SECRET
SECURITY INFORMATION

ORNL-1173
34a

PROGRESS REPORT

Part - I

ELECTROMAGNETIC RESEARCH DIVISION

JULY 1, 1951 to SEPTEMBER 30, 1951

OAK RIDGE NATIONAL LABORATORY
U.S. ATOMIC ENERGY COMMISSION

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

SECRET
SECURITY INFORMATION

[redacted]

Index No. ORNL-1173
This document contains 35 pages
This is copy 34 of 83, Series A

Subject Category: Particle Accelerators and High-Voltage Machines

PROGRESS REPORT - PART I

ELECTROMAGNETIC RESEARCH DIVISION

July 1, 1951 to September 31, 1951

Robert S. Livingston, Director

October 15, 1951

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-1173
Particle Accelerators and
High-Voltage Machines

Distribution, Series A:

1-17.	Carbide and Carbon Chemicals Company (Y-12 Area)
18.	Aircraft Nuclear Propulsion Project
19-26.	Argonne National Laboratory
27-28.	Atomic Energy Commission, Washington
29-31.	Brookhaven National Laboratory
32-39.	Carbide and Carbon Chemicals Company (ORNL)
40.	Chicago Patent Group
41.	Chief of Naval Research
42.	Columbia University (Failla)
43.	Columbia University (Havens)
44-45.	Idaho Operations Office
46.	Iowa State College
47-48.	Knolls Atomic Power Laboratory
49-51.	Los Alamos
52.	Mound Laboratory
53.	National Advisory Committee for Aeronautics
54.	National Bureau of Standards
55.	Naval Research Laboratory
56-57.	New York Operations Office
58-59.	North American Aviation, Inc.
60.	Patent Branch, Washington
61.	UCLA Medical Research Laboratory (Warren)
62-66.	University of California Radiation Laboratory
67-68.	Westinghouse Electric Corporation
69-83.	Technical Information Service, Oak Ridge

Carbide and Carbon Chemicals Company internal distribution as follows:

1.	C. E. Center
2.	C. E. Larson
3.	W. D. Lavers
4.	A. M. Weinberg
5.	E. D. Shipley
6.	J. A. Swartout
7.	E. J. Boyle
8.	C. P. Keim
9.	R. S. Livingston
10.	F. T. Howard
11.	A. L. Boch
12.	R. A. Charpie
13.	L. E. Parsons
14-17.	Reports Office, TIC

Issuing Office
Technical Information Center, Y-12 Area
Date Issued: [illegible]

[redacted]

[redacted]

ABSTRACT

The 86-inch cyclotron has operated steadily for periods exceeding 100 hours at an average beam power of 17 kw at 19 Mev; targets are being designed to withstand larger beam currents. Inconel tubes containing UF_4-NaF-KF eutectic have been irradiated with protons in the 86-inch cyclotron in an investigation of radiation damage effects. All major components of the 63-inch cyclotron have been designed and are being fabricated; the magnetic field has been made uniform to ±0.1%. Electromagnetic shims are being used in the 22-inch cyclotron in an investigation of the effect of magnetic field shape upon beam focus. The special separation of 1.8 grams of 95% U 236 in a two-stage calutron operation is summarized; facilities are being prepared for the separation of isotopes of plutonium on a laboratory scale. In an experimental injector ion source for a cyclotron, protons are accelerated through a fixed-potential electrode.

[redacted]

[redacted]

TABLE OF CONTENTS

THE 86-INCH CYCLOTRON

Greater dependability of operation and increased proton beam power have been obtained from the 86-inch cyclotron. Steady operation for runs exceeding 100 hours have been obtained at an average beam power of 17 kw at 19 Mev. The beam innage, time the beam is on the target, has been in excess of 95% for the above runs. A peak beam power of 33 kw was reached on a test target at 19 Mev; this corresponds to a beam current of 1740 μa. Several ion source filaments have operated continuously for over 100 hours before being replaced. Biasing the dees for the control of ion loading has proven very satisfactory. With the improved performance of the cyclotron and the target design, individual targets have been bombarded in excess of 100,000 μa-hours.

Cyclotron Performance

The cyclotron has been operated for a period of over eleven weeks at consistently high beam currents without it being necessary to open the vacuum chamber for repairs or changes to the cyclotron components. Several long runs for isotope production have been made at average beam currents of 900 μa. At the present time it is believed possible to operate continuously at beam strengths of 1,500 μa if a target which could absorb the beam power were available.

For the past three months the beam innage and the microampere-hours of beam on target were as follows:

Month	Innage (%)	Total Beam on Target (μa-hr)
July	15.7	4,454
August	55.5	117,968
September	67.8	289,748

Innage is defined as the percentage of available time that the beam is on the target. During July and August the available time was 160 hours per week. Since then it has been 168 hours per week. The beam innage would be closer to 90% if all the bombardments were of long duration. The physics and radiation damage runs usually continue less than an hour, which results in a large portion of the time being used in inserting and removing targets and in adjusting apparatus.

At present the chief restriction to obtaining larger beam currents is the limited capacity of the targets. The most successful high current target to date has consisted of a copper plate, 5" by 6", silver plated, internally water cooled, with a radius of curvature of 32", and tilted to provide a four degree angle of incidence. This target successfully withstood a beam of 33 kw or 1,740 μa at 19 Mev.

A total of 140 cyclotron bombardments have been completed during the quarter. These runs have ranged from a few microampere-seconds to 105,000 microampere-hours. They are tabulated as follows:

Isotope production	39
Experimental runs for checking ion source performance and beam patterns	25
Radiation damage	35
Physics	41
TOTAL	140

Modifications

The large increases in proton beam and innage have been made possible by several factors, the most important of which are:

1. A reliable method of insulating the dees for dc biasing purposes.

2. Elimination of hot spots at the dee stem and spider clamps and at the plate line connection to the dee stem by improved connections.

3. Elimination of all water leaks in the dee water header with the resultant improvement in operating vacuum.

4. Development of targets to provide the proper radius and tilt for effectively spreading the beam.

5. Increase in the target-cooling water velocity.

Dee Bias System. In the present dee bias arrangement the dee support frame rests upon four insulators mounted from the inner surface of the vacuum tank, Figure 1. With this arrangement, there is no direct electrical connection from any portion of the dee system to ground. When this system was first used the tank heated in the region of the dee support frame, due to ground currents produced by unbalanced dees. The heating was reduced by extending the liner up and over the tank rail so as to form a copper ground shield for the dee support frame. This extension was water cooled by the addition of flattened 7/8" tubing joined in parallel with the liner water system. An rf voltmeter circuit was installed for monitoring the potential on the dee support frame. This potential, which is an indication of the dee unbalance, is minimized by adjustment of the dee trimmer. The above described arrangement has been successful in reducing the outside temperature of the tank extension to 57°C. No trouble has been experienced with heating or melting of the rf high-current joints at the dee stem spider clamps.

