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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

December 1952

AEC RESEARCH AND DEVELOPMENT REPORT

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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

December, 1952

J. P. Lane

Date Issued: JAN 9 1953

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OAK RIDGE NATIONAL LABORATORY

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OAK RIDGE NATIONAL LABORATORY

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PROGRAM 2000 - SOURCE AND FISSIONABLE MATERIALS

Metal Recovery - A process for conversion of the $UO_2(NO_3)_2$ product from Metal Recovery Plants to UF_4 for gaseous diffusion plant feed material has been developed on a laboratory scale. The process consists of treating UNH with a hydrogen fluoride and sulfamic acid mixture, then electrolytically reducing and precipitating the uranium as UF_4. This process is potentially better than existing processes for conversion of UNH to UF_4 because it involves fewer steps. A study is underway to determine its economic feasibility.

The ORNL is developing chemical and equipment flow sheets for the recovery of normal and slightly enriched uranium from waste solutions at the K-25 gaseous diffusion plant. In the past these solutions were put into storage. Because of the complex compositions of the wastes, separate processes will be required to recover uranium from 1) laboratory wastes, 2) sodium carbonate wastes, and 3) converter wash wastes. A chemical process, similar to Purex, has been developed for the carbonate waste. (AEC Activity 2344)

Purex Process - When 60 day cooled uranium metal is processed, radioactive fission iodine is retained in the solvent. Since a successful method of removing this iodine has not been developed, the new Hanford Purex Process Plant design will include necessarily concrete-shielded rooms (canyons) in which the solvent recovery equipment is located.

In recent experiments, the "C" column (uranium stripping column) was operated with the organic phase continuous rather than the aqueous phase continuous, as in previous operation. This means that, since the column is largely filled with organic solution, less hydrostatic head is needed from the B column. Thus, several feet in the over-all height of the new Hanford Purex Plant canyons may be saved. Ferrous sulfate and sulfamic acid can be added directly to the IB column as a plutonium reducing agent; this will eliminate the solution make-up step of preparing ferrous sulfamate that was previously necessary. (AEC Activity 2803)

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PROGRAM 4000 - REACTOR DEVELOPMENT

HOMOGENEOUS REACTOR PROJECT

Homogeneous Reactor Experiment - Since the time criticality was first reached in the Homogeneous Reactor Experiment April 15, 1952, a total of 230 KWH power output has been accumulated during 200 hours of operation. The nuclear experiments at low-power have been completed and some experiments at higher power have been carried out. Nuclear characteristics observed to date have been satisfactorily close to predictions and have justified confidence in the simplicity and stability of operation claimed as advantages of homogeneous reactors.

Mechanical difficulties have been troublesome during 1952 and two major fuel leaks have occurred. The net loss of U-235, after recovery efforts were completed, was about 30% of the amount spilled and almost all of this material was lost during the first incident when some of the hot fuel dried as it leaked out of the system and apparently was carried out with the reactor cell ventilating air. Alterations made after the first leak occurred greatly simplified detection of the second leak and recovery of the fuel that escaped from the system.

The HRE now appears to be leak-tight and trouble-free on the basis of thorough tests during the past two months. Operation of the reactor will be resumed early in January. (AEC Activity 4103.1)

ISHR Design - During 1952 the program of the Homogeneous Reactor Project has been clarified by the establishment of power production as the most important objective for new reactors and by corrosion studies which offer promise for the feasibility of long-term operation of high-temperature homogeneous reactor systems. The specific system from which long-term compatibility now appears favorable is the dilute uranyl sulfate fuel ($\sim$5 g U/l) contained in 347 stainless steel or possibly titanium or zirconium.

The homogeneous reactor system selected for further development is a two-region (core and blanket) converter or prototype thermal breeder using 5 g U/l UO_2SO_4 in a 347 stainless steel system with (possibly) titanium or zirconium pieces in critical locations.

