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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

SEPTEMBER 1956

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September, 1956

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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

September, 1956

This status and progress report summarizes somewhat less than one-half of the Laboratory's activities. A few of the activities are reported every month but most of them are reported on a bimonthly schedule. Program 4400 is reported separately.

PROGRAM 2000 - SPECIAL NUCLEAR MATERIALS

Waste Metal Recovery - The Metal Recovery Plant equipment was decontaminated and modified, and continuous processing of the ORNL tank farm sludge was started. The uranium throughput is 500 lb/day. A Purex-type flowsheet with 15% tributyl phosphate in Amsco as the solvent is being used. (AEC Activity 2350)

Fluorox Process - In the Fluorox process uranium oxide is simultaneously reduced and hydrofluorinated to UF_4, which can then be reduced to metal or oxidized to UF_6. Both the feed to and product of the reduction-hydrofluorination reaction is in pellet form. Carbon present in the product pellets caused overheating in the moving-bed oxidation reactor; pellets containing no carbon have now been prepared from Excer product UF_4.

In a single preliminary test approximately 3% of an 18-g UF_4 sample was oxidized in 1 hr by either air or oxygen at 600°C. At 800°C oxygen was twice as effective as air, with oxidation 75% and 38%, respectively. Uranium pentafluoride was isolated from the oxidation system and was positively identified by x-ray analysis. This compound is either an intermediate in the oxidation reaction or a product of a UF_4-UF_6 reaction. (AEC Activity 2702)

Metallex Process - In the Metallex process $ThCl_4$ is reduced with sodium amalgam; the thorium is separated from the resulting thorium quasi amalgam by filtering, pressing, and sintering. Continuous reduction at a rate of 3 lb/hr was demonstrated in a Dispersall mixer. The product was very thick; there was some difficulty in removing it from the reactor.

The addition of 0.003 wt % magnesium to the reaction products after the reduction and prior to aqueous washing, to decrease the oxidative effect of the washing, reduced the atmosphere-connected voids of the resulting thorium sinters but left a residue in the thorium metal of 300-400 ppm magnesium and increased the HCl-insoluble material from ~ 1% to ~ 3%. The use of 5 g of hydrazine dihydrochloride per liter of aqueous wash solution to inhibit amalgam oxidation slightly improved overall reduction yields and markedly increased the recovery of reduced thorium to 96%. Attempts to eliminate the washing

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procedure by filtering the quasi amalgam at 356°C were unsuccessful. Approximately 95% of the mercury phase, carrying less than 50% of the reduced thorium, passed through the filter. Five percent of the mercury, carrying >50% of the thorium and >99% of the chloride by-products, remained on the sintered glass filter. The experiments were made with thorium amalgams prepared by both dry reduction of $ThCl_4$ and dissolution of thorium metal in mercury.

The species of thorium mercuride in the thorium quasi-amalgam reduction product was shown to be dependent on the temperature and the time the amalgam was held at reaction temperature, but not by the washing reagents and technics. (AEC Activity 2704)

Power Reactor Fuel Reprocessing--Zircex Process - In the Zircex process uranium-zirconium fuel elements are hydrochlorinated to remove the zirconium as the volatile $ZrCl_4$. The residue is dissolved in nitric acid, and the uranium is solvent-extracted. The hydrochlorination step was demonstrated with 100-200 g of U-Zr alloy. There was a straight-line relationship between the reaction rate and the reciprocal of the temperature; the rate varied from 6.4 to 22.4 mg/cm^2-min as the temperature increased from 528° to 680°C. The maximum reaction temperature has been set at 750°C, but indications are that operation at this temperature will not be satisfactory. In a 30-min hydrochlorination at 750°C, 54% of the uranium in an STR specimen appeared in the $ZrCl_4$ sublimate, 21% was distributed on inner surfaces of the reactor, and 25% remained in the reaction boat. Two-thirds of that in the boat was insoluble in nitric acid.

A Zircaloy-2-clad PWR blanket element was dejacketed by 2 hr hydrochlorination at 330°C; 0.4% of the uranium in the UO_2 core was insoluble in 2 M HNO_3. Tin in Zircaloy-2 is expected to remain in the metallic state during hydrochlorination. When $SnCl_4$ was added to the vapor, a layer of metallic tin covered the specimen; the hydrochlorination rate (370°C) was 0.68 mg/cm^2-min.

Impurities in the HCl decreased the hydrochlorination rate at 300°C. The rate was 3.13 mg/cm^2-min with pure HCl and 0.2 mg/cm^2-min with HCl saturated with CCl_4. When the HCl had been saturated with water vapor at 20°C, the rate decreased to 2.6 mg/cm^2-min but the nitric acid-insoluble uranium in the residue did not increase.

Liquid-phase hydrochlorination, which offers easier temperature control than vapor-phase, may be feasible. At 340°C in liquid aluminum ammonium chloride, in which NH_3 and HCl are formed by dissociation, the initial dissolution rate of an STR fuel element specimen was 7.65 mg/cm^2-min. The melt was agitated with a stream of HCl. The temperature was raised from 340°C at the start to 370°C at the end to keep the melt fluid. The overall dissolution rate was 2.25 mg/cm^2-min. Only 1.4% of the uranium in the residue was insoluble in nitric acid. The dissolution rate in aluminum sodium chloride at 300°C, agitated with a stream of HCl, was only 0.5 mg/cm^2-min. (AEC Activity 2924)

Power Reactor Fuel Reprocessing--Darex Process - In the Darex process uranium-stainless steel fuel elements are dissolved in dilute aqua regia, the chloride is distilled off, and the uranium is solvent-extracted. Preliminary experiments indicated that Consumers Public Power (CPP) fuel elements and Detroit Edison Axial Blanket (DEAB) elements can be processed by a Purex-type solvent extraction flowsheet. The CPP and DEAB element solutions will be 1-2 M in HNO_3 and will contain, per liter, 324 g of uranium, and 28 and 88 g of stainless steel, respectively. In tests with synthetic feeds of these compositions the CPP feed did not precipitate at ordinary operating temperatures at acidities of 0.4 to 1.2 M. However, all DEAB feeds of these acidities precipitated after standing a few days at room temperature. The DEAB feed could be stabilized by as little as 10% dilution if the acidity was held to 0.5 M; with 1.0 M HNO_3 in the feed, 25% dilution was needed.

