EITEL-McCULLOUGH, INC.

SAN BRUNO, CALIFORNIA

4-250 R
(RMA 5D22)
POWER TETRODE
MODULATOR
OSCILLATOR
AMPLIFIER

The Eimac 4-250A is a high-vacuum power tetrode having a maximum plate dissipation rating of 250 watts. It is intended for amplifier, oscillator and modulator service. Cooling of the 4-250A is accomplished by radiation from the plate, which operates at a visibly red temperature at maximum dissipation, and by forced air circulation through the base and around the envelope.

The low driving power required by the 4-250A, together with its low grid-plate capacitance and compact and rugged construction, allows considerable simplification of the associated circuits and the driver stage.

ELECTRICAL

| ELECTRICAL | | | | | | | | | | | | | | | | | |
|--------------------------------|------------------|----------------|-----------------|------------------|-----------------|---------------|---------------|-----------------|----------------|----------------|--------------|-----------|----|--------------------|-------------------|-------------------------|------|
| Filament: Thoriated | d tur | ngst | en | 200 | | | | | | | | | | | | | 1 15 |
| Voltage Current | Ħ | (#) | # 2 | | * 2 | | :: :2 | | 2 | 17 | - | fi: a: | 14 | 5.0 1.5 a | mr | volts | |
| Grid-Screen Amplif | | | | | | | | | | | | | | | | | |
| Direct Interelectro | de C | apac | itar | nces | s (<i>F</i> | Vei | rage | e) | | | | | | | | | 1. |
| Grid-Plat Input - Output | e (w - - | ithc - - | out : - - | shie - - | eldir - - | ng, - - | bas - - | e g - - | roui - - | nded - - | d) - - | * | • | 0.12 12. 4.5 | 2 μ 7 μ 5 μ | ιμfd. ιμfd. ιμfd. | |
| Transconductance | i _b = | 100 | ma. | , E _δ | = 2 | 500 |) v., | E _{c2} | = 5 | 00 • | v.) | | 4 | 000 | μn | nhos | N. |
| MECHANICAL | | | | | | | | | | | | | | | | | |
| Base | | - | :722 -: 18 | 5 | • | - | 3 | - 50 | 872 | - | - | RA | ٨A | typ | e . | 008B 5BK d air | |



6.38 inches 3.56 inches

> 8.0 ounces 2.5 pounds

RADIO FREQUENCY POWER AMPLIFIER AND OSCILLATOR

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

MAXIMUM RATINGS

Net Weight

| D-C PLATE VOLTAGE | 2 | | 4 | - | 20 | | 20 | | | 32 | 4000 MAX. VOLTS |
|---------------------|---|---|---|----|----|---|----|-----|-----|-----|-----------------|
| D-C SCREEN VOLTAGE | | | | | | | | | | | |
| D-C GRID VOLTAGE - | | | | 1 | | | | | | | -500 MAX. YOLTS |
| D-C PLATE CURRENT | | | | | - | | - | | | | 350 MAX. MA. |
| PLATE DISSIPATION - | | - | | 83 | | 0 | 20 | 120 | 37 | 125 | 250 MAX. WATTS |
| SCREEN DISSIPATION | | | | | | | | | | | 35 MAX. WATTS |
| GRID DISSIPATION - | | ¥ | | | | | * | - | (*) | | 5 MAX. WATTS |

TYPICAL OPERATION (Frequencies below 75 Mc.)

Length

Shipping Weight (Average)

Diameter

| | | | | | | | | | | 3000 | 4000 | volts |
|--------|--|---|------|------|------|------|------|------|------|------|------|--|
| tage - | | | | | | | | | 500 | 500 | 500 | volts |
| | | | | | | | | | | -180 | -225 | volts |
| rent - | -0 | | | | | • | 20 | | 300 | 345 | 312 | ma. |
| rent - | | | | | - | | | | 60 | 60 | 45 | ma. |
| rent - | | • | | ٠ | | | • | | 9 | 10 | 9 | ma. |
| tion - | - | * | • | | | 20 | - | | 30 | 30 | 22.5 | watts |
| n | - | | | | | | | | 0.35 | 0.8 | 0.46 | watts |
| Inpút | Vo | lta | ge | (| app | oro | x.) | • | 220 | 265 | 303 | volts |
| (appro | x.) | * | | œ. | | | 171 | u re | 1.70 | 2.6 | 2.46 | watts |
| put - | | | | | | | | | 750 | 1035 | 1250 | watts |
| n | | | + | | - | + | | + | 175 | 235 | 250 | watts |
| tput - | | | | | - | | | - | 575 | 800 | 1000 | watts |
| | tage - rent - rent - rent - rent - tion - Input (appro | tage rent rent rent tion Input Vo (approx.) | tage 500 500 500 age 150 — 180 — 225 rent 300 345 312 rent 60 60 45 rent 30 30 22.5 rent 0.35 0.8 0.46 Input Voltage (approx.) - 220 265 303 (approx.) - 1.70 2.6 2.46 reput 750 1035 1250 ren 175 235 250 |

Indicates change from sheet dated 9-1-46.

