THE UNIVERSITY OF MICHIGAN
ANN ARBOR, MICHIGAN

QUARTERLY PROGRESS REPORT NO. 14

FOR

RESEARCH AND DEVELOPMENT ON HIGH-POWER CRESTATRONS

FOR THE 100-300 MC FREQUENCY RANGE

This report covers the period October 1, 1963 to January 1, 1964

Electron Physics Laboratory
Department of Electrical Engineering

By: G. T. Konrad
C. K. Rhee

Approved by: G. T. Konrad
G. T. Konrad
Project Engineer

J. E. Rowe
J. E. Rowe, Director
Electron Physics Laboratory

Project 03783

NAVY DEPARTMENT BUREAU OF SHIPS
ELECTRONICS DIVISION
CONTRACT NO. NObsr-81403
PROJECT SERIAL NO. SF0100 201
TASK NO. 9294

January, 1964

ABSTRACT

A series of trajectory plots is shown which led to a reasonably good electrical design for the $P_\mu = 20$ gun. The work done on the electrostatically focused tube using a $P_\mu = 4.46$ gun indicates that much better focusing can be obtained with the improved gun. At reduced voltages the beam transmission is only fair but it is shown that the percentage of transmission is improving as the design voltage is approached.

In order to center the operating band of the 100-watt Crestatrons more nearly within the desired frequency range and in order to overcome the r-f losses observed in the couplers, a revision is made in the tube design. The new dimensions and electrical parameters are shown.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

PERSONNEL

Scientific and Engineering Personnel		Time Worked In Man Months*
J. Rowe	Professor of Electrical Engineering	.20
J. Boers	Associate Research Engineers	.88
G. Konrad		.93
W. Rensel	Assistant Research Engineer	.47
C. Rhee	Research Assistants	1.58
D. Terry		.40
Service Personnel		9.53

*Time Worked is based on 172 hours per month.

QUARTERLY PROGRESS REPORT NO. 14

FOR

RESEARCH AND DEVELOPMENT ON HIGH-POWER CRESTATRONS

FOR THE 100-300 MC FREQUENCY RANGE

1. Introduction (G. T. Konrad)

Contract NObsr-81403 comprises a research and development program on high-power 100-300 mc Crestatrons. The aim is to construct compact 100-watt Crestatrons employing permanent magnet focusing. Initially the tubes will be tested in a solenoid until they meet electrical specifications, but ultimately the permanent magnet focused tubes employing a depressed potential collector will be ruggedized so as to meet environmental specifications. This work is being conducted by the Bendix Research Laboratories on a subcontract from the University of Michigan.

Theoretical as well as experimental studies on high-perveance hollow-beam electron guns, in addition to electrostatic focusing systems initiated some time ago on this program, are being continued by the University of Michigan. The ultimate goal of these studies is to demonstrate the feasibility of using electrostatically focused, high-power, hollow electron beams in microwave devices. In addition, it is intended to work out a design for an electron gun compatible with a high-power vhf Crestatron.

2. Computer Design of High-Perveance Hollow-Beam Guns (C. K. Rhee)

The first set of beam trajectories for the $P_\mu = 20$ gun shown in the last quarterly report indicated the necessity of a stronger focusing lens in order to overcome the large space-charge forces within the

the electron beam. Since the focusing action does not penetrate into the beam deep enough with the present lens electrodes, a modification of the shape of the lens electrodes is suggested.

A series of figures (Figs. 2.1 - 2.7) shows the various stages in the modification of the lens-shape during the past quarter. Figure 2.1 shows a great improvement eliminating the gun region interception entirely. However, the degree of beam trajectory crossing is increased due to overly strong focusing action at the beam edge, as expected. In Fig. 2.2 the lens-shape was changed in such a way that there exists a stronger defocusing force, and hence the amount of trajectory crossing is somewhat reduced. In Fig. 2.3 the last anode was opened up a little with the anticipation of a stronger defocusing action at the beam edge, but there is not an appreciable change in the trajectory crossing. In Fig. 2.4 the lens-shape was changed to enhance the defocusing action and the last anode was closed back to the original position. The beam trajectory crossing is seen to be much improved but still it is not good enough to assemble a gun. In Fig. 2.5 the lens voltage was reduced from $\frac{V_o}{10}$ to $\frac{V_o}{100}$, but the trajectory crossing is enhanced due to a very strong lens action. In Fig. 2.6 the lens electrodes were moved away from the beam and the last anode was opened again. There still exists a small amount of trajectory crossing. In Fig. 2.7 a further removal of the lens electrodes eliminated the trajectory crossing completely. Although the beam interception and trajectory crossing have not occured in the gun region the beam as a whole is diverging and interception would take place in the interaction region. In this respect Fig. 2.6 has a potentially better transmission even though there exists a small amount of trajectory

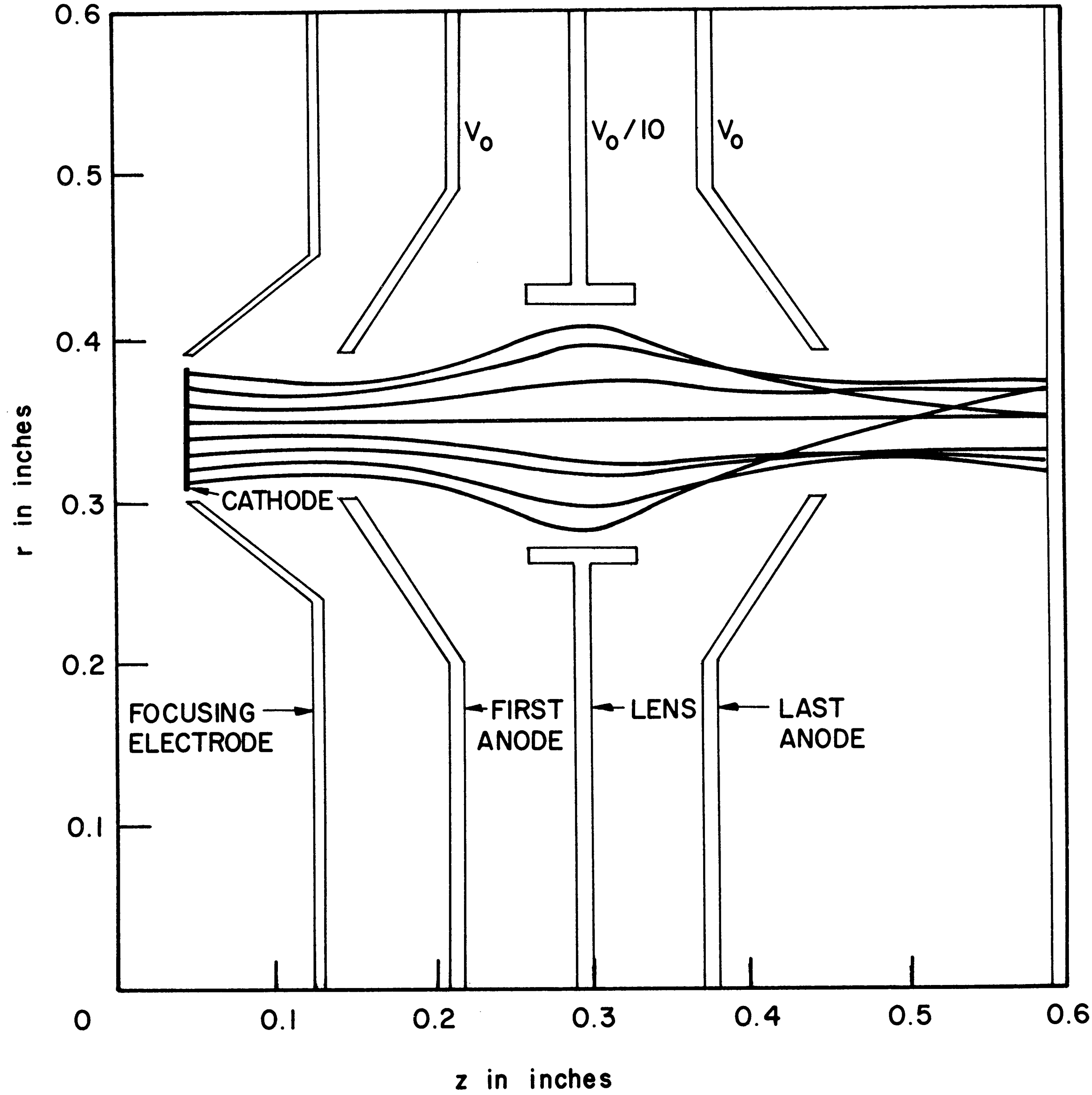

FIG. 2.1 TRAJECTORY PLOT FOR ELECTROSTATICALLY FOCUSED P_μ = 20 GUN.

(J_o = 3.732 x 10^3 AMP/m^2, P_μ = 18.017)

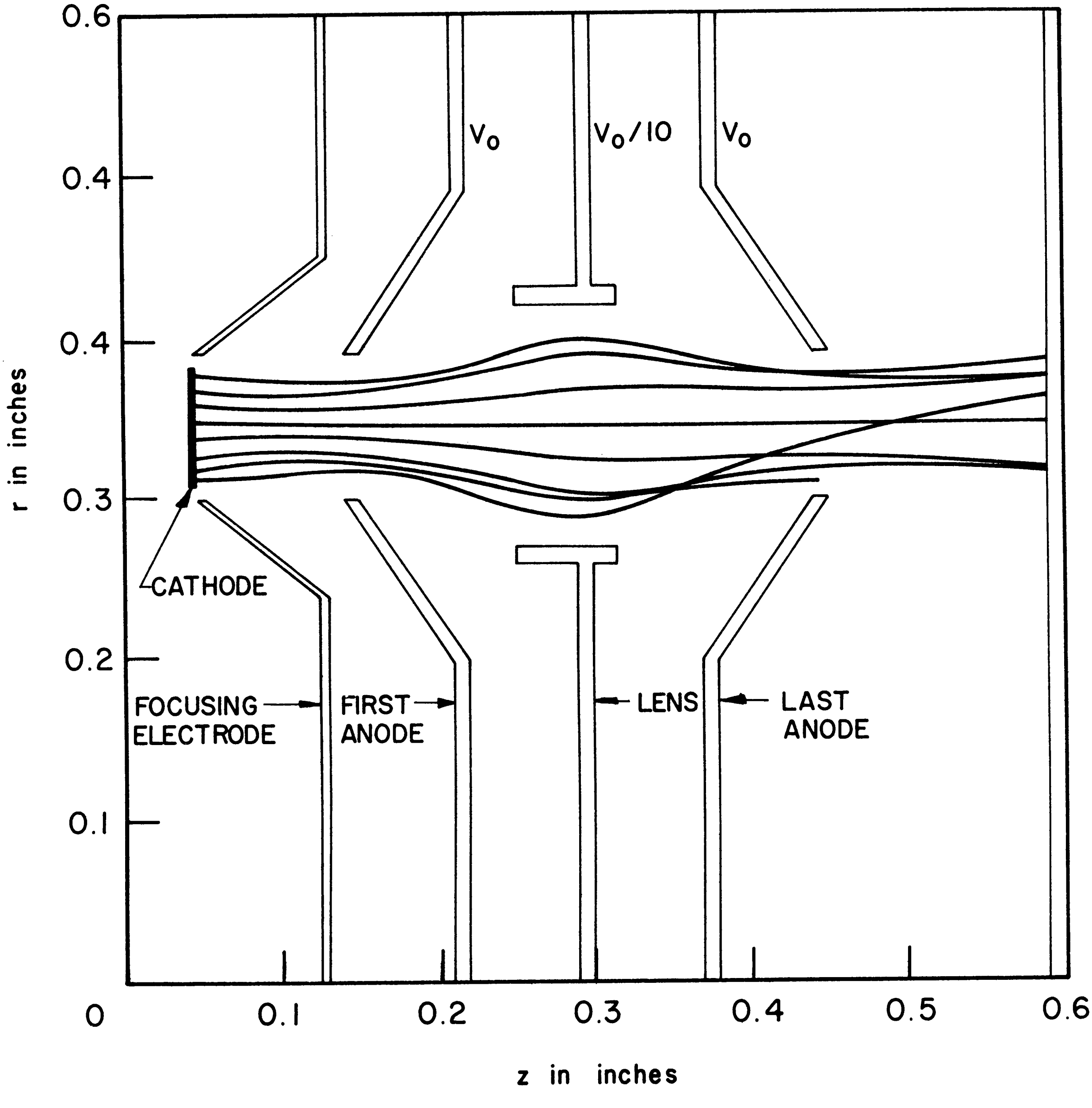

FIG. 2.2 TRAJECTORY PLOT FOR ELECTROSTATICALLY FOCUSED $P_\mu = 20$ GUN.

