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AEC RESEARCH AND DEVELOPMENT REPORT

LABORATORY RECORDS
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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

January, 1952

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OAK RIDGE NATIONAL LABORATORY
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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

January, 1952

J. P. Lane

Date Issued: FEB 8 1952

OAK RIDGE NATIONAL LABORATORY
Operated By
CARBIDE AND CARBON CHEMICALS COMPANY
A Division of Union Carbide and Carbon Corporation
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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

January, 1952

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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

January, 1952

TABLE OF CONTENTS

	Page
PROGRAM 2000 - SOURCE AND FISSIONABLE MATERIALS	6
Purex Process	6
SCRUP Separation	6
PROGRAM 3000 - WEAPONS	7
Special Separations	7
RaLa Production	7
MTR RaLa Development	7
Radioactive Particulate Program	7
PROGRAM 4000 - REACTOR DEVELOPMENT	9
MATERIALS TESTING REACTOR	9
LITR Operations	9
MTR Project Engineering	9
MTR Fuel and Control Elements	9
HOMOGENEOUS REACTOR PROJECT	9
Building #7500 - HRE	9
Experimental and Design Engineering	10
HRE Design	10
AIRCRAFT NUCLEAR PROPULSION PROJECT	10
ANP Experimental Engineering	10
ANP Radiation Damage	12
ANP Central Design	12
ANP Metallurgy	13
ANP Reactor Chemistry	13
ANP Corrosion Studies	14
GENERAL REACTOR RESEARCH	14
General Reactor Radiation Damage	14
Idaho Chemical Plant	14
PROGRAM 5000 - PHYSICAL RESEARCH	15
PRODUCTION OF ISOTOPES	15
Radioisotope Production	15
Stable Isotope Production	15

[redacted]

[redacted]

OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

January, 1952

TABLE OF CONTENTS Continued

Page

(PROGRAM 5000 - PHYSICAL RESEARCH)

PHYSICS. 15
Neutron Velocity Selector. 15
Neutron Diffraction. 15
Scintillation Spectrometry and Instrument Development. 16
High Voltage Program 16
Pile Operations. 16
Isotope Analysis Methods Laboratory. 16
Electronuclear Machines. 17
86-Inch Cyclotron. 18
Research Reactor 18

CHEMISTRY. 18
Heavy Element and Fission Product Separation 18
Chemistry of the Solid State 18
Instrumentation for Nuclear Chemistry. 19
Chemistry of Uranium Raw Materials 19
Thorex Process Chemical Development. 19
23 Processing. 20

METALLURGY 20
Fundamental Radiation and Physical Metallurgy. 20
Physical Metallurgy of Reactor Materials 20
Fundamental Physico - Metallurgical Research 21
Fundamental Radiation Damage 21

PROGRAM 6000 - BIOLOGY AND MEDICINE. 23
Radiation Protection 23
Cytogenetics 23
Radiation Effects. 23

PROGRAM 9000 - RESEARCH FACILITIES 24
Research Laboratory Building #4500 24
Isotope Research and Unit Operations Building #4501. 24
East Portal Building #5000 24
High Voltage Laboratory Building #5500 24
Test Facilities Building #7503 (ARE) 24
ORSORT Laboratory Building #3017 25
Chemical Isolation and Purification Laboratory Building #3508. 25
Steam Supply Line to Building #7503 (ARE). 25
Additions to Metal Recovery Building #3505 25
Permanent Facilities Plan. 25

[redacted]

[redacted]

OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

January, 1952

TABLE OF CONTENTS Continued

	Page
Radioisotope Sales	26
Gross Operating Costs	26
Personnel Summary	27

[redacted]

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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

January, 1952

PROGRAM 2000 - SOURCE AND FISSIONABLE MATERIALS

Purex Process (AEC Activity 2803.2)

The cold test runs in the modified Purex Pilot Plant demonstrated satisfactorily low uranium losses. The next series of runs will contain plutonium as well as uranium to test the performance of plutonium in the new equipment. After this, the Pilot Plant will be ready again to resume hot runs. Laboratory studies were continued on the silica gel adsorption step for the final uranium product purification, the plutonium ion exchange coupling step, waste concentration studies, and the recovery of plutonium from metallurgical wastes.

SCRUP Separation (AEC Activity 2344)

The equipment installation for the SCRUP Program was completed and the various pieces of plant equipment are now being tested. The first cold run through the plant will be made during the month of February.

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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

January, 1952

PROGRAM 3000 - WEAPONS

Special Separations (AEC Activity 3601)

The two-arc ion source unit for the plutonium program is being tested to optimize performance. Collector design has been determined from experience in previous separation projects. The preparation of plutonium trichloride fuel at Los Alamos is to be started in a month. The plutonium chemistry area, recovery line, and transfer devices are to be completed in the near future.

RaLa Production (AEC Activity 3982)

The RaLa run which began January 13, 1952, has been completed with fair success. A very large batch was separated at the final stage of the chemical process, but some difficulty was experienced in getting the product into solution to transfer it into the shipping cone. It is thought that the high radiation level caused the product to precipitate; proper chemical steps have now been developed that should prevent future difficulty at the product loading stage.

MTR RaLa Development (AEC Activity 3982)

Studies in the laboratory were carried out on both ion exchange and precipitation steps for the final purification of barium. Barium chloride precipitation showed promise for separating barium from impurities; however, barium losses were high in this step.

