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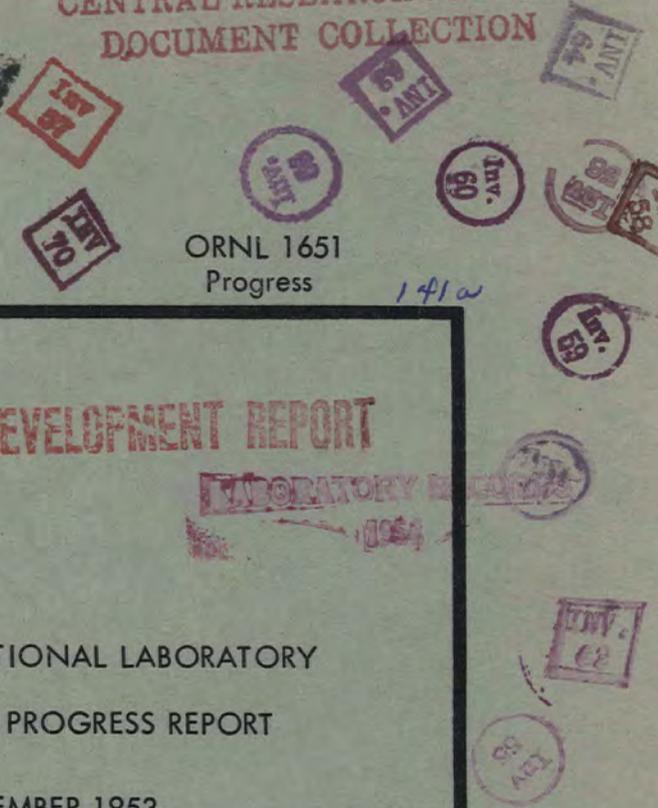
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November, 1953

W. H Sullivan

and

F T. Howard

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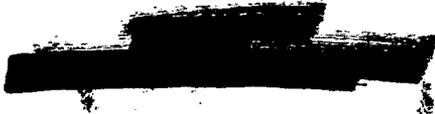
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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

November, 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

Waste Metal Recovery Plant Operation - A total of 77,366 kilograms of uranium has been recovered in the Metal Recovery plant from X-10 tank farm waste. Of this amount, 48,600 kilograms has been shipped to Mallinckrodt Chemical Works in St. Louis and 28,766 kilograms has been transferred to Y-12 for conversion to uranium trioxide. The uranyl nitrate product beta and gamma activity was 1 and 50 per cent, respectively, of that of natural uranium, and the plutonium contamination was 15 parts per billion. (Current K-25 specifications are for the beta and gamma activity each to be less than 100 per cent of that of natural uranium, and plutonium contamination to be less than 10 parts per billion; the 15 parts per billion reported for the Metal Recovery Plant product meets this specification within the limits of experimental error.) The total ionic contamination in the uranium product was less than 700 parts per million of uranium. The major contaminants were phosphate and ferrous ion, which totalled 500 parts per million parts of uranium.

The metal recovery plant operated at 96 per cent efficiency (time) during October and November and processed an average of 354 kilograms of uranium per operating day.

One hundred and thirteen grams of plutonium was isolated from the resin column, which is used in this process, and transferred to the S. F. Accountability Office. (AEC Activity 2344)

Amex Process - A tentative flowsheet has been developed for recovering the 25 grams of americium contained in 50,000 gallons of aqueous waste from the Hanford slag and crucible plutonium recovery program. The waste, which is about 5 M in nitric acid, is neutralized with calcium oxide. The americium is extracted with 30 per cent tributyl phosphate-- 70 per cent Amsco (an inert hydrocarbon diluent), then the extract is scrubbed with one-fifth volume of 3.0 M ammonium nitrate, and the americium is stripped with one-tenth volume of water. The americium and any plutonium remaining as a contaminant are sorbed on Dowex 50 cation exchange resin, the plutonium is eluted with 0.25 M sulfuric acid, and the americium is eluted with 2 M

PROGRAM 2000 - SOURCE AND FISSIONABLE MATERIALS (Continued)

ammonium acetate. In laboratory-scale tests with synthetic waste solution, containing 1 to 2 ppm of americium, the americium loss was only 0.05 per cent in the extraction step. (AEC Activity 2344)

Excer Process Development - A Nepton demineralizer cell, employing a mercury cathode and a platinum anode, is being investigated for reduction of uranyl fluoride to uranium tetrafluoride. Sulfuric acid, 0.25 M, is employed as anolyte, uranyl fluoride--hydrofluoric acid as catholyte, and the anode and cathode compartments are separated by a "permaselective" cation exchange membrane. The use of such a cell reduces the power consumption twofold because of the close electrode spacing, and corrosion of the platinum anode is reduced fivefold (i.e. to 2.4 mg per pound of uranium reduced) by using sulfuric acid rather than hydrofluoric acid, which was used in the single compartment cell.

In studies on hydrofluoric acid recovery, 1.6 M acid was concentrated to 6.6 M by electrodialysis, employing Nepton permselective ion exchange membranes.

The possibility of converting uranyl nitrate to uranium dioxide electrolytically, then reacting the wet uranium dioxide precipitate with 40 per cent hydrofluoric acid to produce uranium tetrafluoride is being investigated. The experiments to date have not succeeded in producing uranium dioxide but rather a complex, unidentified, oxide. (AEC Activity 2604)

PROGRAM 4000 - REACTOR DEVELOPMENT

HOMOGENEOUS REACTOR PROJECT

Homogeneous Reactor Experiment - From November 20 to November 26, the reactor was run continuously at power levels from 500 to 1000 kw, and a total of 100 megawatt hours accumulated during this time. No mechanical difficulties were experienced over this period, and reactor operation was largely routine. Prior to this time, difficulty was experienced with the instrument which indicates liquid level in the pressurizer stem of the reactor core and which also controls the discharge of decomposition gases of the core. Gamma-ray pictures indicated that the float in the instrument was stuck in a downward position and that its supporting arms were possibly bent. Since no attempts to dislodge the float were successful, it was decided to attempt a direct repair by drilling into the instrument housing. The radiation field of approximately 50 r/hr was reduced by constructing the lead shield with a small hole to permit the drilling operation. In this way repair of the float chamber was made successfully and reactor operations were resumed on November 19.

PROGRAM 4000 - REACTOR DEVELOPMENT (Continued)

The reactor was shut down on November 25 in preparation for the Thanksgiving holiday. The experimental program will be resumed on December 1 to evaluate the effectiveness of the homogeneous internal catalyst, CuSO_4 , for the recombination of hydrogen and oxygen directly in the fuel solution. (AEC Activity 4103.10)

Conceptual Design - Flowsheet and design studies have been started on a reactor to follow the HRE as the next step toward the development of full-scale homogeneous reactors. The general characteristics used as a starting point for the design will follow as closely as possible the basic HRE design, with improvements where indicated by HRE operating experience or by recent research and development results. Other modifications considered include increasing the core size from 18 inches to 24 inches in diameter, the design power level from 1 Mw to 3 Mw, and the operating temperature from 250°C to 300°C . It is currently planned that the D_2O reflector will be kept, with some provision for converting it to a thorium blanket if this proves desirable and feasible in the future.