All feeds tested had sufficient salting strength to provide uranium extraction coefficients large enough for efficient solvent-extraction with minor modification of the basic Purex flowsheet. In a batch countercurrent experiment simulating the first-cycle extraction-scrub operation of a Purex-type flowsheet, operability and recovery of uranium and plutonium from synthetic CPP fuel solution were entirely satisfactory. Feed stage extraction coefficients for uranium and plutonium were 5.96 and 2.49, respectively. Only three stages were required to reduce losses of both uranium and plutonium to 0.01%. Results of a similar experiment with synthetic DEAB solution indicated that 2 and 4.5 stages are needed to reduce the losses of uranium and plutonium, respectively, to 0.01%. (AEC Activity 2924)

Power Reactor Fuel Reprocessing--Mechanical Processes - Tests with a consumable electric arc (Elox) cutting machine indicated that it is accurate enough to remove the side plates from an Atomic Power Development Associates reactor fuel element so that the uranium and thorium fuel plates that make up the element can be separated. A Mackintosh rotary straightener was used satisfactorily in removing the unbonded stainless steel jacket from a 3-ft stainless steel rod used as a dummy fuel element for testing purposes. (AEC Activity 2924)

PROGRAM 3000 - WEAPONS

RaLa - A RaLa run was made, and approximately 13,750 curies of product were shipped on September 14, 1956. (AEC Activity 3641)

HOMOGENEOUS REACTOR PROJECT

Homogeneous Reactor Test - The entire month was required for the removal of the intolerable chloride contamination which resulted from the use of chloride-bearing stainless steel in the leak-detector lines. Each length of 1/4-in. tubing was flushed for 36 hr with distilled water, allowed to soak for 24 hr, and then approved for drying if the chloride content of the sample indicated less than 1 ppm. The lines were then dried under vacuum. The ring-joint flanges were cleaned and reassembled with new gaskets. At the same time, the old bolts were replaced with longer bolts and ferrules to provide greater elasticity in the bolted joint.

The decision was made to use high-pressure oxygen as the test fluid instead of heavy water in order to eliminate the chance of extracting more chloride from the tubing. Although the sensitivity of the leak-detector system may be reduced by the use of gas, the reduction is not considered serious.

Preparations were completed for testing the pressure-balancing system which controls pressures during the dumping operation. (AEC Activity 4103.3)

HRT Chemical Pilot Plant - In a 3000-psi hydrostatic test of the HRT Chemical Plant high-pressure system, performance was satisfactory. The system was then cleaned with 3% trisodium phosphate solution and rinsed three times with distilled water. Washing with 5% nitric acid at 80°C is currently under way to determine whether any off-specification material was used.

Design of the dissolver system, to be used to obtain a solution sample of the solids removed from the reactor, is about 40% completed. Delivery of the tantalum-lined dissolver vessel is scheduled in six weeks; installation of the entire dissolver system will then begin. (AEC Activity 4103.1)

Mathematics and Computation--Homogeneous Reactor Development - Analytical solutions were obtained for the time behavior of fuel concentrations in single-region reactors containing either U^{235}, U^{238}, Pu^{239}, and fission-product poisons; or U^{233}, U^{235}, Th^{232}, and fission-product poisons. These solutions were coded for the Oracle. (AEC Activity 4103.1)

Reactor Analysis - The radiation level within the HRT cell due to activation of the shield and the steel liner of the cell was estimated. Following 5-Mw operation of the reactor for one year, the radiation level within the cell 4 hr after reactor shutdown would be about 3 r/hr and one day after shutdown would be about 0.8 r/hr. The cell activity due to activation of the concrete relative to that due to activation of the cell liner would be about 2:1 after shutdown for 4 hr and about 10:1 after shutdown for one day.

Calculations were performed to determine the power level attainable in natural-circulation homogeneous reactor systems. The results indicate that for comparable systems the power level achievable by a natural-circulation system is about one-fifth to one-third that attainable by a forced-flow system.

For given operating conditions, the power output of a natural-circulation system would be increased by decreasing the resistance to fluid flow and/or by increasing the vertical height between the reactor core and heat exchanger. Thus an increase in fuel inventory would be associated with an increase in power level. (AEC Activity 4103.1)

HRP Design - Approximately 40% of the HRT piping and installation drawings were revised and brought up-to-date to agree with actual field installation. A more elastic system of flange bolting was designed for installation in the HRT. In the new design the bolts have longer shanks with ferrules, which will provide for more reliable flange sealing under the thermal-cycle conditions of the HRT. (AEC Activity 4103.1)

HRP Metallurgy - As a portion of the effort to obtain zirconium alloys with improved corrosion resistance, a heat-treatment and metallographic study is being made of the zirconium-niobium system. This system was found to be much more complex than had been expected in that several transformations appear to be possible. The system must be better understood before it is used for reactor fabrication.

In a study of the oxide films on zirconium alloys, an oxide film with a densely packed structure was obtained on only the zirconium-niobium alloys, and on these only by high-temperature oxidation. All films formed by oxidation at 300° and 600°C were predominantly monoclinic.

It was shown that with Zircaloy-2 large changes in the shape and location of the impact transition curve may be obtained by small changes in specimen geometry. By using a deep, sharp notch in a subsize Charpy V type of specimen, it is possible to eliminate the transition region completely. A subsize specimen, suitable for radiation studies, which will give a curve comparable to a standard full-size Charpy V notch specimen has now been developed. (AEC Activity 4103.1)

Radiation Damage HRP - Results of recent tests showed that irradiation of carbon steels increased notched-bar impact transition temperatures as much as 300°F at about 10^{20} nvt (>1 Mev). Previous tests gave maximum increases of 160°F at a lower dose. Tensile tests on irradiated carbon steels showed that no observable work hardening occurred before necking took place in some steels irradiated to 10^{20} nvt (>1 Mev). The results from both tensile and impact tests are in agreement as to which of the steels suffered the greatest degradation of ductility. (AEC Activity 4103.1)

HRP Spectroscopy Development - Spectrochemical methods of analysis for aluminum, titanium, and zirconium were developed for application to chemical concentrates of HRP thorium slurry samples; the spectrochemical range established for these impurities is 2 to 100 μg/ml. Rapid spectrochemical identification procedures established for stainless steels and Stellites were continued unchanged during this period. The sensitivity of detection of uranium on Saran supporting films was investigated in order to establish the detectability of uranium in thin corrosion films; the present detection limits appear to be of

the order of 50 μg. Four batches of depleted loading fuel for the HRT were analyzed to certify U^{235} content, with the following results:

Batch	U^{235} Assay (%)
309	0.376
344	0.289
345	0.293
346	0.287

(AEC Activity 4103.1)

Laboratory Corrosion Studies - Chloride concentrations of 25 and 50 ppm produced stress-corrosion cracking in type-347 stainless steel specimens stressed at 15,000 and 30,000 psi during the period between 100 and 200 hr of exposure in a boiling and aerated 0.04 m UO_2SO_4 solution containing 0.02 m H_2SO_4 and 0.005 m $CuSO_4$. Chloride concentrations of 0, 5, 10, and 100 ppm and bromide and iodide concentrations of 100 ppm each failed to produce cracking at these stress levels after a total exposure time of 1000 hr under similar conditions.

