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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

October, 1955

F. T. Howard

and

W. H Sullivan

Date Issued: NOV 7 1955

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STATUS AND PROGRESS REPORT

October, 1955

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

PROGRAM 2000 - SPECIAL NUCLEAR MATERIALS

Thorex Process - Eight development runs with Hanford-irradiated thorium feed were completed; each run, operated at a thorium throughput of 200 kg/day, lasted approximately 72 hr. The irradiation level of the slugs was such that the U^{233} varied from 600 to 1000 g/ton; the fuel had decayed about 180 days. The one-cycle flowsheet used (ORNL-1757, Fig. 2.1) included dissolving aluminum-jacketed thorium metal slugs in excess nitric acid; evaporating to remove the excess acid and diluting with water; acid recovery; solvent extraction, partitioning, and stripping; continuous solvent recovery; continuous concentration of the thorium product; and isolation of U^{233} on Dowex-50 ion-exchange resin.

Uranium was separated from thorium by a factor of 10^4, the thorium from gross fission products by a factor of 10^4, and the uranium from gross fission products by a factor of 5×10^4. The radiation from the recovered 2 M thorium nitrate product, when drummed, was comparable to that of natural thorium. The radiation from the recovered uranium product was a factor of 10 less than that from uranium nitrate which had previously been safely processed to the metal.

Design of the second solvent extraction cycle for additional decontamination of thorium is approximately 95% complete; completion is expected about November 1. Construction is currently scheduled for completion December 1. In tests on the proposed cycle, flooding rates in the extraction column were 720, 526, and 386 gal/ft^2-hr at pulse frequencies of 50, 60, 70 cycles/min with a 0.8-in. pulse amplitude. At 60 cycles/min in an 8-ft-high column the thorium loss was 0.6%.

An alternate solvent recovery system was designed, constructed, and installed as a test facility in the Thorex pilot plant. The system consists of a pair of vertical spray columns, in which the spent solvent from the first cycle is contacted with 0.2 M Na_2CO_3 and then with 0.01 M HNO_3. (AEC Activity 2423)

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PROGRAM 4000 - REACTOR DEVELOPMENT

HOMOGENEOUS REACTOR PROJECT

Homogeneous Reactor Test - The hydrostatic test of the reactor shield tank was completed. After the tank was filled with water, an overpressure was applied to give measured pressures of 26 psig at the top of the tank and 36 psig at the bottom of the tank, an average pressure of 31 psig. The pressure and strain-gauge data indicated that the tank will withstand an internal gas pressure of 30 psig (the pressure which might result from the instantaneous release of all hot liquids in the reactor core and blanket high-pressure systems) without failure. Following the pressure test, the roof structure was removed and the tank cleaned in preparation for the installation of equipment, which was begun at the end of the month. The low-pressure blanket assembly performed satisfactorily during its final test and was installed in the reactor cell.

Testing of the low-pressure fuel assembly continued through October. Excessive entrainment occurred during a full-scale dumping test; revisions are being made to reduce the entrainment.

The contractor's work in the building and chemical processing cells is complete except for a small amount of additional work on the steam system. The over-all HRT construction continues to be about four working weeks behind schedule. (AEC Activity 4103)

HRT Chemical Pilot Plant - Concrete walls of cells B and C were poured, and five coats of Amercoat were applied to the interiors. The 5-ton bridge crane was installed, and the outer walls of the chemical plant addition were erected. (AEC Activity 4103)

HR Blanket Studies--Chemical Development - Slurries of thorium oxide, prepared by the thermal decomposition of the oxalate at 650° and 900°C, were irradiated at 300°C in the LITR for 66 and 175 hours, respectively, without apparent damage. A 650°C preparation irradiated for one month at 300°C in the Graphite Reactor also showed no apparent change. Slurries containing 1000 g of thorium per kg of H_2O were stirred without difficulty at 300°C in the dash-pot irradiation bomb, both in and out of the reactor.

Palladium, at a concentration of 1030 parts per million parts of thorium, in a thorium oxide slurry containing 660 g of thorium per kg H_2O and containing also 0.5 wt % uranium (based on the thorium), gave a hydrogen-oxygen combination rate of 19 moles of hydrogen per hour per liter at 115°C and a hydrogen pressure of 500 psi. Nickel and copper, as metal and oxide powders, were much less effective as recombining catalysts; even at 0.1 m concentration not more than two moles of hydrogen was combined per hour per liter at 280°C and the same hydrogen partial pressure.

In laboratory studies, pyrohydrolysis of thorium oxalate gave a greater yield of finely divided oxide than did thermal decomposition. The oxide particles from the pyrohydrolysis appeared to be of the same dimensions as the x-ray

crystallite and were independent of the oxalate precipitation temperature. The particles showed no tendency to grow on recalcination up to 900°C. The settling rates of pyrohydrolyzed thorium oxide slurries increased with increasing calcination temperature of the oxide and decreasing slurry concentration. In the absence of a dispersing agent ($Na_4P_2O_7$), the settling rates were higher and the bulk densities lower at pH's above 7. Slow settling rates, pronounced dispersion effects, and higher bulk densities were obtained at lower pH's with sulfuric acid, phosphoric acid, and thorium phosphate additives. The average size of sedimentation particles from thorium oxide slurry was considerably decreased, to an equilibrium value of approximately 0.5 μ, by pumping at 250-300°C.

Approximately 1000 pounds of thorium oxide meeting specification was prepared from Lindsay high purity thorium nitrate tetrahydrate. The oxide was prepared by precipitating thorium oxalate with a 15% excess of oxalic acid at 70°C, filtering and washing, and step calcination at 375°, 520°, and 800°C. The calcined oxide was blended in 200-pound lots and wet screened through 200 mesh. An additional 9000 pounds of thorium oxide will be required during the next six months. (AEC Activity 4103)

HR Fuel Reprocessing - X-ray diffraction studies showed that the structure of solids precipitated from simulated fuel solutions, which contained rare-earth sulfates at elevated temperatures, varied not only with the concentration of the rare-earth sulfate but also with the acidity. Apparently simpler solids were obtained when the amount of sulfuric acid present was larger than 25 mole % excess. The final concentration of rare-earth sulfates remaining in solution was not significantly affected, however, by varying the excess acid from 25 to 100 mole %. The behavior of cerium sulfate, in the presence of oxygenated fuel solution in contact with a Zircaloy-2 surface hotter than the solution, was inconsistent. In some instances crystalline solids were deposited on the hot surface and in other cases they were absent. Synthetic solids, partially simulating those expected from reactor operations, dissolved slowly in boiling 63% nitric acid.

The ORNL 5-gpm canned pump powered by a 3-phase motor has satisfactorily accumulated 1700 hr of operation with 80-cycles/sec current.

