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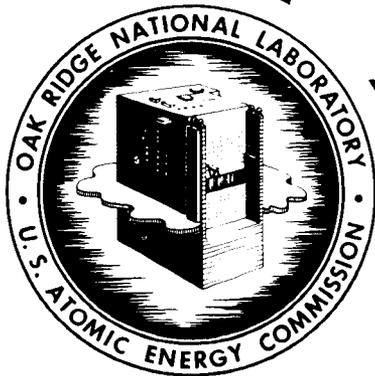
OAK RIDGE NATIONAL LABORATORY
STATUS AND PROGRESS REPORT

DECEMBER 1955

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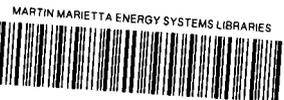
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STATUS AND PROGRESS REPORT

December, 1955

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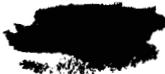
STATUS AND PROGRESS REPORT

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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

December, 1955

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

PROGRAM 2000 - SPECIAL NUCLEAR MATERIALS

Thorex Process - The design for the second thorium cycle (for recovery of thorium from irradiated thorium) was completed; construction is scheduled for completion in January, 1956. The stage efficiency (HTU) of the second-cycle solvent extraction column is 2.9 ft at 74% (390 gal/hr-sq ft) of flooding, which is believed to be the optimum operating condition. (AEC Activity 2423)

PROGRAM 3000 - WEAPONS

Special Electromagnetic Separations - A seventh separation of the heavier plutonium isotopes from highly irradiated plutonium was completed. The estimated production was 1 gram of 85% Pu²⁴⁰, and 160 mg of 55% Pu²⁴¹. Calutron performance was much improved over previous runs; the efficiency of conversion of PuCl₃ to well focussed Pu⁺ ions was approximately 9% compared to an average of 6% for previous runs. (AEC Activity 3610)

PROGRAM 4000 - REACTOR DEVELOPMENT

HOMOGENEOUS REACTOR PROJECT

Homogeneous Reactor Test - The over-all reactor construction is 75% complete. It is estimated that the remaining work can be accomplished in three to four months. The installation of all process piping in the blanket low-pressure system is finished. Work on service piping, including air lines to valves, leak-detector lines, and electrical conduit, will require at least one more month. The process piping for the fuel low-pressure system is approximately 65% complete; this work is scheduled to follow the blanket piping by four to six weeks. The first shipment of high-pressure piping was received from the Crane Company; pieces are being welded onto the core-pressure vessel assembly, which is scheduled to be placed in its final position January 9, 1956. The main heat exchangers were shipped to the Nooter Corporation for the installation of blast shields. (AEC Activity 4103.4)

HRT Chemical Pilot Plant - The work of the contractor was completed, and his field forces have left the area. The installation of process services will be started by ORNL crafts in January. The shop fabrication of components is approximately 25% complete. Process equipment layout design is 80% complete. Essentially all material and equipment has been requisitioned, and about 50% has been received. Shop fabrication schedules have been issued by the Engineering and Mechanical Division, and a field schedule is in preparation. Installation of component assemblies is currently scheduled to start in March. (AEC Activity 4103.1)

Blanket Studies--Chemical Development - Slurries of thorium oxide, 1000 g Th/kg H₂O and containing 0.5% natural uranium and 1000 ppm of PdO catalyst, were irradiated in the LITR at 300°C in a stirred condition for 264 and 240 hours without difficulty. Similar slurries containing 93% enriched U²³⁵ were irradiated in the graphite reactor for 216 and 200 hours without indication, from the operation of the stirrer, of any change in the properties of the slurry. Palladium oxide, added to a thorium oxide slurry at a concentration of 550 parts of palladium per million parts of thorium, proved to be an effective catalyst for recombining radiolytic-produced gases. Molybdenum oxide was also an efficient recombination catalyst.

Hindered-settling rate data were obtained at 27°, 50°, 75°, and 98°C for slurries prepared from oxides calcined at 650°, 800°, 900°, 1000°, and 1300°C. The materials calcined at temperatures higher than 900°C behaved anomalously in that in some cases the settling rate decreased markedly with increasing temperature.

Five thousand pounds of thorium oxide of specified purity was prepared and made available for blanket engineering development studies.

Preliminary data on the preparation and characteristics of mixed thorium-uranium oxides containing up to 5% uranium showed that coprecipitated mixed oxides have characteristically low surface areas, i.e., 2-5 sq m/g compared to 18-20 sq m/g for a comparable physical mixture which was autoclaved and refired. (AEC Activity 4103.1)

PROGRAM 4000 - REACTOR DEVELOPMENT (Continued)

Fuel Reprocessing - The solubility of fission-product praseodymium in simulated uranyl sulfate fuel solution was compared with that of cerium and neodymium; under given conditions the solubilities are in the order $Nd > Pr > Ce$. The solubility decreased with increasing temperature, increased with increasing uranium concentration, and was not greatly affected by changes in acidity.

The behavior of neodymium sulfate in uranyl solutions, contained in quartz and inductively heated by a zirconium-clad metal pin submerged in the solution, was erratic. Crystal growth on the zirconium surface was erratic. No marked tendency for a crystalline particle moving about in the solution to adhere to the hot metal was observed.

The ratio of free to combined iodine in uranyl sulfate fuel solution contained in stainless steel was 5/1, as determined by experimental techniques in which iodine material balances of 90% could be obtained. In larger scale studies than those reported previously (ORNL-1968), the vapor-liquid phase distribution of elemental iodine was nearer 7/1 than 21/1.

In circulating loop studies of a simulated uranyl sulfate fuel solution, a hydroclone removed 30% of the neodymium, as insoluble $Nd_2(SO_4)_3$, and 85% of the zirconium, as insoluble ZrO_2 . The remainder of the neodymium was equally distributed between the preheater and the main loop; the remainder of the zirconium was in the preheater. (AEC Activity 4103.1)

Plutonium Producer Blanket Processing - Experimental results indicated that at high temperatures plutonium is adsorbed on metal as long as a solution containing it is in contact with the metal. As much as 0.5 mg of plutonium/cm² was adsorbed on titanium and Zircaloy-2 from 1.4 M UO_2SO_4 at 250°C without reaching equilibrium. Equilibrium was reached at 25°C. With Zircaloy-2, equilibrium values were 0.006, 0.045 and 0.17 mg/cm² from 1.4 M UO_2SO_4 solutions with plutonium concentrations of 12, 61 and 109 mg/kg H_2O , respectively; with titanium, the values were 0.007 and 0.12 mg/cm² from the first two solutions. X-ray diffraction analysis gave no evidence that the plutonium in the corrosion film deposited at room temperature was in the form of an oxide.

