

Eitel-McCULLOUGH, Inc.

SAN BRUNO, CALIFORNIA

4-1000A

RADIAL-BEAM
POWER TETRODE
MODULATOR
OSCILLATOR
AMPLIFIER

The Eimac 4-1000A is a radial beam tetrode with a maximum plate dissipation rating of 1000 watts. Intended for use as an amplifier, oscillator, or modulator, the 4-1000A is capable of efficient operation well into the vhf range.

In FM broadcast service on 110 Mc., two 4-1000A tetrodes will deliver a useful power output over 5000 watts.

Operating under class AB₁ modulator conditions with less than 10 watts of peak driving power, two of these tubes will deliver 3900 watts of output power.

With zero watts driving power in class AB₂, a pair of 4-1000A tetrodes will deliver 3800 watts of power output.

► Cooling of the tube is accomplished by radiation from the plate and by circulation of forced-air through the base and around the envelope. Cooling can be simplified through the use of the Eimac SK-500 Air-System Socket.

GENERAL CHARACTERISTICS

ELECTRICAL

Filament: Thoriated tungsten	
Voltage	- 7.5 volts
Current	- 21 amperes
Grid-Screen Amplification Factor (Average)	- 7
Direct Interelectrode Capacitances (Average)	
Grid-Plate (without shielding, base grounded)	- 0.24 $\mu\mu\text{fd}$
Input	- 27.2 $\mu\mu\text{fd}$
Output	- 7.6 $\mu\mu\text{fd}$
Transconductance ($i_b = 300 \text{ ma.}, E_b = 2500 \text{ v.}, E_{c2} = 500 \text{ v.}$)	- 10,000 μmhos
Highest Frequency for Maximum Ratings	- 110 Mc

MECHANICAL

Base	- 5-pin metal shell (see dwg.)
Basing	- See drawing
► Recommended Socket	- Eimac SK-500 Air-System Socket
Mounting position	- Vertical, base down or up
Cooling	- Radiation and forced air

Recommended Heat Dissipating Connector:

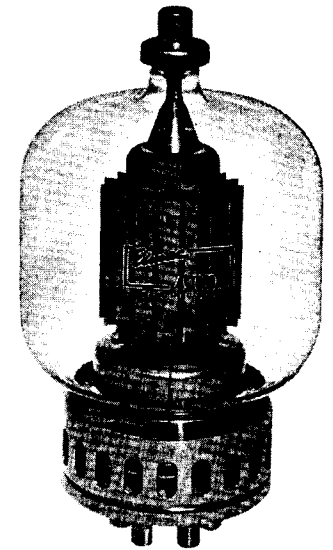
Plate	- Eimac HR-8
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Maximum Over-all Dimensions:

Length	- 9.63 inches
Diameter	- 5.25 inches
Net Weight (tube only)	- 1.5 pounds
Shipping Weight	- 12 pounds

If an Air-System Socket is used, mounted on a 1/4" deck, the over-all dimensions of the system including chimney and HR-8 cooler are

Length	- 11.75 inches
Diameter	- 7.5 inches



Eimac HR-8

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 Telephony or FM Telephony

MAXIMUM RATINGS (Key-down conditions, per tube to 110 Mc.)

D-C PLATE VOLTAGE	- 6000 MAX. VOLTS
D-C SCREEN VOLTAGE	- 1000 MAX. VOLTS
D-C GRID VOLTAGE	- 500 MAX. VOLTS
D-C PLATE CURRENT	- 700 MAX. MA
PLATE DISSIPATION	- 1000 MAX. WATTS
SCREEN DISSIPATION	- 75 MAX. WATTS
GRID DISSIPATION	- 25 MAX. WATTS

TYPICAL OPERATION (Frequencies below 110 Mc., one tube)

D-C Plate Voltage	- 3000	4000	5000	6000	volts
D-C Screen Voltage	- 500	500	500	500	volts
D-C Grid Voltage	- -150	-150	-200	-200	volts
D-C Plate Current	- 700	700	700	700	ma
D-C Screen Current	- 146	137	147	140	ma
D-C Grid Current	- 38	39	45	42	ma
Screen Dissipation	- 73	69	73	70	watts
Grid Dissipation	- 5	6	7	6	watts
Peak R-F Grid Input Voltage (approx.)	- 290	290	355	350	volts
Driving Power (approx.)*	- 11	12	16	15	watts
Plate Power Input	- 2100	2800	3500	4200	watts
Plate Dissipation	- 670	700	690	800	watts
Plate Power Output	- 1430	2100	2810	3400	watts

