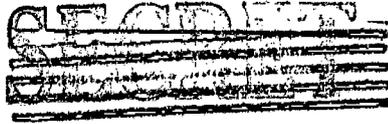


DECLASSIFIED

UCRL $\frac{361}{Cy 15/A}$



UNIVERSITY OF
CALIFORNIA

Radiation Laboratory

TWO-WEEK LOAN COPY

This is a Library Circulating Copy
which may be borrowed for two weeks.
For a personal retention copy, call
Tech. Info. Division, Ext. 5545

BERKELEY, CALIFORNIA

UCRL-361
e2

DISCLAIMER

This document was prepared as an account of work sponsored by the United States Government. While this document is believed to contain correct information, neither the United States Government nor any agency thereof, nor the Regents of the University of California, nor any of their employees, makes any warranty, express or implied, or assumes any legal responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by its trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or the Regents of the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof or the Regents of the University of California.

DECLASSIFIED

~~SECRET~~

UCRL 361

UNIVERSITY OF CALIFORNIA

Radiation Laboratory

Contract No. W-7405-eng-48

CLASSIFICATION CANCELLED

BY AUTHORITY OF THE DECLASSIFICATION
BRANCH USAEC

BY *B. J. Bennett* *101113*
SIGNATURE OF THE PERSON MAKING THE CHANGE
DATE *3-31-86*

PROGRESS REPORT No. 73

April 15 to May 15, 1949

CAUTION

This document contains information affecting the National Defense of the United States. Its transmission or the disclosure of its contents in any manner to an unauthorized person is prohibited and may result in severe criminal penalties under applicable Federal laws.

Berkeley, California

UNCLASSIFIED

Operating Model Conversion. Design work has started on the conversion of the quarter scale operating model to obtain the full 16 kilogauss field strength. This change necessitates the reduction of the aperture to 3 x 12 inches, the installation of pole pieces, and the replacement of the air cooled coils with water cooled coils. The installation of three flywheel generators already obtained from War Surplus is also required. With these changes and the installation of the 4 Mev injector linear accelerator mentioned above, the instrument should produce protons of 1 Bev energy.

2. 184-inch Cyclotron OperationUNCLASSIFIED

The cyclotron was used for research purposes ninety-three percent of the 483 hours that the crew was on duty.

A carbon brush to bypass the radio-frequency current around the rotary condenser support ball bearings was tried. This did not work satisfactorily and the old molybdenum type brushes were reinstalled.

3. 60-inch Cyclotron OperationUNCLASSIFIED

The 60-inch cyclotron has not been in operation during the major part of the period due to the burning out of the east dee stem liner. The instrument is undergoing major repairs and remodeling.

4. Synchrotron OperationUNCLASSIFIED

The injector with a slot in the ground shielding in the back appears to be a promising device for increasing the machine output. Several experiments were made on the best position and width of this slot. The best performance to date has given an increase in output of approximately five times the previous best performance.

The synchrotron has been dis-assembled in order to perform several repair jobs and to replace temporary equipment. The following list of items covers most of the revisions and repairs which will be completed when operation is resumed:

1. Installation of additional magnet winding clamps to prevent motion of the cable.
2. Replacement of compensating coils with heavier gauge wire.
3. Installation of remotely controlled flux bar reactors.
4. Installation of "n" coil adjustments in control room.
5. Installation of a beam integrating meter in control room.
6. Replacement of diffusion pumps with stiffer structure to reduce vibration.
7. Removal of the "n" coil lead terminal block from the beam path.
8. Inspection of the vacuum chamber for insulating patches.
9. Installation of bias coil covers and reversing switch.
10. Size of the fuses in compensating circuits increased.
11. Incorporation of patch panel and time delay controls in control desk.
12. Installation of more adequate insulation on tie bolts and the location and repair of tie bolt grounds.
13. Installation of butyl rubber segment connectors.
14. Removal of the high voltage bleeder from the capacitor room.

UNCLASSIFIED

15. Redesign of the door signal pickup to prevent the possibility of high voltage reaching the control desk in case of insulation failure.
16. Installation of a blower to cool the injector segment.

5. Linear Accelerator and Van de Graaff Operation UNCLASSIFIED

Because the electricians have had considerable work to do in the linear accelerator bombardment area, the machine has been run only at night. The beam was measured and is up by a factor of 10 over the previous beam values. It is expected that more than this will be obtained when the duty cycle of the radars is doubled and the Van de Graaff ion source opening increased.

Facilities were installed for letting equipment down to dry nitrogen from the Van de Graaff supply instead of air. The pumpdown time for experiments should be greatly decreased by this.

The refrigerator to be put in the Van de Graaff will be installed in about two weeks and this is expected to give better operation with less x-ray background. A buncher cavity is being readied also, although it is not planned for immediate installation. This will increase the beam by insuring that the protons arrive in the proper phase for acceleration in the linear accelerator tank.

6. Experimental Physics

RESTRICTED

Film Program. A study is now in progress to find the relative number of negative π mesons created by protons of various energies. The energies were obtained by placing the targets at different radii in the 184-inch cyclotron. The study is limited to star-producing mesons with energies of approximately 2-6 Mev emitted within $\pm 45^\circ$ of the forward direction from a 1/32-inch carbon target. Eastman type NTB Plates were used to record the mesons.

Preliminary data is given in the table. Column 1 gives the energy of the bombarding protons; column 2, the numbers of mesons actually counted; and column 3, the numbers of mesons relative to the number at 340 Mev, corrected for beam current, plate thickness, and area scanned.

