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a subsidiary of

System Development Corporation

CERAMIC VACUUM TUBES

FOR GEOTHERMAL WELL LOGGING



MRI-2942-TR1

12 January 1977

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## Prepared for:

Energy Research and Development Administration Division of Geothermal Energy Washington, D.C. 20545



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Measurement and Analysis Department

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### 1.0 INTRODUCTION

This report summarizes the results of investigations carried out by Mechanics Research, Inc. (MRI) into the availability and suitability of ceramic vacuum tubes for the development of logging tools for geothermal wells. This investigation is one task being performed for the U. S. Energy Research and Development Administration (ERDA) as part of Contract E(04-3)-1330 for the design, development and test of an instrumentation amplifier capable of operating in a downhole well logging environment including ambient temperatures up to 500°C.

One objective of this contract is to demonstrate the feasibility of meeting the ERDA long term temperature capabilities of 500°C in downhole logs with present day technology. The technical approach is based on the prior successful use of ceramic vacuum tubes for a 250°C downhole instrumentation amplifier (References 1 and 2) and successful operation of ceramic vacuum tubes for 4000 hours at 500°C (Reference 3).

The information in this report is presented to aid future development of high temperature electronics with ceramic vacuum tubes. This information is in no manner intended to be an exhaustive study of the subject of ceramic vacuum tubes, but rather to present useful design data acquired in the evaluation of ceramic vacuum tubes for the development of a 500°C instrumentation amplifier. Section 2 of this report discusses the general requirements for ceramic vacuum tubes for application to the development of high temperature well logs. Commercially available tubes are described in Section 3 and future contract activities that specifically relate to ceramic vacuum tubes are detailed in Section 4. Supplemental data is presented in the appendix.

# 2.0 GENERAL REQUIREMENTS

Stringent and frequently conflicting requirements exist on active electronic devices for their use in downhole geothermal well logging. Even though these devices are usually packaged in rugged, pressure proof sondes, the devices must be able to function properly in very hostile temperature and shock environments. The devices should be small to permit efficient packaging. They should consume small amounts of power, have a long life and have a reasonable cost. The following paragraphs describe these requirements in more detail.

## 2.1 Temperature

The goal of the amplifier design is for operation at, or near, 500°C. This represents the long term temperature objective for geothermal well logging instruments as stated in Reference 4. Thus, the tube envelope must be at somewhat higher temperature to transfer heat to the external environment.

High temperature can cause a number of problems in the operation of ceramic vacuum tubes. The high ambient temperature can cause elevated filament and cathode temperature, which can result in accelerated depletion of the thermionic emission material of the cathode and/or loss of tube life by filament burn-out. The high temperature can also cause an increase in the rate of outgassing and loss of tube performance and/or life by contamination. In addition, temperature changes cause changes in the spacings between tube elements because of thermal expansion. This change in tube spacing is reflected in tube performance characteristic changes.

#### 2.2 Shock

Well logs are subjected to severe mechanical shocks during deployment and recovery. The logs are generally deployed and recovered by a single electro-mechanical cable. Thus, the log is unconstrained laterally, and it slams against the sides of the well as the log is lowered or raised. In addition, the logs are sometimes used as battering rams to reopen the hole if bridging occurred when the drill string was removed. This environment is unknown, but intuitively it must be a severe shock environment. The primary requirement for active electronic devices is to survive a large number of these shocks without performance degradation.

## 2.3 Size

In general, it is desirable to have the active electronic device as small as possible so that the complete instrument can be packaged in a small volume. Some slimbole sondes are only 1.4 inches in internal diameter. However, with ceramic vacuum tubes, the reduced size must be compromised with a loss in some performance characteristics, most notably reduced transconductance from reduced cathode area.

#### 2.4 Power

It is desirable to keep the total power required low and the number of power supplies required low as discussed below:

Present operational techniques require transmission of the electrical power over long cables (3 to 5 miles) from the surface downhole to the log. Also, the total number of electrical conductors is usually quite limited (frequently 1 conductor plus the mechanical strength member, or 7 conductors plus the strength member).

Filament power should be as low as possible. Most of the ceramic vacuum tubes applicable to high temperature well logging are designed for nominal 6.3 volt filament power. Thus, the tube should require a minimal filament current. The filament current is normally the largest current required and over long lines this current causes a very noticeable voltage drop. For example, the round trip resistance of an 18 gage conductor, 20,000 feet long is 256 ohms

at room temperature. For a one-third ampere filament current, the line drop is about 85 volts. The filament current must not exceed the current carrying capability of the conductor at its maximum useage temperature. For these reasons, the filaments of multiple stages are often wired in series. However, there are two limits on the use of series filament connections. First, the series filament drop plus the line drop voltage must not exceed the voltage rating of the insulation material of the cable. Second, there is a finite limit on the allowable voltage difference between the filament and cathode of a given tube. This voltage must not be exceeded. It is desirable for this tube characteristic to be as large a voltage as possible.

For the B+ supply, it would simplify amplifier design if multiple B+ and B- supplies could be used. However, with the limitations on the number of conductors in the logging cable, the amplifier design is forced toward a single B+ supply. Lack of large coupling capacitors for operation at these temperatures further forces the amplifier design toward direct coupling. Therefore, the tube should be capable of linear operation over a wide range of B+ voltages, because in cascaded direct coupled amplifiers it is desirable to start with a low plate voltage at the initial stage and increase with subsequent stages.

Another requirement on the B+ power supply is that the voltage at the amplifier plus the line drop not exceed the allowable voltage rating of the cable insulation. (Thus, low B+ current requirements for the tubes are desireable.)

The amplifier design should be such that its performance is tolerant of fairly broad B+ and/or filament power variations.

## 2.5 Performance

Economically, it is presently desirable to minimize the number of types of tubes used in an instrument design to enhance the quantity price breaks. Yet in a typical amplifier, quite different performance requirements exist for tubes used in different stages. Input stage tubes must be able to amplify

very small voltages from transducers, intermediate stage tubes must amplify relative high level voltages and output stage tubes must be able to drive long, lossy transmission lines. The input and intermediate stage tubes should have high mu's, but with different linear operating points and the output stage tube should have a very low plate resistance. High mu and low plate resistance tend to be conflicting requirements, especially when the desire is to minimize B+ current and physical size. To minimize the temperature dependence of tube characteristics is desirable, but to some extent conflicts with good performance characteristics.

#### 3.0 COMMERCIALLY AVAILABLE TUBES

A survey was made to determine which commercially available ceramic vacuum tubes appear to be the most applicable to the design of a 500°C instrumentation amplifier. The following suppliers of ceramic vacuum tubes were located by MRI:

- Amperex Electronic Corporation A North American Phillips Company Distributor Sales Operation 230 Duffy Avenue Hicksville, L.I., New York 11802 (516) 931-6200
- EIMAC
  Division of Varian
  1678 S. Pioneer Road
  Salt Lake City, Utah 84104
  (801) 487-7561
- General Electric Electronic Components Business Division Tube Products Department 316 East Ninth Street Owensboro, Kentucky 42301 (502) 683-2401
- The Machlett Laboratories, Inc. A Subsidiary of Raytheon Company 1063 Hope Street Stamford, Conn. 06907 (203) 348-7511

Most of the commercially available ceramic vacuum tubes are not suitable for high temperature downhole well logging for one, or more, of the following reasons:

- too large,
- excessive power requirements and/or
- development required for 500°C ambient operation.

The one exception found was in the General Electric product line. They manufacture a number of planar triodes and a few diodes that are sufficiently small, have low power requirements, and have demonstrated high temperature capabilities. Other suppliers have the capabilities to develop tubes for high temperature well logging, which is of interest to future developments, but not compatible with the schedule and budget requirements of our present contract. Table 1 summarizes the characteristics of the GE ceramic vacuum tubes that appear most useful for high temperature well logging applications. Figure 1 displays the various physical configuration of these tubes. Electrical connections can be made to these tubes by soldering, wire wrapping, welding, brazing and mechanical clips. Sockets are available for some tube types, though not recommended for other than testing purposes.

Tube types 7296 and 7588 were used by MRI in the development of a 250°C downhole well logging amplifier (see reference 1). The 7296 type of tube was tested by GE at elevated temperatures (see reference 3). One of these test conditions was a 4000 hour life test at an ambient environment of 500°C. Thus, these tubes appear to have immediate potential for application to the long range (500°C) well logging requirements.

Detailed data sheets for some of these tubes are presented in the Appendix.

## Table 1

Nominal Characteristics of Selected General Electric Production Type Ceramic-Metal Vacuum Tubes (Extracted From GE Publication, "Ceramic Tubes for Original Equipment Design", EI-61A and "Reference Data for General Electric Microwave Products".

	GENERAL MAXIMUM RA	TINGS					
TYPE	GENERAL DESCRIPTION	OUT- LINE	HEA VOLTS	TER	MAX PLATE VOLTS AND WATTS	MAX GRID CUR- RENT	MAX FREQ. (MHz)
7077	METAL-CERAMIC TRIODE INTENDED FOR LOW-NOISE UHF AMPLIFIER SERVICE	Ħ	6.3	0.24	250 1.1	<b>-</b>	3000
7266	METAL-CERAMIC DIODE INTENDED FOR INSTRUMENT- PROBE SERVICE	Ī	6.3	0.215	600 (1)	•	3000
7296	METAL-CERAMIC TRIODE INTENTED FOR VHF OSCILLATOR OR AMPLIFIER SERVICE	J	6.3	0.4	330 5.5	10 MA	500
7391	METAL-CERAMIC TRIODE INTENDED FOR UHF OSCILLATOR SERVICE	Ŧ	6.3	0.38	200 2.25	3.0 MA	6000
7462	METAL-CERAMIC TRIODE INTENDED FOR LOW-NOISE VHF AMPLIFIER SERVICE	ĸ	6.3	0.24	250 1.1	•	500
7486	METAL-CERAMIC TRIODE INTENDED FOR UHF OSCILLATOR OR AMPLIFIER SERVICE	H,	6.3	0.24	250 1.0	2.2 MA	3000
7588	METAL-CERAMIC TRIODE INTENDED FOR VHF AMPLIFIER SERVICE	J	6.3	0.4	300 5.5	_	500
7625	METAL-CERAMIC TRIODE INTENDED FOR LOW-LEVEL AUDIOFREQUENCY AMPLIFIER SERVICE	K	6.3	0.215	275 0.85	-	-
7644	METAL-CERAMIC TRIODE INTENDED FOR LOW-NOISE UHF AMPLIFIER SERVICE	F	6.3	0.3	200 2.0		3000

### NOTES

(1) Peak inverse voltage.

.(2) This is the bogey value at which average characteristics are determined. For some classes of operation, a lower value may be recommended.

- (3) These are the highest values listed for any class of CW operation; lower values may be indicated for some classes of CW operation. Refer to the complete Product Information sheets for this information.
- Adjusted for 1b = 75 milliamperes.

Peak voitage rating for pulse service.

(6) Pulse Service.

- Adjusted for 1b = 75 milliamperes.
- The frequency listed is one at which significant application data are available or expected, and does not necessarily represent an absolute frequency limit. Adjusted for lb = 10 milliamperes.

Adjusted for 1b = 10 milliamperes; range must be variable from 75 to 200 volts.

Bypassed resistor (18k) in plate-supply lead.

- (12) With Rk = 910 and Eg = +6.0 volts.
  (13) With Rk = 270 and Eg = +6.0 volts.
  (14) Bypassed resistor (17.5k) in plate-supply lead.
- (15) Plate dissipation of 100 watts is permissible with forced-air cooling.

Table 1A

2	GENERAL MAXIMUM RA	TINGS			•		
TYPE	GENERAL DESCRIPTION	OUT- LINE	HEA VOLTS	TER	MAX PLATE VOLTS AND WATTS	MAX GRID CUR- RENT	MAX FREQ. (MHz)
7720	METAL-CERAMIC TRIODE INTENDED FOR VHF OSCILLATOR SERVICE	ĸ	6.3	0.24	250 1.0	2.2 MA	500
7768	METAL-CERAMIC TRIODE INTENDED FOR UHF AMPLIFIER SERVICE	L	6.3	0.4	330 5•5	<b>.</b>	3000
7784	METAL-CERAMIC TRIODE INTENDED FOR LOW-NOISE UHF AMPLIFIER SERVICE	М	6.3	0.3	200 2.0	-	3000
7841	METAL-CERAMIC DIODE INTENDED FOR DETECTOR SERVICE	I	6.3	0.215	350 (1)	-	3000
7910	METAL-CERAMIC TRIODE INTENDED FOR UHF PLATE- PULSED OSCILLATOR OR AMPLIFIER SERVICE	P	6.3	0.275	1200 (5) 1.5 (6)	200 MA (6)	750
7913	METAL-CERAMIC TRIODE INTENDED FOR OSCILLATOR OR AMPLIFIER SERVICE	L	6.3	0.4	330 3.5	10 MA	3000
8081	METAL-CERAMIC TRIODE INTENDED FOR LOW-LEVEL AUDIOFREQUENCY AMPLIFIER SERVICE	R	6.3	0.215	275 0.85	_	-
8082	METAL-CERAMIC TRIODE INTENDED FOR UHF OSCILLATOR SERVICE	R	6.3	0.24	250 1.0	2.2 MA	500
8083	METAL-CERAMIC TRIODE INTENDED FOR LOW-NOISE VHF AMPLIFIER SERVICE	R	6.3	024	250 1.1	-	500

## NOTES

(:) Peak inverse voltage.

(2) This is the bogey value at which average characteristics are determined. For some classes

(5) Peak voltage ration (6) Pulse Service.

(6) Pulse Service.
(7) Adjusted for lb = 75 milliamperes.
(8) The frequency listed is one at which significant application data are available or expected, and does not necessarily represent an absolute frequency limit.
(9) Adjusted for lb = 10 milliamperes.
(10) Adjusted for lb = 10 milliamperes; range must be variable from 75 to 200 volts.
(11) Bypassed resistor (18k) in plate-supply lead.
(12) With Rk = 910 and Eg = +6.0 volts.
(13) With Rk = 270 and Eg = +6.0 volts.
(14) Bypassed resistor (17.5k) in plate-supply lead.
(15) Plate dissipation of 100 watte is paymingthly with formed and application.

(15) Plate dissipation of 100 watts is permissible with forced-air cooling.

of operation, a lower value may be recommended.

(3) These are the highest values listed for any class of CW operation; lower values may be indicated for some classes of CW operation. Refer to the complete Product Information sheets for this information.

(4) Adjusted for lb = 75 milliamperes.

Peak voltage rating for pulse service.

	CHARACTERISTICS AND TYPICAL OPERATION										
TYPE		PLATE VOLTS	NEG. GRID VOLTS	PLATE MILLI- AM- PERES	GRID MILLI- AM- PERES		Rp, OHMS	Gm., LIMHOS	GAIN IN DECI- BELS	R.F. POWER OUT- PUT	FREQ.
			Rk =	6.5		90	9000	10000	_	-	_
7077	AVG. CHAR. GROUNDED-GRID AMP.	250 (11) 250 (11)	82 Rk = 82	6.5				•	14.5	•	450
7266	INSTRUMENT DETECTOR	TUBE ≠ 2.	VOLTAG 2 MA; M	E DROP: AX PEAK	1.0 VOLT	es at Curre	1B = 1.0 NT = 11 1	MA. VAX IA.	D-C CA	THODE C	URRENT
7296	AVG. CHAR.	200	Rk = 68	17		90	5450	16500	<b>+</b>	-	•
7391	AVG. CHAR. CLASS C OSCILLATOR CLASS C OSCILLATOR		1.5	10 12 12	3.0 3.0	62 -		11000		65mW 500mW	5400 500
7462	AVG. CHAR.	150	(12)	7.2		94	9000	10500	-	-	-
7486	AVG. CHAR.	150	Rk = 82	7.5		90		10500	-		-
	CLASS C OSCILLATOR	150	Rg =	8.0	2.0	-	-	-	-	300mW	1200
	CLASS C AMPLIFIER	150	1000 Rg = 3000	5.0	1.0	-	-	-	•	300mW	450
7588	AVG. CHAR.	200	(13)	24		175	3900	45000		-	-
7625	AVG. CHAR.	150	Rk = 1000	0.95	•	80	57000	1400	-	-	-
7644	AVG. CHAR. CLASS A RF AMP GROUNDED-GRID	175 300 (14) 300	(9)	10 10		110	7300	15000	i	-	3000

Table 1C

·			CHA	RACTERIS	TICS AND	TYPI	CAL OPERA	TION		9: 1	
TYPE		PLATE VOLTS	NEG. GRID VOLTS	PLATE MILLI- AM- PERES	GRID MILLI- AM- PERES	<b>4</b>	Rp, OHMS	Gm, .µMHOS	GAIN IN DECI- BELS	R.F. POWER OUT- PUT	FREQ.
7720	AVG. CHAR.	150	Rk = 82	7.5	-	90	•	10500	-	-	
	CLASS C OSCILLATOR	150	Rg = 7000	4.0	0.5	•	. <b>-</b> Kalendari	<b>-</b>	-	100mW	450
7768	AVG. CHAR.	200	(13)	24	+	225	4500	50000			
7784	AVG. CHAR. CLASS A RF AMP GROUNDED -GRID	175 (10) (10)	(9) 0 0	10 10 10	-	110 - -	7300 - -	15000 - -	- 17.5 11		450 3000
7841	SIGNAL DETECTOR						1B = 5.0 ENT = 22 N		X D-C C	ATHODE	CURRENT
7910	AVG. CHAR.	125	Rk =	11.5	•	75		16000	-	- <u>-</u> -	_
	PLATE-PULSED OSC D.F. = 0.001	1000 PEAK	82 -	600 PEAK	200 PEAK	-	-	-	_	100W PEAK	5900
7913	AVG. CHAR.	200	Rk =	25	-	1.00	2500	40000	-	7	-
	CLASS C OSCILLATOR	300	Rg = 1500	25	5.0	-	-	<b>-</b>	_	4.OW	400
8081	AVG. CHAR.	150	Rk = 1000	0.95	-	80	57000	1400	-	2	•
8082	AVG. CHAR.	150	Rk =	7.5	-	90	•	10500	-	-	•
	CLASS OSCILLATOR	150	82 Rg = 7000	4.0	0.5	-	-	-	-	100mW	450
8083	AVG. CHAR.	150	(12)	7.2	<b>-</b> .	94	9000	10500	-	<b>-</b>	-

Table 1D

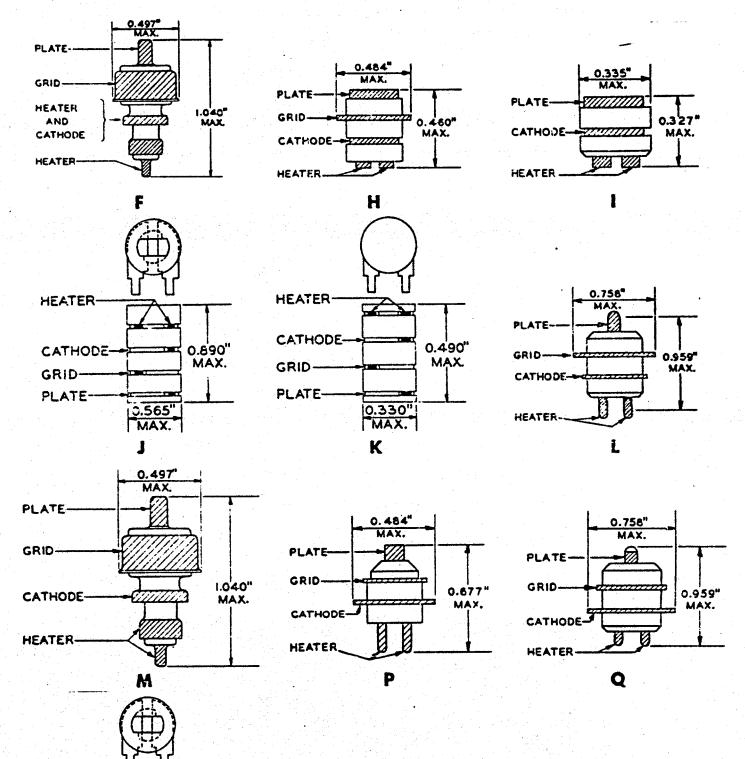


Figure 1. Outlines of Selected General Electric Production Type Ceramic Metal Vacuum Tubes (Extracted from GE Publication "Ceramic Tubes for Original Equipment Design", EI-61A.)

0.330" MAX. 0.600"

MAX.

HEATER

CATHODE

GRID-

## 4.0 FUTURE ACTIVITIES

Before selecting tube types for use in the development of the Ultra High Temperature Amplifier, MRI plans to perform some supplemental temperature testing of selected tubes. Small quantities of tube types 7296, 7588, 7625 and 7462 have been ordered. These particular tubes have been selected to permit trade-offs of characteristics such as voltage amplifier performance, line driver performance, temperature performance, physical size, plate power requirements, filament power requirements and cost. Table 2 summarizes pertinent nominal characteristics of the selected tube types.

Table	2. Nominal	Tube Character	istics							
	Tube Type									
Characteristic	7296	7588	7462	7625						
mu	90	175	94	80						
G <sub>m</sub> (Micromhos)	16,500	45,000	10,500	1,400						
I <sub>p</sub> (ma.)	17	24	7	1						
If (ma.)	400	300	240	215						
Diameter (in.)	1/2	1/2	1/3	1/3						
Unit Cost (\$)	94	180	63	84						

The primary emphasis of the planned testing will be the determination of tube characteristic variations with temperature, since no data is available on this characteristic. It is important that tube characteristics do not change in a major way with temperature because the well log must operate over a broad spectrum of temperatures, not just a single temperature.

In addition to the above four commercially available tube types, one special tube is being developed by GE for a nominal cost. The objective

of this tube is to provide both a high amplification factor and high transconductance in a single tube. If successful, this approach will permit a single tube type to perform both the voltage amplification and line driving functions. The design goals for this tube are:

- Size: 1/3 inch diameter (8081 configuration)
- Filament Current: 215 ma @ 6.3V
- Amplification Factor: 300  $\pm 75$  @ I<sub>p</sub> = 5 ma
- Transconductance: 21,000  $\pm$ 1000 Mmhos @ I<sub>p</sub> = 10 ma

Use of a single tube type is advantageous from the standpoints of volume price discount and spares requirement. This tube type will be tested in the same manner as the standard product line tubes.

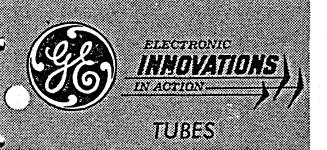
### REFERENCES

- 1. W. Cannon, "Development of a Prototype High Temperature Amplifier for Geothermal Well Logging", Mechanics Research, Inc., report MRI 2870, May 1976.
- 2. R. D. Kelly, "Brief Report on Downhole Tests", letter to Larry Ball, ERDA Division of Geothermal Energy, May 27, 1976.
- 3. Unknown, "Life Test Summary of Ceramic Types Under High Temperature
  And High Humidity Conditions", General Electric Engineering Information EI-43A
- 4. L. E. Baker, R. P. Baker, and R. L. Hughen, "Report of the Geophysical Measurements in Geothermal Wells Workshop", Sandia Laboratories report SAND75-0608, December 1975.

# APPENDIX

Detailed Data Sheets for

Selected Ceramic Vacuum Tubes



# 7077

# METAL-CERAMIC TRIODE

FOR UHF AMPLIFIER APPLICATIONS



# DESCRIPTION AND RATING

The 7077 is a high-mu-triode of ceramic and metal planar construction primarily intended for use as an r-f amplifier in the UHF range. It features an extremely low noise figure throughout its frequency range. The 7077 is especially suited for use where unfavorable conditions of mechanical shock, mechanical vibration, and nuclear radiation are encountered.

