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Production Engineering Measure on
High Perveance Cathode-Ray Tubes

SIXTH QUARTERLY PROGRESS REPORT

This report covers the period:
9 September 1962 to 8 December 1962

Contract Number DA 36-039 SC-85965
Order Number 6020-PP-61-81-81

U. S. Army Signal Supply Agency
Philadelphia, Pennsylvania

CATHODE RAY TUBE DEPARTMENT
GENERAL  ELECTRIC
Syracuse, N. Y.

Production Engineering Measure on
High Perveance Cathode-Ray Tubes

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Object of Study: To develop a low
drive (high perveance) cathode-ray
tube incorporating electron guns of
Focus Reflex Modulation design.

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I. ABSTRACT

This is the sixth quarterly report describing the progress of the production engineering measure on high perveance cathode-ray tubes for the period ending 8 December 1962. After attempts to reduce the wide beam angle inherent in the FRM structure were unsuccessful, the wide beam angle problem was circumvented with the development of an electrostatic lens utilizing the spiral optics technique. After experimental results on the device proved successful, the construction of engineering samples was begun.

II. PURPOSE

The Focus Reflex Modulation (FRM) principle in electron-gun design has demonstrated a capacity for low level modulation that makes the concept useful for transistorized display equipment. The FRM development program has been based on theoretical electron-optics work and laboratory-produced models. The techniques used in the manufacture of these models have been very exacting so that correspondence between theory and measured results could be achieved. This has required precisely machined parts incorporating designs based on complex mathematical relationships.

Manufacturing methods for the current developmental models are considerably different from those used in a relatively high volume cathode-ray tube production facility. A review of the FRM structure from the manufacturing standpoint needs to be made, particularly in terms of part shapes, stamping techniques, alignment requirements, and gun assembly techniques.

The focus reflex electron-gun designs also have to be adapted for use in military cathode-ray tube envelopes and in accordance with military specifications.

The logical steps toward providing manufacturing capability of focus reflex modulation cathode-ray tubes would be as follows:

1. Establish tube designs that would be suitable for quantity production and would meet Signal Corps specifications.

II. PURPOSE (Continued)

2. Establish a limited manufacturing facility capable of producing two hundred-gross focus reflex modulation tubes per month on a single-shift basis. The cathode-ray tubes to be produced are divided into two representative types. The General Electric Company development tube number Z4808 has been assigned to the twelve-inch round faceplate cathode-ray tube that is to meet the requirements of Signal Corps specification SCS-105. The other type is a five-inch diameter faceplate cathode-ray tube which has been assigned the General Electric Company development number Z4809 and which is to meet Signal Corps specification SCS-106.
3. Train unskilled or semiskilled direct labor operators to perform the process work.
4. Test the productivity and quality control with a pilot run.

A program such as this was begun with the awarding of Signal Corps Contract DA 36-039 SC-85945 to the General Electric Company. The progress of this program during the sixth three-month period is described in the following sections.

III. TUBE DESIGN

Efforts to reduce the large beam angle which is inherent in the high current operation of the FRM design have been largely unsuccessful. In those designs where the beam angle has been reduced, a spot distortion, which has been introduced, is undesirable in view of the spot-size requirements of this contract. When a large beam angle FRM gun is focused by a conventional low voltage electrostatic lens, the result is excessive beam diameter, in the focus lens, which gives rise to distortion in the focused image. If the focus lens is stopped down with a limiting aperture to a point where a good focusing characteristic is obtained, then excessive beam current is intercepted by the limiting aperture and prevented from reaching the phosphor screen. In view of the unsuccessful attempts to reduce the beam angle to a conventional value, Dr. Schlesinger of this department began work on designing a focus lens that would be capable of focusing the large-diameter beam. The initial lens-design effort, as shown in Figure 1, was constructed of machined-metal electrodes and ceramic separators. An experimental tube was built, and the data obtained showed an improvement in focusing characteristic over a conventional lens structure. The amount of improvement was not sufficient, however; and a different approach was decided upon. Dr. Schlesinger's work on spiral optics under Contract #AF 33(657)-7682 has demonstrated the ability to focus large-diameter beams successfully, and a tube utilizing this principle was constructed. An einzel lens was formed by painting a conductive