Radioactive Particulate Program (AEC Activity 10533)

During FY 1950 and 1951, under the joint sponsorship of the AEC and the Army Chemical Corps, the Protective Equipment Evaluation Group studied the collection efficiency of CWS Type #6 paper and the sorption characteristics of charcoal canisters against radiological warfare simulated agents, i.e., radioactive smokes and gases. In the course of this work, paralleled by independent studies of Atomic Weapons Test cloud samples at the Army Chemical Center and elsewhere, it became apparent that the technology associated with the study of small particles had to be extended to include sub-micron particles, i.e., from 0.1 micron diameter down to atomic size particulates. Furthermore, the discovery in recent years that the so-called standard smoke of 0.3 micron diameter (optimum size for maximum penetration) has been invalidated and that some of the parameters of Langmuir's theory should be re-evaluated has enlivened a more widespread interest in sub-micron particles.

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(Radioactive Particulate Program)

In FY 1952 the Army Chemical Corps determined that the program should consist of a study of the penetration of radioactive, sub-micron (0.1 - 0.01 micron diameter) particulates (liquid and solid aerosols) through filter media, and an investigation of techniques designed to separate or differentiate radioactive particles from inert particles in the aerosol mixtures obtained in Atomic Weapons Test cloud samples in sizes ranging below 2 microns diameter. The Dioctyl Phthalate (DOP) test would be effected with existing liquid aerosol test equipment. This test method, which has been in use for several years by the Army Chemical Corps and the Bureau of Mines for the standardization of dust respirators, consists of: (1) a generator designed to furnish DOP smoke, (2) a direct-reading photoelectric penetrometer designed for rapid and accurate readings to 0.001% penetration; and (3) an instrument, called the "Owl," which measures the degree of polarization of light scattered at right angles to determine the particle size of a homogeneous smoke of spherical particles.

Progress to date has led to the development of a servo mechanism tied in with an improved photoelectric Owl to control and record particle size and the construction of a LaMer-Sinclair type liquid aerosol generator as an intended substitute for the existing generator. Since the practical application of a light scattering method of measuring particle size is limited to particles larger than 0.1 micron diameter, an encouraging experimental verification of Nolan's and Guerrini's equations for flow between parallel plates in work with SO_3 and ammonia gas resulted in the design and fabrication (almost complete) of a diffusion battery. The battery will be calibrated against 0.3 micron diameter DOP smoke and investigated as a possible method for determining particle size in sub-micron aerosols. The application of a modified Pauling Electrostatic Precipitator for measuring small particles and Vonnegut's method of generating solid homogeneous smokes is also being investigated.

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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

January, 1952

PROGRAM 4000 - REACTOR DEVELOPMENT

MATERIALS TESTING REACTOR

LITR Operations

The LITR operated at 766 KW per operating hour during January. Down time was 14.1% as compared with 15.0% in December. New cooling water pumps and a heat exchange are being installed so that the reactor power can be increased.

MTR Project Engineering (AEC Activity 4221)

Four technical men from ORNL are located at the ARCO MTR site and will be until the reactor goes critical. They are working particularly on the reactor controls and assembly of the lattice. Also, various craftsmen from ORNL have from time to time been assisting in the assembly of the reactor components.

MTR Fuel and Control Elements (AEC Activity 10543)

Fifteen additional fuel units have been assembled and brazed to make a total of 72 on hand. Four cadmium shim rods are ready for shipment to Idaho, and nine additional rods are in the process of final machining and inspection. If end boxes can be satisfactorily cast by an outside contractor, the initial loading of 23 fuel units will be ready for shipment to the ARCO site by March 1, 1952.

The cladding of thorium with aluminum now appears promising. The present method is to mechanically remove oxides from the surface of the thorium, weld the edges of aluminum cladding in vacuo, and roll the aluminum-thorium sandwich at 500°C with a reduction in thickness of 20 to 1. So far tests have indicated that the bond is satisfactory.

HOMOGENEOUS REACTOR PROJECT

Building #7500 - HRE (AEC Activity 4261)

Further testing of HRE components disclosed a leak in the heat exchanger head gasket and failure of the pulsafeeder pump outlet line weld. Following the repair of the heat exchanger gasket leak, other leaks developed in the inlet and outlet pipe welds after operating at temperature and pressure for an additional fifty hours. The weld leak in the pulsafeeder line has been repaired satisfactorily, but some difficulty has been experienced in replacing welds in the heat exchanger.

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(Building #7500 - HRE)

The pulsafeeder line weld is the only ORNL-made weld to fail to date; its failure is attributed to excessive vibration caused by the pump. The heat exchanger welds which failed were among the few which were made by contract fabricators before the stringent welding inspection program was adopted.

Completion of the component and operational testing program may require another full month before satisfactory performance is demonstrated.

Experimental and Design Engineering (AEC Activity 4264)

Subcontracts with Allis-Chalmers and the Worthington Pump and Machinery Company are being negotiated for the development and fabrication of 20,000-gpm pumps suitable for use in large scale homogeneous reactors. Development of other large scale components, such as valves and heat exchangers, is expected to be carried out in a similar manner by other subcontractors. Negotiations with possible subcontractors have been started.

HRE Design (AEC Activity 4261)

Design of the HRE is complete except for the fuel, gas and reflector system samplers. These are expected to be completed in time to be fabricated and installed before they are needed during critical experiments. In the meantime temporary samplers are being used to take the "cold" samples during the HRE testing program.