TYPICAL OPERATION (110 Mc., two tubes, push-pull)

D-C Plate Voltage	- 4000	5000	6000	volts
D-C Screen Voltage	- 450	500	500	volts
D-C Grid Voltage	- -150	-160	-180	volts
D-C Plate Current	- 1.15	1.25	1.25	amps
D-C Screen Current	- 280	240	250	ma
D-C Grid Current	- 80	80	100	ma
Screen Dissipation (per tube)	- 63	60	63	watts
Driving Power (approx.)	- 350	400	400	watts
Plate Power Input	- 4600	6250	7500	watts
Plate Dissipation (per tube)	- 650	850	900	watts
Useful Power Output	- 3000	4200	5200	watts

These 110 Mc. typical performance figures were obtained by direct measurement in operating equipment. The output power is useful power measured in a load circuit. The driving power is that taken by the tube and a practical resonant circuit. In many cases with further refinement and improved techniques, better performance might be obtained.

* Apparent driving power requirements increase above 30 Mc. At 110 Mc. the driver should be capable of supplying 200 watts per tube to take care of feed-through, circuit losses, and radiation.



4-1000A

PLATE MODULATED RADIO FREQUENCY AMPLIFIER

Class-C Telephony—Carrier Conditions

MAXIMUM RATINGS (Per tube to 110 Mc.)

D-C PLATE VOLTAGE	5000	MAX. VOLTS*
D-C SCREEN VOLTAGE	1000	MAX. VOLTS
D-C GRID VOLTAGE	-500	MAX. VOLTS
D-C PLATE CURRENT	600	MAX. MA.
PLATE DISSIPATION	670	MAX. WATTS
SCREEN DISSIPATION	75	MAX. WATTS
GRID DISSIPATION	25	MAX. WATTS

*5500 Max. volts below 30 Mc.

TYPICAL OPERATION (Frequencies below 110 Mc., one tube)

D-C Plate Voltage	3000	4000	5000	5500*	volts
D-C Screen Voltage	500	500	500	500	volts
D-C Grid Voltage	-200	-200	-200	-200	volts
D-C Plate Current	600	600	600	600	ma
D-C Screen Current	145	132	130	105	ma
D-C Grid Current	36	33	33	28	ma
Screen Dissipation	72	66	65	52	watts
Grid Dissipation	5	4	4	3	watts
Peak A-F Screen Voltage (100% modulation)	250	250	250	250	volts
Peak R-F Grid Input Voltage	340	335	335	325	volts
Driving Power**	12	11	11	9	watts
Plate Power Input	1800	2400	3000	3300	watts
Plate Dissipation	410	490	560	670	watts
Plate Power Output	1390	1910	2440	2630	watts

*5500 volt operation may be used only below 30 Mc.

**Apparent driving power requirements increase above 30 Mc. At 110 Mc. the driver should be capable of supplying 200 watts per tube to take care of feed-through, circuit losses, and radiation.

AUDIO FREQUENCY POWER AMPLIFIER AND MODULATOR

Class AB

MAXIMUM RATINGS (PER TUBE)

D-C PLATE VOLTAGE	6000	MAX. VOLTS
D-C SCREEN VOLTAGE	1000	MAX. VOLTS
MAX-SIGNAL D-C PLATE CURRENT	700	MAX. MA
PLATE DISSIPATION	1000	MAX. WATTS
SCREEN DISSIPATION	75	MAX. WATTS

TYPICAL OPERATION

Class AB, (Sinusoidal wave, two tubes unless otherwise specified)

D-C Plate Voltage	4000	5000	6000	volts
D-C Screen Voltage	1000	1000	1000	volts
D-C Grid Voltage (approx.)*	-115	-125	-135	volts
Zero-Signal D-C Plate Current	300	240	200	ma
Max-Signal D-C Plate Current	1.05	1.00	.95	amp
Zero-Signal D-C Screen Current	0	0	0	ma
Max-Signal D-C Screen Current	60	60	64	ma
Effective Load, Plate-to-Plate	7000	10,000	14,000	ohms
Peak A-F Grid Input Voltage (per tube)	115	125	135	volts
Driving Power	0	0	0	watts
Max-Signal Plate Dissipation (per tube)	930	950	930	watts
Max-Signal Plate Power Output	2340	3100	3840	watts

*Adjust to give stated zero-signal plate current. The D-C resistance in series with the control grid of each tube should not exceed 250,000 ohms.