The presently visualized schedule calls for construction of the new reactor to be started in the first half of FY 1955. It is planned that the reactor will be located in the present HRE building and will take full advantage of existing facilities. (AEC Activity 4109.1)

In-Pile Loop - A 200-hour run has been completed with the first model of the in-pile loop, which contained a 40 g U/l UO_2SO_4 solution with 0.01M CuSO_4 at 250°C . An ORNL-developed and fabricated pump with a chrome-plated journal and Graphitar bearing was used and apparently performed very well. Data obtained are not complete at present. In general, indications of performance were favorable, although a steady decrease in oxygen concentration suggested stratification of the fuel solution and gaseous phase or an unaccounted loss of gas. A second loop containing design modifications suggested by experience with the first model and adequate instrumentation should be ready for operation the first week in December. (AEC Activity 4109.4)

Dynamic Loop Tests - A substantial portion of this effort is now devoted to studies of the effect of temperature on corrosion by uranyl sulfate solutions. Early studies in which the only measure of corrosion was obtained by following the rate of nickel buildup in the solution indicated a steady increase in corrosion attack as the temperature was increased. However, more detailed studies with specimens have shown that this apparent increase in corrosion resulted from a fortuitous combination of rates and the effect of temperature on critical velocity. In the table given below, the low velocity corrosion rate is that observed when a coating of oxide (Fe_2O_3 and Cr_2O_3) forms on the specimen. The high velocity corrosion rate refers to that observed when the fluid flow conditions are such that no oxide coating forms. The critical velocities given indicate the regions of transition from oxide coating to no oxide coating, as observed in the standard taper coupon corrosion specimen holders.

PROGRAM 4000 - REACTOR DEVELOPMENT (Continued)

Effect of Temperature on the Corrosion of
347 Stainless Steel by 40 g U/l UO_2SO_4 Solutions

Temp. ° C	Low Velocity Corrosion Rate mpy	High Velocity Corrosion Rate mpy	Critical Velocity fps
200	9	52*	None observed
225	29	160	10 - 20
250	0.1	240	15 - 25
275	0.1	540	25 - 35
300	0.1	1,000	35 - 45

*This high rate was observed in spite of the fact that the specimens were coated and the usual transition from coated to bare metal was not observed. It is apparent that the coating formed at the lower temperatures gives little protection even though it adheres in the high-velocity regions.

The data indicate clearly that as a practical matter the higher temperatures are advantageous. Present studies are extending the data to lower concentrations and temperatures. The lower temperature corrosion rates, as a function of time, are also being studied to verify whether the indicated high rates at low velocity continue or not. (AEC Activity 4109.4)

AIRCRAFT NUCLEAR PROPULSION PROJECT

Aircraft Reactor Experiment - The installation of the Aircraft Reactor Experiment has proceeded uneventfully; no further modifications in concept or design are indicated.

A sump tank for the fuel system and one for the sodium system were received, and installation of the main piping systems is proceeding. Installation of the electrical heaters on all fluoride and sodium containers is about 75 per cent complete. Insulation of the heated lines and components must await installation of heaters but, nevertheless, about 95 per cent of the most difficult job, that of insulating the tank pit, is complete and about 15 per cent of the other insulation is installed.

Some checking of the reactor and auxiliary systems was accomplished. The fuel tubes in the reactor were flushed with tap water, rinsed with distilled water, dried (as much as possible) with compressed air, and evacuated. Work on the reactor will continue when the Inconel-clad stainless steel control rod sleeves arrive from the International Nickel Company. The hydraulic

PROGRAM 4000 - REACTOR DEVELOPMENT (Continued)

systems (for the helium blower power units), the vacuum system, and the helium supply system have been checked and accepted, as far as the preliminary tests are concerned. (AEC Activity 4401.1)

General Aircraft Reactor Design - The USAF requested that a series of design studies be prepared for 100- to 600-megawatt reactors, but it was found that existing data do not justify an extrapolation beyond a reactor power level of 300 megawatts. Since the effects of power density in the core, the reflector and the heat exchanger become progressively more important as the reactor power is increased, changes in the bases for design studies cause major deviations in reactor proportions for power levels greater than 150 to 200 megawatts. Detailed designs for the reactor cores, heat exchangers, and pumps for 50-, 100-, 200-, and 300-megawatt reactors were prepared. (ORNL memorandum CF 53-11-160) (AEC Activity 4401.1)

Experimental Engineering - A prototype of the ARE gas-sealed centrifugal pump is being tested with molten sodium to evaluate its performance at high temperatures. Two auxiliary cooling systems are used in the pump, oil to cool the shaft and bearings and dibutyl carbitol to act as a heat barrier between the hot sodium and the primary gas seal; the oil and carbitol are water-cooled in external heat exchangers. With the pump operating at 1500°F, the heat loads were 7,000 and 11,000 Btu/hr, respectively. Silver-impregnated graphite appears to be satisfactory as a face-seal component, since no deleterious effects were observed after 300 hours of use in vapors from 1200°F sodium. The provision of an interference fit between shaft and bearing races apparently has eliminated previously encountered race slippage and bearing wear. Pump degassing characteristics are also satisfactory; gas entrainment, as a result of pump startup, can be rejected in 1/2 minute at a pumping rate of 35 gpm and in 4 minutes at a pumping rate of 125 gpm.

All the Inconel impeller castings for the actual ARE pumps were rejected because of imperfections, such as sand inclusions, cold "shots" in the cast metal, and porosity. Consequently, the ARE pump impellers are being fabricated from Inconel plate stock.

Calibration of the bearing materials tester was completed, and the several materials which will be subjected to compatibility tests in the fluoride, $\text{NaF-ZrF}_4\text{-UF}_4$ (50-46-4 mole %), at 1500°F are now being assembled. These materials are: B, ZrC + Fe, MgO + Ni, BeO + Ni, BeO, hot-pressed Al_2O_3 , high-density graphite, TiC + Ni, TiC + Co, CrC, B_4C , WC + Co, and WC + Ni. (AEC Activity 4401.1)

Mathematics and Computation - Previously, the multi-group diffusion equations had been coded for the UNIVAC in order to compute the static characteristics of a two-region reactor. These calculations are now being made on a routine basis in which the machine running time is approximately 18 min per case (although the total elapsed time per case is about 45 minutes). In order to assist in the evaluation of the reflector-moderated reactors, the UNIVAC has now been coded for a nine-region thirty-two-group diffusion problem and this type problem is also in routine operation. (AEC Activity 4401.2)

PROGRAM 4000 - REACTOR DEVELOPMENT (Continued)

Reactor Chemistry - Fourteen of the required fifteen batches of ARE fuel concentrate (Na_2UF_6) have been processed by the Y-12 Production Division. Only one batch had a level of impurities higher than tolerable; it will be reprocessed. The excellent agreement between the analyses of samples of the fused concentrate made by two analytical laboratories indicates that these analyses should be accepted as the basis for accountability transfer, rather than the analyses of the UF_4 initially charged to the equipment.

Preliminary data indicate that the equilibrium constant (assuming activities for the dissolved salts equal to their mole fractions) of the postulated corrosion mechanism



with NaZrF_5 as the reaction medium, is about 1.2×10^{-3} at 600°C . The ΔF° for the reaction as written is, accordingly, +11.4 kcal. Available thermodynamic data indicate that the ΔF° for reaction of the crystalline solids at this temperature is -7 kcal. This 18.4 kcal difference is undoubtedly associated with the almost complete complexing of UF_4 (probably as UF_6) in such melts.

