successfully completed. Metered ion currents averaged 25 ma for a period of 22 hours; this corresponds to a production rate of 315 mg Pu/hr. The enrichment factors for Pu²⁴⁰ and Pu²⁴¹ were approximately 50 and 65, respectively. The quantities and isotopic analyses

PROGRAM 3000 - WEAPONS (Continued)

of the feed material and the separated product are tabulated below:

	<u>Isotopic Content (atom percent)</u>			<u>Pu (g)</u>
	<u>Pu 239</u>	<u>Pu 240</u>	<u>Pu 241</u>	
Feed Vaporized	93.8	5.8	0.43	120
Pu ²⁴⁰ Product	23.6	75.8	0.58	0.51
Pu ²⁴¹ Product	61.8	15.3	22.8	0.12
Pu ²³⁹ Product	99.5	0.5	---	6.30

(AEC Activity 3601)

PROGRAM 4000 - REACTOR DEVELOPMENT

HOMOGENEOUS REACTOR PROJECT

Homogeneous Reactor Experiment - The HRE core was cut open, while working through 5 ft of water as shielding, and portions were removed for detailed study. Visual examination of the core inlet pipe and the core wall in the vicinity of the inlet pipe showed no significant damage by corrosion. The nvt for the core wall was greater than 10^{19} neutrons/cm² at the time of shutdown.

The oxide scale that remained in the homogeneous reactor system after it had been decontaminated with alternate treatments of 8 M HNO₃ and alkaline tartrate solution contained some plutonium and large amounts of niobium and zirconium. Of the plutonium found in the reactor, about 15% was in the fuel solution and 85% was removed from the system by the decontaminating solution.

The fuel solution was transferred from the outer storage tanks to Eversafe containers which will be used to transport the solution to the Chemical Technology pilot plant for fuel recovery. (AEC Activity 4103.1)

Homogeneous Reactor Test - In view of the recent agreement that major emphasis be placed on the thorium blanket program, with a supplemental program on the uranium blanket, plans for construction and operation of the HRT were somewhat revised. Present plans call for construction and operation of the HRT with a heavy-water blanket and with subsequent modification of the design and construction to test a thorium blanket. By following this course, reliable long-term operation and ease of maintenance can be demonstrated with a heavy-water blanket while the thorium oxide slurry system is being designed and procured.

PROGRAM 4000 - REACTOR DEVELOPMENT (Continued)

The detailed design of dump tanks, evaporators, catalytic recombiner, cold traps, pressurizer, and condensate tanks is nearing completion. Equipment arrangements for high-pressure and low-pressure systems were decided upon; the flowsheet remains essentially unchanged.

Development work has shown the gas separator design to be adequate. Pressurizer heaters were found to perform satisfactorily, also. A hydraulic test of the core indicated several design revisions would be required to ensure good mixing, and these changes are being incorporated in the work at the Newport News Co. A test to determine the accuracy of calculations on the shield pressure rise after a sudden release of all the reactor liquid indicated that the estimate of a 25-psi pressure rise was reasonable; the shield design is continuing on this basis. (AEC Activity 4103.1)

Engineering Investigation of Slurries - A slurry of ThO_2 made from thorium formate was circulated for more than 1100 hr in an essentially complete stainless steel system, with linear velocities at some points in the system as high as 90 fps. During most of this period, oxygen was monitored at about 500 ppm. During the course of this run, the concentration of thorium was increased, by the addition of solids, from about 300 to over 700 g/l. After the first 100 hr of the run, during which time the iron, nickel and chromium in the slurry increased slowly, no further increase in these elements was found, representing a period of over 1000 hr during which time no measurable attack of stainless steel took place. (AEC Activity 4109.31)

Chemical Investigations of Slurries - The ammonium hydroxide-thorium formate-prepared thorium hydroxide, from which a thorium oxide slurry of very low abrasiveness was made (see report ORNL-1719), was found to be amorphous to x-rays, both as precipitated and after drying at 105°C for 72 hr. Heating the solid at 500°C for 24 hr dehydrated it and converted it to crystalline ThO_2 . Autoclaving, at 250°C , of aqueous slurries of both the undried hydroxide and the 500°C dried material for 912 and 324 hr, respectively, did not increase the abrasiveness of these slurries but did convert the undried hydroxide to crystalline ThO_2 .

Addition of 20 mole % ZrO_2 and 10 to 30 mole % Al_2O_3 to ThO_2 by coprecipitation of the hydroxides and subsequent calcination of the mixtures at 400°C inhibited thorium oxide crystal development, but addition of 20 mole % Bi_2O_3 did not, as shown by a comparison of the x-ray-diffraction patterns of the mixed oxides with the pattern of a pure ThO_2 standard.

Oxides prepared by 16-hr calcination at 650°C of two cold-precipitated (40°C) and two hot-precipitated (76°C) thorium oxalate preparations formed much less abrasive aqueous slurries than Ames oxide. The cold precipitation technique presumably gave smaller particle sizes. (AEC Activity 4109.31)

PROGRAM 4000 - REACTOR DEVELOPMENT (Continued)

Solution Chemistry - The acidity, at $25.00 \pm 0.04^\circ\text{C}$, of $\text{UO}_3 - \text{H}_2\text{SO}_4 - \text{H}_2\text{O}$ mixtures was determined to a precision of ± 0.004 pH units from 0.024 to 10^{-4} molal H_2SO_4 and at $\text{UO}_3/\text{H}_2\text{SO}_4$ mole ratios from 0.70 to 1.20. The solubility of UO_3 in sulfuric acid at elevated temperatures (150 to 300°C) was determined by oscillating a UO_3 -saturated sample, and comparing, at 25°C , the pH of the saturated solution with the pH data mentioned above. By this method, seven isotherms in the concentration range from 1.0 molal down to 10^{-4} molal were obtained. (AEC Activity 4109.31)

Metallurgy - As-welded coupon specimens of Zircaloy-2 and of commercial purity titanium, with root and final passes exposed, were tested in 1.34 M UO_2SO_4 for 200 hr at 250°C and at solution velocities of 50 to 92 fps. All specimens were covered with thin adherent films and showed weight gains in the scrubbed condition.

Similar specimens containing type 347 stainless steel welds were tested in 1.34 M UO_2SO_4 for 100 hr at 250°C , and the welds containing 2 to 4% ferrite appeared to be in better condition than those containing 7 to 9% ferrite.

Impact tests have been completed on "iodide" titanium specimens exposed in dynamic corrosion test loops (not under irradiation) to 0.06 M UO_2SO_4 containing 0.006 M H_2SO_4 at 310 to 320°C for 977 hr. No effects of this environment on the impact properties of iodide titanium were noted. (AEC Activity 4109.4)

Fuel Reprocessing - Further studies on the solubility of $\text{Nd}_2(\text{SO}_4)_3$ in simulated reactor fuel solutions showed it to be 0.20 g/1000 g H_2O at 250°C and 0.10 g/1000 g H_2O at 295°C when neodymium was the only rare earth present. Continued addition of mixed rare earth sulfates to a simulated reactor fuel at 280°C did not raise the $\text{Ce}_2(\text{SO}_4)_3$ solubility above 0.01 g/1000 g H_2O . The solubilities were determined in filtration experiments with a sintered platinum disk.

