

BUILD YOUR OWN TRANSMITTER



A GUIDE FOR DESIGNERS

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This bulletin has been compiled by Eimac engineers to provide others with data necessary for the construction of a complete transmitter. It was prepared as a guide, with emphasis on dependability and satisfactory operation. The Eimac tubes which are indicated for use in the output stages, both radio - frequency and audio - frequency, in each of the several power classifications, have proved themselves eminently capable of that kind of service.

Throughout the equipment, the number of tube types is kept to a minimum, so the station can operate with smallest possible stock of spare tubes for stand-by purposes. All components are selected of ample ratings to give the long trouble-free operation essential to broadcast service.

Brief and to the point, the descriptions to follow include the salient features of the stations from microphone input circuits to antenna systems. Microphones, pickups, and antennas are left to the discretion of the user. Microphone and pickup selection is largely a matter of taste, while the an-

tenna system is dependent upon the type of service contemplated and to a large degree on operating frequency.

Power outputs of the transmitters described are 250 watts, 1 kw, 5 kw, and 10 kw. Besides the transmitters, speech amplifiers and associated studio equipment are shown in circuit detail complete with parts lists.

Each transmitter uses the same studio equipment to provide a high-quality audio signal to the modulator. Also, each transmitter with the exception of the 250 watt size uses a universal radio-frequency driver for excitation of the final amplifier. The 250-watt transmitter is a modification of this driver and is separately shown with its associated modulator.

This transmitter uses the famous Eimac 4-250A power tetrode which requires less than four watts r-f driving power and consequently uses a greatly simplified overall circuit to reach a given power output.

RADIO COMMUNICATION, the first electron-tube application, has continually called for better tubes as its needs have expanded to greater powers and higher frequencies. In this technical advance, Eimac tubes have long led the field.

Today, in the most exacting broadcast service in existence, the new US 88-108 Mc FM band, Eimac tubes are to be found in each of the 700-odd transmitters in operation. In the Medium—and High-Frequency bands—those covered in the engineering data which follows—Eimac tubes have thoroughly proved themselves in commercial, broadcast, emergency, airline, industrial, and military services.



CONTENTS

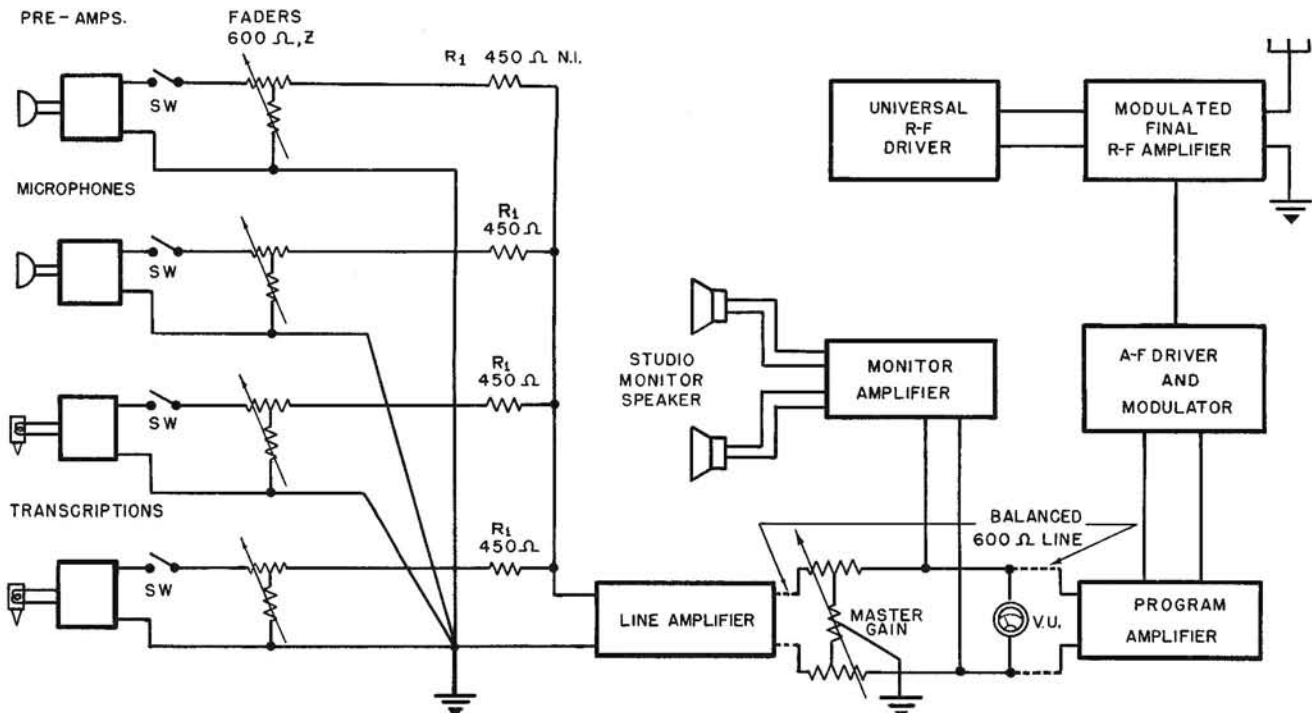
Block diagram and general notes - - - - -	Page 3
Universal R-F Driver - - - - -	Page 6
250-watt Transmitter - - - - -	Page 8
1-kw Transmitter - - - - -	Page 9
5-kw Transmitter - - - - -	Page 10
10-kw Transmitter - - - - -	Page 11
Preamplifier, line amplifier, and power supply - - - - -	Page 12
Monitor and program amplifier - - - - -	Page 13

THE BASIC SYSTEM

Illustrated below is a block diagram, Fig. 1, showing schematically the arrangement of units for a complete application of the amplifiers to be described on succeeding pages. The gear represented by each of the blocks is individually described on the page indicated within the block. Microphones, transcription pickups, and antennas are omitted from the discussion and thus no impedance value is specified for the preamplifier input.

It will be noted that in each circuit a separate inductor is used to feed the modulated d-c to the r-f stage. This method permits a compact modulation transformer without danger of audio distortion resulting from secondary-current saturation.

Vacuum Capacitors. To reduce bulk in the final r-f amplifier, Eimac vacuum capacitors can be used to advantage for padding tank circuits as well as for



GENERAL NOTES

Control-circuit protection for the Eimac 4-250A tetrode is indicated in the driver and 250-watt transmitter diagrams and similar precautions can be applied to all the transmitters. A time-delay relay should be arranged to withhold the application of high voltage for 30 seconds after the cathodes are energized in the cases of Eimac 866A/866, RX21, or 872A/872 mercury-vapor rectifiers. Also, the method of application of power to the transmitters should always prevent the turning on of high-voltage before the filament, cooling air, and bias supplies have been energized. This will afford protection to both the equipment and operating personnel.

References. Diagrams are marked with significant values of voltage and current to provide the desired input conditions in each case. For more information on operating conditions, Eimac tube data

coupling and neutralization. Tank circuits shown are arranged for capacitance variation to achieve resonance. It is frequently desirable, however, to make only the inductance variable. With this arrangement the capacitive branch of the tuned circuit is not so subject to dust accumulation or atmospheric conditions with resulting arc-over. Comparatively small, low-cost, and highly-efficient circuits are thus possible and replacement maintenance is minimized.

Cooling blowers must be installed to direct air at the plate and grid seals of Eimac 450T or 2000T tubes. The 2000T socket is arranged with duct which permits air to be forced into the base and out by way of base vent holes. A low pressure blower is required.

Sockets for Eimac 4-250A tubes must be provided with 5 ventilating holes which match holes in the tube bases. Here the chassis is entirely en-

closed and a 2-in. fan is mounted in a clearance hole in the chassis to force air through the chassis interior, through the base of the tube, and out the vent holes provided in the base.

The following are considered good engineering rules in regard to cooling and ventilating of the transmitters described:

1. The envelopes of all tubes should be generously provided with moving air as indicated in the diagrams.
2. To protect equipment, air entering the transmitter should be filtered free of dust. This air is best secured by duct from outside the transmitter building except in cold climates. Maintain a transmitter temperature in the neighborhood of 40 C wherever possible. This will allow the rectifier tubes to operate at an optimum temperature, as well as keep other tubes and components at a favorable temperature.
3. The plate, grid and filament seals should be cooled by blower. Of the tube types included here, only the 4-250A and 2000T require filament seal cooling. Flexible copper ribbon leads making good thermal as well as electrical contact at the plate and grid terminals will, in combination with Eimac heat-dissipating connectors, maintain adequate seal cooling.

Tuning the transmitter, when ready for testing can be accomplished when the following procedure is used with crystal and buffer circuits functioning. Steps 1, 2, 3, and 5 are common to the universal exciter and 250 watt modulator transmitter. Step 4 applies to the 1—, 5—, or 10-KW amplifiers.

1. Bias on the Eimac 4-250A is adjusted by means of R_{11} until approximately -100 volts bias is present at M_3 (to ground). Only the exciter power supply is used during this operation.
2. Adjustment is made at R_7 to provide approximately 10 ma. of grid current at M_3 with the 4-250A filament on and the blower running. Check C_2 and C_5 for resonance.
3. With the 4-250A screen resistor set at maximum resistance (R_{11} in the driver unit) apply plate voltage to the 4-250A with minimum coupling between L_3 and L_1 . Tune the plate circuit to resonance (minimum current) then increase coupling and raise screen voltage (R_{11}) to secure the desired output. Do not permit excessive screen current (M_3) which will exist if either plate voltage or load is removed while screen voltage and drive are present. Once the correct conditions of voltage and load are established, relays RY_1 and RY_2 will protect the 4-250A in this respect. Adjust M_3 to approximately 11 ma. (R_7).
4. In the 1—, 5—, or 10-kw transmitter, the following stage can then be tuned and neutralized using minimum antenna coupling and zero plate voltage with filament and bias power on. A close check on neutralization can be had by varying the plate tank tuning and adjusting the neutralization capacitors until no deflection is

noted in the grid current meter as the plate tank is tuned through resonance.