The Fulton-Sylphon bellows valve demonstrated much more satisfactory service with stainless steel-to-stainless steel trim than with the previously tested Stellite-to-Stellite trim. After 12,000 cycles with the stainless steel trim the lead rate was only 20 ml/min at 500 psi pressure.

With a 0.4-in.-dia hydroclone and a 2-gal underflow pot, the underflow rate was 1%, and the contents of the pot were essentially 96% displaced in 24 hr.

In studies on the thermal breeder blanket processing, the lower protactinium recoveries obtained when larger amounts of ThO_2 were leached with 6 to 8 M H_2SO_4 for 3 hr were apparently a result of poor contacting, which resulted in slower leacing rates. Higher recoveries from 3- to 11-g batches of ThO_2

were obtained by diluting to dissolve the $Th(SO_4)_2$ and recrystallizing the $Th(SO_4)_2$ by evaporation at 80°C. In these tests, 60 to 70% of the protactinium was leached with thorium losses of less than 0.5%. In order to remove 95% of the protactinium, it was necessary to dissolve 6 to 11% of the thorium. This procedure involves large volumes and is not attractive for full-scale processing.

The $Th(SO_4)_2$ obtained by refluxing ThO_2 in sulfuric acid was converted to ThO_2 by calcination in air at 900°C for 24 hr. Washing in air for 2 hr reduced the sulfate content from 0.11% to only 100 ppm. (AEC Activity 4103)

HR Plutonium-Producer Blanket Processing - Studies on the adsorption of plutonium from 1.26 m UO_2SO_4 on Zircaloy-2 and titanium (possible materials of construction for the blanket shell) under simulated reactor conditions appeared essentially nonreversible. As much as 1 mg/cm^2 was adsorbed on titanium and 0.25 mg/cm^2 on Zircaloy-2, with no indication of an approach to equilibrium. The rate of adsorption was markedly dependent on the concentration of plutonium in solution. When about 1 liter of 1.25 m UO_2SO_4 containing 100 mg Pu/kg H_2O was passed over Zircaloy-2 at 250°C, about 30 μg Pu/cm^2 was adsorbed. When the uranyl sulfate contained 3 mg Pu/kg H_2O, only 0.03 μg Pu/cm^2 was adsorbed. This latter value is of most interest since the soluble plutonium in the blanket solution will be about 3 mg/kg H_2O. Essentially all the plutonium on the metal walls is present as PuO_2. It seems likely that small crystals of PuO_2 are formed or trapped in the corrosion film and that these crystals may grow.

Factors for PuO_2 concentration by a $\frac{1}{4}$-in.-dia hydroclone from a water slurry at room temperature varied from 3.0 to 4.6. Much greater concentration factors can be expected at 250°C.

Measurements of plutonium solubility and adsorption, obtained from experiments in which 1.25 m UO_2SO_4 (0.03% U^{235}) was irradiated in the LITR at 250°C, were not reproducible. This may be a result of assuming that neither the neptunium nor the plutonium migrated during the 3- to 4-day decay period. Plutonium in solution was calculated at 6 - 28 mg/kg H_2O. Adsorption of plutonium was only 1 - 6 μg/cm^2; however, this represented 20-50% of the total plutonium present. At least 80% of the neptunium was in solution. (AEC Activity 2723)

HR Fuel Circulation Equipment - A 400A Westinghouse pump completed a run of 920 hours at approximately 285°C with a solution of approximately 0.04 m UO_2SO_4 with 0.005 m $CuSO_4$ and 50 mole % excess H_2SO_4. The loop was dismantled at the end of the run. All parts of the system were in excellent condition except the new hollow-type thermal barrier. The "O"-ring gasket on the thermal barrier had leaked and some corrosion of the barrier had occurred. A heavier walled "O" ring was supplied by Westinghouse and a new run with the same solution is now being made.

The 300-gpm pump in the fuel-system mockup was stopped after several thermal cycles, because of a gasket leak. When the pump was dismantled, it was noted

that the gold plating had flaked off a large part of the gasket surface. An unplated gasket was substituted, which again showed a leak after two thermal cycles. The flange was tightened further, and thermal insulation was removed. This appears to have corrected the trouble.

The 230-gpm prototype pump for the blanket system completed two runs for a total of 300 hours with thorium dioxide slurry. The second run lasted approximately one week. The pump and loop were in good condition at the end of the run. This pump was released for installation in the HRT blanket mockup system.

The stainless steel 400-gpm HRT fuel circulating pump has been shipped. The stainless steel 230-gpm HRT blanket circulating pump is now being tested and inspected; it will be shipped early in November. The titanium pumps for similar applications are scheduled for delivery in November or early December.

Using the proposed start-up schedule for the addition of UO_2SO_4 to the HRT, the 4000-gpm fuel circulation loop was started and run. After 410 hours, a concentration of 5 g of uranium per liter was reached, at which time corrosion of the Hastelloy-D check valve balls in the feed pump forced a shut-down.

The prototype HRT purge pump for adding water to the reactor has operated 1700 hours without trouble. Tests show that it is unable to resume pumping once it becomes gas bound; however, by raising the inlet pressure to 17 to 20 psi, it will restart against a discharge pressure of 2000 psi. (AEC Activity 4103)

HR General Reactor Component Development - The HRT fuel-system mockup loop completed a 110-hr run with 0.04 m UO_2SO_4 solution containing 50 mol % excess H_2SO_4 at 300°C and 2000 psi. Although the O_2 level had been increased over the previous run, to 110 ppm, corrosion rates were still high, as indicated by Ni analysis. Considerable precipitation was observed in the pressurizer heater legs which were severely pitted; it is probable that most of the corrosion took place in them. The pressurizer heater legs were replaced with new pipe. Gas pressurization will be used in the next run to determine if elimination of the hot legs will result in a lower corrosion rate.

The Crane Company presented design calculations for the titanium-lined pipe test sections which they are building. The Pfaudler Company submitted drawings of the small titanium-lined heat exchanger which they are building. A contract was placed with Armour Research Foundation for a 6-month study of the metallurgical cladding of titanium on steel. (AEC Activity 4103)

HR Heat Removal Equipment - The fabrication of the two HRT heat exchangers was nearly completed. Small leaks, which developed around the tube joints during thermal cycle testing, were repaired, and the units underwent an additional ten cycles. If no additional leaks have developed, the units will be cleaned and subjected to a final helium leak test.

Gasket leakage, as a result of thermal cycling, was stopped by using longer (more flexible) bolts, preheating the steam drum before cycling, and modifying the specifications for the thermal cycle. After the thermal-cycle test, one unit was pressurized to 3750 psi before leakage was observed.

