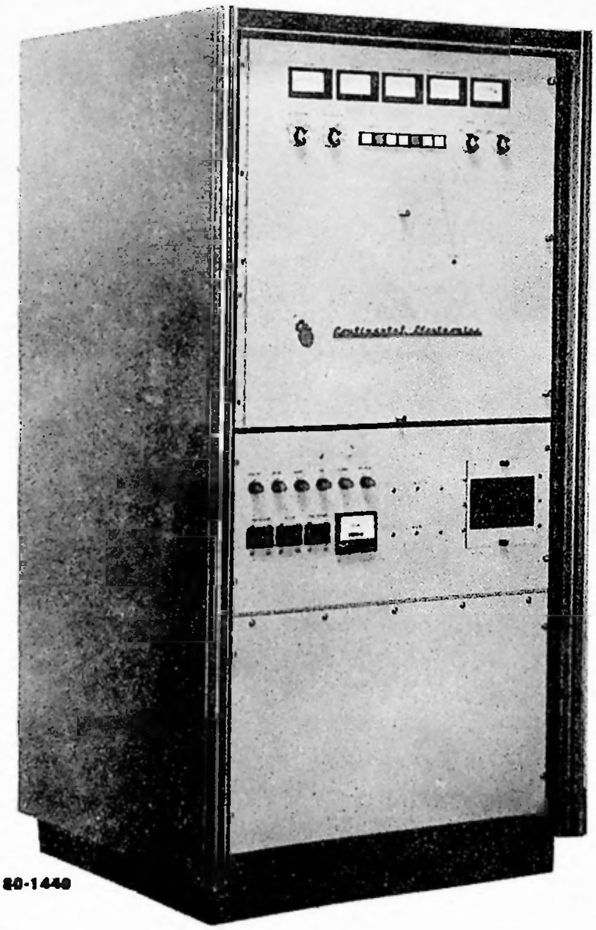
TYPE 315R-1

AM BROADCAST TRANSMITTER WITH SOLID STATE EXCITER

INSTRUCTION MANUAL



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CHANGE NOTICE

CHANGE NO. 27

TO

315R-1

5 KW AM BROADCAST TRANSMITTER

INSTRUCTION MANUAL

This Change No. 27 to the 315R-1 AM Broadcast Transmitter Instruction Manual is effective for all transmitters. Changes are denoted by an asterisk (*). Remove all changed pages and insert the new pages. Insert this Change Notice Page just after the Title Page.

NEW PAGE		OLD PAGE	
7-19/7-20	C27/C13	7-19/7-20	-/C13
7-29/7-30	C4/C27	7-29/7-30	C4/C17
7-61/7-62	-/C27	7-61/7-62	-/-
7-69/7-70	-/C27	7-69/7-70	-/C12

30 JULY 1987

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SECTION 1 - GENERAL DESCRIPTION

1-1. INTRODUCTION

This instruction book contains the information necessary to install, operate, maintain, and service the 315R-1 5-kW AM Transmitter. Figure 1-1 shows the external configurations of the transmitter. The following sections of this instruction book provide the following classes of information concerning this transmitter.

a. Section 1, General Description, provides a description of the equipment, identifies the major components, lists physical and electrical characteristics, and describes options.

b. Section 2, Installation, provides information relative to incoming inspection, input/output connections, initial adjustments, and component mounting instructions (where required).

c. Section 3, Operation, identifies and describes the functions of panel mounted and component mounted controls and indicators, and provides information necessary to operate the transmitter.

d. Section 4, Principles of Operation, provides descriptions of functional circuits within the transmitter, beginning with an overall functional description of the basic circuits, and proceeding to a description of the basic circuits, and proceeding to a description of the function and operation of each individual circuit.

e. Section 5, Maintenance, describes procedures for preventive and corrective maintenance.

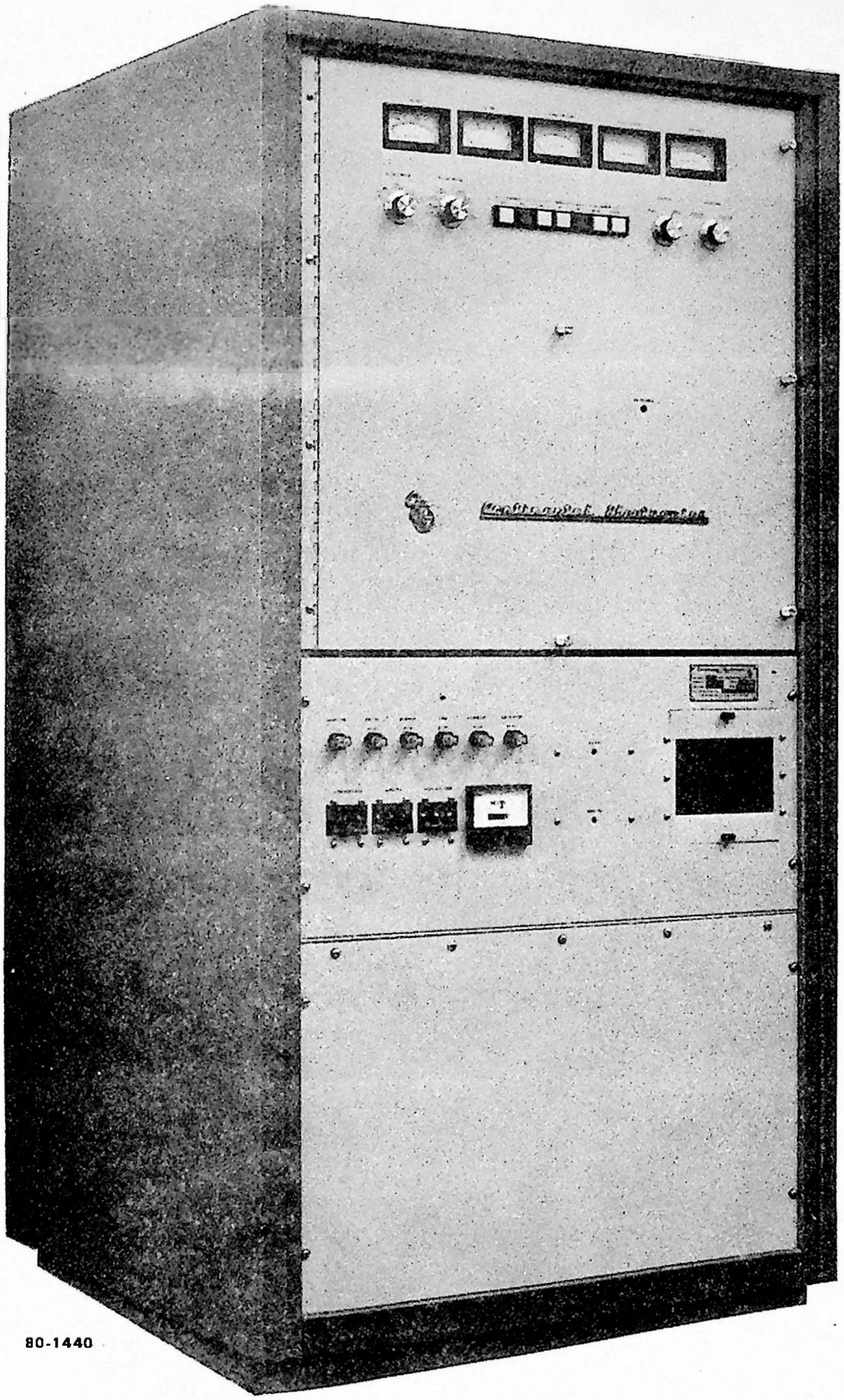
f. Section 6, Troubleshooting, provides fault location guidance and troubleshooting procedures.

g. Section 7, Parts List, provides information for ordering replacement components and assemblies, and parts location illustrations for each major assembly and each circuit board.

h. Section 8, Diagrams, contains schematic and wiring diagrams required for transmitter maintenance.

1-2. EQUIPMENT PURPOSE

The 315R-1 transmitter is a high efficiency 5-kW radio transmitter for amplitude modulation broadcast use. It employs a series switching modulator to provide amplitude modulation up to 125 percent positive, with lower power consumption and better performance.



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KM1-1(15)

Figure 1-1. 315R-1 5KW AM Transmitter

1-3. PHYSICAL DESCRIPTION

The transmitter is housed in a single cabinet, which requires only 2.3 m^2 (7.6 ft^2) of floor space. The cabinet is painted with a gray, light diffusing, abrasion resistive paint. The top front panel, which contains meter and control switches, has a piano hinge and opens as a door to permit front access to interior components. Just below this meter door, the circuit breaker panel also has a piano hinge that permits it to be opened downwards or the lower panel to open upwards. The rear cover is removable to permit rear access to interior components. The meter door, the lower panel, and the rear panel are electrically interlocked. Listed below is the 315R-1 subassemblies.

SYMBOL	NAME	PART NUMBER
A1	RF Exciter	636-8434-001
A2	PWM Card	636-8480-001
A3	Control Logic Card	636-8467-001
A4	Logic PS Card	636-8471-001
A5	Meter Panel/Door	636-8427-001
A5A1	Meter Terminal Board	636-9673-001
A6	Circuit Breaker Panel	636-9680-001
A6A1	Backplane	636-8490-001
A7	Power Control Chassis	636-8502-001
A7A1	Control Relay Board	636-8510-001
A7A2	LVPS Board	636-8503-001
A7A3	Bias PS Board	636-9674-001
A7A4	Remote Control	627-9721-002
A8	HVPS Chassis	636-8494-001
A9	RF Compartment	636-9690-001
A9A1	Feedback Divider	636-8417-001
A9A2	Not Used	
A9A3	Switchmod Driver	636-8457-001
A9A4	RF Driver	636-9688-001
A9A5	HV Meter Driver	636-8413-001
A9A6	RF Power Meter	636-9687-001
A10	HV Bleeder Assy	640-9677-001
A10A1	HV Sample Divider	636-8418-001
A11	Signal Access Card	640-9699-001

The transmitter output connection is nominally a 50-ohm, 41.275-mm (1-5/8 in.) EIA flange. A transmission line that terminates in an AM antenna or in a dummy load of the proper impedance must be connected to the transmitter output before the equipment is energized. The transmitter may be tuned for other impedance levels by special order.

1-4. FUNCTIONAL DESCRIPTION

The transmitter contains an RF oscillator, an RF driver, a power amplifier, audio input and modulator circuits, and power supplies. The circuitry is hybrid in design, employing both discrete and monolithic components. Operating controls are conveniently arranged on the front panel.

A dual crystal oscillator feeds the solid-state RF driver. The desired oscillator output can be selected by front panel switches.

The RF driver operates at a 500-watt power level to drive the RF power amplifier. The power amplifier uses a high efficiency circuit with a third harmonic resonator to increase its efficiency to nearly 88 percent for significant power costs savings. The power amplifier operates with its plate at DC ground, eliminating the usual RF blocking capacitor, bypass capacitor, and RF choke in the high voltage feed. This simplifies maintenance, and also allows direct metering at ground potential for both the local and remote metering functions.

The transmitter employs a series switching modulator (class D) between the RF power amplifier and its high voltage power supply (HVPS). To modulate the carrier, the on/off duty cycle (40 percent on at nominal carrier) of the modulator output is varied at the modulation rate. This causes the average voltage supplied to the RF power amplifier to vary as the modulation. The RF power amplifier and the switching modulator each employ a single low cost, high mu triode tube, Eimac 3CX3000F7. The low amount of drive required for these tubes simplifies the driver circuits and power requirements. Spares requirements are reduced by the use of a single tube type.

The incoming audio signal is applied to the pulse width modulator (PWM), which converts it into a 70-kHz pulse width modulated signal, which is coupled to the switching modulator through a fiber optic cable. Optical coupling is used to isolate the low-level PWM circuit from the high voltage switching modulator circuit and Audio and DC feedback from the high voltage switching modulator circuit. Audio and DC feedback from the modulated voltage are used to provide nearly perfect power output control and to improve distortion, response, and transient performance with processed audio waveforms. The RF output network and load are excluded from the feedback loop, eliminating the stability and response problems associated with high Q nonsymmetrical loads. Automatic modulation control maintains the desired modulation level with changes in power output settings or line voltage fluctuations.

The output of the RF power amplifier is coupled to the antenna through a bandpass Q Taper output network. This network has a very flat passband response about the carrier frequency to pass the sidebands, and steep skirts for better harmonic and spurious signal attenuation.

No traps are required and network stress is reduced by operating with lower Q circuits; this permits use of much smaller than usual components in the output network.

The transmitter can be controlled locally by controls on the meter door, or through an (optional) extended control panel, or remotely through a remote control interface assembly. Remote control connections are provided on terminal boards inside the transmitter.

1-5. CHARACTERISTICS

Physical and electrical characteristics are listed in Table 1-1.

1-6. OPTIONS

The following optional equipment is available for use with the 315R-1 transmitter.

DESCRIPTION	PART NUMBER
Filament Regulator (60 Hz)	662-0292-070
Filament Regulator (50 Hz)	662-0292-080
RF Ammeter	640-3432-001
Extended Control Panel	636-7171-002

Where the studio and the transmitter are separated by sufficient distance, the operating functions of the transmitter can be controlled from the studio by most of the various remote control systems available today. However, since they provide only momentary contact closures, they usually require remote control interface assembly A7A4 (PN 627-9721-002). This unit, installed in the transmitter, uses the control signals to operate relays that apply 28 volts to the appropriate transmitter control circuits.

For short distances [up to 60.9 m (200 ft)], the optional extended control panel (PN 636-7171-002) may be used for controlling the operating and monitor functions of the transmitter. Paragraph 2-4.5.1 describes the connection and operation of the extended control panel. The remote control interface assembly is not required.

TABLE 1-1. 315R-1 PHYSICAL AND ELECTRICAL CHARACTERISTICS.

ITEM	CHARACTERISTICS
1. Size	1752.6 mm (68.38 in.) high 882.6 mm (34.75 in.) wide 846.07 mm (33.31 in.) deep
2. Weight	523 kg (1150 lb) (approximate)
3. Service Conditions	
a. Ambient Temperature	0 degrees to +50 degrees C (+32 degrees to 122 degrees F)
b. Relative Humidity	Up to 95 percent
c. Altitude	Up to 2286 M (7500 ft) at +30 degrees C (+86 degrees F)
d. Vibration and Shock	Normal handling and transportation
4. Power Requirements	
a. Voltage	200 to 250 volts or 345 to 435 volt
b. Frequency	50 or 60 Hz, 3-phase, 3- or 4-wire
c. Wattage	9.3 kW (carrier), 0.95 power factor; 12.7 kW (100% modulation), 0.95 power factor
5. RF Power Output	250 to 5500 watts
6. Frequency Range	535 to 1605 kHz; exact operating frequency determined by oscillator crystals
7. RF Output Impedance	50 ohms, 41.2 mm (1-5/8 in.) EIA (other impedance by special order)
8. Audio Response	+/-1 dB, 20 to 10,000 Hz
9. Audio Distortion	Less than 2%, 20 to 10,000 Hz
10. Modulation Capability	+125%, -100%
11. Harmonic Suppression	Greater than -80 dB below carrier
12. Audio Input Level	+10 dBm +/-2 dB or 0 dBm +/-2 dB

SECTION 2 - INSTALLATION

2-1. INTRODUCTION

Installation of the transmitter is accomplished in four steps: unpacking and inspecting, transmitter location, external connections, and preoperational checks and adjustments.

2-2. UNPACKING AND INSPECTING

2-2.1 DOMESTIC SHIPMENTS

The transmitter is shipped completely assembled and ready for installation, uncrated on a shipping skid, via air-ride van. Unpack and inspect the transmitter as follows:

CAUTION

USE CARE IN MOVING THE TRANSMITTER. USE APPROPRIATE LIFTING AND MOVING EQUIPMENT WITH AT LEAST 523-KG (1150-LB) CAPACITY. SOME COMPONENTS MAY BE DAMAGED IF THE TRANSMITTER IS DROPPED OR SEVERELY JARRED.

a. Remove the transmitter from the van to a position near its installation site.

b. Lift the transmitter from the shipping skid.

c. Remove the rear covers and open the meter door and the circuit breaker panel.

d. Inspect the transmitter for loose hardware. Ensure that all controls operate freely. Examine the cabinet for dents and scratches.

e. File any damage claims properly with the transportation company. Retain all packing material if a claim is filed.

2-2.2 FOREIGN SHIPMENTS

The transmitter is shipped in a skid type crate via a commercial transportation company. Unpack the transmitter as follows:

CAUTION

USE CARE IN UNPACKING AND MOVING THE TRANSMITTER. USE APPROPRIATE LIFTING AND MOVING EQUIPMENT WITH AT LEAST 523-KG (1150-LB) CAPACITY. SOME COMPONENTS MAY BE DAMAGED IF THE TRANSMITTER IS DROPPED OR SEVERELY JARRED.

a. Position the crated transmitter near its installation site.

b. Refer to the instructions stenciled on the side of the shipping crate and carefully uncrate the transmitter.

c. Remove the rear covers and open the meter door and the circuit breaker panel.

d. Inspect the transmitter for loose hardware. Ensure that all controls operate freely. Examine the cabinet for dents and scratches.

e. Remove the modulator and power amplifier tubes from their separate containers. Inspect for damage.

f. File any damage claims properly with the transportation company. Retain all packing material if a claim is filed.

2-3. LOCATION

The 315R-1 transmitter may be installed in either an attended or, with remote control, unattended location. Refer to Figure 2-1 for transmitter dimensions and cable entry information. Observe the following siting practices to ensure optimal transmitter operation.

a. Allow at least 1.1 meter (3.5 ft) of clearance at front and rear for servicing access.

b. Ascertain that environmental conditions are within the temperature, humidity, and altitude limits listed in Table 1-1.

c. Make certain that the transmitter site is clean and that the air is not excessively dusty or dirty.

2-3.1 COOLING AIR REQUIREMENTS

Care must be taken in ventilating the room housing the transmitter to provide an adequate flow of cooling air. The 315R-1 transmitter requires 152.4m^3/min (500 ft^3/min) of cooling air. If a sufficient supply of cooling air is not supplied, overheating may cause equipment failure.

2-3.2 HEAT LOAD

The heat load to the room including exhaust air is 5500 watts or 18,772 BTU.

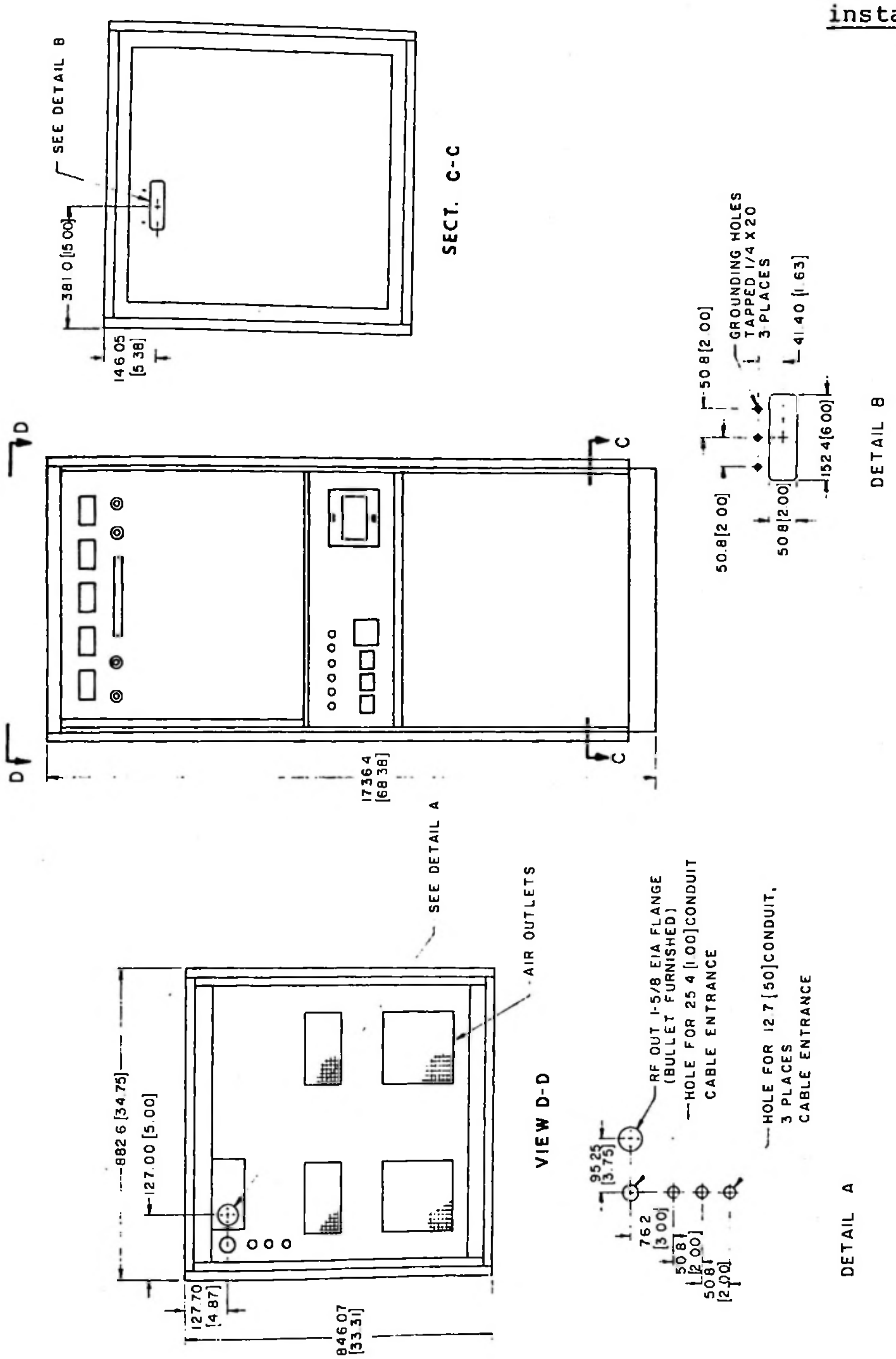

Figure 2-1. Outline and Installation Drawing.

WARNING: DISCONNECT PRIMARY POWER BEFORE SERVICING.

2-3.3 AIR FLOW

The total air flow through the 315R-1 transmitter cabinet is 152.4 m^3/min (500 ft^3/min) at 1.97 2g/m^2 (0.75 in. of water).

2-4. EXTERNAL CONNECTIONS

WARNING

HIGH VOLTAGE IS USED IN THIS EQUIPMENT. DEATH ON CONTACT MAY RESULT IF YOU FAIL TO OBSERVE SAFETY PRECAUTIONS. WHEN WORKING INSIDE THE EQUIPMENT, BE SURE THAT ALL CIRCUIT BREAKERS ARE OFF AND THAT PRIMARY POWER IS DISABLED AT THE WALL DISCONNECT OR CIRCUIT BREAKER UNLESS OTHERWISE DIRECTED. IF A PROCEDURE REQUIRES TRANSMITTER OPERATION WITH ACCESS PANELS REMOVED, DO NOT ALLOW BODILY CONTACT WITH ANY ELECTRICAL COMPONENT, TAP, OR TERMINAL. USE HEAVILY INSULATED TOOLS TO ADJUST VARIABLE COMPONENTS.

2-4.1 PRIMARY POWER CONNECTIONS

The 315R-1 transmitter requires either a 200/250-volt or 345/435-volt, 3- or 4-wire primary power source. It should be either a closed delta or wye primary power source. The power source must be capable of supplying 13.7 KVA at 95 percent power factor due to a phase monitor relay installed in the transmitter. The phase rotation is important. However, open delta power sources are not recommended because of poor phase balance and high harmonic voltages generated in the open delta configuration. Provision should be made for either a fused main power disconnect switch or a main power circuit breaker. The fuse or breaker should be rated at 60 amperes for a 200/250-volt input, or at 35 amperes for a 345/435 volt input.

Connections from the output of the main power disconnect switch or breaker to the transmitter should be made with number 8 AWG wires. Entrances in both the top and bottom of the transmitter are provided to bring in the power wiring, audio lines, interlocks, and control lines. (See the outline and installation drawing, Figure 2-1, for details.) At the transmitter, these wires are connected to input power terminal board TB1, located on the floor inside the cabinet.

Connections are as follows:

Phase A	A7TB1-1	
Phase B	A7TB1-2	(phase rotation is
Phase C	A7TB1-3	important due to
Neutral or		Phase Monitor Relay K1.)
Power Ground	A7TB1-4	

When a 3-wire delta primary power source is used, a safety power ground of number 8 AWG wire should be connected from the station or building power ground to the transmitter frame ground. This frame ground (E1) is located on the floor of the transmitter cabinet at the left side, near terminal board A7TB1. The ground wire is connected to one of the 1/4-20 tapped holes provided for this purpose in the transmitter floor. Rotation of phase connection may be necessary for power to energize the transmitter due to Phase Monitor, Relay K1.

For proper operation, a good RF ground connection is required, using a copper strap 102 to 152 mm (4 to 6 in.) wide for a low inductance RF connection.

2-4.1.1 TRANSFORMER TAPS

The taps on all transformers are connected at the factory for 250-volt, 3-phase operation. If any other primary power source is to be used, the transformer taps must be changed to the nearest tap to the supply voltage. Table 2-1 lists the correct taps for each supply voltage on each transformer.

NOTE

In Table 2-1, A, B, and C refer to phase A, phase B, and phase C. N refers to neutral.

Figures 2-2 through 2-13 show the details of the proper line connections to HVPS transformer T1 for various line voltages. If the HVPS voltage exceeds 15.0 kV at any line voltage variation during a normal day's operation, move connections to the next higher line voltage connection.

TABLE 2-1. TRANSFORMER TAPS FOR EACH VOLTAGE

TRANSFORMER TAP	LINE-TO-LINE VOLTAGE											
	200	210	220	230	240	250	345	360	380	400	415	435
T1-HVPS												
1				A	A	A				A	A	A
2	A	A	A				A	A	A			
3	J7			J6			J8			J8		
4		J7			J6			J9			J9	
5			J7			J6			J10			J10
6				B	B	B				B	B	B
7	B	B	B				B	B	B			
8	J12			J11			J13			J13		
9		J12			J11			J14			J14	
10			J12			J11			J15			J15
11				C	C	C				C	C	C
12	C	C	C				C	C	C			
13	J2			J1			J8			J8		
14		J2			J1			J9			J9	
15			J2			J1			J10			J10

TRANSFORMER TAP	200	210	220	230	240	250	345	360	380	400	415	435
A7T1-28 VOLT PS												
COM A7K1-2	B	B	B	B	B	B	N	N	N	N	N	N
208 A7TB2-14	A	A						A	A			
230 A7TB2-15				A	A						A	A
240 A7TB2-16						A	A				A	A

TRANSFORMER TAP	200	210	220	230	240	250	345	360	380	400	415	435
A7T2 DRIVER PS												
1	A	A	A	A	A	A	N	N	N	N	N	N
2	B						B					
3		B						B				
4			B						B			
5				B						B		
6					B						B	
7						B						B

TABLE 2-1. TRANSFORMER TAPS FOR EACH VOLTAGE

TRANSFORMER TAP	LINE-TO-LINE VOLTAGE											
	200	210	220	230	240	250	345	360	380	400	415	435
A10T1-LOGIC PS												
A10TB1-6	B	B	B	B	B	B	N	N	N	N	N	N
A10TB1-7	A	A	A				A	A	A			
A10TB1-8				A	A	A				A	A	A
A9T4 PA FIL*												
1	A	A	A	A	A	A	N	N	N	N	N	N
2	C	C	C				C	C	C			
3				C	C	C				C	C	C
A9T5 MOD FIL*												
1	A	A	A	A	A	A	N	N	N	N	N	N
2	C	C	C				C	C	C			
3				C	C	C				C	C	C
A7T3 BIAS PS												
1	J5	J5	J5	J6	J6	J6	N	N	N	N	N	N
2	A	A	A				A	A	A			
3				A	A	A				A	A	A
4	J8	J8	J8	J9	J9	J9	J1	J1	J1	J1	J1	J1
5	B	B	B				B	B	B			
6				B	B	B				B	B	B
7	J2	J2	J2	J3	J3	J3	J4	J4	J4	J4	J4	J4
8	C	C	C				C	C	C			
9				C	C	C				C	C	C

*If the filament regulator option is used, the filament transformers must be connected for 240 volts regardless of the line voltage.

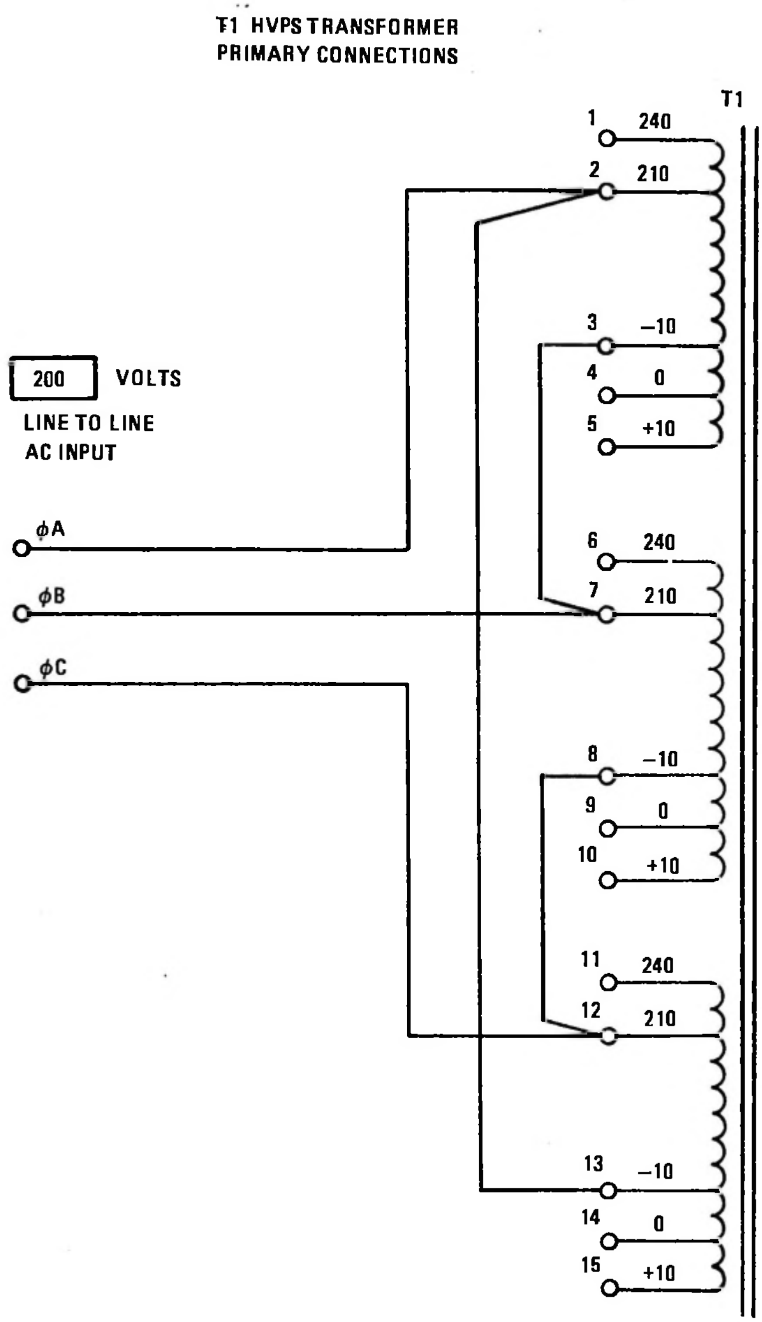

Figure 2-2. High-Voltage Power Supply Transformer Taps, 200-Volt Input.

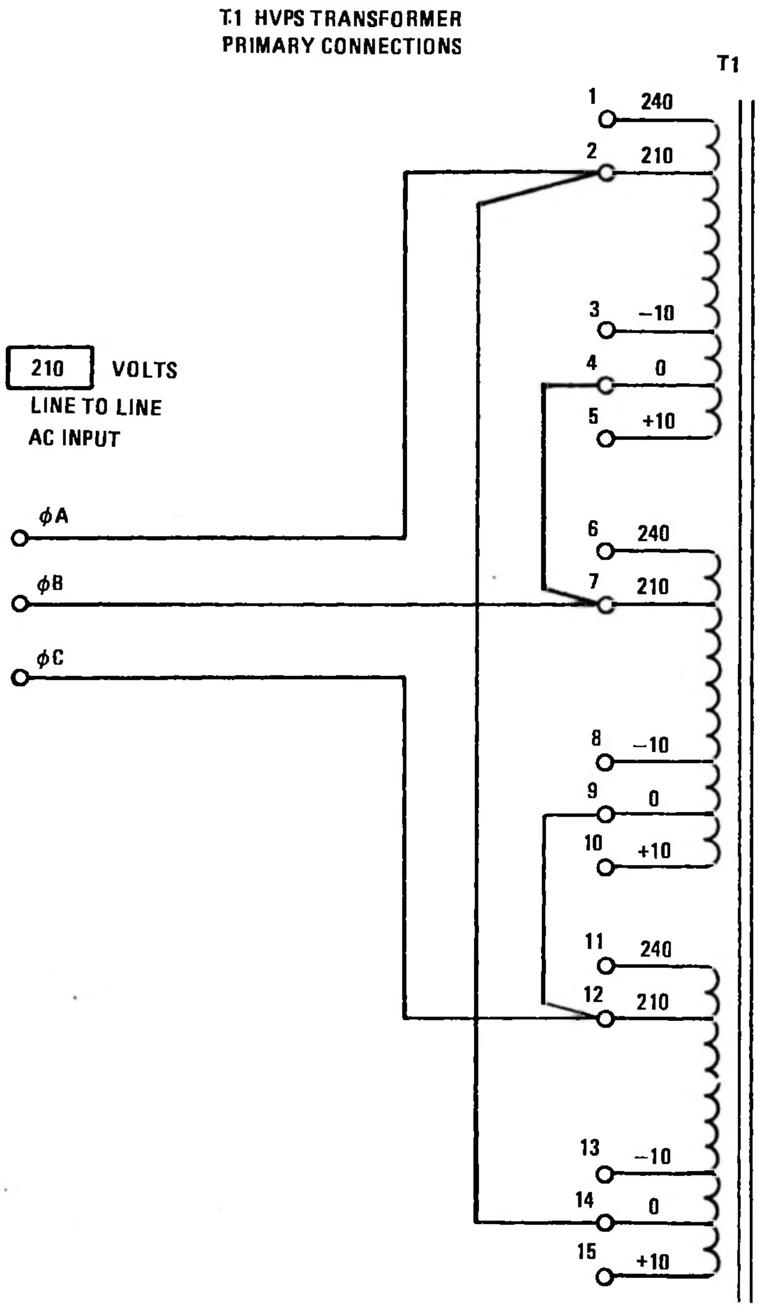

Figure 2-3. High-Voltage Power Supply Transformer Taps, 210-Volt Input.

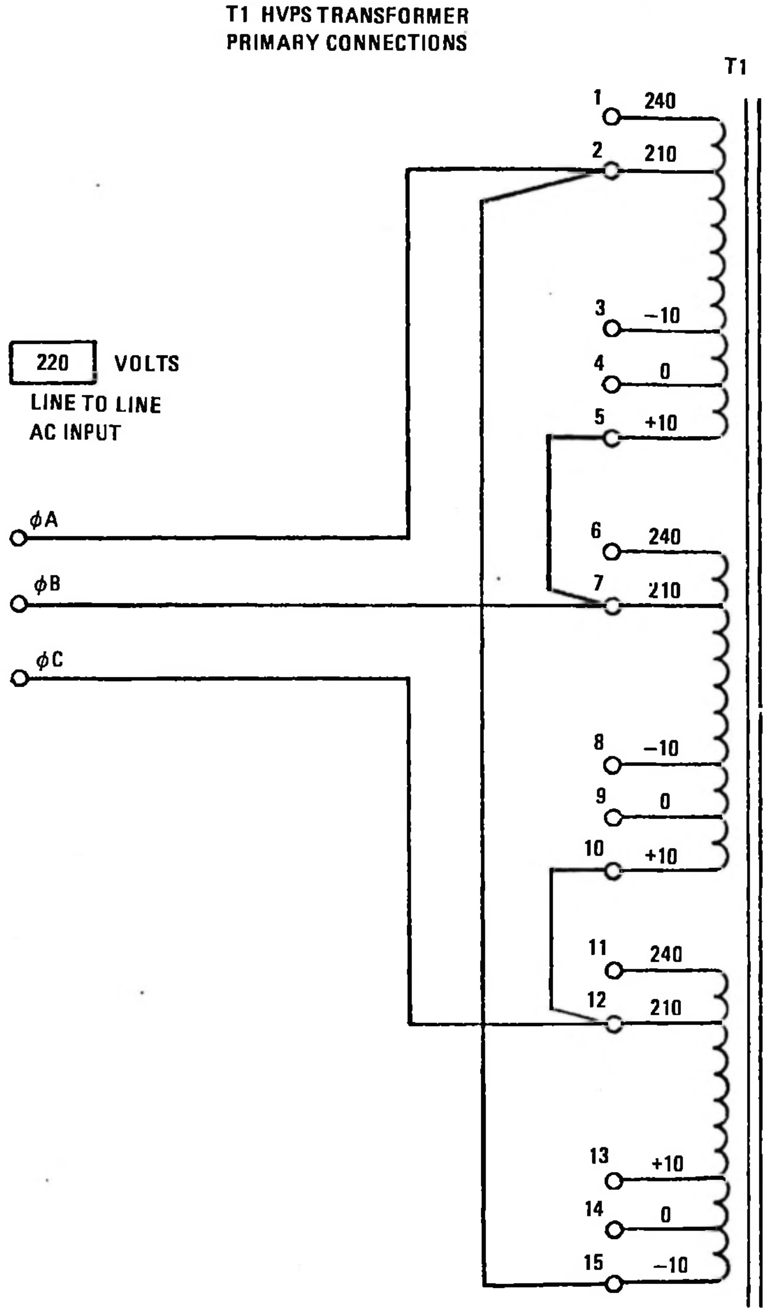

Figure 2-4. High-Voltage Power Supply Transformer Taps, 220-Volt Input.

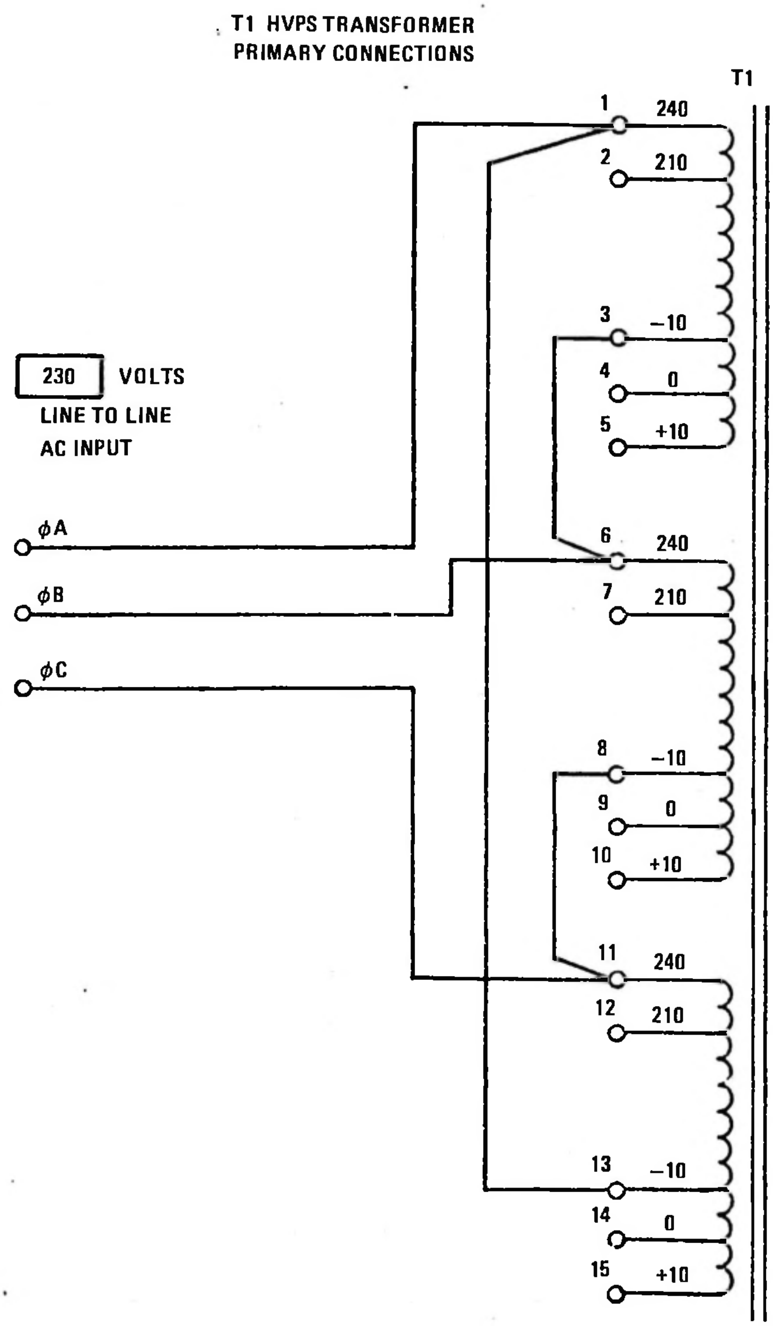

Figure 2-5. High-Voltage Power Supply Transformer Taps, 230-Volt Input.

WARNING: DISCONNECT PRIMARY POWER BEFORE SERVICING.

installation

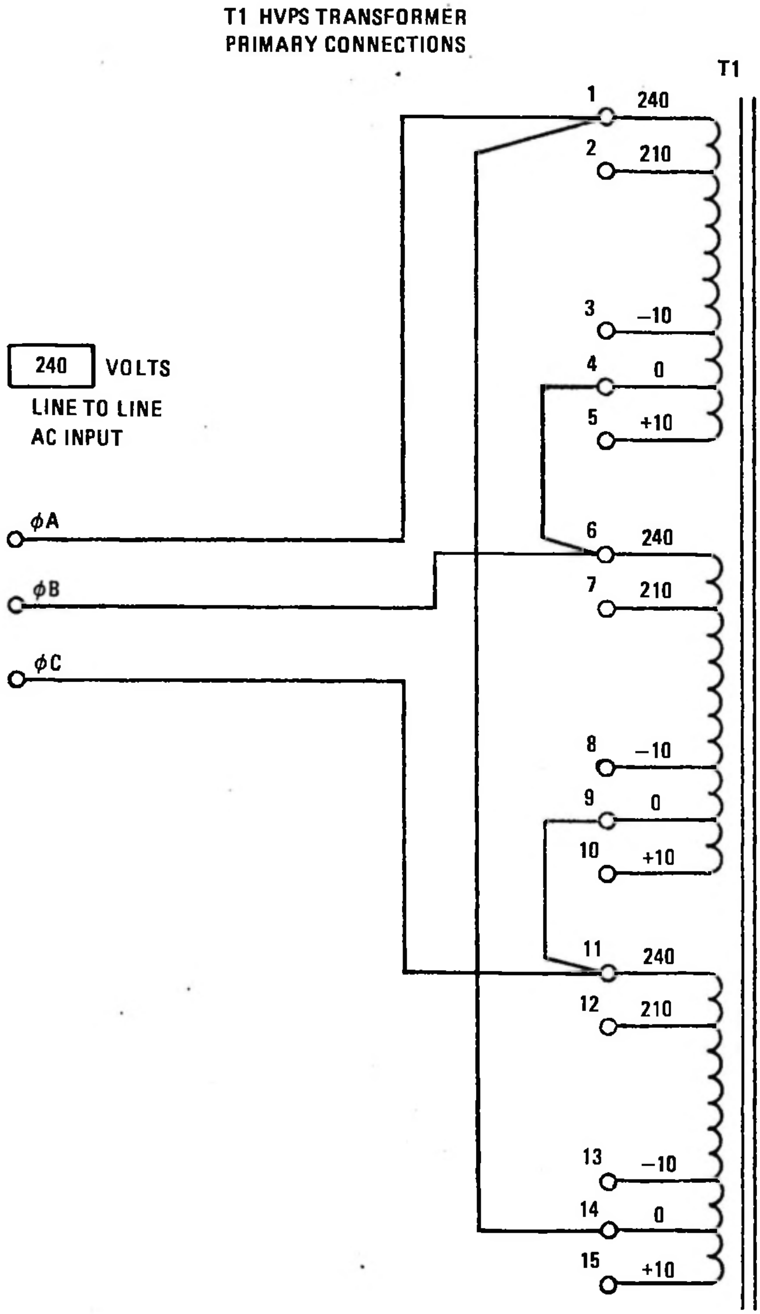

Figure 2-6. High-Voltage Power Supply Transformer Taps, 240-Volt Input.

WARNING: DISCONNECT PRIMARY POWER BEFORE SERVICING.

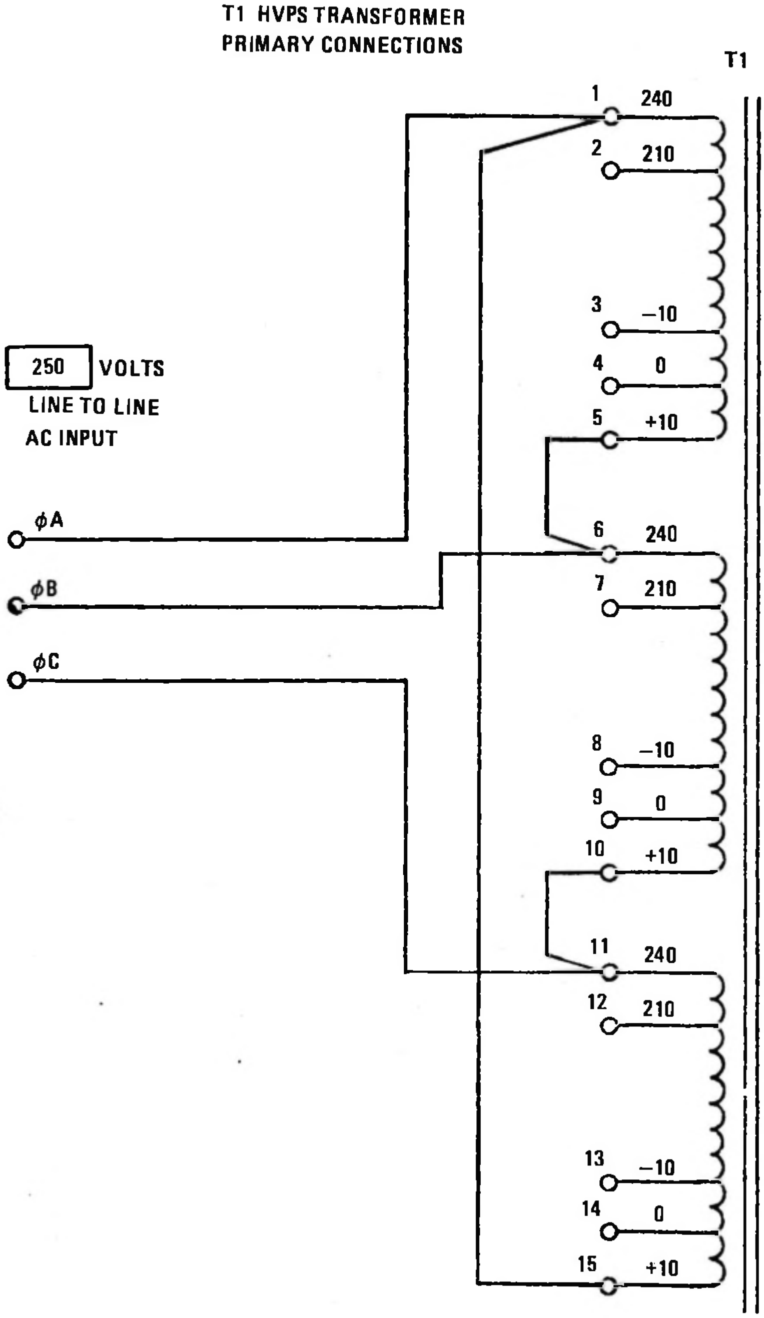

Figure 2-7. High-Voltage Power Supply Transformer Taps, 250-Volt Input.

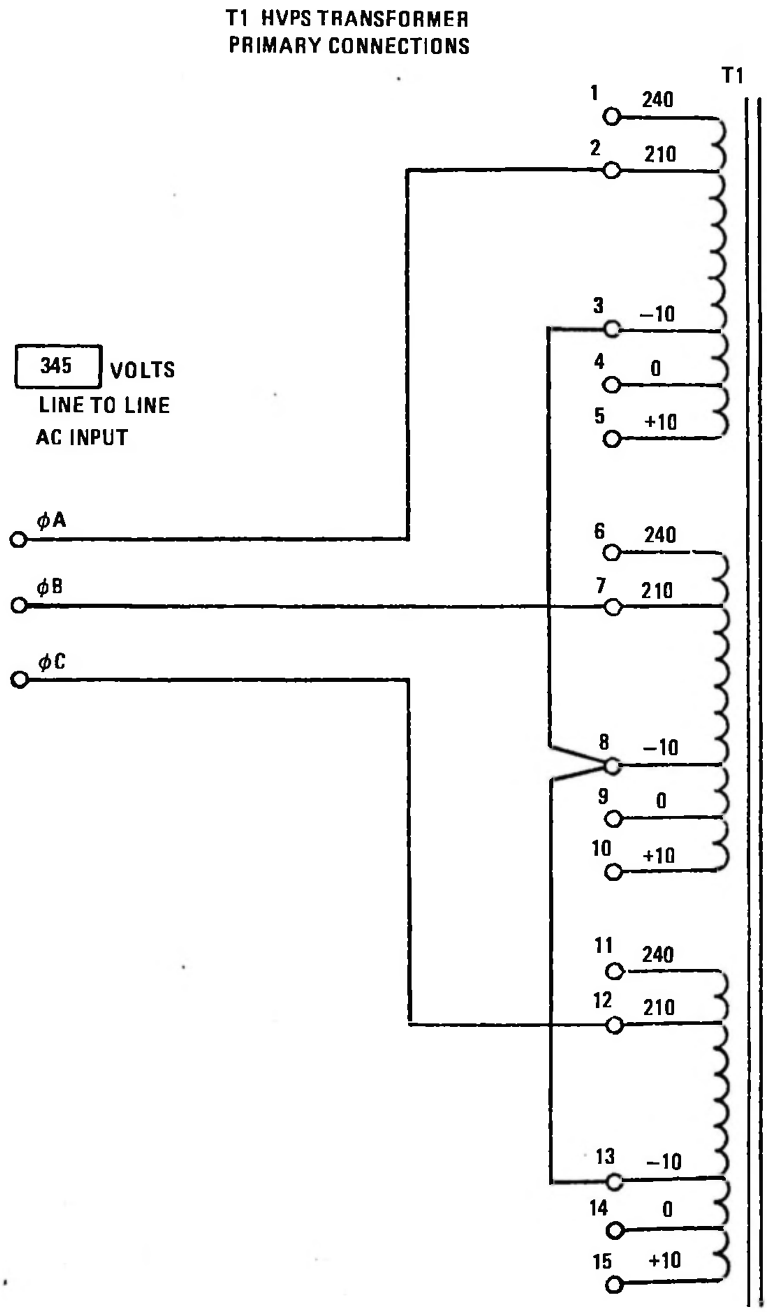

Figure 2-8. High-Voltage Power Supply Transformer Taps, 345-Volt Input.

WARNING: DISCONNECT PRIMARY POWER BEFORE SERVICING.

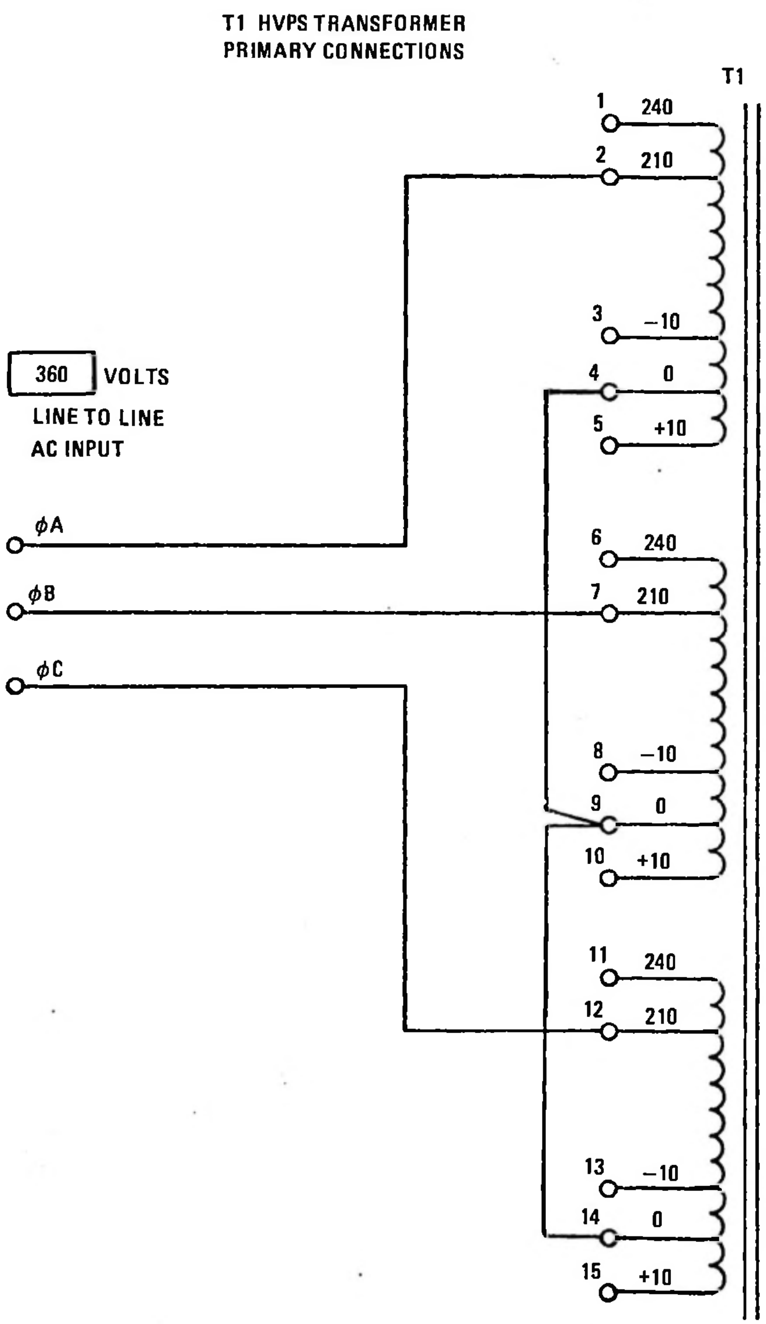

Figure 2-9. High-Voltage Power Supply Transformer Taps, 360-Volt Input.

WARNING: DISCONNECT PRIMARY POWER BEFORE SERVICING.

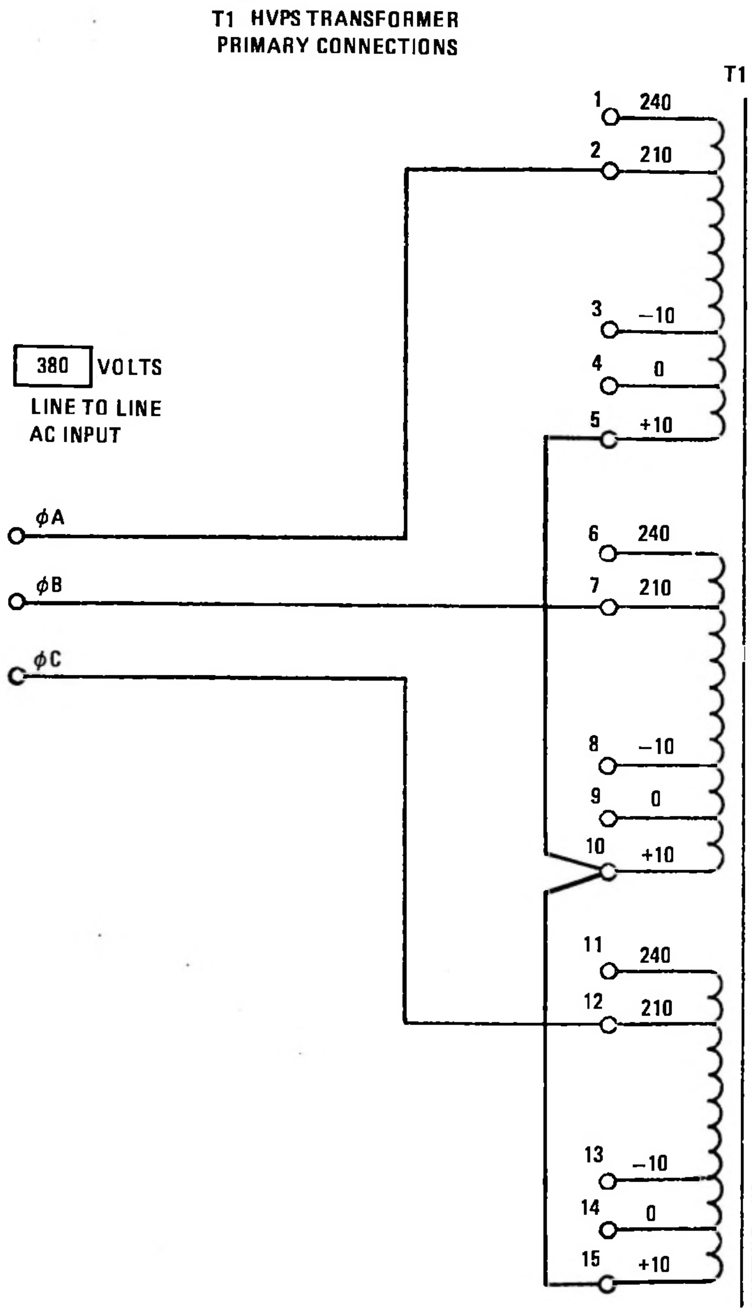

Figure 2-10. High-Voltage Power Supply Transformer Taps, 380-Volt Input.

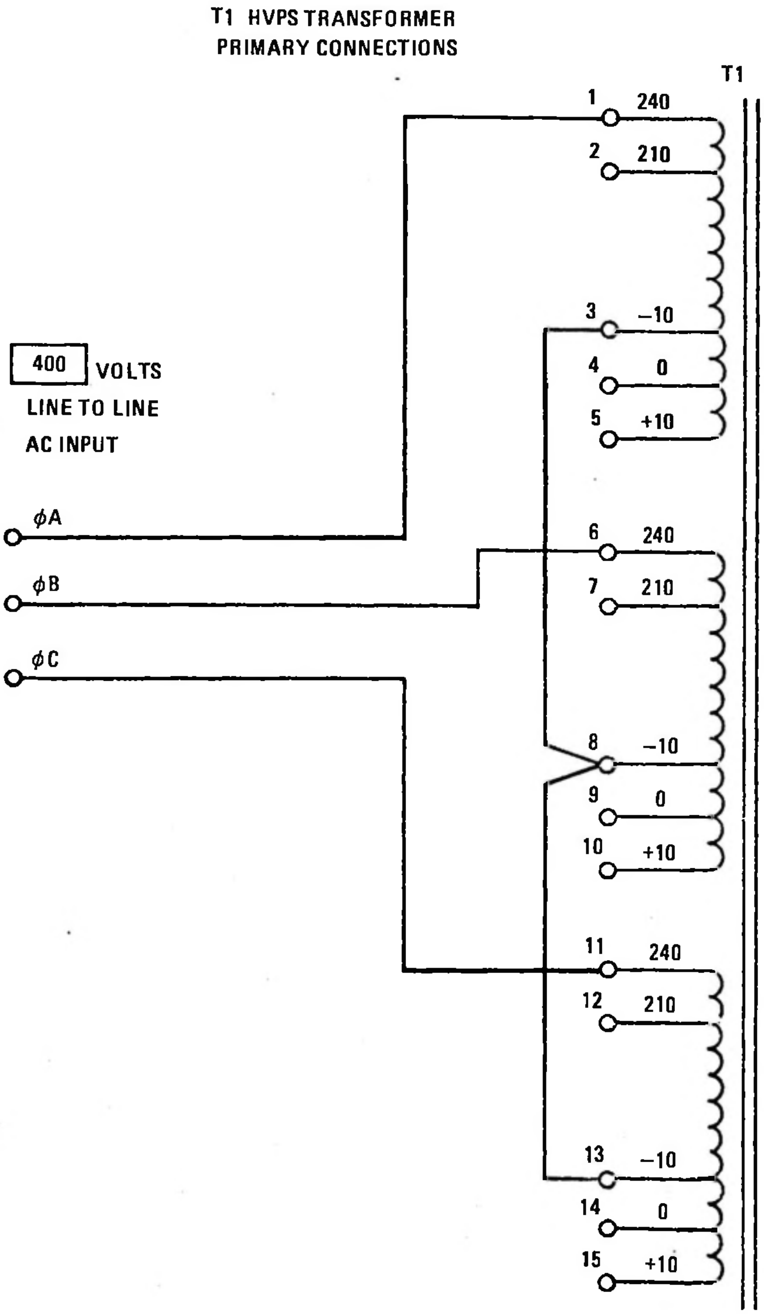

Figure 2-11. High-Voltage Power Supply Transformer Taps, 400-Volt Input.

WARNING: DISCONNECT PRIMARY POWER BEFORE SERVICING.

