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UNIVERSITY OF CALIFORNIA RADIATION LABORATORY

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MONTHLY PROGRESS REPORT NO. 55

Covering Contract No. W-7405-Eng-48

November, 1947

1. 184-Inch Cyclotron Program

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During the month of November about 60 percent of the cyclotron operating time was spent on the research program. The remaining 40 percent of the time was devoted to installing and testing new equipment and to correcting operating difficulties. Much of the operating trouble still occurs in the rotary condenser. Two shut-downs were caused by the failure of the new brush design and further trouble was encountered with the vacuum gaskets.

A beam focussing magnet was installed which turns the deflected beam through 18 degrees and refocusses it outside the shielding wall. The new deflector high voltage supply was installed and is operating in a completely satisfactory manner. Handling equipment for removing large targets by remote control has been put into operation. Both design and production work have continued on the proton conversion.

2. 60-Inch Cyclotron Program

Approximately 500 hours of bombardments were carried out with the 60-inch cyclotron during the month of November. The design for the new dees, which incorporates a number of major improvements, is approximately 95 percent complete. The new probe stand for the vacuum lock has been completed and will be installed shortly.

3. Synchrotron Program

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The outer vacuum chamber ring has not yet been successfully implemented. The latest vacuum test shows the presence of numerous small leaks which make it impossible to obtain a satisfactory operating vacuum. Tests are now in progress to determine the best way of curing this difficulty.

The magnetic slabs received during the past month have permitted the resumption of work on the magnet. According to the present delivery schedule it is believed that the magnet assembly can continue to completion without further interruption. Five magnet slabs and nine flux bars remain to be delivered.

The percentage of completion of various components is as follows:

Magnet assembly	60%
Control rack	85%
Transformer yard	90%
Impregnation and testing of wedges	98%
Magnet excitation	90%

It is estimated that the entire job is 92 percent complete.

4. Linear Accelerator Program

Van de Graaff Generator. The installation of the ion source pulser was completed and is operating satisfactorily. It is now possible to get extremely steady operation at four million volts with both a d.c. beam of several microamperes, and a pulsed beam of about 100 microamperes. The focus at four million volts is very good. The new nitrogen storage system is complete and in operation.

Forty-foot Section. A number of changes have been made which have markedly improved the reliability of the 40-foot section. The voltage for the pre-exciting oscillator has been shifted to the "Ametran" transformer to permit the use of five pulsed power lines in the place of the previous three. The coupling loops have been decreased in area by approximately 20 percent, the 95 percent transmission grids have been soldered into the grid holders, and the drift tube caps soldered into place. As a result of these changes it has been possible to operate with an r.f. voltage 10 percent above the former maximum with very little sparking and only one tube failure in twenty-seven hours of operation.

5. Experimental Physics

Neutron-Proton Scattering. Work continues on neutron-proton scattering studies both by counting and cloud chamber techniques. A total of over five-hundred protons have now been measured by the first method. In view of the importance of this problem an independent measurement using counting methods is in progress. Several runs were made with the apparatus of Hadley, Leith and York and with the apparatus of Kelly and Wiegand. The results on the angular distribution of proton-neutron scattering although qualitatively the same did not agree quantitatively. A detailed investigation of the behavior of the apparatus involved in both experimental set-ups was made which revealed several causes of error. The errors involved were not large although they were appreciable. This investigation is continuing. Rutherford scattering in the proton absorbers used with the proportional counter is also under examination. A study of the diffraction effects observed when fast neutrons pass close to a nucleus is being made. In principle, such measurements carried out with neutrons of sufficient energy and with sufficient detail of observation can lead to information regarding the detailed structure of the nucleus.

Scattering of Deuterons and Cross Section Measurements. With the availability of an external beam, preparations are being made to study the scattering of deuterons by various materials including hydrogen. Also the external beam permits measurement of the absolute cross sections for various nuclear reactions to be made with comparative ease. Such measurements are now in progress.

Alpha-Particle Studies. The previously reported work on the production of stars by alpha-particles in photographic plates is continuing.

Other Experiments. Elastic scattering of neutrons from lead, copper, and aluminum is still under study. Further data indicates even more definitely the diffraction character of this process. Measurements of absolute cross sections for the process indicate values of approximately 1/2 the total cross sections.

