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OAK RIDGE NATIONAL LABORATORY

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May, 1956

Edited by:

F. T. Howard

Date Issued: JUN 6 1956

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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

May, 1956

This status and progress report represents 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

Metallex Process - Countercurrent packed-column washing of thorium quasi amalgam, formed by sodium amalgam reduction of $ThCl_4$, was 5 times as fast as batch washing. The decontamination from sodium was a factor of >70 in an 18-in.-high column. Thorium losses were 0.062%. The carbon decontamination factor was 16, but there was no decontamination from zinc, aluminum, iron, copper, or nickel. Washing with 1 N HCl, rinsing with argon-sparged water, and vacuum drying of thorium amalgam demonstrated a clear-cut advantage over other methods in producing an oxide-free amalgam from which thorium metal containing less than 1% ThO_2 could be recovered. The determination of the free void fraction in sintered thorium metal was shown to correlate with washing, reduction, and sintering conditions. (AEC Activity 2704)

Power Reactor Fuel Reprocessing - The Zircex process for removing cladding from fuel elements was demonstrated on a laboratory scale. Hydrochlorination of a section of Zircaloy-2--clad uranium-molybdenum alloy at 300°C removed the jacket completely in 3.75 hr. The core dissolved readily in 10 M HNO_3. The insoluble molybdic acid that formed during the dissolution was suspended in the dissolver solution and apparently did not materially decrease the dissolving rate; it was removed by filtration. The aqueous solution contained 99.9% of the total uranium. When irradiated uranium-zirconium alloy that had decayed 3 weeks was hydrochlorinated, 38% of the β and 45% of the γ activity followed the sublimed $ZrCl_4$. Corrosion tests indicated that Inconel, which corroded at a rate of 0.2 mil/month when hydrochlorinated at 400°C, is a suitable material of construction for a hydrochlorination reactor. A-nickel, 304L stainless steel, and Monel had favorable corrosion rates, i.e., 0.5, 0.7, and 1.0 mol/month, respectively.

Sulfuric acid, which is being considered as a reagent for removing thin stainless steel or zirconium jackets, dissolved various core metals very slowly. In boiling 6 M H_2SO_4 uranium metal dissolved at a rate of 0.032 mg/cm^2-min; 0.5% Si--99.5% U at 0.043 mg/cm^2-min; 1.2% Si--98.8% U at 0.064 mg/cm^2-min; and 90% U--10% Mo showed a weight gain of 0.0077 mg/cm^2-min. The core alloys containing silicon and molybdenum dissolved readily in nitric acid. A 0.5% Si--99.5% U alloy dissolved in 8 M HNO_3 at an initial rate of 58 mg/cm^2-min; a 1.2% Si--98.8% U alloy at 77 mg/cm^2-min.

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Chlorides in aqua regia solutions of metals were reduced to less than 5 ppm by passing the liquid down a stripping column which was fed with vapor from boiling 15.2 M HNO_3. The concentration of the chlorides in the column feed was kept below 0.6 M to prevent oxidation of the HCl by the HNO_3.

Type-347 stainless steel dissolved in 6 M HNO_3--4 M HCl at a rate of 9.7 mils/min at 75°C; the heat of reaction was 41.8 kcal/mole. The dissolution could probably be carried out in a tantalum vessel, since tantalum gained weight only slightly under the same conditions. Titanium corroded at a rate of 1.5-3 mils/month. Hastelloy and Durochlor corroded too rapidly to be of interest.

In studies on the Hermex process for recovering uranium by dissolving in mercury, uranium irradiated to 5×10^{16} n/cm^2-sec and decayed 10 days was decontaminated from gross β and γ activities by factors of 70 and 20, respectively. Cesium, Sr, and rare earth factors were 130, 16,000, and 4700, respectively, while those for Ru, Zr, Nb, and Pu were 6, 5, 4, and 3. For the tests, the uranium was dissolved in boiling mercury, and the quasi amalgam thus formed was washed with 1 M HCl. The amalgam was heated under vacuum to 1200°C to volatilize the mercury and melt the uranium. Continuous mercury removal and subsequent uranium melting from cold-pressed uranium amalgam compacts was demonstrated.

Uranium chloride from Zircex-processed U-Zr alloy was reduced to uranium amalgam by a sodium amalgam reduction with a yield of 80%. (AEC Activity 2924)

PROGRAM 3000 - WEAPONS

RaLa - A RaLa run was made, and approximately 16,000 curies of product was shipped on May 12, 1956. (AEC Activity 3641)

PROGRAM 4000 - REACTOR DEVELOPMENT

HOMOGENEOUS REACTOR PROJECT

Homogeneous Reactor Test - Engineering tests were begun on the HRT. Equipment tested included the high-pressure package boiler, deaerator, boiler feed pumps, steam condenser, charcoal beds, and the refrigeration system. Hydrostatic tests were completed on the fuel and blanket steam system and on the reactor process piping. Preparations are partially completed for cleaning the system with trisodium phosphate and nitric acid. (AEC Activity 4103.1)

HRT Chemical Pilot Plant - All mechanical equipment for the HRT Chemical Plant has been fabricated and is scheduled to be installed by June 30. The installation of low-pressure piping is about 95% complete. Remote-control valves for the process cell arrived May 15 and will be installed immediately. The service piping and refrigeration piping in Cell C are complete. The roof plugs, which are being fabricated by an outside contractor, are to be delivered by June 15. Membrane sheets for making the top seal for the process cells are scheduled for delivery by the end of May. Probably the last items to be delivered will be electrical equipment, such as starters and switch gear. It is expected, however, that all conduit and junction boxes will be installed by the end of June. The control room is about 70% complete; the control panel was received and checked. (AEC Activity 4103.1)

Reactor Analysis - The power-time relation for the HRT after shutdown was calculated for several possible situations. If the steam valve from the core heat exchanger were closed, the reactor would become subcritical in ~ 2 min if the 400A pump continued to operate, but might remain critical indefinitely if the 400A pump were stopped. In the latter case the rate of energy release would be less than ~ 600 kw for times greater than several seconds following stoppage of the pump. If the heat exchanger were operated in a normal fashion, natural convective flow would keep the reactor power at ~ 700 kw following stoppage of the pump.

The insertion of corrosion specimens into the HRT core region will effectively add poisons to the reactor and thus increase the fuel concentration required for criticality. The maximum poisoning associated with these specimens was calculated to be less than 11%. This maximum poisoning would increase the core critical concentration from ~ 7.1 to ~ 8.7 g U^{235}/kg D_2O at 280°C.

If two-phase operation occurred in the HRT core with the 400A pump off, large amounts of reactivity could be injected into the reactor upon pump startup. This situation can be eliminated by requiring critical conditions before pump startup, following reactor operation.

Nuclear and economic calculations were made for some cylindrical two-region thorium breeder reactors. The results indicate that the maximum power density at the core wall can be appreciably decreased only by making a substantial increase in reactor length. Minimum fuel costs appear, however, to be associated with high core power densities, since increasing the reactor length increased the inventory charge until that charge controlled the fuel cost; the associated increase in breeding ratio was slight.