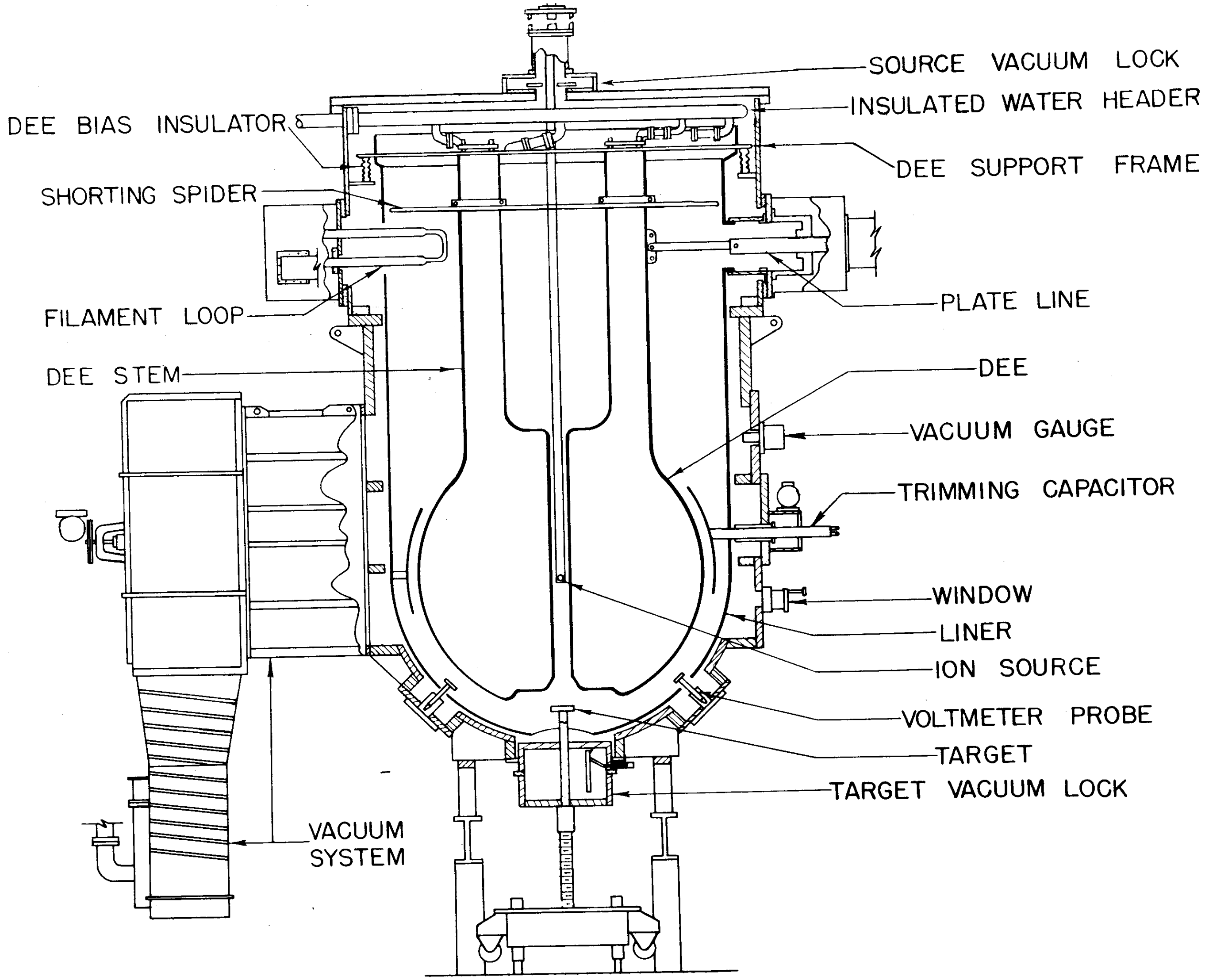

FIGURE I. CROSS SECTION OF 86 INCH CYCLOTRON

Ion Source Assembly. Considerable trouble was experienced with the ion source filament failing after relatively short periods of operation, 5 to 15 hours. The majority of the failures were due to mechanical and magnetic stresses imposed on the filament, which resulted in breakage. This trouble was corrected by welding a square support piece, 3/8" by 3/8", by 15' on the inside of the ion source tube and notching the filament conductor spacers to prevent rotation of the conductors due to magnetic forces. Vertical motion of the filament was also prevented by a more rigid method of spacer support. With these changes filament life now averages 80 hours; some filaments have been used over 100 hours.

Handling Equipment

The operation of the cyclotron at high currents for prolonged periods has necessitated improvements in methods and equipment for handling radioactive targets. A 20-inch shielding wall of prefabricated concrete blocks with a 16-inch zinc-bromide-filled window has been installed in the cyclotron pit in front of the target dolly. A simple mechanical hand has been installed through the shield so that targets can be safely removed from the target dolly, the operator remaining behind the shield.

Future Modifications

The following modifications are scheduled for the next servicing period.

1. A more reliable method of measuring dee voltage.
2. The addition of a larger target vacuum lock which will permit the use of rotating targets.
3. The installation of refrigerated baffles in the vacuum system. This will increase innage by eliminating the need for manually adding liquid nitrogen to the vapor traps.

Other modifications being considered for some future date are:

1. The installation of the second tube in the oscillator. This will approximately double the present rf power output.

2. The addition of a dc injection system to the present source. This is expected to increase the ion source output by a substantial factor.

Measurement of Neutron Flux

As a test of the effectiveness of the shields built around the 86-inch cyclotron the fast neutron flux has been measured at various places around the shield. The measuring instruments, a portable fission counter and a long counter shielded with a cadmium sheet, were both calibrated with a standard Po-Be source. At the time the measurements were made the proton current was 900 μa at 19 Mev. The tolerance level, 250 neuts/cm^2-sec was exceeded at the openings of both the maze and the emergency exit, Figure 2. A door to close the maze entrance is being constructed and measures for reducing flux at the exit are under consideration.

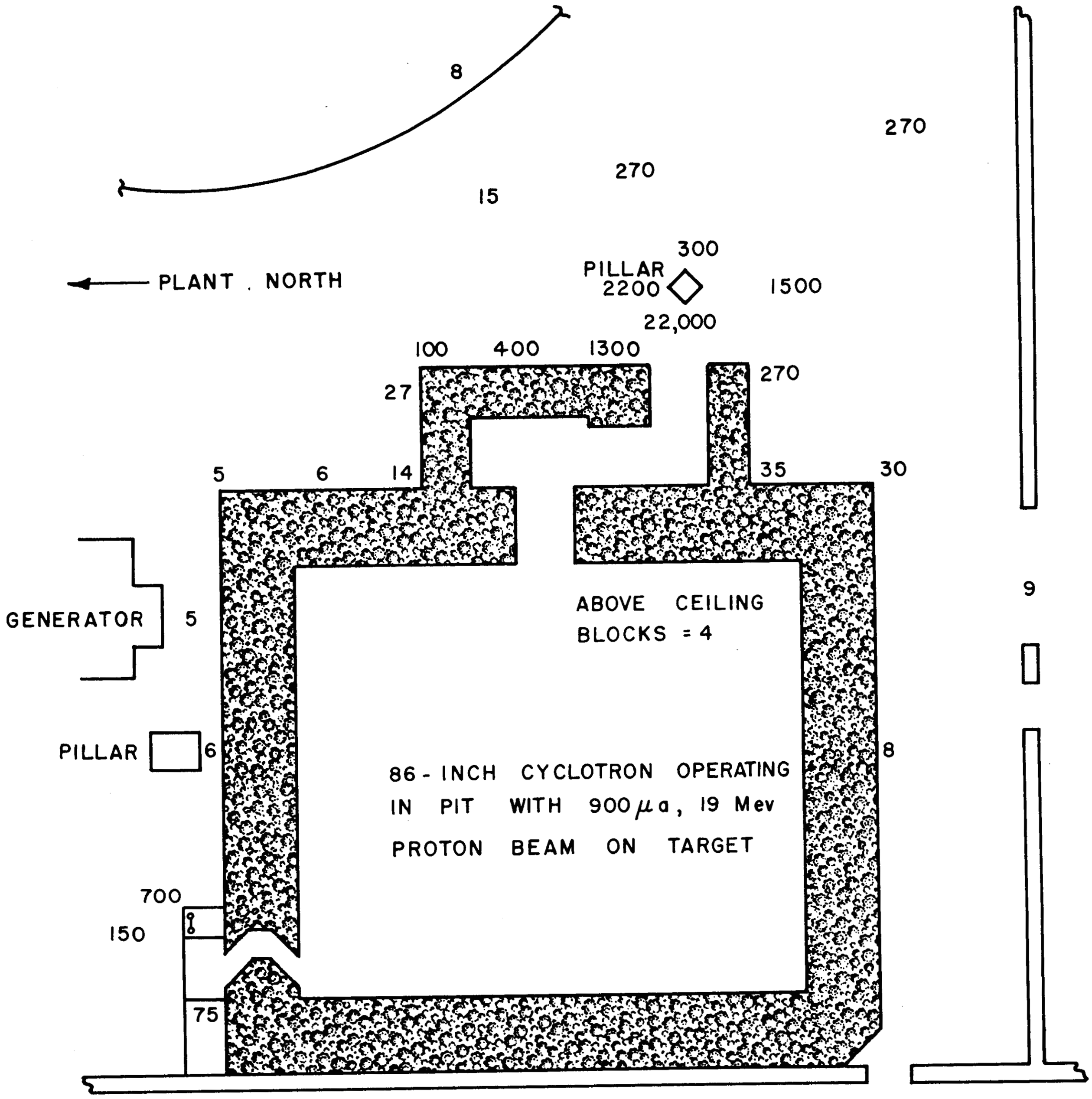

FIGURE 2. FAST NEUTRON FLUX MEASUREMENTS, NEUT/cm^2-sec.

