





Research and Development Technical Report DELET-TR-78-2958-2

LOW NOISE EBS JAMMER



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FOREWORD

Identification of Engineering Personnel

Douglas B. Clark, Project Engineer John B. Rettig, Member of Technical Staff

Descriptive Background of Key Personnel

Biographical sketches for each of the key personnel are included in the Appendix.

Publication, Lectures, Reports and Conferences

1.	Publications	None
2.	Lectures	None
3.	Reports	Monthly Status Reports December 1978 through March 1979
4.	Conferences	Progress on subject contract. Watkins-Johnson Company personnel and Mr. Robert M. True of ERADCOM, Fort Monmouth, N.J. Held at Watkins-Johnson Company on 20-22 March 1979.

Program for the Next Internal

The Program Plan shown in Figure 2-2 and described in Section 6.0 represents our best estimate of work to be carried out during the next reporting period.

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1.0 INTRODUCTION

1.1 Objective

The program objective is to reduce the output power level of spurious noise signals, intermodulation (IM) products and harmonic distortion generated by deflection modulated electron beam semiconductor (EBS) amplifiers.

1.2 Technical Approach

Figure 1-1 illustrates the configuration of a deflected beam EBS amplifier. This type of amplifier has been developed by Watkins-Johnson Company over a period of several years. Measurements of existing EBS amplifiers will be made to determine the typical values of IM products, spurious noise and harmonic distortion. The existing electron beam profile will be characterized using a slit beam analyzer. The EBS performance will be correlated to the measured beam profile using a mathematical analysis implemented by a computer program. A second computer program will perform an analysis of the expected beam profile generated by the existing gun geometry and these results will be correlated with the measured beam profile. Modifications will then be performed on the electron gun to improve the linearity, IM products and harmonic distortion; and the re-designed gun will be fabricated and tested on the beam analyzer. Two devices using the re-designed gun will be fabricated, tested and delivered as part of this contract.





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2.0 PROGRAM SUMMARY

2.1 Summary of Work

During the four month period covered by this report, the following was accomplished:

- 1. The existing EBS amplifiers having 2×6 diode arrays were completely characterized in terms of linearity and intermodulation products as a function of device efficiency.
- 2. The computer aided analysis of the present gun performance was completed. Several conclusions were drawn from the results, and areas of potential improvements were identified.
- 3. Work continued on methods of analyzing actual shape of electron beams. Calibration of an existing slit diode array was not satisfactory, so a fabrication of a new slit diode array was begun. Phosphor screens were used as a secondary method of beamshape observation.
- 4. Several guns were checked using the phosphor screen method. Poor beam shape was observed, and the guns were checked for dimensional conformation to the present design. Some problems were identified in this regard, and redesigned tooling and parts were ordered to correct these problems.

2.2 Program Schedule

Figure 2-1 shows the Program Schedule, updated as of April 1979. The primary cause of slippage has been lack of a suitable method of measuring beam shape. This problem has been solved by the use of phosphor screens and the fabrication of a new slit diode array.

All other tasks are proceeding on schedule with one exception: because of results obtained by beam shape analysis performed as part of this program, emphasis has been shifted away from the development of the metal-ceramic version of the sheet beam gun and increased emphasis has been put on fabrication techniques using the present glass envelope configuration. For this reason, the two tasks having to do with development of the metal ceramic gun have been deleted from the program. Dec P Nov PP 9 Oct 2 A A Sep 5 P Aug 4 Jul P 2 A TASK DELETED Jun P D 4 [4 4 DI May 1 Apr C ٢ Mar 1 1 4 1 ٢ 1 4 Feb 1 4 TASK DELETED ł 1 1 Jan 1 1 Dec 1 1 1 Nov 4 4 Oct Sep Aug Correlate Data to Beam Measurements. Month Present Electron Gun Characterization Fabricate Metal-Ceramic Prototype Test Linearity, Noise, Intermods Design Metal-Ceramic Prototype Correlate Measured Beam Shape Present Device Characterization Linearity, Noise, Intermodulation & Efficiency Test New Gun Using Slit Beam Fabricate Gun with Optimized Electrode Configuration Deliverable EBS Amplifiers (Two) A. Calibrate Slit Beam Analyzer **Optimize Gun Configuration** with Predicted Beam Shape A. Create Computer Programs Correlate RF Data with Measured Beam Shape ____ Electron Gun Modifications Computer-Aided Analysis Measure Beam Shape & Efficiency A. Fabric te Analyzer Α. ь. в. в. D. с. D. в. .. . Task III. IV. п. ν. ..

Figure 2-1. Program Milestone Schedule

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3.0 CHARACTERIZATION OF EXISTING DEVICES

Extensive linearity and intermodulation measurements were performed on a deflected beam amplifier, WJ-3662-1 S/N 9. The device was set up for saturated output power of 46.0 dBm at maximum efficiency. The balanced two tone method of measurement was used, and in most cases, the fundamental tones and their 3rd, 5th, and 7th intermodulation products were measured over a 20-33 dB dynamic range. The parameter varied during these tests was the voltage on anode 3, the next to last anode in the gun stack. (Anode 4 is held at ground potential.) Figures 3-1 through 3-5 summarize these results, and Figure 3-6 expresses the tradeoff between linearity and efficiency. The criterion for linearity is the maximum 3rd order intermodulation product referenced to fundamental saturation level; note that the case for "best" linearity by this criterion $(A_3 = 3400)$ is not coincident with the case where the fundamental deviates the least from constant gain $(A_3 = 3500)$, nor with the case where single tone saturated efficiency is maximum $(A_3 = 3300)$. The reason for this is attributed to the sidelobes present in the beam density profile, which has been observed on phosphor screens. At maximum efficiency, the amplifier is running in class C, i.e., with a tightly focused beam smaller than the diode spacing. At other points, class AB predominates, with current spillover severely reducing efficiency. Since the beam profile as predicted by computer for class C is not perfectly rectangular, the intermodulation products are more severe than for class AB, which in spite of spillover has a better beamshape within the width of the diode spacing.

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4.0 MEASUREMENT OF ELECTRON BEAM SHAPE

4.1 Slit Diode Array

EBS device linearity is largely dependent upon the profile of the current density of the sheet electron beam. An accurate means is required to measure this profile. A special diode target called a "slit beam analyzer" shown schematically in Figure 4-1 was prepared for this purpose. The target contains 10 diodes, each having a metalized top surface with a narrow slit etched through the metalization to the active diode layer. If an electron beam is swept across this array as illustrated, each diode will respond only to the portion of the beam striking the narrow slit area. The diode current from each of the diodes in the array can be monitored and a profile of the beam density can be thus obtained.

During the first four months of the contract, an existing slit diode array was assembled to a sheet beam electron gun and was tested.

Because of the inconsistencies of response from diode to diode, it was suspected that the array itself was not responding uniformly to excitation by the electron beam. It became apparent that a calibration of the slit beam analyzer array was required before meaningful data could be obtained.

A gun having a well-defined circular beam of small radius was needed to calibrate the slit diode array. Such a gun is typically used in a cathode ray tube (CRT) for information display. The Stewart Division of Watkins-Johnson Company produces these "pencil beam" guns for CRT use, and arrangements were made to purchase such a gun from them. A suitable production type gun was identified and the problems associated with interfacing the gun to the slit beam analyzer target were solved. In order to provide sufficient deflection of the electron beam to cover the entire target, using available sawtooth generators, the deflection coil to be used must be designed to match the physical dimensions of the gun and its coil impedance. A suitable coil was designed and procured from an outside vendor.

When the pencil beam gun was operated with the slit diode array, the diode current obtained was insufficient to provide a high enough signalto-noise ratio. In addition, problems were experienced in obtaining a reasonable amount of cathode current from the gun.

The gun was removed from the slit diode array and sent back to the Stewart Division for installation of a new cathode. In conjunction with



Figure 4-1. Slit Beam Analyzer Array

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this, fabrication of a new slit diode array was begun, since several of the diodes in the slit diode array were not functioning.

The new slit diode array will have wider (0.002 inches) slits to provide greater response amplitude. Since the optimum beam width is 0.040 inches, resolution will still be far in excess of what is required. The new slit diode array will be first tested with the pencil beam gun to calibrate it, and can then be used to test beam shape on EBS sheet beam guns.

4.2 Phosphor Screen Beam Measurements

Because of the problems experienced with the slit diode array, an alternate method of testing the beam shape was explored. A phosphor screen similar to that used on a CRT is mounted to the EBS device in place of the EBS diode array. The beam cross-section is observed when the beam strikes and illuminates the phosphor. The phosphor is very sensitive to electron bombardment so that very low beam current is sufficient to observe the beam shape. However, it is not possible to run high beam current at normal EBS operating levels, because the phosphor is evaporated at low power levels. This disadvantage was partially alleviated by pulsing the electron beam at very low duty cycle. In addition, there seems to be little change in beam shape as the beam current is increased.

The first gun tested was originally used on WJ-3662-1 S/N 16, which failed at low power levels for unknown reasons. The beam shape shown on the screen had a much greater intensity at one end than at the other, and the beam was not straight but exhibited a significant amount of curvature. Maximum deviation of the beam center from straight line was approximately 0.04 inch. A photograph of the beam image on the phosphor screen is shown in Figure 4-2.

The second gun tested produced a beam having better overall shape, but still with too much curvature and with some increase in intensity and beam size at the very ends of the beam, shown in Figure 4-3. The third gun was the worst tested, having a deviation from straight line of approximately 0.05 inches, shown in Figure 4-4.

The first and third electron guns were removed from the phosphor screens and visually examined. In both guns, misalignment was noted in the plane of the beam between the cathode and focus electrode assembly and the anode assembly. The fixturing used to assemble the guns was checked and the problem was apparent – when the lengthwise dimension of the focus electrode assembly was increased in early 1978, the fixture had not been modified to take up the slack. New fixturing to correct the problem was ordered.



Figure 4.2 - Beam shape of gun #42 measured on a phosphor screen



Figure 4.3 - Beam shape of gun #47 measured on phosphor screen.



Figure 4.4 - Beam shape of gun #49 measured on a phosphor screen.

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The last gun, which had the most pronounced beam curvature, also had a noticeable warpage in the first anode.

To reduce the "dogbone" effect of higher beam size and intensity near the ends of the beams, modifications were begun on the gun electrode designs. The modifications will increase the length of the slot in all the gun electrodes.

To increase the precision of the anodes themselves, a new method of fabricating the anodes was developed. Presently, each anode is machined to the desired dimensions. The new method involves machining each anode in two parts, placing the parts on a mandrel, and laser welding the two pieces together. Since the mandrel can be made with very good accuracy, the internal dimensions of the finished anode should be better using the new method.