Plutonium was effectively removed from the oxide film, which had been deposited on metals from UO_2SO_4 solutions at 250°C, by three different solutions: (1) 3.0 M HNO_3 - 0.1 M $(NH_4)_2 Ce(NO_3)_6$; (2) 3.0 M HNO_3 - 0.0025 M HF; and (3) 0.4 M $CrSO_4$ - 0.2 M K_2SO_4 - 1.0 M H_2SO_4 under CO_2 . The corrosion rates for type-347 stainless steel, titanium and Zircaloy-2 in the nitric acid-cerate solution at 87°C were 75, 1.4 and 0.6 mils/year, respectively. Corrosion rates in the chromous sulfate solution at 87°C were 10, 7, and 2 mils/year, respectively. (AEC Activity 2723)

Blanket Engineering Development - Failure of the front bearing of the 200-gpm slurry-circulation pump was found to be caused by the presence of slurry in the motor cavity, due to leakage across the thermal barrier and subsequent recirculation through the bearing-cooling cycle. Since arrangements had been

PROGRAM 4000 - REACTOR DEVELOPMENT

made for continuous purge water injection into the rear of the pump, it was possible to close the recirculation line which returned liquid from the space between the front bearing and the thermal barrier to the small impeller at the rear of the canned rotor. This procedure effectively isolated the motor cavity and should protect the front bearing from wear as long as the purge water is flowing, even if some slurry should leak across the thermal barrier.

During the third full-temperature slurry run in the 200-gpm loop, a 1/4-inch thick cake formed throughout the entire loop. Several theories were advanced to explain the phenomenon; one of the 100A loops was remodeled for testing these theories and for studying caking in general.

Two types of thorium oxide slurry dump tanks showed promise in small-scale testing; these were a conical tank with steam introduction at the bottom, and a combination of several HRT-type slant-leg evaporators attached to a toroidal tank in such a way as to give a combination of vertical circulation in each leg with continuous horizontal circulation in the toroidal tank. Full-scale models of these systems are being constructed for further tests.

A high-pressure pipeline viscometer was constructed and tested at 300°C. With this apparatus, measurements of yield stress, modulus of rigidity, pressure drop in turbulent flow, and point of transition from laminar to turbulent flow were made for thorium oxide slurries. Preliminary measurements were completed of the flow velocities required to move and maintain in suspension thorium oxide slurries in 3/4-inch glass tubes at room temperature. At low slurry concentrations, higher flow rates are required than at higher concentrations. The point of resuspension appeared to be very near the point of transition from laminar to turbulent flow.

A statistical analysis of thorium oxide slurry erosion-corrosion data from circulation runs in two 100A loops suggested that, during the first 20-300 hours, the attack rate was inversely proportional to the dissolved oxygen concentration and decreased parabolically with time. Presumably this effect is related to the initial period of degradation of larger particles when the attack is due to the impingement of large particles on the surface breaking and dislodging the protective film. Subsequent to this initial period, the rate appears to increase with increasing pH, with increasing thorium oxide concentration, and with increasing calcination temperature of the oxide, and to be independent of the sulfate concentration except as this concentration affects the pH. Attack rates on stainless steel were 2-4 times those on titanium.

An improved method of predicting the relative velocity of a gas rising through a liquid was developed at Tulane University under a Laboratory subcontract. Three regimes--bubbling, transition, and slug flow--were identified experimentally. A criterion was established for predicting which regime will obtain for a specified gas throughput. (AEC Activity 4103.1)

PROGRAM 4000 - REACTOR DEVELOPMENT (Continued)

Fuel Circulating Equipment - The first 400A Westinghouse pump has completed two runs, totaling 1500 hours, on 0.04 m UO_2SO_4 with 0.005 m CuSO_4 and 50 mole % excess H_2SO_4 at 250°C. The last run was made with HRT-design cast Stellite bearing shoes, which had not been run previously. Some corrosion was observed on the back hub of the impeller and on the adjacent area of the thermal barrier. Slight corrosion and evidence of leakage were observed on examination of the thermal-barrier gasket.

When the 300-gpm pump in the fuel system mockup leaked with a new gold-plated gasket, the annular space between the gasket and the seal weld preparation was tapped for a purge-water tube connection, the pump was reassembled with the gasket, and the unit was seal welded at the pump flanges. The pump has operated 500 hours since the weld was made.

The second 400A pump has been operated about 900 hours on water and has been thermal cycles between 250°C and room temperature about 20 times. The cycling was performed to determine whether there were problems in fastening the thermal barrier to the stator flange.

The 400-gpm and 230-gpm stainless steel HRT fuel and blanket circulating pumps were received. The analogous titanium pumps were completed and will be delivered after hydrostatic tests at Westinghouse.

Preliminary specifications for a 500-gpm hydrostatic bearing pump were prepared.

The 4000-gpm loop was shut down because of erratic operation of the feed pump. New Hastelloy "C" check valve balls were procured and the feed-pump head was reworked at the factory. The loop will be ready for operation about January 3.

The HRT purge pump has run 3300 hours without incident.

The equipment for the second phase of the HRT dump test is completed and testing should start January 3. In this second phase of the program, two concentric tanks will be dumped simultaneously through separate valves and lines, thus simulating the conditions anticipated for a dump of the HRT. The test results will indicate how successful the system is for control of the differential pressure between core and blanket systems. (AEC Activity 4103.1)

General Reactor Component Development - The HRT fuel system mockup was operated 371 hrs on 0.04 m UO_2SO_4 solution containing 50 mole % excess H_2SO_4 at 300°C and 2000 psi. The loop was pressurized with air, and the dissolved oxygen concentration was about 200 ppm. The corrosion rate, initially about 2.5 mils/year, decreased to 1 mil/year after 140 hours. These rates were considerably better than the generalized rates observed previously. The loop was subsequently modified to include a pressurizer of a new design and a hydraulically damped float level controller. Both appear to operate satisfactorily on water.

PROGRAM 4000 - REACTOR DEVELOPMENT (Continued)

Permanent aluminum foil insulation is now employed on the HRT fuel mockup loop and appears to be satisfactory from the thermal standpoint. Several designs of remotely replaceable aluminum foil insulation for HRT use are being tested, and handling tools for insulation maintenance are being developed. (AEC Activity 4103.1)

Heat Removal Equipment - One HRT heat exchanger was completed at the Foster-Wheeler plant and was delivered to the Nooter Corporation for installation of blast shields. Gold trim was applied to the pass partition plate to restrict leakage. The final seal weld passed dye penetrant, hydrostatic, and helium leak tests.

The second HRT heat exchanger was contaminated with rubber residues during an attempt to clean the unit with acid washes. Xylene was circulated to remove the rubber residue. This treatment was followed by brushing the insides of the tubes while injecting Oakite solution in the opposite end of the tubes. The cleaning has removed almost all of the dirt and residue from the primary side of the exchanger. (AEC Activity 4103.1)

PACKAGE REACTOR DEVELOPMENT

Army Package Power Reactor Program - A series of critical experiments on the Army Package Power Reactor is in progress; the assembly consists of forty-five fuel elements, or boxes, with dimensions similar to those for the core of the reactor. In the experimental apparatus, it is possible, however, to vary the loading of enriched uranium, structural material, and boron (the burnable poison) by appropriately arranging plates of the various materials in each fuel element. The apparatus is installed in a tank which can be filled with water to provide the neutron moderator and reflector.