Preliminary nuclear calculations were made for a single-region, high-flux, homogeneous research reactor. To obtain a maximum thermal flux of ~ 6.5 x 10^{15} neutrons/cm^2-sec, a total thermal power of 500 Mw would be required; the power density would be ~ 2 kw/liter at the wall, ~ 110 kw/liter maximum, and ~ 35 kw/liter average. At 250°C the core critical mass would be ~ 9 kg of U^{235}, corresponding to a U^{235} concentration of about 0.7 g/kg D_2O. The temperature coefficient of reactivity would be near -9 x 10^{-4} Δk_e/°C at 20°C and about -2.5 x 10^{-3} Δk_e/°C at 250°C. (AEC Activity 4103.1)

Reactor Instrumentation - The metering stations for the oxygen valve and the capillary pressure drop were calibrated and found suitable for use in the HRT low-pressure system. Before being installed in the HRT instrument cubicles, they will be tested on the HRT mockup high-pressure oxygen generator system. It is hoped that the units will be suitable for injecting oxygen in both high and low pressure systems.

An operating prototype of the HRT remote-area radiation-monitoring system was inspected at the plant of the Victoreen Instrument Company in mid-April. It is believed that the final system will be ready for inspection the first week in June.

A valve identical to the modified dump valve of the reactor blanket was cycles 400 times on the valve test loop, and leakage after cycling was not appreciably greater than before. The nominal 12-gal volume of the loop pressure vessel and the consequent rapid decrease in upstream pressure at the valve result in a much less severe test than will be obtained in the reactor. However, this dump cycle test is severe enough to reveal inherent mechanical faults in the valve design, such as those found in the blanket dump valve before the plug angle was changed from 25 to 65 deg. The core dump valve was cycled 430 times but has not yet been leak checked or disassembled for inspection. (AEC Activity 4103.1)

HR Design - The following items in the design of the HRT were completed: assembly and mounting details for fuel and blanket space cooler, instrument tube fission-chamber positioning equipment, fuel and blanket pressurizer layout and supporting details, pressurizer liquid-leve-indicator support drawings, redesign of injection pump check valves, rupture-disc assembly and details, revised designs for temporary and permanent freezer units and determination of locations of the various types of these units in the process piping, Monitron installation for the pumps and stack, cell microphone housing and mounting details, and revision of the HRT sampler drawings to incorporate changes required on the basis of experimental work on the prototype sampler.

Approximately 99% of the working drawings needed for the design of the reactor are completed.

Recommendations were made for the copper-catalyst concentrations required for the HRT fuel solution at all power levels up to 10 Mw and as a function of gas letdown and overpressure.

Extensive maintenance and tooling programs have been adopted. Job-analysis sheets were prepared for the inspection and/or replacement procedures for 92 specific cases. A detailed outline of 24 reactor maintenance operations was compiled, and actual trials will be completed.

A procedure was written and drawings were prepared for the removal of shielding plugs and the insertion of a periscope and a remote lighting facility in any of six openings in the control-room area. (AEC Activity 4103.1)

Metallurgy - Although x-ray studies of quenched 15 and 20% Nb-Zr alloys indicated the presence of only a sing-phase cubic structure, a metallographic examination revealed the presence of a very fine second phase as a Widmanstätten precipitate. This second phase is thought to be α-zirconium. Both x-ray and metallographic examination of quenched 5 and 10% Pd-Zr alloys revealed a completely cubic structure at room temperature.

Procedures were developed by which high-purity nitrogen may be substituted for expensive helium or argon as a backup gas in the inert-gas arc welding of type-347 stainless steel. Welds of HRP quality were made. (AEC Activity 4103.1)

In-Pile Autoclave Tests - An experiment was performed to determine the radiation corrosion of Zircaloy-2 by a UO_2SO_4 solution containing no copper. (Previous Zircaloy-2 experiments have, in every case, been with solutions which contained added $CuSO_4$.) The uranium enrichment employed was low, and the fission power density in solution was about 1 w/ml during exposure in the LITR HB-5 facility. At this low power density the gamma-ray intensity in the facility proved sufficient to effect recombination of most of the radiolytic gas produced by fission recoils. The pressure of radiolytic gas during exposure both at 250 and 280°C reached a steady state of about 100 psi. For approximately 100 hr at the start of irradiation, which was at a temperature of 250°C, the corrosion rate remained quite low. It then increased to about 1.9 mil/yr and remained fairly constant at a given temperature. The rate at 280°C was approximately double that at 250°C. The 250°C rate is essentially the same as that determined for loop specimens exposed at the same power density but in solutions which contained 0.03 m $CuSO_4$. Hence, there is little indication that the presence or absence of cupric ion influences the radiation-induced corrosion.

An examination of the data from the various LITR experiments with Zircaloy-2 autoclaves revealed that the corrosion rate determined in a given experiment was approximately proportional to the square root of the fission power density which prevailed in the experiment. The experiments considered were those for which the solutions were about 0.17 m in UO_2SO_4. Some of these solutions contained added H_2SO_4 at a concentration of 0.04 m; others contained no added acid. On a plot of corrosion rate vs the square root of the fission power density, it appears, in general, that a straight line passing through the origin can be drawn approximately through experimental points obtained with solution which contained acid and was exposed at 250°C.

Another line can be drawn through the points for solution which contained acid and was exposed at 280°C. Other straight lines can be drawn for the system which contained no acid. In agreement with the conclusion mentioned in the preceding paragraph, the corrosion rate under irradiation appeared to be unaffected by the presence or absence of copper. (AEC Activity 4103.1)

In-Pile Loop Tests - Examination of the dismantled parts of loop L-4-11 was essentially completed. The aluminum oxide pump bearings showed no appearance of wear or change in dimensions. Irradiation of loop L-4-12 was completed. The total circulation time was 2020 hr and the accumulated LITR energy during this run was 4375 Mwhr. Dismantling of the loop and examination of the specimens are now in progress. (AEC Activity 4103.1)

Laboratory Service Corrosion - Stress-corrosion cracking was observed on six U-bends of type-347 stainless steel pipe after 11,000 hr of service with 60-psi steam (165°C) passing through the U-bends, which were externally cooled by a tap-water spray. The cracks were located randomly over the entire outer surface of the pipes and, in a few cases, had almost completely penetrated the wall thickness. Presumably the low concentration of chloride ions in the tap water was responsible for the cracking. The chloride ions were concentrated in the deposit which formed on the water-cooled surfaces of the pipes; the deposit contained 760 ppm chloride. One of the original U-bends was removed from the test system after 3000 hr of operation, and numerous small cracks had already formed.

The effect of chloride concentrations of 5, 10, 25, 50, and 100 ppm and of bromide and iodide concentrations of 100 ppm on the promotion of stress-corrosion cracking of type-347 stainless steel was examined in boiling and aerated solutions of 0.04 m UO_2SO_4 containing 0.02 m H_2SO_4 and 0.005 m $CuSO_4$. Specimens were stressed at 15,000 and 30,000 psi. After 200 hr of exposure, stress-corrosion cracks were found on the specimens stressed at 30,000 psi in the solutions containing 25, 50, and 100 ppm of chloride. No cracking occurred on any of the other specimens during this period. (AEC Activity 4103.1)

Dynamic Loop Tests - The corrosion of stainless steel at 250°C in 1.3 m uranyl fluoride was about half as severe as in 1.3 m uranyl sulfate at the same temperature. The addition of an almost equimolar amount of sodium fluoride to the uranyl fluoride further decreased the corrosion rates (by a factor of 10) to about 10 mil/yr at flow rates below 20 to 25 ft/sec. Lower corrosion rates could be expected in long-term tests because protective films had formed on the specimens. Titanium and several titanium alloys were attacked in crevices by the solution containing the added sodium fluoride. No zirconium specimens were exposed to solution, but even in the vapor phase Zircaloy-2 sheet specimens were totally dissolved in tests at 250 and 300°C. Titanium specimens in the vapor were unattacked, and type-347 stainless steel showed only slight attack.

