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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

FEBRUARY, 1953

AEC RESEARCH AND DEVELOPMENT REPORT

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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

February, 1953

W. H Sullivan
and
F. T. Howard

Date Issued: MAR 6 1953

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February, 1953

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TABLE OF CONTENTS

	Page
PROGRAM 3000 - WEAPONS	6
Special Electromagnetid Separations	6
PROGRAM 4000 - REACTOR DEVELOPMENT	6
HOMOGENEOUS REACTOR PROJECT	6
Homogeneous Reactor Experiment	6
HRP Critical Experiments	7
HRP Chemistry	7
Dynamic Corrosion Studies	7
HRP Fuel Reprocessing	8
HRP Fuel and Blanket Studies	8
AIRCRAFT NUCLEAR PROPULSION PROJECT	8
ANP Experimental Engineering	8
Aircraft Reactor Experiment	10
Critical Experiments	10
Radiation Damage	11
Reactor Chemistry	11
Corrosion Studies	12
Metallurgy	12
Heat Transfer and Physical Properties Research	13
Shielding Research	13
GENERAL REACTOR RESEARCH	14
General Reactor Radiation Damage	14
Idaho Chemical Plant	15
PROGRAM 5000 - PHYSICAL RESEARCH	15
ISOTOPE PRODUCTION	15
Stable Isotope Production	15
PHYSICS	15
Short Period Activities	15
High Voltage Program	16
Scintillation Spectrometry and Instrument Development	17
Short Lived Isomers	17
Angular Distribution of Gamma Rays	18
86-Inch Cyclotron Nuclear Physics	18
86-Inch Cyclotron	19
Fundamental Electromagnetic Research	19
Electro-Nuclear Machines	19
Isotope Analysis Methods Laboratory	19
Mass Spectrometer Laboratory	20

[redacted]

[redacted]

TABLE OF CONTENTS Continued

Page

Program 5000 - Physical Research, Physics, (Continued):

63-Inch Cyclotron Physics 20
Stable Isotope Neutron Cross Sections 20
Research and Development, Stable Isotopes 20

CHEMISTRY 20
Inorganic Solution Chemistry 20
Chemical Physics 21
Chemistry of the Solid State 22
Radio-Organic Chemistry 22
Radiation Chemistry 23
Chemistry of Fused Salts 23
Uranium Chemistry of Raw Materials 24
Electro Chemical Studies 24
Thorex Process Development 24

METALLURGY 25
Ceramics Research 25
Physical Metallurgy of Reactor Materials 25
Fundamental Physico-Metallurgical Research 25
Fundamental Investigations of Radiation Damage in Solids . . 26

PROGRAM 6000 - BIOLOGY AND MEDICINE 26
Waste Disposal Research 26
Radioactive Particulate Problem 26

RADIOISOTOPE SALES 28

GROSS OPERATING COSTS 28

PERSONNEL SUMMARY 29

[redacted]

[redacted]

OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

February, 1953

PROGRAM 3000 - WEAPONS

Special Electromagnetic Separations - The plutonium dispersed over the surfaces of calutron equipment used in two test isotope separation runs has been recovered and converted to plutonium oxalate. In preparation for processing in the calutron the oxalate is being reconverted to the trichloride by refluxing with hexachloropropene. Facilities and techniques for handling this highly alpha-active material have been satisfactory.

The residue from a thorium isotope separation run has been recovered from the calutron equipment and converted to thorium tetrachloride by heating the oxide with phosgene at 650°C. The thorium contains 10% ionium (Th^{230}). (AEC Activity 3601)

PROGRAM 4000 - REACTOR DEVELOPMENT

HOMOGENEOUS REACTOR PROJECT

Homogeneous Reactor Experiment - Successful removal of the 40 parts per million of chloride ion accidentally introduced into the HRE fuel solution was achieved by precipitating AgCl with Ag_2SO_4 solution and filtering the precipitate. This processing, done in the reactor system, reduced the chloride concentration in the fuel to less than 1 part per million.

After operation of the reactor for a day at low power showed that the system was free from leaks and in good operating condition, it was decided to go at once to higher power. On February 21 the HRE was operated at a power of about 250 kilowatts with entirely satisfactory results, except that power level oscillations of about 20% were observed, due to the opening and closing of the gas let-down valve. The temperature was below 150°C and the system pressure was 400 psi. On February 23 the reactor was started up at 200°C and 1000 psi. The power level was increased stepwise from 25 kw to 225, 500, 800 and 1000 kw. At each new power level the level of radio activity around the shield, building and off-gas system was surveyed. A heat balance of the reactor system was made also. No oscillations in power level were observed until the 1000-kw level was reached and then the oscillations were slight, only about 4% of the power level.

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At 1:00 a.m. on February 24 the full design power of 1000 kilowatts was reached and the turbine-generator was operated with reactor steam, producing from 150--170 kilowatts of electricity. The performance of the HRE at full power was entirely satisfactory.

With the turbine-generator operating, the building and reactor power requirements of ~70 kw were more than met, and the excess power was fed into the ORNL electrical system. (AEC Activity 4103.1)

HRP Critical Experiments - Some further studies have been made of the criticality behavior of aqueous slurries of enriched uranium oxide in a cylindrical geometry. Measurements have been made of the critical masses of well-agitated mixtures having a concentration range of from 30 gm to greater than 100 gm U^{235}/l. In addition, an attempt has been made to evaluate the nuclear stability of the system as a function of the speed of the axial stirrer. This stirrer and a set of vertical baffles on the inside of the cylinder were designed to produce an essentially vertical circulation with no vortex. In most of the cases thus far observed there seems to be a minimum agitator speed below which the reactivity, k, is not stable. When the agitation is reduced below this minimum speed, either stepwise or suddenly by stopping the stirrer, the reactivity goes through a maximum which is several percent above its stable value. (AEC Activity 4109.2)

HRP Chemistry - Studies of the solubility of UO_3 in uranyl sulfate solutions at 25° show that the solid phase, found when the total uranium concentration is less than about 2 molar, differs from that found when the uranium concentration is above 2 molar. Neither of the solid phases has been identified positively. Experimental data indicate that the heat of transition from one solid phase to the other is small.

The activity of copper ion catalyst, for promoting the liquid-phase recombination of hydrogen and oxygen, was found to be depressed upon increasing the sulfate ion concentration. It is believed that this effect is caused by a complexing of the copper and sulfate ions and therefore the active species must be either the uncomplexed copper ion or the hydrated copper ion. (AEC Activity 4109.3)

Dynamic Corrosion Studies - Studies of the corrosion of various materials exposed to uranyl sulfate solutions at temperatures from 150° to 250°C show that among the major factors affecting the corrosion rate are solution flow velocity, uranium concentration, temperature, and metallurgical treatment of the metal. With type 347 stainless steel the highest temperature, at which tolerable corrosion rates are observed with uranium concentrations of 40 g U/l or more, seems to be about 150°C; low corrosion rates at higher temperatures are observed only when uranium concentrations are in the range of 5--15 g U/l.

Titanium exhibits better corrosion resistance to uranyl sulfate under all conditions tested than any other metal. In all tests to date the corrosion rate of titanium has not been greater than 1 mil per year, even though concentrations of uranium as high as 300 g U/l and temperatures up to 250°C have been investigated.

