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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

DECEMBER 1953

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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

December, 1953

W. H Sullivan

and

F. T. Howard

Date Issued: JAN 8 1954

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OAK RIDGE NATIONAL LABORATORY

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December, 1953

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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

December, 1953

The subject material of this report represents approximately half of the Laboratory's program, which is covered with some exceptions on a bimonthly schedule.

PROGRAM 2000 - SOURCE AND FISSIONABLE MATERIALS

Amex Process - The Amex process flowsheet outlined previously (ORNL-1651) has been modified by substituting gaseous ammonia for solid calcium oxide as the neutralizing agent for the waste to be processed. Since a gaseous reagent is easier to use than a solid one, this change has simplified the process engineering. (AEC Activity 2344)

PROGRAM 3000 - WEAPONS

Special Electromagnetic Separations - In a successful plutonium separation run the estimated yield was 0.5 gram of 50 per cent Pu^{240} and 0.2 gram of 10 per cent Pu^{241}. The $PuCl_3$ feed material assayed 5.1 per cent Pu^{240} and 0.4 per cent Pu^{241}. In the two-arc calutron an average total current of 34 milliamperes was maintained for 24 hours; the charge consumption rate was 5.4 g Pu/hr and the process efficiency 5.7 per cent.

A new supply of more highly irradiated material, assaying 13 per cent Pu^{240}, 1.8 per cent Pu^{241}, 0.2 per cent Pu^{242}, and 85 per cent Pu^{239} was obtained from Chalk River.

In a thorium separation run, 1.25 grams of Th^{230} (ionium) was enriched to 90 per cent purity. (AEC Activity 3601)

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HOMOGENEOUS REACTOR PROJECT

Homogeneous Reactor Experiment - The HRE was operated at nearly full power (1000 kilowatts) for a large part of the time during the month of December, with a total of 215 megawatt hours being accumulated. There was one unscheduled shutdown because of a plugged dump line, which cleared after a week; for most of the remainder of the month the reactor was operated continuously.

An experiment was conducted to determine the effectiveness of copper ion as an internal recombination catalyst. Incompletely analyzed data indicate that the catalyst performed essentially as predicted from laboratory tests and in-pile bomb experiments. The concentrations of copper used, i.e., approximately 0.001M, 0.0025M and 0.0075M, were chosen so that recombination of the quantity of gas formed would be incomplete at a 1000-kw power level, a 250°C temperature and 1000 psi pressure. When the copper concentration was 75 per cent of that theoretically required for complete recombination, 75 per cent of the gas was recombined in the solution; at 25 per cent of the required concentration, 25 per cent of the gas was recombined. The concentration of copper required for complete recombination is sufficiently low to be of interest in a homogeneous breeder reactor. During the experiments it was observed that operation at power levels around 1000 kw was steadier, with most of the gas recombined in the solution, than when gas was separated and recombined by the usual method, without the presence of copper.

Somewhat erratic generalized corrosion data obtained during the month indicate that with fission product concentrations now approximately 30 per cent of those expected in a larger scale reactor and with accumulated power densities of 3000 kwh per liter (215 megawatt hours, 70 liters), corrosion rates in the HRE are not appreciably different from those observed in out-of-pile tests under the same conditions. (AEC Activity 4103.1)

Engineering Investigation of Slurries - Studies of uranium slurries have been discontinued for the time being to permit full effort to be devoted to the study of thorium slurries for use as reactor "blankets." To date the major difficulty encountered with these slurries has been abrasion, which is serious in places of high velocity and/or sudden changes in direction, as in the pump impeller and wear rings and in orifices, but apparently not serious in standard pipe and fittings, including elbows. Abrasiveness is characteristic of all types of slurries prepared to date; and, although differences in the abrasiveness of slurries prepared by different methods have been observed, no slurry has yet been found to be non-abrasive to stainless steel. A variety of materials and surface treatments such as hard chromium plating are being tested for resistance to abrasion. (AEC Activity 4109.31)

Chemical Investigation of Slurries - A slurry with a thorium concentration of 1300 grams per liter was prepared from thorium oxide made by igniting thorium oxalate first at 350-400°C and then at 550-600°C. This thorium

oxide was less abrasive than the (Ames) oxide made by igniting thorium oxalate at 650°C, had an average particle diameter of 0.02 micron (range, 0.01 to 1 micron), contained less than 200 ppm (parts per million) of nitrate, and showed no tendency to pack after being autoclaved in water at 250°C. The autoclaving of thorium oxalate in an aluminum-lined vessel in water at 250°C produced an oxide with the same average particle size and size range as that described above but it dispersed more readily after settling and contained less than 50 ppm of nitrate or aluminum. It was also less abrasive but the slurry prepared from it had a thorium concentration of only 600 grams per liter. Igniting this oxide product at 900°C did not change its particle size or the bulk density of slurries prepared from it, but did increase its abrasiveness. Attempts to prepare thorium oxide by decomposing the oxalate with steam at 250-300°C and atmospheric pressure were unsuccessful.

Thorium oxide prepared by igniting thorium formate at 300°C produced a slurry that was very abrasive. The autoclaving of thorium formate in water at 250°C caused extensive corrosion of the aluminum liner. Attempts to prepare thorium oxide by decomposing the formate in water at 100°C were unsuccessful. (AEC Activity 4109.31)

Solution Chemistry - In continuing work on the phase equilibria in the system, UO_3 - NiO - SO_3 - H_2O, several regions have been completed. Increasing attention is being devoted to the low uranium region because of its particular interest for power reactor fuel solutions.

Work on the two liquid phase-vapor equilibrium in the system $UO_2SO_4 \cdot H_2O$ (300° to 400°C) has been delayed by not unexpected difficulties in the fabrication of leak-proof view windows of the required dimensions in the high pressure system. (AEC Activity 4109.31)

Metallurgy - Impact tests were performed on Zircaloy-2 specimens, which had been exposed in an all-titanium loop to 5 g U/liter UO_2SO_4 + 25 mol per cent excess H_2SO_4 for 1010 hours at 250°C with 200 psi O_2 overpressure. Impact testing temperatures from -195.6°C to +300°C were employed. Comparison of these results, with those from impact tests on unexposed control specimens, revealed that no harmful effects resulted from the environment as far as such effects could be detected by the testing methods employed. Similar slow-bend tests performed on Zircaloy-2 standard dynamic corrosion notched test-pins, showed no observable effects of the environment on susceptibility to notch-brittle behavior.

