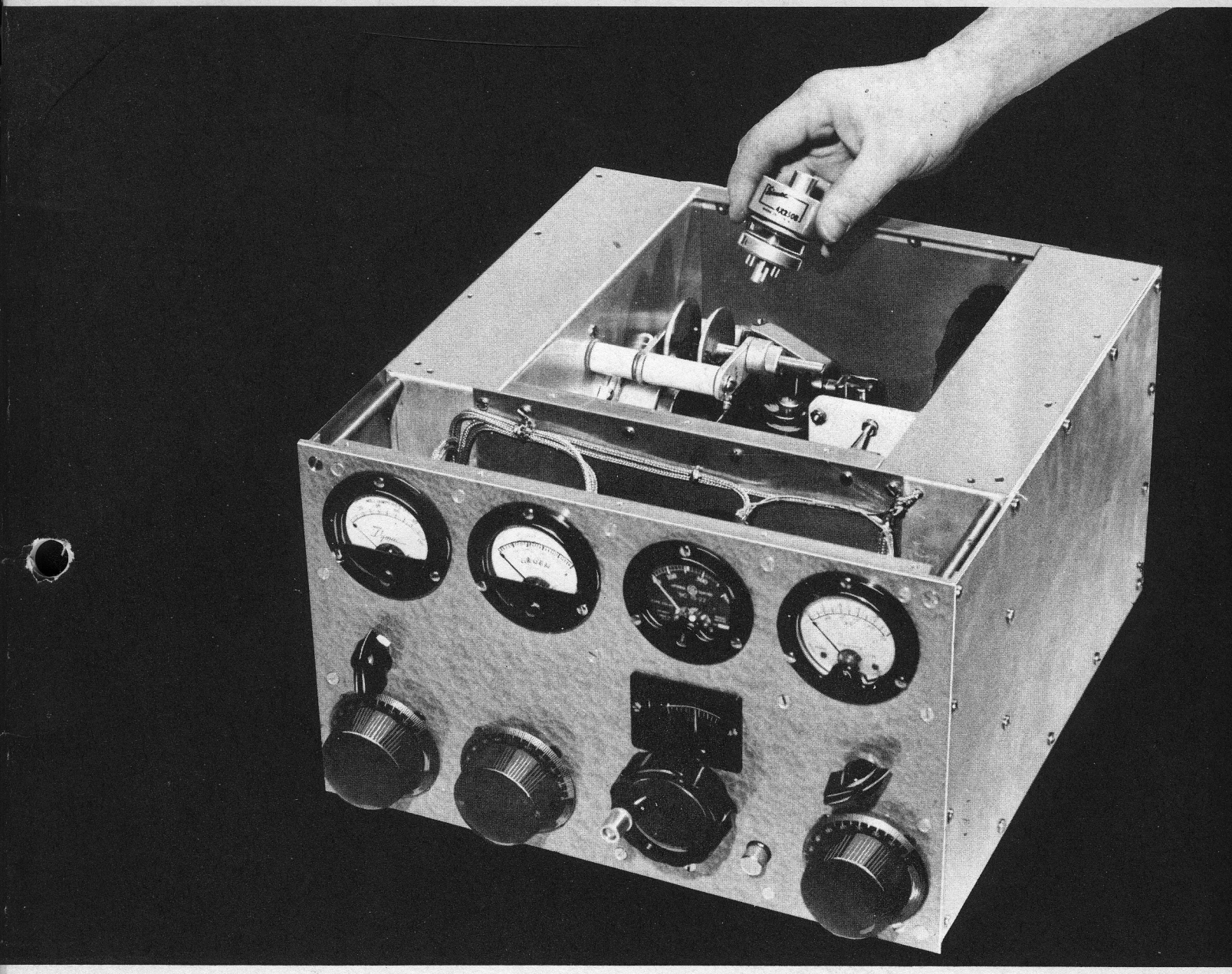
SINGLE SIDEBAND



APPLICATION BULLETIN NUMBER NINE

EITEL-McCULLOUGH, INC.
SAN BRUNO • CALIFORNIA

SINGLE SIDEBAND

CONTENTS

On the cover is an all-band one-kilowatt single sideband amplifier using a pair of easy cooling 4X250B radial-beam power tetrodes. See page 15 for information on the amazing 4X250B. Amplifier was built by Ray Rinaudo, W6KEV.

Introduction

WITH the increasing demands being made upon the radio frequency spectrum, single-sideband systems provide a means of making more efficient use of the available channels.

The advantages of single-sideband transmission over conventional amplitude-modulated transmission have been discussed in the literature[1], and might be summarized as follows:

1. The bandwidth requirement of the signal being transmitted is reduced by a factor of over two. For example, if a signal carrying the normal speech frequencies of 200 to 3000 cycles per second is transmitted via conventional amplitude-modulated carrier, the bandwidth required is equal to twice the highest frequency being transmitted, or 6000 cycles. By elimination of the carrier and one sideband (neither of which is essential to the transmission of intelligence) the bandwidth is reduced to 2800 cycles as shown in Fig. 1. The actual improvement is greater because of the elimination of interfering heterodyne "whistles."

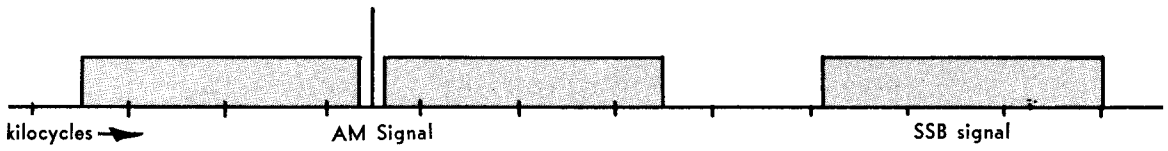


Fig. 1—Relative spectrum space occupied by AM signal and SSB signal modulated by frequencies of 200 to 3000 cycles.

2. With the narrower band of frequencies required, it is possible to improve the receiver by reducing the bandwidth of the selective circuits in the receiver to that actually needed to receive the signal without distortion. There is some improvement in signal-to-noise ratio, but the greatest gain is a reduction in the strength (at the detector) of some of the interfering signals which would otherwise be received with the wider bandpass.

3. It is possible to provide a relatively high level of information-bearing sideband power without the use of a high-powered modulator; and with lower average power in the final radio frequency stage, a substantial reduction in the total power input, total weight and total cost of the transmitting equipment is effected.

4. There is a greater freedom from the distortion frequently encountered over long-path transmissions with amplitude-modulated signals caused by selective fading of the carrier.

[1] J. F. Honey, Performance of AM and SSB Communications, TELE-TECH, Sept. 1953.

RATINGS OF TUBES FOR SINGLE-SIDEBAND

The amount of power to be expected from a given tube in single-sideband operation depends upon the nature of the signal being transmitted, the power-dissipating capabilities of the tube and the skill used in the adjustment of the transmitting equipment. In addition, the method of establishing ratings on tubes for single-sideband service should be such that relatively simple test equipment is required to determine that a tube is operating within its maximum ratings.

It is impractical to establish a rating based on voice-signal modulation because of the irregular waveforms encountered in the voice and the varying ratios of peak-to-average signal power found in the various sounds. The most convenient method, and probably the most practical, is to use a single-tone signal, such as from a sine-wave audio signal generator or a steady whistle, to modulate the transmitter. The use of such a test signal at full modulation level will operate the amplifier at steady, maximum-signal conditions which are easily duplicated and observed.

When a single sine-wave tone is used to modulate a single-sideband transmitter, the r-f output seen on an oscilloscope (Fig. 2a) appears as a steady, unmodulated signal, like an unmodulated AM carrier, for the simple reason that the output is a continuous signal with a frequency removed from that of the carrier by the modulating-tone frequency as in Fig. 2b.

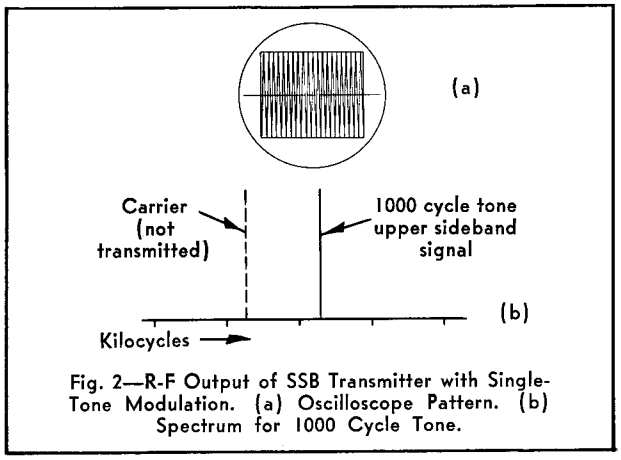


Fig. 2—R-F Output of SSB Transmitter with Single-Tone Modulation. (a) Oscilloscope Pattern. (b) Spectrum for 1000 Cycle Tone.

Consequently, the operation of an amplifier under single-tone modulation is very much like that of a telegraph transmitter under keydown conditions. As such it is possible to ascertain by meter readings the performance of the stage at maximum-signal (or peak) conditions, but information on the linearity of the stage is lacking. To study linearity thoroughly by observation of the amplifier output some means must be provided which will vary the output level from zero to maximum signal with a regular pattern that is easily interpreted. A simple means of obtaining such an output signal is to use two audio tones of equal amplitude to modulate the single-sideband transmitter[1]. This procedure will cause the transmitter to emit two steady signals (see Fig. 3) separated by the frequency difference of the two tones.

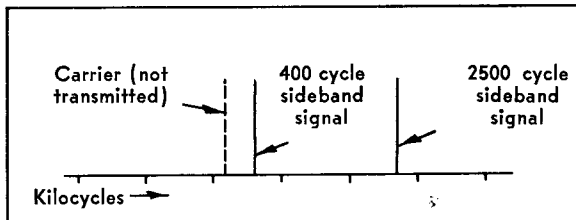
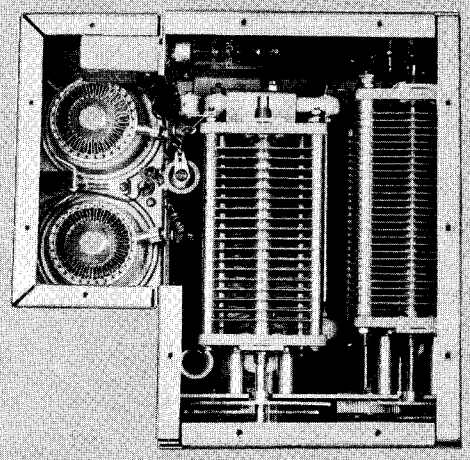


Fig. 3—Spectrum of SSB Transmitter Modulated by Two-Tone Test Signal Containing 400 and 2500 cycle Tones and Transmitting Upper Sideband.

