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UNIVERSITY OF CALIFORNIA

Radiation Laboratory

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MONTHLY PROGRESS REPORT NO. 59 FOR MARCH 1948

Berkeley, California

UNIVERSITY OF CALIFORNIA, RADIATION LABORATORY

MONTHLY PROGRESS REPORT NO.59 for MARCH 1948

1. 184-inch Cyclotron Program

The cyclotron was used for research experiments eighty per cent of the 496 hours the crew was on duty. It was definitely determined this month that mesons are produced by the 184-inch cyclotron, hence about forty percent of the time used for research experiments was spent on the investigation of mesons.

The cyclotron is now back on the original operation schedule (8:00 a.m. through 12:00 midnight), however it is shut down for sixteen hours one day each week. This shutdown complies with the power saving program. These scheduled shutdowns are being used for maintenance and repair work and for the installation of new equipment on the cyclotron.

2. 60-inch Cyclotron Program

The activities of the 60-inch cyclotron were curtailed during March 1948 by a factor of approximately 15.4 percent due to the power conservation measures. This time was utilized to put in order necessary maintenance jobs which required complete shutdown. The bombardments and operation schedule occupied 75 percent of the time the power was available.

3. Synchrotron Program

The past month has been devoted to testing of the magnet excitation equipment and adjustment of the magnetic field. Some trouble was encountered in making the "trailing" pair of ignitrons properly share the magnet current. After consultation with the General Electric Company, some revisions in the ignitron firing circuits were made. The performance as regards load sharing is now satisfactory. The frequency of arc backs in one of the trailing tubes still seems to be abnormally high and a cure for this difficulty has not yet been devised. Operation of the equipment is not seriously affected, but it is feared that the tube life may be appreciably shortened by this trouble.

Most of the magnetic measurements and adjustments have been associated with the problem of satisfying the betatron flux condition for a sufficiently long time interval after the magnetic field passes through zero. So far, this period is not long enough to permit betatron acceleration to 2 Mev (the design value). It is believed that the trouble is caused by variations in the spacing between flux bar laminations resulting in a spread in the saturation time for individual laminations. Observations of the saturation times of individual flux bars indicate that they may be individually adjusted to improve this condition. The most promising means of adjustment is to insert sheets of transformer iron in the flux bar air gap, thereby utilizing the eddy currents in these sheets as a means of delaying the saturation of the

laminations in the centers of the flux bars.

A rough survey of the azimuthal variation of magnetic field showed errors of approximately 6 gauss at the time of injection. No attempt has been made to equalize these errors to date, but it is believed that this variation is well within the range of adjustment available by use of the shading coils.

A revision of the handling equipment designs has been necessary because the dimensional errors in the magnet slabs did not permit the use of sufficient insulating material between the lifting straps and the slabs. It was found that the insulation which could be inserted was inadequate to withstand the induced voltages which resulted in sparking between the slabs and the lifting straps. The handling equipment parts associated with this trouble have been removed in order to permit operation while they are being re-worked.

4. Linear Accelerator Program

Van de Graaff Generator. The principal concern of the Van de Graaff is still that of improving operational reliability. The machine was delivering a 4-million volt beam for 70 hours, or about 17-1/2 percent of our total working time during March. The first two weeks were spent largely in finding and fixing a leak in one of the flexible connections at the ground end of the accelerating tube.

The problem of keeping the tank temperature low enough during prolonged running has been partially alleviated by circulating ice water through the heat exchanger in the tank. The basic problem involved here is that of providing adequate cooling for the air-cooled pump on the ion source, to keep the vapor pressure of oil in the ion source system low. Scattering of the beam by oil vapor has two undesirable effects- (1) it reduces the beam intensity, (2) it gives a diffuse, unfocused beam which strikes the electrodes of the accelerating tube on the way down and initiates secondary processes which lead to breakdown of the tube. Tests are under way to find a satisfactory permanent solution to the problem. A baffle refrigerated with a freon system reduces the vapor pressure of oil by a factor of 100, but is rather complex to be installed in the high voltage terminal. It is planned to conduct tests with an activated charcoal trap, and various schemes for getting liquid air into the high voltage shell are being considered.

A great deal of trouble has been experienced with the brushes and commutators of the DC generators in the shell. The principal use for the DC is for driving the hypervac pump. A direct drive for the hypervac pump is being designed. When this is completed and installed, the DC generators can be dispensed with, if desired.

Work is progressing on the 90° magnetic deflecting system for the Van de Graaff beam which will permit its use independent of the linear accelerator.

