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ORNL-1339

ELECTROMAGNETIC RESEARCH DIVISION

QUARTERLY PROGRESS REPORT

Part I

For Period Ending March 31, 1952

AEC RESEARCH AND DEVELOPMENT REPORT

CLASSIFICATION CHANGED TO: DECLASSIFIED
BY AUTHORITY OF: E. J. Murphy 1·31·62
BY: S. Beidel 6·21·62

OAK RIDGE NATIONAL LABORATORY
OPERATED BY
CARBIDE AND CARBON CHEMICALS COMPANY
A DIVISION OF UNION CARBIDE AND CARBON CORPORATION
OAK RIDGE, TENNESSEE

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Index No. ORNL-1339
This document contains 31 pages
This is copy 5 of 90 , Series A

Subject Category:
Particle Accelerators and High-Voltage Machines

ELECTROMAGNETIC RESEARCH DIVISION

Robert S. Livingston, Director

QUARTERLY PROGRESS REPORT, PART I
for Period Ending March 31, 1952

Edited by F. T. Howard

[redacted]

OAK RIDGE NATIONAL LABORATORY
Operated by
Carbide and Carbon Chemicals Company
A Division of Union Carbide and Carbon Corporation
Oak Ridge, Tennessee

Contract No. W-7405-eng-26

[redacted]

[redacted]

Index No. ORNL-1339
Particle Accelerators and
High-Voltage Machines

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ABSTRACT

Relocation of the ion source in the 86-inch cyclotron has increased the available beam energy substantially. Modifications have also been made to permit the use of targets of 100 square inches. Proton currents of one milliampere can now be obtained readily at $\sim$ 24 Mev.

The 63-inch cyclotron has been completely assembled and checked. In rf tests a 75 kv dee-to-dee voltage has been maintained, under vacuum, for long periods without evidences of failures, thus exceeding the 60 kv design specification.

In an investigation of proton beam distribution on the 22-inch cyclotron it has been shown that almost all of the loss of protons from the beam occurs within one-half of the maximum radius. The ratio of H_3^+ to H_1^+ ions in the beam increases at lower arc intensities in the ion source.

Accelerated corrosion was found in an Inconel tube containing #14 eutectic (ARE) after a six-hour bombardment with 20 Mev protons at 4,500 watts/cc.

Installation of facilities for the preparation of plutonium isotopes is nearing completion; preliminary tests are being made.

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PREVIOUS QUARTERLY REPORTS

Quarterly reports have been issued by the Electromagnetic Research Division for the periods ending:

September 30, 1949	Y-495
December 31, 1949	Y-548
March 31, 1950	Y-584
June 30, 1950	Y-637
September 30, 1950	Y-676
December 31, 1950	Y-722
March 31, 1951	Y-767
June 30, 1951	Y-795
September 30, 1951, Part I	ORNL-1173
December 31, 1951, Part I	ORNL-1269

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THE 86-INCH CYCLOTRON

Operation of the 86-inch cyclotron was interrupted on January 14, 1952 for modifications which would permit the use of larger targets and provide for operation at higher energies. The reliability of operation at the time of the shutdown was excellent. A steady beam current of one milliampere could be obtained at an energy of ~19 Mev, but attempts at increasing the energy, by lowering the target, resulted in the beam striking the periphery of the south dee. This condition resulted from the center of rotation of the beam being offset to the south by a distance of approximately three inches.

A shutdown period of four weeks was scheduled. When operation was resumed, however, unexpected difficulties developed due to the increased power input to the cyclotron. The upper portion of the liner and the spider became overheated from rf heating. Operation was further delayed for installing additional water cooling in these portions of the resonant system. With these changes, the desired results were obtained; the energy was increased from ~19 Mev to ~24 Mev for a target at 30.5 inches. Beam currents of one milliampere can easily be attained at this new energy. It is anticipated that the cyclotron will be back in continuous operation within a few weeks.

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Cyclotron Performance

During the past revision and development period, a number of experimental targets for determining the new energy and beam shape were operated and only a few isotope production runs were made. The bombardments are tabulated below:

Beam profile	10
Isotope production	8
Experimental	16
Energy	5
Physics	7
Radiation damage	4
	50

The increase in proton energy resulted from relocation of the ion source 1 1/2" upward; the source is now effectively only one inch below the magnetic center. The accelerating slit, mounted on the south dee, was also raised the same distance. The dees were moved 1/2" south, measured at the horizontal center line of the dees.

A table of pertinent operating data for various beam conditions for the old and the new energies are given below:

Beam (μa)	Energy (Mev)	Input to Osc. (kw)	Beam Power (kw)		Frequency (Mc/sec)
			Calculated	Measured	
500	19	147	9.50	9.27	13.18
600	19	157	11.40	10.80	13.18
900	19	181	17.10	16.80	13.18
400	24	180	9.40	9.60	13.62
1000	24	263	23.9	24.00	13.60

The measured beam power is determined from the measured temperature rise in the target cooling water. The calculated power and measured power readings agree within 5%.

With a beam of one milliampere the useful beam power to the target is approximately 9% of the total input power to the oscillator, but at 500 μa the same factor is approximately 6%. This is due to the fixed loads required for dee excitation and ion loading which are present with a beam of any magnitude.

Due to increased power requirements for higher dee-to-dee voltages these fixed loads go up slightly with an increase in beam but at a much lower rate than the beam power increase.

Construction and Revisions

Several modifications were made to the cyclotron proper during the past period, the most important of which are described below:

Instrumentation. The recording potentiometer used for measuring the temperature differential between the inlet and outlet target water, formerly located at the utilities panel, has been relocated in the main control room. Such an arrangement makes it possible for the operator to maintain a continuous check on the power being absorbed by the cooling water.

One method of checking the validity of the target water temperature measurements is to introduce a known amount of power into the target water circuit and to check the temperature rise obtained on the recorder. A boiler heated by three 3-phase heaters, each rated at 9 kw, was inserted in the water line to the target. The heaters are connected with a recording wattmeter and appropriate controls located below the recording potentiometer in the control room. It is now possible for the operator to obtain in a few minutes a complete calibration of the probe water temperature differential up to a maximum power of 27 kw.

