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NATIONAL UNION RADIO CORPORATION
Orange, New Jersey

NU 2163 MINIATURE CATHODE RAY
TUBE FINAL ENGINEERING REPORT

Air Force Contract

No AF 33(038)-17345

FINAL ENGINEERING REPORT

MINIATURE CATHODE RAY TUBE

R-2163

AIR FORCE CONTRACT NUMBER AF33(038)-17345

NATIONAL UNION RADIO CORPORATION

PROJECT NO. R-2163

FOREWORD

This report is concerned with those aspects of the work done under Contract AF 33(038)-17345 which concern the development of miniature cathode-ray tubes. The designation R-2163 was given to this aspect of the work and, when used in this report, will refer to the miniature cathode-ray tube.

Abstract

The design and production of an electrostatic focus and deflection miniature cathode ray tube are described. The tube was developed by National Union Radio Corp., Research Division, at Orange, N. J. during the period from November 1950 to April 1953. The tubes resulting from this work have good light output, resist shock and vibration, have no exposed exhaust tip, and should be widely applicable.

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INTRODUCTION

There is a wide field for application of a miniature cathode-ray tube, which will operate at low applied voltages, for monitoring and trouble shooting. Such a tube was developed under Contract AF-33 (038)-17345 for the United States Air Force by National Union Radio Corp. Two versions of the tube were developed, which are identical except for the type of fluorescent screen employed. One version, hereafter designated R-2163P1, uses a Willemite screen (P-1), which gives a green trace and has medium persistence. The other, hereafter designated R-2163P7, uses a long persistence cascade phosphor (P-7).

In the following, the information applies equally well to the R-2163P1 or R-2163P7 unless specifically restricted to one model.

SECTION I Design of Tube

Envelope

The envelope is made of lead glass, Corning 0120, except for the face plate, which is made of "foureo" glass. Foureo is a soft glass which seals readily to 0120. Separate face plates are required to fulfill the face flatness specification of Exhibit MCRRE-776. Figure 2 shows the envelope in cross-section with the stem shown sealed in; the face plate is shown in Figure 1.

Stem

The stem is a modified small button 9 pin stem. The modification is the use of a tubulation sealed to the stem at its center. The tube is evacuated through this tubulation. After processing, the tip-off is made as close as possible to the stem, and the glass tip remaining is pressed down nearly flush with the outside surface. Figure 3 shows the stem in cross-section before and after tip-off. This construction yields a tube with no exposed tip-off. The tube fits in a standard 9-pin miniature socket.

Electron Gun

The electron gun utilizes electrostatic focus and deflection. The metal parts are made of stainless steel, except for the cathode sleeve which is made of nickel. These parts are supported in their proper positions by two mica supports; the various focusing and deflecting plates have tabs which extend through holes in the mica and

are bent over flush with the mica. The tabs are also used to make electrical connections to the stem. The gun assembly is shown in Figure 4 and Figure 17 is a photograph of a complete mount. Figure 5 shows the mica support.

The cathode is flat and is mounted perpendicular to the tube axis; this construction helps reduce the length of the mount. Figure 7 shows the cathode sleeve. A folded tungsten heater (Figure 8) fits inside the cathode sleeve and heats it. One side of the heater is connected to the cathode. The cathode is coated only on that portion adjacent to the grid aperture (Figure 6). On the R-2163P7, a light shield, (Figure 9) is used over the hot end of the heater to reduce heater glow visible through the screen under low ambient light conditions. For the R-2163P1 the use of the light shield is optional.

The beam of electrons starts at the cathode, and passes through the grid aperture, whose potential with respect to the cathode determines the beam intensity. The beam then passes through the aperture in the lens cup (Figure 10) which is spotwelded to the anode cylinder (Figure 11) and, after traversing the anode cylinder emerges from the aperture in aperture plate A_2 (Figure 12). This aperture also limits the diameter of the beam. The next two plates, aperture plate A_1 (Figure 13) and a second aperture plate A_2 , form a lens which focuses the beam. The focus is obtained by adjusting the potential on aperture plate A_1 .

The beam next passes between two sets of mutually perpendicular deflection plates; first through #3 and #4 deflection plates (Figure 14),

then through #1 and #2 deflection plates (Figure 15). The beam then strikes the screen.

The electron gun is supported in the envelope by four support springs (Figure 16), which also serve to absorb shock and vibration. The tube is made more versatile by connecting each deflection plate to a separate stem pin. About ten percent of the cathode current reaches the screen, the rest having been absorbed by the limiting apertures. This figure compares favorably with other electrostatic guns.

Screen

The screen weight was adjusted to give maximum light output with minimum low-voltage electron burn. Low voltage electron burn is a decrease in screen sensitivity which occurs after bombardment with electrons of less than 1000 electron-volts energy. Sometimes there is a screen darkening as well.

For the R-2163P1 screen the optimum phosphor weight is 4 mg. per sq. cm. For the R-2163P7 the optimum screen is 20 mg. per sq. cm. total weight of which 60% is the yellow component and 40% the blue component.

The Complete Tube

Figure 18 is a photograph of the finished tube. The tentative specifications appear on pp 9-12.

Measurements and Tests

During its development and production, the tube was subjected

to the tests required in Exhibit MCREE-772. The tube passed the vibration test and a 500 g shock test. The tube meets all the requirements of the exhibit except the deflection factor and possibly the life test.

Life Test

Both the R-2163P1 and R-2163P7 tubes suffer a burning of the phosphor screen during life test. This is called low-voltage burn, and it is a characteristic property of cathode-ray tube phosphors. Efforts were made to eliminate this burning but all failed. What was finally done was to select the screen thickness and particle size which minimized the burn.

The burn phenomena causes the light output of the R-2163P1 to drop during life. Figure 20 shows a typical curve of light output vs time of operation. The life test of 20 R-2163P1 tubes showed that after 1000 hrs of operation, the tubes would produce 5 ft lamberts brightness with the standard test raster. However, the initial brightness of the tubes was about 20 ft lamberts. For the R-2163P7 tube the burn occurs in the blue layer; less light is produced here and thus the yellow layer is less strongly excited. The result is the persistence actually available for a given beam current drops during life.

For the R-2163P7, the persistence, estimated as directed in Note 1 of the R-2163P7 Tentative Specification, is still acceptable after a 1000 hours life test. 15 R-2163P7 tubes were life tested.

For the R-2163P1, the light output after a 1000 hours life test is just about 5 ft. lamberts according to measurements in this laboratory. But the absolute value of brightness values obtained by

a given method and setup is subject to considerable error. This means that other laboratories might fail to check these results and the tubes would fail the life test.

Another point which should be mentioned is the fact that, with both tubes, when the screen burns, its secondary emission ratio drops, and, if the ratio falls below one, the screen will soon charge to cathode potential and there will be no trace. This^{is} particularly important for the lower operating voltages.

For these reasons, it is felt that a more realistic life test period would be 500 hours or less.

A word should be said about the P-7 screen operated at these voltages. The P-7 phosphor was developed for operation at several thousand volts, and has been rated at voltages no lower than 1500 volts. At the test voltage for the R-2163P7, 600 volts, persistence is shorter than that for higher voltages, but may still be long enough for some applications.

At an accelerating voltage of 500 volts, the light output falls, and the focus is poorer, while the deflection factor is improved.

Light Output

Light output was measured with a Weston photronic cell with Viscon filter, the output of which is amplified by a d-c amplifier. The set-up was calibrated against a Macbeth illuminometer using several calibrated color filters. A curve of light output vs. cathode current is shown in Figure 19.

SECTION II Production of the Tube

Envelope

The cylindrical wall of the envelope is made from 0120 glass tubing. The proper lengths are cut; then the face plates are sealed on, and the finished envelopes are annealed.

Screen

The screens for the R-2163P1 and R-2163P7 were applied by the settling process. Normal procedure was followed except for the decanting and drying steps. The process followed here was;

1. Clamp envelope at an angle.
2. Siphon off the settling liquid
3. Allow envelope to remain in this position for 10 minutes.
4. Remove envelope from clamped position.
5. Place envelope on table, face down.
6. Cover open end of envelope with aluminum foil.
7. Allow envelope to remain in this position for approximately two hours or until screen is dry.
8. Pump envelope for one minute and check with sparking coil.

An alternative method of screen application was developed for the R-2163P1. This consisted of spraying the face plates with phosphor before they were sealed to the wall cylinders. This method might have some advantages for larger production.

After the screen is applied, the cylinder walls are coated with aquadag by brush. The coated envelope is baked at 450°C; flushing with a

a stream of nitrogen while baking is desirable but not necessary.

