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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

FEBRUARY 1957

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STATUS AND PROGRESS REPORT

February, 1957

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

ORNL Health Physics Research--Boston - In the study (ORNL-2151) of the retention of enriched uranium and its distribution and excretion following the inhalation of metal fume aerosol by dogs, the findings to date are:

1. The initial retention of the inhaled aerosol in the dog's body is 7.6% ± 3.6%.

2. Urine specimens from the dogs taken daily during the first week after an inhalation exposure contain little or no uranium.

Three modifications of the electrodeposition method for recovering uranium in urine were recommended to Y-12 and were tested independently by this group and the Y-12 Analytical Laboratory. The recommendations were: (1) increase the volume of the aliquot to be analyzed; (2) pre-digest the urine prior to electroplating; and (3) maintain constant current and temperature in the electrodeposition cell during the course of plating. It was concluded from this cooperative study that each of the recommendations improved the recovery and precision of the method, and that the greatest improvement was achieved when all three recommendations were incorporated into the method. (AEC Activity 2120)

Thorex Process - The pilot plant continued to operate satisfactorily. In the recovery of 1300 kg of thorium and 3300 g of uranium, solvent extraction losses averaged 2.4 and 0.9%, and gross γ-decontamination factors were 3×10^4 and 4×10^4, respectively. Both products met tentative activity specifications.

When short-decayed thorium is processed, further decontamination of the uranium product is necessary. A uranium solvent-extraction cycle to follow the co-decontamination flowsheet (ORNL-2248) was designed.

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In process improvement studies, decontamination of the products from ruthenium decreased with increased radiation exposure of the aqueous feed, in both the presence and the absence of the organic solvent, 42.5% tributyl phosphate in Amsco. This increase in extractability of ruthenium by the organic solvent is considered due to the formation of nitrite in the feed during the irradiation.

The use of Decalin (decahydronaphthalene) as a diluent for the tributyl phosphate increased the concentration of thorium in the organic phase from 75 to 104 g/liter at the feed plate. Decontamination of the products from ruthenium was increased by a factor of 7.

Waste solvent used in processing short-decayed fuel contains I^{131} extracted from the feed; the iodine is not completely removed in the solvent-recovery system (ORNL-2205). In the laboratory-scale studies the addition of iodide to the feed greatly reduced the amount of iodine extracted. The addition of sulfite to the extraction-column scrub stream also greatly reduced the amount of iodine in the waste solvent. (AEC Activity 2423)

In-Line Instrumentation - Tests indicated that the in-line colorimeter for measuring the uranium concentrations of process streams (ORNL-2248) is sensitive to ± 1 g/liter in the range 25-35 g/liter. The r-f monitor for nitric acid concentrations in process solutions (ORNL-2248) was found to be sensitive to ± 0.05 M in the range 2-4 M HNO_3. In this instrument the temperature effect is eliminated with a thermostat-controlled heat exchanger.

An instrument for determining liquid velocity in the range 0-100 gal/hr was designed and constructed. In this device the rate of rise of an air bubble, which is dependent on the liquid velocity, is measured by a photoelectric timer.

An in-line instrument for continuous indication of interface level in plant solvent-extraction contactors was designed and installed. The instrument operates on electrical conductivity and is independent of density and interfacial debris. (AEC Activity 2724)

PROGRAM 4000 - REACTOR DEVELOPMENT

HOMOGENEOUS REACTOR DEVELOPMENT

Homogeneous Reactor Test - Oxygenated-water run No. 4, started on January 23, was interrupted briefly to replace the blanket dump valve, and was then continued. After 105 hr of steady operation at 1500 psi and 270-280°C, the run was terminated. During the down period, the differential-pressure control cells were replaced with new units having a range of $\pm$ 100 psi, and the blanket dump and letdown valves were replaced.

The operating conditions for the next run (No. 5) were the same as for run No. 4; 72 hr of operation were accumulated at temperature and pressure. The reactor was manually shut down three times during the run: to replace the fuel pressurizer purge pump, which had a ruptured diaphragm; to investigate severe gas binding in the fuel and blanket feed pumps; and to replace a blown blanket-to-core rupture disk in the pressure equalizing system. An inventory loss of 200 lb of water was traced to a leak in the dome flange joint, which was retightened. Except for this leak, all flanges have been very tight; the loss of water from the leak-detector system was less than 2 cc/day.

Run No. 6 is being made at 1700 psi and 270-280°C. More gas-binding difficulties were encountered during startup, but they were eliminated by freezing off one head of the blanket feed pump. The reactor then ran smoothly for a total of 72 hr at temperature and pressure before a manual shutdown was made to replace the blanket feed-pump head. It was also found that the blanket-to-core rupture disk, replaced after run No. 5, was leaking again. The disk was removed and a thicker disk (rated at 200 psi instead of 100 psi) was installed. Run No. 6 was then continued. (AEC Activity 4103.3)

HRT Chemical Pilot Plant - Installation of fission- and corrosion-product dissolution equipment in the low-pressure system is 85% complete. A closed-cycle cooling system for the HRT core processing plant is being designed to obviate the risk of corrosion from chlorides that may be contained in the cooling water. (AEC Activity 4103.1)

HRT Fuel Processing - In studies on the physical properties of simulated reactor corrosion-product solids, which contain large amounts of zirconium, chromium, and iron, the particle-size distribution was nonuniform. Autoclaving a mixed hydroxide precipitate of these elements in 0.02 m UO_2SO_4 solution at 250°C gave larger particles than autoclaving at 300°C. Agglomeration of the autoclaved solids was pronounced at 300°C, and probably started at 275°C; a uniform suspension could not be obtained in shaker bombs at the higher temperature. Hindered settling rates increased threefold with a 25°C increase in temperature.

The stability of iodate under radiation in the presence of H_2 and O_2 mixtures was increased by increasing the UO_2SO_4 concentration from 0.02 m to 0.04 m. With 2/1 mixture of H_2 and O_2, the stability of iodate was apparently increased by increasing the radiation intensity; with only air initially present the reverse was true in 0.02 m UO_2SO_4 solutions.

In loop tests of the precipitation of ZrO_2 from a circulating stream of UO_2SO_4 (10 g U/kg H_2O), half the solids added to the loop disappeared from circulation in about 2 hr; the hydroclone was not being used.

Separation efficiencies of the 0.25- and 0.40-in.-dia hydroclones operating on synthetic corrosion products suspended in water were 10 to 20% at room temperature with a pressure drop of 44 psi from feed to overflow. (AEC Activity 4103.1)

Uranyl Sulfate Blanket Processing - An ultrafine glass filter, nominal 1.5-μ pore size, was as effective for removing PuO_2 from 1.4 m UO_2SO_4 as a laboratory clinical centrifuge.

In the presence of cobalt gamma radiation about 80% of the plutonium was present as Pu(IV) when 1.4 m UO_2SO_4 containing 16 mg Pu/kg H_2O was heated at 250°C under oxygen in a stainless steel container. In the absence of irradiation, plutonium was all oxidized to Pu(VI), even when stoichiometric H_2 and O_2 overpressure was present.

