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UCRL-1844

UNIVERSITY OF CALIFORNIA

Radiation Laboratory

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MONTHLY PROGRESS REPORT
No. 109

April 15, 1952 to May 15, 1952

June 9, 1952

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UNIVERSITY OF CALIFORNIA, RADIATION LABORATORY

April 15, 1952 to May 15, 1952

MONTHLY PROGRESS REPORT No. 109*

June 9, 1952

1. BEVATRON (A.E.C. Program No. 9500) UNCLASSIFIED

Coil Winding

UCRL machined coil spacers are becoming available and the winding has been resumed. One-half (88 turns) of the fourth quadrant is now wound.

Magnet

The U.S. Steel Company has promised the fabricator that delivery of the steel for the pole bases and tips will be completed during the third quarter of 1952.. The fabricator has completed the die design for the pole bases, but the die design for the pole tips is awaiting results of the UCRL magnet model tests.

Vacuum System

Assembly of the first curved tank is expected to be started at UCRL by August 1. Design has been completed on the forevac oil and water systems.

Injector

As a result of the Brookhaven visit by UCRL personnel, it has been decided to offset the centerline of the ion gun 40 degrees relative to the centerline of the linac and to use a magnet for turning the beam. This permits monitoring the molecular hydrogen ion portion of the beam for injector voltage control purposes and also results in better access to the building cranes.

The measured "Q" of the linac with drift tubes was between 85,000 and 90,000, which is better than expected. The voltage gradient along the tank was constant within 6 percent, which is satisfactory.

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*Previous report UCRL-1798

Controls

Three alternatives for triggering the rf and injector and for tracking the rf are being investigated to determine the jitter accuracy, and general suitability for use on the Bevatron. Meetings to outline the control requirements have been held. An electrostatic pickup (drift tube) electrode as used at Brookhaven will be installed.

2. 184-INCH CYCLOTRON OPERATION (A.E.C. Program No. 5741) UNCLASSIFIED

The cyclotron was used for research experiments approximately 93 percent of the 567 hours that the crew was on duty. The time distribution was as follows:

Operation for customers	526.75 hours	92.8 percent
Electrical troubles	12.00	2.1
Mechanical troubles	24.00	4.2
Maintenance	4.50	0.8
Others	0.50	0.1
Totals	567.75 hours	100.00 percent

3. 60-INCH CYCLOTRON OPERATION (Operated by the University of California) UNCLASSIFIED

Some operation time was lost during this period because of excessive sparking at two vital points in the high voltage system - the feeler and exit strip. Repair and replacement were carried out and smooth operation resulted. The monthly operating efficiency was 79.5 percent.

4. SYNCHROTRON OPERATION (A.E.C. Program No. 5731) UNCLASSIFIED

No useable beam was obtained from the synchrotron during this report period. The beam was brought up to slightly more than half energy but could not be increased.

Considerable time was spent in mapping the magnetic field. Distortions in the field were found to differ from a previous field plot in the vicinity of the replaced quartz segment. Tests showed that non-uniformity of the conducting coating could account for the field distortions. These distortions due to the new quartz segment have been corrected electrically. The beam has reached full energy and adjustments to increase beam intensity are under way. The daily operation schedule has been increased from 16 hours a day to 20 hours a day in order to make the beam useable in the shortest possible time.

5. LINEAR ACCELERATOR AND VAN DE GRAAFF OPERATION (A.E.C. Program No. 5751) UNCLASSIFIED

The toroidal coil beam monitor for the linear accelerator was installed at the exit end of the linear accelerator between the electron magnet and the analyzing magnet.

The monitor seems promising as a visual and metered beam magnitude instrument.

A second electron magnet is being built to make the beam monitor independent of exit electrons which vary in number and energy with rf operating conditions of the beam.

Statistics:

Running time	- 81.5 percent
Maintenance	- 18.5 percent

6. EXPERIMENTAL PHYSICS (A.E.C. Program No. 5211) UNCLASSIFIED

Film Program

Spall Analysis. The analysis of spallation fragments by range and radius of curvature in a magnetic field is proceeding actively. Using Li^8 spalls which are readily identified by their "hammer" tracks, range-energy curves for lithium have been obtained. A few hammer tracks also arise from B^8 so that it is probable that range-energy curves for the boron isotopes may also be plotted. The analysis of the spalls will be greatly aided by reliable range-energy curves.

Meson Spectrometer. The vertical focusing conditions for the large spectrometer magnet have been studied with a model magnet using beta radiation. A satisfactory combination of vertical and horizontal focusing has been obtained.