($J_o = 3.813 \times 10^3$ AMP/m^2, $P_\mu = 18.397$)

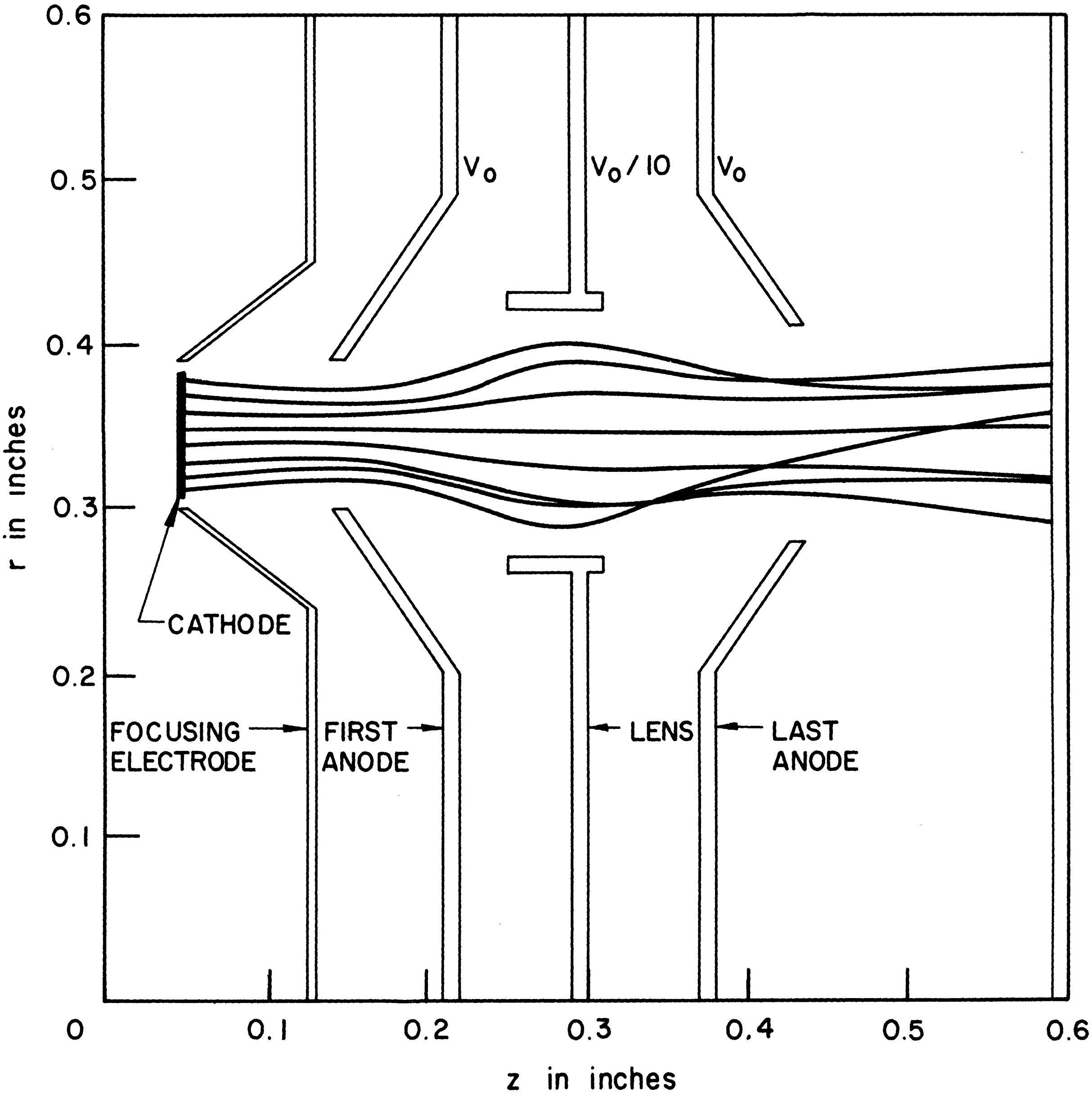

FIG. 2.3 TRAJECTORY PLOT FOR ELECTROSTATICALLY FOCUSED P_μ = 20 GUN. ($J_o = 3.811 \times 10^3$ AMP/m^2, P_μ = 18.388)

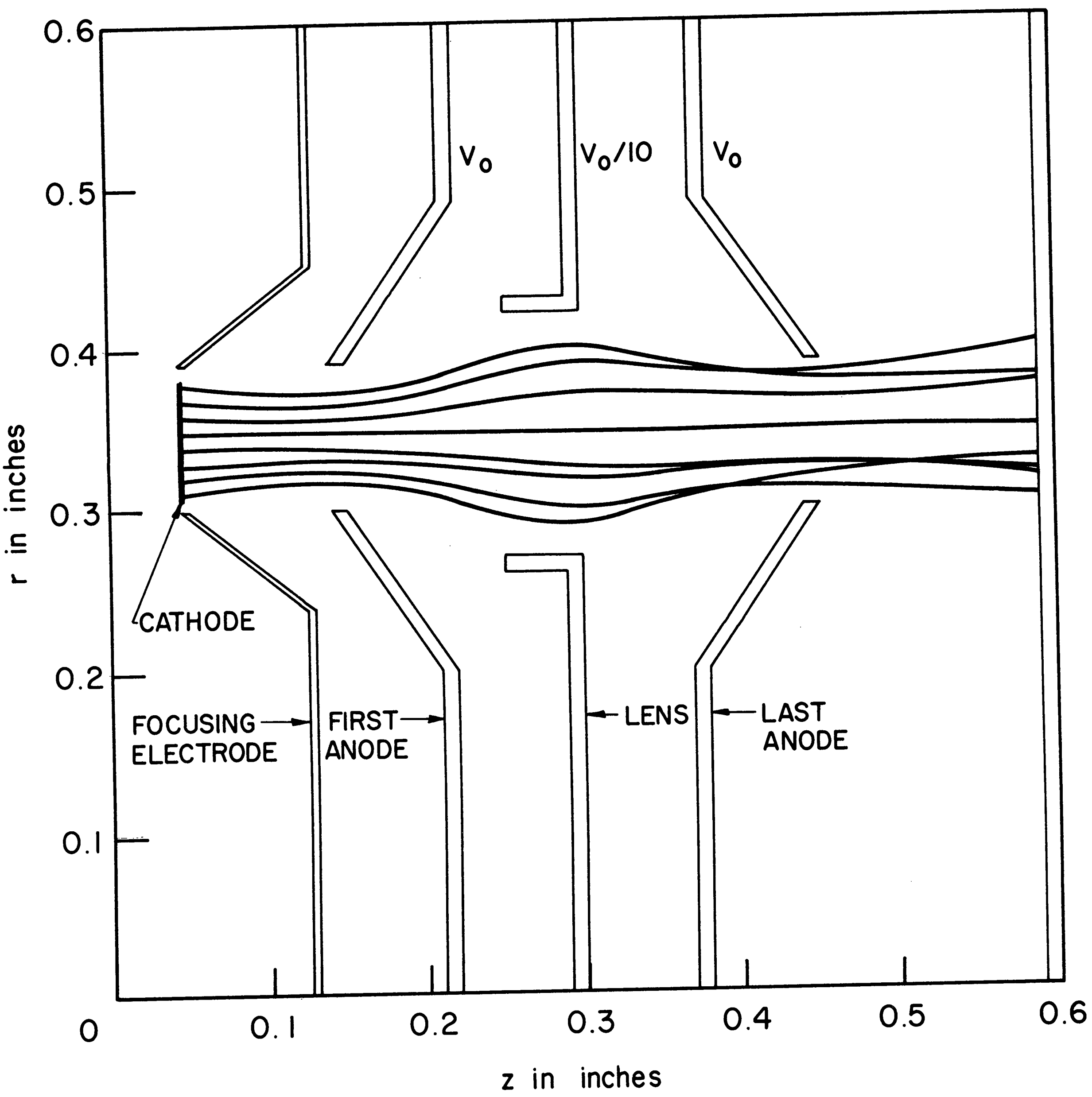

FIG. 2.4 TRAJECTORY PLOT FOR ELECTROSTATICALLY FOCUSED

P_μ = 20 GUN. ($J_o = 3.726 \times 10^3$ AMP/m^2, $P_\mu = 17.991$)

