An Eimac Family of 4CX600 Tetrodes

APPLICATION BULLETIN NUMBER FOURTEEN $1.50

ON THE COVER

The 4CX600 family are ruggedized, compact, ceramic / metal tetrodes which combine small size, high plate current, high gain and excellent linearity. The tubes are available in air cooled and liquid cooled versions. The 4CX600B (left) is suggested for use in VHF wideband distributed amplifier service and other applications up to 890 MHz. It may be supplied with an optional coaxial adapter base (shown) which is bolted to the four grid terminals. A pin adapter threads on the center heater stud. Typically, the 4CX600B provides 700 watts at 432 MHz in grid driven class AB service with a power gain of over 10 decibels.

The 4CW800B (center) is a liquid cooled version of the 4CX600B. Both air and liquid cooled tubes feature screen and cathode flange rings which mate with a special low inductance bypass capacitor to provide improved operation in the VHF region.

The 4CX600J/8809 (right) is suggested for high linearity service up to 150 MHz. High power gain allows the tube to be driven to full output with a solid-state driver and excellent linearity provides a clean output signal at maximum power level.

CONTENTS **PAGE**

The 4CX600 Family of Eimac Tetrodes

INTRODUCTION

The 4CX600 family of EIMAC tetrodes represents an outstanding technical advance in power tubes designed for today's space-age communications. These high-gain, precision tetrodes were developed in an in-depth computer-aided design program for ceramic/metal tetrodes, aimed to meet the increasingly stringent demands of complex communications systems.

The 4CX600 family are ruggedized, compact, radial beam tetrodes for use in ground or air-borne electronic circuitry up to 890 MHz. Closely controlled parameters plus state-of-the-art assembly and testing techniques permit a high gain-bandwidth product and an extremely low intermodulation distortion level to be simultaneously achieved in these tubes, establishing a new criterion of performance. The advanced EIMAC segmented cathode structure and unique electron focusing action combine to enhance these excellent characteristics and provide the user with tetrodes adaptable to widely diversified services:

- low distortion linear amplification
- high reliability air-ground communication.
- wideband VHF distributed amplifier service.
- frequency-agile systems
- synchrotron accelerator service.
- rf pulse application at VHF.
- airborne ECM application.

The initial members of this advanced family of EIMAC tetrodes include the following tubes:

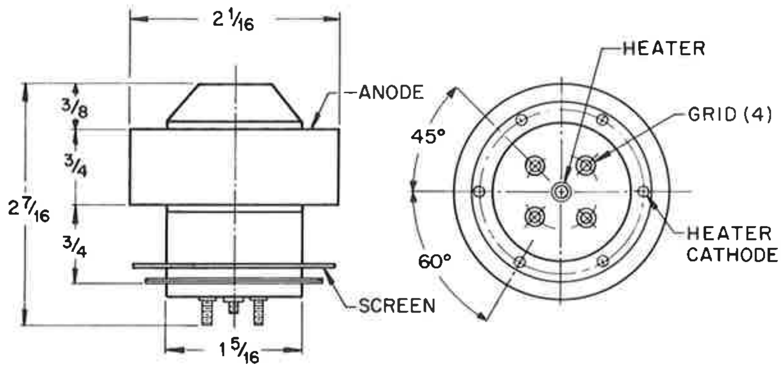
EIMAC 4CX600B

EIMAC 4CX600F

The 4CX600B is a 600 watt dissipation, ceramic/metal, air cooled radial beam tetrode suggested for use in high gain, wideband distributed amplifiers. This precision power tube features a special base designed for UHF circuitry, having the cathode structure mounted to a large circular connecting flange. The flange provides very low cathode lead inductance, thus reducing input degeneration and holding tube gain high at the higher frequency portion of the operating range. Input and output capacitances of the tube are low due to the compact mounting structure.

The control grid termination consists of threaded studs protruding from the ceramic base. The multiple configuration allows the circuit designer the option of using any number of grid studs up to four, thus permitting adjustment of grid lead inductance to comply with circuit requirements. This manipulation is useful in certain distributed amplifier designs in the VHF-UHF regions.

Contact is made to the screen grid of the 4CX600B tetrode by means of a second, low inductance circular flange. The screen may be placed at dc ground, or bypassed with a low inductance VHF capacitor assembly (EIMAC part SK-680) bolted directly to the cathode flange of the tube. In addition, a base adapter (drawing number 016273) is available for use with coaxial input assemblies.



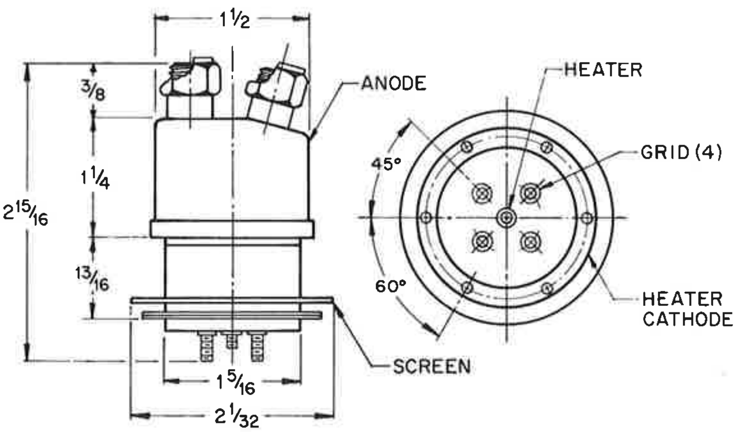
SIDE VIEW BASE

PLATE DISSIPATION (WATTS)	SEA LEVEL		10,000 FEET	
	AIR FLOW (CFM)	PRESSURE DROP (INCHES OF WATER)	AIR FLOW (CFM)	PRESSURE DROP (INCHES OF WATER)
600	14.7	0.72	21.5	1.05

OUTLINE AND SOCKETING 4CX600B / 4CX600F

Figure 2.

[2]



SIDE VIEW BASE

PLATE DISSIPATION WATTS	SEA LEVEL	
	WATER FLOW (GPM)	PRESSURE DROP (PSI)
800	.202	.100

OUTLINE AND SOCKETING 4CW800B / 4CW800F

Figure 3.

Ruggedized construction featuring a unitized electrode structure makes the 4CX600B suitable for environments encountering severe shock and vibration.

The 4CX600F is a 26.5 volt heater version of the 4CX600B. Outline dimensions and cooling data for both tubes are shown in figure 2.

EIMAC 4CW800B and 4CW800F

The 4CW800B and 4CW800F ceramic/metal, radial beam tetrodes are liquid-cooled counterparts of the 4CX600B and 4CX600F (figure 3). Maximum plate dissipation of these types is 800 watts. The cooling jacket of these tubes is designed for water or liquid coolants such as Coolanol 35. The required flow rate and pressure drop for the maximum plate dissipation of 800 watts, when water is used as the coolant, is listed in the illustration. In addition to the plate cooling, heat sink or forced air base cooling is required.

EIMAC 4CX600J/8809

The 4CX600J/8809 is a 600 watt dissipation, ceramic/metal, air cooled radial beam tetrode specifically designed for high linearity, high gain amplifier service up to 150 MHz (figure 4). The 4CX600J/8809 is a low plate voltage, high plate current tube combining minimum intermodulation distortion and low grid interception with high electrical efficiency. An EIMAC segmented cathode is used, composed of many small "electron guns" arranged around the circumference of the cathode structure (figure 5). The excellent distortion characteristics of the 4CX600J/8809 at various plate potentials are summarized in figure 6.

Because the 4CX600J/8809 has very low grid interception, it is possible to drive the grid positive in linear service without adverse effect upon the distortion level and with minimum reaction on the driver. Class AB_2, low distortion operation is therefore possible and recommended. The use of a low impedance driver is suggested to achieve minimum intermodulation distortion (1).

The 4CX600J/8809 will provide 550 watts output with intermodulation distortion products down -43 decibels. The drive power required is one-half watt providing a stage gain of 35 db.

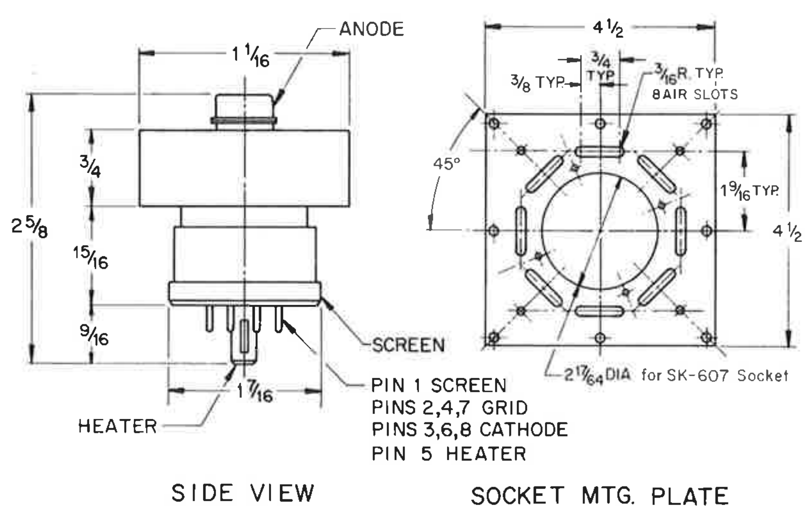


PLATE DISSIPATION (WATTS)	SEA LEVEL		10,000 FEET	
	AIR FLOW (CFM)	PRESSURE DROP (INCHES OF WATER)	AIR FLOW (CFM)	PRESSURE DROP (INCHES OF WATER)
600	19.8	0.76	29.0	1.12

OUTLINE AND SOCKETING - 4CX600J/8809

Figure 4.

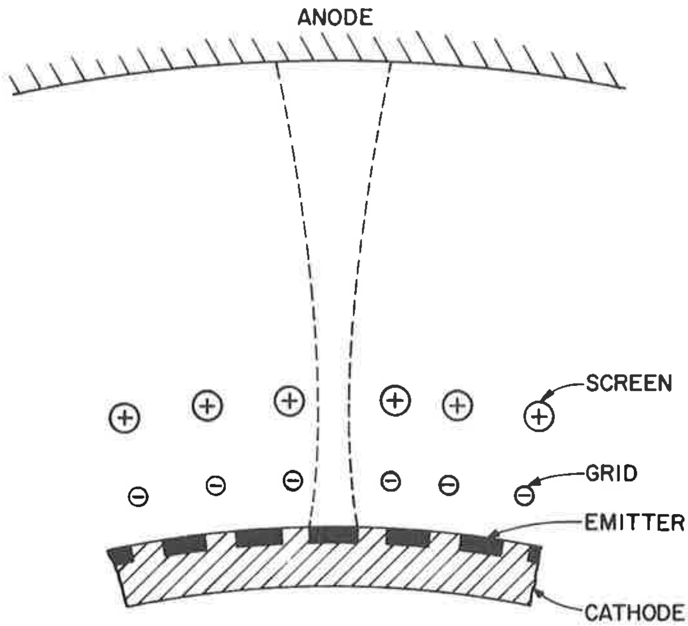


Figure 5. The EIMAC segmented cathode is composed of many small electron "guns" arranged around the circumference of the cathode structure. Computer aided design program allows optimization of low intermodulation distortion and low grid interception by achieving proper electron focusing. This advanced cathode is featured in the 4CX600J/8809.

Figure 6

Typical Operation Below 30 MHz for 4CX600J/8809
Class AB_2, Grid Driven, Peak Envelope Conditions

Plate Voltage	2000	2500	3000	Vdc
Screen Voltage	350	350	350	Vdc
Grid Voltage 1	-41	-41	-45	Vdc
Zero-Signal Plate Current	300	175	175	mAdc
Single Tone Plate Current	500	680	665	mAdc
Single Tone Screen Current 2	5	30	6	mAdc
Single Tone Grid Current 2	0	0.5	0	mAdc
Peak R-f Grid Voltage 2	32	70	71	v
Peak Driving Power	0.5	2.6	2.7	w
Useful Output Power	550	1100	1235	W
Resonant Load Impedance	2000	2000	2400	Ω
Intermodulation Distortion Products:3				
3rd Order	-43	-40	-35	db
5th Order	-43	-40	-50	db
Cathode Resistor (R_k)	0	11	11	ohms

Note: Various operating conditions at a plate potential of 3 kV are shown in Figure 7 and 9.

1. Adjust to specified zero-signal dc plate current.
2. Approximate value.
3. Referenced against one tone of a two equal tone signal.

