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Radiation Laboratory

Contract No. W-7405-eng-48

PROGRESS REPORT No. 74

May 15 to June 15,1949

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Berkeley, California

UNIVERSITY OF CALIFORNIA, RADIATION LABORATORY

May 15 to June 15, 1949

PROGRESS REPORT No.74

1. Bevatron

UNCLASSIFIED

Quarter Scale Model. Operation on the quarter scale bevatron model has been interrupted several times by the warm weather which causes the maximum pressure to rise from its base value of about 2×10^{-6} mm to over 5×10^{-6}. This increase in pressure greatly reduces the accelerated beam. Two methods of injection have been found possible on this model. In one the inflector is placed on the fringing field (outside n = 1) and the ions clear the inflector in a radial direction due to its large radial motion per turn. In the second method the inflector is placed in the uniformly decreasing field (n = 0.6) and the ions clear the inflector by passing over and under the electrode. This was determined by the use of a clipper the full height of the aperture to prevent the ions passing above or below the electrode. With injection in the fringing field passing currents through the pole face windings increased the beam. The beam which clears the injector and spirals into a probe on the inside radius with the r.f. off has been measured as 2×10^{-8} amp. 30-50 percent of this is caught by the r.f. The beam injected within a horizontal angle spread $\pm$ 1/2 degrees has been measured as 15 μa. As the vertical aperture is reduced, the accelerated beam measured 10 milliseconds after injection starts to decrease at 6 inches aperture and disappears at 3 inches. As the total vertical aperture planned for the model conversion is 3 inches, it is important to determine the reason for these results. Measurements of the effect of reducing the vertical aperture indicate that the beam fills the tube. A measurable beam has been obtained down to 2 inches aperture with injection in the fringing field. Scattering explains part of the variation of the beam current with aperture but other effects also appear to be important. Every effort is being made to reduce the jitter in the frequency control which causes fluctuations in the accelerated beam from pulse to pulse. The refrigeration capacity has been increased and operating pressure is now in the range of 2 to 3×10^{-6} mm on normal days.

Full Scale Bevatron. Tentatively it has been decided that the largest aperture required will be 2 x 6 ft. rather than 4 x 10 ft. and minor modification of the magnet design may be made on this basis. For example, making the core yokes parallel instead of at an angle as required to obtain n = 0.6 without poles. Test of pole pieces for the 1 x 4 aperture using the 1/12 scale AC model has shown design of the pole tip wings is not good magnetically. A revised shape is to be tested. Radial uniformity runs made at various fields show the useful width to decrease more slowly than the radio oscillation amplitude with decreasing field. Steel for the full size sample section is being received and the building drawings are in the bidders' hands.

Linac Injector. Parts for r. f. model test on the experimental linear accelerator type injector of .5 x 4 Mev energy for use with the operating model are in the shop and studies are being made on the high voltage supply for the 0.5 Mev ion gm. Changes in the latter to accommodate the P.I.G. source and differential pumping are being designed.

Operating Model Conversion. Engineering is proceeding on the design of the water cooled coil, the magnet poles, and the vacuum tube.

2. 184-inch Cyclotron Operation UNCLASSIFIED

The cyclotron was used for research experiments ninety-five percent of the 486 hours that the crew was on duty.

The construction of a new collimator for the deflected proton beam was started. This collimator will be adjusted during operation by remote control so that accurate alignment with the beam will be possible.

3. 60-inch Cyclotron Operation UNCLASSIFIED

During this period the 60-inch cyclotron has been undergoing repairs and alterations. The machine has been completely dismantled, new parts are being fabricated and installed and work in this connection is proceeding according to schedule. There were no bombardments made.

4. Synchrotron Operation UNCLASSIFIED

The repairs and design changes listed in the previous monthly report have been completed, and the machine has been placed in operation. The steadiness of operation appears to be greatly improved, probably due to the better compensation achieved with the new octant coils.

The maximum intensity which has been obtained is now 17 r per hour, measured with an 8-inch ionization chamber behind 1/8 inch of lead. This corresponds to 1700 r/hr. at 1 meter in the beam.

5. Linear Accelerator and Van de Graaff UNCLASSIFIED

The 32 Mev beam of the linear accelerator has now reached .2 μa average current. This is an increase of about 200 times the former beam values of a year ago. Radio frequency bunching has not yet been tried, but the equipment is almost ready to install. There can now be little doubt that within months, the accelerator will deliver average currents in excess of 1 μa. Such currents have been the goal of the beam improvement program for the past nine months. Surveys are being made to determine whether additional shielding will be necessary around the bombardment area, if the machine is to be operated for long periods at the present beam level.

The Van de Graaff proton beam is now 1.5 ma peak for a 400 μsecond pulse and a repetition rate of 15 p.p.s. The highest average current that has been taken from the machine at increased repetition rates has been about 50 μa at 4 Mev. It is believed that this number can be doubled.

6. Experimental Physics

Film Program. Positive-Negative Ratio. In early experiments with mesons produced by 380 Mev alpha particles, the ratio of positive to negative π-mesons was measured for low meson energies. For mesons of energy roughly 2-3 Mev in the laboratory system, the ratio of π^+ to π^- -mesons was found[1] to be about 1/4. This is in agreement with a calculation by Serber, which gives a ratio of 1 to 3.5. A study is now in progress to find the positive-negative ratio for mesons produced by 350 Mev protons. The main interest is in mesons of high energy (e.g. 50 Mev). Apparatus has been built to receive mesons which leave the target at right angles to beam direction. Two channels are provided which have curvatures appropriate to positive and negative mesons of high energy. At the ends of the channels the mesons pass through 1/4 inch blocks of copper to slow them down before they are recorded by the photographic plates. Theory predicts a positive-negative ratio of 3 for the high energy mesons from proton bombardment of carbon. Preliminary experimental results show a ratio of at least 5, in definite disagreement with the theoretical predictions.

Study of π^+ Meson Decay. A study of π^+ meson tracks in photographic plates is being conducted by Professor L. W. Alvarez to find whether some π^+ mesons decay by beta emission. Previous studies have shown that most π^+ mesons decay by emitting a μ^+ meson. In about 95 percent of the cases μ^+ meson tracks are found at points at which π^+ mesons stop in the emulsion. In the past it has been assumed that the remaining 5 percent of the cases represented events in which the μ^+ meson was not seen because it came off at an unfavorable angle. Techniques have, however, gradually improved and plates are now available in which it is possible to see μ^+ tracks from π-μ decay, even when the μ^+ meson goes straight up or straight down. There is still the possibility of missing the μ^+ track if the π^+ track ends near the top or bottom of the emulsion. In the present study, plates end about half way down in the emulsion. In the present study, plates have have been exposed in the cyclotron in such a way that many π^+ tracks end about half way down in the emulsion. In order to eliminate μ^+ tracks which might be mistaken for π^+ tracks, a channel is used which has a radius large enough so that μ^+ mesons from the target cannot get through. By making one run with a channel which accepts π^+ mesons from the target and another with a channel which does not, it is possible to subtract out the mesons initiated by stray neutrons. Preliminary results show that one π^+ meson in 40 decays without the appearance of a μ meson.

Mesons from Deflected Proton Beam. During the past month the apparatus of Richman and Wilcox has been redesigned, to permit vacuum runs with small targets. Experiments are being made, using protons from the linear accelerator travelling at an accurately known angle through the emulsion, to measure the thickness of photographic emulsions.

