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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

JANUARY 1953

AEC RESEARCH AND DEVELOPMENT REPORT

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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

January, 1953

W. H Sullivan

Date Issued: FEB 12 1953

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TABLE OF CONTENTS

	Page
PROGRAM 2000 - SOURCE AND FISSIONABLE MATERIALS	6
Metal Recovery	6
Purex Process	6
PROGRAM 4000 - REACTOR DEVELOPMENT	7
HOMOGENEOUS REACTOR PROJECT	7
Homogeneous Reactor Experiment	7
Solution Chemistry	7
Engineering Development	8
Reactor Physics	8
AIRCRAFT NUCLEAR PROPULSION PROJECT	8
Aircraft Reactor Experiment	8
ANP General Design	9
ANP Experimental Engineering	9
ANP Metallurgy	10
ANP Reactor Physics	11
Shielding Research	11
PROGRAM 5000 - PHYSICAL RESEARCH	11
ISOTOPE PRODUCTION	11
Stable Isotope Production	11
PHYSICS	12
High Voltage Program	12
Theoretical Physics	12
Short Period Radioisotopes	12
86-Inch Cyclotron Nuclear Physics	13
The 86-Inch Cyclotron	13
The 63-Inch Cyclotron	13
The 44-Inch (22-Inch) Cyclotron	13
Isotope Analysis Methods Laboratory	14
Mass Spectrometer Laboratory	14
CHEMISTRY	14
Thorex	14
Chemistry of Uranium Raw Materials	15
Waste Treatment Studies	16
METALLURGY	16
Fundamental Physico-Metallurgical Research	16
Fundamental Investigations of Radiation Damage in Solids	16

[redacted]

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TABLE OF CONTENTS Continued

Page

PROGRAM 6000 - BIOLOGY AND MEDICINE 17

BIOLOGY 17
Cytogenetics 17

BIOPHYSICS 18
Radio-Chemical Analyses 18
Physics of Nuclear Radiations 18
Physics of Radiation Dosimetry 18
Permissible Internal Dose for Radioisotopes 19
Experimental Radiation Measurements 19

RADIOISOTOPE SALES 20

GROSS OPERATING COSTS 20

PERSONNEL SUMMARY 21

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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

January, 1953

PROGRAM 2000 - SOURCE AND FISSIONABLE MATERIALS

Metal Recovery - The processing of ORNL tank farm wastes, for recovery of uranium and plutonium by solvent extraction, with tri-butyl phosphate (TBP), was begun in the Metal Recovery Plant. The process developed for this purpose was found to be optimum if the feed solution resulting from nitric acid dissolution of the waste slurry contained 90 to 110 g/l of uranium. The plant was constructed on this basis with a rated capacity of 750 pounds of uranium per day. At the present time, the plant is operating with a feed solution containing only about 40 gms U/l and at a rate of 200 pounds of uranium per day. The lower rate is due to difficulty in removing a waste slurry of higher uranium concentration from the tanks. Means are being investigated for removing a higher solids content slurry from the tanks. Until such means are developed and equipment installed, it will be necessary to concentrate the present slurry after removal from the tanks. A combination of settling, acidification, and evaporation will probably be used as soon as equipment alterations can be made. (AEC Activity 2344)

Purex Process - The present "tail-end" treatment to remove Zr and Nb in the uranium product solution (necessary in order to meet γ activity specifications) yields a decontamination factor of 5-10 for these elements when the product is passed through a column of 20-40 mesh silica gel. It has been shown that if 60-80 mesh silica gel is used, decontamination factors three fold greater can be obtained. This higher capacity of the 60-80 mesh gel suggests the use of a column of sufficient size so that the radioactive decay of Zr and Nb to stable Mo on the bed equals their removal from the uranium product solution. Such a scheme would then eliminate the need for frequent column regeneration. It is estimated that this objective could be accomplished, at a uranium processing rate of three tons per day, with a silica gel column 20 inches in diameter and 20 feet high.

The last in a series of five Pilot Plant runs conducted to supply design information applicable to the Hanford Purex facility was completed. The uranium processed had been irradiated 580 MWD/T and cooled 71 days.

In this run the degree of uranium saturation of the TBP solvent from the first extraction column was reduced to 50 percent from the normal 75 percent and the pulse amplitude used was reduced. As a result of these changes, the gross beta and gamma decontamination factors were lowered by a factor of 20 and the uranium product failed to meet specifications (after two solvent extraction cycles). This off-standard uranium product was processed through a third solvent extraction cycle and then through a silica gel column for removal of Zr and Nb. The resulting product met specifications.