Other Projects. During the past month a number of additional projects have been active but no new results have been obtained. The projects include:

Mu Meson Interaction with Matter
Studies of Meson Production by Nucleon-Nucleon Collision
Meson Masses and The Energy Balance in Meson Decay
Large Angle Meson Scattering
High Energy Beta Spectra
High Energy Electron Processes
Diffraction and Coulomb Scattering of High Energy Protons

Cloud Chamber

A preliminary exploratory run has been made in the proton cave at the cyclotron using the meson cloud chamber. This chamber is designed to be placed close to the proton beam and to focus low energy (15 Mev) mesons into the sensitive region of the chamber. The number

of mesons was as expected. The shielding problem, which was the main reason for the run, has been solved. The main background was caused by low energy neutrons. Plans are being made for a data run in the near future.

An experiment in which it is necessary to collimate low energy neutrons is contemplated. In order to check the possibility of collimating such a beam of neutrons it was decided to make a run using the one gram neutron source (Po, Be). This source was placed three feet from the 22-inch cloud chamber and collimated by copper slabs with a one-inch by two-inch collimating slot. The results indicate a good collimation pattern.

A new short focal length stereoscopic projector has been assembled and is now being adjusted. Also, new space tables have been designed eliminating many inaccuracies inherent in the old style space tables.

A high-pressure (thirty-five atmospheres) continuously sensitive cloud chamber is being designed. This chamber will fit into the 22-inch cloud chamber magnet and will be approximately 19 inches in diameter.

Proton-Proton Scattering at Reduced Energies (160 to 250 Mev).

The liquid hydrogen target, which had previously developed leaks after successive evacuations, has now been made to hold its vacuum properly. It had been necessary to thicken the walls of the liquid hydrogen flask over the original specifications. The present wall thickness is 0.004 inches of stainless steel.

A preliminary run, in which only the full energy beam (345 Mev), was used, shows rather close agreement with the differential cross sections measured here previously. An exact comparison will have to await recalibration of the ionization chamber (used for proton beam monitoring) against a Faraday cup. Since the preliminary run went rather well, we are hopeful that the desired small angles can be attained within the next few months.

Total Proton-Proton Scattering Cross Section (345 Mev).

Little progress is expected until the liquid hydrogen target is available from the shops. This will probably be several months in the future.

Alpha-particle Scattering in Complex Nuclei using 390 Mev Alpha-particles.

Some attempts will be made to observe the elastic collision of an alpha particle with another alpha-particle within a complex nucleus. This should eventually involve alpha-particle beams from both the 184-inch and the 60-inch cyclotrons. The purpose of these investigations is twofold. Firstly, some information may be obtained concerning the ability of the alpha-particle to withstand large momentum transfers without being broken up. (Some of this information may also come from

other experiments, and may also involve scattering of alpha-particles by free alpha-particles.) Secondly, it may be possible to test the extent of preformation of alpha-particles within complex nuclei, and perhaps to determine their momentum spectrum, if they are present. A first attempt to observe elastic collisions between alpha-particles within a carbon nucleus was not conclusive. The effect observed was so small that it could have been zero, within the available statistical accuracy. One useful piece of information was obtained rather late during the first run, namely that a fairly good scattered beam of alpha-particles was obtained from the 184-inch cyclotron. The beam was contaminated by an approximately equal number of deuterons. This contamination was not considered unexpectedly bad, since under best conditions of the electrostatically deflected beam the ratio of the number of alpha-particles to the number of deuterons is about 2.5 to 1. At the time this beam was obtained (the scattered beam) the cyclotron had not been used to accelerate deuterons for several days previous.

Elastic Proton-Deuteron Scattering Using 345 Mev Protons

A great effort is being made to perfect the optics of the scintillators and photomultipliers without direct use of the cyclotron. Some tests are being made at the cyclotron while other experiments are being run, and some tests involve radiations from radioactive substances. These tests, combined with indicated refinements, are apparently quite necessary if deuterons are to be resolved from protons satisfactorily by observations of pulse height.

Effects of Chemical Binding on the Stopping Power of Substances for High Energy Protons

This work is nearing completion. A few checks of significant substances have yet to be made. As was expected from the start, the effect of chemical binding on stopping power is exceedingly small. To a large extent the use of all of the detailed results will have to await rather involved theoretical work. At present the simplest aspect of the results is that unstaurated organic hydrocarbons have slightly higher stopping powers than do mixtures of graphite and saturated hydrocarbons having the same elemental constitution.