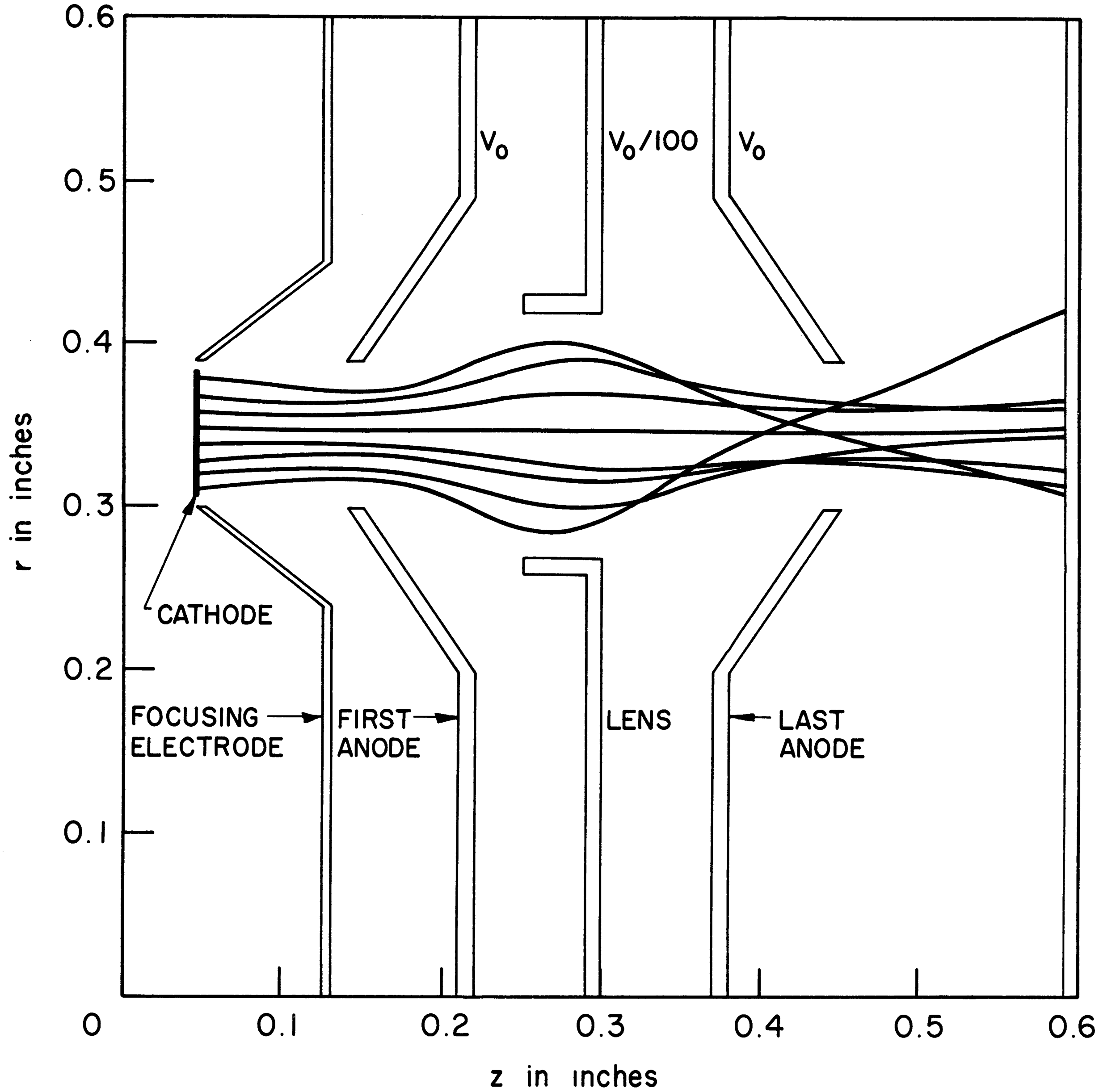

FIG. 2.5 TRAJECTORY PLOT FOR ELECTROSTATICALLY FOCUSED $P_\mu = 20$ GUN. ($J_o = 3.698 \times 10^3$ AMP/m^2, $P_\mu = 17.854$)

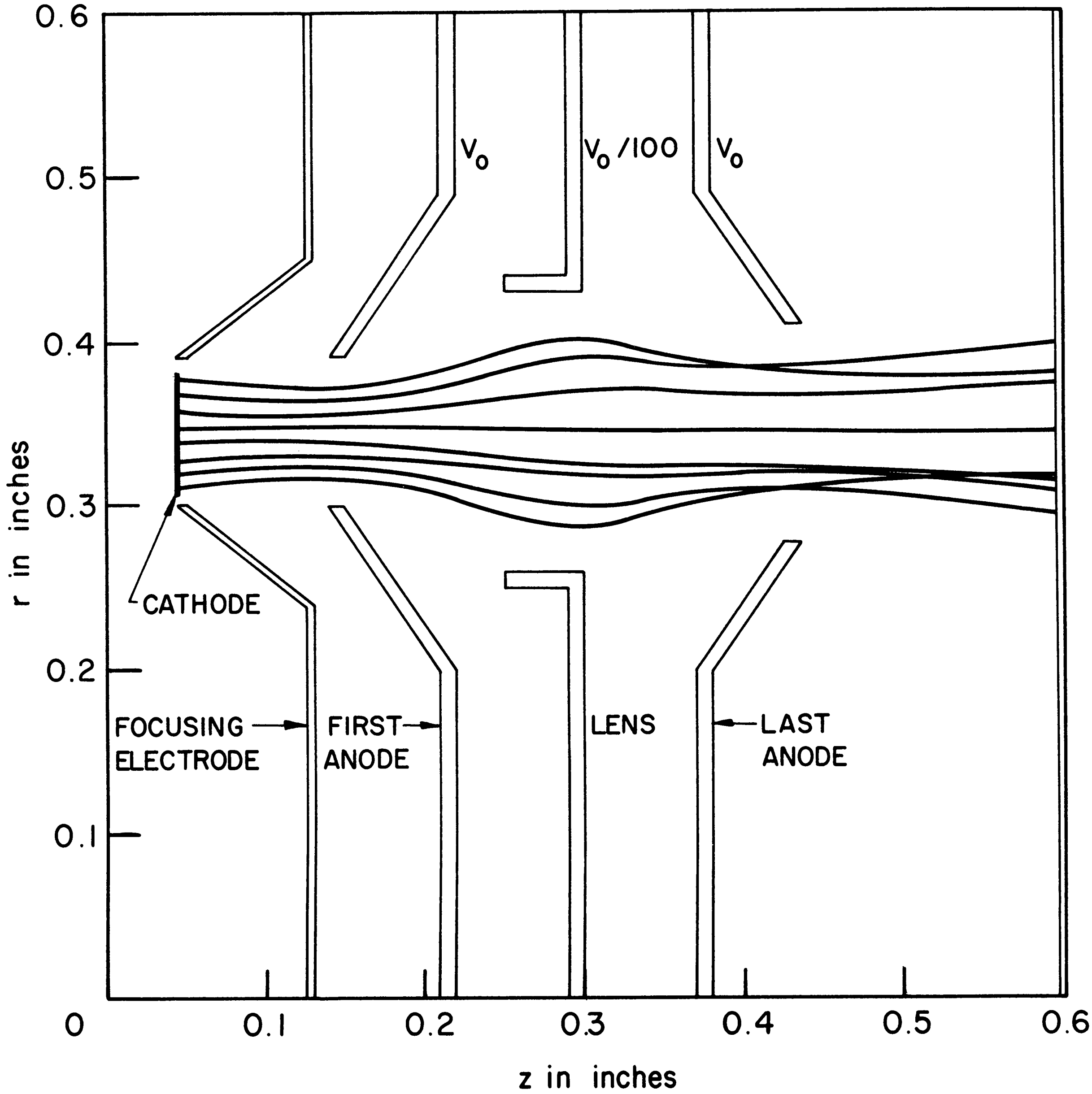

FIG. 2.6 TRAJECTORY PLOT FOR ELECTROSTATICALLY FOCUSED P_μ = 20 GUN. (J_o = 3.722 x 10^3 AMP/m^2, P_μ = 17.97)

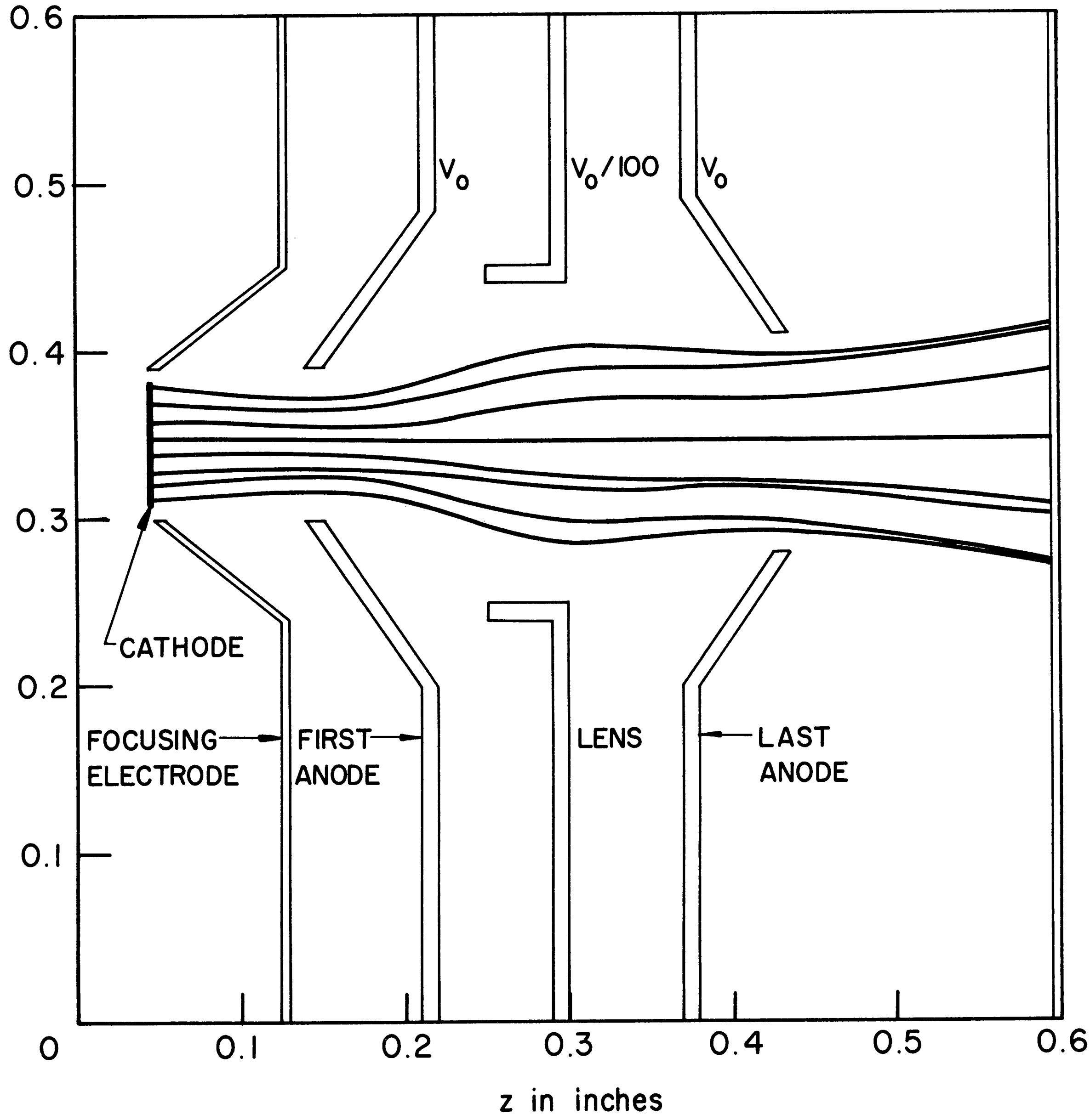

FIG. 2.7 TRAJECTORY PLOT FOR ELECTROSTATICALLY FOCUSED P_μ = 20 GUN. ($J_o = 3.751 \times 10^3$ AMP/m^2, P_μ = 18.109)

crossing. The final gun will be built using the geometry of Fig. 2.6 during the coming quarter.

The other $P_{\mu} = 20$ gun with a smaller mean beam radius has been programmed, and the initial run was made. The major portion of the design of this gun will be completed during the next quarter.

3. Experiments on the Electrostatically-Focused Hollow-Beam Tube

(C. K. Rhee)

The vhf electrostatically focused Crestatron was repaired and reprocessed. The initial focusing test was conducted up to a beam voltage of 900 volts, which is still considerably lower than the operating voltage.

