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UNIVERSITY OF CALIFORNIA

Radiation Laboratory

Contract No. W-7405-eng-48

PROGRESS REPORT No. 71

February 15 to March 15, 1949

Berkeley, California

UNIVERSITY OF CALIFORNIA, RADIATION LABORATORY

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PROGRESS REPORT NO. 71

1. Bevatron

UNCLASSIFIED

The vacuum chamber in the first quadrant of the one-quarter scale operating model is being vacuum tested, and a pressure as low as 5×10^{-6} mm Hg has been obtained with freon refrigerated baffles on the pumps but without liquid nitrogen in the traps. The addition of liquid nitrogen reduces the pressure by only 1×10^{-6} mm, indicating that the use of large quanties of liquid nitrogen on the model and on the full-scale machine may not be necessary. A second quadrant of the tube was installed on March 11.

Observations of the divergence of the external beam of the injector cyclotron for the quarter scale model show a total divergence in both vertical and horizontal directions of only 1-1/2 degrees. These results are considerably better than expected. It was decided to mount the injector cyclotron with the pole faces horizontal rather than vertical as first planned. The focusing magnet for the cyclotron injector has been installed and the focus is gradually being improved by adjustments and changes in the pole pieces and tube.

Further tests of the one-twelfth scale a.c. model gave a magnetization curve within one percent of the d.c. curve. It reaches approximately 16.2 kilogauss at the design value of 732,000 ampere turns full scale.

It was decided in view of the performance of the synchrotron and the possibilities of a large injected beam from the cyclotron to reduce the size of the bevatron magnet aperture from 4 x 14 to 4 x 10 ft. This reduces the length of the steel plates and saves about 600 tons of steel. The design and construction of the large vacuum chamber is also simplified. The order for 145,000 ft. of 1660 MCM cable for the magnet coil will be placed shortly.

Work has proceeded actively on a system for a frequency control in which a ferroxcube reactor is placed in the field of a small magnet connected in series with the bevatron magnet and used to vary the frequency of an oscillator. The oscillator frequency was expected to be a reproducible function of magnet current and hence of the magnetic field. First tests in the magnet field showed insufficient variation in frequency below 600 gauss so that a biasing field obtained from a permanent magnet will be added to the varying field produced by the magnet in series with the bevatron magnet in an attempt to improve this situation.

Further tests on the 184-inch cyclotron in conjunction with experiments to measure the lifetime of ions in the cyclotron beam showed that at 70 inches radius, which is equivalent to an energy of approximately 250 mev, some beam continues to circulate for as long as half a minute after the oscillator is turned off. During this time the ions travel over 3 million miles.

2. 184-inch Cyclotron Operation UNCLASSIFIED

The cyclotron was used for research experiments ninety-two percent of the 433 hours that the crew was on duty.

The stability of the proton unit is shown by the fact that only about 6 percent of the time was devoted to tests and adjustments.

About one-half of the shutdown time was devoted to the installation of the electric deflector for the deflection of protons.

3. 60-inch Cyclotron Operation UNCLASSIFIED

As the result of the magnet current discrepancy noted last period, an energy determination was made of the alpha beam. The energy was found to be 37.5 mev which obviates the magnet current difficulty. A thorough check of the metering system disclosed it to be the source of the discrepancy and nothing had occurred in the magnet system itself. Operation efficiency has been at a normal level of approximately 70 percent.

4. Synchrotron Operation UNCLASSIFIED

It has been noted that the synchrotron output varies by a factor of ten with different injectors which have no known differences in construction. The reason for this phenomenon is not known, but it is planned to provide a mechanism for aiming the injector by rotating it about a vertical axis to see if the intensity is non-uniform and if different injectors have some focusing action due to minor dimensional differences. It has also been noted that different injectors require widely different "n" coils. This phenomenon may substantiate the belief that electrons are being injected at varying angles.

A number of the synchrotron components are being re-designed to eliminate temporary construction and to facilitate maintenance. These include the bias winding, compensating resistors, and control console.

A great deal of time has been spent in determining the location and intensity variation of the radiation from the synchrotron. It has been noted that the x-ray beam is quite sharp, the angle between its center line and the point of half intensity being $\pm$ 16 minutes. At a distance from the machine, it is noted that the apparent width of the beam increases faster than linearily with the distance from the target. This apparent increase, however, has been found to be due to the presence of low energy secondary ionization in the air. These secondaries can be eliminated by using a filter of 1/16 inch of lead which brings the beam back to the expected sharpness. A study of the stray radiation on the median plane near the machine shows it to have an intensity of approximately 1/500 of that in the center of the beam. It decreases to half this intensity at about 2-1/2 inches above and below the median plane.

A number of runs have been made with nuclear plates to obtain statistical data on the production of mesons. These data are not yet numerous enough for evaluation.

Additional studies are underway for the transition thickness and absorption of various materials. A study of these data has made possible a rough calibration of the absolute intensity and the efficiency of the machine. Only one electron out of 5000 which is injected into such a solid angle that it should be accelerated is found to strike the target and produce x-rays at the end of the acceleration. The reasons for this poor efficiency are not yet understood.

5. Linear Accelerator and Van de Graaff Operation UNCLASSIFIED

The linear accelerator was in use for 32 mev experiments a total of 264 hours, or 82 percent of the available time during the period February 16 to March 15. The Van de Graaff was in operation 280 hours, or 87 percent of the time. The 5 percent difference between the two figures is accounted for by experiments with the 4 mev Van de Graaff beam. (The linear accelerator had no breakdowns lasting more than a few minutes.)

The major 32 mev activity was directed toward bombardments relating to proton-proton scattering. Other experiments included inelastic scattering, chemistry group bombardments, a new short half-life activity from boron, range energy relationships, and health physics experiments.

6. Experimental Physics UNCLASSIFIED

Film Program. Plates have been exposed to determine the half life of the heavy positive meson using an apparatus similar to that employed by Richardson. By working in a region of more uniform field and calibrating the apparatus with protons ejected backward from the target a higher degree of accuracy is anticipated.

A preliminary run has been made in the deflected beam with the apparatus of Richman and Wilcox for obtaining simultaneously the distribution in energy and angle of mesons produced in carbon. The high energy meson plates show a reasonably good ratio of mesons to background.

Electron sensitive plates received from Ilford and Kodak Ltd. in England, and Eastman Kodak in Rochester have been exposed inside the cyclotron for study of meson decay. Only one π-μ-e decay has been observed, with an electron which was followed for 840 μ in the emulsion.

An experiment made to determine the sources of background indicated that more than 50 percent now comes directly from the target.

Cloud Chamber. The cloud chamber group has spent the past month improving equipment. The time intervals in the fast cycle for the cloud chamber at the synchrotron have been measured, one of the reprojectors has been improved, some experiments have been performed to ascertain the best development conditions for the photographic film being used, and a great deal of work has been done on the optical system of the cloud chamber at the cyclotron.

Proton-Proton Scattering-Proportional Counter Method. Measurements made thus far using proportional counters to detect the scattered protons have not used the analyzing magnet to separate out the low energy components of the linear accelerator beam.