RADIATION DAMAGE

UF_4-NaF-KF eutectic contained in Inconel tubes has been proton irradiated in the 86-inch cyclotron to determine radiation damage effects. These Inconel tubes were fabricated as shown in Figure 3. The method of preparation consists of heli-arc welding one end of an Inconel tube, 6" long, 1/4" OD, and 0.010" wall. A three-inch section is flattened to 0.052" ID at the welded end. The tube is then partially filled with powdered UF_4-NaF-KF eutectic and heated to melt the eutectic into the flattened section of the tube. After the tube is evacuated and heli-arc welded the void above the eutectic allows for thermal expansion.

Radiation-Cooled Tubes

In order to obtain preliminary information four tubes were irradiated with 20 Mev protons with no provision for heat dissipation except by radiation. During irradiation the temperature was recorded continuously with alumel-chromel thermocouples welded to the irradiated face of the tubes. Approximately 40 watts beam power was required to maintain the irradiated face of the fuel tubes at 700°C. Three of the tubes were irradiated for one hour and one tube for four hours. Chemical analysis of the eutectic for uranium, fluorine, iron, nickel, and chromium indicated no significant change in composition. Metallographic tests of the Inconel tubes irradiated for one hour showed very slight intergranular penetrations and some growth in grain size. Since grain size growth was also observed in control tubes with the same heat treatment, but not irradiated, it was concluded that the grain growth resulted from heat treatment.

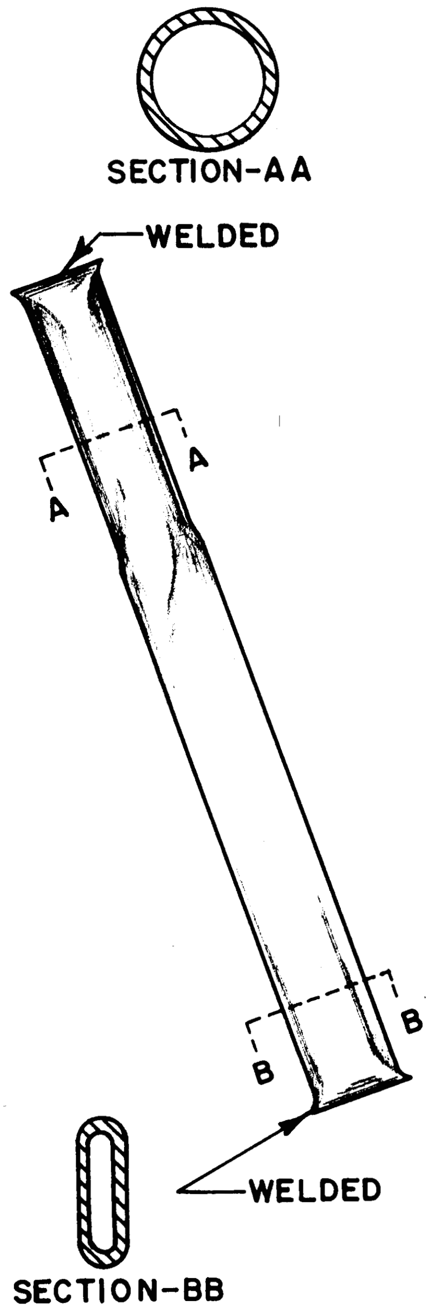

FIGURE 3. FUEL TUBE TARGET

Water-Cooled Tubes

Fuel tubes prepared in the same manner as the radiation-cooled tubes were furnace brazed to a water-cooled target. The water-cooled target was prepared by flattening 1/2" copper tubing to 1/16". This resulted in a water passage 1/16" by 9/16". Eleven water-cooled tubes have been irradiated. The power input to the tubes required to maintain an equilibrium temperature of approximately 700°C varies from 180 watts to 320 watts. Two possible causes of variation in power required to maintain a given tube temperature are inaccuracy of thermocouple readings and non-uniform distribution of the proton beam. The thermocouples were calibrated in position by attaching them to samples of lead, aluminum, and silver. The thermocouples were held under tension by weights so that an open circuit would result when the material melted. The proton beam current was then increased slowly until each open circuit was observed on the thermocouple recorder. The observed melting point for lead, aluminum, and silver were 325°C, 655°C, and 957°C, respectively. Each of these temperatures is within 4° of the known melting point.

The proton beam distribution was determined for various cyclotron conditions from radioautographs of irradiating aluminum plates. It was found that at low dee voltage and with the magnetic field below resonance the proton beam distribution was very non-uniform. High dee voltage and magnetic field above resonance reduced intensity variations to approximately 25% over a distance of 6 cm in the central portion of the proton beam.

ELECTRO-NUCLEAR MACHINES

THE 63-INCH CYCLOTRON

The major components of the 63-inch cyclotron have been designed. The present state of design and fabrication of various parts of the cyclotron is shown below.

Component	Design % Complete	Fabrication % Complete
Reaction Chamber	100	100
Oscillator House	100	100
Coupling Shields	100	100
Liner Faceplate	100	100
Liner	100	90
Vacuum Tank Changes	100	20
Dees and Stems	100	15
Transmission Line Shield	100	0
Dee Faceplate	100	0
Deflector	60	0
Deflector Septum	50	0
Trimmer	25	0
Handling Equipment	20	0

Magnetic Field

Magnetic field measurements have continued, as well as concomitant shimming. The field now is flat to approximately ±0.1%. Some question has arisen to whether the field shape will remain constant when the tank is under vacuum. The magnetic field will be measured under vacuum to determine the field shape under actual operating conditions. Apparatus is now being constructed for such magnetic field measurements.

Nuclear Reactions

The reaction chamber to be used for nuclear reactions involving high energy nitrogen particles has been completed. Tests on it will be initiated in the next three-month period. In addition, a magnet design for magnetic analysis of reaction products has been settled upon. This will be a 180° focusing type magnet, such as is commonly used for the analysis of light particles in many nuclear laboratories.

One of the difficulties forseen in the proposed experiments is the accurate measurement of the incident beam current. Such information is, of course, vital in any nuclear cross section work. Most likely the reaction N 14(α,p)O 17 will be used to monitor the beam. The protons produced by this reaction lend themselves readily to accurate observation and the alpha particles can be provided by admixing helium to the target nitrogen gas. The observed protons will serve also for the determination of the energy of the incident nitrogen particles.

Field Operations

Changes in the area in which the 63-inch cyclotron is to be located are now being made. The necessary water and compressed air lines have been laid, including all controls such as interlocks, valves, and appropriate outlets. The power supply which is to provide the plate voltage for the oscillator, the deflector voltage, the dee bias voltage, and the arc power has been completed. Ten Beta cubicles have been joined in parallel and their controls consolidated on one control console.

Oscillator

The required frequency of oscillation has changed from 4.57 to 5.1 megacycles per second due to changes in the value of the average magnetic field. Consequently, the coupling circuits were redesigned for the values given in Figure 4.

