

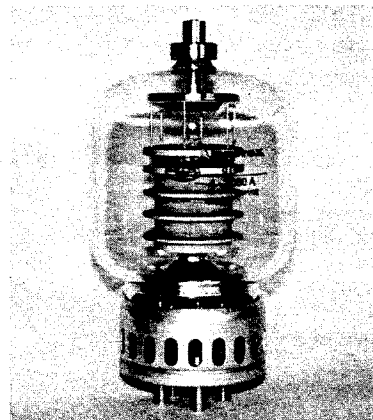
Amperex

8166/4-1000A

**RADIAL-BEAM
POWER TETRODE**

**MODULATOR
OSCILLATOR
AMPLIFIER**

The 8166/4-1000A is a beam power 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 MHz, two 4-1000A tetrodes will deliver a useful power output over 5000 watts. Operating under class AB, 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 AB, 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.



GENERAL CHARACTERISTICS

ELECTRICAL

Filament : Thoriated Tungsten		
Voltage	7.5	Volts
Current	21	Amps
Amplification Factor (Grid to screen)	7	
Direct Interelectrode Capacitances (Average)		
Grid Plate (without shielding base grounded)	0.24	pf
Input	27.2	pf
Output	7.6	pf
Transconductance ($I_b = 300$ ma, $E_b = 2500$, $E_{c2} = 500V$)	10	ma/v
Highest Frequency for Maximum Ratings	110	MHz

MECHANICAL

Base	5 Pin metal shell
Basing	See drawing
Recommended Socket	SK510 Air-System Socket
Operating Position	Vertical base down or up.
Maximum Operating Temperatures :	
Base Seals	150°C
Plate Seal	200°C
Cooling	Radiation and forced -air
Recommended Heat-Dissipating Plate Connector	HR-8
Maximum Over-all Dimensions :	
Length	(9.25 inches) 235 mm
Diameter	(5.24 inches) 133 mm
Net Weight (tube only)	(1.6 lbs.) 0,74 kg
Shipping Weight in Shielded Fixture	(8.1lbs) 3,70 kg
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	(11.8 inches) 299 mm

Note: Typical operation data are based on conditions of adjusting to a specified plate current, maintaining fixed conditions of grid bias, screen voltage and r-f grid 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.

 **Richardson Electronics, Ltd.**

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8166/4-1000A

RADIAL-BEAM POWER TETRODE

RADIO FREQUENCY POWER AMPLIFIER AND OSCILLATOR Class-C Telephony or FM Telephony

MODULATOR OSCILLATOR AMPLIFIER

MAXIMUM RATINGS (Key-down conditions per tube to 110 MHz)

DC Plate Voltage	6000	max. volts
DC Screen Voltage	1000	max. volts
DC Grid Voltage	- 500	max. volts
DC Plate Current	700	max. volts
Plate Dissipation	1000	max. watts
Screen Dissipation	75	max. watts
Grid Dissipation	25	max. watts

TYPICAL OPERATION (Frequencies below 110 MHz, one tube)

DC Plate Voltage	3000	4000	5000	6000	volts
DC Screen Voltage	500	500	500	500	volts
DC Grid Voltage	-150	-150	-200	-200	volts
DC Plate Current	700	700	700	700	mA
DC Screen Current	146	137	147	140	mA
DC Grid Current	38	39	45	42	mA
Screen Dissipation	73	69	73	70	watts
Grid Dissipation	5	6	7	6	watts
Peak RF 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

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

PLATE MODULATED RADIO FREQUENCY AMPLIFIER Class-C Telephony - Carrier Conditions

MAXIMUM RATINGS (Per tube to 110 MHz)

DC Plate Voltage	5000	max. volts *
DC Screen Voltage	1000	max. volts
DC Grid Voltage	- 500	max. volts
DC Plate Current	600	max. mA
Plate Dissipation	670	max. watts
Screen Dissipation	25	max. watts
Grid Dissipation	75	max. watts

* 5500 max. volts below 30 MHz

TYPICAL OPERATION (110 MHz, two tubes, push-pull)

DC Plate Voltage	4000	5000	6000	volts
DC Screen Voltage	450	500	500	volts
DC Grid Voltage	- 150	- 160	- 180	volts
DC Plate Current	1.16	1.25	1.25	amps
DC Screen Current	280	240	250	mA
DC 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 MHz 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.

