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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

MARCH 1953

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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

March, 1953

W. H Sullivan

and

F. T. Howard

Date Issued: APR 8 1953

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March, 1953

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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

March, 1953

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

PROGRAM 2000 - SOURCE AND FISSIONABLE MATERIALS

Metal Recovery - Recovery of uranium by solvent extraction from material stored in the ORNL waste tanks is continuing. The production rate has been increased from 200 lbs U/day to 550 lbs U/day by the installation of an evaporator to increase the uranium concentration of the feed solution. Although the uranium product (UNH solution) has been satisfactory with respect to plutonium and fission product contamination, it has been necessary to remove undissolved solids from the UNH solution by filtration to obtain an acceptable product. During February and March approximately 8000 kgs of uranium were processed successfully in the plant with uranium losses of less than 0.2%. The uranyl nitrate is being shipped to the Mallinckrodt Chemical Works for conversion to UO_3. (AEC Activity 2344)

Purex - At present, it is necessary to install separate solvent recovery systems for the first and second uranium cycles. Solvent recovered from first cycle operations is sufficiently high in fission product contamination to result in cross-contamination of the uranium product if it is used in the second cycle, contributing 2.5 times the permissible gamma ray activity to the uranium product. The use of a common recovery system for both the first and second cycle solvent, which would yield a solvent suitable for use in either cycle, would obviously reduce process costs.

Adsorption is being explored as a possible method of removing fission products from the process solvent. Of the sorbents tested so far, Fisher adsorption alumina appears most promising. Laboratory-scale fixed beds, packed with 80-200 mesh alumina, have been operated with first cycle solvent (grossly contaminated) and also with this solvent partially decontaminated by washing in the usual way with Na_2CO_3 and dilute HNO_3. In both cases, the solvent effluent was essentially free of activity. Removal of ruthenium, zirconium and niobium was nearly complete; however, the behavior of iodine was uncertain due to its initially low concentration. These preliminary results suggest that alumina sorption, when coupled to the present solvent recovery procedure, will permit the use of a common system for reclaiming the solvent from both the first and second cycles. (AEC Activity 2802)

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HOMOGENEOUS REACTOR PROJECT

Reactor Physics - A study of the criticality requirements and plutonium production of bare homogeneous reactors establishes an overall relationship between variables that influence criticality calculations so that the evaluation of reactor types is made easier. At low enrichments, the presence of the S in UO_2SO_4 solutions is detrimental to neutron economy, and much advantage can be obtained by going to UO_3 slurries. If slurry reactors are stable, they have a distinct advantage over circulating solutions (UO_2SO_4) with respect to economical plutonium production. The details of this work are reported in the memo, CF-53-3-109.

A program for evaluation of a thermal U^{233} breeder reactor has been undertaken. Internal breeding as well as blanket breeding is being investigated. Since the breeding gain, particularly in the blanket breeder, is quite sensitive to the relative neutron fluxes in the core and the blanket, the two-group theory calculations may not be sufficiently accurate. Thus three-group conventional diffusion theory and a modified Serber-Wilson method are being applied to the static reactor calculations. (AEC Activity 4102.2)

Homogeneous Reactor Experiment - The experimental operating program for the HRE was continued through March, with the longest continuous run being for 10 hours at a power level of 1 megawatt or above. At present, operation is limited to two working shifts; trained operators are being added to permit around-the-clock operation. In general, the experimental program is primarily concerned with determining what portions of the HRE system can be eliminated or simplified. For example, the control rods have been shown to be unnecessary for startup and operation. In fact, they have not been used at all in the high power runs. The reactor is started up by concentrating (by evaporation) the fuel solution. After steam is being produced in the heat exchanger, the power level is controlled entirely by regulation of the steam throttling valve.

Major emphasis is being placed on obtaining data for a comparison of the corrosion rate in the HRE with those observed in the non-irradiated dynamic corrosion test loops. Operation at high power levels has increased the activity of the 0.5 ml. samples, taken from the fuel stream at 250°C and 1000 psi, to a level of 100 r/hr at one meter so that additional shielding is required in the analytical laboratory. Also, all analyses are now performed on a volumetric (vice some on gravimetric) basis to reduce the amount of sample handling required.

It has also been necessary to make minor changes to decrease the fast neutron leakage from instrument holes and to improve the shielding over the underground off-gas lines that carry fission gases out to the charcoal adsorbers and to the stack.

The gas evolution rates observed in the HRE at high power correspond very closely to the predicted value of 1.3 - 1.4 water molecules dissociated per 100 ev. (AEC Activity 4103.1)

ISHR Design - The reactor system now being considered for the Intermediate Scale Homogeneous Reactor consists of an 8-foot pressure vessel surrounding the blanket and the 4-foot core through which dilute uranyl sulfate solution (5g U/l) will be circulated at the rate of 5000 gallons per minute at 250°C and 1000 psi. The fuel system consists primarily of core, pump, heat exchanger, gas separator and high pressure fuel storage tanks. The gas handling system includes an entrainment separator, high pressure catalytic recombiner, heat exchanger and gas pump.

Current effort is being devoted to the detailed stress analysis of the core and pressure vessel, the design of a heat exchanger head to permit access to the tubes, the design of the high pressure gas system, calculations of xenon distribution between the fuel and the recirculating gas stream, a study of the concentration of copper required in the fuel to recombine completely the hydrogen and oxygen before bubbles form, and process studies on various systems for fuel concentration control. (AEC Activity 4109.1)

Engineering Development - The 50,000 gmp (gallons/minute) water circulating system for hydraulic studies of different large reactor core configurations has been completed and tested for leaks, etc. Operation of the system to determine flow patterns and pressure drops in the 8-foot sphere with two tangential equatorial inlets and two polar outlets will be started during April.

The preliminary design of an in-pile circulating "loop" for studying radiation effects on corrosion is nearing completion and the detailed design of portions of the loop has been started. The loop, which is to be used in the LITR, has a fuel capacity of 1 liter and is six feet in length from the pump, located near the shield face, to the small core near the lattice. The flow rate of 5 gpm will give an average fuel solution velocity of 7 ft/sec., which can be increased to 50 ft/sec. in the sample holders. The neutron flux expected in the core of the loop is 3×10^{12}; neutron shields will be used to reduce the flux in the rest of the loop. The tentative schedule for the in-pile loop calls for its completion in October if no procurement or fabrication delays are encountered. (AEC Activity 4109.4)

Uranium Converter Reactor - Work on the production of suitable aluminum-clad thorium plate-type elements for service in the UCR continues. Aluminum can now be bonded directly to the thorium without protection. Roll-clad plates, tested at 300°F and 400°F for 14 days, have no brittle compound layer at the thorium-aluminum interface such as that found at testing temperatures in excess of 550°F.

The combination of lower cladding temperature, smaller diameter rolls, and 52S aluminum cladding tends to minimize the objectionable effects at the ends of pieces caused by the difference in plasticity of the two metals.

Time-temperature diffusion studies show that zirconium, aluminum-silicon and aluminum-beryllium alloys, as well as SAP (Sintered Aluminum Powder--Al + Al_2O_3), are not effective barrier materials for preventing the formation of an intermetallic compound at elevated brazing or welding temperatures.