Design and component development efforts are directed toward construction of a non-nuclear mock-up of an intermediate scale homogeneous reactor (ISHR) having a 4-foot dia. core with a 2-foot thick blanket. The design operating conditions for both core and blanket are 1000 psi pressure at 250°C. The nominal power level is 50 MW. (AEC Activity 4109.1)

Homogeneous Reactor Critical Experiments - Experimental equipment has been installed whereby an aqueous slurry of enriched $UO_3.H_2O$ can be pumped into a cylindrical vessel, immersed in water, and the system made chain reacting. The apparatus consists essentially of a circulating loop with the connection to the reactor vessel from the discharge side of the pump. Agitation of the slurry in the reactor is effected by a variable speed stirrer. Necessary

safety and control devices, for both fluid flow rates and reactor operation, are included. The system has been charged with enriched uranium slurry having a concentration of about 50 gm U^{235} per liter and been made critical with a cylinder whose height is somewhat greater than its diameter. The indications are that, at this low concentration and geometry, the critical conditions are sensitive to the amount of agitation. The reactivity first increases as the stirrer speed is reduced, then decreases. The program is to be continued with slurries of higher concentrations and vessels of different diameters. (AEC Activity 4109.2)

Corrosion - The number of 100 gpm circulating loops for dynamic corrosion studies has been increased to ten during 1952; four more, including an all-titanium loop, are either under or awaiting construction.

Dynamic corrosion studies during the year have made it clear that uranyl sulfate solutions containing 40 or more grams of uranium per liter cannot be contained satisfactorily in 347 stainless steel (ss) at 250°C. With uranyl sulfate solutions, containing as high as 300 g U/l, experiments have shown that, at 100°C in 347 stainless steel, the corrosion rates were < 1 mil per year (mpy).

Solutions containing 5 g U/l have exhibited corrosion rates of < 1 mpy in 347 stainless steel (ss). In one case the period of exposure was over 6000 hours at 250°C.

Titanium appears satisfactorily corrosion resistant in tests thus far to all uranyl sulfate concentrations up to 300 g U/l, either at 100°C or 250°C. The few tests on zirconium and zirconium-tin alloy that have been carried out indicate that these have promise.

At the beginning of 1953, it appears that the following systems have promise from the corrosion standpoint:

300 (or possibly more) g U/l UO_2SO_4 in 347 "ss" at 100°C

5 g U/l UO_2SO_4 in 347 "ss" at 250°C

UO_2SO_4 (all concentrations tested) in titanium at 250°C

UO_2SO_4 in zirconium at 250°C

However, even with these more promising systems, there are problems that may be severe. With UO_2SO_4 solutions in stainless steel at 100°C, crevice corrosion has been observed at concentrations of 100 and 300 g U/l. The corrosion effects of radiation, fission products, and possibly other variables are not known, but preliminary investigations indicate that they are likely to be detrimental.

The major effort in 1953, according to present plans, will be devoted to the systems that have appeared more promising in the tests to date: 5 g U/l UO_2SO_4 in 347 ss at 250°C, and in titanium and zirconium at 250°C. (AEC Activity 4109.4)

HR Fuel and Blanket Studies - Marbles of ThO_2, about 5 mm in diameter, were heated in water at 250°C and were found to be stable, in that they did not dissolve. Such "marbles" are of interest as blankets for breeder reactors because their high density permits high neutron economy. Also, these ThO_2 marbles may have advantages over thorium slurries, which are abrasive when circulated in stainless steel. The marbles could be handled mechanically by rolling them into and out of the blanket. (AEC Activity 4112.31)

AIRCRAFT NUCLEAR PROPULSION PROJECT

Aircraft Reactor Experiment - The formal presentation of the Aircraft Reactor Experiment was made to the Reactor Safeguard Committee on December 17, 1952, in a meeting at Idaho Falls, Idaho. Although the Committee's report on the safety of ARE operation has not been made, informal discussions have indicated that no significant modification of the design of the ARE will be necessary before its approval.