Certain anomalies in the 800°C hydrogen reduction of NiF_2 , an impurity dissolved in NaZrF_5 , were shown to be due to the graphite liners used in the reaction vessels, and therefore this and similar experiments are being repeated in nickel equipment. (AEC Activity 4401.5)

Corrosion Studies - The corrosion of Inconel thermal convection loops by the various fluorides of interest to the Aircraft Reactor Experiment is a maximum of from 5 to 9 mils of attack in the "hot leg" of the loop after 500 hours at 1500°F ; the attack by the fuel solvent, a fuel mixture (containing 6.5 mole per cent UF_4), and the fuel concentrate is 5, 6, and 9 mils, respectively. Fluoride purification procedures have reduced the fluoride attack from values which previously were about 50 per cent higher than those given above. In some instances, notably with the fuel concentrate, Na_2UF_6 , and the fuel solvent, NaZrF_5 , a thin unidentified layer was found in the cold leg.

One Inconel loop, in which the purified fluoride $\text{NaF-ZrF}_4\text{-UF}_4$ (50-46-4 mole %) was circulated for 1000 hours at a hot-leg temperature of 1500°F , showed a maximum attack of 8 mils; thus, the belief that the depth of attack decreases with time and at a decreasing rate was partially confirmed.

Thermal convection loops of Izett iron and Hastelloy B were operated with fluoride mixtures in them. The iron loop was terminated in 39 hours because of plugging, and the four Hastelloy-B loops developed leaks in thermocouple welds because of oxidation initiated by the thermocouple cement, "Saurizen".

Samples of a number of cermets, composed of heavy metal carbides in a nickel base, were found to be moderately stable to molten fluoride mixtures with and without UF_4 . None of these materials were resistant to NaOH at 1500°F .

PROGRAM 4000 - REACTOR DEVELOPMENT (Continued)

Static corrosion tests of two brazed specimens, each of Inconel and 316 stainless steel, were tested for 100 hours at 815°C in a molten fluoride mixture. The brazing alloys Ni-P and Ni-P-Cr were used with both metals and were essentially unattacked except for the Ni-P-Cr alloy with 316 stainless steel, in which there was 2-3 mils depth of subsurface voids.

The mass transfer characteristics of Hastalloy B and types 347 and 304 stainless steels in molten lead are being examined in quartz thermal convection loops containing specimens of these metals. In the tests completed with the 347 stainless steel specimens, it was found that the loop containing lead oxide contamination operated for 240 hrs before plugging--approximately 70% longer than a similar loop containing hydrogen purified lead.

Static corrosion tests were conducted in Inconel capsules, containing molten fluoride mixtures and impurities that might contact the fluoride from lubricated bearing or sealing surfaces. In general, additions of oil or MoS₂ increased corrosion very little, but severe carburization of the Inconel occurred when the fluoride was contaminated with graphite. (AEC Activity 4401.5)

Physical Properties - The equations for the density of the ARE fuel concentrate Na₂UF₄, and the fluoride fuel, NaF-ZrF₄-UF₄ (53.5-40.0-6.5 mole %) are, respectively:

$$\rho(\text{g/cc}) = 5.60 - 0.0012 T, \text{ where } 660 < T < 1000^\circ\text{C}$$

$$\rho(\text{g/cc}) = 4.06 - 0.00097 T, \text{ where } 600 < T < 800^\circ\text{C}$$

(AEC Activity 4401.5).

Metallurgy Research - The effects of various environments on the stress-rupture properties of Inconel annealed at 1650°F are tabulated below:

<u>Environment</u>	<u>Stress, psi</u>	<u>Rupture Life, hrs</u>	<u>Final Elongation, %</u>
Hydrogen	3500	446	13.0
Fluoride*	3500	550	12.0
Sodium	3500	1333	35.0
Argon	3500	1467	12.0
Nitrogen	3500	1770	11.6
Air	3500	2567	50.0

*NaF-ZrF₄-UF₄, 46-50-4 mole per cent

The above data are not specifically applicable to the Aircraft Reactor Experiment because of the different conditions encountered. However, one may infer from these data that the design stress of the reactor pressure shell will be adequate, while that of the reactor fuel tubes will be more than ample. It is interesting to note that, with the exception of air and sodium, the specimens reached about the same elongation at rupture independent of the

PROGRAM 4000 - REACTOR DEVELOPMENT (Continued)

rupture time. The greater ductility in air and in sodium is probably the result of decarburization of the Inconel. Current tests of specimens annealed at 2050°F show a marked decrease in the environmental effect of hydrogen and the fluoride.

Studies of the flammability of jets of sodium alloys in wet and dry air at temperatures up to 800°C were continued in an attempt to discover a non-self-igniting liquid-metal alloy with favorable heat transfer and nuclear characteristics. Only the sodium-mercury alloys containing less than 34 mol per cent sodium and the sodium-bismuth alloys containing less than 40 mol per cent sodium do not ignite. The following alloys are self-igniting: binary alloys of sodium-with 90 per cent aluminum, 50 to 60 per cent bismuth, 90 per cent indium, 90 per cent lead, 0.6 to 66 per cent mercury, 90 per cent silver, or 90 per cent zinc; ternary alloys having a 45 per cent sodium-50 per cent bismuth base and containing 5 per cent each of calcium, copper, magnesium, mercury, potassium, or silver, and ternary alloys having a 30 per cent sodium--65 per cent mercury base with 5 per cent each of aluminum, bismuth, calcium, copper, magnesium, potassium, or silver. (AEC Activity 4401.5)

Reactor Control - The design of the control system for the Tower Shielding Facility (TSF) was completed. Approximately 80 per cent of the components of the control system were received. The servo mechanism was completed and 80 per cent of the wiring in the amplifier cabinet, console, and reactor "dolly" was finished. (AEC Activity 4401.6)

Shielding Research - The neutron reflection coefficient for water has been calculated to be 0.085 by using the concept of the removal cross section; this value is in fair agreement with the experimental value of 0.08.

In a preliminary experiment, the radiation dose from air-scattered neutrons penetrating a crew shield appears to be due to those neutrons which penetrate along the slant path. This result is not unexpected for thin shields (< 7.5 cm); but if it also proves to be true for thicker shields, the crew shield can be made lighter and the divided shield arrangement becomes even more attractive.

The Simon-Clifford theory for neutron streaming in air ducts has been further corroborated by recent Lid Tank data which, when substituted in the formula, give values of 1.0 and 0.9 for the albedo (reflection factor) in the first two bends; the theory predicted a value of 1.0 for each.

A re-evaluation of all Lid Tank measurements for the determination of removal cross sections has altered some values. The presently accepted cross sections (barns/atoms) for the following elements are: Al, 1.31; Be, 1.05; Bi, 3.43; C, 0.80; Cu, 2.08; Fe, 1.95; Ni, 1.85; W, 2.6 + 0.2. The cross section values (barns/molecule) for compounds are: C₇F₁₆, 26.6; C₂F₃Cl, 6.50; B₄C, 4.26. The effective removal cross sections of both hydrogen and deuterium are energy dependent; however, the rough values of 2.90 barns/molecule for

PROGRAM 4000 - REACTOR DEVELOPMENT (Continued)

H_2O and 2.78 barns/molecule for D_2O , based on 140-cm shields, indicate the relative shielding properties of light and heavy water.

