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OAK RIDGE NATIONAL LABORATORY  
STATUS AND PROGRESS REPORT

September 1953



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September, 1953

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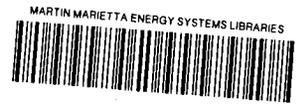
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September, 1953

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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

September, 1953

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

PROGRAM 2000 - SOURCE AND FISSIONABLE MATERIALS

Excer Process - The Excer process is a method for converting uranyl nitrate, the product of the solvent extraction columns, to uranium tetrafluoride without going through the denitration, reduction, and hydrofluorination steps now required. A chemical flowsheet (published in ORNL-1561) was developed in which the uranyl nitrate is fed to a cation exchange resin column where the uranium is sorbed. It is eluted with hydrofluoric acid, and the uranyl fluoride eluate is fed to an electrolytic cell with a flowing mercury cathode where it is converted to  $UF_4 \cdot 3/4H_2O$

This product, when dried and dehydrated to  $UF_4$ , meets K-25 specifications for ionic and radioactive contaminants. (AEC Activity 2604)

Waste Metal Recovery Plant Operation - More than 59,300 kg of uranium has been recovered from waste in the Metal Recovery plant. The product was well within current K-25 specifications (i.e., fission product beta and gamma activity less than 100% of that of natural uranium, and plutonium contamination less than 10 parts per billion). The uranium loss from solvent extraction processing was 0.2%, and the total plant loss, including waste dissolution, was 1.5%. Approximately 125 g of plutonium has been recovered.

The recovery of nitric acid from the aqueous raffinate was discontinued in July because of excessive corrosion of recovery equipment by fluorides and chlorides in the presence of air. Quantitative plutonium recovery is not economical without efficient acid recovery, and currently a flowsheet, with a lower acid concentration, is being used to recover 99.8% of the uranium and 70 to 80% of the plutonium.

Although waste sludge is currently removed from the storage tanks by air sparging, a method for dissolving the solids in 1 M sodium carbonate—0.75% hydrogen peroxide, has been devised, in collaboration with K-25, so that the waste can be pumped out more easily. Since the new method of removing the waste from the tanks is more costly than the present procedure, it will not be used unless the sludge becomes too viscous to be lifted by air.

## PROGRAM 2000 - SOURCE AND FISSIONABLE MATERIALS (Continued)

The waste, which contains nitric acid, is evaporated to increase its uranium concentration before it is fed to the solvent extraction columns. It was found that, if water is added to the evaporator at a rate somewhat less than the evaporation rate, a greater volume reduction of the waste and better nitric acid recovery from the vapors is possible than if the evaporation is carried out in the usual way. Laboratory-scale studies on precipitation of phosphates during the evaporation showed that this precipitation can be prevented by keeping the initial nitric acid concentration above 2 N and the initial phosphate concentration below 8 g/liter, and discontinuing the evaporation when the uranium concentration reaches 100 g/liter.

During the evaporation of the final uranyl nitrate product, a finely divided precipitate of mono- or dibutyl uranyl phosphate formed as a result of the exposure of residual tributyl phosphate vapors to hot, dry evaporator surfaces. Since this precipitate greatly increased the foaming that occurred during denitration of the uranyl nitrate, its formation is now routinely prevented by steam stripping residual tributyl phosphate from the product solution before evaporation. (AEC Activity 2344)

Purex Process - Laboratory-scale studies showed that reduction of Pu(IV) to Pu(III) by hydroxylamine sulfate at an acidity of 0.5 N, which is the maximum acidity of the second plutonium cycle feed, was sufficiently rapid to permit effective stripping of the plutonium.

The properties of uranium trioxide formed from the uranyl nitrate recovered by the Purex process were studied. The reactivity of the uranium trioxide with respect to reduction and hydrofluorination was shown to depend primarily on particle size. Traces of sodium and iron in the uranyl nitrate had little effect on the uranium trioxide reactivity. (AEC Activity 2802)

## PROGRAM 4000 - REACTOR DEVELOPMENT

### HOMOGENEOUS REACTOR PROJECT

Homogeneous Reactor Experiment - A series of experiments to provide information on the effect of radiation on corrosion of the fuel system was started during September. During experiments at low power level, several as yet unexplained events occurred. First, there was a reactor scram, evidently caused by faulty operation of the fuel level indicator; second, the  $\frac{1}{4}$ -inch-diameter fuel dump line was found to be plugged; third, there was evidence of uranium precipitation; and fourth, chemical analyses of the fuel indicated an exceptionally high corrosion rate.

Although the plugged fuel dump line at first resisted pressures as high as 1,500 psi, it loosened and cleared three days later. The cause of the plugging remains unknown, but it is suspected that the line was plugged by scale from the oxidation of stainless steel and/or a uranium precipitate which accumulated over the 48 hours operating time.

## PROGRAM 4000 - REACTOR DEVELOPMENT (Continued)

Fuel analyses during the experimental run at 250°C indicated an increase in nickel content representing a corrosion rate of approximately 40 mils per year, which is several times the rate expected in the absence of high irradiation. The cause of the high corrosion rate is not yet determined. Further corrosion experiments were postponed until the data from the first run can be analyzed and understood.

Upon resuming operations, to perform kinetic experiments, a precipitate, later shown to be uranium peroxide, was detected in a fuel sample. The peroxide precipitation, predictable from chemical data on peroxide production and decomposition rates, resulted from a power excursion at too low a temperature (70° - 100°C) for rapid peroxide decomposition. The precipitate disappeared when the temperature of the fuel solution was held at 100° - 120°C for two hours with the reactor at zero power.

In a later test both the shim and safety rods failed to function properly and were removed for repair. Even though the reactor had operated at high power, the repairs were made with relative ease by direct maintenance with long-handled tools. Kinetic experiments, which are intended, 1) to determine the amount of excess reactivity which the reactor can safely overcome, and 2) to demonstrate that mechanical control rods are not essential, are now in progress. (AEC Activity 4103.10)

ISHR Conceptual Design - The rough draft of an economic evaluation and feasibility report on aqueous homogeneous reactors for central station electric power production has been completed and is being reviewed. (AEC Activity 4109.1)

Engineering Development - Bids on the development and fabrication of pumps and heat exchangers for a large-scale homogeneous reactor have been received, but a contractor has not been selected, pending the receipt of additional information. The contract with Allis-Chalmers for design of a 20,000-gpm pump is essentially complete.

Hydraulic tests on a full-scale model of a large reactor core demonstrate that straight-through flow, directed by screens, will be adequate for the ISHR. Analytical work at Johns Hopkins University has led to a very promising means of predicting flow in straight-through-type cores; but the problem of predicting, by analytical means, the effect of density differences within the core has not yet been solved. Tests at ORNL indicate that density differences will make a core "self-correcting" with regard to possible localized high temperature regions. A "vaned elbow" has been tested at high flow rates and appears to be satisfactory for guiding the flow through a right-angle bend without cavitation or undue turbulence. A stainless-steel vaned elbow is being fabricated for the 4,000-gpm test loop to permit studies of local corrosion near the elbow.

Completion of the 4,000-gpm loop has been delayed because the required quality of welds necessitates special training of welders. Within the last few weeks several perfect welds (based on x-ray inspection) have been made in

## PROGRAM 4000 - REACTOR DEVELOPMENT (Continued)

heavy-wall 347 stainless steel pipe samples. Actual welding of the loop is expected to start in two or three weeks.