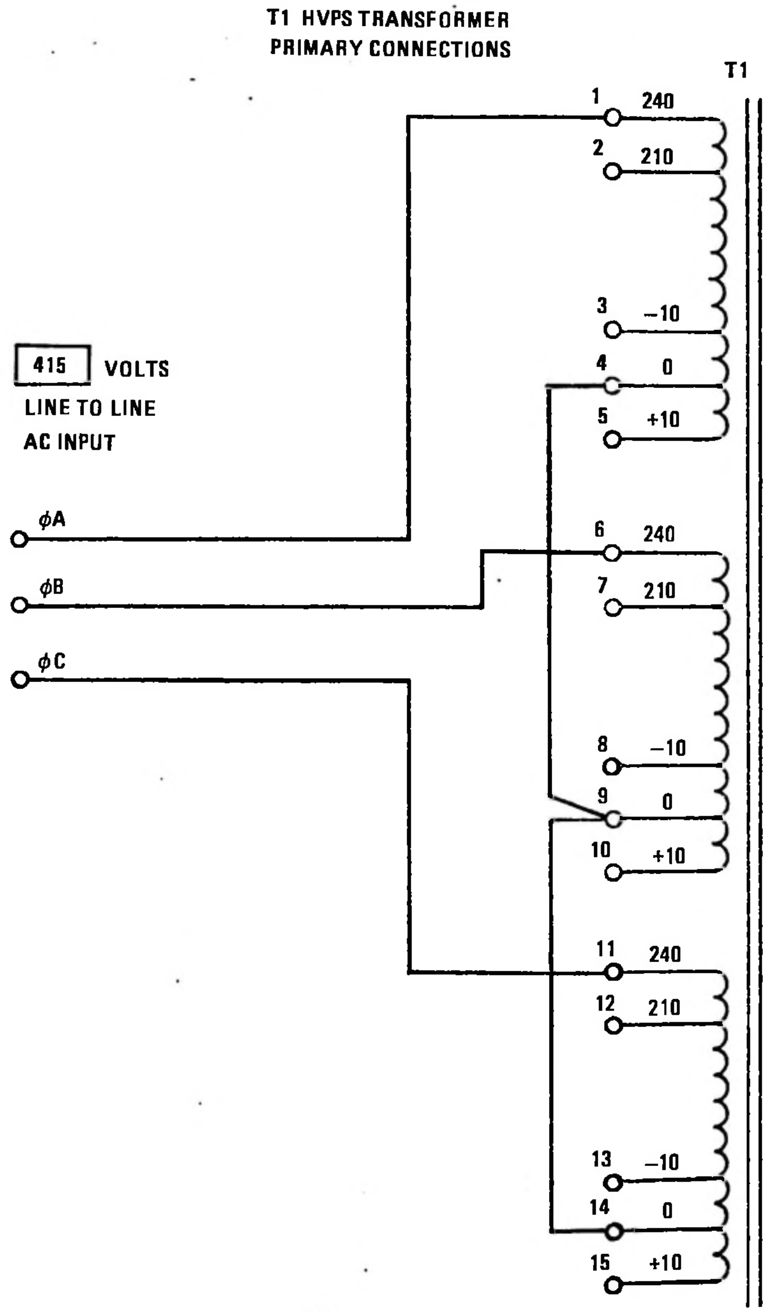

Figure 2-12. High-Voltage Power Supply Transformer Taps, 415-Volt Input.

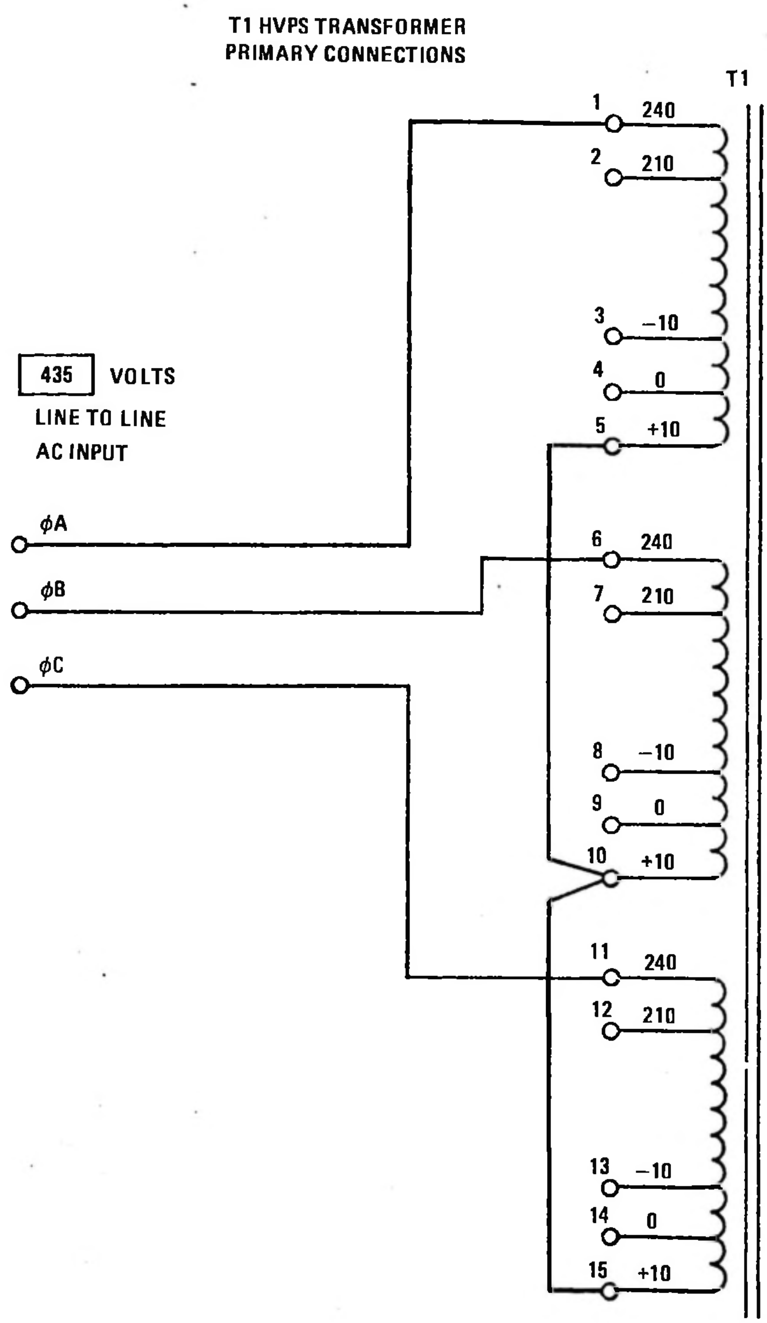

Figure 2-13. High-Voltage Power Supply Transformer Taps, 435-Volt Input.

WARNING: DISCONNECT PRIMARY POWER BEFORE SERVICING.

2-4.1.2 CONNECTIONS FOR 345/435-VOLT OPERATION

For operation at line-to-line voltages of from 345 to 435 volts, the normal 200/250-volt load and metering circuits must be reconnected, from the delta (line-to-line) to a wye (line-to-neutral) configuration. To accomplish this, move seven wire connections as shown in Table 2-2. In the resulting configuration, the AC TEST meter reads line-to-neutral voltage instead of line-to-line voltage.

* TABLE 2-2. CONNECTIONS FOR LINE-TO-NEUTRAL LOAD AND METERING

WIRE CONNECTION		CHANGE	
NAME	NUMBER (color)	FROM	TO
A7T1-COM	721-(#22 - 7)	A7K1	A7E1
A7T2-COM	12 (#22 - 3)	A7K2-12	A7E1
A7TB1-16	737 (#22 - 95)	A7K2-12	A7E1
BI-COM	17 (#18 - 6)	A7K2-2	A7E1
JUMPER	A6TB1	C-F	F-J
JUMPER	A6TB1	B-3	E-H
JUMPER	A6TB1	A-D	D-G
A6CB1	CIRCUIT BREAKER RATING CHANGE	15 A	10 A
A6CB2		1.0 A	0.75 A
A6CB3		50 A	35 A

2-4.2 RF OUTPUT CONNECTION

CAUTION

DEPENDING ON THE RF OUTPUT IMPEDANCE, RF VOLTAGE AND RF CURRENT AT THE TRANSMITTER OUTPUT CONNECTION CAN RANGE AS HIGH AS 2000 VOLTS RMS AND 20 AMPERES RMS. TO PREVENT VOLTAGE BREAKDOWN AND/OR CURRENT HEATING FAILURES, EXTREME CARE MUST BE EXERCISED TO MAKE A PROPER CONNECTION AT THIS POINT.

The 5-kW RF output connection is located at the left rear of the top of the transmitter cabinet (refer to Figure 2-1). It is either a standard EIA 41.275-mm (1-5/8-in.) coax connection, or a sleeve with a 1/4-20 tapped hole. An adapter to 22.2-mm (7/8-in.) Heliax is also available (PN 124-3023-170).

2.4.3 AUDIO INPUT CONNECTIONS

The 315R-1 transmitter accepts audio input, at a level of +10 dBm +/-2 dB, from a source requiring a load impedance of either 150 or 600 ohms. The transmitter is wired at the factory for operation with an input impedance of 600 ohms. If 150-ohm input impedance is desired, connect the jumper provided on the PWM card, A2, between terminals at J2 instead of terminals at J1 (see schematic). If 0-dBm input level is desired, it can be obtained by placing a jumper on J3 (see schematic).

Use number 22 AWG, shielded twisted pair wire (Belden 8451 or equivalent) to connect the audio source to terminal board A7TB2-1, -2, and -3. The audio "high" wire connects to terminal 1, the "low" wire connects to terminal 2, and the shield to terminal 3.

2-4.4 CARRIER INTERLOCK

Terminals 10 and 11 on terminal board A7TB2 are provided to interlock the carrier for purposes of pattern switching. Terminal 11 has plate controlled +28 volts, which passes through the carrier interlock circuit and returns to terminal 10. From here it goes to PWM card A2, where it controls the PWM signal. If there is no connection between terminals 10 and 11, the PWM signal is interrupted (70-kHz switching stops) and the plate voltage is thereby removed from the RF power amplifier. However, the plate contactor and HVPS remain on. When the carrier interlock is closed, the PWM signal resumes and plate voltage returns to the RF power amplifier. If this circuit is not utilized, a jumper must be connected between terminals 10 and 11 for proper operation of the transmitter.

It should be noted that this circuit carries a very low current. Therefore, the external wiring should be kept as short as possible and external contacts used in this circuit must be low resistance, low current sealed contacts.

It should also be noted that the RF drive loss circuit (located on the rear of the backplane) works in series with the carrier interlock. If the RF driver current drops below approximately 1.5 amperes, the carrier interlock signal is interrupted, thereby removing high voltage from the RF power amplifiers.

2-4.5 REMOTE CONTROL AND MONITOR CONNECTIONS

Remote control of the 315R-1 transmitter can be accomplished in either of two ways. For relatively short distance, the (optional) extended control panel can be connected directly to the control relay card in the transmitter. For longer distances, remote control can be exercised through remote control interface assembly A7A4.

2-4.5.1 DIRECT REMOTE CONTROL CONNECTIONS

Remote control by direct connection of the extended control panel to A7A1TB1 on the control relay card in the transmitter can be accomplished at distances up to 61 meter (200 ft). Twenty-two number 22 AWG wires are required, connected as shown in Figure 2-14. The jumpers between A7A1TB1-3 and -4 and A7A1TB1-7 and -8 must be removed when the extended control panel is connected.

The extended control panel (Figure 2-15) for the 315R-1 transmitter can be connected to function directly in parallel with the local transmitter controls, or only when LOCAL-REMOTE switch A5S10 on the 315R-1 is in the REMOTE position.

When the FILAMENT OFF (pin 7) is connected to A7A1TB1-1, the extended control panel receives +28 volts only when the LOCAL-REMOTE switch is in REMOTE. In this condition, the local transmitter FILAMENT OFF and FILAMENT ON switches are disabled. However, the other local transmitter controls function normally.

By connecting to A7A1TB1-3, all controls are operational at all times, except the extended RAISE-LOWER control. Power output can be raised or lowered on the extended control panel only when the transmitter LOCAL-REMOTE switch is in the REMOTE position.

2-4.5.2 REMOTE CONTROL INTERFACE ASSEMBLY

If remote control interface assembly (Figure 2-17.1) A7A4 (PN 627-9721-002) is used, the remote control connections are connected to terminal board A7A4TB1 on the remote control interface assembly (see schematic, Figure 2-16), instead of A7A1TB1. The output control signals from the remote control interface assembly are connected to A7A1TB1. The transmitter internal +28-volt supply is used to power the remote control panel; connections to A7A4TB1 are as shown in Figure 2-18.

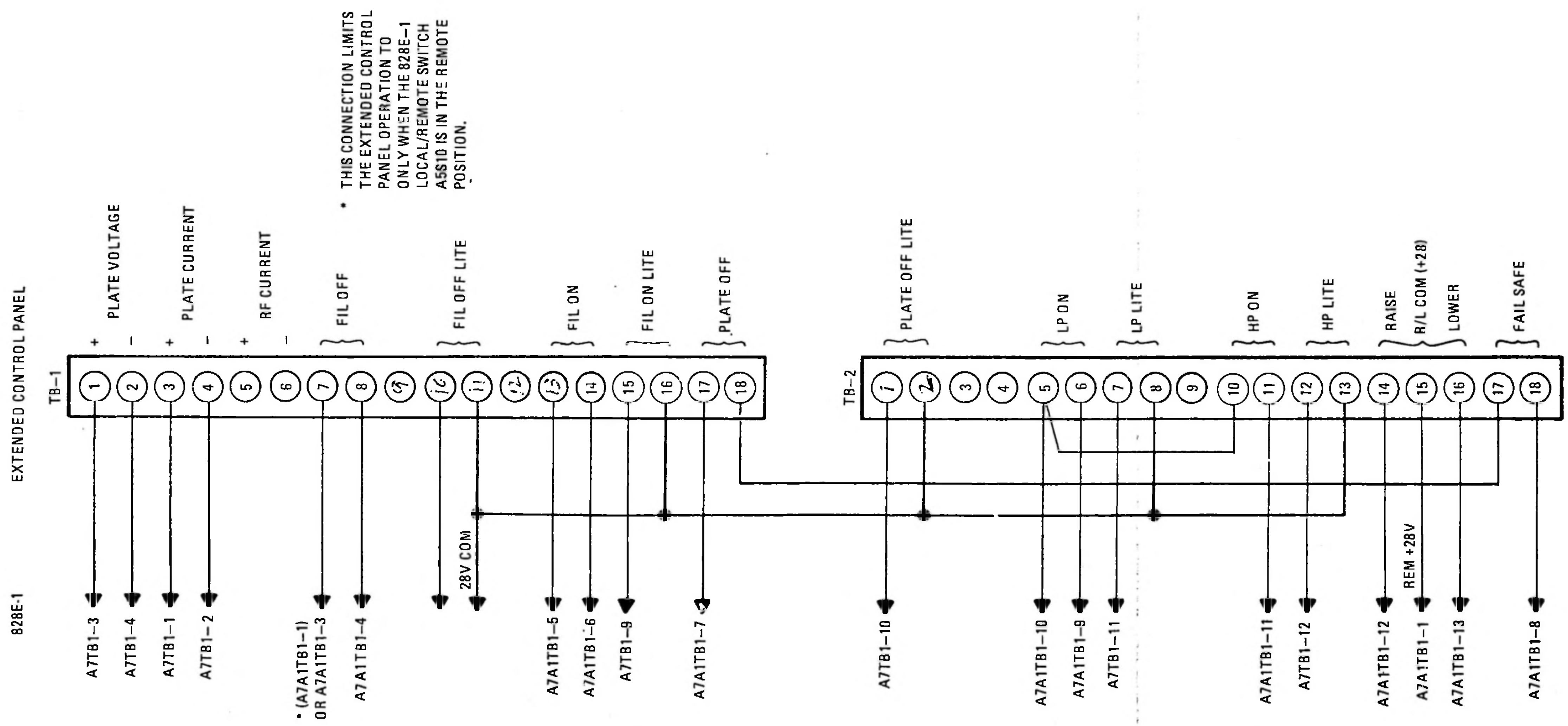

Figure 2-14. 315R-1 Interconnect Wiring for Extended Control Panel.

WARNING: DISCONNECT PRIMARY POWER BEFORE SERVICING.

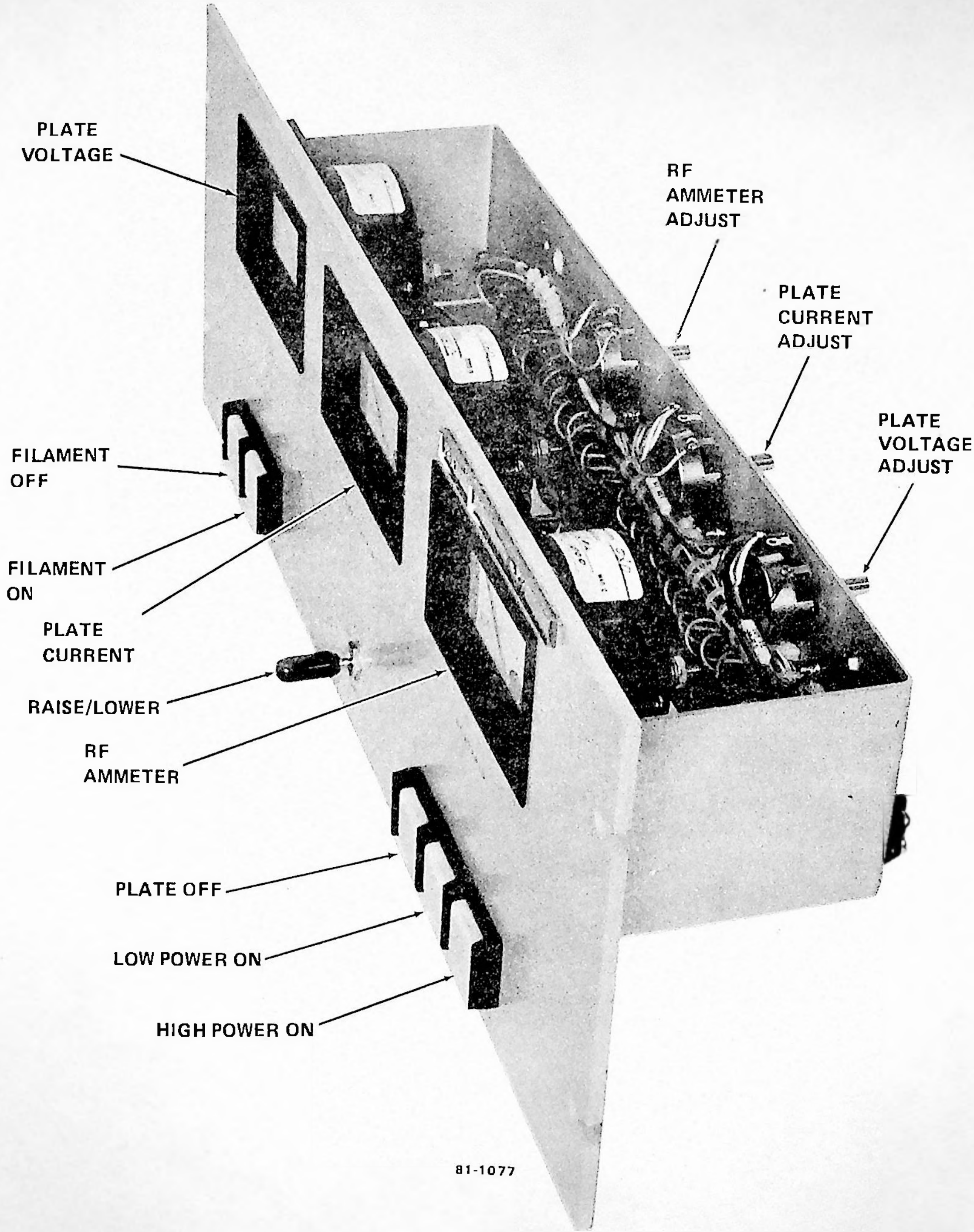

Figure 2-15. Extended Control Panel.

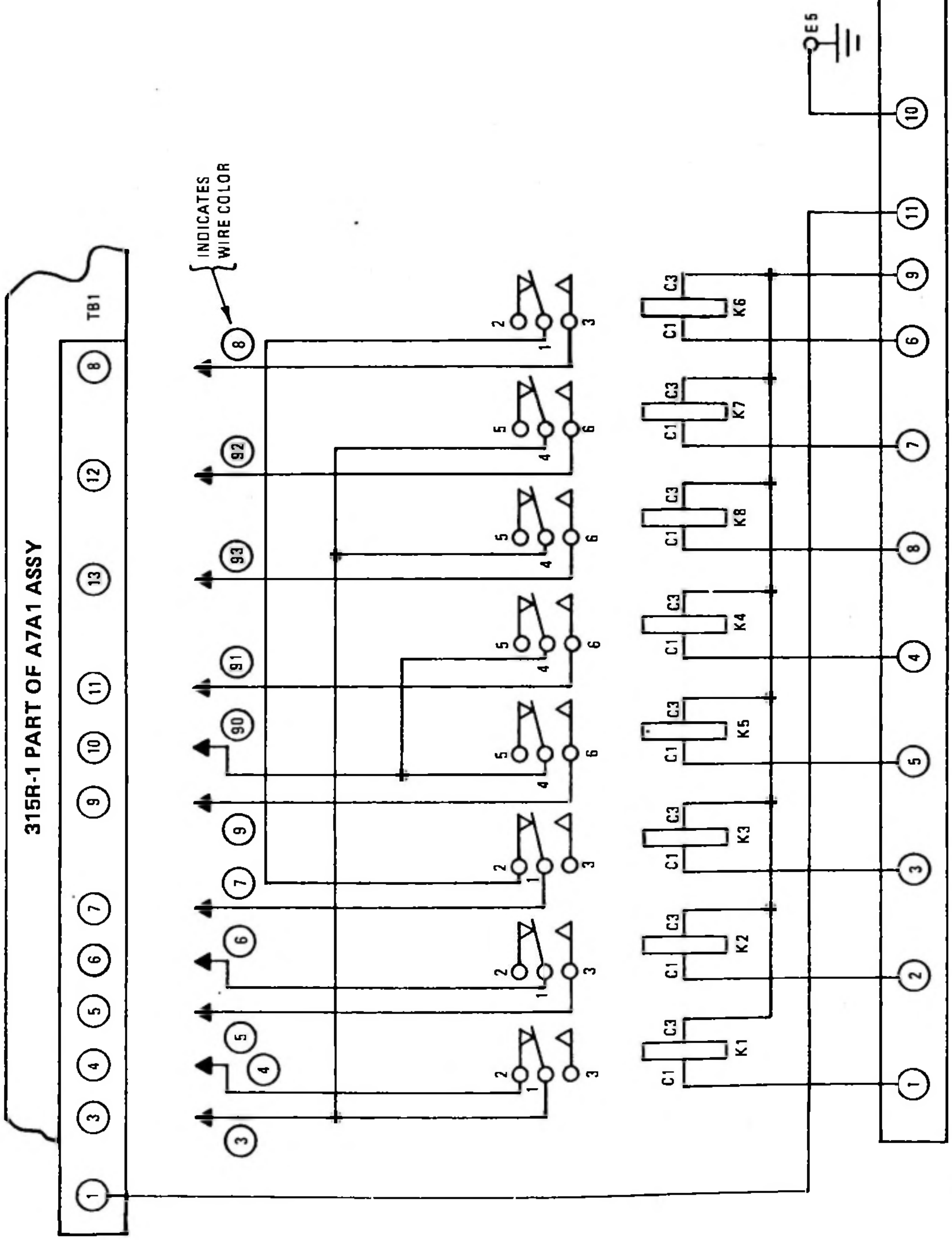

Figure 2-16. Remote Control Interface Assembly Schematic.

WARNING: DISCONNECT PRIMARY POWER BEFORE SERVICING.

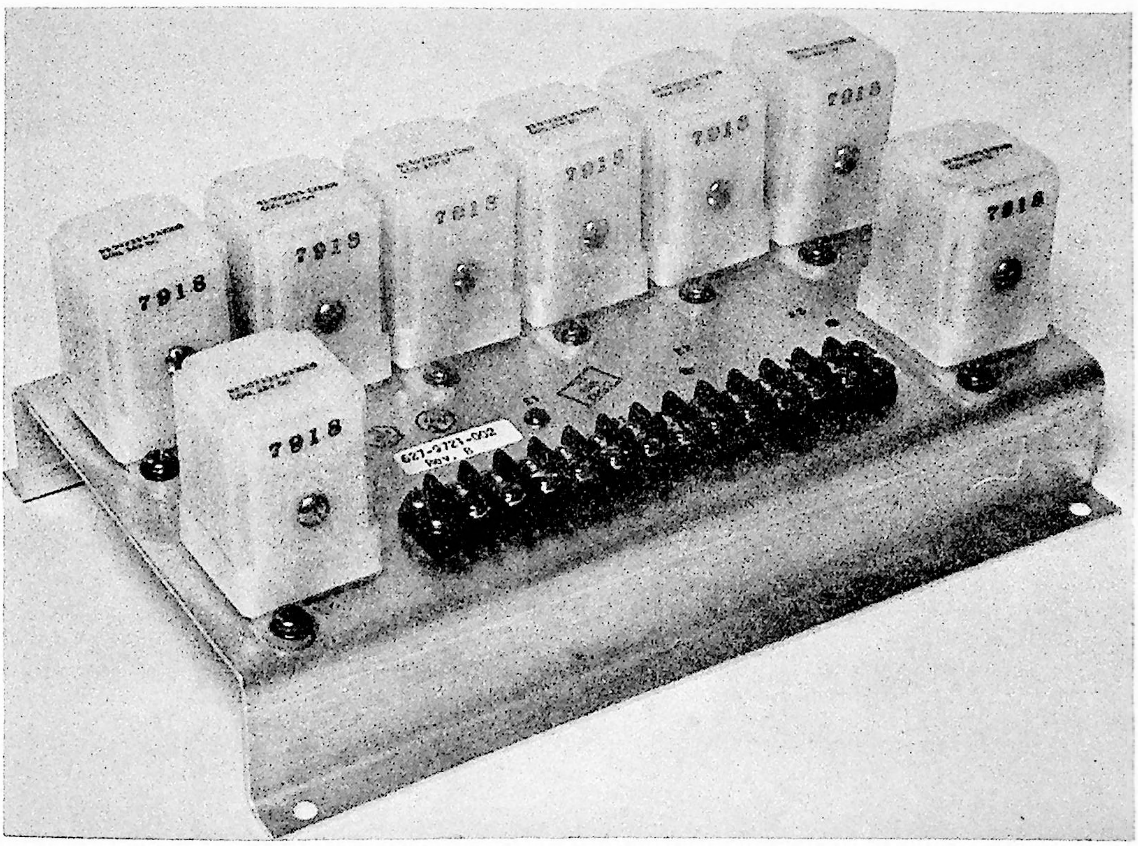

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Figure 2-17. Remote Control Interface

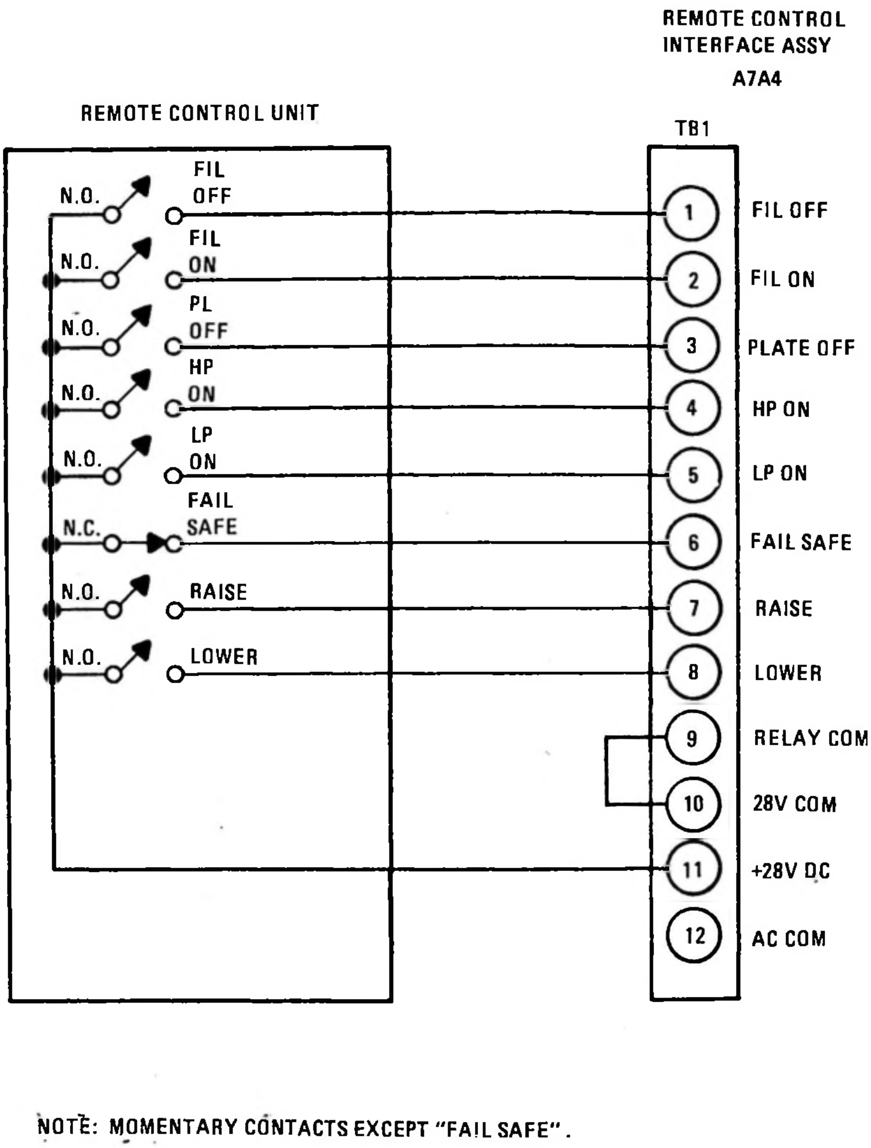

Figure 2-18. Connections Using Internal +28 Volts to Power Remote Panel.

2-4.5.3 REMOTE MONITOR CONNECTIONS

The 315R-1 transmitter has provisions for remote metering of power amplifier plate current, power amplifier plate voltage, and forward and reflected RF power. These remote monitor circuits are designed to use 100-mA meters having an internal resistance of 1750 ohms +/-1 percent. The remote monitor meters can be used at distances from the transmitter of up to 61 meter (200 ft), using number 22 AWG wire. Figure 2-19 shows the required connections to A7TB1 on the power control chassis in the transmitter. Full scale readings for each remote meter are also shown.

2-4.6 HIGH POWER INTERLOCK & HIGH/LOW POWER SWITCHING

A high power interlock is provided between terminal 14 and 15 A7A1TB1. These are in series with the HP coil on latching relay A7A1K1. If the relay is in the LP position and the HP interlock is open, it cannot be switched to HP. However, it should be noted that if the relay is in the HP position and the HP interlock is opened, it will NOT automatically switch to LP. It must be commanded to switch to LP from either the front panel LP button, or through the remote control system by applying +28 volts to A7A1TB1-9 (or a contact closure between A7A1TB1-9 and 10).

A more complete high/low power switching arrangement is shown in Figure 2-20. This sort of circuit may be implemented if fully automatic switching and interlocking is desired. The 315R-1 connections are shown down the left side, phasor connections are shown down the right side, and remote control connections are at the bottom. Of course, control of K4 and K5 may come from either the remote control, as shown, or from the phasor if remote control is not used.

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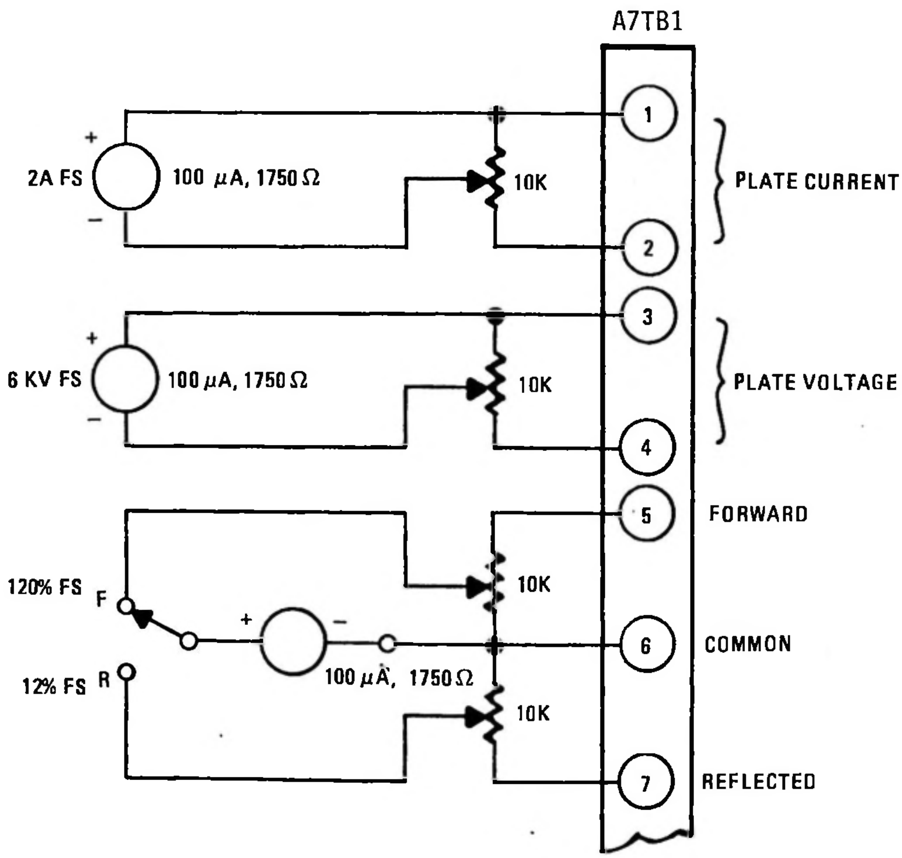
FIGURE 2-19. REMOTE MONITOR CONNECTIONS



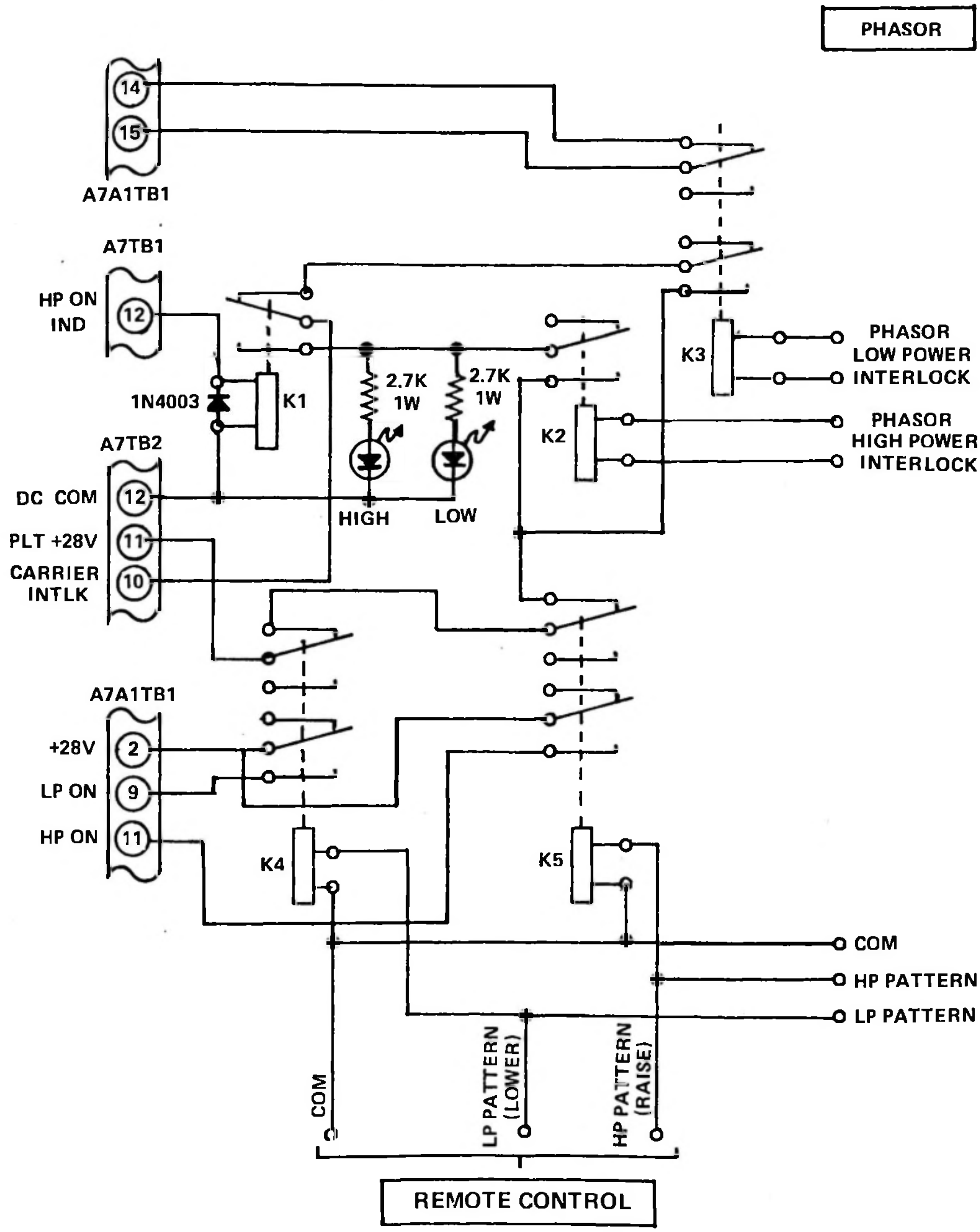


Figure 2-20. High/Low Power Switching Circuit

SECTION 3 - OPERATION

3-1. INTRODUCTION

This section contains information pertaining to the identification, location, and function of the controls and indicators on the 315R-1 5-kW AM Transmitter. The procedures required to set up and operate the transmitter are also presented.

3-2. CONTROLS AND INDICATORS

Table 3-1 lists and explains the functions of the front panel controls and indicators on the transmitter. Table 3-2 similarly lists and explains the functions of internal controls and indicators. Table 3-3 lists the meters on the transmitter; and Table 3-4 shows typical meter readings for correct operation.

TABLE 3-1. FRONT PANEL CONTROLS AND INDICATORS

CONTROL/INDICATOR	FUNCTION
FILAMENT:	
OFF (A5S1/A5DS1)	Removes power from both blower relay A7K1 and filament relay A7K2 by interrupting holding contact 4 and 12 on relay A7K1. When lighted, shows filament power is off.
ON (A5S2/A5DS2)	Applies 28 volt power to blower relay A7K1, which then energizes filament relay A7K1, which then energizes filament relay A7K2 through air interlock switch A9S3. When lighted, shows filament and blower power are on.
PLATE:	
OFF (A5S3/A5DS3)	Disconnects high voltage from plate circuit by interrupting holding contacts 9 and 10, and 5 and 6 on HIGH VOLTAGE ON relay A7A1K3. In series with three door interlock switches A7S1, A7S2, A9S1; temperature switch A9S4; and with overload relay A7A1K2. When lighted, indicates that no high voltage is applied to plate, three door interlocks are closed, and overload relay is not energized, and the temperature interlock is closed.
LP (A5S4/A5DS4)	Applies 28-volt power to low power latch relay A7A1K1B through diode A7A1CR2, and to high voltage on A7A1K3 through diode A7A1CR4; also energizes filament on sequence through diode A7A1CR17. When lighted, indicates that power is applied to low power relay A2K1 and modulation monitor relay A9K1.

TABLE 3-1. FRONT-PANEL CONTROLS AND INDICATORS (CONT).

CONTROL/INDICATOR	FUNCTION
HP (A5S5/A5DS5)	Applies 28 volt power to high power latch relay A7A1K1A through diode A7A1CR1 and to high voltage on relay A7A1K3 through diode A7A1CR3; also energizes filament on sequence through diode A7A1CR17. When lighted, indicates that high Power latch relay A7A1K1A is energized.
POWER:	
RAISE (A5S6)	Applies 28 volt power to RAISE relay A7A1 through normally closed contacts on LOWER relay A7A1K4.
LOWER (A5S7)	Applies 28 volt power to LOWER relay A7A1K4 through normally closed contacts on RAISE relay A7A1K5.
PA TUNING (A9C6)	Screwdriver adjustment; sets PA tuning capacitor A9C6 to resonate node 1 of the output network.
CONTROL-LOCAL/REMOTE (A5S10)	In LOCAL position, connects jumper between "remote plate off" and "fail safe" circuits. In REMOTE position, applies 28 volt power to remote control terminal board A7A1TB1-1.
PA FIL (A6R1)	Screwdriver adjustment to set PA filament voltage.
MOD FIL (A6R2)	Screwdriver adjustment to set modulator filament voltage.

TABLE 3-2. INTERNAL CONTROLS AND INDICATORS

CONTROL/INDICATOR	FUNCTION
Oscillator 1 Select (A1S1)	Operates A1K1 latching relay to select RF oscillator 1.
Oscillator 2 Select (A1S2)	Operates A1K1 latching relay to select RF oscillator 2.
Oscillator 1 Frequency (A1C2)	Screwdriver adjustment to set frequency of oscillator 1.
Oscillator 2 Frequency (A1C9)	Screwdriver adjustment to set frequency of oscillator 1.
Oscillator 1 Indicator (A1CR7)	LED on module A1 showing that oscillator 1 has been selected.
Oscillator 2 Indicator (A1CR6)	LED on module A1 showing that oscillator 2 has been selected.
RF Indicator (A2S1)	LED on module A1 showing that there is RF output from the module.
IPL On/Off (A2S1)	Connects instantaneous peak limiter (positive and negative af clippers) into the circuit.
Carrier Interlock (A2CR8)	LED on module A2 showing that carrier interlock (A7TB10 and 11) is closed, plate contactor (A8K1 is energized, and RF drive loss circuit is not energized.

TABLE 3-2. INTERNAL CONTROLS AND INDICATORS

CONTROL/INDICATOR	FUNCTION
Low Power Adjust (A2R37)	Screwdriver adjustment to set low power output to desired fraction of high power output.
Negative Clipper (A2R73)	Screwdriver adjustment to set level of negative af clipper.
Positive Clipper (A2R76)	Screwdriver adjustment to set level of af positive af clipper.
Indicator Reset (A3S1)	Removes +28 volt power from overload indicators to reset them to "off" condition.
VSWR (A3CR1)	LED on module A3 showing that reflected power overload circuit has been tripped.
ARC (A3CR2)	LED on module A3 showing that arc sensor circuit has been tripped.
HVPS (A3CR3)	LED on module A3 showing that HVPS overload circuit has been tripped.
HVPS O/L (A3R1)	Screwdriver adjustment to set trip level for HVPS overload circuit.
VSWR O/L (A3R5)	Screwdriver adjustment to set trip level for reflected power overload circuit.
RF Drive Loss (A6A1CR6)	LED on backplane showing that RF driver current is greater than 1.5 A.
RF Driver Overcurrent (A9A4R103)	Screwdriver adjustment to set level of driver current that will cause RF drive to be removed from driver.

TABLE 3-3. METERS ON THE TRANSMITTER.

METER	FUNCTION
AC TEST (A5M1)	Provides front panel metering of AC power line voltages (line to line in 200- to 250-V operation and line to neutral for 345- to 435-V operation) and both PA and modulator filament voltages.
DC TEST (A5M2)	Provides front panel metering of all power supply voltages except switching modulator bias. Also shows RF driver current.
PLATE VOLTAGE (A5M3)	Indicates PA plate-to-cathode DC voltage.
PLATE CURRENT (A5M4)	Indicates PA plate current.
RF POWER (A5M5)	Indicates forward or reflected RF power output terminals.
RF CURRENT (A9M1)	Optional meter to read RF current at transmitter power output terminals.

TABLE 3-4. TYPICAL METER READINGS

METER	SWITCH POSITION	FULL-SCALE READING	TYPICAL READING
AC TEST	PHASE A	300 V	210 V
	PHASE B	300 V	210 V
	PHASE C	300 V	210 V
	PA Fil	9 V	7.3 V
	MOD FIL	9 V	7.3 V
DC TEST	-12 V	15 V	12.0 V
	-6 V	15 V	6.0 V
	+5 V	15 V	5.0 V
	+12 V	15 V	12.0 V
	+28 V	30 V	28.0 V
	DR Ec	300 V	200.0 V
	DR Ic	15 A	3.0 A
	HVPS	15 kV	14.0 kV
PLATE VOLTAGE		6 kV	5.0 kV
PLATE CURRENT		2 A	1.25 A
RF POWER	Forward	120%	100% (5 kW)
	Reflected	12%	0
RF Current		15 A	10 A (Unmodulated)

3-3. OPERATING PROCEDURE

Read and study this complete section before trying to operate the 315R-1 transmitter.

3-3.1 PRIMARY POWER

Apply 3-phase power to the transmitter by closing the fused disconnect wall switch.

Close all three circuit breakers located on the circuit breaker panel on the front of the transmitter to the ON (up) position.

The control circuits are now energized and ready to receive commands.

3-3.2 FILAMENT ON

Press the FILAMENT ON button. This applies power to the blower. When the blower comes up to speed, the air interlock closes, applying power to the PA and modulator filaments, the RF driver, and the bias power supply. If all the door interlocks are closed, the modulator thermal interlock is closed, and the overload relay is not operated, the PLATE OFF light will be lighted, indicating that the plate circuit is ready to be operated in either low power (LP) or high power (HP).

3-3.3 PLATE ON, LOW POWER

Press the LOW POWER ON button. Adjust the LOW POWER control on the PWM module (A2R37) to set the plate voltage to the level required to produce the proper low power output.

3-3.4 PLATE ON, HIGH POWER

Press the HIGH POWER ON button. Use the RAISE or LOWER controls to set the plate voltage to the level required to produce the proper high power output. Return to LOW POWER and reset the LOW POWER adjustment for the proper low power level again (operating the RAISE or LOWER controls in high power changes both the high and low power settings).

3-3.5 OPERATIONAL ADJUSTMENTS

3-3.5.1 FILAMENT VOLTAGE

Adjust both the PA and modulator filament voltages to 7.3 +/-0.1 volts as indicated on the AC TEST METER on the front panel. Filament voltage specified on the manufacturer's data sheets for the 3CX3000F7 is 7.5 volts RMS. However, tube life can be increased significantly by operating a slightly reduced filament voltage. Performance in the 315R-1 transmitter is not degraded by reduction of 2 to 3 percent below specified filament voltage and tube life is increased appreciably.

CAUTION

IN NO CASE SHOULD THE FILAMENT VOLTAGE BE REDUCED MORE THAN 5 PERCENT (BELOW 7.13 VOLTS) BECAUSE THE "GETTERING" ACTION OF THE TUBES WILL BE IMPAIRED, CAUSING FILAMENT "POISONING" AND CONSEQUENT TUBE FAILURE.

3-3.5.2 POWER OUTPUT CONTROL, HIGH POWER

Transmitter "loading" is adjusted at the factory to the customer's specified value. No "loading control" is provided on the 315R-1 transmitter. When operating in high power, or if the power output as indicated by the customer "common point" meter is either too high or too low due to minor changes in the antenna system, the power output should be adjusted to the proper value by operating the RAISE or LOWER controls on the front panel. If changes in the antenna system are greater than approximately 5 percent, the tap on the coupling coil (A9L3) must be repositioned to accommodate the changed condition. If the plate voltage required for the proper "common point" current exceeds the range of 1.2 to 1.3 A, coupling coil should be adjusted to bring the voltage and current within these limits. See Paragraph 5-3.9 for this procedure.

3-3.5.3 POWER OUTPUT CONTROL, LOW POWER

NOTE

The proper high power settings should be made as described in Paragraph 3-3.5.2 before the low power settings are made.

After setting the power output to its proper level, as described in Paragraph 3-3.5.2, the desired low power can be set by pressing the LOW POWER button and then adjusting the low power control on the PWM card (A2R37) to obtain the power level desired.

3-3.5.4 INSTANTANEOUS PEAK LIMITER (IPL)

The IPL negative and positive limiters are energized by turning the IPL switch on the PWM card (A2S1) to the ON position. When this switch is in the OFF position, both the negative and positive IPL limiters are disconnected from the audio circuitry and have no effect on the audio levels. However, the clamp circuit (A2R58) is always active and is set at the factory to limit the positive peaks to +130% modulation of the 5.5-kW carrier. If this circuit needs readjustment, follow the procedure outlined in Section 5, Paragraph 5-4.1.3.

To set the positive and negative IPL limiters, first turn the IPL switch to the OFF position and adjust the audio input level with program material (not single tones) until the program material just lights the +125% indicator on the modulation monitor. At this time, the transmitter will be rather severely overmodulated in the negative direction. Turn the IPL switch to the ON position and adjust the negative limiter (A2R76) until it just prevents the negative 100% indicator on the modulation monitor from indicating (counterclockwise lowers the limiting level). Now adjust the positive limiter (A2R76) until it just prevents the +125% indicator on the modulation monitor from indicating.

When properly set, the negative levels of modulation down to -95 percent can be achieved without reading -100 percent, and positive levels of modulation up to +120 percent can be achieved without reading +125 percent.

It should be noted that the IPL circuits in the 315R-1 transmitter are not intended to replace processing of the audio program material. The design intent is to allow the program material to be set to provide a slightly higher average modulation level without exceeding the peak limits set in either the negative or positive direction. This is accomplished by hard limiters that have no AC coupling following them. Thus tilt and overshoot are minimized and a better limiting performance is achieved. It is therefore recommended that, if limiting is to be used, it should be done by the IPL circuits in the transmitter and not in the external audio processor.

The ability to achieve good positive peak modulation depends on two things in a PWM transmitter. First, it must be loaded properly. In the case of the 315R-1 this means that the ratio of plate voltage to plate current must be equal to 4000 ohms.

E_{BB}/I_B = 4000 ohms

Any deviation from this nominal value causes an improper termination of the 70-kHz filter and therefore degrades the audio performance in both peak capability and distortion. Second, the HVPS voltage must be high enough to allow the positive peaks. In the 315R-1 the HVPS should be about 13.7 kV under load (high power carrier at 95-percent modulation) and it will rise to about 14.5 kV under no load (low power carrier or when the carrier interlock is open, which turns off the 70-kHz switching).

CAUTION

IN NO CASE SHOULD THE HVPS VOLTAGE EVER EXCEED 15.0 KV.

Power supply components may be damaged if the HVPS is operated with the voltage above 15.0 kV.

Depending on the station line voltage, and the line voltage variation experienced during operation, the taps on the HVPS transformer should be set to give a nominal HVPS output voltage of 13.7 kV at high power (5.0- to 5.5kW carrier) under program modulation. This will provide adequate positive peak capability if the transmitter is properly loaded (E_{BB}/I_B= 4000) and the IPL limiters are set properly.

Again in no case should the HVPS voltage be allowed to rise above 15.0 kV or damage to the transmitter may result. Refer to the tables and charts in Section 2 to select the proper transformer taps for your line voltage. If you have set the taps for your line voltage, and still the HVPS voltage is too low, you may increase it by setting the taps for one step (5 percent) lower than your line voltage.

CAUTION

DO NOT EXCEED SETTING THE TAPS FOR ONE STEP (5%) LOWER THAN YOUR LINE VOLTAGE OR SATURATION AND OVERHEATING OF THE TRANSFORMER MAY RESULT.

If you have different antenna impedance for different antennas (night and day) or for your dummy load, these should all be adjusted to present the same load to the 315R-1 to achieve proper performance in all the loads; otherwise, performance will differ in the different loads depending on how the transmitter is loaded in each load.

3-3.5.5 POWER AMPLIFIER TUNING

The PA TUNING control (A9C6) is a screwdriver adjustment available through the hole in the meter door. It should be adjusted to the "dip" in plate current, as indicated on PLATE CURRENT meter A5M3. In some cases, a slight improvement in PA efficiency and/or a slight reduction in audio distortion can be achieved by detuning about one-half division CW (high frequency side) from the plate current dip. Under no conditions should the plate be detuned more than 50mA from the dip in plate current.

3-3.6 MAINTENANCE ADJUSTMENTS

The following controls, although available on the front of the 315R-1 transmitter, are maintenance adjustments and should only be adjusted by qualified personnel with the proper test equipment following the procedures described in the paragraphs listed below:

CONTROL	PROCEDURE PARAGRAPH NO.
Carrier Regulation	5-3.6
Audio Tracking	5-3.5
LF Distortion	5-3.4
Oscillator 1 Frequency	5-3.1
Oscillator 2 Frequency	5-3.1
Pulse Width	5-3.2
HVPS Overload	5-3.7
VSWR Overload	5-3.8

3-4. SHUTDOWN PROCEDURE

3-4.1 NORMAL SHUTDOWN

a. Press PLATE OFF switch.

b. Press FILAMENT OFF switch.

c. Open the HIGH VOLTAGE, BIAS PS and LOW VOLTAGE circuit breakers on the transmitter front panel.

d. Open the primary power disconnect switch.

3-4.2 EMERGENCY SHUTDOWN

a. Press FILAMENT OFF switch.

b. Open HIGH VOLTAGE, BIAS PS, and LOW VOLTAGE circuit breakers

or

c. Open primary power disconnect switch.

SECTION 4 - PRINCIPLES OF OPERATION

4-1. INTRODUCTION

This section presents the principles of operation for the 315R-1 5-kW AM Transmitter at two levels. The first level is an overall functional description of the transmitter on a block diagram basis. The second level provides a detailed explanation of the individual transmitter circuits.

4-2. OVERALL FUNCTIONAL DESCRIPTION

The basic circuits of the 315R-1 transmitter are the RF oscillator, driver, power amplifier, audio input, modulator, and power supplies. Figure 4-1 is a simplified block diagram of the transmitter.

4-2.1 RF CIRCUITS

A dual crystal oscillator feeds the solid state driver circuit. The RF driver operates at a 500-watt power level to drive the high efficiency RF power amplifier. The power amplifier uses a third harmonic resonator in its plate circuit to approximate square wave or switching operation; this increases the RF power amplifier efficiency from about 82 percent to nearly 90 percent. The power amplifier operates with its plate at DC ground. This eliminates the usual RF blocking capacitor, bypass capacitor, and RF choke in the high voltage feed circuit, simplifying maintenance, and allowing direct metering at ground potential.

The RF output is coupled to the antenna through a 4 node bandpass network. This network has a very flat response near the carrier frequency in order to pass the sidebands but has very steep skirt attenuation. This provides adequate attenuation of all harmonics without the use of traps.

An RF power meter is provided at the transmitter output to read both forward and reflected power on a 50-ohm transmission line.

4-2.2 HIGH VOLTAGE POWER SUPPLY/MODULATOR CIRCUITS

Plate voltage for the RF power amplifier is provided by a series regulated high voltage power supply (HVPS). The series regulator is operated in the switching mode to achieve high efficiency (about 90%).

The high voltage power supply must provide enough voltage to permit the RF power amplifier to achieve +125 percent modulation on positive peaks. With no modulation, the series switching regulator (modulator) regulates the high voltage power supply voltage (about 13.7 kV) down to the level required for the normal 5-kW carrier (about 5 kV). This is done by allowing the tube to be "on" for approximately 40 percent of the time and "off" for about 60 percent of the time. This on/off cycle operates at a 70-kHz rate.

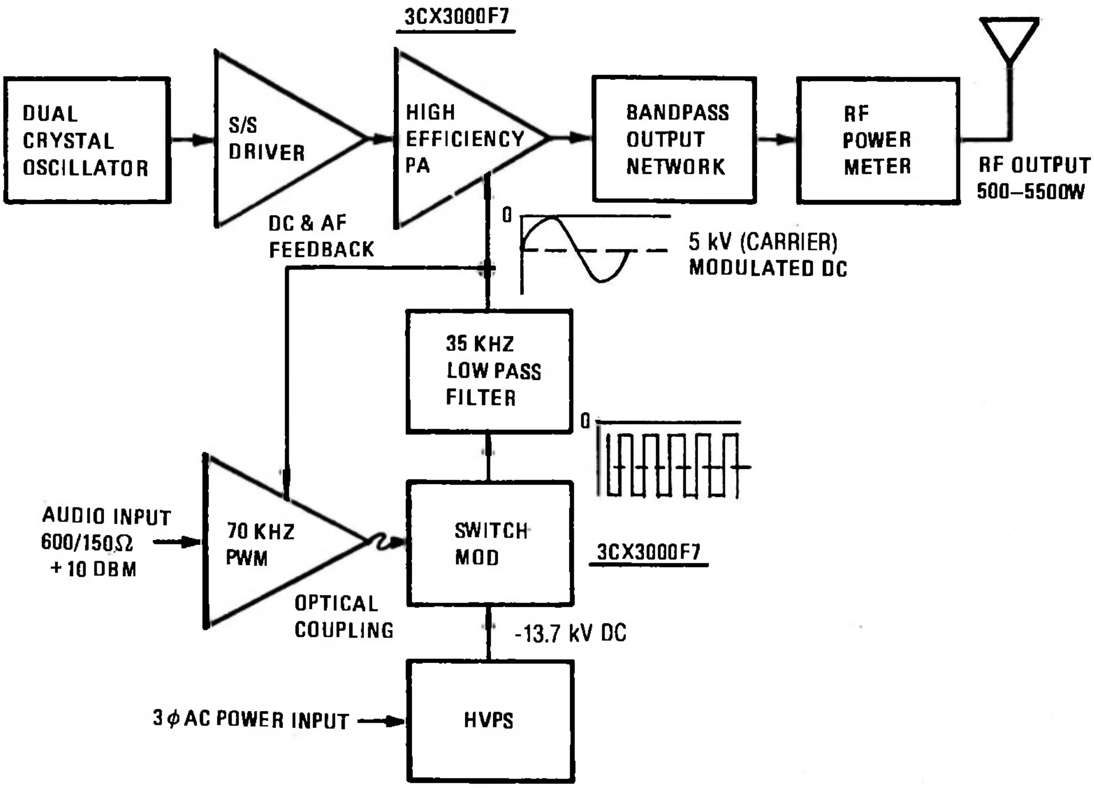


Figure 4-1. 315R-1 Simplified Block Diagram.

To modulate the carrier, the on/off duty cycle (40 percent on) is varied at the modulation rate. This causes the average voltage supplied to the RF power amplifier to vary modulation. On maximum (125 percent) positive modulation peaks, the voltage increases to 11.25 kV, which means that the modulator is on nearly all the time. In the negative modulation trough, the voltage decreases to 0 volt, which means that the modulator is off all the time.

Since the modulator is switching at a very fast rate (about 70 kHz), it can follow the audio frequencies from DC to higher than 10 kHz. A filter is used between the modulator and the RF power amplifier to allow DC and audio modulation to pass, but prevents the 70-kHz switching signal from modulating the carrier. This filter is very important in determining the performance of the transmitter and is discussed in detail in Paragraph 4-3.2.3.

4-2.3 AUDIO INPUT CIRCUITS

The incoming audio signal is applied to the pulse width modulator (PWM), which converts it into a 70-kHz pulse width modulated signal to drive the switching modulator. The PWM output is coupled to the switching driver module through a fiber optic cable. Optical coupling is used to isolate the low level voltage PWM circuit from the high voltage modulator circuit.

4-2.4 LOW VOLTAGE POWER SUPPLIES

The transmitter contains four low voltage power supplies to provide the various DC voltages required by the transmitter. These supplies are the logic power supply, 28 volt power supply, RF driver power supply, and switching modulator bias power supply.

4-2.5 CONTROL AND MONITOR CIRCUITS

The 315R-1 transmitter control circuits can be operated either locally at the front panel, from an optional extended control panel, or from a remote control interface assembly. Remote control is established by setting the front panel CONTROL switch to REMOTE; however, the local controls are always active regardless of the CONTROL switch setting.

Monitors are provided for the major functions in the transmitter. Both local and remote monitor functions are always energized.

The LED indicators are included on certain circuit cards to aid in troubleshooting.

4-3. DETAILED DISCUSSION OF CIRCUITS

The following subparagraphs discuss the individual circuits in detail. These subsystems are RF circuits, modulator circuits, audio input circuits, high voltage power supply, low voltage power supplies, and control and monitor circuits.

4-3.1 RF CIRCUITS

The RF circuits are a dual crystal oscillator, a solid state RF driver, an RF power amplifier, a 4 node bandpass network, and an RF power meter.

4-3.1.1 RF EXCITER MODULE A1

The RF exciter module contains two separate crystal oscillators, a frequency divider, amplifiers, a one-shot multivibrator, and a relay. Figure 4-2 is a block diagram of the RF exciter.

Each crystal oscillator operates at either twice or four times the transmitter output frequency, depending on the frequency. If the frequency is 1070 kHz or below, the oscillators operate at four times the output frequency; if the frequency is 1080 kHz or above, the oscillators operate at twice the output frequency. The desired oscillator output is selected by double coil latching relay K1, which is operated by the OSC 1 SEL or OSC 2 SEL push-button switches on the RF exciter module front panel. The relay can also be operated from the remote control panel by applying +28 volts either to A7TB2-6 to select oscillator 1 or to A7TB2-9 to select oscillator 2. The LED indicators (CR7 and CR8) on the module front panel indicate which oscillator has been selected. Remote indication is provided by a +28-volt signal, either on A7TB2-7 for oscillator 1, or on A7TB2-8 for oscillator 2.

Relay K1 couples the output of the selected oscillator to buffer amplifier Q3, which drives frequency divider U1. The outputs from U1 are connected at jumper pins 1, 2, 3, and 4 so that either division by 2 (jumper pin 1 to pin 3) or division by 4 (jumper pin 1 to pin 2 and pin 3 to pin 4) can be selected.

From jumper pin 3, the divider output at the operating frequency is applied to one-shot multivibrator U2. The PULSE WIDTH control (R20) on the module front panel adjusts the multivibrator time constant to provide a 120 degree wide, rectangular output pulse. The output from pin 1 of U2 is fed to isolation amplifier Q9 to provide a frequency monitor output to A7J1. The output from pin 6 of U2 is applied through buffer amplifier Q8 to output amplifiers Q4, Q5, and Q6 to provide the drive signal to RF driver module A9A4 (refer to Paragraph 4-3.2.1). The RF INDICATOR (CR6) lights when RF output is present.