A design has been completed for a shim-safety rod drive and release mechanism applicable to both the ORNL Research Reactor and the NAA Uranium Converter Reactor. A test stand, simulating normal reactor water flow conditions and which will provide for a complete testing of the mechanism, is scheduled for completion April 1. (AEC Activity 4115)

AIRCRAFT NUCLEAR PROPULSION PROJECT

Summary - Equipment for the Aircraft Reactor Experiment is being assembled and installed at a rate which will permit completion of the construction phase in June. The development of a satisfactory fuel pump seal remains as a major problem in the design of the experiment. The tests of the bellows, valves, reflector coolant pump, and reactor bypass pump indicate that these components will be adequate. The depth of corrosion of Inconel (of which the reactor and fuel system are fabricated) by the ARE fuel, $NaF-ZrF_4-UF_4$ (50-46-4 mole %), is still about 8 mils after 500 hours at 1500°F. Studies have shown, however, that the corrosion rate decreases markedly with time and that the oxidation of chromium by the fuel contaminants, FeF_3 and NiF_2, may account for much of the observed corrosion. Initial tests indicate that the uranium in the spent fuel from the ARE may be recovered satisfactorily.

The extension of the circulating liquid fuel concept to include lumped fuel, the moderation of neutrons by a thick reflector, and the use of a spherical heat exchanger gives promise of permitting a compact, low weight, nuclear power plant for aircraft propulsion.

General Aircraft Reactor Design - The advantages of the reflector-moderated circulating-fuel reactor arrangement for an aircraft power plant have lead to considerable design and some material research on such a system. In general, the reactor consists of lumped regions of fuel and moderator or reflector. An essential element in this reactor is the use of a thick beryllium reflector-moderator which not only contributes to neutron economy but also effects the first layer of the aircraft shield. The combination of this reactor type with the compact spherical heat exchanger arrangement permits realization of a 200 Mw reactor with a reactor-heat exchanger-shield weight in the neighborhood of 75,000 lbs. Critical experiments on a mockup of this reactor assembly indicated a critical mass of about 17 pounds which, coupled with the compact "external" fuel system, results in a total uranium investment of approximately 125 pounds. A preliminary estimate of the weight of the power plant assembly is $\sim$ 100,000 pounds. (AEC Activity 4401.1)

Aircraft Reactor Experiment - Installation of equipment for the Aircraft Reactor Experiment was delayed by a 10-day work stoppage by the pipefitters and welders. However, they have since returned to work and it still appears that the installation may be completed some time in June, 1953.

The reactor pressure shell has been completed except for the final welding which must await prior installation of the fuel tubes and BeO moderator blocks. The moderator blocks are machined but are being held pending corrosion tests in sodium to determine whether canning will be necessary. The serpentine fuel tubes have been assembled for final welding but the job has not been completed. The thermal jacket for the reactor has been finished.

Installation of the fuel piping has been started. The reactor bypass loop is partially installed and all piping, which for prestressing is dependent upon the location of the bypass, can now be worked on without delay. Fabrication of valves is well ahead of installation requirements. The sodium heat-disposal systems are completely assembled except for the Na-to-He heat exchangers. These exchangers have been received from the vendor and two of the three have satisfactorily passed the hydraulic test. The electromagnetic bypass pump has been received from Experimental Engineering but the frozen-sodium-seal pumps for the reflector circuit and the fuel pump are not yet completely satisfactory.

The motor generator sets have been moved outside the building because of their high operating noise level. The electrical wiring of heater thermocouples and control panel cables has been continued. (AEC Activity 4401.1)

Experimental Engineering—Mechanical Contrivances - A centrifugal pump with a frozen sodium seal was operated for 300 hours, pumping sodium at 1200°F. Some difficulty was experienced with the shaft binding, probably due to oxide formation at the outer end of the seal. This seal was six inches long, three times the length of former seals; the longer seal is proposed for use on the ARE reflector-circuit pump.

The electromagnetic pump for circulating NaK in ARE precleaning operations has been tested completely at 1500°F and has been delivered to the ARE building for installation. The pump will deliver 74 gpm at 5 psi with an efficiency of 7.5%.

The combination packed-frozen-seal pump for fluorides was operated intermittently during the month with a graphite-packed seal in which the fluoride freezes. Difficulty was encountered in retaining the graphite packing; a copper-braid sleeve filled with MoS_2 is now being tried as the packing material.

The feasibility of using a frozen-lead seal for sealing molten fluorides was demonstrated in a test in which a molten-lead-molten-fluorides interface was maintained. Some shaft seizure was encountered, again probably due to oxidation, but operation was usually smooth.

Several modifications were made in the design of a sump-type pump of ARE size in which a single tank combines the functions of pump sump and surge tank. These modifications are to improve the liquid flow pattern, to improve degassing of the liquid, and to minimize liquid holdup in the surge tank.

Tests have continued in the program to develop improved seals for high temperature fluids. The most promising materials for packing are graphite and MoS_2. In the face-seal program silver-impregnated graphite has been tried against both stainless steel and tungsten carbide as a gas seal at 700°F with some success.

The hydraulic mockup of the ARE fluid circuit was operated with acetylene tetrabromide, medium weight lubricating oil, and a 50-50 mixture of oil and kerosene in order to study further the hydrodynamics of the ARE system; particular emphasis was placed on the study of the flow pattern through the surge tanks. (AEC Activity 4401.1)

Experimental Engineering—Chemical Engineering - Construction of the equipment for preparation of the ARE fuel solvent ($NaZrF_5$) was completed. One of the two production lines was tested and is ready for use. Adequate stockpiles of the starting materials, ZrF_4 and NaF, of acceptable purity have been accumulated.

The fluoride production facility in Building 9928 was used to produce approximately 200 lbs. of fluoride salt mixtures in batches of 5 and 50 pounds for experimental purposes.

Supplementary tests of fluoride salts production procedure indicate that the rate of reaction of H_2 with UF_4 in molten $NaUF_5$-$NaZrF_5$ systems is apparently independent of the UF_4 concentration; at 750°C, UF_3 is produced at the rate of 10^{-4} moles per liter of H_2 whether the mixture is 8 mole % or 50 mole % $NaUF_5$. (AEC Activity 4401.1)

Mathematics and Computations - The steady state space distribution of temperature for a fluid flowing in a long, thin pipe of circular cross section was determined from machine integrations performed on the AEC's "Univac" computer. The differential equation is given by

$$u(r) \frac{\partial t}{\partial x} = a \nabla^2 t + \frac{G}{wc_p} ,$$

where

$$\frac{\partial t}{\partial r} = 0 \quad \text{at} \quad r = 0 \text{ and } r = r_0 ,$$

$$t = 0 \quad \text{at} \quad x = 0 .$$

and in which G is the source strength, w is the density, and a is the thermal diffusivity.

The pipe is infinite in the x direction, but the integration was carried out to a finite value.

