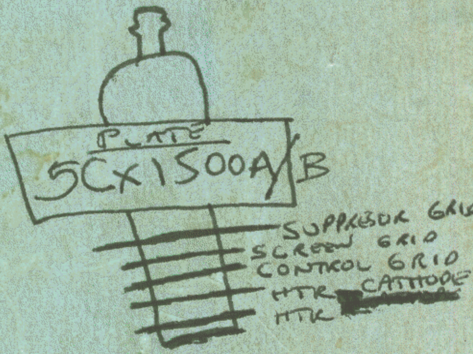
AEL

# INSTALLATION AND MAINTENANCE MANUAL

## FOR

## FM-12KD & FM-25KD

## FM BROADCAST TRANSMITTERS




ALL OPERATION IN STEREO MODE

AEL®

AMERICAN ELECTRONIC LABORATORIES

P.O. Box 552, Lansdale, Pa. 19446 • (215) 822-2929 TWX: 510-661-4976

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FOR

FM-12KD & FM-25KD

FM BROADCAST TRANSMITTERS

AMERICAN ELECTRONIC LABORATORIES, INC.

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## SECTION I

## GENERAL INFORMATION

### 1-1 Introduction

This manual contains information required to install, operate and maintain the American Electronic Laboratories FM Transmitters, Model FM-25KD and Model FM-12KD. These transmitters are rated at 25KW and 12KW output respectively. The circuitry, operation, and maintenance of these two models are so similar that this one manual will be used to detail all information necessary for proper utilization of the units. Where specific differences exist between the transmitters, these will be pointed out in the descriptive text. Where there is identity between units, general references will be made to "the transmitter" or to "the driver stage", etc.

Section I describes the transmitters and their respective specifications, Section II provides installation instructions, Section III contains operating procedures and Section IV describes the principles of operation. Maintenance procedures and trouble shooting diagrams are contained in Section V, and replaceable parts are identified and listed in Section VI. A complete operating and servicing manual covering the Model 2202A FM Exciter is included as a part of this manual

### 1-2 General Description

The Model FM-25KD FM Transmitter, also typical of the Model FM-12KD, see frontispiece photographs, consists of an AEL Model 2202A FM Exciter, two-stage RF amplifier and power supply, low-pass harmonic filter, and RF directional couplers. One coupler monitors forward or reflected power between the FM exciter and


Frontispiece. FM-25KD FM Transmitter, Front View the driver grid input circuit. The second performs a similar function at the output of the harmonic filter into the transmission line. The FM-25KD transmitter provides an output of 10 to 25 kilowatts and the FM-12KD an output of 5 to 12 kilowatts in the frequency range of 88 to 108 MHz, they are type accepted by the Federal Communication Commission for use under Part 73, Broadcast Services.

The Model 2202A FM Exciter is a solid-state unit that provides monaural FM and, with an AEL Model 2213 Stereo Generator, full stereo modulation. Subsidiary Communication Authorization (SCA) mode of operation is also available with the use of a Mosely SCG-4T SCA Generator. The exciter modulation method is "direct FM" at the assigned carrier frequency and employs automatic frequency control by comparing the modulated oscillator frequency to a temperature stabilized crystal oscillator.

### 1-2.1 Physical Characteristics

Physical characteristics of the transmitters, excluding the Model 2202A FM Exciter and Model 2203 Stereo Generator, are given in Table 1-1.

Table 1-1. Physical Characteristics

| | |
|---|---|
| Cabinet Dimensions | 77¼"H x 48"W x 36"D (overall)<br>77¼"H x 48"W x 33"D (trim & doors removed) |
| Weight | 2000 lbs. approx., (FM-25KD) 1800 lbs. approx. (FM-12KD) |
| Floor Loading | 162 lbs./sq. ft. approx. |
| Cabinet Style | Enclosed steel cabinet; access through front doors & quickly removable panels, swing-down centrally-located meter and control panel, rear doors. |

Input/Output Connections

| | | |
|---|---|---|
| a. | RF Output | 3-1/8 inch coaxial line flange |
| b. | Sampled RF Output to Station Monitor | Type BNC coaxial |
| c. | Audio Inputs (to FM Exciter) | |
| | Composite Stereo | Type BNC coaxial |
| | SCA | Type BNC coaxial |
| | Monaural | Barrier terminal strip |

| | |
|---|---|
| Ambient Temperature | Storage: -20°F to +120°F<br>Operating: 20°F to +113°F |
| Altitude | 7,500 ft. maximum |
| Harmonic Filter/ Coupler | 58-5/8" long with 3-1/8" EIA flanges each end. Mounts externally. Coupler has two pairs of BNC output connectors. One pair for forward & reflected power at a 30 KW level--the other pair for a 15 KW level. |
| Cooling Provisions | Self-contained blowers plus a rear door filtered air intake fan for positive cabinet pressure. |

## 1-2.2 Functional Characteristics

Functional characteristics of the transmitters, including the Model 2202A FM Exciter, are given in Table 1-2.

Table 1-2. Functional Characteristics

| | |
|---|---|
| Frequency Range | 88 to 108 MHz |
| Modulation | F3, F9 |
| Power Output | 10 to 25 KW capability - FM-25KD<br>5 to 12 KW capability - FM-12KD |
| Load Impedance | 50 ohms (nominal) |
| VSWR | 2:1 maximum |
| FM Noise | -63 db (max.) |
| AM Noise | -55 db (max.) |

Table 1-2. Functional Characteristics (cont'd)

| | |
|---|---|
| Harmonic & Spurious Output | Exceeds FCC requirements |
| Power Source | 200 to 240 volts, 60 Hz, 3 phase, 90% power factor, ±5% regulation. |
| Power Consumption | 42 KVA (at 90% power factor), 200 Amp Service (for 25 KW output)<br>26 KVA - for FM-12KD, 100 Amp Service |
| Tube Types | 3CX15000A7 (PA) - FM-25KD<br>3CX10000A7 (PA) - FM-12KD<br>4CX1000K (Driver) |
| Deviation Capability | ±100 KHz |
| Frequency Stability | ±1 KHz |
| Monaural Input | 600 ohms balanced +10 dbm ±2 db for ±75 KHz deviation |
| Monaural Response | 50-15,000 Hz, ±1 db |
| Monaural Pre-emphasis | 75 u sec. standard |
| Monaural Distortion | 0.5% THD max. (50-15,000 Hz) |
| Controls and Indicators | See Table 3-1 |

## 1-3 Accessories

Each transmitter is supplied with the following accessories:

a. One Printed Circuit Card Extender

AEL Part No. 3152853-1

b. Two Insertion/Extraction Levers for PA Tube

AEL Part No. 2155500-1

The card extender permits measurement of printed circuit operating parameters. The tube installation levers permit easily controlled insertion and seating of the PA tube in its socket as well as convenient, gradual extraction for replacement purposes.

## 1-4 Optional Equipment

Available optional equipment consists of the following items:

a. Stereo Generator, AEL Model 2213

b. SCA Generator, Moseley Model SCG-4T

c. FM-12KD option - Remote Power Control

d. FM-12KD option - Automatic VSWR Protection

## SECTION II

## INSTALLATION

### 2-1 Installation Planning

Dimensions required for proper installation of the Model FM-25KD FM Transmitter are shown in Figure 2-1.

#### 2-1.1 Environmental Requirements

Location of the Model FM-25KD must be within an environment that satisfies the following limits:

| | | |
|---|---|---|
| a. | Maximum altitude | 7,500 ft. |
| b. | Maximum temperature | $+113^{o}F$ |
| c. | Minimum temperature | $+20^{o}F$ |

#### 2-1.2 Space Requirements

When installing the Model FM-25KD, it is important that sufficient space be left at the front and rear to permit full opening of all access doors and swing-down control panel. As shown in Figure 2-1, at least 25 inches of space must be provided in front of the cabinet and the unit should be placed with the rear surface no closer than 25 inches from the wall.

Adequate overhead space must also be provided to permit installation of the harmonic filter and to allow for adequate dispersal of air discharged through the cabinet top. A minimum distance of two feet from the cabinet top to the ceiling is recommended.

#### 2-1.3 Power Requirements

Requirements for input power and power consumption are provided in Table 1-2, functional characteristics, in Section I.

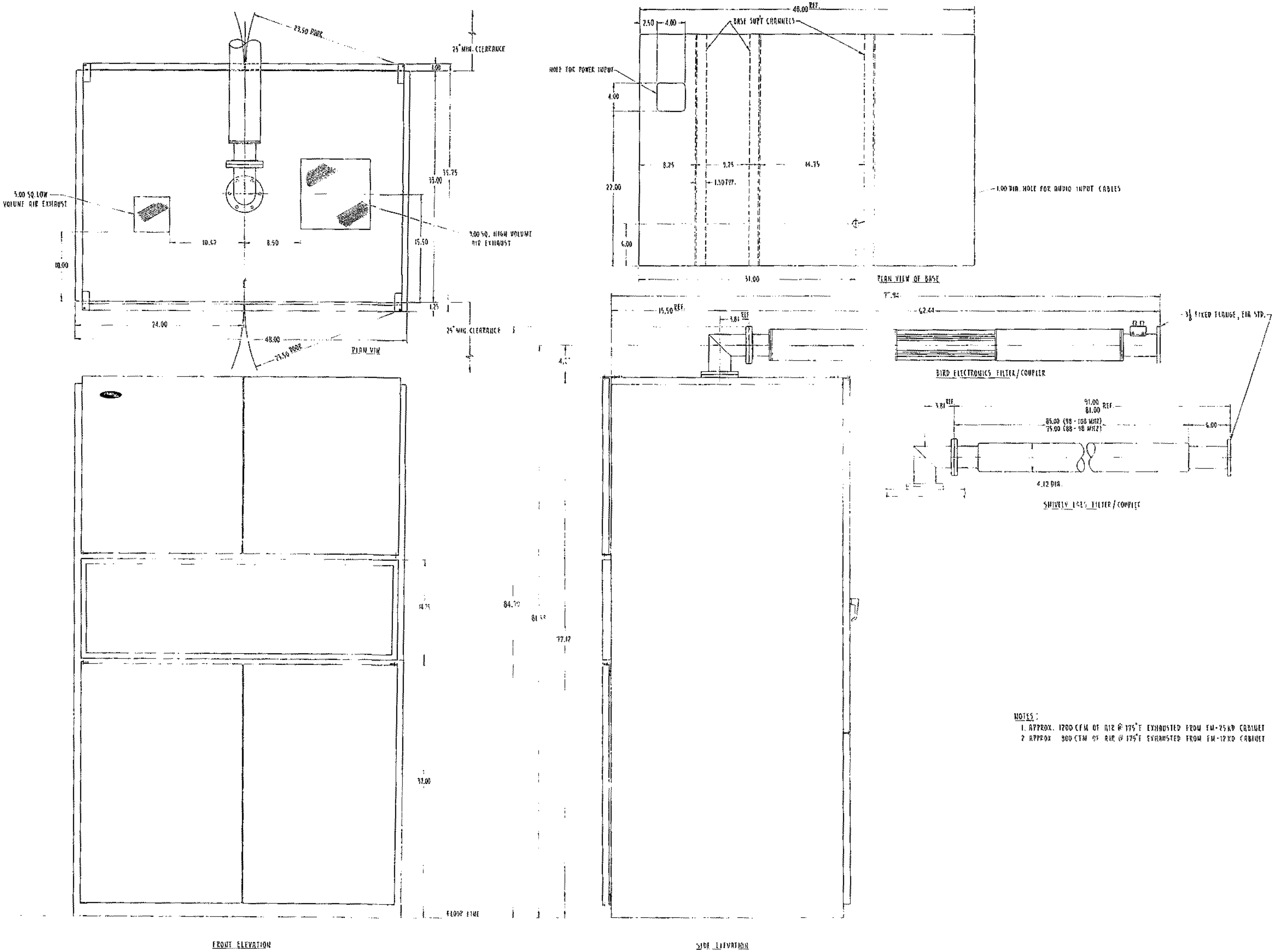



Figure 2-1. Transmitter Installation Outline Drawing

## 2-1.4 Cooling Requirements

The external cooling requirements for the FM-12KD and FM-25KD must be such so as to prevent the ambient temperature from rising above the maximum specified in paragraph 1-2.1 (113°F). This would most likely occur during hot summer weather in a small closed transmitter building. Under these conditions the user must be prepared to circulate external air through the transmitter room at a rate of at least 1000 cubic feet per minute for the FM-12KD and a rate of at least 1500 CFM for the FM-25KD. Inlets for cool air should be provided so that natural flow into the transmitter input air filters is possible. An output wall fan or hot air duct should carry off the exhausted hot air at the required rate.

During the cooler winter months, the transmitter exhaust may be utilized to heat the transmitter building. It is suggested that a thermostat element be used to turn on the building exhaust fan when the room temperature rises above 80°.

The FM-12KD at full output exhausts air at a rate of 900 CFM with a heat rise of 75°F above ambient temperature. The FM-25KD heat rise is 95° F above ambient at a volume of 1500 CFM when operated at 25KW output.

If air conditioning is to be used for transmitter room temperature control it is suggested that a qualified air conditioning engineer be consulted to ensure that sufficient cooling capacity is provided.

A minimum clearance of 2 feet is suggested above the top of the transmitter as being sufficient space so as not to create any back pressure on the cooling system and causing reduction of air flow rate.

2-2 Unpacking and Inspection

Inspect the equipment for shipping damage as soon as it is unpacked. Check for broken knobs, tubes, meter faces, and connectors. Inspect surfaces for dents and scratches. If the equipment is damaged in any way, notify the carrier immediately and report the damage.

2-3 Input and Output Connections

The PA RF output will come out of the cabinet via a 3-1/8" EIA flange and a 90° elbow to the Harmonic Filter/Coupler. RF output to the station monitor will be brought out from BNC style connector, identified as 2J2 on P.A. cavity wall.

Audio inputs and control lines will be brought in by means of grommeted holes in the lower left side of the cabinet rear.

2-3.1 RF Input/Output Connections

The RF input and output connections are made to the transmitter as follows:

a. A short length of RG-58/U coaxial cable with BNC connectors at each end is connected between the exciter RF OUTPUT jack and the exciter directional coupler, 1DC1, mounted on the right wall of the transmitter cabinet just to the rear of the exciter. NOTE:- A 50 ohm attenuator box may also be used between the exciter and the directional coupler. The attenuation is usually 2 db or 3 db. This is used to stabilize tuning VSWR variations on the FM exciter. The output of the directional coupler should be connected to the DRIVER RF INPUT jack, 2J1 located at the upper rear of the driver cavity. Ensure that these connectors are firmly in place.

b. Using a 3-1/8 inch 90° coaxial elbow, connect the PA RF output coaxial line to the Harmonic Filter/ Coupler.

c. Using RG-58/U coaxial cable and BNC coaxial connectors, connect station monitor to jack 2J2 located on rear of P.A. enclosure.

d. RF output for ALC circuits is obtained at 2J3. A large chassis ground terminal is provided for connecting the transmitter main frame to system or building ground.

## NOTE

It is essential that the exact primary voltage be determined before connecting the primary windings of the PA filament transformer (1T), the bias transformer (2T3) and the plate transformer (1T4). See appropriate photos with parts call-outs for location. Typically, taps are provided at each end of transformers 1T1, 1T4, and 2T3 and are arranged as shown below in Figure 2-2. The 3-phase transformer, 1T4, of course, has each winding tapped in this manner. A primary voltage range of 180 to 260 volts can be accomodated. Refer to Tables 2-2 and 2-3 for the proper plate potentials to be used for specific legal power levels. Adjust the taps of 1T4 to provide the indicated plate voltages.

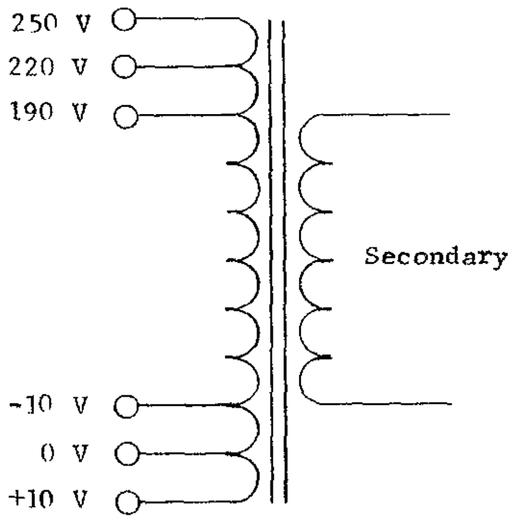



FIGURE 2-2

TABLE 2-1

REMOTE CONTROL FUNCTIONS

| TERM | FUNCTION |
|---|---|
| 1. | Pre-Heat/After-Cool Line |
| 2. | +24 Volts Control Voltage |
| 3. | START/STOP Line |
| 4. | STOP & Interlock Line Return |
| 5. | Interlock |
| 6. | Reset Line (Momentary return to #2) |
| 7. | Plate ON/OFF Interlock or Plate Voltage Remote Control |
| 8. | " " " " " " " " |
| 9. | PA Plate Voltage - remote read (+) |
| 10. | PA Plate Current - remote read (-) |
| 11. | Power Output - Ground |
| 12. | Power Output - Remote Read (-) |
| 13. | Remote Raise Power |
| 14. | Remote Lower Power |
| 15. | Ground |

TABLE 2-2

FM-25KD OPERATING DATA

Frequency = 98 MHz

| | 25 KW | 20 KW | 15 KW | 12 KW | 10KW |
|---|---|---|---|---|---|
| PA Plate Current | 4.4 Amp | 3.5 Amp | 2.8 Amp | 2.2 Amp | 2.0 Amp |
| PA Cathode Current | 5.3 A | 4.1 A | 3.2 A | 2.5 A | 2.5 A |
| PA Plate Voltage | 7.6 KV | 7.6 KV | 7.2 KV | 7.2 KV | 6.8 KV |
| Efficiency | 75% | 75.2% | 74.5% | 75.8% | 73.5% |
| Driver Cath. Current | 0.70 Amp | 0.54 A | 0.46 A | 0.40 A | 430 MA |
| Driver Plate Voltage | 3.35 KV | 3.4 KV | 3.3 KV | 3.4 KV | 3.1 KV |
| PA Cathode Resistance | 12.5 ohms | 17 ohms | 25 ohms | 50 ohms | 50 ohms |

TABLE 2-3

FM-12KD OPERATING DATA

Frequency = 98 MHz

| | 12 KW | 10 KW | 8 KW | 6 KW | 5 KW |
|---|---|---|---|---|---|
| PA Plate Current | 2.45 A | 2.0 A | 1.85 A | 1.4 A | 1.25 A |
| PA Cathode Current | 2.85 A | 2.35 A | 2.2 A | 1.6 A | 1.4 A |
| PA Plate Voltage | 6.4 KV | 6.5 KV | 5.7 KV | 5.8 KV | 5.8 KV |
| Efficiency | 76.5 % | 76.8 % | 75.7 % | 74 % | 69 % |
| Driver Cath. Current | 0.54 A | 0.39 A | 0.40 A | 0.31 A | 0.27 A |
| Driver Plate Voltage | 2.9 KV | 3.0 KV | 2.6 KV | 2.7 KV | 2.75 KV |
| PA Cath. Resistance | 50 ohms | 50 ohms | 50 ohms | 100 ohms | 100 ohms |
| Pi Loading Cap. (2C44 & 2C45) | 125 pf | 125 pf | 150 pf | 150 pf | 150 pf |

## 2-3.2 Primary Power and Grounding Connections

Primary power connections are made through the floor of the transmitter cabinet to a heavy duty terminal block 1TB3. Minimum cable size shall be No. 2. The safety disconnect switch supply, the primary power to the transmitter should be rated at 200 amperes for the FM-25KD and 100 amperes for the FM-12KD. A separate terminal is provided on 1TB3 for the three-phase neutral lead. CAUTION Consult your local power company's engineering department to determine if the "neutral" is a true symmetrical neutral line or as in some power systems is an artificial center-tap connection between two of the three phases. If the later is the case, carefully measure to determine which phases the artificial neutral is related to and connect these two phases to terminals #1 and #2 of 1TB3. Connect the remaining 3-phase wire to terminal #3. The internal single phase neutral return line is brought out to a separate terminal 1TB4-4 and identified as "NEUTRAL RETURN". Connect a jumper wire (#16) between this terminal and the incoming "neutral" for the power system. This will insure that the single phase circuits (fan 1B1, blower 2B2, and relays 3K18 and 3K19) are provided proper operating voltages.

The local electrical code will specify whether it is permissible to connect the neutral of the power system to ground or to let it "float". Consult your local power company or electrical contractor before proceeding.

## 2-3.3 Exciter Input Connections - See Model 2202A Manual

Refer to Figure 3 "FM Exciter - Rear View" and the transmitter schematic diagram which show the location of input connectors and patching circuits. Going from left to right, the following connectors and controls are located on the lower rear deck of the FM Exciter chassis.

a. A three-wire AC connector with the center conductor connected to chassis ground.

b. A three-terminal barrier strip (TB2) makes provision for local AC power control from a front panel switch by placing a jumper from terminal 1 to 2.

c. The SCA input is injected into the AF input circuits via a BNC connector. There is no level control for this input. The level must be adjusted at the SCA generator.

d. The RF output from the 10-watt solid-state amplifier of the exciter unit is also obtained from a BNC connector to be patched via an RG-58/U coaxial cable to the driver RF input connector at the upper rear portion of the driver RF compartment (2J1).

e. A six-terminal barrier strip (TB1) provides a patching capability for either the monaural or stereo mode of operation.

(1) Monaural Operation. Place a jumper wire between terminals 4 and 5 and apply the AF signal to the balanced 600-ohm input terminals 1 and 3 with the ground connected to terminal 2. The modulation level can be adjusted by varying control R97.

(2) Stereo Operation. Place a jumper wire between terminals 5 and 6 instead of 4 and 5. Apply the composite stereo signal to the BNC con-connector captioned STEREO INPUT. The modulation level can be adjusted by varying control R98.

## 2-4 Transmitter Remote Control

2-4.1 Both the FM-25KD and the FM12-KD may be operated remotely by using a local short run of control cable to a nearby operator's console. Remote operation via telephone line or microwave Studio-Transmitter Link is possible if an appropriate remote control unit is used.

### 2-4.2 Short Run Remote Control

Connections to the transmitter control circuits, power, voltage, and current monitoring points and power level control circuits are brought out on terminal board, 1TB2. Figure 2-3 shows the necessary connections that must be made to terminal board 1TB2 in order to functionally remote control the transmitter. It must be understood that the remote meters must be calibrated to agree with the transmitter indicating panel instruments.

2-4.3 Remote Control via Telephone Line or STL

Selection of a remote control unit should include the facilities desired by the user and whose input and output characteristics are compatible with the remote control functions as shown in Figure 2-3. Note the polarities of the various metering signals available at 1TB2. The remote control unit selected must be capable of accepting either a positive or negative voltage for its conversion from voltage to audio frequency circuitry. The systems usually encountered have strapping terminals available so as to accept either polarity of metering signal.

The operational functions on the remote control terminal represent "dry contact" relay closures and should be so connected.

Note that the "remote STOP" function is operated by the normally closed "back contacts" of a relay. The remaining functions are served by normally open relay contacts.

CAUTION: The Pre-Heat/After-Cool contacts must be closed momentarily on both START and STOP commands to insure proper time delayed operation. This will normally require two DPDT relays properly connected--one relay for remote START and one for remote STOP.

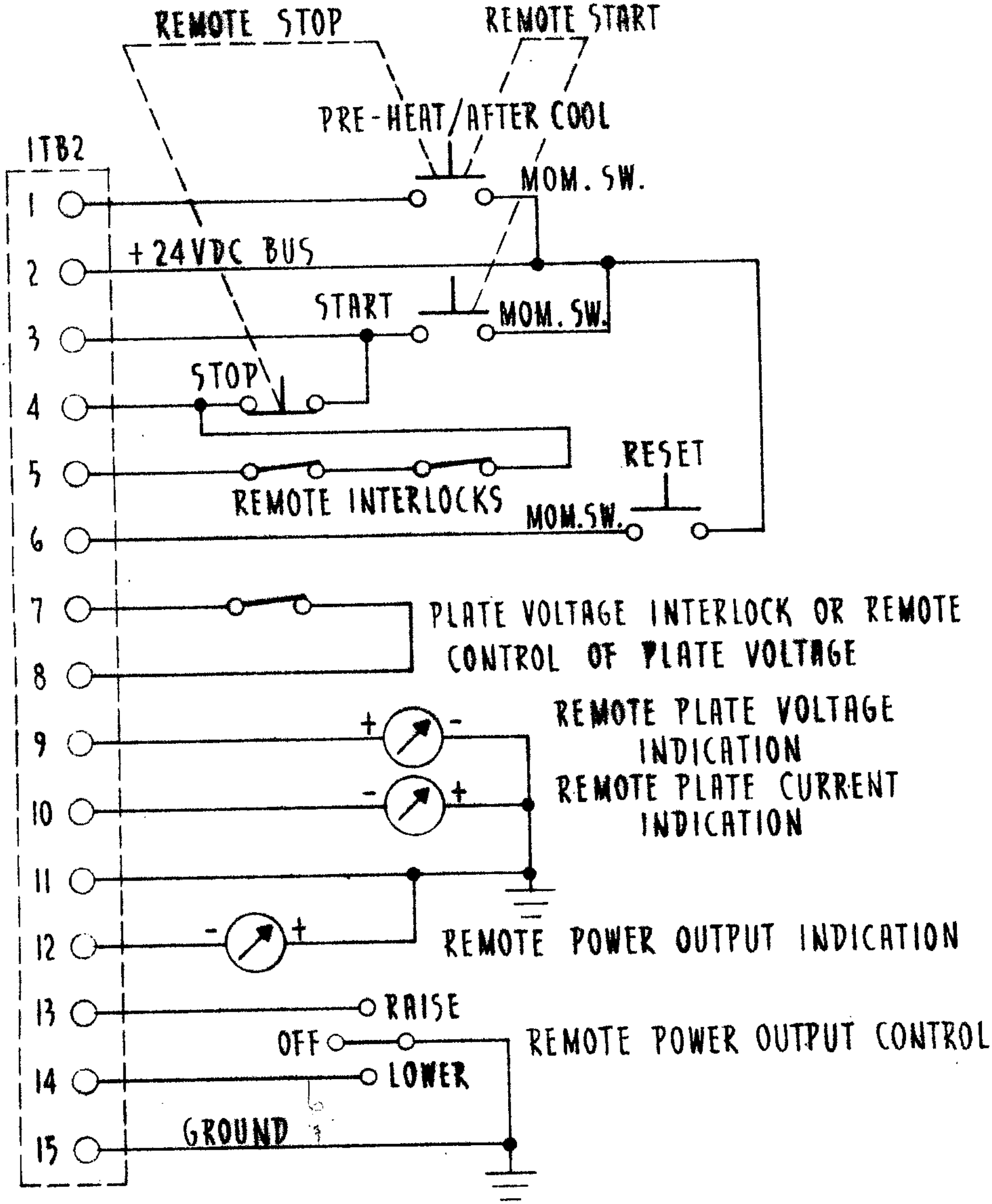



FIGURE 2-3. Remote Control Connection Diagram.

## 2-5 Initial Turn-On Procedures

### 2-5.1 Exciter Initial Turn-On

a. Check the exciter front panel fuse (F1) and the fuse located behind the removable front panel near the power supply regulator (F2) to determine that they are of the proper value (1 ampere). When the fuses are properly installed and the power line safety switch for the transmitter is closed, power is applied to the crystal oscillator oven and FM oscillator chassis heater strips regardless of the position of the LINE switch on the exciter front panel. This feature provides an instant "on-frequency" condition, when the transmitter is turned on, since the heated areas are always at thermal equilibrium.

b. While the exciter unit is properly tuned to the assigned operating frequency; it would still be wise to get acquainted with the RF tuning procedure. It would also ensure that nothing has happened in shipment that would impair performance.

(1) Set the RF OUTPUT LEVEL control to the maximum clockwise position.

(2) Operate the exciter LINE switch to the ON position.

(3) Set the meter selector switch to the B+ position and observe an indication of approximately 25 on the multimeter.

(4) Set the meter selector switch to the DRIVER position.

(5) Adjust the DRIVER TUNING for a minimum on the multimeter.

(6) Set the meter selector switch to the OUTPUT position.

(7) Adjust the POWER AMP TUNING control for a maximum indication on the multimeter.

(8) Alternately adjust the DRIVER TUNING, DRIVER LOADING and POWER AMP TUNING for a maximum indication on the multimeter.

(9) Set the RF OUTPUT LEVEL control for the desired output power.

(10) Repeat Step 8.

c. For maximum initial frequency accuracy and stability, the crystal and FM oscillator chassis should be allowed to warm up thoroughly before setting frequency. (One hour minimum.)

d. Rotate the function switch to the LO position. With a small insulated tuning stick, adjust the LO coil (see Figure 2 of Model 2202A Manual).

While adjusting the coil, a slowly rising reading will be indicated on the multimeter. The reading will rise to approximately 26 and then a sharp drop will occur. (This is the resonance characteristic of the crystal.) Reverse the tuning adjustment until the meter reading is on the slowly changing side of the crystal slope.

Adjust for a reading of approximately 20.

e. Rotate the function switch to the AFC position and operate the AFC disable switch to the disable position (switch toggle pointing toward the feedback adjust potentiometer).

f. With an insulated tuning tool, adjust the FM oscillator tuning capacitor (located through front chassis cover) in a clockwise direction until the capacitor is fully meshed, and mechanical resistance is felt. Reverse the tuning direction, turning the capacitor in a counterclockwise direction, until a full null is observed on the multimeter. Continue counterclockwise again until a meter indication of approximately 28 is obtained.

g. Operate the AFC disable switch into the AFC position (toggle away from feedback potentiometer).

h. Set front panel FREQ. ADJ. potentiometer for a dial scale reading of 5.

i. Adjust the feedback potentiometer until the exciter output frequency is within 1 KHz of the assigned frequency, as observed on a frequency counter or the deviation meter of the station monitor. Fine adjustment to the exact frequency is then accomplished by means of the FREQ. ADJ. control.

NOTE: The feedback adjust potentiometer is a 500 ohm multiturn potentiometer, and a frequency change may not be noted until after it is adjusted in a clockwise direction and then reversed in a counterclockwise direction to bring the AFC circuit within lock-in range. OVEN TEMP controls the temperature within the exciter FM oscillator chassis.

## 2-5.2 RF Amplifier Initial Turn-On

Protective devices and circuits are incorporated into the transmitter to provide maximum safety to operating personnel and minimize the occurrence of component damage during operation. High voltage circuits cannot be energized unless all access door interlocks are closed. A 180-second time delay circuit prevents screen and plate voltages from being applied to the driver and PA tubes until the filaments have achieved their proper operating temperature. The same delay circuit provides after-cooling for the tubes after the STOP button is pushed. At the end of the 180-second period, the blowers will turn off.

To energize the transmitter proceed as follows:

> **WARNING**
>
> This unit contains high-voltage and high-current power supplies. Potentials up to 7500 volts are present and exposed to maintenance personnel working with power on and interlocks defeated. Keep hands and metallic tools out of all high voltage areas. The principal purpose of defeatable interlock switches is to permit viewing areas where arcing may occur to determine the nature of a fault. Have another person standing by at all times.

a. Check that rear doors, swing-down control panel, and the two RF compartment access covers are all in position and tightly secured. Open lower cabinet doors.

b. Make certain that all circuit breakers are in the OFF position before turning on the 3-phase line safety switch.

c. Operate the LINE circuit breaker to the ON position.

d. Check the LINE voltage on all three phases by sequentially operating the three push-button switches located under the LINE meter.

e. If the voltages are normal for the tap positions selected on the transformer primary windings, operate the BLOWER circuit breaker to the ON position.

   The control circuit power supply is now energized.

f. Operate the FILAMENT circuit breaker to the ON position.

g. If the PLATE ON-OFF push-button switch is in the ON position, the built-in lamp will be lit. Push the switch to transfer it to the OFF condition and extinguish the lamp before proceeding to the next step. This switch has a push-ON, push-OFF type action.

h. Press the START push-button switch. If the air interlocks pull in when the blowers function, the filament transformers and grid bias circuits will be energized by the closure of contacts on relay 3K18. The 180-second pre-heat timing cycle will also be initiated.

i. Check the PA filament voltage by pressing the PA push-button below the FILAMENT meter. The meter should read 6.3 volts for the FM-25KD and 7.5 volts for the FM-12KD. If it does not, rotate the PA FIL ADJUST control to obtain the proper reading.

j. Check the driver filament voltage by pressing the DR push-button. The FILAMENT meter should again read 6.3 volts, or, very close to it. There is no adjustment for this voltage since it is obtained from a Sola constant-voltage transformer.

k. With the OUTPUT POWER control rotated to its counterclockwise (CCW) extreme, the control grid bias on the tetrode driver tube should be approximately 250 volts as read on the DRIVER meter. The GRID push-button switch should be pressed. Leave the OUTPUT POWER control in the extreme CCW position. The driver screen voltage cannot be measured at this time since it is not applied until the high voltage power supply is energized.

l. Operate the PLATE VOLTAGE switch (on lower panel) to the LOW position. (This applies to the FM-25KD only.)

m. If the 180-second pre-heat cycle (referred to in Step h) has been completed, pressing the PLATE ON-OFF switch should close the contactors in the primary circuit of the high-voltage power supply. The lamp in the PLATE ON-OFF switch will be energized.

n. Readings on the PLATE voltmeter (approximately)

| | | | |
|---|---|---|---|
| FM-25KD:- | DR (driver) | 1.8 | KV |
| | PA (amplifier | 4.0 | KV |
| FM-12KD:- | DR (driver) | 3.0 | KV |
| | PA (amplifier) | 6.7 | KV |

o. Press the SCRN push button under the DRIVER meter. A reading of 300 volts should be obtained.

p. Press the PLATE ON-OFF switch to the OFF position. This completes the initial turn-on sequence for the FM-12KD. If operating the FM-25KD, proceed with the following two steps.

q. Operate the plate voltage switch to the HIGH position.

r. Check to ascertain that the OUTPUT POWER control is still in the CCW position, press the PLATE ON-OFF switch to the ON position. Again measure the DR and PA plate voltages for the FM-25KD. They should read approximately 3.5KV and 7.5KV respectively.

This completes the FM-25KD initial turn-on sequence.

## SECTION III

## OPERATION

3-1 Front Panel Controls and Indications

As shown in Figures 3-1 through 3-4, all operational controls and indicators for the Model FM-25KD are located on the front of the unit. Table 3-1 lists these operating controls and indicators and gives their reference designators and a brief functional description of each. Photos for the FM-25KD are shown because the only visible difference is the absence of the Low-High Power Switch on the FM-12KD panel just underneath the elapsed time meter.

3-2 Tune Up Procedure

The transmitter is normally supplied tuned and tested at the factory on the customer's assigned operating frequency. The procedure used at the factory for initial tuning and final check out is as follows. (Assumes proper installation and connection of AC line, audio, monitors, filter, directional coupler and load, and a knowledge of operating control functions and location.)

a. The exciter should be allowed 10 minutes to reach temperature stabilization. It is wired so that the crystal heater and circuit heater are on continuously if the line cord is connected to a 120 V. AC source. The exciter is otherwise turned on by operating its own On-Off switch. A 3db resistive 50-ohm pad should always be used in the coaxial line between the exciter and input to the driver stage, and initially the exciter power output control (screwdriver front panel adjustment) should be set to its full CCW direction.

b. Operate the following circuit breakers to the "ON" position.

(1) Blower

(2) Filament

(3) High Voltage (Note that control panel plate On/Off push button switch should be off at this point.)

c. Press the "START" button. Blowers and fans will start. Observe that the following indicator lamps light.

(1) Bias Indicator

(2) Interlock Indicator

(3) Ready Indicator-lights after 3 minutes filament heating time.

Observe filament voltages. Adjust if necessary for proper voltage.

d. Operate the "POWER OUTPUT" control to maximum CCW position.

e. Operate the High-Low Power switch to the Low position. (FM-25KD only.)

f. Observe Forward Power from the exciter. Adjust exciter power output control for about 1/3 scale reading. Adjust exciter driver and output tuning for maximum output power. If necessary reduce power output for a 1/3 scale forward indication.

g. Observe Reflected Power on the exciter output line. Carefully adjust DRIVER INPUT TUNING and DRIVER GRID TUNING for minimum reflected power.

After initial adjustment for minimum reflected, increase exciter power output to maximum and re-peak exciter tuning for maximum output.

Readjust DRIVER INPUT TUNING and DRIVER GRID TUNING for minimum reflected power. It is important that care be taken to optimize these input circuit adjustments to assure maximum transfer of power to the driver grid.

h. Operate plate voltage switch. This is a "push-on/push-off" push button switch. It is illuminated red any time the plate circuit is "On".

i. Observe plate voltage on both the PA and the Driver for proper values. Plate current at this point should be approximately 0 ma for the Driver (cut off) and 300 ma for the PA (normal zero bias idling current).

j. Operate the POWER OUTPUT control for a small increase in Driver Plate Current. Adjust DRIVER PLATE TUNING for maximum PA plate current.

k. Adjust PA PLATE TUNING and PA PLATE LOADING for maximum Power Output as indicated on the Power Output Meter. Readjust DRIVER PLATE TUNING and PA TUNING and PA LOADING for maximum Power Output.

l. Operate Plate Voltage Switch to turn off high voltage.

m. Operate the High-Low Power Switch to the High Position (FM-25KD only). Return Power Output Control to maximum CCW position.

n. Operate Plate Voltage Switch to turn on high voltage. Driver and PA plate voltages should be approximately 3.5 KV and 7.6 KV respectively (FM-25KD). The FM-12KD voltages should be correspondingly 3KV and 6.7 KV.

o. Increase Power Output to 10 KW by operating the Power Output Control.

p. Adjust DRIVER PLATE TUNING and PA PLATE TUNING and PA PLATE LOADING for maximum Power Output.

q. Check to see that reflected power in the exciter output line is minimum. Carefully adjust DRIVER INPUT and GRID TUNING as required for minimum reflected power.

r. Operate Power Output Control to increase output to 25 KW (FM-25KD) or 12 KW for the FM-12KD or lower power as required.

s. Allow at least 1/2 hour operation and then make final trimming adjustments of DRIVER PLATE TUNING and PA PLATE TUNING and PA PLATE LOADING to maximize power output. Readjust Power Output control for required Power Output.

NOTE: For all modes of operation, driver screen current should be maintained between +25 ma and -25 ma. This is a function of driver level and driver output loading. The latter is adjusted by the driver output loading capacitor, 2C64. Decreasing the value of this capacitor decreases loading, causing an increase in positive screen current, while increasing the value of capacitor increases loading and decreases screen current. Screen current will vary for varying power levels and from tube to tube. Any value between the limits indicated is satisfactory providing operation is otherwise satisfactory.

## 3-3 Automatic Power Control (ALC)

After completing the tune-up procedure shown in Section 3-2, the automatic level control may be set to maintain constant power output against varying line voltage of up to $\pm$ 5%. Use the following procedure:-

a. Turn the manual OUTPUT POWER control (3R10) full clockwise.

b. Turn the screwdriver automatic level control, ALC ADJ, (3R13), full clockwise.

c. Load and retune the PA for one to two kilowatts over the authorized station transmitter output power. Under this condition the PA "apparent" plate circuit efficiency will often exceed 80%.

d. Under condition of c. (above) note the Driver Screen current. It should read +20 to +35 ma for "full bore". This is satisfactory for this temporary condition.

e. Turn the ALC ADJ screwdrive control counterwise to reduce the output power to the authorized output power level. Set the power output carefully by observing the OUTPUT FWD meter reading.

f. Again observe the Driver Screen current. The reduced power setting should bring the screen meter to the mid-scale position with the preferred range for normal line voltage conditions being between -10 ma and 0 ma.

g. Check the PA plate circuit efficiency at the authorized output power. It will be found that the efficiency has decreased to a value between 70% and 75%. This efficiency will vary with the amount of ALC reserve power allowed and the AC line voltage. The power output will, however, be held relatively constant for line variations. Experience will show the operator how much "ALC reserve" is necessary to maintain authorized power output for the prevailing power line voltage variations.

3-4 Automatic VSWR Protection

Refer to Figure 3-5, which shows the relationship between reflected power on the output line and scale indications on the SWR protection meter relay. For any given transmitter operating power, select a reflected power limit which corresponds with a VSWR of 2:1 or less. The meter relay when set to this limit will provide an overload signal to the recycling control circuit if the reflected power exceeds the preset level.

NOTE:- For reference, a VSWR of 2:1 represents a reflected power of approximately 11% of the forward power in the 50 ohm line.

3-5 Driver Neutralizing

The 4CX1000K driver stage contains a capacitive bridge neutralizing arrangement with the variable capacitor coupled to the driver plate. It normally will not require attention. However, if necessary, any standard neutralizing procedure may be used. When properly neutralized, there should be little or no influence on the driver reflected power as the driver plate circuit is tuned through resonance and/or power is increased or decreased.

### 3-5.1 Neutralization Procedure

If reneutralization is necessary, the method employing a grid-dip oscillator operating as a diode absorption meter is recommended. NOTE:- No plate or screen voltages should be applied to the Driver stage. Remove the Driver cavity front-panel cover and mount the absorption meter in a stable position so that the pick-up coil is loosely coupled to the Driver plate tank line. Apply drive from the FM exciter and resonate grid and plate circuits for a maximum indication on the grid-dip meter. Without disturbing the coupling of the grid-dip meter to the plate tank circuit adjust the neutralizing capacitor a turn or two at a time-retuning the driver plate tuning each time for a maximum indication. A broad minimum indication in the output will be noted as the neutralizing capacitor is run through its tuning range. The most accurate setting will be obtained if the rotational turns of the capacitor are counted from a convenient reference and several passes are made through the minimum indication. NOTE:- A complete null will not be obtained. When satisfied that a minimum has been obtained, replace the Driver front panel cover and proceed with the tuning procedure described elsewhere. NOTE:- As an option an air pressure interlock system is sometimes used. For this system, the interlock must be bypassed with a jumper to operate the filament of the tube when the front panel cover is removed.