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The plutonium product after the usual two cycles of solvent extraction followed by adsorption and elution from an ion exchange resin bed met specifications. (AEC Activity 2802)

PROGRAM 4000 - REACTOR DEVELOPMENT

HOMOGENEOUS REACTOR PROJECT

Homogeneous Reactor Experiment - Operation of the HRE was resumed in January after tests indicated the system to be leak-tight and trouble-free. After about twelve hours operation at power levels between 1 and 20 kilowatts, a break occurred in the electrical connectors on the Calrod heating elements of the 10-KW boiler. This small boiler, located inside the shield, supplies high-temperature steam to heat the pressurizer to 285°C, yielding 1000 psi steam pressure in the fuel system. While the reactor was shut down for repairs, additional steam lines were installed through the shield to provide an alternative means of heating the pressurizer.

While these repairs were being made, a complete analysis of the HRE fuel showed the presence of chloride to the extent of about 40 parts per million. It is suspected that most of the chloride was introduced when the oil from a manometer on the low-pressure fuel system was accidentally blown out of the instrument into the fuel system. The manometer oil was found to contain about 12 percent chloride.

Because of the effect of the chloride contamination in accelerating corrosion, the fuel has been drained into the outer dump tanks that are located underground outside the shield, and the fuel system has been completely rinsed with water. Special effort is being devoted to testing methods for removing the chloride ion contamination from the fuel without taking the solution out of the reactor system. (AEC Activity 4103.1)

Solution Chemistry - Recent investigations have indicated that hydrolytic precipitation of uranium occurs in stoichiometric UO_2SO_4 - H_2O solution at 250°C, if the UO_2SO_4 concentration is below approximately 0.017 M.

Studies on $CuSO_4$-H_2O solutions indicate that hydrolytic precipitation occurs in the temperature range, 90 - 140°C, at $CuSO_4$ concentrations from 10^{-3} molar to 1 molar. It is evident that complexing action or acidity is responsible for the solubility of $CuSO_4$ in UO_2SO_4 solution at 250°C.

Solutions of 0.021 M UO_2SO_4 containing from 2 x 10^{-3} to 0.02 M $CuSO_4$ were found not to be phase stable at 250°C. An investigation is underway to determine the amount of excess sulfate necessary to prevent precipitation at this temperature in 0.021 and 0.125 M UO_2SO_4 containing from 0.02 to 0.10 M $CuSO_4$. (AEC Activity 4109.31)

Engineering Development - The assembly of a 50,000 gallons per minute water circulating system, for studying flow patterns and pressure drops in large pipes and vessels of interest in the design of large scale homogeneous reactors, is nearing completion. The system consists of an 8-foot spherical core having two tangential equatorial inlets and two polar outlets, eight 6000-gpm centrifugal pumps operating in parallel, and two 10,000 gallon hold-up tanks. All piping is 24 inches in diameter. The system is to be operated with water at room temperature and near atmospheric pressure. (AEC Activity 4109.6)

Reactor Physics - A theoretical investigation was conducted to determine the criticality behavior of a slurry reactor as a function of the settling of the fuel particles. From this study one finds there are two important factors affecting criticality as the fuel settles: the change in the ratio of hydrogen to uranium (H/U) and the build-up of a nearly pure reflector layer as the particles settle to the bottom.

The formation of a top reflector layer in itself always leads toward a more critical condition, while a decrease in H/U ratio may cause the assembly to become either more or less critical, depending upon the initial H/U value. The effect of fuel settling upon criticality behavior is determined by the combination of both factors.

The calculations show that a given critical reactor, having an initial H/U ratio greater than that required for minimum critical mass, can attain a supercriticality condition as a result of decreasing the agitation of the slurry. Complete stopping of the agitation should lead to a less dangerous situation in comparison to just decreasing the agitation.

For initial H/U ratios below that corresponding to minimum critical mass, there is a range of H/U ratios in which fuel settling can result in a supercritical condition, due to the effective addition of a top reflector. This range of H/U ratios is dependent upon the size and type of reactor considered. For all cases large decreases in the H/U ratio, as when the slurry settles almost completely, will result in a subcritical assembly. This work is reported in detail in memorandum CF-53-1-294. (AEC Activity 4112.2)

AIRCRAFT NUCLEAR PROPULSION PROJECT

Aircraft Reactor Experiment - All major shop work on the pressure shell, prior to installation of the internal fuel tubes and moderator blocks, has been completed. The fuel tubes have been shipped by the vendor but have not yet been received. Control mechanisms will be completed in about two more weeks. Large parts for the pumps are completed but work continues on the seal parts and smaller items.

With regard to installation in the ARE building, the fuel heat disposal loops are 50% installed. The main effort in the electrical installation went into the heater circuits for which a trial heater assembly (the hot fuel dump tank emptying lines) was made up and tested. The large motor generator set was received, installed in place, but not wired.