In heat-transfer tests of the cooling jacket for the core vessel of loop P-2, used for dynamic blanket-processing tests, the heat-removal rate was 55 Btu/hr-°F for water cooling and 30 Btu/hr-°F for air cooling, with 163°C steam. (AEC Activity 4103.1)

Thorium Oxide Blanket Processing - Although the recoil energy of U^{233} fission fragments is sufficient to eject most of the fission products into the aqueous phase of a ThO_2 slurry, essentially all of these fission products are adsorbed irreversibly on the ThO_2. Treatment of the ThO_2 to prevent adsorption might make continuous removal of the fission-product poisons possible without dissolving the ThO_2. ThO_2, with a surface area of ~ 35 m^2/g, slurried in 0.01 m UO_2SO_4 at 250°C adsorbed 56,000 ppm of uranium. ThO_2 which was treated with absolute ethyl alcohol saturated with sulfur adsorbed only 3700 ppm uranium under these conditions. In neither case was the uranium eluted with dilute acid. When sulfur-treated ThO_2 and hydrated magnesium silicate (-325 mesh) were coslurried in dilute uranyl sulfate at 250°C, uranium was preferentially adsorbed on the $MgSiO_3$, with only 400 ppm adsorbed on the ThO_2.

Complexing solutions, such as ammonium citrate at pH 5.5, effectively eluted uranium from $MgSiO_3$ and did not destroy the exchange properties of the silicate. Dilute acids used as eluants converted the magnesium silicate to silicic acid. (AEC Activity 4103.1)

Homogeneous Reactor Thorium Blanket Studies--Chemical Development - In out-of-pile tests on the catalytic combination of hydrogen and oxygen by molybdenum oxide catalyst in aqueous thorium-uranium oxide slurries, thorium sulfate in concentrations of up to 10,000 ppm sulfate, based on ThO_2, did not deactivate the catalyst. The gas combination rates varied somewhat with increasing sulfate, but in all cases were sufficient for the use of such a slurry in a TBR-type blanket. At high sulfate concentrations, increased corrosion appeared to affect the activity of the catalyst, but activation with hydrogen restored the catalytic activity of the slurry.

In thermogravimetric studies thorium oxalate was more stable than thorium-uranous oxalate (5 mole % uranium), which was, in turn, more stable than uranous oxalate. Decomposition temperatures for the three were 275, 200, and 175°C, respectively.

Dispersion effects were marked in a slurry of 800°C-fired thorium oxide, 250 g Th/kg H_2O, which had been heated overnight at 300°C with 13,000 ppm of bentonite in the hydrogen-ion form. Dispersion was also obtained with similar slurries heated with 5000 ppm SiO_2, based on ThO_2, added as $Na_2O \cdot SiO_2$, SiO_2, or H_2SiO_3. Dispersion with this concentration of silicate was relatively insensitive to pH over the range 6-12.

Addition of sodium metasilicate up to 20,000 ppm SiO_2, based on ThO_2, decreased the settling rates of thorium oxide slurries up to a temperature of 275°C. Above this temperature, little change was observed to result from the silicate addition. (AEC Activity 4103.1)

HRP Chemistry--Fuel Studies - In the system UO_2SO_4-$CuSO_4$-H_2SO_4-H_2O, temperatures of appearance of a second liquid phase were determined as a function of UO_2SO_4 and $CuSO_4$ concentrations in solutions containing 29.11 mole % excess acid, based on the total salt content. Precipitates appeared in the more dilute solutions at temperatures below the two-liquid phase region. The approximate position of the boundary between precipitate formation and second-liquid-phase formation was established.

Study of the homogeneous recombination of hydrogen and oxygen in aqueous solutions, catalyzed by dissolved copper salts, was resumed after a lapse of several years. Interest is presently focused on the effects of temperature, acidity, and copper concentration because of the interim developments with respect to the mechanism of the reaction and the needs of the Project. In tests at 200°C the effects of 0.025 to 0.100 M sulfuric acid on the activity of 0.01 M cupric sulfate solutions were determined; increasing the acidity lowered the activity, but the effect was not so strong as that previously found at 250°C. Hydrogen was found to be more reactive than deuterium under comparable circumstances at 200°C, as had been found at 250°C. (AEC Activity 4103.1)

Slurry Component Development and Slurry Testing - A slurry containing 1000 g Th/kg H_2O, 2% U added as $UO_3 \cdot H_2O$, and 3000 ppm sulfate was circulated in S-loop at 300°C and 1600 psig with oxygen overpressure. During the 300-hr run there was no difficulty in handling the slurry and there was no evidence of sphere formation. The generalized corrosion rate was not significantly different from that obtained with pure thoria slurries.

Run 200-A-10 was completed in the 200-gpm loop to check the new components of the loop and to determine the handling characteristics of an 800 g Th/kg H_2O mixed-oxide slurry at 250°C. The run was started with pure thoria slurry containing 3400 ppm sulfate, and U was added stepwise as $UO_3 \cdot H_2O$ until a concentration of 3% was reached. Examination of the slurry after 775 hr of routine circulation revealed no caking. The generalized attack was about 0.5 mils/year. (AEC Activity 4103.1)

Special Slurry Problems - Hard thoria cakes produced in the 200-A loop were partially disintegrated by flooding them with dilute electrolytes after air drying at 110°C. Large pieces remaining after treatment were further reduced in size by repeating the procedure.

A resuspension loop was constructed for use in studies of the critical factors associated with the maintenance of thoria in suspension and with the resuspension of settled beds. (AEC Activity 4103.1)

Slurry Blanket System Development - In the blanket test system the first long-term slurry run, which reached a charged concentration of 500 g Th/kg H_2O and 3000 ppm sulfate, was terminated after 1730 hr. During the run the following phenomena occurred:

1. Water with a high chloride content was repeatedly drawn from the pressurizer, indicating leaching of impurities from the thoria.

2. The larger part of the thoria apparently lay in the blanket without circulation.

3. The thoria concentration in the circulating stream varied in an inverse manner with loop temperature and at all times was much below the charged concentration.

4. There was a steady downward drift in stream concentration with time, not attributable to temperature.

5. The stream concentration was extremely sensitive to temperature rises just above about 180°C. (AEC Activity 4103.1)

Blanket Engineering Research - A heat-transfer system was constructed to check the validity of the Lawson equation (ORNL-2222, p. 59). The system is being calibrated on water. (AEC Activity 4103.1)

Fuel Circulating Equipment - The 400A-1 pump was inspected after 7200 hr of trouble-free circulation of 0.04 m UO_2SO_4 solution at 250°C. The bearings and thermal-barrier seal weld were in excellent condition, and the pump was put back in service.

The 400A-2 pump, fitted with a 1/16-in.-wide gold-plated thermal-barrier gasket, was shut down after circulating 0.04 m UO_2SO_4 at 250°C for 1226 hr. The shutdown was caused by leakage past the barrier seal; the pump is being fitted with a new thermal barrier which combines the main flange and barrier seals.

During a 482-hr run on water and 1.3 m UO_2SO_4 the thermal-barrier seal weld of the 300A-1 pump developed a leak and some cracking damage occurred. A redesigned thermal-barrier seal weld was used in making repairs, and the pump was operated for 517 hr without further difficulty.

