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AEC RESEARCH AND DEVELOPMENT REPORT

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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

MAY 1953

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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

May, 1953

W. H Sullivan

and

F. T. Howard

Date Issued: JUN 5 1953

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STATUS AND PROGRESS REPORT

May, 1953

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TABLE OF CONTENTS

	Page
PROGRAM 2000 - SOURCE AND FISSIONABLE MATERIAL	6
Metal Recovery	6
PROGRAM 4000 - REACTOR DEVELOPMENT	6
HOMOGENEOUS REACTOR PROJECT	6
Homogeneous Reactor Experiment	6
ISHR Design	7
HRP Metallurgy	7
URANIUM CONVERTER REACTOR	8
AIRCRAFT NUCLEAR PROPULSION PROJECT	9
Aircraft Reactor Experiment	9
General Aircraft Reactor Design	9
Experimental Engineering—Mechanical Contrivances	9
Metallurgy	10
Reactor Chemistry	11
Corrosion Studies	11
Reactor Control	12
Reactor Physics	12
Shielding Research	12
ARE Fuel Recovery	13
GENERAL REACTOR RESEARCH	13
School of Reactor Technology	13
PROGRAM 5000 - PHYSICAL RESEARCH	14
ISOTOPE PRODUCTION	14
Radioisotope Research	14
PHYSICS	14
High Voltage Program	14
Theoretical Physics	15
Interaction of Radiation and Matter	15
Neutron Time-Of-Flight Spectrometer	16
CHEMISTRY	16
Waste Treatment Studies	16
Uranium Chemistry of Raw Materials	16
"Hot" Laboratory Research	17
General Reactor Chemistry	17
Chemistry of Corrosion	18

[redacted]

[redacted]

TABLE OF CONTENTS (Continued)

Page

Program 5000 - Physical Research (Continued)

Ion Exchange Studies 18
Isolation Processes for Uranium and Plutonium 19
Chemical Engineering Research Studies 19
Ion Exchange Studies 20
Thorex Process 20

PROGRAM 6000 - BIOLOGY AND MEDICINE 21

BIOLOGY 21
Cytogenetics 21
Mammalian Genetics 22
Microbiology 22
Radiation Protection 23
Biochemistry 23
Biophysics 24
Plant Biochemistry 24
Enzymology 25
Pathology and Physiology 25
Math for Biology 26

BIOPHYSICS 26
Math for Health Physics 26

RADIOISOTOPE SALES 27

GROSS OPERATING COSTS 27

PERSONNEL SUMMARY 28

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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

May, 1953

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

PROGRAM 2000 - SOURCE AND FISSIONABLE MATERIAL

Metal Recovery - During April and May approximately 12,000 kg of uranium and 50 g of plutonium (tank farm wastes) were processed, with the plant operating at an average uranium throughput of 600 lb/day. The solvent extraction losses averaged 0.6% for uranium and 13% for plutonium. These losses are not considered to be excessive considering the complex nature of the feed material and the very low concentration of plutonium in it. Fission product beta and gamma activities of the recovered uranium were 1 and 40%, respectively, of aged natural uranium, and the plutonium contamination of the recovered uranium was less than 10 ppb (parts per billion). These purity values meet K-25 specifications, which require that the fission product beta and gamma activities be less than 10 and 100%, respectively, of the activity of aged natural uranium, and that the plutonium concentration be less than 10 ppb.

An insoluble material that formed in the uranyl nitrate product from the metal recovery plant was shown to be a phosphate of undetermined composition. It was removed from the product by filtration.

The design of the second uranium cycle, proposed for installation in the metal recovery plant, was completed. (AEC Activity 2344)

PROGRAM 4000 - REACTOR DEVELOPMENT

HOMOGENEOUS REACTOR PROJECT

Homogeneous Reactor Experiment - The fuel circulating pump installed in the HRE last month failed after 60 hours operation because of electrical trouble. Another replacement pump is now being sealed by welding and is being tested prior to installation in the fuel circulating system.

In order to obtain more meaningful corrosion data, it was decided to recharge the HRE with new fuel, since there was evidence that previous corrosion data were affected by impurities accumulated in the fuel during one year of exper-

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imental operation. The fuel was removed from the reactor system in 6-liter batches after concentration in the underground dump tanks outside the shield. Each batch, which contained about 1.5 kg of uranium, read 500 r/hour at contact. The removal was accomplished without difficulty by using vacuum to pull the fuel solution from the dump tanks into 5-inch diameter, shielded, ever-safe carriers in which the solution was transported to the Chemical Technology Division semi-works for reprocessing.

The entire fuel system, including the waste evaporator and waste storage, is now being thoroughly cleaned for complete recovery and inventory of fuel. (AEC Activity 4103.10)

ISHR Design - The Intermediate Scale Homogeneous Reactor is conceived as a two-region reactor consisting of a 4-foot-diameter core tank concentrically surrounded by a 2-foot-thick blanket, all contained in a 8 foot-diameter pressure vessel. The fuel is a dilute solution of enriched UO_2SO_4 (5 g U/l) circulated through the core at a rate of 5000 gallons per minute, at a temperature of 250°C and a pressure of 1000 pounds per square inch. Excess neutrons are absorbed in a blanket containing thorium in the form of a solution, a slurry or oxide pellets. Neutrons are moderated by D_2O in both the core and blanket.

At present the conceptual design of the high pressure system is nearing completion. Although the plans for this system have passed through several revisions, they now appear ready for detailed design. The detailed stress analysis and design of the reactor vessel are being completed. Auxiliary equipment, such as pumps, heat exchangers, recombiners and storage tanks, are in the advanced stages of preliminary design. The specifications are being prepared for this equipment and for the high pressure piping. Progress is being made on drawings showing the installation of the equipment in the reactor cells. The plans for installation of ISHR equipment as a full scale mock-up in the reactor experimental engineering laboratories are being worked out.

It is believed that full scale mock-up tests will yield more useful information in less time and at lower costs than could be obtained from extensive tests of individual components.

Since the Intermediate Scale Reactor has reached an advanced stage of conceptual design, it is now possible to make better estimates of the cost of equipment and the cost of fuel processing. In consequence the Long Range Reactor Planning Group is conducting a new study of the economics of power production, based on calculations for two-region reactors operating on the thorium-U-233 cycle and on information obtained from the ISHR design studies. (AEC Activity 4109.1)

HRP Metallurgy - Welding procedural specifications and operators' qualification tests for welding heavy sections (1/2 to 2 inches thick) of type 347 plate and pipe have been prepared and approved for use in HRP construction.

These procedures involve making the first few passes using the inert-gas, shielded-arc method with consumable or non-consumable electrodes, followed by filler passes using the coated-electrode metal-arc technique. The feasibility of these procedures, as determined by metallurgical and mechanical evaluation of the welded joints, has been confirmed experimentally under shop conditions.

Because of the excellent resistance of titanium to corrosion in presently conceived homogeneous reactor fuel solutions, work is in progress to evaluate this metal as a potential material of construction for aqueous homogeneous reactor systems. Of particular concern is its suitability for holding hot, pressurized liquids in such components as reactor pressure vessels, pressure piping and heat exchangers. In conventional impact tests, the usual grades of commercial purity titanium exhibit what appears to be a ductile-to-brittle transition at temperatures sufficiently high to cause some concern about its application in pressurized reactor fuel systems. Although impact test results are not direct criteria of suitability of materials for pressure vessel use, they are, nevertheless, indicative.

