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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

November, 1956

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

PROGRAM 2000 - SPECIAL NUCLEAR MATERIALS

Waste Metal Recovery - The Metal Recovery Plant has recovered, to date, 13.4 tons of uranium, as uranyl nitrate, from ORNL tank waste. A Purex-type chemical flowsheet, with 15% tributyl phosphate in Amsco as the solvent, was used. The uranium throughput rate was 500 lb/day. The one-cycle product, with gross β and γ decontamination factors of 8×10^4 and 2×10^3, respectively, met specifications. (AEC Activity 2350)

Fluorox Process - In the Fluorox process uranium oxide is simultaneously reduced and fluorinated to UF_4, which is then converted to UF_6 with dry oxygen. The oxidation step proceeds very slowly below 700°C when the initial specific surface area of the UF_4 is low. In experiments on increasing reaction rates by using UF_4 with greater surface area, the UF_4 samples sintered rapidly, so that the surface area decreased from 1.2 to 0.37, 0.19, and 0.16 m^2/g at 600°, 700°, and 800°C, respectively. Probably no UF_4 sample would maintain a high specific surface area at these temperatures. The experiments were made with UF_4 produced by the Excer process, the specific surface area of which is five times that of UF_4 from hydrogen reduction of UF_6.

A directly heated fluidized oxidation reactor was operated successfully with 30-100 mesh UF_4 powder fluidized in oxygen. The oxidation reaction is apparently first-order with respect to the U(IV) content of the powder; the half-time was 5 hr at 725°C. A successful moving-bed oxidation run of 10 hr duration was completed with internal heating supplied by carbon monoxide oxidation in the bed. Product pellets containing 95% U(VI) were obtained from an impure carbon-free UF_4 feed. (AEC Activity 2702)

Excer Process - In the Excer process, in which uranium is electrolytically reduced to UF_4, emphasis has in the past been on reduction of UO_2F_2 and simultaneous precipitation of $UF_4 \cdot 3/4H_2O$ in the electrolytic cell. In preliminary studies on electrolytic reduction with precipitation outside the cell, the $UF_4 \cdot 3/4H_2O$ product purity was the same as in the one-step procedure. The tap density of the product was 1.2-2.6 g/cc, as compared to 2.2-3.5 when formed at the cathode surface, but was increased to 3.2-3.6 by pressing at 10-40 tsi (tons/in^2) and regrinding.

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The chief advantage of this two-step procedure is the elimination of fluoride from the cell, since either UO_2SO_4 or UO_2Cl_2 may be reduced in the cell to the corresponding uranous salt. With these solutions current efficiency was somewhat higher with lead cathodes than with nickel. Electrode corrosion was somewhat less in the sulfate system. (AEC Activity 2702)

Power Reactor Fuel Processing: Metallex Process - Attempts to apply the Metallex process (sodium-amalgam reduction of thorium or uranium chloride, followed by pressing and retorting) to recovery of uranium from zirconium-uranium fuel elements were not successful. Zirconium, Zircaloy-2, and STR-II prototype fuel elements dissolved readily in two fused-salt mixtures over boiling mercury; the mixtures tested were 60-20-20 mole % $ZnCl_2$-NaCl-KCl and 50-50 mole % $AlCl_3$-NaCl, each containing $HgCl_2$ and/or NH_4Cl. Insignificant amounts of uranium were transferred to the mercury phase, however, and significant amounts of the mercury sublimed from the molten salt.

When the experiments started with 50-50 mole % $AlCl_3$-NaCl containing 10 mole % UCl_4 or $ZrCl_4$, agitation with Na(Hg) at 300°C for 20 min resulted in transfer of aluminum to the mercury phase. Electrolysis of a melt of the same composition, with a mercury cathode and carbon anode, deposited aluminum in the mercury but no zirconium or uranium.

The oxide film on zirconium, Zircaloy-2, or STR-II prototypes was quickly replaced by mercury bonded to clean metal by immersing the specimen in a fused 60-20-20 mole % $ZnCl_2$-NaCl-KCl or a 50-50 mole % $AlCl_3$-NaCl matrix containing 5 to 10 wt % $HgCl_2$ or 10 to 15 wt % NH_4Cl at 250°-275°C. The rate of dissolution of these metals in mercury at 356°C was not significantly increased by this treatment or by the addition of zinc or bismuth to the boiling mercury. (AEC Activity 2924)

Power Reactor Fuel-Reprocessing Studies: Darex Process - In the Darex process, stainless steel-containing fuel elements are dissolved in aqua regia, the chloride is distilled off, and uranium is extracted from the residue with an organic solvent. The optimum aqua regia concentration for dissolution of type-304L stainless steel is 2 M HCl-5 to 6 M HNO_3. Over a 2-min period, at 90°-100°C, the metal dissolved at a rate of 100 mg/min-cm^2. The rate decreased with higher or lower nitric acid concentrations. Dissolution rates of type-347 stainless steel were comparable, except when the HNO_3/HCl mole ratio was >3/1; in this case the metal was passivated. In general, acid decomposition was maximum with maximum dissolution rates.

Vapor-liquid equilibrium data on APPR fuel element solutions, containing 85 g of fuel per liter, indicated that the chloride can be removed in 16 stages, or less, when 14% of the pot volume is distilled at each stage and replaced with 15.2 M HNO_3 for the next stage. All but a trace of chloride appeared to be removed in 10 stages. Even fewer stages should be as effective in column operation where the vapor/liquid ratio in the column can be made greater than 1/1. Acid decomposition during chloride distillation was at a maximum in stage 5, where about 8% of the HCl and 0.5% of the HNO_3

distilled were decomposed. At this stage the mole ratio of chlorine oxides to nitrogen was about 3.5/1 for decomposition and 0.2/1 for distillation. With 12 M HNO_3 as refluxing agent, more stages were required for chloride removal. (AEC Activity 2924)

Power Reactor Fuel-Reprocessing Studies: Zircex Process - In the Zircex process, zirconium-containing fuel elements are hydrochlorinated to form volatile $ZrCl_4$, the residue is dissolved in nitric acid, and the uranium is extracted by an organic solvent. In a liquid-phase hydrochlorination of zirconium, with aluminum ammonium chloride, 95% of the zirconium sublimed. The melt temperature was kept at 400°C (boiling). Under the same conditions, in separate experiments, uranium and thorium chlorides remained in the melt.

Gas-phase hydrochlorinations of Zircaloy-2 rods and of sections of STR prototype fuel elements were conducted to obtain design data for a larger scale reactor. It was observed that approximately 50% of the heat of reaction was removed by radiation. In order to relate this behavior to design problems, the emissivities of the metal sections were determined as a function of alloy composition and temperature. Present data indicate that, for complete hydrochlorination of an STR-type fuel element, a 16-hr reaction time will be necessary. (AEC Activity 2924)

PROGRAM 4000 - REACTOR DEVELOPMENT

HOMOGENEOUS REACTOR PROJECT

Homogeneous Reactor Test - Reactor engineering tests were discontinued late in October so that extensive revisions could be made in the pressurizer-level-indicator piping and in the core-blanket pressure balancing system. Also, the packed valves in the leak-detector system were replaced with bellows-sealed valves.