An r-f milliammeter or other sensitive indicator can be used then to indicate resonance and re-check neutralization. Plate voltage can be applied and coupling to the antenna increased to the indicated value of input (see diagram involved) as shown by the d-c plate-current meter. Readjust driving power as determined by the grid-current meter and check all tuned circuits.

In the foregoing procedure, the assumptions made are that unwanted oscillations and feedback are not present and that all tuned circuits including the antenna are capable of resonance.

5. Before program presentation, a check on modulated characteristics of the transmitter is recommended. Final adjustments are made during observation of audio output versus rectified r-f output by means of an oscilloscope in conjunction with an audio signal-generator as a modulation source. Audio output can be taken from a high-resistance divider connected to the high side of the modulation-transformer secondary through a suitable capacitor to block d-c from the resistor. The other end of this resistor is connected to ground. A few volts of audio can then be tapped from ground upward on the divider to operate the horizontal plates on the oscilloscope.

The resulting pattern will be an inclined straight line² for conditions of 100 per cent or less modulation, circuit adjustments being correct. Studio and station volume indicators can be set to show maximum program level short of over-modulation or distortion as seen in the oscilloscope trace. On peaks of modulation, this line should show no curvature at either end.

Distortion in any unit throughout the audio system can be found by applying amplifier input to one set of oscilloscope plates versus amplifier output to the other set of plates. The inclined line pattern should be free of curvature up to maximum program level. Due to phase changes in an amplifier with variation of frequency, a frequency from the variable audio oscillator should be selected for this test which will give a single line trace on the oscilloscope screen. This point will usually be found in the middle frequencies.

SPEECH AMPLIFIERS

POWER SUPPLY. Preamplifier and line amplifiers³ are provided with a single power supply which is capable of handling up to eight preamplifiers and one line amplifier of the sizes shown.

PREAMPLIFIERS. Each of these preamplifiers can be built to include a program switch and fader. When more than one studio is contemplated, this switch can also be used to deactivate a studio monitor speaker, thus preventing inopportune feedback.

The fader or mixer system is shown for use with

a four-position studio set up. Other arrangements require modification of the value of the non-inductive 450-ohm resistor R_1 .⁴ Lines should be carefully shielded as a guard against external electric or magnetic fields and an effective ground should be used to minimize undesirable disturbances. Grounding of the common leads from faders or mixers is particularly important in this respect. This has been emphasized in the block diagram on page 2.

LINE AMPLIFIER. A line amplifier is included to compensate for the insertion losses of faders and lines. It raises the power level to one suitable for transmission from studio to transmitter. In the output circuit is located a master gain control followed by a monitor amplifier which is provided with a high-impedance ungrounded input circuit to avoid disturbing the balanced 600-ohm line. The volume indicator allows a predetermined program level to be transmitted to the line.

This indicator should include a balanced high-impedance attenuator for adjustment to a reference value found desirable at the transmitter. If the transmitter and studio are separated by any appreciable distance, a duplicate volume indicator and master gain control at the transmitter will be found invaluable. It will allow a check on line conditions and permit adjustments by the transmitter engineer when circumstances require.

Maximum operating level of the program line can be defined as that needed to bring the transmitter to full modulation at least 60 db above the inherent zero-signal line noise. Obviously, the line should be as quiet as possible.

Where the line is several miles long some equalization will be required to restore the high-frequency response. One way of accomplishing this is to precede the program amplifier and optional gain control with a filter consisting of a parallel-resonant circuit in series with a variable resistor. This filter is placed across the line to attenuate frequencies other than the filter resonant frequency to a degree depending on the frequency and the value of R in series.⁵ A setting can usually be found that will restore the frequency response satisfactorily.

PROGRAM AMPLIFIER. Located at the transmitter, the program amplifier restores the level to a value adequate for properly exciting the modulator grids. A fixed H attenuator (600-600 ohms)

can be used to establish the desired operating level into the program amplifier once the line level has been determined.

All amplifiers shown will give excellent frequency response assuming that high-quality transformers are used. Noise level and distortion will be found to be low. Negative feed-back has been used advantageously to produce these desirable results.

Additional equipment not indicated but worth consideration, may consist of a spare 600-ohm line for use as a studio-transmitter telephone or telegraph circuit and also as an emergency program line. A transmitter output monitor will be found valuable for overall performance tests in conjunction with an audio-frequency signal generator and should, of course, have excellent frequency response in itself.

AMPLIFIER OUTPUT CHARACTERISTICS

Amplifier	Maximum Output V.U.	Approx. Gain db	Adjus. to db
PRE-AMP	16	38	28 or 18
LINE	28	55	45 or 35
MONITOR	43	43	variable
PROGRAM	43	63

¹The plate choke can in general be made with a greater inductance than that of the grid choke to avoid possible parallel oscillation on unwanted frequencies due to tuned-plate tuned-grid effect.

²If desired, a trapezoidal pattern can be obtained by applying r-f to the vertical plates of the oscilloscope directly without first rectifying the r-f. The audio connection remains the same as for the inclined-line method. A high C/L ratio tuned circuit connected to the vertical-plate terminals will eliminate harmonic pick-up on the trapezoidal pattern.

³Provision is made in the preamplifier and line amplifier for a 10 db or 20 db reduction in gain for each unit.

⁴ R_1 (ohms) = line (& fader) impedance
 $\frac{\text{—line impedance}}{\text{numbers of faders}} = 600 - (600/4) = 450$ ohms.

⁵For a 6-kc equalizer, $L=0.0035$ h, $C=0.2$ μ f, $R=500$ -ohm variable; for an 8-kc equalizer, $L=0.004$ h, $C=0.1$ μ f, $R=500$ -ohm variable.

UNIVERSAL R-F DRIVER

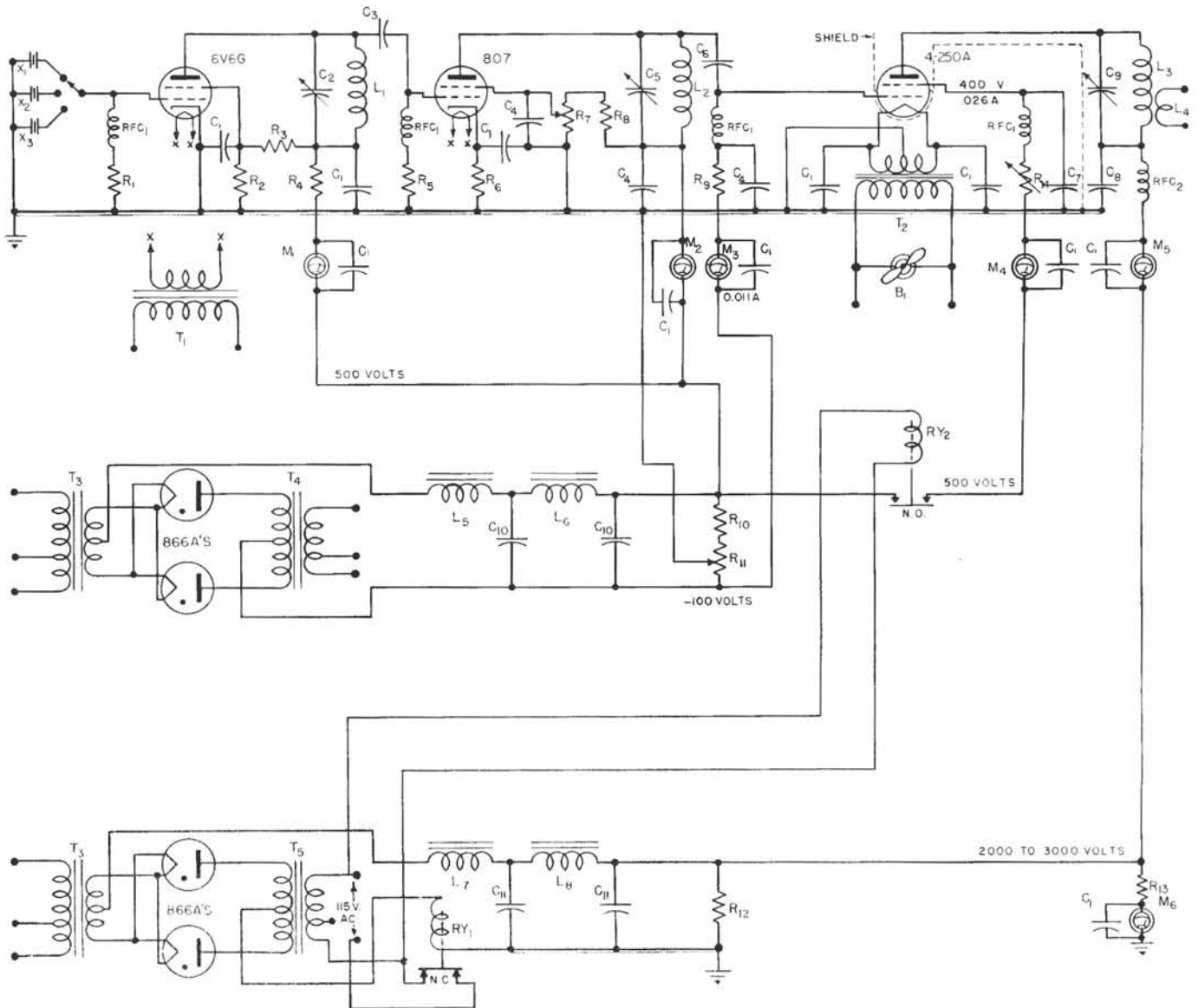
For any of the amplifier stages above the 250-watt class shown in the following pages, r-f driving power can be obtained from the simple driver unit diagrammed in Fig. 2. Use of an Eimac 4-250A power tetrode in the output stage of this unit makes possible a three-stage driver capable of exciting any of the power amplifiers including the 10-kw stage at frequencies up to 20 mc.