The spectrum of gamma rays emitted by the BSF (Bulk Shielding Facility), as measured with the three-crystal spectrometer, shows the usual broad peaks at 2.2 Mev due to water capture and at 7 to 8 Mev due to capture in aluminum and possibly in other materials. A peak, observed at 0.4 Mev, appears to be real although it has not yet been explained.

Upon the basis of some experiments on visible light from a polonium source, as given in report LA-687, it has been estimated that an airplane would be visible within approximately 200 ft if the radiation level near the shield were 5×10^6 r/hr. At a distance of 50,000 ft, the radiation level would have to be about 10^9 r/hr.

The steel tower structure of the TSF was completed. The ground structures are approximately 75 per cent complete. The mechanical components of the reactor are now being assembled. The reactor tank was received. (AEC Activity 4401.7)

Fuel Recovery - Although the method for processing used fuel from the Aircraft Reactor Experiment has been established for some time, the method of transporting the fuel from the experiment to the chemical processing equipment has not been considered in detail up to the present time. By using aluminum transfer containers, 9 in. in diameter and 18 in. long, fuel batches containing approximately 4 kg of uranium as fluoride can be transferred. Thus, only about 25 transfer containers will be required. This 4 kg of uranium is equivalent to 53 kg of fluoride salt mixture and when dissolved makes about 265 gal of solution. The dissolution time for a 4 kg batch is estimated to be from 4 to 6 hours. No difficulty is anticipated in transferring the fluorides (mp, $<550^\circ C$) from the hot-fuel dump tank to the aluminum (mp, $660^\circ C$) containers, although the entire operation will have to be conducted in a confined and inert atmosphere. (AEC Activity 4401.8)

GENERAL REACTOR RESEARCH

Idaho Chemical Plant - Separation of U^{235} from fission products in the Idaho Chemical Processing Plant has been considerably poorer than that predicted from early 25 process pilot plant studies at ORNL. The ruthenium decontamination factor of 5.9×10^4 observed in the ICPP (Idaho Chemical Processing Plant) is 20-fold too low for the product to meet Y-12 specifications (beta and gamma activities less than 100 per cent of background of natural uranium) when MTR assemblies, cooled 120 days, are processed.

Recent process improvement studies at ORNL show that a 14-fold increase in decontamination can be achieved by making the second cycle feed 0.05 M in sodium nitrite, simmering for 3 hours at $85^\circ C$, and cooling prior to the second cycle extraction. (AEC Activity 10543)

PROGRAM 5000 - PHYSICAL RESEARCH

PHYSICS

Math and Computation--Physics - A code was completed and tested for the computation and tabulation of Racah coefficients on the Univac. The tabulation offers a considerable number of advantages over existing tables in completeness of coverage, freedom from error, and relative inexpensiveness. The calculations are complete, with only the automatic typing of results and the photographic reproduction yet to be performed.

Work is underway to code for the Univac the calculation of the high energy electron scattering from an assumed nuclear charge density. It is anticipated that this code will be useful in the interpretation of experiments now being performed at other laboratories.

Previously reported work on quantum electrodynamics was continued with the aim of reaching a decision on the status of the controversial Uehling effect in the Lamb shift. Existing calculations, using the presently accepted formalism, were shown to require the inclusion of the Uehling term. An alternate acceptable formalism was found in which the Uehling term was not required. Since this latter formalism seems to offer definite conceptual advantages, some work is being performed on the theory of a crucial experiment to explore the Coulomb field around the nucleus by charged particle scattering, and therefore to decide between the two alternatives. (AEC Activity 5211)

Neutron Decay Experiment - An existing spectrometer magnet was modified for use as a charged particle analyzer in recoil experiments. Fitted with flat pole pieces, the magnet nevertheless focuses in two directions by the use of oblique incidence and exit of the particles through the fringing fields. Rotating iron sectors on the exit edges of the poles permit the double focus to be achieved at various source and image positions with an actual deflection angle of 96° . The ion-optical properties of the device have been studied, and the focal length and the positions of the principal planes are known. It is possible to obtain high resolution in such a spectrometer by using only a small magnet; however, the transmission is rather low (0.12 per cent), and the instrument is best suited for the deflection of charged particle beams that are already collimated within a few degrees. (AEC Activity 5211)

Neutron Diffraction - To investigate the existence of any magnetic structures, the neutron diffraction patterns of V_3Si , Cr_3Si , and Mo_3Si were obtained at several temperatures. According to Zener's theory of magnetism, these compounds should possess antiferromagnetic structures at room temperature with the magnetic moments of the transition group atoms equal to those of the free atoms. The structures predicted by this theory would give rise to very sizeable coherent magnetic intensities on the neutron diffraction patterns, and for V_3Si , in particular, the magnetic intensities would predominate since the coherent nuclear scattering cross section for vanadium is very small. The data were taken at temperatures between room temperature

PROGRAM 5000 - PHYSICAL RESEARCH (Continued)

and 20.4°K, and no magnetic reflections were observed. From the lack of observable reflections, a value of 0.1 Bohr magneton was set as the upper limit for the strength of any aligned atomic magnetic moments. Furthermore, from an analysis of the diffuse scattering, the strength of any unaligned magnetic moments must also have been less than 0.1 Bohr magneton. (AEC Activity 5211)

Slow Neutron Physics - A Stern-Gerlach experiment was performed with a beam of slow neutrons (from the graphite reactor), which were polarized by reflection from a magnetized iron mirror. Preliminary experiments, with the iron mirror as polarizer and a magnetized iron transmitter as analyzer, established that the direction of the polarization, relative to the applied magnetic field for a reflector-type polarizer, is opposite to that for a transmitter-type polarizer. Measurements were made of the variation of neutron intensity in the deflected beam with distance across the beam; the data showed the velocity distribution and spin state for all neutrons present, as well as small effects ascribed to "depolarization". Present results indicate that the sign of the polarization agrees with the theoretical prediction; i.e., for a transmitter-type polarizer the spin state of largest population has its spin oriented antiparallel to the applied magnetic field. (AEC Activity 5211)

High Voltage Physics - The reaction $\text{Li}^7(n,t)\alpha,n$ (or He^5) was detected by measuring the tritium produced by neutrons from both fission and polonium-beryllium sources. The fission neutron activation was made inside an enriched uranium doughnut. By employing massive boron and cadmium shielding it was possible to reduce the $\text{Li}^6(n,t)$ reaction in enriched Li^7 (55 ppm Li^6) to manageable proportions. The computed threshold for the reaction $\text{Li}^7(n,t)\alpha,n$ is 2.8 Mev. A cross section of 72 ± 18 mb was indicated from the results of tritium recovery and by the fission neutron flux near 3 Mev. The polonium-beryllium neutron activation was carried out with source and samples suspended on a steel wire, 5 meters from any neutron-moderating structures. The cross section for the total flux (broad maximum near 4.5 Mev) was 30 ± 20 mb. In all activations the $\text{Li}^6(n,t)\alpha$ tritium contribution was evaluated by simultaneous exposure of natural lithium. The tritium was recovered by fusing the LiF samples in 1 per cent hydrogen-argon and measuring the activity of the evolved gas in a proportional counter. The tritium recovery and counting technique has been previously described in connection with the $\text{Li}^7(d,t)\text{Li}^6$ cross section study (ORNL-1622).