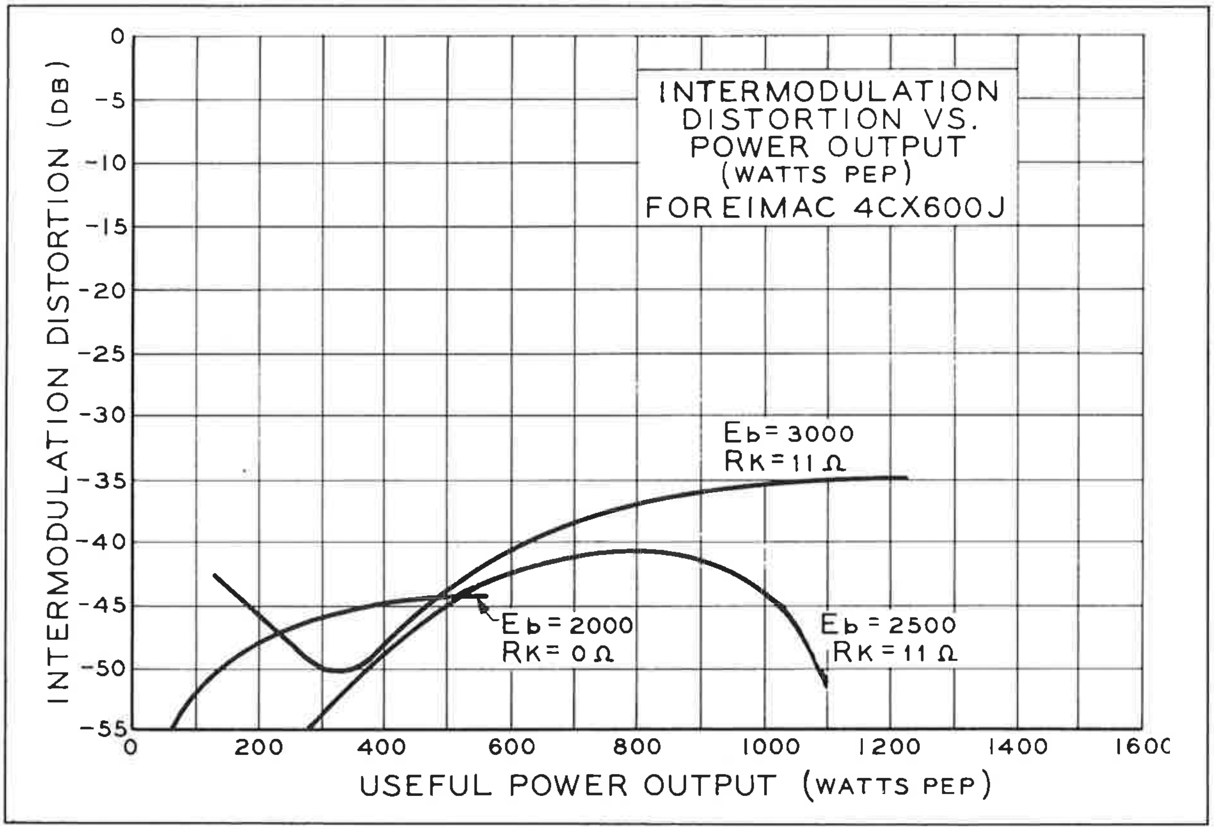


Figure 7. Intermodulation characteristics for 4CX600J/8809 for operating conditions listed in Figure 6. Distortion level is referred to one tone of a two tone test signal. A distortion figure better than -40 db is achieved at plate potentials of 2000 and 2500 volts. Distortion products are better than -35 db at plate potential of 3000.

Curves illustrate third order .products. The curves are plots of intermodulation distortion at different levels of power output. As the drive level is decreased, the distortion products pass through maxima and minima points. Misleading conclusions of tube performance may be drawn if the tube happens to be tested near a cusp on the intermodulation curve where a particular product drops to an extremely low level. The whole operating range of the tube must be examined to draw a true picture of intermodulation distortion performance, as shown in the above curves.

The distortion figures given in this bulletin are determined by test with a two tone signal and the results are referred to one tone of the two tone signal. The peak envelope power (PEP) noted is the root-mean-square (rms) power at the peak of the modulation envelope.

In the EIMAC test procedure, the tube under test is adjusted to full drive condition and the pertinent parameters measured. The drive signal is then reduced in a predetermined manner and parameters noted and plotted as a function of drive voltage. It should be noted that maximum intermodulation distortion does not necessarily occur at maximum drive level.

Choice of idling plate current, screen voltage and drive level will effect intermodulation distortion. Typical intermodulation distortion figures for the 4CX600J/8809 are given in figure 7, and additional data for less demanding service at 2 kW PEP input level are given in figure 9. In these examples, efficiency and power output are boosted by raising screen voltage and reducing idling plate current. Improved distortion characteristics may be still achieved by applying the drive signal to the cathode, or by incorporating envelope modulation in a grid driven circuit. An unbypassed cathode resistor is used to develop the modulating voltage.

A complete discussion of intermodulation measurement and interpretation is contained in the EIMAC Application Bulletin #12, Linear Amplifier and Single Sideband Service, available upon request.

USING EIMAC 4CX600 TETRODES

The following designs are representive, but not inclusive, of the circuitry adaptable to the 4CX600 family of tetrodes. For full application information, inclusive data sheets and circuitry for these or other EIMAC products, contact the Application Engineering Department, EIMAC division of Varian, 301 Industrial Way, San Carlos, California, 94070.

4CX600J/8809
LINEAR AMPLIFIER FOR HF SERVICE

Shown in figure 8 is a typical 2 kW PEP input linear amplifier for high gain, high linearity service in the 2 - 54 MHz region. The 4CX600J/8809 is used in a neutralized, grid driven configuration. Operational data for Class AB_2 linear service is tabulated in figure 6.

To reduce intra-stage feedback to a minimum, the 4CX600J/8809 may be neutralized, thus providing a high degree of linearity and stabilizing the load on the driver. A pi-L plate tank circuit is used in this circuit for maximum
[6] harmonic suppression (2). Plate voltage is fed to the tube through a double rf choke configuration to decouple harmonic currents from the power circuitry. A tuned grid circuit, loaded by a noninductive resistor (R_1) helps to present a constant load to the exciter. A drive signal of about 2.7 watts PEP is required to achieve full output from the stage. A maximum stage gain of 27 decibels in Class AB_2 service may be achieved at a power output of 1235 watts.

An unbypassed cathode resistor of 11 ohms (R_2) provides envelope modulation of the output signal. The degree of inverse feedback provided by this simple network results in an intermodulation distortion figure of -43 db at 2 kV, -40 db at 2.5 kV and -35 db at 3 kV.

The 4CX600J/8809 in common with other high gain tetrodes may, under some operating conditions, indicate a negative screen current of the order of 10 milliamperes. The screen supply is stabilized by resistor R_4. The grid bias supply is stabilized in a similar manner. Grid and screen currents are monitored, and the cathode current meter (M_3) is placed in the B-minus return to the high voltage supply.

Maximum grid dissipation of the 4CX600J/8809 is 1 watt. The design features which make the 4CX600J/8809 such an exceptionally linear tube also contribute to the very low grid interception and dissipation. It is normal for the grid to be driven slightly into the positive condition in the typical operation of the tube in the linear mode. Peak grid current will usually be less than 1 milliampere.

Amplifier layout is conventional, with the input circuit placed in an rf-tight enclosure to reduce intra-stage feedback. This enclosure also acts as a plenum chamber for the pressurized air cooling system. The 4CX600J/8809 requires less than 20 cu/ft per minute of cooling air at a back pressure of about 0.76 in. of water for proper cooling at sea level to provide 600 watts anode dissipation. The air is blown across the tube base, through the EIMAC Air System socket and chimney, and exhausted through the radial anode cooler of the tube. A chassis cutout for the socket and air ducts is shown in figure 4. Air flows in the base-to-anode direction.

The 4CX600J/8809 may be used in cathode driven service for improved intermodulation distortion figures (figure 9). Power gain is reduced due to the relatively large amount of drive power fed through the tube into the plate circuit. Additional data on this class of operation may be obtained from the Application Engineering Department of EIMAC.

For the lowest levels of intermodulation distortion, the use of an unbypassed cathode resistor and grid driven service, such as shown in figure 8 is recommended. The resistor must be noninductive and capable of dissipating the power developed by the sum of the average rf cathode current plus dc cathode current flowing through the unit.

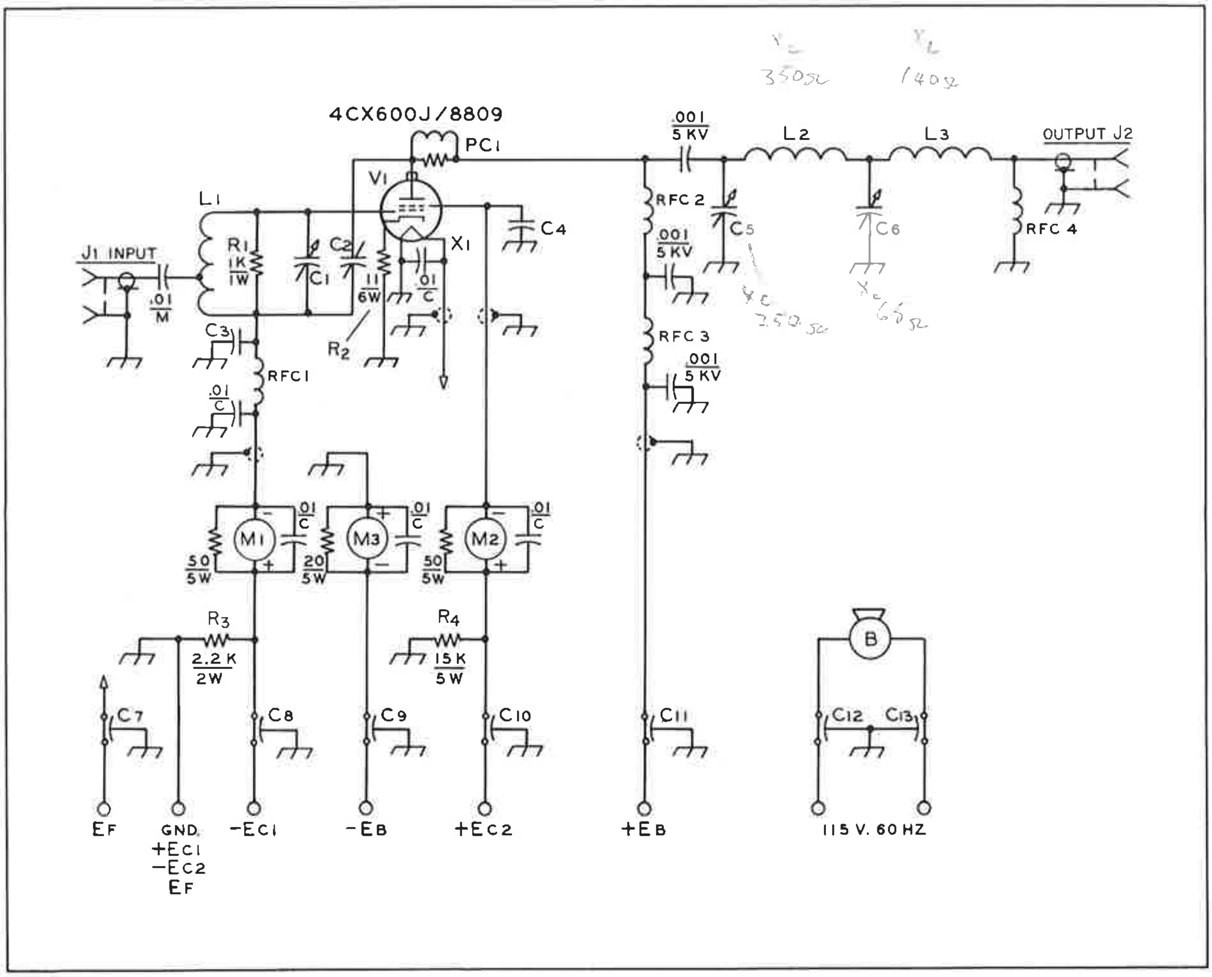


Figure 8. Representative 4CX600J/8809 linear amplifier for h-f service. Components are listed for 3 kV operation (see Figure 6, column 3 for operating data). Tank circuits are designed for a Q of 10.

