EITEL-McCULLOUGH, INC.
SAN CARLOS, CALIFORNIA

5D22
4-250A

RADIAL BEAM POWER TETRODE

MODULATOR
OSCILLATOR
AMPLIFIER

The Eimac 5D22/4-250A is a compact, ruggedly constructed power tetrode having a maximum plate dissipation rating of 250 watts. It is intended for use as an amplifier, oscillator or modulator. The low grid-plate capacitance of this tetrode coupled with its low driving-power requirement allows considerable simplification of the associated circuit and driver stage.

The 5D22/4-250A is cooled by radiation from the plate and by circulation of forced-air through the base and around the envelope.

GENERAL CHARACTERISTICS

ELECTRICAL

Filament: Thoriated tungsten	
Voltage	5.0 volts
Current	14.5 amperes
Grid-Screen Amplification Factor (Average)	5.1
Direct Interelectrode Capacitances (Average)	
Grid-Plate	0.12 $\mu\mu$f
Input	12.7 $\mu\mu$f
Output	4.5 $\mu\mu$f
Transconductance (I_b = 100 ma., E_b = 2500V., E_{c2} = 500V.)	4000 μmhos
Frequency for Maximum Ratings	110 Mc.

MECHANICAL

Base		5-pin metal shell
Recommended Socket		E. F Johnson Co. socket No. 122-275, National Co. No. HX-100, or equivalent.
Basing		See drawing
Mounting Position		Vertical, base down or up
Cooling		Radiation and forced air
Recommended Heat Dissipating Plate Connector		Eimac HR-6
Maximum Temperature of Base and Plate Seals	Base Seals	200° C.
	Plate Seal	170° C.
Maximum Over-all Dimensions	Length	6.38 inches
	Diameter	3.56 inches
Net Weight		8.0 ounces
Shipping Weight		2.0 pounds

Note: Typical operation data are based on conditions of adjusting the r-f grid drive to a specified plate current, maintaining fixed conditions of grid bias and screen voltage. It will be found that if this procedure is followed, there will be little variation in power output between tubes even though there may be some variation in grid and screen currents. Where grid bias is obtained principally by means of a grid resistor, to control plate current it is necessary to make the resistor adjustable.

RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR

Class-C FM or Telegraphy (Key-down conditions, 1 tube)

MAXIMUM RATINGS

D-C PLATE VOLTAGE[1]	4000 MAX. VOLTS
D-C SCREEN VOLTAGE	600 MAX. VOLTS
D-C GRID VOLTAGE	—500 MAX. VOLTS
D-C PLATE CURRENT	350 MAX. MA
PLATE DISSIPATION	250 MAX. WATTS
SCREEN DISSIPATION	35 MAX. WATTS
GRID DISSIPATION	10 MAX. WATTS

TYPICAL OPERATION (Frequencies below 110 Mc.)

D-C Plate Voltage	2500	3000	4000	volts
D-C Screen Voltage	500	500	500	volts
D-C Grid Voltage	—150	—180	—225	volts
D-C Plate Current	300	345	312	ma
D-C Screen Current	60	60	45	ma
D-C Grid Current	9	10	9	ma
Screen Dissipation	30	30	22.5	watts
Grid Dissipation	0.35	0.8	0.46	watts
Peak R-F Grid Input Voltage (approx.)	220	265	303	volts
Driving Power (approx.)[2]	1.70	2.6	2.46	watts
Plate Power Input	750	1035	1250	watts
Plate Dissipation	175	235	250	watts
Plate Power Output	575	800	1000	watts

PLATE-MODULATED RADIO-FREQUENCY AMPLIFIER

Class-C Telephony
(Carrier conditions unless otherwise specified, 1 tube)

MAXIMUM RATINGS

D-C PLATE VOLTAGE[1]	3200 MAX. VOLTS
D-C SCREEN VOLTAGE	600 MAX. VOLTS
D-C GRID VOLTAGE	—500 MAX. VOLTS
D-C PLATE CURRENT	275 MAX. MA
PLATE DISSIPATION	165 MAX. WATTS
SCREEN DISSIPATION	35 MAX. WATTS
GRID DISSIPATION	10 MAX. WATTS

TYPICAL OPERATION (Frequencies below 110 Mc.)