The critical mass at room temperature with the stainless steel loading of the reactor but with neither distributed boron loaded nor with boron control rods inserted is 10.4 ± 0.4 kg U^{235} , a value about 25% more than predicted by Univac calculations (ORNL-1613 rev.). The uranium is loaded somewhat more heterogeneously in the critical experiment than it will be in the reactor. A "P₅" calculation, which was subsequently verified experimentally, showed that more pronounced self-shielding of the fuel in the critical experiment accounted for most of the discrepancy between experiment and calculations. The additional fuel required to override several combinations of the APPR control rods was measured. Results are in substantial agreement with previous calculations, but experimental values are somewhat lower. Power and neutron flux distribution measurements were made with a number of core configurations. (AEC Activity 4201.1)

GENERAL REACTOR RESEARCH

Radiation Damage--Advanced Engineering and Development - The change in electrical resistivity of a brass wire was measured as a function of neutron

PROGRAM 4000 - REACTOR DEVELOPMENT (Continued)

irradiation. A brass wire containing 12.9 at % zinc was irradiated in a hollow fuel element in the center of the ORNL Graphite Reactor for a period of 29 weeks at ambient reactor temperature. The resistivity and temperature were measured daily during the irradiation, and the resistivity measurement was corrected to 20°C for comparison purposes. The resistivity decreased rapidly during the first four weeks (nvt $\sim 2 \times 10^{18}$); it then leveled off and began to rise. The minimum value reached in four weeks amounted to a decrease of 0.036 $\mu\text{ohm-cm}$ or about 0.9%. At the end of 17 weeks, the resistivity had increased linearly back to its original value; and at the end of 29 weeks (nvt $\sim 1.5 \times 10^{19}$) the linear increase amounted to 0.040 $\mu\text{ohm-cm}$ or about 1.0%.

In a unique experiment, the amount of precipitation in a precipitation-hardening alloy was measured as a function of neutron dosage. The alloy Ni-Be (14.5 at % Be) can be prepared as a supersaturated solid solution by quenching from 1125°C. Further intermediate heat treatments in the general vicinity of 450°C permit the beryllium atoms to precipitate. A consequence of this precipitation is an increase in the ferromagnetic Curie temperature. The experiment used a microtransformer with a Ni-Be sample core which was designed to operate in the ORNL Graphite Reactor at 300°C. A similar apparatus, used as a control, was operated outside the reactor. The Curie temperatures were measured periodically on both the control and irradiated samples. The Curie temperature changed as a function of time for both samples, but much more in the case of the irradiated sample, which indicated an increase in precipitation caused by the neutron irradiation. (AEC Activity 4540)

Basic Reactor and Shielding Research - In an experiment to determine the increase in the temperature of the water in the pool with increased power levels of the Bulk Shielding Reactor (BSR), 25 thermocouples were positioned on the top of the reactor in such a manner that there was one thermocouple approximately at the top center of each full fuel element. The reactor loading (No. 33) was a completely water-reflected 5 x 6 element arrangement with two corner elements missing (the three control-rod elements were not monitored), and the power level ranged from 1 kw to 1 Mw. Because of the uneven heating of the water in the natural convection process, the thermocouple readings varied. To minimize the error introduced by these variations, the reactor was allowed to stabilize at each power level for 10 min, after which 20 readings were taken for each thermocouple. The average of all the readings was considered to be the average outlet water temperature of the reactor. The probable error at 1 Mw power level is roughly $\pm 7.5\%$. The inlet temperature was monitored by only two thermocouples, since the inlet temperature had previously been found to be essentially constant over the bottom of the reactor. The difference between the averaged outlet water temperature and the inlet temperature was thus obtained for various power levels as follows:

PROGRAM 4000 - REACTOR DEVELOPMENT (Continued)

| <u>Nominal Power Level (kw)</u> | <u>Avg. Temperature Rise (°C)</u> |
|---------------------------------|-----------------------------------|
| 10 | 1.04 |
| 50 | 2.61 |
| 100 | 4.01 |
| 200 | 6.44 |
| 300 | 8.75 |
| 400 | 10.5 |
| 500 | 12.2 |
| 750 | 16.1 |
| 1000 | 18.9 |

The fast-neutron dose rate in the water shield around the BSR was measured with three types of Hurst dosimeters, a 1-in.-dia. Hornyak button, and with a 3/16-in.-dia. Hornyak button. The measurements, which were made along the reactor centerline at distances of from 40 to 190 cm away from the north face of the reactor, agree to within 5% with earlier data obtained for water thicknesses up to 140 cm. (AEC Activity 4570)

Reactor Theory - The translation of the BNL-325 data to a form suitable for the compilation of the cross section library on magnetic tape was completed. The library tape compiler and edit-check programs were written and "debugged". A revised code, utilizing this library, for determining the age of neutrons in mixtures by Monte Carlo methods is in the final stages of completion. (AEC Activity 4570)

Power Reactor Waste Disposal Engineering Studies - Uptake studies on aqueous fission-product solutions (single tracers) by Conasauga shale were completed at pH 1.5, 1.8, 3.5, and 5, and on mixed fission products at pH 1.5, 1.8, 2.3, 2.8, 3.5, 4.0, and 5. The single-tracer data show that a decrease in pH value (more acid) resulted in an increase in the amount of soil required to effect a given removal of the radionuclide under investigation.

The sand flume was modified to permit concurrent evaluation and photographic recording of the chemical effects of both acid and neutralized aluminum nitrate waste solution on tamped Tennessee ball clay liner material. A preliminary dye study was made of liquid flow through the sand underlying the clay liner material. Continued observation since November 10, has indicated spallation of the clay liner in contact with the acid medium and a discrete cracking of the clay liner in contact with the alkaline medium. Crystallization (of sodium aluminate?) at leakage sites and the presence of dye tracer in the underlying sand are further indications of the deterioration of the clay liner in contact with the alkaline wastes. (AEC Activity 4630)

PROGRAM 5000 - PHYSICAL RESEARCH

ISOTOPE PRODUCTION

Stable Isotope Production - The enriched stable isotopes of the very rare element europium are now available for use in research. This work is the culmination of unusual effort in calutron operation and an unprecedented program in the chemical separation of europium from rare earth mixtures. A total of 725 grams of Eu_2O_3 of high purity was available for preparation of charge material. The weights of the enriched Eu^{151} and Eu^{153} (estimated enrichment >90% for each) produced are 21.8 and 25.1 grams, respectively.

New lots of enriched Rb^{87} , Sr^{84} , Sr^{86} , Sr^{87} , Sr^{88} , Te^{120} , Te^{122} , Te^{124} , Te^{125} , Te^{126} , Te^{128} , and Te^{130} were added to the inventory.