The crystal oscillator tube is a 6V6 operated at low plate and screen voltages. This is followed by an 807, which can be operated as either an amplifier or frequency doubler for output frequencies up to approximately 8 mc. Between 8 and 16 mc, the 807 is used as a frequency doubler. Above 16 mc, the 807 is operated as a frequency tripler. A variable resistor, R_7 , is provided for control of the 807 screen voltage, to allow convenient adjustment of the driving power to the 4-250A stage. Plate supply for this tube is adjustable between 2000 and 3000 volts

by means of taps on T_5 . This permits establishing proper plate voltage for driving chosen final amplifier. Plate current should not exceed 350 ma., in any case.

To prevent application of screen voltage to the 4-250A when plate voltage is off, relay RY_2 is arranged to remove the screen supply voltage when the primary of the plate supply transformer is not energized.

Due to the high gain of the 4-250A, the shielding between its plate circuit and all preceding circuits on the same frequency must be complete to prevent oscillation. It is particularly important to shield the plate of the 807 from the 4-250A plate circuit through the use of an effective shield partition or a complete enclosure. By-pass leads in the 4-250A stage should be short, and should be made to a common point on the chassis.



A small fan or blower is required to cool the 4-250A tube base. Openings are provided in this base to cool the leads and seals with air admitted through the socket under the chassis and exhausted via the holes in the metal shell above. A minimum flow of 5 cfm of cooling air should be passed through

the base. A convenient way of doing this is to position the fan blade in a circular opening in the chassis- a clearance hole for the fan diameter. A bottom cover is used on the chassis, and air is forced through the space below the chassis and exhausted through the tube base.

COMPONENT LIST FOR UNIVERSAL DRIVER DIAGRAM

CAPACITORS

- C₁ 0.006-uf 600-volt mica
 - C₂ Variable capacitor, 0.070-in. spacing-capacitance (uuf) = 2X wavelength (meters), approximately*
 - C₃ 0.003-uf 1200-volt mica
 - C₄ 0.006-uf 600-volt mica
 - C₅ Variable capacitor, 0.070-in. spacing-capacitance (uuf) = 2X wavelength (meters), approximately*
 - C₆ 0.003-uf 2500-volt mica
 - C₇ 0.006-uf 2500-volt mica
 - C₈ 0.005-uf 10,000-volt mica
 - C₉ Variable capacitor, 0.250-in. spacing-capacitance (uuf) = 2X wavelength (meters), approximately*
 - C₁₀ 4-uf 1000-volt oil-filled
 - C₁₁ 4-uf 4000-volt oil-filled
- *Effective capacitance across inductance at resonance.

RESISTORS

- R₁ 10,000-ohm 1-watt
- R₂ 15,000-ohm 1-watt
- R₃ 20,000-ohm 2-watt
- R₄ 8000-ohm 15-watt
- R₅ 6000-ohm 5-watt

- R₆ 250-ohm 10-watt
- R₇ 30,000-ohm 20-watt adjustable tap
- R₈ 20,000-ohm 20-watt
- R₉ 10,000-ohm 10-watt
- R₁₀ 20,000-ohm 20-watt
- R₁₁ 1000-ohm 100-watt adjustable tap
- R₁₂ 100,000-ohm 200-watt
- R₁₃ Voltmeter resistor
- R₁₄ 10,000-ohm 50-watt rheostat

TRANSFORMERS

- T₁ Secondary 6.3-volt, 5-amp; primary 115-volt
- T₂ Secondary 5-volt c-t, 20-amp; primary 105-, 110-, 115-, 120-volt tapped
- T₃ Secondary 2.5-volt c-t, 10-amp; primary 115-volt, 4500-volt insulation, tapped
- T₄ Secondary 1500-volt c-t, 300 ma.; primary 115-volt
- T₅ Secondary 4720-, 5900-, 7080-volt c-t, 500-ma; primary 115-volt

INDUCTORS

- L₁, L₂, L₃, L₄, Oscillator, buffer, and amplifier plate-tank and coupling-link coils inductance values depend on frequency
- L₅ 60/12-h swinging choke, 350-ma,

- 2000-volt insulation
 - L₆ 20-h, 350-ma, 2000-volt insulation
 - L₇ 60/12-h swinging choke, 500-ma, 3500-volt insulation
 - L₈ 20-h, 500-ma, 3500-volt insulation
 - RFC, 20-mh between 200 and 2000 kc, 2.5-mh above 2000 kc; 125-ma
 - RFC₂ 1-mh, 500-ma
- ### METERS
- M₁ 0-50 ma. d-c
 - M₂ 0-150 ma. d-c
 - M₃ 0-50 ma. d-c
 - M₄ 0-100 ma. d-c
 - M₅ 0-300 ma. d-c
 - M₆ 0-5000-volt d-c

MISCELLANY

- B, 3-inch fan or blower for circulating air through 4-250A base
- RY₁ 500-ma. plate-overload relay
- RY₂ Screen-voltage relay, 115-volt coil
- X₁, X₂, X₃, Quartz crystals desired frequencies or sub-multiples.

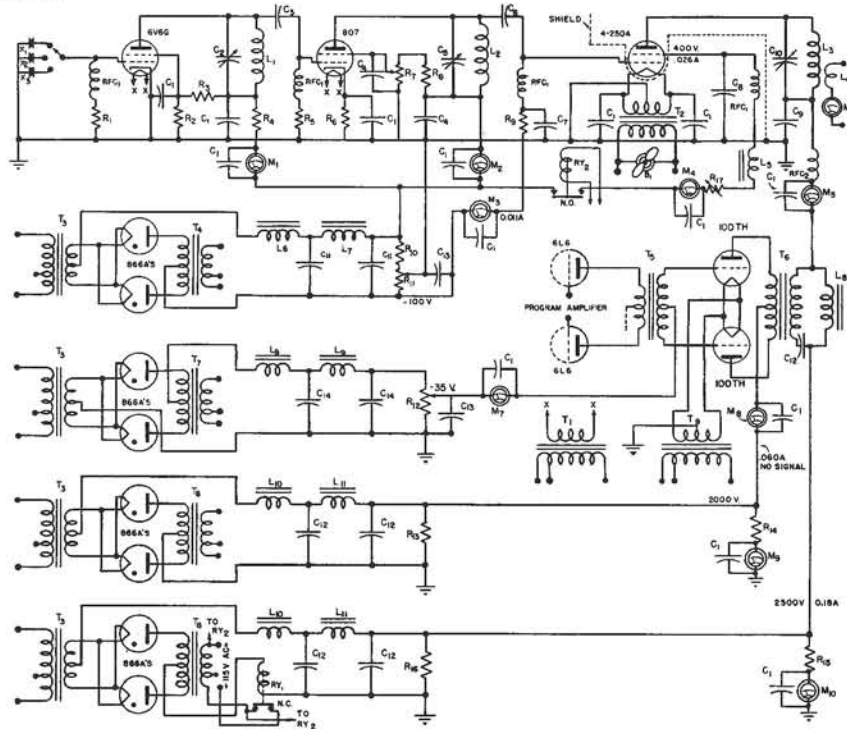
TUBES

- 6V6G, 807
- Eimac 866A
- Eimac 4-250A



250-WATT TRANSMITTER

The 250-watt transmitter presented schematically in Fig. 3 is a modification of the universal driver described on page 6. Like that unit it includes a single Eimac 4-125A tetrode but includes as well a pair of Eimac 100TH triodes. These remarkably versatile tubes are illustrated in Fig. 3 on page 14. Separate power supplies are provided for the two stages. The 100TH plates receive 2000 volts at 60 ma. with zero-signal (un-modulated). The 4-250A plate power runs 180 ma. from a 2500-volt supply. When modulation is present, plate currents can rise to several times the zero-signal condition. A component list for the 250-watt transmitter follows:



CAPACITORS

- C₁ 0.006-uf 600-volt mica
- C₂ Variable 0.070-in. spacing-capacitance (uuf) = 2X wavelength (meters), approximately*
- C₃ 0.003-uf 1200-volt mica
- C₄ 0.006-uf 600-volt mica
- C₅ Variable 0.070-in. spacing-capacitance (uuf) = 2X wavelength (meters), approximately*
- C₆ 0.003-uf 2500-volt mica
- C₇ 0.006-uf 600-volt mica
- C₈ 0.002-uf 2500-volt mica
- C₉ 0.005-uf 10,000-volt mica
- C₁₀ Variable 0.250-in. spacing-capacitance (uuf) = 1X wavelength (meters), approximately*
- C₁₁ 4-uf 1000-volt oil-filled
- C₁₂ 4-uf 4000-volt oil-filled
- C₁₃ 40-uf 600-volt oil-filled
- C₁₄ 8-uf 600-volt oil-filled

*Effective capacitance across inductance at resonance.

RESISTORS

- R₁ 10,000-ohm 1-watt
- R₂ 15,000-ohm 1-watt
- R₃ 20,000-ohm 2-watt
- R₄ 8,000-ohm 15-watt
- R₅ 6,000-ohm 5-watt
- R₆ 250-ohm 10-watt
- R₇ 30,000-ohm 20-watt, adjustable tap
- R₈ 20,000-ohm 20-watt
- R₉ 10,000-ohm 10-watt
- R₁₀ 20,000-ohm 20-watt
- R₁₁ 1,000-ohm 100-watt, adjustable tap
- R₁₂ 250-ohm 100-watt, adjustable tap
- R₁₃ 100,000-ohm 200-watt
- R₁₄ Voltmeter resistor

R₁₅ Voltmeter resistor

- R₁₆ 100,000-ohm 200-watt
- R₁₇ 10,000-ohm 50-watt, rheostat

TRANSFORMERS

- T₁ 6.3-volt, 5-amp; primary 115-volt; 600-volt insulation
- T₂ 5-volt c-t, 20-amp; primary tapped 105-, 110-, 115-, 120-volt; 600-volt insulation
- T₃ 2.5-volt c-t, 10-amp; primary tapped 105-, 110-, 115-, 120-volt; 4500-volt insulation
- T₄ 1500-volt c-t, 0.3-amp; primary 115-volt
- T₅ 20-watt driver transformer: primary 10,000-ohm impedance plate-to-plate c-t, d-c resistance approximately 600-ohms; secondary impedance 1330-ohms per side
- T₆ 400-watt modulation transformer: primary 15,000-ohm impedance plate-to-plate c-t; secondary 14,000-ohm, secondary not required to carry d-c
- T₇ 220-volt c-t, 0.5-amp; primary 115-volt
- T₈ 4720-, 5900-, 7080-volt c-t, 0.5-amp; primary 115-volt
- T₉ 5-volt c-t 20-amp; primary tapped 105-, 110-, 115-, 120-volt; 600-volt insulation