Dynamic corrosion tests, on moist hydrogen-pretreated austenitic stainless steel pin specimens, showed that oxide films formed at 1850°to 1900°F (in hydrogen containing 0.1 to 3 per cent moisture by volume for 1/2 to 1 hour) afforded good protection against attack by 15 g U/l UO_2SO_4 + 25 mol per cent excess H_2SO_4at 250°C and a flow rate of 60 feet per second. The consistently good behavior of pretreated type 309SCb, a columbium-stabilized 25 Cr-12 Ni stainless steel, has prompted some work on pretreated chromized (surface enriched in chromium) 18-8 alloys. These protective pretreatment films contain

spinel structures with relatively high lattice parameters, corresponding to those of manganese chromite, along with small amounts of chromic oxide. (AEC Activity 4109.4)

Boiling Reactor Research - Recent investigations have shown that an important factor which may significantly increase the rate of power removal from boiling reactors is the "slip" of bubbles in boiling solutions; that is, the difference in the upward velocity of bubbles and in the velocity of the liquid. It has been observed that it is possible in some systems to obtain streams of bubbles rising 50 or more feet per second faster than the liquid is traveling. A factor of importance in establishing bubble velocities appreciably higher than liquid velocities is the diameter of the vessel, since in large-diameter vessels eddy currents upset the stream flow of the bubbles and thus reduce the difference in velocity of bubbles and liquid. Pressure also seems to be a relatively important factor, with higher pressures resulting in lower bubble velocities. An attempt that is being made to correlate ORNL experimental data with those from the Argonne Heterogeneous Boiling Reactor has met with moderate success in spite of the differences between homogeneous and heterogeneous boiling systems. (AEC Activity 4112.1)

AIRCRAFT NUCLEAR PROPULSION PROJECT

Aircraft Reactor Experiment - No new problems of significance have arisen in connection with the Aircraft Reactor Experiment (ARE); equipment is being installed and tested as rapidly as possible. All welding in the major systems was completed except for final closure stress welds which must await flushing of the completed systems with rinse water. This flushing will be done after the closure flanges for the sump pumps are received and installed; all sump tanks are now in place. The installation of electrical heaters and the insulation around them is now approximately 90 percent complete. The four reactor control rod sleeves were received and one was installed in the reactor. (AEC Activity 4401.1)

Experimental Engineering - Six gas-seal sump-type centrifugal pumps for the ARE are in various phases of construction and testing. One of the pump impellers, fabricated from Inconel sheet stock, was completed. A moderator-coolant pump was tested successfully with water, and loops are being constructed for testing this pump with sodium and for testing the fuel pumps with the fluoride fuel. The small down-flow sump-type pump for in-pile loop operation is also being tested with water. (AEC Activity 4401.1)

Radiation Damage - Petrographic and chemical examinations were made of NaF-ZrF_4-UF_4 fuels in Inconel capsules which were irradiated in the MTR for several hundred hours at 1500°F and at power densities of 2500, 3800, and 8000 watts/cc of fuel. No deleterious changes due to irradiation were detected. (AEC Activity 4401.4)

Reactor Chemistry - Preparation of the ARE fuel concentrate (Na_2UF_6) was completed by the Y-12 Production Division. This material, which comprises 15 separate batches totaling about 450 pounds, meets all specifications and is ready for use. Assays of the total uranium content, as determined by two different analytical laboratories, agree to within 1 part in 5000.

Sodium hydroxide, under an inert atmosphere at 700°C in sealed nickel capsules, oxidizes added graphite (and presumably other carbonaceous compounds) to carbonate. In 24 hours at 700°C the carbonate content of a typical sample of caustic rose from 0.04 to 0.4 percent by weight when 0.2 percent by weight of graphite was used; about 40 percent of the added graphite was converted to carbonate ion. It is likely that the increases in carbonate content sometimes observed in caustic during corrosion tests may be due to decarburization of the test metal.

High temperature filtrations of samples in the NaF primary crystalline field of the $NaF-ZrF_4-UF_4$ system have shown that the first precipitation of NaF from such materials on cooling is detected more readily in this manner than by routine thermal analysis. These studies have also demonstrated that, after the NaF concentration in the liquid phase falls to about 81 mole percent, a zirconium-rich phase (probably Na_3ZrF_7) begins to separate and the composition of the liquid moves toward the $NaF-UF_4$ binary eutectic.

Spectrophotometric examination of super-cooled glasses containing equimolar concentrations of UF_4 and ZrF_4 with added NaF showed that there is a transition from an "uncomplexed UF_4" pattern to a $UF_6^=$ pattern as the NaF concentration is varied from 50 to 67 mole percent. (AEC Activity 4401.5)

Corrosion Studies - In connection with the screening of potential materials for use in bearings exposed to fluorides, several Kentanium titanium carbide compacts were tested in the tilting (see-saw) furnace. In these tests the specimens were exposed to the fluoride fuel No. 30 in Inconel tubes for 100 hours at 816°C; the cold zone temperature was maintained at 730°C. In spite of the usual inertness of nickel to fluorides, the nickel and Ni-Mo binder material appeared to be selectively attacked in these compacts.

In a previous set of tests in which small amounts, 1/2, 1 and 2 percent, of Li_3N were added to lithium contained in type 316 stainless steel at 816°C, serious intergranular corrosion was observed. Additional tests were run at 871°C with a smaller amount of Li_3N to determine the effect that this easily obtained impurity (resulting from exposure of lithium to air) has on corrosion when the temperature is above the melting point of the Li_3N (845°C). The type 316 stainless steel was severely attacked in these tests; intergranular penetration became deeper as the concentration of Li_3N was increased. The carbides at the grain boundaries appeared to be attacked; in tests at a temperature (1000°C) where most of the carbides are in solution, penetration via the grain boundaries was not detected. (AEC Activity 4401.5)

Metallurgy - Several nickel binary systems were tested in 100-hour oxidation tests at 1500°F to see if any of the alloy systems merited further investigation as brazing alloys for use in fabricating heat exchangers. The results of this work are tabulated as follows:

Alloy	Melting Point °C	Resistance to oxidation at 1500°F after 100 hours
65 Ni-35 Sb	1091	Good (toxic stibene may be formed during brazing)
75 Ni-25 Cb + 5% P	1265	Good
75 Ni-25 Ge	1151	Good
60 Mn-40 Ni	1005	Poor
60 Pd-40 Ni	1237	Excellent
90 Ni-10 P	880	Good
68 Ni-32 Sn	1124	Fair

It was found that, due to the interdiffusion of the metals, Inconel-clad copper is not satisfactory for use in high-conductivity fins. Studies were then made to find ways in which to eliminate or minimize this interdiffusion in the roll-clad metals. The effect of surface preparation of the Inconel cladding on the diffusion of the alloy into copper was briefly investigated. For these experiments the Inconel was oxidized in air for 1/2 hour and 1 hour at 700°C, and the composites were roll-clad at 1000°C at a total reduction of 50 percent. After a 200-hour exposure at 815°C no differences between plates thus prepared and an unoxidized control sample were observed.