<u>Beam Energy (Mev)</u>	<u>No. of Mesons</u>	<u>Corrected Relative Yield</u>
340	22	100 percent
306	41	43 percent
272	22	27 percent
238	5	5 percent
204	2	1 percent
170	0	0 percent

Plates have been successfully exposed to the deflected proton beam, and data are now being compiled on the angular distribution from approximately 15° to 165° and the energy distribution up to 150 Mev of mesons produced in a carbon target. Preliminary results at 90° , with meson of approximately 50 Mev energy, show a ratio of π^- to π^+ of 1.4.

RESTRICTED

Cloud Chamber. Cloud chambers have been operated in the neutron beam and the deflected proton beam of the 184-inch cyclotron as well as in the x-ray beam of the synchrotron. Pictures of mesons have been obtained in the neutron beam. Various kinds of collimation have been tried in the deflected proton beam.

Magnetic Energy Discrimination Method. Further experiments to determine the energy distribution of the high energy neutron beam produced by protons accelerated in the 184-inch cyclotron have been made, using the magnetic method of energy discrimination. In addition, some general investigations of this method have been undertaken in order to determine the feasibility of using it to measure angle and energy distributions of particles produced in various nuclei bombarded with 270 Mev neutrons.

High Energy Photons Produced by Bombarding Nuclei with 100 Mev Particles. Investigations of the high energy quanta emitted by the cyclotron target have been continued using 180° and 90° pair counters with a resolution of .2, that is the width of each energy interval is about .2 of the mean energy. The energy range of the quanta investigated extends from 30 Mev to 200 Mev.

The most that can be said about the origin of quanta produced by 350 Mev protons is as follows: they are not heavy particle bremsstrahlung, and they are not due to nuclear excitation. The results are consistent with the existence of some intermediate particle formed in a high energy nucleon-nucleon collision, which then decays with the emission of at least one quantum. The intermediate particle could be for example either a neutral meson of mass 300-400 electron masses, or an excited nucleon. Some preliminary investigations of the relative yield of these quanta as a function of proton energy have been made.

Measurement of Total Cross Sections of Nuclei for 40 Mev Neutrons. Measurements of the total cross sections of nuclei are being made using the 40 Mev neutron beam produced in the 184-inch cyclotron by the stripping of 90 Mev deuterons in a 1/2 inch thick Be target. The method of detection is that used by Cook, McMillan, Peterson and Sewell in making similar measurements for 90 Mev neutrons. The neutron intensity is determined by counting the 20 min C^{11} positron activity resulting from the $C(n, 2n)$ reaction in carbon discs. The threshold for this reaction is about 20 Mev. The average energy detected is 40 ± 2 Mev.

90 Mev Neutron Differential Scattering Cross Sections. During this period it was felt desirable to bring this program to a reasonable conclusion as soon as possible at its present status with the completion of a report of the experimental results. What might be considered the final experiment in this program was completed in April, and consisted in a redetermination of total cross sections by means of the recoil proton proportional counters, and a full report is in progress.

Mass Spectrograph. An emission voltage meter and a separate meter for the trap current have been added. Switching circuits have been built for each recorder with nine different outputs for greater flexibility. A new sample system has been designed and installed, but not tested, using a 10 liter reservoir and a leak which is $\sim .001$ " diameter. With about 20 microns sample pressure there should be molecular flow only.

A sample of deuterium was run. The results showed the presence of about 5 percent atomic hydrogen. This will be repeated with greater accuracy when the new sample system is operating.

RESTRICTED

Total Cross Sections for 270 Mev Neutrons. Measurements of nuclear total cross sections for 270 Mev neutrons with bismuth fission counters were continued. In particular the cross sections of hydrogen and deuterium were determined. The deuterium cross section was $.059 \pm .003$ barns and the hydrogen cross section was $.039 \pm .002$ barns, which agreed with the previous measurement of $.037 \pm .002$ barns. The elements measured from deuterium to tin have total cross sections at 270 Mev which are all practically .575 times their values at 95 Mev.

The second draft of the report of the 95 Mev cross section work is practically completed.

Neutron-proton Scattering. Several experimental runs have been made during the month and a curve obtained for the angular distribution of the scattered protons. It remains to evaluate the correction due to nuclear absorption in the absorber which is placed in front of the counters, the total hydrogen cross section, and the energy distribution of the primary neutrons.

7. Theoretical PhysicsUNCLASSIFIED

In a study of neutron-proton scattering it has been shown that an exponential well gives a smaller cross section than a Yukawa well, and that most of the discrepancy between the observed and calculated total cross section is thus removed. Possible long range tails are being investigated.

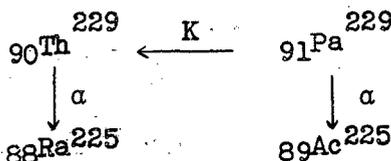
At the moment it does not seem possible to fit the proton-proton scattering results with scattering by a potential. More accurate experimental results are being awaited. Calculations are also in progress on the scattering of protons and neutrons on deuterons.

No explanation has been found for the large negative-positive ratio of synchrotron produced mesons. A ratio of three is expected for proton produced mesons. Calculations of the γ -ray spectrum expected from neutral meson decay are in progress.