Work at other locations, as well as ORNL, indicates no such ductile-to-brittle transition in high purity crystal bar titanium, even at very low temperatures. Therefore, it appears that brittleness is not an inherent property of titanium, but rather is due to impurities in the metal. An investigation is in progress to establish the feasibility of producing by commercial methods titanium which shows no ductile-to-brittle transition in the range of temperatures considered for reactor operation. The present experimental evidence indicates that titanium in which there is no ductile-to-brittle transition in the temperature range of interest can be produced by the arc-melting of selected Kroll process sponge, which is preferred to melting the much more expensive "iodide process" crystal bar titanium. Efforts are being made to obtain a sufficient amount of the high quality commercially-produced material to permit extensive investigation of possible effects of radiation and of hydrogen (which may or may not be introduced into the metal in HR fuel systems) on the ductile-to-brittle transition. (AEC Activity 4109.4)

URANIUM CONVERTER REACTOR

A series of Alclad thorium plates has been tested for periods of from one to eight weeks at temperatures of 150° and 200°C. Incomplete results indicate that plates clad with 52S aluminum, by rolling at 260°C with a total reduction (40% per pass) in thickness of 8 to 1, will probably be thermally stable under the above test conditions.

In view of the fact that no barrier material has been found to prevent formation of the intermetallic compounds (~85% $ThAl_3$, ~15% others) at elevated temperatures, the effort has been shifted to mechnical assembly of the various thorium feed loading components. Work has been started also on the construction of a full-scale, dummy fuel element.

Detailed design work is in progress on the release mechanism, shock absorber, guide bearing, seal, etc. for the UPR (uranium production reactor) shim and safety control rod. The salient features which have been checked and proven in test-stand operation are being incorporated into the UPR control rod. (AEC Activity 4115)

AIRCRAFT NUCLEAR PROPULSION PROJECT

Aircraft Reactor Experiment - The fuel tubes were placed in the shell of the experimental reactor and the BeO moderator blocks were stacked in place. The core now lacks only the final closure welds to be completed. These welds include the inlet and outlet welds (six of each), the instrument hole welds (a total of twelve), and the pressure vessel heavy peripheral weld.

Pump casings and surge tanks for the fuel circuit were installed. The fuel system piping is approximately 85% complete. Heaters and insulation were installed on the hot-fuel dump tank and the heater installation on the fill and flush tanks in both the fuel and the NaK systems was completed. The Na-He heat exchangers were accepted from the vendor after having been previously rejected because of leaks.

The water system was checked completely, cleaned, and filled with a rust inhibitor solution to hold it in readiness for use. Checking of the off-gas system was started. (AEC Activity 4401.1)

General Aircraft Reactor Design - Study of the full-scale aircraft power plant employing a reflector-moderated reactor, is continuing. To facilitate evaluation of the control system, a representative 200 Mw sea-level power-plant was examined with respect to various flow rates, transit times, and thermal capacities. While many of the data are quite general, and would be expected to vary considerably for any particular design, the following results are significant: (1) the 0.23-sec required for NaK to pass through the intermediate heat exchanger indicates that even if a step-change in NaK temperature could be effected in the secondary circuit, such a temperature change would be damped out over a period more than 0.23 sec in the intermediate heat exchanger; (2) the combined "prompt" thermal capacities of the fluoride and NaK circuits is about 2,000 Btu/°F, consequently even if the reactor were operating at 200 Mw and heat removal in the engine radiators were stopped instantaneously (something that would be impossible to effect) the temperature in the reactor could not rise at a rate greater than 100°F/sec. However, the reactor with its negative temperature coefficient, is self-stabilizing even with such a temperature increase. (AEC Activity 4401.1)

Experimental Engineering—Mechanical Contrivances - The frozen-sodium-seal centrifugal pump for the ARE reflector-coolant system has now logged over 1000 hours of successful operation at near ARE design conditions (100 gpm, 20 psi discharge pressure, 1100 to 1250°F Na temperature). Operation was

sufficiently reliable and reproducible to permit taking quantitative data while varying shaft speed, pressure, and seal-coolant temperature.

Two combination packed-frozen-seal centrifugal pumps were tested at 1200°F with the fluoride mixture, $NaF-ZrF_4-UF_4$ (50-46-4 mole %). The leakage rates in both tests were of the order of only 20 to 40 grams per day, and mechanical failures rather than leakage were responsible for the early termination of both runs. A pump, in which copper rope was used as the packing material, was operated for 50 hours at 45 gpm, 55 psi. The test was terminated because of the thermal stress failure of the Carboloy sleeve in the seal area. The second pump was operated for 385 hours with the seal gland packed with copper rope impregnated with MoS_2. Although early operation was smooth, it became progressively bad, possibly because of an unfavorable seal geometry and/or the use of a shaft that had been severely scored in previous tests.

A gas-seal sump-type centrifugal pump with adequate capacity for the circulation of molten fluorides in the ARE is being fabricated. The sump of this pump can also serve as one of the surge tanks for the ARE system. Preliminary hydraulic tests with the low temperature mock-up of this pump demonstrated that no difficulty is encountered with pump priming, vortexing, degassing of fluid, or maintaining stabilized flow.

Two packed-frozen test seals, one with copper rope as the packing material and the other with silicon-bronze wool impregnated with MoS_2 and graphite, each operated for approximately 1000 hours at 10 psi, sealing a 1300°F fluoride mixture of $NaF-ZrF_4-UF_4$ (50-46-4 mole %). Somewhat smoother operation was experienced with the bronze wool—MoS_2-graphite packing; however, both seals gave satisfactory performance and low (5 - 10 g/day) leakage.

A frozen-lead seal on a 1-3/16" diameter shaft operated very smoothly for 250 hours, sealing 1000°F lead at 10 psi, with no discernable leakage or power loss; previous tests had demonstrated that a frozen-lead seal is feasible for fluorides (with no significant intermixing of fluorides and lead occurring when molten lead and molten fluorides are in contact). (AEC Activity 4401.1)

Metallurgy - The fluidity of the Nicrobraz brazing alloy is decreased by the nitrogen contamination in the hydrogen brazing atmosphere as well as the premature diffusion of boron from the alloy. The diffusion of boron has been observed in the fabrication of sections of stainless steel aircraft-type radiators which are slowly brought up to the brazing temperature to avoid thermal shock. During this interval of time the boron diffuses from the alloy thus raising its melting point; then, the alloy does not flow properly at the 2200°F brazing temperature. Small tube-to-header type tests have confirmed these observations, and it is now planned to bring Nicrobrazed parts to the brazing temperature faster to minimize the diffusion of boron.