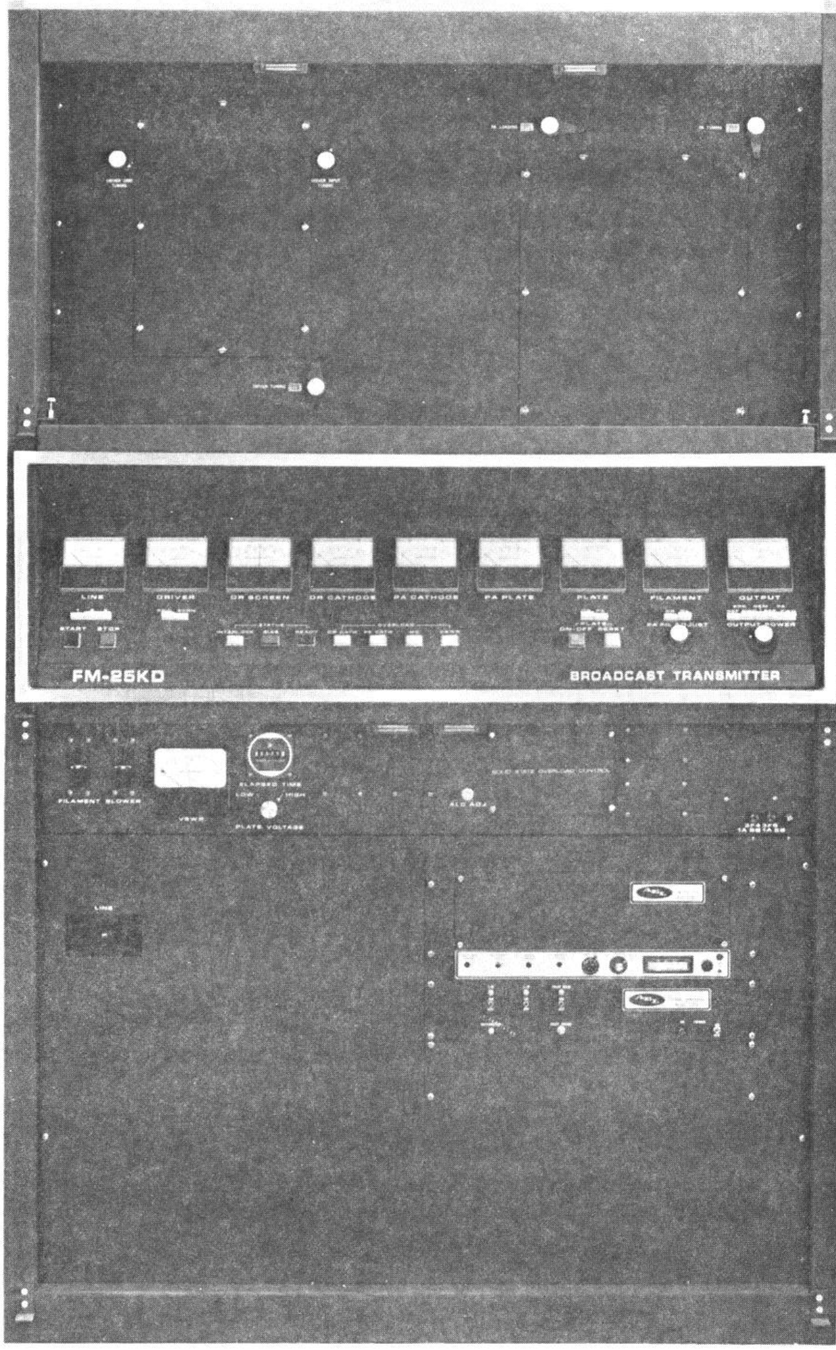



Figure 3-1. FM-25KD Front View, Doors Removed

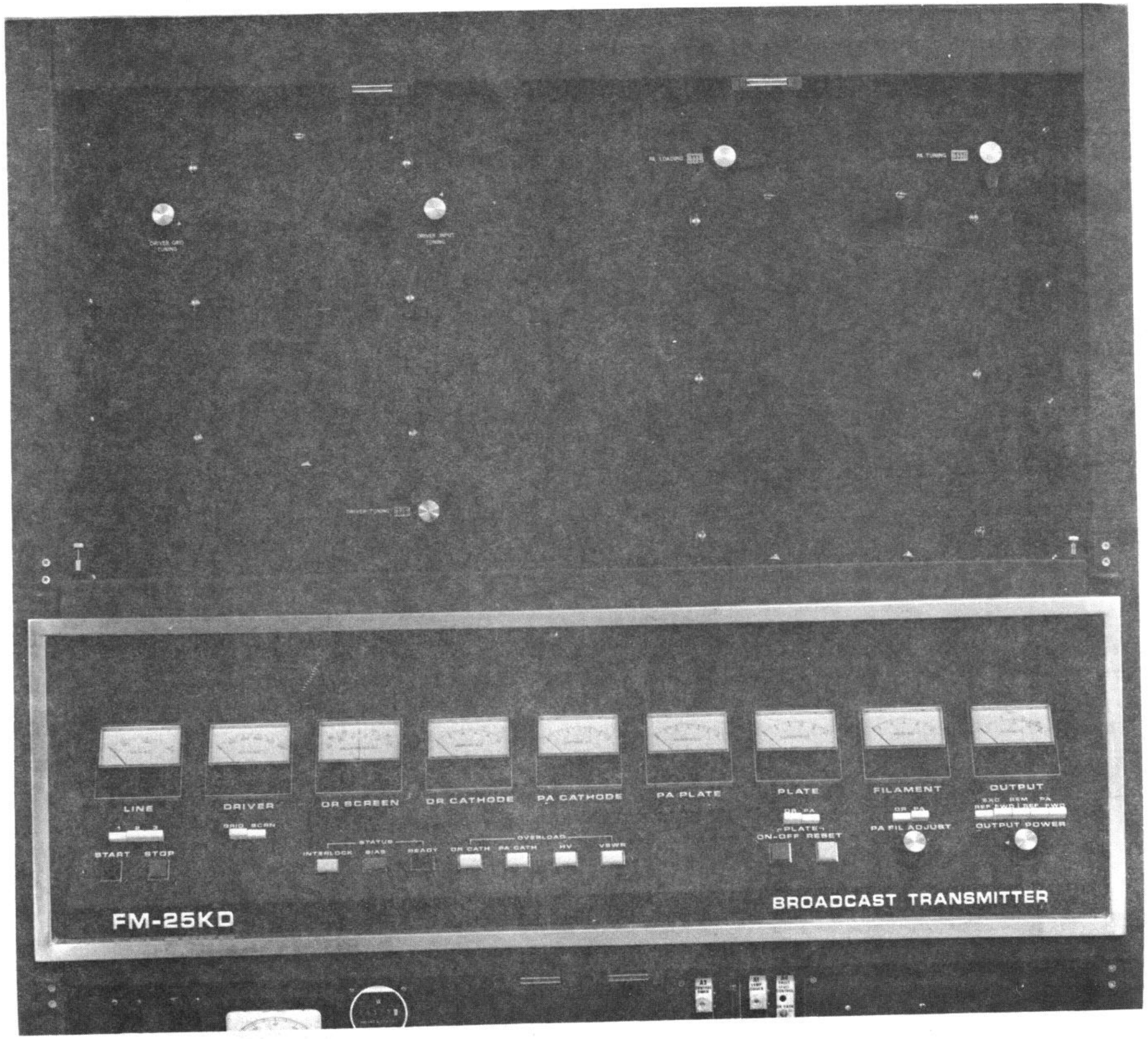
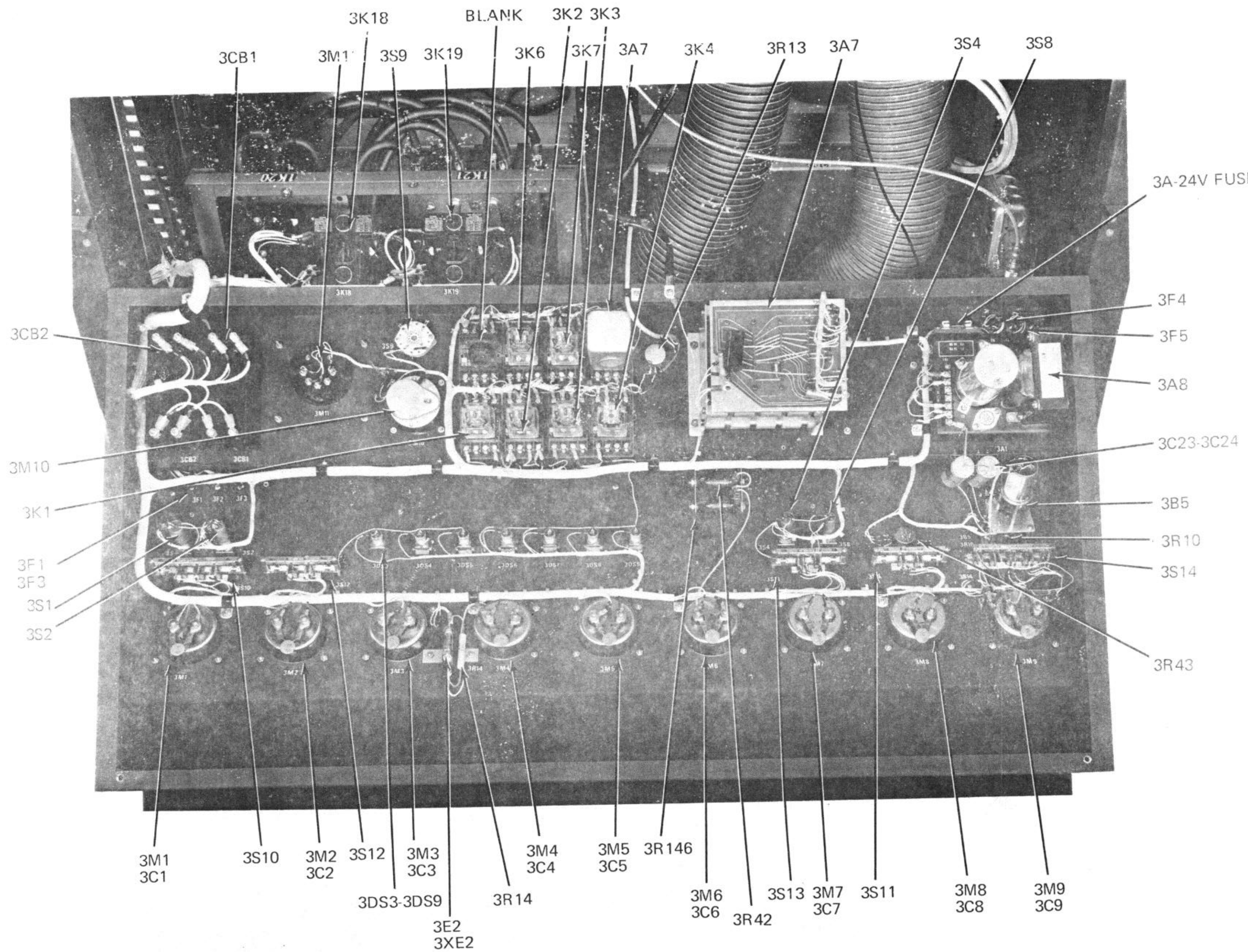



Figure 3-2. FM-25KD Control Panel Close-up


3K18
BLANK
3K2 3K3
3CB1
3M11
3S9
3K19
3K6
3K7
3A7
3K4
3R13
3A7
3S4
3S8
3A-24V FUSE
3F4
3F5
3A8
3C23-3C24
3B5
3R10
3S14
3R43
3CB2
3M10
3K1
3F1
3F3
3S1
3S2
3M1
3C1
3S10
3M2
3C2
3S12
3M3
3C3
3DS3-3DS9
3E2
3XE2
3R14
3M4
3C4
3M5
3C5
3R146
3M6
3C6
3R42
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3M7
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3S11
3M8
3C8
3M9
3C9

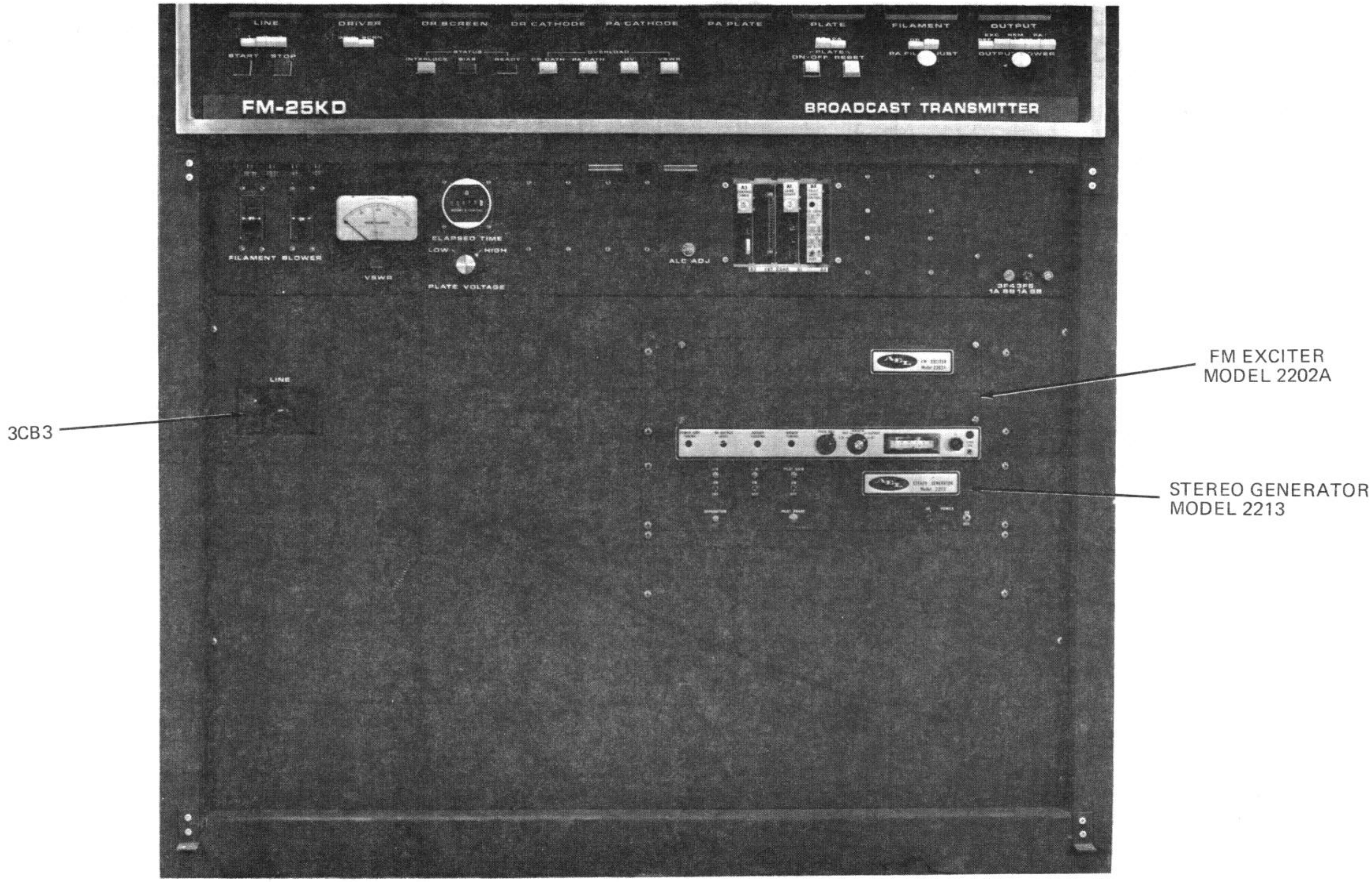



Figure 3-4. FM-25KD Lower Cover Panel Close-up

NO. 340 R-20 DIETZGEN GRAPH PAPER
20 X 20 PER INCH

EUGENE DIETZGEN CO.
MADE IN U.S.A.

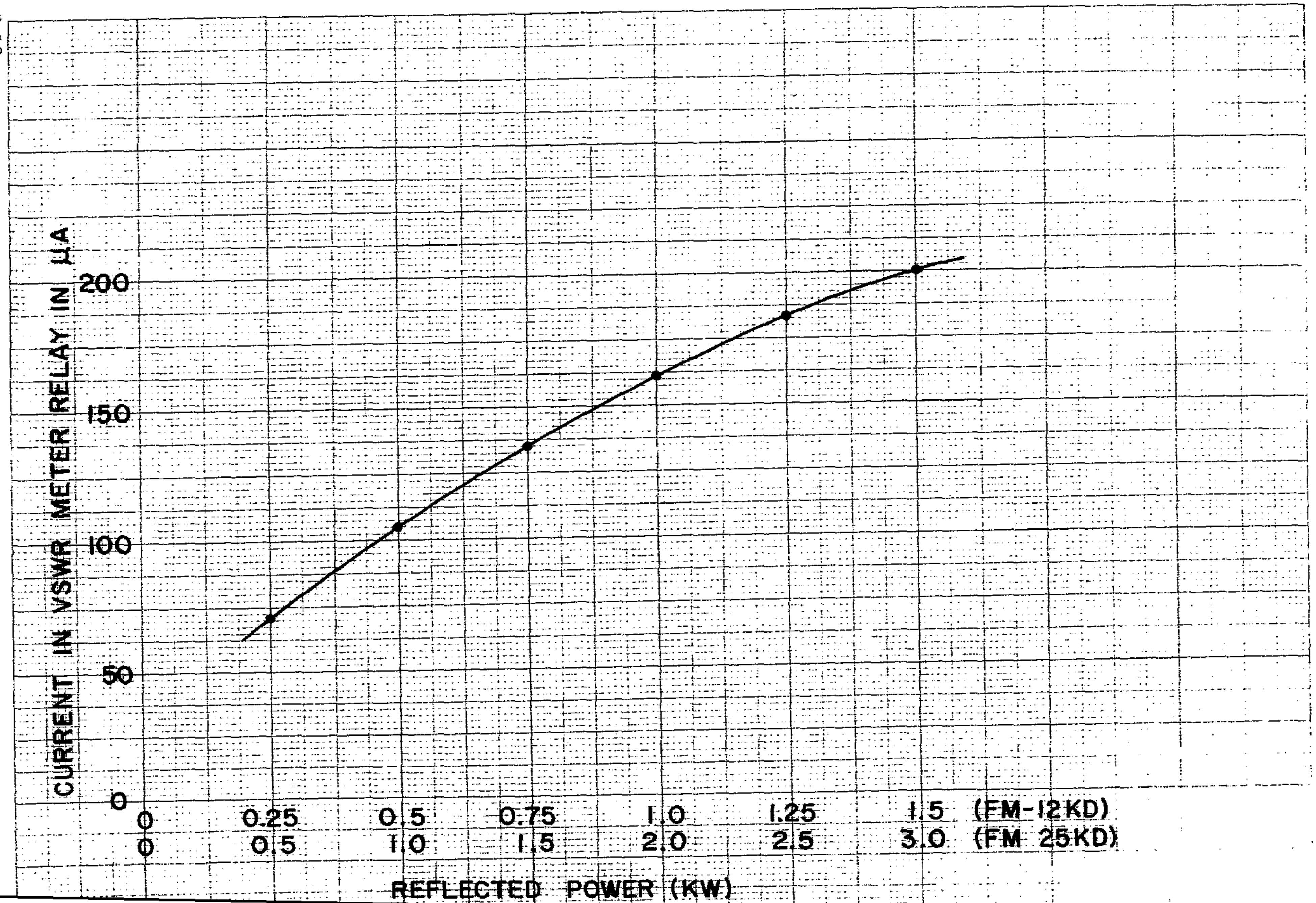


Table 3-1. Operating Controls and Indicators

| Ref. Des. | Nomenclature | Function |
|---|---|---|
| MODEL 2202-A FM EXCITER (Front Panel) | | |
| S2 | Line On | Applies AC power to exciter power supply. |
| DS1 | Line On | Lamp indicates when AC power is applied. |
| S1 | (None) | Meter switch for multimeter. |
| | L.O. | Monitors voltage drop across the emitter resistor of the crystal oscillator transistor. |
| | AFC | Measures level of voltage derived from integration of the AFC IF frequency. |
| | Driver | Measures relative collector current of driver transistor. |
| | Output | Measures level of a rectified sample of the RF output. |
| | B+ | Measures the output of the 15 volt power supply. |
| M1 | (None) | Performs multimeter function as determined by the position of S1, described above. |
| C50 | Driver Tuning | Tunes resonant frequency of driver tank circuit. |
| C52 | Driver Loading | Adjusts loading on driver collector circuit and matches it to the base of the power amplifier Q18. |
| R30 | RF Output Level | Adjusts the collector voltage applied to the driver transistor. |
| C55 | Power Amp Tuning | Tunes resonant frequency of power amplifier collector tank circuit. |
| R25 | Freq. Adjust | Adjusts the conduction period of a monostable multivibrator in the AFC loop. |
| F1 | Fuse - 1 A | Provides overload protection for exciter power transformer. |

Table 3-1. Operating Controls and Indicators
(continued)

| Ref. Des. | Nomenclature | Function |
|---|---|---|
| MODEL 2202-A FM EXCITER (Behind Removable Panel) | | |
| S3 | AFC-Lock | Closes AFC loop to establish FM oscillator frequency control by comparing it to a crystal controlled reference frequency. |
| S3 | AFC-Disable | In this position, the AFC loop is opened and the FM oscillator operating frequency can be readily adjusted. |
| R106 | Temp Adjust | Controls level of regulated temperature within the FMO chassis. |
| R8 | R8 | Establishes a reference voltage against which the integrated AFC IF frequency is compared. |
| L5 | L.O. Tune | Tunes resonant frequency of crystal oscillator tank circuit. |
| C77 | FMO Tune | Capacitor tunes the free-running frequency of the FM oscillator. |
| F2 | F2 - 1A | Protects against damage from possible short circuits in the FMO chassis heater circuits. |
| R87 | (None) | This control, mounted on the power supply regulator PC card, adjusts the +15 volt regulated output used by the FMO chassis circuits. |
| MODEL 2202-A FM EXCITER (Rear of Chassis) | | |
| | 115 VAC Input | Three wire (one grounded) input power connector. |
| TB2 | TB2 | AC terminal board. With LINE ON switch (S2) closed and jumper removed from terminals 1 and 2, the exciter can be remotely controlled by placing a closure across these terminals. Ancillary equipment power (Stereo Generator, SCA) can be obtained from terminals 2 and 3. |

Table 3-1. Operating Controls and Indicators
(continued)

| Ref. Des. | Nomenclature | Function |
|---|---|---|
| | | MODEL 2202-A FM EXCITER (Rear of Chassis) |
| | SCA | A modulated SCA carrier can be introduced at this connector to be combined with either a monaural or composite stereo signal to modulate the FM exciter. |
| | RF Output | High level output (10 watts nominal) from solid-state power amplifier. |
| TB1 | TB1 | Audio terminal board. For monaural operation, the audio signal would be applied to terminals 1, 2, and 3 at a 600 ohm impedance level, balanced to ground. Terminal 2 is ground. A jumper is also placed across terminals 4 and 5. For stereo operation, the jumper would be placed across terminals 5 and 6. The composite stereo signal would be introduced via an unbalanced line to the connector captioned STEREO INPUT. |
| | Stereo Input | Accepts a composite stereo signal to modulate the exciter. A jumper should be placed across terminals 5 and 6 on terminal board TB1. |
| R97 | R97 | Adjusts the level of the monaural AF signal applied to the FM oscillator. |
| R98 | R98 | Adjusts the level of the composite stereo signal applied to the FM oscillator. |
| | | FM-12KD OR FM-25KD TRANSMITTER (Main Control Panel) |
| 3M1 | Line (Meter) | AC Voltmeter (0-300 VAC) Measures input power line voltages. |
| 3S10 | Line (Switch) | Selects each of the three phases to measure line voltage. |
| 3M2 | Driver (Meter) | DC voltmeter (0-500 V) to measure driver grid bias and screen voltages. |

Table 3-1. Operating Controls and Indicators (continued)

| Ref. Des. | Nomenclature | Function |
|---|---|---|
| FM-12KD OR FM-25KD TRANSMITTER (Main Control Panel) | | |
| 3S12 | Driver (Switch) | Selects either grid bias (GRID) screen voltage (SCRN) to be measured on meter 3M2. |
| 3M3 | DR Screen | DC Milliammeter (50-0-50 ma) to measure driver screen current. |
| 3M4 | DR Cathode | DC Ammeter (0-1 amp DC) mesures driver cathode current. |
| 3M5 | PA CATHODE | DC Ammeter (0-6 amp DC) measures power amplifier cathode current. |
| 3M6 | PA Plate | DC Ammeter (0-6 amp DC) measures power amplifier plate current. |
| 3M7 | Plate (Meter) | DC Voltmeter (0-10 KVDC) measures either driver or PA plate voltages. |
| 3S13 | Plate (Switch) | Selects either driver (DR) or power amplifier (PA) plate voltages to be measured on meter 3M7. |
| 3M8 | Filament (Meter) | AC Voltmeter (0-10 VAC) measures either driver or PA filament voltages. |
| 3S11 | Filament (Switch) | Selects either driver (DR) or PA filament voltages to be measured on meter 3M8. |
| 3R43 | PA Fil Adjust | Controls operation of SCR regulator in primary of the PA filament transformer. |
| 3M9 | Output (Meter) | Measures forward and reflected power between the FM exciter and the driver grid and also between the output of the harmonic filter and the antenna transmission line. The various functions are selected by means of a push-button switch 3S14. In the REMOTE position the PA forward power reading can be monitored at a remote point. |
| 3S14 | Output (Switch) | Selects the various functions described in the preceding paragraphs. |

Table 3-1. Operating Controls and Indicators (continued)

| Ref. Des. | Nomenclature | Function |
|---|---|---|
| FM-12KD OR FM-25KD TRANSMITTER (Main Control Panel) (cont'd) | | |
| 3R10 | Output Power | Controls transmitter output power by varying the grid bias on the driver and as a consequence, the RF drive to the PA stage. It is also motorized so it can be operated from a remote point. |
| 3S1 | Start (Switch) | Initiates the turn-on sequence of the transmitter after the LINE, BLOWER, and FILAMENT CIRCUIT breakers are turned on. |
| 3DS1 | Start (Lamp) | P/O START switch assembly. It will light when the START switch is actuated and is latched in by contacts on relay 3K1. |
| 3S2 | Stop | Opens up the coil circuit of relay 3K1, causing the START switch latching contacts to open. This shuts down the transmitter except for a 180-second after-cooling period initiated by operation of the STOP switch. The blowers will automatically shut down after this period. |
| 3DS3 | Interlock Status | If all door interlocks are closed the INTERLOCK STATUS lamp will be energized upon closure of the START switch. |
| 3DS4 | Bias Status | If the bias supply is functioning properly contacts on relay 3K4 will close to energize this indicator. |
| 3DS5 | Ready Status | Contacts of relay 3K3, that had opened at the instant the START switch was closed will again close, after the 180-second pre-heat period has been completed, and energize the READY STATUS indicator lamp. |
| 3DS6 | DR Cath Overload | If a malfunction occurs that increases the driver cathode current beyond a preset value, this indicator will light and remain lit until reset. |

Table 3-1. Operating Controls and Indicators (continued)

| Ref. Des. | Nomenclature | Function |
|---|---|---|
| FM-12KD OR FM-25KD TRANSMITTER (Main Control Panel) (cont'd) | | |
| 3DS7 | PA Cath Overload | If a malfunction occurs that increases the PA cathode current beyond a preset value, this indicator will light and remain lit until reset. |
| 3DS8 | HV Overload | If a malfunction occurs that causes an increase in current, in high voltage circuits external to the power supply, beyond a preset value, this indicator will light until reset. |
| 3DS9 | VSWR | A meter relay, located on the lower front panel, monitors reflected power sampled at the output of the harmonic filter. When the current reading reaches a preset value due to excessive VSWR an impulse is sent to the fault cycling circuit and the VSWR lamp will light. |
| 3DS11 | Reset (P/O Plate Reset Switch) | With 3K7 energized at the time the +24 volt control power supply is activated, normally closed contacts in series with the RESET indicator (3DS11) will be opened preventing it from lighting. It will stay unlit until three faults occur and the HV supply control circuits are locked out when it will light to indicate a need for a manual reset of plate voltage and overload indicators. |
| 3S4 | Plate On-Off | If all previous steps have functioned normally and the fault-cycling control relay 3K7 is energized, pressing the PLATE ON-OFF switch will cause the high voltage plate transformer contactors to close to provide plate voltage for driver and PA plate circuits and via a Zener regulator circuit to the screen of the driver. Pressing the SCRN push-button under the DRIVER meter should obtain a reading of +300 volts. |

Table 3-1. Operating Controls and Indicators (continued)

| Ref. Des. | Nomenclature | Function |
|---|---|---|
| FM-12KD OR FM-25KD TRANSMITTER (Main Control Panel) (cont'd) | | |
| 3S8 | Plate Reset | Reset the fault counter, in the fault-cycling circuit, to its original state and high voltage circuits are re-activated. |
| (Lower Control Panel) | | |
| 3F1 | | Fuse in #1 section of 3S10 LINE switch. Protects against wiring harness damage in case of a short in the switch. |
| 3F2 | | Fuse in #2 sectionof 3S10 LINE switch. Same function as above. |
| 3F3 | | Fuse in #3 section of 3S10 LINE switch. Same function as above. |
| 3CB3 | Line | Main power line circuit breaker. Rated at 225 amp max. |
| 3CB2 | Filament | Filament circuit breaker. Rated at 20 amp max. |
| 3CB1 | Blower | Blower circuit breaker. Rated at 20 amp max. |
| 3M11 | VSWR | Meter relay provided for protection against excessive VSWR. Can be set to provide a contact closure at any preset value. Closure would activate the fault re-cycling circuit. |
| 3M10 | Elapsed Time | Elapsed time meter. Indicates accumulated operating time. |
| 3S9 | Plate Voltage (FM-25KD Only) | Provides a capability for reducing the high voltage during initial tuning procedures by connecting the 3-phase primary power source to the transformer primary windings connected in a WYE configuration (LOW). In the (HIGH) position, a DELTA primary circuit arrangement is used and full voltage is obtained. |

Table 3-1. Operating Controls and Indicators
(continued)

| Ref. Des. | Nomenclature | Function |
|---|---|---|
| FM-12KD OR FM-25KD TRANSMITTER (Lower Control Panel) (cont'd) | | |
| 3R13 | ALC Adjust (Optional) | Establishes RF output power level that will be maintained constant regardless of normal tube aging and power line variations. |
| 3F4 | 3F4 | Primary circuit fuse for 24-volt control circuit power supply. |
| 3F5 | 3F5 | Same as above. |
| A4 (PC Board) | Overload Threshold Controls | Located behind an easily removable cover plate are three overload threshold adjustment controls. From top to bottom their functions are: DRIVER OL, PA OL & PLATE. Lower control is fault system test switch. |
| (Upper Front Panel) | | |
| 2C11 | Driver Input Tuning | Tunes the primary of the input coupling transformer between the exciter and driver control grid. |
| 2C12 | Driver Grid Tuning | Tunes the secondary of the input coupling transformer. |
| 2L4 | Driver Tuning | Varies the effective length of the driver-to-PA coupling transformer. |
| 2L9 | PA Tuning | Tunes the input to the pi output matching network. |
| 2L10 | PA Loading | Tunes the series inductance of the network to control loading of the PA by the antenna circuits. |