In some types of single-sideband generators this type of signal is obtained by using a single tone at the audio input and injecting the carrier (by unbalancing the "balanced modu-

Top view of one-kilowatt linear amplifier section of Collins KWS-1 single sideband, CW and AM transmitter capable of using Eimac 4X250B or 4X150A radial-beam power tetrodes. Also shown is a front view of the transmitter. (Photos courtesy of Collins Radio Company)



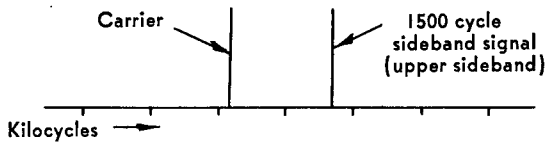


Fig. 4—Spectrum of SSB Transmitter Modulated by 1500-cycle Tone and Injecting Carrier to Obtain Second R-F Signal Equal in Amplitude to Tone.

lator") to provide the second equal r-f signal as shown in Fig. 4.

The resultant (or beat between the two r-f signals) produces a pattern which, when observed on an oscilloscope, has the appearance of a carrier, 100% amplitude modulated by a series of half sine waves, as shown in Fig. 5.

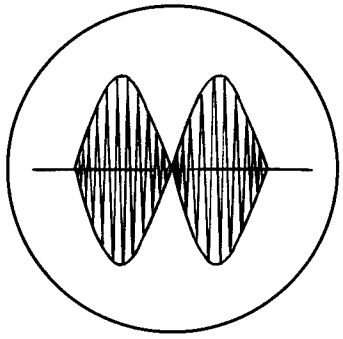


Fig. 5—R-F Output of SSB Transmitter Modulated by Two-Tone Test Signal as Seen on the Oscilloscope.

A test of this nature is called a "two-tone" test, and is often referred to in discussions of single-sideband linear amplifier operation. This test permits the linearity of the amplifier to be studied in detail because the wave form is regular, recurrent and one from which deviations are quite easily interpreted. Flattening of the peaks of the half sine wave form or an abnormal "cross-over" may be indicative of non-linearity in the amplifier stage, assuming, of course, that the single-sideband generator is functioning properly.

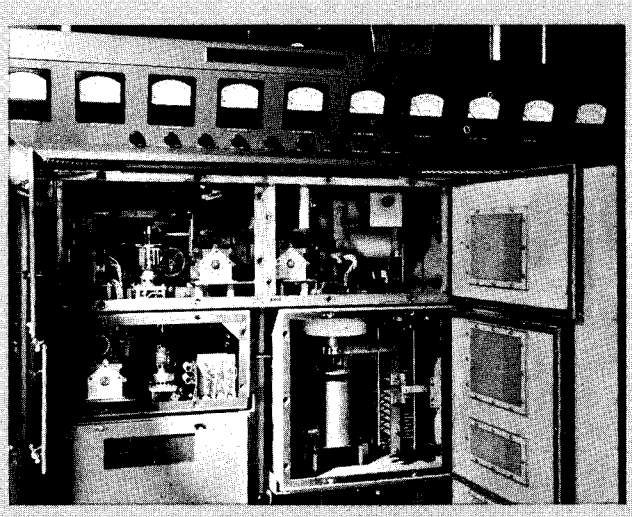
SELECTION OF TUBES FOR SINGLE-SIDEBAND

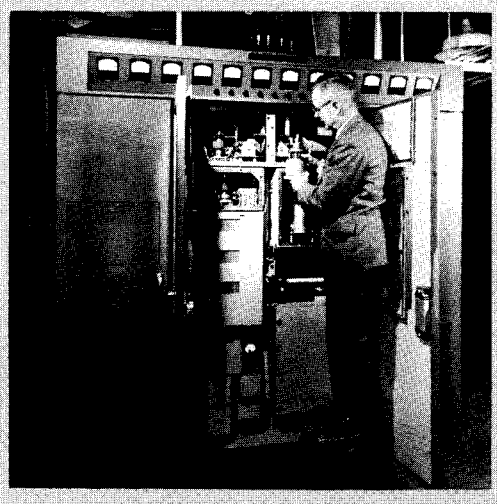
As a guide in the selection of tubes for various power levels of single-sideband output, typical operating conditions in single-sideband service for several Eimac tubes have been prepared and are included in this bulletin. These data give values at the maximum-signal condition for a sustained single-tone modulation, and also give the average current values (as read on a D-C meter) with a two-tone test signal when adjusted to have the same peak power value as the single tone conditions. Voice-signal average currents will, of course, be lower yet.

In general, the criteria used in the selection of tube operating conditions in high-quality audio amplifiers are applicable when selecting operating conditions for linear r-f amplifiers. Of considerable importance in the case of the sideband linear amplifier is the degree of linearity of the stage. The results of non-linearities in audio amplifiers are often unnoticeable to the ear and are identified only with the aid of instruments. In the single-sideband amplifier non-linearity can result in the formation of intermodulation products in the form of spurious radiations outside the desired band, thus causing unnecessary interference and reducing the effectiveness of the single-sideband system as a means of conserving spectrum space.

When electron tubes are operated as Class-A amplifiers the degree of linearity is quite high but the efficiency of the Class-A amplifier is relatively low—on the order of 25-30%. In the case of higher powered amplifiers, this represents quite a substantial power loss in the form of plate dissipation. By operating Class-AB_1 the principal advantages of Class-A operation are retained while the efficiency is raised to values on the order

Western Electric LD-T2 Single sideband suppressed carrier transmitter showing Eimac 4E27A's, 4-400A's and 3X2500F3's in final three RF stages. (Photo courtesy of Bell Telephone Laboratories)





of 60-70%. (Single tubes can, of course, be operated in Class-AB_1 in r-f service because the resonant plate circuit filters out the r-f harmonics.) If operation is further advanced on into the Class-AB_2 region, the efficiency is improved only slightly, but any gain in this direction may be offset by the more stringent requirements imposed upon the driver stage brought about by the variation in driver loading as the amplifier grid is driven into the positive region. This can result in a compression of the modulation peaks, and non-linearity, if the driver is incapable of furnishing the required current. Usually, in order to maintain driver regulation in Class-AB_2 operation, a relatively large percentage of the driver output is dissipated in a swamping resistor so that when the grid is driven positive the relative increase in driver loading is small.

In the consideration of these various factors one finds that Class AB_1 operation has much to offer. To be most effective in this type of operation, tubes should have certain well defined characteristics. Of these the most important is that the tube be capable of permitting the flow of relatively high values of plate current at conditions of low instantaneous plate voltage and zero grid voltage. Most triodes having a quite low value of amplification factor (low-mu) will satisfy the requirement. In tetrode and pentode tubes the grid to screen amplification factor is usually low so if the tube is operated with a relatively high screen voltage the above-mentioned characteristic is obtained.

In the design and adjustment of amplifiers operating under Class-AB_1 conditions there are several points which, if observed, will greatly simplify placing the amplifier in operation. Pertinent design information of a general nature on tetrode amplifiers will be found in "The Care and Feeding of Power Tetrodes," Eimac Application Bulletin No. 8, a copy of which may be obtained upon request. Adherence to the constructional principles outlined therein will reduce the difficulties which might be experienced with parasitic oscillations, harmonics, etc. In addition, the following suggestions may prove to be helpful, particularly in regard to power supply design and amplifier adjustment:

AMPLIFIER DESIGN AND OPERATION

1. *PLATE VOLTAGE:* Several convenient values of plate voltage are listed in the data for the various tube types. If the regulation of the plate voltage supply is such that the voltage rises appreciably under no-load conditions, the Zero-Signal D-C Plate Current should be reduced proportionately to maintain the proper Zero-Signal Plate Dissipation. Poor plate voltage supply regulation may result in poor linearity of the amplifier stage and reduce peak output power.

2. *SCREEN VOLTAGE:* The screen voltages listed in the tube data are those which provide most advantageous operation of the tube at a given plate voltage. The source of screen voltage should have good regulation (from zero values up to the screen currents encountered in normal operation) and, at the same time, afford some measure of protection to the screen in case the screen current becomes excessive, as might be caused by momentary removal of the plate circuit load during tuning procedures or loss of plate voltage. If a screen supply of low impedance is used, an overload relay, set to trip out at a current equal to that necessary to obtain Maximum-Rated Screen Dissipation at the screen voltage employed, should be used.

In some applications, a method of obtaining screen voltage without the use of a separate supply, having the desired characteristics outlined above but with automatic protection, is the use of a series combination of voltage regulator tubes to obtain screen voltage from the plate supply through a dropping