Tests of a Romec pump for use as a fission gas pump in the HRE showed that, with the pump and motor incased in a can, this device is adequately leak-proof. A pump of this type will be installed in the HRE system in preference to a mercury pump, which is more complicated and less trustworthy than the Romec pump.

Discussions have been held with the manufacturers of the Lapp Pulsafeeder pump to share with them experience in pump development. From the discussions it appears that a new Pulsafeeder can be developed to incorporate the following improvements: lower stress in a thicker diaphragm, improved check valves, and improved primary pumping system. The manufacturer has agreed to develop and fabricate the improved pump. It will then be tested at ORNL. (AEC Activity 4109.4)

### AIRCRAFT NUCLEAR PROPULSION PROJECT

Aircraft Reactor Experiment - Changes are being made in the reactor and the associated fluid circuits to reduce the uranium investment. Detailed calculations of the fuel circuit volume show it to be 4.97 cu ft at 1300°F - not including approximately 1 cu ft required by the addition of the fuel concentrate. A critical mass in the range from 32 to 40 lb of U<sup>235</sup> will thus require a total uranium investment of from 140 to 180 lb.

In order to reduce the structural poison in the core, the three concentric Inconel control rod sleeves were replaced by a single Inconel-coated stainless steel sleeve. To further increase reactivity, the void between the new sleeve and the BeO moderator blocks will be filled with BeO pellets. The pellets will not only add moderating material to the core but will also reduce the flow of sodium in that region and thus minimize erosion of the moderator blocks.

The importance of reliable valves in the ARE fluid systems has led to numerous changes since some of the bellows-seal valves leaked in initial tests. It was subsequently found, however, that the leaky valves had been held open by metal chips, weld droppings, etc., and tests in fluorides showed the valves to be tight. The following changes, which will minimize the valve problem, were made: 1) all bellows-seal valves are located in cold (<1200°F) sections of the system, 2) the spare pumps are isolated by frangible disk valves, 3) the operating pumps may be isolated by "freeze valves," 4) some critical bellows-seal valves are backed-up by "freeze valves."

A preliminary Operations Manual (document CF-53-9-15) was completed. A supplement (document CF-53-9-53) to the ARE Hazards Summary Report, which described the recent changes in the experiment, was sent to the Advisory Committee on Reactor Safeguards.

## PROGRAM 4000 - REACTOR DEVELOPMENT (Continued)

The fuel fill-and-flush tanks were insulated and cleaned with water. The fluid-circuit heat exchangers were flushed with water in both directions to remove particulate matter. The final cleaning, degreasing, and scale removal will not be attempted until the system is complete. (AEC Activity 4401.1)

General Aircraft Reactor Design - Work on the detailed design of a family of reactors from 50 to 600 Mw, suitable for tactical aircraft, continued with most of the effort going into the design of the vital pump and header tank region. Design studies of this region, using a sump-type gas-seal pump, indicate that 1) there will be no appreciable shield weight penalty with this type of pump, 2) entrained gas bubbles (i.e., helium containing xenon) may be removed, 3) the free liquid surfaces may be maintained by a centrifugal field (so that negative G loads and maneuvers will not introduce gas bubbles into the fuel), and 4) the pump sump serves as a convenient point for introducing rich fuel in pellet form for shim control purposes. Preliminary designs for such a fuel enrichment system, incorporating a machine to dispense and count the pellets, look very promising.

The shielding studies were extended to determine the effects, on over-all reactor-crew weight, produced by varying the neutron to gamma-ray ratio of the design dose in the crew compartment. Shield weights were calculated on the basis of a 50 Mw reactor having a core diameter of 18 in. Reactor shields were designed to give 10 r/hr and 100 r/hr at 50 ft, with the neutron dose from 1/16 to 1/2 of the total dose. Crew shields were then designed to give a dose of 1 r/hr inside the crew compartment, again with the neutron dose 1/16 to 1/2 of the total dose. The results disclosed that the over-all shield weight was not very sensitive to neutron-gamma ray dose ratio, the maximum variation being around 6%. Generalizing, the minimum over-all weight was obtained when the neutron dose was about 1/4 of the total crew dose under conditions such that reactor shields transmitted about 1/8 of the total dose as neutrons.

An analysis of the power plant system was made, assuming a 200,000 lb aircraft, with both a 100 or 200 Mw reflector-moderated reactor and 2 or 4 Wright turbojet engines. From the study it appears that the off-design, as well as the normal, performance and control of these subsonic planes is satisfactory when four engines, with chemical augmentation as required for additional output, are employed. (AEC Activity 4401.1)

Experimental Engineering - The gas-seal sump-type centrifugal pump, specified for both the ARE fuel and sodium circuits, is now being tested. Preliminary operation of the pump with sodium indicates that the performance is satisfactory. Independent tests indicate that the silver-impregnated graphite face-seal will not be impaired by sodium or sodium vapor.

Of the numerous tests being conducted in the program to develop a satisfactory packed seal for a fluoride pump, the following seals have operated with acceptable leakage rates (<35 cc/day):

PROGRAM 4000 - REACTOR DEVELOPMENT (Continued)

<u>Seal</u>	<u>Shaft Dia. (inches)</u>	<u>Time (hours)</u>
BeF <sub>2</sub>	1-3/16	2300
Graphite in Spiral Groove	1-3/16	1600

It should be noted that these seals were not tested on pumps and that the shaft diameter is less than half that of the ARE pump shaft. Packed-seal tests recently with a 2-1/2 in. diameter shaft have been unsuccessful.

Both frozen-sodium seals and frozen-fluoride seals have been applied to pumps circulating sodium and molten fluorides, respectively. The short (1/2") sodium seal continues to operate well, pumping 125 gpm sodium at 200 psi and 1000°F with low leakage. On the other hand the short (1/4") fluoride seal not only leaked badly but also the wear rates and reliability were so poor that development of this type of seal for a fluoride pump has been discontinued. (AEC Activity 4401.1)

Mathematics and Computation - The multi-group diffusion equations, which have been used in the past for computing the static characteristics of ANP reactors on IBM machines, were coded for the UNIVAC. For these calculations there are 36 sets of diffusion equations, one each for the 32 fast neutron and 4 thermal neutron groups. This problem is now in production. Data on twenty perturbations of the basic ARE reactor and 101 perturbations of the reflector-moderated reactor are presently being calculated. The computation time is approximately 20 minutes per reactor. Computation data on about 50 reactors have already been completed and are being analyzed. (AEC Activity 4401.2)

Reactor Chemistry - Preparation of the ARE fuel concentrate, Na<sub>2</sub>UF<sub>6</sub>, began in the Y-12 Production Division and the first batch was successfully completed. According to present plans the manufacture of the concentrate of desired purity will be completed by December 1. The apparent activation energy necessary for hydrogen reduction of the UF<sub>4</sub> to UF<sub>3</sub> in the fuel concentrate is 33,700 cal/mole in the neighborhood of 800°C.