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[1] Burfening, Gardner, and Lattes, Phys. Rev. 75, 382 (1949)

Cloud Chamber. The cloud chamber group has begun an experiment to determine the energy spectrum of the electron-positron pairs that are produced when the γ-ray beam of the synchrotron strikes a 0.001 inch lead foil. In preparing for this experiment it was necessary to: (1) devise a new method for controlling the temperature of the cloud chamber, (2) set up instruments for measuring the timing accurately and (3) build an adequate collimator and position it correctly between the synchrotron and cloud chamber.

A cloud chamber has been operated in the neutron beam and several low energy mesons have been found.

A cloud chamber was operated in the deflected 350 Mev proton beam for p-p scattering. Here the collimation is still not adequate and there are some difficulties with the cloud chamber operation.

Finally preparations are being made to do n-d scattering at 90 Mev. A new cloud chamber is being assembled for this purpose. Various calculations concerning this experiment are also in progress.

Magnetic Energy Discrimination Method. Apparatus is being developed for the study of secondary particles produced in various materials under bombardment by 270 Mev neutrons from the 184-inch cyclotron. This apparatus, which is of a sort to make much more efficient use of cyclotron time than heretofore, will consist of the following: a battery of Geiger-Muller counters, which, used in conjunction with a large magnet, will count and sort out scattered particles of various energies; a proportional counter designed to give particularly good resolution in pulse height, which will sort out particles of various kinds (e.g., protons, deuterons, etc.); a fifty channel pulse height analyser; and an eighty channel paper type recorder which will simultaneously record pulses from the various channels of the pulse height analyser and from the Geiger-Muller counters. By means of this system it will be possible to determine at once the distributions in energy of all the charged particles knocked out of a given material.

Mass Spectrograph. Sample system. The new sample system described in previous reports has been installed and tested. About 4 cm^3 of HD at a pressure of 10 cm was expanded into the sample reservoir (v= 10 liters) giving a sample pressure of about 40 microns. Masses 3 and 4 were scanned repeatedly for a half an hour. Although there was a small decline in the total peak current the ratio of mass 3 to mass 4 changed less than one percent.

Emission regulator. The emission regulator has been altered so that the emission voltage must be varied between 20 and 120 volts while the voltage between the trap and the shield remains constant ($\sim$75 v.).

Normal butane has been run in the new system, giving results very close to those published (Bureau of Standards).

Scintillation Counting of Gammas. A counter complete with power supply and vacuum tube coincidence circuit has been completed and delivered to Donner Laboratory. It has been operating there for several weeks and consistently counts 5 to 6 percent of the gamma rays going through the anthracene crystal. The sample is placed right on the crystal so that the geometry is near 50 percent.

With about 4 inches of lead around the counter, the extraneous count from cosmic rays, etc., is considerably greater than the noise count from the photomultiplier tubes. The coincidence circuit therefore seems to be satisfactory as far as reduction of background is concerned.

Measurement of Total Cross Section of Nuclei for 40 Mev Neutrons. The cross sections of about 20 nuclei for 40 Mev neutrons have been measured using the C(n,2n) reaction as a detector. All of the materials used so far have been in liquid or solid form. Containers suitable for packing powdered materials are being made. A high pressure gas tube has been designed and is under construction which will be used for measuring the cross sections of gaseous materials, in particular He.

Cerenkov Radiation from Protons. Cerenkov radiation from the 345 Mev deflected proton beam passing through a sample of dense flint glass (index of refraction 1.91) was detected photographically. That it was not simple fluorescence was demonstrated by the directional character of the radiation which was in quantitative agreement with theoretical prediction. Copper absorbers were used to reduce the energy of the beam and the reduction of the angle between the proton direction and the direction of the Cerenkov radiation was in agreement with theory. The experiment was repeated using amorphous silver chloride instead of the glass and again there was agreement with the theory.

Further Observations on High Energy Neutrons, Using Bi Fission Counters. The previously reported values of $\sigma i/\sigma t$ for Pb and Al using 270 Mev neutrons were somewhat in error due to a mistake in the attenuation data. The value of $\sigma i/\sigma t$ for Pb should have been $.49 \pm .02$. As the neutron flux density from the bombardment of a 2 inch Be target by 350 Mev protons is uniform in intensity over a much larger area than with the 90 Mev neutrons, it was possible to measure $\sigma i/\sigma t$ for carbon using two large blocks of C_{18} (7-1/4 inch x 20-5/8 inch x 24-1/4 inch). The value of $\sigma i/\sigma t$ obtained was $.505 \pm .02$ for carbon. A repeat of the Pb measurement yielded $.512 \pm .013$. All the measurements, thus far, indicate a value of about .5 for $\sigma i/\sigma t$ at these high energies.

A measurement of the angular distribution of the neutrons resulting from the bombardment of a 2-5/8 inch Be target with 350 Mev protons was made. The neutron distribution had a broad maximum falling off to half value at 24.5° from the incident proton direction.

High Energy Photons Emitted by Cyclotron Targets. The principal effort of the group in the past month has been devoted to improving the efficiency of the pair counter system in the low energy (30-50 Mev) region. The geometry was changed so as to make scattering in the target less important, and radiators whose thickness was proportional to E^2 were used in order to make the mean scattering angle the same at all energies. Measurements of the photon spectrum made after these changes show that at least part of the previously observed decrease in photon yield with decreasing energy below 70 Mev was of instrumental origin, and the previously reported peak at 70 Mev has shifted downwards to not more than about 55 Mev.

Proton-proton Scattering. An explanation of an apparent low energy component to the protons scattered by protons is sought using the 340 Mev external beam of the 184-inch cyclotron. The conclusion has been reached that it is not the beam itself which contains lower energies. Other sources of low energy protons will be checked.

Proton-proton Scattering-32 Mev.

Statistics of the proton-proton scattering experiment using the photographic technique has been improved. Slightly over 13,000 tracks have been tabulated thus far. The results are in essential agreement with those obtained by the counter method and still there is the essential complete absence of scattering contribution of any higher angular momentum state of interaction.

Neutron-proton Scattering-300 Mev. N-p scattering awaits more certain knowledge of the proton-proton scattering inasmuch as there still remains doubt in interpretation. The correction for nuclear absorption in the neutron-proton scattering is expected to come from the proton-proton experiments.

Inelastic Scattering. The analysis of photographic plates obtained in the experiments on inelastic scattering of protons on carbon and aluminum has been completed. The result is that even at the highest excitation available with the linear accelerator, carbon shows only three distinct levels and no indication of a continuum. On the other hand, the aluminum data give a continuum of inelastically scattered protons in fair agreement with a statistical nuclear model.

Life Time of the Neutron. The apparatus is now in operating condition and has been used in exploratory runs. Effects associated with the ion decay in the Van de Graaff column after a pulse and also various fluorescence effects have obscured any possible results which might be associated with neutron decay.

Fission Studies. It has been found unfeasible to measure the energy distribution of fission in the external beam from the 184 inch cyclotron. Measurements are being made of fission cross sections for U^{235}, U^{238}, Th and Bi with 380 Mev alpha-particles.

Total Cross Sections for 180 Mev Deuterons. Measurements are being made of the relative cross sections of A, N and C for Li^8 production by 180 Mev and lower energy deuterons.

