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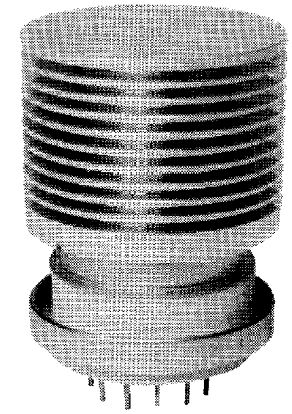
8121
Power Tube

Linear Beam Power Tube

- **Coaxial-Electrode Structure**
- **Ceramic-Metal Seals**
- **Full Ratings up to 500 MHz**
- **Forced-Air Cooled**
- **170 Watts PEP Output at 30 MHz**
- **235 Watts CW Output at 470 MHz**



The BURLE 8121 is a small, forced-air-cooled beam power tube suitable for use as an RF power amplifier, distributed amplifier, linear RF power amplifier, oscillator, or regulator in mobile or fixed equipment.

Because of its high power sensitivity and high efficiency, the 8121 produces a large power output when operated at relatively low anode voltage with small driving power. In CW operation with 1500 volts on the anode, the 8121 provides 235 watts useful output at frequencies up to 500 MHz.

The anode radiator is specially designed for effective anode cooling with air flow in a direction normal to the tube’s major axis. The air-cooled radiator permits a maximum anode dissipation of 150 watts.

The 8121 features a light-weight, cantilever-supported cylindrical electrode structure in a ceramic-metal envelope. This construction provides a very sturdy tube and permits high-temperature operation.

The terminal arrangements of the 8121 facilitate use of the tube with tank circuits of the coaxial or strip-line type. Effective isolation of the output circuit from the input circuit is provided at the higher frequencies by the low-inductance ring terminal for grid No.2. Base-pin terminals for grid No.2 are also available for operation of the 8121 at the lower frequencies.

The tripod arrangement of cathode, grid No.1, and grid No.2 leads simplifies construction and enhances electrical characteristics. The three cathode pins reduce the inductance path to RF ground and reduce the input admittance at high frequencies. One of the cathode pins (preferably No. 4 pin) may be series tuned to ground with a capacitor to provide broadband neutralization in the upper frequency range of the tube. The three grid No.1 pins accommodate a split-input circuit for distributed amplifier service.

This data sheet gives application information unique to the BURLE 8121. It should be used in conjunction with the publication, “Application Guide for BURLE Power Tubes,” TP-1 05, for general operating information.

General Data

Electrical

Heater, for Unipotential Cathode:		
Voltage (AC or DC)[1] 13.5	13.5 ± 10%	V
Current at 13.5 volts	1.3	A
Minimum heating time	60	sec
Mu-Factor, Grid No.2 to Grid No.1 for Anode Volts = 450, Grid-No.2 Volts = 325, and Anode Current 1.2 A	12	
Direct Interelectrode Capacitances:[2]		
Grid No.1 to anode	0.15 max.	pF
Grid No.1 to cathode	16.3	pF
Anode to cathode	0.011	pF
Grid No.1 to grid No.2	23.3	pF
Grid No.2 to anode	7.0	pF
Grid No.2 to cathode	2.7	pF
Cathode to heater	3.3	pF

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General Data (Cont'd)

Mechanical

Operating Position	Any
Maximum Overall Length	558 mm (2 196 in)
Seated Length	47 0 ± 1.65 mm (1 850 ± 0.065 in)
Greatest Diameter	37 08 ± .04 mm (1.460 ± 0.015 in)
Base	Large Wafer Elevenar 11-Pin with Ring(JEDEC No-E11-81)
Socket	Erie No.9813-000[3] or equivalent Johnson No.124-311-100[4]
Grid No.2 By-pass Capacitor	Erie No.9812-000[3] or equivalent, Johnson No.124-0113-001[4]
Weight (Approx.)	3 oz

Thermal

Terminal Temperature (All Terminals)	250	max.	°C
Radiator Core Temperature (See Dimensional Outline)	250	max.	°C

Air Flow:

See **Figure 8** - Typical Cooling Requirements

Linear RF Power Amplifier
Single-Sideband Suppressed-carrier Service

Peak envelope conditions for a signal having a minimum peak-to-average power ratio of 2.