In the short term tests to date zirconium shows better corrosion resistance to uranyl sulfate than type 347 stainless steel. Results of the corrosion tests to date indicate that neither titanium nor zirconium is likely to be usable with any concentration of UO_2F_2. Type 347 stainless steel has shown good resistance to uranyl fluoride solutions containing 5 g U/l, with a slight excess of HF at 250°C. (AEC Activity 4109.4)

HRP Fuel Reprocessing - Methods for removing fission product poisons cheaply and continuously from homogeneous reactor fuel solutions are being investigated. It has been calculated that the rare earths contribute 70-80% of the poisoning due to non-gaseous fission products in a reactor fueled with uranium-233. Calcium fluoride has proven to be an excellent adsorbent for rare earths with a capacity of about 20 mg of rare earths per cc of CaF_2. Seven cc of CaF_2 were capable of removing 75% of the rare earths from 450 ml of uranium solution at the concentration of rare earths expected in the ISHR fuel. Based on this result, a 1,500 cc bed of CaF_2, changed daily, appears promising for reprocessing the fuel solution of the ISHR on a 40 day chemical processing cycle. Uranium holdup on such a bed is only about 0.03% of that processed. (AEC Activity 4109.81)

HRP Fuel and Blanket Studies - A fully enriched $UO_3 \cdot H_2O$ platelet slurry containing 40 grams of uranium per liter was irradiated at a flux of 7×10^{11} n/cm^2-sec. for four weeks at a temperature of 250-295°C. Only 30% of the original slurry was easily removed from the test bomb, and examination showed the remainder to have plated out on the interior surfaces of the bomb. (AEC Activity 4112.31)

AIRCRAFT NUCLEAR PROPULSION PROJECT

ANP Experimental Engineering - Three Inconel thermal convection loops in which the fluoride mixture $NaF-ZrF_4$ (50-50 mole %) was circulated at a maximum temperature of 1500°F have been examined. The top "hot-leg" section of one loop which operated for 500 hrs exhibited slight corrosion, with a maximum penetration of 0.008", while the lower section was essentially unattacked. When ZrH_2 was added to this same fluoride in a second loop the maximum penetration in the hot-leg was only 0.0015" after 500 hrs. One loop was operated for 1000 hours with the same fluoride mixture and showed a widely scattered attack with a maximum penetration of 0.005". Two loops of 316 stainless steel circulated the ARE fuel, $NaF-ZrF_4-UF_4$ (50-46-4 mole %) for 500 hours without plugging. The first of these loops to be examined had a very rough hot-leg surface, with sub-surface voids to a depth of 0.011", and contained a heavy metallic-appearing deposit in the cold-leg.

Tests of the ARE pump with a frozen sodium seal were terminated because of excessive oxygen contamination of the sodium in the loop. The loop has been cleaned and the pump reassembled. An alternate type of pump, with gas-face seal, has been subjected to preliminary tests using water instead of the ARE fuel. These tests indicate that when the surge tank is also the pump sump, degassing of the fluid can be accomplished in a matter of minutes, and that such a pump will operate with a sump volume of less than 1/2 cu ft.

A two-stage electromagnetic pump was tested with NaK over the temperature range of from 750°F to 1500°F. Maximum NaK flow was 94 gal/min. This test was discontinued because of failure of a brazed joint in the secondary winding of the pump.

The Durco pump with the combination packed-frozen seal, using powdered graphite as the packing material, circulated the ARE fuel for more than 300 hours at 1200°F. The pump was shut down because of the failure of the pump drive mechanism. Leakage of solid material from the seal averaged approximately 25 gm/day, which is in excess of that experienced in previous tests. Pump operation was smoother in this test than in previous tests.

The ARE valve, constructed of Inconel with the shaft seal consisting of a 4-ply Inconel bellows, has been under test for several hundred hours with the ARE fuel at 1100° to 1500°F. Valve seat sticking and excessive fuel leakage was experienced at the higher temperature, but operation at the lower temperature was satisfactory.

The bi-fluid heat transfer loop has operated for approximately 1000 hours with data being taken for overall heat transfer from ARE fuel to NaK. Overall heat transfer coefficient for heat fluxes of 300,000 to 500,000 Btu/hr-ft^2 has varied from 1000 to 2500 Btu/hr-ft-°F. The maximum temperature of the fuel was 1400°F, with a 40°F maximum temperature drop.

The mock-up of the ARE fluid circuit has been operated with water, water-glycerine solution, and acetylene tetrabromide. This mock-up with two pumps operating in parallel has revealed some of the operational difficulties, such as vortexing and oscillations, which would otherwise have been encountered in the actual operation of the ARE. These difficulties have been corrected and it has been demonstrated that stable operating conditions can be obtained for such a system.

A test was conducted to determine the compatibility of molten lead and the ARE fuel in intimate contact at 1500°F. No mixing of the two fluids was in evidence after they had been stirred together for 24 hours. It appears that a sharp molten lead--molten fluoride interface exists at all times. It should, then, be feasible to seal fluorides with a frozen lead seal above which there is a molten lead--molten fluoride interface.

Present work on the development of mechanical face seals for high temperature operation has consisted mainly of materials' compatibility tests at elevated temperatures. The most promising materials tested to date are silver-impregnated graphite against 316 stainless steel.

The most effective packed seals developed to date have been those packed with graphite and with Inconel braid impregnated with MoS_2. These have been operated as combination packed-frozen seals but the leakage rate has in some cases been in excess of 25 gm/day. One test of a graphite packing operated well above the fluoride melting temperature with no apparent leakage, and post-run examination failed to reveal penetration of fluorides into the graphite.

The fluoride production facility in Building 9928 has routinely produced fluoride mixtures for experimental purposes in batches ranging from 2 kg to approximately 25 kg. The process treatment for fluoride mixtures has been altered to bring about a more thorough removal of HF from the fluorides and has reduced the HF concentration to 4×10^{-4} moles/liter of stripping gas. The fluoride production facility in Building 9201-3 is nearing completion, and the installation of process equipment has begun; a tentative operating date of March 16 has been established. The process of converting the low hafnium-bearing $ZrCl_4$ to ZrF_4 for use in ARE fuel has been completed and the equipment has been put in stand-by for use in case there is further need for ZrF_4 production. (AEC Activity 4401.1)

Aircraft Reactor Experiment - The serpentine fuel tubes have been received, tested, and are being welded together in the reactor core. All shop work on reactor control components is complete and assembly of the control mechanism was started in Building 7503.

The fuel heat disposal systems are completely installed except for fuel lines, but the sodium heat disposal systems are only 50% installed. Three sections of fuel piping have been fabricated and are ready for installation. The bellows-type valves for the fuel and sodium systems are beginning to arrive from the Fulton Sylphon Company. The first two fuel valves are ready for installation. Check valves and solenoid gas valves are being tested in Building 7503 prior to installation. Pump seal parts await the results of final experiments in Building 9201-3.

Both stand-by motor generator sets have been received and tested. Heaters have been installed on three fill and flush tanks for the fuel carrier, and installation of the heater control panels for the entire experiment is complete. Instrument pneumatic piping is 98% complete and some thermocouple leads have been installed. The control room is complete except for inter-connection of the various units. (AEC Activity 4401.1)

Critical Experiments - In the first critical mockup of the reflector-moderator fluid fuel-coolant reactor, enriched uranium and metallic sodium were placed in a 3" thick layer around a 12" beryllium core and were surrounded, in turn, by a beryllium and graphite reflector. Uranium pieces 0.02" thick were placed between canisters of sodium, resulting in a self-shielding from fission neutrons of about 34% and thereby requiring about 15 kg U^{235} for criticality to be reached. In a second assembly, more nearly approximating the proposed reactor, uranium tetrafluoride was mixed with sodium and zirconium fluorides as a homogeneous powder having a uranium density of about 0.2 gm/cc. This material was loaded in aluminum containers and placed in an annulus between the central and peripheral beryllium. The critical mass for this assembly was 7.7 kg U^{235}.