A neutron counter was installed in the control room which enables the operator to monitor the bombardment of physics targets which require beams of less than a microampere.

The controls for operating the auxiliary magnetic field have been moved to the control room. From this location it is now possible to stop, start, set, and monitor the current energizing the auxiliary field windings.

In a new method of measuring the dee voltage the signal from the electrostatic probes inside the vacuum tank is rectified by a Type 2C40 vacuum tube in place of the former germanium diodes. The location of the germanium crystals was such that neutron bombardment from the cyclotron affected the resistivity calibration. With the present system, the vacuum tube rectifiers are unchanged by neutron bombardment and, unless the probe-to-dee distance is changed, the calibration remains constant.

Ion Source Position. The ion source on the 86-inch cyclotron is supported by a 15 ft copper tube which is inserted through the top of the tank. To insure proper positioning and grounding of the lower end of the ion source, a bracket has been attached to the west side of the liner which places the ion source one inch below the center of the magnetic field. This arrangement insures that the position will be the same from run to run and also reduces heating of the tube due to rf pickup.

Target Facilities. A new target vacuum lock with a 24" by 24" opening has been installed. Due to the magnetic gap width and the beam width and with allowance for clearances, the maximum practical target size is now 15" by 6". This permits an additional 30 sq in of target surface. The target carriage has also been modified by the addition of improved vacuum and water seals.

Remote control valves were placed in the target water supply, return, and drain, and in the air line for blowing water out of the target. The controls for the above valves were installed in both the control room and the cyclotron pit. Now, in the event of a target failure, the operator can almost immediately stop the flow of water through the target and therefore limit the water introduced into the vacuum tank; also, the valves can be operated without radiation hazard to personnel.

The high gamma activity now produced in some targets has required the installation of special protective equipment for removing and handling targets. A 42-inch concrete shielding wall, with viewing window and remote handling equipment, has been installed in the pit so that a "hot" target can now be removed from the cyclotron and sealed in a lead-shielded container without hazard to the operator. The target can then be transported from the pit and transferred to a shipping container, or stored to permit decay of the gamma emitters of short half-life.

THE 63-INCH CYCLOTRON

The assembly of the 63-inch cyclotron has been completed. The dees were mounted on the faceplate by means of zircon bushings, as shown in Figures 1 and 2. Seventeen-foot dee stems are enclosed in a grounded shield which extends back from the dee faceplate. The rf is coupled to the dees, inductively, by means of coils placed between the dee stems. The deflector is mounted next to the lower dee, and the tungsten septum is attached to the dee. The deflector adjustments provide for vertical translation and for tilt. The septum is hinged at the entrance slit, the back portion being movable. Two adjustable trimmer condensers are provided to balance the voltage on the dees. All of these adjustments can be made from outside of the vacuum tank during operation.

Figure 3 shows the ion source, probe, and vacuum lock assembly. The ion source itself is inserted between the dees on two copper-plated stainless steel tubes. A grounded anode carbon chamber, Figure 4 contains the arc; two water-cooled tantalum rods serve as cathodes. The arc is struck by raising the cathodes to approximately 3 kv negative potential while gas is fed through a tube near the right cathode. Upon striking, the arc voltage drops to approximately 500 volts. The gas flow is regulated with a needle valve and remotely controlled from the operating console by means of two Selsyn motors. The probe is movable to any desired radius, and beam current to the insulated probe head can be measured. The vacuum lock makes it possible to remove the ion source without breaking the main vacuum.

The cyclotron has been assembled in the tank and after some leak-hunting the pressure was reduced to 10^{-5} mm Hg. A rate of rise of 0.00025 microns/sec indicates that the system is vacuum tight.

