Beam Power Tube

CERAMIC-METAL SEALS
CONDUCTION COOLED

COAXIAL-ELECTRODE STRUCTURE
UNIPOTENTIAL CATHODE

For Use in Low-Voltage Mobile Equipment at Frequencies up to 500 Mc

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:

Voltage range (AC or DC)[a]	12.0 to 15.0	volts
Current (Approx.) at 13.5 volts	1.3	amp
Minimum heating time	60	sec
Mu-Factor, Grid No.2 to Grid No.1 for plate volts = 250, grid-No.2 volts = 200, plate amperes = 1.2	11	
Direct Interelectrode Capacitances:[b]		
Grid No.1 to plate	0.13 max.	μμf
Grid No.1 to cathode	16	μμf
Plate to cathode	0.011	μμf
Grid No.1 to grid No.2	22	μμf
Grid No.2 to plate	6.5	μμf
Grid No.2 to cathode	3.2	μμf
Cathode to heater	3.4	μμf

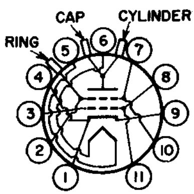
Mechanical:

Operating Position	Any
Maximum Overall Length	2.26"
Seated Length	1.920" ± 0.065"
Diameter	1.426" ± 0.010"
Weight (Approx.)	2 oz
Socket	Mycalex[c] No.CP464-2, or equivalent
Base	Large-Wafer Elevenar 11-Pin with Ring (JEDEC No.E11-81)

Terminal Connections (See *Dimensional Outline*):

BOTTOM VIEW

- Pin 1 - Cathode
- Pin 2 - Grid No.2
- Pin 3 - Grid No.1
- Pin 4 - Cathode
- Pin 5 - Heater
- Pin 6 - Heater
- Pin 7 - Grid No.2
- Pin 8 - Grid No.1
- Pin 9 - Cathode
- Pin 10 - Grid No.2
- Pin 11 - Grid No.1



- CAP - Plate-Terminal Connection
- CYLINDER - Plate-Terminal Contact Surface
- RING[d] - Grid-No.2 Terminal Contact Surface

Thermal:

Terminal Temperature (All terminals)	250 max.	°C
Plate Core Temperature (See *Dimensional Outline*)	250 max.	°C

Cooling, Conduction:

The plate-terminal (cylinder) must be thermally coupled to a constant temperature device (heat-sink—solid or liquid) to limit the plate terminal to the specified maximum value of 250° C. The grid No.2, grid No.1, cathode, and heater terminals may also require coupling to the heat sink to limit their respective terminal temperature to the specified maximum value of 250° C.

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 Mc		
DC PLATE VOLTAGE	2200	max.	volts
DC GRID-No.2 VOLTAGE	400	max.	volts
DC GRID-No.1 VOLTAGE	-100	max.	volts
DC PLATE CURRENT AT PEAK OF ENVELOPE	450[e]	max.	ma
DC GRID-No.1 CURRENT	100	max.	ma
PLATE DISSIPATION	100[f]	max.	watts
GRID-No.2 DISSIPATION	8	max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	150	max.	volts
Heater positive with respect to cathode	150	max.	volts

Typical CCS Operation with "Two-Tone Modulation":

	At 30 Mc	
DC Plate Voltage	700	volts
DC Grid-No.2 Voltage[g]	250	volts
DC Grid-No.1 Voltage[g]	-20	volts
Zero-Signal DC Plate Current	100	ma
Effective RF Load Resistance	1420	ohms
DC Plate Current:		
Peak of envelope	205	ma
Average	150	ma
DC Grid-No.2 Current:		
Peak of envelope	16	ma
Average	10	ma
Average DC Grid-No.1 Current	1[h]	ma
Peak-of-Envelope Driver Power Output (Approx.)[j]	0.3	watt
Output-Circuit Efficiency (Approx.)	95	%
Distortion Products Level:[k]		
Third order	30	db
Fifth order	35	db
Useful Power Output (Approx.):		
Peak of envelope	80[m]	watts
Average	40[m]	watts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance under any condition:			
With fixed bias	25000	max.	ohms
With fixed bias (In Class-AB$_1$ operation).	100000	max.	ohms
With cathode bias	Not recommended		
Grid-No.2-Circuit Impedance	10000		ohms
Plate-Circuit Impedance	n		