The Vitro Corporation, in filtration experiments with a crushed-quartz-filled tube, showed $\text{Nd}_2(\text{SO}_4)_3$ solubility to be 0.14 g/1000 g H_2O whether the neodymium was alone or mixed 50% with other rare earth sulfates in a simulated reactor fuel at 280°C . The apparent cerium solubility was reduced in a mixture of rare earths to one-fourth the solubility observed when cerium alone was present in the uranyl sulfate solution.

The solubility of neptunium is apparently greater than 0.07 g/1000 g H_2O at 250° to 300°C . This indicates the need for removing neptunium from the blanket solution of a plutonium producing homogeneous reactor if the Np^{239} capture cross section for reactor neutrons should be greater than 100 barns. In the program for measuring the capture cross section of Np^{239} , 3 mg of plutonium was isolated from six 12-hr LLTR-irradiated uranium slugs.

PROGRAM 4000 - REACTOR DEVELOPMENT (Continued)

The solubility of Pu(IV) in uranyl sulfate solution was shown to be unaffected by varying the uranium concentration between 250 and 300 g/1000 g H₂O but increased slightly by adding sulfuric acid.

In initial studies at low pressure (100 psig) on a 10-mm hydraulic cyclone, for possible use in continuous removal of precipitated fission products and plutonium from the core and blanket solutions of the proposed two-region homogeneous reactor, some liquid-solid separation was obtained. The work was carried out with thorium oxide-water slurries as a stand-in for the reactor core and blanket material.

In pressure drop studies made with the 10mm clone and with a 3-in. clone, there was no apparent effect of temperature and viscosity up to 200°F, and the pressure drop varied directly as the first power for low flow rates and large entrance and discharge nozzles and as the square for high flow rates and small nozzles. (AEC Activity 4109.8)

AIRCRAFT NUCLEAR PROPULSION PROJECT

Aircraft Reactor Experiment - The oil circuits rebuilt to provide adequate oil flow for cooling the main bearings of both sodium pumps were installed and satisfactorily checked. Corresponding lubrication equipment is to be installed for the fuel pumps. The fuel bypass line around the fuel-to-helium heat exchanger was removed because turbulent-flow tests showed this bypass to be unnecessary. A magnetic-clutch drive unit for the fuel-heat-extraction helium fan was installed to replace the hydraulic drive previously provided because the power output of the hydraulic drive was marginal for design-point reactor power. Also the hydraulic drives for the sodium-circuit helium fans were replaced with larger hydraulic units. An additional drain line to the fuel dump tank is being installed to provide greater safety in this operation. (AEC Activity 4401.1)

Experimental Engineering - Two types of horizontal-shaft sump pumps for circulating fused fluoride mixtures in in-pile loops were designed. These pumps are small enough for insertion in LIIR and MTR horizontal beam holes. One pump is being assembled in a test unit, and the other is being fabricated. Tests are under way on a small 1/2-hp, gear-type, hydraulic drive motor for these pumps in order to determine its dependability at 6000 rpm. A vertical-shaft sump pump for use just outside a horizontal hole in the LIIR passed acceptance tests and was delivered for installation.

Operation of a large-scale loop for circulating fluoride mixtures to test the corrosion and structural stability of ARE components started June 5, 1954; the duration aim of the test is 2000 hr. The loop contains an ARE-type pump, a fuel-to-helium heat exchanger, and two reactor core hairpin tubes. This system is operating isothermally at $1375 \pm 250^\circ\text{F}$, with a flow rate of 20 gpm.

PROGRAM 4000 - REACTOR DEVELOPMENT (Continued)

A Nozzle designed for injecting the molten ARE fuel concentrate into the ARE fuel pump was tested and is ready for use. (AEC Activity 4401.1)

ANP Reactor Chemistry - The solubility of UF_3 in the NaF-LiF-RbF system at 600°C appears to be as high as 3.5 mole % (12.3 wt % U). The system LiCl-LiH shows a eutectic containing 80 mole % LiCl that melts at 485°C; the system LiF-LiH, however, appears to form solid solutions without a pronounced minimum in the melting point.

Equilibrium constants for hydrogen reduction of FeF_2 in $NaZrF_5$ at 800°C have been measured by matching the HF concentration of the influent and effluent hydrogen streams. Dilute solutions of FeF_2 in this solvent appear to be nearly ideal.

When zirconium metal is used to scavenge the reducible impurities from 2 kg of a ternary eutectic of alkali fluorides after removal of the HF with helium stripping, less than 100 ppm of total impurities remains and about 1.5% of Zr^{4+} is picked up by the melt. Experiments on the purification of molten fluorides by electrolysis have shown that the decomposition potential of FeF_2 in $NaZrF_5$ is 0.9 volts and that the $NaZrF_5$ decomposes at 2.0 volts at 800°C.

Values of the concentration constant for the reaction



have been measured in molten $NaZrF_5$ at 600 and 800°C with various initial concentrations of UF_3 and UF_4 . Consistent values of K_c are obtained when the ratio of UF_3 to UF_4 is 3 or less; however, the measured constant increases rapidly at higher ratios. The consistent values agree quite well with previous values obtained for reactions in which the initial UF_3 concentration was negligible. (AEC Activity 4401.5)

Corrosion Research - An Inconel thermal convection loop which had circulated for 2000 hr a zirconium-base fluoride fuel with almost all the uranium present as UF_3 showed hot-leg attack that was very light and widely scattered with a maximum penetration in the form of subsurface voids to a depth of 4 mils. In similar tests with all the uranium present as UF_4 , the attack on the Inconel was heavy and the maximum penetration was to a depth of 15 mils.

Preliminary metallographic examination was made of a type 316 stainless steel thermal-convection loop in which lithium was circulated for 1000 hr at hot- and cold-leg temperatures of 810° and 660°C. There was 0.5 to 1 mil of subsurface void formation, with a maximum attack of 1 mil in the hot zone. There was some evidence of a slight amount of phase transformation on the surfaces. No crystals were found in the cold zone (660°C) but a few small crystals (0.2 mil thick) were found in the longer horizontal leg (690°C). Quite a few crystals (up to 3 mils thick) were found at the bath level line below the fill pipe.