Maximum CCS Ratings, Absolute-Maximum Values

	up to 500 MHz	
DC Anode Voltage	2200	V
DC Grid-No.2 Voltage	400	V
DC Grid-No. 1 Voltage	-100	V
DC Anode Current at Peak of Envelope[6]	450	mA
DC Grid-No.1 Current	100	mA
Anode Dissipation	150	W
Grid-No.2 Dissipation	8	W
Peak Heater-Cathode Voltage		
Heater negative with respect to cathode	150	V
Heater positive with respect to cathode	150	V

Typical CCS Operation with "Two-Tone Modulation"

	At 30 MHz		
DC Anode Voltage	1000	1500	V
DC Grid-No.2 Voltage[6]	250	250	V
DC Grid-No.1 Voltage[6]	-20	-20	V
Zero-Signal DC Anode Current	100	100	mA
Effective RF Load Resistance	2270	3800	ohms
DC Anode Current at Peak of Envelope	210	210	mA
Average DC Anode Current	160	160	mA
DC Grid-No.2 Current at Peak of Envelope	10	10	mA
Average DC Grid-No 2 Current	7	7	mA
Average DC Grid-No.1 Current[7]	0.05	0.05	mA
Peak-Envelope Driver Power Output (Approx.)[8]	0.3	0.3	W
Output-Circuit Efficiency (Approx.)	90	85	%
Distortion Products Level:[9]			
Third order	35	35	dB
Fifth order	40	40	dB
Useful Power Output (Approx.).			
Average[10]	55	85	W
Peak envelope[10]	110	170	W

Maximum Circuit Values

Grid No.1 Circuit Resistance Under Any Condition:		
With fixed bias	25,000	ohms
With fixed bias (In Class AB_1 operation)	100,000	ohms
With cathode bias	Not Recommended	
Grid-No.2 Circuit Impedance	10,000	ohms
Anode Circuit Impedance	See Note 11	

RF Power Amplifier & Oscillator - Class C Telegraphy and RF Power Amplifier - Class C FM Telephony
Maximum CCS Ratings, Absolute-Maximum Values

	Up to 500 MHz	
DC Anode Voltage	2200	V
DC Grid-No.2 Voltage	400	V
DC Grid-No.1 Voltage	-100	V
DC Anode Current	300	mA
DC Grid-No.1 Current	100	mA
Grid-No.2 Dissipation	8	W
Anode Dissipation	150	W
Peak Heater-Cathode Voltage:		
Heater negative with respect to cathode	150	V
Heater positive with respect to cathode	150	V

Typical CCS Operation

	In Grid-Drive Circuit at 50 MHz			
DC Anode Voltage	700	1000	1500	V
DC Grid-No.2 Voltage	175	200	200	V
DC Grid-No.1 Voltage	-10	-30	-30	V
DC Anode Current	300	300	300	mA
DC Grid-No.2 Current	25	20	20	mA
DC Grid-No.1 Current	50	40	40	mA
Driver Power Output (Approx.)[12]	1.2	2.0	2.0	W
Useful Power Output[10]	120	175	275	W

	In Grid-Drive Circuit at 470 MHz			
DC Anode Voltage	700	1000	1500	V
DC Grid-No.2 Voltage	200	200	200	V
DC Grid-No.1 Voltage	-30	-30	-30	V
DC Anode Current	300	300	300	mA
DC Grid-No.2 Current	10	10	5	mA
DC Grid-No.1 Current	30	30	30	mA
Driver Power Output (Approx.)[12]	5	5	5	W
Useful Power Output[10]	100	165	235	W

Maximum Circuit Values

Grid-No.1 Circuit Resistance Under Any Condition:		
With fixed bias	25,000	ohms
Grid-No.2 Circuit Impedance	10,000	ohms
Anode Circuit Impedance	See Note 11	

Characteristics Range Values

	Min.	**Max.**	
Heater Current[14]	1.15	1.45	A
Direct Interelectrode Capacitances:			
Grid-No.1 to anode[15]		0 15	pF
Grid-No. 1 to cathode[15]	14.6	18 0	pF
Anode to cathode'[5]	.004	. 016	pF
Grid-No.1 to grid-NO.2[15]	20.0	26.5	pF
Grid-No.2 to anode[15]	6.3	7.7	pF
Grid-No.2 to cathode[15]	2.1	3.3	pF
Cathode to heater'[5]	2.5	4.1	pF
Grid-No.1 Voltage'[4] 16	-8	-19	V
Reverse Grid-No.1 Current[1415]		-25	uA
Grid-No.2 Current'[4 15]	-5	+6	mA
Peak Emission[14'17]	13		Peak A
Interelectrode Leakage Resistance[15]	1.0		Mohm