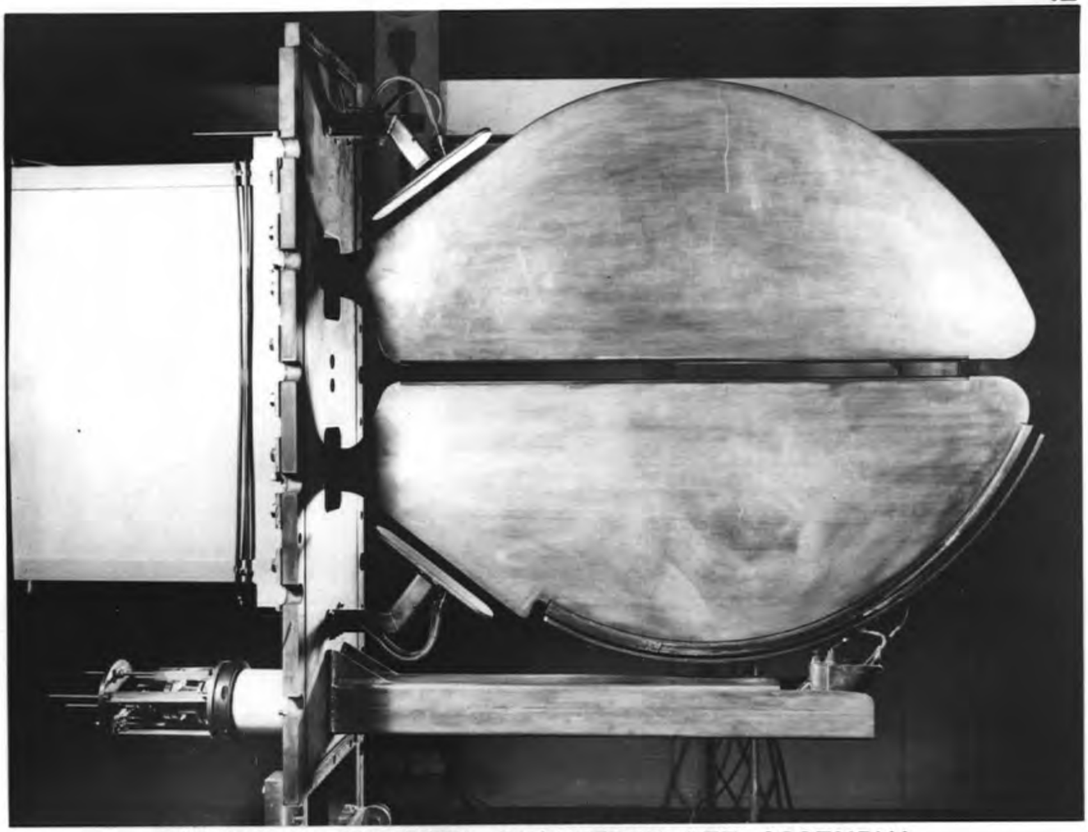

FIGURE 1 63-INCH CYCLOTRON DEE ASSEMBLY

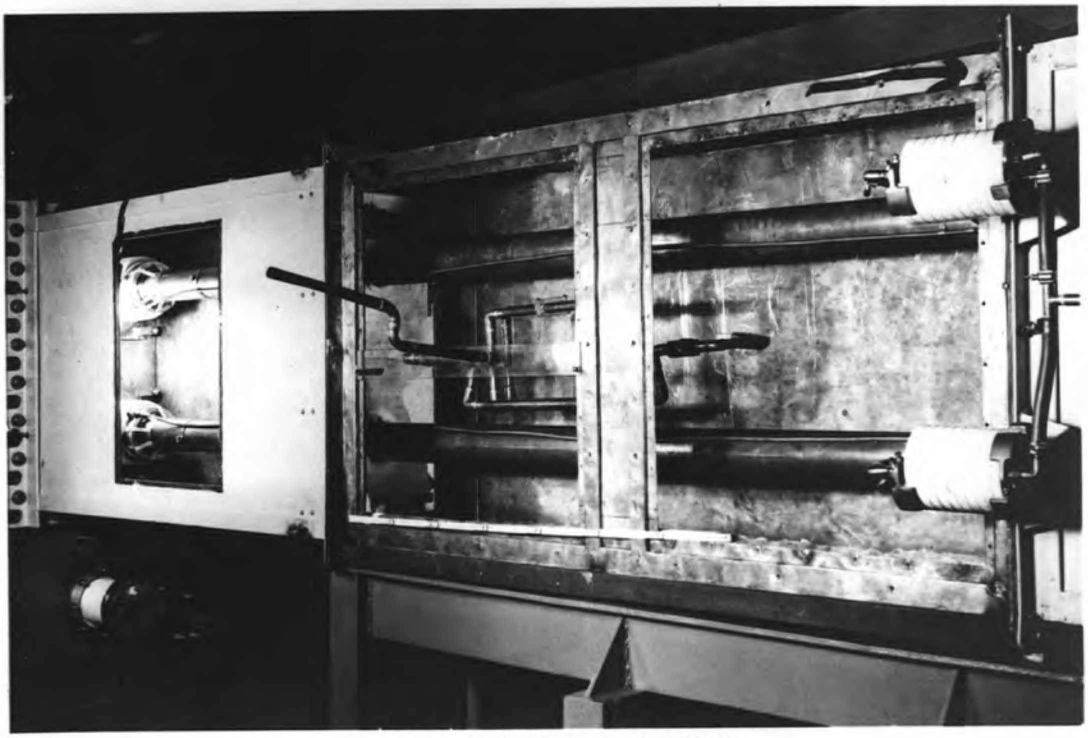

FIGURE 2. DEE STEMS

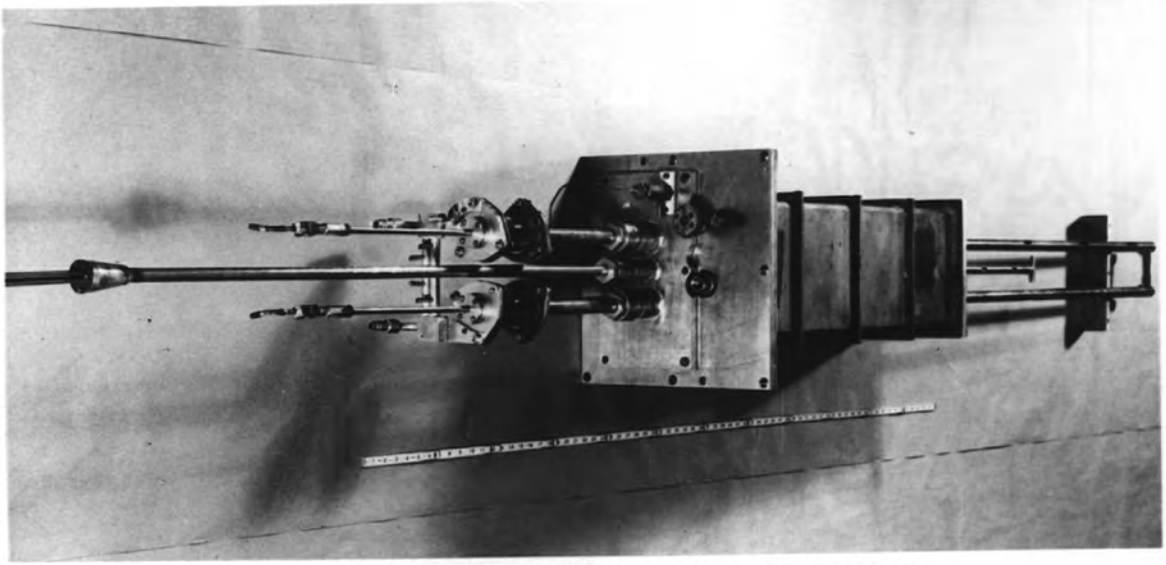

FIGURE 3. ION SOURCE AND PROBE ASSEMBLY

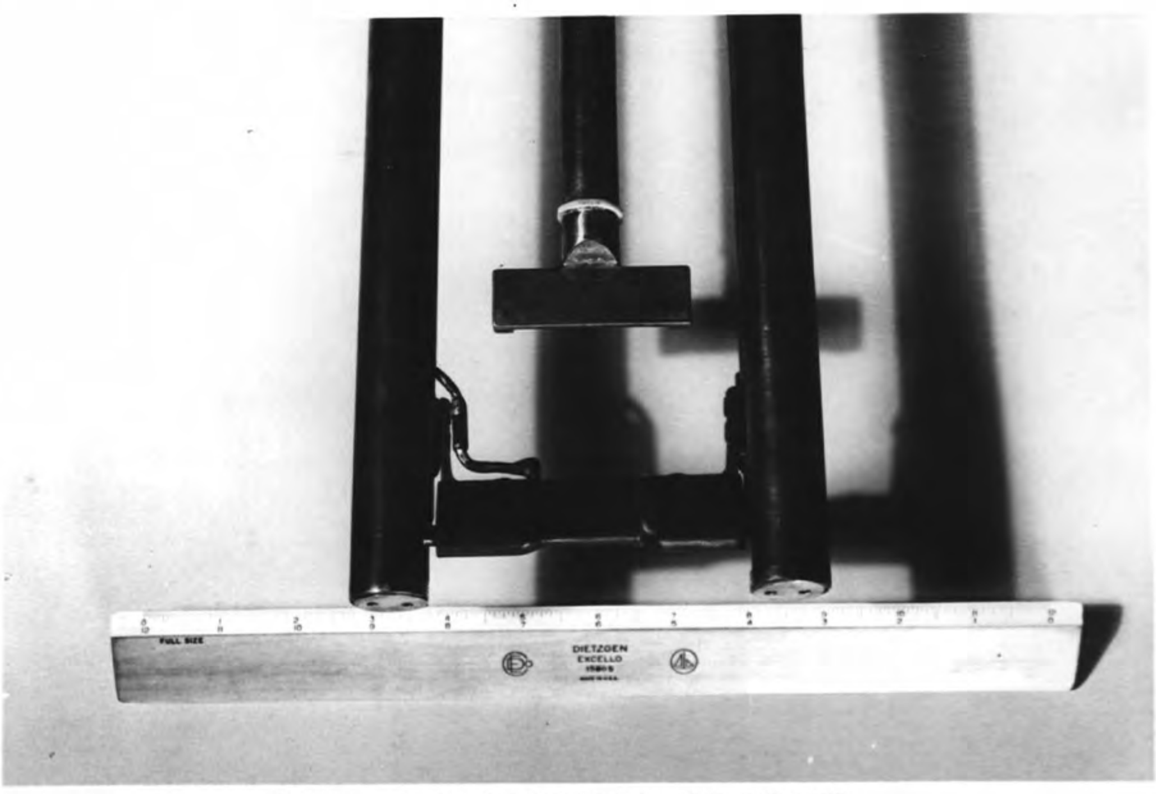

FIGURE 4. ION SOURCE AND PROBE

Radio-frequency tests on the cyclotron occupied the major portion of the past quarter. The cyclotron was first oscillated under atmospheric pressure then under vacuum. A dee voltage of 75 kv dee-to-dee was reached after some routine difficulties were overcome. The cyclotron now maintains this voltage for long periods of time without showing any tendencies to failure. Since the design voltage was 60 kv dee-to-dee, the rf problem may be considered as satisfactorily solved.

Initial tests have been made on the ion source. An arc of 400 volts and 3.5 amperes was observed and this, judging from dc tests of the source, should be sufficient for the production of triply-charged nitrogen ions.

The magnetic field of the cyclotron was again measured, this time under vacuum. It was found that distortion of the magnetic field when the tank is evacuated is negligible. Latest measurements of the magnetic field reveal a first harmonic inhomogeneity of approximately 0.03%.

Experiments were conducted on a proportional counter which will be used for the detection of heavy particles. The energy of the alpha particles from Po 208 was measured with this counter in conjunction with a single-channel pulse-height analyzer. The observed peak had a half-width at half maximum of about 4%. Part of this lack of resolution may be due to the thickness of the polonium source.