A hydrostatic test was performed at 2800 psig on November 12, and preparations were completed for a normal startup. In the course of the startup, the 400-A pump exhibited symptoms of a faulty bearing and was removed for examination. No evidence of damage could be found, so the pump was reassembled and operation resumed. Another test in the series of dump tests was made, with the reactor at 600 psig and 230°C. Then the reactor was test-operated at 280°C and 1700 psig for over 100 hr before a dump test was made under these conditions. (AEC Activity 4103.3)

HRT Chemical Pilot Plant - Shakedown operation of the chemical plant high-pressure system continued at 275°-300°C and 1250-1500 psi with uranyl sulfate solution at a concentration of 10 g/liter. The chemical plant will remain disconnected from the reactor circuit until the natural-uranium runs are complete. Four runs were completed in which solids were added to simulate expected corrosion products. In the first two runs the solids (10 g) were added only to the solids feed loop, but in the next two runs circulation was also through the chemical plant high-pressure loop, which contains the hydroclone. During these last two runs the hydroclone concentrated the solids by factors of 25 and 72, which is satisfactory. A leaking freeze plug probably accounted for the lower concentration factor.

The design of the modifications to the low-pressure system, for dissolution of solids, is 90% complete; the storage tank and carrier have not yet been designed. The tantalum-lined dissolver was received, and procurement of instrumentation is 90% complete. Approximately one-half of the components have been fabricated. The plant will be shut down in December for installation of this system. (AEC Activity 4103.1)

Mathematics and Computation--Homogeneous Reactor Development - Oracle codes were devised to calculate the fraction of gamma rays (originating from a shielded source) which would escape through a hole in the shield as a result of air scattering and wall scattering. It was assumed that no direct line-of-sight existed between the gamma source and positions outside the shield. Only a single scattering was assumed in the air-scattering calculations. For wall scattering, the scattering of gamma rays penetrating into the wall, as well as surface scattering, was considered. (AEC Activity 4103.1)

Reactor Analysis - Two-group, two-region studies were made for 10- and 12-ft-dia spherical reactors containing D_2O-ThO_2-$U^{233}O_2$ in both the core and the blanket regions. For these reactors, the breeding ratio increased when the thorium concentration was increased in either the core or the blanket region; the core-wall power density decreased when the blanket thorium concentration was increased; decreasing the core size increased the breeding ratio, but also increased the power density at the core wall; and increasing the blanket U^{233} concentration slightly decreased the breeding ratio. The wall power density was relatively insensitive to changes in the blanket fuel concentration for specified thorium concentrations greater than 100 and 500 g/liter in the core and blanket, respectively.

The effect of neutron resonance absorption in the fuel, upon breeding ratio and critical mass, was investigated for single-region ThO_2-D_2O-$U^{233}O_2$ reactors. If the resonance-energy value of η^{23} is 0.95 that of the thermal-energy value, the breeding ratio will be decreased by 1.3% and the critical mass increased by 1.3%, in comparison with values obtained with η independent of energy, for a slurry containing 300 g Th/liter.

Physical-property data for light and heavy water and their mixtures, UO_2SO_4 solutions, UO_2SO_4-Li_2SO_4 equimolal solutions, UO_2SO_4-$BeSO_4$ equimolal solutions, ThO_2 slurries, and uranium oxide slurries were compiled for use in nuclear calculations. (AEC Activity 4103.1)

Homogeneous Reactor Instrumentation - A proposed design of the control circuit for the revised HRT cooling-water system was submitted to the Design Review Committee. Included in the proposed design was a provision for the supply of emergency cooling water from the cooling tower. Valve and pilot solenoid actions were selected to give "fail-safe" action, with reactivity containment considerations given precedence over system operation and equipment protection.

The design and procurement of instrumentation for the radioactive-waste disposal system of the HRT were completed, and the installation is under way.

The prototype letdown valve in the HRT mockup was inspected after 4500 hr operation; it showed little wear and was re-installed for further testing.

The differential-temperature measuring system on the feed-pump coolers and the purge pump heaters of the HRT for metering these pump flows was installed and has performed satisfactorily. This type of metering system introduces no pressure drops, involves no regions of high fluid velocity, and meters without the use of moving parts.

Two remote-area radiation monitoring assemblies for the HRT were received from the Victoreen Instrument Company and were accepted after they were tested for performance.

In a frequency-response analysis of the pressurizer-level control system in the HRT mockup, it was found that the air signal from the transducer contained too much noise. The control was improved by the installation of pulsation dampeners in the pneumatic transmission line.

A Fulton Sylphon stainless steel bellows of the type used in the HRT for sealing valve stems was gold-plated and then life-tested in uranyl sulfate at 2000 psi and 300°C. The bellows failed after 3600 cycles; however, it had been overstressed in the shop before it was plated. It is planned that another bellows be plated and the test repeated.

A valve trim, designed for tight shut-off, which incorporated a gold gasket recessed in a groove in the plug for sealing against an annular seat ring, was tested in the valve test loop. Performance was poor because the flow impinging on the plug tended to force the gold out of its retaining groove. Another model, with the gold-gasketed groove in the seat and the annular ring on the plug, will be tested in an effort to avoid the impingement problem. (AEC Activity 4103.1)

HRP Design - The design of the HRT cooling-water system was modified to permit the use of distilled water (building service-steam condensate) in a closed cooling loop serving the in-cell components. Cooling-tower water will be used to cool the distilled water in the closed loop.

Designs of a portable shield in which the HRT neutron source will be transported to the HRT from the LITR, a sample station for the HRT waste

evaporator, and a corrosion specimen holder to be installed in the HRT core and blanket regions, together with coffins and other handling facilities, were completed.

A study was initiated to determine a suitable substitute for Freon-11 as a primary coolant for the HRT refrigeration system; Freon-11 was eliminated because it has been found to react unfavorably under radiation. (AEC Activity 4103.1)

HRP Metallurgy - It was shown that the room-temperature impact properties of high-purity commercial titanium (A-55), containing various amounts of added hydrogen were not adversely affected by aging for times up to 1000 hr at 300°C with amounts of hydrogen up to 350 ppm.

A preliminary study of titanium and zirconium, using the drop-weight fracture test, indicated that the usual concepts developed for steels cannot be applied. The drop-weight test determines the maximum temperature at which a crack will propagate through the metal, which, in turn, is an indication of the maximum temperature for brittle fracture. With both titanium and zirconium, ductile fractures are found at much lower temperatures than would be indicated by the Charpy transition temperature or from the impact strengths at low temperature.

A study has been made of the cracked bolts found in the HRT. From an inspection of a reasonable percentage of the total number of bolts used, the cracks appear to have resulted from faulty heat treatment of the steel. While it is recommended that the remaining bolts be inspected as soon as possible, a sufficient number of cracked bolts have not been found to warrant a special reactor shutdown and dismantling for this inspection.