D-C Plate Voltage	2500	3000	volts
D-C Screen Voltage	400	400	volts
D-C Grid Voltage	—200	—310	volts
D-C Plate Current	200	225	ma
D-C Screen Current	30	30	ma
D-C Grid Current	9	9	ma
Peak A-F Screen Voltage (100% modulation)	350	350	volts
Screen Dissipation	12	12	watts
Grid Dissipation	1.8	2.7	watts
Peak R-F Grid Input Voltage (approx.)	255	365	volts
Driving Power (approx.)	2.2	3.2	watts
Plate Power Input	500	675	watts
Plate Dissipation	125	165	watts
Plate Power Output	375	510	watts

[1]Above 110 Mc. the maximum plate voltage rating depends upon frequency. See page four.

[2]Driving power increases above 40 Mc. See page four.

AUDIO-FREQUENCY POWER AMPLIFIER AND MODULATOR—CLASS AB

MAXIMUM RATINGS (PER TUBE)

D-C PLATE VOLTAGE	4000 MAX. VOLTS
D-C SCREEN VOLTAGE	600 MAX. VOLTS
MAX-SIGNAL D-C PLATE CURRENT	350 MAX. MA
PLATE DISSIPATION	250 MAX. WATTS
SCREEN DISSIPATION	35 MAX. WATTS
GRID DISSIPATION	10 MAX. WATTS

TYPICAL OPERATION CLASS AB_1

(Sinusoidal wave, two tubes unless otherwise specified)

D-C Plate Voltage	1500	2000	2500	3000	volts
D-C Screen Voltage	600	600	600	600	volts
D-C Grid Voltage [1,2]	—95	—104	—110	—116	volts
Zero-Signal D-C Plate Current	120	110	120	120	ma
Max-Signal D-C Plate Current	400	405	430	417	ma
Zero-Signal D-C Screen Current	—0.4	—0.3	—0.3	—0.2	ma
Max-Signal D-C Screen Current	23	22	13	10.5	ma
Effective Load, Plate-to-Plate	6250	9170	11,400	15,000	ohms
Peak A-F Grid Input Voltage (per tube)	64	88	90	93	volts
Driving Power	0	0	0	0	watts
Max-Signal Plate Dissipation (per tube)	145	175	225	250	watts
Max-Signal Plate Power Output	310	460	625	750	watts
Total Harmonic Distortion	4	2.5	2	2.5	per cent

[1]Adjust for stated zero-signal plate current.
[2]The effective grid-circuit resistance must not exceed 250,000 ohms.

TYPICAL OPERATION CLASS AB_2

(Sinusoidal wave, two tubes unless otherwise specified)

D-C Plate Voltage	1500	2000	2500	3000	volts
D-C Screen Voltage	300	300	300	300	volts
D-C Grid Voltage [1]	—48	—48	—51	—53	volts
Zero-Signal D-C Plate Current	100	120	120	125	ma
Max-Signal D-C Plate Current	485	510	500	473	ma
Zero-Signal D-C Screen Current	0	0	0	0	ma
Max-Signal D-C Screen Current	34	26	23	33	ma
Effective Load, Plate-to-Plate	5400	8000	10,900	16,000	ohms
Peak A-F Grid Input Voltage (per tube)	96	99	100	99	volts
Max-Signal Avg. Driving Power (approx.)	2.1	2.3	2.2	1.9	watts
Max-Signal Peak Driving Power	4.7	5.5	4.8	4.6	watts
Max-Signal Plate Dissipation (per tube)	150	185	205	190	watts
Max-Signal Plate Power Output	428	650	840	1040	watts
Total Harmonic Distortion	3	4	4	4.5	per cent

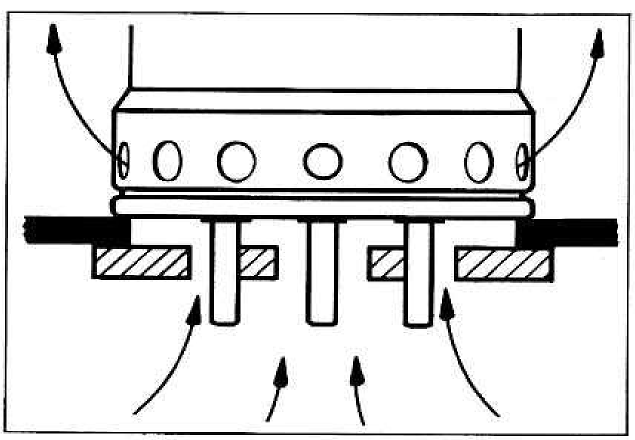
IF IT IS DESIRED TO OPERATE THIS TUBE UNDER CONDITIONS WIDELY DIFFERENT FROM THOSE GIVEN UNDER "TYPICAL OPERATION", POSSIBLY EXCEEDING THE MAXIMUM RATINGS GIVEN FOR CW SERVICE, WRITE EITEL-McCULLOUGH, INC., FOR INFORMATION AND RECOMMENDATIONS.