In order to make corrections to the present scattering data, the energy spectrum has been measured, using a coincidence counter and aluminum absorbers. Since the beam intensity from the Van de Graaff generator was too great for application of this technique, the Van de Graaff arc was not pulsed. The observed spectrum under these conditions should have a maximum of low energy components because the low energy protons are accelerated during the build-up of radio frequency voltage across the drift tubes.

The observed low energy components in the spectrum require that a maximum correction of possibly as much as 3 percent be made in the present scattering data at 90°, and 15 percent at 30° in the center of mass system. When these corrections are made, the probable error is increased at small angles to $\pm$ 8 percent, but the differential scattering cross-section is compatible with a pure S wave.

Arrangements are being made now to use the analyzing magnet so that corrections due to the energy spectrum will be unnecessary.

Proton-Proton Scattering - Photographic Method. Three successful bombardments for exposing plates to protons scattered in hydrogen were made. Also several background plates were taken in vacuo, or in hydrogen with the scattered protons blocked. As the result of these runs, the following conclusions appear certain:

1. The number of tracks not due to scattered protons at the correct energy which can be confused with correct tracks does not exceed 2 percent.

2. The bombarding beam (through the analyzing magnet and slit collimators) is homogeneous within the accuracy of range measurements.

3. For 4,000 tracks tabulated in the range from 10° to 80° in the laboratory system, the angular distribution in the range $10^\circ < \theta < 45^\circ$ is identical within statistics with the distribution in the range $80^\circ > \theta > 45^\circ$ (as is required for proton-proton scattering).

4. Within statistics (4,000 tracks) the angular distribution is essentially flat from 90° (center of mass system) to 45°, and monotonically decreasing from 45° to 20°. The decrease from 90° to 30° appears to be 32 percent $\pm$ 7 percent which is not compatible with S scattering or repulsive P scattering.

The plates referred to above are now being read to improve statistics.

Inelastic Scattering. Plates have been obtained for the energy distribution of protons from aluminum, indium, and gold. The results are being analyzed.

High Energy Gamma Rays. Efforts during this month have been devoted to search for coincidences of the high-energy gamma rays which might be expected from certain assumptions about their origin. Because a deflected proton beam is not yet available these effects have been sought by neutron bombardment. No evidence of the production of the gamma rays by the neutron beam is usefully measurable quantity was found.

Instrumentation is in preparation for performing this experiment with the deflected proton beam.

Studies of Shielding. The attenuation of the primary neutrons from a target bombarded by 350 mev protons has been studied using concrete, copper, and lead. A broad beam was employed, with broad plates of absorbing material placed in the central region of the forward yield of high-energy neutrons.

Half-value thicknesses measured were as follows.

Material	Half-value thickness	Detectors employed
Concrete:	17-18 inches	Bi fission, Ionization chamber, C(n,2n)
Copper:	5.7 inches	Bi fission
Pb:	5.8 inches	Bi fission, C(n,2n)

High Energy Secondaries from Various Nuclei. Protons and deuterons knocked out of nuclei by 90 mev neutrons have been investigated by means of a system which measures simultaneously the H ρ and ionization of these particles. The H ρ measurements are made using a 30 x 12 x 1-3/4 inch magnetic field and the ionization measurements by a proportional counter feeding into a 10 chennel pulse height analyzer.

Results are similar to those obtained by Brueckner and Powell using a cloud chamber and by the author using a method involving simultaneous measurement of H ρ and range.

Scintillation Counting of γ Rays. A counter designed to take test tube samples has been nearly completed. No anthracene crystals are at present available for this counter but some very good ones are being produced at Donner Laboratory and some of them may be obtained for the test tube counter.

A crystal diode coincidence circuit, designed to reduce the background counts, has been constructed and is operating, but tests have not been completed.

Mass Spectrometer. Analyses were made on C_{12} and C_{13} samples. The CO_2^+ peaks (44, 45 and 46) were used; the error was less than 1 percent.

Two samples of ethylene (CH_2:CH_2) were analyzed for experimenters at the University of California at Davis. Results were fairly satisfactory.

Total Cross Sections for 270 Mev Neutrons. Total neutron cross-sections have been measured for the following elements: C, H, Be, H^2, O, Al, Cu, Sn, Pb. Paraffin was used at about 9 ft. from the attenuator to generate recoil protons. The latter were detected with two scintillation counters in coincidence with 2 inches of copper absorber between them to provide a 250 mev lower energy limit.

Neutron Scattering Cross Sections of 90 Mev. Total cross sections of H, C and Cu were determined with the recoil proton counting equipment employed in the measurements of differential scattering cross sections. To check the calculated mean detection energy results are consistent with a mean detection energy of 95 mev but additional measurements are needed to improve the statistical accuracy.

Nuclear Cross Sections. Total cross sections of seven different elements have been measured for the neutron beam produced by bombarding a 2 inch Be target with 350 mev

protons. Bismuth fission chambers were employed as both monitors and detectors. The results are:

Element	$\sigma_t \times 10^{24}$ cm^2
Be	.229 ± .003
C	.287 ± .007
Al	.555 ± .010
Cu	1.15 ± .02
Sn	1.86 ± .03
Pb	2.82 ± .04
U	3.04 ± .09

Two monitors and two detectors were used in all the measurements except copper. Dural was used for the aluminum measurement.

A preliminary draft of the report summarizing the cross-section measurements for 90 mev neutrons using fission detectors has been completed.

7. Theoretical Physics — UNCLASSIFIED

The attempt to interpret the nuclear cross sections for 270 mev neutrons has so far not been very successful. It has not been possible to reproduce the remarkably small variation of cross section with atomic number that the experiments seem to indicate.

The meson production calculations are progressing. The expected cross section for production by synchrotron x-rays is about 10^{-29}cm^2 per nucleon. The effect the electric current of the proton (in addition to that of the mesons) in producing a difference in the cross sections for positive and negative mesons is being studied.

Relativistic effects in particle scattering are also being considered.

The program of bevatron calculations is continuing.

8. Chemistry — CONFIDENTIAL

Part A

A New Isotope of Polonium. Bombardment of enriched Pb^{204} with 38 mev helium ions on the 60-inch cyclotron has produced a 1.5-hour K-capture polonium activity which is believed to be due to Po^{205}. The alpha branching is small, less than about 10^{-4}. The bismuth daughter, Bi^{205}, is not yet known, but other experiments have yielded a very long-lived activity which may be Bi^{205}.

Positrons from Gold. The radiations from 4.7-hour Au^{192} and 39.5-hour Au^{194} have been examined with the crude beta spectrograph and have been found to include positrons. These isotopes are now the heaviest known positron emitters.

Lutecium and Tungsten Isotopes. A lutecium isotope of half-life approximately 120 days has been observed in pile bombarded lutecium and assigned to Lu^{174}. The same activity has been produced by (d,α) reaction of 19-mev deuterons on hafnium. The

isotope decays by both orbital electron capture and beta-particle emission with comparable probabilities.

Two new tungsten isotopes have been observed in spallation of tantalum. A 39 minute electron-capture activity is believed to be W^{179}. A 134 minute electron-capture activity is attributed to W^{177}.