FOCUS REFLEX MODULATION GUN ASSEMBLY
WITH COMPACT FOCUS LENS

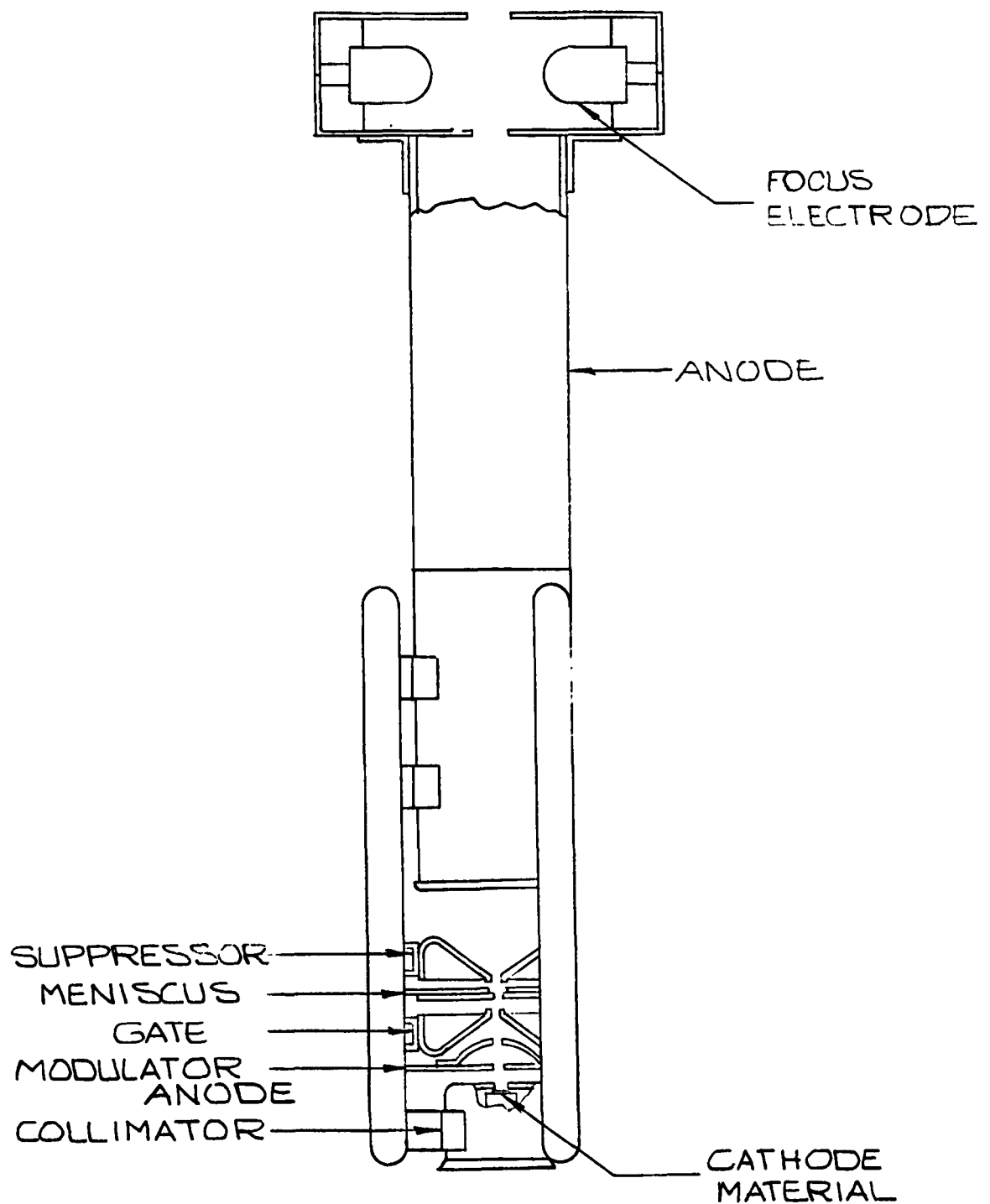


FIGURE 1

III. TUBE DESIGN (Continued)

spiral on the inside of a piece of glass tubing. This anode-lens assembly was then joined to a Focus Reflex Modulation structure.

Test results on the device are shown in Figure 2, and a comparison is made between data taken on a conventional 5AHP7A, operated under low-drive conditions, and data taken on the Focus Reflex Modulation tube.