5.0 COMPUTER AIDED ANALYSIS OF ELECTRON GUN

During the present reporting period, the final computer program was written to complete the correlation between the rectangular gun geometry and the Fourier components of the output signal. All of the programs currently used for gun analysis are listed in Table I. The first three perform the function of determining beam profile through the acceleration region, i.e., up to the meanderline. The fourth accounts for beamspread through the drift region, from the meanderline to the target. Finally, the last performs a convolution of the beam density profile with diode shape to determine the output waveform, then does a Fourier transform on this waveform to determine the spectral components and calculates the target efficiency for the fundamental.

The design of a new gun structure has typically involved the use of only the first two programs. Generally, the quality of the beamshape is quite obvious after the second program is run, and if there are severe problems with a design, there is no point in carrying out further calculations. For this reason, Parts (1) and (2) of Table I have been streamlined to run with one job submission. The remainder of the programs, however, take a great deal of effort to run, and are used only to check out a design that has been finalized from (2). A complete listing of all above programs is given in Appendices I through IV. Table I

COMPUTER ELECTRON OPTICS PROGRAMS AVAILABLE FOR GUN ANALYSIS

Listing	Appendix I	(Proprietary)	Appendix II	Appendix III	Appendix IV
Author	John Rettig	George Wada	John Rettig	John Rettig	Steve Brierley
Purpose	Equipotential locator to set up RCTGUN II	Slow region beam analysis	Fast region, large area beam analysis	Beamspread through drift space	Beam density convolu- tion, and FFT analysis of output waveform and efficiency calculation
Language	FORTRAN	FORTRAN	FORTRAN	НРL	HPL
System	IBM VM370	IBM VM370	IBM VM370	HP 9825A	HP 9825A
Name	RCTGUN I	RCTGUN II (XMGUN)	RCTGUN III	Beamspread	Convolve
	1.	2.	3.	4.	5.

6.0 MODIFICATION TO ELECTRON GUN

Figure 6-1 and 6-2 illustrate the 2-dimensional beam profile resulting from the present electrode geometry and ideal Pierce geometry, respectively. Figure 6-2 has served as a model for the development of a new anode geometry, based on the following areas of improvement that have been identified from Figure 6-1:

- 1. The effective cathode location is not necessarily at the zero potential line.
- 2. The grid is biased negative relative to the cathode, in order to reduce emission. As mentioned previously, this crowds the emission density into the center of the cathode.
- 3. Potentials farther from the cathode are such that emission at the cathode can not be reduced without causing the beam area to be smaller, thereby increasing current density.

Problems (2) and (3) are being addressed by construction of a gridded anode in front of the cathode, which will take over the function of beam control and allow the focus anode to be run at or near cathode potential. Problem (1) is not being pursued at this time because the flexibility of the new geometry should allow small adjustments to be made on the focus anode potential, in order to satisfy the Pierce field characteristics. Note that the intent of the gridded anode is to shield the Pierce field region from the acceleration region of the gun, to prevent the lensing effects seen in Figure 6-1. The beam control function is a necessary side effect of the primary shielding function, and is predicted to require potentials of 100-200 volts relative to cathode.







7.0 PROGRAM FOR THE NEXT PERIOD

During the next four month period, effort will be directed at developing a method of producing election guns with improved cross-sectional profiles, by means of increasing the accuracy of the piece parts and the fixturing used for assembly.

A grid will be added to the first anode and the gridded gun will be constructed and tested. The gridded design should provide a more wellshaped beam because emission can take place over the entire cathode surface at all levels of cathode current.

Another modification which will be done to the existing gun is to increase the length of the anodes and focus electrode, leaving the cathode at 0.700 inches. This will improve the beam shape near the ends of the beam.

The slit diode array having 0.002 inch wide slits will be fabricated and calibrated, and will then be used to test EBS sheet beam guns. The results of the beam cross-section analysis will be correlated with measured intermodulation performance of the same electron gun.

Appendix I RCTGUN I

GUN00010 С С GUN00020 C GUN00030 C GUN00040 С RECTANGULAR GUN ANALYSIS PACKAGE GUN00050 С GUN00060 C JOHN B RETTIG 1/31/79 GUN00070 С GUN00080 C GUN00090 С MAIN DRIVER ROUTINE, PART I - EQUIPOTENTIAL SOLUTIONS GUNDO10C GUN00110 С IMPLICIT REAL *8 (A-H, 0-Z) GUN00120 REAL*8 V(41,401) GUN00130 REAL*8 CUND(9) GUN00140 GUN00150 REAL*8 X(200), Y(200), UX(200), UY(200) REAL*8 TITLE(4) GUN00160 INTEGER ICOND(9) GUN00170 COMMON /A/ V GUN00180 COMMON /B/ XMIN, XMAX, DXO, GUN00190 YMIN, YMAX, DYO, GUN00200 M, N, NXY GUN00210 COMMON /C/ COND, ICUND, NCOND, CMIN, CMAX, COFF GUN00220 CCMMON /D/ X,Y,UX,UY GUN00230 COMMON /E/ TITLE GUN00240 DATA BW / . 2/ GUN00250 DATA NEQP /31/ GUN00260 DATA YEQP /4.50-3/ GUN00270 DATA RELERR /1.D-4/ GUN00280 GUN00290 DATA ITER /20/ DATA X1, X2, Y1, Y2 /0., 4.D-3, 0., 6.D-3/ GUN00300 DATA ENGMET /39.37/ GUN00310 С GUN00320 С READ IN INITIAL INFORMATION GUN00330 C GUN00340 CALL INIT GUN00350 С GUN00360 С READ IN VOLTAGES FROM PREVIOUS RUN GUN00370 С GUN00380 READ(8) V GUN00390 Ċ GUN00400 С READ IN CONDUCTOR CONFIGURATION GUN00410 С GUN00420 CALL MESH GUN00430 С GUN00440 С RELAX VOLTAGE MATRIX GUN00450 С GUN00460 ERR MAX=RELERR*(CMAX-CMIN) GUN00470 CALL RELAX (1, 1, ERROR, ERRMAX) GUN00480 IF (ERROR.LT.ERRMAX) GO TO 4 GUN00490 KSTEP=1 GUN00500 KSTEP=2*KSTEP GUN00510 1 IF (MOD(M-1,KSTEP).NE.0) GO TO 2 GUN00520 IF (MOD(N-1,KSTEP).NE.0) GO TO 2 GUN00530 GC TO 1 GUN00540 2 KSTEP=KSTEP/2 GUN00550 I-1

	CALL RELAX (ITER,KSTEP,ERROR,ERRMAX)	GUN00560
	IF (ERROR.LT.ERRMAX) GU TO 3	GUN00570
	CALL RELAX (ITER, 1, ERROR, ERRMAX)	GUN00580
C		GUN00590
C	RECORD V MATRIX FOR NEXT USAGE	GUN00600
С		GUN00610
	3 REWIND 8	GUN00620
	WRITE(B) V	GUN00630
	4 WRITE(1,100) FRRDR	GUN00640
C		GUN00650
C	PLOT CONTOURS	GUN00660
C		GUN00670
	CALL CONPLT (BW, NEQP)	GUN00680
С		GUN00690
c	DETERMINE EQUIPOTENTIAL SURFACE IN VICINITY OF Y=YEQP	GUN00700
č		GUN00710
-	$v_0 = p_{1NT}(x_1, y_1 + .75*(y_2 - y_1)) - COFF$	GUN00720
	CALL EQPTL $(y_0, x_1, x_2, y_1, y_2)$	GUN00730
C		GUN00740
č	WRITE OUT THEN CONVERT TO INCHES	GUN00750
č		GUN00760
•	WRITE(1.101) VO	GUN00770
		GUN00780
	$WRITE(1.102) \times (1) \cdot Y(1)$	GUN00790
	X(T) = X(T) + ENGMET	GUN00800
	Y(1)=Y(1) + ENGMET	GUN00810
1	0 CONTINUE	GUN00820
c		GUN00830
č	GENERATE INPUT FILE FOR XMGUN	GUN00840
č		GUN00850
	WRITE(2.103) TITLE(3).VO.VO	GUN00860
	X(1) = X(2)	GUN00870
	Y(1)=,2125	GUN00880
	NCARDS = 1 + (NXY - 1)/7	GUN00890
	WRITE(2.104) NCARDS.COND(2).COND(3)	GUN00900
	DC 20 I=1.NXY.7	GUN00910
	$JF=MINO(8 \cdot NXY + 1 - I)$	GUN00920
	WRITE(2,105) (Y(NXY+2-I-J),X(NXY+2-I-J),J=1,JF)	GUN00930
2	OCCNTINUE	GUN00940
_	WRITE(2,106)	GUN00950
	STOP	GUN00960
10	0 FORMAT (/// MAXIMUM CHANGE IN MESH ON LAST ITERATION = $(-D12, 4)$	GUN00970
10	1 FORMAT LITT COORDINATES IN METERS OF EQUIPOTENTIAL LINE '.	GUN00980
	* $V_0 = \frac{1}{2} \frac{12}{4} \frac{4}{6} \frac{4}{6} \frac{11}{4} \frac{11}$	GUN00990
10	2 FORMAT (2012.4)	GUN01000
10	3 FORMAT (A8.2X.2F10.0." .10 6 2 2 100 60 10001001100".6X	GUN01010
-	* '6.'/'.212510000115.015 .0115.050 .0115.100 .0115')	GUN01020
10	4 FORMAT ('3',9X,12,' 2',6X,2('1'F9.0))	GUN01030
10	5 FORMAT (8(2F5.4))	GUN01040
10	6 FURMAT (.0 .200 .0 .017 .0149.017 .42911.017	GUN01050
	* /*.41421.081.1041.1254.1041.0807.119 .0807.44391.081*	GUN01060
	* /3('.0',8X),'10009875')	GUN01070
	END	GUN01080
C		INI00010
C		INI00020