APPLICATION

Mechanical

Mounting—The 4-250A must be mounted vertically, base down or base up. The socket must be constructed so as to allow an unimpeded flow of air through the holes in the base of the tube and must also provide clearance for the glass tip-off which extends from the center of the base. The tube should be mounted above the chassis deck to allow free circulation of air in the manner shown in the mounting diagram below. The above requirements are met by the E. F. Johnson Co. socket No. 122-275, the National Co. socket No. HX-100, or a similar socket.

A flexible connecting strap should be provided between the HR-6 Heat Dissipating Plate Connector on the plate terminal and the external circuit. The tube must be protected from severe vibration and shock.



4-250A mounting providing base cooling, shielding and isolation of output and input compartments.

Cooling—Adequate cooling must be provided for the seals and envelope of the 4-250A. At frequencies above 30Mc, cooling air in the amount of five cubic feet per minute through the base of the tube is required. This quantity is obtained when the pressure drop across the base of the tube is equal to 0.20 inch of water column. At frequencies below 30Mc the volume may be reduced to two cubic feet per minute. At this reduced air flow, the pressure drop is equal to 0.10 inch of water column. Base-cooling air should be applied simultaneously with filament power. The temperature of the plate seal, as measured on the top of the plate cap, should not exceed 170°C in continuous-service applications.

A relatively slow movement of air past the tube is sufficient to prevent a plate seal temperature in excess of the maximum rating at frequencies below 30 Mc. At frequencies above 30 Mc., radio-frequency losses in the leads and envelope contribute to seal and envelope heating and special attention should be given to bulb and plate seal cooling. A small fan or centrifugal blower directed toward the upper portion of the envelope will usually provide sufficient circulation for cooling at frequencies above 30 Mc. (The Eimac SK-400 Air-System Socket provides a convenient method of mounting and cooling the 4-250A at VHF, should the user desire to use it. Full information is available on the SK-400 Air-System Socket data sheet, or it will be sent from the factory on request.)

In intermittent-service applications where the "on" time does not exceed a total of five minutes in any ten-minute period, plate-seal temperatures as high as 220° C. are permissible. When the ambient temperature does not exceed 30° C. it will not ordinarily be necessary to provide forced cooling of the bulb and plate seal to hold the temperature below this maximum at frequencies below 30 Mc., provided that a heat-radiating plate connector is used, and the tube is so located that normal circulation of air past the envelope is not impeded. The five cubic feet per minute base-cooling requirement must be observed in intermittent service.

Electrical

Filament Voltage—For maximum tube life the filament voltage, as measured directly at the base pins, should be the rated value of 5.0 volts. Variations should be held within the range of 4.75 to 5.25 volts.

Bias Voltage—D-c bias voltage for the 4-250A should not exceed 500 volts. If grid-leak bias is used, suitable protective means must be provided to prevent excessive plate or screen dissipation in the event of loss of excitation.

Grid Dissipation—Grid dissipation for the 4-250A should not be allowed to exceed ten watts. Grid dissipation may be calculated from the following expression:

$$P_g = e_{cmp} I_c$$

where P_g = Grid dissipation

e_{cmp} = Peak positive grid voltage, and

I_c = D-C grid current.

e_{cmp} may be measured by means of a suitable peak voltmeter connected between filament and grid.

Screen Voltage—The d-c screen voltage for the 4-250A should not exceed 600 volts.

Screen Dissipation—The power dissipated by the screen of the 4-250A must not exceed 35 watts. Screen dissipation is likely to rise to excessive values when the plate voltage, bias voltage or plate load is removed with filament and screen voltages applied. Suitable protective means must be provided to limit screen dissipation to 35 watts in the event of circuit failure.

Plate Voltage—The plate-supply voltage for the 4-250A should not exceed 4000 volts for frequencies below 110 Mc. Above 110 Mc., the maximum permissible plate voltage is less than 4000 volt, as shown by the graph on page four.