7. Theoretical Physics — UNCLASSIFIED

Studies on neutron-proton scattering are being written for publication.

Experimental proton-proton scattering results are now sufficiently compatible with scattering by a potential. A detailed analysis is therefore felt justified and is being embarked upon. Calculations are also in progress on the scattering of protons and neutrons on deuterons.

Various calculations are being made on meson production, in particular the γ spectrum to be expected of neutral meson decay, is being investigated.

8. Chemistry

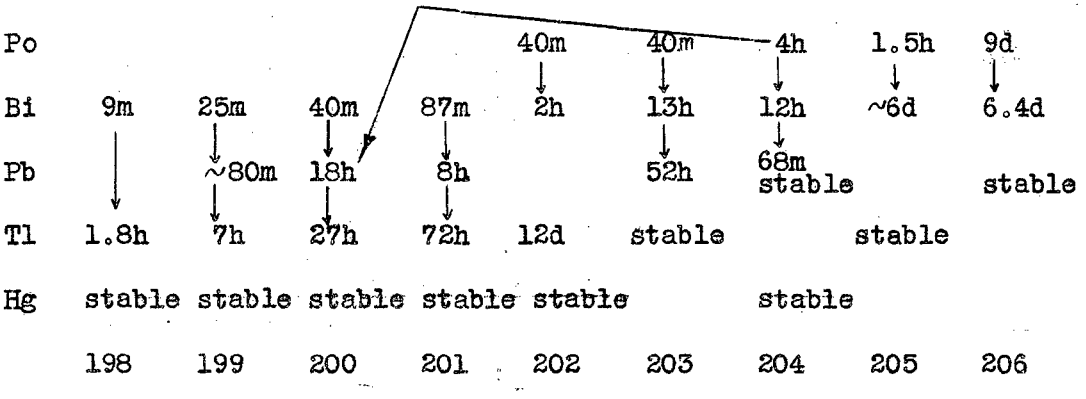
Part A

Alpha Decay of Am^{242} and Am^{243}. The milking of neptunium from the americium fraction of a sample of Am^{241} which had been long irradiated with neutrons has been repeated. The presence of Np^{238} and Np^{239} again show the long-lived isotopes Am^{242} and Am^{243} are decaying in part by alpha emission. A recent improved determination of the alpha-branching of Am^{242} gives about 0.5 percent.

If the slow neutron capture cross-sections of Am^{241} and Am^{242} are assumed to be reasonable values, but ones which may very well not be the true values, the alpha half-lives of Am^{242} and Am^{243} are 2.6×10^5 and 10^4 years respectively.

Properties of U^{231}. Better data have been obtained for the yields of Th^{227} and Pa^{231} as daughters of U^{231}, and the radiations of U^{231} have been studied further. The radiations consist of K and L x-rays and a 9.5 Kev gamma ray. The yield of Pa^{231} corresponds to 2 electron capture events per L x-ray; i.e., and Auger coefficient of 0.5 if one L vacancy occurs per disintegration. The yield of Th^{227} corresponds to a 200 year half-life for alpha decay of U^{231}.

Neutron-deficient Polonium, Bismuth, and Lead Isotopes. Experiments are continuing on the complicated mixture of isotopes in the mass range 198 to 206. The present status of the problem is summarized in the table below, where arrows show the genetic relationships which have been established by milking experiments. The half-lives in most cases come from milking experiments, because the decay curves defy resolution.



Neutron Deficient Isotopes of Neodymium. Bombardment of praseodymium (Pr^{141}) with 40 Mev protons has produced the known 3.5 day Nd^{140} and also a new 5.2-hour neodymium activity. Experiments are in progress to establish if this latter isotope is the grandparent of the known 140-day Ce^{139}.

Mass-spectrographic Efficiency for Cesium. Three salts of cesium have been tested with the mass spectrograph to determine loss factors. The results are as follows:

$CsNO_3$	1.4×10^6
$CsCl$	8.3×10^4
Cs_2SO_4	1.8×10^2

The loss factor due to geometry is of the order of 50 to 100. Thus the sulfate is being ionized with rather high efficiency. The great loss of chloride and sulfate is probably due to high vapor pressure. These results explain some of the difficulty with early cesium experiments using nitrate and chloride solutions. They emphasize the fact that the chemical state of the material on the source is of primary importance.

Mass Assignment of Cs^{127} and Cs^{129}. There has been evidence for some time that the 5.5-hour and 32-hour cesium isotopes belong to 127 and 129 respectively. These facts have been substantiated by mass spectrograph experiments. Spectra have been obtained with a stable line at 133 and radioactive lines at 127 and 129. The transfer technique has been used to show the line at 127 to correspond to the 5.5 hour period and the line at 129 to be the 32 hour isotope.

Anion Exchange Separation of Zirconium and Hafnium. A separation of zirconium and hafnium by the anion exchange resin Amberlite IR-400 has been accomplished by the following procedure. A quantity of 2.5 mg each of zirconium and hafnium was converted to fluo-ions by the addition of somewhat more than six molar equivalents of H_F. These anions were absorbed on 100 mg of resin, which was then placed at the head of an 18.5 cm column of 1.0 cm diameter.

Elution with a solution 0.2 M in HCl and 0.01 M in HF, at the rate of 4.5 ml/hr., recovered 80 percent of both the zirconium and hafnium in a spectroscopically pure state.

Chemistry — UNCLASSIFIED

Part B

Synthetic and Experimental Chemistry. Work has continued on a variety of C^{14} synthetic project. These are directed toward possible biological and photosynthetic work and include the synthesis of the following compounds: lactic acid-1-C^{14}, lactic acid-2-C^{14}, lactic acid-3-C^{14}, leucine-α-C^{14}, isoleucine-α-C^{14}, valine-α-C^{14}, malic-methylene-C^{14} acid, succinic-methylene-C^{14} acid, fumaric-C^{14} acid, tartaric-C^{14} acid, demerol-1-methyl-C^{14}, codeine-3-methoxy-C^{14}, glucose-1-C^{14}, mannose-1-C^{14}, cyclohexanone-2-C^{14}, alanine-3-C^{14}, leucine-β-C^{14} and valine-methyl-C^{14}. Among the more important and interesting intermediates that will be or are being prepared in the synthesis of these compounds are: isobutyl bromide-1-C^{14}, 2-bromopropane-1-C^{14}, potassium cyanide-C^{14}, i-bromopropionic acid-1 or 2 or 3-C^{14}, propyl bromide-1 or 2 or 3-C^{14}, and oxalacetic acid-methylene-C^{14}.

The study of the mechanism of the Tiffeneau ring expansion has continued with good results so far. Attempts are being made to formulate a mechanism for

the free radical decomposition of acetyl peroxide in acetic acid, but thus far no single path proposed is consistent with the data obtained.

Biological Chemistry. The study on the fate of radiocarbon taken into the lungs or blood stream of mice as $BaC^{14}O_3$ has been concluded, and it has been shown that most of the activity (85 percent) is expired as carbon dioxide in the first twelve hours. When the percentages of the injected carbon fixed by the mouse are plotted on semi-logarithmic graph paper it is found that the excretion shows an exponential law. This curve may be broken down into two straight line segments corresponding to biological half-lives of one and nine hours, respectively. From the data we can conclude that most of the C^{14} absorbed by animals as $BaC^{14}O_3$ is expired by the lungs as $C^{14}O_2$.