Absolute Yield of Pi^0 Mesons in the Proton Bombardment of Carbon

The work on the photon spectra received at various angles from targets bombarded with 340 Mev protons allows one to infer the angular distribution of both the photons and the pi^0 mesons. However, in that work it was not possible to use an absolute proton beam monitor, since for reasons of intensities the target was placed within the cyclotron tank and multiple passage of the beam rendered a confident measurement of its current impossible. The relative numbers of photons received at various angles were measured by the use of thin aluminum foils or thin polystyrene foils fastened to the carbon target. The activities of sodium 24 or of carbon 11, respectively, served to gain relative normalization.

The present report deals with an absolute evaluation of the photon yield received at 90° from a carbon target bombarded by the external proton beam, whose current could be precisely measured. Comparison with the 90° spectrum received from internal targets then made it possible to place the data upon an absolute scale of intensity. Results have been obtained for the various angles of observation in the laboratory system. The differential cross section presented by the carbon nucleus for the production of photons at the peak of the spectrum seen at the angle specified, the total photon yields in terms of the cross sections for the delivery of high-energy photons into unit solid angle in the direction specified, and the amount of solid angular space to be associated with each of the spectra at the various angles of view have been determined. The total cross section of the carbon nucleus for the production of high energy photon radiation has been determined from these results. Figures will be given in a forthcoming Quarterly Report.

If all the high energy photons are considered to arise from neutral mesons then neutral meson cross section are one half of that for photon production, or 1.8 ± 0.4.

On the Ratio of Charged Mesons from Carbon Bombarded by High Energy Neutrons

Experiments are continuing on the production of positive and negative mesons from carbon bombarded by the 280 Mev neutron beam from the 184-inch cyclotron. Observations have recently been made at 15° to the neutron beam on carbon. The meson energy range is about 50 Mev $\pm$ 25 Mev. The ratio is $\pi^-/\pi^+ = 3.3 \pm 0.7$. This is a noticeable decrease from the ratio of $\pi^-/\pi^+ = 10 \pm 2$ at 90°. For the same energy range the counting rate at 15° is about four negative mesons per minute. The apparatus consists of time of flight detectors with magnetic channel midway in the flight path. Very little contamination due to recoil protons is found with this arrangement.

Charged Particle Identification

The identification of charged particles by means of pulse height and time of flight has prompted the following preliminary investigations. a. The sweep speed calibration of the E.G.G. scope. b. The effective time resolution of the E.G.G. scope using 35 mm Linagraph Pan to photograph the pulses. c. The time jitter of 5819 photomultiplier pulses. d. The comparison of available 5819's as to overall pulse height using various γ ray sources with a sodium iodide crystal. e. The optimum voltage between the cathode and first dinode of a 5819 photomultiplier compared to the voltage across the subsequent multiplication stages. f. The effect of high counting rates on the fatigue of 5819 photomultipliers. g. The equivalence of measuring relative pulse heights on a d.c. basis with a microameter and the measuring of relative pulse heights using a differential discriminator. h. Measurement of relative photosensitivities and absolute gains of a number of 5819's, using an ultra violet source and a microameter. i. The comparison of the two liquid scintillators: 1. xylene + terphenyl + diphenylhexatriene and 2. phenylcyclohexane + terphenyl + diphenylhexatriene . j. The construction of Lucite liquid scintillation counters incorporating the

ideas of Garwin et al at Chicago.

7. THEORETICAL PHYSICS (A.E.C. Program No. 5211)

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During the period of this report five members of the group attended the Washington, D.C. meeting of the American Physical Society. The following eight papers were presented: "Photo Production of π^0 -Mesons from Deuterium", W. Heckrotte, L. R. Henrich, and J. V. Lepore; "Meson Exchange Contributions to the High Energy Deuteron Photoeffect", R. H. Huddlestone and J. V. Lepore; "Low Energy Properties of Pseudoscalar Interaction with Hard Core", R. Jastrow; "Phenomenological Potentials in Meson Scattering", R. LeLevier; "Nuclear Forces Yielded by the Symmetrical Pseudoscalar Meson Theory with Pseudoscalar Coupling", J. V. Lepore; "On the Fermi-Thomas Model of the Nucleus", R. J. Riddell, Jr; "Multiple Meson Production", M. Ruderman; "Interpretation of High Energy p-p Scattering", D. R. Swanson.

In addition, various members of the group visited the following institutions for discussions of theoretical physics, interviewing of prospective new members of the group, and gathering general information about work in progress elsewhere: University of Chicago (Institute for Nuclear Studies), Columbia University, Columbia University (Nevis Cyclotron), Massachusetts Institute of Technology, Princeton Institute for Advanced Study, Princeton University, Princeton University (Project Matterhorn), Brookhaven National Laboratory, and Oak Ridge (Y-12 and ORNL).