Several plates of Zircaloy-2 were successfully fabricated by an outside vendor, by using the fabrication procedure developed at the Laboratory. This procedure yields a fine-grained structure with no stringers and with much less preferred orientation than was found with procedures previously used.

As a development in the hydrogen studies, a new high-vacuum valve was invented. This valve is completely enclosed and eliminates all vacuum grease and ground-glass joints. The seal is provided by a low-melting-point metal, and the movement by means of magnets. (AEC Activity 4103.1)

HRP Spectroscopy Development - A standard 6-in. radius, 60-deg sector dual collection spectrometer of the type used for uranium is being converted to permit ratio recording down to mass 16; all components are now fabricated, and installation is nearing completion. (AEC Activity 4103.1)

Laboratory Corrosion Studies - Chloride concentrations of 200 and 500 ppm in boiling and aerated 0.04 m UO_2SO_4 - 0.02 m H_2SO_4 - 0.005 m $CuSO_4$ solutions failed to produce cracking on stressed specimens of type-347 stainless steel during 200 hr of exposure. Corrosion damage on the stainless steel was severe; the average generalized corrosion rate was 10 mpy in the 200 ppm chloride-containing solution and 15 mpy in the 500 ppm chloride-containing solution for 200-hr exposures. Chloride concentrations of 25 and 50 ppm produced stress-corrosion cracks in less than 200 hr.

The average number of cycles for occurrence of rupture on HRE-type 1-in.-dia, 3-ply, HRP-approved, type-347 stainless steel bellows was determined to be 25,000. The bellows were run with a total stroke of 1/8 in. at a rate of 10 cycles/min at 285°C in oxygen-pressurized 0.04 m UO_2SO_4 solution containing 0.006 m H_2SO_4 and 0.005 m $CuSO_4$. The pressure gradient across the bellows was approximately 2300 psi. Previous work under similar conditions of operation with HRE-type bellows fabricated from type-347 stainless steel that was not purchased necessarily to meet HRP material specifications indicated an average value of 38,900 cycles before failure.

Hard-facing materials of Colmonoy 5, Colmonoy 6, and Stellite 40, deposited on hardened and on unhardened type-322W stainless steel, were found to be completely unsatisfactory in boiling 0.04 m UO_2SO_4 solution containing 0.02 m H_2SO_4 and 0.005 m $CuSO_4$. Observed corrosion rates for the three materials ranged from 200 to 1000 mpy after 100-hr exposure periods. (AEC Activity 4103.1)

Dynamic Solution Loop Corrosion Tests - A mockup of the expansion joint and Zircaloy - stainless steel transition joint as used in the HRT reactor vessel was installed in a 100A corrosion loop and tested through 50 daily thermal cycles. The stainless steel bellows was also mechanically deflected daily. The test consisted in circulating 0.04 m UO_2SO_4 containing 0.02 m H_2SO_4 and 0.005 m $CuSO_4$ around the outside of the bellows and joint. The inside of the bellows was filled with water at a pressure 35 to 50 psi below that on the outside of the bellows, to provide for detecting leaks through the bellows or across the expansion joint flange. Examination of the mockup after the test indicated no leaks. Corrosion specimens installed in the assembly and in the loop indicated no excessive attack due to the thermal cycling, although the generalized corrosion rate of the loop was higher than for a similar run made at 300°C. Stressed and galvanically coupled corrosion specimens also indicated no excessive attack. However, a region of pitting attack on the bellows was detected where the bellows was prevented from flexing at the ends by a tightly fitting stainless steel ring. Several pits were found above and below the ring (but not under the ring). The deepest pits were estimated to be 10 to 15 mils deep, indicative of a corrosion rate of 70 to 100 mpy. The exact cause of the pitting attack was not determined. The test is being continued.

A new 100A corrosion loop, designed particularly to circulate beryllium-containing solutions, was placed in operation. The initial runs were made with 1.0 m $BeSO_4$ containing dissolved UO_3 to give 40, 60, and 85 g of uranium per liter. These solutions were all stable with respect to uranium concentration at 250°C. Corrosion of stainless steel specimens was more similar to that observed in dilute sulfuric acid than to that in uranyl sulfate; that is, weight losses were very erratic and there was no simple velocity dependence. On the average, stainless steel corrosion rates were lower than in solutions of uranyl sulfate containing the same concentration of uranium. (AEC Activity 4103.1)

Small-Scale Dynamic Slurry Corrosion Tests - Studies in toroids on the effect of the addition of electrolytes to thorium oxide slurries were continued. Under similar operating conditions (1000 g Th/kg H_2O, 250°C, 26 fps relative velocity, and either hydrogen or oxygen atmospheres) slurries containing 0.01 M $Na_4P_2O_7$ or 0.01 M NaH_2PO_4 - 0.1 M Na_2HPO_4 showed much less attack on titanium (about 5 mpy) than similar slurries containing 0.1 M concentrations of these salts (100 to 2000 mpy). Attack on corrosion pin specimens of type-347 stainless steel, titanium 75A, and A-212 grade-B carbon steel appeared to be primarily dependent on the gas atmosphere employed; the specimens were exposed for 330 hr either to slurries containing these phosphate solutions (0.01 M) or to slurries of the same alkalinity (pH 7 to 10 adjusted with sodium hydroxide). The presence of phosphate ions affected the appearance of the slurry but did not seem to affect the corrosion. Type-347 stainless steel and titanium appeared to be attacked less when oxygen was used than when a hydrogen atmosphere was employed; the carbon steel appeared to be more resistant with hydrogen than with oxygen (about 90 psi); and Zircaloy-2 appeared to be unaffected with either oxygen or hydrogen atmospheres. Titanium in 0.01 M Na_2SiO_3 in the presence of oxygen was relatively severely attacked (20 mpy); Zircaloy-2 appeared to be unattacked; the stainless steel was only slightly attacked; and the carbon steel showed some localized attack.

Thorium oxide slurries of 1000 g Th/kg H_2O have been circulated in toroids at 250°C, 26 fps relative velocity, and under an oxygen atmosphere for varying lengths of time. With oxides calcined at 800° and 1200°C, the attack of type-347 stainless steel and titanium 75A observed during the first 50-hr exposure to raw slurries (average particle diameter: initially, about 2.5 μ; finally, about 0.6 to 0.9 μ) was relatively greater than for precirculated slurries (average particle diameter, initially and finally, about 0.6 μ).