The neutron time-of-flight experiment progressed to the point where the velocity of 4-Mev neutrons was measured over a flight path of one meter. Further development of the technique is being made in preparation for measuring the energies of inelastically scattered neutrons and of neutrons produced in charged particle reactions.

The fission cross section of U^{233} , relative to U^{235} , has been measured in the neutron energy range from 120 kev to 600 kev. No significant deviations from the measurements previously reported by Los Alamos were found.

PROGRAM 5000 - PHYSICAL RESEARCH (Continued)

The technique of counting fissions in coincidence with neutron recoils was used to investigate the variation of $\bar{\nu}$ with neutron energy for U^{235} fission versus 0.5 Mev and 2.7 Mev neutrons produced by the $Li^7(p,n)Be^7$ source on the 5.5 Mev Van de Graaff. The results indicate that $\bar{\nu}(0.5 \text{ Mev})/\bar{\nu}(\text{thermal}) = 1.14 \pm 0.14$, and that $\bar{\nu}(2.7 \text{ Mev})/\bar{\nu}(\text{thermal}) = 1.42 \pm 0.27$. (AEC Activity 5211)

Interaction of Radiation and Matter - One important process for energy loss by low energy, heavy particles, such as atoms recoiling after being struck by fast neutrons or fission fragments, is the repeated capture and loss of electrons. For each capture and subsequent loss, the particle loses an energy equal to the ionization energy of the atoms of the stopping material. The ratios of the electron-capture to electron-loss cross sections were measured for various heavy ions ($H^+, He^+, H^+, He^+, A^+$) through hydrogen, helium, nitrogen, oxygen, neon, air, and argon. The heavy ions had energy values ranging from 0 to 250 kev. The ion beam from the Cockcroft-Walton accelerator was passed through a differentially-pumped gas cell, and the fraction of the emergent beam in the various charge states (neutral, singly ionized, etc.) was measured as a function of energy. It was found that in this energy range the ratio of complementary electron capture and loss cross sections can be well represented by a relation of the form $\sigma_c/\sigma_l = Kv^m$, where σ_c and σ_l are the capture and loss cross sections, v is the incident particle velocity, and K and m are constants for the particular incident particle-stopping gas combination. Although no simple relation appears to exist, the exponent m is larger for the heavier stopping gases and has values between 1 and 4. It should be noted also that for a given velocity the fraction of the emergent beam which is doubly charged is between ten and one hundred times as large for the heavier incident ions as it is for He^+ . (AEC Activity 5211)

CHEMISTRY

Waste Treatment Studies - Two asphalts, "P₂O₅-blown" and "air-blown", and two asphalt-impregnated materials, one with a vegetable fiber base, and the other with an asbestos base, are being investigated for possible use in lining waste tanks. The two asphalts expanded 60 to 70 per cent, due to gas bubble formation in the asphalt, and increased in hardness after an irradiation of 5×10^6 roentgens. The asphalt-impregnated materials appeared to be physically unchanged when exposed to the same amount of irradiation. In all cases asphalt dehydrogenation, occurring during the irradiation, resulted in evolution of gas at a rate of 3.6×10^{-3} to 7.0×10^{-3} cc/g/ 10^6 r. (AEC Activity 5361)

Chemical Separation of Isotopes - The system, ammonium carbonate (aqueous) versus ammonia (gas), has been suggested as a method of enriching N^{15} . Regeneration of ammonia from the ammonium carbonate solution at the bottom of the system should be readily achieved by the use of a calcium hydroxide slurry. The calcium carbonate formed in this process could then be calcined

PROGRAM 5000 - PHYSICAL RESEARCH (Continued)

to yield the carbon dioxide needed to form ammonium carbonate at the other end of the system. Economically, such a closed cycle reflux system would be very attractive.

This system was tested in a 22 ft high glass column packed with glass helices. A 14 ft high packed reflux column was used to strip the ammonia from the carbonate solution. An "infinite" reservoir of ammonium carbonate was used as the feed solution at the head of the column. Operation of the slurry reflux column was satisfactory; however, saturation of the ammonium carbonate solution with ammonia resulted in the precipitation of a considerable amount of ammonium carbonate, which plugged the column. It was found that ammonium hydroxide or aqueous ammonia formed by absorption of ammonia in the solution lowered the solubility of the ammonium carbonate to such an extent that the isotope separation factor of the system would be expected to approach that of the aqueous ammonia versus ammonia (gas) system (1.005) instead of that for the ammonium ion versus ammonia (gas) system (1.034). It thus appears that the carbonate system offers no advantages over the other systems available.

A liquid-liquid system for the enrichment of boron isotopes is under study. This proposed system is H_2BO_3 (aqueous) vs HBf_4 (organic). The organic phase consists of benzene plus a water insoluble amine, di(2-ethyl hexyl amine). Distribution studies, starting with boric acid and fluoboric acid in the aqueous phase, showed that very little boric acid was extracted into the organic phase and very little fluoboric acid was left in the aqueous phase. One other observation is that hydrofluoric acid appears to be extracted into the organic phase; this displaces the equilibrium such that more boric acid is formed in the aqueous phase. (AEC Activity 5361)

Instrumentation for Nuclear Research - Further tests on the DuMont Multi-channel Pulse Analyzer Cathode Ray tube having a "picket fence" type of target have shown that: (1) when the tube is used as a thirty channel analyzer the channel widths are uniform to 2 per cent; (2) the channel widths remain unchanged for beam current changes of 20 per cent or trigger sensitivity changes of 20 per cent; (3) the inherent stability of this type of pulse analyzer makes it feasible to consider 120 channel analyzers which will require no channel width adjustments.

A multichannel pulse height analyzer of the type described by the Ames Laboratory group (Zaffarano, Hunt, et al) was built. In this circuit the output from a linear amplifier is converted to very flat-topped pulses, whose amplitudes are proportional to the original signals. These pulses are applied to the vertical deflecting plates of an oscilloscope. The electron beam of the cathode ray tube (CRT) is turned on for a short time after a pulse has reached its maximum amplitude. If a slow sweep voltage, not synchronized with the incoming signals, is applied to the horizontal plates of the CRT, the spectrum will appear on the face of the tube as a random array of bright dots, which can be recorded individually on a slowly moving photographic film.

PROGRAM 5000 - PHYSICAL RESEARCH (Continued)

The analyzer that was built here has a bias control so that a portion of the spectrum may be amplified to get better resolution. There is also a provision for making coincidence measurements between this analyzer and another single channel analyzer.