No stress-corrosion cracking has been observed yet on precorroded type-347 stainless steel stressed at 20,000 psi after 2400 hr in the solution and vapor phases of boiling 0.04 m UO_2SO_4 - 0.004 m H_2SO_4 - 0.005 m $CuSO_4$ solution containing 60 ppm of chloride ion. The stress specimens were previously exposed for 7630 hr in a similar chloride-free boiling uranyl sulfate solution.

Corrosion-fatigue tests with a 1-1/8-in.-OD high-pressure type-347 stainless steel bellows of HR design gave an average value of 38,900 cycles for occurrance of rupture during exposure in simulated HRT core solution at 285°C with a total pressure gradient of approximately 2200 psi across the wall of the bellows. The total travel of the bellows was 1/8 in. at a rate of 10 cycles per minute. The type-347 stainless steel used in the fabrication of the three-ply bellows did not meet present HRP material specifications. (AEC Activity 4103.1)

Dynamic Solution Corrosion - The long-term runs in which a solution containing 0.04 m UO_2SO_4, 0.005 m $CuSO_4$ and 0.02 m H_2SO_4 was circulated at 250° and 300°C were shut down for examination of the corrosion specimens after approximately 2000 hr. Very low corrosion rates were observed up to 40 to 45 fps at 300°C and up to 25 to 30 fps at 250°C on all austenitic stainless steels. Types-347 and 309 SCb stainless steel, titanium, and Zircaloy-2, each stressed to 75% of its room-temperature yield strength, showed complete absence of stress-corrosion cracking. The concentrations of copper and uranium appeared to remain constant during both runs.

Runs, with 0.17 m UO_2SO_4 in which the chromium(VI) concentration was maintained at various levels, were made at 250° and 275°C. The corrosion rate of type-347 stainless steel at 70 fps increased markedly and that at 10 fps decreased markedly as the chromium(VI) concentration was increased. Similarly, the corrosion rate at 70 fps was higher and that at 10 fps was lower at

275°C than at 250°C; that is, an increase in the chromium(VI) concentration produced qualitatively the same effect on the corrosion rate as an increase in temperature. (AEC Activity 4103.1)

Small-Scale Dynamic Slurry Corrosion Tests - Several tests were completed in which thorium oxide product from loop run 200A-6, so-called "standard" slurry, was circulated in toroids. The "standard" slurry had been produced by 100 hr of circulation at 200°C. Circulation in toroids for 97 hr at 200°C with oxygen and at 10 or 20 fps, at concentrations of 500, 1000, or 1500 g Th/kg H_2O, showed that the "standard" slurry increased in particle size from 10-18 μ balls with fines present to relatively uniform 38 μ spheroids with no fines present. The raw slurry from which the "standard" slurry had been produced did not produce any balls when circulated under the same conditions at a concentration of 500 g Th/kg H_2O. Corrosion rates for type-347 stainless steel were 1 to 6 mpy for the "standard" slurry and 2 to 5 mpy for the raw slurry. Circulation of raw (2.1 μ) and "standard" (10 μ) slurries for 225 hr at 250°C with oxygen and at 26 fps, at 1000 g Th/kg H_2O, showed degradation to 0.7 μ particles for each, with stainless steel corrosion rates of 3 mpy by the raw and 4 mpy by the "standard" slurry. (AEC Activity 4103.1)

Dynamic Slurry Loop Corrosion Tests - One dynamic corrosion test of 300 hr duration with previously circulated slurry was made at 300°C in the 100A pump loop CS at an average circulating concentration of 346 g Th/kg H_2O to observe the effects of the use of previously pumped slurry on particle degradation and corrosion rates. Corrosion rates for pin specimens of the austenitic stainless steels, titanium and its alloys, and Zircaloy-2 were about 50% lower than the rates observed on the same materials in a previous test under the same conditions, except with raw slurry. In both tests the slurry was prepared from ORNL-produced thorium oxide which had been calcined at 800°C.

A second corrosion test at 250°C with "standard" slurry was terminated after 26 hr of operation because of caking in the centrifugal pump and deposition of solids in the loop piping. The "standard" slurry, which was prepared as an experimental slurry by circulating 800°C-calcined thoria at 200°C in a 200A pump loop, was composed of spherical agglomerates ranging from 8 to 30 μ in diameter. Corrosion rates observed during the test, at an average circulating concentration of 410 g Th/kg H_2O at 10 and 24 fps, respectively, were (in mpy): austenitic stainless steels, 10 and 14; gold, 0.8 and 2; titanium and alloys, 0 and 1; and Zircaloy-2, 0 and 0.8. (AEC Activity 4103.1)

In-Pile Solution Corrosion Loops--LITR - Irradiation of in-pile loop L-2-10 was completed. The total circulation time was 1672 hr, of which the loop was in-pile for 1468 hr. The energy output of the LITR during the in-pile time was 3765 Mwhr, essentially all of which was liberated at the 3-Mw level. This was the eighth in-pile loop experiment and the first in the HB-2 hole, which has an available thermal-neutron flux 2 to 3 times that in the HB-4 hole. The solution, which was similar to HRT solution, was 0.04 m UO_2SO_4, 0.0075 m $CuSO_4$, and 0.02 m H_2SO_4. The main-stream temperature was 280°C, and the pressurizer temperature was 305°C. The overall corrosion rate of this stainless steel

loop, based on oxygen consumption, was 0.4 to 0.5 mpy. Based on nickel in solution, the rate was slightly lower. (AEC Activity 4103.1)

Autoclave Radiation Corrosion Studies--LITR - The effect of the addition of inert sulfates to the uranyl sulfate solution on radiation-induced corrosion was tested both in Zircaloy-2 and in stainless steel. A Zircaloy-2 autoclave experiment (Z-21) was run in the HB-5 hole of the LITR with an aqueous solution containing 0.17 m UO_2SO_4 (93.2% enriched), 0.04 m $CuSO_4$, and 0.17 m Li_2SO_4 (no free acid). The temperature of this bomb was maintained at 280°C for two days. At the end of this period it was discovered that the capillary leading to the pressure cell was plugged, rendering further oxygen-pressure measurements impossible. The pin weight-loss data were considered valid and indicated a corrosion rate of 10.1 mpy, which was less than half the rate anticipated for similar systems without the added Li_2SO_4.