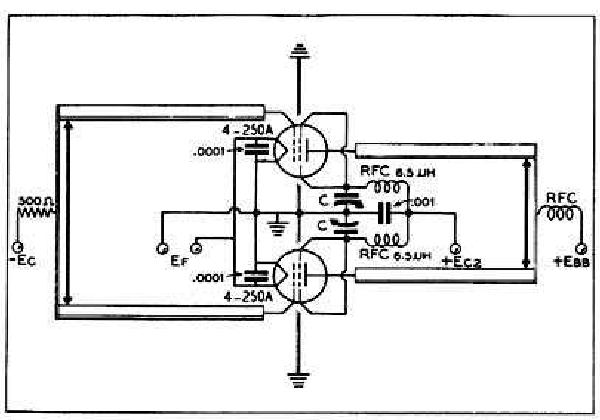
Plate Dissipation—Under normal operating conditions, the plate dissipation of the 4-250A should not be allowed to exceed 250 watts in unmodulated applications.

In plate-modulated amplifier applications, the maximum allowable carrier-condition plate dissipation is 165 watts.

Plate dissipation in excess of the maximum rating is permissible for short periods of time, such as during tuning procedures.

Operation

Class-C FM or Telegraphy—The 4-250A may be operated as a class-C amplifier, FM or telegraphy, without neutralization up to 30 Mc. if reasonable precautions are taken to prevent coupling between input and output circuits external to the tube. A grounded metallic plate on which the socket may be mounted and to which suitable connectors may be attached to ground the tube base shell, provides an effective isolating shield between grid and plate circuits. In single-ended circuits, plate, grid, filament and screen by-pass capacitors should be returned through the shortest possible leads to a common chassis point. In push-pull applications the filament and screen terminals of each tube should be by-passed to a common chassis point by the shortest possible leads, and short, heavy leads should be used to interconnect the screens and filaments of the two tubes. Care should be taken to prevent leakage of radio-frequency energy to leads



Screen-tuning neutralization circuit for use above 45 Mc.
C — Approximately 100$\mu\mu$fd. per section, maximum.

entering the amplifier in order to minimize grid-plate coupling between these leads external to the amplifier.

At frequencies from 30 Mc. to 45 Mc. ordinary neutralization systems may be used.

Where shielding is adequate, the feed-back at frequencies above 45 Mc. is due principally to screen-lead-inductance effects, and it becomes necessary to introduce in-phase voltage from the plate circuit into the grid circuit. This can be done by adding capacitance between plate and grid external to the tube. Ordinarily, a small metal tab approximately ¾-inch square connected to the grid terminal and located adjacent to the envelope opposite the plate will suffice for neutralization. Means should be provided for adjusting the spacing between the neutralizing capacitor plate and the envelope. An alternative neutralization scheme is illustrated in the diagram below. In this circuit, feedback is eliminated by series-tuning the screen to ground with a small capacitor. The socket screen terminals should be strapped together, as shown on the diagram, by the shortest possible lead, and the leads from the screen terminal to the capacitor, C, and from the capacitor to ground should be made as short as possible.

Driving power and power output under maximum output and plate voltage conditions are shown on page 4. The power output shown is the actual plate power delivered by the tube; the power delivered to the load will depend upon the efficiency of the plate tank and output coupling system. The driving power is likewise the driving power required by the tube (includes bias loss). The driver output power should exceed the driving power requirement by a sufficient margin to allow for coupling-circuit losses. The use of silver-plated linear tank-circuit elements is recommended for all frequencies above 110 Mc.

Class-C AM Telephony—The r-f circuit considerations discussed above under Class-C FM or Telegraphy also apply to amplitude-modulated operation of the 4-250A. When the 4-250A is used as a class-C plate-modulated amplifier, modulation should be applied to both plate and screen. Modulation voltage for the screen may be obtained from a separate winding on the modulation transformer, by supplying the screen voltage via a series dropping resistor from the unmodulated plate supply, or by the use of an audio-frequency reactor in the positive screen-supply lead. When screen modulation is obtained by either the series-resistor or the audio-reactor method, the audio-frequency variations in screen current which result from the variations in plate voltage as the plate is modulated automatically give the required screen modulation. Where a reactor is used, it should have a rated inductance of not less than 10 henries divided by the number of tubes in the modulated amplifier and a maximum current rating of two or three times the operating d-c screen current. To prevent phase shift between the screen and plate modulation voltages at high audio frequencies, the screen by-pass capacitor should be no larger than necessary for adequate r-f by-passing.

For plate-modulated service, the use of partial grid-leak bias is recommended. Any by-pass capacitors placed across the grid-leak resistance should have a reactance at the highest modulation frequency equal to at least twice the grid-leak resistance.

Class-AB$_1$ and Class-AB$_2$ Audio—Two 4-250A's may be used in a push-pull circuit to give relatively high audio output power at low distortion. Maximum ratings and typical operating conditions for class-AB$_1$ and class-AB$_2$ audio operation are given in the tabulated data.