Total cross sections for fast neutrons as measured by bismuth fission chamber detectors are being observed with satisfactory results. Values found are consistently less than those found with carbon activation detection, and the deviation from the $R \sim A^{1/3}$ law appears to occur at a higher atomic number.

6. Theoretical Physics

The interpretation of the measurements of total cross sections of nuclei for 90 Mev neutrons has been completed. The cross section for the scattering of the incident neutrons by a particle in the nucleus, deduced from the total cross section measurements, agrees quite well with that determined directly using the measured n - p and n - d cross sections. The variation-principle method of computing n - p scattering has finally been put into a form easy to use even with the inclusion of the tensor forces. Good agreement has been obtained between the variation calculations and the numerical integrations. Work has continued on a number of other problems including excitation functions, range curves, and the theory of the bevatron.

7. Chemistry

Part A

Chemistry and Structure of Actinide Elements. NpCl_4 has been prepared from NpO_2 and AlCl_3 . The product was identified by indexing its x-ray diffraction pattern against the lattice structure reported by Zachariasen.

A sample of AmO_2 has been prepared with pure americium and its lattice constant determined to be 5.376 ± 0.0001 . This value is within the range of the experimental values that Zachariasen obtained with a sample of AmO_2 thought to be impure, and is significantly different from his corrected value and from the curve of the U-Np-Pu lattice constants.

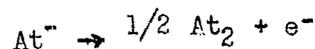
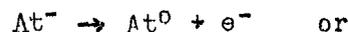
The method of preparation of heavy metals by reducing the fluorides with barium has proved quite successful in the cases of uranium, neptunium and plutonium, but not for americium. It has been found recently that of the rare earths europium metal also cannot readily be produced in this fashion, which is another piece of evidence for considering europium and americium to be homologues.

Nuclear Properties of the Heavy Elements. Recently the orbital electron capture isotope Np^{235} has been prepared by the $(d,2n)$ reaction with U^{235} . In the neptunium and plutonium fraction from this bombardment there was a great deal of alpha activity from Pu^{236} . When the plutonium was carefully separated from the neptunium a small amount of alpha activity persisted which had a range corresponding to an energy of about five Mev. It will be necessary to ascertain whether or not this activity decays with the same half life as the Np^{235} x-rays before it can be definitely assigned to alpha-branching of the isotope.

Nuclear Reactions with High Energy Particles. The region below tantalum is being investigated in order to determine the products of spallation reactions and therefore the types of reactions which occur in this region. All of the activities from the reaction of tantalum with 200 Mev deuterons have not yet been separated and identified, but it is already apparent that the highest yields appear in the immediate neighborhood of the target element and that there is a gradual decrease in yields through about five atomic numbers after which there is a sharp drop in yield for isotopes of lower elements.

Chemistry of Astatine. The migration experiments reported last month were completed. It was found that astatine migrated as a negative ion in a number of solutions but that there was no migration as a positive ion.

The distillation of astatine dissolved in carbon tetrachloride was carried out and experiments on the solvent extraction of astatine by carbon tetrachloride and benzene were begun. Experiments are in progress which employ the extraction experiments as a tool to determine the approximate oxidation potential of the reaction



Electrodeposition experiments on astatine and gold from the 0 and -1 states were attempted using the method of Joliot. No deposition on gold was observed in the potential region +0.2 to -0.6 volts.

Chemistry. Part B

Synthetic and Experimental Organic Chemistry. Lactic acid labeled with C^{14} has been prepared, and its degradation studied. Work has continued on the various phases of the synthetic program among which are the

synthesis and degradation of labeled propylene, the synthesis of ethyl alcohol, and an improved synthesis of glycine.

The experiments are being carried out to determine the loss of activity of solid barium carbonate counting samples when exposed to laboratory air. It was concluded that sensible care in the storage of counting samples should prevent serious loss over moderate periods of time.

Biological Chemistry. The distribution of radioactivity following intravenous administration of DL radiotyrosine to mice bearing melanosarcoma has been investigated. Radioactivity is found in every tissue of the body. Isolation work has begun on the tumors from these mice. It has been found that tyrosine is definitely converted to pigment in the tumor and that about half of the total activity in the tumor can be accounted for as melanin and tyrosine.