Stem

The stems are made from standard small button 9 pin stems. The tubulations are sealed on, the stems are annealed and, after cleaning the leads, are ready for mounting.

Electron Gun

The metal parts are assembled in the mica supports and the tabs are bent over. In this process care must be taken to avoid damaging the coated surface of the cathode. The structure is then mounted on the stem, the electrodes connected to the proper pins, and the heater installed. Then the getters are attached, the support springs installed, and the mount checked.

Processing

The mounts are sealed in and the area heated by the sealing is flame-annealed. The tubes are checked for electrical shorts and glass cracks and then sealed on the pump. They are baked for 20 minutes at 370°C. The parts are out-gassed by r.f. bombardment and the cathode is activated in the usual way. The tubes are then tipped off as closely as possible to the stem and the little tip left is flattened out while it is still hot. The area around the stem is annealed for 20 minutes at 430°C in a little oven which leaves the rest of the tube at room temperature. This keeps the amount of gas liberated during annealing to a minimum. When the tube is cool, the getters are flashed and it is ready for test.

Aging and Testing

The cathode is aged first to stabilize the electron emission.

Then the tube is tested for electron emission, grid cut-off voltage, raster centering, and raster focus and appearance.

Conclusions

A miniature cathode-ray tube has been developed which operates at low voltages, has good light output, resists shock and vibration, and has no exposed exhaust tip. The versatility and small size of the tube should make it widely applicable for monitoring, trouble-shooting and many other uses.

Orange, N. J.

10 April 1953

F. Holborn

C. Bartholomew

Contract AF-33(038)17345

NATIONAL UNION RADIO CORPORATION
TENTATIVE SPECIFICATIONS FOR MINIATURE
CATHODE-RAY TUBE

R-2163P1

Description: Medium Persistence Miniature Cathode-Ray Tube

Ratings:	E _f V	E _{o1} V _{do}	E _d V _{dc}	E _{b1} V _{do}	E _{b2} V _{do}	R _g Meg	Z _d Meg	R _d Meg	Scan. Freq. Cps
Max.	6.3+10%	0	400	300	600	2	2	2	
Min.	6.3-10%	-50							
Test Conditions:	6.3	adj	-	Focus	600				60x2100-6300
Height:	Max. 3.125 in.; Diameter Max. 0.875 in.								
Base:	Modified Small Button 9 pin								
Pin No.	1	2	3	4	5	6	7	8	9
Element	G ₁	D ₁	D ₃	H	HK	D ₂	A ₂	A ₁	D ₄
Cathode - Coated Unipotential.									

Ref.	Test	Conditions	Min.	Bogie	Max.
F 8b(1)	* Heater Current	E _f =6.3 V	195	215	235 ma
F 8b(2)	* Anode 1 Current	Light 5 ft.L	-10	0	+10 ua
F 8b(2)	* Cathode Current	Light 5 ft.L			1000 ua
F 8b(4)	Voltage Breakdown				
F 8c(1)	+ Gas	Light 5 ft.L			
F 8d(1)	* Base Alignment	1D2 between Pins 2 & 3			
F 8f(2)	Fluorescent Color		P1		
F 8f(3)	** Persistence		P1		
F 8f(5)	Modulation	Light 5 ft.L	E _{o1}		40V
F 8f(4)	+ Light Output	Raster 1/2" X 1/2"	5 ft.L		
F 8g(1)	* Line Width "A"		Width		.25 mm
F 8j	Grid out-off Voltage				40 V
F 8k(1)	* Focus Voltage	E _{b2} =600V	100		200

<u>Ref</u>	<u>Test</u>	<u>Conditions</u>	<u>Min.</u>	<u>Boie</u>	<u>Max.</u>
F 8a	* Defl. Factor 1D2	$E_{b2} = 600 \text{ V}$	230	280	330
F 8a	* Defl. Factor 3D4	$E_{b2} = 600 \text{ V}$	230	280	330
F 6p(1)	** Capacitances				
	G ₁ to all				4uuf
	K to all				2 uuf
	D ₁ to D ₂				1 uuf
	D ₃ to D ₄				1 uuf
	D ₁ to all				3 uuf
	D ₃ to all				3 uuf
	D ₁ to all except D ₂				2 uuf
	D ₂ to all except D ₁				2 uuf
	D ₃ to all except D ₄				2 uuf
	D ₄ to all except D ₃				2 uuf
F 4a(2)	Life Test	Note 1	T = 1000 hrs		
F 4b	Life Test End Point		Line width A	0.50 mm	
			Line width B	0.75 mm	
			Modulation	50 V	

Note 1 - To be run with Light Output at 5 ft. lamberts.

Contract AF-33(038)-17345

NATIONAL UNION RADIO CORP.
TENTATIVE SPECIFICATIONS FOR MINIATURE
CATHODE-RAY TUBE

R-21637

Description: Long Persistence Miniature Cathode-Ray Tube

Ratings:	E_f V	E_{c1} Vdc	E_d Vdc	E_{b1} Vdc	E_{b2} Vdc	R_g Meg	Z_d Meg	R_d Meg	Scan.Freq. cps
Max. 6.3+10%		0	400	300	600	2	2	2	
Min. 6.3-10%		-50							

Test Con-
 ditions: 6.3 adj - Focus 600 60 x 2100-6300

Height: Max. 3.125 in.; Diameter Max. 0.875 in.

Base: Modified Small Button 9 pin

Pin No.	1	2	3	4	5	6	7	8	9
Element	G_1	B_1	D_3	H	HK	D_2	A_2	A_1	D_4

Cathode - Coated Unipotential.

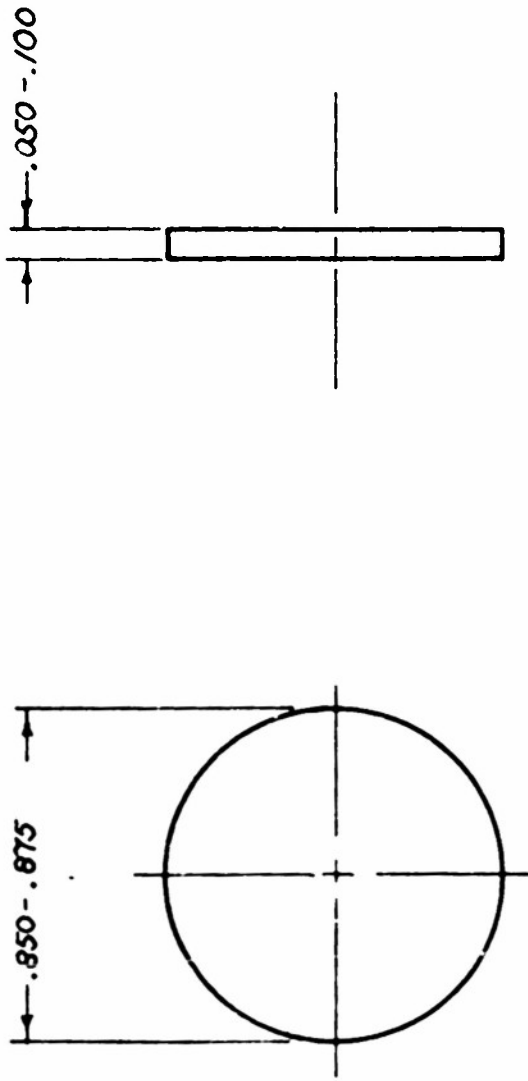
Ref.	Test	Conditions	Min.	Bogie	Max.
F 8b(1)	Heater Current	$E_f = 6.3$ V	195	215	235 ma
F 8b(2)	Anode 1 Current	$I_k = 500$ ua	-10	0	+10 ua
F 8b(2)	Cathode Current				1000 ua
F 8b(4)	Voltage Breakdown				
F 8c(1)	Gas	$I_k = 500$ ua			
F 8d(1)	Base Alignment	I_{d2} between Pins 2 & 3			
F 8f(3)	persistence	See Note 1	P-7		
F 8g(1)	Line Width "A"		Width		.25 mm
F 8j	Grid cut-off Voltage				40 V
F 8k(1)	Focus Voltage	$E_{b2} = 600$ V	100	150	200
F 8m	Defl. Factor I_{d2}	$E_{b2} = 600$ V	230	280	330
F 8m	Defl. Factor I_{d4}	$E_{b2} = 600$ V	230	280	330

<u>Ref.</u>	<u>Test</u>	<u>Conditions</u>	<u>Min.</u>	<u>Bogie</u>	<u>Max.</u>
F 6p(1)	Capacitances				
	g1 to all				4 uuf
	K to all				2 uuf
	D ₁ to D ₂				1 uuf
	D ₃ to D ₄				1 uuf
	D ₁ to all				3 uuf
	D ₃ to all				3 uuf
	D ₁ to all except D ₂				2 uuf
	D ₂ to all except D ₁				2 uuf
	D ₃ to all except D ₄				2 uuf
	D ₄ to all except D ₃				2 uuf
F 4a(2)	Life Test	See Note 2	T=1000 hrs.		
F 4b	Life Test End Point		Line width A		0.50 mm
			Line width B		0.75 mm
			Modulation		50 V

Note 1. The persistence shall be estimated as follows:
 with a raster of $1/2'' \times 1/2''$, 35 to 105 lines, $I_k = 800 \text{ ua}$, excite the screen for 30 sec., then cut off the beam suddenly. In a dark room, the persistent trace must be visible after 5 sec.