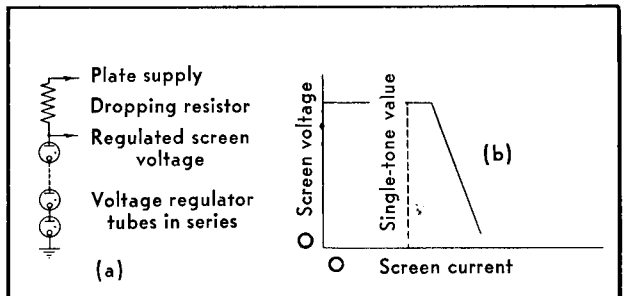
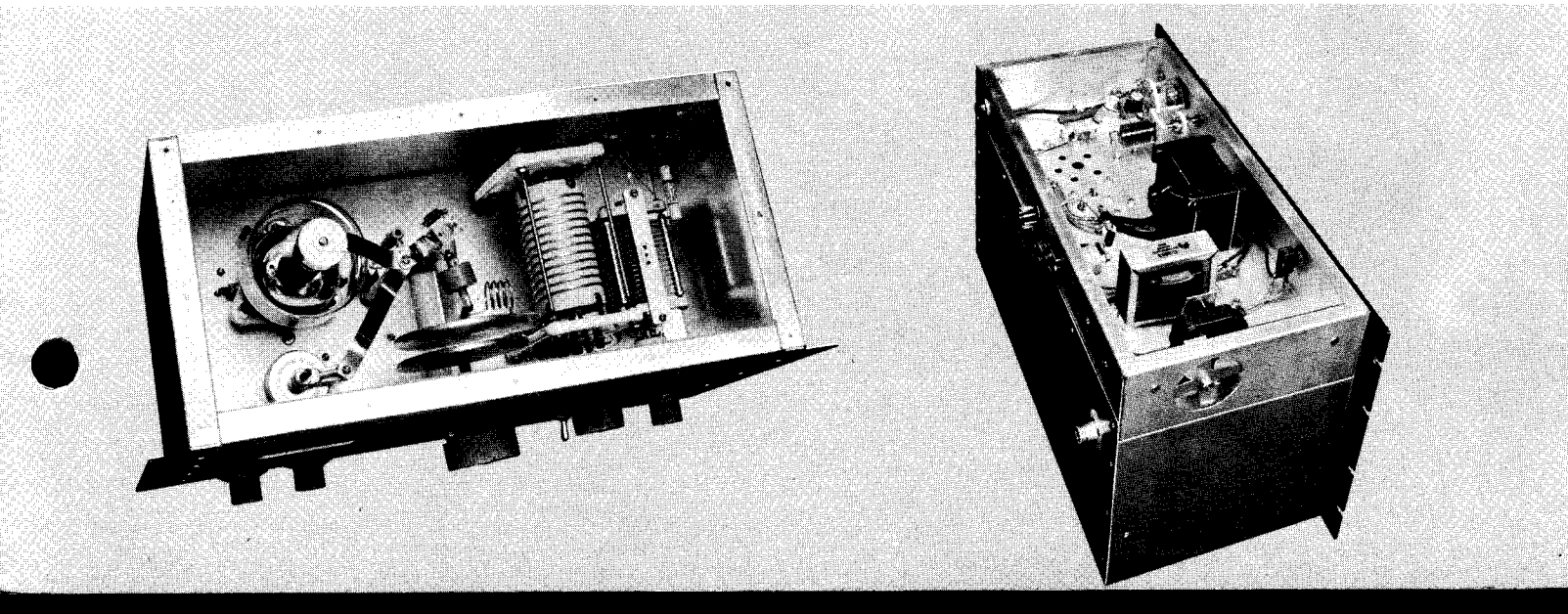
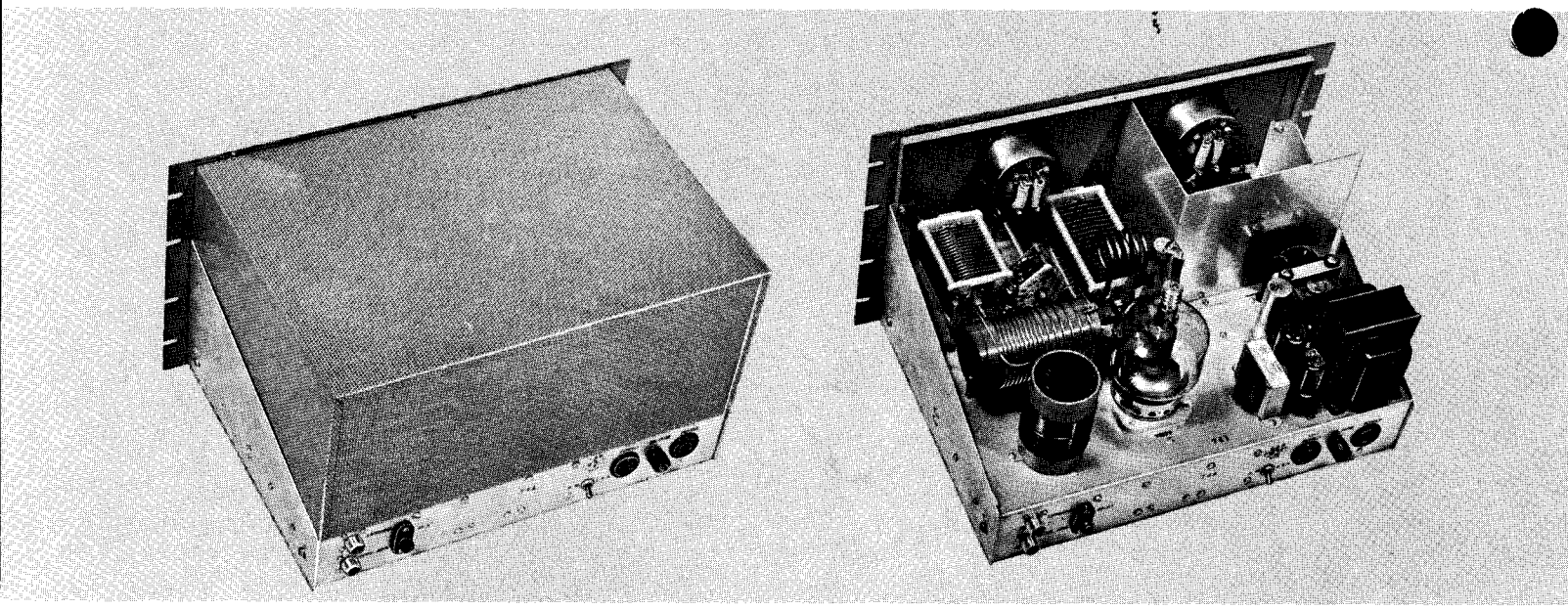


Fig. 6—(a) Circuit for Obtaining Screen Voltage from Plate Supply and (b) Graph Showing Protection Afforded in Event of Excessive Screen Current Conditions.

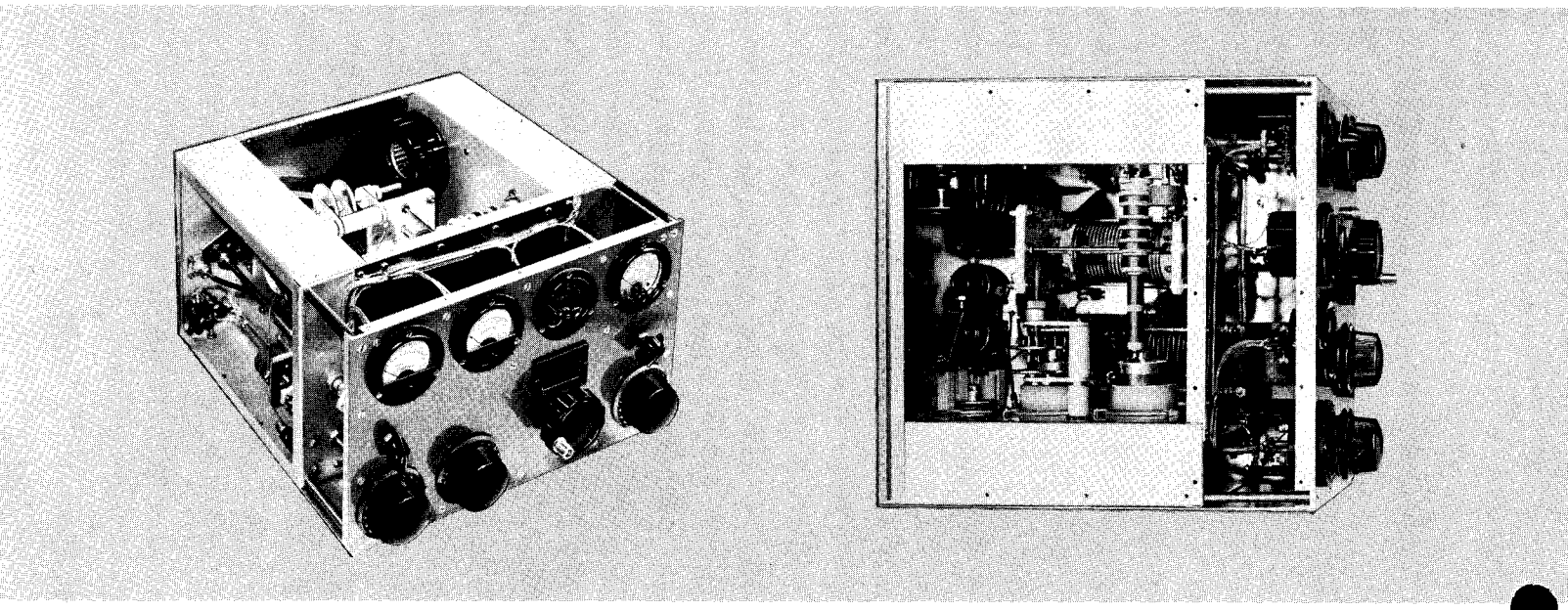
Amplifier using 4-250A with pi-network plate circuit. Note fan for providing tube base cooling air. (Photos courtesy of American Radio Relay League)

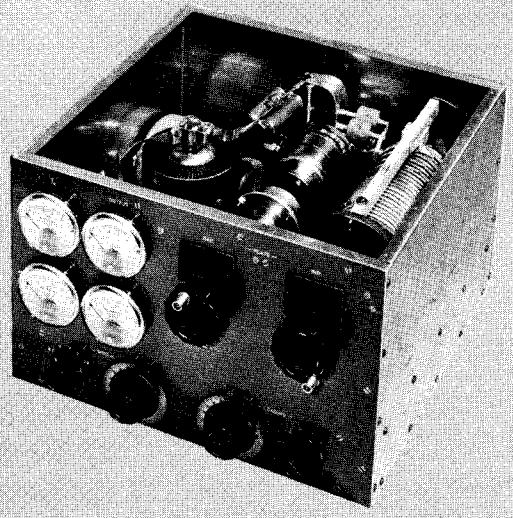


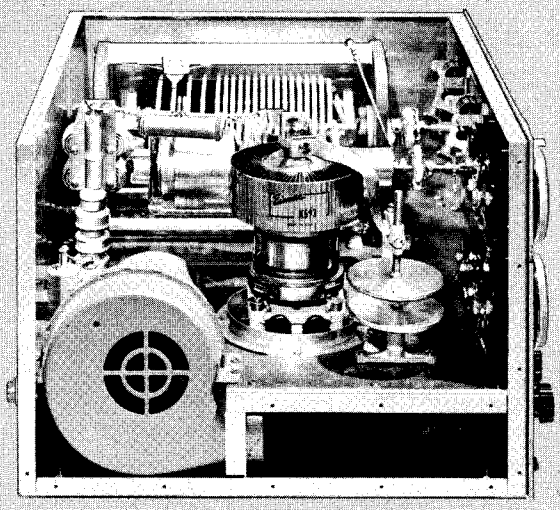


Eimac 4-250A radial-beam power tetrode amplifier stage of Globe King 500 showing circuit and RF shielding details. (Photo courtesy of World Radio Laboratories)

Two views of all-band one-kilowatt amplifier using a pair of Eimac 4X250B radial-beam power tetrodes. Equipment built by Ray Rinaudo, W6KEV.