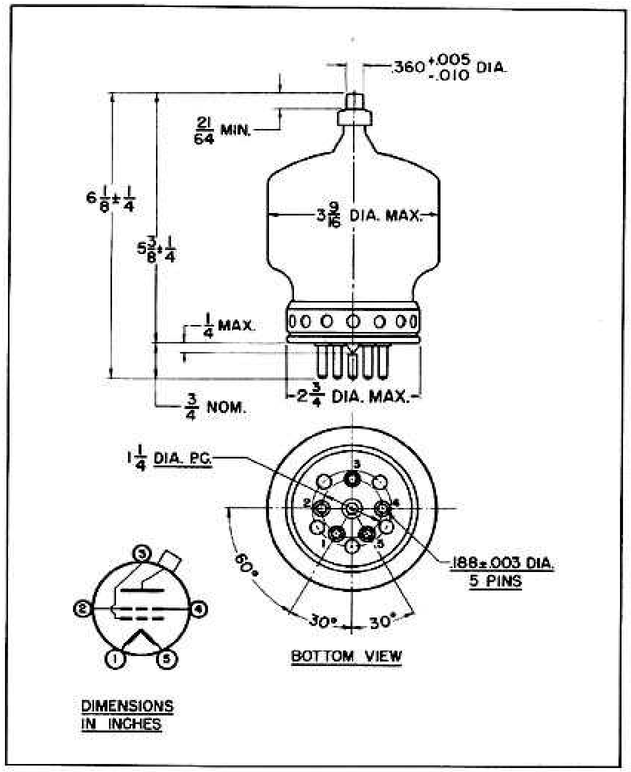
Screen voltage should be obtained from a source having reasonably good regulation to prevent variations in screen voltage from zero-signal to maximum-signal conditions. The use of voltage regulator tubes in a standard circuit should provide adequate regulation.

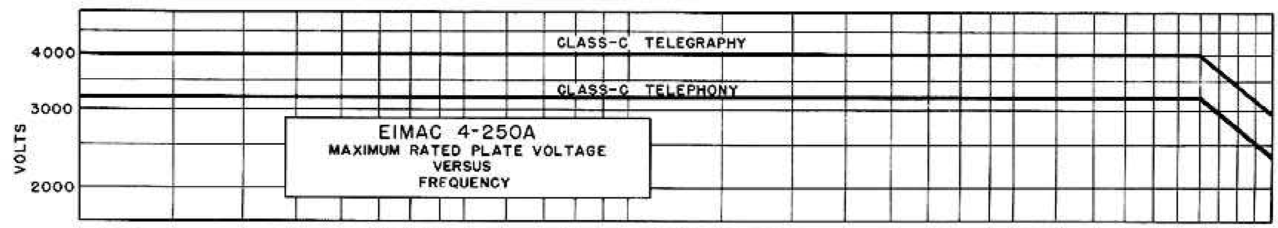
Grid bias voltage for class-AB$_2$ service may be obtained from batteries or from a small fixed-bias supply. When a bias supply is used the d-c resistance of the bias source should not exceed 250 ohms. Under class-AB$_1$ conditions the effective grid-circuit resistance should not exceed 250,000 ohms.