Note 2. To be run with $1/2'' \times 1/2''$ raster of 60 frames per second, 35 to 105 lines, $I_k = 250 \text{ ua}$.

DWG. NO.
A-2163-22 A



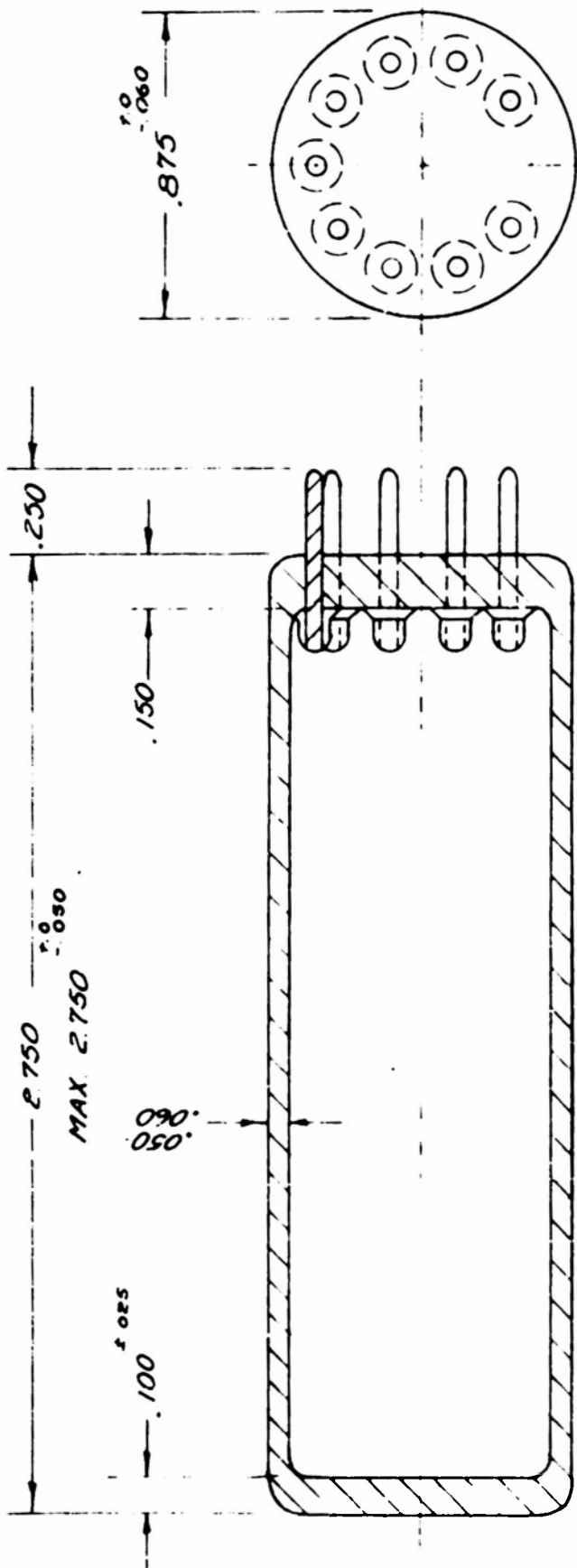
MAT. : - CLEAR FOURCO GLASS

NATIONAL UNION RADIO CORPORATION - RESEARCH DIVISION - 350 SCOTLAND ROAD - ORANGE, N. J.

Figure No		RECORD OF CHANGES		Originally Designed For Tube Type		MAIN TITLE	
Date						FACE PLATE	
7-8-52		DIAL WAS .850 - .860 NOW .850 - .875					
7-8-52		CORNERS WERE ROUNDED					
				SUBTITLE			
				A-2163-1-22			
				Scale 2:1			
				Date			
				AEB.			
				Date			
				7-8-52			
				Dwg No			
				A-2163-1-22 A			
				Checked			
				Date			

Underlined Dimensions are Not to Scale
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
All Parts Must Be Free From Burrs
True Centers Within .001" of Center Line
Unless Otherwise Specified, Tolerances
Are Decimal Dimensions $\pm .005$ or $\pm .003$
Whichever is Smaller
Fractional Dimensions $\pm .015$
Angles $\pm \frac{1}{2}$

A-2163-1-21



NATIONAL UNION RADIO CORPORATION - RESEARCH DIVISION - 350 SCOTLAND ROAD, ORANGE, N J

MAIN TITLE
MINIATURE CRT ENVELOPE

Originally Designed
For Tube Type:

RECORD OF CHANGES

Date

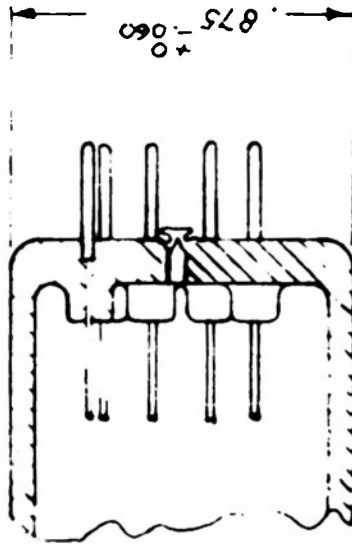
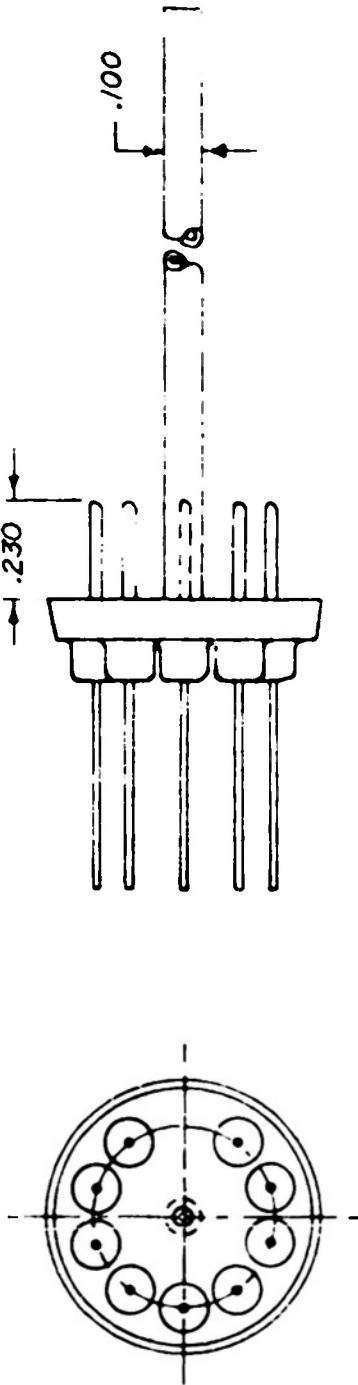
Figure No

2

SUB TITLE
Supersedes
Date
Appd
Date
Checked
Date
A-2163-1-21

Underlined Dimensions are Not to Scale.
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
All Parts Must Be Free From Burrs.
True Centers Within .001" of Center Line
Unless Otherwise Specified, Tolerances
Are Decimal Dimensions $\pm .5\%$ or $\pm .005$
Whichever is Smaller.
Fractional Dimensions $\pm .015$
Angles $\pm .1^\circ$

A-2163-1-24



NATIONAL UNION RADIO CORPORATION - RESEARCH DIVISION - 350 SCOTLAND ROAD, ORANGE, N. J.