The control room installation in the building is nearing completion. The relay rack wiring is complete and the console wiring is 75% complete. The graphic panel is installed and has been checked out. All instruments, except six recorders not yet received, have been mounted on the panel and all panel marking and labeling has been completed.

As far as can be foreseen all outstanding components for the ARE will be ready for the field by March 1 with the possible exception of the pumps which are still held back pending the outcome of experimental work in progress in the Experimental Engineering Department. One 2" bellows-type valve was turned over to Experimental Engineering for testing. (AEC Activity 4401.1)

ANP General Design - Consultations with personnel from Wright Air Development Center, and Boeing Airplane Company have led to the decision to prepare a rough layout of several reactor-shield-radiator-turbojet engine systems in the form of compact package units that would lend themselves readily to installation in an airplane. Three units are envisioned--a 120 Mw unit for preliminary flight tests in a B-36, a 200 Mw sea-level unit for flight at Mach .7 to .9, and a 200 Mw unit that might be suited to flight at Mach 1.5 at 45,000 ft. Most of the data on turbojet engines for these units have been accumulated.

Arrangements have been completed for Lid Tank tests on the Be-B_4C-NaF-Fe-Pb-H_2O shield on which preliminary design work for the Fireball was based. Activation of Na in the heat exchanger region and the effects of ducts will be investigated as well as the optimum locations and thicknesses of the B_4C layers.

Attempts to braze the first two large radiators for the Boeing turbojet engine test have been unsuccessful. This seems to be the result in part of the considerable differences in heating rate of various regions in large assemblies, and in part to the fact that severe embrittling of thin stainless sections (.016" wall tubes in the case) tends to occur. The sensitivity of both Nicrobraz and a gold-nickel alloy to both brazing time and temperature is being investigated. (AEC Activity 4401.1)

ANP Experimental Engineering - Evidence was obtained that an increase in fused salt temperature does not greatly increase the corrosion rate. In one test, which circulated Fuzrna 30 in an Inconel thermal convection loop for 500 hours at a temperature of 1650°F, the maximum depth of attack was 11 mils, as compared to 10 mils for similar loops operated at 1500°F. This same fuel was circulated in a "316 stainless steel" loop for 500 hours without evidence of plugging.

A bi-fluid heat transfer loop was operated almost continuously during the month and measurements of heat transfer from fluorides to NaK were made over a wide range of flow rates and temperatures.

Sodium will probably be used in place of NaK as the ARE moderator coolant, since attempts to prevent leakage of the NaK from the ARE pump seal have been unsuccessful. It was found that high temperature sodium could be retained in an ARE pump, which incorporated a frozen sodium seal.

A weight loss of 25% was found for BeO samples placed inside a thermal convection loop in which NaK was circulated at a velocity of 8 ft/min for 212 hours at 1500°F. Evidence for the solubility of BeO in NaK was obtained from chemical analyses of the coating on the walls of the loop.

The hydraulic mock-up of the ARE fuel circuit was operated with water and with a water-clycerine solution having a viscosity similar to the ARE fuel. These tests revealed a severe vortexing action in the ARE surge tanks. (AEC Activity 4401.1)

ANP Metallurgy - Room and elevated temperature tensile test data on type 316 stainless steel joints brazed with a Cr-Si-Ni alloy were obtained. The room temperature data show considerable scatter with a maximum tensile strength of 86,300 psi, a minimum of 40,900 psi and an average for four tests of 64,400 psi. This scatter of data is thought to result from the extremely brittle room temperature behavior of this alloy. One test bar failed in the parent metal while the others failed in the brazed joint. The average joint efficiency at room temperature was 75% while the average elongation of the test bars was 26% in a 1 inch gage length.

At 1500°F, the average tensile strength of these joints was 25,000 psi, which corresponds to a joint efficiency of 98%. The average elongation of the test bars was 19% over a 1 inch gage length. The strength of four test bars was much more consistent at this elevated temperature indicating a more ductile brazed joint. All test bars failed in the brazed joint.

As had been previously predicted, the room temperature tensile strengths of joints brazed with high nickel alloys seem to be considerably greater when using stainless steel as the base metal than when using Inconel. For example, the average tensile strength of the 16.5 Cr-10.0 Si-73.5 Ni alloy when brazed on stainless steel was 64,400 psi while it was only 33,700 psi when brazed on Inconel. At 1500°F, the stainless joints fractured at 25,000 psi while the Inconel joints fractured at 23,100 psi. The increased strength of the stainless joints is thought to result from the increased diffusion of the brazing alloy due to the higher concentration gradients in the stainless steel than in the Inconel.