T

INI00030 SUBROUTINE INIT INI00040 INI00050 RECTANGULAR GUN ANALYSIS PACKAGE INI00060 INI00070 JOHN B RETTIG 1/31/79 INI00080 INI00090 INI00100 CATA INITIALIZATION ROUTINE INI00110 INI00120 INI00130 IMPLICIT REAL*8 (A-H, O-Z) INIJ0140 REAL*8 V(41,401) INI00150 REAL*8 COND(9) INI00160 REAL*8 TITLE(4) INTEGER ICOND(9) IN100170 INTEGER NCHAR(9), LINE(120), SPACE INI00180 DATA NCHAR /1H1,1H2,1H3,1H4,1H5,1H6,1H7,1H8,1H9/ INI00190 DATA SPACE /1H / IN100200 CCMMON /A/ V INI00210 COMMON /B/ XMIN, XMAX, DXO, IN100220 IN100230 YMIN, YMAX, DYO, M. N. NXY IN100240 COMMON /C/ COND, ICOND, NCOND, CMIN, CMAX, COFF IN100250 COMMON /E/ TITLE INI00260 DATA CMINO /1.04/ INI00270 INI00280 DATA DECK SETUP ON LOGICAL RECORD 3 (ALL UNITS MKS) INI00290 INI00300 CARD VARIABLE FORMAT DESCRIPTION INI00310 INI00320 **IDENTIFICATION** 1 TITLE(1-2) 2A8 INI00330 INI00340 TITLE 2 TITLE(3-4) 248 INI00350 IN100360 3 215 **V MESH SIZE** INI00370 M.N INI00380 4 DX0, DYO 2012.2 V MESH INCREMENTS (M) IN100390 INI 00400 CONDUCTOR CODES - ICOND IS 5-13 ICCND, COND I1,3X, INI00410 F6.0 THE CHARACTER USED IN THE MESH INI00420 TO REPRESENT POTENTIAL COND IN100430 (9 OR LESS MAY BE SPECIFIED) INI00440 INIJ0450 (END OF RECORD CARD) LAST INI00460 INI00470 INI00480 READ(3,100) (TITLE(1), I=1,4), M, N INI00490 READ(3,101) DX0, DY0 INI00500 INI00510 ESTABLISH BOUNDARIES INI00520 INI00530 XMIN=0. INI00540 XMAX=XMIN+DXO*CFLCAT(M-1) INI00550 YMIN=0. INI00560 YMAX=YMIN+DYO*CFLCAT(N-1) INI00570

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C INI00580 С WRITE OUT GEOMETRICAL AND INITIAL CONDITION INFORMATION INI 00590 C INI00600 WRITE(1,102) (TITLE(1), I=1,4), M, N, INI00610 XMIN, XMAX, DXO, INI00620 IN100630 YMIN, YMAX, DYO ------C INI00640 IN100650 С READ CONDUCTOR CODING AND POTENTIALS INI00660 С DO 10 I=1.9 INI00670 INI00680 NCOND=1 READ(3,103,END=11) ICOND(I),COND(I) INI00690 INI00700 10 CONTINUE INI00710 С 11 NCOND=NCOND-1 INI00720 С INI00730 С CALCULATE MAX, MIN, AND OFFSET INI00740 С IN100750 -------CMIN=COND(1) INI00760 CMAX=COND(1) INI00770 INI00780 C DO 20 I=1.NCOND INI00790 IF (CMIN.GT.COND(I)) CMIN=COND(I) INI00800 IF (CMAX.LT.COND(I)) CMAX=COND(I) INI00810 20 CONTINUE INIC0820 COFF=CMINO-CMIN INI00830 RETURN INI00840 C INI00850 100 FORMAT (248/248/215) INI00860 FORMAT (3012.4) FORMAT (7/////OX, TDENT ',2487/10X, TITLE ',2487// 101 INI00870 INI00880 102 * MESH SIZE IS ', I3, * *, I3, * PDINTS'// INI00890 • XMIN = •,D10.4,10X,•XMAX = •,D10.4,10X,•XINC = •,D10.4, INI00900 METERS'77 INI00910 • YMIN = ',D10.4,10X,'YMAX = ',D10.4,10X,'YINC = ',D10.4, IN100920 METERS ///) INI00930 FORMAT (11, 3X, F6.0) INI00940 103 END INI00950 C MES00010 C MES00020 С MES00030 SUBROUT INE MESH MES00040 - -----С MES00050 C MES00060 RECTANGULAR GUN ANALYSIS PACKAGE С MES00070 -----1/31/79 С JOHN B RETTIC ME \$00080 С MES00090 THIS ROUTINE SETS UP A BRAND NEW MESH OF CONDUCTORS IN THE C MES00100 POTENTIAL MATRIX V. ADVANTAGE IS TAKEN OF ANY PREVIOUS С MES00110 С SOLUTION OF A SIMILAR TYPE BY CHANGING ONLY THOSE MESH MES00120 С VALUES WHERE A NEW CONDUCTOR IS LOCATED. MES00130 MES00140 C IMPLICIT REAL#8 (A-H, 0-Z) MES00150 MES00160 KEAL*8 V(41,401) REAL+8 COND(9) MES00170

INTEGER (COND(9) MES00180 MES00190 INTEGER NCHAR(S), LINE(120), SPACE DATA NCHAR /1H1,1H2,1H3,1H4,1H5,1H6,1H7,1H8,1H9/ MES00200 DATA SPACE /1H / MES00210 CCMMON /A/ V MESOU220 CCMMCN /B/ XMIN, XMAX, DXO, MES00230 YMIN, YMAX, DYO, MES00240 MES00250 M, N, NXY COMMON /C/ COND, ICOND, NCOND, CMIN, CMAX, COFF ME\$00260 С MES00270 DATA DECK SETUP ON LOGICAL RECORD 4 (CONDUCTOR GEOMETRY) С ME\$00280 С MES00290 С DESCRIPTION CARD VARIABLE FORMAT MES00300 С MES00310 С CONDUCTOR MESH CODES M*A1 MES00320 1-N С ME \$00330 С (END OF RECORD CARD) LAST MES00340 С MES00350 С MES00360 C READ IN CONCUCTOR INFORMATION ME \$00370 C MES00380 DG 20 J=1,N MES00390 MES20400 READ(4,100) (LINE(I), I=1, M) ME \$00410 DC 10 I=1,M V(I,J) = DMAX1(DABS(V(I,J)), CMINO)MES00420 IF (LINE(I).EQ.SPACE) GO TO 10 ME \$00430 DC 11 K=1,9 MES00440 KO=K ME \$00450 IF (LINE(I).EQ.NCHAR(KO)) GO TO 12 ME\$30460 CCNTINUE ME \$00470 11 GC TO 30 MES00480 DC 13 K=1,NCOND MES00490 12 ME\$00500 K1 = KIF(KO.EQ.ICOND(K1)) GO TO 14 MES00510 CCNTINUE MES00520 13 MES00530 GC TC 30 V(I,J) = -(COND(K1)+COFF)MES00540 14 MES00550 10 CONTINUE 2) CONTINUE MES00560 MES00570 RETURN WRITE(1,101) J, I, (LINE(I), I=1, M) ME\$00580 30 MES00590 STOP C MES00600 100 FCRMAT (12041) MES00610 FORMAT (///// INPUT MESH ERROR', LOX, ' LINE ', 15, ME \$00620 101 10X, ' CHARACTER ', 15//1X, 120A1) MES00630 * MES00640 END С REL00010 REL00020 С С REL00030 SUBROUTINE RELAX (ITER, KSTEPO, ERROR, ERRMAX) **REL00040** С REL 00050 С REL00060 RECTANGULAR GUN ANALYSIS PACKAGE REL00070 С REL00380 С JOHN B RETTIG 1/31/79

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C **REL00090** С **REL**00100 С THIS ROUTINE IMPLEMENTS THE 4-NODE DISCRETIZED LAPLACIAN **RELJ0110** С OPERATOR TO SOLVE LAPLACE'S EQUATION WITHIN A SPECIFIED REL 00120 С M*N MESH. A SUCCESSIVE OVERRELAXATION TECHNIQLE IS **REL00130** С EMPLOYED TO PROVIDE FAST CONVERGENCE, ALONG WITH A SCHEME **REL00140** С THAT STARTS WITH A COARSE MESH AND SUCCESSIVELY WORKS TO **REL00150** THE FINE MESH (I.E. EVERY SINGLE MESH POINT). THE LARGEST С REL 00160 С OF MESH GRADES EMPLOYED IS SPECIFIED BY KSTEP, WITH THE **REL00170** С RESTRICTION THAT KSTEP BE AN INTEGRAL DIVISOR OF BOTH (M-1) REL00180 С AFTER EACH COARSE RELAXATION IS COMPLETE, THE AND (N-1). REL00190 С NEXT FINER MESH IS INTERPOLATED LINEARLY. THIS INTERPOLATION REL00200 С IS PERFORMED USING A FOUR NEAREST NEIGHBOR CALCULATION FIRST REL00210 С FOR THOSE POINTS FALLING AT DISTANCE SQRT(2) FROM THE COARSE REL00220 С MESH, AND THEN FOR THOSE POINTS FALLING AT DISTANCE (.5) REL00230 С FROM THE COARSE MESH. PEL00240 С THE LAST FEW STEPS FOR THE FINEST GRADE MESH (KSTEP=1) REL00250 С RELAXATION ARE GAUSS-SEIDEL (W=.25) IN ORDER TO SMOOTH OUT REL00200 С THE ROUGH EDGES LEFT OVER FROM THE OVERRELAXATION. REL00270 C REL00280 С IF KSTEPO=1, ONLY KSTEP=1 IS USED, AND THE PROGRAM WILL **REL00290** C REPEAT UNTIL ERRORCERRMAX. OTHERWISE, MORE COARSE MESHES ARE **REL00300** С USED TO START, WORKING TO THE FINER MESH AND REPEATING THIS RELOC31C FINE MESH UNTIL ERROR<ERRMAX. С USE CAUTION WHEN CHOUSING ERRMAXREL00320 С AS A 41#401 MESH TAKES ABOUT 4-5 MINUTES ON AN IBM 370/148 **REL00330** С WITH ERRMAX SET TO .01 PERCENT OF THE MAXIMUM LESS MINIMUM REL00340 С MESH POTENTIALS. REL00350 С REL00360 С SEE CARNAHAN, LUTHER, AND WILKES, APPLIED NUMERICAL REL00370 С METHODS, WILEY, 1969, OR FORSYTHE AND WASOW, FINITE DIFFER-**REL00380** С ENCE METHODS FOR PDE, WILEY, 1960. **REL00390** С **RELJ0400** С IF THE MESH IS NOT ENCLOSED BY CONDUCTORS, PERIODICITY OF REL00410 С THE SOLUTION IS ASSUMED AND THE BOUNDARIES ARE FOLDED OVER **REL00420** С (I.C. MIRROR IMAGE SYMMETRY IS ASSUMED). IF THIS CANNOT **REL00430** С BE TOLERATED, BE SURE TO SPECIFY CONDUCTORS ALL THE WAY **REL0044C** C AROUND THE MESE. **REL00450** C REL00460 IMPLICIT REAL*8 (A-H,C-Z) REL00470 REAL#8 V(41,401) REL00480 CCMMON /A/ V REL00490 CCMMON /B/ XMIN, XMAX, DXO, **REL00500** YMIN, YMAX, DYO, **REL00510** M. N. NXY REL00520 С **REL00530** С MESH COARSENESS LOOP **REL00540** С REL00550 KSTEP=2*KSTEP0 **REL00560** 1 KSTEP=MAXO(1,KSTEP/2) **REL00570** KCFF=KSTEP REL00580 T=3.14159/DFLOAT(MIND(M/KSTEP,N/KSTEP)) REL00590 w=0.5/(1.+DSIN(T)) REL00600 IF (KSTEPO.EQ.1) W=.25 REL00610 LMAX=ITER/KSTEP REL00620 10=1 REL00630