Further work on the deuteron photoeffect is now directed toward estimating the constributions from higher orders of perturbation theory and obtaining a better approximation for the effects of deuteron binding. The implications for the saturation problem of the recent successful fit of low energy n-p parameters with meson theoretic potentials cut off at short range with a strong repulsion are being examined. High energy n-p effects are also being evaluated. The work on singular p-p tensor interactions has been concluded and a thesis covering results of this research is being written. A thesis has been written describing the work on neutral photomeson production from deuterium.

A Letter to the Editor of the PHYSICAL REVIEW on the production of π^0 and π^+ mesons from protons on deuterons is being prepared. Higher order corrections to the nuclear forces yielded by pseudoscalar meson theory with pseudoscalar coupling are being studied. Compton scattering of photons from protons, treating the mesons classically, is being investigated, as a part of the work in strong coupling meson theory. The influence of exchange currents on the energy dependence of π^+ photoproduction from deuterium is being studied. This is of interest since preliminary experiments seem to indicate a decrease of the ratio of deuterium to hydrogen production cross sections with increasing energy.

A general study of the theory of multiple scattering is in progress; it is hoped to treat nucleon-nucleus scattering in this way.

Calculations to test the feasibility of a low field (0-100 gauss) high precision magnetometer have been completed. Some work is in progress on the problem of evaluating the suitability of a proposed bevatron pole tip design from model measurements. The study of beam loss in a linear accelerator due to scattering by focusing foils, through use of a diffusion approximation, has been extended to the case of relativistic particle energies.

8. THE M.T.A. PROGRAM
(A.E.C. Program No. 9200)

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Research Program for Mark I

A comprehensive research program on the Mark I accelerator has been outlined to give further information for the design of the A-12 accelerator. Some of the items proposed for study are: 1. The effect of the drift tube magnets on the ability to hold rf voltage and also the effect of the drift tube magnets on the beam. 2. The possibility of tapering the drift tube bias from center to each end to prevent P.I.G. discharge. 3. The determination of the highest gradient obtainable. 4. An investigation of graphite as a drift tube surface material to decrease the sparking rate and the damage from sparks. 5. Design of a sensitive spark detection unit which will crowbar the tank before destructive sparking occurs. 6. New methods for shielding pre-exciter transmission line loops from rf feedback to eliminate the rotating seal problem. 7. Methods to prevent electrical surges from being transmitted back through the magnet feed lines, thereby stopping sparking in magnet generators. 8. A new amplifier design and automatic tuning circuit needed to control the phase drifting in the A-12 cavity. 9. The effect of beam load on the rf frequency. This can be studied for the first time, since the A-12 will have a large beam current. 10. Design of an injector for A-12 with the high beam current which will eliminate the intense central core of ions. Preliminary studies indicate such an injector is possible by allowing the ions from an arc source to form a rotating beam around a central electrode placed axially through an outer cylinder. The outer cylinder is divided into drift tube sections that are rf modulated. A d.c. potential between outer cylindrical conductor and central wire conductor forms an attractive field toward the central wire. The central charged wire in the beam overcomes the radial space charge forces and the resulting stability provides sufficient time to bunch and accelerate the ions with the rf modulated drift tubes. 11. Determination of the effect of misaligning drift tubes to reduce the peak to average beam intensity. 12. An investigation of the electrical field configuration in the cavity during sparking. This program it is felt would be a long term one carried out by CRDC with Radiation Laboratory personnel serving as consultants.

Vacuum Studies

The Livermore vacuum laboratory obtained a pumping speed on a rectangular mercury pump of 18,000 liters per second with only one jet

in place. It is felt that two jets will allow a pumping speed of 20,000 liters per second. The optimum pressure of 1 x 10^{-5} mm of mercury was obtained with a power consumption of 2.5 kilowatts. A study is being made of the possibility of gold or copper plating of mercury diffusion pump baffles for better heat transfer. A mercury vapor detector has been designed, utilizing resonance absorption, to detect mercury vapor that might backstream into the main tank.

Development work is continuing on the ion pumps. The hot cathodes which are used in the ion pump are still found to burn out within a period of approximately three days. The pumping speed is 7,000 liters per second with a base pressure of 2 x 10^{-6} mm of mercury. One pump has now operated approximately 400 hours. The use of cold cathodes was found to made the pump unstable. A new pump 18 inches in diameter and 3 feet in length will be built to study the problem of cathode life.