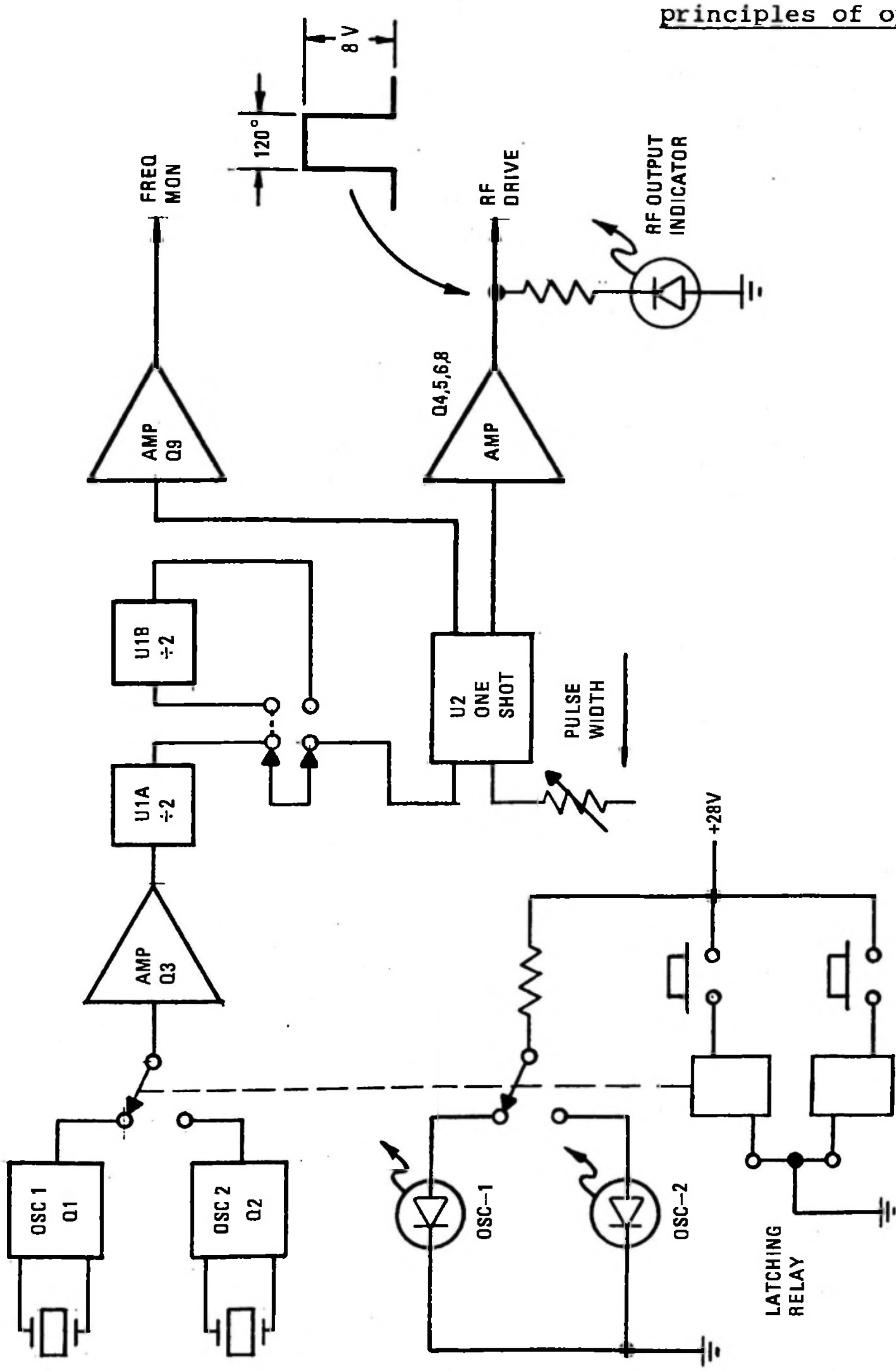


Figure 4-2. RF Exciter Block Diagram.

4-3.1.2 RF DRIVER MODULE A9A4

The RF driver is a totem pole bridge amplifier operating in the switching mode. It contains eight power transistors driven by complementary pair emitter follower Q10 and Q11.

A transformer with one primary and four secondaries drives the bridge amplifier so that opposite legs are turned on and off in sequence by the 120 degree drive signal. The output is taken from the common junctions in the bridge, and is AC coupled through C3 and C13 to power amplifier grid transformer A9T1 (refer to Paragraph 4-3.1.3).

R1 provides a metering sample for the driver collector current. Normal current is 3.0 amperes at 200 volts Ecc.

A protection circuit comprised of U101 and Q101 is used to remove RF drive from the driver during times of excessive driver current. This is done by sampling the voltage developed across meter shunt R1 and using it to trigger one-shot multivibrator U2. This in turn drives transistor Q101, which shunts the input drive signal at the collector of Q9 and temporarily (for about 100 milliseconds) removes drive to the power stages, preventing them from being driven to overload conditions. If the overload persists, the drive will be shut off again after a 100-ms delay. Under these conditions, the driver is effectively turned off continuously.

Another protection circuit involving the driver is located on card cage backplane A6A1. This circuit senses the RF driver current by sampling the voltage developed across R1. This sample is coupled from the driver through pin 6 to pin 14 of XA1 on the backplane. When the driver current drops below 1.5 amperes, Q1 turns off, which turns off drive loss indicator CR6 and allows Q2 to turn on. This shorts out the carrier interlock signal going to PWM card A2, stops the 70-kHz switching, and removes high voltage from the RF power amplifier.

4-3.1.3 HIGH EFFICIENCY POWER AMPLIFIER A9V1

The high efficiency power amplifier is an Eimac 3CX3000F7 high mu, zero bias triode, operating class C with a third harmonic resonator in its plate circuit to enhance the efficiency. Figure 4-3 is a simplified schematic of the power amplifier.

The power amplifier (PA) is driven by the RF driver output through broadband PA grid transformer T1. Grid leak bias is provided by C25 and R10. L13 limits the RF power in R10. The transformer secondary is center-tapped to permit neutralizing the power amplifier through C14, C15, C16, C17, C18 and C29.

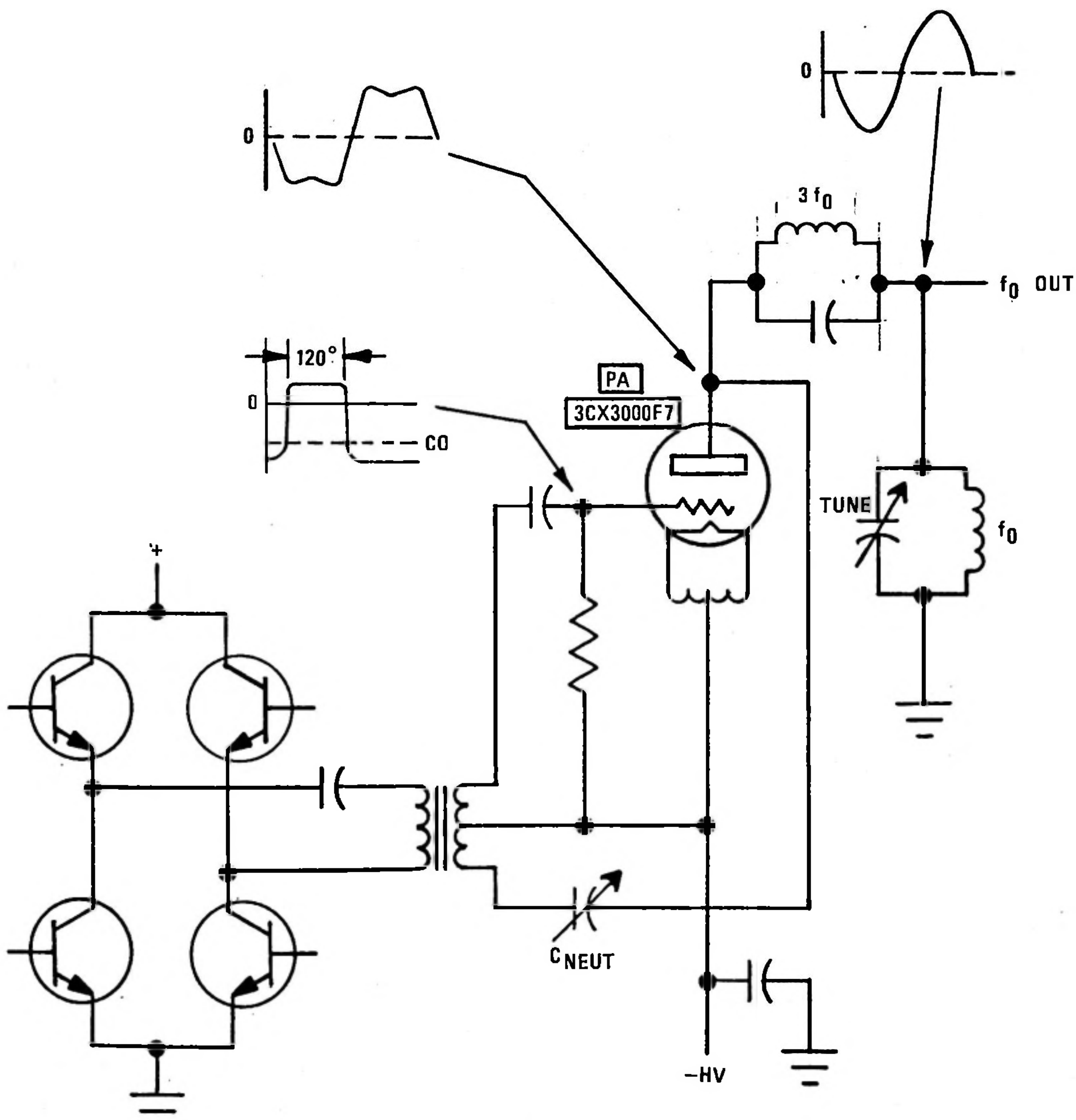


Figure 4-3. Power Amplifier, Simplified Schematic.

The power amplifier plate circuit is coupled to the RF output network through the third harmonic resonator, which consists of C10 and L7. There is no coupling or blocking capacitor or RF feed choke. These components are not required because the plate is connected to DC ground through L1 of the RF output network.

High voltage is supplied to the power amplifier as a negative voltage on the cathode (filament) instead of a positive voltage on the plate. This arrangement eliminates several high voltage components and simplifies the metering circuits. The negative high voltage comes from the switching modulator (refer to Paragraph 4-3.2.1) through the 70-kHz filter. The final capacitor in the 70-kHz filter also serves as the cathode RF bypass to ground. The negative high voltage (approximately 11.25 kV on modulation peaks) is applied to the center tap of PA filament transformer T4. The center tap of the PA grid transformer is also connected to the center tap of T4. This means that both the PA filament transformer and the PA grid transformer must isolate the negative high voltage from their primary circuits. For this purpose, these transformers have special high voltage insulation ratings between their primary and secondary windings.

The drive signal on the power amplifier grid is adjusted to be a 120 degree rectangular pulse so that its third harmonic content is the correct amount and phase to add with the fundamental signal to produce a semisquare wave at the power amplifier plate. By properly shaping this waveform (refer to Figure 4-4), the efficiency of the power amplifier is raised from normal 82 percent to approximately 88 percent. With pulse width control on the RF exciter module, A2R20, correctly set, the power amplifier supplies a 5500-watt output at 5.0-kV plate-to-cathode voltage, with a plate current of 1.25 amperes. This is an efficiency of 88 percent.

The pulse width should never be adjusted to a pulse narrower than 100 degrees nor wider than 140 degrees. Adjustment to pulse widths beyond these values can cause excessive harmonic currents in the power amplifier and lead to poor efficiency and problems with arcing, instability, and bad distortion.

4-3.1.4 RF OUTPUT NETWORK

The RF output network is a 4 node, synchronously tuned, bandpass network. It consists of four parallel tuned circuits with 90 degree inductive couplings. Figure 4-5 is a simplified schematic diagram of the output network, showing the method of coupling and design center values for each node Q.

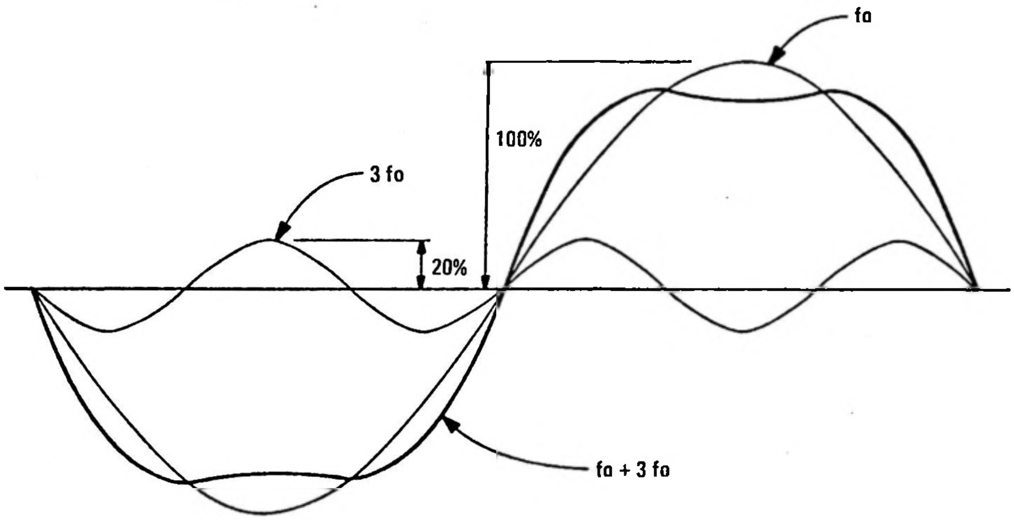


Figure 4-4. High-Efficiency Waveform.

WARNING: DISCONNECT PRIMARY POWER BEFORE SERVICING.

The RF power amplifier feeds node 1. Node 1 is bottom-coupled to node 2. Node 2 is top-coupled to node 3. Node 3 is bottom-coupled to node 4, which feeds the RF output through the RF power meter (refer to Paragraph 4-3.1.5). The bottom coupling between nodes 1 and 2 and between nodes 3 and 4 is achieved by tapping one coil on the other as shown in Figure 4-5. The top coupling between nodes 2 and 3 is determined by the value of L3. The coupling values are set at the factory to provide proper loading on the power amplifier. Slight adjustment of the power amplifier loading can be made without degrading performance by changing the value of L3 a turn or two. Decreased inductance decreases the loading. If more adjustment is required than can be obtained with L3, the antenna impedance variation is probably excessive and should be corrected.

The shape of the passband response is determined by the relative value of each node Q to the others. Generally, the Q is high at node 1 and following node Q's taper downward to node 4. This is the origin of the term Q Taper network. In this application, the Q Taper is chosen to give a critically coupled response that is very flat. When properly tuned into a 50-ohm load, the network passband response is flat to within +/-1 dB over 5 percent of the carrier frequency. If the load impedance is not flat or symmetrical over the sideband frequency range, the transmitter output network cannot correct this deficiency.

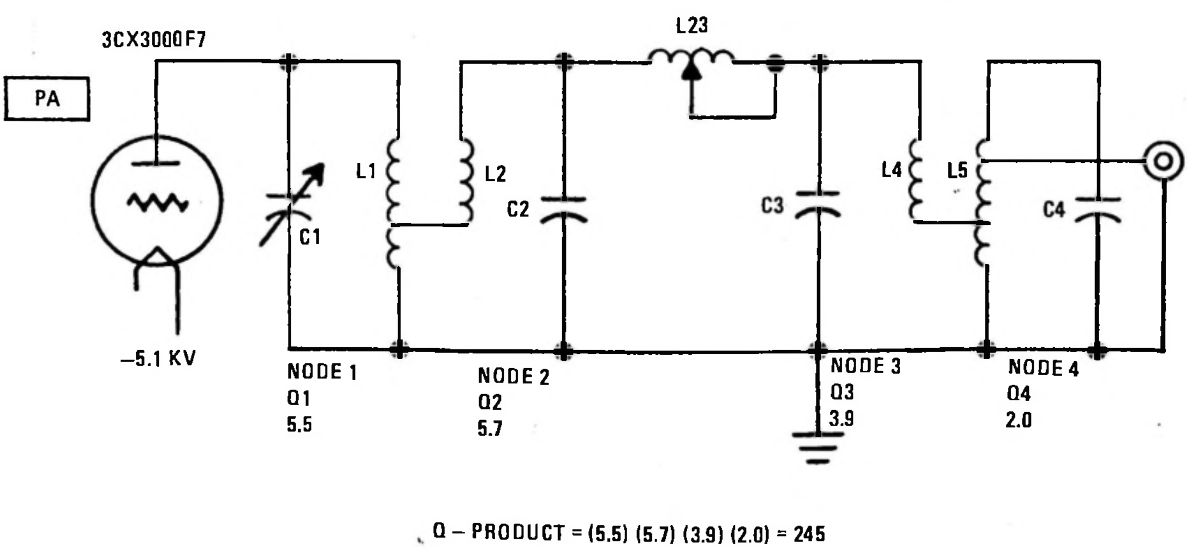


Figure 4-5. 4-Node RF Output Network.

Because it is symmetrical (being bandpass, not low pass) and has a very broad flat response, the Q Taper network contributes very little additional attenuation to sidebands. By comparison, the conventional low-pass network is neither symmetrical nor broad in response and normally contributes significant additional attenuation to the sidebands. Figure 4-6 provides a comparison of the response curves of a Q Taper bandpass network and the low-pass network.

The Q product (Q1 X Q2 X Q3 X Q4) determines the steepness of the skirts of the passband. With four nodes and three inductive couplings, the Q product required to obtain 80-dB attenuation of the second and higher harmonics is 245. The Q required for each individual node to attain this product is quite low, as shown in Figure 4-5. This results in low circulating current, which translates to low component stress. The network components in the 315R-1 transmitter may appear to be very small for a 5-kW transmitter, but they are completely adequate, because the unique Q Taper network reduces component stress to levels far below those in other 5-kW transmitters.

The modulation monitor sample is provided by coil L6. It has adjustable taps for high and low power settings. The sample is obtained from a tap on node 4 coil L5.

4-3.1.5 RF POWER METER A9A6

The RF power meter circuit is a directional coupler designed to provide both forward and reflected power readings relative to a 50-ohm unbalanced load. It consists of a line current sampling pickup in the form of a shielded ferrite toroidal coil in combination with two capacity dividers to sample the line voltage. The current sample is taken in a balanced fashion (center-tap ground). The two current samples are combined with the voltage samples and rectified. One output provides a reading proportional to forward power and the other provides a reading proportional to reflected power. The voltage samples are adjustable to permit balancing the circuit to the 50-ohm load. The forward and reflected power sensing circuit can be balanced for impedances other than 50 ohms, but the values of A9A6C3 and C4 may have to be changed. For higher impedance lines, these capacitors may need to be reduced in value.

Calibration adjustments permit setting the forward and reflected power meters to the desired power level readings. Isolation amplifiers in control logic module A3 isolate the metering circuit from the detectors. The reflected power signal is used to actuate an overload circuit in control logic module A3 when the reflected power reaches a predetermined level. The meters are calibrated at the factory to read 100% (120% full scale) at 5.0 kW in the forward power position and 10% (12% full scale) at 500 watts in the reflected position. The VSWR overload is set to trip at 500 watts reflected power, which represents a 2:1 VSWR with 5.0-kW forward power.

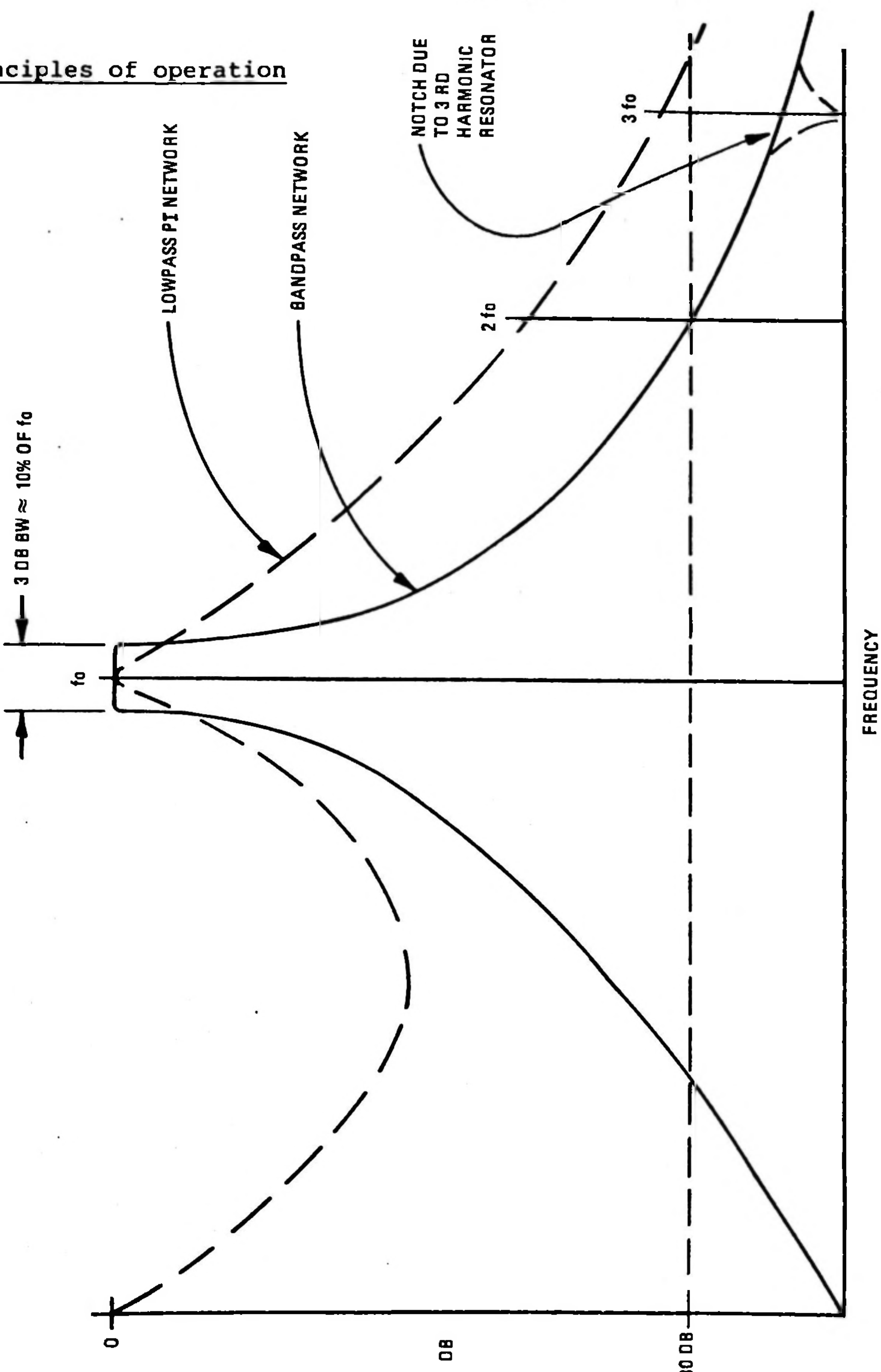


Figure 4-6. Comparison of Q Taper™ Bandpass and Usual Low-Pass (PI) Network Response.

Switch S1 permits reversing the current sample, which in turn reverses the forward and reflected readings (forward now reads reflected power and vice versa). This permits balancing both forward and reflected power and setting the VSWR overload without physically turning the VSWR detector around. Remember that the reflected power (now reading forward) is only 500 watts full scale and will trip the VSWR overload. Transmitter power must be reduced below 500 watts during these adjustments.

4-3.2 MODULATOR CIRCUITS

The modulator in the 315R-1 transmitter is basically a series regulator between the high voltage power supply (refer to Paragraph 4-3.3) and the RF power amplifier (refer to Paragraph 4-3.1.3). It is operated in the switching mode at a frequency of 70 kHz. This allows the modulator to operate at a very high efficiency (about 90 percent), and requires a fast recovery clamp diode and a low-pass filter circuit to function properly. Figure 4-7 is a simplified schematic diagram of the 315R-1 transmitter and illustrates the functions of the modulator and associated circuits.

The modulator circuits are a pulse-width modulator, a switching driver, a switching modulator, feedback circuits, automatic modulation control, and instantaneous peak limiter.

4-3.2.1 PULSE-WIDTH MODULATOR (PWM) MODULE A2

The pulse-width modulator accepts the incoming audio signal and converts it to a 70-kHz pulse width modulated signal to drive the switching modulator. This conversion is performed by comparing the audio signal with a 70-kHz triangular waveform in integrated circuit U9, which is a comparator amplifier. The comparator output is a PWM waveform, as illustrated in Figure 4-8. This is a series of pulses at a 70-kHz rate whose widths vary the audio signal. The PWM output from the comparator is fed through an inverter and a NAND gate to provide interlock and overload functions. The NAND gate output drives transistor Q1, which controls an LED mounted on the backplane behind the A2 module.

The LED light output is coupled through a fiber optic cable to a photodiode mounted on switching driver module A9A3 (refer to Paragraph 4-3.2.2). Fiber optic coupling is used for high-voltage isolation. The PWM module (A2) is low-level circuitry, very close to ground potential. Switching driver module A9A3 floats on the negative high-voltage power supply, which feeds the cathode of the switching modulator. This approximately 13.7-kV difference in potential is isolated by the fiber optic cable.

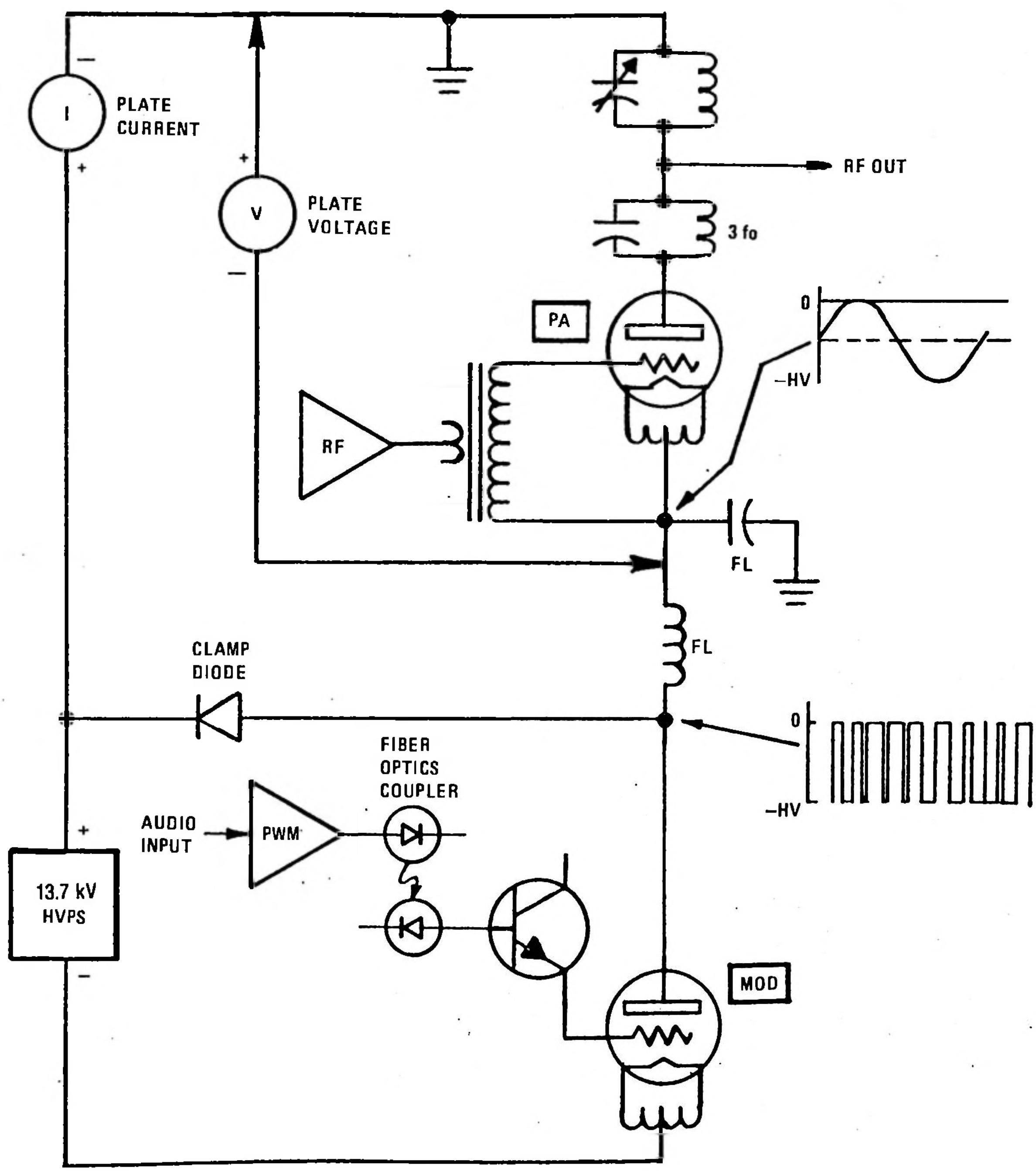


Figure 4-7. Transmitter Simplified Schematic.

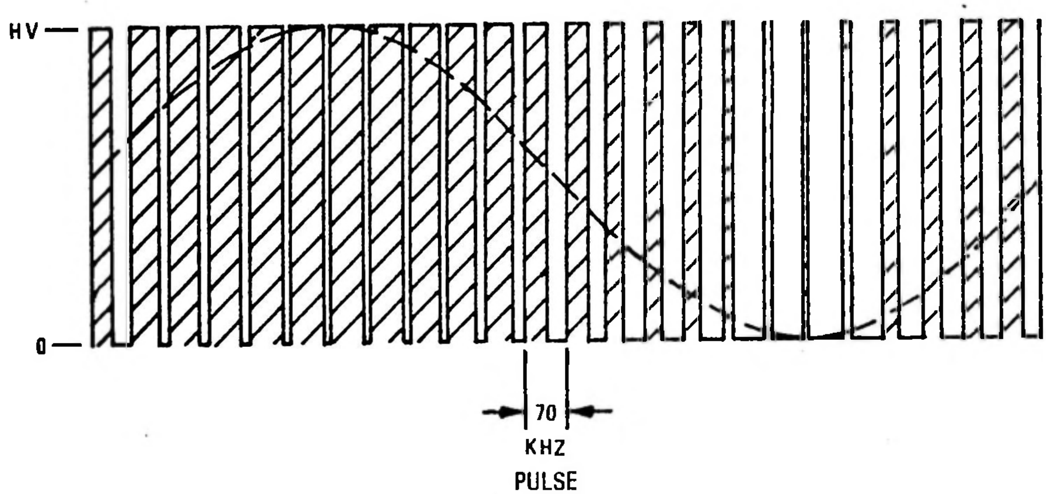


Figure 4-8. Typical PWM Waveform.

WARNING: DISCONNECT PRIMARY POWER BEFORE SERVICING.

4-3.2.2 SWITCHING DRIVER MODULE A9A3

The switching driver is a solid state amplifier that amplifies the PWM signal output to the level necessary to drive switching modulator A9V2 (refer to Paragraph 4-3.2.3). Figure 4-9 is a simplified block diagram of the switching driver and its interrelations with other modules of the transmitter.

The input signal to the switching driver is the PWM light (ultraviolet) signal output, carried by the fiber optic cable to the photodiode.

The output of the photodiode triggers a comparator at the PWM rate, and thereby regenerates the original PWM electrical signal. A complementary pair emitter follower stage isolates the comparator output and drives the intermediate amplifier stage at the 28-volt level. This intermediate amplifier is a common emitter stage driving another complementary pair of emitter followers. The intermediate amplifier drives the high voltage amplifier, which in turn drives the Darlington switch stage that is directly coupled to the modulator grid. When the Darlington switch is turned on, it drives the modulator grid to +125 volts with respect to the cathode and the modulator conducts. When the Darlington switch is turned off, the modulator grid is connected to -125 volts with respect to the cathode and the modulator is biased off.

The switching driver stages are all DC coupled and the light signal in the fiber optic cable has a DC component. It follows that the entire signal path, from the PWM generator to the modulator grid, is DC coupled.

The switching driver circuits are referenced to the modulator cathode, which is connected to the negative high voltage power supply. Therefore, the +125-volt and -125-volt power supply, which furnishes power for the switching driver and acts as bias for the switching modulator, is also floating on, or referenced to, the negative high voltage. For this reason, this power supply requires a special transformer with high voltage insulation between the primary and secondary windings.

4-3.2.3 SWITCHING MODULATOR A9V2

The switching modulator is an Eimac 3CX3000F7 high mu, zero bias triode operated as a switching regulator in the negative high voltage supply to the power amplifier. A 70-kHz filter and a clamping diode are associated with the modulator. Figure 4-10 is a simplified schematic of the switching modulator circuit.

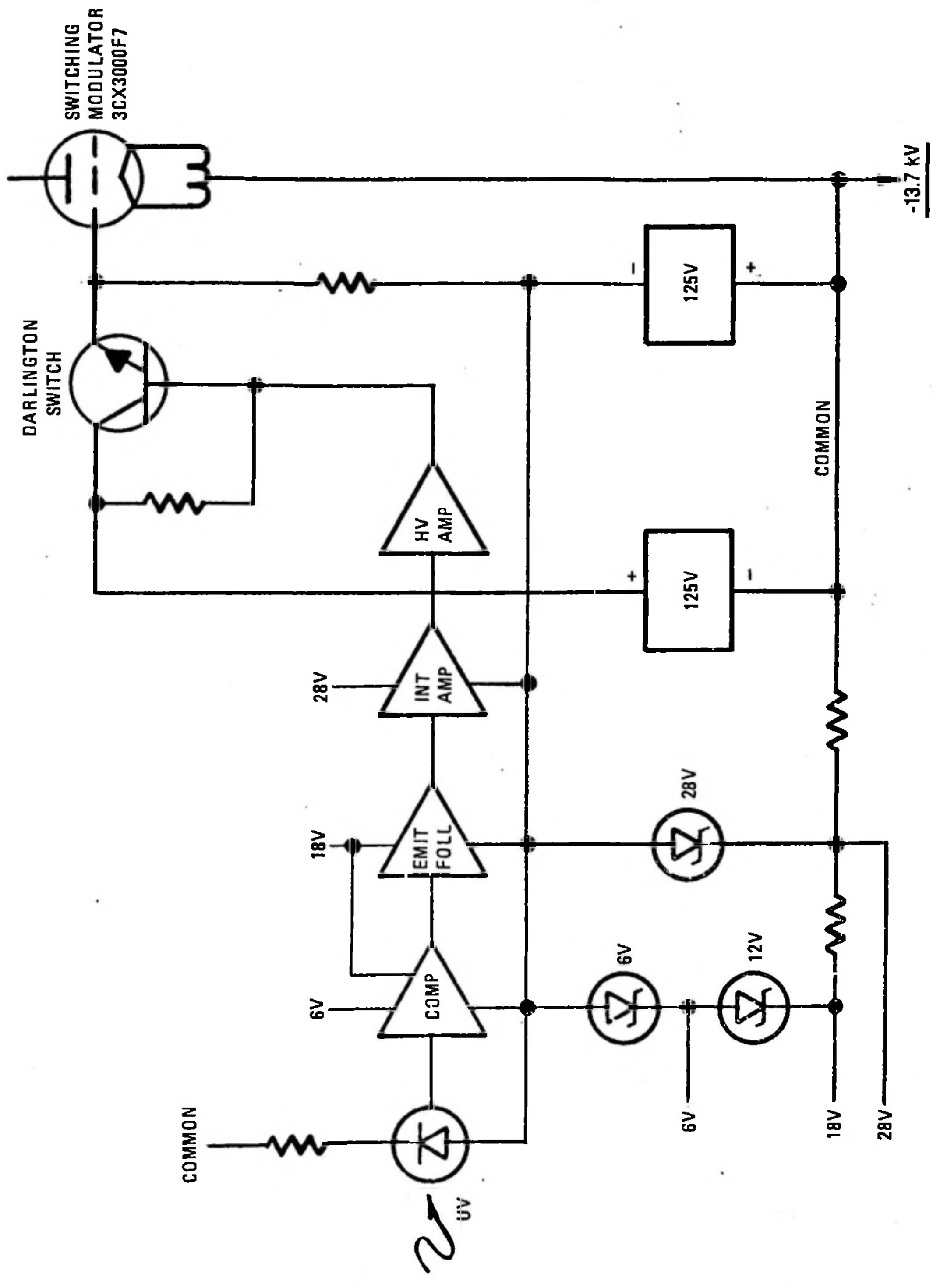


Figure 4-9. Switching Driver Operation, Block Diagram.

WARNING: DISCONNECT PRIMARY POWER BEFORE SERVICING.

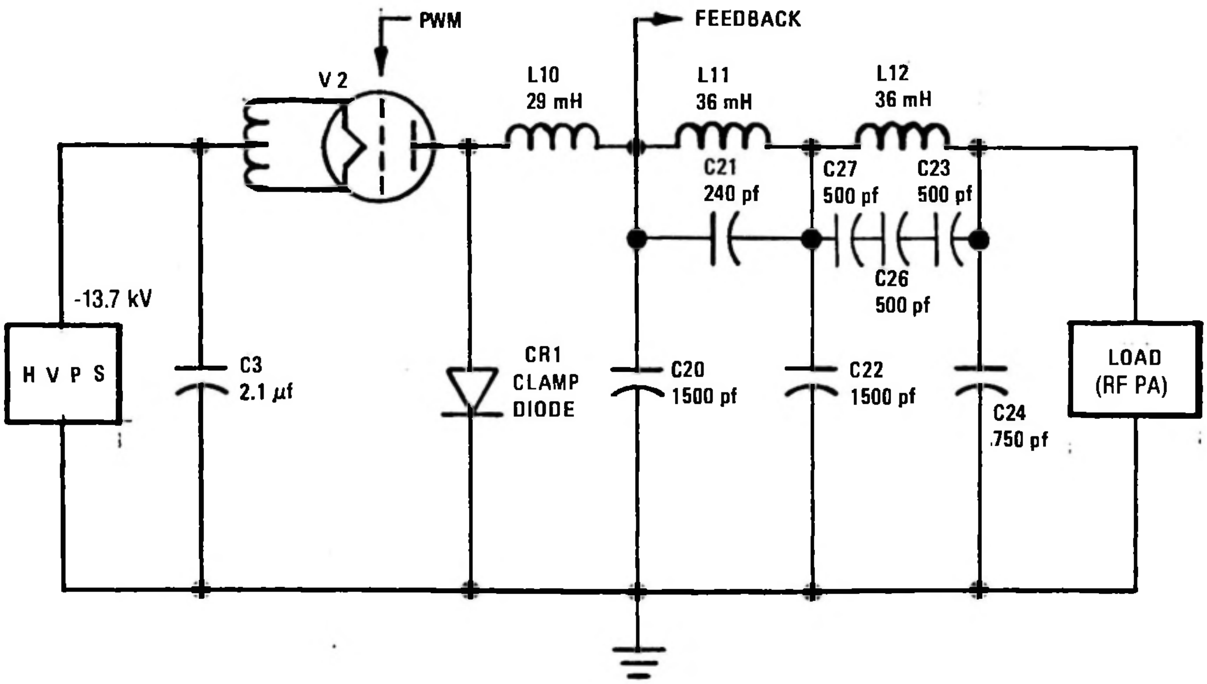


Figure 4-10. Switching Modulator Circuit.

The -13.7-kV high voltage supply output is applied to the switching modulator cathode. The switching driver drives the modulator grid alternately +125 volts and -125 volts with reference to its cathode. This causes the tube to act as a switch in the negative high voltage line to the power amplifier cathode, developing a waveform on the modulator plate, which switches between -13.7 kV when the tube is on and 0 volts when the tube is off.

The duration of the "on" time is a function of the PWM drive signal, and determines the average voltage level of the high voltage switching waveform.

The switching modulator plate is connected to the input of the 70-kHz filter and to the clamping diode. The clamping diode provides a current path when the switching modulator tube is biased off. The current flowing in the input coil of the 70-kHz filter flows alternately through the tube when it is on and through the clamping diode when the tube is off.

The switching waveform contains a DC component (the plate voltage for the RF power amplifier), an audio component (the modulation), and 70-kHz components of the switching signal. The 70-kHz filter is low pass with a cutoff frequency at approximately 35 kHz. This allows the DC and audio modulation components of the waveform to pass through the filter but stops the 70-kHz switching signal and its sidebands and harmonics. This low pass filter is very important in the performance of the switching modulation system. It is designed to terminate in an impedance of 4000 ohms, as provided by the properly loaded RF power amplifier. If the loading of the RF power amplifier is not correct, the effect on the filter termination can cause some degradation in the high frequency audio performance. For this reason, it is necessary to maintain proper loading on the RF power amplifier.

4-3.2.4 FEEDBACK CIRCUITS

Audio feedback is taken from the modulated high voltage DC rather than from the detected RF envelope. This is done to minimize the effect of RF power amplifier loading on the audio feedback. The feedback is taken from the first node of the 70-kHz low pass filter. A compensated R/C divider (A9A1) delivers a feedback signal at the -4-volt level to PWM module A2. A low-level filter in the PWM module filters out the 70-kHz components and passes the DC and audio components with a minimum of audio phase shift. This permits the feedback to be used to higher audio frequencies and with better high frequency audio performance.

Since the switching modulator and the feedback circuits are DC coupled, the feedback is effective down to and including DC. This has two advantages; first, it provides excellent low frequency audio performance, and second, it makes it a very simple matter to adjust the power output. A DC reference voltage is set by a motor driven potentiometer and the feedback loop adjusts the plate voltage to match it.

4-3.2.5 AUTOMATIC MODULATION CONTROL AND INSTANTANEOUS PEAK LIMITER

Two modulation level control circuits contribute to the superior audio performance of the 315R-1 transmitter. These are the automatic modulation level control circuit and the instantaneous peak limiter (IPL). These two circuits, in combination, adjust the audio level to maintain a high level of modulation at all power levels and to compensate for power line voltage variations.

A sample of the high voltage power supply voltage, which varies with power line voltage variations, is combined with a sample of the DC feedback voltage, which varies with the power output level. This combination controls the gain in the AGC circuit to compensate for these variations.

The IPL is a diode clipper circuit that uses a pair of Schottky diodes to achieve a very sharp clipping level. Separate diodes are used to provide both positive and negative peak clipping of the audio signal. Note that these clippers are not intended to be used as an audio processor; many commercially available units are designed for that purpose. The IPL is intended only to prevent overmodulation due to a few peaks in the audio signal, while allowing a relatively high average level of modulation to be maintained. The very sharp knee of these diodes makes it possible to achieve an average negative modulation level between 90 and 95 percent without exceeding 100 percent on strong music passages, and an average positive modulation from 115 to 120 percent without exceeding the +125 percent limit.

4-3.3 HIGH VOLTAGE POWER SUPPLY

The high voltage power supply used in the 315R-1 transmitter is a 12-phase power supply, in which the ripple frequency is doubled and the filtering requirements are reduced to the point where a filter choke is unnecessary. Only a filter capacitor is required. Elimination of the filter choke also eliminates low audio frequency resonances that occur in most high voltage power supply filters. Figure 4-11 is a simplified schematic diagram of the high voltage power supply.

The high voltage power supply is composed of two 3 phase full wave bridge rectifiers, each operating at half the output voltage, connected in series to obtain the full output voltage. A special power transformer is furnished, which has two separate 3 phase secondary windings, one for each of the 3-phase full wave rectifiers. Both secondaries are extended delta circuits. Each secondary has a ripple frequency six times the line frequency - (6 x 60 = 360 Hz). Since the two secondary outputs are 60 degrees out of phase, the ripple frequencies are additive in series (360 + 360 = 720 Hz). This is 12 times the line frequency; hence the name, 12-phase power supply. The ripple magnitude at this frequency is very small (nearly 40 dB down from the DC output level), so the filtering required is minimal.

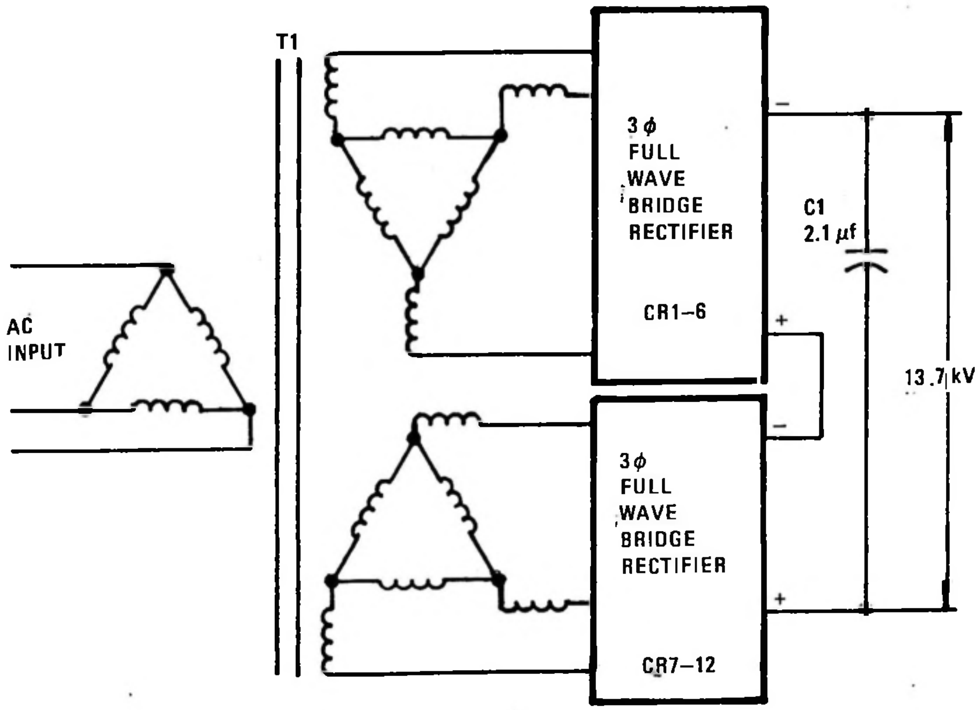


Figure 4-11. High-Voltage Power Supply Circuit.

WARNING: DISCONNECT PRIMARY POWER BEFORE SERVICING.

In this power supply, adequate filtering is provided by a capacitance of only 4.2 microfarads, A10C1 and A9C3.

The nominal output voltage of the high voltage power supply is 13.7 kV, and the normal load current at carrier conditions is about 500 mA. At 100 percent modulation, the current increases to about 750 mA. It should be remembered that, in the switching type of series modulator, the high voltage power supply is connected to the load for only approximately a 40 percent duty cycle. This means that the average current is about 40 percent of the power amplifier plate current (1.25 A X 40% = 500 mA). The difference current, between 1.25 A and 500 mA, flows through the clamping diode. Note that these numbers represent no modulation conditions. The relative currents vary during modulation, with the power supply furnishing more current and the clamping diode less, as the modulation level increases.

The transformer is rated for either 50- or 60-Hz operation. Taps are provided on the primary windings to accommodate input voltages from 200 to 250 volts in delta or from 345 to 435 volts in a wye connection. Section 2, Installation, of this instruction book contains tables showing the proper tap connections for various lines voltages.

4-3.4 LOW-VOLTAGE POWER SUPPLIES

The 315R-1 transmitter uses only two triode tubes. This simplifies low-voltage power supply requirements. As a result, there are only four low-voltage power supplies in the transmitter. These are logic power supply module A4, the 28 volt power supply, the RF driver power supply, and the modulator bias power supply.

4-3.4.1 LOGIC POWER SUPPLY MODULE A4

The logic power supply module provides the +5, -6, and +/-12 volts required by the various low level circuits. The transformer for this power supply is mounted on the bottom of the RF box to the left rear; it supplies 24 volts AC to the full wave rectifier in the module. The transformer center tap is also carried through to provide +/-18 volt outputs. Integrated circuit regulators provide the regulated +5, -6, and +/-12 volt outputs. The regulators are mounted on heat sinks in the module for cooling. The negative regulators (-6 and -12 volts) are located on a separate isolated heat sink and the positive regulators (+5 and +12 volts) on the module shield. The LED indicators on the module front panel indicate the presence of each of the four voltages and the DC TEST meter reads all four output voltages.

4-3.4.2 28-VOLT POWER SUPPLY

The 28-volt power supply is a single phase, full wave bridge circuit, followed by a regulator on the A7A2 card and power transistors A7Q1 and A7Q2. It is capable of supplying about 4 amperes of output current.

CAUTION

CAUTION SHOULD BE EXERCISED TO ENSURE THAT THE 28-VOLT POWER SUPPLY IS NOT LOADED WITH EXTERNAL LOADS IN EXCESS OF 2 AMPERES.

This power supply furnishes power for the various 28 volt relays and the high voltage power supply contactor. In addition, the +28 volts is used for intermediate RF amplifiers in RF driver module A9A4. A 28 volt output is also available at the remote control terminal strip A7TB2 for use in remote control of the transmitter.

4-3.4.3 RF DRIVER POWER SUPPLY

The RF driver power supply is a single phase, full wave bridge circuit that supplies 3.0 amperes at 200 volts to the solid state RF driver module. A single LC filter section, consisting of A7L1 and A7C2, provides adequate filtering of the ripple frequency.

The transformer for this power supply has a 1:1 turns ratio, primary to secondary. It supplies 208 volts RMS to RF driver-rectifier A7CR2. Additional taps on the secondary provide 115 volts RMS to furnish power for RAISE/LOWER motor A6B1 and cabinet fan B2.

4-3.4.4 MODULATOR BIAS POWER SUPPLY

The modulator bias power supply is a 3 phase, full wave bridge circuit that uses the center tap of the secondary to provide +125 and -125 volt outputs. Each output, therefore, is a half wave rectified signal.

The common center tap of this power supply is connected to the negative high voltage (-13.7 kV), which is connected to the modulator (A9V2) cathode. Thus, the modulator grid can be switched by the switching driver from +125 to -125 volts with reference to its cathode to control the modulator output.

Note that the transformer for this power supply has special insulation between the secondary windings and the primary and frame to withstand the 13.7-kV potential between them. Note also that the printed circuit board containing the rectifiers and filters is isolated electrically from the chassis because of the 13.7-kV differential.

4-3.5 CONTROL AND MONITOR CIRCUITS

The control circuits operate from an internal +28-volt power source. The local controls are always active, regardless of the position of LOCAL/REMOTE switch A5S10. With the switch in the REMOTE position, the +28-volt power source, in addition to operating the local controls, is connected to A7A1TB1-7 to furnish power for remote control interface assembly A7A4 (PN 627-9721-002). In the LOCAL position, the LOCAL/REMOTE switch connects a jumper across the remote fail-safe terminals at A7A1TB1-7 and -8.

4-3.5.1 POWER CONTROL CIRCUITS

The power control circuits include the indicating control push-button switches on the front door of the transmitter, the low-level 28-volt relays located on the control relay printed circuit board on the rear of the left side panel, the blower and filament contactors on the left side panel, and the high voltage contactor on the right side panel. Three door interlock switches are connected in series to prevent application of high voltage if the front door is open or if either the lower front panel or the rear cover is removed. An air interlock switch that senses air pressure in the power amplifier grid compartment prevents application of filament power without proper cooling. The operation of the power control circuits when the FILAMENT ON and the PLATE ON sequences are initiated is described in the following subparagraphs.

a. Filament-On Sequence. When LOW VOLTAGE circuit breaker A6CB1 is closed, 28-volt power is applied to the power control circuits. The FILAMENT OFF switch will light, indicating that the filament power is off. If all three door interlock switches are closed, overload relay A7A1K2 on the control relay card is not energized, and the thermal interlock switch is closed, then the PLATE OFF switch will also light. This is the normal condition prior to turn-on.

When the filament on switch is pressed, it energizes blower contactor A7K1, which is then held in through its holding contacts, 4 and 12. These contacts are in series with the FILAMENT OFF switch and the remote FILAMENT OFF switch (or if the LOCAL/REMOTE switch is in the LOCAL position, the jumper on A7A1TB1-3 and -4). When the blower contactor is operated, it applies AC power to blower B1 and cabinet fan B2. When the blower and the fan reach operating speed and the resulting air pressure in the power amplifier grid compartment reaches 19 mm (0.75 in.) of water, air interlock switch A9S3, located on the bottom of the power amplifier grid compartment, closes and applies 28 volts to filament contactor A7K2. When the filament contactor is operated, it connects AC power to both the power amplifier and modulator filament transformers. It also switches 28-volt power from the lamp in the FILAMENT OFF switch to the lamp in the FILAMENT ON switch (both local and remote on A7TB1-8 and -9).

The FILAMENT OFF switch is normally closed. When it is pressed, it causes the holding circuit on the blower contactor to be interrupted; de-energizing the blower contactor and shutting off the blower and cabinet fan. It also removes the 28-volt power from the filament contactor. This disconnects the AC power from the two filament transformers and switches 28-volt power from the FILAMENT ON switch lamp to the lamp in the FILAMENT OFF switch.

There is no filament time delay circuit because the filaments in both the power amplifier and modulator tubes are thoriated tungsten and require no warm-up period. They reach operating temperature in about 1 second and are not damaged or degraded by immediate application of high voltage power.

b. Plate-On Sequence. The PLATE OFF switch must be lighted, indicating that the door interlocks are all closed, the bias circuit breaker is on, the thermal interlock is closed, and overload relay A7A1K2 is not energized before 28-volt power is available for the plate on sequence.

The plate on sequence is started by pressing either the PLATE LP or the PLATE HP switch. Because there is choice of either low power or high power, latching relay A7A1K1 is provided on the control relay card to "remember" which has been selected. Pressing either switch puts the latching relay in the corresponding position. The latching relay controls the LP ON relay in PWM module A2 and also energizes HV ON relay A7A1K3 on the control relay card. When the HV ON relay is energized, through either diode A7A1CR3 (LP ON) or CR4 (HP ON), it holds itself through holding contacts 9, 10 and 5, 6 in series with the overload relay, the door interlocks, and the PLATE OFF switches (local and remote at A7A1TB-7 and -8). It also applies 28 volt power to high voltage contactor A8K1. This connects 3 phase power to the high voltage plate transformer and 28-volt power to the carrier interlock terminal on terminal board A7TB2-11. This terminal is connected through any desired external interlock circuit and returned to A7TB2-10, where it allows the PWM signal in PWM module A2 to start switching. This arrangement makes it possible to remove voltage on the power amplifier without de-energizing the high voltage power supply and can be used for such purposes as interlocking day/night switching, dummy load interlock, etc.

The PLATE ON signal, either PLATE LP or PLATE HP is also coupled back to the FILAMENT ON circuit through diode A7A1CR17 to enable a complete turn on sequence by merely pressing either the PLATE LP switch or the PLATE HP switch without first turning the filaments on. When this is done, there is only a slight delay until the blower reaches operating speed and about 1 second thereafter until the filaments in the power amplifier and modulator tubes reach operating temperature.

The LED indicators on the A7A1 card indicate which relays are actuated to aid in troubleshooting the power control circuits.

4-3.5.2 OVERLOADS AND RECYCLE

Control logic module A3 contains the overload and recycle circuits. The three overload circuits are the high voltage power supply overload, the arc sensor, and the VSWR overload. Each overload circuit is connected to a separate LED indicator on the front panel of the control logic module. If any one of the overload circuits is actuated, it lights its indicator. It also sends a signal through the U1 logic gate to one shot multivibrator U2. The Q total output from U2 is coupled to U10B in PWM card A2. This causes the PWM pulse train to stop for about 100 milliseconds, removing high voltage from the RF power amplifier for that period of time. If the overload was due to some temporary cause and is no longer present after the 100 millisecond interruption, the PWM resumes, and normal operation continues. However, the LED indicator remains lighted until IND RESET switch S1 on the control logic module front panel is pushed to reset the SCR and extinguish the LED.

The Q total signal from U2 is also applied to the input of counter U3. The signal through logic gate U1 that causes U2 to operate is also coupled through a section of U6 to timer U5 and starts a timing cycle of about 20 seconds. The output of timer U5 is coupled through a section of U6 back to counter U3. The counter counts only during the timing cycle of timer U5. If it counts four overloads during the 20 second timing cycle, it then has an output on pin 9 of U3.

If RECYCLE switch A3S2 is in the ON position, the output on pin 9 of U3 is coupled to the second one shot multivibrator, the output operates overload relay driver A7A1K2 on control relay card A7A1, which opens the plate control circuit, dropping the high voltage. After this occurs, high voltage can be restored only by pressing either the PLATE LP switch or the PLATE HP switch again.

If RECYCLE switch A3S2 is in the OFF position, the recycle circuitry is bypassed. The original overload signal from U1 is coupled directly to U4 to operate overload relay driver Q4 and cuts off the high voltage on the first overload.

The circuit of Q5 and Q6 is an integrator, which also can operate overload relay A7A1K2. If the RECYCLE switch is ON, but a single extended (long time) overload occurs, integrator C20 charges, operating Q5, which operates the overload relay.

4-3.5.3 MONITOR CIRCUITS

The monitor circuits consist of the front-panel meters, the lighted switches, and the various LED indicators that show status, overloads, and performance.

Five front panel meters provide readings of input voltages, power amplifier DC input and RF output, and other internal voltages to be used in trouble shooting (refer to Section 6 of this instruction book). These five meters are AC TEST, DC TEST, PLATE VOLTAGE, PLATE CURRENT, and RF POWER.

The AC TEST meter has an iron vane movement, which allows RMS readings of the three AC input lines and the power amplifier and modulator filament voltages. The voltage shown on the meter is selected by the associated 5 position rotary AC TEST meter switch. In normal line voltage operation (200 to 250 volts), the input line voltage is measured line-to-line. In high voltage operation (345 to 435 volts), the input line voltage is measured line-to-neutral. The filament voltages are measured at the primaries because the secondaries are floating at the high voltage potential of -13.7 kV.

The DC TEST meter reads the logic power supply output voltages, the 28 volt DC power supply voltage, the RF driver supply voltage and current, and the high voltage power supply voltage. The voltage shown on this meter is selected by the associated 8 position rotary DC TEST meter switch.

The PLATE VOLTAGE meter reads the power amplifier plate-to-cathode DC voltage.

The PLATE CURRENT meter reads the power amplifier plate current.

The RF POWER meter reads either the forward power or the reflected power at the transmitter output to the antenna. Choice of forward or reflected power reading is chosen by operation of an associated 2-position rotary RF POWER FORWARD/REFLECTED switch.

In the FORWARD position, the meter reads up to 120 percent power; in the REFLECTED position up to 12 percent.

SECTION 5 - MAINTENANCE

5-1. INTRODUCTION

The maintenance section is divided into three major segments: Routine Maintenance, which should be performed on a routine or regular basis to prevent transmitter performance from deteriorating; Maintenance Adjustments, which might be needed from time to time, especially if a part or component is changed; and Special Maintenance Adjustments, which might be required in the event of a major change in operating conditions. The recommended test equipment to perform the maintenance described here is listed in Table 5-1.

Table 5-1. Recommended Test Equipment for 315R-1 Maintenance

Volt-ohmmeter
Oscilloscope, 5 MHz
Audio Oscillator, 20 KHz
Audio Distortion Analyzer
RF Dummy Load (10 kW)
Frequency Counter, 20 Hz to 5 MHz
Variable DC Power Supply (1.1 A)

5.2 ROUTINE MAINTENANCE

Routine maintenance should be performed on a regularly scheduled basis to guarantee adequate cooling of the transmitter for long life, cleanliness to minimize both high voltage and heating problems, and regular checks of operational adjustments to ensure top performance and to note any changes in the transmitting system that might indicate potential problem areas.

5-2.1 INLET AIR FILTER AND AIR SWITCH

The inlet air filter located on the lower rear cover of the transmitter should be inspected weekly and cleaned or replaced as necessary. Operation with a dirty filter can cause air starvation and result in reduced life and excessive failure of components, including the modulator and PA tubes. Frequency of this maintenance should be dictated by the general cleanliness of the transmitter environment.

The air interlock switch, A9S3, located on the bottom of the PA grid compartment behind the card cage, should be checked periodically to assure that it is operating properly to protect the transmitter. It is a pressure switch and is set to open when the pressure in the PA grid compartment drops below a safe level. To test its operation, either remove the blower fuse or open the meter panel door while the filaments are energized. If the air interlock is functioning properly, the filaments will be de-energized as indicated by the green FILAMENT-ON lamp extinguishing. If this does not happen, readjust the adjustment screw on the air interlock switch until proper operation is restored. If proper operation can not be achieved by adjusting the adjustment screw, the position of the microswitch may have slipped and need realignment. This can best be accomplished by removing the air switch and setting the position of the microswitch in combination with the adjustment screw to allow full travel [approximately 6.3 mm (1/4 in.)] of the diaphragm with the application of light air pressure at the inlet tube.

The switch should be adjusted while in the same relative position that it is when mounted in the transmitter, because gravity does have an effect on its operation. Because its operation is relatively delicate and its function rather important, it is advisable to check its operation routinely. As the air filter is inspected for cleanliness, the operation of the air interlock should be checked.

5-2.2 CLEANING

The transmitter should be inspected weekly for general cleanliness, particularly in areas where high voltage is present. Dust is attracted by the high voltage and will eventually lead to high voltage arcing and overload problems if not controlled by a preventive maintenance routine of regular cleaning. It is recommended that cleaning of the transmitter be accomplished using a vacuum cleaner rather than blowing with air pressure. Air pressure tends to blow the dirt into areas where it may lodge and cause more trouble than if it were left alone in the first place. Again, frequency of this maintenance should be dictated by the general cleanliness of the transmitter environment.

5-2.3 LUBRICATION

The only points in the 315R-1 transmitter requiring lubrication are the bearings of the blower motor. These can be accessed from the rear of the transmitter and should be lubricated with a few drops of a good grade light machine oil every 3 months of continuous operation under normal conditions. Under high ambient temperatures (100 degrees F or higher) more frequent lubrication, probably every 1 or 2 months, would be advisable.

5-2.4 NORMAL OPERATIONAL ADJUSTMENTS

There are very few normal operational adjustments required in the 315R-1. These are PA tuning, power output, and the IPL clipping levels.

5-2.4.1 PA TUNING

The PA tuning is a front-panel screwdriver adjustment and should be set for a dip in plate current. Sometimes the tuning can be turned slightly (approximately one-half turn) off the plate current dip to improve the audio distortion. This varies from one transmitter to another, depending on the operating frequency and loading of the PA. In any case, the amount of detuning should never exceed one-half division (25 mA) on the plate current meter. Any more detuning than this results in lowering the efficiency to an unacceptable level.

5-2.4.2 POWER OUTPUT LEVEL

Since there is no loading control, the power output level would be adjusted in high power by using the RAISE and LOWER controls to set the plate voltage to the level required to give the desired power output. After setting to the proper level in high power, switch to low power and adjust the LOW POWER adjustment on PWM module A2R37 to set the low power to the desired level.