## **GENERAL**

#### ELECTRICAL

### 

## MECHANICAL

Mounting Position—Any

See Outline Drawing on page 3 for dimensions and electrical connections

#### MAXIMUM RATINGS

## ABSOLUTE-MAXIMUM VALUES

Plate Voltage	Volts	Heater Positive with Respect to	
Positive Peak and DC Grid Voltage0		Cathode50	Volts
Negative Peak and DC Grid Voltage50		Heater Negative with Respect to	
Plate Dissipation	Watts	Cathode50	Volts
DC Cathode Current		Envelope Temperature	
Heater-Cathode Voltage		Brid-Circuit Resistance0.01	Megohms

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron tube of a specified type as defined by its published data and should not be exceeded under the worst probable conditions.

The tube manufacturer chooses these values to provide acceptable serviceability of the tube, making no allowance for equipment variations, environmental variations, and the effects of changes in operating conditions due to variations in the characteristics of the tube under consideration and of

all other electron devices in the equipment.

The equipment manufacturer should design so that initially and throughout life no absolute-maximum value for the intended service is exceeded with any tube under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in the characteristics of the tube under consideration and of all other electron devices in the equipment.

The tubes and arrangements disclosed herein may be covered by patents of General Electric Company or others. Neither the disclosure of any information herein not the sale of tubes by General Electric Company conveys any license under patent claims covering combinations of tubes with other devices or

elements. In the absence of an express written agreement to the contrary, General Electric Company assumes no liability for patent infringement arising out of any use of the tubes with other devices or elements by any purchaser of tubes or others.



## CHARACTERISTICS AND TYPICAL OPERATION

## **AVERAGE CHARACTERISTICS**

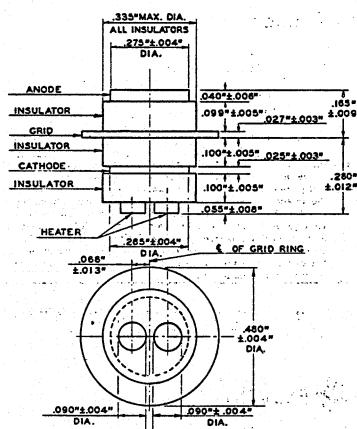
Plate Supply Voltage	Ohms Ohms	Transconductance		Milliamperes
GROUNDED-GRID AMPLIFIER-450 ME	GACYCLES			
Plate Supply Voltage¶       250         Resistor in Plate Circuit (bypassed)¶       18000         Cathode-Bias Resistor       82         Plate Current       6.5         Bandwidth, approximate       7.5	Ohms Ohms Milliamperes	Power Gain, approximate Noise Figure (Measured with matched input, using argonoise source), approximate	power- n lamp	

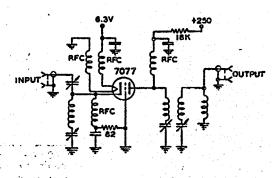
## **FOOTNOTES**

- \* The equipment designer should design the equipment so that heater voltage is centered at the specified bogey value, with heater supply variations restricted to maintain heater voltage within the specified tolerance.
- † Heater current of a bogey tube at Ef = 6.3 volts.
- Measured using a grounded adapter that provides shielding between external terminals of tube.
- § Operation below the rated maximum envelope temperature is recommended for applications requiring the longest
- possible tube life. The 7077 is also capable of operation at envelope temperatures much higher than the rated maximum values. For specific recommendations concerning higher temperature operation, contact your General Electric tube sales representative.
- ¶ Lower supply voltage and a lower value of resistor may be used in the plate circuit with some sacrifice in uniformity of performance.

#### **OUTLINE DRAWING**

# TYPICAL GROUNDED-GRID AMPLIFIER CIRCUIT USING THE 7077





- —Maximum eccentricity of anode, grid, and cathode 0.005" from center line.
- 2—Maximum eccentricity of insulators 0.010' from center line.
   3—Center line of grid ring used as reference line for horizontal talerances.
- 4—Bottom surface of grid ring used as reference line for vertical tolerances.

# INITIAL CHARACTERISTICS LIMITS

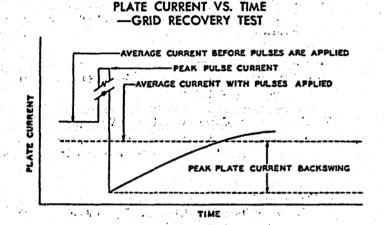
	44.		•	
Heater Current	Min.	Bogey	Max.	
Ef = 6.3 volts	222	240	258	Milliamperes
	•		i maratari dan Maratari	
Plate Current				
Ef = 6.3 volts, Ebb = 250 volts, $R_L$ = 18000 ohms, $Rk$ = 82 ohms				2.000
(bypassed)	4.5	6.5	8.5	Milliamperes
Transconductance				
Ef = 6.3 volts, Ebb = 250 volts, R <sub>L</sub> = 18000 ohms (bypassed) Rk = 82 ohms (bypassed)	7000	10000	13000	Micromhos
Transconductance Change with Heater Voltage				
Difference between Transconductance measured at Ef = 6.3 and		•		
Ef = 6.0 volts (other conditions the same) expressed as a per				
centage	*.	••••	20	Percent
Amplification Factor				
Ef=6.3 volts, Ebb=250 volts, R <sub>L</sub> =18000 ohms (bypassed)	,		b .	. •
Rk = 82 ohms (bypassed)	65	90	115	
Interelectrode Capacitances				
Grid to Plate: (g to p)		1.00		Picofarads
Input: g to (h+k)		1.70		Picofarads
Output: p to (h+k).  Heater to Cathode: (h to k)		0.010 1.10	, , , , , , , , , , , , , , , , , , , ,	Picofarads Picofarads
		4.10	1.70	Ficulations
Heater-Cathode Leakage Current				
Ef = 6.3 volts, Ehk = 100 volts			1.5	
Heater Positive with Respect to Cathode			20	Microamperes
Heater Negative with Respect to Cathode		• • • • •	20	Microamperes
Interelectrode Leakage Resistance			1.54115	HALL TO THE
Ef = 6.3 volts, Polarity of applied d-c interelectrode voltage is such that no cathode emission results.			## 17 14 # #1 27 17 17 11	
Grid to All at 100 volts d-c.		• • • • •	• • • •	
Plate to All at 300 volts d-c	. 100	·		Megohms
Grid Emission Current	<u>il barn</u>	rit (kj. kt. jeste)		
Ef = 7.0 volts, Ebb = 250 volts, Ecc = $-20$ volts, Rk = 82 ohm (bypassed), Rg = 0.1 meg, R <sub>L</sub> = 18000 ohms (bypassed)		er da da en en El montos	2.0	Microamperes
(Dypassed), 11g - 0.1 meg, 11L - 10000 omms (Dypassed)	• • • •	la la carre y profession		wilet basisper es
COPOLAL DEDEADMAN	or Tro	46		•
SPECIAL PERFORMAN	CE 1E3	13		
	Min.	Bogey	Max.	
Noise Figure				
Ef = 6.3 volts, Ebb = 250 volts, $Rk = 82$ ohms, $R_L = 18000$ ohms	•			
F = 450 mc:	• • • •	5.5	6.6	Decibels
발표 기업을 보고 있는 것이 되었다. 그리고 함께 가장하는 그 물건이 되었다. 그리고 있는 것이 되었다. 그렇게 하는 것이 되었다. 그리고 있는 것이 되었다. 그리고 있는 것이 있는 것이 되었다. 그리고 있다.				
Noise Figure at Reduced Heater Voltage			Prassic P	
Ef = 6.0 volts, Ebb = 250 volts, $Rk = 82$ ohms, $R_L = 18000$ ohms	• 1.1 40.		191	
F = 450 mc	• ••••	••••	8.1	Decibels
Power Gain	•			
Ef = 6.3 volts, Ebb = 250 volts, Rk = 82 ohms, $R_L$ = 18000 ohms		14 5		Desibals
F = 450 mc	. 12.5	14.5	••••	Decibels

# SPECIAL PERFORMANCE TESTS (Continued)

Grid Recovery

Tubes with poor grid recovery affect circuit operation, when the grid is driven positive by a pulse of signal or noise, somewhat as if a parallel RC circuit were in series with the grid. This effect may occur in tubes of any type, but is unimportant in many applications. In the majority of 7077 tubes the effect is negligible, but to eliminate the few in which it may be excessive, tubes are tested under the following conditions: Ef = 6.3 volts, Ebb = 250 volts,  $R_L = 0.01$  meg. Ec is adjusted for Ib = 3.0 ma.

Upon application to the grid of a 5 volts positive pulse (prr = 60 pps, duty factor = 0.0012) the change in average plate current is noted, and the peak plate current backswing is measured. The following diagram shows qualitatively the plate current-time relationship for a tube (with poor grid recovery) subjected to this test.



Low Frequency Vibrational Output.....

at men the state of

Min. Bogey

Max. 10 Millivolts RMS

Statistical sample is subjected to vibration in each of two planes at 40 cps, with peak acceleration 15G. Tube is

operated with Ef = 6.3 volts, Ebb = 150 volts, Rk = 82 ohms (bypassed),  $R_L = 10000$  ohms.

Variable Frequency Vibrational Output

The tube is designed to be free of vibrational outputs in excess of 15 mv RMS at any frequency within the range 100-2000 cps, when vibrated in either of two planes at 10G

peak acceleration. Electrical conditions for this test are the same as for Low Frequency Vibrational Output.

Low Pressure Voltage Breakdown Test

Statistical sample tested for voltage breakdown at a pressure of 8mm Hg, to simulate an altitude of 100,000 feet. Tubes shall not give visual evidence of flashover or corona

when 300 volts RMS, 60 cps, is applied between the plate and grid terminals.

## DEGRADATION RATE TESTS

Fatigue

Statistical sample vibrated for a total of 96 hours, 48 hours in each of two planes, at a peak acceleration of 10G<sub>n</sub>. Frequency is 60 cps. Tubes are operated during the test with Ef = 6.3 volts (no other voltages applied). Following the test, tubes are evaluated for low frequency vibrational output, heater-cathode leakage, heater current, noise figure, and gain.

12003

Shock

Statistical sample subjected to 5 impact accelerations of approximately 450G in each of four positions. The accelerating forces are applied by the Navy-type, High Impact (flyweight) Shock Machine using a 30° hammer angle. Tubes are operated during the test with Ef = 6.3 volts, Eb = 150 volts, Ehk = +100 volts, and Rk = 82 ohms. Following the test, tubes are evaluated for low frequency



# METAL-CERAMIC DIODE



# DESCRIPTION AND RATING=

The 7266 is a cathode-type diode of ceramic-and-metal planar construction. It is intended for detector, high-frequency instrument probe, and low-current rectifier applications. The 7266 is especially suited for use where unfavorable conditions of mechanical shock, mechanical vibration, and nuclear radiation are encountered.

## GENERAL

#### ELECTRICAL

Cathode—Coated Unipotential
Heater Characteristics and Ratings
Heater Voltage, AC or DC\*......6.3 =0.3 Volts

Heater Current† . . . . . . . . . . . 0.215 Amperes

Direct Interelectrode Capacitances:

Plate to Cathode: (p to k) . . . . 1.0 pf Heater to Cathode: (h to k) . . . . 1.3 pf

#### MECHANICAL

Mounting Position-Any

See Outline Drawing on page 3 for dimensions and electrical connections

#### MAXIMUM RATINGS

### ABSOLUTE-MAXIMUM VALUES

Peak Inverse Plate Voltage 600 Volts Cathode 50 Volts
Steady-State Peak Plate Current 11 Milliamperes
DC Output Current 2.2 Milliamperes
Heater-Cathode Voltage Envelope Temperature at Hottest
Heater Positive with Respect to

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron tube of a specified type as defined by its published data and should not be exceeded under the worst probable conditions.

The tube manufacturer chooses these values to provide acceptable serviceability of the tube, making no allowance for equipment variations, environmental variations, and the effects of changes in operating conditions due to variations in the characteristics of the tube under consideration and of

all other electron devices in the equipment.

The equipment manufacturer should design so that initially and throughout life no absolute-maximum value for the intended service is exceeded with any tube under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in the characteristics of the tube under consideration and of all other electron devices in the equipment.

#### AVERAGE CHARACTERISTICS

Tube Voltage Drop

Ib = 1.0 Milliamperes DC

1.0 Voits

The tubes and arrangements disclosed herein may be covered by patents of General Electric Company or others. Neither the disclosure of any information herein nor the sale of tubes by General Electric Company conveys any liceasured under patent claims covering combinations of tubes with after devices or

elements. In the absence of an express written agreement to the contrary, General Electric Company assumes no liability for patent infringement arising out of any use of the tubes with other devices or elements by any purchaser of tubes or others.



## AVERAGE CHARACTERISTICS (Continued)

#### **FOOTNOTES**

- The equipment designer should design the equipment so that heater voltage is centered at the specified bogey value, with heater supply variations restricted to maintain heater voltage within the specified tolerance.
- † Heater current of a bogey tube at Ef = 6.3 volts.
- Measured using a grounded adapter that provides shielding between external terminals of tube.
- § Operation below the rated maximum envelope temperature is recommended for applications requiring the longest possible tube life. The 7266 is also capable of operation at envelope temperatures much higher than the rated maximum values. For specific recommendations concerning higher temperature operation, contact your General Electric tube sales representative.

## INITIAL CHARACTERISTICS LIMITS

	Min.	Bogey	Max.	
Heater Current		- •	2.50	and the second
Ef = 6.3 volts	198	215	232	Milliamperes
Tube Voltage Drop				
Ef = $6.3$ volts, Eb adjusted for Ib = $1.0$ ma	0.4	1.0	2.0	Volts
Tube Voltage Drop at Reduced Heater Voltage				
Ef = 5.7 volts, Eb adjusted for Ib = 1.0 ma			2.3	Volts
Emission				
Ef = 6.3 volts, Eb = 9 volts d-c	10			Milliamperes
Plate Current				_
Ef = 6.3 volts, Ebb = 0 volts, $R_t$ = 40000 ohms	2	8	16	Microamperes
Interelectrode Capacitances				
Plate to Cathode: (p to k)	0.7	1.0	1.3	Picofarads
Heater to Cathode: (h to k)	0.9	1.3	1.7	Picofarads
Heater-Cathode Leakage Current				
Ef = 6.3  volts, Ehk = 100  volts				
Heater Positive with Respect to Cathode			20	Microamperes
Heater Negative with Respect to Cathode			20	Microamperes
Interelectrode Leakage Resistance				
Ef = 6.3 volts. Polarity of applied d-c interelectrode voltage is				
such that no cathode omission results.				
Plate to All at 500 voits d-c.	10000			Megohms

## SPECIAL PERFORMANCE TESTS

Low Pressure Voltage Breakdown Test Statistical sample tested for voltage breakdown at a pressure of 8mm Hg, to simulate an altitude of 100000 feet. Tubes shall not give visual evidence of flashover or corona when 300 volts RMS, 60 cps. is applied between the plate and cathode terminals.

#### **DEGRADATION RATE TESTS**

#### Fatigue

Statistical sample vibrated for a total of six hours, three hours in each of two planes, at a peak acceleration of 10G. Frequency is continuously varied from 30 cps to 2000 cps and back to 30 cps, with a period of ten minutes. Tubes are operated during the test with Ef = 6.3 volts and Ehk = +100 volts. Following the test, tubes are evaluated for heater-cathode leakage and heater current.

#### Shock

Statistical sample subjected to 5 impact accelerations of approximately 450G in each of four positions. The accelerating forces are applied by the Navy-type, High Impact (flyweight) Shock Machine using a 30° hammer angle. Tubes are operated during the test with Ef = 6.3 volts and Ehk = +100 volts. Following the test, tubes are evaluated for heater-cathode leakage and heater current.

#### Survival Rate Life Test

The combined statistical samples subjected to the Intermittent and Standby Life Tests are evaluated for shorted and open elements and tube voltage drop following approximately 100 hours of life test.

#### Intermittent Life Test

Statistical sample operated for 1000 hours under the following conditions: Ef = 6.3 volts (cycled—on  $1\frac{3}{4}$  hours, off  $\frac{1}{4}$  hour), Ebb = 220 volts RMS, Ehk = -70 volts d-c,  $R_L = 0.13$  meg,  $C_L = 1.0$   $\mu$ f, and  $R_S = 1300$  ohms. Tubes are evaluated, following 500 and 1000 hours of life test, for shorted or open elements, heater current, tube voltage drop, heater-cathode leakage, interelectrode leakage resistance, and emission.

#### Standby Life Test

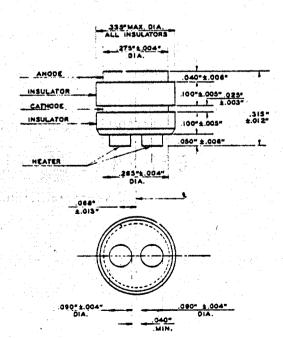
Statistical sample operated for 1000 hours under the following conditions: Ef = 6.3 volts (cycled—on 134 hours, off 14 hour) no other voltages applied. Tubes are evaluated, following 500 and 1000 hours of life test, for shorted or open elements, heater current, tube voltage drop, heater-cathode leakage, interelectrode leakage resistance, and emission.

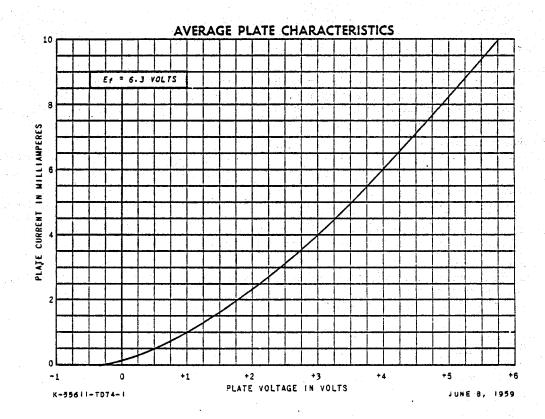
#### Heater-Cycling Life Test

Statistical sample operated for 2000 cycles minimum to evaluate and control heater-cathode defects. Conditions of test include Ef = 7.0 volts cycled for one minute on and one minute off, Eb = 0 volts, and Ehk = 70 volts with heater positive with respect to cathode. Following this test, tubes are evaluated for open heaters, heater-cathode shorts, and heater-cathode leakage current.

Note: The conditions for some of the indicated tests have deliberately been selected to aggravate tube failures for test and evaluation purposes. In no sense should these conditions be interpreted as suitable operating conditions.

OUTLINE DRAWING





# RECEIVING TUBE DEPARTMENT

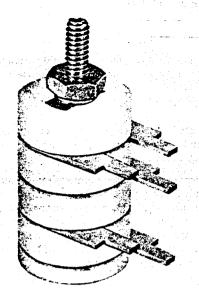


Owensboro, Kentucky

# **7296**

# METAL-CERAMIC TRIODE

7296 ET-11538B Page 1



# DESCRIPTION AND RATING

#### FOR VHF OSCILLATOR AND AMPLIFIER APPLICATIONS

The 7296 is a high-mu triode of ceramic-and-metal planar construction primarily intended for use as an oscillator, broadband radio-frequency amplifier, or VHF power amplifier. The 7296 is especially suited for use where unfavorable conditions of mechanical shock, mechanical vibration, and nuclear radiation are encountered.

#### GENERAL

#### 

ELECTRICAL

#### MECHANICAL

Mounting Position—Any §

#### **MAXIMUM RATINGS**

ABSOLUTE-MAXIMUM VALUES		Heater-
Plate Voltage330	Volts	Heate Cat
Positive DC Grid Voltage0	Volts	Heate
Negative DC Grid Voltage50	Volts	Cat Grid Cir
Plate Dissipation5.5	Watts	With
DC Grid Current10	Milliamperes	With
DC Cathode Current30	Milliamperes	Envelop Plate l
Peak Cathode Current	Milliamperes	Plate l

Heater-Cathode Voltage	
Heater Positive with Respect to	
Cathode50	Volts
Heater Negative with Respect to	
Cathode50	Volts
Grid Circuit Resistance	
With Fixed Bias0.1	Megohms
With Cathode Bias0.18	Megohms
Envelope Temperature at Hottest Point #	
Plate Dissipation not over 3.3 Watts300	С
Plate Dissipation up to 5.5 Watts250	С

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron tube of a specified type as defined by its published data and should not be exceeded under the worst probable conditions.

The tube manufacturer chooses these values to provide acceptable serviceability of the tube, making no allowance for equipment variations, environmental variations, and the effects of changes in operating conditions due to variations in the characteristics of the tube under consideration and of

all other electron devices in the equipment.

The equipment manufacturer should design so that initially and throughout life no absolute-maximum value for the intended service is exceeded with any tube under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in the characteristics of the tube under consideration and of all other electron devices in the equipment.

The tubes and arrangements disclosed herein may be covered by patents of General Electric Campany or others. Neither the disclosure of any information herein nor the sale of tubes by General Electric Company conveys any license under patent claims covering combinations of tubes with other devices or

elements. In the absence of an express written agreement to the contrary, General Electric Company assumes no liability for patent infringement arising out of any use of the tubes with other devices or elements by any purchaser of tubes or others.



# CHARACTERISTICS AND TYPICAL OPERATION

#### AVERAGE CHARACTERISTICS

Plate Voltage	Volts	Transconductance	Micromhos
Cathode-Bias Resistor68	Ohms	Plate Current	Milliamperes
Amplification Factor90		Grid Voltage, approximate	
Plate Resistance, approximate5450	Ohms	Ib = 10 Microamperes	Volts

- The equipment designer should design the equipment so that the heater voltage is centered at the specified bogey value, with heater supply variations restricted to maintain heater voltage within the specified tolerance.
- † Heater current of a bogey tube at Ef = 6.3 volts.
- Without external shield.
- § One method of mounting the 7296 is to use a stainless-steel "T" bolt (see drawing) to attach the mounting base of the tube to a chassis or circuit board. The "T" bolt should be inserted in the slot in the base of the tube, turned 90
- degrees, and attached to the chassis or circuit board with a 4-40 nut and lock washer. Torque used to tighten the nut should not exceed 3 inch-pounds.
- \*Operation below the rated maximum envelope temperatures is recommended for applications requiring the longest possible tube life. The 7296 is also capable of operation at envelope temperatures much higher than the rated maximum values. For specific recommendations concerning higher temperature operation, contact your General Electric tube sales representative.