A stainless steel corrosion experiment (H-97-2 in HB-6 of the LITR) was conducted at 250°C with an aqueous solution of high sulfate-ion concentration: 0.17 m UO_2SO_4 (93.2% enriched), 0.04 m $CuSO_4$, 0.03 m H_2SO_4, and 0.17 m $MgSO_4$. The gradual consumption of oxygen indicated a stainless steel corrosion rate under these conditions of 0.45 mpy. This rate is about half that observed in similar experiments without added inert sulfates. (AEC Activity 4103.1)

GENERAL REACTOR RESEARCH

Basic Reactor Research--Experimental and Theoretical - Initial calculations were made to determine the critical mass of the Bulk Shielding Reactor with UO_2-stainless steel fuel elements. Two cores were investigated: a 12-in. cube of 16 elements (4 by 4 array) and a 15 in. cube of 25 elements (5 by 5 array). The 12-in. cube was found to be infeasible; the critical mass was too high. The 15-in. cube with four plate-type control rods would be critical at only 5.8 kg of U^{235}; with four conventional BSR-type control rods, the critical mass would be 6.4 kg of U^{235}. The assumptions for the calculations were: a cold, clean core with 20-plate elements, each plate consisting of a 5-mil-thick cladding and a 20-mil-thick meat containing 15 to 16% of UO_2 by weight.

Temperatures of the plate surfaces and of the bulk water within the core were calculated for a 15-in. cubical core with stainless steel cladding. The tentative conclusion is that for 20 plates per fuel element the peak plate surface temperature in the central fuel element will exceed the boiling point of water at a total heat output of 1 Mw. (AEC Activity 4020)

School of Reactor Technology - Eleven group projects were undertaken by the 1955-56 class. Reports on these reactor studies were presented to the Laboratory on August 22 and 23.

The 1955-56 class completed its work on August 24. The 1956-57 session began on September 10 with an enrollment of 118 students (an increase of 23%), all sponsored by industry or government agencies. In addition to the regular

students, there are approximately 30 ORNL employees (or loanees to ORNL) who have registered for single courses.

The staff at ORSORT is actively participating in the AEC's plans for increasing the capacity of the School by encouraging universities to assume responsibility for some of the preparatory work. Members of the staff took part in the Deans' Conference on Atomic Energy Education at Gatlinburg on September 5-8. (AEC Activity 4704)

PROGRAM 5000 - PHYSICAL RESEARCH

Reactor Operations - Reactor operations were normal except for a relatively high incidence of ruptured slugs in the Graphite Reactor. Eight ruptured slugs were located and discharged in July and eleven in August. Since 1952 the highest number of ruptures in a given month had been four. The current ruptures are believed to result from longitudinal growth due to incomplete beta transformation.

In continuation of a study of the use of enriched fuel elements a double-cylinder type element was inserted in channel 1669. This element contains the same quantity of fuel as the single cylinder reported previously (97 g U^{235}) and presents 2 ft^2 of surface area, 62% more than the single-cylinder type. A small tube is located eccentrically within a larger tube with the single region of contact being the non-fuel-bearing seams of the tubes. The double-cylinder element attained a maximum temperature 30°C lower than the corresponding single cylinder.

The Oak Ridge Research Reactor (ORR) - Construction of the reactor building, shielding, and cooling system is estimated to be 68% complete; unofficial estimates indicate completion during December, 1956.

The major problem during this period has continued to center around work on aluminum pipe lines and the tie-in with aluminum fabrications which will be encased in concrete. A reorganization of the relationship between the mechanical subcontractor and the union was effected, and the contractor asserts this will do much toward alleviating the problem mentioned above.

The aluminum liner, on which the reactor tank rests, is in position, the pipe lines are attached, thermocouples are in place, and the barytes aggregate has been placed; the "Pre-Pakt" Company has equipment set up for the pressure grouting of this region. Completion of the pool floor shielding will allow the remainder of the concrete main floor to be poured. The contractor will then be able to rebuild his work force which has been substantially reduced due to the interference caused by delays in completing the pool floor.

Fabrication of the reactor tank continued with no major setbacks. The reactor lower grid plate and most of the internal parts of the reactor were completed. The mechanical controls assembly was completed, and the reactor control equipment is on hand; corrections are being made as found necessary during inspection. Experimental work is in progress to check the proposed servo design.

A preliminary design was made for a collimator which will serve as a plug for initial installation in the six horizontal beam holes and also as a part of the experimental equipment necessary for use of the beam holes.

The AEC has turned town the request for additional funds needed for added work space, hot cells, air conditioning, etc.; further discussions on this matter will be held.

ISOTOPE PRODUCTION

Radioisotope Production - Approximately 16,000 curies of cobalt-60 were received from the Arco site and 50,000 curies from Savannah River. The new storage "garden" for cobalt now contains approximately 90,000 curies.

The remote welding of stainless steel caps onto radiation-source capsules was demonstrated. This procedure permits the fabrication of cobalt-60 and cesium-137 sources for use at higher temperatures than with sources having soldered caps. (AEC Activity 5111)

Radioisotopes, Process Development - Construction of the fission-product pilot plant is about 78% complete. Testing operations are now scheduled for April 1957.