A New Isotope of Protactinium. Deuteron bombardment of uranium in the 60-inch cyclotron has produced a protactinium activity of 23.7 ± 0.5 minute half-life, decaying by emission of beta particles of about 1.4 mev energy limit. This isotope has been assigned tentatively to Pa^{235} mainly on the basis of Sargent curve relationships between decay energy and half-life for various types of nuclei in the heavy region.

A New Isotope of Plutonium. Evidence for Pu^{235} has been found in bombardment of U^{233} with 30 mev helium ions from the 60-inch cyclotron. Geiger activity was observed which followed Pu^{239} tracer through chemical separation from the target material and final purification on a resin column. The activity decayed with a 25-minute half-life, and rough absorption measurements indicated that the observed counts were primarily L x-rays. No corresponding alpha activity was observed, setting an upper limit of 10^{-4} for the ratio (alpha) / (electron capture).

Neutron Deficient Isotopes of Emanation. Among the spallation products obtained from the 350 mev proton bombardment of thorium we have identified two gaseous alpha-emitters. The half-lives observed were 23 minutes and 2.1 hours. Since these gaseous atoms emit alpha-particles it is assumed that they are isotopes of emanation (element 86). If they were heavy isotopes such as Em^{221} or Em^{223}, both unknown, they should decay into known alpha-decay series which we would have detected. No such known series were observed, and the isotopes therefore are probably lighter than the known emanations. From a consideration of trends in alpha decay energies and half-lives, it seems most reasonable that they are of masses less than 213. It is expected that the decay is in part by electron-capture, and the latter is quite likely to control the decay time. No information is yet available concerning such branching ratios, because of interference from gaseous fission product beta activity.

One alpha-emitting daughter (4.4 hour half-life) has been observed to grow from a gaseous parent, but it has not been identified otherwise.

A New Isotope of Americium. A sample of Am^{241}, which had had a 15 months' neutron bombardment, has been milked for neptunium daughters. Absorption measurements showed about three times as many soft electrons as can be ascribed to 2.1-day Np^{238}. The decay has a slope of 2.25 day half-life. These observations are interpreted as showing the presence of 2.3 day Np^{239} in secular equilibrium with a long-lived Am^{243} not itself detectable. The Am^{243} would have been produced by two successive neutron capture reactions from Am^{241}.

The Alpha-Active Gold Isotope. Additional chemical experiments have shown that the 5 minute alpha activity induced in gold with high energy particles follows gold chemistry. Therefore, it is a gold isotope or a very short-lived daughter of a 5 minute gold isotope. X-rays of 5 minute half-life are also present. If they are due to the same isotope, the ratio K/α is of the order of 10^4. From a consideration of the known isotopes of gold, it is most reasonable that the 5 minute gold is of mass less than 190.

Decay Products of Po^{204}. It has been reported previously that 4 hour Po^{204} decays by electron capture to 12 hour Bi^{204}. Additional experiments have confirmed that the alpha decay of this polonium produces 18 hour Pb^{200} which in turn decays to 27 hour Tl^{200}. The Tl^{200} was assigned by its excitation curve which agrees with an (α,n) reaction on Au^{197}. Thus we have an independent confirmation of the correctness of the assignments of the Bi^{204} and its daughter, the 68 minute Pb^{204m}, which were based on other evidence. These assignments have been questioned because of the rarity of metastable states of even-even nuclei.

Mass Spectrograph. The assignment of the 19 hour lanthanum activity to La^{135} has been confirmed by the mass spectrograph. The mass scale on the plate was fixed by the inactive line of $(La^{139}O^{16})^+$ at mass 155. A line at mass 151 was shown to be active by the transfer technique and by counting with a slit counter. The decay was followed with the slit counter and agreed with the 19 hour half-life. This result also confirms the assignment of 16 hour Ce^{135}, which decays by β^+ emission to La^{135}.

Heat of Solution of PrO_2. Samples of about one milligram of PrO_2 have been dissolved in 6.002 M HNO_3 at 25°, with $\Delta H = -42.9 \pm 0.3$ kcal/mol. In the presence of 0.1 M $NaBF_4$ the rate of solution was greatly increased, and $\Delta H = -42.1 \pm 0.4$ kcal/mol.

Chemistry of the Rare Earths. It has been observed previously that the treatment of various rare earth fluorides (NdF_3, GdF_3, SmF_3, YbF_3, EuF_3) with sodium vapor at 1000°C in vacuum resulted in the formation of compounds of cubic (fluorite type) structure. Possible formulas are ROF or RF_2. If these compounds are difluorides, their magnetic properties should be substantially different from those of the trifluorides, because of the extra 4f electron.

Magnetic measurements have been made by the non-homogeneous field method of Faraday and Curie, using a sensitive quartz torsion balance to measure the magnetic forces. Samples containing the samarium and the gadolinium compounds have been measured. The results indicate that reduction has taken place, but not necessarily to the divalent state.

Chemistry — UNCLASSIFIED

Part B

Synthetic and Experimental Chemistry. In the program for the distribution of C^{14} labeled compounds three standardized samples of $BaC^{14}O_3$ for calibration of counters have been prepared for shipment to the University of Illinois. The products from 10 or 20 mc. batches of the following compounds, with the corresponding yields based on C^{14}, have been sent to the Isotopes Division of the Atomic Energy Commission at Oak Ridge: sodium propionate-2-C^{14}, 50 percent; sodium propionate-3-C^{14}, 45 percent; calcium glycolate-2-C^{14}, 42.5 percent; glycine-1-C^{14}, 50 percent; alanine-2-C^{14}, 27.5 percent.

The preparation of isopropyl bromide-1-C^{14} is being studied as a necessary intermediate in the preparation of valine. The synthetic preparation of the following compounds is also being studied: phenylalanine-β-C^{14}, alanine-3-C^{14}, leucine-β-C^{14}, valine-γ-C^{14}, codeine-methoxy-methyl-C^{14}, codeine-N-methyl-C^{14}, isobutyl bromide-methyl-C^{14}, isopropyl bromide-methyl-C^{14}, oxalacetic acid-methylene-C^{14}, fumaric acid-C^{14}, tartaric acid-C^{14}, succinic acid-C^{14}, lactic acid-1-C^{14}, lactic acid-2-C^{14},

lactic acid-3-C^{14}, Demerol-N-methyl-C^{14}, diiodo^{131}tyrosine, diiodo^{131} fluorescein, glucose-1-C^{14} and mannose-1-C^{14}.

Work is continuing on the studies of the free radical mechanism of acetyl peroxide decomposition. Some of the preparations listed in the previous program will also involve mechanism confirmation.

Biological Chemistry. A series of Warburg experiments to study the metabolism of normal and neoplastic tissues with C^{14} labeled compounds is being started. As a preliminary to this work the metabolic rate of CO_2 evolution of liver slices and homogenates with carboxyl-labeled sodium propionate has been determined. Other labeled organic compounds will be investigated.

The work on the rate studies of metabolic oxidation to $\overset{*}{C}O_2$ in mice of labeled compounds has continued.

The development of ionization chambers for use as a routine instrument in the measurement of low activity C^{14} samples from biochemical experiments has progressed during the last three months. A considerable amount of difficulty was first experienced in the ionization chambers due to piezo-electric effects in the insulators associated with the strains of evacuation and filling of the chambers with the radioactive carbon dioxide. This difficulty has now been overcome.