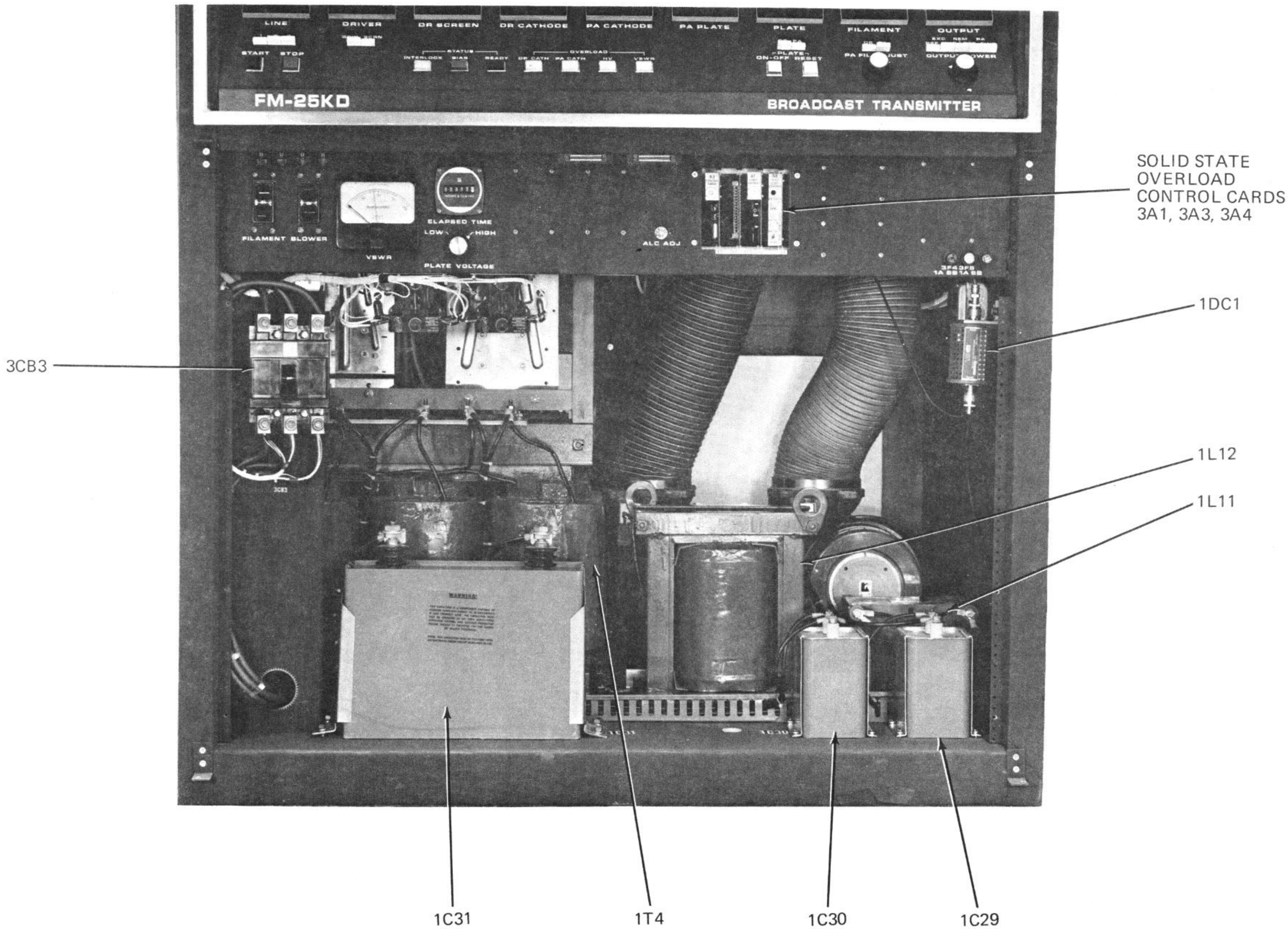



Figure 3-6. FM-25KD Front Lower Panel Removed

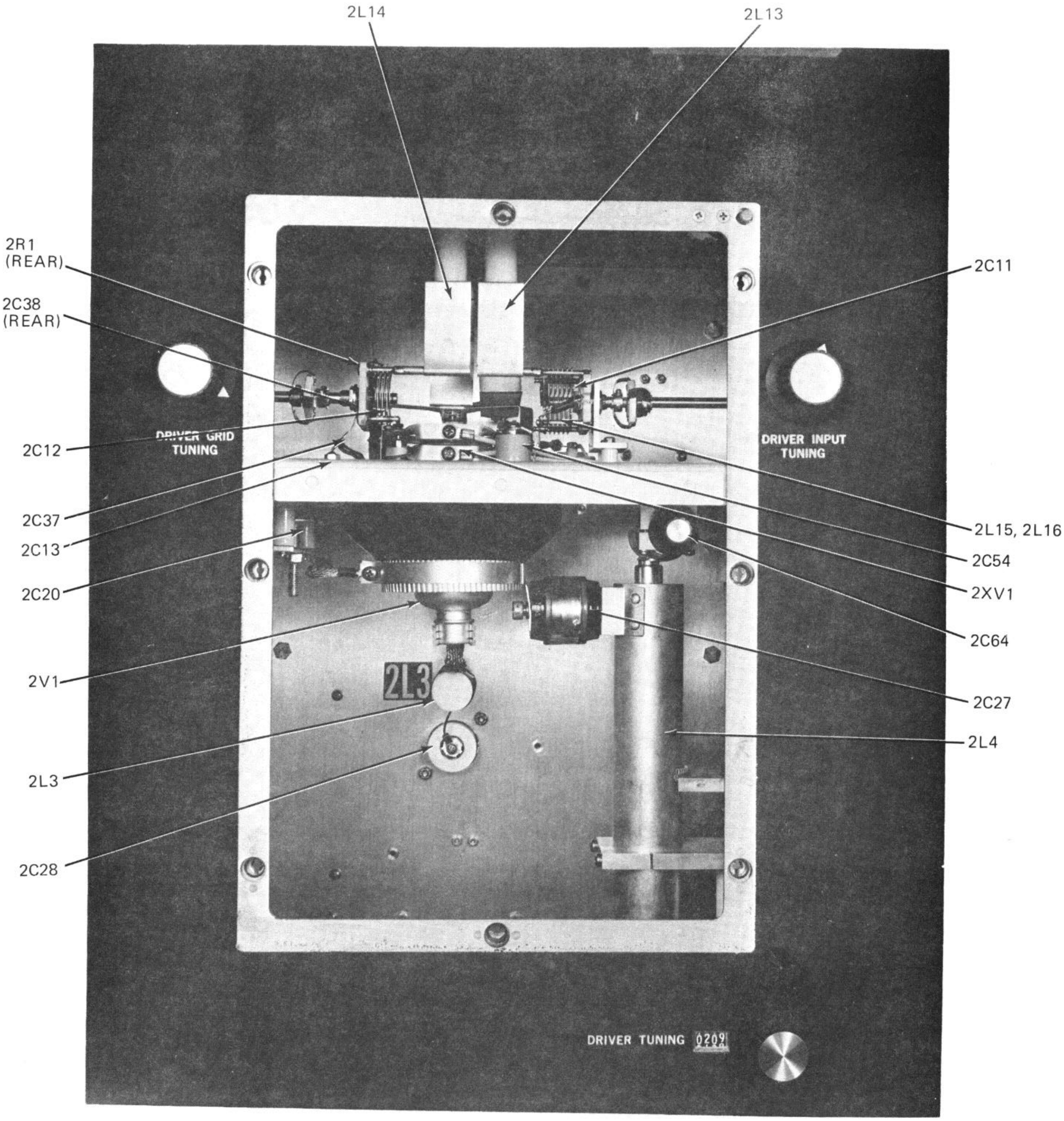



Figure 3-7. Driver Compartment, Cover Removed

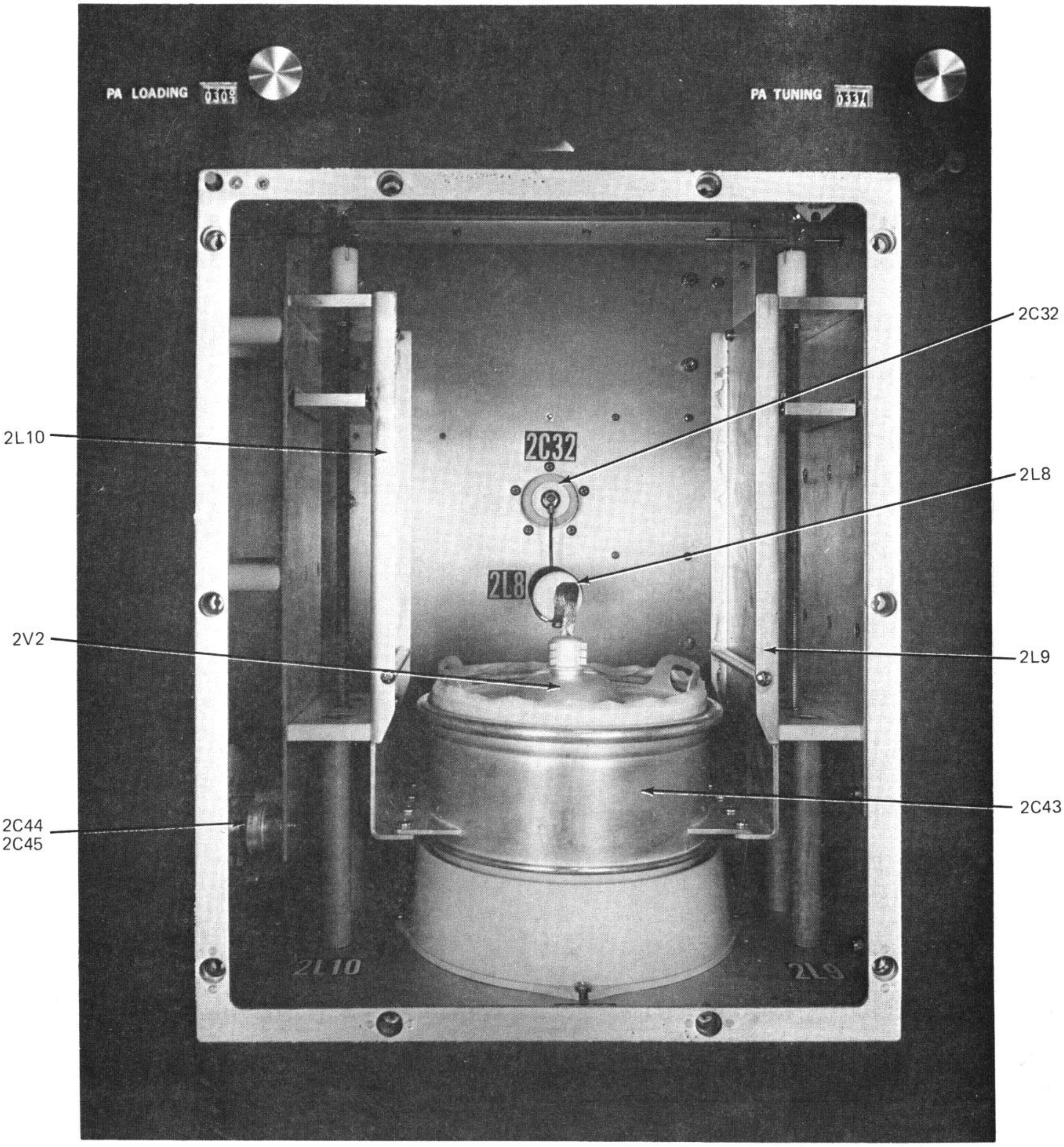



Figure 3-8. Power Amplifier Compartment, Top Cover Removed

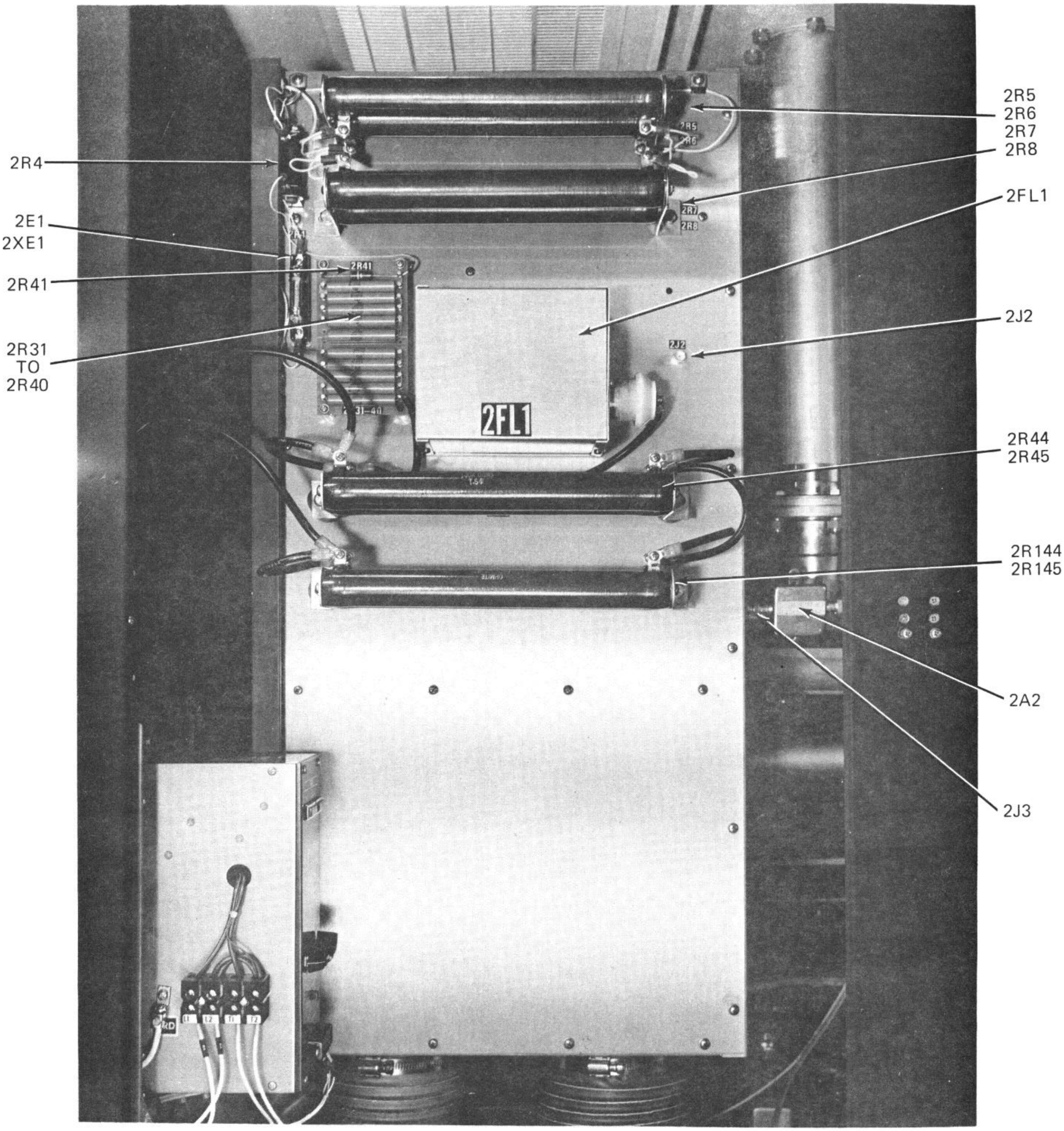



Figure 3-9. Power Amplifier Compartment, Rear View

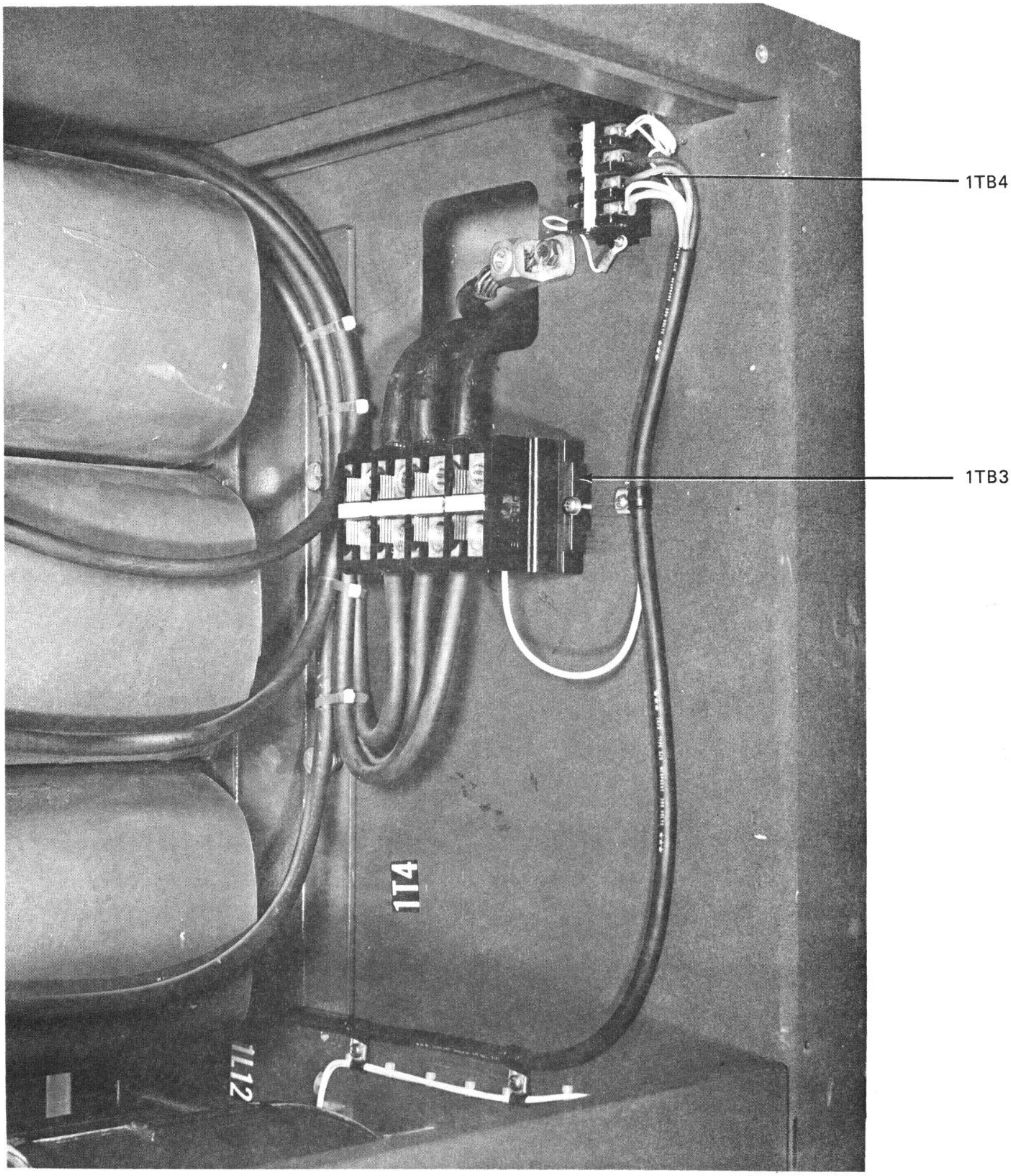



Figure 3-10. AC Power Input Connections

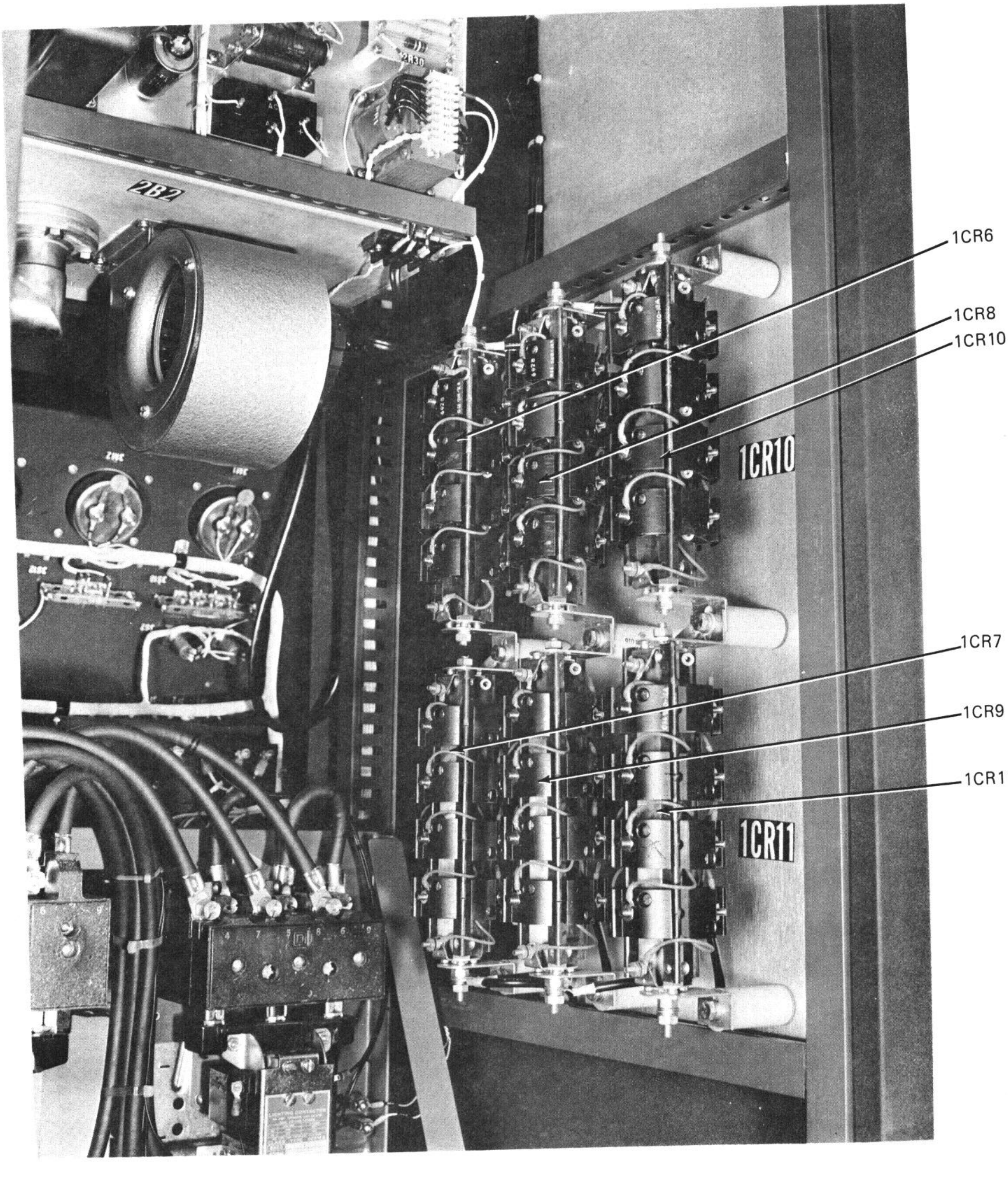



Figure 3-11. HV Rectifier Assembly

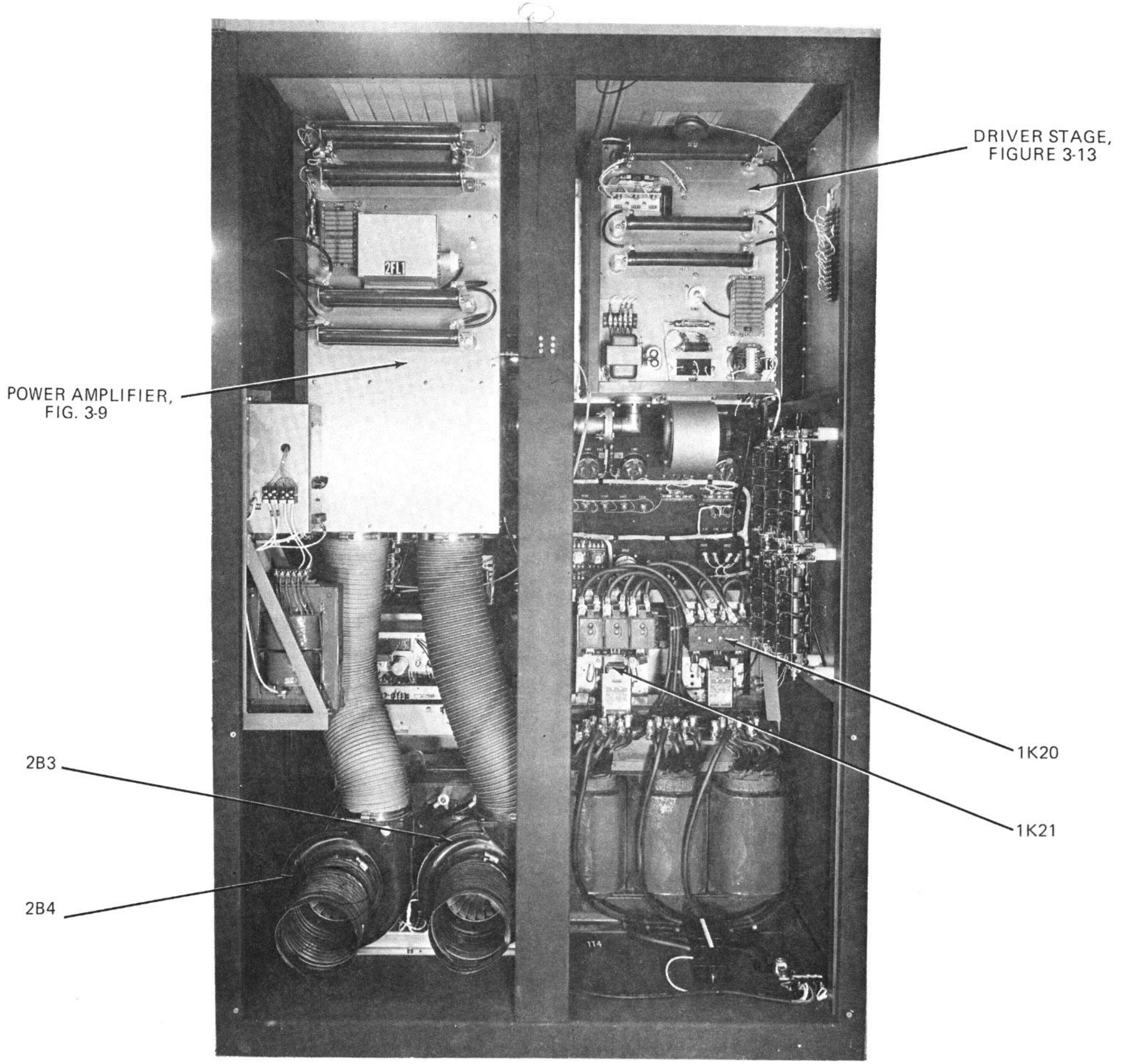



Figure 3-12. FM-25KD, Rear View, Doors Removed

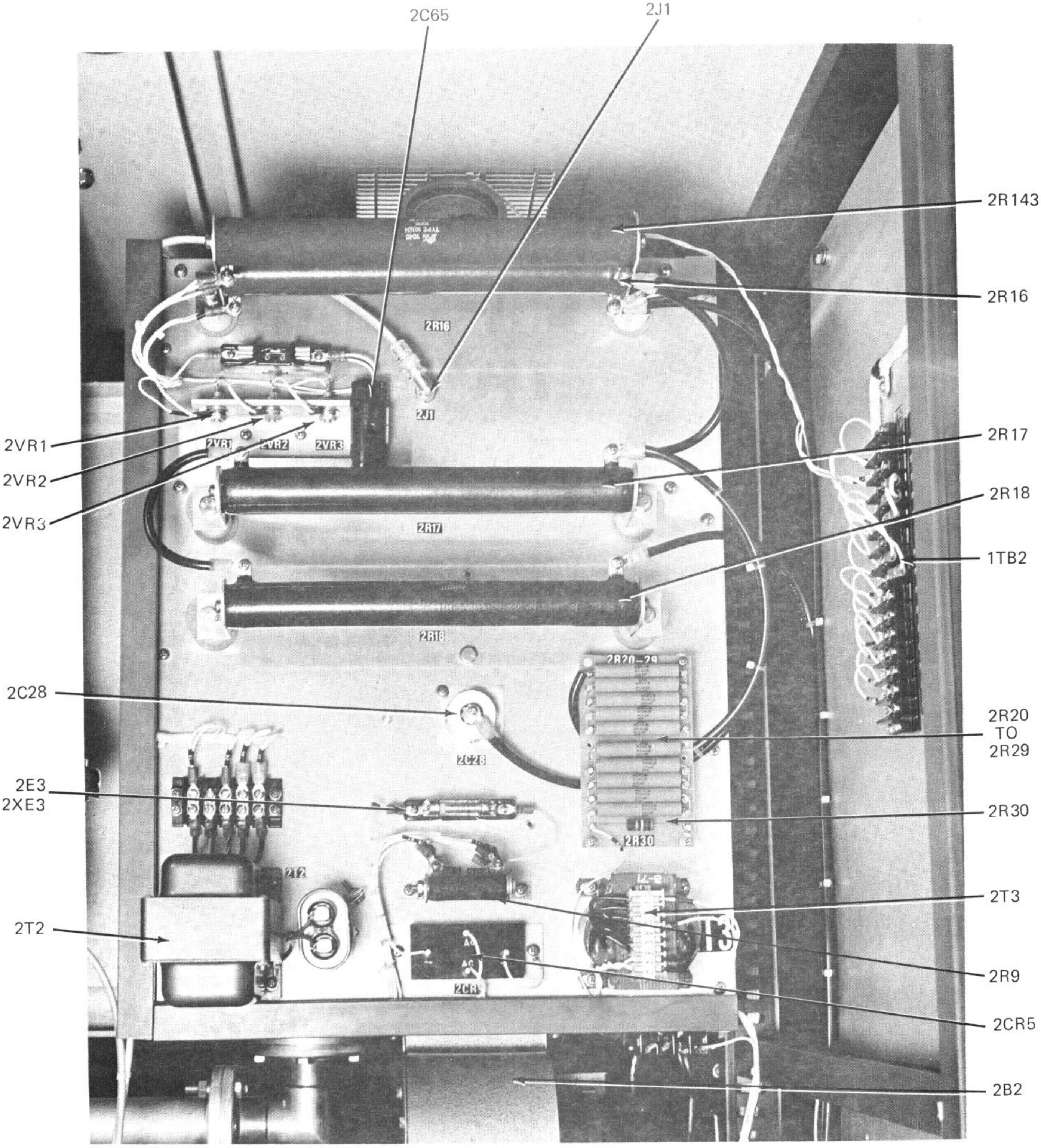



Figure 3-13. Driver Compartment, Rear View

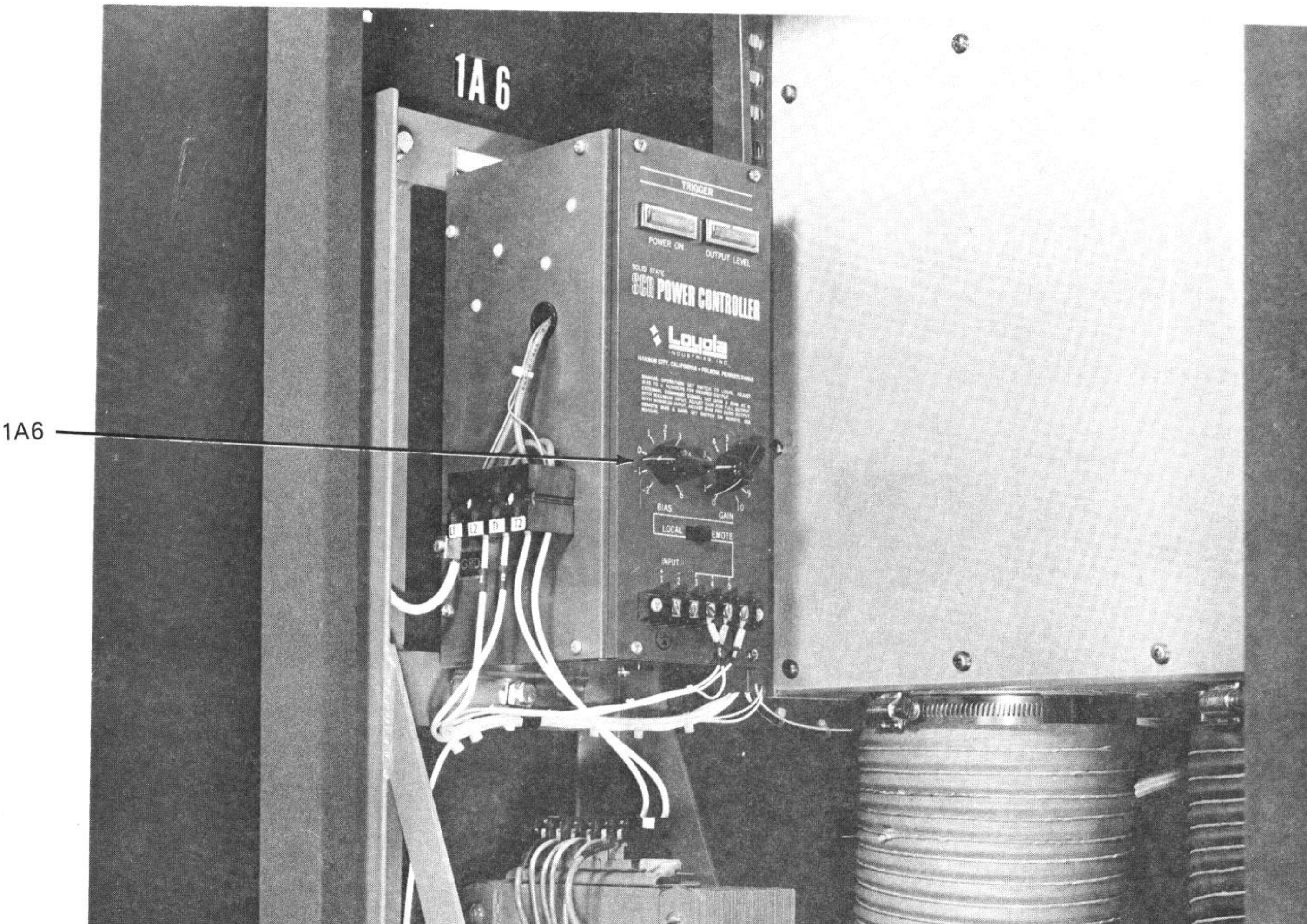



Figure 3-14. FM-25KD PA Filament Regulator and Transformer

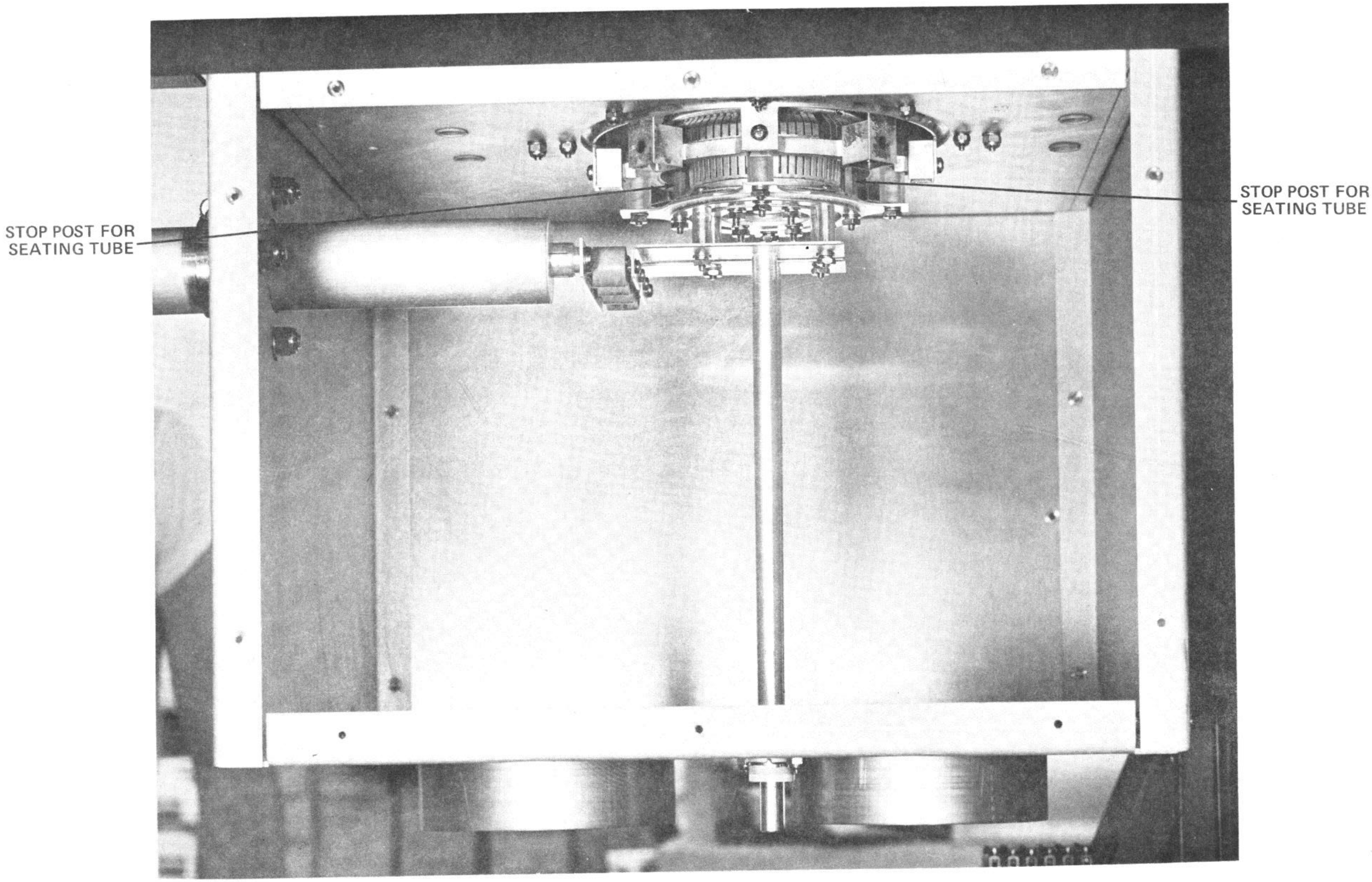



Figure 3-15. Power Amplifier Compartment, Lower Cover Removed

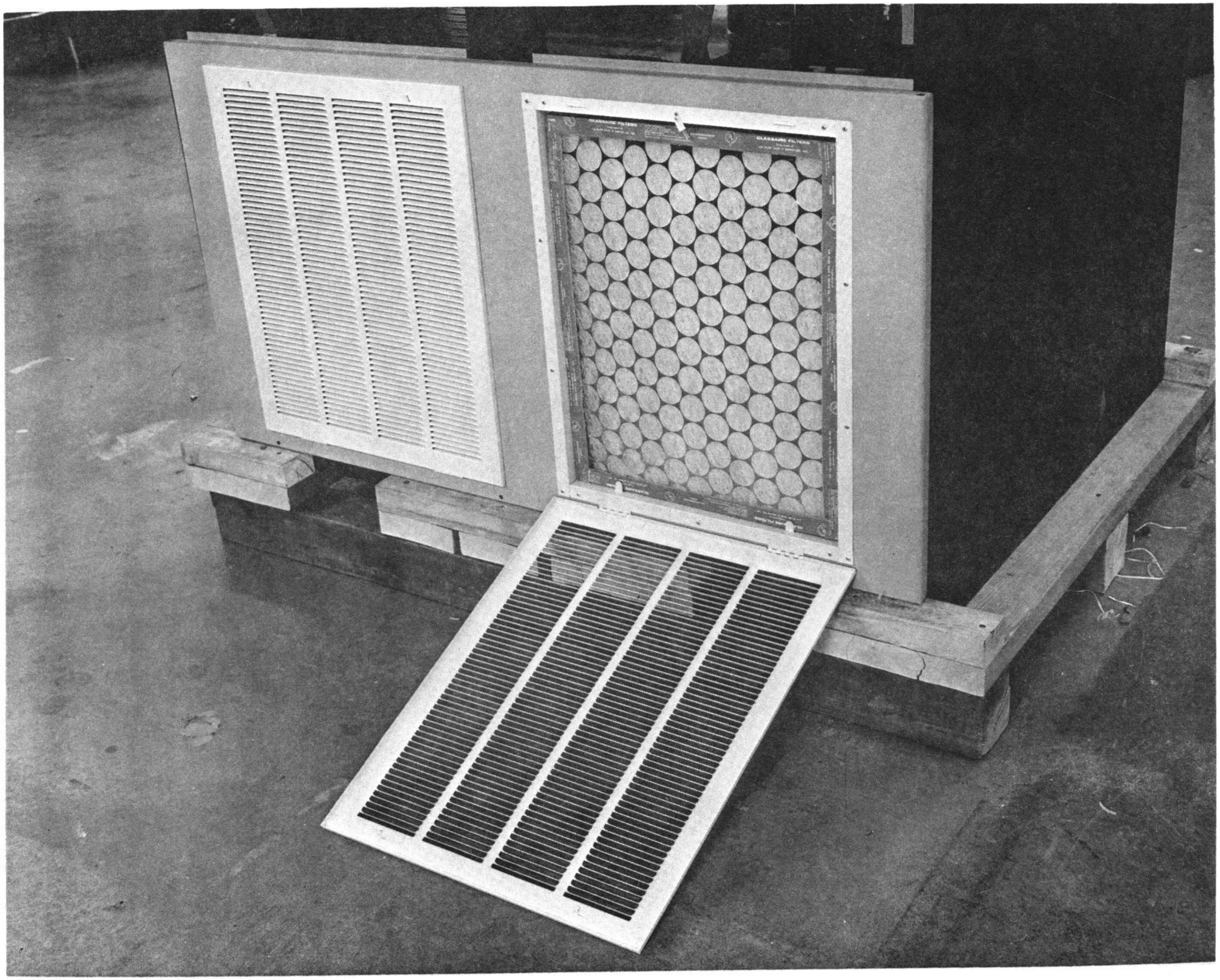


Figure 3-16. Rear Filter Panel

## SECTION IV

## PRINCIPLES OF OPERATION

### 4-1 General

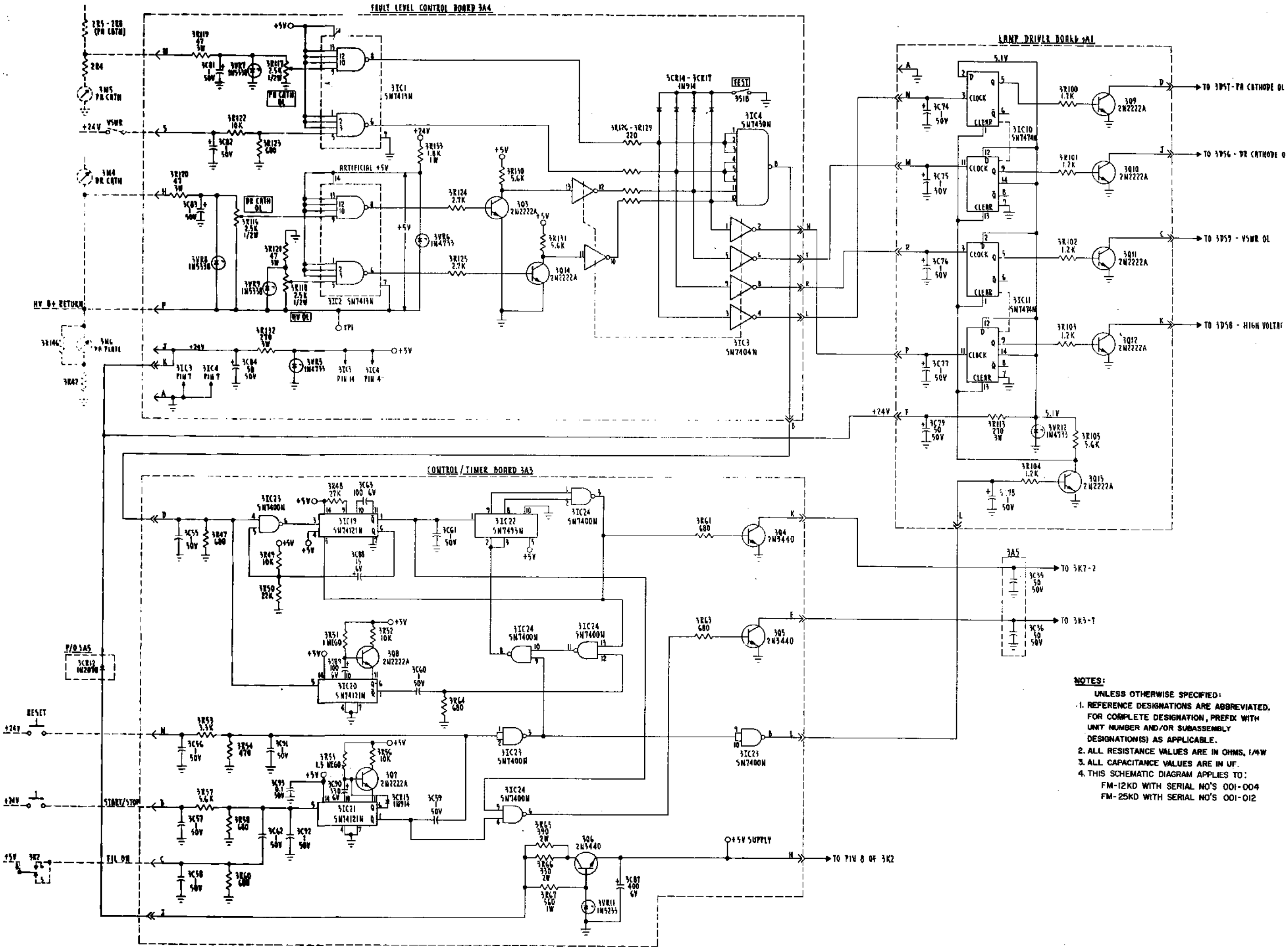
The transmitter is divided functionally into the following: (1) Interlock and Control Circuits, (2) Power Supplies, (3) RF Amplifier Section, (4) Automatic Power Level Control, and (5) Overload Protection and Automatic Recycling Circuits. The Model 2202A FM Exciter will be discussed in detail in its operating and maintenance manual.

### 4-2 Interlock and Control Circuit Analysis

The interlock and control circuits are concentrated at the left side and lower edge of the schematic diagram for the applicable transmitter. Refer to schematics, Fig. 4-1 or Fig. 4-2.

Power is first applied by operating the LINE circuit breaker (3CB3) to the ON position. The voltage available at each of the three phases can be measured on LINE meter (3M1) by sequentially pushing the three push-buttons of LINE switch (3S10). Fuses (3F1), (3F2) and (3F3) are used to prevent damage to the wiring harness if a short circuit occurs in the switches. Capacitor (1C1) serves as an RF by-pass for LINE meter (3M1).

The blower and filament circuits are made ready for subsequent application of power by closing the BLOWER circuit breaker (3CB1) and the FILAMENT circuit breaker (3CB2). Closure of the BLOWERS breaker energizes the 24-volt power supply used for the control circuits. This insures that the cooling blowers will be energized before control circuits can be activated to apply filament and high voltage to the driver and PA tubes.




**NOTES:**

UNLESS OTHERWISE SPECIFIED:

1. REFERENCE DESIGNATIONS ARE ABBREVIATED. FOR COMPLETE DESIGNATION, PREFIX WITH UNIT NUMBER AND/OR SUBASSEMBLY DESIGNATION(S) AS APPLICABLE.
2. ALL RESISTANCE VALUES ARE IN OHMS, 1/4W
3. ALL CAPACITANCE VALUES ARE IN UF.
4. THIS SCHEMATIC DIAGRAM APPLIES TO:
   FM-12KD WITH SERIAL NO'S 001-004
   FM-25KD WITH SERIAL NO'S 001-012

**Figure 4-1. Schematic Diagram Control Circuit Logic**

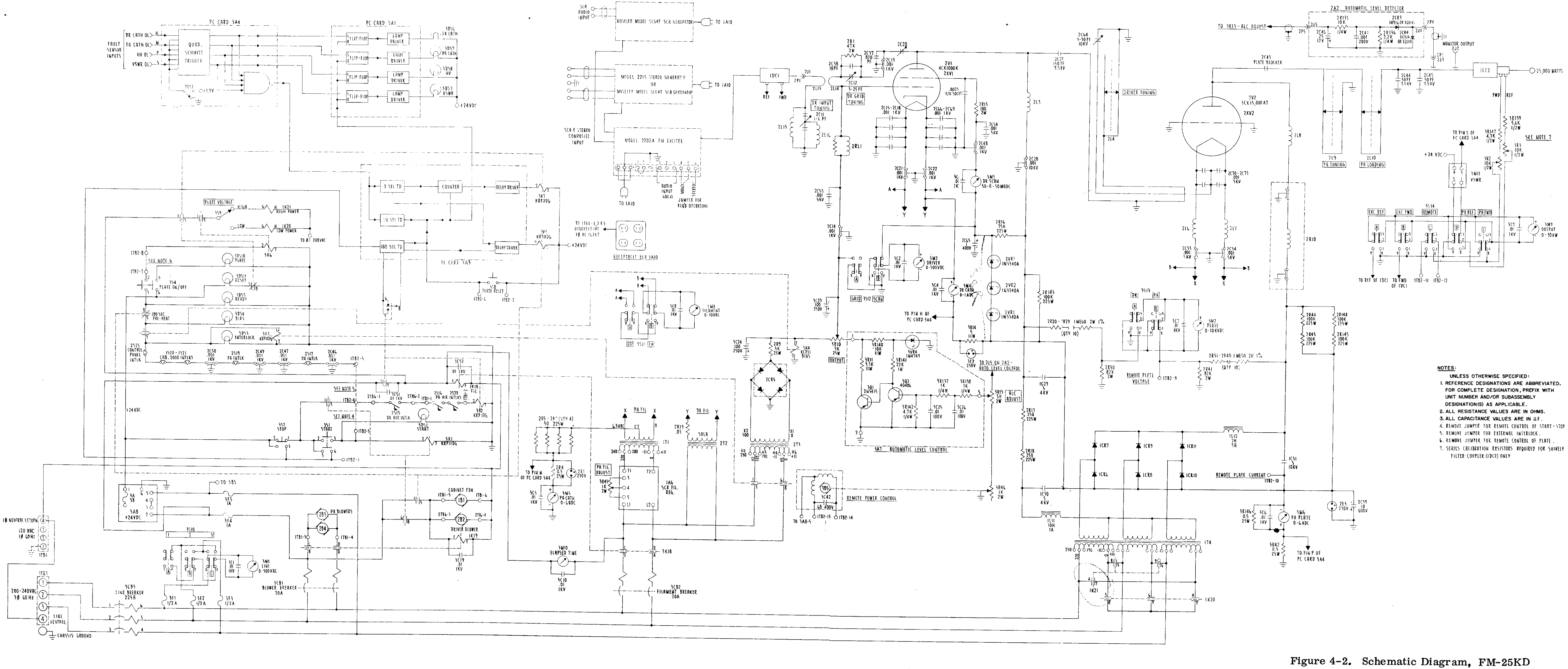



**Figure 4-2. Schematic Diagram, FM-25KD**

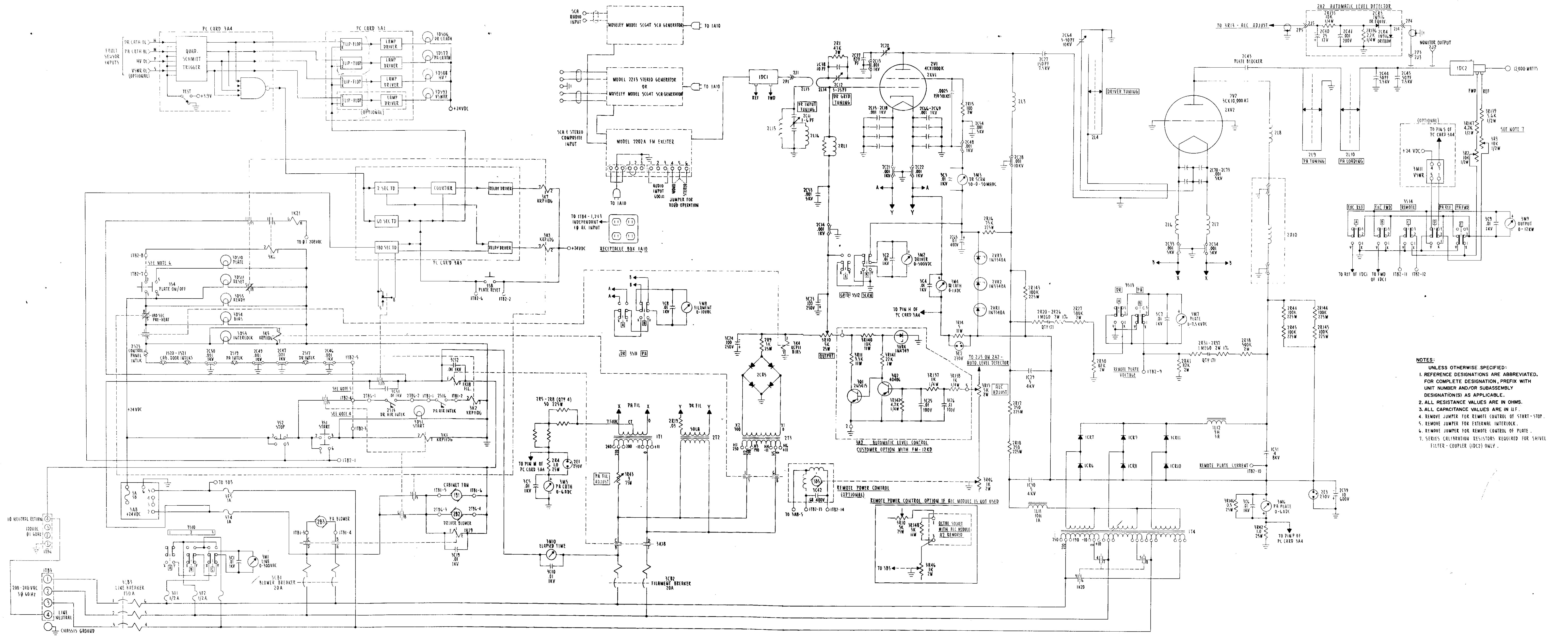
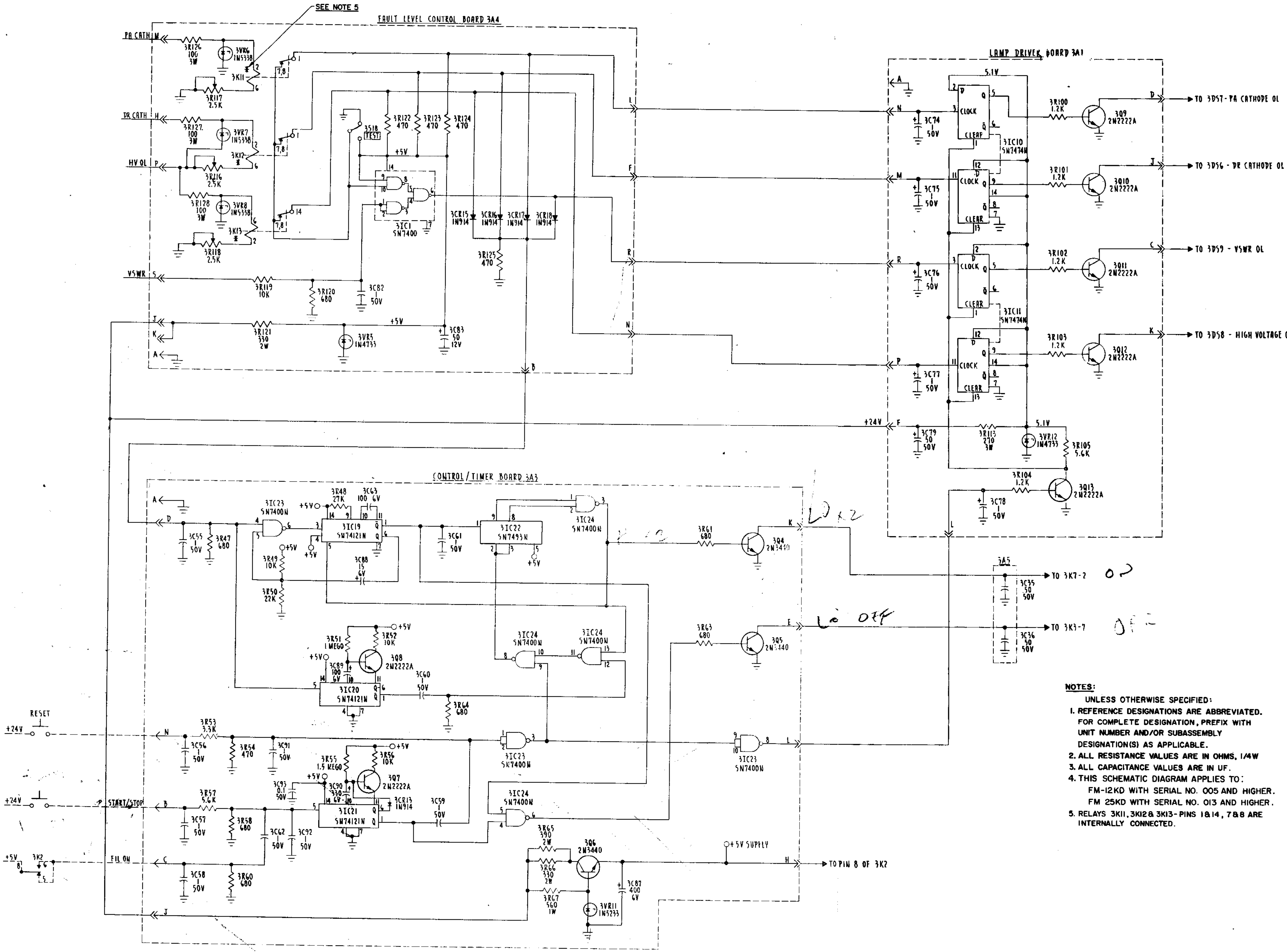


Figure 4-3. Schematic Diagram, FM-12KD

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UNLESS OTHERWISE SPECIFIED:

1. REFERENCE DESIGNATIONS ARE ABBREVIATED. FOR COMPLETE DESIGNATION, PREFIX WITH UNIT NUMBER AND/OR SUBASSEMBLY DESIGNATION(S) AS APPLICABLE.
2. ALL RESISTANCE VALUES ARE IN OHMS, 1/4W
3. ALL CAPACITANCE VALUES ARE IN UF.
4. THIS SCHEMATIC DIAGRAM APPLIES TO:
   FM-12KD WITH SERIAL NO. 005 AND HIGHER.
   FM 25KD WITH SERIAL NO. 013 AND HIGHER.
5. RELAYS 3K11, 3K12 & 3K13-PINS 1 & 14, 7 & 8 ARE INTERNALLY CONNECTED.

**Figure 4-4. Schematic Diagram Control Circuit Logic with Rev. G of 3A4 Fault Board**

When the START push-button switch (3S1) is closed, a number of simultaneous events take place as described below:

a. Relay 3K1 is energized, closing latching contacts across the START switch (3S1), and also closes another set of contacts to apply power to the cabinet fan (1B1), driver blower (2B2), and relay (3K19) whose contact closure energizes PA blowers (2B3) and (2B4).

b. Power is applied to a 180-second monostable multivibrator timer that instantly applies power to relay (3K3) opening normally-closed contacts (5-8) to keep the READY light (3DS5) from operating and normally-open contacts (1-3) are closed. Contacts (1-3) appear to represent a redundancy since contacts (6-8) of relay (3K1) already perform a similar function. However, contacts (1-3) play a role in an after-cooling function when the STOP switch (3S2) is pressed).

c. If all the air interlocks are closed, power is applied to relay (3K2) whose contacts (1-3) energize relay (3K18). Power is thereby applied to the PA filaments, the primary of the driver Sola filament transformer (2T2) and the elapsed-time meter (3M10).

d. If all the door and access hatch interlock switches are closed, the INTERLOCK indicator (3DS3) will illuminate and relay 3K5 will be energized applying power to the Bias transformer, 2T3.

e. At the moment the bias supply delivers voltage, relay (3K4) will close contacts (1-3) to apply power to the

BIAS indicator (3DS4). It will also apply voltage to 3K3 contact 5.

f. After the 180-second pre-heat time interval has elapsed, relay (3K3) contacts (1-3) will open again and contacts (5-8) will close to energize the READY indicator (3DS5). NOTE:- Opening of relay (3K3) contacts (1-3) will not shut down the blowers since they are still being supplied power via relay (3K1) contacts (6-8) and contacts of relay (3K19).

The PLATE VOLTAGE switch (3S9) should be rotated to the LOW position (FM-25KD only). This utilizes contactor, 1K20. When the PLATE ON/OFF latching switch (3S4) is pressed into the ON position, the PLATE indicator (3DS10) will light and relay (1K20) will be energized. Its contacts will connect the high voltage transformer primary windings to the three-phase power source in a WYE configuration. This will provide a reduced secondary output voltage. Rotating the PLATE VOLTAGE switch (3S9) from LOW to HIGH can be done without operating the PLATE ON/OFF switch (3S4) to the OFF position. No damage can occur since the switch has a 90° index and the WYE connection contactor (1K20) will drop out before the DELTA connection contactor (1K21) pulls in and provides the increased secondary voltage.

## 4-3 Power Supplies

### 4-3.1 Bias Power Supply (See photo, Figure 3-13)

The bias power supply consists of transformer (2T3) whose secondary winding is connected to a full-wave bridge rectifier quad (2CR5). An R/C filter is used, consisting of a 3,000 ohm, 25 watt resistor (2R4) and a 100 MFD capacitor (3C24). The coil winding of relay (3K4) is connected across the output of the power supply. A serious malfunction in the power supply that reduces the bias voltage below the hold-in voltage of the relay will cause it to drop out and open up the plate voltage contactor control circuit. The output of the power supply is also connected to one end of OUTPUT POWER control potentiometer (3R10). The arm of this control is connected to the control grid circuit of the driver amplifier. The remaining end of the control is tied into the automatic level control circuits which will be described separately. The automatic level control circuit is optionally available on the FM-12KD transmitter.

### 4-3.2 High Voltage Power Supplies

The high voltage power supply provides power for several circuits. It utilizes a 3-phase power transformer (1T4). The secondary is connected to a full-wave bridge rectifier (diodes 1CR6 through 1CR11) and then through a filter reactor (1L12) to the output filter capacitor (1C31) to provide the high voltage output for the PA tube. The bleeder system consists of resistors (2R44, 2R45, 2R144 and 2R145).

A second power supply configuration utilizes rectifiers (1CR7, 1CR9 and 1CR11) in a half-wave arrangement to provide half the high voltage output for the driver amplifier. The filtering consists of filter reactor (1L11), capacitor (1C30), series resistors (2R17) and (2R18) and the output capacitor (1C29). Resistor (2R143) performs a bleeder function at the output of the power supply.

In addition to supply the driver plate, this half-voltage power supply also supplies the driver screen via dropping resistor (2R16) and series connected Zener regulators (2VR1, 2VR2 and 2VR3). Capacitor (2C65) serves as a by-pass. The driver screen is supplied a regulated 300 volts from this circuit.

### 4-3.3 24-Volt Control Circuitry Power Supply

A commercially available 24-volt power supply is used for the control circuits. Its capacity is 2.5 amperes steady state and is regulated at the 24-volt output level. This power supply has its own self-contained fuse (3 amp) mounted on the power supply sub-chassis. The manufacturer's data sheet and schematic is provided as a part of the appendix of this manual.