INDUCTORS

- L₁, L₂, L₃, L₄ Oscillator, buffer, and amplifier coils-inductance depends on frequency
- L₅ 12-h at 0.26 amp, d-c, 2000-volt insulation
- L₆ 60/12-h choke, 0.35-amp maximum, 2000-volt insulation, 110-ohm d-c

- L₇ 20-h choke at 0.35 amp, 2000-volt insulation, 130-ohm d-c
- L₈ 60-h modulation reactor, 0.2-amp, 7500-volt insulation
- L₉ 6-h choke at 0.5-amp, 1000-volt insulation, 50-ohm d-c
- L₁₀ 60/12-h choke, 0.3-amp maximum, 3500-volt insulation, 90-ohm d-c
- L₁₁ 20-h choke at 0.3-amp, 3500-volt insulation, 90-ohm d-c
- RFC₁ L depends on frequency
- RFC₂ L depends on frequency (see footnote 1 page 2)

MISCELLANY

- B₁ 3-inch fan or blower for circulation of air through 4-250A base
- RY₁ Plate overload relay to operate at 300 ma.
- RY₂ Screen protection relay, 115-volt coil
- X₁, X₂, X₃, Crystals for operating frequencies or sub-multiples

METERS

- M₁ 0-50-ma. d-c
- M₂ 0-150-ma. d-c
- M₃ 0-25-ma. d-c
- M₄ 0-100-ma. d-c
- M₅ 0-300-ma. d-c
- M₆ Ammeter, r-f, of size depending on antenna characteristics
- M₇ 0-25-ma. d-c
- M₈ 0-300-ma. d-c
- M₉, M₁₀ 0-3000-volt d-c

TUBES

- 6V6G, 807
- Eimac 4-250A
- Eimac 100TH
- Eimac 866A

ONE-KW TRANSMITTER

The circuit diagram shown in Fig. 4 includes an r-f amplifier, a modulator and a power-supply system capable of delivering a 1000-watt, 100-per-cent modulated carrier to the antenna system to be selected.

Two Eimac 450TH tubes in the final amplifier stage require approximately 50-watts of r-f driving power at carrier frequency. Plate voltage and current are respectively 3000 volts and 475 ma. The universal driver described on page 5 makes a convenient exciter unit for this amplifier.

Plate-modulating power for the class-C amplifier is supplied by a class-B modulator also employing Eimac 450TH's. A power supply is shown which provides 200 ma. (zero signal) at 3000 volts. The modulator requires a driver unit capable of delivering approximately 15 watts. This driving power can be obtained from the program-amplifier equipment described on page 13.

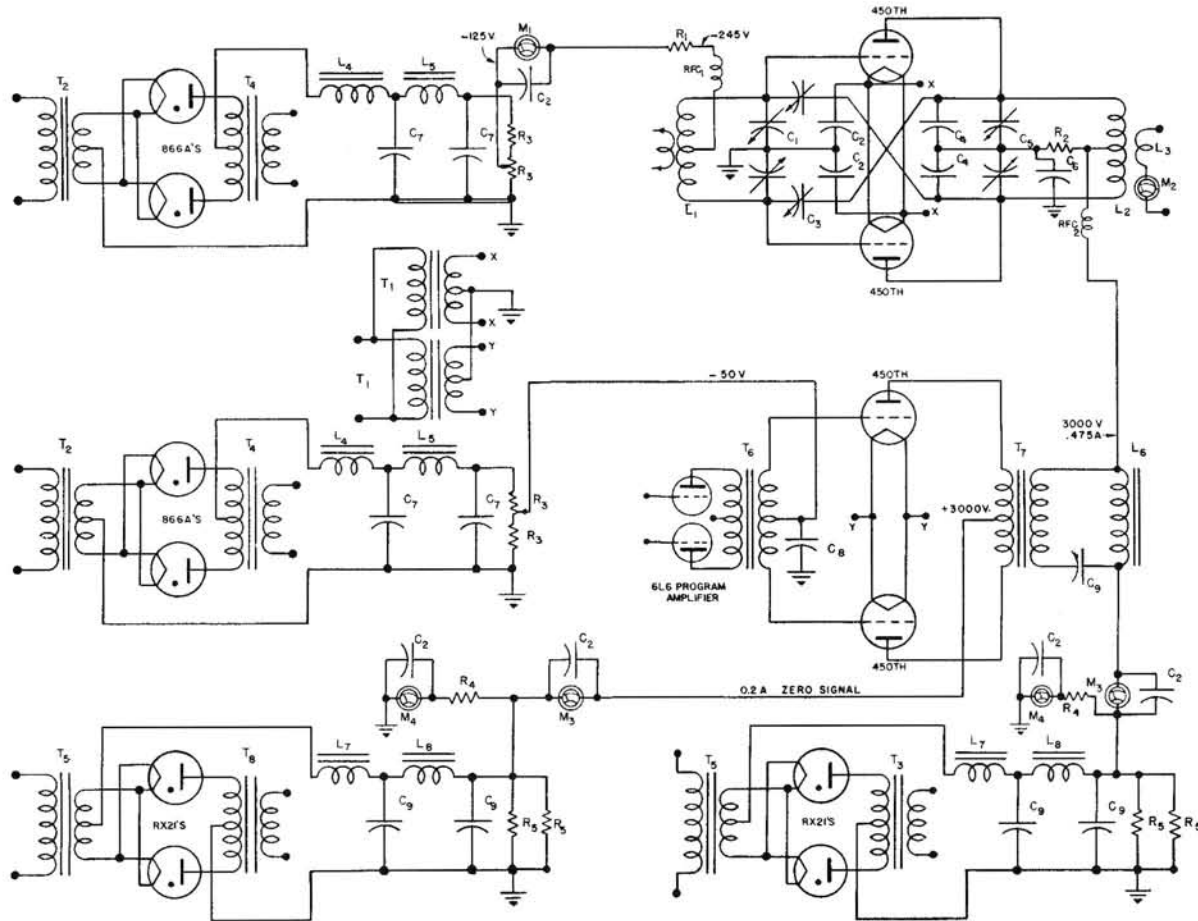


Fig. 4—Circuit of the 1-kw transmitter. Following is a component list which refers to Fig. 6

CAPACITORS

- C₁ Variable split-stator capacitor, 0.1-in. spacing, capacitance (uuf) = 2X wavelength (meters), approximately*
- C₂ 0.006-uf 600-volt mica
- C₃ 2-10-uuf 1-in. minimum spacing
- C₄ Eimac vacuum capacitor (see C₁)
- C₅ Variable split-stator capacitor, 0.6-in. spacing, capacitance of C₄ + C₁ (uuf) = 1X wavelength (meters)*
- C₆ 0.002-uf 12,500-volt mica
- C₇ 10-uf 600-volt, oil-filled
- C₈ 40-uf 600-volt, oil filled
- C₉ 4-uf 4000-volt, oil-filled

*Effective capacitance across inductance at resonance.

RESISTORS

- R₁ 1250-ohm 50-watt
- R₂ 10,000-ohm 10-watt
- R₃ 300-ohm 80-watt each adjustable tap
- R₄ Voltmeter resistor

R₅ 100,000-ohm 200-watt

TRANSFORMERS

- T₁ Secondary 7.5-volt c-t, 30-amp; primary 105-, 110-, 115-, 120-volt
- T₂ Secondary 2.5-volt c-t, 10-amp; primary 105-, 110-, 115-, 120-volt; 2500-volt insulation
- T₃ Secondary 2.5-volt c-t, 20-amp; primary 105-, 110-, 115-, 120-volt; 4500-volt insulation
- T₄ Secondary 750-volt c-t, 500-ma; primary 115-volt
- T₅ Secondary 7080-volt c-t, 750-ma.; primary 210-, 220-, 230-, 240-volt
- T₆ 20-watt driver transformer, 9000-ohm primary; 2.8 turns ratio, primary to 1/2 secondary
- T₇ 1000-watt modulation transformer, 7800-ohm primary to 6500-ohm secondary

INDUCTORS

- L₁, L₂, L₃ Grid, plate and antenna coils, inductance depends on frequency and antenna characteristics

L₄ 60/12-h swinging choke, 500-ma., 3500-volt insulation

- L₅ 20-h, 500-ma, 3500-volt insulation
 - L₆ 30-h 750-ma. modulation reactor, 7500-volt insulation
 - L₇ 40/8-h swinging choke, 750-ma., 4500-volt insulation
 - L₈ 20-h, 750-ma., 4500-volt insulation
- RFC₁, RFC₂ Radio-frequency chokes suitable for operating frequency (see footnote 1 on page 11)

METERS

- M₁ 0-200-ma., d-c
- M₂ Antenna r-f ammeter, range depends upon antenna characteristics
- M₃ 0-1-amp, d-c
- M₄ 0-5000-volt, d-c

*Effective capacitance across inductance at resonance.