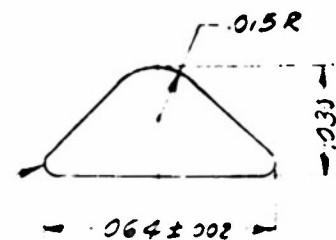
Figure No		MAIN TITLE		STEM - BEFORE & AFTER	
Date		SUB TITLE		Supersedes	
No		Original Designed for Tube Type		Scale 2:1	
3		Underlined Dimensions are Not to Scale UNLESS OTHERWISE SPECIFIED. DIMENSIONS ARE IN INCHES All Parts Must Be Free From Burrs True Centers Within .001" of Center Line Unless Otherwise Specified, Tolerances Are Decimal Dimensions: .5% or + .005 Which ever is Smaller. Fractional Dimensions + .015" Angles 1/2		Date 7-8-52 Aspd Dwg No Checked A-2163-1-24	



NATIONAL UNION RADIO CORPORATION - RESEARCH DIVISION - 350 SCOTLAND ROAD, ORANGE, N. J.					
Date 1-18-51 11-26-51	RECORD OF CHANGES REVISED REVISION AS PER DETAIL 3	Originally Designed for Tube Type: Undefined Dimensions are Not to Scale. UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES All Parts Must Be Free From Burrs True Centers Within .001" at Center Line Unless Otherwise Specified, Tolerances Are Decimal Dimensions ± .5 or .005" Whichever is Smaller. Fractional Dimensions ± 0.5" Angles ± 0°	MAIN TITLE ELECTROSTATIC GUN ASSEMBLY	SUB TITLE	
			Supersedes	Scale:	4-1
Drawn H. DILLI	Date 1-18-51		App'd	Date	
Traced	Date		Dwg No.		
Checked	Date		B-2163-1-13A		

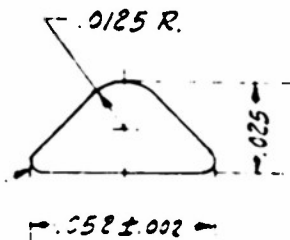
Fig. No.
B-2163-1-118

.003-.004 R.



DETAIL OF HOLES A
SCALE 20-1

.003-.004 R.



DETAIL OF HOLES B
SCALE 20-1

CORNERS MAY BE
ROUNDED

DJ 1 & 2

DJ 3 & 4

A2

A1

A2

G1

SHIELD

.350 ± .005

.175 ± .0025

.112 ± .002

.056 ± .001

B

B

.180 ± .001

.090 ± .0005

B

B

B

B

.125 ± .001

A

.125 ± .001

.030 R.

B

B

A

B

B

.001 ± .0005

.054

.141 ± .002 .119 ± .002 .130 ± .002 .196 ± .002

.077 ± .002

.123

.030

.103 ± .002

.545 ± .002

.098 ± .001

.020 ± .0005

.056 ± .002

.025 ± .0005

1.510

MATERIAL - .008-.012 MICA

Figure No.

5

NATIONAL UNION RADIO CORPORATION - RESEARCH DIVISION - 350 SCOTLAND ROAD, ORANGE, N. J.

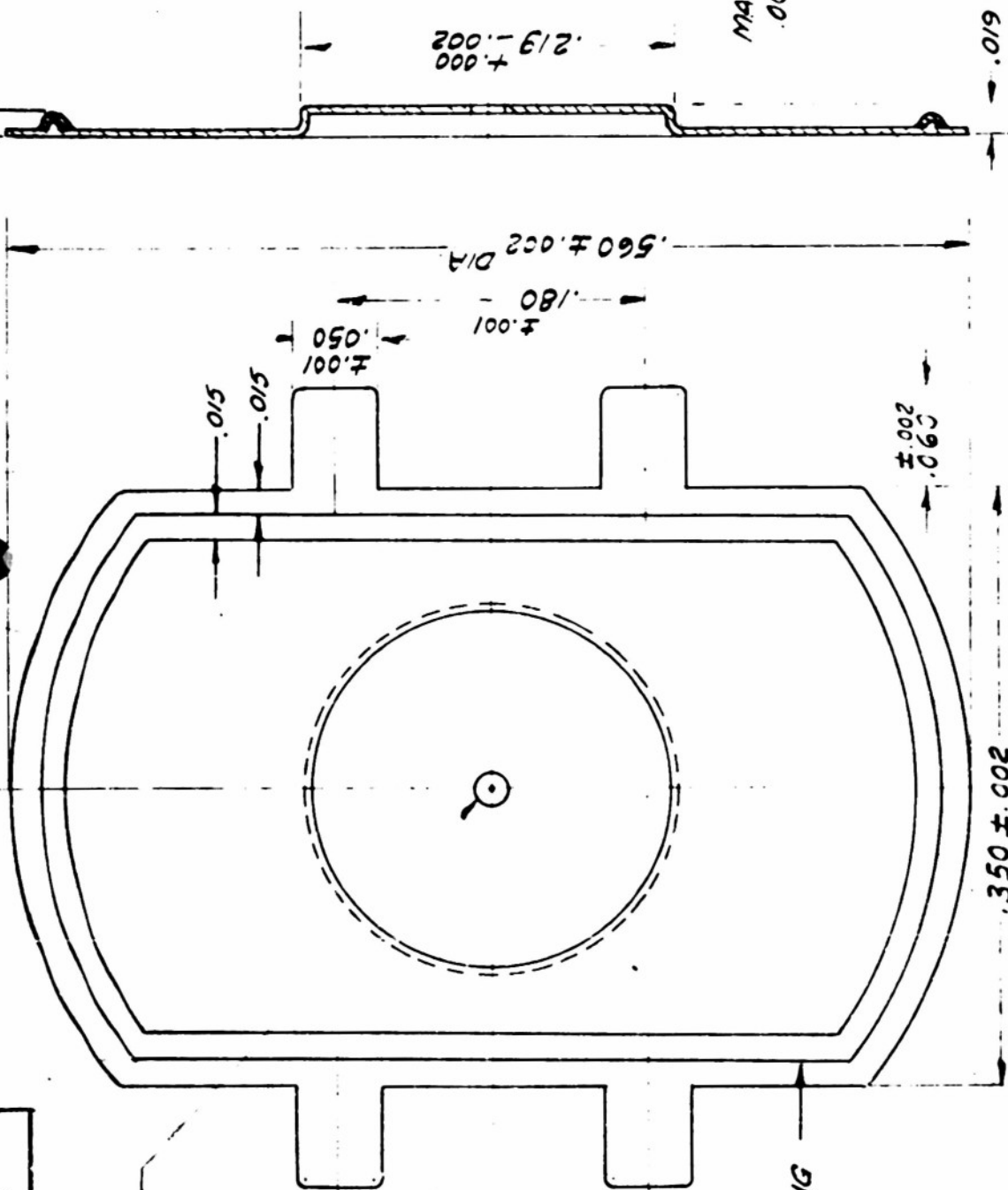
RECORD OF CHANGES			MAIN TITLE	
Date	Change	By	MICA SUPPORT	
			SUB TITLE	
			Supersedes	
			Scale 10-1	
			Drawn H. DILLY 3-13-51	
			Traced	
			Checked	
			Date	
			Fig. No. B-2163-1-118	

Originally Designed
For Tube Type:
Unless Otherwise Specified,
DIMENSIONS ARE IN INCHES.
All Parts Must Be Free From Burrs.
True Centers Within .001" of Center Line
Unless Otherwise Specified. Tolerances
Are Decimal Dimensions .015
Whichever is Smaller.
Fractional Dimensions .015
Angles .0

A-216359

**.C30 DIA.
APERTURE
FREE FROM
BURRS**

EMBOSSED



**MATERIAL -
.005 STAINLESS STEEL**

Figure No

NATIONAL UNION RADIO CORPORATION - RESEARCH DIVISION - 350 SCOTLAND ROAD, ORANGE, N. J.

RECORD OF CHANGES

APPEAL ENROLLING 1:380 DIA. HAS. 200

Originally Designed

Underlined Dimensions are Not to Scale.
UNLESS OTHERWISE SPECIFIED,
DIMENSIONS ARE IN INCHES.