The fabrication of the reactor equipment in the Y-12 shops is progressing satisfactorily. The completion of the ARE pumps and pressure shell has been given first priority. The fuel circuit heat exchangers, the thermal barriers for the fuel circuit, and the fill tanks will soon be installed in Building #7503. (AEC Activity 4401.1)

ANP General Design - A liquid-to-liquid heat exchanger, which requires 420 tube-to-header connections, forming six tube bundles of 35 tubes each, for the "Fireball" reactor has been more than half completed in the shop. The individual tubes are of Inconel, having an o.d. of .150" and an i.d. of .100". Various techniques have been used in welding the tubes in eight sample headers. The heat exchanger should be completed and ready for test by February.

A 30 fin/inch radiator core element has been built and tested. The air pressure drop was about the same as for previous units but the heat transfer performance was much lower. Optical measurements of fin temperature indicated that the low heat transfer performance resulted from a poor bond between the fins and tubes caused by the use of too little Nicrobraz.

The work on gamma-ray heating in both the island and the outer reflector of a "Fireball" arrangement has been completed and is being reported in a separate memorandum. A sample case in which the results are applied to the design of a specific set of parts for a "Fireball" reactor is included. (AEC Activity 4401.1)

ANP Experimental Engineering - The effect on corrosion of metallic additions in a fused salt mixture (Na-K-Li-U)Fx, circulated in Inconcel thermal convection loops, was studied in two tests, one of which used 0.5% iron and 0.5% nickel powders, and the other, 0.5% chromium powder. Both tests gave essentially negative results.

Four attempts have been made to operate the ARE pump, which has a frozen sodium seal, with NaK. Each of these attempts resulted in excessive seal leakage. The Inconel braid packing was removed from the seal and a split ring installed in its place, to eliminate the possibility of local overheating of the shaft adjacent to the frozen seal. This change yielded practically no improvement in performance of the pump seal.

The hydrodynamic mock-up of the ARE fuel circuit, incorporating pumps, surge tanks, rotameters, and a glass model of the ARE core, has been constructed and tests are being conducted with water to determine the stability of the system during startup, shutdown, simulated pump failures, etc.

Four blocks of BeO 1/4" x 1/4" x 1/2" (density - 2.7 gms./cm^3) were suspended in a stream of NaK circulating in a thermal convection loop at 1500°F for 212 hours. Examination of the BeO specimens at the conclusion of the test revealed considerable weight and dimensional losses (of the order of 10%). Surfaces which were originally smooth were grooved after the test.

The mechanical face seal program has been devoted to testing the theory that adsorbed moisture on a thin gas layer is responsible for the lubricity of graphite. Two experiments indicated that graphite may possibly serve as a face seal material at elevated temperatures where no moisture could be present. These tests indicate also that graphite may be used as a face seal without "chattering" at between 700 - 750°F. (AEC Activity 4401.1)

<u>ANP Critical Experiments</u> - A preliminary mock-up of the reflector-moderated "Fireball" reactor has been made and some measurements taken. The core is a 12" cube of beryllium around which is a heterogenous shell, 3" thick, of sodium and enriched uranium metals. The shell is enclosed in a thick beryllium and graphite reflector. The system became critical with about 15 kg U^{235}. Measurements of power and neutron flux distributions have given results confirming the expected high thermal neutron flux in the core. Thermal neutrons cause about 70% of the fissions occurring. (AEC Activity 4401.2)

<u>ANP Radiation Damage</u> - The fuel mixture, comprising 46% NaF, 50% ZrF_4, 4% UF_4 (mol %) in an Inconel capsule, was irradiated in the MTR. Metallographic analyses indicated $\sim$ 5 to 12 mils corrosion of the Inconel in the 116 hour tests. However, since the corrosion was not uniform, and occurred in random spots, this test was not considered to be reliable. The heat generated in this fuel within the MTR was 1900 watts/cc. By comparison the heat produced in the LITR was 140 watts/cc and the corrosion $<$ 1 mil for a 140 hour period of exposure.