# INITIAL CHARACTERISTICS LIMITS

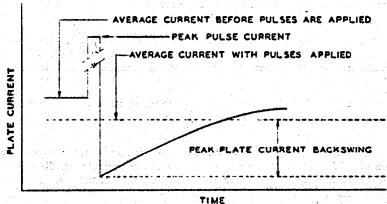
		Min.	Bogey	Max.	
Heater Current		270	400	430	Milliompass
		3/0	400	430	Milliamperes
Plate Current	Dis 60 above (becaused)	10	17	24	Milliamanaa
	Rk = 68 ohms (bypassed)	10	17	44	Milliamperes
Transconductance	Dia - 60 above (bossessed)	12000	16500	20000	Micromhos
·	Rk = 68 ohms (bypassed)	13000	10000	20000	MICTORINOS
Amplification Factor	Di- 60 -h (h	e e	00		
•	Rk = 68 ohms (bypassed)	65	90	115	
Zero-Bias Transconductance	T- 014-	12000	00000		<b>M</b>
·	Ec = 0 volts	13000	20000		Micromhos
Grid Voltage Cutoff	71 40				
	Ib = $10 \mu a$	• • • • • •	<b> 5.5</b>	-9.5	Volts
Interelectrode Capacitances			-		<u>.</u>
			2.2		pf
			5.0 0.075	6.3 0.1	•
			2.8	3.5	•
Negative Grid Current			2.0	3.3	<b>pr</b>
	Ecc = -1.0 volts, $Rk = 68$ ohm				
	Ecc = -1.0 voits, RR = 06 offin			0.5	Microamperes
Heater-Cathode Leakage Currer		• ••••	••••	0.0	arater camperes
Ef = 6.3 volts, Ehk = 100 volts			**	100	
· · · · ·	ct to Cathode			20	Microamperes
	ect to Cathode			20	Microamperes
Interelectrode Leakage Resistan					
	pplied d-c interelectrode voltag	e			ega tida a la tida
is such that no cathode emiss		,-		*	
					Megohms
Plate to All at 300 volts d-	c	100	2		Megohms
Grid Emission Current			2 2		
Ef = 7.0 volts, $Eb = 200$ volts,	Ecc = -15 volts, $Rg = 0.18$ me	g		2.0	Microamperes
		- · · · · · · · · · · · · · · · · · · ·		2.3	

## SPECIAL PERFORMANCE TESTS

		Min.	Bogey	Max.	
400 Megacycle Os	cillator Power Output	1.6	2.0		Watts
Tubes are tested	d for power output as an oscillator under	the			
following condi-	tions: F = 400 mc, Ef = 6.3 volts, Eb =	300		4 .	
volts, Rg = 1400	ohms, $Ib = 20$ ma maximum, $Ic = 6.0-9.0$	ma.			
					Milliamperes
Tubes are tested	for pulse emission under the following co	ndi-			
tions: $Ef = 6.3$	volts, $Eb = 200$ volts, $Ec = -20$ volts, eg	k =			
+12 volts, prr	=1000 pps, duty cycle 1%. Pulse cath	ode			
current is measu	ired.				
Grid Recovery	Change in Average Plate Current			1.0	Milliamperes
	Peak Plate Current Backswing				Milliamperes
Tubes with poor	r grid recovery affect circuit operation, w	hen		100	· . · · ·

the grid is driven positive by a pulse of signal or noise, somewhat as if a parallel RC circuit were in series with the grid. This effect may occur in tubes of any type, but is unimportant in many applications. In the majority of 7296 tubes the effect is negligible, but to eliminate the few in which it may be excessive, tubes are tested under the following conditions: Ef = 6.3 volts, Ebb = 250 volts,  $R_L = 0.01$  meg. Ec is adjusted for Ib = 10 ma.

Upon application to the grid of a pulse driving it 3 volts positive with respect to cathode (prr = 60 pps, duty cycle = 0.12%) the change in average plate current is noted, and the peak plate current backswing is measured. The following diagram shows qualitatively the plate current—time relationship for a tube (with poor grid recovery) subjected to this



Low Frequency Vibrational Output..... Statistical sample is subjected to vibration in each of two planes at 40 cps, with peak acceleration 15 G. Tube is operated with Ef=6.3 volts, Ebb=200 volts, Rk=68 ohms (bypassed),  $R_L = 2000$  ohms.

Variable Frequency Vibrational Output

The tube is designed to be free of vibrational outputs in excess of 100 mv RMS at any frequency within the range 100-2000 cps, when vibrated in either of two planes at 10 G peak acceleration. Electrical conditions for this test are the same as for Low Frequency Vibrational Output.

Low Pressure Voltage Breakdown Test

Statistical sample tested for voltage breakdown at a pressure of 8 mm Hg, to simulate an altitude of 100,000 feet. Tubes shall not give visual evidence of flashover or corona when 300 volts RMS, 60 cps, is applied between the plate and grid terminals.

15 Millivolts RMS

#### **DEGRADATION RATE TESTS**

#### Fatigue

Statistical sample vibrated for a total of six hours, three hours in each of two planes, at a peak acceleration of 10 G. Frequency is continuously varied from 30 cps to 2000 cps and back to 30 cps, with a period of ten minutes. Tubes are operated during the test with Ef = 6.3 volts, Eb = 200 volts, and Rk = 68 ohms. Following the test, tubes are evaluated for low frequency vibrational output, heater-cathode leakage, heater current, and transconductance.

#### Shock

Statistical sample subjected to 5 impact accelerations of approximately 600 G in each of four positions. The accelerating forces are applied by the Navy-type, High Impact (flyweight) Shock Machine using a  $42^{\circ}$  hammer angle. Tubes are mounted by T-bolt with 3 inch-pounds torque, and operated during the test with Ef = 6.3 volts, Eb = 200 volts, Ehk = +100 volts, Rg = 0.1 Meg, and Rk = 68 ohms. Following the test, tubes are evaluated for low frequency vibrational output, heater-cathode leakage, heater current, and transconductance.

#### Stability Life Test

The statistical sample subjected to the Dynamic Life Test is evaluated for percent change in zero-bias transconductance of individual tubes, from the initial reading to readings following 2 hours and 20 hours of the life test.

#### Survival Rate Life Test

The combined statistical samples subjected to the Dynamic and Pulse Life Tests are evaluated for shorted and open elements following approximately 100 hours of life test.

#### **Dynamic Life Test**

Statistical sample operated, with a 60 cps grid signal, at maximum rated DC grid current and cathode current for a period of 1000 hours. Heater voltage is cycled (on 1¾ hours, off ¼ hour). Tubes are evaluated, following 500 and 1000 hours of life test, for shorted or open elements, heater current, zero-bias transconductance, oscillator power output, and heater-cathode leakage.

#### **Pulse Life Test**

Statistical sample operated with 400 ma peak cathode current, 1% duty cycle, for 1000 hours. Heater voltage is cycled (on 1% hours, off % hour). Tubes are evaluated, following 500 and 1000 hours of life test, for shorted or open elements, heater current, pulse emission, and heater-cathode leakage.

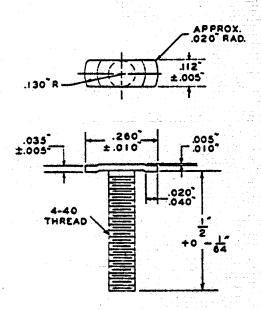
#### Interface Life Test

Statistical sample operated for 1000 hours with Ef = 6.6 volts, no other voltages applied, and evaluated for cathode interface resistance following the life test.

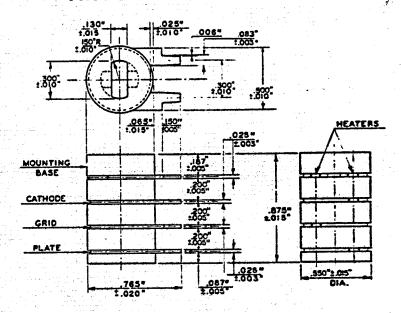
#### **Heater-Cycling Life Test**

Statistical sample operated for 2000 cycles minimum to evaluate and control heater-cathode defects. Conditions of test include Ef = 7.5 volts cycled for one minute on and one minute off, Eb = Ec = 0 volts, and Ehk = 70 volts with heater positive with respect to cathode. Following this test tubes are evaluated for open heaters, heater-cathode shorts, and heater-cathode leakage current.

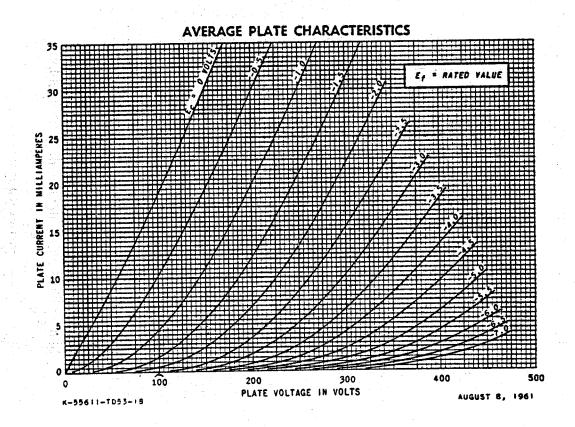
# MOUNTING BOLT

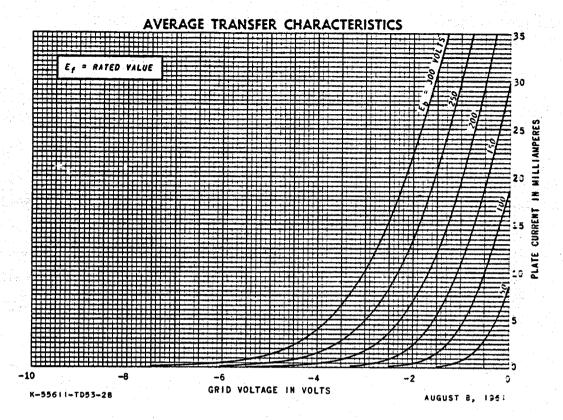


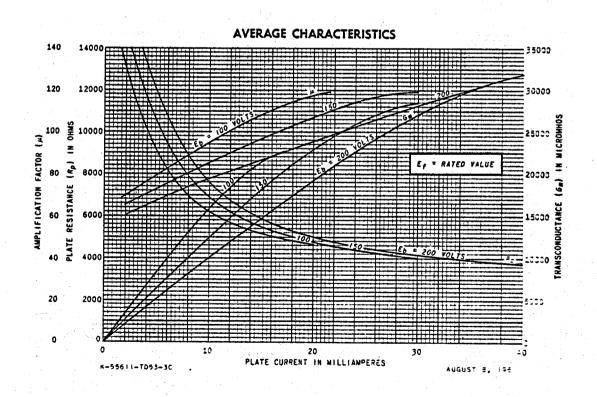
# PHYSICAL DIMENSIONS



Maximum eccentricity of insulators 0.015 in. from center line.







**TUBES** 

#### -PRODUCT INFORMATION-

Page 1

10-66

7391

#### **Planar Triode**

#### FOR GROUNDED-GRID CLASS C OSCILLATOR APPLICATIONS

The 7391 is a high-mu, metal-and-ceramic triode intended for operation as a grounded-grid, Class C oscillator at frequencies as high as 6000 megacycles.

Features of the tube include small size, planar electrode construction with close spacing, inherent rigidity, and an envelope structure convenient for coaxial circuit applications.

The physical appearance and dimensions of the 7391 are identical to those of the 6299.

#### GENERAL

ELECTRICAL	MECHANICAL
Cathode - Costed Unipotential  Heater Characteristics and Ratings Heater Voltage, AC or DC* 6.3±0.3 Volts	Operating Position - Any Net Weight, approximate 1/6 Ounce Cooling - Conduction
Heater Current +	
Cathode Heating Time, minimum 60 Seconds	Kalamatan da kacamatan kalamatan da 💎 🗀 🖂
Direct Interelectrode Capacitances	Taller of the contraction of the
Grid to Plate: (g to p) 1.58 pf Grid to Cathode and Heater:	
g to (h + k) 3.25 pf Plate to Cathode and Heater:	
p to (h + k) 0.0158 pf	
NUMIXAM	M RATINGS

ABSOLUTE-MAXIMU	<b>N VALUES</b>	No. 1	<ul> <li>A second of the s</li></ul>		
Plate Voltage				200 Volts	
Negative DC Grid Voltage					
Plate Dissipation				2.25 Watts	
DC Plate Current					peres
DC Grid Current				3.0 Milliam	peres
DC Cathode Current					peres
Envelope Temperature at	Hottest Poin	ito o o o o		150 C	ī i ii

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron tube of a specified type as defined by its published data and should not be exceeded under the worst probable conditions.

The tube manufacturer chooses these values to provide acceptable serviceability of the tube, making no allowance for equipment variations, environmental variations, and the effects of changes in operating conditions due to variations in the characteristics of the tube under consideration and of

all other electron devices in the equipment.

The equipment manufacturer should design so that initially and throughout life no absolute-maximum value for the intended service is exceeded with any tube under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in the characteristics of the tube under consideration and of all other electron devices in the equipment.

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express written agreement to the contrary, General Electric Company assumes no liability for patent infringement arising out of any use of the tubes with other devices or elements by any purchaser of tubes or others.



Supersedes ET-T1614A dated 12-61

#### CHARACTERISTICS AND TYPICAL OPERATION

Plate Walters		A							Section 1														175		Volts
Plate Voltage.	•	• .	•		•	•	•	•	•	• .	•	•	•	•	•	•	•	•	•	•	•	•	1 1 5		
Grid Voltage .	•	•	•		•	•	•.	•	•		•	•	•	•		•	•	•	•	•	•	•	-1.5		Volts
Amplification Fa	icto	r			•	•	•	÷	•	•	•	•	•	•		•	•	•	•	• ,	•	•	. 62	100	
Transconductance	٠.						٠.	•			. •	•				•	•			•		•	11000		Micromhos
Plate Current.	•											•				٠.					• 5		. 10		Milliampere
																/ I A									
																ζΙÀ									
CLASS C CW	0	SCI	LL/	T	OR		-GI	RO	10	۷D	ED-	-GR	lD	CC	A		L-T	ΥP		CIR	CU		rial st		
CLASS C CW	0	SCI	LL/	\T	OR		-GI	RO	10	۷D	ED-	-GR	ID	CC	A		L-T	YP		CIR	CU		5400		Megacycles
CLASS C CW	0	SCI	LL/	\T	OR		-GI	RO	10	۷D	ED-	-GR	ID	CC	A		L-T	YP		100 15	CU 00 00		5400 150		
CLASS C CW Frequency Plate Voltage. Plate Current.	0	SCI	LL/	AT(	OR :	•	-GI	RO :	1U :	۷D :	ED-	-GR	ID :	:	)A	•	L-T 500 150	<b>YP</b>		100 15	CU		5400		Megacycles
CLASS C CW	0	SCI	LL/	AT(	OR :	•	-GI	RO :	1U :	۷D :	ED-	-GR	ID :	:	)A	•	L-T 500 150	<b>YP</b>		100 15	CU 00 00 10		5400 150		Megacycles Volts

#### NOTES

- \* The equipment designer should design the equipment so that heater voltage is centered at the specified bogey value, with heater supply variations restricted to maintain heater voltage within the specified tolerance.
- # Heater current of a bogey tube at Ef = 6.3 volts.
- § Without external shield.
- The electrical connections to the plate and cathode must provide good thermal conductivity from these electrodes. The plate contact must be sufficiently flexible to keep the lateral force on the plate terminal at a minimum.

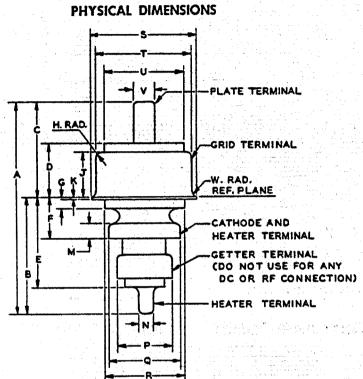
#### INITIAL CHARACTERISTICS LIMITS

Heater Current Ef = 6.3 volts	Minimum Bogey I . 360 380	Maximum 400	Milliamperes
Grid Voltage Ef = 6.3 volts, Eb = 175 volts, Ib = 10 ma	0.7	-2.55	Volts
Transconductance  Ef = 6.3 volts, Eb = 175 volts, Ec adjusted for Ib = 10 ma.	. 8000 11000	13500	Micromhos
Amplification Factor Ef = 6.3 volts, Eb = 175 volts, Ec adjusted for Ib = 10 ma.	. 46 62	80	
Grid Voltage Cutoff Ef = 6.3 volts, Eb = 175 volts, Ib = 100 μa	2.4 -4.2	-7.0	Volts
Interelectrode Leakage Resistance  Ef = 6.3 volts, Polarity of applied d-c interelectrode voltage is such that no cathode emission results.  Grid to Cathode and Heater at 45 volts d-c	. 0.25		Megohms Megohms
Interelectrode Capacitances  Grid to Plate: (g to p)	. 2.60 3.25		pf pf pf
SPECIAL PERFORMANCE 5400 Megacycle Oscillator Power Output Ef = 6.3 volts, Eb = 150 volts, Rg = 2000 ohms, Ib = 15±0.5 ma	<b>a</b> ,		
F = 5400 MG, min	. 30 65		Milliwatts

#### **DEGRADATION RATE TESTS**

#### 500-Hour Life

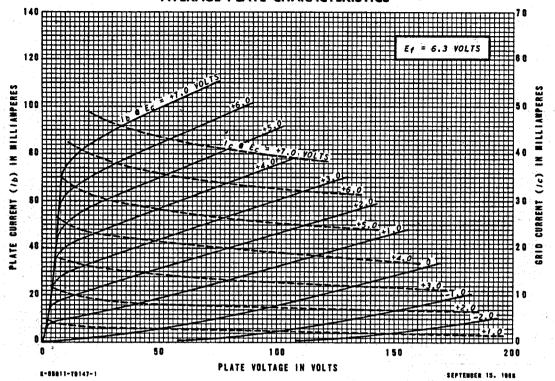
Statistical sample operated for 500 hours to evaluate changes in power output and transconductance with life.



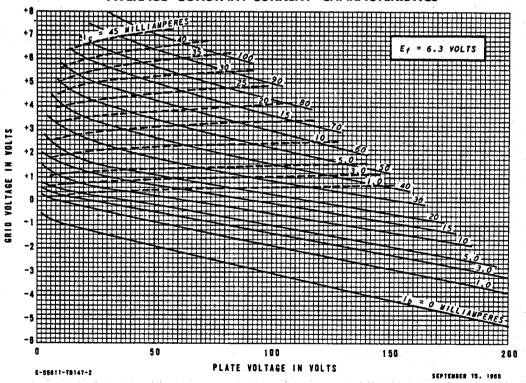
# 

	INC	ES .	MILLI	METERS
Ref.	Minimum	Maximum	Minimum	Maximum
Ā	0.960	1.040	24.38	26.42
В	0.530	0.590	13.46	14.99
C	0.410	0.470	10.41	11.94
D		0.272		6.91
E		0.475		12.07
F	0.163	0.193	4.14	4.90
G		0.060		1.52
H	3.22 <b></b>	0.030		0.76
J	0.190	0.210	4.83	5.33
K	0.009	0.015	0.23	0.38
M	0.040	0.070	1.02	1.78
N	0.059	0.065	1.50	1.65
P		0.257	***	6.53
Q	0.326	0.334	8.28	8.48
R		0.385		9.78
S	0.483	0.497	12.27	12.62
T	0.435	0.445	11.05	11.30
Ü		0.385		9.78
V	0.088	0.094	2.24	2.39
W		0.008	·, (,, ) • • • •	0.20

#### **AVERAGE PLATE CHARACTERISTICS**



#### AVERAGE CONSTANT-CURRENT CHARACTERISTICS



TUBE DEPARTMENT



Owensboro, Kentucky



**TUBES** 

### 7462 METAL-CERAMIC TRIODE



#### DESCRIPTION AND RATING

The 7462 is a high-mu triode of ceramic-and-metal planar construction primarily intended for radio-frequency amplifier service from low frequencies into the ultra-high-frequency range. It is similar to the 7077 in characteristics but differs in having terminal lugs for use in print-board circuits.

#### GENERAL

# ELECTRICAL Cathode—Coated Unipotential Heater Characteristics and Ratings Heater Voltage, AC or DC\* 6.3 ± 0.3 Volts Heater Current† 0.24 Amperes Direct Interelectrode Capacitances‡ Grid to Plate: (g to p) 1.25 pf Input: g to (h+k) 1.8 pf Output: p to (h+k) 0.032 pf Heater to Cathode (h to k) 1.5 pf

#### MECHANICAL

Mounting Position—Any
See Outline Drawing on page 2 for dimensions
and electrical connections.

#### **MAXIMUM RATINGS**

ABSOLUTE-MAXIMUM VALUES		Heater-Cathode Voltage	
Plate Voltage250	Volts	Heater Positive with Respect to Cathode	Volts
Positive Peak and DC Grid Voltage0	Volts	Heater Negative with Respect to	
Negative Peak and DC Grid Voltage 50	and the second s	Cathode50	Volts
Plate Dissipation1.1	Watts	Grid-Circuit Resistance, with Fixed Bias §	Megohms
DC Cathode Current	Milliamperes	Bulb Temperature at Hottest Point¶ 250	

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron tube of a specified type as defined by its published data and should not be exceeded under the worst probable conditions.

The tube manufacturer chooses these values to provide acceptable serviceability of the tube, making no allowance for equipment variations, environmental variations, and the effects of changes in operating conditions due to variations in the characteristics of the tube under consideration and of

all other electron devices in the equipment.

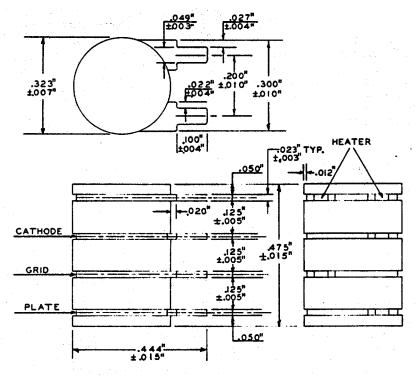
The equipment manufacturer should design so that initially and throughout life no absolute-maximum value for the intended service is exceeded with any tube under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in the characteristics of the tube under consideration and of all other electron devices in the equipment.

#### CHARACTERISTICS AND TYPICAL OPERATION

AVERAGE CHARACTERISTICS			
Plate Voltage	Volts	Plate Resistance, approximate9000	
Grid Voltage +6.0	Volts	Transconductance	
Cathode-Bias Resistor910		Plate Current	Milliamperes
Amplification Factor		Ib = 100 Microamperes2.4	Volts

#### **FOOTNOTES**

- \* The equipment designer should design the equipment so that heater voltage is centered at the specified bogey value, with heater supply variations restricted to maintain heater voltage within the specified tolerance.
- † Heater current of a bogey tube at Ef = 6.3 volts.
- ! Without external shield.
- § If a cathode bias resistor is used, the grid-circuit resistance may be as high as  $(10,000+100 \text{ Rk}+R_L)$  ohms, where Rk is the value of the cathode-bias resistor in ohms and  $R_L$  is the value of the plate-load resistor in ohms.
- ¶ For applications where long life is a primary consideration, it is recommended that the envelope temperature be maintained below 175 C.



NOTE: Maximum eccentricity of insulators 0.010 in. from center line.

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elements. In the absence of an express written agreement to the contrary, General Electric Company assumes no liability for patent infringement arising out of any use of the tubes with other devices or elements by any purchaser of tubes or others.

#### **INITIAL CHARACTERISTICS LIMITS**

	Min.	Bogey	Max.	
Heater Current				** · · · · · · · · · · · · · · · · · ·
Ef = 6.3 volts	222	240	258	Milliamperes
Plate Current				
Ef = 6.3 volts, Eb = 150 volts, $Rk = 82$ ohms (bypassed)	4.5	7.5	11	Milliamperes
Transconductance				
Ef = 6.3 volts, Eb = 150 volts, Ec = $+6$ volts, Rk = 910 ohms (bypassed).	8000	10500	13000	Micromhos
Amplification Factor				
Ef = 6.3  volts, Eb = 150  volts, Ec = +6  volts, Rk = 910  ohms (bypassed).	65	94	115	

#### INITIAL CHARACTERISTICS LIMITS (Continued)

	Min.	Bogey	Max.	
Transconductance Change with Heater Voltage  Difference between transconductance at Ef = 6.3 volts and transconductance at Ef = 6.0 volts (other conditions the same) expressed as a percentage of transconductance at Ef = 6.3 volts			15	Percent
Grid Voltage Cutoff Ef = 6.3 volts, Eb = 150 volts, Ib = 100 μa		-2.4	-4.5	Volts
Interelectrode Capacitances Grid to Plate: (g to p) Input: g to (h+k) Output: p to (h+k) Heater to Cathode: (h to k)	0.013	1.25 1.8 0.032 1.5	1.45 2.25 0.045 1.9	
Heater-Cathode Leakage Current  Ef = 6.3 volts, Ehk = 100 volts  Heater Positive with Respect to Cathode  Heater Negative with Respect to Cathode	ala mada Alamanda Alaman		20 20	Microamperes Microamperes
Interelectrode Leakage Resistance  Ef = 6.3 volts. Polarity of applied d-c interelectrode voltage is such that no cathode emission results.  Grid to All of 100 volts d-c				Megohms Megohms
Grid Emission Current  Ef = 7.0 volts, Eb = 100 volts, Ecc = -10 volts, Rg = 0.1 meg			2.0	Microamperes
SPECIAL PERFORMANCE	TESTS			

Low Frequency Vibrational Output	
Statistical sample is subjected to vibration in each of two planes at 40 cps, with peak acceleration 15 G. Tube is operated with Ef=6.3 volts, Ebh=150 volts, Rk=82 ohms (bypassed), R <sub>L</sub> =10000 ohms.	10 Millivolts RMS
Variable Frequency Vibrational Output Statistical sample is subjected to vibration according to the pro cedure given below. Tube is operated with Ef = 6.3 volts, Ebb = 150 volts, Rk = 82 ohms (bypassed) R <sub>L</sub> = 10000 ohms	

The variable-frequency vibration test shall be performed as follows:

- 1. The frequency shall be increased from 100 to 2000 cps with approximately logarithmic progression in 3 = 1 minutes. The return sweep (2000 to 100 cps) is not required.
- The tube shall be vibrated with simple harmonic motion in each of two planes: first, parallel to the cylindrical axis; second, perpendicular to the cylindrical axis and parallel to a line through the major axis of a terminal lug. At all frequencies from 100 to 2000 cps, the total harmonic distortion of the acceleration waveform shall be less than 5%.
- 3. The peak acceleration shall be maintained at 10 = 1.0 G throughout the test.
- 4. The value of the alternating voltage produced across the load resistor (R<sub>I</sub>), as a result of the vibration, shall be measured with a suitable device having a response to the RMS value of the voltage to within =0.5 db of the response at 400 cps for the frequency range of 100 to 3000 cps, and having a band-pass filter with an attenuation rate of 24 db per octave below the low frequency cutoff point of 50 cps and above the high frequency cutoff point of 5000 cps. The meter shall have a dynamic response characteristic equivalent to or faster than a VU meter (operated in accordance with ASA Standard No. C16.5-1954).