PROGRAM 4000 - REACTOR DEVELOPMENT (Continued)

Tests of three beryllium specimens in contact with Inconel and molten sodium were made in the NACA dynamic-toroid corrosion-testing apparatus. These tests were of 300 hr duration and the sodium flow rate was 15 fps. After a test at 650°C, the beryllium appeared to be unattacked, and no deposits or attack were visible on the Inconel. Macroscopic examination after a test at 595°C showed a gray, flaky deposit on the surface of the Inconel in two places, but no attack was visible on the beryllium. After a third test at 700°C, the beryllium had a flaky appearance, and several light deposits were visible on the surface of the Inconel. (AEC Activity 4401.5)

Metallurgy - Fabrication - A rapid, satisfactory procedure for applying a protective edge of aluminum bronze to stainless-steel-clad copper high-conductivity radiator fins was developed. The optimum procedure consists of the following: (1) Prepare a slurry of Microbraz cement and subsieve aluminum and apply to the edge of each fin with a brush. (2) Pretreat the fins in hydrogen at 680°C for 10 min. (3) Remove the excess aluminum from the surfaces. (4) Diffuse and bright anneal for 1 hr at 1000°C in dry hydrogen. Metallographic examination of an edge prepared in this manner showed the formation of a yellow bronze that extended from the original surface to a depth of approximately 0.020 in. (AEC Activity 4401.5)

Metallurgy - Welding and Brazing - The extent and rate of high-temperature oxidation of Inconel T joints brazed with 15 different brazing alloys was tested. They were subjected to static air at 1500° and 1700°F for periods of 200 and 500 hr. These tests showed that most of the nickel and nickel-chromium base alloys are suitable at 1500°F, and several were found to be suitable at 1700°F. Coast metals alloy No. 52 (89% Ni-5% Si-4% B-2% Fe), which has a favorable flow point, was very oxidation resistant, even at 1700°F. (AEC Activity 4401.5)

Heat Transfer Research - A Lucite model of the circulating-fuel reflector-moderated reactor was fabricated and is to be used to study the hydrodynamic structure in that system. The results of a mathematical analysis of forced-convection heat transfer were presented in report ORNL-1701 for the case of flow between parallel plates which are ducting fluids with volume heat sources; this analysis can be used to estimate the temperature structure in flow annuli of reflector-moderated reactor cores. (AEC Activity 4401.5)

Physical Properties Research - The enthalpies and heat capacities of the ARE fuel NaF-ZrF₄-UF₄ (53.5-40.0-6.5 mole %) were determined; the heat capacity in the solid state over the temperature range 260° to 490°C was found to be 0.19 cal/g.°C, and the heat capacity in the liquid state over the temperature range 590° to 920°C was found to be 0.23 cal/g.°C. Enthalpy and heat capacity measurements for K₂CrF₆ in the solid state were obtained. The thermal conductivity of solid NaF-KF-LiF (11.5-42.0-46.5 mole %) was found to be about 3 Btu/hr·ft²(°F/ft). Electrical conductivity measurements for molten NaOH were obtained over the temperature range 625° to 1490°F. (AEC Activity 4401.5)

PROGRAM 4000 - REACTOR DEVELOPMENT (Continued)

Analytical Studies - A study of the effect of temperature on the conversion of UF_3 and UF_4 to the corresponding chlorides by fusion with $NaAlCl_4$ indicated a potential method for the separation of U^{4+} from U^{3+} . The solubilities of UF_4 measured at temperatures of 200° and $175^\circ C$ corresponded to 18 and 16 mg of uranium per gram of $NaAlCl_4$, respectively. The solubility of UF_3 was found to decrease from 5 mg of uranium per g of $NaAlCl_4$ at $225^\circ C$ to less than 1 mg per g at $200^\circ C$. Quantitative conversion of the fluorides of the fuel components to the corresponding chlorides was also achieved by heating the fuels in gaseous BCl_3 at $400^\circ C$. Under these conditions Zr is sublimed from the fuel as $ZrCl_4$, while the uranium is converted to UCl_4 , which is soluble in dioxane. Traces of oxidizing agents in the BCl_3 reagent must be removed to prevent partial oxidation of UF_3 to soluble UCl_4 .

An improved method for the determination of lithium in $NaF-LiF-RbF(KF)-UF_4$ fuel mixtures was developed. Lithium, as the chloride, is selectively extracted with 2-ethylhexanol, and the chloride content of the organic phase is determined by direct titration with a standard solution of silver nitrate. The method is rapid and precise (0.3 per cent standard deviation at the 95 per cent confidence level for 1 to 5 mg of lithium).

Solubility studies have been initiated with the reagent sodium tetraphenylboron for the determination of potassium, rubidium, and cesium in ARE fuels and fuel solvents. Data obtained to date indicate that a separation of rubidium and cesium from potassium as the tetraphenylboron salts is feasible based on the unique solubility of $KB(C_6H_5)_4$ in diethylketone and acetylacetone. (AEC Activity 4401.7)

Shielding Research - Extensive measurements made at the TSF (Tower Shielding Facility) indicate that at an altitude of 200 ft the ground-scattered radiation reaching the crew compartment 64 ft from the reactor does not exceed 3% of the total radiation. This quantity was derived from measurements of the dose at an altitude of 4 ft and of the angular distribution of the radiation leaving the reactor tank. In order to obtain a maximum estimate of the ground-scattered radiation, all the dose measured at 4 ft was attributed to ground scattering. The calculation, which showed a decrease by a factor of 50 in the ground-scattered radiation with variation of the altitude from 4 to 200 ft, assumed isotropic reradiation from the ground and required a numerical integration.

Several capsules containing the ARE fuel and fuel carriers have been exposed in a known flux of the BSF (Bulk Shielding Facility) reactor and counted for gamma radiation at various time intervals after irradiation, in order to investigate a method whereby the power of the ARE can be determined. It appears that the technique of comparing the activity of fuel irradiated in the BSF reactor with that used in the ARE at low power will be satisfactory for the calibration of the power indicating instruments of the ARE.

A high-flux thermal column of lead and graphite has been assembled at the BSF from materials previously used in other experiments. It will be used

PROGRAM 4000 - REACTOR DEVELOPMENT (Continued)

in conjunction with the neutron spectrometer for a measurement of the U^{233} fission spectrum. The thermal column has a cadmium ratio of approximately 100, and the thermal flux is greater than 10^8 nvt_{th}. (AEC Activity 4401.7)

GENERAL REACTOR RESEARCH

Package Reactor Project - The preliminary design study of a package reactor (ORNL memorandum CF 53-10-106) was revised and issued as a final report, A Conceptual Design of a Pressurized-Water Package Power Reactor, ORNL-1613 (classified). Copies of the report are being supplied to the AEC Chicago Operations Office for inclusion with invitations to bid for construction of the reactor plant on a lump-sum basis. The report will not be available for more general distribution until after the contract has been awarded. Statements concerning plant specifications, design objectives, and test procedures were prepared in cooperation with the Army Reactor Branch of the Reactor Development Division. It is expected that the invitations to bid will be issued in mid-July. (AEC Activity 4510)

General Reactor Radiation Damage - Fast-neutron bombardment of zircon ($ZrSiO_4$) produced effects similar to those found in the natural crystals which have suffered alpha radiation damage from uranium, or in which thorium has been substituted in zirconium positions in the crystal lattice. The lattice expansion and distortion produced by neutron irradiation is partially annealed at 950°C in single crystals.