Typical Component Parts:

Capacitors: C_1 - 100Ω. C_2 - 3 pF, 5 kV. C_3 - 500 pF, 1 kV. C_4 - screen capacitor in SK-607 socket. Typically 1500 pF, 2 kV. C_5 - 250Ω, 3 kV. C_6 - 65Ω, 1 kV. C_7-C_{13} - .001 μf, feedthru capacitors. All 1.6 kV rating except C_{11} which is rated at 6 kV. Inductors: L_1 - 100Ω, L_2 - 350Ω, L_3 - 140Ω. RFC_1- 2.5 mH. RFC_2 - 60 to 100 μH depending upon frequency range of amplifier. RFC_3 - 10 μH. RFC_4 - 2.5 mH. Meters: M_1 - 0-1 mAdc. M_2 - 0-50 mAdc. M_3 - 0-1 Adc. Blower (B): 50 cfm at 0.76" back pressure. X_1 = SK-607 socket, SK-648 chimney.

Imperfect screen bypassing allows coupling between input and output circuits in addition to that amount caused by feedback within the tube. For amplifier operation over a wide range of frequencies the impedance between the screen element and ground must be held to a low value. Improved screen isolation may be achieved by operating the screen at rf ground potential (figure 10) and placing bias and screen voltages below ground.

For improved screen regulation, the screen and plate power supplies may be placed in series, the screen potential adding to the plate voltage. The screen supply, of course, must be capable of passing the total dc cathode current.

Elimination of the screen bypass capacitor reduces the screen lead inductance so as to allow the neutralization to hold over a wide range of frequencies. Additional circuit information pertaining to hf and vhf operation of the 4CX600J/8809 and other EIMAC tubes may be found in "Care and Feeding of Power Grid Tubes", an application manual available from Stacy's, 2575 Hanover, Palo Alto, California, at the price of $3.95.

Constant current curves for the 4CX600J/and other EIMAC tube types and a graphic computer for typical operation conditions may be obtained upon request from the Application Engineering Department of EIMAC.

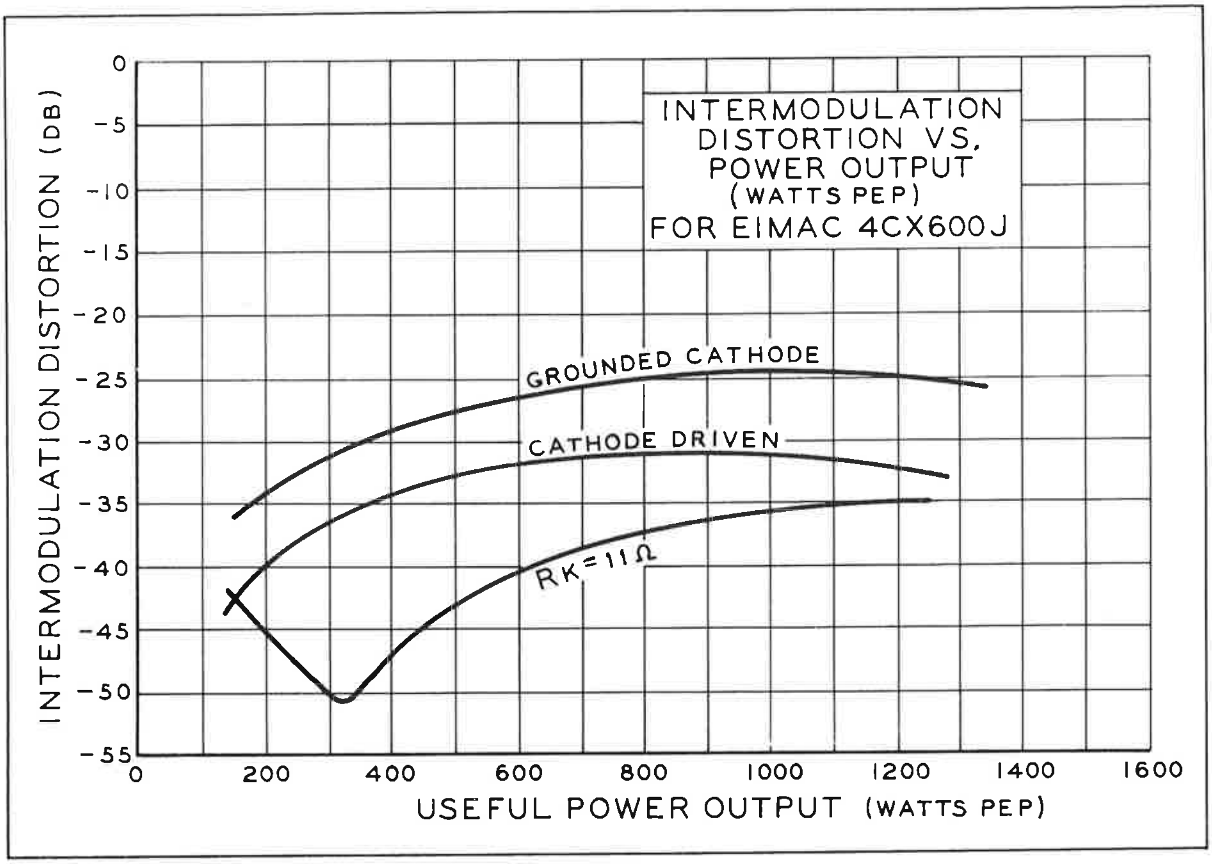


Figure 9. Intermodulation characteristics for
[8] 4CX600J/8809 for three typical operating conditions. Distortion level is referred to one tone of a two tone test signal. In each case, power input is 2 kW PEP, plate potential is 3000 volts, and screen voltage is 350. The cathode feedback curve ($R_k = 11\ \Omega$) applies to the data given in figure 6, third column; and to the circuit shown in figure 8.

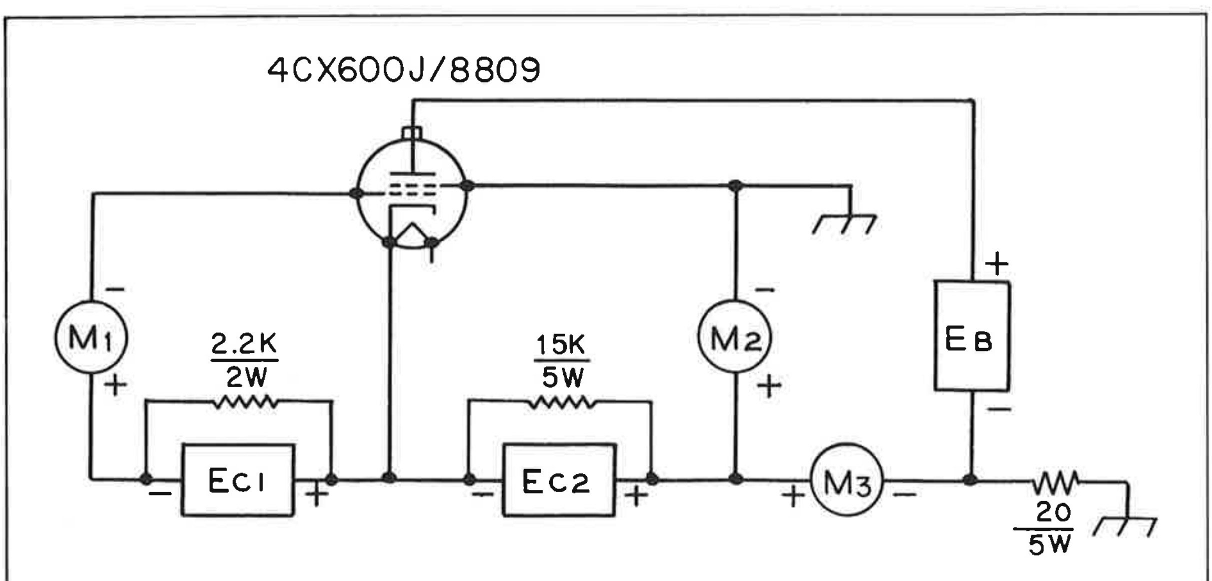


Figure 10. Equivalent circuit of Figure 8 with screen at dc ground potential.

THE 4CX600J/8809 IN A PULSED, 432 MHz AMPLIFIER

This compact coaxial cavity amplifier featuring the 4CX600J/8809 is designed to provide over 20 kW peak output near 432 MHz in grid-pulsed service. Overall views of the unit are shown in figures 11 and 14, with a cross-section representation of the cavity shown in figure 15. A cathode driven circuit is used, employing a half-wavelength open coaxial input line. The exciter is capacitively coupled to the line by adjustable disc capacitor C_1.

The output circuit is a quarter-wavelength coaxial cavity with power coupled out by a second adjustable disc capacitor, C_2. A section of the interior of the plate cavity with the plate bypass capacitor and anode collet is shown in figure 15. The socket for the 4CX600J/8809 is at the base of the assembly with the Isomica dielectric sheet for the plate blocking capacitor (C_3) placed atop the cavity.

The plate cavity is tuned by means of an adjustable short, driven by two threaded rods projecting through the bottom of the cavity. The half-wavelength cathode line is adjustable and provides for cooling air passed by a waveguide-beyond-cutoff filter (3), (4). Typical performance data for this amplifier is summarized below.

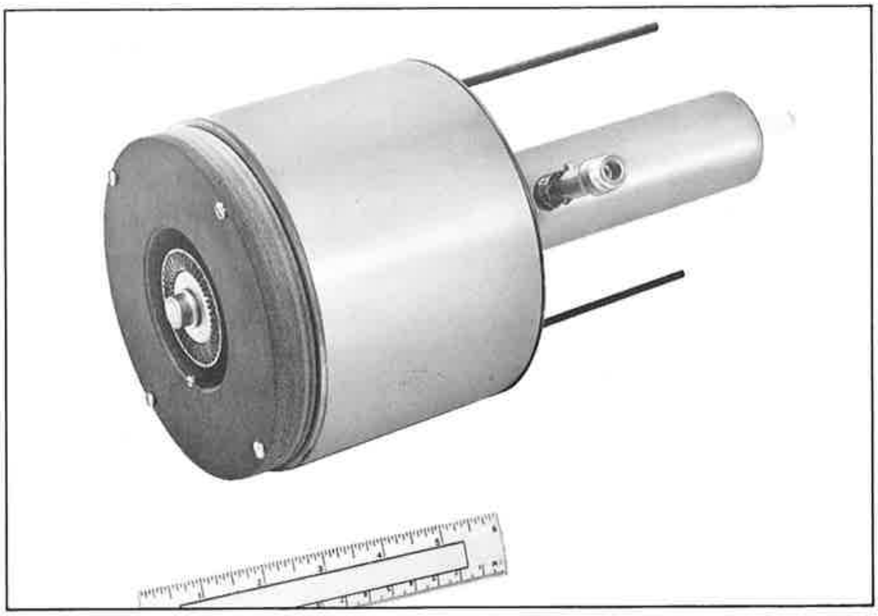


Figure 11. The 4CX600J/8809 is featured in this compact, 20 kW pulsed amplifier operating near 432 MHz. Only 438 watts of peak drive power are required for full output, with a stage gain of 16 decibels. Typical operating data for the amplifier is given in figure 12.

Figure 12

Typical Performance Data For

4CX600J/8809 in Pulse Service at 432 MHz

Plate Voltage	6200	Vdc
Screen Voltage	700	Vdc
Grid Voltage	-125	Vdc
Peak d-c Plate Current	4.6	Adc
Peak d-c Screen Current	180	mAdc
Peak Power Output	20	kW
Peak Drive Power	438	W
Power Gain	16.6	db
Efficiency	70	%
Pulse Width	20	μs
Duty Cycle	.001	

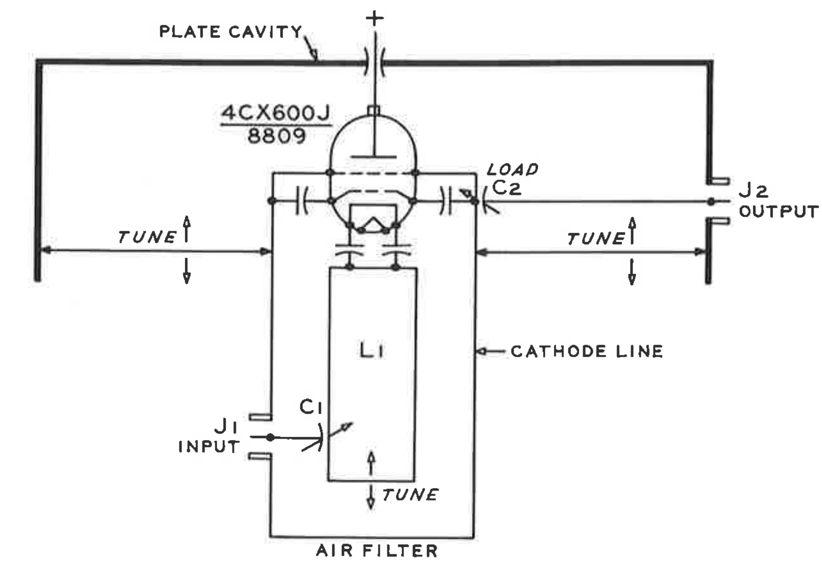


Figure 13. Schematic of 432 MHz cavity. The screen is at dc ground potential, as in Fig. 10, with cathode and bias return below ground. Diameter of plate cavity is 6" and height is 4½".