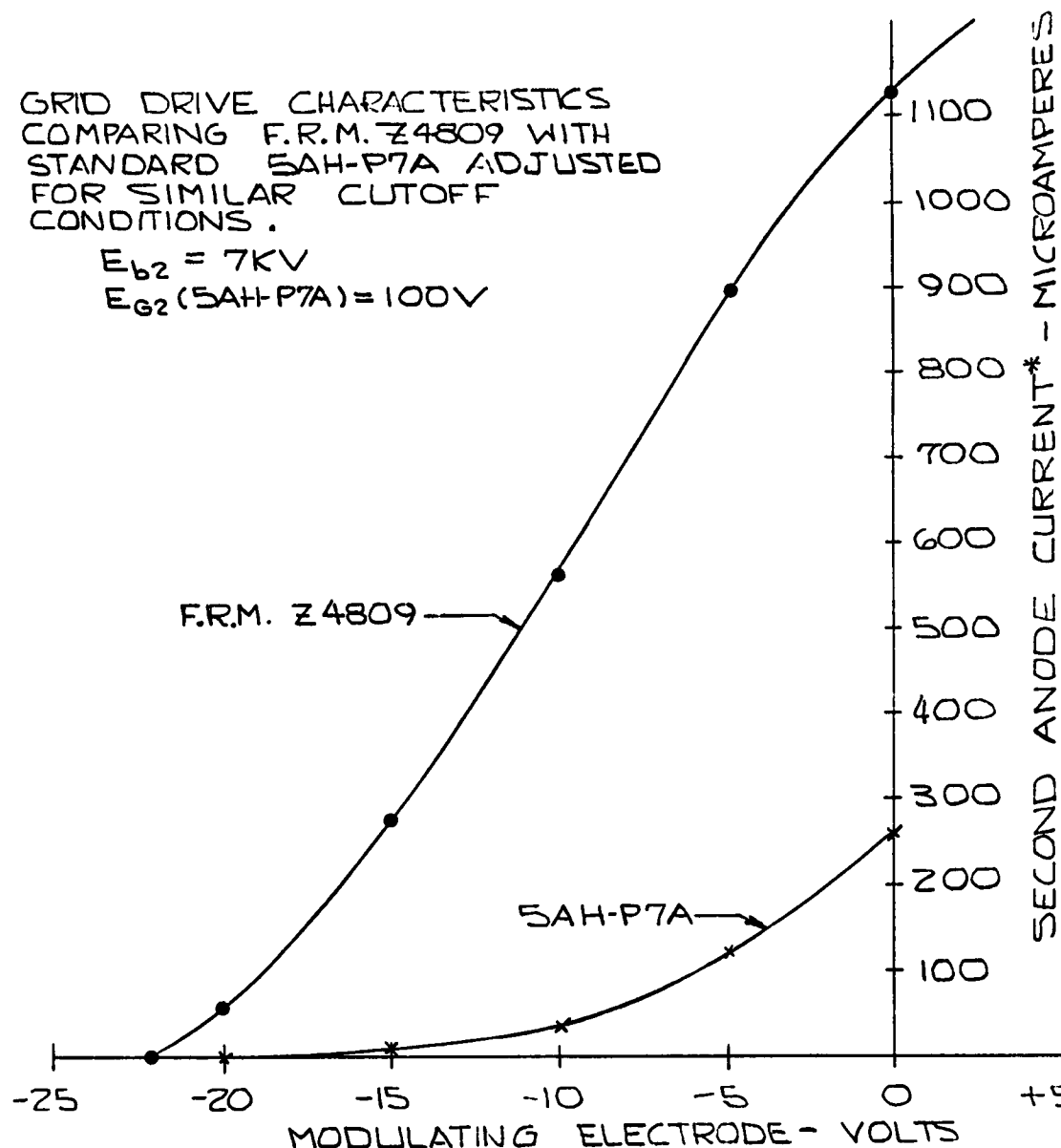
The 5AHP7A was chosen as the comparison tube because of its identical external dimensions and because its electron gun is representative of those used in most magnetic-deflection radar display tubes. The FRM gun, in its present form, is shown in Figure 3. When operated in conjunction with a resistive divider network, it requires five different voltages. These voltages are: 6.3 volts A.C. for the heaters; an adjustable positive D.C. voltage of 0-30 volts for the collimation electrode; a 500-volt D.C. supply for the modulator anode; a bias voltage for the modulating electrode; and a 7-KV high-voltage supply for the second anode. Voltages for the meniscus, suppressor, and focus electrodes are obtained by a simple resistor-divider network.