The results of neutron flux measurements in the two assemblies are comparable and agree with those predicted by multi-group reactor theory calculations. The neutron flux is high in the beryllium core, falling off in the fuel layer, rising again in the reflector, and then decreasing towards

the edge of the reactor. The fraction of these neutrons detected by indium and lying below the cadmium cut-off is 47% in the core center, 15% in the fuel, and approaches unity in the reflector. About 70% of the fissions are produced by thermal neutrons.

A critical mockup of a uniform-flux type of reactor has been assembled and is being tested. Theoretical considerations indicate that an appropriate radial distribution of fissionable material in the moderator of a reactor will yield a uniform radial thermal neutron flux. It is further predicted that the uranium investment with this concentration gradient is less than that required for any other fuel distribution. The project is of interest in the design of certain reactor types in that uniform power distribution and, hence, uniform fuel burn-up may be possible.

The theory has been applied to cylindrical geometry and the necessary materials and equipment for initial tests have been procured. The reactor vessel consists of a central cylinder, 4.3" in diameter, surrounded by four annuli, each about 1" thick. Aqueous solutions of an enriched uranium salt, differing in concentration, are placed in these four annuli and the system made critical by adding an infinitely thick water reflector in the fifth annulus. The liquid height and uranium content (about 1 kg U^{235}) at the critical condition are in close agreement with the predicted values. (AEC Activity 4401.2)

Radiation Damage - Two Inconel capsules containing the ARE fuel were examined after irradiation in the MTR at 2700 watts/cc for 116 and 325 hours. In both cases, portions of the capsule walls attained temperatures well above 1500°F. There were indications of changes in the fuel composition, and corrosion occurred in excess of that which took place in control capsules at 1500°F. A third irradiation is now in progress in the MTR with a more elaborate control system designed to hold the maximum wall temperature at 1500°F.

Additional in-reactor cantilever creep measurements on Inconel, in air, in both the graphite reactor and the LITR confirm previous observations that the irradiation had little effect on the creep rate. (AEC Activity 4401.4)

Reactor Chemistry - The installations for preparation of the ARE fuel solvent ($NaZrF_5$) and of the ARE fuel concentrate are now in advanced construction stages. Final processing plans may still be revised to improve the corrosion behavior of the fuel; the equipment at hand is sufficiently flexible to accomodate all reasonable processing changes.

Small amounts, less than 1%, of either ZrH_2 or NaK in the ARE fuel materially reduce the observed corrosion rate. High temperature filtration studies as well as petrographic examinations have shown that the ARE fuel will tolerate up to 0.7% by weight of ZrH_2 or up to 0.3% by weight of NaK without precipitation of UF_3 at the operating temperatures of the reactor. While ZrH_2 markedly reduces corrosion by the fuel solvent ($NaZrF_5$), it apparently is not soluble in this liquid. By passing hydrogen through

ARE fuel solution at 800°C, UF_4 is reduced slowly to UF_3; nickel fluoride is reduced to metallic nickel, which can subsequently be removed by filtration; and ferric fluoride is probably reduced to the ferrous compound but is certainly not reduced to metallic iron.

Removal of HF from the processed fuel by "stripping" with helium has been shown to be practicable and rapid if adequate precautions are taken to insure that HF is previously removed from the cool lines, valves, and traps. The mechanism of stripping involves a first order reaction and at 800°C the "half life" of HF in the 5-pound scale apparatus is about 10 liters of strip gas.

Filtration of a mixture of BeO in NaK through sintered nickel filters has indicated that BeO is "soluble" in NaK to the extent of 10 ppm and 120 ppm at 30°C and at 700°C, respectively.

Petrographic examinations of specially prepared mixtures have resulted in the tentative identification of a red-orange phase found in some reduced fuels as $UF_3 \cdot 2ZrF_4$ and an olive-drab phase (refractive index 1.564) as $UF_4 \cdot UF_3 \cdot 4ZrF_4$. (AEC Activity 4401.5)

Corrosion Studies - Corrosion of Inconel capsules by the standard ARE fuel mixture ($NaF-ZrF_4-UF_4$, 50-46-4 mole %), with and without added zirconium hydride, was examined as a function of exposure time. In these tests, which made use of the rocking furnace at a maximum temperature of 800°C and a 150°C temperature differential between the ends of the capsules, metallographic examination revealed that the corrosion was materially reduced by the presence of 0.5% ZrH_2. The corrosion was greatest during the first hundred hours and continued very slowly in the interval from 100 to 500 hours.

Tests with structural metal fluorides added to the fuel showed that both NiF_2 and FeF_3 were reduced during the exposure with consequent increase in corrosion and with increased leaching of chromium from the Inconel wall. Addition of ZrO_2 did not affect the corrosion rate observed.

Addition of HF as $NaHF_2$ to the ARE fuel had little effect on the corrosion observed when as much as 0.04% of HF was present. Large additions (0.1 and 0.3%) resulted in considerably increased corrosion severity and increased depth of penetration. (AEC Activity 4401.5)

Metallurgy - Samples of molybdenum and niobium have been suspended in molten lead circulating in quartz thermal-convection loops for 300 and 500 hours with a temperature gradient of 400°C without the appearance of mass transfer. The quartz loops in which Inconel and 304 stainless steel samples were suspended plugged in less than 100 hours operation.

The creep rate of Inconel samples that were pre-oxidized for 200 hours at 815°C then subjected to stress-rupture tests was about the same or less than for control specimens. Shot-peened Inconel specimens had a markedly decreased creep rate when tested in air and in argon. It has been found that large grained Inconel is not as sensitive to changes in the test environment as the fine grained material.

Six tube bundles, each consisting of 70 tube-to-header welds, for a test heat exchanger have been completed by inert arc welding. Six leaks in the 420 welds were detected by a helium leak test and were repaired.

Other studies include the production of ingots of high purity Inconel and the hot pressing of pump ring seals. The Inconel ingots were produced in the vacuum induction furnace and then extruded into rod and tubing for the evaluation of their corrosion resistance. Pump face-seal rings of copper and silver, with additions of 14% MoS_2 by volume, have been hot pressed. (AEC Activity 4401.5)

Heat Transfer and Physical Properties Research - The heat capacity of strontium hydroxide was found to be 0.32 ± 0.03 cal/gm-°C over the temperature range 570 to 900°C. The heat capacity of the fluoride mixture, $NaF-ZrF_4-UF_4$ (50-46-4 mole %), was found to be 0.31 ± 0.03 cal/gm-°C, over the temperature range 550° to 850°C.

Preliminary viscosity measurements on molten sodium hydroxide were found to vary from 4.6 centipoise at 340°C to 2.5 centipoise at 448°C.