TYPICAL OPERATION

Class AB, (Sinusoidal wave, two tubes unless otherwise specified)

D-C Plate Voltage	4000	5000	6000	volts
D-C Screen Voltage	500	500	500	volts
D-C Grid Voltage (approx.)*	-60	-70	-75	volts
Zero-Signal D-C Plate Current	300	200	150	ma
Max-Signal D-C Plate Current	1.20	1.10	.95	amp
Zero-Signal D-C Screen Current	0	0	0	ma
Max-Signal D-C Screen Current	95	90	65	ma
Effective Load, Plate-to-Plate	7000	11,000	15,000	ohms
Peak A-F Grid Input Voltage (per tube)	140	145	130	volts
Max-Signal Peak Driving Power	11.0	11.0	9.4	watts
Max-Signal Nominal Driving Power (approx.)	5.5	5.5	4.7	watts
Max-Signal Plate Dissipation (per tube)	900	850	900	watts
Max-Signal Plate Power Output	3000	3800	3900	watts

*Adjust to give stated zero-signal plate current.

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.

Pulse Service—For information on Pulse Service Ratings, "Application Bulletin No. 3, Pulse Service Notes", will be furnished free on request.

APPLICATION

MECHANICAL

▶ **Mounting**—The 4-1000A must be mounted vertically. The base may be down or up. The recommended socket for this tube is the SK-500 Air-System Socket.

▶ **Cooling**—Adequate forced-air cooling must be provided to maintain the base seal temperatures below 150°C., and the plate seal temperature below 200°C. Cooling is simplified by the use of the Eimac SK-500 Air System Socket, and its SK-506 Air Chimney, which control the flow of air around the tube.

When the Eimac SK-500 Air-System Socket is used, the following flow rates apply to sea level operation, with an ambient temperature of 25°C., for the operating conditions described:

At 110 mc., with maximum rated plate dissipation, an air flow rate of 45 CFM is required. The corresponding pressure drop across the socket is 1.2 inches of water column.

At frequencies below 30 megacycles, an air flow rate of 30 CFM provides adequate cooling. The corresponding pressure drop across the socket is 0.5 inches of water column.

In the event that an Air-System Socket and Air Chimney are not used, air must be circulated through the base of the tube, over the envelope surface and the plate seal in sufficient quantities to maintain the temperatures below the maximum ratings. Seal temperature ratings may require that cooling air be supplied to the

tube if the filament is maintained at operating temperature during standby periods.

In any questionable situation, the only criterion for correct cooling practice is temperature. A convenient method for measuring tube temperatures is the use of a temperature-sensitive paint, which melts at certain designated temperatures. One such product is made by the Tempil Corp., 11 W. 25th St., New York 10, N. Y.

ELECTRICAL

Filament Voltage—For maximum tube life the filament voltage, as measured directly at the filament pins, should be the rated voltage of 7.5 volts. Variations in filament voltage must be kept within the range from 7.13 to 7.87 volts.

Bias Voltage—The D-C bias voltage for the 4-1000A should not exceed 500 volts. With grid-leak bias, suitable means must be provided to prevent excessive plate- or screen dissipation in the event of loss of excitation. The grid-resistor should be made adjustable to facilitate maintaining the bias voltage and plate current at the desired values from tube to tube. In the case of operation above 50 Mc., it is advisable to keep the bias voltage as low as possible. (See "Operation.")

Screen Voltage—The D-C screen voltage for the 4-1000A should not exceed 1000 volts. The screen voltages shown under "Typical Operation" are representative voltages for the type of operation involved.

Plate Voltage—The plate-supply voltage for the 4-1000A should not exceed 6000 volts in CW and audio applications. In plate-modulated telephony service above 30 Mc., the D-C plate-supply voltage should not exceed 5000 volts; however, below 30 Mc., 5500-volt operation may be used.

Grid Dissipation—Grid dissipation for the 4-1000A should not be allowed to exceed 25 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 to cathode voltage, and
 I_c = D-c grid current.

e_{cmp} may be measured by means of a suitable peak volt-meter connected between filament and grid. (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.)

Screen Dissipation—The power dissipated by the screen of the 4-1000A must not exceed 75 watts. Screen dissipation is likely to rise to excessive values when the plate voltage, bias voltage or plate load are removed with filament and screen voltages applied. Suitable protective means must be provided to limit screen dissipation to 75 watts in event of circuit failure.

Plate Dissipation—Under normal operating conditions, the plate dissipation of the 4-1000A should not be allowed to exceed 1000 watts.

In plate modulated amplifier applications, the maximum allowable carrier-condition plate dissipation is 670 watts. The plate dissipation will rise to 1000 watts under 100% sinusoidal modulation.