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1. Because the cathode is subjected to back bombardment as the frequency is increased with resultant increase in temperature, the heater voltage should, for optimum life, be reduced to a value such that at the heater voltage obtained at minimum supply voltage conditions (all other voltages constant) the tube performance just starts to show some degradation; e.g., at 470 MHz, heater volts = 12.5 (Approx.).
2. Measured with special shield adapter.
3. Erie Specialty Products, 645W. 11th St., Erie, PA 16512.
4. E. F. Johnson Co., 299 Johnson Ave., Waseca, MN 56093.
5. The maximum rating for a signal having a minimum peak-to-average power ratio less than 2, such as is obtained in Single-Tone" operation, is 300 mA. During short periods of circuit adjustment under Single-Tone" conditions, the average anode current may be as high as 450 mA.
6. Obtained preferably from a separate, well regulated source.
7. This value represents the approximate grid-No.1 current obtained due to initial electron velocities and contact-potential effects when grid No.1 is driven to zero volts at maximum signal.
8. Driver power output represents circuit losses and is the actual power measured at input to grid-No.1 circuit. The actual power required depends on the operating frequency and the circuit used. The tube driving power is approximately zero watts.
9. With maximum signal output used as a reference, and without the use of feedback to enhance linearity.
10. This value of useful power is measured at load of output circuit.
11. The tube should see an effective anode supply impedance which limits the peak current through the tube under surge conditions to 15 amperes.
12. Driver power output includes circuit losses and is the actual power measured at the input to the grid circuit. It will vary depending upon the frequency of operation and the circuit used.
13. Measured in a typical coaxial-cavity circuit.
14. With 13.5 volts AC or DC on heater.
15. Measured with special shield adapter.
16. With DC anode voltage at 700 volts, DC grid-No.2 voltage of 250 volts, and DC grid-No.1 voltage adjusted to give a DC anode current of 185 mA,
17. For conditions with grid No.1, grid No.2, and anode tied together; and pulse voltage source connected between anode and cathode. Pulse duration is 2.5 microseconds and pulse repetition frequency is 60 pps. The voltage-pulse amplitude is 200 volts peak. After 1 minute at this value, the current-pulse amplitude will not be less than the value specified.
18. Under conditions with tube at 20° to 30° C for at least 30 minutes without any voltages applied to the tube. The minimum resistance between any two electrodes as measured with a 200-volt Megger-type ohmmeter having an internal impedance of 1.0 megohm will be 1.0 megohm.

Definitions

CCS - Continuous Commercial Service

Rating System - In accordance with the Absolute Maximum rating system as defined by the Electronic Industries Standard RS-239A, formulated by the JEDEC Electron Tube Council.

Two-Tone Modulation-Two-Tone Modulation operation refers to that class of amplifier service in which the input consists of two monofrequency RF signals having equal peak amplitude.

General Considerations Temperature

The maximum terminal temperature of 250°C and the maximum radiator core temperature of 250° C are tube ratings and are to be observed in the same manner as other ratings. The temperature may be measured with temperature-sensitive paint, such as Tempilaq. Tempilaq is made by the Tempil Division, Air Liquide America Corporation, 2901 Hamilton Boulevard, South Plainfield, NJ 07080.

Mounting

The anode connection to the 8121 may be made by a metal band or spring contacts to the larger fin of the radiator which is located at the base end.

If rigid connections are made to more than one plane (base, flange, and radiator), adjustment must be made in a plane normal to the major tube axis to compensate for variations in concentricity for the associated parts of the tube. (See Dimensional Outline.)

Electrical Considerations

Grid No.1

Grid No.1 of the 8121 in UHF service is subjected to heating caused not only by the normal electron bombardment as indicated by the grid current, but also by radiation from the cathode and circulating RF currents. For these reasons, more than ordinary care must be taken during operation to prevent exceeding the grid-No.1 current rating and the maximum grid-No.1 terminal temperature rating.

Grid No.2

The grid No.2 current of the 8121 may be negative under certain operating conditions. The voltage for grid No.2 should be obtained from a source of good regulation. If a separate source is used, a maximum impedance of 10,000 ohms and a minimum divider current of 40 mA are required; if a voltage divider from the anode supply is used, a maximum impedance of 10,000 ohms between grid No. 2 and ground is required. The anode voltage should be applied before or simultaneously with grid-No.2 voltage; otherwise, with voltage on grid-No.2 only, its current may be large enough to cause excessive grid-No.2 dissipation.

