GUN DESIGN FOR 8" TV TUBE

BY

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EQUIPMENT TUBE PRODUCT ENGINEERING

March 9, 1960

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Introduction

The project of designing an electron gun for an 8 inch, transistorized TV portable was undertaken early in 1959. Although the project was later discontinued, the gun design was completed to gain an understanding of the problems in the small tube and to have a design for possible future use.

Initially, the gun was to have an ion trap, which accounts for a longer gun necessary for trapping, but when aluminizing through the necked down bulb was developed a straight gun could be used.

Likewise, because of the difficulty in depositing getter through a necked down bulb, a large neck as used on 70° and 90° tubes was incorporated for flashing getter in the neck section. Even though the large physical size was not principally intended for freedom of gun design, it proved to be of great benefit in optimizing this design.

Summary

This tube, requiring a 30% reduction in spot size, was made with a high quality picture as a result of the freedom from restrictions on the design. It is recommended that necked down tubes incorporate 1 7/16" necks to allow freedom in gun design.

Discussion

A simplified description of electron gun design will introduce this discussion followed by a statement of the problem and its restrictions. The specific procedure of design is then given.

Gun Design

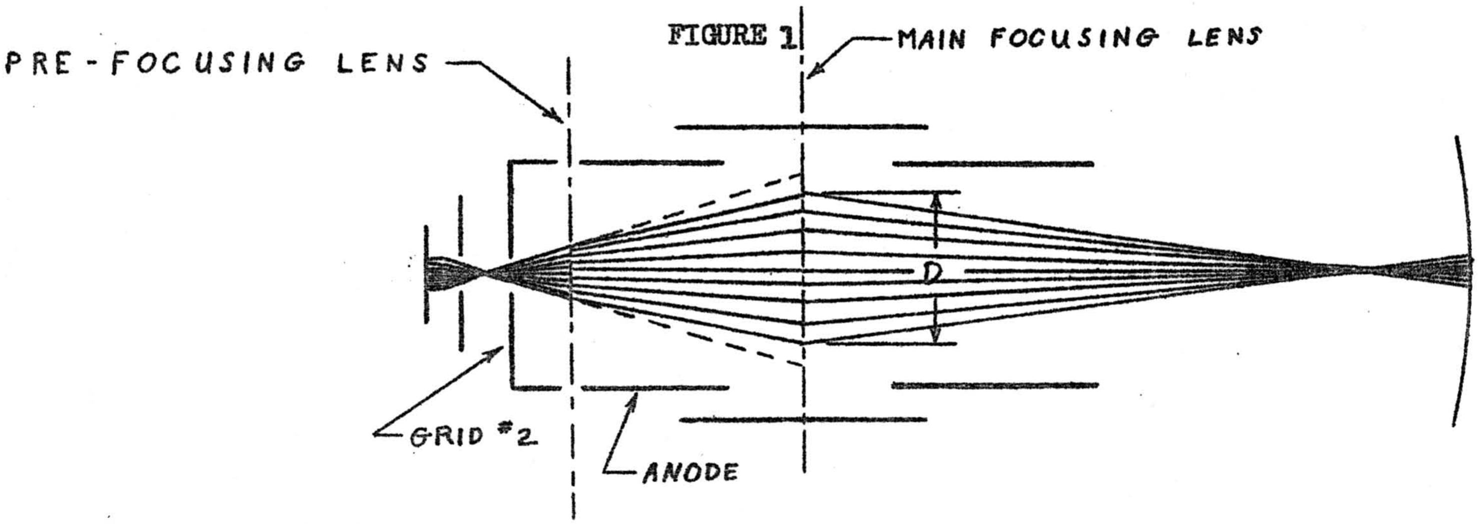
Basically, the design of an electron gun is a compromise between spot size on one hand and depth of focus and blooming on the other. The spot size (d_s) of a focused beam is inversely proportional to the beam diameter in the focusing lens (D);

$$d_s \sim \frac{1}{D} \quad .$$

This follows from eq. 1 of appendix I as formulated by Dr. Gundert from first order theory of electron optics. The parameter (D), over simplified in figure 1, is described in the appendix. The depth of focus (edge focus compared with center focus) and the blooming characteristic are adversely affected by a large beam diameter in the focusing lens.

The diameter of the beam in the focusing lens is a function of the pre-focusing lens and may be adjusted by changing the pre-focusing lens strength, see fig. 1.below. The strength of the pre-focusing lens can be controlled by physically altering the grid #2 - anode configuration.

FIGURE 1



One sees the diameter (D) is also dependent upon the distance from the cathode to the plane of D in the focus lens.

These brief comments should be sufficient for the design of this gun for the 8" tube.

Problem

The restrictions on the gun design, both physical and electrical, had to be determined for this 8" - 90° tube. In retrospect, we can calculate the difficulty of the design problem compared to a standard 21"-110° tube, using the chosen specification. This calculation is made in appendix II showing the spot size as a percentage of raster height is 1.3 times that in a 21" tube. For this reason, the 1 7/16" neck size with a necked down region for the yoke was important from the standpoint of gun design.

Specifications

The specifications which restrict or allow freedom of design are reproduced on the next two pages as prepared by C. A. Perkins. The most pertinent factors derived from the tube specifications are listed below.

1.	Inside neck diameter, min.	1.12"
2.	Max. usable neck length	2.50"
3.	Lens to screen distance	7.00"
4.	Raster height	5.00"
5.	Sweep angle (as related to depth of focus)	90°
6.	Anode voltage	7.5 KV
7.	Cut off at Eg2 = 230V	33-35 V.