Following repair of the rotor can of the 4000-gpm Byron Jackson pump, a stator-can failure occurred, due to malfunction of the stator oil-water pressure balance.

The excessive bearing wear observed in the 20-cfm canned-rotor blower was traced to an improper gasketing which caused a loss in bearing supply pressure. The defect was corrected and the blower ran successfully at atmospheric pressure for 100 hr. The blower loop is ready for 2000-psi operation, with gas-steam mixtures.

Two feed-pump diaphragm failures occurred: one after UO_2SO_4 solution was pumped for 6757 hr, the other after water was pumped for 7403 hr; diaphragm endurance testing is being continued. (AEC Activity 4103.1)

Miscellaneous Equipment - Lengthening freezer coils on 1/2-in. pipe from 7-1/2 in. to 12 in. doubled the leak rate at which water could be frozen off. Raising the refrigerant temperature from -38°C to -11°C reduced the freezable leak from a 300°C system from 22 cc/min to 8 cc/min. (AEC Activity 4103.1)

Heat Removal Equipment - Metallographic examination of nickel-plated type-347 stainless steel tubes in a type-347-clad carbon-steel tube sheet showed that some cracking in the plate and weld metal had been caused by a water-oxygen-chloride boiling environment. (AEC Activity 4103.1)

Gas Handling Equipment - Grain growth and hydrogen pickup were observed in titanium and zirconium samples exposed for 180 hr in the high-pressure recombiner loop.

Operation of a 14-in. gas separator at 5000-gpm liquid flow revealed that the gas-separating efficiency was relatively unaffected by variations in gas flow. The amount of liquid entrainment in the gas takeoff, which varied between 1 and 40 gpm, did not affect performance of the separator; it was concluded that entrainment could conveniently be controlled at 2 gpm in a large separator. (AEC Activity 4103.1)

Solution Systems Development - The HRT mockup operated for 999 hr at 260°C and 1400 psi. During this time UO_2SO_4 solution, containing 300 g U/kg H_2O, was circulated for 576 hr. The generalized corrosion rate at this high concentration was 12 mils/yr. Massive localized corrosion was observed only in an orifice flange where high turbulence was generated. The run was interrupted for circulating-pump maintenance and was terminated by a feed-pump diaphragm failure.

The continued thermal cycling of eight ring-joint flanges was interrupted by a major leak in one of the test flanges; the cause of the leak is undetermined as yet. Four 1-in. flanges, which are known to have serious stress-corrosion cracks, were thermal cycled 100 times from 150°C to 336°C without apparent further damage.

Experimental comparisons of volumetric leakage from gas and water leak-detector systems showed that gas leakage was about 30 times greater than water leakage; this favors the selection of water as a leak-detector medium. A capillary leak-meter for HRT application was developed. (AEC Activity 4103.1)

PACKAGE POWER REACTOR PROGRAM

Army Package Power Reactor (APPR-1) - The Laboratory continued to furnish technical support to the Army Reactors Branch (AEC) on the 10-Mw pressurized water reactor being constructed at Fort Belvoir, Virginia, by Alco Products, Inc. Construction is almost complete. Non-critical testing is scheduled to begin early in March, 1957, and the 700-hour performance test is to start in April.

The Laboratory completed fabrication of the 38 stationary fuel assemblies required for the initial reactor loading. The fuel assemblies for the seven control rods were completed; absorber combs are used to reduce the flux peak in the end portion of the fuel plates. The absorber sections for these control rods, and the required number of spare fuel and control assemblies, are scheduled for completion in March.

A full-scale APPR-1 type control rod has operated satisfactorily in the MTR for four MTR cycles. It is scheduled to be removed on March 11, after the fifth cycle. The boron burnup will then be greater than that expected during the complete lifetime of the rod in the APPR-1. (AEC Activity 4201.1)

Okinawa Reactor - The Army Reactors Branch (AEC) requested that the Laboratory make recommendations concerning the type of reactor which would be most suitable for a 20-megawatt electrical generating station on the island of Okinawa. A report containing the Laboratory's recommendations was drafted and is being reviewed before transmittal. (AEC Activity 4201.1)

Gas-Cooled Reactor Development - Design work containued on the proposed gas-cooled loop for the Oak Ridge Research Reactor. Orders are being placed for long lead-time items. Detailing of the in-pile section is essentially complete. Piping and structural arrangements are being detailed. Discussions with the manufacturer of the proposed particulate filter for hot gasses ($1500^{\circ}F$) indicated that a satisfactory unit can be obtained. The size of the ORR emergency electrical supply was increased to 300 kw to provide power for emergency cooling of the loop in the event of failure of normal electrical power. (AEC Activity 4201.1)

GENERAL REACTOR RESEARCH

Radiation Damage - Single crystals of silicon and germanium were irradiated in the MTR with fast neutron fluxes ranging between 3 and 6 x 10^{20} n/cm^2 at a temperature of approximately $40^{\circ}C$. Preliminary x-ray measurements of the unit cell dimensions of these crystals reveal that small but significant

expansions were produced by the bombardment. The forbidden (200) reflection was found in one silicon sample and is probably due to the freezing-in of defects in the highly preferential positions of the diamond lattice. (AEC Activity 4540)

Basic Reactor Research--Experimental and Theoretical - Numerical integration routines for the Oracle were developed to obtain a thermal-neutron slowing down kernel from an indium resonance kernel and to obtain the Fourier transform from any such kernel. A routine is also being developed to determine a least squares fit to the Fourier transform to determine the constants for use in three-group theory.

The Fourier transform of the Hill, Roberts, and Fitch (ORNL-181) indium resonance kernel was calculated for a range of reactor buckling ($B = 0$ to $0.7\ cm^{-1}$).

Alterations to the Group Constant Preparation Code (CF-55-1-176) cross sections by a neutron balance method were made and results are being tested.

A code incorporating a better approximation to the currents at the interfaces is being incorporated into the series of programs comprising the three-group, three-region reactor code.

In the "debugging" of the Corn Pone integration routine, boundary conditions on flux and current are being satisfied and the code seems to be working for integration over space within a group. Coupling among the groups also appears to be handled as desired. (AEC Activity 4520)

Radiation Detector Development - The scintillation response of a $Li^6I(Eu)$ crystal to monoenergetic neutrons at 2.9 and 14.3 Mev was examined. The pulse height spectra were recorded while the crystal was maintained at -196^oC. These spectra demonstrate well defined and symmetrical peaks from the $Li^6(n,\alpha)T$ reaction, with a full width at half maximum of 14% at 2.9 Mev and 5.5% at 14.3 Mev. The response of the crystal to neutrons produced in the $Be^9(d,n)B^{10}$ reaction by 550-kev deuterons was also examined. In this case, the pulse-height spectrum showed four groups of neutrons between 1 and 5 Mev; the neutron energies determined from the observed spectrum agree well with the known level structure of B^{10}. (AEC Activity 4570)

Power Reactor Waste Disposal Engineering Studies - The amount and chemical form of the radioactive aerosols that will be produced from an aluminum nitrate waste solution are being determined. Limestone, shale, and soda ash are added to the waste solution so that the heat from the decay of the radioactive fission products will form a self-sintered ceramic material. The experimental waste solution is a non-radioactive aluminum nitrate waste to which is added tracer quantities of certain fission products.