The study of the effect of different environments such as air, argon, hydrogen, and the fused fluoride salts on the creep and stress-rupture properties of Inconel was continued and is being extended to include austenitic stainless steels, ferritic stainless steels, and cobalt-base alloys. Preliminary results indicate that Inconel and nickel are much more sensitive to environmental changes than are the austenitic stainless steels, such as types 316 and 304. A design curve for Inconel tested in the fused fluorides at 1500°F was completed over the stress range of 2,500 to 8,000 psi. (AEC Activity 4401.5)

Reactor Chemistry - Continued study of the $NaF-ZrF_4-UF_4$ system has shown that a pseudo-eutectic exists at, or near, the 65-15-20 mole % composition. This new composition will be used as the fuel concentrate in the ARE as it is a non-segregating mixture and has a lower vapor pressure (6 mm at 800°C) than the previously designated 50-25-25 mole %. This concentrate, a UF_4-rich mixture of $NaF-ZrF_4-UF_4$, will be mixed as before with the $NaZrF_5$ fuel solvent to obtain the actual ARE fuel, which will then be 53-43-4 mole % of $NaF-ZrF_4-UF_4$, respectively, as compared to the 50-46-4 mole % mixture previously obtained from the former concentrate.

X-ray diffraction examination and quenching experiments showed that, contrary to previous beliefs, $NaZrF_5$ does not have a congruent melting point (solid and liquid states have same composition).

In the work on fuel mixtures, preliminary tests of $RbF-ZrF_4-UF_4$ (50-46-4 mole %) have indicated a melting point close to 400°C for this composition. The $LiCl-UCl_4$ system appears to have a minimum melting point at approximately 405°C; the composition of this eutectic being 52-48 mole %, respectively.

The process equipment for production of the ARE fuel solvent ($NaZrF_5$) is undergoing final testing, with initial production to begin about June 15. The treatment of five-pound batches of $NaF-ZrF_4-UF_4$ mixtures with H_2 gas at 800°C, as proposed for the process equipment, demonstrates that the concentrations of soluble nickel and iron in the melt are reduced to about one-third of their original values in 1½ and 4 hours, respectively. (AEC Activity 4401.5)

Corrosion Studies - A series of 18-8 and 18-12 austenitic stainless steel alloys with varying carbon and oxygen content was tested in fluorides for 100 hours at 800°C to determine the effect of the metallic impurity on the type of corrosion and also to learn why some materials were attacked intergranularly and others by subsurface voids. From these tests, the following trends were noted: (1) a tendency toward greater depth of corrosion with increased grain size; (2) an increased trend toward intergranular type of attack rather than random subsurface voids with decreased carbon and nitrogen content; (3) much greater concentration of attack with increased carbon and nitrogen, although the depth of attack was less; (4) decarburization in the high carbon content material extending beyond the depth of the corrosive attack—magnetic phases, presumably ferrite, formed in these areas.

The dynamic corrosion of Inconel by the fluoride mixture $NaF-ZrF_4-UF_4$ (46-50-4 mole %) is being examined in a rotating-cam device first developed by NACA. With this apparatus it is possible to obtain fluid velocities up to 10 feet per second without the use of pumps. Some preliminary tests of Inconel at 800°C and 10 feet per second with a 50°C temperature gradient showed a very slight amount of mass transfer, with the corrosion being only slightly greater than that experienced in a static type of test.

Several Inconel thermal convection loops were tested with various fluoride mixtures to determine the effect of fluoride contaminants on corrosion after 500 hours at 800°C. For these tests the attempt was made to prepare several especially pure batches of ARE fuel from low-iron zirconium oxide in graphite-lined pots. The actual increase in purity obtained was so small that any decrease of corrosion in single loops was undectable; however, a fuel batch that had been pretreated with HF and H_2 showed a definite decrease in attack over that found with untreated fuel. When nickel fluoride was added to a pre-treated mixture of the ARE fuel and circulated in an Inconel loop, a considerable increase in depth of attack was noted. (AEC Activity 4401.5)

Reactor Control - The console wiring and instrument cable connections for the ARE are complete. The control-rod actuator assembly and wiring are also complete, and the electrical circuit is being tested with a cyclic actuator test panel built for the purpose. The capacitor-start-type of motors used for driving the shim rods could not be reversed frequently without overheating; they are being replaced with motors of the capacitor-run instantaneous-starting type.

A preliminary design of a semi-sealed fission chamber container for the Tower Shielding Facility was made to obtain long-time operation after a single gas filling. The TSF regulating rod servo mechanism was initially tested and mechanical modifications are being made to eliminate oscillations. Components of the shim-safety rod assembly are still in varied stages of testing and modification. (AEC Activity 4401.6)

Reactor Physics - The neutron absorption cross section of the Inconel was found from critical experiments to be higher than anticipated from theory. This increases the uranium requirement for the ARE, but the amount requested still appears sufficient but by a smaller margin. On the basis of experimental data, the three safety rods of the ARE are expected to be equivalent to 13% in k_{eff}. (AEC Activity 4401.7)

Shielding Research - The Lid Tank was used to investigate the effect of the location of a slab-shaped void in a shield on the dose distribution. If this void is normal to the direction of radiation, it appears that very little effect is produced by moving it within the shield. This not-unexpected result was used to verify some of the corrections that had been made in interpreting Lid Tank data.

Calculations of scattered gamma-rays in a typical divided shield are essentially complete. These calculations were based on spectral and angular data obtained with the multi-crystal spectrometer. Indications are that for much of the radiation the standard simplifying assumption of radial escape from the reactor shield is adequate. However, for the transition region near the edge of the shadow shield this is not valid and the angular measurements must be used.

The Tower Shielding Facility safeguard report was completed and issued to members of the committee. Construction of the facility was delayed for several weeks by a Building Trades Council strike that is now settled. The footings for the tower legs and cable anchors were finished. (AEC Activity 4401.7)

ARE Fuel Recovery - Satisfactory laboratory-scale solvent-extraction runs, using 5% tributyl phosphate in a petroleum naptha diluent, were made on simulated ARE fuel for recovery and decontamination of the uranium. Uranium losses were less than 0.01% and uranium decontamination factors were higher than 10^4.

An aqueous solution of the ARE uranium-sodium-zirconium fluoride fuel suitable for solvent extraction was obtained by reacting the solid fuel with a dilute aluminum nitrate-nitric acid solution under reflux conditions. In the process both type 309 and type 347 stainless steel were corroded but the amount of corrosion was not considered intolerable. (AEC Activity 4401.81)

GENERAL REACTOR RESEARCH

School of Reactor Technology - The academic portion of the 1952-53 session of the Oak Ridge School of Reactor Technology was completed on May 29. Following the final examinations, ORSORT will recess during the week of June 1 through 5, with students reassembling on June 8 to begin work on assigned design problems or summer work in various groups within the Laboratory.

Ten design problems will be undertaken by the students, and will be prepared as "group theses" with group leaders selected by the ORSORT faculty. Tentative titles of the design problems are: "Heterogeneous Boiling Reactor Employing a Superheater," "10-Megawatt Aqueous Homogeneous Circulating Solution Reactor for Producing Electrical Power in Remote Locations," "10-Megawatt Homogeneous Boiler Reactor for Producting Electrical Power in Remote Locations," "10-Megawatt Los Alamos Water Boiler-Type Reactor for Producing Electrical Power in Remote Locations," "Circulating Fluoride Reactor for a Submarine," "Gas-Cooled Package Power Reactor Employing Ceramic Fuel Elements," "Fluoride Thermal Breeder Reactor for Power," "Fused Salt Package Reactor," "Airplane Fireball Compressor Jet Reactor," and "Fluidized Solid Internal Breeder Reactor." (AEC Activity 4841)

ISOTOPE PRODUCTION

Radioisotope Research - It was shown experimentally that extraction of radioactive fission product rare earths in a 10 N HNO_3-TPB Varsol system is practical. Zirconium and Nb are extracted also with the rare earths, but may be separated by first stripping the rare earths from the organic phase with 1-6 N HNO_3, and then stripping the Zr-Nb with 0.5 M oxalic acid. It was noted that the alkaline earths, ruthenium and americium, are not extracted appreciably into TBP from 10 N HNO_3.