Z4604
CATHODE RAY TUBE

8 INCH, RECTANGULAR, GLASS

FOCUS -- ELECTROSTATIC

DEFLECTION -- MAGNETIC

90 DEGREE DEFLECTION ANGLE

ALUMINIZED SCREEN

FACEPLATE -- SPHERICAL

NON ION TRAP GUN

PRELIMINARY

OBJECTIVE TECHNICAL INFORMATION

GENERAL

ELECTRICAL SPECIFICATIONS

Heater Voltage..8.4 Volts
Heater Current.. .225 ± 10% Amperes
Heater Warm Up.. 11 Seconds

MECHANCIAL

Overall Length.. 8 3/8 Inches
Neck Length.. 4 1/4 Inches
Bulb Dimensions (For detail see M69982-32A220 and Lancaster A-1966-3 (1))
Diagonal.. 7 1/2 Inches
Width.. 6 5/8 Inches
Height.. 5 1/8 Inches

MAXIMUM RATINGS

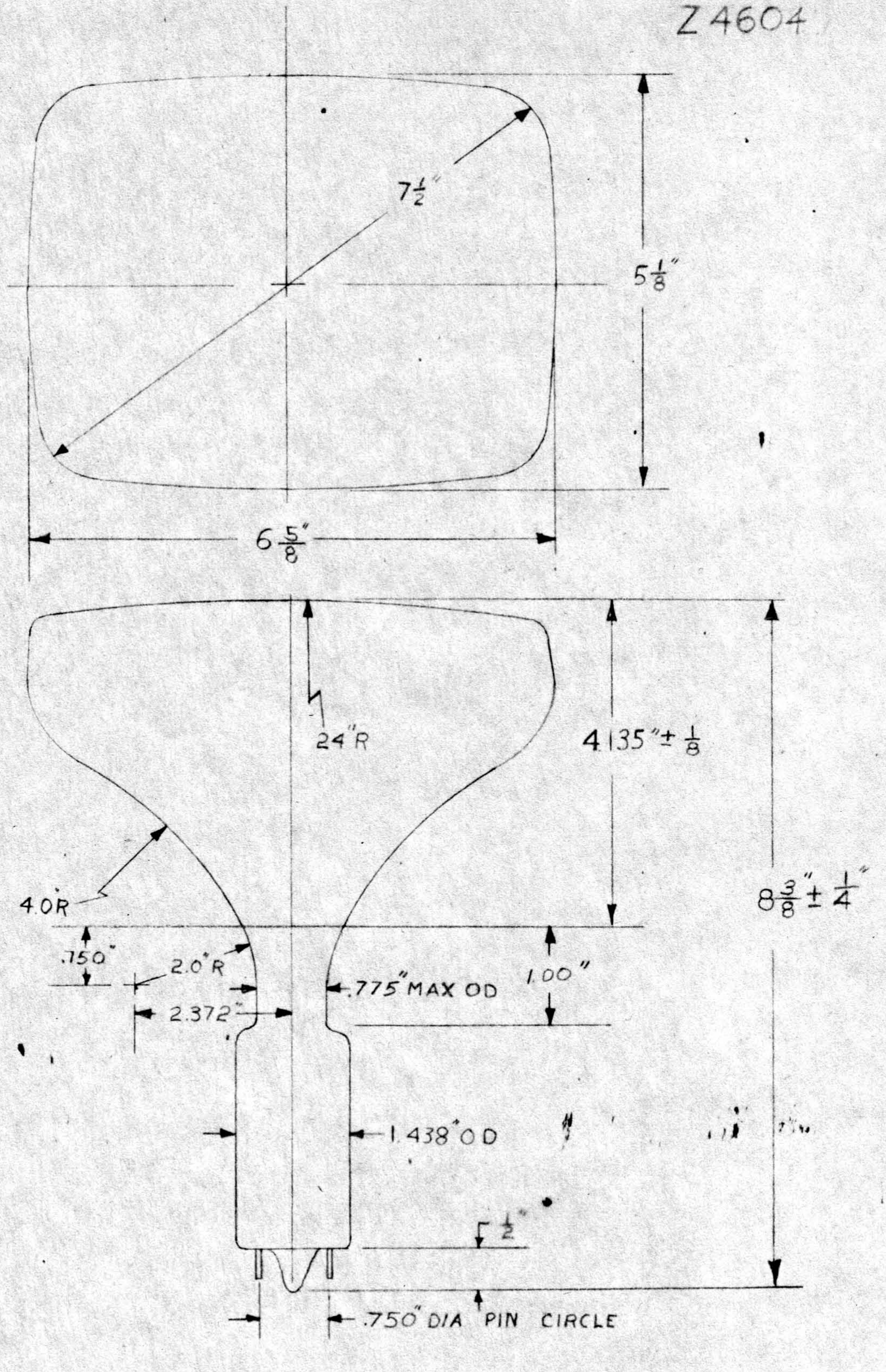
Anode Voltage..10,000 Volts
Focusing Electrode Voltage.. -500 to 1000 Volts
Grid 2 Voltage.. 300 Volts

TYPICAL OPERATING CONDITIONS

Anode Voltage..7,000 Volts
Focus Electrode Voltage for Focus.. 0 to 500 Volts
Grid 2 Voltage.. 230 Volts
Grid No. 1 Voltage (Spot cut-off).. 33-55 Volts DC

(Note: Heavy Aluminum Extinction Voltage to be 6500 Volts Maximum)

Z4604



Z4604

C.P 5-22-59

Design Procedure

A sequence of 7 gun types were built to fully optimize the gun design. See the included job description sheets for construction details. See also the chart of fig. 2 comparing low level detail, blooming, depth of focus and resolution of each design.

Using the basic 1958 gun design, except for a shorter second anode and first grid, (JN191P) the picture was fair in both detail and blooming. The quality was, however, below that of present production.

To improve detail, that is decrease spot size, the diameter of the beam in the focus lens was made larger by shortening the grid #2 cup to .100 inch (refer to JN192P). The improvement was remarkable however, the beam was too large for the lens diameter (.500" ID) so that blooming (spot growth in the hi-lites) was very objectionable.

A parallel approach was taken in JN243P where the length of the first anode was made 1.000" (an increase of .400", cathode to center of lens) so that the beam diameter in the lens was again large. Here the picture was definitely soft. The beam passing too close to the boundries of the focus lens caused excessive aberration.