Preliminary investigations of other refractory crystals in which oxygen is structurally dominant indicate that frozen-in displacements that result from neutron bombardment are not confined to open structures but may also be prominent in close-packed lattices. (AEC Activity 4540)

Dissolution Studies - Study of the dissolution of miniature Savannah River-type slugs (5% uranium--95% aluminum) with caustic in the 1-in.-dia. continuous dissolver showed that a quantitative prediction of column behavior over a wide range of caustic feed flow rates and concentrations, as well as two column bed heights, is possible. A large excess of carbonate did not increase the solubility (loss) of uranium in the caustic solution. It was shown that excess V_2O_5 or catalytic amounts of NaI in the solution would react with the peroxide formed by radiation decomposition of the water and prevent loss of the uranium by formation of the soluble uranium peroxide complex.

Batch centrifugations of a caustic solution of unirradiated uranium slugs, spiked with fission products in the absence of carrier, gave beta and gamma decontamination factors of 25 to 35 and 5 to 10, respectively. In this process the uranium oxide particles, which were dispersed in the caustic solution, were separated from the solution. The bulk of the activity followed the solid phase. (AEC Activity 4581)

PROGRAM 4000 - REACTOR DEVELOPMENT (Continued)

Heterogeneous Reactor Fuel Reprocessing - Results of reactivity tests on carburized stainless steel show that the carbon content of the stainless steel of both the cladding and core of uranium dioxide fuel plates should be between 2 and 4% to ensure rapid dissolution of the stainless steel. Excessive carburization of the surface without subsequent diffusion of the carbon into the subsurface reduces surface reactivity. Diffusion of the carbon into the bulk of the stainless steel at about 1000°C renders the subsurface metal reactive; when this diffusion was brought about in a helium atmosphere, decarburization of the surface did not occur simultaneously. In a hydrogen atmosphere at 900°C, decarburization of the surface occurred and the reactivity of the surface was diminished. (AEC Activity 4581)

PROGRAM 5000 - PHYSICAL RESEARCH

ISOTOPE PRODUCTION

Stable Isotope Production - Separations of the isotopes of chromium (masses 50, 52, 53, 54) are being made. The collection rate of gram quantities of Cr^{54} (natural abundance 2.38%) was accelerated materially by the design and development of a new type of two-arc ion source capable of operation in the 600° to 800°C range and producing chromium ion beams of over 200 ma at the collectors. Enriched Cr^{54} will be used as a target in the 86-in. cyclotron to produce $^{310}\text{d Mn}^{54}$ by the $\text{Cr}^{54} (p,n) \text{Mn}^{54}$ reaction.

The processing of nickel was completed in June with the production of an estimated 250 g of separated nickel isotopes (masses 58, 60, 61, 62, 64) and 76 g of separated copper isotopes (masses 63, 65), the latter being collected as sideband beams resulting from the reaction of Cl_2 , from the NiCl_2 charge material, with metallic copper components in the ion source.

New lots of enriched K^{40} , Zr^{96} , Hf^{174} , Hf^{177} , and Hf^{179} were added to the inventory. Preparation of charge materials for isotope separation included the synthesis of 32 kg of CrCl_3 .

Construction of a pilot plant for the separation of rare earths by liquid-liquid extraction was completed in Building 9731 near the production mass spectrographs.

Seventy-two shipments were made consisting of 63 different isotopes of 35 elements. (AEC Activity 5121)

PROGRAM 5000 - PHYSICAL RESEARCH (Continued)

PHYSICS

High Voltage Program - Analysis of the α -particles emitted by the $\text{Be}^9(\text{He}^3, \alpha)\text{B}^{10*}$ reaction at 90° with respect to the He^3 beam indicates a very strong, if not complete, suppression of the α -group leading to the ground state of Be^8 . This situation is to be compared with that of the $\text{B}^{10}(\text{d}, \alpha)\text{Be}^{8*}$ reaction which was also studied. In this latter case, the ground state α -group, observed on the same instrument, was found to be quite prominent. Angular distributions for the two companion reactions should yield information about the spins and parities of the levels involved.

Measurements were made of the variation with neutron energy of the fission cross sections for U^{233} , U^{234} , U^{236} , and U^{238} relative to U^{235} from 150 kev to 4.0 Mev, using monokinetic neutrons from the 5-Mev Van de Graaff with targets of lithium metal for neutrons up to 500 kev, and tritium gas from 400 kev up to 4.0 Mev.

Although the calculations have not been completed, a preliminary survey of the data for U^{233} and U^{238} shows generally fair agreement with the Los Alamos work reported in report LA-1495.

Five points were taken along the flat portion of the curve for U^{234} to 1% statistics. These points show that the curve of fission cross section given in report ORNL-1312 should be raised 16%.

Five points were taken along the flat portion of the curve for U^{236} to 1% statistics. These points show that the curve of fission cross section reported in report ORNL-1312 should be raised 2.7%.

In all cases foil errors are believed to be below 1%. Further work is planned on the low-energy region, down to about 10 kev, of U^{233} , after which a complete report on all of the above measurements will be made.

The polarization of fast neutrons from the $\text{Li}^7(\text{p}, \text{n})\text{Be}^7$ reaction was studied using scattering from oxygen as the analyzer. The data actually give the product polarizations of the $\text{Li}^7(\text{p}, \text{n})\text{Be}^7$ reaction at 42° and the $\text{O}^{16}(\text{n}, \text{n})\text{O}^{16}$ reaction at 90° . These were remeasured with 12-kev resolution from 270- to 620-kev incident neutron energy. Results follow the calculated curve for the $\text{O}^{16}(\text{n}, \text{n})\text{O}^{16}$ assuming a $\text{P}_{3/2}$ resonance at 435 kev interfering with $\text{S}_{1/2}$ potential scattering, indicating the $\text{Li}^7(\text{p}, \text{n})\text{Be}^7$ neutrons are polarized with a nearly constant value of 50% in this region. The anticipated reversal in sign was observed in these measurements. (AEC Activity 5211)

86-Inch Cyclotron Nuclear Physics - The projects on measurement of "(p, pn), (p, 2n), and Total Reaction Cross Sections in Medium Weight Elements", "Fission and Total Reaction Cross Sections in Th^{232} , U^{235} , and U^{238} ", and "Comparison Between Proton and Heavy Ion Induced Reactions" were completed and the papers were submitted for publication in The Physical Review. Continued progress

PROGRAM 5000 - PHYSICAL RESEARCH (Continued)

was made on measurements of angular distributions of alpha particles from (p, α) reactions, measurements of (p, α) and (p,He₃) cross sections, and isotope identification in the rare earths. (AEC Activity 5261)

Electronuclear Machines - A full-scale model of the magnetic-channel coil, to be used in the 86-in. cyclotron for deflecting the proton beam into a reaction room, was constructed. Preliminary tests indicate that the field, normally 8800 oersteds, is reduced to about 500 oersteds at the center of the channel, while outside the channel the disturbance is only 1%. This is a gradient of about 3300 oersteds/inch. The conditions near the ends of the coil have not been analyzed but it is known that they will be somewhat less favorable in small areas. The power input to the coil is 150 kw with a current density in the water-cooled conductor of 20,000 amp/in². (AEC Activity 5261)

63-Inch Cyclotron - The excitation functions for nitrogen-induced reactions in nitrogen, oxygen, and boron were measured. An upper limit for the differential cross section of the reaction $N^{14}(N^{14})C^{12}O^{16}$ was found to be 30 millibarns. The equilibrium charge of 26-Mev nitrogen ions passing through thin foils was previously found to be 6.1. Analysis of the beam of stripped ions in the fringing field of the cyclotron now shows that the distribution of charge is as follows: 7⁺ - 38%, 6⁺ - 46%, 5⁺ - 16%, with negligible amounts of smaller charges. (AEC Activity 5261)

Isotope Analysis Methods Laboratory - Utilizing the Oracle, computations of the rotational energy levels of HCOF and DCOF were made for several assumed FCO bond angles and bond distances. The data are best fitted by a bond angle of $122 \pm 2^\circ$ and bond distances in agreement with electron diffraction data.