The in vitro study of the metabolism of propionic acid in normal and neoplastic tissues has continued as well as the rate studies.

Among the other biological studies being continued are the rate of conversion of metabolic intermediates and amino acids to $C^{14}O_2$ and the metabolism of C^{14}-labeled stilbamidine.

Photosynthetic Chemistry. The study of the dark respiration of photosynthetic products described in previous reports has been continued with barley seedlings and algae. The products of photosynthesis with $C^{14}O_2$ as separated and identified on filter paper chromatograms are converted to respiration intermediates when the plants are kept in the dark after the initial photosynthetic period. Many interesting differences between algae and barley have been observed.

The primary difference between barley and algae (Scenedesmus) respiration is the relatively slow appearance of labeled glutamic acid in barley. It may be that an oxidation process other than the Krebs tricarboxylic acid cycle either functions very slowly or not at all in barley leaves. Only a trace of active glutamic appears in two minutes dark respiration following 30 seconds photosynthesis. With Scenedesmus, on the other hand, active glutamic is the major radioactive constituent after two minutes respiration. After longer periods, algae produce considerable amounts of labeled succinic, and fumaric acids. Algae are able to respire their photosynthesized sucrose while barley leaves apparently have no rapid mechanism for sucrose oxidation. Barley rapidly respire the phosphate esters, intermediates in sucrose synthesis, and glycolic acid.

Experiments to define glycolic acid as the storage reservoir for the two-carbon acceptor molecule in barley have been conducted. It has been shown in our earlier work that phosphoglyceric acid is the first stable product of photosynthesis and it is presumably carboxyl-labeled. Experiments to verify this are in progress. The two-carbon molecule, to which $C^{14}O_2$ is added in photosynthesis, appears to be related to glycolic acid. Glycolic acid has been observed to be a major product when barley, containing previously synthesized intermediates, is illuminated in CO_2-free air. We have observed that when illumination ceases, glycolic acid is the first compound to disappear. An experiment has been performed to determine whether or not glycolic acid is a storage reservoir for the two-carbon acceptor. Barley, illuminated in CO_2-free air and which contains much glycolic acid, was given $C^{12}O_2$ both in the dark and in the light. It is expected that degradation of glyceric acid and alanine isolated in chromatograms of these

experiments will be non-radioactive in the carboxyl groups. This experiment, then, will further our understanding of the phenomenon of dark fixation by pre-illuminated leaves and algae.

Ion exchange resin separation of phosphate esters has been continued. Dowex A1 anion exchange resin in the chloride form is being used to obtain sodium chloride elution curves of available phosphate esters. Elution curves for the following compounds have been determined: fructose-1,6-diphosphate (0.2 N NaCl), 3-phosphoglyceric acid (0.2 N NaCl), 6-phosphoglyconic acid (0.2 N NaCl), glucose-1-phosphate (0.1 N NaCl), α-glycerophate (0.1 N NaCl), β-glycerophate (0.1 N NaCl), glucose-6-phosphate (0.1 N NaCl), fructose-6-phosphate (0.1 N NaCl) and inorganic phosphates (0.1 N NaCl). Large fractions of impurities have been observed in commercially available phosphate esters and it is hoped that successful methods may be developed for obtaining these important metabolic intermediates in a pure state.

Chemistry

Part C Project 48B

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

1. Studies of refractory carbides, borides, and silicides.
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 and iron oxides and hydroxides.
6. Low melting metal systems.

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.
3. Thermodynamic studies on rhenium.

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

1. Solvent extraction using chelate process.
2. Pilot plant design for TTA synthesis.

Ore Reduction. The following subjects are under investigation:

1. Solvent extraction using chelate process.
2. The dropping Hg electrode is being used to investigate phosphate complexing of U^{III} as ground work for a method of determining the oxidation state of uranium.
3. The construction of a photomultiplier is nearing completion, to be used in fluorimetric determination of micro amounts of uranium. A photovolt Model 512 Fluorimeter is being used for uranium analysis in conjunction with the solvent extraction using chelate process.

9. Medical Physics UNCLASSIFIED

Part A

Tracer Studies. The fate of Np^{237} has been worked out in rats 1 and 16 days after intramuscular injection. This element was complexed with citrate before administration. This facilitates absorption from the injection site for the immediate time periods following injection. For example, at 1 day, all but 13.6 percent of the activity was absorbed but that further absorption rate was not continued since at 16 days 12.2 percent of the activity remained.

After absorption, the major site of deposition was the skeleton which contained 44 percent of the total Np absorbed. There is appreciable concentration in soft tissues such as liver and kidney. Np is primarily excreted in the urine with some fecal excretion apparent. Sixteen days after administration of Np, the skeletal level was still the same, namely 44 percent, with a 50 percent to 30 percent reduction of the soft tissue concentration in the body.

Decontamination Studies and Bone Metabolism Studies. Decontamination. To obtain an estimate of possible "carrier" effect of massive "decontamination" doses of zirconium citrate, an experiment was set up last month in which massive "decontaminant" doses of zirconium citrate tagged with Zr^{95} were administered to rats simultaneously with a tracer dose of carrier-free Y^{90}. The samples from this experiment are now being analyzed.

Bone Metabolism. Significant data on bone deposition, particularly in rachitic rats, has been obtained with radiostrontium. These experiments are now being repeated and extended, using radio-calcium. The dose of 0.5 mg. Ca (containing 7 microcuries of Ca^{45}) as calcium chloride in isotonic saline, was administered by intraperitoneal injection. The following experiments have been set up, but no analyses are available at this time.

1) Retention of Ca^{45} in the skeleton of rachitic animals at 1 and 72 hours: previous experiments with Sr^{89} showed that a large part of an administered dose was taken up by the skeleton at 1 hour, but that most of this deposited material is released from the skeleton and excreted by 72 hours. This experiment has now been repeated with Ca^{45} because of its significance in relation to bone metabolism and its possible value in decontamination. Radioautographs are being prepared from split sections of femurs from rachitic rats sacrificed 15 minutes, 30 minutes, 1 hour, 2 hours, 24 hours and 72 hours following injection of Ca^{45} to determine if there is any significant shift in the distribution of Ca^{45} in the bone with time, correlated with the rapid loss from the skeleton in these animals.

2) Effect of growth hormone on the retention of Ca^{45} by rachitic animals: preliminary experiments have shown that the growth hormone of the anterior pituitary increases the severity of the rickets induced by phosphorus deficiency, and results in a still further reduction in the retention of Sr^{89} in the skeleton. This effect is being investigated with Ca^{45} in rachitic rats which received a dose of 2 mg. of pure growth hormone daily for 4 days.

Radioautographic Studies. In preliminary studies with plutonium, results indicated that this element was not laid down in the region of the periochondrium-

calcified cartilage junction, as was found with strontium and element 61. Further studied, in which alpha track autographs were made (instead of density autographs) showed that plutonium was deposited in this area, although to a very small degree. When the original autographs were set up for 3 times the original exposure time, there was a faint blackening in this area.

Praseodymium studies, due to very low activity present, are still in progress. Further experiments using element 61, plutonium, and strontium to study the uptake at the costo-chondral junction will be set up shortly.