The NaF-ZrF<sub>4</sub>-UF<sub>4</sub> system, to which the ARE fuel belongs, is the subject of extended phase studies. An incomplete study of the Na<sub>3</sub>ZrF<sub>7</sub>-Na<sub>3</sub>UF<sub>7</sub> system indicates that solid solutions are formed over a wide range of compositions. However, an anomaly was found near the Na<sub>3</sub>UF<sub>7</sub> end of the series; mixtures in this region contained an isotropic phase as yet unidentified.

The ratio of HF concentration in the molten NaF-ZrF<sub>4</sub> mixture to that in the gas phase during hydrogenation at 800°C appears to be nearly independent of partial pressure of HF over the range 0.5 - 10<sup>-6</sup> atmosphere. This ratio,  $\frac{\text{moles HF/liter H}_2}{\text{moles HF/kg melt}}$ , has a value of 0.44 ± 0.02 kg/liter. Since the HF content of the gas is readily determined, the preceding ratio may be used to evaluate the HF content of the melt. (AEC Activity 4401.5)

## PROGRAM 4000 - REACTOR DEVELOPMENT (Continued)

Corrosion Studies - Laboratory scale dynamic corrosion tests have shown that treatment of the ARE fuel solvent ( $\text{NaZrF}_5$ ) with metallic zirconium is effective in reducing the corrosion of Inconel by such melts; the corrosion is decreased as the quantity of dissolved zirconium is increased.

Upon completion of static tests of Inconel in graphite capsules containing the  $\text{NaZrF}_5$  melt, to which relatively high concentrations (up to 1%) of  $\text{FeF}_2$  or  $\text{FeF}_3$  were added, a continuous coating of metallic iron was observed on both the Inconel and the graphite. This layer apparently protected the metal specimen since the chromium content of the melt after exposure was quite low and the specimen showed few, if any, subsurface voids. What happened to the fluorine from the iron compounds is not yet known.

Static tests of possible bearing materials in sodium, lead, and the fluoride mixture,  $\text{NaF-ZrF}_4\text{-UF}_4$  (50-46-4 mole %), were completed. In these tests the bearing materials were first deposited on the type-347 stainless steel specimens and then tested in type-347 stainless steel capsules for 100 hours at  $816^\circ\text{C}$  in the various corrosive environments. Of the numerous Hastalloy and Stellite specimens tested, Hastalloy B and Stellite 25 exhibited the best corrosion resistance in all media.

Specimens of oxidized Armco iron, oxidized 347 stainless steel, and a special Ni-Mo alloy, were tested for corrosion by lead in quartz convection loops. The test with Armco iron was not completed because of a loop failure not connected with the test. The tests with the oxidized 347 stainless steel and the Ni-Mo alloy were both voluntarily terminated after 548 and 572 hours, respectively. Neither loop showed a large amount of mass transfer, which was surprising in view of the fact the high nickel-base alloys previously tested had plugged in the neighborhood of 70 hours.

In convection loop tests at  $1500^\circ\text{F}$  for 500 hrs, the corrosion of Inconel by molten fluoride mixtures was doubled (from 5 to 10 mils) when the  $\text{UF}_4$  content of the fluoride was increased from 0 to 4 mole percent. However, in other tests there was no detectable increase in corrosion attributable to an increase in the  $\text{UF}_4$  content of the fluoride mixture from 4 to 6.5 mole percent. Indeed, static tests indicated no difference in corrosion between a 4 mole percent mixture and one with 25 mole percent. It is probable that there is a tendency toward greater corrosion with higher uranium content but this effect is so small as to be indistinguishable from the normal variation of corrosion results. (AEC Activity 4401.5)

ANP Metallurgy - A high-temperature, high-performance liquid-to-air radiator section with 5,000 tube-to-fin joints and 15 fins per inch (of tube) was successfully constructed. The GE #62 brazing alloy (69 Ni - 20 Cr - 11 Si) was applied as a slurry to the tube-to-fin joints and the header and manifold assembly was altered so that the tube-to-header joints and the closing of the manifold could be accomplished by Heliarc welding. The completed assembly was satisfactorily leak-tested under both pressure and vacuum.

## PROGRAM 4000 - REACTOR DEVELOPMENT (Continued)

In the continuing attempt to develop a high-conductivity radiator fin with oxidation resistance, copper was electroplated with various metals. Platings, with the relative proportions of 446 and 310 stainless steel, were obtained by the plating with Fe-Cr and Fe-Cr-Ni, respectively. As plated, these coatings were brittle, but after annealing, for 16 hours at 1600°F in a hydrogen atmosphere, could be bent 180°. The electroplated coatings failed completely during a 500 hour test at 1500°F, permitting the subsequent oxidation of the copper. Inconel-clad copper fabricated previously was sent to the Griscom-Russell Co. for fabrication and testing in a radiator assembly.

The recrystallization behavior of niobium sheet stock cold-rolled 87  $\frac{1}{2}$  percent was determined. The material was annealed for 1/2 hour at temperatures from 300 to 1200°C in a vacuum of  $10^{-5}$  to  $10^{-6}$  mm of mercury. From the results of hardness and tensile data it appears that the recrystallization temperature of niobium is in an approximate temperature range of 950° to 1050°C for this material. (AEC Activity 4401.5)

ANP Design Physics - The first results of the UNIVAC calculations concerning the revised critical mass of the ARE were received and are now being processed by hand calculation to adapt them to the non-homogeneous, non-spherical structure of the ARE.

The in-hour equation for the circulating-fuel ARE was completed. At design flow velocity, about 50% of the delayed neutrons are given off within the core. Thus, a substantial amount of excess reactivity, i.e., 0.4% would be required to bring the ARE to prompt critical. However, only a very small increase in reactivity will bring the reactor from just critical to a 10 second period, and the "pile period," because it is so sensitive to any further increases in reactivity, will be very difficult to measure.

Shielding Research - A new high-sensitivity dosimeter was calibrated and put in operation in the Lid Tank. This instrument differs from previous dosimeters in that it 1) has three sensitivity chambers instead of one or two as have been used heretofore, and 2) employs a flowing gas instead of being statically filled as were the earlier models.

A new source plate for the Lid Tank is being constructed. The allotment of U<sup>235</sup> has been approved by the AEC and instrumentation is being developed to measure the power when it is installed. This new source plate will afford a considerable improvement (in power calibration) over the one presently in use, which consists of reject X-10 natural uranium slugs.

Construction of the TSF (tower shielding facility) is still approximately on schedule although the prospects for delivery of the hoists in time for the scheduled start-up appear at present to be poor and it accordingly may be necessary for the manufacturer to subcontract some of the work. One-half of the tower structure itself has been erected with no unexpected difficulties and, barring drastic changes in the weather, the remaining construction should be completed on schedule. The instrumentation of the tower is being developed. A crew compartment mockup has been designed and estimates of costs of construction have been obtained. (AEC Activity 4401.7)

## PROGRAM 4000 - REACTOR DEVELOPMENT (Continued)

### GENERAL REACTOR RESEARCH

Idaho Chemical Processing Plant - The Idaho plant has been operated satisfactorily at full capacity. The field work by ORNL personnel at the Idaho site has been completed. (AEC Activity 10543)

## PROGRAM 5000 - PHYSICAL RESEARCH

### REACTOR OPERATIONS

Low Intensity Test Reactor - After adding additional shielding, the LITR power was increased from 1500 kw to 300 kw on September 2; the new power level has been maintained since then without difficulty. To supplement the cooling capacity of the fluid cooler, use has been made of the shell-and-tube heat exchanger, which probably will be required only during hot weather.