TUBES

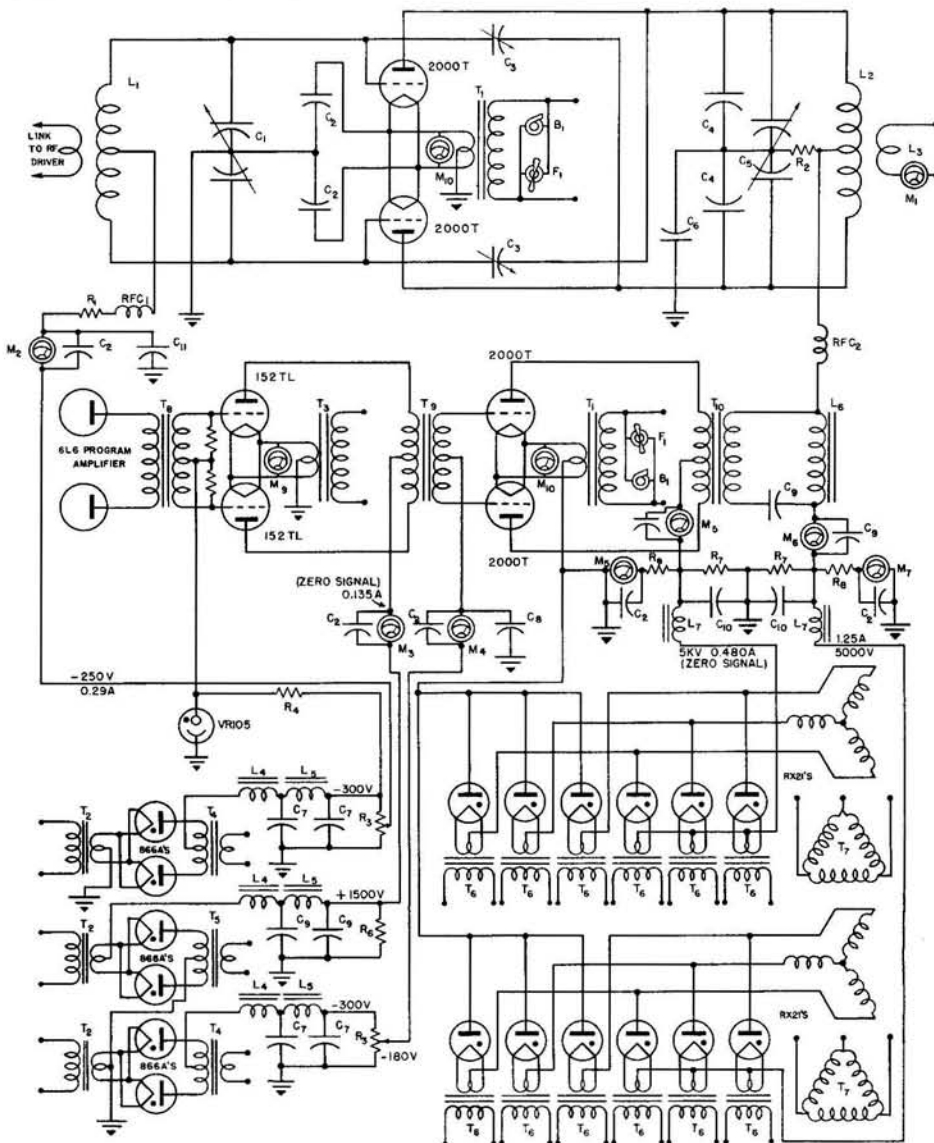
- Eimac 450TH
- Eimac RX21
- Eimac 866A

FIVE-KW TRANSMITTER

This radio-frequency amplifier and modulator unit (Fig. 5) is conservatively rated to deliver a power of 5-kw high-level-modulated to the antenna system as selected.

The final amplifier uses two Eimac 2000T triodes in a conventional push-pull amplifier circuit and requires approximately 330-watts of r-f grid driving power, which is amply available from the universal driver unit. See page 6. Plate power for the final amplifier comes from a 5000-volt 3-phase power supply. Plate current is 1.25 amp.

The class-B modulator also uses two Eimac 2000T's which obtain their drive from a pair of Eimac 152TL triodes operating as class-A-B amplifiers. Another 5000-volt power supply provides 480 ma. plate power at zero-signal input. Input to the 152TL stage can be obtained from the program amplifier described on page 13 of this bulletin. Under unmodulated conditions (zero signal) plate current for the two 152TL's is 135 ma. at 1500-volts.



The component list follows:

CAPACITORS

- C₁ Variable split-stator capacitor, 0.1-in. spacing, capacitance (uuf) = 2X wavelength (meters), approximately
- C₂ 0.006-uf 600-volt mica
- C₃ 2-10-uuf 1.5-in. minimum spacing
- C₄ Eimac vacuum capacitor (see C₂)
- C₅ Variable split-stator capacitor, 0.8-in. spacing, capacitance of C₄ + C₅ (uuf) = 0.75 X wavelength (meters)*

- C₆ 0.002-uf 12,500-volt mica
 - C₇ 10-uf 1000-volt, oil-filled
 - C₈ 40-uf 1000-volt, oil-filled
 - C₉ 4-uf 2500-volt, oil-filled
 - C₁₀ 4-uf 6000-volt, oil-filled
 - C₁₁ 0.006-uf 2500-volt, mica
 - *Effective capacitance across inductance at resonance
- ### RESISTORS
- R₁ 2100-ohm 200-watt
 - R₂ 10,000-ohm 50-watt
 - R₃ 500-ohm 200-watt adjustable-tap
 - R₄ 10,000-ohm 20-watt

- R₅ 750-ohm 20-watt
- R₆ 50,000-ohm 100-watt
- R₇ 50,000-ohm 1000-watt (5 10,000-ohm 200-watt)

R₈ Voltmeter resistor TRANSFORMERS

- T₁ Secondary 10-volt c-t, 60-amp; primary 105-, 110-, 115-, 120-volt
- T₂ Secondary 2.5-volt c-t, 10-amp; primary 105-, 110-, 115-, 120-volt; 4500-volt insulation
- T₃ Secondary 5-volt c-t, 25-amp; primary 105-, 110-, 115-, 120-volt
- T₄ Secondary 600-, 800-volt c-t, 500-ma.; primary 105-, 110-, 115-, 120-volt
- T₅ Secondary 3580-volt c-t, 500-ma.; primary 105-, 110-, 115-, 120-volt
- T₆ Secondary 2.5-volt c-t, 10-amp; primary 115/230-volt; 7500-volt insulation
- T₇ Secondary 2200-volt per leg, y-connected; primary 220-volt 3-phase 10.5-kva delta-connected
- T₈ 20-watt driver transformer, 9000-ohm primary; 3.45:1 turns ratio, primary to 1/2 secondary
- T₉ 130-watt driver transformer, 5100-ohm primary; 1.95:1 turns ratio, primary to 1/2 secondary
- T₁₀ 3500-watt modulation transformer, 4900-ohm primary c-t to 4000-ohm secondary

INDUCTORS

- L₁, L₂, L₃ Grid, plate and antenna coils, inductance depends on frequency and antenna characteristics.
- L₄ 60/12-h swinging choke, 500-ma., 3500-volt insulation
- L₅ 20-h, 500-ma., 3500-volt insulation
- L₆ 30-h, 1.25-amp, modulation reactor, 12,500-volt insulator
- L₇ 10-h, 2-amp, 7500-volt insulation
- RFC₁ Depends on frequency
- RFC₂ Depends on frequency (see footnote 1 on page 11)

METERS

- M₁ Antenna r-f ammeter, range depends upon antenna characteristics
- M₂ 0-0.5-amp, d-c
- M₃ 0-300-ma., d-c
- M₄ 0-0.5-amp, d-c
- M₅, M₆ 0-2.5-amp, d-c
- M₇, M₈ 0-7500-volt, d-c
- M₉ 0-7.5-volt, a-c
- M₁₀ 0-15-volt, a-c

MISCELLANY

- B₁, B₂ Blower for 2000T seal cooling 12 cfm
- F₁, F₂ Fan for 2000T envelope cooling, 10-in. blades

TUBES

- Eimac 2000T
- Eimac 152TL
- Eimac RX21
- Eimac 866A

TEN-KW TRANSMITTER

Fig. 6 shows the arrangement of parts in a final amplifier and modulator which will deliver a power of 10 kw, high-level-modulated, to the antenna system.

The audio driver stage consists of two Eimac 304TL triodes operating in class AB₁. They can obtain their driving power from the program amplifier discussed on page 13, and their plate power from a 1500-volt supply at 270 ma., zero signal input. Output of the 304TL stage is used to drive the grids of four Eimac 2000T triodes used in a push-pull parallel class-B modulator stage. Plate input is 5000-volts at 960 ma. zero signal.

The final amplifier uses four Eimac 2000T triodes in a push-pull-parallel circuit and requires approximately 650 watts of grid driving power which is readily available from the universal driver unit described on page 6. Plates receive power from a separate 5-kv supply at 2.5 amp.

The component list follows:

RESISTORS

- R₁ 1050-ohm 200-watt
- R₂ 10,000-ohm 50-watt
- R₃ 500-ohm 400-watt
- R₄ 10,000-ohm 20-watt
- R₅ 750-ohm 20-watt
- R₆ 50,000-ohm 100-watt
- R₇ 50,000-ohm 1000-watt
- R₈ Voltmeter multiplier resistor
- R₉ 30-ohm 100-watt
- PS 20-ohm carbon 5-watt, space wound with 8 turns No. 12 wire

METERS

- M₁ Antenna r-f ammeter, scale depends upon antenna resistance
- M₂ 0-1-amp d-c
- M₃ 0-750-ma. d-c
- M₄ 0-1-amp d-c
- M₅ 0-5-amp d-c
- M₆ 0-5-amp d-c
- M₇ 0-7.5-kv volts d-c
- M₈ 0-7.5-kv volts d-c
- M₉ 0-15-volt a-c
- M₁₀ 0-15-volt a-c
- M₁₁ 0-15-volt a-c