At least 50 discrete channels may be measured without the use of the bias controls. (AEC Activity 5361)

Hot Laboratory Research - While re-analyzing the radiation from 5.3d promethium-148 (Pm^{148}), an opportunity was afforded to review the status of its reported 42d isomer. The Pm^{148} was prepared in the reactor by an n, γ reaction on 2.7y Pm^{147} . A 50 mC sample of Pm^{147} , when carefully analyzed on the scintillation spectrometer before irradiation, was found to contain the principal gamma rays (450, 620 and 720 kev) of Pm^{146} , indicating that a small amount of it had been produced originally by an n,2n reaction on Pm^{147} . After the irradiation, and decay through seven half-lives, the sample was still decaying with a five to six day half life. Thus, a longer-lived isomer, if present, must be less than 1 per cent of the original 5.3 day activity. The single gamma ray (0.8 mev) originally reported for Pm^{148} was found to consist mainly of three gamma rays of 540, 900, and 1400 kev. (AEC Activity 5361)

General Reactor Chemistry - An experiment was performed in conjunction with the Chemical Technology Division to determine whether or not cathodic protection, using a carbon anode, would decrease the corrosion rate of 309 S Nb stainless steel exposed to a solution containing 3 M-Th(NO_3)₄, 6 M-HNO₃, 1.2 M-Al(NO_3)₃, 0.15 M-F⁻, and 0.01 M-Hg⁺⁺. The composition of this mixture is approximately that causing excessive corrosion to the stainless steel dissolver, during the boiling off of excess acid after the dissolution of aluminum-jacketed thorium slugs in an HNO₃-HF mixture. The experiment was run at 120°C for 225 hours with a cathode current density of 15 ma/ft². It was found that under these conditions the corrosion rate of the steel was decreased from 60 mpy to 6 mpy, or by a factor of 10. (AEC Activity 5361)

Chemistry of Corrosion - The effectiveness of the pertechnetate ion, TcO_4^- , as an inhibitor of corrosion was studied over a considerable range of concentrations. The experiments were made with carbon steel (SAE 1010) specimens in distilled water alternated diurnally between 100° and 23°C in test tubes open to the air through a short condenser. Concentrations as low as 5×10^{-5} F. (5 ppm of Tc) were effective (no weight loss \pm 0.1 mg. and water-clear solution), whereas attack occurred at 3 ppm. When the tests were carried out with 5 ppm and 10 ppm Tc in a platinum-lined bomb at 250°C, the solutions remained water clear during the 116-hour run. The 2 cm² area metal specimen suffered no weight change (\pm 0.1 mg); there was some tarnish where it was stuck in the Teflon mount, but elsewhere only a thin interference film was observed. An exactly similar 96-hour run without technetium showed a weight loss of 9 mg from a specimen having an area of 2 cm².

PROGRAM 5000 - PHYSICAL RESEARCH (Continued)

Earlier it was reported that the perrhenate ion, in spite of its considerable similarity to the pertechnetate ion, did not inhibit corrosion in the concentration range in which technetium was inhibitive. Tests were made with carbon steel at 100°C in seven potassium perrhenate concentrations between 5×10^{-5} F (formal) and 0.067 F (saturated at room temperature). At all concentrations tested a black reaction film was formed in a few minutes and corrosion proceeded steadily.

In an attempt to determine whether or not the simultaneous presence of perrhenate ions diminished the amount of technetium required for protection, it was found that corrosion of carbon steel at 100°C proceeded as rapidly in a mixture of 3 ppm of technetium with 1×10^{-4} F perrhenate as in the technetium solution alone. (AEC Activity 5361)

Ion Exchange Technology - By a sorption-elution process in the 2-inch-diameter continuous ion exchange contactor, more than 99.9 per cent of the uranium was recovered from a synthetic sulfuric acid leached-ore solution using one-seventh the amount of resin needed with a fixed bed contactor.

A major problem in the use of ion exchange resins for recovery of uranium from South African ore leach liquor has been cobalt cyanide poisoning of the resin. It was found that 75 per cent of the resin exchange capacity could be regenerated by passing 2 M potassium thiocyanate through the poisoned resin, followed by 3 M sulfuric acid.

In preliminary studies, fluoride-free uranium was obtained from a hydrochloric acid digest of uranium reduction bomb and liner waste, which contains fluoride. The uranium, as uranyl fluoride, was sorbed on Dowex A-1 anion exchange resin, converted on the resin to uranyl nitrate by 4 M magnesium nitrate, and then eluted with dilute nitric acid. (AEC Activity 5361)

Equipment Decontamination Studies - Samples of type 347 stainless steel, contaminated by Purex process waste, were decontaminated from 10-25 mr/hr/cm² essentially to background by suspending them for 1 hour in 16 M nitric acid, then for 23 hours in 10 per cent sodium hydroxide--2.5 per cent sodium tartrate--1.5 per cent hydrogen peroxide. The only evidence of corrosion of the stainless steel after ten such treatments was the appearance of numerous spots less than 0.01 millimeter deep. The spots appeared when the samples had been in the first alkaline tartrate solution only 2 hours but grew little if any during the subsequent treatments. No iron could be detected (less than 1 part per million) in the solutions at the end of the testing period.

Decontamination factors of less than 2 were obtained when contaminated stainless steel was suspended in stirred slurries of anion exchange resin, cation exchange resin, or Filtrol, an inorganic adsorbent. The ultrasonic irradiation of a water suspension of these solids increased the decontamination factors to 5-10.

PROGRAM 5000 - PHYSICAL RESEARCH (Continued)

The gamma radiation picked up by stainless steel test specimens in contact with Purex waste was decreased about 80 per cent by making the waste 0.015 M in sodium fluoride, 0.002 M in inactive zirconium, and 0.002 M in inactive niobium prior to contact with the sample. (AEC Activity 5361)

Thorex Process Development - Experiments showed that the thorium nitrate feed solution from the dissolver did not have to be acidified, as had been prior practice, before the extraction step, even though it was acid-deficient at the end of the digestion period, as a result of evaporation of nitric acid. The thorium precipitates, which had formed in the extraction column in early experimental runs, did not form when the dissolver solution was digested for some time before the extraction step.

The hydraulic pulse generator system that is being tested for use in the Thorex pilot plant pulse columns has operated continuously for 216 hours. The leakage rate past a 2-inch-diameter stainless steel piston, having four Graphitar seal rings, is a permissible 1 cc/minute. The maximum variation in pulse frequency and pulse amplitude is ± 2 cycles per minute and 0.03 inch, respectively. (AEC Activity 5361)

ORACLE - After two years of design and construction at the Argonne National Laboratory, the Oracle arrived at ORNL on October 8, 1953. The physical size and complexity of the computer, as well as its delicate construction, make the installation in building 4500 a major undertaking. At the present time approximately 95 per cent of the main computer installation is completed. Exceptional care has been exercised in the installation design to provide adequate protection and controlled environment for the machine during operation. A forty-ton air conditioning system has been installed for computer and room cooling. An operator's console is currently being wired to the computer, as are the power supplies and associated control equipment. This final part of the installation is expected to be completed by December 7, and troubleshooting of the various units will then begin. (AEC Activity 5511)

PROGRAM 6000 - BIOLOGY AND MEDICINE

BIOLOGY

Cytogenetics - In continuation of the studies on the mechanism of chromosome recombination, flies, segregating for the autosomal M(3)y minute gene, were used so that the data could be more closely compared with the data on unattached-X chromosomes reported by C. Stern, Genetics 21, 625 (1936). These experiments support the hypothesis that recombination between homologous chromosomes is limited to the newly-formed chromatids. It was found that the frequency of twin spots in attached-X females could be greatly increased if the mothers were subjected to those environmental conditions,

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such as aging, which increase sister strand crossing over in the offspring (S. W. Brown and A. Hannah, Proc. Natl. Acad. Sci., 38, 687 (1952)). These experiments strongly suggest that chromosomal recombination is a result of two events: (1) crossing over between the newly formed chromatids of homologous chromosomes, and (2) sister-strand crossing over.