As long as the antenna and/or dummy load impedance at the transmitter (measured at jack A9J1 in the rear of the RF box) is constant and presents the correct load to the transmitter, the only adjustments necessary are minor adjustments of the PA tuning and power level as previously described. If the transmitter load impedance varies more than approximately 5 percent from the correct value, the performance will be degraded to some degree. The proper loading is when the ratio of plate voltage to plate current is 4000 ohms.

$$E_{BB}/I_B = 4000 \text{ ohms}$$

At full power (5400 watts), this should nominally be a plate voltage of 5000 volts at a plate current of 1.25 amperes. If the loading varies enough to cause the plate voltage to go below 4800 volts or above 5200 volts, or if the plate current goes below 1.2 amperes or above 1.3 amperes, then the loading error is significant enough so that either the antenna/dummy load impedance needs to be corrected or the loading on the transmitter needs to be changed. This can be done by following the procedure outlined in Paragraph 5-3.9.

5-2.4.3 IPL CLIPPING CIRCUITS

The only other adjustments that might be required in normal operation are settings of the IPL clipping circuits. It should be remembered that these circuits are not intended to substitute for normal audio processing. They are designed only for protection of the transmitter and to prevent any audio spikes from overmodulating the transmitter in either the negative or positive direction.

To properly set them, first turn off the IPL switch located on PWM module A2. Adjust the incoming program audio material level until it just lights the +125% indicator on your modulation monitor. At this time, the transmitter will be heavily overmodulated in the negative direction. Now turn on the IPL switch and adjust the NEGATIVE LIMIT (A2R73) until the negative peaks of modulation no longer lights the -100% indicator on your modulation monitor, but does allow the negative peaks to achieve -95 percent modulation. Adjust the POSITIVE LIMIT (A2R76) until the positive peaks no longer light the +125% indicator on your modulation monitor, but do allow the positive peaks to achieve +120 percent modulation.

Once set, the IPL adjustments should remain the same unless the loading variations exceed the limits stated above.

5-2.5 TUBE FILAMENT VOLTAGE

If you have the filament regulator option, the filament voltages will remain very constant, even with line voltage fluctuations and, if properly set, will give very good tube life.

If you do not have the filament regulator option, the filament voltages should be monitored regularly and adjusted as required to stay within the desired operating range of 7.3 to 7.5 volts.

Adjust both the PA and modulator filament voltage rheostats (A6R1 and A6R2) to 7.3 +/-0.1 volts as indicated on the AC TEST meter on the front panel. Filament voltage specified on the manufacturer's data sheets for the 3CX3000F7 is 7.5 volts RMS. However, tube life can be increased significantly by operating at slightly reduced filament voltage. Performance in the 315R-1 transmitter is not degraded by reduction of 2 to 3 percent below specified filament voltage of 7.5 volts and tube life is increased appreciably.

In no case should the filament voltage be reduced more than 5% (below 7.13 volts) because the "gettering" action of the tubes will be impaired, causing filament "poisoning" and consequent tube failure.

5-2.6 ARC GAPS

There are three sets of arc gaps in the 315R-1 transmitter to protect various components from excessive voltages during fault conditions. The A9E11 and A9E13 gaps are located to the left of the modulator tube and should be set to a gap of 7.92 mm (5/16 in.) from the center post to negative high voltage (E13) and set to a gap of 6.35 mm (1/4 in.) from the center post to ground (E11).

The A9E9 and A9E10 gaps are located on PA grid transformer A9T1 and should be set to 0.254 mm (0.010 in.) each. These are very closely spaced and tend to collect dirt. They should be cleaned periodically depending on the general cleanliness of the transmitter environment.

Gap A9E5 is mounted to the right of the PA tube on the front of the neutralizing capacitors (A9C14-18) and is connected to an arc sensor circuit. This gap should be adjusted to 7.92 mm (5/16 in.).

5-3. MAINTENANCE ADJUSTMENTS

The following adjustments should not be required as a normal operating procedure, but may be required periodically due to slight changes in operating conditions, replacement of parts, or changes in ambient conditions.

5-3.1 RF OSCILLATOR FREQUENCY

The RF exciter module (A2) contains two separate crystal oscillators. Either oscillator circuit may be used, or if a spare crystal is installed, both oscillators can be used interchangeably. Each oscillator has an adjustment for setting the frequency of operation available from the front panel of the RF exciter module. A frequency monitor output of 5 volts p-p into 50 ohms is provided at A7J1, located on the left rear of the transmitter. This is adequate to drive most 50-ohm counters. If oscillator 1 is selected, as indicated by the LEDs on the front of the module, adjust C2. IF oscillator 2 is selected, adjust C9. If the crystal will not oscillate or stops oscillating before the correct frequency is achieved, the crystal is probably defective and should be replaced. The oscillator circuits are temperature-compensated to have less than 20-Hz change in frequency over a temperature range of -10 degrees to +50 degrees C ambient.

5-3.2 RF PULSE WIDTH

The RF pulse-width adjustment (R20) is also located on the front of the RF exciter module. Its purpose is to set the pulse width of the RF drive signal into the RF driver module to approximately 120 degrees. This provides the proper amount of third harmonic content in the RF drive signal to make the high efficiency Tyler circuit function properly. The output of the RF exciter module can be monitored with a scope by observing the waveform on pin 14 of the RF exciter module while it is operating on the card extender. This signal should be approximately 8 volts p-p and should show a positive-going pulse of about 120 degrees (onc-third duty cycle). With the proper setting of the pulse width, the PA anode waveform on C45 should look like the one shown in figure 5-1. Try to keep the positive pulse width between 110 and 130 degrees. A final slight adjustment of the control can be made while observing the audio distortion while modulating the transmitter with 1 kHz at 95 percent modulation. A very slight dip in the distortion of about 0.1 or 0.2 percent can be obtained by very carefully adjusting the pulse width, but not exceeding the limits of 110 to 130 degrees.

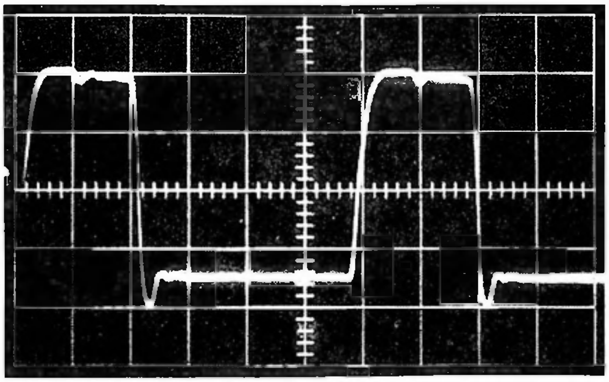


Figure 5-1. RF Exciter Output Waveform.

5-3.3 RF DRIVER PROTECTION CIRCUIT

The RF driver protection circuit acts to protect the RF driver when it is overloaded for any reason. It senses RF driver collector current, Ic, and if it exceeds a predetermined level, removes the drive signal to the RF driver by shorting the collector of the driver input stage to ground. To adjust the protect circuit, slowly increase the sensitivity by turning R103 in a CW direction in one-half turn steps until the transmitter either will not turn on (high power on) or sustain +125 percent positive modulation peaks. Correct setting is one-half turn CCW from this point. This allows the driver to handle turn-on transients and load variations due to normal modulation, but will protect the driver from fault conditions that might otherwise damage transistors.

5-3.4 LOW FREQUENCY DISTORTION

The LF distortion control (A2R3), located on the front of the PWM module (A2), should be adjusted for minimum intermodulation distortion or for minimum total harmonic distortion at 100 Hz. Sometimes there is a slight variation in results between high power and low power and a compromise setting should be made to achieve the best overall performance.

If distortion measuring equipment is not available, adjusting the LF distortion control for minimum audio at TP3 on the PWM module, while modulating 95 percent in high power with a 1-kHz tone, will be very close to the correct setting.

5-3.5 AUDIO TRACKING

The audio tracking adjusts the audio gain control circuits in the PM module (A2) to maintain the proper audio gain at any power level and will therefore always keep the modulation level constant with a given input audio level. The audio tracking control, A2R26, is located on the front of the PWM module and should be adjusted as follows:

a. Set 90 percent modulation at 1 KHz in high power operation.

b. Switch to a convenient low power level of about 1kW or less.

c. With the same audio input level, adjust the audio tracking control to get exactly the same 90 percent modulation level.

d. Return to high power; modulation level will now be slightly off from original 90% level. Reset input level to achieve 90% again.

e. Return to low power and again adjust the audio tracking control to get exactly 90% modulation.

f. Repeat steps d. and e. until there is no variation between high and low power. Reset the low power level, if necessary, back to the desired level.

5-3.6 CARRIER REGULATION

The carrier regulation should be set only after the LF distortion and audio tracking have been properly adjusted per Paragraphs 5-3.4 and 5-3.5.

The carrier regulation control, A2R49, is located on the front of the PWM module (A2). It adjusts the level of a small rectified audio signal that balances the natural tendency for a slight negative carrier shift. The carrier shift varies slightly with audio frequency and should be adjusted using a 400-Hz audio signal. Set the modulation to 95% in high power and adjust the carrier regulation control until the carrier shift is zero when the 400-Hz modulating signal is alternately turned off and on.

5-3.7 HIGH VOLTAGE POWER SUPPLY (HVPS) OVERLOAD

The HVPS overload adjustment, A3R1, is located on the front of the control circuit module (A3). The HVPS overload sensor, A10R1, is located on the A10 subassembly mounted on the rear bottom of the RF network compartment. Electrically, it is in the positive ground return of the HVPS and samples the HVPS current not the PA plate current. Due to the nature of the switching modulator action and the clamp diode action, the HVPS current is approximately 40% of the PA plate current at carrier conditions. At 100 percent modulation, the HVPS current increases to approximately 80 percent of the PA plate current value. The rest of the current flows in the clamp diode, which is returned to ground so its current does not flow in the HVPS overload sensor.

To adjust the HVPS overload, turn the transmitter off and connect a variable low voltage DC power supply (LVPS) between A10E9 and ground with the negative side grounded. Adjust the variable LVPS to produce 1.1 amperes of current flow in A10R1. With this connection, the plate current meter, A5M4, on the transmitter front panel will read the correct current of 1.1 amperes. Turn on only the low voltage circuit breaker, A6CB1, and adjust the HVPS overload adjustment on the control circuits module until the HVPS O/L indicator lights. Then recheck the trip point by turning down the current in the variable LVPS, resetting the HVPS O/L indicator by pressing IND RESET pushbutton A3S1, then slowly increase the current through the HVPS overload sensor from the variable LVPS again and observe the trip point. Readjust the HVPS overload adjustment, A3R1, until it trips at 1.1 amperes.

5-3.8 VSWR OVERLOAD

The following five adjustments are to be made to the RF power meter and the VSWR overload.

a. Reflected power balance, A9A6C6

b. Forward power balance, A9A6C5

c. Reflected power calibrate, A9A6R10

d. Forward power calibrate, A9A6R9

e. VSWR overload, A3R5.

The balance and calibrate controls for both forward and reflected power are located in the RF power meter sensor and can be accessed from the top of the transmitter. The VSWR overload is located on the front of control circuits module A3. In order to make the first four adjustments, a good load of the proper value must be connected to the transmitter with a means of accurately measuring the RF power output. These adjustments were made at the factory into a nominal 50 +j0 ohm dummy load. For loads between 48 +j0 ohms and no more reactance than +/-j5 ohms (SWR = 1.22:1), the factory settings are adequate and proper operation can be achieved without readjustment. If your antenna impedance exceeds this range, you have two choices: either change the antenna impedance to be within that range, or readjust the RF power meter to a new impedance range. This can be done only under power and therefore requires a known load and means of accurately measuring the power delivered to it. Paragraph 5-4.2 describes the procedure for balancing and calibrating the RF power meter, A9A6. If the calibration is adequate, the VSWR overload may be set as follows:

a. Set transmitter power output to 500 watts.

b. Place NORMAL-REVERSE switch, A9A6S1, in REVERSE (down) position.

c. Modulate transmitter to 95% at 1 kHz.

d. Adjust VSWR overload, A3R5, until VSWR overload trips. This sets VSWR overload to trip with a 2:1 VSWR with modulation. Return the NORMAL-REVERSE switch to its NORMAL (up) position.

5-3.9 POWER AMPLIFIER LOADING

If the loading on the transmitter is incorrect (see Paragraph 5-2.4.2 of this section), it can be readjusted to the proper value by following the procedure listed below.

Increasing the inductance (adding more active turns) to coupling coil A9L3 increases the loading on the power amplifier. This means that for the sample plate voltage, the plate current and power output will be higher. A very small adjustment in the value of A9L3 has a fairly large effect on loading. Never change its value by more than one turn in a step. After each change of A9L3, the PA tuning will need to be checked to make sure it is still tuned to the dip in plate current. Be sure that the RF pulse width is properly set to 120 degrees per Paragraph 5-3.2 and that the third harmonic resonator is properly tuned. If either one of these adjustments is not correct, it can erroneously cause the plate current to deviate from its normal value and make it seem that the loading is off. Correct operation is achieved with a ratio of plate voltage to plate current of 4000 ohms,

$$\frac{E_{BB}}{I_B} = 4000 \text{ ohms}$$

with the proper power output and PA efficiency. The efficiency is normally about 86 to 88 percent and the readings in Table 5-2 are typical.

5-3.10 PA NEUTRALIZING

The PA neutralizing is adjusted by varying the position of "clamshell" neutralizing capacitor (A9C29) mounted behind and to the left of the PA tube. This adjustment is made with the filament voltage on but with high voltage and bias voltage removed; therefore, it is necessary to have only the LOW VOLTAGE breaker turned on. To prevent the possibility of dangerous high voltage being present during this procedure, remember to turn off the BIAS and HVPS circuit breakers.

TABLE 5-2. 315R-1 TYPICAL METER READINGS

POWER OUTPUT (Watts	E_{BB} (Volts)	I_c (Amperes)	EFFICIENCY (%)
5500	5000	1.25	88
5400	4975	1.24	88
5000	4800	1.20	87
2500	3400	0.85	87
1000	2200	0.53	86
500	1500	0.40	84
250	1100	0.27	84

The transmitter must be terminated into a load resistor (not an antenna). This may be accomplished either by utilizing the station's dummy load or, if that is not available, simply by connecting a resistor of the proper value (normally 50 ohms) across the transmitter output. Two 100-ohm/2-watt resistors in parallel are recommended. The most convenient location to connect the resistor is from the J-plug connector to ground after removing the J-plug, which will disconnect the antenna from the transmitter output.

Remove the rear transmitter panel and the output network cover.

WARNING

THERE ARE 250 VOLTS AC PRESENT AT EXPOSED TERMINALS IN THE BOTTOM OF THE CABINET.

Since no high voltage will be present for this adjustment, it is not necessary to "cheat" or disable the rear door interlock. Loosen the setscrew that locks the neutralizing capacitor in place. Connect an oscilloscope to the modulation monitor sample (A9J2). With the front door closed, press the FIL ON push-button, which will apply filament voltage and will turn on the RF driver. Change the distance of the neutralizing to the PA tube while observing and adjusting for a minimum RF signal as indicated on the oscilloscope. This signal is RF energy that is coupled from the grid to anode due to inter-electrode capacitance of the PA tube. The effect of this capacitance is cancelled with proper negative feedback provided by the neutralizing capacitors. Use an insulated rod or dowel for adjusting capacitor A9C29 to minimize any shock hazard and to eliminate the effect your hand will have on the circuit. If A9C29 does not have the range to neutralize the PA tube, it may be necessary to replace A9C19 with another value.

Neutralization is factory adjusted and does not require adjustment unless there have been major changes in the output network, the third harmonic resonator, or when the PA tube is changed.

5-3.11 THIRD HARMONIC RESONATOR

The third harmonic resonator coil, A9L7, located above and behind the PA tube, is adjusted to give the proper waveform at the anode of the PA tube. This waveform can be observed with an oscilloscope connected to test point A9C46, mounted in the wall to the right of the PA tube. If the transmitter installation does not permit access to the outside of the cabinet at that point, test point A9C46 and its small pickup plate can be remounted in the top of the RF box above the PA, but not directly in the hot air stream. Make adjustments to the resonator coil in very small increments, no larger than 12.7 mm (one-half inch), until the waveform looks like that shown in Figure 5-2. The pulse width must also be adjusted properly to 120 +/-10 degrees to achieve this waveform.

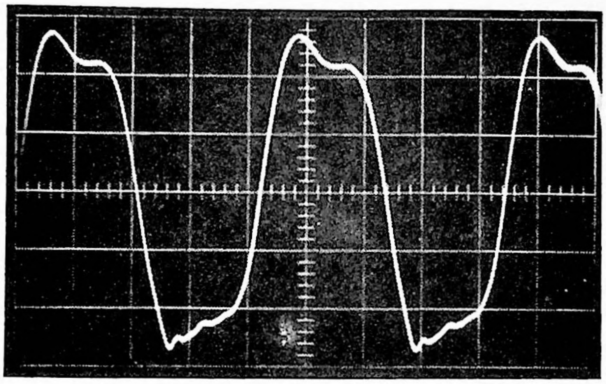


Figure 5-2. High Efficiency PA Anode Waveform.

5-4. SPECIAL MAINTENANCE ADJUSTMENTS

The following adjustments are major adjustments that are normally not required unless major components have been changed, operating frequency is changed, or the antenna impedance is changed. These adjustments should not be attempted unless a thorough understanding of the procedure and the proper test equipment are available.

5-4.1 PWM INTERNAL ADJUSTMENTS

There are four internal adjustments to be made in the PWM module. These adjustments are available when the PWM module is on the extender card with its top cover removed. All adjustments, except the clamp adjustment, can be made on the PWM module with the filaments and high voltage off. Only the low voltage circuit breaker, A6CB1, should be on.

5-4.1.1 SWITCHING FREQUENCY

Connect a counter to TP5 in the PWM module. Adjust switch frequency R62 to obtain a frequency of 70.0 +/-0.5 kHz. The waveform at TP5 should be a 70-kHz symmetrical triangular waveform of approximately 8 volts p-p.

5-4.1.2 COMMON MODE

Connect the two audio input lines together and apply an audio signal between these connected lines and ground. The audio should be at the +10-dBm level and 1 kHz. Observe the audio signal at TP1 with an oscilloscope and adjust R17 for minimum audio signal at TP1. Remove the connection between the audio input lines.

5-4.1.3 CLAMP

Operate the transmitter at high power into an antenna or dummy load. Modulate to 100 percent with a 1-kHz audio tone. Observe the modulated output waveform with an oscilloscope. Turn the IPL switch to the OFF position and increase the audio input level until it becomes flat on top (clipped by the clamp circuit), breaks into a ringing condition like that shown in Figure 5-3, or reaches +130 percent positive modulation. Adjust clamp R58 to just stop the ringing effect or to limit the positive peaks to +130 percent, whichever comes first. During this adjustment, it is normal to be overmodulated heavily in the negative direction. If a function generator is available, this adjustment can be made using non-symmetrical waveforms to achieve the 130 percent peak without overmodulating in the negative direction.

5-4.1.4 OFFSET ADJUSTMENTS

These adjustments can be made with the filaments and plate voltage off. Only the low voltage circuit breaker needs to be on. Remove U4 from its socket and connect the positive lead from a variable LVPS to TP3. Connect the negative lead to ground. With no audio input, observe the DC voltage at TP2 with an oscilloscope. With the variable LVPS set to 0 volt, adjust amplifier offset R42 for 0-volt DC at TP2. With the variable LVPS set to +6.0 volts at TP3, adjust control offset R40 for 0-volt DC at TP2. Repeat the above to steps until zero volt appears at TP2 under both conditions; that is, with either 0 or +6.0 volts at TP3. The voltage at TP2 may go either positive or negative and must be adjusted very carefully to be exactly zero volt.

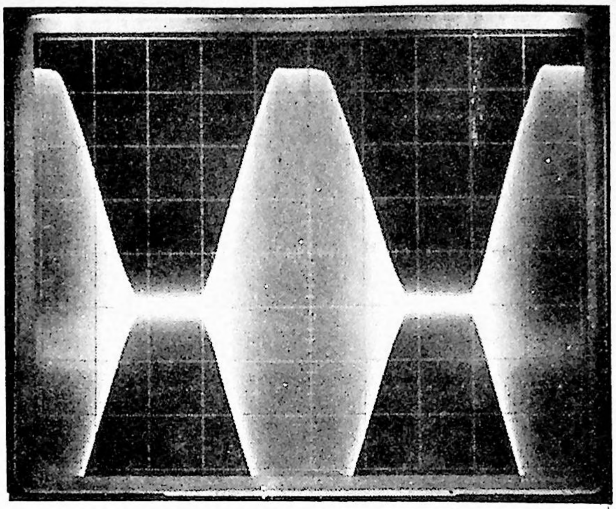
After the DC offsets have been set as described above, apply an audio input signal of 1 kHz at a +10-dBm level. Set the variable LVPS to 0 volt at TP3 and adjust audio offset R41 to obtain minimum audio voltage at TP2. Remove the variable LVPS and reinstall U4.

5-4.2 RF POWER METER BALANCE AND CALIBRATE

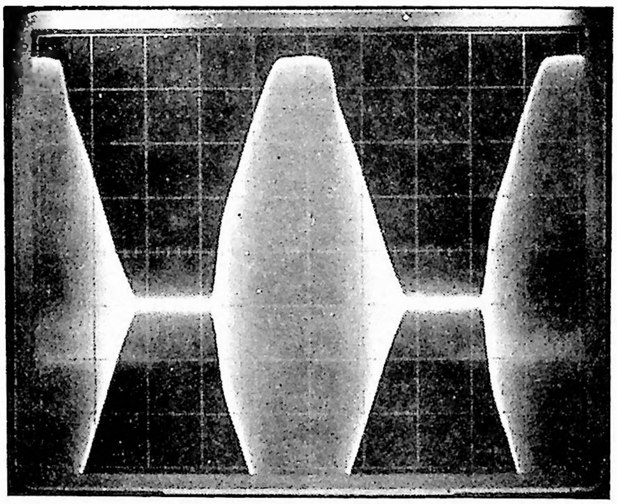
The RF power meter has been balanced and calibrated for a nominal 50 +j0 ohm load. If R or X components of the load at transmitter output A9J1 are within +/-5 ohms of these values, the SWR is 1.22:1 or less and the operation of the RF power meter and the VSWR overload circuit is probably adequate. This VSWR is represented by a reflected power of about 1 percent. If the reflected power is greater than this, either the antenna impedance is incorrect and needs to be readjusted to the correct value, or the RF power meter is not correctly balanced and calibrated for the antenna impedance being used.

5-4.2.1 REFLECTED POWER BALANCE

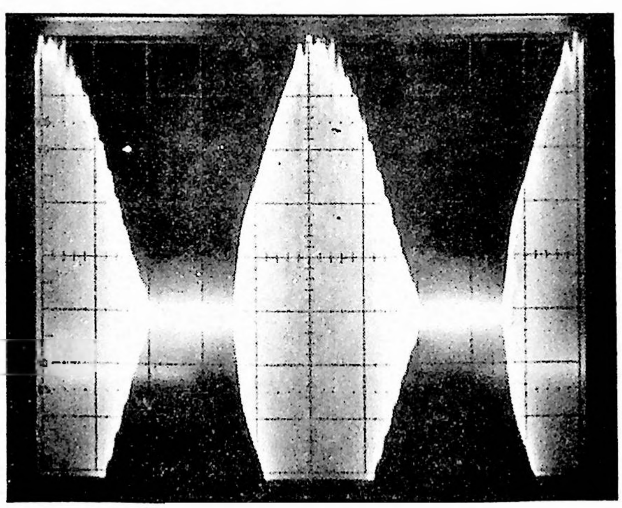
Operate the transmitter into the desired load at the 5-kW power level with no modulation. Adjust the reflected power balance, A9A6C6, located on top of the transmitter, for minimum indication of the REFLECTED position of the RF power meter, A5M5, located on the front panel. The NORMAL-REVERSE switch, A9A6S1, located behind the back cover of the RF output network compartment on the RF power meter subassembly, must be in the NORMAL (up) position.



A. WITH THE IPL ON AND PROPERLY ADJUSTED.



B. IPL OFF WITH CLAMP PROPERLY SET.



C. IPL OFF WITH CLAMP SET TOO HIGH.

FIGURE 5–3. AUDIO WAVEFORM

5-4.2.2 FORWARD POWER BALANCE

Reduce the transmitter power output to 500 watts. Place the NORMAL-REVERSE switch, A9A6S1, in the REVERSE (down) position. Adjust forward power balance A9A6C5, located on top of the transmitter, for minimum indication on the FORWARD position of RF power meter A5M5. Return the NORMAL-REVERSE switch to its NORMAL (up) position.

5-4.2.3 REFLECTED POWER CALIBRATE

Set transmitter power output to 500 watts. Place the NORMAL-REVERSE switch, A9A6S1, in the REVERSE (down) position. Adjust reflected power calibrate A9A6R10, located on top of the transmitter, to obtain a reading of 10 percent (full scale is 12 percent) in the REFLECTED position of RF power meter A5M5. Return the NORMAL-REVERSE switch to its NORMAL (up) position.

5-4.2.4 FORWARD POWER CALIBRATE

Set transmitter power output to 5000 watts. Place the NORMAL-REVERSE switch A9A6S1, in the NORMAL (up) position. Adjust forward power calibrate A9A6R9, located on top of the transmitter, to obtain a reading of 100 percent (full scale is 120 percent) in the FORWARD position of RF power meter A5M5.

5-4.3 RF OUTPUT NETWORK TUNING

Before proceeding with any tuning of the output network, be sure that the correct components for the desired operating frequency are installed. The tuning chart of Table 5-4 indicates the coil and capacitor values required for each of the four bands. The parts list in Section 7 might also be helpful in verifying the correct components.

The RF output network used in the 315R-1 consists of four parallel-tuned circuits, all tuned to the carrier frequency, coupled together to form a bandpass filter between the power amplifier plate and the antenna. The RF output network actually serves two purposes. One is to filter out harmonics and spurious signals created in the class C high efficiency power amplifier. The other function is to match antenna or load impedance to the plate of the power amplifier. Figure 5-4 shows a simplified schematic of the RF output network, including the third harmonic resonator in series with the PA anode. To tune the RF output network, the third harmonic resonator must be tuned to the third harmonic of the carrier frequency; the four parallel tuned circuits, or nodes, must be tuned to resonance at the carrier frequency; and finally the coupling between nodes must be set to get the proper impedance level at each node, in particular at node 1, which is the PA anode. This impedance level determines the loading of the PA (see Paragraph 5-3.9). The tuning is accomplished in the following two steps:

a. Set coil taps to their approximate position by using the chart and curves included here.

b. Fine-tune, with an RF signal and RF indicator, either an oscilloscope or RF voltmeter.

Before changing any taps on any coils, record and mark the present location of all taps in order to be able to return to the original tuning condition if necessary. The copy of the factory test data shows the tap positions for all coil as they were set in the original factory test.

5-4.3.1 THIRD HARMONIC RESONATOR

Tuning of the third harmonic resonator can be accomplished two ways. If the transmitter is operational, the value of the capacitor in the third harmonic resonator, A9C10, can be verified in the tuning chart of Table 5-4. The taps on the third harmonic resonator coil, A9L7, can be set in accordance with the curves of Figure 5-5. This sets the coarse tuning of the third harmonic resonator. The final fine-tuning is accomplished by operating the transmitter and fine-tuning the resonator coil in accordance with Paragraph 5-3.11.

If the transmitter is not operational, the fine-tuning can be done by driving an RF signal at exactly the third harmonic frequency into the PA mode circuit through a 10-kilohm resistor. Observe the signal on the PA anode with an oscilloscope or RF voltmeter, and tune the resonator for maximum signal.

5-4.3.2 NODE COUPLINGS

Before tuning any of the nodes (parallel-tuning circuits) in the RF output network, the coupling between nodes should be set according to the network tuning chart of Table 5-4 and the curves of Figure 5-6, 5-7, 5-8, and 5-9.

The coupling between nodes 1 and 2 is set by the position of the connection from the node 2 coil, A9L2, where it taps the node 1 coil, A9L1. The number of turns up from ground on the node 1 coil is shown in the curves of Figure 5-6.

The coupling between nodes 2 and 3 is set by the active (used) turns in coupling coil A9L3. In bands 1 and 2, L3 is actually two coils, L3A and L3B. Coil L3B is used up to 850 kHz, but between 850 and 930 kHz, only L3A is required, so L3B either should be shorted out completely or removed. In bands 3 and 4, only L3A is used. The number of active turns required in L3 is shown in Figure 5-7.

The coupling between nodes 3 and 4 is set by the position of the connection from the node 3 coil, A9L4, to where it taps the node 4 coil, A9L5. The number of turns up from ground on the node 4 coil is shown in Figure 5-8.

The output coupling is also a tap on node 4 coil A9L5. The position of this tap is shown on the curves of Figure 5-9 as the number of turns up from ground.

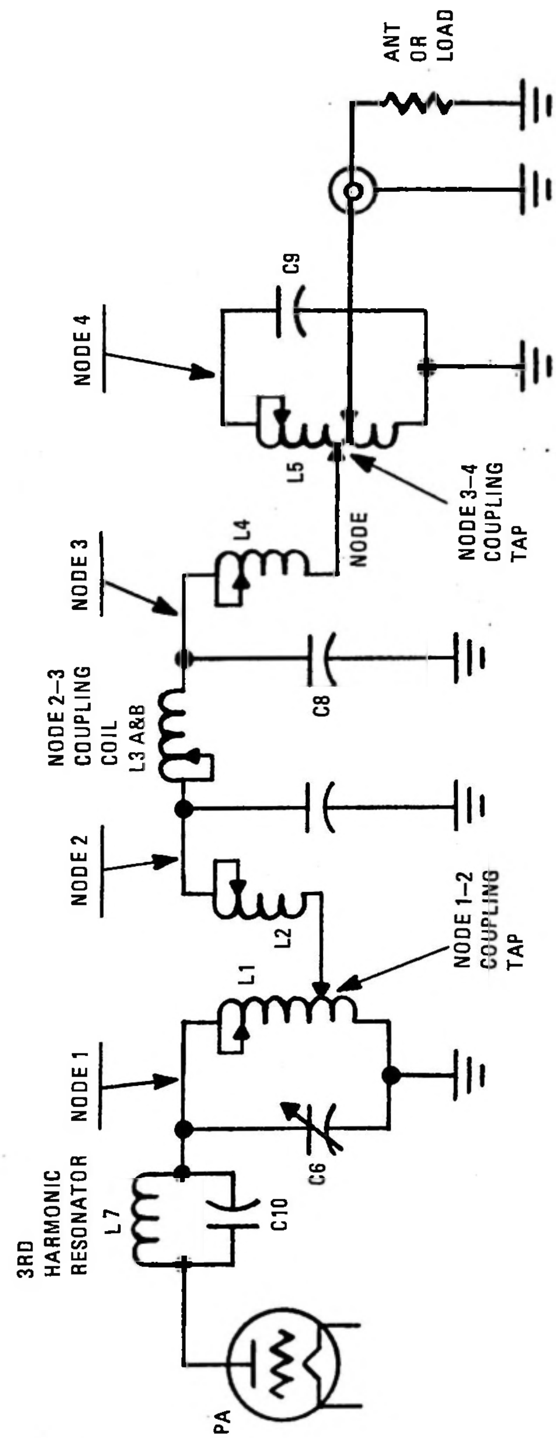


Figure 5-4. RF Output Network, Simplified Schematic.

WARNING: DISCONNECT PRIMARY POWER BEFORE SERVICING.

Table 5-4. 315R-1 Network Tuning Chart.

NOM R_{NN}	BAND FREQ	1			2			3			4		
		540	620	700	710	820	930	940	1080	1230	1240	1400	1600
3rd	C10	330 pF	330 pF	330 pF	220 pF	220 pF	220 pF	139 pF	130 pF	130 pF	82 pF	82 pF	82 pF
3rd	L7	20t	16t	13t	18t	13t	9t	16t	12t	9t	14t	11t	8t
3000	R11	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000
	C6	541 pF	471 pF	417 pF	411 pF	356 pF	314 pF	311 pF	270 pF	237 pF	236 pF	209 pF	183 pF
	L1	120 µH	120 µH	120 µH	120 µH	120 µH	120 µH	120 µH	120 µH	120 µH	82 µH	82 µH	82 µH
	L1	46t	41t	35t	45t	37t	30t	43t	34t	28t	40t	33t	26t
	L2T	7t	5t	4t	7t	5t	4t	7t	5t	4t	7t	5t	4t
1250	R22	1400	1240	1070	1270	1110	980	1270	1110	980	1400	1240	1070
	C7	1200 pF	1200 pF	1200 pF	1000 pF	1000 pF	1000 pF	750 pF	750 pF	750 pF	510 pF	510 pF	510 pF
	L2	120 µH	120 µH	120 µH	82 µH	82 µH	82 µH	82 µH	82 µH	82 µH	82 µH	82 µH	82 µH
	L2	35t	28t	23t	34t	28t	23t	28t	23t	18t	23t	20t	16t
	L3A	56t	30t	6t	25t	6t	48t	56t	48t	42t	47t	41t	35t
	L3B	56t	56t	56t	56t	56t	0t	0	0	0	0	0	0
625	R44	660	580	500	730	640	560	660	570	500	660	580	500
	C8	1500 pF	1500 pF	1500 pF	1200 pF	1200 pF	1200 pF	1000 pF	1000 pF	1000 pF	750 pF	750 pF	750 pF
	L4	44t	36t	28t	34t	27t	22t	24t	19t	15t	19t	16t	13t
400	R55	400	350	300	400	350	300	400	350	300	400	350	300
	C9	2000 pF	2000 pF	2000 pF	1200 pF	1200 pF	1200 pF	1000 pF	1000 pF	1000 pF	750 pF	750 pF	750 pF
	L5	46t	35t	23t	36t	29t	23t	31t	23t	16t	26t	20t	13t
	L4T	33t	22t	12t	24t	18t	12t	19t	12t	7t	16t	10t	5t
	50ΩT	24t	18t	12t	20t	15t	11t	16t	11t	7t	14t	10t	6t

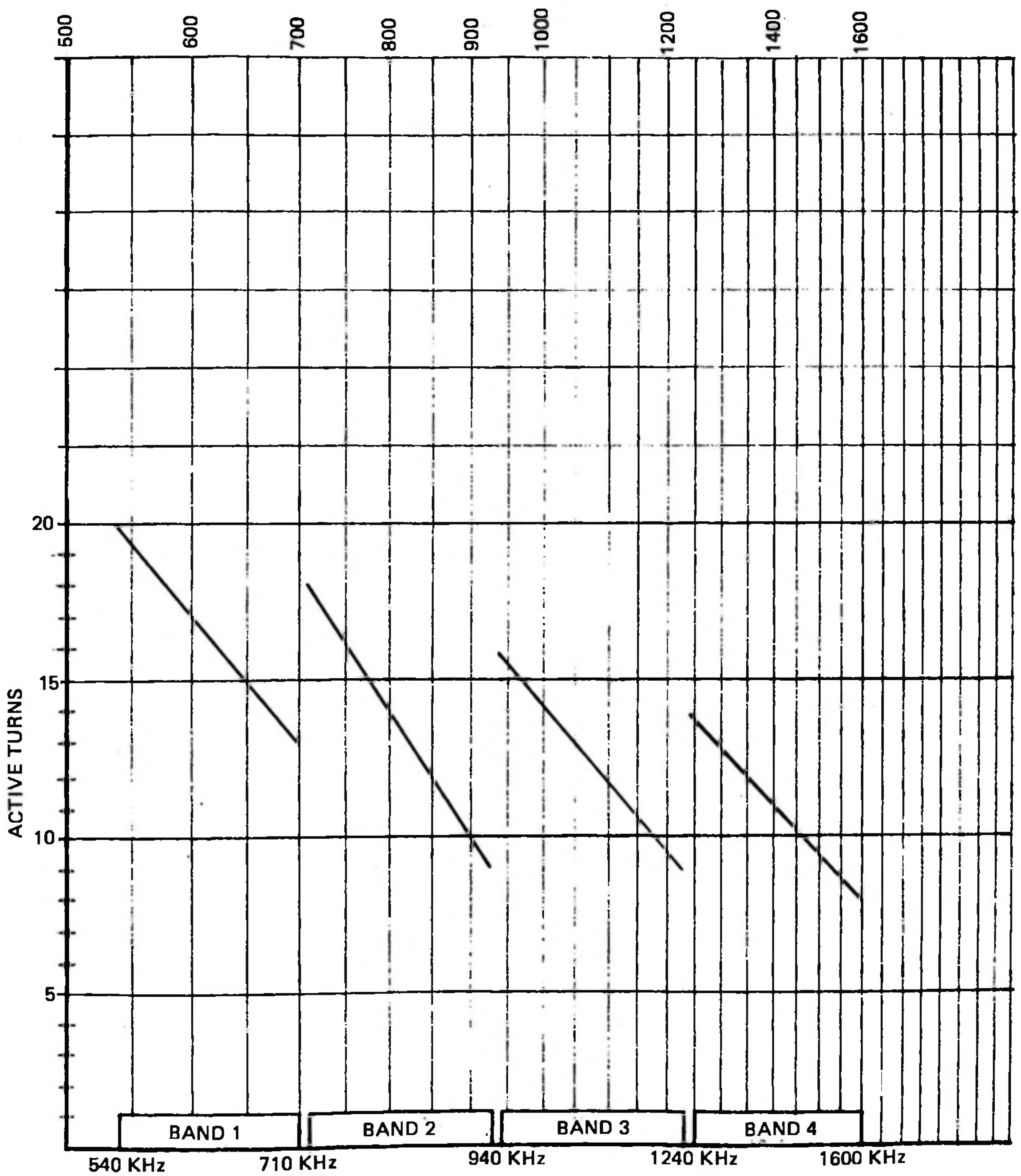


Figure 5-5. 315R-1Third Harmonic Resonator Coil A9L7.

WARNING: DISCONNECT PRIMARY POWER BEFORE SERVICING.

maintenance

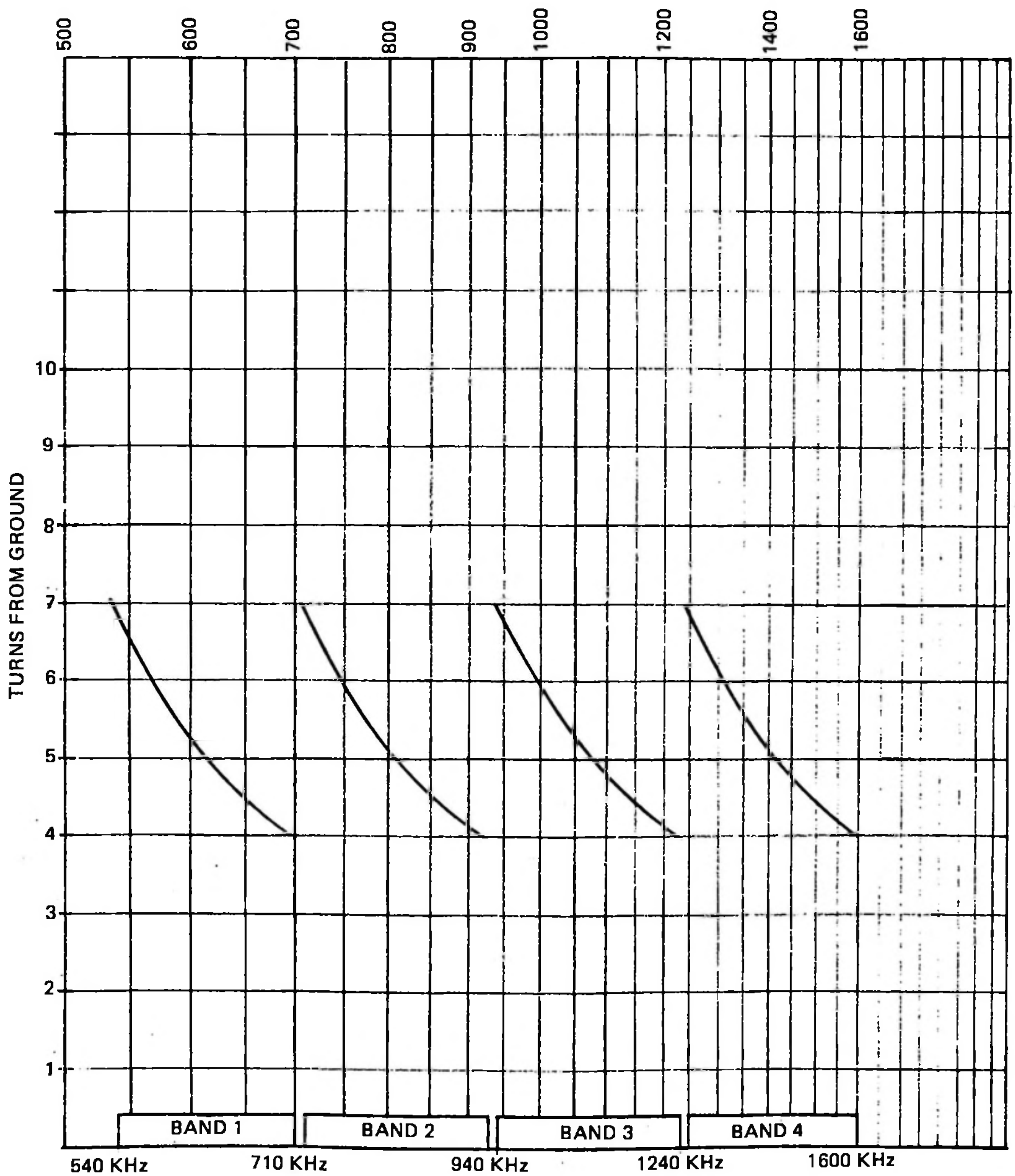


Figure 5-6. 315R-1 Node 1-2 Coupling Tap (on A9L5).

WARNING: DISCONNECT PRIMARY POWER BEFORE SERVICING.

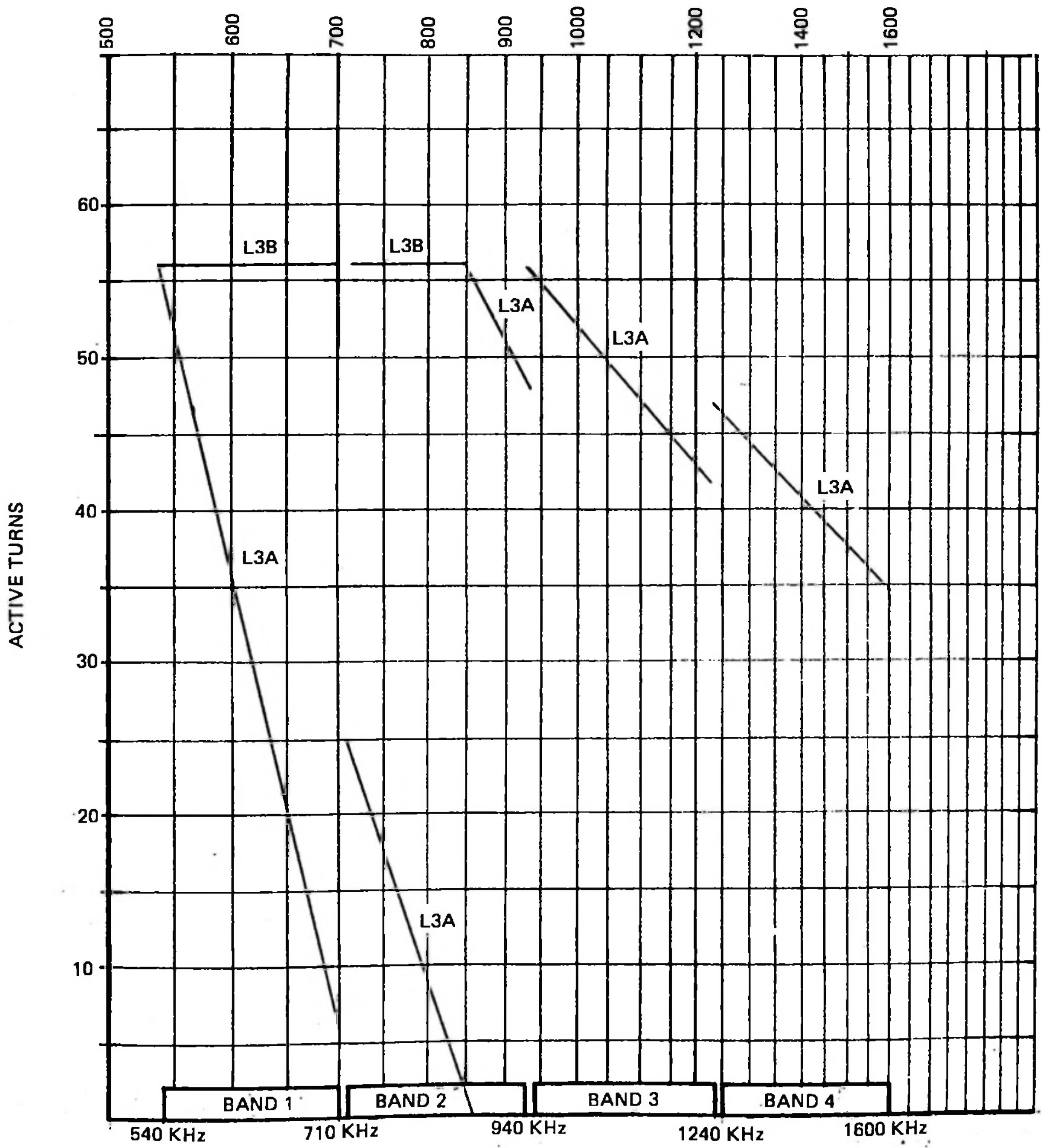


Figure 5-7. 315R-1 Node 2-3 Coupling Coil A9L3.

maintenance

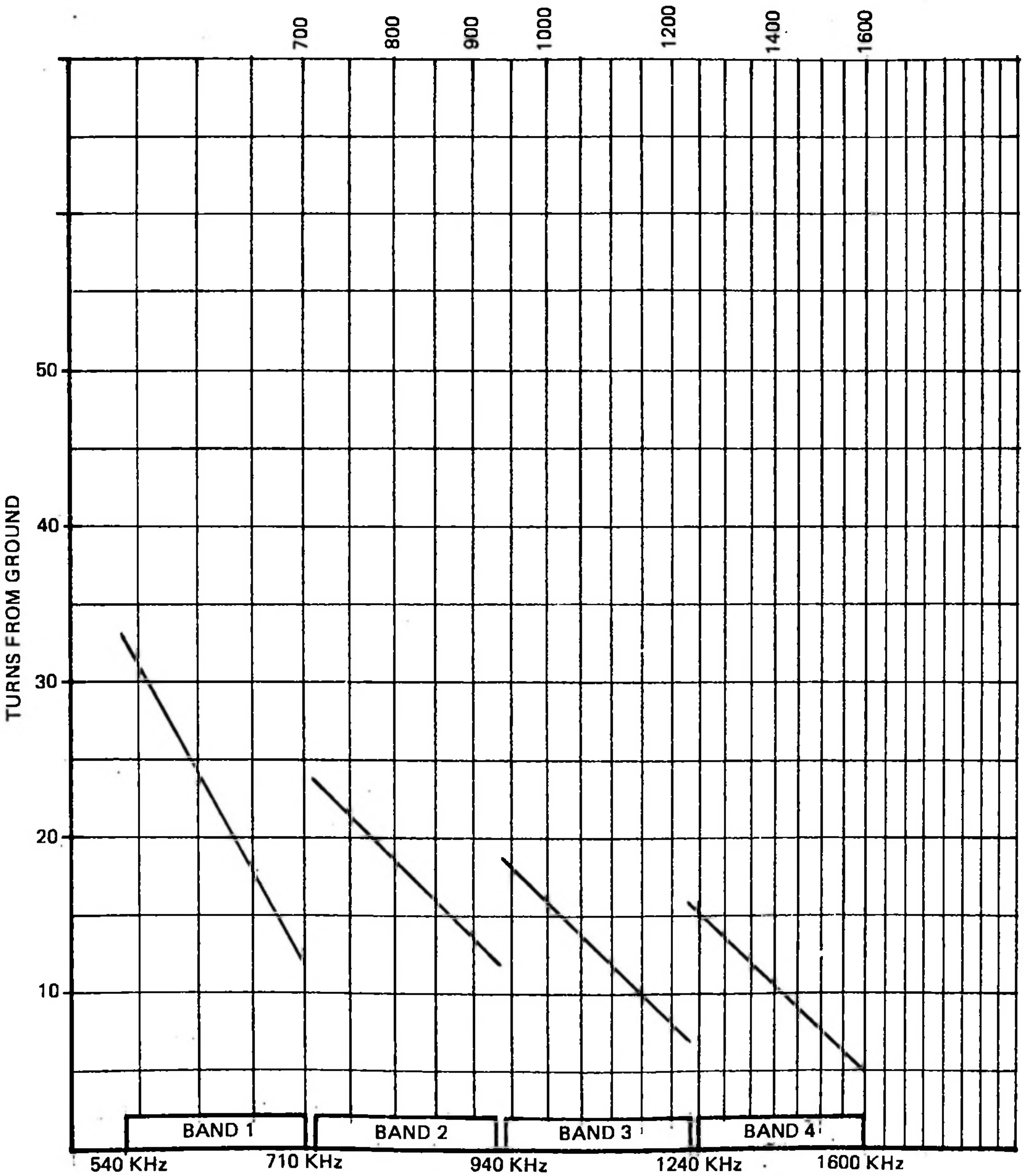


Figure 5-8. 315R-1 Node 3-4 Coupling Tap (on A9L5).

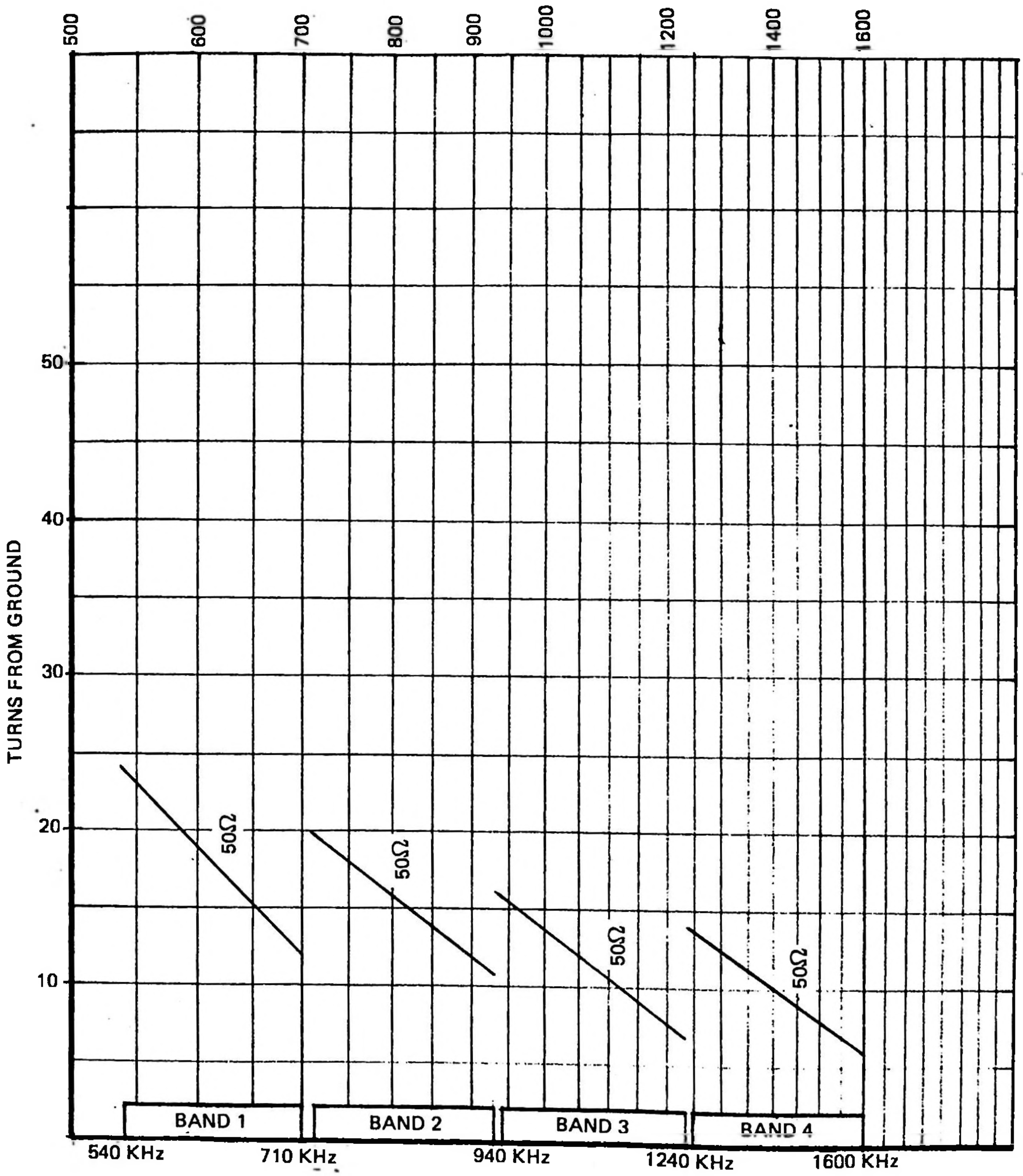


Figure 5-9. 315R-1 Output Tap (on A9L5).

There is no fine-tuning of the couplings between nodes. These are set per the curves. After the nodes are tuned, the coupling can be verified by checking the RF voltage at each node. The relative voltage on each node indicates the impedance level at that node. The curves of Figure 5-10 show the node voltages relative to node 1 (the PA anode). After the node tuning is complete, and before power is applied, the relative nodal voltages should be checked to verify proper coupling. If they vary more than +/-10 percent from the curves of Figure 5-10, the coupling should be adjusted to correct these variations. Very slight adjustments will affect the nodal voltages, so any adjustments to the couplings should be made in small steps. There is a "teeter-totter" effect in the couplings. When a coupling is changed, it affects all the nodal voltages between it and the PA tube anode in an alternating fashion. That is, if the node 3 to 4 coupling is increased, the relative voltage at node 2 will increase, the relative voltage at node 3 will decrease, the relative voltage at node 4 will increase, and the output will increase. This can lead to confusion in trying to adjust the couplings, because they interact. Therefore, proceed in very small increments and record a series to identify trends in adjustment.

Adjustment of the couplings also affects the tuning of the nodes, so the tuning will have to be rechecked if the couplings are changed.

It should be obvious that the network tuning can be a tedious operation without specialized test equipment not normally available to the broadcast. For this reason, we recommend that retuning be attempted only if absolutely necessary.

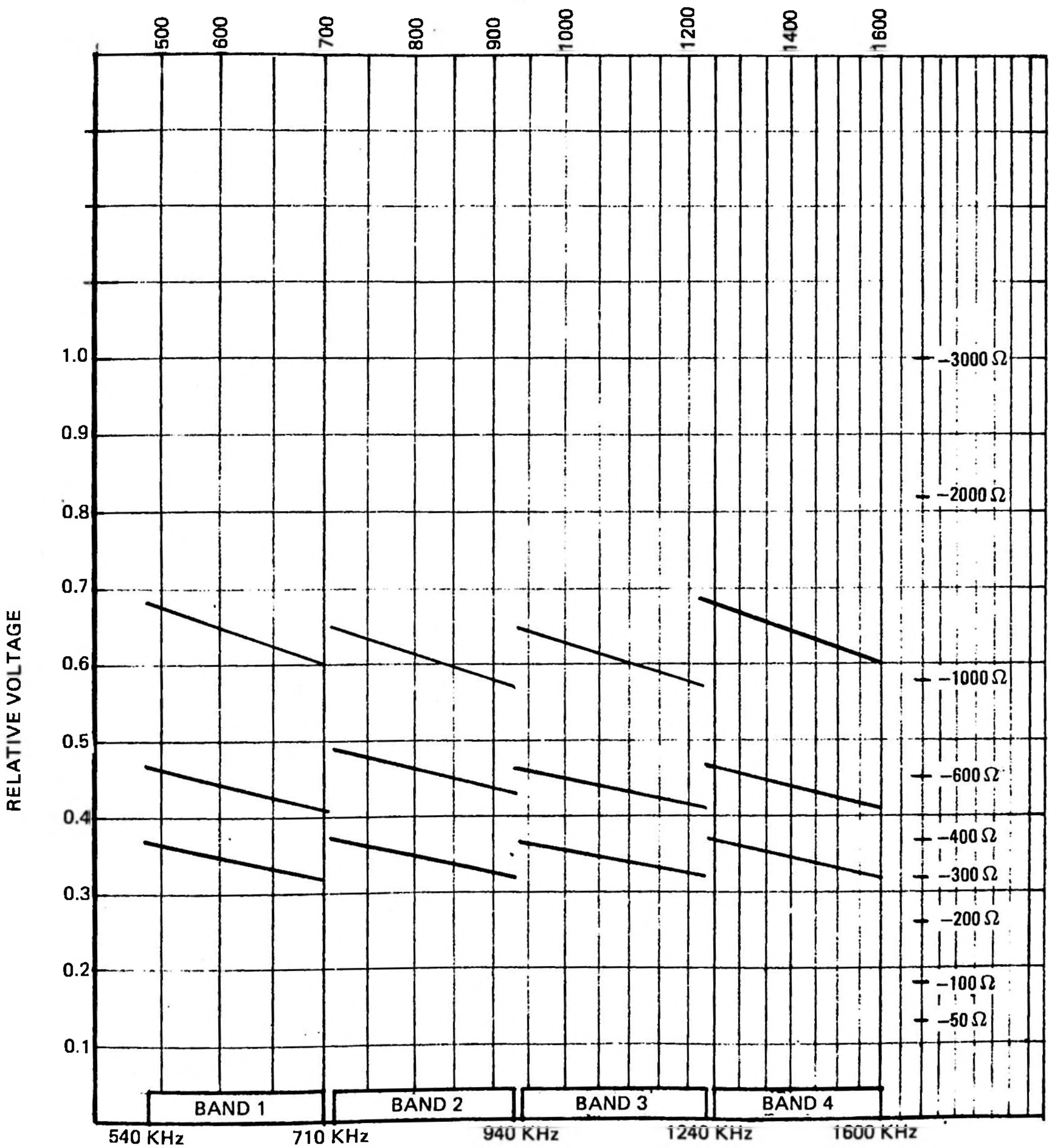


Figure 5-10. 315R-1 Relative Nodal Voltages.

WARNING: DISCONNECT PRIMARY POWER BEFORE SERVICING.

5-4.3.3 NODE TUNING

The nodes are tuned in sequence beginning with node 1. Feed a signal at the carrier frequency to the PA anode through a 10-kilohm resistor. Temporarily short out the third harmonic resonator capacitor, A9C10, Also temporarily place a short from node 2 to ground. Observe the signal at the anode of the PA. With the tap on node 1 coil A9L1 set as indicated on the curve of Figure 5-11, adjust PA tuning capacitor A9C6 for a maximum (peak) signal at the PA anode. The curve of Figure 5-12 shows the approximate setting for tuning capacitor A9C6. Tuning should not deviate more than 10 percent from this curve.

After tuning node 1, remove the short from node 2 to ground, and place it from anode 3 to ground. Adjust the tap on node 2 coil A9L2 for a minimum (dip) signal at the PA anode. The approximate setting for the node 2 tap is shown in the curves of Figure 5-13.

After tuning node 2, remove the short from node 3 to ground and place the short from node 4 to ground. Set the tap on node 3 coil A9L4 to the approximate setting shown in the curve of Figure 5-14. Now, adjust the tap on the node 3 coil for a maximum (peak) signal at the PA anode.

After tuning node 3, remove the short from node 4 to ground and be sure that the correct load is connected to the output tap on the node 4 coil (see Figure 5-9). Set node 4 coil A9L5 tap to its approximate position as shown on the curves of Figure 5-15. Adjust the tap for a minimum (dip) signal at the PA anode.

After tuning node 4, verify the proper coupling adjustments as described in Paragraph 5-4.3.2 and the curves of Figure 5-10, which show the relative nodal voltages when the network is properly tuned.

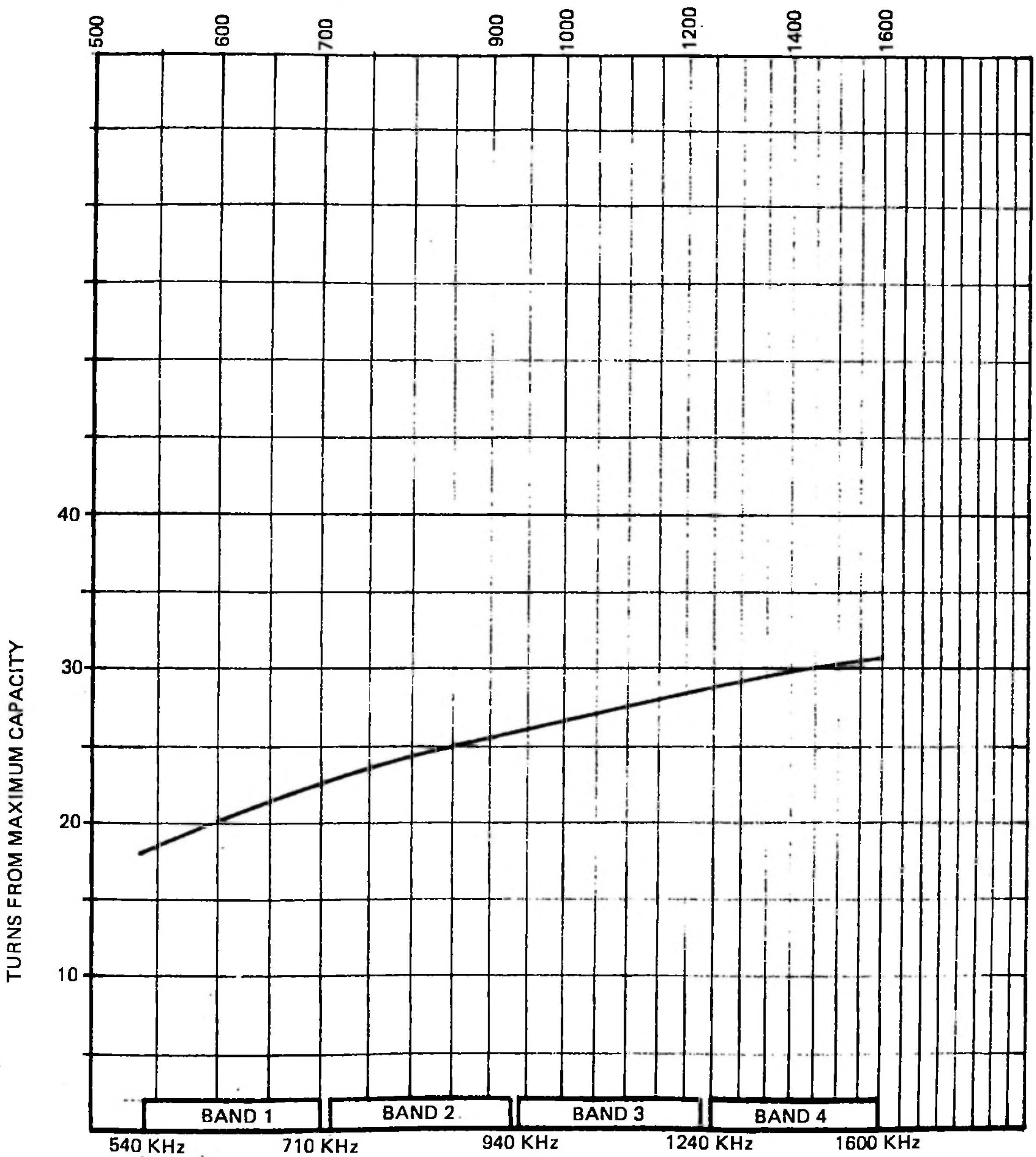


Figure 5-11. 315R-1 Tuning Capacitor A9C6.