A procedure was developed for the separation of Sr^{90} and its barium carrier by precipitating $BaCl_2$ in 12-13.5 N HCl (produced by absorption of HCl gas in concentrated HCl). Previous methods have required the use of ethyl ether with HCl to lower the solubility of $BaCl_2$ enough to allow quantitative precipitation. The effects of process variables on overall Sr^{90} yield and co-precipitation of Sr^{90} with $BaCl_2$ were studied. Co-precipitation of Sr^{90} with $BaCl_2$ is favored by higher acid concentration and lower temperatures; however, barium is left with the Sr^{90} fraction (solute) at lower HCl concentrations and higher temperatures. $BaCl_2$ solubility curves go through minima at about 12.5 N HCl at two temperatures tested, 10°C and 5°C. $Sr^{90}Cl_2$ may also be precipitated directly from 13.5 N HCl below 0°C in fairly high yield and high purity. Since all wastes may be recycled, stepwise yield was considered secondary to purity and operating conditions were selected accordingly: precipitation of barium at 12.5 N HCl and 25°C followed by precipitation of $Sr^{90}Cl_2$ at 13.5 N HCl and -10°C. (AEC Activity 5131)

PHYSICS

High Voltage Program - The cross section of the $Li^7(d,t)Li^6$ reaction as a function of energy is being determined on the ORNL 2.5-Mev Van de Graaff generator by measuring the amount of tritium produced in a known amount of Li^7 by a known number of deuterons. This reaction has a threshold value of 1.27 Mev. The energy of the tritons in the backward direction relative to the beam does not exceed 100 kev at bombarding energies up to 2.3 Mev. Therefore, it is possible to trap the tritium on the Li^7 by an overcoat of aluminum which is thick to the tritons but thin to the deuterons. The tritium produced in the reaction is removed by melting the targets. The extracted tritium is introduced into a Geiger counter and counted to determine the total amount. Preliminary results have shown that the threshold appears at the expected energy and the cross section increases to about 100 mb at the maximum deuteron energy of 2.3 Mev. It is estimated that the cross section values are probably not in error by more than 20%.

The 100 μa beam of the 2.5 Mev generator has been used to continue the (p,n) threshold determinations. The following additional values have been obtained: Mn^{55} - 1039 ± 5 kev, Ga^{71} - 1040 ± 30 kev, and Cu^{65} - 2170 ± 10 kev. In cases where a large spin change accompanies the (p,n) reaction, the neutron yield rises sufficiently slowly to make an accurate threshold determination difficult. Two such cases are Ca^{48} and Se^{82}, whose thresholds were found to lie below 650 kev and 1100 kev, respectively.

Relative (p,n) neutron yields were obtained for the following nuclei: K^{41}, Ti^{49}, V^{51}, Mn^{55}, Co^{59}, Cu^{65}, Zn^{67}, Zn^{70}, Ga^{71}, As^{75}, and Ge^{76}.

The study of the $He^3(d,p)He^4$ reaction in the energy range 100 - 800 kev was completed. The angular distribution of the protons is isotropic in the center of mass system at 200, 290 and 350 kev bombarding energy. The cross section shows a broad maximum of 695 millibarns at 640 kev. Nuclear parameters, obtained from a one level-dispersion formula-fit to the cross section curve, agree rather well with those obtained from the reaction $H^2(t,n)He^4$, after elimination of Coulomb effects. (AEC Activity 5211)

Theoretical Physics - A study has been made of the energy spectrum of recoils and the angular correlation between positron and recoil nucleus in the decay of O^{14}. Since the β transition is followed by a 2.3 Mev γ, it was necessary to take into account the effect of the γ recoil in both cases. The importance of these considerations stems from the fact that this is the only practical transition known that is allowed and that depends only on the Fermi component of the β interaction. The results indicate that a distinction between the two possible types of Fermi interaction could be made from experiments of the type mentioned above. However, there are difficulties connected with the question of ion formation.

A previous expression for the spin tensor moments, resulting from a nuclear reaction initiated by an arbitrarily polarized initial beam, has been extended to reactions involving gamma-rays. It is found, for example, that circularly polarized gamma-rays cannot result from any reaction initiated by unpolarized particles. In addition, s-wave particles of spin 1/2 cannot produce linearly polarized light.

Application of the general result has also been made to arbitrarily polarized target nuclei, the angular distribution and polarization of gamma-rays from aligned nuclei, the theory of angular correlation, and the problem of the detection of polarized particles.

An extension of the usual formalism of nuclear reaction theory has been made which allows the definition and interpretation of a scattering matrix for cases where a photon is emitted and/or absorbed. Previous theoretical treatments have suffered from inconsistencies in this regard. The scattering matrix thus obtained can be expanded in terms of angular functions which are just the ordinary multipole vector potentials. This expansion then allows a treatment of the angular correlation and distribution problems involving electromagnetic radiation, which does not make use of the invalid perturbation theory, and is on an equal footing with the existing theory of particle reactions. (AEC Activity 5211)

Interaction of Radiation and Matter - The study of an electrostatic electron multiplier for use as a detector of positive ions was completed. It was determined that the output pulse heights are sufficiently large that 100% counting efficiency can be attained for positive ions (H^+, H_2^+, He^+, N^+, Ne^+,

N_2^+, A^+, Kr^+) of energy greater than about 10 kev. However, at increasingly high counting rates it becomes convenient to measure output current rather than count pulses. Used in this way the electron multiplier is a current multiplier whose gain can be called the ratio of output electron ion current to input ion current. This gain increases as the energy of the incident particle increases. Except at very low energies, the multiplier gain is greater, in general, for heavier ions. Irregularities do exist, however, which can be attributed to differences in electronic structure of the incident ion apparently influencing the secondary electron emission from the first multiplier dynode and so perturbing the general increase of multiplier gain with increasing mass. For example, the gain for Ne^+, mass 20, is less than that for N^+, mass 14. The neutral particle response of the multiplier was also investigated, and it was found that the pulse height appears to be slightly smaller for neutral particles than for positive ions of the same mass and energy.