A 3200-hr test at 300°C with 0.04 m UO_2SO_4 containing 0.005 m $CuSO_4$ and 0.015 m H_2SO_4 was terminated. The austenitic stainless steels exposed to this solution were filmed over at velocities up to 34 ft/sec and showed corrosion rates less than 1 mil/yr. Several titanium alloys showed low, though measurable, corrosion rates of 0.2 to 0.5 mil/yr, but commercially pure titanium, zirconium, and Zircaloy-2 showed no measurable corrosion rates. Several stainless steels and titanium alloys stressed to 80% of their room-temperature yield strengths were exposed in the liquid, spray, and vapor regions; no increased attack or cracking was observed. (AEC Activity 4103.1)

Dynamic Slurry Tests - A dynamic corrosion test in 100A-pump loop CS using a slurry charge of 1000 g Th/kg H_2O was terminated after 49 hr of operation at 300°C because of plugging in the loop pressurizer. At an average circulating concentration of 547 g Th/kg H_2O for the 49-hr period and with a velocity of 10 ft/sec, the following corrosion rates (in mils per year) were obtained for pin-type specimens: types-347, 316, and 309-SCb stainless steel, 3; gold, 0.4; and SAE-type 212 steel, 150. No detectable weight losses occurred with type-75A or type-RC-55 titanium or with a titanium alloy containing 3% Al and 5% Cr. Average attack rates at 20 ft/sec were: types-347, 316, and 309-SCb stainless steel, 8; gold, 0.4; SAE-type 212 steel, 165; types 75A and RC-70 titanium, 4; and titanium alloy containing 3% Al and 5% Cr, 5.

ORNL-produced ThO_2 was recalcined at a temperature of 1400°C for respective periods of 2, 4, 24, and 96 hr. The particle-size distribution of this material, as determined by gravitational sedimentation in $Na_4P_2O_7$, was not detectably different from that of the charge material. However, even 2 hr at 1400°C produced marked changes in the average crystallite size from that shown by the charge material (from 107 to 2500 Å) and in the specific surface area (from 30.3 to 1.4 m^2/g). Longer periods of heating (96 hr) produced only relatively slight further changes in crystallite size (>5000 Å) and specific surface are (0.9 m^2/g). Slurries of these oxides at a concentration of 1000 g Th/kg H_2O were circulated in toroids under 90 psi oxygen at 250°C for 263 hr at 26 ft/sec relative velocity. The attack rates on corrosion pin specimens of type-347 stainless steel varied between 2 and 7 mil/yr and of Zircaloy-2 between 2 and 3 mil/yr. These rates are indistinguishable from the attack by ThO_2 fired at lower temperatures.

Preliminary investigations into the effect of a hydrogen blanket atmosphere and the value of phosphates as dispersing agents for ThO_2 gave the following results. Titanium was severely attacked (100 to 2000 mil/yr) by circulating slurries of ThO_2 (calcined at 800°C) at 1000 g Th/kg H_2O, at 250°C, and at 26 ft/sec relative velocity in the presence of 0.1 M $Na_4P_2O_7$ (pH 10.9) or 0.1 M NaH_2PO_4-0.1 M Na_2HPO_4 (pH 7.0) and in the presence of O_2 or H_2. Zircaloy-2 appeared to be essentially unaffected in all these systems. Type-347 stainless steel was much less affected than the titanium, although some attack rates in the alkaline medium with O_2 and H_2 atmospheres were higher than those generally found in the nearly neutral slurries under O_2. (AEC Activity 4103.1)

HR Math and Computation - Fermi ages and diffusion constants for two-group calculations were evaluated for thorium oxide slurries, UO_2SO_4 solutions, and equimolar UO_2SO_4-Li_2SO_4 solutions over a range of concentrations and temperatures for various mixtures of light and heavy water. (AEC Activity 4103.1)

GENERAL REACTOR RESEARCH

Basic Reactor and Shielding Research - Critical experiments with University of Michigan reactor elements in the BSR grid were performed for three configurations. A 5 by 5 element array was critical with 3119 g of U^{235}, and a 6 by 4 array was critical with 3259 g of U^{235}. A 3 by 9 array was not critical with 3675 g of U^{235}. The University of Michigan elements were also substituted individually in a subcritical assembly of BSR elements to determine their relative worth. The reactivity of each element was comparable to the best cold BSF elements and all the elements were remarkably consistent.

An experiment for the National Advisory Committee for Aeronautics is being performed to determine the effect on the reactivity of: (1) removing air from specific locations within the core; (2) removing plates from an element; and (3) inserting an experiment within the core. For the third test containers of various lengths and compositions are inserted in the void of the central control rod.

A preliminary experiment was performed to determine the diffusion coefficient of neutrons in graphite. The results showed that a strong background of neutrons (reflection of neutrons from the walls of the room) will necessitate a shield around the sample to be investigated. An additional experiment will be performed to determine whether a cadmium shield will be sufficient. (AEC Activity 4570)

Reactor Theory - The homogeneous effective resonance integral of U^{238} metal was calculated from resonance data at T = 300°K reported in BNL-325. In contrast to a previous calculation (L. Dresner, Nuc. Sci. and Engr. 1, 681, 1956) allowance was made for the possibility that a neutron makes several collisions in the vicinity of one resonance rather than at most one collision as in the Wigner theory (E. P. Wigner, et al., J. App. Phys. 26, 260, 1955). Only the 6.7- and 21-ev resonances are appreciably affected. The calculated value is 10.1 barns, a 1.6-barn increase over the 8.5-barn value previously obtained. This value is in agreement with the best experimental value of 10.2 barns (R. Macklin and H. Pomerance, Prog. Nuc. Energy, Pergamon, London, Vol. I, 184, 1956). (AEC Activity 4570)

Radiation Detector Development - The scintillation response of LiI(Eu) crystals to monoenergetic 5.3-Mev neutrons was examined as a function of crystal temperature in the region between room temperature and -142°C. Two effects were noted with cooling to the lowest temperature: (1) the pulse height increased by a factor of 1.7; (2) the fast-neutron peak was sharpened considerably and assumed a semi-Gaussian shape with a full width at half maximum of 10%. An unactivated LiI crystal was found to scintillate at low temperatures; the energy resolution for therman and fast neutrons was poor, however. (AEC Activity 4570)

Instrument Development for Reactors - New controls for the Bulk Shielding Reactor were designed and equipment is expected very soon. This will be the first "Automatic Start" reactor to be installed permanently at ORNL.