WARNING: DISCONNECT PRIMARY POWER BEFORE SERVICING.

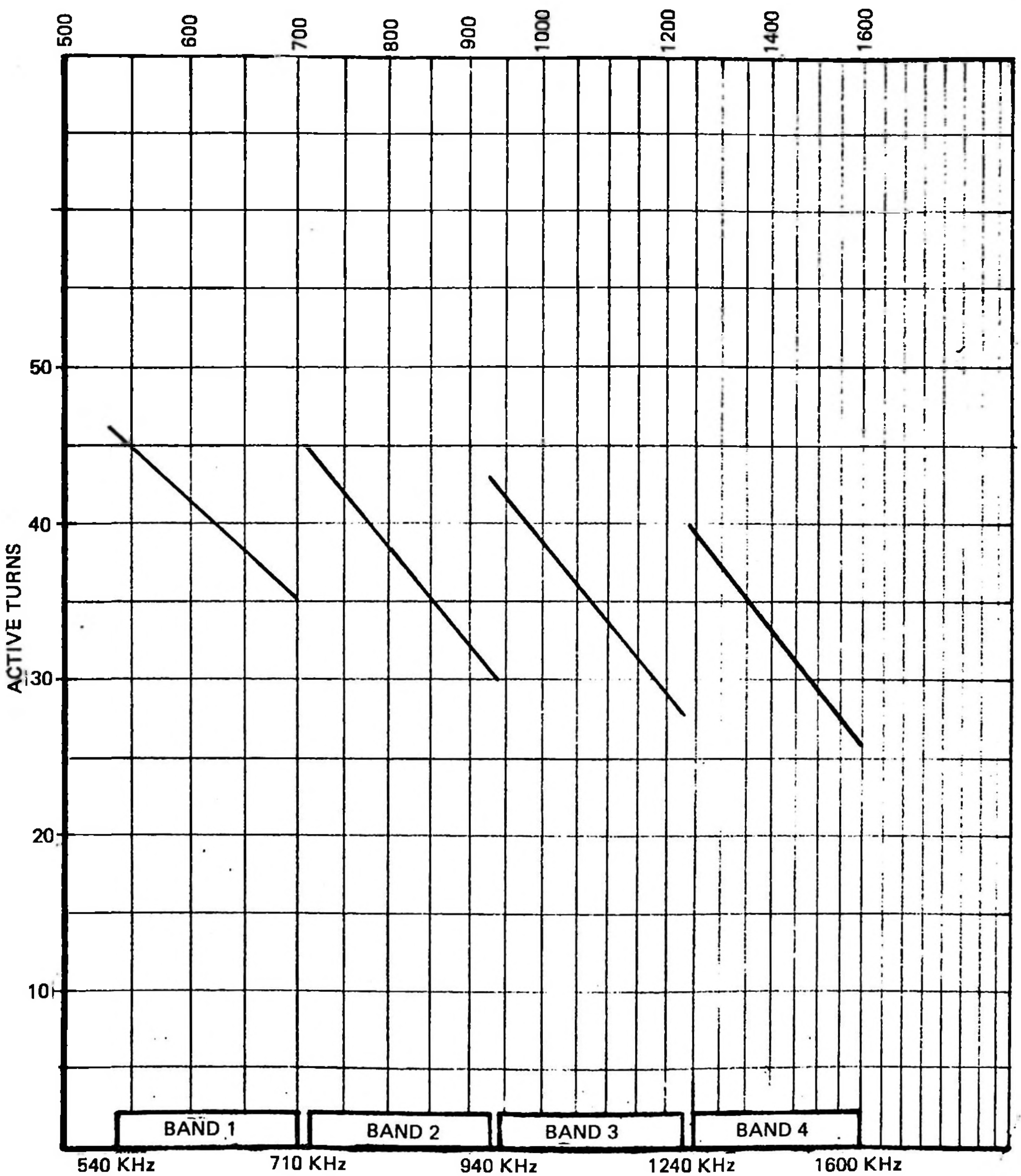


Figure 5-12. 315R-1 Node 1 Coil A9L1.

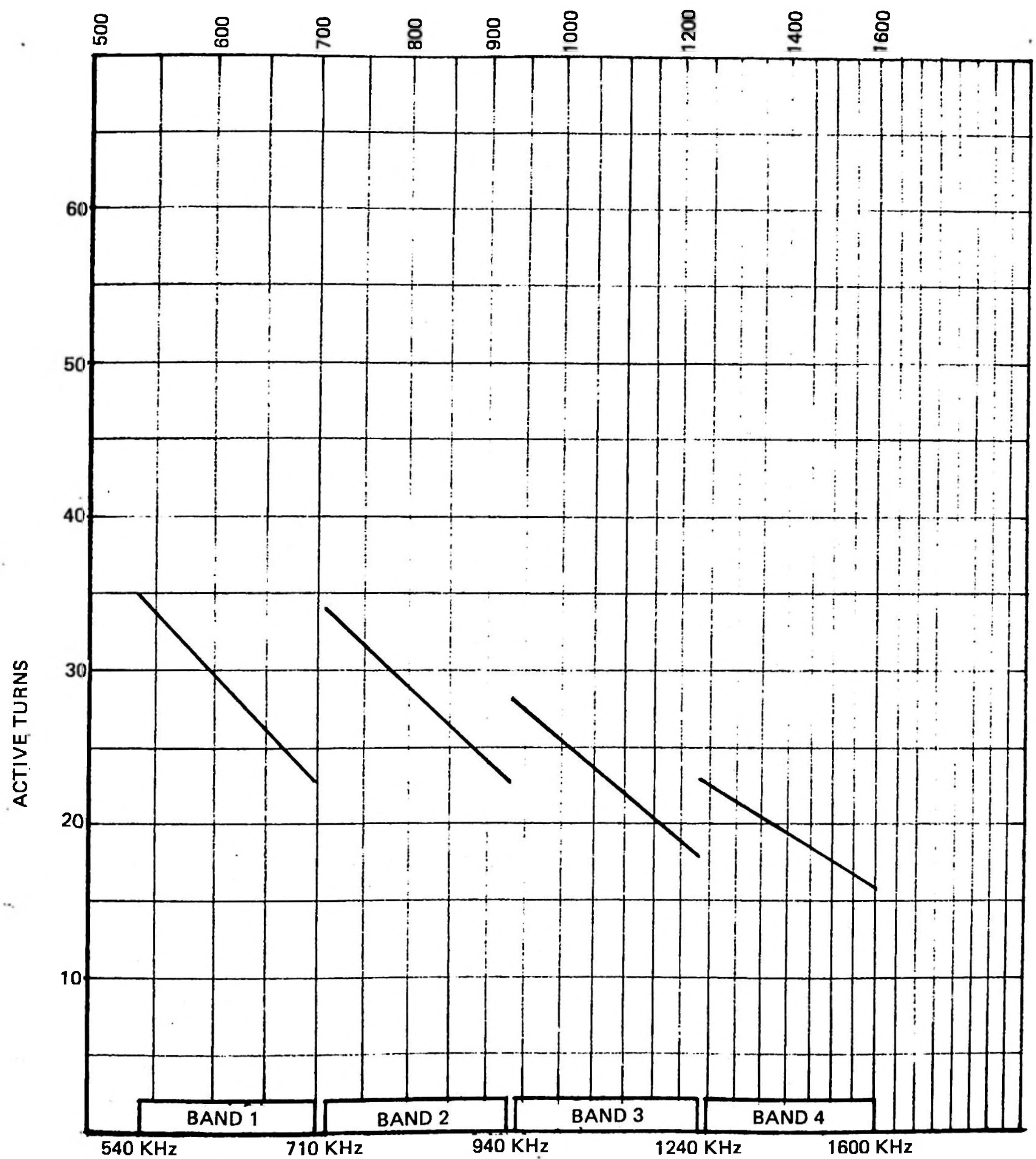


Figure 5-13. 315R-1 Node 2 Coil A9L2.

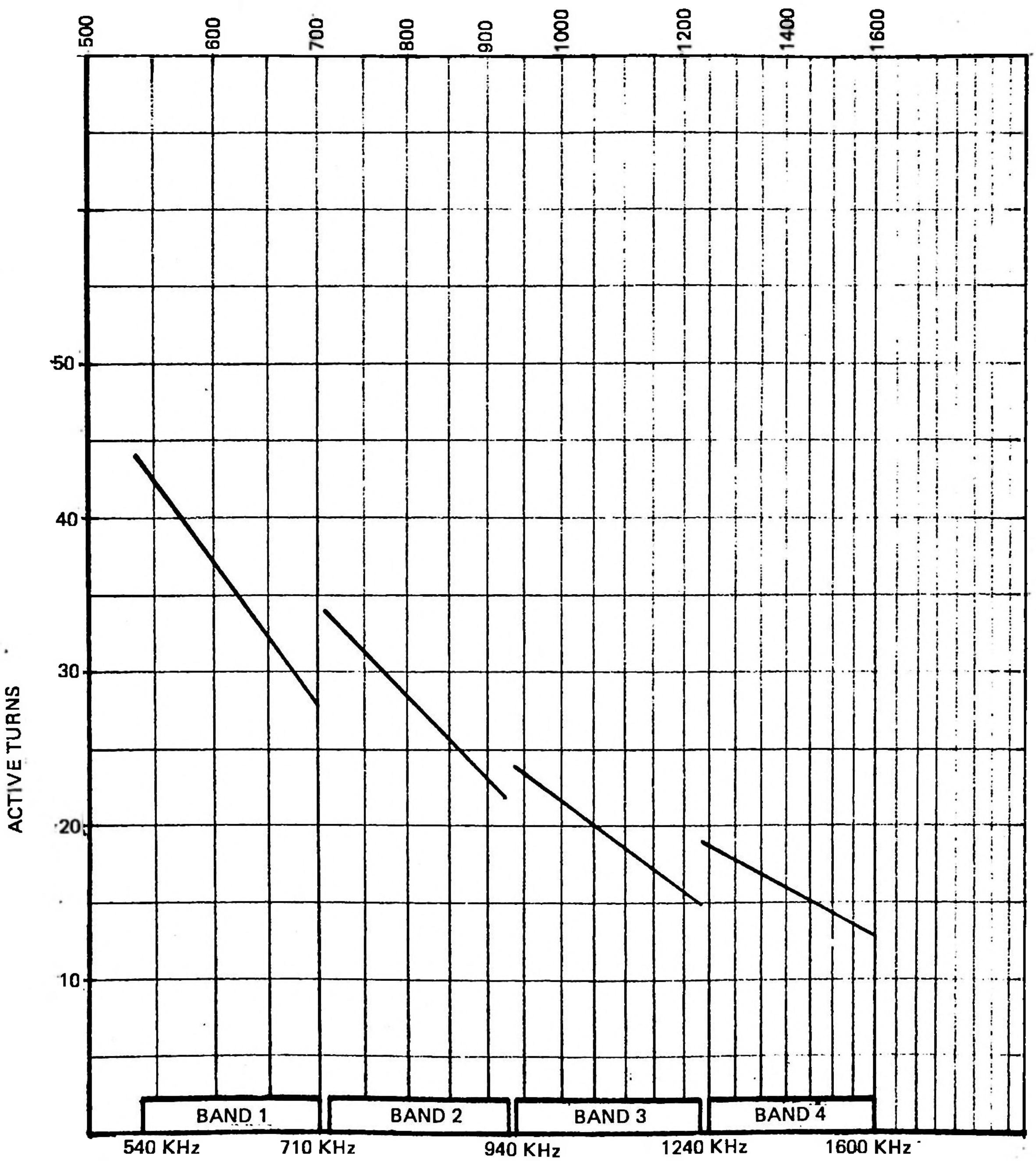


Figure 5-14. 315R-1 Node 3 Coil A9L4.

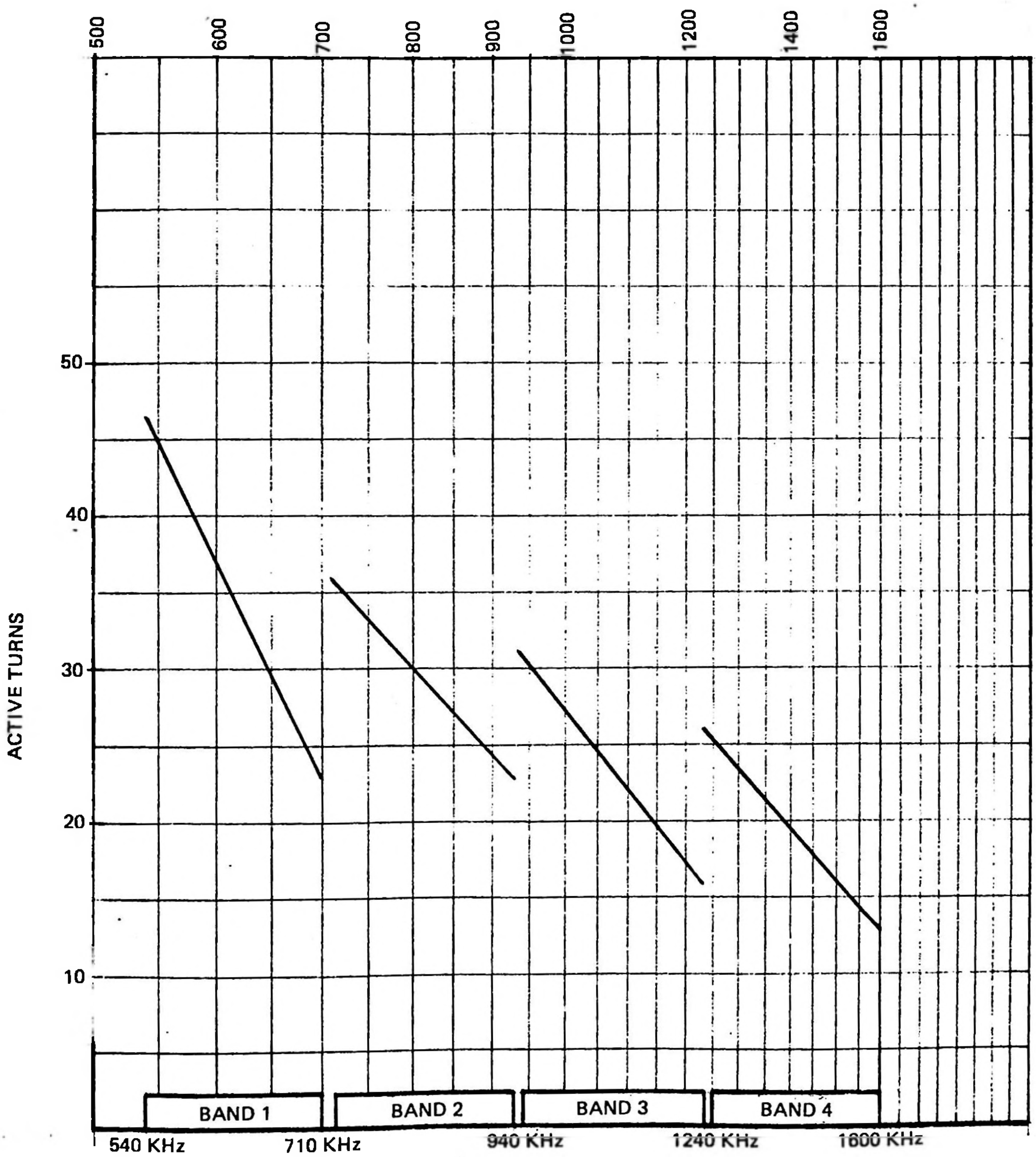


Figure 5-15. 315R-1 Node 4 Coil A9L5.

WARNING: DISCONNECT PRIMARY POWER BEFORE SERVICING.

SECTION 6 - TROUBLESHOOTING

6-1. INTRODUCTION

This section contains simplified diagrams of various circuits grouped by function, such as control circuits, RF circuits, PWM circuits, power supplies, and metering circuits. Included with the simplified diagrams are some suggestions on how to troubleshoot each area in order to more quickly isolate a problem.

6-2. CONTROL CIRCUITS

Figure 6-1 is a simplified schematic of the control circuits for the 315R-1 transmitter. It shows the complete path from +28 volts to the operation of all control relays up to high power on. It also shows the connection of the high/low power relay and the carrier interlock circuits in the PWM module.

A typical problem of the control circuit may be an interruption in the carrier interlock circuit between terminals A7TB-10 and -11 or interruptions in the interlock chain feeding the high/low power-on circuits. Interruption of the carrier interlock between A7TB2-10 and A7TB2-11 causes the 70 KHz switching to stop, but does not drop the plate contactor to turn off the HVPS. So, loss of plate voltage (due to loss of 70 KHz switching), but not loss of HVPS, is probably a carrier interlock fault. An interruption of the carrier interlock circuit will extinguish the LED carrier interlock indicator on the PWM card.

A loss of RF driver current will also interrupt the carrier interlock control circuit, which can be diagnosed quickly by observing the LED, A6A1CR6, mounted on the card cage backplane. When driver current is present, the LED glows brightly. (Refer to Paragraph 6-3 for RF circuit troubleshooting).

Interruptions of the interlock chain feeding the high/low power-on circuits causes the plate contactor to drop the HVPS. It should be noted that the PLATE OFF light is connected so that it is lighted only when the interlock chain is complete. This permits an operator to check the interlock chain without energizing the plate contactor.

The high/low power-on circuits are connected back to the filament-on circuits through diode CR17 on the A7A1 control relay card. This allows operation from a filament-off condition directly to high/low power-on by pressing a single button.

It should also be noted that LEDs are provided on the A7A1 control relay card to indicate operation of the various relays to assist in troubleshooting.

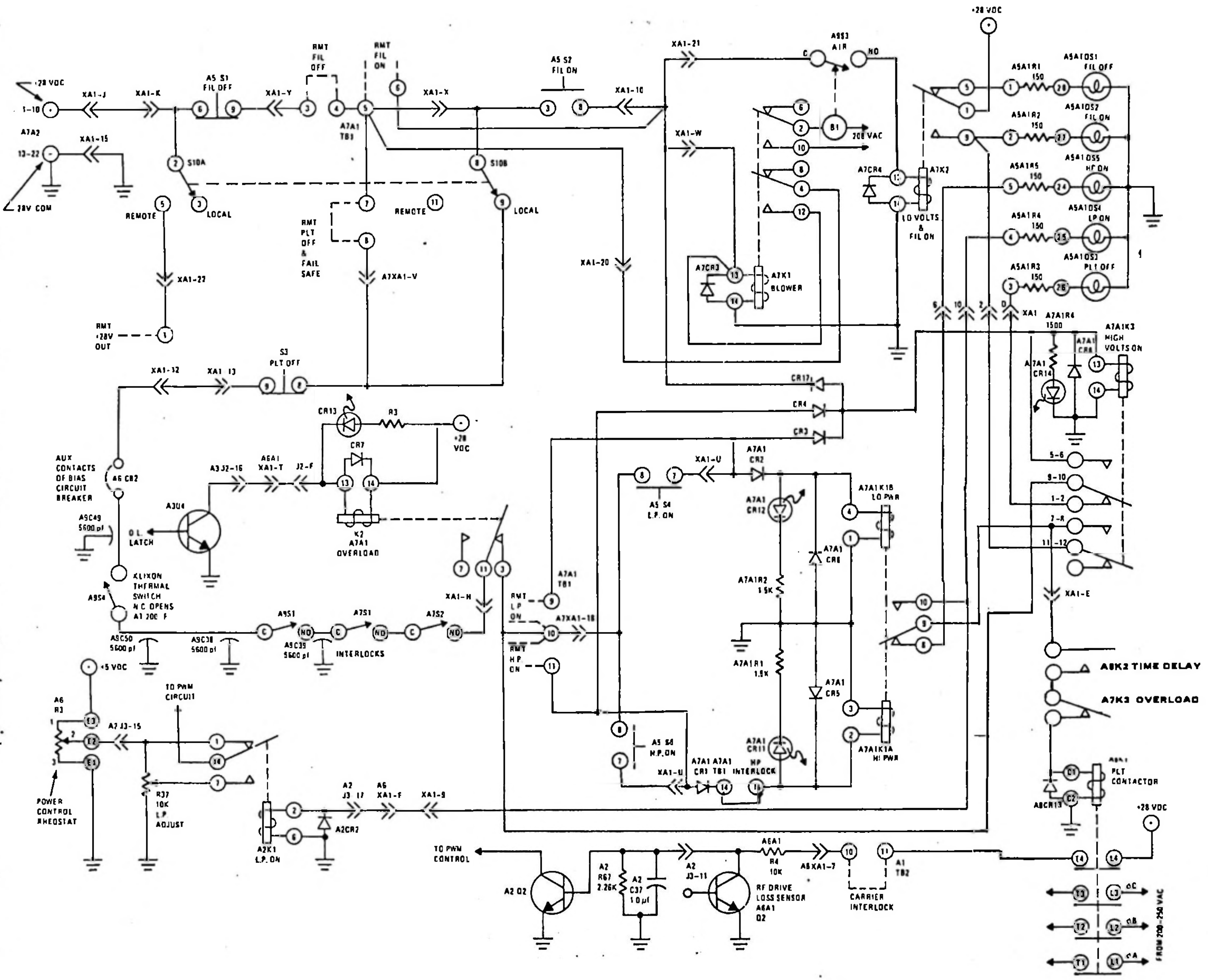


Figure 6-1. 315R-1 5-kW Control Circuit

6-3. RF CIRCUITS

Figure 6-2 shows the RF signal path from the crystal to the antenna output terminals. A very quick determination of fault areas can be made by observing the RF indicator LED on the RF exciter card.

If the RF indicator is lighted, this immediately establishes proper functioning of the RF exciter card. The positive pulse width can be checked at this point on the card extender and should be 120° wide (one-third duty cycle) and 8 volts peak to peak at pin 14.

With the proper adjustment of the 120-degree pulse width, the waveform at PA anode A (on C46 test point) will be the proper high efficiency waveform if the third harmonic resonator in the PA anode circuit is also tuned properly to the third harmonic (see Paragraph 5-3.11). The waveform shown in Figure 6-3 shows the correct high efficiency waveform along with typical examples of incorrect adjustment of either the pulse width or the third harmonic resonator tuning.

The RF driver operation usually can be verified by noting the I_c (driver-collector current) on the DC multimeter. It normally reads between 2.5 and 3.0 amperes depending on frequency of operation. Lower frequencies usually have lower current. The driver has a protective circuit (U101) that acts to short out its own drive signal if the driver I_c gets too high. Also, if fuse F1 in the driver blows, the driver I_c goes to zero. If F1 opens, it nearly always indicates a shorted transistor(s) in the driver card. It should be noted that arc gaps E9 and E10 on the PA grid transformer are set at 0.254 mm (0.010 in.). This is a very close gap and may tend to collect dirt or come out of adjustment easily if it is bumped during routine cleaning or inspections. IF set too close or if dirty, the arc gaps will short out the RF drive to the PA. See Paragraph 5-2.6 for proper settings of arc gaps. It should also be remembered that there is a high DC potential between the primary and secondary of the PA grid transformer. The secondary is at the negative high voltage potential of -5 kV modulated to -11.25 kV, while the primary is at approximately 200 volts.

WARNING

THE 315R-1 TRANSMITTER HAS THE PA GRID AND CATHODE CIRCUITS AT HIGH DC VOLTAGE. UNLIKE THE OLDER, CONVENTIONAL TRANSMITTER, THE MODULATED DC IS NEGATIVE AND APPLIED TO THE PA CATHODE RATHER THAN POSITIVE AND APPLIED TO THE ANODE. THIS CAN BE A SAFETY CONCERN FOR TECHNICIANS OR SERVICE PERSONNEL NOT ACCUSTOMED TO THIS CIRCUIT CONFIGURATION.

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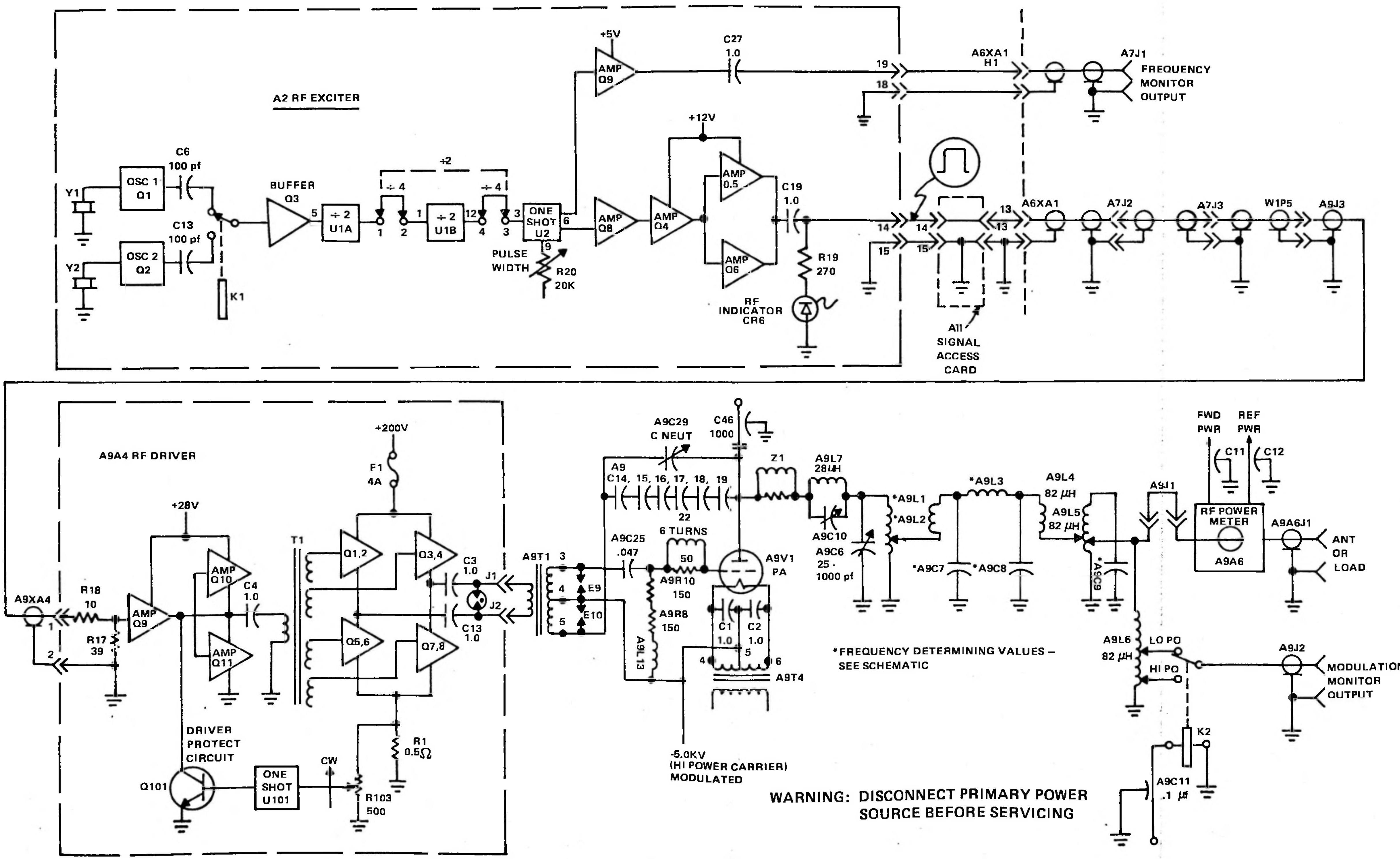
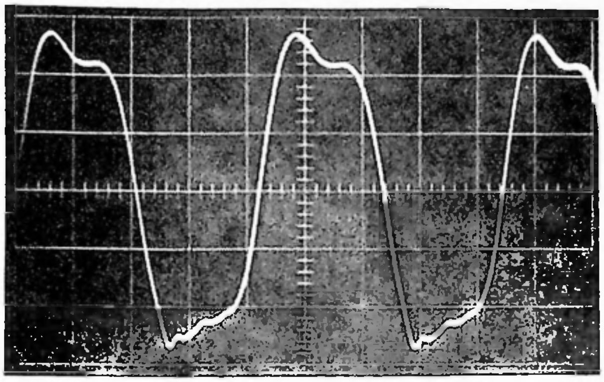
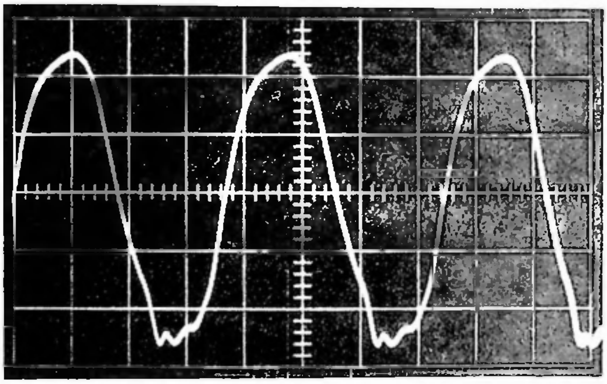


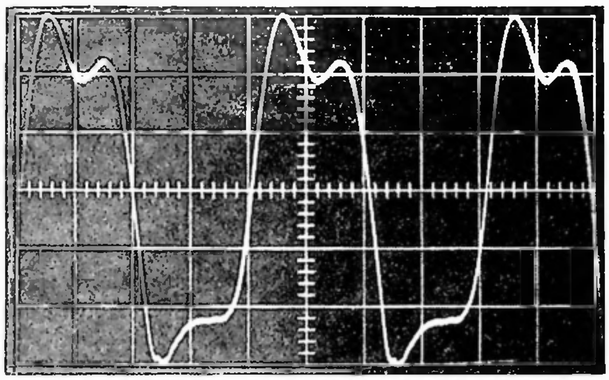
Figure 6-2. RF Signal Path



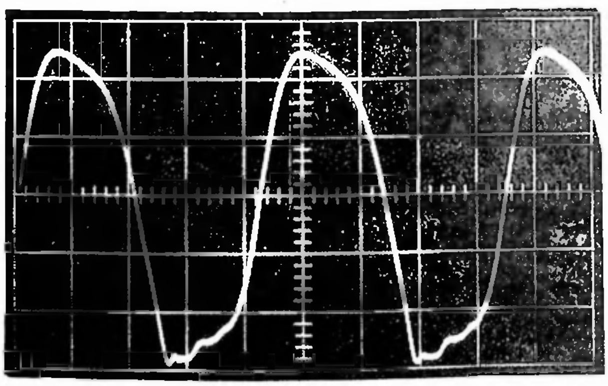
A. CORRECT ADJUSTMENT



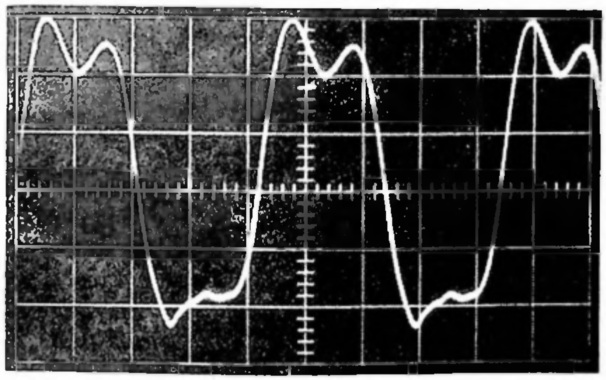
B. PULSE WIDTH TOO NARROW



C. PULSE WIDTH TOO WIDE



D. RESONATOR TOO LOW



E. RESONATOR TOO HIGH

Figure 6-3. PA Anode Waveforms.

WARNING: DISCONNECT PRIMARY POWER BEFORE SERVICING.

This configuration has another unusual aspect. The PA anode is at DC ground - not RF ground. This means there is no plate blocking capacitor or plate DC feed choke. These components are not necessary in this configuration. This does, however, permit an easy test of the PA tube itself. Remove the drive by removing the RF driver module. Connect the PA anode directly to the chassis using a short [not longer than 152-mm (6-in.)] test lead. The collector of A2Q2 in the PWM card will have to be shortened to override the drive loss/carrier interlock circuit, which can be accomplished by grounding the case of the transistor with a short clip lead. Apply high voltage and the zero bias static current can be read on the plate current meter. It should be approximately 0.5 ampere for 5 kV of plate voltage.

The output network is not like the networks in older, conventional transmitters. It contains a third harmonic resonator in the PA anode, and is a bandpass configuration as opposed to the more common low-pass pi network. See Paragraphs 4-3.1.4 for discussions of the output network theory of operation and tuning. Ammeter jack A9J1 is provided for two reasons: (1) to allow insertion of an RF ammeter in the line at this point, and (2) to provide a convenient point to attach an RF bridge to measure the actual load impedance presented to the transmitter.

The RF power meter shows the condition of the antenna or dummy load. It is affected only by the transmission line and/or the load impedance, not by anything inside the transmitter. Any reflected power can be reduced only by correcting the load impedance and not by tuning of the transmitter network. The RF power meter is calibrated for a nominal 50-ohm load at the factory. For other impedance levels, see Paragraph 5-4.2.

6-4. PWM CIRCUITS

Figure 6-4 is a simplified schematic of the PWM circuits from the audio input lines to the modulated DC supplied to the RF power amplifier.

With this circuit configuration of achieving AM, it should be remembered that the HVPS is approximately -13.7 kV and is controlled by the plate contactor, but the plate voltage is approximately -5.0 kV and is controlled by the PWM circuits. Therefore, presence of HVPS and absence of plate voltage indicates a problem in the PWM circuits. An exception to these symptoms would be a loss of RF drive, which would cause the drive loss protect circuit to shut off the PWM signal.

A good checkpoint is the output of the PWM module on pin 9. The waveform here is normally a 70 kHz square wave from 0 to +1.5 volts (see Figure 6-5). Zero volt turns plate voltage off and +1.5 volts turns it on. So, if the voltage at pin 9 is low (zero volt) and the plate voltage is missing, the fault is probably in the PWM card. However, if the voltage at pin 9 is high (+1.5 volts) and the plate voltage is missing, the fault is probably in the LED on the backplane (A6A1CR1), the fiber optic cable, or in switching modulator (switchmod) card A9A3.

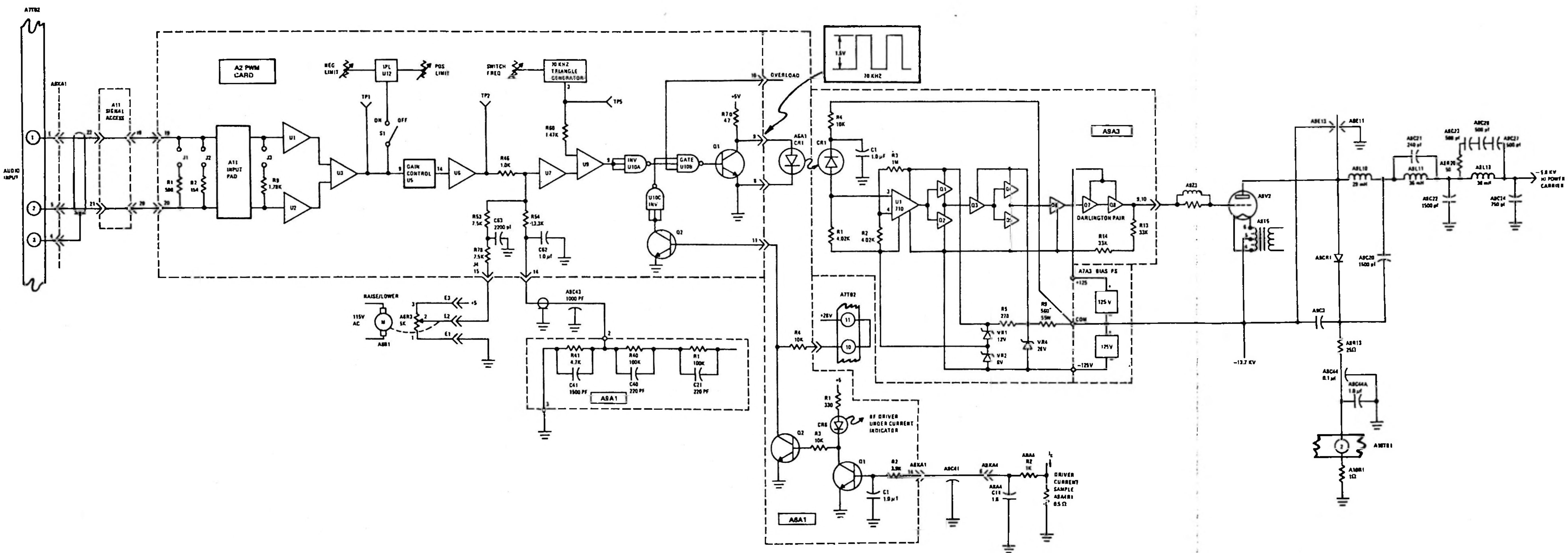
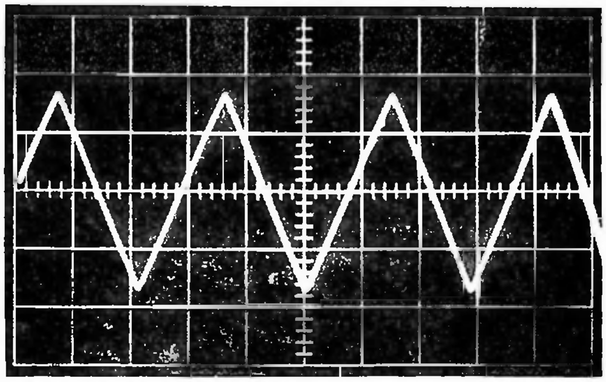
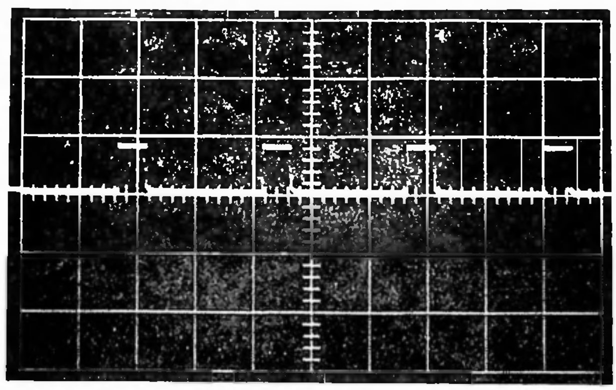


Figure 6-4. PWM Circuits.

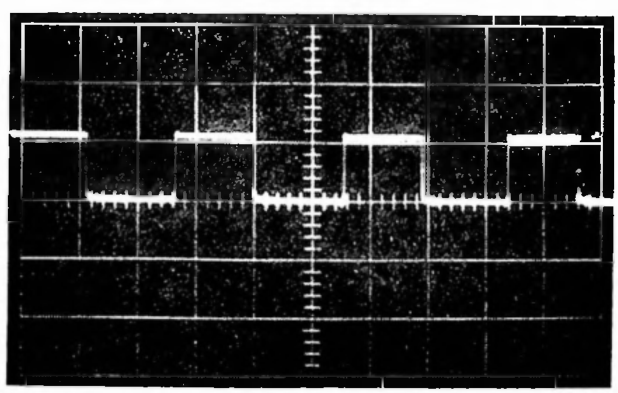
WARNING: DISCONNECT PRIMARY POWER BEFORE SERVICING.



A. WAVEFORM AT A2TP5



B. WAVE FORM AT XA2-9, LOW POWER



C. WAVE FORM AT XA2-9, HIGH POWER

Figure 6-5. PWM Waveforms.

WARNING: DISCONNECT PRIMARY POWER BEFORE SERVICING.

To test the PWM card output, it is necessary to operate the power controller to its minimum position and bypass the carrier interlock by grounding the case (collector) of Q2 in the PWM card. The PWM card may then be tested with only the LOW VOLTAGE circuit breaker on. The positive voltage from the power control resistor, A6R3, offsets part of the -4.5 volts from the feedback divider, A9A1, to control the width of the pulses and thus the amount of plate voltage. Without feedback, the output of the PWM card will be full on (steady state +1.5 volts) unless the positive power control voltage is reduced.

If the trouble appears to be located on the switchmod card, it can be serviced, but extreme care must be exercised, because in its normal operation, it is connected to the negative high voltage bus, which is -13,700 volts. To service this card, first turn off all voltages, use the grounding stick to discharge all capacitors (including the switchmod card itself), and disconnect the fiber optic cable connection on the lower left-hand corner of the card. Then the card can safely be removed for servicing. Arcing the modulator circuit can cause damage to one or more of the three power transistors, Q6,Q7, or Q8 (2N6575), and sometimes a change in value of R10 resistor.

Improper setting of arc gaps A9E11 and 13, located to the left of switching modulator tube A9V2, can cause unnecessary arcing or failure to protect the tube. See Paragraph 5-2.6 for proper gap settings.

When the bias power supply fails, a peculiar failure mode for the switching modulator exists. Normally, this will trip bias circuit breaker A6CB2, which has an auxiliary contact in the high voltage interlock chain. This will in turn open the interlock chain and remove the HVPS. If, for some reason, the bias is lost without tripping the bias circuit breaker, the switching regulator becomes a "class A" regulator operating in the zero bias mode. The output voltage to the PA is fairly normal, but may be slightly more or less than the normal 5 kV. No control of the voltage is present and no modulation occurs.

CAUTION

THE "CLASS A" REGULATOR IS DISSIPATING NEARLY 10 KW IN ITS ANODE DUE TO THE INEFFICIENT MODE OF OPERATION. IT WILL BE DAMAGED IN A VERY FEW MINUTES OF OPERATION IN THIS CONDITION.

To sense this condition, a thermal sensor is located in the exhaust air stream above the modulator tube. It is in the high voltage interlock chain and when 240 degrees F is reached, it will open and disconnect the HVPS.

The 70-kHz filter between the modulator anode and the PA cathode is a very special design and is critical to achieving proper audio performance. It very directly affects the feedback, audio response, and audio distortion, particularly at the higher audio frequencies like 5 kHz and above. Input coil A9L10 is slightly different from the other two, A9L11 and 12. The DC resistance of each coil is approximately 21 to 22 ohms. Any deviation of more than 10 percent from this value probably indicates a damaged coil.

Clamp diode A9CR1, connected to the anode of the switching tube, is also critical to the operation of the switching modulator. Of course, a shorted diode will short the HVPS when the switching tube is on, and if the diode should somehow open, there will be severe arcing at arc gap A9E13. To test this diode, it takes approximately 35 to 40 volts in the forward direction to cause it to conduct, because there are many diode junctions in series in it. Its reverse voltage is 25 kV.

6-5. POWER SUPPLIES

There are only five power supplies in the 315R-1 transmitter.

a. Logic Power Supply, +12, +5, -6, -12 Volts

b. 28-Volt Power Supply, +28 Volts

c. Driver Power Supply, +200 Volts

d. Bias Power Supply, +125, -125 Volts

e. High Voltage Power Supply, -13,700 Volts

The simplified diagram of Figure 6-6 shows the connections of the logic power supply. Figure 6-7 shows the distribution of the loads on the 28-volt power supply.

Figure 6-8 shows the connections of the 200-volt driver power supply and how the 120-volt AC is used for the cabinet fan and the raise/lower motor.

Figure 6-9 shows the connections of the HVPS and how the +/-125-volt bias power supply is connected to it.

WARNING

THE BIAS POWER SUPPLY FLOATS ON THE NEGATIVE HIGH VOLTAGE AND IS THEREFORE 13,7000 VOLTS AWAY FROM GROUND. CARE SHOULD BE EXERCISED WHEN TROUBLESHOOTING THIS AREA. DO NOT TURN ON THE LOW OR HIGH POWER SWITCHES. PROPER PROCEDURE IS TO DE-ENERGIZE THE TRANSMITTER, CONNECT THE VOLTMETER, AND THEN TURN THE FILAMENT ON TO READ THE VOLTAGE. DE-ENERGIZE THE TRANSMITTER AGAIN TO REMOVE THE VOLTMETER.

The plus and minus 125 volts can be measured by turning high voltage circuit breaker A6CB3 off. This ensures that the high voltage can not be accidentally applied. The bias, +125 and -125 volts, is energized by turning on the filament only, with bias circuit breaker A6CB2 closed.

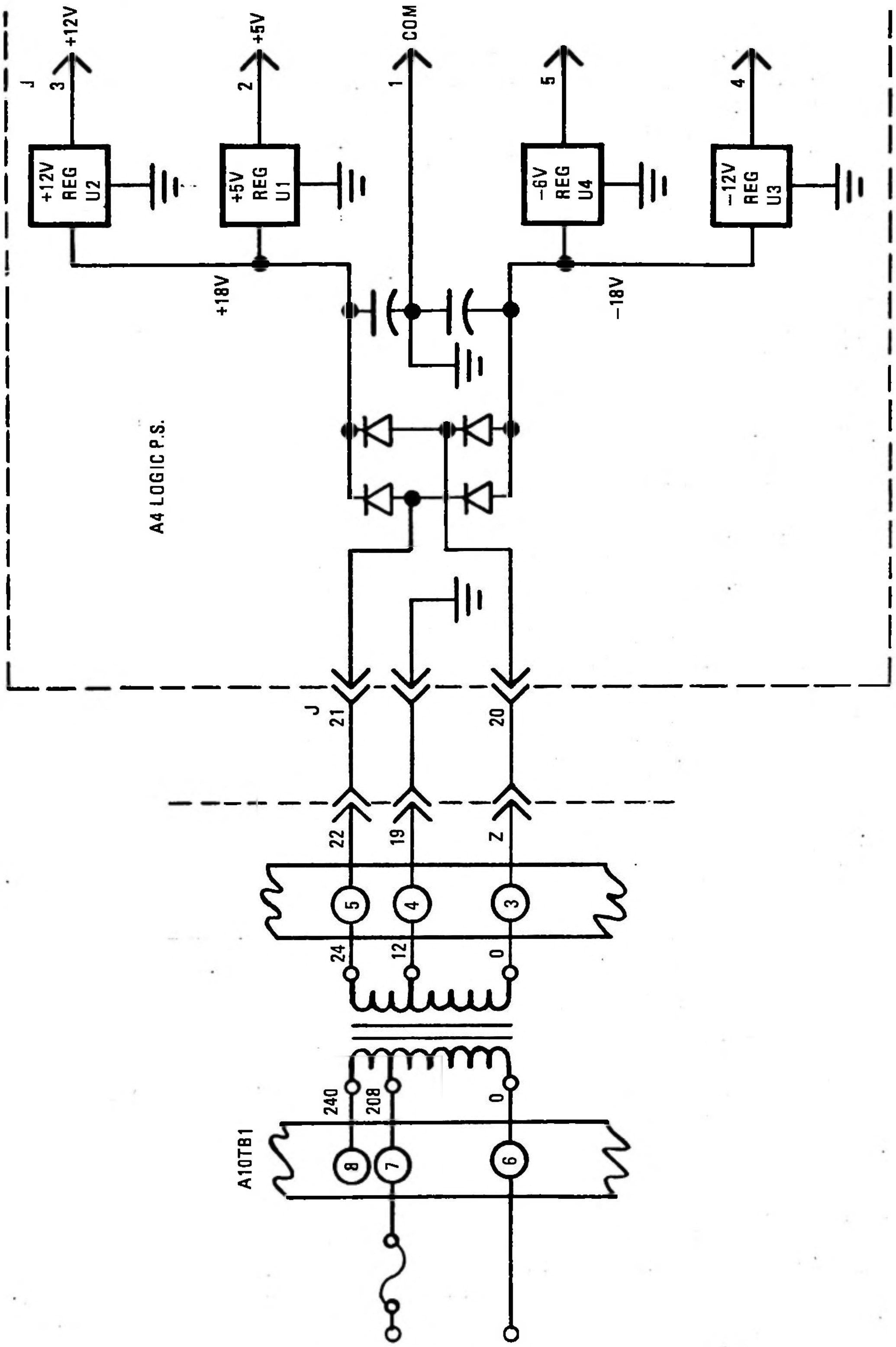


Figure 6-6. Logic Power Supply.

WARNING: DISCONNECT PRIMARY POWER BEFORE SERVICING.

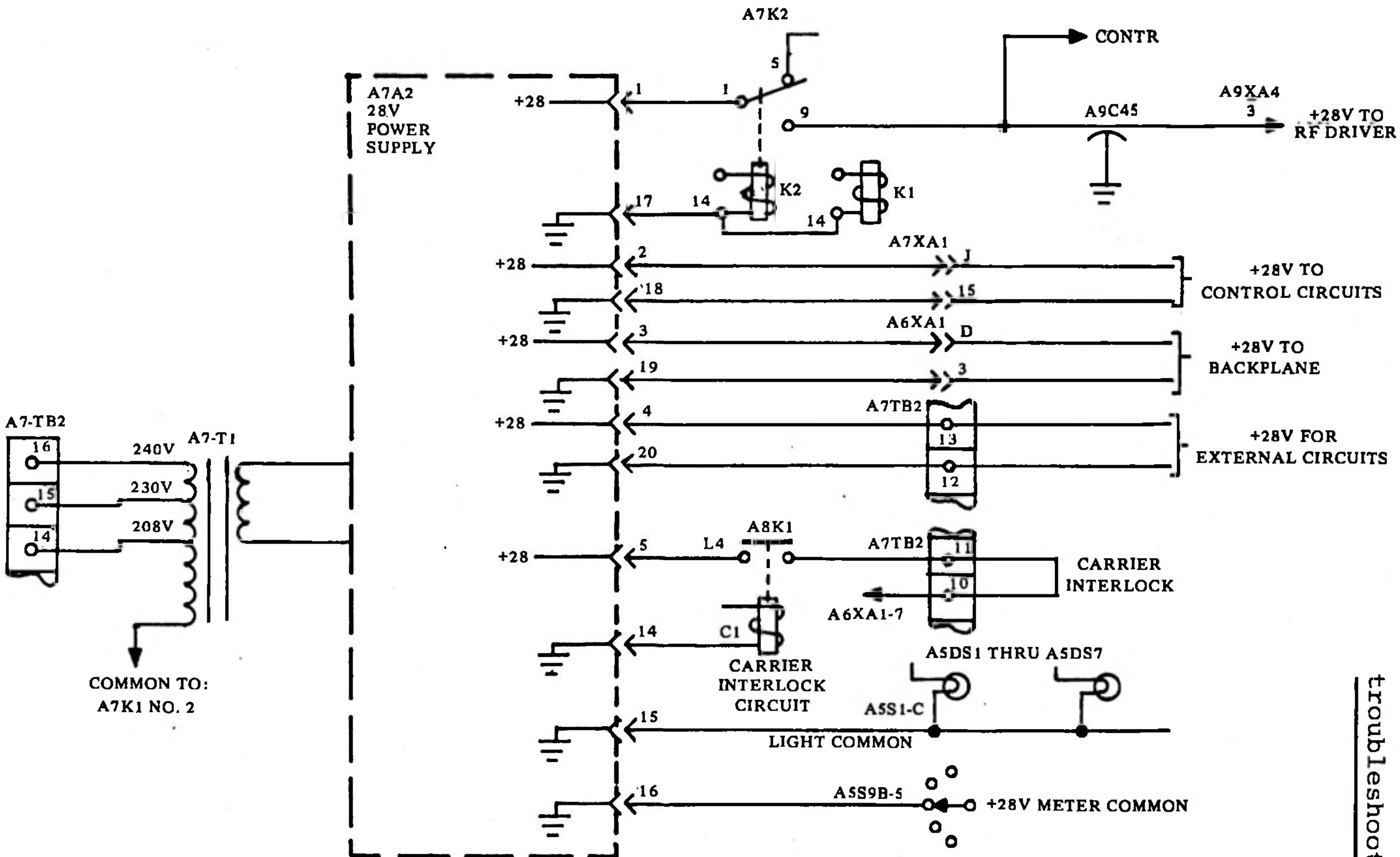


Figure 6-7. 28-Volt Power Supply Distribution

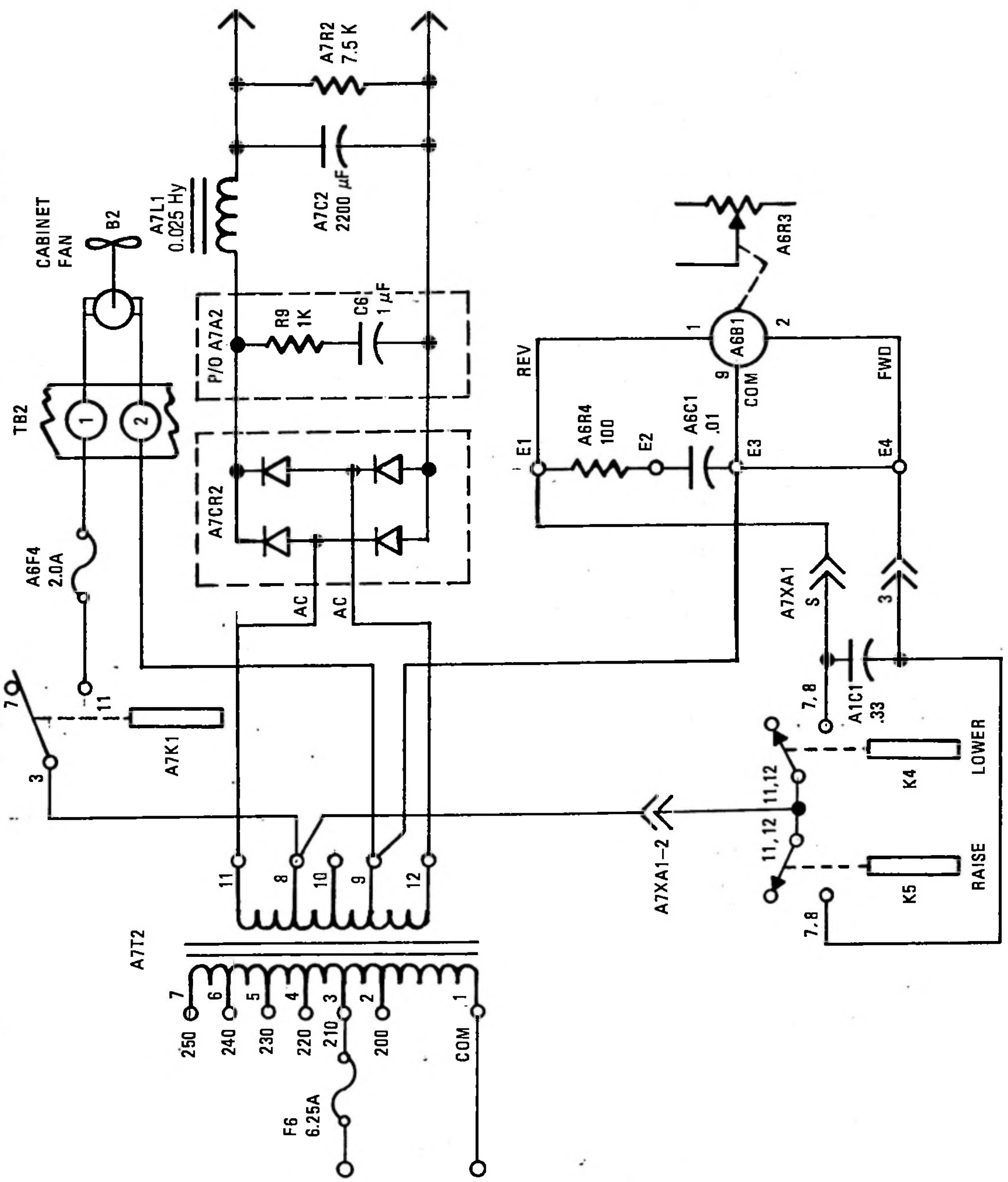


Figure 6-8. Driver Power Supply.

WARNING: DISCONNECT PRIMARY POWER BEFORE SERVICING.

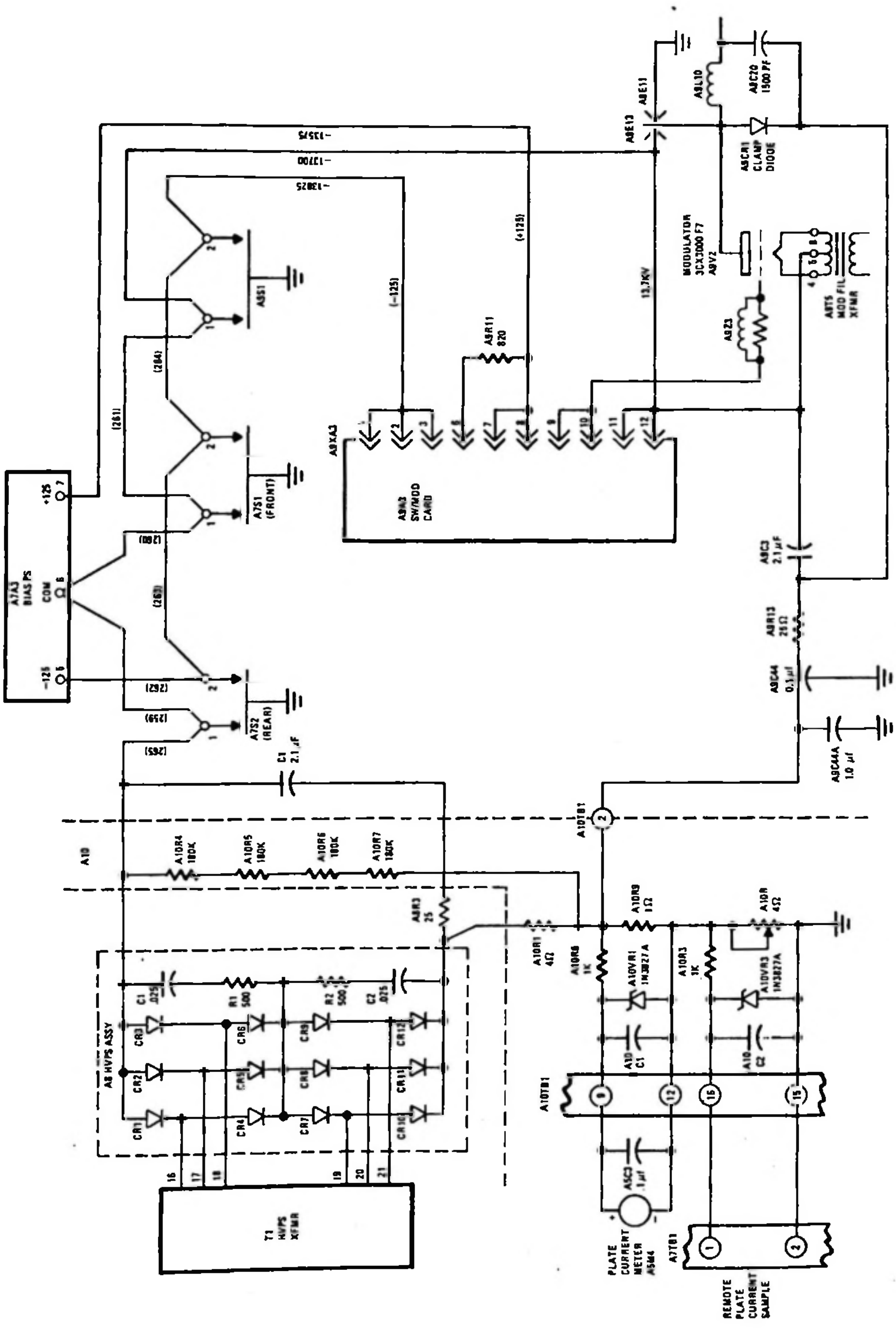


Figure 6-9. High-Voltage Power Supply Distribution.

WARNING: DISCONNECT PRIMARY POWER BEFORE SERVICING.

6-6. AC METERING CIRCUITS

The simplified diagram of Figure 6-10 shows the connections of the AC metering circuits. The metering resistors for the AC metering circuits are all located on the metering terminal board under the cover on the inside of the front door.

It should be noted that the filament metering circuit actually meters the primary of the filament transformer rather than the secondary, because of the negative high voltage on the secondary circuits. The metering always connects to the 208-volt transformer taps regardless of line voltage.

The meter is a 10-mA iron vane movement and reads true RMS.

6-7. DC METERING CIRCUITS

Figure 6-11 is a simplified diagram of the DC multimeter circuits. Unlike the AC metering circuits, the DC meter multipliers are all located at their source rather than on a common board. The meter movement is a 1-mA movement with internal resistance of 1500 ohms.

6-8. PLATE VOLTAGE METERING CIRCUITS

Figure 6-12 is a simplified circuit of the plate voltage metering circuits showing both the front-panel meter and the remote metering connections.

6-9. PLATE CURRENT METERING CIRCUITS

Figure 6-13 is a simplified circuit of the plate current metering circuits showing both the front-panel meter and the remote metering connections. Notice the protective zener diodes across both circuits. Failure of these can affect the metering circuits.

6-10. RF POWER METERING CIRCUITS

Figure 6-14 is a simplified diagram of the RF power metering circuits. The levels involved in the RF power metering are relatively low, so amplifiers are provided to prevent loading of the RF detector circuits. These amplifiers are not located in the RF power meter, but in the control circuits module due to availability of supply voltages and the fact that the reflected power signal is used for the VSWR overload. The internal meter used is a 100-microampere movement with internal resistance of 1750 ohms. The remote meters, if desired, should be 100 microamperes also. Downscale readings, or no readings at all, usually indicate failure of operational amplifier U8 or U9 used in the control circuits module as amplifiers.