A failure of the 24-volt power supply primary fuses (3F4 or 3F5) or its own D.C. output fuse will disable the control circuits and it will be impossible to start the transmitter. A failure of this sort will be obvious since none of the panel lights will be illuminated.

## 4-4 RF Amplifiers

### 4-4.1 Driver Amplifier (See Figure 3-7)

The driver amplifier employs a 4CX1000K tetrode (2V1) operated in a neutralized grounded cathode circuit. It uses the Bruene method of neutralization by sampling plate RF voltage and applying it via a capacitance divider consisting of a variable capacitor (2C20) and the feedthrough by-pass capacitor (2C13). This latter capacitor presents an "imperfect" by-pass in that its value is deliberately selected to allow a small amount of controllable "out-of-phase" RF voltage to be fed back into the grid circuit, thereby stabilizing its operation.

The input of the driver control grid circuit is double tuned by means of inductance/capacitance combinations (2L14-2C12) (DR GRID TUNING) and (2L13-2C11) (DR INPUT TUNING). Inductive coupling is used between the two tuned circuits. Bias voltage is shunt fed to the driver control grid by means of RF choke (2RL1).

A directional coupler (1DC1) is installed between the exciter RF output and the driver input coaxial connector (2J1). This permits monitoring the reflected and the forward power on meter (3M9) via switch (2S14) to optimize the impedance match and transfer of power.

Capacitors (2C15 through 2C18) and (2C66 through 2C69) provide low-inductance RF by-passing of both sets of filament wiring is further decoupled by feed-through by-pass capacitors (2C21 and 2C22) prior to being connected to metering circuits and the Sola filament transformer (2T2).

The cathode side of the filament is wired through the DR CATHODE meter (3M4) and an overload sampling resistor (3R14) back to the ground circuit of the high voltage power supply. Capacitor (3C4) provides an RF by-pass for the meter (3M4).

Resistor (2R15), directly at the screen of the driver, minimizes any tendency toward parasitic oscillations. It is followed by by-pass capacitor (2C54) and then goes through DR SCRN current meter (3M3) to the regulated 300 volt supply. RF by-passing of the meter is provided by capacitor (3C5). RF by-passing of the 300 volts to the DRIVER SCRN voltage metering circuit is accomplished by capacitor (2C65). Metering of DRIVER GRID and SCRN voltages is provided by meter (3M2) and push-button selector switch (3S12).

The plate of the tetrode driver amplifier (2V1) is shunt-fed through RF choke (2L3). Capacitor (2C27) serves as a plate-voltage blocking and coupling capacitor to a coaxial quarter-wave coupling transformer that serves to match the driver plate impedance to the input impedance of the grounded-grid PA stage. The effective length of the "quarter-wave" line and its impedance transformation characteristics are controlled by variable capacitor (2C64) and the variable shunt inductance DRIVER TUNING (2L4).

4-4.2 Power Amplifier (See Figures 3-8 and 3-15)

The power amplifier is a 3CX15,000A7 in the FM-25KD and a 3CX10,000A7 for the FM-12KD arranged in a grounded-grid circuit configuration. RF driving power is coupled into the filament circuit by means of a moderately balanced physical layout through ceramic coupling capacitors (2C70 through 2C73). The filament is maintained above RF ground by RF chokes (2L6 and 2L7).

NOTE:- Physically, these chokes are straight silver-plated rods. However, at the frequency of operation, they exhibit sufficient inductive reactance to prevent short-circuiting the driving power to ground.

The rods pass through the floor of the lower RF shield compartment by means of feed-through capacitors (2C33 and 2C34) wherein the rods themselves serve as one surface of each capacitor. At the bottom end of each rod, heavy gauge wiring is used to connect the rods to a high-reactance filament transformer (1T1). The primary winding of the transformer in the FM-25KD is provided a regulated input voltage obtained from the SCR regulator (1A6). The regulated output can be manually controlled over a limited range by the front panel control PA FIL ADJUST (3R43). The FM-12KD filament voltage is adjusted by means of a transformer primary manually-adjusted filament power rheostat identified as 3R43 in the FM-12KD schematic. Wiring is run from points B-B on the schematic diagram to the filament metering circuit consisting of FILAMENT meter (3M8) and the push-button selector switch (3S11). Four resistors (2R5 through 2R8) are wired in series parallel combination and are connected in series with the PA filament transformer secondary winding center tap through the PA CATH meter (3M6) to ground. Capacitor (3C6) serves as an RF by-pass for the meter. The PA cathode current passes through resistor 2R4 creating a voltage drop which is monitored by the PA CATH overload protection circuits.

DC power is shunt fed to the plate of the power amplifier through a single L-section filter (2FL1), feed-through by-pass capacitor (2C32) and RF choke (2L8). Capacitor (2C43), built into the PA tube socket assembly, serves as a DC blocking and coupling capacitor to the output RF tuned circuits.

While the PA output tuned circuit does not look like a pi-section filter, schematically, it actually is. The input capacitance of the pi-network is actually the plate-to-filament capacity of the output PA tube (2V2). However, it very obviously cannot be varied.

If a variable inductor, such as (2L9), is placed in shunt with this capacitance to be tunable at some frequency below the operating frequency, it can provide a variation in the effective negative reactance. This would appear as a variable capacitor at the input to the pi-network to tune its overall resonant frequency. The value of the loading capacitors (2C43 and 2C44) are determined at the factory for the specific operating frequency. Control of the degree of loading is accomplished by variation of the pi-network series inductance (2L10).

The output of the pi-network is coupled to a harmonic filter (1FL2). Two pairs of directional couplers are installed at the load end of the filter. One pair is used to sample reflected and forward power up to a 30 kilowatt level. The other pair performs a similar function for the FM-12KD transmitter in which power can be measured up to a 15 kilowatt level.

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The output of the directional couplers is connected via two sections of OUTPUT switch (3S14) to meter (3M9), which is calibrated to read output power directly. If the switch section, associated with PA FWD, is depressed the reflected power is then monitored on the VSWR meter relay (3M11) (located on lower front panel). The contacts on this meter can be set to provide a pulse to the overload cycling circuit when the VSWR exceeds some preset value. When switch (3S14) is in the REM position, the forward power level can be monitored at some remote location from terminals 1TB2-11 and 1TB2-12 by one of many remote monitoring methods.

A small wire probe in a BNC coaxial connector (2J2) on the rear of the PA upper shield compartment samples the PA RF power to be applied to station monitoring equipment. Output to the automatic level control is obtained from coaxial connector (2J3).

## 4-5 Automatic Power Level Control (ALC)

The transmitter ALC system maintains the transmitter output power constant for varying conditions of line voltage, RF drive, and tube aging. It is essentially a feedback scheme in which the system gain is controlled by varying the bias level on the driver stage. The PA output signal is sampled by an envelope detector, filtered and used as a feedback control signal in a transistor DC amplifier. The desired output power level is set by adjusting the ALC ADJ potentiometer, 2R13.

The sampled RF energy is detected and converted to a filtered DC voltage by Automatic Detector level module 2A2 mounted on the side of the PA chamber. This DC signal which is proportional to the amplitude of the RF carrier is fed via a coax cable to the Automatic Level Control module, 3A7, mounted in the control panel. ALC control potentiometer, 3R13, adjusts the amount of negative DC feedback voltage applied to the two-stage DC coupled amplifiers, 3Q1 and 3Q2, of 3A7 module.

Transistor (3Q1) is biased to draw a reasonable amount of current to cause a voltage drop across the OUTPUT POWER control (3R10). The controlling action is such that an increase in the sampled RF, perhaps due to an increase in line voltage acts to increase the base bias on transistor (3Q2) causing it to draw more collector current resulting in an increased voltage drop across resistor (3R141). This increased voltage drop produces a reduction in forward bias on the base of transistor (3Q1). The reduced bias decreases (3Q1) collector current flow permitting the bias voltage on the driver to increase.

The increased bias reduces the RF output of the driver and tends to compensate for the initial rise in the power amplifier RF output. The action is practically instantaneous and is very much the same as an automatic gain control in a receiver.

Resistor (3R140) is a voltage dropping resistor for the Zener regulator (3VR4).

## 4-6 Overload Protection and Automatic Recyling Circuits

### 4-6.1 Basic Overload Protection

Protection against serious damage in the event of a component failure is provided at many points in the transmitter and is done in many ways.

The following paragraphs will describe the various forms:

| Component | Symbol | Rating |
|---|---|---|
| Line Breaker | 3CB3 | 225 Amp |
| Blower Breaker | 3CB1 | 20 Amp |
| Filament Breaker | 3CB2 | 20 Amp |
| Fuse (for 220 VAC-Phase 1) Meter Ckt. | 3F1 | 1/2 Amp |
| Fuse (for 220 VAC-Phase 2) Meter Ckt. | 3F2 | 1/2 Amp |
| Fuse (for 220 VAC-Phase 3) Meter Ckt. | 3F3 | 1/2 Amp |
| Fuse (24V Power Supply) | 3F4 | 1 Amp |
| Fuse (24V Power Supply) | 3F5 | 1 Amp |
| Fuse (24V Supply Output) | - | 3 Amp |

### 4-6.2 Automatic Re-cycling System - General

Other forms of protection are provided by the overload re-cycling system. The following four parameters are monitored and the system will react to any change in excess of a preset threshold:

Driver Cathode Current

Power Amplifier Cathode Current

High Voltage (Excess current drain external to power supply).

VSWR at output of harmonic filter. (Optional in FM-12KD)

In the event of an excess in any of the four parameters, an overload re-cycling system is brought into action. An overload will shut down the high-voltage circuits for a 2-second period and also start a 60-second timing interval. After the 2-second interval, the high-voltage will again be applied. If the fault is still present the process will be automatically repeated. This can take place three times within the 60-second period after which the system will lock out the high voltage circuits. Fault indicator lights will show the location of the fault. Re-setting of the system must be done manually by pushing the PLATE RESET switch (3S8) after the fault has been cleared.

If the fault occurs only once, the 2-second timer will automatically re-cycle the system to its initial state. The fault light associated with the circuit trouble will remain lit until manually extinguished by the RESET button. This is to provide a memory function for the major faults causing shut-down.
The first overload will shut down the high voltage circuits for a 2-second interval and also start a 60-second timing interval. After the 2-second interval the circuits are again enabled, however, if the fault has not cleared, the circuit will disable the high voltage before the voltage is applied. If, as in a power overload, the fault disappears when the high voltage is down, then the high voltage will again be applied. If the fault should appear again when the high voltage is applied the

process will repeat itself. If the process occurs 3 times within a 60-second time interval the system will lock out the high voltage circuits. The system may be cleared by depressing the Plate Reset Switch (3S8) after the fault has been corrected.

4-6.3 Automatic Recycling System - Detailed Analysis

4-6.3.1 The Automatic Recycling System utilizes computer type integrated circuits to perform control logic functions. The system is designed to:

1. Detect a fault on one of four lines
2. Light and maintain a lamp indicating the specific fault
3. Remove the high voltage for a period of 2 secs.
4. Return the transmitter to operation only if the fault has cleared.
5. If three faults occur in 60 seconds remove the transmitter from operation (locks out the high voltage).
6. If 60 seconds elapse with 2 or less faults, clear the count.
7. Clear the count and indication when a start command occurs (Note:- When power is applied to the unit one or more fault indications occur due to the random order in which the logic is energized. This clears the meaningless indication automatically.)

## 4-6.3.2 Introduction to logic

Since use of logic devices in broadcast transmitters is relatively new, the basic functions will be described here. The devices used on Transistor-Transistor-logic (TTL) 7400 series which operates at voltage levels of about 5 Volts. It is mostly Medium Scale Integration (MSI) manufactured in Dual in-line Plastic (DIP) packages rather than discrete circuits.

These circuits operate at levels called Ø and 1. A "Ø" level is 0 to .8 Volts and a "1" is 2.0 to 5.0 Volts. The region from .8 to 2.0 is usually a "1", but cannot be depended upon.

Devices Used:

(A) Nand Gate

Symbol: 


Types: SN7400N quad dual input nand gate

SN7430N eight input nand gate

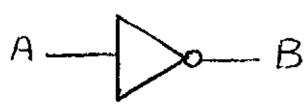
The Truth Table to describe a 2 input nand gate is:

| Case | Inputs A | Inputs B | Output C |
|---|---|---|---|
| #1 | 0 | 0 | 1 |
| #2 | 0 | 1 | 1 |
| #3 | 1 | 0 | 1 |
| #4 | 1 | 1 | 0 |

It can thus be seen that the output is a "1" for all cases except when both inputs are high or it can be said the output is low only when all inputs are high.

For an eight input gate the same is true - the output is low only when all inputs are high.

(B) The Inverter or Not Gate

Symbol: 


Type: SN7404N

Truth table:

| Input A | Output B |
|---|---|
| 0 | 1 |
| 1 | 0 |

Thus the output is always the opposite of the input.

An inverter may also be created by using a nand gate. This done by tying both inputs together as shown below. Operation may be verified from the truth table of 4-6.3.2-A

(C) Or Gate:

Symbol: 


Type: No individual or gates used, but used in other devices.

Truth table:

| Inputs | | Output |
|---|---|---|
| A | B | C |
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

Thus the output is high whenever any input is high. It may also be said to have a Ø output only if all inputs are Zero.

(D) Schmitt Triggers

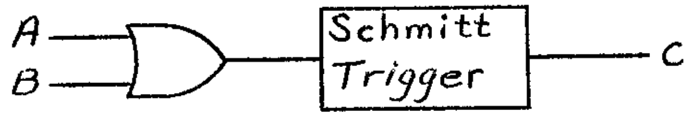
Symbol: No Special Symbol

Types: MC9809P - Quad Dual Input Schmitt Trigger

SN7413N - Dual Quad Input Schmitt Trigger

Description: The Schmitt trigger is a device which remains off until a specified voltage level is reached (called threshold level). It then turns on (output = 1) and remains on until the voltage decreases to another specified level. This turn off level usually is less than the turn on level.

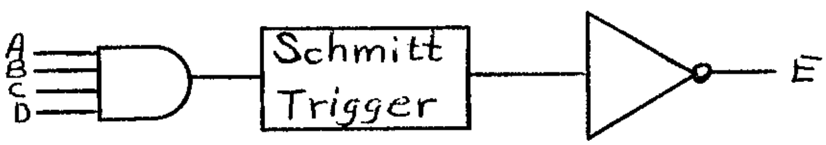
MC9809P: Each Schmitt Trigger is preceded by a dual input <u>OR</u> gate. The symbol circuitry may appear as follows:



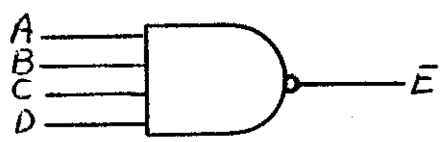

The device MC9809P contains four of these circuits.

V On = 1.40 V    V Off = .70 V

SN7413N: Each Schmitt Trigger is preceded by a four input AND gate. The output is followed by an inverter. The symbol circuits appears as follows:




This may be simplified to appear as a four input Nand Gate as shown below:




(E) Monostable Multivibrator or one shot.

Symbol: No symbol

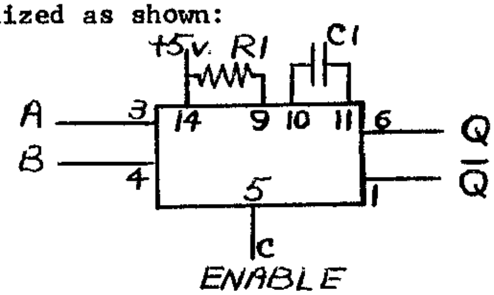
Type: SN74121N

Description: This is a typical one shot with 3 inputs, 2 outputs and external timing circuits. When fired the Q output goes high, $\overline{Q}$ goes low. When reset Q is low and $\overline{Q}$ is high.

The device may be fired in two ways.

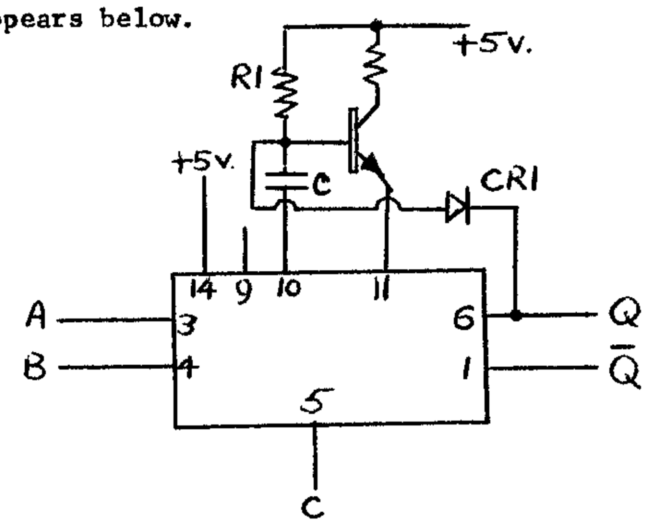
1. If C is high, it will fire when either A or B goes low.
2. If either A or B is low it will fire when C goes high.

The one shot does require a transistion to trigger. Once fired the inputs are locked out for future transitions until the cycle has completed itself. Normally the one shot is utilized as shown:




With $R_1$ and $C_1$ being timing components the 2-second timer utilized is constructed in this manner.

For longer periods a transistor is used to multiply the capacity. The circuit configuration appears below.



$CR_1$ provides a rapid discharge for the capacitor to insure proper termination of the cycle.

Both the 60-second and 180-second timer use the capacitor multiplier. Only the 180-second timer uses the discharge diode.

(F) Counter - 4 Bit Resettable Up Counter

Symbol: No special symbol

Type: SN7493N

Description: This device contains 2 sections A & B. The A section contains a single bit flip-flop and is not used. The B section contains a 3 Bit Counter which counts negative transitions. Only the first 2 bits are actually used. There are 2 inputs to reset and both must operate together thus they are tied together. The reset inputs reset the count to zero when high. They must be held at 0 to count.

(G) Flip-Flop

Symbol: No special symbol is used for a Flip-Flop

Type: SN7474N Dual D-Type Edge-Triggered Flip-Flop

This device has one input (D) and two outputs (Q and $\overline{Q}$). When the clock input is pulsed, the D input is transferred to the output. The clear input must be held at a "1" in order to clock an input, and when set at Logic Ø will reset the Q output to Logic Ø. The device has a preset input which automatically sets the Q output to a Logic 1.

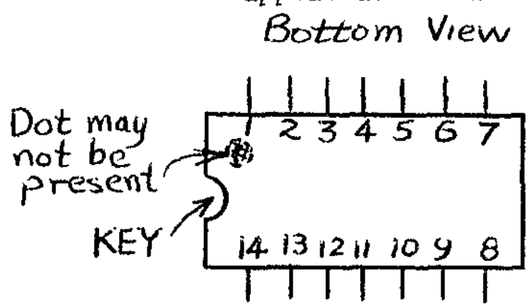
The circuit which is used in the Lamp Driver Circuit ties the input D to Logic 1. The fault signal from the fault detector board goes to the clock input. Thus when a fault occurs the Logic 1 is clocked to the Q output. The Q output remains at Logic 1 until a clear signal is received.

All the devices are 14 lead DIP.

Vcc (+5) and Gnd are supplied on the following pins:

| Device | Vcc | Gnd |
|---|---|---|
| SN7400N | 14 | 7 |
| SN7404N | 14 | 7 |
| SN74121N | 14 | 7 |
| SN7413 | 14 | 7 |
| SN7474 | 14 | 7 |
| SN7493N | 5 | 10 |
| MC9809D | 11 | 4 |

The devices appear as below:




The following reproductions from the Texas Instrument manual are shown for the reader's convenience.

**recommended operating conditions**

| | | SN5413 | | | SN7413 | | | UNIT |
|---|---|---|---|---|---|---|---|---|
| | | MIN | NOM | MAX | MIN | NOM | MAX | |
| Supply voltage $V_{CC}$ | | 4.5 | 5 | 5.5 | 4.75 | 5 | 5.25 | V |
| Fan-out from each output, N | High logic level | | | 20 | | | 20 | |
| | Low logic level | | | 10 | | | 10 | |
| Operating free-air temperature range, $T_A$ | | −55 | 0 | 125 | 0 | 25 | 70 | °C |
| Maximum input rise and fall times | | No restriction | | | No restriction | | | |

**electrical characteristics over recommended operating free-air temperature range (unless otherwise noted)**

| PARAMETER | | TEST FIGURE | TEST CONDITIONS† | | MIN | TYP‡ | MAX | UNIT |
|---|---|---|---|---|---|---|---|---|
| $V_{T+}$ | Positive-going threshold voltage | 94 | $V_{CC} = 5$ V | | 1.5 | 1.7 | 2 | V |
| $V_{T-}$ | Negative-going threshold voltage | 95 | $V_{CC} = 5$ V | | 0.6 | 0.9 | 1.1 | V |
| $V_{T+} - V_{T-}$ | Hysteresis | 94 & 95 | $V_{CC} = 5$ V | | 0.4 | 0.8 | | V |
| $V_I$ | Input clamp voltage | 97 | $V_{CC}$ = MIN, | $I_I = -12$ mA | | | −1.5 | V |
| $V_{OH}$ | High-level output voltage | 95 | $V_{CC}$ = MIN, $I_{OH} = -800\ \mu A$ | $V_I = 0.6$ V, | 2.4 | 3.3 | | V |
| $V_{OL}$ | Low-level output voltage | 94 | $V_{CC}$ = MIN, $I_{OL} = 16$ mA | $V_I = 2$ V, | | 0.22 | 0.4 | V |
| $I_{T+}$ | Input current at positive-going threshold | 94 | $V_{CC} = 5$ V, | $V_I = V_{T+}$ | | −0.65 | | mA |
| $I_{T-}$ | Input current at negative-going threshold | 95 | $V_{CC} = 5$ V, | $V_I = V_{T-}$ | | −0.85 | | mA |
| $I_I$ | Input current at maximum input voltage | 96 | $V_{CC}$ = MAX, | $V_I = 5.5$ V | | | 1 | mA |
| $I_{IH}$ | High-level input current | 96 | $V_{CC}$ = MAX, | $V_I = 2.4$ V | | | 40 | μA |
| $I_{IL}$ | Low-level input current | 97 | $V_{CC}$ = MAX, | $V_I = 0.4$ V | | −1 | −1.6 | mA |
| $I_{OS}$ | Short-circuit output current§ | 98 | $V_{CC}$ = MAX | | −18 | | −55 | mA |
| $I_{CCH}$ | Supply current, high-level output | 99 | $V_{CC}$ = MAX, | $V_I = 0$ | | 14 | 23 | mA |
| $I_{CCL}$ | Supply current, low-level output | 99 | $V_{CC}$ = MAX, | $V_I = 4.5$ V | | 20 | 32 | mA |

†For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions for the applicable device type.
‡All typical values are at $V_{CC} = 5$ V, $T_A = 25°C$.
§Not more than one output should be shorted at a time.

**switching characteristics, $V_{CC} = 5$ V, $T_A = 25°C$, N = 10**

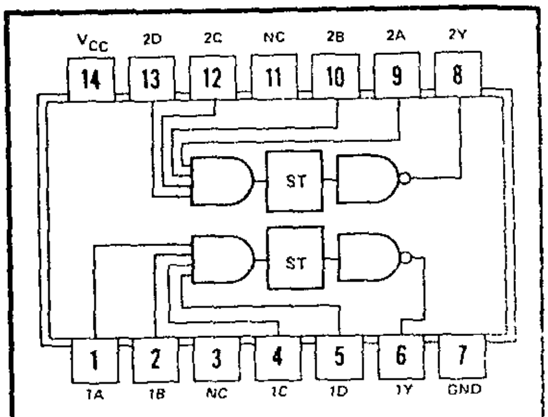
| PARAMETER | | TEST FIGURE | TEST CONDITIONS | | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|---|
| $t_{PLH}$ | Propagation delay time, low-to-high-level output | 100 | $C_L = 15$ pF, | $R_L = 400\ \Omega$ | | 18 | 27 | ns |
| $t_{PHL}$ | Propagation delay time, high-to-low-level output | 100 | $C_L = 15$ pF, | $R_L = 400\ \Omega$ | | 15 | 22 | ns |

6

# CIRCUIT TYPES SN5413,SN7413
# DUAL NAND SCHMITT TRIGGERS

- *Operation from Very Slow Edges*
- *Temperature-Compensated Threshold Levels*
- *Temperature-Compensated Hysteresis, Typically 0.8 V*
- **High Noise Immunity**

J OR N DUAL-IN-LINE OR
W FLAT PACKAGES (TOP VIEW)†




positive logic: $Y = \overline{ABCD}$

NC—No internal connection.
†Pin assignments for these circuits are the same for all packages.

## description

The SN5413 and SN7413 dual Schmitt triggers consist of two identical Schmitt-trigger circuits in monolithic integra- circuit form. Logically, each circuit functions as a four-input NAND gate, but because of the Schmitt action, the gate has different input threshold levels for positive- and negative-going signals. The hysteresis, or backlash, which is the difference between the two threshold levels, is typically 800 mV.

An important design feature is the built-in temperature compensation which ensures very high stability of the threshold levels and the hysteresis over a very wide temperature range. Typically, the hysteresis changes by 3% over the temperature range of −55°C to 125°C and the upper threshold changes by 1% over the same range. The SN5413/SN7413 can be triggered from the slowest of input ramps and still give clean, jitter-free output signals. It can also be triggered from straight d-c levels.

These circuits are fully compatible with most other TTL, DTL, or MSI circuits. The SN5413 is characterized for operation over the full military temperature range of −55°C to 125°C; the SN7413 is characterized for operation from 0°C to 70°C.

### absolute maximum ratings over operating free-air temperature range (unless otherwise noted)

| | |
|---|---|
| Supply voltage $V_{CC}$ (see Note 1) | 7 V |
| Input voltage (see Note 1) | 5.5 V |
| *Interemitter voltage (see Note 2)* | 5.5 V |
| Operating free-air temperature range: SN5413 Circuits | −55°C to 125°C |
| SN7413 Circuits | 0°C to 70°C |
| *Storage temperature range* | −65°C to 150°C |

NOTES: 1. Voltage values, except interemitter voltage, are with respect to network ground terminal.
2. *This is the voltage between two emitters of a multiple-emitter transistor.*

# CIRCUIT TYPES SN54121, SN74121
# MONOSTABLE MULTIVIBRATORS

## logic

TRUTH TABLE (See Notes 1 thru 3)

| $t_n$ INPUT | | | $t_{n+1}$ INPUT | | | OUTPUT |
|---|---|---|---|---|---|---|
| A1 | A2 | B | A1 | A2 | B | |
| 1 | 1 | 0 | 1 | 1 | 1 | Inhibit |
| 0 | X | 1 | 0 | X | 0 | Inhibit |
| X | 0 | 1 | X | 0 | 0 | Inhibit |
| 0 | X | 0 | 0 | X | 1 | One Shot |
| X | 0 | 0 | X | 0 | 1 | One Shot |
| 1 | 1 | 1 | X | 0 | 1 | One Shot |
| 1 | 1 | 1 | 0 | X | 1 | One Shot |
| X | 0 | 0 | X | 1 | 0 | Inhibit |
| 0 | X | 0 | 1 | X | 0 | Inhibit |
| X | 0 | 1 | 1 | 1 | 1 | Inhibit |
| 0 | X | 1 | 1 | 1 | 1 | Inhibit |
| 1 | 1 | 0 | X | 0 | 0 | Inhibit |
| 1 | 1 | 0 | 0 | X | 0 | Inhibit |

1 = $V_{in(1)} \geq 2$ V

0 = $V_{in(0)} \leq 0.8$ V

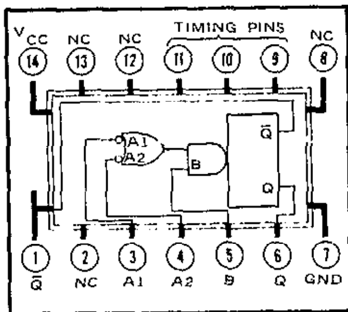
NOTES: 1. $t_n$ = time before input transition.

2. $t_{n+1}$ = time after input transition.

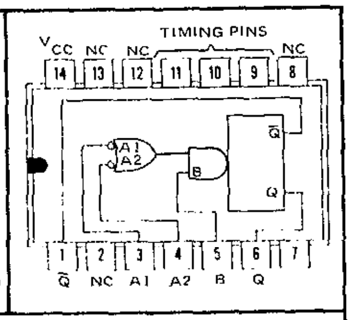
3. X indicates that either a logical 0 or 1 may be present.

4. NC = No internal Connection.

S FLAT PACKAGE
(TOP VIEW)
(SEE NOTES 6 THRU 9)




J OR N DUAL-IN-LINE PACKAGE
(TOP VIEW)
(SEE NOTES 6 THRU 9)




positive logic: see truth table and notes 5 and 6

5. A1 and A2 are negative-edge-triggered logic inputs, and will trigger the one shot when either or both go to logical 0 with B at logical 1.

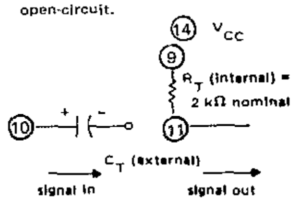
6. B is a positive Schmitt-trigger input for slow edges or level detection, and will trigger the one shot when B goes to logical 1 with either A1 or A2 at logical 0. (See Truth Table)

7. External timing capacitor may be connected between pin (10) (positive) and pin (11). With no external capacitance, an output pulse width of typically 30 ns is obtained.

8. To use the internal timing resistor (2 kΩ nominal), connect pin (9) to pin (14).

9. To obtain variable pulse width connect external variable resistance between pin (9) and pin (14). No external current limiting is needed.

10. For accurate repeatable pulse widths connect an external resistor between pin (11) and pin (14) with pin (9) open-circuit.




## description

This monolithic TTL monostable multivibrator features d-c triggering from positive or gated negative-going inputs with inhibit facility. Both positive and negative-going output pulses are provided with full fan-out to 10 normalized loads.

Pulse triggering occurs at a particular voltage level and is not directly related to the transition time of the input pulse. Schmitt-trigger input circuitry (TTL compatible and featuring temperature-independent backlash, See Figure L) for the B input allows jitter-free triggering from inputs with transition times as slow as 1 volt/second, providing the circuit with an excellent noise immunity of typically 1.2 volts. A high immunity to $V_{CC}$ noise of typically 1.5 volts is also provided by internal latching circuitry.

Once fired, the outputs are independent of further transitions on the inputs and are a function only of the timing components. Input pulses may be of any duration relative to the output pulse. Output pulse lengths may be varied from 40 nanoseconds to 40 seconds by choosing appropriate timing components. With no external timing components (i.e., pin (9) connected to pin (14), pins (10), (11) open) an output pulse of typically 30 nanoseconds is achieved which may be used as a d-c triggered reset signal. Output rise and fall times are TTL compatible and independent of pulse length.

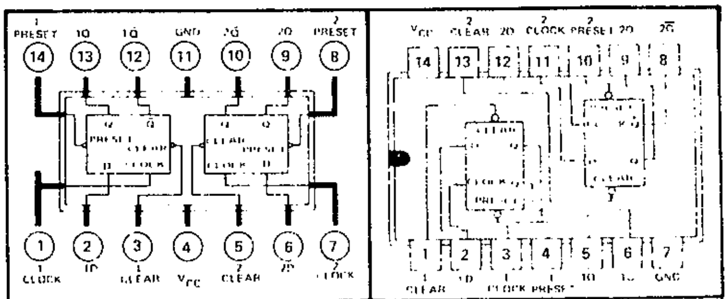
Pulse width is achieved through internal compensation and is virtually independent of $V_{CC}$ and temperature. In most applications, pulse stability will only be limited by the accuracy of external timing components.

—SEE ORDERING INSTRUCTIONS PAGE 1-1—

# CIRCUIT TYPES SN5474, SN7474
# DUAL D-TYPE EDGE-TRIGGERED FLIP-FLOPS

## logic

S FLAT PACKAGE (TOP VIEW) — J OR N DUAL-IN-LINE PACKAGE (TOP VIEW)



positive logic: Low input to preset sets Q to logical 1
Low input to clear sets Q to logical 0
Preset and clear are independent of clock

TRUTH TABLE (Each Flip-Flop)

| $t_n$ | $t_{n+1}$ | |
|---|---|---|
| INPUT D | OUTPUT Q | OUTPUT $\bar{Q}$ |
| 0 | 0 | 1 |
| 1 | 1 | 0 |

NOTES: 1. $t_n$ = bit time before clock pulse.
2. $t_{n+1}$ = bit time after clock pulse

## description

These monolithic, dual, D-type, edge-triggered flip-flops feature direct clear and preset inputs and complementary Q and $\bar{Q}$ outputs. Input information is transferrred to the outputs on the positive edge of the clock pulse.

Clock triggering occurs at a voltage level of the clock pulse and is not directly related to the transition time of the positive going pulse. After the clock input threshold voltage has been passed, the data input (D) is locked out.

These dual flip-flops have the same clocking characteristics as the SN5470/SN7470 gated (edge-triggered) flip-flop circuits, and both are ideally suited for medium- to-high-speed applications. They can result in a significant saving in system power dissipation and package count in applications where input gating is not required.

## recommended operating conditions

| | MIN | NOM | MAX | UNIT |
|---|---|---|---|---|
| Supply Voltage $V_{CC}$: SN5474 Circuits | 4.5 | 5 | 5.5 | V |
| SN7474 Circuits | 4.75 | 5 | 5.25 | V |
| Operating Free-Air Temperature Range, $T_A$: SN5474 Circuits | 55 | 25 | 125 | °C |
| SN7474 Circuits | 0 | 25 | 70 | °C |
| Normalized Fan-Out From Each Output, N | | | 10 | |
| Width of Clock Pulse, $t_{p(clock)}$ (See figure 71) | 30 | | | ns |
| Width of Preset Pulse, $t_{p(preset)}$ (See figure 67) | 30 | | | ns |
| Width of Clear Pulse, $t_{p(clear)}$ (See figure 67) | 30 | | | ns |

–SEE ORDERING INSTRUCTIONS PAGE 1-1–

# CIRCUIT TYPES SN5493, SN7493
# 4-BIT BINARY COUNTERS

## MSI TTL HIGH-SPEED RIPPLE-THROUGH COUNTERS

for applications in

- Digital Computer Systems
- Data-Handling Systems
- Control Systems

### logic

TRUTH TABLE (See Notes 1, 2, and 3)

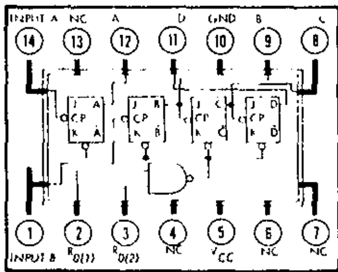
| COUNT | OUTPUT D | C | B | A |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | [illegible] | 1 |
| 2 | [illegible] | [illegible] | 1 | 0 |
| [illegible] | [illegible] | [illegible] | 1 | 1 |
| 4 | [illegible] | 1 | [illegible] | 0 |
| [illegible] | 0 | 1 | 0 | 1 |
| [illegible] | 0 | 1 | 1 | 0 |
| [illegible] | 0 | [illegible] | 1 | 1 |
| 8 | 1 | [illegible] | [illegible] | [illegible] |
| 9 | 1 | 0 | [illegible] | 1 |
| 10 | 1 | [illegible] | 1 | [illegible] |
| 11 | 1 | [illegible] | 1 | 1 |
| 12 | 1 | 1 | [illegible] | [illegible] |
| 13 | 1 | 1 | [illegible] | 1 |
| 14 | 1 | 1 | 1 | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |

NOTES: 1. Output A connected to input B

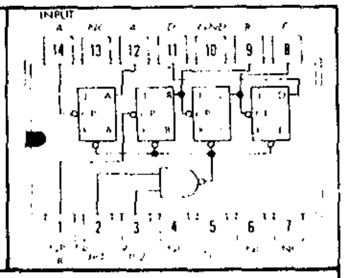
2. To reset all outputs to logical 0 both $R_{0(1)}$ and $R_{0(2)}$ inputs must be at logical 1.

3. Either (or both) reset inputs $R_{0(1)}$ and $R_{0(2)}$ must be at a logical 0 to count.

S
FLAT PACKAGE (TOP VIEW)




J OR N
DUAL-IN-LINE PACKAGE (TOP VIEW)




positive logic: see truth table

NC No Internal Connection

### description

These high-speed, monolithic 4-bit binary counters consist of four master-slave flip-flops which are internally interconnected to provide a divide-by-two counter and a divide-by-eight counter. A gated direct reset line is provided which inhibits the count inputs and simultaneously returns the four flip-flop outputs to a logical 0. As the output from flip-flop A is not internally connected to the succeeding flip-flops the counter may be operated in two independent modes:

1. When used as a 4-bit ripple-through counter, output A must be externally connected to input B. The input count pulses are applied to input A. Simultaneous divisions of 2, 4, 8, and 16 are performed at the A, B, C, and D outputs as shown in the truth table above.

2. When used as a 3-bit ripple-through counter, the input count pulses are applied to input B. Simultaneous frequency divisions of 2, 4, and 8 are available at the B, C, and D outputs. Independent use of flip-flop A is available if the reset function coincides with reset of the 3-bit ripple-through counter.

These circuits are completely compatible with Series 54/74 TTL and DTL logic families. Average power dissipation is 32 mW per flip-flop (128 mW total).

### absolute maximum ratings (over operating temperature range unless otherwise noted)

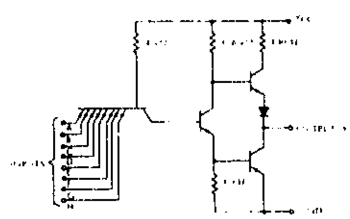
| | |
|---|---|
| Supply Voltage $V_{CC}$ (See Note 4) | 7 V |
| Input Voltage, $V_{in}$ (See Notes 4 and 5) | 5.5 V |
| Operating Case Temperature Range: SN5493S | −55°C to 125°C |
| Operating Free-Air Temperature Range: SN5493J, SN5493N | −55°C to 125°C |
| SN7493 Circuits | 0°C to 70°C |
| Storage Temperature Range | −65°C to 150°C |

NOTES: 4. These voltage values are with respect to network ground terminal.

5. Input signals must be zero or positive with respect to network ground terminal.

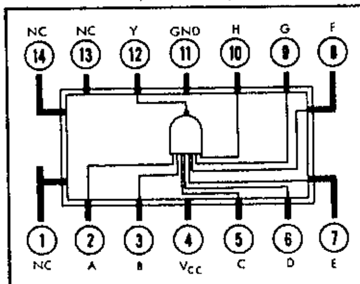
# CIRCUIT TYPES SN5430, SN7430
# 8-INPUT POSITIVE NAND GATES

**schematic**

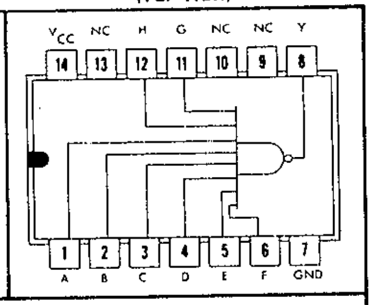


Component values shown are nominal.
NC – No Internal Connection

S FLAT PACKAGE
(TOP VIEW)




J OR N DUAL-IN-LINE PACKAGE
(TOP VIEW)




positive logic: $Y = \overline{ABCDEFGH}$

**recommended operating conditions**

| | MIN | NOM | MAX | UNIT |
|---|---|---|---|---|
| Supply Voltage $V_{CC}$: SN5430 Circuits | 4.5 | 5 | 5.5 | V |
| SN7430 Circuits | 4.75 | 5 | 5.25 | V |
| Normalized Fan-Out From Output, N | | | 10 | |
| Operating Free-Air Temperature Range, $T_A$: SN5430 Circuits | −55 | 25 | 125 | °C |
| SN7430 Circuits | 0 | 25 | 70 | °C |

**electrical characteristics (over recommended operating free-air temperature range unless otherwise noted)**

| PARAMETER | | TEST FIGURE | TEST CONDITIONS† | | MIN | TYP‡ | MAX | UNIT |
|---|---|---|---|---|---|---|---|---|
| $V_{in(1)}$ | Logical 1 input voltage required at all input terminals to ensure logical 0 level at output | 1 | $V_{CC}$ = MIN | | 2 | | | V |
| $V_{in(0)}$ | Logical 0 input voltage required at any input terminal to ensure logical 1 level at output | 2 | $V_{CC}$ = MIN | | | | 0.8 | V |
| $V_{out(1)}$ | Logical 1 output voltage | 2 | $V_{CC}$ = MIN, $V_{in}$ = 0.8 V, $I_{load}$ = −400 μA | | 2.4 | 3.3 | | V |
| $V_{out(0)}$ | Logical 0 output voltage | 1 | $V_{CC}$ = MIN, $V_{in}$ = 2 V, $I_{sink}$ = 16 mA | | | 0.22 | 0.4 | V |
| $I_{in(0)}$ | Logical 0 level input current (each input) | 3 | $V_{CC}$ = MAX, $V_{in}$ = 0.4 V | | | | −1.6 | mA |
| $I_{in(1)}$ | Logical 1 level input current (each input) | 4 | $V_{CC}$ = MAX, $V_{in}$ = 2.4 V | | | | 40 | μA |
| | | | $V_{CC}$ = MAX, $V_{in}$ = 5.5 V | | | | 1 | mA |
| $I_{OS}$ | Short-circuit output current§ | 5 | $V_{CC}$ = MAX | SN5430 | −20 | | −55 | mA |
| | | | | SN7430 | −18 | | −55 | |
| $I_{CC(0)}$ | Logical 0 level supply current | 6 | $V_{CC}$ = MAX, $V_{in}$ = 5 V | | | 3 | 6 | mA |
| $I_{CC(1)}$ | Logical 1 level supply current | 6 | $V_{CC}$ = MAX, $V_{in}$ = 0 | | | 1 | 2 | mA |

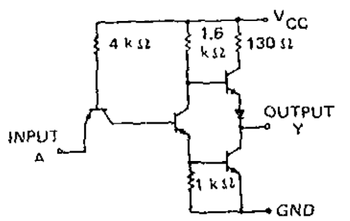
**switching characteristics, $V_{CC}$ = 5 V, $T_A$ = 25°C, N = 10**

| PARAMETER | | TEST FIGURE | TEST CONDITIONS | | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|---|
| $t_{pd0}$ | Propagation delay time to logical 0 level | 65 | $C_L$ = 15 pF, | $R_L$ = 400 Ω | | 8 | 15 | ns |
| $t_{pd1}$ | Propagation delay time to logical 1 level | 65 | $C_L$ = 15 pF, | $R_L$ = 400 Ω | | 13 | 22 | ns |

† For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions for the applicable device type.
‡ All typical values are at $V_{CC}$ = 5 V, $T_A$ = 25°C.
§ Not more than one output should be shorted at a time.

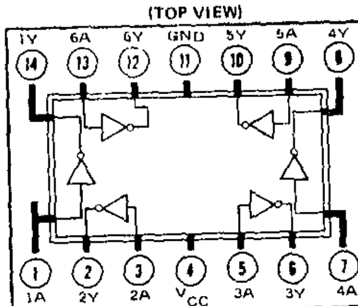
—SEE ORDERING INSTRUCTIONS PAGE 1-1—

schematic (each inverter)

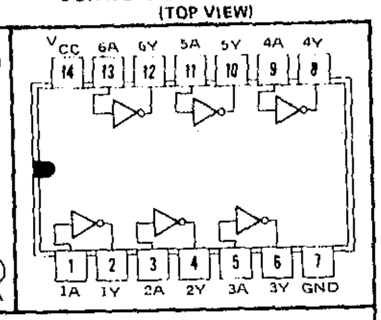



NOTE Component values shown are nominal

S FLAT PACKAGE (TOP VIEW)




J OR N DUAL IN-LINE PACKAGE (TOP VIEW)




positive logic: $Y = \bar{A}$

## recommended operating conditions

| | MIN | NOM | MAX | UNIT |
|---|---|---|---|---|
| Supply Voltage $V_{CC}$: SN5404 Circuits | 4.5 | 5 | 5.5 | V |
| SN7404 Circuits | 4.75 | 5 | 5.25 | V |
| Normalized Fan-Out From Each Output, N | | | 10 | |
| Operating Free-Air Temperature Range, $T_A$: SN5404 Circuits | −55 | 25 | 125 | °C |
| SN7404 Circuits | 0 | 25 | 70 | °C |

## electrical characteristics (over recommended operating free-air temperature range unless otherwise noted)

| PARAMETER | | TEST FIGURE | TEST CONDITIONS† | | MIN | TYP‡ | MAX | UNIT |
|---|---|---|---|---|---|---|---|---|
| $V_{in(1)}$ | Logical 1 input voltage required at input terminal to ensure logical 0 level at output | 15 | $V_{CC}$ = MIN | | 2 | | | V |
| $V_{in(0)}$ | Logical 0 input voltage required at any input terminal to ensure logical 1 level at output | 16 | $V_{CC}$ = MIN | | | | 0.8 | V |
| $V_{out(1)}$ | Logical 1 output voltage | 16 | $V_{CC}$ = MIN, $V_{in}$ = 0.8 V, $I_{load}$ = − 400 μA | | 2.4 | 3.3 | | V |
| $V_{out(0)}$ | Logical 0 output voltage | 15 | $V_{CC}$ = MIN, $V_{in}$ = 2 V, $I_{sink}$ = 16 mA | | | 0.22 | 0.4 | V |
| $I_{in(0)}$ | Logical 0 level input current (each Logical 0 level input current | 17 | $V_{CC}$ = MAX, $V_{in}$ = 0.4 V | | | | −1.6 | mA |
| $I_{in(1)}$ | Logical 1 level input current | 18 | $V_{CC}$ = MAX, $V_{in}$ = 2.4 V | | | | 40 | μA |
| | | | $V_{CC}$ = MAX, $V_{in}$ = 5.5 V | | | | 1 | mA |
| $I_{OS}$ | Short-circuit output current§ | 19 | $V_{CC}$ = MAX | SN5404 | −20 | | −55 | mA |
| | | | | SN7404 | −18 | | −55 | |
| $I_{CC(0)}$ | Logical 0 level supply current | 20 | $V_{CC}$ = MAX, $V_{in}$ = 5 V | | | 18 | 33 | mA |
| $I_{CC(1)}$ | Logical 1 level supply current | 20 | $V_{CC}$ = MAX, $V_{in}$ = 0 | | | 6 | 12 | mA |

## switching characteristics, $V_{CC}$ = 5 V, $T_A$ = 25°C, N = 10

| PARAMETER | | TEST FIGURE | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|
| $t_{pd0}$ | Propagation delay time to logical 0 level | 65 | $C_L$ = 15 pF, $R_L$ = 400 Ω | | 8 | 15 | ns |
| $t_{pd1}$ | Propagation delay time to logical 1 level | 65 | $C_L$ = 15 pF, $R_L$ = 400 Ω | | 12 | 22 | ns |

† For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions for the applicable device type.