A mathematical heat transfer analysis has been completed which can be used to minimize the weight of a radiator for a given power output by optimizing the fin spacing, fin thickness, tube diameter, and tube spacing for plate-fine radiators operating in the laminar flow region. (AEC Activity 4401.5)

Shielding Research - A mockup of a unit shield for the "Fireball" reactor being tested in the LID tank consists of a beryllium reflector, a heat exchanger, a boron layer, a pressure shell, and layers of lead and water. The fluoride-to-sodium heat exchanger was simulated by steel sheets and powdered sodium fluoride; sheets of boron were added to avoid activation of the sodium. The pressure shell is simulated by an iron layer, and outside of this are several layers of lead. The effect of adding boron to the water is being explored, and the optimum configuration of lead is also being determined. Although results are not yet complete, indications are that the shield will be lighter than any unit shield heretofore contemplated. This is a direct result of the small volume (22-cm radius) to which the fissions are to be confined.

A very brief experiment was performed in the LID Tank to determine the effect of a lead shield on the reading of a fast neutron dosimeter. A small hemispherical shield of lead 7 in. thick was mounted in the tank, centered on the source axis, and the dose immediately behind it was measured with a Hurst-type dosimeter. Comparison of this reading with that obtained when the lead shield was removed indicated that 7 inches of lead reduced the fast neutron dose by a factor of 3.

An experiment was performed last summer in the Bulk Shielding Facility to measure the air-scattered radiation which enters the side of a crew shield in a divided shield design. In this experiment the water was lowered in

the pool, to simulate the side shield on an aircraft reactor. Some distance away a lead box containing instruments was positioned a short distance beneath the water surface, thus representing a shielded crew compartment. This experiment has recently been repeated in order to clear up some anomalies. Conclusions now are that the structure in the pool does not contribute significantly to the scattered dose; the contribution of gamma rays is somewhat higher than expected, and that of neutrons somewhat lower. The results of the experiment support, insofar as comparison is possible, the estimates of the over-all shield weight given in ANP-53, the Report of the Shielding Board (1950).

The irradiation of monkeys in the Bulk Shielding Facility (BSF) was completed and the animals were returned to the U. S. Air Force Aviation School of Medicine for observation. It is to be hoped that the threshold for formation of eye cataracts has been bracketed by this series of experiments, and if so, this will afford a much clearer basis for choice of military tolerance dose than has heretofore been available. The results will not be forthcoming for some time since the experiment is designed to determine cararact formation during a lifetime rather than in the period immediately following exposure.

In some preliminary tests satisfactory resolution was achieved with the fast neutron spectrometer, with the measurements being made in the first 30 cm of water shield around the BSF reactor.

A preliminary design of the Tower Shielding Facility as proposed by the firm of Knappen-Tippets-Abbett-McCarthy, architectural engineers, was accepted by the Laboratory in late January. Four vertical towers 315 ft. high are held in place by guy cables. Two 100-ft. trusses connect each pair of towers at the top. Hoists attached to the trusses, to be used to lift the reactor and the crew compartment, are so arranged as to afford adequate freedom in positioning. The reactor design is nearly complete, and some of the control components have been built and tested. (AEC Activity 4401.7)

GENERAL REACTOR RESEARCH

General Reactor Radiation Damage - A density change in diamonds as a function of position in the LITR has been established. The rate of change diminished rapidly when the exposure reached a level of approximately 7 x 10^{19} nvt. The total flux as well as the fast flux is important to the expansion properties of diamond.

X-ray diffraction patterns of quartz, disordered by a 6.6 x 10^{19} nvt exposure and then annealed at 900°C, show a re-ordering of the structure insofar as normal lattice parameters are concerned. However, a small residual disorder or strain exists in the crystal structure despite the high temperature treatment.

The density change of quartz, exposed to 1.35×10^{20} nvt, was found to be -12.4% by the hydrostatic method.

Before-after irradiation studies of graphite-UO_2 bars indicate that resistivity changes induced by neutron bombardment anneal out much more readily than changes caused by fission fragments. Fission fragment damage to the graphite structure builds up much more rapidly than neutron damage and, according to present experimental evidence, probably reaches an equilibrium value. (AEC Activity 4540)

Idaho Chemical Plant - The Idaho Plant is now operating successfully at 0.08% of rated capacity. A decontamination factor of 7.7×10^4 was obtained for the first solvent extraction cycle and after two cycles the product met specifications (radioactivity). The activity level in the feed solution will be gradually increased from now on until full production level is obtained. (AEC Activity 10543)

PROGRAM 5000 - PHYSICAL RESEARCH

ISOTOPE PRODUCTION

Stable Isotope Production - Three elements, lithium, boron and palladium, were processed in the calutron during the month, with nine isotopes being collected. Palladium was processed for the first time. For this run a novel type of source was used in which palladium metal was vaporized from a tantalum boat placed in the arc chamber and heated by bombardment with electrons from an auxiliary filament.

Chemical refinement of tin, lithium, and neodymium samples was completed. Progress was made in the refinement of isotopes of neodymium, sulfur, tin, and lithium. Twelve shipments and transfers of isotopes were made. (AEC Activity 5121)

PHYSICS

Short Period Activities - Evidence has been obtained for two nuclear reactions involving tritium by neutron irradiation in the ORNL graphite reactor of Li compounds enriched in Li^6. The fast tritons from the reaction $Li^6(n,\alpha)H^3$ interact with the nuclei in the same sample in which the tritons are produced, giving rise to short period radioisotopes which are detected after the sample is ejected rapidly from the reactor by means of the ORNL fast pneumatic tube.

In particular, the 0.8-sec Li^8 from the reaction $Li^6(H^3,p)Li^8$, previously discovered when Li^6 was bombarded by tritium ions accelerated in the high voltage apparatus, has been identified in neutron-irradiated LiF and Li_2SO_4

enriched in Li^6. It can be distinguished from the Li^8 produced by the $Li^7(n,\gamma)Li^8$ reaction only by noting how the intensity of the activity varies with the relative isotopic abundance. In the case of highly enriched Li^6F the 0.8-sec activity is over ten times as great as could be ascribed to the $Li^7(n,\gamma)Li^8$ reaction on the small amount of Li^7 present in the sample.

In samples of neutron-irradiated LiF, a new radioisotope of half life 5 ± 1 sec was found. It was present in samples containing both Li^6 and F, and was not found when Li^6 or F were irradiated separately. Since the intensity varies directly with the relative abundance of Li^6 in the sample, it may be attributed to a triton-produced reaction. Of the energetically possibly nuclear reactions of tritons with F, the only one which appears consistent with these data is the reaction $F^{19}(H^3,p)F^{21}$, producing a new radioisotope of F. The semi-empirical decay energy of F^{21} is about 4 Mev, implying according to beta decay theory a half life of about 10 sec. This value is in excellent agreement with the observed half life. (AEC Activity 5211)

High Voltage Program - The 5.5 Mev Van de Graaff accelerator has been reassembled in its permanent location and is now operating satisfactorily. Preliminary experiments have been completed to determine the feasibility of using an electrostatic "strong focusing" lens system [Courant, Livingston, and Snyder, Phys. Rev. 88, 1190 (1952)]. With an experimental system a well-focused beam was obtained on a target 24 feet from the magnet. A permanent focusing system is now being constructed.

In preparation for an experiment to determine neutron energies in the range from 1 to 10 Mev by "flight time", a study was made of magnetic focusing schemes for obtaining time-bunching of the beam from the Van de Graaff accelerator. By a generalization of the ideas of Hintenberger (Rev. Sci. Inst. 20, 748 (1949), it has been found possible to devise field shapes which give perfect plane focusing for a fairly wide acceptance angle and which have the additional property that the path length from focus to focus is a predetermined function of the angle at which the ray leaves the source. It is thus possible to use (for example) a linear or a sinusoidal voltage on deflector plates which sweep the beam across the focusing magnet and thus obtain perfect time-bunching, barring the effect of the fringing field.