The Sarlun-type seal weld was tested and found to be adequate for use on these exchangers. Tests and calculations indicated that the pass partitions of these exchangers will leak slightly during operation. (AEC Activity 4103)

HR Gas Handling Equipment - The effectiveness of the thermal convection recombiner was tested with steam diluent at 100 psia, and air diluent at atmospheric pressure; the diluents are used to prevent the formation of explosive mixtures. The feasibility of the method was established, and criteria for the design of future units were developed. The capacity of the recombiner was above 1 scfm of H_2 at 100 psia and 0.2 scfm of H_2 at 15 psia.

The layout drawing and bill of materials for a 20 cfm gas circulator were approved. Allis Chalmers Manufacturing Company is completing details and procuring materials to fabricate the unit. (AEC Activity 4103)

PACKAGE REACTOR DEVELOPMENT

Package Power Reactor Program - The fabrication and testing of the APPR-1 critical experiment facility was completed and criticality measurements are now in progress.

The APPR-type fuel-element irradiation program in the MTR is now well underway. In Phase I of the program, a series of small APPR-type fuel plates with varying fuel-particle sizes are to be irradiated to 20% and 40% burn-up. This irradiation was started on June 24 and is expected to be completed by December. In Phase II, a full-size fuel assembly was inserted in the lattice of the MTR on June 24 and removed August 22, with an estimated average burn-up of 25% and a maximum burn-up of 40%. The individual fuel plates will be milled apart in the MTR hot cell, after a sufficient cooling period, and shipped to Oak Ridge for metallurgical examination. A preliminary examination of the fuel assembly was made in the MTR canal by means of an underwater periscope; no damage could be observed.

At the request of the AEC, Alco Products, Inc., contractor for the APPR-1 has agreed to complete the plant by July of 1957. This is a speed-up of 5 months and will necessitate a speed-up in the supporting development and fabrication programs at this Laboratory. (AEC Activity 4201.1)

GENERAL REACTOR RESEARCH

Radiation Damage--Advanced Engineering and Development - The thermal conductivity of ceramics that were irradiated with up to 2×10^{20} fast neutrons/cm^2 was measured at room temperature. Silica glass, Al_2O_3, BeO, and plate

glass showed no change. Pyrex glass, TiO_2, spinel, steatite, mica, ZrO_2, HfO_2, and lead glass all showed considerable change, but none changed by much more than a factor of two. The thermal conductivity of Forsterite changed from 180×10^{-4} to 43×10^{-4} cal/sec-cm^2-$^\circ$C/cm. Cordierite changed from 77×10^{-4} to 21×10^{-4}; and a high-thermal-conductivity zircon changed from 120×10^{-4} to 21×10^{-4}. X-ray diffraction studies of the same materials indicated that the MgO which was irradiated in air decomposed quite drastically. Lead glass was devitrified. The monoclinic phase of ZrO_2 disappeared and left only the cubic phase. Lattice expansion was observed in the following materials: $BaTiO_3$, 2.87% in a_0; BeO, 0.3% in c_0; ZrO_2, 0.28% in a_0, mica, 1.7% in c_0. The following materials showed loss of crystallinity: lava, SiC, zircon, and mica.

Structural changes produced by fast-neutron bombardment of single crystals of InSb are being observed. Radiation produces a highly distorted lattice, giving rise to considerable mosaic broadening of diffraction lines. Bombardment with 2×10^{20}neuts/cm^2 results in the transmutation of more than 3% of the In to Sn, and this complicates the structural defects due to knock-on displacements. Despite the large amount of bombardment-induced distortion, no measureable lattice expansion was observed. However, diffuse x-ray scattering characteristic of radiation-damaged of the crystals is apparent.

In-pile measurements of the expansion of LiF single crystals were made at 60 and -160°C with strain gages. From the initial slopes of the linear-expansion versus nvt curves, the strain per 10^{15} neutrons/cm^2 is 1.0×10^{-4} at 60°C and $(1.0 \pm 0.2) \times 10^{-4}$ at -160°C. Thus, the expansions are the same at both temperatures, within experimental errors. (AEC Activity 4540)

Basic Reactor and Shielding Research - Temperature measurements were made throughout fuel plates in the Bulk Shielding Facility (BSF) to investigate the variation both along the length of the plates and from surface to center. The maximum temperature rise observed was 64°C. The maximum temperature difference from the meat (center) to the surface was about 3°C. These temperatures appeared in the fuel element located between the safety rods when the reactor was operating at a power of 1 Mw. The shading effect of the safety rod position on the temperature distribution was also studied.

The program to provide definitive values for the attenuation of radiations from a pool-type reactor in water was extended to include fast-neutron dose. Measurements were made with three dosimeters: a Hurst-type "absolute dosimeter" with alpha-particle calibration, a Hurst-type "phantom dosimeter" with low gamma-ray response for measurements near the reactor core, and a 1-in. diameter "Hornyak button". Measurements were made through water thicknesses from 30 cm to 150 cm. Further measurements will be made when the testing of other dosimeters is completed.

Measurements were completed of some fission properties of separated plutonium isotopes. The thermal neutron fission cross section (0.025 ev) for Pu^{240} was determined to be 4 ± 7 b, by comparison with the known value for U^{235}.

The number of neutrons emitted per themal fission is 3.30 ± 0.23 for Pu^{241}, determined also by comparison with the known value for U^{235}. The number of fissions was determined in a small parallel-plate fission chamber and the fission neutrons were detected by a 5-in.-dia Hornyak button. All exposures were made in the beam from Hole 57 of the ORNL Graphite Research Reactor.

In view of the proposed operation of the ORR at a power of 30 Mw, an analysis was made of the shielding. The review was made for five positions outside the biological shield and for the cooling system. The reactor shield was found to be adequate, except at the experimental facilities. It was anticipated that the shielding there would be augmented locally to reduce the dose to the permissible level. The dose in the sub-pile room may be excessive, due to streaming through openings provided for the control rods, but there is no need for personnel to remain in this room for extended periods while the reactor is operated at 30 Mw. The shielding for the cooling system is also apparently adequate under normal conditions. In the event of demineralizer failure, however, the dose at the pump house wall and at the heat exchanger exclusion fence will be above the permissible level. (AEC Activity 4570)

Reactor Theory - Surface absorption of resonance neutrons in uranium lumps was investigated by Wigner's theory. The ratio of surface to volume absorption times the scattering cross section per uranium atom was predicted to be equal to 1/8; an analysis of the experimental data yielded 1/14 for this constant. (AEC Activity 4570)