HIGH-LEVEL-MODULATED RADIO FREQUENCY AMPLIFIER

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

MAXIMUM RATINGS

| D-C PLATE VOLTAGE | ٠ | - | 8 | -0 | | | | | - | 40 | | 3200 MAX. VOLTS |
|---------------------|---|----|---|----|----|---|------------|---|---|----|---|-----------------|
| D-C SCREEN VOLTAGE | | 2. | - | 71 | • | | | | - | 50 | | 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 - | | ÷. | | - | +3 | | 134 | | | * | | 5 MAX. WATTS |

TYPICAL OPERATION (Frequencies below 75 Mc.)

| D-C Plate Voltage | | | - | | | | 127 | | | 1170 | 2500 | 3000 | volts |
|---------------------|-----|------|----|-----|----|----|-----|-----|----|------|------|------|-------|
| D-C Screen Voltage | | | | | | | | | | | 400 | 400 | volts |
| D-C Grid Voltage | | * | ÷ | | ٠ | | - | | * | | -200 | -310 | volts |
| D-C Plate Current | | | | *0 | | | 122 | | - | | 200 | 225 | ma. |
| D-C Screen Current | | | | | | | | | | | 30 | 30 | ma. |
| D-C Grid Current - | | + | ٠ | 40 | | | | * | * | | 9 | 9 | ma. |
| Screen Dissipation | 5 | 20 | - | er. | | | | 20 | - | | 12 | 12 | watts |
| Grid Dissipation - | | • | | | | | | | | | 1.8 | 2.7 | watts |
| Peak R-F Grid Input | 1 | Vol. | ta | ge | (4 | pp | oro | x.) | • | | 255 | 365 | volts |
| Driving Power (appr | ox. | .) | | | | | | | | | 2.2 | 3.2 | watts |
| Plate Power Input - | - | | | | | | | | | | 500 | 675 | watts |
| Plate Dissipation - | - | • | • | | | 2 | 3 | | 70 | | 125 | 165 | watts |
| Plate Power Output | | | | | | | | | | | 375 | 510 | watts |

¹ Above 75 Mc. the maximum plate voltage rating depends upon frequency, see page six.

² Driving power increases above 40 Mc. See Page Six.



4000 MAX, VOLTS

AUDIO FREQUENCY POWER AMPLIFIER AND MODULATOR

Class-AB₁ (Sinusoidal wave; two tubes unless otherwise specified)
MAXIMUM RATINGS

D-C PLATE VOLTAGE - - - - - - - - -

| D-C SCREEN VOLTAGE | | | 0 10 | 600 MA | X. VOLTS |
|--------------------------------|--------|---------|-------|--------|----------|
| MAX-SIGNAL D-C PLATE CUE | RRENT, | PER TU | BE - | 350 MA | X, MA. |
| PLATE DISSIPATION, PER TUI | BE | | ¥ 194 | 250 MA | X. WATTS |
| SCREEN DISSIPATION, PER TU | BE | | | 35 MA | X. WATTS |
| TYPICAL OPERATION | | | | | |
| D-C Plate Voltage | - 15 | 00 2000 | 2500 | 3000 | volts |
| D-C Screen Voltage | - 5 | 00 500 | 500 | 500 | volts |
| D-C Grid Voltage 2 | | 64 -88 | -90 | -93 | volts |
| Zero-Signal D-C Plate Current | - 1 | 20 110 | 120 | 120 | ma. |
| Max-Signal D-C Plate Current | - 4 | 00 405 | 430 | 417 | ma. |
| Zero-Signal D-C Screen Current | 0 | .4 -0.3 | -0.3 | -0.2 | ma. |
| | | | | | |

| 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 | watt |
| Max-Signal Plate Dissipation (per tube) | * | 145 | 175 | 225 | 250 | watts |
| Max-Signal Plate Power Output | | 310 | 460 | 625 | 750 | watts |

Total Harmonic Distortion - - -

AUDIO FREQUENCY POWER AMPLIFIER AND MODULATOR

Class-AB₂ (Sinusoidal wave, two tubes unless otherwise specified)