Linear Accelerator. The following runs were made, with a current of approximately 10^{-11} amperes of 32 Mev protons: Excitation curve on B_4C, calibration of nuclear research plates for range of 32 Mev protons, background measurements for cloud chamber experiments, search for delayed neutrons from $C^{18}(p,2p)$ reaction, search for short half lives in eleven of the light elements, search for exchange reaction at 32 Mev, alignment and preliminary run on p-p scattering via photographic plates, and alignment and preliminary run of inelastic scattering apparatus.

The 32 Mev beam was available 70 hours (limited by the Van de Graaff). The rf part of the accelerator has been remarkably free of troubles. The 40-foot tank has not been opened for three months. Full rf voltage can be obtained in the cavity resonator at any time, within ten minutes.

5. Experimental Physics

Film Program and Meson Experiments. Work has continued on the mesons produced from the bombardment of various targets with 380 Mev alpha particles. In addition to the mesons of mass in the neighborhood of 300 electron masses, evidence is found for the production of lighter negative mesons at the target with comparable yield and of mass apparently of the order of 200 electron masses. These mesons are distinguished from the heavier ones by their increased range at a given $H\rho$, by grain counting, and by the comparative absence of stars at the end of their range. In addition, positive mesons (300 electron masses) have been observed and their decay into lighter mesons observed as reported by the Bristol group.

Efforts to reduce the background in these experiments have so far been comparatively unsuccessful.

Since the meson yield is too small to permit experiments using the external alpha particle beam, arrangements are being made to remove the mesons produced at an internal target by means of a magnetic shield. It is thus hoped that lifetime and decay properties can be studied.

The detection of mesons in a meson fission chamber using Pb and Th foils was attempted successfully.

Neutron-Proton Scattering (Cloud Chamber). Experiments continue on the subject and are now giving very satisfactory results. Measurement techniques and criteria have been improved to the point where the theoretical neutron energy distribution is confirmed by measurements at all scattering angles. The results are then in excellent agreement with the counting experiments in the regions where they overlap. Additional photographs are being taken

with the stereoscopic cameras rotated so as to give maximum accuracy for large angle protons.

Neutron-Proton Scattering (Counter). The work done during this month consisted of the preparation of a vacuum chamber and associated apparatus for the extension of the scattering measurements to wider angles (45°-70°) than have previously been obtainable; checking the electronics apparatus used, to find the source of faults in its operation; actual experiments in the neutron beam from the cyclotron; and analysis of results.

Range Energy Measurements. Comparative range energy measurements in various materials are now in progress using the external deuteron beam and an ionization chamber for detection.

Neutron Diffraction Experiments. Measurements were continued using a set of three coincidence counters behind paraffin as a neutron detector. A BF_3 counter with paraffin used as a monitor gave the same results as a coincidence monitor and operated over a longer range. Differential scattering cross sections (4°) for Pb, Cu, and Al were in the same ratios as were found using carbon detectors.

Delayed Emission of Neutrons. Period measurements for the delayed neutrons from cerium and lead have been studied as a function of target position in the cyclotron. Both yield the same array of half lives, namely: 55-57 sec, 15-20 sec, and ~4 sec. This suggests that the activity from Ce may be due to contamination of one of the heavy elements, possibly Th.

6. Theoretical Physics

The problems worked on included cross sections for the production and annihilation of mesons; nuclear forces required to fit the n-p scattering; star production by deuterons and mesons; and bevatron calculations.

7. Chemistry

Part A

A New Collateral Chain of the Uranium Series. A great number of alpha-emitting isotopes have been observed following the bombardment of thorium with 60 Mev deuterons. Among these is a new decay series starting with Pa^{226} and which runs into the uranium series at RaE. The mass number was identified by observing the growth of Po^{210} from a sample of separated protactinium. The Pa^{226} has a half-life of 38 minutes and decays by the emission of a 6.46 Mev alpha-particle. The half-lives of the other members of the decay series cannot be longer than a few minutes since they appear at equilibrium several minutes after the separation of protactinium. It is also probable that there

is little branching in the alpha decay at any point along the chain since in all cases appreciable orbital electron capture branching would lead to identifiable isotopes. None of these were observed. The probable members of the decay series and their alpha energies in Mev are Pa^{226} -6.46, Ac^{222}-6.64, Fr^{218} -7.30, At^{214} -8.00. The pairings of alpha energy and isotopic assignment as shown are reasonable assignments but are otherwise not proved.

Cross Sections of Nuclear Reactions at High Energies. Following the bombardment of antimony with high energy particles the yields have been determined for the production of a number of isotopes of antimony and tellurium, that is, isotopes in the neighborhood of the target element. The cross sections in barns are listed in the accompanying table and show that these are fairly independent of energy for the isotopes and energy range studied. Factors of two are probably not significant because of uncertainties in the beam current.