Figure 3.1 shows the beam transmission vs. beam voltage. Although the transmission is poor at this stage, Fig. 3.1 shows that it is possible to get a much better beam transmission as the operating voltage is increased. It is expected that at the design voltage of 1500 volts the transmission will be quite good. The beam current density started decreasing markedly at approximately 800 volts due to a pressure rise within the tube as various parts became hot. In order to overcome this difficulty it may be necessary to pulse the beam voltage in future tests.

4. Work Conducted at the Bendix Research Laboratories *

4.1 Experimental Data on Tubes. Seventeen tubes have been completed to date. Twelve have been r-f tested and one is undergoing r-f tests at the present time. Table 4.1 lists the more important physical and electrical parameters of the tubes. Detailed data on the first thirteen tubes has been presented in previous progress reports.

---

* This material was submitted by K. C. Earl of the Bendix Research Laboratories.

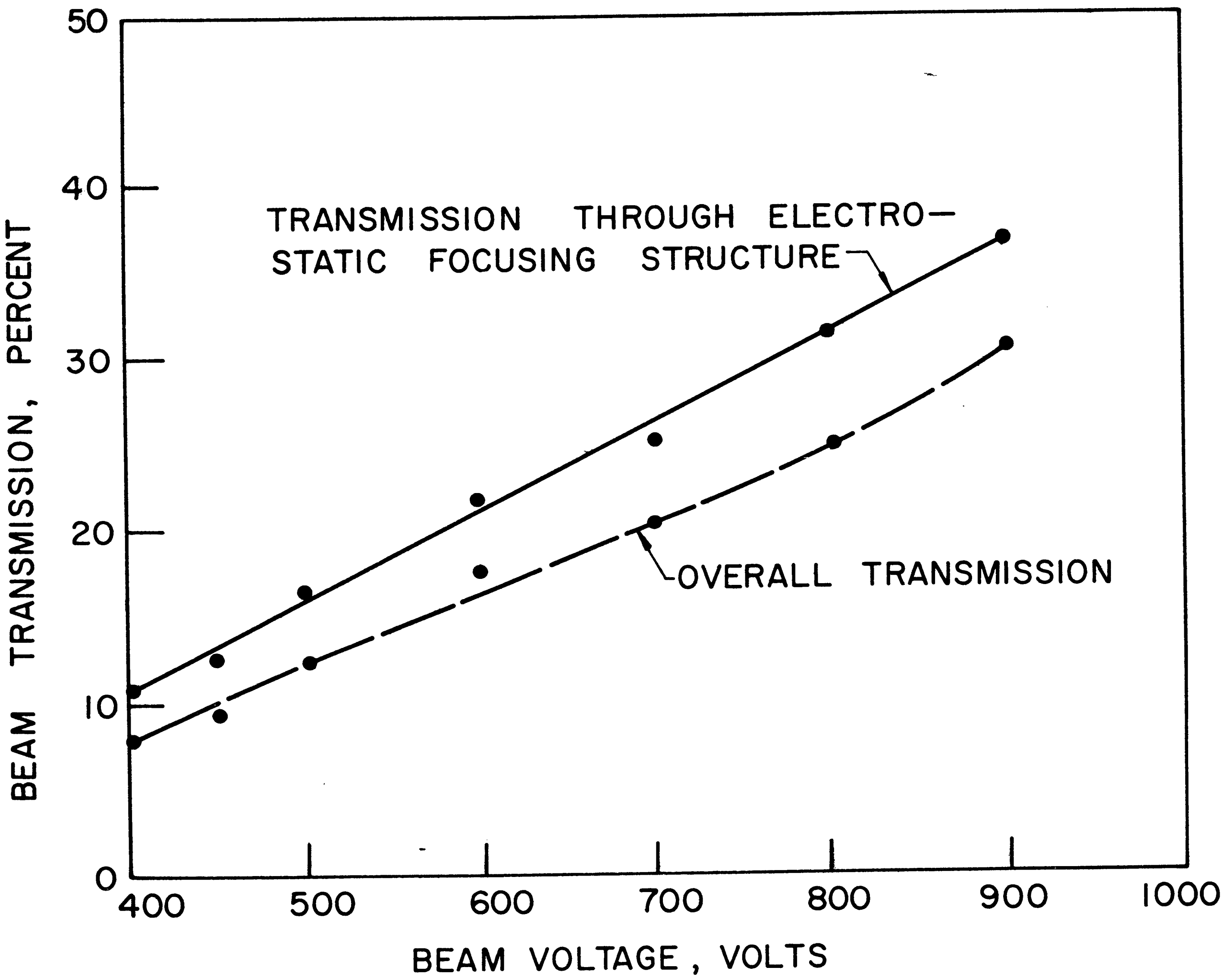

FIG. 3.1 BEAM TRANSMISSION VS. BEAM VOLTAGE.

TUBE NUMBER	PHYSICAL								ELECTRICAL							SPECIAL NOTES
	OVERALL LENGTH	HELIX LENGTH	HELIX MEAN DIA. (IN.)	HELIX TPI	HELIX WIRE SIZE	TYPE R.F. CONNECTORS	MATCHING SECTIONS		GUN TYPE	BEAM DIA. INCHES		RATED COLLECTOR CURRENT	RATED VOLTAGE	OPERATING CONDITIONS		
							TYPE	LENGTH EACH END		INNER	OUTER			BEAM CURRENT	BEAM VOLTAGE	
TWT-143-A-1	16	9.6	0.756	11.5	0.030	COAX DIRECT PIN. CONN.	TAPERED OUTER SHIELD	4"	HOLLOW BEAM	0.478	0.590	452	870	105	680	GLASS TO KOVAR RF FEEDTHROUGHS AND STEM HEADER
TWT-143-A-2	16	9.6	0.756	11.5	0.030	COAX DIRECT PIN CONN.	TAPERED OUTER SHIELD	4"	HOLLOW BEAM	0.478	0.590	452	870	----	----	TUBE NOT COMPLETED DUE TO DATA ON TWT-143-A-1 INDICATING CHANGE OF PLANS
TWT-143-A-3	16	9.6	0.756	10	0.030	COAX DIRECT PIN CONN.	TAPERED OUTER SHIELD	4"	HOLLOW BEAM	0.478	0.590	452	870	143	700	THIS TUBE DEVELOPED AN OPEN INNER ANODE AND ARC BREAKDOWN
TWT-143-A-4	11	5.6	0.756	10	0.030	COAX DIRECT PIN CONN.	TAPERED OUTER SHIELD	2"	HOLLOW BEAM	0.478	0.590	452	870	350	830	ULTIMATE FAILURE DUE TO LEAKAGE IN GUN
TWT-143-A-5	11	5.6	0.756	10	0.030	COAX DIRECT PIN CONN.	TAPERED OUTER SHIELD	2"	HOLLOW BEAM	0.478	0.590	452	870	----	----	HEATER FAILURE BEFORE DATA WAS OBTAINED
TWT-143-A-6	11	5.6	0.756	10 TAPERED TO 20	0.030	COAX DIRECT PIN CONN.	TAPERED OUTER SHIELD	2"	HOLLOW BEAM	0.478	0.590	452	870	----	----	HELIX CONNECTION TO RF FEEDTHROUGH FAILED DURING BAKEOUT
TWT-143-A-7	11	5.6	0.756	10 TAPERED TO 20	0.030	COAX DIRECT PIN CONN.	TAPERED OUTER SHIELD	2.8"	HOLLOW BEAM	0.478	0.590	452	870	200	490-560	HELIX TAPERED TOO MUCH. RF PERFORMANCE WAS POOR
TWT-143-A-8	11	5.6	0.756	10 TAPERED TO 15	0.030	COAX DIRECT PIN CONN.	TAPERED OUTER SHIELD	2"	HOLLOW BEAM	0.478	0.590	452	870	280	770	HELIX TAPERED 1/2 THAT OF TWT-143-A-7 BUT STILL TOO MUCH.
TWT-143-A-9	11	5.6	0.756	11.5	0.030	COAX DIRECT PIN CONN.	TAPERED OUTER SHIELD	2"	HOLLOW BEAM	0.478	0.590	452	870	400	1180	FIRST TUBE TO GIVE 100 WATTS
TWT-143-A-10	11	5.6	0.756	11.5 STRETCHED OUTPUT MATCH	0.030	COAX DIRECT PIN CONN.	TAPERED OUTER SHIELD	2"	HOLLOW BEAM	0.478	0.590	452	870	250	680-940	OBTAINED MOMENTARY I_{Ks} OF 600 MA
TWT-143-A-11	11	5.6	0.756	13 UNIFORM	0.030	COAX DIRECT PIN CONN.	TAPERED OUTER SHIELD	2"	HOLLOW BEAM	0.478	0.590	452	870	----	----	RF FEEDTHROUGH FAILURE DURING BAKEOUT - EVERYTHING LOST
TWT-143-A-12	11	5.6	0.756	13 UNIFORM	0.030	COAX DIRECT PIN CONN.	TAPERED OUTER SHIELD	2"	HOLLOW BEAM	0.478	0.590	452	870	150	580-700	POOR ACTIVATION OF CATHODE, 150 MA, MAXIMUM CATHODE CURRENT
TWT-143-A-13	11	5.6	0.756	13 UNIFORM	0.030	COAX DIRECT PIN CONN.	TAPERED OUTER SHIELD	2"	HOLLOW BEAM	0.478	0.590	452	870	200	625-840	200 MA, MAXIMUM CATHODE CURRENT OBTAINED
TWT-143-A-14	11	5.6	0.756	11 UNIFORM	0.030	COAX DIRECT PIN CONN.	TAPERED SHIELD COUPLED HELIX	2" 2"	HOLLOW BEAM	0.478	0.590	452	870	400	930-990	HIGH LOSS IN OUTPUT COUPLER DEGRADED PERFORMANCE
TWT-143-A-15	14	7.7	0.756	11 UNIFORM	0.030	COAX DIRECT PIN CONN.	TAPERED SHIELD COUPLED HELIX	2" 2"	HOLLOW BEAM	0.478	0.590	452	870	600	1140 1240	SEVERE INVERSE OVERLOAD HIGH LOSS IN OUTPUT COUPLER DEGRADED PERFORMANCE
TWT-143-A-16	13	6.6	0.756	11 UNIFORM	0.030	COAX DIRECT PIN CONN.	COUPLED HELIX	2"	HOLLOW BEAM	0.478	0.590	452	870	400	820 910	HIGH LOSS DEGRADED PERFORMANCE; DATA OBTAINED ON DEPRESSED POTENTIAL COLLECTOR

P-1769

TABLE 4.1 PHYSICAL AND ELECTRICAL PARAMETERS OF TUBES TESTED.

Tube number 14 utilized an 11.5-TPI helix 5.6 inches long, a triode gun, and a coupled helix output matching section. Figures 4.1 and 4.2 show plots of power output vs. power input for this tube. The gain, power output, and efficiency are less than the average values obtained from previous tubes, and the optimum efficiencies ranged from 10 to 14 percent as compared to a general level of 18 to 21 percent for previous tubes. The reduction in performance appears to be due to the increased insertion loss of the coupled helix output coupler. A comparison of insertion loss between a tube with two tapered matching sections and a tube with one tapered and one coupled helix matching section is shown in Fig. 4.3. The figure shows that the interaction efficiency is apparently equivalent for the two types of output matching sections. A new multi-electrode gun was then incorporated into the tube, but the heater failed prior to r-f testing.