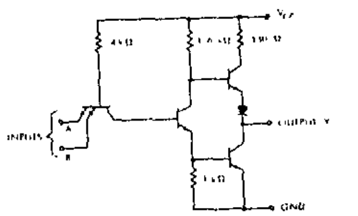
‡ All typical values are at $V_{CC}$ = 5 V, $T_A$ = 25°C.

§ Not more than one output should be shorted at a time.

—SEE ORDERING INSTRUCTIONS PAGE 1-1—

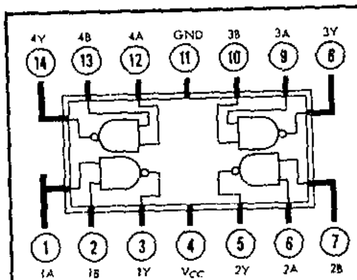
# CIRCUIT TYPES SN5400, SN7400
# QUADRUPLE 2-INPUT POSITIVE NAND GATES

schematic (each gate)

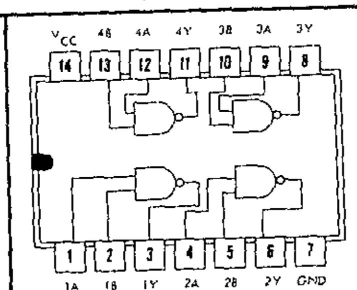



NOTE. Component values shown are nominal.

F FLAT PACKAGE (TOP VIEW)




J OR N DUAL-IN-LINE PACKAGE (TOP VIEW)




positive logic: $Y = \overline{AB}$

## recommended operating conditions

| | | MIN | NOM | MAX | UNIT |
|---|---|---|---|---|---|
| Supply Voltage $V_{CC}$: | SN5400 Circuits | 4.5 | 5 | 5.5 | V |
| | SN7400 Circuits | 4.75 | 5 | 5.25 | V |
| Normalized Fan-Out From Each Output, N | | | | 10 | |
| Operating Free-Air Temperature Range, $T_A$: | SN5400 Circuits | −55 | 25 | 125 | °C |
| | SN7400 Circuits | 0 | 25 | 70 | °C |

## electrical characteristics (over recommended operating free-air temperature range unless otherwise noted)

| PARAMETER | | TEST FIGURE | TEST CONDITIONS† | | MIN | TYP‡ | MAX | UNIT |
|---|---|---|---|---|---|---|---|---|
| $V_{in(1)}$ | Logical 1 input voltage required at both input terminals to ensure logical 0 level at output | 1 | $V_{CC}$ = MIN | | 2 | | | V |
| $V_{in(0)}$ | Logical 0 input voltage required at either input terminal to ensure logical 1 level at output | 2 | $V_{CC}$ = MIN | | | | 0.8 | V |
| $V_{out(1)}$ | Logical 1 output voltage | 2 | $V_{CC}$ = MIN, $V_{in}$ = 0.8 V, $I_{load}$ = −400 μA | | 2.4 | 3.3 | | V |
| $V_{out(0)}$ | Logical 0 output voltage | 1 | $V_{CC}$ = MIN, $V_{in}$ = 2 V, $I_{sink}$ = 16 mA | | | 0.22 | 0.4 | V |
| $I_{in(0)}$ | Logical 0 level input current (each input) | 3 | $V_{CC}$ = MAX, $V_{in}$ = 0.4 V | | | | −1.6 | mA |
| $I_{in(1)}$ | Logical 1 level input current (each input) | 4 | $V_{CC}$ = MAX, $V_{in}$ = 2.4 V | | | | 40 | μA |
| | | | $V_{CC}$ = MAX, $V_{in}$ = 5.5 V | | | | 1 | mA |
| $I_{OS}$ | Short-circuit output current§ | 5 | $V_{CC}$ = MAX | SN5400 | −20 | | −55 | mA |
| | | | | SN7400 | −18 | | −55 | |
| $I_{CC(0)}$ | Logical 0 level supply current | 6 | $V_{CC}$ = MAX, $V_{in}$ = 5 V | | | 12 | 22 | mA |
| $I_{CC(1)}$ | Logical 1 level supply current | 6 | $V_{CC}$ = MAX, $V_{in}$ = 0 | | | 4 | 8 | mA |

## switching characteristics, $V_{CC}$ = 5 V, $T_A$ = 25°C, N = 10

| PARAMETER | | TEST FIGURE | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|
| $t_{pd0}$ | Propagation delay time to logical 0 level | 65 | $C_L$ = 15 pF, $R_L$ = 400 Ω | | 7 | 15 | ns |
| $t_{pd1}$ | Propagation delay time to logical 1 level | 65 | $C_L$ = 15 pF, $R_L$ = 400 Ω | | 11 | 22 | ns |

† For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions for the applicable device type.
‡ All typical values are at $V_{CC}$ = 5 V, $T_A$ = 25°C.
§ Not more than one output should be shorted at a time.

—SEE ORDERING INSTRUCTIONS PAGE 1-1—

4-6.3.3.1 Fault Level Control Board (3A4), Rev. D

Basically the fault level control board operates by detecting a threshold voltage level and then sending parallel fault signals to the control timer board (3A3) and the lamp driver board (3A1).

(a) The VSWR fault level is detected by the closing of meter contacts on the VSWR meter (3M11). Contact closure applies 24 V to the fault level detector board. This signal is scaled by 3R122 and 3R123 and then inverted by 3IC1. (Note: The no fault output of 3IC1, Pin 6, is a Logic 1). Information on setting the VSWR meter contacts may be found in Para. 3-4.

(b) The PA cathode fault level is sensed by 2R4 in the cathode circuit of the PA. The signal level is sent to the fault level control board, scaled by 3R117, and sent to the Schmitt trigger, The Schmitt trigger detects the fault level and inverts the signal. (Note: The no fault signal at 3IC1, Pin 8, is a Logic 1).

(c) The High Voltage overload fault level (HVOL) The HVOL fault level is a negative voltage sensed by 3R42. Since the Schmitt trigger is capable of dealing with positive voltages only and we are only interested in the magnitude of the voltage, the HVOL input is treated as follows:

1. The HVOL becomes the Reference or "Ground".

2. Ground becomes the signal input.

3. Power to supply the device is developed through 3R133 and 3VR6.

4. Fault level input may be measured from TP1 to ground.

5. This input is scaled by 3R118, detected and inverted by 3IC2, converted to a normal logic level by 3Q14. 3Q14 inverts the signal so 3IC3 again inverts it to restore it to the required form.

Normal no fault logic levels are:

3IC2 Pin 6 - Logic 1 Reference TP1

3Q14 Collector - Logic 0 Reference Gnd.

3IC3 Pin 10 - Logic 1 Reference Gnd.

(d) The driver Cathode fault level is sensed by 3R14, but is referenced from the HVOL input. The same technique for fault detection as that of the HVOL is used, but the level input is the top of 3R14. The signal is scaled by 3R116, detected and inverted by 3IC2, converted and inverted by 3Q3.

The normal no fault levels and references are:

3IC2 Pin 8 - Logic 1 Reference TP1

3Q3 Collector - Logic 0 Reference Gnd.

3IC Pin 12 - Logic 1 Reference TP1

(e) Test Switch (3S18), diodes 3CR14 to 3CR17 and resistors 3R126 to 3R129 force "low" inputs to 3IC4 and the four inverters which drive the lamp drivers. Operating this switch creates an artificial fault to test the operation of the lamp driver board (3A1) and the control timer board (3A3). This switch will test the entire fault system but will not test the actual input to the Schmitt trigger. It should be used as a system test but not as a fault test.

(f) The normal no fault outputs from the board are Logic 0.

(g) Zener Diodes 3VR7, 3VR8 and 3VR9 with resistors 3R119, 3R120, and 3R121 provide protection from large excursions of the fault levels. They provide protection in the order of several hundred volts. Externally mounted surge protectors limit these voltages to 230 V. 2E1 protects the PA Cathode Circuit and is located adjacent to 2R4. 3E2 protects the Driver Cathode Circuit and is located adjacent to 3R14. 2E3 protects the HVOL input and is located adjacent to 2R9.

4-6.3.3.2 Fault Level Control Board (3A4), Rev. F

Fault Level Control Boards 3A4 revisions D and F are similar in function and are interchangeable. Refer to the schematic diagrams Fig. 4-1 and Fig. 4-4 for the following explanation.

(a) The VSWR fault level is detected by the closing of meter relay contacts in the VSWR meter, 3M11. Contact closure applies 24 volts to the fault level detector board. This signal is scaled by voltage-divider 3R119 and 3R120 and inverted by 3IC1. The fault test signal from 3S18 is also inverted by 3IC1, thus the two signals are combined and inverted. The net operation is the OR function of a fault signal or a test signal.

(b) The PA cathode fault level is sensed by the voltage drop across resistor 2R4 in the cathode circuit of the PA. The signal level is sent to the fault level control board. Variable resistance 3R117 and the relay coil resistance form a voltage divider. The fault level voltage is about 4 volts and 3R117 is used to set the fault threshold level at a convenient point below this level.

(c) The High Voltage Overload fault level (HVOL) is a negative voltage (with respect to chassis ground) sensed across 3R42. Variable resistor 3R118 and relay 3K13 are the sensing elements. Operation is similar to that described above.

(d) The Driver Cathode fault level is sensed across 3R14 but is referenced to the HVOL fault signal input (this is the "B-off ground point-not chassis ground). The relay trigger level is controlled by 3R116.

(e) Each fault signal circuit is held to ground by the back contact (N.C.) of its respective reed relay. When one of the relays is energized the individual line is pulled to logic level "1" by a pull-up resistor connected to A+. This sends a logic "1" to the lamp driver board and to a diode OR gate composed of 3CR15 to 3CR18.

(f) The TEST switch provides a logic "Ø" condition to all relays and the test input of 3IC1. When 3S18 is operated its output is switched to a logic "1" and the output of all relays and 3IC1 switch to a logic "1".

(g) Externally mounted surge suppressors limit overload voltages to 230 volts in the event that large overload currents are drawn due to arc-overs or lightning strikes. Suppressor 2E1 protects the PA circuit and is located adjacent to 2R4. 3E2 protects the Driver cathode circuit and is located adjacent to 3R14. 2E3 protects the HVOL input circuit and limits the B- signal to 230 volts. 2E3 is located adjacent to 2R9.

4-6.3.4 Control Timer (3A3)

The control timer board A-3 contains two subsystems:

1. Preheat/after cool 180-second timer.
2. Fault counter and recycling system.

180-Second Timer

The timer utilizes a long period monostable multivibrator described in Section 4-6.3.2E.

Inputs: (1) When either the start switch (3S1) or the stop switch (3S2) is operated, 24 V is applied to the voltage divider 3R57 and 3R55. The output of this is about 2.6 V when 24 volts is applied. This voltage is applied to the input of 3IC21.

(2) Whenever the filament circuit is energized +5 volts is applied by means of contacts 6 and 8 of 3K2 to a capacitor to the "one shot". The capacitor causes only a pulse to be applied thus making the one shot available for a stop command. The primary purpose of this input is to prevent the plate voltage from being applied should the filament relay drop out momentarily.

An interruption to the air flow could cause this.

Outputs: (1) The 180-second timer provides a steady drive to 3IC23 which in turn operates 3K3 whenever the 180-second timer operates. Further explanation of 3K3 appears in Section 4-2-b and 4-2-f.

(2) A pulse is coupled through 3C59 into the manual reset bus. If power failure occurs to the entire transmitter the system often energizes to a full fault count. This pulse insures that the counter and memory are cleared prior to resumption of normal operation.

Note: The function of relay 3K3 is to:

1. Prevent application of plate voltage during "preheat" period and during 2-second fault recycling period.
2. To insure blower operation during 180-second "cool-down" period.

4-6.3.5 Fault Counter and Recycling System

Refer to Fig. 4-1. When a fault occurs the output of the fault level control board (3IC14 Pin 8) goes high. This signal is fed to one input of a nand gate (3IC23 Pin 4) the remaining input is held high by voltage divider 3R49 and 3R50. At this time both inputs are high and the output goes low which triggers the 2-second timer (3IC19). The Q output goes to "1", the $\overline{Q}$ output to "0". The $\overline{Q}$ output is fed to one input of a nand gate (3EC24 Pin 5). The other input is from the 180-second timer. During a no fault condition both inputs of this nand gate (3IC23 Pin 5 and Pin 4) are high. When 3IC23 Pin 5 goes low and its output (3IC23 Pin 6) goes high it turns on 3Q6 which operates relay 3K3. This removes the plate voltage. This same "Ø" level increments the counter. For a count of 1, 3IC22 Pin 9 is "1", Pin 8 is "0". At the end of 2 seconds the Q output goes low, the $\overline{Q}$ output goes high. When the $\overline{Q}$ output goes high both inputs of the 3IC24 Gate are high and the Plate Voltage is subsequently restored.

When the fault occurred the Q output of the 2-second one shot (3IC19 Pin 6) went high, which "pushed" the output of the voltage divider higher until the capacitor discharged. This point was already high, thus there was no change of logic state. When the Q output goes low it forces this point low. This is a change in logic state. When the 2-second shut-down occurs most faults or overloads will disappear and the fault signal will go low. The input to the 2-second timer will go high and remain so. The "Ø" pulse fed back from the Q output will normally have no effect. If, for some reason such as the VSWR meter contacts sticking, the fault condition stays, this pulse fed back to the gate (3IC23 Pin 5) insures that the input to the 2-second timer goes high and low again triggering off a second fault and so on until a count of 3 is reached.

The third change that happens when a fault occurs is the starting of the sixty-second timer. Capacitor 3C60 feeds a "Ø" pulse to an input which is already "Ø" thus affecting no logic state change.

When a second fault occurs, the process repeats itself. The sixty-second timer has already started and its inputs are locked out. The counter increments to a count of 2. 3IC22 Pin 9 becomes "Ø" and Pin 8 become "1".

When a third fault occurs the 2-second process again repeats itself. The counter outputs 3IC22 Pin 9 and Pin 8 both become "1". These points feed the inputs of a nand gate, 3IC24. Since both inputs are now high, the output now goes low. Thus with a count of 0, 1, or 2 this output is high and is used to enable the 2-second timer. When the count reaches 3, this output goes low and inhibits the 2-second timer and also turns off 3Q4 which in turn drops out 3K7. The back contacts of 3K7 Pins 5 & 8 close, lighting the reset light. The front contacts 1 and 3 prevent 1 plate voltage from being applied.

The nand gate of 3IC24 Pins 11, 12 & 13 act as a gate. The input from the counter circuit (3IC24 Pin 13) is normally a "1" thus enabling the gate. Any time a "1" is applied to Pin 12 by the sixty-second timer both inputs will be high and the output will go to zero. If the count goes to 3 the input to the nand gate goes low and the gate is inhibited. No reset pulse can be transmitted from sixty-second timer.

A manual reset signal, or an automatic signal from the 180-second timer (3IC21 Pin 1) coupled through 3IC23 Pin 1-2 produces a "Ø" level which is coupled through 3IC24 Pin 9, the output is inverted and is applied to the reset input of the counter and to the reset input of the lamp Driver Board.

The Relay Drivers are simply 5 watt transistors which complete the ground connection for the relay.

4-6.3.6 Lamp Driver Board (3A1)

The lamp driver board consists of 2 dual edge triggered flip-flops. The Q output of the flip-flop drive transistors which complete the ground path of the individual fault lamps.

The D input of the flip-flop is continuously connected to Logic 1 and the fault signals are fed to the clock input. A fault signal will clock a Logic 1 into the output.

The reset is accomplished by inverting the reset signal with 3Q13. The normal no reset condition of the collector of 3Q13 is a Logic 1.

4-6.3.7 Alignment Procedure for Fault Level Control Board (3A4 Rev. D)

Tools: Accurate VOM

Screw Driver

5/16" Wrench

Extender Board (3A9)

Transmitter:

1. Stop transmitter.
2. Attach dummy load and bring transmitter to normal operational power.
3. Remove A-4 board, remove locknuts from 3R116, 3R117 and 3R118. Tighten retainer nut. Replace locknut loosely.
4. Plug A-4 into extender board and then plug both boards into A-4 slot.
5. Set driver cathode control (3R116), PA cathode control 3R117, and H. V. O/L control (3R118) to full CCW position.
6. Depress reset switch (3S8), then plate switch (3S4) to ON.
7. With the meter on the 2.5 V scale (or equivalent) measure the voltage on Pin 9 of IC-1. Advance (cw) PA cathode control (3R117) until the transmitter trips off and the PA cathode lamp lights. This voltage should be 1.7 V ± .2.
8. Turn control to full CCW. Depress plate to OFF, depress reset switch, depress plate to ON.

9. Adjust metering Pin 9 of IC-1. Adjust the voltage for 1.0 V.

10. Attach the negative lead of the meter to TP-1.

11. Meter Pin of IC-2 (to TP-1). Repeat steps 6 to 9 adjusting the driver cathode control (3R116). The driver cathode lamp (3DS6) should light.

12. Meter Pin 5 of IC-2 (to TP-1). Repeat steps 6 to 9 adjusting the H.V. O/L control 3R118. The HV OL lamp 3DS8 should light.

13. Reset meter Pin 6 of 3IC-1 to ground using 10 V scale. Adjust the contact of the VSWR meter until the contact touches the meter needle. Pin 6 should go low, the transmitter should trip off and the VSWR lamp should light. Return the contact to the previous setting. (See Para. 3-4).

14. Depress and release test switch 3S18. Transmitter should trip off for 2 sec. (± 1 sec.). All four should extinguish for 2 seconds and relight. Repeat 2 more times. On 3rd time reset light should come on and stay on. Transmitter should not come on.

15. Wait 75 seconds after all previous faults then depress and release 3S18 for 2 faults. Wait 75 seconds and repeat Step 14. The number of faults should be 3.

16. Let transmitter operate at normal operating power for 10 minutes. Readjust each level to 1.0 volts. Tighten lock nuts, recheck, adjust if necessary.

17. Shut down transmitter, remove extender board, and replace A-4.

<u>Note</u>: The above procedure establishes a fault level as 140% of normal operating levels.

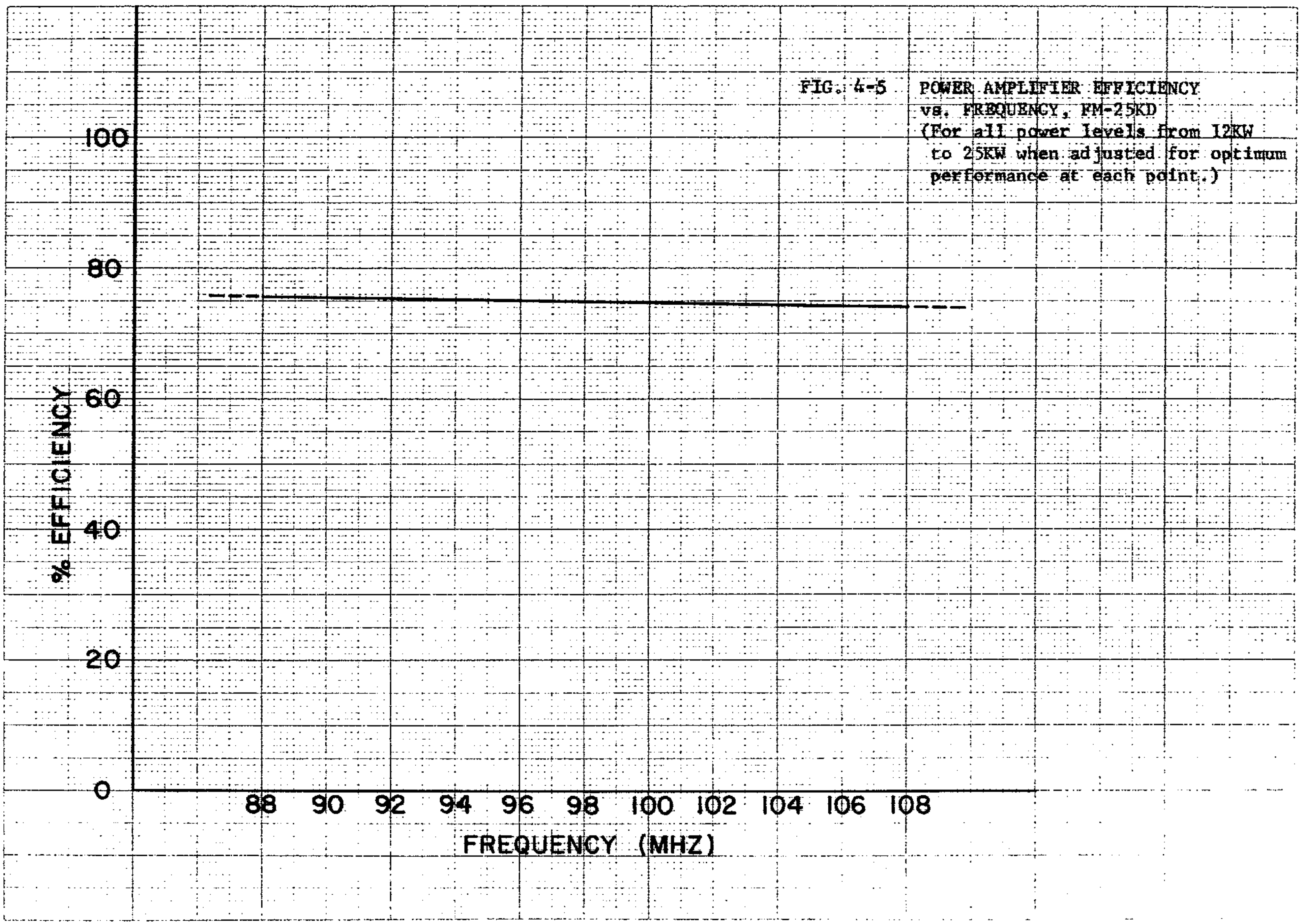



FIG. 4-5 POWER AMPLIFIER EFFICIENCY vs. FREQUENCY, FM-25KD (For all power levels from 12KW to 25KW when adjusted for optimum performance at each point.)

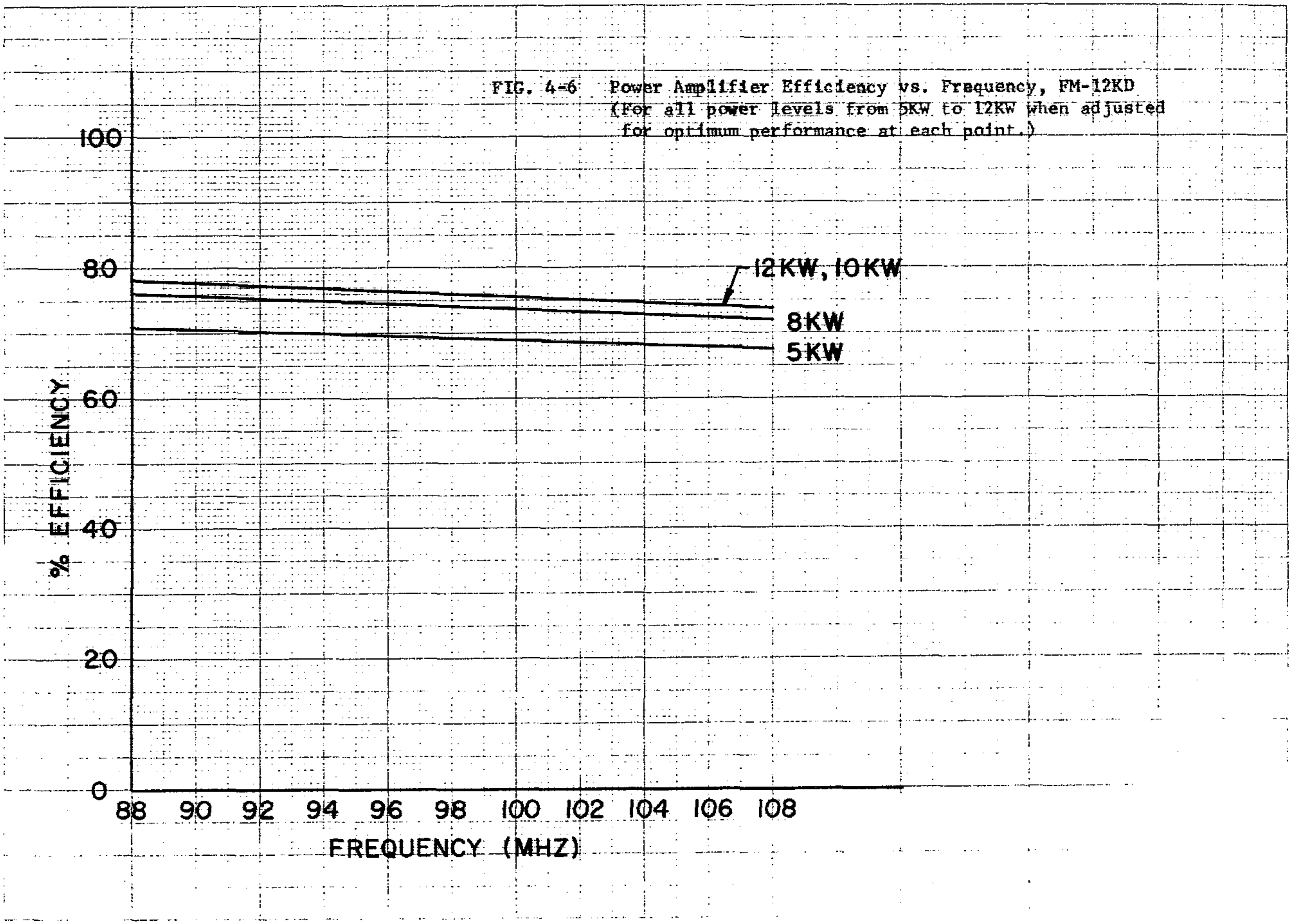



FIG. 4-6 Power Amplifier Efficiency vs. Frequency, FM-12KD
(For all power levels from 5KW to 12KW when adjusted for optimum performance at each point.)

## SECTION V

## MAINTENANCE

CAUTION: Disconnect safety switch before starting any maintenance procedures. This will insure that there will be no voltage of any level present within the cabinet.

Use a grounding stick and ascertain that all filter capacitors are discharged. There are redundant discharge paths on both high-voltage supplies to minimize the possibility of any charge remaining but it is always wise to be safe.

All blower and fan motors are permanently lubricated and require no periodic maintenance except the occasional cleaning of the squirrel cage and fan blades. There should be very little entry of dust into the cabinet since the fan at the cabinet rear maintains a positive internal air pressure.

Lead screws for the adjustable shorting bars are combined with Oilite mating threads and also do not require lubrication. The right-angle gears for the driver input and grid tuning are lubricated with Lubriplate. Because of the very limited usage, these gear pairs should only require an occasional inspection.

The replacement interval for the air filters at the cabinet rear will, of course, depend upon the environment and the local dust conditions. Periodic visual inspection will make it obvious when replacement becomes necessary.

Air filters can easily be inspected by turning counter-clockwise (2) 1/4 turn latches located at top of the louvered grille. This allows the hinged grille to drop down exposing the filter. See Figure 3-16. Filters are 16" x 20" x 1" thick fiberglass type used in heating and air conditioning systems.

Blow-out the driver and PA tube anode heat sinks with an air hose.

Examine the condition of the screen mesh in the lower sections of the driver and PA RF compartments. Clean, if necessary.

Check the conditions of the flexible air ducts and their associated clamps.

Look for discoloration or charring of resistor surfaces that would indicate excessive dissipation.

Also check for signs of overheating at finger stock contacts on the shorting bars for the driver and PA RF tuned circuits.

Operation of overload cycling circuits can be tested by manipulating the individual threshold controls, while the transmitter is operating, to deliberately simulate the repeated overload 2-second shutdowns until three have occurred and the system locks out. Reset all controls to original settings.

SECTION VI

REPLACEABLE PARTS

6-1 Ordering Information

If replacement or spare parts are required for any AEL transmitting equipment write or call:-

American Electronic Laboratories, Inc.
P. O. Box 552
Lansdale, Penna., 19446

Phone:- (215) 822-2929
Ask for Broadcast Sales or if not available, ask for Broadcast Engineering

Information required:-

(1) Station Call

(2) Transmitter in use:- Model and Serial No.

(3) Circuit symbol of part needed.

(4) AEL Part Number or Manufacturer's part number.

(5) Desired method of shipment including pick-up information for emergency shipments.

Every effort will be made to expedite shipment of urgently needed parts. The station operator should make an effort to keep on hand spare parts for transmitting components which experience indicates might be needed. AEL engineering personnel will be glad to confer with station personnel in making recommendations for a reasonable list of running spare parts.

6-2 Parts Location

All major parts are identified by component labels attached either on the component or on the chassis or cabinet surface near the component.

Many of the photographs included in this manual have part call-outs indicated by arrow and part number. Reference to the schematics will allow identification of components that are impossible to label.

It is to be noted that the components have prefix numbers to indicate general location areas as follows:-

(a) No prefix, i.e., R19-FM Exciter chassis

(b) "1" prefix, i.e., 1T4 - Main Cabinet mounted component

(c) "2" prefix, i.e., 2C12 - Driver or Power Amplifier component

(d) "3" prefix, i.e., 3S8 - Control Panel component

6-3 Replaceable Parts List

The following tabulated list of parts is to be used by the station personnel in ordering spare or replacement parts for the FM-25KD or FM-12KD transmitters.

PARTS LIST FM-25KD

| SYMBOL | DESCRIPTION | MANUF. PART NO. | MANUFACTURER |
|---|---|---|---|
| 3A1 | PC Board - Complete Listing At End | | 10001 |
| 2A2 | PC Board - Complete Listing At End | | 10001 |
| 3A3 | PC Board - Complete Listing At End | | 10001 |
| 3A4 | PC Board - Complete Listing At End | | 10001 |
| 3A5 | PC Board - Complete Listing At End | | 10001 |
| 1A6 | SCR Filament Control | LPAC-J-240-2 | 20121 |
| 3A7 | ALC Module - Complete Listing At End | | 10001 |
| 3A8 | Power Supply - 24 VDC | C-214 | 20221 |
| 3A9 | PC Board - Complete Listing At End | | 10001 |
| 2A10 | B + Filter Ass'y - Complete Listing At End | | 10001 |
| 1B1 | Filter Fan | KB1000S | 20112 |
| 2B2 | Blower | KBB35 | 20112 |
| 2B3 | Blower | CXH33A3G | 20172 |
| 2B4 | Blower | CXH33A3G | 20172 |
| 3B5 | Drive Motor - Remote Output | BK4452-875406-250117 | 10304 |
| 3C1 | Capacitor - Disk - .01 @ 1KV | DD-103 | 10301 |
| 3C2 | Capacitor - Disk - .01 @ 1KV | DD-103 | 10301 |
| 3C3 | Capacitor - Disk - .01 @ 1KV | DD-103 | 10301 |
| 3C4 | Capacitor - Disk - .01 @ 1KV | DD-103 | 10301 |
| 3C5 | Capacitor - Disk - .01 @ 1KV | DD-103 | 10301 |
| 3C6 | Capacitor - Disk - .01 @ 1KV | DD-103 | 10301 |
| 3C7 | Capacitor - Disk - .01 @ 1KV | DD-103 | 10301 |
| 3C8 | Capacitor - Disk - .01 @ 1KV | DD-103 | 10301 |

| SYMBOL | DESCRIPTION | MANUF. PART NO. | MANUFACTURER |
|---|---|---|---|
| 3C9 | Capacitor - Disk - .01 @ 1KV | DD-103 | 10301 |
| 3C10 | Capacitor - Disk - .01 @ 1KV | DD-103 | 10301 |
| 2C11 | Capacitor - Air Variable | 167-22 | 10903 |
| 2C12 | Capacitor - Air Variable | HFA-25-B | 10700 |
| 2C13 | Capacitor - Feed Thru - .001 @ 1KV | 54-752-001-102M | 20187 |
| 2C14 | Capacitor - Feed Thru - .001 @ 1KV | 54-752-001-102M | 20187 |
| 2C15 | Capacitor - Disk - .001 @ 1KV | DD-102 | 10301 |
| 2C16 | Capacitor - Disk - .001 @ 1KV | DD-102 | 10301 |
| 2C17 | Capacitor - Disk - .001 @ 1KV | DD-102 | 10301 |
| 2C18 | Capacitor - Disk - .001 @ 1KV | DD-102 | 10301 |
| 3C19 | Capacitor - Disk - .01 @ 1KV | DD-103 | 10301 |
| 2C20 | Capacitor - Neutralizing Disk | 3252764-501 | 10001 |
| 2C21 | Capacitor - Feed Thru - .001 @ 1KV | 54-752-001-102M | 20187 |
| 2C22 | Capacitor - Feed Thru - .001 @ 1KV | 54-752-001-102M | 20187 |
| 3C23 | Capacitor - Paper - 100uF @ 250V | TVA-1522 | 20188 |
| 3C24 | Capacitor - Paper - 100uF @ 250V | TVA-1522 | 20188 |
| 3C25 | Capacitor - Part of 3A7 | | |
| 3C26 | Capacitor - Part of 3A7 | | |
| 2C27 | Capacitor - Vacuum - .00015 @ 7.5KV | VC150-30-10 | 20126 |
| 2C28 | Capacitor - Feed Thru - .001 @ 10KV | 2450285-1 | 10001 |
| 1C29 | Capacitor-Oil-5uF @ 5KV | 702012-8301 | 20181 |

| SYMBOL | DESCRIPTION | MANUF. PART NO. | MANUFACTURER |
|---|---|---|---|
| 1C30 | Capacitor - Oil - 5uF @ 5KV | 702012-8301 | 20181 |
| 1C31 | Capacitor - Oil - 5UF @ 10KV | 702013-7603 | 20181 |
| 2C32 | N/A | | |
| 2C33 | Capacitor - Feed Thru - .001 @ 1KV | 2251275-501 | 10001 |
| 2C34 | Capacitor - Feed Thru - .001 @ 1KV | 2251275-501 | 10001 |
| 3C35 | Part Of 3A5 | | |
| 3C36 | Part of 3A5 | | |
| 2C37 | Cap - MICA - 820pf @ 500V | CMO6FD821J03 | 30001 |
| 2C38 | Cap - Ceramic - 10pf @ 5KV | 854-10Z | 10301 |
| 2C39 | Capacitor - Oil - 10UF @ 600V | 702012-3002 | 20181 |
| 2C40 | P/O 2A2 | | |
| 2C41 | P/O 2A2 | | |
| 2C42 | Capacitor - 0.68UF @ 400V | WMF4P68 | 10307 |
| 2C43 | Capacitor - Plate Blocker | 4152042-1 | 10001 |
| 2C44 | Capacitor - Vacuum - .00005 @ 7.5KV | VC50-30-7.5 | 20126 |
| 2C45 | Capacitor - Vacuum - .00005 @ 7.5KV | VC50-30-7.5 | 20126 |
| 2C46 | Capacitor - Feed Thru - .001 @ 1KV | 54-752-001-102M | 20187 |
| 2C47 | Capacitor - Feed Thru - .001 @ 1KV | 54-752-001-102M | 20187 |
| 2C48 | Capacitor - Feed Thru - .001 @ 1KV | 54-752-001-102M | 20187 |
| 2C49 | Capacitor - Feed Thru - .001 @ 1KV | 54-752-001-102M | 20187 |
| 2C50 | Capacitor - Feed Thru - .001 @ 1KV | 54-752-001-102M | 20187 |

| SYMBOL | DESCRIPTION | MANUF. PART NO. | MANUFACTURER |
|---|---|---|---|
| 3C51 | Capacitor - Disc - .01 @ 1KV | DD-103 | 10301 |
| 3C52 | Capacitor - Disc - .01 @ 1KV | DD-103 | 10301 |
| 2C53 | Capacitor - Ceramic - .001 @ 5KV | 858S-1000 | 10301 |
| 2C54 | Capacitor - Ceramic - .001 @ 5KV | 858S-1000 | 10301 |
| 2C64 | Capacitor - Vacuum - 3-30pf @ 10KV | CVG-3/30-10KV | 10104 |
| 2C65 | Capacitor - 1.0 - @ 400VDC | P8292ZN | 10101 |
| 2C66 | Capacitor - Disk - .001 @ 1KV | DD-102 | 10301 |
| 2C67 | Capacitor - Disk - .001 @ 1KV | DD-102 | 10301 |
| 2C68 | Capacitor - Disk - .001 @ 1KV | DD-102 | 10301 |
| 2C69 | Capacitor - Disk - .001 @ 1KV | DD-102 | 10301 |
| 2C70 | Capacitor - Ceramic - .001 @ 5KV | 858S-1000 | 10301 |
| 2C71 | Capacitor - Ceramic - .001 @ 5KV | 858S-1000 | 10301 |
| 2C72 | Capacitor - Ceramic - .001 @ 5KV | 858S-1000 | 10301 |
| 2C73 | Capacitor - Ceramic - .001 @ 5KV | 858S-1000 | 10301 |
| 3CB1 | Circuit Breaker - 20A - 2 Pole - Curve 3 | 2263S | 10702 |
| 3CB2 | Circuit Breaker - 20A - 2 Pole - Curve 3 | 2263S | 10702 |
| 1CB3 | Cirucit Breaker - 225A - 3 Pole - Curve 3 | CJ3-G3-U-225-3 | 10702 |
| 2CR1 | N/A | | |
| 2CR2 | N/A | | |
| 2CR3 | N/A | | |
| 3CR4 | N/A | | |
| 2CR5 | Diode Block | SPF-16 | 20185 |
| 1CR6 | Rectifier Ass'y - 12A | RS3.5-24-12S | 10104 |

| SYMBOL | DESCRIPTION | MANUF. PART NO. | MANUFACTURER |
|---|---|---|---|
| 1CR7 | Rectifier Ass'y - 12A | RS3.5-24-12S | 10104 |
| 1CR8 | Rectifier Ass'y - 12A | RS3.5-24-12S | 10104 |
| 1CR9 | Rectifier Ass'y - 12A | RS3.5-24-12S | 10104 |
| 1CR10 | Rectifier Ass'y - 12A | RS3.5-24-12S | 10104 |
| 1CR11 | Rectifier Ass'y - 12A | RS3.5-24-12S | 10104 |
| 1DC1 | Meter Coupler | 261.3, 3252972-502 | 10202, 1000 |
| 1DC2 | Filter Coupler | 3330A, 2030L-25C, 2030H-25C | 10203, 2017 |
| 3DS1 | Indicator - Part of 3S1 | * | 20131 |
| 3DS3 | Indicator | 532-70112-51-327 | 20131 |
| 3DS4 | Indicator | 532-7016-51-327 | 20131 |
| 3DS5 | Indicator | 532-7017-51-327 | 20131 |
| 3DS6 | Indicator | 532-7015-51-327 | 20131 |
| 3DS7 | Indicator | 532-7015-51-327 | 20131 |
| 3DS8 | Indicator | 532-7015-51-327 | 20131 |
| 3DS9 | Indicator | 532-7015-51-327 | 20131 |
| 3DS10 | Indicator - Part of 3S4 | * | 20131 |
| 3DS11 | Indicator - Part of 3S8 | * | 20131 |
| 3F1 | Fuse - 1/2A - 250VAC | 3AG-250-1/2A | 30001 |
| 3F2 | Fuse - 1/2A - 250VAC | 3AG-250-1/2A | 30001 |
| 3F3 | Fuse - 1/2A - 250VAC | 3AG-250-1/2A | 30001 |

| SYMBOL | DESCRIPTION | MANUF. PART NO. | MANUFACTURER |
|---|---|---|---|
| 3F4 | Fuse - 1A - 250VAC Slo-Blo | 3AG-250-1A-SLO-BLO | 30001 |
| 3F5 | Fuse - 1A - 250VAC Slo-Blo | 3AG-250-1A-SLO-BLO | 30001 |
| 2J1 | BNC Connector - Female Chassis | UG-625B/U | 30001 |
| 2J2 | BNC Connector - Female Chassis | UG-625B/U | 30001 |
| 2J3 | BNC Connector - Female Chassis | UG-625B/U | 30001 |
| 3K1 | Relay - DPDT - 24VDC | KRP11DG | 20165 |
| 3K2 | Relay - DPDT - 24VDC | KRP11DG | 20165 |
| 3K3 | Relay - DPDT - 24VDC | KRP11DG | 20165 |
| 3K4 | Relay - DPDT - 10K Ohm Coil | KCP11-10K | 20165 |
| 3K5 | Relay - DPDT - 24 VDC | KRP11DG | 20165 |
| 3K6 | Relay - DPDT - 24VDC | KRP11DG | 20165 |
| 3K7 | Relay - DPDT - 24VDC | KRP11DG | 20165 |
| 3K8-3K17 | N/A | | |
| 3K18 | Relay - 20A - 3 Pole - 115VAC | 2200-EB-230-AA | 20171 |
| 3K19 | Relay - 20A - 3 Pole - 115VAC | 2200-EB-230-AA | 20171 |
| 1K20 | Contactor - 60A - 3 Pole - 230VAC | 8903-PO-2 | 20189 |
| 1K21 | Contactor - 100A - 3 Pole - 230VAC | 8903-QO-2 | 20189 |
| 2L1 | N/A | | |
| 2L2 | N/A | | |
| 2L3 | Choke Ass'y | 2251310-501 | 10001 |

| SYMBOL | DESCRIPTION | MANUF. PART NO. | MANUFACTURER |
|---|---|---|---|
| 2L4 | Driver Output Tuning Ass'y.<br>Note: Complete Ass'y. Not considered replaceable item. However, Shorting Block No. 2251255-501 may be replaced if required. | * | 10001 |
| 2L5 | N/A | | |
| 2L6 | Choke - Filament Rod Connector | 2155464-1 | 10001 |
| 2L7 | Choke - Filament Rod Connector | 2155464-1 | 10001 |
| 2L8 | Choke - PA | 3252927-501 | 10001 |
| 2L9 | PA Output Tuning Ass'y<br>Note: Complete Ass'y. not considered replaceable item. However, Shorting Block No. 3252634-501 may be replaced if required. | * | 10001 |
| 2L10 | PA Output Loading Ass'y.<br>Note: See note above on 2L9. | * | 10001 |
| 1L11 | Choke - 10 Hy. @ 1A | 3450767-1 | 10001 |
| 1L12 | Choke - 2 Hy. @ 5A | 2450279-1 | 10001 |
| 2L13 | Driver Input Tuning Link - Left | 2251269-501 | 10001 |
| 2L14 | Driver Grid Tuning Link - Right | 3252672-501 | 10001 |
| 2L15 | Inductor - Driver Input | 74F126AP | 20134 |
| 2L16 | Inductor - Driver Input | 74F126AP | 20134 |
| 3M1 | Meter - 0-300VAC | 4450222-5 | 10001 |
| 3M2 | Meter - 0-500VDC | 4450222-8 | 10001 |
| 3M3 | Meter - 50-0-50MADC | 4450222-11 | 10001 |

| SYMBOL | DESCRIPTION | MANUF. PART NO. | MANUFACTURER |
|---|---|---|---|
| 3M4 | Meter - 0-1ADC | 4450222-10 | 10001 |
| 3M5 | Meter - 0-6ADC | 4450222-3 | 10001 |
| 3M6 | Meter - 0-6ADC | 4450222-3 | 10001 |
| 3M7 | Meter - 0-10KVDC | 4450222-2 | 10001 |
| 3M8 | Meter - 0-10VAC | 4450222-6 | 10001 |
| 3M9 | Meter 0-30KW | 4450222-9 | 10001 |
| 3M10 | Meter - Elapsed Time - 230VAC | K42203-P5 | 10103 |
| 3M11 | Meter - VSWR - 0-200uADC | 7603-Model 29 | 20183 |
| 3R1 | Resistor - Carbon - 47K @ 2W 5% | RC42GC473J | 30001 |
| 3R2 | Resistor - Variable - 10K @ 1/2W | RV6LAYSA103A | 30001 |
| 3R3 | Resistor - Variable - 10K @ 1/2W | RV6LAYSA103A | 30001 |
| 2R4 | Resistor - 0.5 @ 25W | Type 474-0.5 | 20151 |
| 2R5 | Resistor - 50 @ 225W | 0902 | 20151 |
| 2R6 | Resistor - 50 @ 225W | 0902 | 20151 |
| 2R7 | Resistor - 50 @ 225W | 0902 | 20151 |
| 2R8 | Resistor - 50 @ 225W | 0902 | 20151 |
| 2R9 | Resistor - 3K @ 25W | 0209 | 20151 |
| 3R10 | Resistor - Variable - 5K @ 25W | 0162 | 20151 |
| 3R13 | Potentiometer - 5K @ 2W 10% | RV4LAYSA502A | 30001 |
| 3R14 | Resistor - 5 @ 11W | 4749 | 20151 |
| 2R15 | Resistor - Carbon - 100 @ 2W 5% | RC42GF101J | 30001 |
| 2R[illegible] | R[illegible]tor - [illegible]5K @ [illegible]25W | 092[illegible] | 20151 |