ALL PARTS MUST BE FREE FROM BURRS.
TRUE CENTER WITHIN .001" OF CENTER LINE
UNLESS OTHERWISE SPECIFIED. TOLERANCES

1.00 Decimal Dimensions $\pm .5\%$ or $\pm .005$.
Whichever is Smaller.

Fractional Dimensions + .015"

STUNNED

GRID APERTURE, 'HEAT' SHIELD

SUB TITLE

Supersedes

Scale: 1A /

Drqwn

Drawn Date
H.L. DILLON 12/23/55

Date _____

Traced

Date _____

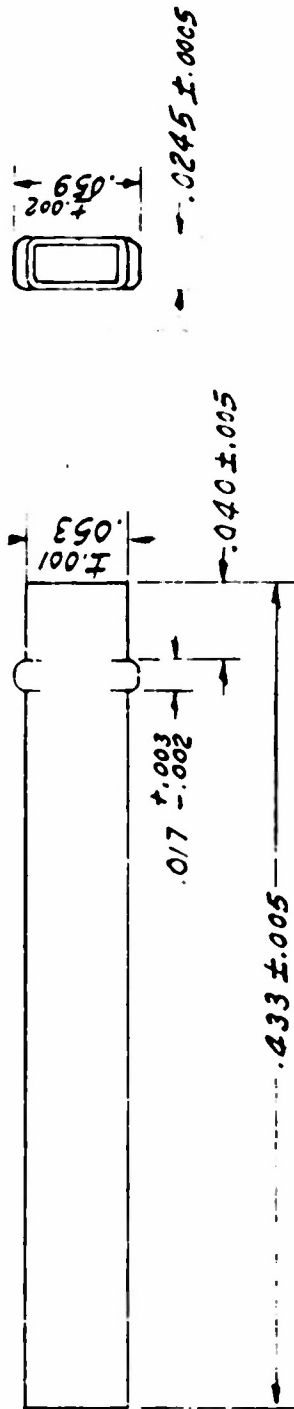
Drug No.

Checked

Date _____

A-2163-1-9

A-2163 12A



NOTE:
SEAMLESS

MATERIAL -
.002 ± .00025 NICKEL

NATIONAL UNION RADIO CORPORATION - RESEARCH DIVISION - 350 SCOTLAND ROAD, ORANGE, N. J.

Figure No

RECORD OF CHANGES

Date

1-22-50

REVISED

Originally Designed
For Tube Type

Undefined Dimensions are Not to Scale.
UNLESS OTHERWISE SPECIFIED,
DIMENSIONS ARE IN INCHES
All Parts Must Be Free From Burrs
True Centers Within .001" of Center Line
Unless Otherwise Specified, Tolerances
Are Decimal Dimensions ± .5% or ± .005"
Whichever is Smaller.
Fractional Dimensions ± .015"
Angles ± 1/2°

Job Title

CATHODE

Supersedes

R-2163

10-1

D.W.

Attd.

Date

1-2-51

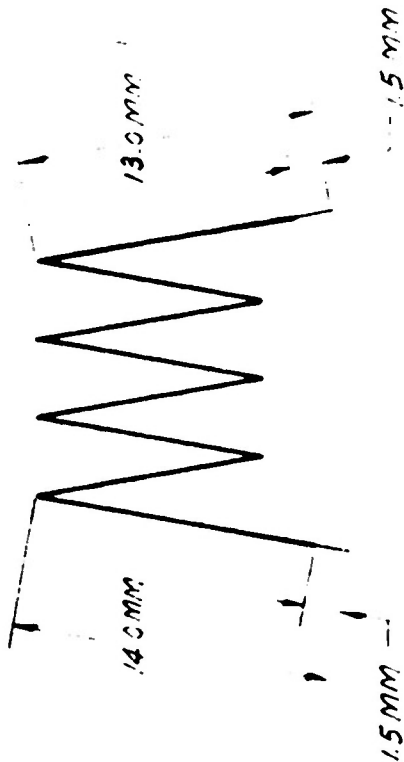
Traced

Checked

Date

1-12A

A-2163- '4



MATERIAL - TUNGSTEN
 WT PER 200 MM - 4.81 MG. 200 MM
 CUT LENGTH - 87 MM
 LEGS - 14-10-10-10-10-10-13
 COATED DIA - .007-.008
 DIP COATING - ALL BENDS (OPTIONAL)
 COATING MATERIAL - INSULATION MIXTURE #HC-8 MURC McCARTER HWY PLANT, NEWARK, N.J.
 DIP COATING MATERIAL - " " #DA-3

NATIONAL UNION RADIO CORPORATION - RESEARCH DIVISION - 350 SCOTLAND ROAD, ORANGE, N. J.

Figure No.

RECORD OF CHANGES

Originally Designed For Tube Type

7.01.007 WAS 7.20.007 (OPTIONAL) ADDED TO DIP COATING NOTE

Underlined Dimensions are Not to Scale. UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES.

All Parts Must Be Free From Burrs. True Centers Within .001" of Center Line Unless Otherwise Specified. Tolerances Are Decimal Dimensions $\pm .5\%$ or $\pm .005$ Whichever is Smaller. Fractional Dimensions $\pm .015$ Angles $\pm 1/2^\circ$

MAIN TITLE

HEATER

SUB TITLE

Supersedes

Scale

3-1

Drawn

Date

Appd.

Date

Treated

Date

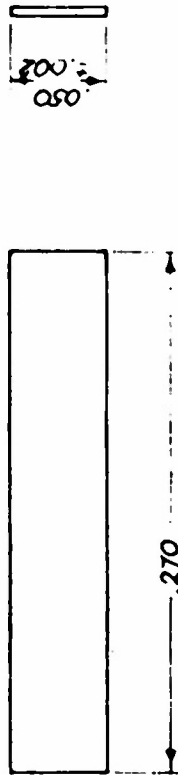
Dwg. No.

Checked

Date

A-2163-1-14

A-216. 1-26



MATERIAL .005 STAINLESS STEEL

NATIONAL UNION RADIO CORPORATION - RESEARCH DIVISION - 350 SCOTLAND ROAD, CRANGE, N. J.

RECORD OF CHANGES

Date

Original Design
for Tube Type

Unstamped Dimensions are Not to Scale
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
All Parts must be Free From Burrs
True Centers Within .001 of Center Line
Unless Otherwise Specified Tolerances
Are Decimal Dimensions .125, .150, or .005
Whichever is Smaller
For Tapped Dimensions: .015
Angles: 1/2