Separation of barium produced 145 grams of barium isotopes (masses 130, 132, 134, 135, 136, 137, and 138). Separation of magnesium isotopes (masses 24, 25, and 26) and tungsten isotopes (masses 180, 182, 183, 184, and 186) are nearing completion.

Isotopic iron metal targets 1 to 3 mils thick and without backings were prepared by electroplating on copper from an alkaline iron sulfate-ethylene-diamine tetraacetate bath. The plated cathode was then made the anode in a chromic acid bath and the copper stripped off electrolytically, leaving the iron foil.

Three one-gram elemental targets of W^{183} , 1 by 1/3 in., were prepared by reducing WO_3 in hydrogen at 900°C , then compacting the metal powder in a die at a pressure of 30 tons per square inch. (AEC Activity 5121)

PHYSICS

Scintillation Spectrometry and Instrument Development - An AID amplifier was modified for the tests on crystal resolution described elsewhere in this report to increase its speed. During the course of this development a number of small changes were made which have resulted in a considerably improved amplifier for general use. The preamplifier circuit was rearranged to give increased speed of pulse rise and incidentally a very low impedance output which permits the use of long input terminated cables between the preamplifier and main amplifier. Preamplifier linearity is much better than in the AID. The gain of the main unit was reduced by a factor of 3 in each feedback loop to increase its speed. An improved attenuator and the use of a new type of delay line for "clipping" brings the gain back to within a factor of 3 of the unmodified circuit. Overall rise time for a step input is 0.11 μsec , and overload and high counting rate performance is considerably better than in the AID. The new circuit, including Fairstein's modification of the output loop, will be called the AIE.

In a further investigation of the disparity of crystal and pulser resolution reported previously, the resolution of a NaI-Tl crystal was measured as a function of linear amplifier clipping time. It would be expected that, if

PROGRAM 5000 - PHYSICAL RESEARCH (Continued)

the resolution were dependent primarily on photomultiplier statistics, it would vary inversely with the square root of the fraction of the pulse effective in producing the measured peak. This fraction is dependent upon the decay time of the phosphor, the characteristics of the amplifier, and the clipping time. If the statistics were time independent, however, the result would be the same as that produced by any other means of attenuation of the light, and should show the effect of intrinsic crystal resolution. A 3 x 3 inch crystal on a DuMont 6363 photomultiplier gave the following results:

| <u>Clipping Time (μsec)</u> | <u>Fractional Pulse Height</u> | <u>Resolution (1%)</u> |
|-----------------------------|--------------------------------|------------------------|
| 1.0 | 0.98 | 7.6 |
| 0.5 | 0.76 | 8.3 |
| 0.25 | 0.47 | 8.7 |
| 0.125 | 0.25 | 9.3 |

These results are not completely compatible with the proposed intrinsic crystal resolution but the discrepancy may be within experimental error.

The total efficiency for gamma ray detection of the large thallium-activated sodium iodide crystal was calculated. The crystal is a 9-1/4 inch diameter 6 inch high cylinder topped by a 45 deg cone, which is truncated at a 3-1/2 inch diameter. A hole 1/2 inch in diameter had been drilled to the approximate center of the crystal. The method used to determine the total efficiency of the crystal was to calculate the solid angle at various distances from the center of the crystal by a method partly graphic and partly by calculation of spherical segments. The total efficiency is essentially 100% up to 300 kev, 90% at 1 Mev and 76% at 5 Mev. It increases above 5 Mev due to pair production.

The peak efficiency is at present being determined by finding peak-to-total intensity for single gamma-ray spectra of various energies and multiplying the peak-to-total intensity (counts in the full energy peak divided by the counts in the total spectrum) by the total efficiency. (AEC Activity 5220)

High Voltage Program - During the past three years, a series of measurements were made on the ratios of the fission cross sections of the uranium isotopes 233, 234, 236, and 238 to the fission cross section of U²³⁵. With the recent measurements between 5 and 150 kev on U²³³ this series was concluded. These ratios are now believed to be known to 2% accuracy from 5 kev to 4 Mev. Therefore, the fission cross sections of these isotopes are known to an accuracy comparable to that of the U²³⁵ measurements, as reported in the current issue of BNL-325.

The activation cross section of iodine for neutrons from an antimony-beryllium source was redetermined as 0.78 + 0.8 barns. The 25-min I¹²⁸ beta activity was counted internally in 1-1/2 by 1-1/2 in. NaI(Tl) crystals. The source strength was based on a manganese bath calibration at the National Bureau of Standards. The result compares with a value of 1.0 barn, interpolated from

PROGRAM 5000 - PHYSICAL RESEARCH (Continued)

work at other energies, and 2.2 barns, as measured with an antimony-beryllium source at Argonne National Laboratory in 1950. The corrections for geometry, multiple scattering in NaI, energy loss in beryllium, and source anisotropy were computed or measured.

The beam from the 3-Mev Van de Graaff machine was bent 60 deg by the analyzing magnet rather than the usual 90 deg and allowed to enter the room below the normal scattering room. A second magnet, with its coils connected in series with the coils of the analyzing magnet, bent the beam the additional 30 deg to horizontal. This second magnet is double focusing and brings the beam to a spot about 3 mm in diameter. Horizontal beams are now available in two laboratories so that one experiment may be in progress while another is set up. (AEC Activity 5220)

Classification of Low-Lying Nuclear Energy Levels - The directional angular correlation of the 909-1850 keV gamma-gamma cascade in Sr^{88} was measured with a coincidence scintillation spectrometer using NaI detectors. The spins and parities of the initial and intermediate states of the cascade were measured in other experiments; hence the angular correlation measurement is a sensitive method of determining the purity of the first transition in the cascade. The observed correlation function is given by $W(\theta) = 1 - (0.0699 \pm 0.0025) P_2(\cos \theta)$. The theoretical function for the sequence $3(D) 2(Q) 0$ is $W(\theta) = 1 - 0.07143 P_2(\cos \theta)$; thus it is concluded that both of the transitions in the cascade are pure multipoles. This result is in disagreement with previous less precise measurements made in two other laboratories. (AEC Activity 5220)

86-Inch Cyclotron, Operation - A separation of 3 in. was obtained between the deflected beam and the circulating beam; the newly installed r-f electrostatic deflector is being tested. An attempt is being made to increase the separation to 4 in. to direct the deflected beam into the magnetic channel which will then be installed. A maximum deflected beam current of 70 microamperes was collected on an internal target. (AEC Activity 5220)

Electronuclear Machines--The 44-Inch Cyclotron - The initial test operation of the 44-inch cyclotron was begun on December 14. A small proton beam was obtained on the experimental probe near the ion source. No accelerating electrode was used, and the dee voltage was limited by the close coupling of feed-back circuit. The filament-coupling loop was then shortened and an accelerating electrode is being installed. (AEC Activity 5220)

The 63-Inch Cyclotron--Physics - The energy spectra, at zero deg. of protons and alpha particles emerging from thin targets of nitrogen, lithium-6, and lithium-7, bombarded with nitrogen ions were measured. The excitation functions for stripping type reactions in sodium and phosphorus are being investigated. Further work was done on the elastic scattering of nitrogen from the two separated lithium isotopes. (AEC Activity 5220)

PROGRAM 5000 - PHYSICAL RESEARCH (Continued)

Spectroscopy Research Laboratory - The nuclear magnetic resonances of the barium isotopes were observed, and the magnetic moments, without diamagnetic correction, were determined to be

$$\begin{aligned}\mu (\text{Ba}^{135}) &= 0.832293 \pm 0.000025 \\ \mu (\text{Ba}^{137}) &= 0.931074 \pm 0.000055\end{aligned}$$

A number of chemical shifts of the boron isotope resonances were studied in support of a boron isotope separation project of the Materials Chemistry Division; significant differences were observed in the different BF_3 organic complexes.