| SYMBOL | DESCRIPTION | MANUF. PART NO. | MANUFACTURER |
|---|---|---|---|
| 2R17 | Resistor - 250 @ 225W | 0906 | 20151 |
| 2R18 | Resistor - 250 @ 225W | 0906 | 20151 |
| 2R19 | Resistor, 0.03 Ohm | | 10001 |
| 2R20 | Resistor - 1 Mego @ 2W 1% | RN80B1004F | 30001 |
| 2R21 | Resistor - 1 Mego @ 2W 1% | RN80B1004F | 30001 |
| 2R22 | Resistor - 1 Mego @ 2W 1% | RN80B1004F | 30001 |
| 2R23 | Resistor - 1 Mego @ 2W 1% | RN80B1004F | 30001 |
| 2R24 | Resistor - 1 Mego @ 2W 1% | RN80B1004F | 30001 |
| 2R25 | Resistor - 1 Mego @ 2W 1% | RN80B1004F | 30001 |
| 2R26 | Resistor - 1 Mego @ 2W 1% | RN80B1004F | 30001 |
| 2R27 | Resistor - 1 Mego @ 2W 1% | RN80B1004F | 30001 |
| 2R28 | Resistor - 1 Mego @ 2W 1% | RN80B1004F | 30001 |
| 2R29 | Resistor - 1 Mego @ 2W 1% | RN80B1004F | 30001 |
| 2R30 | Resistor - Carbon - 82K @ 2W 5% | RC42GF823J | 30001 |
| 2R31 | Resistor - 1 Mego @ 2W 1% | RN80B1004F | 30001 |
| 2R32 | Resistor - 1 Mego @ 2W 1% | RN80B1004F | 30001 |
| 2R33 | Resistor - 1 Mego @ 2W 1% | RN80B1004F | 30001 |
| 2R34 | Resistor - 1 Mego @ 2W 1% | RN80B1004F | 30001 |
| 2R35 | Resistor - 1 Mego @ 2W 1% | RN80B1004F | 30001 |
| 2R36 | Resistor - 1 Mego @ 2W 1% | RN80B1004F | 30001 |
| 2R37 | Resistor - 1 Mego @ 2W 1% | RN80B1004F | 30001 |

| SYMBOL | DESCRIPTION | MANUF. PART NO. | MANUFACTURER |
|---|---|---|---|
| 2R38 | Resistor - 1 Mego @ 2W 1% | RN80B1004F | 30001 |
| 2R39 | Resistor - 1 Mego @ 2W 1% | RN80B1004F | 30001 |
| 2R40 | Resistor - 1 Mego @ 2W 1% | RN80B1004F | 30001 |
| 2R41 | Resistor - Carbon - 82K @ 2w 5% | RC42GF823J | 30001 |
| 3R42 | Resistor - 0.5 @ 25W | Type 474-0.5 | 20151 |
| 3R43 | Pot - 1K @ 2W | RV4NAYSA102A | 30001 |
| 2R44 | Resistor - 100K @ 225W | 0925 | 20151 |
| 2R45 | Resistor - 100K @ 225W | 0925 | 20151 |
| 3R46 | Potentiometer - 1K @ 2W | RV4NAYSA102A | 30001 |
| 3R47-142 | See Subassemblies at end. | | |
| 3R139 | Resistor - 5.6K @ 1/2W | RC20GF562J | 30001 |
| 2R143 | Resistor - 100K @ 225W | 0925 | 20151 |
| 2R144 | Resistor - 100K @ 225W | 0925 | 20151 |
| 2R145 | Resistor - 100K @ 225W | 0925 | 20151 |
| 3R146 | Resistor - 0.5 @ 25W | Type 474-0.5 | 20151 |
| 3R147 | Resistor - 4.7K @ 1/2W | RC20GF472J | 30001 |
| 2RL1 | Choke | 2251334-501 | 10001 |
| 3S1 | Presslite | 521-4017-51-327 | 20131 |
| 3S2 | Presslite | 518-4016-51-327 | 20131 |
| 3S4 | Presslite | 520-4016-51-327 | 20131 |
| 3S8 | Presslite | 518-40112-51-327 | 20131 |
| 3S9 | Switch - $90^{o}$ Index - 4 Position | 2542 | 10301 |
| 3S10 | Switch - 3 Section - Intlk. | 3Sect/B301 | 10301 |

| SYMBOL | DESCRIPTION | MANUF. PART NO. | MANUFACTURER |
|---|---|---|---|
| 3S11 | Switch - 2 Section - Intlk. | 2Sect/B301 | 10301 |
| 3S12 | Switch - 2 Section - Intlk. | 2Sect/B301 | 10301 |
| 3S13 | Switch - 2 Section - Intlk. | 2Sect/B301 | 10301 |
| 3S14 | Switch - 5 Section - Intlk. | 2155501-1 | 10001 |
| 2S15 | Switch - Air Intlk. | 2A-1800 | 20172 |
| 2S16 | Switch - Air Intlk. | 2A-1800 | 20172 |
| 2S17 | Switch - Door Intlk. | 2AC6 | 20132 |
| 3S18 | Switch - Momentary SPDT(Part of 3A4) | 7108SYZBE | 10303 |
| 2S19 | Switch - Door Intlk. | 2AC6 | 20132 |
| 1S20 | Switch - Door Intlk. | 2AC6 | 20132 |
| 1S21 | Switch - Door Intlk. | 2AC6 | 20132 |
| 2S22 | Switch - Air Intlk. | 2A-1000 | 20132 |
| 2S23 | Switch - Control Panel Intlk. | 2AC6 | 20132 |
| 1T1 | Transformer - 6.3V @ 160A | 3450766-1 | 10001 |
| 2T2 | Transformer - Sola | 20-04-065 | 20184 |
| 2T3 | Transformer - Bias | 3450768-1 | 10001 |
| 1T4 | Transformer - Plate - 40KVA | 3450763-1 | 10001 |
| 1TB1 | Terminal Block - 7 Terminals | 541-7 | 10302 |
| 1TB2 | Terminal Block - 15 Terminals | 541-15 | 10302 |
| 1TB3 | Terminal Block | 42704 | 10206 |
| 1TB4 | Terminal Block | 22204 | 10206 |
| 2V1 | Tube | 4CX1000K | 10402 |
| 2V2 | Tube | 3CX15000A7 | 10402 |
| 2VR1 | Zener Diode | 1N3340A | 20133 |

| SYMBOL | DESCRIPTION | MANUF. PART NO. | MANUFACTURER |
|---|---|---|---|
| 2VR2 | Zener Diode | IN3340A | 20133 |
| 2VR3 | Zener Diode | IN3340A | 20133 |
| 3XF1 | Fuse Holder | HCM-D | 10205 |
| 3XF2 | Fuse Holder | HCM-D | 10205 |
| 3XF3 | Fuse Holder | HCM-D | 10205 |
| 3XF4 | Fuse Holder | HCM-D | 10205 |
| 3XF5 | Fuse Holder | HCM-D | 10205 |
| 3XF6 | Fuse Holder (Spare) | HCM-D | 10205 |
| 3XF7 | Fuse Holder (Spare) | HCM-D | 10205 |
| 2XV1 | Socket - Driver Tube | 3252669-501 | 10001 |
| 2XV2 | Socket - PA Tube | SK1320 | 10402 |
| 2E1 | Protector, Voltage Surge | L2-A230 | 20190 |
| 2XE1 | Holder | A2-L1 | 20190 |
| 3E2 | Protector, Voltage Surge | L2-A230 | 20190 |
| 3XE2 | Holder | A2-L1 | 20190 |
| 2E3 | Protector, Voltage Surge | L2-A230 | 20190 |
| 2XE3 | Holder | A2-L1 | 20190 |

## PARTS LIST LAMP DRIVER 3A1

| SYMBOL | DESCRIPTION | MANUF. PART NO. | MANUFACTURER |
|---|---|---|---|
| 3C74 | Capacitor 1 MFD @ 50 V | NLW 1-50 | 10307 |
| 3C75 | Capacitor 1 MFD @ 50 V | NLW 1-50 | 10307 |
| 3C76 | Capacitor 1 MFD @ 50 V | NLW 1-50 | 10307 |
| 3C77 | Capacitor 1 MFD @ 50 V | NLW 1-50 | 10307 |
| 3C78 | Capacitor 1 MFD @ 50 V | NLW 1-50 | 10307 |
| 3C79 | Capacitor 50 uf @ 50 V | TE-1307 | 20188 |
| 3IC10 | Integrated Circuit | SN7474N | 30001 |
| 3IC11 | Integrated Circuit | SN7474N | 30001 |
| 3R100 | Resistor 1.2 K 1/4 W 5% | RCR07G122J | 30001 |
| 3R101 | Resistor 1.2 K 1/4 W 5% | RCR07G122J | 30001 |
| 3R102 | Resistor 1.2 K 1/4 W 5% | RCR07G122J | 30001 |
| 3R103 | Resistor 1.2 K 1/4 W 5% | RCR07G122J | 30001 |
| 3R104 | Resistor 1.2 K 1/4 W 5% | RCR07G122J | 30001 |
| 3R105 | Resistor 5.6 K 1/4 W 5% | RCR07G562J | 30001 |
| 3R113 | Resistor 270 Ω 3 W | 4403 | 20151 |
| 3Q9 | Transistor | JAN 2N2222A | 30001 |
| 3Q10 | Transistor | JAN 2N2222A | 30001 |
| 3Q11 | Transistor | JAN 2N2222A | 30001 |

## PARTS LIST LAMP DRIVER 3A1

| SYMBOL | DESCRIPTION | MANUF. PART NO. | MANUFACTURER |
|---|---|---|---|
| 3Q12 | Transistor | JAN 2N2222A | 30001 |
| 3Q13 | Transistor | JAN 2N2222A | 30001 |
| 3VR12 | Diode, Zener, 5.1 V | 1N4733 | 30001 |
| | Connector, 15 Pin | 133-015-03 | 10102 |
| | Board, Printed Circuit | 4152136-1 | 10001 |

## 2A2 - AUTOMATIC LEVEL DETECTOR

| SYMBOL | DESCRIPTION | MANUF. PART NO. | MANUFACTURER |
| --- | --- | --- | --- |
| 2C40 | Capacitor - 25 uf @ 12 V | TE-1131 | 20188 |
| 2C41 | Capacitor - .001 MFD @ 200V | CK06BX102K | 30001 |
| 2CR3 | Diode | 1N916* | 30001 |
| 2CR4 | Diode | 1N916* | 30001 |
| 2J4 | Connector - Bulkhead BNC | UG/625B/U | 30001 |
| 2J5 | Connector - Bulkhead BNC | UG/625B/U | 30001 |
| 2R135 | Resistor - 10K @ 1/4 W 5% | RCR07G103J | 30001 |
| 2R136 | Resistor - 2.2K @ 1/4 W 5% | RCR07G222J | 30001 |
| | Housing | 3152921-1 | 10001 |
| | Board, Printed Wiring | 3152924-2 | 10001 |

* Or equivalent

# 3A3 - CONTROL/TIMER ASSEMBLY

| SYMBOL | DESCRIPTION | MANUF. PART NO. | MANUFACTURER |
|---|---|---|---|
| 3C55 | Capacitor - 1 MFD @ 50 V | 5C023-105-X05-00B3 | 20164 |
| 3C56 | Capacitor - 1 MFD @ 50 V | 5C023-105-X05-00B3 | 20164 |
| 3C57 | Capacitor - 1 MFD @ 50 V | 5C023-105-X05-00B3 | 20164 |
| 3C58 | Capacitor - 1 MFD @ 50 V | 5C023-105-X05-00B3 | 20164 |
| 3C59 | Capacitor - 1 MFD @ 50 V | 5C023-105-X05-00B3 | 20164 |
| 3C60 | Capacitor - 1 MFD @ 50 V | 5C023-105-X05-00B3 | 20164 |
| 3C61 | Capacitor - 1 MFD @ 50 V | 5C023-105-X05-00B3 | 20164 |
| 3C62 | Capacitor - 1 MFD @ 50 V | 5C023-105-X05-00B3 | 20164 |
| 3C63 | Capacitor - 100 MFD @ 6 V | 150D107X0500GS2 | 20188 |
| 3C87 | Capacitor - 400 MFD @ 6 V | TE-1107 | 20188 |
| 3C88 | Capacitor - 15 MF @ 6 V | TE-1089 | 20188 |
| 3C89 | Capacitor - 100 MFD @ 6 V | 150D107X0500GS2 | 20188 |
| 3C90 | Capacitor - Tantalum 330 MFD @ 6 V | 150D-337-X900-6S2 | 20164 |
| 3C91 | Capacitor - 1 MFD @ 50 V | 5C023-105-X05-00B3 | 20164 |
| 3C92 | Capacitor - 1 MFD @ 50 V | 5C023-105-X05-00B3 | 20164 |
| 3C93 | Capacitor - 0.1 MFD @ 50 V | 5C023-104-X05-00B3 | 20164 |
| 3CR13 | Diode | 1N914* | 30001 |

* Or equivalent

# 3A3 CONTROL/TIMER ASSEMBLY

| SYMBOL | DESCRIPTION | MANUF. PART NO. | MANUFACTURER |
|---|---|---|---|
| 3IC19 | Integrated Circuit | SN74121N | 30001 |
| 3IC20 | Integrated Circuit | SN74121N | 30001 |
| 3IC21 | Integrated Circuit | SN74121N | 30001 |
| 3IC22 | Integrated Circuit | SN7493N | 30001 |
| 3IC23 | Integrated Circuit | SN7400N | 30001 |
| 3IC24 | Integrated Circuit | SN7400N | 30001 |
| 3Q4 | Transistor | 2N3440 | 30001 |
| 3Q5 | Transistor | 2N3440 | 30001 |
| 3Q6 | Transistor | 2N3440 | 30001 |
| 3Q7 | Transistor | 2N2222A JAN | 30001 |
| 3Q8 | Transistor | 2N2222A JAN | 30001 |
| 3R47 | Resistor - 680 1/4W 5% | RCR07G681J | 30001 |
| 3R48 | Resistor - 27K 1/4W 5% | RCR07G273J | 30001 |
| 3R49 | Resistor - 10K 1/4W 5% | RCR07G103J | 30001 |
| 3R50 | Resistor - 22K 1/4W 5% | RCR07G223J | 30001 |
| 3R51 | Resistor - 1M 1/4W 5% | RCR07G105J | 30001 |
| 3R52 | Resistor - 10K 1/4W 5% | RCR07G103J | 30001 |
| 3R53 | Resistor - 3.3K 1/4W 5% | RCR07G332J | 30001 |

## 3A3 CONTROL/TIMER ASSEMBLY

| SYMBOL | DESCRIPTION | MANUF. PART NO. | MANUFACTURER |
|---|---|---|---|
| 3R54 | Resistor - 470 1/4W 5% | RCR07G470J | 30001 |
| 3R55 | Resistor - 1.5M 1/4W 5% | RCR07G155J | 30001 |
| 3R56 | Resistor - 10K 1/4W 5% | RCR07G103J | 30001 |
| 3R57 | Resistor - 5.6K 1/4W 5% | RCR07G562J | 30001 |
| 3R58 | Resistor - 680 1/4W 5% | RCR07G681J | 30001 |
| 3R59 | N/A | | |
| 3R60 | Resistor - 680 1/4W 5% | RCR07G681J | 30001 |
| 3R61 | Resistor - 680 1/4W 5% | RCR07G681J | 30001 |
| 3R62 | N/A | | |
| 3R63 | Resistor - 680 1/4W 5% | RCR07G681J | 30001 |
| 3R64 | Resistor - 680 1/4W 5% | RCR07G681J | 30001 |
| 3R65 | Resistor - 390 2W 10% | RC42GF391K | 30001 |
| 3R66 | Resistor - 330 2W 10% | RC42GF331K | 30001 |
| 3R67 | Resistor - 560 1W 10% | RC32GF561K | 30001 |
| 3VR11 | Zener Diode | 1N5233 | 30001 |
| | Board, Printed Circuit | 4152135-1 | 10001 |
| | Connector, 15 Pin | 133-015-03 | 10102 |

# 3A4 REV. 'C' FAULT LEVEL CONTROL BOARD

| SYMBOL | DESCRIPTION | MANUF. PART NO. | MANUFACTURER |
|---|---|---|---|
| 3C81 | Capacitor 1 MFD @ 50 V | NLW 1-50 | 10307 |
| 3C82 | Capacitor 1 MFD @ 50 V | NLW 1-50 | 10307 |
| 3C83 | Capacitor 1 MFD @ 50 V | NLW 1-50 | 10307 |
| 3C84 | Capacitor 50 MFD @ 50 V | TE-1307 | 20188 |
| 3CR14 | Diode | 1N914 | 30001 |
| 3CR15 | Diode | 1N914 | 30001 |
| 3CR16 | Diode | 1N914 | 30001 |
| 3CR17 | Diode | 1N914 | 30001 |
| 3IC1 | Integrated Circuit | SN7413N | 30001 |
| 3IC2 | Integrated Circuit | SN7413N | 30001 |
| 3IC3 | Integrated Circuit | SN7404N | 30001 |
| 3IC4 | Integrated Circuit | SN7430N | 30001 |
| 3Q3 | Transistor | 2N2222A JAN | 30001 |
| 3Q14 | Transistor | 2N2222A JAN | 30001 |
| 3R116 | Resistor Variable 2.5K @ 1/2W 10% | RV6LAYSA252A | 30001 |
| 3R117 | Resistor Variable 2.5K @ 1/2W 10% | RV6LAYSA252A | 30001 |
| 3R118 | Resistor Variable 2.5K @ 1/2W 10% | RV6LAYSA252A | 30001 |
| 3R119 | Resistor 47Ω 3W | 4379 | 20151 |
| 3R120 | Resistor 47Ω 3W | 4379 | 20151 |
| 3R121 | Resistor 47Ω 3W | 4379 | 20151 |

# 3A4 REV. 'C' FAULT LEVEL CONTROL BOARD

| SYMBOL | DESCRIPTION | MANUF. PART NO. | MANUFACTURER |
|---|---|---|---|
| 3R122 | Resistor 10K 1/4 W 5% | RCR07G103J | 30001 |
| 3R123 | Resistor 680 1/4 W 5% | RCR07G681J | 30001 |
| 3R124 | Resistor 2.7K 1/4W 5% | RCR07G272J | 30001 |
| 3R125 | Resistor 2.7K 1/4W 5% | RCR07G272J | 30001 |
| 3R126 | Resistor 220 1/4 W 5% | RCR07G221J | 30001 |
| 3R127 | Resistor 220 1/4 W 5% | RCR07G221J | 30001 |
| 3R128 | Resistor 220 1/4 W 5% | RCR07G221J | 30001 |
| 3R129 | Resistor 220 1/4 W 5% | RCR07G221J | 30001 |
| 3R130 | Resistor 5.6 K 1/4 W 5% | RCR07G562J | 30001 |
| 3R131 | Resistor 5.6 K 1/4 W 5% | RCR07G562J | 30001 |
| 3R132 | Resistor 270Ω 3W | 4403 | 20151 |
| 3R133 | Resistor 1.8K 1W | RC32GF182J | 30001 |
| 3S18 | Switch, Momentary | 7108SYZBE | 10303 |
| 3VR5 | Zener Diode | 1N4733 | 30001 |
| 3VR6 | Zener Diode | 1N4733 | 30001 |
| 3VR7 | Zener Diode | 1N5338 | 30001 |
| 3VR8 | Zener Diode | 1N5338 | 30001 |
| 3VR9 | Zener Diode | 1N5338 | 30001 |
| | Board, Printed Circuit | 4152137-1 | 10001 |
| | Connector 15 Pin | 133-015-03 | 10102 |

## 3A4 REV. 'G' FAULT LEVEL CONTROL BOARD ASS'Y.

| SYMBOL | DESCRIPTION | MANUF. PART NO. | MANUFACTURER |
|---|---|---|---|
| 3C82 | Capacitor 1 MFD @ 50 V | NLW 1-50 | 10307 |
| 3C83 | Capacitor 50 MFD @ 12 V | TE-1133 | 20188 |
| 3CR15 | Diode | 1N914 | 30001 |
| 3CR16 | Diode | 1N914 | 30001 |
| 3CR17 | Diode | 1N914 | 30001 |
| 3CR18 | Diode | 1N914 | 30001 |
| 3R116 | Resistor, Variable 2.5K @ 1/2 W | RV6LAYSA252A | 30001 |
| 3R117 | Resistor, Variable 2.5K @ 1/2 W | RV6LAYSA252A | 30001 |
| 3R118 | Resistor, Variable 2.5K @ 1/2 W | RV6LAYSA252A | 30001 |
| 3R119 | Resistor, 10K @ 1/4 W 5% | RCR07G103J | 30001 |
| 3R120 | Resistor, 680 Ohm @ 1/4 W 5% | RCR07G681J | 30001 |
| 3R121 | Resistor, 330 Ohm @ 2 W 10% | RC42GF331K | 30001 |
| 3R122 | Resistor, 470 Ohm @ 1/4 W 5% | RCR07G471J | 30001 |
| 3R123 | Resistor, 470 Ohm @ 1/4 W 5% | RCR07G471J | 30001 |
| 3R124 | Resistor, 470 Ohm @ 1/4 W 5% | RCR07G471J | 30001 |
| 3R125 | Resistor, 470 Ohm @ 1/4 W 5% | RCR07G471J | 30001 |
| 3S18 | Switch, Momentary | 7108SYZBE | 10303 |
| 3VR5 | Zener Diode | 1N4733 | 30001 |
| 3IC-1 | Integrated Circuit | SN7400N | 30001 |

# 3A4 REV. 'G' FAULT LEVEL CONTROL BOARD ASS'Y.

| SYMBOL | DESCRIPTION | MANUF. PART NO. | MANUFACTURER |
|---|---|---|---|
| 3K11 | Relay | GB821B-3 | 20124 |
| 3K12 | Relay | GB821B-3 | 20124 |
| 3K13 | Relay | GB821B-3 | 20124 |
| 3XIC-1 | Socket | 014ST-7519 | 20125 |
| 3XK11 | Socket | 014ST-7519 | 20125 |
| 3XK12 | Socket | 014ST-7519 | 20125 |
| 3XK13 | Socket | 014ST-7519 | 20125 |
| | Board, Printed Circuit | 4152137-1 | 10001 |
| | Connector, 15 Pin | 133-015-03 | 10102 |
| 3VR6 | Zener Diode | IN5338 | 30001 |
| 3VR7 | Zener Diode | IN5338 | 30001 |
| 3VR8 | Zener Diode | IN5338 | 30001 |
| 3R126 | Resistor - 100 Ohms @ 3W | 4392 | 20151 |
| 3R127 | Resistor - 100 Ohms @ 3W | 4392 | 20151 |
| 3R128 | Resistor - 100 Ohms @ 3W | 4392 | 20151 |

## 3A5 - MASTER MODULE ASSEMBLY

| SYMBOL | DESCRIPTION | MANUF. PART NO. | MANUFACTURER |
|---|---|---|---|
| 3C35 | Capacitor - 50 UF @ 50 V | TE-1307 | 20188 |
| 3C36 | Capacitor - 50 UF @ 50 V | TE-1307 | 20188 |
| 3CR12 | Diode | 1N2070* | 30001 |
| | Board, Printed Circuit | 3152920-501 | 10001 |
| | Connector, 15 Pin | 143-015-03 | 10102 |

* Or equivalent

## 3A7 - ALC ASS'Y

| SYMBOL | DESCRIPTION | MANUF. PART NO. | MANUFACTURER |
|---|---|---|---|
| 3C25 | Capacitor - Disk - .01 @ 100V | Z-5U | 10301 |
| 3C26 | Capacitor - Disk - .01 @ 100V | Z-5U | 10301 |
| 3Q1 | Transistor | 2N5415 | 30001 |
| 3Q2 | Transistor | 40406 | 20173 |
| 3R11 | Resistor - 3.3K @ 11 W | 4836 | 20151 |
| 3R137 | Resistor - 1K @ 1/4 W 5% | RCR07G102J | 30001 |
| 3R138 | Resistor - 1K @ 1/4 W 5% | RCR07G102J | 30001 |
| 3R140 | Resistor - 10K @ 11 W | 4854 | 20151 |
| 3R141 | Resistor - 22K @ 1 W 5% | RC32GF223J | 30001 |
| 3R142 | Resistor - 4.7K @ 1/4 W 5% | RCR07G472J | 30001 |
| 3VR4 | Diode - Zener | 1N4749 | 30001 |
| | Case, Housing | 2155557-1 | 10001 |
| | Board, Printed Circuit | 3152924-1 | 10001 |

## 3A9 - EXTENDER CARD

| SYMBOL | DESCRIPTION | MANUF. PART. NO. | MANUFACTURER |
|---|---|---|---|
| | Board, Printed Wiring | 2155617-1 | 10001 |
| | Connector, 15 Pin | 133-015-03 | 10102 |
| | Connector, 15 Pin | 143-015-03 | 10102 |

## 2A10 - B+ FILTER ASSEMBLY - 4254253-501

| SYMBOL | DESCRIPTION | MANUF. PART. NO. | MANUFACTURER |
|---|---|---|---|
| 2C95 | Capacitor - 500 PF @ 30 KV | 30DK-T5 | 20188 |
| 2C96 | Capacitor - 500 PF @ 30 KV | 30DK-T5 | 20188 |
| 2C97 | Capacitor - 500 PF @ 30 KV | 30DK-T5 | 20188 |
| 2C98 | Capacitor - 500 PF @ 30 KV | 30DK-T5 | 20188 |
| 2C99 | Capacitor - 500 PF @ 30 KV | 30DK-T5 | 20188 |
| 2C100 | Capacitor - 500 PF @ 30 KV | 30DK-T5 | 20188 |
| 2L17 | Inductor - 8 turns #10 formvar | 1.50 ID | 10001 |

## FM-12KD SUPPLEMENTAL PARTS LIST

| SYMBOL | DESCRIPTION | PART NO. | MANUFACTURER |
|---|---|---|---|
| 1C31 | Capacitor, 4uF @ 8 KV | AOC8M4 | 20122 |
| 3CB | Circuit Breaker, 150A | CJ3-G3-U-150-3 | 10702 |
| 1L12 | Choke, 3HY @ 3A | 2450280-1 | 10001 |
| 3M5 | Meter, 0-3.0 A | 4450222-4 | 10001 |
| 3M6 | Meter, 0-3.0 A | 4450222-4 | 10001 |
| 3M7 | Meter, 0-7.5 KVDC | 4450222-1 | 10001 |
| 3M9 | Meter, 0-15 KW | 4450222-17 | 10001 |
| 2R4 | Resistor, 1.0 Ohm @ 25W | 0200J | 20151 |
| 2R27 | Resistor, 500K @ 2 W 1% | RN80B5003F | 30001 |
| 2R28 | N/A | | |
| 2R29 | N/A | | |
| 2R38 | Resistor, 500K @ 2 W 1% | RN80B5003F | 30001 |
| 3R42 | Resistor, 1.0 Ohm @ 25W | 0200J | 20151 |
| 3R43 | Potentiometer, 3 Ohms @ 75 W | 1103 | 20151 |
| 3R148 | Resistor, 3K @ 11W | 4835 | 20151 |
| 1T1 | Transformer, Filament | 3450765-1 | 10001 |
| 1T4 | Transformer, Plate | 3450764-1 | 10001 |
| 2V2 | Tube, Power | 3CX10,000A7 | 10402 |

# MANUFACTURERS' DESIGNATION LISTING

| DESIGNATION NO. | MANUFACTURER | DESIGNATION NO. | MANUFACTURER |
|---|---|---|---|
| 10001 | American Electronic Labs | 20131 | Marco Oak |
| 10101 | Aerovox | 20132 | Microswitch |
| 10102 | Amphenol | 20133 | Motorola |
| 10103 | A. W. Haydon | 20134 | Miller |
| 10104 | Amperex | | |
| 10202 | Bendix | 20135 | Mullard |
| 10203 | Bird | 20141 | Nothelfer Winding Labs |
| 10205 | Buss | 20151 | Ohmite |
| 10206 | Buchannan | | |
| 10301 | Centralab | 20162 | Phaostron |
| 10302 | Cinch Jones | 20165 | Potter & Brumfield |
| 10303 | C-K | | |
| 10304 | Dale Electronics | 20164 | Pytronics |
| 10307 | Cornell-Dublier | 20170 | RDI |
| 10401 | E. F. Johnson | 20171 | Rowan |
| 10402 | Eimac | 20172 | Rotron |
| 10403 | Elmenco | 20181 | Sangamo |
| 10700 | Hammarlund | 20183 | Simpson |
| 10702 | Heinemann | 20184 | Sola |
| 10902 | Jennings | 20185 | Solitron |

# MANUFACTURERS' DESIGNATION LISTING

| DESIGNATION NO. | MANUFACTURER | DESIGNATION NO. | MANUFACTURER |
|---|---|---|---|
| 10903 | E. F. Johnson | 20187 | Spectrum Control |
| 20112 | Kooltronic | 20188 | Sprague |
| 20121 | Loyola | 20189 | Sq D |
| 20122 | Condenser Products | 20190 | Siemens |
| 20123 | Electro Engineering | 20221 | Wanlass |
| 20124 | Grisby-Barton | 30001 | Mil Std. |
| 20125 | Texas Instruments | | |
| 20126 | Dolenko-Wilkens | | |
| 20173 | RCA | | |
| 20174 | Unitrode | | |
| 20175 | Sarkes-Tarzian | | |
| 20176 | Carborundum | | |
| 20177 | Triad | | |
| 20178 | Shively Labs | | |

Eimac®

**E I M A C**

Division of Varian

SAN CARLOS

CALIFORNIA

# 8352 / 4CX1000K

**CERAMIC**

**POWER TETRODE**

The Eimac 8352/4CX1000K is a ceramic and metal, forced-air cooled, radial-beam tetrode with a rated maximum plate dissipation of 1000 watts. It is a low-voltage, high-current tube specifically designed for Class-$AB_1$ rf linear-amplifier applications where its high gain and low distortion characteristics may be used to advantage. The 8352/4CX1000K is similar to the 8168/4CX1000A but contains a solid screen ring that improves isolation between input and output circuits and permits use of the tube in UHF service.


## GENERAL CHARACTERISTICS

### ELECTRICAL

| | Min. | Nom. | Max. | |
|---|---|---|---|---|
| Cathode: Oxide Coated, Unipotential | | | | |
| Heating Time | 3 | | | minutes |
| Heater: Voltage | | 6.0 | | volts |
| Current | 8.1 | | 9.9 | amperes |
| Transconductance ($I_b$=1.0 ampere) | | 37,000 | | umhos |
| Direct Interelectrode Capacitances, Grounded Cathode:* | | | | |
| Input | 77 | | 90 | uuf |
| Output | 11 | | 13 | uuf |
| Feedback | | | 0.022 | uuf |

| | Min. | Nom. | Max. | |
|---|---|---|---|---|
| Direct Interelectrode Capacitances, Grounded Grid and Screen:* | | | | |
| Input | 32.5 | | 38.0 | uuf |
| Output | 11 | | 13 | uuf |
| Feedback | | | 0.004 | uuf |
| Maximum Useable Frequency | | | 400 | Mc |

*In shielded fixture.

### MECHANICAL

| | |
|---|---|
| Base | Special, breechblock terminal surfaces |
| Maximum Operating Temperatures: | |
| Ceramic-to-Metal Seals | 250° C |
| Anode Core | 250° C |
| Recommended Socket | Eimac SK-820 or SK-830 |
| Operating Position | Any |
| Maximum Over-All Dimensions: | |
| Height | 4.8 inches |
| Diameter | 3.37 inches |
| Net Weight | 27 ounces |

### RADIO-FREQUENCY LINEAR AMPLIFIER—Class AB or B

(Single Side-Band Suppressed-Carrier Operation)

MAXIMUM RATINGS

| | |
|---|---|
| DC PLATE VOLTAGE | 3000 MAX. WATTS |
| DC SCREEN VOLTAGE | 400 MAX. VOLTS |
| DC PLATE CURRENT | 1.0 MAX. AMP |
| PLATE DISSIPATION | 1000 MAX. WATTS |
| SCREEN DISSIPATION | 12 MAX. WATTS |
| GRID DISSIPATION | 0 MAX. WATTS |

TYPICAL OPERATION (Frequencies below 30 Mc)

| | | | |
|---|---|---|---|
| DC Plate Voltage | 2000 | 2500 | 3000 volts |
| DC Screen Voltage | 325 | 325 | 325 volts |
| DC Grid Voltage[1] | —60 | —60 | —60 volts |
| Zero-Signal DC Plate Current | 250 | 250 | 250 mA |
| Single-Tone DC Plate Current | 890 | 885 | 875 mA |
| Two-Tone Average DC Plate Current | 645 | 650 | 635 mA |
| Zero-Signal DC Screen Current* | 8 | 6 | 5 mA |
| Single-Tone DC Screen Current* | 35 | 35 | 35 mA |
| Two-Tone Average DC Screen Current* | 10 | 8 | 8 mA |
| Plate Output Power | 930 | 1300 | 1630 watts |

*Approximate values.

[1]Adjust grid bias to obtain listed zero-signal plate current.



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## AUDIO AMPLIFIER OR MODULATOR Class AB$_1$

| MAXIMUM RATINGS | |
|---|---|
| DC PLATE VOLTAGE | 3000 MAX. VOLTS |
| DC SCREEN VOLTAGE | 400 MAX. VOLTS |
| DC PLATE CURRENT | 1.0 MAX. AMP |
| PLATE DISSIPATION | 1000 MAX. WATTS |
| SCREEN DISSIPATION | 12 MAX. WATTS |
| GRID DISSIPATION | 0 MAX. WATTS |

TYPICAL OPERATION (Sinusoidal wave, two tubes unless noted)

| | | | | |
|---|---|---|---|---|
| DC Plate Voltage | 2000 | 2500 | 3000 | volts |
| DC Screen Voltage | 325 | 325 | 325 | volts |
| DC Grid Voltage[1] | —60 | —60 | —60 | volts |
| Zero-Signal DC Plate Current | 500 | 500 | 500 | mA |
| Max-Signal DC Plate Current | 1.78 | 1.77 | 1.75 | amps |
| Zero-Signal DC Screen Current* | 16 | 12 | 10 | mA |
| Max-Signal DC Screen Current* | 70 | 70 | 70 | mA |
| Effective Load, Plate to Plate | 2040 | 2850 | 3680 | ohms |
| Driving Power | 0 | 0 | 0 | watts |
| Max-Signal Plate Output Power | 1860 | 2600 | 3260 | watts |

*Approximate values.

[1]Adjust grid bias to obtain listed zero-signal plate current.

"TYPICAL OPERATION" data are obtained by calculation from published characteristic curves; NO ALLOWANCE is made for circuit losses. Adjustment of the grid bias to obtain the specific zero-signal plate current is assumed. The screen voltage required to obtain the listed value of maximum plate current, without drawing grid current, MAY VARY from the typical values shown. These conditions are valid to approximately 100 Mc. at higher frequencies, power output will be lower due to tube and circuit losses.

# APPLICATION

## MECHANICAL

**Cooling**—Sufficient cooling must be provided for the anode and ceramic-to-metal seals to maintain operating temperatures below the rated maximum values:

| | |
|---|---|
| Ceramic-to-Metal Seals | 250°C |
| Anode Core | 250°C |

A flow rate of 25 cubic feet per minute will be adequate for operation at maximum rated plate dissipation at sea level and with inlet air temperatures up to 40°C. Under these conditions, 25 cfm of air flow corresponds to a pressure difference across the tube and socket of 0.2 inch of water column. Experience has shown that if reliable long-life operation is to be obtained, the cooling air flow must be maintained during standby periods when only the heater voltage is applied to the tube.

At higher altitudes and at UHF increased air flow will be required. For example, at an altitude of 10,000 feet, a flow rate of 37 cfm will be required and will be obtained with a pressure drop across tube and socket of 0.3 inch of water column. In selecting a blower for use at high altitudes, care must be taken to assure that the blower is designed to deliver the desired volume of air at the corresponding pressure drop and *at the particular altitude*.

In cases where there is any doubt regarding the adequacy of the supplied cooling, it should be borne in mind that operating temperature is the sole criterion of cooling effectiveness. Surface temperatures may be easily and effectively measured by using one of the several temperature-sensitive paints or sticks available from various chemical or scientific-equipment suppliers. When these materials are used, extremely thin applications must be made to avoid interference with the transfer of heat from the tube to the air stream, which would cause inaccurate indications.

## ELECTRICAL

**Heater**—The rated heater voltage for the 4CX1000K is 6.0 volts. The voltage, as measured at the socket, should be maintained at this value to minimize variations in operation and to obtain maximum tube life. In no case should the voltage be allowed to exceed 5% above or below the rated value.

The cathode and one side of the heater are internally connected.

It is recommended that the heater voltage be applied for a period of not less than 3 minutes before other operating voltages are applied. From an initial cold condition, tube operation will stabilize after a period of approximately 5 minutes.

**Control Grid Operation**—The grid dissipation rating of the 4CX1000K is zero watts. The design features which make the tube capable of maximum power operation without driving the grid into the positive region also make it necessary to avoid positive-grid operation.

Although the average grid-current rating is zero, peak grid currents of less than five milliamperes as read on a five-milliamperes meter may be permitted to flow for peak-signal monitoring purposes.

**Screen Grid Operation**—Tetrode tubes may exhibit reversed screen current to a greater or lesser degree depending on individual tube design. This characteristic is prominent in the 4CX1000K and, under some operating conditions, indicated negative screen currents in the order of 25 milliamperes may be encountered.

The maximum rated power dissipation for the screen grid in the 4CX1000K is 12 watts and the screen power should be kept below this level. The product of the peak screen voltage and the indicated dc screen current approximates the screen input power except when the screen current indication is near zero or negative. In the usual tetrode amplifier, where no signal voltage appears between cathode and screen, the peak screen voltage is equal to the dc screen voltage. Experience has shown that the screen will operate within the limits established for this tube if the indicated screen current, plate voltage and drive voltage approximate the "Typical Operation" values.

The screen supply voltage must be maintained constant for any values of negative and positive screen currents that may be encountered. Dangerously high plate currents may flow if the screen power supply exhibits a rising voltage characteristic with negative screen current. Stabilization may be accomplished in several different ways. A bleeder resistor may be connected from screen to cathode; a combination of VR tubes may be connected from screen to cathode; or an electron-tube regulator circuit may be used in the screen supply. It is absolutely essential to use a bleeder if a series electron-tube regulator is employed. The screen bleeder current should approximate 70 milliamperes to adequately stabilize the screen voltage. It should be observed that this bleeder power may be usefully employed to energize low-power stages of the transmitter.

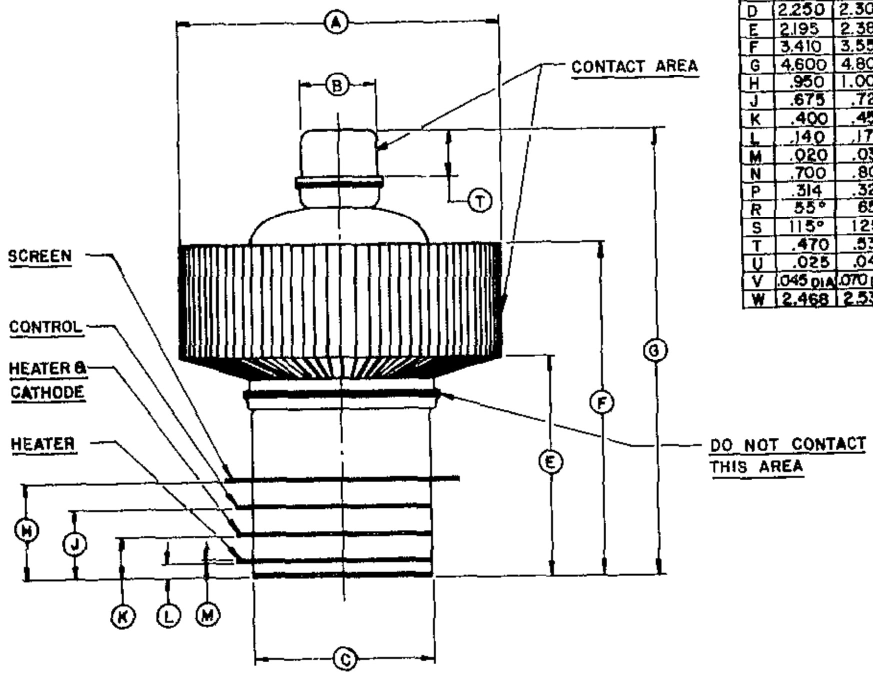
**Plate Operation**—The maximum rated plate dissipation power is 1000 watts. Except for brief periods during circuit adjustments, this maximum value should not be exceeded.

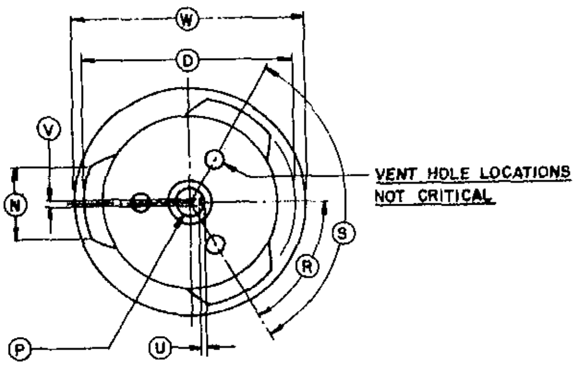
The top cap on the anode cooler may be used as a plate terminal at low frequencies or a circular clamp or spring-finger collet encircling the cylindrical outer surface of the anode cooler may be used at high frequencies.

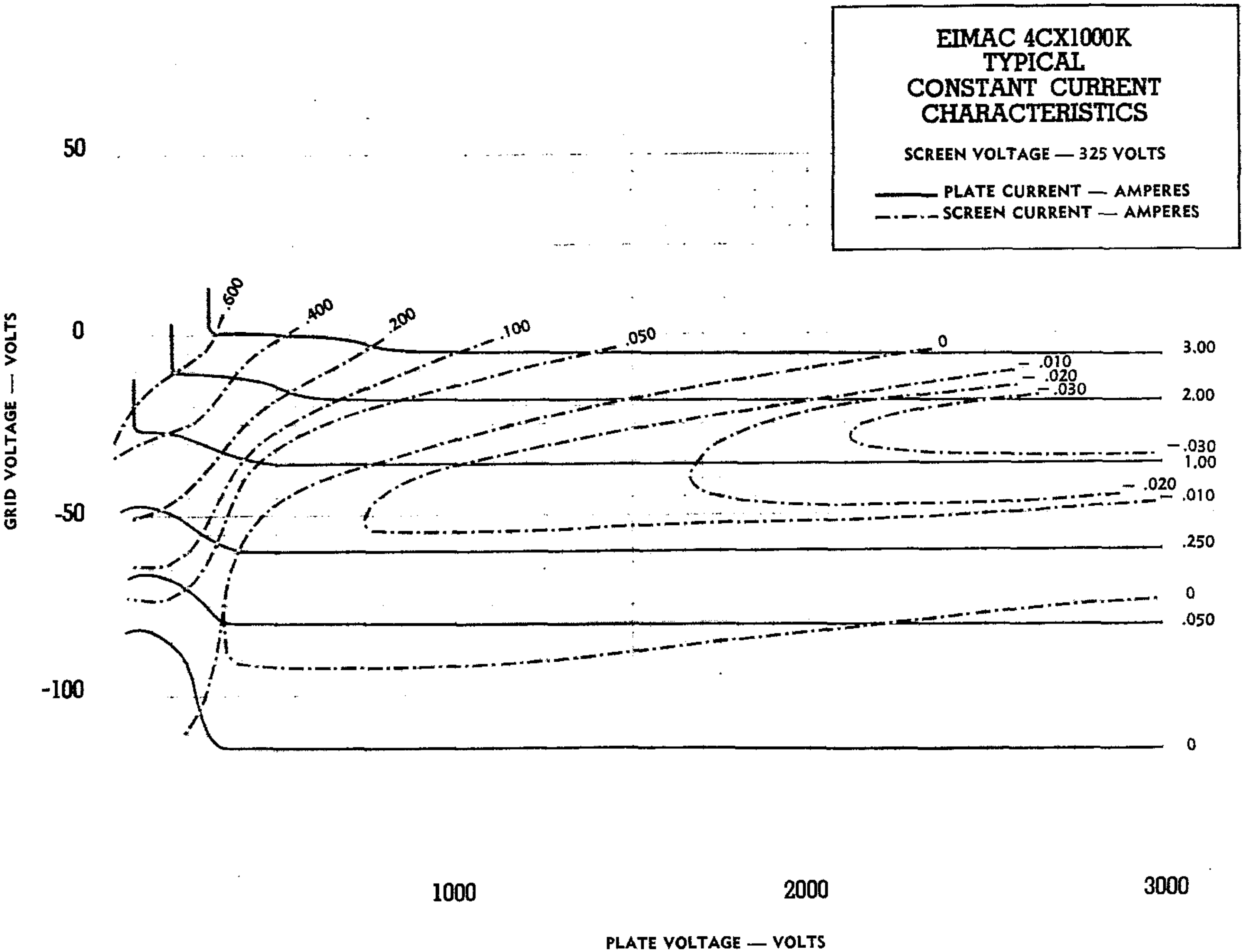
Points of electrical contact with the anode cooler should be kept clean and free of oxide to minimize radio-frequency losses. The anode cooler should be inspected periodically and cleaned when necessary to remove any dirt which might interfere with effective cooling.