Low Pressure Voltage Breakdown Test

Statistical sample tested for voltage breakdown at a pressure of 8 mm Hg, to simulate an altitude of 100,000 feet. Tubes shall not give visual evidence of flashover or corona when 300 volts RMS, 60 cps, is applied between the plate and grid terminals.

#### **DEGRADATION RATE TESTS**

#### Fatiave

Statistical sample vibrated for a total of six hours, three hours in each of two planes, at a peak acceleration of 10 G. Frequency is continuously varied from 30 cps to 2000 cps and back to 30 cps, with a period of ten minutes. Tubes are operated during the test with Ef = 6.3 volts, Eb = 150 volts, and Rk = 82 ohms. Following the test, tubes are evaluated for low frequency vibrational output, heater-cathode leakage, heater current, and transconductance.

#### Shock

Statistical sample subjected to 5 impact accelerations of approximately 450 G in each of four positions. The accelerating forces are applied by the Navy-type, High Impact (flyweight) Shock Machine using a 30° hammer angle. Tubes are operated during the test with Ef = 6.3 volts, Eb = 150 volts, Ehk = +100 volts, Rg = 0.1 meg, and Rk = 82 ohms. Following the test, tubes are evaluated for low frequency vibrational output, heater-cathode leakage, heater current, and transconductance.

#### Stability Life Test

The statistical sample subjected to the Intermittent Life Test is evaluated for percent change in transconductance of individual tubes, from the initial reading to readings following 2 hours and 20 hours of the life test.

#### Survival Rate Life Test

The statistical sample subjected to the Intermittent Life Test is evaluated for shorted and open elements, and transconductance, following approximately 100 hours of life test.

#### Intermittent Life Test

Statistical sample operated 1000 hours under the following conditions: Ef = 6.3 volts, Eb = 150 volts, Ecc = +6 volts, Ehk = -70 volts, Rk = 910 ohms, Rg = 0.1 meg. Heater voltage is cycled (on  $1\frac{3}{4}$  hours, off  $\frac{1}{4}$  hour). Tubes are evaluated, following 500 and 1000 hours of life test, for shorted or open elements, heater current, transconductance, heater-cathode leakage, and interelectrode leakage resistance.

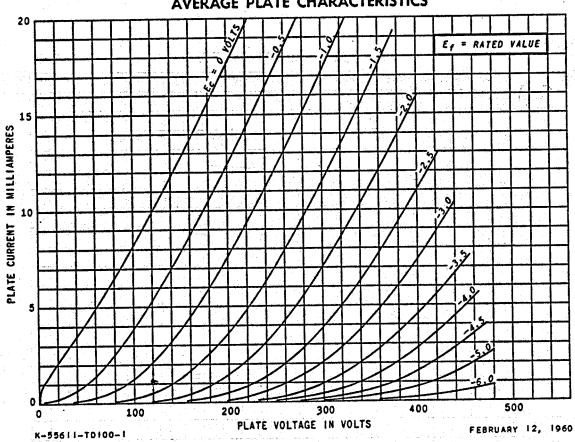
#### Interface Life Test

Statistical sample operated for 500 hours with Ef = 6.6 volts, no other voltages applied, and evaluated for cathode interface resistance following the life test.

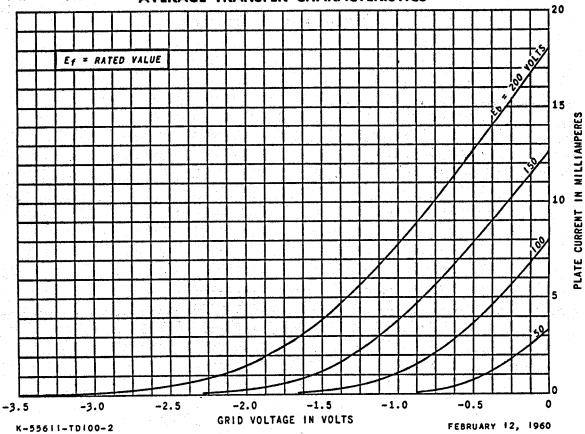
#### Heater-Cycling Life Test

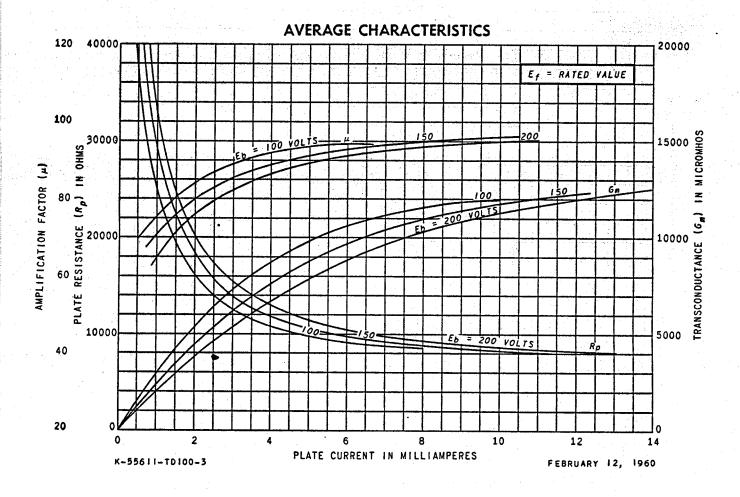
Statistical sample operated for 2000 cycles minimum to evaluate and control heater-cathode defects. Conditions of test include Ef = 7.0 volts cycled for one minute on and one minute off, Eb = Ec = 0 volts, and Ehk = 70 volts with heater positive with respect to cathode. Following the test, tubes are evaluated for open heaters, heater-cathode shorts, and heater-cathode leakage.

















#### 7486

#### METAL-CERAMIC TRIODE

#### FOR UHF OSCILLATOR AND POWER AMPLIFIER APPLICATIONS

#### DESCRIPTION AND RATING

The 7486 is a high-mu triode of ceramic-and-metal planar construction intended for use as an oscillator or radio-frequency power amplifier in the ultra-high-frequency range. The 7486 is especially suited for use where unfavorable conditions of mechanical shock, mechanical vibration, and nuclear radiation are encountered.

#### GENERAL

#### ELECTRICAL

#### Cathode—Coated Unipotential Heater Characteristics and Ratings Heater Voltage, AC or DC\*.....6.3 = 0.3 Volts Direct Interelectrode Capacitances! Output: p to (h+k)..................0.01 pf

#### MECHANICAL

Mounting Position-Any

See Outline Drawing on page 3 for dimensions and electrical connections

..............50 Volts .........10000 Ohms

.....250 C

#### MAXIMUM RATINGS

#### ABSOLUTE-MAXIMUM VALUES

Plate Voltage	Heater-Cathode Voltage
Positive DC Grid Voltage Volts	Heater Positive with Respect to
Negative DC Grid Voltage	Cathode
Plate Dissipation	Heater Negative with Respect to
DC Grid Current	Grid Circuit Resistance
DC Cathode Current	Envelope Temperature at Hottest
Peak Cathode Current	Points

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron tube of a specified type as defined by its published data and should not be exceeded under the worst probable condi-

The tube manufacturer chooses these values to provide acceptable serviceability of the tube, making no allowance for equipment variations, environmental variations, and the effects of changes in operating conditions due to variations in the characteristics of the tube under consideration and of all other electron devices in the equipment.

The equipment manufacturer should design so that initially and throughout life no absolute-maximum value for the intended service is exceeded with any tube under the worst probable operating conditions with respect to supplyvoltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in the characteristics of the tube under consideration and of all other electron devices in the equipment.

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elements. In the absence of an express written agreement to the contrary, General Electric Company assumes no liability for patent infringement arising out of any use of the tubes with other devices or elements by any purchaser of



#### CHARACTERISTICS AND TYPICAL OPERATION

AVERAGE CHARACTERISTICS			
Plate Voltage. Grid Voltage. Cathode-Bias Resistor.	••••••••		50 Volts Volts 82 Ohms
Amplification Factor Transconductance Plate Current	1	1500 105	90 00 Micromhos 7.5 Milliamperes
UHF Oscillator Service	The second second		
Plate Voltage. Grid Resistor. Plate Current. Grid Current. Frequency. Power Output, approximate.		1000 10 8.0 1 2.0 2	50 Volts 00 Ohms 3.0 Milliamperes 2.0 Milliamperes 00 Megacycles 00 Milliwatts
Class C RF Amplifier			
Plate Voltage Grid Resistor Plate Current Grid Current Frequency Power Output, approximate	••••••		50 Volts 00 Ohms 5.0 Milliamperes 1.0 Milliamperes 50 Megacycles 00 Milliwatts

#### **FOOTNOTES**

- \* The equipment designer should design the equipment so that heater voltage is centered at the specified bogey value, with heater supply variations restricted to maintain heater voltage within the specified tolerance.
- † Heater current of a bogey tube at Ef = 6.3 volts.
- Measured using a grounded adapter that provides shielding between external terminals of tube.
- § Operation below the rated maximum envelope temperature is recommended for applications requiring the longest possible tube life. The 7486 is also capable of operation at envelope temperatures much higher than the rated maximum values. For specific recommendations concerning higher temperature operation, contact your General Electric tube sales representative.

#### INITIAL CHARACTERISTICS LIMITS

		*****		
	Min.	Bogey	Max.	
Heater Current Ef = 6.3 volts	. 222	240	258	Milliamperes
Plate Current  Ef = 6.3 volts, Eb = 150 volts, Rk = 82 ohms (bypassed)	. 4.5	••••	11	Milliamperes
Zero-Bias Transconductance Ef = 6.3 volts, Eb = 100 volts, Ec = 0 volts	. 8000	11500	••••	Micromhos
Transconductance Change with Heater Voltage Difference between Zero-Bias Transconductance measured a Ef = 6.3 volts and Ef = 6.0 volts (other conditions the same expressed as a percentage	)		20	Percent
Amplification Factor  Ef = 6.3 volts, Eb = 150 volts, Rk = 82 ohms (bypassed)	. 65	90	115	
Grid Voltage Cutoff  Ef = 6.3 volts, Eb = 150 volts, Ib = 100 µa	• • • • •	-2.4	-4.5	Volts
Interelectrode Capacitances				
Grid to Plate: (g to p)		1.00	1.16	Picofarads
Input: g to (h+k)	. 1.25	1.70	2.15	Picofarads
Output: p to (h+k)		0.010	0.016	Picofarads
Heater to Cathode: (h to k)	. 0.80	1.10	1.40	Picofarads

#### INITIAL CHARACTERISTICS LIMITS (Continued)

Heater-Cathode Leakage Current	Min. Bogey	Max.	
Ef=6.3 volts, Ehk=100 volts	ol i a kirar bet	1.50.50	
Heater Positive with Respect to Cathode		20	Microamperes
Heater Negative with Respect to Cathode		20	Microamperes
Interelectrode Leakage Resistance			
Ef=6.3 volts. Polarity of applied d-c interelectrode voltage		A CARETA	
is such that no cathode emission results.			
Grid to All at 100 volts d-c	100	• • • • •	Megohms
Plate to All at 300 volts d-c	100		Megohms
Grid Emission Current			
Ef = 7.0 volts, Eb = 150 volts, Ecc = $-20$ volts, Rg = 0.1 meg	••••	2.0	Microamperes

#### SPECIAL PERFORMANCE TESTS

	Rg = 1000		Milliwatts =8.0 ma maximum,
Pulse Emission	prr = 1000	pps, duty	Milliamperes factor = 0.01. Pulse
Grid Recovery Change in Average Plate Current Peak Plate Current Backswing			Milliamperes Milliamperes

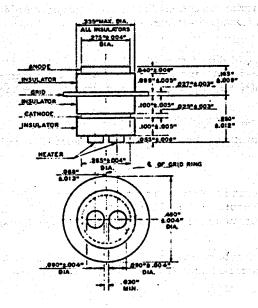
Tubes with poor grid recovery affect circuit operation, when the grid is driven positive by a pulse of signal or noise, somewhat as if a parallel RC circuit were in series with the grid. This effect may occur in tubes of any type, but is unimportant in many applications. In the majority of 7486 tubes the effect is negligible, but to eliminate the few in which it may be excessive, tubes are tested under the following conditions: Ef = 6.3 volts, Ebb = 250 volts,  $R_L = 0.01$  meg. Ec is

adjusted for Ib = 3.0 ma.

Upon application to the grid of a 5-volt positive pulse (prr = 60 pps, duty factor = 0.0012) the change in average plate current is noted, and the peak plate current backswing is measured. The following diagram shows qualitatively the plate current-time relationship for a tube (with poor grid recovery) subjected to this test.

#### **OUTLINE DRAWING**

#### PLATE CURRENT VS TIME— GRID RECOVERY TEST



- AVERAGE CURRENT BEFORE PULSES ARE APPLIED

  PEAK PULSE CURRENT

  AVERAGE CURRENT WITH PULSES APPLIED

  PEAK PLATE CURRENT BACKSWING
- —Maximum eccentricity of anode, grid, and cathode 0.005" from center line.
- 2—Maximum eccentricity of insulators 0.010' from center line.
- —Center line of grid ring used as reference line for horizontal tolerances.
- 4—Bottom surface of grid ring used as reference line for vertical tolerances.

#### SPECIAL PERFORMANCE TESTS (Continued)

Min.

Bogey

Max.
10 Millivolts RMS

operated with Ef = 6.3 volts, Ebb = 150 volts, Rk = 82 ohms (bypassed),  $R_L$  = 10000 ohms.

and the oppy with pour desirement to the

Variable Frequency Vibrational Output

The tube is designed to be free of vibrational outputs in excess of 15 mv RMS at any frequency within the range 100-2000 cps, when vibrated in either of two planes at 10G

peak acceleration. Electrical conditions for this test are the same as for Low Frequency Vibrational Output.

Low Pressure Voltage Breakdown Test

Statistical sample tested for voltage breakdown at a pressure of 8 mm Hg, to simulate an altitude of 100,000 feet. Tubes shall not give visual evidence of flashover or corona

when 300 volts RMS, 60 cps, is applied between the plate and grid terminals.

#### **DEGRADATION RATE TESTS**

#### Fatigue

Statistical sample vibrated for a total of six hours, three hours in each of two planes, at a peak acceleration of 10G. Frequency is continuously varied from 30 cps to 2000 cps and back to 30 cps, with a period of ten minutes. Tubes are operated during the test with Ef = 6.3 volts, Eb = 150 volts, and Rk = 82 ohms. Following the test, tubes are evaluated for low frequency vibrational output, heater-cathode leakage, and heater current.

#### Shock

Statistical sample subjected to 5 impact accelerations of approximately 450G in each of four positions. The accelerating forces are applied by the Navy-type, High Impact (flyweight) Shock Machine using a 30° hammer angle. Tubes are operated during the test with Ef = 6.3 volts, Eb = 150 volts, Ehk = +100 volts, and Rk = 82 ohms. Following the test, tubes are evaluated for low frequency vibrational output, heater-cathode leakage, and heater current.

#### Stability Life Test

The statistical sample subjected to the Dynamic Life Test is evaluated for percent change in zero-bias transconductance of individual tubes, from the initial reading to readings following 2 hours and 20 hours of the life test.

#### Survival Rate Life Test

The combined statistical samples subjected to the Dynamic and Pulse Life Tests are evaluated for shorted and open elements following approximately 100 hours of life test.

#### Dynamic Life Test

Statistical sample operated, with a 60 cps grid signal, at maximum rated DC grid current and cathode current for a period of 1000 hours. Heater voltage is cycled (on 1½ hours, off ½ hour). Tubes are evaluated, following 500 and 1000 hours of life test, for shorted or open elements, heater current, oscillator power output, zero-bias transconductance, heater-cathode leakage, and interelectrode leakage resistance.

#### Pulse Life Test

Statistical sample operated with 120 ma peak cathode current, 0.01 duty factor, for 1000 hours. Heater voltage is cycled (on  $1\frac{3}{4}$  hours, off  $\frac{1}{4}$  hour). Tubes are evaluated, following 500 and 1000 hours of life test, for shorted or open elements, heater current, pulse cathode current, heater-cathode leakage, and interelectrode leakage resistance.

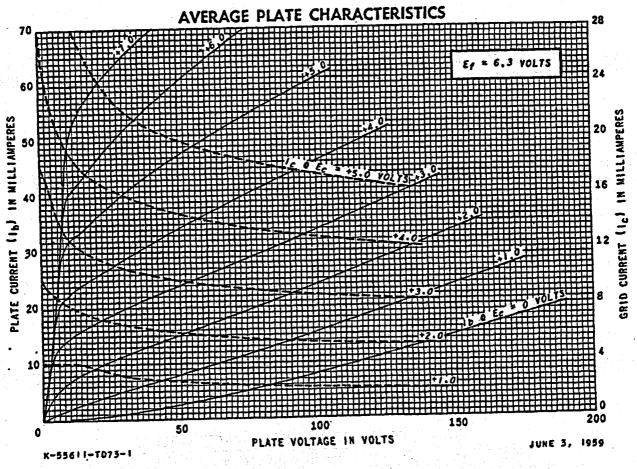
#### Interface Life Test

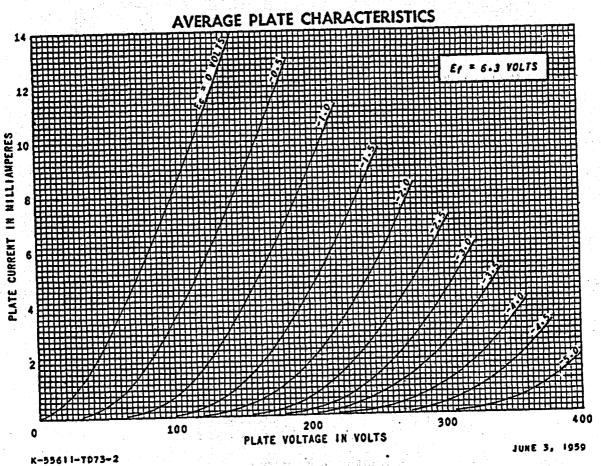
Statistical sample operated for 1000 hours with Ef = 6.6 volts, no other voltages applied, and evaluated for cathode interface resistance following the life test.

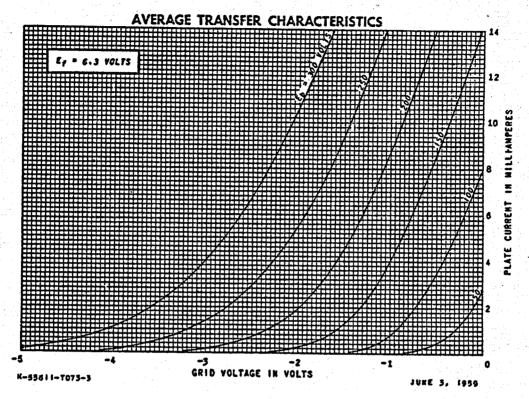
#### Heater-Cycling Life Test

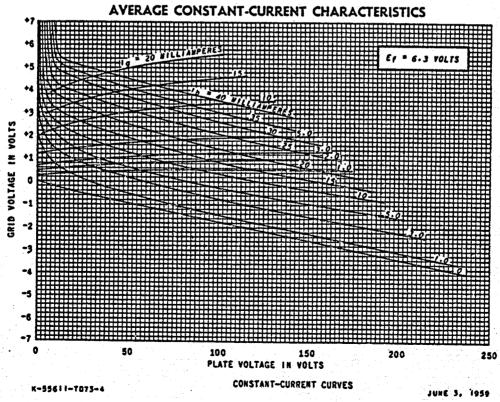
Statistical sample operated for 2000 cycles minimum to evaluate and control heater-cathode defects. Conditions of test include Ef = 7.0 volts cycled for one minute on and one minute off, Eb = Ec = 0 volts, and Ehk = 70 volts with heater positive with respect to cathode. Following this test, tubes are evaluated for open heaters, heater-cathode shorts, and heater-cathode leakage current.

Note: The conditions for some of the indicated tests have deliberately been selected to aggravate tube failures for test and evaluation purposes. In no sense should these conditions be interpreted as suitable circuit operating conditions.









#### RECEIVING TUBE DEPARTMENT

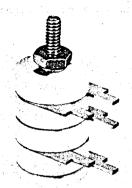


Owensboro, Kentucky



#### ACTAL CEDALAIC TOL

#### METAL-CERAMIC TRIODE



#### DESCRIPTION AND RATING

The 7588 is a high-mu triode of ceramic-and-metal planar construction. The tube is intended for use as a broadband radio-frequency amplifier at frequencies up to 500 megacycles.

#### GENERAL

ELECTRICAL	
Cathode—Coated Unipotential	
Heater Characteristics and Ratings	
Heater Voltage, AC or DC*6.3 $\pm 0.3$	Volts
Heater Current†0.4	Amperes
Direct Interelectrode Capacitances!	
Grid to Plate: (g to p)	pf
Input: g to (h+k)	pf
Output: p to (h+k)	pf
Heater to Cathode: (h to k) 2.6	

#### MECHANICAL

Mounting Position—Any §
See Physical Dimensions on page 4 for dimensions and electrical connections.

#### **MAXIMUM RATINGS**

ABSOLUTE-MAXIMUM VALUES		
Plate Voltage	. 300 Volts	i de la valor de Egita de la Galegia
Positive DC Grid-to-Cathode Voltage	0 Volts	•
Negative DC Grid Voltage	50 Volts	
Plate Dissipation	. 5.5 Watts	1
DC Cathode Current	30 Milliampe	eres

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron tube of a specified type as defined by its published data and should not be exceeded under the worst probable conditions.

The tube manufacturer chooses these values to provide acceptable serviceability of the tube, making no allowance for equipment variations, environmental variations, and the effects of changes in operating conditions due to variations in the characteristics of the tube under consideration and of

all other electron devices in the equipment.

The equipment manufacturer should design so that initially and throughout life no absolute-maximum value for the intended service is exceeded with any tube under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in the characteristics of the tube under consideration and of all other electron devices in the equipment.

