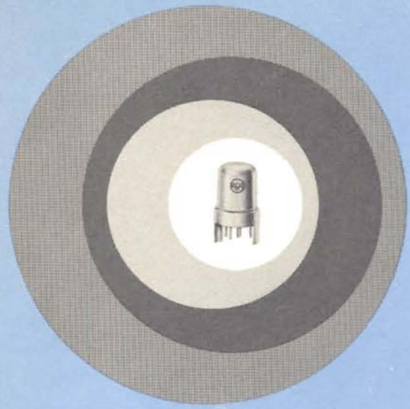


2CW4
6CW4
13CW4

RCA nuvistor

HIGH-MU TRIODES

FOR TV AND FM TUNER DESIGNS

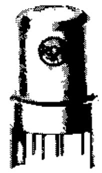
RADIO CORPORATION OF AMERICA
ELECTRON TUBE DIVISION HARRISON, N. J.

PRINTED IN U.S.A.

RCA-2CW4, 6CW4, 13CW4

High-Mu Nuvistor Triodes

RCA-2CW4, 6CW4, and 13CW4 are high-mu triodes of the nuvistor type, intended for use as grounded-cathode, neutralized rf-amplifier tubes. The 2CW4 and 6CW4 are particularly useful in vhf tuners of television and FM receivers. The 13CW4 is designed especially for use in antennaplex and antenna-system booster amplifiers. In these applications the tubes provide exceptional performance in fringe areas and other locations where signal levels are extremely weak. These nuvistor triodes feature excellent signal power gain and a noise factor significantly better than tubes currently in use in such applications.



The high-gain and low-noise capabilities of these tubes are achieved by very high transconductance and excellent transconductance-to-plate-current ratio (12500 micromhos at a plate current of 7.2 milliamperes and a plate voltage of 70 volts).

The 2CW4, 6CW4, and 13CW4 nuvistor triodes, because of their unique design, offer these additional advantages: extreme reliability; exceptional uniformity of characteristics from tube to tube; very small size; and low heater-power and plate-power requirements. All metal-and-ceramic construction insures ruggedness and long-term stability.

These nuvistors utilize the RCA Dark Heater to insure long life and dependable performance. The heater of the 2CW4 has controlled warm-up time for use in series heater-string arrangements.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:	*2CW4*	*6CW4*	*13CW4*	
Voltage (ac or dc)	2.1	6.3 ±10%	13.5 ±10%	volts
Current	0.45 ±6%	0.135	0.060	amp
Warm-up Time (Average)	8	-	-	seconds

Direct Interelectrode Capacitances (Approx.):		
Grid to plate	0.92	pf
Grid to cathode, shell, and heater	4.3	pf
Plate to cathode, shell, and heater	1.8	pf
Plate to cathode	0.18	pf
Heater to cathode	1.6	pf

Characteristics, Class A_1 Amplifier:

Plate Supply Voltage	110	volts
Grid Supply Voltage	0	volts
Cathode Resistor	130	ohms
Amplification Factor	65	
Plate Resistance (Approx.)	6600	ohms
Transconductance	9800	µmhos
Plate Current	7	ma
Grid Voltage (Approx.) for plate current = 10 µa	-4	volts

Mechanical:

Operating Position	Any
Maximum Over-all Length	0.8"
Maximum Seated Height	0.625"
Maximum Diameter	0.440"
Envelope	Metal Shell
Base	Medium Ceramic-Wafer Twelvar 5-Pin (JEDEC No.E5-65)

Maximum Ratings, *Design-Maximum Values:*

PLATE SUPPLY VOLTAGE	300●	max.	volts
PLATE VOLTAGE	135	max.	volts
GRID VOLTAGE:			
Negative-bias value	55	max.	volts
Peak positive value	0	max.	volts
PLATE DISSIPATION:			
With a minimum series plate-circuit resistance of 5000 ohms	1.5	max.	watts
For lower values of series plate-circuit resistance	See *Fig.1 and Operating Considerations*		
CATHODE CURRENT	15	max.	ma
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	100	max.	volts
Heater positive with respect to cathode	100	max.	volts

Typical Operation:

Plate Voltage	70	volts
Grid Supply Voltage	0	volts
Grid Resistor	47000	ohms
Amplification Factor	68	
Plate Resistance (Approx.)	5440	ohms
Transconductance	12500	μmhos
Plate Current	7.2	ma

Maximum Circuit Values:

Grid-Circuit Resistance:★			
For fixed-bias operation	0.5	max.	megohm
For cathode-bias operation	2.2	max.	megohms

● A plate supply voltage of 300 volts may be used provided sufficient plate-circuit resistance and agc voltage are used to limit the voltage at the plate of the tube to 135 volts under conditions of maximum rated plate dissipation (1.5 watts).

★ For operation at metal-shell temperatures up to 135° C.

OPERATING CONSIDERATIONS

The *base pins* of the 2CW4, 6CW4, and 13CW4 fit the Cinch Manufacturing Co. socket No.133 65 10 001 and the Industrial Electronic Hardware Co. socket Nos.Nu 5044 and Nu 5060, or their equivalents.

In some previous publications reference has been made to a JEDEC No.E5-65 socket. This number is not a socket designation but is a base designation which defines the JEDEC Medium Ceramic-Wafer Twelvar 5-pin base used in nuvistor tubes.

Use of Plate-Dissipation Rating Chart

The *Plate-Dissipation Rating Chart* shown in Fig.1 presents graphically the maximum rated plate dissipation of the 2CW4, 6CW4, and 13CW4 for various minimum values of series plate-circuit resistance. The region of permissible operation is bounded by the lines representing plate dissipation = 1.5 watts, plate voltage = 135 volts, and plate current = 15 milliamperes. In class A1 amplifier service, because no grid current flows, the plate current rating is equivalent to the cathode current rating.

To determine the required minimum series plate-circuit resistance for a given set of operating conditions:

1. From Fig.2, Average Plate Characteristics, select the desired operating conditions.

2. From Fig.1 determine the corresponding maximum plate dissipation and required minimum value of series plate-circuit resistance.

Example: (a) From Fig.2 — for a plate voltage of 130 volts and a grid voltage of -1 volt, the corresponding plate current is 10.5 milliamperes.
(b) From Fig.1 — the plate dissipation for a plate voltage of 130 volts and a plate current of 10.5 milliamperes is approximately 1.37 watts. The required minimum series plate-circuit resistance for this plate dissipation is 3700 ohms.

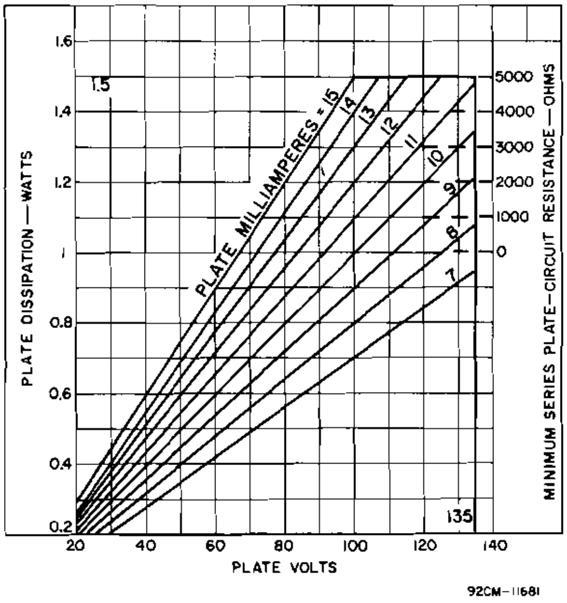


Fig.1 - Plate-Dissipation Rating Chart for Types 2CW4, 6CW4, and 13CW4.

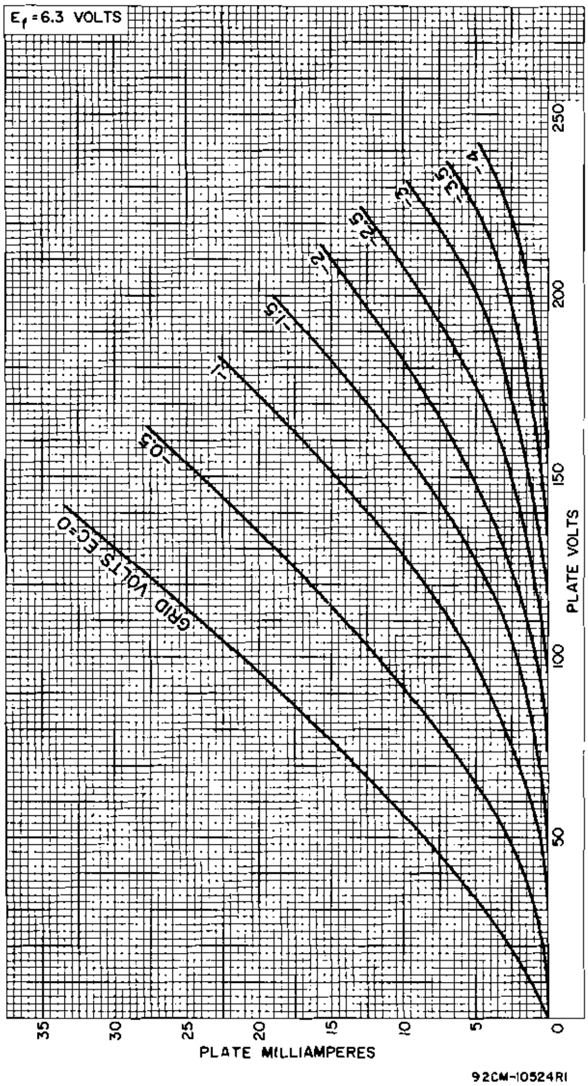


Fig.2 - Average Plate Characteristics for Type 6CW4 and for Types 2CW4 and 13CW4 Except for Heater Voltage.

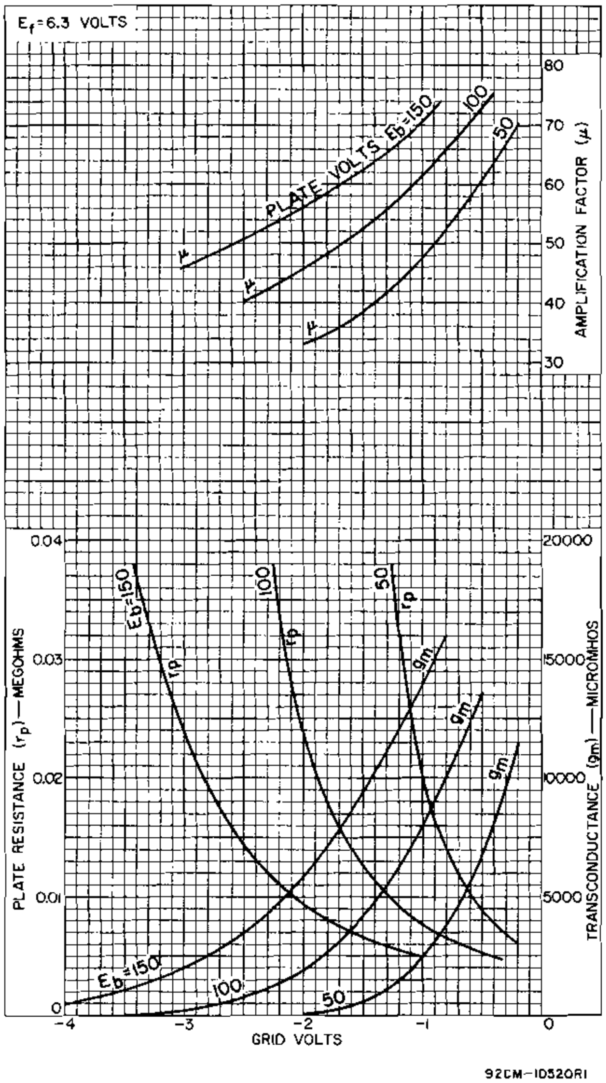
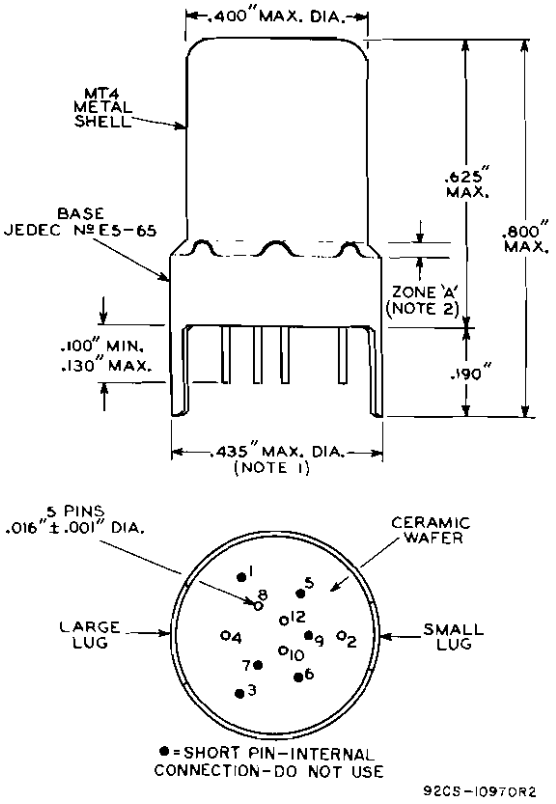


Fig.3 - Average Characteristics for Type 6CW4 and for Types 2CW4 and 13CW4 Except for Heater Voltage.

DIMENSIONAL OUTLINE

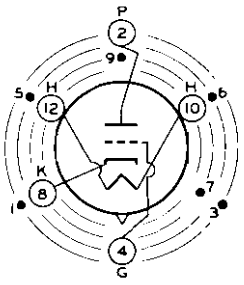


NOTE 1: MAXIMUM O.D. OF 0.440" IS PERMITTED ALONG 0.190" LUG LENGTH.

NOTE 2: SHELL TEMPERATURE SHOULD BE MEASURED IN ZONE 'A'.

BASING DIAGRAM
(Bottom View)

PIN 1: ●
PIN 2: PLATE
PIN 3: ●
PIN 4: GRID
PIN 5: ●
PIN 6: ●

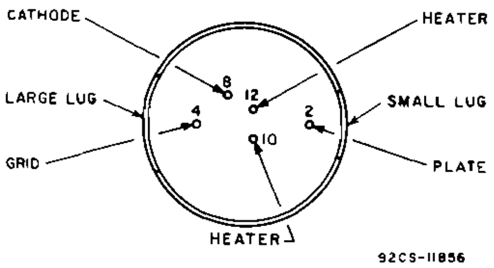


PIN 7: ●
PIN 8: CATHODE
PIN 9: ●
PIN 10: HEATER
PIN 11: OMITTED
PIN 12: HEATER

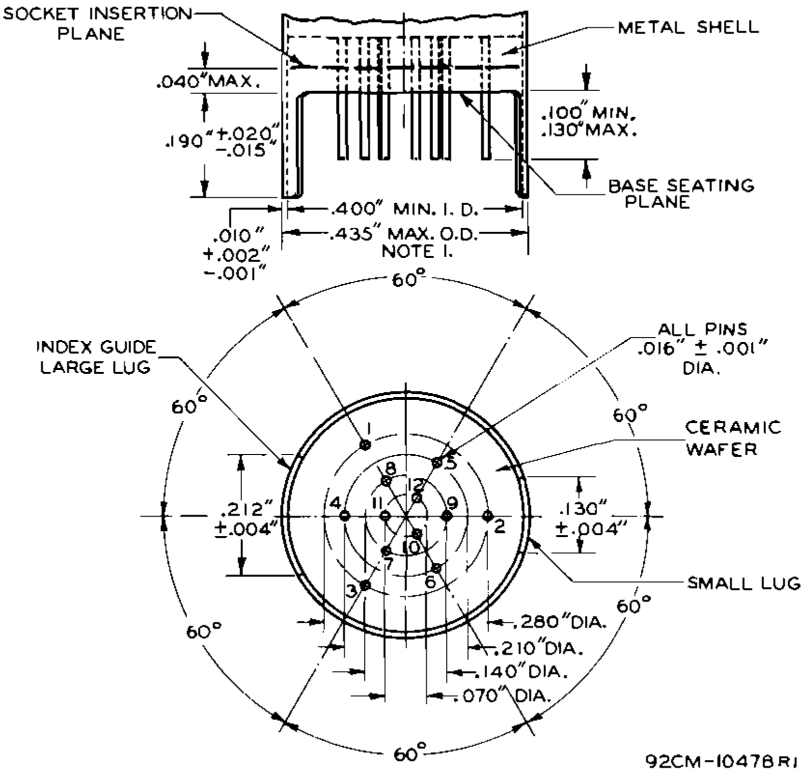
INDEX = LARGE LUG
● = SHORT PIN—INTERNAL CONNECTION—DO NOT USE

12AQ

ARRANGEMENT OF BASE PINS



MEDIUM CERAMIC-WAFER TWELVAR BASE



JEDEC No.	NAME	PINS
E12-64	12-Pin Base	1,2,3,4,5,6,7,8, 9,10,11,12
E5-65	5-Pin Base	2,4,8,10,12, (Note 2)

Note 1: Maximum O.D. of 0.440" is permitted along the 0.190" lug length.

Note 2: Pins 1,3,5,6,7, and 9 are of a length such that their ends do not touch the socket insertion plane. Pin 11 is omitted.

PIN-ALIGNMENT GAUGE

Base-pin positions and lug positions shall be held to tolerances such that entire length of pins and lugs will without undue force pass into and disengage from flat-plate gauge having thickness of 0.25" and twelve holes of 0.0350" ± 0.0005" diameter located on four concentric circles as follows: Three holes located on 0.2800" ± 0.0005", three holes located on 0.2100" ± 0.0005", three holes located on 0.1400" ± 0.0005", three holes located on 0.0700" ± 0.0005" diameter circles at specified angles with a tolerance of ± 0.08° for each angle. In addition, gauge provides for two curved slots with chordal lengths of 0.2270" ± 0.0005" and 0.1450" ± 0.0005" located on 0.4200" ± 0.0005" diameter circle concentric with pin circles at 180° ± 0.08° and having a width of 0.0230" ± 0.0005".


RCA

RCA Application Note

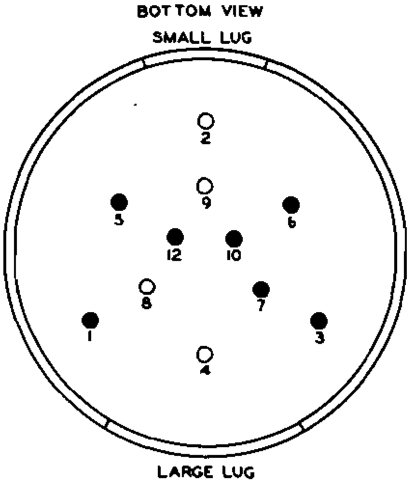
AN-191

RCA 6CW4 and 2CW4 Nuvistor Triodes as RF Amplifiers in VHF Television Tuners

This Note describes the high-frequency performance of the 6CW4 and 2CW4 nuvistor triodes and their application as rf-amplifier tubes in vhf television tuners. The performance of these tubes is evaluated in an experimental neutralized grid-drive amplifier circuit, an experimental turret tuner, and a production-type switch tuner. Optimum noise-factor data and practical circuit considerations are also presented.

Design Features of the 6CW4 and 2CW4

The 6CW4 and 2CW4 are high-mu, high-transconductance triodes of the nuvistor design, featuring extremely small size and light weight. The cylindrical active elements of the tubes are mounted coaxially on ceramic base wafers. Each element is supported by a tripod arrangement of leads which extend through the ceramic base wafer. One lead of each set is used as the external connector, as shown in the bottom view of Fig. 1.



PIN 1: PLATE
PIN 2: SEE NOTE
PIN 3: PLATE
PIN 4: SEE NOTE
PIN 5: GRID
PIN 6: GRID
PIN 7: CATHODE
PIN 8: SEE NOTE
PIN 9: SEE NOTE
PIN 10: HEATER
PIN 11: OMITTED
PIN 12: HEATER

NOTE: INTERNAL CONNECTION. DO NOT USE. PIN IS CUT OFF CLOSE TO CERAMIC WAFER.

Fig. 1 - Bottom view of pin arrangement for the 6CW4 and 2CW4.

Sections of the shell which extend beyond the base wafer serve as indexing lugs for socket insertion. These indexing lugs also provide protection for the tube leads and ground the metal shell through the socket, making the use of a tube shield unnecessary.

ELECTRON TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

2-61

Several important advantages are inherent in the unique nuvistor design used in these tubes. For example, high transconductance is obtained with a high transconductance-to-plate-current ratio, as shown by the transfer characteristics in Fig. 2. These characteristics are achieved with a considerable reduction of both plate-input and heater-input power.

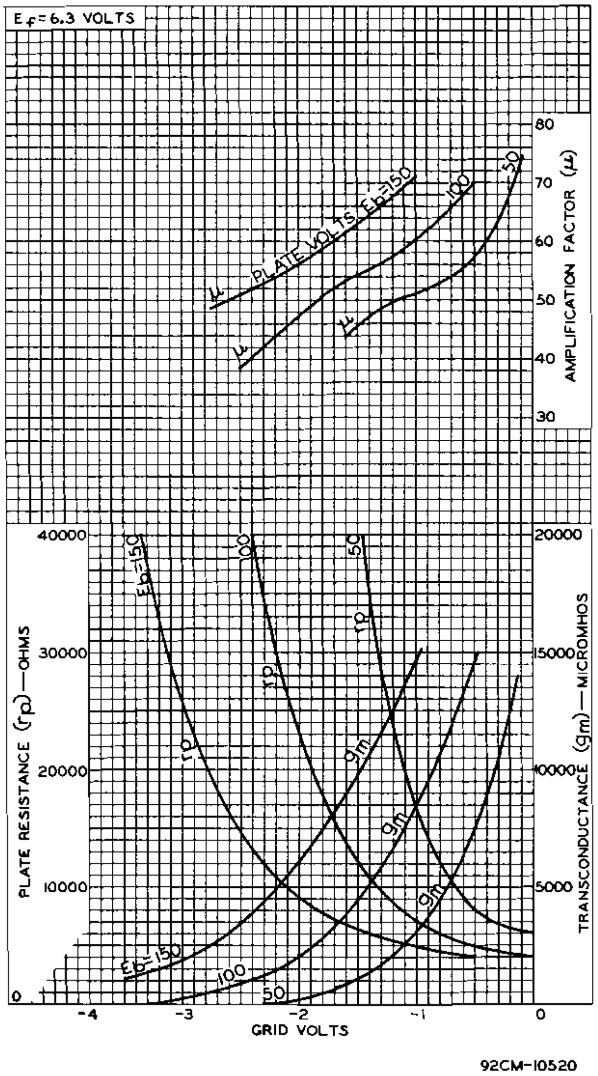


Fig. 2 - Average characteristics for the 6CW4.

Interelectrode capacitances are comparable to those of conventional miniature triodes. In addition, accurate element spacing in the tubes during assembly permits a high degree of uniformity of characteristics from tube to tube, especially with respect to interelectrode capacitances. As a result, tubes can be replaced with a minimum of circuit adjustment.

The small size and short lead lengths of the tubes make them particularly suitable for rf-amplifier applications in vhf television tuners. The high transconductance-to-plate-current ratio contributes to low tube noise factor. In addition, short-circuit input-impedance measurements indicate that these tubes have higher input resistance than other tubes having equivalent input capacitance and transconductance. These measurements approximate the input resistance of a completely neutralized triode in grid-drive operation. As shown by the following equation for power gain at vhf frequencies (impedance-matching losses neglected), increased input resistance results in increased gain.

$$\text{Power Gain} = \frac{\mu^2 R_s R_L}{(r_p+R_L)^2}$$

where μ is the amplification factor,
R_s is the source resistance (matched to input resistance),
R_L is the load resistance, and
r_p is the plate resistance of the tube.

Neutralized Grid-Drive Amplifier

Fig.3 is a circuit diagram of a neutralized grid-drive amplifier employing a 6CW4. In this circuit, input and output networks are matched to a 50-ohm signal generator and load impedance, respectively. A capacitive-bridge network is used for neutralization. The plate circuit, a double-tuned transformer-coupled network tuned to 200 megacycles, has a six-megacycle bandwidth. For determination of optimum noise factor, source admittance was varied by use of the "pi" input-matching network. Fig.4 shows curves of noise factor and gain as functions of source conductance and susceptance for this circuit.

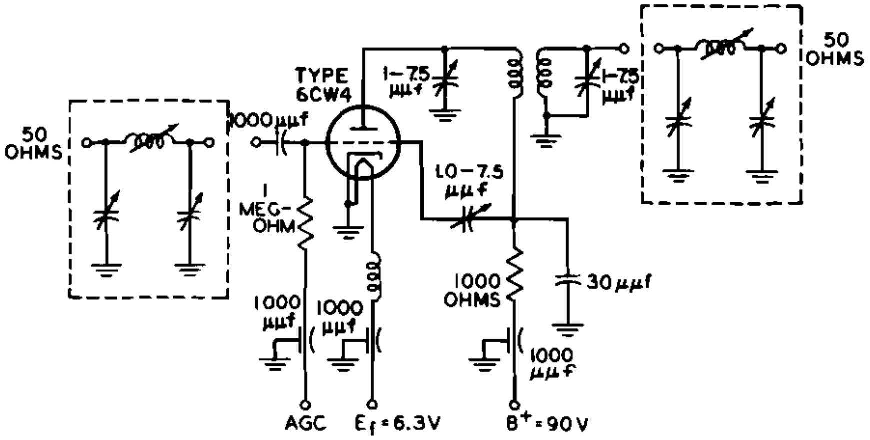


Fig.3 - Circuit diagram of a neutralized grid-drive amplifier employing the 6CW4.

Noise-factor measurements were made by use of a coaxial temperature-limited diode noise generator. The noise power of the circuit, as indicated by a detected output signal, was increased 3 db by the introduction of rf noise signals from the noise generator. The noise generator used was calibrated to indicate noise factor directly when the noise power was doubled.

A substitution method was used for measurement of power gain. In this method, the voltage output of a signal generator was set to some arbitrary reference level. The amplifier was then placed in the circuit, and the signal-generator output was attenuated to reduce the amplified signal to the original reference level. The difference between the dial readings of the signal generator, which was calibrated in db, indicated the gain of the amplifier directly.

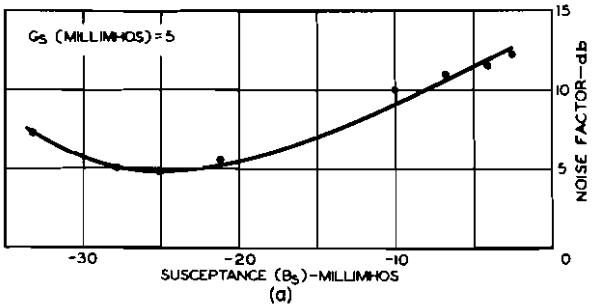


Fig.4(a) - Noise factor as a function of susceptance for the amplifier shown in Fig.3.

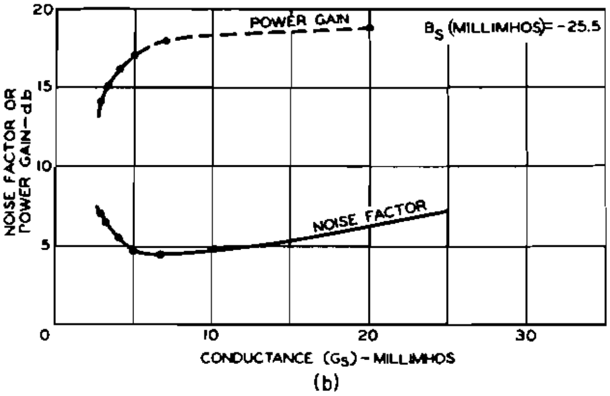


Fig.4(b) - Noise factor and power gain as functions of conductance for the amplifier shown in Fig.3.

Turret Tuner and Switch Tuner

Fig.5 is a circuit diagram of the rf-amplifier section of an experimental turret tuner. In this circuit, a 300-to-70-ohm balanced-to-unbalanced transformer input is used for impedance matching, and a mixer tube serves as the load for the rf section. Conventional tuner

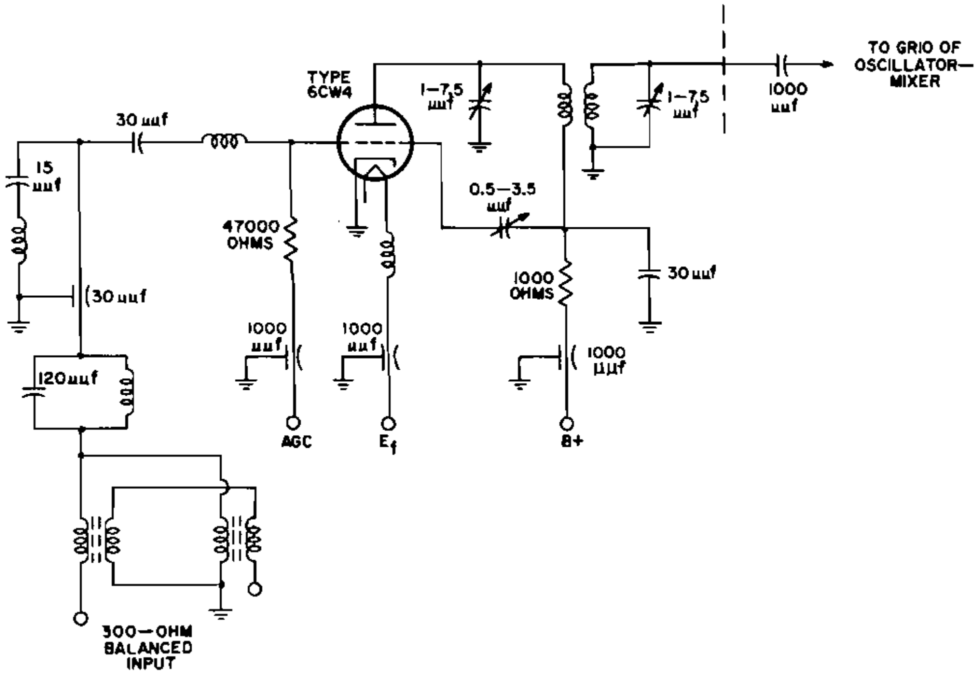


Fig.5 - Circuit diagram of the rf-amplifier section of an experimental turret tuner.

design techniques and components are used throughout. Noise factor and over-all tuner voltage-gain performance are tabulated in Table I.

Channel	Noise Factor (db)	Tuner Voltage Gain (db)
2	3.9	47.9
6	4.0	45.3
7	5.3	45.0
13	5.5	44.0

Table I - Noise-factor and gain performance of an experimental turret tuner employing a 6CW4 at different television-channel frequencies.