For one set of parameter values the problem was solved for two lattice spacings, the finer spacing involving 200,000 mesh points in order to check the reliability of the integration. The integration using one spacing was repeated for three other sets of parameters. For each set of parameters, the integration required about 10 hours of Univac time. (AEC Activity 4401.2)

Metallurgy—Welding and Brazing - Niobium sheet, 0.030 inch thick, was arc butt-welded in an inert atmosphere for a preliminary evaluation of its weldability. Bend tests indicated that helium rather than argon should be used as the shielding gas since welds made in argon were found to be extremely brittle and those made in helium could be bent 180° without fracture. Impurities in the argon, possibly nitrogen, are probably responsible for this result.

It has been shown that brazing alloy dilution and diffusion are the most important factors to control in the fabrication of heat exchangers. The individual and combined effects of the quantity of brazing alloy, of the length of time at the brazing temperature, and of the brazing temperature on the dilution and penetration of the brazing alloys, Nicrobraz, 82 Au-18 Ni, and 60 Mn-40 Ni, into the structural metal were investigated. It was found that base metal dilution 1) increased rapidly with increased amounts of the brazing alloy, 2) increased with the brazing temperature, and 3) appeared to be independent of the brazing time. Base metal dilution by the Au-Ni and Mn-Ni alloys was much less than with Nicrobraz; the maximum penetration was $\sim$ 1/2 mil, whereas with Nicrobraz the diffusion zone was $\sim$ 20 mils. (AEC Activity 4401.5)

Metallurgy—Fabrication - Pump seal rings of copper, silver, and 304 stainless steel with additions of MoS_2 were hot pressed. Attempts are being made to form MoS_2 on the surface of a hot pressed molybdenum ring.

The B_4C-Fe mixture being used in control rods for the GE-ANP Program, is very difficult to braze to the walls of the stainless steel tubing in which it is contained. An alternate method of fabrication was tried in which a mixture of Cu-B_4C and Al-B_4C were hot rolled and hot swaged. The test specimens are being examined to see if this hot-working operation bonded the core matrial to the stainless steel tube.

Special high purity Inconel bars and tubes have been extruded and found to vary only slightly from the desired analysis. These alloys are being corrosion tested in fused salts and liquid metals. (AEC Activity 4401.5)

Reactor Chemistry - Preliminary thermal analyses indicate that mixtures of LiF-BeF_2-ThF_4 melting below 500°C may contain up to 20 mole % of ThF_4. No data on the physical properties of such mixtures is yet available.

The vapor pressure of the mixture $NaF-KF-ZrF_4-UF_4$ (5-50-43-2 mole %) has been determined and can be expressed by the equation

$$\log_{10} P_{mm\ Hg} = \frac{-6879}{T(^oK)} + 6.743.$$

(AEC Activity 4401.5)

Corrosion Research - The corrosive action of the ARE fluoride fuel mixture, $NaF-ZrF_4-UF_4$ (50-46-4 mole %), on Inconel as a function of time is illustrated in a test in which two loops were operated at 1500°F for 500 hrs. In one loop the fluoride salt mixture was replaced by fresh fluoride (from the same fuel batch) after 250 hrs. while the second loop used the same fuel throughout. The loop with the renewed fuel charge produced a heavy attack, with a maximum penetration of 17 mils as compared to a maximum attack of 8 mils in the second loop.

The above results are consistent with the analytical data from a number of other corrosion experiments which indicate that oxidation of chromium by FeF_3, FeF_2, and NiF_2 in the fuel may account for 30 to 60% of the corrosion observed. The remainder of the leached chromium in the system may be explained by the presence of HF in the fuel mixtures or, more probably, by oxidation of chromium by UF_4 with consequent production of UF_3.

One hydrogen-treated fuel batch was prepared in a graphite-lined vessel to avoid the formation of the deleterious NiF_2. However, when this fuel was subsequently tested in a loop for 500 hrs. at 1500°F there was still a moderate attack, from 3 mils to 9 mils deep.

The corrosion of Inconel was tested in the tilting furnace as a function of the efficiency of removal of HF from the molten ARE fuel by "stripping" with He. The samples of salt which had been stripped for one hour showed light to moderate attack; materials stripped for three to five hours showed virtually no attack which could be attributed to residual HF. In conjunction with these tests several Inconel loops were operated for 500 hrs. with ARE fuel that had been hydrogen-treated. The average attack in these loops was about 8 mils, which was no improvement over earlier tests. This result suggests that the fuel should be subject to even longer periods of hydrogenation.

A 316 stainless steel loop, operated for 500 hrs. at 1500°F with the ARE fuel, showed a "hot leg" attack of 7 mils.

The addition of ZrH_2 to $NaZrF_5$ was shown to produce decreased corrosion in subsequent tests in Inconel. The examination of this mixture revealed, however, the presence of unidentified insoluble materials in the melt, which leaves doubt as to the feasibility of the addition of ZrH_2 to the fuel solvent before startup of the ARE.

Specimens of 347 stainless steel were put in a quartz thermal convection loop in which liquid lead was circulated. The mass transfer of the material caused cessation of liquid flow at 140 hours.

Graphite tubes were placed in contact with the ARE fuel for 100 hours at 815°C to determine if graphite solubility in the fluorides could cause carburization of Inconel. There was no evidence of carburization in this test. A subsequent test in which the Inconel was coated with Stellite #6 (a hard facing alloy) before being exposed to the fluoride, resulted in preferential attack of complex chromium and tungsten carbides to a depth of 8 to 9 mils at 815°C and to a maximum of 6 mils at 540°C.

Carboloy 907, 779, 44A, and 55A, which were tested in sodium and lead for 100 hours at 815°C, had good corrosion resistance in both media except for minor spalling and cracking at the edges. Carboloy 608 had good corrosion resistance in sodium but in lead there was a preferential attack to a depth of ~26 mils. (AEC Activity 4401.5)

Reactor Control - Equipment for testing the magnet release time for safety rods in reactors was used with mockups of both the ARE and Tower Shielding Facility safety rod systems. The tests also permitted experimental evaluation of the testing equipment. A report covering this work is in preparation. (AEC Activity 4401.6)

Design Physics - The studies on the kinetics of a circulating-fuel reactor demonstrated that the fuel circulation causes damping of power oscillations of the reactor in all cases in which the power distribution and flow pattern remain constant and in which there are no mechanical oscillations. This constitutes an important generalization of the previously reported results. A summary report is in preparation.

The power distribution curves obtained from the critical experiment on the reflector-moderated reactor were compared with the corresponding curves computed by the age diffusion theory on IBM machines. The agreement was not quite as good as for the critical masses, but the discrepancies are not expected to affect the program. Improvements on the computation method are under investigation. (AEC Activity 4401.7)

Shielding Research—Tower Shielding Facility - Site preparation for the Tower Shielding Facility was started February 1, 1953. A preliminary report was made to the Reactor Safeguard Committee and given tentative approval on March 5. Separate contracts were let for the construction of the tower and for manufacture of the hoists in mid-March.