Photosynthetic Chemistry. It has been found that phosphorylation is not directly involved in photosynthesis. Methods have been developed for studying the rate of exchange of radioactive phosphate ions with the organic cell constituents of the working plant. No differences in rate were found upon illumination of the plant. It was discovered that algae can fix 16 or more times as much carbon dioxide after proper illumination for an hour as they can without this pre-illumination. Longer illumination than an hour without carbon dioxide endangers the life of the chlorella.

Chemistry Part C

Subproject 48B

Metals and High Temperature Thermodynamics. A successful run has been performed to determine the heat of formation of CN and the relative absorption coefficients of CN and C₂. The results are now being analyzed. A number of determinations of the heat of formation of sodium tin alloys have been carried out in a high temperature calorimeter. The apparatus for the preparation of TiC, ZrC, CbC, and TaC objects has been completed and tested. It works quite well up to 1200 and 1300°C.

Basic Chemistry. Measurements of the solubility of the Pu(IV) TTA chelate in 1.00M-HClO₄ are in progress to determine the various chelation constants between Pu(IV) and TTA. The Pu(IV) chelate behaves in aqueous solution like an organic compound insoluble in water. The solubility as a function of time appeared to fluctuate but there was no trend greater than the error introduced by the technique. Consequently only an approximate value of 4×10^{-8} M can be given.

Distribution measurements of Zr(IV) between aqueous perchloric acid and benzene TTA solutions have been continued at various perchloric acid concentrations from 2M to 0.2M. Extraction experiments are in progress to determine the distribution coefficients of U(VI) between aqueous acid solution and benzene solution of TTA.

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Several more attempts were made to prepare anhydrous uranyl nitrate for use in the study of its extraction into ether.

8. Medical Physics

Part A. Project 48A - 1

The radioautographic work with uranium, plutonium, americium, curium, element 61 and zirconium is continuing. New studies are being set up with carrier free radiocolumbium.

The tracer experiments with radiocadmium, indium, antimony, element 61, actinium, and U^{233} are also continuing. A high degree of retention of cadmium in the carrier free state is noted in the liver and pancreas. This effect is also noted with carrier free indium but to a much less marked degree. Tracer studies with carrier free radiotin have just been started.

Rats which have been injected with radioyttrium intramuscularly were given immediate treatment with zirconium citrate to determine the effect on yttrium excretion. Urinary excretion was markedly increased on all the treated animals. When rats were fasted for three to four days the up-take of radiostrontium from the gut and its retention in the skeleton following either oral or intraperitoneal injection is almost twice as great as in the well fed controls.

Part B. Project 48A - II

Preliminary biological studies have been carried out with the 90 Mev neutron beam from the 184-inch cyclotron. Mice have been exposed to various doses delivered at several dosage rates and the mean lethal dose for the animals has been estimated. The results of these preliminary studies may be summarized briefly by saying that with a dosage rate of 1000 "Victoreen units" per hour the LD50/60 days was about 375 Victoreen units. However, when the rate was decreased to 288 Victoreen units per hour the LD25/60 days was 650 units, while at 800 Victoreen units there was complete mortality. It is estimated therefore that the LD50 is somewhere between 600 and 850 Victoreen units.

Equipment is being constructed to make use of the direct beam of the 184-inch cyclotron for biological experiments. The beam will first be brought out to air through the deflector system, collimated and various biological test objects exposed to it. The specific ionization may be varied between wide limits and by collimation and judicious selection of particle energy, selective ionization of animal organs becomes possible.

9. Health Physics

Radiation Measurements in the Vicinity of the 184-inch Cyclotron. Further work with boron trifluoride survey meters has shown that in the region near the east yoke of the 184-inch magnet there is a fast neutron field of

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considerable intensity. This has been checked by a comparison of measurements with an aluminum wall ionization chamber and with a thick plastic walled chamber in this region. The slow neutron flux intensity outside the concrete shielding is of the order of 100 to 300 per cm^2 per second with a deuteron beam of $1/2$ microampere. Fast neutron effects as observed by the use of paraffin with the boron trifluoride chambers are small except in the region opposite the magnet yokes.