Radiochemistry. 110 microcuries of carrier-free Zn^{65} were separated from a copper target using a previously described method.

A method has been developed for isolating carrier-free Mu^{54} and $Co^{56,57}$ from deuteron bombarded iron. A total of 10^4 c/s of 310 day manganese were separated in the carrier-free state from ~2 millicuries of carrier-free cobalt.

Chemical activation of Br^{80} by isomeric transition has been studied in NaBr protein solutions. Separation of the 4.4 hr. and 18 m. activities was obtained by precipitation of protein after 2 hours. The protein showed a growth of the 18 m. isomer. Citrate solutions of Cb-Zr mixture are being prepared. Na^{22} is being separated from a magnesium target.

Medical Physics UNCLASSIFIED

Part B

Investigations with Radioactive Iron. In using Fe^{59} a method has been developed for measuring the rate at which iron disappears from the plasma and is incorporated into hemoglobin. In a group of normal subjects it was found that the half-time of iron clearance runs about 2 hours and in patients with aplastic anemia the half-time is much prolonged. In patients with polycythemia vera the half-time is speeded up markedly. Knowing the half-time and the percentage of the iron which appears in hemoglobin it is possible to calculate the milligrams of iron utilized for 24-hour periods in the production of hemoglobin. The results indicate that in the normal subject about 1 percent of the hemoglobin is renewed per day which fits very well the known life of the red cell which is approximately 120 days. It has also been found that as little as 5 roentgens of whole body radiation interfers with the incorporation of radioactive iron into red cells.

The Biological Effects of Radiation. Studies with parabiotic rats have continued and when one member of a pair of parabiotically united rats was subjected to 900 r of x-rays, both members of the pair lost their hair. It is suggested that metabolic disturbances are induced in the irradiated animal which induces epilation in the co-twin as a result of circulatory exchange. The unirradiated animal got approximately 25 r scattered radiation.

Studies on Trace Analysis by Induced Activity. These studies are continuing and new samples of normal and tumor tissue have gone into the pile for exposure.

Biological Effects of 190 Mev Deuterons. These experiments have been started again and a large number of rats and mice carrying tumors have been exposed to this high

energy beam of particles. As in the previous experiments, it is possible to pass the beam directly through the animal and direct it against the tumor on the other side of the animal with destruction and disappearance of the tumor in about half the animals.

Biological Effects of Radiation on Nucleo-protein Metabolism. This work is continuing in the study of the utilization of simple organic compounds labeled with radioactive carbon. Recent investigations with carboxy-labeled propriónic acid have shown that there is an altered rate of oxidation of this material in a group of tumor animals as compared with normal animals when the exhaled radioactive CO_2 is measured. When the label is in the methyl position, such differences are not found and this lead is being followed further.

Effects of Specific Irradiation of Liver, Spleen, Bone Marrow and Lymphatic Tissue on the Circulating Plasma Proteins. This work is continuing with the aid of radioactive isotopes, the ultracentrifuge, and the electrophoresis apparatus.

Studies with Radioactive Cobalt. The study of the distribtuion of radioactive cobalt in normal and polycythemic rats has been completed. The tissues having the highest cobalt uptake are liver, kidney, and bone marrow. As little as one microgram of cobalt per gram of tissue can be detected. When histidine is complexed with cobalt prior to administration to the animal the bone marrow distribution of cobalt is slightly diminished. The bone marrow concentration fails to gradually increase in the longer administrations as is true in the normal animal. The effect can also be obtained with the cobalt-cysteine complex.

Studies with Radioactive Stilbamidine. Studies with C^{14}-labeled stilbamidine in mice reveal that most of this material is excreted in the urine, and the peak of excretion occurs during the first 48 hours. A smaller percentage is excreted in the feces. Less than 0.1 percent has been found in breath samples so far, and most of this occurs during the first 12 hours. Studies of tissue distribution are not yet completed but it now appears that the kidneys concentrate the highest activity and this rapidly decreases during the first four days. A month after injection no activity could be found in bone. At present it appears that a month after injection only a fraction of 1 percent of injected activity is still present in the animals. Clinical trial in patients with multiple myeloma seems to be indicated.

Studies with Radioactive Water. The mixing curves of injected radioactive water and total body water determinations are being carried out on animals and men.

10. Health Physics and Chemistry UNCLASSIFIED

Shielding. A program of studying relative amounts of neutrons in various energy ranges within the material of the shielding is continuing. This makes use of fission chambers of Bi, Th, and U, of carbon detectors, and of indium foils, placed at desirable and variable depths in narrow holes in the concrete.

Neutron Counters and Surveys. As part of the neutron flux measuring equipment for health physics surveys, two fission chambers have been constructed. One, containing bismuth coated, aluminum plates, is like those used previously in high energy

neutron surveys; the other is similar but thorium-coated plates are used in order to measure neutron flux down to about 1 Mev.

A survey has been made of the area around the neutron-decay apparatus in Building 10. One small region showing fast neutron energy flux about 25 times the tolerance level was found. Several others showing 6 to 20 times tolerance were found and the shielding thickness increased.

Studies. In addition to the routine monitoring and decontaminating services and the disposal of active waste products, the Health Chemistry Group completed 4 box assemblies, and 4 special boxes are about 50 percent complete. Work on another special box for preparation of P^{32} chromate is about 25 percent complete. Work has been initiated on tongs for picking up radio active foils and on a nitric acid mist separation for use with a filtering system on gloved and manipulation boxes. Work has been resumed on alpha meter power supply and on the redesign of glove parts for boxes.

LMB/6-29-49
Information Division

SUMMARY OF RESEARCH ACTIVITIES

May 15 to June 15, 1949

60-inch Cyclotron — UNCLASSIFIED

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

   During the overhaul of the cyclotron, development of counting equipment and new types of sources are being considered. Tests must wait until operation is resumed.

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

   Studies have been completed and fabrication is underway.

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

   New pole faces have been installed. Dimensions are based on studies made on the 184-inch cyclotron.

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

   All new installations during overhaul are being designed with this point in mind.

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

   Installation is being made during overhaul.

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

   This development is temporarily suspended.

7. Other developments.

   General overhaul of the machine is underway.

184-inch Cyclotron — UNCLASSIFIED

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

   New building for housing the generator is being awaited.

2. Development of improved beam monitoring equipment.

   Under construction.

184 inch Cyclotron (Continued) UNCLASSIFIED

3. Construction of proton beam deflector.

   The deflector has been installed.

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

   Under construction.

5. Other developments.

   A new collimator for the deflected proton beam is under construction.

300 Mev Synchrotron UNCLASSIFIED

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

   Studies are in progress on effect of injector emission on beam intensity.

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.

   Nothing new during this period.

3. Search for mesons using 300 Mev X-rays.

   Nuclear plates have been exposed to determine the angular and energy spectrum of mesons from a carbon target. Some work on the corresponding excitation function has started. The plates are being examined.

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

   Design of a pair spectrometer has been started.

300 Mev Synchrotron (Continued) UNCLASSIFIED

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

(γ,n) and (γ,2n) reactions have been produced in Cu and Zn. Also studies are being made of the absorption coefficients in Pb and Cu of the radiation producing these reactions. Also identified are the (γ,2p) reaction in Cu, the (γ,2p,n) reactions in Al, and the (γ,p,n) reaction in Zn.