Similar data are shown in Table II for a production-type switch tuner using a 6CW4. The circuit for this tuner is almost identical to those shown in Figs. 3 and 5; however, the load on the tuned circuits is increased to improve coupling on the lower-frequency channels.

Channel	Noise Factor (db)	Tuner Voltage Gain (db)
2	5.1	45.0
6	5.0	43.5
7	4.7	44.5
13	5.5	45.0

Table II - Noise-factor and gain performance of a production-type switch tuner employing a 6CW4 at different television-channel frequencies.

A 50-ohm signal generator equipped with a balun to match to the tuner input was used for gain measurements of the turret tuner and switch tuner. Both tuner circuits incorporated a dummy if stage consisting of an if-amplifier tube with a 10,000-ohm grid resistor. Again, the substitution method outlined previously was used to measure gain. Table III compares the average performance of the 6CW4 at channel 13 with that of conventional miniature types in the same circuit.

Tube Type	Noise Factor (db)	Tuner Voltage Gain (db)
6BN4-A	8.5	38.0
6FH5	7.5	41.0
6ER5	7.5	41.0
6CW4	5.5	45.0

Table III - Noise-factor and gain comparison of the 6CW4 with conventional miniature triodes in a television tuner at channel 13.

General Considerations

The 6CW4 and 2CW4 are designed to operate at relatively low plate voltages for best rf performance. Optimum tuner performance is obtained with a plate voltage in the order of 70 to 80 volts. Fig.6 shows curves of noise factor and tuner gain as a function of plate power dissipation at various B+ values applied to the tuner. The B+ voltage is dropped slightly across a 1000-ohm resistor. At a given level of plate dissipation, performance improves as the plate voltage is reduced. (The limit of plate-voltage reduction is determined by the amount of plate current that can be drawn without the application of positive bias voltage.) The optimum plate voltage is determined as a balance between performance and plate dissipation. Maximum signal-to-noise ratio at a given plate voltage is obtained at an applied bias of zero volts.

Under these conditions, the 6CW4 and 2CW4 have a sharp-cutoff characteristic which is unsuitable in systems employing agc. Supply voltages available in television receivers are, however, considerably higher than the operating plate voltage of these tubes. As a result, cutoff can easily be extended by the addition of a plate-voltage dropping resistor. Fig.7 shows curves of gain reduction as a function of grid bias for different values of supply voltage. As indicated, the circuit designer determines the value of plate-voltage dropping resistor or series shunt combination which provides the desired cutoff characteristic.

Use of the 6CW4 or 2CW4 with a series dropping resistor at high supply voltages requires careful choice of tube-element operating values so that maximum ratings are not exceeded. Maximum plate dissipation, for example, does not necessarily occur when the tube is drawing maximum plate current, but can occur at some bias value other than zero. Fig.8(a) shows a circuit configuration using a typical 6CW4. Fig.8(b) shows curves of plate dissipation as a function of bias voltage obtained from the agc circuit. With the indicated circuit and voltage values, maximum plate dissipation (as shown by the solid-line curve) occurs at a bias voltage of slightly less than one volt.

With the values of resistors adjusted to either the upper or lower limits of their 10-percent tolerances to simulate the worst probable conditions of operation and with the high heater and B+ voltages indicated,

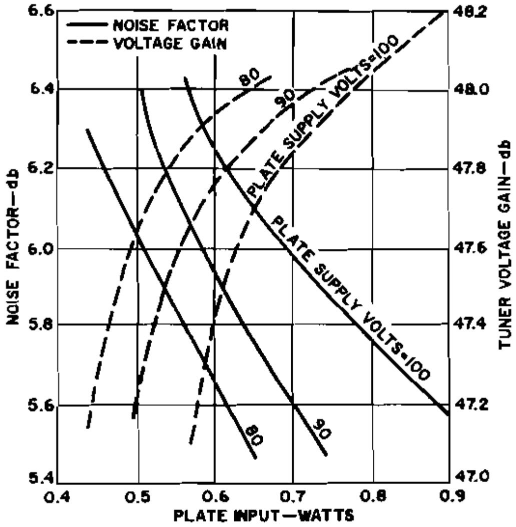


Fig.6 - Voltage gain and noise factor as functions of input power for various B+ voltages applied to the turret tuner.

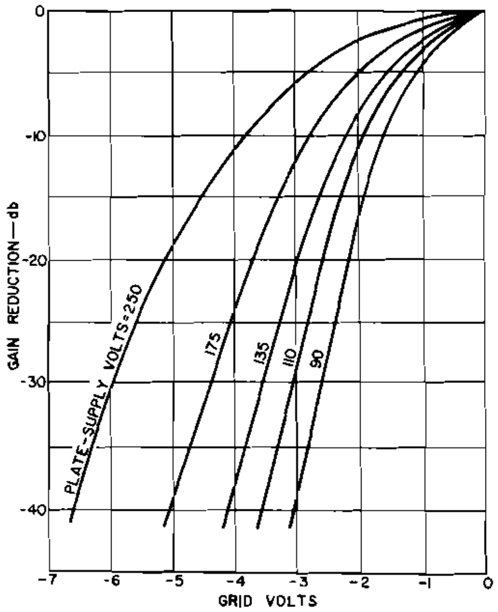
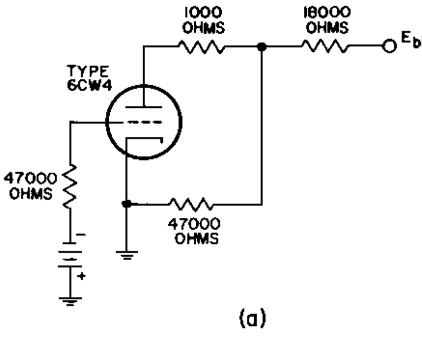


Fig.7 - Gain reduction as a function of grid-bias voltage for different values of supply voltage.



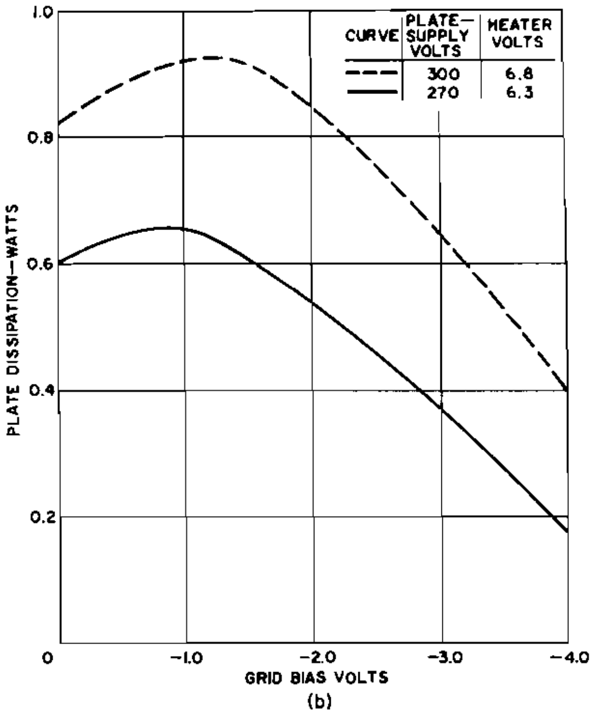


Fig.8(a) - Typical circuit configuration using the 6CW4 and (b) - curves of plate dissipation as a function of agc bias voltage under normal and worst probable conditions of operation.

the resultant maximum plate dissipation is shown by the dashed curve in Fig.8(b). In this case, maximum plate dissipation occurs at a bias voltage slightly above 1 volt. The equipment designer has the responsibility of choosing values of circuit components which will prevent maximum ratings of the tube from being exceeded under the worst probable operating conditions.

As mentioned previously, optimum performance of the 6CW4 and 2CW4 is obtained when they are operated with an applied bias of about zero volts. Under these conditions, the tube draws current, and is at some negative potential depending on the grid impedance to ground. Because automatic-gain-control systems generally present high impedances to ground, care must be taken to assure that a low grid bias voltage is applied to the tube. A common method is to return the agc terminal to a positive voltage through a large-value resistor to clamp the grid voltage at low signal levels.

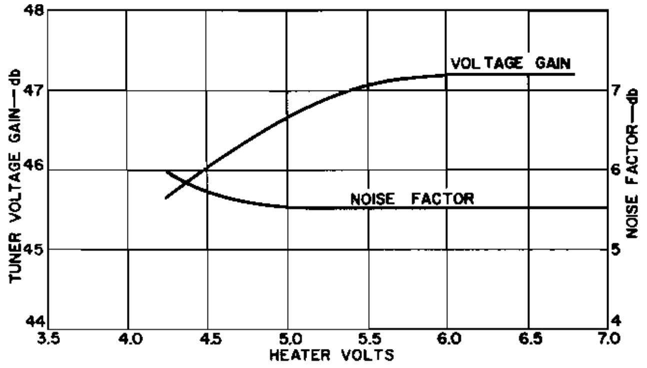


Fig.9 - Voltage gain and noise factor as functions of heater volts for the turret tuner.

Fig.9 shows the variation of tuner noise factor and voltage gain produced by reduction in heater voltage. The curves show that noise factor is only slightly affected at reduced heater voltage, and that gain drops only about 0.5 db with a change in heater voltage from 6.3 to 5.0 volts.

RCA nuvistor 6DS4 2DS4

HIGH-MU TRIODES

with semiremote-cutoff characteristic

FOR TV AND FM TUNER DESIGNS

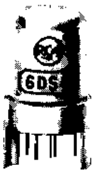
RADIO CORPORATION OF AMERICA
ELECTRON TUBE DIVISION HARRISON, N. J.

RCA-2DS4, 6DS4

High-Mu Nuvistor Triodes

With Semiremote-Cutoff Characteristic

RCA-2DS4 and 6DS4 are high-mu triodes of the nuvistor type intended for use as grounded-cathode, neutralized rf-amplifier tubes in vhf tuners of television and FM receivers. The 2DS4 and 6DS4, in this application, provide exceptional performance in fringe areas and other locations where signal levels are very weak. These nuvistor triodes feature excellent signal power gain and a very low noise factor. In addition, the semiremote-cutoff characteristic of these tubes reduces cross-modulation distortion.



The high-gain and low-noise capabilities of the 2DS4 and 6DS4 are achieved by very high transconductance and excellent transconductance-to-plate-current ratio (12500 micromhos at a plate current of 7 milliamperes and a plate voltage of 70 volts).

The 2DS4 and 6DS4 nuvistor triodes offer extreme reliability, exceptional uniformity of characteristics from tube to tube, very small size, and low heater-power and plate-power requirements. In addition, their all metal-and-ceramic construction insures exceptional ruggedness and long-term stability.

GENERAL DATA

Electrical:

	2DS4	*6DS4*	
Heater, for Unipotential Cathode:			
Voltage (ac or dc)	2.1	6.3 ± 10%	volts
Current	0.45 ± 6%	0.135	amp
Warm-up time (Average)	8	-	sec
Direct Interelectrode Capacitances (Approx.):			
Grid to plate		0.92	pf
Grid to cathode, shell, and heater		4.3	pf
Plate to cathode, shell, and heater		1.8	pf
Plate to cathode		0.18	pf
Heater to cathode		1.6	pf

Characteristics, Class A_1 Amplifier:

Plate Supply Voltage	110	volts
Grid Supply Voltage	0	volts
Cathode Resistor	130	ohms
Amplification Factor	63	
Plate Resistance (Approx.)	7000	ohms
Transconductance	9000	μmhos
Plate Current	6.5	ma
Grid Voltage (Approx.) for plate current = 100 μa	-5	volts
Grid Voltage (Approx.) for plate current = 10 μa	-6.8	volts

Mechanical:

Operating Position	Any
Maximum Over-all Length	0.8"
Maximum Seated Height	0.625"
Maximum Diameter	0.440"
Envelope	Metal Shell
Base	Medium Ceramic-Wafer Twelvar 5-Pin (JEDEC No.E5-65)

Maximum Ratings, *Design-Maximum Values:*

PLATE SUPPLY VOLTAGE	300[●]	max.	volts
PLATE VOLTAGE	135	max.	volts
GRID VOLTAGE:			
Negative-bias value	55	max.	volts
Peak positive value	0	max.	volts
PLATE DISSIPATION:			
With a minimum series plate-circuit resistance of 5000 ohms	1.5	max.	watts
For lower values of series plate-circuit resistance	See *Fig.1* and *Operating Considerations*		
CATHODE CURRENT	15	max.	ma
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	100	max.	volts
Heater positive with respect to cathode	100	max.	volts

Typical Operation:

Plate Voltage	70	volts
Grid Supply Voltage	0	volts
Grid Resistor	47000	ohms
Amplification Factor	68	
Plate Resistance (Approx.)	5440	ohms
Transconductance	12500	μmhos
Plate Current	7	ma

Maximum Circuit Values:

Grid-Circuit Resistance:[★]			
For fixed-bias operation	0.5	max.	megohm
For cathode-bias operation	2.2	max.	megohms

[●] A plate supply voltage of 300 volts may be used provided sufficient plate-circuit resistance and agc voltage are used to limit the voltage at the plate of the tube to 135 volts under conditions of maximum rated plate dissipation (1.5 watts).

[★] For operation at metal-shell temperatures up to 135° C.

OPERATING CONSIDERATIONS

The *base pins* of the 2DS4 and 6DS4 fit the Cinch Manufacturing Co. socket No.133 65 10 001 and the Industrial Electronic Hardware Co. socket Nos.Nu 5044 and Nu 5060, or their equivalents.

In some previous publications reference has been made to a JEDEC No.E5-65 socket. This number is not a socket designation but is a base designation which defines the JEDEC Medium Ceramic-Wafer Twelvar 5-pin base used in nuvistor tubes.

Use of Plate-Dissipation Rating Chart

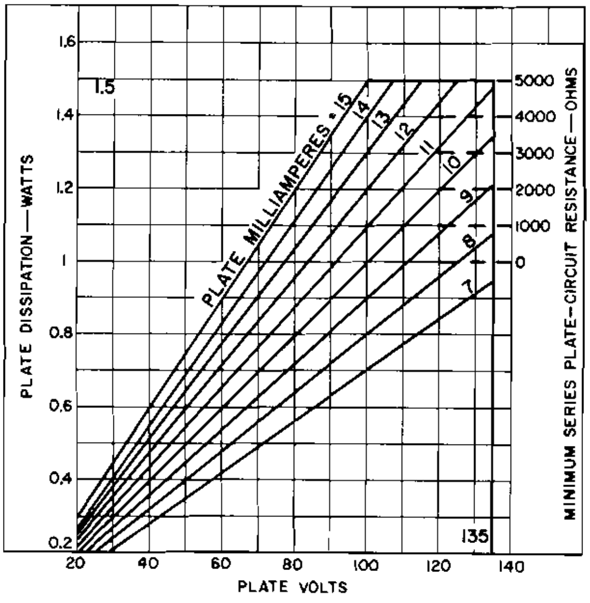
The *Plate-Dissipation Rating Chart* shown in Fig.1 presents graphically the maximum rated plate dissipation of the 2DS4 and 6DS4 for various minimum values of series plate-circuit resistance. The region of permissible operation is bounded by the lines representing plate dissipation = 1.5 watts, plate voltage = 135 volts, and plate current = 15 milliamperes. In class A_1 amplifier service, because no grid current flows, the plate current rating is equivalent to the cathode current rating.

To determine the required minimum series plate-circuit resistance for a given set of operating conditions:

1. From Fig.2, Average Plate Characteristics, select the desired operating conditions.
2. From Fig.1 determine the corresponding maximum plate dissipation and required minimum value of series plate-circuit resistance.

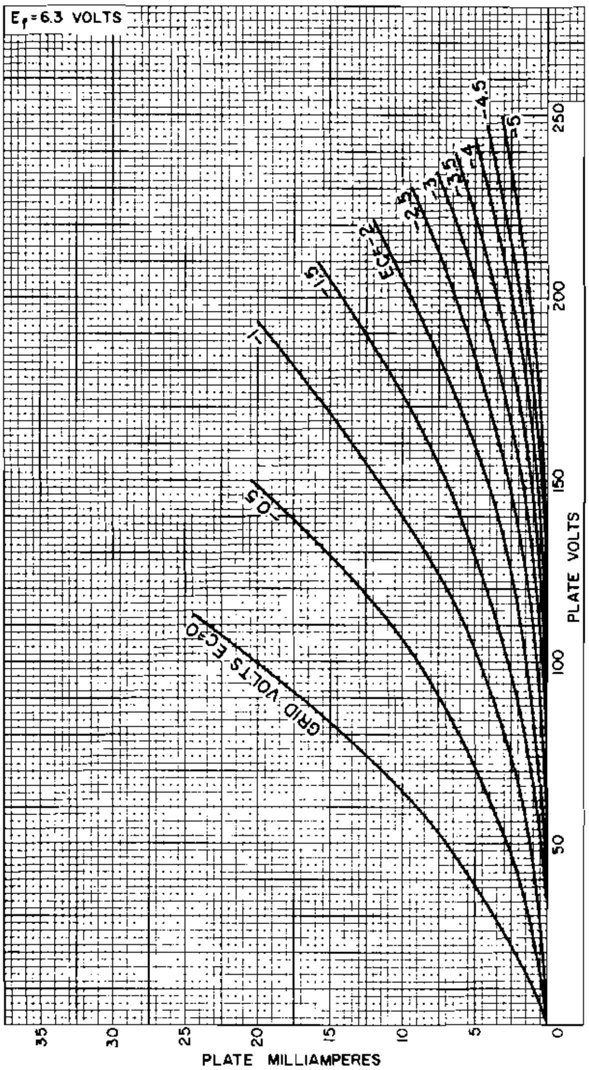
Example: (a) From Fig.2—for a plate voltage of 110 volts and a grid voltage of -0.5 volt, the corresponding plate current is 10.7 milliamperes.

(b) From Fig.1—the plate dissipation for a plate voltage of 110 volts and a plate current of 10.7 milliamperes is approximately 1.18 watts. The required minimum series plate-circuit resistance for this plate dissipation is 1800 ohms.



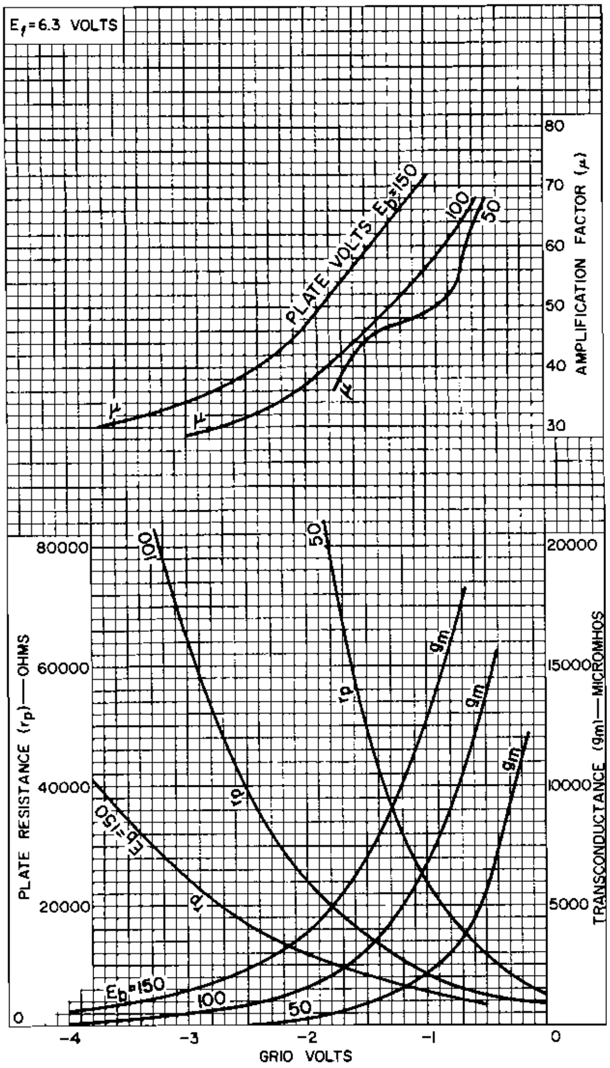
92CM-11681

Fig.1 - Plate Dissipation Rating Chart for Types 2DS4 and 6DS4.



92CM-11209

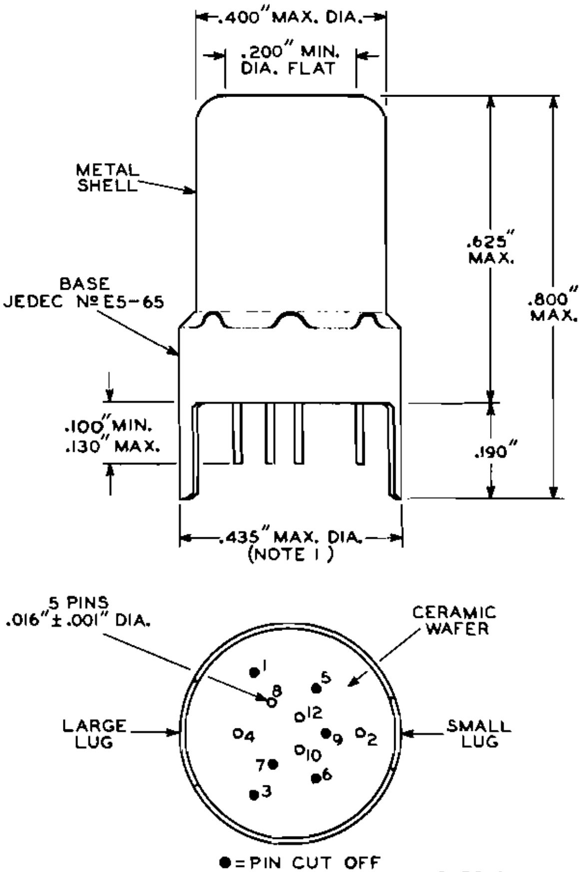
Fig.2 - Average Plate Characteristics for Type 6DS4 and for Type 2DS4 except for Heater Voltage.



92CM-11210

Fig.3 - Average Characteristics for Type 6DS4 and for Type 2DS4 except for Heater Voltage.

DIMENSIONAL OUTLINE

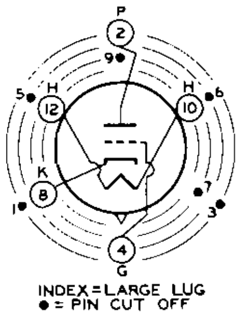


92CS-10484R1

NOTE 1: MAXIMUM O.D. OF 0.440" IS PERMITTED ALONG 0.190" LUG LENGTH.

BASING DIAGRAM
(Bottom View)

PIN 1: ▲
PIN 2: PLATE
PIN 3: ▲
PIN 4: GRID
PIN 5: ▲
PIN 6: ▲

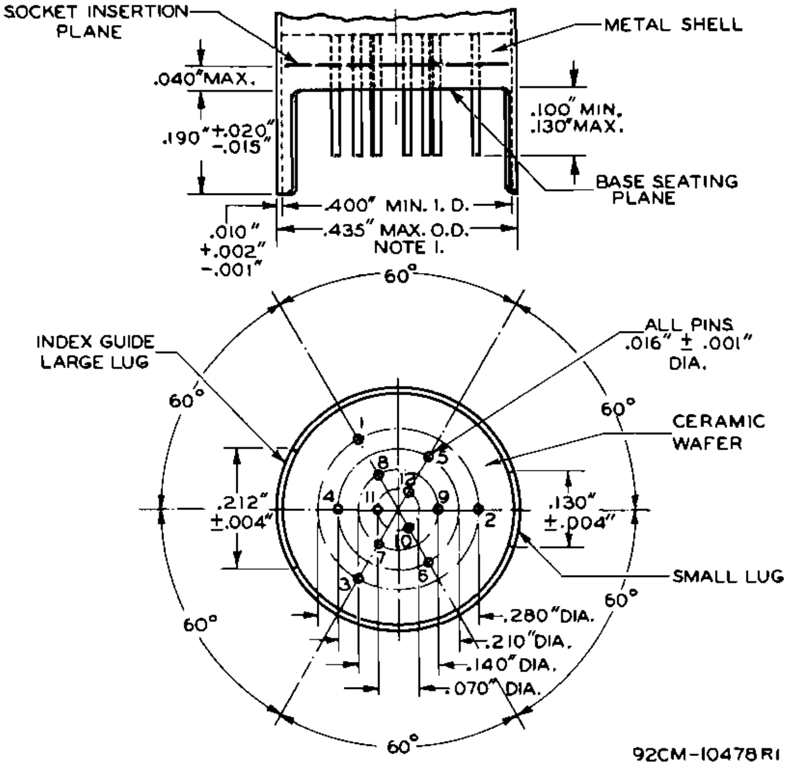


12AQ

PIN 7: ▲
PIN 8: CATHODE
PIN 9: ▲
PIN 10: HEATER
PIN 11: OMITTED
PIN 12: HEATER

▲ Pin has internal connection and is cut off close to ceramic wafer—Do Not Use.

MEDIUM CERAMIC-WAFER TWELVAR BASE



JEDEC No.	NAME	PINS
E12-64	12-Pin Base	1,2,3,4,5,6,7,8, 9,10,11,12
E5-65	5-Pin Base	2,4,8,10,12, (Note 2)

Note 1: Maximum O.D. of 0.440" is permitted along the 0.190" lug length.

Note 2: Pins 1,3,5,6,7, and 9 are cut off to a length such that their ends do not touch the socket insertion plane. Pin 11 is omitted.

PIN-ALIGNMENT GAUGE

Base-pin positions and lug positions shall be held to tolerances such that entire length of pins and lugs will without undue force pass into and disengage from flat-plate gauge having thickness of 0.25" and twelve holes of 0.0350" ± 0.0005" diameter located on four concentric circles as follows: Three holes located on 0.2800" ± 0.0005", three holes located on 0.2100" ± 0.0005", three holes located on 0.1400" ± 0.0005", three holes located on 0.0700" ± 0.0005" diameter circles at specified angles with a tolerance of ± 0.08° for each angle. In addition, gauge provides for two curved slots with chordal lengths of 0.2270" ± 0.0005" and 0.1450" ± 0.0005" located on 0.4200" ± 0.0005" diameter circle concentric with pin circles at 180° ± 0.08° and having a width of 0.0230" ± 0.0005".

RCA nuvistor

General-Purpose Industrial Medium-Mu Triode

7586

- Low-voltage operation
- Low heater drain
- Very high transconductance at low plate current
- Exceptional uniformity of characteristics from tube to tube
- Operation at full ratings at all altitudes
- Rigorously controlled and tested
- All-metal-and-ceramic construction
- High resistance to shock and vibration
- Only 8/10 inch long; less than 1/2 inch in diameter; weighs 1/15 oz.

RADIO CORPORATION OF AMERICA
Electron Tube Division **Harrison, N. J.**

RCA-7586

MEDIUM-MU TRIODE

Nuvistor Type for Industrial Applications

Actual Size

RCA-7586 is a medium-mu general-purpose nuvistor triode of the heater-cathode type designed for use in a wide variety of applications in industrial equipment where compactness, low-drain low-voltage operation, exceptional uniformity of characteristics from tube to tube, and ability to withstand mechanical shock and vibration are primary design requirements. It is capable of providing high gain with low noise in amplifier service, and excellent stability as an oscillator, over a wide range of frequencies.

General Features

The 7586 has a metal envelope provided with two peripheral lugs of unequal width for indexing, is only 8/10" long, less than 1/2" in diameter, and weighs approximately 1/15 ounce (1.9 grams). It features (1) a very rugged structure of unique design, (2) a 6.3-volt low-wattage heater, and a specially designed cathode made of passive material to assure very low interface resistance and leakage, (3) very high transconductance at low plate voltage and current (11500 micromhos at 75 volts and 10.5 milliamperes), (4) very high input impedance, (5) high perveance, and (6) ability to operate at any altitude at full ratings.

Structural Features

A major feature of the 7586 is its all-ceramic-and-metal construction utilizing a light-weight, cantilever-supported cylindrical electrode structure. This unique type of electrode structure, inherent in the nuvistor design, uses only strong metals and ceramics to provide a structure of extreme ruggedness. All connections are brazed at very high temperatures in a hydrogen atmosphere to eliminate the structural strain and element distortion often caused by welding. The tube is also exhausted and sealed at very high temperatures to eliminate the gases and impurities which are generally present in electron devices processed at low temperatures.

The structure of the 7586 nuvistor triode also permits automatic assembly using parts made to extremely small tolerances, thus assuring exceptional uniformity of characteristics from tube to tube.

Special Tests and Controls

The 7586 is rigidly controlled during manufacture, and is subjected to rigorous tests for intermittent shorts and interelectrode leakage; for early-hour, 100-hour, and 1000-hour conduction life performance; for resistance to impact shock, low-frequency vibration, variable-frequency vibration, low-pressure breakdown, 1000-hour standby-life performance, and heater cycling.

These special controls and tests, together with high transconductance at low plate currents and voltages, small power requirements, ability to operate at full ratings at any altitude, and extremely small size, make the 7586 nuvistor triode exceptionally desirable for critical industrial applications--for example, in communications equipment, control and instrumentation equipment, medical electronic equipment, TV cameras, and test and measurement instruments.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage (ac or dc)	6.3 ± 10%	volts
Current at 6.3 volts	0.135	amp
Direct Interelectrode Capacitances:		
Grid to plate	2.2	μμf
Grid to cathode, heater, & shell	4.2	μμf
Plate to cathode, heater, & shell	1.6	μμf
Heater to cathode	1.4	μμf
Plate to cathode	0.26	μμf

Characteristics, Class A_1 Amplifier:

Plate-Supply Voltage	-	-	75	volts
Plate Voltage	26.5	40	-	volts
Grid-Supply Voltage	0	0	0	volts
Cathode Resistor	-	-	100	ohms
Grid-Circuit Resistance	0.5	0.5	-	megohm
Amplification Factor	31	35	35	
Plate Resistance (Approx.)	4400	3200	3000	ohms
Transconductance	7000	11000	11500	μmhos
Plate Current	2.8	6.8	10.5	ma
Grid Voltage (Approx.) for plate current = 10 μa	-	-	-7.0	volts

Mechanical:

Operating Position	Any
Maximum Over-all Length	0.8"
Maximum Seated Height	0.625"
Maximum Diameter	0.440"
Envelope	Metal Shell
Base	Medium Ceramic-Wafer Twelvar 5-Pin (JEDEC No. E5-65)
Socket	Cinch Mfg. Co. No. 133 65 10 001, or Equivalent

INDUSTRIAL SERVICE

Maximum Ratings, *Absolute-Maximum Values:*

For Operation at Any Altitude

PLATE SUPPLY VOLTAGE	330 max.	volts
PLATE VOLTAGE	110 max.	volts
GRID VOLTAGE:		
Negative-bias value	55 max.	volts
Peak positive value	4 max.	volts
PLATE DISSIPATION	1 max.	watt
GRID CURRENT	2 max.	ma
CATHODE CURRENT	15 max.	ma
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	100 max.	volts
Heater positive with respect to cathode	100 max.	volts

Maximum Circuit Values:

Grid-Circuit Resistance*:		
For fixed-bias operation	0.5 max.	megohm
For cathode-bias operation	1 max.	megohm

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* For Operation at Metal-Shell Temperatures up to 150° C (See *Dimensional Outline* on Page 9).