AIRCRAFT NUCLEAR PROPULSION PROJECT

ANP Experimental Engineering (AEC Activity 4271)

During this month emphasis was placed on two types of thermal convection loops: one for dynamic corrosion studies and another for materials engineering purposes, valve packing development, Figure 8 loop operations with liquid metals, pump development for high temperature fluorides, and development of heaters for preheating loops and for furnishing the main heat source for loop operations.

Thermal convection loops constructed of 347 stainless steel, 410 stainless steel, 310 stainless steel and nickel were terminated during the month of January. All of these loops contained (Na Li K U)Fx. The 347 stainless steel loop leaked at the end of 39 hours; the 410 and 310 stainless steel loops plugged at the end of 9 and 73 hours respectively. Only the nickel loop ran to a scheduled 500-hour termination.

Thermal convection loops in operation at the end of January are a 316 stainless steel loop containing Na Li K fluoride, a 316 stainless steel loop containing Na Li K fluoride with approximately 20 cc of NaK added, an Inconel loop containing Na Li K fluoride with approximately 20 cc of NaK added, and an Inconel loop containing NaF BeF_2 UF_4.

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(ANP Experimental Engineering)

One specially designed thermal convection loop has been fabricated and is waiting to be placed in operation. This loop has a cooling coil across which a stream of cold air will be blown in order to give a maximum temperature drop across the loop. A second convection loop for engineering purposes is under construction which is designed to give a 600°F temperature drop between the hot and cold legs.

Tests were conducted on a valve stem packing consisting of Inconel braid, a layer of nickel powder, a layer of graphite, and a second layer of nickel powder. These tests have operated for a total of approximately 250 hours sealing against 1500°F fluorides with no leakage.

The Figure 8 loop incorporating a NaK to NaK heat exchanger had logged a total of 1916 hours of operation at the end of January. The Figure 8 loop containing a frozen sodium seal centrifugal pump had logged a total of 700 hours operation at the end of January. Maximum temperature for both NaK and sodium in these loops was 1500°F.

The vertical shaft centrifugal pump operated for a total of 287 hours pumping fluorides at 1200°F in an isothermal loop. This test was terminated due to a leak in the ring joint at the parting face of the pump.

All drawings were completed for an ARE centrifugal pump and fabrication is now in progress in the Y-12 machine shop. Fabrication is almost complete on a 35 gpm 150 ft. head centrifugal pump for fluorides. This pump incorporates a frozen fluoride shaft seal.

Resistance heating was used for preheating thermal convection loops. The method employed was to use the loop to short the secondary of a low voltage, high current transformer. The advantages of this method are: (1) Elimination of calrod heaters which reduces fabrication time; (2) More uniform heating is obtained; (3) Time required for preheating is drastically reduced.

An integral "clamshell" heater - insulation assembly was developed. The assembly, using performed high-temperature insulation, can be prefabricated to required sizes and stocked as a unit. The advantages of this assembly are: (1) Reduction in loop erection time; (2) Reduction of maintenance costs since this insulation can be reused; (3) Increase in effectiveness of insulation. The outer surface temperature of the preformed insulation is 150°F compared to a outer surface temperature of 500°F for lead mill slag insulation.

Work has continued during this period in the development of improved methods of preparing systems for use with fluorides. Methods now under consideration are degreasing solutions, pickling solutions, hydrogen firing, and cleaning with hot Na or NaK.

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(ANP Experimental Engineering)

During this period routine manufacture of fluorides has continued and development work has been done to improve the fluoride production equipment.

ANP Radiation Damage (AEC Activity 4274)

Previous tests in the X-10 pile and in the 86-inch cyclotron on Na-K-U fluoride fuel indicated no significant evidence of radiation damage. However, after this eutectic mixture was inserted into the LITR for 115 hours, there was indicated an increase in corrosion over previous tests by a factor of ten when corrosion was determined by chemical analysis, and by factors of three to six when determined by metallographic examination. This means an increase in corrosion from 1 mil in the X-10 pile to 3 mils in the LITR. One answer to this difference of results is that in the X-10 pile 65 watts/cc were dissipated, in the cyclotron an average of 300 watts/cc, and in the LITR 1,100 watts/cc. Samples of Na-Be-U fluorides are now being irradiated in the LITR.

ANP Central Design (AEC Activity 4275)

The design of a 3 megawatt circulating-fuel Aircraft Reactor Experiment is being developed from the design of the circulating-fuel Aircraft Reactor previously described. The fluid circuit inside the reactor core now consists of 78 parallel, 1¼" tubes which are connected in 6 parallel circuits, each traversing the axial length of the core 13 times. The Reynolds number of this fluid circuit is around 10,000 - assuring flow in the turbulent region as is required to minimize temperature gradients within the fuel. The fuel exits from the center of the core and enters around the periphery of the core - maintaining reflector and pressure shell at inlet temperatures. Both inlet and outlet headers (for the six fluid circuits) are external to the pressure shell.

The melting point of the circulating fuel requires that the fluid systems be preheated at startup. This will be effected in the core by the circulation of electrically heated helium through the fuel tubes. External fluid circuits will be constructed with a helium jacket to permit heating during loading, while the pressure shell and reflector will be heated externally. The output (heat) of the reactor when operating will be dissipated in water through an intermediate helium circuit.