Work is continuing on the 2 Mev Van de Graaff to determine (p,n) thresholds for several isotopes of medium mass number. The threshold of Ge^{73} was found to be 1207 ± 10 kev. Preliminary measurements were made on Ca^{48}, Ge^{76} and Ga^{71} but the neutron yield for these isotopes was lower than for those previously reported. In order to increase the neutron counting rate, an attempt is being made to increase both the proton current and the counter sensitivity. In this connection a stainless steel screen has been installed to collect the up-charge from the belt. (AEC Activity 5211)

Scintillation Spectrometry and Instrument Development - Investigations have continued with the purpose of obtaining better energy resolution in large sodium iodide scintillation crystals. For a crystal 3 inches in diameter and 3 inches thick, a peak on the curve of intensity vs. energy with a resolution of 9½% (full width at half maximum) has been obtained in response to the 0.661 Mev gamma ray of Cs^{137}. This improved resolution was obtained using α Al_2O_3 as a reflector for the crystal.

Many materials, both white powders and metallic films, were investigated to find the best reflectors. Measurements of reflectivity were made with a diffusion spectrophotometer designed for this purpose. In the emission wave length range of the NaI crystals (3200 Å to 5000 Å), MgO and α Al_2O_3 were found to be superior to the other materials. MgO is not desirable because it seems to react chemically with the crystal.

The total gamma-ray absorption coefficients of sodium iodide have been measured for gamma-ray energies ranging from 0.141 to 1.114 Mev. Measurements were made on thick absorbers, which were surrounded by hydrogen to reduce effects of small angle scattering by the atmosphere, and a scintillation spectrometer was used to measure the primary and undegraded radiation falling on the detector. Throughout the entire energy range, total absorption coefficient values were obtained which are several per cent lower than those obtained by the National Bureau of Standards.

Additional instruments have been completed for the new multi-channel analyzer. This analyzer is expected to give greater precision and accuracy than previous multi-channel analyzers, and it will be used for general pulse height analysis. A more accurate sliding pulse generator with a differential linearity of 0.1% has been constructed for calibration and adjustment of the analyzer, and a sub-miniature scaling unit with a total power demand of only 0.6 watts for a complete scale of 16 has been developed. (AEC Activity 5211)

Short Lived Isomers - A fast coincidence spectrometer employing sodium iodide detectors has been developed for both immediate and delayed gamma-ray coincidences. For gamma-rays of a few hundred kev, a time resolution of $2\tau = 8.8 \times 10^{-9}$ seconds with no loss of coincidences has been realized using the fast-slow coincidence principle. The trailing edge of a time resolution curve for prompt events has a slope corresponding to a half-period of 5×10^{-10} seconds. Under these conditions nuclear metastable states with half lives $T_{1/2} > 10^{-9}$ seconds are measurable.

The K-shell internal conversion coefficients (ratio of the number of K-shell internal conversion electrons to the number of gamma-ray photons) of certain gamma rays have been measured with this fast coincidence spectrometer. These coefficients, α^K_{exp}, together with the classification of the gamma radiation determined from them, are listed in the following table.

Nucleus	β-ray Energy	α^{K}_{exp}	Classification
Ta^{181}	132 kev	0.48 ± 0.02	E2
Ta^{181}	135 kev	1.88 ± 0.10	M1
Ir^{191}	128 kev	2.07 ± 0.10	M1 + E2

(AEC Activity 5211)

Angular Distribution of Gamma Rays - The angular correlation of 1.17 Mev and 1.33 Mev gamma rays emitted in cascade from the excited states of Ni^{60} has been measured at increments of 10° from 90° to 270° with automatic apparatus using sodium iodide detectors and 5819 photomultipliers. For a dilute $CoCl_2$ solution source, the correlation obtained from a total of about 2×10^6 coincidence counts was $W(\theta) = 1 + (0.131 \pm 0.017) \cos^2\theta + (0.024 \pm 0.017)\cos^4\theta$. The theoretical correlation, taking into account the finite resolution of the apparatus, is $W(\theta) = 1 + 0.1203 \cos^2\theta + 0.0314 \cos^4\theta$. The observed anisotropy, $\alpha_2 + \alpha_4/\alpha_0 \equiv R$, where $W(\theta) = \alpha_0 + \alpha_2 \cos^2\theta + \alpha_4 \cos^4\theta$, was 0.1557 ± 0.0010. The theoretical value of R is 0.1517.

In one experiment a change in the anisotropy to a value of 0.1453 ± 0.0023 was observed due to a chemical change in a source in which the liquid apparently disappeared. This observed change is surprising since the first measurements of the lifetime of the intermediate state in the cascade are of the order of 10^{-11} seconds. With this short life time one would expect that the correlation would be unperturbed by external fields. However, with a dilute solution source of $CoCl_2$, the anisotropy of the cascade does not appear to be attenuated by external effects. (AEC Activity 5211)

86-Inch Cyclotron Nuclear Physics - The experimental results of studies on the angular distribution of deuterons from the reaction $Be^9(p,d)Be^8$ (ground state) indicate that the reaction proceeds by "neutron pickup." The nature of this reaction is of especial interest because it provides the necessary "link" for the parities and spins of several nuclear states. Evidence was obtained for the "double neutron pickup" (p,t) reaction on niobium, which has two neutrons outside of a "closed shell." Excitation functions for the (p,t) reactions in beryllium and iron were measured to obtain further information on the (p,t) reaction. The measurement of the excitation functions for (p,αn), (p,α), and (p,pn) reactions in several elements failed to support a recent proposal by Wheeler that coulomb barriers are lower in the decay of a compound nucleus than in its formation. The deuteron yield from proton bombardment was measured and found to be too small to contribute appreciably to the apparent yields of (p,pn) reactions, as proposed by Weisskopf.

A new isotope, Dy^{157}, produced by the Tb^{159} (p,3n) reaction, was identified; it decays by K-electron capture with a half life of 8.2 hrs. Several other new isotopes have been tentatively identified in preliminary surveys. A liquid flow system for measuring short half lives of isotopes produced in the 86-inch cyclotron was put into operation and found to be easily capable of measuring half lives shorter than one second. (AEC Activity 5211)

86-Inch Cyclotron - For the detection of short-lived radioisotopes, a solution of the target element can now be pumped through an Inconel tube target in the cyclotron; the solution also acts as the coolant. A sample of the solution is trapped as it leaves the machine and is immediately counted. With this arrangment, isotopes having half lives of less than one second can be detected.