A number of type-347 stainless steel toroids in which thorium oxide slurries had been circulated for a total of about 4000 to 5000 hr were replaced with new units; the old toroids are to be sectioned and examined metallographically. One of the toroids exposed to circulating thoria slurries for about 4900 hr, of which 4100 hr were at 250° to 300°C, 26 fps relative velocity, 1000 g Th/kg H_2O, and with an oxygen atmosphere, showed visually only mild attack, chiefly at, or just downstream of, protuberances (i.e., welds and corrosion pin specimens). However, metallographic examination of some sections of this toroid revealed several transgranular cracks, 20 to 30 mils deep; preliminary evidence suggests these to be stress-corrosion cracks. (AEC Activity 4103.1)

Dynamic Slurry Loop Corrosion Tests - Three short-term runs and one 334-hr run were made in the new slurry corrosion test loop BS. The slurry charges for each run, made at concentrations of approximately 500 g Th/kg H_2O, were prepared from a new batch of ORNL-produced, high-purity thorium oxide which had been calcined at 800°C. Two tests at 250°C and a test at 300°C with oxygen overpressure were terminated after 11, 22, and 195 hr of slurry circulation, respectively, because of caking in the centrifugal pump. In each test, slurry spheroids, ranging from 6 to 25 μ in diameter, were formed during circulation. During the 195-hr run (and the subsequent 334-hr run) the pump was operated at half speed, with adjustments made to maintain loop flow rates the same in all runs. In the 334-hr run, made at 300°C with oxygen overpressure, an addition of ~ 0.03 m $SO_4^{=}$, as Na_2SO_4, was made to the slurry. Spheroids of 3 to 5 μ in diameter were formed, but no caking took place. In general, corrosion rates of austenitic stainless steels, Zircaloy-2, and titanium pin specimens were of the same order of magnitude as had been observed during previous tests with slurries prepared from other 800°C-calcined thoria batches, without sulfate, and where spheroid formation had not occurred.

During a test of 83-hr duration in loop CS at a circulating concentration of 400 g Th/kg H_2O, with the same slurry preparation as above, at 300°C with 2 atm hydrogen overpressure and ~ 400 ppm hydrazine, spheroids were formed and severe caking occurred in the pump. In a duplicate 139-hr test in loop CS, with a different batch of ORNL-produced, 800°C-calcined thorium oxide, no spheroid formation or caking developed. Corrosion rates of pin specimens exposed during this test at an average circulating concentration of 420 g Th/kg H_2O at 11 and 23 fps, respectively, were (in mpy): austenitic stainless steels, 0.5 and 2; titanium and alloys, 0 and 3; Zircaloy-2, 0 and 0; and carbon steels, 25 and 48. (AEC Activity 4103.1)

In-Pile Solution Corrosion Loops--LITR - Exposure of the ninth in-pile loop experiment, L-4-13, was completed. This experiment was conducted in hole HB-4 at the LITR. The UO_2SO_4 concentration (0.17 m) was the same as used in the first seven HB-4 in-pile loop experiments. The $CuSO_4$ and H_2SO_4 were 0.31 m and 0.02 m, respectively. For the first time the solution was made up with heavy water as the solvent. The main-stream operating temperature was 250°C. The loop was fabricated from type-347 stainless steel. The total circulation time with enriched uranium solution was 1039 hr. The energy output of the LITR during the in-pile time was 2362 Mwhr, essentially all of which was at the 3-Mw level.

The over-all corrosion rate of the stainless steel based on oxygen-consumption data for the first 100 hr of irradiation was 2.5 mpy. The over-all rate during the remainder of the run was about 1.1 mpy. The nickel data indicated slightly lower rates. (AEC Activity 4103.1)

Autoclave Radiation Corrosion Studies--LITR - A Zircaloy-2 autoclave experiment (Z-20) was exposed recently in the HB-5 beam hole of the LITR. The conditions of the experiment (250°C, 0.17 m UO_2SO_4, 0.04 m $CuSO_4$, 0.04 m H_2SO_4) were as usual except that the solvent was D_2O (97%). The corrosion based on oxygen-consumption data agreed very well with that indicated by

pin-weight data, but the observed rate of 9.7 mpy at a fission power density of 18.6 w/ml power is about 30% higher than would be predicted from previous data for a similar system with water as the solvent.

Another interesting point was brought out during the half-power operation of the LITR during the Z-20 experiment. The corrosion rate during the half-power operation was 7.2 mpy at 9.3 w/ml, as compared to 9.7 mpy at the 18.6 w/ml at full power. A nonlinear relationship between corrosion rate and fission power density was clearly shown for these operating conditions.

Experiment Z-25 was recently exposed to explore the radiation-corrosion behavior of Zircaloy-2 in contact with a uranyl carbonate solution [0.0091 m UO_3 (93.2% enriched), 0.129 m Li_2CO_3, ~ 800 psi of CO_2, and ~ 400 psi O_2]. After several hours of intermittent operation, because of radiolytic-gas buildup at 250° and 255°C, it was found that continuous exposure at 260°C was possible with a radiolytic-gas pressure of about 700 psi. A corrosion rate of 5.6 mpy was computed from defilmed-pin weight losses. This rate is nearly a factor of 2 higher than would be predicted for Zircaloy-2 in contact with UO_2SO_4 at a similar power density, i.e., about 1.4 w/ml. (AEC Activity 4103.1)

Supporting Radiation Corrosion Studies - Recently completed irradiation tests indicate that Freon-11 is subject to excessive radiation damage yielding corrosive products. It was recommended, therefore that refrigerants which do not form corrosive decomposition products be considered for use in the HRT secondary refrigeration system.

Zircaloy-2 foils contained in a thermal loop were exposed for approximately 40 hr at 250°C to electrons from a van de Graaff generator. Current densities of about 90 $\mu a/cm^2$ at the metal surface were used, and it is estimated that the power density in the solution adjacent to the specimens was 60-90 w/ml. Under these experimental conditions, it appears that ionizing radiation had little if any effect on the rate of corrosion of Zircaloy-2. The previous history of the surface appears to be a more important factor than either the composition of the solution or the amount of ionizing radiation employed.

The corrosion of 347 stainless steel at 250°C in a system containing 0.17 m UO_2SO_4 solution and free of the products of corrosion was studied in a system in which the sample was continuously exposed to fresh solution. It was shown that the corrosion was markedly greater than that observed for systems in which corrosion products accumulate in solution but which are otherwise similar. Passivation of the steel took place after about 100 hr of exposure and after a penetration of about 0.12 mil. The results of experiments at 290°C, with a solution of the same composition, indicated a less-severe attack. Passivation took place in less than 24 hr and after a penetration of about 0.04 mil. The effect of the addition to the solution of 10 mole % excess H_2SO_4 was studied at 250° and 290°C. At 250°C the penetration prior to passivation in the acid solution was 0.4 mil. At 290°C passivation took place in a shorter time but the penetration prior to passivation was again 0.04 mil. (AEC Activity 4103.1)

GENERAL REACTOR RESEARCH

Basic Reactor Research - A calculation of the total gamma-ray energy spectrum at the surface of the proposed UO_2--stainless steel core of the Bulk Shielding Reactor was performed by dividing the energy spectrum into seven energy intervals and computing separately the contributions from prompt, capture, fission-product, and inelastic scattering gamma rays in those intervals. A similar calculation was performed for the uranium-aluminum core now used; the results indicate that the intensity of the high-energy component from the stainless steel core is much greater than from the aluminum core. As a check on the method the calculated spectrum for the aluminum core was compared with earlier experimental measurements. The calculated total intensity is much lower, but the shapes of the two spectra are approximately the same. (AEC Activity 4520)

Basic Shielding Research - The latest determination of the power of the new source plate (SP-2) at the Lid Tank Shielding Facility resulted in a value of 5.18 ± 0.26 watts for the standard monitor reading; this assumes an energy dissipation of 200 Mev per fission. The power was determined by three independent experimental methods; the results were mutually consistent to within 1.2%. On the basis of these results and a ratio of the observed thermal-neutron fluxes in the LTSF water, an effective neutron power of the old source plate (SP-1) was determined to be 1.7 watts $\pm$ 11%.