Zeeman spectra of plutonium have led to the identification of atomic energy levels involving the low f⁰s electron configuration of singly ionized plutonium. The proportion of neutral plutonium atoms in the arc source in a field of 25,000 oersteds is extremely low.

Continuing studies of the theory of the aperture-limited Fabry-Perot interferometer have established no significant differences in coherent and non-coherent illumination methods, except for the case of the small exit aperture which favors the coherent illumination.

Important impurity effects on the element line intensities in the X-ray fluorescence analysis method when applied to ternary or higher mixtures of elements were observed in the investigation of rare earth mixtures.

The experimental phase of a joint research program with the Florida State University on the isotope effect in the $L\beta_3$ ($L_I - M_{III}$) lines of U²³³, U²³⁵, and U²³⁸ has been completed. It is concluded that any isotope shift effect in uranium must be less than 1/3 volt; however, anomalies in line shape may be real, the U²³⁵ $L\beta_3$ line being broader. (AEC Activity 5261)

PROGRAM 5000 - PHYSICAL RESEARCH (Continued)

Mass Spectrometer Laboratory - Preliminary experiments were completed on the use of iridium as an electron source filament. It was found that filaments 0.003 in. thick and 0.025 in. wide gave a total emission of from 0.2 to 0.3 ma and a collimated beam in the ionization chamber of from 10 to 20 μ amp. These currents and the measured lifetime for the filament of 10 hr are quite adequate for mass spectrometer use.

The composition of air was investigated using an iridium filament as the source of electrons. It was found that no corrections were needed to obtain the known composition, whereas when tungsten is used as the filament for producing electrons the ion currents due to oxygen are only 0.71 as large as they would be due to the reaction of oxygen with the hot tungsten filament. This suggests the use of iridium for the source of electrons when measuring the isotopic abundances of oxygen to eliminate the well-known irregular changes in the emission characteristics of tungsten in the presence of oxygen.

A search was made for polymers of oxygen at pressures of 10^{-4} mm of Hg in the General Electric mass spectrometer using an iridium filament as the source of electrons. Ions were found in the mass 64 position which may be O_4^+ or possibly a fragment which was produced by a large mass ion losing a charge in the field-free region between the electrostatic accelerator and the magnetic field; this is being further investigated.

A sample of Cs^{135} , recovered from the decay of Xe^{135} produced in the HRE, was analyzed using the isotope-dilution technique and was found to have the following composition: mass 133, 84.12% ± 0.06 abundance; mass 135, 15.83% ± 0.06 abundance. (AEC Activity 5261)

Research and Development, Stable Isotopes - The preparation of special forms of isotopic materials included: (1) electrolytic deposition of a 1-mil Ni^{60} target for the 86-in. Cyclotron Group; (2) fabrication of a 32-g Fe^{54} target, approximately $1-1/4 \times 1-1/4 \times 3/16$ in., for Westinghouse Research Laboratories; (3) making a 3-in.-dia hollow sphere of normal lithium metal for cross-section work. The Fe^{54} target was prepared by reducing the oxide by hydrogen and employing a powder metallurgical technique to obtain the final metal. The density of the target was about 90% of theoretical.

A procedure was worked out for obtaining cesium metal by thermal reduction of either $CsCl$ or CsF with metallic calcium. Heating was done by induction, and the yields in small-scale operation were about 80% of the theoretical value. (AEC Activity 5261)

PROGRAM 5000 - PHYSICAL RESEARCH (Continued)

CHEMISTRY

Inorganic Solution Chemistry - The anion exchange adsorption of the alkaline earths from citrate solutions was completed with a study of Be(II). Strong adsorption of Be(II) was found, distribution coefficient $D = \sim 7000$ in 0.01 M $(\text{NH}_4)_3\text{Cit}$ and $D = \sim 15$ in 1.0 M $(\text{NH}_4)_3\text{Cit}$. Combining these results with earlier data on alkaline earths, it was possible to demonstrate separation of all alkaline earths from each other by anion exchange.

Further equilibrium ultracentrifugations of Bi(III)-perchlorate solutions confirmed that a predominantly monodisperse species (pentamer or hexamer) is formed during the hydrolysis of Bi(III) and that this polymer has a remarkably large stability range and exists even in highly acid-deficient $\text{Bi}(\text{ClO}_4)_3$ systems.

During the study of temperature effects on the polymerization of Zr(IV) and Hf(IV) it was found that in 0.08 M HCl solutions polymerization decreases with decreasing temperature in the temperature range of about 0° to 30°C, suggesting that the apparent heat of polymerization is positive. Heating of ZrOCl_2 solutions to 100°C for 1 hr was found to increase the molecular weight of the polymers considerably (degree of polymerization of about 30 to 40), although the formation of typical colloids, which has often been postulated, was not found.

An ultracentrifuge study of Au(III) in 3 M HCl was carried out, since there was some evidence from solvent extraction and anion exchange data (J. W. Irvine, private communication) that under these conditions Au(III) is dimerized. No evidence for such dimerization was found, the centrifugation results giving a molecular weight of about 330, which may be compared with the theoretical formula weight 340.0 for HAuCl_4 . (AEC Activity 5311)

Chemical Physics - The paramagnetic resonance method was used to demonstrate the formation of atomic hydrogen on glass surfaces by gamma irradiation at liquid nitrogen temperature. The hydrogen comes from adsorbed water, and by using porous glasses and heavy water, the diffusion and exchange of heavy water on the surfaces were followed. Atomic hydrogen was not observed in bulk water irradiated at 77°K with gamma rays.

Scattering-reaction experiments with molecular beams of K and of HBr were extended by varying the temperature of the HBr. The increase of the apparent KBr with temperature confirmed the reality of the previous observations, which indicated a definite but small amount of reaction. (AEC Activity 5311)

Chemistry of the Solid State - Preliminary results with the system lithium iodide - lithium metal at 760°C indicate high solubility (30 mole %) of the metal in the fused salt and small solubility (<1 mole %) of salt in the liquid metal. The latter result agrees with the expectation of low solubility in the liquid metal, based on experience with cesium, potassium, and sodium

PROGRAM 5000 - PHYSICAL RESEARCH (Continued)

halide systems. It may be explained by the much higher cohesive energy, or heat of vaporization, of lithium as compared with that of the other alkali metals.