The study of the production of a high conductivity fin for radiators is continuing. It was found that commercial type tough pitch copper when electroplated with chromium would blister after going through the brazing cycle. Therefore, samples of commercial copper were heated for 18 hours at 1800°F in hydrogen prior to being electroplated. These samples did not blister after being cold plated and subjected to the brazing cycle. Samples of the oxygen free high conductivity copper after being electroplated were also subjected to the brazing cycle and did not blister. This is rather conclusive proof that the blistering was due to oxygen in the copper.

ANP Reactor Physics - Further data from the ARE critical experiment have been analyzed, in particular those regarding power distribution inside a fuel element and the axial and radial power distribution of the whole reactor. These values are as follows:

Core axial max-to-avg power ratio	=	1.5
Core radial max-to-avg power ratio	=	1.6
Fuel tube radial max-to-avg power ratio	=	1.7

The more realistic mockup of the three-region, Fireball-type reactor required a critical mass about 15% higher than the theoretical prediction.

Shielding Research - The recoil-proton fast neutron spectrometer has been used to measure the spectrum of outwardly-directed neutrons in the water near the Bulk Shielding Facility reactor. To date, measurements have been made from 0 to 30 cm from the edges of reactor, and it is expected that this study can be extended for perhaps another 20 cm, although with some sacrifice in resolution. The results are extremely interesting since water is the prototype for all light weight neutron shields. The data are sufficiently detailed to give accurate information concerning the relative importance of the various attenuation mechanisms. For example, a previously unsuspected minimum in the oxygen cross section just below 10 Mev constitutes a window which probably accounts for most of the penetration of radiation in thick water shields. In view of the importance of this effect, measurements have been immediately initiated to measure the attenuation of paraffin in order to demonstrate that this peak in transmission is attributable to oxygen. It is entirely possible that some mixture of hydrocarbons and water may be more effective than either alone if, as is to be expected, the minima in carbon and oxygen cross sections do not coincide. These revelations have increased the incentive for measurements in the Lid Tank on attenuation of transformer oil, a saturated hydrocarbon. Some of this work has already been carried out, but it is anticipated that it will be extended to include a measurement with the Lid Tank filled with this oil.

The preliminary proposal for the Tower Shielding Facility was completed, including an estimate of $1,800,000 for the total cost of construction. (AEC Activity 4401.7)

PROGRAM 5000 - PHYSICAL RESEARCH

ISOTOPE PRODUCTION

Stable Isotope Production - Three elements, lithium, silicon and boron were processed during the month yielding seven isotopes. Production "innage" for the four calutrons was 1595 hours, while 148 hours of XBX time were devoted to non-productive platinum exploratory runs. "Outage" time was 22.6 per cent as compared with 12.2 per cent last month. The integrated output was 434,654 ma hours for the Alpha channels and 14,206 ma hours for the Beta channels.

The chemical refinement of eight isotope samples was completed, leaving twenty-two isotopes in process of refinement and fourteen in the backlog at the end of the month. Seventeen shipments and transfers of stable isotopes were made. Chemical refinement of isotopes of neodymium, tin, germanium, lithium and sulfur is in progress. (AEC Activity 5121)

PHYSICS

High Voltage Program - The cross section of the He^3-He^3 reaction has been measured as a function of bombarding energy in the energy interval 85 to 800 Kv. In this energy range the cross section curves rises monatomically from a value of $\sim$ 0.035 microbarns at 85 Kv to a value of 4,000 microbarns at 800 Kv.

During the calibration of the analyzing magnet for the 2 Mv Van de Graaff the following (p,n) threshholds were observed:

Ti^{49}	1.42 Mev
As^{75}	1.68 Mev
Zn^{67}	1.81 Mev
Zn^{70}	1.47 Mev

The reassembly of the 5 Mv Van de Graaff in the High Voltage Building is nearing completion. Debugging operations are now in progress. (AEC Activity 5211)

Theoretical Physics - Whenever one measures a β spectrum it has been necessary to make very laborious numerical computations on the basis of formulae which are not quite accurate in order to analyze the spectrum; that is, to classify the beta transition as to order of forbiddenness, parity change and spin change. The necessity for repeating such calculations over and over again has now been eliminated by calculations which have been made and now completed for all relevant quantities which enter every beta decay up through third forbidden. For each of 46 electron emitters and 46 positron emitters, 24 different quantities have been tabulated as a function of beta particle energy where over 30 values of the latter are considered. These calculations have been made on the basis of an exact theory. (AEC Activity 5211)