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN

	Note	*Min.*	*Max.*	
Heater Current	1	0.125	0.145	amp
Direct Interelectrode Capacitances:				
Grid to plate	2	1.8	2.6	μμf
Grid to cathode, heater, & shell	2	3.8	4.6	μμf
Plate to cathode, heater, & shell	2	1.4	1.8	μμf
Heater to cathode	2	1.1	1.7	μμf
Plate to cathode	2	0.2	0.32	μμf
Plate Current (1)	1,3	9.0	12.5	ma
Plate Current (2)	1,4	-	50	μa
Transconductance (1)	1,3	10000	13000	μmhos
Transconductance (2)	3,5	9000	-	μmhos
Transconductance Change:				
Difference between Transconductance (1) and Transconductance (2), expressed in per cent of Transconductance (1)	-	-	15	%
Reverse Grid Current	1,6	-	0.1	μa
Amplification Factor	1,3	28	40	
Heater-Cathode Leakage Current:				
Heater negative with respect to cathode	1,7	-	5	μa
Heater positive with respect to cathode	1,7	-	5	μa
Leakage Resistance:				
Between grid and all other electrodes tied together	1,8	1000	-	megohms
Between plate and all other electrodes tied together	1,9	1000	-	megohms

Note 1: With 6.3 volts ac or dc on heater.

Note 2: Measured in accordance with EIA Standard RS-191-A.

Note 3: With dc plate volts = 75, cathode resistor = 100 ohms, and cathode-bypass capacitor = 1000 μf.

Note 4: With dc plate volts = 75, dc grid volts = -7, and metal shell grounded.

Note 5: With 5.7 volts ac or dc on heater.

Note 6: With dc plate volts = 80, grid supply volts = -1.2, grid resistor = 0.5 megohm, and metal shell grounded.

Note 7: With 100 volts dc applied between heater and cathode.

Note 8: With grid 100 volts negative with respect to all other electrodes tied together.

Note 9: With plate 300 volts negative with respect to all other electrodes tied together.

SPECIAL RATINGS AND PERFORMANCE DATA

Shock Rating:

Impact Acceleration . . . . 1000 max. g

This test is performed on a sample lot of tubes from each production run to determine ability of tube to withstand the specified impact acceleration. Tubes are held rigid in four different positions in a Navy Type, High-impact (flyweight) Shock Machine and are subjected to 20 blows at the specified maximum impact acceleration. At the end of this test, tubes are criticized for change in transconductance, reverse grid current, and heater-cathode leakage current, and are then subjected to the Variable-Frequency Vibration Test described later.

Fatigue Rating:

Vibrational Acceleration. . . . . 2.5 max. g

This test is performed on a sample lot of tubes to determine ability of tube to withstand the specified vibrational acceleration. Tubes are rigidly mounted, supplied with nominal heater voltage only, and subjected for 48 hours to 2.5 g vibrational acceleration at 60 cycles per second in the X_1 position. At the end of this test, tubes are criticized for the same characteristics and end-point values as in the Shock Rating Test described previously.

Variable-Frequency-Vibration Performance:

This test is performed on a sample lot of tubes from each production run. The tube is operated under the conditions specified in CHARACTERISTICS RANGE VALUES for Transconductance (1) with the addition of a plate-load resistor of 2000 ohms. During operation, tube is vibrated in the X_1 position through the frequency range from 50 to 15000 cycles per second under the following conditions: a sweep rate of one octave per 30 seconds from 50 to 3000 cps and a 7-second sweep from 3000 to 15000 cps, with a constant vibrational acceleration of 1 g. During the test, tube will not show an rms output voltage across the plate-load resistor in excess of the value shown in the adjoining chart for the specified frequency range.

FREQUENCY RANGE (cps)	MAX. PERMISSIBLE RMS OUTPUT VOLTAGE (millivolts)
50 to 6000	25
6000 to 15000	500

Low-Pressure Voltage-Breakdown Test:

This test is performed on a sample lot of tubes from each production run. In this test tubes are operated with 240 rms volts applied between plate and all other electrodes and will not break down or show evidence of corona when subjected to air pressures equivalent to altitudes of up to 100000 feet.

Heater Cycling

Cycles of Intermittent Operation. . . . . 2000 min. cycles

This test is performed on a sample lot of tubes from each production run under the following conditions: heater volts = 7.5 cycled one minute on and two minutes off; heater 100 volts negative with respect to cathode; grid, plate, and metal shell connected to ground. At the end of this test tubes are tested for open heaters and heater-cathode shorts.

Intermittent Shorts

This test is performed on a sample lot of tubes from each production run. Tubes are subjected to the Thyratron-Type Shorts Test described in MIL-E-ID, Amendment 2, Par. 4.7.7, except that tapping is done by hand with a soft rubber tapper*. The Acceptance Curve for this test is shown in Fig.4. In this test tubes are criticized for permanent or temporary shorts and open circuits.

Early-Hour Stability Life Performance

This test is performed on a sample lot of tubes from each production run to insure that tubes are properly stabilized. In this test tubes are operated for 20 hours at maximum rated plate dissipation. After two hours of operation and again after 20 hours of operation tubes are checked for transconductance under the conditions specified in CHARACTERISTICS RANGE VALUES for Transconductance (1). A tube is rejected if its transconductance after two or 20 hours of operation has changed more than 10 per cent from the 0-hour value.

100-Hour Life Performance

This test is performed on a sample lot of tubes from each production run to insure a low percentage of early-hour inoperatives. Tubes are operated for 100 hours at maximum rated plate dissipation, and then subjected to the Intermittent Shorts Test previously described. Tubes must then show a transconductance of not less than 8300 micromhos under the conditions specified in CHARACTERISTICS RANGE VALUES for Transconductance (1).

1000-Hour Conduction Life Performance

This test is performed on a sample lot of tubes from each production run to insure high quality of the individual tube and guard against epidemic failures due to excessive changes in any of the characteristics indicated below. In this test tubes are operated for 1000 hours at maximum rated plate dissipation,• and then criticized for inoperatives, reverse grid current, heater-cathode leakage current, and leakage resistance. In addition, the average change in transconductance of the lot from the 0-hour value for Transconductance (1) specified in CHARACTERISTICS RANGE VALUES, must not exceed 15 per cent at 500 hours, and 20 per cent at 1000 hours.

1000-Hour Standby Life Performance

This test is performed on a sample lot of tubes from each production run. The tubes are operated for 1000 hours with only heater voltage applied. The

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* Specifications for this tapper will be supplied on request.

• At a shell temperature of 150° C.

tubes are then criticized for interelectrode leakage, reverse grid current, change in transconductance of individual tubes from the zero-hour values and for cathode interface resistance greater than 25 ohms. Interface resistance is measured by Method B of ASTM specification F300-57T.

OPERATING CONSIDERATIONS

The *base-pins* of the 7856 fit the Cinch Mfg. Co. socket No. 133 6510 001 or equivalent. The socket may be mounted to hold the tube in any position.

The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Absolute-Maximum Rating System* for rating electron devices.

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, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

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 device characteristics.

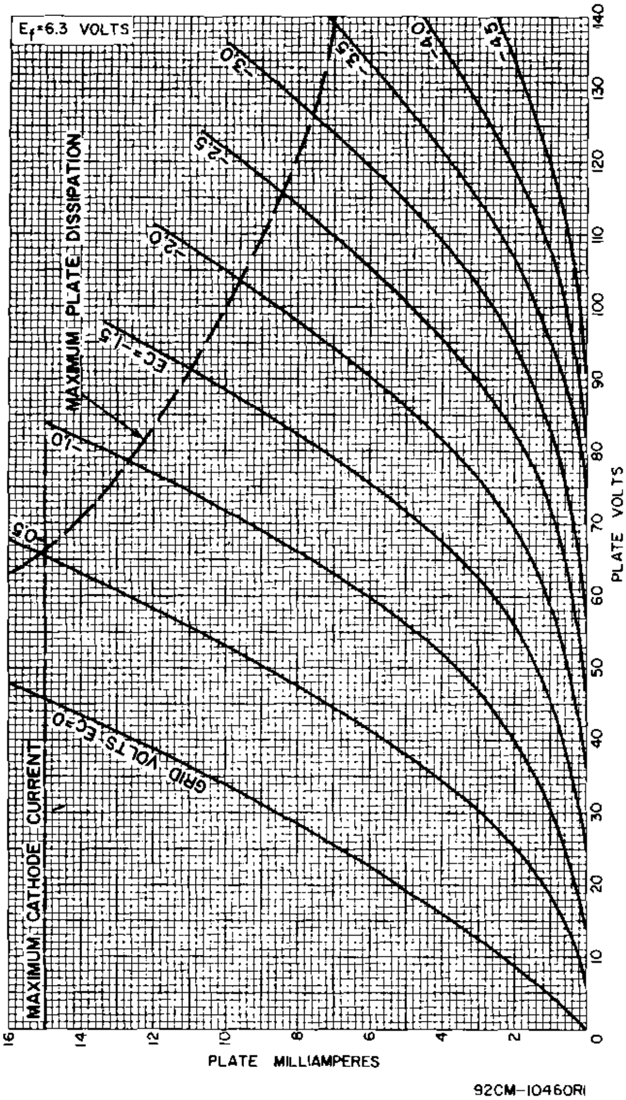

Fig. 1 - Average Plate Characteristics for Type 7586.

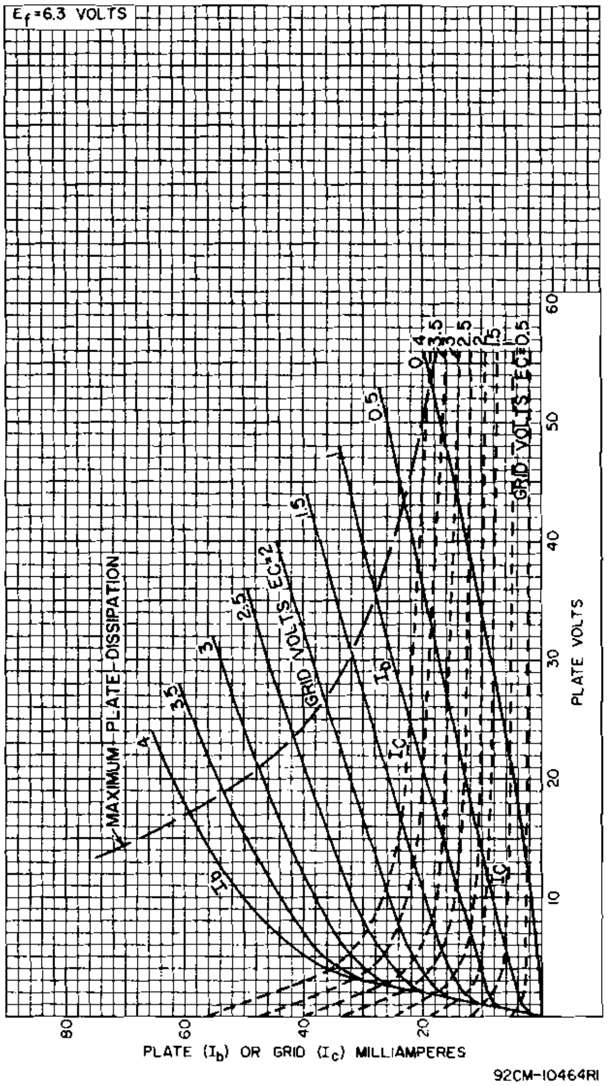

Fig. 2 - Average Characteristics for Type 7586.

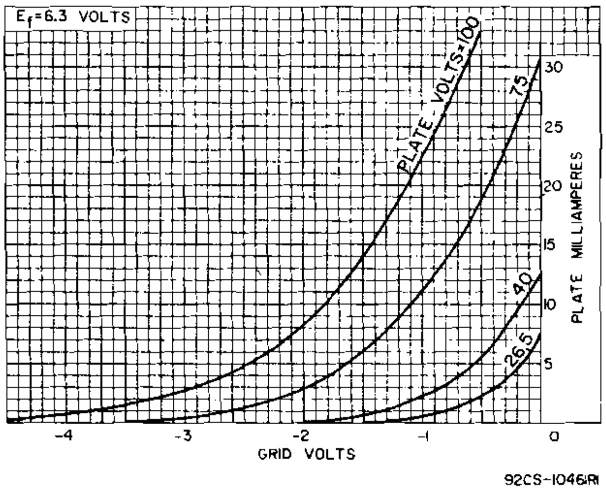

Fig. 3 - Average Characteristics for Type 7586.

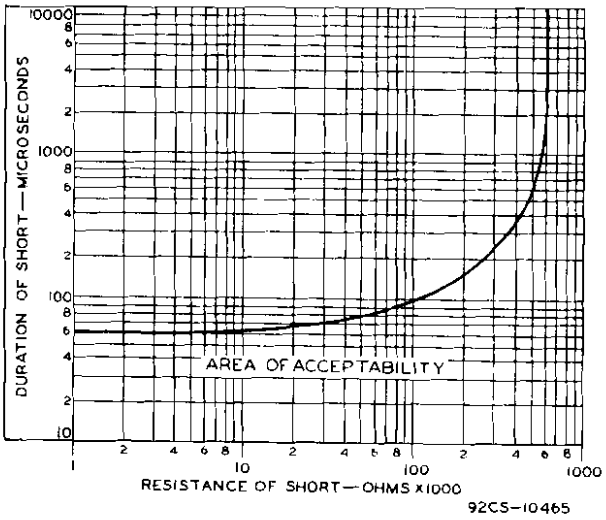

Fig. 4 - Thyratron-Type Shorts Test for Type 7586.

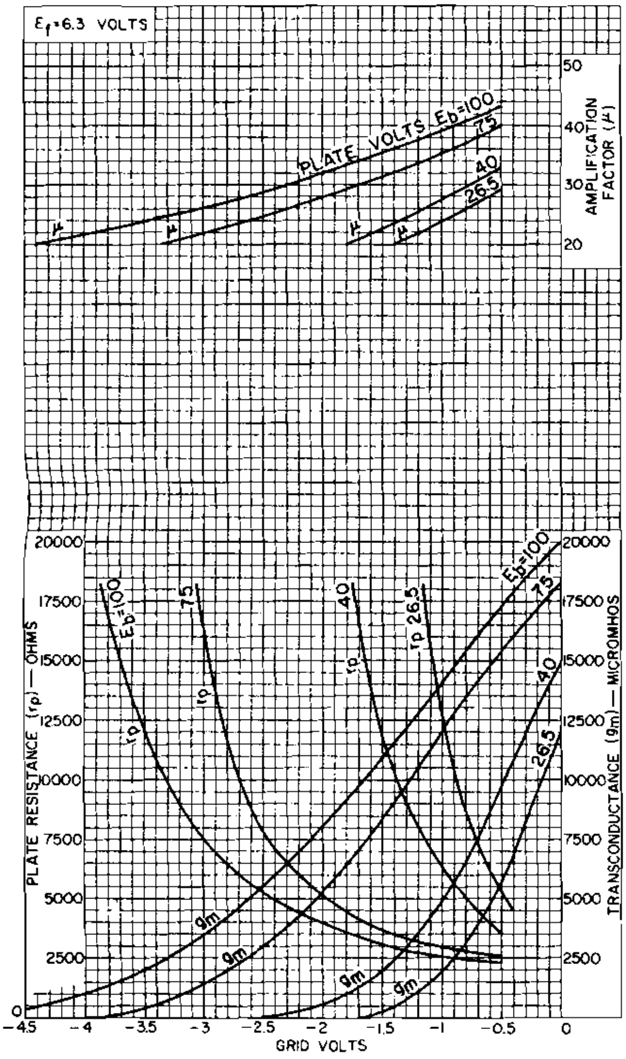

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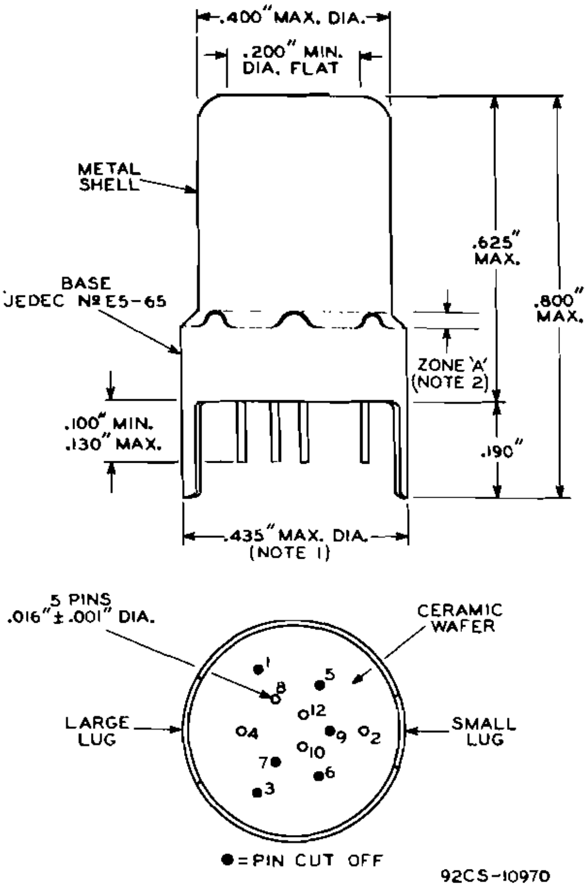
Fig.5 - Average Characteristics for Type 7586.

DIMENSIONAL OUTLINE



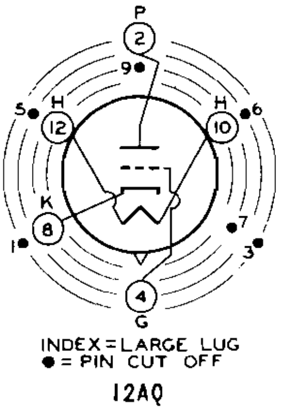
92CS-10970

Note 1: Maximum O.D. of 0.440" is permitted along 0.190" lug length.

Note 2: Shell temperature should be measured in the zone 'A' indicated by broken lines.

BASING DIAGRAM (Bottom View)

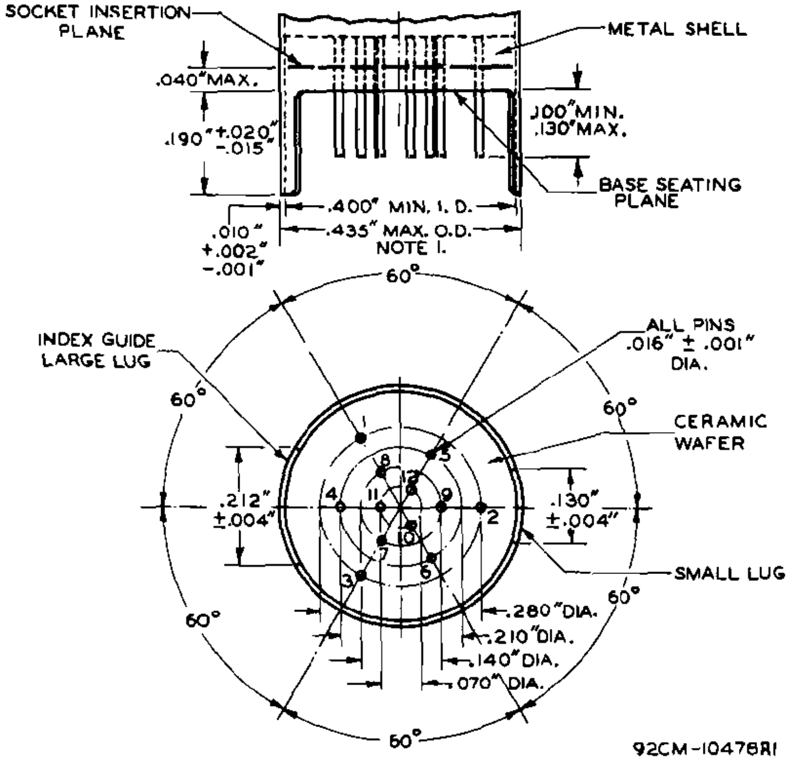
Pin 1: ▲
Pin 2: Plate
Pin 3: ▲
Pin 4: Grid
Pin 5: ▲
Pin 6: ▲



Pin 7: ▲
Pin 8: Cathode
Pin 9: ▲
Pin 10: Heater
Pin 11: Omitted
Pin 12: Heater

▲ Pin has internal connection and is cut off close to ceramic wafer--Do Not Use.

MEDIUM CERAMIC-WAFER TWELVAR BASE



JEDEC No.	NAME	PINS
E12-64	12-Pin Base	1,2,3,4,5,6,7,8, 9,10,11,12
E5-65	5-Pin Base	2,4,8,10,12, (Note 2)

Note 1: Maximum O.D. of 0.440" is permitted along the 0.190" lug length.

Note 2: Pins 1,3,5,6,7, and 9 are cut off to a length such that their ends do not touch the socket insertion plane. Pin 11 is omitted.

PIN-ALIGNMENT GAUGE

Base-pin positions and lug positions shall be held to tolerances such that entire length of pins and lugs will without undue force pass into and disengage from flat-plate gauge having thickness of 0.25" and twelve holes of 0.0350" ± 0.0005" diameter located on four concentric circles as follows: three holes located on 0.2800" ± 0.0005", three holes located on 0.2100" ± 0.0005", three holes located on 0.1400" ± 0.0005", three holes located on 0.0700" ± 0.0005" diameter circles at specified angles with a tolerance of ± 0.08° for each angle. In addition, gauge provides for two curved slots with chordal lengths of 0.2270" ± 0.0005" and 0.1450" ± 0.0005" located on 0.4200" ± 0.0005" diameter circle concentric with pin circles at 180° ± 0.08° and having a width of 0.0230" ± 0.0005".

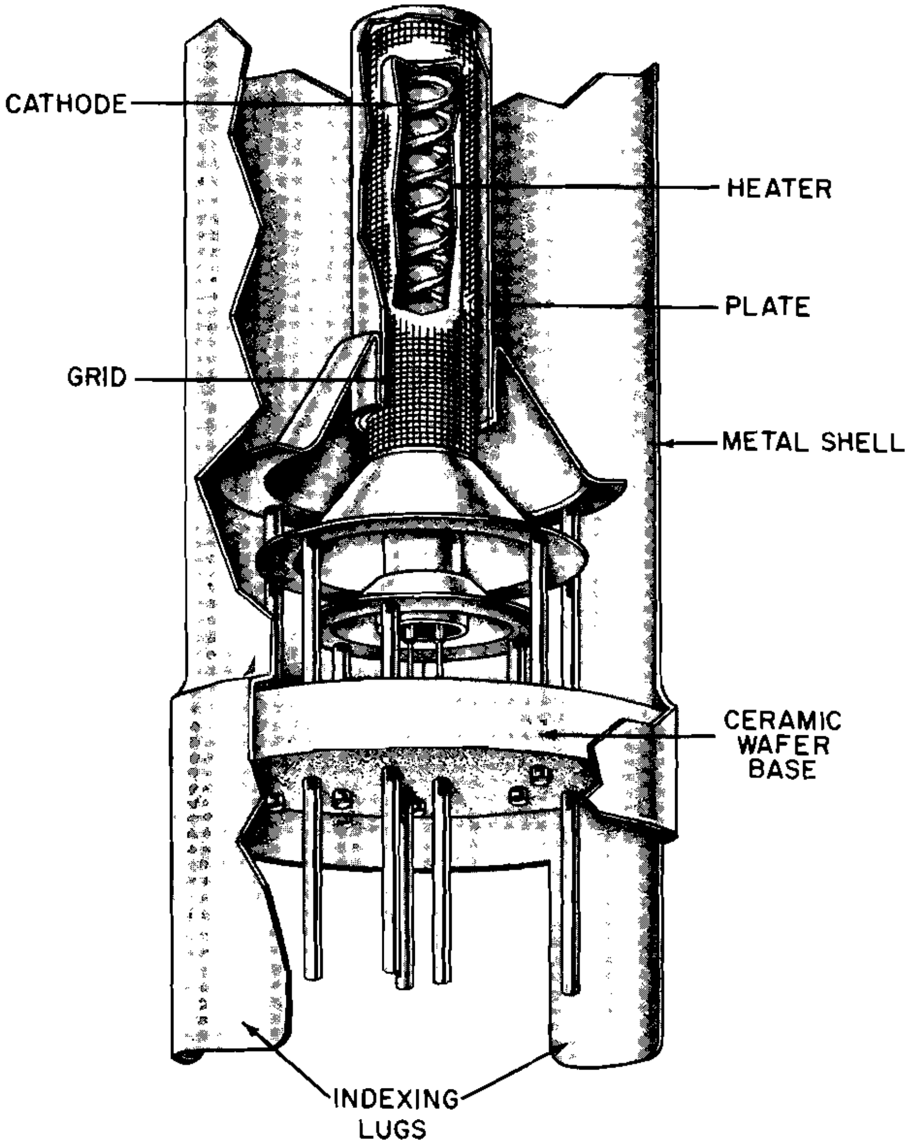
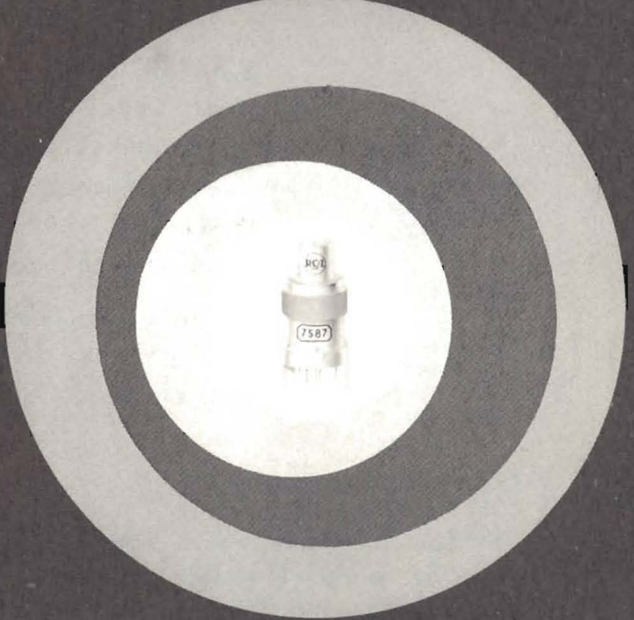


Fig. 6 - Illustration of a nuvistor triode showing cylindrical electrodes and tripod-like supports.

RCA nuvistor



GENERAL-PURPOSE INDUSTRIAL SHARP-CUTOFF TETRODE

7587

• Low heater drain • Very high transconductance at low plate current • Exceptional uniformity of characteristics from tube to tube • Operation at full ratings at all altitudes • Rigorously controlled and tested • All-metal-and-ceramic construction • High resistance to shock and vibration • Operation at metal shell temperatures up to 150° C • Sharp-cutoff characteristics • Approx. 1 inch long; less than ½ inch in diameter; weighs approx. 2.35 g

RADIO CORPORATION OF AMERICA
Electron Tube Division Harrison, N. J.

RCA-7587

SHARP-CUTOFF TETRODE

Nuvistor Type for Industrial Applications

Actual Size

RCA-7587 is a sharp-cutoff, general-purpose tetrode of the nuvistor type. It is designed for use in a wide variety of industrial and military small-signal applications requiring compactness, low current drain, relatively low-voltage operation, exceptional uniformity of characteristics from tube to tube, and ability to withstand severe mechanical shock and vibration.

These features plus its small size and light weight make the 7587 particularly suitable for rf-if, video-amplifier, and mixer service.

General Features

The 7587 has an all-metal-and-ceramic envelope provided with two peripheral lugs of unequal width to facilitate insertion in a socket. It is only 1.05" long, less than 1/2" in diameter, and weighs approximately 2.35 g. The 7587 features (1) a very rugged structure of unique design (2) a 6.3-volt low-wattage heater, and a specially designed cathode to assure very low heater-cathode leakage, (3) high transconductance at low plate current (10600 micromhos at 10 milliamperes), (4) very high input impedance, (5) high perveance, and (6) ability to operate at full ratings at any altitude.

Structural Features

A major feature of the 7587 is its all-ceramic-and-metal construction utilizing a light-weight, cantilever-supported cylindrical electrode structure. This unique type of electrode structure, inherent in the nuvistor design, provides a structure of excellent mechanical stability and extreme ruggedness. All connections are brazed at very high temperatures in a hydrogen atmosphere to eliminate the structural strain and element distortion often caused by welding. The tube is also exhausted and sealed at very high temperatures to eliminate the gases and impurities which are generally present in electron devices processed at low temperatures.

The structure of the 7587 nuvistor tetrode also permits automatic assembly using parts made to extremely small tolerances, thus assuring exceptional uniformity of characteristics from tube to tube.

Special Tests and Controls

The 7587 is rigidly controlled during manufacture, and is subjected to rigorous tests for intermittent shorts; for early-hour, 100-hour, and 1000-hour life performance; for resistance to impact shock, low-frequency vibration, variable-frequency vibration, low-pressure breakdown, and heater cycling.

Special Tests and Controls (Cont'd)

These special controls and tests, together with high transconductance at low plate current and voltage, small power requirements, ability to operate at full ratings at any altitude, and extremely small size, make the 7587 nuvistor tetrode exceptionally desirable for critical industrial applications — for example, in communications equipment, control and instrumentation equipment, medical electronic equipment, TV cameras, and test and measurement instruments.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage (ac or dc)	6.3 ± 10%	volts
Current at 6.3 volts	0.15	ampere
Direct Interelectrode Capacitances:		
Grid-No.1 to plate	0.012 max.	µµf
Grid-No.1 to cathode, grid-No.2, heater & shell	7.0	µµf
Plate to cathode, grid-No.2, heater & shell	1.4	µµf
Heater to cathode	1.4	µµf

Characteristics, Class A_1 Amplifier:

Plate-Supply Voltage	125	volts
Grid-No.2 Supply Voltage	50	volts
Cathode Resistor	68	ohms
Plate Resistance (Approx.)	0.2	megohm
Transconductance	10600	µmhos
Plate Current	10	ma
Grid-No.2 Current	2.7	ma
Grid-No.1 Voltage (Approx.) for plate current of 10 µa	4.5	volts

Mechanical:

Operating Position	Any
Maximum Overall Length	1.050"
Maximum Seated Length	0.840"
Maximum Diameter	0.440"
Envelope	Metal and Ceramic Shell
Cap	JEDEC No.C1-44
Base	Medium Ceramic-Wafer Twelvar 5-Pin (JEDEC No.E5-65)
Socket	Cinch Mfg. Co. No.133 65 10 001, or Equivalent

INDUSTRIAL SERVICE

Maximum Ratings, *Absolute-Maximum Values:*

For Operation at Any Altitude

PLATE SUPPLY VOLTAGE	330 max.	volts
PLATE VOLTAGE	250 max.	volts
GRID-No.2 (SCREEN-GRID) SUPPLY VOLTAGE	330 max.	volts
GRID-No.2 VOLTAGE	110 max.	volts
GRID-No.1 (CONTROL-GRID) VOLTAGE:		
Negative bias value	55 max.	volts
Peak positive value	2 max.	volts
CATHODE CURRENT	20 max.	ma
GRID-No.1 CURRENT	2 max.	ma

PLATE DISSIPATION	2.2 max.	watts
GRID-No.2 INPUT	0.2 max.	watt
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	100 max.	volts
Heater positive with respect to cathode	100 max.	volts

Maximum Circuit Values:

Grid-No.1 Circuit Resistance:[a]		
For fixed-bias operation	0.5 max.	megohm
For cathode-bias operation	1 max.	megohm

[a] For Operation at Metal-Shell Temperatures up to 150° C (See Dimensional Outline Drawing on Page 9).