The grid-No.2 current is a very sensitive indication of anode-circuit loading. When the 8121 is operated without load, the grid-No.2 current rises excessively, often to a value which damages the tube. Therefore, care should be taken when tuning the 8121 circuit under no-load or lightly loaded conditions to prevent exceeding the grid-No.2 input rating of the tube. In this connection, reduction of the grid-No.2 voltage will be helpful.

Anode

In tubes such as the 8121 having very closely spaced electrodes, extremely high voltage gradients occur even with moderate tube operating voltages. Any tube flash-arcing may be destructive. It is recommended that each tube see an effective anode supply impedance which limits the peak current through the tube under surge conditions to 15 amperes. Failure of the tubes due to internal flashing is more prevalent when the circuit is not tuned to optimum conditions. Even though laboratory tests indicate that no such protection is needed, poor-circuit adjustment in the field may result in shortened tube life.

Driver

The driver power output shown in the typical operation for the 8121 in RF service is considerably more than is normally calculated for typical driving power input in order to permit considerable range of adjustment, and also to provide for losses in the grid-No.1 circuits and the coupling circuits. This consideration is particularly important at the higher frequencies where circuit losses, radiation losses, and transit-time losses increase, and the effects of cathode-lead inductive reactance become significant.

Cathode-Drive Circuits

In cathode-drive circuits, driver power output and the developed RF power output act in series to supply the load circuit. If the driving voltage and grid-No.1 current are increased, the output will always increase. Such is not the case in a grid-drive circuit where a saturation effect takes place, i.e., above a certain value of driving voltage and current, the output increases very slowly and may even decrease. It is important to recognize this difference and not try to saturate a cathode-drive stage because the maximum grid-No.2 input may easily be exceeded.

In tuning a cathode-drive RF amplifier, it must be remembered that variations in the load on the output stage will produce corresponding variations in the load on the driving stage. This effect will be noticed by the simultaneous increase in anode currents of both the output and driving stages.

Class C RF Telegraphy Service

In class C RF telegraphy service, the 8121 may be supplied with bias by any convenient method except when the tube is used in the final amplifier or a preceding stage of a transmitter designed for break-in operation and oscillator keying. In this case, an amount of fixed bias must be used to limit the anode current, and therefore the anode dissipation, to a safe value.

Standby Operation

During standby periods in intermittent operation, the heater voltage may be maintained at normal operating value for most applications.

In those applications which require maximum reliability, it is recommended that the heater voltage be maintained at normal operating value when the period is less than 15 minutes; that it be reduced to 80 per cent of normal when the period is between 15 minutes and 2 hours; and that for longer periods, the heater voltage should be turned off.

Protective Devices

Protective devices should be used to protect not only the anode but also grid No.2 against overload. In order to prevent excessive anode current flow and resultant overheating of the tube, the common ground lead of the anode circuit should be connected in series with the coil of an instantaneous overload relay. This relay should be adjusted to remove the DC anode and grid-No.2 voltage when the average value of anode current reaches a value slightly higher than normal anode current. A protective device in the grid-No.2 supply should remove the grid-No.2 voltage when the DC grid-No.2 current reaches a value slightly higher than normal.

Precautions

The rated anode and grid-No.2 voltages of this tube are extremely dangerous. Great care should be taken during the adjustment of circuits. The tube and its associated apparatus, especially all parts which may beat high potential above ground, should be housed in a protective enclosure. The protective housing should be designed with interlocks so that personnel cannot possibly come in contact with any high-potential point in the electrical system. The interlock devices should function to break the primary circuit of the high-voltage supplies when any gate or door on the protective housing is opened, and should prevent the closing of the primary circuit until the door is again locked.

Warning – Personal Safety Hazards

Electrical Shock- Operating voltages applied to this device present a shock hazard.

Cooling Considerations

System

Forced-air cooling of the 8121 is required as indicated in **Figure 8.** A suitable air filter is required in the air supply. Care should be given to cleaning or replacing the filter at intervals in order that accumulated dirt will not obstruct the required flow of air through the radiator.

Precautions

The cooling system should be properly installed to insure safe operation of the tube under all conditions and for this reason should be electrically interconnected with the heater and plate power supplies. This arrangement is necessary to make sure that the tube is supplied with air simultaneously with electrode voltages. Air-flow interlocks which open the power transformer primaries are desirable for protecting the tube when the air flow is insufficient or ceases.