Power Reactor Waste Disposal--Airborne Radioactivity Studies - In a study of aerosol entrainment from bubbling liquids, air was bubbled through radioactive potassium carbonate solutions, contained in a glass cylindrical vessel 3 cm in diameter, to determine the amount of air contamination produced. The air dispersers were (1) a simple open-end tube, and (2) a tube fitted on the end with a fritted glass disc. In both cases the tubes extended about 5 cm into the solution. The bubbles produced by the fritted disc were much smaller than those produced by the open-end tube. The contamination factor was expressed as the activity per ml of air pumped divided by the activity per ml of solution. The results show that (1) the larger bubbles produce much higher contamination factors; and (2) both high solids concentrations and low flow rates reduce the contamination factor. (AEC Activity 4630)

PROGRAM 5000 - PHYSICAL RESEARCH

ISOTOPE PRODUCTION

Stable Isotope Production - The collection of enriched isotopes of the following elements was completed: sulfur, 46.4g, (masses 32, 33, 34, and 36); titanium, 63.4g (masses 46, 47, 48, 49, and 50); strontium, 45.4g (masses 84, 86, 87, and 88); bromine, 81.g, (masses 79 and 81); molybdenum, 49.2g (masses 92, 94, 95, 96, 97, 98, and 100) and samarium, 29.2g (masses 144, 147, 148, 149, 150, 152, and 154).

Enrichment of the isotopes of barium (masses 130, 132, 134, 135, 136, 137, and 138) is in progress. Commercial barium metal for calutron charge material was stripped of strontium contamination by vacuum distillation; the Sr-free material permits high beam currents with reduced sparking. The initial calutron separation of the isotopes of europium (masses 151 and 153) was started in Beta channels using $EuCl_3$ charge.

New lots of enriched Li^6, Li^7, Ca^{42}, Ca^{43}, Ca^{44}, Ca^{46}, Te^{123}, Te^{124}, Te^{125}, Te^{126}, Te^{128}, and Te^{130}, were added to the inventory.

A total of 170 lots of returned isotopes were submitted for chemical analysis as the first step in getting such material back into inventory in usable form. (AEC Activity 5121)

PHYSICS

Scintillation Spectrometry and Instrument Development - The largest known NaI scintillation crystal, a 9.25-in. dia. conical-topped cylinder equivalent to a 10-in. dia. sphere, was received. A $\frac{1}{2}$-in. hole was drilled to the center of the crystal and a housing of 5-mil Al foil was made for the crystal and photomultiplier tubes. The crystal and tubes are suspended by wires from a surrounding cage in order to maintain low scattering conditions. The resolution of the crystal and phototubes is being studied from 320 kev to 7 Mev. When this crystal was used with three 5-in. photomultiplier tubes, a resolution of 11% was obtained on the 661-kev Cs^{137} peak. At 2.76 Mev a resolution of 5.8% was found, while at 513 kev 94.6% of all pulses lie within the peak. The present 2-in. thick lead shield, 18 x 18 x 24 in., is inadequate to stop the ThC" and K^{40} γ-rays; a 4-in. thick semiportable shield is being designed to remedy this condition.

Tests of photomultiplier tubes performed in an effort to understand the resolution limitations of scintillation counters confirmed the report of the Savannah River group that most phototubes show better resolution with a light pulser than with crystals, for the same number of incident photons per pulse. The resolution is about a factor of two better for almost all tubes. Cutting scintillation crystals into smaller and smaller pieces, down to $\frac{1}{2}$ x 1 x 1 mm, shows the crystal resolution to be essentially independent of size, which indicates that if the spread is due to faults in the crystal, an extremely fine grained phenomenon is involved. Attenuation of the light between the

crystal and phototube seemed to indicate that there is an inherent resolution in crystals of ~6% (full width at half maximum) for Cs^{137} radiation. No conclusion has been reached as to the cause of this effect.

The decay of 8.6-min Ca^{49} and its 57-min daughter, Sc^{49}, were studied with beta- and gamma-ray scintillation spectrometers. Excited states in Sc^{49} from Cu^{49} were found to be 3.10, 4.05 and 4.68 Mev, with relative intensities of 1.0, 0.11 and 0.0038. Two beta groups were resolved in the Ca^{49} spectrum with maximum energies of 1.95 and 0.89 Mev. In agreement with previous work, Sc^{49} was found to be a pure beta-ray emitter with an energy of 2.05 Mev. The excited states of Sc^{49} are reasonably consistent with qualitative shell model predictions but seem higher in energy than would be expected from comparison with the similar nucleus, Ca^{41}.

The gamma rays following the decay of 9.45-min Mg^{27} were studied with a NaI scintillation spectrometer and through beta-gamma coincidence counting. The decay proceeds 70% through a 0.834-Mev gamma ray, 29% through a 1.015-Mev gamma ray and 1% through a 0.170-Mev gamma ray. The isotopic thermal neutron activation cross section for the production of Mg^{27} is found to be 25 $\pm$ 2 millibarns. The spins and parities of the first two excited states of Al^{27} are consistent with simple shell-model predictions. (AEC Activity 5220)

High Voltage Program - The operation of the 2.5-Mv Van de Graaff machine was improved by the installation of a new terminal spinning and by refinishing the inside of the pressure tank. The generator now operates reliably at 3 Mev and has produced an analyzed beam at 3.5 Mev. A new electrostatic lens which incorporates an einzel lens was installed in the high voltage terminal. Design consideration emphasized small aberrations, low magnification, and precision alignment. The predicted magnification is two at the entrance to to the magnet; experimentally the diameter of the beam at this point is less than 0.10 inch. The lens elements are constructed of beryllium and stainless steel; as a result of this construction the X-ray intensity near the terminal is about 2% of its previous value. Measurements have not yet been made to determine the effect of this construction on the maximum operating value.

Further measurements were made on the $T(d,n)He^4$ reaction to determine the absolute cross section. Neutrons were produced by the bombardment of a tritium gas target with deuterons from the 5.5-Mv Van de Graaff. The monoenergetic neutron spectrum was observed in a radiator-type triple coincidence spectrometer consisting of two proportional counters and a NaI crystal. With both a target thickness and deuteron energy increment of 50-100 kev the 0-deg cross section was measured from E_d = 1 to 5 Mev. The 0-deg COM cross section continues to drop with increasing energy from the well-known resonance at 107 kev to 11 mb/ster at 2.5 Mev and then rises steadily to 18 mb/ster at 5 Mev. The previously observed angular distributions were normalized to these results at 0-deg and integrated. The total cross section decreases to 76 mb at 3.5 Mev and increases to 82 mb at 5 Mev.