Diffusion barriers between Inconel and copper were evaluated after 500-hour exposures at 1500°F. The refractory metals were unsatisfactory due to the discontinuous layer formed. Barriers of iron, 310 stainless steel, and 446 stainless steel in 0.5-mil and 1-mil thicknesses were found to prevent the alteration of copper. Some reaction between the barrier material and Inconel was evident. (AEC Activity 4401.5)

Analytical Studies - Methods were developed for determining the oxidation states of iron and chromium in ARE fuel solvent, $NaZrF_5$. The solid material was leached with 1-M H_2SO_4 to remove quantitatively the divalent iron, the concentration of which was determined by eliminating the reduction step before applying the o-phenanthroline colorimetric method. The total chromium concentration of this acid leach solution was also measured colorimetrically. A second leaching of the material was made with a solution of ferric sulfate. The divalent chromium therein was measured by determining the divalent iron formed by the reaction

$$Cr^{+2} + Fe^{+3} \longrightarrow Cr^{+3} + Fe^{+2} .$$

Divalent iron, in excess of that determined in the 1-M H_2SO_4 leach, is equivalent to the original concentration of divalent chromium. The method was applied successfully to a number of corrosion test samples. (AEC Activity 4401.5)

Shielding Research - The weight savings to be expected by replacing water of an aircraft shield with LiH were estimated to be somewhat greater than 50 percent insofar as the hydrogenous content is concerned. Some of this advantage would be surrendered, however, to compensate for the relatively poorer gamma-ray attenuation in LiH. Estimates of the temperature-rise in LiH to be expected from radiation heating indicated that it would not be excessive; a 15°F rise was obtained in a sample calculation for a reflector-moderated reactor application.

Because the capture cross section of bismuth is low, it has been suggested that the shielding properties of this material might be superior to those of lead. An investigation of bismuth-borated-water shields was initiated; the data taken to date have not revealed any difference between bismuth and lead.

Some estimates of removal cross sections, based on the continuum theory for the scattering of neutrons from nuclei, were made for several materials; the resulting values, listed below, are very near those measured in the Lid Tank Facility.

Material	Removal Cross Section (barns/atoms) From experiment	From calculation
Al	1.31	1.23
Fe	1.95	1.95
Cu	2.08	2.21
Pb	3.4 (estimated)	3.36
Bi	3.43	3.32

In the design of the secondary shielding for the GE-ANP Heat Transfer Reactor Experiment considerable uncertainty existed due to a lack of information concerning leakage through the air ducts in the reactor shield. A mockup of the proposed duct arrangement, fabricated by GE, was tested in the Bulk Shielding Facility to determine the streaming of neutrons and gamma-rays through the large voids.

Experiments were performed with the Tower Shielding Facility (TSF) reactor fuel elements in the BSF reactor. Critical configurations of the fuel elements were determined.

The neutron and gamma ray doses obtainable for biological experiments in the Tower Shielding Facility were estimated for a 100-kw reactor power level, as below:

Point of Measurement	Neutron dose (rep/hr/100 kw)	Gamma dose (r/hr/100 kw)
At surface of 18-cm pure water shield around reactor	100,000	1,600,000

Point of Measurement	Neutron dose (rep/hr/100 kw)	Gamma dose (r/hr/100 kw)
At surface of 18-cm lead-borated-water shield around reactor (11.4 cm lead)	620,000	80,000
135 ft from 18-cm lead-borated-water shield	10	1.9
250 feet from 18-cm pure water shield	0.3	10

(AEC Activity 4401.7)

GENERAL REACTOR RESEARCH

Package Reactor - Several programs for the development of components for the 10-megawatt package reactor project are underway; namely, (1) a contract is being arranged with American Machine and Foundry Company for the fabrication and testing of a control rod drive mechanism, (2) the Metallurgy Division is developing a stainless steel-clad fuel plate for use in the reactor, and (3) corrosion tests of several fuel plate brazings are being made as part of the program. Preparations for machine calculations on the nuclear properties of the reactor are underway. (AEC Activity 4510)

General Reactor Radiation Damage - Diamond powder and single crystals of diamonds were subjected to progressive fast neutron bombardments totalling 3.0×10^{20} neutrons/cm^2 at a temperature of approximately 100°C. The density decrease resulting from this irradiation rapidly approached a saturation value of approximately 3.5 percent. Since the increase in the lattice constant is related to the density decrease, it is estimated that the lattice constant should increase by 1.16 percent at saturation.

Single-crystal x-ray diffraction patterns of diamonds irradiated with 2×10^{20} neutrons/cm^2 revealed only very slight reductions in intensities of reflections. One crystal, giving the anomalous second order (111) reflection, retained this intensity of reflection even after bombardment with 2×10^{20} neutrons/cm^2. In addition, the thermal diffuse reflections, characteristic of the unirradiated diamond, were persistent in the irradiated crystals and indicated that the elastic constants of damaged crystals may be measured successfully by x-ray methods.

It appears likely that carbon atoms, displaced from normal lattice sites, are trapped in interstitial positions and form localized disordered regions which expand the lattice into a higher energy state. Numerous interstitial trapping sites are available in the diamond lattice and these, in addition to the uncertain configuration of vacancy sites, make it difficult to estimate the number of displacements produced. As an upper limit, however, it is probable that the number of "frozen-in" displacements certainly does not exceed the number, i.e. approximately 10^3, to be expected from calculations using the method of Seitz (Discussions Faraday Soc. 5,280 (1949). (AEC Activity 4540)

ISOTOPE PRODUCTION

Stable Isotope Production - In isotope separation runs with high temperature ion sources, an estimated 36 grams of separated lanthanum isotopes (La^{138} and La^{139}) were collected. The formation of molten deposits in the ion exit slit contributed to low output and poor beam focus. A new run for collection of hafnium isotopes (masses 174, 176, 177, 178, 179, 180) from $HfCl_4$, processed at 140° - 165°C in low temperature sources, is in progress. Because of close spacing of pockets in the collector, adjacent masses cannot be collected simultaneously so two of the six isotopes cannot be collected in each run.

Collections of potassium, using charge material enriched in K^{40} in the Chalk River reactor, are in progress. Preliminary runs with normal potassium were made to check on the proper operating procedures, and, to insure a K^{40} collection of the highest possible purity, "bake-out" runs were carried out to remove sodium impurities from the charge material. Also, the production rate during the run was carefully controlled to avoid unsteady beam reception which might contaminate the K^{40}. Furthermore, the K^{40} collector pocket was fully shielded from the adjacent K^{39} and K^{41} pockets and was partitioned internally so that the most highly enriched K^{40} toward the center of the pocket can be recovered separately from the less rich K^{40} at the ends of the pocket.

Enriched Ir^{193} was added to the inventory of isotopes for the first time. Two new lots of titanium isotopes (masses 46, 47, 48, 49, 50) were added to the inventory. Dysprosium oxide of 90 percent purity was obtained by a tributyl phosphate-nitric acid solvent extraction technique. Thirty-seven shipments involving 36 different isotopes of 15 elements were made. (AEC Activity 5121)

PHYSICS

High Voltage Physics - The experiment to determine, by detecting fission neutrons in coincidence with fission fragments, the variation of ν with neutron energy for U^{235} was carried out with neutrons of four different energies between 0 and 5 Mev and with Po-Be neutrons. A curve through the experimental points indicates the $\nu(E)/\nu$ thermal is about 1.3 at 2 Mev and 1.5 at 5 Mev. A measurement at 14 Mev gave this ratio as 2.0. Sources of error are being investigated but it is felt the ratios given are good to $\pm$ 15%.

The cross section for excitation of the 0.8-sec isomeric state of Pb^{207} by the inelastic neutron scattering process was measured as a function of the neutron energy. The threshold is approximately 1.6 Mev. Near the threshold value the cross section is a few tenths of a millibarn and rises to about 10 millibarns for 3 Mev neutrons. The excitation curve appears to have structure but better statistics are needed to establish this fact.