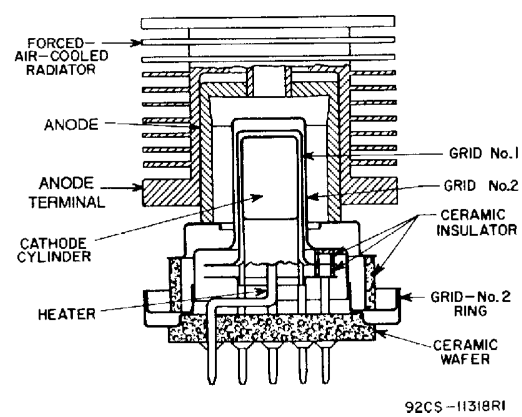

Figure 1 - **Structural Arrangement**

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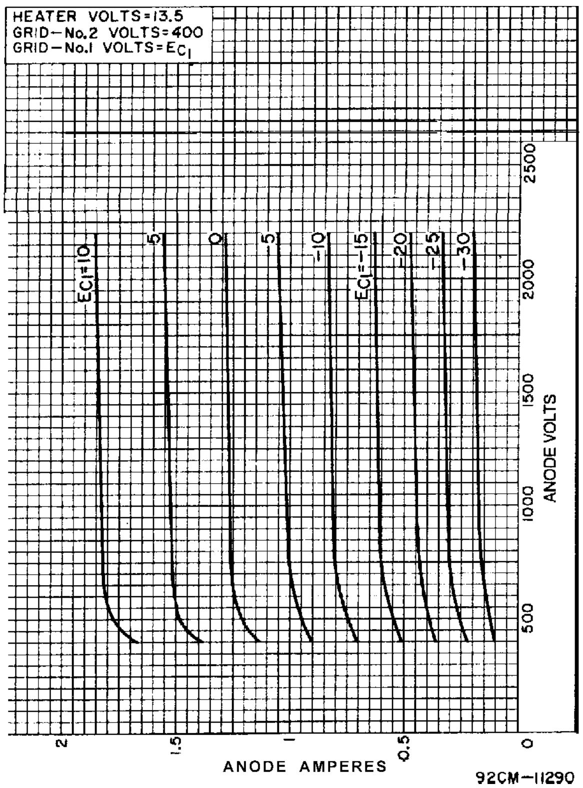