TYPICAL OPERATION (Frequencies below 110 MHz, one tube)

DC Plate Voltage	3000	4000	5000	5500*	volts
DC Screen Voltage	500	500	500	500	volts
DC Grid Voltage	- 200	- 200	- 200	- 200	volts
DC Plate Current	600	600	600	600	mA
DC Screen Current	145	132	130	106	mA
DC Grid Current	36	33	33	28	mA
Screen Dissipation	72	66	65	52	watts
Grid Dissipation	5	4	4	3	watts
Peak AF Screen Voltage (100% modulation)	250	250	250	250	volts
Peak RF 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 MHz

** Apparent driving power requirements increase above 30 MHz.

At 110 MHz, the driver should be capable of supplying 200 watts per tube to take care of feed-through, circuit losses and radiation.

8166/4-1000A

RADIAL-BEAM
POWER TETRODE

AUDIO FREQUENCY POWER AMPLIFIER AND MODULATOR
Class AB

MODULATOR
OSCILLATOR
AMPLIFIER

MAXIMUM RATINGS (per tube)

DC Plate Voltage	6000	max. volts
DC Screen Voltage	1000	max. volts
Max-Signal DC Plate Current	700	max. mA
Plate Dissipation	1000	max. watts
Screen Dissipation	75	max. watts

TYPICAL OPERATION

Class AB₁ (sinusoidal wave, 2 tubes unless otherwise specified)

DC Plate Voltage	4000	5000	6000	volts
DC Screen Voltage	1000	1000	1000	volts
DC Grid Voltage (approx.)	-115	-125	-135	volts
Zero-Signal DC Plate Current	300	240	200	mA
Max-Signal DC Plate Current	1.05	1.00	0.95	amp
Zero-Signal DC Screen Current	0	0	0	mA
Max-Signal DC Screen Current	60	60	64	mA
Effective Load Plate-to-Plate	7,000	10,000	14,000	ohms
Peak AF Grid Input Voltage (per tube)	115	125	135	volts
Driving Power	0	0	0	watts
Max-Signal Plate Dissipation	930	950	930	watts
Max-Signal Plate Power Output	2340	3100	3840	watts

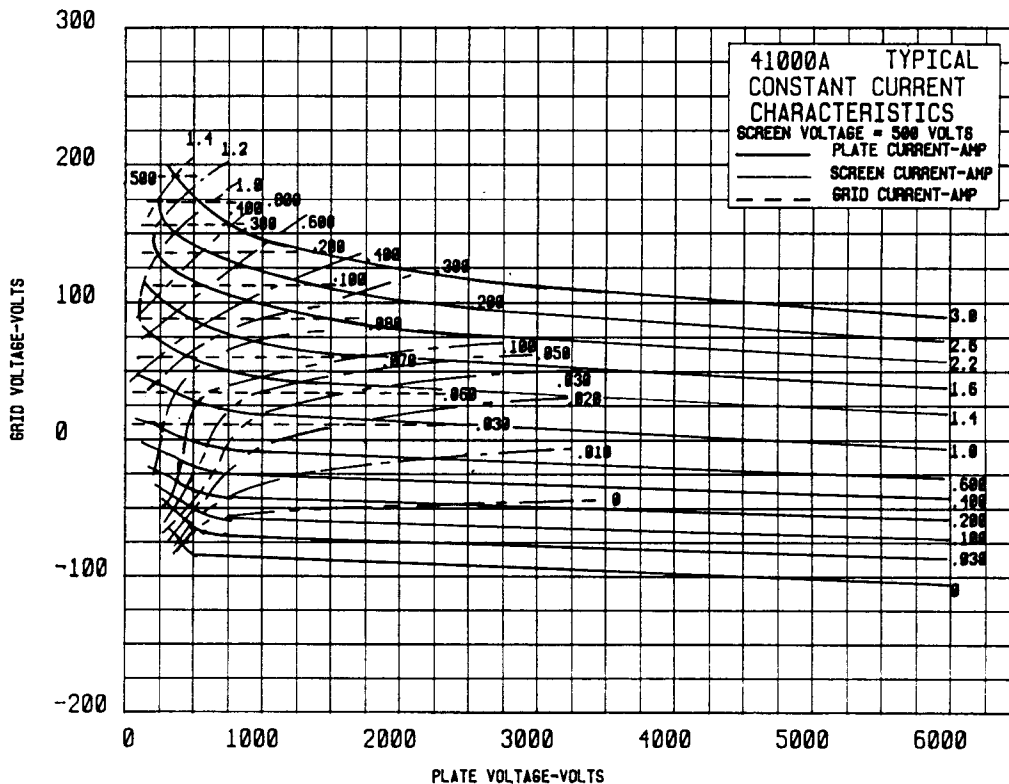
** Adjust to give stated zero-signal plate current. The DC resistance in series with the control grid of each tube should not exceed 250.000 ohms.