In the interest of good depth of focus and blooming, gun design JN224P was built. This design placed an aperture (.120") at anode potential within .080" of the grid #2 aperture which accelerates the beam before it has a chance to spread. The result was good depth of focus and blooming as hoped, but the resolution was only fair.

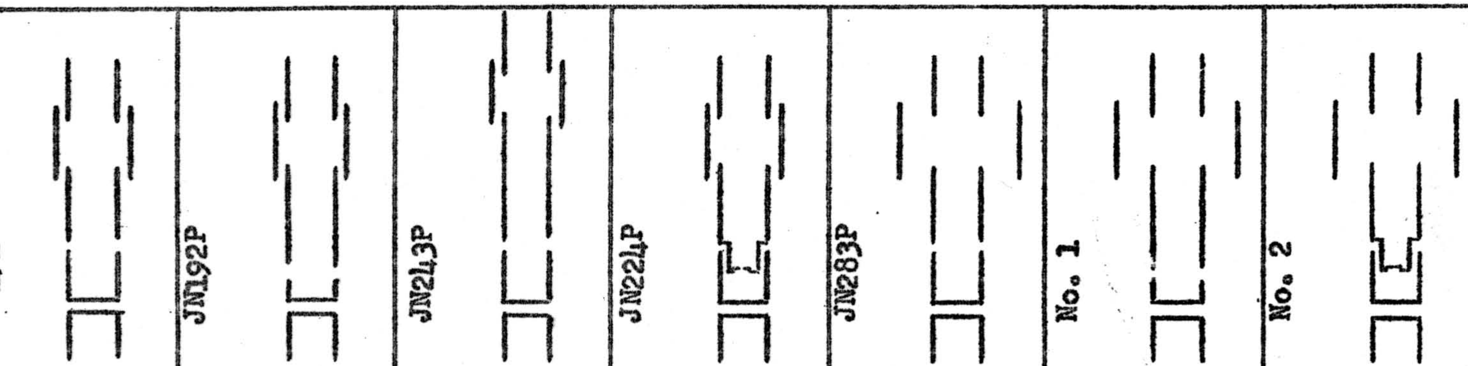
It was apparent that good detail and non-blooming were not compatible with the .500" focus diameter. Taking advantage of the large neck (1.12" ID), three gun designs were built having a focus diameter of .600 inch. These were JN283P, No. 1 and No. 2 as designated in fig. 2.

The first (JN283P) incorporated a .200" grid #2 cup similar to JN191P except for the larger focus cylinder. The detail or resolution were good and the non-blooming characteristic was excellent.

To further improve the low level detail, as was accomplished in JN192P with the .100" grid #2 cup, a similar gun (No. 1) was built with a .600" ID focus cylinder. The resolution was excellent; the video picture possessed crispness. The picture was good from the standpoint of blooming in the hi-lites, even at a brightness level of 200 foot lamberts the hi-lites were acceptable.

The best non-blooming and depth of focus characteristics were obtained in gun design No. 2, in which the larger focus cylinder was used in conjunction with an anode dipping into the grid #2 cup (similar to JN224P). This tube was excellent in the hi-lites having sparkling quality. The low level detail, although having 50 - 50 resolution, was poorer than that in design No. 1 which incorporated a short grid #2, .100" long.

FIGURE 2



	JN191P	JN192P	JN243P	JN224P	JN283P	No. 1	No. 2
GRID #2	.200" LG.	.100	.200	.200	.200	.100	.200
1st ANODE			1" LONG	DIPS INTO G2			DIPS INTO G2
FOCUS	.500" I.D.	.500	.500	.500	.600	.600	.600
LOW LEVEL DETAIL	E	A	G	F	D	B	C
BLOOMING	E	G	F	D	B	C	A
DEPTH OF FOCUS	B	F	G	D	C	E	A
RESOLUTION	45 - 50	50 - 50	40 - 50	45 - 50	45 - 50	50 - 50	50 - 50

RELATIVE SCALE: A B C D E F G

EXCELLENT ——> POOR

E. M. Krackhardt
2-26-60

Conclusions

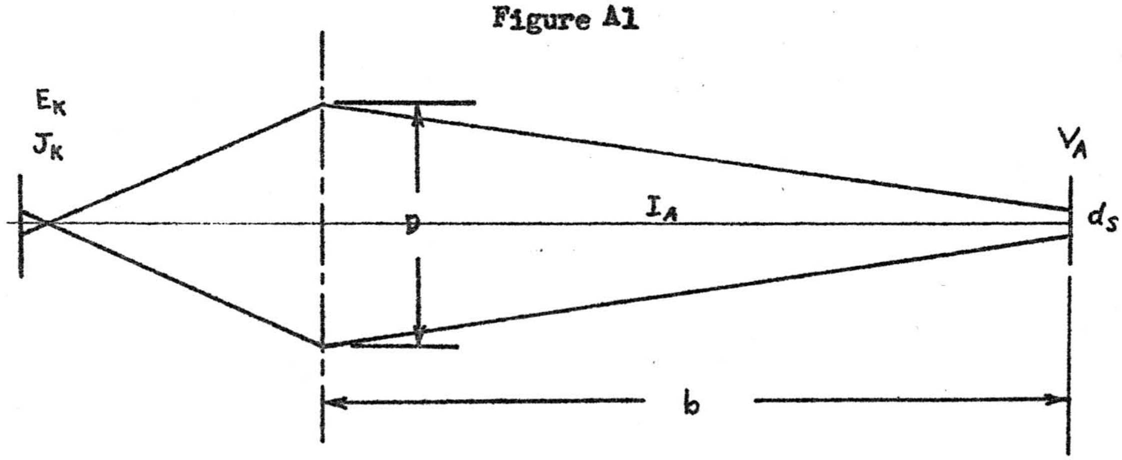
Gun No. 1 (with large focus and short G2) is in my opinion the best design for this 8 inch tube. It is chosen over Gun No. 2 for two reasons. First, because of better detail and second because of an alignment problem in placing the anode aperture with respect to the grid 2.