In the first test run, tracer quantities of Sr^{90} were introduced and this synthetic waste was heated to 160°C. The maximum temperature was limited to 100°C in the second run. The Sr^{90} activity evolved from the heated mixture was found in the condensate from the first condenser; there was no indication of activity in the fiber glass filter following the condenser. The amount of Sr^{90} activity evolved decreased as the temperature of the waste material increased above 110°C. No information is available as yet for Sr^{90} evolution at waste solution temperatures greater than 160°C.

$$\text{The DF} = \frac{\text{c/m-ml of waste solution}}{\text{c/m-ml of condensate}} \cong 10^3 \text{ at } 110^\circ\text{C}.$$

AEC Activity 4630

PROGRAM 5000 - PHYSICAL RESEARCH

ISOTOPE PRODUCTION

Isotope Separation - The processing of tin in the Alpha calutrons was completed during the month of January. The metered collections of all ten isotopes (masses 112, 114, 115, 116, 117, 118, 119, 120, 122, and 124) totaled 227 grams. The large-radius calutrons are now being used in the separation of iron isotopes (masses 54, 56, 57, and 58). Both the regular Alpha-2 unit and an Alpha-1 are being used for comparison purposes. The Alpha-1 unit, which operates with the ion source at ground potential, has not been previously investigated for collection of isotopes of an element other than uranium. Separation of the isotopes of platinum in the Beta calutrons was completed in December, with a total metered collection of 40 grams of all the isotopes (masses 190, 192, 194, 195, 196, and 198). Separation of the ruthenium isotopes is in progress; the metered collection to date totals 14 grams of masses 96, 98, 99, 100, 102, and 104. Both of these elements were processed in the high-temperature ion source in which the charge chamber is heated by electron bombardment. (AEC Activity 5121)

Isotope Chemistry - Chemical refinement was completed for new lots of enriched Mg^{24}, Mg^{25}, S^{32}, S^{34}, S^{36}, Ca^{48}, Ti^{48}, Cu^{63}, Cu^{65}, Br^{79}, Cd^{108}, Cd^{112}, Cd^{113}, Cd^{116}, Ba^{130}, Pb^{204}, Pb^{206}, Pb^{207}, and Pb^{208}, and these lots were added to the inventory. Returned lots of Li^7 and Fe^{57} were chemically reprocessed and made available for distribution.

Conversions of inventory forms were made as follows: B^{10} element to boric acid (three shipments), Li^6 element to Li_2SO_4, $H_3B^{11}O_3$ to elemental boron, $NaCl^{37}$ to $AgCl^{37}$, and preparation of a Ni^{60} cyclotron target. (AEC Activity 5121)

PHYSICS

High Voltage Program - Measurements of the time dependence of the thermal neutron flux in sub-critical U^{235}-H_2O solutions, following bursts of fast neutrons from a square-wave modulated neutron source, provide information on properties of these systems with respect to prompt multiplication. The half-life for the fundamental mode of the thermal neutron flux was observed to increase from 21.7 μsec for a 3 x 3 in. cylinder of solution (26.5 grams U^{235}/liter) to 110 μsec for a 10 x 10 in. cylinder. Similar measurements were made for a solution containing 53.0 grams U^{235}/liter. Interpretation of these results by means of existing theory gives the probability that a fission neutron will be thermalized inside a system of a given size. Additional measurements of the spatial distribution, made with a small $Li^6I(Eu)$ scintillation probe, indicated that only the fundamental diffusion mode was present 200 μsec after the end of the neutron burst. Measurements of the spatial neutron distribution were made in the 8 x 8 in. cylinder with a central Cd control rod, and also with a water reflector. The delayed neutrons and their descendants give rise to a small background which decays only imperceptibly during the short counting intervals of the present experiments. The critical size for U^{235}-H_2O systems obtained by extrapolation from the present measurements are in good agreement with those observed.

The neutron differential elastic scattering cross section of O^{16} was measured at and in the vicinity of the 1-Mev resonance level, as well as at higher non-resonance energies. The energies at which measurements were made include 0.73, 1.00, 1.21, 1.50, 1.75, and 2.15 Mev. The s-wave phase shift analysis of this data, together with information on single-particle bound-state levels in O^{17} and similar data for the C^{13} nucleus allow one to fix the parameters of a potential well which describes the s-wave information. The potentials so determined have a diffuse boundary and are consistent with empirical wells which are found to fit data for nuclei of higher mass numbers (A. E. S. Green, Phys. Rev. 104, 1617, 1956). To give the energy position of the $d_{3/2}$ unbound state in O^{17} at 1-Mev neutron energy, a spin-orbit energy term of the Thomas form is introduced. The factor by which this Thomas term has to be increased is consistent with that found in other work for nuclei of much higher mass. The $d_{3/2}$ phase shifts calculated with this model compare favorably with that observed in the O^{16} neutron scattering experiment. (AEC Activity 5220)

86-Inch Cyclotron, Nuclear Physics - The energy distributions of inelastically scattered protons and deuterons from (p,d) reactions on Au, Pt, Th, Ag, and Pd were measured; a paper summarizing this and similar work on the isotopes of Pb and Bi was submitted for publication. Previous studies of the angular correlations of protons from the Ni(p,2p) reaction were checked and extended. The long-range particles from uranium fission in the X-10 Graphite Reactor were studied by magnetic rigidity, range, and scintillation pulse-height measurements. Their identification as alpha particles was definitely confirmed; their energy distribution was accurately determined (no fine structure was revealed); and their frequency was found to be one per 300 fissions. (AEC Activity 5220)

86-Inch Cyclotron, Applied Nuclear Physics - The isotopes F^{18}, Mn^{54}, and As^{74} were produced in service irradiations for outside customers and F^{18} was produced for use within the Laboratory. The yields of Be^{7}, Na^{22}, Rb^{84}, and In^{114} are being investigated.

Since several new guide, or "trimming", field circuits were recently installed on the magnet pole tips, a segmented target was used to determine the effects of these guide fields on the shape and position of the internal proton beam. When these circuits are optimized a steady 2-ma proton beam can be positioned so that 75% of the beam is within 1-1/4-in. of the median plane of the magnetic field, that is, the axial width of this central portion of the beam is 2-1/2 in. (AEC Activity 5220)

86-Inch Cyclotron, Operation - Operation of the 86-inch cyclotron was routine during this period. The machine was shut down for ten days in February to permit a 12 by 20 in. hole to be drilled through the 5-foot concrete shield. This was done by drilling six overlapping 8-in. holes with a diamond-tipped core drill. The hole facilitates positioning of the deflected beam pipe and provides for future development. (AEC Activity 5220)

63-Inch Cyclotron, Physics - The chemical separation of radioactive end-products from the nuclear reactions produced by nitrogen on potassium was continued. So far, seven nuclides have been identified and their yields measured. These reactions correspond to the evaporation of n, p, pn, α, αn, αpn, and 2α from the compound nucleus Fe^{53}. Cross sections will be determined after the yields have been measured at lower energies. The spectrum of protons from the reaction $Al^{27}(N^{14},p)Ca^{40}$ was measured at 0, 10, and 20 degrees in the laboratory system. In all cases it appears that the constant a in the level density formula $w = e^{2\sqrt{aE}}$ is equal to 5 ± 0.3. This is in good agreement with the predictions of the statistical theory. The experiment is being extended to other angles, and to α-particles as well.