TYPICAL OPERATION

Class AB₂ (sinusoidal wave, 2 tubes unless otherwise specified)

DC Plate Voltage	4000	5000	6000	volts
DC Screen Voltage	500	500	500	volts
DC Grid Voltage approx*	-60	-70	-75	volts
Zero-Signal DC Plate Current	300	200	150	mA
Max-Signal DC Plate Current	1.20	1.10	.95	amp
Zero-Signal DC Screen Current	0	0	0	mA
Max-Signal DC Screen Current	95	90	65	mA
Effective Load Plate to Plate	7,000	11,000	15,000	ohms
Peak AF 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



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APPLICATION

MECHANICAL

Mounting — The 4-1000A must be mounted vertically, base up or base down. The socket must be constructed so as to allow an unimpeded flow of air through the holes in the base of the tube. The socket must also provide clearance for the glass tip-off which extends from the center of the base. The metal tube-base shell should be grounded by means of suitable spring fingers. A flexible connecting strap should be provided between the HR cooler on 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.

Cooling — Adequate forced-air cooling must be provided to maintain the base-seal temperatures below 150°C and the plate seal below 200°C. The problem of cooling is greatly simplified by using the 4-1000A Air-System Socket and its accompanying chimney. This system is designed to maintain the correct balance of cooling air for the various parts of the tube. The minimum quantity of air required by this system for maximum power output at 110 MHz is 45 cubic feet meter at an inlet static pressure of approximately 1.2 inches of water.

In the event that an Air-System Socket is not used, provision must be made to circulate air through the base around the envelope and over the plate seal. This is in addition to the normal cooling required by the base. Seal temperature limitations may require that cooling air be supplied to the tube even when filament alone is on during standby periods.

Tube temperatures may be measured with the aid of "Tempilaq", a temperature-sensitive lacquer.

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. Unavoidable variations in filament voltage must be kept within the range of 7.13 to 7.87 volts.

Bias Voltage — The D-C bias voltage for the 4-1000A 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 and the grid-leak 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 MHz, 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 MHz, the D-C plate-supply voltage should not exceed 5000 volts; however, below 30 MHz, 5500 volts 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 :

$$P_g = V_p \times I_c$$

where : P_g = Grid dissipation
 V_p = Peak positive grid to cathode voltage and
 I_c = DC grid current

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 MHz region without neutralization. In the region between 10 MHz and 30 MHz, 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.

At frequencies above 30 MHz, 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 pf will provide sufficient capacitance to neutralize each tube in the region of 100 MHz. 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 MHz 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 was 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 MHz, 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 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.