It is generally conceded that the major hazard of operating the LITR at power levels in the range of 3,000 kw is the possibility of the "hot" fuel elements melting if a loss of water from the reactor tank should occur. As reported previously, a spray tank has been made an integral part of the water system; it is always full and will automatically supply water to spray the fuel elements for  $\sim 2$  hours after loss of water from the reactor tank. In August, two "water drop" tests were made in which the water was rapidly drained from the reactor tank so that the loss of moderator automatically shut down the reactor. With the emergency spray in operation the maximum temperature of the fuel was then determined. After operation at 1,900 kw, the fuel temperature rose to 80-85°C; after 2300 kw,  $\sim 92^\circ\text{C}$ . Since the maximum temperature after 3000 kw operation is expected to be only  $\sim 100^\circ\text{C}$  no further tests are planned.

A recently installed by-pass filter through which several hundred gallons of water can be passed per minute is very effective in removing the turbidity of the LITR cooling water.

### PHYSICS

Neutron Diffraction - Previous neutron diffraction experiments at this laboratory showed that metallic chromium is slightly antiferromagnetic below a transition temperature of 475°K. Although the samples used were quite pure (99+%), there was reason to believe that the small amount of oxygen (0.45 weight per cent) in the samples could be dissolved in the chromium lattice in a manner that would alter the electronic structure and give rise to the small magnetic moment which was detected. The experiment has been repeated with an extremely pure sample of chromium prepared by the U. S. Bureau of Mines and containing only 0.02 weight per cent of oxygen. Data on this pure sample indicate the same degree of antiferromagnetism that was detected in the previous samples. (AEC Activity 5211)

PROGRAM 5000 - PHYSICAL RESEARCH (Continued)

Low Temperature Studies - Apparatus consisting of a mutual inductance bridge and cryostat, which is capable of measuring magnetic susceptibility from 77°K down to adiabatic demagnetization temperatures, has been put into operation. The precision of measurement of the relative susceptibility of a spherical sample 12 mm diameter is about  $10^{-6}$  cgs. The apparatus provides the following features: a usable frequency range of 5 kc/sec for the study of paramagnetic relaxation and paramagnetic specific heat; measurement of longitudinal susceptibilities in fields up to 300 oersted, and transverse susceptibilities in fields up to 13000 oersted; and a simple method for changing samples with a minimum dismantling of the equipment.

Preliminary studies of the magnetic susceptibility of powdered samples of anhydrous  $MnCl_2$  and  $UCl_3$  demonstrate that these compounds are antiferromagnetic. At the higher temperatures the susceptibility of  $MnCl_2$  follows a Curie-Weiss law with a Weiss constant of 4.35°K, but there is an apparent transition to the antiferromagnetic phase at 2.2°K. The magnetic susceptibility of  $UCl_3$  as a function of temperature appears to have maxima at both 3.2°K and 1.5°K. The maximum at 3.2°K is believed to be the Néel temperature, and the observations are tentatively accounted for by assuming that the bulk of the material develops an antiferromagnetic ordering below 3.2°K, while some of the atoms (about one in  $10^5$ ) form a ferromagnetic lattice with a Curie temperature of about 1.5°K. This phenomenon is in some respects similar to the ferromagnetic effects found by Kurti and Simon in iron ammonium alum near 0.04°K. (AEC Activity 5211)

Nuclear Alignment Research -  $Sm(C_2H_5SO_4)_3 \cdot 9H_2O$  in the powder form is characterized by an average hyperfine structure coupling constant of  $0.0153 \text{ cm}^{-1}$  from which one might expect about 30% polarization of  $Sm^{149}$  nuclei at 0.05°K in an applied magnetic field of a few kilogauss. In preliminary experiments the transmission of slow neutrons has been observed as a function of the relative spin orientations of the nuclei and neutrons. With  $Fe(NH_4)_2(SO_4)_2 \cdot 6H_2O$  as a coolant and a metal bar connecting the coolant and the  $Sm(C_2H_5SO_4)_3 \cdot 9H_2O$  target, the temperature of the Fe salt was decreased from 1.2°K by demagnetization from 15.4 kilogauss. A field of about 5 kilogauss was applied to the Sm salt sample and, as the heat of magnetization of the Sm salt was conducted to the Fe salt, the Sm nuclei became polarized. A thermal neutron beam from the graphite reactor was then directed on the Sm salt, and the transmitted neutrons were reflected from the (220) planes of a magnetized  $Fe_3O_4$  crystal and counted with a  $BF_3$  long counter. The magnetite crystal and neutron counter were set at angles for the first order Bragg reflection corresponding to an energy of 0.075 ev which lies near the peak of the 0.094-ev resonance in  $Sm^{149}$ . The polarized Sm salt sample served as a neutron polarizer, while the magnetite crystal served as an energy selector and analyzer. Data were obtained (a) in the arrangement described, (b) with a thin unmagnetized sheet of polycrystalline Fe in the beam to depolarize the neutrons after transmission through the Sm sample, and (c) with the  $Sm^{149}$  nuclei unpolarized. A maximum single transmission effect of about 4% and a maximum net double transmission effect of about 19% were observed. These changes in transmission are interpreted as being due to the spin dependence of the capture cross-section of  $Sm^{149}$ . (AEC Activity 5211)

## PROGRAM 5000 - PHYSICAL RESEARCH (Continued)

High Voltage Program - The tritium recovery and counting system used in evaluating the cross section of the reaction  $\text{Li}^7(d,t)\text{Li}^6$  was calibrated. Two methods, one yielding the geometrical efficiency of the counter and the other measuring the tritium recovery and geometrical efficiency of the counter together, gave results agreeing to within  $2\frac{1}{2}$  percent, well within their anticipated uncertainty. The third method, depending on pile flux measurements, overlapped the others, but it also provided an estimate of  $\pm 4\%$  (95% statistical confidence level) for the weighing and tritium assay errors per target. The new calibration will result in about a 7% decrease in some of the cross section values reported previously (e.g.  $\text{Li}^7(d,t)\text{Li}^6$ ). (AEC Activity 5211)

Theoretical Physics - A completely general expression for polarization in nuclear reactions has been formulated. The expression gives the polarization resulting from a nuclear reaction initiated by an arbitrarily polarized initial beam in terms of the so-called G-function, which is related to the Fano  $\chi$ -function. The extension of the S-matrix formalism to include gamma-rays has also been made.

Previous tables (i.e. report ORNL-1098 by L. C. Biedenharn) of the Racah function  $W(abcd;ef)$  did not include those functions that had four odd-half-integral arguments and two integral arguments. The tables are now being revised and extended to include these values by making use of the UNIVAC. An interesting time comparison for these computations is that the coding for the UNIVAC, which is almost complete, will have taken less than one man-month. The actual machine time will be about ten hours. The previous hand computations for report ORNL-1098, which was only  $2/3$  as complete as the new tabulation, required over twenty-four man-months.