Figure 2 - Typical Anode Characteristics

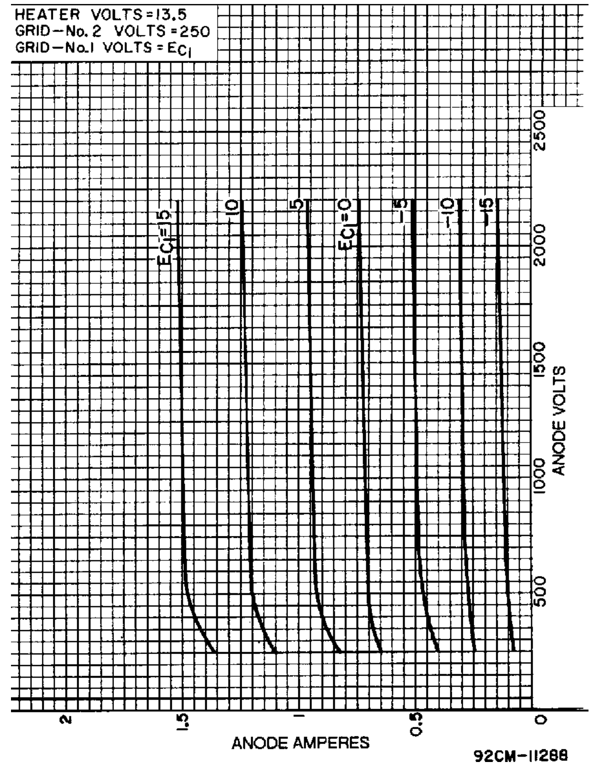

Figure 4- Typical Anode Characteristics

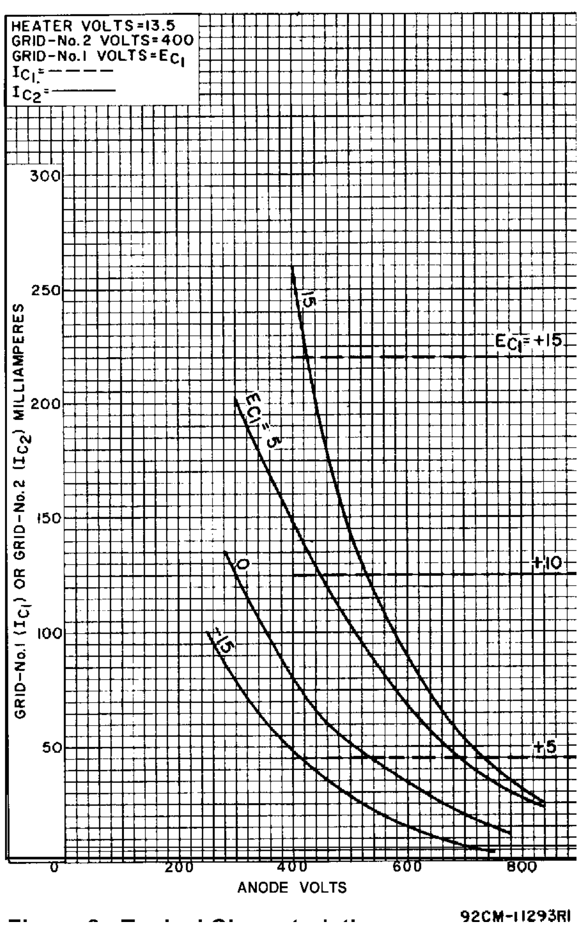

Figure 3 -Typical Characteristics

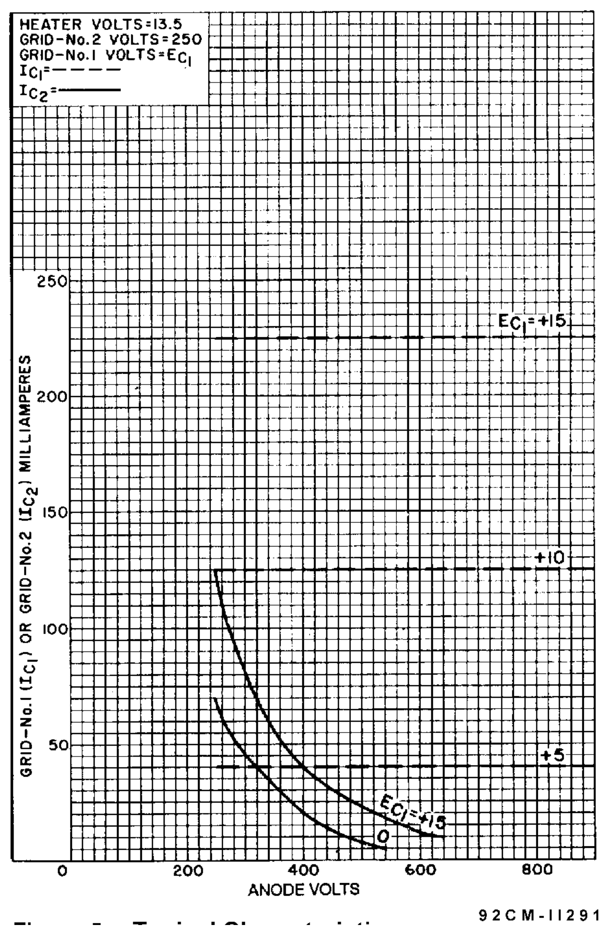

Figure 5- Typical Characteristics

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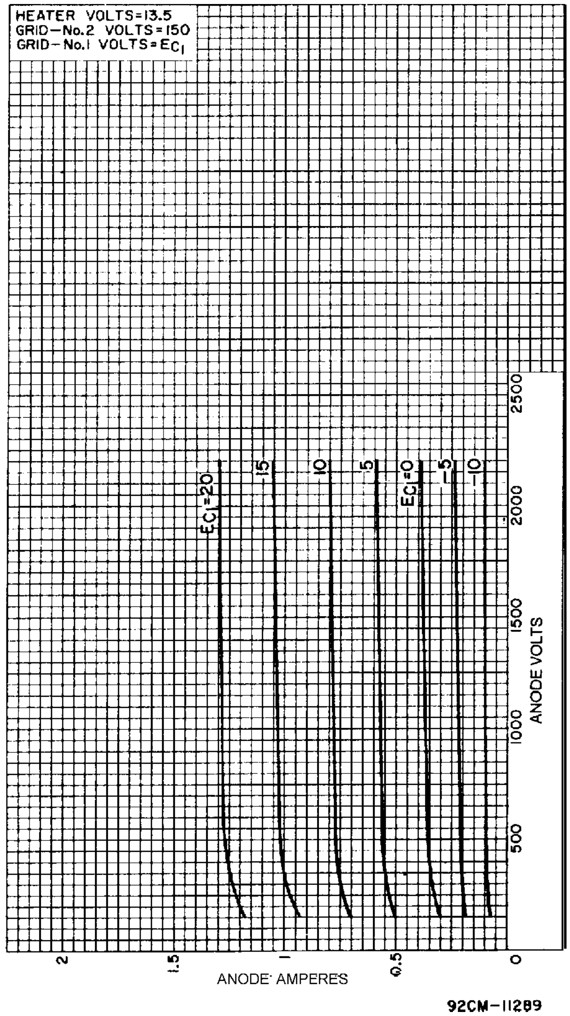