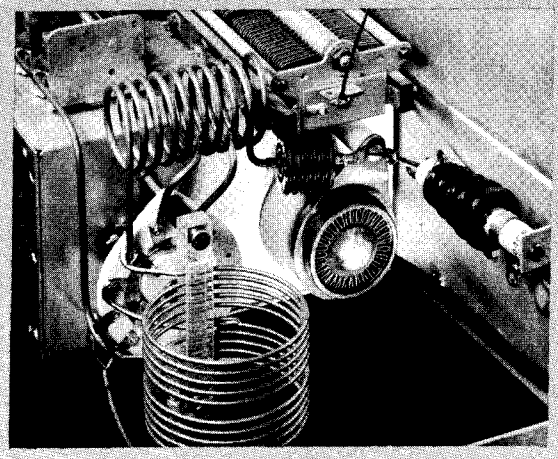






Top and side views of high powered all-band Single Sideband amplifier using the Eimac X593 experimental tetrode.

Front panel view and close-up of plate circuitry in amplifier stage of Eldico SSB 500 capable of using 4X250B or 4X150A radial-beam power tetrodes. (Photos courtesy of Eldico)



resistor as shown in Fig. 6a. It provides the necessary regulation of the screen voltage at normal screen currents, yet allows the screen voltage to drop if the current is excessive, as indicated in Fig. 6b, thus providing protection against overloading the screen of the tube. To obtain protection, the plate supply voltage should be at least twice the voltage actually required at the screen.

The series dropping resistor should be adjusted so that the regulator tube current under Zero-Signal conditions is 5 to 10 milliamperes greater than the Maximum-Signal D-C Screen Current. Obviously, this method of screen voltage regulation can be used in cases where the Maximum-Signal D-C Screen Current is approximately 5 milliamperes less than the maximum-rated regulator tube current. The Zero-Signal D-C Screen Current will be zero, or nearly so, in most cases. With the above adjustment, if the screen current becomes excessive for any reason, the screen voltage drops and the regulator tubes automatically go out. It should be noted that the values of screen voltage in the tube data are combinations of 75, 105 and 150 volts for ease of obtaining screen voltage by this latter method.

3. *GRID VOLTAGE:* In Class-AB_1 (as in Class-A) there is no severe restriction placed upon the impedance of the grid bias supply; however, the grid to cathode resistance should be held to a reasonably low value to reduce erratic operation of the amplifier if occasional high peaks of grid current occur from excessive modulation. If the grid bias supply impedance is high a slight amount of grid current will tend to cause a large fluctuation in the grid bias causing a change in the Zero-Signal D-C Plate Current. This, in turn, will materially affect the linearity of the amplifier.

4. *PLATE CURRENT:* Listed under Single-Tone D-C Plate Current are the values expected when the amplifier is driven to maximum level by a single tone. For the convenience of those interested in making linearity studies using the "two-tone" test, the expected values are listed under Two-Tone Average D-C Plate Current. The latter apply when the two-tone peak of envelope power equals the single-tone maximum signal power.

5. *SCREEN CURRENT:* The values given for D-C Screen Current may vary somewhat from tube to tube, but serve as a rough guide in adjusting to the peak conditions of the linearity curve. In tetrode and pentode amplifiers operating with a relatively small average plate swing (low average plate efficiency) the screen current meter readings may be very low. Under some conditions of operation it is possible that the screen current may read negative except under sustained tone modulation at peak level where the plate swing is large and the efficiency is high. The negative screen current obtained under such conditions is not detrimental to r-f amplifier operation, it being a function of the screen-voltage, screen-current characteristics of the tube.

ADJUSTMENT AND MONITORING

Toward the end of the bulletin will be found data sheets for a number of Eimac tubes with data for single-sideband service as Class-AB_1 linear radio-frequency amplifiers. As a convenience, several values of plate voltages are given together with typical operating conditions which will be helpful in adjusting the Class-AB_1 amplifier. The following procedures may be helpful in setting up the single-sideband linear amplifier and monitoring its operation:

1. *Adjustment with Single-Tone Modulation*

The Single-Tone should be obtained from an audio oscillator (whistling also gives a fair sine wave but is difficult to hold at the desired maximum signal level). The most straightforward procedure for adjusting an amplifier with only Single-Tone modulation is as follows:

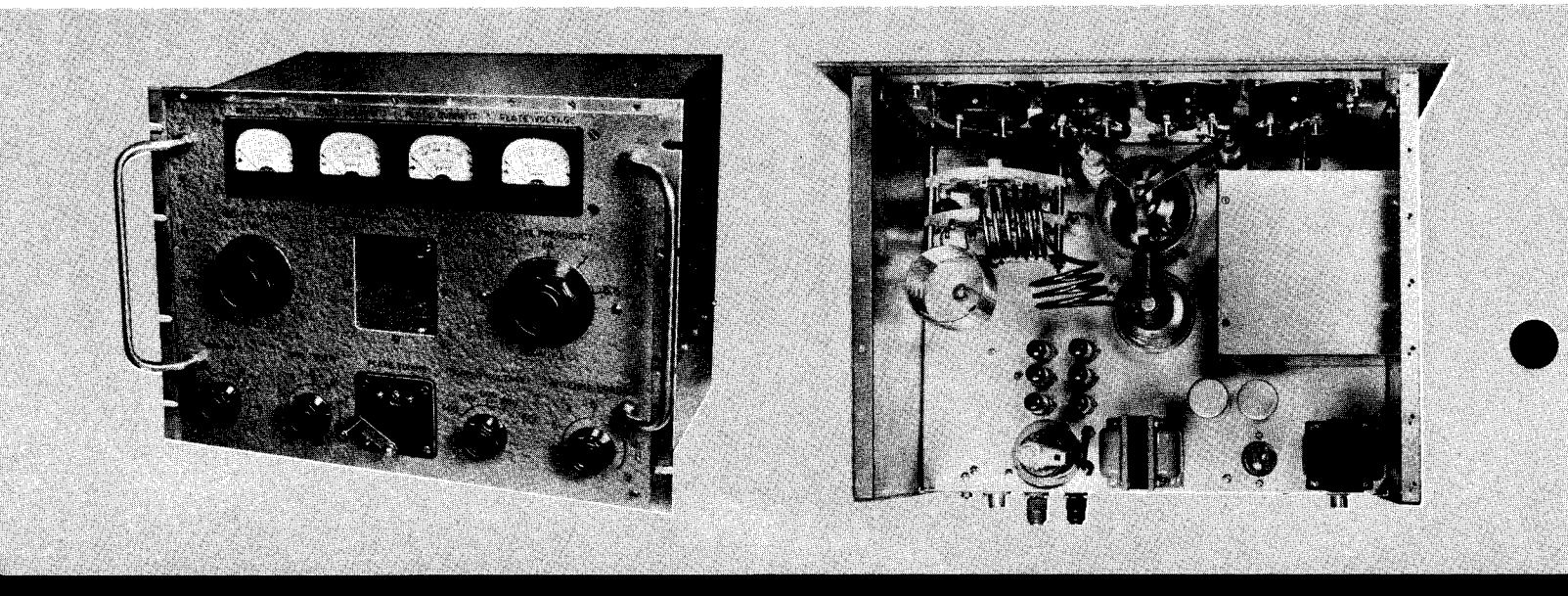
a. The Zero-Signal D-C Plate Current should be set to the specified value by adjustment of the grid bias.

b. Increase the grid drive (or audio level) until grid current barely starts to flow, reducing it slightly until no current flows.

c. Adjust the plate current loading until the indicated Single-Tone D-C *Screen* current flows. (Do not attempt to set the D-C plate current by varying the loading since it is controlled almost solely by the excitation and screen voltage.) The screen current varies rapidly with the amount of r-f plate voltage developed and is a sensitive indicator of the proper peak level at which limiting or lack of linearity begins.

It should be noted that the procedure above depends upon fixing the zero signal point and the maximum signal point with a Single-Tone test signal. It is assumed for the particular tube type and the tabulated values that the calculated linearity will result. It is a rough procedure and useful when only meters and a Single-Tone test signal are available. It is, however, better to make some linearity measurement to prove that the

Amplifier using 4-400A with pi-network plate circuit. Note miniature voltage regulator tubes to provide screen-voltage regulation for single-sideband operation. Meter shield has been removed for photo. Grid circuit inductors located in shielded enclosure above chassis. (Photos courtesy of Adams Electronics Corporation)



amplifier is actually operating with the desired linearity.

After the adjustments have been made with a Single-Tone test signal, it should be realized that the voice is a different type of signal. The values of plate and screen currents under voice signal modulation will be considerably lower than for the Single-Tone modulation.

With Single-Tone modulation it is possible to make approximate measurements of transmitter linearity by the use of a linear gain control (such as a wire-wound potentiometer) in the audio input and either an r-f current meter, r-f peak-reading voltmeter or an oscilloscope to observe the transmitter output. The gain control should be calibrated in equal divisions between the "off" position and that point at which the Single-Tone maximum-signal conditions, as established in the above paragraph, are obtained. By "plotting" the output r-f current, voltage, or the amplitude of the oscilloscope pattern against the position of the gain control, it is possible to obtain a curve of the linearity of the transmitter. The accuracy of the curve will be dependent upon the care used in the calibration of the gain control and in reading the output meter.

2. *Adjustment with Two-Tone Modulation*

Initial adjustments should be made with single-tone modulation according to the above procedure in order to obtain Zero-Signal and Maximum-Signal conditions. Once these conditions have been established, the amplifier should be driven with the previously described two-tone test signal and the r-f output pattern observed on an oscilloscope. When the amplifier is operating at full modulation level with the two-tone test, it may be necessary to make minor adjustments of bias voltage or output loading settings in order to obtain the best linearity.

Once the adjustment for linearity has been made for a given tube, the adjustment may be duplicated on a two-tone test at another frequency of operation by loading to the same screen current under maximum drive conditions. Under two-tone test conditions the average power output is one-half of the single-tone or peak-signal level.

3. *Adjustment and Monitoring with Envelope Detectors*

In addition to the methods outlined above for adjusting the single-sideband linear amplifier at maximum-signal level with single-tone modulation and for linearity with two-tone modulation, it is possible to utilize a recently described procedure[2] to make linearity adjustments and to provide a means of "on-the-air" monitoring of the signals being transmitted. It is possible, by the use of a pair of envelope detectors in conjunction with an oscilloscope, to observe the linearity of an amplifier of single-sideband signals regardless of the waveform of the modulating signal. Further, it is particularly useful because the effects of amplifier adjustments can be observed instantly.

An envelope detector for this purpose has been described by Bruene[2]. For exact measurements the two diodes should be identical in performance. The characteristics of the two detectors may be compared by coupling the two detector inputs to the same resonant circuit in the transmitter and the outputs connected to the horizontal and vertical inputs of the oscilloscope. The resultant oscilloscope trace should be observed with equal input voltages to the envelope detectors. If the two detectors and the two oscilloscope amplifiers are identical in characteristics (frequency response, audio phase shift, curvature in the diode voltage-current characteristic, etc.), the oscilloscope trace will be a straight line. Any deviation from a straight line under this comparison test will indicate differences either in the detectors or in the oscilloscope amplifiers.