The reactor components are being built in ORNL shops. The development of reactor controls and instrumentation is taking somewhat longer than expected but should not delay the project. Design information and specifications for the reactor controls have been transmitted to the Engineering Department to permit substantial completion of the mechanical design of the Tower Shielding Facility reactor. Control equipment deliveries are 80% complete and the

general equipment layout has been established. Detailed design of the interconnections of the control system is in progress. Tests are nearing completion on the safety rod and shock absorbers. (AEC Activity 4401.7)

Shielding Research - The mockup of the top plug for the SIR was installed in the pool of the Bulk Shielding Facility and a large number of measurements were made. The indications of neutron leakage through control plugs and other points of the shield are being exhaustively explored. All paths through iron to the outside are suspected, many of them justifiably so, as radiation leaks. The decision as to remedial measures will be made as soon as the tests are completed.

The cross sections for the (n,p) reactions on O^{16} and O^{17} were measured. Above an effective threshold of 12.3 Mev the (n,p) cross section of O^{16} is $\sim$210 mb and above an assumed effective threshold of 8 Mev the cross section of O^{17} is $\sim$15 mb. These cross section values are, of course, very important in the design of all water-cooled reactors and their shields.

Measurements of about twenty configurations of the "fireball" reactor were made in the Lid Tank for unit and near-unit shields. The weights of such shields are promisingly low, even allowing for activation of sodium in the heat exchanger, as estimated on the basis of actual measurements in the Lid Tank.

A study is being made of the available information on gamma rays from the decay of fission fragments in an effort to understand a few experiments made with the Bulk Shielding Facility or one of its fuel elements. So far, addition of the known components of radiation does not give an intensity large enough to compare to that measured near the BSR. In view of the importance of this result for many shield problems, additional studies are contemplated and perhaps some further experiments will be prescribed. (AEC Activity 4401.7)

ARE Fuel Recovery - Methods for recovering uranium from the mixture of the ARE fuel, $NaF-ZrF_4-UF_4$ (50-46-4 mole %), and from the flush solution, $NaF-ZrF_4$ (50-50 mole %), are being investigated. It has been found that the fluoride melt can be readily dissolved in a solution of aluminum nitrate and nitric acid. Under optimum dissolving conditions a solution is obtained which is 4 M HNO_3, 0.67 M $Al(NO_3)_3$, and contains 2.2 grams of uranium per liter. Preliminary work on recovering uranium from this solution by tributyl phosphate solvent extraction indicates that uranium recoveries in excess of 99.9% may be obtained and that good separation from all contaminants may be achieved. (AEC Activity 4401.81)

School of Reactor Technology - The Committee on Admissions of the Oak Ridge School of Reactor Technology met on March 13, 1953, and selected 80 students to attend the 1953-54 session, which will begin next September. Of these students, approximately fifty will be sponsored by industrial organizations or governmental agencies, and the remaining thirty will be Laboratory-paid students who come directly from colleges and universities.

The current class of ORSORT includes thirty-one students who will be available for employment at the end of the present session in August, 1953. Government agencies, AEC contractors, and other industries having a particular need for young engineers and scientists trained in reactor technology have been advised that interviews with these students can be arranged after April 1. Eleven installations contacted by ORSORT have already scheduled interviews, five of them in April.

The ORSORT Laboratory course has been augmented this year by the addition of four new experiments: "Albedo of Neutron Moderators," "Reactor Control Mechanisms," "The Mean Transport Path and Diffusion Length in Water," and "Iron as a Shield for Fission Neutrons." (AEC Activity 4841)

PROGRAM 5000 - PHYSICAL RESEARCH

REACTOR OPERATIONS

Low-Intensity Test Reactor - A 500-gallon water tank has been installed in the LITR water system in such a way that it is always full during reactor operations but will release approximately 3 to 4 gallons of water per minute through a spray nozzle, located over the fuel elements, if the water is lost from the main reactor tank. In a series of tests, the water was quickly drained from the reactor tank and the maximum temperature observed. After the reactor had been operated for a week at 1,250 kw the temperature rose to $\sim 250^{\circ}C$ without the spray. In a similar test, after operation at 1500 kw, use of the spray limited the maximum temperature to $\sim 85^{\circ}C$.

ISOTOPE PRODUCTION

Radioisotope Production - Several hundred curies of Cs^{137} have been separated from tank farm wastes by the ammonium-alum crystallization process. The Cs^{137} is being accumulated for the preparation of a kilocurie teletherapy source. (AEC Activity 5111)

Radioisotope Research - A method for separating Na^{22} from magnesium cyclotron targets without added carrier was developed. This method is a variation of the sodium uranyl acetate precipitation process for micro-amounts of sodium in that radio-colloidal sodium magnesium uranyl acetate ($NaMg(UO_2)_3(C_2H_3O_2)_9 \cdot 6\frac{1}{2} H_2O$) is formed in solution containing < 5 ppm Na and subsequently is separated by adsorption on an ultra-fine filter disc at $10^{\circ}C$. Uranium and acetate ions are then removed by an ion exchange process, using Dowex-50 resin. A yield of 99.9% was obtained and no measurable solids were detected in the product solution of Na^{22}.

It was found that 72d Co^{58}, uncontaminated by 5.2y Co^{60}, was produced by the (n,p) reaction in an ultra-pure nickel target. Millicurie amounts of Co^{58} were separated from Hanford-irradiated targets as a by-product of the purification of Ni^{63}. This result suggests the possibility that Co^{58}, which previously has been made only in the cyclotron, could be produced in nuclear reactors.

A sample of A^{37}, produced by an (n,α) reaction on calcium was purified by fractionation on charcoal columns at -150°C and methods were developed for assaying this material by G-M counting of the diluted gas in a Libby-type long gas chamber.

Satisfactory Zr-H^3 targets were made by evaporating as little as 50 micrograms/cm^2 of Zr onto tungsten or silver and absorbing tritium in the films. A satisfactory and uniform distribution of the H^3, as determined by radioautography, with absorption ratios of Zr:H^3 as high as $\sim$ 1:1, were achieved. It was found necessary to handle the thin targets in an argon atmosphere; also it was observed that satisfactory tritium absorption was obtained only in a quartz-furnace chamber. (AEC Activity 5131)

PHYSICS

Neutron Diffraction - The magnetic moment distribution within various ordered and disordered samples of binary alloys of the transition elements has been studied by means of neutron diffraction patterns. Very little information is available either theoretically or experimentally on the values of the atomic magnetic moments in these alloys, but it is evident from saturation magnetization experiments that these individual moments must be different from the values that are measurable in the elemental metals. In ordered samples of FeCo, Ni_3Fe, and Ni_3Mn, magnetic superstructure as well as chemical superstructure has been found. From the absolute intensity of the magnetic superstructure lines, determined by two independent methods, and from bulk magnetization data, the magnetic moment associated with each atom in these alloys has been determined. Likewise for disordered samples of Ni_3Fe and FeCr, a determination of the magnetic disorder scattering has given information on the values of the localized magnetic moments in these lattices. The individual magnetic moments in some of these alloys are considerably different from the values obtained for the corresponding elements, but no definite interpretation of the data has been made. (AEC Activity 5211)