The newly-installed analyzing magnet was used to deflect the stripped nitrogen beam from the cyclotron. In these initial tests about 1/10 of the total deflected beam was focused through the analyzing magnet. (AEC Activity 5220)

Spectroscopy Research Laboratory - Interpretation of the infrared spectra of NT_3, NHT_2, and NH_2T previously reported (ORNL-2248) was found to depend strongly on the vibrational assignments for ND_3, NHD_2, and NH_2D reported in the literature (see for example J. S. Burgess, Phys. Rev. 76, 1267, 1949). The deuterium data showed marked inconsistencies and therefore a study was undertaken to verify the fundamental frequencies of these molecules. A technique using the double-beam spectrometer was developed; it allows independent observation of the spectrum of each molecular species. This study revealed errors in the previously published assignments for both the mixed species, NHD_2 and NH_2D, and for ND_3. A normal coordinate analysis was performed, and force constants are being obtained from the corrected frequencies.

The compilation of thorium spectrum data was completed. This compilation includes energy levels and classified lines with Zeeman effects and isotope shifts for TH IV, Th III, Th II, and Th I. Also included are tables of Zeeman data and isotope shifts for unclassified lines, a table of unclassified furnace spectrum lines, and a table of unclassified absorption lines. (AEC Activity 5230)

Electronuclear Machines - All major components of the Cyclotron Analogue I, except the r-f system, are now fabricated and assembled. The Analogue is a fixed-frequency test cyclotron designed for studying the acceleration of electrons up to the first integral resonance. Focusing at these relativistic velocities is obtained by the use of an azimuthally varying magnetic field configuration; eight pairs of sector coils provide an eight-cycle variation in the field. These complex coils have all been fabricated; in tests of their magnetic property they were found to reproduce Oracle calculations to within the expected accuracy. Test operation of the Analogue will begin as soon as the r-f system is completed. (AEC Activity 5220)

Mass Spectrometry Research and Applied Mass Spectrometry - The mass spectrum of CO was investigated in the pressure range of 1×10^{-6} to 1×10^{-4} mm of Hg. Two collision-induced dissociations corresponding to the reactions $CO^+ \rightarrow C^+ + O$ and $CO^+ \rightarrow C + O^+$ were observed. These reactions were investigated as a function of the energy of the CO^+ ion in the energy range of 2000 to 5000 ev. The ratio of the O^+ ion to the C^+ ion increased with an increase of the energy of the CO^+ ion, in the energy range under investigation. As the acceleration potential for the CO^+ ion was increased the collision-induced dissociation of the CO^+ ion also increased. The reaction $CO^+ \rightarrow C^+ + O$ was also investigated by using the following gases to produce the collision-induced dissociation: He, CO, Xe, Kr, H_2, O_2, N_2, and D_2. Helium was found to be the most effective gas for producing the dissociation.

During January and February, the mass spectrometer MSA was operated two shifts a day to reduce the backlog of analyses for the stable isotope inventory.

The method of analyzing argon (as used for blanketing in welding) for impurities was applied to nitrogen. Several types of samples were analyzed for the Chemical Isotopes Separations group in their search for systems for separating oxygen, nitrogen, and sulfur isotopes. (AEC Activity 5250)

Research and Development, Stable Isotopes - Enrichment of argon-36 in the two parallel four-column thermal diffusion cascades reached approximately 30% before a series of mishaps culminated in the loss of one of the columns. Approximately half of the enriched inventory was salvaged. Studies of the transport had indicated that with a single column it would be possible, operating at atmospheric pressure, to reach an enrichment of approximately 50% in argon-36 and that connecting the units in series was serving no useful purpose. The plant was therefore revised and the eight hot-wire columns are now operating in parallel from a common feed and are terminated at the light-isotope end by half-liter volumes. By means of a circulating loop argon gas is continuously circulated to the bottom, or feed end of the eight units, and is bled to

atmosphere through a controllable relief valve. The plant survived a recent power failure without loss of a heating wire. The four liters of enriched argon-36 which will be accumulated in the end volumes will, together with other material on hand, permit operation of a series arrangement of columns in which the enrichment can be carried to higher levels. This batch operation is an alternative to the construction of a tapered plant specifically engineered for this separation.

An electromagnetic separator was investigated in which a focus is obtained on a collimating slit at the 90-deg position. An isotopic beam of single mass passes through this defining slot and is again focused after a further deflection of 180 degrees. Baffles between the ion source and the collector greatly reduce the migration of neutral molecules into the collector.

A procedure for preparing elemental boron-11 was developed. It includes the formation of KBF_4 from boric acid, followed by subsequent reduction of the KBF_4 with elemental potassium under argon. Unreacted substances are leached out with dilute HCl and the resulting elemental boron is centrifuged and washed with alcohol. The overall yield of elemental boron is approximately 90%, based on the boric acid.

An overall separation factor of 628 between ytterbium and yttrium was obtained in a 17-stage liquid-liquid exchange system. (AEC Activity 5250)

CHEMISTRY

Raw Material Chemistry - In connection with fundamental studies on the extraction of uranium(VI) and iron(III) from sulfuric acid-sodium sulfate mixtures by amines, the dissociation of bisulfate ion in such mixtures in the range 0.25-1.5 m was estimated. It was assumed that the ionic activity coefficient product $(\gamma^2_{H^+} \gamma_{SO_4^=})$ in such a mixture is equal to $(\gamma_{\pm})^3_{Na_2SO_4}$ in pure sodium sulfate solution at the same ionic strength. The validity of this estimation method was confirmed by Raman spectra measurements which thus far have been satisfactorily consistent with the calculations. (AEC Activity 5310)

Equipment Decontamination - Electrolytic reduction of chromic sulfate to chromous sulfate, to be used in a decontaminating solution for the homogeneous reactor, was obtained satisfactorily in a multichamber anion-exchange membrane cell. Three types of anion-exchange membranes were used; of these, Nalfilm-2 gave the best service under operating conditions.