The power density rating in watts/cc of fused salt fuel mixtures is a function of density, uranium concentration, and neutron flux. For example, the (Na-Zr-U)Fx eutectic (containing 50% uranium by weight), that was proposed as a non-circulating fuel in early ARE designs, generated 80 watts/cc in the X-10 graphite reactor and 800 watts/cc in the LITR. The extent of corrosion by this fuel in Inconel was 1-2 mils in the graphite reactor and 3-6

mils in the LITR for 140 hour irradiation periods. A (Na-K-Be-U)Fx salt showed <1 mil corrosion in similar tests in the LITR; the heat generated was 500 watts/cc.

Melting point determinations of the mixtures containing zirconium, before and after irradiation, have shown no significant change (i.e. less than ~ 5°C). In fuel mixtures containing zirconium and at power densities below 500 watts/cc, there are no indications thus far of radiation damage. Better experimental techniques must be developed before one can state definitely that radiation damage occurs in the region above 800 watts/cc. (AEC Activity 4401.4)

ANP Metallurgy - An addition of 5% by weight of germanium to Ni-Pd alloys lowered the melting point enough so that the new alloy had excellent flow characteristics at a brazing temperature of 2110°F. By comparison the original basic Ni-Pd alloy required a brazing temperature of 2300°F. Corrosion tests must be conducted to prove the applicability of this brazing alloy.

Several other brazing alloys, with melting points in the necessary temperature range of 1800°-1900°F, were tried in tests, joining clad copper fins to Inconel tubes for use in radiators. A modified Nicrobraz alloy prepared by the Wall-Colmonoy Corporation wet both the copper and the Inconel. Other alloys such as 75% Cu - 25% Sn and 82% Au-18% Ni did not wet both metals. If the copper fin is clad with Inconel, the Au-Ni alloy, which flows well at 1830°F, makes a satisfactory Inconel to Inconel bond.

A basic investigation was conducted to determine the effect of joint spacing upon the short-time room temperature tensile strength of Nicrobrazed Inconel joints.

The results of these tests, using a brazing time of ~20 minutes for each joint, are tabulated as follows:

Joint Spacing (Inch)	Average Tensile Strength (Psi)
0.002	32,900
0.005	35,500
0.010	36,900
0.015	35,000
0.020	39,000

The results of this investigation indicate that joint spacing is not a critical factor in the room temperature tensile strength of Nicrobrazed Inconel joints, at least within the investigation's range, which should cover nearly all applications.

The control rods for the Direct Cycle Aircraft Reactor are B_4C-Fe "compacts" in stainless steel tubes. Since the heat flux in these rods will be very high, it is necessary that a metallurgical bond exist between the B_4C-Fe "compacts" and the stainless steel to conduct heat. Of several materials tested, only nickel powder, heated to 1175°C, showed acceptable wetting properties. (AEC Activity 4401.5)

ANP Reactor Chemistry - In an effort to reduce the corrosive properties of fluoride fuels, various reducing agents, as additives, have been investigated. One of the more favorable reducing agents is zirconium hydride, which will reduce approximately one-half of the UF_4 to complexed UF_3 without causing precipitation of the uranium.

Methods for preparing zirconium fluorides directly from the hafnium-free ZrO_2 produced at Y-12 are under development. One approach is to hydrofluorinate a zirconium oxide-sodium fluoride mixture in the molten state, but this process has the disadvantage of requiring mechanical stirring. In order to prepare $NaZrF_5$ from ZrO_2 and NaF it is necessary either to use a long, low temperature treatment or start with a heel of $NaZrF_5$ from a previous run so that conversion can be completed in a relatively short time at high temperature.