In an attempt to determine the magnitude of the contributions of the various sources (primary and secondary) to the total gamma-ray dose rates measured in the water of the LTSF, the contribution from each source was calculated and the sum of the contributions was compared with the measured dose rate. The calculation took into account the capture gamma rays produced by the hydrogen in the water, the iron in the tank walls, and the lead and aluminum in the source plate assembly. The calculated total dose rate agreed within 10% with the measured dose rate at 50 cm and within 60% at 160 cm. The calculated primary dose rate was 70% of the total at 50 cm and 56% at 160 cm. The most important contributors to the secondary dose rate were the 2.23-Mev gamma rays from hydrogen capture and the 10.2-Mev gamma rays from neutron capture in iron.

Measurements in oil beyond a 5 ft by 5 ft by 8 in. thick steel tank containing chunks (approximately 2-cm cubes) of tungsten resulted in an effective neutron removal cross section for tungsten of $0.18\ cm^{-1} \pm 15\%$. It is planned to check this result with measurements behind relatively homogeneous slabs of tungsten alloy. (AEC Activity 4570)

Radiation Detector Development - The response of several crystals of LiI(Eu) to gamma rays from the $B^{11}(p,\gamma)C^{12}$ reaction was studied in an attempt to evaluate the gamma-ray contribution to a fast-neutron spectrum as measured with a $Li^6I(Eu)$ neutron scintillation spectrometer. The results of these experiments, performed with 2-mm thick crystals, indicate that essentially no gamma-ray pulses are observed above a pulse height corresponding to 6.5 Mev. Further, it now appears to be feasible to monitor the gamma-ray contribution to a fast-neutron spectrum with an auxiliary crystal of $Li^7I(Eu)$. (AEC Activity 4570)

Metallurgical Materials and Processing - A carburized APPR fuel element was subjected to dissolution tests. The results indicate that the carburization treatment was quite effective in that the fuel plates disintegrated completely in dilute nitric acid containing urea. The leach solutions contained 99.89% of the uranium present. Approximately 25% of the stainless steel was left as solid waste, 10% as partially dissolved side plates and 15% as a fine carbide powder.

The corrosive effects of liquid magnesium on zirconium are being examined. Initial experiments indicate that up to 66 wt % of the 0.030-in.-thick samples is removed during an 8-hr exposure at 800°C. Metallographic examination disclosed a further intergranular penetration of 0.003-in. at each surface. (AEC Activity 4610)

PROGRAM 5000 - PHYSICAL RESEARCH

Reactor Operations - Reactor operations were normal except for the continued occurrence of ruptured slugs in the Graphite Reactor. Three ruptured slugs were located and discharged in September and four in October. Measurements of unruptured slugs from the same fuel channels indicated longitudinal growth as much as one inch beyond the original 4-1/8-in. length. In over 70% of slug ruptures in the past two years, the uranium was only incompletely beta transformed.

A smaller grid was installed in the LITR to free 14 core spaces for overhead access.

Oak Ridge Research Reactor (ORR) - Construction of the reactor building, shielding, and cooling system is estimated to be 86% complete; the contractor is now estimating turnover to the Laboratory for about March 1, 1957.

Many of the difficulties concerning aluminum welding were resolved and this work is progressing in a satisfactory manner. The barytes shielding of the pool floor was completed. Erection of the aluminum pool liner is about 66% complete; the large facility liners and the six beam hole tubes are in place and are being aligned. The main floor of the building was completed and the building shell is now weather-tight. The building electrical system was energized thus allowing use of the 20-ton crane and the permanent lighting.

Reactor tank fabrication continues with an expected delivery date in the middle of February. Fabrication of the large facility plugs is under way in the shops at Paducah; detail design of the combination collimators and plugs for the six beam holes is being done here. The reactor mechanical controls, grid plates, shim rods, bearings, reflector and dummy fuel elements are being assembled in a mockup in the X-10 reactor building; this will enable operating personnel to become familiar with all components and to check for errors.

The request for an additional $515,000 for added work space, hot cells, air conditioning, etc., was approved by the AEC and design is under way.

ISOTOPE PRODUCTION

Radioisotope Production - The Co^{60} storage-garden irradiator, now in operation, utilizes the gamma radiation of stored Co^{60} for irradiation studies; the exposure "cage" is a 10-in. cube. The gamma flux in the cage from 85,000 curies of stored Co^{60} was measured at 1.1×10^6 R/hr. (AEC Activity 4111)

Radioisotopes, Process Development - A production method was developed to remove the silver iodide from berl saddles used in a scrubber tower. Chemical treatment of the silver iodide yielded the product, I^{129}. The half-life reported in the literature was verified, with analytical results indicating a half-life of 1.69×10^7 years. Construction of the Fission-Product Pilot Plant is about 87% complete. (AEC Activity 5112)

PHYSICS

Neutron Diffraction - Neutron diffraction studies were made on $MnBr_2$ and $MnCl_2$ at temperatures down to 1.25°K to determine the types of antiferromagnetic ordering which occur in these compounds at very low temperatures. Specific heat measurements exhibit λ-type anomalies in $MnBr_2$ at 2.18°K and in $MnCl_2$ at 1.96°K and 1.81°K. In contrast to $FeBr_2$, $FeCl_2$, and $CoCl_2$, which order with the atomic moments in each metal layer coupled ferromagnetically and with adjacent layers aligned antiparallel, the magnetic ordering in these compounds is extremely complex. Since it was impossible to determine the magnetic structures from powder diffraction data, a single-crystal goniometer capable of performing at these low temperatures within an external magnetic field of fifteen thousand oersteds was designed, constructed, and put into use. The results from these single-crystal measurements are indicative that both compounds have antiferromagnetic structures which are very different from any reported previously. Large unit cells are required to index the magnetic reflections, and there appears to be more than one axis of magnetization. Furthermore, reflections were found in $MnCl_2$ which originate from two different magnetic structures with Néel temperatures corresponding to the two specific heat maxima. (AEC Activity 5220)