The use of the Born approximation, to interpret the results of the elastic scattering of 150 and 125 Mev electrons from the Stanford linear accelerator by heavy nuclei, has been shown by Hofstadter et al and Schieff to lead to a nuclear charge distribution radically different from the constant density model usually assumed. Since the predictions of the Born approximation are of uncertain value for these heavy nuclei, e.g., Pb with  $Z = 82$ , it has been decided to compute the cross section, by the method of partial waves for several different charge distributions, with the aid of an electronic digital computer. The work of preparing the problem for the computer is now in progress. At the same time the effects of nuclear polarization and radiative effects on the scattering are being studied.

An accurate calculation of the level shift in hydrogen is crucial in the theoretical development of quantum electrodynamics. No available calculation seems to possess sufficient accuracy, and a definitive calculation has therefore been undertaken. The shift has been split into three parts: 1) a large, unobservable contribution (mass renormalization); 2) a smaller, observable part which is relatively easy to compute analytically; and 3) a comparable part which is impossible to compute analytically but is quite susceptible to numerical computation. The first two steps are complete, and a preliminary hand computation of the third part is nearly finished. It is anticipated, however, that a machine computation of this part will prove vital in obtaining the desired accuracy; and some work has been done in this direction. (AEC Activity 5211)

## PROGRAM 5000 - PHYSICAL RESEARCH (Continued)

### CHEMISTRY

Chemical Separation of Isotopes - A two phase, countercurrent system, comprising 4-chlorobutanol-1 versus hydrogen chloride (gas), has been proposed as a possible means of separating chlorine isotopes. The investigation of the chemical feasibility of the system was begun by examining the reflux reactions. Hydrogen chloride was found to react readily with tetrahydrofuran, producing the 4-chlorobutanol-1. Quantitative thermal decomposition of this compound to regenerate hydrogen chloride and tetrahydrofuran could not be attained due to side reactions. Since refluxing appears difficult, if not impossible, no further work is planned for this system. (AEC Activity 5361)

Uranium Chemistry of Raw Materials - Some primary and secondary aliphatic amines in a hydrocarbon diluent have exhibited the ability to extract thorium from sulfate solutions. With 0.1M amine, extraction coefficients in the order of 5 were obtained from 1M sulfate solutions at a pH of 1.8.

The cobalticyanide ion, which contaminates some extracted uranium solutions, is sorbed almost irreversibly by strong-base anion exchange resins, but it is extracted strongly from acid solution by trioctyl amine and is readily stripped from the latter by dilute alkali.

The estimated amounts of ore and of acid required to produce one pound of uranium from each of ten Leached Zone ores tested ranged, under the best conditions found, from 2 to 6 tons of ore and from 400 to 2400 pounds of sulfuric acid. These quantities were determined principally by the ore grades, although the acid consumptions also varied widely.

The sodium salts of di(2-ethylhexyl)phosphoric and di(2-ethylhexyl)phosphinic acids (0.1M) in kerosene containing a few percent of capryl or 2-ethylhexyl alcohol, remain in the organic phase when in contact with 5 to 10% sodium carbonate solution; hence, uranium can be stripped from these reagents with comparatively inexpensive basic solutions. (AEC Activity 5361)

General Reactor Chemistry - Preliminary investigations have been made toward the development of an aqueous homogeneous thorium blanket for a U<sup>233</sup> breeder reactor. The anions considered, in addition to the nitrate, were fluoride, sulfate and phosphate, it being hoped that some combination of these anions would allow sufficiently high thorium solubility and sufficiently low neutron losses. Thorium oxide or phosphate is quite soluble in strong H<sub>3</sub>PO<sub>4</sub> media (up to about 1 kg per liter); however, the corrosive action of such media on stainless steel appears to be prohibitively high at around 200°C, the viscosity is much higher than desired, and the required phosphorus to thorium atomic ratio (between 5:1 and 10:1) causes undesirably high neutron losses. Adding water or substances containing sulfate or fluoride ion to the H<sub>3</sub>PO<sub>4</sub> media does not result in media with significantly improved characteristics before precipitation occurs. A sulfate-fluoride mixture appears to afford a higher thorium solubility than a medium containing only one of these two anions. However, precipitation in the mixed medium occurs slowly and gives evidence of approaching a solubility not outstandingly greater than that of

## PROGRAM 5000 - PHYSICAL RESEARCH (Continued)

the pure sulfate. As with the sulfate the temperature coefficient is negative above about 50°C. It now appears that the only soluble thorium compound at all suitable for use in an aqueous homogeneous breeder blanket is the nitrate (using separated N-15). The radiation and thermal stabilities of the nitrate at elevated temperatures are yet to be evaluated definitively. (AEC Activity 5361)

Chemistry of Corrosion - A brief study was made of the effect of welding upon the chemical activity of stainless steel, type 347. The deposition of a beta ray-emitting material (presumably technetium dioxide) from a solution of potassium pertechnetate was used as a measure of the relative chemical activity of the metal surface. The experiments showed that the unpolished weld surface and adjacent area were excessively active, being anodic to polished or machined surfaces in the same neighborhood. The excess activity extended over a 2-cm. distance at the weld, with inconclusive evidence of a secondary increase near the ends of a 15-cm. bar which had the weld in the middle. When a specimen bar was electropolished on three sides and ground on the fourth, the ground surface picked up 80 percent of the activity, although it had only 25 percent of the total surface. Autoradiograms of weld areas disclosed clearly the contours of the weld zone in both a fusion weld and one made with filler rod.

The solubility of the yellow form of tungstic acid ( $H_2WO_4$ ) in uranyl sulfate (30 g and 300 g U/liter) was determined at temperatures up to that at which two liquid phases separate. The solubility is much greater in the uranyl solution of higher concentration and, in this solution, increases with temperature. The measurements were made in order to determine whether or not the solubility is sufficiently high to permit consideration of tungstic acid as a possible corrosion inhibitor. The experiments in which sodium tungstate was used in aqueous solution at 100°C have continued to show inhibition of the corrosion of carbon steel for a total of four months to date.

It has been found possible to obtain inhibition of the corrosion of carbon steel in water by use of potassium pertechnetate under such conditions that only about 20 counts per minute per square cm. were found after exposure. This result apparently confirms the previous indications that the inhibition is not dependent upon a film of precipitated reaction products. (AEC Activity 5361)

Ion Exchange Studies - A significant advance in the understanding of ion exchange selectivity with cation and anion exchangers is believed to have been achieved recently. By employing isopiestic measurements to determine osmotic coefficients for various salt forms of exchangers, it was possible to compute values of the selectivity, using a modified form of Harned's equation for electrolyte mixtures. A surprising correlation of thermodynamic properties with ionic (crystal) radii was observed. Sodium-hydrogen selectivities for exchangers of variable exchange capacity could be explained by this same general treatment.

Self-diffusion coefficients of cations in un-cross-linked polysulfonate solutions were found to agree with earlier self-diffusion coefficients obtained

## PROGRAM 5000 - PHYSICAL RESEARCH (Continued)

with cross-linked polysulfonate ion exchange resins of the same degree of hydration. This behavior indicates that the mechanism of ion diffusion in ion exchangers is quite similar to that in polyelectrolyte solutions. It is noteworthy also that the cation self-diffusion coefficients at very low un-cross-linked ion exchanger concentrations approach the limiting values for ordinary aqueous solutions, despite the extremely large electrostatic forces surrounding the molecules existing in polyelectrolyte solutions. (AEC Activity 5361)

Isolation Processes for Uranium and Plutonium - It was reported in report ORNL-1600 that an acetate-citrate elutriant, for uranium sorbed on Dowex 50W resin, had been found which gave the highest eluate uranium concentration of any solution thus far studied, but there was no significant decontamination of the fission products from the uranium. The precipitation of the uranium as  $UO_4$  from this solution was shown to be entirely satisfactory.