The solubility of solid potassium chloride in potassium metal and its temperature dependence were found to be quite similar to those of potassium fluoride, that is, approximately 12 mole % at 700°C, and somewhat less than 1 mole % at 500°C.

The absence of a phase transformation in cesium iodide in the temperature range up to 5°C below its melting point was established by means of the high-temperature x-ray diffractometer. This observation lends strong support to the assumption that the large volume increase on melting (approximately 30%) is the result of a structural change consisting of a lowering of the ionic coordination number of 8 in the crystal to an average of perhaps 6 in the fused salt. (AEC Activity 5311)

Radio-Organic Chemistry - Triphenylethylene glycol, labeled in the 1 and 2 positions in the chain and in the phenyl groups both stereospecifically and nonstereospecifically, was subjected to the pinacol rearrangement under a variety of conditions. It was shown that an isotope effect attends the rearrangement and that three different reaction paths are followed during the rearrangement. The contribution made by each of these paths under a given set of conditions was determined. (AEC Activity 5311)

Radiation Chemistry - The kinetics of the reactions of CO in the presence and absence of Xe under alpha-particle irradiation indicate that Xe does not alter the velocity constant. Hence there is no charge transfer from CO to Xe, which have ionization potentials of 14.1 eV and 12.1 eV, respectively. The velocity constant of 11.4, for both reactions, for a sphere 2 cm in diameter, agrees with previous values of 11.4 for CO alone and 11.2 for CO and Xe. These values are calculated considering the partial pressure of CO only. (AEC Activity 5311)

Chemistry of Fused Salts - The application of absolute reaction rate theory to electrical conductance by fused salts has permitted the derivation of a rate expression for equivalent conductance which involves the dielectric constant, the distance between two adjacent equilibrium positions of the diffusing ion, the entropy of activation for diffusion, and the heat of activation for diffusion. Entropies of activation were calculated for the systems potassium chloride - sodium chloride and potassium chloride - lithium chloride with reasonable assumed values for the dielectric constant, which is unknown. The entropies of activation show a smooth progression of values with changing composition and tend to a maximum negative value for those compositions which show minimum conductance. These same compositions tend to have maximum values for heats of activation.

A preliminary measurement of the heat of combustion of boron carbide was made which indicates a value in the range of 640 kcal/mole.

PROGRAM 5000 - PHYSICAL RESEARCH (Continued)

The heat capacity of a second sample of crystalline cadmium iodide was measured. A seemingly anomalous peak was again found in the heat capacity curve of the magnitude and location observed with a previous sample. However, the heat and entropy involved in this peak are very small. Although interpretation of the peak is uncertain, the results indicate no change in the thermodynamic constants reported in ORNL-1674.

The high-temperature, adiabatic, heat-capacity calorimeter, mentioned previously, was put into operation for test runs and calibration. The apparatus appears to operate satisfactorily, although a few minor difficulties have been experienced. (AEC Activity 5311)

Uranium Chemistry of Raw Materials - Preliminary tests have shown that certain long-chain primary and secondary amines in hydrocarbon diluents are efficient and selective extractants for thorium from liquors obtained by sulfuric acid digestion of Monazite sand. The thorium can be easily and economically recovered from the organic extract by stripping with a solution of nitric acid or by precipitating with a concentrated solution of sodium or ammonium hydroxide. Initial analyses of the extraction products indicate a rare earth contamination of less than 5%.

Previous reports described the use of tri(n-alkyl) phosphine oxides as solvent extraction agents for uranium from acidic aqueous liquors. Initial tests with the structurally similar tri(n-alkyl) phosphoramides show promise of equivalent or perhaps greater extraction ability under identical conditions. These latter compounds could be obtained at a lower manufacturing cost.

Uranium extraction coefficients of 3 to 4 were obtained from 10% solutions of sodium carbonate using 0.1 M solutions of several quaternary ammonium sulfate salts in chloroform; for example, paradiisobutylcresoxyethoxyethyl dimethylbenzyl ammonium sulfate, paradiisobutylphenoxyethoxyethyl dimethylbenzyl ammonium sulfate, and cetyldimethylbenzyl ammonium sulfate. With benzene as the diluent the extractions were poor due to limited solubilities of the reagents in the organic phase and heavy reagent losses to the aqueous phase. (AEC Activity 5361)

Analytical Chemistry - Studies of the precision of methods to be used in analyzing homogeneous reactor samples were continued and the polarographic method for nickel was shown to have a relative standard deviation of 0.8%.

The high cross section of B^{10} for thermal neutrons has been used as the basis of an in-line method for the continuous indication of the isotopic ratio of boron in a plant for the separation of boron isotopes. This method has been shown to be sensitive to as little as 0.006 milligrams of natural boron per milliliter.

Methods for the determination of neptunium in its various valence states is being studied because of the significance of this element in a homogeneous

PROGRAM 5000 - PHYSICAL RESEARCH (Continued)

plutonium producer. Considerable difficulty has been encountered in obtaining satisfactory results on tracer levels by radiochemical methods, the most satisfactory procedure consisting of the determination of Np(IV) by TTA extraction then obtaining total Np by TTA extraction of a reduced sample.

METALLURGY

Ceramics Research - A petrographic examination of the strata underlying the proposed radioactive waste disposal area (Hope Project) showed the prevalence of calcareous rocks. Thirty-two disks of ThO_2 and approximately 2000 g of ThO_2 cylinders 1/2 in. x 1/8 in. O.D. x 1/16 in. I.D. were prepared (96% of theoretical density) for shipment to Hanford in a cooperative project to study conversion ratio and radiation stability. Twelve Hanford aluminum slug cans 1.36 in. O.D. and 4 in. long were vibratory-packed with sized particles of fused UO_2 to a density of 73% of theoretical for shipment to Hanford, also, as part of the above project.

A survey of some 400 SiC-Si bodies covering a range of compositions, particle sizes, and forming pressure resulted in the selection of a body with optimum physical properties for further development for use in gas-cooled, solid fuel elements. Specimen fuel elements in the form of disks 1/2 in. in diameter and 1/10 in. thick, with approximately 0.03 g of UO_2 contained in the core, were prepared for fission product retention studies from a specimen of Cr-Mo and the following cermets: TiC-Ni, ZrC-Fe, MgO-Ni, CrAl_2O_3 . Specimens of commercial glass-coated steel supplied by the Pfaudler Company have been exposed in a radioactive waste solution for one month with no visually observable effects. (AEC Activity 5411)

Physical Metallurgy of Reactor Materials - Continuation of the work on the removal of uranium from stainless steel- UO_2 fuel elements by treatment of the melted element with fluoride slags has shown that ferrous fluoride + calcium fluoride and ferrous fluoride + sodium fluoride slags are equally effective. The residual uranium content of the stainless steel was less than 0.004% in both cases.