Photosynthetic Chemistry. The study of phosphorylated photosynthetic intermediates has been continued and intensified. Since these phosphorylated compounds are of considerable importance in all plant metabolic processes, it is necessary to know their location on paper chromatograms and something of their behavior in preliminary extraction processes. The behaviour of phosphorylated sugar intermediates of fructose-1,6-diphosphate, phosphoglyceric acid and phosphoglyceraldehyde has been investigated; ion exchange columns and the technique of rechromatography have been used.

Phosphopyruvic acid has been identified in 5-second photosynthetic fixations; approximately 10 percent of the total activity was so fixed.

Work on the dark fixation of $C^{14}O_2$ by plants has continued, and it has now been demonstrated that radioactive sucrose is formed in considerable amounts in the dark in 2 minutes from $C^{14}O_2$ by preilluminated Chlorella algae. This amount corresponds closely to that formed in a normal 90-second photosynthesis by the same plants. However, the other intermediates of normal plant respiration do not appear in appreciable amounts in the 2-minute period.

The work on the relationships between the rate of respiration and photosynthesis and the inhibition of respiration by light has been continued. The chemical identification of the intermediates has been studied as well as extensive work on the gas phase kinetics.

Chemistry SECRET

Part C. Project 48B

Metals and High Temperature Thermodynamics. Work is in progress on the following problems.

1. Refractory studies.
2. Thermodynamics of CN and N_2.
3. Absorption coefficients of CN and C_2.
4. Thermodynamics of molybdenum halides and oxides.
5. Thermodynamics of gaseous aluminum oxides.
6. Low melting metal systems.
7. Structure of solids and gas-solid surface interactions.

Basic Chemistry. Solvent Extraction. The following problems are under investigation.

1. The exchange of iodine atoms between iodate ion and iodine.
2. The chelate complex of lanthanum with TTA.

Engineering Development of Plutonium Separation. The following subjects are being investigated.

1. Solvent extraction using chelate process.
2. Pilot-scale synthesis of TTA.

Ore Reduction. A micro titration method for U(VI) is being developed.

9. Medical Physics UNCLASSIFIED

Part A

Tracer Studies. The major activities of the tracer group have been centered around the metabolism of Nd^{147}. This data is complete and has been carried out to 32 days after intramuscular administration. Rats given carrier-free Nd^{147} showed a major deposition in liver, kidney and skeleton. The material deposited in liver and kidney is gradually eliminated in the feces and urine. However, that deposited in the skeleton appears to be much more permanently fixed. When Nd^{147} is complexed with citrate, the material is more readily absorbed from the injection site than the uncomplexed Nd, but the ultimate fate after absorption is not markedly different between complexed and uncomplexed material. Attempts to complex Nd^{147} with oxalate failed and these studies gave deposition values and uptake values from the injection site similar to the carrier-free material. The addition of Pr carrier or Nd carrier to Nd^{147} greatly retards the absorption from the injection site although these data are not completely calculated as yet. Nd^{147} is not absorbed in the intestinal tract to any great extent. The deposition of Nd^{147} after intravenous injection is similar to that observed after intramuscular injection. Similar studies to those described with Nd^{147} have been set up with Pr^{143} and will be completed within the next 60 days.

Radioautographic Studies. Experiments to determine the uptake of Pu in scar tissue have been set up. 1, 3, 8, and 15 day old scars are being studied.

The uptake pattern of Pu in the tissues adjacent to the costochondral junction have been set up for the 1 day interval, and further experiments at other time intervals will be set up in the near future.

The short time interval Sr study and the Nd experiments are in progress. Praseodymium radioautographic studies are being set up in the next week.

Decontamination Studies. Investigation of bone metabolism and factors effecting fission product retention are being continued with specific emphasis to endocrines and diet. The kinetics of radio-zirconium excretion and uptake by bone is being studied by following blood level and distribution at various time intervals after intravenous administration.

Radiochemistry. Carrier-free Cu^{64} was prepared from a deuteron bombarded zinc target using an extraction method which has been reported previously. 3.4 millicuries was obtained in 3 ml isotonic saline solution. Mass absorption curves and half-life data agreed in the published values.

An Oak Ridge shipment of carrier-free Pr^{143} was checked by column separation and was found to contain only one activity. A column separation with added Pr carrier is in progress.

Carrier-free Se^{75} is being separated from a deuteron bombarded arsenic target. The activity is separated from As by precipitation with Tellurium in 3N HCl. The Te distills in $HBr-Br_2$ mixture; Se remains in the residue. Details have been reported previously.

Work on At^{211} has continued. A satisfactory method of separating At from organic material has not been found. The X/α counting ratio was found to be 1/850 with geometry approximating that to be encountered in thyroid studies in the humans.

Medical Physics — UNCLASSIFIED

Part B

Determination of Liver Circulation. The liver circulation in the mouse, rat, rabbit, dog, and human has now been studied through a period of several months. The technique consists of observation of the rate of uptake in the liver of colloidal chromic phosphate. If the particle size of the suspension is an average particle diameter of 3 microns, then as much as 98 percent of the colloid injected to the circulation is in the liver and spleen. The rate of uptake of the colloid by the liver is indicative of the rapidity of liver circulation. The half-time for uptake of normal mice is about 16-40 seconds and calculations indicate that liver circulation of the mouse is of the order of two cubic centimeters per gram liver per minute. Irradiation of the liver by P^{32} beta rays from chromic phosphate present in the liver results in an apparent change of the circulation rate. If large doses are given, the change in the rate of uptake of the colloid becomes great. For example, the mouse receiving about 50,000 rep in the liver over a period of three months exhibits a 6 minute half-

time of uptake of the colloid in the liver.

Activation Analysis. A number of tissue samples prepared from red cells, white cells, and plasma of normal, polycythemic, leukemic, and anemic subjects have been irradiated at the Hanford Pile with slow neutrons. The induced radioactivity was studied by separating the different elements in ion exchange columns. Radioactivity due to ten different elements were identified and separated to various degrees and several other active fractions have been obtained which are presently being identified. Using hydrochloric acid as an eluting agent, characteristic activity versus volume of the eluting agent may be plotted. The curves obtained are characteristic for red cells, white cells, or plasma.

Radiation Effects on Bacteria. Last month we reported the protective effect of visible light on E. coli when these were treated with ultraviolet radiation. The studies have been expanded to x-rays and it is found that survival of bacteria after x-radiation is not measurably influenced by the application of visible light.

10. Health Physics and Chemistry UNCLASSIFIED

The projects currently in progress in the Research and Development Section of the Health Chemistry Division during the period of this report are as follows:

1. S. G. Thompson interceptor run. This 3-months' bombardment of curium by alpha particles on the 60 inch cyclotron has been successfully completed. The beta-gamma lead box with the laminated lead glass window plus the equipment therein proved satisfactory for the processing of this target.

2. Portable lead cave with lead glass brick window. Completed and successfully used.

3. Hanford slug 12B (May 1949). Work on slug opener, chemistry box and general shielding under way.

4. Liquid target holder shield box and transportation facilities from 60-inch cyclotron. Completed and in use.

5. Automatic air sampler for detection of presence of alpha emitters. The sampler was completed and is being tested.

6. Improved interceptor for use on 60-inch cyclotron. Instrument completed and used successfully.

7. Special hood for vacuum system containing plutonium. The adjustable hood with glove ports for enclosing the vacuum system is ready for use.