Atomic Beam Experiment - Radiofrequency resonance was observed in a beam of K^{42} atoms in a Rabi-type atomic beam apparatus. Detection of the beam was accomplished by allowing the beam to deposit on a copper tape and then moving the active spot into a scintillation counter assembly. The resonance was observed at 4/5 the frequency of resonance of K^{39} atoms in the same magnetic field. This confirms that the nuclear spin of K^{42} is 2, as reported by Bellamy and Smith (Phil. Mag. 44, 33, 1953). (AEC Activity 5220)

Neutron Velocity Selector - The 256-channel, magnetic-core time analyzer was received from the Instrumentation and Controls Division. (AEC Activity 5220)

High Voltage Program - The non-resonant, neutron differential elastic scattering cross sections for oxygen and beryllium were measured as a function of angle at several energies by the technique of detecting scattered neutrons with a shielded recoil counter. For oxygen, the data, together with other measurements reported in the literature, make it possible to estimate the scattering phase shifts in the 0-2 Mev energy range. In this range the s-wave potential scattering phase shifts very smoothly with energy and can be calculated from a static potential well. If one also requires that the energy position of the $J = 1/2^+$ bound state of O^{17} be correctly given by the well, the parameters are determined for any given shape. Analysis of published scattering data for C^{12} and the use of the bound s-level in C^{13} in the same manner gives a similar potential well for a neutron due to the C^{12} core. In order to make the effective radius of the potentials change in the expected way in going from C to O, one must introduce a diffuse boundary to the well.

The measurement of the absolute neutron flux, which is necessary for the determination of the absolute $Be^9(n,\alpha)$ cross section, was previously made by using a Po-Be neutron source and a long counter. This method has several drawbacks. The efficiency of the long counter as a function of neutron energy was formerly thought to be constant to within $\pm$ 5% for neutron energies of 0.3 to 3.0 Mev. This has recently been shown not to be the case. In addition, the Po-Be source emits neutrons with a continuous range of neutron energies (peak at 4 to 5 Mev). To obtain a more reliable measure of the neutron flux, a U^{238} fission chamber was used. The absolute fission cross section is known to $\pm$ 6%. The fission foil was placed so as to subtend the same solid angle as the thin Be foil. The $Be^9(n,\alpha)$ cross section at a neutron energy of 3 Mev is found to be 100 $\pm$ 10 millibarns. This value differs by 10% from our previous value. (AEC Activity 5220)

CHEMISTRY

Volatility Studies - In the fused salt--fluoride volatility process, uranium-clad and/or alloyed fuel elements are dissolved in fused fluoride salts, in the presence of HF. The UF_4 formed is then fluorinated to UF_6 which volatilizes and is collected in NaF traps. A pilot plant for large-scale study of the process is nearly completed.

In further laboratory tests, dissolution rates of zirconium in fluoride melts increased rapidly as the zirconium content decreased:

Melt (mole %)			Temp	Zr Dissolution
LiF	NaF	ZrF_4	(°C)	Rate (mg/min-cm^2)
35	27	38	600	5.5
26	19	55		1.0
57	43		700	13.2
35	27	38		8.3
26	19	55		4.8

Type-347 stainless steel dissolved in molten 50-50 mole % $NaF-ZrF_4$ saturated with HF at rates of 0.1, 1.4, and 1.8 mg/min-cm^2 at 600°, 700°, and 800°C, respectively.

In further laboratory tests gross β and γ decontamination factors were $>10^6$. The experiments were made with uranium, which had been irradiated to a level of 600 Mwd/t and had decayed 120 and 420 days, dissolved in 50-50 mole % $NaF-ZrF_4$. Repeated use of the NaF absorption system was possible with 420-day-decayed material, but with the 120-day-decayed material ruthenium and niobium activity broke through after the first run. The decontamination limit in the absorption step is due to the ruthenium activity which is not swept out of the first NaF bed to the extent desired. For ruthenium, niobium--zirconium, and total rare earths overall decontamination factors were 10^4, 10^5-10^6, and at least 10^7, respectively. This work was conducted in a shielded laboratory test facility duplicating many of the features incorporated in the volatility pilot plant. (AEC Activity 5310)

Ion-Exchange Studies - A continuous run was made in the 2-in.-dia Higgins contactor on a UO_2Cl_2 ore concentrate obtained from Vitro Laboratories. The uranium was sorbed on an anion-exchange resin and eluted with water. The uranium production rate was about 440 lb/day-ft, and the product uranium concentration was 187 g/liter. For washing the resin about 3.5 lb of HCl (100%) was used per pound of uranium.

A 36-in.-dia resin test loop was constructed. The loop contains 125 ft^3 of 10-20 mesh resin and simulates the hydraulic behavior of a 100-ton/day ore processing Higgins contactor. In preliminary hydraulic tests the slip water ratio during pulsing was lower than that of the 12-in.-dia contactor and ranged from 1.5/1 to 2.0/1 for solids-free water feed. (AEC Activity 5310)

Feed Materials Processing: Hermex Process - In the Hermex process uranium is dissolved in boiling mercury and recovered by pressing and retorting. Good quality uranium metal, containing <1 ppm magnesium, was recovered from uranium quasi amalgam produced by dissolving uranium scrap metal in mercury containing 0.1 wt % magnesium. A poor metal yield, 35% of scrap charged, was attributed to equipment difficulties. (AEC Activity 5310)

Feed Materials Processing: Metallex Process - In the Metallex process thorium or uranium chloride is reduced with sodium amalgam, and the reduced metal is recovered by pressing and retorting. Attempts to separate the thorium amalgam from by-product NaCl, ThO_2, and $ThOCl_2$ without using water have not, so far, been successful. When product thorium amalgams were boiled to dissolve the thorium mercuride in the mercury and filtered hot, the fritted glass filters appeared to react with the thorium mercuride and became plugged with ThO_2.

The bulk density of the sintered thorium metal product of the retorting step was greater and the voidage was smaller when the temperature differential between the retort wall and specimen was 40-50°C than when it was 10° or 100°C. (AEC Activity 5310)

Extraction Reagent Performance - The formation of unsaturated compounds was established as being one of the chief effects of radiation on kerosene-type diluents commonly used in tributyl phosphate solvent-extraction processes. With Co^{60} irradiation up to 68 watt-hr/liter, the formation of unsaturated compounds was detected by iodine number in Amsco 125-82, Deobase, and an experimental $C_{14}H_{30}$ diluent; there was a linear increase at a rate of 0.36%/watt-hr/liter. As the dosage increased, there was a pronounced shift toward lower boiling fractions and an increase in the odor. Specimens irradiated to 68 watt-hr/liter in the presence of aqueous aluminum nitrate--nitric acid developed a yellow coloration, indicative of limited nitration.

The irradiated diluents showed no tendency to complex the long-lived fission products or to produce stable emulsions. Possibly, the emulsifiers that disrupt solvent-extraction systems such as Thorex at high radiation levels may be associated with the chemical degradation of the diluent and/or tributyl phosphate. (AEC Activity 5310)

High-Level Nuclear Chemistry - The direct measurement of the half-life of fission-produced Sm^{151} by specific activity has not been reliably reported previously because of the inherent difficulty of low-energy absolute beta counting.