Investigation of the stability of the circulating-fuel reactor was carried out on a simplified model: the delayed neutrons were neglected and constant power (flux) distribution was assumed; no mechanical distortions were allowed for, except for the thermal expansion of the fuel which was assumed to follow the temperature change instantly; the inlet temperature was also assumed to be constant. In this simplified model, undamped oscillations can persist. The period of these oscillations is equal to the transit time of the fuel through the reactor, or it is a submultiple of this transit time. In spite of these oscillations, the outlet temperature remains constant because during its

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(ANP Central Design)

passage through the reactor each particle sees a whole cycle, or several whole cycles, of the oscillations. Since the heat extraction depends on the outlet temperature, the heat removal is constant and the case degenerates to the constant-heat-removal case, which is known to permit undamped oscillations.

ANP Metallurgy (AEC Activity 4275)

In previous tests of metals in NaCN, the metals have become seriously embrittled. It is generally believed that oxygen is necessary for the carburization of metals in a cyanide bath. With this idea in mind, tests are now being run with additions of various getters as zirconium, titanium, and magnesium to the corrosion medium. It has been found that the addition of zirconium to the fluoride mixture decreases the amount of corrosion on stainless steel and Inconel tested in this media. Experiments in which manganese has been added to NaOH have shown that this addition increases the corrosion resistance of Inconel in tests conducted for 100 hours at 815°C.

After an extensive investigation of the variables of the cone arc welding process, the proper current settings, arc distance, argon gas flow, and arc time have been determined for the consistent making of tube to header welds.

Six typical heat exchanger sub-assemblies were fabricated which consisted of seventeen type 316 stainless steel tubes 0.100 inch O.D., 0.010 inch wall cone arc welded into a 1/8 inch thick type 316 stainless steel header sheet in a cluster geometry which allowed for a minimum of 0.100 inch between holes.

Various brazing alloys, such as Nicrobraz, 60% Pd-40% Ni, 60% Mn-40% Ni, have been tested to determine the proper brazing conditions. Typical brazed joints have been made and then subjected to corrosion testing in liquid metals, fluorides, and hydroxides. All the brazing alloys stand up well in sodium, but they are heavily attached in the fluorides and hydroxides with the exception of nickel-palladium alloy.

ANP Reactor Chemistry (AEC Activity 4275)

Preliminary experiments on fuels and equipment construction were directed toward understanding corrosion by molten fluorides. One important line of attach concerns the nature of the reaction products resulting from interaction with container metals. Attention is also being given the rate of reaction of atmospheres containing small amounts of water and of oxygen with molten fuels.

A current hypothesis is that fluorides cannot be dried by heat and vacuum without at least a small amount of hydrolysis, and that the hydrolysis products present in trace amounts are deleterous from the standpoint of corrosion. Drying by fluorination is to be used, in spite of the inconvenience entailed, to permit tests with fuels free from the effects of hydrolyzing conditions.

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(ANP Reactor Chemistry)

Phase Studies on systems containing BeF_2 and ZrF_4 were studied further, and heating curves have been used to avoid the supercooling difficulties encountered at high BeF_2 concentration. The apparatus for preparing large batches of fuel mixtures has been operated repeatedly.

ANP Corrosion Studies (AEC Activity 4275)

Experiments with fuels having a low uranium content have continued. No improvement, from the standpoint of penetration and weight gain, has been found to result from the pretreatment of the beryllium bearing fuels. The viscosity of fuel No. 17 (51 mol % BeF_2) was approximately 12 centipoises at 800°C, according to the modified Brookfield method.

GENERAL REACTOR RESEARCH

General Reactor Radiation Damage (AEC Activity 4540)

The study of the physical properties of irradiated rubbers and plastics is continuing. Rubbers such as Hycar OR, Hycar Pa, GRS 50, Silastic, neopreme W, and natural rubber become harder and lose their elasticity after an exposure of 3×10^{18}nvt. Butyl rubber and Thiocol become soft and gummy after irradiation; Butyl rubber loses its elasticity after an exposure of 1×10^{17}nvt and Thiocol after 1×10^{18}nvt. Certain plastics have been found to continue deteriorating after removal from irradiation sources. An investigation is being made of gamma radiation damage versus fast neutron radiation damage.

Idaho Chemical Plant (AEC Activity 10547)

The design work still in progress at ORNL is primarily concerned with the design of mechanical gadgets for remote laboratory operations. Foster Wheeler is being assisted with the design of the dissolver off-gas decontamination unit. The major ORNL effort is now involved in the field engineering program at Idaho and the calibration of the plant equipment at that site has now been started.

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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

January, 1952

PROGRAM 5000 - PHYSICAL RESEARCH

PRODUCTION OF ISOTOPES

Radioisotope Production (AEC Activity 5111)

The total accumulated KWH for pile operations during January were 2,430,734, averaging 3776 KW per operating hour. Pile down time was 13.5%, as compared with 14.4% in December. There were three ruptures, of which two were probably the result of soldering thermocouples to the slugs. The third was the second worse in pile experience; eight slugs ruptured in one channel. However, after sixteen hours down time the slugs were removed without damage to the fuel channel.

There were 903 radioisotope shipments during January.