8. Gloved and other type boxes completed. One box for transferring americium from gloved box to mass spectrograph box; one microscope-front box with well centrifuge for L. Werner; one box for transferring curium from gloved box to balance room; one lucite-front sampler box; five regular Berkeley boxes assembled and installed; one lead glass front, covering regular front, secured on a standard gloved box; an annex box for a #2 centrifuge, to be used in connection with a regular gloved box, is near completion.

9. Jiffy probe target equipment. Target holder completed; special tongs for jiffy probe 75 percent complete.

10. Work on baffling of hoods for streamlining hood air flow. This work is 85 percent complete.

LMB/3-30-49
Information Division

SUMMARY OF RESEARCH ACTIVITIES

February 15 to March 15, 1949

60-inch Cyclotron

UNCLASSIFIED

1. Development of ion sources for carbon and oxygen ion beams.

   Delayed pending development of counting equipment that can be used to evaluate the source output. Emphasis is being placed on a counting rate meter that will operate with the current available.

2. General studies aimed at increasing power output. (E.g., the replacement of dees, dee supports and grounding spiders with new design.)

   Temporarily suspended.

3. Application of studies of magnetic shimming to reducing the dee and deflector voltage requirements and to increasing the energy.

   Various pole face and shim types being tested on the 184 inch model of the 60-inch cyclotron.

4. Improvement of handling equipment for targets and ion source to reduce the exposure of personnel.

   All that remains here is the redesigning of the target assemblies, which is now being completed. Present design eliminates the use of time consuming operations that involve screws.

5. Application of remote control to filament depth and other adjustments.

   Unit is in the shops being fabricated.

6. Development of hydraulic motor for remote control of adjustments inside the vacuum.

   Temporarily suspended.

7. Other devopments.

   Shops are fabricating new parts to further test the use of a grounded type deflector on the 60-inch cyclotron.

184-inch Cyclotron

UNCLASSIFIED

1. Installation of new, higher-power magnet generator.

   Waiting for motor. This job is a long term project and may be in this stage for months.

184-inch Cyclotron (Continued) UNCLASSIFIED

2. Development of improved beam monitoring equipment.

   This equipment is practically finished but not yet installed.

3. Construction of proton beam deflector.

   Installed.

4. Design and construction of improved targets and target handling equipment to meet continuing experimental requirements.

   This program consists of many parts; some are finished, others will be undertaken as the situation demands.

5. Other developments.

   New lead-in bushings were installed for the electric deflector. These have lower inductance and low capacitance to ground than the old ones.

300 Mev Synchrotron UNCLASSIFIED

1. Studies of influence of operating parameters on synchrotron output.

   Output depends on injector properties. Varies by factor of 10 with different injectors which have no known differences in construction. Currents required in different "N" coils vary widely when different injectors are used.

2. Operational studies, related to bevatron problems, such as studies of effect on beam current of (a) magnetic field variations, (b) vacuum chamber cross sectional area, (c) beam scattering; study of catching conditions for pulling ions into synchronous orbit.

   No work during this month.

3. Search for mesons using 300 mev x-rays.

   A study is being made of mesons produced in photographic emulsions by 300 mev x-rays.

4. The determination of absorption coefficients of various materials for high energy x-rays.

   Measurements are in progress.

5. Study of nuclear reactions produced by high energy electrons and x-rays.

   Same activities have been observed, notably copper (γ,n) of approximately 10 minutes half life.

300 Mev Synchrotron (Continued) UNCLASSIFIED

6. Other developments.

Extensive studies of beam location and shape have been made to establish the design of a collimator. Stray radiation has been investigated.

Linear Accelerator and Van de Graaff UNCLASSIFIED

1. General replacement of temporary construction and changes indicated by operational experience.

No changes made.

2. Redesign and replacement of component parts of Van de Graaff generator as required in light of continuing operation.

No changes.

3. Development of ion sources for Van de Graaff generator and bevatron.

New ion source was described in last report. It has been run on the bend for two weeks and will be installed at high potential in the Van de Graaff in a week.

4. Use of 32 mev proton beam for proton-proton scattering and other experiments exploring the fundamental properties of nucleons.

Proton-proton experiments using the 32 mev proton beam have progressed during the month with two independent sets of apparatus.

5. Other developments.

None.

Bevatron UNCLASSIFIED

1. Operational studies using low-power one-quarter scale operating model.

Vacuum system 50 percent installed. Injector cyclotron magnet tests completed. Cyclotron expected to be ready to run April 1.

2. Erection of crane and magnet. Construct and install magnet coils, vacuum system, controls and accessory equipment.

Magnet cable order placed. Steel plate specifications issued for bids. Design work on core and coil continuing.

Bevatron (Continued) UNCLASSIFIED

3. Development of an injection system.

Approximately 1/2 milliampere of proton current has been obtained focussed to a spot approximately 1/2 x 2 inches six feet from the 18-inch cyclotron. Tests of an improved oscillator are now in progress.

PHYSICS RESEARCH

General UNCLASSIFIED

1. Range measurements for fast particles.

Range measurements for protons in the deflected beam of the 184-inch cyclotron have been made in tungsten. The range corresponds to an energy of 340 mev. Some range calculations have also been made.

Fundamental Properties of Nucleons. UNCLASSIFIED

1. Neutron-proton scattering.

Three runs have been made with 330 mev neutrons. This experiment is continuing. A theoretical analysis of neutron-proton scattering is being prepared.

2. Proton-proton scattering.

Scattering experiments using the 32 mev proton beam of the linear accelerator are being done both with proportional counters and with photographic emulsions. Preparations are being made to use the proton beam from the 184-inch cyclotron for proton-proton scattering experiments. The theoretical work is awaiting new data.

3. Scattering of protons and neutrons on deuterons.

Inactive this month.

4. Other scattering experiments.

The study of charged particles emitted from nuclei under 90 mev neutron bombardment continues.

5. Life time of the neutron.

No progress during the period of this report.

Fundamental Properties of Nucleons. (Continued) UNCLASSIFIED

6. Production of mesons by 390 mev alpha particles, 350 mev protons, and 300 mev x-rays.

Cross section calculations are in progress. The cross section for the production of mesons by 300 mev x-rays has been computed to be $\sim 10^{-29} cm^2$.

A program is underway involving the determination of the half-life of π^+ meson, the energy and angular distribution of mesons from protons on carbon, mass measurement of mesons from protons on carbon, and a study of meson decay by the use of electron sensitive plates.

7. Other experiments.

Study of high energy gamma rays from a target bombarded with 350 mev protons is continuing.

Nuclear Reactions. UNCLASSIFIED

1. Types of reactions produced by particles and x-rays at various energies.

The high energy neutron spectrum produced by targets bombarded with 350 mev protons is being examined theoretically.

2. Energy dependence of reactions.

A program was begun for the determination of the excitation function for the production of mesons by protons.