Oscillator Tube Development

Developement work by RCA resulted in the design of a shielded grid tube, A-2332, capable of over 1 megawatt rf output CW, compared to the 0.6 megawatt output from the RCA tube 5381. By changes of circuit components and transmission lines, a reduction in capital cost of two million dollars could be realized with the A-2332 tube. With the postponement of the A-12 program it was decided to extend the RCA contract to determine the possibility of obtaining 1.6 to 2.0 megawatts output per tube. The extended contract will freeze the tube design by September of 1952, allowing three months from September through December for the development of production specifications.

RCA will soon be able to make preliminary tests, but the resonance load tests at 12-20 megacycles will still be conducted at Berkeley and Livermore. It is expected that all of the improved oscillator tubes for A-12 can be fabricated by June 1954.

A-12 Dummy Load

A study has been made of the effect on the main power stations when the 300 megawatts in the A-12 cavity is crowbar to ground. Since the power station must shortly shut down when relieved of its load, it is desired to shunt the power through a back of ignitron tubes to a dummy load consisting of a 12 foot by 12 foot by 8 foot water pool. This load would allow the power plant to continue operating at its rated output and thereby be able to supply the power to the A-12 accelerator when again needed.

A-12 Target Studies

Proton and Neutron Spectra. The neutron spectrum resulting from 190 Mev deuteron bombardment of uranium and beryllium has been determined and a similar study completed for protons. The combined proton and neutron data should yield a much better picture of the details of

the high energy deuteron-uranium and beryllium interactions. In these experiments 0.01 inch uranium and 0.1 inch beryllium targets were employed which were bombarded by a 190 Mev deuteron beam. The counter was set at various angles to determine the number and energy of protons emitted at that angle. The counting system used was a three unit coincidence counter followed by a variable thickness absorber. They were followed by a fourth coincidence counter.

So far all measurements of proton and neutron spectra have been in the range above 18 Mev. However there is a great deal of interest in the measurement of spectra at lower energies. This has not been possible because of the difficulties of counting particles of lower energy. If a thinner target were used and measurements made in vacuum, it might be possible to count particles of some lower energy. A method has been devised getting around the difficulties of thick targets and ionization losses, by the use of a pair of stilbene crystals and a multiple coincidence system. The time of flight between the crystals is used in determining the neutron energy. With this method energies in the range of from 1 to 20 Mev are readily measured. Above 20 Mev the velocities are too high for coincidence counting, and below 1 Mev the thermal noises of the photomultipliers are the same magnitude as the ionization pulses from the recoiling protons.

Angular Distribution Measurements. Angular distribution measurements of neutrons from a moderated target have been started. These target measurements are being made with the use of a shielded long boron trifluoride counter. This is the same counter previously used in measurements made with the Chicago cyclotron. The primary target consists of a 3 foot by 3 foot uranium, polyethylene sandwich one inch thick composed of alternate layers of uranium 1/10 inch thick and polyethylene 3/32 inches thick. The secondaries are 2 and 2-1/2 inches thick and consist of 1/2 inch uranium bars with 3/32 inch polyethylene surrounding each bar. The rows of bars are staggered so that the spaces between the bars in the first row lie on the center line of the bars of the second row. The boron-trifluoride counter is surrounded by paraffin which in turn is surrounded by a one-inch thick layer of boron carbide and the whole surrounded by more paraffin. The counter was calibrated with a polonium-beryllium source placed 20 feet away. The design of the counter was governed by a desire to count neutrons of all energies. It has a very fast response to neutrons in the range of 1 to 5 Mev.

Effect of Water Blanket on Pu Production. Recently a problem concerned with the effect of a water blanket on the target has received considerable attention. Theoretical calculations showed that in going from no water blanket to a water blanket of one inch thickness a 25 percent loss in plutonium production results. In checking these calculations a lattice of uranium bars was placed with its first row of bars initially one-eighth inch and then one and one-eighth inches from the tank wall, corresponding to one-eighth inch and one and one-eighth inch water blankets. Preliminary results show a loss in plutonium production in these two different runs of 33 percent and 48 percent for bars in the front row and in the same two runs a loss of 10 percent and 32 percent for bars centrally located in the lattice.

9. CHEMISTRY
Part A
(A.E.C. Program No. 5311)

Alpha Spectroscopy

Recent work with the magnetic alpha spectrograph has been principally concerned with the alpha group abundances of Ra^{226} and with the level scheme of Pu^{239}. In the latter case, all results by various techniques and various laboratories seem to be in agreement except that the place for 100 kev electrons in 0.5 percent abundance is not yet known. Two gamma rays reported elsewhere which did not fit with the alpha data have now been attributed to other nuclides. The decay scheme has been determined.