The polarization of fast neutrons, produced by the 2.3-Mev resonance in the proton bombardment of lithium, was studied using the elastic scattering of oxygen as an analyzer. A maximum left-right asymmetry of 2.06 ± 0.10 was observed at 50° in the laboratory system at about 400 kev neutron energy. This corresponded to the neutron beam being 40 percent polarized. Corrections from multiple scattering in the sample will tend to increase this value. (AEC Activity 5211)

Scintillation Spectrometry and Instrument Development - Investigations of the γ-ray response of NaI scintillation counter crystals of various sizes were made to determine what shape, for a particular crystal size, would give the best energy resolution, with the smallest distribution of Compton pulses. The most suitable crystal shape observed at present is a right circular cylinder with the height equal to the diameter and with the edge nearest the γ-ray source cut back at an angle of 45° to give an exposed face of 1 to 2 cm length depending on the crystal size. Crystals of this shape have fewer pulses in the "Compton distribution" (i.e. interactions in crystal have not dissipated total γ-ray energy) that are caused by corner penetration of the γ-radiation. A resolution of 8 percent (full width at half maximum) was obtained with the 0.661 Mev gamma ray of Cs^{137} for a NaI crystal 3" high and 3" in diameter.

Studies were made on the interaction of neutrons and protons with LiI, which was activated by europium. A complex pulse distribution, consisting of a broad flat-topped group of pulses, was observed for fast neutrons, and neither edge of this pulse distribution appeared to vary linearly with the neutron energy. Thermal neutrons produced a very sharp peak with a full width at half maximum as small as 4 percent. Fast protons, with energies up to 15 Mev, produced a sharp line of pulses. LiI:Eu is the only known phosphor in which the ratio of the pulse height obtained to the energy of the particle is considerably greater for fast protons than for electrons, even though both particles produce sharp lines. The reason for this remarkable behavior is being investigated, and at present it is believed to be due to the overlapping of absorption and emission bands in the phosphor. The process by which self-quenching of the fluorescence, due to highly ionizing radiations, is produced may also cause a shift of the emitted fluorescent wave length and a consequent reduction of self-absorption in the phosphor. (AEC Activity 5211)

Short Lived Isomers - Investigations have been made of the γ-rays from Eu^{153}, using a delayed coincidence scintillation spectrometer which has NaI detectors. Eu^{153}, produced by the beta decay of 47h Sm^{153}, emits gamma rays of 70 kev and 102 kev, and while one of these excited states in Eu^{153} was known to be metastable, the position of the metastable state and the order of emission of the gamma rays were not known. Recent measurements have shown conclusively that the 70-kev transition precedes the 102-kev isomeric transition and that the latter has a half-life of 3.4×10^{-9} sec. Furthermore, the 102-kev transition, following the electron capture (e-capture) decay of 225d Gd^{153}, decays with a half-life of 3.4×10^{-9} sec. In addition, the

e-capture decay of Gd^{153} leads to another excited state, within a few kev of the 102-kev level, in Eu^{153}. The γ-ray from the decay of this state is in prompt coincidence ($T_{1/2} < 10^{-9}$ sec) with the K x-rays from e-capture and is 1.4 times as intense as the 102-kev γ-ray. (AEC Activity 5211)

Nuclear Physics, 86-Inch Cyclotron - The project on angular distributions of fission products from 22-Mev proton-induced thorium fission was completed. The data can be fitted to the relation $I(\theta) = a + b \cos^2 \theta$, where b/a is 0.26, 0.25, 0.19, 0.15, and 0.10 for Ba^{139} (1.53), $Sr^{91,92}$ (1.52), Zr^{97} (1.37), Ru^{105} (1.19), and $Ag^{112,113}$ (1.09) fission products, respectively (numbers in parentheses are mass ratios). A similar project on U^{238} fission was undertaken; preliminary results give b/a values of 0.17, 0.22, and 0.08 for Ba, Zr, and Ag fission products, respectively. Measurements of angular distributions of alpha particles from (p,α) reactions in Nb and Ta showed strong maxima in the forward direction. This result indicates that some interaction other than compound nucleus formation is present.

Excitation functions for proton-induced fission in natural uranium and thorium were measured; for uranium, the fission cross section is approximately equal to the total reaction cross section, but in thorium it is only about half as large. Excitation functions for several (p,2p) reactions were measured; the shapes of the curves approximate those predicted from theory, and the cross sections at 22 Mev are 50 mb, 6 mb, and 0.3 mb, respectively, for Mg^{25}, Ca^{44}, and Zn^{68}. The excitation function for the reaction Li^7(p,n) Be^7 exhibits a sharp maximum at about 8 Mev, decreasing by at least a factor of six between that energy and 22 Mev, where the cross section is about 45 mb. (AEC Activity 5211)

The 86-Inch Cyclotron - In a single 38-hour bombardment in the 86-inch cyclotron approximately three curies of 80d Co^{56} were produced for use in gamma-ray scattering studies at UCRL.

The thick-target yield for several radioisotopes was determined; one milliampere (ma) of protons on nickel produced 270d Co^{57} at the rate of 50 mc/hr; 200 microamperes (μa) bombardment of sodium metal produced Na^{22} at the rate of 1.1 mc/hr from (p,2n) and (p,pn) reactions; and, at 200 μa, 17.5d As^{74} was produced at the rate of 10 mc/hr. The powdered germanium metal was inclosed in a water-cooled thin-walled capsule target; the metallic sodium, coated on a 6" by 10" grazing incidence target, was exposed to a 4.4-kw beam for five hours without melting the surface of the metal.

In a test to determine the proton output of the 86-inch cyclotron at lower energy, the magnetic field was reduced to one-third of its normal value; protons were then accelerated every third half-cycle of the rf potential instead of every half-cycle. Calorimetric measurements obtained with a target placed at a distance of 25 in. from the magnetic center of the cyclotron indicate a very large output, 30 milliamperes of $\sim$1-Mev protons. The ion transport efficiency was 60%, as determined from the target current and the dee-bias drain. (AEC Activity 5261)

Fundamental Electromagnetic Research - Equations were set up to describe a steady state condition of a controlled thermonuclear reactor in which the method for electron-ion pair generation is the ionization of neutral particles. Subject to certain approximations, these equations were solved to give the potential function, ion density, neutral particle density, generation function, and the leakage. The leakage, defined as ion current to the wall, was found to be 5×10^{17} particles/cm^2-sec for the parameters being considered. (AEC Activity 5261)

Electro-Nuclear Machines - In the development of a beam deflector for the 86-inch cyclotron, a septum fabricated from 52S aluminum tubing, 50-mil OD with 3-mil wall thickness, is being tested. A section of this water-cooled septum withstood short exposures to a one-milliampere beam of 22-Mev protons; a life test is planned. A new set of dees for use with the deflector system is scheduled to be delivered by an outside vendor in January. (AEC Activity 5261)

Isotope Analysis Methods Laboratory - The infrared spectra of formyl fluoride (HCOF) and preliminary Raman studies on $LiAlH_4$ and $LiAlD_4$ were investigated. Examination of the infrared spectra of formyl fluoride, HCOF, has established the six fundamental vibrations of HCOF (2954, 1838, 1062, 1021, 822, 659 cm^{-1}). The deuterated compound, DCOF, was successfully synthesized. Experimental studies of the atomic hyperfine structure patterns of U^{233} and U^{235} gave incomplete resolution of the 235 structures due to the nuclear quadrupole perturbation of 235 lines. A review of the early theory of the aperture-limited Fabry-Perot interferometer showed a serious error in the published treatment due to the squaring of wave amplitudes as though all the incident beams were coherent. Under experimental conditions designed to minimize this aperture effect the hyperfine structures of the U^{235} lines are still unresolved due to the residual nuclear quadrupole effect.