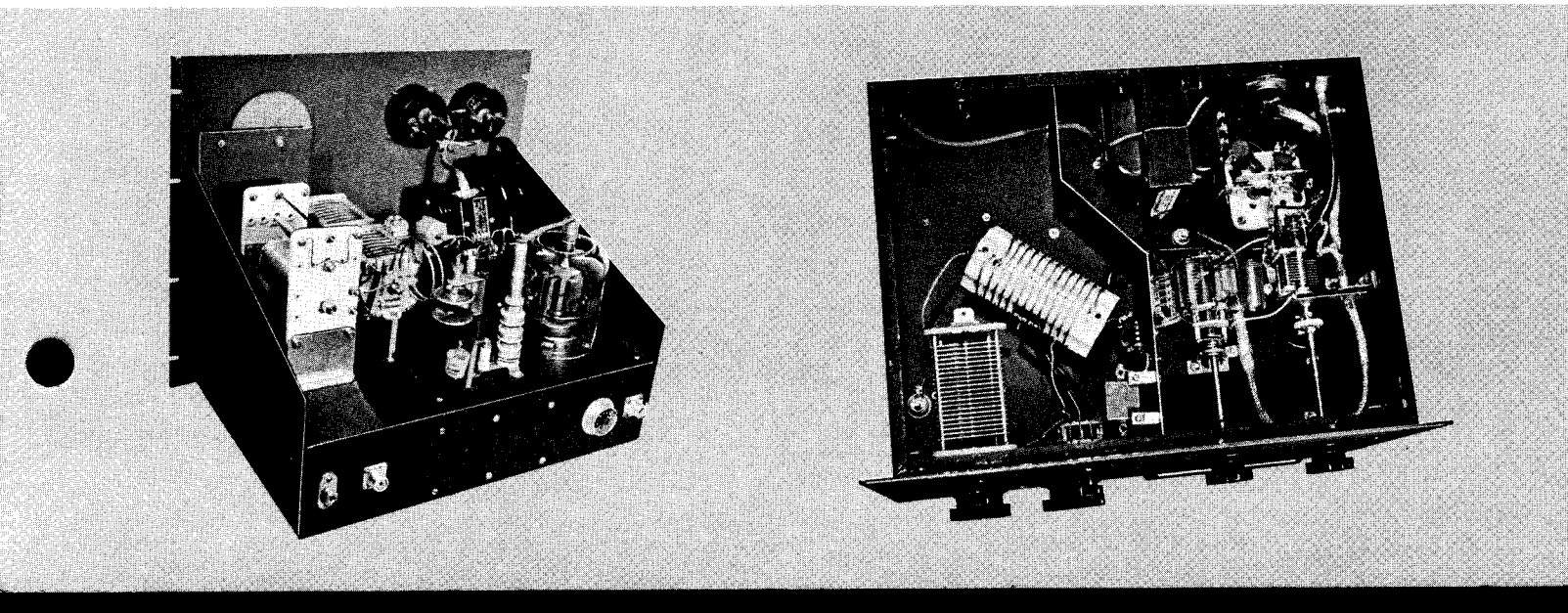
Once the characteristic trace of the two detectors has been established, one detector can be coupled to the output of the amplifier under test with the other coupled to the amplifier input, and the linearity of the stage, or stages, is displayed for visual inspection. Any deviation from the characteristic trace of the detectors described above will represent a misadjustment of the amplifier drive, loading or operating voltages. This procedure is a very convenient method for adjusting the linear amplifier if only voice-signal modulation is used and is particularly useful if high ratios of peak-to-average power are to be obtained with freedom from distortion.

REFERENCES:

[1] R. F. Tschannen, A Compact Two-Tone Test Generator, QST, May, 1955.

[2] W. Bruene, Distortion in Single-Sideband Linear Amplifiers, QST, Nov., 1954.

Rear and bottom view of single sideband amplifier using an Eimac 4-400A radial-beam power tetrode, showing circuits and cooling details. Equipment built by I. H. Mintz, WØJSY.



Eimac Tubes for Single Sideband

4-65A
RADIAL-BEAM POWER TETRODE

The Eimac 4-65A is a small radiation-cooled transmitting tetrode having a maximum plate-dissipation rating of 65 watts. The plate operates at a red color at maximum dissipation. Short, heavy leads and low interelectrode capacitances contribute to stable efficient operation at high frequencies.

Although it is capable of withstanding high plate voltages, the internal geometry of the 4-65A is such that it will deliver relatively high power output at a low plate voltage.

The quick-heating filament allows conservation of power during standby periods in mobile applications.

GENERAL CHARACTERISTICS

ELECTRICAL

Filament: Thoriated tungsten	
Voltage	6.0 volts
Current	3.5 amperes
Grid-Screen Amplification Factor (Average)	5
Direct Interelectrode Capacitances (Average)	
Grid-Plate	0.08 $\mu\mu$f
Input	8.0 $\mu\mu$f
Output	2.1 $\mu\mu$f
Transconductance (I_b = 125 ma., E_b = 500v., E_{c2} = 250v.)	4000 μmhos
Frequency for Maximum Ratings	150 Mc.

MECHANICAL

Base — 5-pin—Fits	{ National HX-29 Socket Johnson 122-101 Socket
Mounting Position	Vertical, base down or up
Cooling	Convection and Radiation
Recommended Heat Dissipating Connector	Eimac HR-6
Maximum Over-all Dimensions	
Length	4.38 inches
Diameter	2.38 inches
Net Weight	3 ounces
Shipping Weight	1.5 pounds

RADIO-FREQUENCY LINEAR POWER AMPLIFIER—Class AB_1 (one tube)

MAXIMUM RATINGS

D-C PLATE VOLTAGE	3000 MAX. VOLTS
D-C SCREEN VOLTAGE	600 MAX. VOLTS
D-C PLATE CURRENT	150 MAX. MA
PLATE DISSIPATION	65 MAX. WATTS
SCREEN DISSIPATION	10 MAX. WATTS

TYPICAL OPERATION

Class AB_1 R-F Linear Amplifier (Frequencies to 150 Mc, per tube)

D-C Plate Voltage	1000	1500	2000	2500	3000 volts
D-C Screen Voltage	510	480	450	405	360 volts
D-C Grid Voltage*	—110	—105	—100	—90	—85 volts
Zero-Signal D-C Plate Current	45	30	22	17	15 ma
Single-Tone r-f (peak) Grid Voltage	110	105	100	90	85 volts
Single-Tone D-C Plate Current	100	90	80	70	65 ma
Single-Tone D-C Screen Current	17	13	11	8.5	6.5 ma
Single-Tone D-C Grid Current	0	0	0	0	0 ma
Single-Tone Plate Power Input	100	135	160	175	195 watts
Single-Tone Plate Power Output	40	75	100	115	130 watts
Two-Tone Average D-C Plate Current	80	70	60	50	45 ma
Two-Tone Average D-C Screen Current	6.0	4.0	3.0	2.5	1.5 ma

* Adjust to give stated Zero-Signal D-C Plate Current.

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 screen currents.

COOLING

Adequate ventilation must be provided so that the seals and envelope do not exceed a temperature of 225°C under operating conditions. For operation below 50 Mc, normal free circulation of air around the envelope and through the socket is considered adequate.

4-125A
(4D21)
RADIAL-BEAM POWER TETRODE

Eimac Tubes for Single Sideband

The Eimac 4-125A is a radial-beam power tetrode intended for use as an amplifier, oscillator, or modulator. It has a maximum plate-dissipation rating of 125 watts and a maximum plate-voltage rating of 3000 volts at frequencies up to 120 Mc.

The low grid-plate capacitance of this tetrode together with its low driving-power requirement allows considerable simplification of the associated circuit and driver stage.

Cooling is by radiation from the plate and by air circulation through the base and around the envelope.

The 4-125A in class-C r-f service will deliver up to 375 watts plate power output with 2.5 watts driving power. Two 4-125A's in class-B modulator service will deliver up to 400 watts maximum-signal power output with 1.2 watts nominal driving power.

GENERAL CHARACTERISTICS

ELECTRICAL

Filament: Thoriated tungsten	
Voltage	5.0 volts
Current	6.5 amperes
Grid-Screen Amplification Factor (Average)	5.9
Direct Interelectrode Capacitances (Average)	
Grid-Plate	0.05 $\mu\mu$fd
Input	10.8 $\mu\mu$fd
Output	3.1 $\mu\mu$fd
Transconductance (I_b = 50 ma., E_b = 2500v., E_{c2} = 400v.)	2450 μmhos
Highest Frequency for Maximum Ratings	120 Mc

MECHANICAL

Base	5-pin metal shell
Socket	E. F. Johnson Co. socket No. 122-275, National Co. No. HX-100, or equivalent
Mounting Position	Vertical, base down or up
Cooling	Radiation and forced air
Recommended Heat-Dissipating Plate Connector	Eimac HR-6
Maximum Over-all Dimensions	
Length	5.69 inches
Diameter	2.81 inches
Net Weight	6.5 ounces
Shipping Weight	1.5 pounds

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

RADIO-FREQUENCY LINEAR POWER AMPLIFIER—Class AB_1 (one tube)

MAXIMUM RATINGS

D-C PLATE VOLTAGE	3000 MAX. VOLTS
D-C SCREEN VOLTAGE	700 MAX. VOLTS
D-C PLATE CURRENT	225 MAX. MA
PLATE DISSIPATION	125 MAX. WATTS
SCREEN DISSIPATION	20 MAX. WATTS

TYPICAL OPERATION

Class-AB_1 R-F Linear Amplifier (Frequencies to 120 Mc, per tube)

D-C Plate Voltage	1500	2000	2500	3000 volts
D-C Screen Voltage	660	615	555	510 volts
D-C Grid Voltage*	—105	—105	—100	—95 volts
Zero-Signal D-C Plate Current	55	40	35	30 ma
Single-Tone r-f (peak) Grid Voltage	105	105	100	95 volts
Single-Tone D-C Plate Current	150	135	120	105 ma
Single-Tone D-C Screen Current	15	14	10	6 ma
Single-Tone D-C Grid Current	0	0	0	0 ma
Single-Tone Plate Power Input	225	270	300	315 watts
Single-Tone Plate Power Output	100	150	180	200 watts
Two-Tone Average D-C Plate Current	115	100	85	75 ma
Two-Tone Average D-C Screen Current	5.0	4.0	3.0	1.5 ma

* Adjust to give stated Zero-Signal D-C Plate Current.