Other nuclides whose alpha rays have been studied by this instrument include Cm^{242}, Cm^{243}, Cm^{244}, Am^{241}, Pu^{240}, U^{230}, U^{232}, U^{233}, U^{234}, Th^{226}, and Tb^{149}.

Fission and Spallation of Tantalum

The yields of isotopes of several elements from nickel to ruthenium have been measured for the disintegration of tantalum by 340 Mev protons.

Excitation Functions for Uranium

The yield of the reaction $U^{238}(d,p)U^{239}$ has been measured up to 190 Mev on the 184-inch cyclotron and up to 20 Mev on the 60-inch cyclotron. The peak yield (at about 15 Mev) is over 0.26 barn, and the plateau at the highest energies is about 0.01 barn.

The production of U^{237} from U^{238} by high energy deuterons has also been studied. It comes from two reactions: $U^{238}(d,p2n)U^{237}$ and $U^{238}(d,2pn)Pa^{237} \xrightarrow{\beta^-} U^{237}$. The curve starts at 10 Mev, has a maximum below 40 Mev, then levels off at high energy with a cross section of about 0.25 barn. This very high yield indicates that the reactions might better be written as (d,dn) and (d,dp), since probably only a single nucleonic collision is involved.

Time-of-Flight Mass Spectrometer

The new time-of-flight mass spectrometer, which is designed also to collect isotope samples, has been completed and has been tested with cesium from a thermal source. The vacuum is not good enough for other work, and a new trap has been designed and is under construction.

Szilard-Chalmers Reaction on Bismuth

An attempt was made to prepare the long-lived Bi^{210} in high specific activity by irradiation of tri-α-naphthyl bismuthine with neutrons at the Oak Ridge pile. The experiment failed due to decomposition of the organic compound in the pile. It is not yet known whether the decomposition was due to heat or radiation.

CHEMISTRY
Part B
(A.E.C. Program No. 5311)

Metals and High Temperature Thermodynamics

Work is in progress on the following problems:
1. Gaseous hydroxides.
2. Thermal conductivity of gases at high temperatures.
3. Refractories.
4. Gaseous molecules.
5. Gaseous oxides.

Basic Chemistry

The following problems are under investigation:
1. Thermodynamics of rhenium.
2. The hydrolytic polymerization of zirconium.
3. Germanium chemistry.
4. Thermodynamics of indium.
5. Thermodynamics of thiosulfate.
6. Solubility of rare earth fluorides.
7. Studies in non-aqueous solvents.
8. Heats of complexing.
9. Chemistry of ruthenium.

CHEMISTRY
Part C
(A.E.C. Program No. 6400)

UNCLASSIFIED

In the field of plant bio-chemistry, the study of the path of carbon in photosynthesis, using carbon-14 as a tracer element, has continued along three lines: (1) Exposure of organisms to $C^{14}O_2$ under previously untried conditions, and examination of the resulting pattern of carbon reduction; (2) Study and refinement of presently used experimental conditions, with the aim of controlling more exactly all of the variables; (3) Improvement of analytical techniques, both in the preparation and identification of labeled compounds from plant extracts and in the degradation of specific compounds.

The synthesis of carbon-14 labeled compounds has continued with work on leucine-3-C^{14}, acetic-2-C^{14} acid, cholic-23-C^{14} acid, and ring-labeled benzene and aromatic derivatives such as phenylalanine. A number of rearrangements and mechanisms studies or organic reactions have been investigated.

A patient has been given 20 microcuries of morphine-N-methyl-C^{14}, and the breath (CO_2), urine, feces and stomach contents analysed for radioactivity. Excretion was rapid, about 70 percent was eliminated by way of urine and feces in 48 hours, and 5 percent was found in the breath.

Other projects of a bio-chemical nature have been continued with the studies on: (1) Steroid metabolism; (2) Metabolic oxidation of labeled organic compounds in small animals, and the effects of drugs on the rates; and; (3) Nucleic acid metabolism.

10. MEDICAL PHYSICS UNCLASSIFIED
Part A
(A.E.C. Program No. 6400)

Tracer Studies

Studies on the effect of versene upon the excretion of plutonium in rats have been completed. The studies upon the metabolism of fission products in rats and monkeys are being continued.

Radioautography

A group of six rats was employed in an experiment to check leaching in the processing solutions in preparations of thyroid glands; the rats were injected with At^{211}. The fixatives used were 80 percent alcohol, 10 percent formalin, and Bouin's solution. Two complete thyroid glands were used for each fixative and autographs were prepared for final comparison. The control monkey in the At^{211} experiment was sacrificed and thyroid autographs are in progress.