Assay of Li^6 by spectroscopic methods was improved to permit analyses of individual samples at a rate of 15 minutes per sample with precision of about 1.5 per cent limit of error at the thirty per cent abundance level.

Approximately 4500 X-ray, spectroscopic and spectro-isotopic determinations have been made for Laboratory groups. X-ray fluorescent methods have been applied to the investigation of rare earth mixtures and of oxide scales formed on 304 stainless steels having varying metallurgical histories. Filament activation by pure gadolinium indicates a work function of about 3.63 volts. (AEC Activity 5261)

Mass Spectrometer Laboratory - Preliminary experiments on the mass spectra of cuprous chloride and cuprous bromide revealed there were molecular ions of one to four CuX units. The ionization efficiency curves of the ions in the CuCl spectrum indicated that enough appearance potential (i.e. minimum energy to form an ion) data could be obtained to calculate the heat of formation of the various polymers. The presence of Cu_2^+ and Cu_3^+ ions in these mass spectra suggests that the vapor in equilibrium with copper metal itself may consist in part of polyatomic units.

Exploratory mass spectrometer analyses, run in duplicate using the isotope dilution technique, for the uranium content of three samples of Chattanooga oil shale showed good precision and may be compared as follows:

Sample No.		Uranium by Dilution (ppm)	Uranium by Fluorescence (ppm)
YB-9-E	I	96.7 ± 0.5	92 ± 5
	II	96.0 ± 0.5	
YB-14-E	I	92.8 ± 0.3	66 ± 3
	II	92.6 ± 0.3	
YB-14-A	I	36.5 ± 0.3	27 ± 3
	II	36.5 ± 0.3	

Automatic scanners were installed on both mass spectrometers. With these circuits, the magnetic field is raised to view any chosen group of masses, then quickly returned to its initial value, after which the field is permitted to rise slowly. Both the upper and lower limits of the field are independently variable. A second scanning device was added to the filament oven current supply. This mechanism slowly increases the heater power; it has given more reliable quantitative time-integration studies of mixtures of materials with different vapor pressures. (AEC Activity 5261)

The 63-Inch Cyclotron - The deflected beam of the cyclotron is now being used for a variety of physics experiments; a 1.5-μa beam of ~28-Mev N^{3+} is available at the exit port. Absolute cross sections for the reactions $C^{12}(N^{14})F^{18}Be^{8}$, $C^{12}(N^{14})Na^{24}2H^{1}$, $C^{12}(N^{14})Na^{22}He^{4}$, and $Be^{9}(N^{14})F^{18}He^{4}n$ were determined as a function of incident beam energy. In these experiments the energy of the incident beam was varied from 5 to 28 Mev with thin nickel absorbers. The range-energy relation of nitrogen ions in nickel was determined, as well as the variation of charge of nitrogen ions as they slow down in nickel absorbers. The average charge for 28-Mev nitrogen ions emerging from a very thin nickel foil (~0.5 mg/cm^2) appears to be about 6.2. (AEC Activity 5261)

CHEMISTRY

Inorganic Solution Chemistry - In earlier work, strong acids were found to be separable from non-adsorbable materials, including certain salts and weak acids, by adsorption on a strong base anion exchange resin in the sulfate form. However, in recent tests with weak acids, it was shown that some of these substances are strongly adsorbed by the resin. For example, Dowex-1 in the sulfate form adsorbed all the phenol from over 6 column volumes of an

0.5 M solution. Considerable care is thus indicated in the use of this new separation's technique and each weak acid and probably each non-electrolyte will have to be tested individually.

The adsorbability of Os(IV) by Dowex-1 from chloride solutions was studied in 1 to 12-M HCl solutions by the equilibrium method, using Os^{191} tracer. Distribution coefficients, at less than 1 percent loading of the resin with respect to Os, were ca. 20,000 in 1 M HCl and decreased to $\sim$ 2,300 in 12-M HCl. This behavior is reminiscent of the adsorbability of other platinum elements, such as Pd(II) and Pt(IV), and may be typical of the behavior of chloride complexes of charge minus two in the platinum group. As discussed earlier, Ir(III), however, is not adsorbed under these conditions and hence separation of osmium from iridium should readily be feasible by this technique. (AEC Activity 5311)

Nuclear Chemistry - The radioactive decay of purified samples of Ce^{144}, Co^{60} and Kr^{85} have been measured with precision over a period of six months. Statistical analyses of the data give the following half-lives: Ce^{144} - 284.4 $\pm$ 1d, Co^{60} - 5.45 $\pm$ 0.1y and Kr^{85} - 10.7 $\pm$ 0.2y. This value for Co^{60} is appreciably longer than several recently published values; hence, measurements are being started on several Co^{60} samples with different bombardment, decay, and purification histories. (AEC Activity 5311)

Chemical Physics - Further experiments were conducted in which the reaction products from a beam of K atoms scattered by a beam of HBr molecules were sought at angles up to 80° from the K beam. With increased precision and sensitivity, a very small amount of KBr was measured when the K was at about 510° and the HBr at 460° K. This amount (roughly 2 KBr for each 1000 atoms of K measurably scattered) is small enough so that previous qualitative conclusions, based on no detectable reaction, are unchanged. The distribution of KBr over the scattering angle and variation of the distribution with temperature are being investigated.

Zeeman studies on the pure quadrupole spectra of potassium chlorate were completed. A very small field gradient asymmetry, $\eta \approx 0.01$, was detected and the direction of the z component of the field gradient tensor accurately measured.

Paramagnetic resonance observations on a large variety of irradiated substances were made. The presence of atomic hydrogen was established in frozen aqueous solutions of H_2SO_4 and H_3PO_4, irradiated at liquid nitrogen temperature with cobalt gamma rays.

The ferroelectric modification of KH_2PO_4, which exists at temperatures below 121°K, was examined by neutron diffraction at 113°K. The arrangement of hydrogen atoms is ordered. The coordination about phosphorus is roughly tetrahedral; the $P(OH)_2O_2$ groups have 2-fold axial symmetry, the axes being polar and parallel to the c-axis of the drystal. The O-H distance is about 1.05 A.

The molecule of urea, $(NH_2)_2CO$, is planar, including the hydrogen atoms. At room temperature the molecules undergo an asymmetrical thermal motion of exceptionally great amplitude. The N-H distance is about 1.01 Å.