RF POWER AMPLIFIER & OSCILLATOR — Class C Telegraphy
and
RF POWER AMPLIFIER — Class C FM Telephony

Maximum CCS Ratings, *Absolute-Maximum Values:*

	Up to 500 Mc		
DC PLATE VOLTAGE.	2200	max.	volts
DC GRID-No.2 VOLTAGE.	400	max.	volts
DC GRID-No.1 VOLTAGE.	−100	max.	volts
DC PLATE CURRENT.	300	max.	ma
DC GRID-No.1 CURRENT.	100	max.	ma
GRID-No.2 DISSIPATION	8	max.	watts
PLATE DISSIPATION	100[f]	max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode.	150	max.	volts
Heater positive with respect to cathode.	150	max.	volts

Typical CCS Operation:

In grid-drive circuit at frequency of	*50*		*175*		*470*	*Mc*
DC Plate Voltage.	500	700	500	700	700	volts
DC Grid-No.2 Voltage. . .	160	175	200	200	200	volts
DC Grid-No.1 Voltage. . .	−10	−10	−30	−30	−30	volts
DC Plate Current.	300	300	300	300	300	ma
DC Grid-No.2 Current. . .	25	25	30	20	10	ma
DC Grid-No.1 Current. . .	50	50	40	40	20	ma
Driver Power Output (Approx.)[p].	1.2	1.2	3	3	5	watts
Useful Power Output:						
Typical	85[m]	110[m]	70[m]	105[m]	85[m]	watts
For minimum useful-power output see *Characteristics Range Values, Test. . . . .*	*No. 8*		*No. 9*		*No. 10*	

Maximum Circuit Values:

Grid-No.1-Circuit Resistance under any condition:			
With fixed bias	25000	max.	ohms
Grid-No.2-Circuit Impedance	10000	max.	ohms
Plate-Circuit Impedance	n		

[a] 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 Mc, heater volts = 12.5 (Approx.).

[b] Measured with special shield adapter.

[c] Mycalex Corporation of America, 125 Clifton Boulevard, Clifton, New Jersey.

[d] For use at higher frequencies.

[e] 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 plate current may be as high as 450 ma.

[f] Maximum plate dissipation is limited by the maximum plate core temperature and the cooling system to maintain tube operation below the specified maximum plate core temperature. With simple low-cost cooling techniques, maximum plate dissipation may be only about 100 watts; with more sophisticated cooling techniques, maximum plate dissipation may be as high as 300 watts.

[g] Obtained preferably from a separate, well-regulated source.

[h] 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.

[j] 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.

[k] With maximum signal output used as a reference, and without the use of feedback to enhance linearity.

[m] The value of useful power is measured at load of output circuit.

[n] The tube should see an effective plate supply impedance which limits the peak current through the tube under surge conditions to 15 amperes.

[p] 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.

CHARACTERISTICS RANGE VALUES

Test No.		*Note*	*Min.*	*Max.*	
1.	Heater Current	1	1.15	1.45	amp
2.	Direct Interelectrode Capacitances:	2			
	Grid No.1 to plate	-	-	0.13	μμf
	Grid No.1 to cathode	-	14.3	17.7	μμf
	Plate to cathode	-	0.0065	0.0155	μμf
	Grid No.1 to grid No.2	-	19.8	24.2	μμf
	Grid No.2 to plate	-	5.7	7.1	μμf
	Grid No.2 to cathode	-	2.6	3.6	μμf
	Cathode to heater	-	2.5	4.1	μμf
3.	Grid-No.1 Voltage	1,3	-8	-19	volts
4.	Reverse Grid-No.1 Current	1,3	-	-25	μa
5.	Grid-No.2 Current	1,3	-7	+6	ma
6.	Peak Emission	1,4	13	-	peak amp
7.	Interelectrode Leakage Resistance	5	1	-	megohm
8.	Useful Power Output	1,6	90	-	watts
9.	Useful Power Output	1,7	85	-	watts
10.	Useful Power Output	1,8	75	-	watts
11.	Cutoff Grid-No.1 Voltage	1,9	-	-44	volts

Note 1: With 13.5 volts ac or dc on heater.