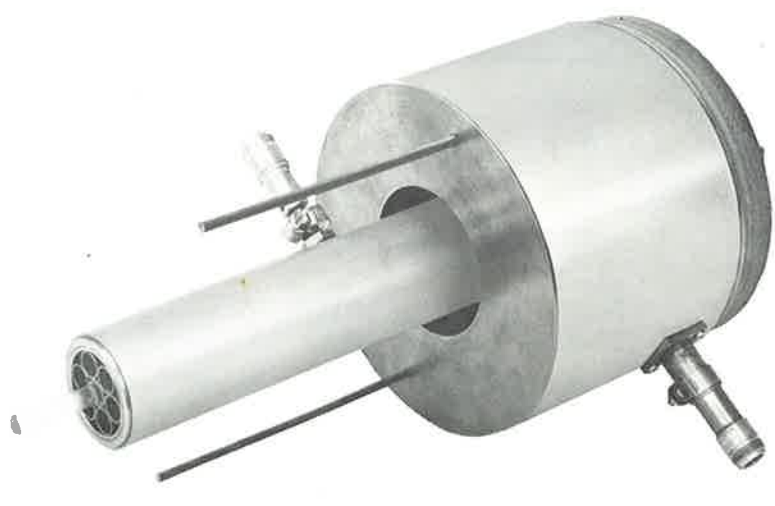
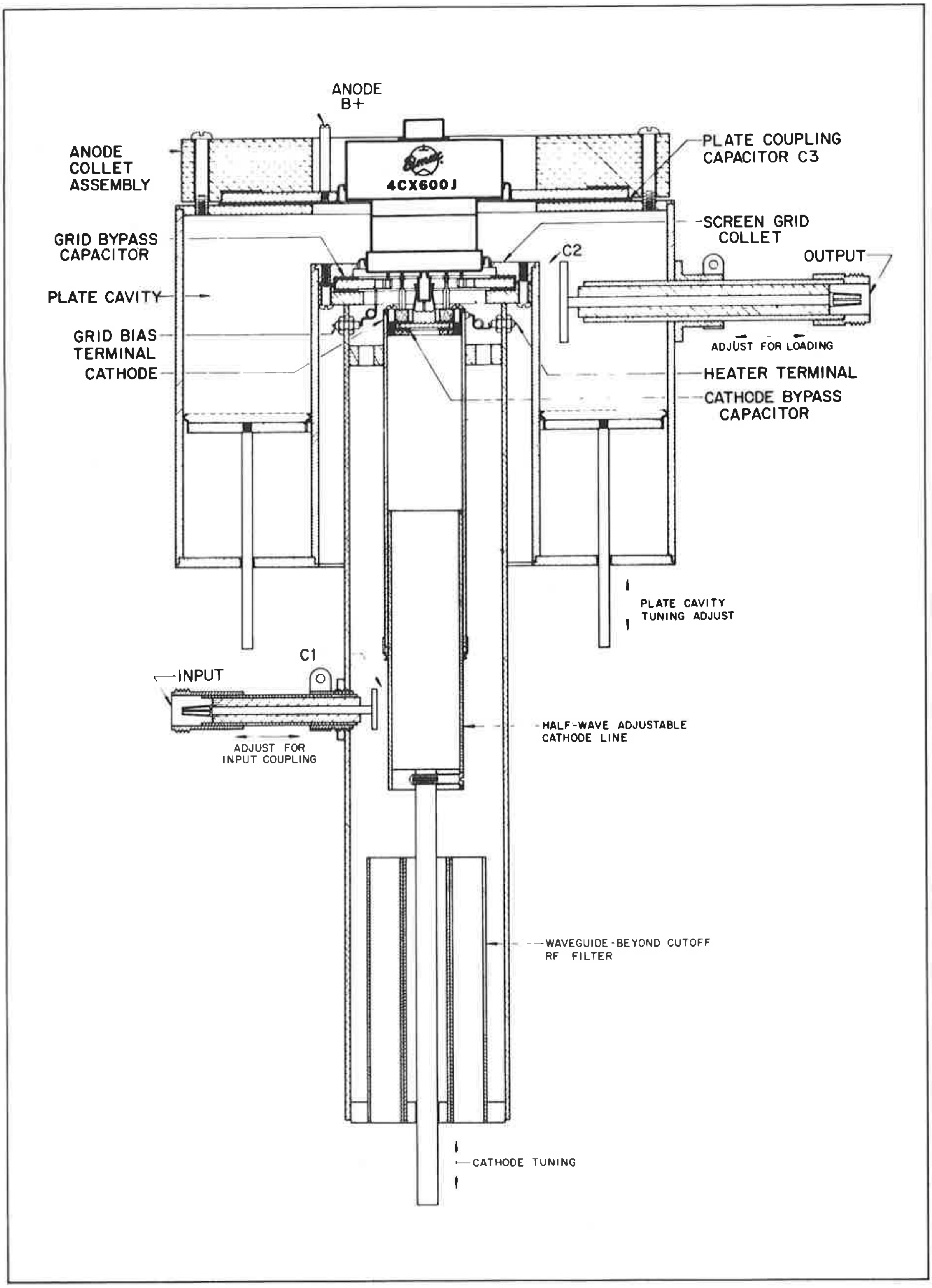


Figure 14. End view of cavity. Coaxial input receptacle is at left on cathode line. The two plate tuning rods project from the bottom of the cavity. The cathode tuning rod projects from the end of the air filter at left. A sectional view of the rf filter is shown in Fig.15.



[11]

Figure 15. Cross section view of pulsed cavity. Grounded screen circuit similar to that of Figure 10 is used, with bias and screen return below dc ground point. Cooling air is exhauxted through special filter placed at end of cathode cavity which permits high degree of rf isolation through opening.

THE 4CX600J/8809 IN A 150 MHz CLASS B AMPLIFIER

This heavy duty VHF amplifier is designed for continuous service with the 4CX600J/8809. The layout is arranged so that the tube may be removed through a door in the amplifier panel (figure 16). The unit is used for rigorous life test of the tubes in the EIMAC Power Tube Development Laboratory. Circuitry of the 150 MHz amplifier is shown in figure 17. With a change in socket arrangement, a 4CX600B may be used in this unit.

The amplifier plate circuit consists of two silver plated slug-tuned inductors in parallel, with selected values of capacitance placed at the low impedance points of the resonant circuit. By reducing the total reactance in the branch of the circuit containing coil L_3, more current will flow to the load, thereby increasing plate circuit loading. Resonance is achieved by adjusting the slug of coil L_2. The inductance of either coil may be varied over a small range by movement of a shorted turn within the inductor.

The shorted turn is fabricated from one inch diameter copper pipe inside a one and one-quarter inch diameter coil. With this diameter, the tuning range of the amplifier is five megahertz. Smaller diameter pipe will allow a higher unloaded "Q" inductor, and therefore a higher efficiency tank circuit, but the tuning range will be reduced.

A lumped-constant grid circuit is used. The tuning capacitance approximates the input capacitance of the tube. The tuning capacitance and the input capacitance are in series across the grid circuit inductance. The grid inductance is made from a one-half inch wide strap of copper. The resulting tuned circuit is the classic split-stator configuration. The amplifier is link coupled to exciter. The coupling loop is positioned over the "cold" part of the tuned circuit.

Cooling air is blown into the grid compartment from the rear of the unit and exhausted through the socket, chimney and anode cooler of the tube. The enclosed grid area houses the input circuit, the power terminals and the various coaxial bypass capacitors on the power leads. A summary of typical amplifier performance is tabulated in figure 18.

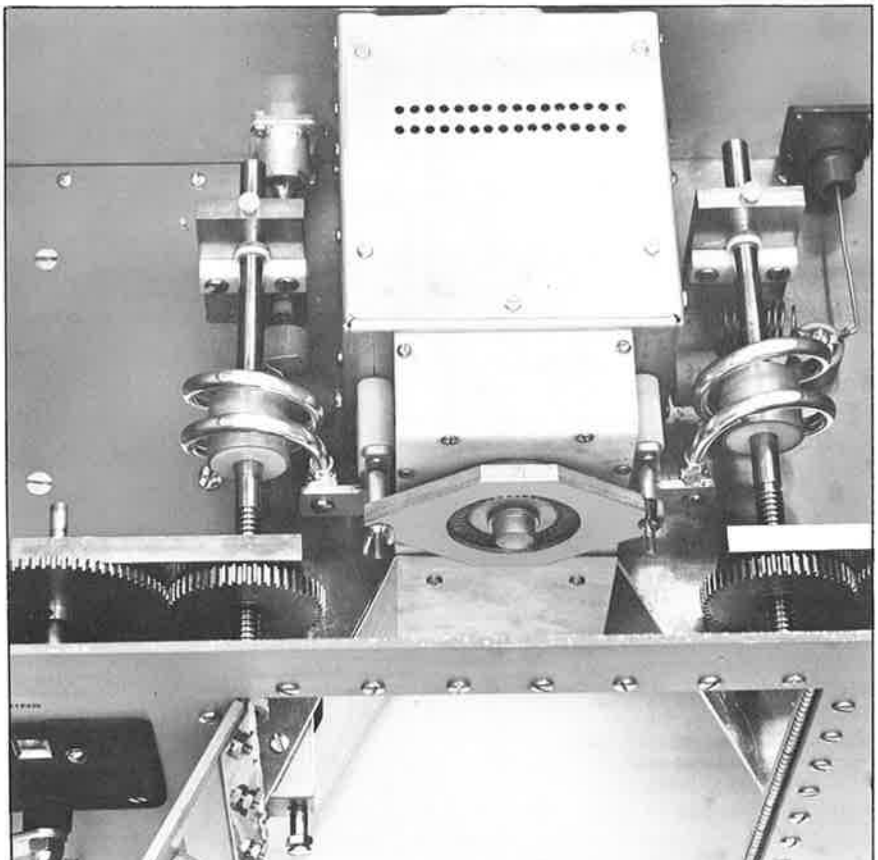


Figure 16. Rack mounted 150 MHz amplifier employs two inductors in parallel in plate circuit. Coils are slug tuned through vernier counter dials. Left control adjusts tuning and right control adjusts loading. Amplifier is arranged so 4CX600J/8809 may be removed through door in panel of the amplifier. Grid circuit is in pressurized compartment at rear of assembly.

The 4CX600J/8809 is neutralized by adjusting the series reactance of the screen-to-ground path by means of the inductor L_N. The series inductance in the screen lead lowers the self-neutralizing frequency of the tube and socket to the operating frequency of the amplifier. The high gain of the amplifier requires that good shielding and bypassing be used on all power leads feeding the amplifier.

The performance of the 4CX600B in this amplifier is very similar to the data given in figure 18. Because of the lower cathode lead inductance inherent in the 4CX600B base design, the drive power is 2.6 watts for the same output power given in the chart. The amplifier gain is therefore 23.7 decibels.