	Energy (Mev) and particle			
Isotope	100 Mev d	200 Mev d	300 Mev d	400 Mev He
Te^{118}(6.0 days)	0.053	0.018	0.017	0.029
Te^{119}(4.5 days)	0.066	0.023	0.021	-----
Sb (2.5 hr)	0.021	0.013	-----	0.020
Sb^{119}(40 hr)	0.18	0.16	-----	-----
Sb^{120*}(6.0 days)	0.16	0.07	0.14	0.18
Sb^{122}(2.8 days)	0.065	0.042	0.045	0.072
Sb^{124}(60 days)	-----	0.0011	0.0016	-----

Preparation of Am_2O_3. The treatment of "black americium oxide" with hydrogen at around 800° C has led to the observation through x-ray diffraction measurements of a new phase which is thought to be Am_2O_3. This phase is isomorphous with a praseodymium sesquioxide, which has a new unidentified structure of neither the usual cubic nor hexagonal type.

Separation of Lanthanide and Actinide Elements by Column Absorption and Elution. In a study of agents for eluting lanthanide and actinide elements from nalcite (Dowex 50) resin columns, it has been found that with ammonium fluosilicate the rate of elution of the lanthanides is increased relative to the actinides as compared to elution with ammonium citrate. Thus, europium, samarium, and promethium are eluted well ahead of curium and americium in the case of ammonium fluosilicate, but with ammonium citrate the promethium

and americium come off together. Elution with 3 M HCl gives essentially the same results as with ammonium citrate but with increasing HCl concentrations there is an increase in the rate of elution of the actinide elements relative to the lanthanides so that curium and americium come off ahead of promethium and possibly even ahead of lutecium with 12 M HCl.

Chemistry

Part B

Synthetic and Experimental Chemistry. Synthesis of stilbamidine labeled in the amidine carbon is being studied. The free base has been prepared in cold runs, but yields to date are poor. This compound is being synthesized to investigate its behavior in multiple myeloma in which, according to previous reports, it has a chemo-therapeutic effect associated with a tendency to localize in the tumor tissue.

Preliminary experiments on the cyclic dehydrogenation of heptene-1, 1-C^{14} to toluene indicate that the activity of the one position is found both in the ring and in the methyl group. Experiments are being continued on degradation and identification of the various intermediates and the uncyclized heptene. The effective contact time on this reaction will be studied. It may well be that this reaction will serve as a satisfactory high yield, high specific activity synthesis for ring-labeled compounds. The study of the synthesis of C^{14}-carboxyl labeled anthranilic acid is being continued. Yields of about 60 percent, based on carbon dioxide, have been obtained and efforts are being made to increase this value. In addition to this work, the preparation of the three amino acids and beta-labeled alanine is being continued.

Biological Chemistry. The studies on the metabolism of various carbon 14 labeled compounds is being continued. These include 9,10-labeled dibenzanthracene, beta-labeled tryptophane, and beta-labeled tyrosine. Work is in progress on the full characterization and identification of the metabolites of dibenzanthracene in the body. In the study of the biological conversion on beta-labeled tryptophane to nicotinic acid and kynurenic acid (in dogs and rats), techniques are being devised by the isolation from the urine of the various metabolic intermediates.

Photosynthetic Chemistry. Work has continued on the identification of the carbon dioxide fixation products in green algae. Aspartic acid labeled with C^{14} has been identified by use of filter paper chromatography in conjunction with radio autographic technic. In these experiments, no labeled glutamic acid was observed. This would indicate that the tricarboxylic acid cycle was not involved in the earlier stages of photosynthesis. On the other hand, the discovery of aspartic acid confirms a previously published dicarboxylic acid cycle which involves oxalacetic acid (The Dark Reduction of Photosynthesis, A. Benson and M. Calvin, Science 105, 648 (1947)). Presumably, the aspartic and oxalacetic acids are in rapid equilibrium.

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The carboxyl carbon of alanine isolated from 5 minute dark fixations by pre-illuminated algae has approximately the same specific activity as that of carbon dioxide fed the plants. This would again tend to confirm the published dicarboxylic acid cycle since the alanine and the pyruvic acid are in equilibrium.

Plant-synthesized malic acid, which has been previously shown to be the major carboxylic acid synthesized in short periods of photosynthesis as well as the major product in dark fixation after pre-illumination, has now been degraded and shown to have about 1 percent of its activity in the alpha and beta positions and 99 percent in the carboxyl groups. Alanine from the same experiments has also been degraded and shown to contain less than 1 percent of the C^{14} activity in the alpha and beta carbon.