There was considerable freedom in the design of this gun because of the large physical size and as a result the optimized gun gave a picture with sparkle and crispness. Although the main reason for having a 1 7/16 inch neck was because of the gettering problem, I would recommend that the larger neck be used for obtaining higher performance electron gun designs whenever a necked down tube is considered.

APPENDIX I

Neglecting abberation, the minimum theoretical spot at the screen is given by eq. 1 as formulated by Dr. Gundert at Telefunken. In the design of this gun all parameters are fixed or limited excepting D, therefore eq. 2 is used in the discussion. Figure A1 and the listing define the quantities in the expression.

Figure A1



1.

$$d_s = \frac{4}{\sqrt{\pi}} \frac{b}{D} \sqrt{\frac{I_A E_K}{J_K V_A} \ln \frac{1}{P}}$$

2.

$$d_s \sim \frac{1}{D}$$

d_s - spot size at screen

b - plane of dia. (D) in lens to screen

D - beam diameter in lens

I_A - beam current

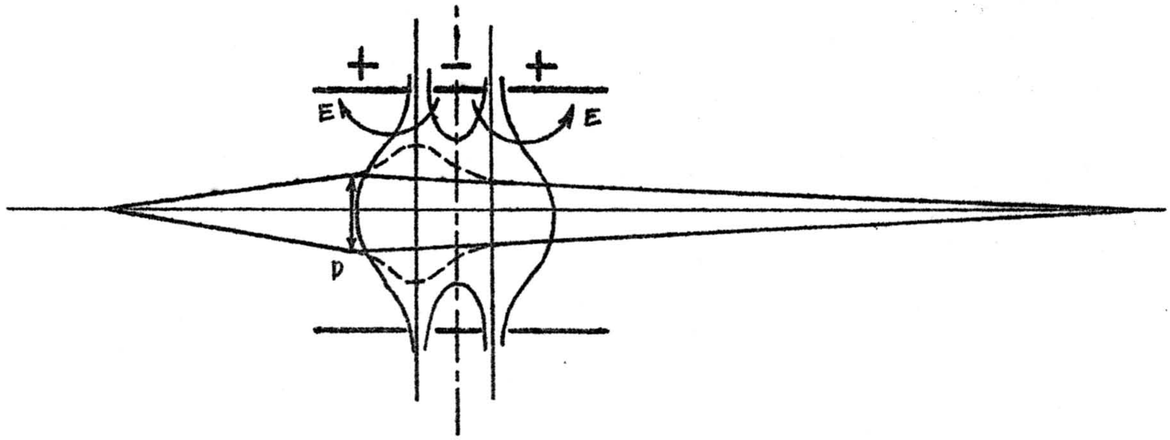
E_K - most probable energy at the cathode

J_K - current density at the cathode

V_A - anode potential

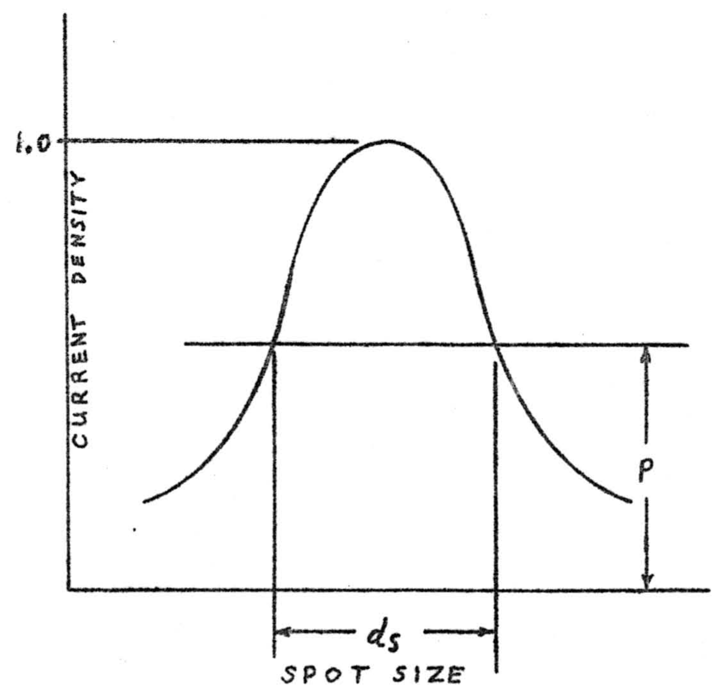
The position and magnitude of the diameter D in the focus lens is determined by the intersection of the lines drawn along the outermost rays entering and leaving the lens. See fig. A2 where the dashed line is the actual electron trajectory.

Figure A2



Since the current distribution in the beam at the screen is approximately Ganssian[1], some reference point must be assigned. The factor (p) is the percent of the mean spot current density as illustrated in fig. A3.