Low Temperature Physics - Small deviations in the absolute temperature scale in the liquid helium region (1°K to 4.2°K) were found during the course of work on nuclear polarization. Temperatures in this region are usually obtained in terms of the equilibrium vapor pressures of a liquid helium bath. The liquid helium vapor pressure relationship in current use is that given by Keesom (1937) and by Bleaney and Simon (1939). In 1946, Kistemaker proposed a slight subtractive correction to the above temperature scale in the temperature range from 1.0°K to the lambda point (2.169°K) with a maximum

deviation of 13 millidegrees at the lambda point. By fitting a Curie-Weiss law to the measured magnetic susceptibility of $Mn(NH_4)_2(SO_4)_2 \cdot 6\ H_2O$ or $FeNH_4(SO_4)_2 \cdot 12\ H_2O$ at 1.3°K, 4.2°K and 77°K, the magnetic temperatures so obtained were compared with the accepted temperature scale. In the temperature region from 1.4°K to 2.2°K, results are in rather good agreement with those of Kistemaker. Furthermore, in the temperature range from 2.2°K to 4.2°K, another deviation in the same direction is observed. This additional deviation rises to a maximum of 6 millidegrees at 3.5°K. (AEC Activity 5211)

Nuclear Alignment - During the past several months data have been accumulated which demonstrate a change in the thermal neutron capture cross section of polarized Mn^{55} nuclei with the relative orientation of the incident polarized neutrons. In this experiment a sample of manganous ammonium sulphate was maintained at a temperature of 0.2°K in a magnetic field of 2350 gauss. The paramagnetic electrons, which were experimentally determined to be 84% polarized, polarized the Mn nuclei via the hyperfine structure coupling. The activity of the sample, which was measured after the bombardment with polarized neutrons, was found to change by 3.4% when the relative orientation of the two particles was changed from parallel to the anti-parallel. Since the observed change in cross section was quite small, considerable time is now being spent in making certain that the observed effect was not due to other causes. (AEC Activity 5211)

High Voltage Program - The 5.5 Mev Van de Graaff accelerator was used to measure the (p,n) threshold of N^{15} and to investigate the neutron and gamma-ray yields resulting from the proton bombardment of N^{15}. A tentative value of 3.78 ± 0.01 Mev was found for the threshold. (AEC Activity 5211)

Theoretical Physics - The effect of Fierz interference terms in the analysis of angular correlation experiments in beta decay was considered, with reference both to the experiments in which coincidence between recoil nucleus and emitted beta particle are measured and to measurements of the spectrum of recoil energies. The application of these considerations in which the presence of interference terms in the recoil distributions is taken into account awaits the availability of experimental data which should be forthcoming at this and other laboratories.

The theory of the Auger effect has been reconsidered in order to clarify certain points which have not hitherto been investigated in a satisfactory manner. Because the same procedure as applies to the Auger effect permits an investigation of the effect of the finite size of the nucleus in internal conversion, this question was also re-examined. It was established that the existing theory is actually on a firm foundation and that the correspondence principle approach is justified. Gauge transformations were also examined.

A general expression was derived for the spin tensor moments resulting from a nuclear reaction initiated by an arbitrarily polarized initial beam. The results which were obtained by the use of the S-matrix and Racah formalisms, are valid for all particle spins and angular momenta. All selection rules

for the vanishing of tensor moments follow immediately from the properties of the "X-function" introduced by Fano.

Many interesting physical problems are special cases of the previous result. For example, an expression for the angular distribution resulting from a nuclear reaction may be obtained by a special choice of one parameter; an alternate choice yields the polarization.

This general expression should be very useful for systematic analysis of angular distribution and polarization experiments in terms of the spin-dependent properties of the nuclear forces.

The calculation of the probability of barrier penetration is a central problem in the analysis of nuclear reactions involving charged particles. A rather limited tabulation of the required functions is available, but for many cases of interest only the results calculated by the simple WKB approximation (of unknown validity) are known. A technique for systematically improving the "WKB" results has been devised, so that simple formulae are available for the required functions, and estimates of the error involved in the WKB values can be found easily.

Previous theoretical treatments of the magnetic scattering of neutrons by atoms have been restricted to atoms in which the orbital moments are either absent (S state) or quenched by crystalline fields. The neutron diffraction investigation of the magnetic properties of the crystalline rare earth oxides, conducted by Wollan and Koehler, has made a theoretical calculation without the above restriction desirable. Taking account of the fact that the 4f electrons of the rare earths are coupled according to the Russell-Saunders scheme and are little affected by crystalline fields, an expression for the magnetic scattering cross section has been obtained which involves known coefficients and radial integrals over the 4f electrons' charge distribution. The experiments of Wollan and Koehler may now be analyzed so as to yield information concerning the structure of the 4f shell. (AEC Activity 5211)

CHEMISTRY

Uranium Chemistry of Raw Materials - New samples of lignite from the Slim Buttes, South Dakota region have varied considerably in uranium content. Those from the west side of the Mendenhall Area have a uranium content between 0.009 and 0.017% on an "as-mined" basis. Those from the east side have contained 0.004 to 0.007% uranium. Direct treatment of the raw lignite with large amounts of mineral acids (H_2SO_4, NCl, HNO_3 and H_3PO_4) have given extractions of 80-85% of the uranium. Uranium has been extracted also into ammonium carbonate, but the resulting slurry is almost impossible to filter.

The acid consumption of several samples of Florida Leached Zone ore was increased as the result of calcination between 400° and 800°C before leaching. This operation resulted in a higher pH of the liquors, but did not significantly change the uranium extraction. The extraction of uranium from the

raw ores by hot oxidizing leaches (nitric acid or ferric sulfate-sulfuric acid) were similar to but no better than extractions by hot sulfuric acid alone. The best extractions, leaching with basic reagents, were obtained with sodium carbonate or sodium hydroxide-sodium carbonate, with hydroxide favored for those ore samples containing the least calcium. Di(1-isobutyl, 3,5-dimethylhexyl) amine in kerosene has given good results for the extraction of uranium from pure uranyl sulfate solutions and from actual sulfate leach liquors. This is the only amine among many tested that has given good results in a kerosene diluent. It has been possible to obtain "stripping coefficients" using a solution 0.9M in NH_4Cl and 0.1M in HCl without formation of a precipitate. In contrast to other previous studies, emulsion formation was not observed after the first contact in an extraction-stripping experiment which was carried through several cycles.

The reduction of U(VI) by Fe(II) in phosphoric acid (0.4M in H_2SO_4) conforms approximately to the following expression.

$$\frac{[Fe(III)]^2 \quad [U(IV)]}{[Fe(II)]^2 \quad [U(VI)] \; [H_3PO_4]^8} \simeq 3\text{x}10^{-4}$$

Electrode potential measurements of the Fe(II)/(Fe)III couple, when related to the above equation, lead to the following approximate expression for the electrode potential of U(IV)/U(VI) in phosphoric acid, 0.4M H_2SO_4.

$$E_{U(IV),\ U(VI)} = -426 - \frac{59.1}{2} \log [H_3PO_4]^5 \; [U(VI)]$$

wherein the resulting potential (against a hydrogen electrode) is expressed in millivolts. This expression applies, within the accuracy of the data, to phosphoric acid concentrations from about 2M to 6M. (AEC Activity 5361)

Instrumentation for Nuclear Chemistry - The following circuit elements which are to be used with the new grid target type of multichannel analyzer reported in ORNL-1482 were developed:

A binary scaler circuit, having a 0.1 microsecond resolving time and capable of supplying 8 milliamperes at 110 volts to an external load, was built using 6AF4 tubes. This circuit will be used in conjunction with a suitable matrix to sort and transfer information to the final storage channel of the new type pulse analyzer.