In oxalic acid dihydrate, the acid molecule is planar, including the hydrogen atoms, the C-C bond distance is 1.53 Å, the C=O distance is 1.25 Å, the C-O(H) distance is 1.23 Å, and the O-H distance is 1.06 Å. The water molecule has dimensions almost identical with those existing in the gas. There is asymmetric thermal motion interpretable as libration about the carbon-carbon single bond.

The molecule of iodic acid, HIO_3, is an asymmetrical pyramid with I-O distances of 1.82 A and 1.78 A, an I-O(H) distance of 1.90 A and an O-H distance of 0.99 A. (AEC Activity 5311)

Chemistry of the Solid State - First results obtained with the sodium-sodium fluoride system are in good agreement with predictions based on an extrapolation from data for the three other sodium-sodium halide systems. At the monotectic temperature (one solid in equilibrium with two liquids) of 991°C, i.e. 4.25 ± 0.25° below the melting point of pure sodium fluoride, the salt is soluble to approximately 16 mole percent in the liquid metal, a figure that compares with 45 mole percent of KF in K, and with 3 mole percent of NaCl in Na. For the purpose of this comparison the state of the systems at the monotectic temperatures is taken as a "corresponding state". The data justify the assumption that the relative size of anion and metal atoms are an important, if not the most important, factor, with the solubility of the salt in the metal increasing with increasing size of the metal atom and with decreasing size of the anion. With Raoult's law, the melting point depression and heat of fusion of the salt yield approximately 1 mole percent Na for the composition of the monotectic salt-rich phase. Again, this figure is in rational relation not only to those for the corresponding phases in the NaCl-Na and NaBr-Na systems, containing 2.4 and 4.2 mole percent Na, respectively, but also to 2.3 mole percent of K in the KF-K system. (AEC Activity 5311)

Radio-Organic Chemistry - The distribution of tri-n-octyl phosphine oxide P^{32} between n-decane and aqueous solutions was measured. The aqueous solutions as tested show that the solubility losses of the phosphine oxide will be no more than 5 mg./l. These losses (representative of the minimum loss to be expected when the oxide is applied to the processing of solutions containing small amounts of uranium) are encouragingly low.

The exchange of ester groups between tri-n-butyl phosphate and labeled phosphoric acid at 170°C resulted in the simultaneous preparation of the three butyl esters labeled with radioactive phosphorus. Separations of these esters were facilitated by use of anion exchange resins. Unexpected problems were encountered with the appearance of the radioactive phosphorus in compounds that have not yet been identified. One possible reaction is the dehydration (at the elevated temperature) of the labeled phosphoric acid

to form pyrophosphates and metaphosphates. However, the rapidity of the preparation and the ease of separation of the esters make the method useful for the synthesis of phosphorus-labeled esters. (AEC Activity 5311)

Radiation Chemistry - In a study of the effect of fast electrons on the corrosion of stainless steel by uranyl sulfate solution at 250°C, two 50-hour irradiations have been completed. Three specimens were used in the convection loop; one specimen upstream and one downstream from the irradiated specimen. The same three specimens were used in the second run, but in different positions in the specimen holder. There appeared to be no correlation between the corrosion as indicated either by the film weight or total weight of metal lost, and the position of the specimen relative to the electron beam. Instead, the observed corrosion appeared to be characteristic of the individual specimens. The data indicated that fast electrons (beam density 35 watts/gram) had little effect on the formation and preservation of a protective film at the low flow rates used.

The results of two separate experiments on alpha particle-induced recombination of H_2 and O_2 in the presence of CO_2, in good agreement with each other, showed that CO_2 did not enter into the chemical reaction, nor did the ionization of the CO_2 contribute to the reaction rate. No solid polymer was formed and there was no depletion of the CO_2. (AEC Activity 5311)

Chemistry of Fused Salts - Measurement of the potentials of concentration cells with transference showed that in certain favorable cases such cells can be used to determine the activities of melt components when the transport numbers are known from other sources. Conversely, an estimate of transport numbers can be obtained if activities are known. Measurements indicated that if one considers molten $NaNO_3$ -$AgNO_3$ solutions to be ideal at about 85% $NaNO_3$ - 15% $AgNO_3$, with silver electrodes the Ag^+ ion transports about 45% of the current. Thus, Ag^+ is a better conductor than Na^+, bearing out previous results performed by another, independent method at this Laboratory.

Calculations of the thermodynamic functions for crystalline cadmium iodide from measurements of the low temperature heat capacity were completed. CdI_2 has a high heat capacity at 15°K ($\sim$ 2.5 cal/mole deg.); however, there is some uncertainty in the extrapolation to absolute zero since no simple power dependence was found. Consequently, studies in the very low (liquid helium) temperature range are planned.

A new, adiabatic heat capacity calorimeter for measurements to 1000°C was built. Tests of component parts were satisfactory and it appears that the calorimeter will have good performance characteristics. (AEC Activity 5311)

Uranium Chemistry of Raw Materials - With tri-n-dodecylamine, extraction coefficients as high as those given by the homologous compounds tri-n-octylamine and tri-n-decylamine (ORNL-1600 and ORNL-1612) have been obtained for the extraction of uranium from acidic sulfate solutions. These tertiary

amines can be used in kerosene or kerosene modified by the addition of a small amount of aromatic hydrocarbon, in contrast to the corresponding secondary amines, which require a diluent with a high aromatic content.

As reported previously, the long chain trialkylphosphine oxides are effective in extracting uranium from nitrate solutions and from sulfate solutions containing some nitrate. Recent tests also show effective extraction of uranium(VI), without nitrate, from unbuffered solutions of hydrochloric or sulfuric acid. The extraction coefficients increased with increase of the concentration of either acid up to at least 4M, and were higher for hydrochloric than for sulfuric acid. (AEC Activity 5361)

METALLURGY

Ceramics Research - Petrographic examinations were made of ANP Fuels No. 30 and No. 44 which had been irradiated a maximum of 492 hours in the MTR; unirradiated control samples were examined at the same time. These fuels are normally composed of $NaZr(U)F_5$, which is green in color, and perhaps a very small amount of a complex with a lower refractive index, which is designated E-2. The irradiated samples were normal except for the $NaZr(U)F_5$ having a slightly low refractive index and being slightly reduced. No difference between the irradiated and the control samples could be observed with a petrographic microscope.

Work on the development of a satisfactory viscous high temperature seal was continued. Ten test rings, 2-1/2" ID, 3-1/2" OD, and 7/16" thick, of a beryllium fluoride glass were prepared by melting the glass in a platinum crucible and casting it in graphite dies. The rings were cooled slowly in a blanket of glass wool to minimize cracking. The finished rings were sent to Experimental Engineering Group for tests.