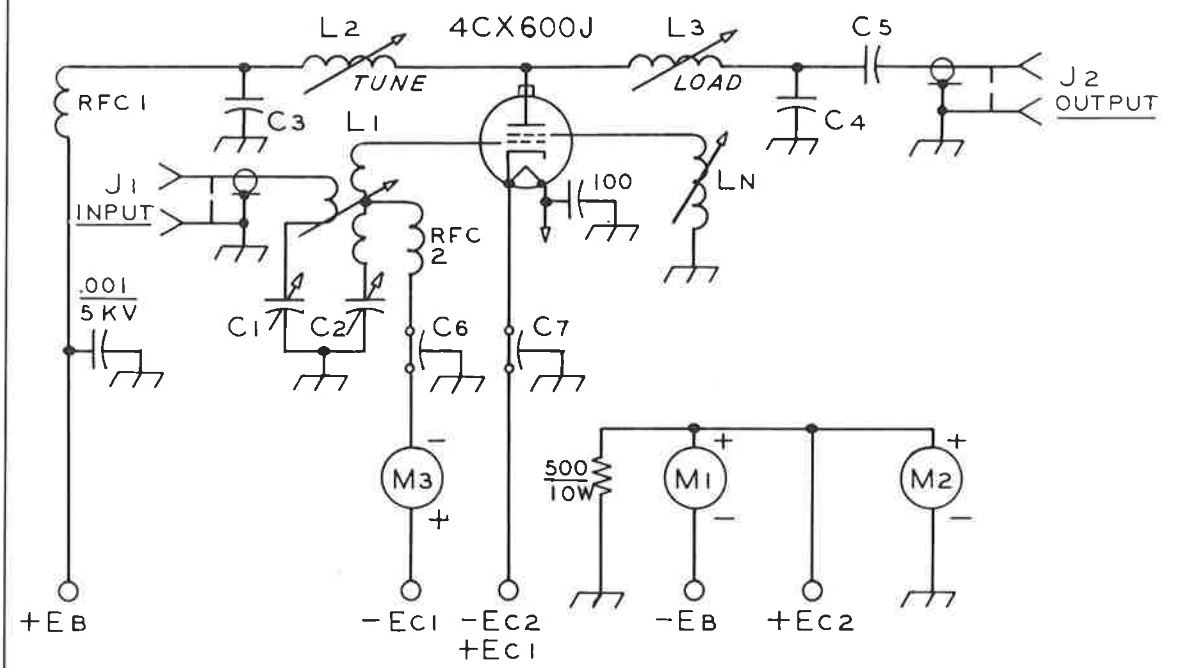


Figure 17. Schematic of the 150 MHz amplifier. The amplifier is grid driven. The screen grid is at dc ground potential. The cathode is operated below ground potential by an amount equal to the screen grid voltage.

Figure 18

Typical Performance Data For 4CX600J/8809 in 150 MHz Service

Plate Voltage	1540	Vdc
Screen Voltage	325	Vdc
Grid Voltage	(1)	
Max Signal Plate Current	600	mAdc
Max Signal Screen Current	10	mAdc
Max Signal Grid Current	1	mAdc
Useful Power Output	620	W
Drive Power	5.2	W
Power Gain	20.7	db
Efficiency	67	%

(1)- Adjust for zero signal plate current of one milliampere.

THE 4CX600B IN A 140-250 MHz STRIP LINE AMPLIFIER

This efficient VHF amplifier is designed for operation with the 4CX600B at any frequency in the 140-250 MHz range. Quarter-wavelength strip lines are used in both input and output circuits. The 4CX600B is operated in grounded cathode, grid driven service, class B mode (figure 20).

Figure 19 shows a portion of the plate circuit strip line. The plate blocking capacitor (C_c) is visible adjacent to the anode of the tube. This component is a "sandwich" composed of the strip line, a sheet of Isomica, and the copper plate supporting the anode collet of the tube. The capacitor is clamped together by means of a rectangular block of Rexolite. A cylinder of Teflon sits atop the 4CX600B cooler, serving as an air chimney for proper plate cooling.

Plate tuning is accomplished by an adjustable short at the low impedance end of the strip line. The short is gear driven from the amplifier panel.

The grid circuit of the amplifier is shown in figure 21. A strip line "sandwich" is used, with one plate operating at dc ground. The circuit is resonated by means of an adjustable short at the end of the line, and the input is tapped directly on the line. The coaxial input receptacle (J_1) is mounted in such a way as to permit rotation about its axis. Contact fingers are soldered to the fitting on the inside of the grid compartment. As the receptacle is rotated, the contact fingers move along the strip line in a circular motion, thus tapping across a different amount of line (figure 22).

Neutralization of the amplifier is accomplished by adjustment of the screen lead inductance. The screen bypass capacitor and collets are insulated from the chassis. By using the correct number of metal screws to bolt the bypass assembly to the chassis, the screen lead inductance can be adjusted for proper neutralization.

The amplifier is housed in a double compartmented brass box, with cooling air exhausted through a "honeycomb" air filter at one end of the plate compartment.

Typical performance of the amplifier is summarized in figure 23.

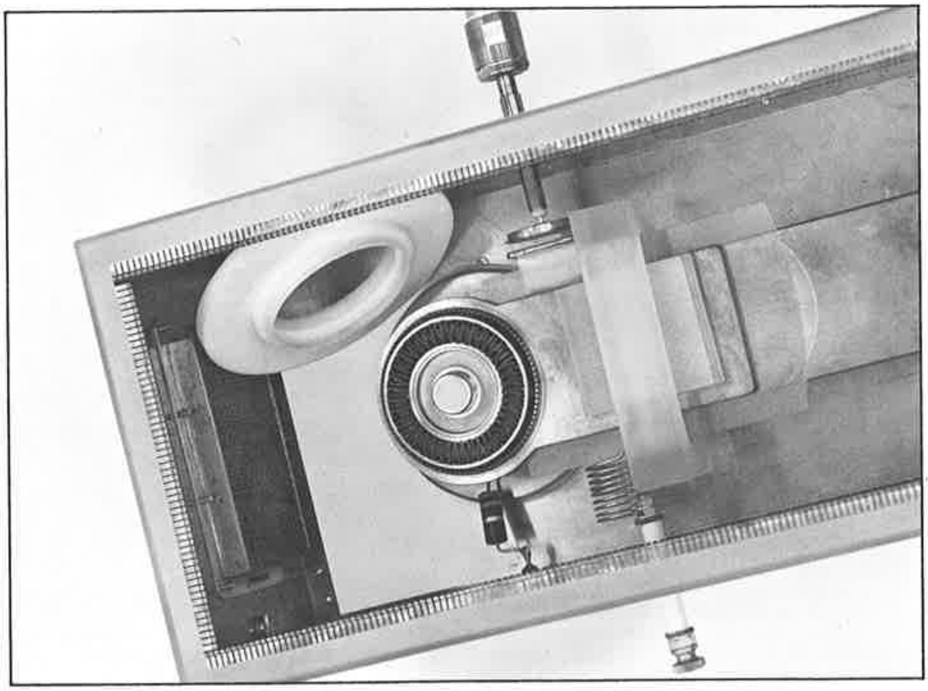


Figure 19. Strip line amplifier tunes 140-250 MHz with 4CX600B. The plate line is made of two copper strips, one at dc ground potential and the other at B-plus potential. The strips are separated by an Isomica dielectric. The "hot" plate line is only 4" long, and has an anode collet brazed at one end. A Rexolite clamp holds capacitor assembly together. Teflon cylinder sits atop 4CX600B, serving as an air chimney. The capacitance coupled output assembly is at right of the photograph.

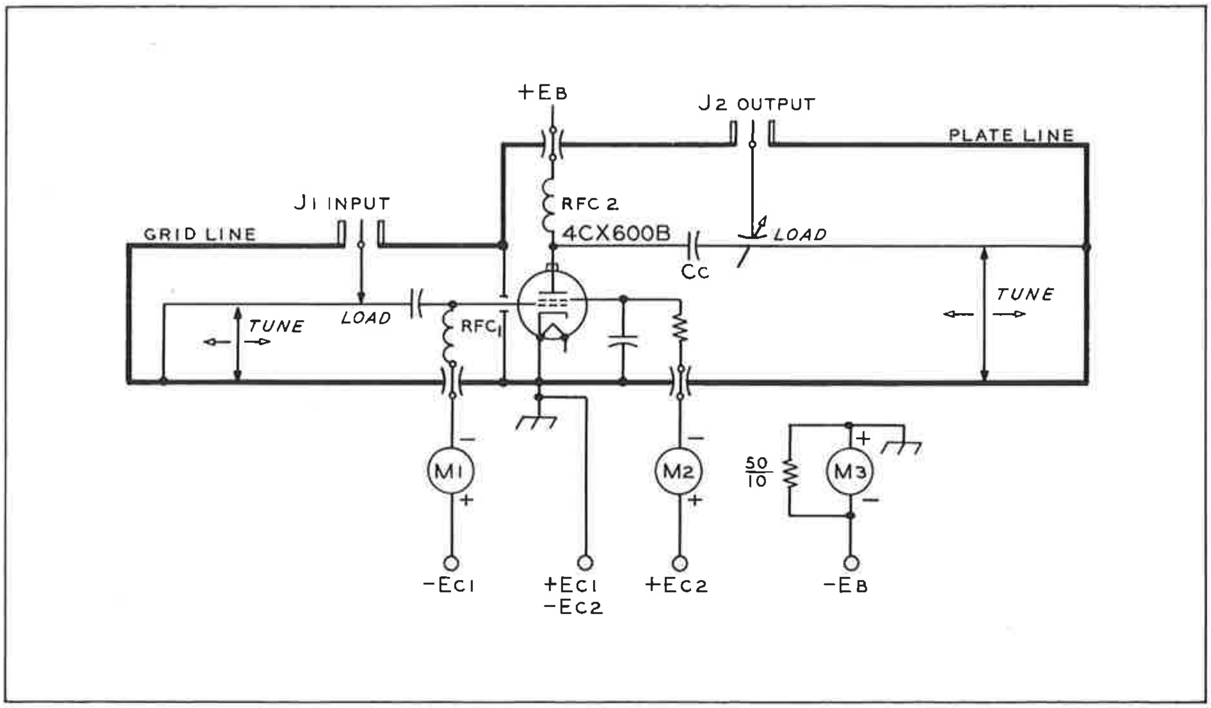


Figure 20. Representative circuit of strip line amplifier. Grid and plate lines are resonated by means of sliding shorts placed at far end of lines. A capacitive output probe is used in the plate circuit and direct coupling is used in the grid circuit (Figure 22). The plate coupling capacitor (C_C) is a portion of the strip line, having one plate at ground potential. The other plate is an extension of the anode collet.

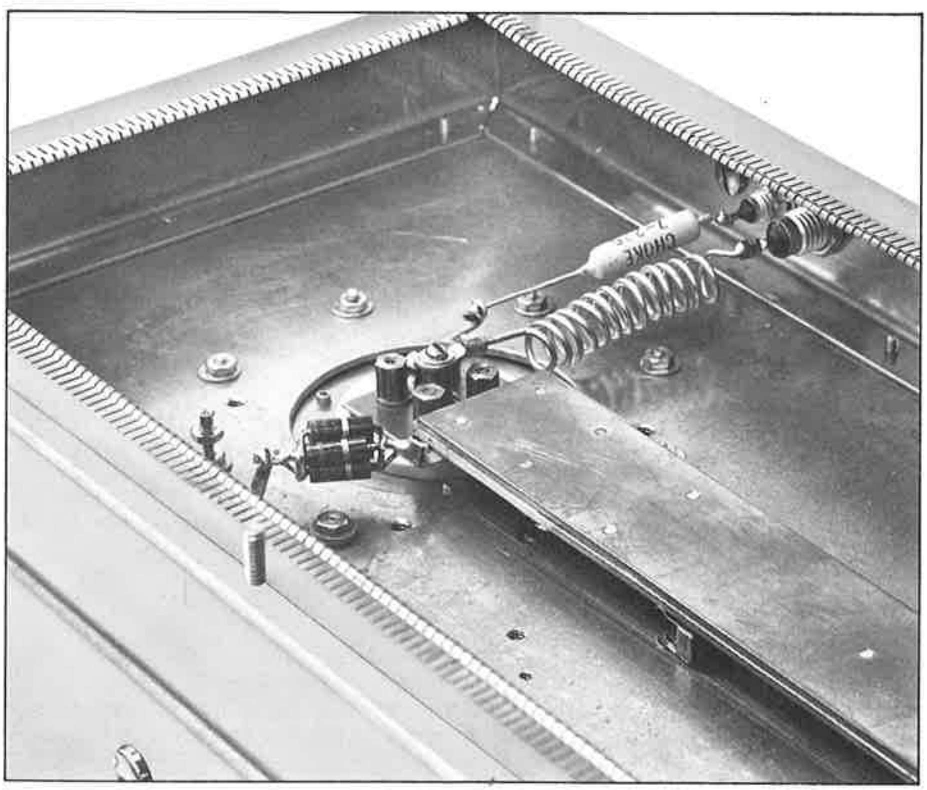


Figure 21. Grid circuit of strip line amplifier. The "sandwich" construction is used, with one plate at dc ground potential. Line is resonated by means of an adjustable short at the end of the line. Grid and filament chokes are at the right of the socket. The under chassis area is sealed with a bottom plate to provide a plenum chamber for proper cooling and to isolate the input circuit.