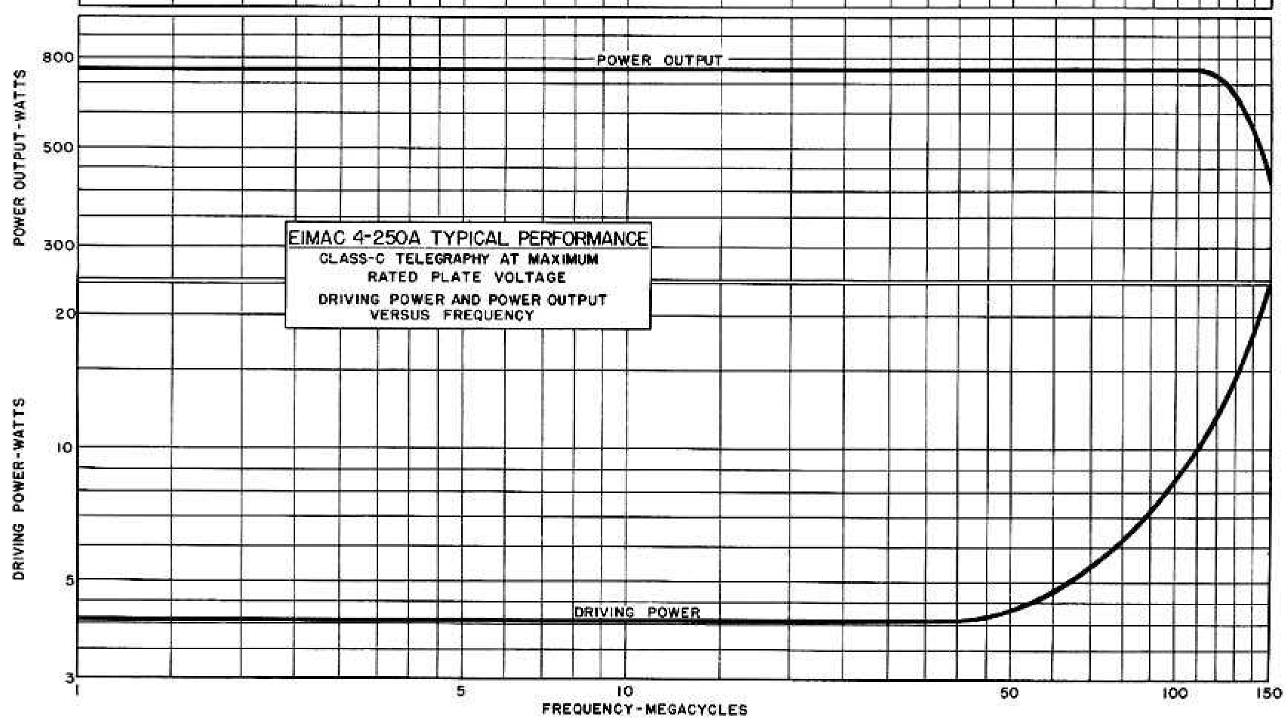
The peak driving power figures given in the class-AB_2 tabulated data are included to make possible an accurate determination of the required driver output power. The driver amplifier must be capable of supplying the peak driving power without distortion. The driver stage should, therefore, be capable of providing an undistorted average output equal to half the peak driving power requirement. A small amount of additional driver output should be provided to allow for losses in the coupling transformer.

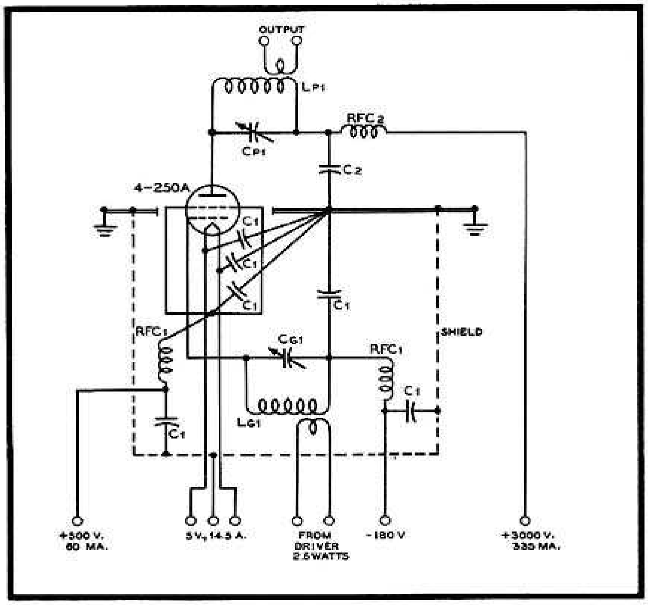
In some cases the maximum-signal plate dissipation shown under "Typical Operation" is less than the maximum rated plate dissipation of the 4-250A. In these cases, the plate dissipation reaches a maximum value, equal to the maximum rating, at a point somewhat below maximum-signal conditions.

The power output figures given in the tabulated data refer to the total power output from the amplifier tubes. The useful power output will be from 5 to 15 per cent less than the figures shown, due to losses in the output transformer.