Over 90 separate bombardments were made during the month of February. New bombardments included the exposure of pregnant female mice to fast neutrons for the Biology Division, and a bombardment of Sn^{112} for the production of In^{111} for the ORINS Medical Division. (AEC Activity 5261)

Fundamental Electromagnetic Research - A new type of mass spectrograph, the apotron, is being developed for separation of isotopes of the lighter elements. In the apotron, closely-spared grid-type ion source electrodes, curved to provide beam focusing, accelerate ion currents exceeding 0.5 ampere per square inch of ion source area. The construction of a development model, mounting six apotron units (source and collectors) in one vacuum chamber, is 60% complete. In the preliminary testing of a single apotron unit steady ion beams in excess of two amperes have been measured in the ion collector. A newly designed electron dumping system which requires one-half the space required by the former system is very effective in reducing electron oscillations in the region of the ion source. (AEC Activity 5261)

Electro-Nuclear Machines - The design of modifications required for increasing the energy of the 44-inch experimental cyclotron to 5 Mev is 50% complete. A design study for the deflection of the beam in the 86-Inch cyclotron was completed; it was found that the effective beam center in this machine could be controlled by means of "half coils" mounted on the magnet pole pieces. The preliminary study for a proposed variable energy cyclotron was completed. (AEC Activity 5261)

Isotope Analysis Methods Laboratory - Equipment with a resolution approaching 1 part in 700,000 has been used for studies of the hyperfine structures of U^{235}. The quadrupole "smearing-out" of the pattern is still too great to permit unique resolution of all components. Spectro-isotopic standards of lithium have been established in the concentration range, 0.1% to 99% Li^6. Echelle spectrographic studies of impurities in uranium indicate that Ru, Ir, Rh, and Pt may be detected at concentrations as low as 50 ppm but that Ta and W are detected with difficulty even at 2000 ppm. A scintillation counter (NaI-Tl) has three times the noise and only 70% the counting rate of the proportional counter for X-rays under present operating conditions. A study of the operation of calutron filaments has resulted in a significant improvement of filament life but at some sacrifice of ion beam. During the month 2,628 spectrochemical, 64 spectro-isotopic and 70 X-ray analyses have been made of reactor materials, corrosion products, stable isotopes, rare earths, and special assays. The tables of Nuclear Magnetic Moments are being corrected for final issuance as ORNL-1469. (AEC Activity 5261)

Mass Spectrometer Laboratory - A synthetic sample of purified uranium tetrafluoride (UF_4) and uranyl fluoride (UO_2F_2) was investigated in the mass spectrometer to test our "time-integral" method of analysis for UO_2F_2 which often appears as a contaminant in UF_4. The prepared sample contained 1.23 mole per cent of UO_2F_2 and the experimental value obtained was 1.4 per cent. This result is well within the expected range of accuracy. This method of analysis is based in part on our previous discovery that UO_2F_2 reacts with UF_4 in the mass spectrometer to generate uranium pentafluoride (UF_5). (AEC Activity 5261)

63-Inch Cyclotron Physics - Efforts were made to increase the magnitude of the deflected beam of nitrogen ions by altering the deflector and septum arrangement. Relative measurements of the deflected ion beam were obtained with a scintillation screen-photo cell arrangement. Work is continuing on the analysis of nuclear emulsions which were exposed to the internal beam prior to the beam deflection studies. (AEC Activity 5261)

Stable Isotope Neutron Cross Sections - The thermal neutron capture cross section of Th^{230} (ionium), as measured with the ORNL pile oscillator, is 26 $\pm$ 2 barns. Gold (σ_t = 95 barns) was used as the standard for comparison. The sample consisted of 335 mg of ThO_2 separated at Y-12 by electromagnetic methods from an enriched source of material, supplied by the Argonne National Laboratory, and assaying 87.85% Th^{230} and 12.15% Th^{232}. Chemical impurities, known spectrographically, accounted for 1.5% of the sample's capture cross section.

Research and Development, Stable Isotopes - In continuing the work on lithium metal preparation, investigations of reduction techniques led to the proposal of two new procedures: (1) a batchwise process in which large amounts of LiCl are used to purify previously reduced metal, then this same LiCl is utilized as charge material for a subsequent reduction; (2) a continuous countercurrent procedure in which LiCl is introduced and lithium metal removed at one end, and Ba metal introduced and $BaCl_2$ removed at the other end of the reactor. Both methods give higher purity lithium metal than that obtained previously. A distillation procedure for further purification of lithium metal to > 99 per cent was also worked out.

In an investigation to try to determine definitely if the vortex principle, as exemplified by the Hilsch tube, is advantageous for isotopic separation, an apparatus for recycling gases through a Hilsch (vortex) tube was set up, and two pieces of equipment (viscometers) for analyzing the gases were built.

CHEMISTRY

Inorganic Solution Chemistry - In recent studies the anion exchange behavior of Au(III) and iridium (probably Ir(III)) in hydrochloric acid solutions (1 to 12 M) was determined. Gold is very strongly adsorbed on

Doxex-1 with distribution coefficients of about 10^6 in 2 M HCl and 6×10^3 in concentrated HCl. Ir(III) is reasonably strongly adsorbed in 1 M HCl and negligibly adsorbed in concentrated HCl. Because of this unusual property, it can readily be separated from most adsorbable elements in the periodic table, including palladium and platinum.

The adsorbability of Hg(II), which had been studied earlier, was rechecked and the results were found to agree closely with the previous results. Hg(II) is strongly adsorbed throughout the whole experimental range, (distribution coefficient $D = \sim 8 \times 10^4$ in 1 M HCl, $D = \sim 50$ in 12 M HCl).

Further data on the adsorption of gallium were obtained and a theoretical analysis of anion exchange behavior in concentrated electrolyte solution carried out. The fraction $(GaCl_4^-)/m_{Ga}$ (where m_{Ga} is the total gallium concentration) for the aqueous phase was found to change from $\sim 10^{-7}$ in 1 M HCl to ~ 1 in 7 M HCl. The probable equilibrium involved is $GaCl^+ + 3\ Cl^- \longrightarrow GaCl_4^-$ with a stability constant, near μ (ion strength) = 1, of $\sim 10^{-7}$. (AEC Activity 5311)

Chemical Physics - Apparatus was assembled and tested for studying the reaction between a molecular beam of potassium atoms and an effusive stream of HBr molecules. Scattered reactants as well as reaction products (KBr) are to be measured as a function of angle by a combination of two methods--a surface ionization gage for potassium and neutron activation of collected deposits for bromine. During this period it was found that the use of two surface ionization gages, one with a tungsten wire and one with a platinum wire, allowed discrimination between free and combined potassium. As a result, the number of activation analyses can be reduced to only those required for calibration of the surface ionization gages and some special analyses.

The chemical development for the microwave problem of determining the nuclear moments of 8.0d I^{131} by observing the rotational spectrum of CH_3I is now essentially complete. A method, purifying carrier-free 8d I^{131}, was developed and a satisfactory test experiment with 100 mC of activity was completed. An experiment with 750 mC I^{131} was unsuccessful because of radiation-chemical effects. Further experiments indicate that the adverse radiation effects can be minimized, and additional full scale experiments will be undertaken soon.

Neutron diffraction data were obtained for the a and b zones of oxalic acid dihydrate; a Fourier projection on the a face disclosed that the hydrogen atoms are ordered, one being situated in each carboxyl group and two in each water molecule. The neutron scattering amplitudes of natural Tl and its isotopes have been measured, from diffraction data on thallous bromide, to be 0.61 for Tl^{203}, 0.91 for Tl^{205}, and 0.82 for natural Tl (preliminary values at room temperature uncorrected for temperature effects). (AEC Activity 5311)

Chemistry of the Solid State - The study of solutions of alkali metals in their molten halides has led, during this period, to the determination of the solubility of sodium in molten sodium chloride as a function of temperature between 850 and 950°C, where it increases from 15 to 25 mole per cent. The solubility of potassium in potassium fluoride was found to be 16 mole per cent at 880°C and 22 mole per cent at 905°C. The comparatively rapid increase in solubility with temperature is thought to be connected with structural changes in the molten salts.