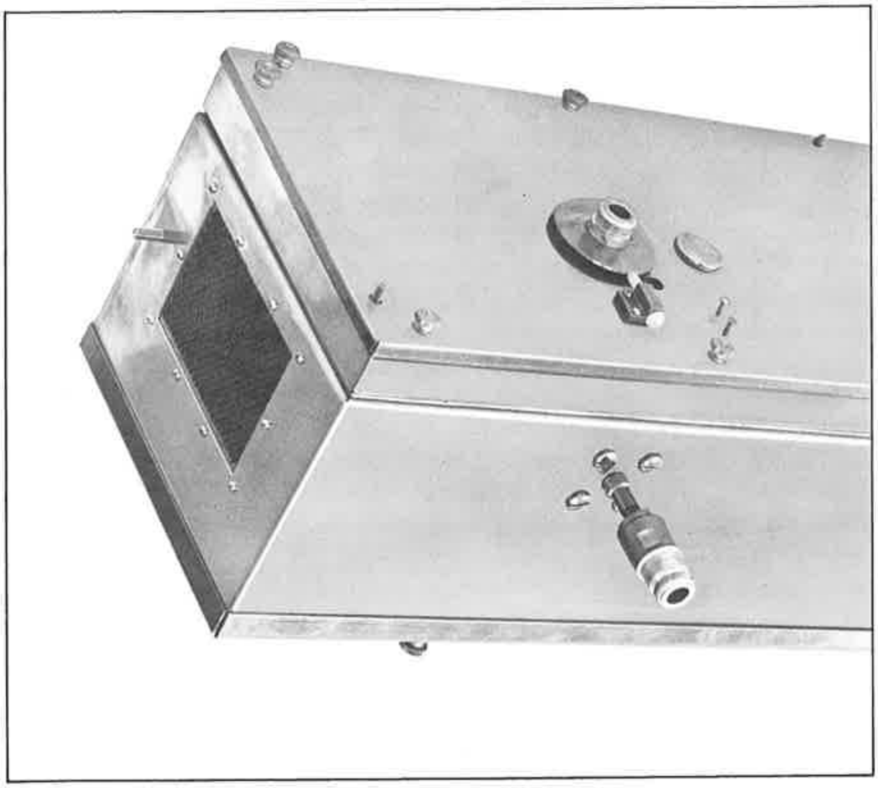


Figure 22. Close up of coaxial input receptacle. Unit is mounted on circular fitting so it may rotate about its axis. Multiple contact fingers attached to the center conductor sweep across the grid line in a circular motion, thus moving the input tap up and down the line. The fitting may be locked in place once proper input match is found.

Figure 23

Typical Performance Data For 4CX600B in Strip Line Amplifier

Plate Voltage	1650	1950	2500	Vdc
Screen Voltage	400	300	300	Vdc
Grid Voltage	-75	-60	-60	Vdc
Zero Signal Plate Current	15	15	15	mAdc
Max Signal Plate Current	600	530	600	mAdc
Screen Current	14	11	11	mAdc
Grid Current	-6	-2	8	mAdc
Useful Power Output	540	555	820	W
Bandwidth (3db) of amplifier	6	6	4.5	MHz

THE 4CX600B AND 4CW800B IN DISTRIBUTED AMPLIFIER SERVICE

The mechanical and electrical features of the 4CX600B and the 4CW800B tetrodes are compatible with distributed amplifier circuit requirements, combining the qualities of low lead inductance, low input and output capacitances, high transconductance and small size. Connection is made to the control grid by means of four threaded studs. By using the correct number of connections, the designer has available a choice of several values of grid lead inductance. This feature is quite useful in the design of VHF/UHF distributed amplifiers. Ruggedized construction consisting of a unitized electrode structure and a solid direct-chassis flange mount are features which make these tubes suitable for environments exhibiting severe shock and vibration, such as encountered in mobile or airborne service.

A distributed amplifier(5)is a wideband, cascade device, employing vacuum tubes placed along an artificial transmission line, the tube capacitances appearing as the shunt elements of the line(figure 24). In a properly designed distributed amplifier, the driving impedance is virtually independent of the number of tubes. The amplifier may make use of the characteristics of the low pass, the band pass, or the high pass filter configuration.

The 4CW800B liquid cooled tetrode is an ideal tube for distributed amplifier service, as anode heat may be readily disposed of by a compact, external cooling system. An amplifier using this tube type is an advantage in instantaneous bandwidth rf systems as it eliminates the need of complex and slow tuning and tracking equipment necessary for a tuned amplifier. Figure 24 shows a typical distributed amplifier design using the constant-k prototype approach. The 4CW800B lead inductances and interelectrode capacitances are absorbed into the lumped constants calculated for the desired band pass characteristic. M-derived terminating half-sections are used to improve the cut-off characteristic and the impedance match over the band. Typical operation for the 4CW800B in wideband amplifier service is tabulated in figure 25.

The 4CW800B can be mounted in any position. No socket is required, as the tube may be affixed directly on the EIMAC SK-680 screen bypass capacitor which, in turn, is mounted

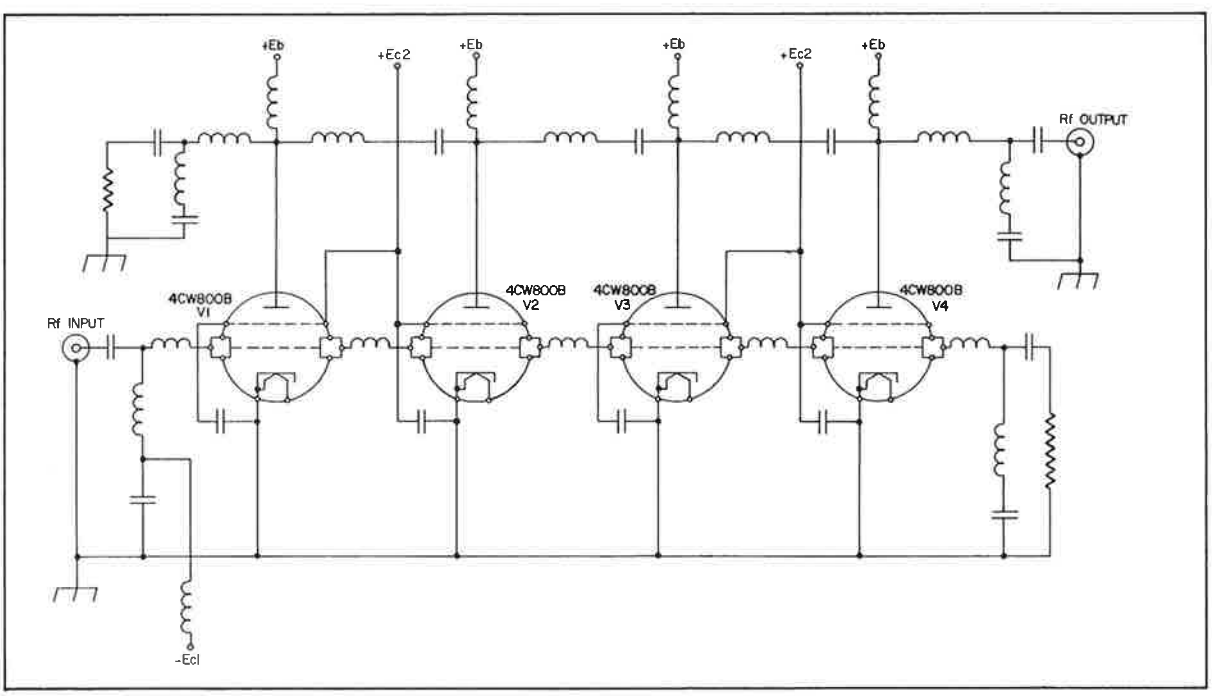


Figure 24. Distributed amplifier uses vacuum tubes placed along an artificial transmission line. Driving impedance is independent of the number of tubes used. Output voltage is proportional to the number of tubes.

A distributed amplifier provides amplification at frequencies greater than the bandwidth index frequency of the tube.

to the chassis with four screws. Chassis thickness should be about 0.06" to insure rigidity and to allow adequate space for connections to the base of the tube. Care should be exercised to insure a flat mounting surface to minimize cathode lead inductance. The cathode and one side of the heater are connected within the tube.

It is recommended that heater voltage be applied for a period of not less than 3 minutes before current is drawn from the cathode, or before other potentials are applied to the tube. Tube operation will stabilize after a period of approximately five minutes from a cold start.

The 4CW800B control grid has a maximum dissipation rating of 3 watts and precautions should be observed to avoid exceeding this rating. Derating of control grid dissipation will be necessary if the base flange temperature exceeds 150 °C.

Maximum rated screen dissipation is 15 watts. Under certain operating conditions, the screen current of a high gain tetrode may reverse as indicated by the screen current meter. This condition is a result of secondary emission from the screen and is normal. If the impedance of the screen power supply is high, negative screen current may cause the screen voltage to rise, thus increasing plate current. A run-away condition may result, with subsequent damage to the tube or circuit components. This condition can be avoided if sufficient bleeder current is drawn from the screen supply by a resistor or regulator tube. The recommended screen bleeder current for the 4CW800B is 20 mA for each tube connected to a common screen supply. Care should be taken to retain the bleeder in circuit of the 4CW800B if the screen supply is protected by an overcurrent relay or fuse, or series regulator.

The air cooled equivalent 4CX600B is also well suited to distributed amplifier circuitry.

Figure 25

Typical Performance Data for 4CW800B in Wideband Amplifier Service

Plate Voltage	1000	1500	2500	Vdc
Screen Voltage	275	275	275	Vdc
Grid Voltage	-40	-40	-40	Vdc
Zero Signal Plate Current	100	100	100	mAdc
Max Signal Plate Current	570	580	585	mAdc
Screen Current	32	29	17	mAdc
Peak rf Grid Voltage	44	43	42	v
Useful Power Output	320	590	1000	W
Rf Load Impedance	765	1225	2325	Ω

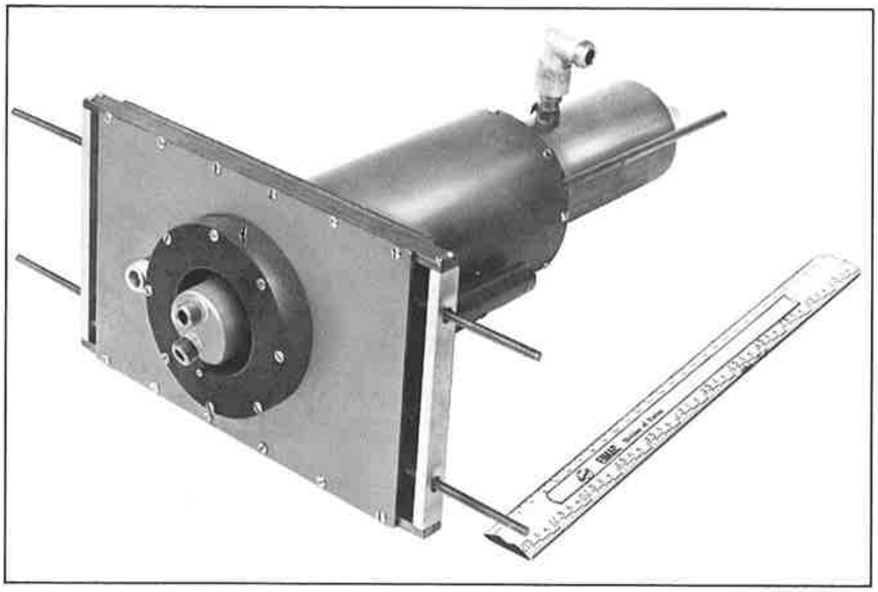


Figure 26. 865 MHz flat cavity amplifier using 4CW800B provides 550 watts output with over 10 db power gain. Plate cavity is tuned by sliding shorts at ends. Micarta ring atop the cavity encloses laminar plate blocking capacitor. Input receptacle is at rear of grid line. An auxiliary screen tuned line is provided to maintain the screen at rf ground potential.