Radiation monitoring equipment for the 63-inch cyclotron has been installed. This includes a boron-trifluoride neutron counter, as well as a Geiger counter. Personnel working on the cyclotron will be provided with film badges and pen-type ionization chambers.

THE 22-INCH CYCLOTRON

In continuation of the effort to increase cyclotron efficiency and cyclotron output, a study of the z-wise proton beam distribution (parallel to magnetic field lines) in the 22-inch cyclotron has been made. It has been found, as predicted by theory, that most of the loss of protons to the dees occurs during early revolutions. Only a small percentage of the beam is lost beyond one-half of maximum radius, Figure 5.

In a test aimed at understanding methods of improving the efficiency of the cyclotron, the ion source arc slit was shortened from 2 1/2" to 1/2". Thereafter the ratio of accelerated beam power to ion loading power was increased, as predicted. Further study of optimum arc slit length for a given dee geometry is planned.

Beam composition at maximum radius has been investigated by a study of magnetic resonance curves, Figure 6. At low arc current the ratio of H_3^+ ions to H_1^+ ions is high. The total number of H_1^+ ions and the ratio of H_1^+ ions to H_3^+ ions may be increased by increasing the arc current. Because of lack of a ready means of measuring the number of 1.5 Mev H_1^+ ions and 0.5 Mev H_3^+ ions, exact ratios cannot be stated from this study.