Uranium removal from the oxide corrosion film on type-347 stainless steel exposed to UO_2SO_4 solution for 200, 1000, and $\gg$2000 hr at 250°C was 96, 30, and 3%, respectively, with 5% HNO_3 at 90°C for 40 hr. (AEC Activity 5310)

Chemical Physics - Paramagnetic resonance observations were made on several single crystals that had been irradiated with gamma rays at liquid nitrogen temperature. In the case of single crystals of 100% hydrogen peroxide,

striking paramagnetic effects were found with both gamma and ultraviolet irradiation, but the results are quite different for the two cases. Not only are the paramagnetic spectra different, but also the temperature behavior. The ultraviolet-produced radicals disappear with roughly a one-hour half-life at liquid nitrogen temperature while those formed by gamma rays last for long periods above dry ice temperature. At this time it is presumed that the ultraviolet-produced substance is the OH radical. The gamma-ray-produced substance could be a different radical, say HO_2, or the same radical in a different environment. (AEC Activity 5330)

High Temperature and Structural Chemistry - The first series of measurements of the electrical conductivity of solutions of sodium metal in molten sodium bromide was completed. It appears that the results differ from those obtained in earlier measurements with potassium metal in potassium chloride in that the rate of increase in conductivity tends to decrease somewhat with concentration in the range up to 10 mole % Na, rather than to increase as in the case of potassium. If confirmed, this observation may perhaps be interpreted in terms of the greater stability of Na_2 molecules than of K_2 molecules.

The phase equilibria in the systems of NaCl-Na and NaF-Na were reinvestigated with a modification of the method used earlier. Unexplained peculiarities of the earlier data were found to be due to unsuspected dispersion of the liquid metal phase in the molten salt phase and were now eliminated as equilibration was achieved by milder stirring even in considerably shorter time periods. The consolute temperatures were found to be 1115 $\pm$ 5°C and 1200 $\pm$ 20°C, respectively; this is approximately 100° higher than reported earlier. (AEC Activity 5330)

Radio-Organic Chemistry - The study of the properties of addition compounds between phosphine oxides and uranyl salts continued. A solution of uranyl sulfate and tributyl phosphine oxide in diphenyl was maintained at 260°C for three weeks with no loss in the amount of dissolved uranium (20 g/kg mixture). However, severe coking was evident in the reaction vessel. The amount of coking was greater than in diphenyl heated alone. (AEC Activity 5330)

Radiation Chemistry - The radiation decomposition of various organic and inorganic solids is being studied by mixing the material with KBr crystals, pressing it into a disc, and, after irradiating the disc at room temperature, observing the changes by infra-red analysis. Preliminary irradiations of pure KBr discs with 1.5-Mv electrons in atmospheres of He, O_2, N_2, and CO_2 showed some interesting radiation-induced gas-solid reactions. In the presence of pure He, no chemical product is observed, but the trace of water initially present in all discs disappears on irradiation. Bromate is formed in the presence of pure O_2, but not in air. In the presence of air, nitrate is the principal product, but small amounts of nitrite and several unidentified species are also produced.

The effects of thallous ion and formic acid on the reduction of Cr(VI) in 0.4 M sulfuric acid solution by coablt-60 gamma radiation were found to be similar to those effects reported for the reduction of Ce(IV) solutions.

The yield for Cr(VI) reduction is markedly enhanced by the addition of a small amount of thallous ion. Increasing the concentration of thallous ion has no further effect on this yield. Chromium (VI) reduction is also enhanced by formic acid but the yield increases with increasing formic acid concentration. These results again indicate that the sulfuric acid enters into the reaction mechanism.

Acetylene and a 3:1 C_2H_2 - C_6H_6 mixture were irradiated simultaneously in very small spheres (radius approximately 1 cm) with radon at 100°C under identical conditions (i.e. volume, and quantities of C_2H_2 and Rn) so that the C_2H_2 in both cases absorbed the same amount of energy. The polymerization rate, due to ionizing radiations, of C_6H_6 is very slow compared to that of C_2H_2 (approx. 1/20). Hence, even for the mixture the rate of utilization of gas during the initial stages of the reaction will be practically only the rate of utilization of C_2H_2.

Plots of Log P (pressure of C_2H_2 and $C_2H_2 + C_6H_6$) vs fraction of radon remaining gave straight lines for the initial phases with the slope (reaction rate) of the mixture 32% less than the comparative reaction. This is the first reported instance of retardation of a gaseous radiochemical reaction upon the admixture of a gas of lower ionization potential than the reactant gas, presumably due to charge transfer: $C_2H_2^+ + C_6H_6 \longrightarrow C_2H_2 + C_6H_6^+$. (AEC Activity 5330)

Molten Salt Thermodynamics - In continuing a study of activities in molten salts, the vapor pressures of ZrF_4 from molten RbF-ZrF_4 mixtures were determined for a comparison of the effect of alkali cation size on negative deviations from Raoult's law in alkali fluoride-zirconium fluoride systems. The vapor pressures were measured as a function of temperature for eleven RbF-ZrF_4 compositions ranging between 35 and 100 mole % ZrF_4. In this range ZrF_4 could be considered as the only volatile constituent. The method, a quasi-static technique which measures absolute total pressure, permitted a pressure range of 10 to 200 mm (800-1300°C). At 912°C, the melting point of ZrF_4, the activity coefficient of ZrF_4 is given by the empirical relation

$$\log \gamma_{ZrF_4} = -N^2_{RbF} (2.05 + 6.40 N_{RbF})$$

where N is mole fraction. Application of the Gibbs-Duhem equation gives, for the activity coefficient of RbF, the relation

$$\log \gamma_{RbF} = -N^2_{ZrF_4} (12.37 - 7.74 N_{ZrF_4}).$$

The pronounced negative deviations in the alkali fluoride-ZrF_4 systems are greater with increasing alkali cation size. Described as an acid-base behavior in which ZrF_4 is a strong acid because it is a good fluoride acceptor, the basicity of the alkali flourides increases with increasing cation size in a manner that can be qualitatively correlated with cation-anion electrostatic attraction. (AEC Activity 5330)

Analytical Chemistry Research - Samples of thorium oxide were analyzed for submicron particles, as small as 0.07 micron, by an activation analysis - centrifuge method of analysis. Measured portions of the irradiated thorium oxide slurry are centrifuged at various speeds and for different time intervals aliquotted, and the induced radioactivity (as 27.4-d Pa^{233}) of these aliquots assayed with a gamma scintillation counter. The radioactivity measurement along with the speed and time of centrifugation, is used in calculating the concentration of particles of a given size. This method is also adaptable to the particle size analysis of sample materials other than thorium oxide in the submicron range.

It was found that controlled-potential coulometric titration is particularly applicable to the determination of copper and uranium in HRT fuel solutions. Copper is determined by electrolysis at -0.04 volts, followed by uranium determination at -0.3 volts (vs Ag-AgCl reference electrode). The standard deviation of uranium determinations (5-mg sample) was 0.4%. This technique will be particularly valuable in the analysis of "hot" fuel samples from the HRT.

The extraction of hexavalent molybdenum from acidic solutions with 0.1 M tri-n-octylphosphine oxide (TOPO) was studied. The extraction coefficients varied markedly with changing concentration of HCl. For example, maximum extraction coefficients of the order of 600 were found in 3 to 5 M HCl systems, and a minimum coefficient of 8 in 1 M HCl. The extraction coefficients for Mo(VI) in HNO_3, $HClO_4$, and H_2SO_4 systems are less than 50; the maximum values were obtained in 0.1 M HNO_3, 0.1 M $HClO_4$, and 3 to 5 M H_2SO_4 media.