The spiral-focus lens, as shown in Figure 3, is operated in the following manner: The two ends of the resistive spiral are connected by metal straps, welded to the metal end caps, which pass down the outside of the glass cylinder. The upper-anode end cap is connected by spring contacts to the aquadag coating on the inside wall of the bulb and, hence, to the 7000-volt second-anode power supply. The conductive stripe in the center of the spiral is brought out through

GRID DRIVE CHARACTERISTICS
COMPARING F.R.M. Z4809 WITH
STANDARD 5AH-P7A ADJUSTED
FOR SIMILAR CUTOFF
CONDITIONS.

$E_{b2} = 7KV$

$E_{g2} (5AH-P7A) = 100V$



	E_{b2} VOLTS	I_{b2} MICROAMPERES	LINE WIDTH "A" INCHES	LIGHT OUTPUT FT. L.
Z4809-P7A	7000	100*	0.011	60
5AH-P7A	7000	100	0.009	39

*NOTE: Z4809 ANODE CURRENTS ABOVE ARE ACTUAL
BEAM CURRENTS AND DO NOT INCLUDE THE
RESISTIVE SPIRAL CURRENTS ALSO FLOWING
IN THE 2ND ANODE CIRCUIT.

FIGURE 2

FOCUS REFLEX MODULATION GUN ASSEMBLY
WITH SPIRAL FOCUS LENS ELECTRODE

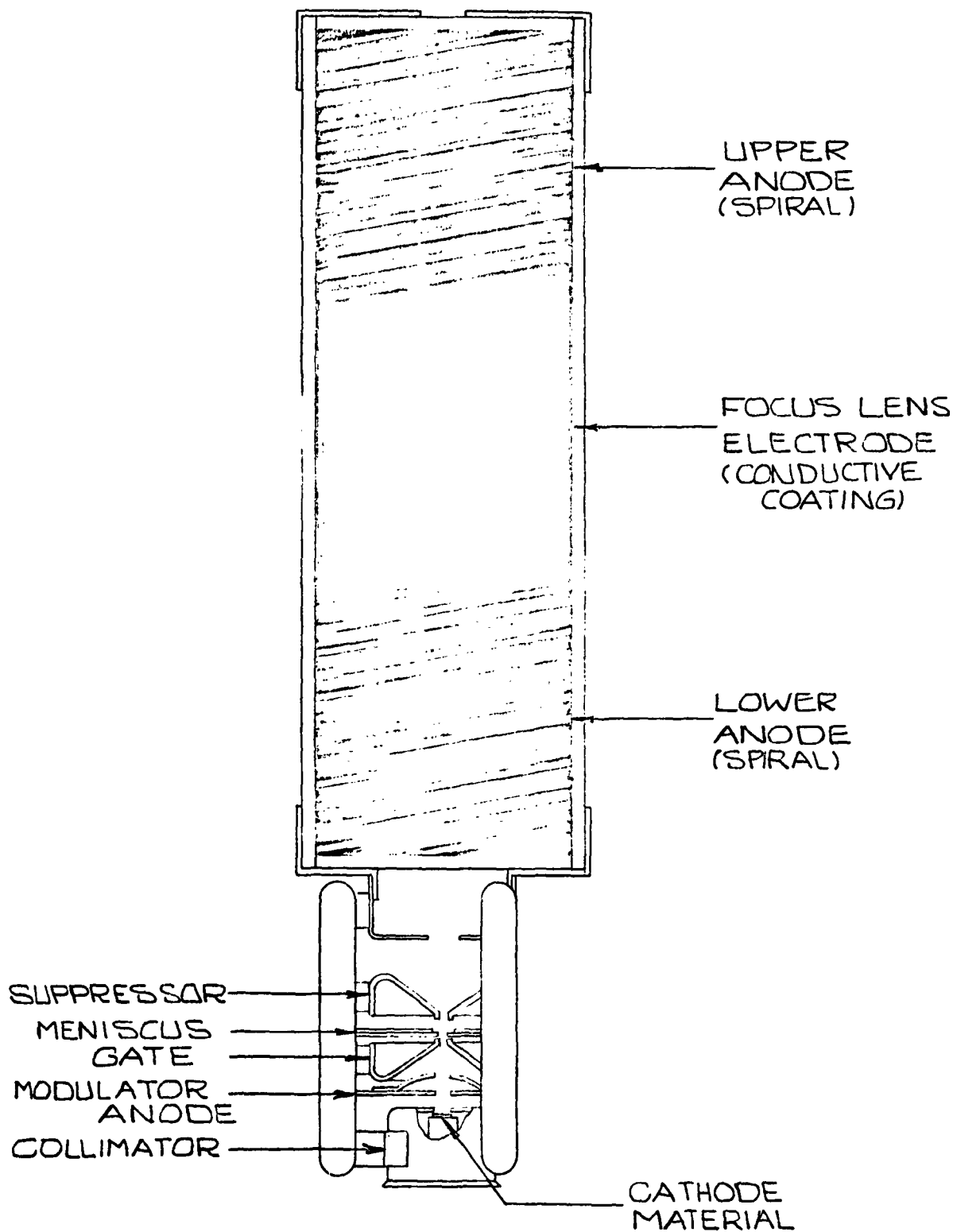


FIGURE 3

III. TUBE DESIGN (Continued)

the base to a resistor network, permitting focus adjustment. Smooth focusing action is obtained on the laboratory model with these connections. For comparison purposes, the spiral lens was disabled; and the tube was operated with a good magnetic focus lens to observe spot quality. This test showed no appreciable difference in focusing performance of the two lenses, even under high-beam-current conditions. One disadvantage of the spiral lens is readily apparent. Inherent in spiral-lens operation is the presence of resistive current being drawn from the high voltage power supply. The present design limit is one milliamperere maximum of spiral lens current.

IV. ENGINEERING SAMPLE TUBES

Construction of tubes for submission as engineering samples is underway. The tubes consist of both the 5-inch and 12-inch versions, as required by the contract. Due to the adoption of the spiral lens technique, some of the parts needed for the production effort will require outside vendor tooling; however, for the sample tubes, parts fabrication is being accomplished by the Department machine-shop facility.

V. CONCLUSIONS