BLOWERS

- B₁ Blower, 2000T cooling
 - F₁ Fan, 10-in. blades
- } see 2000T data sheet

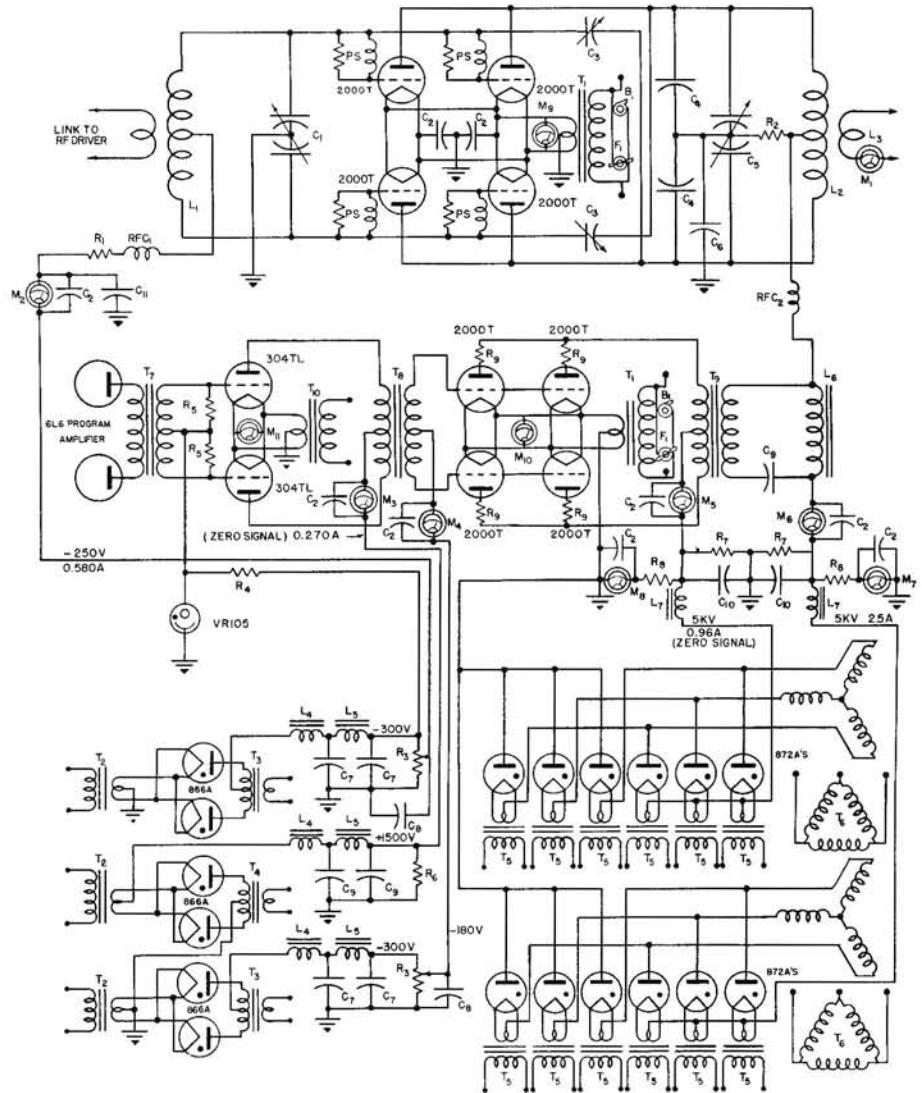
CAPACITORS

- C₁ Variable air capacitor, split-stator, approximately 2-uuf per meter wavelength, 0.1-in. air gap
- C₂ 0.006-uf 600-volt mica
- C₃ 12-30-uuf 0.7-in. minimum air gap
- C₄ Eimac vacuum capacitor, capacitance depends on frequency
- C₅ Variable air capacitor, split stator type, size dependent on combination with C₃ and wavelength factor of approximately 1.5-uuf per meter.*
- C₆ 0.002-uf 12,500-volt mica
- C₇ 10-uf 1,000-volt oil
- C₈ 40-uf 1,000-volt oil
- C₉ 4-uf 2,500-volt oil
- C₁₀ 4-uf 6,000-volt oil
- C₁₁ 0.006-uf 2,500-volt mica

*Effective capacitance across inductance at resonance.

INDUCTORS

- L₁ Inductance depends on frequency and C₁
- L₂ Inductance depends on frequency and C₄, C₅
- L₃ R-F output coupling depends on antenna
- L₄ 60/12-h, 600-ma., 3500-volt insulation, 90-ohm d-c
- L₅ 20-h, 600-ma., 3500-volt insulation, 90-ohm d-c
- L₆ 30-h at 3.5 amp, 12,500-volt insulation
- L₇ 10-h at 4 amp, 7,500-volt insulation
- RFC₁ r-f choke 1 amp inductance depends on frequency



RFC₂ r-f choke 4 amp (see foot note 1 on page 11)

TRANSFORMERS

- T₁ 10-volt c-t, 120-amp; primary tapped 105-, 110-, 115-, 120-volt
- T₂ 2.5-volt c-t, 10-amp; tapped primary, 4500-volt insulation
- T₃ 600-800-volt c-t, 0.5-amp d-c; tapped primary
- T₄ 3580-volt c-t 0.5-amp d-c; tapped primary
- T₅ 5-volt c-t, 10-amp tapped primary, 7,500-volt insulation
- T₆ 2200-volt rms per leg, y-connected, 20-kva; primary 3 phase 220-volt delta-connected

T₇ Primary impedance 9000-ohm, 20-watt, ratio primary to 1/2 secondary 3.46 to 1

T₈ Primary impedance 2540-ohm, 260-watt, ratio primary to 1/2 secondary 1.95 to 1

T₉ Primary impedance 2450-ohm c-t, secondary 2000-ohm no d-c to flow in secondary

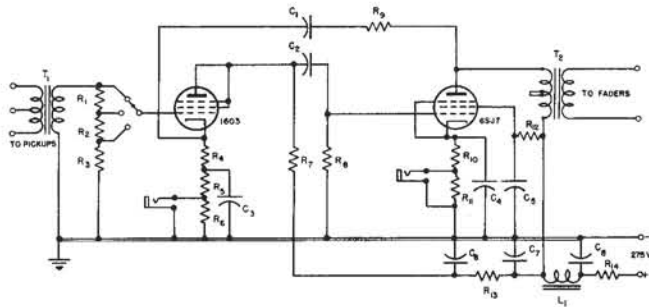
T₁₀ 10-volt c-t, 30-amp tapped primary

TUBES

- Eimac 2000T
- Eimac 304TL
- Eimac 866A
- Eimac 872A

PREAMPLIFIER FOR MICROPHONES AND PICKUPS

Figure 7 shows the circuit of a preamplifier suitable for microphone and transcription pickup use as shown in the block diagram Fig. 1, on page 3. Because of the elements of individual taste involved in the choice of microphones and pickups, no primary impedance is indicated for the preamplifier input transformers.



Components used and specifications are as follows:

TRANSFORMERS

- T_1 Input Transformer—primary suitably tapped so impedance can be matched to source (microphone, electrical-transcription pickup, etc.); secondary impedance 30,000 ohms
 T_2 Output Transformers—primary impedance each winding 4000 ohms (connected as shown), each winding to have approximately 1350-ohm d-c resistance, primary inductance greater than 30 henrys; secondary impedance 600 ohms

INDUCTORS

- L_1 Choke—greater than 240 henrys at 7 ma., d-c resistance approximately 6000 ohms.

RESISTORS

- | | |
|-------------------|------------------------|
| R_1 100,000-ohm | R_7 100,000-ohm |
| R_2 36,000-ohm | R_8, R_9 250,000-ohm |
| R_3 15,000-ohm | R_{10} 390-ohm |
| R_4 1,000-ohm | R_{11} 20-ohm |
| R_5 3,000-ohm | R_{12} 30,000-ohm |
| R_6 270-ohm | R_{13} 39,000-ohm |
| R_7 100,000-ohm | R_{14} 6,200-ohm |

CAPACITORS

- | | |
|--|---|
| C_1 0.5-uf | C_5 40-uf 150-volt d-c working |
| C_2 0.25-uf | $C_{11}, C_{12}, C_{13}, C_{14}$ 20-uf 450-volt d-c working |
| C_3 40- + 40-uf 150-volt d-c working | |

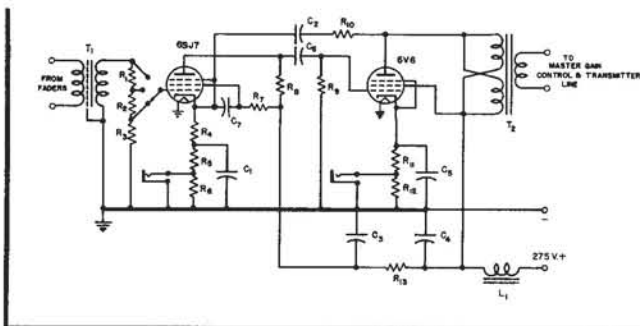
TUBES

1603

6SJ7

LINE AMPLIFIER

Two small tubes serve the functions of the line amplifier which takes the audio from individual microphone and pick-up faders and delivers it to master gain control and transmitter line at a suitable level. This unit is shown in Fig. 8.



Line amplifier component list and specifications follow:

TRANSFORMERS

- T_1 Input Transformer—input impedance 600 ohms, electrostatic shield; secondary impedance from 30,000 ohms to 60,000 ohms.
 T_2 Output Transformer—primary impedance each winding 4000 ohms, d-c resistance each winding approximately 1350 ohms connected as shown; secondary impedance 600 ohms.

INDUCTOR

- L_1 Choke—greater than 30 henrys at 30 ma. d-c, d-c resistance approximately 800 ohms.