A 100-curie sample of TCN was studied for its fundamental molecular vibrations; the following preliminary data were obtained:

| <u>Vibration</u> | <u>Observed</u> | <u>Theoretical</u> |
|----------------------|----------------------|----------------------|
| ν_2 (CN stretch) | 513 cm^{-1} | 510 cm^{-1} |
| ν_3 (TC stretch) | 2458 | 2538 |

The ν_3 theoretical value does not include any anharmonicity correction.

An electrodeless discharge tube containing HfCl_4 was constructed for nuclear hyperfine structure studies; successful spectrum excitation was obtained on normal hafnium.

A previously reported bias between x-ray fluorescence and chemical analysis of Zr-U and Nb-Zr-U alloy samples was resolved; agreement is now consistent to within a few percent of the zirconium content. An experimental study of x-ray diffraction patterns of over seventy compounds of uranium was completed; the data are now in a form especially suited for routine compound identification by powder techniques. (AEC Activity 5230)

Mass Spectrometer Laboratory - The mass spectra of n-butane and i-butane were carefully studied for the presence of metastable transitions. A number of new transitions were found in both spectra. Among these are:

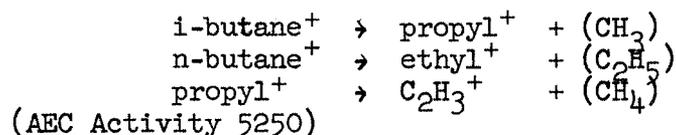
| <u>n-butane</u> | | <u>Relative Abundance</u> mass 43 = 100 units | <u>Remarks</u> |
|-----------------|---------------------|--|--|
| <u>m</u> | <u>Transition</u> | | |
| 29.5 | 57 \rightarrow 41 | 0.03 | |
| 13.75 | 53 \rightarrow 27 | 0.006 | |
| 31.32 | 59 \rightarrow 43 | 0.002 | isotopic transition corresponding to 58 \rightarrow 42 which has relative abundance 0.08 |
| 32.85 | 59 \rightarrow 44 | 0.004 | isotopic transition corresponding to 58 \rightarrow 43 which has relative abundance 0.11 |
| 15.3 | 55 \rightarrow 29 | 0.009 | |

PROGRAM 5000 - PHYSICAL RESEARCH (Continued)

| <u>i-butane</u> | | | |
|-----------------|-------------------|---------------------------|---------------------|
| <u>m</u> | <u>Transition</u> | <u>Relative Abundance</u> | <u>Remarks</u> |
| 13.75 | 53 → 27 | 0.0015 | |
| 15.3 | 55 → 29 | 0.001 | |
| 24.15 | 28 → 26 | 0.003 | |
| 29.48 | 57 → 41 | 0.01 | |
| 31.3 | 59 → 43 | 0.0002 | isotopic transition |
| 30.4 | 58 → 42 | 0.01 | |

The metastable character was confirmed by using a metastable suppressor. The relative abundances were shown to be pressure independent over the range 10^{-7} - 10^{-5} mm. All transitions are in accord with theoretical predictions.

Pressure-dependence studies at higher pressures led to the discovery of a number of "metastable" transitions which vary approximately with the square of the pressure. They are also suppressed by the metastable suppressor. These could arise from dissociative collision of a 2-kv ion with residual gas in the field-free region between the source and analyzer. Henglein and Ewald (Henglein, A. and H. Weald, NBS Circular 522, p 205, Jan. 23, 1953) report similar cases as appearing in their parabola spectrograph. They state that it is an experimental fact that these collisions occur without appreciable transfer of kinetic energy. Our results are in complete accord with theirs. The following dissociation products were found:



Research and Development--Stable Isotopes - A zone-melting apparatus was constructed for performing chemical purifications of enriched stable isotopes and of calutron charge materials. Trial runs with mixtures of LiF and NaF showed very good results.

Experimental separations of argon in the calutron produced approximately 0.5 milligram of argon containing 36% A³⁶. The difficulty in the separation of noble gases is, of course, the retention of ions in the collector. In these experiments a magnesium lattice was used in the collector to trap the argon; retention was in excess of 50%. (AEC Activity 5250)

CHEMISTRY

Raw Materials Chemistry - A demonstration of the continuous countercurrent solvent extraction process for recovery of uranium and vanadium with di(2-ethylhexyl) phosphoric acid was made using a sample of leach liquor from the Shiprock, New Mexico plant (operated by Kerr-McGee Oil Industries). Prior to extraction most of the ferric iron in the liquor was reduced with powdered iron and the liquor pH was adjusted with lime to 1.8. With 0.3M di(e-ethylhexyl)

PROGRAM 5000 - PHYSICAL RESEARCH (Continued)

phosphoric acid in kerosene + 5 w/v % TBP, 99.9% recovery of uranium and 94% recovery of vanadium was accomplished in five extraction stages. Vanadium was selectively stripped from the extract with 0.75M H_2SO_4 (3 stages) from which it was recovered as a high grade product by precipitation with ammonia. Uranium was stripped with 10% sodium carbonate (2 stages):

Further studies of the possible degradation of amine extractants under simulated process conditions were made with a new automatic reagent testing device which was designed and constructed at ORNL. In the test procedure, a representative amine (tri-n-octylamine) in a kerosene diluent was subjected to 200 complete extraction-stripping cycles under controlled temperature conditions. It was found that the losses of amine through degradation are negligibly low under normal conditions of operation. Also, even under more stringent conditions, i.e., highly oxidized liquors at a temperature of 45°C, the losses were unimportantly low from a reagent cost standpoint.