Tube number 15 contained a coupled helix output coupler and a tapered matching section at the input. The 11.5-TPI helix was 7.7 inches long. This tube had a tendency to oscillate when operated at high beam currents with low beam voltages. Maximum power output was observed at these high voltages where the inverse overload characteristic of the tube occurs. Figure 4.4 shows a plot of power output vs. power input, which illustrates this type of operation.

The coupled helix output coupler of tube number 15 had an average insertion loss of approximately 3 db, reaching 8 to 9 db at some frequencies. Figure 4.5 shows the insertion loss of the tube vs. frequency; in addition, the insertion loss of the coupled helix coupler is also plotted at several frequencies. An indication of the r-f power generated by the circuit can be obtained by correcting the output power

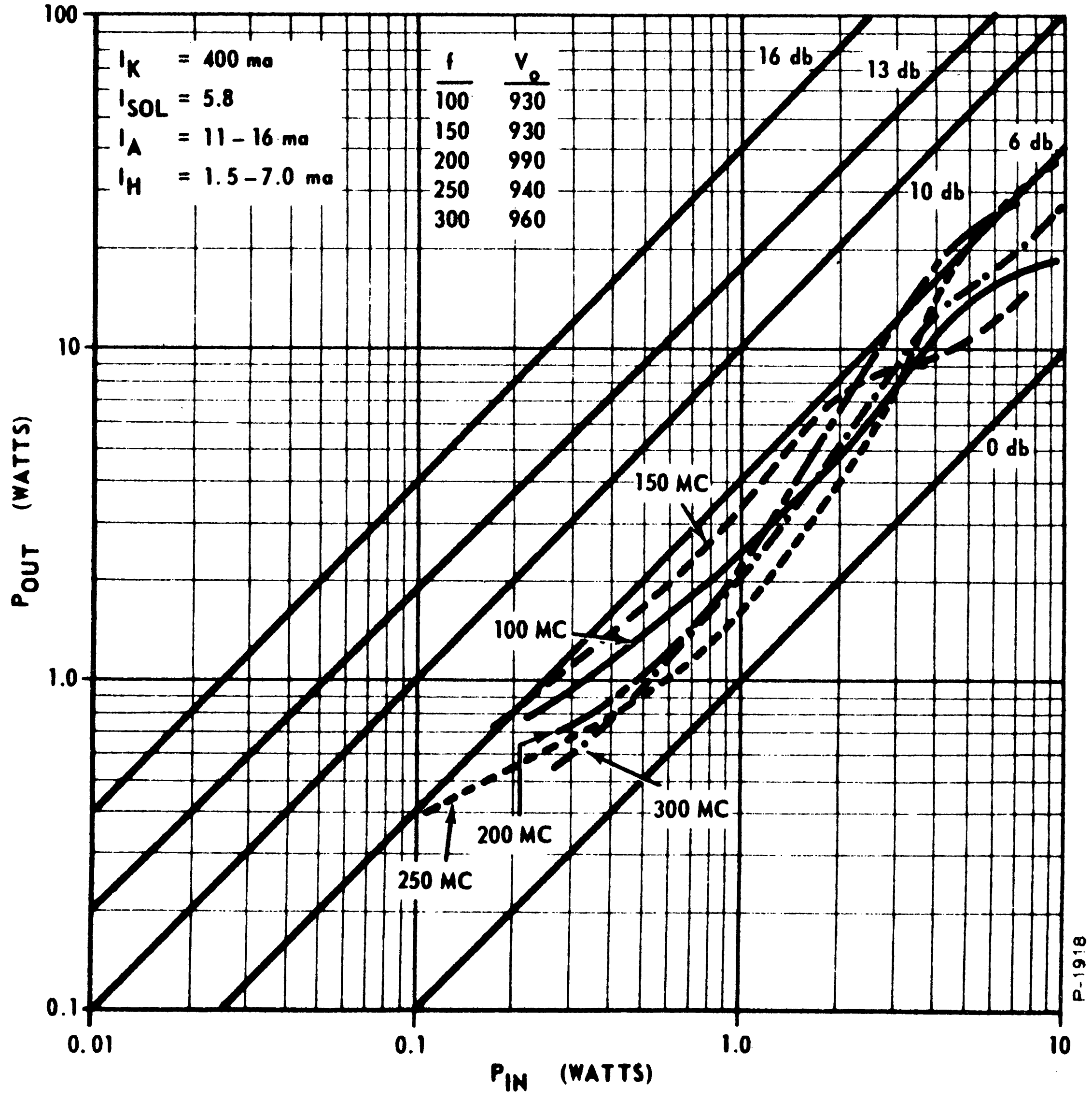

FIG. 4.1 POWER OUTPUT CHARACTERISTICS OF

TWT-143-A-14. (I_K = 400 ma)

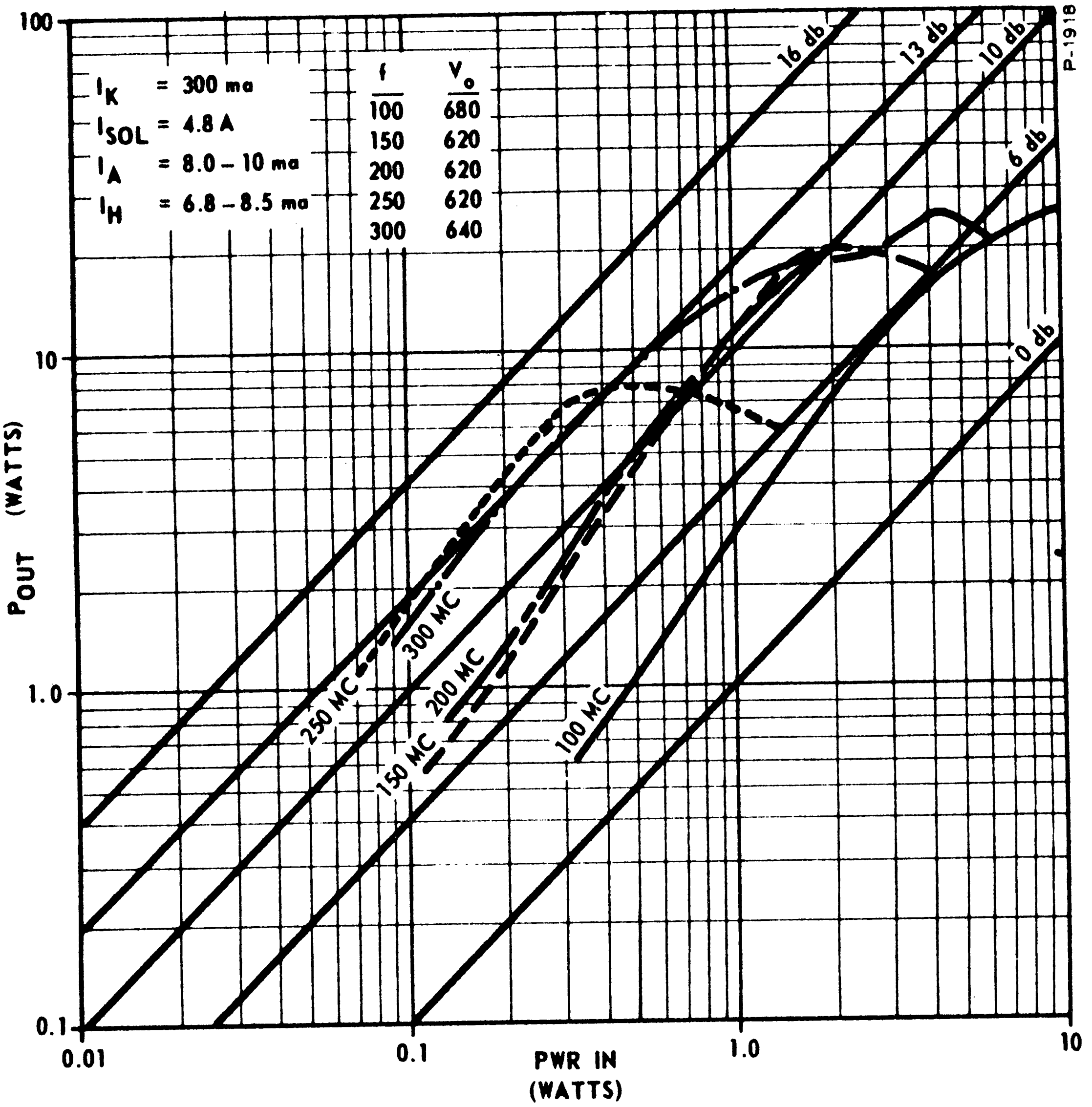

FIG. 4.2 POWER OUTPUT CHARACTERISTICS OF

TWT-143-A-14. (I_K = 300 ma)

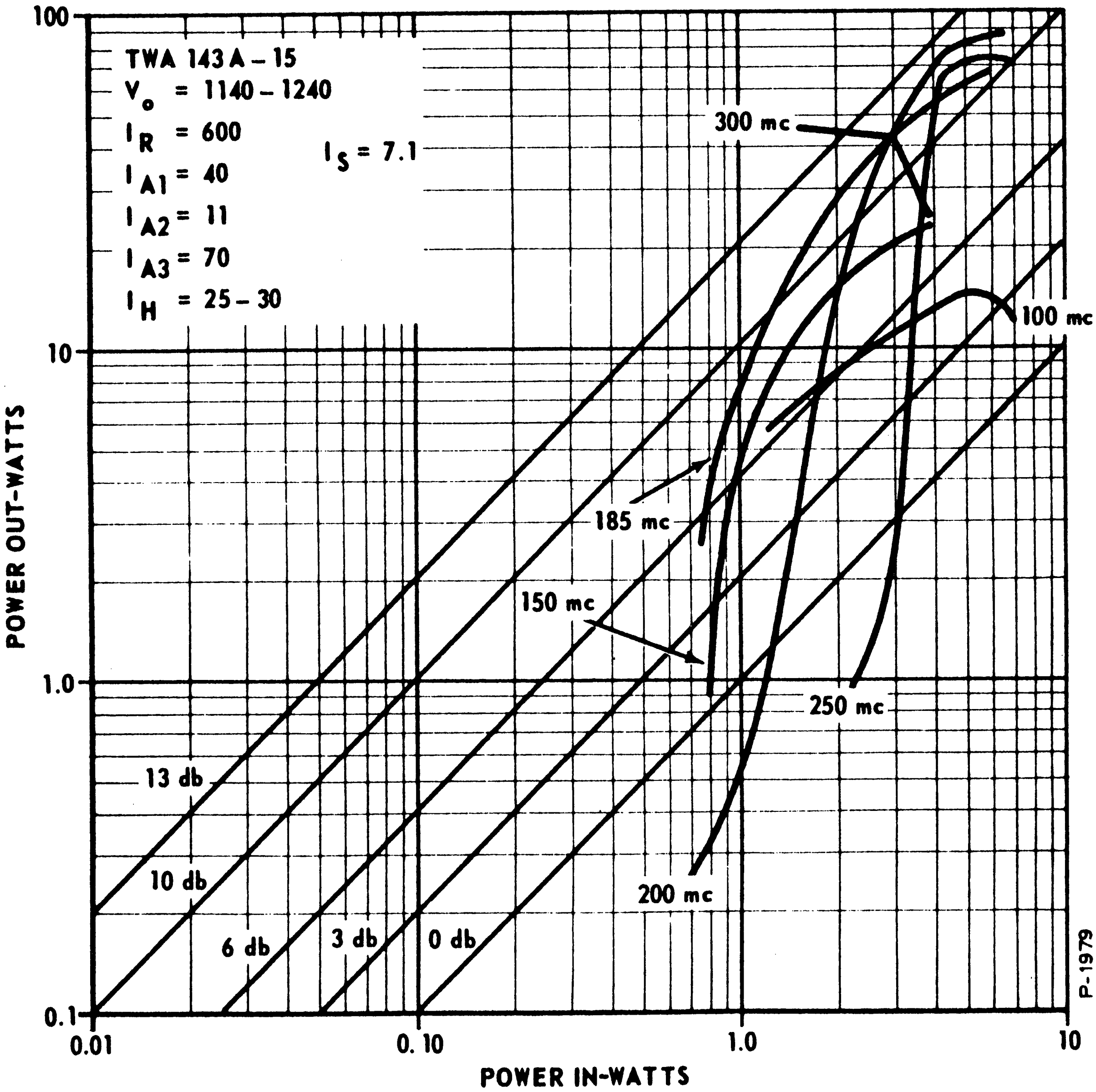

FIG. 4.3 POWER OUTPUT OF TWT-143-A-15.