6. Other developments.

Studies of transition curves in Pb and other materials, by means of ionization chambers, are well along. Cloud chamber study of pair production in lead has been started. Preliminary experiments have been started on production of neutrons by x-rays in different target materials.

Linear Accelerator and Van de Graaff UNCLASSIFIED

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

Bombardment area completion and beam safety system completion has been accomplished during this period. There have been no major changes in construction.

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

No major changes in Van de Graaff components.

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

Van de Graaff ion source output has been increased to 1.5 milliamperes peak current by increasing arc current capabilities of pulser.

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

Since the machine has been restored to operation it has been used for preliminary alignment bombardments for both p-p scattering experiments as well as other experiments.

5. Other developments.

Average Linac beam measured as greater than 0.1 μa at 15 cps rep rate, 0.2 μa at 30 cps. The energy checked was approximately 32 Mev.

Bevatron — UNCLASSIFIED

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

   Preliminary aperture measurements indicate that the full scale machine can be initially designed for at least 2-1/2 Bev. The scattering loss and injection process are being studied.

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

   The first sample shipment of magnet steel has left the mill. Equipment design is continuing.

3. Developments of an injection system.

   The linear accelerator injector is being designed.

PHYSICS RESEARCH

General — UNCLASSIFIED

1. Range measurements for fast particles.

   Theoretical analyses are being done on available data.

   Numerous exposures have been made on photographic plates to recheck the range-energy relations for photographic emulsions with those obtained in the 184 inch cyclotron. It appears now, as a result of these exposures, that the linear accelerator energy has moved downward during the last few months by possibly as much as 1 Mev. This observation has been confirmed by measurements with proportional counters and with the threshold of the $C^{12}(p,d)C^{11}$ reaction. Measurements have also been made on Bragg curves in air.

   Range-energy relations for protons up to 39 Mev in nuclear emulsions are being investigated.

Fundamental Properties of Nucleons. — UNCLASSIFIED

1. Neutron-proton scattering.

   Theoretical results are being written for publication. No further work has been done experimentally. The correction for nuclear absorption in the absorber is to be obtained in proton-proton scattering measurements.

Fundamental Properties of Nucleons (Continued) UNCLASSIFIED

2. Proton-proton scattering.

The statistics of the proton-proton scattering experiment using the photographic technique has been improved. The results are in essential agreement with those obtained by the counter method.

Although there is good reason to believe that the proton beam from the 184 inch has been made essentially monoergic, still some low energy component appears to reach the last counter of the counter telescope. The source of this component must be found before the cross sections can be established with certainty.

A run was made with the cloud chamber in the 350 Mev deflected proton beam.

Experimental results are now considered sufficiently solid to justify a detailed theoretical analysis.

3. Scattering of protons and neutrons on deuterons.

Further work awaits the understanding of effects within the counter telescope which are being studied in the proton-proton scattering.

Preparations are being made for cloud chamber studies on n-d scattering at 90 Mev.

Theoretical calculations are in progress.

4. Other scattering experiments.

The analysis of photographic plates obtained in the experiments on inelastic scattering of protons on carbon and aluminum has been completed. The essential result is that even at the highest excitation available with the linear accelerator, carbon shows only three distinct levels and no indication of a continuum. On the other hand, the aluminum data give a continuum of inelastically scattered protons in fair agreement with a statistical nuclear model.

5. Life time of the neutron.

The apparatus for observing the life-time of a neutron is now in operating condition and has been used in a number of exploratory runs. Thus far, effects associated with the ion decay in the Van de Graaff column after a pulse and also various fluorescence effects have obscured any possible results which might be associated with neutron decay.

Fundamental Properties of Nucleons (Continued) UNCLASSIFIED

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

Various calculations are being made, in particular the γ spectrum to be expected of neutral meson decay.

The Cloud Chamber Group has been looking for mesons made in the 285 Mev neutron beam.

In the Film Program it has been found that the ratio of the number of 50 Mev π^+ to π^-, produced at 90° from a 350 Mev proton beam on carbon, is greater than 3:1.

7. Other experiments.

A study of $\pi^+ - \mu^+$ decay shows that probably 2 to 3 percent of π^+ decay without forming μ.

Study of Cerenkov radiation from 350 Mev protons has been begun to provide a method for studying energy loss.

Work continues on high energy γ rays.

Nuclear Reactions. UNCLASSIFIED

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

Theoretical calculations are being made on spallation reactions.

2. Energy dependence of reactions.

Preliminary exposures have been made on a new apparatus for the excitation function of π mesons by protons on C. One stack of evaporated bismuth foils has been bombarded with the linear accelerator proton beam and a preliminary excitation function for the production of Po^{208} has been obtained. It is planned to study Po^{207} in a similar manner.

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

Work is continuing.

Nuclear Reactions (Continued) UNCLASSIFIED

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

Measurements have been have been made of the relative cross sections for formation of Li^8 by bombardment of A, N, and C with 180 Mev and lower energy deuterons. As yet these cross sections have not been checked. Measurements of total cross sections at 40 Mev are also in progress. Better data is needed in theoretical calculations with the 280 Mev neutron cross section.

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

Present apparatus seems inadequate for measuring the energy distribution of fission produced by the external beam of charged particles from the 184-inch cyclotron. Some runs have been made and the fission cross sections for U^{235}, U^{238}, Th and Bi will be measured.

6. Other Experiments.

A good deal of theoretical work is being done on bevatron problems, such as scattering effects. Both film and counter experiments are in progress for studying the particles ejected from nuclei under high energy bombardment.

Instrumentation UNCLASSIFIED

1. Instrumentation in support of cloud chamber development.

A new system for controlling the temperature of the cloud chamber at the synchrotron has been developed. It controls within $0.1^{\circ}C$ satisfactorily.

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

No progress during this period.

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

This study is continuing.

4. General development of electronic counting equipment.

Certain delayed counting arrangements are under development.

Instrumentation (Continued) UNCLASSIFIED

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

   Various types of proportional counters are being built from time to time.

6. Development of radiation survey instruments.

   U and Th fission survey instruments are about ready for testing.

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

   In constant use on assorted problems, mainly in study of chemical results of irradiation.

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 instrument development in support of chemistry and health physics programs are being actively pursued.

Electromagnetic Isotope Separation SECRET

1. Design and construction of experimental units.

   Inactive.

2. Development of rf source units.

   Inactive.

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

   Inactive.

Nuclear Chemistry CONFIDENTIAL

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

   Active work is underway on isotopes of strontium, tin, iodine, cesium, rare earths, iridium, platinum, gold, mercury, thallium, lead, bismuth, polonium, astatine, emanation, francium, protactinium, uranium, neptunium, plutonium, americium and curium.

Nuclear Chemistry (Continued)

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

   Excitation curves have been measured for production of various protactinium isotopes from thorium and uranium. Yields of spallation products from copper have been determined for additional energies of projectiles.

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

   No progress during this period.

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

   No progress during this period.

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

   Additional yield distribution data have been obtained for fission of uranium with high energy protons.

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

   Work continues on milking experiments.

7. Attempt preparation of elements 97 and 98.

   No progress during this period.

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

   The neutron irradiated plutonium plus americium plus curium is undergoing chemical separations.