Further studies on the stripping of uranium from di(2-ethylhexyl) phosphoric acid-kerosene solvent show that efficient stripping can be achieved with solutions of ammonium carbonate. Unlike the sodium salt, the ammonium salt of di(2-ethylhexyl)-phosphoric acid is soluble in kerosene and thus the basic stripping cycle may be used without addition of alcohol, TBP, or other diluent extenders. Recovery of uranium from the strip solution is accomplished by decomposing the ammonium carbonate with steam, thereby precipitating the uranium. The ammonia which is distilled off may be recovered and recycled. (AEC Activity 5310)

Mass-233 Studies - Protactinium-233, which is a good source of isotopically pure U^{233} , must be recovered in the processing of irradiated thorium which has decayed less than 8 months. The protactinium in nitric acid solutions of irradiated thorium was found to be adsorbed on $Zr_3(PO_4)_4$ but, due to the small particle size of the adsorber, a packed column of this material would not be operable on a pilot plant scale. $Zr_3(PO_4)_4$ present on various inert support materials did not adsorb a significant amount of protactinium. The protactinium could not be adsorbed from neutral or acid-deficient waste solutions, apparently because of the formation of nonionic species.

In a single experiment in which protactinium and fission products in the dissolver solution were precipitated by carrier MnO_2 and the supernatant then solvent-extracted by a Thorex first-cycle scheme, the decontamination was not significantly increased over that obtained in solvent extraction alone. The conditions of the experiment were not optimum. (AEC Activity 5310)

Equipment Decontamination Studies - Contaminated fused fluorides adhering to nickel equipment can be removed by either a molten KF flush or by dissolution in 10% H_3BO_3 - 3% HF. The adsorbed activity remaining after dissolution of the fluoride salt in 10% H_3BO_3 - 3% HF was completely removed in 5 min by 30% HNO_3 , which also corroded the nickel. (AEC Activity 5310)

PROGRAM 5000 - PHYSICAL RESEARCH (Continued)

Hope Project - Decontamination of aluminum-containing aqueous wastes would permit inexpensive storage of these large-volume wastes. From aluminum wastes that had been heated to convert the $\text{Al}(\text{NO}_3)_3$ to $\text{Al}(\text{OH})_2\text{HO}_3$ (diban), fission products were reduced by a factor of 10^3 , with a fixed bed of Dowex-50 cation exchange resin. In a single run in the Higgins 1-in.-dia. continuous ion exchange column with a 3-ft sorption section, 80% of the cesium present was removed from a diban solution (decontamination factor of 5). In the scrubbing section, aluminum was removed from the loaded resin with 4 moles of oxalic acid per mole of aluminum in the feed. A higher oxalic acid/aluminum ratio and/or a longer sorption section should increase the separation in the continuous equipment.

In a pulse column system, a pulse-actuated mechanism satisfactorily returned to the column system all fluid that leaked past the pulser piston. No auxiliary recycle pump was required.

In preliminary radiochemical tests, spray column contactors for treating used Thorex solvent performed satisfactorily. The recovered solvent was comparable in quality to the solvent product of the existing Thorex solvent recovery system, which uses pulse column contactors. A hydroclone also satisfactorily replaced the supercentrifuge now used. (AEC Activity 5310)

High Temperature and Structural Chemistry - Renewed experimental work on the KCl - K system showed the phase equilibria to be not only qualitatively but also quantitatively similar to those of the KF - K system. The temperature of complete miscibility lies only about 25°C above the melting point of the pure salt. This reduces the temperature range of immiscibility to approximately 40° . The lowering of the melting point of the salt (770°) to the monotectic temperature of 752° by the dissolution of about 11 mole % K metal is only about one-half of that which would occur if the solution were ideal. The thermal effect accompanying precipitation of the second liquid phase was observed in cooling curves and will be used to delineate further the liquid - liquid phase equilibria in this and other systems.

Electrical conductance measurements with improved conductivity cells showed the specific conductivity to rise (at 2.8 mole % K) to a value only about 50% above that of pure molten KCl. This is in agreement with earlier views that "dissociation" of the metal into ions and electrons takes place only to a minor degree at these low concentrations. Additive behavior, not actually expected in these solutions, would have increased the conductivity (at 2.8 mole % K metal) 140 times over that of the pure molten salt. (AEC Activity 5330)

Radio-Organic Chemistry - Diphenyl-p-tolylacetaldehyde- 1-C^{14} ; chain- and ring-labeled 1,2-diphenyl-1-p-tolyethylene glycol; and 1,1-diphenyl-2-p-tolyethylene- 2-C^{14} glycol were prepared and subjected to rearrangement a) in cold concentrated sulfuric acid and b) in boiling formic acid. Under both sets of conditions two ketones, p-tolyldesoxybenzoin and benzhydryl-p-tolyl ketone, are produced from each reactant. By using double-labelling

PROGRAM 5000 - PHYSICAL RESEARCH (Continued)

techniques and by generating a common intermediate ion under identical conditions from the three different sources, it was possible to relative the pinacol and aldehyde-ketone rearrangements mechanistically. For the rearrangement of the aldehyde the simple ratios of the products (4.7 in sulfuric acid and 3.5 in formic acid) would appear to indicate phenyl/p-tolyl migration ratios of 2.35 and 1.75, respectively, which are inverted with respect to the usual migratory abilities of the two groups. It was shown that the migration ratio of the one p-tolyl and the two phenyl groups is not reversed and is not given by the ratio of the ketonic products. The true p-tolyl/phenyl migration abilities in the rearrangement of diphenyl-p-tolylacetaldehyde in either sulfuric or formic acid were estimated by the use of a kinetic expression which follows from the mechanism to be between two and four as normally expected.

The continued study of organophosphorus compounds in relation to solvent extraction included the synthesis of a new compound, tetrabutyl pentamethylene diphosphine dioxide. It is soluble in water and consequently largely of theoretical interest. The butyl phosphoric acids were found to be sensitive to heat, yielding products in which the butyl groups are redistributed. Organophosphorus acids apparently yield complexes with divalent metals in solution of the type $M(R_2P_2O_2)^+$. More complex configurations must also exist in solutions. (AEC Activity 5330)

Radiation Chemistry - Radiation induces the reduction of either ceric or chromate ion by thallos ion, and also the reduction of chromate ion by bromide ion. The pairs of solutes efficiently scavenge the radicals produced by decomposition of the water, thereby allowing the yields to be measured and their distribution in space to be studied.

Warming curves of the glassy product obtained in a cold trap after passing water vapor through an electric discharge were compared with those for the glass prepared by rapidly cooling 60% hydrogen peroxide. The curves were similar from $-196^{\circ}C$ to $-80^{\circ}C$. Both showed the glass transition and crystallization regions. In addition, at temperatures above $-110^{\circ}C$ the products of the discharge foamed continuously. At $-60^{\circ}C$ the temperature rose suddenly simultaneous with a violent evolution of gas indicating chemical reactions of unstable species.

In the gamma-ray decomposition of di-n-butyl phosphate, yields for disappearance of substrate and for the formation of various gases, of dibutyl and monobutyl phosphates, and of polymer were measured. The principal products were hydrogen gas, dibutyl phosphate, and polymer. A reaction mechanism was proposed to account for the observed stoichiometry of products. (AEC Activity 5330)

Chemistry of Fused Salts - Cryoscopic measurements gave further evidence of the general applicability of the "common ion" effect in fused electrolytes. Dissociation constants in fused salts roughly parallel those in aqueous solution. Further studies with $ZrF_6^{=}$ and $TiF_6^{=}$ ions show them to be reasonably stable in dilute solution in fused $NaNO_3$.