3. Study of radioactive isotopes formed and their decay properties.

New short lived isotope was found with the linear accelerator. It has a half life of 1/2 sec. and emits heavy particles. (Probably C^9 from reactions $B^{10}(p,2n)C^9$, $C^9 \longrightarrow \beta^+ + B^{9*}$, $B^{9*} \longrightarrow H^1 + 2\alpha$.)

4. Total cross sections for neutrons and charged particles for various elements.

Calculations of 280 mev neutron cross sections are in progress. Experimental work is being extended to neutrons produced by 350 mev protons. Measurements are also being made at a neutron energy of 45 mev. The work with 90 mev neutrons is nearly complete.

5. Study of the characteristics of fission and fission product yields produced by high energy particles.

Experiments on fission cross sections have been made using a differential chamber and alpha particles and deuterons.

Instrumentation UNCLASSIFIED

1. Instrumentation in support of cloud chamber development.

   One of the reprojectors has been improved and a great deal of work has been done on the optical system of the cloud chamber at the cyclotron.

2. Development of ionization chambers and Lindeman or vibrating reed electrometers for specific purposes, such as hydrogen 3 analysis for use in medical physics.

   Ionization chamber methods are in use in attempt to evaluate dosage delivered by radioisotopes in tissue.

3. Continuing development of solid counters, and studies of suitable materials, including naphthalene, anthracene, etc.

   Application of scintillation counters to medical physics is being pursued.

4. General development of electronic counting equipment.

   A multi-channel coincidence counting system is nearly complete.

5. Development of gas-filled counters in various forms to meet specific research requirements, such as n-p scattering, neutral meson detection, etc.

   Various types of counters are being developed and built.

6. Development of radiation survey instruments.

   The development of fast-neutron survey instruments is in progress.

7. Applications of Nier spectrometer and development of low-mass spectrometer.

   Routine analyses in progress.

8. Instrumentation in support of chemistry program, including special mass-spectrograph for assigning mass numbers, x-ray spectrograph, beta-ray spectrograph, spontaneous fission counters and special counters for measurements in accelerator beams.

   Various phases of the instrument development in support of the chemistry program are being actively pursued.

Electromagnetic Isotope Separation — SECRET

1. Design and construction of experimental units.

   No progress.

2. Development of rf source units.

   No progress.

3. Investigation into neutralization of space charge, including rf photoelectric and thermionic emission methods.

   No progress.

Nuclear Chemistry — CONFIDENTIAL

1. Preparation and properties of all neutron-deficient isotopes that can be reached with the 60-inch and 184-inch cyclotrons.

   New activities have been assigned to Pu^{235}, Po^{205}, W^{177}, W^{179}, and Lu^{174}. Two light emanation alpha activities have been prepared. Positrons have been observed in gold activities. A 5-minute alpha activity has been shown to follow gold chemistry. La^{135} has been confirmed with the mass spectrograph.

2. Determination of cross sections for the many spallation reactions at high energies.

   Work continues on uranium, thorium, arsenic and copper spallation.

3. Characteristics of bismuth, lead, and other element fission. Theory for the process.

   Tantalum is being studied.

4. Extension of fissionability measurements below tantalum into the rare earth elements.

   No progress.

5. Characterization of fission of uranium and thorium induced by high energy particles.

   Work is in progress.

6. Identification of the interesting new bismuth alpha-emitters.

   No progress.

Nuclear Chemistry (Continued) CONFIDENTIAL

7. Attempt preparation of elements 97 and 98.

No progress.

8. Preparation of larger amounts of americium 241 and curium 242 for chemical and nuclear studies.

No progress.

9. Preparation of those isotopes of americium and curium (also neptunium and plutonium) which have not yet been prepared, and the determination of their properties, including spontaneous fission rate and slow neutron fissionability.

The presence of a long-lived alpha active Am^{243} has been demonstrated in neutron irradiated Am^{241}.

10. Determination of amounts and properties of transplutonium isotopes produced by the intense neutron irradiation of plutonium and americium.

Work is in progress to adapt the mass spectrograph to this purpose.

11. Chemical identification of the products from nuclear reactions with 350 mev protons.

Much of the work described under items 1 and 2 utilized the high energy protons.

12. Study of meson reactions by chemical means.

No progress.

13. Development of chemical analysis techniques utilizing radioactive tracers.

No progress.

14. Other experiments.

An activity believed to be Pa^{235} has been observed.

Chemistry of Heavy Elements. CONFIDENTIAL

1. Microchemical Studies of curium in pure form to determine its chemical properties.

No progress.

2. Further studies of americium including its oxidation states and other basic chemical and metallurgical properties.

Work is underway to study the oxygen-americium system at high temperature.

Chemistry of Heavy Elements (Continued) CONFIDENTIAL

3. Chemistry of protoactinium and neptunium and other elements about which little is known. Studies of their metallurgy.

No progress.

4. Chemical properties of the rare earth elements for comparison with the actinide elements.

Magnetic properties of rare earth fluoride systems are in progress. Study of the praseodymium oxide system continues. Study of the hydrolysis of $LaCl_3$ continues. A new phase similar to LaOCl has been observed with x-ray diffraction methods.

5. Methods of separating americium, curium, and higher elements from each other and from the rare earths.

No progress.

6. X-ray diffraction determination of crystal structure of compounds of neptunium, americium, and curium.

No new compounds have been observed, but samples for calorimetric work have been identified.

7. Thermochemical studies of compounds and metals of heavy elements.

Calorimetric experiments on heat of solution of Am, Am_2O_3, and AmO_2 are being made.

8. Investigation of the chemistry of astatine (element 85) on a tracer scale. Formation and study of new isotopes of astatine.

Experiments are in progress to assign several neutron deficient isotopes of astatine.

9. Other experiments.

Praseodymium and its oxides are being investigated with the calorimeter in connection with the americium experiments. X-ray diffraction patterns have been obtained for some rare-earth oxide hydrates whose structures and compositions are not yet known.

High Temperature and Pile Chemistry SECRET

1. Metals and high temperature thermodynamics.

Work is in progress on the thermodynamics of CN and N_2, refractory studies, the absorption coefficients of CN and C_2, the thermodynamics of molybdenum halidia and oxides and of aluminum oxides, low melting metal systems, and the structure of solids and gas-solid surface interactions.

High Temperature and Pile Chemistry (Continued) SECRET

2. Basic chemistry. Solvent extraction.

Experiments on the exchange of iodine atoms between iodate ion and iodine are continuing as are experiments on the chelate complex of lanthanum with TTA.

3. Engineering development of plutonium separation.

The solvent extraction using chelate process and the pilot scale synthesis of TTA are under investigation.

4. Ore reduction.

A micro titration method for U(VI) is being developed.

Plant and Equipment UNCLASSIFIED

1. Completion of bevatron building; continuation of bevatron construction.

Work has been progressing slowly on the 48 inch drain line as a result of extremely heavy rains. As a result of not being able to complete the drain line, no grading could be done. Architects are continuing work on the final drawings for the foundation and building. The 1/4 scale model bevatron has two tank quadrants in place, testing of remainder continuing. It is contemplated that this instrument will be completed by the middle of april. Design of full scale equipment continuing as rapidly as possible.