The characteristics of the electron multiplier are independent of pressure over the range 10^{-5} to 10^{-4} mm Hg, and the gain stability is such that it does not change by more than a few percent during a period of several days. (AEC Activity 5211)

Neutron Time-Of-Flight Spectrometer - It has been established experimentally that there is no overlap between successive neutron bursts in the time-of-flight spectrometer. An improved geometrical arrangement of the detector has resulted in an overall increase in counting rates. (AEC Activity 5261)

CHEMISTRY

Waste Treatment Studies - The operation, i.e., evaporation rate, of the ORNL high activity waste evaporator is limited by the formation of foam. It has been shown that this foam can be broken by a spray of the waste feed solution, at 110°C, on the boiling liquor. A splash plate to produce the necessary spray was designed and demonstrated to operate satisfactorily. (AEC Activity 5361)

Uranium Chemistry of Raw Materials - Studies of the recovery of uranium from high-temperature lignite ash indicate that uranium may be recoverable from the ashes from power plant furnaces in which uraniferous lignite is burned. No refractory uranium compounds were formed when the ash was held at 1100°C for four minutes; this is considerably longer than materials are held in the hottest zone of some furnaces.

From 60 to 75% of the uranium content of five samples of Leached-Zone ores from various localities in Florida was extracted by leaching with NaOH (1000 lb/ton) following calcination at 1000°C. The degree of extraction obtained after calcination at lower temperatures and by leaching without calcination varied from sample to sample. Extraction from the calcined material was changed very little by ageing. When the ore was leached with 500 lb NaOH/ton

the extraction of phosphate from the samples was fairly uniform and complete except for a fraction equivalent to the calcium content. Increasing the calcination temperature tended to reduce the extraction of aluminum and to improve the filtration of the slurries.

Preliminary runs were made to demonstrate with mixer-type columns the use of amines in hydrocarbon diluents for the extraction of uranium from typical sulfate leach liquors by continuous countercurrent techniques. Sodium carbonate solution was used to strip the organic phase. Although optimum operating conditions have not yet been realized, continuous extractions of 97-99% of the uranium have been obtained. (AEC Activity 5361)

"Hot" Laboratory Research - In anticipation of resumed operation of the HRE as a source of fission product gases for the Xe^{135} cross section experiments, several additions and improvements were incorporated in the gas equipment at the reactor site. These changes included the installation of some high-intensity gamma actinometers, a detector for delayed neutrons, a sampling facility for radioactive gases, and a recording and integrating flowmeter on the incoming gas to the charcoal adsorbers.

In the hot cells for the Xe^{135} experiments, the major purification units were tested and found to be satisfactory. Among these pieces of equipment were a final stage all-metal automatic Toepler pump, a uranium-chip "gas getter," and a palladium valve hydrogen stripper.

In work on uranium-aluminum alloy melting and out-gassing, it was found that thermal cycling between 600° and 900°C in a hydrogen atmosphere gave a higher yield of xenon than had any previous method. The yield was about 50%, as compared to that for a dissolution process which is assumed to give a 100% yield. One additional process for out-gassing the molten metal being explored is that of purging the gases through a sintered (porous) stainless steel bed using hydrogen or nitrogen. (AEC Activity 5361)

General Reactor Chemistry - Calculations were carried out on the effects of heavy isotope build-up on neutron losses in a U^{233} breeder reactor, starting out with U^{235} in the core. The results are very similar to those obtained on starting with U^{233} in the core, showing a maximum loss (per fuel atom destroyed) of about 0.6% at a flux-time of 4×10^{21} neutrons/cm^2, a minimum loss of about -0.4% (i.e., a net gain) at a flux-time of 4×10^{22} neutrons/cm^2 and a final equilibrium value of about 0.24% (loss) at flux-times greater than 10^{24} neutrons/cm^2.

The effect of cathodic protection on the corrosion of type 347 stainless steel by UO_2SO_4 solution (300 g U/liter) was studied at 100° and 250°C. No difference could be detected between current densities of zero and 40 milliamp./ft.^{2} of stainless steel cathode at 100°C. At 250°C, a current density of 15 milliamp./ft.^{2} showed less corrosion by a factor of 2.3 over a 3 day period than a similar piece of steel which was not cathodically protected; raising the current density to 40 and to 80 milliamp./ft.^{2} showed only negligible further reduction in corrosion. (AEC Activity 5361)

Chemistry of Corrosion - Specimens of carbon steel (S.A.E. 1010) used in studying the inhibitory properties of the pertechnetate ion have now been exposed for 20 weeks without detectable corrosion. In these particular tests the specimens were kept in water containing 10 p.p.m. of chloride ion and 50 p.p.m. of technetium. During the first 12 weeks the samples were held alternately at 100°C and at 23°C; since then they have stood at room temperature. Throughout the test the tubes were loosely stoppered to permit access of air. A specimen of the same steel suffered no corrosive attack after 93 hours exposure at 250°C to water containing 100 p.p.m. of technetium. The corrosion of stainless steel type 347 in uranyl sulfate at 250°C appears to be inhibited by technetium in deaerated solution but not when oxygen under 150 psi. pressure is present.

The study of the inhibitory behavior of elements adjacent to chromium, technetium and osmium in the periodic table has demonstrated the formation of reaction films by vanadium, molybdenum, ruthenium, rhenium and osmium, none of which is an effective inhibitor. A ruptured film in all these cases leads to severe pitting.

The alteration of the potentials of stainless steel 347 electrodes, in 0.100 N H_2SO_4 at 85°C, by the addition of small amounts of various salts is being investigated. It has been found that NaCl, and the sulfates of Na(I), Ca(II), Cd(II), Ce(III), Cr(III), Pb(II), Bi(III), La(III), Zn(II), and UO_2(II), when present in concentrations of approximately 10^{-6} to 10^{-3} M, do not affect the potentials of the electrodes. However, K_2CrO_4, and the sulfates of Ag(I), Cu(II), Hg(I), Hg(II), and Fe(III), at comparable concentrations, ennoble the stainless steel electrodes as much as 200 to 500 millivolts. The potential effect may be expressed by a Nernst equation, $E = {}^{RT}/_{nF} \log_e [M] +$ constant; where n is 1 for Ag(I), and Cu(II); $\frac{1}{2}$ for CrO_4^{-2}; first $\frac{1}{2}$, then 1 for Fe(III) and Hg_2(II); and 2 and/or 1 for Hg(II). The constant, however, is less than the normal potential for the oxidation-reduction system involved. (AEC Activity 5361)

Ion Exchange Studies - Some degree of success has been attained previously in correlating ionic selectivities for the Na-Li Dowex-50 system as a function of cross-linking (1 to 24%) and of equivalent loading of the resins by means of the solution concept and known rules (Harned and Akerloff) of ionic behavior in concentrated aqueous solutions. To determine the generality of such behavior selectivity measurements have now been extended to the systems: Na-Cs Dowex-50 (1-24% divinyl benzene (DVB) and Br-F Dowex A-2 (1-16% DVB).

For the Na-Cs Dowex-50 system the measured selectivities for Na over Cs were found to decrease almost linearly for each crosslinking with increasing equivalent fraction of Na^+. For example, with the 24% DVB resin the distribution coefficient vat 0, K_d, which is the measure of this selectivity is 120 at trace Na^+ and falls linearly to 0.18 at trace Cs^+, while for the 1% DVB resin the corresponding values are 0.81 and 0.62. (The reversal in selectivity for the 24% resin is to be noted.) However, Harned's rule would predict such a linear function for log K_d instead of K_d itself. Thus the behavior in the Na-Li

system is not a general one and one must either postulate that the ionic interaction here differs strikingly from that in the Na-Li system or, more fundamentally, that the simple solution concept is not entirely valid. Further evidence for the latter postulate is given by the Br-F Dowex A-2 selectivity data. In this system the variation of selectivity with loading for the higher cross-linked resins is markedly different from that for the lower cross-linked materials and in fact there is a pronounced reversal in selectivity in the 16% DVB Dowex A-2 exchanger.