Short Period Radioisotopes - The 0.82 second Pb^{207m} isomer, which can be produced by fast neutron irradiation of lead, was shown to be the daugher of $\sim$ 50y. Bi^{207} by a technique utilizing an anion exchange resin, Doxex-1. The separation of the daughter Pb^{207m} from its parent Bi^{207} depends on the fact that Bi(III) is more strongly adsorbed on an anion exchange resin than Pb(II) when they are in chloride solution. Thus the Pb^{207m} formed by decay diffuses out of the resin into the surrounding solution medium and drops of this solution could be transferred quickly to a counter to follow the decay of the short lived isomer. The theoretical interest in this isomer centers about the fact that it represents a case in which the predictions of the nuclear shell theory are experimentally verified. (AEC Activity 5211)

86-Inch Cyclotron Nuclear Physics - Further data were obtained on angular distributions of elastically scattered protons. A new method of determining absolute cross sections was only partially successful; improvements in the method are being studied. Several of the difficulties in the NaF deuteron detection method used in measuring angular distributions were eliminated; a measurement of the angular distribution of deuterons from the $Be^9(p,d)Be^8$ (ground state) reaction was then found to agree well with results previously obtained with Pb detection. Preliminary test measurements of angular distributions from (p,t) and (p,α) reactions in heavy element targets were made; both experiments appear to be feasible in spite of previous difficulties. A new isotope, dysprosium 157, was identified and its decay scheme determined. It is produced by the (p,3n) reaction on terbium. New isotopes, Mn^{57} and Mn^{58}, were tentatively identified. The work on measurement of excitation functions was continued and the circulating system for determining short half lives was improved. (AEC Activity 5211)

The 86-Inch Cyclotron - By the use of orbit-positioning coils an energy of 24.8 Mev was obtained on the 86-inch cyclotron. No operational difficulties were experienced when a reduction from three-shift to two-shift operation, five days per week, was made on January 1, 1953. A total of 131 bomardments were made during the month. A new shielded enclosure installed in the cyclotron pit for the use of the ORNL Biology Division permits the simultaneous exposure of 24 mice to high energy neutrons; four-inch thick lead walls reduce the gamma-ray flux to a satisfactory level. Gallium 67 production for the ORINS Medical Division was continued at a rate of 400 to 500 mC per week. A sodium metal target was bombarded to produce Na^{22}, by the (p,pn) and (p,2n) reactions, and is being assayed by the ORNL Operations Division. (AEC Activity 5261)

The 63-Inch Cyclotron - The internal beam of the 63-inch cyclotron was deflected successfully; the deflected beam currents are still very small, probably no greater than 50 μμa. From the bombardment of di-deutero-cupreine in the internal beam, absolute values for the average cross sections of some 20 nitrogen-induced reactions were determined. The cross sections vary from 1.3×10^{-26} cm^2 for the $N^{14} + Be^9 \longrightarrow F^{18} + He^5$ reaction to 4×10^{-29} cm^2 for the $N^{14} + N^{14} \longrightarrow N^{13} + N^{15}$ reaction. (AEC Activity 5261)

The 44-Inch (22-Inch) Cyclotron - Since the equivalent pole piece diameter of the cyclotron, in which the 22-inch diameter circulating beam has been obtained, is 44 inches the machine will henceforth be identified as the ORNL 44-Inch Experimental Cyclotron, in keeping with the established practice for cyclotrons. Several dc injection tests were made with a dc accelerating electrode between the source and the rf electrode mounted on the dee. Beam current during these tests was observed to be less than the current obtainable with an rf electrode used alone. Tests are being continued. (AEC Activity 5261)

Isotope Analysis Methods Laboratory - Equipment has been converted to 2.5 megacycle range at fields up to 16,000 gauss to permit search for the U^{235} nuclear resonance at $g \cong 0.24$. A preliminary check of the fluorine resonance indicates that the equipment is, at present sensitivity, limited to the U^{235} resonance.

Carbon monosulphide has been produced and kept for approximately 20 seconds in an absorption tube. Lithium butyl is being prepared for microwave and nuclear resonance studies of the rotational spectrum. n-butyl-lithium was synthesized and its infrared spectrum was determined in the region from 2 to 15 microns wavelength.