MAIN TITLE

LIGHT SHIELD

SUB TITLE

Supervisors

Scale 10:1

Date

Drawn R.C.B. 1-27-53
Date

App'd

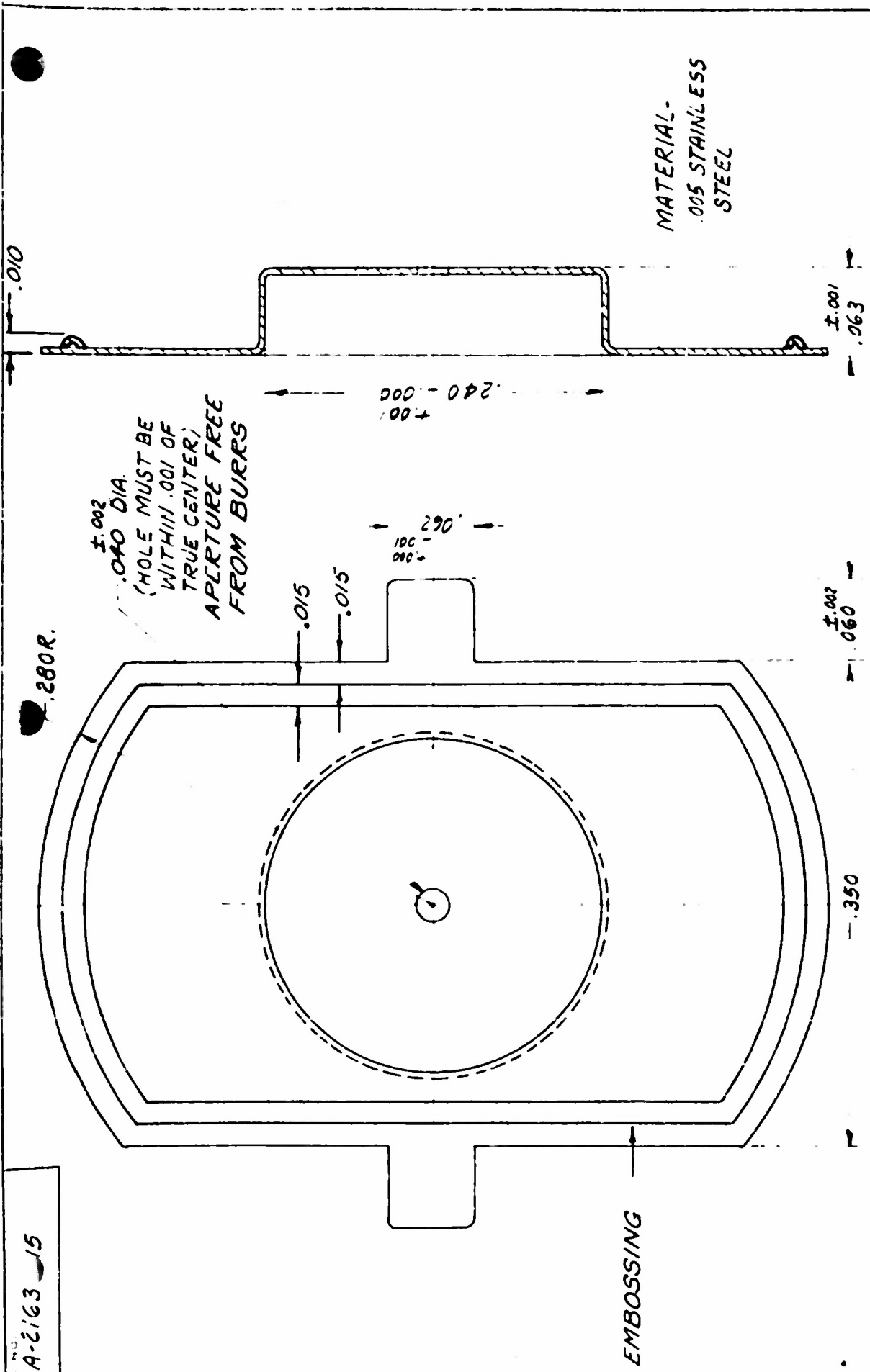
Draw No

A-2163-1-26

Date

Checked

A-2163-15

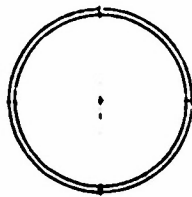
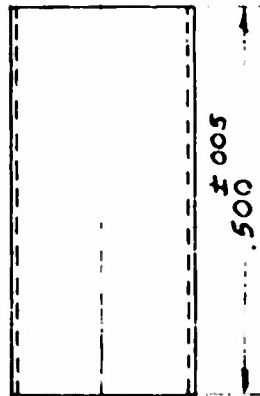


NATIONAL UNION RADIO CORPORATION - RESEARCH DIVISION - 350 SCOTLAND ROAD, ORANGE, N. J.

Figure No. 10		RECORD OF CHANGES		MAIN TITLE	
Date	11-21-51	ADDED EMBOSsing .040 DIA. WAS OK		SUB TITLE	
				LENS CUP	
				Supercedes	
				Scale: 10-1	
				Drawn	
				Date	
				Appd	
				Date	
				Drawn No	
				A-2163-1-15	
				Checked	
				Date	
				Traced	
				Date	
				Original Design	
				For Tube Type:	
				Underlined Dimensions are Not to Scale	
				UNLESS OTHERWISE SPECIFIED,	
				DIMENSIONS ARE IN INCHES.	
				All Parts Must Be Free From Burrs	
				True Center: Within .001 of Center Line	
				Unless Otherwise Specified, Tolerances	
				Are Decimal Dimensions $\pm .5\%$ or $\pm .005$	
				Whichever is Smaller.	
				Fractional Dimensions $\pm .015$	
				Angles $\pm .1^\circ$	

OWB. NO.
A-2163- B

→ .219 ± .002
→ .239 ± .002



MATERIAL - STAINLESS STEEL

NATIONAL UNION RADIO CORPORATION - RESEARCH DIVISION - 350 SCOTLAND ROAD, ORANGE, N. J.

Figure No

RECORD OF CHANGES

Date
11-21-51
4-6-53

NOT WAS NICKEL
TOLERANCE ON .500 DIMENSION WAS .002

R.E.B.

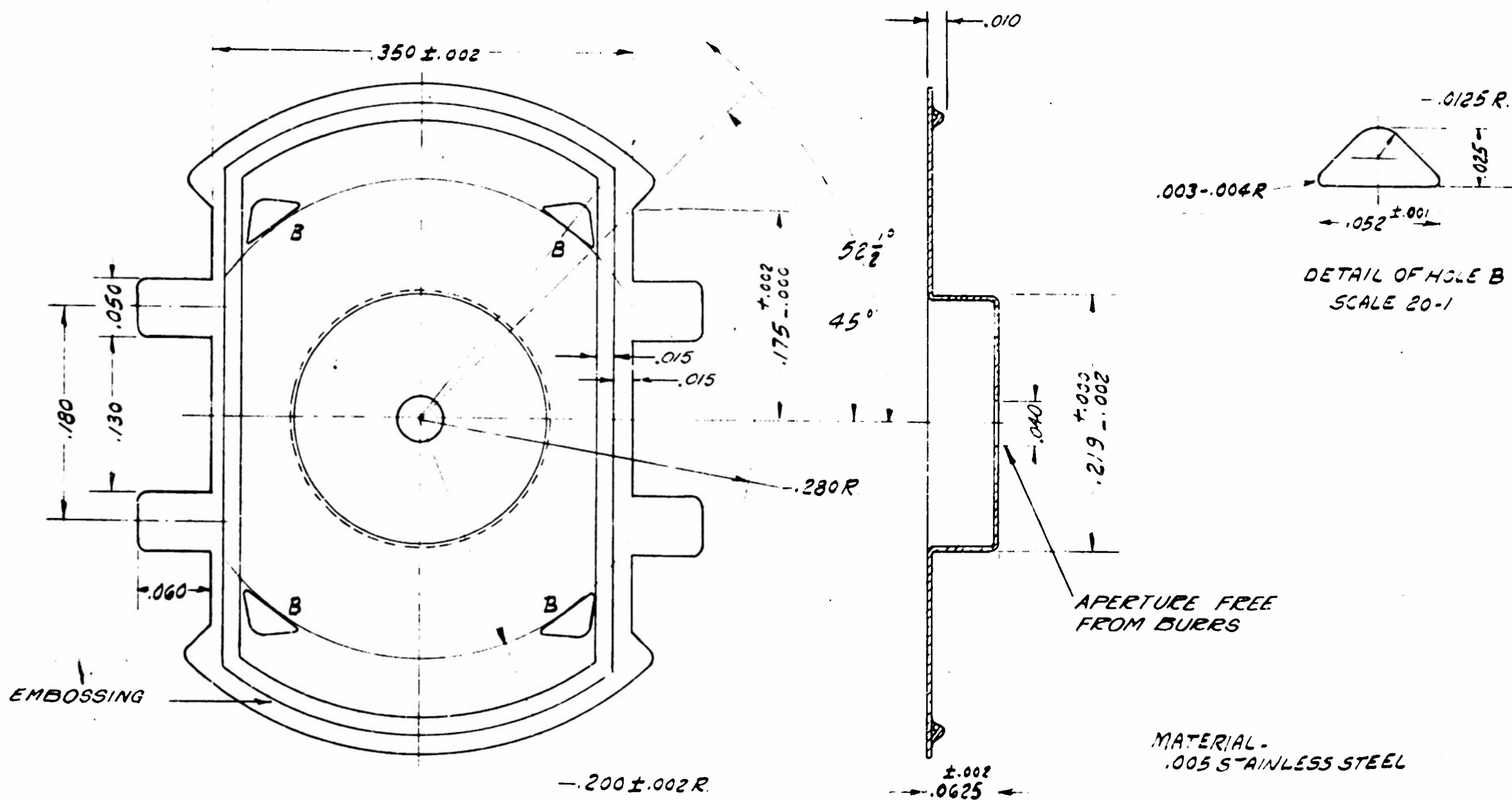
Originally Designed
For Tube Type:

Underlined Dimensions are Not to Scale.
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
All Parts Must Be Free From Burrs.
True Centers Within .001" of Center Line
Unless Otherwise Specified, Tolerances
Are Decimal Dimensions: .5% or + .003"
Whichsoever is Smaller.
Fractional Dimensions + .015"
Angles + 1/2°

MAIN TITLE
ANODE CYLINDER

SUB TITLE

Supersedes
Scale: 4-1
Date
Drawn H.L. LILLY 5-28-51
Traced Date
Checked Date
Dwg No A-2163-1-18



NATIONAL UNION RADIO CORPORATION - RESEARCH DIVISION - 350 SCOTLAND ROAD, ORANGE, N. J.