Note 2: Measured with special shield adapter.

Note 3: With dc plate voltage of 700 volts, dc grid-No.2 voltage of 250 volts, and dc grid-No.1 voltage adjusted to give a dc plate current of 185 ma.

Note 4: For conditions with grid No.1, grid No.2, and plate tied together; and pulse voltage source connected between plate 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.

Note 5: 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 megohm, will be 1 megohm.

Note 6: In a CW grid-driven, conduction-cooled amplifier circuit at 50 Mc and for conditions: dc plate voltage of 700 volts, grid-No.1 voltage of -10 volts, driver power output of 1.2 watts, and grid-No.2 voltage varied to obtain a plate current of 300 ma.

Note 7: In a CW grid-driven, conduction-cooled amplifier circuit at 175 Mc and for conditions: dc plate voltage of 700 volts, grid-No.1 voltage of -30 volts, driver power output of 3 watts, and grid-No.2 voltage varied to obtain a plate current of 300 ma.

Note 8: In a CW grid-driven, conduction-cooled amplifier circuit at 470 Mc and for conditions: dc plate voltage of 700 volts, grid-No.1 voltage of -30 volts, driver power output of 5 watts, and grid-No.2 voltage varied to obtain a plate current of 300 ma.

Note 9: With dc plate voltage of 700 volts, dc grid-No.2 voltage of 250 volts, and dc grid-No.1 voltage varied to obtain a plate current of 5 ma.

COOLING CONSIDERATIONS

The conduction-cooling system consists, in general, of a constant temperature device (heat sink) and suitable heat-flow path (coupling device) between the heat sink and tube. Primary consideration of the system should be given to the design of a heat-flow path (coupling device) with high thermal conductivity.

Thermal conductivity[q] may be calculated from the equation:

$$K = \frac{W}{A \frac{(T_2 - T_1)}{L}} \qquad (1)$$

where;

K = thermal conductivity of the material

W = power transfer in watts

A = area measured at right angles to the direction of the flow of heat in square inches

T_1, T_2 = temperature in degrees Centigrade of planes or surfaces under consideration

L = length of heat path in inches through coupling material to produce temperature gradient

[q] Thermal conductivity is defined as the time rate of transfer of heat by conduction, through unit thickness, across unit area for unit difference of temperature. It is measured in watts per square inch for a thickness of one inch and a difference of temperature of 1° C.

For a given system Equation (1) must be integrated to consider changes in area (A) dependent on the coupling configuration and changes in thermal conductivity (K) dependent on various coupling materials and interfaces. Equation (1) may now be reduced to the following:

$$K_S = \frac{W_P}{T_2 - T_1} \qquad (2)$$

where;

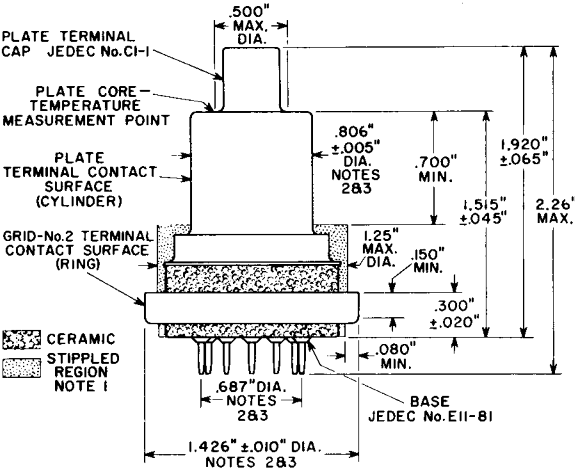
K_S = thermal conductance of the system

W_P = maximum permissible plate dissipation in watts

T_2 = temperature in degrees Centigrade at tube terminal

Note: *This value may never exceed the specified maximum rating for terminal temperature.*