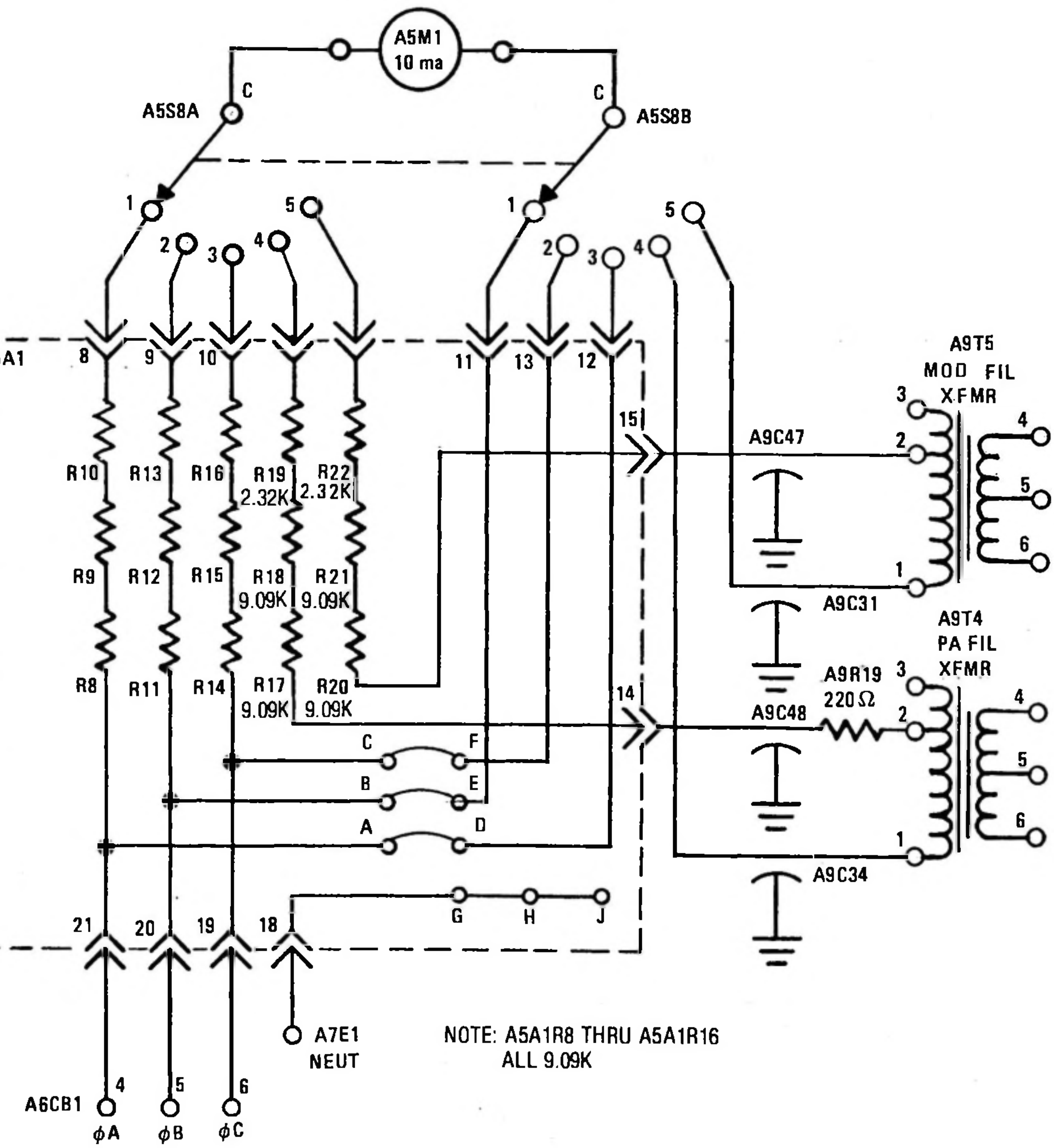


Figure 6-10. AC Metering Circuits.

WARNING: DISCONNECT PRIMARY POWER BEFORE SERVICING.

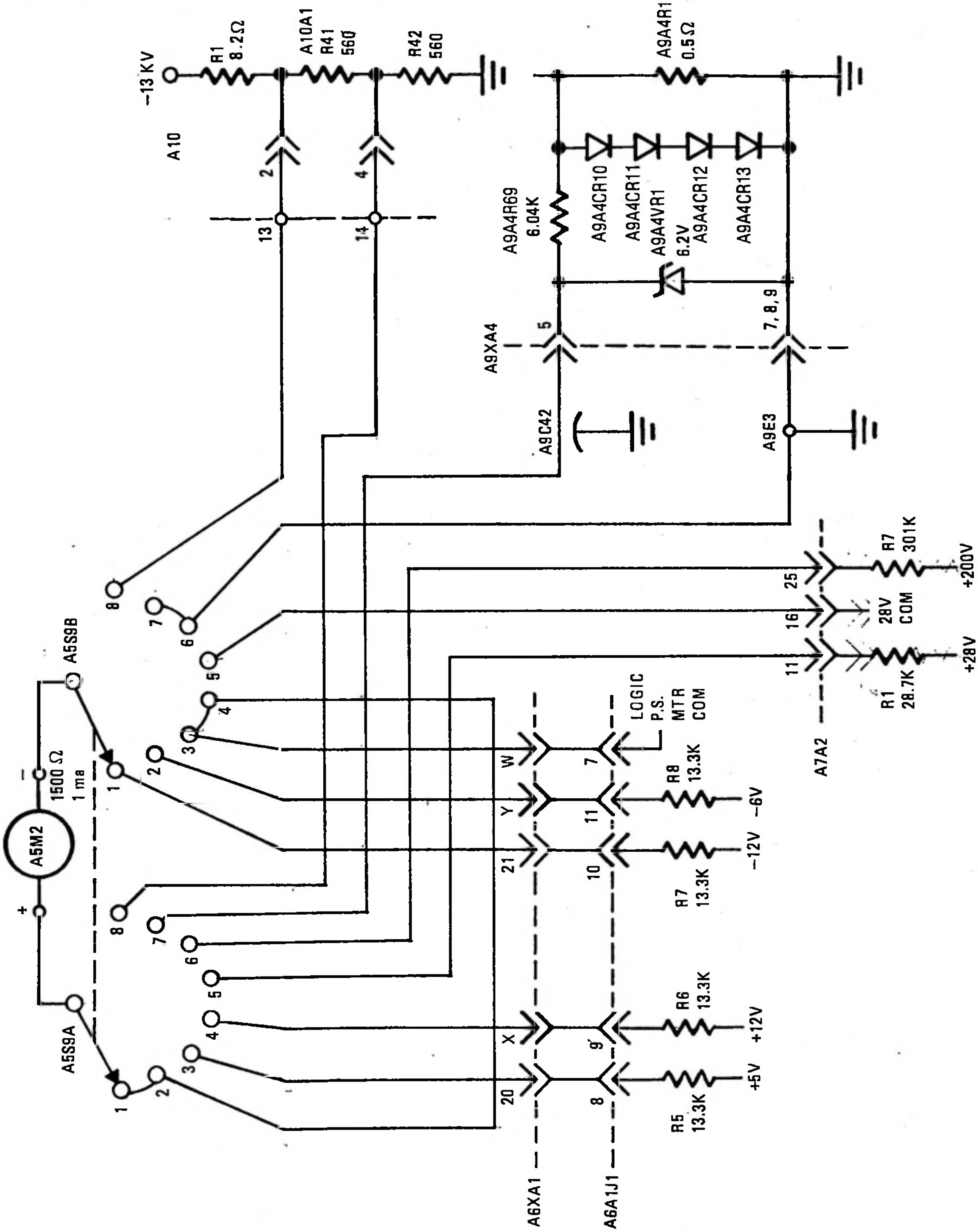


Figure 6-11. DC Metering Circuits.

WARNING: DISCONNECT PRIMARY POWER BEFORE SERVICING.

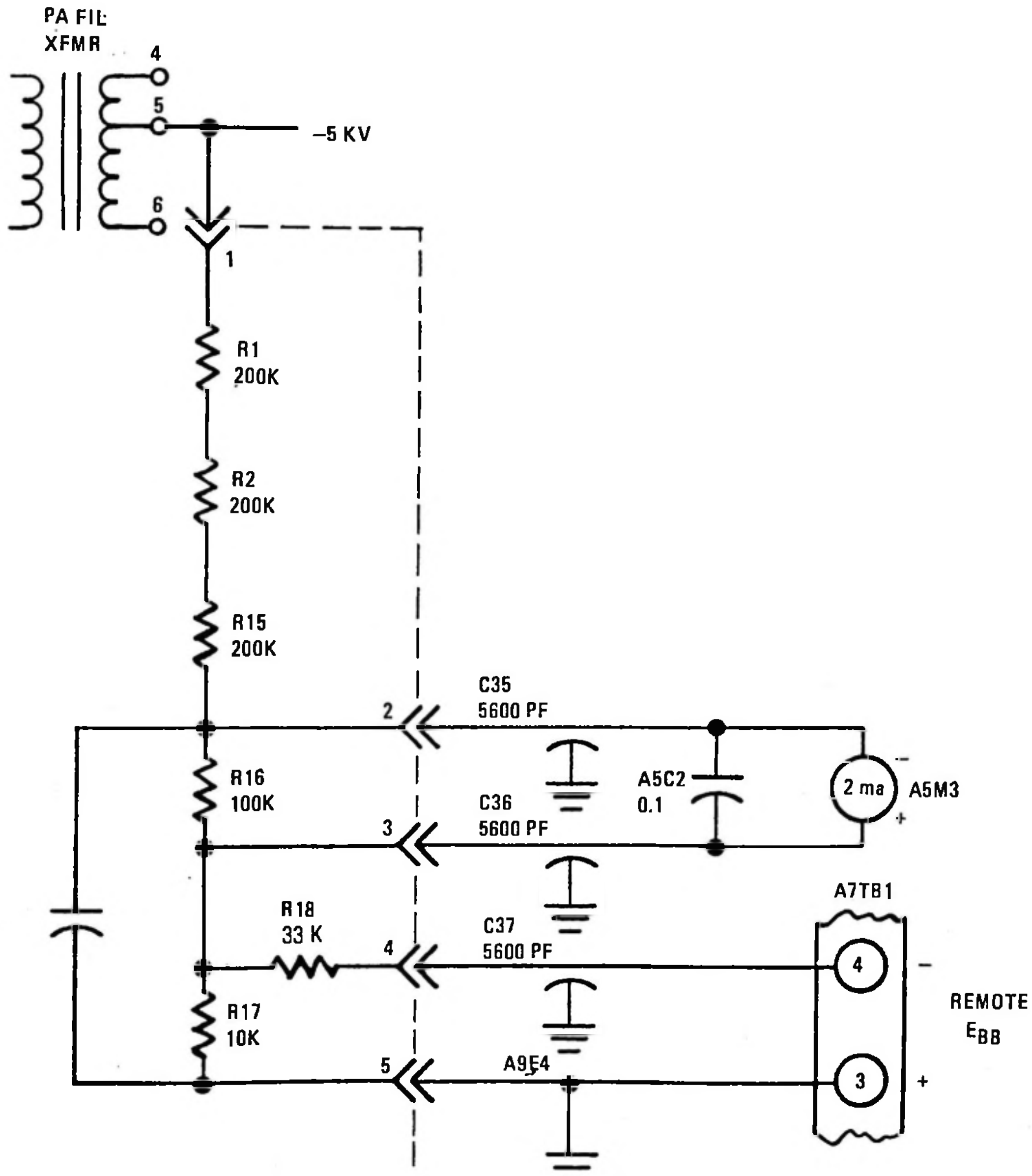


Figure 6-12. Plate Voltage Metering Circuits.

WARNING: DISCONNECT PRIMARY POWER BEFORE SERVICING.

troubleshooting

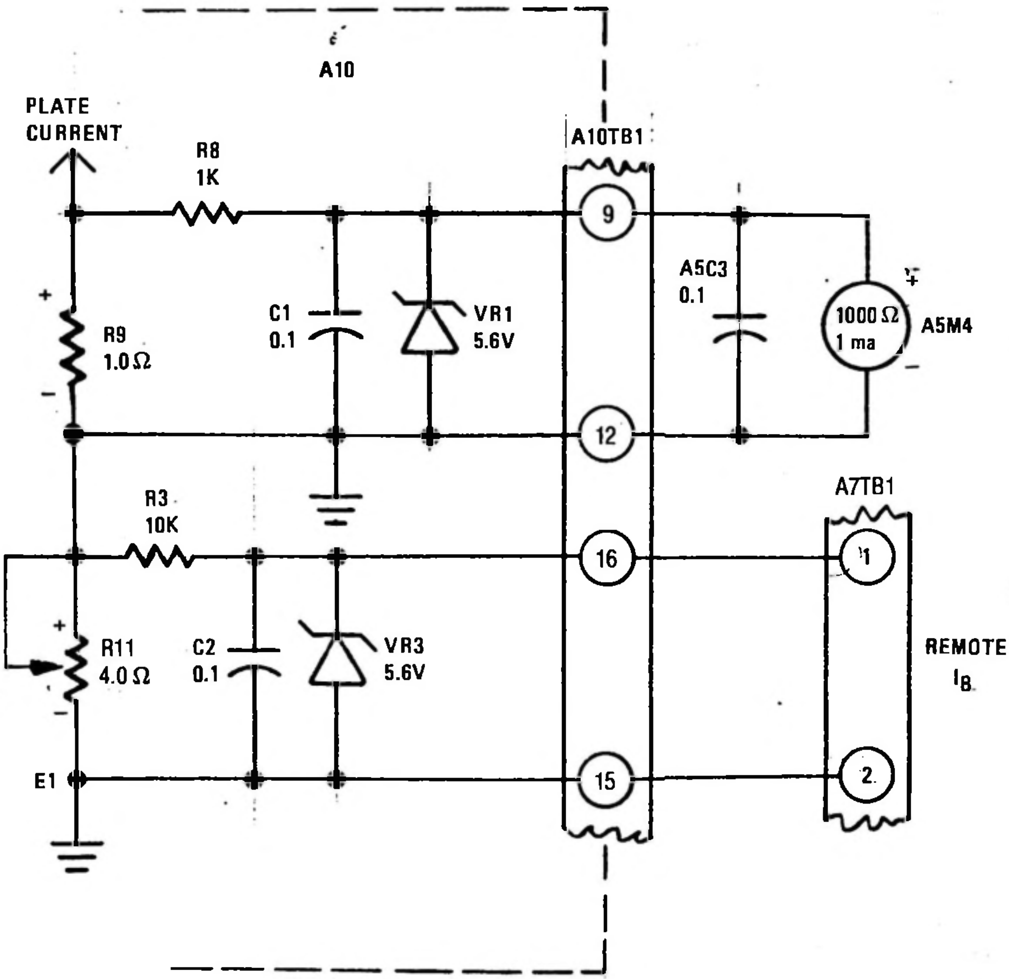


Figure 6-13. Plate Current Metering Circuits.

WARNING: DISCONNECT PRIMARY POWER BEFORE SERVICING.

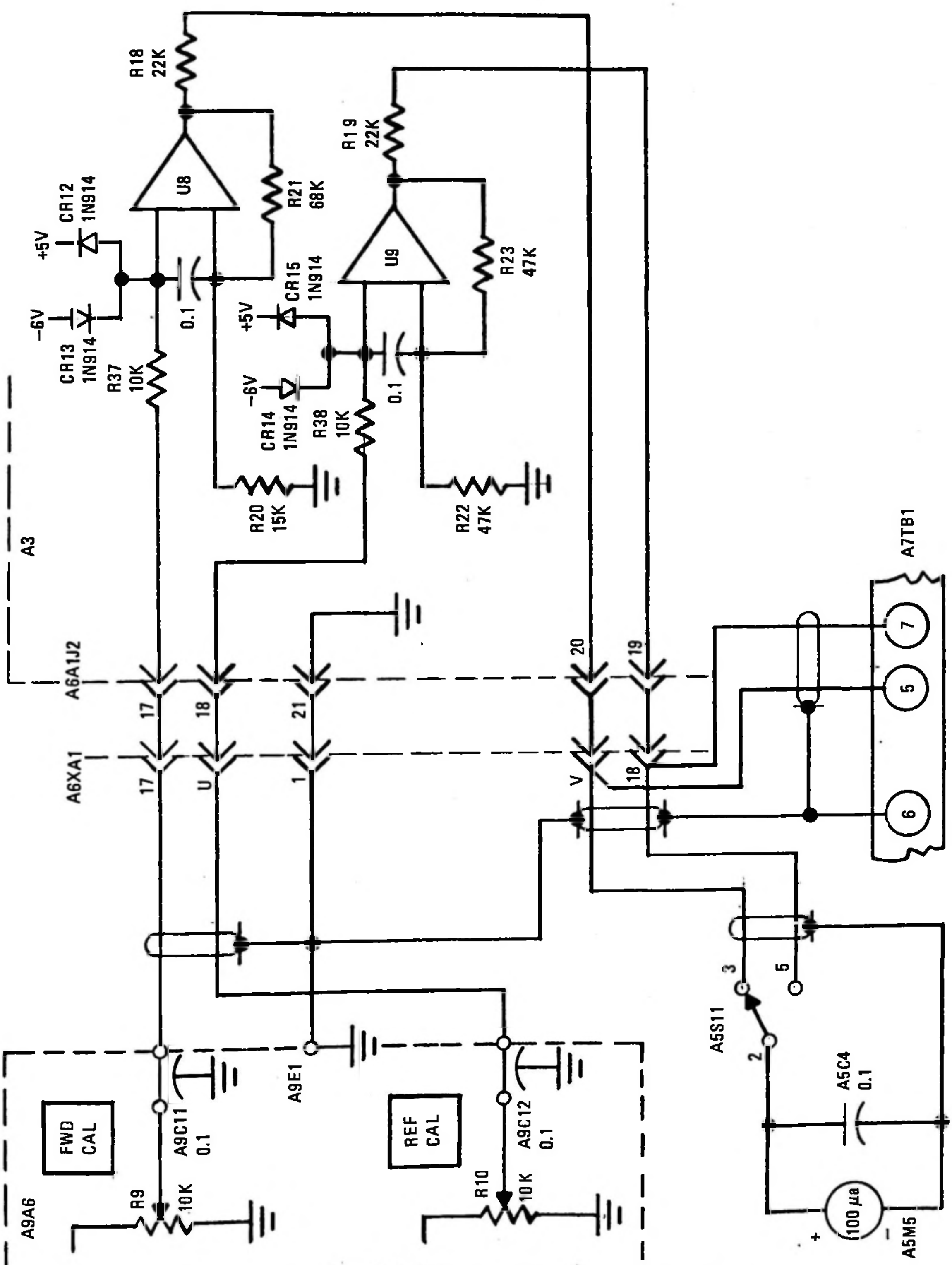


Figure 6-14. RF Power Metering Circuits.

WARNING: DISCONNECT PRIMARY POWER BEFORE SERVICING.

6-11. BACKPLANE

Figure 6-15 is a simplified schematic of backplane A6A1, showing the interconnectins between cards, the high voltage turnoff circuit, and the protective zeners on the logic power supply buses.

The high voltage turnoff circuit senses the RF driver current, and when the current drops below approximately 1.5 amperes, causes Q2 to shunt out the carrier interlock voltage. The LED, CR6, is visible when the A6 panel is down, and indicates presence of driver current. It is on when the driver current is higher than 1.5 amperes.

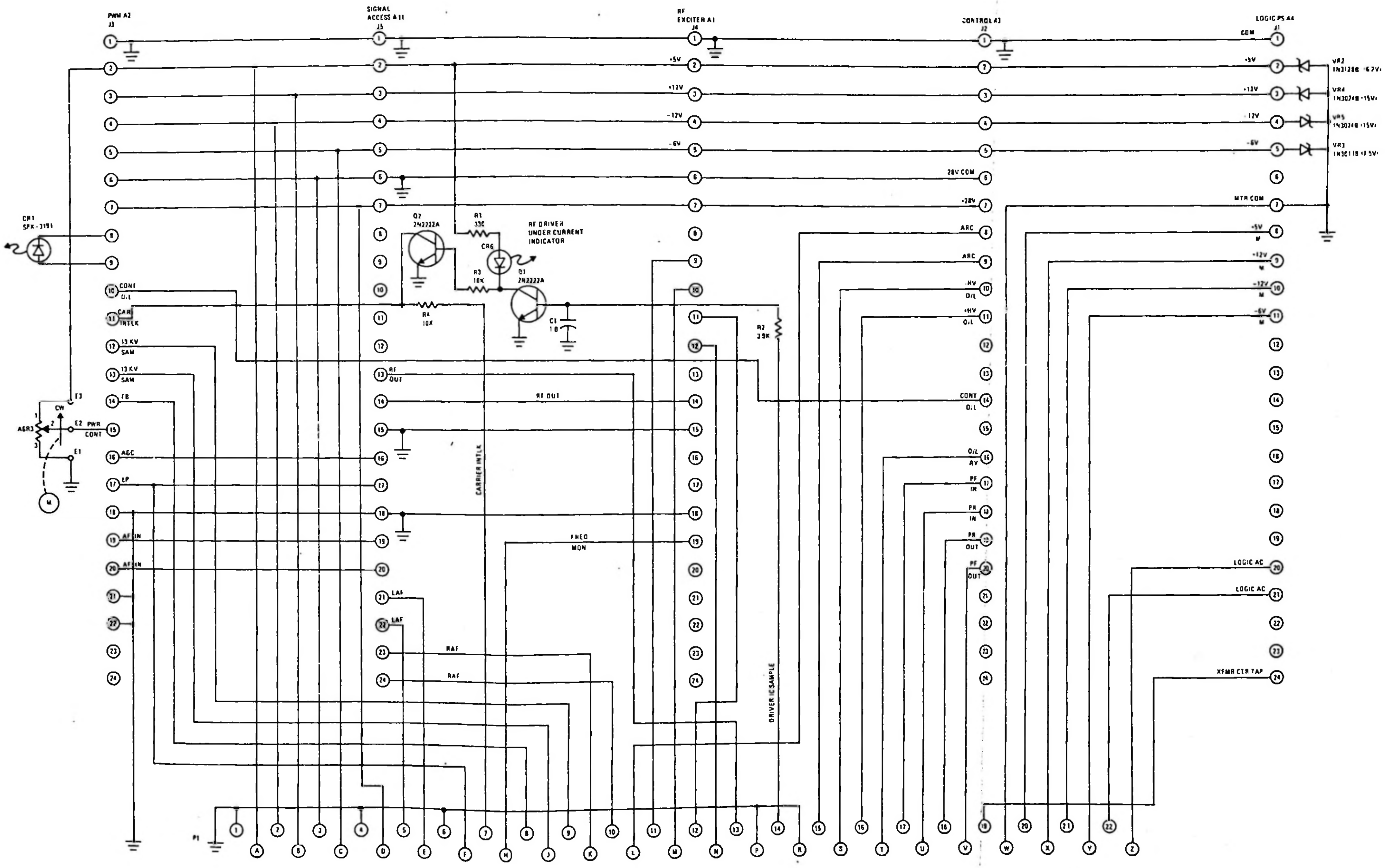


Figure 6-15. Backplane Schematic.

WARNING: DISCONNECT PRIMARY POWER BEFORE SERVICING.

6-12. OVERALL PERFORMANCE CHECK

When checking the 315R-1 Transmitter for modulation characteristic, be sure that test is limited to the transmitter only. Disconnect audio leads from station equipment and have only the audio oscillator connected to the transmitter audio inputs.

Ascertain that the audio test equipment is not part of the problem. Even recently maintained audio oscillators, modulation monitors and distortion analyzers can malfunction.

The 315R-1 transmitter is capable of positive modulation in excess of 125%, better than two percent Total Harmonic Distortion at 95% modulation and between two and four percent Intermodulation Distortion at full power. This performance can be expected if the load is flat and the transmitter is in proper operating condition.

The following covers some of the things that can go wrong with the transmitter that will prevent good performance and what can be done to correct these problems.

6-12.1 POSITIVE PEAK MODULATION

The positive peak capability is checked by turning the clamp adjustment, A2R58 on the PWM card, clockwise to allow 130-140% positive modulation at full power. With an audio oscillator connected to the audio input, set audio frequency to 1000 Hz, and increase the modulation level while observing the RF envelope. The positive peak should show no indication of oscillation or flattening until at least 130% positive modulation is obtained. If this condition is not obtained, the following paragraphs describe some of the corrective action that can be taken. After making the positive peak check, reset the clamp so that it just limits the positive peak at 125-130% modulation as described in Section 5-4.1.3.

Usually positive peak modulation and distortion will deteriorate at the same time. There are a number of things that will cause this. The most common reasons are lack of emission in either the RF tube or the Switch tube, lack of sufficient RF drive, or insufficient High Voltage.

6-12.2 TUBE EMISSION

Low emission in either the RF or the Switch tube will limit the positive peak ability of the transmitter. The emission may be quite adequate to make full carrier power but not nearly enough to support the peak plate current demand during modulation. The instantaneous RF tube plate current at 100% modulation is two times the plate current without modulation. If there is not enough emission available, the positive peaks will be limited and the audio waveform will not be symmetrical, resulting in distortion. It is possible that distortion may be good but the emission will not support the plate current necessary to make 125% positive peaks. This is the first indication of the need to either increase filament voltage or replace the RF tube.

If the filament emission of the Switch tube is severely limited, it will not go into saturation and will overheat. The thermal switch, located above the Switch tube will open taking the transmitter off the air. When the RF tube is severely emission limited, the efficiency may suffer, carrier shift will be excessive, and distortion will be high.

6-12.3 RF TUBE EMISSION CHECK

Checking for low emission in the RF tube is simple. All that is necessary is to observe distortion and positive modulation peaks while the filament voltage is changed. If the emission is sufficient there will be no observed change in performance within the rated filament voltage range. Assume that the filament voltage is 7.5 volts and if the distortion or the positive peak capability improves as voltage is increased, then the tube is suspect. Conversely, it should be possible to reduce filament voltage one or two tenths of a volt below normal operating voltage without affecting performance.

6-12.4 SWITCH TUBE EMISSION CHECK

First review what happens with the switch tube during operation. A shaped 70 kHz waveform is applied to the Switch tube grid that either turns the tube full on or full off. During the time that the tube is off, there is no power dissipation and while the tube is full on, the dissipation is low, providing that the filament emission is sufficient to saturate the tube. If the emission is limited, the tube will not be in saturation during the period that the grid is positive and there will be excessive dissipation in the switch tube and distortion in the modulated DC voltage that is applied to the RF tube. The most reliable method of checking the Switch tube requires an oscilloscope observation of the Switch tube anode waveform. The RF sample may be moved from the RF compartment and installed in the cover of the Switch tube compartment. Make the scope connection to the sample pickup and with the transmitter unmodulated and operating at 5500 watts, observe the negative portion of the waveform. The bottom line represents the voltage across the tube during the time that the tube is supposed to be saturated. It should be a straight line with little or no slope. Figure 6-16 illustrated the possible indications that may be obtained. Change the filament voltage and observe the waveform. It should be possible to get the correct waveform within the rated filament voltage range which is 7.5 volts +/-5%.

NOTE

> If the tube requires 7.9 volts (7.5 +/-5%) that particular tube may be near the end of its life and a replacement tube should be available. However, do not take the the tube out of service as long as increasing filament voltage restores proper performance characteristics.

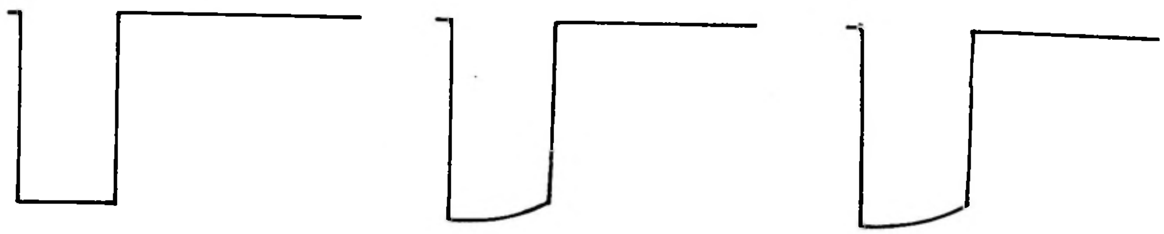


FIGURE 6-16. SWITCH TUBE POSSIBLE WAVEFORMS

6-12.5 NEW TUBE STABILIZATION

It is important to "break in" a new tube and to maintain proper filament voltage throughout the tube's life. Eimac recommends that new tubes be operated at rated voltage for 200-300 hours and then reduce filament voltage until filament is just above the emission limited point but not reduced more than 5%. As the tube ages and the emission decreases, the filament voltage can be increased, always keeping about one or two tenths of a volt more than is needed. For the tubes used in the 315R-1, the filament voltage can be as low as 7.1 or as high as 7.9 volts and still be within the five percent tolerance that Eimac allows. Operating tubes outside these limits will void Eimac's warranty and must be avoided during the first 3000 hours of tube operation to protect the tube warranty. After the initial stabilization period, the filament voltage sequence will be one of operating near the -5% limit and gradually increasing the filament voltage as the life is expended.

6-12.6 FILAMENT VOLTAGE MEASUREMENT

WARNING

WHEN MEASURING FILAMENT VOLTAGE. TURN HIGH VOLTAGE BREAKER OFF. THE SWITCH TUBE FILAMENT TRANSFORMER HAS 15,000 VOLTS AND THE RF FILAMENT TRANSFORMER HAS 5,000 VOLTS APPLIED WHEN IN NORMAL OPERATION. THIS VOLTAGE COULD DAMAGE THE METER AND IS DEADLY TO HUMANS ON CONTACT.

The filament voltage should be measured at the secondary of the filament transformer with an accurate True RMS meter each time a tube is replaced. Only a True RMS meter should be used since a measurement of voltage that represents the heating power is required. Most Volt-Ohm-Milliamp meters are average responding and RMS calibrated which means that they will present an RMS indication only on an undistorted sine wave. Where harmonic type regulators are used and where high current filament circuits are involved the waveform may be distorted.

6-12.7 RF DRIVE

Adequate drive to the RF tube is necessary to get 125% positive peak modulation. Many times an engineer will replace tubes thinking that emission is low when the real problem is either insufficient drive or marginal drive. If drive is marginal, replacing tubes will temporarily restore the positive peaks, but the tubes will appear to be in need of replacement sooner than normal. Low RF drive will cause most of the same symptoms that low emission causes, poor efficiency, positive peak limiting, distortion, and carrier shift. So do not be premature in declaring a tube bad without making the checks outlined previously.

Normal Driver collector current will be between 2.6 and 3.0 amps, depending on frequency. The most common cause of drive problems in the 315R-1 are the grid resistors. These resistors, A9R1, A9R2, A9R3, are located on the right wall under the RF tube.

There are two fixed value 100 ohms resistors, one adjustable 100 ohm resistor. These resistors are wired in series and making a total of 300 ohm maximum in the grid circuit. The value of the adjustable resistor is determined by measuring RF tube grid current and setting to 780-820 Milliamps. The grid current meter should be a one (1) ampere full scale meter. The meter is inserted between the bottom end of A9L13 and the center tap of the RF tube filament transformer, A9T4.

6-12.8 GRID CURRENT MEASUREMENT

WARNING

WHEN MEASURING GRID CURRENT, TURN HIGH VOLTAGE BREAKER OFF. THE FILAMENT TRANSFORMER AND THE TUBE GRID HAVE MORE THAN 5,000 VOLTS APPLIED WHEN THE TRANSMITTER IS IN NORMAL OPERATION. THIS VOLTAGE COULD DAMAGE THE METER AND IS DEADLY TO HUMANS ON CONTACT.

It will be necessary to jumper the rear end of the Driver fuse, F6, to the center input terminal of the High Voltage Breaker, CB3, in order to get primary voltage to the driver supply without the High Voltage Breaker being on. (Make sure jumper is removed after test.)

WARNING

MAKE SURE THAT WALL BREAKERS ARE OFF BEFORE OPENING TRANSMITTER DOOR. BEFORE ANY ADJUSTMENTS OR CONNECTIONS ARE MADE, USE GROUNDING ROD TO DISCHARGE ALL CAPACITORS IN RF COMPARTMENT AND ASCERTAIN THAT THE BUILT-IN SHORTING SWITCHES ARE OPERATIONAL. THIS VOLTAGE IS DEADLY TO HUMANS ON CONTACT.

The following procedure is used to measure grid current:

1. Connect meter in place of wire that connects between the bottom end of A9L13 and the center tap of T4.

2. Place clip lead between rear end of F6 and center terminal of CB3. (Input to CB3 is closest to top edge of access panel.)

3. Make certain that the HV breaker does not get turned on during test. Turn LV and BIAS breaker ON.

4. Turn filaments ON. Driver collector current and an indication of grid current on the meter should be present.

5. If the grid resistor modification has been installed, adjust the 100 ohm adjustable resistor for a grid current indication of approximately 800 milliamps.

6-12.9 HIGH VOLTAGE REQUIREMENTS

The high voltage supply must be at least 13.7 KV in order to reach 125% positive modulation peaks. This voltage is determined by the available line voltage and the transformer tap setting. In no case should the High Voltage be greater than 15,000 volts.

6-12.10 DISTORTION CHECKS

Make a distortion check at the usual audio frequencies, check efficiency and carrier shift at full power. If not within limits, the transmitter loading or exciter pulse width may be at fault. Set the output pulse from the exciter to 120 degrees as described in the instruction manual. Observe the plate voltage and plate current without modulation. The ratio of plate voltage to plate current should be 4000/1 or slightly less. For frequencies below about 910 KHz, the ratio may be as low as 3600/1. Change the tap setting of L3 in the RF network to get the desired ratio. Experiment with the setting of L3 to get the best distortion figures. Each time that L3 is changed, it will be necessary to readjust the plate tuning. Plate tuning should be adjusted in the clockwise direction for plate current increasing out of dip by about 50 - 100 milliamps for best efficiency. Adjust taps on L32 to get best distortion and exciter pulse width and plate tuning for best efficiency. If distortion is good at all frequencies except about 7.5 KHz, check the negative trough of the RF envelope with a scope while modulating at 7.5 KHz and 110% positive modulation. If the negative part of the waveform does not pinch off in a smooth manner, the loading will need to be increased by changing tap setting on L3.

6-12.11 70 KHz FILTER

The 70 KHz filter is often suspected of causing distortion problems but is seldom the reason. However, if there is reason to suspect the 70 KHz filter, it is easy to check. First make a visual check of each coil, L10, L11 and L12. If any section of a coil is discolored or a different color than other sections, the coil is probable defective. When the coils are at room temperature, the resistance of L10 is 19 ohms and coils L11 and L12 is 23 ohms. Coil resistance will be approximately four ohms higher when transmitter is at normal operating temperature. Make a visual and bridge check of the filter capacitors.

6-12.12 BIAS SUPPLY

The bias supply provides plus 125 volts DC to turn the switch tube fully on during the positive part of the 70 KHz switch signal, and negative 125 volts DC during the remaining period. When there is a problem obtaining sufficient positive modulation peaks, the bias supply should be checked for proper operation.

6-12.13 PWM MODULE ADJUSTMENTS

The adjustments in the PWM module are not likely to change and adjustment of these controls to correct a modulation problem should be delayed until the checks described here are performed. Many times PWM module adjustments are taken out of adjustment in attempt to correct a problem not related to the PWM module. These adjustments are described in Section 5-4.1 if adjustment is found necessary.

SECTION 7 - PARTS LIST

7-1. INTRODUCTION

The following include the 315R-1 5-kW AM Transmitter Parts List Table 7-1; the Frequency Kits, Table 7-2; Crystal Frequencies, Table 7-3; the Semiconductor List, Table 7-4, and the suggested Spare Parts list Table 7-5.

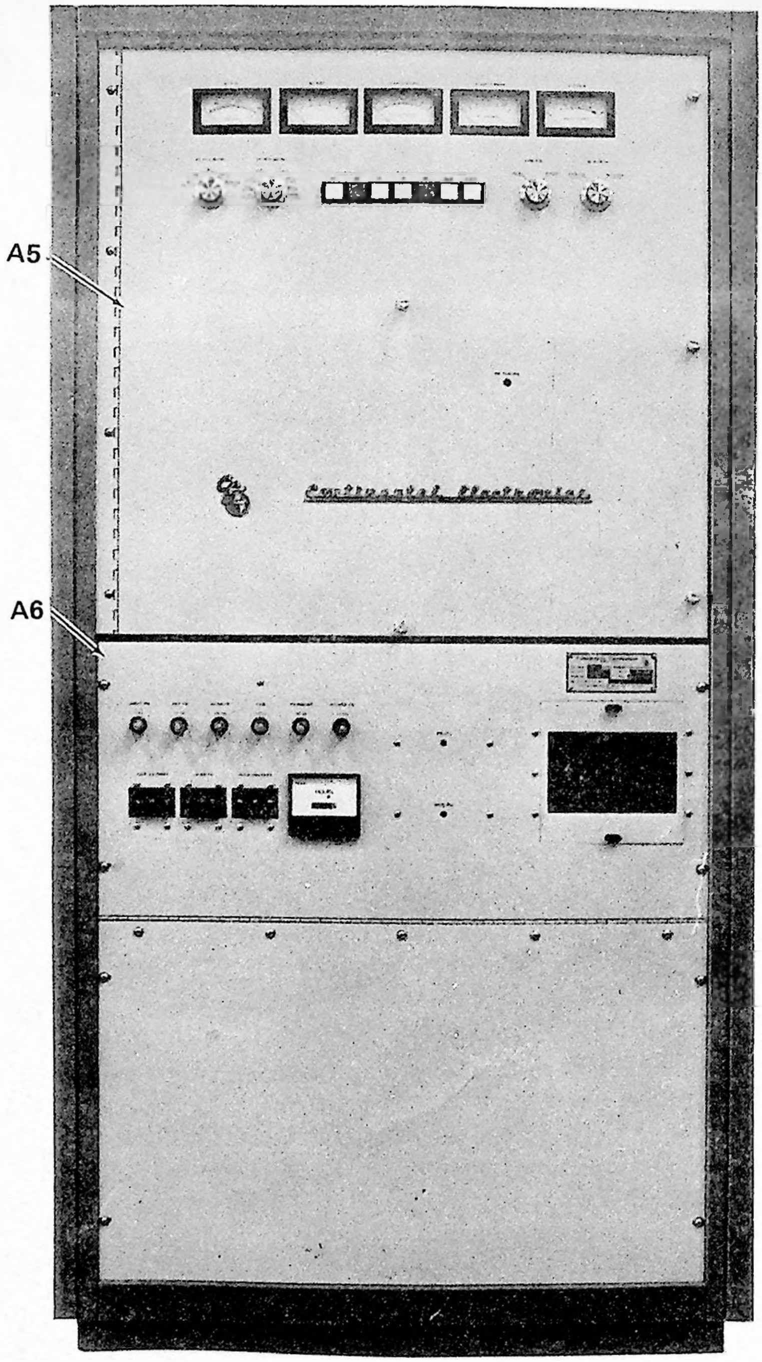


Figure 7-1. 315R-1 Main Frame (Front View)

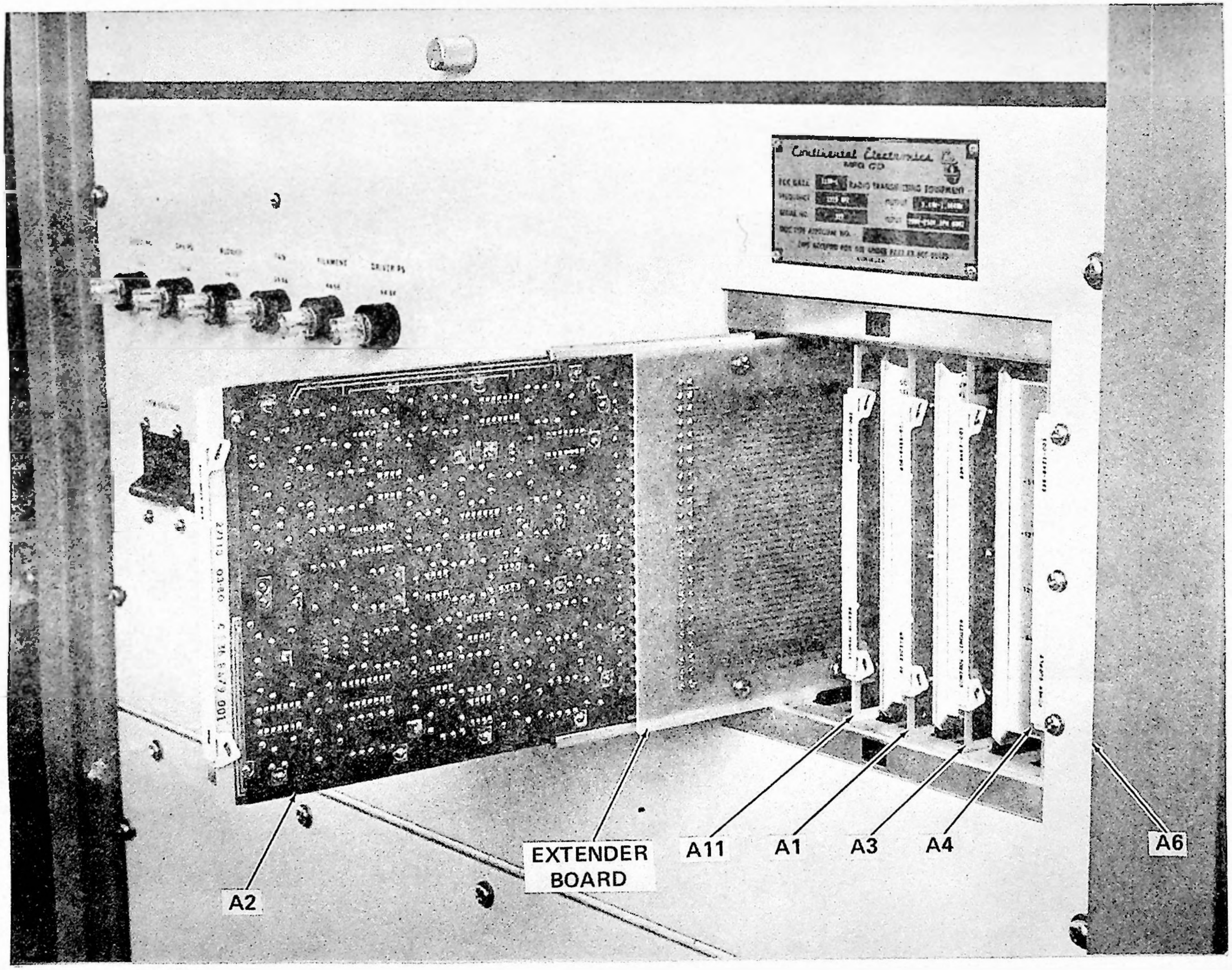


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Figure 7-2. 315R-1 Main Frame (With Extender Card Shown)

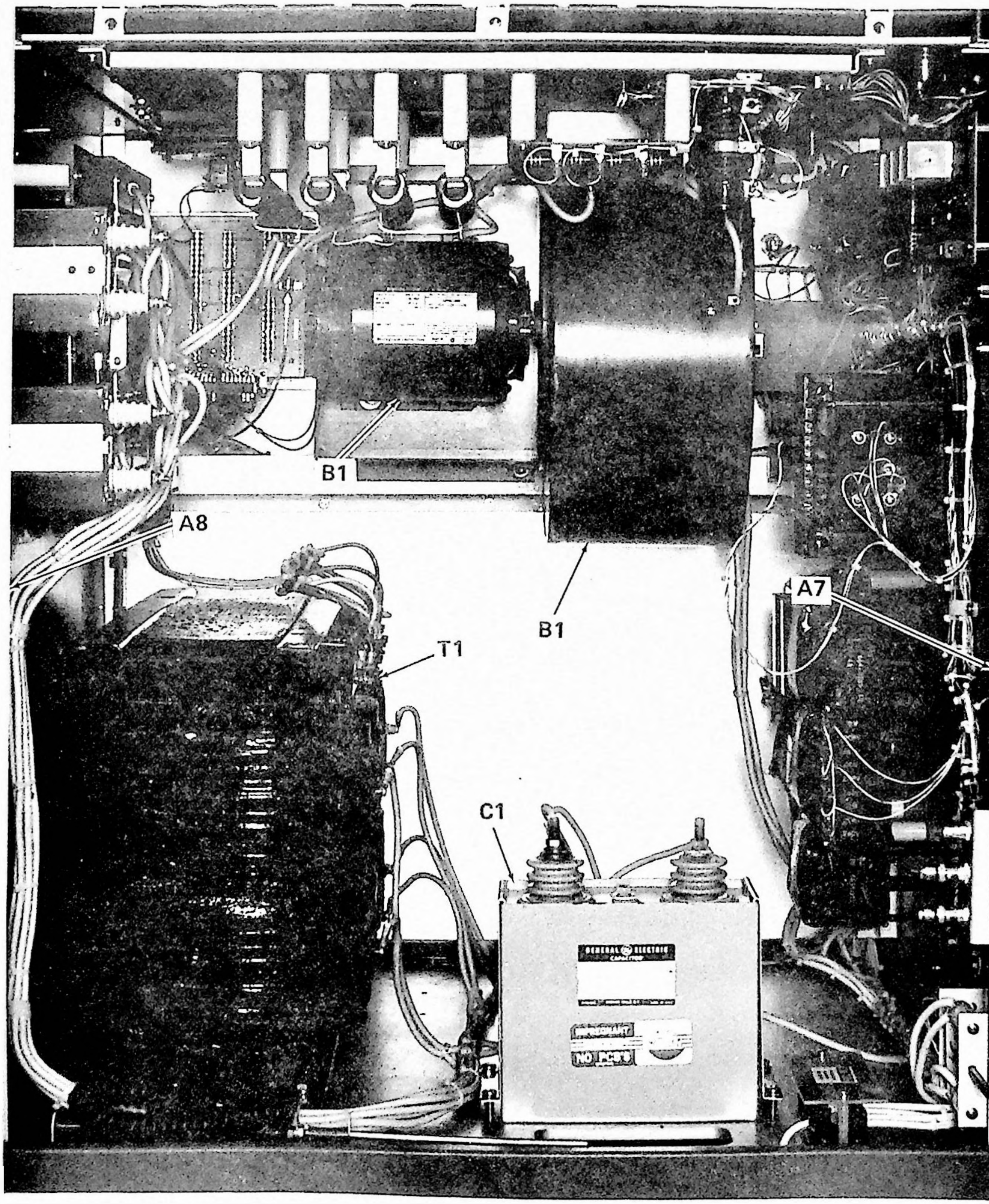

Figure 7-3. 315R-1 Main Frame (Rear View)

TABLE 7-1. PARTS LIST - MAIN FRAME

REF DES	DESCRIPTION	VALUE	PART NUMBER
A1	RF Exciter	PC Assy	636-8434-001
A2	PWM Card	PC Assy	636-8480-001
A3	Control Logic Card	PC Assy	636-8467-001
A4	Logic PS Card	PC Assy	636-8471-001
A5	Meter Panel/Door	Assy	636-8427-001
A6	Circuit Breaker Panel	Assy	636-9680-001
A7	Power Control Chassis	Assy	636-8502-001
A8	High Voltage Power Supply Chassis	Assy	636-8494-001
A9	RF Compartment	Assy	636-9690-001
A10	High Voltage Bleeder	Assy	640-9677-001
A11	Signal Access Card	Assy	640-9699-001
B1	Motor, 60 Hz	1/3HP 230V 60HZ 1725 RPM 220V 50HZ 1425RPM	230-0651-~~010~~ 030
	Motor, 50 Hz (Option)	1/3HP	230-0651-020
-	Blower, Dayton 2 C889	480 CFM	009-1938-010
B2	Cabinet Fan	750 CFM	009-1933-010
C1	HVPS Filter	2.1 mfd 5kV	930-0766-040
K1	Relay, Phase Loss		403-0038-010
T1	Plate Xfmr, 12-phase	13.7kV @ 0.7A	662-0606-010
T2	Filament Reg, 60 Hz (Option)	190-260/236V	661-0191-070
T2	Filament Reg, 50 Hz (Option)	190-260/236V	662-0292-080
TB1	AC Input TB	4 Term, 600V	306-0778-000
W1P1-4	NOT USED		
W1P5	RF Drive	BNC Plug	375-9292-000
XA6A1	Backplane	44-Pin Plug	372-7499-050
XA7A1	Control Relay Card	44-Pin Plug	372-7499-050
XK1	Socket, Octal		220-1121-000
-	Fiber Optic Cable	SPX 3130-201	270-0547-050

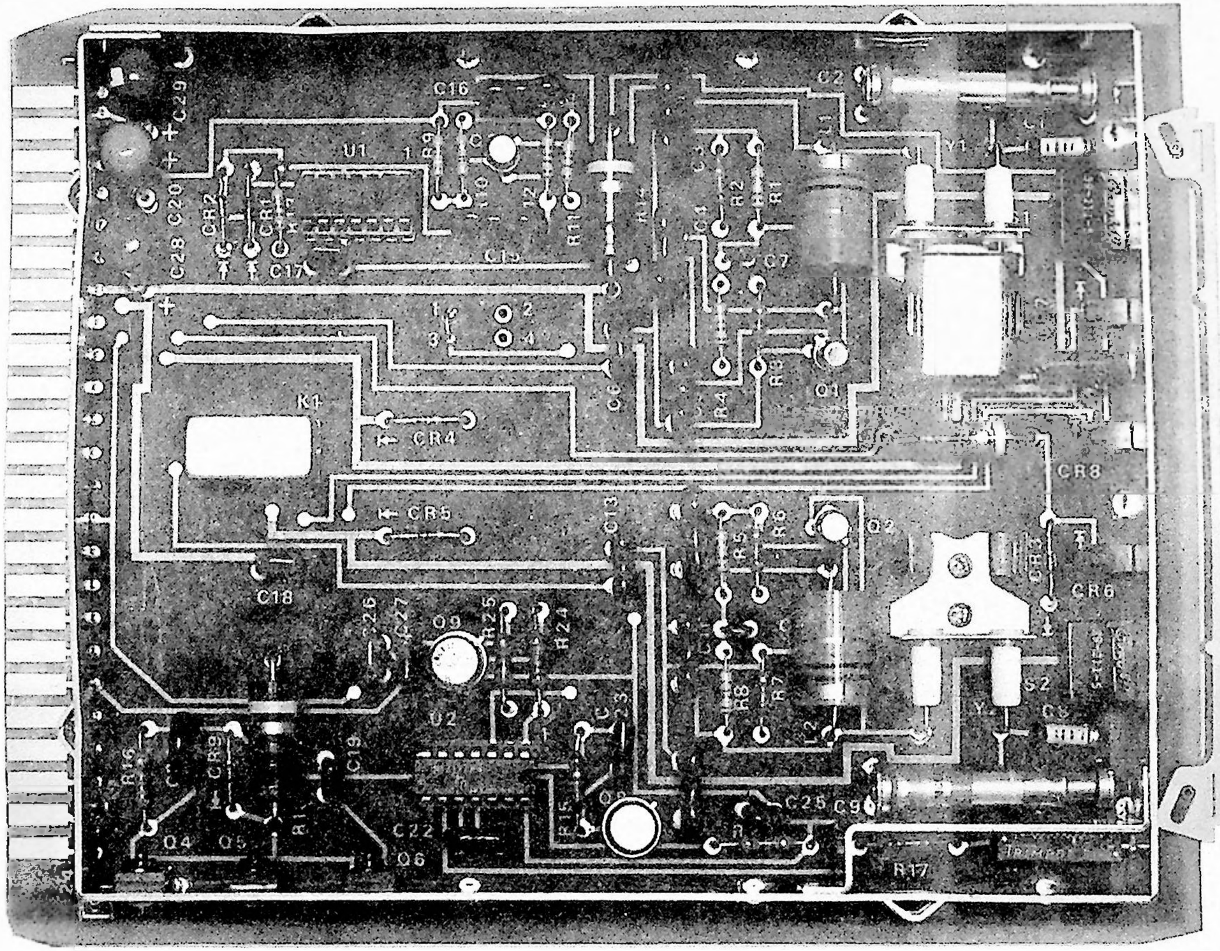

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Figure 7-4. RF Exciter Card A1

RF Exciter Card, A1

REF DES	DESCRIPTION	VALUE	PART NO.
	RF Exciter Card	PC Assy	636-8434-001
C1	Y1 Pad	15pF, 500V	916-0671-000
C2	Osc 1 Adj	1-60 pF Var	922-0609-000
C3	Q1 Base	2200 pF, 500	912-3025-000
C4	Q1 Emitter	510 pF, 500 V	912-2980-000
C5	Q1 Emitter	510 pF, 500 V	912-2980-000
C6	Q1 Emitter	100 pF, 500 V	912-2816-000
C7	1 Bypass	0.1 micro farad 50 V	913-3279-200
C8	Y2 Pad	15 pF, 500 V	916-0671-000
C9	Osc 2 Adj	1-60 pF Var	922-0609-000
C10	Q2 Base	220 pF	912-3025-000
C11	Q2 Emitter	510 pF	912-2980-000
C12	Q2 Emitter	510 pF	912-2980-000
C13	Q2 Emitter	100 pF	912-2816-000
C14	Q2 Bypass	0.1 mfd.,50V	913-3279-200
C15	Q3 Collector	2200 pF, 500 V	912-3025-000
C16	Q3 Emitter	2200 pF, 500 V	912-3025-000
C17	U1 Bypass	1.0 mfd, 50V	913-3279-270
C18	Q5 Bypass	1.0 mfd, 50V	913-3279-270
C19	Q5/Q6 Coupling	1.0 mfd, 50V	913-3279-270
C20	C12-V Bypass	150 mfd, 15V	184-9102-160
C21	---------------------	NOT USED	---------------------
C22	U2 Timing 05	39 pF, 500V	912-2786-000
C23	Q8 Coupling	150 pF, 500V	912-2828-000
C24	Q4 Coupling	390 pF, 500V	912-2858-000
C25	U2 Bypass	1.0 mfd, 50V	913-3279-270
C26-27	Q9 Bypass	1.0 mfd, 50V	913-3279-270
C28	28-V Bypass	33 mfd, 35V	184-9102-440
C29	28-V Bypass	220 mfd, 10V	184-9102-110
CR1	+5-V Clamp	1N914	353-2906-000
CR2	Gnd Clamp	1N914	353-2906-000
CR3	RF Det	1N914	353-2906-000
CR4	K1 Sup	1N4004	353-6442-040
CR5	K1 Sup	1N4004	353-6442-040
CR6	RF Output Ind	Red LED	636-6171-001
CR7	Osc 1 Ind Assy	Red LED	636-6171-001
CR8	Osc 2 Ind Assy	Red LED	636-6171-001
CR9	Clamp Diode	1N914	353-2906-000
K1	Osc Select	28-V Latch Coil	408-0003-010
L1	Osc 1	10 micro H	240-0844-000
L2	Osc 2	10 micro H	240-0844-000
Q1	Osc 1	2N2222A	352-0661-020
Q2	Osc 2	2N2222A	353-0661-020

RF Exciter Card (Cont.)

REF DES	DESCRIPTION	VALUE	PART NO.
Q3	Buffer	2N2222A	352-0661-020
Q4	Output Amp	MJE-243	352-1104-010
Q5	Output Amp	MJE-243	352-1104-010
Q6	Output Amp	MJE-253	352-1105-010
Q7	----------NOT USED----------		
Q8-9	Pulse Amp	2N2102	352-0646-010
R1	Q1 Bias	22 K Ohms1/4W	745-0910-970
R2	Q1 Bias	6.8 K Ohms, 1/4	745-0910-850
R3	Q1 Emitter	680, 1/4W	745-0910-610
R4	Q1 Collector	5.6 K Ohms, 1/4W	745-0910-830
R5	Q2 Bias	22 K Ohms, 1/4W	745-0910-970
R6	Q2 Bias	6.8 K Ohms, 1/4W	745-0910-850
R7	Q2 Emitter	680, 1/4W	745-0910-610
R8	Q2 Collector	5.6 K Ohms, 1/4W	745-0910-830
R9	Q3 Bias	39 K Ohms, 1/4W	745-0911-040
R10	Q3 Bias	10 K Ohms, 1/4W	745-0910-890
R11	Q3 Emitter	2.2 K Ohms, 1/4W	745-0910-730
R12	Q3 Collector	5.6 K Ohms, 1/4W	745-0910-830
R13	U1 Input	2.2 K Ohms, 1/4W	745-0910-730
R14	CR7 & CR8 Limit	1 K Ohm, 2W	745-5652-000
R15	Q8 Base	2.2 K Ohms, 1/2W	745-0914-730
R16	Q4 Base	1.5 K Ohms, 1/2W	745-0914-690
R17	U2 Timing	1.0 K Ohms, 1/2W	745-0914-650
R18	Q4 Collector	100, 2W	745-5610-000
R19	CR6 I Limit	270, 1 W	745-3328-000
R20	Pulse Width	20 Kilohm Pot	382-0012-300
R21	----------NOT USED----------		
R22	----------NOT USED----------		
R23	Q8 Collector	100, 1/2W	745-0914-410
R24	Q9 Base	1 Kilohm, 1/2W	745-0914-650
R25	Q9 Emitter	100, 1/2W	745-0914-410
S1	Osc 1 Select	Switch Push-button	266-6943-080
S2	Osc 2 Select	Switch Push-button	266-6943-080
TP1		Test Point,Brown	360-0268-000
U1	Divider	SN7473N	351-7640-010
U2	One-Shot	SN74121	351-7645-010
XU1-2	Socket for U1,U2	14-Pin	220-0075-020
XY1	Crystal 1 Holder		292-0305-020
XY2	Crystal 2 Holder		292-0305-020
Y1	Freq. Crystal 1	See Crystal Table	289-7274-XXX
Y2	Freq. Crystal 2	See Crystal Table	289-7274-XXX
A1-02	Insulator	For Q4,Q5, Q6	352-9655-070

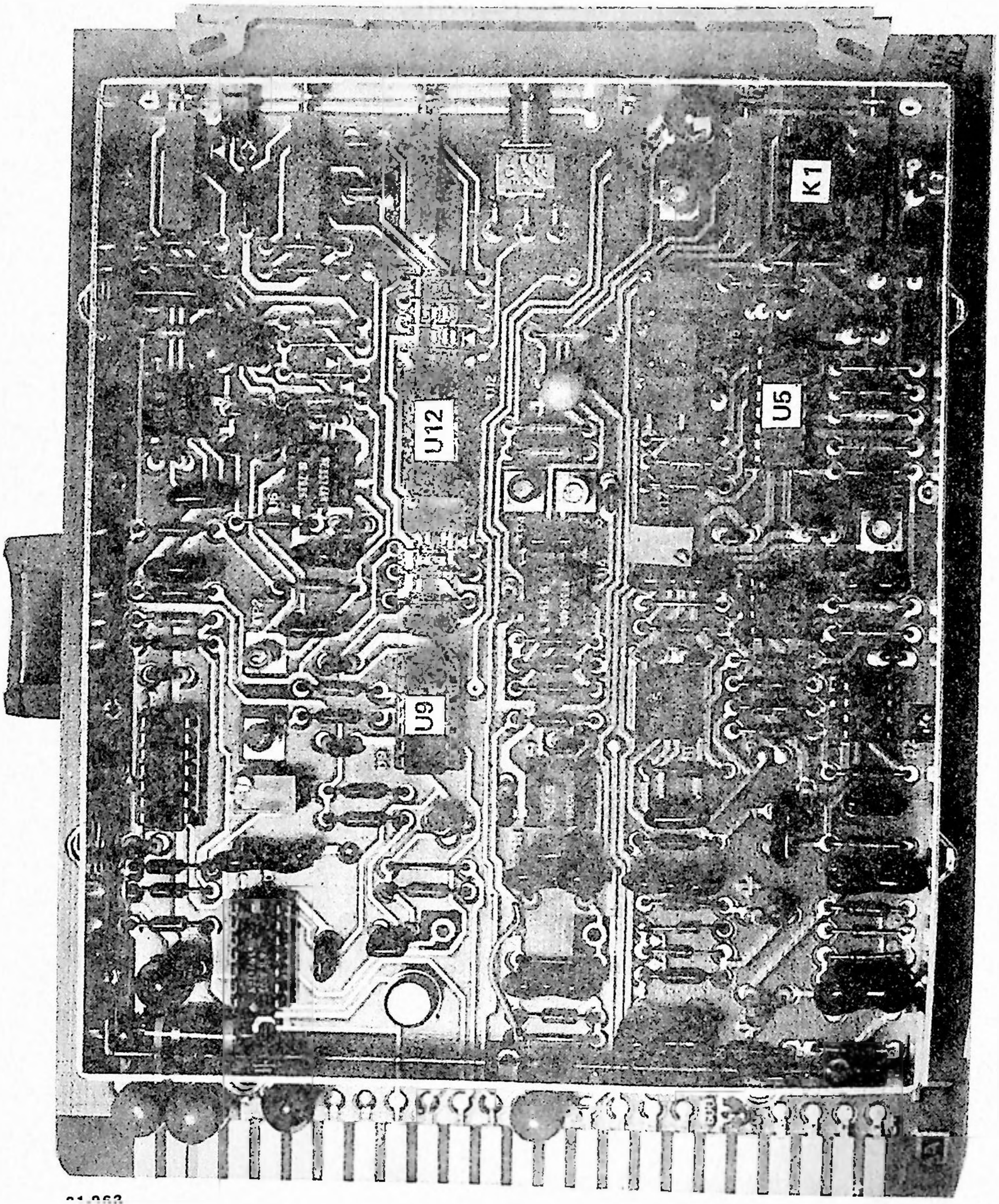

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Figure 7-5. PWM Card A2

parts list

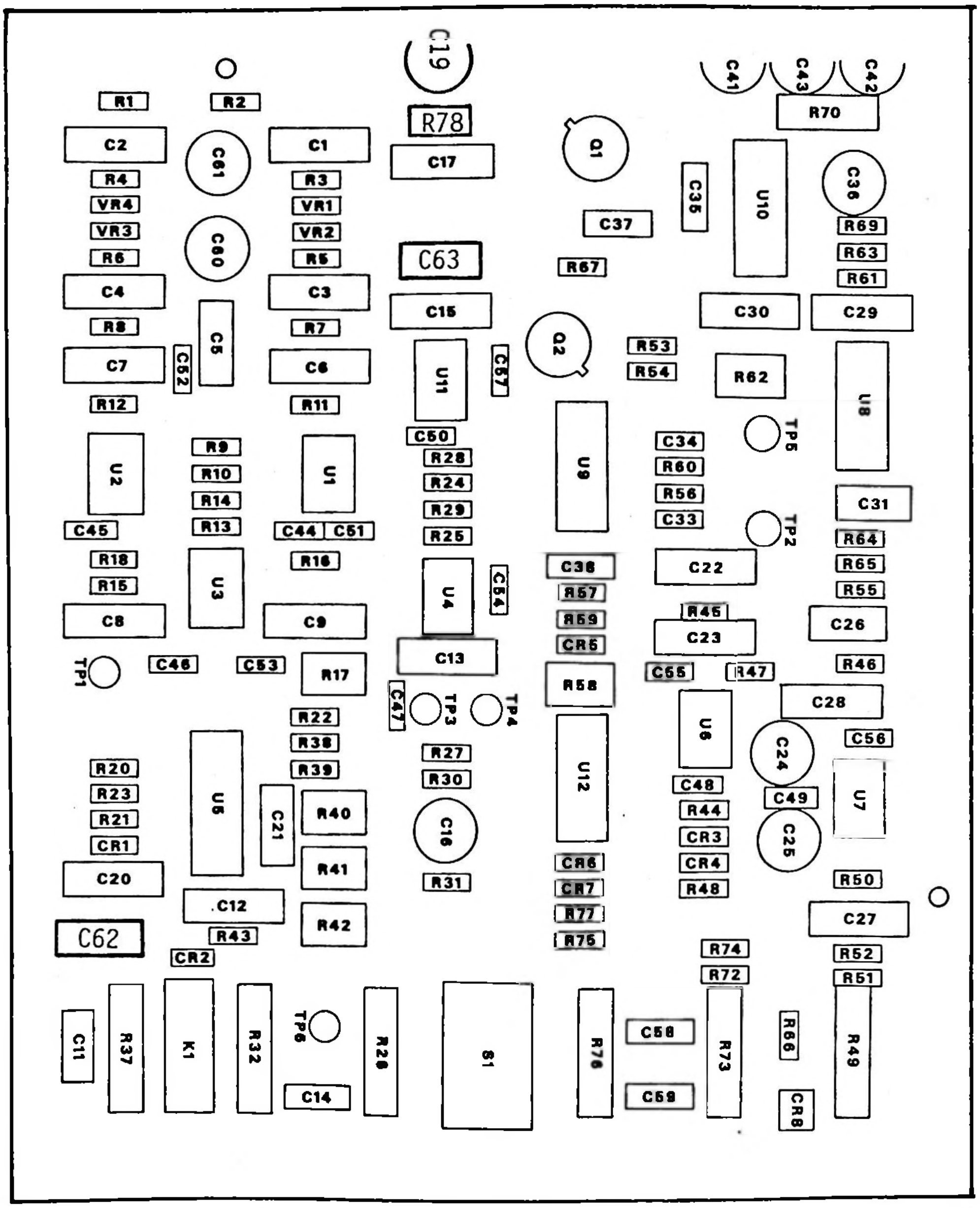

Figure 7-6. Silkscreen of PWM Card A2.