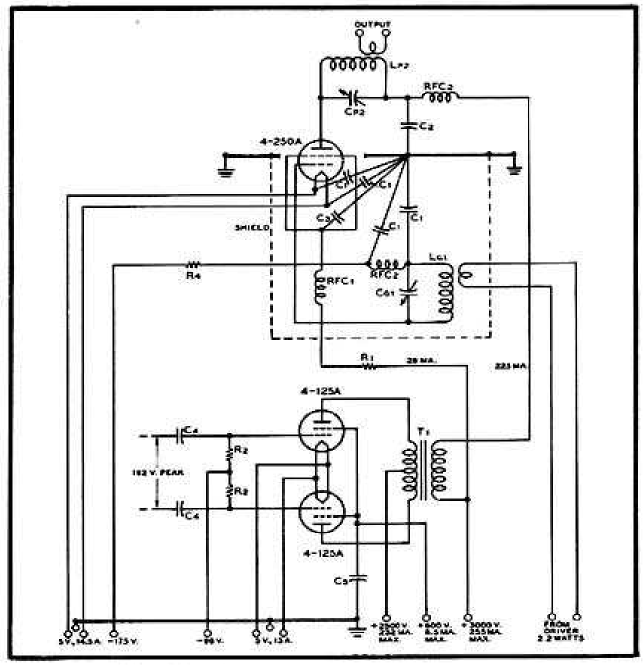




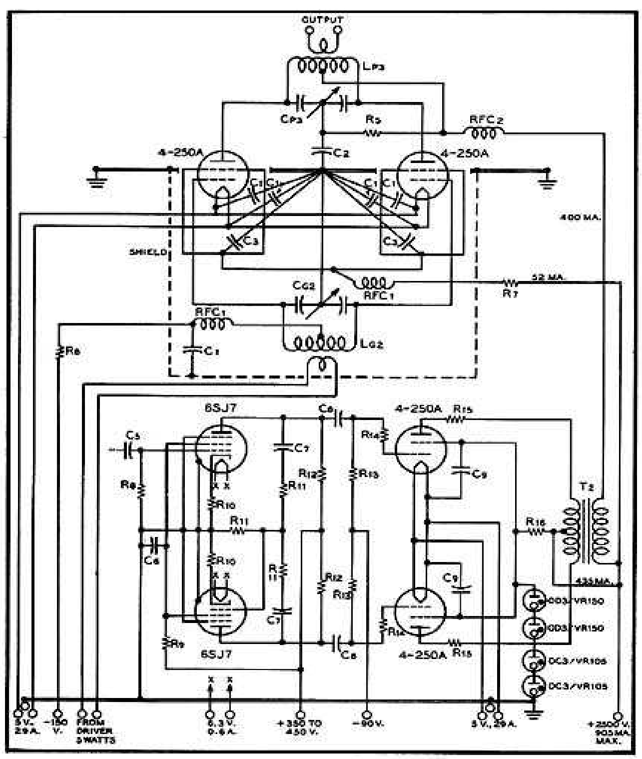




Typical radio frequency power amplifier circuit, Class-C telegraphy, 1000 watts input.