The 10-channel oscillograph-galvanometer-type pulse analyzer previously described was extended to 20-channel arrangement and found to operate satisfactorily.

A channel selector matrix, utilizing NE-2 neon lamps as passive coupling elements, was tested for use with a binary scaler. The matrix is of a pyramid

type and channel selection is obtained by virtue of the conducting neon lamps which provide a low impedance path for an interrogating signal. Tests showed that a 200 volt interrogating pulse into a 32 channel pyramid matrix provided sufficient output signal to drive a thyratron rate meter. Only 62 passive elements, i.e. neon lamps, in the matrix were required for a 63 channel analyzer.

Ten single-tube rate meter circuits, using 5696 thyratrons and Mallory HC2540 capacitors, have been operating continuously for more than 800 hours with no drift in the zero point and less than 1% drift in the calibration point. The output of each rate meter was recorded on a Brown electronic multipoint recorder. The circuits were operated for approximately 500 hours at a rate of 15 pulses per second, after which time the rate was increased to 1500 pulses per second. (AEC Activity 5361)

Hot Laboratory Research - Considerable effort was directed toward the extraction of Xe^{135} from MTR type U-Al alloy in anticipation of continuing, in cooperation with ORNL physicists, the experiments on neutron transmission and scattering at the 1000 curie level. In general, the melting experiments with helium "sweeping" or melting in vacuo with sweeping to remove the rare gas were notably unsuccessful. It is thought that flushing the gas through a dispersing medium such as sintered metal will give better yields.

Sampling experiments, including one conducted at the end of the most recent (March 18) operation of the Homogeneous Reactor at one megawatt power level, were exceptionally promising. During a collection period of one-half hour the entire gas stream from the reactor was diverted into sampling traps. All equipment performed satisfactorily. A preliminary estimate of the level of activity present in the sample at collection time is of the order of 200 curies of Xe^{135} and 2000 curies of Kr^{88}. (AEC Activity 5361)

General Reactor Chemistry - In an attempt to elucidate the species existing in certain aqueous electrolyte solutions at elevated temperatures, measurements of the e.m.f. of the cell

$$Hg,\ Hg_2SO_4, 1M\ H_2SO_4,\ Ag_2SO_4,\ Ag$$

were carried out as a function of temperature and concentration of H_2SO_4. The net reaction and hence the e.m.f. of this cell should be independent of the electrolyte as long as no additional reactions are involved. At 0.5M H_2SO_4 the observed e.m.f. values up to 150°C agreed with those calculated from heat capacity and free energy data. This indicates that either the Ag, Ag_2SO_4 or the Hg, Hg_2SO_4 electrode could be used as a standard electrode in 0.5M H_2SO_4 media at temperatures up to 150°C. At H_2SO_4 concentrations of 0.2M and lower the observed e.m.f. deviated reproduceably from that expected above about 100°C, presumably due to some reversible additional reaction.

The calculations on the determination of the Pa^{233} capture cross section for LITR and Hanford pile neutrons were completed. The method involved pile

irradiations of thorium followed by a mass-spectrographic U^{234} analyses of the U^{233} produced. A final average value of 120 ± 15 barns was obtained. The value obtained for the LITR (127 b) was about 12% higher than that for the Hanford H pile (112 b); while this difference is probably within experimental error it is in the right direction for a greater resonance absorption in the LITR. (AEC Activity 5361)

Chemistry of Corrosion - The study of the inhibition of corrosion by the pertechnetate ion, TcO_4^-, was continued. Tests on carbon steel (SAE 1010) samples in water at 250°C for 93 hours disclosed complete protection in the presence of 100 p.p.m. of technetium at temperatures ranging from 100°C to 23°C and there was no detectable corrosion of carbon steel even with 10 p.p.m. of chloride ion present. Inhibition tests of stainless steel type 347 in uranyl sulfate at 250°C are in progress.

It was found that osmium tetroxide, OsO_4, can act as a passivating agent for carbon steel. This discovery is of interest in connection with the technetium work, in that it provides an additional experimental approach to the general theory of corrosion and inhibitor action that is being investigated. (AEC Activity 5361)

Ion Exchange Studies - The iso-conducting properties of Amberplex C-1, a strong acid cation exchange membrane, were studied. The H-form of the "exchanger" appeared to conduct like a 0.16 N HCl solution while the iso-conductance of the other monovalent cations decreased in the sequence H, NH_4, K, Na and Li to a low of 0.05 N for the LiCl system. Interestingly, the conductances in this series of elements were in the same order as the self-diffusion coefficients, determined for conventional exchangers. It appears that the Einstein equation relating self-diffusion to conductance is applicable for ion exchangers and the "concept" of considering an exchanger a solution has considerable validity.

Radiation damage studies on anion exchangers revealed a significant point. Upon irradiation with a Co^{60} source, the capacity of the membrane was reduced but the ion exchange selectivity per equivalent was unaltered. This phenomenon strongly suggests that little or no breaking of crosslinks occurs in a membrane upon irradiation with gamma rays.

In an attempt to test the "solution concept" for ion-exchange equilibria the Na-Li system was studied for a series of exchangers varying in composition from 1% to 24% divinyl benzene (DVB). Values of the distribution coefficient, K_d, ranged from 1.05 for the 1% resin to 2.4 for the 24% preparation. Moreover, the selectivity for Na ion remained reasonably independent of the ratio of Na to Li sorbed within the exchanger. Furthermore, this relationship appeared to hold reasonably well for all cross-leakings (a function of DVB content) except at 24% DVB. (AEC Activity 5361)

Isolation Processes for U & Pu - A total of 1187 grams of $U^{233}O_2(NO_3)_2$ was converted to $U^{233}O_2F_2$ for use in criticality studies. The conversion was accomplished by adsorbing the uranium from nitrate solution on a Dowex-50 cation exchange resin, followed by elution with 4 M HF. (AEC Activity 5361)

Chemical Engineering Research Studies - Work is in progress to determine the best technique for removing surface fission product contamination from HRE equipment and from chemical processing plant equipment. At present, emphasis is being placed upon the use of aqueous solutions of various chemicals. To date, the most promising procedure for use on HRE equipment has proven to be a descaling operation followed by two successive half hour treatments with a 6.5 M NaOH - 0.67 M sodium tartrate solution. The descaling is accomplished by using either a 1.2M HCl - 1.8M H_2SO_4 or a 1.2M HCl - 0.7M H_3PO_4 solution (both inhibited with alkyl Pyridine HB) at 80-85°C. This procedure has yielded decontamination factors of 100-240, and in all cases has reduced the activity of the stainless steel test specimens from an initial activity of the order of 50 mr/hr. to less than 0.6 mr/hr. Corrosion of the test specimens was less than 0.1 mil per treatment.