Evidence has been given previously that H_2O_2 is not an effective mutagen for Paramecium and so cannot be responsible, as some workers have suggested, for the influence of oxygen on mutagenesis by X rays. The following experiments were done to test this conclusion: (1) repeated exposures to sublethal concentrations of H_2O_2 in an attempt to accumulate mutations to a detectable level while avoiding the nongenetic lethal effects; (2) exposure to X rays and to X-ray-produced H_2O_2 simultaneously to reproduce as closely as possible the situation in an X-ray experiment; (3) exposure to extremely high concentrations of H_2O_2 for a very brief time immediately after X irradiation to simulate as closely as possible the concentrations that might be found in electron tracks. Since no effect of H_2O_2 on mutation was found in any of these experiments, the previous conclusion was confirmed.

Previous work in this laboratory demonstrated that equal doses of X rays (125 kvp) and beta rays (P^{32}) have different quantitative effects on the mitotic rate of neuroblast cells in grasshopper embryos, the former causing more mitotic inhibition than the latter. The frequency of chromosome fragments found at a given interval after subsection of cells to the two types of radiation was also shown to be greater in the X-irradiated cells than in the beta-irradiated ones.

Two possible interpretations of the higher fragmentation rate in the X-rayed cells are: (1) it is due to greater efficiency of X rays in producing chromosome breaks, or (2) it is due to different mitotic rate effects, i.e., cells which reach anaphase (stage at which fragments produced earlier in mitosis are visible) at a given time after X or beta radiation were treated at different stages of mitosis--the difference in chromosome fragmentation might, in this case, be the result of a differential sensitivity of the various stages of mitosis. Detailed studies of the effects of the two types of radiation on the stages of mitosis were completed and reveal that all stages are considerably more retarded by X than by beta rays but that the cells in anaphase at any given time after exposure to either type of radiation were treated at several different stages of mitosis. Unequivocal choice of either of the two above interpretations is, therefore, impossible in a mitotically heterogeneous tissue such as the grasshopper embryo. (AEC Activity 6400)

Mammalian Genetics - Several reports on radiation damage to the mammalian testis have attributed depletion of spermatogenic elements to inhibition of mitosis of type A spermatogonia. This conclusion is difficult to reconcile with the marked decrease in number of spermatogonia by four days after irradiation, and suggests the possibility that intervals selected for study have been inadequate for demonstration of degenerating cells. As cell death

PROGRAM 6000 - BIOLOGY AND MEDICINE (Continued)

may have an important bearing on the transmission of mutations induced in spermatogonia, an attempt was made to obtain quantitative data on cell degeneration which occurs in the testes of mice following exposure to X rays. Sections from testes of mice killed at intervals of one hour to 28 days after exposure to 600 r of X rays indicated degenerative changes both in type A and type B spermatogonia. Quantitative estimates of cell destruction will depend upon the relationship of sampling intervals to the rate of disappearance of necrotic cells. Since degenerating spermatogonia show rapid lysis, an underestimate of "total death" probably was obtained. Nevertheless, sufficient degeneration of spermatogonia was observed to explain depletion of the germinal epithelium following irradiation, without recourse to the theory of inhibition of mitosis. (AEC Activity 6400)

Microbiology - In connection with the coenzyme A (CoA)-dependent succinate decarboxylation system (isolated from propionic acid bacteria and described in report ORNL-1622), fractionation studies were initiated in order to separate the enzyme systems involved. In addition to a highly active CoA transphorase, the complete system appears to consist of at least the following enzyme fractions: (1) three different types of succinate-activating enzymes, (2) a succinate "decarboxylase", and (3) a CO₂-producing enzyme which is separate from (2). (AEC Activity 6400)

Radiation Protection - Paper chromatography (butanol-propionic acid-H₂O) of an ethanol-soluble beef spleen extract has shown that maximal activity for the recovery of irradiated E. coli B/r is concentrated in the R_f-value range 0.4 to 0.8. Amino acids which have R_f-values in this range have been assayed for activity. An intensive investigation of the relative activities of these amino acids alone and in combinations has revealed that maximal activity may be obtained with four or less amino acids. At the optimal concentration of amino acids the activity approximates 20 per cent of that obtained with complex natural materials.

Experiments, designed to identify the material other than adenosine triphosphate released by X-irradiated Escherichia coli B/r subsequently incubated in a phosphate buffer-glucose solution at 37°C, are under way. The amino acid assay of the supernatants from such suspensions by paper chromatography has shown that alanine is the only amino acid consistently released in identifiable quantities by such exposed cells. The material in the supernatant, responsible for absorption in the ultraviolet, is being analyzed by means of ion-exchange chromatography. (AEC Activity 6400)

Biochemistry - An essential part of the identification of the nucleotide isomers reported earlier is the characterization of ribose-3-phosphate and the hitherto unknown ribose-2-phosphate. The preparation of the requisite amounts of these substances in pure form has required the development of new methods for the removal of inorganic phosphate and for the fractional crystallization of well-defined salts. The first of these problems has been solved; the second is on the way to solution using brucine salts.

PROGRAM 6000 - BIOLOGY AND MEDICINE (Continued)

The bacterial deoxy-ribo-nuclease (DNase) of phage lysates has been freed of contaminating phosphatases and deaminases. It is inhibited by bacterial ribo-nucleic-acid (RNA) and, like pancreatic DNase, is activated by Mg^{++} . It will hydrolyze the DNA of T₄r⁺ phage to the extent of 19 per cent of the total P content, measured by titration, or 23 per cent if measured by liberation of end-group phosphates. Only 5 per cent of the total DNA exists as mononucleotides in such digests; the rest is a variety of polynucleotides.

Several aspects of bacterial extract luminescence have been investigated. The Michaelis constants vary from 10^{-5} to 10^{-7} M. The "half-rise time," when diphospho-pyridine nucleotide (DPN) or malate are added last, is about 108 sec.; 0.08 sec when O₂ is last; 0.1 sec when kidney cortex factor (KCF) (palmitaldehyde) is last; 0.07 sec when reduced flavine mono-nucleotide (FMNH₂) is last; and 2.8 sec when DPNH₂ or FMN are last. Activation energies for the sequence DPN + malate → DPNH₂; DPNH₂ + FMN → DPN + FMNH₂; FMNH₂ + O₂ → FMNH₂O₂ + light are 25 to 31 kcal. (AEC Activity 6400)

Plant Biochemistry - It has been demonstrated by ion-exchange chromatography and by paper chromatography that acid treatment of the seven-carbon sugar, sedoheptulose, results in a mixture of four compounds. Two of these are the expected sedoheptulose and sedoheptulosan, but the other two are unknown compounds. The formation of extraneous compounds is undesirable for biological tracer work with this new sugar. Thus, the extent of formation, the separation and isolation, and the identification of these compounds were investigated. The new compounds were tentatively identified as a furanose anhydride of sedoheptulose and a furfuraldehyde derivative of sedoheptulose. Small scale isolation of all these compounds was effected by the use of thick-paper chromatography. Large scale isolation of the furanose anhydride was made possible by the ion-exchange chromatography of the borate complexes of the compounds.