Envelope Temperature at Hottest Point. . 250 C

#### CHARACTERISTICS AND TYPICAL OPERATION

AVERAGE CHARACTERISTICS	Plate Resistance, approximate3900 Ohms
Plate Voltage	Transconductance
Positive Grid Voltage	Plate Current
Cathode-Bias Resistor 270 Ohms	Ib = 100 Microamperes5 Volts
Amplification Factor	Noise Figure \( \tag{3.0 Decibels}



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#### **FOOTNOTES**

- \* The equipment designer should design the equipment so that heater voltage is centered at the specified bogey value, with heater supply variations restricted to maintain heater voltage within the specified tolerance.
- † Heater current of a bogey tube at Ef = 6.3 volts.
- ‡ Without external shield.
- § One method of mounting the 7588 is to use a stainless-steel "T" bolt (see drawing) to attach the mounting base of the tube to a chassis or circuit board. The "T" bolt should be inserted in the slot in the base of the tube, turned 90 degrees, and attached to the chassis or circuit board with a 4-40 nut and lock washer. Torque used to tighten the nut should not exceed 3 inch-pounds.
- ¶ Measured at 200 megacycles in a grounded-grid amplifier and corrected for second-stage noise figure and diode temperature.

The tubes and arrangements disclosed herein may be covered by patents of General Electric Company or others. Neither the disclosure of any information herein nor the sale of tubes by General Electric Company conveys any license under patent claims covering combinations of tubes with other devices or

elements, in the absence of an express written agreement to the contrary, General Electric Company assumes no liability for patent infringement arising out of any use of the tubes with other devices or elements by any purchaser of tubes or others.

#### INITIAL CHARACTERISTICS LIMITS

THE CONTRACTOR OF THE PARTY OF			
Min. Heater Current	Bogey	Max.	
	400	400	3.7444
	400	430	Milliamperes
Plate Current			
Ef = 6.3  volts, Eb = 200  volts, Rk = 22  ohms. 17	25	33	Milliamperes
Transconductance			
Ef = 6.3 volts, Eb = 200 volts, Ec = $+6$ volts, Rk = 270 ohms (bypassed)35000	45000	55000	Micromhos
Amplification Factor			
Ef = 6.3 volts, Eb = 200 volts, Ec = $+6$ volts, Rk = 270 Ohms (bypassed) 140	175	210	
Transconductance Change with Heater Voltage			
Difference between transconductance at Ef = 6.3 volts and trans-			
conductance at $Ef = 5.7$ volts (other conditions the same) ex-			, in the second
pressed as a percentage of transconductance at Ef = 6.3 volts		20	Percent
Grid Voltage Cutoff			
Ef = 6.3 volts, Eb = 200 volts, Ib = 100 $\mu$ a	-5.0	-8.0	Volts
Noise Figure			
Ef = 6.3 volts, Ebb = 265 volts, Ec = 0 volts, $R_L = 3300$ ohms,			
(bypassed), $Rk = 22$ ohms, $F = 200 = 10 MC$	3.0	4.8	Decibels
Interelectrode Capacitances			
Grid to Plate: (g to p) 2.1	2.8	3.5	pf
Input: g to $(h+k)$ 5.1	6.7	8.3	pf
Output: p to (h+k)	0.075	0.1	pf
Heater to Cathode: (h to k)	2.6	3.3	pf
Negative Grid Current			
Ef = 6.3 volts, Eb = 200 volts, Ecc = $-1.0$ volts, Rk = 22 ohms			1
(bypassed), Rg = 0.1 meg.	• • • • •	0.5	Microamperes
Heater-Cathode Leakage Current			
Ef = 6.3 volts, Ehk = 100 volts			
Heater Positive with Respect to Cathode		20 20	Microamperes
	• • • • •	20	Microamperes
Interelectrode Leakage Resistance			en e
Ef = 6.3 volts. Polarity of applied d-c interelectrode voltage is such that no cathode emission results.			
Grid to All at 100 volts d-c			Megohms
Plate to All at 300 volts d-c			Megohms
Grid Emission Current			
Ef = 7.0 volts, Eb = 200 volts, Ecc = $-15$ volts, Rg = 0.1 meg		2.0	Microamperes
and the state of t	· · · · ·	2.0	oamperes

#### SPECIAL PERFORMANCE TESTS

Min. Bogey Max. Grid Recovery Change in Average Plate Current..... 1.0 Milliamperes Milliamperes Peak Plate Current Backswing..... 2.0

Tubes with poor grid recovery affect circuit operation when the grid is driven positive by a pulse of signal or noise, somewhat as if a parallel RC circuit were in series with the grid. This effect may occur in tubes of any type but is unimportant in many applications. In the majority of 7588 tubes the effect is negligible, but to eliminate the few in which it may be excessive, tubes are tested under the following conditions: Ef = 6.3 volts, Ebb = 250 volts,  $R_1 = 0.01$  meg. EC is adjusted for Ib = 10 ma.

Upon application to the grid of a pulse driving it 3 volts positive with respect to cathode (prr = 60 pps, duty cycle = 0.12%) the change in average plate current is noted, and the peak plate current backswing is measured. The following diagram shows qualitatively the plate current-time relationship for a tube (with poor grid recovery) subjected to this

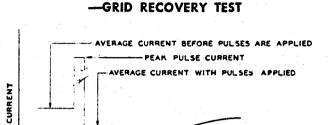


PLATE CURRENT VS TIME

TIME

PEAK PLATE CURRENT BACKSWING

#### Min. Bogey Max. Low Frequency Vibrational Output Statistical sample is subjected to vibration in each of two planes at 40 cps, with peak acceleration 15G. Tube is operated with Ef = 6.3 volts, Ebb = 250 volts, Rk = 68 ohms (bypassed), $R_L = 2000$ Millivolts ohms...... **RMS** Variable Frequency Vibrational Output Statistical sample is subjected to vibration according to the procedure given below. Tube is operated with Ef = 6.3 volts, Ebb = 250 volts, Rk = 68 ohms (bypassed), $R_L = 2000$ ohms.... Millivolts **RMS**

PLATE

The variable-frequency vibration test shall be performed as follows:

- 1. The frequency shall be increased from 100 to 2000 cps with approximately logarithmic progression in  $3 \pm 1$ minutes. The return sweep (2000 to 100 cps) is not required.
- 2. The tube shall be vibrated with simple harmonic motion in each of two planes: first, parallel to the cylindrical axis; second, perpendicular to the cylindrical axis and parallel to a line through the major axis of a terminal lug. At all frequencies from 100 to 2000 cps, the total harmonic distortion of the acceleration wave form shall be less than 5%.
- 3. The peak acceleration shall be maintained at 10 = 1.0 G throughout the test.
- 4. The value of the alternating voltage produced across the load resistor (R<sub>L</sub>), as a result of the vibration, shall be measured with a suitable device having a response to the RMS value of the voltage to within ±0.5 db of the response at 400 cps for the frequency range of 100 to 3000 cps, and having a band-pass filter with an attenuation rate of 24 db per octave below the low frequency cutoff point of 50 cps and above the high frequency cutoff point of 5000 cps. The meter shall have a dynamic response characteristic equivalent to or faster than a VU meter (operated in accordance with ASA Standard No. C16.5-1954).

#### Low Pressure Voltage Breakdown Test

Statistical sample tested for voltage breakdown at a pressure of 8mm Hg, to simulate an altitude of 100,000 feet. Tubes shall not give visual evidence of flashover or corona when 300 volts RMS, 60 cps, is applied between the plate and grid terminals.

#### **DEGRADATION RATE TESTS**

#### Fatigue

Statistical sample vibrated for a total of six hours, three hours in each of two planes, at a peak acceleration of 10 G. Frequency is continuously varied from 30 cps to 2000 cps and back to 30 cps, with a period of ten minutes. Tubes are operated during the test with Ef = 6.3 volts, Eb = 250 volts, and Rk = 68 ohms. Following the test, tubes are evaluated for low frequency vibrational output, heater-cathode leakage, heater current, and transconductance.

#### **DEGRADATION RATE TESTS (Continued)**

#### Shock

Statistical sample subjected to 5 impact accelerations of approximately 450 G in each of four positions. The accelerating forces are applied by the Navy-type, High Impact (flyweight) Shock Machine using a 30° hammer angle. Tubes are mounted by T-bolt with 3 inch-pounds torque, and operated during the test with Ef = 6.3 volts, Eb = 250 volts, Eb = 4.00 volts, Eb = 250 volts, Eb

#### Stability Life Test

The statistical sample subjected to the Intermittent Life Test is evaluated for percent change in transconductance of individual tubes, from the initial reading to readings following 2 hours and 20 hours of the life test.

#### Survival Rate Life Test

The statistical sample subjected to the Intermittent Life Test is evaluated for shorted and open elements, and transconductance, following approximately 100 hours of life test.

#### Intermittent Life Test

Statistical sample operated 1000 hours under the following conditions: Ef = 6.3 volts, Eb = 200 volts, Ecc = +6 volts, Ehk = -70 volts, Rk = 270 ohms, Rg = 0.1 meg. Heater voltage is cycled (on  $1\frac{3}{4}$  hours, off  $\frac{1}{4}$  hour). Tubes are evaluated, following 500 and 1000 hours of life test, for shorted or open elements, heater current, transconductance, negative grid current, noise figure, heater-cathode leakage, and interelectrode leakage resistance.

#### Interface Life Test

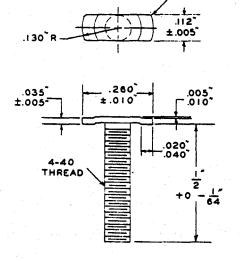
Statistical sample operated for 1000 hours with Ef = 6.6 volts, no other voltages applied, and evaluated for cathode interface resistance following the life test.

#### Heater-Cycling Life Test

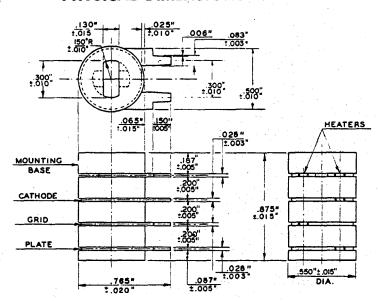
Statistical sample operated for 2000 cycles minimum to evaluate and control heater-cathode defects. Conditions of test include Ef = 7.5 volts cycled for one minute on and one minute off, Eb = Ec = 0 volts, and Ehk = 70 volts with heater positive with respect to cathode. Following this test, tubes are evaluated for open heaters, heater-cathode shorts, and heater-cathode leakage current.

#### MOUNTING BOLT

APPROX.

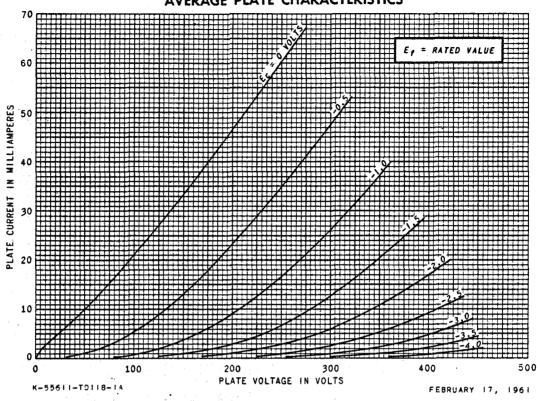


#### PHYSICAL DIMENSIONS

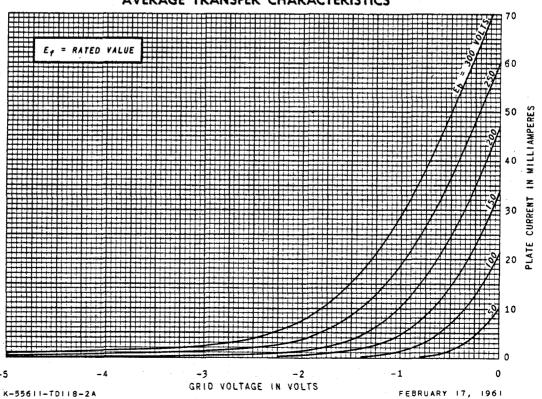


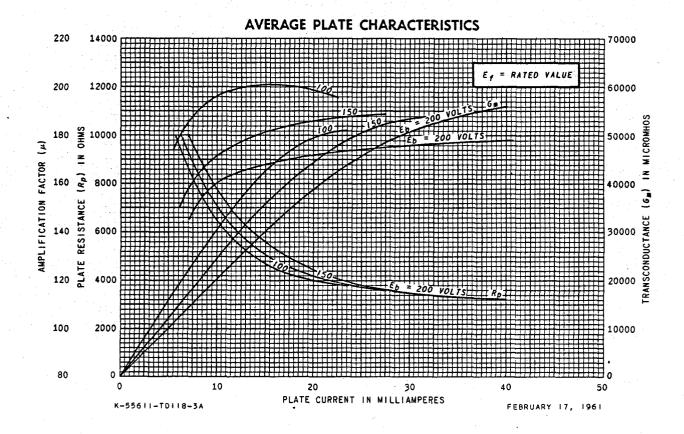
Maximum eccentricity of insulators 0.015 in. from center line.



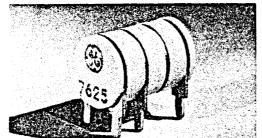


#### **AVERAGE TRANSFER CHARACTERISTICS**





# GENERAL ELECTRIC Owensboro, Kentucky



#### METAL-CERAMIC TRIODE

#### DESCRIPTION AND RATING=

The 7625 is a high-mu triode of ceramic-and-metal planar construction primarily intended for low-level audio-frequency amplification.

#### GENERAL

Cathode—Coated Unipotential	
Heater Characteristics and Ratings	
Heater Voltage, AC or DC* $\dots 6.3 \pm 0.3$	Volts
Heater Current†0.215	Ampere
Direct Interelectrode Capacitances‡	
Grid to Plate: (g to p)1.3	pf
Input: g to $(h+k)$	
Output: p to $(h+k)$	
Heater to Cathode: (h to k)1.5	

**ELECTRICAL** 

#### MECHANICAL

Mounting Position-Any

See Outline Drawing on page 3 for dimensions and electrical connections

#### **MAXIMUM RATINGS**

#### **ABSOLUTE-MAXIMUM VALUES**

DC Plate Voltage275	Volts
Peak Plate Voltage400	Volts
Positive Peak and DC Grid Voltage0	Volts
Negative Peak and DC Grid Voltage 50	Volts
Plate Dissipation 0.85	Watts
DC Cathode Current	Milliamperes

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron tube of a specified type as defined by its published data and should not be exceeded under the worst probable conditions.

The tube manufacturer chooses these values to provide acceptable serviceability of the tube, making no allowance for equipment variations, environmental variations, and the effects of changes in operating conditions due to variations in the characteristics of the tube under consideration and of

all other electron devices in the equipment.

The equipment manufacturer should design so that initially and throughout life no absolute-maximum value for the intended service is exceeded with any tube under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in the characteristics of the tube under consideration and of all other electron devices in the equipment.

#### CHARACTERISTICS AND TYPICAL OPERATION

AVERAGE CHARACTERISTICS	
Plate Voltage150	Volts
Cathode-Bias Resistor	Ohms
Amplification Factor	
Plate Resistance, approximate 57000	Ohms

Transconductance	1400	Micromhos
Plate Current	0.95	Milliampere
Grid Voltage, approximate		
Ib = 10 Microamperes,		
Th = 250 Volts	-46	Volts

#### **FOOTNOTES**

- \* The equipment designer should design the equipment so that heater voltage is centered at the specified bogey value, with heater supply variations restricted to maintain heater voltage within the specified tolerance.
- † Heater current of a bogey tube at Ef = 6.3 volts.
- ‡ Without external shield.
- § If resistance is used in the cathode or plate circuits, the grid-circuit resistance may be high as (200,000+500 RK+
- 10 RL) ohms, where RK is the cathode-bias resistance in ohms, and RL is the DC plate load resistance in ohms.
- ¶ Operation below the rated maximum envelope temperature is recommended for applications requiring the longest possible tube life. The 7625 is also capable of operation at envelope temperatures much higher than the rated maximum values. For specific recommendations concerning higher temperature operation, contact your General Electric tube sales representative.



#### SPECIAL PERFORMANCE TESTS

#### Maximum

Variable-Frequency Vibration . . . . . . . . . . . . . . . . . Millivolts

Ef = 6.3 volts, Ebb = 150 volts, Ec = 0 peak to peak

volts d-c, Rk = 1000 ohms (bypassed),

R<sub>I</sub> = 10000 ohms; Note 1

#### Low Pressure Voltage Breakdown Test

Statistical sample tested for voltage breakdown at a pressure of 8mm Hg, to simulate an altitude of 100,000 feet. Tubes shall not give visual evidence of flashover or corona when 300 volts RMS, 60 cps, is applied between the plate and grid terminals.

Note 1: The variable-frequency vibration test shall be performed as follows:

- a. The frequency shall be increased from 100 to 2000 cps with approximately logarithmic progression in 3=1 minutes. The return sweep (2000 to 100 cps) is not required.
- b. The tube shall be vibrated with simple harmonic motion in each of two planes; first, parallel to the cylindrical axis; second, perpendicular to the cylindrical axis and parallel to a line through the major axis of a terminal lug.
- c. The peak acceleration shall be maintained at 10 = 1 G throughout the test.
- d. The vibrational output produced across  $R_L$  as a result of the vibration shall be coupled to a low-pass filter that has the following characteristics:
  - (1) A response within ±1 db of the response at 1000 cps over the frequency range of 100 to 17000 cps.
  - (2) The response shall be down at least 1.5 db at 20000 cps and have a cut-off rate of at least 18 db per octave above 20000 cps.
- Note 2: The tube shall be vibrated with harmonic motion in each of two planes, (1) parallel to the cylindrical axis and (2) perpendicular to the cyclindrical axis and perpendicular to a line through the major axis of a terminal lug.

#### **DEGRADATION RATE TESTS**

#### Fatigue

Statistical sample vibrated for a total of six hours, three hours in each of two planes, at a peak acceleration of 10 G. Frequency is continuously varied from 30 cps to 2000 cps and back to 30 cps, with a period of ten minutes. Tubes are operated during the test with Ef = 6.3 volts, Eb = 150 volts, and Rk = 82 ohms. Following the test, tubes are evaluated for low frequency vibrational output, heater-cathode leakage, transconductance, and negative grid current.

#### Shock

Statistical sample subjected to 5 impact accelerations of approximately 450 G in each of four positions. The accelerating forces are applied by the Navy-type, High Impact (flyweight) Shock Machine using a 30° hammer angle. Tubes are operated during the test with Ef = 6.3 volts, Eb = 150 volts, Ehk = +100 volts, Rg = 0.1 Meg, and Rk = 82 ohms. Following the test, tubes are evaluated for low frequency vibrational output, heater-cathode leakage, transconductance, and negative grid current.

#### Stability Life Test

The statistical sample subjected to the Intermittent Life Test is evaluated for percent change in transconductance of individual tubes, from the initial readings to readings following 2 hours and 20 hours of the life test.

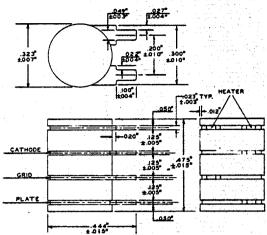
#### Survival Rate Life Test

The statistical sample subjected to the Intermittent Life Test is evaluated for shorted and open elements and transconductance following approximately 100 hours of life test.

#### Intermittent Life Test

Statistical sample operated for 1000 hours under the following conditions: Ef = 6.3 volts (cycled—on  $1\frac{3}{4}$  hours, off  $\frac{1}{4}$  hour), Ebb = 300 volts, Ehk = +70 volts d-c, Rk = 82 ohms,  $R_L$  = 18000 ohms, and Rg = 0.1 meg. Tubes are evaluated, following 500 and 1000 hours of life test, for shorted or open elements, heater current, grid current, transconductance, heater-cathode leakage, and interelectrode leakage resistance.

#### **DEGRADATION RATE TESTS (Continued)**



Maximum eccentricity of insulators 0.010 in. from center line.

#### Interface Life Test

Statistical sample operated for 1000 hours with Ef = 6.6 volts, no other voltages applied, and evaluated for cathode interface resistance following the life test.

#### Heater-Cycling Life Test

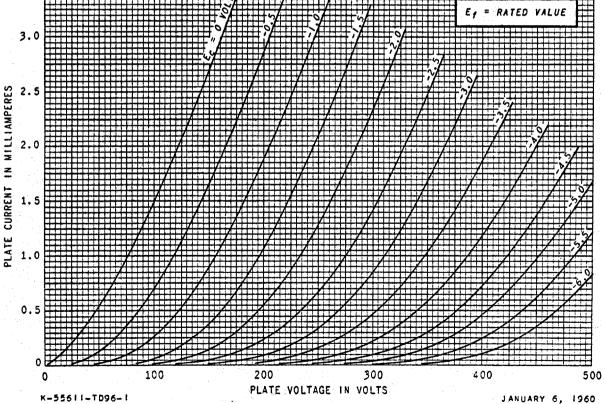
Statistical sample operated for 2000 cycles minimum to evaluate and control heater-cathode defects. Conditions of test include Ef = 7.0 volts cycled for one minute on and one minute off, Eb = Ec = 0 volts, and Ehk = 70 volts with heater positive with respect to cathode. Following this test, tubes are evaluated for open heaters, heater-cathode shorts, and heater-cathode leakage current.

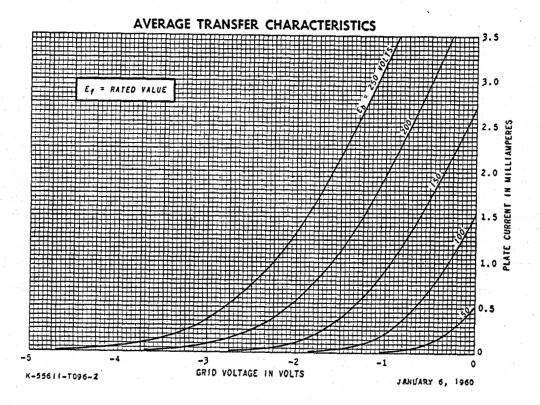
Note: The conditions for some of the indicated tests have deliberately been selected to aggravate tube failures for test and evaluation purposes. In no sense should these conditions be interpreted as suitable circuit operating conditions.

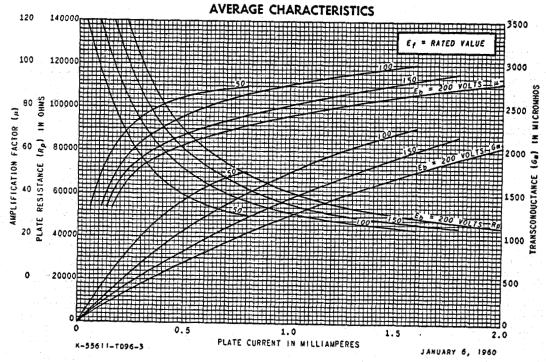
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elements. In the absence of an express written agreement to the contrary, General Electric Company assumes no liability for patent infringement arising out of any use of the tubes with other devices or elements by any purchaser of tubes or others.

## AVERAGE PLATE CHARACTERISTICS







RECEIVING TUBE DEPARTMENT



Owensboro, Kentucky



#### -PRODUCT INFORMATION -

Page 1

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7644

1/6

Ounce

#### **Planar Triode**

FOR GROUNDED-GRID CLASS A UHF AMPLIFIER APPLICATIONS

TUBES

The 7644 is a high-mu, metal-and-ceramic triode intended for operation as a grounded-grid, Class A radio-frequency amplifier at frequencies as high as 3000 megacycles. Features of the tube include small size, planar electrode construction with close spacing, inherent rigidity, and an envelope structure convenient for coaxial circuit applications.

Within the limitations of its ratings, the 7644 may be used in radar receivers, or similar applications, where the grid of the tube may be driven positive by leakage pulses. The physical appearance and dimensions of the 7644 are identical to those of the 6299, and the electrical characteristics are nearly identical.