It has been observed that an increase in bias potential on the dees increases the beam accelerated to maximum radius by a factor of as much as 30% when the cyclotron is operated without an accelerating slit (rf) mounted on the dee. This effect is not observable when an accelerating slit is used. At present, it seems that the mechanism of the bias effect may be understood by saying that the increased negative bias potential gives non-optimum-phased ions issuing from the source a deeper penetration into the rf electric field

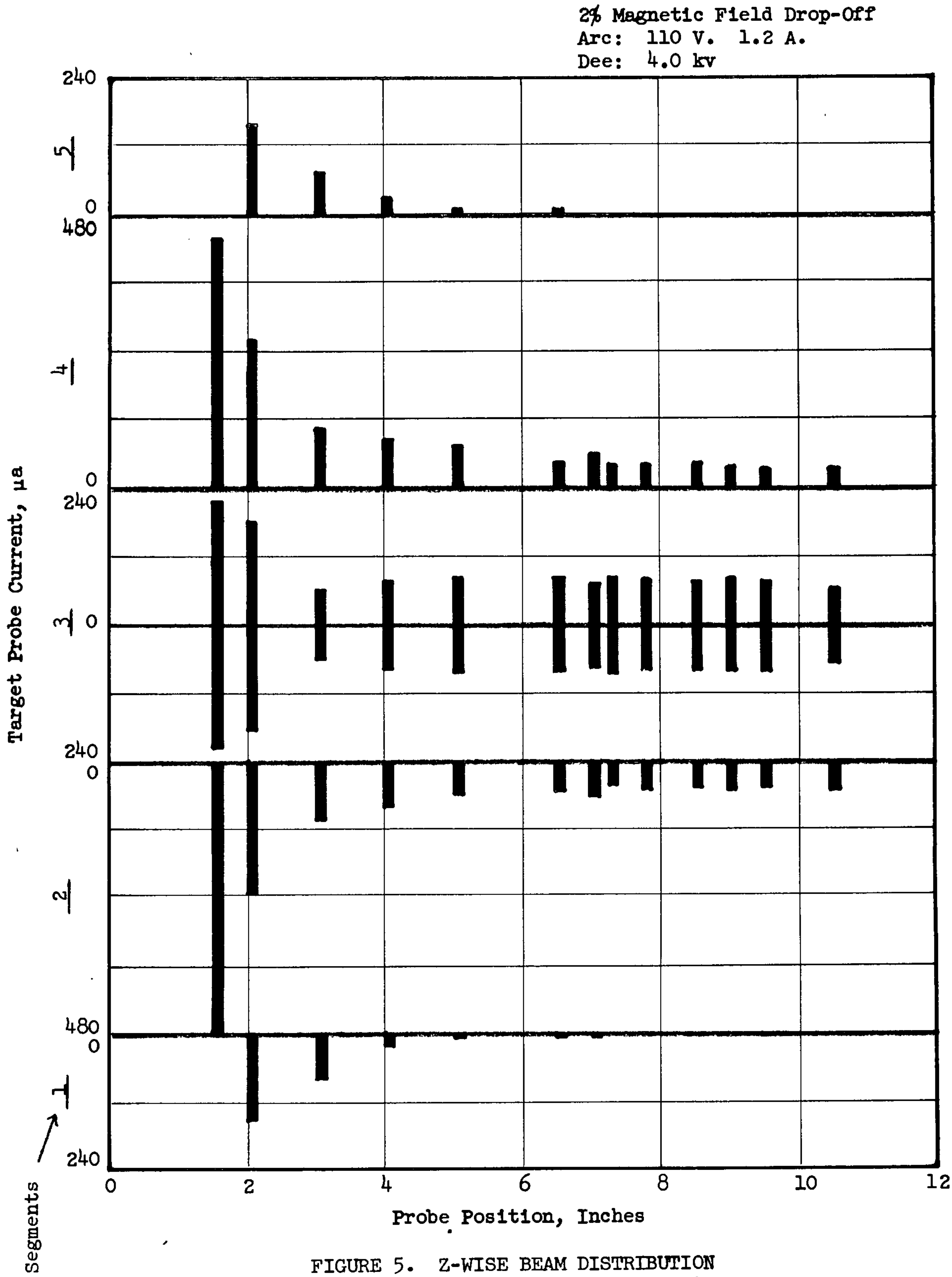

FIGURE 5. Z-WISE BEAM DISTRIBUTION
on Each of Five Segments

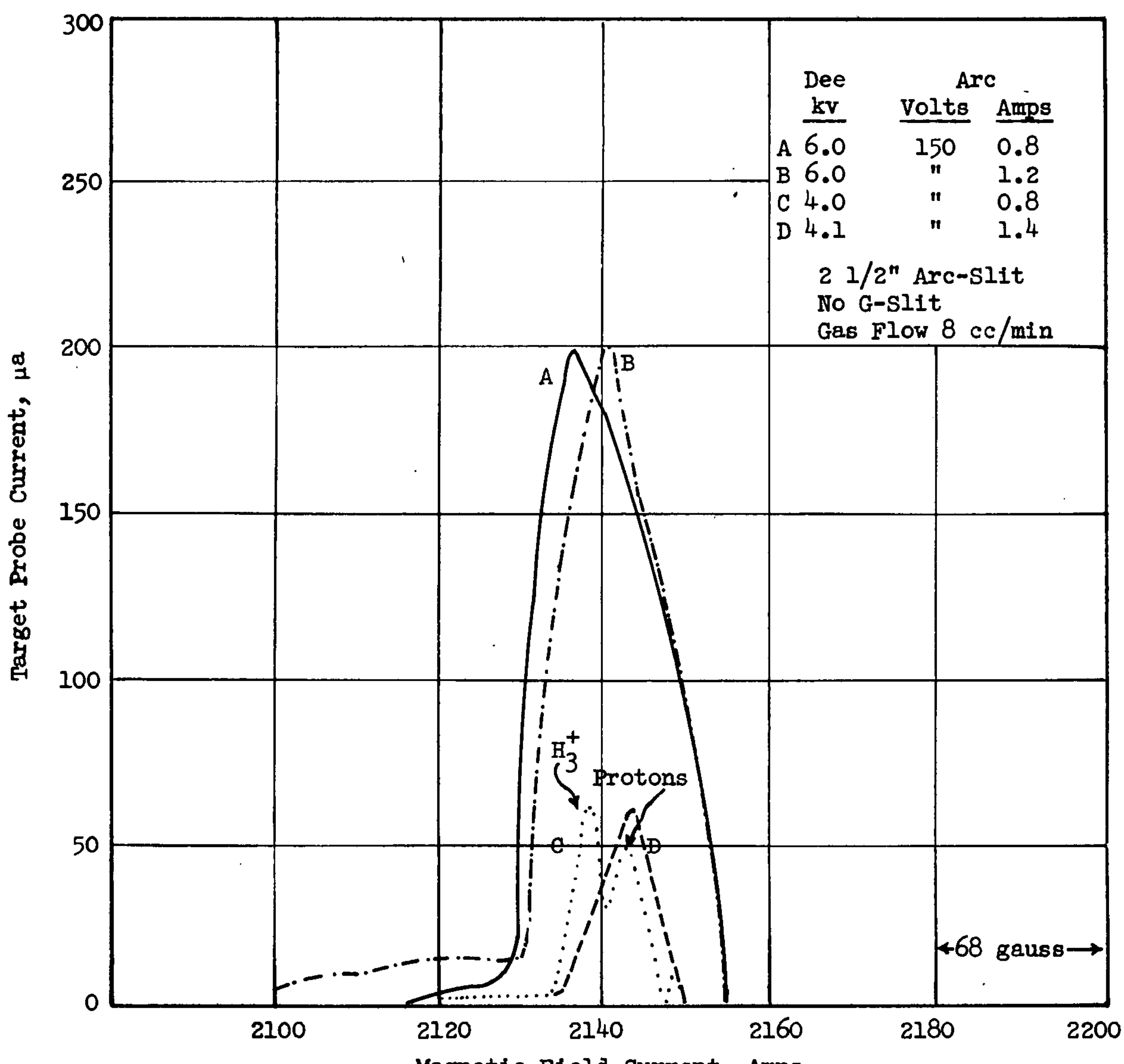

FIGURE 6. BEAM COMPOSITION

produced by the dees during the first acceleration. In agreement with observation this effect should be essentially obscured by the use of an accelerating slit. It further appears that the accelerating slit is more effective than the optimum bias without the slit.

In an effort to improve beam focusing in the inner orbits, five 20-mil wire grids were placed 3/4" apart across the entrance side of the lower dee. The experiment performed indicated significant changes in the focusing characteristic of the machine. However, the value of grids for getting larger beams cannot be firmly established without additional study.

RADIATION DAMAGE

Experiments on ARE structural components have been limited to the investigation of the effects of proton bombardment at 815°C upon corrosion in Inconel. The corroding agents in the cases recently studied have been two of the various forms of fluoride eutectic fuel being considered as fuel for the experimental reactor. The #2 eutectic is a mixture of sodium, potassium, and uranium fluorides melting at about 540°C. The #14 eutectic contains sodium, potassium, lithium, and uranium fluorides and has a melting point of about 450°C. The scheduled shutdown of the cyclotron has provided an opportunity to bring chemical and metallurgical analysis of radiation damage test targets up to date.

In an earlier report (ORNL-1269) describing the irradiation of eutectic-filled Inconel tubes with a maximum of 415 watts/cc, the conclusion was that, in the range of integrated proton currents used and within the limits of corrosion detection, no radiation-induced corrosion was found. In an effort to increase the specific proton energy dissipated in the fuel substance, several new types of targets were employed for the measurements discussed below.

The #2 Eutectic In Inconel