A heavy contamination of aluminum and sulfate ions in 1,919 curies of cesium-137 product was removed by precipitating the cesium as the chloroplatinate. After the precipitate was washed, the cesium was recovered quantitatively (>99%) by reducing the platinum to the metal with hydrazine. (AEC Activity 5112)

PHYSICS

Neutron Diffraction - The diffraction of neutrons by erbium orthoferrite ($ErFeO_3$) was studied as a function of temperature. Between 790°K and 550°K the neutron diffraction data are interpretable in terms of the $GdFeO_3$ structure found by Geller (J. Chem. Phys. 24, 1236, 1956) and are characteristic of a paramagnetic solid. At 550°K the iron ions are found to develop a G-type (Phys. Rev. 100, 545, 1955) antiferromagnetic structure which saturates near 77°K; at 4.2°K antiferromagnetic ordering of the Er ions in a C-type structure is observed. This ordering saturates at temperatures near 1.25°K. Evidence for antiferromagnetic ordering in Er_2O_3 at liquid helium temperatures was observed. (AEC Activity 5220)

Neutron Velocity Selector - The transmission measurements of specimens enriched in Eu^{151} and Eu^{153} were analyzed to obtain parameters of all the resonances from 1 to 10 ev. Transmission measurements of a sample of fission-product iodine (68% I^{129}) are now in progress. (AEC Activity 5220)

Low Temperature, Nuclear, and Solid State Physics - Further studies on α-particle emission from oriented U^{233} nuclei in $UO_2Rb(NO_3)_3$ indicate an angular distribution given by

$$W(\vartheta) = 1 - \frac{0.06}{T} P_2(\cos \vartheta).$$

The apparent saturation mentioned in the January report was found to be due to temperature differences between the sample and the liquid helium bath. (AEC Activity 5220)

High Voltage Program - The $B^{10}(He^3,p)C^{12}$ reaction was studied with a NaI charged-particle spectrometer. New B^{10} targets from England, assaying better than 99% isotopic purity, made it possible to look very carefully for a group of protons from a level predicted to lie at 5.53-Mev excitation in C^{12}. The level was not found. If a group of protons corresponding to 5.53 Mev was present in the experiment, its intensity would have to be a factor of 300 less than that of the group from the 4.4-Mev level in C^{12}. Several higher levels which had not previously been thoroughly established were observed and measured.

The differential elastic neutron cross section was measured for the scattering of 1.5- and 0.73-Mev neutrons from oxygen and beryllium. The neutrons were produced by bombarding a tritium gas target with protons from the 5.5-Mv Van de Graaff; energy resolution was about 50 kev. A propane recoil counter, biased to give a flat response for the scattered neutron energies, served as detector. The samples were a BeO cylinder and a metallic Be cylinder of same length and having equal number of Be nuclei as the BeO sample.

The total cross section of C^{12} was remeasured in the region of the 2.07-Mev resonance. After corrections are made for background, inscattering, energy resolution, and the second group of neutrons from the $Li^7(p,n)$ reaction, the result is in good agreement with the assignment of $D_{5/2}$ to the 6.86-Mev excited state of C^{13}.

The cross sections for electron capture of fast hydrogen atoms and the equilibrium charge distribution from a thick gas target were determined in the energy range 250 kev - 1 mev. The target gases studied were hydrogen, helium, nitrogen, and argon. From the measurement of the electron-loss cross section and the equilibrium charge distribution ($n_1/n_0 = \sigma_{01}/\sigma_{10}$) it is possible to compute the electron-capture cross section. The electron-loss cross sections for the various gases change in magnitude by a factor of approximately three throughout the energy range. For hydrogen and helium the loss cross section is approximately 10^{-17} cm^2/gas atom and is of the order of 10^{-16} cm^2/gas atom for nitrogen and argon. The cross section for electron capture is a very steep function of energy or velocity. For example, for hydrogen as a

target gas the cross section decreases from 10^{-18} cm^2/gas atom at 200 kev to 2×10^{-22} cm^2/gas atom at 1 mev. As a target gas, helium shows similar behavior. For the heavier gases, such as nitrogen and argon, the slope of the cross section as a function of energy decreases rapidly at the higher energies. (AEC Activity 5220)

CHEMISTRY

Volatility Studies - In the fused salt--fluoride volatility process, fuel elements are dissolved by hydrofluorination in a mixture of molten fluorides, and the UF_4 formed is fluorinated to UF_6, which volatilizes and is collected in NaF absorbers. A pilot plant was designed and constructed for the fluorination and collection step. Preliminary design studies were made for large-scale dissolution equipment. The dissolution flowsheet now under consideration uses $NaF-ZrF_4$ at 600°C to dissolve zirconium-uranium fuel elements. As a result of a literature survey, $NaF-LiF-ZrF_4$ is being investigated as the solvent. In preliminary laboratory studies the dissolution rate of dummy uranium-zirconium fuel elements in the ternary mixture was 20 mg/min-cm^2, about 4 times that in $NaF-ZrF_4$; the uranium concentration of the final melt was twice as high. (AEC Activity 5310)

Ion-Exchange Studies - The 12-in.-dia Higgins contactor was operated at Grand Junction for 12 24-hr days on Dysart pulp. For about 5 days the feed rate was 600 gal/hr-ft^2; then it was increased to about 770 gal/hr-ft^2, which is equivalent to about 16 tons of ore per day. The feed U_3O_8 concentration varied from 0.9 to 1.0 g/liter and the tails varied from 0.001 to 0.005 g/liter. There was no pulp plugging, and mechanical difficulties were minor. (AEC Activity 5310)

Americium Recovery - A process for recovering americium from the waste from the plutonium isotopes separation program was developed and demonstrated on a laboratory scale. The major impurities of the waste--iron, nickel, copper--are complexed with thiocyanate and extracted into amyl ether. The plutonium and americium are then concentrated and separated by ion exchange. (AEC Activity 5310)

Feed Materials Processing - In further studies on the Hermex process for metal purification by dissolution in mercury or amalgams and subsequent recovery by retorting and melting, the average dissolution rate for massive thorium in mercury at 356°C, 1 atm, over a 24-hr period was 0.143 mg/cm^2-min. Zirconium, Zircaloy-2, and STR-2 prototype elements dissolved in mixtures of Hg and $HgCl_2$ at a rate of about 10 mg/cm^2-min when the Cl/Zr ratio was >4/1. The quantity of free mercury present did not affect the rate.

A new retorting furnace for continuous distillation of mercury and for batch uranium melting was operated successfully in two runs. About 70% of the uranium charged was recovered from pressed uranium amalgam in the first run and 55% from U-Mg-Hg pressed uranium-magnesium amalgam in the second. Aluminum, calcium, copper, iron, magnesium, manganese, and silicon were

removed by factors of 5-30 in Hermex processing. The effectiveness of the process in removing boron and nickel is in doubt. (AEC Activity 5310)

High Level Nuclear Chemistry - For fission-product cross section studies, the long-lived nuclides Sm^{151}, Zr^{93}, and I^{129} were specially prepared and mounted in lots of from 200 mg to over 1 gram. The time-of-flight spectrometer now in use is sufficiently sensitive for such quantities. A preparation of Pm^{147} (200 to 500 mg) is being processed for study. (AEC Activity 5330)

Chemistry of Corrosion - Continued study of the breakdown of the nobility of iron electrodes caused by addition of foreign electrolytes to inhibited systems apparently established the fact that the Flade (activating) potential applies to these systems as well as to electrodes passivated by strong anodic polarization. These observations provide a definite connection between the phenomena of passivation and inhibition under oxidizing conditions.