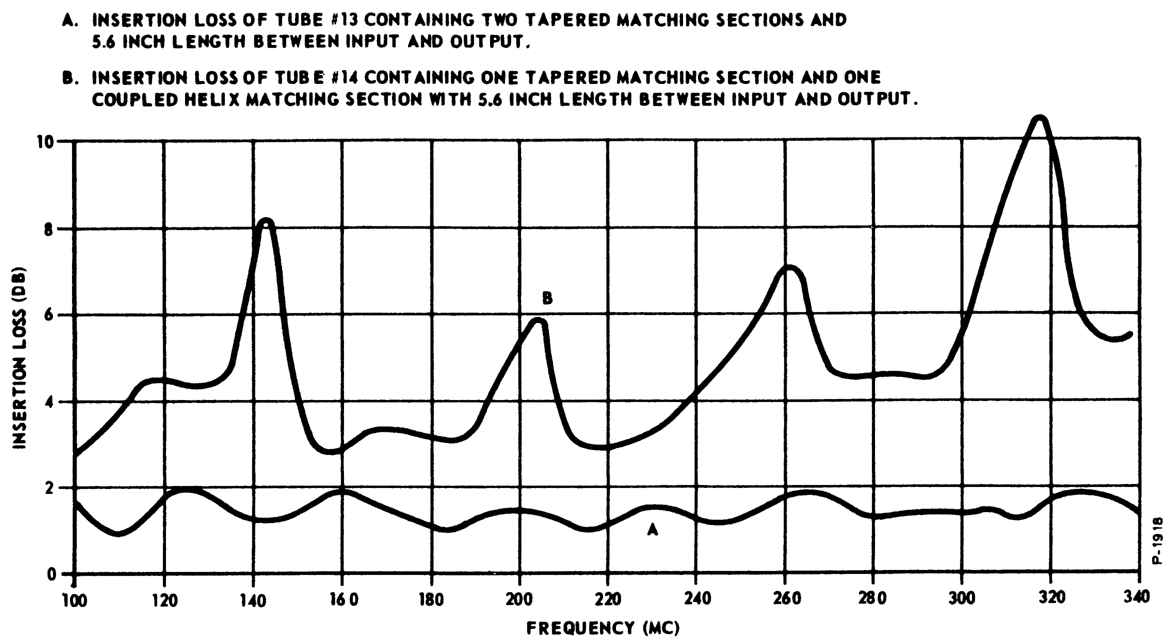

FIG. 4.4 COMPARISON OF INSERTION LOSSES OF TUBES NO. 13 AND NO. 14.

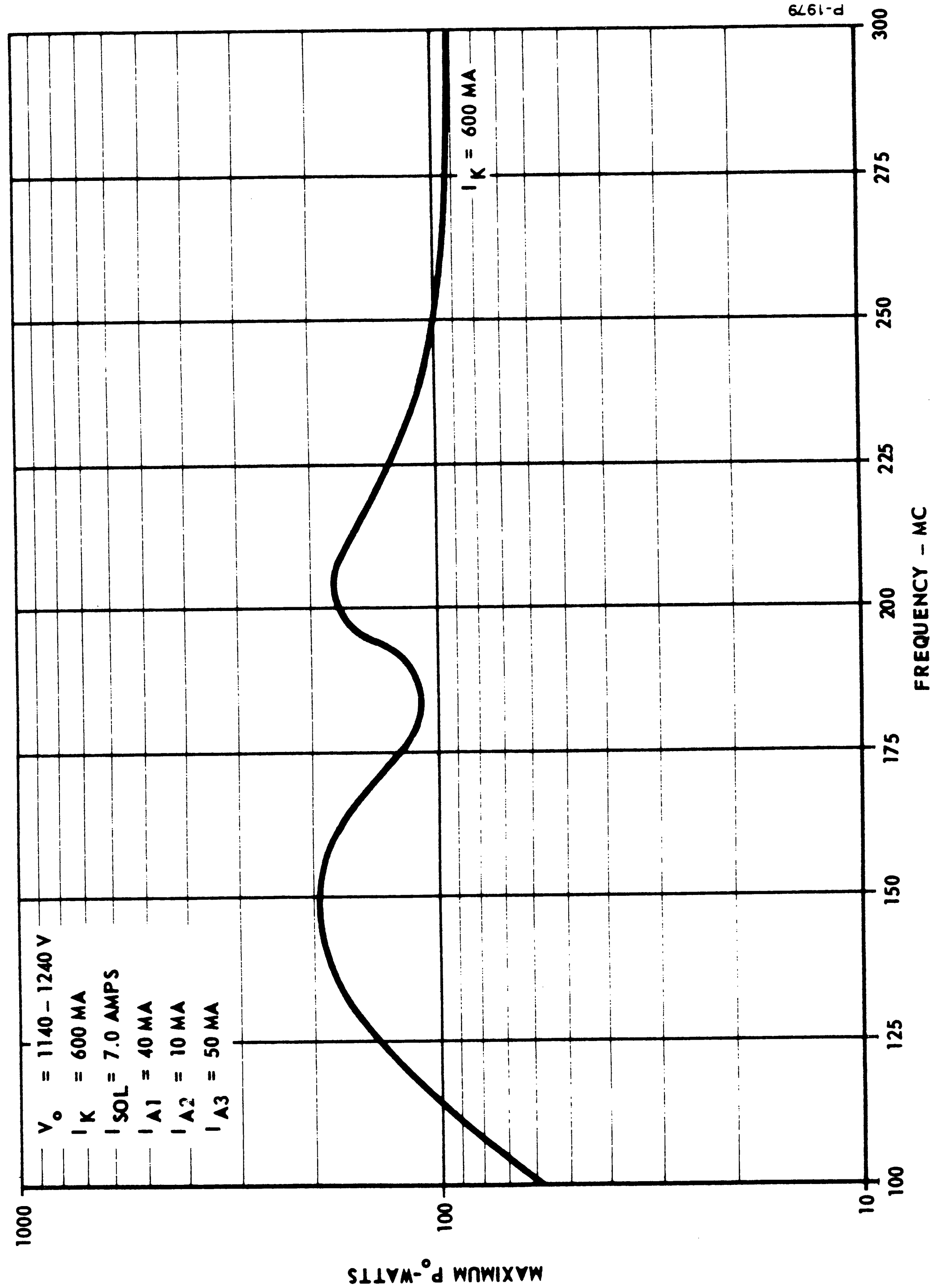

FIG. 4.5 COMPUTED POWER LEVEL ON HELIX IN TWT-143-A-15.

upward by the amount of the output coupler insertion loss. Figure 4.6 shows a plot of the computed r-f power level on the circuit vs. frequency.

Tube number 16 used coupled helix couplers at both the input and the output. The resultant high insertion loss degraded the performance of the tube to such an extent that no new useful information on r-f performance was obtained. However, tube number 16 contained a depressed potential collector assembly and successful r-f operation was obtained with the collector operating at $3V_0/4$. In addition, a noticeable decrease in the interception current on the third anode of the electron gun was observed, which indicated that the depressed collector allowed fewer secondary electrons to enter the interaction region.

4.2 Summary and Evaluation of Tube Performance. The maximum sustained power output thus far has been 105 watts; this was obtained with tube number 9 operating at 300 mc. An output variation of 40 watts occurred across the band from 100 to 300 mc. Tube number 10 produced an output of 140 watts at 250 mc, 110 watts at 200 mc, 85 watts at 150 mc, and 40 watts at 100 mc, when operated with a cathode current of 600 ma. These data were obtained by pulsing the current to 600 ma, since the tube could not be operated continuously at this current because of a gradual decrease of cathode emission. Tube number 15 had lower power outputs but the r-f interaction was good and the power level corrected for output loss was above 90 watts from 110 to 300 mc. This tube had severe inverse overload characteristics, however, and improvement of small signal gain is required. In addition, all of the tubes have been centered high in frequency. It was thought at first that the low frequencies were not amplified as much as the high