About 1177 g of  $U^{233}$  was converted by the ion exchange process from uranyl nitrate to uranyl fluoride for use in criticality studies, making a total of 2364 g converted (see report ORNL-1529). The work on this problem was completed.

Experiments on conversion of uranyl nitrate to uranyl sulfate, for application in reprocessing of homogeneous reactor fuel, showed that a product with a sulfate/uranium mole ratio of 1.05 and containing more than 90% of the uranium sorbed on the column could be obtained. Nearly 4,000 g of enriched uranium was isolated and converted to uranyl sulfate with a composite sulfate/uranium mole ratio of 1.041.

Details of the isolation studies are reported in report ORNL-1585. (AEC Activity 5361)

Ion Exchange Technology - The 2-in.-diameter continuous ion exchange resin contactor mentioned in report ORNL-1600 was demonstrated with the Excer process. A uranyl nitrate solution with a uranium concentration of 50 g/liter was converted, at a rate of 64 lb of uranium per day, to a uranyl fluoride solution with a uranium concentration of 120 g/liter. The waste from the process contained less than 0.01% of the uranium in the feed solution. Approximately twice as much resin would have been needed for a batch process, at the same rate of conversion.

Studies on continuous contactors reported to date have been made on a "jerked-bed" resin column in which the resin is moved a little at a time, with a slight pause between the movements. A continuous system has now been constructed in which the resin moves down the column as a dense bed rather than in small units, and the liquid flows up the column countercurrent to the resin flow. A hydraulic ram is used at the top of the column to create a back pressure and thereby prevent the fluidization of the resin bed that would occur at the feed flow rates required for efficient operation. (AEC Activity 5361)

## PROGRAM 5000 - PHYSICAL RESEARCH (Continued)

Instrumentation for Nuclear Chemistry - A very simple method for improving pulse amplifier linearity by a factor of five to ten was developed. The output of the cathode follower is fed back to the preceding power stage in such a way as to keep its plate current, and therefore its transconductance, constant; this results in constancy of gain throughout the range of voltage swing. Besides improving the linearity, this modification doubles the available output voltage and increases the tube life. (AEC Activity 5361)

Hot Laboratory Research - In an attempt to produce samarium-146 by the (p,2n) reaction on promethium, about 10 mg of enriched Pm<sup>147</sup> was bombarded with 19-Mev protons for three hours in the ORNL 86-inch cyclotron. No short-lived activities were found but the 2y Pm<sup>146</sup> from the (p,pn) reaction was readily detected. According to expected reaction ratios, ten times as many atoms of Sm<sup>146</sup> as of Pm<sup>146</sup> should have been produced. The Sm<sup>146</sup>, if present, evidently has a long half life; an alpha activity with a half life of  $\sim 10^7$  years has been predicted in the literature.

One anomalous gamma-ray energy was observed at 120 kev in a proportion too large to agree with the alpha half-life proposed. This indicated discrepancy is being examined further by ion-exchange techniques. Eventually the results will be compared with those from a second product to be prepared through the electron-capture decay of 38h Eu<sup>146</sup>, following separation from proton-bombarded Sm<sup>147</sup>.

(Since this experiment was initiated a report from UCRL identifies Sm<sup>146</sup> as a 2.5 Mev alpha emitter with a half life of  $5 \times 10^7$  years.) (AEC Activity 5361)

Thorex Process Development - A concatenated pulse column, as described in report ORNL-1328 (p. 12), was shown to be satisfactory for use in the Thorex pilot plant preferential strip (B) and uranium strip (C) columns. A hydraulic pulse generator system that permitted variation of the wave shape and of the pulse frequency and amplitude was set up for testing. The controls and the pump in this system could be located remotely from the hydraulic motor and "pulser," which was mounted on or adjacent to the column. (AEC Activity 5361)

The Oracle - On June 2, 1953, the memory system was linked to the arithmetic unit and the testing of the integrated computer began. By September 17, the computer had been completely tested, and dismantling operations began in preparation for the move to Oak Ridge. Although most of the time during this period was spent in testing the Oracle, a total of 218 hours of computer time was made available during July, August and September for the solution of problems. Problems run during this time included: a Monte Carlo estimate for the damaging effects of neutrons on human tissue; a heat flow problem for long circular pipes; and a method for finding the characteristic values of a matrix by first reducing it to Jacobi Form. In addition to these and other problems, several routines were checked out for the Oracle Subroutine Library. (AEC Activity 5511)

## PROGRAM 5000 - PHYSICAL RESEARCH (Continued)

Research Participation and Traveling Lecture Programs - Under the Research Participation Program for 1953, 31 participants in the physical sciences, representing 20 universities, have completed their tour of duty with the Laboratory and have returned to their home universities. One research participant will continue his research through next year.

The Traveling Lecture Program for the academic year 1953-54 is just beginning. The names of the lecturers have been submitted to the Oak Ridge Institute of Nuclear Studies for their review and subsequent circulation to interested universities. (AEC Activity 5620)

## PROGRAM 6000 - BIOLOGY AND MEDICINE

### BIOLOGY

Cytogenetics - Radiation intensity experiments were performed on soaked Vicia faba seed that indicate 1) there is a two hour period during which no restitution of chromosome breaks occur and 2) the presence of BAL (British anti-Lewisite) in the system reduces this two hour period by increasing the restitution rate of broken chromosome ends. This is consistent with experiments performed on the effect of fractionated dosage in this system.

Fractionated dosage experiments were then performed, in the presence of BAL, on seeds that had been pretreated by irradiation either in water or in BAL. Only in those pretreated with irradiation in the presence of BAL was the number of two-hit aberrations decreased due to fractionation of the dosage. This is interpreted as indicating that irradiation in water inhibits those metabolic systems that provide the energy for the restitution of broken chromosome ends. BAL evidently exerts its protective effect on chromosome radiation damage by protecting these metabolic systems. Consequently, if the system is inactivated for two hours by irradiation in water, then BAL cannot exert any effect on the restitution rate within this time. The data also indicate that the broken ends formed in BAL and in water are not sufficiently different from one another as to preclude interaction between them.

The multinucleate heterokaryotic conidia of Neurospora crassa were exposed to neutron and mixed radiation from nuclear devices in a recent atomic weapons test program. The relation between the surviving fraction of whole cells and the surviving fraction of cell nuclei was the same as that predicted by the hypothesis that the nuclei are the units of inactivation of the cells. This relationship has already been demonstrated in the laboratory. The elementary composition of the cells was varied by growing the cultures, prior to irradiation, on media containing different amounts of  $N^{15}$  and  $B^{10}$ . Replacement of 65 atom percent of the normal nitrogen by  $N^{15}$  made no difference to lethal effects or recessive mutations. Increase of boron content to 16 ppm  $B^{10}$ , however, slightly but significantly increased radiation death of

## PROGRAM 6000 - BIOLOGY AND MEDICINE (Continued)

the cells, but did not affect the incidence of recessive mutations. It is concluded that a small, but biologically significant slow neutron component was present.