Equipment for the Oak Ridge Research Reactor is designed and is on order. Instrumentation and inter-connections are also under design. This will also include automatic start. Further, the control room is designed to operate three of the reactors from one console; the X-10 Graphite Reactor, the LITR and the ORR. To this end, the LITR has been controlled for the past year from the graphite reactor control room for the purpose of investigating the feasibility of such an operation. Contracts were let to Taylor Instrument Company for the control apparatus. Delivery of major equipment components started May 14. All process instrumentation has been detailed.

The shield mock-up reactor (SMR) control system is in the preliminary design stage; the cost estimate was prepared.

Oak Ridge School of Reactor Technology - During April and May, representatives of more than 50 companies visited Oak Ridge for the purpose of interviewing Category "A" students (those without employment contracts). During these same months, the entire class was given lectures on reactor projects by approximately 25 visitors from the reactor sites.

Formal classes end on June 1. Work on the summer reactor design problems will begin on June 11. (AEC Activity 4703)

PROGRAM 5000 - PHYSICAL RESEARCH

Reactor Operations - Operations of the reactors were normal and there are no unusual incidents to report.

Much attention is now being given to the study of the reloading of the Graphite Reactor with enriched uranium fuel elements. A test fuel element of the proposed design was fabricated; it contains about 10 times the amount of enriched uranium expected to be used in the final design, in order to obtain the higher temperatures expected when the reactor is reloaded. The test element was equipped with thermocouples and inserted in the reactor on May 22. The element was placed in the front part of a channel and will be slowly advanced toward the central part of the reactor. Principal attention is being given to the temperature rise in the fuel piece after shutdown. Data are also being collected to determine the heat transfer coefficient. Supplemental

equipment consisting of a full length of graphite channel was set up to determine the air flow characteristics with a full row of dummy fuel elements. Fuel elements made from natural uranium will be melted to determine the flow characteristics of the molten metal with streams of high velocity air passed over it.

A study was completed on the fan and duct system. It is indicated that, with minor alterations of the ducts and water-spray cooling of the exit air, the fans will provide cooling at a power level of 10 megawatts.

A feasibility report was completed on the conversion of the Graphite Reactor to enriched fuel; approximately 80% of the work has been done on the report to be submitted to the Reactor Safeguards Committee.

The Oak Ridge Research Reactor - Construction is proceeding at a very slow rate, the current schedule for completion of the building, reactor shielding and the cooling system indicates that the contractor should be 92% complete; an estimate of the work actually completed is 48%.

The foundations of the reactor structure were completed and further work in this region is now being delayed by the lack of acceptable welding of aluminum pipe by the subcontractor. Progress is being made toward resolving this difficulty; however, the situation is not entirely cleared up at this time.

The cooling tower for the reactor pool was delivered and erected. Installation of the main reactor cooling loop radiators has been started; all pumps are on hand. The crane trolley was shipped and will be installed on arrival; this will permit closing in the east end of the building. The third floor level is progressing satisfactorily and installation of the movable-type partitions will very nearly complete work in this area.

Fabrication of the aluminum reactor tank is also behind schedule; steps are being taken to insure delivery prior to completion of the reactor building. The reactor mechanical controls unit is being assembled and will be tested in the ORNL Shop.

Design of several large experiments planned for the ORR is approaching the detail stage. Information developed during this work and also during a recent survey of space and facility requirements indicates an experimental program of considerably larger magnitude than anticipated. A request for additional funds was sent to the AEC in order to allow construction of added laboratories, air conditioning, a hot cell over the storage pool and other features which are now deemed necessary to properly accommodate this expanded program. If this request for $515,000 is approved it is anticipated that the work can be completed during the period of time required for ORNL installation of the reactor and control system, and thus not delay the overall job.

ISOTOPE PRODUCTION

Radioisotope Production - Approval has been received to continue the coablt-60 production program at Savannah River. The present loading of cobalt at Savannah will be discharged between May and August of this year. Preliminary measurements indicate that the specific activity of the cobalt and the production rate substantially agree with the calculated values. The annual production from this source will be between 125,000 and 150,000 curies.

All organizations on the cobalt priority list have been notified that the list has been discontinued and that cobalt shipments will be made upon receipt of their shipping containers.

Alterations on the tank farm evaporator to convert it to a cesium-alum crystallizer are about 80% completed.

Additional equipment is now being installed for the production of short-lived fission products from the waste uranium solution from the I^{131} plant. This plant will greatly increase in the availability of miscellaneous short-lived fission products. (AEC Activity 5111)

Radioisotope, Process Development - Tests were made on the chemical process to be used in the fission product plant; liter quantities of actual high level Purex waste were used. The test indicated that the procedures were adequate for cesium, ruthenium, and mixed alkaline and rare earths. However, the procedure for fractionating rare earths was found to be inadequate and will be studied further. It was noted that the Purex waste was contaminated with excessive quantities of uranium and thorium, which caused very great difficulties in the separation of the fission product groups. It is believed that the uranium and thorium were accidentally introduced into the waste during pilot plant operations.

Construction of the fission-product pilot plant is proceeding at a fairly slow rate. Cell liners are now being installed; the ventilation duct was completed. Negotiations were made for the purchase of all the equipment and instruments required in the second phase of the construction program. (AEC Activity 5112)

PHYSICS

Neutron Diffraction - Neutron diffraction data were obtained for selected samples of the rare earth perovskites, and the rare earth sesquioxides at temperatures ranging from room temperature to 1.2°K. The results of some of these measurements are briefly summarized.

Rare earth orthoferrites: The neutron diffraction data for $LaFeO_3$ indicate a magnetic ordering of iron ions on a G-type lattice (E. O. Wollan and W. C. Koehler, Phys. Rev. 100, 545, 1955) with a Néel point of 750°K. The corresponding erbium compound, $ErFeO_3$, also undergoes an ordering transition

at 550°K in which the iron atoms order on a G-type lattice but, in addition, at very low temperatures there is strong evidence that the erbium ions become ordered on a C-type sublattice. The ordering temperature for the erbium ions is 4.5°K. These results can be correlated with the complex magnetic properties which have been observed for these compounds (Guiot-Guillain, Pauthenet, and Forestier, Comptes Rendus 239, 155, 1954) and with the theoretical predications of Néel (L. Néel, Comptes Rendus 239, 8, 1954).