During a search by means of the high temperature X-ray spectrometer for solid phase transitions, an apparently anomalous type of an anisotropic thermal expansion was observed in the high temperature crystal modification of plumbous oxide. Thermal expansion was found to be far greater in one direction within the atomic layers of the layer lattice-type structure than in the direction perpendicular to these layers. Pending confirmation by neutron diffraction of the crystal structure of plumbous oxide, this observation may be explained by the nature of the chemical binding between strongly polarizing anions such as oxygen and highly polarizable cations such as bivalent lead. The absence of a similar effect in the low temperature form of lead oxide and in the isostructural compounds, stannous oxide and lithium hydroxide, might be connected with the higher ionic coordination, i.e. 4 instead of 3 nearest neighbors, with resulting smaller polarization. (AEC Activity 5311)

Radio-Organic Chemistry - A new, inexpensive, continuous, fractional extraction apparatus was designed and used, for the quantitative separation of acetic and propionic acids. It is hoped that other mixtures of aliphatic acids may also be separated by this method.

It was demonstrated by mass-spectrographic, infrared, and tracer techniques, that methanol-C^{14} decomposes under self-irradiation to produce hydrogen, methane, ethylene glycol, glycerol, and erythritol, $(CHOH \cdot CH_2OH)_2$.

Two commonly used organic reactions were shown to proceed with normal carbon isotope effects. Thus, stilbene-α-C^{14} ozonized in the presence of 2,4-dinitrophenylhydrazine yields the diphenyl ketone-C^{14} derivative at a rate which is 0.958 as fast as that by which unlabeled stilbene is converted to the unlabeled diphenyl ketone derivative. The rate constants for the hydrogenation of stilbene-α-C^{14} and stilbene to dibenzyl-α-C^{14} and dibenzyl are in the ratio of 0.98. Similar rate constants for the hydrogenation of aceto-1-C^{14}-phenone and acetophenone to their respective carbinols, are in the ratio of 0.88. Aceto-1-C^{14}-phenone is converted to methyl phenyl carbinol-C^{14} by lithium aluminum hydride with an isotope effect which is the same as that reported for the catalytic hydrogenation. The nearly identical results for these two cases suggest that the isotope effect during catalytic hydrogenation is a chemical rather than a physical phenomenon.

The pinacol rearrangement of 2-bromo-1,1,2-triphenylethanol-1-C^{14} was shown to occur with 100 percent phenyl migration.

The preparation of a number of compounds labeled with P^{32} was undertaken to assist the process group at Y-12. Particular interest was placed in the estimation of the solubility and distribution of these compounds when applied to the extraction of low concentrations of uranium from solutions of ores containing much higher concentrations of other elements (iron, aluminum, sulfate and phosphate).

The first of these compounds was prepared and tested. Di(2-ethylhexyl) phosphinic acid-P^{32}, dissolved in decane, was contacted with aqueous solutions that simulated process solutions. The loss of phosphinic acid to the aqueous solution was nearly always less than 10 mg. per liter. These low losses are sufficiently encouraging to warrant further developmental testing.

Water dissolved 15 mg. of the phosphinic acid per liter while normal solutions of sulfuric or hydrochloric acid dissolved less than 3.5 mg. per liter. (AEC Activity 5311)

Radiation Chemistry - The radiation-induced formation and disappearance of hydrogen peroxide in ice is being investigated as a function of total radiation exposure, temperature, concentration and the presence of dissolved gas and other solutes. The initial rate of disappearance of hydrogen peroxide, in hydrogen-saturated ice containing hydrogen peroxide, increased with temperature in the range from -175°C to -5°C. A sevenfold increase in rate occurred between -100°C and -50°C. At -196°C, the H_2O_2 concentration first decreased with increasing radiation exposure, but for longer periods of irradiation the H_2O_2 concentration increased again. The initial rate of peroxide disappearance at -196°C increased with greater initial H_2O_2 concentration. When a sample was subjected to several short irradiations, the observed final concentration of H_2O_2 was less than that for an equivalent irradiation with the sample held at -196°C. We interpret this increased disappearance of peroxide on intermittent warming as a reaction induced by release of energy stored during irradiation at -196°C. (AEC Activity 5311)

Chemistry of Fused Salts - The determination of the low temperature heat capacity of crystalline boron nitride was completed. The very significant discovery was made that this substance shows a T^2 dependence of its heat capacity up to 65°K, rather than following the usual Debye T^3 law. This behavior is attributed to the layered lattice structure of boron nitride. Similar results have been obtained by others for graphite, which has a crystal structure and lattice parameters very much like boron nitride, with which it is isoelectronic, and gallium, but boron nitride is the first compound to show a T^2 relationship. We believe the phenomenon to be general for layered, quasi-two dimensional crystals and indeed a theoretical investigation allows one to derive an equation in support of this. A gradual though very slight hump in the plot of the heat capacity vs. temperature curve for boron nitride was found near 100°K. The heat capacity at 298.16°K is 4.76_0 cal/mole deg while the standard entropy at 298.16°K is 3.67_0 e.u. A tentative value of about 62 kcal/mole for the heat of formation of boron nitride was obtained, but this value is subject to revision. (AEC Activity 5311)

Uranium Chemistry of Raw Materials - High temperature (1000-1100°) lignite ashes, which are refractory to an ordinary treatment with dilute sulfuric acid or ammonium carbonate solution can be treated for the extraction of uranium (90% or better) by baking with ammonium bifluoride. The silicon tetrafluoride, volatilized during the baking step, was washed with dilute aqueous ammonia to reform the ammonium bifluoride reagent by metathesis. The separation into soluble NH_4F and insoluble $SiO_2.xH_2O$ is quantitative and the silicic acid is free from fluorine and easily filtered. Addition of NH_4HSO_4, which may be formed in a subsequent processing step, to the litnite ash-ammonium bifluoride "bake" will reduce the amount of fluorine retained by the residue to a small percentage.

Di(n-octyl)amine, tri(3,5,5-trimethylhexyl) phosphine oxide and tri(n-octyl)phosphine oxide have been tested as reagents for recovering uranium by liquid-liquid extraction from raw materials process-type liquors. The first reagent extracts well from sulfate solutions when clorinated solvents are used. (AEC Activity 5361)

Electro Chemical Studies - An electrolytic procedure utilizing a silver anode was developed during studies on the removal of chloride ion from the HRE fuel solution. This technique may have application in the continuous removal of fission product iodine from homogeneous reactor fuel.

Thorex Process Development - In the Thorex process, the thorium, uranium-233 and protactinium in irradiated thorium are separated from fission products and recovered separately by solvent extraction. This is accomplished by dissolving the irradiated thorium in nitric acid and extracting thorium and uranium from the fission products and protactinium with tributyl phosphate solvent. Uranium and thorium are separated in later operations by selective stripping of first thorium and then uranium from the solvent.

Ruthenium is the fission product which limits the decontamination of the extracted uranium and thorium. Its separation is barely adequate in the presently developed process and an improved separation is highly desirable to provide a safety factor. It has been found that an approximately ten fold increase in ruthenium decontamination can be obtained if the dissolver solution is digested at 90-100°C for three hours just prior to the solvent extraction operation.