Figure A3

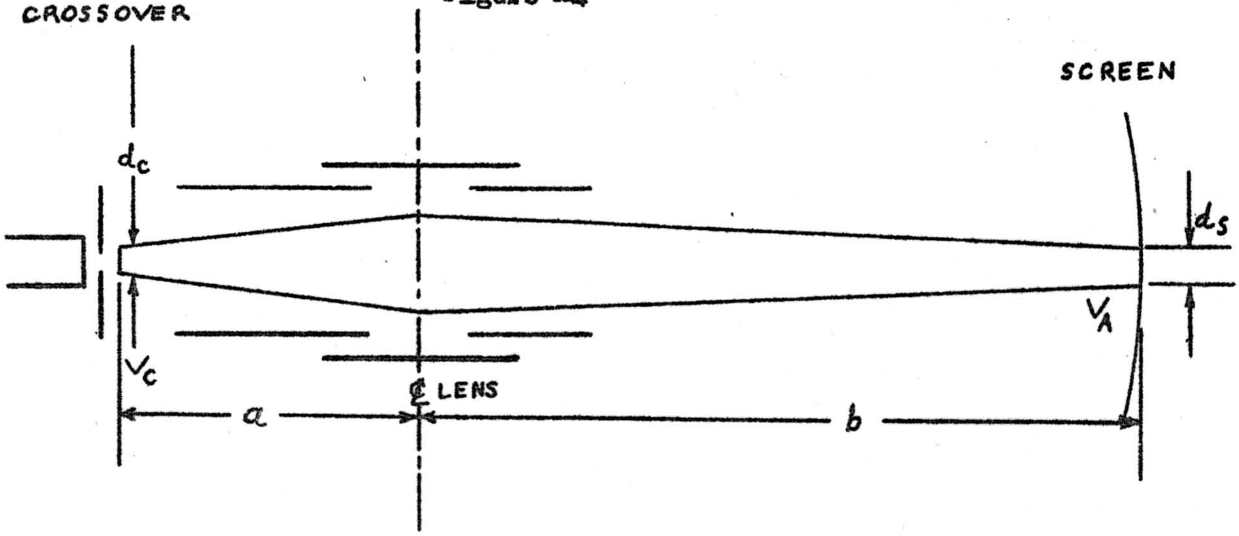


[1] TIS R55ETC10, S.T. Jutila, "A Measuring Technique for Determing Spot Characteristics"

APPENDIX II

Calculation of the spot size requirement relative to a standard 21" tube is carried out using Snell's law of electron optics. Since the comparison is relative, the first order approach is adequate.

Figure A4



3.

$$d_s = d_c \frac{b}{a} \sqrt{\frac{V_A}{V_c}}$$

where d_s - spot size at the screen

d_c - crossover size

a - crossover to center of focus lens

b - center of focus lens to screen

V_A - anode voltage

V_L - voltage at the crossover

Comparing spot size in the 8" and 21" tubes, the relation reduces to:

4.

$$\frac{d_{s\,(8)}}{d_{s\,(21)}} = \frac{b_{(8)}}{b_{(21)}} \frac{\sqrt{V_{A\,(8)}}}{\sqrt{V_{A\,(21)}}}$$

From the specifications for the 8 and 21 inch tubes, the values of b and V_A are determined,

	8" tube	21" tube
b	7"	11"
V_A	7.5 KV	16 KV

$$\frac{d_{s\,(8)}}{d_{s\,(21)}} = \frac{7\sqrt{7.5}}{11\sqrt{16}} = \frac{.44}{1.00}$$

Calculating spot size as a percentage of raster height d_s/h, where $h(8) = 5"$ and $h_{(21)} = 15"$:

$$(d_s/h_8) = 1.30\ (d_s/h_{21})$$

From this result, one sees that the gun in the 8 inch tube must be 30% improved in spot size over the gun in the 21" tube.

Elliott M. Krackhardt

Elliott M. Krackhardt
Equipment Tube Prod. Eng'g.
CATHODE RAY TUBE DEPARTMENT

EMK/gmd
Attachments

Engineer KRACKHARDT (3990)

USE I+M 6.3V HEATERS FOR .090 CATHODE

Glass 4 Guns

Complete 3 Mounts

Use I+M .090 Cathodes

Cathode Information

Use 902 Stems

Use 65MG-8YP4 X 1/4" Getters FLASHING

Use SPECIAL Springs USE NEW WELDING JIG

Misc. Notes SEAL STEM LEAD #3 WITH ANODE BUTTON

Gun #s 798-801 [redacted] T.N. 19LP

Accumulated 6-5-59

Mounts Completed

Use Pin C

PULL BACK 1/16 Gun Seal Length

Gun Length (Bottom of stem to contact with paint)

1.900" Paint Length

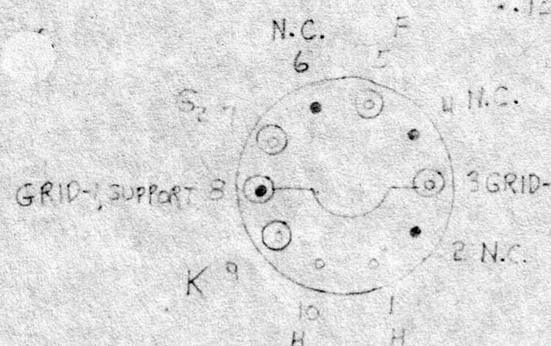
1.550" TOP OF GUN TO Y.P.L.