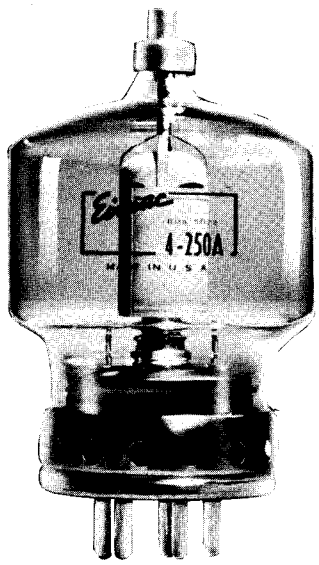
COOLING

Adequate cooling must be provided for the seals and envelope. In continuous-service applications, the temperature of the plate seal, as measured on the top of the plate cap, should not exceed 170°C. A relatively slow movement of air past the tube is sufficient to prevent seal temperatures in excess of maximum at frequencies below 30 Mc if a suitable heat-radiating connector is used.

4-250A
(5D22) RADIAL-BEAM POWER TETRODE

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

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



GENERAL CHARACTERISTICS

ELECTRICAL

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

MECHANICAL

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

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

RADIO-FREQUENCY LINEAR POWER AMPLIFIER—Class AB_1 (one tube)

MAXIMUM RATINGS

D-C PLATE VOLTAGE	4000 MAX. VOLTS
D-C SCREEN VOLTAGE	750 MAX. VOLTS
D-C PLATE CURRENT	350 MAX. MA
PLATE DISSIPATION	250 MAX. WATTS
SCREEN DISSIPATION	35 MAX. WATTS

TYPICAL OPERATION

Class-AB_1 R-F Linear Amplifier (Frequencies to 110 Mc, per tube)

D-C Plate Voltage	2000	2500	3000	3500	4000 volts
D-C Screen Voltage	705	660	600	555	510 volts
D-C Grid Voltage*	—115	—115	—110	—105	—100 volts
Zero-Signal D-C Plate Current	85	65	55	45	40 ma
Single-Tone r-f (peak) Grid Voltage	115	115	110	105	100 volts
Single-Tone D-C Plate Current	250	230	210	185	165 ma
Single-Tone D-C Screen Current	20	15	12	9.5	7.5 ma
Single-Tone D-C Grid Current	0	0	0	0	0 ma
Single-Tone Plate Power Input	500	575	630	650	660 watts
Single-Tone Plate Power Output	250	335	400	425	450 watts
Two-Tone Average D-C Plate Current	190	170	150	130	115 ma
Two-Tone Average D-C Screen Current	5.5	3.5	2.5	2.0	1.5 ma

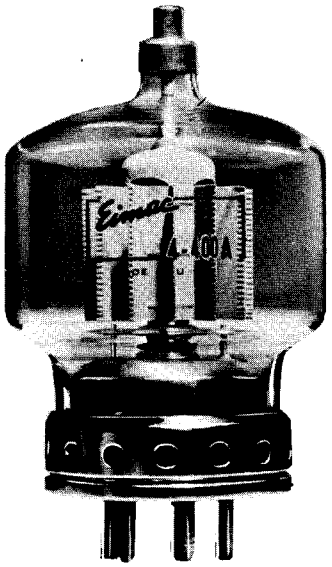
* Adjust to give stated Zero-Signal D-C Plate Current.

COOLING

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

4-400A
RADIAL-BEAM POWER TETRODE

Eimac Tubes for Single Sideband



The Eimac 4-400A is a compact, ruggedly constructed power tetrode having a maximum plate dissipation rating of 400 watts. It is intended for use as an amplifier, oscillator or modulator. The low grid-plate capacitance of this tetrode coupled with its low driving-power requirement allows considerable simplification of the associated circuit and driver stage.

The 4-400A is cooled by radiation from the plate and by circulation of forced-air through the base, around the envelope, and over the plate seal. Cooling can be greatly simplified by using an Eimac SK-400 Air-System Socket and its accompanying glass chimney, SK-406. This socket is designed to maintain the correct balance of cooling air between the component parts of the tube.†

GENERAL CHARACTERISTICS

ELECTRICAL

Filament: Thoriated tungsten	
Voltage	5.0 volts
Current	14.5 amperes
Grid-Screen Amplification Factor (Average)	5.1
Direct Interelectrode Capacitances (Average)	
Grid-Plate	0.12 $\mu\mu$fd
Input	12.5 $\mu\mu$fd
Output	4.7 $\mu\mu$fd
Transconductance (I_b = 100 ma., E_b = 2500v., E_{c2} = 500v.)	4,000 μmhos
Frequency for Maximum Ratings	110 Mc.

MECHANICAL

Base	5-pin metal shell
Mounting Position	Vertical, base down or up
Cooling	Radiation and forced air
Recommended Heat Dissipating Plate Connector	Eimac HR-6
Recommended Socket	Eimac SK-400 Air-System Socket and SK-406 Chimney
Maximum Over-all Dimensions	
Length	6.38 inches
Diameter	3.56 inches
Net Weight	9 ounces
Shipping Weight	2.5 pounds

With an Eimac SK-400 Air-System Socket and SK-406 Chimney, mounted on a 1/4 inch deck, the over-all dimensions of the system including chimney and HR-6 Heat Dissipating Plate Connector are:

Length	8.0 inches
Diameter	5.5 inches

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 screen currents.

RADIO-FREQUENCY LINEAR POWER AMPLIFIER—Class AB_1 (one tube)

MAXIMUM RATINGS

D-C PLATE VOLTAGE	4000 MAX. VOLTS
D-C SCREEN VOLTAGE	850 MAX. VOLTS
D-C PLATE CURRENT	350 MAX. MA
PLATE DISSIPATION	400 MAX. WATTS
SCREEN DISSIPATION	35 MAX. WATTS

TYPICAL OPERATION

Class-AB_1 R-F Linear Amplifier (Frequencies to 110 Mc. per tube)

D-C Plate Voltage	3000	3500	4000 volts
D-C Screen Voltage	810	750	705 volts
D-C Grid Voltage*	—140	—135	—130 volts
Zero-Signal D-C Plate Current	90	75	65 ma
Single-Tone r-f (peak) Grid Voltage	140	135	130 volts
Single-Tone D-C Plate Current	300	280	250 ma
Single-Tone D-C Screen Current	18	15	11 ma
Single-Tone D-C Grid Current	0	0	0 ma
Single-Tone Plate Power Input	900	980	1000 watts
Single-Tone Plate Power Output	500	600	650 watts
Two-Tone Average D-C Plate Current	215	200	175 ma
Two-Tone Average D-C Screen Current	4.0	3.0	2.0 ma

* Adjust to give stated Zero-Signal D-C Plate Current.

COOLING

Adequate forced-air cooling must be provided to maintain the base seals at a temperature below 200°C, and the plate seal at a temperature below 225°C. With the Eimac SK-400 Air System Socket and SK-406 Chimney, an air flow of 14 cubic feet per minute at a static pressure of 0.25 inch of water column, as measured in the socket, will provide adequate cooling under most conditions of operation. At high elevations the volume will have to be increased. Seal temperature limitations may require that cooling air be supplied to the tube even when the filament alone is on during standby periods.

† Guarantee applies only when the 4-400A is used as specified with adequate air in the SK-400 Air-System Socket and SK-406 Chimney, or equivalent.

Eimac Tubes for Single Sideband

4-1000A
RADIAL-BEAM POWER TETRODE

The Eimac 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 Mc., two 4-1000A tetrodes will deliver a useful power output over 5000 watts.

Operating under class AB_2 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_1, 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 and SK-506 Chimney.

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 $\mu\mu$fd
Input	27.2 $\mu\mu$fd
Output	7.6 $\mu\mu$fd
Transconductance (I_b = 300 ma., E_b = 2500v., E_{c2} = 500v.)	10,000 μmhos
Highest Frequency for Maximum Ratings	110 Mc

MECHANICAL

Base	5-pin metal shell
Recommended Socket	Eimac SK-500 Air-System Socket and SK-506 Chimney
Mounting Position	Vertical, base down or up
Cooling	Radiation and forced air
Recommended Heat Dissipating Plate Connector	Eimac HR-8
Maximum Over-all Dimensions	
Length	9.63 inches
Diameter	5.25 inches
Net Weight (tube only)	1.5 inches
Shipping Weight	12 pounds

With an Eimac SK-500 Air-System Socket and SK-506 Chimney, mounted on 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

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 screen currents.

RADIO-FREQUENCY LINEAR POWER AMPLIFIER—Class AB_1 (one tube)

MAXIMUM RATINGS

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

TYPICAL OPERATION

Class-AB_1, R-F Linear Amplifier (Frequencies to 110 Mc, per tube)

D-C Plate Voltage	4000	5000	6000 volts
D-C Screen Voltage	1000	1000	930 volts
D-C Grid Voltage*	—130	—135	—130 volts
Zero-Signal D-C Plate Current	167	133	110 ma
Single-Tone r-f (peak) Grid Voltage	130	135	130 volts
Single-Tone D-C Plate Current	480	480	440 ma
Single-Tone D-C Screen Current	40	35	32 ma
Single-Tone D-C Grid Current	0	0	0 ma
Single-Tone Plate Power Input	1920	2400	2640 watts
Single-Tone Plate Power Output	1130	1510	1750 watts
Two-Tone Average D-C Plate Current	345	340	310 ma
Two-Tone Average D-C Screen Current	16	13	12 ma

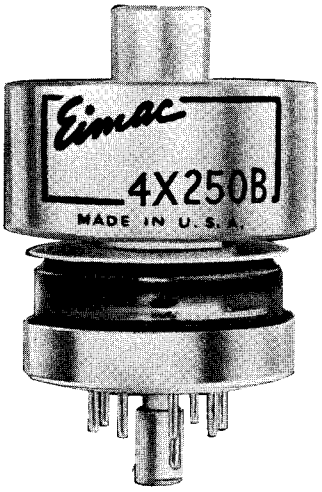
* Adjust to give stated Zero-Signal D-C Plate Current.

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 Eimac SK-500 Air-System Socket and SK-506 Chimney. This system is designed to maintain the correct balance of cooling air for the various parts of the tube. The quantity of air required by this system for maximum rated plate dissipation of the tube is 45 cubic feet per minute at a static pressure of approximately 1.2 inches of water column.

4X250B
RADIAL-BEAM POWER TETRODE

Eimac Tubes for Single Sideband



The Eimac 4X250B is a compact, oxide-cathode, external-anode power tetrode, unilaterally interchangeable with the 4X150A in most applications, and is intended for use as an amplifier, oscillator or frequency multiplier over a wide range of frequencies extending into the UHF region. It is cooled by convection and forced air.