Figure 6 - Typical Anode Characteristics

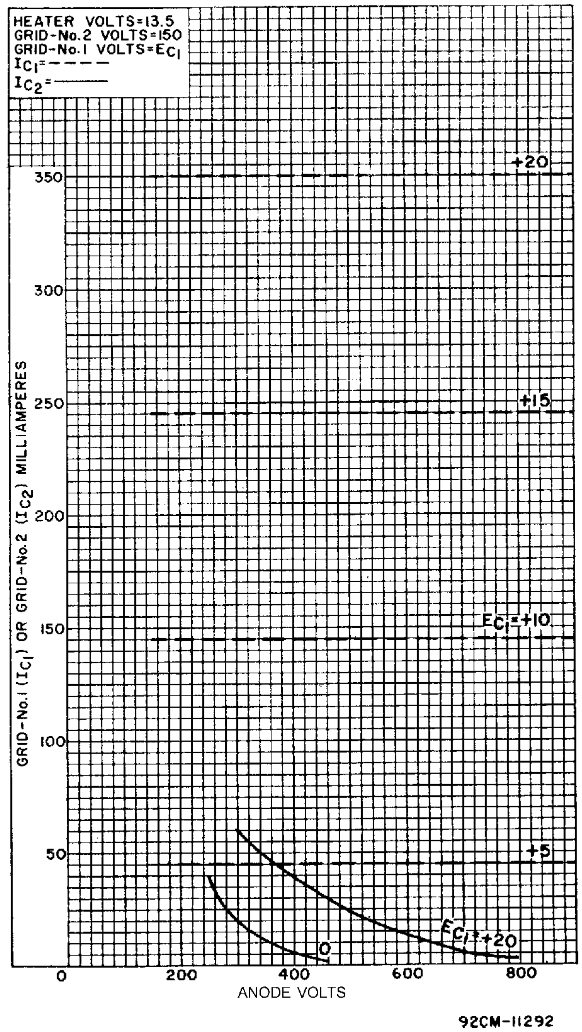


Figure 7 - Typical Characteristics

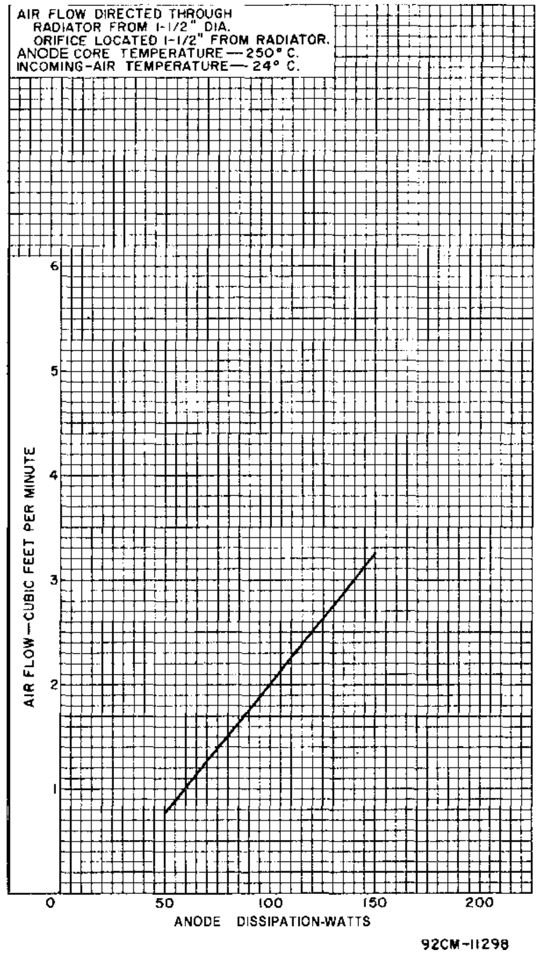


Figure 8 - **Typical Cooling Requirements**

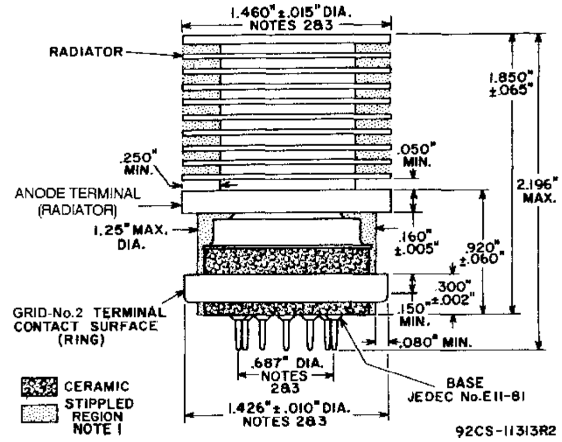


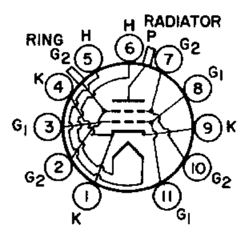
Figure 9- Dimensional Outline

Note 1: Keep all stippled regions clear. Do not allow contacts or circuit components to protrude into these annular volumes.

Note 2: The diameters of the radiator, grid-No. 2 terminal contact surface, and pin circle to be concentric within the following values of maximum full indicator reading:

Radiator to Grid-No.2	
Terminal Contact Surface	0.76 mm (0.030 in) max.
Radiator to Pin Circle	1.02 mm (0.040 in) max.
Grid-No.2 Terminal Contact	