Experiments of the previous type were repeated with the newer, more reliable targets. The effective bombardment was extended to eight hours and the average power dissipation to 365 watts/cc. Ten targets, containing the #2 uranium-bearing eutectic in Inconel tubing, were bombarded for one, two, four, or eight-hour periods, allowed to decay radioactively, and then subjected to chemical and metallurgical analysis, Table I. The chemical analysis, limited to trace-quantity determination of Inconel alloy component metals in

Sample No.	Bombardment Time (hrs)	Power Density (watts/cc)	Control Sample No.	Fe (ppm)	Ni (ppm)	Cr (ppm)	Depth of Corrosion (inches)
865	1	-	864	240	950	2,630	~ 0.0005
858	1	-	864	320	900	2,410	None
864	1	-	-	250	340	2,600	None
862	2	-	863	350	1,000	2,200	None
863	2	-	-	260	450	2,900	None
868	4	-	861	160	590	2,640	None
860	4	425	861	190	760	2,760	None
861	4	-	-	220	580	2,500	None
859	8	365	867	150	500	2,410	None
867	8		-	230	600	2,800	None

In all tests 0.010" Inconel tubing, containing eutectic 0.052" thick, was bombarded with ~21 Mev protons at 815°C.

TABLE I: THE #2 EUTECTIC IN INCONEL

the eutectic, showed little net effect of radiation upon the corrosion rate; there was only a slight increase in nickel and a decrease in chromium. Control specimens, subjected to the same thermal history as the bombarded samples, showed very similar contamination with iron, chromium and nickel.

Metallographic examination of polished cross-section segments of bombarded and unbombarded Inconel tube specimens gave results which correlated well with the chemical analysis. In no case was there evidence of radiation-induced corrosion more extensive than the limit of sensitivity (0.0005 inches in these newer measurements) of the method.

The #14 Eutectic in Inconel

A series of irradiations exactly analogous to those described above were made for the lithium-containing eutectic in Inconel. Bombardments of one, two and four hours were used, Table II. Chemical analysis showed again a decrease in chromium and an increase in the nickel content of the eutectic, the iron content remaining relatively constant. Two of the one-hour targets (#62 and #56) showed an increase in trace element content and a corresponding increase in the depth and number of corrosion pits. Since other samples bombarded for the same or greater lengths of time do not exhibit this corrosion and since the corrosion is not localized in the region of most intense proton beam, it appears that the corrosion in these two one-hour targets may be attributed to local overheating in the target. Overheating is possible in tubes of this series because of the larger area exposed to the beam (1/4" x 1.5") and the occasional inhomogeneity of the proton beam over this area. Otherwise, for the two and four-hour runs no sign of radiation-corrosion is found.