IF=M REL00640 J0=1 REL00650 JF=N REL00660 REL00670 С REL00680 С RELAXATION LOOP С **REL00690 REL00700** DE 30 L=1,LMAX **REL00710** ERRCR=0. DC 20 1=10,1F,KSTEP **REL00720** IUP=I+KOFF **REL00730** ICN=1-KOFF REL00740 IF (I.EQ.M) IUP=IDN **REL00750 REL00760** IF (I.EQ.1) ICN=IUP DC 10 J=JO, JF, KSTEP REL00770 **REL00780** V0=V(1, J) IF(VO.LT.O.) GC TC 10 **REL00790** JUP=J+KOFF **RELC0800** JON=J-KOFF REL00810 REL00420 IF (J.EQ.N) JUP=JON IF (J.EQ.1) **REL00830** JEN=JUP VOFF=W*(DABS(V(IDN, J))-VO+DABS(V(IUP, J))-VO REL00840 **REL00850** +DABS(V(1, JDN))-V0+DABS(V(1, JUP))-V0) V(1,J) = VO + VOFF**REL00860** ERROR=DMAXI(ERROR, DABS(VOFF)) **REL00870** 10 CENTINUE **REL00880** 20 CENTINUE **REL00890** WRITE(6,200) L,KSTEP,W,ERROR REL00900 С REL00910 С RETURN IF ERROR SATISFIED WITH FINEST MESH AND GAUSS-SEIDEL REL0092C С HAS BEEN PERFORMED REL00930 С **REL00940** IF (KSTEP.EQ.1.AND.ERROR.LT.ERRMAX.AND.W.EQ..25) RETURN REL00950 С **REL00960** С IF ALMOST COMPLETE, SWITCH TO GAUSS-SEIDEL **REL00970** С **REL00980** IF (ERROR.LT. 10.*ERRMAX.AND.KSTEP.EQ.1) W=.25 REL00990 С REL01000 30 CENTINUE **REL01010** С REL01020 С CHECK IF INTERPOLATION NECESSARY FOR NEXT FINER MESH **REL01030** С OR IF COMPLETED REL01040 С **REL01050** IF (KSTEPO.EQ.1) RETURN REL01060 IF (KSTEP.EQ.1) GO TO 1 REL01070 С **REL01080** С INTERPOLATE INBETWEEN POINTS REL01090 С RELOLIOJ KCFF=KSTEP/2 RELOILIO 10=1+KOFF REL01120 IF=M-KOFF REL01130 J0=1+K0FF REL01140 **REL01150** JF=N-KOFF С REL01160 С **REL01170** С **REL01180**

	DC 50 J=J0, JF, KSTEP	REL01190
	JUP=J+KOFF	REL01200
	JDN=J-KOFF	REL01210
	DO 40 I=I0, IF, KSTEP	REL01220
	IF (V(I,J).LT.0.) GO TO 40	REL01230
	IUP=I+KOFF	REL01240
	I DN=I-KOFF	REL01250
	V(I,J) = .25*(DABS(V(IDN,JDN))+DABS(V(IUP,JDN))	REL01260
	<pre>* +DABS(V(ION,JUP))+DABS(V(IUP,JUP)))</pre>	REL01270
40	CCNTINUE	REL01280
50	CCNTINUE	REL 01290
	10=1+KCFF	REL01300
	IF=M-KOFF	REL01310
	JC=1	REL01320
	JF=N	REL01330
С		REL01340
С		REL01350
С		REL01360
	DC 70 J=J0, JF, KSTEP	REL01370
	JUP=J+KOFF	REL01380
	JUN=J-KUFF	RELOI390
	IF (J.EQ.I) JUN=JUP	REL01400
	IF (J.EQ.N) JUP=JUN	REL01410
		REL01420
		REL 01430
		REL01440
	$\frac{1}{1} = \frac{1}{2} = \frac{1}$	RELUL450
		PEL 01400
60		REL01480
70	CONTINUE	REL01400
	10=1	REL 01500
	IF=N	REL01510
	10=1+KOFF	REL 01520
	JE=N-KOFF	REL 01530
	DC 90 J=J0.JE.KSTEP	REL 01540
	JUP=J+KOFF	REL01550
	JON=J-KOFF	REL 01560
	DC 80 I=IO.IF.KSTEP	REL01570
	IF(V(I.J).LT.0.) GO TO 80	REL 01580
	IUP=I+KOFF	REL01590
	ICN=I-KOFF	REL01600
	IF (I.EQ.M) IUP=IDN	RELOIGIC
	IF (I.F.C.1) ION=IUP	REL01620
	V(I,J) = .25*(DABS(V(IDN,J))+DABS(V(IUP,J))	REL01630
	<pre>* +DAES(V(I, JDN))+DABS(V(I, JUP)))</pre>	REL01640
80	CENTINUE	REL01650
90	CCNTINUE	REL01660
	GC TO 1	REL01670
200	FORMAT (*****,2110,F10.4,F10.2)	REL01680
	END	REL01690
C		CON00010
C		CON00020
С		CON00030
	SUBPOUTINE CONDIT (BW.NEOD)	CON00040

I-8

RECTANGULAR GUN ANALYSIS PACKAGE

JOHN B RETTIG 1/31/79

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THIS ROUTINE GENERATES A CONTOUR EQUIPOTENTIAL PLCT ON THE LINE PRINTEP. CONDUCTORS, CODED AS NEGATIVE NUMBERS IN THE MESH, ARE SYMBOLIZED BY DIGITS FROM 1-9, ACCORDING TO THE SCHEME SET UP IN THE ARRAYS ICOND AND COND. OPEN SPACES ARE REPRESENTED BY LETTERS ACCORDING TO THE VALUES OF BW AND NEQP. THE PARAMETER NEQP IS THE NUMBER OF DESIRED EQUI-POTENTIALS (MAXIMUM 48), WHILE BW IS A BANDWIDTH SPECIFIER. THE WAY THE PARAMETER BW WORKS IS BEST ILLUSTRATED BY AN EXAMPLE.

ASSUME NEQP=4, BW=.10, AND 10 < V < 40

Δ	9	<	۷	<	11
8	19	<	۷	<	21
С	29	<	۷	<	31
D	39	<	۷	<	41

HOWEVER, IF BW=.50 WITH ALL ELSE THE SAME

2	7.5	<	۷	<	12.5
3	17.5	<	۷	<	22.5
2	27.5	<	۷	<	32.5
)	37.5	<	۷	<	42.5

THUS, BW=O WILL PRINT A BLANK PAGE, AND BW=1 WILL PRINT A SOLID PAGE OF CHARACTERS.

THE PARAMETER NERP MIGHT BE ADJUSTED BY THE PROGRAM TO OBTAIN AESTHETIC EQUIPOTENTIAL SPACINGS.

```
IMPLICIT REAL #8 (A-H, 0-Z)
REAL*8 V(41,401)
REAL*8 COND(9)
INTEGER ICOND(S)
COMMON /A/ V
COMMON /8/ XMIN, XMAX, DXO,
            YMIN, YMAX, DYO,
            M, N, NXY
CCMMON /C/ COND, ICOND, NCOND, CMIN, CMAX, COFF
DATA MAX /120/
INTEGER NCHAR(9), ACHAR(48), SPACE, UNIDNT, PRT(120)
DATA NCHAR /1H1,1H2,1H3,1H4,1H5,1H6,1H7,1H8,1H9/
DATA ACHAR /1HA,1HB,1HC,1HD,1HE,1HF,1HG,1HH,
             1HJ, 1HK, 1HL, 1HM, 1HN, 1HP, 1HQ, 1HR,
             1HS, 1HT, 1HU, 1HV, 1HW, 1HX, 1HY, 1HZ,
             1HA, 1HB, 1HC, 1HD, 1HE, 1HF, 1HG, 1HH,
             1HJ, 1HK, 1HL, 1HM, 1HN, 1HP, 1HQ, 1HR,
             1HS, 1HT, 1HU, 1HV, 1HW, 1HX, 1HY, 1HZ/
DATA SPACE /1H /, UNIDNT /1H*/
```

CON00050 CON00060 CON00070 CON00080 CON00090 CON00100 CON00110 CON00120 CON00130 CON00140 CON00150 CON00160 CON00170 CON00180 CON00190 CON00200 CON00210 CON00220 CON00230 CON00240 CON00250 CON00260 CON00270 CUN00280 CON00290 CON00300 CON00310 CON00320 CON00330 CON00340 CGN00350 CON00360 CON00370 CON00380 CGN00390 CCN00400 CON00410 CON00420 CON00430 CON00440 CON00450 CON00460 CON00470 CON0048C CON00490 CON00500 CON00510 CON00520 CON00530 CUN00540 CON00550 CON00560 CON00570 CON00580

CON00590

	VINC=(CMAX-CMIN)/DFLOAT(NEQP-1)	CON00600
	VLINC=DLOGIO(VINC)	CON0061C
	IEXP=IDINT(1.01*VLINC)	C0N00620
	IFRCT=IDINT(1.C1+10.++(VLINC-DFLOAT(IEXP)))	CON00630
	IF (IFRCT.EQ.7.UR.IFRCT.EQ.9) IFRCT=IFRCT+1	CON00640
	VINC=DFLUAT(IFRCT)+10.**IEXP	CON00650
	IMIN=1DINT(1.001*CMIN/VINC)	CON00660
	IMAX=1+1DINT(.999*CMAX/VINC)	CON00670
	NEQP=IMAX-IMIN+1	CON00680
	WRITE(1,100)	CCN00690
	DC 10 I = 1, NCOND	C0N00700
	WRITE(1,101) ICOND(I),COND(I)	CON00710
10	CONTINUE	CON00720
	WRITE(1,102) BW	CON00730
	DC 20 I=1,NEQP	CON00740
	VCFNT=DFLCAT(IMIN+I-1)*VINC	CCN00750
	VLO=VCENT-VINC*BW/2.	CUN00760
	VHI=VCENT+VINC*BW/2.	CON00770
	WRITE(1,103) ACHAR(I), VLO, VCENT, VHI	CON00780
20	CONTINUE	CON00790
	WRITE(1,104)	CONODSOO
	MO = MIND(MAX, M)	CCNJ0810
	ICFF=0	C0N00320
40	DC 60 $J=1,N$	CUN00830
	00 50 IO=1,MO	CCND0840
	I=10+10FF	CCN00350
	PRT(10)=SPACE	CON00860
	(L, I)V=0V	CON00870
	IF (VO.LT.O.) GO TO 51	CGN00380
	V1 = (V0 - C0FF)/VINC+BW/2.	CON00890
	IVI = ID[NT(VI)]	CON00900
	IF(DABS(V1-DFLCAT(IV1)).GT.3W) GO TO 50	CUN00910
	PRT(IO) = ACHAR(IVI - IMIN+1)	CON00920
	GC TO 50	CON00930
51	DC 52 $K=1.NCCND$	CON00940
	K0=K	CON00950
	IF (-VO.EQ.COND(KO)+COFF) GO TO 53	C0N00960
52	CONTINUE	CGN00970
	PRT(IO) = JNIDNT	C0N00980
	GC T0 50	CCN00990
53	IV1 = ICOND(KO)	CON01000
	PRT(IO) = NCHAR(IVI)	CDN01010
50	CENTINJE	CON01020
	WRITE(1,105) (PRT(I),I=1,M0)	CON01030
60	CONTINUE	CON01040
	IF (MO+IDEF-GE-M) RETURN	CON01050
	ICEF = IUEF + MO	CON01060
	MQ = MINQ(M - LOFF - MQ)	CON01070
	WRITE(1,104)	CON01030
	GC TO 40	CGN01090
100	ECRMAT (///// ***** CONDUCTOR CUDES *****!//	CONDITION
	* 10X.' CODE VOLTS'/	CONDILLO
101	FCRMAT (12X-11-F12-2)	CONDITIZO
102	FCRMAT (//// ***** POTENTIAL CODES *****!//	CONOLIZO
	* 10X.' WINDOW = '.F6.4//	CGN01140