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN

	Note	*Min.*	*Max.*	
Heater Current	1	0.140	0.160	ampere
Direct Interelectrode Capacitances:				
Grid-No.1 to plate	2		0.012	µµf
Grid-No.1 to cathode, grid No.2, heater & shell	2	6.0	8.0	µµf
Plate to cathode, grid No.2, heater & shell	2	1.2	1.6	µµf
Heater to cathode	2	1.1	1.7	µµf
Plate Current (1)	1,3	8.5	11.5	ma
Plate Current (2)	1,4	-	50	µa
Grid-No.2 Current	1,3	1.8	3.6	ma
Transconductance (1)	1,3	9000	12200	µmhos
Transconductance (2)	3,5	8000	-	µmhos
Transconductance Change:				
Difference between Transconductance (1) and Transconductance (2), expressed in per cent of Transconductance (1)	-	-	20	%
Reverse Grid Current	1,6	-	0.1	µa
Heater-Cathode Leakage Current:				
Heater negative with respect to cathode	1,8	-	5.0	µa
Heater positive with respect to cathode	1,8	-	5.0	µa
Leakage Resistance:				
Between grid No.2 and all other electrodes tied together	1,7	500	-	megohms
Between grid No.1 and all other electrodes tied together	1,9	500	-	megohms
Between plate and all other electrodes tied together	1,10	500	-	megohms

Note 1: With 6.3 volts ac or dc on heater.

Note 2: Measured in accordance with EIA Standard RS-191-A.

Note 3: With dc plate volts = 125, dc grid-No.2 volts = 50, cathode resistor = 68 ohms, and cathode-bypass capacitor = 1000 µf.

Note 4: With dc plate volts = 125, dc grid-No.2 volts = 50, dc grid-No.1 volts = -6, and metal shell grounded.

Note 5: With 5.7 volts ac or dc on heater.

Note 6: With dc plate volts = 200, dc grid-No.2 volts = 70, grid-No.1 supply volts = -1.6, grid-No.1 resistor = 0.5 megohm, and metal shell grounded.

Note 7: With grid-No.2 100 volts negative with respect to all other electrodes tied together.

Note 8: With 100 volts dc applied between heater and cathode.

Note 9: With grid No.1 100 volts negative with respect to all other electrodes tied together.

Note 10: With plate 300 volts negative with respect to all other electrodes tied together.

SPECIAL RATINGS AND PERFORMANCE DATA

Shock Rating:

Impact Acceleration. . . . . 1000 max. g

This test is performed on a sample lot of tubes from each production run to determine ability of tube to withstand the specified impact acceleration. Tubes are held rigid in four different positions in a Navy Type, High-impact (flyweight) Shock Machine and are subjected to 20 blows at the specified maximum impact acceleration. At the end of this test, tubes are criticized for change in transconductance, reverse grid current, and heater-cathode leakage current, and are then subjected to the Variable-Frequency Vibration Test described later.

Fatigue Rating:

Vibrational Acceleration. . . . . 2.5 max. g

This test is performed on a sample lot of tubes to determine ability of tube to withstand the specified vibrational acceleration. Tubes are rigidly mounted, supplied with rated heater voltage only, and subjected for 48 hours to 2.5 g vibrational acceleration at 60 cycles per second in a direction perpendicular to the longitudinal axis of the tube. At the end of this test, tubes are criticized for the same characteristics and end-point values as in the Shock Rating Test described previously.

Variable-Frequency-Vibration Performance:

This test is performed on a sample lot of tubes from each production run. The tube is operated under the conditions specified in CHARACTERISTICS RANGE VALUES for Transconductance (1) with the addition of a plate-load resistor of 2000 ohms. During operation, tube is vibrated in a direction perpendicular to the longitudinal axis of the tube through the frequency range from 50 to 15000 cycles per second with a constant vibrational acceleration of 1 g. During the test, tube must not show an rms output voltage across the plate-load resistor in excess of:

35 millivolts over the frequency range from 50 to 6000 cps
500 millivolts over the frequency range from 6000 to 15000 cps

Low-Pressure Voltage-Breakdown Test:

This test is performed on a sample lot of tubes from each production run. In this test tubes are operated with 240 rms volts applied between plate and all other electrodes and will not break down or show evidence of corona when subjected to air pressures equivalent to altitudes up to 100000 feet.

Heater Cycling:

Cycles of Intermittent Operation. . . . . 2000 min. cycles

This test is performed on a sample lot of tubes from each production run under the following conditions: heater volts = 7.5, cycled one minute on and two minutes off; heater 100 volts negative with respect to cathode; grid No.1, grid No.2, plate, and metal shell connected to ground. At the end of this test tubes are tested for open heaters and heater-cathode shorts.

Intermittent Shorts:

This test is performed on a sample lot of tubes from each production run. Tubes are subjected to the Thyratron-Type Shorts Test described in MIL-E-1D, Amendment 2, Par. 4.7.7, except that tapping is done by hand with a soft rubber tapper[b]. The Acceptance Curve for this test is shown in Fig.3. In this test tubes are criticized for permanent or temporary shorts and open circuits.

Early-Hour Stability Life Performance:

This test is performed on a sample lot of tubes from each production run to insure that tubes are properly stabilized. In this test tubes are operated for 20 hours at maximum rated plate dissipation. After two hours of operation and again after 20 hours of operation tubes are checked for transconductance under the conditions specified in CHARACTERISTICS RANGE VALUES for Transconductance (1). A tube is rejected if its transconductance after two or 20 hours of operation has changed more than 10 per cent from the 0-hour value.

100-Hour Life Performance:

This test is performed on a sample lot of tubes from each production run to insure a low percentage of early-hour inoperatives. Tubes are operated for 100 hours at maximum rated plate dissipation, and then subjected to the Intermittent Shorts Test previously described. Tubes must then show a transconductance of not less than 7600 micromhos under the conditions specified in CHARACTERISTICS RANGE VALUES for Transconductance (1), and a value not greater than one microampere for reverse grid current.

1000-Hour Life Performance:

This test is performed on a sample lot of tubes from each production run to insure high quality of the individual tube and guard against epidemic failures due to excessive changes in any of the characteristics indicated below. In this test tubes are operated for 1000 hours at maximum rated plate dissipation and then criticized for inoperatives, reverse grid current, heater-cathode leakage current, and the leakage resistance. In addition, the average change in transconductance of the lot from the 0-hour value for Transconductance (1) specified in CHARACTERISTICS RANGE VALUES, must not exceed 20 per cent at 500 hours and 25 per cent at 1000 hours.

[b] Specifications for this tapper will be supplied on request.

OPERATING CONSIDERATIONS

The *base-pins* of the 7587 fit the Cinch Mfg. Co. socket No.133 65 10 001 or equivalent. The socket may be mounted to hold the tube in any position.

The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Absolute-Maximum Rating System* for rating electron devices.

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, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

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 device characteristics.

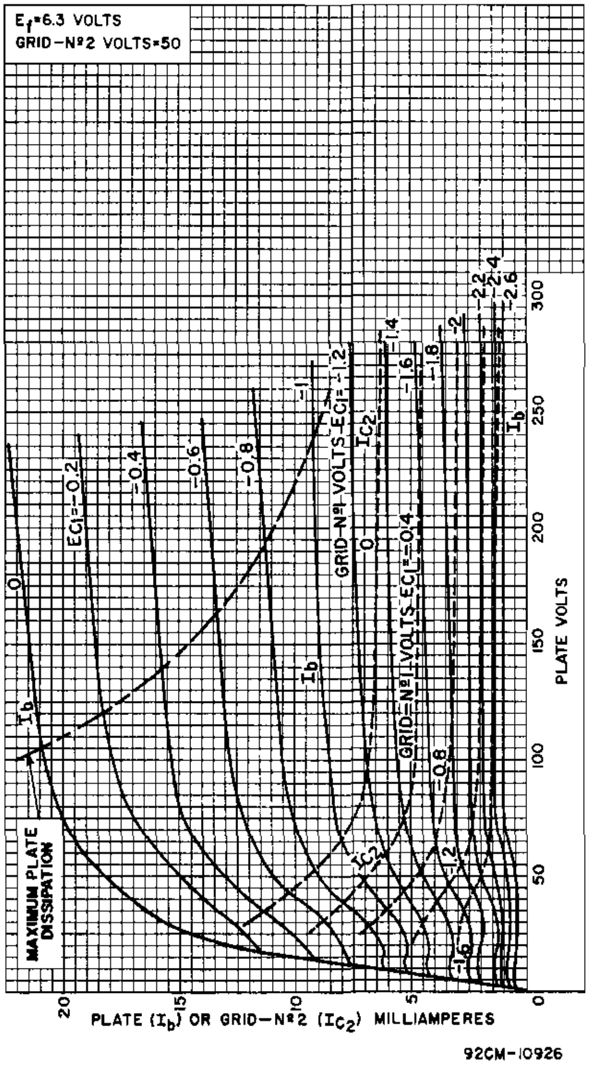


Fig. 1 - Average Characteristics for Type 7587.

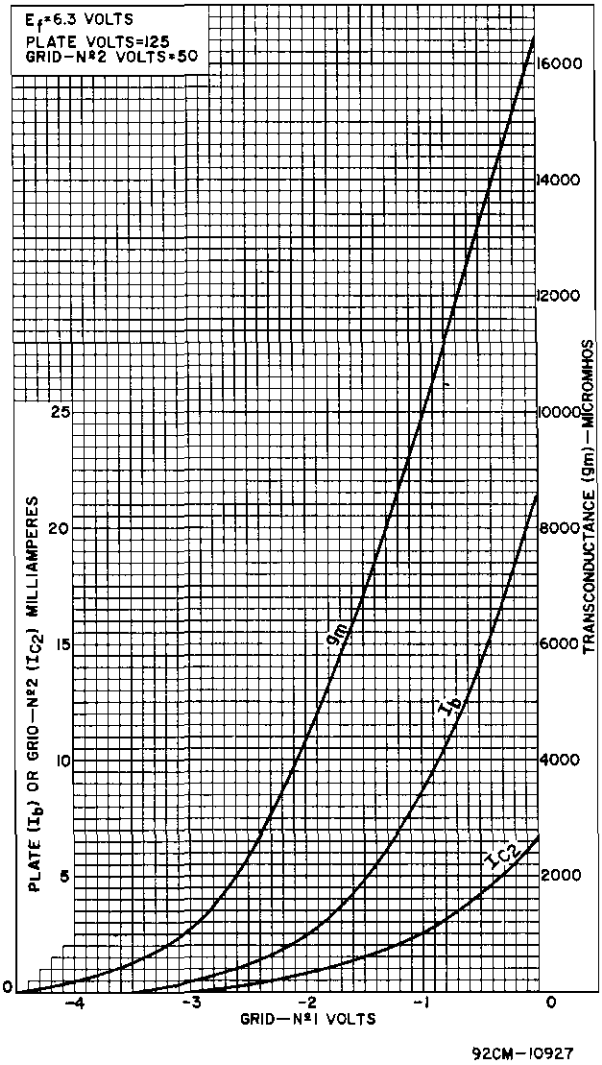


Fig. 2 - Average Characteristics for Type 7587.

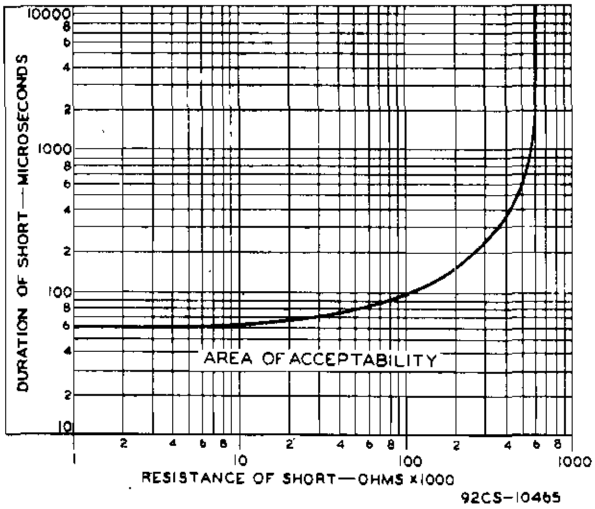
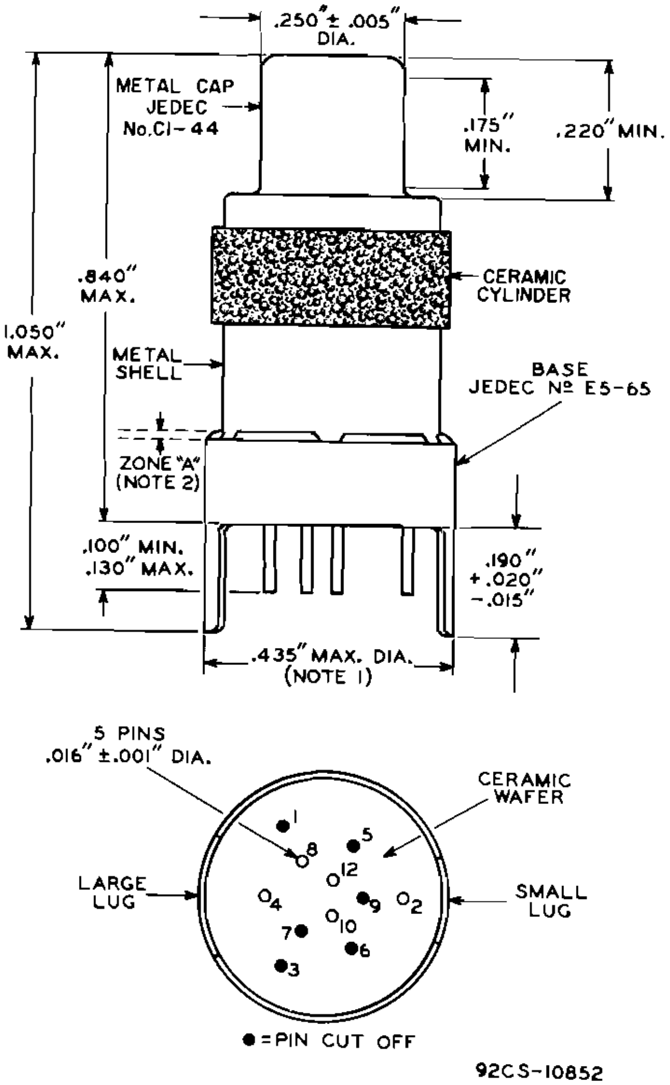


Fig. 3 - Thyratron-Type Shorts Test for Type 7587.

DIMENSIONAL OUTLINE



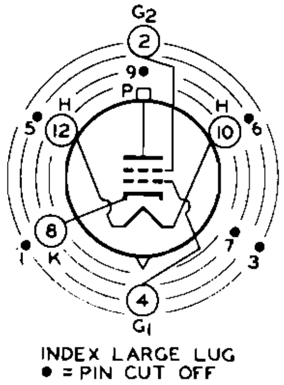
92CS-10852

NOTE 1: MAXIMUM O.D. OF 0.440" IS PERMITTED ALONG 0.190" LUG LENGTH.

NOTE 2: SHELL TEMPERATURE SHOULD BE MEASURED IN ZONE "A" BETWEEN BROKEN LINES.

BASING DIAGRAM (Bottom View)

PIN 1: ▲
PIN 2: GRID No.2
PIN 3: ▲
PIN 4: GRID No.1
PIN 5: ▲
PIN 6: ▲

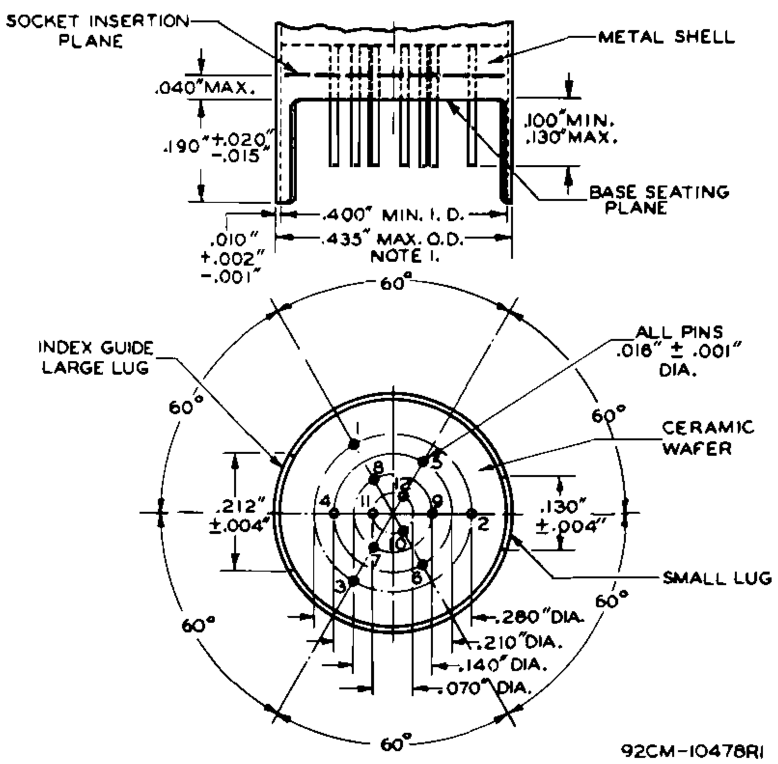


PIN 7: ▲
PIN 8: CATHODE
PIN 9: ▲
PIN 10: HEATER
PIN 11: OMITTED
PIN 12: HEATER
CAP: PLATE

12AS

▲ Pin has internal connection and is cut off close to ceramic wafer--Do Not Use.

MEDIUM CERAMIC-WAFER TWELVAR BASE



JEDEC No.	NAME	PINS
E12-64	12-Pin Base	1,2,3,4,5,6,7,8, 9,10,11,12
E5-65	5-Pin Base	2,4,8,10,12, (Note 2)

Note 1: Maximum O.D. of 0.440" is permitted along the 0.190" lug length.

Note 2: Pins 1,3,5,6,7, and 9 are cut off to a length such that their ends do not touch the socket insertion plane. Pin 11 is omitted.

PIN-ALIGNMENT GAUGE

Base pin positions and lug positions shall be held to tolerances such that entire length of pins and lugs will without undue force pass into and disengage from flat-plate gauge having thickness of 0.25" and twelve holes of 0.0350" ± 0.0005" diameter located on four concentric circles as follows: Three holes located on 0.2800" ± 0.0005", three holes located on 0.2100" ± 0.0005", three holes located on 0.1400" ± 0.0005", three holes located on 0.0700" ± 0.0005" diameter circles at specified angles with a tolerance of ± 0.08° for each angle. In addition, gauge provides for two curved slots with chordal lengths of 0.2270" ± 0.0005" and 0.1450" ± 0.0005" located on 0.4200" ± 0.0005" diameter circle concentric with pin circles at 180° ± 0.08° and having a width of 0.0230" ± 0.0005".

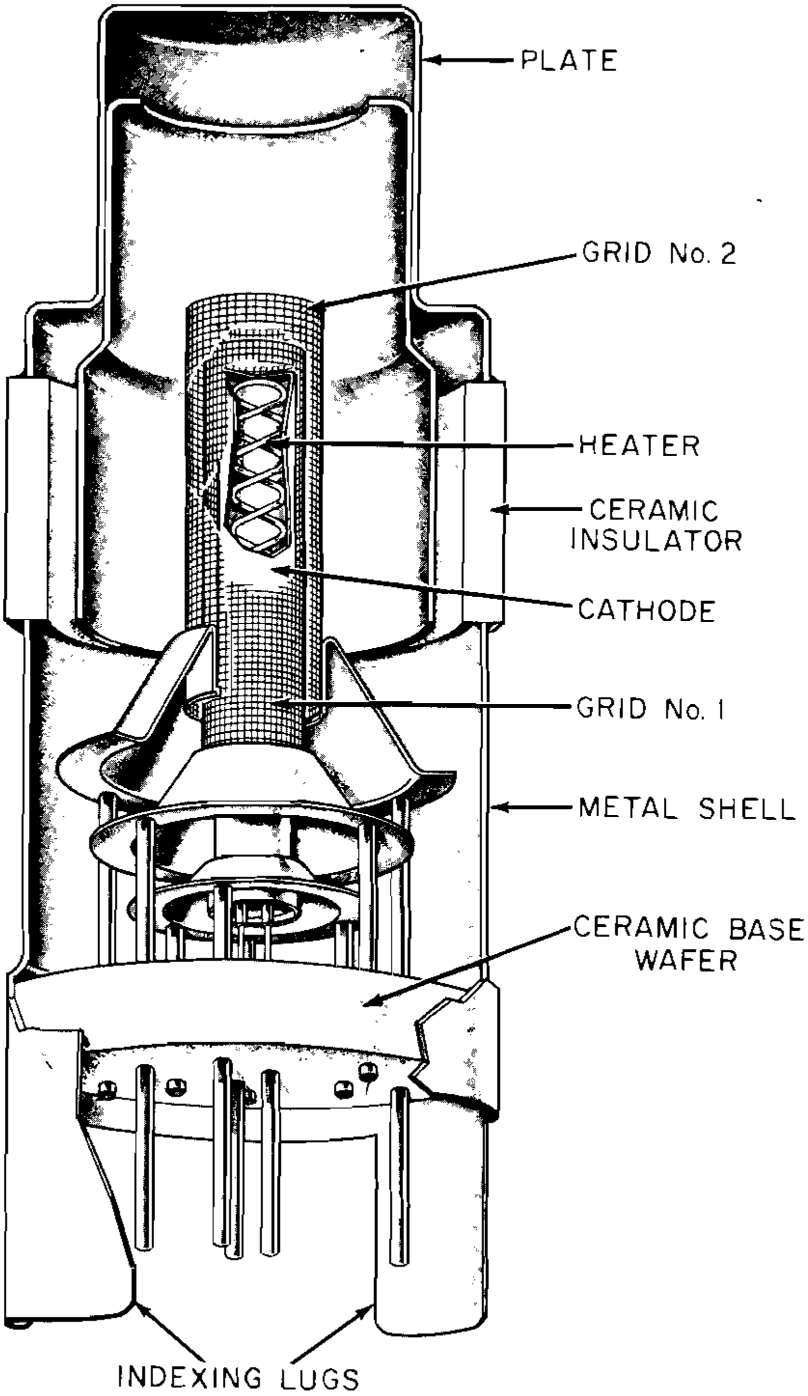
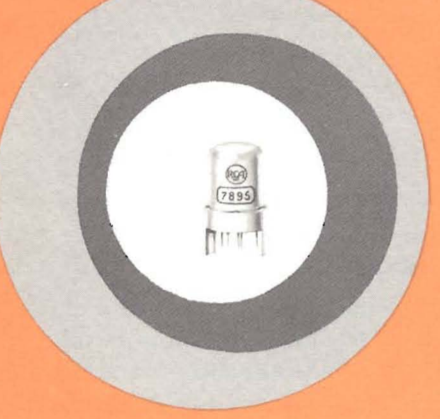


Fig.4 - Illustration of a nuvistor tetrode showing cylindrical electrodes and tripod-like supports.


RCA

RCA
nuvistor



7895
HIGH-MU TRIODE
($\mu=64$)
for INDUSTRIAL APPLICATIONS

- High transconductance at low plate current
- High gain with low noise
- Low heater drain
- High resistance to shock and vibration
- Exceptional uniformity of characteristics from tube to tube
- Operation at full ratings at all altitudes
- Rigorously controlled and tested
- All-metal and ceramic construction
- Only 8/10 inch long; less than 1/2 inch in diameter; weighs 1/15 oz.

RADIO CORPORATION OF AMERICA
Electron Tube Division Harrison, N. J.

Printed in U.S.A.

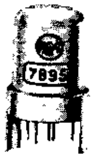
RCA-7895

HIGH-MU TRIODE

Nuvistor Type for Industrial Applications

Amplification Factor = 64

RCA-7895 is a high-mu nuvistor triode of the heater-cathode type designed for use in a wide variety of applications in industrial equipment where compactness, low drain, negligible interface resistance, exceptional uniformity of characteristics from tube to tube, and ability to withstand severe mechanical shock and vibration are primary design requirements. It is capable of providing high gain with low noise in amplifier service, excellent stability as an oscillator over a wide range of frequencies, and reliable performance in applications such as on-off control involving long periods of standby operation.



Actual Size

The 7895 is rigidly controlled during manufacture, and is subjected to rigorous tests for intermittent shorts and interelectrode leakage; for early-hour, 100-hour, and 1000-hour conduction life performance; for 1000-hour standby life performance; for resistance to impact shock, low-frequency vibration, variable-frequency vibration, low-pressure breakdown, and heater cycling.

These special controls and tests, together with high transconductance at low-plate current and voltage, small power requirements, ability to operate at full ratings at any altitude, and extremely small size, make the 7895 nuvistor high-mu triode exceptionally desirable for critical industrial applications.

General Features

The 7895 has a metal envelope provided with two peripheral lugs of unequal width for indexing, is only 8/10" long, less than 1/2" in diameter, and weighs approximately 1/15 ounce (1.9 grams). It features (1) a very rugged structure of unique design, (2) a 6.3 volt low-wattage heater, and a specially designed cathode made of passive material to assure very low interface resistance and leakage, (3) high transconductance at low plate voltage and current (9400 micromhos at 110 volts and 7.0 milliamperes), (4) very high input impedance, (5) high perveance, and (6) ability to operate at full ratings at any altitude.

Structural Features

A major feature of the 7895 is its all-ceramic-and-metal construction utilizing a light-weight, cantilever-supported cylindrical electrode structure. This unique type of electrode structure, inherent in the nuvistor design, uses

Structural Features (Cont'd)

only strong metals and ceramics to provide a structure of extreme ruggedness. All connections are brazed at very high temperatures in a hydrogen atmosphere to eliminate the structural strain and element distortion often caused by welding. The tube is also exhausted and sealed at very high temperatures to eliminate the gases and impurities which are generally present in electron devices processed at low temperatures.

The structure of the 7895 nuvistor triode also permits automatic assembly using parts made to extremely small tolerances, thus assuring exceptional uniformity of characteristics from tube to tube.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage (ac or dc)	6.3 ± 10%	volts
Current at 6.3 volts	0.135	amp
Direct Interelectrode Capacitances (Approx.):		
Grid to plate	0.9	μμf
Grid to cathode, heater, and shell	4.2	μμf
Plate to cathode, heater, and shell	1.7	μμf
Heater to cathode	1.3	μμf
Plate to cathode	0.22	μμf

Characteristics, Class A$_1$ Amplifier:

Plate-Supply Voltage	110	volts
Grid-Supply Voltage	0	volts
Cathode Resistor	150	ohms
Amplification Factor	64	
Plate Resistance (Approx.)	6800	ohms
Transconductance	9400	μmhos
Plate Current	7.0	ma
Grid Voltage (Approx.) for plate current = 10 μa	-4	volts

Mechanical:

Operating Position	Any
Maximum Over-all Length	0.8"
Maximum Seated Length	0.625"
Maximum Diameter	0.440"
Envelope	Metal Shell
Base	Medium Ceramic-Wafer Twelvar 5-Pin (JEDEC No.E5-65)
Socket	Cinch Mfg. Co. No. 133 65 10 001, or Equivalent

INDUSTRIAL SERVICE

Maximum Ratings, *Absolute-Maximum Values:*

For Operation at Any Altitude

PLATE SUPPLY VOLTAGE	330 max.	volts
PLATE VOLTAGE	110 max.	volts
GRID VOLTAGE:		
Negative-bias value	55 max.	volts
Peak positive value	2 max.	volts

PLATE DISSIPATION	1 max.	watt
GRID CURRENT	2 max.	ma
CATHODE CURRENT	15 max.	ma
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	100 max.	volts
Heater positive with respect to cathode	100 max.	volts

Maximum Circuit Values:

Grid-Circuit Resistance:*		
For fixed-bias operation	0.5 max.	megohm
For cathode-bias operation	1 max.	megohm

* For Operation at Metal-Shell Temperatures up to 150° C (See Dimensional Outline Drawing on Page 9).

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN

	Note	*Min.*	*Max.*	
Heater Current	1	0.125	0.145	amp
Direct Interelectrode Capacitances:				
Grid to plate	2	0.8	1.0	μμf
Grid to cathode, heater, and shell	2	3.4	5.0	μμf
Plate to cathode, heater, and shell	2	1.3	2.1	μμf
Heater to cathode	2	1.0	1.6	μμf
Plate to cathode	2	.16	.28	μμf
Plate Current (1)	1,3	5.5	8.8	ma
Plate Current (2)	1,4	-	50	μa
Transconductance (1)	1,3	7900	10900	μmhos
Transconductance (2)	3,5	6900	-	μmhos
Transconductance Change:				
Difference between Transconductance (1) and Transconductance (2), expressed in per cent of Transconductance (1)	-	-	15	%
Reverse Grid Current	1,6	-	0.1	μa
Amplification Factor	1,3	54	74	
Heater-Cathode Leakage Current:				
Heater negative with respect to cathode	1,7	-	5	μa
Heater positive with respect to cathode	1,7	-	5	μa
Leakage Resistance:				
Between grid and all other electrodes tied together	1,8	1000		megohms
Between plate and all other electrodes tied together	1,9	1000		megohms

Note 1: With 6.3 volts ac or dc on heater.

Note 2: Measured in accordance with EIA Standard RS-191-A.

Note 3: With dc plate volts = 110, cathode resistor = 150 ohms, and cathode-bypass capacitor = 1000 μf.

Note 4: With dc plate volts = 110, dc grid volts = -5, and metal shell grounded.

Note 5: With 5.7 volts ac or dc on heater.