Sample No.	Bombardment Time (hrs)	Power Density (watts/cm^3)	Control Sample No.	Fe (ppm)	Ni (ppm)	Cr (ppm)	Depth of Corrosion (inches)
62	1	100	63	2,800	22,400	6,300	0.001
55	1	160	63	170	170	1,100	None
60	1	235	63	230	900	1,800	None
56	1	130	63	1,500	4,350	3,440	0.001
63	1	-	--	250	260	1,800	None
59	2	130	58	230	180	1,400	None
58	2	-	--	130	500	2,100	None
57	4	100	61	220	170	1,300	None
61	4	-	--	130	140	1,800	None

In all tests 0.010" Inconel tubing, containing eutectic 0.10" thick, was bombarded with 21 Mev protons at 815°C.

TABLE II: THE #14 EUTECTIC IN INCONEL

The #14 Eutectic in Inconel Microcapsules

To avoid ambiguities such as were apparent in the results of the series of tests discussed above, a smaller type of target was introduced. In this "micro" version of the usual target, the length of the Inconel tube is diminished by a factor of $\sim$2.5. The area bombarded becomes 1/4" by 1/4", for which the proton beam is fairly uniform. In addition the temperature of the target face was measured with two symmetrically mounted thermocouples; the temperature gradient on this face did not exceed 10-15°C.

With these modifications, the series discussed above was repeated, with one, two, three, and six-hour runs, Table III. There was again little evidence of radiation-induced corrosion except for the longest run. Here, although little evidence is found in the trace element analysis, the metallographic analysis shows the first evidence (sample #102F) of an increased corrosion rate due to the proton bombardment, Figure 7. This corrosion, occurring within 1/16" of the thermocouple, was produced at 815 ± 25°C. The depth of penetration was about 0.0025" greater than that in the unirradiated control sample with similar thermal history. Chemical results show little evidence of this corrosion. Corrosion of 0.0005" depth is too near to the limit of sensitivity of the method to be taken as significant.

In all previous tests, the specific energy dissipation has been given in watts/cc; the volume component has in every case been the total volume of fluoride eutectic in the capsule. From the point of view of the metallographically determined depth of corrosion it would be more appropriate to consider only the irradiated volume. Since the radiation enhancement of corrosion rate is, in the first approximation, a dynamic phenomenon, occurring only when and where the radiation appears, the effective volume is only that in which

Sample No.	Bombardment Time (hrs)	Power Density (watts/cc)	Control Sample No.	(ppm)	(ppm)	(ppm)	Depth of Corrosion (inches)
104C	1	125	103C	660	3,300	3,600	0.005
103C	1	-	-	220	660	2,600	None
100F	2	150	101F	280	420	2,900	None
101F	2	-	-	240	360	2,800	None
101C	3	?	102C	1,240	6,800	4,000	0.005
102C	3	-	-	550	1,500	3,400	None
103F	6	75	104F	330	820	2,600	None
102F	6	425	104F	470	580	3,200	0.0025
104F	6	-	-	150	290	3,800	0.0005

In all tests 0.010" Inconel tubing, containing eutectic 0.10" thick, was bombarded with 21 Mev protons at 815°C.

TABLE III: THE #14 EUTECTIC IN INCONEL MICROCAPSULES

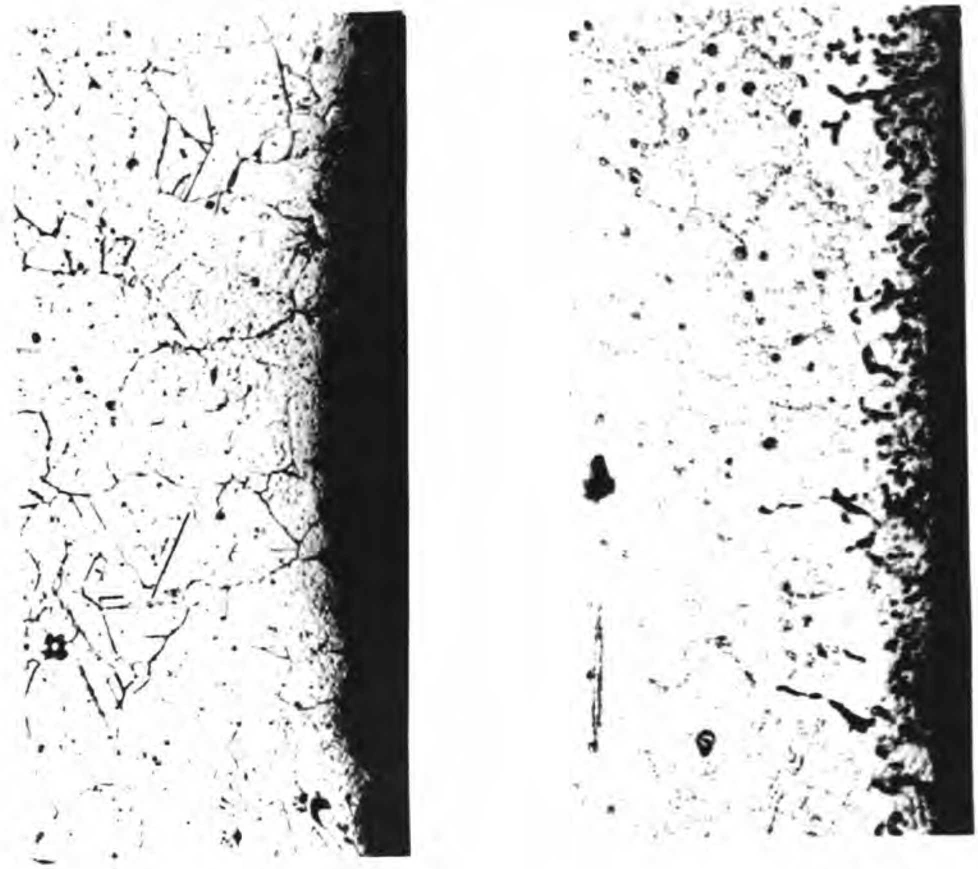

FIGURE 7 RADIATION INDUCED CORROSION IN INCONEL

the radiation dissipates its energy. This, of course, neglects second order effects, such as the effect of the radiation-altered chemical composition in eutectic and Inconel, upon the corrosion rates. It is likely, however, that such effects, if they exist, are relatively small. Consequently, on this basis radiation densities in the eutectic for this "micro" group of targets lie in the range of 1,000 to 4,500 watts/cc in a bombarded volume of about 0.05 cc. The accuracy of power measurements does not exceed about ±30%.