Study of the passivation of iron by osmium(VIII) oxide and by aerated pertechnetate solutions led to the development of a new theory of the Flade potential wherein it is considered to be the equilibrium potential between normal Fe_2O_3, as the more highly oxidized component, and a two-dimensional interfacial layer of an iron-oxygen compound having somewhat more negative free energy than normal FeO. Water and hydrogen are also involved in the electrode process (but not the iron itself) when the passivation is essentially complete, as it was in these experiments. The theory eliminates the need for assuming an unknown higher oxide of iron, as has been often postulated in the past. (AEC Activity 5330)

Ion-Exchange Studies - Measurements of the cesium-sodium and the sodium-hydrogen ion-exchange selectivity coefficients were completed with new variable-capacity polystyrene sulfonic acid exchangers. These new cation exchangers were prepared by a technique wherein the extent of solfonation could be closely controlled. As with other recent measurements on variable-capacity cation exchangers prepared by different techniques, it was again found that the uptake of the preferred ion increases as the exchange capacity decreases.

The water content of a variety of cross-linked Dowex-2 anion exchangers was determined as a function of the iodide ion "loading" in the iodide-bromide anion-exchange equilibrium; this information is for use in exact thermodynamic calculations of selectivity coefficients for this system. It appears that the equivalent water content is not in general a linear function of the "loading" as had been commonly supposed. (AEC Activity 5330)

Chemistry of Technetium - Quantitative measurements of the solvent extraction of heptavalent technetium from acid, neutral, and alkaline aqueous solutions by pure TBP, cyclohexanol, cyclohexanone, and 0.1 M trioctylphosphine oxide in a hydrocarbon diluent revealed: (a) a retrograde extraction with all strong acids in concentrations above 1 M; (b) an increased extraction with concentration up to 5 M with pure $NaNO_3$ and to 2.5 M with $Al(NO_3)_3$ solutions; and (c) a slowly increasing extraction with concentration up to 6 M from NaOH solutions. The results with acid solutions appear to be consistent with the

hypothesis that the extraction of pertechnetate ion depends on "onium" salt formation, and that a labile anion exchange equilibrium is involved. A "salting-out" mechanism appears to be operative with neutral and alkaline solutions, with the nature of the bulk cation being important. For example, with 1 M Cs, Rb, K, Na, and Li chloride solutions, E_a^o, the extraction coefficient, was 3.66, 2.45, 2.14, 1.20 and 0.55, respectively, with nitromethane as an extractant. (AEC Activity 5330)

Characterization of Short-Lived Fission Products - A study of the decay of 32-min Br^{84} was begun. Samples were rapidly separated from uranium fission products and examined by beta-ray and gamma-ray scintillation spectrometers. The gamma-ray spectrum of Br^{84} is very complex, with gamma-rays of 0.879 ± 0.007, 1.03, 1.23, 1.51, 1.71, 1.92, 2.22, 2.50, 3.03, 3.29, and 3.93 ± 0.04 Mev. Gamma-gamma coincidence spectrometry results may be summarized as follows: the 0.879-Mev gamma-ray is in coincidence with gamma-rays of 1.02, 1.23, 1.50, 1.75, 2.52, 2.82, 3.07, and 3.28 Mev; the 1.92-Mev gamma-ray was in coincidence with 0.80, 0.89, 1.23, 1.62, and 2.07 Mev; the 3.92-Mev gamma-ray was in coincidence with a weak 0.27-Mev gamma-ray. In all cases there appeared to be unresolved, low energy gamma-rays in the coincidence spectra.

A preliminary value of 4.77 ± 0.09 Mev was obtained for the most energetic component of the Br^{84} beta-ray spectrum; this component is not in prompt coincidence with any of the gamma-rays and is believed to be the transition to the ground state of Kr^{84}. With beta-gamma coincidence spectrometry, a beta-ray group of 3.83 ± 0.08 Mev energy was found in coincidence with the 0.88-Mev gamma-ray; a weak group of about 2.8 Mev and a strong group of about 1.75 Mev were coincident with the 1.92-Mev gamma-ray. (AEC Activity 5330)

Chemical Separation of Isotopes - The single-stage separation factors for oxygen and for carbon between gaseous CO and CO absorbed by an aqueous acidic solution of CuCl were redetermined. The separation factors were measured at 25°C and a CO pressure of 69 cm of Hg. The factors presented below are lower than those previously reported (ORNL-2044), but they are considered more reliable since additional precautions were taken to prevent contamination, and the mass spectrometer analyses were performed with extreme care.

$$\alpha = (O^{16}/O^{18})_{gas}/(O^{16}/O^{18})_{liq} = 0.993 \pm 0.007 \text{ (95\% C.I.)}$$

$$\alpha = (C^{12}/C^{13})_{gas}/(C^{12}/C^{13})_{liq} = 1.005 \pm 0.001 \text{ (95\% C.I.)}$$

Gaseous CO_2 vs an aqueous solution of CO_2 in diethanol amine was found to be unsuitable for oxygen isotope enrichment because of the slow rate of exchange, and probably also the low separation factor. (AEC Activity 5340)

METALLURGY

High-Temperature Reactions of Metals and Ceramics - The study of the oxidation characteristics of the alkali metals, designed primarily as an investigation of the criteria for protective oxide film formation, was continued. Oxidation rate curves for potassium at -50° and -20°C were obtained. At -50°C the oxide

film appeared to be highly protective. At -20°C the oxide, although initially protective, was transformed into a non-protective film as the oxidation proceeded. These data, taken together with the results already obtained for sodium and rubidium, establish a pattern for the oxidation behavior of the alkali metals. In dry oxygen these metals tend to form completely protective films at temperatures ranging from about 25°C for sodium to somewhat below -79°C for rubidium. At higher temperatures the oxidation mechanism becomes more complex, and non-protective oxidation is observed. These results also demonstrate conclusively that, contrary to currently accepted theory, the ratio of the specific volume of an oxide to that of an equivalent amount of the parent metal is not an adequate criterion for judging the protective qualities of the oxide. (AEC Activity 5420)

PROGRAM 6000 - BIOLOGY AND MEDICINE

BIOLOGY

Insect Cytology and Genetics - A commonly employed criterion of induced genetic damage is the sex-linked recessive lethal. This test depends on the absence of males which carry the irradiated X chromosome from the progeny of a female heterozygous for an irradiated genome. Such males would be of the constitution irradiated X/Y, and their absence would indicate that some lethal change had been induced on the irradiated X chromosome (X^*). Since the Y chromosome is known to be homologous with the proximal heterochromatin of the X chromosome, it would seem that the Y might cover any recessive lethal change in this region and that such lethals would consequently be missed in the above test.