Study of the γ-rays produced by the inelastic scattering of protons by Si^{28} with the 5.5-Mv Van de Graaff generator was continued. Yield curves were taken with a target 2-kev thick, at 3-Mev bombarding proton energy, and with points approximately 1 kev apart. Gamma-rays were detected by means of a 3 x 3 in. NaI(Tl) crystal. Five additional narrow, low intensity resonances were found at 2.63, 3.88, 3.93, 3.97 and 4.93-Mev proton bombarding energy. A value of 64 $\pm$ 12 mb/steradian was obtained for the peak 0-deg cross section at the 3.10-Mev resonance.

The absorption cross sections of U^{235} and Pu^{239} were measured at six energies in the 5 to 50-kev energy range. Neutrons from the reaction $V^{51}(p,n)Cr^{51}$ were used in spherical shell transmission measurements with NaI as the detector. The analysis included corrections for geometry (finite source-to-detector distance and finite detector size), multiple scattering, and fission activation. The absorption cross sections are as follows:

E_n, (kev)	σ_a^{25}, (barns)	σ_a^{49}, (barns)
4.4	5.5 $\pm$ 0.5	4.4 $\pm$ 0.6
11.8	4.1 $\pm$ 0.4	3.2 $\pm$ 0.5
33.1	2.7 $\pm$ 0.4	1.7 $\pm$ 0.5
39.6	3.0 $\pm$ 0.5	2.2 $\pm$ 0.5
44.0	2.7 $\pm$ 0.4	2.4 $\pm$ 0.5
48.8	2.9 $\pm$ 0.4	2.5 $\pm$ 0.5

(AEC Activity 5220)

Classification of Low-Lying Nuclear Energy Levels - The simple empirical model applied previously to the problem of the correlation of nuclear magnetic moments was extended to the analysis of nuclear electric quadrupole moments. The empirical rules found in the previous work have in general been confirmed; however, the $d_{3/2}$ nuclei form an exceptional group. A correlation of the moments of these nuclei is possible, however, within the context of the present model and suggests that the description of the properties of the I = 3/2 nuclei may be particularly model-dependent. A possible explanation of the anomalous magnetic moment of W^{183} was found. (AEC Activity 5220)

86-Inch Cyclotron, Nuclear Physics - The project on the measurement of cross sections for (n,α) reactions induced by 14-Mev neutrons was completed and a paper is being prepared for publication. The results indicate that the cross sections are an order of magnitude smaller than previously reported in the literature.

The fission-fragment spectrograph was completed and installed in the ORNL Graphite Reactor. Preliminary data indicate that the energy distribution of mass-97 fragments from U^{235} fissions induced by thermal neutrons has a half width of at least 6 Mev. (AEC Activity 5220)

86-Inch Cyclotron, Operation - The beam deflector system has been installed in the 86-inch cyclotron, and the machine is now in the testing and adjustment stage. The dees and other components of the r-f system within the vacuum tank were replaced or modified when the deflector was installed. The installation was made in such a way as to permit the continued use of high-current internal targets. The first stage of the testing program is to determine the general characteristics of the internal circulating beam and to optimize the shape and position of the beam. In early tests a 500 microampere beam of 22-Mev protons was obtained on the internal target. The general characteristics of the beam appear to be relatively unchanged by the modifications. (AEC Activity 5220)

Electronuclear Machines - A study is being made of the practicability of a fixed-frequency cyclotron designed to accelerate protons to about one Bev. At this energy the large beam currents usually associated with a continuous wave machine would be extremely useful in meson research. In the design being considered the relativistic mass effect is overcome by an unusual magnetic field configuration; the ions are held in phase by a radially increasing average field and defocusing forces are compensated for by periodic azimuthal field variations. Calculations which have shown the feasibility of such a system were analyzed to determine the most practicable field configuration. Interest is presently centered on a configuration which has eight azimuthal cycles with about 70 degrees of spiral. A test model electron cyclotron was designed for use in solving certain experimental and design problems. A study is now being made of the most economical design for the large magnet and accelerating system. The magnet would be of sufficient size to permit acceleration of protons to about 850 Mev. (AEC Activity 5220)

63-Inch Cyclotron, Physics - The excitation functions for five reactions of nitrogen on boron and two reactions on oxygen were determined. Chemical separation of reaction products was required in determining the cross sections for three reactions of nitrogen on aluminum; two of the reactions are of the evaporation type, and the third is probably due to the stripping of a neutron. The elastic scattering of nitrogen from Li^6 and Li^7 is being investigated; the bombardments were made and the plates are now being read. Experiments were initiated to determine the importance of parity change in stripping-type reactions from nitrogen on Mg, Si, and Na. (AEC Activity 5220)

Spectroscopy Research Laboratory - The fundamental molecular vibrations of T_2O, THO, and TDO were remeasured to improve the accuracy. Vibrational assignments of 211 band heads of Po_2^{210} and 195 of Po_2^{208} have been made to date. Empirical vibrational equations were developed for Po_2^{210} states as follows:

$$G'(v) = 25125.7 + 108.12\, v' - 0.443\, v'^2$$
$$G''(v) = 0 + 155.78\, v'' - 0.360\, v''^2$$

Zeeman measurements and g-factor calculations of tellurium spectra are being obtained at a precision of $\pm$ 0.001 g unit, or better. Independent methods of magnetic field determination are being developed using nuclear resonance techniques; the possibility of obtaining a precise value of e/m is good. X-ray fluorescence measurements on a 200-mg sample of americium (Am^{241}) oxide with a Cauchois-type curved-crystal transmission spectrometer gave $L\alpha_2$ 14.407, $L\alpha_1$ 14.614, $L\beta_2$ 17.672, $L\beta_1$ 18.845, and $L\gamma_1$ 22.056 kilovolts with an error of less than 8 volts, in substantial disagreement with less precise values of other workers.

The infrared assay method for $>$99% D_2O samples was improved to a precision of $\pm$ 0.005% and is limited in accuracy only by a lack of adequate standards. Spectrographic methods of analysis for rare earths was improved significantly in the 1-100 ppm range. X-ray fluorescence studies of Zr-U, Nb-Zr-U, and Mo-U alloys reveal unsatisfactory correlations with chemical analysis; it is believed the error is in the chemical method. A total of 273 samples were analyzed (2900 element determinations) by spectrographic means, 130 samples were analyzed for compound identification by x-ray diffraction methods, and 4 isotope determinations were made by infrared methods. (AEC Activity 5230)

Mass Spectrometry Laboratory - The heat of polymerization for the reaction $3\ AgCl \longrightarrow Ag_3Cl_3$ was determined by a new method. The quantities experimentally determined are ratios of ion currents of a monomer peak and a trimer peak at a variety of temperatures. A log-log plot of monomer versus trimer peak heights yields a straight line whose slope is the heat of vaporization of the monomer to that of the trimer. It was possible to determine these ratios both for solid and liquid silver chloride. The reproducibility in five experiments was fair. The resultant data are consistent with the known heat of fusion and a high temperature value for the heat of vaporization. These data yield a heat of polymerization of about 95 kcal/mole compared to a value of about 120 kcal/more reported for $3\ CuCl \longrightarrow Cu_3Cl_3$. This parallels the slight increase in bond energies for the diatomic molecules, AgCl, for which D = 72 kcal/mole and CuCl for which D = 88 kcal/mole.