In the course of investigating the transformation kinetics of zirconium-silver alloys, a metallographic technique was developed which allows positive identification of the various eutectoid reaction products, that is, pearlite, bainite, alpha zirconium, martensite and retained beta zirconium. This technique consists of electrolytic polishing in concentrated HCl with a small amount of added NH_4HF_2 , followed by an anodizing electrolytic etch in a water solution of lactic acid, phosphoric acid, citric acid, and glycerine. The difference in oxidizing rate of the various alloy phases produces different oxide film thicknesses which are distinguishable by the interference colors produced. (AEC Activity 5411)

PROGRAM 5000 - PHYSICAL RESEARCH (Continued)

Fundamental Physico-Metallurgical Research - Recent results on annealing various types of Grade I crystal-bar zirconium show significant trace amounts of β phase in a 15°C temperature range immediately below the main part of the α/β transition. Tests have indicated that a metallic impurity, such as iron or nickel, rather than carbon, hydrogen, oxygen, or nitrogen is responsible for this effect.

Annealing and quenching studies of the details of the Zr-Ag eutectoid region now place the composition and temperature between the limits 3.5 to 3.6 atomic percent silver at 814° to 823°C. This agrees with previously reported results of thermal analysis. In the Zr-Sb system, microstructures of as-cast alloys in the region 20 to 30 atomic percent antimony showed the first intermediate phase to be Zr₂Sb, in agreement with results reported in the literature.

A study is being made of the effect of fabrication variables on the preferred orientation found in extruded aluminum rod. Axis distribution charts were prepared for sections taken from the front, middle, and back of a rod extruded at 450°F at a rate of 0.10 fpm; the amount of deformation increases from front to back. Axis distribution charts are being prepared for similar sections of a rod extruded at the same temperature but at a rate of 615 fpm. As shown in the table

<u>Extrusion Temperature</u>	<u>Extrusion Speed</u>	<u>Location of Specimen</u>	<u>Texture</u>	<u>Volume % of Material with</u>	
				<u>$\sqrt{111}/\sqrt{100}$</u>	<u>$\sqrt{111}/\sqrt{100}$</u>
450°F	0.10 fpm	Front	$\sqrt{111} + \sqrt{100}$	2.0	67 33
450	0.10	Middle	$\sqrt{111} + \sqrt{100}$	0.9	47 53
450	0.10	Back	$\sqrt{111} + \sqrt{100}$	0.45	31 69
450	615	Middle	$\sqrt{111} + \sqrt{100}$	5.1	83 17

the amount of the $\sqrt{100}$ component increases markedly from front to back of the specimens. According to present theories of deformation textures, the amount of $\sqrt{111}$ component should increase with the amount of deformation, and the increased amount of $\sqrt{100}$ component should be due to thermal effects.

As a new approach to the quantitative determination of preferred orientations in rolled sheet, the texture was treated as fiber textures about three mutually perpendicular axes. Fiber axis distribution charts were prepared for a specimen of cold-rolled brass sheet, taking as "fiber axes" the rolling, normal, and transverse directions. From these charts, the texture was found to have three components: (110) $\sqrt{112}$, (110) $\sqrt{001}$, and (111) $\sqrt{121}$. Previous investigators, using conventional techniques, have reported only the (110) $\sqrt{112}$ component for cold-rolled brass sheet. (AEC Activity 5411)

PROGRAM 5000 - PHYSICAL RESEARCH (Continued)

Fundamental Investigations of Radiation Damage in Solids - The magnetic susceptibility vs temperature curve of a specimen of piezo-crystal quartz, subjected to a fast neutron bombardment of 5×10^{19} neutrons/cm² at 100°C, has been compared to that of an unirradiated specimen. The difference curve, plotted as a function of $1/T$, is a straight line with a slope indicative of approximately 6.2×10^{19} paramagnetic centers (assuming a spin of 1/2) being introduced by the bombardment. The bombarded sample has a slight pink coloration and underwent a density decrease of 2%. (AEC Activity 5411)

OTHER PHYSICAL RESEARCH PROJECTS

Research Participation and Traveling Lecture Programs - The Traveling Lecture Program for the academic year 1953-1954 was completed with the final lecture delivered on May 27. Of the total of 221 lectures delivered at 48 universities, 165 were presented by lecturers in the physical sciences.

Research Participants who will spend this summer at the Laboratory have all reported for their assignments, with a total of 57 university faculty members taking part in this program. Of these, 46 are engaged in physical science research in Laboratory Divisions as follows: Analytical Chemistry, 2; Aircraft Reactor Engineering, 3; Chemical Technology, 4; Chemistry, 9; Electro-nuclear Research, 3; Instrumentation and Controls, 1; Materials Chemistry, 2; Mathematics Panel, 3; Metallurgy, 6; Physics, 7; Reactor Experimental Engineering, 2; Solid State, 1; and Stable Isotope Research and Production, 3. (AEC Activity 5620)

PROGRAM 6000 - BIOLOGY AND MEDICINE

BIOPHYSICS

Waste Disposal Research - The radioisotopes, Cs¹³⁷, Ru¹⁰⁶-Rh¹⁰⁶, Sr⁹⁰-Y⁹⁰, I¹³¹, and Zr⁹⁵-Nb⁹⁵, each contained in a solution of NaAlO₂ to which no carrier was added, were passed through small soil columns (about 1 in. dia and 12 in. long). After the passage of 45 to 50 ml of solution, the columns clogged, but essentially complete removals of Cs¹³⁷, Sr⁹⁰-Y⁹⁰, and Zr⁹⁵-Nb⁹⁵ were obtained. Some Ru¹⁰⁶-Rh¹⁰⁶ and 100% of the I¹³¹ was found in the effluent.

Neutralization with 18 N NaOH of an Al(NO₃)₃ waste solution, containing trace amounts of radioisotopes, gave the following removal of activity: Sr⁹⁰, 61 to 70%; Y⁹⁰, 91 to 95%; Cs¹³⁷, 2 to 3%; Zr⁹⁵-Nb⁹⁵, 99+%; I¹³¹, 0 to 6%, and Ru¹⁰⁶-Rh¹⁰⁶, 77 to 87%. Strontium removals could be increased by the addition of Ca, Sr, or Ba carriers.

PROGRAM 6000 - BIOLOGY AND MEDICINE (Continued)

A procedure developed for recovering the major fission products fixed to clay soils consists of leaching the soils with suitable solutions while shaking and separation by centrifugation. Ten grams of local clay soil were leached with three successive 25-ml portions of 0.5 N HCl, 55 g/l H₂C₂O₄, and concentrated HCl for periods of 20 min.

Laboratory permeability studies of soils, contiguous to the proposed ground disposal area, indicated that the soil had a permeability coefficient of about 4×10^{-6} cm/sec (18°C). Attempts to reduce this value to $<10^{-7}$ by chemical stabilization of the soil were partially successful.