Vapor pressure measurements on $NaZrF_5$ are tabulated as follows:

Temperature	Vapor Pressure
994°C	90 mm
923°C	39 mm
800°C	8 mm
700°C	1.6 mm
600°C	0.02 mm

(AEC Activity 4401.5)

Shielding Research - The thermal column in the Bulk Shielding Facility has now been installed and preparations are being made to use it for measurements of capture gamma-rays, devoting particular attention to the yield per neutron absorbed, a quantity which has been more or less neglected in other developmental programs.

Recent experiments at Brookhaven National Laboratory had indicated an appreciable difference in the neutron-attenuating properties of carbon steel and of stainless steel. This could be explained on the basis of a theory that the "hole" in the iron cross section at 25 kv is responsible for this penetration, whereas the nickel in stainless steel effectively "plugs the hole" by virtue of a high cross section at 25 kv.

Experiments have been under way in the Lid Tank to determine the magnitude of this effect. A small cylinder of iron was placed in the Lid Tank with its axis coincident with that of the source plate. This was followed by a

15" air space, and the thermal neutron distribution was measured in the water just beyond the air space. If the "hole" were the dominant contributor to penetration, then the neutrons leaving the small cylinder would be collimated, and would show a peak intensity beyond the air. On the other hand, if the neutrons penetrate the iron primarily by diffusion at intermediate energies (below the inelastic scattering threshold) then no sharp peak would appear in the water beyond the air. The latter thesis appears to be the case, indicating that the "hole" contributes less than the general diffusion, although the data taken thus far is insufficient to draw this conclusion unequivocally. Other experiments with large slabs of stainless steel, however, seem to show that while the diffusion effect is more pronounced in stainless steel and iron, it is not very great. The intensity of the source in the Lid Tank is insufficient for a really exhaustive study of this comparison, and the experiment may have to be moved to the Bulk Shielding Facility before a complete answer can be obtained.

In the interest of economy, the design of the Tower Shielding Facility has been modified. The configuration now consists of four vertical, ~300' high, compression members on the corners of a 100 x 200' rectangle. At the top of the tower on the 100' side are trusses, hinged to the vertical members. On the 200' sides at the top, the legs are connected by a cable. The whole structure is guyed in the vertical position. The loads are lifted by means of a double cable arrangement extending in a "V" shape from the loads up to the tops of the legs.

A mock-up of the CP-6 thermal shield has been tested in the Lid Tank. The experimental results, which improved previous calculations by a factor of 100, will enable the duPont Company to design with greater accuracy the shielding for the Savannah River reactors. (AEC Activity 4401.7)

PROGRAM 5000 - PHYSICAL RESEARCH

REACTOR OPERATIONS

During the month the X-10 graphite reactor operated for a total of 2,569,688 KWH, averaging 3823 KW per operating hour. The reactor "down time" was 9.7%, as compared with 8.5% in November. There was one slug rupture, which was discharged without difficulty.

The LITR operated during December for a total of 1,014,646 KWH, averaging 1,500 KW per operating hour. The "down time" was 9.1%, as compared to 9.9% in November.

ISOTOPE PRODUCTION

Stable Isotope Production - Two elements, lithium and silicon, were processed during the month, yielding five isotopes. Production "innage" for the four calutrons was 1815 hours. A total of 40 hours of Alpha channel time was devoted to non-productive experimental work and the Beta channels were down for a major overhaul for 212 hours. "Outage" time was 12.2% as compared with 14.4% last month. Production operations of the XAX equipment were discontinued December 15. The integrated output was 722,834 ma hours for Alpha channels and 17,595 ma hours for Beta channels during December.

Chemical services were supplied to the calutrons for the separation of isotopes of lithium and silicon.