T_1 = temperature in degrees Centigrade of heat sink



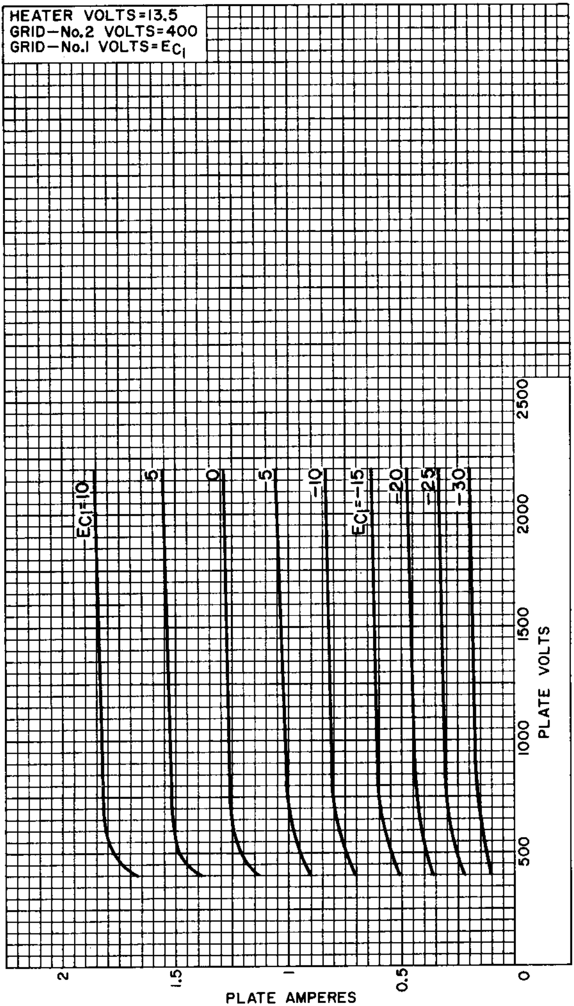
NOTE 1: KEEP ALL STIPPLED REGIONS CLEAR. DO NOT ALLOW CONTACTS OR CIRCUIT COMPONENTS TO PROTRUDE INTO THESE ANNULAR VOLUMES.

NOTE 2: THE DIAMETERS OF THE PLATE TERMINAL CONTACT SURFACE, GRID-No.2 TERMINAL CONTACT SURFACE, AND PIN CIRCLE TO BE CONCENTRIC WITHIN THE FOLLOWING VALUES OF MAXIMUM FULL INDICATOR READING:

Plate Terminal Contact Surface to Grid-No.2 Terminal Contact Surface	0.030"
Plate Terminal Contact Surface to Pin Circle	0.040"
Grid-No.2 Terminal Contact Surface to Pin Circle	0.030"

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.

TYPICAL PLATE CHARACTERISTICS



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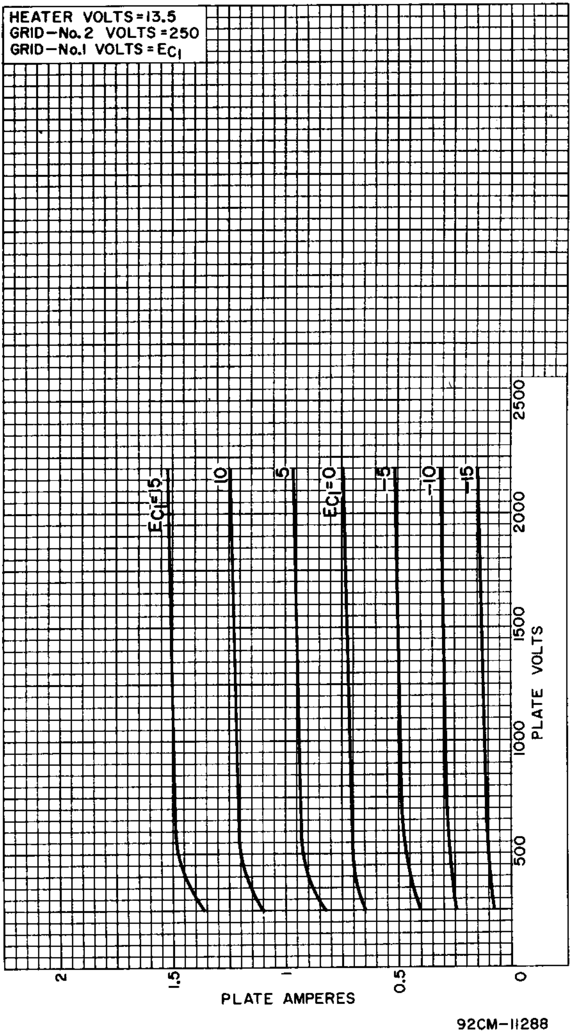
TYPICAL PLATE CHARACTERISTICS