Finally, experiments were completed dealing with the effects of capacity on the equilibrium moisture per equivalent of "ion exchanger." Resins of varying capacities were obtained by using a weak acid exchanger which contained different relative amounts of Na^+ and H^+. Water adsorption isotherms were measured on these resins. The significant observation was made that the moisture per equivalent increases as the capacity of the resin decreases. (AEC Activity 5361)

Isolation Processes for Uranium and Plutonium - An ion exchange process was used in recovering the uranium from about 12,000 liters of water that became contaminated in an experiment to the extent of ~8 ppm (parts per million) with 95% enriched $U^{235}O_2F_2$. The uranium was sorbed on Dowex 50W, then eluted with ammonium acetate-ammonium citrate-acetic acid solution to give a product with a uranium concentration of about 10 g/liter. The total uranium recovered was approximately 100 g, a recovery of more than 99.9%.

The plutonium product solution from the ORNL Metal Recovery Plant is very dilute in plutonium and contains about 500 times as much uranium (~0.015 g of plutonium and 7.5 g of uranium per liter). An ion exchange process for isolating and concentrating (~800 fold) the plutonium has been developed and is in use. The process consists of sorbing the plutonium as Pu(IV), reducing to Pu(III) in situ, eluting the uranium with dilute sulfuric acid, and eluting the plutonium with nitric acid containing sulfamic acid. (AEC Activity 5361)

Chemical Engineering Research Studies - The best method found so far for decontaminating test plates of stainless steel was used with moderate success for stainless steel equipment in situ. The procedure consisted of suspending the contaminated metal in a mixture of 6.2 M sodium hydroxide and 0.16 M sodium tartrate for 4 hr at 85°C and then treating it similarly at the same temperature for another 4 hr with either (a) 1.2 M oxalic acid, or (b) a mixture of 1.6 M hydrofluoric acid and 3.5 M nitric acid.

Steam and water containing 1% Tide applied at 190 psig (pounds per square gauge) by a Sellers steam jet siphon was effective in decontaminating the interior walls of process cells and the external surfaces of stainless steel vessels and piping. (AEC Activity 5361)

Ion Exchange Studies - An ion exchange process for continuous conversion of uranyl nitrate to uranyl fluoride (for eventual conversion to uranium hexafluoride) was demonstrated in Uscolite plastic columns 1 in. in diameter and 7 ft. long. The process consisted of sorbing the uranium on Dowex 50W, a resin resistent to HF, and then eluting it with hydrofluoric acid. Both the yield and the concentration of the uranyl fluoride so produced were satisfactory.

Ion exchange operations are usually carried out batchwise on fixed resin beds in two cycles. During the first cycle the feed solution is passed through the bed and the desired component adsorbed on the resin. Then another solution is passed through the bed to elute the adsorbed material from the resin.

A continuous ion exchange apparatus, originated at ORNL, is in an advanced stage of development (report ORNL-1310). In this apparatus, the feed solution is introduced near the middle of a column containing the exchange resin and the eluting solution near the top. The lower part of the column then becomes the adsorption section and the upper portion, the desorption section. Product is drawn off at the lower end of the desorption section, just above the feed point. Waste solution is drawn off at the bottom of the column. The resin is moved by intermittantly stopping the flow of solutions and pushing the resin bed upward in a piston-like manner with no movement of resin particles relative to one another. Eluted resin from the top of the column overflows into a settling column and is recycled to the bottom of the sorption-desorption column.

The continuity and superior efficiency of the operation, compared to conventional fixed bed exchange columns have been demonstrated. It has also been shown that resin can be moved as a bed in a 4-in.-diameter column at rates up to 950 lb/hr ($\sim$3000 lb/hr/ft^2). (AEC Activity 5361)

Thorex Process - One scouting run was made at full activity level using 0.5 inch-diameter pulsed columns. The purpose of the run was to bring to light any problems connected with either metal dissolution or the solvent extraction operation which were not apparent in laboratory scale investigations.

One problem, which was apparently associated with the high level of activity, was the formation of two types of insoluble precipitate during dissolution of the metal. One precipitate was a silicon-aluminum clay-like material that carried large amounts of fission products, and the other was an unidentified compound of thorium. Such precipitates cause emulsions to form during solvent extraction operations and undoubtedly result in poorer decontamination. A feed clarification step may be required.

The column lengths used for this test run did not prove to be optimum but the results obtained will provide a basis for sizing columns to be used in subsequent test runs.

The use of a water scrub solution in the upper portion of the partitioning (B) column described in ORNL-1545, was demonstrated to be feasible and will be incorporated in the Thorex pilot plant. (AEC Activity 5361)

BIOLOGY

Cytogenetics - One phase of the mechanism of photoreactivation (PhR) of bacteriophage inactivated by ultraviolet light is the relationship between PhR and the necessary preliminary adsorption of the phage particle to its host bacterium. Two steps of adsorption have been demonstrated in essentially static experiments by other workers. For comparison with the development of the ability to photoreactivate, it has been necessary to develop a technique permitting kinetic studies of the adsorption steps.

The first step, consisting of the physical attachment of the particle to the cell, is followed easily by the disappearance of free particles from the medium. It has been shown previously that this step is unrelated to PhR, except as a necessary preliminary. Although the first step is irreversible in the phosphate buffer medium used for adsorption, the particles were washed free by rapid dilution in cold distilled water. The second adsorption step is the irreversible chemical union of particle and cell, which is not affected by this treatment. It is therefore possible to determine the number of particles that have completed the first but not the second step of adsorption, and thus to follow the kinetics of the second step.

The experiments so far performed seem to indicate a time constant of 1/2 - 1 minute for the second adsorption step at 36°C, which is to be compared with about 1½ minutes for the development of the ability to photoreactivate. Work is continuing with the purposes of making the results more precise and of extending them to other temperatures.

Genetically marked stocks of Paramecium were developed which make possible a more detailed study of the effects of high doses of X-rays upon nuclear behavior during the sexual process of conjugation. Several kinds of abnormal nuclear behavior were found and are being investigated further. The effects are not purely temporary but are transmitted over a number of cell divisions, perhaps indefinitely. Surprisingly enough, dominant lethal mutations are rather rare even at high doses. Further investigations of this discrepancy between Paramecium and most organisms are in progress.

The effects of X-rays on the adenosine triphosphate (ATP) content of grasshopper embryos (separated from yolk and membranes) were determined by means of the firefly luminescent reaction. Immediately after exposure to 10,000 r of X-rays (250 KVP) the ATP content in irradiated embryos was 25% lower than in controls. Since the ATP content in irradiated embryos decreased with time at the same rate as in control embryos, 4 hours after irradiation it was still 25% lower than in the controls.

Final results have been obtained on the induction of dominant lethals in Drosophila melanogaster by neutrons from Upshot-Knothole-1 weapon test. Flies were exposed at six stations, at which the estimated dosage ranged from 131 to 3952 rep. The dosage curve obtained agrees very well with the results from exposure to 1-Mev cyclotron-produced neutrons. These data

indicate that for producing dominant lethals, the relative biological effectiveness of neutrons from this nuclear detonation is from four to six times as great as 250-kvp X-rays.