WARNING: DISCONNECT PRIMARY POWER BEFORE SERVICING.

PWM Card A2

REF DES	DESCRIPTION	VALUE	PART NO.
	PWM Card	PC Assy	636-8480-001
C1-2	U1, U2 Input	4700 pF, 500V	912-3052-000
C3-4	U1, U2 Input	470 pF, 500V	912-2974-000
C5	U1, U2 Input	100 pF, 500V	912-2816-000
C6-7	Feedback Cap	22 pF, 500V	912-2768-000
C8	U3 Feedback Capacitor	18 pF, 500V	912-2762-000
C9	Capacitor	560 pF, 500VA2	912-2983-000
C10	Delete		
C11-12	U4 Output Network	0.1 mfd,50V	913-3279-110
C13	U4 Feedback Capacitor	22 pF, 500V	912-2768-000
C14	U4 Input Network PS Sample	220 mfd,10V	184-9102-110
C15	U11 Feedback Capacitor	22 pF, 500V	912-2768-000
C16	U11 Output Network	47 mfd, 20V	184-9102-190
C17	U11 Input Network	1500pF, 500V	912-3013-000
C18	-----------------------	NOT USED-----------	-------------
C19	Pwr Control K1	150 mfd.15V	184-9102-160
C20	U5 +12V Bypass	0.1 mfd,50V	913-3279-200
C21	U5 -12V Bypass	0.1 mfd,50V	913-3279-200
C22	U6 Feedback Network	33 pF, 500V	912-2780-000
C23	U6 Feedback Capacitor	10 pF, 500V	912-2754-000
C24-25	U6 Output Network	10 mfd,35V	184-9102-410
C26	U6 Output Network	390 pF, 500V	912-2858-000
C27	U7 Feedback Network	1500 pF, 500V	912-3013-000
C28	U7 Feedback Cap	10 pF, 500V	912-2754-000
C29	U8 +12V Bypass	0.1 mfd,50V	913-3279-200
C30	U8, -12V Blocking Capacitor	1000 pF, 500V	912-3001-000
C31	U8, -12v Bypass	0.1 mfd,50V	913-3279-200
C32	-----------------------	NOT USED-----------	-------------
C33	U9, +12V Bypass	0.1 mfd,50V	913-3279-200
C34	U9, -6V Bypass	0.1 mfd,50V	913-3279-200
C35	U10A, +5V Bypass	1.0 mfd,50V	913-3279-270
C36	Q1,+5V Bypass Collector	220 mfd,10V	184-9102-110
C37	Q2 Bypass Base	1.0 mfd-,50V	913-3279-270
C38	U12C, +Input Bypass	1.0 mfd,50V	913-3279-270
C39-C40	-----------------------	NOT USED-----------	-------------
C41	-6V Bus Bypass	220 mfd,10V	184-9102-110
C42	+12V Bus Bypass	100 mfd,20V	184-9102-200
C43	-12V Bus Bypass	100 mfd,20V	184-9102-200
C44-C57	Bypass U1-U4, U6, U7, U11	0.1 mfd,50V	913-3279-200

PWM Card A2 (Cont.)

REF DES	DESCRIPTION	VALUE	PART NO.
C58	U12A, +Input Bypass	1.0 mfd,50v	913-3279-270
C59	U12B, +Input Bypass	1.0 mfd,50V	913-3279-270
C60-61	AF Input Coupling	4.7 mfd, 35V	184-9102-390
C62	Ref Filter	1.0 mfd,50V	913-3279-270
C63	FB Rolloff	1000 pF, 5%	912-3001-000
CR1	U4 Output Network	1N4454	353-3644-010
CR2	K1 Coil Transient Suppressor	1N4004	353-6442-040
CR3-4	U6 Output Network	1N4454	353-3644-010
CR5-7	U12A, B, C, Output Iso Diode	1N5711	353-3691-010
CR8	Carrier Interlock	Red LED	636-6171-001
K1	Power Select	Relay, 28V	410-0572-010
L1	-------------------------	NOT USED------------------------	
Q1	LED Bias Driver	2N2102	352-0646-010
Q2	Carrier Intlk Line Dvr	2N2222A	352-0661-020
R1	U1, U2 Input	590, 1%, 1/8W	705-0985-000
R2	U1,U2,Input Network	154,1%, 1/8W	705-0957-000
R3-8	U1, U2 Input Network	10.0K Ohms 1%,1/8W	705-1044-000
R9	Input Termination	1.54K Ohms,1%,1/8W	705-1005-000
R10	Input Network	6.81K Ohms,1%,1/8W	705-1036-000
R11-12	U1,U2 Feedback Resist	3.16K Ohms,1%,1/8W	705-1020-000
R13-14	U1, U2 Output Load	22.6K Ohms,1%,1/8W	705-1061-000
R15	U3 Feedback Resistor	46.4K Ohms,1%,1/8W	705-1076-000
R16	U3 Input Cm Adj	44.2K Ohms,1%,1/8W	705-1075-000
R17	Common Mode Adj Internal	5 K Ohms, 25T Var	382-1405-060
R18	U3 Output Network	20.5K Ohms, 1%, 1/8W	705-1059-000
R19	-------------------------	NOT USED-------------------------	
R20	U3 Output Network	10K Ohms, 1%,1/8W	705-1044-000
R21	U4 Output Network	1.0K Ohms, 1%, 1/8W	705-0996-000
R22	U5 Pullup Resistor	30.1 K Ohms, 1%, 1/8W	705-1067-000

PWM Card A2 (Cont.)

REF DES	DESCRIPTION	VALUE	PART NO.
R23	Pullup Resistor	15.4 K Ohms, 1% 1/8W	705-1053-000
R24	U4 Output Network	1.0 K Ohms, 1% 1/8W	705-0996-000
R25	U4 Feedback Resistor	52.3 K Ohms, 1%, 1/8W	705-3605-820
R26	PS Offset Adj Front Panel	10.0 K Ohms, 15 T Var	382-0012-290
R27	U4, +Input Iso Res +5 Bus	78.7 K Ohms,1%, 1/8W	705-1087-000
R28	U11 Input Network	33.2K Ohms, 1%, 1/8W	705-1069-000
R29	U11 Output Network	38.3K Ohms, 1%, 1/8W	705-1072-000
R30	U4, +Input From PS Sample	8.25K Ohms, 1%, 1/8W	705-1040-000
R31	U11 Output Network	2.26K Ohms, 1%, 1/8W	705-1013-000
R32	Network Audio Nul Adj Internal	5K Ohms, 15T Var	382-0012-280
R33-R36	---------------------------NOT USED------------------------		
R37	Low Power Adj Front Panel	10K Ohms, 15T Var	382-0012-290
R38-39	U5 Output Network	2.61K Ohms, 1%, 1/8W	705-1016-000
R40	Audio Balance Adj Internal	10K Ohms, 25T Var	382-1405-070
R41	Control Balance Adj Internal	10K Ohms,25T Var	382-1405-070
R42	Amplifier Balance Adj Internal	10K Ohms,25T Var	382-1405-070
R43	U5 Pin 1 Load	16.2K Ohms, 1%, 1/8W	705-1054-000
R44	U6 Feedback Network	15.4K Ohms, 1%, 1/8W	705-1053-000
R45	U6 Output Network	3.48K Ohms, 1%, 1/8W	705-1022-000
R46	U6 Output Network	1.0K Ohm, 1%,1/8W	705-0996-000
R47	U6 Output Network	10.0K Ohms, 1%, 1/8W	705-1044-000
R48	U6 Output Network Car Reg	22.6 Ohms, 1%, 1/2W	705-0917-000
R49	Carrier Reg Adj Front Panel	10K Ohms,15 T Var	382-0012-290

CHANGE 1

PWM Card A2 (Cont.)

REF DES	DESCRIPTION	VALUE	PART NO.
R50	U7 Feedback Network	100K Ohms, 1%,1/8W	705-1092-000
R51	U7 Input Network Carrier Reg	22.6K Ohms, 1%, 1/8W	705-1061-000
R52	U7 Input Pin 3	1.62K Ohms, 1%, 1/8W	705-1006-000
R53	Feedback Input to U7	7.5K Ohms, 1%, 1/8W	705-1038-000
R54	Pwr Ctrl Input to U7	13.3K Ohms, 1%, 1/8W	705-1050-000
R55	U7 Output Ntwk	2.15K Ohms, 1%, 1/8W	705-1012-000
R56	U9 Input	4.87K Ohms, 1%, 1/8W	705-1029-000
R57	U12C Input	1.05K Ohms, 1%, 1/8W	705-0997-000
R58	Clamp Adj Internal	1K Ohm, 25T Var	382-1405-040
R59	U12C Input	1.0K Ohms,1%, 1/8W	745-0910-650
R60	U8 Output Pin 3	1.47K Ohms,1%, 1/8W	705-1004-000
R61	U8 Pin 6	1.54K Ohms, 1% 1/8W	705-1005-000
R62	Switch Freq Adj Internal	500, 25 T Var	382-1405-030
R63	U8 Pin 4	100 Ohms, 1%, 1/8W	705-0948-000
R64	U8 Pin 5	100 Ohms, 1%, 1/8W	705-0948-000
R65	U8 Pin 12	82.5K Ohms, 1%, 1/8W	705-1088-000
R66	Anode of Carr Intlk LED CR8	348 Ohms, 1%, 1/8W	705-0974-000
R67	Q2 Base	2.26K Ohms, 1%, 1/8W	705-1013-000
R68	DELETED		
R69	U10B Pin 6	825 Ohms, 2%, 1/8W	705-0992-000
R70	Q1 Collector	47 Ohms, 10%, 1W	745-3296-000
R71	-----------------------	NOT USED----------------	----------------
R72	U12A Input Neg Limit	1.47K Ohms, 1%, 1/8W	705-1004-000
R73	U12A Neg Limit Adj Front Panel	2 K Ohms,15T Var	382-0012-270
R74	U12A Input	1K Ohm,1%,1/8W	705-0996-000
R75	U12B Input	10 Ohms, 1%,1/8W	705-0900-000
R76	Pos Limit Adj Front Panel	2 K Ohms,15T Var	705-0012-270

PWM Card A2 (Cont.)

REF DES	DESCRIPTION	VALUE	PART NO.
R77	U12B Input	750 Ohms, 1%,1/8W	705-0990-000
R78	Feedback	7.5 K Ohms, 1%	705-1038-000
VR1-4	Audio Input Clamp,See U1, UA	1N756A, 8.2V	353-2720-000
S1	IPC On-Off Front Panel	SPDT Switch	266-5321-980
TP-1	Audio Output	Red TP	360-0489-020
TP-2	AGC Output	Green TP	360-0489-040
TP-3	Control Amplifier Output	Yellow TP	360-0489-060
TP-4	Ground	Black TP	360-0489-030
TP-5	Switch Freq Output	White TP	360-0489-010
TP-6	PS Sample	Blue TP	360-0489-080
U1	Audio Input	NE5534AN	351-1339-010
U2	Audio Input	NE5534AN	351-1339-010
U3	Audio Sum	NE5534AN	351-1339-010
U4	AGC Comp	NE5534AN	351-1339-010
U5	AGC Control	MC-1494L	351-1116-010
U6	AGC Amplifier	NE5534AN	351-1339-010
U7	PWM Sum	NE5534AN	351-1339-010
U8	Function Generator	8038	351-1231-020
U9	PWM Generator	710	351-7189-050
U10	PWM Gate	7410	351-7635-010
U11	Audio Null	NE5534AN	351-1339-010
U12	Limit Amp	3403	351-1223-020
XU1	8-Pin Dip	Socket	220-0075-010
XU2	8-Pin Dip	Socket	220-0075-010
XU3	8-Pin Dip	Socket	220-0075-010
XU4	8-Pin Dip	Socket	220-0075-010
XU5	16-Pin Dip	Socket	220-0075-030
XU6	8-Pin Dip	Socket	220-0075-010
XU7	8-Pin Dip	Socket	220-0075-010
XU8	14-Pin Dip	Socket	220-0075-020
XU9	14-Pin Dip	Socket	220-0075-020
XU10	14-Pin Dip	Socket	220-0075-020
XU11	8-Pin Dip	Socket	220-0075-010
XU12	14-Pin Dip	Socket	220-0075-020
XK1	14-Pin Dip	Socket	220-0075-020

81-964

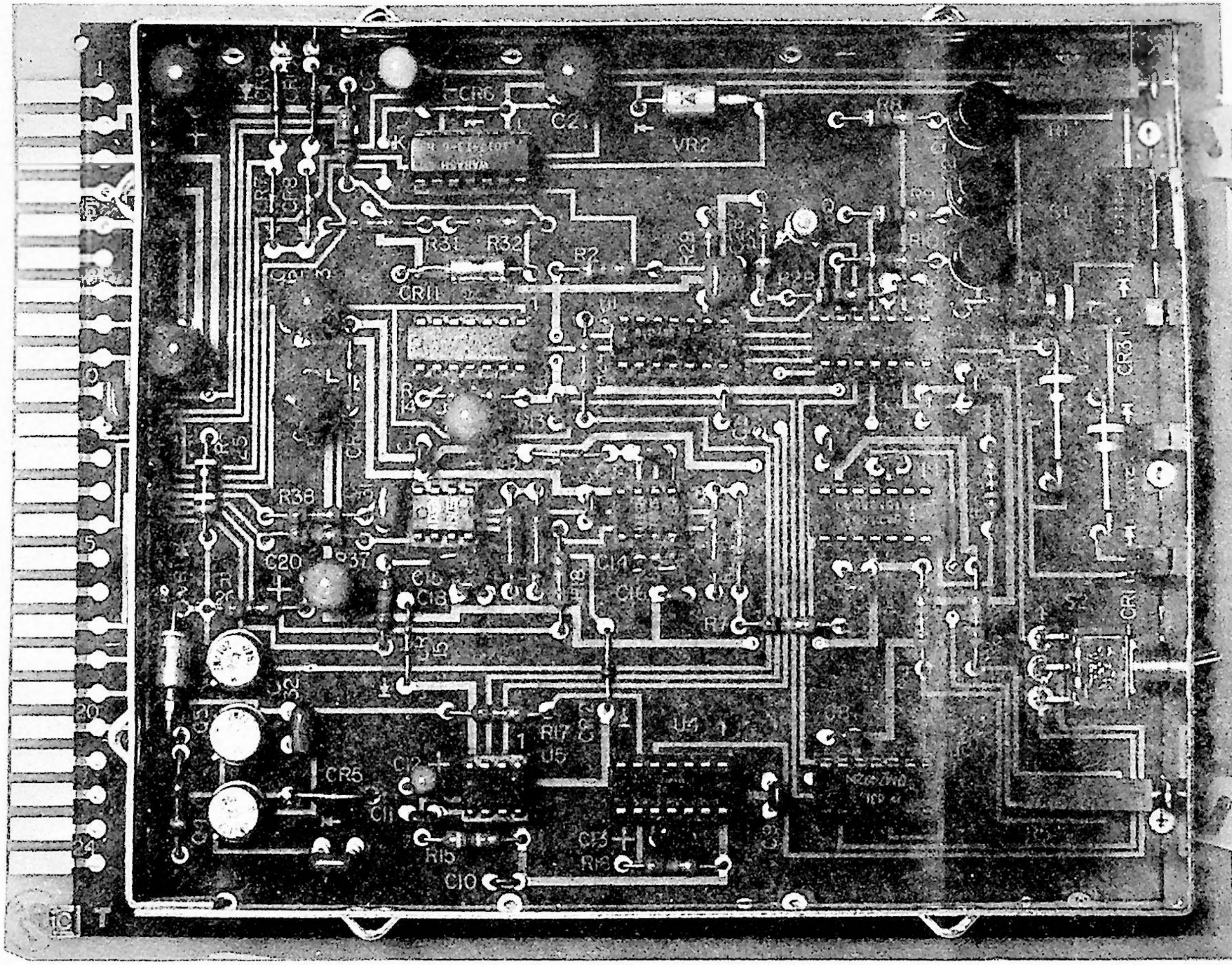

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Figure 7-7 Control Circuit Card A3

Control Circuits Card A3

REF DES	DESCRIPTION	VALUE	PART NO.
	Control Logic Card	PC Assy	636-8467-001
C1	U9,-12-VBypass	0.1 mfd, 50V	913-3279-200
C2	U7,+12-V Bypass	0.1 mfd, 50V	913-3279-200
C3	U7, -6-V Bypass	0.1 mfd, 50V	913-3279-200
C4	U6, +5-V Bypass	0.1 mfd, 50V	913-3279-200
C5	U1, +5-V Bypass	0.1 mfd, 50V	913-3279-200
C6	U2, +5-V Bypass	0.1 mfd, 50V	913-3279-200
C7	U2 Recycle Timing	47 mfd, 20V	184-9102-190
C8	U3, +5-V Bypass	0.1 mfd, 50V	913-3279-200
C9	U4, +5-V Bypass	0.1 mfd, 50V	913-3279-200
C10	U5, +5-V Bypass	0.1 mfd, 50V	913-3279-200
C11	U5 Bypass	0.1 mfd, 50V	913-3279-200
C12	U5 Timing	33 mfd, 10V	184-9102-090
C13	U4 Timing	10 mfd, 50V	184-9102-240
C14	U8 Comp	100 pF 50V	912-2816-000
C15	U9 Comp	100 pF 50V	912-2816,000
C16	U8,+12-V Bypass	0.1 mfd, 50V	913-3279-200
C17	U8,-12-V Bypass	0.1 mfd, 50V	913-3279-200
C18	U9,+12-V Bypass	0.1 mfd, 50V	913-3279-200
C19	U7 Input Filter	0.1 mfd, 50V	913-3279-200
C20	Integrator	33 mfd, 35V	184-9102-440
C21-23	5-V Bypass	220 mfd, 10V	184-9102-110
C24-25	12-V Bypass	150 mfd, 15V	184-9102-160
C26	28-V Bypass	33 mfd, 35V	184-9102-440
C27	Bypass	0.1 mfd, 50V	913-3279-200
C28	Bypass	1.0 mfd, 50V	913-3279-270
C29-30	Bypass	0.1 mfd, 50V	913-3279-200
C31-33	Bypass	1.0 mfd, 50V	913-3279-270
C34	R1 Protect	1.0 mfd, 50V	913-3279-270
CR1	VSWR	Red LED	636-6171-001
CR2	Arc	Red LED	636-6171-001
CR3	HVPS	Red LED	636-6171-001
CR4	1N4004	400 V, 1A	353-6442-040
CR5	1N4004	400 V, 1 A	353-6442-040
CR6	1N4004	400 V, 1 A	353-6442-040
CR7-10	Diode	1N914	353-2906-000
CR11	Diode	1N3827A	353-6316-000
CR12-15	Diode	1N914	353-2906-000
K1	HVPS O/L	SPST, 5 V,500	410-0572-020
Q1	SCR C6F	50 V, 100 mA	353-6468-010
Q2	SCR C6F	50 V, 100 mA	353-6468-010
Q3	SCR C6F	50 V, 100 mA	353-6468-010

Control Circuits Card A3 (Cont.)

REF DES	DESCRIPTION	VALUE	PART NO.
Q4	O/L Driver	2N2102	352-0646-010
Q5	O/L Driver	2N2102	352-0646-010
Q6	Integrator	2N2102	352-0646-010
Q7	-----------------------	--NOT USED------------------------	
Q8	Arc Sensor	2N2222A	352-0661-020
R1	O/L Adj	1K Ohm Pot 15	382-0012-260
R2	O/L Pullup	4.7K Ohms,1/2	745-0914-810
R3	Arc Pullup	4.7K Ohms,1/2	745-0914-810
R4	U7	2.2K Ohms,1/2	745-0914-730
R5	U7	5K Ohms,Pot 15T	382-0012-280
R6	U7	1K Ohms,1/2 W	745-0914-650
R7	U7	10K Ohms, 1/2 W	745-0914-890
R8	U6	470 Ohms, 1/2 W	745-0914-570
R9	U6	470 Ohms, 1/2 W	745-0914-570
R10	U6	470 Ohms, 1/2 W	745-0914-570
R11	CR1	2.2K Ohms, 1 W	745-3366-000
R12	CR2	2.2K Ohms, 1 W	745-3366-000
R13	CR3	2.2K Ohms, 1 W	745-3366-000
R14	U2	22K Ohms, 1/2 W	745-0914-970
R15	U5	470K Ohms,1/2 W	745-0915-300
R16	U4	22K Ohms, 1/2 W	745-0914-970
R17	U4	1K Ohm, 1/2 W	745-0914-650
R18	U8	22K Ohms, 1/2 W	745-0914-970
R19	U9	22K Ohms, 1/2 W	745-0914-970
R20	U8	15K Ohms,1/4 W, 1%	705-3602-460
R21	U8	68K Ohms,1/4 W, 1%	705-0911-100
R22	U9	47.5KOhms,1/4W, 1%	705-3602-680
R23	U9	47.5K Ohms,1/4W, 1%	705-3602-680
R24	U1B	2.2K Ohms,1/2 W	745-0914-730
R25	Q6	3.9K Ohms,1/2 W	745-0914-790
R26	Q6	27 Ohms,1/2 W	745-0914-270
R27	Q5	4.7K Ohms,1/2 W	745-0914-810
R28-29	U1	470 Ohms,1/2 W	745-0914-570
R30	U7	100 Ohms,1/2 W	745-0914-410
R31-32	Q7	220 Ohms,1/2 W	745-0914-490
R33	---------------------	NOT USED----------------------------	
R34-35	---------------------	NOT USED----------------------------	
R36	Arc Sensor	1.0K Ohm, 1/2W	745-0914-650
R37-38	U8, U9	10K Ohms, 1/2 W	745-0914-890
S1	Reset	NC Momentary	266-6943-080
S2	Recycle	SPDT	266-5321-980
U1	NAND Gate	7410	351-7635-010

CHANGE 7

Control Circuits Card A3 (Cont.)

REF DES	DESCRPITION	VALUE	PART NO.	
U2	One-Shot	74121	351-7645-010	
U3	Counter	7492	351-7771-010	
U4	One-Shot	74121	351-7645-010	
U5	Timer	NE555V	351-1137-020	
U6	Hex Invertor	7404	351-7630-010	
U7	1mA 710	Comparator	351-7189-050	
U8	Op Amp	NE531U	351-1164-010	
U9	Op Amp	NE531U	351-1164-010	
VR1-VR2	Diode	1N4744A	353-6481-330	*
XU1-4	U1, 2, 3, 4	14-Pin Socket	220-0075-020	
XU5	U5	8-Pin Socket	220-0075-010	
XU6-7	U6,7	14-Pin Socket	220-0075-020	
XU8-9	U8, 9	8-Pin Socket	220-0075-010	

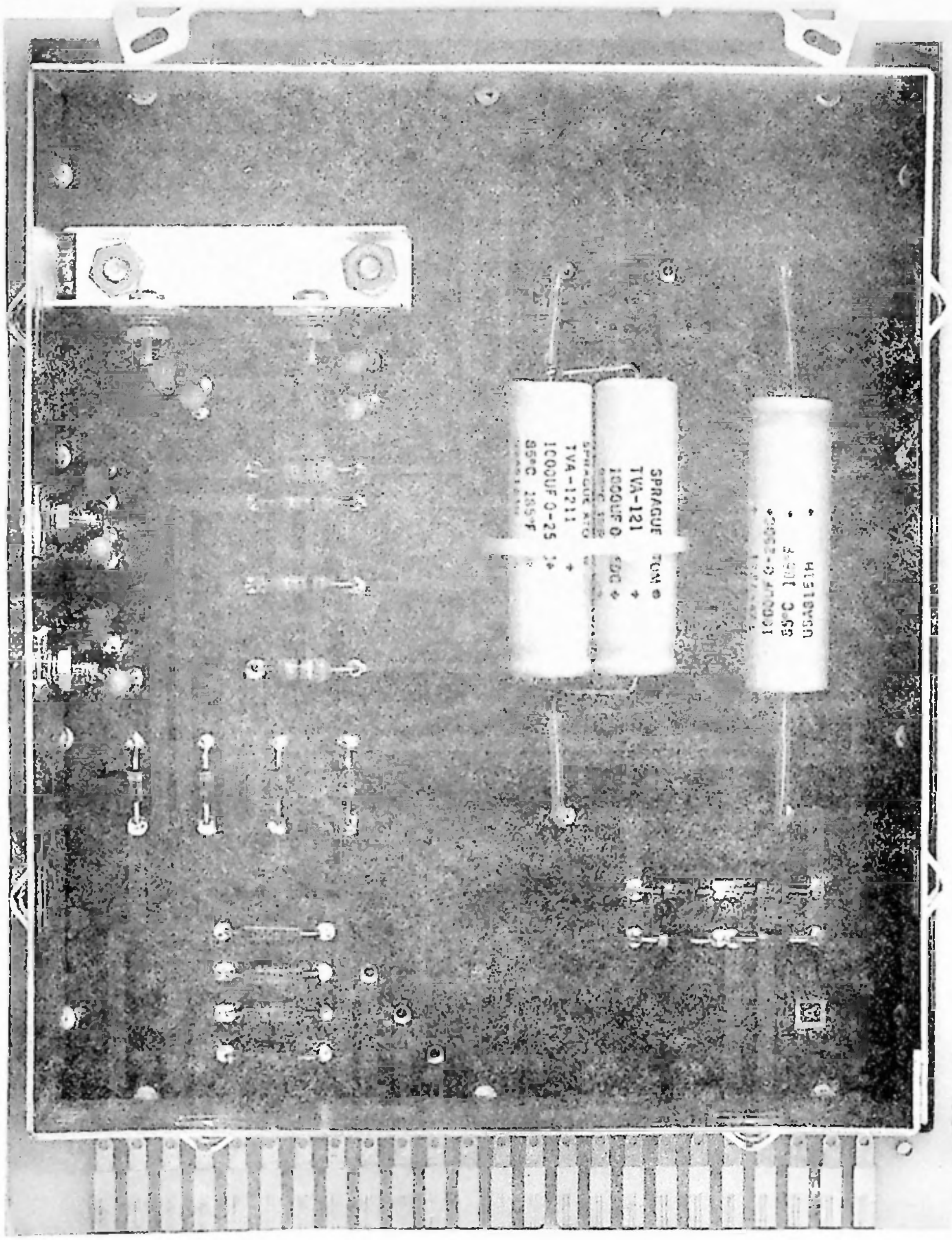

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Figure 7-8. Logic Power Supply Card A4

Logic Power Supply Card A4

REF DES	DESCRIPTION	VALUE	PART NO.
	Logic PS Card	PC Assy	636-8471-001
C1A/B	+Filter	1000 mfd, 25V	183-1313-000
C2	-Filter	1000 mfd, 25V	183-1313-000
C3	+5-V Filter	2.2 mfd, 35V	184-9102-370
C4	+12-V Filter	2.2 mfd, 35V	184-9102-370
C5	-12-V Filter	2.2 mfd, 35V	184-9102-370
C6	-6-V Filter	2.2 mfd, 35V	184-9102-370
C7	+12-V Bypass	0.1 mfd, 50V	913-5019-720
C8	+5-V Bypass	0.1 mfd, 50V	913-5019-720
C9	-6-V Bypass	1 mfd, 35V	184-9102-350
C10	-12-V Bypass	1 mfd, 35V	184-9102-350
CR1	1N4004	400V, 1A	353-6442-040
CR2	1N4004	400V, 1A	353-6442-040
CR3	1N4004	400V, 1A	353-6442-040
CR4	1N4004	400V, 1A	353-6442-040
CR5	1N4004	U2 Protect	353-6442-040
CR6	1N4004	U1 Protect	353-6442-040
CR7	1N4004	U4 Protect	353-6442-040
CR8	1N4004	U3 Protect	353-6442-040
CR9	+12V Indicator	Red LED	636-6171-001
CR10	+5V Indicator	Red LED	636-6171-001
CR11	-6V Indicator	Red LED	636-6171-001
CR12	-12V Indicator	Red LED	636-6171-001
R1	+5V Indicator	390 Ohms, 1/2W	745-0914-550
R2	+12V Indicator	1000 Ohms, 1/2W	745-0914-650
R3	-12V Indicator	1000 Ohms, 1/2W	745-0914-650
R4	-6V Indicator	390 Ohms, 1/2W	745-0914-550
R5	+5V Meter	13.3K Ohms, 1%, 1/4W	705-6650-000
R6	+12V Meter	13.3K Ohms, 1%, 1/4W	705-6650-000
R7	-12V Meter	13.3K Ohms, 1%, 1/4W	705-6650-000
R8	-6V Meter	13.3K Ohms, 1%, 1/4 W	705-6650-000
U1	+5V Regulator	LM340T-5	351-1120-010
U2	+12V Regulator	LM340T-12	351-1120-040
U3	-12V Regulator	LM320T-12	351-1178-060
U4	-6V Regulator	LM320T-6	351-1178-040

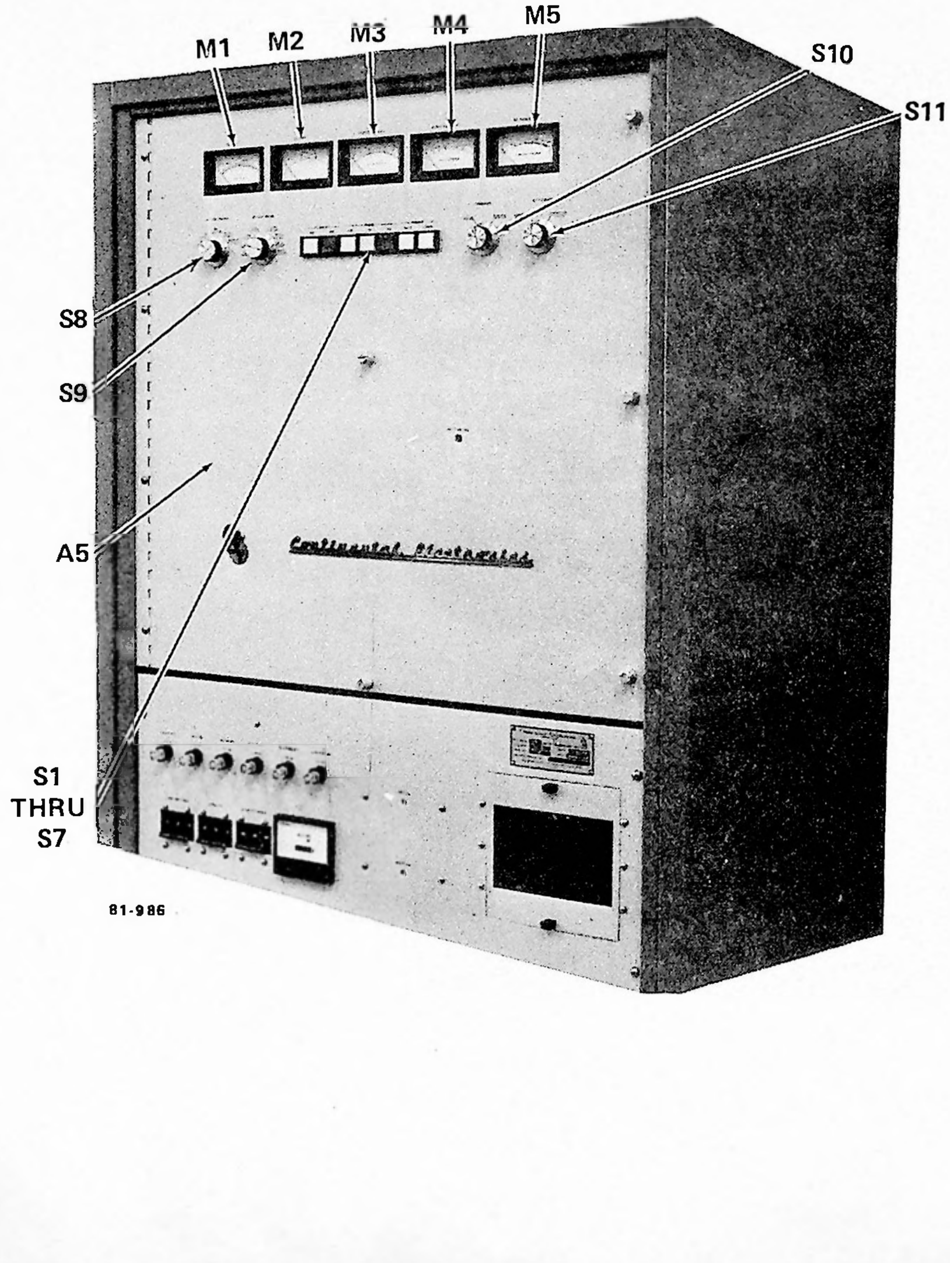

Figure 7-9. Meter Panel/Door A5

Meter Panel/Door A5

REF DES	DESCRIPTION	VALUE	PART NO.
	MeterPanel/Door	Assy	636-8427-001
A1	P/O A5 Meter T	PC Assy	636-9673-001
C1	M2 Mtr Bypass	0.1 mfd, 50V	913-3279-200
C2	0.1 mfd, 50V	M3 Mtr Bypass	913-3279-200
C3	0.1 mfd, 50V	M4 Mtr Bypass	913-3279-200
C4	0.1 mfd, 50V	M5 Mtr Bypass	913-3279-200
DS1	Fil Off Lamp	28 V	262-0179-010
DS2	Fil On	28V	262-0179-010
DS3	Plate Off	28V	262-0179-010
DS4	LP On	28V	262-0179-010
DS5	HP On	28 V	262-0179-010
DS6	Raise	28 V	262-0179-010
DS7	Lower	28 V	262-0179-010
M1	AC Test Meter	2550 Ohms, 10 mA	458-5006-010
M2	DC Test Meter	1500 Ohms, 2%, 1 mA	458-5005-010
M3	Plate Voltage	1000 Ohms, 1%, 2 mA	458-5005-020
M4	Plate Current	1000 Ohms, 1%, 1 mA	458-5005-040
M5	RF Power	1750 Ohms, 2%, 100mA	458-5005-100
S1	Fil Off	Momentary Contact	266-7509-020
S2	Fil On	Momentary Contact	266-7509-020
S3	Plate Off	Momentary Contact	266-7509-020
S4	LP On	Momentary Contact	266-7509-020
S5	HP On	Momentary Contact	458-7509-020
S6	Raise	Momentary Contact	266-7509-020
S7	Lower	Momentary Contact	266-7509-020
S8	AC Test Meter	2P, 5 Pos, 30 degrees	259-9475-150
S9	DC Test Meter	2P, 8 Pos, 30 degrees	259-9475-180
S10	Local/Remote	2P, 2 Pos, 60 degrees	259-2759-010
S11	RF Power	2P, 2 Pos, 60 degrees	259-2759-010

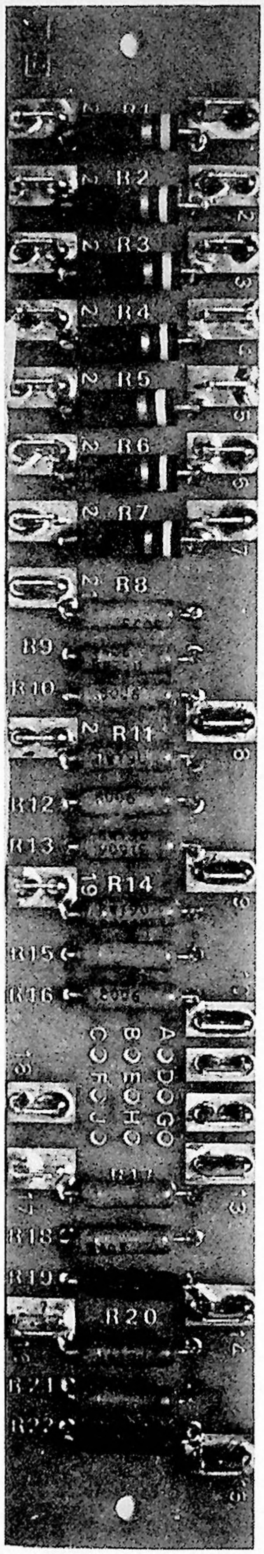

Figure 7-10. Metering Board A5A1

Metering Board A5A1

REF DES	DESCRIPTION	VALUE	PART NO.
	Meter Term Board	PC Assy	636-9673-001
R1	Fil Off	150 Ohms, 1W	745-3317-000
R2	Fil On	150 Ohms, 1W	745-3317-000
R3	Plate Off	150 Ohms, 1W	745-3317-000
R4	LP On	150 Ohms, 1W	745-3317-000
R5	HP On	150 Ohms, 1W	745-3317-000
R6	Raise	150 Ohms, 1W	745-3317-000
R7	Lower	150 Ohms, 1W	745-3317-000
R8	A Mtr	9.09K Ohms, 3W, 1%	747-0998-960
R9	A Mtr	9.09K Ohms, 3W, 1%	747-0998-960
R10	A Mtr	9.09K Ohms, 3W, 1%	747-0998-960
R11	B Mtr	9.09K Ohms, 3W, 1%	747-0998-960
R12	B Mtr	9.09K Ohms, 3W, 1%	747-0998-960
R13	B Mtr	9.09K Ohms, 3W, 1%	747-0998-960
R14	C Mtr	9.09K Ohms, 3W, 1%	747-0998-960
R15	C Mtr	9.09K Ohms, 3W, 1%	747-0998-960
R16	C Mtr	9.09K Ohms, 3W, 1%	747-0998-960
R17	PA Fil Mtr	9.09K Ohms, 3W, 1%	747-0998-960
R18	PA Fil Mtr	9.09K Ohms, 3W, 1%	747-0998-960
R19	PA Fil Mtr	2.32K Ohms, 3W, 1%	747-0998-390
R20	Mod Fil Mt	9.09K Ohms, 3W, 1%	747-0998-960
R21	Mod Fil Mt	9.09K Ohms, 3W, 1%	747-0998-960
R22	Mod Fil Mt	2.32K Ohms, 3W, 1%	747-0998-390

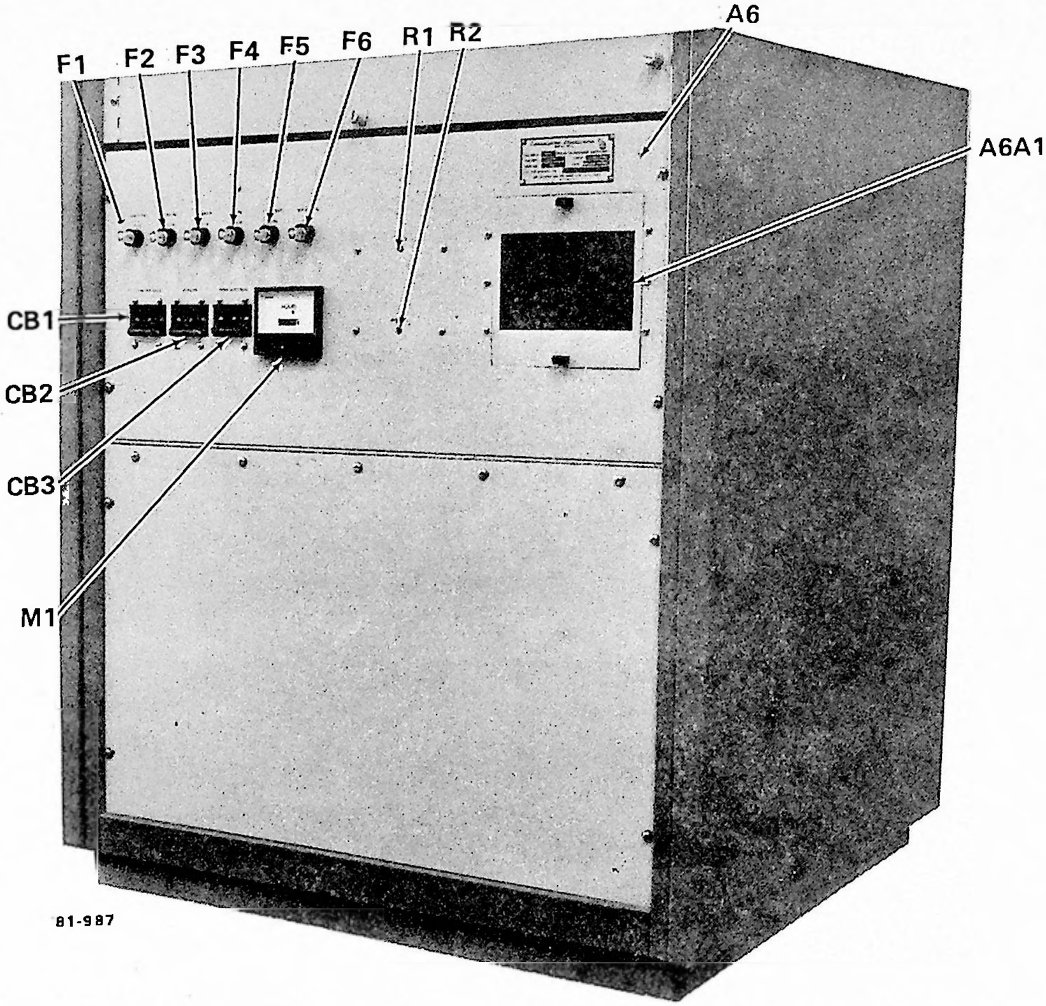

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Figure 7-11. Circuit Breaker Panel A6 (Front View)

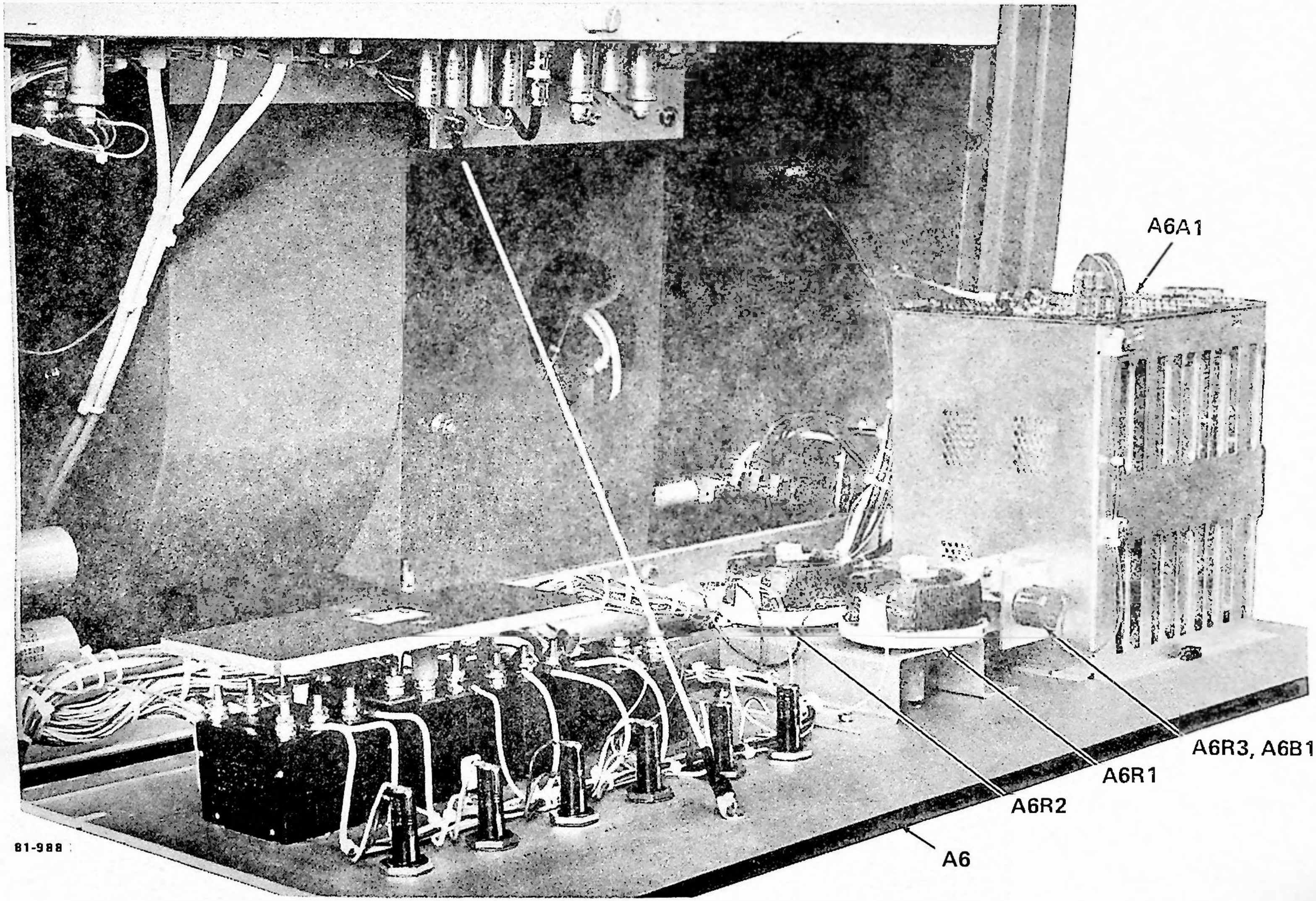

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Figure 7-12. Circuit Breaker Panel A7, Rear View

Circuit Breaker Panel A6

REF DES	DESCRIPTION	VALUE	PART NO.
	Ckt Bkr Panel	Assy	636-9680-001
A1	Backplane		636-8490-001
B1	Raise/Lower Motor	Split 0 115	230-5006-010
C1	Filter	0.01 mfd, 500V	913-1188-000
CB1	Low Voltage (240V)	3 P,15A,Curve 20	260-4011-720
CB2	Bias PS (240V)	3 P,1.0A,Curve 20	260-4014-660
CB3	High Vol (240V)	3 P,50A,Curve 20	260-4011-790
F1	Logic PS	0.5 A	264-0719-000
F2	Control 28-V PS	2-A SB	264-0305-000
F3	Blower	6.25-A SB	264-0219-000
F4	Fan	2-A SB	264-0305-000
F5	Filament	8-A SB	264-0912-320
F6	Driver PS	6.2-A SB	264-0219-000
M1	Fil Timer	240V, 60Hz	458-0860-020
M1	Fil Timer	240V, 50Hz (Optional)	458-0860-010
R1	PA Fil Adj	25 Ohms,100W, Var	738-0052-000
R2	Mod Fil Adj	25 Ohms,100W, Var	738-0052-000
R3	Power Adjust	5 K Ohms,2 W	381-1648-020
R4	Filter	100 Ohms, 1 W	745-3310-000
XF1-6	Fuseholder	Lighted	265-1241-090

Backplane A6A1

	REF DES	DESCRIPTION	VALUE	PART NO.
			Backplane	636-8490-001
	C1	Q1 Bypass	1.0 mfd, 50V	913-3279-270
	CR1	Optical LED	SPX 3191	270-0547-080
*	CR2	Diode	1N3017B	353-3122-000
*	CR3	Diode,	1N3828A	353-6317-000
*	CR4-CR5	Diode	1N4744A	353-6481-330
	CR6		LED,RED	353-3725-010
	Q1-2	Amplifier	2N2222A	352-0661-020
	R1	Q1 Collector	330 Ohms	745-0914-530
	R2	Q1 Base	3.9 K Ohms	745-0914-790
	R3	Q1 Base	10 K Ohms	745-0914-890
	R4	Q1 Collector	10 K Ohms	745-0914-890
	VR2	6.2 V, 1-W Zener 5-V Protect	1N3828A	353-6317-000
	VR3	7.5 V, 1-W Zener -6-V Protect	1N3017B	353-3122-000
	VR4-5	15 V, 1-W Zener 12-V Protect	1N3024B	353-3129-000
	J1-5	Card Jacks	12-Pin(2 EACH)	372-7084-040

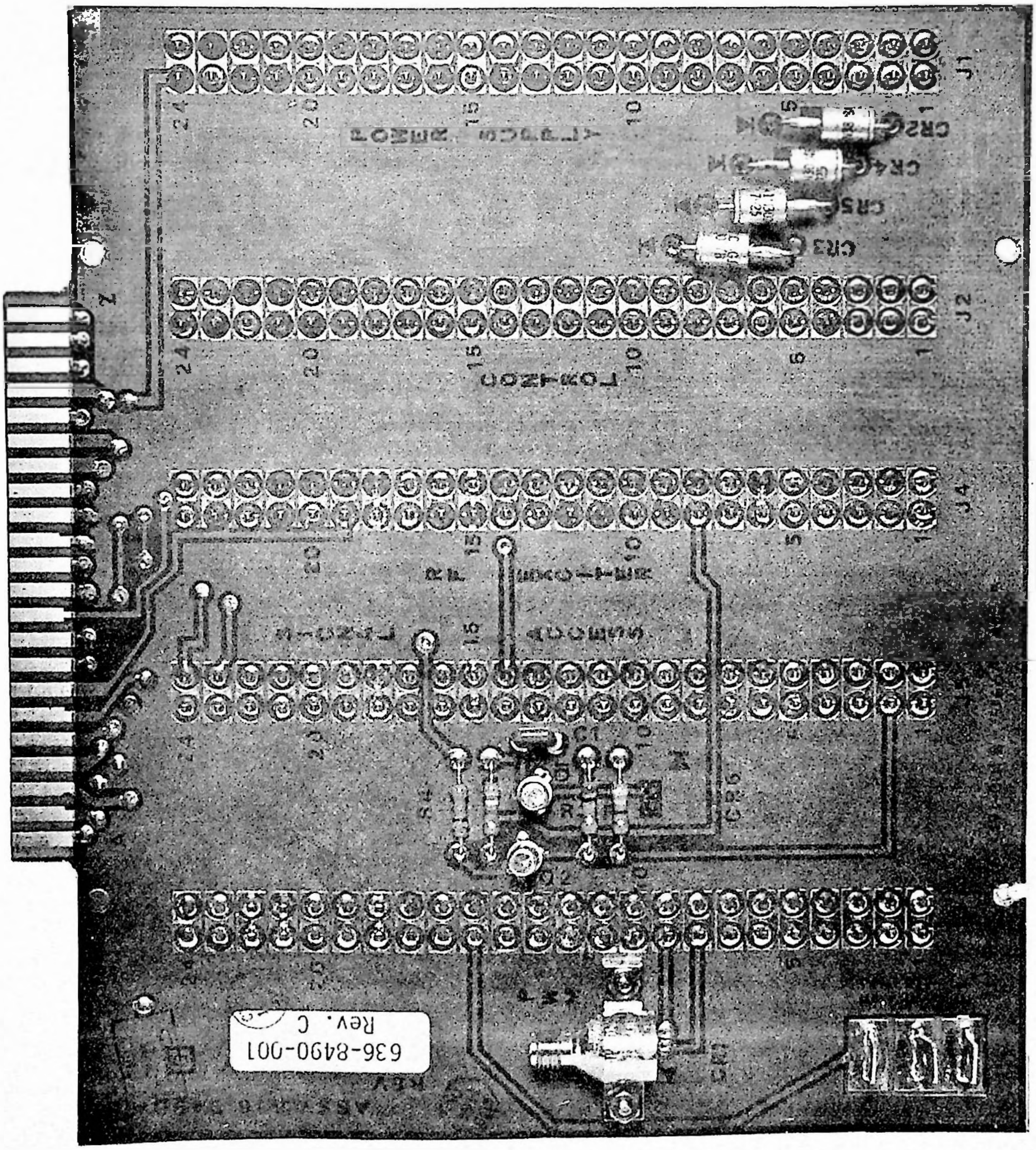

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Figure 7-13. Backplane A6A1.

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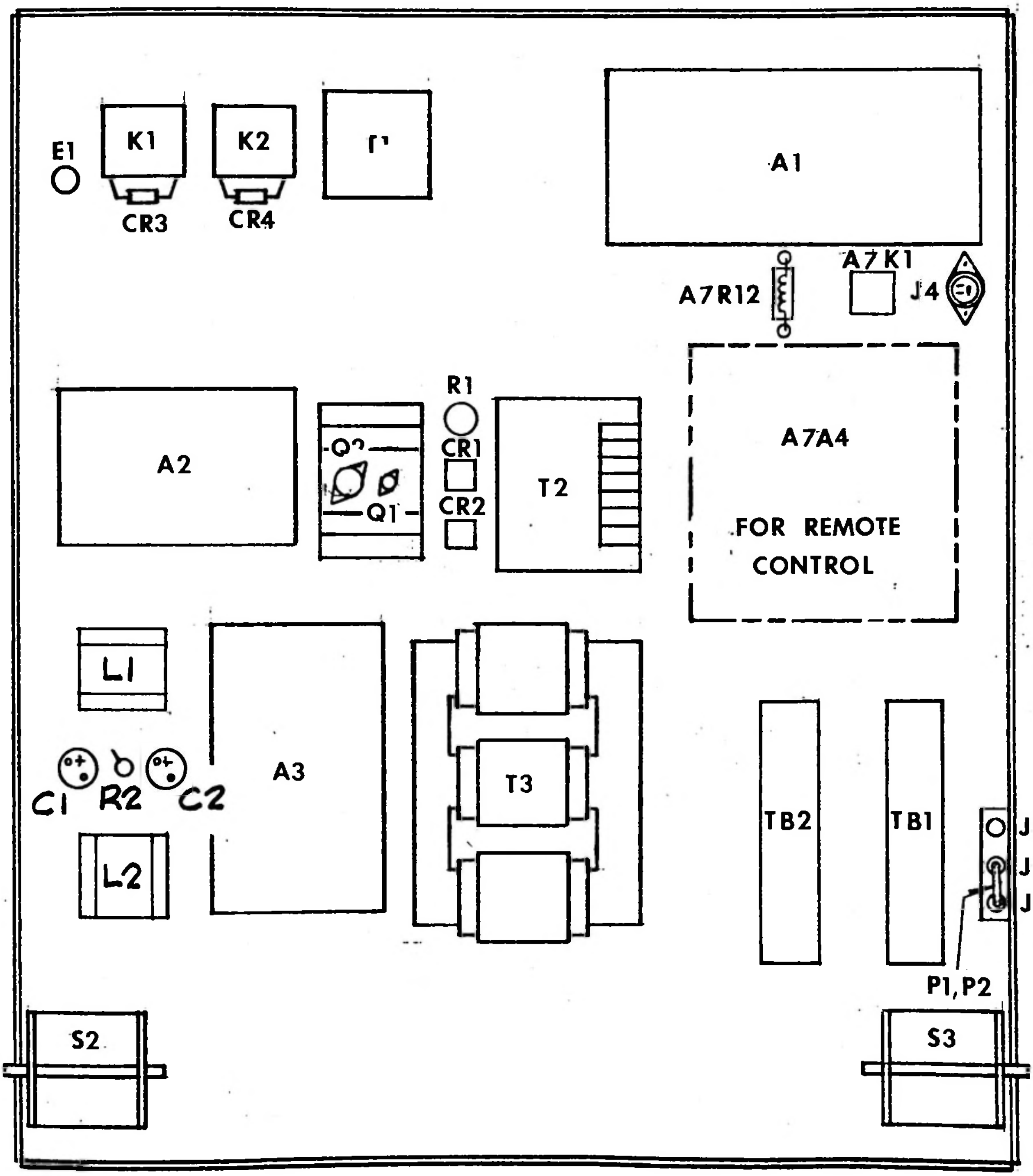

Figure 7-14. Power Control Chassis A7.