A total of 210 mass analyses were performed for other groups in ORNL. (AEC Activity 5250)

Research and Development--Stable Isotopes - Additional equipment necessary for the separation of 100 grams of Li^6 having a minimum purity of 99.99% was designed, and fabrication of parts is now in progress.

During the collection of argon isotopes, a new surface of magnesium will be continually deposited on the walls of the collector pockets to entrap the gaseous isotopes. An alternate pressure-vacuum-operated mechanism for feeding magnesium ribbon into the region from which it can be vaporized was operated successfully.

Yttrium oxide of extremely high purity was prepared by oxalate precipitation from homogeneous solution. Cross section measurements with the ORNL pile

oscillator gave a value of approximately 1.40 barns, in close agreement with a previously reported value of 1.38. Hydrolysis, amalgam reduction, and citrate elution from a cation exchanger were all found less effective than oxalate precipitation in removing traces of rare earths with high cross sections.

A technique for vacuum-plating silver cyclotron targets with elemental calcium was developed; Ca^{48} was deposited in this way for preparing 4.8-day radioactive Ca^{47}. A 2-3 mil foil of Cu^{63} was prepared electrolytically from dilute solutions of its salt. A revised procedure for obtaining isotopic boric acid from elemental boron includes solution of the boron in concentrated HNO_3, followed by crystallization of the H_3BO_3 from hot water. (AEC Activity 5250)

CHEMISTRY

Uranium Chemistry of Raw Materials - As mentioned previously (ORNL-1920), when TBP and di(2-ethylhexyl) phosphoric acid are used in combination as a uranium extractant, the extraction power is considerably greater than the cumulative extraction power of each component used separately. Recently it has been found that a similar or even greater synergistic effect is given by other "neutral" organophosphorus reagents in combination with di(2-ethylhexyl) phosphoric acid, e.g., dialkyl alkylphosphonates, trialkylphosphine oxides, and trialkylphosphites. Comparative extractions from an acidic sulfate liquor (0.5M SO_4, 0.004M U(VI), pH1) by combinations of such reagents with 0.1M di(2-ethylhexyl) phosphoric acid kerosene were as follows:

Added Reagent	Concentration, M	E_a^o
Acid reagent alone	-	135
Tributylphosphate	0.08	800
Triamylphosphate	0.10	1000
Dibutyl butylphosphonate	0.08	3000
Di(2-ethylhexyl) 2-ethylhexylphosphonate	0.05	800
Tributylphosphoric oxide	0.05	7000
Tridecylphosphoric oxide	0.02	8000

It may be noted from these results that the magnitude of the synergistic effect depends upon the type and structure of the reagents. For example, in the series of normal butyl derivatives of tributylphosphate-dibutyl butylphosphonate-tributylphosphine oxide the enhancement of extraction coefficient increased in the order listed, i.e., with increasing number of carbon-phosphorus bonds.

The high extraction power shown by these synergistic reagents may be of considerable practical value in the solvent extraction of liquors ordinarily difficult to extract. In addition, the reagents have shown other useful

properties, e.g., (1) the uranium may be economically stripped from the organic phase by a solution of sodium carbonate, (2) the selectivity for uranium is improved in that the extraction of such contaminants as iron, aluminum, vanadium, and titanium is not correspondingly enhanced, (3) losses of the reagent through solubility in the aqueous phase during extraction are low.

The solvent extraction process for recovering uranium from Western ore sulfate leach liquor, utilizing di(2-ethylhexyl) phosphoric acid or other dialkylphosphoric acids in kerosene as the extractant, is now being successfully used in treatment of liquors from ~150 tons of ore per day at the Shiprock, New Mexico, plant operated by the Kerr-McGee Oil Industries. (AEC Activity 5310)

Equipment Decontamination - Since fission products are bound in the corrosion film deposited on stainless steel by uranyl sulfate reactor fuels at 250° to 300°C, removal of this film is necessary for adequate decontamination. The use of strong reducing agents is the most promising method for effectively removing this oxide film. Of the reducing agents tested, $TiCl_3$ gave the most rapid reduction and dissolution of the film. At room temperature, solutions containing 20, 10, 2, and 1% $TiCl_3$ removed such a film in 1, 4, 20, and 25 hr, respectively. Although these results are encouraging, the use of $TiCl_3$ may not be practical since it oxidizes and hydrolyzes to produce a TiO_2 precipitate and HCl; it would be difficult to remove these materials from the reactor system. (AEC Activity 5310)

Hope Project - A pulse mechanism was used for pumping the feed solutions to solvent extraction columns as well as for intercolumn pumping, thus significantly reducing the number of pumps required. The reproducibility of the flow rates was ± 5% in a 12-in.-dia 40-ft-high twin-concatenated pulsed column system.

Tests indicated the Garloc connector to be the most satisfactory for remote disconnect applications.

Heating of synthetic process wastes to convert aluminum nitrate to dibasic aluminum nitrate (diban) permitted ion exchange sorption of fission products preferencially to aluminum. Since the effluent from the ion exchange column would have a very low activity, it could be stored cheaply in open asphalt-lined pits. The highly radioactive fission products could be eluted and either recovered or concentrated for small-volume storage. (AEC Activity 5310)

Inorganic Solution Chemistry - Study of the ion exchange properties of zirconium hydroxide for anions, and of zirconium tungstate and zirconium phosphate for cations, was continued. Emphasis was placed on the effect of changes in preparation procedures on adsorptive properties.

Zirconium phosphate was found to adsorb Pa^{233} tracer from solutions containing aluminum nitrate (ca 1.5 M) and small concentrations (up to 0.2 M) of

HNO_3 and KF. The distribution coefficient D (counts per kg adsorbent/counts per liter of solution) was greater than 10^4. From 1 M thorium nitrate and 2 M thorium nitrate-aluminum nitrate solutions, adsorption also occurred, with values of D in the range 150-400.