Surface to Pin Circle	0.76 mm (0.030 in) max.

Note 3: The full indicator reading is the maximum deviation in radial position of a surface when the tube is completely rotated about the center of the reference surface. It is a measure of the total effect of run-out and ellipticity.



Radiator: Anode Terminal
Ring: Grid-No.2 Terminal Contact Surface
(For use at higher frequencies)

Figure 10 - Basing Diagram - Bottom View

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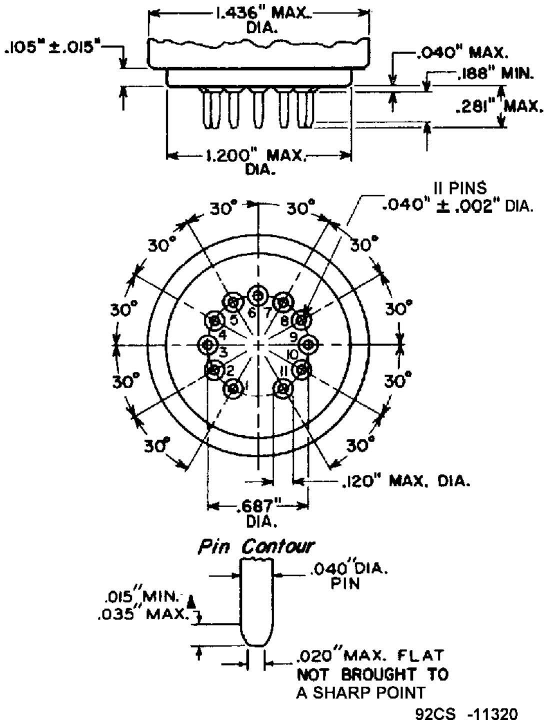

Figure 11 - **Base Drawing Large-Wafer Elevenar 11 -Pin with Ring JEDEC No.E11-81**

This dimension around the periphery of any individual pin may vary within the limits shown.

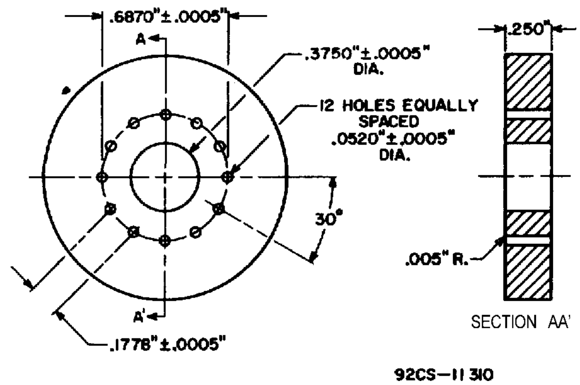

Figure 12 - **Gauge Drawing JEDEC No.GE11-1**