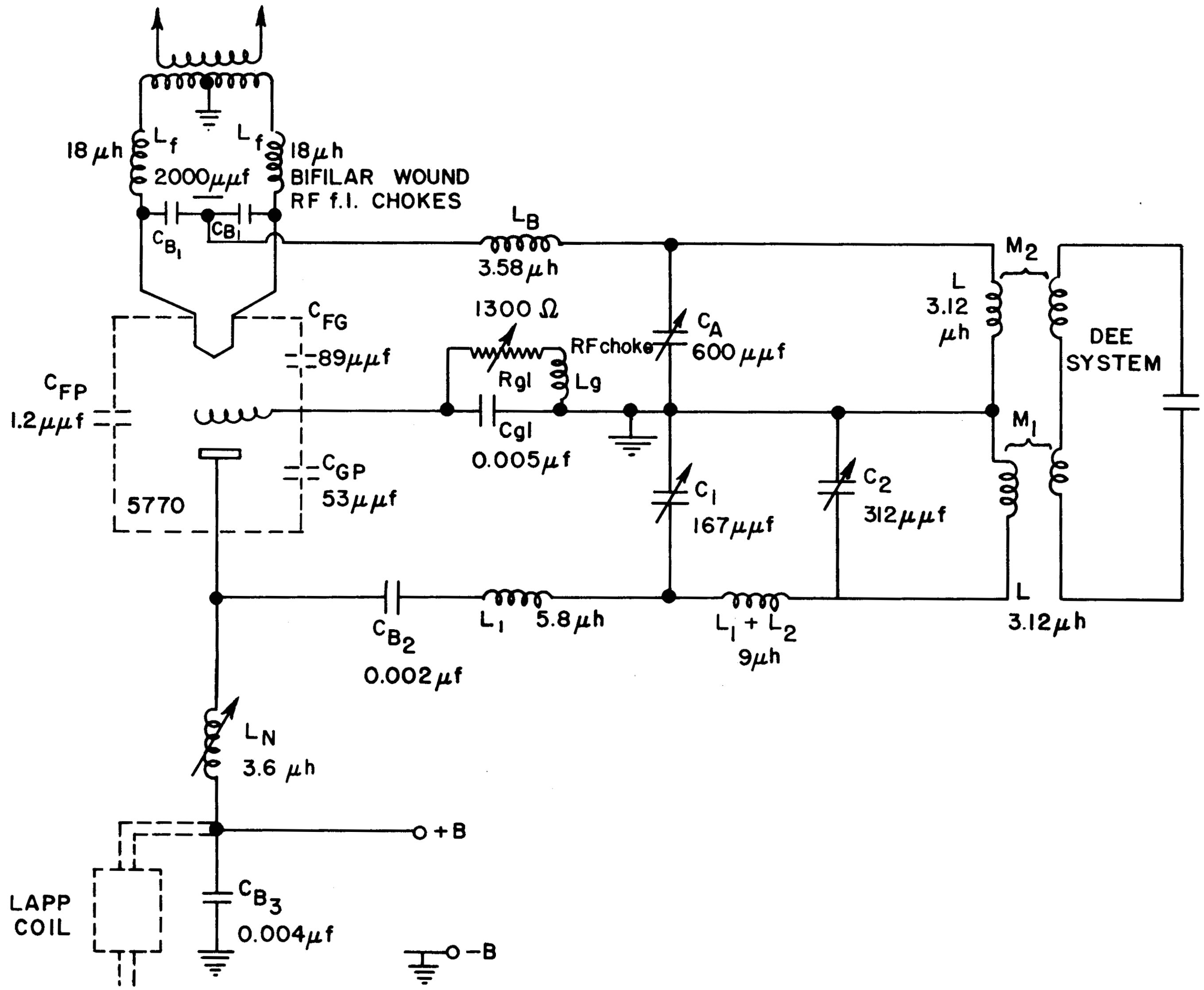

FIGURE 4. SIMPLIFIED RF CIRCUIT, 63" CYCLOTRON

Plate Circuit

The function of the coupling network consisting of L_1, $L_1 + L_2$, L_2, C_1, and C_2 is two-fold: first, the network provides a phase lag of 180° between the plate-to-ground rf voltage and the rf current in inductance L_2; second, the network transforms the impedance, $\left(\frac{\omega m_1^2}{z_2}\right)$, coupled into inductance L by the dee system, into an appropriate value at the plate-to-ground point of the network. When the tube is fully loaded the impedance should be approximately 1400 ohms. Due to the uncertainty of the series impedance, z_2, of the dee system caused by fluctuations in required beam power, practical achievement of optimum impedance matching may be difficult. It may be noted that the network considered here has some of the properties of a half-wave transmission line. The plate circuit also includes the coil L_N, which is for neutralization of the grid-to-plate capacitance; the blocking condenser C_{B_2}, which removes the dc voltage from the coupling network mentioned above; and the by-pass condenser C_{B_3}, which provides rf by-passing of the plate supply voltage and Lapp coil.

Filament Circuit

The coupling network consisting of L_B, C_A, and L provides for a 180° phase lag between the voltage induced into L by the current in the dee stems and the voltage appearing from filament-to-ground at the tube. This circuit also exhibits the necessary voltage amplification to provide the proper magnitude of driving voltage at the filament. The condensers C_{B_1} provide a grid-filament return and remove the dc voltage from the coupling circuit. The coils, L_f, are bifilar wound rf chokes and serve to protect the filament transformer windings. The elements R_g, L_g, and C_g make up the grid-leak biasing circuit. It is to be noted that the action of the grid-to-filament capacitance and the rf filament chokes are included as a part of the coupling network characteristics. In order to use the filament transformer from a large Megatherm, it was necessary to rewind the secondary to provide for a center-tap connection.

Construction

All of the essential components of the rf circuit except the blower for the tube are on hand. The oscillator cabinet and the coupling circuit shields have been completed. The component parts are now being mounted in these two housings. All of the coupling circuit coils were wound from 7/8" OD annealed copper tubing on round coil forms approximately 12 inches in diameter. The plate and filament coupling coils proper were constructed of 90° copper elbows and straight sections of hard-drawn copper tubing silver soldered into these elbows so as to give rectangular forms. This latter method is very simple and seems to be quite satisfactory electrically.

63-Inch Electrical Model

The electrical model was moved from Building 9201-2 to 9204-3, thus consolidating all the work on the 63-inch cyclotron in one building. The first test oscillator used on the model employed a grounded-grid circuit with a 5771 tube. This circuit was padded with lumped circuit components so that it exhibited essentially the same characteristics as one using the 5770 tube. No difficulty was experienced in achieving oscillation at the required frequency. For measurement purposes it was found, however, that the minimum power output of the 5771 was too large for use on the model due to the available minimum voltage from the supply for the 5771. This oscillator was replaced by one using a 304TL type tube in essentially the same circuit. This change resulted in a very satisfactory test oscillator.

Effects of Dee Position

Provisions have been made for adjusting the position of the dees relative to the liner for purposes of optimizing the deflected beam. Attendant with this change of geometry are effective dee capacitance changes. An analysis of this problem shows that the capacitance of the broad sides of one dee may be written as follows:

$$C_D = \frac{AD}{4\pi} \frac{1}{d_1(D - d_1)}$$

where d_1 and d_2 are distances, in centimeters, between the dee walls and liner walls.

$$D = (d_1 + d_2)$$

$$A = \text{area of both sides of dee, in cm}^2$$

A plot of the ratio of the capacitance as a function of d_1 to the capacitance at $d_1 = D/2$ (the centered position of the dee) against the distance d_1 is shown in Figure 5. Since $D/2 = 1\ 1/8''$, this indicates that the dee-to-ground capacitance changes by about 6% for a 1/4-inch shift from the centered position. For off-center positions in excess of 1/4 inch the change in capacitance increases rapidly, requiring a shorter length for the dee stems if the frequency is to remain unchanged.