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 radiations of Pu^{234} have been better characterized. Additional data concerning the alpha decay of the long-lived isomer of Am^{242} and of Am^{243} have been obtained. An apparatus has been constructed for counting spontaneous fissions with coincident scintillation counters. Equipment is under construction to measure the energy distribution of spontaneous fission fragments.

CONFIDENTIAL

Nuclear Chemistry (Chemistry)

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

See item 8, page 24.

11. Chemical identification of the products from nuclear reactions with 350 Mev Protons.

A large amount of the work outlined under items 1, 2, 5, 6 and 9 is done with high energy protons.

12. Study of meson reactions by chemical means.

Some iodine isotopes have been characterized for use in interpretation of abnormal reactions on tin.

13. Development of chemical analysis techniques utilizing radioactive tracers.

No progress during this period.

CONFIDENTIAL

Chemistry of Heavy Elements

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

No progress during this period.

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

No progress during this period.

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

No progress during this period.

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

Work is in progress to analyze the rare earth fluorides which are suspected of being divalent. Additional experiments have been done on determination of the equilibrium constant for the high temperature hydrolysis of lanthanum chloride.

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

No progress during this period.

Chemistry of Heavy Elements (Continued)

CONFIDENTIAL

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

No progress during this period.

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

No progress during this period.

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

Work continues on the isotopes of astatine, and on milking of polonium daughters.

9. Other experiments.

Praseodymium oxide has been mounted in the high-temperature x-ray camera for study of its crystal structure at high temperature.

High Temperature and Pile Chemistry

SECRET

1. Metals and high temperature thermodynamics.

Work is in progress on refractory studies, thermodynamics of CN and N_2, absorption coefficients of CN and C_2, thermodynamics of molybdenum halides and oxides, thermodynamics of gaseous aluminum and iron oxides and hydroxides and low melting metal systems.

2. Basic chemistry. Solvent extraction.

Studies are being made on the exchange of iodine atoms between iodate ion and iodine, the chelate complex of lanthanum with TTA, and the thermodynamics of rhenium.

3. Engineering development of plutonium separation.

Investigations are being pursued on solvent extraction using the chelate process and pilot plant design for TTA synthesis.

4. Ore reduction.

Subjects under investigation are solvent extraction using the chelate process, a method for determining the oxidation state of uranium. In addition the construction of a photomultiplier is nearing completion to be used in fluorimetric determination of micro amounts of uranium.

Plant and Equipment UNCLASSIFIED

1. Bevatron Building.

Recommendations of the consulting geologist have required further excavation and drainage. Work on this phase is nearing completion so that placing of pipe and compaction may continue. Bids are being solicited on the bevatron building and it is hoped that the contract can be awarded before June 30, 1949. Plans are being made for the assembly of the magnet steel for the full-scale bevatron. Present plans call for either renting an assembly shop or letting a contract for the assembly. Other phases of the work are progressing according to schedule.

2. Central Research Laboratory Building.

The finishing work on the Central Research Laboratory Building is continuing. The elevator will be in service this week. It is anticipated that the glazing will start shortly. Waterproofing and plastering are continuing, as is the roofing.

3. Construction of Animal House and Cafeteria.

Preliminary plans have been submitted on the cafeteria and approval is being sought from the Regents of the University of California. The animal house is being delayed pending finishing of design of the cafeteria.

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

The contract has been awarded for the construction of the first building to house electricians, plumbers and maintenance machinists. It is anticipated that work will begin this week. The second building is scheduled for next fiscal year.

5. Miscellaneous Construction.

Warehouse. Excavation is essentially complete and grading is nearing completion. Work is in progress on drainage facilities to remove excessive ground water.

Alterations to Laboratory Buildings. Work in the Old Radiation Laboratory is in the finishing stage. Room 306, Donner, will be started shortly.

Power Distribution. The ditch digging for the 12 kv line from the campus substation to the hill area substation is about one-half finished. Laying of conduit is getting underway.

Plant and Equipment (Continued) UNCLASSIFIED

5. Miscellaneous Construction (Continued)

Fire Protection. Installation of pipe into new area is continuing.

Parking Lot. Excavation, grading and sub-base have been completed. Job should be completed this week, except for bumpers.

Connecting Road. Complete except for posts and signs.

Univ. of Calif. Hospital Radiological Laboratory. The site has been chosen and preliminary drawings are being studied for the building. An order is being placed with General Electric for a 70 Mev synchrotron.

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 fate of Np^{237} has been worked out in rats. The primary organ of deposition is the skeleton when this material is administered as the citrate complex.

2. Decontamination studies.

Use of massive decontaminant doses of Zr citrate tagged with Zr^{95} simultaneously with tracer doses of Y^{90} to study the mechanism of decontamination. Radioautographs of Ca^{45} in rachitic bone at various time intervals after administration to determine changes in distribution. Study of the effect of growth hormone in increasing the severity of rickets and the elimination of Ca^{45} from bone.

3. Radioautographic studies.

Radioautographic studies are continuing with plutonium and praseodymium. Further experiments using element 61, plutonium and strontium to study the uptake at the costochondral junction will be set up shortly.

4. Radiochemistry.

Na^{22}, Zn^{65}, Mu^{54} and $Co^{56,57}$ has been prepared by separation or isolation. Chemical activation of Br^{80} by isomeric transition has been studied in NaBr protein solutions. Citrate solutions of Cb-Zr mixture are being prepared.

Medical Research at Donner Laboratory UNCLASSIFIED

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

   This work is discontinuing as explained in the last monthly report.

2. Biological effects of radiation.

   When one member of a pair of parabiotically united rats was subjected to 900 r of x-rays, both members of the pair lost their hair. It is suggested that metabolic disturbances are induced in the irradiated animal which induces epilation in the co-twin as a result of circulatory exchange. The un-irradiated animal got approximately 25 r scattered radiation.

3. Biological effects of high energy neutrons.

   Continuing use of 184-inch cyclotron.

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

   Contingent upon completion of animal house.

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

   Experiments on biological aspects of 190 Mev deuterons have been resumed and a large number of rats and mice carrying tumors have been exposed to this high energy beam. As found previously, it is possible to pass the beam directly through the animal and direct it against the tumor on the other side of the animal with destruction and disappearance of the tumor in about half of the animals.

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

   This work is continuing in the study of the utilization of simple organic compounds labeled with radioactive carbon. Recent investigations with carboxy-labeled propionic acid has shown that there is an altered rate of oxidation of this material in a group of tumor animals as compared with normal animals when the exhaled radioactive CO_2 is measured. When the label is in the methyl position such differences are not found. This is being investigated.

Medical Research at Donner Laboratory (Continued) UNCLASSIFIED

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

   See item 1 in regard to the reticuloendothelial system. Immunity studies mainly have been transferred to Hunter's Point Laboratory.

8. Microchemical assay of tissue components by induced radioactivity.

   analysis by induced activity is being investigated and new samples of normal and tumor tissue have gone into the pile for exposure.

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

   Continuing.

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

    Studies of metabolism measured by the utilization of simple organic compounds such as valenate, alanine, and one labelled glucose are being pursued.

11. Study of genetic effects of radiation.

    Genetic effects of irradiation are continuing.

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

    Work is in progress.

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

    This work is being carried forward with the aid of radioactive isotopes, the ultracentrifuge, and the electrophoresis apparatus.

14. Metabolic studies on normal and leukemic cells.

    This study is continuing.