#### GENERAL

#### ELECTRICAL MECHANICAL Operating Position - Any Cathode - Coated Unipotential Net Weight, approximate Heater Characteristics and Ratings Cooling - Conduction 6.3±0.13 Heater Voltage, AC or DC\*. . . Volts Heater Current . 0.3 Amperes Direct Interelectrode Capacitances Grid to Plate: (g to p) . . 1.75 рf Grid to Cathode and Heater: g to (h + k). . 3.65 Plate to Cathode and Heater: p to (h + k). 0.015 pf

#### **MAXIMUM RATINGS**

ABSOLUTE-MAXIMUM	VALUES		• * * * * * * * * * * * * * * * * * * *		# . * · · · · · · · · · · · · · · · · · ·	•
Plate Voltage			·		200	Volts
Negative DC Grid Voltage .	• . •, . •		• • •		15	Volts
Negative DC Grid Voltage . Plate Dissipation					2.0	Watts
DC Plate Current		• •	• • •	• • • • •	12	Milliamperes
Leakage Pulse						
Duty Cycle	• • •				0.0011	
Pulse Width						Microseconds
Peak RF Grid Voltage# .						Volts
Envelope Temperature at Ho	ttest Point				150	C

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron tube of a specified type as defined by its published data and should not be exceeded under the worst probable conditions.

The tube manufacturer chooses these values to provide acceptable serviceability of the tube, making no allowance for equipment variations, environmental variations, and the effects of changes in operating conditions due to variations in the characteristics of the tube under consideration and of

all other electron devices in the equipment.

The equipment manufacturer should design so that initially and throughout life no absolute-maximum value for the intended service is exceeded with any tube under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in the characteristics of the tube under consideration and of all other electron devices in the equipment.

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express written agreement to the contrary, General Electric Company assumes no liability for patent infringement arising out of any use of the tubes with other devices or elements by any purchaser of tubes or others.



#### CHARACTERISTICS AND TYPICAL OPERATION

AVERAGE CHARACTER	ISTICS											
Plate Voltage						• . •					. 175	Volts
Grid Voltage∆		1. i.e.	•		•							Volts
Amplification Factor		• •					•				. 110	and the second second
Plate Resistance, approxima												Ohms
ransconductance					•		•				15000	Micromhos
late Current							•				. 10	Milliampere
Plate Voltage, approximate							~					
Ib = 10 Milliamperes, Ec	= 0  volt	s	•				•				. 125	Volts
CLASS A, RF AMPLIFIE					•					1200	3000	Megacycles
Plate Supply Voltages										300	300	Volts
Resistor in Plate Circuit (	(bypassed)			: :			·		17500	17500	17500	Ohms
rid Voltage**										0	0	Volts
Plate Current										10	10	Milliampere
Sandwidth, min										10	10	Megacycles
Sain										17	11	Decibels
Noise Figure, Power-Matched	i		_		_			_	. 4.5	8.2	13.2	Decibels

#### NOTES

- \* The equipment designer should design the equipment so that heater voltage is centered at the specified bogey value, with heater supply variations restricted to maintain heater voltage within the specified tolerance.
- + Heater current of a bogey tube at Ef = 6.3 volts.
- § Without external shield.
- ¶ Good thermal contact to the anode and cathode must be provided to conduct heat from the elements. The anode contact must be sufficiently flexible to keep lateral force on the anode at a minimum.
- # The 7644 is rated only for Class A amplifier service.
- $\Delta$  Adjusted for Ib = 10 milliamperes.
- & Supply should be regulated.
- \*\* For operation above 1000 megacycles, the minimum noise figure will generally be obtained by operation at zero bias. For operation below 1000 megacycles, the use of a cathode resistor or grid bias should be evaluated for the particular application.

#### INITIAL CHARACTERISTICS LIMITS

Heater Current Ef = 6.3 volts	Min. . 280	Bogey 300	Max. 320	Milliamperes
Plate Voltage Ef = 6.3 volts, Ec = 0 volts, Eb adjusted for Ib = 10 ma	. 75	125	175	Volts
Transconductance  Ef = 6.3 volts, Eb = 175 volts, Ec adjusted for Ib = 10 ma	11500	15000	20000	Micromhos
Amplification Factor Ef = 6.3 volts, Eb = 175 volts, Ec adjusted for Ib = 10 ma	. 85	110	140	
Interelectrode Leakage Resistance  Ef = 6.3 volts, Polarity of applied d-c interelectrode voltage is such that no cathode emission results  Grid to Cathode and Heater at 45 volts d-c				Megohms Megohms
Interelectrode Capacitances Grid to Plate: (g to p)	. 1.5	1.75 3.65 0.015	2.0 5.0 0.025	Picofarads Picofarads Picofarads
SPECIAL PERFORMANCE	TESTS			
Noise Figure - 450 MC  Ef = 6.3 volts, Ec = 0 volts, Eb adjusted for Ib = 10 ma, F =	450±5 MC	Min.	Max. 5.0	Decibels
Noise Figure - 1200 MC  Ef = 6.3 volts, Ec = 0 volts, Eb adjusted for Ib = 10 ma, F =	1200±5 MC	•••	8.5	Decibels
Power Gain - 450 MC  Ef = 6.3 volts, Ec = 0 volts, Eb adjusted for Ib = 10 ma, F = Bandwidth = 9 MC, min	450±5 MC,	. 15		Decibels
Power Gain - 1200 MC  Ef = 6.3 volts, Ec = 0 volts, Eb adjusted for Ib = 10 ma, F = Bandwidth = 10 MC, min	1200±5 MC,	. 15		Decibels
DEGRADATION RATE T	ESTS			

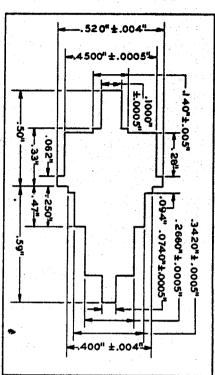
#### 1000-Hour Life

Statistical sample operated for 1000 hours to evaluate changes in transconductance and noise figure with life.

#### PHYSICAL DIMENSIONS

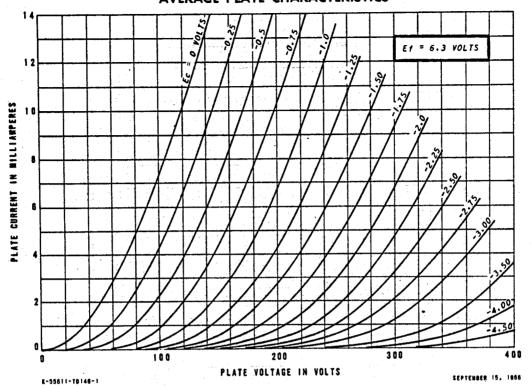
# PLATE TERMINAL GRID TERMINAL W. RAD. REF. PLANE CATHODE AND HEATER TERMINAL (DO NOT USE FOR ANY DC OR RF CONNECTION) HEATER TERMINAL

#### ALIGNMENT GAUGE

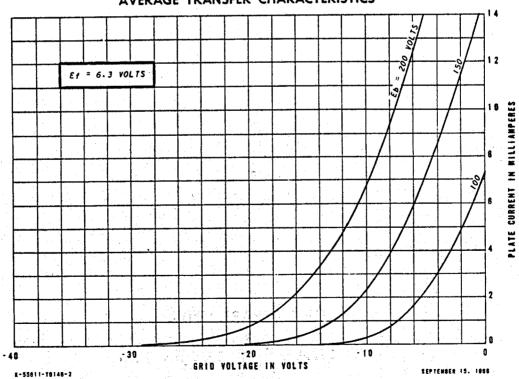


Ref.	INC	HES	MILLIMETERS			
Wer.	Minimum	Maximum	Minimum	Maximum		
A	0.960	1.040	24.38	26.42		
В	0.530	0.590	13.46	14.99		
С	0.410	0.470	10.41	11.94		
D		0.272		6.91		
E		0.475		12.07		
F	0.163	0.193	4.14	4.90		
G		0.060		1.52		
H		• 0.030		0.76		
J	0.190	0.210	4.83	5.33		
K	0.009	0.015	0.23	0.38		
M	0.040	0.070	1.02	1.78		
N	0.059	0.065	1.50	1.65		
P		0.257		6.53		
Q	0.326	0.334	8.28	8.48		
R		0.385		9.78		
S	0.483	0.497	12.27	12.62		
T	0.435	0.445	11.05	11.30		
U		0.385		9.78		
V	0.088	0.094	2.24	2.39		
W	***	0.008		0.20		

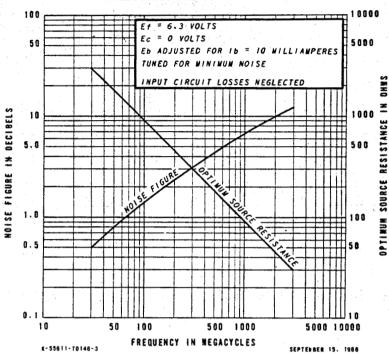
#### AVERAGE PLATE CHARACTERISTICS



#### AVERAGE TRANSFER CHARACTERISTICS



#### PREDICATED NOISE PERFORMANCE



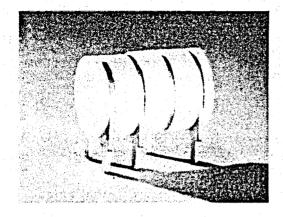
#### TUBE DEPARTMENT



Owensboro, Kentucky

#### **7720**

#### METAL-CERAMIC TRIODE



#### DESCRIPTION AND RATING

The 7720 is a high-mu triode of ceramic-and-metal planar construction primarily intended for use as an oscillator in the ultra-high-frequency range.

#### GENERAL

#### ELECTRICAL

#### 

#### **MECHANICAL**

Mounting Position—Any See outline drawing on page 2 for dimensions and electrical connections.

#### **MAXIMUM RATINGS**

#### ABSOLUTE MAXIMUM VALUES

ADDOCATE MANAGEMENT TAXABLE			
Plate Voltage	Volts	Heater-Cathode Voltage	
Positive DC Grid Voltage0	Volts	Heater Positive with Respect to	
Negative DC Grid Voltage 50	Volts	Cathode50	Volts
Peak Negative Grid Voltage50	Volts	Heater Negative with Respect to	
Plate Dissipation1.0		Cathode50	Volte
DC Grid Current	Milliamperes		
DC Cathode Current		Grid-Circuit Resistance	Ohms
Peak Cathode Current	Milliamperes	Bulb Temperature at Hottest Point**250	C

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron tube of a specified type as defined by its published data and should not be exceeded under the worst probable conditions.

The tube manufacturer chooses these values to provide acceptable serviceability of the tube, making no allowance for equipment variations, environmental variations, and the effects of changes in operating conditions due to variations in the characteristics of the tube under consideration and of

all other electron devices in the equipment.

The equipment manufacturer should design so that initially and throughout life no absolute-maximum value for the intended service is exceeded with any tube under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in the characteristics of the tube under consideration and of all other electron devices in the equipment.

The tubes and arrangements disclosed herein may be covered by patents of General Electric Company or others. Neither the disclosure of any information herein nor the sale of tubes by General Electric Company conveys any license under patent claims covering combinations of tubes with other devices or

elements. In the absence of an express written agreement to the contrary, General Electric Company assumes no liability for patent infringement arising out of any use of the tubes with other devices or elements by any purchaser of tubes or others.



#### Page 2 3-63

#### CHARACTERISTICS AND TYPICAL OPERATION

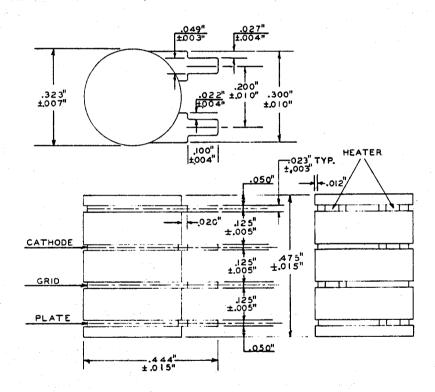
AVERAGE CHARACTERISTIC	CS		UHF OSCILLATOR SERVICE				
Plate Voltage	100 150	Volts	Plate Voltage	Volts			
Grid Voltage	0	Volts	Grid Resistor	Ohms			
Cathode-Bias Resistor	<del></del>	Ohms	Plate Current 4.0	Milliamperes			
Amplification Factor	<del></del>		Frequency 450	Megacycles			
Transconductance 11	,500 10,500	Micromhos	Grid Current 0.5	Milliamperes			
Plate Current	9.0 7.5	Milliamperes	Power Output, approximate 100	Milliwatts			

#### **FOOTNOTES**

- \* The equipment designer should design the equipment so that heater voltage is centered at the specified bogey value, with heater supply variations restricted to maintain heater voltage within the specified tolerance.
- † Heater current of a bogey tube at Ef = 6.3 volts.
- † Without external shield.

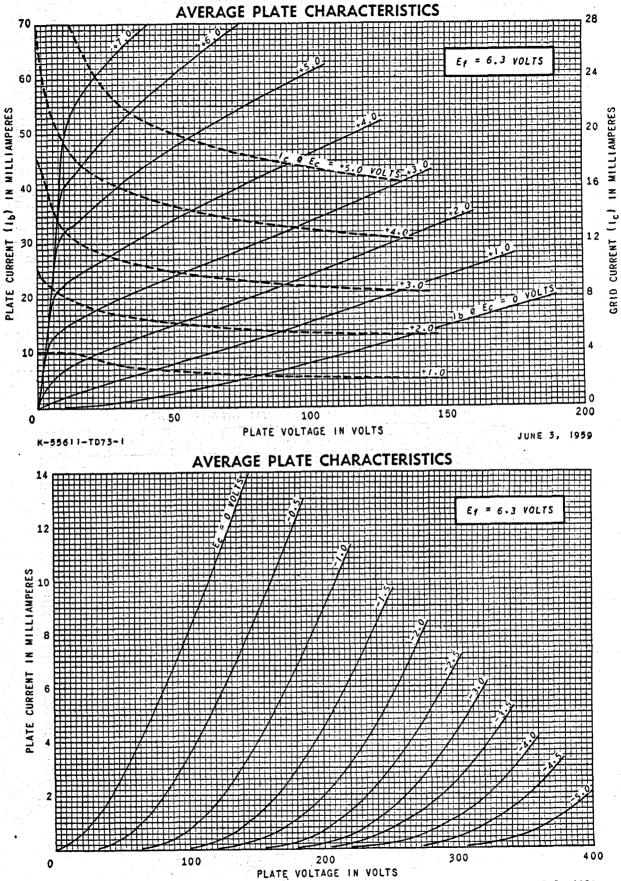
  \*\*For applications where long life is a primary consideration, it is recommended that the envelope temperature be maintained below 175 C.

#### **OUTLINE DRAWING**



Maximum eccentricity of insulators 0.010 in. from center line.

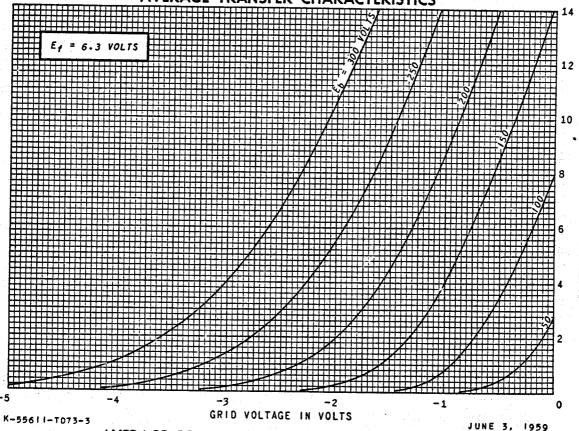
JUNE 3, 1959



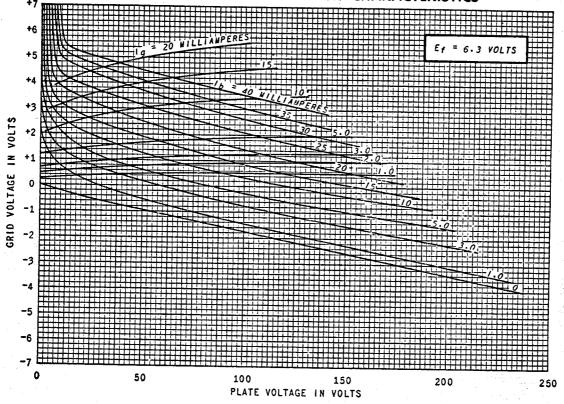
K-55611-TD73-2



#### **AVERAGE TRANSFER CHARACTERISTICS**



AVERAGE CONSTANT-CURRENT CHARACTERISTICS



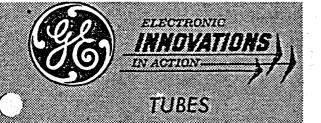
K-55611-T073-4

RECEIVING TUBE DEPARTMENT

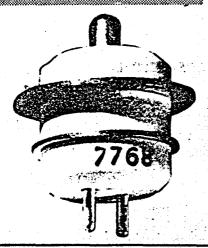
GENERAL ELECTRIC

JUNE 3, 1959

Owensboro, Kentucky



### 7768



### METAL-CERAMIC TRIODE

### DESCRIPTION AND RATING=

# FOR BROADBAND RADIO-FREQUENCY AMPLIFIER APPLICATIONS

The 7768 is a high-mu triode of ceramic-and-metal planar construction primarily intended for use as a broadband radio-frequency amplifier. The 7768 is especially suited for use where unfavorable conditions of mechanical shock, mechanical vibration, and nuclear radiation are encountered.

### GENERAL

### ELECTRICAL

### 

### MECHANICAL

Mounting Position—Any

See Outline Drawing on page 3 for dimensions and electrical connections

### MAXIMUM RATINGS

ABSOLUTE-MAXIMUM VALUES	•	Heater Positive with Respect to	
Plate Voltage	Volts	Cathode50	Volts
Positive DC Grid Voltage0	Volts	Heater Negative with Respect to	
Negative DC Grid Voltage50	Volts	Cathode50	Volts
Plate Dissipation	Watts	Grid Circuit Resistance With Cathode Bias0.01	Megohms
DC Cathode Current30	Milliamperes	Envelope Temperature at Hottest	2.2080
Heater-Cathode Voltage		Point §	C

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron tube of a specified type as defined by its published data and should not be exceeded under the worst probable conditions.

The tube manufacturer chooses these values to provide acceptable serviceability of the tube, making no allowance for equipment variations, environmental variations, and the effects of changes in operating conditions due to variations in the characteristics of the tube under consideration and of

all other electron devices in the equipment.

The equipment manufacturer should design so that initially and throughout life no absolute-maximum value for the intended service is exceeded with any tube under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in the characteristics of the tube under consideration and of all other electron devices in the equipment.

The tubes and arrangements disclosed herein may be covered by patents of General Electric Campany or others. Neither the disclosure of any information herein nor the sale of tubes by General Electric Company conveys any licease under patent claims covering combinations of tubes with other devices or

elements. In the obsence of an express written agreement to the contrary, General Electric Campony assumes no liability for patent infringement arising out of any use of the tubes with other devices or elements by any purchaser of tubes or others.

### CHARACTERISTICS AND TYPICAL OPERATION -

### AVERAGE CHARACTERISTICS

	1 4 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		•
Plate Voltage	200 Volts	Transconductance50000	Micromhos
Grid Voltage+		Plate Current	Milliamperes
Cathode-Bias Resistor	270 Ohms	Grid Voltage, approximate	· •
Amplification Factor		Ib = 100 Microamperes	Volts
Plate Resistance, approximate	500 Ohms		

### **FOOTNOTES**

- The equipment designer should design the equipment so that heater voltage is centered at the specified bogey value, with heater supply variations restricted to maintain heater voltage within the specified tolerance.
- † Heater current of a bogey tube at Ef = 6.3 volts.
- ‡ Without external shield.
- Operation below the rated maximum envelope temperature is recommended for applications requiring the longest possible tube life.

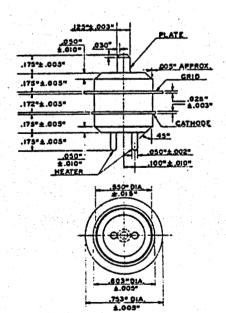
### INITIAL CHARACTERISTICS LIMITS

	Min.	Bogey	Mex.	
Heater Current				
Ef = 6.3 volts	370	400	430	Milliamperes
Plate Current				State of the
Ef = 6.3 volts, Eb = 200 volts, $Rk = 22$ ohms (bypassed)	14	22	30	Milliamperes
Fransconductance				
Ef = 6.3 volts, Eb = 200 volts, $Rk = 22$ ohms (bypassed)	40000	50000	60000	Micromhos
Amplification Factor				
Ef = 6.3 volts, Eb = 200 volts, $Rk = 22$ ohms (bypassed)	170	225	280	**
Grid Voltage Cutoff				
Ef = 6.3 volts, Eb = 200 volts, Ib = 100 μa	••••	-3.0	-5.0	Volts
Noise Figure	•			
Ef = 6.3 volts, Ebb = 280 volts, $R_L$ = 3300 ohms, $Rk$ = 22 ohms				- * . <del>-</del>
(bypassed), F = 200 MC = 10 mc	• • • • •	3.0	4.8	Decibels
nterelectrode Capacitances				
Grid to Plate: (g to p)	1.3	1.7		pf
Input: g to (h+k)	4.5 0.01	6.0 0.018	7.5 0.026	
Heater to Cathode: (h to k)	1.5	2.4	3.3	
Vegative Grid Current Ef = 6.3  volts, $Eb = 200  volts$ , $Ecc = -1.0  volts$ , $Rk = 22  ohms$				
(bypassed), Rg = 0.1 meg			0.5	Microamperes
Heater-Cathode Leakage Current				
Ef = 6.3 volts, Ehk = 100 volts				
Heater Positive with Respect to Cathode		••••	20	Microamperes
Heater Negative with Respect to Cathode	••••		20	Microamperes
nterelectrode Leakage Resistance				
Ef = 6.3 volts. Polarity of applied d-c interelectrode voltage is	*			
such that no cathode emission results.  Grid to A11 at 100 volts d-c	50			Megohms
Plate to A11 at 300 volts d-c.	50			Megohms
Grid Emission Current				· •
Ef = 7.0 volts, Eb = 200 volts, Ecc = $-15$ volts, Rg = 0.1 meg.	• • • • •		2.0	Microamperes

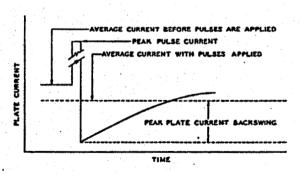
### SPECIAL PERFORMANCE TESTS

	in the first service with	Min.	Bogey	Max.	
Peak Plate Current Tubes with poor grid re grid is driven positive by parallel RC circuit were occur in tubes of any ty tions. In the majority of eliminate the few in wh under the following cor R <sub>L</sub> = 0.01 meg. Ec is adj Upon application to pps, duty factor = 0.001 noted, and the peak pl following diagram shows	Plate Current. Backswing. covery affect circuit operation when to a pulse of signal or noise, somewhat as it in series with the grid. This effect may be, but is unimportant in many applied 7768 tubes the effect is negligible, but ich it may be excessive, tubes are test additions: Ef = 6.3 volts, Ebb = 250 voltusted for Ib = 10 ma. The grid of a 3 volt positive pulse (prr = 2) the change in average plate current atte current backswing is measured. To qualitatively the plate current-time repoor grid recovery) subjected to this te	the f a ay ca- to ed ts, 60 is the		1.0 2.0	Milliamperes Milliamperes
Statistical sample in planes at 40 cps, we ated with Ef = 6.3 sepassed), R <sub>L</sub> = 2000 ce Low Pressure Voltage B. Statistical sample to		wo er- by- are		50 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	Millivolts RMS
not give visual evid	ence of flashover or corona when 300 vo lied between the plate and grid termina	lts	orini Salah Barana Barana Barana Barana Barana Barana Barana		

### **OUTLINE DRAWING**



# PLATE CURRENT VS. TIME —GRID RECOVERY TEST



### **DEGRADATION RATE TESTS**

#### Fatigue '

Statistical sample vibrated for a total of six hours, three hours in each of two planes, at a peak acceleration of 10G. Frequency is continuously varied from 30 cps to 2000 cps and back to 30 cps, with a period of ten minutes. Tubes are operated during the test with Ef = 6.3 volts, Eb = 250 volts, and Rk = 68 ohms. Following the test, tubes are evaluated for low frequency vibrational output, heater-cathode leakage, heater current, and transconductance.