Work was done on the chemical refinement of isotopes of neodymium, tin, germanium, lithium, and thallium. (AEC Activity 5121)

PHYSICS

High Voltage Program - The angular distribution of elastically-scattered neutrons, at neutron energies corresponding to resonances in the total cross section of nitrogen, was measured by the method of pulse height analyses of nitrogen recoil energies. The resonance energies are 1.35, 1.40, 1.60, 1.80, and 2.25 Mev. There were in general two types of angular distributions: (a) one type at the 1.40, 1.60, and 2.25 Mev resonances, which corresponds to increased forward scattering of neutrons and, (b) another type at 1.35 and 1.80 Mev, which corresponds to increased backward scattering of neutrons. (AEC Activity 5211)

The 86-Inch Cyclotron - The possibility of fabricating a beam deflector septum of water-cooled stainless steel tubing was investigated. A 0.025" OD tube with 0.003" wall thickness and 5-3/4" long has dissipated 190 watts/inch when cooled with water at 160 lbs/in^2. (125 cc/min). Such tubing has withstood pressure tests at 200 lbs/in^2. When exposed to the cyclotron beam the tubing becomes extremely radioactive. (AEC Activity 5261)

86-Inch Cyclotron Nuclear Physics - Further data were obtained on the angular distribution of elastically-scattered protons and on excitation functions for (p,t) reactions.

An apparatus for measuring short half-lives has been installed, in which a solution of the material to be investigated is pumped under high pressure through a thin-walled target tube in the cyclotron and, thence, to the counter chamber; the transfer time is about one second.

In a newly developed method for detecting deuterons, the high energy gamma-rays from 14.8 h. Na^{24}, produced by the (d,p) reaction on Na^{23}, are counted in a scintillation spectrometer. (AEC Activity 5261)

Electromagnetic Fundamentals - It has been found that intense ion beams which can be well focused on a flat collector plate may become badly defocused when directed into a pocket-type collector. Modifications of the ion source and an increase in water cooling in the collector have made possible the collection of larger ion currents. A well-focused beam of over two amperes has been observed in the collector pockets; the pocket-to-faceplate current ratio has been increased from 3:1 to 18:1. (AEC Activity 5261)

Isotope Analysis Methods Laboratory - Preliminary values of the nuclear moments of U^{235} have been determined as $\mu = 0.66 \pm 0.2$ nuclear magnetons and $Q \sim 8 \times 10^{-24}$ cm^2. This asymmetry in the shape of the U^{235} nucleus is quite extreme, especially by comparison with most other isotopes.

Isotope spectrum shifts in the 3451 A lines of the boron isotopes, B^{10} and B^{11}, have been observed, with separated isotopes. The spectral lines splitting agrees with measurements of Opechowski and de Vries in 1939 and this technique may be applicable to spectro-isotopic assay.

X-ray absorption studies on uranium, in concentrations of 100 ppm to 1000 ppm in uncontaminated solutions, show an apparent dependence of the L III absorption coefficient on concentration. (AEC Activity 5261)

Mass Spectrometer Laboratory - In preparing to study mixtures of technetium and ruthenium, considerable time has been spent in developing techniques for handling and evaporating droplets of radioactive solutions in the high temperature ion source. The development of this technique has progressed satisfactorily but the work is incomplete. (AEC Activity 5261)

CHEMISTRY

Chemical Physics - The pure quadrupole spectra for I^{129} and I^{127} were observed in a sample of SnI_4. In measurements at 20°K and at 77°K, which permitted the cross-checking of results, pairs of lines were seen for each iodine transition because of the fact there are two non-equivalent positions for iodine in the SnI_4 crystal lattice. These measurements gave data such that four independent quadrupole moment ratios could be calculated for the iodine isotopes. The average value of the ratio $\frac{Q\ (I^{129})}{Q\ (I^{127})}$, from these measurements was 0.701213 ± 0.00001.
(AEC Activity 5311)

Chemistry of Corrosion - The investigation of the pertechnetate ion as a corrosion inhibitor was extended to uranyl sulfate and 347 stainless steel systems. In a 46 hour test conducted at 235-250°C, in which pins of 347 stainless steel were rotated in a 300 g U/l uranyl sulfate solution containing technetium, no weight loss of the pins was detected. In the control test, where no technetium was in the UO_2SO_4 solution, a 347 stainless steel pin lost 1.0 mg. weight. Similar tests will be conducted for longer periods of times, and if these tests also indicate low corrosion rates, technetium will be added to the solution in loops circulating 100 gallons per minute of uranyl sulfate in 347 stainless steel.