The inherent wide-beam-angle problem of the FRM guns has been circumvented by the adoption of a spiral-optics electron lens capable of focusing large-diameter electron beams. With the removal of this design obstacle, work is proceeding on the production of FRM tubes for approval as engineering samples.

VI. PROGRAM FOR NEXT INTERVAL

Submission of engineering sample tubes for approval will be accomplished in the next report period. Production drawings and fixtures will be made; and vendor parts, ordered for the production-run requirements. The manufacture of the spiral-lens element presents several problem areas, and different methods of producing this lens will be studied.

VII. PUBLICATIONS AND REPORTS

Monthly Status Report #16 - Edward T. Rate

Monthly Status Report #17 - Edward T. Rate

Monthly Status Report #18 - Edward T. Rate

VIII. PERSONNEL

The Manpower Hours Table on page 15 shows the estimated and actual hours worked during the sixth-quarter period. Laboratory personnel time required to process the experimental tubes is included under the working leader heading.

TABLE I

MANPOWER HOURSESTIMATED AND ACTUAL

<u>Contributor</u>	<u>Sixth Quarter</u>		<u>Grand Total</u>	
	<u>Estimated</u>	<u>Actual</u>	<u>Estimated</u>	<u>Actual</u>
E. T. Rate	60	150	600	772
Dr. K. Schlesinger and Assistant	0	80	80	159
W. J. Noroski	30	0	160	0
D. Botsford	60	0	180	0
Drafting	20	6	145	53
Working Leader including Laboratory	60	133	510	928
Machine Shop	120	28	420	436.5
Factory	50	0	50	0
Test Equipment	0	0	240	16
	—	—	—	—
SUB TOTAL	400	397	2385	2364.5

FOCUS REFLEX MODULATION PROGRESS CHART

Phases	Quarter	1			2			3			4			5			6			7			8		
	Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1. REPORTS a. Monthly b. Quarterly c. Final																									
2. TUBE DESIGN a. Z-4808 Design b. Z-4809 Design																									
3. FACILITY a. Specification and Design b. Procurement and Preparation																									
4. PERSONNEL TRAINING a. Leader b. Direct Labor Operators																									
5. PRODUCTION a. Engineering Samples b. Pilot Run of 200 Tubes c. Preproduction Samples																									

Proposed  Actual 

GENERAL ELECTRIC

INDUSTRIAL AND MILITARY CATHODE RAY TUBES

PROPOSED SPECIFICATIONS (MIL-E-1 FORM)

Z-4808
Page 1
11-23-60

The requirements and tests of the latest issue of Specification MIL-E-1 shall apply except as otherwise required herein.