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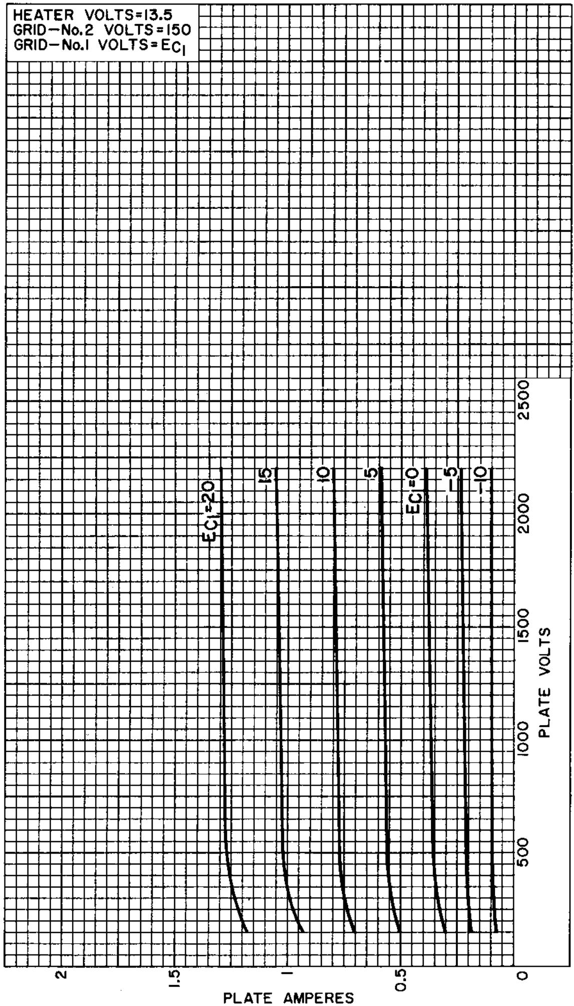
TYPICAL PLATE CHARACTERISTICS



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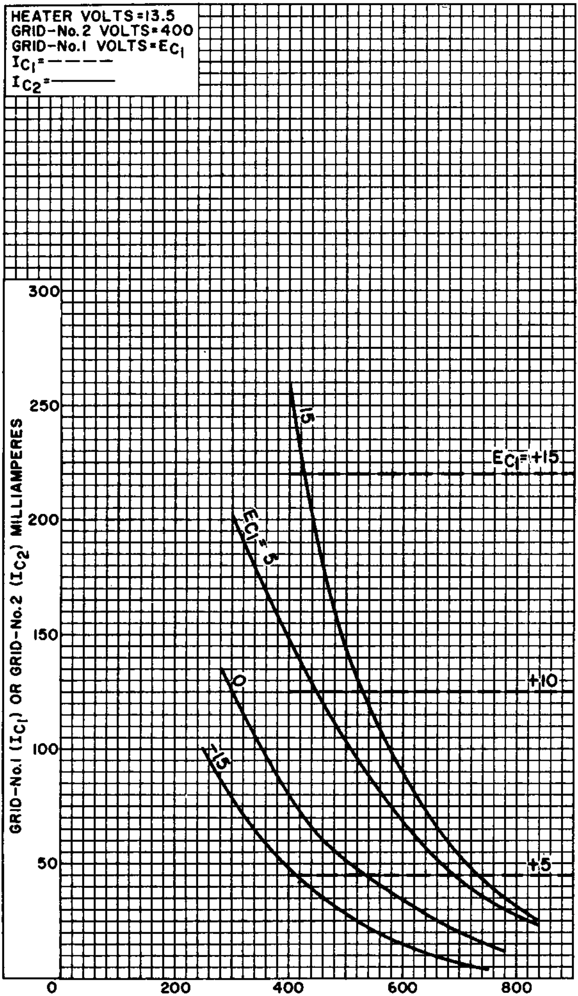
TYPICAL CHARACTERISTICS