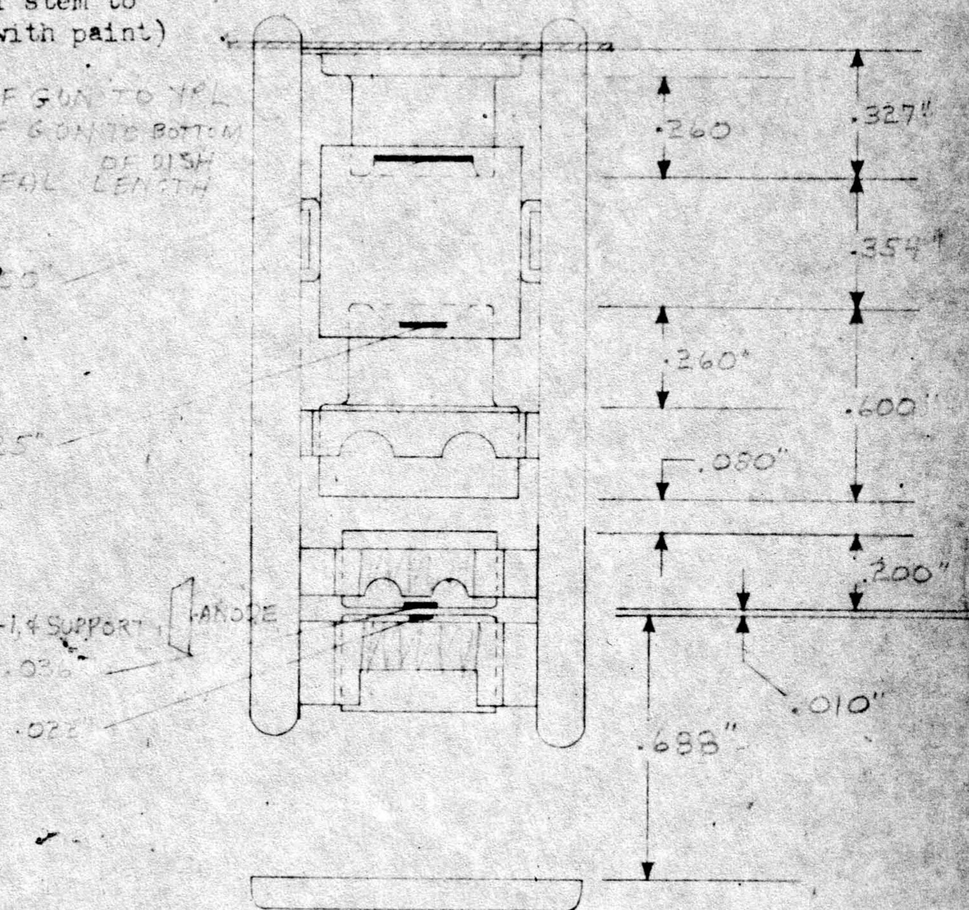
2.364" TOP OF GUN TO BOTTOM OF DISH

3.914" GUN SEAL LENGTH

EYELETS ON LEADS 3,5,7,8+9

TRIM STEM LEADS 2,8,6+4





G1K .0045

Gun Numbers

798

799

800

801

G1 Description

EMBOSSED .007" Avg. Top Thickness

5200 Received 2-17-59

BASE CONNECTIONS

PIN # 2 = G1

1 = H

12 = H

11 = K

10 = G2

6 = F

Engineer KRACKHARDT 3970

USE TYM 6.3V HEATERS FOR .090" CATHODE

Glass 4 Guns

Gun #s 801-805 [redacted] J.N. 192P

Complete 3 Mounts

Use TYM .090" Cathodes

Accumulated 6-5-59

Mounts Completed

Cathode Information

Use 90° Stems

Use 65MG-8/14X1/4" Getters FLASHING

Use Pin C

Use SPECIAL Springs USE NEW WELDING JIG

Misc. Notes SEAL STEM LEAD #3 WITH ANODE BUTTON

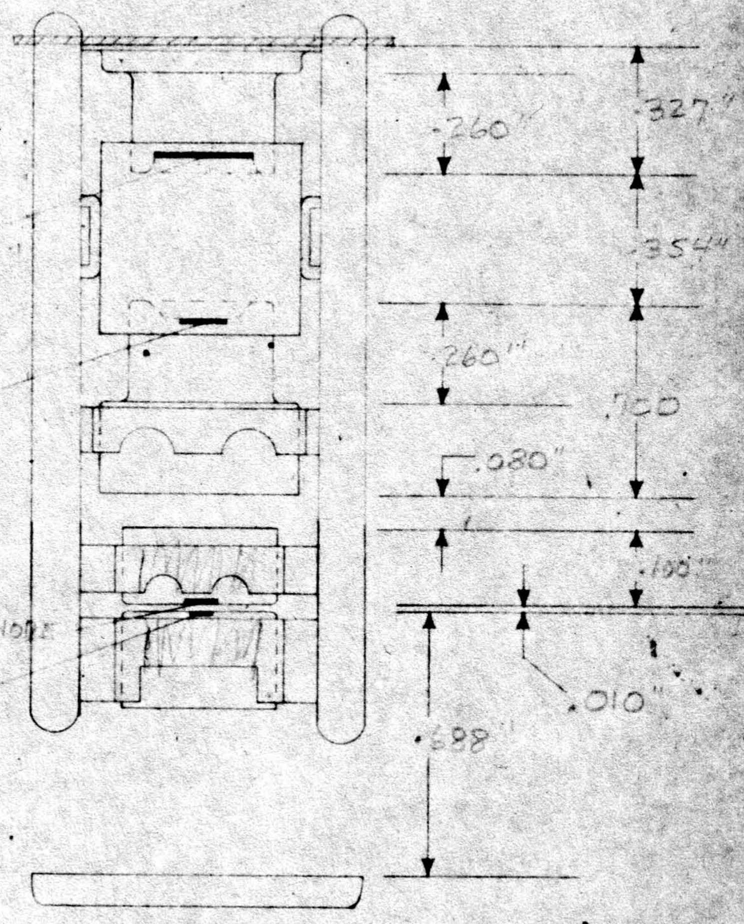
PULL BACK 1/16" Gun Seal Length

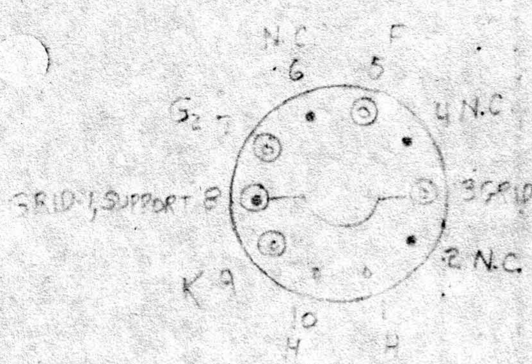
Gun Length (Bottom of stem to contact with paint)

1.900" Paint Length

EYELETS ON LEADS 3,5,7,8,9

TRIM STEM LEADS 2,3,6,14





G_1K .0045

Gun Numbers

802
803
804
805

G_1 Description

EMBOSSED G_1 .007" Avg. Top Thickness

5200 Received 3-17-59

BASE CONNECTIONS

PIN # 2 = G_1

= H

12 = H

= K

10 = G_2

6 = F

Engineer KRACKHARDT

USE I&M 6.3V HEATERS FOR .090 CATHODES (397D)