Stable Isotope Production (AEC Activity 5121)

The total calutron tank time was devoted to the collection of calcium, molybdenum, and lithium isotopes. Chemical separations were devoted to isotopes of lithium, strontium, and vanadium. Over-all innage for the four calutrons was 1400 hours with an integrated output of 225,900 ma.-hrs. for the two Alpha channels and 93,700 ma.-hrs. for the two Beta channels. Outage time was 36.6% as compared with 31.0% during December.

There were 33 stable isotope shipments during January.

PHYSICS

Neutron Velocity Selector (AEC Activity 5211)

Fabrication and installation of the neutron velocity selector is essentially complete. At present the characteristics of the eighty channel circuit is being tested; so far the circuitry as well as the rotor and counter seem to be functioning satisfactorily.

Neutron Diffraction (AEC Activity 5211)

Neutron diffraction studies have been effected on a number of rare earth oxides. Total and coherent nuclear scattering cross-sections have been determined for members of the first group of rare earth elements and a number of their separated isotopes. Crystal structure of compounds in question has been determined.

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(Neutron Diffraction)

Paramagnetic scattering for a number of these nuclei has been studied and work on this aspect of the problem is continuing.

Free scattering cross-sections for a number of elements and separated isotopes have been accurately determined by transmission measurements at the indium reasonance energy. The elements chosen for study are those for which there is a special interest in neutron diffraction studies such as coherent cross-sections, (m, p) scattering, and (n, e) interaction.

Scintillation Spectrometry and Instrument Development (AEC Activity 5211)

It has recently been observed that crystals of tin activated lithium iodide are good phosphors and can be used in conjunction with a standard scintillation counter to detect neutrons. By this method neutrons can be detected with much higher efficiency than has previously been possible; such detection is urgently needed in conjunction with neutron velocity selectors and for experiments on inelastic scattering of neutrons. It is hoped that such instruments will be useful for measuring the energy of neutrons in the 1 to 2 Mev region when and if better resolution is obtained.

An experimental model of a twenty channel pulse height analyzer has been fabricated and placed in operation. It is more stable than previous analyzers and is capable of resolving pulses spaced only five microseconds apart. A contract for the construction of three such analyzers has been awarded.

High Voltage Program (AEC Activity 5211)

The reaction $D + He^3 \longrightarrow He^4 + p$ has been studied up to 400 kilovolts. The yield curve was much different from that of the companion reaction $D + T \longrightarrow He^4 + n$. As yet the reason is unknown.

Pile Operations (AEC Activity 5211)

The development of silicon bonded slugs for refueling the X-10 pile seems promising. One test has shown no failures after heating 500 bonded slugs at 400°C for three weeks, and another has shown no failures after heating 1000 slugs at 400°C for two weeks.

Isotope Analysis Methods Laboratory (AEC Activity 5261)

Nuclear Resonance. Additional frequency ratios on several nuclei have been obtained as follows:

Elements	Frequency Ratio	Elements	Frequency Ratio
P^{31}/Li^7	1.0416 ± 0.0001	Bi^{81}/Na^{23}	1.0209 ± 0.0001
Cs^{133}/D^2	0.85448 ± 0.0001	Br^{79}/Na^{23}	0.94714 ± 0.0001
Ac^{27}/Na^{23}	0.98509 ± 0.0001	V^{51}/Na^{23}	(0.99436 ± 0.0001
			(0.99383 ± 0.0001

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(Nuclear Resonance)

Measurement of frequencies of vanadium show a chemical shift effect of about 0.05%; the higher frequency corresponding to $VOCl_3$ and the lower frequency to V_2O_5.

Molecular Spectroscopy. A preliminary search for quadrupole transitions in impure $VOCl_3$ has been made over the frequency range 12 to 40 megacycles. A Perkin-Elmer infrared spectrometer has been activated for survey of uranium floride complexes in aqueous solutions. Vinyl iodide microwave measurements are now being completed.

Spectrochemical Activities. Investigations of the effect of alkali dilution of samples show approximately 50 percent intensity reduction for line spectra of ionized atoms and a slight enhancement of several of the neutral atom lines. A total of 3088 element determinations were made this month.

X-Ray. A control unit for automatic recycling of scalar and a printing timer in the X-ray absorption spectrometer is under development. Preliminary investigations of the effect of a wide range of lead contaminants (14,750 ppm to 0 ppm) in a 3686 ppm uranium solution show a worst error (3.1%) in the uranium determination in the solution containing 14,750 ppm lead.

Mass Spectrometer Laboratory. Metallic crystals were previously found by other research groups to be present in the plugged portion of the stainless steel loops undergoing tests with Na-K-U fluorides. After complexing the soluble fluoride salts and uranium with saturated aluminum nitrate in the cold, washing and drying, the residue was examined under a microscope. Four species of crystals were found to be present, two metallic and two colored, all of the cubic system. A distinct separation could be effected by a magnet which removed the most abundant metallic crystals. These residues have been examined by X-ray diffraction, optical spectroscopy and by the mass spectrometer. The results strongly indicate that metallic iron and probably chromium crystals are responsible for the stainless steel loop failures.

Electronuclear Machines (AEC Activity 5261)

Measurements on the 22-inch cyclotron have been made of the z-wise distribution of the proton beam as a function of radius; this is being related to the radical attenuation of the beam. A cyclotron ion source of the dc injector type is being tested.