By observing ring chromosomes in Drosophila sperm, unequivocal evidence has been obtained that the oxygen effect on X-ray-induced chromosome breaks acts through the differential recombination of broken ends rather than through differential chromosome breakage. (AEC Activity 6400)

Mammalian Genetics - The collection of the first of several sets of data on the genetic effects of neutrons from a nuclear explosion has been completed. The results show that the rate of induction of dominant lethal mutations in male mice, exposed in lead hemispheres to one of the Upshot-Knothole series of detonations, is not significantly different from the rate obtained in male mice exposed in a lead box placed in a beam of neutrons from a beryllium target in the 86" cyclotron. The relative biological effectiveness, compared with 250 kvp X-rays at the 100 rep point, is about 8 in both cases. The maximum dominant lethal effect of the weapon was found in matings made about 3 weeks after exposure, when, for example, the lowest dose used (23 rep) caused death in utero of 24% of the first generation offspring, corrected for normal viability. (AEC Activity 6400)

Microbiology - Cell-free extracts of the microaerophilic bacterium Streptococcus faecalis, strain 10C1, prepared from organisms grown to carry out a homolactic acid fermentation, contain a potent $DPNH_2$ (reduced diphosphopyridine nucleotide) oxidase (80 µl of O_2 utilized per hour per mg of protein in crude extracts). Although these organisms contain no cytochrome components or, as far as is known, any other iron catalysts, added cytochrome c is a very efficient electron acceptor in the $DPNH_2$ oxidation and when it is present, $DPNH_2$ is oxidized about four times as rapidly as in air. The $DPNH_2$-cytochrome c reductase apo-enzyme has been prepared and can be reactivated with flavine adenine dinucleotide.

In the absence of cytochrome c, the mechanism involves an intermediate peroxidation as follows:

$$DPNH_2 + O_2 \longrightarrow DPN + H_2O_2$$

$$DPNH_2 + H_2O_2 \longrightarrow DPN + 2H_2O$$

$$\text{SUM: } 2\ DPNH_2 + O_2 \longrightarrow 2\ DPN + 2\ H_2O$$

It has not yet been established whether two separate enzymes are involved in this oxidation.

This reaction offers a mechanism whereby these organisms, which contain no catalase, may utilize oxygen as an electron acceptor without accumulating toxic amounts of hydrogen peroxide. The utilization of oxygen as a hydrogen

acceptor for $DPNH_2$ oxidation and the consequent nonenergetically coupled peroxidation of one-half of the $DPNH_2$ does not result in a lowered efficiency compared to the lactic acid fermentation, since in the latter process the oxidation of $DPNH_2$ by pyruvic acid is also not energetically coupled. (AEC Activity 6400)

Radiation Protection - Partial reversal of the lethal effects of ionizing radiation can be brought about by incubation of irradiated bateria in a complex medium such as mammalian tissue extracts. The protein precipitation and ethanol or butanol extraction of homogenized beef spleen yielded highly active material which is still too crude, however, to yield any conclusive information about the identity of the factor(s) required for the radiation recovery process. A very sensitive assay system was devised to detect less than microgram quantities of spleen extracts. Larger quantities of highly purified material are being accumulated for chemical identification of the compounds present.

The effects of postirradiation temperature treatment on the induction of mutations in a proline-requiring strain of Escherichi coli was investigated. As in the previously reported results with a purine auxotroph, it has been found that at the temperatures (24° and 37°C) giving optimal survival following X irradiation, the number of induced mutations in the population of surviving organisms is minimal.

The site of coupled oxidation and phosphorylation in cell-free extracts of E. coli B/r was found to be located in the particulate fraction (particles 20-50 mμ in diameter). This is the fraction that was previously reported to break down following X-ray exposure. (AEC Activity 6400)

Biochemistry - The study of the formation of complexes by α-chymotrypsin with synthetic substrates has been extended to the previously reported glyconyl peptides. These substrates not only contain all the necessary structures for maximum binding and activity (i.e., a carbonyl group at the sensitive bond, an α acylamino group, an α-p-hydroxylbenzyl group, and an l configuration on the α carbon) but in addition the acylamino group at position 2 is also asymmetric. The glyconyl peptides make a large number of configurations available for testing the extent of binding at position 2. The conventional kinetic approach yielded the Michaelis constant K_s and the k_3 for a series of fourteen glyconyl-l-tyrosine amides where the acyl group contained 4, 3, 2, and 1 asymmetric carbon atoms of varying configuration. At present several conclusions can be drawn. 1. The compounds are similar to the true peptides, with an l configuration in the α position of the aldonic acid being necessary for maximum activity although this requirement is not an absolute one. 2. This evidence is indirect enzymatic proof that an l configuration in the carbohydrate series is equivalent to an l configuration in the amino acids. 3. The rate of hydrolysis is faster if both α and β carbons have the l configuration. 4. The configuration of the aldonic acid as a whole, i.e., d or l series, is not important. (AEC Activity 6400)

Biophysics - Information concerning dosimetry and the radiation field in the Biology Facility of the ORNL 86-inch cyclotron have been summarized in a report recently completed (ORNL-1559). The new Cockcroft-Walton accelerator to be used by the Biology Division as a fast-neutron source is now in operation. In preliminary tests, a well-focused 0.5 ma proton beam was obtained at 250 kv.

A long-term program, to reduce the empiricism which now characterizes the various methods for the isolation of cell components, has been initiated. The physical properties (density and viscosity) of isolation media and homogenates are being determined accurately, as well as the sedimentation rates of the various cell particulates. This information, together with data on the effects of various perfusion media and homogenization techniques on the degree of cell breakage, should allow the development of more exact methods for purifying nuclei, mitochondria, and microsomes.

The improvement of viscosimetric techniques for the study of the degree of polymerization of desoxyribonucleic acid, as previously described in ORNL-1456 and 1497, was continued. Further studies on the effects of low doses of ionizing radiation on fresh preparations suggest that the decline in viscosity observed with a 50 r dose is preceded by a transient rise in viscosity. Similar initial increases in viscosity of other high polymers, followed by depolymerization as a result of irradiation, have been reported previously by other workers.

Complete chromosome and chromatid dose-aberration frequency relations for Tradescantia exposed to neutrons in the first 1953 Nevada shot were obtained. The dose curves are in agreement with the calibration dose-aberration frequency curves made at the ORNL 86-in. Cyclotron before and after the bomb test.

Preliminary testing of the performance of the paramagnetic resonance equipment is in progress. Free radicals in quantities down to 10^{-7} mole have been detected. Considerably greater sensitivity is expected in the near future, when the low-noise amplifier and detector is installed. (AEC Activity 6400)

Plant Biochemistry - Further studies on the metabolism of sedoheptulose-C^{14} by plant sap has led to the identification of ribose, fructose phosphate, glucose phosphate, and sedoheptulose phosphate as breakdown products from this 7-carbon sugar. Each of these compounds is known to have an important role in the metabolic processes in plants. In addition, trace amounts of glyceric acid are formed, as well as two unknowns, one of which has properties similar to glycolic acid. All the products were isolated by two-dimensional paper chromatography.