A simulated reactor process waste was deposited in the unlined experimental pit near White Oak Lake. Twenty test wells surrounding this pit are being sampled daily and "radio-logged" in order to determine the direction, rate of movement, and dimensions of pollution flow through the weathered shale formation. The lined pit in the same locality was filled with water and is being tested for water-tightness of the asphaltic membrane lining.

From previous core hole explorations of sites for liquid waste pits, an area of approximately four acres is being studied intensively. By means of four 200-ft deep core holes, two of which were completed, and one 300-ft deep 6-in. cable-tool well to be located in the center of the area, pumping tests of the central well and pressure tests of the core holes will be made in an effort to define quantitatively the overall permeability of this site. (AEC Activity 6510)

Physics of Radiation Dosimetry - Each mouse in two groups was given a single dose of Co⁶⁰ by stomach tube, and the drinking water of a third group was maintained at a constant level of Co⁶⁰ contamination. At intervals the animals were sacrificed - ten at a time - and the tissues assayed. From these data it was found that the calculated values for continuous exposure (using single exposure data) checked with the experimental data for continuous exposure within the limits of error of the experiment. This would verify the current practices of using single exposure data to calculate the maximum permissible concentration of a radioisotope in water for continuous use.

In recent publications, the liver, gastrointestinal tract, and spleen have been mentioned as choices for the critical organ for Co⁶⁰. The above experiment indicated that the gastrointestinal tract is to be considered as the first choice for critical organ and the liver as the second choice.

There are wide discrepancies between published values relative to the per cent retention of ingested Co⁶⁰ in the liver and the effective half-life in the liver. The per cent retention and effective half-life in this experiment are $0.7 \pm 0.3\%$ and 0.5 ± 2 days, which values are in satisfactory agreement with those given in Handbook 52. (AEC Activity 6510)

PROGRAM 6000 - BIOLOGY AND MEDICINE (Continued)

Experimental Radiation Measurements - The crew compartment of the Tower Shielding Facility was used to support the small aircraft scintillation equipment. Measurements to determine absorption and scattering in air of the gamma rays from Au¹⁹⁸ and Ra were made at heights up to 200 feet. These data supplement measurements taken previously at higher levels with the use of aircraft.

Aerial surveys for uranium prospecting in the joint program with the U. S. Geological Survey were conducted in the vicinity of Cedar City, Utah. The efficiency of the survey was hampered by contamination that was presumably fall-out from the Pacific bomb tests. (AEC Activity 6520)

Radioactive Particulate Problem - In the study of the efficiency of sand filters to entrain aerosols from a boiling solution of the Hope Process wastes (report ORNL-1638), a solution consisting of AlNO₃ neutralized with an excess of NaOH was introduced below the surface of a layer of gravel contained in a 4-in.-dia glass column. At boil-up rates of about 2 to 8 lb H₂O/ft²/hr, the decontamination factors obtained were of the order of 10⁷. A small quantity of soap was added to the solution to study the effect of foaming on disen-trainment. The foaming reduced the decontamination factor from ~10⁷ to ~10⁶. These tests, made without a sand entrainment layer, established a base point for further investigations of the efficiency of sand layers as entrainment separators.

To eliminate the tedious use of a Microscope for counting droplets photographed in the ORNL cloud chamber used for measuring the concentration of particulates in aerosols, a film holder has been attached to a microcard reader. (AEC Activity 6520)

Professional Health Physics Training - The 21 AEC Fellows in Radiological Physics began their Applied Health Physics Training at the Oak Ridge National Laboratory on June 8, 1954. Ten of the Fellows were granted extensions of their fellowships to complete the thesis requirement for the Master's Degree from Vanderbilt U. The remainder of the Fellows will be available to take positions as Health Physicists after September 1, 1954. (AEC Activity 7620)

Research Participation and Traveling Lecture Programs - The Traveling Lecture Program for the academic year 1953-1954 was completed with the final lecture delivered on May 27. Of the total of 221 lectures delivered at 48 universities, 56 were presented by lecturers in the fields of biology and biophysics.

Research participants who will spend this summer at the Laboratory have all reported for their assignments, with a total of 57 university faculty members taking part in this program. Of these, 9 are working in the Biology Division and 2 in Health Physics. (AEC Activity 6720)

[REDACTED]

RADIOISOTOPE SALES AND COSTS

<u>Type of Transaction</u>	<u>May</u>	<u>FY to Date</u>
Domestic Sales	\$ 88,617	\$ 833,573
Foreign Sales	1,770	48,766
Project-Cash Sales	31,317	176,226
Project-Transfer Credits	---	4,283
Technical Cooperation Program Credits	-138	7,957
Plant Credits	4,555	107,374
Civilian Defense Credits	265	655
Cancer Program Credits	16,911	218,741
*Miscellaneous Income	---	337
Total Income	\$ 143,297	\$ 1,397,912
**Income - No Production costs incurred		
Subtract from Total Income	<u>1,810</u>	<u>48,249</u>
Net Radioisotope Income	<u>\$ 141,487</u>	<u>\$ 1,349,663</u>
Radioisotope Costs	<u>\$ 152,868</u>	<u>\$ 1,096,021</u>
Radioisotope Shipments	<u>1,050</u>	<u>11,389</u>
*Miscellaneous Income - D ₂ O, Freight, Missing parts, TCP.		
**Income from H ³ , He ³ , B ¹⁰ , and miscellaneous items in excess of handling cost.		

GROSS OPERATING COSTS

	<u>Cost for May</u>	<u>FY 1954 Cost to Date</u>
Programmatic Operating Cost - Net	\$ 2,517,162	\$ 26,320,136
Plant and Equipment Cost	220,584	3,109,365
Construction Program "H"	21,210	536,660
Work for Other Parties - Transfers	32,585	475,399
Inventory Changes	45,971*	320,868*
Reimbursable Work for Other Parties	181,383	1,601,857
Deferred Charges	<u>3,082</u>	<u>7,258</u>
Total Laboratory Cost - Net	<u>\$ 2,930,035</u>	<u>\$ 31,729,807</u>
Estimated Cost for Next Month - Net	<u>\$ 3,000,000</u>	<u>\$ 34,729,807</u>
*Credit		

[REDACTED]

PERSONNEL SUMMARY

	<u>Number of Employees</u> <u>June, 1954</u>	<u>New Hires</u> <u>June</u>	<u>Terminations</u> <u>June</u>
Administration	64	0	0
Operations*	119	2	2
Engineering, Shops and Mechanical	829	30	8
Laboratory and Research	1899	153	16
Protection	149	2	0
Service	<u>388</u>	<u>8</u>	<u>1</u>
	3448	195	27

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

A total of 712 Laboratory personnel are located in the Y-12 Area.

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Previous reports in this series:

June 1953	ORNL-1576
July 1953	ORNL-1600
August 1953	ORNL-1612
September 1953	ORNL-1622
October 1953	ORNL-1643
November 1953	ORNL-1651
December 1953	ORNL-1665
January 1954	ORNL-1676
February 1954	ORNL-1695
March 1954	ORNL-1703
April 1954	ORNL-1719
May 1954	ORNL-1733