The 63-inch cyclotron has been assembled and the oscillator connected to the resonant system. Oscillations of the desired frequency, 5.18 megacycles per second, were obtained with low power and at atmospheric pressure. The power supplies and control circuits for the oscillator and also the utilities, such as water and air cooling, have been tested and found satisfactory.

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The 86-Inch Cyclotron (AEC Activity 5261)

By moving the ion source upward, an increase from 19 to 21 Mev in proton beam energy was obtained.

In mid-January the 86-inch cyclotron was shut down to permit a number of alterations intended to increase the energy and current of the proton beam, to improve continuity of operation, and to provide safer working conditions. This is the first time the cyclotron dees had been removed since July 1951; during this period the cyclotron had accumulated an integrated beam of over 1.1 million microampere-hours.

Research Reactor (AEC Activity 5261)

The preliminary design study for the ORNL Research Reactor has been completed. A major departure from the basic MTR design resulted from this study; it has been decided to operate the control and shim-safety rods through the bottom of the reactor instead of the top, as in the MTR. The most important advantages of operating the control rods through the bottom of the reactor are (a) more positive control during fuel loading (in the MTR control rod drives must be removed to load fuel) and (b) greater flexibility of experimental facilities.

Actual design of the research reactor is being started and is expected to be completed early in FY 1953.

CHEMISTRY

Heavy Element and Fission Product Separation (AEC Activity 5311)

Since the uranium in urinal fluoride and urinal sulfate solutions of reasonable concentrations is probably electrically neutral on an average and most fission products positively or negatively charged, it should be feasible to purify such solutions by electromigration in two or three compartment cells. From preliminary experiments using cesium and lanthanum tracers in the uranium solutions this prediction seems reasonable in that purification has been obtained on the order of 90% removal of the cesium with an accompanying removal of only 5% of the uranium. Since electromigration readily tends itself to continuous as well as multi-stage operations, there is encouragement of using this means for purification of uranium solutions from electrolites as well as for the specific problem of processing Homogeneous Reactor solutions.

Chemistry of the Solid State (AEC Activity 5311)

The Geiger counter X-ray diffraction spectrometer for study of crystalline solids at high temperatures has been operated at temperatures up to 2100°C. Transformation from the low-temperature, tetragonal modifications into cubic structures was observed in the dicarbide of uranium and lanthanum, and this transformation is being studied in other compounds of this type. Structural changes in refractory oxides such as those of zirconium and hafnium are also under study.

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Instrumentation for Nuclear Chemistry (AEC Activity 5361)

With selected 5819 photomultipliers and 1" x 1½" cylindrical solium iodide crystals activated with thallium iodide, an 8.0% full width at half maximum is obtained for the photoelectric peak from a 670 - kilovolts gamma ray. The peak to valley ratio is 52 to 1. At 42 kilovolts the width is 26%. An electron energy loss of 200 electron volts in the crystal releases a single photoelectron from a photocathode whose efficiency is 60 micro amperes per lumen. Magnesium Oxide diffuse rectifiers were found superior to aluminum foil, especially for the larger crystals; 30% more light was obtained. Using 3" x 3" cylindrical NaI crystals a resolution of 9.0% was obtained for a 670 kilovolt gamma ray.

Chemistry of Uranium Raw Materials (AEC Activity 5361)

Reduction tests of uranium-bearing carbonate solutions with sodium hydrosulfite have been continued and extended to solutions containing vanadium. Spectrophotometric measurements have confirmed that a soluble U^{+4} complex is formed.

Extraction of a sulfuric acid solution of monazite sand with certain alkyl phosphates shows selective separation of thorium from the rare earth elements. Alkane phosphonic acids show ability to extract uranium from aqueous solution; four of these have been synthesized for further testing.

In conjunction with the analysis of U^{+4} phosphate solutions by means of Kolthoff's dichromate method, it was discovered that the reduction of these solutions in the Jones reductor yields only U^{+4}; passage of U^{+3} solution containing phosphate through the reductor results in quantitative oxidation to U^{+4}. A 3 M sulfuric acid solution of U^{+6} in excess phosphate can be reduced without precipitation of U^{+4} phosphate.

Multicolumn anion exchange sorption of uranium from low-sulfate Bartow clay leach liquor has shown satisfactory pickup and loading. Several column units have been saturated for a multistage elution test.

A small bomb reactor has been designed so that pressure leaching tests can be made on high lime ores, Marysvale ores, and slag and liners from metal production.

Representatives of this section visited the Vitro Chemical Company plant in Salt Lake City to observe the plant facilities and to aid in improving the uranium recovery process.

Thorex Process Chemical Development (AEC Activity 5361)

The study of the Thorex Process chemistry has continued. It has been found that the separation of thorium from protactinium represents a major problem and a specific procedure for Pa removal may be required. For this purpose a solvent extraction procedure seems to be more effective than the alternate precipitation procedure.

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23 Processing (AEC Activity 5361)

The operability of the proposed process for separating 23 from Hanford irradiated metal has been demonstrated in the pulse type solvent extraction column. The equipment modification of the existing pilot plant in which this process is to be carried out was continued and a shipment for the transfer of the metal to ORNL was established.

METALLURGY

Fundamental Radiation and Physical Metallurgy (AEC Activity 5411)

Studies have been made of the effect of neutron irradiation on the properties of a super-saturated alloy of beryllium in copper. Radiation damage in this alloy has been found to have two components: first, the interstitial and vacancy mechanism similar to that in pure copper; second, the formation of nuclei of a precipitating phase similar to the initial formation of nuclei during thermal aging. The irradiation induced nucleation occurs at temperatures too low for appreciable growth, whereas thermally induced nucleation is accomplished by growth of the precipitate particles.