Preliminary results indicate that potassium pertechnetate, in 32.6 g/l. 93% enriched UO_2SO_4 solution, is stable to irradiation levels of magnitude, 10^{20}-10^{21} ev/cc. It is not reduced either in simple aqueous solution or when dissolved in a (93% enriched U^{235}) uranyl sulfate solution containing 32.6 g U/l.

Test pieces of 347 stainless steel were maintained at 250°C for 234 hours in water, with and without technetium present, and containing 2 p.p.m. of chloride ion. Rust formed on the steel sample of the control (water), but there was no such corrosion of the steel test piece in the solution containing technetium.

Although the perrhenate ion is similar in its behavior to the pertechnetate ion, it exhibits no corrosion inhibiting properties in a carbon steel-water system, using potassium perrhenate. (AEC Activity 5361)

Chemistry of Uranium Raw Materials - Tributylphosphate at concentrations of 5% or higher has given good extraction of uranium (extraction coefficient >1) from a high phosphate-nitrate liquor, as obtained from the processing of Florida Leached Zone ore. Good results (extraction coefficients $\gg$ 1) were obtained in recycle extraction tests with 1) tri (2-ethylhexyl) phosphine oxide, using sodium carbonate solution for stripping the uranium from the solvent, and 2) di (2-ethylhexyl) phosphoric acid, using hydrochloric acid as the stripping agent.

Samples of Leached Zone ore, reported to contain the phosphatic mineral, millisite, have proved almost completely refractory to acid leaching in the cold. These samples have been made labile to leaching at high acid levels by hot leaching or by preliminary calcination. (AEC Activity 5361)

METALLURGY

Fundamental Investigations in Radiation Damage - The progressive anisotropic expansion of α type quartz with increasing dosages of fast neutrons was found to undergo a density change, after a total nvt of 6.6×10^{19}, of $\frac{\Delta\rho}{\rho} \times 100 = 3.5 \pm 0.1$, as measured by the hydrostatic weighing method and 4.8 ± 1.5, as determined by the X-ray crystallographic method. The expanded lattice constants were $a_o = 5.01 \pm 0.01$ Å and $C_o = 5.41 \pm 0.02$ Å as compared with non-irradiated quartz lattice constants, $a_o = 4.903$ Å and $C_o = 5.393$ Å. The quartz crystal temperature during irradiation was about 100°C.

The expanded SiO_2 lattice had considerable thermal stability as evidenced by the fact that annealing at 485°C for two hours produced no detectable relief from lattice strain and no lattice contraction. Annealing for four hours at 650°C resulted in no lattice contraction but there was an indication of reduction of lattice strain. This annealing temperature of 650°C is 77°C higher than the normal inversion temperature of $\alpha \longrightarrow \beta$ quartz. By annealing the sample for twelve hours at 900°C, the lattice strain was relieved completely, and the lattice contracted to normal.

The anisotropic expansion in the a direction is believed due to the trapping of dislocated atoms in the large interstitial spaces which appear as long irregular channels parallel to the principal axis in molecular models of α quartz crystals. (AEC Activity 5411)

Ceramics Research - Chromium-alumina "compact" fuel elements, for use in high temperature air-cooled reactors, have been fabricated. The uranium in this fuel element will be positioned as a core of UO_2. A fuel element containing no uranium is being irradiated in a Hanford Reactor to determine the extent of radiation damage to the chromium-alumina base material.

Fuel elements, composed of silicon carbide-silicon "compacts" and with uranium disilicide (USi_2) distributed as a layer or dispersed throughout the base material, are also being fabricated. (AEC Activity 5411)

PROGRAM 6000 - BIOLOGY AND MEDICINE

BIOLOGY

Mammalian Genetics - Several mutations have now been obtained with mice at the 300 r exposure range; enough to indicate that eventually a statistically reliable mutation rate can be obtained for this dose. Accordingly, these experimental mutation studies will be applicable to the upper region of the dose range encountered by man.