Spectral studies of highly refractory materials in uranium samples were made using a high resolution echelle spectrograph. Hyperfine splittings of numerous lines may even permit spectrochemical analysis using individual hyperfine components. Preliminary testing equipment for a high resolution monochromator is underway. (AEC Activity 5261)

Mass Spectrometer Laboratory - A mixture of natural uranium oxyfluoride (UO_2F_2) and enriched uranium tetrafluoride (U^*F_4) was investigated to establish the origin of uranium pentafluoride (UF_5) previously observed when untreated UF_4 was investigated in the mass spectrometer. As expected, the fluorine from UO_2F_2 reacted with the U^*F_4. The following postulated reaction was confirmed:

$$UO_2F_2 + 2\ U^*F_4 \rightarrow UO_2 + 2\ U^*F_5$$

(AEC Activity 5261)

CHEMISTRY

Thorex - The continuous dissolution of irradiated thorium slugs, which has been under development during the past year, is now operating satisfactorily in that it delivers a solution of constant and proper composition for direct flow into the first extraction column of the process. The use of continuous instead of batch dissolution will eliminate the necessity for metering the flow of a radioactive solution (dissolver solution). Only the acid used to dissolve the thorium slugs need be metered. Since no subsequent feed adjustment will be required, feed adjustment tanks, feed samples and their analysis will not be necessary.

In the present Thorex flowsheet, thorium and uranium are separated from Pa and fission products by solvent extraction in column A, the thorium preferentially stripped from the solvent with dilute HNO_3 in column B, uranium stripped from the solvent with 0.01 M HNO_3 in column C, and the C column strip product passed through a bed of ion exchange resin where the uranium is adsorbed, effecting concentration and further purification. The present flowsheet delivers a uranium product solution in which the uranium concentration is low (0.1 g/l) and the acid fairly high ($\sim$0.1 M). Both factors tend to decrease the capacity of the ion exchange bed. In a production plant of

3 ton capacity, the number of ion exchange beds ($\sim$ 20) required becomes so large that this method of uranium concentration becomes very cumbersome. Laboratory scale tests show that if a short column (B') is included between columns B and C and if the solvent stream is contacted with the scrub solution to be used in the A column, the acidity of the solvent can be lowered and the volume of C column strip solution can be reduced fivefold. The net result is a fivefold increase in the concentration or uranium and about an eight to tenfold decrease in the acidity of the C column strip product. These changes will reduce materially the number of ion exchange beds necessary for uranium isolation. (AEC Activity 5361)

Chemistry of Uranium Raw Materials - By carbonization of various lignites in a Fischer retort, using steam as a scavenger, sufficient ammonia may be produced for the ammonium carbonate extraction process for uranium.

High temperature (1100°C) lignite ash, which is unsatisfactory for extraction of the uranium with sulfuric acid or ammonium carbonate, responds to a chloridizing roast and subsequent leaching. Up to 80% of the uranium was solubilized in the tests thus far.

Physical concentration tests have demonstrated that both the uranium and molybdenum in lignite are associated with carbonaceous matter. Accordingly, physical concentration processes prior to extraction operations should not prevent the production of molybdenum as a by-product.

Tests were completed on the liquid-liquid extraction of uranium from high phosphate-nitrate liquors, obtained in processing Florida Leached Zone material. Of some thirty solvents tested, seven, including tri(2-ethylhexyl) phosphine oxide, di(2-ethylhexyl) phosphinic acid, butyldibutylphosphinate, di(2-ethylhexyl) phosphoric acid, tributyl phosphate, tetrabutyl ethylenediphosphonate, and octylpyrophosphoric acid, are of sufficient interest for further studies.

Investigations were continued on new organic reagents, which might be used in recovering uranium (and thorium) by liquid-liquid extraction techniques from sulfate-phosphate, nitrate-phosphate, and other liquors commonly encountered in raw materials processing. With methyldodecylamine in benzene, up to 93% of the uranium was recovered from Marysdale ore. Tri(2-ethylhexyl) phosphine oxide was used successfully in extractions from nitrate-phosphate (Leached Zone) process liquors, as well as sulfate liquors from western ores.

Studies were continued on the behavior of tetravalent uranium in orthophosphate solutions. The compound $U(HPO_4)_2 \cdot 4H_2O$ was prepared and identified chemically. The X-ray diffraction pattern of the compound was obtained also. The solubility of $U(HPO_4)_2 \cdot 4H_2O$ in phosphoric acid and perchloric acid solutions was measured in a fairly wide range of acid concentrations. (AEC Activity 5361)

Waste Treatment Studies - Considerable foaming trouble has been encountered in the ORNL radiochemical waste evaporator operation, resulting in loss of capacity. Preliminary results indicate that a cold feed spray will be satisfactory for breaking this foam. (AEC Activity 5361)

METALLURGY

Fundamental Physico-Metallurgical Research - The quantitative study of the fiber texture type of preferred orientation developed by mechanical deformation or recrystallization of metal samples of approximately cylindrical symmetry requires precise information on the distribution of the fiber axis among the various crystallographic directions. The ordinary pole figure, which presents the orientation distribution of poles of a given crystallographic plane with reference to some principal direction in the sample, as derived from x-ray diffraction studies, does not give this information directly. Accordingly, a method has been developed for deducing from ordinary pole figure data for various diffracting planes an inverse or reciprocal pole figure, which presents the orientation distribution of the fiber axis with reference to the axes of the crystal system.