In an attempt to estimate the frequency of sex-linked lethals which are covered by the Y chromosome, a cross was designed which produced equal numbers of males of constitutions $X^*/sc^8.Y$ (y^+) and $X^*/0$ (y). The absence of both y and y^+ males indicates a lethal of the type detected in the orthodox test; the absence of y males but not y^+ males indicates a sex-linked recessive lethal covered by the Y chromosome; and the absence of y^+ males but not y males indicates a genetic change which is lethal in the presence of a Y and viable in the absence of a Y.

Of 1462 X chromosomes irradiated with 3000 r of X rays, 162 were lethal by one of the above three criteria; of these 34 were of the type that is covered by the Y chromosome, and 3 were of the type that is lethal in the presence of a Y and viable in its absence. It appears that roughly 20% of

sex-linked recessive lethal changes are covered by the Y chromosome and consequently are missed by orthodox testing procedures. (AEC Activity 6130)

Pathology and Physiology - To determine whether or not aminoethylisothiuronium-Br·HBr (AET) might protect the lens of the eye against radiation injury, the uptake of S^{35}-labeled AET in the aqueous humor of the eye was measured in rabbits at intervals after intravenous injection. A significant amount of activity was found in the aqueous humor, but the time required for maximal transfer of the material from the blood was relatively long, i.e., 20-40 minutes. Hence, AET enters the environment of the lens relatively slowly, but its concentration at the lens may be high enough to protect against cataract induction.

The radio-resistance of the reticuloendothelial system was assayed in rats injected daily with trypan blue followed by a single dose of whole-body X irradiation (400 r). As the existing macrophages became progressively loaded with colloidal dye, new macrophages were formed by proliferation, so that no detectable reticuloendothelial "blockade" was induced despite repeated injections of trypan blue. Irradiation did not significantly impair the ability of the reticuloendothelial system to remove injected colloidal gold from the blood stream nor did it prevent the proliferation of reticulum cells in response to the administration of trypan blue.

Studies undertaken in an attempt to explain the selective incorporation of S^{35}-sulfate in platelets led to the extraction of an S^{35}-labeled compound which has not been heretofore identified. This material was found similar to heparin and chondroitin sulfate in electrophoretic mobility. Further characterization with paper chromatography disclosed that it more closely resembled chondroitin sulfate than heparin. (AEC Activity 6130)

Biochemistry - The ion-exchange chromatographic method (ORNL-2109) developed for the examination of the rearrangement products obtained from a solution of the radiation protective compound S,2-aminoethylisothiuronium·Br·HBr (AET) was applied to S,3-aminopropylisothiuronium·Br·HBr (APT) and S,4-aminobutylisothiuronium·Br·HBr (4ABT). APT readily undergoes intratransguanylation at neutral and alkaline pH's as required by the hypothesis (D. G. Doherty et al., Biol. Semiann. Prog. Rep. Aug. 15, 1955, ORNL-1953, pp 88-91) to yield 2-mercaptoethylguanidine, the actual protective compound. Under acid conditions APT, in similarity to AET, forms a thiazoline. In contrast, 4ABT does not intratransguanylate to form 4-mercaptobutylguanidine, probably because such a reaction requires the formation of a 7-membered ring intermediate. This result is in excellent agreement with the radiation testing in mice where 4ABT was found to be completely ineffective in providing survival after a lethal dose of X-radiation. (AEC Activity 6130)

Biophysics - A method of measuring a low gamma-ray contamination in a fast neutron field was developed in which a single detector is operated sequentially as an ionization chamber and as a proportional counter. The range of collecting voltage for which the apparent gas multiplication is independent of particle type or mode of operation was determined. The method attains

high accuracy in the measurement of the neutron-to-total dose ratio and has been applied to several neutron sources.

The Cockcroft-Walton accelerator continues to be used by various research groups in the Biology Division; the 14-Mev neutrons are used in studies of the following effects: in mice, lens opacity from single and fractionated doses, RBE versus Co^{60} gamma rays at the same dose rate for 30-day LD^{50}, and bone marrow recovery from acute radiation injury; and in Vicia fabia on the interaction of X-ray and neutron-induced chromosome breaks. Use of the bone marrow in the treatment of mice was found to enhance the chance of recovery from the 14-Mev neutron radiation injury but not as markedly as from X-ray radiation injury.

The ultraviolet action spectrum for photo-induced oxidation of fatty acids was studied in collaboration with K. M. Wilbur of Duke University. The curve obtained shows a broad maximum in the 2537 A^{o} region, a pronounced minimum at 2800 A^{o} and a very definite peak at 3100 A^{o}. In general, it resembles the erythema action spectrum.

An experiment was designed to show whether two independently generated chromatid breakage-fusion-bridge cycles, if present together in one cell, will coalesce to yield a single chromosome type cycle, or will remain independent. The indications, so far, are that they remain independent.

Enough is now known about the mechanism of marker loss in maize to make possible an approximate forecast of relative induced loss rate. Published data were analyzed and shown to agree reasonably well with such a forecast, which requires only a knowledge of the cytological position of the marker. (AEC Activity 6130)

Mammalian Recovery - Preliminary investigations on the recovery phase of the immune mechanism in mice following sublethal X irradiation indicate that it is not comparable to that of the rabbit. Transplantation of heterologous bone marrow is a function of X irradiation dose. Definitive heterologous transplantation can take place following an X-ray dose as low as 710 r for C_3H x 101 mice.

The injection of two-day tissue cultures of bone marrow cells, obtained from C_3H x $101F_1$ mice exposed to 900 r, failed to bring about a recovery of lethally irradiated isologous mice. Effective cultures of bone marrow cells obtained from untreated mice have been maintained for 11 days at 37°C and 16 days at 25°C. There is some preliminary evidence that a concentration of an effective cell type may be occurring by 16 days in the 25°C cultures.