A single 4X250B in a coaxial-cavity amplifier circuit will deliver up to 300 watts of useful power output at 400 megacycles although this is not the upper frequency limit of the tube.

Outstanding features of the 4X250B are: 1. Simple air-cooling requirements. 2. A maximum plate-dissipation rating of 250 watts available for low-efficiency applications. 3. A maximum d-c plate voltage rating of 2000 volts at frequencies up to 400 Mc. The high transconductance of the 4X250B makes the tube useful at relatively low plate voltages. The high ratio of transconductance to inter-electrode capacitance and the 250-watt plate dissipation make the tube very useful for wide-band amplifier applications.

The use of the Eimac SK-600 or SK-610 Air-System Socket and SK-606 Chimney, or a socket providing equivalent air cooling characteristics, is required.

GENERAL CHARACTERISTICS

ELECTRICAL

Cathode: Oxide Coated, Unipotential	
Minimum Heating Time	30 seconds
Cathode-to-Heater Voltage	150 max. volts
Heater: Voltage	6.0 volts
Current	2.1 amperes
Grid-Screen Amplification Factor (Average)	5
Direct Interelectrode Capacitances (Average)	
Grid-Plate	0.04 $\mu\mu$f
Input	18.5 $\mu\mu$f
Output	4.7 $\mu\mu$f
Transconductance (E_b = 500v., E_{c2} = 250v., I_b = 200 ma)	12,000 μmhos
Frequency for Maximum Plate Voltage Ratings	400 Mc
(All other Maximum Ratings applicable to 500 Mc)	

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 screen currents.

MECHANICAL

Base	9-pin, special
Recommended Socket	Eimac SK-600 or SK-610 Air-System Socket and SK-606 Chimney
Mounting Position	Any position
Cooling	Convection and Forced air
Maximum Over-all Dimensions	
Length	2.59 inches
Diameter	1.65 inches
Seated Height	2.03 inches
Net Weight	4.0 ounces
Shipping Weight	1.6 pounds

RADIO-FREQUENCY LINEAR POWER AMPLIFIER—Class AB_1 (one tube)

MAXIMUM RATINGS

D-C PLATE VOLTAGE	2000 MAX. VOLTS
D-C SCREEN VOLTAGE	400 MAX. VOLTS
D-C PLATE CURRENT	250 MAX. MA
PLATE DISSIPATION	250 MAX. WATTS
SCREEN DISSIPATION	12 MAX. WATTS

TYPICAL OPERATION

Class-AB_1, R-F Linear Amplifier (Frequencies to 175 Mc, per tube)

D-C Plate Voltage	1000	1500	2000 volts
D-C Screen Voltage	350	350	350 volts
D-C Grid Voltage*	—50	—50	—50 volts
Zero-Signal D-C Plate Current	100	100	100 ma
Single-Tone r-f (peak) Grid Voltage	50	50	50 volts
Single-Tone D-C Plate Current	250	250	250 ma
Single-Tone D-C Screen Current	25	20	15 ma
Single-Tone D-C Grid Current	0	0	0 ma
Single-Tone Plate Power Input	250	375	500 watts
Single-Tone Plate Power Output	125	225	325 watts
Two-Tone Average D-C Plate Current	170	170	170 ma
Two-Tone Average D-C Screen Current	6.0	5.0	4.0 ma

* Adjust to give stated Zero-Signal D-C Plate Current.

COOLING

Under conditions of normal room temperatures and installation in the SK-600 or SK-610 Air-System Socket and SK-606 Chimney, the 4X250B requires no forced air during standby periods where only the heater power is on. Anode cooling air may be started and stopped simultaneously with the power on the anode. At frequencies below 175 Mc and at 250 watts plate dissipation the quantity of air flow required is 3.6 cubic feet per minute. At this air flow the pressure drop across the Air-System Socket and the tube cooler is equal to 0.23 inch of water column.

Eimac Tubes for Single Sideband

4W300B
RADIAL-BEAM POWER TETRODE

The Eimac 4W300B is a compact power tetrode intended for use as an amplifier, oscillator, modulator or frequency multiplier over a wide range of frequencies extending into the UHF region. It is cooled by water and forced air.

A single 4W300B in a coaxial-cavity amplifier circuit will deliver up to 300 watts of useful power output at 400 Mc, although this is not the upper frequency limit of the tube.

The use of the Eimac SK-600 or SK-610 Air-System Socket, or a socket providing equivalent air cooling characteristics, is required.

GENERAL CHARACTERISTICS

ELECTRICAL

Cathode:	Oxide Coated, Unipotential	
	Minimum Heating Time	30 seconds
	Cathode-to-Heater Voltage	150 max. volts
Heater:	Voltage	6.0 volts
	Current	2.1 amperes
Grid-Screen Amplification Factor (Average)		5
Direct Interelectrode Capacitances (Average)		
	Grid-Plate	0.04 $\mu\mu$f
	Input	18.5 $\mu\mu$f
	Output	4.7 $\mu\mu$f
Transconductance (E_b = 500v., E_{c2} = 250v., I_b = 200 ma)		12,000 μmhos
Frequency for Maximum Plate Voltage Ratings		400 Mc
(All other Maximum Ratings applicable to 500 Mc)		

MECHANICAL

Base	9-pin, special
Recommended Socket	SK-600 or SK-610 Air-System Socket
Mounting	Vertical, base down or up
Maximum Over-all Dimensions	
Length	3.31 inches
Diameter	1.56 inches
Seated Height	2.75 inches
Net Weight	5.25 ounces

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 screen currents.

RADIO-FREQUENCY LINEAR POWER AMPLIFIER
Class AB_1 (one tube)

MAXIMUM RATINGS

D-C PLATE VOLTAGE	2000 MAX. VOLTS
D-C SCREEN VOLTAGE	400 MAX. VOLTS
D-C PLATE CURRENT	250 MAX. MA
PLATE DISSIPATION	250 MAX. WATTS
SCREEN DISSIPATION	12 MAX. WATTS

TYPICAL OPERATION

Class-AB, R-F Linear Amplifier (Frequencies to 175 Mc, per tube)

D-C Plate Voltage	1000	1500	2000 volts
D-C Screen Voltage	350	350	350 volts
D-C Grid Voltage*	—50	—50	—50 volts
Zero-Signal D-C Plate Current	100	100	100 ma
Single-Tone r-f (peak) Grid Voltage	50	50	50 volts
Single-Tone D-C Plate Current	250	250	250 ma
Single-Tone D-C Screen Current	25	20	15 ma
Single-Tone D-C Grid Current	0	0	0 ma
Single-Tone Plate Power Input	250	375	500 watts
Single-Tone Plate Power Output	125	225	325 watts
Two-Tone Average D-C Plate Current	170	170	170 ma
Two-Tone Average D-C Screen Current	6.0	5.0	4.0 ma

* Adjust to give stated Zero-Signal D-C Plate Current.

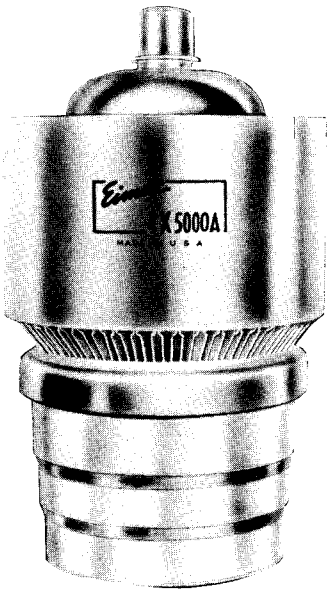
COOLING

The water-cooled anode requires 1/16 gallon (one-half pint) of cooling water per minute for the rated plate dissipation of 300 watts. The outlet water temperature should not exceed 70°C. The inlet water pressure should not exceed 50 pounds per square inch. The pressure drop across the anode at the stated flow rate is approximately 0.02 pound per square inch, which is negligible compared to the drop in the associated piping.

The base and the metal-to-glass seals of the tube must be cooled by forced circulation of air through the socket. At frequencies below 30 Mc a quantity of one cubic foot per minute is sufficient, at which volume the pressure drop across the socket and tube base is 0.1 inch of water column. As the frequency of operation is increased the quantity of air must be increased in order to limit the temperature of the seals.

4X5000A
RADIAL-BEAM POWER TETRODE

Eimac Tubes for Single Sideband



The Eimac 4X5000A Ceramic Radial-Beam Power Tetrode is a compact, forced-air-cooled tube with a maximum plate-dissipation rating of 5000 watts. It is intended for use as an oscillator, amplifier or modulator at frequencies below 30 Mc. The characteristics of the 4X5000A make it particularly suitable for single-sideband linear amplifier service. The use of the Eimac SK-300 Air-System Socket, or a socket providing equivalent air cooling characteristics, is required.

GENERAL CHARACTERISTICS

ELECTRICAL

Filament: Thoriated tungsten	
Voltage	7.5 volts
Current	75 amperes
Grid-Screen Amplification Factor (Average)	5.0

Direct Interelectrode Capacitances (Average)

	Grounded Cathode	Grounded Grid
Feedback	0.75 $\mu\mu$f	0.14 $\mu\mu$f
Input	106 $\mu\mu$f	47 $\mu\mu$f
Output	18 $\mu\mu$f	18 $\mu\mu$f

MECHANICAL

Base	Special
Recommended Socket	SK-300 Air-System Socket
Mounting Position	Vertical, Base down or up
Cooling	Forced-Air
Maximum Over-all Dimensions	
Length	8 3/4 inches
Diameter	4 7/8 inches
Net Weight (approx.)	9 1/2 pounds

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

RADIO-FREQUENCY LINEAR POWER AMPLIFIER—Class AB_1 (one tube)

MAXIMUM RATINGS

D-C PLATE VOLTAGE	7500 MAX. VOLTS
D-C SCREEN VOLTAGE	1500 MAX. VOLTS
D-C PLATE CURRENT	4.0 MAX. AMPERES
PLATE DISSIPATION	5000 MAX. WATTS
SCREEN DISSIPATION	250 MAX. WATTS

TYPICAL OPERATION

Class-AB_1 R-F Linear Amplifier (Frequencies to 30 Mc, per tube)

D-C Plate Voltage	5000	6000	7500 volts
D-C Screen Voltage	1000	1150	1250 volts
D-C Grid Voltage*	—210	—240	—300 volts
Zero-Signal D-C Plate Current	670	560	450 ma
Single-Tone r-f (peak) Grid Voltage	210	240	300 volts
Single-Tone D-C Plate Current	1430	1650	1860 ma
Single-Tone D-C Screen Current	250	215	200 ma
Single-Tone D-C Grid Current	0	0	0 ma
Single-Tone Plate Power Input	7000	10000	14000 watts
Single-Tone Plate Power Output	5200	7200	10000 watts
Two-Tone Average D-C Plate Current	910	1050	1150 ma
Two-Tone Average D-C Screen Current	60	55	50 ma

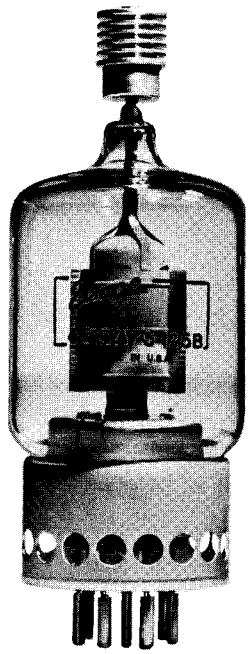
* Adjust to give stated Zero-Signal D-C Plate Current.