PROGRAM 5000 - PHYSICAL RESEARCH (Continued)

A study of the possible exchange reactions of fluorine between salts and gases at high temperature was started. Preliminary work established several satisfactory procedures for preparation of salts containing F^{18} as a tracer. (AEC Activity 5330)

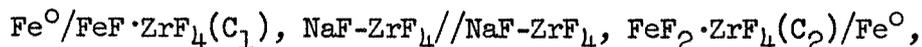
Analytical Chemistry Research - A satisfactory method was developed for the separation of tin in very low concentrations (0.1 to 10 μg per ml) from interfering components, particularly uranium, in uranyl sulfate solutions. Tin is separated by co-precipitation as the hydrous oxide, with aluminum as carrier, from a basic carbonate medium. After the separation, tin is then determined by a conventional, polarographic method. For samples which contain 1 to 10 μg of tin per ml, the coefficient of variation is 12%. With lower concentrations, of tin, in the range 0.1 to 1 μg per ml, the precision is of the order of 50%.

Initial studies on the use of tridecylphosphine oxide as an extractant for uranium in the fluorimetric procedure proved to be quite promising. The results of work to date reveal that, by the simple expedient of adding 6 M nitric acid, it is possible to extract uranium from an aqueous solution of 1 M H_2SO_4 and H_3PO_4 when this solvent is utilized. Such being the case, the use of tridecylphosphine oxide will prove to be a distinct improvement over tributyl phosphate for this purpose.

The spectrographic analysis of mixtures, containing comparable microgram or sub-microgram quantities of rare earths, is made difficult by the fact that changes in the abundance ratio of the various rare earths cause pronounced shifts in working curves, and cause some rare earth lines to disappear altogether. It was found that the addition of zinc to the rare earth mixture eliminates both effects for gadolinium at the 0.08 - 0.2 microgram level.

Variance in spectrochemical results believed due to spectral self-absorption was greatly reduced by the use of a powerful exhaust immediately behind the spark gap. (AEC Activity 5330)

Molten Salt Thermodynamics - In the study of molten salts some solubilities were determined by the use of molten electrolyte concentration cells, such as



where the composition of the NaF-ZrF_4 was 53-47 mole %. The bridge between the half cells was composed of ZrO_2 impregnated with the NaF-ZrF_4 mixture, and the solubility sought was that of the $\text{FeF}_2\cdot\text{ZrF}_4$. As the temperature was decreased, first one and then the other half cell became saturated, causing in each case a sharp break in the temperature coefficient of the cell at the temperature corresponding to saturation. Although only 0.27 mole % FeF_2 was soluble at 550° , the solubility of FeF_2 increased to 11 mole % at 750° ; this later figure was higher than had been expected. (AEC Activity 5330)

PROGRAM 5000 - PHYSICAL RESEARCH (Continued)

METALLURGY

Fundamental Physico-Metallurgical Research - An earlier assumption that zirconium and titanium have a metallic valency of two on the basis of the alpha/beta phase boundaries is now supported by a theoretical analysis of the axial ratio of titanium alloys. This analysis was extended successfully to include the alloying effect of the tetravalent solute tin in titanium and the alloying effects of silver, indium, and antimony upon the axial ratio of zirconium. The results show the electron concentration dependence of the axial ratio of the hexagonal phase which agrees with the approximate divalency of these solvents. The axial ratio of pure zirconium is greater than that of pure titanium, which may indicate that zirconium is of slightly greater valency than titanium.

In connection with the study of the development of preferred orientations, the fiber axis distributions were determined for as-extruded and annealed thorium rods. The rods were fabricated at 850°C with an extrusion rate of 2.3 feet/min, and the cross section area was then reduced 91.5%. A specimen of this material was annealed 1 hr at 750°C. The more preferred crystallographic directions of the fiber axis in the as-extruded rod were $\langle 111 \rangle$ and $\langle 001 \rangle$, the former component constituting 75% and the latter 25% of the volume. The more preferred crystallographic directions of the fiber axis in the annealed rod were $\langle 115 \rangle$ and $\langle 236 \rangle$. The former component appeared to be slightly the stronger. The $\langle 236 \rangle$ component has not been previously reported for any metal, and the $\langle 115 \rangle$ component has been noted only in one specimen of aluminum. (AEC Activity 5420)

Fundamental Investigation of Radiation Damage in Solids - High-purity n- and p-type samples of germanium were exposed to γ -rays from a 900-curie Co^{60} source. The extrinsic electron concentration of n-type material decreased at a rate $\sim 10^{-3}$ as great as when irradiated with fast neutrons. Two electron-trapping levels were observed at approximately the same position as occurred in n-type material that was irradiated with fast neutrons. Extended exposure converts n-type material to p-type; this indicates the presence of an acceptor state at ~ 0.26 eV above the valence band, an energy that is somewhat larger than was found in fast-neutron irradiated material. Interstitial clustering and nonuniform defect distribution are believed to account for the lower acceptor level that is produced by fast-neutron irradiation; hence energetic electromagnetic irradiation may produce individual interstitial vacancy pairs throughout the volume of the specimen. Exposure of p-type material results in a decrease in acceptor concentration over the whole temperature range, and the removal rate approaches saturation after appreciable exposure. (AEC Activity 5430)

PROGRAM 6000 - BIOLOGY AND MEDICINE

BIOPHYSICS

Internal Dose Studies - Tissues from autopsies of 7 still births have been analyzed for the trace elements by spectrographic analysis. The data are reported in micrograms per gram of ash and in micrograms per gram of wet tissue. Of particular interest are the strontium and chromium values and the appearance of these two elements in all of the tissues analyzed. Cadmium is found in most adults' tissue but in only a very few of the still birth tissues which were analyzed. The tissue collection program has been established in three more cities in the United States. (AEC Activity 6240)

Experimental Ecology Program - Carrier strontium, together with the normal nutrients, was adsorbed on Conasauga shale and the amount taken up by bean plants at various stages of maturity was determined. In addition each series of cultures received equal amounts of strontium-90.