8. ChemistryCONFIDENTIAL

Part A

Relation of Decay Energy to Electron Capture Half-Life. The available data for isotopes heavier than lead have been examined with regard to decay energies and half-lives for orbital-electron capture. In sixteen cases it is possible to deduce total decay energies from cycles of the type:



$$\begin{aligned}
 E_K(\text{Pa}^{229}) &= E_\alpha(\text{Pa}^{229}) + E_{\text{recoil}}(\text{Pa}^{229}) - E_\alpha(\text{Th}^{229}) \\
 &= E_\alpha(\text{Th}^{229}) - E_\beta(\text{Ra}^{225}) \\
 E_K(\text{Pa}^{229}) &= 0.5 \text{ Mev}
 \end{aligned}$$

CONFIDENTIAL

In some cases recourse was made to energies for alpha decay estimated from the alpha systematics. The observed half-lives were corrected as well as possible for the effects of alpha decay branching, to give the half-life for the electron capture process.

A plot of half-life against total decay energy for these data shows surprising regularity. Eleven cases of odd-even and even-odd isotopes fall reasonably well on a smooth curve. These isotopes in most cases have little or no observed hard gamma radiation, and it may be that many of these transitions are between the ground states. Five cases of odd-odd isotopes have longer lifetime for corresponding energy, and form a second higher curve. Some of these transitions involve more gamma radiation, and the decay energy in each case for the principal mode of decay is not known.

If one plots on logarithmic scales the half-lives vs. decay energies less the K binding energy, the data for the odd-even and even-odd cases approximate a straight line of slope corresponding to about fourth power dependence of half-life on energy.

For equal decay energy, electron capture seems to be slower than beta decay for heavy isotopes.

No electron capture data of this type are available for even-even nuclei.

Excitation Curves for High Energy Transmutations. Experiments are in progress to determine excitation curves for reactions with high energy particles using a stacked foil technique and the electrostatically deflected beam in the 184-inch cyclotron. A measurement has been made on the reaction $\text{Th}^{232}(p,6n)\text{Pa}^{227}$. It shows a threshold at ~ 50 Mev and a rather sharp maximum at 90 Mev, contrary to earlier crude experiments in which the sharp maximum was not observed. The sharp maximum indicates that the compound nucleus mechanism is still important in this kind of reaction.

Neutron Deficient Astatine Isotopes. A number of astatine isotopes lighter than At^{210} have been known for some time, but no precise mass assignments were known. Recent measurements of the ratios of Po^{208} , Po^{209} , and Po^{210} formed by decay of astatine samples purified at various intervals subsequent to a bombardment give approximate values for the half-lives of At^{208} and At^{209} . Taking the At^{210} half-life as 8.5 hours as an internal standard to correct for chemical losses, that of At^{209} is 3 ± 2 hours and of At^{208} is 6.5 ± 0.5 hours.

A consequence of this result is that, except for the unlikely event of a long lived isomer, there is probably no isotope of astatine with half-life greater than 8.5 hours. Until now, At^{209} was the best chance for a long-lived astatine.

It also seems likely that, like promethium and technetium, astatine has no beta stable isotopes. The only remaining possibilities, At^{213} , At^{215} , and At^{217} , are estimated to be heavier than neighboring isobars, but by small amounts which are not outside experimental error.

Metastable Isomer of RaE. A long-lived bismuth alpha-emitter (5.0 Mev) was found some time ago in a sample of bismuth which had undergone prolonged neutron irradiation. Recently a better sample of it was isolated and milked for thallium. A four-minute beta activity was found. If this is 4-minute Th^{206} , the long-lived alpha

-8-

CONFIDENTIAL

emitter is an isomer of Bi^{210} (RaE), excited by about 0.2 Mev. Such an isomer is unstable with respect to four processes: alpha emission, beta decay to Po^{210} , isomeric transition to RaE, and electron capture to RaD.

The assignment of the 4-minute thallium to 206 rather than 204 has been confirmed recently by neutron irradiation in the Clinton pile of samples enriched in Tl^{203} and Tl^{205} respectively. There remains of course a possibility of an undetected isomer of Tl^{204} with similar half-life.

Evidence for Bi^{205} . Periodic milking of bismuth from a mixture of polonium isotopes has shown that 6-day bismuth activity is formed at a rate corresponding to a parent of half-life approximately 1-4 hours mixed with the 9-day Po^{206} which is already known to decay to 6.4 day Bi^{206} . This half-life agrees well with the 1.5-hour electron capture activity which has been assigned to Po^{205} by yield arguments. Thus it is concluded that Bi^{205} has a half-life of about 6 days. It has long been known that Bi^{206} must be very short, very long, or nearly 6.4 days to escape detection in other experiments.

Crystal Structure of Mo_3Si . The crystal structure of Mo_3Si has been determined from powder diffraction patterns. The lattice is cubic, with $a_0 = 4.888 \pm 0.002$ and 4.901 ± 0.002 for two different samples. In both cases other phases were present, and it is not known what dimension corresponds to the ideal composition. The structure is like β -tungsten, with two silicon atoms and six molybdenum atoms to each cubic cell. The isomorphous compounds Cr_3Si and V_3Si were already known.

ChemistryUNCLASSIFIED

Part B

Synthetic and Experimental Chemistry. The preparation of low specific activity lactic acid- 1-C^{14} has been completed. Approximately 65 percent yield based on CO_2 was obtained after one recrystallization of the zinc lactate. Another high activity preparation of codeine-methoxy- C^{14} has been undertaken to prepare material for distribution by the Isotopes Division of the Atomic Energy Commission.

The synthesis of isopropyl bromide by the reaction of labeled methyl magnesium iodide with acetaldehyde has been carried out on a low specific activity run. The yield of isopropyl alcohol based on CO_2 was 57 percent and of isopropyl bromide was 42 percent. Work has continued on new techniques for the reduction of carboxyl acids using lithium aluminum hydride.