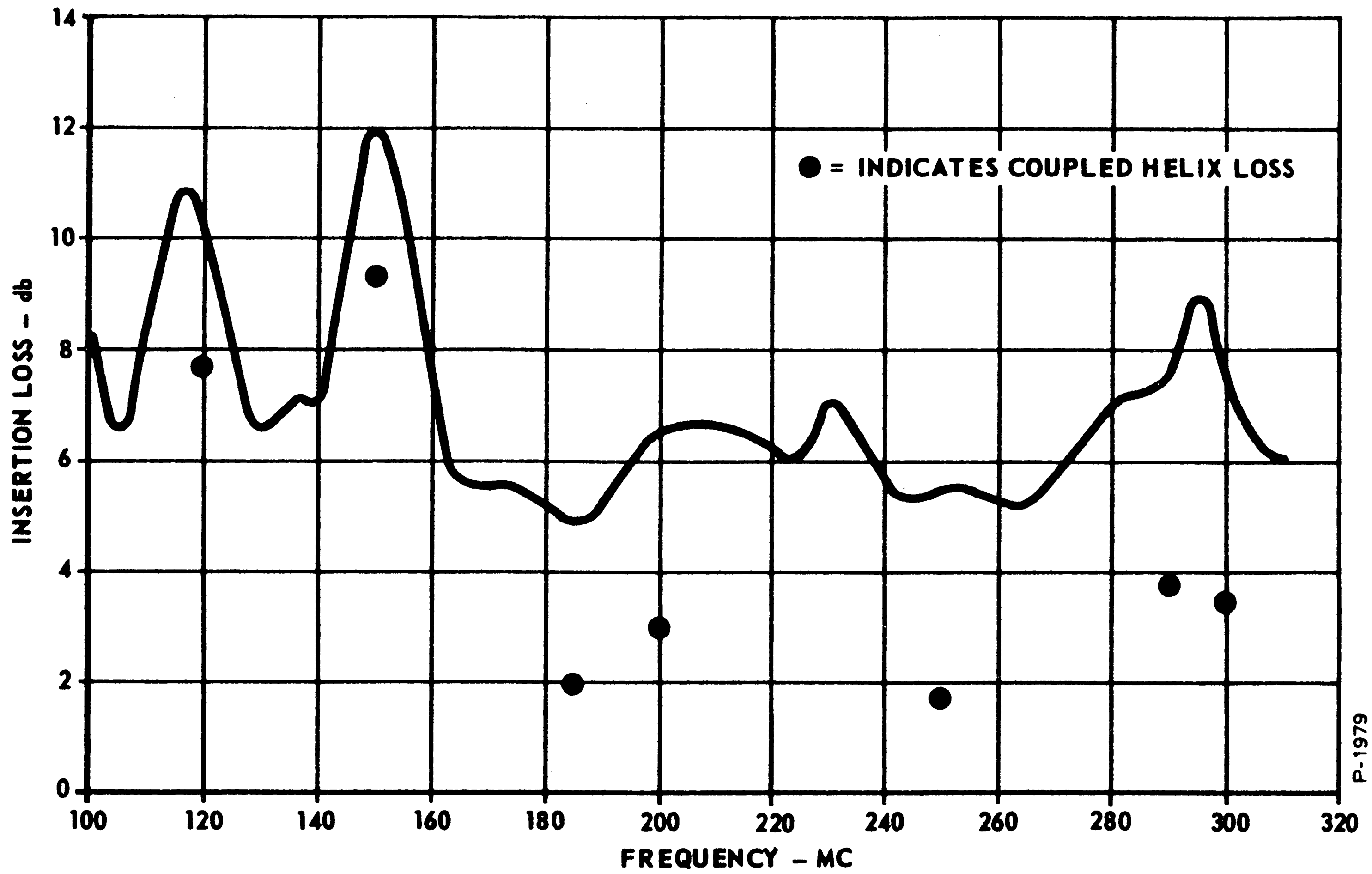

FIG. 4.6 INSERTION LOSS OF TWT-143-A-15.

frequencies because of r-f mismatch degradations in the low frequency range. However, it has since become apparent that the r-f structure-electron beam configuration design caused the tubes to be centered high in frequency.

The performance of the r-f couplers have all been degraded more than expected by either excessive insertion loss or detrimental effects on the r-f interaction in the coupling region.

In view of the above results three improvements are required in a new design. These are:

(a) higher beam power so that the required interaction efficiency may be lower

(b) adjustment of the electrical operating conditions so that the small signal gain is at least as large as the large signal gain, thereby eliminating the inverse overload characteristics

(c) adjustment of helix-beam geometry relationships so that the normal band of operation is in the 100 to 300 mc range, rather than the approximate 200 to 600 mc range of the present tubes.

4.3 New Electrical Design, TW-147. The new electrical design assumes a power output of 125 watts at midband to allow a 1 db fall-off of power level at the band edges while giving a minimum of 100 watts at the band edges. Assuming a maximum conversion efficiency of 22.5 percent at midband, the beam will require 550 watts of d-c power. A 0.500-ampere 1100-volt electron beam was chosen for the operating parameters for optimum large signal performance. Small signal gain data was therefore calculated at 1000 volts. The physical dimensions and the small signal electrical parameters were calculated for the new design which uses the same electron gun as the TWT-143-A tubes and are listed in Tables 4.2 and 4.3.

Table 4.2

Physical and Electrical Parameters of TW-147

V_o	=	1000-(1100 large signal optimum) volts
I_o	=	0.500 amp
a	=	0.472 inch (helix mean radius)
b	=	0.950 inch (shield radius)
TPI	=	8
r-f match	-	coupled helix couplers
collector	-	1 stage depressed potential
gun	-	4 electrode lens cancellation presently used in TW-143
J_o	=	0.84 amp/cm^2
B_B	=	182 (Brillouin magnetic field)
B	=	350 gauss (expected operating magnetic field)
α	=	0.55 (beam thickness/beam to helix spacing)

Table 4.3

Design Parameters of TW-147

	100 mc	200 mc	300 mc
γa	0.58	1.29	2.09
C	0.38	0.30	0.21
QC	0.117	0.176	0.341
DLF (assumed)	0.8	0.8	0.8
ka	0.025	0.050	0.075
$\gamma(a-r_o)$	0.252	0.560	0.910

The mechanical design of the new TW-147 tube has been completed. Figure 4.7 shows the mechanical design. All tube parts are under construction and cold tests are under way at the present time. The first TW-147 tube will be constructed and tested early during the coming quarter.

5. Summary and Future Work (G. T. Konrad)

The $P_\mu = 20$ gun design has been completed as far as the electrical parameters and the geometry are concerned. The mechanical design of this gun will be along similar lines as the $P_\mu = 4.46$ gun. It is expected that the gun will be constructed and tested in the beam analyzer during the coming quarter. The computer work on the smaller diameter $P_\mu = 20$ gun ultimately to be usable in a high power vhf tube will continue during the next quarter.

The data obtained on the electrostatically focused tube has been encouraging. A broken lead within the tube prevented complete data from being taken. At the voltages that could be obtained before the tube has to be rebuilt, much improved beam focusing was observed. Early during the next quarter the tube will be rebuilt and testing will be resumed.

Several more 100-watt Crestatrons have been constructed and tested during the past quarter. The data indicates that the power levels achieved with the present tube design have been sufficiently high, but that the tubes are centered too high in frequency. This is believed to be due to a nonoptimum design in the r-f structure-electron beam configuration. Thus some design changes have been made in order to overcome these difficulties.

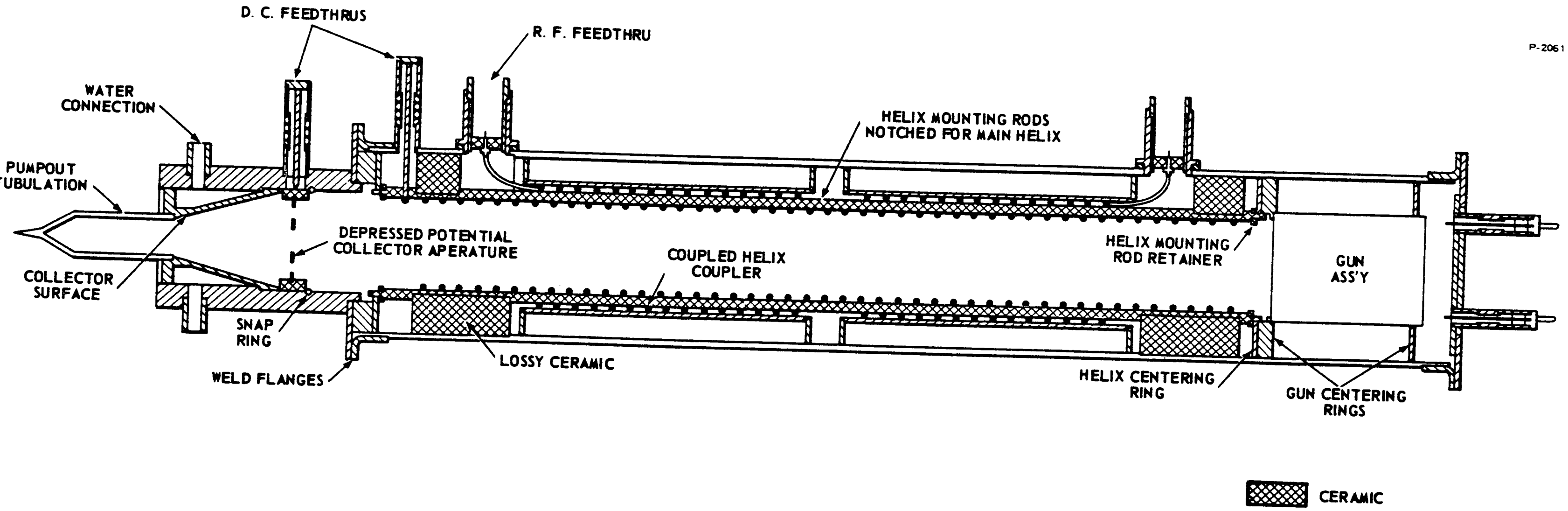

FIG. 4.7 CROSS SECTION VIEW OF TW-147.

At the present time the mechanical design of the modified tube has been completed and cold tests as well as construction of the new tube are underway. It is expected that the new tube will be under test early during the coming quarter.

DISTRIBUTION LIST

No. Copies	Agency
1	Commanding Officer and Director, U. S. Navy Electronics Laboratory, San Diego 52, California
2	Commander, Aeronautical Systems Division, Wright-Patterson Air Force Base, Ohio, Attn: ASRN
1	Mr. J. Enright, ASRNET-1, Electronic Technology Laboratory, Aeronautical Systems Division, Wright-Patterson Air Force Base, Ohio
1	Commanding Officer, Harry Diamond Laboratories, Electron Tube Branch, Washington 25, D. C.
2	Commanding Officer, U. S. Army Electronics Research and Development Laboratory, Electron Devices Division, Fort Monmouth, New Jersey
1	Commander, New York Naval Shipyard, Material Laboratory, Code 924, Naval Base, Brooklyn 1, New York
2	Chief, Bureau of Naval Weapons, Department of the Navy, Washington 25, D. C., Attn: RAAV-4423
1	Chief, Bureau of Ships, Department of the Navy, Washington 25, D. C., Attn: Code 691A4
4	Chief, Bureau of Ships, Department of the Navy, Washington 25, D. C., Attn: Code 335
1	Director, U. S. Naval Research Laboratory, Washington 25, D. C., Attn: Code 5240, Dr. S. T. Smith
1	Director, U. S. Naval Research Laboratory, Washington 25, D. C., Attn: Mr. L. A. Cosby, Code 5437
2	Director, U. S. Naval Research Laboratory, Washington 25, D. C., Attn: Library
2	Advisory Group on Electron Tubes, 346 Broadway, 8th Floor, New York 13, New York
1	Commanding General, Rome Air Development Center, Griffiss Air Force Base, Rome, New York, Attn: Documents Library RCOIL-2
1	Commander, Rome Air Development Center, Griffiss Air Force Base, Rome, New York, Attn: Mr. H. Chiosa, RCLRR-3
10	Commander, Defense Documentation Center, Cameron Station, Alexandria, Virginia

No. Copies	Agency
1	Dr. G. Rosselot, Bendix Corporation, Research Laboratories, Northwestern Highway and 10-1/2 Mile Road, Southfield, Michigan
1	Dr. J. G. Meeker, Bendix Corporation, Research Laboratories, Northwestern Highway and 10-1/2 Mile Road, Southfield, Michigan
3	Mr. A. G. Peifer, Bendix Corporation, Research Laboratories, Northwestern Highway and 10-1/2 Mile Road, Southfield, Michigan
1	Bendix Corporation, Systems Division, 3300 Plymouth Road, Ann Arbor, Michigan, Attn: Technical Library
1	Litton Industries, 960 Industrial Road, San Carlos, California, Attn: Technical Library
1	Dr. R. P. Wadhwa, Electron Tube Division, Litton Industries, 960 Industrial Way, San Carlos, California
1	The University of Michigan, Willow Run Laboratories, Ypsilanti, Michigan, Attn: Dr. J. T. Wilson
1	Microwave Associates, Burlington, Massachusetts, Attn: Technical Library
1	Microwave Electronic Tube Company, Inc., Salem, Massachusetts, Attn: Technical Library
1	Radio Corporation of America, Power Tube Division, Harrison, New Jersey
1	Raytheon Company, Burlington, Massachusetts, Attn: Technical Library
1	S-F-D Laboratories, 800 Rahway Avenue, Union, New Jersey, Attn: Technical Library
1	Tucor, Inc., 18 Marshall Street, South Norwalk, Connecticut, Attn: Technical Library
1	Westinghouse Electric Corporation, P. O. Box 284, Elmira, New York, Attn: Technical Library
1	Bendix Corporation, Red Bank Division, Eatontown, New Jersey, Attn: Dr. James Palmer
2	Scientific and Technical Information Facility Attn: NASA Representative (SAK/DL) P. O. Box 5700 Bethesda, Maryland 20014

DD ______________

The University of Michigan, Electron Physics Laboratory, Ann Arbor, Michigan. RESEARCH AND DEVELOPMENT OF HIGH POWER CRESTATRONS FOR THE 100-300 MC FREQUENCY RANGE, by G. T. Konrad, C. K. Rhee. January, 1964. 25 pp. incl. illus. (Contract No. NObsr-81403, Project Serial No. SF0100 201, Task No. 9294)

A series of trajectory plots is shown which led to a reasonably good electrical design for the $P_\mu = 20$ gun. The work done on the electrostatically focused tube using a $P_\mu = 4.46$ gun indicates that much better focusing can be obtained with the improved gun. At reduced voltages the beam transmission is only fair but it is shown that the percentage of transmission is improving as the design voltage is approached.