· CCDE MEAN HIGH 1) CON01150 LOW 103 FCRMAT(2X, A1, 4X, 3F12.2) CON01160 104 FCRMAT (1H1/1HQ) CON01170 105 FORMAT (1X,120A1) CON01180 END CON01190 С EQP00010 С EQP00020 С EQP00030 SUBROUTINE EQPTL (VO, X1, X2, Y1, Y2) EQP00040 С EQP00050 С RECTANGULAR GUN ANALYSIS PACKAGE EQP00060 С EQP00070 С EQP00080 JOHN B RETTIG 1/31/79 С EQP00090 С EQP00100 С THIS PROGRAM LOCATES AND PROVIDES COORDINATES FOR THE EQP00110 EQUIPOTENTIAL LINE OF VALUE VO, IN THE V MESH. A LINEAR С E0P00120 С INTERPOLATION IS PERFORMED BETWEEN MESH POINTS. IT IS EQP00130 C ASSUMED THAT THE VOLTAGE MATRIX V IS STRICTLY MENOTONIC E0P00140 С IN THE Y DIRECTION, WITHIN A REGION ABOUT THE EQUIPOTENTIAL EQP00150 С LINE. ECP00160 C E0P00170 IMPLICIT REAL*8 (A-H, 0-Z) EUP00180 REAL*8 V(41,401) E0P00190 REAL*8 X(200), Y(200), UX(200), UY(200) E0P00200 COMMON /4/ V EQP00210 COMMON /B/ XMIN, XMAX, DXO, ECPOC220 * YMIN, YMAX, DYO, ECPJ0230 * EQP00240 M, N, NXY REAL*8 COND(9) EQP00250 INTEGER ICOND(9) EQP00260 COMMON /C/ CONC, ICOND, NCOND, CMIN, CMAX, COFF EQP00270 CCMMON /J/ X,Y,UX,UY EQP00280 V1=V0+COFF EQP00290 11 = MAXO(1, 1+IDINT((X1-XMIN)/DXO))EQP00300 I2=MINO(M, 1+IDINT((X2-XMIN)/DXO))EQP00310 J1=MAXO(1,1+IDINT((Y1-YMIN)/DYO))E0P00320 J2=MINO(N, 1+IDINT((Y2-YMIN)/DYO))EQP00330 NXY=0 EQP00340 DC 10 I=11,12 EQP00350 JDN=J1 EQP00360 JUP = J2EQP00370 VDN=DABS(V(I, JDN))-V1 EQP00380 EQP00390 VUP=DABS(V(I, JUP))-V1 IF (VON*VUP) 1,10,10 ECP00400 EQP00410 1 JMD = (JDN + JUP)/2VMD=DABS(V(I, JMD))-V1 ECP00420 IF (JDN.EQ.JMD) GO TO 4 EQP00430 IF (VDN*VMD) 2,1C,3 EQP00440 JUP = JMDEQP00450 2 VUP=VMD E0P00460 EQP00470 GC TO 1 E0P00480 3 JDN=JMD EQP00490 VON=VMD EQP00500 GC TO 1

4	NXY = NX Y + L	EQP00510
	0J=0.	EQP00520
	IF (VDN.EQ.VUP) GO TO 5	EQP00530
	D = V D N / (V U P - V D N)	EQP00540
5	X {NXY}=XMIN+DFLOAT(I-1)+DX0	EQP00550
	Y (NXY) = YMIN+DY O* (DFLOAT (JMD-1)-DJ)	EQP00560
10	CONTINUE	EQP0057C
	RETURN	EQP00580
	END	EQ200590
C		PIN00010
c		PIN00020
C		PIN00030
	FUNCTION PINT (X.Y)	PIN00040
С		PIN00050
c	RECTANGULAR GUN ANALYSIS PACKAGE	PIN00060
č		PINODOTO
č	IOHN & RETTIG 1/31/79	PINOOABO
č		PINODOGO
č		PIN30100
č	DINT INTEDDOLATES THE V MATERY IN DETWEEN THE NEED DOTNIS	PINOOIDO
r	HIGH A A DOINT FINGAD INTEDDALATION IS ANY REHADADY IS	PINOULIO
č	EVERAL AT FULLY LINEAR INTERPLATION. IT AND BUDGHART IS	PINJ0120
č	EACECUED, MEARCH IMAGE STMMETRY IS ASSUMED ABOUT THAT	PIN00150
č	BUONDART AND THE INTERPOLATION PERFORMED AS IF THE POINT	PINJ014J
č	FELL IN THE MESH.	PINJUISU
L		PIN00160
	IMPLICIT REAL*8 (A-H,U-Z)	PINJOLIO
	$REAL^{\texttt{A}\texttt{B}} \lor V(41, 401)$	PINUOI80
	CEMPUN ZAZ V	PINJ0190
	CUMMON /B/ XMIN, XMAX, DX0,	PINJ0200
	★ YMIN,YMAX,DYO,	PIN00210
	₩ N,N,NXY	P1N00220
	XINI=X	PIN00230
		P1N00240
	$IF (X \in L \cap XM(N)) X IN (= 2 \cdot T XM(N) - X$	PIN00250
	$IF (Y \cdot LI \cdot YMIN) YINI= 2 \cdot YMIN= Y$	PIN00260
	IF (X,GI,XMAX) XINI=2.*XMAX-X	PIN00270
	$1 + (Y \cdot G \cdot \cdot Y \cdot M A X) + Y \cdot N \cdot = 2 \cdot \pi Y \cdot M A X - Y$	PIN00280
	$x_0 = 0 + 0 + 1 + (x_1 + y_1 - x_1 + y_1 - x_1 + y_1 - x_1 + y_1 - x_1 + y_1 + y_1$	PIN00290
	$Y = DFLUAT(N-1) \neq (YINI-YMIN)/(YMAX-YMIN)$	PIN00300
	I = I + I D I N I (XO)	P1N00310
	$\mathbf{Y} = 1 + 1 \mathbf{D} + 1 \mathbf{N} + 1 \mathbf{Y} \mathbf{D}$	PIN00320
	F = X 0 - 0 F E U A I (I X - I)	PIN00330
	$\mathbf{Y} = \mathbf{Y} - \mathbf{D} + \mathbf{U} + $	PIN00340
	$v_0 = DABS(v(1x, 1y))$	PIN00350
	VI = 0.485 (V(1x+1, (Y)))	PIN00360
		PIN00370
	$V_{J} = U_{A} U_$	PIN00380
	DVI = VO + (VI - VO) * FX	PIN00390
	0V2=V2+(V3-V2)*FX	PIN00400
	PINI=DVI+(DV2-DVI)*FY	PIN00410
	RETURN	PIN00420
	END	PIN00430

Appendix II RCTGUN III

GUN00010 С С GUN00020 С GUN00030 С RECTANGULAR GUN ANALYSIS PACKAGE GUN00040 С GUN00050 С JOHN B RETTIC 1/31/79 GUN00060 С GUN00070 С MAIN DRIVER ROUTINE, PART III- TRAJECTORY CALCULATIONS GUN0008C С GUN00090 GUN00100 IMPLICIT REAL*8 (A-H,0-Z) REAL*8 V(41,401) GUN00110 GUN00120 REAL*8 COND(9) REAL*8 X(200), Y(200), UX(200), UY(200) GUN00130 GUN00140 INTEGER ICOND(5) GUN00150 CCMMON /A/ V CCMMON /B/ XMIN, XMAX, DXO, GUN00160 GUN00170 YMIN, YMAX, DYO, GUN00180 M, N, NXY COMMON /C/ CONC, ICOND, NCOND, CMIN, CMAX, COFF GUN00190 CCMMON /D/ X,Y,UX,UY GUN00200 CCMMON /E/ TITLE1, TITLE2, TITLE3, TITLE4 GUN00210 CALL INIT GUN00220 READ(8) V GUN00230 CALL TRAJ GUN00240 STOP GUN00250 END GUN00260 С IN100010 C INI00020 С IN100030 IN100040 SUBROUTINE INIT С IN100050 С RECTANGULAR GUN ANALYSIS PACKAGE IN100060 С INI00070 С JCHN B RETTIG 1/31/79 IN100080 С INI00090 С INIOU100 С DATA INITIALIZATION ROUTINE INI0011C С INIOG120 IMPLICIT REAL#8 (A-H, 0-Z) INI00130 REAL*8 V(41,401) IN100140 REAL*8 COND(9) INIJ0150 INI00160 REAL*8 TITLE(4) INTEGER ICOND(S) INI00170 INTEGER NCHAR(S), LINE(120), SPACE INI00180 DATA NCHAR /1H1,1H2,1H3,1H4,1H5,1H6,1H7,1H8,1H9/ INI00190 DATA SPACE /1H / INI00200 CEMMON /A/ V IN100210 CEMMON /8/ XMIN, XMAX, DXO, INI00220 INI00230 YMIN, YMAX, DYO, INI00240 M, N, NXY COMMON /C/ CUNC, ICOND, NCOND, CMIN, CMAX, COFF INI00250 CCMMON /E/ TITLE INI00260 DATA CMINO /1.04/ INIC0270 С IN100280 С DATA DECK SETUP ON LOGICAL RECORD 3 (ALL UNITS MKS) INI00290