Preliminary studies of the textures developed in uranium, thorium, and aluminum extruded rod with this method has shown that the relative proportions of the various components of the fiber texture can be accurately deduced; that certain inhomogeneities in the texture, such as tilting of fiber axis or tendency toward radialness, can be detected; and that in general very fine distinctions in texture can be made. (AEC Activity 5411)

Fundamental Investigations of Radiation Damage in Solids - The extensive research program to understand reactor irradiation effects in copper crystals has continued. More extensive measurements of the physical and mechanical properties were made and may be summarized as follows.

Electrical resistance - Measurements have been for irradiations to 1×10^{19} nvt. For this integrated neutron flux the resistivity was increased by 7.5×10^{-9} ohm-cm corresponding to .44% at 20°C. The data also indicate that this change is a change in residual resistance and that for irradiation less than 1×10^{19} nvt the resistivity has a linear dependence on the integrated neutron flux.

Density by hydrostatic weighing - For an exposure of 3×10^{19} fast neutrons it was found that the density decreased by 0.01%. The corresponding shift in lattice parameter is too small to observe by the conventional X-ray methods.

Diffraction patterns - Using a double crystal X-ray spectrometer, the breadth of 110 reflection was found to be unchanged as a result of an exposure to 3×10^{19} fast neutrons. These results substantiated earlier data which showed that the intensity of Kikuchi lines were unaffected by an irradiation of 1×10^{18} fast neutrons.

Critical shear stress - The critical shear stress (roughly equivalent to the elastic limit in annealed isotropic material) showed pronounced changes with irradiation. For example, an exposure of 1.3×10^{20} nvt raised the critical shear stress from $0.2 Kg/mm^2$ to $8 Kg/mm^2$ at 20°C. The relationship between critical shear stress (CSS) and integrated neutron flux was found to fit the equation $(CSS - 0.2)^3 = 3.5 \times 10^{18}$ (nvt) in the region of exposure from 5×10^{16} nvt to 1.3×10^{20} nvt. It is significant that an exponential factor is not required as it suggests that not more than 10^3 atoms are affected per primary knock-on.

It was found also that the critical shear stress of irradiated crystals showed a strong dependence on the temperature at which it was measured. The relationship between critical shear stress and exposure is given by

$$(CSS-.2)^3 = 5.5 \times 10^{18} \text{ (nvt) at } 200^\circ K$$
$$(CSS-.2)^3 = 18 \times 10^{18} \text{ (nvt) at } 78^\circ K$$

It should be noted that measurements made here show that unirradiated copper crystals have critical shear stresses independent of temperature, while unirradiated α brass crystals show a temperature dependence similar to that of irradiated copper.

Stress-strain curves - In addition to the appearance of a yield phenomenon, conclusive evidence was obtained to show that the latent slip system hardens at a faster rate than the active system.

All the above data suggest that the lattice distortion induced by reactor irradiation is similar to that induced by the presence of impurity atoms in a pure metal.

Annealing - The activation energy for annealing the defects produced by neutron irradiation has been determined to be 2.2 ev. This value is the same as that required for the activation of self diffusion. There is also evidence that the process is a 1st order reaction. (AEC Activity 5411)

PROGRAM 6000 - BIOLOGY AND MEDICINE

BIOLOGY

Cytogenetics - The factor responsible for the recovery of *E. coli* from X-ray damage during incubation at suboptimal temperatures has been isolated by means of paper chromatography. The substance, which is not a protein, is fairly heat resistant, and apparently consists of three different substances which appear next to each other on the paper chromatogram. The isolation of this material in larger quantities is now in progress.

Careful investigations of the sensitivity of bacteria at very low temperatures has indicated a wide variation in the energy necessary to kill E. coli under different conditions. The difference in the lethal dose between irradiations at -196° in the presence of sodium hydrosulfite and irradiation at +40° in the presence of oxygen is fourteen fold. In other words, if it takes about 10,000 r to kill at 40°C in oxygen, it takes 140,000 r to produce the same effect at -196° in sodium hydrosulfite solution.