The formation of C^{14}-labeled sedoheptulose phosphate from sedoheptulose-C^{14}, ATP, and $MgCl_2$ by cell-free preparations from plants and yeast indicates the presence of an enzyme which would be called heptulose kinase. Further investigation of this enzyme is to be undertaken.

From previous work it has been suggested that the dianhydride, "sedosan," might be biologically inactive or an inhibitor for the enzymes catalyzing reactions with sedoheptulose. Sedosan was found not to inhibit sedoheptulose utilization, but rather to be utilized itself by the plant sap as a substrate at pH 7.5. Sedoheptulose is one of the products and it is probable that the free sugar is formed first from the sedosan and then the free sugar is further oxidized by the plant sap. (AEC Activity 6400)

Enzymology - A new project, to investigate the possible presence of molybdenum in xanthine oxidase of milk, using 67h Mo^{99} as tracer, was undertaken in collaboration with the UT-AEC agricultural farm group. The element was found to be associated with the enzyme and appears to be inseparable from the enzyme activity. This is the first demonstration of the presence of this element in a compound of importance in animal metabolism. (AEC Activity 6400)

Pathology and Physiology - Experiments were initiated last year to determine the threshold cataract-inducing dose and relative biological effectiveness of fast neutrons, X-rays, and gamma rays made at low dose rates in mice, rats, and rabbits. The threshold dose which induces "+" cataracts in mice six months after fast-neutron irradiation is 3×10^9 n/cm^2; fractionating the dose, ten intermittent exposures, did not materially diminish the incidence of cataract. The corresponding dose in rats and rabbits is above 1×10^{10} neutron/cm^2.

Now, more than two years after exposure, surviving mice from Operation Greenhouse number less than 40% of the original group and represent for the most part nonexposed or lightly irradiated animals. The incidence of lymphoid leukemia was 14.7% at the 785-812 rep dose level, 3.8 to 8.4% for the 491-711 rep exposure range, and 0% among 611 controls.

The enhanced permeability of the dermis of X-irradiated rats to intradermally injected dye was found to be correlated with capillary permeability and with the presence of excessive stainable acid mucopolysaccharide in the dermal ground substance.

Cortisone-induced atrophy of lymphoid tissues and thymus inhibits the spontaneous development of lymphoma in mice. The effects of cortisone on the induction of myeloid and lympoid leukemia by X rays are complex and are found to depend, among other factors, on the timing of the cortisone injections with relation to irradiation.

The viability of rat blood platelets following *in vitro* incubation was tested by transfusion into X-ray-induced thrombocytopenic rats. Comparison with similar rats transfused with fresh platelets indicated that incubation at 37°C for three hours markedly reduced the number of viable platelets. The disappearance rate of perfused circulating platelets was in agreement with earlier estimates on platelet life span (~5 days). The *in vivo* labeling of platelets with S^{35} injected in the form of radioactive methionine was successful and is now being used in the study of the role of platelets in the control of irradiation hemorrhage.

Experiments now being processed for publication indicate that the growth of "dependent" (induced by thyroid deficiency) pituitary tumors in radiothyroidectomized hosts can be controlled by thyroid hormones whereas other "autonomous" tumors are stimulated by this hormone. Bioassays in chicks indicated that primary pituitary tumors induced by radiothyroidectomy contained about as much thyroid-stimulating hormone as normal pituitaries; "dependent" grafted tumors contained somewhat less hormone and autonomous tumors about one-fifth of the latter. (AEC Activity 6400)

Math for Biology - The weekly course in elementary biometrics which began last fall was concluded this period. The class was composed mostly of biologists who apply statistical principles in the design and interpretation of their experiments. If the need arises a more advanced course dealing with specialized topics related to radiobiology will be conducted next fall.

A linear relation between degree of depigmentation of the hair follicles of Operation Greenhouse mice and dose was established for animals receiving between 287 and 711 roentgens. As the period since original exposure is increased the line representing this linear relation is shifted to the right. For an animal receiving a dose in the range 287 to 711 roentgens the dose may be estimated from the degree of greying, with a standard error of about 55 roentgens. (AEC Activity 6400)

BIOPHYSICS

Math for Health Physics - As part of the Health Physics Division program concerned with effects of disposal of radioactive waste from Oak Ridge installations, Dr. O. R. Placak and M. J. Cook conducted a laboratory experiment on uptake of radioactivity in Gambusia. A 3^4 factorial design (4 variables at 3 different levels) replicated several times was selected for the experiment. The factors (variables) studied were temperature, kind of isotope, water level of radioactivity and length of exposure. The analysis of variance was completed with the aid of the Numerical Analysis Laboratory at K-25.

As part of the same program, Dr. C. P. Straub has investigated the effects of isotope, type of coagulant, concentration of coagulant and turbidity on the removal of radioactivity from waste water. On the basis of a suggestion that the amount of work could be reduced by means of fractional replication, a few trial experiments were tried that were successful. Thus, a $\frac{1}{3}$ replication of a 3^4 factorial, replicated twice, was adopted as standard procedure for this type of experiment. The net result is a reduction of 78 per cent in the amount of work required previously, using a 3^4 factorial replicated thrice. In a more complex experiment involving 12 factor, a design was constructed for a $\frac{1}{16}$ replication of a 2^{12} (12 variables at 2 levels) factorial. This procedure will be replicated twice, requiring only 512 determinations instead of the 4096 needed for one complete replication. (AEC Activity 6510)

RADIOISOTOPE SALES

Type of Transaction	April	FY to Date
*Domestic Sales	$ 84,252	$ 801,340
Foreign Sales	6,563	28,271
Project-Cash Sales	3,278	66,125
Project-Transfer Credits	120	4,347
Technical Cooperation Program Credits	1,686	4,275
Plant Credits	3,674	27,402
Civilian Defense Credits	-0-	575
Radioisotope Income	$ 99,572	$ 932,333
Other Income - No Costs Incurred	16,615	137,769
Total Income	$116,187	$1,070,102
Radioisotope Costs	$ 86,519	$ 853,454
*Cancer Program Costs	$ 19,516	$ 195,619
Radioisotope Shipments	1,022	9,089

*The Cancer Program costs subsidized by AEC included in "Domestic Sales"

GROSS OPERATING COSTS

	Cost for April	FY 1953 Cost to Date
Programmatic Operating Cost	$ 2,695,986	$ 24,758,596
Plant and Equipment Cost	391,232	3,645,520
Construction Program "H"	22,460	256,062
Work for Other Parties - Transfers	51,515	728,919
Inventory Changes	275,996*	546,268*
Reimbursable Work for Other Parties	95,864	778,276
Deferred Charges	7,416	418
Total Laboratory Cost	$ 2,988,477	$ 29,621,523
Estimated Cost for Next Month	$ 2,850,000	$ 32,471,523

*Credit

[redacted]

PERSONNEL SUMMARY

	Number of Employees May, 1953	New Hires May	Terminations May
Administration	75	0	0
Operations*	120	1	0
Engineering, Shops and Mechanical	881	0	4
Laboratory and Research	1497	9	8
Protection	175	0	1
Service	393	2	2
Total	3141	12	15

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

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