#### Shock

Statistical sample subjected to 5 impact accelerations of approximately 450G in each of four positions. The accelerating forces are applied by the Navy-type, High Impact (flyweight) Shock Machine using a  $30^{\circ}$  hammer angle. Tubes are operated during the test with Ef = 6.3 volts, Eb = 250 volts, Ehk = +100 volts, and Rk = 68 ohms. Following the test, tubes are evaluated for low frequency vibrational output, heater-cathode leakage, heater current, and transconductance.

### Stability Life Test

The statistical sample subjected to the Intermittent Life - Test is evaluated for percent change in zero-bias transconductance of individual tubes, from the initial reading to readings following 2 hours and 20 hours of the life test.

### Survival Rate Life Test

The statistical sample subjected to the Intermittent Life Test is evaluated for shorted and open elements and transconductance following approximately 100 hours of life test.

#### Intermittent Life Test

Statistical sample operated for 1000 hours under the following conditions: Ef = 6.3 volts (cycled—on  $1\frac{1}{4}$  hours, off  $\frac{1}{4}$  hour), Eb = 200 volts, Ecc = +7 volts, Ehk = -70 volts d-c, Rk = 270 ohms, and Rg = 0.01 meg. Tubes are evaluated, following 500 and 1000 hours of life test, for shorted or open elements, heater current, grid current, transconductance, noise figure, heater-cathode leakage, and interelectrode leakage resistance.

#### Interface Life Test

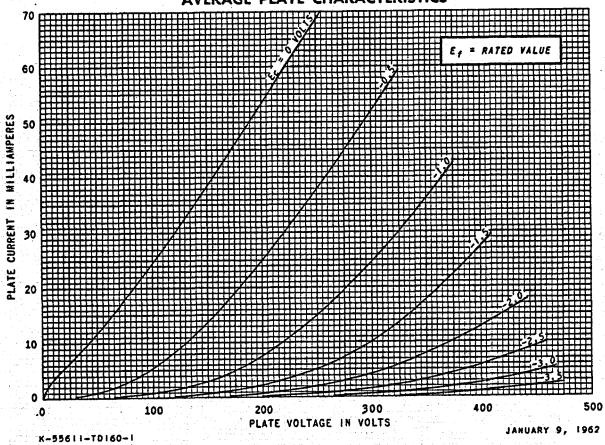
Statistical sample operated for 1000 hours with Ef = 6.6 volts, no other voltages applied, and evaluated for cathode interface resistance following the life test.

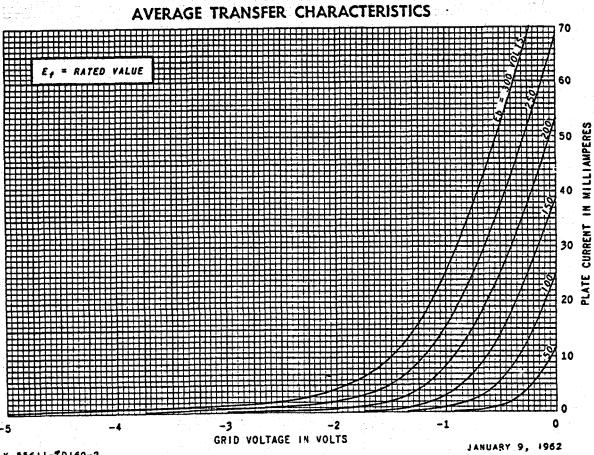
### Heater-Cycling Life Test

Statistical sample operated for 2000 cycles minimum to evaluate and control heater-cathode defects. Conditions of test include Ef = 7.5 volts cycled for one minute on and one minute off, Eb = Ec = 0 volts, and Ehk = 70 volts with heater positive with respect to cathode. Following this test, tubes are evaluated for open heaters, heater-cathode shorts, and heater-cathode leakage current.

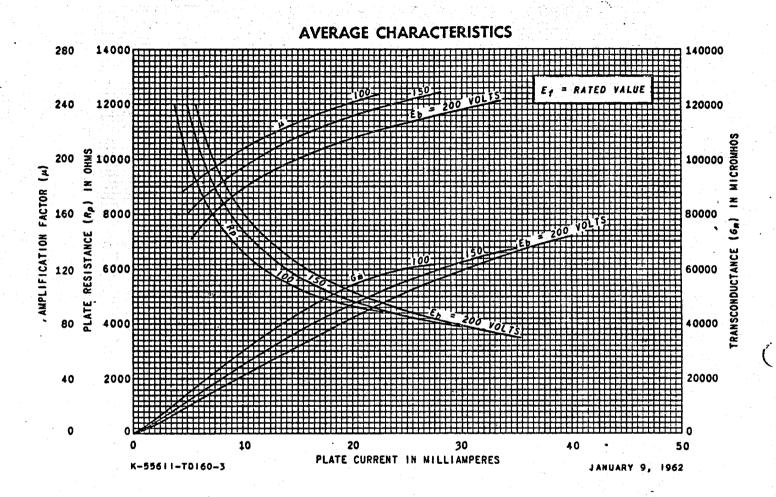
Note: The conditions for some of the indicated tests have deliberately been selected to aggravate tube failures for test and evaluation purposes. In no sense should these conditions be interpreted as suitable circuit operating conditions.







K-55611-TD160-2



### RECEIVING TUBE DEPARTMENT



Owensboro, Kentucky



TUBES

### -PRODUCT INFORMATION -

Page 1

10-66

7784

# **Planar Triode**

# FOR GROUNDED-GRID CLASS A UHF AMPLIFIER APPLICATIONS

The 7784 is a high-mu, metal-and-ceramic triode intended for operation as a grounded-grid, Class A radio-frequency amplifier at frequencies as high as 3000 megacycles.

Features of the tube include small size, planar electrode construction with close spacing, inherent rigidity, and an envelope structure convenient for coaxial circuit applications.

At 1200 megacycles a noise figure of less than 8.5 decibels may be obtained when the 7784 is used in a grounded-grid coaxial circuit.

The 7784 differs from the 6299 only in having an isolated heater.

### **GENERAL**

ELECTRICAL	MECHANICAL
Cathode - Coated Unipotential Heater Characteristics and Ratings Heater Voltage, AC or DC* 6.3±0.3 Volts	Operating Position - Any Net Weight 1/6 Ounce Cooling - Conduction
Heater Current + 0.3 Amperes Direct Interelectrode Capacitances	
Grid to Plate: (g to p) 1.75 pf Grid to Cathode and Heater:	
g to (h + k) 3.65 pf  Plate to Cathode and Heater:  p to (h + k) 0.015 pf	
	Tape to be for a consideration of the second second second
ABSOLUTE-MAXIMUM VALUES	A RATINGS

ABSOLUTE-MAXIMUM					
Plate Voltage	·	· · · ·			200 Volts
Positive DC Grid Voltage .				 	0 Volts
Negative DC Grid Voltage .				 	15 Volts
Plate Dissipation					
DC Plate Current					
DC Grid Current#					
Heater-Cathode Voltage	1000		Mary 12 to 1889		with the state of
Heater Positive with Re-					
Heater Negative with Re					
Envelope Temperature at Ho	ttest Point			 • • • • • •	150 C

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron tube of a specified type as defined by its published data and should not be exceeded under the worst probable conditions.

The tube manufacturer chooses these values to provide acceptable serviceability of the tube, making no allowance for equipment variations, environmental variations, and the effects of changes in operating conditions due to variations in the characteristics of the tube under consideration and of

all other electron devices in the equipment.

The equipment manufacturer should design so that initially and throughout life no absolute-maximum value for the intended service is exceeded with any tube under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in the characteristics of the tube under consideration and of all other electron devices in the equipment.

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express written agreement to the contrary, General Electric Company assumes no liability for patent infringement arising out of any use of the tubes with other devices or elements by any purchaser of tubes or others.



### CHARACTERISTICS AND TYPICAL OPERATION

AVERAGE CHARACTERISTICS	
Plate Voltage	75 Volts
Grid Voltager	Volts
Amplification Factor	lo
Plate Resistance, approximate	Ohms
Transconductance	00 Micromhos
Plate Current	IO Milliamperes
Tb = 10 Milliamperes, Ec = 0 Volts	25 Volts
CLASS A, RF AMPLIFIER—GROUNDED-GRID, COAXIAL-TYPE CIRCUIT	
	Nogaevelea
Frequency	
Frequency	00 Megacycles ** Volts
Frequency	** Volts
Frequency	** Volts Volts
Frequency	Volts Volts Ohms
Frequency	Volts Volts Ohms Volts
Plate Voltage	Volts Volts Ohms Volts Milliamperes

### **NOTES**

- \* The equipment designer should design the equipment so that heater voltage is centered at the specified bogey value, with heater supply variations restricted to maintain heater voltage within the specified tolerance.
- # Heater current of a bogey tube at Ef = 6.3 volts.
- § Without external shield.
- ¶ The electrical connections to the plate and cathode must provide good thermal conductivity from these electrodes. The plate contact must be sufficiently flexible to keep the lateral force on the plate terminal at a minimum.
- # The 7784 is rated only for Class A amplifier service.
- Δ Does not apply to initial-emission-velocity current
- ♠ Adjusted for Ib = 10 milliamperes.
- \*\* Adjust for Ib = 10 milliamperes; range must be variable from 75 to 200 volts.
- ## Supply should be regulated.
- §§ For operation above 1000 megacycles, the minimum noise figure will generally be obtained by operation at zero bias. For operation below 1000 megacycles, the use of a cathode resistor or grid bias should be evaluated for the particular application.
- ¶¶ Adjusted for Ib = 10 milliamperes; 200-ohm variable cathode resistor recommended.

### INITIAL CHARACTERISTICS LIMITS

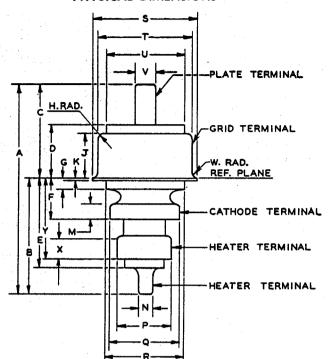
Heater Current Ef = 6.3 volts				Min. . 280	Bogey 300	Max. 320	Milliamperes
Plate Voltage Ef = 6.3 volts, Ec	= 0 volts, Eb adjusted f	or Ib = 10 ma		. 75	125	175	Volts
Transconductance Ef = 6.3 volts, Eb	= 175 volts, Ec adjusted	for Ib = 10	ma	11500	15000		Micromhos
Amplification Factor Ef = 6.3 volts, Eb	= 175 volts, Ec adjusted	for Ib = 10	ma	. 85	110	140	: 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1
Heater-Cathode Leakage Ef = 6.3 volts, Ehl	k = 50 volts		jan ya	- 1			
	with Respect to Cathode with Respect to Cathode					20 20	Microamperes Microamperes
	larity of applied d-c int						
Grid to Cathode	at no cathode emission re at 45 volts d-c : 500 volts d-c						Megohms Megohms
	to p)				1.75	2.0	Picofarads
Grid to Cathode and Plate to Cathode ar	Heater: g to (h + k).  d Heater: p to (h + k)	• • • •		. 3.0	3.65 0.015	5.0 0.025	Picofarads Picofarads
	CDECIAL E	PERFORMA	NCE 1	PECTC			
Noise Figure - 450 MC	SPECIAL P	ERFORMA	MINCE	16313	Min.	Max.	
Ef = $6.3$ volts, Ec F = $450\pm5$ MC	= 0 volts, Eb adjusted fo	or Ib = 10 ma				5.0	Decibels
-	= 0 volts, Eb adjusted fo		· · ·			8.5	Decibels
	= 0 volts, Eb adjusted for idth = 9 MC, min			• , • •	. 15		Decibels
Power Gain - 1200 MC	= 0 volts, Eb adjusted for						

1000-Hour Life

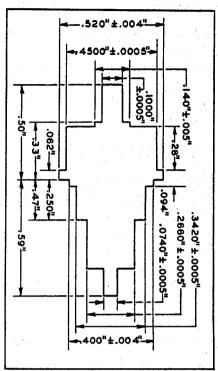
**4**.

Statistical sample operated for 1000 hours to evaluate changes in transconductance and noise figure with life.

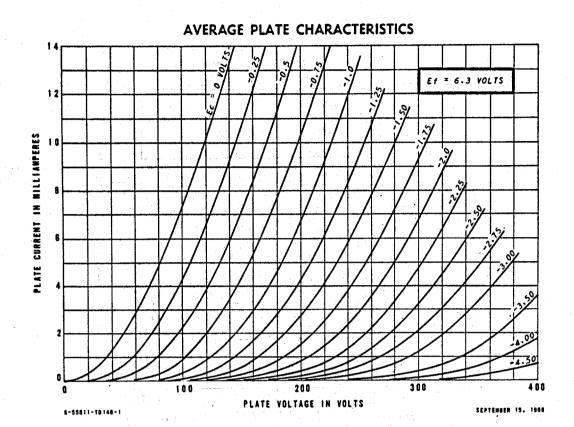
### PHYSICAL DIMENSIONS

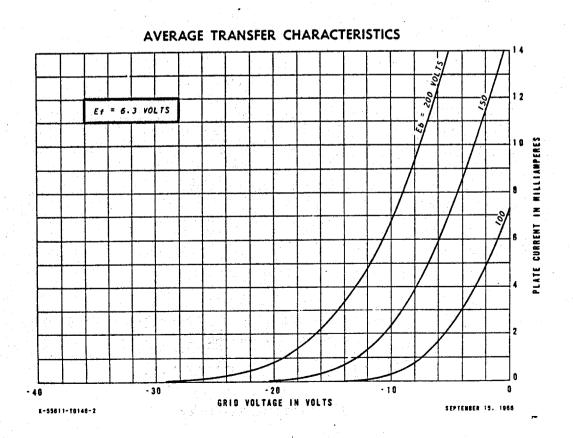


### ALIGNMENT GAUGE

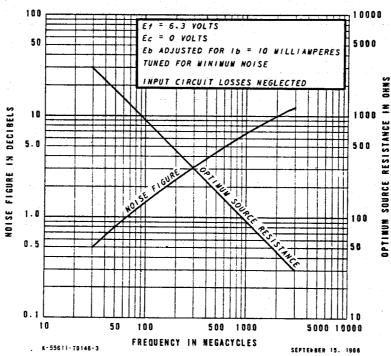


Ref.	INCH	INCHES		METERS
Kei.	Minimum	Maximum	Minimum	Maximum
Α .	0.960	1.040	24.38	26.42
В	0.530	0.590	13.46	14.99
C	0.410	0.470	10.41	11.94
D		0.272		6.91
E		0.475		12.07
F	0.163	0.193	4.14	4.90
G		0.060		1.52
H		0.030		0.76
J	0.190	0.210	4.83	5.33
K	0.009	0.015	0.23	0.38
M	0.040	0.070	1.02	1.78
N	0.059	0.065	1.50	1.65
P	0.247	0.257	6.27	6.53
Q	0.326	0.334	8.28	8.48
R		0.385		9.78
S	0.483	0.497	12.27	12.62
T	0.435	0.445	11.05	11.30
Ü		0.385		9.78
V	0.088	0.094	2.24	2.39
W		0.008		0.20
X	0.070	0.100	1.78	2.54
Y	0.355	0.395	9.02	10.05





### PREDICATED NOISE PERFORMANCE



TUBE DEPARTMENT



Owensboro, Kentucky

## 7841 CEDAMIC DIG

Page 1

METAL-CERAMIC DIODE

### DESCRIPTION AND RATING=

The 7841 is a cathode-type diode of ceramic-and-metal planar construction intended for detector and low-current rectifier applications.



### GENERAL

### **ELECTRICAL**

Cathode—Coated Unipotential
Heater Characteristics and Ratings
Heater Voltage, AC or DC\*...6.3 ±0.3 Volts
Heater Current†......0.215 Amperes
Direct Interelectrode Capacitances§
Plate to Cathode: (p to k).....1.1 pf
Heater to Cathode: (h to k).....1.2 pf

#### MECHANICAL

Mounting Position—Any
See outline drawing on page 2 for dimensions and electrical
connections.

### MAXIMUM RATINGS

#### **ABSOLUTE MAXIMUM VALUES**

Peak Inverse Plate Voltage 350 Volts Cathode 50	Volts
Steady-State Peak Plate Current 22 Milliamperes Heater Negative with Respect to	
DC Output Current	Volts
Heater-Cathode Voltage Envelope Temperature at Hottest	
Heater Positive with Respect to Point**250	C

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron tube of a specified type as defined by its published data and should not be exceeded under the worst probable conditions.

The tube manufacturer chooses these values to provide acceptable serviceability of the tube, making no allowance for equipment variations, environmental variations, and the effects of changes in operating conditions due to variations in the characteristics of the tube under consideration and of

all other electron devices in the equipment.

The equipment manufacturer should design so that initially and throughout life no absolute-maximum value for the intended service is exceeded with any tube under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in the characteristics of the tube under consideration and of all other electron devices in the equipment.

#### AVERAGE CHARACTERISTICS

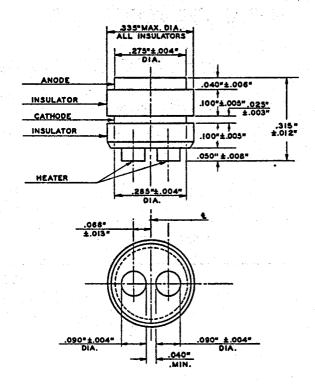
### **FOOTNOTES**

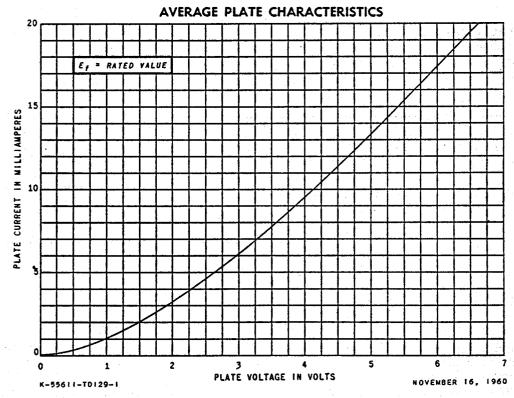
- \* The equipment designer should design the equipment so that the heater voltage is centered at the specified bogey value, with heater supply variations restricted to maintain heater voltage within the specified tolerance.
- † Heater current of a bogey tube at Ef = 6.3 volts.
- § Measured using a grounded adapter that provides shielding between external terminals of tube.
- \*\*For applications where long life is a primary consideration, it is recommended that the envelope temperature be maintained below 175 C.

The tubes and arrangements disclosed herein may be covered by patents of General Electric Company or others. Neither the disclosure of any information herein nor the sale of tubes by General Electric Company conveys any license under patent claims covering combinations of tubes with other devices or

elements. In the absence of an express written agreement to the contrary, General Electric Company assumes no liability for patent infringement arising out of any use of the tubes with other devices or elements by any purchaser of tubes or others.







RECEIVING TUBE DEPARTMENT



Owensboro, Kentucky

### -PRODUCT INFORMATION-

MICROWAVE DEVICES

# **Planar Triode**

7910

The 7910 is a triode of ceramic-and-metal planar construction primarily intended for use as a plate-pulsed oscillator or amplifier at frequencies up to 7500 megahertz.

### CHARACTERISTICS AND TYPICAL OPERATION

AVERAGE CHARACTERISTICS			Fri Sprit		Test (	conditions	
	2 May 1 6 1			Ef	Eb	lb Eg	Rk
<u>Minimum</u>	Bogey	Maximum	<u>Units</u>	<u>v</u>	<u>v</u>	Ma V	Ohms
Heater Voltage, AC or DC * 6.0	6.3	6.6	Volts	100			
Heater Current	290	312	Milliamperes	6.3			
Plate Current 7	12	18	Milliamperes	6.3	125 -		82
Amplification Factor 50	75	100	. •	6.3	125 -		82
Transconductance	16000	20000	Micromhos	6.3	125 -		82
Grid Voltage, Cutoff	-3.5	-6	Volts	6.3	125	0.1	
Direct Interelectrode Capacitances							
Grid to Plate: (g to p) 0.85	1.05	1.25	pf	4.0	1. 1		
Input: g to (h+k) 1.5	2.1	2.7	pf				
Output: p to (h+k)	0.018	0.026	pf		· 4111	•	
Cathode Heating Time			Seconds		6 pr 5 m		•.

### PLATE-PULSED OSCILLATOR SERVICE

Frequency	 5900	Megahertz
Duty Factor	 0.001	
Pulse Duration		Microseconds Pulses Per
		Second
Peak Positive - Pulse Supply Voltage		Volts
Plate Current: Average During Pulse		
Grid Current: Average During Pulse  Power Output: Average During Pulse		Amperes Watts

### NOTES

- \* The equipment designer should design the equipment so that heater voltage is centered at the specified bogey value, with heater supply variations restricted to maintain heater voltage within the specified tolerance. In some applications, longer tube life may be obtained at reduced heater voltage. For specific recommendations, contact your General Electric sales representative.
- Measured at 450 KHz using a grounded adapter that provides shielding between external terminals of tube.

### ABSOLUTE-MAXIMUM RATINGS

### PLATE-PULSED OSCILLATOR SERVICE

Peak Positive-Pulse Plate Supply Voltage		
1 Microsecond Pulse Duration		Volts
4 Microsecond Pulse Duration	 .800	Volts
Duty Factor of Plate Pulse	 0.001	
Plate Current: Average During Pulse#	 . 0.6	Amperes
Negative Grid Voltage: Average During Pulse	 50	Volts
Grid Current: Average During Pulse	 . 0.2	Amperes
Plate Dissipation	 . 1.5	Watts
Peak Heater-Cathode Voltage		
Heater Positive with Respect to Cathode	 50	Volts
Heater Negative with Respect to Cathode	 50	Volts
Envelope Temperature at Hottest Point A	 . 250	<b>℃</b>
Temperature Differential Between Two Adjacent Electrodes ♦		•C
Mechanical Vibration (20-2000 Hz Sinusoidal)		G Peak

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data and should not be exceeded under the worst probable conditions

The device manufacturer chooses these values to provide acceptable serviceability of the device, making no allowance for equipment variations, environmental variations, and the effects of changes in operating conditions due to variations in the characteristics of the device under consideration and

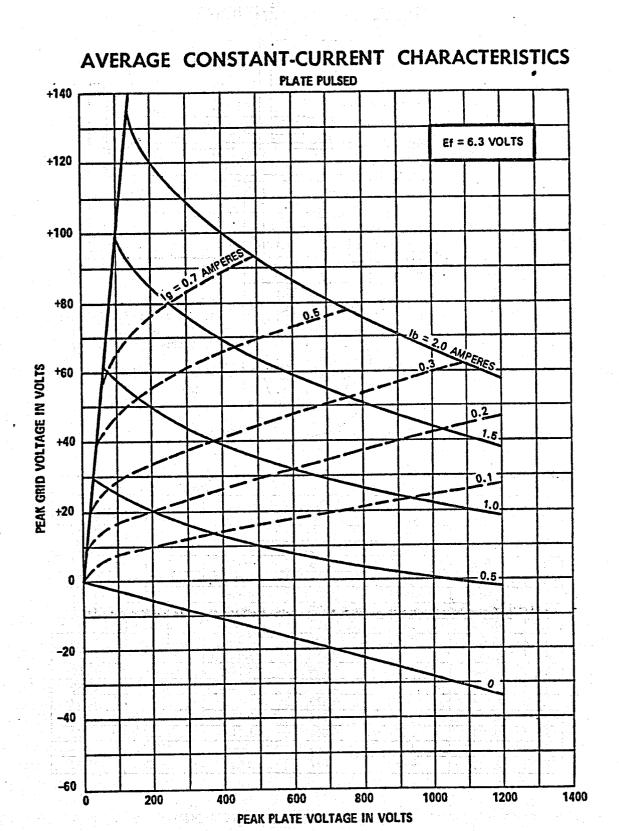
of all other electron devices in the equipment.