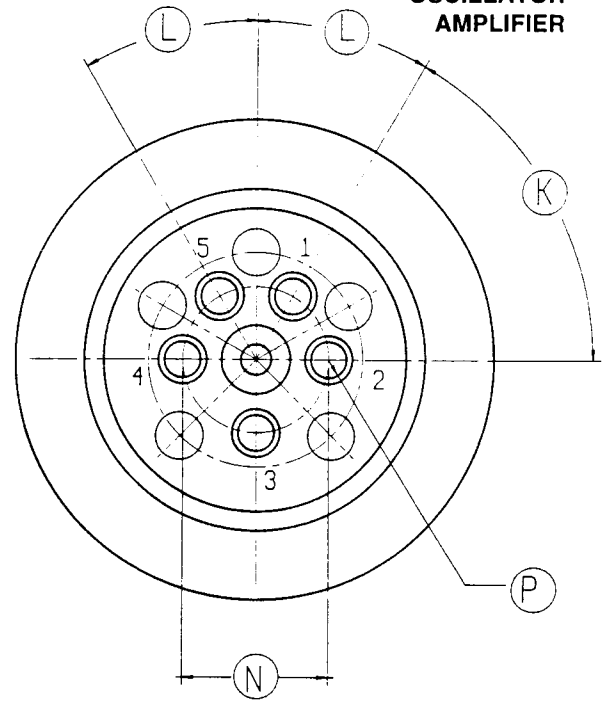
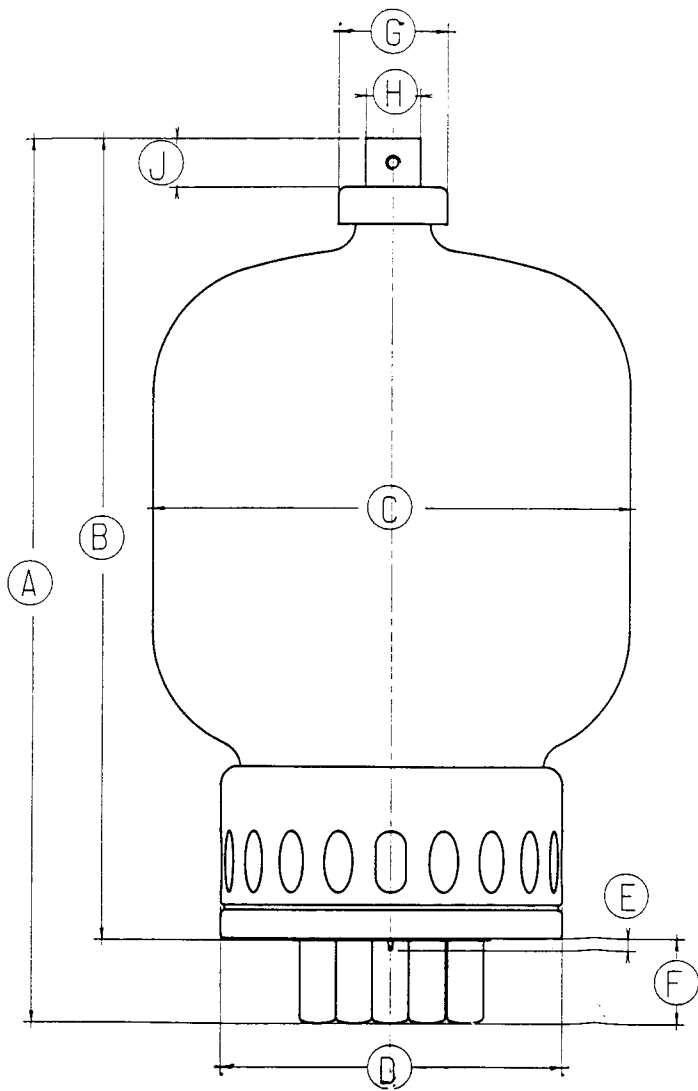
In order to minimize stray bombardment, the following rules should be followed in vhf operation of straight through amplifiers.

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.

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BOTTOM VIEW

DIMENSIONAL DATA						
DIM	INCHES			MILLIMETERS		
	MIN	MAX	REF	MIN	MAX	REF
A	8.875	9.625	9.250	225.4	244.5	234.9
B	8.000	8.750	8.375	203.2	222.2	212.7
C	—	5.250	—	—	133.3	—
D	—	3.625	—	—	92.1	—
E	—	.313	—	—	7.9	—
F	.825	.925	.875	20.9	23.5	22.2
G	1.110	1.140	1.250	28.2	29	28.6
H	.559	.573	—	14.2	14.55	—
J	.484	—	—	12.3	—	—
K	—	—	60°	—	—	60°
L	—	—	30°	—	—	30°
N	1.495	1.505	1.500	38	38.2	38.1
P	.371	.377	.374	9.42	9.57	9.49