MAXIMUM RATINGS

| D-C | PL | ATE | VOLT. | AGE | TEN. | _ | 2 | 25 | 2 | _ | | 920 | (20) | - | 4 | 4000 MAX, VOLTS |
|-----|-------|-------|--------|-----|------|----|---------|----|-----|------------|----|-----|------|---|---|-----------------|
| D-C | SCI | REEN | VOLT | AGI | | - | <u></u> | - | 22 | 9 4 | 1 | - | - | - | ¥ | 600 MAX, VOLTS |
| MA) | K-SIG | SNAL | D-C | PLA | TE | CI | JRR | E | NT, | PI | ER | TU | BE | | | 350 MAX. MA. |
| PLA | TE | DISSI | PATIC | N, | PER | | TUE | BE | | | | | | | * | 250 MAX. WATTS |
| SCR | EEN | DIS | SIPATI | ON, | PE | R | TU | BE | | J. | ė | | | | - | 35 MAX. WATTS |

TYPICAL OPERATION

| D-C Plate Voltage | 1500 | 2000 | 2500 | 3000 | volts |
|---|------|------|--------|----------|----------|
| D-C Screen Voltage | 300 | 300 | 300 | 300 | volts |
| D-C Grid Voltage | -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 | | | • • • | 1.9 | 20023400 |
| (approx.) | 2.1 | 2.3 | 2.2 | 4.00.401 | 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 |
| | | | | | |

APPLICATION

MECHANICAL

Mounting—The 4-250A must be mounted vertically, base up or base down. The socket must provide clearance for the glass tip-off which extends through the center of the base. The metal base shell should be grounded by means of suitable spring fingers. A flexible connecting strap should be provided between the plate terminal and the external plate circuit. The socket must not apply excessive lateral pressure against the base pins. The tube must be protected from severe vibration and shock.

Adequate cooling must be provided for the seals and envelope of the 4-250A. Forced-air circulation in the amount of five cubic feet per minute through the base of the tube is required. This 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 maximum 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., however,

In intermittent-service applications where the "on" time does not exceed a total of five minutes in any tenminute 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 proIndicates change from sheet dated 9-1-46.

vide 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.

ELECTRICAL

Filament Voltage—The filament voltage, as measured directly at the filament pins, should be between 4.75 and 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 five watts. Grid dissipation may be calculated from the following expression:

$$P_g\!=\!e_{emp}I_e$$

where Pg=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 grid³.

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 dissipa-

² The effective grid-circuit resistance must not exceed 250,000 ohms.

³ For suitable peak v.t.v.m. circuits see, for instance, "Vacuum Tube Ratings," Eimac News, January, 1945. This article is available in reprint form on request.



tion 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 75 Mc. Above 75 Mc., the maximum permissible plate voltage is less than 4000 volts, as shown by the graph on page 6.

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

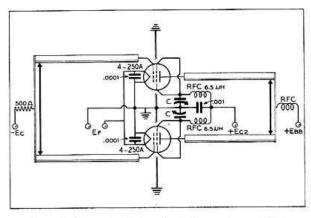
Plate dissipation in excess of the maximum rating is permissible for short periods of time, such as during tuning procedures.

OPERATION

Class-C FM or Telegraphy-The 4-250A may be operated as a class-C FM or telegraph amplifier 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 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-



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

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 34-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 thic circuit, feed-back 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 6. 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 75 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 high-level-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 high-level 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, and Class-AB. 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, and class-AB, 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.

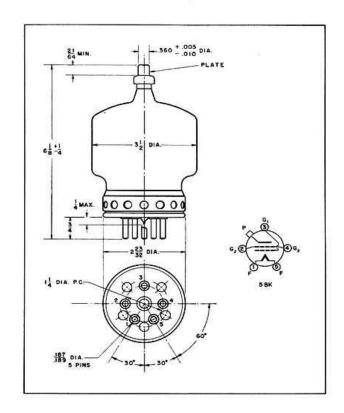


Grid bias voltage for class-AB₂ service may be obtained from batteries or from a small fixed-bias supply. When a bias supply is used, the d-c resistance of the bias source should not exceed 250 ohms. Under class-AB₁ conditions the effective grid-circuit resistance should not exceed 250,000 ohms.

The peak driving power figures given in the class-AB, 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.