The protective effect of anoxia was tested by exposing some of the samples in an atmosphere of nitrogen. No significant protection was obtained. One would expect, from laboratory experience, that gamma-ray effects would be considerably ameliorated by anoxia. Therefore, it would seem that the fast neutron effects were predominant despite the gamma-ray contamination, the RBE for the neutrons being very high.

Genetic studies on chromosome segregation in translocation heterozygotes of Drosophila virilis indicate that an anomalous type of chromosome pairing is occurring in certain of the male heterozygotes. A particular translocation between the Y chromosome and chromosome 5 shows the abnormal behavior. Normally, in a XYY male of D. virilis there is more pairing between the Y's than between X and a Y. In translocation heterozygotes of the constitution  $5^Y YX$  (the  $5^Y$  chromosome is one in which most of the Y is attached to just the centromeric region of chromosome 5) the pairing is greatest between the  $5^Y$  and Y, and pairing between X and Y is somewhat greater than between X and  $5^Y$ . Thus these relations appear to be perfectly normal. However, in males of the constitution  $5^Y 5^Y X$  where one would expect a great deal of pairing between the two  $5^Y$  chromosomes, very little is found—most of the pairing occurs between a  $5^Y$  and the X. At the present time experiments are being conducted to obtain additional confirmation that the two  $5^Y$  chromosomes in the  $5^Y 5^Y X$  males are identical. An attempt is being made to determine cytologically the anomalous pairing. (AEC Activity 6400)

Mammalian Genetics - Data being accumulated from a 1000-r X-ray experiment on specific loci in mice strengthen the evidence that the mutation rate at this dose is lower than expected, on the hypothesis of linearity, from the 600-r rate determined earlier. This suggested that the rates for doses lower than 600 r may be higher than expected from the 600-r rate. An experiment, using 300 r, was started to test this possibility.

Preliminary data from the 300-r experiment show a total of 14 presumed mutations, at the seven loci tested, in a total of 23,036 offspring examined. This rate is slightly, but not significantly, higher than expected on the hypothesis of linear increase between 0 r and 600 r. Final conclusions on the shape of the curve must await the testing of the mutants and the collection of more data.

The 300-r data already collected are adequate in one respect. They support, at this dose level, the most important conclusion reached from the 600-r data, namely, that the induced mutation rate in the mouse is approximately one order of magnitude higher than the rates obtained from similar experiments on Drosophila. (AEC Activity 6400)

## PROGRAM 6000 - BIOLOGY AND MEDICINE (Continued)

Microbiology - Previous reports on the biochemistry of propionic acid bacteria covered the coenzyme A (CoA)-adenosinetriphosphate(ATP) requirements for activation and decarboxylation of succinate, yielding propionate and a one-carbon complex which would form CO<sub>2</sub> or recombine with propionate reversibly to form succinate. This one-carbon complex now has been shown also to be fixed into malate, presumably by combination with a C<sub>3</sub> compound, without previous conversion to CO<sub>2</sub>. Experiments, using as a substrate succinyl-CoA labelled with C<sup>14</sup> in the unactivated carboxyl, have shown that the decarboxylation occurs at the C<sup>14</sup>-labelled, unactivated end. Thus, it is interpreted that the propionyl CoA and an activated one-carbon complex are the first products of the reaction. This is supported by the finding that both succinyl and propionyl-CoA, as well as other acyl-CoA compounds, "spark" the reaction, replacing the requirement for ATP and CoA. The presence of a coenzyme-A transphorase system, which transfers CoA directly from one acyl group to another without loss of the high-energy ester linkage, has been shown to be present by several different methods. The over-all reaction appears to be as follows: activation of succinate by ATP and CoA, followed by decarboxylation to propionyl-CoA and a one-carbon fragment which can then form CO<sub>2</sub>, be fixed into malate, or be refixed into succinate; the propionyl-CoA and another molecule of succinate form succinyl-CoA and propionate, by the action of CoA transphorase, thus completing the catalytic cycle. (AEC Activity 6400)

Radiation Protection - Studies on the release of material (absorbing in the ultraviolet) from X-irradiated Escherichia coli, have shown that the phosphate concentration of the suspending medium has an important influence on this release of material. In the absence of added phosphate or in the presence of relatively high concentrations, this release is almost completely prevented. Arsenate in proper concentration antagonizes the release of material. A relationship between phosphorylation and the development of "leakage" in X-irradiated cells is suggested by these data.

Purification of a factor from beef spleen which affects bacterial recovery from irradiation is continuing. A 90 percent ethanol extraction of the hot water extract from homogenized decapsulated spleen has yielded a 50-fold purified product. A pool of this filtrate is being accumulated and dried by lyophilization. This material will serve as source material for further purification by several methods including solvent extraction, charcoal adsorption, and chromatography. Preliminary experiments with adsorption on charcoal and elution with absolute ethanol indicate that another several-fold purification may be accomplished in a single step. Experiments are in progress to determine if the partially purified material is destroyed by ionizing radiation. (AEC Activity 6400)

Biochemistry - During the past two months, the factor from hog kidney cortex responsible for the great stimulation of luminescence in luminous bacterial extracts was identified as palmitic aldehyde. This compound was identified as follows: the 2,4-dinitrophenylhydrazone of KCF (kidney cortex factor) was prepared. Its molecular weight was determined by its extinction per unit weight; its elementary composition was determined; and its identity with a synthetic sample of the palmitic aldehyde derivative was checked by mixed melting points.

## PROGRAM 6000 - BIOLOGY AND MEDICINE (Continued)

A second line of work involves the examination of the relationship of the various known components in bacterial extract luminescence by kinetic measurements. The rise time for luminescence when various limiting components are added has been determined, as well as temperature dependence and dissociation constants for the reactions involved. (AEC Activity 6400)

Plant Biochemistry - The adaptation of an ion-exchange method for the isolation, identification, and determination of phosphorylated compounds has been applied to phosphate samples from plants. The preparation of a sample from plants containing all the phosphate compounds has been a critical phase of this work. It has been found that trichloroacetic acid extraction of plant tissue followed by removal of the trichloroacetic acid by ether extraction is the best method so far studied. Plants, which had incorporated phosphorus-32, were used as a source of material since this permitted detection of phosphorylated compounds by their radioactivity as they were eluted from the ion-exchange columns. (AEC Activity 6400)

Biophysics - Further studies of the artifacts which affect the bioassay of acetylcholine indicate more than ever that interference by X-rays with the possible synthesis of acetylcholine is not the mechanism of X-ray injury of erythrocytes.

Analysis of physiological data on the perfusion of isolated portions of the canine circulation indicates that the progress of the elements of a small amount of an injected labelled compound through a capillary labyrinth can be interpreted by statistical methods.

Studies on the physical properties of deoxyribonucleoprotein dissociated in 1-molar saline are being continued. A Couette viscometer, which is suitable for the measurement of viscosity and birefringence of flow under identical circumstances, has been designed and built. Modifications have been incorporated which allow the elasticity and yield points of very weak gels to be estimated. A more complete description of the very radiosensitive system previously described can now be made.