Note 6: With dc plate volts = 150, grid-supply volts = -1.7, grid resistor = 0.5 megohm, and metal shell grounded.

Note 7: With 100 volts dc applied between heater and cathode.

Note 8: With grid 100 volts negative with respect to all other electrodes tied together.

Note 9: With plate 300 volts negative with respect to all other electrodes tied together.

SPECIAL RATINGS AND PERFORMANCE DATA

Shock Rating:

Impact Acceleration . . . . 1000 max. g

This test is performed on a sample lot of tubes from each production run to determine ability of tube to withstand the specified impact acceleration. Tubes are held rigid in four different positions in a Navy Type, High-impact (flyweight) Shock Machine and are subjected to 20 blows at the specified maximum impact acceleration. At the end of this test, tubes are criticized for change in transconductance, reverse grid current, and heater-cathode leakage current, and are then subjected to the Variable-Frequency Vibration Test described later.

Fatigue Rating:

Vibrational Acceleration. . . . . 2.5 max. g

This test is performed on a sample lot of tubes to determine ability of tube to withstand the specified vibrational acceleration. Tubes are rigidly mounted, supplied with normal heater voltage only, and subjected for 48 hours to 2.5 g vibrational acceleration at 60 cycles per second in a direction perpendicular to the longitudinal axis of the tube. At the end of this test, tubes are criticized for the same characteristics and end-point values as in the Shock Rating Test described previously.

Variable-Frequency-Vibration Performance:

This test is performed on a sample lot of tubes from each production run. The tube is operated under the conditions specified in CHARACTERISTICS RANGE VALUES for Transconductance (1) with the addition of a plate-load resistor of 2000 ohms. During operation, tube is vibrated in a direction perpendicular to the longitudinal axis of the tube through the frequency range from 50 to 15000 cycles per second under the following conditions: a sweep rate of one octave per 30 seconds from 50 to 3000 cps, a 7-second sweep from 3000 to 15000 cps, and a constant vibrational acceleration of 1g. During the test, tube must not show an rms output voltage in excess of:

35 mv over the frequency range from 50 to 3000 cps
60 mv over the frequency range from 3000 to 6000 cps
500 mv over the frequency range from 6000 to 15000 cps

Low-Pressure Voltage-Breakdown Test:

This test is performed on a sample lot of tubes from each production run. In this test tubes are operated with 240 rms volts applied between plate and all other electrodes and will not break down or show evidence of corona when subjected to air pressures equivalent to altitudes of up to 100000 feet.

Heater Cycling:

Cycles of Intermittent Operation. . . . . 2000 min. cycles

This test is performed on a sample lot of tubes from each production run under the following conditions: heater volts = 7.5 cycled one minute on and two minutes off; heater 100 volts negative with respect to cathode; grid, plate, and metal shell connected to ground. At the end of this test tubes are tested for open heaters, heater-cathode shorts, and heater-cathode leakage current.

Intermittent Shorts:

This test is performed on a sample lot of tubes from each production run. Tubes are subjected to the Thyratron-Type Shorts Test described in MIL-E-ID, Amendment 2, Par. 4.7.7, except that tapping is done by hand with a soft rubber tapper*. The Acceptance Curve for this test is shown in Fig.3. In this test tubes are criticized for permanent or temporary shorts and open circuits.

Early-Hour-Stability Life Performance:

This test is performed on a sample lot of tubes from each production run to insure that tubes are properly stabilized. In this test tubes are operated for 20 hours at maximum rated plate dissipation. After 2 hours of operation and again after 20 hours of operation tubes are checked for transconductance under the conditions specified in CHARACTERISTICS RANGE VALUES for Transconductance (1). A tube is rejected if its transconductance after 2 or 20 hours of operation has changed more than 10 per cent from the 0-hour value.

100-Hour Life Performance:

This test is performed on a sample lot of tubes from each production run to insure a low percentage of early-hour inoperatives. Tubes are operated for 100 hours at maximum rated plate dissipation, and then subjected to the Intermittent Shorts test previously described. Following this, tubes must show a value not less than 6200 micromhos for Transconductance (1), and a value not greater than 0.2 microampere for Reverse Grid Current under the conditions specified in CHARACTERISTICS RANGE VALUES.

1000-Hour Conduction Life Performance:

This test is performed on a sample lot of tubes from each production run to insure high quality of the individual tube and guard against epidemic failures due to excessive changes in any of the characteristics indicated below. In this test tubes are operated for 1000 hours at maximum rated plate dissipation with a metal-shell temperature of 150° C and then criticized for inoperatives, reverse grid current, heater-cathode leakage current, and leakage resistance. In addition, the average change in transconductance of the lot from the 0-hour value for Transconductance (1) specified in CHARACTERISTICS RANGE VALUES, must not exceed 15 per cent at 500 hours, and 20 per cent at 1000 hours.

1000-Hour Standby Life Performance:

This test is performed on a sample lot of tubes from each production run. The tubes are operated for 1000 hours with only normal heater voltage applied. The tubes are then criticized for interelectrode leakage, reverse grid current, change in transconductance of individual tubes from the values at zero hours and cathode interface resistance greater than 25 ohms. Interface resistance is measured by Method B of ASTM specification F300-57T.

* Specifications for this tapper will be supplied on request.

OPERATING CONSIDERATIONS

The *base pins* of the 7895 fit the Cinch Mfg. Co. socket No. 133 65 10 001 or equivalent. The socket may be mounted to hold the tube in any position.

The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Absolute-Maximum Rating System* for rating electron devices.

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, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

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 device characteristics.

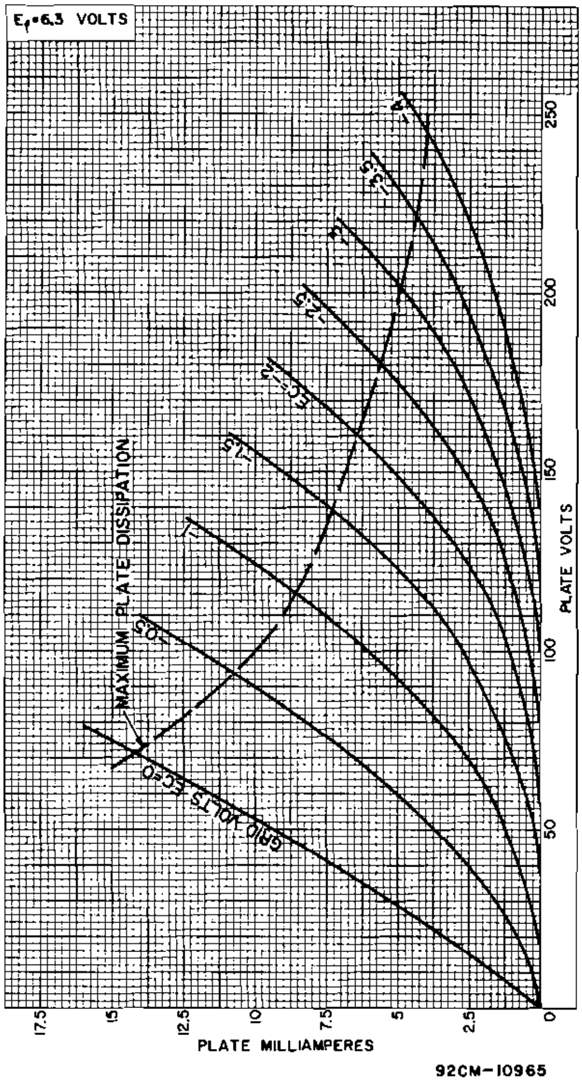


Fig. 1 - Average Plate Characteristics for Type 7895.

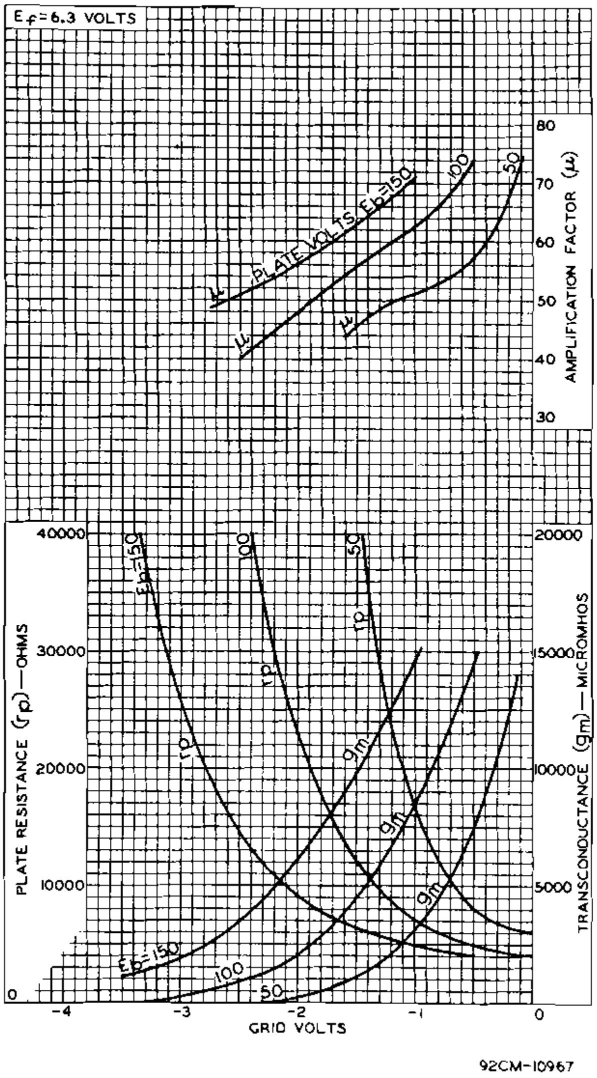


Fig. 2 - Average Characteristics for Type 7895.

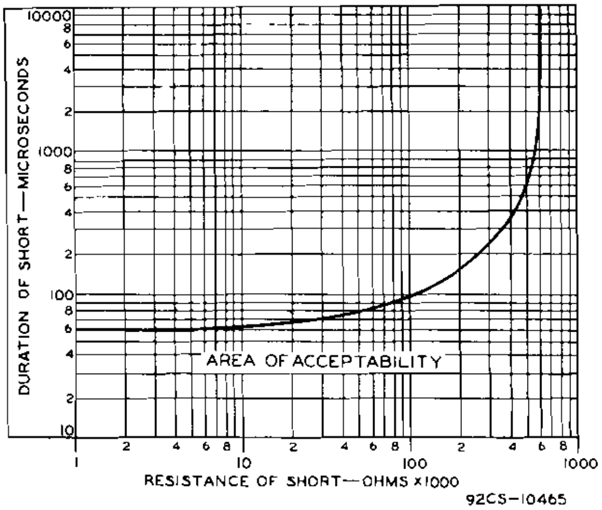
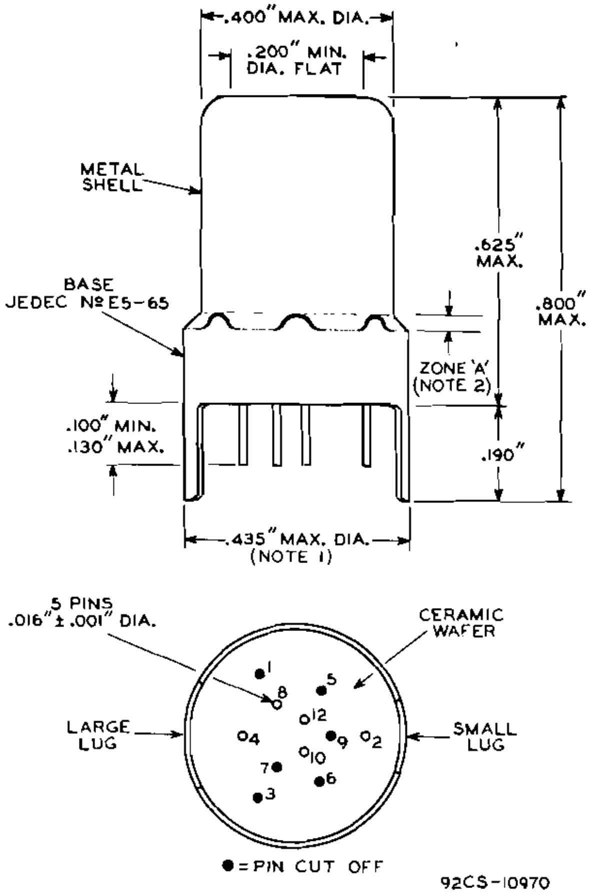


Fig. 3 - Thyratron-Type Shorts Test for Type 7895.

DIMENSIONAL OUTLINE

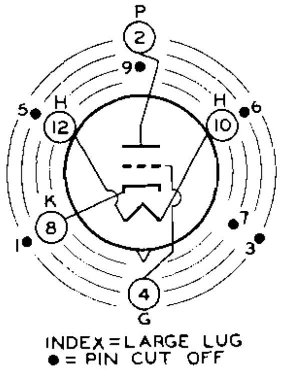


NOTE 1: MAXIMUM O.D. OF 0.440" IS PERMITTED ALONG 0.190" LUG LENGTH.

NOTE 2: SHELL TEMPERATURE SHOULD BE MEASURED IN ZONE "A" BETWEEN BROKEN LINES.

BASING DIAGRAM (Bottom View)

PIN 1: ▲
PIN 2: PLATE
PIN 3: ▲
PIN 4: GRID
PIN 5: ▲
PIN 6: ▲

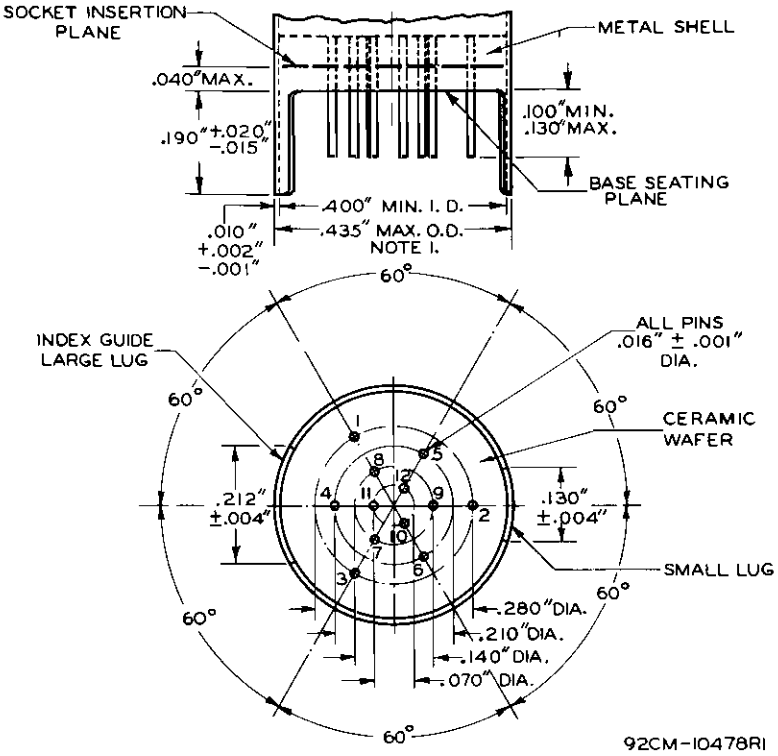


PIN 7: ▲
PIN 8: CATHODE
PIN 9: ▲
PIN 10: HEATER
PIN 11: OMITTED
PIN 12: HEATER

12AQ

▲ Pin has internal connection and is cut off close to ceramic wafer--Do Not Use.

MEDIUM CERAMIC-WAFER TWELVAR BASE



92CM-10478R1

JEDEC No.	NAME	PINS
E12-64	12-Pin Base	1,2,3,4,5,6,7,8, 9,10,11,12
E5-65	5-Pin Base	2,4,8,10,12, (Note 2)

Note 1: Maximum O.D. of 0.440" is permitted along the 0.190" lug length.

Note 2: Pins 1,3,5,6,7, and 9 are cut off to a length such that their ends do not touch the socket insertion plane. Pin 11 is omitted.

PIN-ALIGNMENT GAUGE

Base-pin positions and lug positions shall be held to tolerances such that entire length of pins and lugs will without undue force pass into and disengage from flat-plate gauge having thickness of 0.25" and twelve holes of 0.0350" ± 0.0005" diameter located on four concentric circles as follows: Three holes located on 0.2800" ± 0.0005", three holes located on 0.2100" ± 0.0005", three holes located on 0.1400" ± 0.0005", three holes located on 0.0700" ± 0.0005" diameter circles at specified angles with a tolerance of ± 0.08° for each angle. In addition, gauge provides for two curved slots with chordal lengths of 0.2270" ± 0.0005" and 0.1450" ± 0.0005" located on 0.4200" ± 0.0005" diameter circle concentric with pin circles at 180° ± 0.08° and having a width of 0.0230" ± 0.0005".

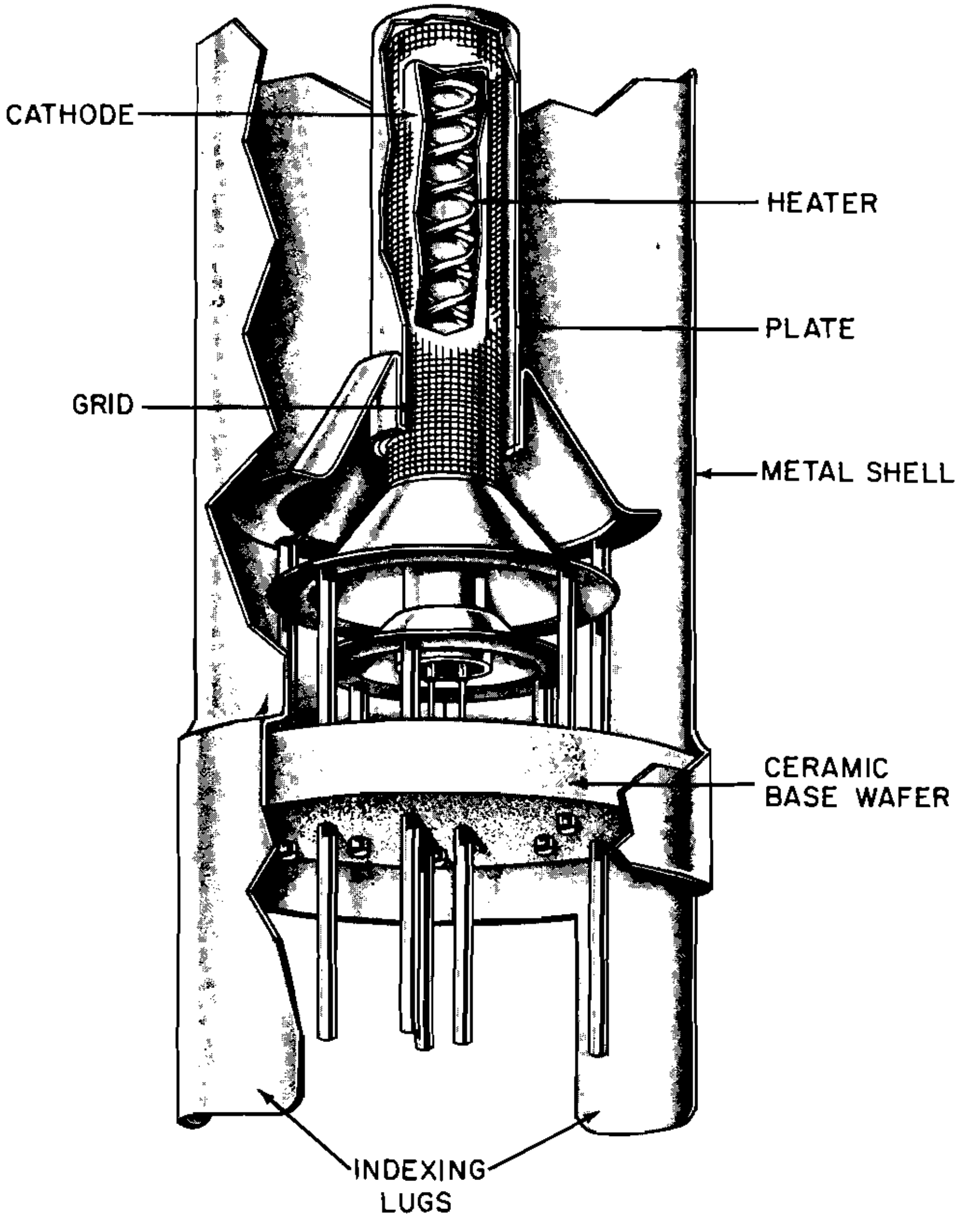


Fig.4 - Illustration of a nuvistor triode showing cylindrical electrodes and tripod-like supports.

RCA

RCA Application Note

AN-195

Noise and Gain of the RCA-8056 Nuvistor Triode at 200 Megacycles

This Note provides information on the noise figure and gain of the RCA-8056 low-voltage nuvistor triode under noise-matched conditions at 200 megacycles over a range of practical values of plate current and voltage. When used in conjunction with values of other characteristics given in the technical data for these types, this information makes it possible to estimate the performance of these tubes under small-signal conditions at any operating point with reasonable accuracy.

Design Features of the 8056

The 8056 is a low-mu high-transconductance triode of nuvistor design, featuring small size and light weight, especially developed for operation at plate-supply voltages of 12 to 30 volts. The cylindrical active elements of the tube are mounted coaxially on ceramic base wafers. Each element is supported by a tripod arrangement of leads which extend through the base wafer. One lead of each set is used as the external connector. Sections of the shell extending beyond the base wafer serve as indexing lugs for socket insertion. These indexing lugs also provide protection for the tube leads and can be used to ground the metal shell through the socket so that the use of a tube shield is unnecessary.

Noise Figure and Gain

Curves of constant noise figure and gain for the 8056 are shown in Figs. 1 and 2, respectively. These curves permit the effect of a change of operating point to be determined at a glance. In particular, the curves show how the operating point can be varied to change two parameters simultaneously in a desired direction.

For example, a tube operated at a plate voltage of 35 volts and a plate current of 11 milliamperes has a noise figure of 4.5 db and a gain of approximately 16.4 db. If it is desired to increase the gain and reduce the noise figure, the operating point should be moved to the left of the 4.5-db noise-figure curve in Fig. 1, and above the (interpolated) 16.4-db gain curve in Fig. 2. If the plate voltage is decreased to 29 volts and the plate current is increased to 13 milliamperes, the noise

ELECTRON TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

3-63

figure is reduced to 4 db and the gain is increased to slightly more than 17 db.

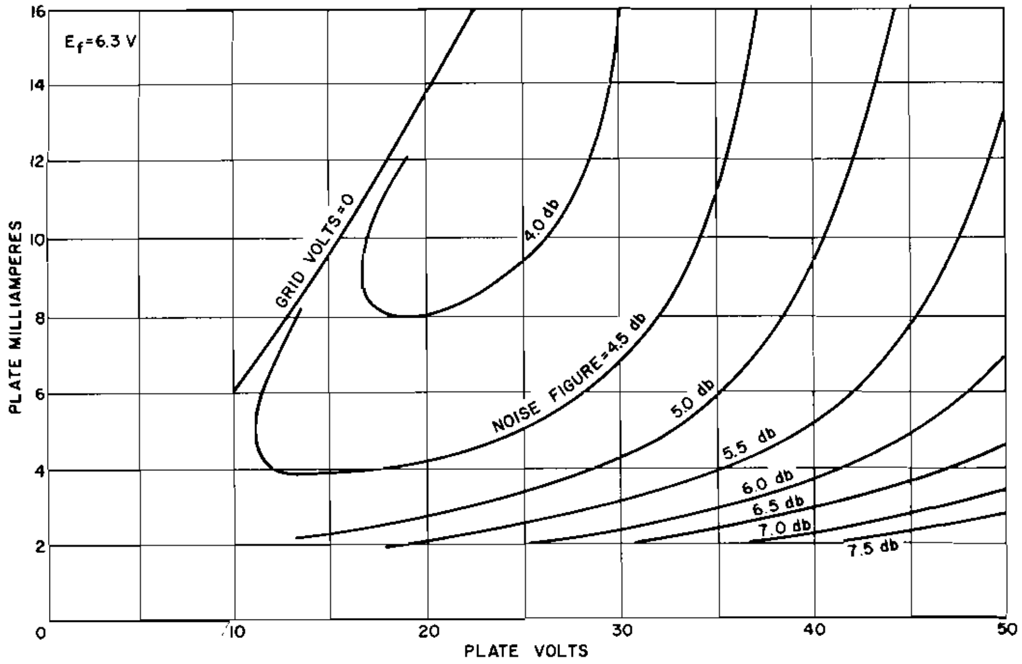


Fig. 1 - Noise figure at noise match.

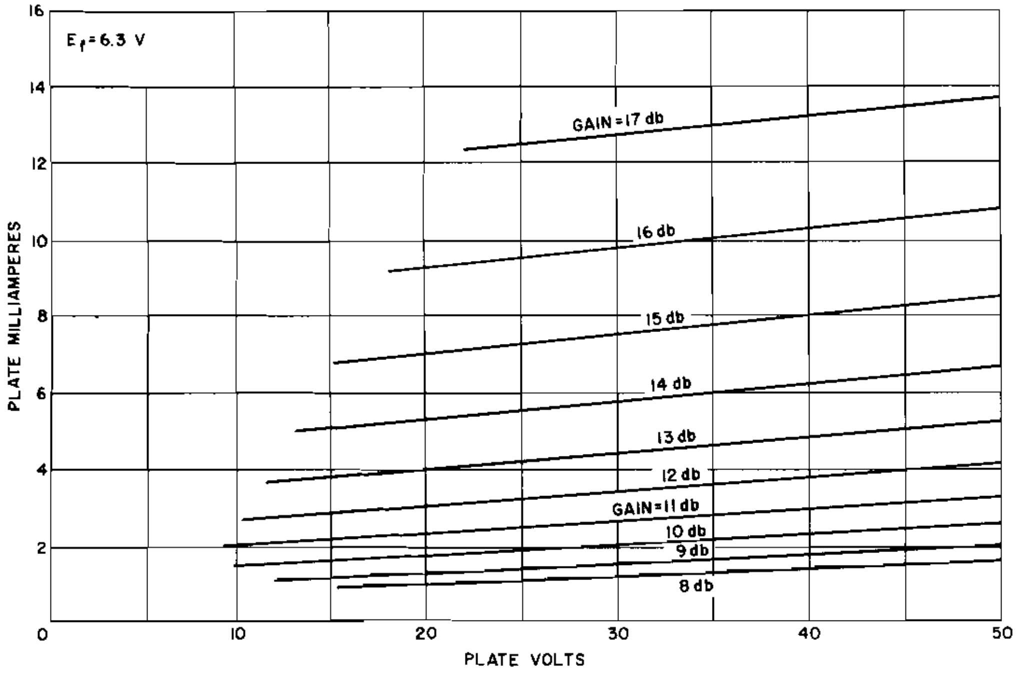


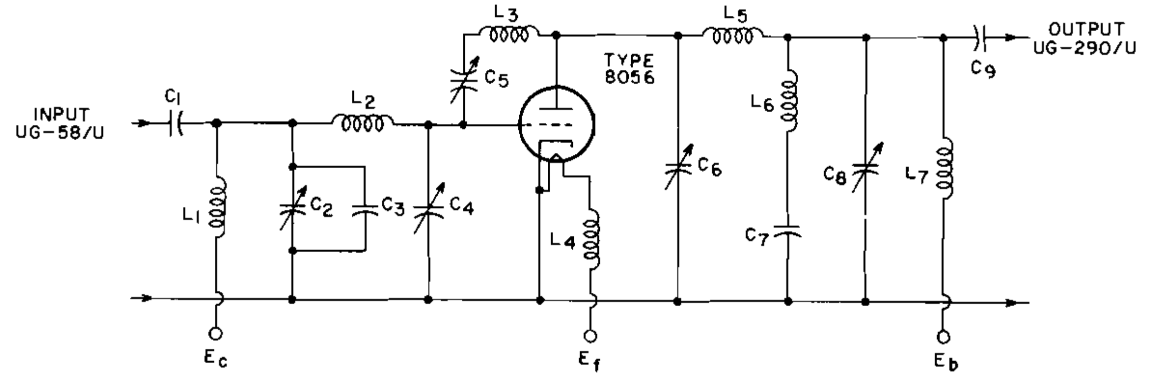
Fig. 2 - Power gain at noise match.

The optimum noise figure within the rated plate-current and dissipation limits is about 3.7 db; this value is obtained with a plate voltage of 24 volts and a plate current of 15 milliamperes. The noise figure of the 8056, therefore, is somewhat better than that of the 7586, or the 7895, and is achieved at much lower plate voltage and dissipation with somewhat lower transconductance (gain). As a result, the 8056 is particularly useful in the input stages of mobile communications receivers.

Although the 8056 is not specifically controlled for noise, the data shown in Fig. 1 represent typical noise performance.

Description of Measuring Circuit

The test circuit used for the gain and noise measurements described in this Note is shown in Fig. 3. The circuit consists of a partially



C_1: 2200 pf, uncoated disc ceramic, soldered directly on input connector

C_2: Hammarlund APC-50

C_3: 22 pf, tubular ceramic

C_4: E. F. Johnson 5 M11

C_5: E. F. Johnson 9 MB11

C_6: E. F. Johnson 9 M11

C_7: 2200 pf, uncoated disc ceramic, soldered directly on chassis

C_8: Hammarlund APC-25

C_9: 2200 pf, uncoated disc ceramic, soldered directly on output connector

L_1, L_4, L_7: Ohmite rf choke, Z-235

L_2: 1 loop of No. 14 magnet wire 9 cm long, bent to form a U 2 cm wide, 1 to 2.5 cm from chassis

L_3: B & W Miniductor 3002, 5-1/2 turns

L_5: 5 cm of No. 14 magnet wire, slightly bent, 1.8 cm from chassis

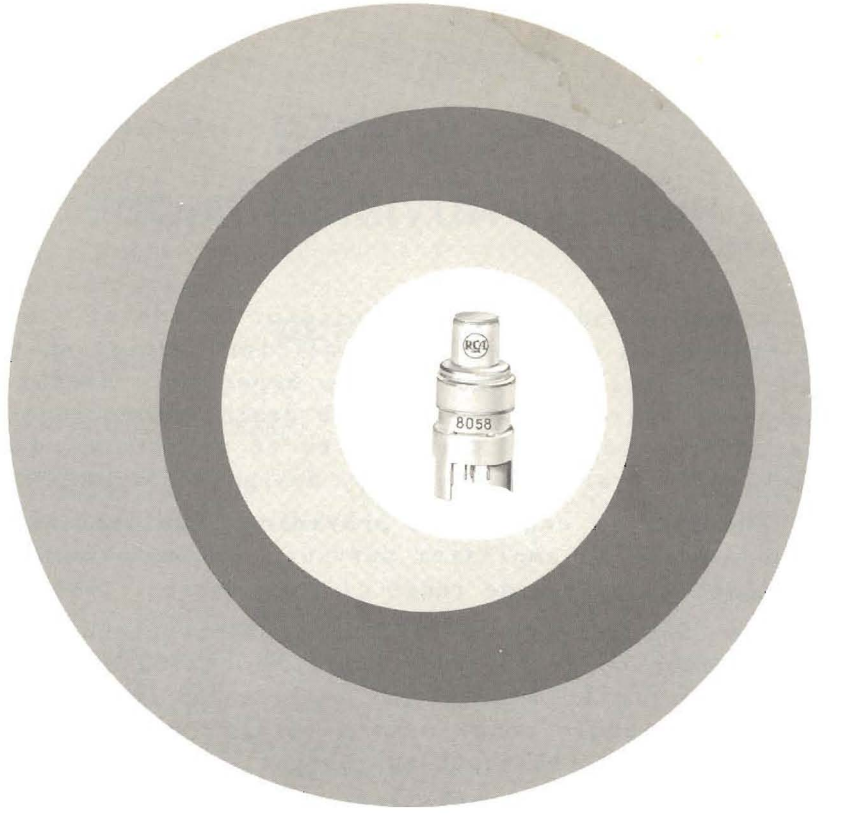
L_6: silvered strap 0.4 cm wide, 2.5 cm long, bent to form a U 1 cm wide

Chassis 5-1/2 inches long, 4 inches wide, 1-1/2 inches deep, of 0.024-inch copper tinned on the wiring side, partitioned to the full depth 2-1/2 inches from the input wall. The partition cuts across the center of the socket and is sliced 1/16 inch into the socket. Neutralizing coil L_3 and capacitor C_4 are mounted on the grid side of the partition and partially shielded from the input circuit.