12½ INCH ROUND

SPHERICAL

ELECTROSTATIC FOCUS

P7 PERSISTENCE

MAGNETIC DEFLECTION

MODULATION: FOCUS REFLEX

<u>RATINGS:</u>	Ef V	Ec Vdc Collimator	Ea Vdc Modulator Anode	Eb1 Vdc	Eb2 Vdc	Eh-k Vdc	Eg Gate	Em Aperture
Absolute Maximum:	6.3±10%	30	1000	900	10,000	-180	0	200
Minimum:	--	-50	--	-450	--	--	-50	--
Test Conditions:		Adjust	Adjust	Adjust	7000	--	Adjust	150

<u>REFERENCE</u>	<u>TEST</u>	<u>CONDITIONS</u>	<u>MIN.</u>	<u>MAX.</u>	<u>UNITS</u>
4.9.2.1	Dimensions	Per Drawing Fig. 1			
4.6.1	Pre-heating				
4.5	Holding Period				
4.9.18.1.2	Carton Drop				
4.10.8	Heater Current	If	540	660	ma
4.12.1.2	Voltage Breakdown				
4.12.1.4	Voltage Breakdown				
4.12.2.2	*Gas Ratio			.25	
1 4.12.3.3	*Alignment, Side Terminal and Base	Pin #3			
4.12.3.6	*Alignment, Neck and Bulb				
4.12.3.8	*Face Tilt				

1 Revised 10-11-61

GENERAL ELECTRIC

INDUSTRIAL AND MILITARY CATHODE RAY TUBES

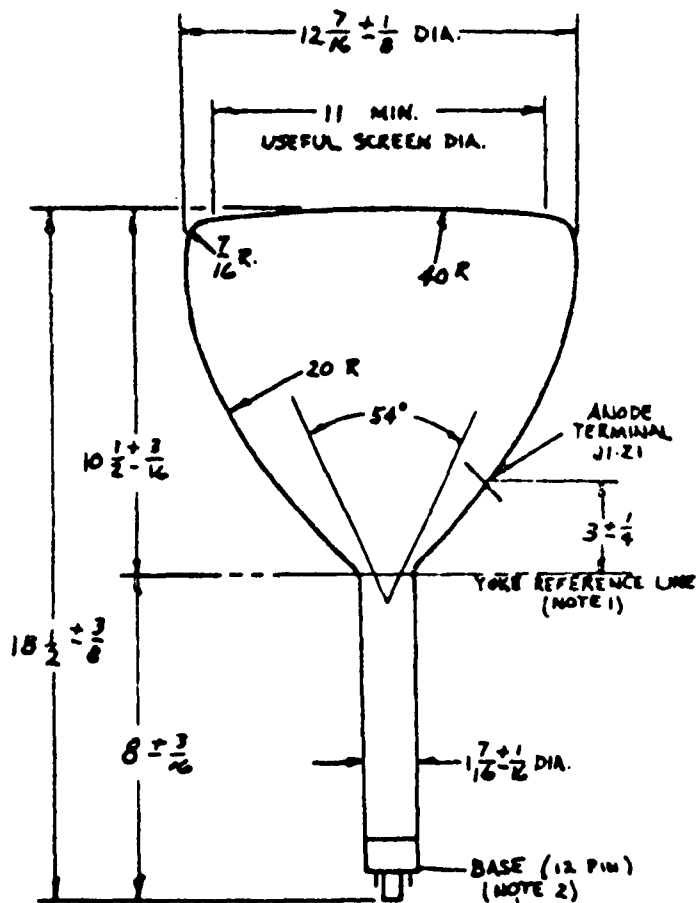
Z-4808
Page 2
11-23-60

<u>REFERENCE</u>	<u>TEST</u>	<u>CONDITIONS</u>	<u>MIN.</u>	<u>MAX.</u>	<u>UNITS</u>
4.12.3.9	Neck Straightness	Cylinder 1.500 + .006 I.D. - .000			
4.12.4.1	**Cathode Illumination				
4.12.4.2	*Stray Emission	Eb2=10KV Eb1=700 Ic=0			
4.12.5.1	Blemishes				
4.12.5.3	Modulation	Ib=750 Eg		18	Volts
4.12.5.4	*Screen (P-7)				
4.12.5.6	*Line Width "A"	Ib2=100µa		.012	Inches
4.12.7.1	Spot Position			18	mm
4.12.9	Grid Cutoff Voltage #1	Ib2=5µamp		20	Volts
- - - -	Grid Cutoff Voltage #2	Ib2=0µamp		40	Volts
- - - -	Focus Voltage	To be determined			
4.12.3.1	*Heater Cathode Leakage				
4.10.14	Capacitance Cg to all			9	mmf
4.9.11	**Pressure				
4.11.2	Life Test	Group C Eb=10,000 Vdc Ib=100µAdc			
4.11.4	Life Test End Point	Line Width A Ib2=100µa Modulation Eg		.018 22	Inches Volts
4.9.5.1	*Torque				
- - - -	Aperture Alignment	Note 1		25	Percent

NOTES:

- The distance between the center of the undeflected, unfocussed spot at low beam current, and the center of the image of the final lens limiting aperture shall not exceed the percentage of the limiting aperture diameter specified.