In continued anion exchange studies of metals from concentrated chloride solutions, principal emphasis centered on adsorbabilities from "neutral" chloride solutions such as LiCl, $MgCl_2$, $CaCl_2$ and $AlCl_3$. Adsorbabilities are in general very much higher in the low acid media than in HCl, for the same chloride concentration. This acid dependence of adsorbabilities should be of considerable advantage in processing neutral chloride solutions by anion exchange. (AEC Activity 5330)

Nuclear Chemistry - A previously unreported radioactive species was found associated with Ce^{139}. The half-life of 55 sec, the gamma-ray energy of 740-kev, and the internal conversion coefficient of 0.08 are consistent with assignment of the radiations to an M4 isomeric transition in Ce^{139}. (AEC Activity 5330)

Chemistry of Fused Salts - Development was almost completed for a new type of apparatus to determine electrical conductance of highly conducting solutions, particularly fused salts, without the necessity of using a capillary cell. This apparatus will be especially useful in measuring conductance of fused salts, such as fluorides, that are very corrosive to quartz and other insulators. A "matched transformer" bridge was designed and built, which has an accuracy of about 0.05% at a total resistance of 0.1 ohm. There is, however, a small unexplained variation of measured resistance with frequency in the range from one to six kilocycles when the resistance of electrolytic solutions is determined. The new "cup" electrodes make it unnecessary to know the exact depth of immersion of the electrode assembly in the solution. Tests with molten sodium nitrate show that the data obtained are in good agreement with published values. An attempt will be made to establish reference standards for conductance measurements on fused salts.

Study of the equilibria of a number of dilute solutions of one salt in a second fused salt were continued by means of the freezing-point depression technique. Some evidence was obtained that appreciable deviations from ideality exist when the sizes of the ions of the solute and solvent are sufficiently different. (AEC Activity 5330)

Analytical Chemistry Research - A rapid and reliable method was developed for the determination of silicon in thorium oxide without prior separation of silicon from the thorium. The thorium oxide is dissolved in hot 4 N nitric acid containing a small amount of HF; under these conditions, no silicon is lost and all silicon is rendered soluble. Silicon is then determined by the silico-molybdenum blue spectrophotometric method. Interference due to precipitation of thorium molybdate is prevented by adding tartaric acid, after development of the heteropoly blue color, to redissolve the thorium precipitate. The absorbancy of the molybdenum blue solution is

measured at a wave length of 840 mμ. By this method, 5 to 100 ppm of silicon in thorium oxide was determined with a precision within 10%.

A flame photometric method was developed for the determination of chloride; it is based on the decrease in emissivity of a dilute silver nitrate solution due to the addition of chloride. The emissivity of a standard dilute solution of silver nitrate is measured at a wavelength of 328 mμ. The sample containing chloride is then added, the resulting silver chloride precipitate removed by centrifugation, and the emissivity of the supernatant solution measured. The reduction in emissivity is proportional to the quantity of chloride added. This method is especially useful for the determination of micro quantities of chloride. For this purpose, it offers the advantages, when compared to conventional titration techniques, of greater simplicity, speed, and precision. By this method, 20 samples can be determined in one hour. For samples containing 1 to 10 μg of chloride per ml, the precision is of the order of 5%.

An ion-exchange-polarographic method was developed for the determination if iron(III) in Homogeneous Reactor fuels. Copper, which interferes, is removed from the fuel by plating it onto a cadmium coil. Iron is oxidized to iron(III) by potassium permanganate, and the iron(III) is separated from interfering metal ions by ion-exchange on Dowex 1 resin in the sulfate form. The iron-(III) in the effluent is determined polarographically in 0.5 M sodium citrate solution as supporting electrolyte. A fairly well defined polarographic wave is obtained for iron(III) — iron(II) reduction at a E1/2 of approximately -0.15 v vs the S.C.E. (sat'd. calomel electrode). (AEC Activity 5330)

METALLURGY

Ceramics Research - Mixtures of rare earth oxides (Sm_2O_3 and Gd_2O_3) and iron or stainless steels were compacted for subsequent extrusion-cladding and evaluation as control rod materials.

A second fission-product clay slurry was heated sufficiently to produce sintering without violent eruption with a heater generating about 0.018 w/cc of dried slurry. The effectiveness of a large number of clay-flux mixtures on retaining waste fission products was measured by determining the activity of leaching water. Activity in the leach water was not more than slightly above background in any case.

The processing and petrography of spodumeme ores is being studied. The relationships among mineral content, structures, heat treatment, and other treatments were investigated with respect to subsequent removal of lithium from the ores.

Approximately 40 different ceramics were sent to the MTR for use in the cooperative radiation damage program with the Solid State Division.

The phases of Eu_2O_3 were determined as cubic to 1150°C and pseudo-rhombohedral or "undetermined" at higher temperatures. No evidence of transition to the hexagonal La_2O_3-type structure was found up to 1700°C. (AEC Activity 5420)

Fundamental Physico-Metallurgical Research - A thorough examination was made of the preferred orientation of some hot-rolled and annealed Zircaloy-2 plate. Pole distribution and axis distribution charts were obtained, taking as "fiber axes" the rolling, normal, and transverse directions. The most preferred crystallographic directions of the three reference axes do not correspond to poles of planes nor to directions of low indices. The most preferred rolling direction was a position 15° from $\langle 10\bar{1}0 \rangle$ and 18° from $\langle 11\bar{2}0 \rangle$; the most preferred normal direction was 13° from $\langle 0001 \rangle$; and the most preferred transverse direction was 20° from $\langle 10\bar{1}0 \rangle$ and 20° from $\langle 11\bar{2}0 \rangle$. The normal direction was closer to $\langle 0001 \rangle$ than would be expected from results on zirconium sheet. This is attributed to a reduction in the thickness of approximately 50% by cross-rolling which preceded the final straight-rolling during the fabrication of the plate. Cross-rolling would be expected to cause the pole of $\langle 0001 \rangle$ to become parallel to the normal direction.

Silver-zirconium alloys made from the best iodide zirconium contain sufficent impurities so that a three-phase region exists near the eutectoid temperature of the β phase. Reduction of the hydrogen content from 10 to 3 ppm showed that hydrogen is not responsible for this anomaly.