Fig. 3 - Test circuit.

neutralized grounded-cathode amplifier stage which has a bandwidth of approximately 4 megacycles. The output of the amplifier is matched to a 50-ohm load through a pi network; a similar network is used to adjust the source admittance for minimum noise figure. A Hewlett-Packard Model 342-A Noise-Figure Meter and Model 343-A VHF Noise Source (diode) are used to adjust the circuit for minimum noise and also for noise measurement. An additional amplifier having a noise figure of 6.3 db is used between the test chassis and the input of the noise-figure meter; the effect of the noise figure of this amplifier is excluded from the test results by calculation.

The test amplifier is neutralized only by use of a shunt inductance between grid and plate; as a result, the feedback conductance is not affected except by losses in the inductor itself. Because of the incomplete neutralization, the ratio of forward to reverse gain is approximately 50 db at normal plate current, and decreases to about 40 db at low plate current. However, the effect of the incomplete neutralization on noise figure and gain appears to be negligible.



nuvistor 8058

HIGH-MU TRIODE

double-ended type for industrial applications

RADIO CORPORATION OF AMERICA ELECTRON TUBE DIVISION, HARRISON, N J

Printed in U.S.A.

RCA-8058

HIGH-MU NUVISTOR TRIODE

RCA-8058 is a double-ended, high-mu nuvistor triode of the heater-cathode type, designed for use in cathode-drive amplifier service up to 1200 Mc in a wide variety of applications. The 8058 is especially useful in industrial equipment where compactness, low drain, exceptional uniformity of characteristics, and the ability to withstand severe mechanical shock and vibration are primary design requirements.


Actual Size

The 8058 is capable of providing high gain with low noise in cathode-drive rf-amplifier service, and excellent stability as an oscillator over a wide range of frequencies.

The 8058 features very high transconductance and a high transconductance-to-plate current ratio (12400 micromhos at a plate current of 10 milliamperes and a plate-supply voltage of 110 volts). In addition, the double-ended construction of this nuvistor provides a high degree of isolation between the input and output circuits.

The 8058 is particularly suitable for cathode-drive applications because the peripheral lugs used for indexing are also used as the connections to the grid. Furthermore, three base-pin connections for the cathode reduce lead inductance and provide flexibility in circuit layout.

General Features

The 8058 has an all metal-and-ceramic envelope provided with two peripheral lugs of unequal width to facilitate insertion in a socket. It is less than one inch long, only 0.440" in diameter, and weighs approximately 2.2 grams. The 8058 features (1) a very rugged structure of unique design, (2) double-ended construction, (3) a 6.3-volt low-wattage heater and a specially designed cathode to assure very low heater-cathode leakage, (4) high transconductance at low plate current, (5) high input impedance, (6) high perveance, and (7) the ability to operate at full ratings at any altitude.

Structural Features

A major feature of the 8058 is its all-ceramic-and-metal construction utilizing a light-weight, cantilever-supported cylindrical electrode structure. This unique type of electrode structure, inherent in the nuvistor design, provides a structure of excellent mechanical stability and extreme ruggedness. All connections are brazed at very high temperatures in a hydrogen atmosphere to eliminate the structural strain and element distortion often caused by welding. The tube is also exhausted and sealed at very high temperatures to eliminate the gases and impurities which are generally present in electron devices processed at low temperatures.

The structure of the 8058 nuvistor triode also permits automatic assembly using parts made to extremely small tolerances, thus assuring exceptional uniformity of characteristics from tube to tube.

Special Tests and Controls

The 8058 is rigidly controlled during manufacture, and is subjected to rigorous tests for intermittent shorts, 1000-hour life performance, interelectrode leakage, impact shock, variable-frequency vibration, low-pressure breakdown, and heater cycling.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3 ± 10%	volts
Current at 6.3 volts	0.135	amp
Direct Interelectrode Capacitances:		
Cathode-Drive Operation:		
Plate to cathode	0.046 max.	pf
Cathode to grid & shell and heater	6	pf
Plate to grid & shell and heater	1.3	pf
Heater to cathode	1.4	pf

Characteristics, Class A_1 Amplifier:

Plate-Supply Voltage	110	volts
Grid-Supply Voltage	0	volts
Cathode Resistor	47	ohms
Amplification Factor	70	
Plate Resistance (Approx.)	5600	ohms
Transconductance	12400	μmhos
Plate Current	10	ma
Grid Voltage (Approx.) for plate current = 10 μa	-5	volts

Mechanical:

Operating Position	Any
Maximum Over-all Length	0.985"
Maximum Seated Length	0.780"
Maximum Diameter	0.440"
Envelope	Metal and Ceramic Shell
Cap	Small, JEDEC No.C1-44
Base	Medium Ceramic-Wafer Twelvar 5-Pin (JEDEC No.E5-79)

INDUSTRIAL SERVICE

Maximum Ratings, *Absolute-Maximum Values:*

For Operation at Any Altitude

PLATE SUPPLY VOLTAGE	330 max.	volts
PLATE VOLTAGE	150 max.	volts
GRID VOLTAGE:		
Positive bias value	0	volts
Negative bias value	55 max.	volts
PLATE DISSIPATION	1.5 max.	watts
CATHODE CURRENT	15 max.	ma
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	100 max.	volts
Heater positive with respect to cathode	100 max.	volts

Maximum Circuit Values:

Grid-Circuit Resistance:[a]		
For fixed-bias operation	0.5 max.	megohm
For cathode-bias operation	1.0 max.	megohm

Typical Operation in Cathode-Drive RF-Amplifier Service:

	At 450 Mc	*At 700 Mc*	*At 1200 Mc*	
Plate Supply Voltage	110	110	110	volts
Cathode Resistor	47	47	47	ohms
Plate Current	10	10	10	ma
Power Gain	16.5	12.5	10.5	db
Bandwidth	6	12	12	Mc
Noise Factor[b]	6.5	9.5	12.2	db

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[a] For operation at metal-shell temperatures up to 150° C (See *Dimensional Outline* on Page 9).

[b] Argon Noise Source. Input is tuned for optimum value.

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN

	Note	*Min.*	*Max.*	
Heater Current	1	0.125	0.145	amp
Direct Interelectrode Capacitances:				
Cathode to grid & shell and heater	2	5.0	7.0	pf
Plate to grid & shell and heater	2	1.1	1.5	pf
Heater to cathode	2	1.1	1.7	pf
Plate to cathode	2	-	0.046	pf
Plate Current (1)	1,3	7.8	12.2	ma
Plate Current (2)	1,4	-	50	µa
Transconductance (1)	1,3	10000	14800	µmhos
Transconductance (2)	3,5	8700	-	µmhos
Reverse Grid Current	1,6	-	0.1	µa
Amplification Factor	1,3	54	86	
Heater-Cathode Leakage Current:				
Heater negative with respect to cathode	1,7	-	5	µa
Heater positive with respect to cathode	1,7	-	5	µa
Leakage Resistance:				
Between grid and all other electrodes tied together	1,8	5000	-	megohms
Between plate and all other electrodes tied together	1,9	10000	-	megohms

Note 1: With 6.3 volts ac or dc on heater.

Note 2: Measured in accordance with EIA Standard RS-191-A.

Note 3: With dc plate volts = 110, cathode resistor = 47 ohms, and cathode-bypass capacitor = 1000 µf.

Note 4: With dc plate volts = 110, dc grid volts = -5.

Note 5: With 5.7 volts ac or dc on heater.

Note 6: With dc plate volts = 150, grid supply volts = -1.3, grid resistor = 0.5 megohm.

Note 7: With 100 volts dc applied between heater and cathode.

Note 8: With grid 100 volts negative with respect to all other electrodes tied together.

Note 9: With plate 300 volts negative with respect to all other electrodes tied together.

SPECIAL RATINGS AND PERFORMANCE DATA

Shock Rating:

Impact Acceleration.	500 max.	g

This test is performed on a sample lot of tubes to determine ability of tube to withstand the specified impact acceleration. Tubes are held rigid in four different positions in a Navy Type, High-impact (flyweight) Shock Machine and are subjected to 20 blows at the specified maximum impact acceleration. At the end of this test, tubes are criticized for change in transconductance, reverse grid current, and heater-cathode leakage current, and are then subjected to the Variable-Frequency Vibration Test described later.

Variable-Frequency-Vibration Performance:

This test is performed on a sample lot of tubes from each production run. The tube is operated under the conditions specified in CHARACTERISTICS RANGE VALUES for Transconductance (1) with the addition of a plate-load resistor of 2000 ohms. During operation, tube is vibrated in a direction perpendicular to the longitudinal axis of the tube through the frequency range from 50 to 15000 cycles per second under the following conditions: a sweep rate of one octave per 30 seconds from 50 to 3000 cps, a 7-second sweep from 3000 to 15000 cps, and a constant vibrational acceleration of 1g. During the test, tube must not show an output voltage in excess of:

35 rms mv over the frequency range from 50 to 3000 cps
80 peak mv over the frequency range from 3000 to 6000 cps
700 peak mv over the frequency range from 6000 to 15000 cps

Low-Pressure Voltage-Breakdown Test:

This test is performed on a sample lot of tubes. In this test tubes are operated with 250 rms volts applied between plate and all other electrodes and will not break down or show evidence of corona when subjected to air pressures equivalent to altitudes of up to 100000 feet.

Heater Cycling:

Cycles of Intermittent Operation	2000 min.	cycles

This test is performed on a sample lot of tubes from each production run under the following conditions: heater volts = 7.5 cycled one minute on and two minutes off; heater 100 volts negative with respect to cathode; grid, plate, and metal shell (grid) connected to ground. At the end of this test tubes are tested for open heaters, heater-cathode shorts, and heater-cathode leakage current.

Intermittent Shorts:

This test is performed on a sample lot of tubes from each production run. Tubes are subjected to the Thyratron-Type Shorts Test described in MIL-E-1D, Amendment 2, Par. 4.7.7, except that tapping is done by hand with a soft rubber tapper.[c] The Acceptance Curve for this test is shown in Fig. 4. In this test tubes are criticized for permanent or temporary shorts and open circuits.

1000-Hour Conduction Life Performance:

This test is performed on a sample lot of tubes from each production run to insure high quality of the individual tube and guard against epidemic failures due to excessive changes in any of the characteristics indicated below. In this test tubes are operated for 1000 hours at maximum rated plate dissipation with a metal-shell temperature of 150° C and then criticized for inoperatives, reverse grid current, heater-cathode leakage current, and leakage resistance. In addition, the average change in transconductance of the lot from the 0-hour value for Transconductance (1) specified in CHARACTERISTICS RANGE VALUES, must not exceed 15 per cent at 500 hours, and 20 per cent at 1000 hours.

Interelectrode Leakage:

Leakage Resistance between Plate and All Other Electrodes tied together	10000 min.	megohms

This test is performed on a sample lot of tubes from each production run under the following conditions: heater volts = 6.3; and plate 300 volts negative with respect to all other electrodes tied together.

Leakage Resistance between Grid and All Other Electrodes tied together	5000 min.	megohms

This test is performed on a sample lot of tubes from each production run under the following conditions: heater volts = 6.3; and grid 100 volts negative with respect to all other electrodes tied together.

OPERATING CONSIDERATIONS

The base pins of the 8058 fit the Medium Ceramic-Wafer Twelvar 5-pin Socket (JEDEC No. E5-79). The socket may be installed to hold the tube in any position. The socket should be made of insulating material having low leakage. Connection to the plate may be made with a cap having the dimensions of the JEDEC No. C1-44 Small Cap.

The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Absolute-Maximum Rating System* for rating electron devices.

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, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no absolute-maximum value for the intended service is exceeded with any

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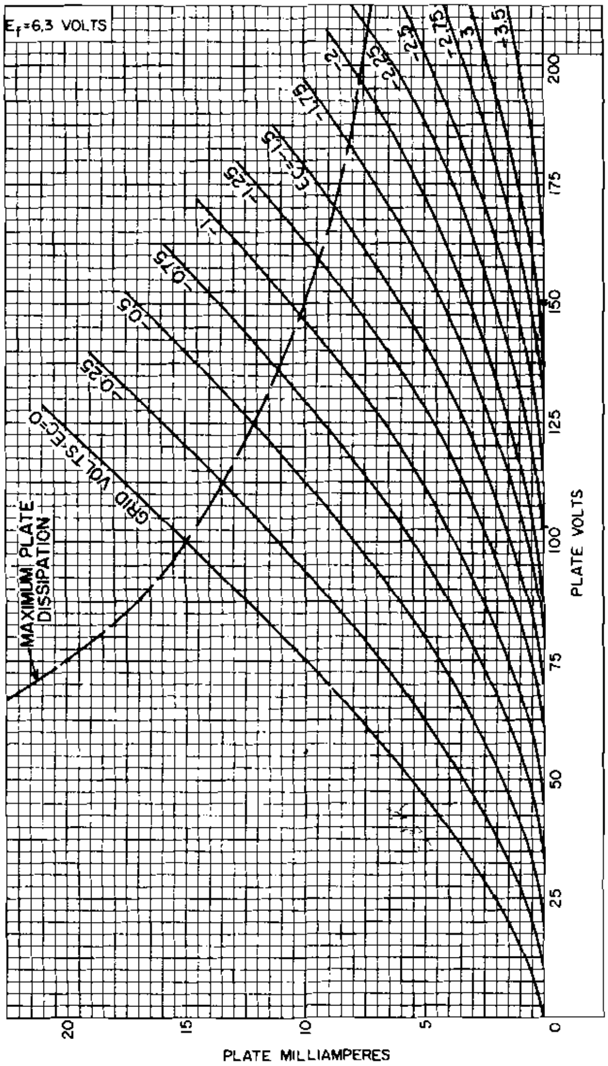
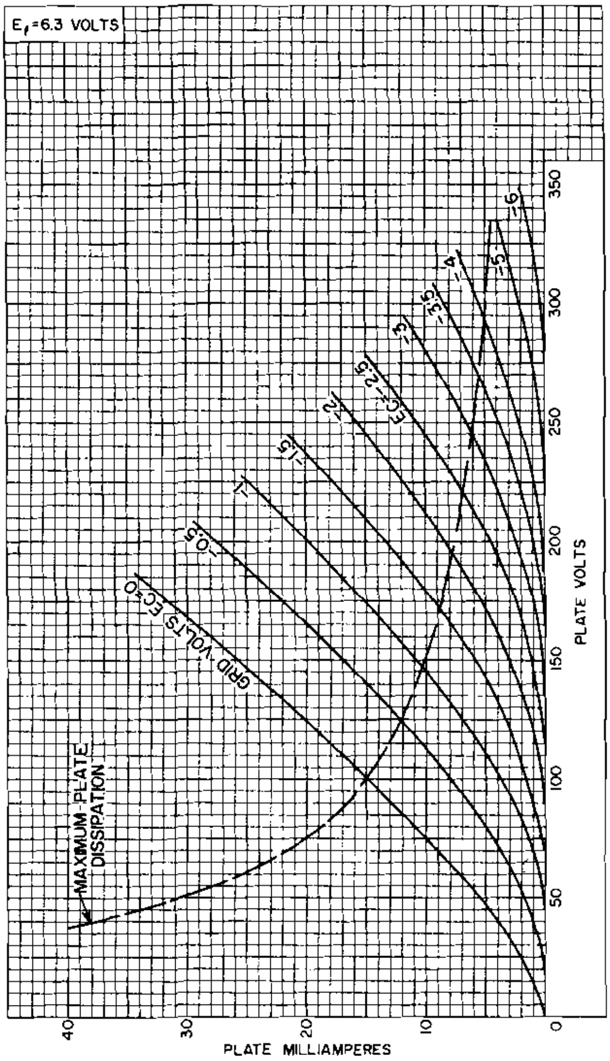
[c] Specifications for this tapper will be supplied on request.

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 device characteristics.



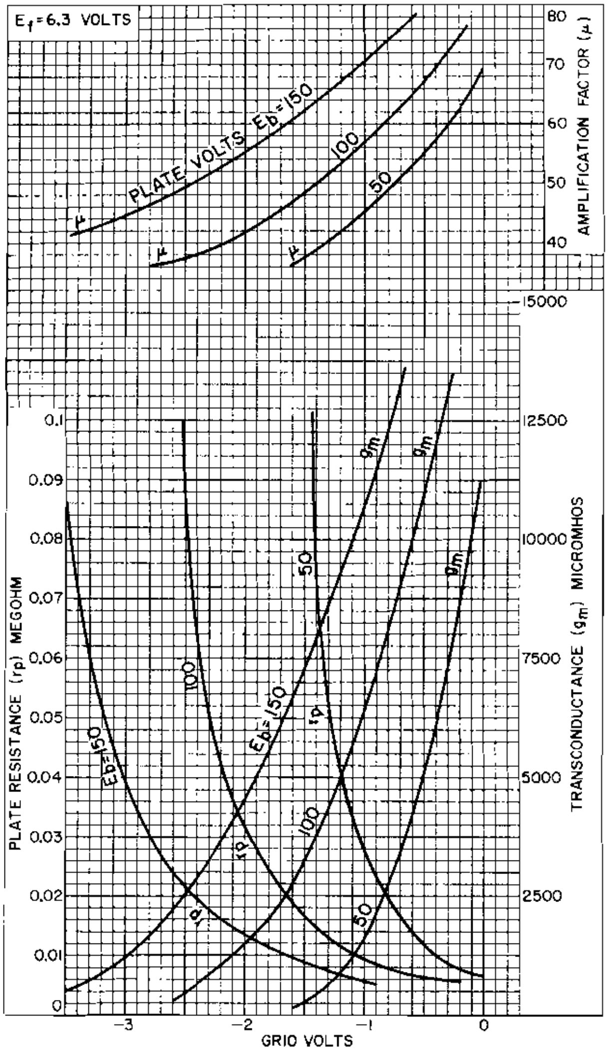
92CM-11426

Fig. 1 - Average Plate Characteristics for Type 8058.



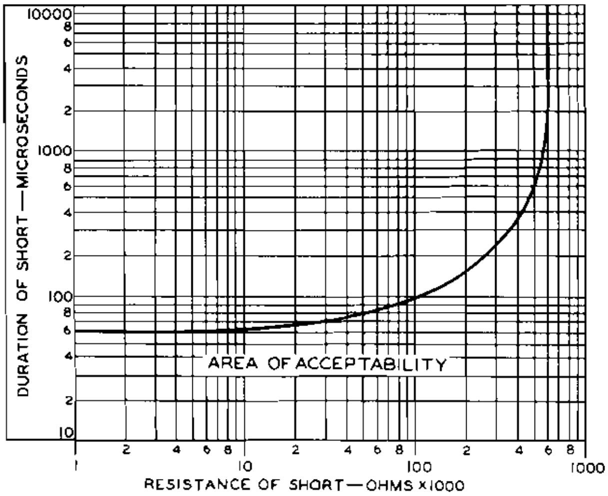
92CM-11430

Fig. 2 - Average Plate Characteristics for Type 8058.



92CM-11410

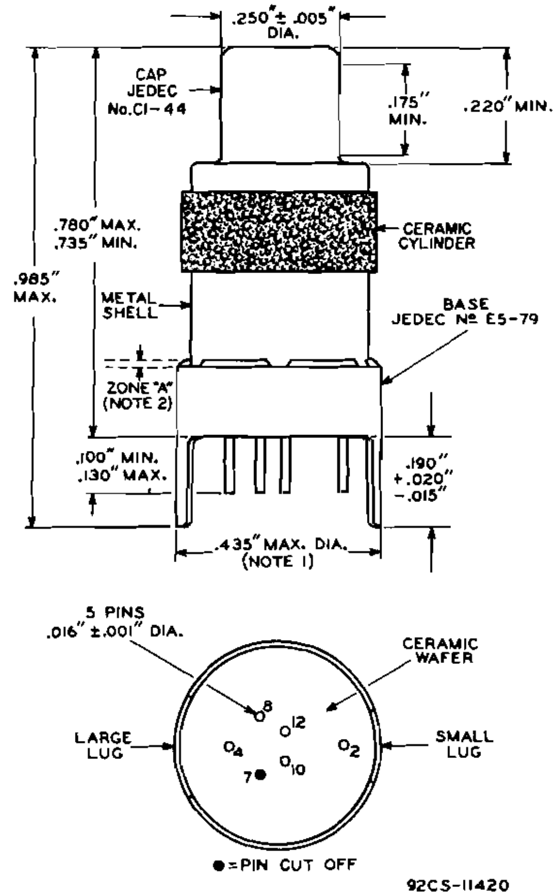
Fig. 3 - Average Characteristics for Type 8058.



92CS-10465

Fig. 4 - Thyratron-Type Shorts Test for Type 8058.

DIMENSIONAL OUTLINE

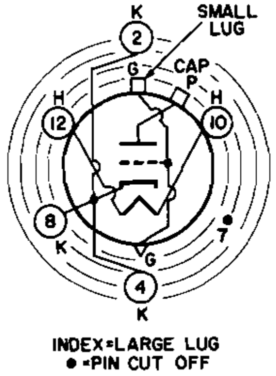


Note 1: Maximum O.D. of 0.440" is permitted along 0.190" lug length.

Note 2: Shell temperature should be measured in the zone 'A' indicated by broken lines.

BASING DIAGRAM (Bottom View)

Pin 2: Cathode
Pin 4: Cathode
Pin 7: a
Pin 8: Cathode
Pin 10: Heater

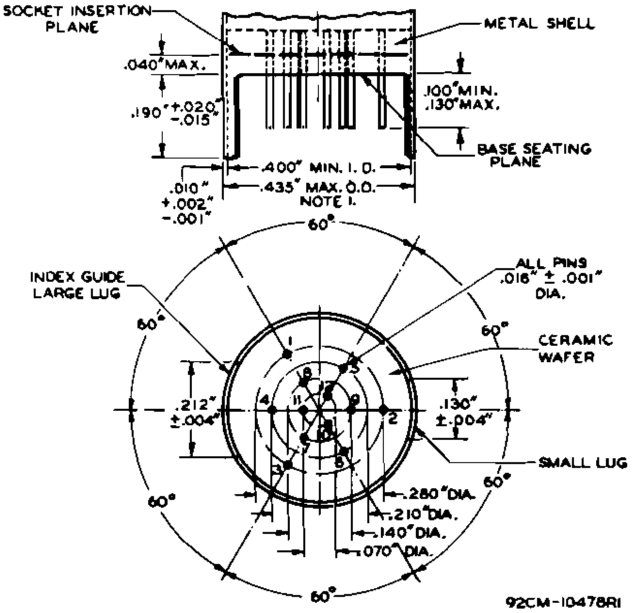


Pin 12: Heater
Small Lug: Grid
Large Lug: Grid
Cap: Plate

12CT

[a] Pin has internal connection and is cut off close to ceramic wafer—Do Not Use.

MEDIUM CERAMIC-WAFER TWELVAR BASE



JEDEC No.	NAME	PINS
E12-64	12-Pin Base	1,2,3,4,5,6,7,8, 9,10,11,12
E5-79	5-Pin Base	2,4,8,10,12 (Note 2)

Note 1: Maximum O.D. of 0.440" is permitted along the 0.190" lug length.

Note 2: Pin 7 is cut off to a length such that its end does not touch the socket insertion plane. Pins 1,3,5,6,9, and 11 are omitted.

PIN-ALIGNMENT GAUGE

Base-pin positions and lug positions shall be held to tolerances such that entire length of pins and lugs will without undue force pass into and disengage from flat-plate gauge having thickness of 0.25" and twelve holes of 0.0350" ± 0.0005" diameter located on four concentric circles as follows: three holes located on 0.2800" ± 0.0005", three holes located on 0.2100" ± 0.0005", three holes located on 0.1400" ± 0.0005", three holes located on 0.0700" ± 0.0005" diameter circles at specified angles with a tolerance of ± 0.08° for each angle. In addition, gauge provides for two curved slots with chordal lengths of 0.2270" ± 0.0005" and 0.1450" ± 0.0005" located on 0.4200" ± 0.0005" diameter circle concentric with pin circles at 180° ± 0.08° and having a width of 0.0230" ± 0.0005".

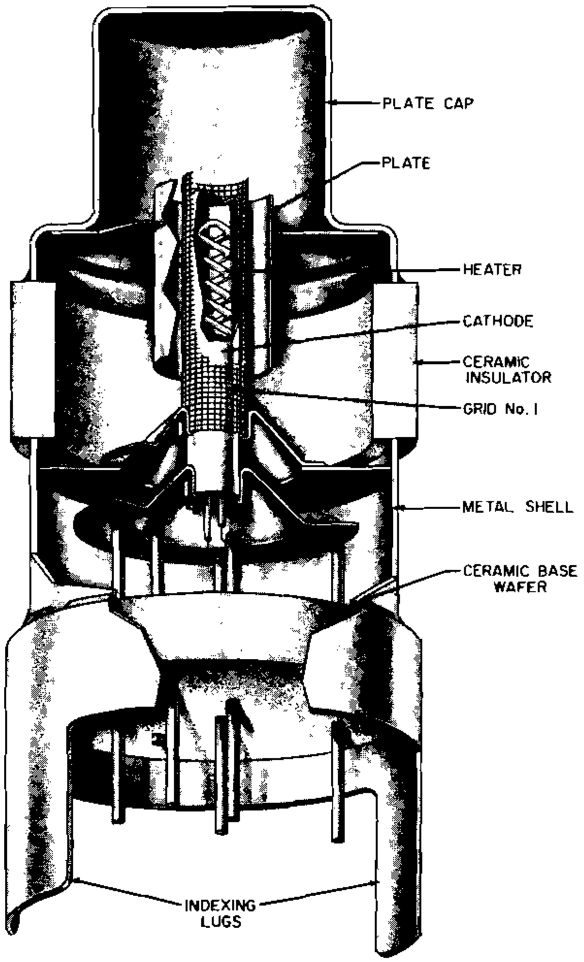


Fig.5 - Illustration of a double-ended nuvistor triode showing cylindrical electrodes and tripod-like supports.

RCA Application Note

AN-196

This Note supersedes AN-194

Temperature Ratings and Thermal Considerations For Nuvistor Tubes

This Note describes the basic rules and procedures used to establish temperature ratings for nuvistor tube types. To achieve maximum usefulness and reliability from nuvistor tubes within their published ratings, equipment designers should give careful consideration to the thermal requirements of the tubes in the early stages of design. It should be clearly understood that the maximum shell-temperature rating of a nuvistor tube is not comparable to the maximum bulb-temperature rating of a glass tube. The heat-transfer mechanisms of the nuvistor structure differ substantially from those of a glass tube; the nuvistor tube is cooled primarily by conduction rather than by radiation and convection. There is no convenient method of directly comparing the nuvistor and glass-tube temperature ratings without exhaustive measurements in a given environment. Although the bulb temperature of glass tubes is greatly affected by ambient air temperature, the surrounding air has little effect on the shell temperature of a nuvistor when proper contact between the shell and the chassis is provided by the tube socket. This statement applies for all normal environments, and also for many abnormal environments involving high packaging density and limited air flow.

Need for Temperature Ratings

Temperature ratings are specified for electron tubes to minimize detrimental effects which may reach excessive magnitude if critical temperatures are exceeded. In particular, two physical processes are accelerated as the temperature of tube electrodes and the surrounding envelope increases: (1) the release of adsorbed or absorbed gases from the tube envelope and structure, and (2) the emission of electrons from all electrodes, and especially from the control grid. Of these two phenomena, gas evolution is more detrimental to tube life because it tends to destroy the emission capabilities of the cathode.

Because the control grid is normally the most negative electrode in an electron tube, it acts as a collector for positive ions produced when gases are released from other electrodes under high temperature. As a result, a variable component of negative grid current may be introduced in the external circuit.

In addition, the control grid is physically near the cathode and normally operates at a relatively high temperature because of radiated heat from the cathode. Any increase in grid temperature enhances the emitting characteristics of the grid and raises the level of primary emission from this electrode. This primary emission then adds another component of negative grid current to the ion current previously mentioned.

ELECTRON TUBE DIVISION
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3-63

The construction and processing techniques used for nuvistor tubes involve extremely high temperatures and high vacuum. As a result, the amount of gas liberated from tube electrodes during normal use is negligible, and thus the value of ion current is negligible. The development of primary emission from the nuvistor control grid is, therefore, the determining factor in establishing the metal-shell temperature rating.

Because the external control-grid circuit for a vacuum tube usually has a high value of resistance, a small change in grid current due to either gas ions or grid emission can lead to a substantial change in the operating point. Both gas and grid-emission currents decrease bias; as a result, dissipation and temperature increase, and a runaway condition may develop. (For example, a 0.1-microampere increase in grid current through a 1-megohm resistor reduces the bias by 0.1 volt. In a tube having high transconductance, a 0.1-volt decrease in bias can cause a 10-per-cent increase in plate current and dissipation.) Similarly, the input impedance will be reduced substantially because of additional grid currents. The effects of grid current, although undesirable, can be greatly minimized in circuit design.