Glass 3 Guns

Complete 3 Mounts

Use I&M .090" Cathodes

Cathode Information

Use 90° Stems

Use 65MG-8YP4X1/4" Getters FLASHING

Use SPECIAL Springs — USE NEW WELDING JIG

Misc. Notes SEAL STEM LEAD# 3 WITH ANODE BUTTON

Gun #s 1083-1085

J.N.-243P

Accumulated

Mounts Completed

Use Pin B2

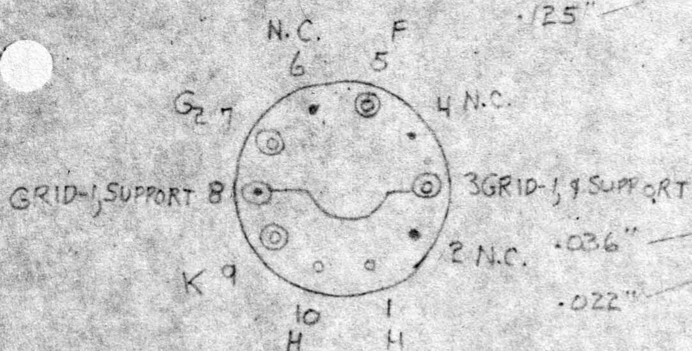
PULLBACK 1/16" Gun Seal Length

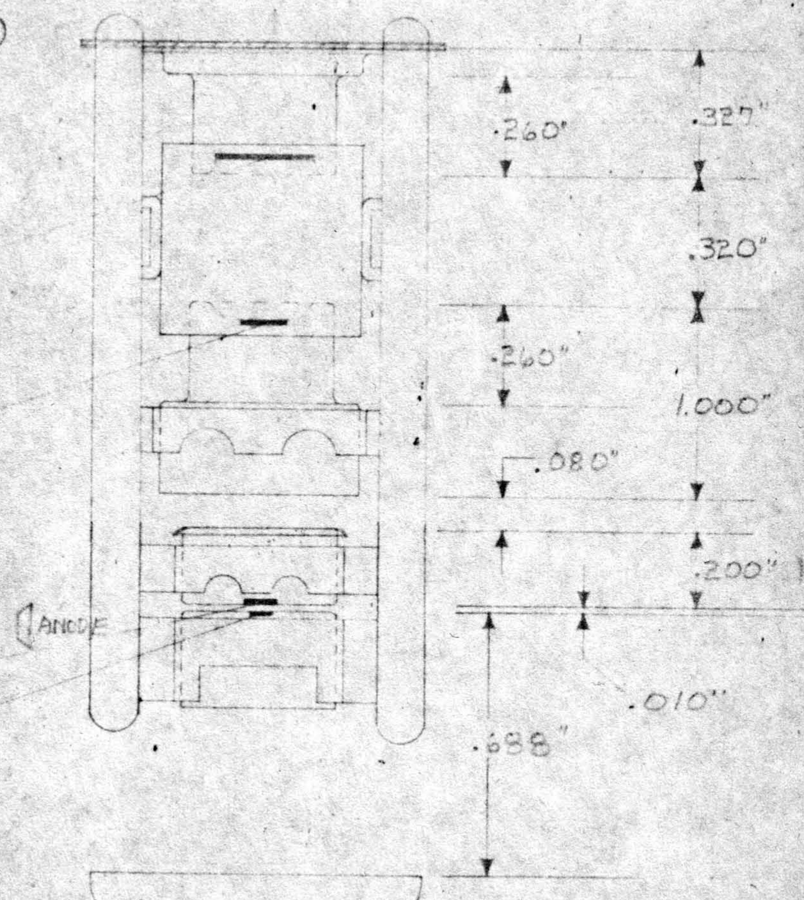
Gun Length (Bottom of stem to contact with paint)

1.900" Paint Length

EYELETS ON LEADS 3,5,7,8 & 9

TRIM STEM LEADS 2, 8,6 & 4 .250"





G-K .0045"

Gun Numbers

1083

1084

1085

EMBOSSED .007" Avg. Thickness

.5200" Received 2-17-59

BASE CONNECTIONS

PIN# 2 = G_1

1 = H

12 = H

11 = K

10 = G_2

6 = F

Engineer KRACKHARDT

USE I&M 6.3V HEATERS FOR .090" CATHODES (3970)