The equipment manufacturer should design so that initially and throughout life no absolute-maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in the characteristics of the device under consideration and of all other electron devices in the equipment.

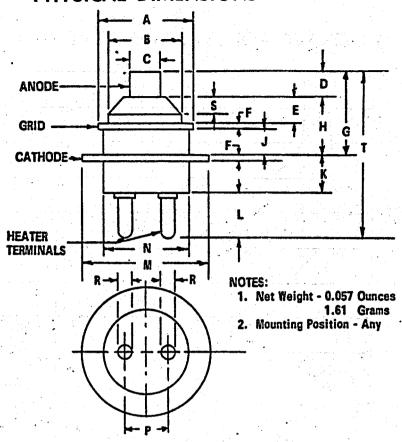
### NOTES

- # The regulation and/or series plate supply impedance must be such as to limit the peak current, with the tube considered a short circuit, to a maximum of 10 times the maximum plate current rating.
- A For specific recommendations concerning higher temperature operation, contact your General Electric sales representative.
- ♦ This assumes no thermal heat sinking to any insulator.

The devices and arrangements disclosed herein may be covered by patents of General Electric Company or others. Neither the disclosure of any information herein nonthe sale of devices by General Electric Company conveys any license under patent claims covering combinations of these devices with other devices or elements. In the absence of an express written agreement to the contrary, General Electric Company assumes no liability for patent infringement arising out of any use of these devices with other devices or elements by any purchaser or others.



## PHYSICAL DIMENSIONS



D-4		INCHES		M	ILLIMETERS	
Ref.	Min.	Nom.	Max.	Min.	Nom.	Max.
Α	0.357	0.360	0.363	9.068	9.144	9.220
В			0.285			7.239
C	0.108	0.110	0.112	2.743	2.794	2.845
D	0.095	0.100	0.105	2.413	2.540	2.667
E	0.095	0.100	0.105	2.413	2.540	2.667
F	0.025	0.028	0.031	0.635	0.711	0.787
G	0.315	0.325	0.335	8.001	8.225	8.509
H	0.216	0.224	0.232	5.486	5.690	5.893
J	0.094	0.098	0.102	2.388	2.489	2.591
K	0.143	0.150	0.157	3.632	3.810	3.988
L	0.165	0.175	0.185	4.191	4.445	4.699
M	0.476	0.480	0.484	12.09	12.19	12.29
N			0.330			8.458
P.	0.130	0.136	0.142	3.302	3.454	3.607
R	0.048	0.051	0.054	1.219	1.295	1.372
S		0.060			1.524	
T	0.623	0.650	0.677	15.82	16.51	17.20

TUBE PRODUCTS DEPARTMENT



Owensboro, Kentucky 42301

## 8082

### METAL-CERAMIC TRIODE





### DESCRIPTION AND RATING

The 8082 is a high-mu triode of ceramic-and-metal planar construction primarily intended for use as an oscillator in the ultra-high-frequency range.

### GENERAL

#### ELECTRICAL

Cathode—Coated Unipotential	
Heater Characteristics and Ratings	
Heater Voltage, AC or DC $\uparrow$ 6.3 = 0.3	Volts
Heater Current	Amperes
Direct Interelectrode Capacitances	
Grid to Plate: (g to p)1.3	pf
Input: g to $(h+k)$	pf
Output: p to (h+k)0.032	pf
Heater to Cathode: (h to k)1.5	pf

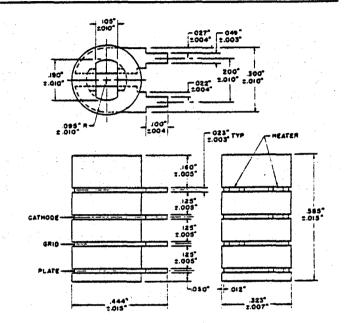
### MECHANICAL

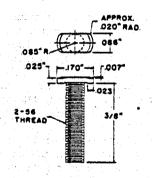
Mounting Position-Any¶

### MAXIMUM RATINGS

### ABSOLUTE-MAXIMUM VALUES

74 - 4 - 52 - 14 050	Volts	
Plate Voltage250		
Positive DC Grid Voltage0	Volts	
Negative DC Grid Voltage 50	Volts	
Peak Negative Grid Voltage50	Volts	
Plate Dissipation	Watt	
DC Grid Current	Milliamperes	
DC Cathode Current	Milliamperes	
Peak Cathode Current	Milliamperes	
Heater-Cathode Voltage		
Heater Positive with Respect to		
Cathode50	Volts	
Heater Negative with Respect to		
Cathode50	Volts	
Grid-Circuit Resistance	Ohms	
Envelope Temperature at Hottest		
Point =	С	





Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron tube of a specified type as defined by its published data and should not be exceeded under the worst probable condi-

The tube manufacturer chooses these values to provide acceptable serviceability of the tube, making no allowance for equipment variations, environmental variations, and the effects of changes in operating conditions due to variations in the characteristics of the tube under consideration and of all other electron devices in the equipment.

The equipment manufacturer should design so that initiglly and throughout life no absolute-maximum value for the intended service is exceeded with any tube under the worst probable operating conditions with respect to supplyvoltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in the characteristics of the tube under consideration and of all other electron devices in the equipment.

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elements. In the absence of an express written agreement to the contrary, General Electric Company assumes no liability for patent infringement arising out of any use of the tubes with other devices or elements by any purchaser of



### CHARACTERISTICS AND TYPICAL OPERATION

#### **AVERAGE CHARACTERISTICS** UHF OSCILLATOR SERVICE 100 150 Volts Volts Plate Voltage..... Ohms Grid Voltage Volts Grid Resistor 7000 0 Cathode-Bias Resistor 82 Ohms Plate Current 4.0 Milliamperes Amplification Factor 90 Frequency 450 Megacycles Micromhos Grid Current 0.5 Milliamperes Transconductance........ 11500 10500 Plate Current Milliamperes Power Output, 9.0 7.5

#### **FOOTNOTES**

- † The equipment designer should design the equipment so that heater voltage is centered at the specified bogey value, with heater supply variations restricted to maintain heater voltage within the specified tolerance.
- I Heater current of a bogey tube at Ef = 6.3 volts.
- Without external shield.
- One method of mounting the 8082 is to use a stainless-steel "T" bolt (see drawing) to attach the mounting base of the tube to a chassis or circuit board. The "T" bolt should be
- inserted in the slot in the base of the tube, turned 90 degrees, and attached to the chassis or circuit board with a 2-56 nut and lock washer. Torque used to tighten the nut should not exceed 3 inch-pounds.
- FOP Operation below the rated maximum envelope temperature is recommended for applications requiring the longest possible tube life. The 8082 is also capable of operation at envelope temperatures much higher than the rated maximum value. For specific recommendations concerning higher temperature operation, contact your General Electric tube sales representative.

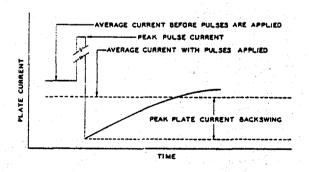
### SPECIAL PERFORMANCE TESTS

	Min.	Bogey	Max.	
Grid Recovery				1986
Change in Average Plate Current			0.6	Milliamperes
Peak Plate Current Backswing			1.0	Milliamperes

Tubes with poor grid recovery affect circuit operation when the grid is driven positive by a pulse of signal or noise, somewhat as if a parallel RC circuit were in series with the grid. This effect may occur in tubes of any type, but is unimportant in many applications. In the majority of 8082 tubes the effect is negligible, but to eliminate the few in which it may be excessive, tubes are tested under the following conditions: Ef = 6.3 volts, Ebb = 250 volts,  $R_L = 0.01 \text{ meg}$ , Ec adjusted for Ib = 3.0 ma.

Upon application to the grid of a 5-volt positive pulse (prr = 60 pps, duty factor = 0.0012) the change in average plate current is noted, and the peak plate current backswing is measured. The following diagram shows qualitatively the plate current-time relationship for a tube (with poor grid recovery) subjected to this test.

# PLATE CURRENT VS. TIME —GRID-RECOVERY TEST



	Min.	Bogey	Max.	
Pulse Cathode Current				
Ef = 6.3 volts, Eb = 150 volts, Ec = $-10$ volts. Grid is driven 7 volts				Company Street
positive with a pulse having a prr of 1000 pps and a duty factor of $0.01$ .	90		M	lilliamperes

### Low Pressure Voltage Breakdown Test

Statistical sample tested for voltage breakdown at a pressure of 8mm Hg, to simulate an altitude of 100,000 feet. Tubes shall not give visual evidence of flashover or corona when 300 volts RMS, 60 cps, is applied between the plate and grid terminals.

### **DEGRADATION RATE TESTS**

#### Fatigue

Statistical sample vibrated for a total of six hours, three hours in each of two planes, at a peak acceleration of 10G. Frequency is continuously varied from 30 cps to 2000 cps and back to 30 cps, with a period of ten minutes. Tubes are mounted by T-bolt with 3 inch-pounds torque, and operated during the test with Ef = 6.3 volts, Ef = 150 volts, and Rk = 82 ohms. Following the test, tubes are evaluated for low frequency vibrational output, heater-cathode leakage, and heater current.

#### Shock

Statistical sample subjected to 5 impact accelerations of approximately 450G in each of four positions. The accelerating forces are applied by the Navy-type, High Impact (flyweight) Shock Machine using a  $30^{\circ}$  hammer angle. Tubes are operated during the test with Ef = 6.3 volts, Eb = 150 volts, Ehk = +100 volts, and Rk = 82 ohms. Following the test, tubes are evaluated for low frequency vibrational output, heater-cathode leakage, and heater current.

### Stability Life Test

The statistical sample subjected to the Dynamic Life Test is evaluated for percent change in zero-bias transconductance of individual tubes, from the initial reading to readings following 2 hours and 20 hours of the life test.

### Survival Rate Life Test

The combined statistical samples subjected to the Dynamic and Pulse Life Tests are evaluated for shorted and open elements following approximately 100 hours of life test.

### Dynamic Life Test

Statistical sample operated, with a 60 cps grid signal, at maximum rated DC grid current and cathode current for a period of 1000 hours. Heater voltage is cycled (on 134 hours, off 14 hour). Tubes are evaluated, following 500 and 1000 hours of life test, for shorted or open elements, heater current, zero-bias transconductance, heater-cathode leakage, and interelectrode leakage resistance.

### Pulse Life Test

Statistical sample operated with 120 ma peak cathode current, 0.01 duty factor, for 1000 hours. Heater voltage is cycled (on 134 hours, off 14 hour). Tubes are evaluated, following 500 and 1000 hours of life test, for shorted or open elements, heater current, pulse emission, heater-cathode leakage, and interelectrode leakage resistance.

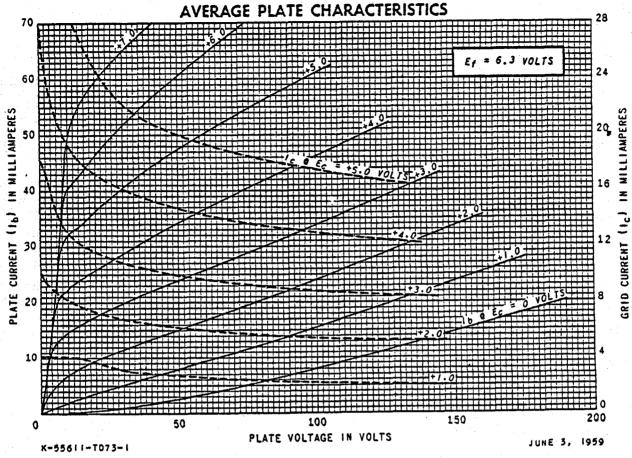
#### Interface Life Test

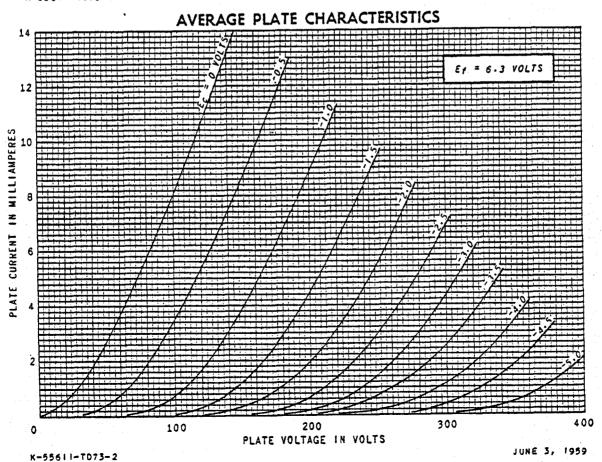
Statistical sample operated for 1000 hours with Ef = 6.6 volts, no other voltages applied, and evaluated for cathode interface resistance following the life test.

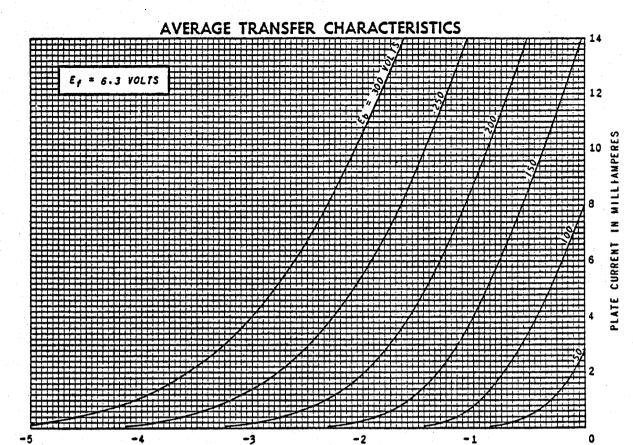
#### Heater-Cycling Life Test

Statistical sample operated for 2000 cycles minimum to evaluate and control heater-cathode defects. Conditions of test include Ef = 7.0 volts cycled for one minute on and one minute off, Eb = Ec = 0 volts, and Ehk = 70 volts with heater positive with respect to cathode. Following this test tubes are evaluated for open heaters, heater-cathode shorts, and heater-cathode leakage current.

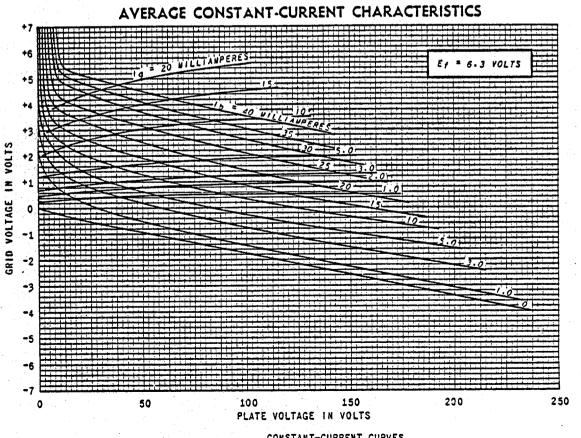
Note: The conditions for some of the indicated tests have deliberately been selected to aggravate tube failures for test and evaluation purposes. In no sense should these conditions be interpreted as suitable circuit operating conditions.







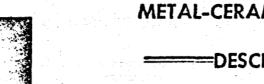
GRID VOLTAGE IN VOLTS



JUNE 3, 1959

K-55611-T073-3

### METAL-CERAMIC TRIODE



DESCRIPTION AND RATING

The 8083 is a high-mu triode of ceramic-and-metal planar construction primarily intended for radio-frequency amplifier service from low frequencies into the ultra-high frequency range.

### **GENERAL**

### ELECTRICAL

Cathode—Coated Unipotential	
Heater Characteristics and Ratings	
Heater Voltage, AC or DC† 6.3 = 0.3	Volts
Heater Current:0.24	Amperes
Direct Interelectrode Capacitances	
Grid to Plate: (g to p)1.2	pf
Input: g to $(h+k)$	
Output: p to (h+k)0.032	pf
Heater to Cathode: (h to k)1.5	

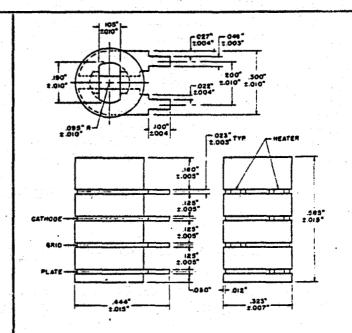
### MECHANICAL

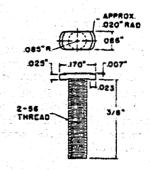
Mounting Position-Any ¶

### **MAXIMUM RATINGS**

### ABSOLUTE-MAXIMUM VALUES

Plate Voltage	Volts
Peak Plate Voltage400	
Positive Peak and DC Grid-to-Cathode	
Voltage0	Volts
Negative Peak and DC Grid-to-Cathode	
Voltage	Volts
Plate Dissipation	Watts
DC Cathode Current	Milliamperes
Heater-Cathode Voltage	talle, beet gas
Heater Positive with Respect to	
Cathode50	Volts
Heater Negative with Respect to	
Cathode50	Volts
Grid-Circuit Resistance, with Fixed	
Bias △	Megohms
Envelope Temperature at Hottest	Barrera
Brint# 250	_





Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron tube of a specified type as defined by its published data and should not be exceeded under the worst probable conditions.

The tube manufacturer chooses these values to provide acceptable serviceability of the tube, making no allowance for equipment variations, environmental variations, and the effects of changes in operating conditions due to variations in the characteristics of the tube under consideration and of all other electron devices in the equipment.

The equipment manufacturer should design so that initially and throughout life no absolute-maximum value for the intended service is exceeded with any tube under the worst probable operating conditions with respect to supplyvoltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in the characteristics of the tube under consideration and of all other electron devices in the equipment.

### CHARACTERISTICS AND TYPICAL OPERATION

#### **AVERAGE CHARACTERISTICS**

Plate Voltage	Volts	Plate Resistance, approximate9000	
Grid Voltage+6.0	Volts	Transconductance 10500 Plate Current 7.2	
Cathode-Bias Resistor910	Ohms	Grid Voltage, approximate	
Amplification Factor94		Ib = 100 Microamperes2.2	Volts

### **FOOTNOTES**

- † The equipment designer should design the equipment so that heater voltage is centered at the specified bogey value, with heater supply variations restricted to maintain heater voltage within the specified tolerance.
- ! Heater current of a bogey tube at Ef = 6.3 volts.
- § Without external shield.
- ¶ One method of mounting the 8083 is to use a stainless-steel "T" bolt (see drawing) to attach the mounting base of the tube to a chassis or circuit board. The "T" bolt should be inserted in the slot in the base of the tube, turned 90 degrees, and attached to the chassis or circuit board with a 2-56 nut and lock washer. Torque used to tighten the nut

should not exceed 3 inch-pounds.

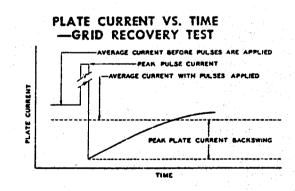
- △If resistance is used in the cathode or plate circuits, the grid-circuit resistance may be as high as (10000+100 RK+10RL) ohms, where RK is the cathode-bias resistance in ohms, and RL is the DC plate load resistance in ohms.
- # Operation below the rated maximum envelope temperature is recommended for applications requiring the longest possible tube life. The 8083 is also capable of operation at envelope temperatures much higher than the rated maximum value. For specific recommendations concerning higher temperature operation, contact your General Electric tube sales representative.

### SPECIAL PERFORMANCE TESTS

and the control of t	MAIIII	O1111
vise Figure	Agree.	
Ef = 6.3 volts, Ebb = 250 volts, $Rk = 82$ ohms, $R_L = 18000$ ohms, $F = 200$ mc	5.5	Decibels
Grid Recovery		
Change in Average Plate Current	0.6	Milliamperes
Peak Plate Current Backswing	1.0	Milliamperes

Tubes with poor grid recovery affect circuit operation, when the grid is driven positive by a pulse of signal or noise, somewhat as if a parallel RC circuit were in series with the grid. This effect may occur in tubes of any type, but is unimportant in many applications. In the majority of 8083 tubes the effect is negligible, but to eliminate the few in which it may be excessive, tubes are tested under the following conditions: Ef = 6.3 volts, Ebb = 250 volts,  $R_L = 0.01$  meg, Ec adjusted for Ib = 3.0 ma.

Upon application to the grid of a 5 volt positive pulse (prr = 60 pps, duty factor = 0.0012) the change in average plate current is noted, and the peak plate current backswing is measured. The following diagram shows qualitatively the plate current-time relationship for a tube (with poor grid recovery) subjected to this test.



### SPECIAL PERFORMANCE TESTS (Continued)

### Low Pressure Voltage Breakdown Test

Statistical sample tested for voltage breakdown at a pressure of 8mm Hg, to simulated an altitude of 100,000 feet. Tubes shall not give visual evidence of flashover or corona when 300 volts RMS, 60 cps, is applied between the plate and grid terminals.

### **DEGRADATION RATE TESTS**

### Fatigue

Statistical sample vibrated for a total of six hours, three hours in each of two planes, at a peak acceleration of 10G. Frequency is continuously varied from 30 cps to 2000 cps and back to 30 cps, with a period of ten minutes. Tubes are operated during the test with Ef = 6.3 volts, Eb = 150 volts, and Rk = 82 ohms. Following the test, tubes are evaluated for low frequency vibrational output, heater-cathode leakage, heater current, and transconductance.

#### Shock

Statistical sample subjected to 5 impact accelerations of approximately 450G in each of four positions. The accelerating forces are applied by the Navy-type, High Impact (flyweight) Shock Machine using a 30° hammer angle. Tubes are mounted by T-bolt with 3 inch-pounds torque, and operated during the test with Ef = 6.3 volts, Eb = 150 volts, Ehk = +100 volts, Rg = 0.1 Meg, and Rk = 82 ohms. Following the test, tubes are evaluated for low frequency vibrational output, heater-cathode leakage, heater current, and transconductance.

### Stability Life Test

The statistical sample subjected to the Intermittent Life Test is evaluated for percent change in transconductance of individual tubes, from the initial reading to readings following 2 hours and 20 hours of the life test.

#### Survival Rate Life Test

The statistical sample subjected to the Intermittent Life Test is evaluated for shorted and open elements and transconductance following approximately 100 hours of life test.

### Intermittent Life Test

Statistical sample operated for 1000 hours under the following conditions: Ef = 6.3 volts (cycled—on  $1\frac{3}{4}$  hours, off  $\frac{1}{4}$  hour), Eb = 150 volts, Ecc = +6.0 volts, Ehk = -70 volts d-c. Rk = 910 ohms, and Rg = 0.1 meg. Tubes are evaluated, following 500 and 1000 hours of life test, for shorted and open elements, heater current, transconductance, heater-cathode leakage, and interelectrode leakage resistance.

### Interface Life Test

Statistical sample operated for 1000 hours with Ef = 6.6 volts, no other voltages applied, and evaluated for cathode interface resistance following the life test.

### Heater-Cycling Life Test

Statistical sample operated for 2000 cycles minimum to evaluate and control heater-cathode defects. Conditions of test include Ef = 7.0 volts cycled for one minute on and one minute off, Eb = Ec = 0 volts, and Ehk = 70 volts with heater positive with respect to cathode. Following this test, tubes are evaluated for open heaters, heater-cathode shorts, and heater-cathode leakage current.

Note: The conditions for some of the indicated tests have deliberately been selected to aggravate tube failures for test and evaluation purposes. In no sense should these conditions be interpreted as suitable circuit operating conditions.

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### **AVERAGE PLATE CHARACTERISTICS**