Physical Basis of Temperature Ratings

For a given input power, the maximum bulb temperature of a glass tube is determined primarily by the temperature of the surrounding air because cooling is achieved largely by radiation. Nuvistor tubes are cooled primarily by heat conduction through the socket to the chassis. Therefore, chassis temperature rather than air temperature determines the maximum nuvistor metal-shell temperature for a given input power.

The temperature of the control grid in an electron tube is affected by three main factors: (1) radiation from the cathode to the grid, (2) radiation and conduction from the plate to other elements and thus externally through the glass bulb or metal shell, (3) radiation and conduction from external sources to the shell or bulb and thus to internal parts of the tube. Factors (2) and (3) are of primary concern to the circuit designer because they interact to establish the shell or bulb temperature. Furthermore, the circuit designer can control these factors to an appreciable degree.

The ceramic base wafer used in nuvistor tubes has very good thermal conductivity as compared to that of glass. This wafer, in conjunction with the metal shell, provides the easiest path for heat transfer by conduction. Radiation from the shell is extremely small. The temperature rise of the nuvistor control grid is determined by the heat radiated to the grid from the cathode and the thermal conductivity of the control-grid structure and base wafer. To establish the maximum grid temperature for stable operation, the nuvistor is rated at the base region of the shell. The term "base temperature" is often used to specify the maximum metal-shell temperature measured in the base region.

Temperature Measurements

The temperature of a nuvistor shell is normally measured at the base of the tube, as shown in Fig.1. A small thermocouple can be welded into a gusset at the base by discharging a capacitor through the junction of the thermocouple and the metal shell. A 200-microfarad capacitor charged to about 75 volts is suitable for this purpose. An alternate method is to apply commercially available temperature-sensitive paints to the base region, indicated as "Zone A" in Fig.1.

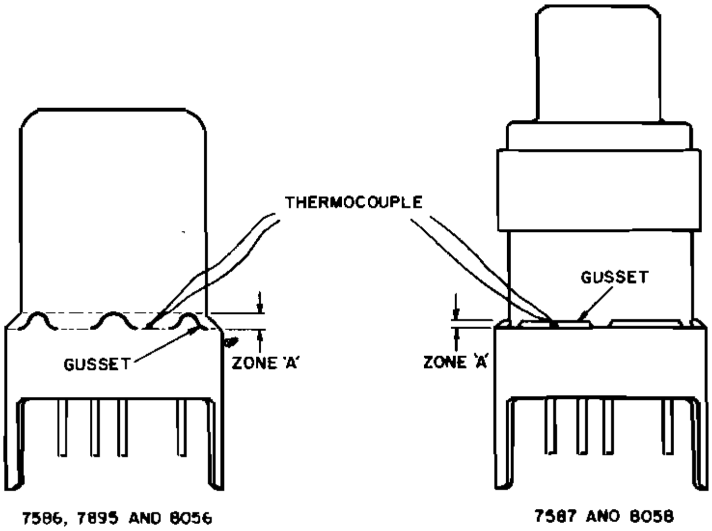


Fig. 1 - Sketch illustrating methods of measuring metal-shell temperature of nuvistors.

Socket-Design Considerations

In the conventional nuvistor socket, heat is transferred from the nuvistor to the chassis by thermal conduction to the socket through metal contacts to the indexing lugs. Conventional sockets are available from Cinch Manufacturing Co. (socket number 133-65-10-001) and Industrial Electronic Hardware (socket numbers NU-5044 and 5060). Although these sockets provide adequate cooling in most applications, much better thermal conduction is achieved through the use of the Cinch socket number 133-65-10-041. In this socket, metal "fingers" bear against the nuvistor shell and facilitate conduction of heat to the metallic saddle. A uhf socket, Cinch number 133-67-90-040, is available for operation at frequencies in the 1000-megacycle range. This socket has a temperature rise above chassis of 33 degrees centigrade at a total power input of 1.85 watts.

Plate-Dissipation Ratings and Chassis Temperature

Whenever possible, nuvistors should be located in the coolest region of the chassis. The temperature of the shell should be measured as described above to assure operation within ratings. Nuvistors are normally life-tested at a shell temperature of 150 degrees centigrade with maximum rated grid-circuit resistance. Fig. 2(a) shows combinations of plate dissipation and chassis temperature which produce base temperatures of 150 degrees centigrade for nuvistor tubes operating in conventional sockets under high-line conditions (heater voltage of 6.9 volts). The curves show that type 7587 may be operated at full dissipation and rated grid-circuit resistance at chassis temperatures up to 70 degrees centigrade, types 7586 and 7895 up to 85 degrees centigrade, type 8056 up to 100 degrees centigrade, and type 8058 up to 110 degrees centigrade without exceeding the maximum metal-shell temperature ratings. At high temperatures, the plate dissipation must be reduced by the indicated percentages to avoid excessive shell temperatures. The chassis temperature limitation at zero plate dissipation is lower than the shell-temperature rating because of a rise in shell temperature due to the heater power.

Fig.2(b) shows similar bulb-temperature curves for glass tubes as a function of ambient air temperatures; these curves were derived from WADC Technical Report 56-53, page 45. The curves are based on the published maximum bulb temperature for each tube type. When the bulb-temperature rating is exceeded, poor life performance due to cathode poisoning may result. The grid-circuit-resistance value for a particular tube type is rated independently. If the grid-circuit-resistance rating is exceeded, circuit instability may occur independent of the bulb temperature.

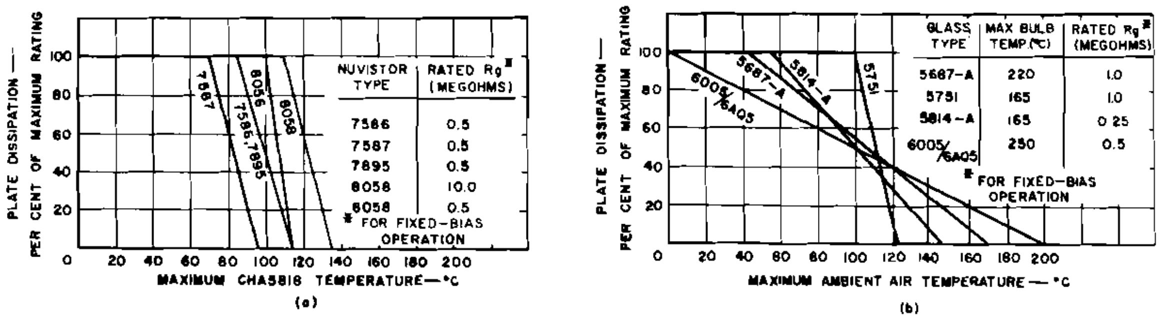
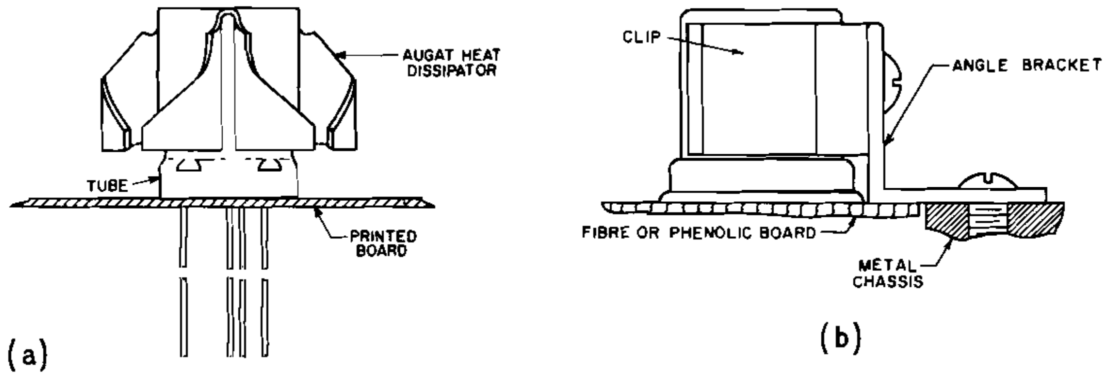


Fig.2 - Curves showing (a) metal-shell temperature of nuvistors as a function of plate dissipation and chassis temperature, and (b) bulb temperature of glass tubes as a function of plate dissipation and ambient air temperature.



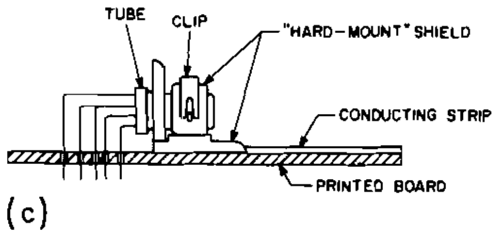


Fig.3 - Sketch illustrating use of heat-conducting clamp with metallic Augat Heat Dissipator, heat sink, and IERC "Hard-Mount" shield for additional cooling of nuvistors.

Chassis Considerations

The curves shown in Fig.2(a) apply only to chassis made of materials having good thermal conductivity, such as steel or aluminum. When nuvistors (especially developmental long-lead types) are mounted on a low-conductivity material, such as a phenolic or fiber "printed-board" chassis, less conduction cooling can occur, and heat is also carried away by radiation and convection. On such chassis, therefore, base temperatures are about 50 degrees centigrade higher than those shown in Fig. 2(a) unless additional cooling means are used. Fig. 3 shows three suitable cooling techniques for nuvistors: (a) the use of a 9036-1P1U heat dissipator manufactured by Augat, Inc.; (b) the use of conventional heat-conducting clips manufactured by Tinnerman Corp.; (c) the use of an International Electronics Corporation (IERC) "Hard-Mount" shield.

Figs. 4, 5, and 6 can be used as a guide in estimating base temperature for various socket, lead size, and chassis combinations for the indicated nuvistor types. Actual base-temperature measurements should be made to insure operation within ratings in printed-circuit applications and in other applications where high packaging density or wide environmental temperature ranges may create hot spots within the equipment.

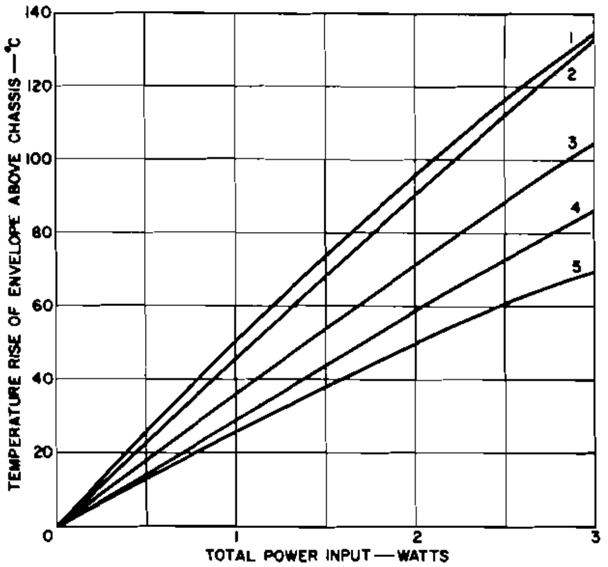


Fig. 4 - Temperature curves for (1) subminiature T-3 tubes; (2) 7586, Cinch socket 133-65-10-009 mounted on printed board; (3) 7586, conventional socket crimp-mounted on aluminum chassis; (4) 7586, Cinch socket 133-65-10-041 crimp-mounted on aluminum chassis; (5) tetrode 7587, conventional socket crimp-mounted on aluminum chassis.

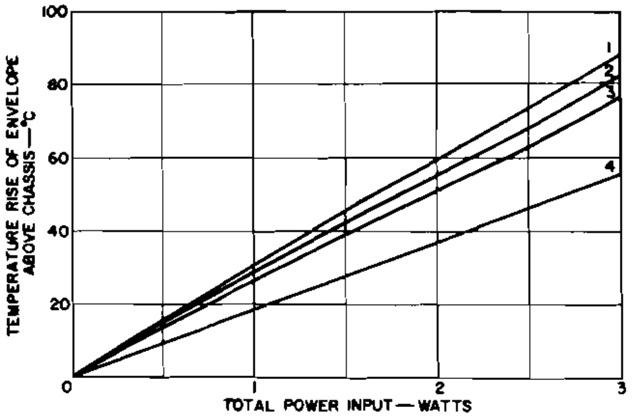


Fig. 5 - Temperature curves for nuvistor triodes solder-mounted on brass chassis: (1) conventional socket, #36 wire; (2) conventional socket, #24 wire; (3) conventional socket, #16 wire; (4) Cinch socket 133-65-10-041, #24 wire.

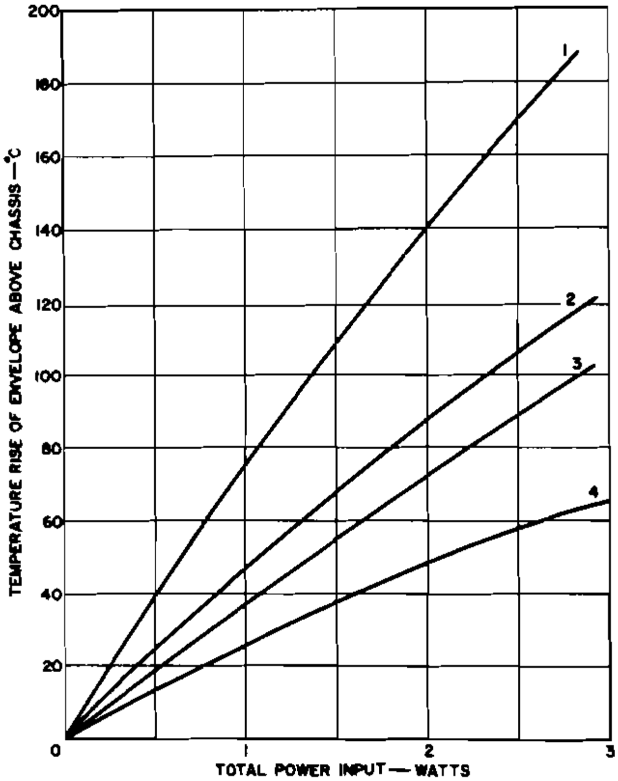


Fig.6 - Temperature curves for developmental long-lead nuvistor triodes: (1) in free air, no socket, not mounted; (2) in free air, no socket, August Heat Dissipator; (3) mounted in IERC clamp, attached to printed board, no socket; (4) mounted in IERC clamp, attached to heat sink, no socket.

Grid-Circuit-Resistance Ratings

At a maximum shell temperature of 150 degrees centigrade, published data for the 7586, 7587, 7895, and 8058 specify a maximum value of one megohm for the control-grid-circuit resistance for cathode-bias operation. In the case of type 8056, a 10-megohm resistance is specified. The 150-degree-centigrade value approximates the typical maximum temperature rating of 85 degrees centigrade established for most conventional circuit components.

In many industrial and military applications, chassis configuration and packaging density require operation at chassis temperatures higher than 85 degrees centigrade. Conversely, in other applications temperature is not a factor, but a larger grid-circuit resistance may be required. Data have been obtained, therefore, to determine the maximum allowable control-grid-circuit resistance for individual nuvistor types at shell temperatures up to 250 degrees centigrade. These data have been measured in conventional sockets crimp-mounted on a 1/16-inch aluminum chassis.

The nomographs in Figs.7 through 11 show the relationship of grid-circuit resistance to chassis temperature and plate dissipation. Any one of these parameters can be determined from the nomographs if the other two are known. For example, if the chassis temperature and plate dissipation are known, the maximum allowable grid-circuit resistance is determined as follows:

First, the intersection of the chassis-temperature and plate-dissipation lines is located on the lower part of the nomograph. A line is then drawn vertically from this point to intersect the cathode-bias or fixed-bias line. From this intersection, a line is drawn horizontally to the left to indicate the maximum allowable grid-circuit resistance on the left-hand scale.

Conversely, if the grid-circuit resistance is known, a horizontal line is drawn from this value to intersect the cathode-bias or fixed-bias line. A vertical line is then drawn from this intersection to the lower part of the nomograph. The intersections of this vertical line with the plate-dissipation lines determine the maximum allowable chassis temperatures for given plate dissipations, or the maximum allowable plate dissipations for given chassis temperatures.

As shown in Figs. 7, 10, and 11, the maximum grid-circuit resistance for types 7586, 8056, and 8058 is 10 megohms. For types 7587 and 7895, it is 3 megohms, as shown in Figs. 8 and 9. Although larger values of circuit resistance can sometimes be used, particularly in cathode-follower designs, circuit designers should consult the tube manufacturer for advice concerning such applications.

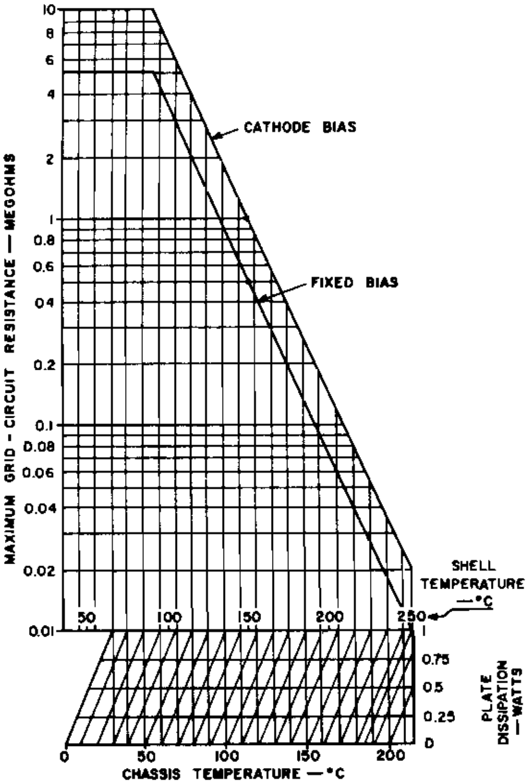


Fig. 7 - Nomograph for type 7586.

The maximum metal-shell temperature rating of 250 degrees centigrade for nuvistors allows operation at chassis temperatures up to 170 degrees centigrade for the 7587, 185 degrees centigrade for the 7586 and 7895, 200 degrees centigrade for the 8056, and 210 degrees centigrade for the 8058. A separate scale of actual nuvistor metal-shell temperatures is also included in the nomographs.

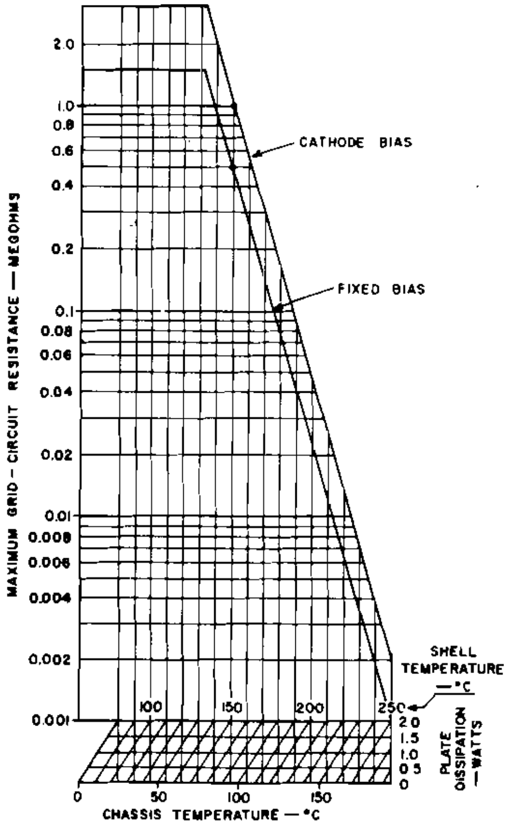


Fig.8 - Nomograph for type 7587.

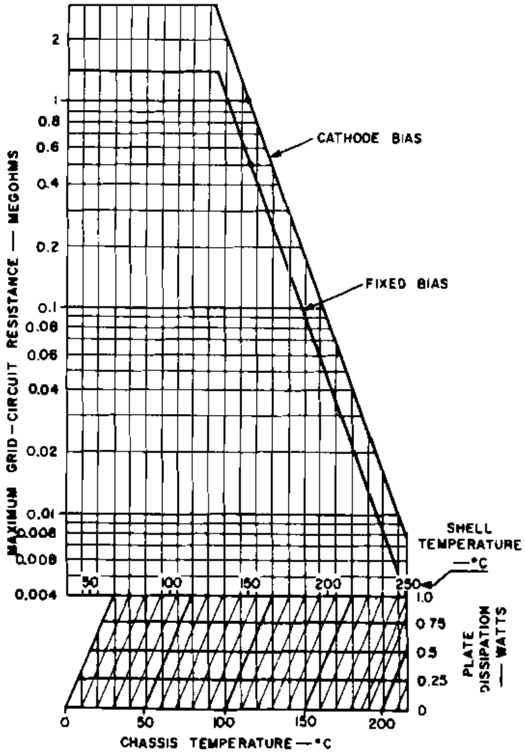


Fig.9 - Nomograph for type 7895.

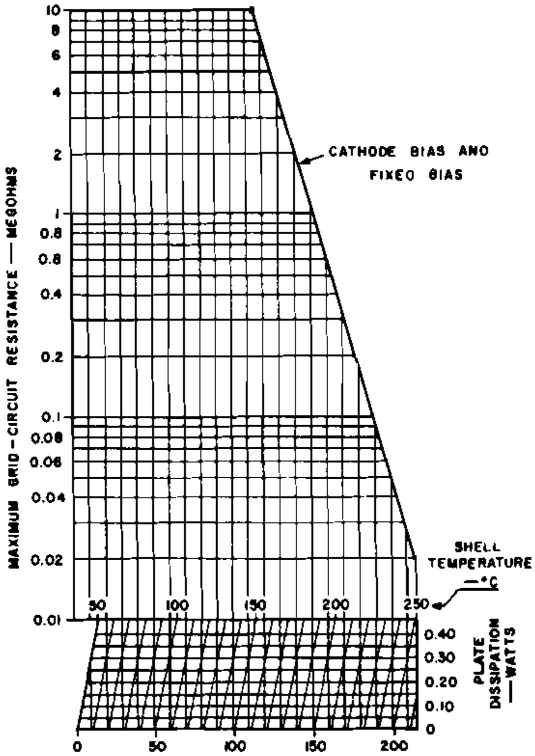


Fig.10 - Nomograph for type 8056.

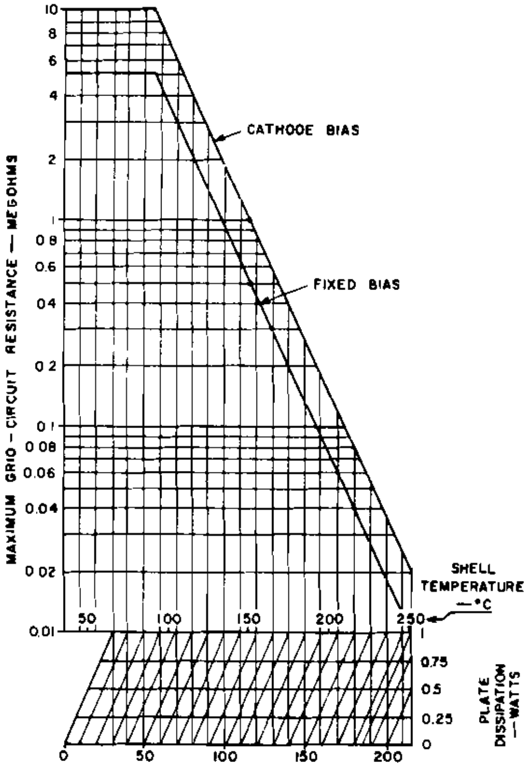


Fig.11 - Nomograph for type 8058.

The Nuvistor Triode In Video IF–Amplifier Circuits

by

K. W. ANGEL and J. GOTE

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ABSTRACT

This paper discusses the use of the Nuvistor triode in two- and three stage if amplifiers and places particular emphasis on neutralization. Theoretical stable-gain limits are also discussed and the results of practical designs are presented.

The development of television tuners using the 6CW4 Nuvistor triode has suggested the possibility that the high-figure-of-merit characteristics of the Nuvistor could also be used to advantage in if systems. The basic question is one of cost for a specified performance; triodes are inherently cheaper and more reliable than tetrodes and pentodes. On the other hand, because of high grid-to-plate capacitance, triodes are more difficult to stabilize at high gains than tetrodes and pentodes and, therefore, require more careful and expensive neutralization techniques. However, the relatively uniform characteristics of the Nuvistor triode greatly simplify neutralization problems.

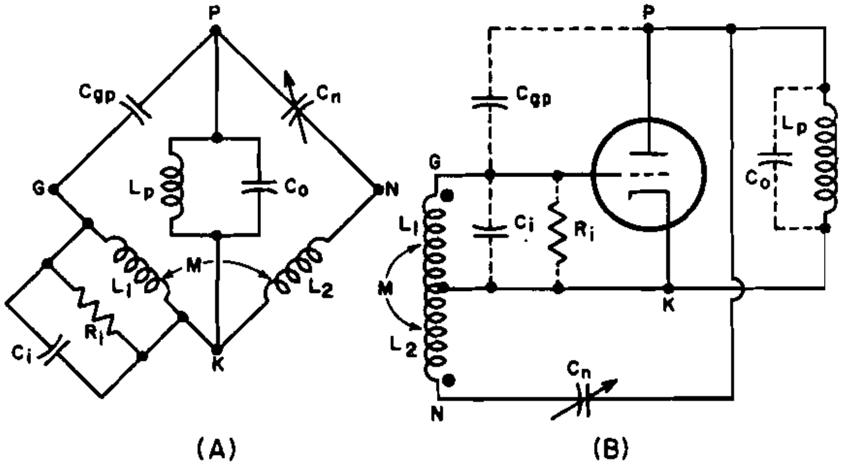
NEUTRALIZATION

If triodes are to be used in an if amplifier, neutralization must be simple, stable with changing conditions and component variation, and inexpensive. A number of circuits could be used to effect neutralization, but all have some drawbacks. Considerable attention has been given to the selection of a good workable and inexpensive neutralization system.

All neutralization circuits involve the balancing of a bridge having either the input or the output of the tube as one branch. With triodes, the resistive component of the bridge branches makes it necessary to compensate for the loading effects of both the plate resistance and the plate dropping resistance. The grid side is less resistive and, therefore, a more satisfactory operating point.

The tapped-coil arrangement shown in Fig.1 (known as the Rice System of neutralization) is the best basic neutralization method for triodes because of its simplicity and its use of the grid circuit as the point of application. As the coefficient of magnetic coupling between L_1 and L_2 approaches unity, the bridge approaches perfect balance. However, the coefficient of coupling in practical systems is usually less than one-half, and more complete balancing may require the addition of an RC network in parallel with L_2.

An equivalent system that is easier to apply and uses fewer components is shown in Fig.2. This arrangement, which uses tapped-capacitor neutralization of the grid circuit, removes the inductive elements from the bridge branches so that tuning of the band pass has little effect on neutralization and facilitates alignment. Unfortunately, this circuit causes an unavoidable 3-db gain reduction. Using a similar tapped-coil arrangement in the plate circuit eliminates the loss in gain, but introduces bridge-balance problems that make the system undesirable.



(A) (B)

Fig.1 - Basic tapped-coil arrangement for triode neutralization (Rice system of neutralization).

STABILITY

In practice, no system can have perfect balance; over-neutralization or under-neutralization must necessarily exist in any practical system. Either condition reflects a negative resistance into the grid tank and instability results if the stage gain is sufficiently high. A stability analysis of the tapped-capacitor circuit shown in Fig.2 defines stability requirements specifically for the Nuvistor triode. This circuit is redrawn in Fig.3 with impedance values typical of the Nuvistor when appropriate scale factors are applied. S is the Laplace-transform variable, and x, y, and z are variation factors of the associated admittance (that is, if x, y, and z are unity, the bridge is perfectly balanced and at maximum gain). By varying x, y, and z, the degree of imbalance which the circuit can tolerate may be determined. Fig.3 also shows the admittance determinant, Δ, the characteristic equation of a single-loop feedback amplifier.

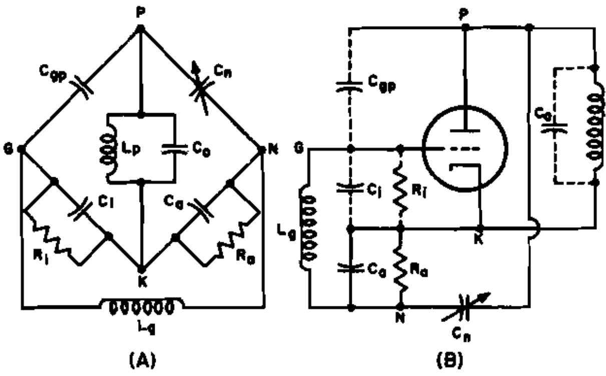


Fig.2 - Tapped-capacitor neutralization of a grid circuit.

The application of Routh-Hurwitz criterion indicates system stability, and several applications using various values of x, y, and z show the effect of parameter changes on the gain margin. This analysis shows that the system is marginally stable at a transconductance of 12,000 micromhos if the only bridge imbalance is a 20 per cent increase or decrease in one of the grid-circuit resistive components. An imbalance of about 20 per cent or less in any bridge impedance is approximately equivalent to reducing the gain margin by that percentage.

When this information is used in the design of a single stage in which the components have a value tolerance of ± 5 per cent, the anticipated variation in parameters can be compensated for by gain reduction. For a ± 5-per-cent variation in grid-to-plate capacitance and a ± 5-per-cent variation in neutralizing capacitor, the gain must be reduced by 20 per cent. The same variation in both capacitors across the grid tank requires another 20-per-cent gain reduction which makes the usable transconductance 60 per cent of 12,000 micromhos, or 7200 micromhos for a well-balanced circuit. If the resistive element of the tank is not balanced (that is, removed entirely from one branch), the transconductance must be further reduced to 3600 micromhos. In practice, it is not necessary to consider the change in the input resistance of a gain-controlled stage because the reduction in transconductance is sufficient to retain stability.

For a television receiver having automatic gain control (agc), the variation in if response can be minimized by using the short-circuit input-loading data shown in Fig.4. These curves indicate that an unbypassed resistor of approximately 47 ohms minimizes loading variations in the agc-controlled stage.