Radiation Chemistry

Work has continued on the isolation and identification of non-volatile acids produced by irradiation of oxygen-saturated solutions of acetic acid. Data have been obtained on this effect of oxygen and pH on the gaseous products. Methods are being developed for the determination of hydrogen peroxide and organic peroxide in the target solutions.

MEDICAL PHYSICS UNCLASSIFIED
Part B
(A.E.C. Program No. 6400)

Biological Effects of Radiation with the 184-inch Cyclotron

Head irradiation experiments on rats were continued. Some animals were irradiated in the hypothalamic region. The animals were divided into two groups and were irradiated in the area of the hypothalamus just anterior and posterior to the pituitary. With 20,000 REP in a cylindrical volume of 1/8 inch diameter, both groups showed radiation effects as soon as one hour after exposure. The effects were particularly severe in the group receiving irradiation posterior to the pituitary. All the animals in this group died within approximately seven days following irradiation. The second group of animals, irradiated with 5,000 REP, showed no gross signs during the first week after irradiation. These animals are being kept for observation for the development of obesity,

which has been observed in previous groups of animals irradiated over the entire hypothalamic region.

Biological Effects of Radiation on Micro-organisms

Two illegitimate diploid yeast strains, with two biochemical genetic markers each, were successfully mated. A new cell was derived which proved to be tetraploid by verifying that the spores of its four-spore Asci were diploid. X-ray survival curves of haploids, diploids, triploids and tetraploids are being studied. Segregation of the genetic markers is also being followed.

Extension was made of the theoretical basis for evaluating survival curves of micro-organisms with different ploidies. The new model makes allowance for the sets of chromosomes in the cell and also for their grouping. It predicts different survival curves for cells with chromosomes packed close together, compared to those cells whose chromosomes are far apart. The new model also provides an explanation for the change in shape of survival curves when high specific ionization radiations are used.

Instrumentation

The multiple scintillation counter apparatus has been successfully tested on two patients, one patient with thyroid carcinoma metastasis, and one patient who received an injection of radioactive gold in the pelvic cavity. This apparatus, which was described in the previous progress report, is arranged so that pictures of the oscilloscope screen can be obtained with a Land camera. These pictures are developed within one minute so that immediate information can be obtained of the distribution of radioactivity in the patient's body.

The patient with the thyroid carcinoma was given a dose of 10 mc of I^{131}. This dose was strong enough to obtain about one picture of the distribution of iodine every two or three minutes, and the absorption of iodine was traced from the stomach and intestines to the blood stream. After four hours, the urinary bladder which was filled with iodine, was visible, and after 24 hours the carcinoma metastasis could be seen. A new metastasis was detected on the patient by this method which had not been diagnosed previously, but which was verified subsequently by x-ray diagnostic technique.

The technique was also successfully used to show the distribution of radioactive gold in the pelvic cavity of another patient. In rabbits colloidal Au^{198} was given by intravenous injection. The scanning apparatus obtained a picture of the distribution of the gold three minutes after injection. At this time practically all of the gold was in the liver and the spleen, which was masked by the liver. At a later time the gold was taken up in the skeleton and an image of the skeletal system was obtained. The sensitivity of this method is such that pictures of the distribution of 1 $\mu c/cm^2$ gamma emitters can be photographed within a

few minutes' exposure.

Effects of Irradiation on Lipoprotein Metabolism

Continuing studies of lipoprotein metabolism indicate that severe irradiation in the rabbit induces an immediate inability to convert lipoproteins. This has been shown by giving irradiated rabbits a large quantity of S_f 20 - 50 lipoproteins to artificially create in the blood a detectable level of these lipoproteins. The unirradiated rabbit quickly transforms this administered load of S_f 20 - 50 lipoproteins and they disappear from the blood, whereas the severly irradiated rabbit lacks this converting ability immediately after irradiation up to three days post irradiation.

The Effects of Altitude on Body Water

Experiments designed to study the effect of altitude on the water content of animals has been in progress for the past six months. These experiments have been conducted in the decompression chamber at an equivalent altitude of 15,000 feet. It has been shown that a rapid loss of approximately 14 percent of body weight occurs within 4 days and it has been demonstrated, by our technique of using tritium to measure water volume, that this initial loss consists almost entirely of water. During acclimatization some of the water is regained but this does not occur as rapidly as the recovery of body weight. Further research on this project is underway.