Date 1-8-51 11-26-51		RECORD OF CHANGES TOL ON .175 DIM WAS $\pm .002$ ADDED EMBOSSED, OPENING IN CENTER HOLE AND		Originally Designed For Tube Type: Undeline Dimensions are Not to Scale. UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. All Parts Must Be Free From Burrs True Centers Within .001" of Center Line Unless Otherwise Specified, Tolerances: Are Decimal Dimensions 5005" Whichever is Smaller. Fractional Dimensions015" Angles 0		MAIN TITLE APERTURE PLATE A₂	
				SUB TITLE			
				Supersedes		Scale: 10-1	
				Drawn H.L. DILLY		Date 12-2-50	
				Traced		Date	
				Checked		Date B-2163-1-5A	

A-2163-7-10



Originally Designed

MAIN TYPE
APERTURE PLATE A,

STYLING

RECORD OF CHANGES

ADDED EMBOSsing

**Originally Designed
for Tube Type:**

Underlined Dimensions are Not to Scale:
UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES.
All Parts Must Be Free From Burrs.

True Centers Within .001" of Center Line

Unless Otherwise Specified, Tolerances

**Are Decimal Dimensions
Which ever is Smaller.**

Fractional Dimensions + .015"

Supplies

Scale 10-1

Drawn

Drawn _____ Date _____

Appd.

Date _____

Traced

Troced **Date**

Dwg. No.

1

Checked

	Date
	Checked

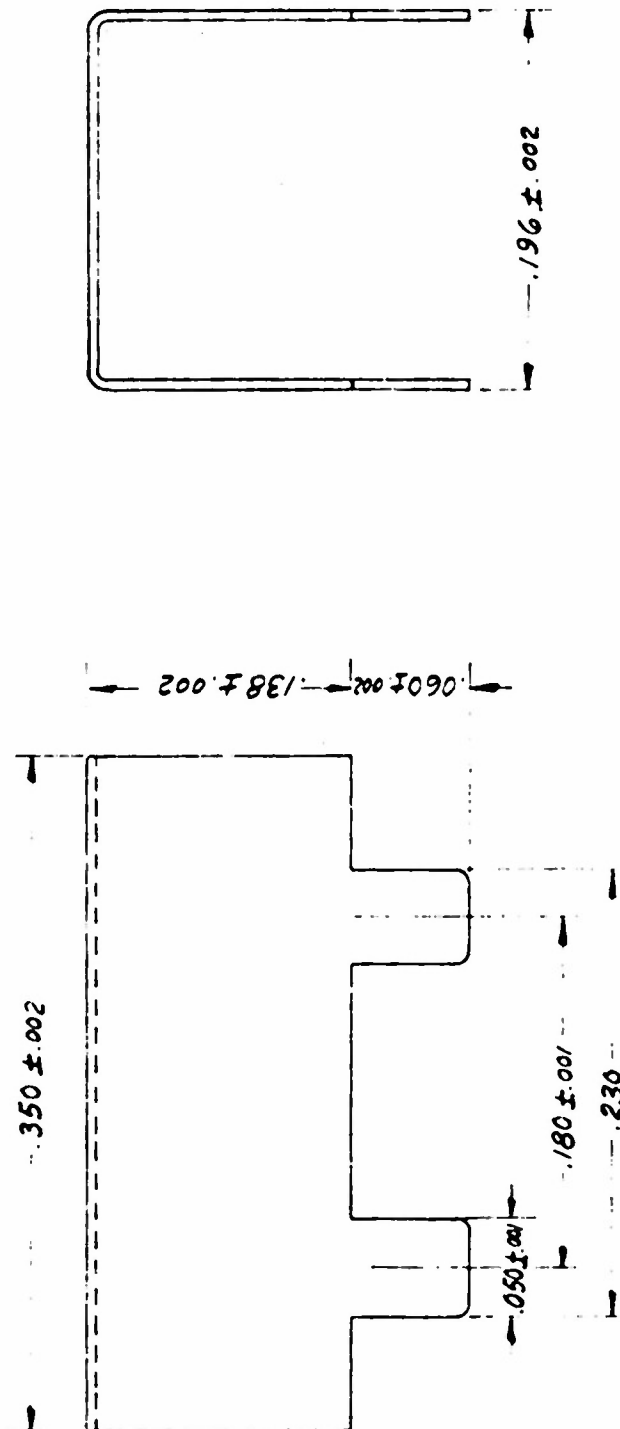
A.21

A-2163-1-10

Figure No

13

Rev. (C) 10-17
A-2163-17

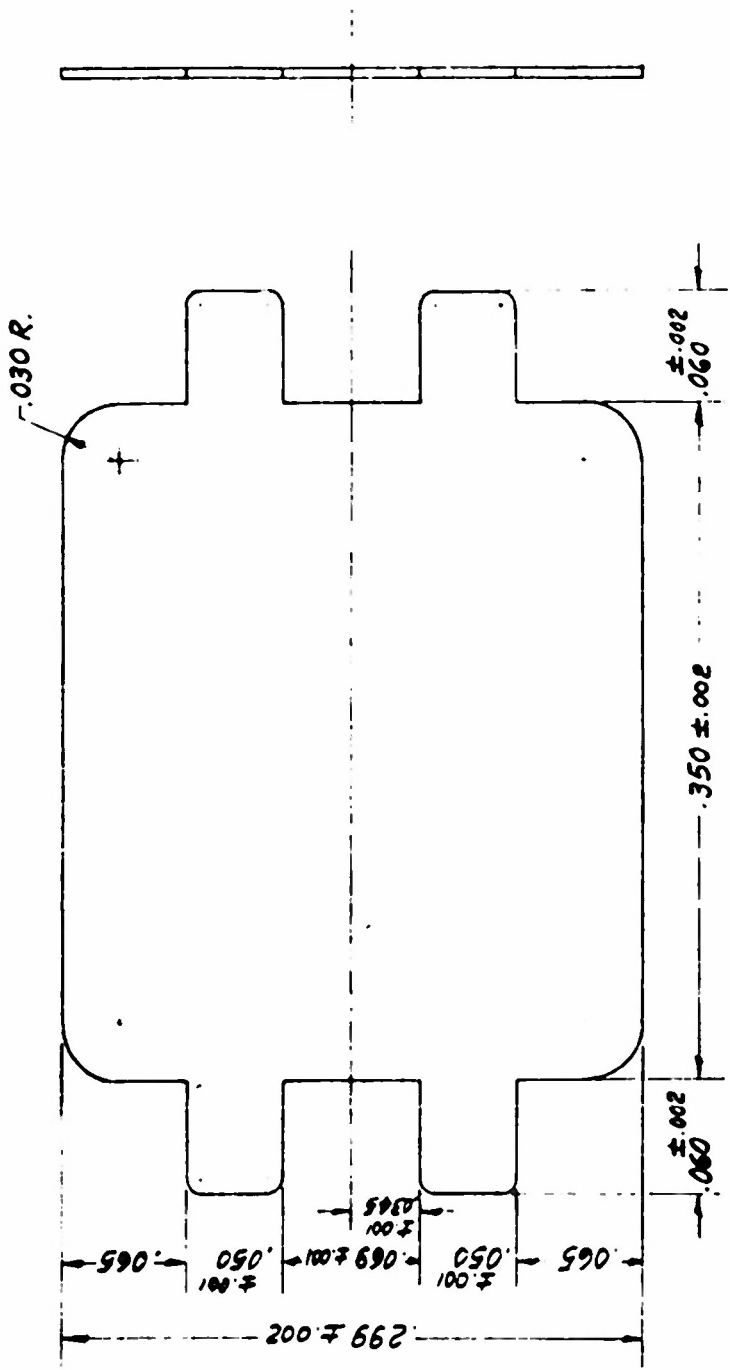


MATERIAL -
.005 STAINLESS STEEL

NATIONAL UNION RADIO CORPORATION - RESEARCH DIVISION - 350 SCOTLAND ROAD, ORANGE, N. J.