II-1

С IN100300 С DESCRIPTION INI00310 CARD VARIABLE FORMAT С INI00320 С IDENTIFICATION IN100330 1 TITLE(1-2) 2A8 С INI00340 С TITLE INI0035C 2 TITLE(3-4) 2A8 С IN100360 С V MESH SIZE IN100370 3 215 M.N С IN100380 С DXC, DYO 2012.2 V MESH INCREMENTS (M) INI00390 4 С INI00400 С 5-13 ICCND.COND 11,3X, CENDUCTOR CODES - ICOND IS IN100410 C THE CHARACTER USED IN THE MESH INI00420 F6.0 TO REPRESENT POTENTIAL COND С INI00430 С (9 OR LESS MAY BE SPECIFIED) INI00440 С INI00450 С LAST (END OF RECCRD CARD) INIOC46C С INI00470 С INI00480 READ(3,100) (TITLE(1), I=1,4), M, N INI 30490 INI0050C READ(3,101) DXC, DYO С INI00510 С INI00520 ESTABLISH BCUNDARIES С INI00530 INI00540 XMIN=0. XMAX=XMIN+DXO*CFLCAT(M-1) INI00550 YMIN=0. IN100560 YMAX=YMIN+DYO*CFLCAT(N-1) INI00570 С INI00580 С WRITE OUT GEOMETRICAL AND INITIAL CONDITION INFORMATION IN100590 С INI00600 WRITE(1,102) (TITLE(I), I=1, 4), M, N,INI00610 INI00620 XMIN, XMAX, DXO, YMIN, YMAX, DYO INI0063C С INI00640 READ CONDUCTOR CUDING AND POTENTIALS С INI00650 С INI00660 OC 10 I=1,9 IN10067C NCOND=1 INI 30680 INI00690 READ(3,103,END=11) ICOND(I),COND(I) INI0070C 10 CCNTINUE IN10071C С NCOND=NCOND-1 IN10072C 11 С IN100730 С CALCULATE MAX, MIN, AND OFFSET IN100740 С INI00750 CMIN=COND(1) INI00760 CMAX=COND(1) INI00770 IN100780 С INI00790 DC 20 [=1,NCOND IF (CMIN.GT.COND(I)) CMIN=COND(I) INI00800 IF (CMAX.LT.COND(I)) INICO810 CMAX=COND(I) 20 CONTINUE INI00820 CCFF=CMINO-CMIN INI00830 INI00840 RETURN II-2

С INI00850 100 FCRMAT (248/248/215) INI00860 101 FCRMAT (3012.4) INIO0370 102 FCRMAT (/////OX, 'IDENT •,248//10X, *TITLE ·,2A8/// IN100380 " MESH SIZE IS ", I3, " * ', I3, " POINTS'// INI00890 XMIN = ", D10.4, 10X, "XMAX = ", D10.4, 10X, "XINC = ", D10.4, INI00900 . METERS 1/ INI00910 * YMIN = ',D10.4,10X,'YMAX = ',D10.4,10X,'YINC = ',D10.4, INI00920 • METERS !//) INI00930 103 FCRMAT (11, 3X, F6.C) INI00940 END INI00950 С TRA00010 C TRA00020 С TRA00030 SUBROUTINE TRAJ TRA00040 С TRA00050 С RECTANGULAR GUN ANALYSIS PACKAGE TRA00060 С TRA00070 С JOHN B RETTIG 1/31/79 TRA00080 С TRA00090 С TRA00100 С THIS PROGRAM FINDS THE TRAJECTORY OF A CHARGED PARTICLE IN TRA00110 С THE PRESENCE OF AN ELECTRIC FIELD CREATED BY CONDUCTORS OF TRA00120 C VARIOUS POTENTIALS. THERMAL EFFECTS, RELATIVITY, AND SPACE TRA00130 С CHARGE EFFECTS ARE NOT TAKEN INTO ACCOUNT. FIELD GRADIENTS TRA00140 С ARE TAKEN FROM THE POTENTIAL MATRIX V (ASSUMED TO HAVE ALREADY TRADOISO С BEEN SOLVED BY SOME MEANSI. THEN, A DISCRETIZED FOURTH TRAOCIGC С CROER DISCRETIZED RUNGE-KUTTA INTEGRATION SCHEME IS USED TO TRA00170 С PIECE OUT THE PATH OF THE PARTICLE THROUGH THE MATRIX. TRA00180 С TRA00190 С IF DESIRED, PARTICLES MAY BE BOUNCED OFF OF BOUNDARIES ABOUT TRADUZOU С WHICH THE FIELD IS ASSUMED TO BE MIRROR IMAGE SYMMETRICAL. TRA00210 С TRA00220 С TRA00230 С **TRAD0240** С DATA DECK SETUP ON LOGICAL RECORD 5 TRA00250 C TRA00260 С FORMAT CARD VARIABLE DESCRIPTION TRA00270 С TRA00280 С X1, Y1, U1, P1 3012.4, INITIAL POSITION AND VELOCITY 1 TRA00290 C F12.2 FCR PARTICLE 1 - X1 AND Y1 IN TRA00300 С METERS, UI IN METERS/S, PI IN TRA00310 С DEGREES FROM +X AXIS TRA00320 С TRA00330 С 2+ (SAME FOR PARTICLE 2, ETC) **TRAC034C** C TRA00350 С (END OF RECORD CARD) LAST TRA00360 С TRA00370 С TRA00380 IMPLICIT REAL*8 (A-H, 0-Z) TRA00390 REAL*8 X(200), Y(200), UX(200), UY(200) TRA00400 CEMMEN /B/ XMIN, XMAX, DXO, TRADC410 * YMIN, YMAX, DYC. TRA00420 M.N.NXY TRA00430 CCMMON /C/ CONC, ICOND, NCOND, CMIN, CMAX, COFF TRADC440 II-3

```
CCMMON /D/ X,Y,UX,UY
                                                                              TRA0045C
      REAL*8 F(4),Z(4)
                                                                              TR A00460
      EQUIVALENCE (X1,2(1)),(Y1,2(2)),(UX1,2(3)),(UY1,2(4))
                                                                              TRA00470
      INTEGER RUNGE
                                                                              TRA00480
      DATA TMIN /0./
                                                                              TRA00490
      DATA DT /2.0-11/
                                                                              TRA00500
      DATA PI /3.14159265350+0/
                                                                              TRA00510
C
                                                                              TRA00520
С
         ELECTRON CHARGE/MASS, MKS
                                                                              TRA00530
С
                                                                              TRA00540
      DATA ETA /1.7587945011/
                                                                              TRA00550
      TMAX=IMIN+2.*(YMAX-YMIN)/DSQRT(2.*ETA*(CMAX-CMIN))
                                                                              TRA00560
С
                                                                              TRA00570
      1=0
                                                                              TRA00580
 10
      1=1+1
                                                                              TRA00590
      READ(5,100,END=30) X1,Y1,U1,P1
                                                                              TRA00600
      RO = (PI / 180.) * P1
                                                                              TRA00610
      UX1=U1*DCCS(RO)
                                                                              TRA00620
      UY1=U1 \neq DSIN(RO)
                                                                              TRA20630
      X(1) = X1
                                                                              TRADD64C
      Y(1) = Y1
                                                                              TRAJ0650
      UX(1) = UX1
                                                                              TRA00660
      UY(1) = UY1
                                                                              TRA00670
      NXY = 1
                                                                              TRA00680
      T=TMIN
                                                                              TRA00690
С
                                                                              TRA00700
С
         COMPUTE STEP
                                                                              TRA00710
С
                                                                              TRA00720
      X=RUNGE (4,Z,F,T,DT)
11
                                                                              TRA00730
С
                                                                              TRA00740
         K=1 FLAGS THAT DERIVATIVES ARE NEEDED
C
                                                                              TRA00750
                                                                              TRA00760
С
      IF (K.NF.1) GC TC 12
                                                                              TRA00710
С
                                                                              TRAUC780
С
         COMPUTE GRACIENTS IN POTENTIAL USING CENTRAL DIFFERENCES
                                                                              TRA00790
С
                                                                              TRA00800
      VXH=PINT(X1+.5*CXC,Y1)
                                                                              TRA00810
      VXL=PINT(X1-.5*CXC,Y1)
                                                                              TRA00820
      VYH=PINT(X1,Y1+.5*DYC)
                                                                              TRA0083C
      VYL = PINT(X1, Y1 - .5 * 0 Y 0)
                                                                              TRA00840
С
                                                                              TRA00850
      GRADVX=(VXH-VXL)/CXO
                                                                              TRAC0360
      GRADVY = (VYH-VYL)/CYA
                                                                              TRA00870
С
                                                                              TRA00380
C
         COMPUTE DERIVATIVES AND CONTINUE RUNGE INTEGRATION
                                                                              TRA00890
С
                                                                              TRA00900
C
           - F(1)=DX/CT=UX
                                                                              TRA00910
С
            - F(2)=DY/DT=UY
                                                                              TRA00920
С
            - F(3)=DUX/DI=ETA*GRACVX
                                                                              TRA00930
С
            - F(4)=DUY/DT=ETA*GRADVY
                                                                              TRA00940
C
                                                                              TRA00950
      F(1)=JX1
                                                                              TP.A00960
      F(?)=UY1
                                                                              TRA00970
      F(3)=ETA#GRADVX
                                                                              TRA00980
      F(4)=FTA#GRADVY
                                                                              TRA00990
```

r		TD 401000
L		TRADIOUU
	GC 10 11	TRADIOIO
С		TRA01020
12	NXY=NXY+1	TRA01030
С		TRA01040
С	BOUNCE OFF CESIRED BOUNDARIES	TRA01050
C		TRA01060
	IF (X1.GT.XMIN) GO TO 13	TRA01070
	X1 = 2 + XMIN - X1	TRACIOSO
		TPA01090
12		TRA01090
-13		TRAULIOU
C		TRAUILLU
C	Y1=2.**YM1N-Y1	TRAUILZO
C		TRA01130
C14	CENTINUE	TRA01140
C	IF (XI .LT.XMAX) GO TO 15	TRA01150
С	$\times 1 = 2 \cdot \star \times M \Lambda X - X 1$	TRA01160
С	$U \times 1 = -U \times 1$	TRAOLLTO
C15	CENTINUE	TRAJ1180
C	IF (Y1.LT.YMAX) GO TO 16	TRA01190
С	Y1=2.*YMAX-Y1	TRA01200
C		TRA01210
C16	CENTINUE	TRA01220
C		TRA01230
c	RECORD POSITIONS	TRA01240
ř		TPA01250
C	X (N X X) - X 1	TPA01260
		TRAULZOU
		TRAULZIU
		TRA01280
		TRAOI290
C		TRA01300
C	CHECK LIMITS	TRA01310
С		TRA01320
	IF (X1.LT.XMIN.OR.X1.GT.XMAX.CR.Y1.LT.YMIN.OR.Y1.GT.YMAX	TRA01330
	* • • • • • • • • • • • • • • • • • • •	TRA01340
	GC TO 11	TRA01350
С		TRA01360
C	PRINT AND PLOT INFORMATION	TRA01370
C		TRA01380
20	WRITE(1.101) I	TRA01390
	DC 21 $K=1$ NXY	TRA01400
	T = TMIN + DELDAT(K-1) + DT	TRA0141C
	$H = 0 SORT (HX(K) \neq HX(K) + HY(K) \neq HY(K))$	TRA01420
		TPA01430
	$And - (100 \cdot f + 1) + DATANZ(0) (K, f) OAK(f)$	TRA01450
	RELIEVELS IS AN IST AND STAND	T0 401450
21		TRA01450
		TRA01460
		IRAU1470
30	CALL PUFF	IRA01480
	RETURN	TRA01490
C		TRA0150C
100	FCRMAT (3D12.4,F12.2)	TRA01510
101	FORMAT (/////10X, * ***** PARTICLE *, 12, * ******//	TRA01520
	* 6X, 'T(S)', EX, 'X(M)', 8X, 'Y(M)', EX, 'U(M/S)', 6X, 'ANGLE')	TRA01530
102	FCRMAT (1X,4012.3,F10.2)	TRA01540