Gadolinium oxide, as well as samarium oxide, can be formed into a dense material by dry pressing and firing in an oxidizing atmosphere to 1500°C. The melting point of samarium oxide was determined to be 2300°C ± 20°C. No phase changes were observed in either gadolinium oxide or samarium at temperatures up to 1250°C. (AEC Activity 5411)

Physical Metallurgy of Reactor Materials - Preliminary experiments have been initiated to determine the feasibility of concentrating the uranium in spent solid fuel elements by metallurgical processing prior to chemical dissolution. Attention has been concentrated on stainless steel-UO_2 elements, such as those planned for the Package Reactor. Two techniques have been tried, i.e.,

(1) carburization of stainless steel-clad, stainless steel-UO_2 fuel plates followed by holding at temperature in the carbide precipitation range and finally by treatment with a H_2SO_4-$CuSO_4$ solution, and

(2) melting of stainless steel-UO_2 fuel elements under a fluoride slag.

The results of a few experiments on the carburization technique appear very encouraging. The grain boundary attack, which can be obtained by treatment of the sensitized stainless steel-UO_2 fuel plates with H_2SO_4-$CuSO_4$ solutions, produces a fairly clean separation between the stainless matrix and the UO_2. Analysis of the sulfuric acid solution shows that it contains less than 0.02% U. Treatment of the stainless steel grains-UO_2 particle sludge, produced by the sulfuric acid treatment, with nitric acid solution produces complete solution of the UO_2 with only slight dissolution of the stainless steel grains. Experiments are continuing on optimizing the carburization treatment and refinements in dissolution technique are being studied by the Chemical Technology Division.

Results on the melting of stainless-UO_2 fuel plates under fluoride slags await the completion of the chemical analyses. (AEC Activity 5411)

Fundamental Physico-Metallurgical Research - Continued investigation of the zirconium alloy systems has shown:

(1) In the Zr-Ag system, the earlier conclusion that $\gamma(Zr_2Ag)$ forms by a peritectic reaction was confirmed by the lower melting point of alloys having a slight excess of silver over the $\gamma(Zr_2Ag)$ phase, and the higher melting point of alloys having slightly less silver. Preliminary investigation of the temperature of the eutectic reaction between $\gamma(Zr_2Ag)$ and $\delta(ZrAg)$ sets this temperature between 1153 and 1167°C; the relative proportions of the two phases in the eutectic structure suggests that the eutectic composition is much closer to $\delta(ZrAg)$ than to $\gamma(Zr_2Ag)$.

(2) In the Zr-In system, the $\gamma(Zr_3In)$ phase is solid up to at least 1280°C, and at this temperature is in equilibrium with the β phase containing about 16 atomic percent indium.

(3) In the Zr-Pb system, the solubility of lead in the β phase at 1100°C is greater than 7.2 atomic percent. (AEC Activity 5411)

Fundamental Investigation of Radiation Damage in Solids - A single-crystal cube of high conductivity n-type germanium was subjected to successive irradiations in hole 51 of the ORNL graphite reactor and the magnetic susceptibility was measured as a function of temperature after each irradiation. The shape and position of the curves so produced were found to change systematically from those of a sample with a large number of electrons in the conduction band toward those of a high-purity sample. Hall coefficient and electrical conductivity measurements performed on a companion crystal irradiated simultaneously with the susceptibility specimen indicate that the sample had not been irradiated sufficiently to trap all of the electrons out of the conduction band.

The values obtained at ORNL for the ratio of the rest mass to the effective mass for electrons and holes in germanium in the study of unirradiated material have been confirmed in part by magnetic resonance measurements at liquid-helium temperature performed at the University of California, Berkeley.

The magnetic susceptibility vs. temperature curve for one sample of polycrystalline n-type silicon was obtained. This curve is similar to that of low-conductivity germanium except that its temperature dependence is only about half that of germanium. The value of the magnetic susceptibility at room temperature was found to be -1.30×10^{-7} cgs. (AEC Activity 5411)

Research Participation Program in Physical Sciences - Under the Research Participation Program for 1953, two Participants are engaged in research in the physical sciences.

Under the Traveling Lecture Program for the academic year 1954-54, ORINS has submitted to the Laboratory 194 requests, (physical science topics). Of these requests, 8 have been fulfilled, and 83 have been accepted. (AEC Activity 5620)

PROGRAM 6000 - BIOLOGY AND MEDICINE

BIOPHYSICS

Waste Disposal Research - The group at ORNL from the Corps of Engineers installed and tested a 30-gpm solids-contact water clarifier, designated "Erdlator." Raw water from White Oak Creek , with approximately 10^{-2} μc/cc of P^{32}, I^{131}, or a fission products mixture added as contaminants, was coagulated by using ferric chloride and pulverized limestone in standard operating procedures. The results from eleven runs indicated that the unit could effect at least the following removals: P^{32}, 90 percent; I^{131}, 45 percent; two-months-old dissolver solution, 50 percent; a three-year-old fission-products mixture from the Chalk River reactor, 65 percent.

The electrodialytic cell with Permselective ion exchange membranes was further evaluated for concentrating low-level radioactive waters and wastes. Representative samples of effluents from the settling basin and from White Oak Pond were concentrated in the cell and the concentrates analyzed radiochemically. Results indicate that it is desirable to remove colloidal radioactive materials prior to treatment, and that under optimum conditions ionic constituents can be almost completely removed by this cell. The cell may prove to be useful for a finishing treatment following conventional waste treatment methods.

With the cooperation of the U. S. Geological Survey, Ground Water Branch, sites have been selected for the drilling of additional test wells in the area around Waste Pit No. 2. The purpose is to supplement the data from the three existing wells to determine more definitely the extent of travel of radioactive contaminants through the shale formation in which the pit is located. The water in two wells (85 and 74 feet from the east and west sides of the pit, respectively) was found to be grossly contaminated with chemical salts, largely nitrates; and with Ru^{106}, possibly as the ruthenate, and its daughter product Rh^{106}. No contamination was found in the well 225 feet from the south end of the pit. During the past 18 months a total of 278,000 gallons of liquid wastes containing approximately 8700 curies of activity have been transferred to this pit. (AEC Activity 6510)

Physics of Nuclear Radiation - A previous report (ORNL-1643) described the effect of small amounts of impurities on the ionization produced by 5-Mev alpha particles in argon. These studies were continued and the results are summarized in the table below which gives values of W (average energy required to produce an ion pair) for mixtures of argon with gases having ionization potentials between 8.5 volts and 15 volts. The percentage of impurity is that required to give the maximum ionization and thus the minimum W.

Impurity to give Minimum W (%)		Ionization Potential (volts)	W (electron volts)
Pure argon		15.7	26.4
0.25	C_7H_8	8.5	22.4
0.10	CH_3I	9.0	21.4
0.10	C_6H_6	9.6	22.4
0.10	C_3H_6O	10.2	24.5
1.0	C_2H_4	10.6	23.8
1.0	C_4H_{10}	10.8	22.8
3.0	C_3H_8	11.2	23.5
1.0	C_2H_5OH	11.3	24.0
0.5	C_2H_2	11.5	20.5
3.0	$C\ Cl_2F_2$	11.7	25.8
5.0	O_2	12.5	26.0
2.0	H_2O	12.6	25.2
3.0	C_2H_6	12.8	24.3
5.0	CO_2	13.2	26.0
10.0	Kr	14.0	24.2
5.0	CH_4	14.5	25.9

The results for gases, whose ionization potentials are above the known 11.5 volt metastable state in argon, are difficult to explain. Steps are being taken to determine if the increase in ionization can be attributed to an excited state of argon with a long lifetime, but not metastable in the sense of a violation of a selection rule. The data suggest that this level should be between 14.5 and 15.5 volts.