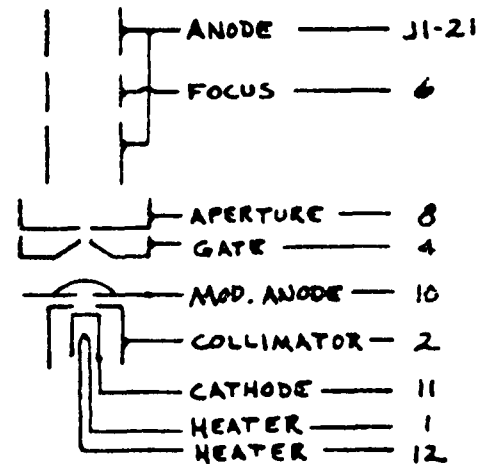
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Z4808

BASING SCHEMATIC DIAGRAM

ELEMENT	PIN NO.
---------	---------



1. Reference line is determined by the plane of the upper edge of the reference-line gage (retma No. 112) when the gage is resting on the cone.
2. Anode terminal aligns with Pin No. 3 position ± 10 degrees.

GENERAL ELECTRIC

INDUSTRIAL AND MILITARY CATHODE RAY TUBES PROPOSED SPECIFICATIONS (MIL-E-1 FORM)

Z-4809
Page 1
11-23-60

The requirements and tests of the latest issue of Specification MIL-E-1 shall apply except as otherwise required herein.

5-INCH ROUND

SPHERICAL

ELECTROSTATIC FOCUS

P7 PERSISTENCE

MAGNETIC DEFLECTION

MODULATION: FOCUS REFLEX

<u>RATINGS:</u>	Ef V	Ec Vdc Collimator	Ea Vdc Modulator Anode	Ebl Vdc
Absolute Maximum:	6.3±10%	30	1,000	900
Minimum:	-	-50	-	-450
Test Con- ditions:	6.3	Adjust	Adjust	Adjust
<u>RATINGS:</u>	Eb2 Vdc	Ehk Vdc	Eg Gate	Em Aperture
Absolute Maximum:	10,000	-180	0	200
Minimum:	-	-	-50	.
Test Con- ditions:	7,000	-	Adjust	150

<u>REFERENCE</u>	<u>TEST</u>	<u>CONDITIONS</u>	<u>MIN.</u>	<u>MAX.</u>	<u>UNITS</u>
4.9.2.1	Dimensions	Per drawing Figure 1			
4.6.1	Pre-heating				
4.5	Holding Period				
4.9.18.1.2	Carton Drop				

<u>REFERENCE</u>	<u>TEST</u>	<u>CONDITIONS</u>	<u>MIN.</u>	<u>MAX.</u>	<u>UNITS</u>
4.10.8	Heater Current	If	540	660	ma
4.12.1.2	Voltage Breakdown				
4.12.1.4	Voltage Breakdown				
4.12.2.2	Gas Ratio				
① 4.12.3.3	*Alignment, Side Terminal and Base	Pin No. 5			
4.12.3.6	*Alignment, Neck and Bulb				
4.12.3.8	*Face Tilt				
4.12.3.9	Neck Straightness	Cylinder 1.500 + .006 I.D. - .000			
4.12.4.1	**Cathode Illumination				
4.12.4.2	*Stray Emission	Eb2 = 10KV Eb1 = 700 Ic=0			
4.12.5.1	Blemishes				
4.12.5.3	Modulation	Ib=750 Eg		18	Volts
4.12.5.4	*Screen (P-7)				
4.12.5.6	*Line Width "A"	Ib2 = 100µa		.012	Inches
4.12.7.1	Spot Position			18	mm
4.12.9	Grid Cut-Off Voltage No. 1	Ib2 = 5µa		20	Volts
- - - -	Grid Cut-Off Voltage No. 2	Ib2 = 0µa		40	Volts