2. Complete equipping of Central Research Laboratory Building.

Pouring of second floor slab nearly completed, ready to start pouring second floor walls and columns on March 17, 1949.

3. Construction of Animal House and Cafeteria.

As stated in last month's report, this project is being studied by the architects, Hertzka and Knowles.

4. Construction of Shops - plumbing, electrical, sheetmetal and salvage.

The architects, Hertzka and Knowles, are putting the finishing touches on working drawings and specifications for the first shop building. The second of these two buildings is not as yet, on the drawing board since funds do not permit its erection until next year.

Plant and Equipment (Continued) UNCLASSIFIED

5. Miscellaneous Small Construction.

Storage Facilities - Warehouse grading has been held up during the month, for the excavation from this area will be used as fill in the bevatron area. Since the bevatron job has been held up, this job has been, likewise, held up.

Paint Shop - The roofing, walls, doors, windows, etc. have been installed and the finishing work is proceeding on this building.

Alterations to Chemistry Buildings - Alterations in ORL have been started and rough plumbing and prefabrication of equipment are in progress.

Power Distribution System - Materials for this job are being ordered.

Fire Protection - Ditching and conduit for fire alarm system are nearing completion. Work is progressing on tying in of circuits. Orders are being placed for new fire main lines.

Roads and Parking Areas - Contracts for these jobs have been let but work has not been started due to rainy weather.

University of California Hospital Radiological Laboratory - Architects' studies are being made and instrument bids are being scrutinized.

MEDICAL RESEARCH

Biological and Medical Studies at Crocker Laboratory UNCLASSIFIED

1. Evaluation of the metabolic properties of fissionable elements, fission products, and other materials of project interest.

The metabolism of Nd^{147} has been investigated in rats as carrier-free material, as carrier-free material complexed with citrate, also with Nd carrier and Pr carrier. The metabolism of Nd is similar to the other La rare earths.

2. Decontamination studies.

The investigation of bone metabolism and factors affecting fission product retention are being continued. The kinetics of radio-zirconium excretion and uptake by bone is being studied by following blood level and distribution at various time intervals after intravenous administration.

Biological and Medical Studies at Crocker Laboratory (Continued) UNCLASSIFIED

3. Radioautographic studies.

Experiments to determine the uptake of Pu in scar tissue have been set up, as well as the Pu uptake pattern in the tissues adjacent to the costochondral junction. The short time interval Sr study and the Nd experiments are in progress. Pr radioautographic studies are being set up.

4. Radiochemistry.

Carrier-free copper and carrier-free selenium have been separated from their respective bombarded materials. An Oak Ridge shipment of carrier-free Pr^{143} was checked by column separation and was found to contain only one activity. Work on At^{211} has continued.

Medical Research at Donner Laboratory UNCLASSIFIED

1. Selective tissue irradiation involving radioactive colloids of phosphorus, yttrium, zirconium, lanthanum and uranium.

A paper dealing comprehensively with the study of colloids done in this laboratory is being prepared for the Journal of Clinical Investigation.

2. Biological effects of fission.

No new results.

3. Biological effects of high energy neutrons.

The work is being continued.

4. Use of large animals in long range studies of item (3) with particular interest centered in carcinogenic and longevity aspects.

We are waiting for the completion of the Animal House.

5. Biological effects of high energy particles (other than neutrons - see item (3) above.

The work is being continued.

6. Biological effects of radiation on nucleoprotein metabolism and protein metabolism.

The work is being continued.

7. Effects of radiation on the reticuloendothelial system and related effects with regard to immunity mechanisms.

The work is being continued.

Medical Research at Donner Laboratory (Continued) UNCLASSIFIED

8. Microchemical assay of tissue components by induced radioactivity.

The analysis of induced radioactivity, in blood has revealed the presence of several elements in trace amounts in blood fraction.

9. Study of the mechanism of radiation injury and possible prophylactic and therapeutic management of such injury.

A study on blood coagulation has been completed on a large series of normal subjects and polycythemic and leukemic patients. Three different kinds of tests were used and the results will be communicated in detail in the Quarterly Progress Report.

10. Study of metabolism measured by the utilization of simple organic compounds labelled with radioactive carbon.

The work is being continued.

11. Study of genetic effects of radiation.

The work is being continued.

12. Radiation effects on micro-organisms and studies on the nature of radiosensitivity and radioresistance.

Protective effect of mice on E. coli hold for x-ray, though light is quite effective in protecting against ultraviolet rays.

13. Effects of specific irradiation of liver, spleen, bone marrow, and lymphatic tissue on the circulating plasma proteins.

Liver circulation using chromic phosphate has been measured in normal mice and irradiated animals.

14. Metabolic studies on normal and leukemic cells.

The work is being continued.

15. Physical chemisty. Physical and chemical methods in dealing with large molecules in biological systems.

The instrumentation necessary for the study of macromolecules in biological material is now nearing completion. Ultracentrifugal studies have been performed on the fractions responsible for the visible lipemia occurring after total body x-irradiation.

Cancer and Medical Research at U. C. Hospital (48C) UNCLASSIFIED

1. Effects of external irradiation of the whole body.

   2 blood counts done on patients treated before or during 1946.

2. Hematological effects of irradiation the body from within. P^{32} and I^{131} work.

   9 blood counts done on patients treated with P^{32} prior to May 24, 1948. 15 blood counts done on patients treated with I^{131}; of these 15, two are new patients.

3. Studies of the metabolism of I^{131} together with tests of its usefulness as a diagnostic and therapeutic agent.

   24 diagnostic studies plus 4 given therapy. Includes one-hour measurements on a series of five and continuation of tooth eruption series and surgical series.

4. Study of skin reaction to radiation from x-rays, gamma-rays, beta-particles, alpha-particles, and neutrons.

   No work being done under this title.

5. Investigations in (4) extended to plants and animals.

   No work being done under this title.

6. Investigations into the cause and cure of radiation sickness.

   No work being done under this title.

7. Other experiments.

   Thyratrophin being used in an effort to stimulate inactive carcinomatous tissue in one case previously thyroidectomized with I^{131}.

8. Construction of Radiological Laboratory.

   Proceedings are going along toward the culmination of the contract with the architects and receipts of bids on the electronic accelerator.

Organic and Biological Chemistry UNCLASSIFIED

1. Use of carbon 14 in study of organic reaction mechanisms and physical-chemical phenomena, such as the mechanisms of molecular rearrangements, cracking of hydrocarbons, etc.

   Work continued on free radical mechanism of peroxide decomposition. Some of the preparations listed in item 3 will involve mechanism confirmation.

Organic and Biological Chemistry (Continued) UNCLASSIFIED

2. Production for shipment of various carbon 14 labelled compounds, such as methyl-labelled sodium acetate, methylene and carboxyl-labelled glycine, carbonyl-labelled sodium pyruvate and glucose.

The standarized $BaC^{14}O_3$ samples have been prepared for shipment to the University of Illinois. The products of 10-20 mc batches of the following compounds have been sent to the Isotopes Division. Sodium propionate-2-C^{14}, Sodium propionate-3-C^{14}, calcium glycolate-2-C^{14}, glycine-1-C^{14}, alanine-2-C^{14}.