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

    This work is continuing.

Medical Research at Donner Laboratory (Continued) UNCLASSIFIED

16. Studies with radioactive iron, cobalt, stilbamidine and water.

In using Fe^{59} a method has been developed for measuring the rate at which iron disappears from the plasma and is incorporated into hemoglobin.

The study of the distribution of radioactive cobalt in normal and polycythemic rats has been completed.

In studies with radioactive stilbamidine, excretion figures have been obtained in experiments with mice. Tissue distribution studies are not yet completed. Clinical trial in patients with multiple myeloma seems to be indicated.

In mixing curves of injected radioactive water and total body water determinations are being carried out on animals and men.

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

1. Effects of external irradiation of the whole body.

Hematology technician on vacation.

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

Hematology technician on vacation.

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

A total of 26 doses was given, 17 as uptake studies and 8 in therapeutic amounts. In one case of metastasized carcinoma in which the tumor accepted iodine, the patient received 85 microcuries, the uptake being determined by urine excretion.

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

No work is being done under this title.

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

No work is being done under this title.

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

No work is being done under this title.

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

7. Other experiments.

Experiments to determine the clinical value of an ionization chamber have been started.

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.

The study of the mechanism of the Tiffeneau ring expansion has continued. Attempts are being made to formulate a mechanism for the free radical decomposition of acetyl peroxide in acetic acid solution based on results obtained with labeled acetic acid.

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.

Work on a high specific activity preparation of Codeine-C^{14} is being concluded, and work has begun on a series of lactic acid preparations for distribution. In addition, some sodium acetate-2-C^{14} and methyl iodide-C^{14} is being prepared for shipment.

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

The study of the following compounds continues: leucine-α-C^{14}, valine-α-C^{14}, lactic acid-1 or 2 or 3-C^{14}, Demerol-1-Methyl-C^{14}, glucose-1-C^{14}, mannose-1-C^{14}, isoleucine-α-C^{14}, valine-methyl-C^{14}, cyclohexanone-2-C^{14}, malic-methylene-C^{14} acid. Numerous intermediates are being prepared in the synthesis of these compounds.

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

Work on the fate of radiocarbon injected in the blood stream or taken into the lungs as barium carbonate has been concluded. The in vitro studies of propionate-1-C^{14} metabolism has continued and the in vivo studies of the metabolism of simple metabolic compounds to $C^{14}O_2$ has been extended.

Organic and Biological Chemistry (Continued) UNCLASSIFIED

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

The study of dark respiration of photosynthetic products has continued with barley seedlings and algae to determine the differences in rate. The compounds involved in dark fixation are being determined to find the acceptor molecule for CO_2 in photosynthesis.

Health Physics UNCLASSIFIED

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

Such measurements are in preparation for the synchrotron.

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

Work is continuing.

3. Controlled exposure of animals in neutron beam.

Program in progress under Medical Physics.

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

Nothing new to report.

5. Other developments and studies.

Shielding studies are continuing.

Health Chemistry UNCLASSIFIED

1. Shielding - materials, stopping power, geometry.

Studies are being made of appropriate material and design to be used in containers with maximum efficiency in shielding, especially for economy of shipping weight.

Health Chemistry (Continued) UNCLASSIFIED

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

   Present techniques are being put to further practical use; of special interest during this period was the commencement of the processing of a special pile sample in a straight-type cave, using remote control manipulations.

3. Plutonium slug design for use in piles.

   No further work on this is contemplated at present; current slug is satisfactory.

4. A "Cow" for milking americium from plutonium.

   Since the first container for plutonium for cow has proved satisfactory, additional containers are being built.

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

   No further development during this month.

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

   Design development and tests of filters is being continued.

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

   Decontamination annex is awaiting construction.

8. Design of special target holders for active material.

   "Jiffy" probe for short-lived isotopes is being tested.

9. 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 Devolopment; statements on progress are beyond the scope of these comments.

10. 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 are being made.

APPROXIMATE DISTRIBUTION OF EFFORT

PROGRAM	SUBDIVISION	MAN MONTHS EFFORT	COMMENTS
184-inch Cyclotron	Operation	10.6	
60-inch Cyclotron	-	-	Non-project
Synchrotron	R.f. System	.8	
	General	.3	
	Injection	1.4	
	Miscellaneous	.8	
	Magnet Tests and Operation	5.9	
	Vacuum Chamber	-	
Linear Accelerator	Linear Accelerator - General	2.2	
	Van de Graaff - General	1.9	
	Development	6.9	
Bevatron	Injector	.1	
	Magnet	3.0	
	1/4 Scale Model Construction	-	
	Miscellaneous	.3	
	1/4 Scale Model Operation	6.6	
Experimental Physics	Cloud Chamber	5.1	
	Film Program	8.4	
	Ionization Chamber and Crystal Counter	1.2	
	Neutron-proton Scattering	2.5	
	Proton-proton Scattering	2.0	
	Neutron Diffraction	.2	
	Meson Range and Decay Measurement	1.8	
	Absolute Cross Section Measurements	3.1	
	Neutron Half Life	.5	
	General Physics Research	9.4	
	Magnetic Measuring Equipment	.9	
	Instruments for General Use	2.0	
	Meson Experiments with Synchrotron	1.5	
	Scintillation Counters - Research Experiments	1.1	
Theoretical Physics	Synchrotron		
	Bevatron	1.2	
	Cyclotron	.3	
	General Physics Research	11.6	
Isotope Separation	Nier Spectrometer	1.2	
	Low Mass Spectrograph	.2	

Approximate Distribution of Effort (Continued)

PROGRAM	SUBDIVISION	MAN MONTHS EFFORT		COMMENTS
Chemistry, Part A	Chemistry of Transuranic Elements	5.8		
	Nuclear Properties of Transuranium Elements	4.0		
	Transmutation with the 184-inch Cyclotron	7.3		
	Transmutation with the 60-inch Cyclotron	-		
	Analytical and Service	15.3		
Chemistry, Part B	Synthetic and Experimental Chemistry	6.8		
	Biological Chemistry	5.5		
	Photosynthetic Chemistry	6.6		
Chemistry, Part C	Metals & High Temperature Thermodynamics	3.0		
	Basic Chemistry, including Metal Chelates	1.0		
	Engineering Development of Plutonium Separation	2.0		
	Ore Reduction	3.5		
	General	4.5		
Medical Physics Part A, Div. I	Metabolism of Fission Products	11.0		
	Decontamination Studies	7.0		
	Radiochemistry	3.0		
	Radioautography	2.0		
Medical Physics Part B, Div. II	Tumor Metabolism	1.7	1.7	Consultant Man Months
	Special X-ray Studies, Radioactive Measurements, etc.	3.9	3.2	
	Radioactive Carbon Studies	1.0	.1	
	Fundamental Medical Research	2.7	3.7	
	Hematology	.4		
	Medical Work with the 184-inch Cyclotron	2.9	1.4	
	Fly Genetics	2.0	.2	
	60-inch Cyclotron Bombardments	.4	-	
	Physical Chemistry	3.4	-	
	Specific Irradiation	3.5	.2	
Health Physics and Chemistry	Monitoring and Disposal	6.4		
	Salvage, Decontamination, etc.	-		
	Research and Development	13.8		
	Film Badge Program	5.0		

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