In current work, the effect of self-absorption was eliminated by extrapolating to zero thickness a curve of counting rate vs sample thickness, for a weighed sample of Sm_2O_3 (4.8% Sm^{151}). The values obtained for the half-life range from 80 to 120 years, which is about the limit of the values reported by the mass spectrographic method.

Efforts to observe coincidences between the 20-kev gamma and the L x-ray have led to the conclusion that less than 1% of the disintegrations involve gamma emission. (AEC Activity 5330)

Chemistry of Heavy Elements - In a study of the absorption spectra of Np(III, IV, V, and VI) it was found that D_2O is a much better medium than H_2O for the infra-red region, since the former shows much smaller absorption up to about 18,500 Å. With this improvement a number of new absorption peaks were found

in the infra-red region for all four of the neptunium valence states, including a pronounced one at about 12,200 Å for Np(VI) which shows no useful peaks in the visible and near infra-red below this wave length. With this new information, all four valence states can be determined directly including the VI state which was previously determined by difference. With an H_2O absorption peak at about 16,600 Å it was shown that it is possible to analyze directly the H_2O content of D_2O in the presence of UO_2SO_4. (AEC Activity 5330)

Chemistry of Corrosion - On the basis of the absolute rate model of electrochemical kinetics, a mathematical theory of two-phase corrosion reactions was developed which, in principle, is applicable to any system in which activation-controlled partial processes occur simultaneously at an electrode-solution interphase. Expressions appropriate to particular cases and operations frequently encountered were derived with emphasis on the mechanistic significance of observable electrochemical quantities. Application of this theory to the interpretation of data obtained for the addition of Cu^{++} to stainless steel electrodes passivated in aerated, dilute H_2SO_4 showed that the reduction of Cu^{++} at the electrode surface is kinetically of the first order with respect to (Cu^{++}) and that a one-electron change is involved in the rate-determining act.

A previously reported observation that an anomaly exists in the potential-corrosion rate curve characteristic of stainless steel undergoing H_2-evolution-type corrosion in dilute aqueous acid media was confirmed. Present indications point to the conclusion that part of the hydrogen liberated cathodically may be accomodated in the stainless steel lattice near the electrode surface at sufficiently basic potentials, resulting in an enhanced corrosion rate, presumably due to a weakening of the metallic bonding.

The open-circuit potential of crystal-bar Zr electrodes in dilute H_2SO_4 was investigated for a variety of conditions. Although the exact behavior depended largely on the pretreatment of the electrode, all samples ennobled rapidly at first and then eventually reached a reasonably steady potential within 100 millivolts of SCE. The electrodes so formed will indicate the thermodynamic potentials of the OsO_2-OsO_4 and Cu-Cu^{++} couples. Corrosion rates were immeasurably small. These observations are interpreted in terms of the formation of an electronically conducting film of ZrO_2. (AEC Activity 5330)

Chemistry of Technetium - Final calculation of the low-temperature heat capacity of potassium pertechnetate, $KTcO_4$, from the experimental data was completed. The entropy of the salt at 298.16°K is 39.74 ± 0.08 cal/deg-mole, of which 0.29 cal/deg-mole was estimated for the entropy below 15°K by means of a Debye-T^3 extrapolation. From existing data on the solubility of $KTcO_4$ and its temperature coefficient, from an estimate of the activity coefficient and in the saturated solution, and from the above entropy of $KTcO_4$, there is obtained a value of 43.2 cal/deg-mole at 298.16°K for the entropy of TcO_4^- in the hypothetical one-molal solution. (AEC Activity 5330)

Characterization of Short-Lived Fission Products - Detailed measurements were made on 14.61 ± 0.07-m Mo^{101} by scintillation methods. Sources of Mo^{101} were measured shortly after separation of the 14.0 ± 0.1-m Tc^{101} by solvent extraction. Gamma-rays having energies of 0.0833, 0.193, 0.403, 0.515, 0.585, 0.707, 0.896, 1.02, 1.19, 1.54, 1.68, and 2.08 Mev were determined. The maximum-energy, beta-ray group was 2.23 ± 0.04 Mev. A search was made for a short-lived isomeric Tc^{101} daughter. Rapid chemistry showed no such activity with a half-life exceeding 5 seconds. (AEC Activity 5330)

Chemical Separation of Isotopes - Studies of the ANCO (anisole-complex) process for enriching the isotopes of boron were continued in an automatically operating laboratory-scale system. Data were obtained on anisole decomposition, and on boron remaining in the decomposer effluent. The stage height for the exchange column was evaluated as a function of flow rate, column diameter, and type of packing. Stage heights of less than 2 in. were obtained in columns as large as 2 inches in diameter.

An oxygen separation factor of 1.012 ± 0.003 (95% confidence interval) was measured between CO_2 in the gas phase and CO_2 absorbed by a solution of monoethanolamine in n-butyl alcohol. As had been previously observed in similar systems, oxygen-18 was enriched in the gas phase.

The nitrogen isotope enrichment facility is currently producing >99% N^{15} at a rate of 1.2 g/day. (AEC Activity 5340)

METALLURGY

High-Temperature Reactions of Metals and Ceramics - Studies are underway to determine the feasibility of using nuclear magnetic resonance techniques and light absorption as tools for the study of fused salt structures. Preliminary investigations with both techniques were successful.

The proton and Na^{23} resonances were measured in fused sodium hydroxide (above 320°C) and were found to give sharp (less than 10 milligauss) lines well above background. Optical absorption spectra were measured for a number of fused salts from 200 to 800 mμ of wave length at temperatures up to 600°C. Well defined absorption bands were found in anticipated positions for several salts. The extinction coefficients of some bands, though not accurately determined, was found to be many times greater was expected. However, the special equipment designed for this work is capable of measuring these unusually high coefficients. (AEC Activity 5420)

BIOLOGY

Insect Cytology and Genetics - A reversed compound ring X chromosome is composed of two complete, or essentially complete, X chromosomes, each of which is attached to the same centromere at one end (as in the case of attached-X chromosomes) with the distal tips of the two chromosomes attached to each other by a heterochromatic segment, thus forming a continuous ring, the component chromosomes of which synapse with each other simply by collapsing the ring.