RESISTORS

- | | |
|-------------------|------------------------|
| R_1 100,000-ohm | R_7 1-megohm |
| R_2 35,000-ohm | R_8, R_9 250,000-ohm |
| R_3 15,000-ohm | R_{10} 150,000-ohm |
| R_4 500-ohm | R_{11} 500-ohm |
| R_5 2,000-ohm | R_{12} 5-ohm |
| R_6 250-ohm | R_{13} 25,000-ohm |

CAPACITORS

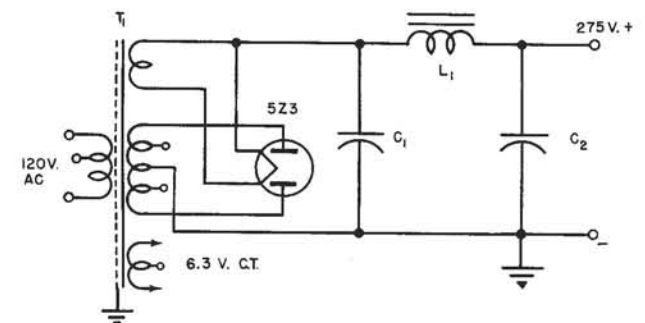
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|--|
| C_1 40- + 40-uf 150-volt d-c working |
| C_2 0.5-uf |
| C_3, C_4 20- + 20-uf, 450-volt d-c working |
| C_5 40-uf, 150-volt d-c working |
| C_6, C_7 0.25-uf |

TUBES

6SJ7, 6V6

POWER SUPPLY FOR LINE AND PRE-AMPLIFIERS

A single 5Z3 acts as power-supply rectifier for as many as eight pre-amplifiers in addition to one line-amplifier as shown in the block diagram on page 3. Monitor and program amplifiers described on page 13 have inbuilt power supplies. Pre- and



line-amplifier power supplies are shown in Fig. 7-8. The component list is as follows:

TRANSFORMER

- T_1 Power Transformer—primary 110-, 120-volts a-c, drawing 110 v-a full load at 120 volts a-c; secondaries (1) one 5-volt 3-amp winding for 5Z3 filament (2) one 6.3-volt 8-amp c-t winding for heaters of amplifier tubes (3) high-voltage winding center-tapped and tapped for 230/260 volts either side of center tap, winding capable of delivering 75 ma. to the load in continuous operation insulation for at least 2000 volts from coils to core and case; electrostatic shield tied to the case.

INDUCTOR

- L_1 Filter choke—not less than 15 henrys at 80 ma. with a d-c resistance not greater than 250 ohms; insulation for 1500-volt rms breakdown test, coil to core and coil to case.

CAPACITORS

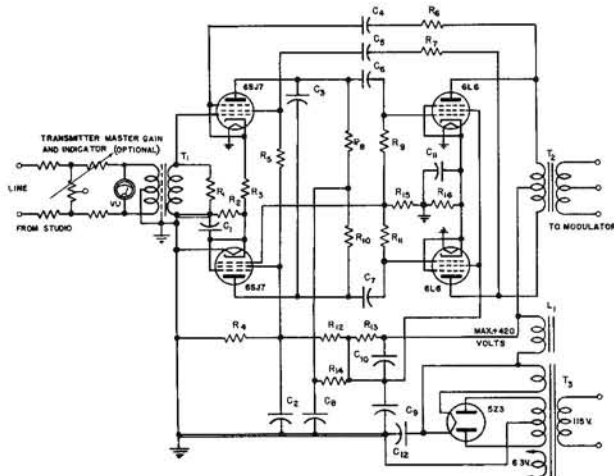
- | |
|---|
| C_1 4-uf 600-volt d-c working, oil-filled |
| C_2 40-uf 450-volt d-c working. |

TUBE

5Z3

PROGRAM AMPLIFIER

Transmitter master gain and volume-indicating facilities are included in Fig. 12, the schematic diagram of a program amplifier for broadcast use. Program material is taken from the studio transmitter line and delivered from a pair of 6L6 beam-power tubes to the modulator unit. The component list for this unit is as follows:



MASTER GAIN CONTROL

600 ohms to 600 ohms terminal impedances

60-db balanced H network

2-db per step wire-wound attenuator

VOLUME-LEVEL INDICATOR

Suitable v-u meter equipped with heavy-duty T-network pad for meter-range control.

RESISTORS

R ₁ 150,000-ohm*	R ₇ , R ₈ , R ₁₁ 100,000-ohm
R ₂ 700-ohm 5%	R ₉ , R ₁₀ 250,000-ohm
R ₃ 350-ohm	R ₁₂ 10,000-ohm 10-watt
R ₄ 2,000-ohm 10-watt	R ₁₃ 3,000-ohm 10-watt
R ₅ 2,000-ohm 10%	R ₁₄ 25,000-ohm
R ₆ 500,000-ohm	R ₁₅ 50,000-ohm
	R ₁₆ 250-ohm 10-watt

*Depends on transformer manufacturer's recommendations.

All resistors are non-inductive and one watt unless otherwise specified.

CAPACITORS

C ₁ 80-uf 150-volt d-c working	C ₇ 80-uf 450-volt d-c working
C ₂ , C ₈ 20-uf 450-volt d-c working	C ₁₀ 40-uf 450-volt d-c working
C ₃ 50-uf mica	C ₁₁ 40-uf 150-volt d-c working
C ₄ , C ₅ 0.05-uf mica	C ₁₂ 4-uf 600-volt oil
C ₆ , C ₉ 0.01-uf mica	

INDUCTOR

L₁ Choke—5.5 henrys at 140 ma. d-c less than 200 ohms d-c resistance 1000 volts rms test.

TRANSFORMERS

T₁ Input Transformer—impedance ratios: primary 600 ohms c-t, d-c resistance approximately 170 ohms, electrostatic shield; secondary 80,000 ohms, d-c resistance approximately 3300 ohms. Insulation test 500 volts rms frequency response 1/2 db 30 to 20,000 cycles operating level —30 to 0 db (0.001 watts reference)

T₂ Out-put Transformer—20 watts; primary, 9000 ohms impedance c-t, turns ratio, primary to 1/2 secondary, for 100TH and 450TH grids: 2.8 to 1, for 152TL and 304TL: 3.5 to 1.

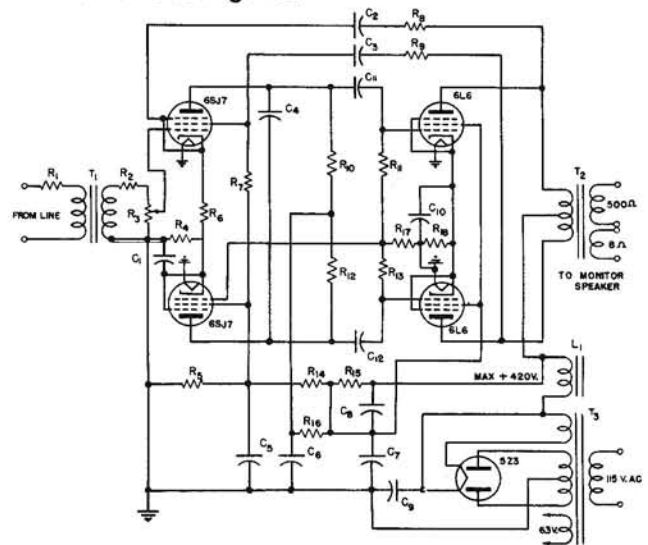
T₃ Power Transformer—primary 110-120 volts a-c; secondaries, (1) 860-volt a-c c-t, taps at 790 volts c-t, (2) 5-volt 3-amp no center tap, (3) 6.3-volt 5-amp c-t; insulation 2500 volts a-c between coils and coils to case; secondary current 140 ma.

TUBES

6SJ7, 6L6, 5Z3

MONITOR AMPLIFIER

Figure 10 is the complete circuit of a monitor amplifier for incorporation in the block diagram on page 3. Power supplies are included. The component list follows Fig. 10.



RESISTORS

R ₁ 12,500-ohm	R ₉ , R ₁₁ , R ₁₂ 100,000-ohm
R ₂ 50,000-ohm	R ₁₀ , R ₁₃ 250,000-ohm
R ₃ 250,000-ohm volume control, audio taper	R ₁₄ 10,000-ohm 10-watt
R ₄ 700-ohm	R ₁₅ 3,000-ohm 10-watt
R ₅ 2,000-ohm 10-watt	R ₁₆ 25,000-ohm
R ₆ 350-ohm	R ₁₇ 50,000-ohm
R ₇ 2,000-ohm 10%	R ₁₈ 250-ohm 10-watt
R ₈ 500,000-ohm	

All resistors non-inductive and one watt unless otherwise specified.

CAPACITORS

C ₁ 80-uf 150-volt d-c working	C ₇ 80-uf 450-volt d-c working
C ₂ , C ₃ 0.05-uf mica	C ₈ 40-uf 450-volt d-c working
C ₄ 0.00005-uf mica	C ₉ 4-uf 600-volt d-c working oil
C ₅ , C ₆ 20-uf 450-volt d-c working	C ₁₀ 40-uf 150-volt d-c working
	C ₁₁ , C ₁₂ 0.01-uf mica

INDUCTOR

L₁ Choke—5.5 henrys at 140 ma. d-c, less than 200 ohms d-c resistance, 1000 volts rms test

TRANSFORMERS

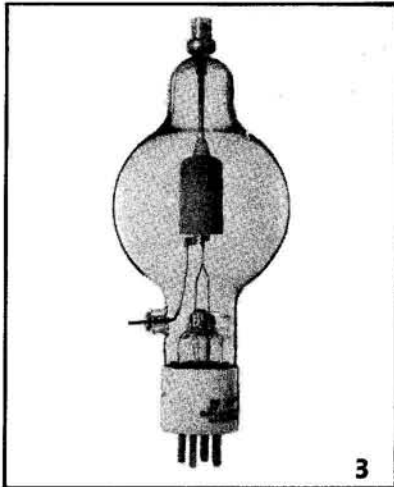
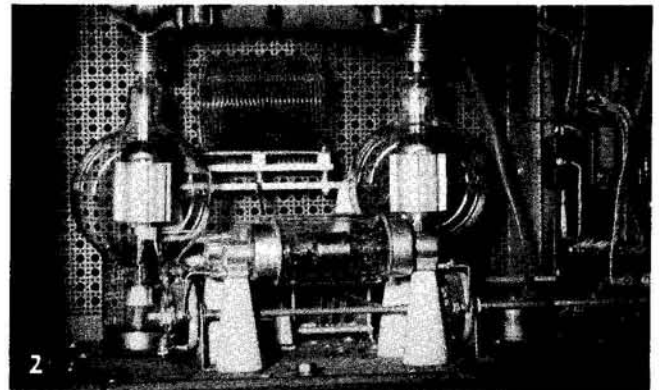
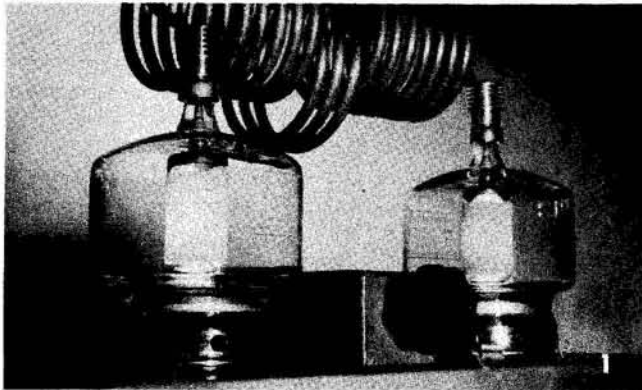
T₁ Input Transformer—impedance ratios: primary Z 15,000 ohms, approximately 900 ohms d-c resistance; secondary Z 80,000 ohms, approximately 3300 ohms d-c resistance. Insulation test 500 volts rms frequency response 1/2 db from 30 to 20,000 cycles operating level —30 to 0 db (0.001 watts reference)

T₂ Output Transformer—impedance ratios: primary Z 10,000 ohms, approximately 600 ohms d-c resistance, c-t; secondaries, (1) Z, 8 ohms, approximately 0.9 ohms d-c resistance, and (2) Z, 500 ohms approximately, d-c resistance 50 ohms. Maximum power 20 watts primary current, 50 ma. per side.