3. Production for experimental use of compounds and as phenylalanine (either beta or ring labelled), complicated amino acids, drugs, hormones, carcinogens, etc.

The synthetic preparation of the following compounds is being studied: phenylalanine-β-C^{14}, alanine-3-C^{14}, leucine-β-C^{14}, valine-γ-C^{14}, codeine-methoxy methyl-C^{14}, codeine-N.methyl-C^{14}, isobutyl bromide-methyl-C^{14}, isopropyl bromide-methyl-C^{14}, oxalacetic acid-C^{14}, fumaric acid-C^{14}, tarteric acid-C^{14}, succinic acid-C^{14}, lactic acid-C^{14}, lactic acid-2-C^{14}, demerol-N-methyl-C^{14}, diiodo^{131}tyrosine, glucose-1-C^{14}.

4. Studies of the mode of action and distribution of the compounds in (3) above in animal and plant metabolism.

A series of Warburg experiments on the metabolism of normal and neoplastic tissues with C^{14} labeled compounds is being started. The study of the rate of metabolism of simple organic compounds is continuing. The metabolism of stilbamidine-C^{14} in mice is being studied.

5. Isolation of the intermediates of photosynthesis and study of the mechanism of this process.

The study of phosphorylated photosynthetic intermediates has been continued and intensified. Phosphopyruvic acid has been identified as an early intermediate. Many others are also listed. Synthesis of sucrose in dark in considerable quantities in dark has been demonstrated. Plant acids have been studied. Rate of respiration and photosynthesis studied.

Health Physics — UNCLASSIFIED

1. Dosimetry in high energy neutron beams; evaluation of energy absorption coefficients for hydrogen, carbon and oxygen; application to tissue.

   No progress.

2. Study of ranges and relative numbers of ionizing secondaries from materials irradiated with high energy neutrons.

   Work on this topic is continuing very actively.

3. Controlled exposure of animals in neutron beam.

   Work on this subject is reported under item 3 of the Medical Research at Donner Laboratory.

4. Applications of new types of counters to dosimetry.

   The program of adapting scintillation counting methods to biological problems is continuing.

5. Extension of health protection program, involving use of film badges and pocket chambers by all personnel.

   The film badge program has now been extended to all personnel in the Laboratory.

Health Chemistry — UNCLASSIFIED

1. Shielding - materials, stopping power, geometry.

   Continued study of the appropriate material and design to be used in containers with maximum efficiency in shielding, especially for economy of shipping weight.

2. Problems in optics for caves and dry boxes, involving mirrors, lenses and liquids.

   Heavy liquids, including thallium formate: optical properties and density studied.

3. Plutonium slug design for use in piles.

   No special design for Pu slug; pile slug and capsule setup already developed satisfactorily for all pile work.

4. Instruments including G. M. tubes, tongs, and particle detecting rings.

   Improved alpha meter being developed; air alarm counter being tested; numerous flexible tons and manipulators created; developments being continued in all of the above fields.

Health Chemistry (Continued) UNCLASSIFIED

5. Decontamination of the air expelled from an area such as the "hot cave".

   CWS filters received for test set up for experimentation; work continuing on blowers and filters. Special filter designs being employed for use with larger volumes of acids being evaporated in the boxed.

6. Surface decontamination for working areas; studies of decontamination technique for large equipment, and development of special equipment for this purpose.

   Decontamination annex awaiting construction.

7. Design of special target holders for active material.

   Design of special target holder is progressing with special emphasis on speed of removal of target for detection of short-lived isotopes.

8. Continuing improvement in dry-box design, construction and associated mechanical equipment for remotely handling and performing specialized manipulations with active materials.

   Work on the above activities constitutes a major portion of the time spent by the Research and Development group; any further statement on the progress therein is beyond the scope of these comments.

9. Receival, storage, monitoring and waste disposal of all radioactive material in Laboratory, and health monitoring for exposure to such activity.

   Continuous attacks on these problems being made, details of which would require too lengthy a description to be suitable for this report.

APPROXIMATE DISTRIBUTION OF EFFORT

PROGRAM	SUBDIVISION	MAN-MONTHS EFFORT	COMMENTS
184-inch Cyclotron	Operation	10.8	
60-inch Cyclotron	--	- -	Non-Project
Synchrotron	R.f. System	.8	
	General	.3	
	Injection	2.2	
	Miscellaneous	1.0	
	Magnet Tests and Operation	3.6	
	Vacuum Chamber	- -	
Linear Accelerator	Linear Accelerator - General	2.2	
	Van de Graaff - General	3.1	
	Development	3.4	
Bevatron	Injector	3.9	
	Magnet	2.1	
	1/4 Scale Model	.1	
Experimental Physics	Cloud Chamber	5.2	
	Film Program	8.0	
	Ionization Chamber and Crystal Counter	1.4	
	Neutron-Proton Scattering	1.2	
	Proton-Proton Scattering	1.8	
	Neutron Diffraction	.2	
	Meson Range and Decay Measurement	2.0	
	Absolute Cross Section Measurements	2.7	
	Neutron Half Life	.5	
	General Physics Research	10.0	
	Magnetic Measuring Equipment	.2	
	Instruments for General Use	1.7	
	Meson Experiments with Synchrotron	3.3	
Theoretical Physics	Synchrotron	- -	
	Bevatron	1.8	
	Cyclotron	.6	
	Linear Accelerator	- -	
	General Physics Research	12.3	
Isotope Separation	Nier Spectrometer	2.2	
	Low Mass Spectrograph	.2	
	XC Isotope Separation Program	.8	

PROGRAM	SUBDIVISION	MAN MONTHS EFFORT	COMMENTS
Chemistry, Part A	Chemistry of Transuranic Elements	6.2	
	Nuclear Properties of Transuranium Elements	4.1	
	Transmutations with the 184-inch Cyclotron	8.3	
	Analytical and Service	15.9	
Chemistry, Part B	Synthetic and Experimental Chemistry	7.5	
	Biological Chemistry	5.0	
	Photosynthetic Chemistry	5.7	
Chemistry, Part C	Metals and High Temperature Thermodynamics	3.0	
	Basic Chemistry, including Metal Chelates	1.5	
	Engineering Development of Plutonium Separation	2.0	
	Ore Reduction	3.5	
Medical Physics Part A, Div. I	Metabolism of Fission Products	11.0	
	Decontamination Studies	7.0	
	Radiochemistry	2.0	
	Radioautography	2.0	
Medical Physics, Part B, Div. II	Uranium Research	- -	- - Consultant
	Tumor Metabolism	1.7	1.7 Man-Months
	Special X-ray Studies, Radioactive Measurements, etc.	4.6	2.2
	Radioactive Carbon Studies	1.0	.6
	Fundamental Medical Research	2.7	2.7
	Hematology	.4	1.4
	Medical Work with the 184-inch Cyclotron	2.9	1.1
	Fly Genetics	2.0	.3
	60-inch Cyclotron Bombardments	.4	- -
	Physical Chemistry	3.4	- -
	Specific Irradiation	2.5	.2
Health Physics and Chemistry	Monitoring and Disposal	5.8	
	Salvage, Decontamination, etc.	- -	
	Research and Development	14.1	
	Film Badge Program	5.0	