A pyrolysis technique was successfully applied to the separation of 10 to 50 micrograms of fluoride from thorium oxide for analytical purposes. Thorium oxide, which contained known amounts of sodium fluoride, was mixed with U_3O_8 and heated in a fused silica tube at 1035°C in a stream of dry oxygen. The oxygen not only serves to sweep the fluoride into the absorption tube but enters into the pyrolysis reaction whereby volatile fluoride is released. The pyrolysis technique, in contrast to the pyrohydrolysis method of Warf, requires no superheated steam and thus avoids dilution of the absorbing solution by condensate. This is of particular advantage when microgram quantities of fluoride are determined. (AEC Activity 5330)

METALLURGY

Ceramics Research - Test specimens of two types of ceramic fuel elements were prepared and are now being irradiated in the MTR. In one type, UO_2 is imbedded in a matrix of Si-SiC; autoradiographs of these test elements show that radioactivity is not diffusing through the matrix during fabrication. Tests also indicate that the fuel content may be increased considerably by mixing the UO_2 with SiC and sugar. In a second type of test element, the UO_2 is imbedded in a Al_2O_3-Cr matrix.

In an investigation of materials for possible use in slurries for breeder blankets, several samples of sintered ThO_2-SiO_2 were prepared. Powder X-ray patterns of the sinters indicate that the $ThSiO_4$, a compound of interest, was produced in some of the samples. (AEC Activity 5420

Fundamental Physico-Metallurgical Research - The effect of deformation on the phase transformations in cerium is to reduce the total amount of transformation from the face-centered cubic form and to suppress very markedly the transformation to the hexagonal close-packed structure. Contrary to most diffusionless transformations, working below the M_s temperature causes a decrease in the amount of the hexagonal phase. The amount of collapsed face-centered cubic phase is greater in deformed than in annealed specimens. It is not yet known, however, if this is a result of more normal face-centered cubic phase being present at the M_s temperature for this transformation due to the suppression of the f.c.c. → h.c.p. transformation, or if the strain introduced actually promotes the f.c.c. → f.c.c'. transformation.

By means of thermodynamic formula and the assumption that alloying changes the free energy largely through changes in the energy at $0^{\circ}K$, the α/β phase boundaries of zirconium and titanium binary systems may be used to determine the relative energy changes of the two phases. These changes are approximately of the form $K_1 \Delta n + K_2 S$ where Δn is the valency change and S is the square of the size factor. Assuming this form, the averaged constants K_1 and K_2 are 0.032 and -3.15×10^{-4} for zirconium alloys and 0.025 and -3.49×10^{-4} for titanium alloys in units of e v/atom. In the above the Δn values are based on divalent zirconium, and an important test of this form for the relative energy change is an investigation of the α/β boundaries of a divalent solute of small size factor, such as cadmium. A zirconium-cadmium alloy containing 4 at. % Cd was found to be homogeneous beta phase at $891^{\circ}C$ and homogeneous alpha phase at 865-$875^{\circ}C$. At $879^{\circ}C$ a curious phenomenon, apparently associated with low rates of nucleation, occurred in which the 4 at. % Cd sample formed two solid layers, one alpha of 5.8 at. % Cd and the other beta of 2.4 at. % Cd. The α/β boundaries on the basis of this alloy rise slowly, with cadmium being about one-third as effective as indium.

Investigation of the α/β transformation in particularly pure dilute alloys of lead in zirconium indicates that the α/β transformation rises with increasing lead content and that a peritectoid reaction occurs for this alloy system at approximately $900^{\circ}C$. The maximum solubility of lead in the beta phase is approximately 7 at. % at $1100^{\circ}C$. (AEC Activity 5420)

Fundamental Investigation of Radiation Damage in Solids - Recently the change in electrical resistivity induced by neutron irradiation at 15 to $20^{\circ}K$ has been studied. The metals studied included bismuth, zirconium, tungsten, beryllium, lead, silver, magnesium, and molybdenum. The results obtained in Bi were especially interesting in that the rate of change of resistivity was 3×10^3 times the rate found earlier in copper. This change in resistivity was found to anneal in the temperature range from $70^{\circ}K$ to $300^{\circ}K$ at an approximately linear rate. It is not clear what caused the large change in resistivity, although the small number of conduction electrons plays a predominant

role, and there is some indication that the neutron irradiation changes the number of conduction electrons. Of the other metals, Be and Zr also show a comparatively high rate of change of resistivity with bombardment. Both of these changes are of the order of 35 times the rate of copper; only Ag has approximately the same rate as copper. It is impossible at the present time to completely rationalize the data obtained on these and other metals on the basis of atomic weight and the number of conduction electrons. It is intended that the investigation be continued, particularly in the case of Bi which may provide a direct experimental estimate of the number of displacements per neutron hit.

N-type germanium was exposed to fast neutrons at $20^{\circ}K$ in the low temperature facility of the ORNL Graphite Reactor. For a specimen containing $\sim 10^{17}$ excess donors per cm^3 the conductivity measured during exposure was observed to decrease at a rate only about one-half that expected for room temperature exposure. After a sixfold decrease in conductivity the specimen was warmed to $80^{\circ}K$; a marked excursion producing a conductivity maximum near $35^{\circ}K$ was observed. This conductivity maximum is undoubtedly associated with some type of relaxation phenomena but it is not clear at present whether it is due to a purely electronic process or an electronic process associated with defect motion. The smaller rate of conductivity change at $20^{\circ}K$, together with pulse annealing studies above $80^{\circ}K$, suggests that minority carrier-trapping processes are very important, as previously reported, and that metastable electronic states are responsible for maintaining the charge carrier concentration at a relatively high level during low temperature irradiation.

Measurements of the magnetic susceptibility of two silicon specimens was extended from liquid nitrogen temperature to the liquid helium range. One arsenic-doped specimen containing $\sim 10^{18}$ extrinsic electrons per cm^3 at room temperature showed a marked increase of paramagnetism as the temperature decreased; below $60^{\circ}K$ the total specimen diamagnetism was less than that for a pure specimen. This behavior is caused by freezing out of the conduction electrons onto their donor sites, thus removing the orbital diamagnetism of the free carriers and making evident only the spin paramagnetism of the unpaired electrons on the un-ionized donors. The low temperature slope of the curve obtained by plotting the excess susceptibility of the impure specimen over that of the pure material against reciprocal temperature is constant, as expected for Curie paramagnetism, and corresponds to 8×10^{17} unpaired spins per cm^3, in reasonable agreement with the concentration of donors. The second specimen contained in excess of 10^{19} extrinsic electrons and was appreciably degenerate. It exhibited only a small increase in paramagnetism in the low temperature range, as would be expected, since at this high donor concentration an impurity band that overlaps the conduction band should result and the carriers are expected to obey degenerate rather than classical statistics. (AEC Activity 5430)

PROGRAM 6000 - BIOLOGY AND MEDICINE

BIOPHYSICS

Experimental Ecology Program - Two small-mammal study areas were surveyed in the vicinity of the ORNL Waste Pits. Traps were set out for the collection of mice and voles to be used in a study of the animal vector in the dissemination of nuclides.