Extensive tests are being prepared by the Biology Division Staff for the forthcoming tests "Operation Uplift" and "Operation Knothole." The following five projects are involved: 1) Mammalian Genetics; 2) Drosophila; 3) Tradescantia; 4) Maize; and 5) Neurospora. This Laboratory is working in close cooperation with the Atomic Energy Commission in Washington and test organization at the proving grounds. (AEC Activity 6400)

BIOPHYSICS

Radio-Chemical Analyses - Since the procedure used at present for the analyses of urine specimens for certain beta-gamma emitting radioisotopes requires numerous precipitations and evaporations and is time consuming, a new method utilizing IRC-50, a carboxylic acid type cation exchange resin with a high exchange capacity, is under investigation. This resin shows promise, particularly for strontium, since it has a high capacity for polyvalent cations. (AEC Activity 6510)

Physics of Nuclear Radiations - Helium of a high degree of purity, attained by passing the gas over activated charcoal at liquid nitrogen temperatures, gives a w value (ev/ip) of 46 electron volts. The w values for hydrogen and carbon dioxide were determined to be 37 ev and 34.3 ev, respectively. (AEC Activity 6510)

Physics of Radiation Dosimetry - In the project for redetermining the energy dependence of the sensitivity of X-ray film, preliminary calculations have been made for one set of filters. With 200 kilovolts applied to the tube, the observed value of the effective kilovoltage was 149, which was in good agreement with the calculated value of 153 Kev. The aim is to determine by calculation the filters to be used at each applied kilovoltage in order to have a beam of useful intensity, reasonably well defined effective voltage, and constant energy spread.

A new radiator, consisting of layers of aluminum foil and paper, is being studied to modify the pocket film dosimeter so that the currently used NTA film can be used as a fast neutron dosimeter. The paper in the new radiator supplies the hydrogen for the generation of recoil protons and the aluminum limits the fraction of generated protons that reach the emulsion to be recorded. Thus, by altering the NTA response, it is hoped to make the track count proportional to tissue dose. Preliminary results on the radiator indicates that the Po-B spectrum (narrowly centered about 2.5 Mev) gives a reading 9% low while the Po-Be (higher energy) spectrum gives a reading a few percent high.

Preliminary experiments on the electron accelerator, using the stopping potential type of energy analyzer, have been completed. The necessary modifications of controls, safety devices, and measurement systems for more permanent use are in progress. A promising technique has been developed whereby the entire energy loss curve is presented on the oscilloscope at one time instead of laboriously taking the data point by point. (AEC Activity 6510)

Permissible Internal Dose for Radioisotopes - In the program for spectrographic determination of trace elements in normal tissue, 15 different tissues from each of 12 victims of sudden accidental death have been analyzed. Tissue from accident victims is preferred since the chemical balance of elements in the body is not disturbed by drugs administered during illness. Improved methods of treating the tissue and analyzing the spectra have increased the accuracy and sensitivity of the method. (AEC Activity 6510)

Experimental Radiation Measurements - The detecting equipment for the U. S. Geological Survey airplane has been redesigned to increase sensitivity, resolution, and stability, and will be tested when the plane is ready. Additional equipment is under construction for outfitting a second plane. (AEC Activity 6520)

RADIOISOTOPE SALES

Type of Sales	November	December
Domestic	$ 74,613.40	$ 91,148.94
Foreign	1,718.50	529.15
Cash Sales	4,024.00	11,293.85
Transfers within AEC	140.00	1,011.10
Technical Cooperation Plan	10.00	-0-
Plant Sales	2,714.00	2,953.95
Civilian Defense	-0-	130.00
Total Sales for Month	$ 83,219.90	$ 107,066.99
Total Radioisotope Sales FY 1953 to Date	402,934.25	510,001.24
Total Other Sales FY 1953 to Date	116,228.25	114,325.75
Total Sales and Transfers FY 1953 to Date	$ 519,162.50	$ 624,326.99
Cancer Program	$ 21,822.32	$ 22,875.84
Total Cancer Program to Date	$1,510,389.98	$1,533,265.82

GROSS OPERATING COSTS

	Cost for December	FY 1953 Cost to Date
Programatic Operating Cost	$ 2,823,891.	$ 14,166,425.
Plant and Equipment Cost	322,154.	2,348,618.
Construction Program "H"	32,344.	152,220.
Work for Other Parties - Transfers	67,944.	548,932.
Inventory Changes	83,801.	136,322*
Reimbursable Work for Other Parties	92,663.	514,917.
Deferred Charges	301.	1,516.
Total Laboratory Cost	$ 3,423,098.	$ 17,596,296.
Estimated Cost for Next Month	$ 3,200,000	$ 20,796,296.

*Credit

[redacted]

PERSONNEL SUMMARY

	Number of Employees January, 1953	New Hires January	Terminations January
Administration	74	1	0
Operations*	120	0	0
Engineering, Shops and Mechanical	914	5	4
Laboratory and Research	1485	8	9
Protection	176	0	0
Service	393	9	6
Total	3162	23	19

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

[redacted]