Cold runs for the preparation of carboxyl-labeled isobutyric acid and isovaleric acid have been completed with yields based on CO_2 of 95 percent and 97 percent, respectively. In addition, the study of the preparation of the following compounds is continuing: alanine- 3-C^{14} , leucine- $\alpha\text{-C}^{14}$, leucine- $\beta\text{-C}^{14}$, valine- $\alpha\text{-C}^{14}$, isobutyl bromide- 1-C^{14} , oxalacetic acid-methylene- C^{14} , fumaric acid- C^{14} , dl-malic acid- C^{14} , dl-succinic acid- C^{14} , pyruvic acid- C^{14} , Demerol-N-methyl- C^{14} , glucose- 1-C^{14} and mannose- 1-C^{14} .

The mechanism of the Tiffeneau ring expansion is being studied with cycloheptanone and cyclohexanone. In addition, it is planned, if yields are satisfactory, to use these compounds as possible intermediates in the synthesis of ring-labeled

UNCLASSIFIED

aromatic compounds.

Counting experiments using a commercial flow-gas counter and a counting gas mixture composed of helium (commercial grade) saturated with ethanol at 0° C and dried with Drierite have been performed. The results thus far look very satisfactory. The results are better using this gas than the argon-butane mixture supplied with this commercial counter.

Biological Chemistry. The in vivo exchange of barium carbonate and carbon dioxide is being studied in mice by intravenous injection or inhalation of labeled barium carbonate. In both cases most of the radioactivity is exhaled as carbon dioxide. In the animals already studied, during the first eight to twelve hour period 45-95 percent of the given dose is observed in the breath. An interesting conclusion, is that barium carbonate accidentally taken into the blood stream or the lungs will exchange carbon and become inactive and thus eliminate the danger of localized radiation.

In the study of the overall body metabolic picture for stilbamidine labeled in the amidine carbon atom, mice have now been injected and autopsied at two, four, six, ten and twenty-four hour periods and four and thirty-day periods. The results of the autopsies have not yet been completely assembled.

Work has continued on the study of the rate of metabolic oxidation of propionate-1-C¹⁴ to carbon dioxide with in vitro Warburg tissue slice experiments. It has been found that in four hours approximately 30 percent of the propionate is oxidized to C¹⁴O₂ and some 65 percent of the activity remains as propionate. The identity of the 5 percent of the radioactivity in the form of non-volatile compounds is being studied.

In the study of the rate in mice of oxidation to C¹⁴O₂ of simple labeled organic compounds two additional compounds, glucose and sodium butyrate, have been analyzed.

Photosynthetic Chemistry. In the investigation of respiration and photosynthesis the relation of algae to barley has been studied for comparison with our kinetic experiments on barley. The same general reactions are found in barley as in the algae. Radiograms have been obtained from the following experiments: (1) 50 minute dark C¹⁴O₂ fixations; (2) 30 second photosynthesis in C¹⁴O₂; (3) 30 second photosynthesis-2 minute dark in CO₂-free air; (4) 30 second photosynthesis-2 minute light in CO₂-free air; (5) 30 second photosynthesis-40 minute dark in CO₂-free air; and (6) 2 minute dark fixation of C¹⁴O₂ by barley preilluminated in pure nitrogen.

Resolution of the hexose monophosphate-inorganic phosphate fractions obtained from previous ion exchange resin separations is being investigated. A number of chromatographic solvents as well as different resin-eluting conditions have been tried in order to separate these compounds.

Chemistry

Part C Project 48B

SECRET

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

-10-(Revised Page)

SECRET

1. Refractory studies.
2. Thermodynamics of CN and N₂.
3. Absorption coefficients of CN and C₂.
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.
8. Design of decontamination processes for high temperature power piles.

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.

Ore Reduction. The following subjects are being investigated.

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 5i2 Fluorimeter is being calibrated for use in conjunction with this work.

9. Medical Physics

Part A

UNCLASSIFIED

Tracer Studies. Preliminary tracer studies on carrier-free selenium have been initiated. These studies show that part of this radio-element is lost in the expired air. However, the primary route of excretion is urinary. There are no decided areas of specific localization in the body of the selenium which was retained one day after intramuscular administration. The studies on carrier-free praseodymium have been completed as well as the correlated studies involving complexing agents, praseodymium carrier and neodymium carrier.

Decontamination Studies. An experiment has been set up in which massive decontaminant doses (40 mg. Zr) of zirconium citrate tagged with freshly separated Zr⁹⁵ were administered to rats by intraperitoneal injection simultaneously with carrier-free Y⁹⁰. The animals were sacrificed after 24 hours, and the distribution, bone uptake and excretion are being determined. The two isotopes will be distinguished in the same animals by differences in half-life (Y⁹⁰ - 60 hrs., Zr⁹⁵ - 65 days). By determining how closely the metabolism of Y⁹⁰ parallels that of the carrier Zr, it is hoped to obtain some estimate as to how much the therapeutic action of Zr is due to a "carrier" effect.

In bone metabolism studies the administration of pure growth hormone to phosphorus deficient rats was found to increase the severity of the rickets, and to reduce considerably the uptake of radiostrontium in the bones of these animals.

Radioautographic Studies. Radioautographic studies with praseodymium in bone, and plutonium in scar tissue have not been completed as yet. Experiments are continuing using bony tissue mounted on NTB plates. The staining of the gelatine continues to be a major problem.

UNCLASSIFIED

Further experiments on the uptake of strontium in the costochondral junction of rachitic and control rats are in the process of being set up.

Radiochemistry. 200 microcuries of carrier-free Se^{75} were separated from a deuteron bombarded arsenic target using a previously described method. A method has been developed for the separation of carrier-free Ta^{182} from alpha bombarded hafnium. The Ta activity was found to carry on MnO_2 in 10 N HNO_3 .