① Revised 10-11-61

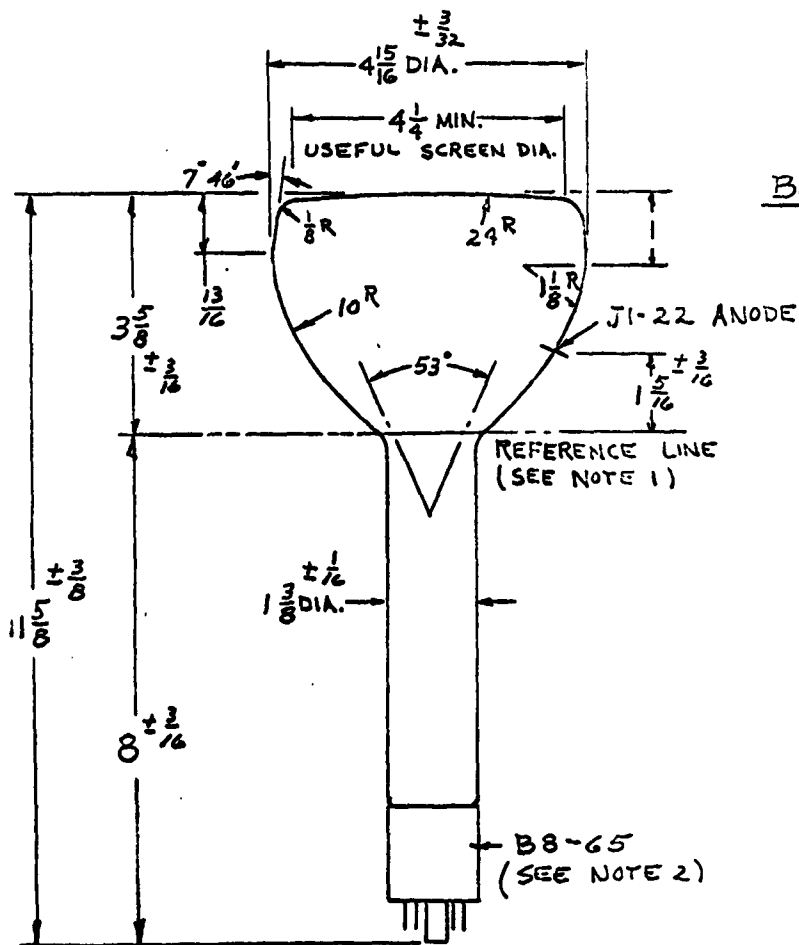
<u>REFERENCE</u>	<u>TEST</u>	<u>CONDITIONS</u>	<u>MIN.</u>	<u>MAX.</u>	<u>UNITS</u>
- - - -	Focus Voltage	To be determined			
4.12.13.1	*Heater Cathode Leakage				
4.10.14	Capacitance Cg to all			9	mmf
4.9.11	**Pressure				
4.11.2	Life Test	Group C Eb = 10,000 Vdc Ib = 100 μ Adc			
4.11.4	Life Test End Point	Line Width "A" Ib2=100 μ a Modulation Eg	.018 22	Inches Volts	
4.9.6.1	*Torque				
- - - -	Aperture Alignment	Note 1		25	Percent

NOTES:

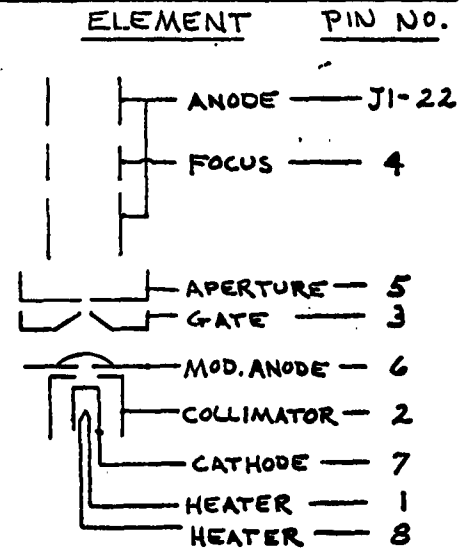
1. The distance between the center of the undeflected, unfocused spot at low beam current, and the center of the image of the final lens limiting aperture shall not exceed the percentage of the limiting aperture diameter specified.
2. A beam alignment magnet is required.

ER:jr

Z 4809



BASING SCHEMATIC DIAGRAM



NOTES:

1. Reference line is determined by the point where a gage 1.430 ± 0.003 inches inside diameter and 2 inches in length stops against the cone.
2. Anode terminal aligns with Pin-No. 5 ± 10 degrees.

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