This caustic-tartrate solution has proven also to be quite effective in removing contamination from the interior surfaces of chemical processing plant equipment. (AEC Activity 5361)

Thorex Process Development - A total of 20.6 mgs of isotopically purified U^{233}, prepared from the decay product of separated Pa^{233}, was shipped to KAPL for use in neutron cross section measurements.

A modified flowsheet for the Thorex B-column (U^{233}-Thorium Partitioning Step) was developed to optimize conditions (higher U concentration and lower acidity) of the final uranium product stream for use in the ion exchange isolation step. The use of a 0.005N to 0.01N HNO_3 stripping solution in the top of the present B-column permits good removal of thorium and nitric acid from the organic stream carrying U^{233}, thus providing a more efficient process for subsequent stripping of that uranium. This development will supplant a previous, more complicated procedure which used "acid-deficient" aluminum nitrate for HNO_3 neutralization and thorium removal.

The three main solvent extraction steps of the Thorex process have been demonstrated by "cold" runs in a cascading system of 1/2 inch diameter "pulsed" columns to be satisfactory. (AEC Activity 5361)

PROGRAM 6000 - BIOLOGY AND MEDICINE

BIOLOGY

Cytogenetics - A study of the effects of x-rays on *Tradescantia* chromosomes over a period of time after irradiation has shown that (1) changes in sensitivity with time are much more pronounced after irradiation in air than after irradiation in nitrogen, (2) the frequency of each type of aberration may

vary independently of the other types, and (3) recovery of the mitotic (division) cycle is more rapid following irradiation in nitrogen than following irradiation in air. The data do not conclusively prove or disprove either of the two current theories as to the action of oxygen on irradiated chromosomes. Homology tests of lethal mutations (i.e. "lethals") induced by X-rays in nuclei of heterokaryons of Neurospora, have established two classes of lethals, those homologous with few if any other lethals and those homologous with most others. Further evidence suggests that lethals in this latter class have an autonomous effect upon the viability of the nuclei containing them which cannot be entirely compensated by other nuclei in the same cytoplasm.

A case in which oxygen decreases rather than increases the effect of X-rays on Paramecia has been found; also, one in which oxygen has no effect on the action of X-rays has been observed. The former case is the inactivation of paramecin, a desoxyribonucleic acid particle produced by certain strains of Paramecium; the latter is the inhibition of the exchange of nuclei between mates in the sexual process of conjugation. These findings support the belief, based upon our own work and that of others, that the role of oxygen in biological damage by X-rays is not the same for all cellular processes.

The lethal effects of radiation on rapidly growing insect tissue were determined by exposing embryonic cells of the grasshopper to doses between 100 r-80,000 r (roentgens) of 250 kvp (kilovolt peak) X-rays. The cells were observed microscopically in living cultures. The cells were retarded in mitotic division after treatment with doses up to 250 r but were able to recover (i.e., the embryos developed to maturity). Although radiation doses above this level were lethal, in that the embryos did not continue development, death (i.e., shriveling) of the cells even after 80,000 r occurred very slowly over a period of days. It is of interest that these rapidly dividing cells, which are so sensitive to radiation that temporary inhibition of their growth can be detected after 3 r of X-rays, are so difficult to destroy.

Preliminary studies were made on the production of dominant lethals in Drosophila melanogaster with cyclotron-produced neutrons of $\sim$ 1 Mev energy. The results indicated that the R.B.E. (Relative Biological Effectiveness), as compared to 250 kvp X-rays, varied from 6 to 4 over the range of 500 to 3500 rep. These R.B.E. values were higher than those found in previous investigations but were comparable to the values found with chromosome aberrations in other organisms. (AEC Activity 6400)

Microbiology - Earlier studies on the biochemistry of propionic acid bacteria indicated that a sequence of reactions between "succinate" and its degradation products, "propionate" and carbon dioxide, are involved in the bacterial and animal oxidation of propionic acid. Cell-free extracts of Propionibacterium pentosaceum, together with adenosine triphosphate (ATP) and coenzyme A (CoA), "activated" succinate, propionate, and acetate (anions). These data may be interpreted in terms of ATP-CoA dependent reactions yielding initially

succinyl-, propionyl-, and acyl-CoA compounds. Carbon-14 tracer experiments with this system indicated existence of a one-carbon compound (derived from succinate) which can reversibly combine with a three-carbon derivative of propionate, in preference to CO_2.

Recent studies (in this and other laboratories) on α-keto acid dehydrogenases of various bacteria and of animal tissues have begun to characterize the enzymes, show their co-factor requirements, and indicate the separate reactions in the decarboxylative, acyl transfer, and oxidative steps. Dicarbonyl compounds, such as diacetyl, undergo an analogous heterolytic cleavage and reaction sequence. Vacuum-dried cells of Streptococcus faecalis 10C1 catalyze the oxidation of one molecule of diacetyl to two molecules of acetate ion, with "ferricyanide" as the hydrogen acceptor. It was shown also that diacetyl oxidation required lipoic acid while the oxidation of free acetaldehyde did not (using ferricyanide for the assays). The fact that a lipoic acid dependent reaction takes place in ferricyanide (a thiol oxidizing reagent) makes it probable that at least one of the functions of lipoic acid in these reactions involves hydrogen transport via the disulfide group. (AEC Activity 6400)

Radiation Protection - A study of the effect of several different incubation temperatures on the induction of reverse mutations in an X-irradiated purine-requiring strain of Escherichia coli has shown that an increasing rate of reversions to the non-purine-requiring state occurs as the temperature of incubation of the plated cells is raised from 12° to 37°C. In contrast, an optimum survival of exposed cells is obtained at 15°C, with temperatures up to 37°C causing a decline in the number of survivors.

Studies of the effects of X-ray exposure on the macromolecular components of E. coli B/r have revealed a marked effect of such exposure on a ribonucleoprotein particle fraction from the cell extracts. This particle fraction, possessing some mitochondria-like characteristics, is found to be greatly reduced in quantity if, prior to extraction, the exposed cells are incubated in a phosphate buffer-glucose solution at 37°C for 90 minutes, whereas no change is noted in non-irradiated cells treated in the same manner.

It had been found previously that Escherichia coli showed a partial recovery after X-irradiation if incubated for short periods of time in a medium composed of the aqueous extracts of various tissues. An attempt is being made to isolate and identify the necessary factor(s) for this increased viability of irradiated bacteria. To date, the mammalian spleen has been found to have the highest specific activity of any tissue tested. Whether this agent for recovery has any relation to the factor in splenic tissue which brings about post-irradiation recovery in mammals remains to be demonstrated. (AEC Activity 6400)

Biochemistry - In the investigation of the structure of nucleic acids, the isomeric adenylic acids, discovered here four years ago and designated a and b, have now been identified as adenosine-2'-phosphate and adenosine-3'-

phosphate, respectively. This identification was carried out by hydrolyzing each substance to its ribose phosphate, separating the two derivatives by ion-exchange, and then determining the structures of each by organic degradative analysis. The obstacles which delayed this identification for so long were: (1) phosphomigration during hydrolysis of the nucleotides, (overcome by using a cation-exchange resin for the hydrolysis, thus eliminating phosphomigration in the derived ribose phosphates); (2) separation of the ribose phosphates (accomplished by the use of the borate complex method developed here); and (3) oxidation and reduction of the ribose phosphates to unique derivatives by procedures that excluded phosphomigration.