Additional data has been obtained on the distribution of At^{211} in the rat. The results agree with previously reported data.

Carrier-free Zn^{65} is being separated from a copper target using a dithizone extraction method. A method is being worked out for the separation of carrier-free Mn^{54} and Co^{56} from a deuteron bombarded iron target.

Several solutions of Cb^{95} have been prepared for injection.

Medical PhysicsUNCLASSIFIED

Part B

The hazard of inhaled barium radiocarbonate dust particles has been reviewed recently. Particular concern has been manifest for the hazard in our own laboratory. The prepared carbonate precipitates are heated to drive off structural water and this process produces a desirable state of slow exchange with atmospheric carbon dioxide. This reduced exchangeability of the barium carbonate due to heating might render it an inert compound in the body so that if fixed to any site it might stay indefinitely accumulating with time detrimental levels of tissue irradiation. Our first experiments have been the intravenous injection of suspensions of barium radiocarbonate (heated). Much of this coarse suspension is trapped in the lungs. The rest is apparently phagocytized by the liver and spleen. Eighty percent of the radiocarbon is eliminated in 8 hours indicating a rapid biological exchange rate. However, the physiological situation of these particles is not quite the same as dust particles which might be inhaled into the deep passages of the lungs and fixed in the lung tissue by phagocytic cells. Therefore, we are in progress of trying the additional experiments of insufflating barium carbonate into the lung.

It is likely, however, from these preliminary results that barium carbonate in any contact with body cells will undergo exchange of carbonate whether it had been heated or not and that the hazard of minute dust particles of radiocarbonate is not enhanced by indefinite insitu retention.

10. Health Physics and ChemistryUNCLASSIFIED

Studies. Work is progressing on measuring the spatial distribution and energy spectrum of the slowed down neutrons in the concrete shielding surrounding the cyclotron. Neutron flux above 20 Mev as determined by the $\text{C}^{12}(n,2n)\text{C}^{11}$ reaction was found to decrease by 1/2 in 1 foot of shielding which is the same decrease that is approached by the thermal and Indium resonance neutrons. Work is being done to give more data on the energy spectrum.

In addition to the routine monitoring and decontaminating service and the disposal of active waste products the Health Chemistry Group completed and installed three gloved boxes and have two special boxes about 50 percent complete. Preparations have also been made for the handling of a special sample from Hanford.

SUMMARY OF RESEARCH ACTIVITIES

April 15 to May 15, 1949

60-inch CyclotronUNCLASSIFIED

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

Plans are being developed during the present major overhaul for continued activity in this field.

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

Design is about completed and fabrication underway for immediate installation of the equipment - about June 15th.

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

New 72" pole tips are under fabrication and are destined for installation about May 27th.

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

New target holders are under design and are being tested.

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

Filament remote control is completed and will be installed with other new equipment.

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

Temporarily suspended. Considerable testing is needed and the time is not now available.

7. Other developments.

Complete rewiring of control circuits is underway designed to provide more flexibility in the system. More spare circuits are being provided.

184-inch CyclotronUNCLASSIFIED

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

Generator and motor have been delivered. Waiting now for building to house the motor generator.

184-inch Cyclotron (Continued)UNCLASSIFIED

2. Development of improved beam monitoring equipment.

Still under design and construction.

3. Construction of proton beam deflector.

This deflector was installed last month.

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

Still under design and construction.

5. Other developments.

A new collimator for the deflected beam is in the shop. This should provide excellent collimation, because the hole can be aligned accurately in the direction of the beam.

300 Mev SynchrotronUNCLASSIFIED

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

Injector with slot on back has increased output from 1 R/hr to 4.5 R/hr.

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.

None during this month.

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

A study of mesons produced in photographic emulsions by the 300 Mev x-ray beam is underway. A number of plates have been exposed and are being analyzed.

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

No work done under this heading.

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

(n, γ) reactions with 300 Mev x-rays are being investigated in a number of substances.

300 Mev Synchrotron (Continued)UNCLASSIFIED

6. Other developments. \

A number of minor changes are being made in the machine to replace temporary construction and to improve the performance.

Linear Accelerator and Van de GraaffUNCLASSIFIED

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

These instruments have been undergoing a general overhaul involving the replacement of temporary construction and a rearrangement to give more space. See section 5 of this report for details.

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

Preparations are being made to install a refrigerator in the Van de Graaff accelerator. A buncher cavity will also be installed.

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

Nothing new during this month.

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

None in the last month, since the machine has been out of operation.

BevatronUNCLASSIFIED

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

Successful operation of the model was obtained on April 30 when protons were accelerated to greater than the design energy of 6 Mev. Tests to increase the beam and study the characteristics of the machine are proceeding.

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

Purchase order for steel fabrication issued and plans for magnet assembly work are being prepared.

3. Developments of an injection system.

It has been decided to build an experimental 4 Mev linear accelerator to test as an injector in place of the cyclotron previously planned.

Bevatron (Continued)UNCLASSIFIED

4. Other developments.

Consideration is being given to the conversion of the quarter-scale operating model to a 1 Bev accelerator.

PHYSICS RESEARCHGeneralUNCLASSIFIED

1. Range measurements for fast particles.

No work during this month.

Fundamental Properties of Nucleons.UNCLASSIFIED

1. Neutron-proton scattering.

Theoretical studies have shown that an exponential well gives a smaller cross section than a Yukawa well, and most of the discrepancy between observed and calculated total cross section is thus removed. Possible long range tails are being investigated.

Several more experimental runs have been made and a curve of the angular distribution has been obtained.