This radiation induced nucleation has been used to study precipitation phenomena in this alloy. By means of retrogression studies (redissolving of a small nuclei at elevated temperatures) it has been possible on the basis of particle size to distinguish between precipitate particles which cause electrical resistance increases and those which cause hardness increases. Resistance increases during the early stages of aging and during irradiation are associated with smaller sized particles than hardness increases. This result indicates that in this alloy such resistance increases are not associated with strain in the lattice, but rather with some mechanism such as coherent scattering of the electrons as Mott has proposed.

Preliminary studies of other super-saturated alloys indicate that the radiation effects are quite specific. Recent results with copper-beryllium suggest that this is associated with the theomodynamics and fluctuation characteristics of the alloy. Further investigations are expected to yield additional information on the effect of irradiation on unstable alloys and a better understanding influence of thermodynamic and fluctuation characteristics in precipitation phenomena.

Physical Metallurgy of Reactor Materials (AEC Activity 5411)

A program has been initiated to compare the primary thorium produced by Ames Laboratory to the remelted turnings recently prepared at Ames. As yet, little data are available but preliminary mechanical testing indicates that the tensile properties obtained for the remelted material fall within the range of values obtained on regular production of the primary metal. An investigation of the rolling qualities of cast Ames thorium indicates that in certain temperature ranges (1000 - 1200°F) brittleness may be encountered. Tensile tests of the

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(Physical Metallurgy of Reactor Materials)

starting material (as cast Ames ingot) show tensile properties roughly equivalent to the extruded material previously tested. The only significant difference is the relative ductility which, in the case of the cast material, is lower than wrought material, as would be expected.

Alloy development work has centered around alloys of oxygen, carbon, beryllium and chromium with high purity iodide crystal bar thorium. The solid solubility limits are being determined by metallographic examination and lattice parameter measurements.

Fundamental Physico - Metallurgical Research (AEC Activity 5411)

Investigation of the preferred orientations developed in extruded thorium rod revealed the deformation texture to be a duplex [111 - 100] fiber (the [111] component being predominant) and the recrystallization texture to be a single [113] fiber texture. The deformation texture, therefore, is similar to that developed by other face-centered cubic metals. The recrystallization texture, however, is somewhat different, as other metals either retain one or both of the components of the deformation texture upon recrystallization or develop a [112] fiber texture.

Aside from any effect from differences in degree of strain hardening, the longitudinal yield and tensile strengths of extruded thorium rod having this deformation texture should be much greater than those of rod having the recrystallization texture. This is a consequence of the lower shear stress on the slip planes in the former resulting from their lower degree of coincidence with planes of maximum shear stress for an applied stress in the longitudinal direction.

Fundamental Radiation Damage (AEC Activity 5411)

The study of the interaction of high energy neutrons with solids has been studied theoretically by Sietz and observed experimentally by several investigators. These investigations indicate that a fast neutron knocks-on an atom and displaces it from its lattice position. This displaced atom has sufficient energy to displace further atoms; hence a localized region with a large number of Frenkel defects should result. If Frenkel defects play a predominate role in the atomic diffusion of metals, neutron bombardment should greatly increase the rate of micro-diffusion. However, macro-diffusion, the atomic diffusion over large distances, will be unaffected since the defects will recombine after moving a small distance. An appropriate material to study this phenomena is a disordered Cu_3Au alloy where every atomic motion will tend towards ordering.

The following experiment was performed. A sample of Cu_3Au was disordered, sealed in vacuum and the electrical resistance measured at 200°C where the relaxation time is of the order of 10^5 hours. The sample was then placed in the X-pile in a location where the fast neutron flux was of the order of 1×10^{12} neutrons per

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(Fundamental Radiation Damage)

cm^2 per sec. The electrical resistance was subsequently measured as a function of time and showed a substantial decrease in the resistance which approaches a constant value after one month's bombardment. A constant neutron flux was assumed. It is particularly interesting to note that a lag of 12 hours was observed when the pile was shut down indicating that the relaxation time for ordering had decreased to about 12 hours at 200°C.

If, as the theoretical treatments indicate, Frenkel defects are formed by fast neutron bombardment, then the above data offers strong evidence that an increase in the number of Frenkel defects will substantially increase the diffusion rate in metals. Further evidence that Frenkel defects play a role in metallic diffusion arise from measurements which indicate that the activation energy for the annealing of neutron radiation effects in copper is in close agreement with the activation energy for self diffusion in copper. Further studies on the effect of radiation on disordered Cu_3Au are in progress and will be reported later.

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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

January, 1952

PROGRAM 6000 - BIOLOGY AND MEDICINE

Radiation Protection (AEC Activity 6400)

It has been possible to separate the indirect from the direct effect of X rays on bacteria by incubation of the organisms after irradiation at low temperature. Organisms which have been irradiated in oxygen show considerable recovery at 18°, whereas in contrast to this, bacteria which have been irradiated in nitrogen show practically no recovery effect.

Cytogenetics (AEC Activity 6400)

The effect of oxygen on chromosome breaks in isolated pollen grains has been found to be dependent on the relative humidity. At low humidity, the effect is much more pronounced than at high humidity. This is only in isolated pollen grains of *Tradescantia*.