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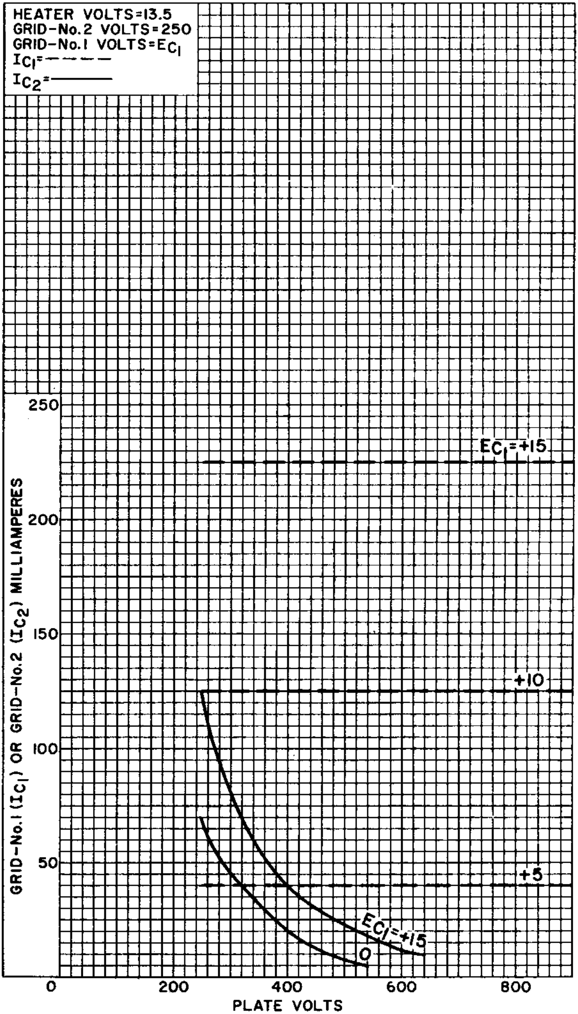
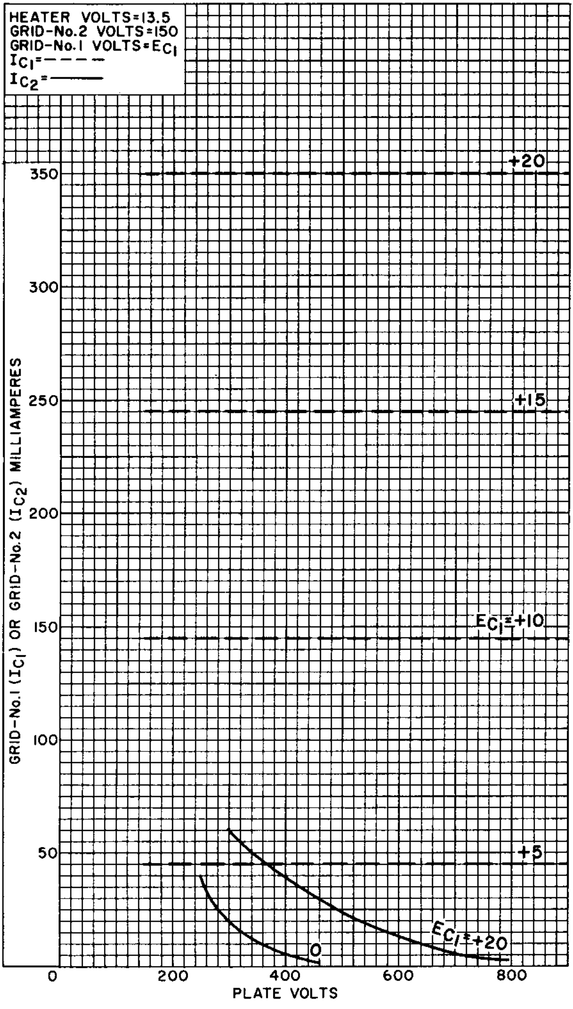
TYPICAL CHARACTERISTICS



TYPICAL CHARACTERISTICS



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