Protactinium, which is contained in the waste solution from the solvent extraction operation, must then be separated from the fission products and concentrated. A second solvent extraction with either tributyl phosphate or diisobutyl carbinol seems to be the most direct method of accomplishing this separation and concentration. Of these two possible solvents, diisobutyl carbinol appears to be the better since the protactinium concentration in the product solution, after stripping from the solvent, will be more than 30 times greater than that obtained when tributyl phosphate solvent is used. (AEC Activity 5361)

METALLURGY

Ceramics Research - As a part of ANP fluoride fuel investigations approximately 200 petrographic analyses were made to determine phase compositions in the systems UCl_4-NaCl, UCl_4-KCl, UF_4-ZrF_4-NaF and $UO_3.H_2O$. Routine examinations of fuels used in corrosion tests were continued.

Improvement of techniques in the production of SiC-Si cermets for fuel elements reduced the number of rejects. To speed up the cermet-forming process, induction heating was substituted for resistance heating. In the vapor-deposition method of coating BeO with silicon, good adherent coatings were obtained by using a very slow flow of hydrogen gas and a decomposition temperature of 900-950°C. It was found that previously-fired BeO blocks can be made non-porous by impregnation with a eutectic mixture of CaF_2-AlF_3.

It was rather definitely established, by thermal expansion and also by high temperature X-ray techniques, that the monoclinic HfO_2 crystal is stable to 1800°C. In this respect it differs from its usual close resemblance to ZrO_2 which undergoes a reversible change from the monoclinic to the tetragonal structure at 1000° to 1200°C. (AEC Activity 5411)

Physical Metallurgy of Reactor Materials - Recent creep test results on thorium at 300°C indicate that thorium is apparently strengthened considerably by strain-aging. Very low creep rates were observed with increasing stress, up to a critical point at which plastic flow occurs. The strain-aging effect observed in thorium was so marked that quite low creep rates were obtained at stresses up to 10,000 psi in excess of the yield strength, as determined in a standard tensile test at 300°C. (AEC Activity 5411)

Fundamental Physico-Metallurgical Research - In connection with the investigation of the alloying behavior of systems involving the Group IVa elements, the zirconium end of the zirconium-silver phase diagram has been outlined on the basis of the following data obtained by thermal analysis and metallographic examination:

1. The β phase decomposes by a eutectoid reaction $\beta \rightarrow \alpha + \gamma$ at a temperature between 800 and 815°C and at a composition between 2.6 and 3.2 atomic percent silver.

2. The maximum solubility of silver in α zirconium is less than 0.14 atomic percent.

3. The γ phase (composition Zr_2Ag) is formed by a peritectic reaction $L + \beta \longrightarrow \gamma$ at a temperature between 1100 and 1173°C.

The "reciprocal-pole figure" method for analyzing preferred orientation data of the fiber texture type, wherein the distribution of the fiber axes is plotted on a standard stereographic projection of the crystal system, has been developed to the point where the reciprocal-pole figure can be determined directly from ordinary pole figure data obtained from X-ray diffraction studies.

Correlation of the fiber textures developed in hot extruded uranium and thorium rods showed that the texture tends to be similar to the cold deformation texture when hot working is done at high temperatures and at slow rates so that only a low degree of strain hardening is induced and only polygonization occurs. The texture tends to be different from the cold deformation texture when sufficient strain hardening is induced to cause actual recrystallization. (AEC Activity 5411

Fundamental Investigations of Radiation Damage in Solids - Conductivity measurements made at ambient temperature ($\sim$30°C) on three germanium samples in the horizontal cryostat in hole 52N of the ORNL graphite reactor permit an estimate of effective fast neutron flux of 1×10^8 nv/kw $\pm$ 20%.

Copper-beryllium samples were irradiated at approximately -150°C, then warmed up to about 50°C. The resistivity increased during the warm-up period so that the total resistance change was approximately that which would have been expected had the irradiation been carried out at room temperature. This behavior definitely indicates that disorder stored at low temperature rearranges by a thermally-activated process, presumably micro-diffusion. (AEC Activity 5411)

PROGRAM 6000 - BIOLOGY AND MEDICINE

BIOPHYSICS

Waste Disposal Research - A second survey of radioactivity in river bottom deposits covered 627 miles of the Tennessee River, about 60 miles of the Clinch River, and portions of all major streams feeding into these rivers. The beta-gamma radiation measurements on samples of bottom deposits taken in the Tennessee River below Chickamauga Reservoir showed a fairly low and uniform counting rate, while samples from above this point showed increasing activity, reaching a maximum at Clinch River Mile 13, where the beta ray activity was approximately six times the background activity.

The counting response of a crystal spectrometer was determined for gamma rays having energies between 280 and 2,760 kev, in preparation for using the instrument to identify the gamma ray-emitting radioisotopes and to determine the amount of such radioisotopes in samples of the water discharged at Whiteoak Dam. (AEC Activity 6510)

Radioactive Particulate Problem - The calibration and tests of the Green continuous-action cloud chamber for making a count of particles in a given volume of air showed that an accuracy within $\pm$ 5% was obtained when 500 droplets were counted on the photographic film. Two other cloud chambers have been developed, one a volume-defined chamber using a sylphon bellow

activated by vacuum or compressed air, the other a pressure-defined cloud chamber activated by vacuum. The virtues of these chambers are their low cost, compactness, and simplicity.

To investigate the possibility of building a device for fractionating aerosols according to particle size, a Hilsch vortex tube that separates an air stream into hot and cold components has been fabricated.

An experimental model of a high speed air top for the production of solid homogeneous aerosols was completed. When driven by air at a pressure of 15 psi, the apparatus gave droplets of dioctyl phthalate as small as 15μ in diameter with a uniformity of ± 10%. (AEC Activity 6520)

RADIOISOTOPE SALES

Type of Sales	December	January
Domestic	$ 91,148.94	$ 85,481.24
Foreign	529.15	2,459.75
Cash Sales	11,293.85	9,175.35
Transfers Within AEC	1,011.10	-0-
Technical Cooperation Plan	-0-	496.85
Plant Sales	2,953.95	1,686.50
Civilian Defense	130.00	-0-
Total Sales for Month	$ 107,066.99	$ 99,299.69
Total Radioisotope Sales FY 1953 to Date	510,001.24	609,300.93
Total Other Sales FY 1953 to Date	114,325.75	115,939.35
Total Sales and Transfers FY 1953 to Date	$ 624,326.99	$ 725,240.28
Cancer Program	$ 22,875.84	$ 20,310.76
Total Cancer Program to Date	$1,533,265.82	$1,533,576.58

GROSS OPERATING COSTS

	Cost for January	FY 1953 Cost to Date
Programatic Operating Cost	$ 2,761,213	$16,927,638
Plant and Equipment Cost	259,696	2,608,314
Construction Program "H"	58,039	210,259
Work for Other Parties - Transfers	27,826	576,758
Inventory Changes	136,101*	272,433*
Reimbursable Work for Other Parties	58,110	573,027
Deferred Charges	1,784	3,300
Total Laboratory Cost	$ 3,030,567	$20,626,863
Estimated Cost for Next Month	$ 2,800,000	$23,426,863

*Credit

[redacted]

PERSONNEL SUMMARY*

	Number of Employees February, 1953	New Hires February	Terminations February
Administration	73	0	1
Operations**	120	0	0
Engineering, Shops and Mechanical	838	7	84
Laboratory and Research	1484	7	11
Protection	176	0	0
Service	397	10	3
Total	3088	24	99

* Because of a change in the basis of reporting, personnel figures for new hires and terminations between January and February will not agree in all cases.

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

[redacted]