Measurements of slow neutron intensity in the shielding as a function of depth are continuing. With an improved shallow ionization chamber and a Lindemann electrometer further measurements are in progress of the ranges of ion particles arising in organic materials irradiated by 90 Mev neutrons.

Monitoring, Decontamination, Salvage, and Storage. Routine monitoring was carried out as usual and a number of special monitoring and decontamination projects were done during the month. Seventy film badges were processed and recorded, none of which showed an over-tolerance to exposure. The number of pocket electroscopes in use has been increased to 65. A set of 65 slow neutron pocket dosimeters has been brought into service for cyclotron crew members. In the analysis of routine air samples over-tolerance contaminations were discovered where spectrographic work was being done with neptunium samples. The filter work on this problem is being investigated. A number of routine collections of radioactive waste was made and disposal of the material carried out.

Research and Development. The 184-inch area radiation integrator which has been under development has shown satisfactory stability under tests extending over several weeks. In order to better analyze fast neutron fields a proton recoil proportional counter project has been initiated. Other items under which research and development work is being carried out include the further development of beta-gamma dry boxes, with special emphasis on the viewing systems, development and testing of air filters, further research on the milking equipment for the periodic extraction of americium from plutonium, and the completion of designs for the fabrication of platinum, aluminum and lead capsules for pile burial.

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APPROXIMATE DISTRIBUTION OF EFFORT

<u>PROGRAM</u>	<u>SUBDIVISION</u>	<u>MAN-MONTHS EFFORT</u>	<u>COMMENTS</u>
1. 184-inch Cyclotron	Operation	11.6	
	Development and Construction	1.9	
2. 60-inch Cyclotron	-----	---	Non-Project
3. Synchrotron	Vacuum Chamber	3.4	
	R. f. System	1.1	
	General Synchrotron Development	0.3	
	General Physics Research	0.5	
	Miscellaneous Equipment	1.4	
	Magnet	.3	
4. Linear Accelerator	Van de Graaff Generator	7.0	
	Oscillators	4.0	
	Vacuum System	3.0	
	Short Sections	0.5	
	General, Development, etc.	8.5	
	Miscellaneous Equipment	2.5	
	General Physics Research	3.0	
5. Experimental Physics	Cloud Chamber	7.5	
	Film Program	1.9	
	Ionization Chamber	0.5	
	General Physics Research	4.9	
6. Theoretical Physics	Synchrotron	0.3	
	Linear Accelerator	0.3	
	Cyclotron	.7	
	General Physics Research	12.5	

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-8-
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<u>PROGRAM</u>	<u>SUBDIVISION</u>	<u>MAN-MONTHS EFFORT</u>	<u>COMMENTS</u>	
7. Chemistry. Part A	Chemistry of Transuranic Elements	5.0		
	Nuclear Properties of Transuranium Elements	3.0		
	Transmutations with the 184-inch Cyclotron	4.5		
	Transmutations with the 60-inch Cyclotron	1.0		
	Analytical and Service Chemistry of Astatine	13.5		
		1.5		
	Chemistry. Part B	Synthetic and Experimental Organic Chemistry	6.8	
		Biological Chemistry	5.2	
		Photosynthetic Chemistry	6.4	
	Chemistry. Part C	Metals and High Temperature Thermodynamics	4.5	
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	11.0		
	Decontamination Studies	6.0		
	Radiochemistry	3.0		
	Radioautography	2.0		

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UCRL-20
-9-

PROGRAM

SUBDIVISION

MAN-MONTHS EFFORT

COMMENTS

Medical Physics. Part B (Project 48A-II)	Uranium Research	3.0	2.5 Consultant Man-months
	Tumor metabolism	0.5	0.5 "
	Special x-ray Studies, Radioactive Measurements, etc.	---	0.5 "
	Radioactive Carbon Studies	0.5	0.5 "
	Fundamental Medical Research	0.5	1.5 "
9. Health Physics and Chemistry	Monitoring and Special Problems	7.1	
	Salvage, Decontamination, Disposal, etc.	2.4	
	Research and Development	6.1	

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