2. Proton-proton scattering.

At the moment, it does not seem possible to fit these scattering results with scattering by a potential. More accurate experimental results are being awaited. The experimental apparatus for work at 350 Mev is being debugged and prepared for use. Some preliminary work is being done to see if a cloud chamber experiment is practical.

3. Scattering of protons and neutrons on deuterons.

Calculations are in progress. It is thought that it will be possible to deduce a n-n cross section from results on n-d scattering. The cloud chamber group is designing an experiment on the scattering of neutrons by deuterons.

4. Other scattering experiments.

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

5. Life time of the neutron.

The experimental equipment has been tested with neutrons produced by protons from the Van de Graaff inside the magnet gap.

Fundamental Properties of Nucleons. (Continued)UNCLASSIFIED

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

Energy and angle distributions are being calculated, as well as total cross sections.

7. Other experiments.

No explanation has been found for the large negative-positive ratio of synchrotron produced mesons. A positive-negative ratio of three is expected for proton produced mesons. Calculations of the γ -ray spectrum expected from neutral meson decay are in progress.

An experiment is being done to measure the high energy protons in the presence of neutron by the use of boron disks in conjunction with carbon disks. Boron gives C^{11} by the reaction $B^{11}(p,n)C^{11}$ while C^{12} gives C^{11} by the reactions $C^{12}(n,2n)C^{11}$ and $C^{12}(p,pn)C^{11}$.

Nuclear ReactionsUNCLASSIFIED

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

Work is being continued on (γ,n) and (γ,p) process. An attempt is also being made to study (γ,p) processes by observing protons with two scintillation counters in coincidence.

2. Energy dependence of reactions.

An experiment is being devised to measure the dependence of (γ,n) cross section on the maximum γ -ray energy in the 100-300 Mev range.

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

The β -rays from Re^{182} , Re^{183} , Re^{184} studied by Hicks and Wilkinson are being investigated. All isotopes seem to emit complicated conversion electron spectra due to γ -rays of energy less than 350 Kev.

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

A program of measuring total cross sections for 40 Mev neutrons is nearly complete. A study of the differential scattering cross section is in the process of being written.

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

The program of measuring fission excitation functions is continuing.

Nuclear Reactions (Continued)UNCLASSIFIED

6. Other experiments.

A study of the very high energy γ -radiation from the cyclotron target is being actively pursued. Experiments have been started on the production of Li^8 from high energy bombardments of various targets.

InstrumentationUNCLASSIFIED

1. Instrumentation in support of cloud chamber development.

The cloud chamber timing circuits are being revised to operate on direct current. It is expected that this will make them more reliable.

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

Hydrogen 3 ionization chamber method has been developed and set into operation.

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

Efforts at applying anthracene counters to medical physics problems are being concluded.

4. General development of electronic counting equipment.

Circuits for gating the amplifiers, and gating the H.V. for special counting problems are under development.

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 proportional counters are being built from time to time.

6. Development of radiation survey instruments.

Neutron survey instruments in form of U and Th fission chambers are under construction.

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

Nier spectrometer functioning regularly. Being applied to study of chemical effects of radiation.

-18-

Instrumentation (Continued)UNCLASSIFIED

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 and health chemistry 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 ChemistryCONFIDENTIAL

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

Work is in progress on isotopes of a large number of elements.

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

An apparatus for measuring excitation curves with the stacked foil technique is being used to study transmutations of thorium.

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

No progress.

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.

Experiments are in progress to measure the ranges of fission fragments from high energy fission.

Nuclear Chemistry (Continued)CONFIDENTIAL

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

Work continues on identifying the bismuth alpha emitters with their electron capture lead and thallium daughters. The study of thallium isotopes is being extended to try to find the daughters of the bismuth alpha decay.

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.

Work continues on cyclotron preparation of neutron deficient isotopes.

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

No progress.

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

Protons are being utilized in practically all the isotope researches, especially in bombardment of copper, tin, lead, bismuth, platinum, gold, thorium, and uranium.

12. Study of meson reactions by chemical means.

No progress.

13. Development of chemical analysis techniques utilizing radioactive tracers.

No progress.

14. Other experiments.

Some experiments have been started on the chemical effects of cyclotron irradiation of ethyl alcohol.

Chemistry of Heavy ElementsCONFIDENTIAL

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.

Experiments have been done on a colored hydroxide precipitated under oxidizing conditions, but with no conclusive result.

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.

Work continues on the magnetic properties of the fluorides which are suspected to be divalent.

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 progress.

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

No progress.

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

Progress has been made on identifying At^{208} and At^{209} .

9. Other experiments.

The crystal structure of Mo_3Si has been determined from x-ray powder diffraction patterns.

The uranium oxide system is under investigation by the technique previously used with praseodymium and americium.

High Temperature and Pile ChemistrySECRET

1. Metals and high temperature thermodynamics.

Work is in progress on refractory studies, the thermodynamics of CN and N₂, the absorption coefficients of CN and C₂, the thermodynamics of molybdenum halides and oxides, the thermodynamics of gaseous aluminum oxides, low melting systems, the structure of solids and solid-gas surface interactions, and on the design of decontamination processes for high temperature power piles.

2. Basic chemistry. Solvent extraction.

Investigations are continuing on the exchange of iodine atoms between iodate ion and iodine, and on the chelate complex of lanthanum with TTA.

3. Engineering development of plutonium separation.

The solvent extraction using chelate process is under investigation. The dropping Hg electrode is being used to investigate the phosphate complexing of U^{III} as ground work for a method of determining the oxidation state of uranium. The construction of a photomultiplier is nearing completion. It is to be used in the fluorimetric determination of micro amounts of uranium.