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

OPERATION

CLASS-C R-F AMPLIFIER

Neutralization—If reasonable precautions are taken to prevent coupling between input and output circuits, the 4-1000A may be operated up to the 10 Mc. region without neutralization. In the region between 10 Mc. and 30 Mc., the conventional type of cross-neutralizing may be used with push-pull circuits. In single-ended circuits ordinary neutralization systems may be used which provide 180° out of phase voltage to the grid. A simple and effective method of neutralizing single-ended tetrode circuits is described by Warren B. Bruene in "How to Neutralize Your Single-Ended Tetrode Final", in the August, 1950, issue of CQ magazine.

At frequencies above 30 Mc. the feedback is principally due to screen-lead-inductance effects. Feedback is eliminated by using series capacitance in the screen leads between the screen and ground. A variable capacitor of from 25 to 50 uufds will provide sufficient capacitance to neutralize each tube in the region of 100 Mc. When using this method, the two screen terminals on the socket should be strapped together by the shortest possible lead. The lead from the mid-point of this screen strap to the variable capacitor and from the variable capacitor to ground should be made with as low inductance as possible.

In general, plate, grid, filament and screen bypass or screen neutralizing capacitors should be returned to r-f ground through the shortest possible leads.

In order to take full advantage of the high power gain obtainable with the 4-1000A, care should be taken to prevent feedback from the output to input circuits. A conventional method of obtaining the necessary shielding between the grid and plate circuits is to use a suitable metal chassis with the grid circuit mounted below the deck and the plate circuit mounted above the deck. Power supply leads entering the amplifier should be by-

passed to ground and properly shielded to avoid feedback coupling in these leads. The output circuit and antenna feeders should be arranged so as to preclude any possibility of feedback into other circuits.

VHF Circuits—A typical linear tank circuit for use with the 4-1000A in the 110 Mc. region consists of a "quarter wavelength" plate tank and a "half wavelength" grid tank circuit. Precautions must be observed in the placement of components to avoid the possibility of accidentally creating higher frequency tank circuits than the desired one. This could occur if a tuning capacitor were placed in a position on the line where it would create a resonant circuit at or near a harmonic frequency. A properly neutralized amplifier at the fundamental frequency would appear regenerative at higher parasitic frequencies and instability or oscillation would result.

Any capacitance tuning in the plate line should be kept to a small value, acting as a trimmer for the shorting-bar tuning. Such a variable capacitor should be positioned on the plate line as close as possible to the plate leads. The tuning capacitor on the "half wave" grid line should be positioned at the extreme end of the line away from the tube.

In many cases where parasitic oscillation or regenerative harmonic amplification occurs, it is not evident until grid excitation at the fundamental frequency is applied. If the amplifier tunes in a normal manner and the efficiency appears normal for the frequency of operation, it may be assumed that the amplifier is free of parasitic oscillation and harmonic regeneration.

VHF Operation—Above 50 Mc., electron transit time factors in the tube become important, increasing in degree as the frequency is increased. When the grid swings highly negative in potential, electrons, "trapped" enroute by the rapidly changing r-f voltage, can be deflected from their normal paths. If excessively large r-f plate voltages exist due to light plate loading, these electrons are rejected at high velocity to bombard tube parts normally outside the electron stream. This effect occurs when an amplifier goes into parasitic oscillation, as there is practically no loading in the plate circuit and the excitation is almost always extremely high. Bombardment can cause premature tube failure by a focusing of stray electrons on metal parts or the glass envelope of a tube. Such concentration of a stray electron stream will usually overheat the material at the point of focus, with the probability of gas evolution that can lead to loss of filament emission or destruction of the tube. Where glass is the overheated material, a small hole or "suck-in" can occur, opening the tube to atmosphere. Dependent upon the degree of bombardment, tube failures can occur in a matter of minutes, or after a few thousand hours of life. Either way, the full life potential is not realized.

In order to minimize stray bombardment, the following rules should be followed in vhf operation of straight through amplifiers.

1. Use a minimum amount of bias (not over 1.5 to 2.0 times cut-off).
2. Use only enough drive to obtain satisfactory operation and good plate efficiency.
3. Use fairly heavy plate loading. Low plate voltage and high plate current is better than high plate voltage and low plate current. Avoid operating the stage unloaded or lightly loaded. If conditions are such that the stage must be operated lightly-loaded, then the driving power should be reduced proportionately. Install under-current protection, especially where unloaded operation can occur due to antenna failures or transmission line icing.
4. Operate the screen grid at a reasonably high voltage, still keeping within screen dissipation ratings.