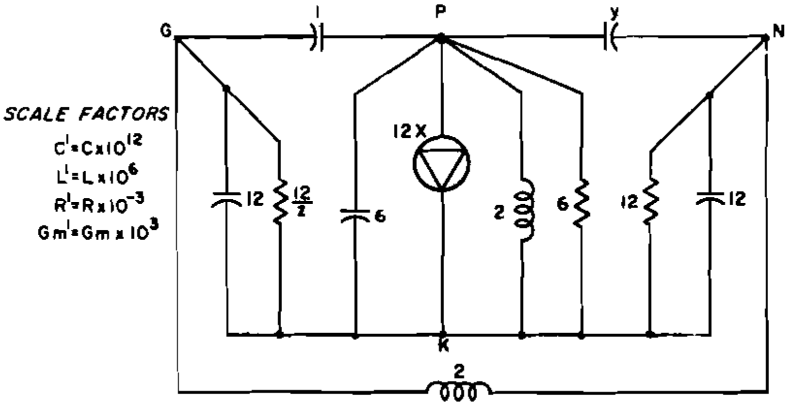


Fig.3 - Tapped-capacitor neutralization circuit having typical Nuvistor impedance values.

$$\Delta = \begin{vmatrix} \left[13s + \frac{z}{12} + \frac{1}{s}\right] & \left[-s\right] & \left[-\frac{1}{s}\right] \\ \left[12x - s\right] & \left[(7+y)s + \frac{1}{6} + \frac{1}{2s}\right] & \left[-ys\right] \\ \left[-\frac{1}{s}\right] & \left[-ys\right] & \left[(12+y)s + \frac{1}{12} + \frac{1}{s}\right] \end{vmatrix}$$

EXPERIMENTAL TWO- AND THREE-STAGE AMPLIFIERS

Because stability analysis of the mutually coupled Rice Neutralization circuit is difficult, experimental circuits were built to determine whether practical coefficients of coupling were large enough to provide usable gains without the use of the more expensive tapped-capacitor circuit. The resulting two-stage amplifier, shown in Fig.5, is a conventional synchronously double-tuned amplifier using a conventional 6EA8 mixer. More than 56 db of gain was obtained with good stability. A normal range of Nuvistors can be substituted without causing excessive tilt or oscillations. The agc control provides more than 40 db of control. The first stage uses the developmental remote-cutoff Nuvistor triode and the output stage uses the 6CW4.

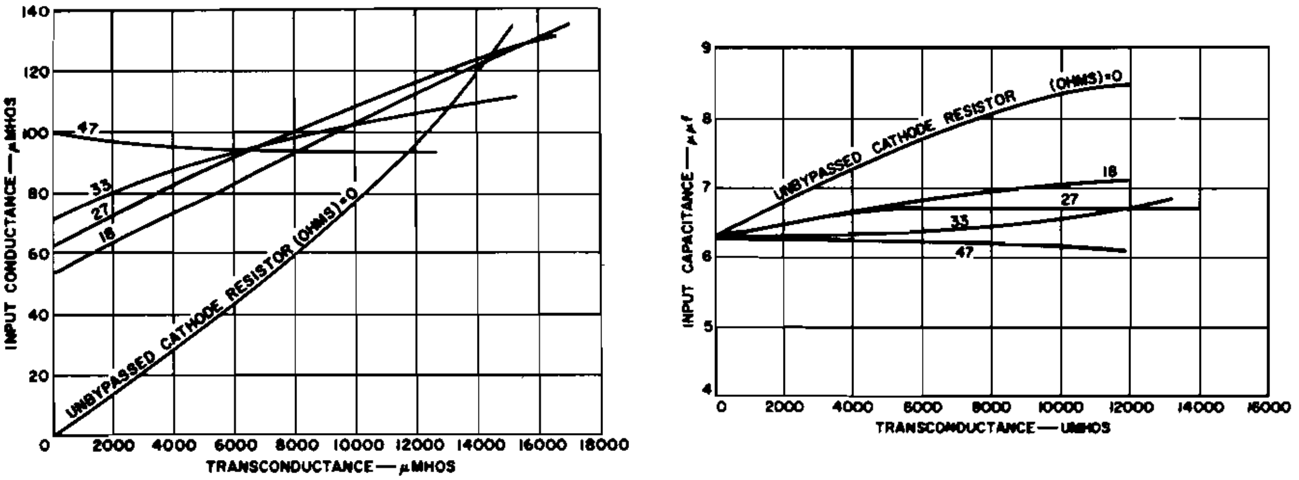


Fig.4 - Short-circuit input-loading data for Nuvistor triode.

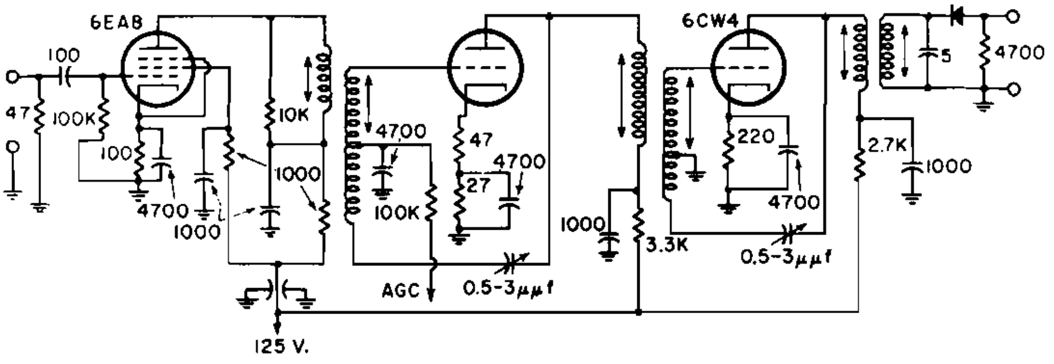


Fig.5 - A two-stage synchronously double-tuned amplifier using a conventional 6EA8 mixer.

The strip has a 3.5-megacycle bandwidth and a 4700-ohm detector load. Because proper bandwidth is obtained by loading of the plate resistance and input loading of the tube, no additional loading is necessary. Bandwidth narrowing with agc gain reduction resulting from increased plate resistance is not severe because of the accompanying increase in coupling. The result was a small drop in the center of the response with only a slight decrease in bandwidth. An unbypassed 47-ohm resistor was used in the first stage to minimize variations in input capacitance with agc control.

The three-stage amplifier shown in Fig.6 is similar to the two-stage counterpart and has two identical gain-controlled stages and a 3900-ohm detector load. This amplifier also uses the conventional 6EA8 mixer shown in Fig.5. Much greater care is necessary with layout and wiring than with the two-stage amplifier. However, without resistive and capacitive balancing of the neutralizing bridges, a stable gain of only 68 db is possible. The agc line provides 80 db of control. More gain may be obtained using the more complete balancing shown in Fig.7. A stable voltage gain of 30.5 db per stage for the first two stages and 12.3 db for the output stage can be obtained. Although the resultant three-stage gain should be 11,400 or 81.14 db, a 3-db loss per stage from the voltage division of the tank capacitors results in a maximum stable gain for the Nuvistor triode three-stage if amplifier of 72 db.

The design shown in Fig.7 uses the capacitor-tapping ratio of approximately 1:1 because this condition minimizes input and output capacitances. In addition, the stage gain is 3 db less than the equivalent ideal Rice neutralized system having unity coefficient of magnetic coupling. A slight improvement in gain can be effected by using a tap ratio that produces a slightly higher grid voltage. Unfortunately, the improvement is small because the input and output capacitances are also increased. The optimum tap ratio for this circuit of approximately 1:1.5 provides 0.4-db improvement over the 1:1 case. Greater ratios result in less gain; beyond a ratio of 1:3 the gain is less than in the 1:1 case.

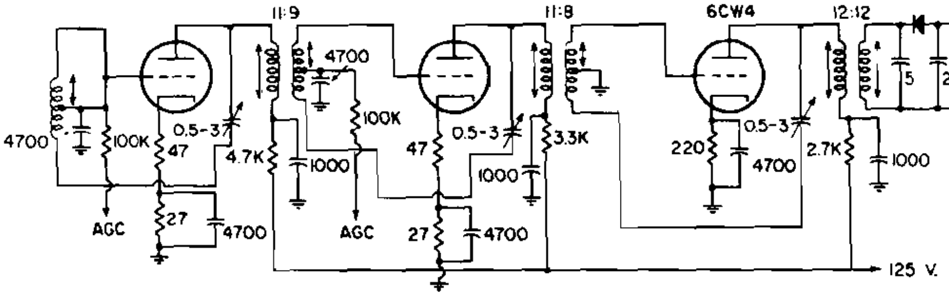


Fig.6 - Three-stage amplifier having two identical gain-controlled stages and a 3900-ohm detector load.

ALIGNMENT

In the alignment procedure, the gain control is set for minimum gain. The neutralizing capacitors of the gain-controlled stages are adjusted for minimum feedthrough, and the output stage is adjusted for minimum tilt. Band-pass adjustment is made in the normal way: the gain is increased by a small amount and the gain-controlled stages are re-neutralized and then cut off to permit adjustment of the output-stage neutralization for minimum tilt. This process is continued until full agc control can be applied without causing tilt or oscillation from maximum to minimum gain. When a given layout has been aligned, the neutralizing capacitors can be set at ± 5 per cent values.

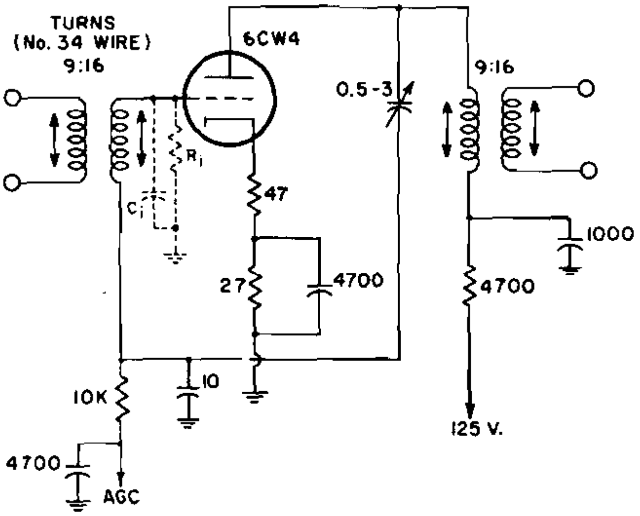


Fig.7 - Neutralization circuit using a 1:1 capacitor-tapping ratio.

CONCLUSION

Two- and three-stage synchronously double-tuned if amplifiers are feasible when the Nuvistor triode is used with simple Rice neutralization and with no additional bridge balancing. This system makes possible a gain of 56 db with a 4700-ohm detector load for the two-stage strip and 68 db with a 3900-ohm load for the three-stage strip. Substitution of tubes within the Nuvistor specification limits does not cause oscillator or excessive tilt. The practical maximum gain possible from the Nuvistor three-stage amplifier is 72 db when ± 5-per-cent-tolerance components are used and a 20-per-cent imbalance in the resistive component of the neutralization bridge and ± 15-per-cent spread in Nuvistor and stray capacitances are assumed.

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RCA Application Note

AN-193

Use of the RCA-7587 Industrial Nuvistor Tetrode In RF and IF Applications

This Note discusses the use of the RCA-7587 nuvistor tetrode in small-signal high-frequency circuits. Input-admittance data are given for frequencies from 20 to 150 megacycles, and a small 60-megacycle wide-band amplifier is described.

Tube Design Features

The all-metal-and-ceramic RCA-7587 sharp-cutoff nuvistor tetrode uses a concentric cylindrical open-ended cantilever construction. The use of a top cap for the plate connection provides excellent input-to-output isolation, a low grid-No. 1-to-plate capacitance of 0.01 micromicrofarad, and a low output capacitance of 1.4 micromicrofarads. In addition, the tube construction provides extremely low residual-gas currents, freedom from buildup of leakage paths, and a rugged internal structure. The low heater drain of 150 milliamperes, the high transconductance of 10,600 micromhos at 10 milliamperes of plate current, and its small size make the RCA-7587 particularly useful for general industrial and military application.

The bandwidth figure of merit GB for a tetrode is given by

$$GB = \frac{g_m}{2\pi \ (C_{in} + C_{out})}$$

The RCA-7587 has a cold input capacitance C_{in} of 6.5 micromicrofarads, a cold output capacitance C_{out} of 1.4 micromicrofarads, and a transconductance g_m of 10,600 micromhos. Substitution of these values in the above formula produces a nominal figure of merit of 214 megacycles. However, the input capacitance for a tube in a socket under operating conditions is approximately 9 micromicrofarads. Consequently, the actual figure of merit for an operating tube is 162 megacycles.

Input Admittance

When the current through a tube is varied, as it may be for the purpose of controlling the gain of an amplifier stage, variations in the input conductance and in the input capacitance affect the gain-vs-frequency characteristic of the circuit connected to the input of the tube.

ELECTRON TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

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Table I shows the values of short-circuit input capacitance and short-circuit input conductance of the RCA-7587 for conditions of normal operation, cutoff, and with the tube cold. These values were measured in a socket at a frequency of 60 megacycles. The capacitance values are nearly independent of frequency up to approximately 150 megacycles. Theoretical considerations indicate that the conductance should increase with the square of the frequency. The measured data shown in the curve of Fig.1 indicate a somewhat more rapid increase with frequency. This difference results from the series inductance in the measurement circuit.

Operating Condition	Input Capacitance ($\mu\mu$f)	Input Conductance (μmhos)
Tube operating (I_b = 10 ma)	9.0	100
Tube cut off (I_b = 0)	7.7	18
Tube cold (no heater voltage applied)	7.1	17
Change from cutoff to I_b = 10 ma	1.3	82
Change when heater voltage is applied	0.6	-

Table I - Variation of Short-Circuit Input Capacitance and Input Conductance of the RCA-7587 at 60 Megacycles.

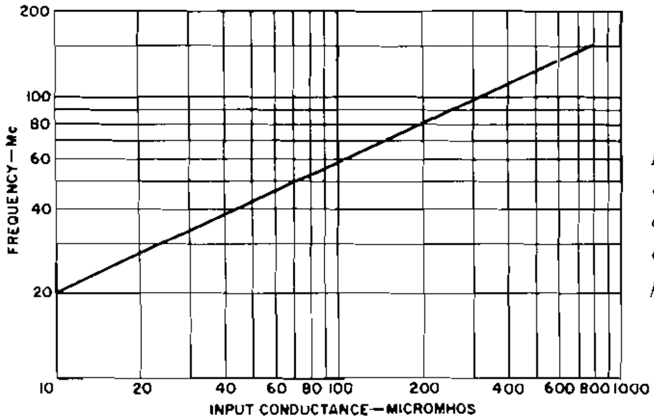


Fig. 1 - Relationship between operating frequency and input conductance of RCA-7587 at typical operating conditions (g_m = 10,600 μmhos; I_b = 10 ma).

The variation of input capacitance and input conductance with operating conditions can be reduced substantially if the tube is used in a circuit which includes an unbypassed cathode resistor. Figs.2 and 3 show data for the 7587 measured in such a circuit. As shown in Fig.2, the value of unbypassed cathode resistance which provides minimum change in capacitance between cutoff and maximum transconductance is about 18 ohms. The value which provides minimum change in conductance is about 33 ohms, as shown in Fig.3. The circuit designer should select a resistance value between these limits which will have the smallest effect on the bandpass characteristic of his particular system.

The data shown in Figs. 2 and 3 were measured at a frequency of 60 megacycles. The choice of resistance values for optimum results is not affected appreciably by changes in frequency, but the magnitude of the conductance values varies approximately with the square of the frequency, as mentioned previously.

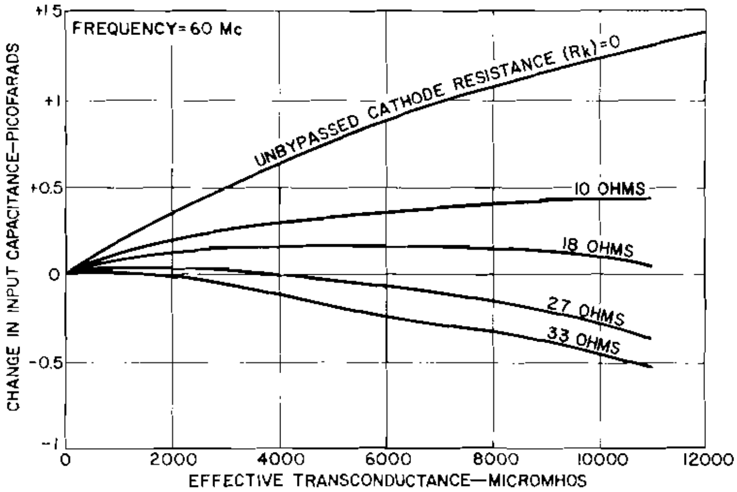
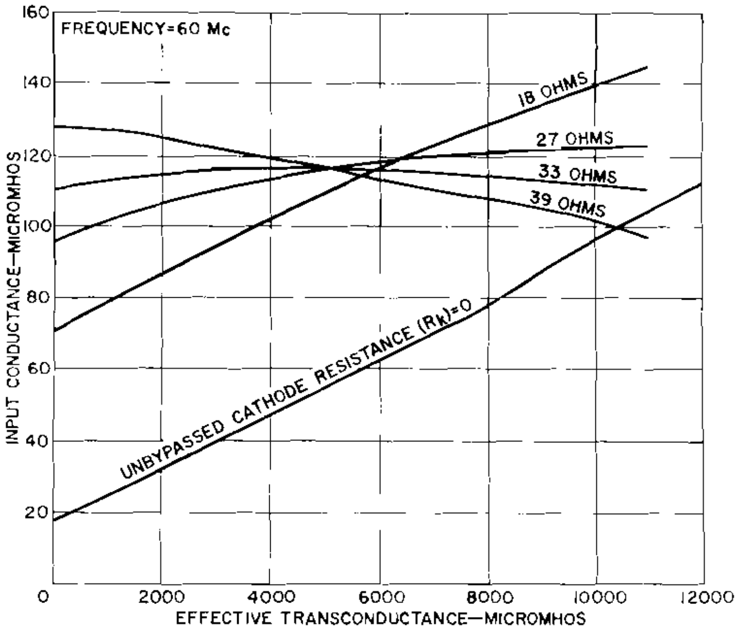


Fig. 2 - Variation of short-circuit input capacitance at 60 megacycles as a function of transconductance for several values of unbypassed cathode resistance.

Fig. 3 - Variation of short-circuit input conductance at 60 megacycles as a function of transconductance for several values of unbypassed cathode resistance.



The amount of unbypassed cathode resistance needed to minimize the variation of capacitance and conductance with operating conditions is less than the total value of cathode resistance suggested in the published "typical operating conditions" for the 7587. Consequently, either an additional bypassed section of cathode resistor or an external source of bias is required. In high-gain circuits with automatic gain control, the initial biasing voltage developed from noise in the system under small-signal conditions is often sufficient to supply enough initial bias to prevent excessive plate and screen-grid currents.

IF Amplifier Design

The simple five-stage 60-megacycle if amplifier shown in Fig.4 demonstrates the capabilities of the 7587. This amplifier consists of staggered single-tuned stages (a flat-staggered quintuple[1]), and has a bandwidth of 8 megacycles.

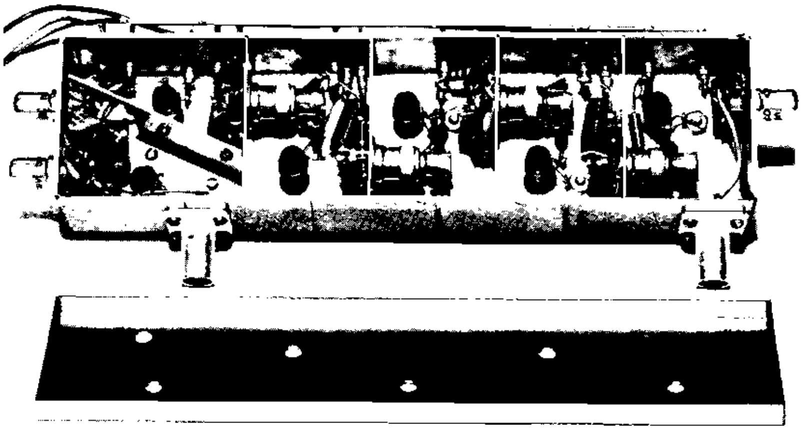


Fig. 4 - Photograph of an experimental 5-stage 60-megacycle if amplifier using RCA-7587.

As shown in Fig.5, the first stage consists of two RCA-7586 nuvistor triodes in cascode arrangement, followed by four 7587 nuvistor tetrodes and a diode-connected 7586 triode used as a detector. The cascode input stage was chosen to take advantage of the low noise figure inherent in this configuration. The tetrodes are single-tuned and staggered. The first two tetrodes V_3 and V_4 are gain-controlled. Unbypassed cathode resistors are mandatory to preserve the proper shape of the bandpass characteristic as the gain is varied. V_5 and V_6 have fixed gain; however, small unbypassed resistors have been added to provide some degeneration to improve stability.

The damping of each tuned circuit in a stagger-tuned amplifier is dependent upon the individual bandwidth and frequency required to achieve an over-all flat bandpass of desired width. In this amplifier, the plate-load resistor of the preceding stage and the input conductance of the tuned grid-No.1 circuit are placed in parallel to achieve the proper bandpass. The value of damping resistance calculated for each stage can be only a first approximation because the short-circuit input-conductance data do not show the input-conductance component resulting from feedback through the grid-No.1-to-plate capacitance. This feedback component, when measured at the grid-No.1-circuit resonant frequency, is positive when the plate circuit is tuned to a frequency lower than that of the grid-No.1 circuit and negative when the plate circuit is tuned to a frequency higher than that of the grid-No.1 circuit.

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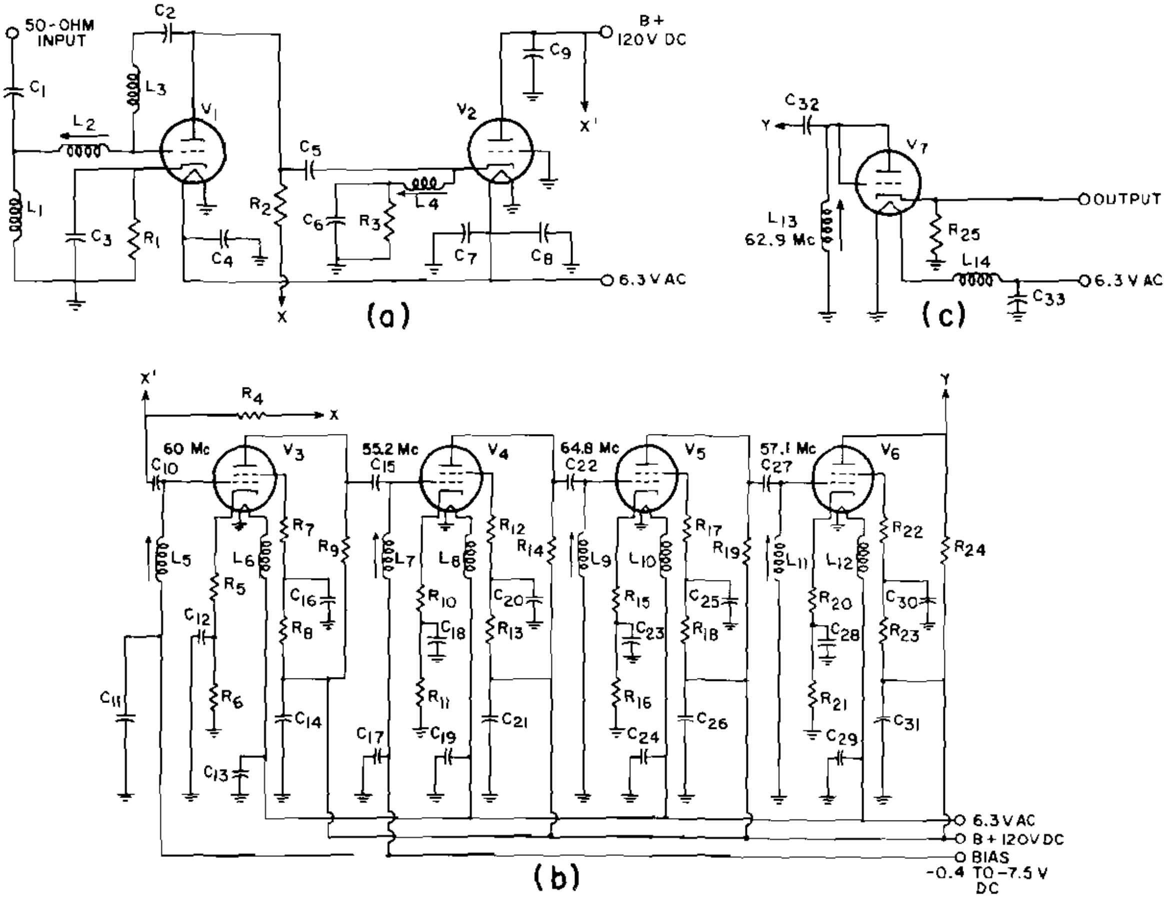
[1] G. E. Valley, Jr. and H. Wallman, *Vacuum-Tube Amplifiers*, 1st Ed., McGraw-Hill Book Company, Inc., New York, N. Y., 1948, pp.180-186.

Each stage is tuned by adjustment of its inductance for resonance with the tube and stray circuit capacitance. Because of the uniformity of nuvistor characteristics from tube to tube, a minimum amount of adjustment is necessary to retain the proper bandpass characteristics when tubes are interchanged.



C_1 C_2 C_5 C_{10} C_{15} C_{22} C_{27} C_{32} = 390 μμf

C_3 C_4 C_6 C_8 C_{12} C_{16} C_{18} C_{20} C_{23} C_{25} C_{28} C_{30} = 500 μμf

C_7 C_9 C_{11} C_{13} C_{14} C_{17} C_{19} C_{21} C_{24} C_{26} C_{29} C_{31} C_{33} = 1000 μμf, feedthrough

L_1 = 4.8 μh

L_2 L_4 = 0.5 μh, ferrite core

L_3 L_6 L_8 L_{10} L_{12} L_{14} = 5 μh

L_5 L_9 L_{13} = 8 turns No. 24 AWG close-wound on 1/4-inch round form (ferrite core)

L_7 L_{11} = 9 turns No. 24 AWG close-wound on 1/4-inch round form (ferrite core)

R_1 = 150 ohms

R_2 R_{14} = 4700 ohms

R_3 = 220 ohms

R_4 R_{24} = 1800 ohms

R_5 R_{10} = 27 ohms

R_6 R_{11} = 39 ohms

R_7 R_{12} R_{17} R_{22} = 10 ohms

R_8 R_{13} R_{18} R_{23} = 27000 ohms

R_9 = 6200 ohms

R_{15} R_{20} = 18 ohms

R_{16} = 47 ohms

R_{19} = 2200 ohms

R_{21} = 68 ohms

R_{25} = 16000 ohms

Fig. 5 - Schematic diagram for amplifier shown in Fig. 4: (a) 7586 preamplifier; (b) 7587 if amplifier; (c) 7586 detector used for measurements.

The effective grid-No.1-to-plate capacitance of an rf amplifier tube is much higher than the value measured at low frequencies if the screen grid is not at rf ground potential. It becomes difficult to ground the screen grid effectively at frequencies above 30 megacycles because of the inductance of the screen-grid and bypass-capacitor leads. Unbypassed 10-ohm series resistors were used to "swamp out" any possible high-Q series resonances that might be caused by the bypass capacitor. The lead inductances can be adjusted to resonate in series with the bypass capacitor to effectively ground the screen grid.

The small size and double-ended construction of the 7587 simplify the circuit layout because the chassis can be made to act as a physical barrier between input and output. Experience has shown that high packaging densities (small over-all size) can be readily achieved with negligible instability provided proper bypassing and decoupling are used. The basic amplifier chassis shown in Fig.4 measures 1-7/8 inches by 1-1/4 inches by 7-5/8 inches. The over-all length is increased slightly to 8-1/4 inches when the cascode 7586 nuvistors are inserted in one end. This unit is not as small as possible; other units using more tubes have been built even more compactly.[2] In this circuit, however, each stage was "compartmentalized" to minimize the external feedback paths by taking advantage of the double-ended feature of the 7587. The plate, bias, and heater-voltage supply or bus lines are strung "outboard" along one side of the chassis.

Gain and Bandpass Measurements

The over-all amplifier gain of the circuit shown in Fig.5 was measured with a 60-megacycle unmodulated signal applied to the input grid of the first stage. A dc voltmeter was connected across the detector load resistor and an rf vacuum-tube voltmeter was connected across the tuned inductance in the detector plate circuit. With the signal on, both rf and dc voltages were measured. The rf meter was then removed, and the level of the input signal was adjusted until the original dc voltage was obtained across the detector load. The rf output voltage was then divided by the adjusted input-signal voltage to calculate the over-all gain. The voltage gain of the 60-megacycle amplifier was 104,000; the average gain per stage was greater than 10.

For measurement of the bandpass characteristics of the amplifier, the input-signal level was varied to maintain a constant dc voltage across the detector load throughout the passband. Fig.6 shows the gain-bandpass characteristics of the amplifier of Fig.5 for gains of 705, 11,100, and 104,000.

Maximum Operating Temperature

Good design practice for reliability and life requires consideration of the maximum operating-temperature ratings for all components. The 7587 can operate at a maximum shell temperature of 150 degrees centigrade, measured at the gussets near the base of the tube. The 150-degree limitation permits chassis temperatures of up to 75 degrees centigrade at full dissipation. Temperature measurements are made with a small thermocouple welded

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[2] "Nuvistors Improve Performance of Beacon IF Strip", ELECTRICAL DESIGN NEWS, Vol.5, No.8, August 1960, p.34.

to a gusset of the nuvistor. The weld can be made by discharging a capacitor through the junction of the thermocouple and the tube shell. A 200-microfarad capacitor charged to about 75 volts welds a thermocouple wire having a diameter of 0.005 inch.

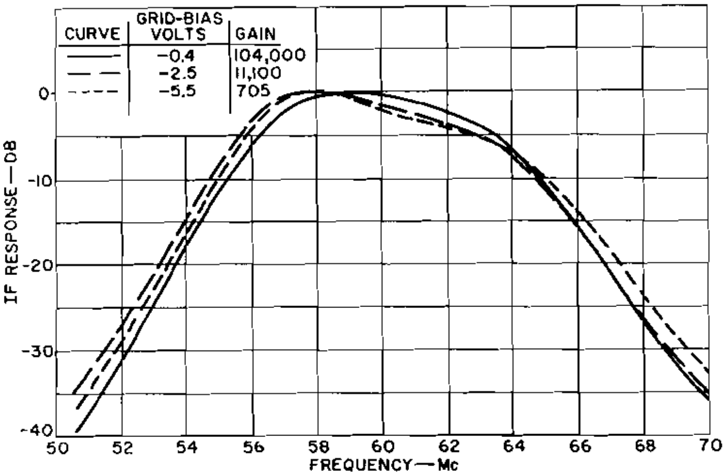

Fig. 6 - Gain-bandpass characteristics of amplifier shown in Figs. 4 and 5.

The 7587 is designed so that the metal shell, particularly the lug contact to the socket, conducts heat away from the tube. When printed-board or other poor-heat-conducting materials are used for the chassis, care should be taken to insure that the tube-shell temperature does not exceed 150 degrees centigrade. Operation at higher temperatures may increase grid current and impair the life of the tube. When the tubes are used at full dissipation on a printed board, the metallic portion of the chassis should be connected to a suitable heat sink.