In studies on bioluminescence it has been possible for the first time to obtain light from cell-free extracts of luminous bacteria. The effects of various environmental factors on this luminescence have been examined, using a sensitive quantum-counting photomultiplier. Of particular interest is the fact that the addition of DPN (diphosphopyridine nucleotide, coenzyme I) will restore the light producing ability to "dark" preparations (extracts). Thus, this central respiratory coenzyme appears to function in bacterial extracts in a manner analogous to adenosine triphosphate in firefly extracts. (AEC Activity 6400)

Plant Biochemistry - The seven-carbon atom sugar, sedoheptulose, is an important carbohydrate in the carbon metabolism of plants and animals, about which little is known. Also, during photosynthesis in green plants it is one of the first products to be formed from carbon dioxide, as measured by radioactive carbon tracer experiments. The labeling of this sugar with C^{14} by biosynthesis has offered an opportunity to test its role in metabolism.

When sedoheptulose-C^{14} was used as a substrate for enzymes in barley sap, it was converted to several other organic compounds. Three of these have been identified as glucose phosphate, fructose phosphate and sedoheptulose phosphate. Only adenosine triphosphate needed to be added to the barley sap with the sedoheptulose for the formation of these three sugar phosphates. The results suggest that sedoheptulose phosphate is directly converted to a six-carbon sugar phosphate. (AEC Activity 6400)

Biophysics - During the past month the principal effort has been devoted to the weapon test Upshot/Knothole at the Nevada Proving Grounds. A large amount of biological material from ORNL was exposed during shot "Annie" of this series. Exposures of *Tradescantia* were made at ten stations, using lead shields remaining from Operation Greenhouse.

Although it is too early to evaluate the tests, preliminary results indicate good agreement between measurements obtained with physical dosimeters and the predicted dosages. Preliminary estimates of the effects were made possible from the results of experiments with the ORNL 86" cyclotron. From these estimates it was possible to locate the ten stations so well that a large percentage of usable exposures was obtained.

Significant decreases in the viscosities of nucleic acid preparations obtained from rat thymus have been produced with X-rays and γ-rays. The doses employed are those which produce important physiological effects in vivo. (AEC Activity 6400)

Enzyme Chemistry - Two years ago, in a study of the production of light by green plants, it was shown that there was an emission of light for a few seconds following illumination of plants. Evidence was presented associating the phenomena with photo synthesis. It was believed that this light production was a reversal of some early step in photosynthesis, in which energy stored in chemical form regenerated excited chlorophyll. If this theory is true the emission spectrum of the phosphorescent light should be the same as that for the fluorescent light from plants. Several methods of measuring the spectra have been tried.

In December, 1952 a special red-sensitive photomultiplier was obtained from the Radio Corporation of America. As measured with this photomultiplier the emission spectra of the phosphorescent light and of the fluorescent light were found to be almost identical. This appears to justify the original belief that the phosphorescent light comes from excited chlorophyll. (AEC Activity 6400)

BIOPHYSICS

Physics of Nuclear Radiation - The measurement of the quantity w, the number of electron volts per ion pair, for 5 Mev alpha particles, was extended to the following gases:

Gas	(w) $(\frac{ev}{ip})$
Freon	29.2
SF_6	34.8
BF_3	36.2
*Tissue equiv gas	30.8

*The gas mixture used by Rossi-Failla to obtain soft tissue equivalent gas consists of 64.4% CH_4, 32.4% CO_2, and 3.2% N_2.

The total number of neutrons with energies greater than 50 ev was measured at various positions from Shot "Annie" of the Spring 1953 atomic weapon test series. The detector was Pu^{239}, which has a flat fission cross section for neutrons above a few electron volts energy. Boron was used to absorb the thermal neutrons. The Pu samples were counted by NaI scintillation counters. At 1500 feet from the 18 kiloton detonation the number of neutrons, as measured with Pu detectors was 2.1×10^{13} n/cm^2, whereas sulphur detectors gave $\sim 2 \times 10^{11}$ n/cm^2. (AEC Activity 6510)

Physics of Radiation Dosimetry - The investigation of the physical processes for the absorption of beta radiation in matter is being pursued in order to get information useful in dose calculations. One investigation, to be published in the Physical Review, describes some measurements of beta ray absorption made with the Health Physics Division spectrometer and compares the experimental data on the variation in the amount of energy lost by an electron passing through a foil with the predictions of the recent theories of Blunck-Leisegang and of Yang. The former theory predicts that a monoenergetic beam of electrons incident on a foil will emerge with an energy distribution whose peak is displaced toward lower energy and whose width depends on the ionization potentials of the various atomic shells. The latter theory estimates the amount by which the electron path length exceeds the foil thickness as a result of scattering. Good agreement with the Blunck-Leisegang theory was found for heavy elements and fair agreement for the light elements, but additional experimental work is necessary before the validity of the Yang scattering correction can be established. (AEC Activity 6510)

Experimental Radiation Measurements - New airborne scintillation detection equipment was installed and tested in the U. S. Geological Survey plane. The sensitivity is approximately twice that of the older equipment. On March 19, the variation of radiation from fission products with height was measured over the Knoxville airport following the fall out from the Nevada tests. The altitude vs activity curve gave excellent agreement with the curve obtained over Casper, Wyoming, May 24, 1952. (AEC Activity 6520)

RADIOISOTOPE SALES

Type of Transaction	February	FY to Date
*Domestic Sales	$ 87,502	$ 614,387
Foreign Sales	6,154	14,640
Project—Cash Sales	6,978	59,842
Project—Transfer Credits	0	3,861
Technical Cooperation Program Credits	485	992
Plant Credits	4,357	20,481
Civilian Defense Credits	0	575
Radioisotope Income	$105,475	$ 714,776
Other Income - No Costs Incurred	1,827	117,766
Total Income	$107,302	$ 832,542
Radioisotope Costs	$114,125	$ 692,366
*Cancer Program Costs	$ 16,622	$ 151,483
Radioisotope Shipments	933	6,954

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

GROSS OPERATING COSTS

	Cost for February	FY 1953 Cost to Date
Programmatic Operating Cost	$ 2,621,724	$ 19,549,362
Plant and Equipment Cost	322,926	2,931,240
Construction Program "H"	10,428	220,687
Work for Other Parties - Transfers	56,331	633,089
Inventory Changes	3,060	269,373*
Reimbursable Work for Other Parties	59,893	632,920
Deferred Charges	592*	2,708
Total Laboratory Cost	$ 3,073,770	$ 23,700,633
Estimated Cost for Next Month	$ 3,000,000	$ 26,700,633

*Credit

[redacted]

PERSONNEL SUMMARY

	Number of Employees March, 1953	New Hires March	Terminations March
Administration	74	2	1
Operations*	121	1	0
Engineering, Shops and Mechanical	902	66	2
Laboratory and Research	1491	18	11
Protection	176	0	0
Service	395	2	4
Total	3159	89	18

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

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