11. HEALTH CHEMISTRY
(A.E.C. Program No. 5311)

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Equipment Development Group

1. A new decontamination chamber has been put in operation; its improved setup is based on a design made after trial use of a pilot model over a period of a year.

2. Preparation continued for two highly active Canadian pile-bombarded samples to be received at the end of May; partial description of the equipment was given in the progress report for December 15, 1951, to January 15, 1952.

3. Work continued on operation of equipment for the "Cows", from which americium is milked.

4. Seven gloved boxes were completed plus the usual repair and reassembling of boxes, centrifuges and auxiliary box equipment.

12. PLANT AND EQUIPMENT

Chemistry Laboratory Building. (Program No. 9500. 5-424-1002) A model of the Chemistry Laboratory Building, together with preliminary plans, have been completed by Eric Mendelsohn, the Architect, and are awaiting approval.

Bevatron Instrument. (Program No. 9500. 5-424-9001) Winding is approximately 87.5 percent complete.

Animal House. (Program No. 9600. 6-424-9007) Paving adjacent to the Animal House has been completed and the landscaping around the Animal House has been started.

Radiological Laboratory at the U.C. Medical Center. (Program No. 9600. 6-424-9008) Sound level measurements have been made and acoustical treatment of the accelerator room is in the process of being designed and installed.

MAN-MONTHS EFFORT REPORT
Scientific Personnel

PROGRAM NO.	SUBDIVISION	MAN-MONTHS EFFORT	COMMENTS
9200 M.T.A. - Mark I	Construction	-	
9500 Bevatron	Miscellaneous	4.70	
Operations			
2000 M.T.A.	Design and Development	73.84	
3000 Weapons Research	General	16.64	
5211 Physics Research			
Experimental Physics	Cloud Chamber	12.05	
	General Physics Research	55.445	
	Instrument for General Use	4.64	
	Magnetic Measuring	3.22	
Theoretical Physics	General	10.76	
Photographic Film Detectors	General	13.10	
5261 Applied Physics Research			
Mark III Cyclotron	Electron and X-C Models	14.96	
Chemistry Research			
5311 Basic Chemistry Research, Part A	Chemistry of Heavy Elements	3.69	
	Nuclear Properties of Heavy Element Isotopes	8.84	
	Transmutations with 184-inch and 60-inch Cyclotrons	7.65	
	Analytical and Services	18.67	
	Special Chemistry Development	1.00	
	Mass Spectroscopy, Beta Ray Spectroscopy	1.00	

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PROGRAM NO.	SUBDIVISION	MAN-MONTHS EFFORT	COMMENTS
Chemistry Research (continued)			
	Instrument Development and Services	3.59	
	X-Ray Crystallographic Measurements	2.62	
	Health Chemistry Research	10.98	
Basic Chemistry Research, Part B	Metals and High Temperature Thermodynamics	6.00	
	Basic Chemistry, including Metal Chelates	3.50	
5361 Applied Chemistry Research	Process Chemistry	4.18	
Reactor and Accelerator Operation			
5731 Electron Synchrotron	Operation	9.41	
5741 184-inch Cyclotron	Operation	10.39	
5751 Linear Accelerator	Operation	8.81	
6300 Biology and Medicine	Internal Irradiation and Hematological Response	5.62	1.23 Consultant
	Health Medicine	7.10	- Man-Months
6400 Biological Research Part A	Metalistic Properties of Various Materials	10.00	
	Radio Chemistry and Radiation Chemistry	6.00	
	Radioautography	2.00	
6400 Biological Research Part B	Instrumentation for Quantitative Measurements of Radiation	2.77	.90
	C^{14} Metabolism	1.82	.85
	Use of Radioactive Materials in Human Physiology and Experimental Medicine	13.01	7.17
	Trace Elements and Irradiation Studies	6.25	2.48

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PROGRAM NO.	SUBDIVISION	MAN-MONTHS EFFORT	COMMENTS
Biological Research (continued)			
	Radiation and Mutation Rate	1.70	.35
	Physical Biochemistry	12.96	4.30
	Biochemical Response to Irradiation	4.61	.25
	Miscellaneous	4.08	3.77
	Metabolism of Lipo Protein and Lipids	5.10	12.61
	Iron Metabolism Hematopoiesis	2.49	.50
	Synthetic and Experimental Organic Chemistry	5.51	-
	Biological Chemistry	6.85	-
	Photosynthesis Chemistry	6.19	-
	Metabolism of Fission Products	17.90	-
6500 Biophysics Research	Biological Effects of Cosmic Radiation	2.00	.25
	Health Physics	1.89	-

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