It appears reasonable from the experiments conducted to conclude that the uptake of strontium-90 from natural soils will be concentrated to a higher degree in the leaves, than in the other parts of the bean plant; that the concentration factor will be approximately six-fold; and that this factor may depend on the total amounts of strontium available in the soil. The amount per unit weight of active strontium absorbed and translocated to leaves declines as more carrier strontium is available in the soil. Uptake of calcium from the soil appears to be almost independent of soil saturation with calcium, at least in the earlier stages of plant growth. Strontium can replace calcium on the soil colloid to make adequate amounts of potassium and magnesium available for plant growth. (AEC Activity 6440)

Professional Health Physics Training Program - Two members of the Education and Training Section of the Health Physics Division, Dr. Elda E. Anderson and Myron F. Fair, conducted a 5-week course in radiation protection at the Institute of Radiophysics, Karolinska Hospital, Stockholm, Sweden. The course was held from November 14 - December 16. (AEC Activity 6690)

STATUS OF CONSTRUCTION

During the month the V. L. Nicholson Construction Company completed work on the 7500 Building alterations and the installation of new facilities for the HRT. In general the work performed included the construction of a steel-lined concrete pit, approximately 60 by 30 by 25 ft deep, in the crane bay area of the existing building. One section of the pit will house the reactor and the other provides space for auxiliary equipment. A water-tight bulkhead makes it possible to flood the reactor pit. Adjacent to the north side of the reactor pit is the operating room, approximately 30 by 20 by 25 ft deep. Adjacent to the south side of the main pit is the area for the chemical processing of the HRT fuel. This is comprised of two steel-lined concrete cells for the processing equipment, a concrete cell for samplers and other auxiliary equipment, and a concrete-shielded operating gallery. The cells occupy a pit approximately 45 by 30 by 30 ft deep. To enclose this pit, which extends beyond the limits of the original building, and to provide additional office and operating space, an extension 25 by 90 ft was added to the south side of the building. Supplementary facilities include a cooling tower with an 800 gpm capacity, a 400-kva substation, and a 300,000-gal retention pond with controlled, measured outfall. The contractor also installed a high-pressure (1200 psi) steam system.

The reactor, blanket system, fuel system, controls, chemical processing, and other specialized equipment are being fabricated and installed by the Laboratory.

VISITORS

Brooks, Harvey*, Harvard University
Creutz, Edward**, Carnegie Institute of Technology
Grant, N. J.**, Massachusetts Institute of Technology
Johnson, T. H., Director, Division of Research, USAEC
MacPherson, H. G.*, National Carbon Research Laboratories
McMillan, Edwin M., Univ. of Cal. Radiation Lab. (AEC General Advisory Com.)
Price, Congressman Melvin
Shaw, David F., AEC Assistant General Manager for Manufacturing
Shevlin, T. S.**, Ohio State University Research Foundation
Sproull, Robert L.*, Cornell University
Vance, Commissioner Harold S.

*Solid State Advisory Committee

**Metallurgy Advisory Committee

FOREIGN VISITORS TO ORNL

Anschutz, O. F., Stenannmueller, W. Germany
Arendt, P. R., Allgemeine Elektrizitätsgesellschaft, Germany
Barlow, E. A., Atomic Energy of Canada, Ltd., Chalk River, Ontario, Canada
Brockhouse, B. N., AECL, Chalk River, Ontario
Burnup, T. E., AECL, Chalk River, Ontario
Carlesworth, D. H., AECL, Chalk River, Ontario
Cowper, George, AECL, Chalk River, Ontario
Craig, D. S., AECL, Chalk River, Ontario
Eve, Ivor S., Medical Officer, World Health Org., Geneva, Switzerland
(citizen of Great Britain)
Hatoyama, Ichiro, Government of Japan, Tokyo, Japan
Henderson, W. J., AECL, Chalk River, Ontario
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Mukaibo, T., Scientific Attache to Japanese Embassy, Washington, D. C.
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Rae, H. K., AECL, Chalk River, Ontario
Riezler, W. H. S., University of Bonn, Germany
Rogers, J. T., AECL, Chalk River, Ontario
Ross, J. B., AECL, Chalk River, Ontario
Siebker, M., Director of L and C, Stenannmueller, W. Germany
Suzuki, M., Ministry of Labor, Tokyo, Japan
Wezkesser, A., Rheinisch Westfälischer Elektrizitätswerk, Essen, Germany

RADIOISOTOPE SALES AND COSTS

| <u>Type of Transaction</u> | <u>November 1955</u> | <u>FY 1956 to Date</u> |
|---------------------------------------|----------------------|------------------------|
| Domestic Sales | \$ 153,065 | \$ 550,946 |
| Foreign Sales | 14,226 | 42,967 |
| Project-Cash Sales | 3,372 | 20,874 |
| Project-Transfer | 1,205 | 4,893 |
| Technical Cooperation Program Credits | 0 | 640 |
| Plant Credits | 3,165 | 8,737 |
| AEC Credits | <u>17,044</u> | <u>55,979</u> |
| Total Radioisotope Income | \$ 192,077 | \$ 685,036 |
| Total Radioisotope Costs | \$ 153,816 | \$ 417,778 |
| Total Radioisotope Shipments | 1,148 | 5,249 |
| Boron and Helium | | |
| Income | \$3,807 | \$17,131 |
| Costs | \$1,288 | \$ 4,823 |
| Shipments | 10 | 34 |

GROSS OPERATING COSTS

| | <u>Cost for November</u> | <u>FY 1956 Cost to Date</u> |
|---|--------------------------|---------------------------------|
| Programmatic Operating Cost - Net | \$3,260,205 | \$15,511,170 |
| Plant and Equipment Cost | 397,475 | 1,465,126 |
| Program "H" | 5,410 | 87,907 |
| Work for Other Parties - Transfers | 36,688 | 78,443 |
| Inventory Changes | 18,506 | 29,408 |
| Reimbursable Work for Other Parties | 249,188 | 1,025,023 |
| Deferred Charges | <u>13,910</u> | <u>45,431*</u> |
| Total Laboratory Cost - Net | <u>\$3,981,382</u> | <u>\$18,151,646</u> |
| Estimated Cost for Next Month - Net | <u>\$4,050,000</u> | <u>\$22,201,646</u> |

*Credit

PERSONNEL SUMMARY

| | <u>Number of Employees December, 1955</u> | <u>New Hires December</u> | <u>Terminations December</u> |
|---------------------------------------|---|-------------------------------|----------------------------------|
| Administration | 62 | 1 | 1 |
| Operations* | 126 | 2 | 1 |
| Engineering, Shops, and Mechanical | 786 | 12 | 3 |
| Laboratory and Research | 1988 | 20 | 26 |
| Protection | 131 | 0 | 6 |
| Service | <u>375</u> | <u>4</u> | <u>0</u> |
| | 3468 | 39 | 37 |

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

A total of 846 Laboratory personnel are located in the Y-12 Area.

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Reports in this series issued during the past year:

| | |
|----------------|-----------|
| December 1954 | ORNL-1838 |
| January 1955 | ORNL-1849 |
| February 1955 | ORNL-1867 |
| March 1955 | ORNL-1878 |
| April 1955 | ORNL-1886 |
| May 1955 | ORNL-1905 |
| June 1955 | ORNL-1920 |
| July 1955 | ORNL-1936 |
| August 1955 | ORNL-1968 |
| September 1955 | ORNL-1980 |
| October 1955 | ORNL-1995 |
| November 1955 | ORNL-2016 |