The rare earth sesquioxides, particularly those of the heavier metals, crystallize in a structure which can, to a first approximation, be considered as face centered in the metal atoms. Neutron diffraction data for Er_2O_3 at low temperatures (4.2 to 1.2°K) have demonstrated the existence of a new antiferromagnetic arrangement of magnetic ions on a face-centered cubic lattice. In the course of studying this structure it was observed that the so-called ordering of the first kind (see, for example, J. H. Van Vleck, J. de Physik et Rad. 12, 262, 1951) corresponds to a set of B-type sublattices; improved ordering of the first kind, to a set of A-type sublattices; ordering of the second kind, to a set of G-type sublattices; and the new Er_2O_3 structure, to a set of C-type lattices. It is interesting to observe that as long as one makes the reasonable assumption that all atoms have the same first and second nearest neighbor relationship, the four general structure types described above constitute the totality of antiferromagnetic structures based on a face-centered cubic lattice. (AEC Activity 5220)

Neutron Velocity Selector - In addition to the high resolution spectrometer being constructed for the ORR, a second spectrometer was designed for installation at the LITR. This second spectrometer will be used to measure partial neutron cross sections (such as scattering, fission, and capture) with a resolution of 0.08 μ sec/meter. This spectrometer will consist of a 16-in. Monel rotor, a 45-meter flight path, banks of BF_3 counters, and a 256-magnetic-core time analyzer. The old time of flight spectrometer is now operating and is being used for total cross section measurements of separated isotopes and long-lived fission products. (AEC Activity 5220)

High Voltage Program - The decay constant of the fundamental diffusion mode of subcritical cylindrical U^{235} - H_2O solutions of various sizes was measured by the use of a variable frequency square-wave modulated fast neutron source together with a synchronized multi-channel analyzer. Thermal neutrons diffusing out of the system in the interval between neutron bursts were detected by means of a small $Li^6I(Eu)$ scintillation counter at the boundary. For the range of buckling from 0.54 to 0.08 cm^{-2}, uranyl fluoride solution containing 53.0 grams U^{235}/liter exhibited half lives ranging from 17.9 to 64.2 microseconds. Delayed neutrons constitute a small constant background. The method appears to be useful for obtaining experimentally all of the nuclear parameters needed to describe the system. Possible applications include routine testing of reactor sub-assemblies.

A manganese sulphate bath was used to observe the $V^{51}(p,n)Cr^{51}$ cross section from threshold to 700 kev above threshold. Protons from the 3-Mev Van de Graaff bombarded 20-kev vanadium targets, and the bath was activated

at six neutron energies from 20 to 700 kev. The activity was compared to that produced by the 27-kev neutrons from a calibrated Sb-Be source. These six points normalize the yield curve obtained with a set of BF_3 counters in paraffin surrounding the target. The cross section averaged over resonances rises almost linearly over this region. (AEC Activity 5220)

Theoretical Physics - There have been under development here for some time flexible and accurate numerical procedures for calculating orbit properties and magnetic fields for high-energy fixed-frequency cyclotrons. The principal theoretical problem seems to be the determination of the difficulty of passing through the various resonances which render the particle orbits unstable at certain energies. Simple analytical formulae were obtained for the increase in amplitude of the focussing oscillations at several of the simpler resonances. From these it appears that a properly shaped magnetic field can hold the orbits isochronous and essentially stable, except for the radial integral imperfection resonances which come at proton energies of about 900, 1800, 2500,--Mev in a 16-sector machine. The half-integral resonances were shown to be quite harmless; a 900-Mev machine of this type appears certainly feasible. Numerical work is in progress, using a flexible and rapid code for calculating orbit properties, to determine the true degree of difficulty at these resonances. It is hoped that a higher energy machine may actually be feasible. In addition, work is being performed with the same code to facilitate the design and adjustment of the electron analogue which, in its second version, will attempt actual passage through the first of the integral resonances. (AEC Activity 5220)

CHEMISTRY

Volatility Studies - In studies on the fused salt--fluoride volatility process, uranium-zirconium fuel elements dissolved in $NaF-ZrF_4$ at a rate of 3-6 mg/min-cm^2 at 600°C; HF was passed into the melt in such a way that good agitation was achieved. Increasing the temperature to 800°C increased the rate only slightly. Since the efficiency of HF utilization is much more dependent on the HF flow rate than is the dissolution rate, being lower at the higher flow rates, there is an advantage in using relatively low flow rates.

The phase diagram of the $NaF-ZrF_4$ system is such that the rather limited region of 38 to 57 mole % ZrF_4 in the melt must be used if dissolutions are to be made at 600°C. These limits correspond to melts with melting points of 550°C, which allows a 50° margin of safety to ensure that no solid-salt pluts form. Such narrow limits imply that the uranium content of the melts after element dissolution must be in the neighborhood of 0.5 g/liter of melt, which is a very low figure.

At high temperatures, NiF_2, a corrosion product in the fluorination step of the fused-salt—fluoride volatility process, formed dispersions in molten $NaF-ZrF_4$ at concentrations greater than that required for saturation. Initial sedimentation of such dispersions was rapid; however, the settling rate

decreased with time as a result of a viscosity effect, with sedimentation probably not complete after 72 hr when the initial nickel concentration was 2%.

The decomposition of $UF_6 \cdot 3NaF$ was about 30% in a closed system at 400°C. Less decomposition, 2%, occurred at 300°C, or about 10% when excess F_2 was present. The decomposition reaction results in a $NaF-UF_5$ complex. (AEC Activity 5310)

Ion Exchange Studies - Several elution methods are being studied in connection with ore recovery processes. They include 1 M NaCl, 1 M NH_4NO_3, and conversion to the chloride with 5 M NaCl, followed by elution with water. A continuous conductivity monitor was shown to be effective in controlling elution conditions. This makes it possible to use 5 M NaCl at a very slow, regulated rate and decreases the amount of NaCl required to the point that NaCl reuse is not required. Advantages of the 5 M NaCl-water system include the following: (1) the cost of eluting agent is the lowest yet demonstrated; NaCl is consumed at a rate of 2.5-3 lb per pound of uranium; (2) neutral NaCl solution is used rather than the acidic solutions used in other schemes, which results in relaxed corrosion specifications; (3) the product, which contains a high concentration of UO_2Cl_2, 50-100 g of uranium per liter, can be fed directly to the Excer process (see section on feed materials processing); this eliminates the alkali precipitation step; and (4) if the uranium is recovered from this solution by precipitation, the alkali required is very small. (AEC Activity 5310)

Chemical Engineering Research Studies - A hydroclone separator, either 1/4 or 1/2 in. dia, was shown to be suitable for separating 20% hexone--80% water dispersions. The products contained only 0.1% of the other phase.

A steam pulser was demonstrated to produce pulsations varying from 1 to 10 in., at about 60 cycles/min. The procedure used was direct injection of steam into a liquid leg. This would eliminate the need for pistons or flexible diaphragms for pulsing solvent extraction contactors.

A 3-in.-dia filter bed of type-431 stainless steel powder and alumina filter aid, held in place by a magnetic flux of 1.4 kgauss, removed precipitated barium sulfate from a water suspension. The stainless steel was corroded by 6 N HNO_3 at a rate of 0.04%/day at room temperature. (AEC Activity 5310)

Feed Materials Processing - In further tests on the Excer process for converting $UO_2(NO_3)_2$ to UF_4 by ion exchange and electrolytic reduction, overall decontamination factors varied from ~ 10^3 for calcium to 3 x 10^5 for iron. Magnesium, Al, Cu, Mn, and Th were removed by large factors; V, B, Mo, Si, SO_4, PO_4, Cr, and Ni were not separated. For the tests, synthetic sulfate ore leach solutions were converted to chloride by an anion exchange step, using the 5 M NaCl--water elution scheme; converted to UO_2F_2 on a cation-exchange column; separated from traces of sodium by a H-form cation exchange resin; and reduced in an electrolytic cell. The $UF_4 \cdot 3/4H_2O$ was dehydrated

in a magnesium tube furnace. For a uranium loading of 50 g/L of resin, only 2.5 lb of NaCl was required per pound of uranium for satisfactory elution in 3 ft of anion exchange resin column (2 in. dia). This is 100% excess of stoichiometric.