	END	TRA01550
C		RUN00010
C		RUN00020
C		RUN00030
	FUNCTION BUNGE (N.Y.E.X.H)	RUN00040
r		PUNDODSO
č	DECTANCHIAD CHN ANALYSTS DACKACE	RUNDOOLO
5	RECTANGULAR CUN ANALTSIS PACKAGE	RUNDOODU
C		RUNODOTO
C	JUHN B RETTIG 1/31/19	RUN00080
C		RUN00090
C		RUN00100
C	FOURTH ORDER RUNGE-KUTTA INTEGRATION	RUN00110
С		RUN00120
C	COPIED FROM CARNAHAN, LUTHER, & WILKES, "APPLIED NUMERICAL	RUN00130
C	METHODS', NEW YORK, WILEY, 1969, PP 374-5.	RUN00140
č		RUN00150
•	INDLICIT REAL #8 (A-H-C-7)	RUNDO160
		PUNOO170
		RUNOOLIC
	REAL * S PHI(4), SAVET(4), T(N), F(N)	RUNUUISU
10.04		RUN00190
C		RUN00200
	M = M + 1	RUN00210
	GC TC (1,2,3,4,5),M	RUN00220
C		RUN00230
C	••••PASS 1••••	RUN00240
1	RUNGE = 1	RUN00250
	RETURN	RUN00260
C		RUN00270
č	PASS Zana	RUN00280
2		RUN00290
-	SAVEY(1) = Y(1)	RUN00300
		PUNDOBIO
22	(1) = (1)	PUNDOZZO
22		RUN00320
		RUN00350
		RUN00340
100	RETORN	RUN00350
C		RUN00360
C	••••PASS 3••••	RUN00370
3	DC 33 J=1,N	RUN00380
	PHI(J)=PHI(J)+2.0*F(J)	RUN00390
33	Y(J)=SAVEY(J)+C.5*H*F(J)	RUN00400
	RUNGE=1	RUN00410
	RETURN	RUN00420
C		RUN00430
C	••••PASS 4••••	RUN00440
4	DC 44 J=1.N	RUN00450
	$PHI(J) = PHI(J) + 2 \cdot 0 \neq F(J)$	RUN00460
44	Y(1) = SAVEY(1) + E + E(1)	RUN00470
	X=X+0.5*H	RUN00480
	RUNGE = 1	RUNDOADO
	DETION	PUNODEDO
•	D C I UNIX	RUNDOSUC
C	DACC E	RUNUUSIO
	••••PA35 5••••	KUN00520
2		KUN00530
55	Y(J)=SAVEY(J)+(PHI(J)+F(J))*H/6+0	RUN00540

	M=0	RUN00550
	RUNGE=0	RUN00560
	RETURN	RUN00570
С		RUN00580
	END	RUN00590
C		PINODOLO
č		PINODOZO
c		PINODO30
~	FUNCTION PINT (X-Y)	PINODOGO
c		PINODOSO
ř	DECTANGINAR CUN ANALYSTS DACKAGE	PIN00050
c	NECTANOLIAN OUN ANALTSIS FACKAGE	PIN00000
č		PINOUUTU
č	JUNN D KEITLG 1/3//49	PIN00080
		P1N00090
5	DINT INTERRET THE A MATRIX IN RETURN THE NEED OFFICE	PINUOIDO
C	PINT INTERPOLATES THE V MARKA IN BETWEEN THE MESH POINTS	PINOUIIO
c	USING A 4 PEINT LINEAR INTERPOLATION. IF ANY BOUNDARY IS	PIN00120
C	EXCEEDED, MIRRUK IMAGE SYMMETRY IS ASSUMED ABOUT THAT	PINJ0130
C	BOUNDARY AND THE INTERPOLATION PERFORMED AS IF THE POINT	PIN00140
С	FELL IN THE MESH.	PIN00150
С		PIN00160
	IMPLICIT REAL#8 (A-H,O-Z)	PIN00170
	REAL*8 V(41,401)	PIN00180
	COMMON /A/ V	PIN00190
	COMMON /B/ XMIN, XMAX, DXO,	PIN00200
	* YMIN,YMAX,CYO,	PIN00210
	★ M, N, NXY	PIN00220
	X (NT=X	PIN00230
	YINT=Y	PIN00240
	IF (X.LT.XMIN) XINT=2.*XMIN-X	PIN00250
	IF (Y.LT.YMIN) YINT=2.*YMIN-Y	PIN00260
	IF $(X \cdot GT \cdot XMAX)$ XINT=2.*XMAX-X	PIN00270
	IF $(Y - GT - YMAX)$ $YINT = 2 + YMAX - Y$	PIN00280
	XO = DEL CAT(M-1) + (XINT - XMIN)/(XMAX - XMIN)	PIN00290
	$Y_{C} = DF(DAT(N-1) \neq (YINI-YMIN)/(YMAX-YMIN)$	PIN00300
	I = I + I O I N T (XO)	PINO0310
	$I \neq I + I \cap I \cap I (\neq 0)$	PIN00320
	F x = x (0 - DE) (CAT(1 x - 1))	PIN00330
	$\mathbf{F} \mathbf{Y} = \mathbf{Y} 0 - \mathbf{D} \mathbf{F} \mathbf{I} \mathbf{C} \mathbf{A} \mathbf{T} (\mathbf{I} \mathbf{Y} - \mathbf{I})$	PIN00340
		PINO0350
		PIN00360
		PIN00300
		PINOUSIC
		PIN00380
		PIN00390
		P1N00400
		PIN00410
	KET UKN	PIN00420
-	END .	PIN00430
C		TJP00010
C	***************************************	TJP00020
С		TJP00030
-	SUBROUTINE TJPLCT	TJP00040
С		TJP00050
С	RECTANGULAR GUN ANALYSIS PACKAGE	TJP00060
С		TJP00070

C	JCHN B RETTIG 1/31/79	TJP00080
С		TJP00090
С		TJP00100
С	TRAJECTORY PLOT SETUP FOR THE ZETA PLOTTER	TJP00110
С		TJP00120
	REAL*8 V(41,401)	TJP00130
	REAL*8 X(200), Y(200), UX(200), UY(200)	TJP00140
	REAL*8 XMIN,XMAX,CXJ,YMIN,YMAX,DYO,TMIN,TMAX,DT	TJP00150
	CCMPLEX*16 IDENT,TITLE	TJP00160
	COMMON /A/ V	TJP00170
	CEMMEN /B/ XMIN, XMAX, DXO,	TJP00180
	YMIN, YMAX, DYO,	TJP00190
	★ M, N, NXY	TJP00200
	CEMMON /D/ X,Y,UX,UY	TJP00210
	CCMMON /E/ IDENT,TITLE	TJP00220
	DATA WIDTH /4./	TJP00230
	DATA IFLAG /0/	TJP00240
С		TJP00250
С	FIRST TIME THROUGH?	TJP00260
С		TJP00270
	IF (IFLAG.NE.O) GC TO 50	TJP00280
	IFLAG=1	TJP00290
	CALL PLOTF (10,2)	TJP00300
	CALL FACTOR (2.)	TJP00310
С		TJP00320
С	DEFINE SCALES	TJP00330
С		TJP00340
	XL=wIDTH	TJP00350
	YL=WIDTH*SNGL((YMAX-YMIN)/(XMAX-XMIN))	TJP00360
	DX=SNCL(XMAX-XMIN)/XL	TJP00370
	DY=SNGL(YMAX-YMIN)/YL	TJP00380
	XO=SNGL(XMIN)	TJP00390
	YO=SNGL (YMIN)	TJP00400
C		TJP00410
C	TITLE	TJP00420
С		TJP00430
	CALL SYMBOL (YL/3.,XL+1.,.15, IDENT,0.,16)	TJP00440
	CALL SYMBOL (YL/3., XL+.50, .15, TITLE, 0., 16)	TJP 30450
С		TJP00460
С	SCALE ALL FUTURE PLOTTING TO GUN DIMENSIONS	TJP00470
C		TJP00480
	CALL OFFSET (YC,DY,XO,CX)	TJP00490
С		TJP00500
С	DRAW CONDUCTORS	TJP00510
C		TJP00520
	DC 20 I=1,M	TJP00530
	XO=SNGL(DXO)*FLOAT(I-1)	TJP00540
	JTEST=0	TJP00550
	DC 10 J=1,N	TJP00560
	IF (V(I,J).LT.CAND.JTEST.EQ.D) GO TO 11	TJP00570
	IF (V(I,J).GT.CAND.JTEST.EQ.1) GO TC 12	TJP00580
	IF (J.EQ.N.AND.JTEST.EQ.1) GO TO 12	TJP00590
	GC TO 10	TJP00600
11	JTEST=1	TJP0061C
	J ST ART = J	T1000620