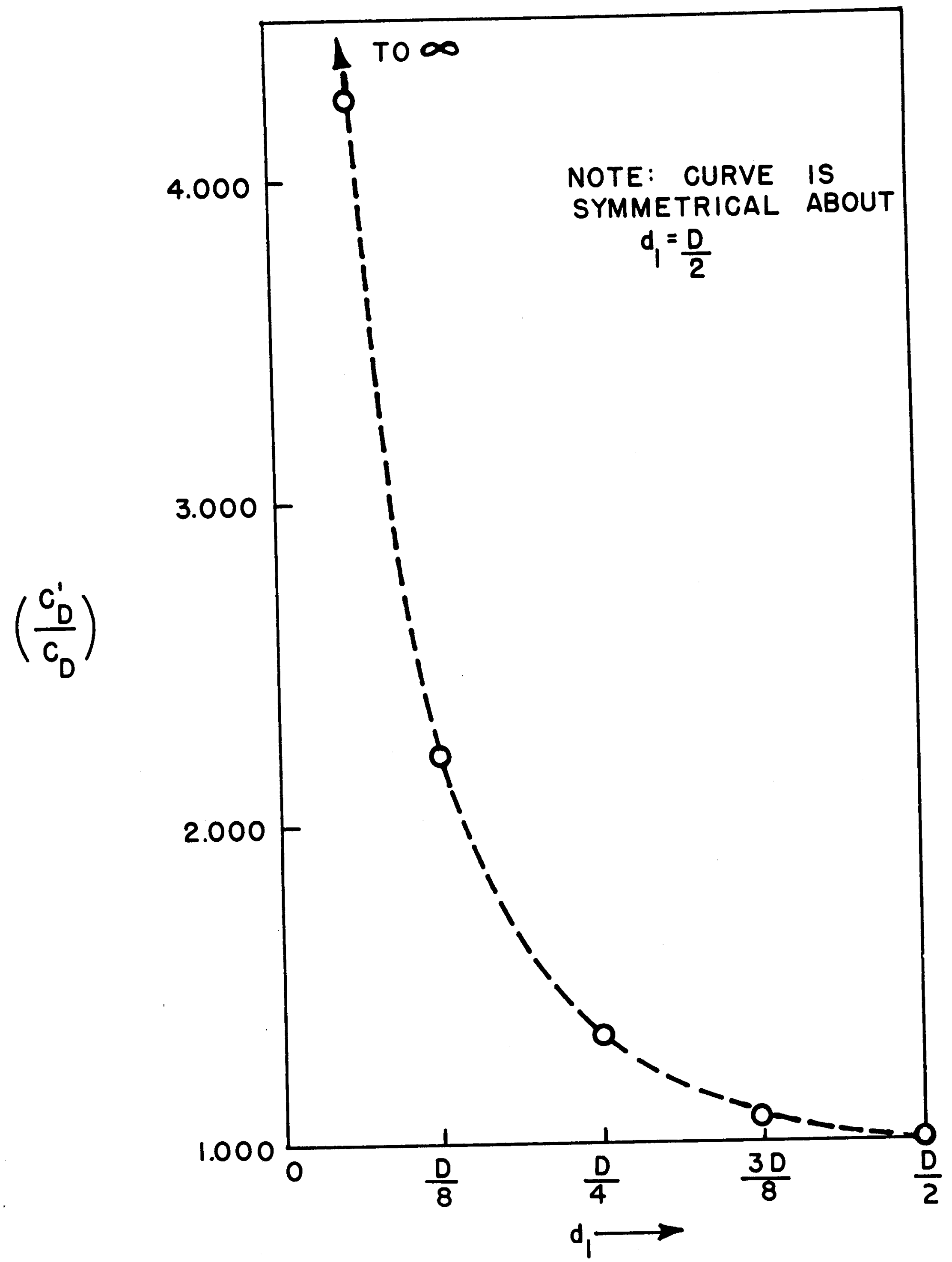

FIGURE 5 CAPACITANCE CHANGE OF ONE DEE AS A FUNCTION OF ITS OFF-CENTER POSITION

THE 22-INCH CYCLOTRON

The use of electromagnetic shims for focusing the proton beam is being investigated in the 22-inch cyclotron. These shims consist of two sets of AWG #2 copper wire coils, one at each side of the tank, Figure 6. Each set contains four concentric coils with external leads which permit the coils to be individually energized. The opposite paired coils are connected in series and the current through each pair is variable from 15 to 150 amperes.

With these coils several magnetic field shapes are possible. Three general field shapes have been examined: (1) an approximately linear drop-off from first to last orbit of the cyclotron beam, (2) a low field at intermediate radii with higher field near the center and at larger radii; and (3) with the higher field at intermediate radii, Figures 7 and 8. The magnitude of field change was varied by changing the current in the shim coils. The field shapes shown were calculated by algebraic addition of magnetic field shapes produced by separate coils. The radial positions of the inflection points in field shapes (2) and (3) above were determined by the magnitudes of shim coil currents. The correspondence of calculated field with measured field is shown by curves A and A_o, Figure 8. Cyclotron operation using the electromagnetic shims indicates that this method of shimming the magnetic field and varying the field drop-off is practical either for tests or for steady operation.

Beam current attenuation curves were obtained by operating the cyclotron with various magnetic field shapes produced by the electromagnetic shims, but analysis of these curves has not been completed. It is anticipated that a study of these curves and the corresponding field shapes will give experimental