The above results on the chemistry of the seven-carbon sugars are analogous to those reactions for the more common hexoses, such as glucose and fructose. It has also been demonstrated that only one of the above four compounds from the acid treatment of sedoheptulose, namely the furfuraldehyde derivative, is responsible for the orcinol test which is specific for the seven carbon sugars. This knowledge permits more quantitative analysis of amounts of this sugar. (AEC Activity 6400)

Biophysics - A preliminary study of the "drive-in" technique for irradiations, whereby accelerated deuterons are driven into a bare metal plate and subsequently serve as target nuclei for the d-d reaction, suggests that this method may provide a very stable and reliable target for low intensity work, such as chronic irradiation studies.

A distributed-type radiation source, designed and built here for the U. S. Department of Agriculture in connection with the screwworm control project, was calibrated and is ready for shipment. The strength of this source, comprising approximately 75 curies of Co⁶⁰, permits samples as large as 800 cc in volume to be irradiated with a dose rate of 15,000 r/hr ± 10 per cent.

PROGRAM 6000 - BIOLOGY AND MEDICINE (Continued)

Chromosome breakage, produced by ultraviolet irradiation of Tradescantia pollen, was studied as a function of ultra violet light wavelength in the range 3130 Å to 2400 Å, and an "action curve" was determined for this region. The results are in close agreement with the well-known curves for the killing of bacteria. Preliminary studies also indicate no difference in the frequency of chromosome breakage for material irradiated with ultraviolet light in air and that irradiated in nitrogen. (AEC Activity 6400)

Pathology and Physiology - Observations, one year after exposure, suggest that the threshold dose with 2.5 Mev neutrons for inducing cataracts is approximately 1×10^9 n/cm² for mice, 1×10^{10} n/cm² for rats, and more than 1×10^{10} n/cm² for rabbits. Rabbits and rats exposed to 333 r of Co⁶⁰ gamma radiation have failed to develop opacities of the lens 16 months after irradiation.

Mice, guinea pigs, and rats have developed severe cataracts within 6 months after exposure to 240 rep of cyclotron-produced neutron radiation. The lens of the mouse appears considerably more radiosensitive than that of the rat or guinea pig. Within the first six months after X radiation, the opacity changes are mild in these species, even at the LD₅₀ level, indicating a consistently high relative biological effectiveness (RBE) for neutrons. Attempts are being made currently to establish precise dosimetry by using several systems of neutron measurements in a new exposure chamber at the cyclotron.

Blood platelets labeled both in vivo and in vitro with C¹⁴ formate have been injected into normal rats and the number of platelets which circulate, in terms of the radioactivity remaining at intervals following injection, has been determined. The initial results indicate that considerably fewer of the in vitro-labeled platelets circulate and also that the death rate of the in vitro-labeled platelets is greater.

Recent interest in the possible effect of irradiation on coenzyme A (CoA) suggested the investigation of the effect of X irradiation on the enzymatic acetylation of choline by rat brain, a system that has been shown to be highly dependent on the activity of CoA. Results of the experiments are in accord with previous observations and show both that CoA activity in this system is unaffected by as much as 19,000 r of X ray and that there is no demonstrable effect of irradiation on the activity of the system as a whole. (AEC Activity 6400)

Enzyme Chemistry - Nucleic acid synthesis in 2-1/2 day old chick embryos, as measured by C¹⁴-formate uptake, is inhibited by γ -irradiation with Co⁶⁰. A dose of 11,000 r at 25°C is sufficient to reduce the uptake of formate by 50 per cent in the two-hour incubation period immediately following the irradiation. In similar experiments with 8-C¹⁴-adenine instead of C¹⁴ formate no inhibition was found for exposures up to 20,000 r. This difference in the two experiments suggests that one or more radiosensitive reactions are important in the conversion of formate to purines. Further proof of the validity of the adenine labelling in the nucleic acids is necessary, however, before further extensive investigations are made.

PROGRAM 6000 - BIOLOGY AND MEDICINE (Continued)

In studies on fluorescence of living plants, it has been observed that the intensity of the light is very low. From this observation it is deduced that the lifetime of the excited chlorophyll is some twenty times less in the living plant than in a chlorophyll solution. Since essentially no depolarization of the fluorescent light, due to rotation of the chlorophyll (which is believed to be combined with a protein), is expected in the living plant, one should observe about a 42 per cent polarization, a value derived theoretically and from observations on chlorophyll in castor oil. Careful measurements have shown that polarization of the fluorescent light from living plants is only of the order of three per cent. This result indicates that the energy absorbed from the light must be transferred, from one chlorophyll molecule to another within the chloroplasts, at a rate that is at least ten times greater than the combined rate for photosynthesis and degradation as heat. (AEC Activity 6400)

RADIOISOTOPE SALES AND COSTS

<u>Type of Transaction</u>	<u>October</u>	<u>FY to Date</u>
Domestic Sales (included cancer cash)	\$ 57,239.	\$302,822
Foreign Sales	4,280	17,727
Project-Cash Sales	12,421	37,091
Project-Transfer Credits	257	413
Technical Cooperation Program Credits	622	3,991
Plant Credits	10,714	46,255
Civilian Defense Credits	-130	390
Cancer Program Credits	18,849	70,779
*Miscellaneous Income	---	177
Total Income	<u>\$104,252</u>	<u>\$479,645</u>
**Income - No production costs incurred	<u>-280</u>	<u>16,085</u>
Radioisotope Income	<u>\$104,532</u>	<u>\$463,560***</u>
Radioisotope Costs	<u>\$ 75,690</u>	<u>\$374,611</u>
Radioisotope Shipments	<u>1,058</u>	<u>3,936</u>

*Miscellaneous income - D₂O, freight, missing parts, TCP

**Income from H³, He³, B¹⁰ and miscellaneous items in excess of handling cost.
This month cost exceeded income by \$280.00

***Adjustment made to correct error in July report.

GROSS OPERATING COSTS

	<u>Cost for October</u>	<u>FY 1954 Cost to Date</u>
Programmatic Operating Cost - Net	\$2,306,417	\$ 9,585,259
Plant and Equipment Cost	378,739	1,193,359
Construction Prog. "H"	5,317	18,116
Work for Other Parties - Transfer	28,598	192,250
Inventory Changes	83,625*	132,384*
Reimbursable Work for Other Parties	118,252	524,922
Deferred Charges	<u>3,516</u>	<u>5,856</u>
Total Laboratory Cost - Net	<u>\$2,757,214</u>	<u>\$11,387,378</u>
Estimated Cost for Next Month - Neg	<u>\$2,850,000</u>	<u>\$14,237,378</u>

*Credit

[REDACTED]

PERSONNEL SUMMARY

	<u>Number of Employees</u> <u>November, 1953</u>	<u>New Hires</u> <u>November</u>	<u>Terminations</u> <u>November</u>
Administration	62	0	0
Operations*	117	0	0
Engineering, Shops and Mechanical	720	18	12
Laboratory and Research	1654	10	16
Protection	171	1	2
Service	<u>398</u>	<u>3</u>	<u>3</u>
Total	3122	32	13

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

A total of 622 Laboratory personnel are located in the Y-12 Area.

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Previous reports in this series:

January 1953	ORNL-1486
February 1953	ORNL-1516
March 1953	ORNL-1529
April 1953	ORNL-1545
May 1953	ORNL-1562
June 1953	ORNL-1576
July 1953	ORNL-1600
August 1953	ORNL-1612
September 1953	ORNL-1622
October 1953	ORNL-1643