THE 4CW800B IN A 865 MHz CAVITY AMPLIFIER

This compact cavity amplifier utilizing a 4CW800B is designed to provide 550 watts CW output with low drive power in the UHF region near 865 MHz. Various views of the unit are shown in the photographs and the schematic is given in figure 28. Figure 26 shows the liquid cooling jacket of the 4CW800B tetrode protruding from the center of the plate circuit cavity. The plate resonator is a rectangular cavity (L_3) having sliding shorts on the ends. Positioning of these shorts will determine resonance and plate loading. Power is coupled out of the plate cavity by means of an inductive loop (L_4). A built-in coaxial bypass capacitor isolates the cavity from the dc plate voltage.

The amplifier is grid driven, using a full wavelength, open circuit coaxial line (L_1) having capacitive input coupling. The input end of the amplifier assembly is seen in figure 29. At the end of the grid line are the various hollow conductors of the waveguide-beyond-cutoff rf filter. The cooling air for the tube base passes out through this filter, which confines the rf energy within the tuned line. The insulated rod along the center axis of the input assembly varies the length of the center conductor of the grid line. The grid circuit is resonated by this adjustment. An additional tuned circuit, composed of a half-wave shorted line (L_2) is placed between the screen grid of the tube and the cathode (ground). The screen grid is operated at dc ground potential, with the cathode "below" dc ground by the amount of the dc screen voltage. To make sure the screen grid and the cathode of the tube are at the same rf potential, the adjustable short of the screen-cathode line is positioned approximately a half-wavelength from the screen so that the short is reflected into the tube. When adjustment is correct, intra-stage feedback is at a minimum and the amplifier is completely stable.

The tube end of the grid line is shown in figure 30. Eight concentric fingers contact one side of the cathode bypass capacitor (C_2) which is returned back to the circular screen grid flange of the tube. One of the fingers serves as the dc connection to the cathode.

Typical CW amplifier performance at 865 MHz is summarized in figure 31.

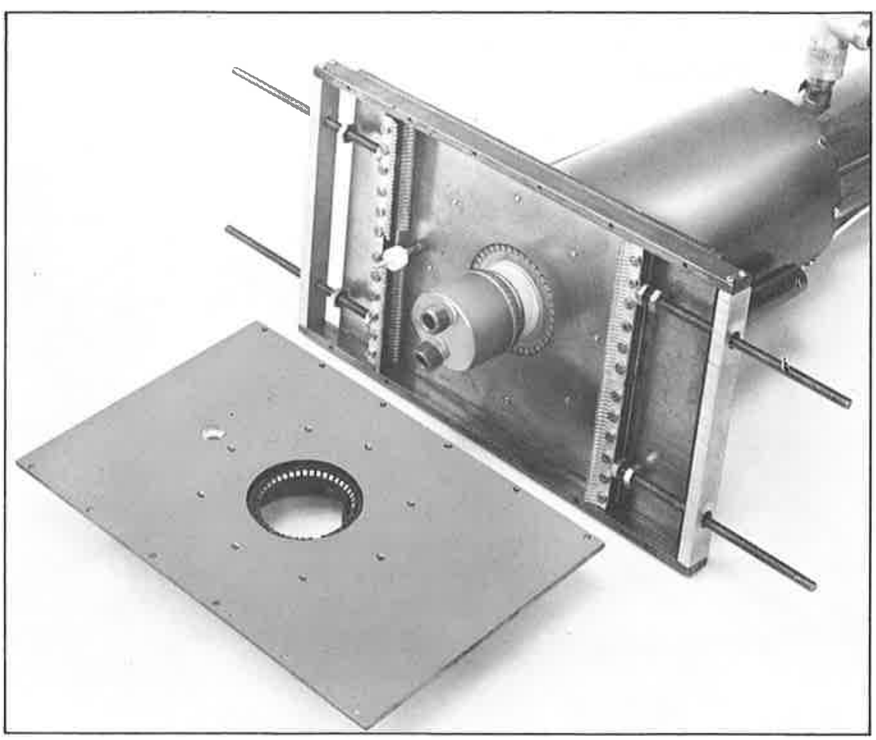


Figure 27. Interior view of plate compartment. Sliding shorts are driven by threaded rods at each end of cavity. Output coupling rod is at left. Screen collet may be seen at base of 4CW800B. Anode collet and plate coupling capacitor are part of top plate assembly of cavity.

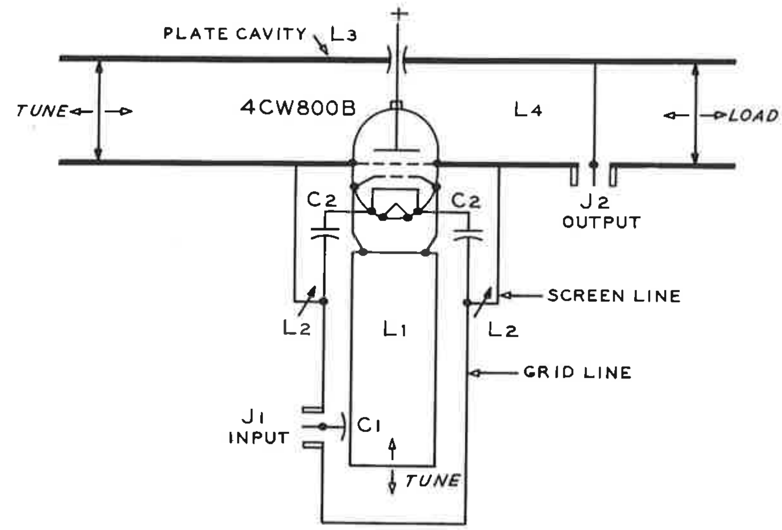


Figure 28. Schematic of 865 MHz cavity. The amplifier is grid driven. The screen grid is at dc ground potential. A half-wavelength tuned line is used to reflect a short into the tube so as to put the screen grid and cathode at the same rf potential.

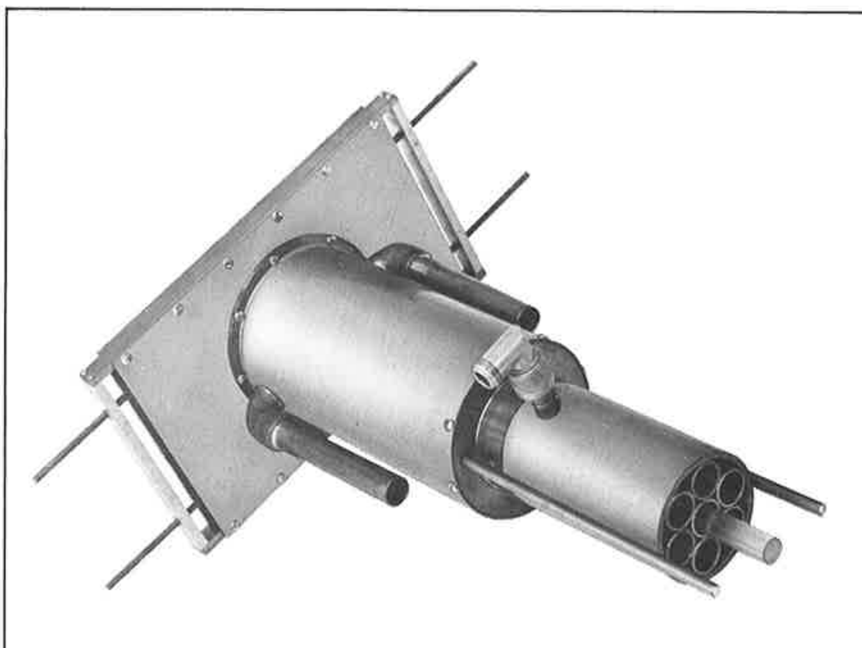


Figure 29. Rear view of 865 MHz cavity showing screen and input lines. Air is blown into main cavity through two ducts at side and is exhausted via rf filter at the end of the grid line. The screen cavity is tuned by means of the two rods projecting from the end of the shorter cavity assembly. The center rod protruding through the rf filter adjusts the grid tuning.

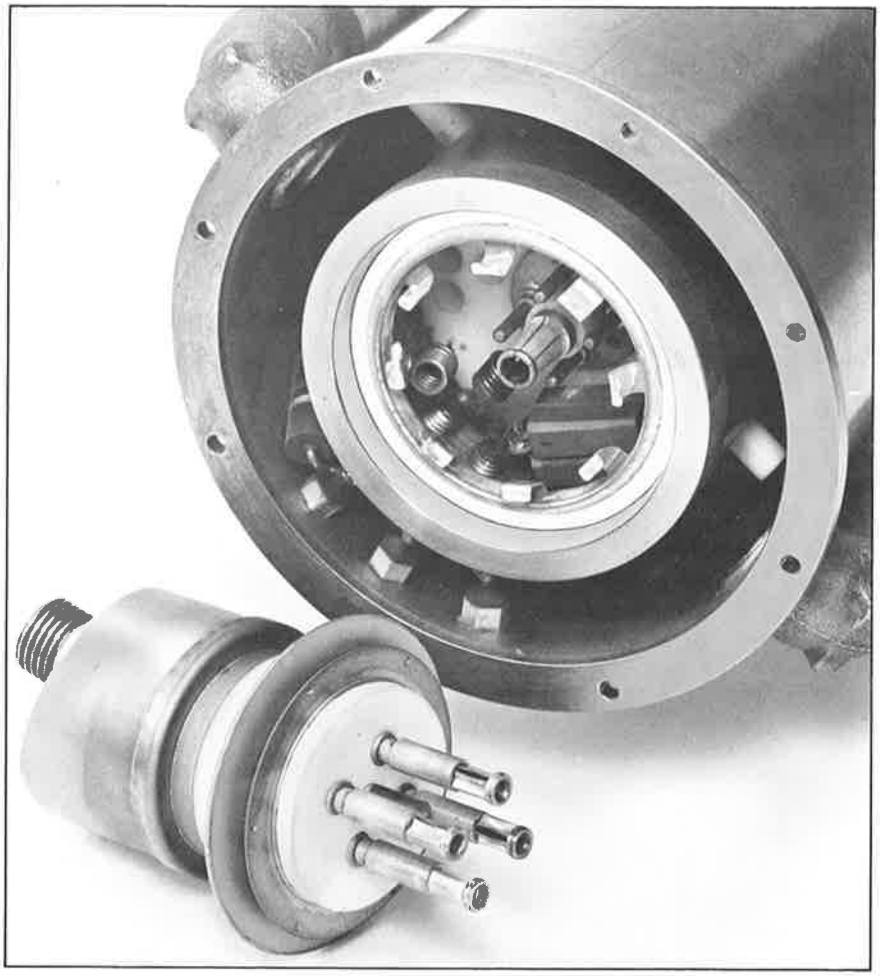


Figure 30. Close up of 865 MHz amplifier with plate cavity and 4CW800B removed. Adapter pins mate tube base to input cavity. Small rf chokes and bypass capacitors associated with the tube are mounted within top of grid cavity. Feedthrough capacitors conduct power leads outside of rf enclosure.

Figure 31.

Typical Performance Data For
4CW800B at 865 MHz

Plate Voltage	2000	Vdc
Screen Voltage	300	Vdc
Grid Voltage	-53	Vdc
Plate Current	600	mAdc
Screen Current	8	mAdc
Grid Current	0	mAdc
Useful Power Output	550	W
Drive Power	51	W
Power Gain	10.4	db
Efficiency	45.8	%
Bandwidth (3 db) (total amplifier)	9	MHz
Bandwidth (1 db) (total amplifier)	5.7	MHz

THE 4CW800B IN A 432 MHz CAVITY AMPLIFIER

The 4CW800B is used in class C service in this cavity amplifier at 432 MHz to deliver about 770 watts of power, with a stage gain of over 15 decibels (figure 32).