The plant metabolism of chemically synthesized C^{14}-labeled acetate is being studied with Chlorella, Scenedesmus and tobacco leaves. The penetration and the fixation of the acetate is being determined and the products formed during respiration and photosynthesis are being characterized. In the case of the experiments with tobacco leaves, the distribution of the fixed acetate between the cytoplasm and the chloroplasts is also being measured.

Chemistry SECRET

Part C Subproject 48B

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

1. Thermodynamics of CN.
2. Thermodynamics of gaseous molybdenum and copper halides.
3. Absorption coefficients of species in sun.
4. Low melting metal alloys.
5. Refractory studies.
6. Heats of formation of Na-Sn and Li-Sn alloys.
7. Theory of the solid state.

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SECRET

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

1. Solvent extraction, complexing and hydrolysis of Zr(IV).
2. Hydrolysis of uranyl ion.
3. TTA chelate complexing of uranyl ion.
4. Identification of uranyl species extracted into ether.
5. Exchange of radioactive iodine between IO_3^- and I_2.

8. Medical Physics

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Part A. Project 48A-I

Radioautographic studies are being continued.

The four day and thirty-two day intramuscular studies with actinium are complete. Of the material absorbed, the major deposition is in the skeleton. Comparative studies using radio-calcium and radio-strontium have been set up and are in the process of being completed. The metabolism of Ge^{71} has been completed up to eight days. This element is very rapidly excreted. Blood studies on radio-silver are being continued. Sixteen and thirty-two day zirconium intramuscular studies have been completed as have the one, four, and thirty-two day studies on Be^{7}. These studies indicate that about 30 percent of the Be administered is deposited in the skeleton. One, four, sixteen, and sixty-four day intramuscular studies with vanadium have been set up.

An experiment was set up to determine the effect, on radio-strontium excretion, of injections of zirconium citrate administered immediately after the administration of the radio-strontium. Previous excretion of radio-yttrium and plutonium. Early results from the experiment comparing the metabolism of radio-calcium and radio-strontium indicate a close similarity between these two elements. The first series of animals on the improved phosphate deficient diet (0.005% P) have been set up to determine the value of this severe deficiency in demineralizing bone.

A method was developed for obtaining vanadium carrier-free from a titanium target. Work is in progress on a method of obtaining carrier-free scandium from the titanium target, as well as an investigation for the presence of calcium. Work has been started on the separation of protoactinium and uranium from a thorium target. The method which is being used has been previously reported.

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Medical Physics

Part B. Project 48A - II

Experiments with the 184-inch cyclotron. The 50 percent LD for Bagg Albino mice appears to be 150 - 30 rep in the direct beam. 190 Mev deuteron particles were used and so directed that they passed lengthwise through the bodies of the mice. The range is much longer than the size of the body of the mice, and the mean energy of the deuterons within the body was calculated to be about 170 Mev. The exposure required for the 50 percent LD was about 15 seconds. It appears from a comparison of these results with other data previously obtained with 90 Mev neutrons that the lethal effect of fast protons and deuterons is a function of the length of time of bombardment. The three experimental points obtained so far (for 10 seconds, 2 hours, and 24 hours) indicate that the LD 50 vary approximately as the fourth root of the exposure time.

Trace Analysis by Induced Radioactivity. Previously (Monthly Progress Report for June, 1947) we have reported on a method of trace analysis by induced radioactivity. A set of 24 mouse tissue ash samples was irradiated at the Hanford pile by slow neutrons and the specific activity and half life of each tissue was followed. The samples with the highest specific activity a week after exposure are bone, adrenals, pancreas, liver, kidney, spleen, brain, and lung. Other samples all have about the same specific activity. The radioactivity of white cells compared to red cells or plasma seems to be higher by a factor of five. The distribution of gold 198 has been determined. Other isotopes are being separated now.

Study of Sodium Space in Rabbits After Irradiation by X-rays. A study of the mechanism of ion exchange through cell walls was begun two months ago. In the first phase of this work the distribution and mixing of sodium ions was studied by the tracer technique with and without x-radiation. Definite effects due to sublethal amounts of x-rays have been demonstrated on the distribution of Na ions. Sodium 24 was injected intravenously in rabbits and the radioactivity of the plasma was measured at frequent intervals.

In unirradiated animals a constant Na level is reached within three hours after injection. This level is maintained almost constant for several hours. In irradiated rabbits (400 r of 200 kv x-rays) the sodium concentration in venous blood decreases over a period of several hours after irradiation. Results may be expressed in terms of sodium space. In normal animals sodium space equals the volume of extracellular fluid. In irradiated animals the sodium space increased compared to the intracellular fluid by as much as 50 percent in some cases. This result was shown in four of the six irradiated animals to date. The work is being continued.