	GC TC 10	TJP00630
12	JTEST=0	TJP00640
	JSTOP=J-1	TJP00650
	IF (J.EG.N) JSTOP=J	TJP00660
	IF(JSTART.EQ.JSTOP) GO TO 10	TJP00670
	YO=SNGL(DYO) *FLUAT(JSTART-1)	TJP00680
	CALL PLOTX (YO, XO, 13)	TJP00690
	YO=SNGL(DYO)*FLCAT(JSTCP-1)	TJP00700
	CALL PLOTX (Y0,X0,12)	TJP00710
10	CONTINUE	TJP00720
20	CONTINUE	TJP00730
С		TJP00740
	DC 40 J=1,N	TJP00750
	YO = SNGL(DYO) * FLOAT(J-1)	TJP00760
	ITEST=0	TJP00770
	DC 30 I=1,M	TJP00780
	IF (V(1,J).LT.CAND.ITEST.EQ.0) GO TO 31	TJP00790
	IF (V(I,J).GT.CAND.ITEST.EQ.1) GD TC 32	TJP00800
	IF (I.EQ.M.AND.ITEST.EQ.1) GC TO 32	TJP00810
	GC TO 30	TJP00820
31	ITEST=1	TJP00830
	I START = I	TJP00840
	GC TO 30	TJP00850
32	ITEST=0	TJP00860
	ISTOP=1-1	TJP00870
	IF (I.EQ.M) ISTOP=I	TJP00880
	IF(ISTART.EQ.ISTOP) GO TO 30	TJP00890
	XO=SNGL(DXO) *FLCAT(ISTART-1)	TJP00900
	CALL PLCTX (YO, XO, 13)	TJP00910
	XO=SNGL(DXO)*FLUAT(ISTOP-1)	TJP00920
	CALL PLCTX (Y0,X0,12)	TJP0093C
30	CONTINUE	TJP00940
40	CONTINUE	TJP00950
50	CALL LINE (Y, X, NXY, 2, 0, 12)	TJP00960
	RETURN	TJP00970
C		TJP00980
	END	TJP00990

Appendix III BEAMSPREAD

sular *" 1: prt "* Beams pread *";spc 2 2: dim Q\$[1], R[3],A\$[3,20] 3: 1.758e11→N; 8.856e-12→E; flt 3 4: cfs 13;enp "Number of disc rete intervals? ",M\$if fla13; JAP 0 5: dim J[2,M], Y[0:N] 6: cfg 13;enp "Spacing of intervals (M)?" ,S;if f1913; jmp Ø 7: dsp "Enter initial current densities"; wait 2000 8: for I=1 to M 9: enp J[1,]]; next I 10: ""→Q\$;ent "Want profile plot(Y/N)?";Q\$ 11: cfa 0;if CAP(Q\$)="Y"; sfa 0;0+R[1]; 9+R[2];12+R[3]; trk 0;1df 10 12: if not fla0; sto "Drift" 13: plt 0:0:1 14: for I=1 to M 15: plt S(I-1): J[1,1],2

1

19: flt 3 20: "Drift": 21: ofe 13jenp "Acceleration potential (kV)? ",V;if fla13; JMP 0 22: ofe 13ienp "Drift Space (M)?",D;if fla1 Sijmp 0 23: 0+K+Y[0]; (1080V) 1(-3/ 2) DD/4Er(2N)→C 24: for I=1 to M;K+SJ[1,I]+K 25: IS+CK+Y[[]; J[1, I] (S/(Y[I]-Y[I-1]))→J[2,I] 26: SPC IPPT "Y = ", Y[1], "J = ",J[2,I] 27: next lispc 28: Prt "K = ", K. A/M" ispo 3 29: if not fla0; sto "Drift" 30: plt 0,0,1 31: for I=1 to M 32: plt Y[I-1], J[2, I], 2 33: plt Y[]], J[2,1],2 34: next I 35: plt Y[M],0, 2ipen 36: sto "Drift" 37: end .

Appendix IV CONVOLVE

Bean = ,". Convolution * "ispo 2 1: dim M[2];dim G[-16:16];dim Y[65];dim N[3]; rad 2: enp "Diode spacing?",S, "Diode width?", 14 3: enp "No. beam points?",Q: "Increment betw een points?",D 4: enp "Start beam drive?", N[1], "End beam drive?",N[3], "Increment?", N[2] 5: enp "Pos. sens.?",M[1], "Neg. sens.?", M[2], "Data sour ce?" , r2 6: if r2#0;enp "File?",r9;jmp 3 7: enp "Beam type?",r16 8: if r16;enp "Truncation?", r17 9: enp "Highest harmonic?":C, "Plot?",r8,"Sat uration drok?", r12 10: if r8=1;sf9 1 c-a: 14N1

- -!--14: if r8=2;sf9 3 15: dim F[-Q:Q] 16: if N[2]=0; JMP 3 17: (N[3]-N[1])/ N[2]+r5 18: dim P[2,0:r5 +1] 19: N+S→L 20: "Beam":cll 'Generate'(Q) 21: cll 'Zero' 22: enp "DC Tran sfer?": r1 23: if r1:c11 100' 24: fmt 2, f6.2, 2x, 68.2 25: SPC iflt 4; prt "Beam profi le"ispc 26: for I=-Q to Q;wrt 16.2, ID, F[]]inext 1 27: N[1]+r3:0+r1 28: "Response":s PC 29: cll 'Convolv 01 30: cll 'Fourier 1 (6) 31: cll 'Efficie ncy ! 32: if N[2]=0; eto "Quit" 33: (r3-N[1])/ .N[2]+r4. 34: r3t2+P[1+r4] 00.

IV-1

"Response" 37: max(F[*])→r1 3:Q+I 38: if F[l]>≠,5r 131 JMP 2 39: I-1>0+1;jmp -1 40: rin(S+10,S-ID+W)+r3 41: cll 'Convolv p. ? 42: cll 'Fourier 2 43: A[1] 12+P[2, r5+1] 44: dsp "Transfe r slot" 45: ste 46: scl -20,10,-20,10 47: axe 0,0,2,2; sf = 14 48: for I=0 to r5;10109(P[1; []/r3†2)→X;10lo 9(P[2,]]/P[2, r5+1])+Y 49: prt "Pin", X, "Pout", Yispa 50: (f X<-20;-20+X 51: if YK-20;-20+1 52: plt X,Y 53: next 1 54: peniplt -20, -201pen 55: "Quit":prt *************** **"ispc 3jend 56: "Generate":i

1.0.0 -58: if r16ijmp 3 59: for 1=-p1 to pi;i+F[]] 60: next lijmp 6 61: for I=-p1 to pliif (exp(-6.9112/012) +F[]])>r17;r17+F[I] 62: next lijmp 4 63: "Data":for I=-pi to pi; ent F[1] 64: next I 65: trk lircf r9,F[*];trk Ø 66: ret 67: "Tape":trk 1;1df r9,F[*]; trk 0 68: ret 69: "Fourier":1/ 32002 70: esb "Foure" 71: if p1=0isto "Finish" 72: prt "Fourier Current Harmon ics (dB)";spc 73: fmt 0,f1.0, \$8.2 74: if (abs(R[0] /A[1])+r7)>1e-10;wrt 16;"A["; 0;"] = ";20109(r7) 75: for I=1 to N 76: if (cbs(A[I] /A[1])+r7)>1e-101 -+ 16. "A[",

IV-2

10, wrt 16, "B[", I,"] = ",20109(r7) 78: spc inext I 79: "Finish":ret 80: "Foure":radi cf = 2;1+J;0+I; 21+03 81: if (I+1→I)>6 5;9to +8 82: -n+(I-1) ¤2→X ; Y [] > Y ; if I=1 or [=65;1+M; 9to +3 83: if M=4;2+M; sto +2 84: 4+M 85: cos(2πX/¤3→E)→p4→F;sin(E)→p 5+G 86: MYF+A[J]+A[J];MYG+B[J] +B[J] 87: if (J+1+J) <= Nip4F-p5G+T; p5F+p4G+G;T+F; 9to -1 88: 1+J; sto -7 89: Y[1]+4Y[2]+ Y[65] + p4;3+1 90: p4+27[1]+ 4Y(1+1] * # 4; jmp (I+2→I)>=65 91: p4p2/3p3+R[0];1+J 92: 28[J]p2/3p3+ A[J];28[J]p2/ 3⊳3≁B[j];jmp (J+1+J)>N 93: ***

· · ·

) →r10 96: next I 97: if r10=0; 0+r11jomp 2 98: 32A[1]r12/ r10→r11 99: ixd 2;prt "Displ = ",r3 100: fxd 4iprt "Effic = ",r11 101: spc iret 102: "Convolve": for I=-16 to 16 103: 0+G[]] 104: r3sin(If/ 32) +P 105: for J=-Q to Q 106: if abs(F+ JD)>L;0→H;sto "Sum" 107: if abs(P+ JD) <S;0+H; ato "Sum" 108: if P+JD<=-S;-M[2] +H; sto "Sum" 109: if P+JD>=S; M[1] + H 110: "Sun":F[J]H $D+G[1] \rightarrow G[1]$ 111: next J 112: next I 113: max(G[*])→Z 114: for I=-16 to i6;Gil)→Y[I+ 17] 115: next I 116: for I=15 to -16 by -1;

IV-3

91/4,-1.2,1.2 120: if fl91; jmp 3 121: axe 0,0,1/ 4,.2 122: sfg 1 123: for K=1 to 65 124: plt (K-1) 1/ 32, Y[K]/Z 125: next K 126: pen 127: "Done":ret 123: "DC":enp "No. of transfe r points", p1 129: 1.5(W+S)/ p1+p2 130: for I=1 to plilp2+P 131: 0+p3 132: for J=-0 to Q 133: if abs(F+ JD) (S;0+H;sto "Add" 134: if cbs(P+ JD)>L:0→Histo "Add" 135: if P+JD<=-S;-M[2]+H;sto "Add" 136: if F+JD)=S; M[1] +H 137: "Add":F[J]H D+p3+p3 138: next J 139: prt "Drive" ,Ip2,"Current", - 01 - - -

Appendix IV KEY PERSONNEL DOUGLAS B. CLARK, Member of the Technical Staff, Tube Division, Devices Group. Born December 31, 1946, Oakland, California. Nine years experience. B.S., Electrical Engineering, University of California at Berkeley, 1969. Graduate studies in Electrical Engineering at Loyola University of Los Angeles.

Mr. Clark is currently a Project Engineer with the Electron Bombarded Semiconductors Group. He is responsible for design and development of state-of-the-art EBS devices.

From February 1974 to May 1977, Mr. Clark was with the Solid State West Division of Varian Associates in Palo Alto, California. He was Project Engineer on a variety of development and production projects involving Gun diode amplifiers, YIG-tuned Gunn Oscillators, and bipolar transistor amplifiers.

From June 1969 to February 1974, Mr. Clark was with the Hughes Aircraft Company, Electron Dynamics Division, where he was a Member of the Technical Staff. His responsibilities included that of Project Engineer on stateof-the-art, dual mode, multi-octave traveling-wave tubes. He also was responsible for production of high pulse power space tubes. JOHN B. RETTIG, Member of the Technical Staff, Tube Division. Born January 8, 1954, Toledo, Ohio. B.S.E.E., 1977, M.S.E.E., 1978, Purdue University.

Mr. Rettig is presently working on the development of an EBS space amplifier for NASA Goddard Research Center that must meet stringent linearity and efficiency specifications.

Formerly he was a research assistant at Purdue University, engaged in High Gradient Magnetic Separation studies. This involved experimental quantization of 3-dimensional buildups of small paramagnetic particles on saturated ferromagnetic wires.

Mr. Rettig is a member of Tau Beta Pi and IEEE.