Gun #s 985-987 [redacted] JN-2249

Class 3 Guns

Complete 3 Mounts

Use I&M .090" Cathodes

Cathode Information

Use 90° Stems

Use 65MG-8YP4 X 1/4 Getters FLASHING &

Use SPECIAL Springs USE NEW WELDING JIG

Misc. Notes SEAL STEM LEAD #3 WITH ANODE BUTTON

Accumulated 7-20-59

Mounts Completed

Use Pin F 1

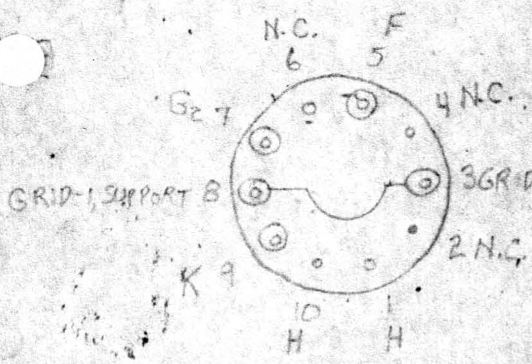
PULLBACK 1/16" Gun Seal Length

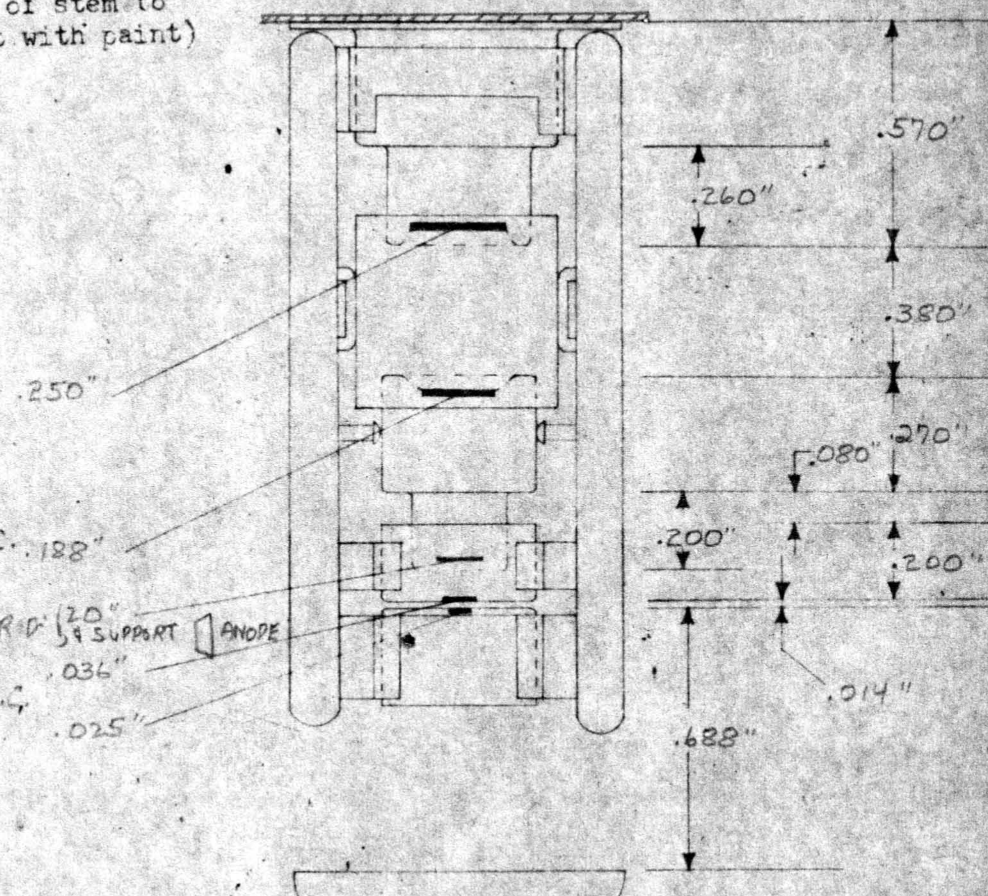
Gun Length (Bottom of stem to contact with paint)

1.900" Paint Length

EYELETS ON LEADS 3,5,7,8 & 9

TRIM STEM LEADS 3, 8, 6 & 4





G_1K .005"

Gun Numbers

985
986
987

G_1 Description

EMBOSSED .007" Avg. Top Thickness

5,500 Received 5/5/59

BASE CONNECTIONS

PIN # 2 = G_1

1 = H

12 = H

11 = K

10 = G_2

6 = F

Engineer KRACKHARDT

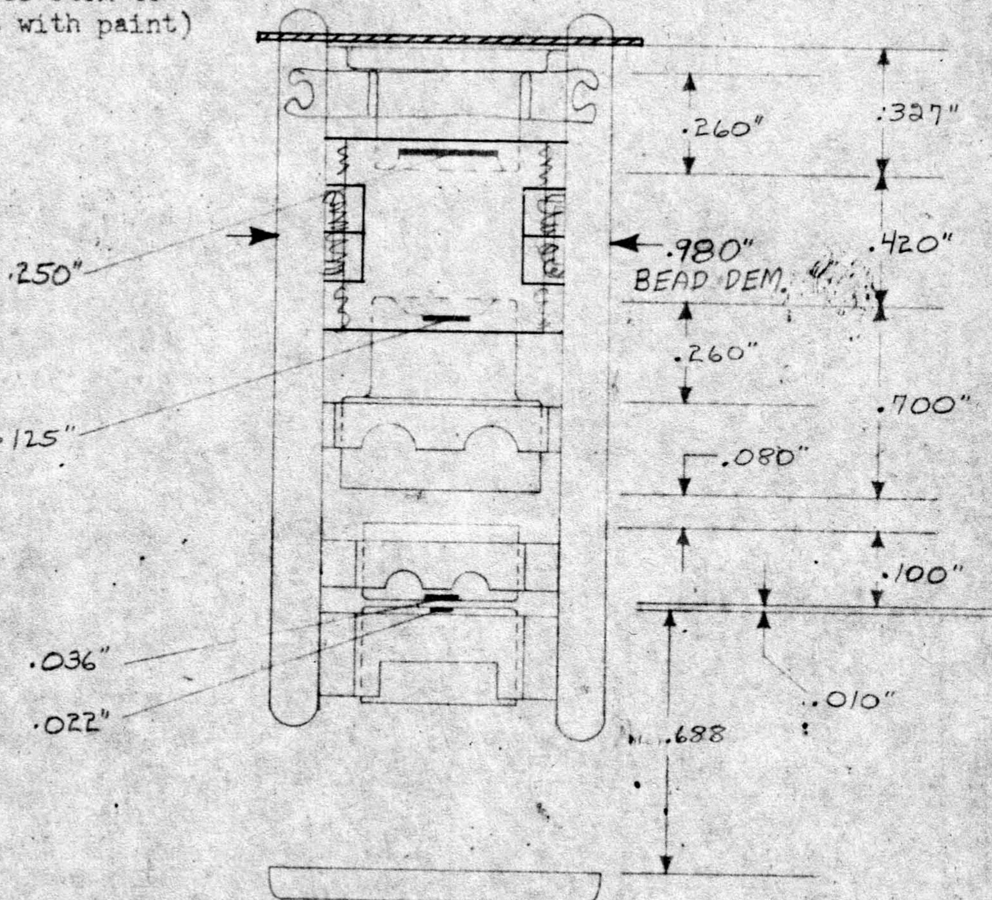
Glass 3 Guns
Complete 3 Mounts
Use I&M .090" Cathodes
Cathode Information
Use 90° Stems
Use ——— Getters
Use SPECIAL Springs — USE NEW WELDING JIG
Misc. Notes USE I&M 3970 FILAMENTS
FOR .090" CATHODES.
BUILD GUNS LESS GETTERS

____ Gun Seal Length
____ Gun Length (Bottom of stem to contact with paint)
____ Paint Length

Gun #s 1327-1329

Accumulated
Mounts Completed

Use Pin C6



G_1K .0045"
Gun Numbers
1327
1328
1329

G_1 Description
EMBOSSED .007" Avg. for Thickness
5,200 Received 2-17-59