Figure No 14		RECORD OF CHANGES		Originally Designed For Tube Type: Underlined Dimensions are Not to Scale UNLESS OTHERWISE SPECIFIED. DIMENSIONS ARE IN INCHES All Parts must Be Free From Burrs True Centers Within .001" of Center Line Unless Otherwise Specified, Tolerances Are Decimal Dimensions ± .5% or + .005 Whichever is Smaller. Fractional Dimensions ± .015" Angles ± 1/2°		MAIN TITLE #3634 DEFLECTION PLATES SUB TITLE Supersedes Scale: 10-1 Drawn H.L. DILLON Date 3-12-51 Appd. Date Eng No A-2163-1-17 Checked Date	
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DWG. NO.
A-2163-1-76



MATERIAL -
.005 STAINLESS STEEL

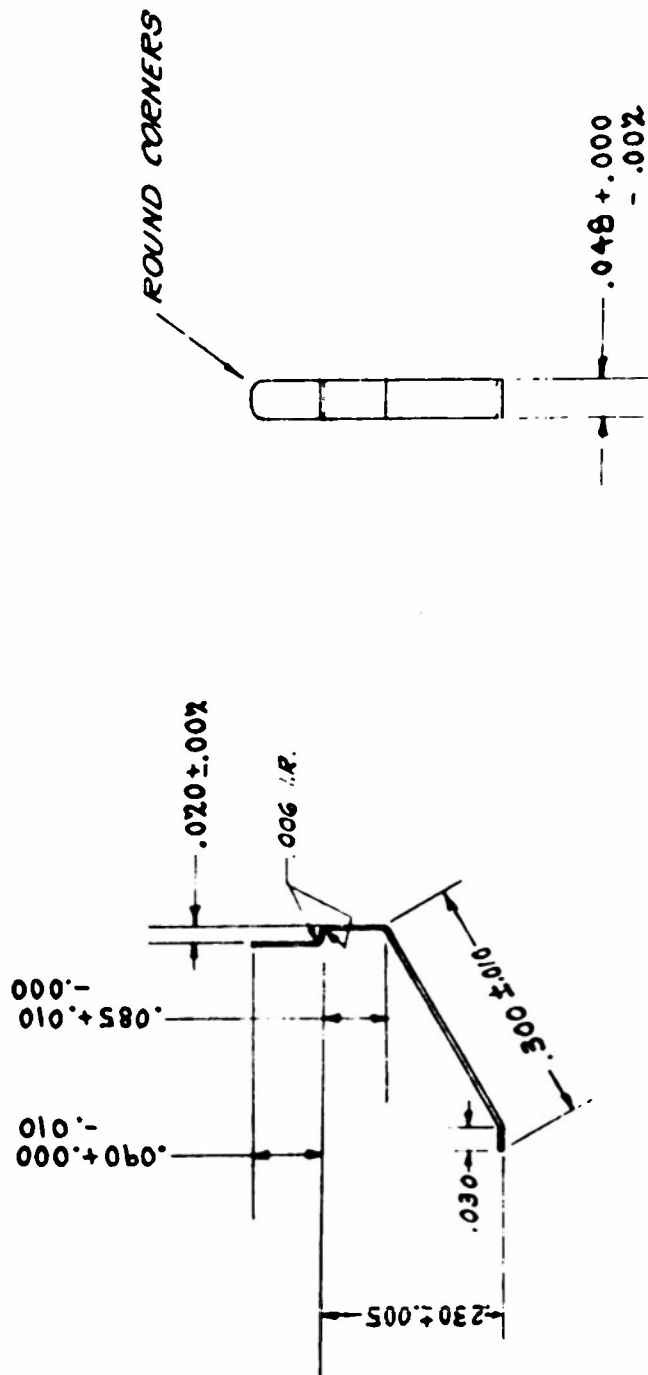
NATIONAL UNION RADIO CORPORATION - RESEARCH DIVISION - 350 SCOTLAND ROAD, ORANGE, N. J.

Figure No. 15		RECORD OF CHANGES		MAIN TITLE #1622 DEFLECTION PLATES	
Date				SUB TITLE	
				Supersedes	
				Scale	10-1
				Drawn	H.L. DILLY
				Date	3-12-51
				Appd.	
				Dwg. No.	A-2163-1-16
				Date	
				Checked	

Originally Designed For Tube Type:

Underlined Dimensions are Not to Scale.
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES.
All Parts Must Be Free From Burrs.
True Centers Within .001" of Center Line
Unless Otherwise Specified, Tolerances
Are Decimal Dimensions ± .005 or + .003"
Which ever is Smaller.
Fractional Dimensions ± .015"
Angles ± 1/2°

OWG. NO.
A-2163-3C



MATERIAL: .004 SPRING TEMPERED
STAINLESS STEEL #305

Figure No

16

NATIONAL UNION RADIO CORPORATION - RESEARCH DIVISION - 350 SCOTLAND ROAD, ORANGE, N. J.

Date 12-13-50		RECORD OF CHANGES		MAIN TITLE SUPPORT SPRING	
1-8-51		.028 WAS .049 .300 WAS .400 ADDED .306 I.P. & .230		SUB TITLE	
7-6-51				Supercedes	
				Scale: 4:1	
				Appd. Date 11-30-50	
				Dwg No. A-2163-1-3C	
				Checked	
				Date	

Originally Designed
For Tube Type:
Underlined Dimensions are Not to Scale
UNLESS OTHERWISE SPECIFIED.
DIMENSIONS ARE IN INCHES
All Parts Must Be Free From Burrs.
True Centers Within .001 of Center Line
Unless Otherwise Specified, Tolerances
Are Decimal Dimensions $\pm .5\%$ or $\pm .005$
Whichever is Smaller.
Fractional Dimensions $\pm .015$
Angles $\pm \frac{1}{2}^\circ$

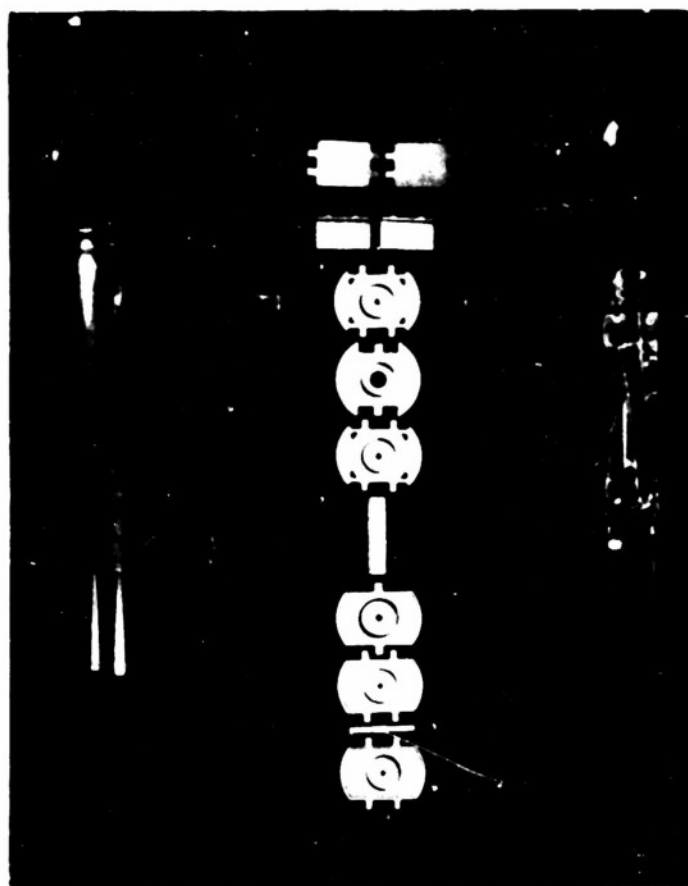


FIG. 17 TUBE COMPONENTS AND GUN

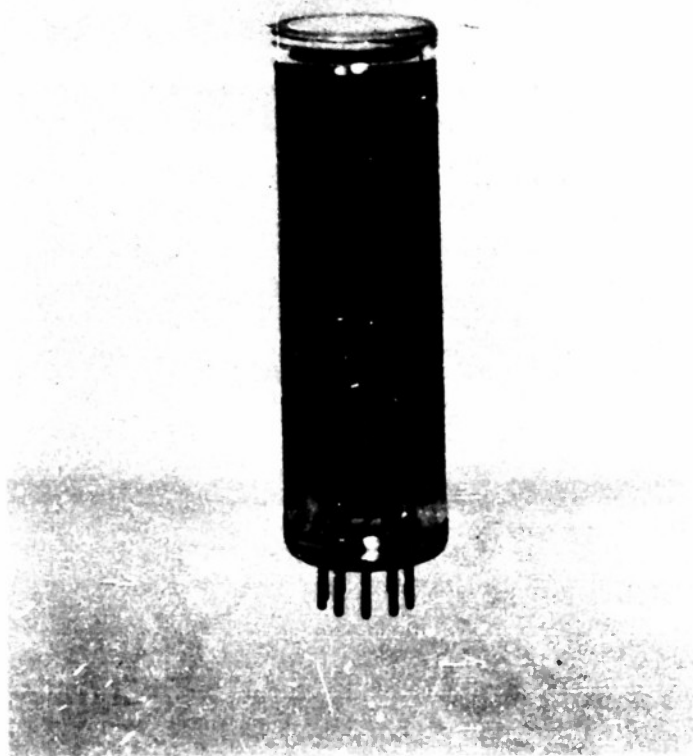


FIG. 18 FINISHED TUBE