Calcining of $UF_4 \cdot 3/4H_2O$ in a screw calciner (3 in. dia x 6 ft long), reduced the water from 3.5% to 1.5% in 35 min under a nitrogen atmosphere; the final UF_4 content was 97.5%. The temperature along the calciner increased from 120°C at the powder entrance to 380°C at the powder exit.

The conversion of UF_4 to UF_6 and UO_2F_2 (a step in the Fluorox process for conversion of uranium oxide to UF_6) by reaction with oxygen at 800 to 900°C was successfully demonstrated in a 4-in.-dia moving bed reactor lined with U_3O_8 brick. The feed rate to the reactor was 10 lb/hr, and about 10 lb of UF_6 was produced. The rate of the oxidation of UF_4 to UF_6 is partially controlled by the UF_4 surface area available. Samples of one type of UF_4 containing ~ 2% UO_2F_2 when heated 1 hr in dry helium apparently had essentially constant specific surface areas over the temperature range 25-600°C. Above 600°C, a decrease in specific surface area was accompanied by a sintering of the sample. (AEC Activity 5310)

Neptunium Studies - In continuous runs in 3/4-in.-dia pulsed columns, neptunium and uranium were separated from K-25 fluorination ash with losses of <0.01%. Aqueous feed for the run was prepared by slurrying 1 kg of ash in 2.67 liters of 3.6 M $Al(OH)_2NO_3$, to which was added 4.5 kg $Al(NO_3)_3$, 1.47 liters of 16 M HNO_3, and water to 13 liters and by digesting at the boiling point, under full reflux, for 2-4 hr to dehydrate colloidal, emulsion-forming impurities. The aqueous feed, 50 g U/liter, 1.8 M $Al(NO_3)_3$, 1 M HNO_3, was made 0.01 M in $Fe(NH_2SO_3)_2$ to reduce neptunium to the IV state, the species most stable and most readily re-extracted by tributyl phosphate.

In the first column, the Np^{237} and uranium were co-extracted by 15% TBP in Amsco, and scrubbed with 0.75 M $Al(NO_3)_3$--2M HNO_3--0.01 M $Fe(NH_2SO_3)_2$. The organic extract was cascaded to the second column where the neptunium was preferentially stripped into 0.5 M HNO_3. Any uranium that was stripped into this aqueous stream was back-extracted in the lower section of this column with 60 volumes of additional extractant. The organic solution from the second column was cascaded into a third column where the uranium was stripped into 0.01 M HNO_3. The system reached equilibrium at between 6 and 12 hr operation.

A simplified procedure that would fit the process to existing metal recovery equipment and lower the cost of the process chemicals consists in adding 1 kg of ash to 13 liters of 1.8 M $Al(NO_3)_3$--1 M HNO_3 and mixing. The mixture is digested at the boiling point, under full reflux, for 2-4 hr, and adjusted to feed concentrations. Lower concentrations of $Al(NO_3)_3$ and HNO_3 may also be used and the final feed concentrations achieved by evaporation. (AEC Activity 5310)

Hot-Laboratory Research - The initial step in the recovery of large quantities of neptunium-237 from Canadian tank-car uranium solution, undertaken in cooperation with the ORNL Metal Recovery Operations, was completed. During the program, several adverse experimental flow-sheet changes were encountered which reduced the yield to 60% of the theoretical or about 22 grams.

The most significant losses were closely correlated with a reduced acid strength in the first extraction column, which occurred either in the feed or in the scrub. The minimum value of acid concentration for good recovery of neptunium was found to be 1.5 N, as measured in the waste stream. The introduction of ferrous ion in this column was also accompanied by a serious neptunium loss; however, extensive studies of the distribution coefficients of Np (IV) and Np (VI) seem to prove that this loss was actually incurred by a simultaneous reduction in acid strength rather than by a change in the distribution of the two valence states.

Valence distribution studies of Np(IV) and Np(VI) in the first extraction cycle showed that essentially all the Np is present as inextractable Np(V) and that on contact with TBP, this is rapidly reduced to Np(IV). A half time for this process is about 10 minutes and the residence time in the column is about one hour. (AEC Activity 5330)

Chemistry of Corrosion - In connection with further studies on the effect of osmium(VIII) oxide on the electrode potential of electrolytic iron, the normal potential of the $Os(OH)_4$-OsO_4 couple was determined for comparison. The corrosion of iron is so effectively stopped by even a 1% solution of OsO_4 that the thermodynamic value of the electrode potential may be realized on iron as well as on platinum. This was demonstrated over the pH range 4 to 6.5. The nobility induced by the osmium compound was sensitive to added electrolytes, like that produced by the inhibitors previously studied.

The effect of gamma irradiation on the corrosion of stainless steel in 0.1 N sulfuric acid appears to be due entirely to the radiolytic products in the solution. On an ennobled sample the usual effect is a debasement due to radiolytic hydrogen; this is followed by a slow ennoblement as peroxide builds up in the solution. The experimental results are perhaps even more sensitive to the degree of aeration than is the case in the absence of radiation, so that a slight change in the atmosphere of the test cell may cause a considerable change in the effects observed.

The relationship between the potential and rate of corrosion of type-347 stainless steel electrodes was studied in aerated 0.1 N H_2SO_4 at 84°C; a potentiostat was used to maintain constant electrode potential until the establishment of a quasi-stationary state characterized by constancy of corrosion rate and applied current. A plot of electrode potential vs corrosion rate indicated that a maximum corrosion rate of ~ 1.5 ma/cm^2 of apparent surface area occurred at a potential 250 mv more negative than the reversible hydrogen electrode potential. The spontaneous corrosion of this steel in a nitrogen atmosphere, free from oxygen, had a rate of ~ 0.13 ma/cm^2 and a steady potential of -100 mv vs hydrogen. Identical potentials were observed in the

quasi-stationary state for the spontaneous corrosion in nitrogen of all electrodes of the same batch of steel, regardless of surface preparation. The presence of oxygen in the solution exerted an effect on the electrode potential-corrosion rate diagram near the reversible hydrogen potential. The proximity of the spontaneous corrosion potential to the potential at which this effect becomes evident appears to determine the fate of the steel, that is, whether ultimate ennoblement and passivation or continued corrosion of the hydrogen-evolution type will occur. (AEC Activity 5330)

Ion-Exchange Studies - A knowledge of the partial molal volumes of ion-exchange resins is necessary for the rigorous thermodynamic computations of ion-exchange selectivities. Consequently the densities of partially hydrated fluoride, chloride, bromide, and iodide salt forms as well as the mixed salt forms, F-Br, Cl-Br, and I-Br, were measured pycnometrically by using an inert liquid. A considerable loss in total volume was observed when the dry resin first absorbed water, presumably as a consequence of electrostriction by the ions. The molar volume of water, 18.06 ml, was never reached in the systems studied, although this value must be approached in highly swollen, loosely cross-linked exchangers.

To further characterize the new phenolformaldehyde sulfonium anion-exchange resin, Stamex S-44, a scale of selectivities was determined by measuring the uptake of trace quantities of bromide ion by 12 anion salt forms of this exchanger. The order of bromide ion affinities were: $F^- > IO_3^- > Ac^- > Cl^- > BrO_3^- > NO_2^- > Br^- > ClO_3^- > NO_3^- > I^- > ClO_4^- > SCN^-$. This order is approximately that observed with Dowex-1 and Dowex-2. A comparison with the water isotherm data shows that the greater the water uptake by a given salt-form the greater the bromide ion affinity.