COOLING

At 5000 watts plate dissipation 120 CFM of air must be supplied. This corresponds to a pressure drop of 1.25" water column across the cooler. The base of the tube is cooled by circulating air of sufficient quantity to maintain seal temperatures below 200°C. For maximum cooling efficiency, the Eimac SK-300 Air-System Socket is recommended.

Eimac Tubes for Single Sideband

4E27A/5-125B
RADIAL-BEAM POWER PENTODE



The Eimac 4E27A/5-125B is a power pentode intended for use as a modulator, oscillator or amplifier. The driving power requirement is very low, and neutralization problems are simplified or eliminated entirely. The tube has a maximum plate-dissipation rating of 125 watts and a maximum plate voltage rating of 4000 volts at frequencies up to 75 Mc. Cooling is by convection and radiation. Type 4E27A/5-125B unilaterally replaces type 4E27.

The 4E27A/5-125B in class-C r-f service will deliver up to 375 watts plate power output with less than 2 watts driving power. It will deliver up to 75 watts of carrier for suppressor modulation.

Two 4E27A/5-125B's will deliver up to 30 watts maximum-signal plate power output in class AB_1 modulator service, 400 watts in class AB_2 with less than 1 watt driving power.

GENERAL CHARACTERISTICS

ELECTRICAL

Filament: Thoriated tungsten	
Voltage	5.0 volts
Current	7.5 amperes
Grid-Screen Amplification Factor (Average)	5.0
Direct Interelectrode Capacitances (Average)	
Grid-Plate	0.08 $\mu\mu$fd
Input	10.5 $\mu\mu$fd
Output	4.7 $\mu\mu$fd
Transconductance (I_b = 50 ma., E_b = 2500v., E_{c2} = 500v., E_{c3} = 0v.)	2150 μmhos
Highest Frequencies for Maximum Ratings	75 Mc.

MECHANICAL

Base	7-pin, metal shell
Socket*	E. F. Johnson Co. No. 122-237, or equivalent
Mounting Position	Vertical, base down or up
Cooling	Convection and radiation
Recommended Heat Dissipating Plate Connector	Eimac HR-5
Maximum Over-all Dimensions	
Length	6.19 inches
Diameter	2.75 inches
Net Weight (Average)	6.0 ounces
Shipping Weight	2.0 pounds

* See "Cooling" below.

RADIO-FREQUENCY LINEAR POWER AMPLIFIER—Class AB_1 (one tube)

MAXIMUM RATINGS

D-C PLATE VOLTAGE	4000 MAX. VOLTS
D-C SCREEN VOLTAGE	750 MAX. VOLTS
D-C PLATE CURRENT	200 MAX. MA
PLATE DISSIPATION	125 MAX. WATTS
SUPPRESSOR DISSIPATION	20 MAX. WATTS
SCREEN DISSIPATION	20 MAX. WATTS

TYPICAL OPERATION

Class AB_1, R-F Linear Amplifier (Frequencies to 75 Mc, per tube)

D-C Plate Voltage	1500	2000	2500	3000	3500	4000 volts
D-C Suppressor Voltage	0	0	0	0	0	0 volts
D-C Screen Voltage	750	705	600	555	510	450 volts
D-C Grid Voltage*	—130	—120	—110	—100	—95	—90 volts
Zero-Signal D-C Plate Current	55	40	35	30	25	20 ma
Single-Tone r-f (peak) Grid Voltage	130	120	110	100	95	90 volts
Single-Tone D-C Plate Current	175	160	130	115	105	90 ma
Single-Tone D-C Screen Current	13	7.0	5.0	4.0	3.3	2.7 ma
Single-Tone D-C Grid Current	0	0	0	0	0	0 ma
Single-Tone Plate Power Input	265	320	325	345	355	360 watts
Single-Tone Plate Power Output	155	210	225	250	265	275 watts
Two-Tone Average D-C Plate Current	125	115	90	80	75	60 ma
Two-Tone Average D-C Screan Current	5.0	2.5	1.5	1.2	0.9	0.7 ma

* Adjust to give stated Zero-Signal D-C Plate Current.

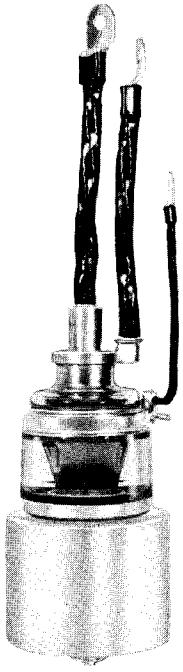
Note: Typical operation data are based on conditions of adjusting the r-f grid drive to a specified plate current, maintaining fixed conditions of grid bias, screen voltage and suppressor voltage. It will be found that if this procedure is followed, there will be little variation in power output between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

COOLING

Provision must be made for the free circulation of air through the socket and the holes in the base of the tube. In addition, a heat-dissipating connector (Eimac HR-5 or equivalent) is required at the plate terminal. Under normal operating conditions below 30 Mc and at room temperature, the tube will be adequately cooled by free circulation of the air. If the ambient temperature is high or the air circulation is impeded, it may be necessary to provide some means of moving the air past the tube and through the base to maintain the temperatures within their maximum-rated values of 225°C.

3X3000F1
LOW-MU TRIODE

Eimac Tubes for Single Sideband



The Eimac 3X3000F1 is a low-mu forced-air-cooled power triode intended for use as amplifier, oscillator or modulator. The maximum-rated plate dissipation is 3000 watts.

Two 3X3000F1's in Class-AB$_1$ audio or radio-frequency linear amplifier service will deliver up to 10 kilowatts maximum-signal plate power output at 6000 plate volts without drawing grid current.

GENERAL CHARACTERISTICS

ELECTRICAL

Filament: Thoriated tungsten	
Voltage	7.5 volts
Current	51 amperes
Amplification Factor (Average)	5
Direct Interelectrode Capacitances (Average)	
Grid-Plate	17 $\mu\mu$fd
Grid-Filament	29 $\mu\mu$fd
Plate-Filament	2.5 $\mu\mu$fd
Transconductance (I_b = 1.0 amp., E_b = 3000v.)	11,000 μmhos

MECHANICAL

Mounting Position	Vertical, base down or up
Cooling	Forced air
Maximum Temperatures:	
Grid and Filament Seals	150°C
Anode Cooler Core	250°C
Maximum Over-all Dimensions:	
Length (except for flexible filament leads)	9.0 inches
Diameter	4.16 inches
Net Weight	6.0 pounds
Shipping Weight	17 pounds

RADIO-FREQUENCY LINEAR POWER AMPLIFIER—Class AB$_1$ (one tube)

MAXIMUM RATINGS

D-C PLATE VOLTAGE	6000 MAX. VOLTS
D-C PLATE CURRENT	2.5 MAX. AMPERES
PLATE DISSIPATION	3000 MAX. WATTS
GRID DISSIPATION	50 MAX. WATTS

TYPICAL OPERATION

Class-AB$_1$ R-F Linear Amplifier (Frequencies to 30 Mc, per tube)

D-C Plate Voltage	4000	5000	6000 volts
D-C Grid Voltage*	—540	—965	—1190 volts
Zero-Signal D-C Plate Current	500	400	385 ma
Single-Tone r-f (peak) Grid Voltage	540	965	1190 volts
Single-Tone D-C Plate Current	1000	1200	1330 ma
Single-Tone D-C Grid Current	0	0	0 ma
Single-Tone Plate Power Input	4000	6000	8000 watts
Single-Tone Plate Power Output	2000	3600	5000 watts
Two-Tone Average D-C Plate Current	650	780	870 ma

* Adjust to give stated Zero-Signal D-C Plate Current. This value can be expected to vary ±15%.

COOLING

The 3X3000F1 requires an air-flow of 120 cubic feet per minute through the anode cooler. This corresponds to a pressure drop across the cooler of 2.2 inches of water column. A flow of 6 cubic feet per minute must also be directed into the filament stem structure, between the inner and outer filament conductors. The air-flow must be started when power is applied to the filament, and must continue without interruption until all electrode voltages have been removed from the tube. It is advisable to permit the air-cooling system to operate for two minutes or more after the removal of power. These air requirements are based upon operation at an ambient temperature of 20°C and at sea level.

NOTE OF CAUTION

When tetrodes are operated in grounded-grid circuits, Eitel-McCullough, Inc., recommends the use of the conventional tetrode connection instead of the high-mu triode connection (control and screen grids connected together), particularly in radio-frequency circuits.

Two distinct methods of connecting tetrode tubes into grounded-grid radio-frequency amplifiers are in common use. Each method provides for grounding the screen and the control grid with respect to the radio-frequency signal voltages. The tetrode connection provides for normal d-c bias and screen voltages to be applied to the tube, with the grid and screen by-passed to ground. The high-mu triode connection is made by direct connection of the grid and the screen to ground.

Amplifiers using high-mu triode-connected tetrodes require somewhat more driving power than do amplifiers with conventionally connected tetrodes. Furthermore, the entire driving voltage appears between the grid and the cathode, and there is no grid bias voltage to be overcome before grid current can flow. As a result of the large driving voltage and high grid current flow, triode-connected tetrodes often operate with control grid dissipation powers in excess of the manufacturers' ratings. This may happen inadvertently if the grid circuit has only a single current meter because 60-75% of the combined grid current may be to the control grid in such a circuit. In the event that the plate circuit loading is not heavy enough, the power formerly fed through the amplifier into the output circuit becomes available to heat the control grid to even higher temperatures than those at which it would normally operate. Such action can destroy the tube in a short time. The use of grid-current overload relays of low coil resistance is recommended so that the driving power will be removed before overheating can damage the tube.