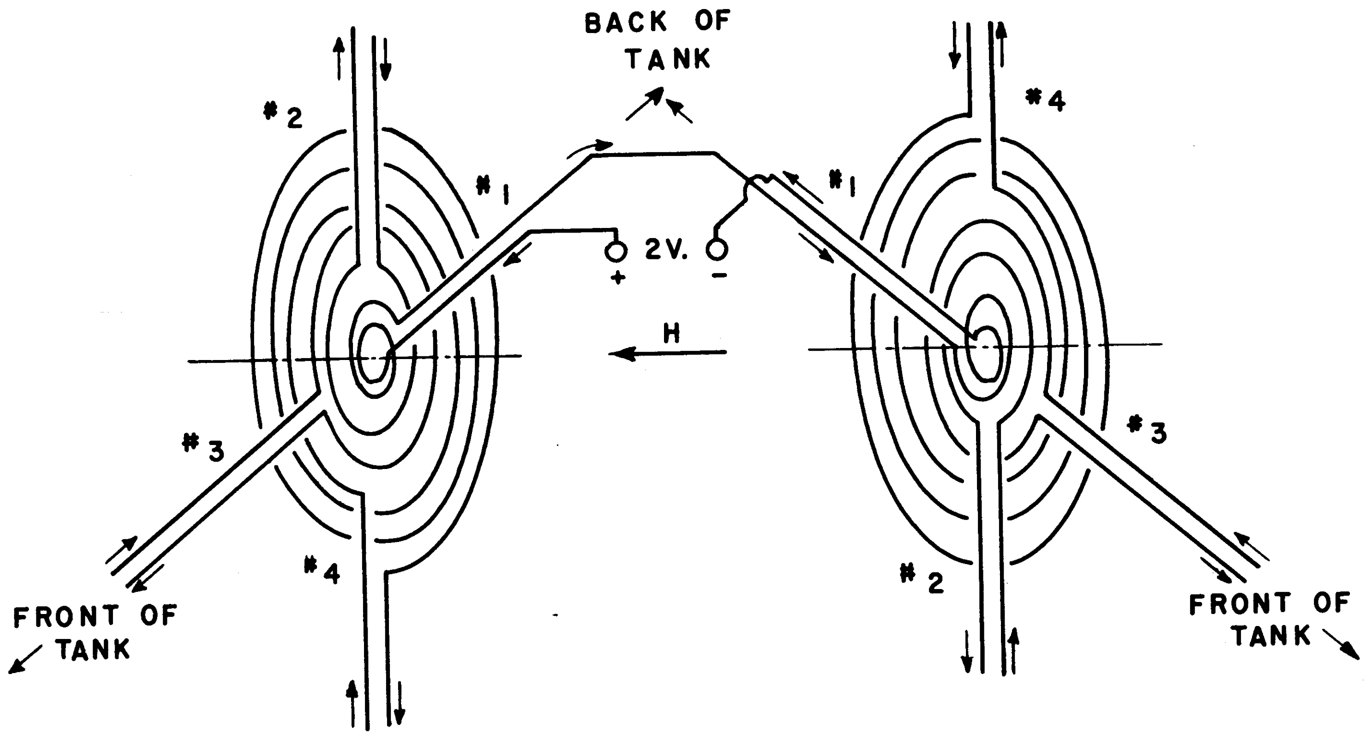

FIGURE 6. ELECTROMAGNETIC SHIM CIRCUITS

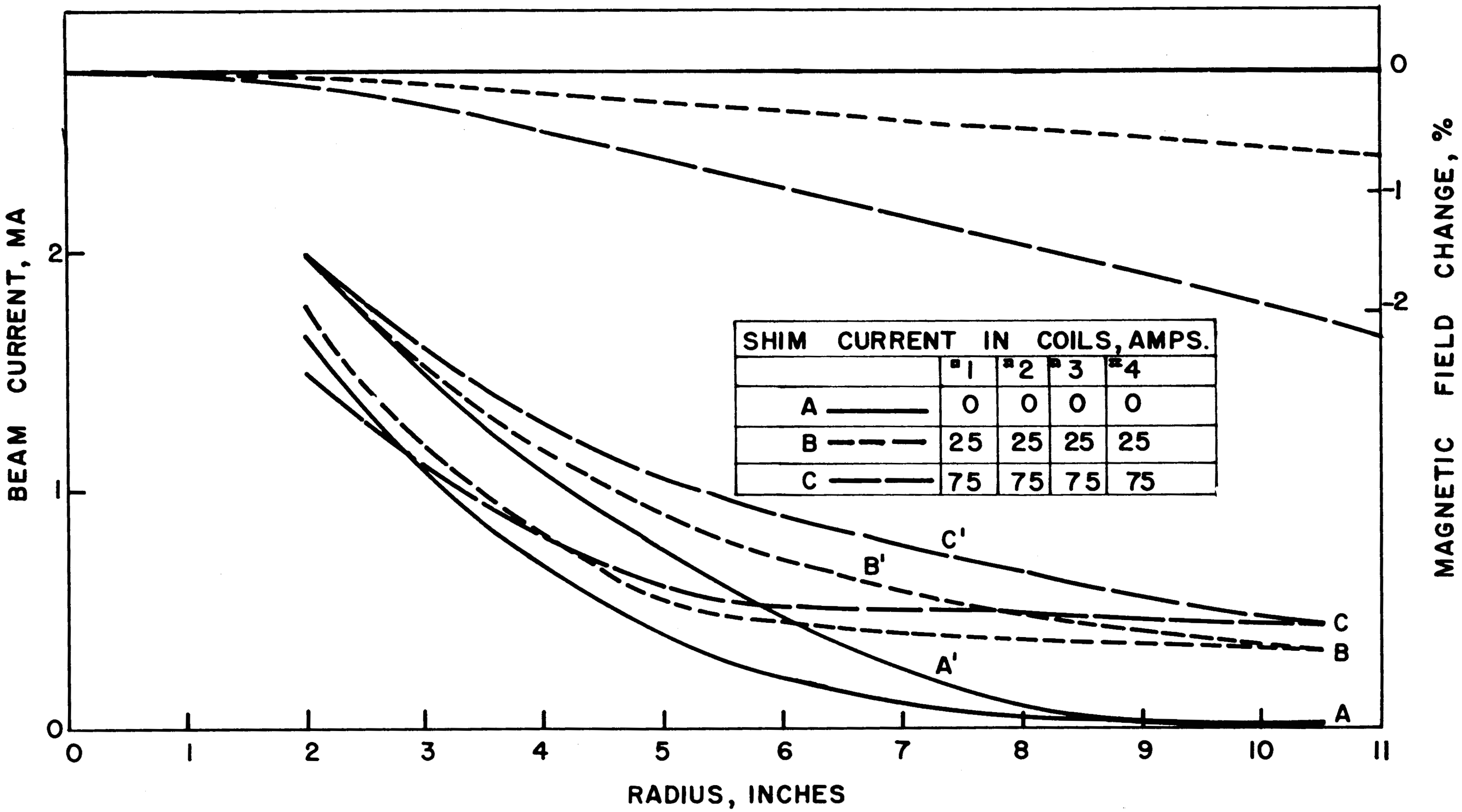

FIGURE 7. BEAM CURRENT ATTENUATION WITH RADIAL REDUCTIONS OF FIELD

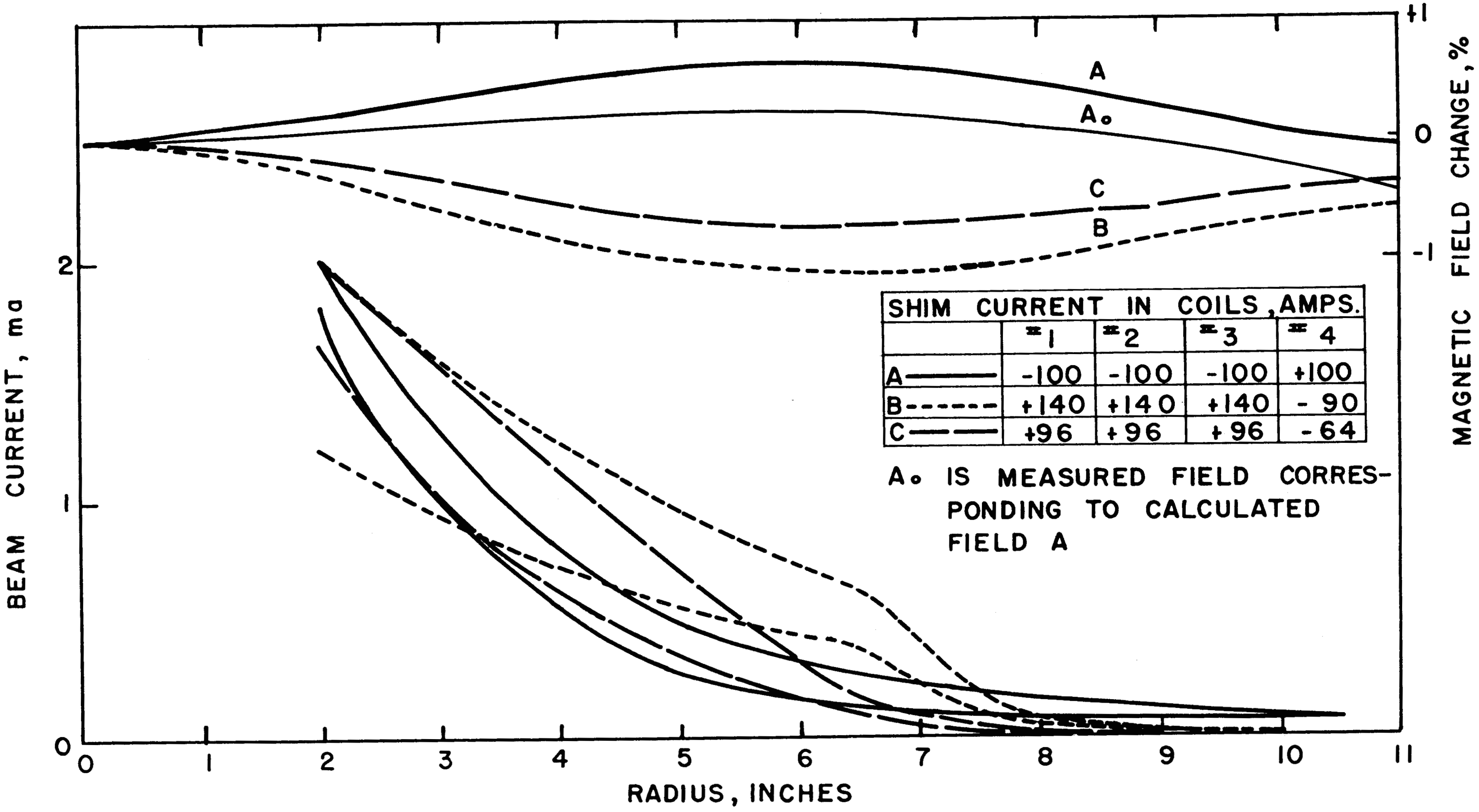

FIGURE 8. BEAM CURRENT ATTENUATION WITH VARIOUS FIELD SHAPES

evidence of the optimum magnetic field conditions for fixed-frequency cyclotrons and of the relative importance of magnetic focusing as compared with electric focusing at different orbital radii of the beam. Typical attenuation curves resulting from various field shapes are shown in Figures 7 and 8. The dee-to-dee potential was held constant throughout the experiment. Two attenuation curves were made for each field shape. In each case the upper curve (A', B', and C') was obtained by resonating the field and frequency at each observation point. For the lower curves resonance was held at the 10.5" radius.