The amplifier plate cavity is built of high conductivity 1100 aluminum alloy and employs sliding end sections to resonate the cavity and to adjust loading. The 4CW800B is located approximately in the middle of the cavity. Output coupling is achieved by continuing the center conductor (L_2) of the output coaxial line across the cavity and terminating it to the cavity wall (figure 33), thus forming an output link. By moving the sliding short adjacent to the link, the area of the coupling loop is varied. As the loop area increases, the coupling is in-

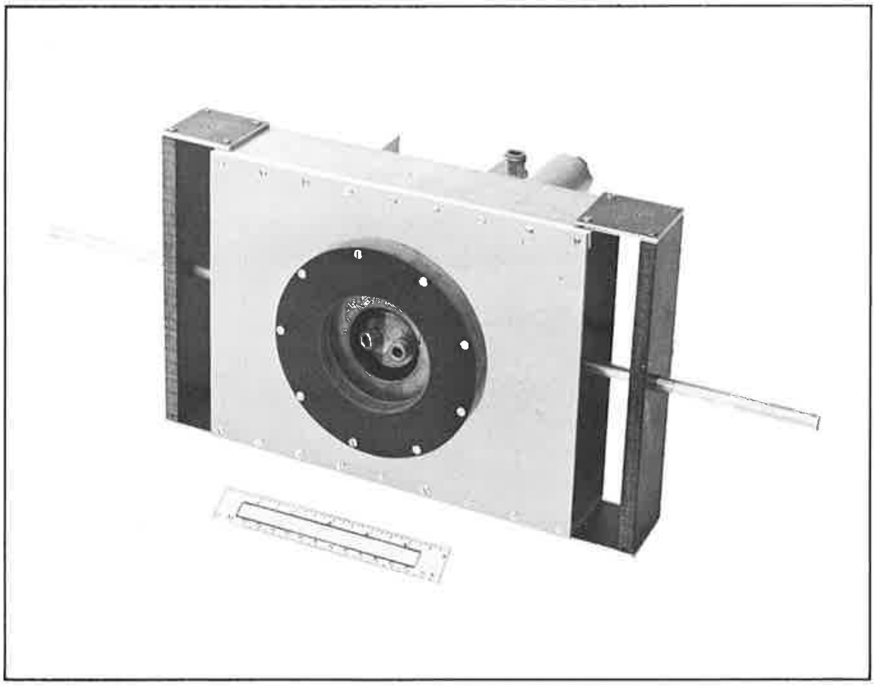


Figure 32. 4CW800B in 432 MHz cavity amplifier. Adjustable shorting contacts at ends of plate cavity permit tuning and loading adjustments to be made. The plate blocking capacitor is held in place by phenolic ring atop the aluminum cavity. Water lines pass through center hole in top cavity plate. Entire assembly is made of high conductivity aluminum.

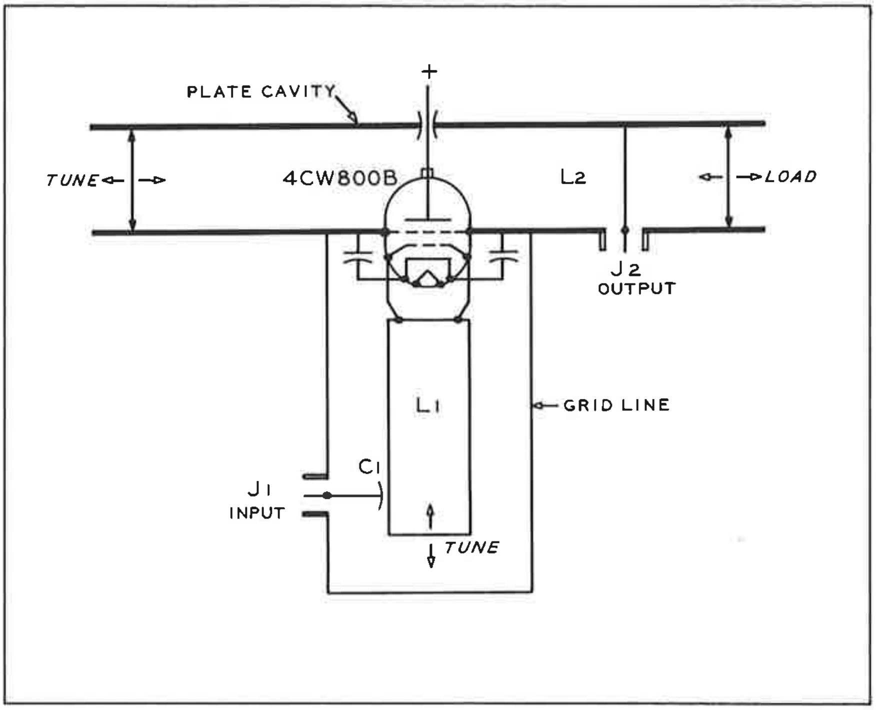


Figure 33. Schematic of the 4CW800B 432 MHz cavity amplifier. The amplifier is grid driven through a one-half wavelength long coaxial resonant circuit. The excitation is fed to the grid circuit by means of a series capacitor coupled to the high potential end of the tuned line. The screen grid is operated at dc ground with the cathode below ground potential by an amount equal to the dc screen voltage.

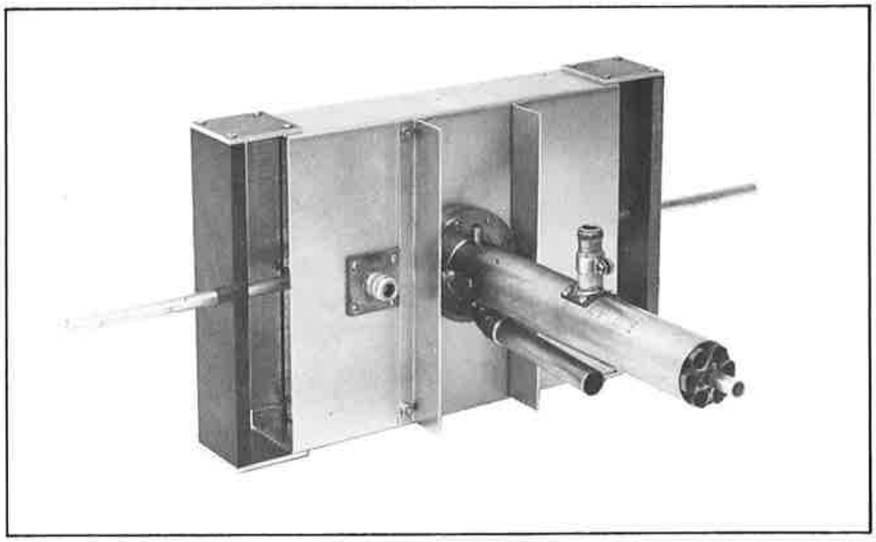


Figure 34. Underside view of 4CW800B amplifier. Output fitting is on bottom of plate cavity and input receptacle is midway on grid line. Cooling air is blown into cavity via a short exhausted through rf filter at end of grid line.

creased. Cavity resonance is established by adjusting the sliding short at the opposite end of the cavity, much as in the manner of the 865 MHz amplifier previously described.

The 4CW800B is grid driven, using a coaxial half-wavelength line with the exciter coupled in by means of a capacitive disc (C_1). A grounded screen circuit is used, with bias and plate voltage returned "below ground" by the amount of the screen voltage.

Base cooling of the 4CW800B is accomplished by air blown into the input compartment and exhausted through an air filter in the grid compartment.

A summary of typical CW amplifier performance is tabulated in figure 35.

Figure 35
Typical Performance Data For
4CW800B in 432 **MHz** Service

Plate Voltage	2000	Vdc
Screen Voltage	300	Vdc
Grid Voltage	-54	Vdc
Zero Signal Plate Current	20	mAdc
Max Signal Plate Current	600	mAdc
Max Signal Screen Current	7	mAdc
Max Signal Grid Current	14	mAdc
Useful Power Output	770	W
Drive Power	23	W
Power Gain	15.3	db
Efficiency	64.1	%

References:

1. *Pappenfus, Bruene and Schoenike, "Single Sideband Principles and Circuits" McGraw-Hill, Inc., N.Y.*
2. *Rinaudo, "The Pi-L Plate Circuit in Kilowatt Amplifiers" QST, July 1962.*
3. *Ramo and Whinnery, "Fields and Waves in Modern Radio" John Wiley and Sons, Inc., N.Y. (Chapter 9.08).*
4. *Albin, "Designing Noisefree Enclosure Openings" Electronic Buyers Guide, June, 1959.*
5. *Ginzton, Hewlett, Jasburg and Noe, "Distributed Amplification" Proc. I.R.E., August 1948, pp. 956-962.*

VARIAN ASSOCIATES
ELECTRON TUBE & DEVICE GROUP
SALES OFFICES

ALBUQUERQUE
9004 Menaul Blvd., N.E.
Albuquerque, NM 87112
505-296-1248

ATLANTA
3110 Maple Drive
Atlanta, Ga 30305
404-261-4574

BOSTON (Waltham)
400 Wyman Street
Waltham, Ma 02154
617-891-4560

CHICAGO (Park Ridge)
205 West Touhy Avenue
Park Ridge, Il 60068
312-825-6686

DALLAS (Richardson)
P.O. Box 689
558 S. Central Expwy., Suite 202
Richardson, Tx. 75080
214-235-2385

DAYTON
Southmoor Bldg.
10 Southmoor Circle
Dayton, Oh 45429
513-298-7318

LONG ISLAND (Melville)
Fort Suffolk Office Center
900 Walt Whitman Road
Melville, L.I., NY 11746
516-549-5422

LOS ANGELES (Santa Monica)
2901 Wilshire Blvd.
Santa Monica, Cal 90403
213-828-5588

NEW YORK (Springfield, NJ)
25 Route 22
Springfield, NJ 07083
201-376-6600

PHILADELPHIA (Cherry Hill, NJ)
1500 Kings Highway
Cherry Hill, NJ 08034
609-428-6800

PHOENIX (Scottsdale)
77 Third Avenue West
Scottsdale, AZ 85251
602-947-5461

SAN FRANCISCO (Los Altos)
4940 El Camino Real
Los Altos, Ca 94022
415-968-7630

SYRACUSE
113 Twin Oaks Drive
Syracuse, NY 13206
315-437-2568

TAMPA (Clearwater)
314 S. Missouri Ave., Suite 205
Clearwater, Fl 33516
813-446-8513

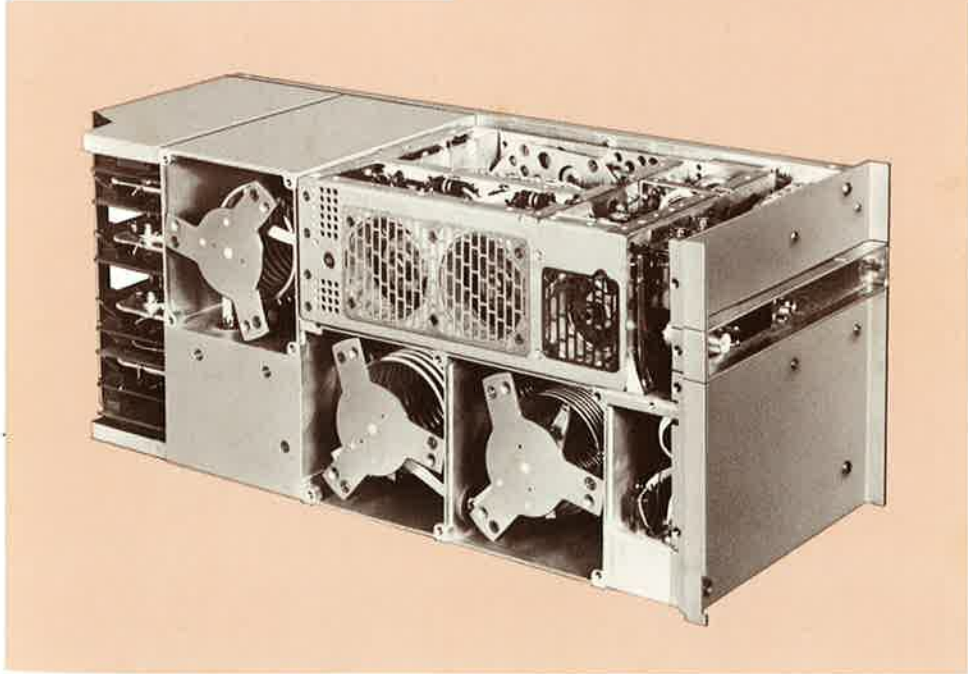
WASHINGTON (Cheverly, Md)
4701 Lydell Drive
Cheverly, Md 20785
301-773-7010

APPLICATION INFORMATION

The Application Engineering Department of the EIMAC Division of Varian is available to design tube into circuit, or to propose circuit designs to fit your requirements. For additional information and data sheets on the 4CX600 family, or other quality EIMAC products, contact your nearest Varian/Eimac Electron Tube and Device Group Office.

Exterior view of the compact Collins 648A-1 linear amplifier.
(below) Interior view of the Collins 648A-1 1 kW airborne hf linear amplifier using two Eimac 4CX600J tetrodes.

Photo courtesy
Collins Radio Company



EIMAC DIVISION OF VARIAN
301 Industrial Way, San Carlos
California 94070