It was found that some of the effects of ionizing radiation on *Paramecium* are caused by the peroxide formed in the suspending medium.

Radiation Effects (AEC Activity 6400)

In a cooperative study with the U. S. Department of Agriculture at Kerrville, Texas, and in Florida, it was verified that X rays will readily sterilize screw-worm pupae. The USDA group had found that the screw-worm female flies will only mate once even if they mate with a sterile male. An extensive preliminary test was made to find out whether practical application could be made of this since screw-worms are one of the most dangerous pests in Florida and Texas. Since the preliminary test showed that such treatment of the screw-worm is feasible, further tests are now being conducted in Florida to check on the practical applicability.

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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

January, 1952

PROGRAM 9000 - RESEARCH FACILITIES

Research Laboratory Building #4500

With the exception of applying asphalt tile flooring to the structural concrete floor slabs throughout this building, all phases of construction have been started and are approximately 90% complete. The piping of services to the laboratory equipment is behind schedule. The contractor claims this is due to lack of materials which are on order and have not been shipped. Due to inclement weather conditions very little progress has been made on the new roads to the east parking lot or of grading around exterior of building. At the present time, all proposed new roads to this building are inaccessible. ORNL forces are fabricating a 12" stainless steel off-gas pipe. This building is 92% complete.

Isotope Research and Unit Operations Building #4501

As sections of loose topping on the structural concrete floor slabs throughout both sections of this building have had to be removed, replaced, and allowed to cure, very little progress has been made toward the completion date of this building. However, the major phases of work still remaining to be completed are the laying of asphalt tile flooring, painting, setting of laboratory equipment, and polishing of the stainless steel liners of the Isotope Research cell blocks. This building is 95% complete.

East Portal Building #5000

The following exceptions exist on this building: (1) installation of permanent power and checking units, and (2) furnishing manuals for operation of equipment and vendor's drawings. Occupancy of this building is contingent on the furnishing of electrical power which is being provided for this area.

High Voltage Laboratory Building #5500

This building is 54% complete. All exterior masonry work is complete. Insulated metal siding is being applied to tower section from the 851.4 elevation. Built-up roofing is being applied to all roofs. All phases of interior construction work have been started but are approximately 10% behind schedule.

Test Facilities Building #7503 (ARE)

This building is in the final stages of completion. The phases of work remaining to be completed are: complete the erection of metal partitions and necessary

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(Test Facilities Building #7503 - ARE)

hardware; complete installation of plumbing, electrical and heating fixtures; complete painting; balance heating and ventilation system; miscellaneous items and cleaning. Occupancy of this building is contingent on the completion of steam service line which is being installed.

ORSORT Laboratory Building #3017

All exceptions occurring on Form F-2 are completed. Final completion Form F-3 will be processed and properly signed.

Chemical Isolation & Purification Laboratory Building #3508

This building is in the final stages of completion. The phases of construction remaining to be completed are: complete installing asphalt tile flooring; complete installing metal partitions; complete plumbing, electrical and heating and ventilating service piping; complete pipe and duct covering; complete installation of plumbing and electrical fixtures; complete painting, cleaning and miscellaneous items; balance heating and ventilating system. ORNL forces are to install laboratory equipment and furniture in this building.

Steam Supply Line to Building #7503 (ARE)

The contractor is installing concrete saddle piers and fabricating pipe.

Additions to Metal Recovery Building #3505

The balcony area to house the new sampling facility and pulser mechanisms is essentially complete, except that metal siding must be installed to enclose the area.

Permanent Facilities Plan

The plan of a well coordinated building program is soon to be submitted formally to the AEC. The purpose of the program is to house ORNL personnel in adequate laboratories and working space.

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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

January, 1952

RADIOISOTOPE SALES

Sales	November	December
Transfers within AEC	$ 45,552.02	$ 42,995.17*
Cash Sales	31,915.38	24,320.65
Foreign	497.00	2,239.10
Cancer Program (Free)	52,381.77	42,724.95
Technical Cooperation Plan	528.27	53.37
Total Sales and Transfers to Date	2,032,586.37	2,025,499.55
Total Cancer Program (Free) to Date	1,114,084.98	1,156,809.93
Technical Cooperation Plan (Shipments to Date)	12,881.27	12,934.64

(* Denotes Credit)

GROSS OPERATING COSTS
(Including X-10 & Y-12)

(a)	Actual Cost for December 1951	$ 2,578,214.00	
	Construction Program "H"	47,989.00	
	Total Operating and Construction Cost for December 1951		2,626,203.00
(b)	Estimated Operating Cost for January 1952		2,600,000.00
(c)	Actual Accumulative FY 1952 Operating Cost through December 1951	15,378,144.00	
	Actual Accumulative FY 1952 Construction Cost through December 1951	225,623.00	
	Total Actual Accumulative FY 1952 Operating and Construction Cost through December 1951		15,603,767.00
(d)	Estimated Operating Cost FY 1952 through January 1952		$18,203,767.00

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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

January, 1952

PERSONNEL SUMMARY

	Number of Employees January, 1952	New Hires January	Terminations January
Administration	100	1	2
Operations*	117	2	0
Engineering, Shops and Mechanical	889	12	1
Laboratory and Research	1399	21	6
Protection	177	1	3
Service	376	3	1
Total	3058	40	13

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

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