The addition of several percent of hydrogen and of nitrogen (ionization potentials 15.4 and 15.5, respectively) produced only a very gradual change in ionization.

In the experiment in progress for measuring the attachment coefficient of electrons, their drift velocity under specific conditions was determined. The apparatus described by Stevenson (R.S.I. 23, 93 (1952) was used and the data obtained for pure N_2 are in good agreement with those reported by Klema and Allen (Phys. Rev. 77, 661 (1950). A mixture of 90 percent argon and 10 percent methane showed a rapid rise to a maximum drift velocity of 6.6 cm/micro-sec at a field strength of 0.1 volt/cm-mm of Hg followed by a gradual decrease to 3.1 cm/micro-sec at a field strength of 0.8 volts/cm-mm of Hg, after which the value remained constant to the maximum measured field strength of 2.0 volts/cm-mm of Hg. These results for the argon and methane mixture have an important practical implication since such mixtures are commonly used in proportional counters and ionization chambers. The data indicate that an optimum voltage can be chosen so as to give a minimum electron collection time. Further, the results are of interest since the maximum drift velocity is approximately four times that of pure argon. (AEC Activity 6510)

Consultation and Special Problems - The relative toxicity of U^{233} was investigated to determine the extent to which the hazards associated with handling U^{233} would influence the costs of manufacturing fuel elements. Chiefly because of its greater specific activity but also because of differences in energies, the hazard in the processing of U^{233} would be 133 times that of U^{235} for the same loss in mass. Preliminary tests indicate that the additional precautions required for U^{233} will lead to an approximately 20 percent increase in costs. In the course of this study the effective energy (that is, the sum of the energies of the radiations of the parent and the daughters weighted for their relative biological effectiveness and normalized to the RBE of alpha particles) of radium, used as a reference value for biological damage, was recalculated and found to be 16.18 effective Mev (see CF-35-9-77). (AEC Activity 6530)

Radioactive Particulate Problem - In the diffusion battery, an assemblage of closely-spaced parallel plates, very small particles are filtered out when their random thermal motion causes them to strike the surfaces of the plates; since the magnitude of this random motion is greater for the smaller particles, diffusion theory predicts that filter efficiency increases with decreasing particle size. Other filters depend upon the inertia of the particles and upon direct interception for particle removal and, consequently, are more efficient for the larger particles. In order to verify this unusual predicted characteristic of the diffusion battery, several tests were made. A "LaMer" type generator was used to produce aerosols of particle radii varying from 0.1 to 0.5 micron, the aerosol sizes being estimated from the amount of material vaporized in the smoke generator and by observing the color of light scattered by the aerosol. In agreement with theory, the results showed decreasing penetration with decreasing particle size.

Tests on a continuous alpha-particle air monitor under development showed the collection efficiency for a dioctylpthalate test smoke, approximately 0.3μ radius, increases markedly as the precipitator voltage approaches the arcing potential. As would be expected, the arcing voltage varied with the spacing between precipitator points and with the flow rate. The maximum efficiencies obtained at various flow rates were:

Flow (cfm)	Collection Efficiency (%)
1	95
2.4	49
3	36
4.1	28
5.3	20

(AEC Activity 6520)

Physics of Radiation Dosimetry - Well-known high frequency techniques can be used for measuring ionizing radiation. In the present technique, when radiation lowers the dc voltage applied to the controlling capacitor, the capacity changes and thus the frequency of the oscillator is changed. The use of ferroelectric capacitors of improved design has increased the sensitivity for radiation detection and resulted in a reduction of undesirable leakage currents. Dose rates above 10 mr/hr can now be measured with an accuracy of 5 percent; below 10 mr/hr only the order of magnitude is certain. The variation in frequency observed for a dose rate of 10 mr/hr is 7 cycles/sec per minute at a center frequency of about 2 mc/sec.

Neutron damage was measured in piezoelectric materials containing boron as follows: A potassium pentaborate crystal was used as a frequency stabilizing element for an oscillator operating at about 1.03 megacycles/sec. The crystal was irradiated with thermal neutrons at temperatures not exceeding 30°C. A neutron exposure of between 1×10^{14} and 4×10^{14} n/cm^2 resulted in a frequency decrease of several hundred cycles/sec. The observed effect may be attributed to the B^{10} (n,α) Li^7 reaction, in which the energy released is 2.75 Mev. During several days at room temperature, the crystal showed a gradual and partial return to its original behavior (i.e. frequency in oscillator). (AEC Activity 6510)

Research Participation Program in Biological Sciences - Under the Research Participation Program for 1953, two Participants are engaged in research in biology.

Under the Traveling Lecture Program for the academic year 1953-54, ORINS has submitted to the Laboratory 67 requests (biological topics). Of these requests, 2 have been fulfilled and 30 have been accepted. (AEC Activity 6720)

RADIOISOTOPE SALES AND COSTS

Type of Transaction	November	FY to Date
Domestic Sales	$ 60,856	$363,678
Foreign Sales	3,755	21,482
Project-Cash Sales	9,996	47,087
Project-Transfer Credits	85	498
Technical Cooperation Program Credits	557	4,548
Plant Credits	21,459	67,714
Civilian Defense Credits	---	390
Cancer Program Credits	19,089	89,868
*Miscellaneous Income	34	211
Total Income	$115,919	$595,476
**Income - No production costs incurred	- 88	15,385
Radioisotope Income	$116,007	$580,091
Radioisotope Costs	$ 95,357	$469,968
Radioisotope Shipments	1,043	4,979

* Miscellaneous income - D_2O, Freight, Missing parts, TCP.

** Income from H^3, He^3, B^{10} and miscellaneous items in excess of handling cost.

GROSS OPERATING COSTS

	Cost for November	FY 1954 Cost to Date
Programmatic Operating Cost - Net	$ 2,338,879	$ 11,924,138
Plant and Equipment Cost	425,571	1,618,930
Construction Program "H"	243	18,930
Work for Other Parties - Transfer	33,942	226,192
Inventory Changes	49,678	82,706*
Reimbursable Work for Other Parties	105,206	630,128
Deferred Charges	1.190*	4,666
Total Laboratory Cost - Net	$ 2,952,329	$ 14,339,707
Estimated Cost for Next Month - Net	$ 3,025,000	$ 17,364,707

*Credit

[redacted]

PERSONNEL SUMMARY

	Number of Employees December, 1953	New Hires December	Terminations December
Administration	62	0	0
Operations*	117	1	0
Engineering, Shops and Mechanical	728	12	4
Laboratory and Research	1660	17	12
Protection	165	0	5
Service	402	6	3
Total	3134	36	24

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

A total of 624 Laboratory personnel are located in the Y-12 Area.

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May 1953	ORNL-1562
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August 1953	ORNL-1612
September 1953	ORNL-1622
October 1953	ORNL-1643
November 1953	ORNL-1651

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