Recently cation-exchange resins of variable capacity prepared by the hydrolysis of p-sulfonamidostyrene and styrene copolymers became available. Cross-linking in these exchangers is obtained by addition of bis-(p-vinylphenyl) sulfone to the reaction mixture; the capacity can be controlled by varying the styrene to p-sulfonamidostyrene ratio. This method of synthesis appears to insure that only para-sulfonic acid exchange groups occur in the exchanger. Sodium-hydrogen ion selectivities for preparations with three different degress of cross-linking, each prepared with four different capacity values, were measured. The selectivity coefficient, D_H^{Na}, was found to decrease with capacity for a given degress of cross-linking, in agreement with earlier findings in this Laboratory on desulfonated Dowex-50. (AEC Activity 5330)

Characterization of Short-Lived Fission Products - Considerable effort was put into installation and testing of improved instrumentation for the characterization of short-lived radionuclides. The gas-handling system for removal of fission product gases from irradiated uranium was extensively modified so that it is now possible to isolate rubidium activities from their krypton parents more rapidly.

Some preliminary measurements were made with the new gas system on the decay of 2.7-minute Rb^{90}. With a 3 x 3-in. NaI(TlI) scintillation spectrometer, gamma rays of 0.84 ± 0.01 Mev energy and high intensity and of 1.39 Mev energy were observed. Both gamma-ray peaks decayed with a half-life of 2.5-3.0 minutes, demonstrating that they occur in the decay of Rb^{90}, and do not arise from some contaminant such as Cs^{138}. Careful searches were made in samples of Rb^{89} + Rb^{90}, after several half-lives of 14.9-minute Rb^{89}, and the gamma-ray spectrum characteristic of Cs^{138} was never seen. A Fermi analysis of the beta-ray spectrum of Rb^{90}, as measured on a well-type anthracene scintillation spectrometer, yielded a preliminary value of 5.0 ± 0.1 Mev for the maximum energy of the most energetic beta-ray group. (AEC Activity 5330)

Chemical Separation of Isotopes - A small facility for producing 1-2 grams per day of >95% N^{15} was constructed and tested. The system employs the Nitrox process (oxides of nitrogen vs HNO_3). Operation is automatic with occasional adjustments and sampling during the working day. The cascade consists of a 2-in. and a 1/2-in. glass column, each 20 ft high, packed with Podbielniak stainless steel "Heli-Pak". The system has a set of auxiliary valves and pumps to permit minor repairs to be made without disturbing operation of the column. The product end refluxer produced about 9M H_2SO_4, containing negligible amounts of nitrogen. The SO_2 flow is regulated by an automatic interface controller actuated by a photocell. Upon completion of a calibration and test run of over a week's duration, the system was shut down to make modifications in the product refluxer to insure smoother and more dependable operation. (AEC Activity 5340)

PROGRAM 6000 - BIOLOGY AND MEDICINE

BIOLOGY

Genetic and Cytogenetic Effect of Radiations - An ideal situation for examination of the effect of polyploidy on chromosomal radiosensitivity was found in a single *Tradescantia* flower bud containing a mixed population of haploid and diploid microspores. The bud had been irradiated in interphase and the cells were stained and observed at the post-meiotic mitosis. Chromosomal frequency per cell in the diploid cells was double that of the haploids. Hence, it can be concluded that, per chromosome, chromosomal radiosensitivity is equal in normal and polyploid cells.

One of the pronounced effects of radiation on the living cell is inhibition of division (mitosis). Division of the grasshopper neuroblast is

temporarily inhibited by as little as 1 r of X-rays; the cells are not killed until doses of about 500 r are administered. A study was imitiated to determine whether radiation-induced mitotic inhibition is correlated with an inhibition of deoxyribonucleic acid (DNA) synthesis. Uptake of thymidine labelled with C^{14} was used as criterion of synthesis. Irradiated cells were cultured in medium containing thymidine, fixed and made into autoradiographs. At low doses of radiation, DNA synthesis is not affected. At doses of about 50 r, uptake of thymidine is reduced but not entirely stopped. At doses of 100 r and above, synthesis is completely inhibited. Thus, it is necessary to seek an explanation other than inhibition of DNA synthesis for the pronounced inhibition of mitosis that occurs in the neuroblast at low doses of radiation. (AEC Activity 6130)

Biochemistry - The equilibrium system postulated (D. G. Doherty, et al., Biol. Semiann. Prog. Rep. Aug. 15, 1955, ORNL-1953, pp. 88-91) for the radiation protective compound S,β-aminoethylisothiuronium·Br·HBr (AET) in solution was investigated by ion-exchange chromatography. A method was developed which permits the quantitative separation of all of the forms in the equilibrium scheme. An artificial mixture of all the forms was absorbed on a Dowex-$50H^+$ column, eluted with increasing concentration of HCl, and the peaks were identified by nitrogen and sulfhydryl determinations and by chromatography of the individual compounds. The results obtained were in agreement with original postulation. The method is now being used to check the stability of AET under various biological conditions and to determine the form responsible for its protective activity. (AEC Activity 6130)

Pathology and Physiology - In a study of the role of blood platelets in irradiation hemorrhage, rat platelets were labeled *in vivo* with S^{35}-sulfate. Investigations have determined the chemical form of sulfate in the platelets. Paper electrophoretic studies of extracts of platelets (2% NaOH, cold) demonstrate the presence of an S^{35}-labeled compound that migrates to a position corresponding to that of chondroitin sulfuric acid and heparin.

The induction of myeloid leukemia in mice of the RF strain is greatly inhibited by splenectomy performed one week before exposure to a single dose of 300 r whole-body X radiation. Although the mechanism of this effect is unknown, it indicates the existence of factors related to the spleen that influence susceptibility to leukemia induction by irradiation. (AEC Activity 6130)

Biophysics - Pollinations were performed in the greenhouse maize crop in an experiment to ascertain whether two independently originated chromatid breakage-fusion-bridge cycles will fuse to produce a single chromosome breakage-fusion-bridge cycle, or whether they will remain independent. A device was constructed for treating maize pollen with plutonium α-particles and treatments were made on a pilot scale to see if such a method is sufficiently effective. The maize material used is capable of detecting whether stable, freshly broken chromosome ends can be produced. There are indications that in *Tradescantia*, such stable ends are produced by α-particles. X rays yield only unstable breaks in maize. (AEC Activity 6130)

Radiation Protection, Living Cells - Mercaptoethylamine (MEA or cysteamine) has been reported to be an exceptional protective chemical agent for bacteria (Doudney and Hollaender, ORNL-1766). Some recent experiments have been designed to elucidate the protective mechanism of this compound. These experiments indicate that under the pre-irradiation conditions described by the above authors, less than 5% of the maximally protective concentration of MEA is associated with the cell. It appears that the concentration of cysteamine required for protection of the cell is independent of the cell concentration, but is dependent on the dose of radiation. The minimal protective concentration per cell may be of the order of one molecule per ion-pair. Preliminary evidence suggests that protection is afforded only if the rate of diffusion of the compound is greater than the rate of radiation destruction of the protective chemical. This hypothesis is subject to experimental testing and will be the subject of future investigation. (AEC Activity 6230)