While the electromagnetic shims were being installed, a movable deflector and septum system was also installed on the cyclotron so that deflector positioning experiments can be conducted more rapidly.

The performance of the cyclotron oscillator in an external position close to, instead of between, the dee stems has been investigated. These tests were made to determine the practicability of this arrangement which will be necessitated by the proposed conversion of the 22-inch cyclotron to a 5 Mev machine with very short dee stems. It was concluded that, with a minimum of expense in design time and construction, the oscillator can be located near the dee stems and connected to the dee system by co-axial, air-dielectric transmission lines inductively coupled.

SPECIAL SEPARATIONS

SUMMARY OF THE U 236 PROGRAM

In the two-stage purification of U 236, just completed, 1.8 grams of 95% U 236 were prepared. The enriched U 236 has been made available for the evaluation of nuclear properties. Concentration of U 236 was a cooperative project: U 235 slugs were irradiated in a Hanford reactor; the irradiated slugs were decontaminated at X-10; and the U 236 was enriched electromagnetically. Highly purified U 235 was obtained as a by-product.

Production

The 37 runs of the initial stage produced 28 grams of 32% U 236 as feed for the second stage. Recycling of this small amount of feed through six runs in the second stage gave an average feed rate of 20 grams of uranium per run. Isotopic composition of the feed material supplied to ORNL and of the first and second stage products are shown graphically in Figure 9 and are tabulated below:

	Uranium (gm)	Isotopic Concentration			
		%U 236	%U 235	%U 238	%U 234
Stage 1					
Starting Feed	2200	1	92	6	1
U 235 Product	1120	0.08	99.72	0.14	0.06
U 236 Product	28	32	63	4	1
Stage 2					
Starting Feed	26	32	63	4	1
U 235 Product	5	1.9	97.9	0.2	0.05
U 236 Product	1.8	95.4	4.1	0.4	0.1

Calutron Performance

Performance of the equipment used in obtaining this one-mass-unit separation is measured in terms of enhancement, process efficiency, and production rate for each stage. Evaluation of recovery efficiency will be reported later.

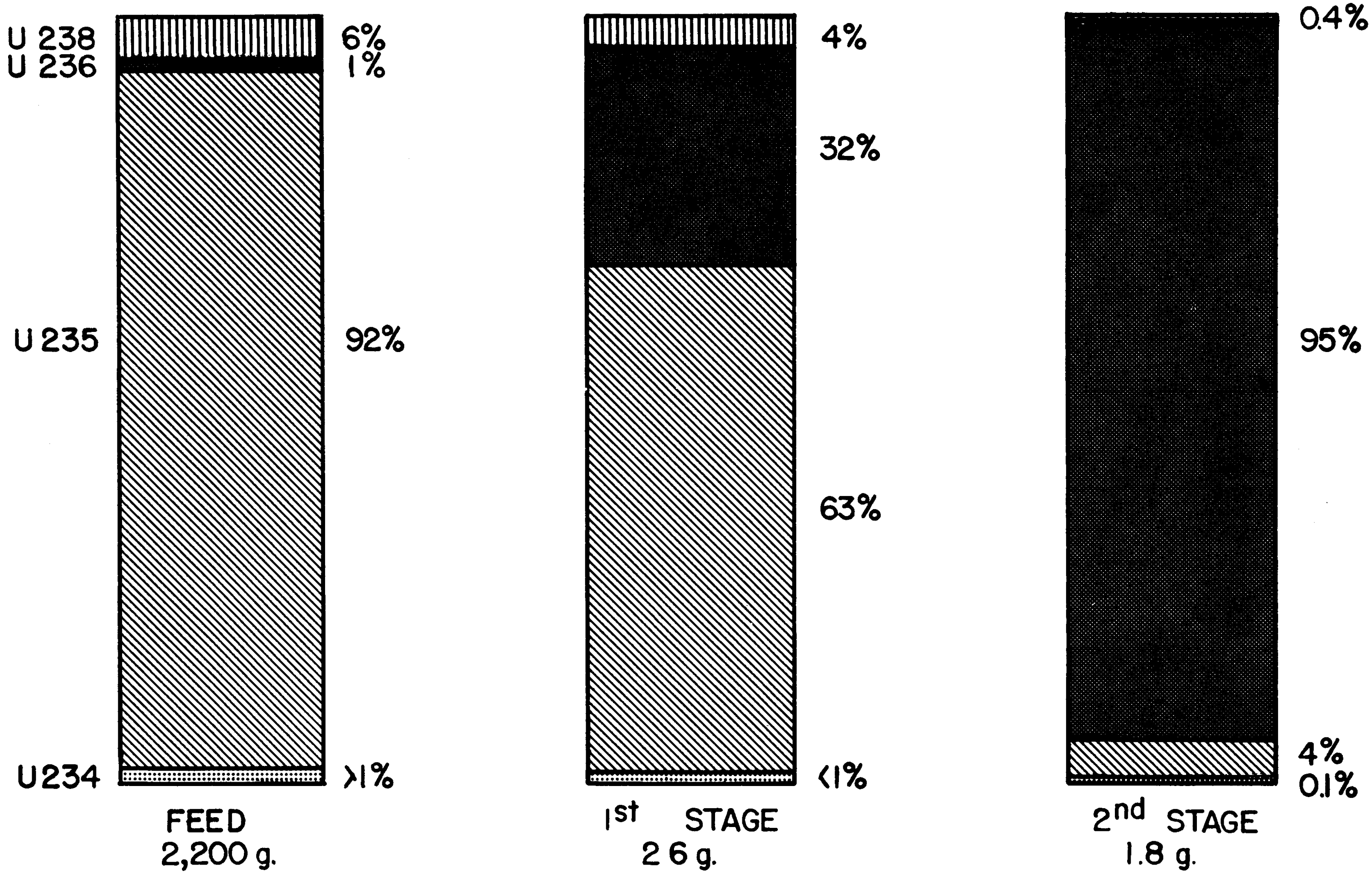

FIGURE 9. U 236 PROGRAM

Enhancement. The quality of resolution between ion beam foci determines the enhancement obtained. Since the U 236/U 235 ratio in the first stage product is 40 times greater than the corresponding feed ratio, the enhancement for the stage is 40. A somewhat higher enhancement was obtained in the second stage. The overall enhancement is the product of enhancements for the two stages.

Product	Enhancement Relative to			
	U 236	U 235	U 238	U 234
First Stage U 235	16	--	71	29
First Stage U 236	--	40	56	54
Second Stage U 236	--	47	61	36
Second Stage U 235	26	--	71	26
Overall U 236	--	1880	3420	1940

Process Efficiency. The efficiency of the process is the product of the source and collector efficiencies. It becomes less at higher resolutions. For the enhancements obtained the U 235 process efficiency is 9.8%, that is, 9.8% of the U 235 atoms vaporized were collected.

Product	Efficiencies, %		
	Source	Collector	Process
First Stage U 235	10	98	9.8
First Stage U 236	10	62	6.2
Second Stage U 236	7.5	63	4.7
Second Stage U 235	7.5	96	7.2

Production Rate. The rate of isotope production varies directly as uranium vaporization rate, process efficiency, and the isotopic abundance in the feed. For the twin-arc ion source of the first stage, the separation period averaged 55 hours per run at a feed vaporization rate of 3.2 gm U/hr per arc. The separation period of the single-arc source used in the second stage averaged 6.5 hours per run at a feed rate of 2.9 gm U/hr. Productivity per run is governed largely by emphasis on enhancement and restrictions on feed batch size.