A mouse given 950 r and an injection of rat bone marrow 75 days before sacrifice showed rat platelets in its blood. The test was made with species-specific anti-platelet sera. (AEC Activity 6230)

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STATUS OF CONSTRUCTION

Construction of the building for the expansion of the reactor metallurgy facility was completed during the period. The building is a two-story concrete and steel-frame masonry structure, 50 ft by 60 ft, located between and connected to the Metallurgy Laboratory, Building No. 2000 and the Health Physics Laboratory, Building No. 2001. Access is provided from Building No. 2001; a fire wall separates the structure from Building No. 2000. The first floor provides four offices and four laboratories. In the initial construction no partitions were installed on the second floor; it is anticipated that the space will be subdivided into laboratories and/or offices as the needs dictate.

This new building of 6000 square feet total floor space is one part of the Laboratory's efforts to provide space to meet the growing requirements of the reactor metallurgy program. Additional space made available by alterations to the Health Physics Waste Research Laboratory, Building No. 3504, permitted the vacating of offices and laboratories in the west end of Building No. 2001; this coupled with other shifting of personnel made a total of 4000 square feet of space available in that building. Thus, by the construction of a building and the rearrangement of existing facilities, some 10,000 square feet of much needed space has been provided in a central location with respect to the activities of the Metallurgy Division.

VISITORS

Division of Military Applications:

Ager, P. W.
Canterbury, Brig. Gen. W. M.
Conarty, Major R. L.
Coulter, Col. J. M.
Dischuck, Col. J. J.
DiLuzio, F. C.
Fowler, G. A.
Hertford, Gen. K. F.
Howarth, M. H.
Hughey, R. W.
Lengnick, Capt. Roger H.
Lovelace, W. R., II, M. D.
O'Beirne, Rear Admiral Frank
O'Bryan, Col. C. L., Jr.
Preuss, Col. P. T.
Roy, M. F.
Schilke, Lt. Col. J. F.
Starbird, Brig. Gen. A. D. (Director)

Mott-Smith, H. M., Gibbs and Cox, Inc.

Office Asst. Secretary Air Force:

Cesaro, R. S.
Hartung, E. L.
Jones, Lt. Col. F. H.
Kelso, Lt. Col. W. R.
McLaughlin, J. J.
Oyster, D. E.
Perkins, C. D.
Powers, Col. A. D.
Robinson, W. C.
Weitzen, W.
Wilson, Major E. S.
Woodruff, Lt. Col. L. V.

Tennessee Valley Authority:

Albrecht, W. L.
Beasley, E. G.
Blee, C. E., Chief Engineer
Chambers, F.
Cooper, W. R.
Curtis, H. A., Director
Dean, W. E., Director, Power Supply
Derryberry, O. M., Director, Health
Ebersole, J. C.
Gartrell, F. E.
Gilfillan, D. R.
Hapgood, K. E.
Johnson, J. M.

TVA (Continued):

Kampmeier, R. A.
Karr, C. L.
Kochtitsky, O. W.
Monroe, R. A., Chief Development Engineer
Parish, J. R.
Patterson, D. R.
Paty, R. R., Director
Robinson, E. E.
Swidler, J. C., General Counsel
Vogel, H. D., TVA Chairman
Wagner, A. J., General Manager
Walthall, J. H., Director, Chemistry
Watson, J. E., Chief, Power Production
Wessenauer, G. O., Manager, Power

FOREIGN VISITORS:

Arendt, P. R. Allgemeine Elektricitatz, Gessellschaft, Germany
Bienvenu, C., French National Power Co., France
Breton, D. G., AEC, France
Carle, R. L., C.E.A., France
Coulson, C. A., Oxford University, London, England
Durham, R. W., AECL, Ontario, Canada
Evans, E. J., AECL, Ontario, Canada
Fogelberg, B. C., Finishing Pulp and Paper, Helsinki, Finland
Melese, G. B., AEC, France
Ryde, N. F., Gothenborg Institute, Sweden
Saleh, A., Pembangunan Daily Newspaper, Indonesia
Van Kranendonk, J., Institute-Lorentz of the Univ. of Leiden, Holland
Vantrey, L. P., AEC, France
Watson, L. C., AECL, Ontario, Canada

RADIOISOTOPE SALES AND COSTS

Type of Transaction	August 1956	FY 1957 to Date
Domestic Sales	$125,916	$221,311
Foreign Sales	3,455	6,171
Project-Transfer	1,745	2,937
Project-Cash Sales	4,117	7,503
Technical Co-Operation Program Credits	10	20
Plant Credits	7,292	9,453
AEC Credits	20,599	29,824
Total Radioisotope Income	$163,134	$277,219
Total Radioisotope Costs	$102,700	$185,727
Total Radioisotope Shipments	1,125	2,208
Helium		
Income	$ 210	$2,300
Costs	$1,356	$2,298
Shipments	1	8

GROSS OPERATING COSTS

	Cost for August	FY 1957 Cost to Date
Programmatic Operating Cost - Net	$4,013,857	$7,833,157
Equipment Cost	196,445	463,225
Construction Costs	126,948	380,326
Work for Other Parties - Transfers	3,502	211,744
Inventory Changes	47,566	(74,640)
Reimbursable Work for Other Parties	150,862	191,373
Deferred Charges	(89,218)	(360,198)
Total Laboratory Cost - Net	$4,449,962	$8,664,987
Estimated Cost for Next Month	$4,500,000	$13,164,987

() Credit

PERSONNEL SUMMARY

	Number of Employees September, 1956	New Hires September	Terminations September
Administration	69	2	0
Operations*	127	2	2
Engineering, Shops, and Mechanical	833	13	4
Laboratory and Research	2119	39	154
Protection	129	0	0
Service	385	9	24
	3662	65	184

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

A total of 945 Laboratory personnel are located in the Y-12 Area.

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Reports in this series issued during the past year:

September 1955	ORNL-1980
October 1955	ORNL-1995
November 1955	ORNL-2016
December 1955	ORNL-2032
January 1956	ORNL-2044
February 1956	ORNL-2062
March 1956	ORNL-2073
April 1956	ORNL-2082
May 1956	ORNL-2109
June 1956	ORNL-2123
July 1956	ORNL-2144
August 1956	ORNL-2166

Edited by F. T. Howard

Approved by Alvin M. Weinberg, Director