**Special Applications** — If it is desired to operate this tube under conditions different from those given here, write to the Power Grid Tube Marketing, EIMAC, Division of Varian, San Carlos California, for information and recommendations.

| DIMENSIONS IN INCHES | | | |
|---|---|---|---|
| DIMENSIONAL DATA | | | |
| REF. | MIN. | MAX. | NOM. |
| A | 3.335 | 3.365 | |
| B | .807 | .817 | |
| C | 1.870 | 1.900 | |
| D | 2.250 | 2.300 | |
| E | 2.195 | 2.380 | |
| F | 3.410 | 3.550 | |
| G | 4.600 | 4.800 | |
| H | .950 | 1.000 | |
| J | .675 | .725 | |
| K | .400 | .450 | |
| L | .140 | .170 | |
| M | .020 | .030 | |
| N | .700 | .800 | |
| P | .314 | .326 | |
| R | 55° | 65° | |
| S | 115° | 125° | |
| T | .470 | .530 | |
| U | .025 | .048 | |
| V | .045 DIA | .070 DIA | |
| W | 2.468 | 2.531 | |





EIMAC 4CX1000K
TYPICAL
CONSTANT CURRENT
CHARACTERISTICS
SCREEN VOLTAGE — 325 VOLTS
PLATE CURRENT — AMPERES
SCREEN CURRENT — AMPERES
GRID VOLTAGE — VOLTS
50
0
-50
-100
.600
.400
.200
.100
.050
0
.010
.020
.030
3.00
2.00
.030
1.00
.020
.010
.250
0
.050
0
1000
2000
3000
PLATE VOLTAGE — VOLTS

Eimac®

**E I M A C**
Division of Varian
SAN CARLOS
CALIFORNIA

# 8160
# 3CX10,000A7

**HIGH-MU POWER TRIODE**

The EIMAC 8160/3CX10,000A7 is a ceramic and metal power triode intended to be used as a zero-bias Class-B amplifier in audio radio-frequency applications. Operation with zero grid bias offers circuit simplicity by eliminating the bias supply. In addition, grounded-grid operation is attractive since a power gain as high as twenty times can be obtained with the 8160/3CX10,000A7.


## GENERAL CHARACTERISTICS

**ELECTRICAL**

| | *Min.* | *Nom.* | *Max.* | |
|---|---|---|---|---|
| Filament: Thoriated-Tungsten | | | | |
| Voltage | | 7.5 | | volts |
| Current | 94 | | 104 | amps |
| Amplification Factor | | 200 | | |
| Direct Interelectrode Capacitances: | | | | |
| Grid-Filament | 50.0 | | 62.0 | pF |
| Grid-Plate | 32.0 | | 40.0 | pF |
| Plate-Filament | | | 0.3 | pF |
| Frequency for Maximum Ratings | | | 160 | MHz |

**MECHANICAL**

| | |
|---|---|
| Base | Coaxial |
| Recommended Socket | EIMAC SK-1300 |
| Operating Position | Vertical, base up or down |
| Cooling | Forced air |
| Maximum Operating Temperatures: | |
| Anode Core | 250°C |
| Ceramic-to-Metal Seals | 250°C |
| Maximum Dimensions: | |
| Height | 8.75 inches |
| Diameter | 7.05 inches |
| Net Weight | 12 pounds |

**RADIO-FREQUENCY LINEAR AMPLIFIER**
Grounded Grid, Class-B

MAXIMUM RATINGS

| | | |
|---|---|---|
| DC PLATE VOLTAGE | 7000 | VOLTS |
| DC PLATE CURRENT | 5.0 | AMPS |
| PLATE DISSIPATION | 12 | KW |
| GRID DISSIPATION | 500 | WATTS |

*Approximate value

TYPICAL OPERATION, Single-Tone Conditions

| | | | |
|---|---|---|---|
| DC Plate Voltage | 7000 | 7000 | volts |
| Zero-Sig DC Plate Current* | 0.60 | 0.60 | amp |
| Max-Sig DC Plate Current | 3.72 | 5.00 | amps |
| Max-Sig DC Grid Current | 0.71 | 1.00 | amp |
| Driving Impedance | 35 | 32 | ohms |
| Resonant Load Impedance | 1020 | 745 | ohms |
| Max-Sig Driving Power | 885 | 1540 | watts |
| Peak Envelope Plate Output Power | 17,700 | 24,200 | watts |
| Power Gain | 20.0 | 15.7 | times |



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## AUDIO-FREQUENCY AMPLIFIER OR MODULATOR

Class-B, Grid Driven

MAXIMUM RATINGS (Per Tube)

| | |
|---|---|
| DC PLATE VOLTAGE | 7000 VOLTS |
| DC PLATE CURRENT | 5.0 AMPS |
| PLATE DISSIPATION | 12 KW |
| GRID DISSIPATION | 500 WATTS |

*Approximate value

TYPICAL OPERATION, Two Tubes, Sinusoidal Wave

| | | | |
|---|---|---|---|
| DC Plate Voltage | 7000 | 7000 | volts |
| DC Grid Voltage | 0 | 0 | volts |
| Zero-Sig DC Plate Current* | 1.20 | 1.20 | amps |
| Max-Sig DC Plate Current | 7.50 | 10.0 | amps |
| Max-Sig DC Grid Current | 1.50 | 2.06 | amps |
| Driving Power | 315 | 560 | watts |
| Peak AF Driving Voltage (Per Tube) | 250 | 310 | volts |
| Load Resistance, Plate-to-Plate | 2000 | 1520 | ohms |
| Max-Sig Plate Output Power | 35,600 | 47,700 | watts |

## RADIO-FREQUENCY LINEAR AMPLIFIER

Carrier Conditions, Grounded-Grid

MAXIMUM RATINGS

| | |
|---|---|
| DC PLATE VOLTAGE | 7000 VOLTS |
| DC PLATE CURRENT | 5.0 AMPS |
| PLATE DISSIPATION | 12 KW |
| GRID DISSIPATION | 500 WATTS |

*Approximate value
**Modulation Crest Conditions

TYPICAL OPERATION

| | |
|---|---|
| DC Plate Voltage | 7000 volts |
| DC Grid Voltage | 0 volts |
| Zero-Sig DC Plate Current* | 0.60 amp |
| DC Plate Current | 2.40 amps |
| DC Grid Current | 0.25 amp |
| Driving Impedance** | 32 ohms |
| Peak Driving Voltage** | 310 volts |
| Driving Power | 330 watts |
| Plate Output Power | 5650 watts |

## RADIO-FREQUENCY POWER AMPLIFIER OR OSCILLATOR

Class-C

MAXIMUM RATINGS

| | |
|---|---|
| DC PLATE VOLTAGE | 7000 VOLTS |
| DC PLATE CURRENT | 4.0 AMPS |
| PLATE DISSIPATION | 10 KW |
| GRID DISSIPATION | 500 WATTS |

TYPICAL OPERATION

| | |
|---|---|
| DC Plate Voltage | 7000 volts |
| DC Plate Current | 4.0 amps |
| DC Grid Voltage | –230 volts |
| DC Grid Current | 775 mA |
| Peak RF Grid Voltage | 555 volts |
| Grid Driving Power | 430 watts |
| Plate Output Power | 21.3 kW |

## PLATE-MODULATED RF POWER AMPLIFIER

MAXIMUM RATINGS

| | |
|---|---|
| DC PLATE VOLTAGE | 5500 VOLTS |
| DC PLATE CURRENT | 3.0 AMPS |
| PLATE DISSIPATION | 6.5 KW |
| GRID DISSIPATION | 500 WATTS |

TYPICAL OPERATION

| | |
|---|---|
| DC Plate Voltage | 5000 volts |
| DC Plate Current | 3.0 amps |
| DC Grid Voltage | –200 volts |
| DC Grid Current | 775 mA |
| Peak RF Grid Voltage | 490 volts |
| Grid Driving Power | 380 watts |
| Plate Output Power | 11.9 kW |

Note: "TYPICAL OPERATION" data are obtainable by calculation from published characteristic curves. No allowance for circuit losses, either input or output, has been made.

# APPLICATION

*Mounting*—The 3CX10,000A7 must be operated vertically base up or down. The tube must be protected from severe vibration and shock.

*Cooling* — The maximum temperature rating for the external surfaces of the 3CX10,000A7 is 250°C. Sufficient forced-air cooling must be provided to keep the temperature of the anode core and the temperature of the ceramic-metal seals below 250°C. Tube life is usually prolonged if these areas are maintained at temperatures below this maximum rating. Minimum air-flow requirements to maintain anode-core and seal temperatures below 225°C with an inlet-air temperature of 50°C are tabulated below. The use of these air-flow rates through the recommended socket/chimney and tube combination in the base-to-anode direction provides effective cooling of the tube.

| Plate** Dissipation (Watts) | Sea Level | | 10,000 Feet | |
|---|---|---|---|---|
| | Air Flow (CFM) | Pressure Drop (Inches of Water) | Air Flow (CFM) | Pressure Drop (Inches of Water) |
| 4000 | 105 | .24 | 154 | .35 |
| 6000 | 178 | .50 | 275 | .80 |
| 8000 | 253 | .90 | 370 | 1.45 |
| 10,000 | 345 | 1.4 | 500 | 2.30 |
| 12,000 | 483 | 2.25 | 710 | 3.40 |

**Since the power dissipated by the filament is about 750 watts and since grid dissipation can, under some circumstances, represent another 500 watts, allowance has been made in preparing this tabulation for an additional 1250 watts dissipation.

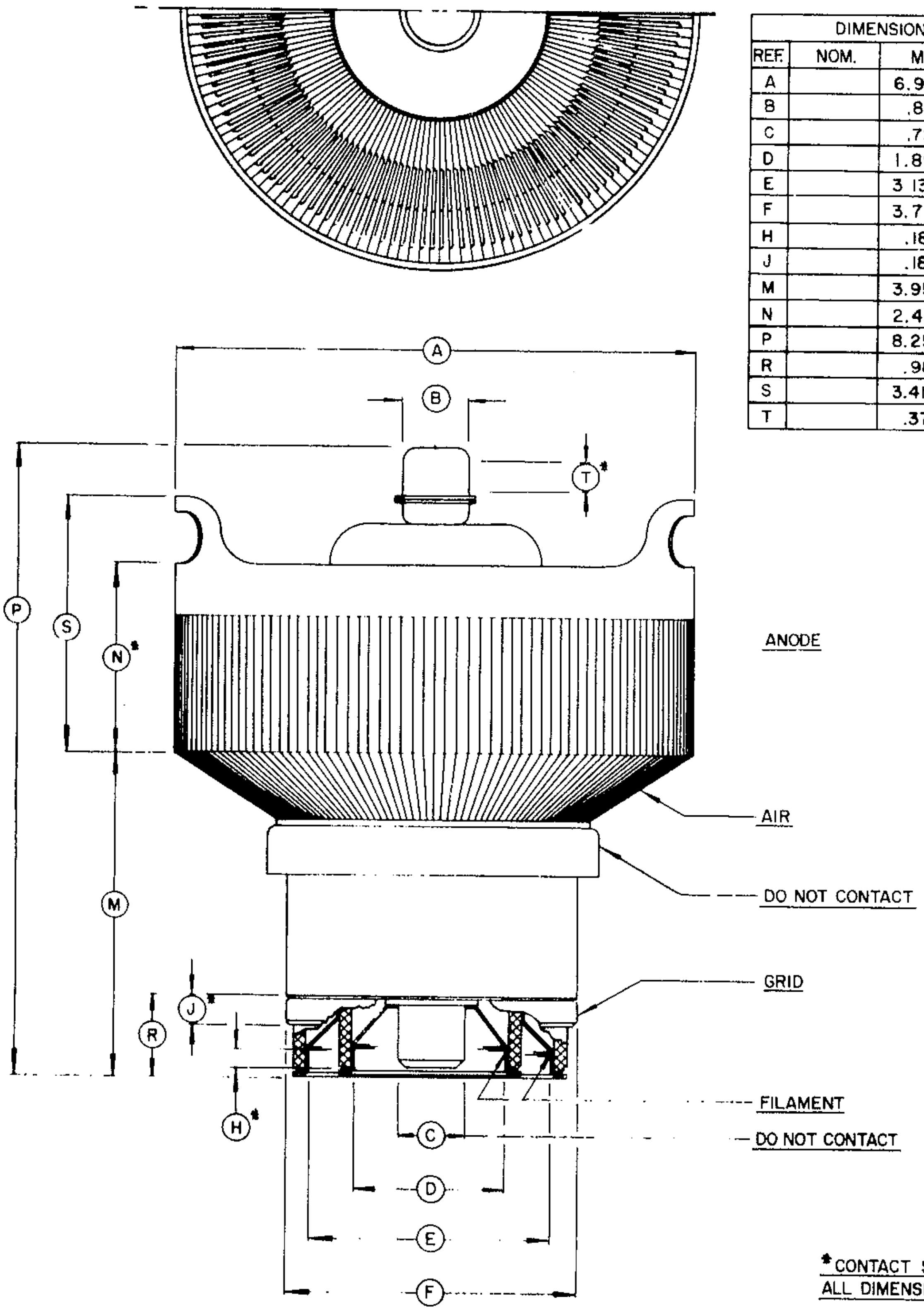
*Input Circuit* — When the 3CX10,000A7 is operated as a grounded-grid rf amplifier, the use of a resonant tank in the cathode circuit is recommended in order to obtain greatest linearity and power output. For best results with a single-ended amplifier it is suggested that the cathode tank circuit operate at a "Q" of two or more.

*Class-C Operation* — Although specifically designed for class-B service, the 3CX10,000A7 may be operated as a class-C power amplifier or oscillator or as a plate-modulated radio-frequency power amplifier. The zero-bias characteristic of the 3CX10,000A7 can be used to advantage in class-C amplifiers by employing only grid-leak bias. If driving power fails, plate dissipation is then kept to a low value because the tube will be operating at the normal static zero-bias conditions.

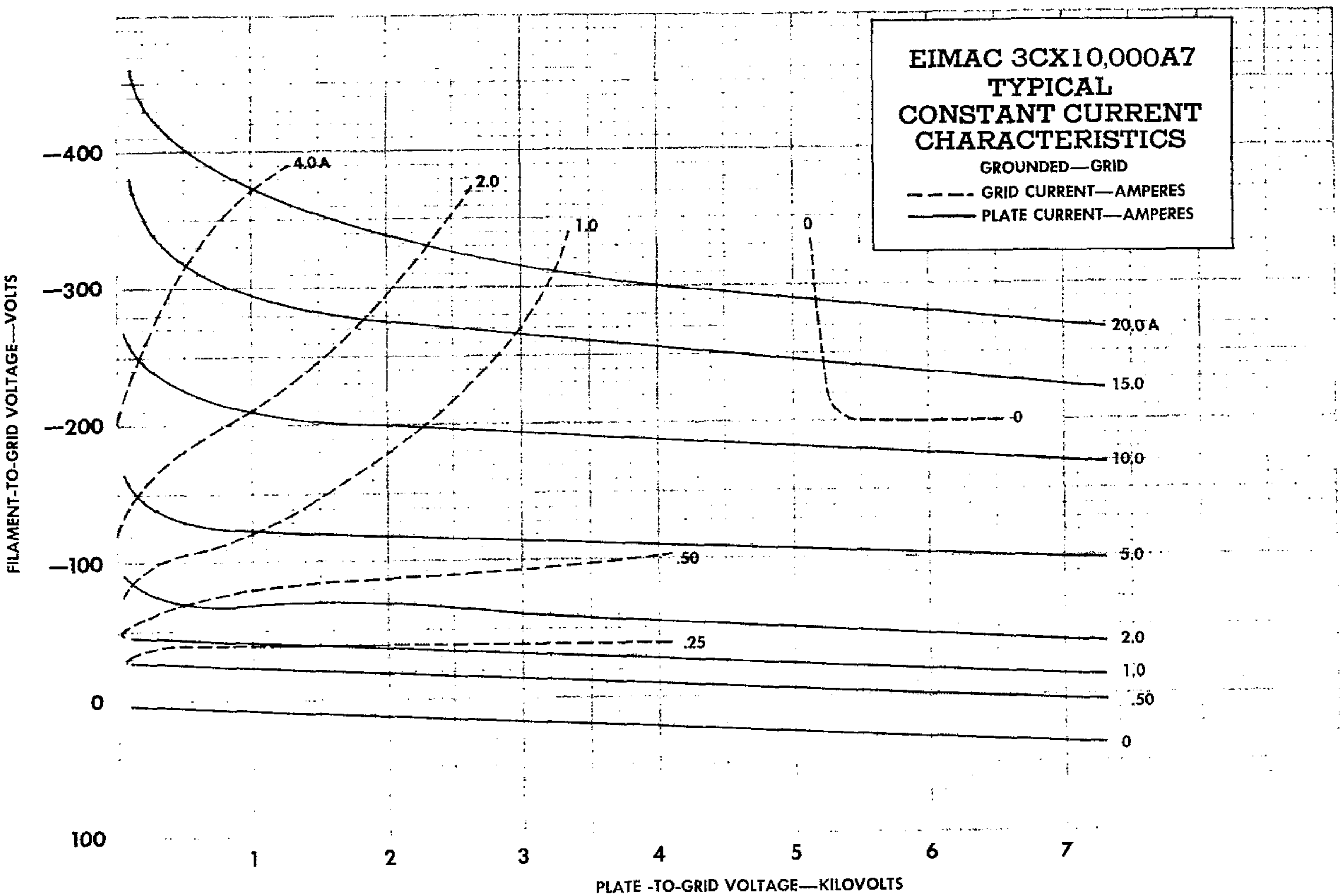
*Filament Operation* — The rated filament voltage for the 3CX10,000A7 is 7.5 volts. Filament voltage, as measured at the socket, should be maintained at this value to obtain maximum tube life. In no case should it be allowed to deviate from the rated value by more than plus or minus five percent.

*Special Applications* — If it is desired to operate this tube under conditions widely different from those given here, write to Power Grid Tube Marketing, EIMAC Division of Varian, 301 Industrial Way, San Carlos, California, for information and recommendations.

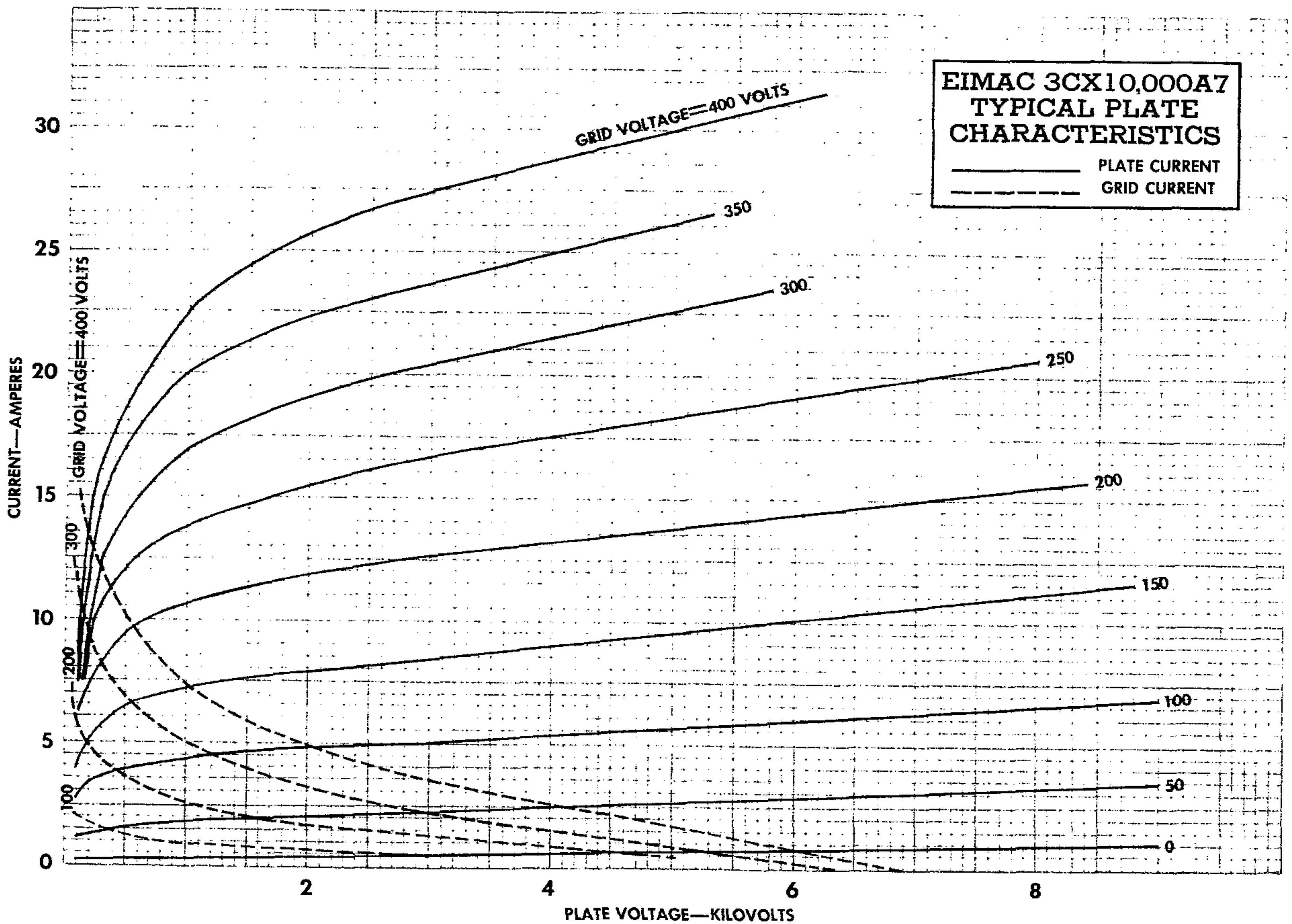
| DIMENSION DATA | | | |
|---|---|---|---|
| REF. | NOM. | MIN. | MAX. |
| A | | 6.928 | 7.050 |
| B | | .855 | .895 |
| C | | .720 | .760 |
| D | | 1.896 | 1.936 |
| E | | 3.133 | 3.173 |
| F | | 3.792 | 3.832 |
| H | | .188 | |
| J | | .188 | |
| M | | 3.950 | 4.300 |
| N | | 2.412 | 2.788 |
| P | | 8.250 | 8.750 |
| R | | .986 | 1.050 |
| S | | 3.412 | 3.788 |
| T | | .375 | |




*CONTACT SURFACE
ALL DIMENSIONS IN INCHES




3CX10,000A7 Eimac



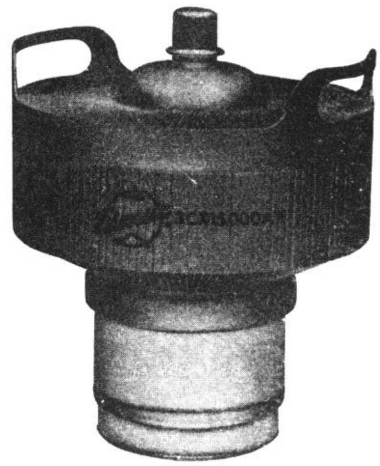
EIMAC 3CX10,000A7
TYPICAL PLATE
CHARACTERISTICS
PLATE CURRENT
GRID CURRENT
GRID VOLTAGE=400 VOLTS
350
300
250
200
150
100
50
0
GRID VOLTAGE=400 VOLTS
300
200
100
CURRENT—AMPERES
PLATE VOLTAGE—KILOVOLTS
30
25
20
15
10
5
0
2
4
6
8

# 3CX15,000A7

TECHNICAL DATA

HIGH-MU POWER TRIODE

The EIMAC 3CX15,000A7 is a ceramic/metal power triode intended for use as a zero-bias Class B rf amplifier or Class C power amplifier or oscillator. Class B operation with zero grid bias offers circuit simplicity by eliminating the bias supply. In addition, grounded-grid operation is attractive since a power gain as high as twenty times can be obtained with the 3CX15,000A7.



## GENERAL CHARACTERISTICS[1]

### ELECTRICAL

| | |
|---|---|
| Filament: Thoriated Tungsten | |
| Voltage | 6.3 ± 0.3 V |
| Current, at 6.3 volts | 160 A |
| Amplification Factor (Average): | 200 |
| Direct Interelectrode Capacitance (grounded cathode)[2] | |
| Cin | 56 pF |
| Cout | 0.2 pF |
| Cgp | 36 pF |
| Direct Interelectrode Capacitance (grounded grid)[2] | |
| Cin | 56 pF |
| Cout | 36 pF |
| Cpk | 0.2 pF |
| Frequency of Maximum Rating: | |
| CW | 110 MHz |

1. Characteristics and operating values are based upon performance tests. These figures may change without notice as the result of additional data or product refinement. EIMAC Division of Varian should be consulted before using this information for final equipment design.

2. Capacitance values are for a cold tube as measured in a special shielded fixture in accordance with Electronic Industries Association Standard RS-191.

### MECHANICAL

| | |
|---|---|
| Maximum Overall Dimensions: | |
| Length | 8.75 in; 222.3 mm |
| Diameter | 7.05 in; 179.1 mm |
| Net Weight | 12 lb; 5.5 kg |
| Operating Position | Vertical base up or down |
| Maximum Operating Temperature: | |
| Ceramic/Metal Seals | 250°C |
| Anode Core | 250°C |



Printed in U.S.A.

| | |
|---|---|
| Cooling | Forced air |
| Base | Coaxial |
| Recommended Air System Socket | SK-1300 or SK-1320 |
| Recommended Air Chimney | SK-1306 |

**RADIO FREQUENCY LINEAR AMPLIFIER CATHODE DRIVEN**

Class AB

ABSOLUTE MAXIMUM RATINGS

| | | |
|---|---|---|
| DC PLATE VOLTAGE | 8000 | VOLTS |
| DC PLATE CURRENT | 6.0 | AMPERES |
| PLATE DISSIPATION | 15,000 | WATTS |
| GRID DISSIPATION | 500 | WATTS |

1. Approximate values.

TYPICAL OPERATION (Frequencies to 110 MHz)
Class $AB_2$

| | | | |
|---|---|---|---|
| Plate Voltage | 7000 | 7000 | Vdc |
| Grid Voltage | 0 | 0 | Vdc |
| Zero-Signal Plate Current[1] | .6 | .6 | Adc |
| Single-Tone Plate Current[2] | 5.92 | 5.0 | Adc |
| Single-Tone Grid Current[1] | 1.22 | 1.0 | Adc |
| Driving Power[1] | 1750 | 1540 | W |
| Plate Dissipation | 13.4 | 10.8 | kW |
| Single-Tone Plate Output Power | 29.6 | 24.2 | kW |
| Resonant Load Impedance | 693 | 745 | Ω |
| Drive Impedance | 27 | 32 | Ω |

2. Adjust to obtain specified value.

**RADIO FREQUENCY POWER AMPLIFIER OR OSCILLATOR** Class C Telegraphy or FM Telephony

Grid Driven

ABSOLUTE MAXIMUM RATINGS

| | | |
|---|---|---|
| DC PLATE VOLTAGE | 8000 | VOLTS |
| DC GRID VOLTAGE | -500 | VOLTS |
| DC PLATE CURRENT | 5.0 | AMPERES |
| PLATE DISSIPATION | 15,000 | WATTS |
| GRID DISSIPATION | 500 | WATTS |

TYPICAL OPERATION (Frequencies to 110 MHz)

| | | |
|---|---|---|
| Plate Voltage | 7000 | Vdc |
| Grid Voltage | -230 | Vdc |
| Plate Current | 4.0 | Adc |
| Grid Current[1] | 775 | mAdc |
| Peak rf Grid Voltage[1] | 555 | v |
| Calculated Driving Power[1] | 430 | W |
| Plate Input Power | 28 | kW |
| Plate Dissipation | 6.7 | kW |
| Plate Output Power | 21.3 | kW |
| Resonant Load Impedance | 963 | Ω |

1. Approximate value.

NOTE: TYPICAL OPERATION data are obtained by measurement or calculation from published characteristic curves. Adjustment of the rf grid voltage to obtain the specified plate current at the specified bias, and plate voltages is assumed. If this procedure is followed, there will be little variation in output power when the tube is changed, even though there may be some variation in grid current. The grid current which results when the desired plate current is obtained is incidental and varies from tube to tube. These current variations cause no difficulty so long as the circuit maintains the correct voltage in the presence of the variations in current. If grid bias is obtained principally by means of a grid resistor, the resistor must be adjustable to obtain the required bias voltage when the correct rf grid voltage is applied.

**RANGE VALUES FOR EQUIPMENT DESIGN**

| | Min. | Max. | |
|---|---|---|---|
| Heater: Current at 6.3 volts | 152 | 168 | A |
| Cathode Warmup Time | 5.0 | --- | sec. |
| Interelectrode Capacitances (grounded grid)[1] | | | |
| Cin | 50.0 | 62.0 | pF |
| Cout | 32.0 | 40.0 | pF |
| Cpk | --- | 0.3 | pF |
| Interelectrode Capacitances (grounded cathode)[1] | | | |
| Cin | 50.0 | 62.0 | pF |
| Cout | --- | 0.3 | pF |
| Cgp | 32.0 | 40.0 | pF |

1. Capacitance values are for a cold tube as measured in a shielded fixture in accordance with Electronic Industries Association Standard RS-191.

## APPLICATION

*MOUNTING & SOCKETING* - The 3CX15,000A7 must be operated vertically, base up or down, and should be protected from severe shock and vibration. The use of an EIMAC air-system socket is recommended. For grid-driven applications, the SK-1300 is used; for cathode-driven circuits, the SK-1320 should be used, as the grid is grounded to the socket frame in this unit. The SK-1306 air chimney is designed to fit around the tube's anode cooler and mount with either socket.

*COOLING* - The maximum temperature rating for the external surfaces of the 3CX15,000A7 is 250°C. Sufficient forced-air cooling must be provided to maintain the temperature of the anode core and the ceramic/metal seals below 250°C. Tube life is usually prolonged if these areas are maintained at temperatures below the maximum rating. Minimum air flow requirements (for air flowing in a base-to-anode direction) to maintain anode core and seal temperatures below 225°C with an inlet-air temperature of 50°C are tabulated below. The use of these air-flow rates through the recommended socket/chimney combination will provide effective cooling of the tube. Air flow should be applied before or simultaneously with the application of electrode voltages (including the filament) and should normally be maintained for a short period of time after all voltages are removed to allow for tube cool-down.

| | SEA LEVEL | | 10,000 FEET | |
|---|---|---|---|---|
| Anode Diss. (watts) * | Air Flow (cfm) | Approx.Press. drop (In.$H_2O$) | Air Flow (cfm) | Approx.Press. drop(In.$H_2O$) |
| 5,000 | 242 | 0.8 | 350 | 1.3 |
| 7,500 | 325 | 1.7 | 470 | 2.4 |
| 10,000 | 475 | 2.8 | 690 | 4.1 |
| 12,500 | 640 | 4.3 | 930 | 6.3 |
| 15,000 | 840 | 6.2 | 1220 | 9.7 |

* Since the power dissipated by the filament is about 1000 watts, and since the grid dissipation can represent another 500 watts, allowance has been made in preparing this tabulation for an additional 1500 watts of dissipation.

*FILAMENT OPERATION* - The rated filament voltage for the 3CX15,000A7 is 6.3 volts. Filament voltage, as measured at the socket, should be maintained at this value to obtain maximum tube life. In no case should it be allowed to deviate from the rated value by more than plus or minus five percent.

*INPUT CIRCUIT* - When the 3CX15,000A7 is operated as a ground-grid rf amplifier, the use of a resonant tank in the cathode circuit is recommended in order to obtain greatest linearity and power output. For best results with a single-ended amplifier, it is suggested that the cathode tank circuit operate at a "Q" of two or more.

*CLASS-C OPERATION* - Although specifically designed for Class-B service, the 3CX15,000A7 may be operated as a Class-C power amplifier or oscillator. The zero-bias characteristic of the 3CX15,000A7 can be used to advantage in Class-C amplifiers by employing only grid-leak bias. If driving power fails, plate dissipation is then kept to a low value because the tube will be operating at the normal static zero-bias conditions.

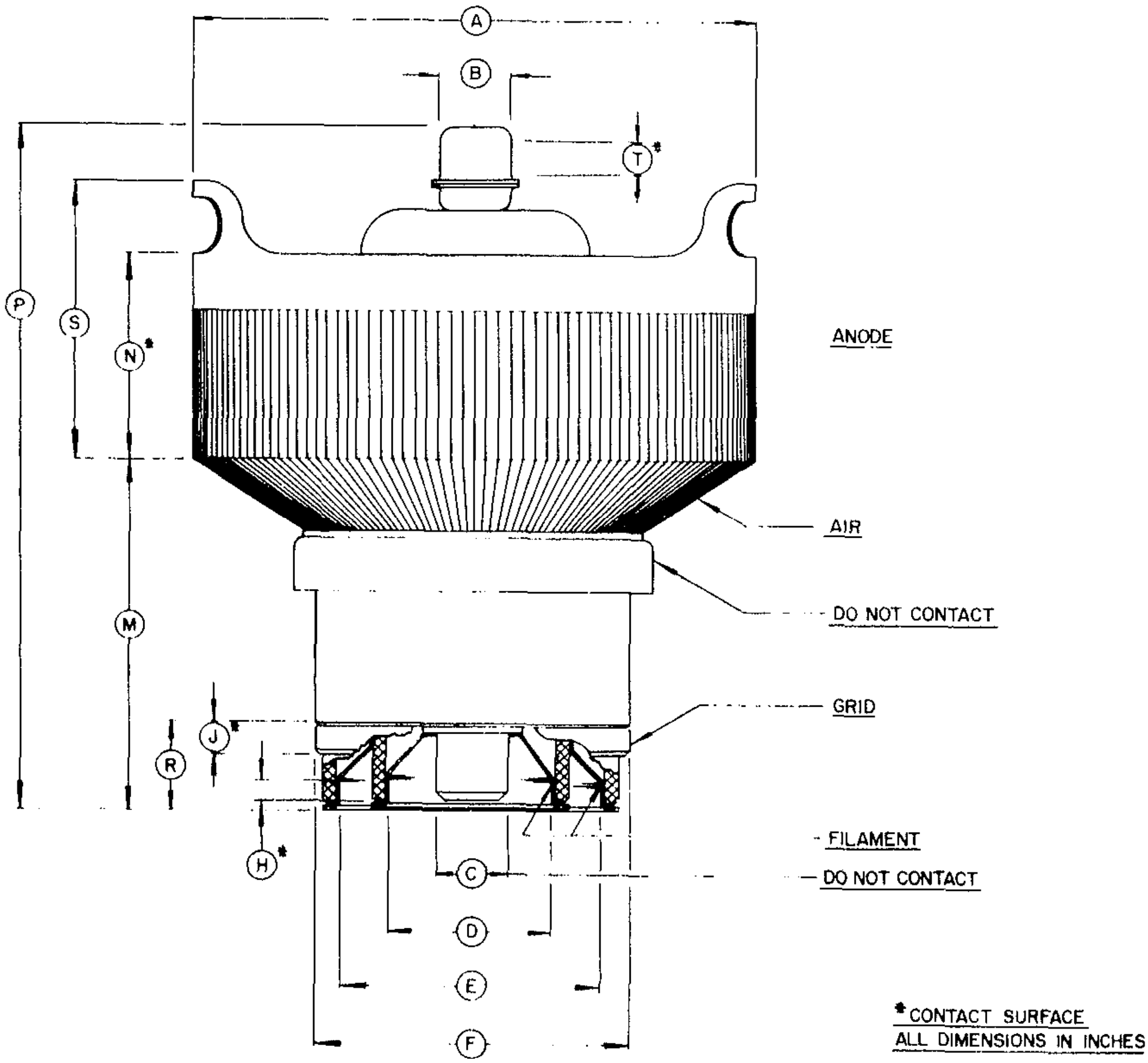
*INTERELECTRODE CAPACITANCE* - The actual internal interelectrode capacitance of a tube is influenced by many variables in most applications, such as stray capacitance to the chassis, capacitance added by the socket used, stray capacitance between tube terminals, and wiring effects. To control the actual capacitance values within the tube, as the key component involved, the industry and the Military Services use a standard test procedure as described in Electronic Industries Association Standard RS-191. This requires the use of specially constructed test fixtures which effectively shield all external tube leads from each other and eliminates any capacitance reading to "ground". The test is performed on a cold tube. Other factors being equal, controlling internal tube capacitance in this way normally assures good interchangeability of tubes over a period of time, even when the tube may be made by different manufacturers. The capacitance values shown in the manufacturer's technical data, or test specifications, normally are taken in accordance with Standard RS-191.

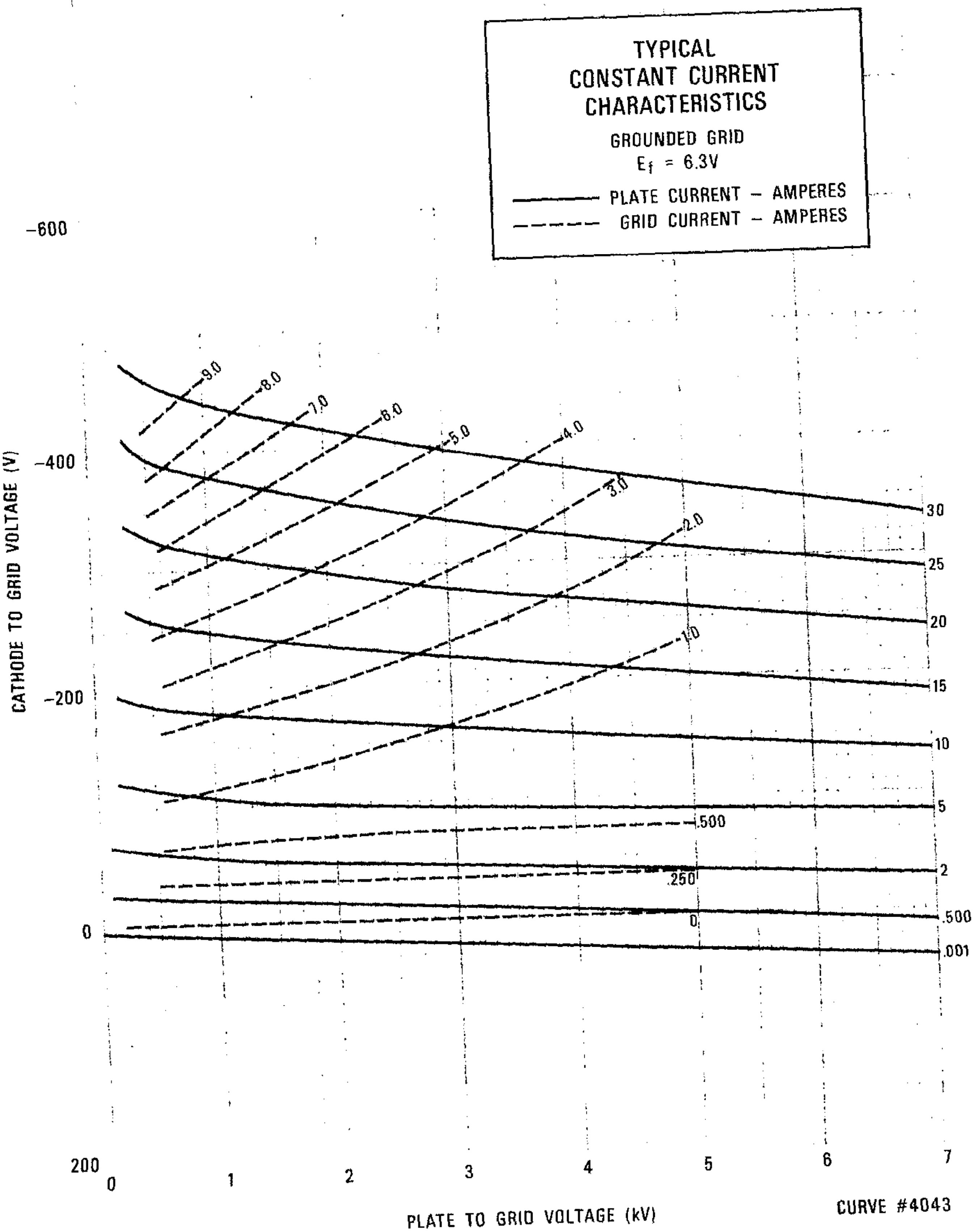
The equipment designer is therefore cautioned to make allowance for the actual capacitance values which will exist in any normal application. Measurements should be taken with the socket and mounting which represent approximate final layout if capacitance values are highly significant in the design.

*HIGH VOLTAGE* - The 3CX15,000A7 operates at voltages which can be deadly, and the equipment must be designed properly and operating precautions must be followed. Equipment must be designed so that no one can come in contact with high voltages. All equipment must include safety enclosures for high-voltage circuits and terminals, with interlock switches to open the primary circuits of the power supplies and to discharge high-voltage condensers whenever access doors are opened. Interlock switches *must not* be bypassed or "cheated" to allow operation with access doors open. Always remember that HIGH VOLTAGE CAN KILL.

*SPECIAL APPLICATIONS* - If it is desired to operate this tube under conditions widely different from those given here, write to Power Grid Tube Division, EIMAC Division of Varian, 301 Industrial Way, San Carlos, CA 94070, for information and recommendations.

| DIMENSIONAL DATA | | | | | | |
|---|---|---|---|---|---|---|
| DIM. | INCHES | | | MILLIMETERS | | |
| | MIN. | MAX. | REF. | MIN. | MAX. | REF. |
| A | 6.928 | 7.050 | - - | 175.97 | 179.07 | - - |
| B | 0.855 | 0.895 | - - | 21.72 | 22.73 | - - |
| C | 0720 | 0.760 | - - | 18 29 | 19.30 | - - |
| D | 1.896 | 1.936 | - - | 48.16 | 49.17 | - - |
| E | 3.133 | 3.173 | - - | 79.58 | 80.59 | - - |
| F | 3.792 | 3.832 | - - | 96.32 | 98.86 | - - |
| H | 0.188 | - - | - - | 4.78 | - - | - - |
| J | 0.188 | - - | - - | 4.78 | - - | - - |
| M | 3.950 | 4.300 | - - | 100.33 | 109.22 | - - |
| N | 2.412 | 2.788 | - - | 61.26 | 70.82 | - - |
| P | 8.250 | 8.750 | - - | 209.55 | 222.25 | - - |
| R | 0.986 | 1.050 | - - | 25.04 | 26.67 | - - |
| S | 3.412 | 3.788 | - - | 86.66 | 96.22 | - - |
| T | 0.375 | - - | - - | 9.53 | - - | - - |




TYPICAL
CONSTANT CURRENT
CHARACTERISTICS
GROUNDED GRID
Ef = 6.3V
PLATE CURRENT – AMPERES
GRID CURRENT – AMPERES
CATHODE TO GRID VOLTAGE (V)
-600
-400
-200
0
200
PLATE TO GRID VOLTAGE (kV)
0
1
2
3
4
5
6
7
30
25
20
15
10
5
2
.500
.001
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
.500
.250
0
CURVE #4043

**WANLASS**

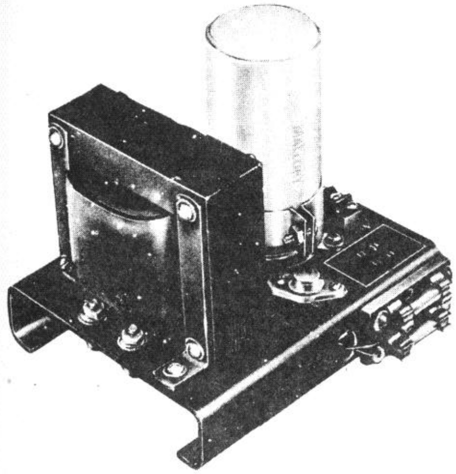
DIVISION OF AMBAC

# INSTRUCTION MANUAL

**C214**

# ECONOMY
# DC RELAY SUPPLY

FOR INDUCTIVE LOADS
SUCH AS
RELAYS
SOLENOIDS
MOTORS



PULSED LOADING
UP TO 4 AMPS

**$39.00**

**TO 60 WATTS**

**QUANTITY PRICE**

60 WATT
AVERAGE POWER

The C214 provides low cost DC power for inductive load applications such as relays, solenoids, and motors. Pulsed loads up to 4 amperes for short durations (20 ms) are easily accommodated. Circuit simplicity and high volume production line manufacturing have produced a reliable low-cost unit. Internal fusing and easy mounting make the unit suitable for a wide range of applications.