Plant and EquipmentUNCLASSIFIED

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

Grading of the bevatron site is proceeding somewhat more rapidly now, but is still contingent on placing of 48 inch and 12 inch drainage lines. The preliminary survey of the site soil and water conditions has been completed and a report prepared which recommends additional drainage lines. Plans and specifications for the bevatron building will be completed in time to advertise for bids early in June. The 1/4-scale model bevatron has been completed and successfully operated during the past fortnight. The order for the fabrication of the full-scale magnet steel has been let.

2. Central Research Laboratory Building.

Pouring of concrete is substantially complete with only the structures over the stairways, the elevator penthouse, the conference room floor and roof yet to be done. Waterproofing and plastering are well along on the ground floor. The utility room equipment is being installed. Fabrication of laboratory furniture is keeping in pace with the building.

3. Construction of Animal House and Cafeteria.

Design work on the cafeteria is proceeding. The animal house is being delayed pending finishing of design of the cafeteria.

Plant and Equipment (Continued)UNCLASSIFIED

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

Bids are being received for the construction of the first building, to house electricians, plumbers and maintenance machinists. The second shop building will not be started until next fiscal year.

5. Miscellaneous Construction.

Warehouse. Work has been resumed on the grading of the warehouse site and will be completed and ready for the footing and foundation work in about two weeks.

Paint Shop. This project is essentially complete.

Alterations to Laboratory Buildings. Work is in progress in Old Radiation Laboratory and Donner Laboratory.

Power Distribution. The first shipment of the order for 47,000 feet of cable has been shipped from the East but has not been received. The potheads, bus supports for overhead station, disconnects and cable grips are complete.

Fire Protection. Work has been progressing on this project and the electrical portion is nearing completion; most of the pipe for the water mains has been delivered and the balance will be delivered in June. Approximately 200 feet of the pipe has been installed.

Parking Lot. Contractor is deferring further work on the surfacing until the connecting road is complete.

Connecting Road. Rough grading has been completed and crusher run placed.

University of California Hospital Radiological Laboratory. Design work by the architects, Blanchard and Maher, is being delayed pending negotiation of occupancy agreement for preferred site by the University and the Atomic Energy Commission.

MEDICAL RESEARCHBiological and Medical Studies at Crocker LaboratoryUNCLASSIFIED

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

Preliminary tracer studies on carrier-free selenium have been initiated. The studies on carrier-free praseodymium have been completed as well as the correlated studies involving complexing agents, praseodymium carrier and neodymium carrier.

Biological and Medical Studies at Crocker Laboratory (Continued)UNCLASSIFIED

2. Decontamination studies.

An experiment has been set up in which massive "decontaminant" doses (40 mg. Zr) of zirconium citrate tagged with freshly separated Zr^{95} were administered to rats by intraperitoneal injection simultaneously with carrier-free Y^{90} . Administration of pure growth hormone to phosphorus deficient rats was found to increase the severity of rickets in bone metabolism studies, and considerably reduce the uptake of Sr in bones.

3. Radioautographic studies.

Studies with praseodymium in bone, and plutonium in scar tissue are not yet completed. Further experiments on the uptake of Sr in the costochondral junction of rachitic and control rats are in the process of being set up.

4. Radiochemistry.

200 microcuries of carrier-free Se^{75} have been separated from a deuteron bombarded arsenic target. Separation methods have been developed for carrier-free Ta^{182} from alpha bombarded hafnium, carrier-free Zn^{65} from a copper target, and carrier free Mn^{54} and Co^{56} from a deuteron bombarded alpha target. Additional data has been obtained on the distribution of At^{211} in the rat. Solutions of Cb^{95} have been prepared for injection.

Medical Research at Donner LaboratoryUNCLASSIFIED

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

Selective irradiation of liver and spleen discontinued. Current work is partly stressing methods of infiltrating lymphatic system with radioactive colloids and a study of mechanism of phagocytosis.

2. Biological effects of fission.

No work currently active.

3. Biological effects of high energy neutrons.

Continuing using 184-inch cyclotron.

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

Contingent upon completion of animal house.

Medical Research at Donner Laboratory (Continued)UNCLASSIFIED

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

Proton beams are being studied with 184-inch cyclotron.

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

Nuclear protein metabolism has currently been shown to be disturbed by as little as 33 roentgen of selective liver irradiation as indicated by depression of desoxyribose nucleic acid turnover.

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

The reticuloendothelial system is being studied as in item 1. with respect to mechanism of phagocytosis. The main study of immunity has been transferred to Dr. Victor Bond, Hunter's Point Laboratory, U. S. Naval Yard, San Francisco. (Dr. Bond was formerly associated with Donner Laboratory).

8. Microchemical assay of tissue components by induced radioactivity.

Microchemical assay of tissue components is being continued particularly with reference to inorganic constituents of the nucleus and cytoplasm.

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

Studies of disturbances of lack of protein metabolism by whole body irradiation and partial body irradiation are continued. (See also item 6.)

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

Metabolism of simple organic compounds are continuing. Currently being studied are valerate, alanine and one labelled glucose.

11. Study of genetic effects of radiation.

Genetic effects of irradiation are continuing with regard to chromosomal breakage and induced mutation. This is a part of the study of the biological effects of high energy particles generated by the 184-inch cyclotron.

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

Study continuing.

Medical Research at Donner Laboratory (Continued)UNCLASSIFIED

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

Characteristics of plasma proteins are continuing using the ultra-centrifuge and electrophoresis apparatus. The control studies are sufficiently complete so that the problem of irradiation of liver, spleen and bone marrow can be interpreted as far as effects on albumin and lipoprotein fractions are concerned.