In order to center the operating band of the 100-watt Crestatrons more nearly within the desired frequency range and in order to overcome the r-f losses observed in the couplers, a revision is made in the tube design. The new dimensions and electrical parameters are shown.

UNCLASSIFIED

1. Introduction
2. Computer Design of High-Perveance Hollow-Beam Guns
3. Experiments on the Electrostatically-Focused Hollow-Beam Tube
4. Work conducted at the Bendix Research Laboratories
5. Summary and Future Work

I. Konrad, G. T.
II. Rhee, C. K

UNCLASSIFIED

DD ______________

The University of Michigan, Electron Physics Laboratory, Ann Arbor, Michigan. RESEARCH AND DEVELOPMENT OF HIGH POWER CRESTATRONS FOR THE 100-300 MC FREQUENCY RANGE, by G. T. Konrad, C. K. Rhee. January, 1964, 25 pp. incl. illus. (Contract No. NObsr-81403, Project Serial No. SF0100 201, Task No. 9294)

A series of trajectory plots is shown which led to a reasonably good electrical design for the $P_\mu = 20$ gun. The work done on the electrostatically focused tube using a $P_\mu = 4.46$ gun indicates that much better focusing can be obtained with the improved gun. At reduced voltages the beam transmission is only fair but it is shown that the percentage of transmission is improving as the design voltage is approached.

In order to center the operating band of the 100-watt Crestatrons more nearly within the desired frequency range and in order to overcome the r-f losses observed in the couplers, a revision is made in the tube design. The new dimensions and electrical parameters are shown.

UNCLASSIFIED

1. Introduction
2. Computer Design of High-Perveance Hollow-Beam Guns
3. Experiments on the Electrostatically-Focused Hollow-Beam Tube
4. Work Conducted at the Bendix Research Laboratories
5. Summary and Future Work

I. Konrad, G. T.
II. Rhee, C. K.

UNCLASSIFIED

DD ______________

The University of Michigan, Electron Physics Laboratory, Ann Arbor, Michigan. RESEARCH AND DEVELOPMENT OF HIGH POWER CRESTATRONS FOR THE 100-300 MC FREQUENCY RANGE, by G. T. Konrad, C. K. Rhee. January, 1964, 25 pp. incl. illus. (Contract No. NObsr-81403, Project Serial No. SF0100 201, Task No. 9294)

A series of trajectory plots is shown which led to a reasonably good electrical design for the $P_\mu = 20$ gun. The work done on the electrostatically focused tube using a $P_\mu = 4.46$ gun indicates that much better focusing can be obtained with the improved gun. At reduced voltages the beam transmission is only fair but it is shown that the percentage of transmission is improving as the design voltage is approached.

In order to center the operating band of the 100-watt Crestatrons more nearly within the desired frequency range and in order to overcome the r-f losses observed in the couplers, a revision is made in the tube design. The new dimensions and electrical parameters are shown.

UNCLASSIFIED

1. Introduction
2. Computer Design of High-Perveance Hollow-Beam Guns
3. Experiments on the Electrostatically-Focused Hollow-Beam Tube
4. Work Conducted at the Bendix Research Laboratories
5. Summary and Future Work

I. Konrad, G T.
II. Rhee, C. K.

UNCLASSIFIED

DD ______________

The University of Michigan, Electron Physics Laboratory, Ann Arbor, Michigan. RESEARCH AND DEVELOPMENT OF HIGH POWER CRESTATRONS FOR THE 100-300 MC FREQUENCY RANGE, by G. T. Konrad, C. K. Rhee. January, 1964, 25 pp. incl. illus. (Contract No. NObsr-81403, Project Serial No. SF0100 201, Task No. 9294)

A series of trajectory plots is shown which led to a reasonably good electrical design for the $P_\mu = 20$ gun. The work done on the electrostatically focused tube using a $P_\mu = 4.46$ gun indicates that much better focusing can be obtained with the improved gun. At reduced voltages the beam transmission is only fair but it is shown that the percentage of transmission is improving as the design voltage is approached.

In order to center the operating band of the 100-watt Crestatrons more nearly within the desired frequency range and in order to overcome the r-f losses observed in the couplers, a revision is made in the tube design. The new dimensions and electrical parameters are shown.

UNCLASSIFIED

1. Introduction
2. Computer Design of High-Perveance Hollow-Beam Guns
3. Experiments on the Electrostatically-Focused Hollow-Beam Tube
4. Work Conducted at the Bendix Research Laboratories
5. Summary and Future Work

I. Konrad, G. T.
II. Rhee, C. K.

UNCLASSIFIED

DD ______________

The University of Michigan, Electron Physics Laboratory, Ann Arbor, Michigan. RESEARCH AND DEVELOPMENT OF HIGH POWER CRESTATRONS FOR THE 100-300 MC FREQUENCY RANGE, by G. T. Konrad, C. K. Rhee. January, 1964, 25 pp. incl. illus. (Contract No. NObsr-81403, Project Serial No. SF0100 201, Task No. 9294)

A series of trajectory plots is shown which led to a reasonably good electrical design for the P_{μ} = 20 gun. The work done on the electrostatically focused tube using a P_{μ} = 4.46 gun indicates that much better focusing can be obtained with the improved gun. At reduced voltages the beam transmission is only fair but it is shown that the percentage of transmission is improving as the design voltage is approached.

In order to center the operating band of the 100-watt Crestatrons more nearly within the desired frequency range and in order to overcome the r-f losses observed in the couplers, a revision is made in the tube design. The new dimensions and electrical parameters are shown.

UNCLASSIFIED

1. Introduction
2. Computer Design of High-Perveance Hollow-Beam Guns
3. Experiments on the Electrostatically-Focused Hollow-Beam Tube
4. Work conducted at the Bendix Research Laboratories
5. Summary and Future Work

I. Konrad, G. T.
II. Rhee, C. K

UNCLASSIFIED

DD ______________

The University of Michigan, Electron Physics Laboratory, Ann Arbor, Michigan. RESEARCH AND DEVELOPMENT OF HIGH POWER CRESTATRONS FOR THE 100-300 MC FREQUENCY RANGE, by G. T. Konrad, C. K. Rhee. January, 1964, 25 pp. incl. illus. (Contract No. NObsr-81403, Project Serial No. SF0100 201, Task No. 9294)

A series of trajectory plots is shown which led to a reasonably good electrical design for the P_{μ} = 20 gun. The work done on the electrostatically focused tube using a P_{μ} = 4.46 gun indicates that much better focusing can be obtained with the improved gun. At reduced voltages the beam transmission is only fair but it is shown that the percentage of transmission is improving as the design voltage is approached.

In order to center the operating band of the 100-watt Crestatrons more nearly within the desired frequency range and in order to overcome the r-f losses observed in the couplers, a revision is made in the tube design. The new dimensions and electrical parameters are shown.

UNCLASSIFIED

1. Introduction
2. Computer Design of High-Perveance Hollow-Beam Guns
3. Experiments on the Electrostatically-Focused Hollow-Beam Tube
4. Work Conducted at the Bendix Research Laboratories
5. Summary and Future Work

I. Konrad, G. T.
II. Rhee, C. K.

UNCLASSIFIED

DD ______________

The University of Michigan, Electron Physics Laboratory, Ann Arbor, Michigan. RESEARCH AND DEVELOPMENT OF HIGH POWER CRESTATRONS FOR THE 100-300 MC FREQUENCY RANGE, by G. T. Konrad, C. K. Rhee. January, 1964, 25 pp. incl. illus. (Contract No. NObsr-81403, Project Serial No. SF0100 201, Task No. 9294)

A series of trajectory plots is shown which led to a reasonably good electrical design for the P_{μ} = 20 gun. The work done on the electrostatically focused tube using a P_{μ} = 4.46 gun indicates that much better focusing can be obtained with the improved gun. At reduced voltages the beam transmission is only fair but it is shown that the percentage of transmission is improving as the design voltage is approached.

In order to center the operating band of the 100-watt Crestatrons more nearly within the desired frequency range and in order to overcome the r-f losses observed in the couplers, a revision is made in the tube design. The new dimensions and electrical parameters are shown.

UNCLASSIFIED

1. Introduction
2. Computer Design of High-Perveance Hollow-Beam Guns
3. Experiments on the Electrostatically-Focused Hollow-Beam Tube
4. Work Conducted at the Bendix Research Laboratories
5. Summary and Future Work

I. Konrad, G. T.
II. Rhee, C. K.

UNCLASSIFIED

DD ______________

The University of Michigan, Electron Physics Laboratory, Ann Arbor, Michigan. RESEARCH AND DEVELOPMENT OF HIGH POWER CRESTATRONS FOR THE 100-300 MC FREQUENCY RANGE, by G. T. Konrad, C. K. Rhee. January, 1964, 25 pp. incl. illus. (Contract No. NObsr-81403, Project Serial No. SF0100 201, Task No. 9294)

A series of trajectory plots is shown which led to a reasonably good electrical design for the P_{μ} = 20 gun. The work done on the electrostatically focused tube using a P_{μ} = 4.46 gun indicates that much better focusing can be obtained with the improved gun. At reduced voltages the beam transmission is only fair but it is shown that the percentage of transmission is improving as the design voltage is approached.

In order to center the operating band of the 100-watt Crestatrons more nearly within the desired frequency range and in order to overcome the r-f losses observed in the couplers, a revision is made in the tube design. The new dimensions and electrical parameters are shown.

UNCLASSIFIED

1. Introduction
2. Computer Design of High-Perveance Hollow-Beam Guns
3. Experiments on the Electrostatically-Focused Hollow-Beam Tube
4. Work Conducted at the Bendix Research Laboratories
5. Summary and Future Work

I. Konrad, G. T.
II. Rhee, C. K.

UNCLASSIFIED

UNIVERSITY OF MICHIGAN
3 9015 03466 2208