Analytical results indicate that by floating-zone refining the iron impurity in zirconium is reduced from 45 to 1 ppm, the nickel impurity from 5 to 1 ppm, and the α/β transition range from 15 to 5°C. These results are in excellent agreement with the theoretical calculations. (AEC Activity 5420)

Fundamental Investigation of Radiation Damage in Solids - Radiation damage in high-purity specimens of germanium is currently being investigated by exposing the specimens to γ-rays from a Co^{60} source. This investigation was prompted by the work of Dugdale at Harwell who suggested that energetic electromagnetic radiation may be capable of introducing lattice defects into crystalline solids through the agency of Compton electrons and recoils from the photoelectric absorption process. He presented evidence for such an effect in the order-disorder alloy Cu_3Au. A decrease in charge carrier concentration was observed in the p-type germanium specimens when they were exposed to the Co^{60} γ-radiation here at ORNL, which suggests that lattice defects were indeed introduced. (AEC Activity 5430)

BIOPHYSICS

Experimental Ecology Program - A single beech tree-hole from the Laboratory environs was completely excavated and the removed substrate treated as follows. One series of 50 gram samples was subjected to gamma radiation (Co^{60}) at doses of: 3×10^3, 8×10^3, 1.5×10^4, 2.5×10^4, 5×10^4, 7.5×10^4, 1×10^5, 1.25×10^5 r. These samples, together with controls, were processed through Berlese funnels after irradiation to determine immediate lethality. No pronounced effects were found under 7.5×10^4 r. Three other series of 100-gram samples were given the same doses and stored in red clay flower pots under conditions of constant temperature, light, and relative humidity. At intervals of 30, 60, and 90 days, 5 controls and 1 sample at each of the aforementioned doses, were processed to extract the surviving arthropod populations. Under the conditions of this experiment it was found that doses of 3,000 and 8,000 r had little effect on the arthropod populations analyzed 30 and 60 days after irradiation.

Gamma radiation studies were also made on the natural microbial populations in the same tree-hole. The substrate was subjected to a range of doses from 5×10^3 to 2.5×10^5 r. Survival curves were determined for six physiological groups of micro-organisms separated with the following media:

1. Basal medium - for enumerating bacteria without complex growth requirements.

2. Amino acid - for organisms requiring one or more amino acids.

3. Soil extract - for enumerating organisms with nutritional requirements more complex than simple amino acids.

4. Cellulose-dextrin - for enumerating organisms able to utilize cellulose as the sole carbon source.

5. Rose-bengal - for separating fungi present.

6. Streptomyectes medium - for the enumeration of streptomycetes present.

Doses of 5×10^3 to 1×10^4 r produced greater than 50% mortality in all these microbial populations but a fraction of each populations survived the highest dose given.

Initial gamma irradiation studies on a single species of soil inhabiting coleoptera (Onthaphagus texanus) were completed. The dose for sterilization was found to be about 5,000 r for both sexes when irradiated as adults. When irradiated as 2nd stage larvae 2,000 r was effective as a sterilization dose. Larvae treated with 4,000 r, either failed to complete development or emerged as deformed adults. (AEC Activity 6440)

Sanitary Engineering Research--Field Investigations and Explorations - Radiologging of observation wells was employed in an attempt to define the vertical configuration of radioactive waste flow through the soil formations. The interpretation of these data will be completed after wastes have entered the well. A casing was grouted in place in one well to prevent waste entrance. By radiologging it should now be possible to define the vertical pattern of wastes intercepted at this well. (AEC Activity 6440)

Health Physics Radiation Dosimetry Programs - The Radiation Dosimetry Section participated in a series of fast neutron measurements at Argonne National Laboratory during the week of October 10, 1955. This was a part of the general program of cooperation with biological investigations in an effort to provide better dosimetry. Dosimetry measurements were made satisfactorily with the proportional counters at both the CP-5 and the ANL 60-Inch cyclotron, and the results were reported to the participants.

The series of threshold detectors (ORNL-1671) which was developed to measure the tissue dose of fast neutrons, was suggested as a fixed monitor for critical facilities and reactor installations. Twelve of these units (containing Pu with 8 cm B_4D shield, U, S, and Au) were installed at various sites at ORNL. In case of an accident these samples will be recovered and counted as soon as possible. If counting can be started within one hour after the accident, tissue doses small as 1 rad can be measured. The dose which a man would have received had he been at the location of the foils can be determined with an error less than 20%.

There has been much interest in the application or relation of information theory to biology since Shannon's paper appeared in 1949; Gamow and Quastler have been prominent contributors to this new field. There has also been a great deal of interest in finding mathematical relations among the variables of biological material. A simple first order differential equation, which has been studied by H. A. Blair appears to relate empirically dose, dose rate, and radiation injury as reflected by a shortened life span. A paper in which this equation is derived from information theory was submitted for publication (H. P. Yockey, Nature). The derivation is based on the storage of genetic specificity in the DNA molecule, as described by Watson and Crick. (AEC Activity 6560)

Professional Health Physics Training Program - The 1955-56 group of AEC Fellows, numbering 20, began the 12-month training period in Radiological Physics under the Fellowship program at Vanderbilt University, September 22, 1955. (AEC Activity 6690)

RADIOISOTOPE SALES AND COSTS

Type of Transaction	September 1955	FY 1956 to Date
Domestic Sales	$ 114,330	$ 310,234
Foreign Sales	18,454	25,207
Project-Cash Sales	4,275	11,923
Project-Transfer	817	1,121
Technical Cooperation Program Credits	175	640
Plant Credits	1,143	2,580
AEC Credits	9,193	22,860
Total Radioisotope Income	$ 148,387	$ 374,565
Total Radioisotope Costs*	$ 185	$ 134,642
Total Radioisotope Shipments	1,038	3,050
Boron and Helium		
Income	$3,298	$11,769
Costs	$1,990	$ 2,300
Shipments	6	13

*Cobalt account was credited with $79,392, unspent funds accrued for MTR cobalt from FY 1955.

GROSS OPERATING COSTS

	Cost for September	FY 1956 Cost to Date
Programmatic Operating Cost - Net	$3,086,556	$9,096,066
Plant and Equipment Cost	302,093	935,125
Program "H"	12,828	32,850
Work for Other Parties - Transfers	24,731	26,894
Inventory Changes	2,104*	19,820*
Reimbursable Work for Other Parties	212,042	624,146
Deferred Charges	468*	81,764*
Total Laboratory Cost - Net	$3,635,678	$10,613,497
Estimated Cost for Next Month - Net	$3,750,000	$14,363,497

*Credit

[redacted]

PERSONNEL SUMMARY

	Number of Employees October, 1955	New Hires October	Terminations October
Administration	63	2	1
Operations*	121	1	0
Engineering, Shops, and Mechanical	774	7	3
Laboratory and Research	1979	27	10
Protection	141	1	1
Service	370	4	3
	3448	42	18

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

A total of 833 Laboratory personnel are located in the Y-12 Area.

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Reports in this series issued during the past year:

October 1954	ORNL-1805
November 1954	ORNL-1824
December 1954	ORNL-1838
January 1955	ORNL-1849
February 1955	ORNL-1867
March 1955	ORNL-1878
April 1955	ORNL-1886
May 1955	ORNL-1905
June 1955	ORNL-1920
July 1955	ORNL-1936
August 1955	ORNL-1968
September 1955	ORNL-1980

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