Mammalian Radiation Recovery - Lethally irradiated mice receiving 90 million rat-bone-marrow cells show recovery of their bone marrow in 12 days. A smaller number of mouse-bone-marrow cells (10-12 million) will also cause recovery in 12 days. Using bone marrow counts as the end point, pretreatment of the irradiated mice with AET showed a bone marrow count curve paralleling but higher than that of the untreated irradiated mice. This indicates a dose-reducing effect of the AET on the irradiated bone marrow. In collaboration with a group at Jefferson Medical College, preservation of mouse bone marrow in glycerol at -73°C was demonstrated. A specific histologic lesion in irradiated mice treated with foreign bone marrow was observed in the spleen and lymph nodes. This finding gives a point of departure for histologic study of the homologous and heterologous reactions. Injected isotope-labelled bone marrow cells have been identified in tissues of irradiated recipients. (AEC Activity 6230)

LIST OF OPEN LITERATURE PUBLICATIONS

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STATUS OF CONSTRUCTION

Alterations to the Liquid Metals Laboratory, Building No. 2011, to provide space for a Liquid Metals Testing Laboratory and the installation of special testing equipment, were completed. These alterations involved a complete renovation of the second-floor area, which included: the removal of the superstructure above an existing second-floor roof; structural revisions to the building to permit the installation of a new roof over the entire building; the installation of utility services, water, gas, lights, etc.; and the installation of partitions to provide appropriate office and laboratory space. The H. K. Ferguson Company (CPFF contractor) furnished materials and labor to accomplish this construction phase of the project, which was completed by the end of February, 1956.

The participation of the Oak Ridge National Laboratory in the installation of the facilities consisted of decontamination work on the second floor, prior to contractor entrance; providing miscellaneous assistance to the contractor; and the procurement and installation of specialized equipment. The equipment consists of convertible-type creep-test machines (12:1 high stress and 6:1 low stress ratios), a helium leak detector for vacuum testing, liquid metals chambers, portable control equipment, a precision indicator capable of reading thermocouple temperatures to plus or minus one-tenth of a degree fahrenheit, and a special relaxation machine which was developed by Laboratory personnel.

VISITORS

Christy, R. F., Advisory Committee for Electronuclear Research
Creutz, E., Advisory Committee for Electronuclear Research
Dunham, C. L., U. S. AEC
Johnson, T. H., U. S. AEC
MacPherson, H. G., Carbide and Carbon Chemicals Corporation
Strauss, Lewis L., U. S. AEC
Thornton, R. L., Advisory Committee for Electronuclear Research
70 Visitors at High Temperature Chemistry Symposium
50 Visitors at Corrosion Symposium

FOREIGN VISITORS TO ORNL:

Boon, E. F., RCN, 59 Molsaan, Delft, Netherlands
Brison, Gen. Pierre, French Embassy, Washington, D. C.
Cartwright, Harry, U.K.A.E.A., Appleton Warrington, England
Cesoni, Giulio, Fiat Co., New York (Italy)
Chanson, Col. Antonie, Military Engr., 8 Rue C. Matrut, Issy Cr Monlinean, France
Erneck, A. F., Commercial Counselor, German Embassy, Germany
Geyer, Mr., President Esso, Hamburg, Germany
Goldenberg, Leon, Embassy, Bonn - Attache in Charge of Atomic Energy, Germany
Goldring, Benjamin G., University of Jerusalem, Israel
Haxel, O. L., Univ. of Heidelberg, Germany
Heatherington, C. H., AECL, Canada
Herold, R., Sulzer Bros. New York, Switzerland
Hess, Eduard, Commerical Sec., German Embassy, Germany
Hirschseld, Hans M., The Hague, Netherlands Reactor Center, Netherlands
Inoue, Shunauke, Kyushu Electric Power Co., Fukuoka, Japan
Krekeler, H. L., German Ambassador to U. S., Germany
Larsson, Karl-Erik Axel, BNL (Sweden)
Mei, Y. C., Tsing Hua University (China Institute, N. Y. City)
Meleikowsky, Curt, Argonne Natl. Lab. (Swedish Citizen)
Milats, J. M., RCN, 112 Schevennie, The Hague, Netherlands
Pelser, Johones, RCN, 5 L Julianelco Arnhew, Netherlands
Polok, Henri, 3301 E. Woodbine Chan., Netherlands
Rossi, Pietro, Fiat Co., New York (Italy)
Schoenbach, K. J., German Counsol, Atlanta (Germany)
Steeknbrink, Antonius, Netherlands Embassy, Washington, D. C.
Strauss, F. J., German Federal Minister for Atomic Energy, Germany
Sulzer, G., Sulzer Bros. New York (Switzerland)
Takeshita, Shuso, Japanese Newspaper Yomiuru Shimhun, Tokyo, Japan
Thornann, R., Sulzer Bros. New York (Switzerland)
Went, J. J., 16 Cronyestrant Dordrecht, Netherlands
Wolfer, H., Sulzer Bros. New York (Switzerland)
Yoshioka, Toshio, Kansai Electric Co., Osaka, Japan

RADIOISOTOPE SALES AND COSTS

Type of Transaction	April 1956	FY 1956 to Date
Domestic Sales	$136,946	$1,183,811
Foreign Sales	12,692	85,726
Project-Cash Sales	3,574	38,517
Project-Transfer	1,206	9,548
Technical Co-Operation Program Credits	210	1,382
Plant Credits	737	16,241
AEC Credits	24,940	171,958
Total Radioisotope Income	$180,305	$1,507,183
Total Radioisotope Costs	$ 74,580	$ 886,537
Total Radioisotope Shipments	1,214	10,958
Boron and Helium		
Income	$ 20,139	$ 62,515
Costs	473	1,655
Shipments	20	98

GROSS OPERATING COSTS

	Cost for April	FY 1956 Cost to Date
Programmatic Operating Cost - Net	$3,455,033	$32,656,386
Plant and Equipment Cost	327,519	3,009,851
Program "H"	- 0 -	90,390
Work for Other Parties - Transfers	81,456	399,904
Inventory Changes	175,615	99,645*
Reimbursable Work for Other Parties	217,087	2,045,609
Deferred Charges	196,678*	51,415
Total Laboratory Cost - Net	$4,060,032	$38,153,910
Estimated Cost for Next Month - Net	$4,300,000	$42,453,910

*Credit

PERSONNEL SUMMARY

	Number of Employees May, 1956	New Hires May	Terminations May
Administration	60	0	0
Operations*	127	1	1
Engineering, Shops, and Mechanical	813	10	3
Laboratory and Research	2071	45	16
Protection	129	0	0
Service	387	3	0
	3587	59	20

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

A total of 851 Laboratory personnel are located in the Y-12 Area.

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September 1955	ORNL-1980
October 1955	ORNL-1995
November 1955	ORNL-2016
December 1955	ORNL-2032
January 1956	ORNL-2044
February 1956	ORNL-2062
March 1956	ORNL-2073
April 1956	ORNL-2082