In summary, then, accelerated corrosion was found to occur in an Inconel tube containing the #14 eutectic at a temperature of 815°C after a 6-hour bombardment with 20 Mev protons and a radiation density of about 4,500 watts/cc. For a similar irradiation at about 750 watts/cc no corrosion was found. Although more confidence will be placed in this result as it becomes possible to repeat the experiment, it seems reasonable to accept the present evidence as indicative of an increase in corrosion rate in this system under proton bombardment.

With the limited information available at the present time, it is not possible to determine much about the rate of increase of corrosion. All of the radiation-corrosion data available to date are collected in Table IV. Questions about corrosion rate as a function of radiation intensity or kind of bombarding particle have no clear answer as yet, nor can more than an indication of the cumulative effect of bombardment be gotten from present data.

Eutectic	Bombarded In	Energetic Particles	Rate watts/cc	Integrated Flux watt hours/cc	Increase in Depth of Corrosion (inches)
#2	LITR	Fission	800	129,000	0.002
#2	LITR	Fission	800	92,000	0.002
#2	X-10 Pile	Fission	80	32,000	0.0005
#14	86-Inch Cyclotron	21 Mev protons	4,500	30,000	0.0025
#2	Berkeley Cyclotron	19 Mev deuterons	1,500	10,000	0.001
#2	86-Inch Cyclotron	21 Mev protons	600	2,500	0.001
#2	86-Inch Cyclotron	21 Mev protons	600	600	0.0005

TABLE IV: INTEGRATED FLUX-CORROSION DATA

SPECIAL SEPARATIONS

The chemical purity of the highly enriched U 235 previously separated has now been determined. Nine shipments of enriched uranium isotopes have been made during the quarter. Installation of facilities for the separation of plutonium isotopes is nearing completion; preliminary tests are being made.

PURITY OF ENRICHED U 235

Two batches of enriched U 235, depleted in U 234, which were previously electromagnetically separated have been purified, converted to oxide, and analyzed for metal impurities. Mr. H. R. Gwinn of the Assay Department extracted and purified the uranium contained in scrapings of the graphite collector pocket. This was done in a new laboratory to avoid contamination from other uranium. Enriched U 235 yield was determined to be 4.7 grams (Batch A) and 2.6 grams (Batch B). Batch A was initially segregated as the fraction of highest isotopic purity. Samples of each batch were analyzed by the Spectrographic Laboratory and the following metal impurities were reported, in parts per million:

	Batch A	Batch B		Batch A	Batch B
Al	10	3	Na	~150	~700
B	0.1	0.6	Ni	150	150
Ca	300	250	Pb	6	35
Cd	0.4	0.7	Si	4	5
Cu	50	50	V	1.5	65
Fe	50	60	Zn	15	15

The relative isotope abundances in this material will be measured by alpha counting and pulse analysis.

SHIPMENTS OF ENRICHED URANIUM ISOTOPES

Distribution of electromagnetically separated uranium isotopes to Atomic Energy Commission laboratories during January, February, and March is tabulated below:

Oak Ridge National Laboratory	226 mg U	96.65% U 236
Argonne National Laboratory	10 mg U	95.31% U 236
University of California	96 mg U	95.31% U 236
Los Alamos Scientific Laboratory	20 mg U	95.31% U 236
University of California	22 mg U	94.84% U 234
University of California	28 mg U	89.35% U 234
Los Alamos Scientific Laboratory	22 mg U	99.9995% U 238
Oak Ridge National Laboratory	41 mg U	99.9995% U 238
Argonne National Laboratory	50.7 gm U	99.9990% U 238

FACILITIES FOR PROCESSING PLUTONIUM

Preliminary testing of facilities for the separation of plutonium isotopes was begun although some facilities are not entirely complete. Components are being tested to insure that the equipment functions adequately, and indicated revisions are being made. Radioactive materials have not yet been introduced into the system.

Alterations to the calutron vacuum tank were completed, and test runs are being made. Early indications are that the reduced pumping speed, which resulted from provisions made for contamination control, will not be adequate for short runs with small charges but will probably be satisfactory for the longer first-stage runs which utilize larger charge batches.

Cocoon strippable coating was applied to the wash area enclosure. The gloved box for disassembly of calutron source and collector was completed. Revisions were made in the acid spray system which will be used for washing calutron liners. The acid spray system is now satisfactory mechanically, but the recovery efficiency has not been determined.

Installation of equipment in the processing laboratory gloved boxes is well advanced. In preliminary tests of the evaporation equipment very heavy scaling was encountered which indicates the need for demineralized water in making up process solutions. The final CWS filter housing in the gloved box exhaust system was revised to permit the use of a plastic bag transfer technique for removing contaminated filters. Chlorination apparatus has not yet been installed; the initial plutonium charges will be supplied by Los Alamos as plutonium trichloride.

Surveys are being made by the Health Physics Group to establish the background activity in an near the areas which will be used for plutonium processing. In some neighboring areas the uranium background is high enough to mask the lower plutonium tolerances, and precautions must be taken to prevent uranium contamination of the plutonium facilities.

ELECTROMAGNETIC FUNDAMENTALS

Injector-Type Ion Source

A hot-cathode type ion source designed to produce N^{+++} for acceleration in the 63-inch cyclotron has been fabricated and tested. The ion source with its associated constant potential accelerating electrode will be used to inject ions into the cyclotron system. In a "bench" test, in which the design injection potential was used and ions were collected at the end of a 180° path, a two-milliampere N^{+++} beam was obtained.