Radiochemical analytical procedures for the determination of ruthenium in tree tissues were tested; a satisfactory method has not yet been developed. (AEC Activity 6440)

Sanitary Engineering Research--Hazards and Criteria for Disposal of Low and Intermediate Level Radioactive Wastes - Through June 1956, 4.2 million gallons of waste containing an estimated 51,000 curies of Cs^{137} and 12,000 curies of Ru^{106} had been discharged to the pits. Three distinct types of waste streams are transferred: (1) a normal waste containing on the average 90% Cs^{137} and Ru^{106}; (2) a special program waste which is high in I^{131}; and (3) a waste with activities principally from the rare earths, the content depending on current operating procedures.

An evaporation study extending over a year was completed and the data are to be correlated with liquid losses. Prior study suggested a daily loss due to seepage of 3200 gallons from Pit No. 2 and 1200 gallons from Pit No. 3.

The pattern of waste movement from Pit No. 4 was followed closely by well sampling and radiologging. The leading front of the waste stream extends primarily in an east-west direction (paralleling the formation strike) and confirms predictions based upon hydrologic and geologic findings. The rate of underground waste movement ranges from 2 to 4 ft per day in this direction, and is less by a factor of 5 to 10 across the formation strike. Nitrates are predominant in the contaminated wells; within the accuracy of present techniques, Ru^{106} is the primary radionuclide involved in underground travel.

The vertical pattern of the waste stream from Pit No. 4, traced by radiologging two grouted wells, shows that the bulk of the cation activity is removed within the first foot of the shale material, while a continuous zone of activity (associated with the anions in the waste) extends 19 ft below the bottom of the pit. The activity intercepted adjacent to the pit occurs in discrete zones to a depth of 40 ft. These results confirm the hydrologic and geologic findings which suggested that the major portion of waste seeping from a shallow pit would flow through the weathered shale. (AEC Activity 6440)

Professional Health Physics Training Program - The 26 AEC Fellows in Radiological Physics and one Air Force officer completed the first quarter of graduate study at Vanderbilt University with better than average records.

A member of the Health Physics Staff at Wright-Patterson Air Force Base has been in the Division for 3 weeks for special training in Neutron Film Monitoring.

Two officers from the Medical Corps of the Air Force arrived February 19 for a six-month course in Health Physics. The Air Force plans to continue training officers in radiation protection to maintain a group of qualified officers. (AEC Activity 6690)

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STATUS OF CONSTRUCTION

Jet Engine Tests--Tower Shielding Facility - At the request of the Atomic Energy Commission the Tower Shielding Facilities were made available to the Pratt and Whitney Aircraft Corporation to conduct a series of tests to determine the effects of radiation on jet aircraft engines. This arrangement required the installation of special facilities for mounting the engines, for the fuel supply, and for engine sludge disposal. The facilities included a 10 by 27 ft reinforced concrete engine base; a reinforced concrete blast pad 150 ft long, flared from 20 ft wide at the front, adjacent to the engine base, to 72 ft wide at the far end; four fuel oil supply tanks each with a capacity of 20,000 gallons and the accessory transfer lines, pumps, and valves; and three 600-gal tanks for lubricating oil, lubricating oil sludge, and fuel oil sludge. The construction of the engine base and blast pad and the installation of the tanks was performed by the H. K. Ferguson Company under a cost-plus-fixed-fee contract. The Laboratory provided design drawings and assistance to Pratt and Whitney personnel in the handling, installation, testing, and removal of the first of the engine tests. Pratt and Whitney supplied the 20,000-gal tanks, pumps, and electrical cable; the Laboratory supplied miscellaneous valves and piping.

Construction by H. K. Ferguson Company was started December 12, 1956, and completed by January 15, 1957, the date specified by Pratt and Whitney. The installation of the jet engine and auxiliary equipment was completed and the test on the engine was started by January 26. On Saturday, February 1, the engine had been dismantled, crated, and loaded aboard a truck.

It is expected that Pratt and Whitney will conduct another similar test sometime in April. The facilities installed for these tests are to be maintained intact for at least six months, or until such time as Pratt and Whitney indicates that the testing has been concluded.

VISITORS

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Kouyoumzelis, T., Greek AEC, Greece
Krishnaswamy, G. S., Dept. of Atomic Energy, India (c/o Embassy of India, Wash.)
Mandel, Henrich, Euratom, Germany
Nakamura, Y., Federation of Metal Mining Worker's Union, Tokyo, Japan
Papaioannou, C., Greek AEC, Univ. of Athens, Greece
Pereira, A. W., Government of India
Quiani, Marcello, Euratom, Italy

VISITORS (Continued)

Ravelli, Jacques, Euratom, France
Regul, Rudolph, Euratom, Germany
Saito, I., Federation of Textile Worker's Union, Tokyo, Japan
Schilling, W., Deputy Swiss Delegate Atomic Affairs, Switzerland
Secord, Campbell, Euratom, Canada
Seifriz, A. W., Pres. Baden-Wuerttenberg Gov't Landes Gewerbeamt, Germany
Soerensen, E. J., M.A.N., Germany
Spinney, K. T., AERE, Harwell, England (BNL)
Zipoy, Andre, Euratom, France

RADIOISOTOPE SALES AND COSTS

Type of Transaction	January 1957	FY 1957 to Date
Domestic Sales	$143,895	$1,047,879
Foreign Sales	17,399	82,294
Project-Transfer	1,255	7,451
Project-Cash Sales	3,286	28,235
Technical Co-operation Program Credits	15	3,395
Plant Credits	2,682	30,223
AEC Credits	13,533	111,159
Total Radioisotope Income	$182,065	$1,310,636
Total Radioisotope Costs	$ 95,489	$ 763,051
Total Radioisotope Shipments	1,189	7,737
Helium		
Income	$7,865	$18,222
Costs	$1,306	$ 4,941
Shipments	4	18

GROSS OPERATING COSTS

	Cost for January	FY 1957 Cost to Date
Programmatic Operating Cost - Net	$4,003,958	$29,384,110
Equipment	162,367	1,487,532
Construction	155,225	1,076,626
Work for Others - Transfers	55,172	335,638
Inventory Changes	(13,786)	(569)
Reimbursable Work for Others	102,715	556,458
Deferred Charges	6,875	(260,849)
Total Laboratory Cost - Net	$4,472,526	$32,578,946
Estimated Cost for Next Month	$4,400,000	$36,978,946

()Credit

PERSONNEL SUMMARY

	Number of Employees February, 1957	New Hires February	Terminations February
Administration	73	0	1
Operations*	130	1	0
Engineering, Shops, and Mechanical	862	7	4
Laboratory and Research	2182	15	18
Protection	117	0	8
Service	386	3	3
	3750	26	34

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

933 Laboratory employees are working in the Y-12 Area.

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Reports in this series issued during the past year:

February 1956	ORNL-2062
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April 1956	ORNL-2082
May 1956	ORNL-2109
June 1956	ORNL-2123
July 1956	ORNL-2144
August 1956	ORNL-2166
September 1956	ORNL-2185
October 1956	ORNL-2205
November 1956	ORNL-2232
December 1956	ORNL-2248
January 1957	ORNL-2261

Edited by F. T. Howard

Approved by Alvin M. Weinberg, Director