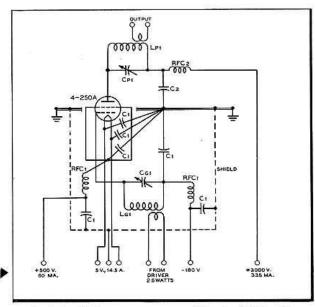


COMPONENTS FOR TYPICAL CIRCUITS

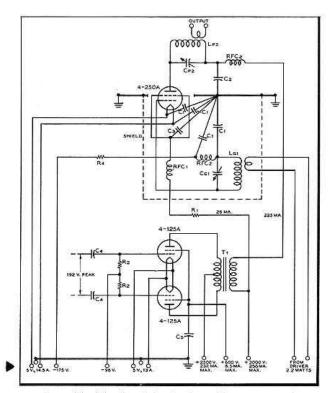
- L_{p1} C_{p1} Tank circuit appropriate for operating frequency; Q = 12. Capacitor plate spacing = .200".
- L_{p2} C_{p2} Tank circuit appropriate for operating frequency; Q=12. Capacitor plate spacing = .200".
- L_{p3} C_{p3} Tank circuit appropriate for operating frequency: Q=12. Capacitor plate spacing=.375".
- L_{s1} C_{s1} Tuned circuit appropriate for operating frequency.
- L_{κ^2} C_{κ^2} Tuned circuit appropriate for operating frequency.
- C1 .002-ufd., 500-v. mica
- C2 .002-ufd., 5000-v. mica
- C₂ -- .001-ufd., 2500-v. mica
- C. .1-ufd., 1000-v. paper
- C₃ .1-ufd., 600-v. paper
- C. .5-ufd., 600-v. paper
- C₇ .03-ufd., 600-v. paper
- Cs .1-ufd., 1000-v. paper
- C₉ .25-ufd., 1000-v. paper
 - R₁ --- 86,700 ohms, adjustable 100,000 ohms, 100 watts
- R2 250,000 ohms, 1/2 watt
- R. 15,000 ohms, 5 watts

- Rs 25,000 ohms, 2 watts
- Rs 2,500 ohms, 5 watts
- R: 35,000 ohms, 160 watts
- Rs 250,000 ohms, 1/2 watt
- R₉ 200,000 ohms, 2 watts
- R₁₀ 500 ohms, 1/2 watt
- R₁₁ I megohm, 1/2 watt
- R₁₂ 100,000 ohms, I watt
- R₁₃ 200,000 ohms, 1/2 watt
- R14 10,000 ohms, 1/2 watt
- R₁₅ 50 ohms, 10 watts
- R16-100,000 ohms, 100 watts
- RFC₁ 2.5-mhy., 125-ma. r-f choke
- RFC₂ I-mhy., 500-ma. r-f choke
- T₁ 350-watt modulation transformer; ratio pri. to sec. approx. 1.5 : 1; pri. impedance 20,300 ohms, sec. impedance 13,300 ohms.
- T₂ 600-watt modulation transformer; ratio pri. to sec. approx. 1.8 : 1; pri. impedance 11,400 ohms, sec. impedance 6,250 ohms.

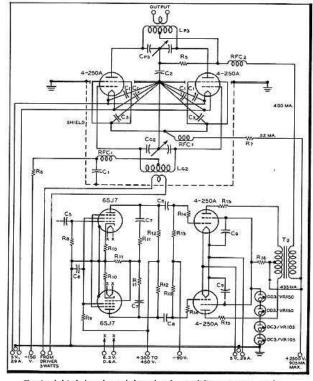




Typical radio frequency power amplifier circuit, Class-C telegraphy, 1000 watts input.

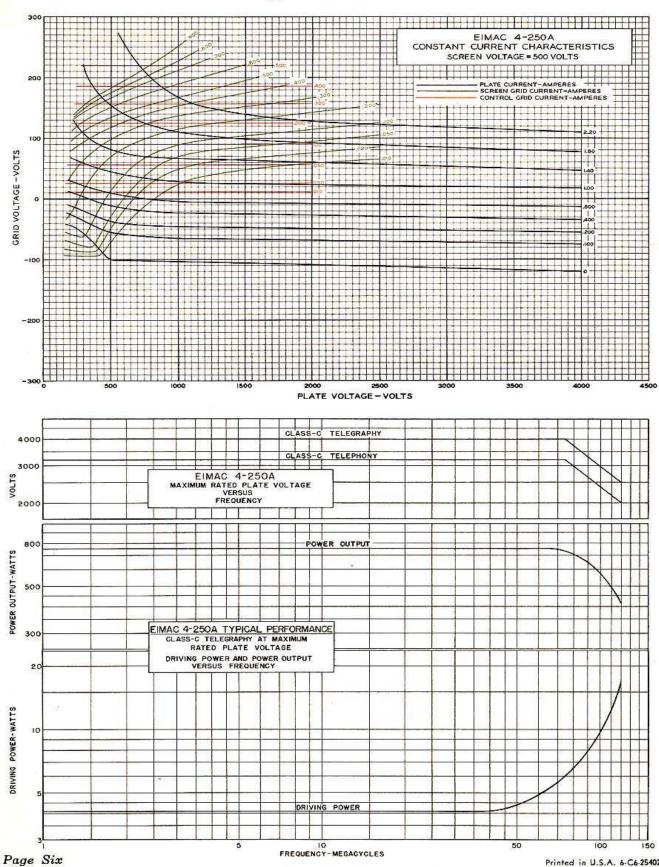


Typical high-level-modulated r-f amplifier circuit, with modulator stage, 675 watts input.



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





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