A genetic analysis of the meiotic behavior of such rings in *Drosophila* was made. Such an analysis is of interest in a number of connections. First, reversed rings are structurally very similar to reversed acrocentric compound X chromosomes (in fact, a reversed ring may be thought of as a reversed acrocentric with the free tip attached to the centromere) which are known to behave extremely atypically during meiosis, when contrasted to either free-X or attached-X chromosomes. Specifically, reversed acrocentrics appear to show a frequency of single-exchange tetrads which is much lower than either no exchange or double-exchange tetrads, and the possibility is not excluded that the real frequency of single exchanges in the reversed acrocentric compound is zero. It is therefore of interest to compare the distribution of the different rank exchanges in reversed rings and reversed acrocentrics. Secondly, ring chromosomes in general, and therefore reversed rings also, provide a test which can distinguish between crossing over taking place between all four non-sister chromatids of a tetrad with no sister-strand exchange, as opposed to crossing over occurring between only the two newly reduplicated non-sister chromatids, with sister-strand crossing over then randomizing the four strands. Finally, physical considerations suggest that ring chromosomes might, after reduplication or crossing over, be mutually interlocked so that in the progeny of ring-bearing parents there would be a reduced recovery of rings due to their elimination as interlocked complexes. The genetic data from single and tandem compound ring X chromosomes in *Drosophila* show, at most, a slight deficiency in the recovery of rings, suggesting either that interlocked complexes do not form, or, that having formed there is some mechanism whereby the interlocks are resolved. Reversed rings represent another situation in which evidence for interlocking of rings might be obtained.

The analysis performed on these reversed rings has shown (1) that the rings do behave similarly to reversed acrocentric compounds, both in the extreme reduction (or complete elimination) of single exchanges and with respect to the distribution of exchanges, (2) that the results from the reversed ring are consistent with the conventional assumptions about crossing over (that is, that there is no sister-strand exchange) and appear to be inconsistent with the assumption of sister-strand crossing over as outlined above, and (3) that there is a sizable reduction in the recovery of reversed rings from compound-bearing females in excess of that which can be accounted for by a tetrad analysis and by inviability suggesting the possibility of unresolved interlocked complexes in reversed rings. (AEC Activity 6130)

Pathology and Physiology - Young adult mice of the RF strain developed dental deformities after exposure of the head to a single dose of 1000-1800 r of X-rays. Mice affected severely were unable to feed adequately on food pellets and gradually starved to death unless provided with a soft diet. One or all of the teeth, more commonly both maxillary teeth, were affected by varying degrees of malformation or loss, erosion of the crown, or tipping, accompanied rarely by hypertrophy. The loss of teeth was attended by ulceration of the gums and abscess formation. The time of onset of dental deformities varied with the dose of radiation. Administration of S,2-aminoethylisothiuronium.Br.HBr before irradiation afforded some protection against these changes. Dental deformities were not observed in animals exposed to doses below 1000 r or in nonirradiated controls. (AEC Activity 6130)

Biophysics - The paramagnetic resonance equipment is now in routine operation and is being used in a number of different investigations of radiation-induced free radicals. Paramagnetic resonance absorption was obtained from chloroplasts when illuminated with strong visible light. The absorption disappeared when the chloroplasts were heated up to less than 140°C. Unpaired electrons responsible for this resonance are held in very stable configurations since they persist for a long time at room temperature in the presence of oxygen.

Chemical compounds known to give protection against radiation damage for mice and mocroorganisms were treated with ionizing radiations. They show interesting, nonsymmetrical resonance patterns, probably as a result of the presence of sulfur atoms. (AEC Activity 6130)

Mammalian Recovery - Ten separate experiments were performed in testing the effect of intravenous injection of bone marrow on lethal total-body fast neutron irradiation. In nine of the ten experiments, the mice treated with bone marrow showed significantly less mortality in the 30-day observation period than the control animals.

The concentration of heterologous bone marrow and the dose of X-ray independently influence the survival pattern of irradiated mice treated with rat bone marrow. It thus appears to substantiate the original hypothesis that at least two independent variables are operating in regard to the delayed effect.

To determine whether or not an effective cell type is being obtained by the tissue culture method, it has become necessary to obtain information concerning the minimal numbers of fresh bone marrow cells capable of bringing about recovery in otherwise lethally irradiated mice. In several experiments, survival of 60% or better was obtained in lethally irradiated mice receiving approximately 50,000 nucleated fresh bone marrow cells. The composition of the suspending fluid as well as the use of antibiotics appear to influence the effectiveness of suboptimal doses of bone marrow cells.

The hematocrits of irradiated mice injected with isologous bone marrow were essentially the same as those injected with whole leukemoid blood during the first 3 weeks after exposure.

Rat platelets were detected in irradiated mice injected with rat bone marrow. (AEC Activity 6230)

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STATUS OF CONSTRUCTION

To meet the requirements for additional space to house personnel and equipment at the Tower Shielding Facility, construction by the Charles Hobson Company of an additional control room was started during the period.

As is the case of the existing control room the additional room will be built under ground with an earth covering of a minimum of three feet to provide shielding during the operation of the reactor.

The reinforced concrete structure thirty feet by fifty-nine feet will be located adjacent to the present control house. Ready access to the addition will be provided by an eight-foot tunnel connecting to the south ramp to the existing control house.

An emergency exit will be incorporated into the air intake duct in a rear corner of the room.

It is expected that the facility will be ready for occupancy about May 1, 1957.

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RADIOISOTOPE SALES AND COSTS

Type of Transaction	October 1956	FY 1957 to Date
Domestic Sales	$139,491	$452,411
Foreign Sales	2,344	48,741
Project-Transfer	1,115	4,883
Technical Co-Operation Program Credits	910	3,380
Plant Credits	2,344	14,630
AEC Credits	25,138	66,098
Total Radioisotope Income	$179,097	$608,927
Total Radioisotope Costs	$ 49,773	$403,783
Total Radioisotope Shipments	1,216	4,410
Helium		
Income	$2,213	$7,663
Costs	221	2,683
Shipments	1	9

FY to Date totals include following adjustments on the July report:

$1,310 transfer from domestic sales to helium sales
$ 810 transfer from foreign sales to helium sales
$ 942 transfer from radioisotope costs to helium costs
Transfer of seven shipments from radioisotope to helium shipments

GROSS OPERATING COSTS

	Cost for October	FY 1957 Cost to Date
Programmatic Operating Cost - Net	$3,774,914	$16,391,389
Equipment	285,001	953,474
Construction	192,090	665,931
Work for Others - Transfers	5,122	237,743
Inventory Changes	57,125	(43,963)
Reimbursable Work for Others	93,128	289,177*
Deferred Charges	8,054	(375,165)
Total Laboratory Cost - Net	$4,415,434	$18,118,586
Estimated Cost for Next Month	$4,500,000	$22,618,586

() Credit
* Project Cash Sales of Isotopes previously excluded - $17,100

PERSONNEL SUMMARY

	Number of Employees November, 1956	New Hires November	Terminations November
Administration	72	0	0
Operations*	128	0	0
Engineering, Shops, and Mechanical	844	9	3
Laboratory and Research	2172	20	8
Protection	126	0	0
Service	385	6	1
	3727	35	12

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

A total of 925 Laboratory personnel are located in the Y-12 Area.

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Reports in this series issued during the past year:

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June 1956	ORNL-2123
July 1956	ORNL-2144
August 1956	ORNL-2166
September 1956	ORNL-2185
October 1956	ORNL-2205

Edited by F. T. Howard

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