A pilot investigation of the biological effects of neutrons from the 86-inch cyclotron has been started. The effects now being measured are a) sterility and lethality of exposed male mice, and b) dominant lethal mutations in their offspring. (AEC Activity 6400)

Microbiology - The proceedings of the 5th Annual Biology Research Conference have been sent for publication as a supplement to the Journal of Cellular and Comparative Physiology. The symposium volume consists of thirteen papers, together with the discussions that followed the lectures. This symposium emphasized topics concerning new pathways in intermediary carbohydrate metabolism and the structure and function of the newly discovered biocatalysts, coenzyme A and lipoic acid. (AEC Activity 6400)

BIOPHYSICS

Physics of Nuclear Radiations - In the search for new and better means of measuring ionizing radiation, a program is underway to utilize radio frequency equipment in such measurements. In a radio frequency generator the frequency is a function of reactance; therefore, if ionizing radiation affects the reactance, a means of radio frequency measurement can be effected.

Two approaches of capacitance variation are (a) the introduction into the frequency determining network an electrometer which changes its capacitance, by mechanical means, as a function of electrical charge and (b) the introduction of a ferro-electric material, such as barium titanate, that varies its dielectric constant--and therefore its capacitance--as a function of its charge. When the ferro-electric material is charged to a certain voltage, the charge leakage can be changed by ionizing radiation and this in turn measured as a frequency variation. The latter system is somewhat less delicate than the electrometer system. This type of instrumentation is adequate for measurements from 100 mr/hr to radiation levels of several hundred r/hr. magnitude. The method will be extended to low radiation dosage measurements.

Material other than barium titanate is desirable since the dielectric constant of barium titanate varies with temperature. It is intended to use a barium titanate—lead zirconate mixture, since its temperature coefficient can be made small at room temperature. (AEC Activity 6510)

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RADIOISOTOPE SALES

Type of Sales	October	November
Domestic	$ 73,294.48	$ 74,613.40
Foreign	1,530.65	1,718.50
Cash Sales	7,485.00	4,024.00
Transfers Within AEC	27.80	140.00
Technical Cooperation Plan	-0-	10.00
Plant Sales	3,406.25	2,714.00
Civilian Defense	-0-	-0-
Total Sales for Month	$ 85,744.18	$ 83,219.90
Total Radioisotope Sales FY 1953 to Date	313,129.35	402,934.25
Total Other Sales FY 1953 to Date	108,559.25	116,228.25
Total Sales and Transfers FY 1953 to Date	$ 421,688.60	$ 519,162.50
Cancer Program	$ 18,371.82	$ 21,822.32
Total Cancer Program to Date	$1,488,567.66	$1,510,389.98

GROSS OPERATING COSTS

	Cost for November	FY 1953 Cost to Date
Programatic Operating Cost	$2,195,991.	$11,342,534.
Plant and Equipment Cost	472,637.	2,026,465.
Construction Program "H"	15,429.	119,876.
Work for Other Parties - Transfers	80,403.	480,988.
Inventory Changes	78,388.	220,133.*
Reimbursable Work for Other Parties	177,081.	422,254.
Deferred Charges	432.	1,215.
Total Laboratory Cost	$3,020,361.	$14,173,199.
Estimated Cost for Next Month	$3,000,000.	$17,173,199.

*Credit

[redacted]

[redacted]

PERSONNEL SUMMARY

	Number of Employees December, 1952	New Hires December	Terminations December
Administration	73	2	2
Operations*	120	1	1
Engineering, Shops and Mechanical	915	2	17
Laboratory and Research	1491	18	7
Protection	176	1	2
Service	389	0	2
Total	3164	24	31

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

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