9. Health Physics and Chemistry

In addition to routine monitoring during the month one-hundred thirty odd packages ranging in size from the side of a house to one foot square were monitored at the Army 2001 Warehouse for alpha contamination in preparation for disposal at sea. Of special interest was the monitoring of a shipment of radioactive xenon, prepared in 106 ORL by Ray Dunn.

Besides the routine trip to sea for disposal of radioactive waste, another trip was made for the dumping of about one-third of the Army 2001 Warehouse alpha-contaminated packages. The remainder will be disposed of during April.

Filters were removed from the dry boxes in Room 193, Old Chemistry, and turned over to the decontamination group.

Research and development work has progressed on the following items:

1. Beta-gamma lead-shielded gloved box-about 80% complete; electrical fixtures and controls completed.
2. Target assembly for 60-inch cyclotron.
3. High temperature furnace for spectrum analyses of radioactive isotopes.
4. Redistillation apparatus for Bldg. 5 completed.
5. Further shielding tests on lead and lead glass.
6. Installation of three centrifuges in Bldg 4.
7. Alteration and installation of twelve small hot plates in hoods.
8. "Inert atmosphere box" created for A. Ghiorso.
9. Further alterations in spinner column.
10. Further centrifuges and gloved boxes in preparation.
11. A water tank and Ra-Be source have been set up for calibrating In foils used in measuring slow neutron fluxes.

APPROXIMATE DISTRIBUTION OF EFFORT

PROGRAM	SUBDIVISION	MAN-MONTHS EFFORT	COMMENTS
1. 184-inch Cyclotron	Operation	13.0	
	Development	0.5	
2. 60-inch Cyclotron	-----	-----	Non-Project
3. Synchrotron	Vacuum Chamber	0.2	
	R.f.System	3.6	
	General	0.4	
	Injection	1.0	
	Miscellaneous Equipment	2.2	
	Magnet Tests and Operation	3.1	
4. Linear Accelerator	Linear Accelerator-General	5.0	
	Van de Graaff Generator	7.0	
	General, Development, etc.	1.0	
5. Experimental Physics	Cloud Chamber	5.1	
	Film Program	2.3	
	Ionization Chamber and Crystal Counter	0.8	
	Neutron-proton Scattering	2.0	
	Proton-proton Scattering	2.0	
	Neutron Diffraction	1.3	
	Delayed Neutrons	2.0	
	Meson Counting	1.0	
	Bevatron Design Studies	4.1	
	General Physics Research	10.3	
	Magnetic Measuring Equipment	.92	
6. Theoretical Physics	Synchrotron	0.3	
	Bevatron	1.5	
	Cyclotron	0.5	
	Linear Accelerator	0.3	
	General Physics Research	8.2	

PROGRAM	SUBDIVISION	MAN-MONTHS EFFORT	COMMENTS
7. Chemistry. Part A	Chemistry of Transuranic Elements	5.0	
	Nuclear Properties of Transuranium Elements	3.5	
	Transmutations with the 184-inch Cyclotron	6.0	
	Transmutations with the 60-inch Cyclotron	1.0	
	Analytical and Service	14.5	
	Chemistry of Astatine	1.5	
Chemistry. Part B	Synthetic and Experimental Organic Chemistry	6.7	
	Biological Chemistry	7.0	
	Photosynthetic Chemistry	6.9	
Chemistry. Part C	Metals and High Temperature Thermodynamics	2.5	
	Basic Chemistry, Including Metal Chelates	4.5	
	General	2.0	
8. Medical Physics. Part A.	Evaluation of Metabolic Properties of Plutonium and Allied Materials in Animal and Man	12.0	
	Decontamination Studies	7.0	
	Radiochemistry	1.0	
	Radioautography	1.0	
Medical Physics. Part B. (Project 48A-11)	Uranium Research	1.5	1.5 Consultant Man-Month
	Tumor Metabolism	0.3	0.5 "
	Special x-ray Studies, Radioactive Measurements, etc.	0.5	--
	Radioactive Carbon Studies	0.3	--
	Fundamental Medical Research	0.5	0.5 "
	Hematology	--	0.5 "
	Medical Work with 184-inch Cyclotron	0.5	0.5 "
9. Health Physics and Chemistry	Monitoring and Special Problems	7.0	
	Salvage, Decontamination, Disposal, Etc.	4.0	
	Research and Development	7.5	