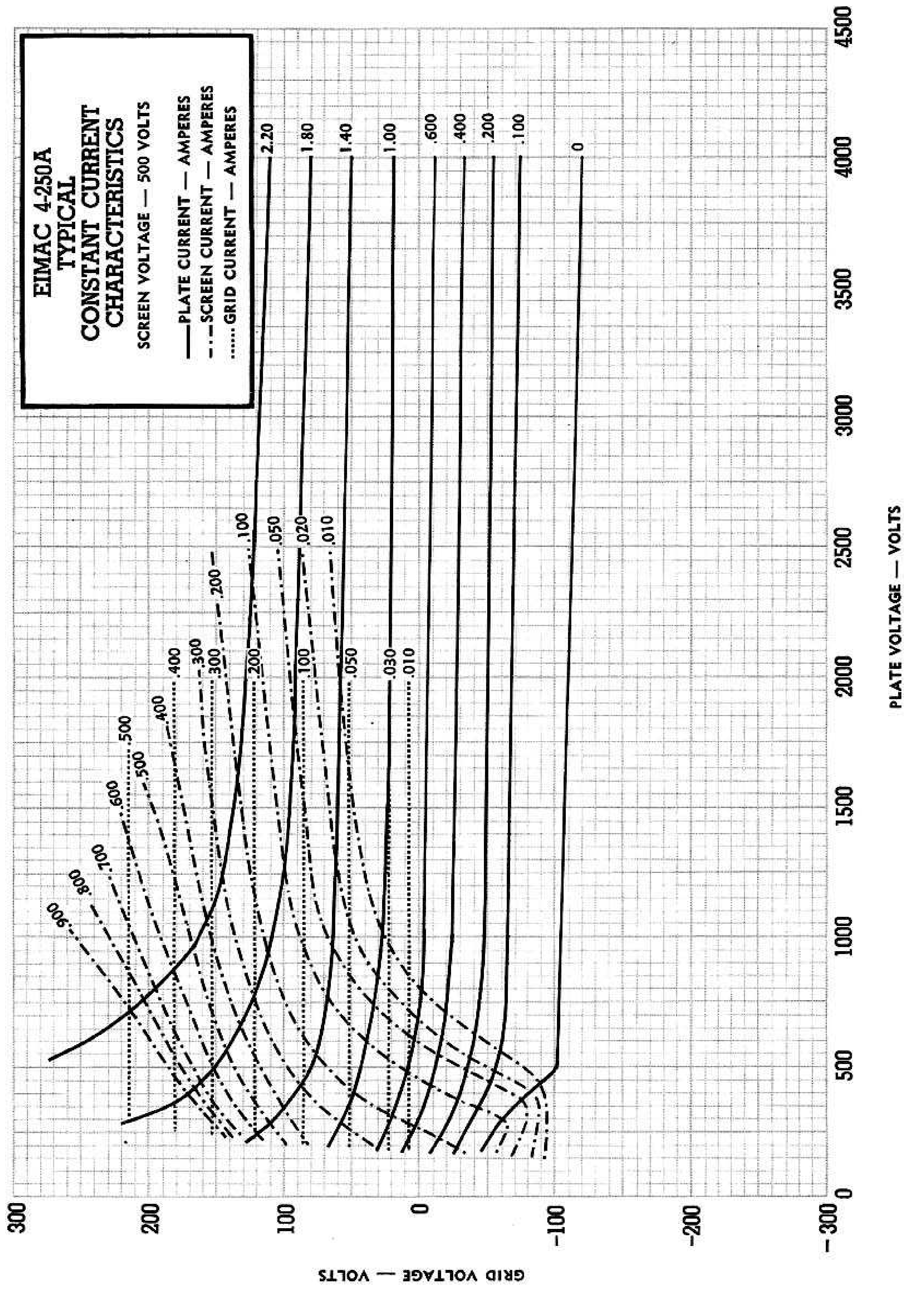
Typical high-level-modulated r-f amplifier circuit, with modulator stage, 675 watts input.



Typical high-level-modulated r-f amplifier circuit, with modulator and driver stages, 1000 watts input.

COMPONENTS FOR TYPICAL CIRCUITS

L_{p1} - C_{p1} — Tank circuit appropriate for operating frequency; Q = 12. Capacitor plate spacing = .200".
L_{p2} - C_{p2} — Tank circuit appropriate for operating frequency; Q = 12. Capacitor plate spacing = .200".
L_{p3} - C_{p3} — Tank circuit appropriate for operating frequency; Q = 12. Capacitor plate spacing = .375".
L_{g1} - C_{g1} — Tuned circuit appropriate for operating frequency.
L_{g2} - C_{g2} — Tuned circuit appropriate for operating frequency.
C_1 — .002-ufd. 500-v. mica
C_2 — .002-ufd. 5000-v mica
C_3 — .001-ufd., 2500-v. mica
C_4 — .1-ufd., 1000-v. paper
C_5 — .1-ufd. 600-v. paper
C_6 — .5-ufd. 600-v paper
C_7 — .03-ufd., 600-v. paper
C_8 — .1-ufd., 1000-v. paper
C_9 — .25-ufd., 1000-v. paper
R_1 — 86,700 ohms, adjustable 100,000 ohms, 100 watts
R_2 — 250,000 ohms, 1/2 watt
R_4 — 15,000 ohms, 5 watts
R_5 — 25,000 ohms, 2 watts
R_6 — 2,500 ohms, 5 watts
R_7 — 35,000 ohms, 160 watts
R_8 — 250,000 ohms, 1/2 watt
R_9 — 200,000 ohms, 2 watts
R_{10} — 500 ohms, 1/2 watt
R_{11} — 1 megohm, 1/2 watt
R_{12} — 100,000 ohms, 1 watt
R_{13} — 200,000 ohms, 1/2 watt
R_{14} — 10,000 ohms, 1/2 watt
R_{15} — 50 ohms, 10 watts
R_{16} — 100,000 ohms, 100 watts
RFC_1 — 2.5-mhy., 125-ma. r-f choke
RFC_2 — 1-mhy., 500-ma. r-f choke
T_1 — 350-watt modulation transformer; ratio pri. to sec. approx. 1.5 : 1; pri. impedance 20,300 ohms, sec. impedance 13,300 ohms.
T_2 — 600-watt modulation transformer; ratio pri. to sec. approx. 1.8 : 1; pri. impedance 11,400 ohms, sec. impedance 6,250 ohms.



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