14. Metabolic studies on normal and leukemic cells.

Metabolic studies on normal and leukemic cells are in progress using radioactive acetate.

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

The light scattering apparatus and the viscometer are still in the progress of construction. The recording infra-red spectra-photometer has just been installed and is being used in conjunction with studies of tissue metabolism to identify compounds involved in metabolic steps.

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

1. Effects of external irradiation of the whole body.

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

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

Five blood counts done on patients treated with P^{32} prior to May 24, 1948. Nineteen blood counts done on patients treated with I^{131} ; of these 19, two are new patients.

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

Twenty-five doses of I^{131} given, 17 for percent uptake studies, 7 for therapeutic purposes, and 1 for autographs following surgery. Paper prepared summarizing work and results on all Graves disease cases to date.

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.

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

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.

One patient with carcinoma of the throat given thyrotrophin to force neoplastic tissue to activity. As yet, no results.

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 free radical mechanism of acetyl peroxide decomposition, the Tiffeneau ring expansion, and the isotope effect in decarboxylation reactions have been studied.

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 is in progress on a hot preparation of codeine-C¹⁴.

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 in progress: alanine-3-C¹⁴, leucine-β-C¹⁴, valine-γ-C¹⁴, leucine-α-C¹⁴, valine-α-C¹⁴, isobutyric bromide-1-C¹⁴, isopropyl bromide-1-C¹⁴, oxalacetic acid, fumaric acid, malic acid, succinic acid, pyruvic acid, Demerol, glucose-1-C¹⁴ and mannose-1-C¹⁴.

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

The in vivo exchange of barium carbonate and carbon dioxide is being studied in mice by intravenous injection and inhalation. Rate studies on stilbamidine metabolism is continuing as also is the rate of oxidation to C¹⁴O₂ of simple organic compounds. The Warburg experiments on liver slices of propionate-1-C¹⁴ are also continuing.

Organic and Biological Chemistry (Continued)UNCLASSIFIED

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

The process of photosynthesis in barley leaves has continued and the studies on the phosphorylated compounds or intermediates has been further expanded.

Health PhysicsUNCLASSIFIED

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

No progress to report.

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.

Study of the equilibrium radiation in the concrete shielding is being actively pursued.

Health ChemistryUNCLASSIFIED

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.

Present techniques being put to further practical use.

3. Plutonium slug design for use in piles.

No further work being done on this at present.

Health Chemistry (Continued)UNCLASSIFIED

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

No developments at present.

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

Design development and tests of filters being continued.

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

Decontamination awaiting construction.

7. Design of special target holders for active material.

No further developments during this month.

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. Receiving, 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.

10. Other developments and studies.

Equipment for processing special sample from pile being developed.

-29-

APPROXIMATE DISTRIBUTION OF EFFORT

PROGRAM	SUBDIVISION	MAN-MONTHS EFFORT	COMMENTS
184-inch Cyclotron	Operation	10.4	
60-inch Cyclotron	-	-	Non-Project
Synchrotron	R.f. System	.4	
	General	2.8	
	Injection	2.0	
	Miscellaneous	1.0	
	Magnet Tests and Operation	4.9	
	Vacuum Chamber	.2	
Linear Accelerator	Linear Accelerator - General	-	
	Van de Graaff - General	-	
	Development	12.5	
Bevatron	Injector	-	
	Magnet	3.1	
	1/4 Scale Model Construction	1.5	
	Miscellaneous	1.6	
	1/4 Scale Model Operation	5.5	
Experimental Physics	Cloud Chamber	5.1	
	Film Program	8.9	
	Ionization Chamber and Crystal Counter	1.7	
	Neutron-proton Scattering	2.5	
	Proton-proton Scattering	1.0	
	Neutron Diffraction	.2	
	Meson Range and Decay Measurement	1.8	
	Absolute Cross Section Measurements	3.2	
	Neutron Half Life	.7	
	General Physics Research	6.3	
	Magnetic Measuring Equipment	.3	
	Instruments for General Use	1.6	
	Meson Experiments with Synchrotron	1.0	
Scintillation Counters - Research Experiments	1.1		
Theoretical Physics	Bevatron	1.4	
	Cyclotron	.2	
	General Physics Research	12.2	

-30-

PROGRAM	SUBDIVISION	MAN-MONTHS EFFORT	COMMENTS	
Isotope Separation	Nier Spectrometer	1.2		
	Low Mass Spectrograph	.2		
Chemistry, Part A	Chemistry of Transuranic Elements	5.8		
	Nuclear Properties of Transuranium Elements	4.0		
	Transmutations with the 184-inch Cyclotron	7.3		
	Transmutations with the 60-inch Cyclotron	-		
	Analytical and Service	14.8		
Chemistry, Part B	Synthetic and Experimental Chemistry	5.8		
	Biological Chemistry	5.3		
	Photosynthetic Chemistry	5.8		
Chemistry, Part C	Metals and 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	Uranium Research	-	- Consultant	
	Tumor Metabolism	1.7	1.7 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	1.4	
	Medical Work with the 184-inch Cyclotron	2.6	1.3	
	Fly Genetics	2.0	.6	
	60 -inch Cyclotron Bombardments	.4	-	
	Physical Chemistry	3.4	-	
	Specific Irradiation	3.5	.2	
	Health Physics and Chemistry	Monitoring and Disposal	5.9	
		Salvage, Decontamination, etc.	-	
Research and Development		14.4		
Film Badge Program		5.2		

DECLASSIFIED

SECRET