	Stage 1	Stage 2
Collector current per arc (ma U^+)	35	25
Production rate per arc (mg U 235/hr)	273	128
(mg U 236/hr)	2.2	42
Vaporized feed per run (gm U 235)	307	11.8
(gm U 236)	3.9	5.9
Per run production (gm U 235)	30	0.85
(gm U 236)	0.24	0.28

SHIPMENTS OF ENRICHED URANIUM ISOTOPES

Shipments of highly purified uranium isotopes supplied to laboratories of the Atomic Energy Commission during July, August, and September are tabulated below:

Los Alamos Scientific Laboratory	150 mg U	95.3% U 236
Oak Ridge National Laboratory	92 mg U	94.0% U 234
Argonne National Laboratory	308 mg U	96.0% U 234
Oak Ridge National Laboratory	100 mg U	99.91% U 235
Brookhaven National Laboratory	100 gm U	99.9988% U 238
Brookhaven National Laboratory	100 gm U	99.9956% U 238
Argonne National Laboratory	50 gm U	99.9938% U 238
Oak Ridge National Laboratory	5 gm U	99.9956% U 238

FACILITIES FOR PROCESSING PLUTONIUM

Facilities for the separation of plutonium isotopes on a laboratory scale are being installed in Building 9204-3. The work which was suspended in June was resumed in September as funds became available. The facilities include a processing laboratory, a calutron wash area, and designated calutron equipment. The equipment for isotope separation being similar to that used in uranium separation is tested and ready. Facilities and techniques for handling highly alpha active materials must be completed and tested before separations can be made.

Fourteen out of sixteen gloved boxes, required for recycle and product chemical operations, have been fabricated and installed in the processing laboratory. The installation of process equipment inside these boxes has begun. Preliminary tests (without radioactive material) were made of the evaporation equipment which will be used for reducing the volume of calutron machine wash solution. Besides the installation and testing of the actual process equipment the major items to be installed in the processing laboratory are:

1. A gloved enclosure for the evaporation equipment
2. Permanent air samplers (already on hand)
3. A CO_2 fire protection system

Construction of an enclosure for the calutron wash area has begun. This enclosure will have an area of approximately 1000 square feet and will contain facilities for disassembly and wash of calutron components. Because of the uncertainties involved in making transfers, this area may be subject to alpha contamination. A large air lock will permit entry of calutron handling equipment; there will be adequate room for the necessary maneuvering in making transfers. Both clean and contaminated change houses are provided with minimum facilities for four to six men. Construction is wood framing (made fire-resistant with Albi-R) with gypsum board on both sides. A gloved box for disassembly and wash of ion source and collector and an acid spray system for washing the liner are being fabricated.

A trial model Vinylite transfer bag for separating calutron components was made and appeared satisfactory, but additional tests with radioactive materials will be necessary before it can be considered adequate for use with plutonium. An electronic seamer for the fabrication of Vinylite transfer bags and glove gauntlets has been purchased. This seamer is also being used by the 86-inch cyclotron group in preparing bags to control contamination from cyclotron targets.

ELECTROMAGNETIC FUNDAMENTALS

DC INJECTION OF IONS IN CYCLOTRON

In a cyclotron the number of ions reaching the target should be appreciably increased if the arc meniscus at the ion source were stabilized and if the ratio of H^+ to H_2^+ ions (in the case of protons) were increased. Since the ion source is exposed to the rf potential of the dees there is a resulting instability of the arc meniscus. At reduced arc current and arc potential a more stable arc meniscus is obtained. Unfortunately, when stability is obtained in this manner the ion source has a low efficiency, producing a relatively high percentage of H_2^+ ions. For the efficient production of an abundance of H^+ ions, both the arc current and voltage should be high and the gas flow small. These opposing requirements interfere with obtaining optimum operating conditions.

The Injection of Ions

In an attempt to stabilize the arc meniscus and to increase the H^+ production the application of a constant accelerating potential at the ion source is being investigated. An electrode at negative potential is mounted between the ion source and the cyclotron dee. The purpose of this electrode is to impress a steady state electric field upon the ion source. The opening (or openings) in the electrode are small enough and the applied potential high enough to minimize the rf field penetration into the arc. Further, arc conditions can be adjusted for optimum H^+ production since bowing of the meniscus can be controlled, within certain limits, by adjusting the potential on the accelerating electrode.

An experimental unit for investigating dc injection has been fabricated, Figure 10, and several trial runs have been made. Protons from the ion source are accelerated through the electrode into the dee system; after 1 1/2 turns they are collected on a probe. An rf frequency of 10 mc/sec is used in a 6700 oersted field.

Preliminary Results

Several preliminary tests have been made with this dc injector. The unit can be operated with or without the dc potential on the injector electrode. While the usual experimental difficulties have been encountered the beam current has been found to increase when the dc injection potential is applied and the beam pattern on the probe appears well defined.

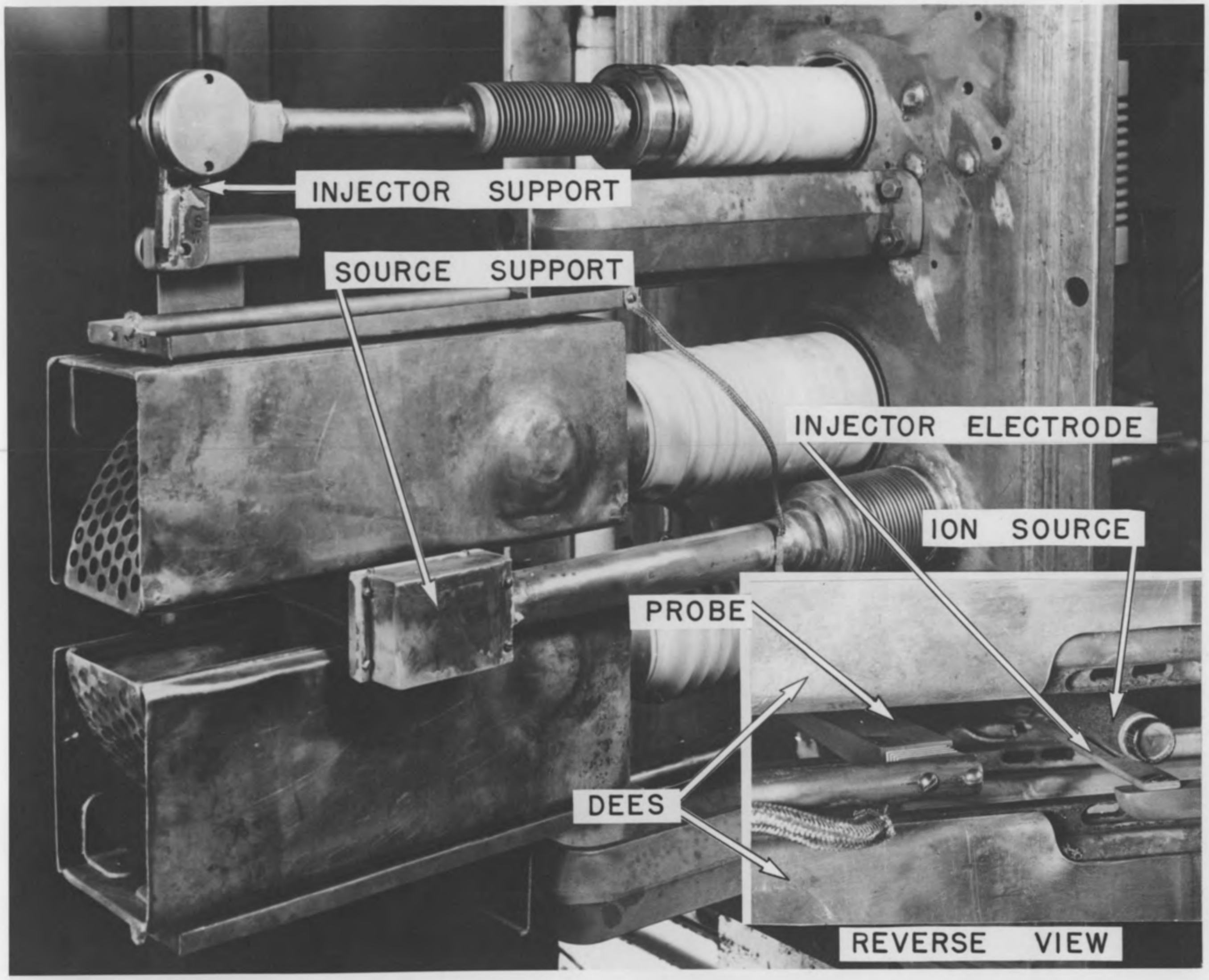

FIGURE 10. ION INJECTOR