T₃ Power Transformer—primary 110-120-volts a-c; secondaries, (1) 860-volt a-c c-t, taps at 790 volts c-t, (2) 5 volts 3-amp no center tap (3) 6.3 volts 5-amp c-t; insulation 2500 volts a-c from coils to core and case; secondary current 140 ma.

TUBES

6SJ7, 6L6, 5Z3

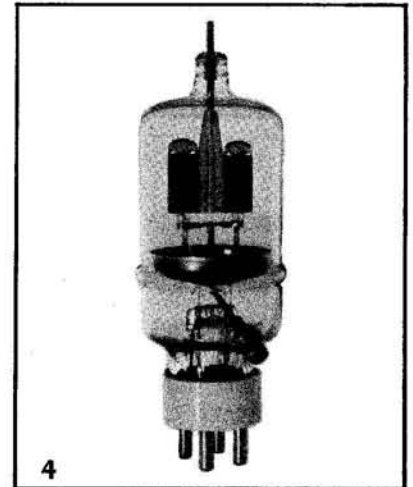


1 Eimac 4-250A tetrodes are pictured here in the final stage of a 1-kw amplifier. The universal driver described on page 9 has been designed around the 4-250A. Characteristics of this tube make the driver capable of exciting any of the power amplifier at frequencies up to 20 Mc.

2 Two Eimac 450TH power triodes are shown undergoing life-tests. Constant testing by the laboratory and production departments of Eitel-McCullough assures uniform performance of any Eimac tube. Note the Eimac vacuum capacitor in the foreground of the illustration.

3 Type 100TH Eimac power triode specified for use in the 250-w transmitter on page 8.

4 Type 152TL Eimac power triode, two of which are required in the 5-kw transmitter.

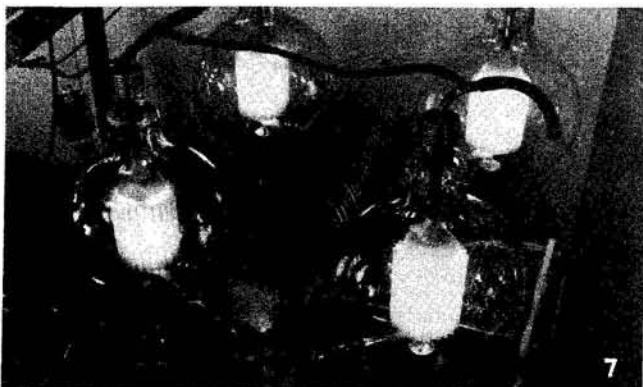
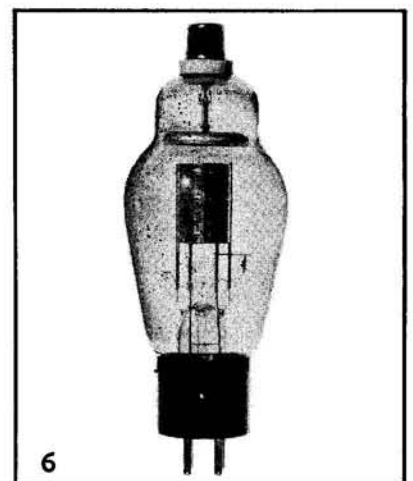
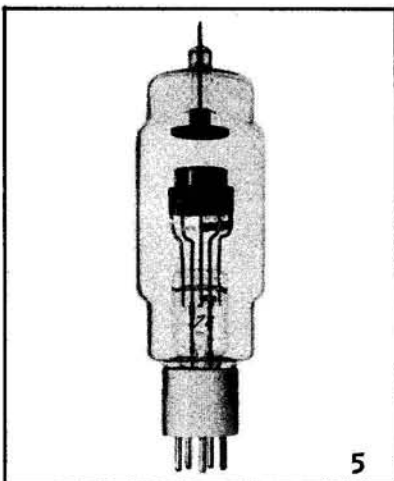


5 Type RX21A Eimac mercury vapor rectifier is used in the 1-kw and 5-kw transmitters.

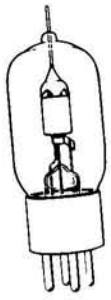
6 Type 866A Eimac mercury vapor rectifier is incorporated in all of the transmitters suggested and also the universal driver.

7 Four Eimac 2000T power triodes are shown operating in the final stage of an induction heating apparatus. These same tubes are the power amplifier of the 5-kw and 10-kw transmitters on pages 10 and 11.

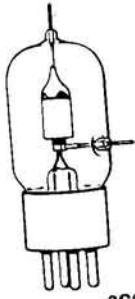
8 Eimac type 304TL tubes operating in a piece of flash brazing equipment. Two of these tubes are operated in class AB₁ in the audio driver stage of the 10-kw transmitter.



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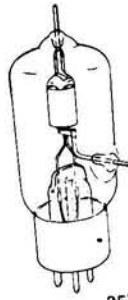
25T



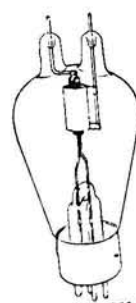
3C24



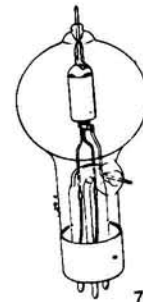
35T



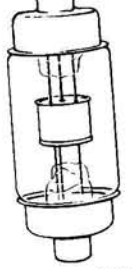
35TG



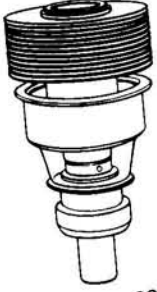
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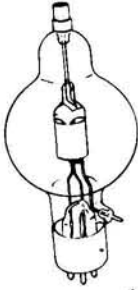
75T



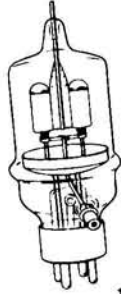
VACUUM CAPACITOR



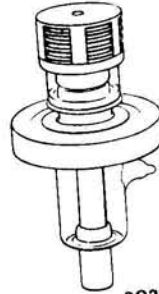
2C39*



100T



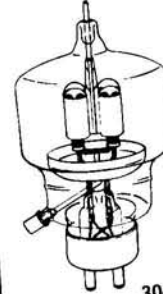
152T



3C37*



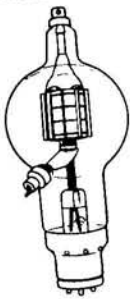
250T



304T

Eitel-McCULLOUGH, INC.

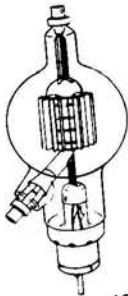
SAN BRUNO, CALIFORNIA



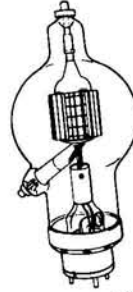
450T



750T



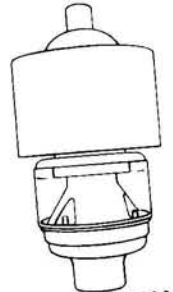
1000T



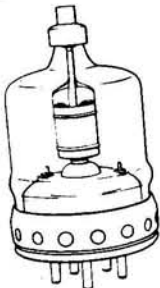
1500T



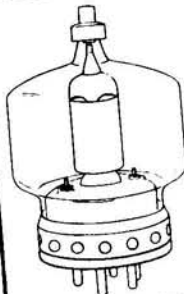
2000T



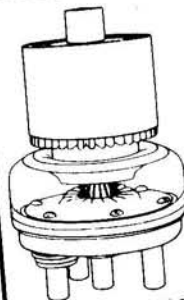
3X2500A3*



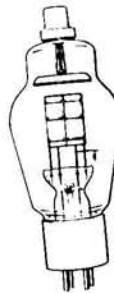
4 - 125A



4 - 250A



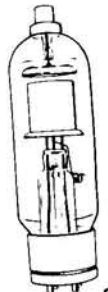
4X500A*



866A
(866)



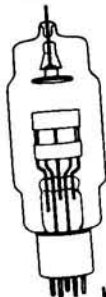
RX21A
(RX-21)



872A
(872)



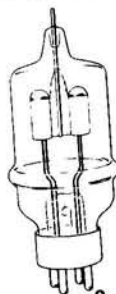
HR HEAT DISSIPATING CONNECTORS



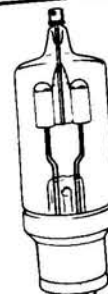
KY21A
(KY-21A)



100 - R



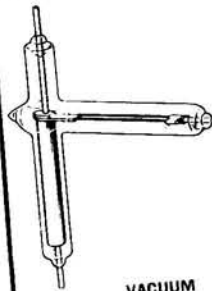
2 - 150A
(152-R)



2 - 150D
(152-RA)



250 - R



VACUUM SWITCH