SIMPLE INSTALLATION

| QUANTITY | PRICE |
|---|---|
| 1 - 9 | $46.00 |
| 10 - 24 | $43.50 |
| 25 - 49 | $41.00 |
| 50 - 99 | $39.00 |

IMMEDIATELY
AVAILABLE
FROM STOCK

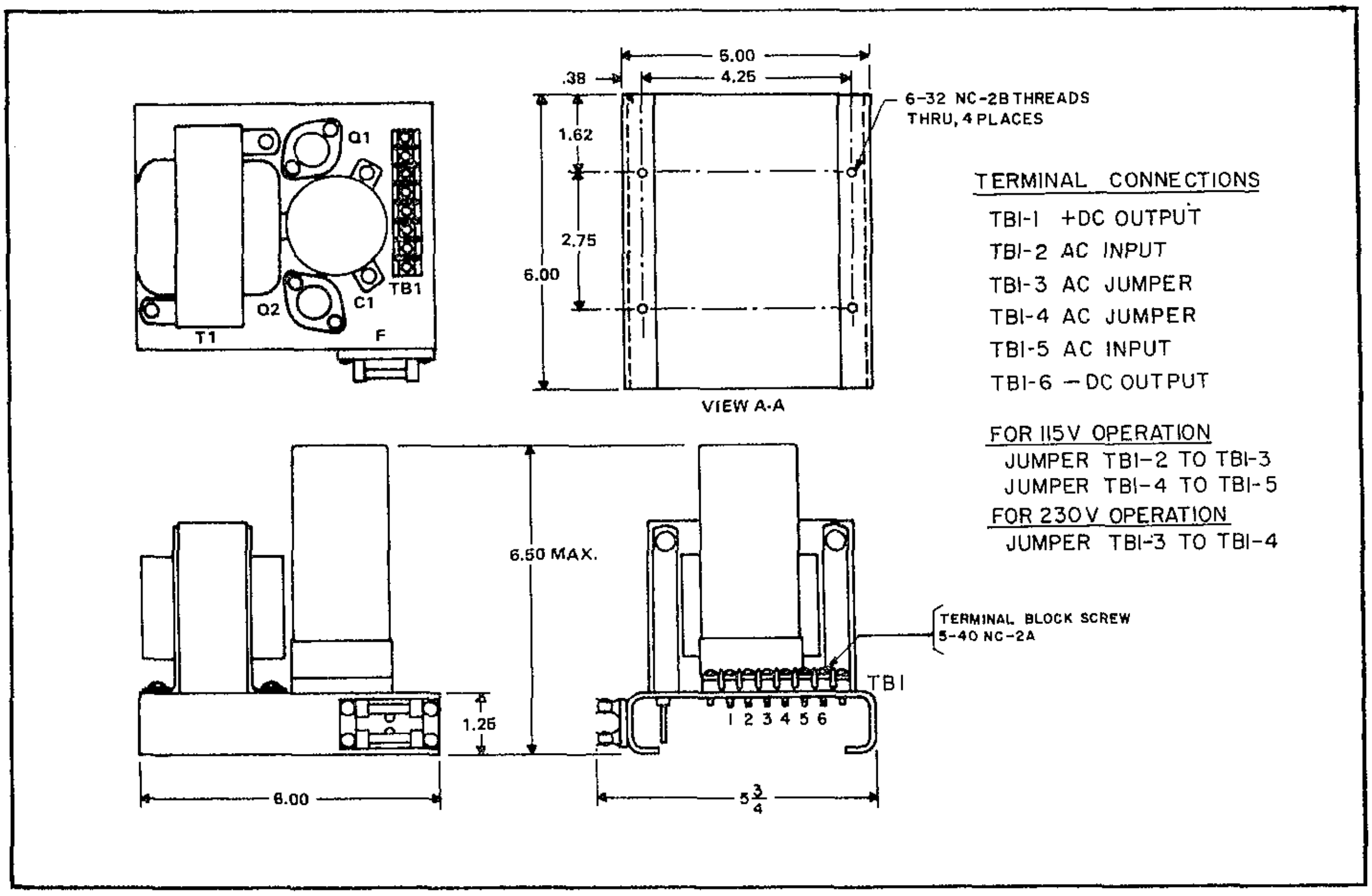
215 224-8510

525 VIRGINIA DRIVE . FORT WASHINGTON, PA. 19034 . PHONE: ~~215-643-6161~~ . TWX 510-661-0C54

## SPECIFICATIONS

**AC input:** 105-125/210-250 volts AC, $1\Phi$, 57 to 63 Hz (derate output 20% at 50 Hz)
**DC output:**
**Voltage:** 26 volts, floating (±2 volts factory tolerance)
**Current:** 2.5 amps (designed for pulsed loading of up to *4 amps when operated with 1 amp continuous load* pulsed at 20 ms intervals)
**Regulation:**
Line: ±2%
Load: ±2%
**Ripple:** 0.1% plus 10 mv rms max
**Overload protection:** Internally fused
**Line fuse:** Internally fused: 2 amps input; 3 amps slow blow output
**Temperature:** 0 to 40°C (to 70°C with 2%/°C derating from 40°C)
**Weight:** 5.5 pounds

## INSTALLATION DIAGRAM




WANLASS DIVISION OF AMBAC

Specifications and prices subject to change without notice.

OPERATION

The C214 is a series-regulated 24-volt dc, 2.5 amp power supply designed for pulsed loading (by inductive loads) of up to 4 amps. Input line and current overload protection is provided by two internal fuses. The dc output is isolated from chassis ground; either the positive or negative terminal can be externally connected to ground or common.

INSTALLATION

Mounting. Outline and mounting dimensions for the C214 are shown on the adjacent installation drawing. The aluminum chassis of the unit serves as a heat sink which may be fastened to a metallic frame to increase heat dissipation. (Allow free air circulation around chassis.)

Electrical. Connect ac-input and dc-output to TB1 as shown on the installation drawing. (Note different jumper connections for 115-vac and 230-vac operation.) Use twisted pairs to separate input and output lines and achieve maximum noise rejection.

NOTE

Input line fuse (F1) is not internally wired. Connect this fuse in series with line when connecting ac input.

ADJUSTMENTS

No adjustments are required for the C214.

TEST PROCEDURE

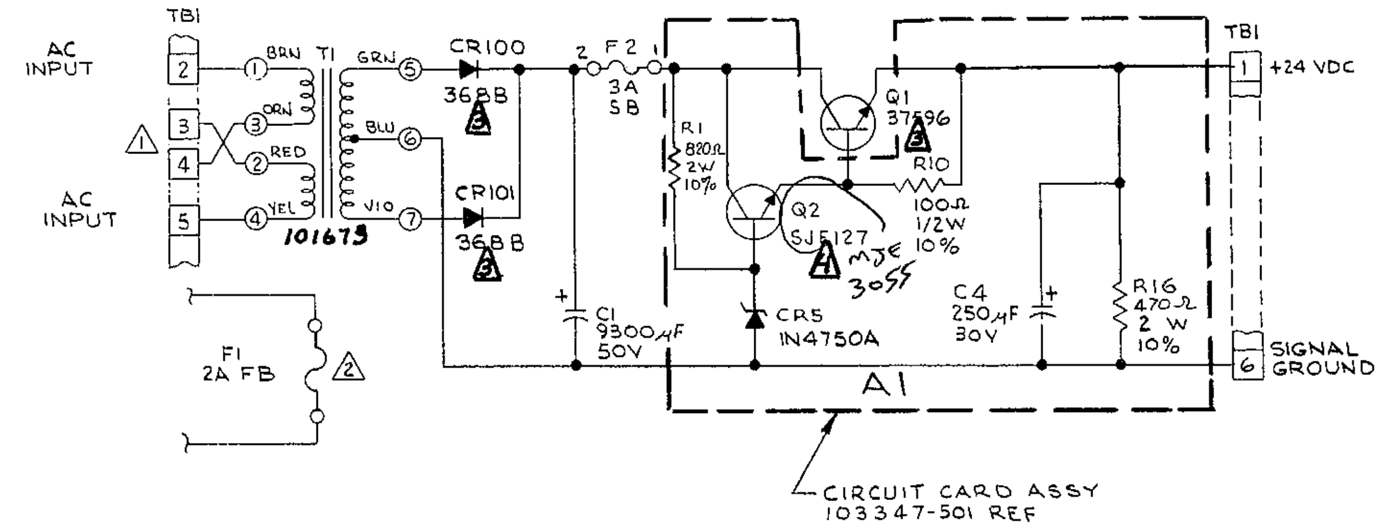
To test the unit, connect the ac input and dc output as instructed for installation and perform the following tests.

Line Regulation. Connect a Variac to ac input line and connect dc output to full load. While varying ac input from 105 to 125 vac (or 210 to 250 vac), use voltmeter to check that dc output voltage variations do not exceed ±2% of output voltage (or more than 1 volt).

Load Regulation. Set ac input to 115 volts (or 230 volts); then measure dc output while varying load from 0% to 100%. Check that dc output voltage variations do not exceed ±2% of output voltage (or less than 1 volt).

Ripple. Set ac input at 115 (or 230) volts and apply full load to dc output. Use oscilloscope with high-gain preamplifier to check that ac ripple at dc output terminals does not exceed 0.1% (plus 10 mv rms) of output voltage.

# C-214 SCHEMATIC DIAGRAM




NOTES:

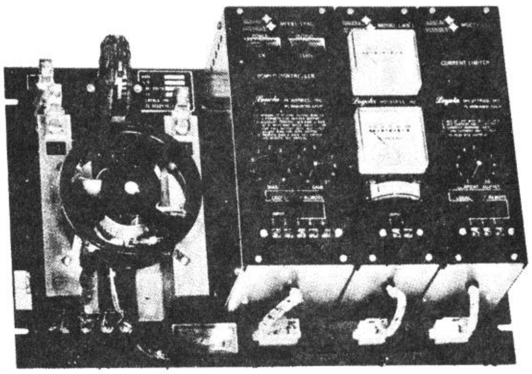
1. Strap TB1-2 to TB1-3 and TB1-4 to TB1-5 for 115-VAC operation. Strap TB1-3 to TB1-4 for 230-VAC operation.
2. F1 is not wired; connect for external AC-input line fusing.
3. Westinghouse Electric Co. Newark, N. J.
4. Motorola Semiconductor Products Box 20912 Phoenix, Arizona

MJE 3055

LOYOLA INDUSTRIES, INC.

# LPAC-1 CONTROLLER

# MAINTENANCE AND REPAIR



## 1. GENERAL

A. Permit only qualified instrument technicians to service and repair Loyola LPAC-1 Controllers.

B. Evidence of proper operation:

1) Trigger-box neon indicator lamps

a) POWER ON neon indicator lamp: constant bright glow when AC line voltage is connected.

b) OUTPUT LEVEL neon indicator lamp: variable from dim to bright glow with power output level.

2) LMB-1 Meter-box

a) Voltmeter indicates output voltage (i.e. from zero to near line voltage)

b) Ammeter indicates LPAC-1 current output (i.e. from approx. zero to maximum rated output or to maximum load current if less than rated.)

c) Milliameter indicates command signal current input from external temperature transducers or other controllers (i.e. from zero to 5 MA)

C. Any one or more of the following circumstances or indications may be evidence of improper operations:

1) No output

2) Continuous but irregular output, as a sharp increase to full output for a small increase in command signal strength or for a partial turn of the BIAS control knob.

3) Intermittent output, as a change from stable output to no output and return to stable output for no apparent reason (i.e. for no change in command signal input or BIAS or GAIN control knob settings)

4) Constant uncontrollable full output

5) Fan not rotating or rotating slowly

6) Overheating of any part of the LPAC-1 Controller unit

## 2. TROUBLESHOOTING

A. General:

1) It is not necessary to disconnect the AC line voltage from the LPAC-1 unit when the evidence of improper operation is "no output". However, do disconnect the AC line voltage from the unit before beginning checking and servicing when disconnection is required for safety.

2) Disconnect the AC line voltage from

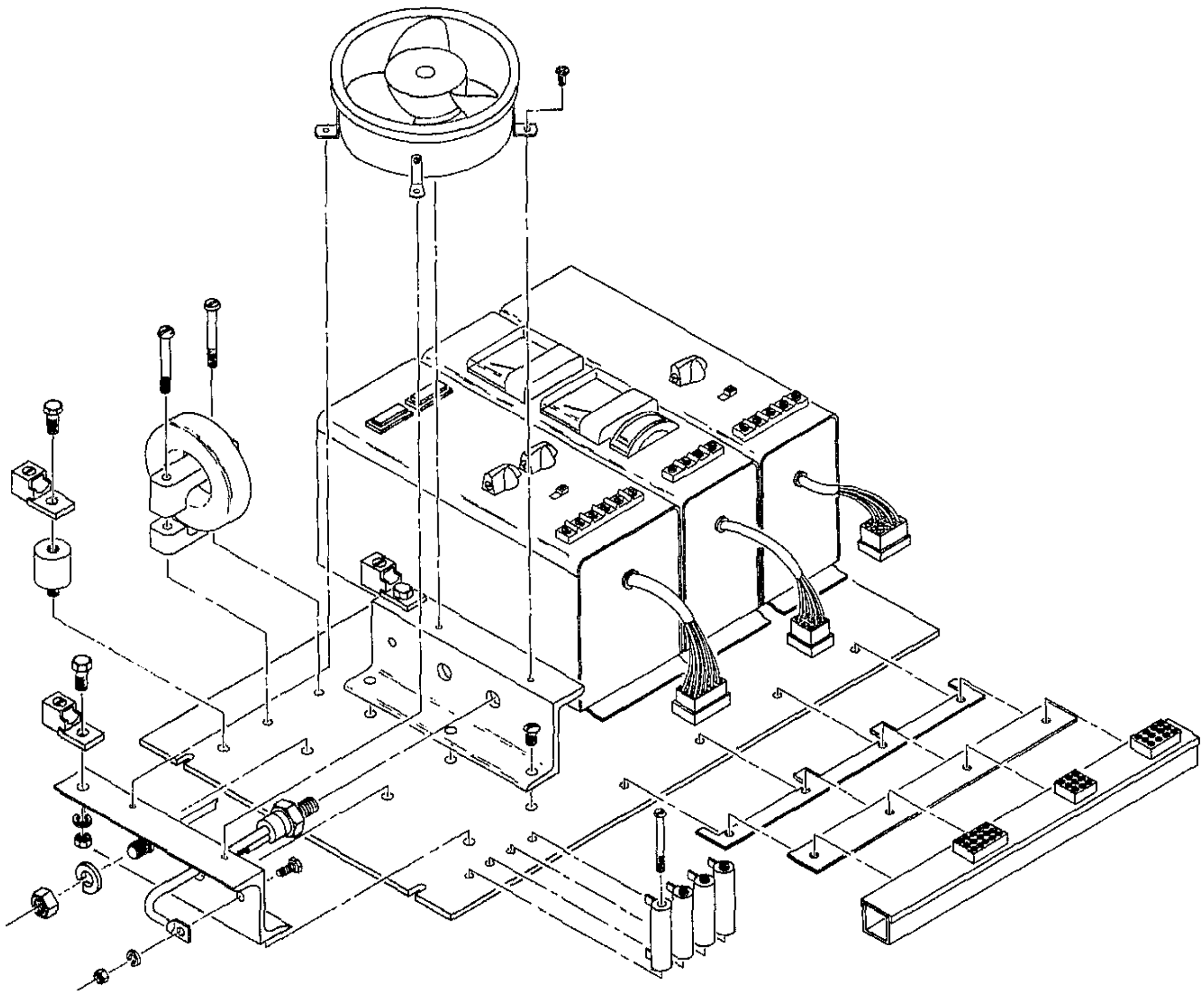


Fig. 1 – Exploded View of LPAC-1 Controller

the LPAC-1 unit immediately for all other evidences of improper operation.

3) Preliminary set-up conditions for testing:

a) Verify that the neon indicator lamps on the trigger module are not faulty.

b) Set the LOCAL-REMOTE switch on the trigger module to LOCAL position.

c) Set the BIAS control knob at zero.

d) Set the GAIN control knob at zero.

e) If the LPAC-1 includes the LCL current-limiter accessory, set the CURRENT ADJUST control knob at zero.

4) If the LPAC-1 *does not* include the LMB meter accessory, use ironvane voltmeters and ammeters, such as the General Electric Biglook Series, A090, 91, and 92, or equal, to accurately check operation and performance. Clamp-on-ammeters or other averaging-type ammeters using rectifier elements and d'Arsonval movements may be used as indicators of relative output and general performance, BUT REMEMBER, the indicated value on such an

ammeter may be in error by as much as 50% in its middle range, even though the indicated value at maximum output voltage may be nearly accurate.

5) Always use a dummy load to check LPAC-1 performance before putting the unit back in service after it has been serviced or repaired. It is recommended that 100 watt incandescent lamps, connected in series to match the rated output voltage, be used as the dummy load.

6) Start-up procedures:

a) Verify that switches and control knobs are positioned as required for testing preliminary set-up in A.3) above.

b) Connect the dummy load to the output terminals.

c) Connect the AC line voltage to the LPAC-1.

d) Turn the BIAS control knob slowly in a clockwise direction. The OUTPUT LEVEL neon indicator lamp and the dummy-load lamps should slowly increase in brightness. When the LPAC-1 includes the LMB meter accessory, the LMB voltmeter indicator should move slowly up-scale, but the LMB ammeter may not move off zero unless a sufficient number of dummy-load lamps is used to provide great enough resistance to register on the LMB ammeter.

B. No output

1) Check the AC line voltage input:

a) The POWER ON neon indicator lamp should glow brightly when the AC line voltage is connected. The LPAC-1 should operate normally when the AC line voltage is between 50% and 110% of the rated input.

b) If found faulty, connect proper AC line voltage to the LPAC-1.

2) Verify that the white nylon connector plugs are firmly plugged in..

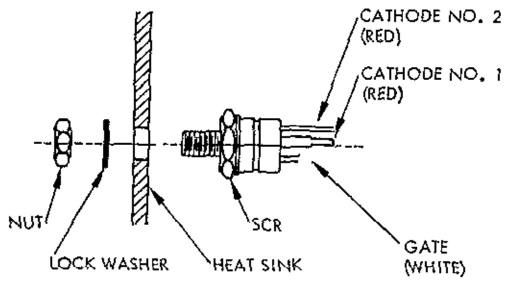



Fig. 2 – Correct installation of SCR

| TORQUE VALUES FOR MOUNTING SCR'S | | |
|---|---|---|
| STUD SIZE | MAXIMUM TORQUE | |
| | INCH LBS. | FOOT LBS. |
| 1/4 inch | 30 | 5 |
| 5/16 inch | 150 | 12 |
| 3/8 inch | 150 | 15 |
| 1/2 inch | 150 | 18 |
| 3/4 inch | 300 | 20 |

3) Verify that the trigger module printed circuit board is firmly and properly plugged into its plug strip. CAUTION: If it is necessary to open the trigger module to do this, then disconnect the AC line voltage from the LPAC-1 unit before opening the trigger module and reconnect the AC line voltage to the LPAC-1 unit after re-closing.

4) Check the SCR's visually to see if one or both have ruptured or disintegrated.

a) If an SCR has ruptured or disintegrated, disconnect the AC line voltage from the LPAC-1 unit. Then carefully unsolder the SCR gate and cathode leads, remove the nut, washers, and terminals from the SCR lug, and remove the defective SCR.

b) Install a new SCR. Apply a little silicone grease under the

SCR. Do not torque the nut on the SCR lug beyond the values set forth in chart. Lockwasher must be between nut and heatsink NOT between SCR and heatsink.

c) Carefully re-solder the SCR gate and cathode leads. Do not use acid flux or acid-core solder.

d) Re-connect the AC line voltage to the LPAC-1.

5) Check external command signal input and the trigger internal signal circuits.

a) Verify the command signal input voltage and current at the trigger module signal input terminals. If there is no command signal input, then the fault is not in the LPAC-1 unit but in the command signal generating device or in the signal wiring.

b) If there is command signal input, then check the trigger internal signal circuits by turning the GAIN control knob slowly from zero in a clockwise direction. As the GAIN control knob is turned the LMB voltmeter indicator or the customer-furnished voltmeter indicator should move slowly up-scale and the OUTPUT LEVEL neon indicator lamp should gradually increase in brightness.

c) If the voltmeter and the OUTPUT LEVEL neon indicator lamp do not indicate proper operation in B.5)b) above, then reset the GAIN control knob at zero and turn the BIAS control knob slowly from zero in a clockwise direction. As the BIAS control knob is turned the LMB voltmeter indicator or the customer-furnished voltmeter indicator should move slowly up-scale and the OUTPUT LEVEL neon indicator lamp should gradually increase in brightness.

d) If no shut-off option is included in the LPAC-1 unit and the above-described check procedures result in negative indications, remove the trigger module and return it to the Service Department for repair. If a shut-off option is included in the LPAC-1 unit, proceed with the following check procedures.

6) Check the LPAC-1 internal latching shut-off circuit:

a) If the LPAC-1 has the non-latching shut-off terminal option, disconnect one lead to the non-latching shut-off terminal without disconnecting the AC line voltage from the LPAC-1 unit. This should return all circuits to normal operating condition. Then re-connect the disconnected lead to the non-latching shut-off terminal before returning the unit to operation.

b) If the LPAC-1 has the latching shut-off terminal option, disconnect one lead to the latching shut-off terminal and then disconnect the AC line voltage from the LPAC-1. Then, with one lead to the latching shut-off terminal still disconnected, re-connect the AC line voltage. This should return all circuits to normal operating condition. Then re-connect the disconnected lead to the latching shut-off terminal before returning the LPAC unit to operation.

c) If the procedures for either option do not return the LPAC-1 circuits to normal operating condition, then disconnect the LPAC trigger module and return it to the

Service Department for repair.

7) Check the LCL current limiter:

a) Set the BIAS and GAIN control knobs on the trigger module at zero, then unplug the current-limiter white nylon plug.

b) Turn the BIAS control knob very slowly from zero in a clockwise direction. The OUTPUT LEVEL neon indicator lamp should change slowly from a dim to a brighter glow, indicating normal trigger-box operation. (NOTE: The LMB ammeter will not operate when the LCL current limiter is unplugged.)

(i) If normal trigger operation is indicated, then the current limiter is defective. Remove it and return it to the Service Department for repair.

(ii) If normal trigger operation is not indicated, then the trigger is defective. Remove it and either return it to the Service Department for repair or bench-check it and repair it as bench checking indicates is required. (Refer to Fig. 3 for recommended set-up for bench-check of the trigger PC board.)

C. Continuous but irregular output

1) If a fully-competent electronic technician is not available, then remove the trigger module from the LPAC-1 and return it to the Service Department for repair.

2) If a fully-competent electronic technician is available, then remove the trigger module from the LPAC unit and bench-check the trigger amplifier circuit voltages and resistances per Circuit Diagram in this manual, and repair carefully or replace defective circuit elements as required. (Refer to Fig. 3 for recommended set-up for bench-check of the trigger-box PC board.)

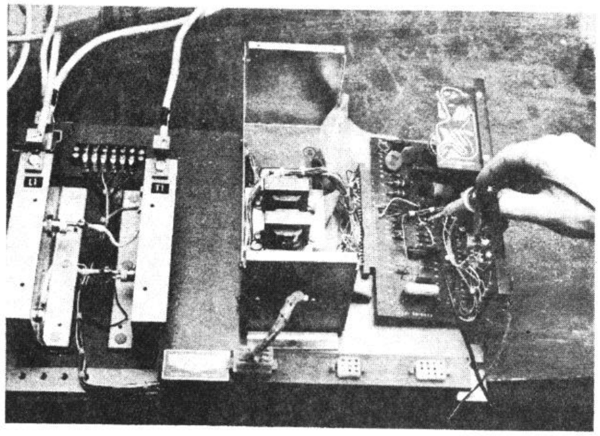


Fig. 3 – Recommended set-up for bench check of P.C. board

D. Intermittent output: If the trigger and the current-limiter have been checked as outlined above and have been found in proper operating condition, then proceed as follows:

1) Check for:

a) Loose terminals in the power circuit.

b) Discontinuity in the external wiring.

c) Loose pins in sockets and plugs.

d) Unsoundness in solder joints.

e) Leaks in the transformer. Use a "meger" or high potential voltage of very low current to check the transformer internal insulation. Check only transformer terminals L, T, and "Common" to the transformer chassis.

2) Repair or replace defective parts or installations as required.

E. Constant uncontrollable full output

1) If there is a full output indication (i.e. the voltmeter indicates full rated output and the OUTPUT

LEVEL neon indicator lamp glows brightly) but there is no output current, then check the load circuit fuse and the load circuit wiring for an open circuit. Replace the fuse or repair the load circuit wiring as required to obtain normal closed circuits.

2) If uncontrollable full output continues after completing 2.E.1) above, then disconnect the trigger-box white nylon connector plug. If uncontrollable full output still continues, then one or both SCR's are probably internally shorted and defective.

   a) Disconnect the load from the load terminals. Measure the resistance between L-1 and T-1 with an ohmmeter at low scale (i.e. X1). If the resistance is less than 5 ohms, then at least one SCR is defective.

   b) Disconnect one SCR cathode lead. Measure the resistance between L-1 and T-1 as in 2.E.2)a) above. If the resistance is less than 5 ohms, then the remaining connected SCR is defective. If the resistance is very much greater than 5 ohms (i.e. if the circuit appears open) then the disconnected SCR is defective.

   c) To test an isolated SCR unit, proceed as follows:

      (i) Measure the resistance across the cathode and anode of the SCR with an ohmmeter set at low scale (i.e. X1). Then reverse the ohmmeter leads on the same SCR terminals and measure the resistance again. If the resistance of the SCR measures less than 1K in either direction, the SCR is defective.

      (ii) If the SCR does not appear defective when tested as outlined above in 1), then check the SCR with 1.5 X line voltage DC across its cathode and anode in both directions. If there is current leakage greater than 2 milliamps in either direction, then the SCR is defective.

   (d) If a defective SCR is found, remove and replace it as described in 2.B.4)a) through 2.B.4)d).

3) If a new SCR is installed, and the output of the unit in service is to a transformer, then check the unit by applying the LPAC-1 current output to a dummy load before returning the LPAC unit to service. (Refer to 2.A.5) for recommended dummy load.)

F. Fan not rotating or rotating slowly

Remove fan unit and repair or replace with a properly operating fan unit.

G. Overheating of any part of the Controller unit

If the air-cooling or water-cooling system is functioning properly and overheating occurs, it indicates one of the following:

   a) Shorting or otherwise defective LPAC-1 circuit elements. Check and repair as described in 2.C.1) and 2.C.2).

   b) Customer load current too high. Check to verify that the customer load current is within the rating of the LPAC-1 unit.

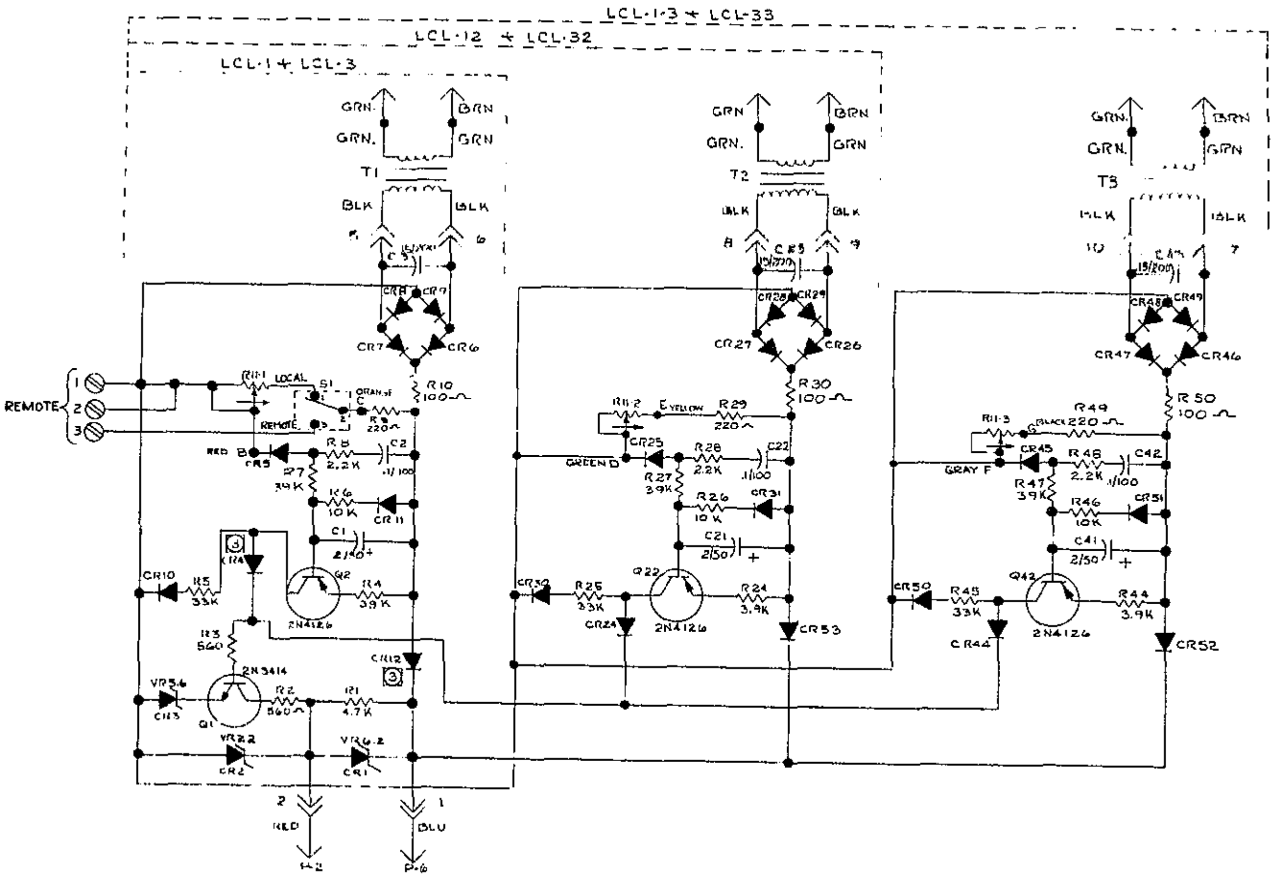



Fig. 4 – Internal schematic LCL Current Limiter

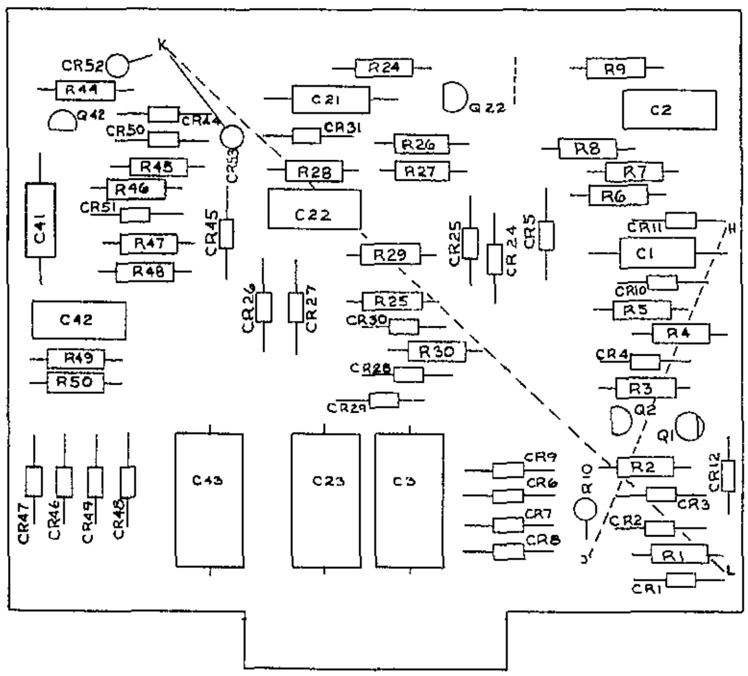
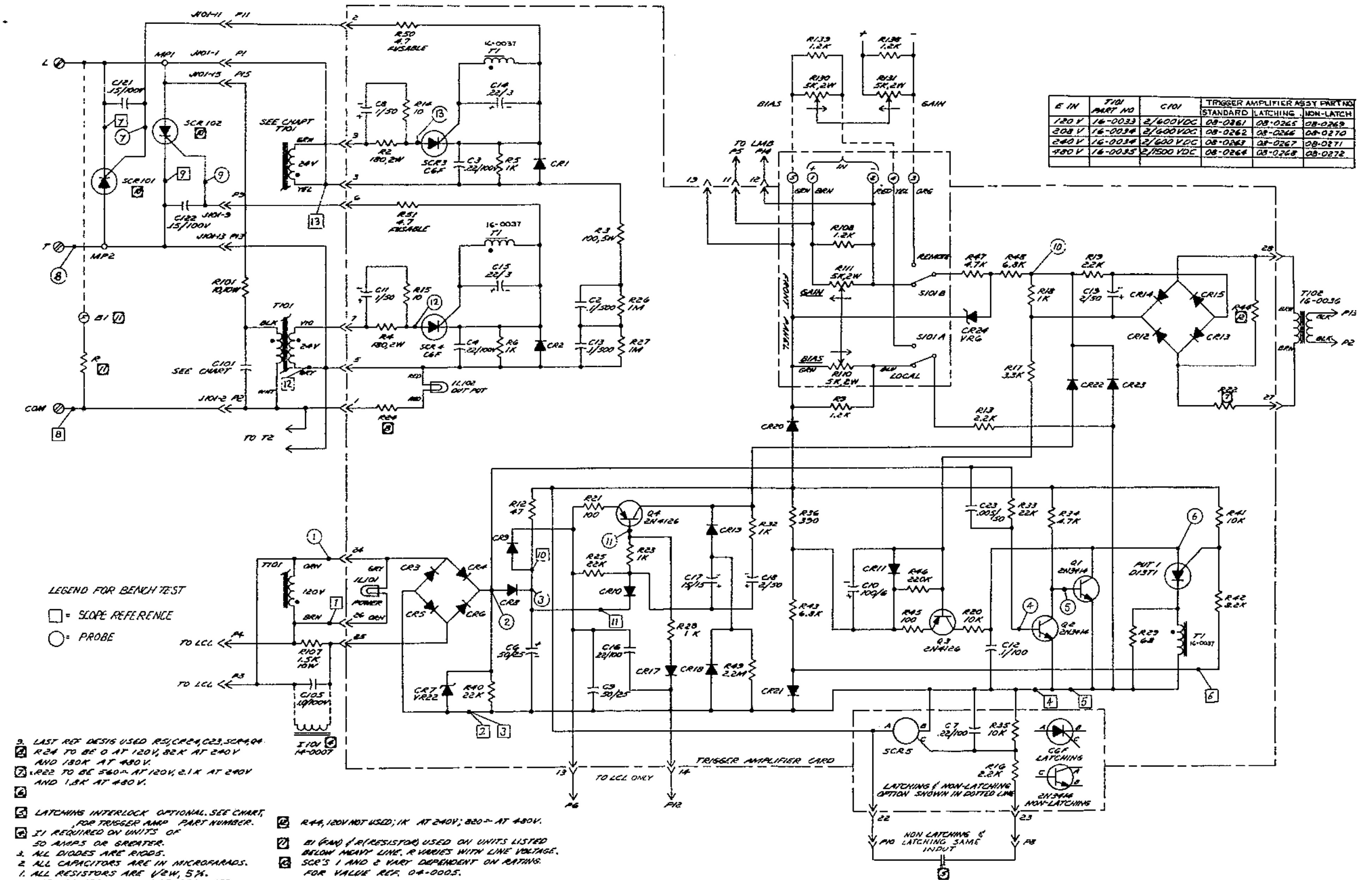



Fig. 5 – Location of components on LCL Current Limiter Printed Circuit Board




| E IN | T101 PART NO | C101 | TRIGGER AMPLIFIER ASSY PART NO. | | |
|---|---|---|---|---|---|
| | | | STANDARD | LATCHING | NON-LATCH |
| 120 V | 16-0033 | 2/600VDC | 08-0261 | 08-0265 | 08-0269 |
| 208 V | 16-0034 | 2/600VDC | 08-0262 | 08-0266 | 08-0270 |
| 240 V | 16-0034 | 2/600 VDC | 08-0263 | 08-0267 | 08-0271 |
| 480 V | 16-0035 | 2/1500 VDC | 08-0264 | 08-0268 | 08-0272 |
| | | | | | |

9. LAST REF DESIG USED R51, CR24, C23, SCR4, Q4.
8. R24 TO BE 0 AT 120V, 82K AT 240V AND 180K AT 480V.
7. R22 TO BE 560Ω AT 120V, 2.1K AT 240V AND 1.8K AT 480V.
6.
5. LATCHING INTERLOCK OPTIONAL. SEE CHART, FOR TRIGGER AMP PART NUMBER.
4. Z1 REQUIRED ON UNITS OF 50 AMPS OR GREATER.
3. ALL DIODES ARE R1005.
2. ALL CAPACITORS ARE IN MICROFARADS.
1. ALL RESISTORS ARE 1/2W, 5%.
NOTES: UNLESS OTHERWISE SPECIFIED

12. R44, 120V NOT USED; 1K AT 240V; 820Ω AT 480V.
11. B1 (FAN) & R (RESISTOR) USED ON UNITS LISTED BELOW HEAVY LINE. R VARIES WITH LINE VOLTAGE.
10. SCR'S 1 AND 2 VARY DEPENDENT ON RATING. FOR VALUE REF. 04-0005.

Fig. 6 – Internal schematic - LPAC-1 Trigger Amplifier

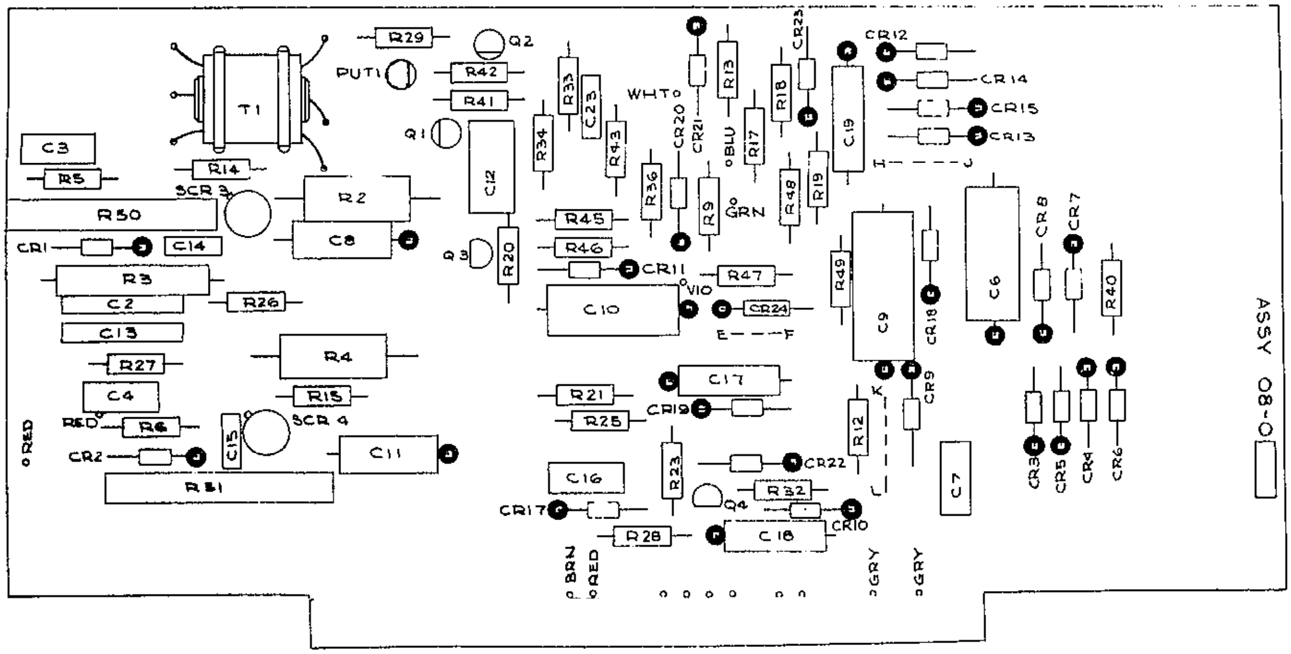



Fig. 7 – Location of components on LPAC-1 Trigger Amplifier Printed Circuit Board

| NO | 0 | 50 % | 100 % | NO | 0 | 50 % | 100 % |
|---|---|---|---|---|---|---|---|
| 1 | 120V | SAME | SAME | 8 | | | |
| 2 | 22V | SAME | SAME | 9 | | | 1.5V |
| 3 | 22V | SAME | SAME | 10 | -1V | -2V | -3V |
| 4 | .5V | SAME | SAME | 11 | -1V | -0.5V | -0.25V |
| 5 | .6V | SAME | SAME | 12 | 38V | 38V | 38V |
| 6 | | 10V | 10V | 13 | 38V | 38V | 38V |
| 7 | | | 1.5V | | | | |

Fig. 8 LPAC-1 Trigger Amplifier Waveforms and Voltages. Reference Numbers on Schematic, Fig. 6

AMERICAN ELECTRONIC LABORATORIES, INC.

FIELD SERVICE DATA SHEET

Type of Service FM25 KG Mod.

Station WAYL Date 6/3/77 Model FM25 KG S/N 052M

| | | | |
|---|---|---|---|
| Frequency | 93.7 | Power Output | 24.5 KW |
| Line Phase 1 | 240 VAC | Driver Screen I | 50 MA |
| Line Phase 2 | 242 VAC | Exciter Forward | 20 |
| Line Phase 3 | 242 VAC | Exciter Reflected | .1 |
| Driver Filament E | 5.1 VAC | Power Amp Forward | 15.5 = 24.5 KW |
| Power Amp Filament E | 6.1 VAC | Power Amp Reflected | 400 |
| PA Cathode I | 4.9 Amps | Cathode Resistance | 12.5 Ω |
| PA Plate I | 4.0 Amps | Transformer Taps | 220, +10 |
| Driver Plate E | 4.2 KV | Efficiency | 72.9 % |
| Power Amp Plate E | 8.4 KV | Counter Settings | |
| Driver Grid E | 85 Volts | PA Output Loading | 02072 |
| Driver Cathode I | .67 Amps | PA Output Tuning | 00443 |
| Driver Screen E | 565 Volts | PA Input Tuning | 00223 |

PROOF OF PERFORMANCE

FM Noise -64 AM Noise 50 dB

| | Distortion @ 100% Mod. | Input Level (dB) |
|---|---|---|
| 50 Hz | .36 | 10.3 |
| 100 Hz | .30 | 10.0 |
| 400 Hz | .33 | 9.5 |
| 1000 Hz | .27 | 8.4 |
| 5000 Hz | .46 | 0.8 |
| 7500 Hz | .46 | -3.0 |
| 10,000 Hz | .40 | -4.6 |
| 15,000 Hz | .51 | -8.5 |

Station Engineer [signature] AEL Engineer Robert C Morris

PRI 1"

BROADCAST ELECTRONICS, INC. MODEL FX-30/FM EXCITER FINAL TEST DATA

75 us DE-EMPHASIS

CUSTOMER ORDER NUMBER 05754 STATION CALL LETTERS ______

CUSTOMER NAME Radio Systems

BEI P/N 909 0009 (19") (21") BEI SERIAL NUMBER 1228

TESTED BY Jim B[illegible] DATE 12-10-84

1. INPUT VOLTAGE SELECTION 120 FUSE 3 AMPS
2. OPERATING FREQUENCY 93.7 MEASURED 93.699999 MHZ.+(-) 1 HZ
3. FREQUENCY CODE 1001 (10) 10MHZ 0011 (3) 1MHZ 0110 (6) 100KHZ 1001 (9)

(0=ON=JUMPER IN) (1=OFF=JUMPER OUT)
OUTPUT FREQUENCY EQUALS CODE + 10KHZ.

4. AFC VOLTAGE 6.6 VOLTS
5. AFC INTERLOCK OK
6. POWER OUTPUT 5 WATTS NOTE: (SET TO 5.0 WATTS "AUTO MODE" UNLESS OTHERWISE REQUESTED)
7. PAV 7 VOLTS PAI 1.22 AMPS
8. HARMONIC AND SPURIOUS SUPPRESSION (58db Min.) OK
9. POWER SUPPLY VOLTAGES OK
10. BARRIER STRIP INPUTS/OUTPUTS OK
11. TEMPERATURE OVERLOAD OK
12. VSWR PROTECTION OK
13. TEST METERING OK
14. COMPOSITE TEST JACKS OK
15. COMPOSITE FM S/N RATIO 79 dB (75 dB MIN. WITH 75 us DE-EMPHASIS)
16. COMPOSITE IMD, 60kHz/7kHz, 1:1 .018 % (75 us DE-EMPHASIS) (0.08% MAX)
17. COMPOSITE THD @ 400Hz .017 % (75 us DE-EMPHASIS) (0.08% MAX)
18. COMPOSITE INPUT LEVELS FOR 100% MODULATION 1.237 V 1.237V RMS, NOMINAL)
19. SCA INPUT LEVELS FOR 10% MODULATION 1.237 V 1.237V RMS, NOMINAL)
20. MONO INPUT LEVELS FOR 100% MODULATION +10 dBm (600 ohm BAL.)
21. MONO FM S/N RATIO 79 dB (75 dB MIN. WITH 75 us DE-EMPHASIS)
22. AM S/N RATIO 75 dB (70 dB MIN. WITH 75 us DE-EMPHASIS)
23. MONO IMD, 60Hz/7kHz, 4:1 .018 % (75 us DE-EMPHASIS) (0.08% MAX)
24. MONO FREQUENCY RESPONSE---50Hz -.2 dB (0.0 ± 0.5dB) 5kHz +8.6 dB (+8.2 ± 0.5dB)
    100Hz 0 dB (Ref 0.0dB) 10kHz +13.8 dB (+13.7 ± 0.5dB)
    400Hz +.2 dB (+0.2 ± 0.5dB) 15kHz +16.8 dB (+17.1 ± 0.5dB)
    1000Hz +1 dB (+0.9 ± 0.5dB)
25. MONO THD---50Hz .019 % 5kHz .023 %*
    100Hz .018 % 10kHz .057 %*
    400Hz .017 % 15kHz .061 %*
    1000Hz .018 %

*INDICATES NOISE LIMITED AFTER DE-EMPHASIS