Calibration of the fast neutron counting equipment by the associated particle method using the D-D reaction with the new Cockroft-Walton accelerator is about 70 percent complete. Good pulse-height distributions have been obtained and extrapolated values yield counting efficiencies for the counter within about 8 percent of the published values for instruments of the same type. Good agreement with the output of a standardized Po-Be neutron source has been obtained. (AEC Activity 6400)

Enzyme Chemistry - Experiments designed to study nucleic acid synthesis under various conditions were continued. Chick embryos two to three days old were found to utilize formate readily in vitro. As in bone marrow, the deoxyribonucleic acid takes up sufficient activity so that the labelling rate can be used as an index of radiation or other damage to the nucleus. A study of the effect of aminopterin, a radiomimetic substance, on the uptake of formate in the embryos was completed. Half-maximum inhibition of radio-formate uptake

PROGRAM 6000 - BIOLOGY AND MEDICINE (Continued)

occurred at about 0.002 mg/ml of aminopterin. This value is approximately twice as large as the similar constant for bone marrow. A comparison with the effects produced by irradiation is under way.

Studies have been made on the determination of quantum yields in bacterial photosynthesis. The conversion of acetone to acetoacetate by Rhodospseudomonas gelatinosa is believed to be the first major photochemical reaction at low light intensities. The rates of photosynthesis with acetone and acetate were determined as a function of light intensity by manometric techniques. When acetate- $2C^{14}$  was used, the uptake of  $C^{14}$  corresponded very closely with the manometric data. A preliminary quantum yield determination was made when a silvered reaction vessel was clamped to the exit slit of a Farrand monochromator, through which was passed a light beam of measured intensity. The light source was a tungsten lamp. Acetone- $1,3C^{14}$  was added to the oxygen-free bacterial suspension in the reaction vessel. Carbon- $14$  assay results are, as yet, incomplete. (AEC Activity 6400)

Math for Biology - In a study of the effects of radiation on cell growth in the root of timothy (Phleum pratense), photographs were taken at equally spaced time intervals and cell length was plotted against distance from the tip of the root; this provided a sensitive measure of radiation effect. Since individual cells vary widely in their length-distance patterns, the possibility of using each cell as its own control was examined in a comprehensive statistical study of untreated cells. It was found that good prediction is possible only if observations are limited to the central portion of the curve which is reasonably linear. In this region prediction within 10 percent is likely and will satisfy the experimental requirements.

Data obtained from mice exposed in a recent weapons test in Nevada and from mice exposed to neutrons in the ORNL 86-inch cyclotron, were compared to provide neutron dose estimates. Satisfactory least squares fits were computed for both sets of data and from these, dose estimates were derived. The estimates were smoothed further by a least squares fit using the relationship  $d = KD^{-2} e^{-\lambda D}$ , where  $d$  is dose and  $D$  is distance. The final estimates seem reasonable, although the possibility of gamma contamination introduces some uncertainty.

A formulation, relating the rate constant for a reaction occurring in intact cells to the observed apparent first order rate constant for the disappearance of substrate from the medium, has been obtained. An experimental design based upon the formulation is now in use in experiments on peroxide utilization by p. aurelia.

The problems of the effects of the spatial distribution of a catalyst upon reaction rate and of the spatial separation of two (or more) catalysts upon the relative rates of two (or more) reactions have been solved for five cases of spherical cells. An approximate method which is quite simple and handles the above cases and other more general has been derived.

PROGRAM 6000 - BIOLOGY AND MEDICINE (Continued)

The common method of estimating the mean life of a formed element of the blood (e.g. erythrocyte, platelet, etc.) from the half-width of the activity-time curve of the element has been subjected to a critical analysis. It was shown that, if the actual mean life and the maximum time for the input function are similar in magnitude, the ratio of actual to computed mean life may be as small as  $1/(2\sqrt{2})$ , or  $\sim 1/3$ .

The following problem has been solved (by numerical integration) for the two-dimensional case: It is required to compute that fraction of the total counts, registered by an immersion counter, which is derived from radioactive material located at any given distance from the counter. The results were computed for  $\beta$ -particles in bone and compared with those from an approximate formulation available in the literature. (AEC Activity 6400)

Research Participation and Traveling Lecture Programs - Under the Research Participation Program for 1953, 15 participants in biology and health physics, representing 13 universities, completed their tour of duty with the Laboratory and returned to their home universities. There are two new research participants now engaged in research in biology.

The Traveling Lecture Program for the academic year 1953-54 is just starting. The names of the lecturers have been submitted to the Oak Ridge Institute of Nuclear Studies for their review and circulation to interested universities. (AEC Activity 6720)

RADIOISOTOPE SALES AND COSTS

<u>Type of Transaction</u>	<u>August</u>	<u>FY to Date</u>
Domestic Sales (Included Cancer Cash)	\$ 80,353	\$ 171,128
Foreign Sales	8,991	10,372
Project-Cash Sales	7,549	12,908
Project-Transfer Credits	-----	-----
Technical Cooperation Program Credits	2,445	2,744
Plant Credits	17,287	27,998
Civilian Defense Credits	520	520
Cancer Program Credits	17,548	33,516
*Miscellaneous Income	<u>6</u>	<u>177</u>
 Total Income	 \$134,699	 \$ 259,363
**Income - No costs incurred	\$ <u>4,457</u>	\$ <u>13,718</u>
 Radioisotope Income	 <u>\$130,242</u>	 <u>\$ 245,645</u>
 Radioisotope Costs	 <u>\$ 87,318</u>	 <u>\$ 184,723</u>
 Radioisotope Shipments	 <u>987</u>	 <u>1936</u>

\*Miscellaneous income - D<sub>2</sub>O, Freight, Missing parts, TCP  
 \*\*Income from H<sup>3</sup>, He<sup>3</sup>, B<sup>10</sup>, and miscellaneous items in excess of cost

GROSS OPERATING COSTS

	<u>Cost for August</u>	<u>FY 1954 Cost to Date</u>
Programmatic Operating Cost - Net	\$ 2,229,170	\$ 4,656,478
Plant and Equipment Cost	270,625	513,950
Construction Program "H"	6,395	8,347
Work for Other Parties - Transfers	76,083	122,787
Inventory Changes	56,154*	77,058*
Reimbursable Work for Other Parties	123,693	274,796
Deferred Charges	<u>1,593</u>	<u>1,818</u>
 Total Laboratory Cost - Net	 <u>\$ 2,651,405</u>	 <u>\$ 5,501,118</u>
 Estimated Cost for Next Month--Net	 <u>\$ 2,800,000</u>	 <u>\$ 8,301,118</u>

\*Credit

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PERSONNEL SUMMARY\*

	<u>Number of Employees</u> <u>September, 1953</u>	<u>New Hires</u> <u>September</u>	<u>Terminations</u> <u>September</u>
Administration	62	3	0
Operations**	116	0	2
Engineering, Shops and Mechanical	717	0	9
Laboratory and Research	1635	33	59
Protection	172	1	2
Service	<u>393</u>	<u>1</u>	<u>10</u>
Total	3095	38	82

\*Due to changes in the Personnel Summary after the August report, ORNL-1612, went to press, there is a discrepancy of 6 persons between that report and this one.

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

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Previous reports in this series:

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