Power Control Chassis A7

REF DES	DESCRIPTION	VALUE	PART NO.
	Pwr Ctrl Chassis	Assy	636-8502-001
A1	Ctrl Relay Card		636-8510-001
A2	LV PS Card		636-8503-001
A3	Bias PS Card		636-9674-001
A4	Remote Control Assy		627-9721-002
C1	Filter	250 mfd, 300V	184-2536-000
C2	Filter	250 mfd, 300V	184-2536-000
CR1	28-V PS Rect	200V, 25A Bridge	353-0417-130
CR2	200-V PS Rec	600V, 22A Bridge	353-0417-060
CR3-4	Transient Supprssor	1N4004 1A, 400V	353-6442-040
J1-3		Conn Bnc	357-9248-010
J4		Socket, A.C.	368-0136-010
K1-K2	Blower Filament	4PDT, 25A, 230V	970-2426-070
K3	Overload Relay		342-0045
L1	Dr Filter Choke	100 mH. 3A,	668-0069-010
L2		100 mH, 3A	668-0069-010
Q1	28-V PS Amplifier	2N3054	352-0581-010
Q2	28-V PS Regulator	2N3772	352-0690-020
R1	28-V PS I Limit	4 Tapped, 100	710-5076-060
R2	Bleeder	7500, 10 W	710-2932-000
R3	Dropping Resistor	220-Ohm, 2-Watt	745-5624-000
S1	Front Door Intrlk	micro-switch 2 HV	627-9743-008
S2	Rear Door Intrlk	micro-switch 2HV	627-9743-009
T1	28-V PS XFMR	208/230/240 V	662-0290-010
T2	200-V PS Xfmr	200-250/115 V	662-0644-010
T3	Bias PS Xfmr	208/240 V 3-Phase	664-0185-010
TB1	Control and Mntr	6-32, 16-Terminal	367-4160-000
TB2	Audio and Intrlck	6-32, 16-Terminal	367-4160-000
-1	16-Term Marker	6-32, 16-Terminal	367-1627-000
XK3	Socket, Relay		590-0140

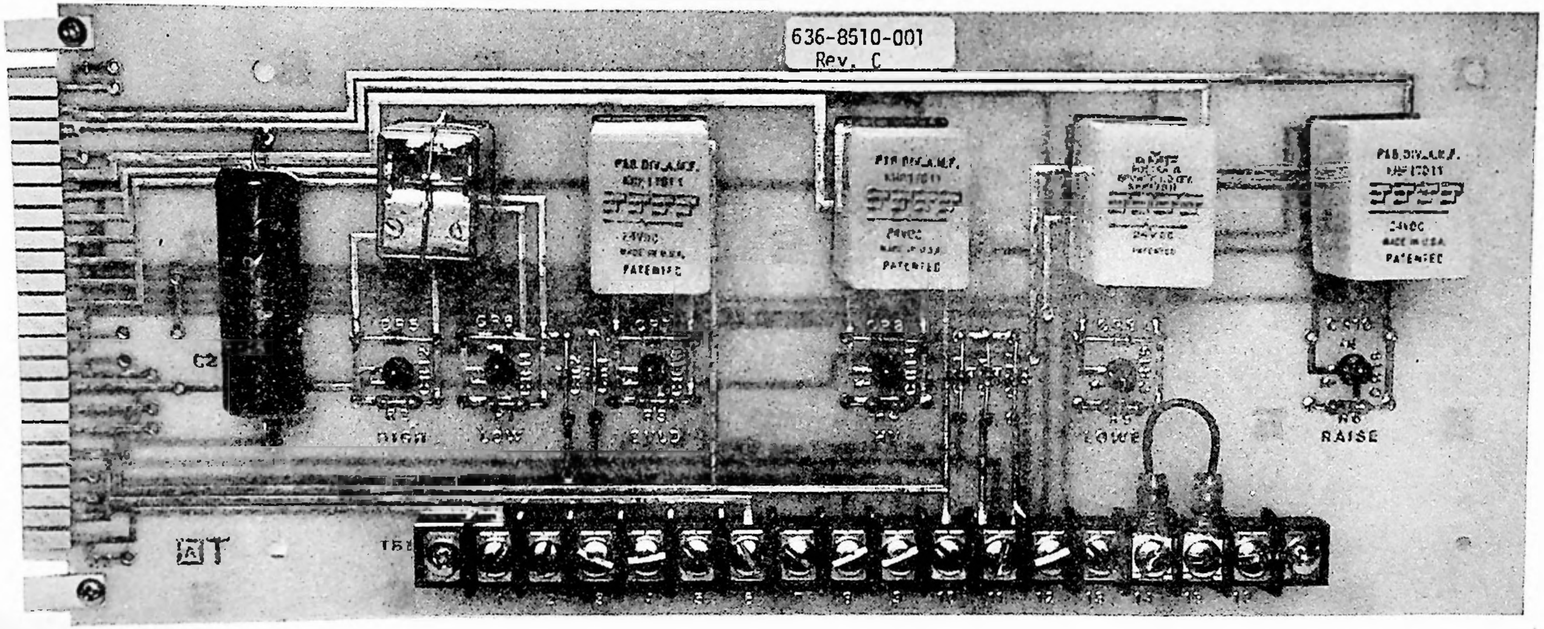

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Figure 7-15. Control Relay A7A1

Control Relay A7A1

REF DES	DESCRIPTION	VALUE	PART NO.
	Control Relay Card	PC Assembly	636-8510-001
C1	Motor Cap	.1 mfd, 600V	933-5005-010
C2	Bypass	0.1 mfd, 200V	913-3681-000
CR1-7	Relay Suppressor	1N4004 400V	353-6442-040
CR8	Relay Suppressor	1N4007, 1000V	353-6442-070
CR9, 10	Relay Suppressor	1N4004, 400V	353-6442-040
CR11-16	Indicator	Red LED	353-3725-010
CR17	Fil On Gate	1N4004, 400V	353-6442-040
K1	LP/HP Latching	28V, DPDT	970-0004-030
K2-5	O/L, HV, Raise, Lower	28V, 4PDT	970-0002-030
R1-6	LED Current Lmtr	1.5K Ohms, 1/2W	745-0914-690
TB1	Remote Cnnctns	16-Term P/C	367-1888-210
XK1	Socket for K1		220-1518-000
XK2-5	Socket for K2-K5		220-1582-010

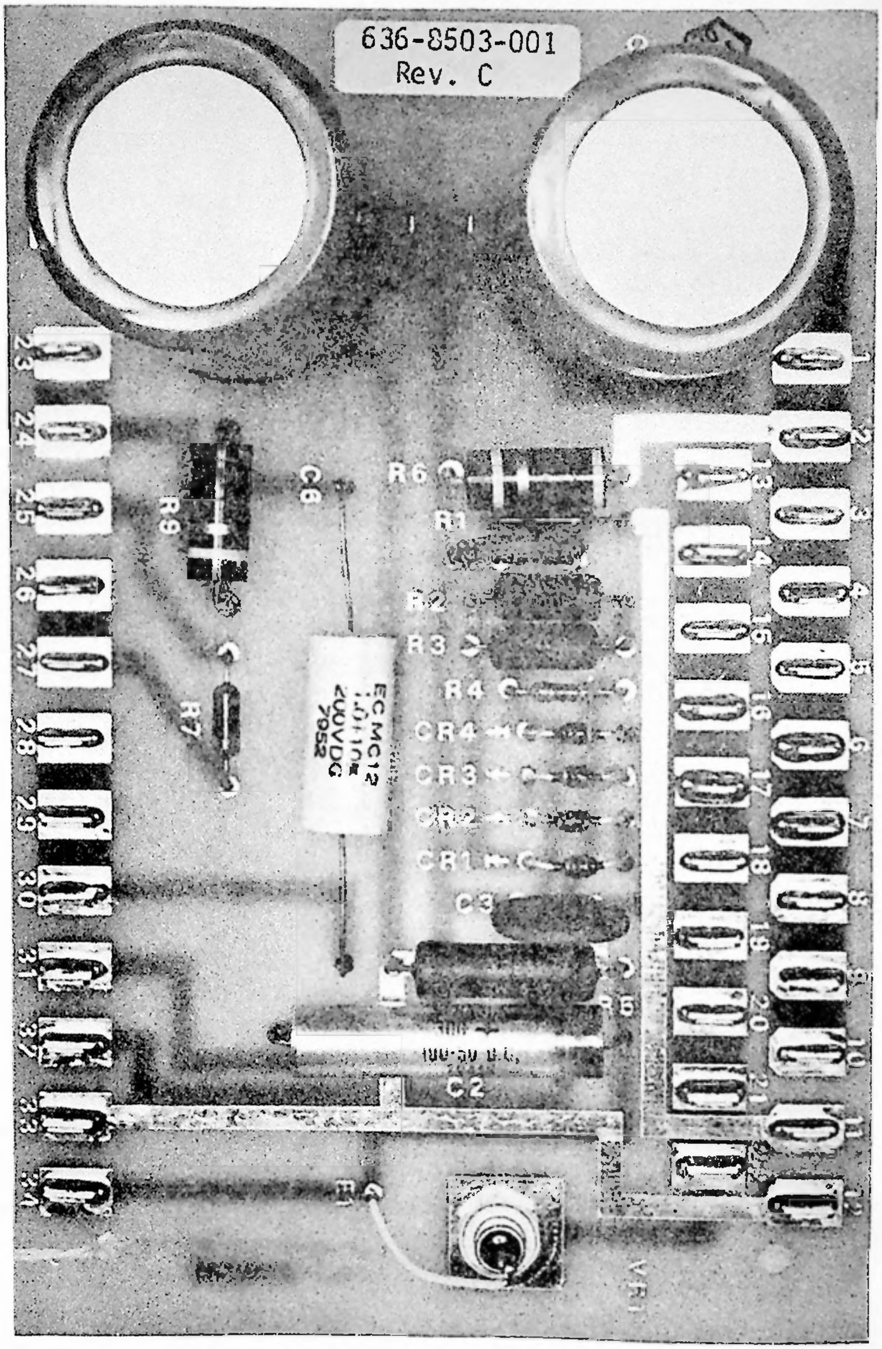

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Figure 7-16. Low Voltage Power Supply A7A2

Low -Voltage Power Supply A7A2

REF DES	DESCRIPTION	VALUE	PART NO.
	LV PS Card		636-8503-001
C1	Ref Filter	0.1 mfd, 200V	913-3681-000
C2	Ref Filter	100 mfd, 50V	183-1281-080
C3	Input Filter	0.1 mfd, 200V	913-3681-000
C4	28-V PS Filter	3900 mfd, 50V	183-1278-370
C5	28-V PS Filter	3900 mfd, 50V	183-1278-370
C6	Damper	1 mfd, 200V	933-1059-050
CR1	28-V PS Limiter	1N5552	353-3718-060
CR2	28-V PS Limiter	1N5552	353-3718-060
CR3	28-V PS Limiter	1N5552	353-3718-060
CR4	28-V PS Limiter	1N5552	353-3718-060
R1	28-V Meter	28.7K Ohms, 1%, 1/4W	705-6666-000
R2	I Limit	0.10 Ohms, 3W	747-5115-000
R3	I Limit	0.10 Ohms, 3W	747-5115-000
R4	I Limit	150 Ohms, 1/2W	745-0914-450
R5	VR Limit	330 Ohms, 5.5W	747-5525-000
R6	Bleeder	470 Ohms, 2W	745-5638-000
R7	300-V Meter	301K Ohms, 1%, 1/4W	705-6715-000
R8	-----------------------	NOT USED	------------------------
R9	Damper	1K Ohms, 2W	745-5652-000
VR1	Regulator	1N2989B	353-1369-000

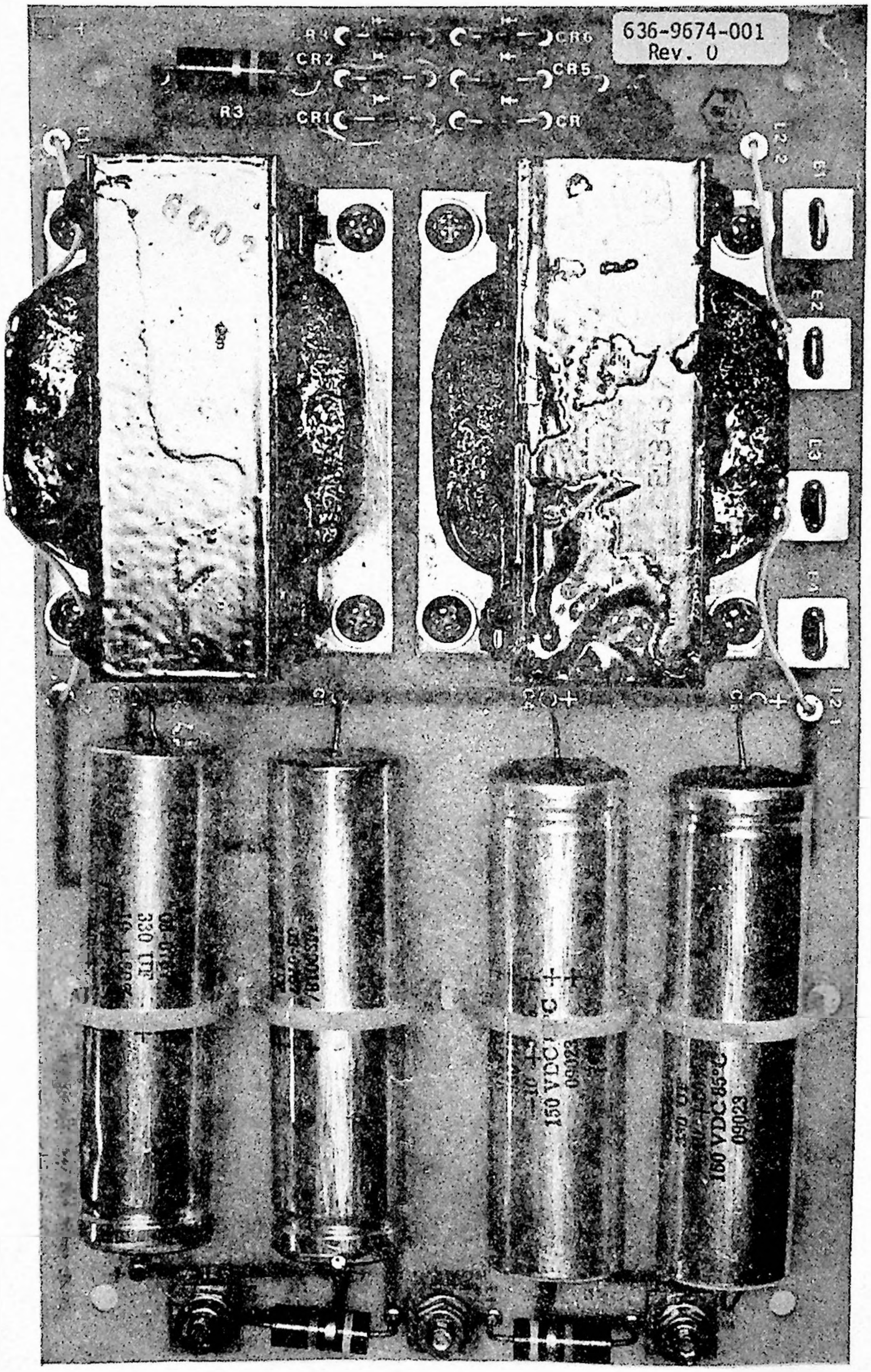

Figure 7-17. Bias Power Supply A7A3

BIAS POWER SUPPLY, A7A3

REF DES	DESCRIPTION	VALUE	PART NO.
	Bias PS Card	PC Assy	636-9674-001
C1-4	125-V Filter	330 mfd, 150V	184-5102-330
C5	Damping	0.01, 600V	913-3013-000
CR1-6	Rectifier	1N5552,3A, 600V	353-3718-060
L1-2	Filter	100 mH, 1.5A	668-0053-000
R1-2	Bleeder	15 K Ohms,2W	745-5701-000
R3	Damping	1 K Ohms,2W	745-5652-000

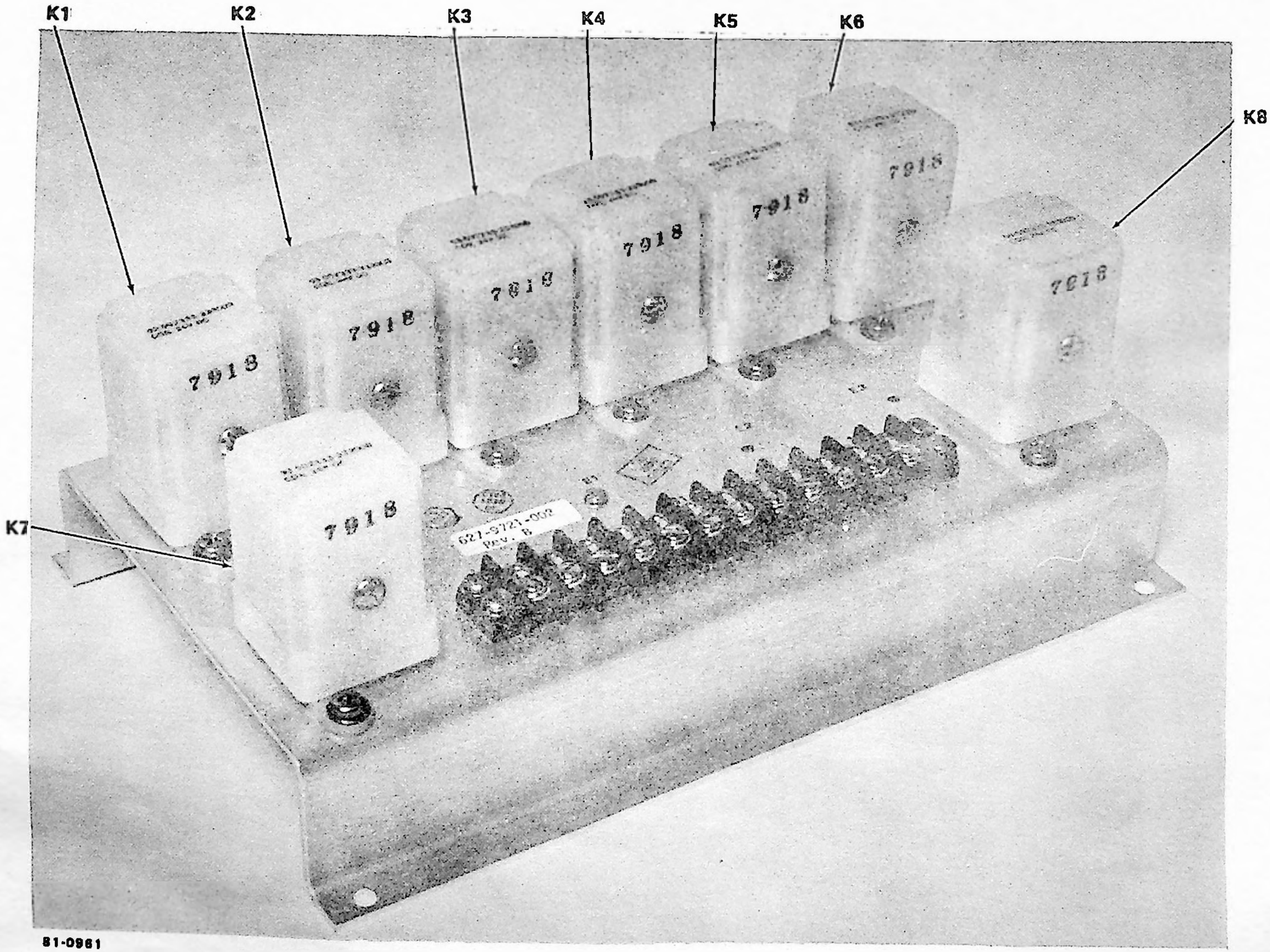

Figure 7-17.1 Remote Control Panel, A7A4

Remote Control Panel, A7A4

REF DES	DESCRIPTION	VALUE	PART NO.
K1-8	Relay		970-2454-270
TB1	Terminal Board	12 Terminals	367-0020-000
XK1-XK8	Relay Sockets		220-1399-010

parts list

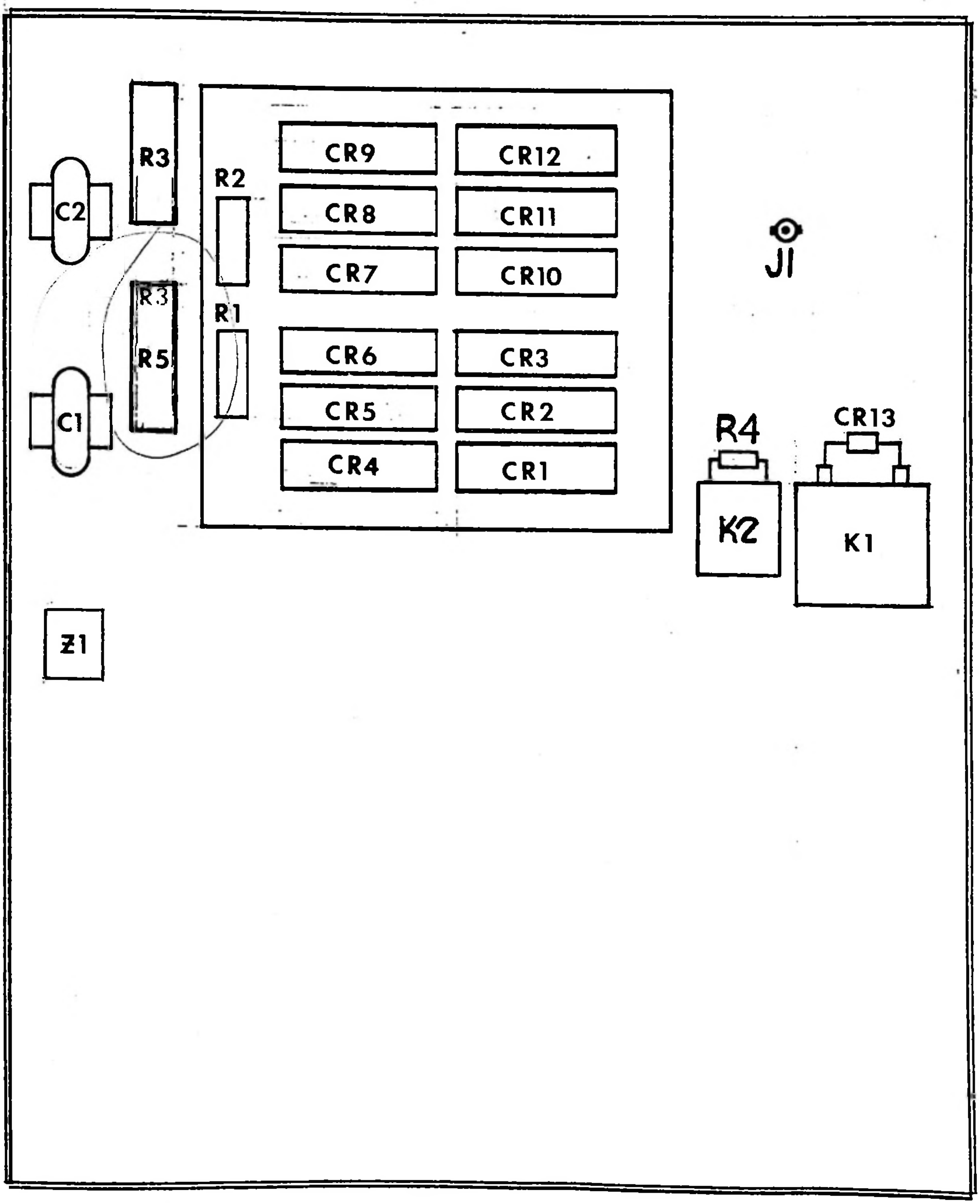

Figure 7-18. High-Voltage Power Supply A8.

High Voltage Power Supply A8

	REF DES	DESCRIPTION	VALUE	PART NO.
		HVPS Chassis	Assy	636-8494-001
	C1	HVPS Damper	0.03 mfd, 15kV	930-0614-000
	C2	HVPS Damper	0.03 mfd, 15kV	930-0614-000
	CR1-12	HV Rectifier	Solitron F89	353-0413-020
	CR13	Plate Cont Damper	1N4004	353-6442-040
	K1	Plate Contactor	40A, 28-V Coil	401-0004-120
		Hold Plate		
	K2	Time Delay	28V	402-0492-250
	R1	HVPS Damper	500 Ohms, 15W	712-4247-000
	R2	HVPS Damper	500 Ohms, 15W	712-4247-000
	R3	Current Limiter	25 Ohms, 100W	712-4232-000
	R4	Time Delay	18K Ohms, 1/2W	745-1405-000
	R5	Limiting	150 Ohms, 50 W	~~460-3452-~~ 745-8009-010
*	Z1	V130HE150	130-V, MOV	714-3258-260

Tube Hold down Pos 640-9685-001 hold down tab 640-9686-001

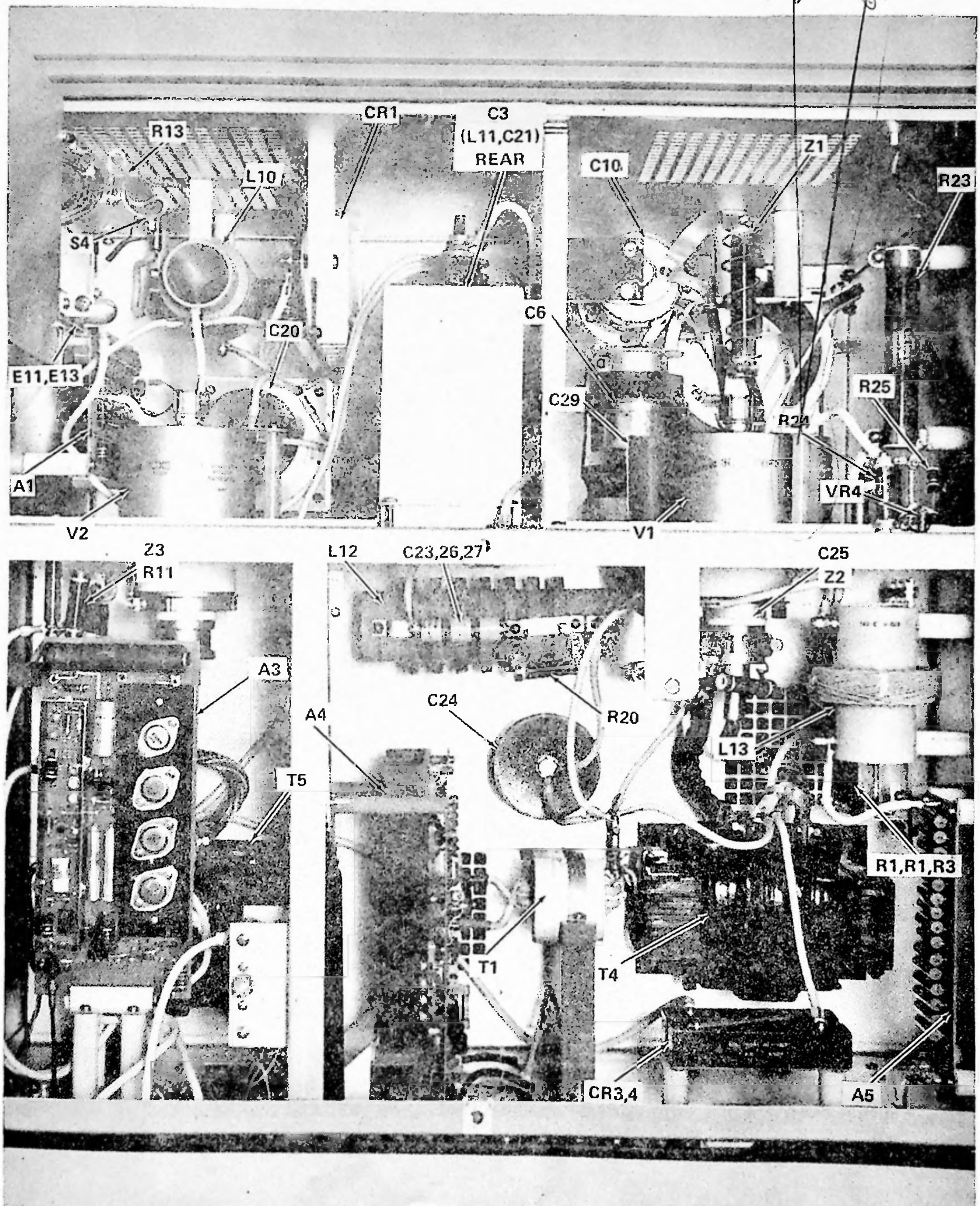

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Figure 7-19. RF Compartment A9 (Front View)

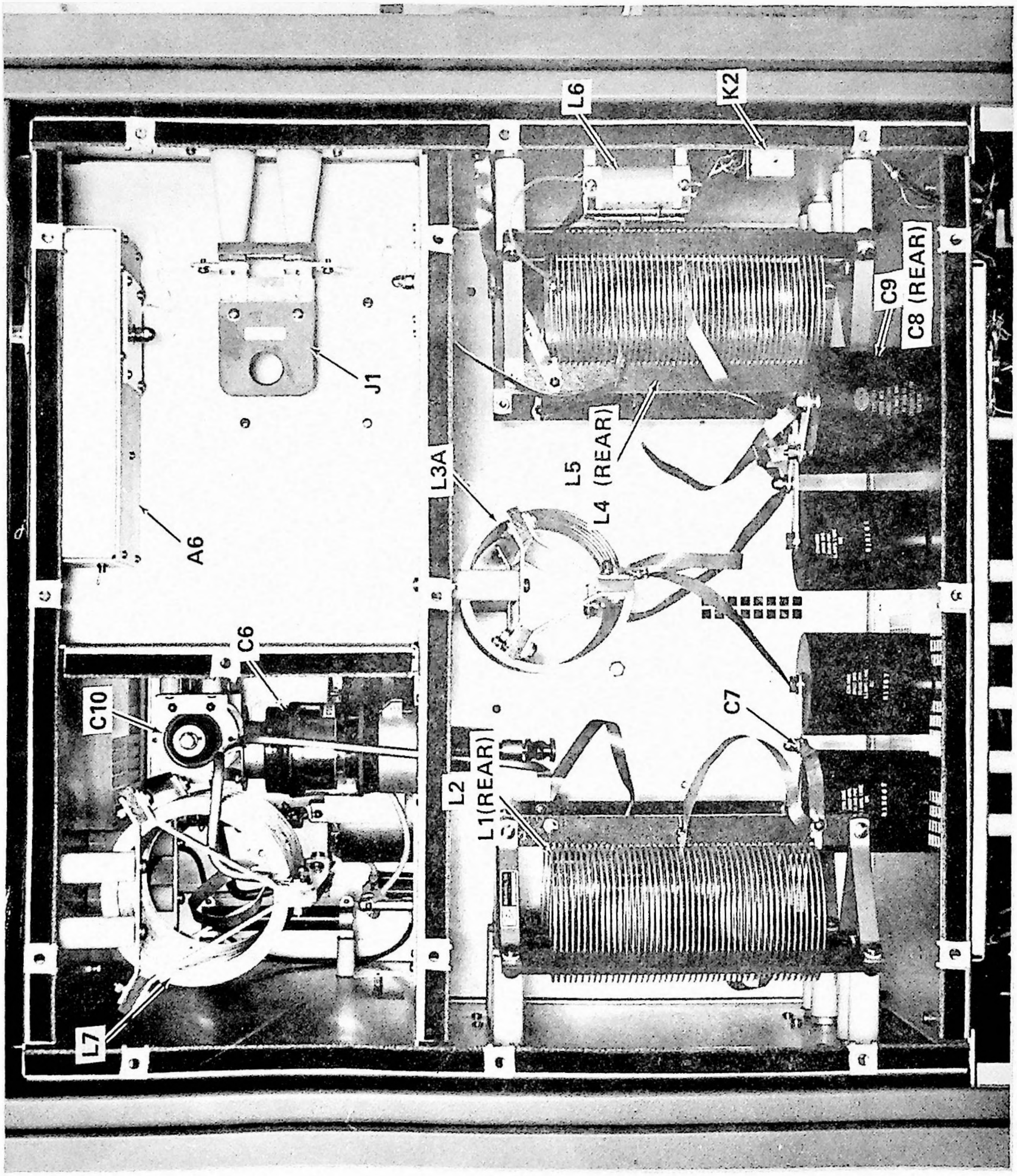

Figure 7-20. RF Compartment A9 (Rear View)

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RF Compartment A9

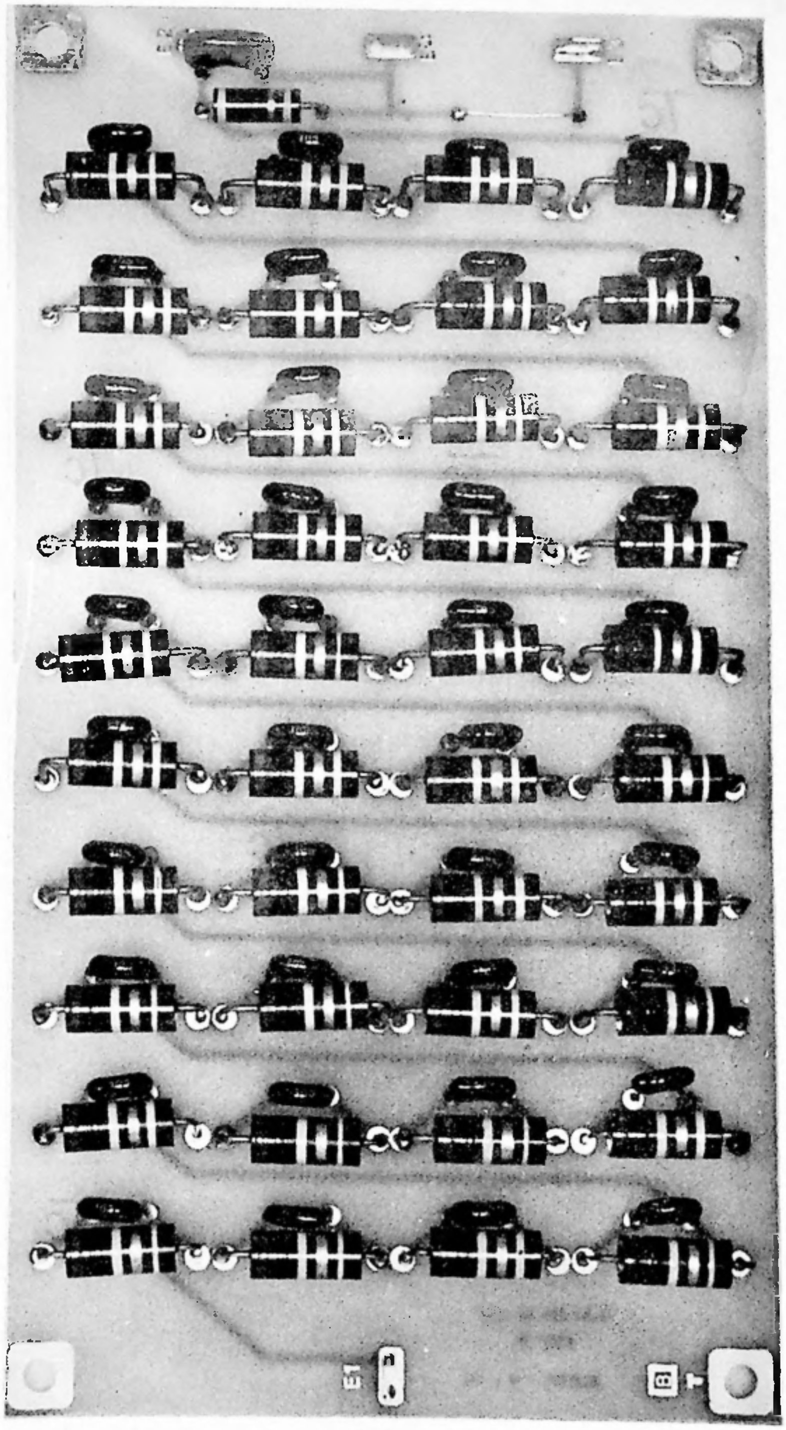
REF DES	DESCRIPTION	VALUE	PART NO.
	RF Compartment	Assembly	636-9690-001
A1	Feedback Divider	PC Assembly	636-8417-001
A2	----------NOT USED----------		
A3	Switchmod Card	PC Assembly	636-9675-001
A4	RF Driver	PC Assembly	636-9688-001
A5	HV Meter Divider	PC Assembly	636-8413-001
A6	VSWR Meter Assy	Assembly	636-9687-001
C1	Fil Bypass	1.0 mfd, 200V	933-1059-050
C2	Fil Bypass	1.0 mfd, 200V	933-1059-050
C3	HV Filter	2.1 mfd, 15kV	930-0766-040
C4	----------NOT USED----------		
C5	----------NOT USED----------		
C6	PA Tuning	25-1000 pF, 15kV	919-0127-010
C7	Freq Node 2		See Freq Kit
C8	Freq Node 3		See Freq Kit
C9	Freq Node 4		See Freq Kit
C10	Plate Resonator	10-400 pF, 15kV	919-0293-060
C11	Mod Mon Relay Bypass Bypass	0.1 mfd 100 V F	241-0088-000
C12	----------NOT USED----------		
C13	----------NOT USED----------		
C14	PA Neut	100 pF, 5kV	913-0833-000
C15	PA Neut	100 pF, 5kV	913-0833-000
C16	PA Neut	100 pF, 5kV	913-0833-000
C17	PA Neut	100 pF, 5kV	913-0833-000
C18	PA Neut	100 pF, 5kV	913-0833-000
C19	PA Neut	500 pF, 5kV	913-5113-250
C20	70-kHz Filter	1500 pF, 25kV	912-4128-060
C21	70-kHz Filter	240 pF, 5kV	912-4125-160
C22	70-kHz Filter	1500 pF, 25kV	912-4128-060
C23	70-kHz Filter	500 pF, 5kV	913-5113-250
C24	70-kHz Filter	750 pF, 20kV	912-4127-020
C25	PA Grid Leak	0.047 mfd, 600V	937-2068-000
C26	70-kHz Filter	67 pF, 5kV	913-0829-000
C27	70-kHz Filter	500 pF, 5kV	913-5113-250
C28	----------NOT USED----------		
C29	PA Neut	1-6 pF 3 X 6 P1	636-9697-001
C30	----------NOT USED----------		
C31	Mod Fil Filter	0.1 mfd, 250V AC	241-0006-000
C32	Mod Fil Filter	0.1 mfd, 250 V AC	241-0006-000
C33	PA Fil Filter	0.1 mfd, 250 V AC	241-0006-000

RF Compartment A9 (Cont.)

REF DES	DESCRIPTION	VALUE	PART NO.
C34	PA Fil Filter	0.1 mfd,250VAC	241-0006-000
C35	HV Div Filter	5600 pF	913-1295-000
C36	HV Div Filter	5600 pF	913-1295-000
C37	HV Div Filter	5600 pF	913-1295-000
C38	Intlk Filter	5600 pF	913-1295-000
C39	Intlk Filter	5600 pF	913-1295-000
C40	Driver Ecc	0.1 mfd, 600V	241-0090-000
C41	RF Drive Control	0.1 mfd,600V	241-0090-000
C42	Dr Ic Mtr	0.1 mfd,600V	241-0090-000
C43	Feedback Divider	1000 pF, 500V	913-1294-000
C44	HV Return	0.1 mfd,100V	241-0088-000
C44A	Bypass	1 mfd, 200V	933-1059-050
C45	Dr +28V	0.1 mfd,600V	241-0090-000
C46	Plate RF Sample	1000 pF, 500V	913-1294-000
C47	Mod Fil Meter Filter	0.1 mfd,400V	241-0089-000
C48	PA Fil Mtr Filter	0.1 mfd,400V	241-0089-000
C49	Intlk Filter	5600 pF, 500V	913-1295-000
C50	Intlk Filter	5600 pF, 500V	913-1295-000
C51	PA Grid Suppressor	22 pF, 500V	914-2545-000
C52	PA Neut Balance	39 pF, 500V	914-2563-000
C53	Arc Sensor	1000 pF, 500V	913-1294-000
CR1	Switchmod Clamp	SA7586	353-6599-010
CR2	Mod Mon Relay Suppressor	1N4004	353-6442-040
CR3	Transient Supp	15kV	353-0413-020
CR4	Transient Supp	15kV	353-0413-020
J1	Conn, RF Jack	Mtr Jack	372-9600-010
J2	Mod Monitor	BNC	357-9248-010
J3	RF Drive	BNC	357-9248-010
K1	Mod Mon Hi/Lo Pwr	4PDT, 28-V Coil	970-0002-030
L1	Freq Node 1 Coil		See Freq Kit
L2	Freq Node 2 Coil		See Freq Kit
L3A	Coupling Coil	150 mH, 10A	980-0041-000
L3B	--------------SEE FREQUENCY KIT--------------------		
L4	Node 3 Coil	82 mH, 10A	980-0047-000
L5	Node 4 Coil	82 mH, 10A	980-0047-000
L6	Mod Mon Tap Coil	81 mH	549-5098-004
L7	Plate Resonator	28 mH, 20A	980-0049-000
L8	----------------------NOT USED----------------------		
L9	----------------------NOT USED----------------------		
L10	70-kHz Filter	29 mH at 2.5A	640-3434-002
L11	70-kHz Filter	36 mH at 2.5A	640-3434-001
L12	70-kHz Filter	36 mH at 2.5A	640-3434-001
L13	PA Grid Coil	4 mH	762-8800-003
M1	Optional Output RF I	15 A ES	640-3432-001

RF Compartment A9 (Cont.)

REF DES	DESCRIPTION	VALUE	PART NO.
R1	Resistor, Var	100 Ohm, 100W	716-0060-090
R2,R3	Resistor	100 Ohm, 100W	710-9284-000
R4	-----------------------NOT	USED---------------------	
R5	-----------------------NOT	USED---------------------	
R6	-----------------------NOT	USED---------------------	
R7	-----------------------NOT	USED---------------------	
R8	PA Grid Leak	150 Ohms, 100W	712-4401-420
R9	Fil Cap Bleeder	100K Ohms, 2W	745-5736-000
R10	PA Grid Leak	150 Ohms, 100W	712-4401-420
R11	Switchmod Bias	820 Ohms, 113 W	747-3802-000
R12	-----------------------NOT	USED---------------------	
R13	Current Limit	25 Ohms, 100W	712-4232-000
R17	-----------------------NOT	USED---------------------	
R18	-----------------------NOT	USED---------------------	
R19	Fil Parasitic Suppressor	220 Ohms, 2W	745-5624-000
R20	Parasitic Suppressor	50 Ohms, 16.5 W	712-0129-000
R21	PA Grid Suppressor	50 Ohms, 16W	712-0129-000
R22	PA Plate Suppressor	50 Ohms, 16W	712-0129-000
R23	PA Plate Suppressor	50 Ohms, 100W	712-4236-000
R24	Arc Sensor	50 Ohms, 16W	712-0129-000
R25	Arc Sensor	4.7 K Ohms,2W	745-5680-000
S1	PA Door Shorting	m-switch & 2HV	627-9743-004
S2	RF Output	J Plug	542-4396-002
S3	Air Interlock	0-2 Ins.of Water	266-8384-060
S4	Thermostat (Close 200°F -	Open 240° F)	267-0243-100
T1	PA Grid Transformer	BB RF Transformer	640-9707-001
T2	-----------------------NOT	USED---------------------	
T3	-----------------------NOT	USED---------------------	
T4	PA Filament	7.5 V at 51A	662-0607-010
T5	Mod Filament	7.5 V at 51A	662-0607-010
T6	-----------------------NOT	USED---------------------	
V1	RF Power Amplifier	3CX3000F7	256-0194-010
V2	Switchmod	3CX3000F7	256-0194-010
VR1	-----------------------NOT	USED---------------------	
VR2	-----------------------NOT	USED---------------------	
VR3	-----------------------NOT	USED---------------------	
VR4	4.3 V, 1W	1N3824A	353-6313-000
XA3	Switchmod Card	Conn/Assy	640-9673-002
XA4	RF Driver Card	Conn/Assy	640-9673-001
XK1	K1 Socket		220-1543-000
Z1	PA Plate Suppressr	50 Ohms,6 Turns	640-9676-001
Z2	PA Grid Suppressr	50 Ohms,6 Turns	762-8820-001
Z3	Mod Grid Suppressr	50 Ohms,40 Turns	640-5370-001



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KM1-1(3)

Figure 7-21. Feedback Divider, Component Layout, A9A1

Feedback Divider, Component Layout, A9A1

REF DES	DESCRIPTION	VALUE	PART NO.
	Feedback Divider	PC Assy	636-8417-001
C1-40	Divider, Mica	220 pF, 500V	912-2840-000
C41	Divider, Mica	1500 pF, 500V	912-3013-000
R1-40	Divider Carbon	100 K Ohms,10% 2W	745-5736-000
R41	Divider	4.7 K Ohms,10% 1W	745-3380-000

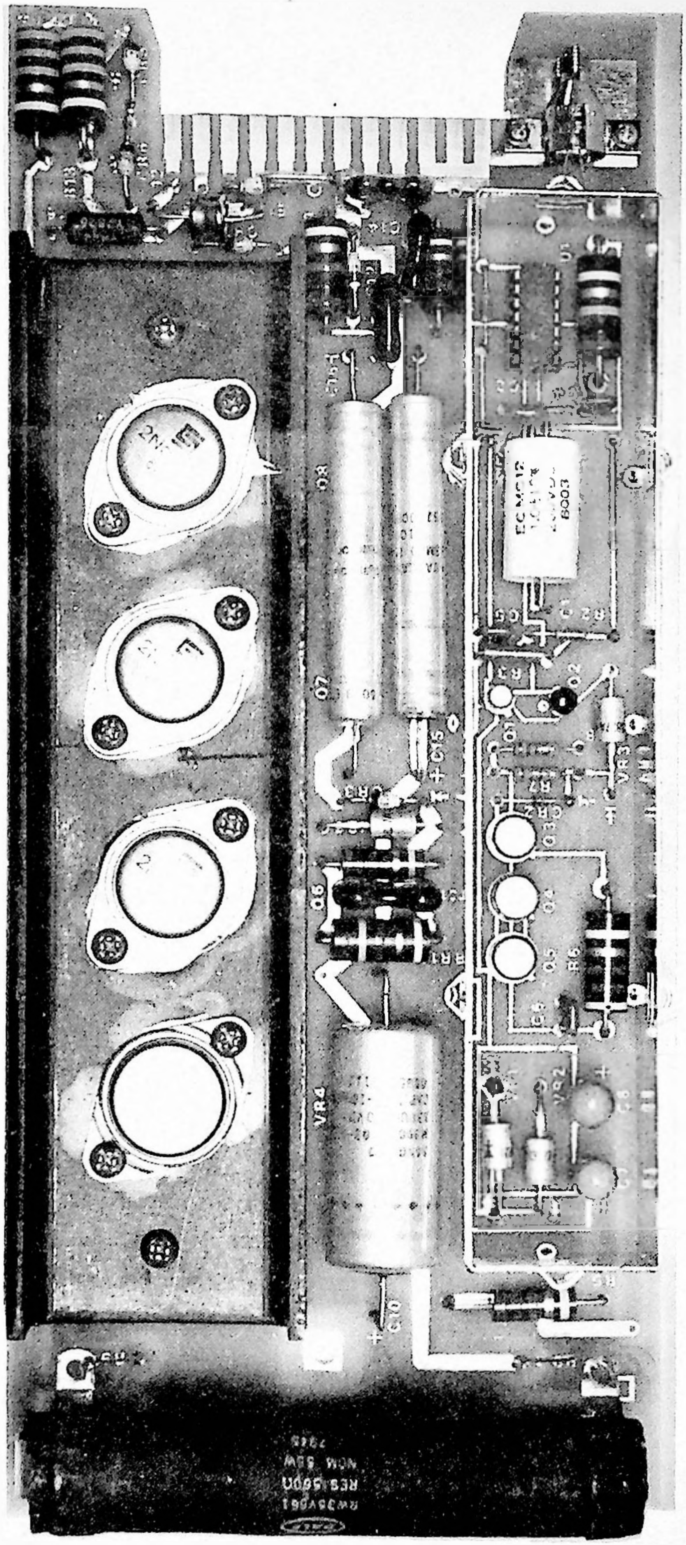

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Figure 7-22. Switchmod Card A9A3

Switchmod Card A9A3

REF DES	DESCRIPTION	VALUE	PART NO.
	Switchmod Card	PA Assy	636-9675-001
C1	Diode Bypass	1.0 mfd,200V	933-1059-050
C2-6	Bypass	1.0 mfd,50V	913-3279-270
C7	VR1 Bypass	150 mfd, 15V	184-9102-160
C8	VR2 Bypass	220 mfd, 10V	184-9102-110
C9	----------------------NOT USED----------------------		
C10	28-V Bypass	330 mfd, 50V	184-5102-040
C11	Q6 Base	6800 pF, 500V	912-2723-000
C12	Comp	2700 pF, 500V	912-3034-000
C13	Comp	2200 pF, 500V	912-3025-000
C14	Comp	680 pF, 500V	912-2989-000
C15	Common Bypass	33 mfd, 150V	183-1277-560
C16	+125 V Bypass	22 mfd, 250V	183-1277-900
C17	----------------------NOT USED----------------------		
C18	Transient Supprsr	1000 pF, 500V	912-3001-000
CR1	Pin Photodiode	SPX-3194	270-0547-030
CR2	Q3 Base	1N914	353-2906-000
CR3-4	Gate	1N5418	353-9009-440
CR5-7	Current Limiter	1N5418	353-9009-440
CR8		1N5418	353-9009-440
CR9	Grid Clamping	1N5418	353-9009-440
E1	350 V Amplifier	Arc Gap	013-1455-040
Q1	Amplifier	2N2222A	352-0661-020
Q2	Amplifier	2N2907A	352-0551-010
Q3-4	Amplifier	2N2102	352-0646-010
Q5	Amplifier	2N4036	352-0714-010
Q6-8	Amplifier	2N6575	352-1134-010
R1-2	U1	4.02K Ohms,1%, 1/2W	705-1025-000
R3	U1	1.0 Megohm, 1%, 1/4W	705-6740-000
R4	Diode Limiter	10K Ohms, 2W	745-5694-000
R5	18-V Regulator	270 Ohms, 1W	745-3328-000
R6	Q3 Collector	470 Ohms, 2W	745-5638-000
R7	Q3 Base	180 Ohms, 1/2W	745-0914-470
R8	Q3 Base	270 Ohms, 1/2 W	745-0914-510
R9	28-V Reg	560 Ohms, 55W	747-2742-000
R10A,B	Resistor	1200 Ohms, 2W	745-5655-000
R11A	Q6 Comp	3300 Ohms, 2W	745-5672-000
R11B	Q6, Comp	2700 Ohms, 2W	745-5669-000
R12	Q6 Comp	2.2K Ohms, 1W	745-3366-000
R13-14	Mod Grid	33K Ohms, 2W	745-5715-000
R15	Q6, Base	10 Ohms, 1W	745-3268-000

Switchmod Card A9A3 (Cont.)

REF DES	DESCRIPTION	VALUE	PART NO.
R16	Current Limit	0.22 Ohm, 3W	747-5122-000
U1	Line Rcvr	mA 710	351-7189-050
VR1	12-V, 1-W Zener	1N3022B	353-3127-000
VR2-3	5.6-V, 1-W Zener	1N3827A	353-6316-000
VR4	27-V, 50-W Zener	1N2822B	353-1915-000
VR5	5.6-V, 1-W Zener	1N3827A	353-6316-000
XU1	U1	14-Pin Socket	220-0075-020
-01	Insulator for Q6-8	Insulator	353-9882-010
-02	For Q3, 4 & 5	Insulator	352-9552-200

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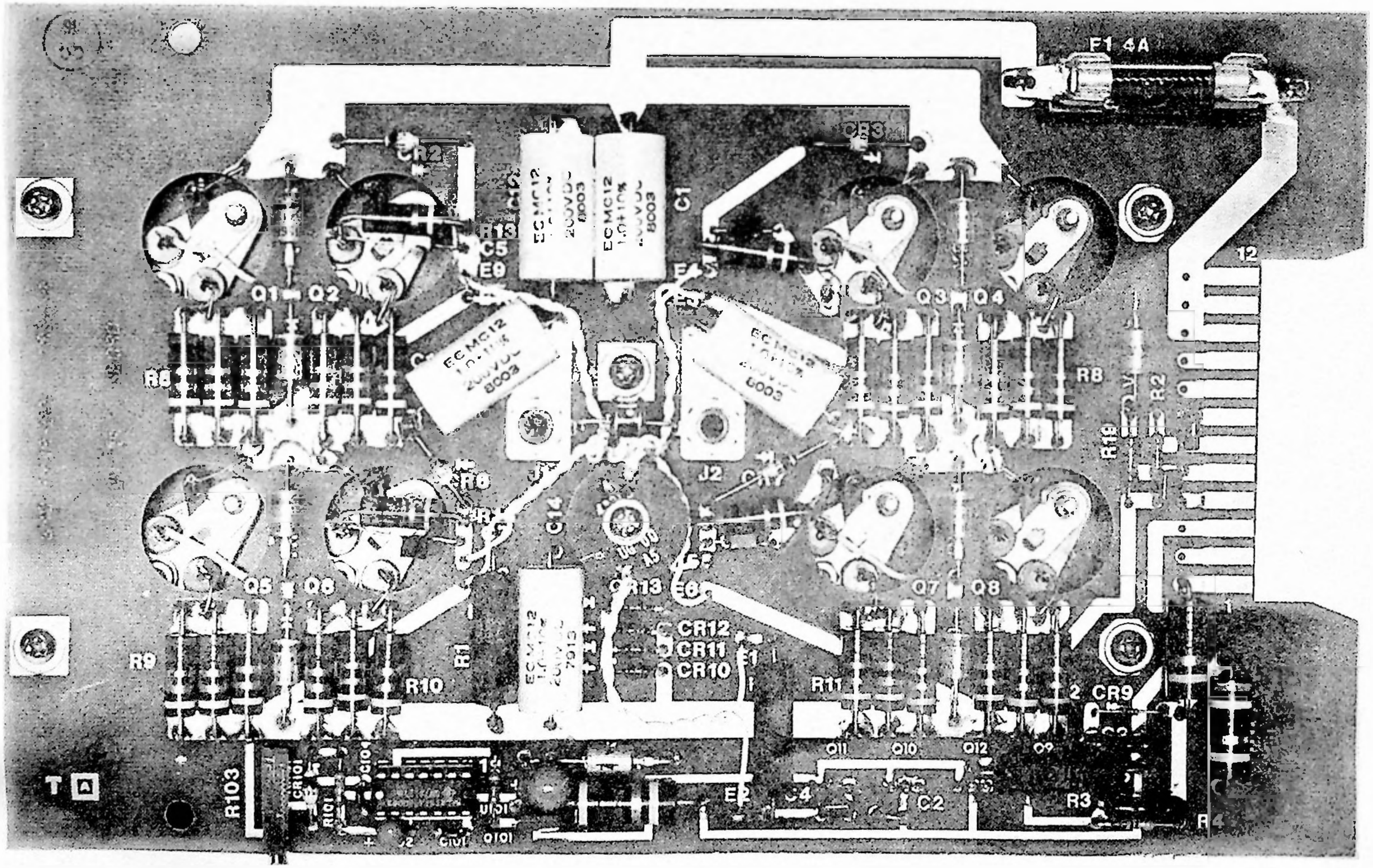

KM1-1(6)

Figure 7-23. RF Driver A9A4

RF Driver A9A4

REF DES	DESCRIPTION	VALUE	PART NO.
	RF Driver	Assy	636-9688-001
C1	200 V Bypass	1.0 mfd,200V	933-1059-050
C2	Bypass	1.0 mfd,50V	913-3279-270
C3	Coupling	1.0 mfd,200V	933-1059-050
C4	Coupling	1.09 mfd, 50V	913-3279-270
C5-8	Base Speed	0.047 mfd,100V	913-5019-280
C9	Q9 Collector	560 pF, 500V	912-2983-000
C10	RF Bypass	1.0 mfd, 50V	913-3279-270
C11	28-V Bypass	1.0 mfd, 50V	913-3279-270
C12-14	Coupling, Bypass	1.0 mfd,200V	933-1059-050
C15	Spike Suppressor	3900 pF, 500V	912-3046-000
C-101	Protect Circuit	0.1 mfd, 50V	913-3279-200
C-102	Protect Circuit	10 mfd, 10V	184-9102-170
C-103	Protect Circuit	220 mfd, 10V	184-9102-110
C-104	Bypass	0.01 mfd, 50V	913-3279-110
CR1,4,5,8	----------------------	NOT USED----------------------	
CR2,3,6,7	Base Protect	1N5418	353-9009-440
CR9	Speed Up	1N914	353-2906-000
CR10-13	Meter Protect	1N5552	353-3718-060
CR-101	Protect Circuit	1N5418	353-9009-440
E11	Protect Circuit	Arc Gap	013-1455-040
F1	Driver Ic	Fuse, 4 A, Normal	264-0449-000
J1,2	Driver Output	Connector	360-2020-000
Q1-8	RF Drivers	2N6575	352-1134-010 ✓
Q9,10,12	Input Amplifier	MJE-243	352-1104-010
Q11	Input Amplifier	MJE-253	352-1105-010
Q101	Protect Circuit	MJE-243	352-1104-010
R1	Ic Meter Shunt	0.5 Ohms, 6.5 W	747-5475-000
R2	RF Filter	1 Kilohm, 1/2 W	745-0914-650
R3	Q9 Collector	100 Ohms, 6.5 W	747-5440-000
R4	Q9 Base	100 Ohms, 1/2 W	745-0914-410
R5-12	Emitter	2.7 Ohms, 1 W	745-3533-000
R13-16	Base	10 Ohms, 1 W	745-3268-000
R17	Input Pad	39 Ohms, 2W	745-5593-000
R18	Input Pad	10 Ohms, 2W	745-5568-000
R19	Ic Meter Cal	6.04K Ohms, 1/4W	705-3602-280
R20	Current Limit	2.0, 6.5 W	747-5406-000
R-101	Protect Circuit	33K Ohms,1/4W	745-0911-020
R-102	Protect Circuit	470 Ohms, 1/4W	745-0910-570
R-103	Protect Circuit	500 Ohms, Var	382-0012-250
R-104	Protect Circuit	470 Ohms, 2W	745-5638-000
T1	3T Pri, 1T Sec Driver Input	Transformer	640-9675-001

RF Driver A9A4 (Cont.)

REF DES	DESCRIPTION	VALUE	PART NO.
U101	Protect Circuit	74121, IC	351-7645-010
VR1	Zener Diode 6.2V,	1N3828A 1W	353-6317-000
VR2-9	Transient Suppressor	1N5661A	353-0221-660
VR101	Protect Circuit	1N3826	353-6315-000
XF1	Driver IC	Fuse Block	265-1037-000
XQ1-8	Q1-8	TO-3 Socket	220-0968-010
01	Insulator	For Q1-8	352-9882-010
02	Insulator	For Q9,10,11,12	352-9655-070
XU-101	Protect Circuit	Dip,Sckt,14-Pin	220-0075-020

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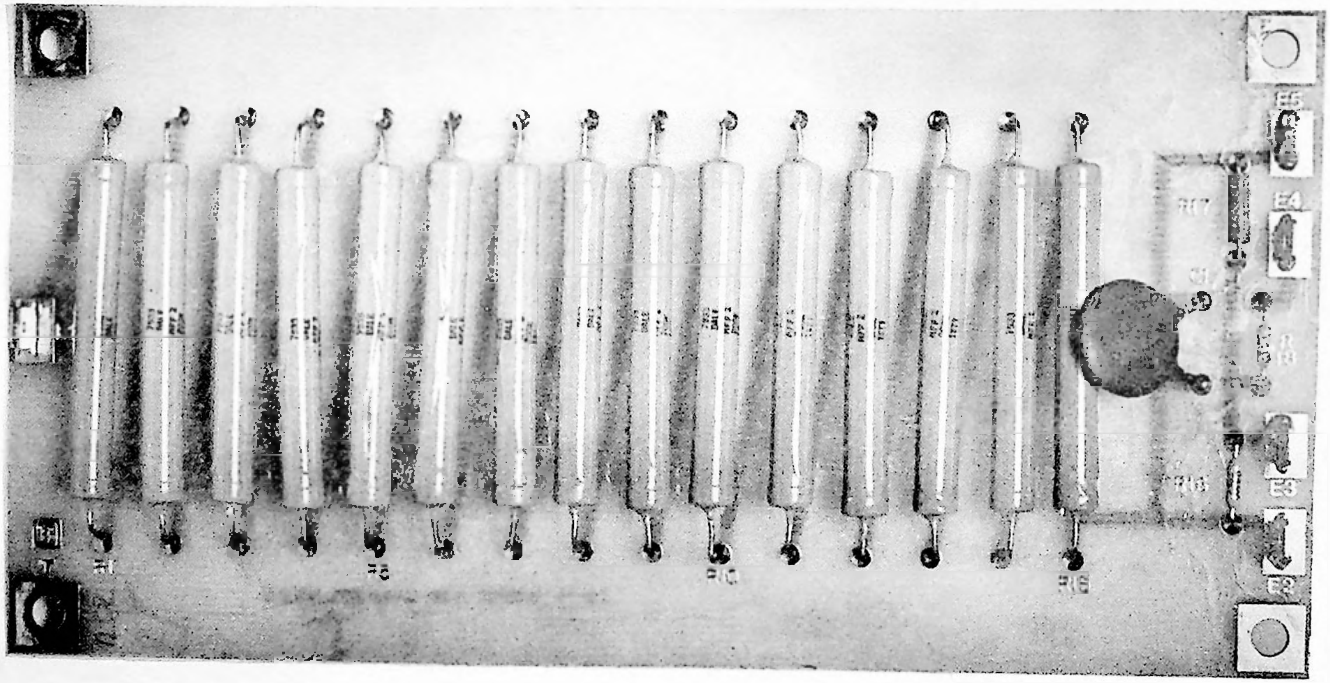

KM1-1(S)

Figure 7-24. High Voltage Divider, Component Layout, A9A5

High Voltage Divider, Component Layout, A9A5

REF DES	DESCRIPTION	VALUE	PART NO.
	HV Meter Divider	PC Assy	636-8413-001
C1	Filter	0.1 mfd,200V	913-3681-000
R1-15	Metering Restr	200K Ohms, 1%,2W	705-1493-050
R16	Meter Protect	100K Ohms, 1/8W,	705-1092-000
R17	Remote Ebb, 1%	10K Ohms, 1/4W,	705-6644-000
R18	Remote Ebb	33K Ohms, 1/4W	745-0911-020

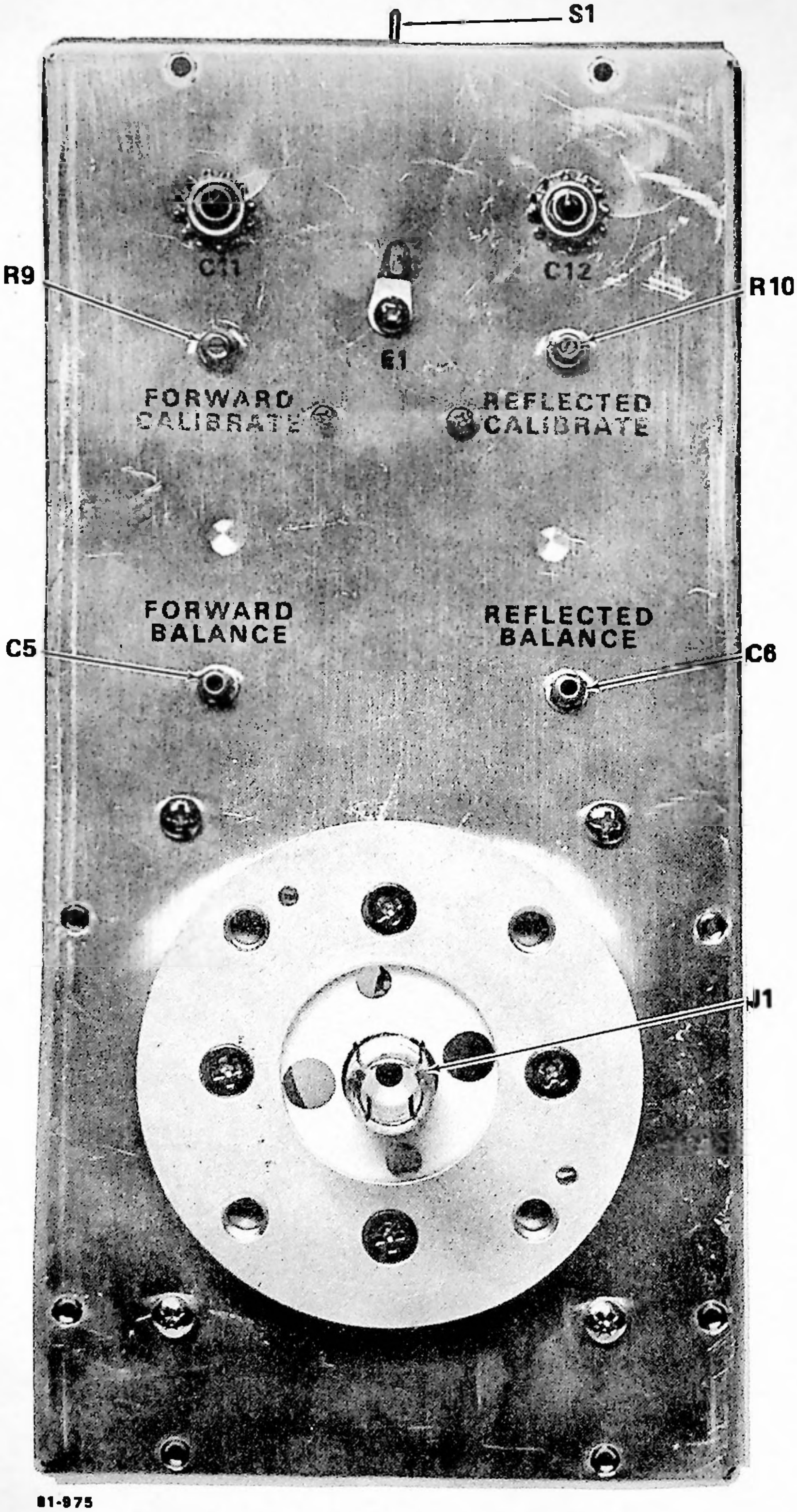

Figure 7-25. RF Power Meter (VSWR) A9A6 (Front View)

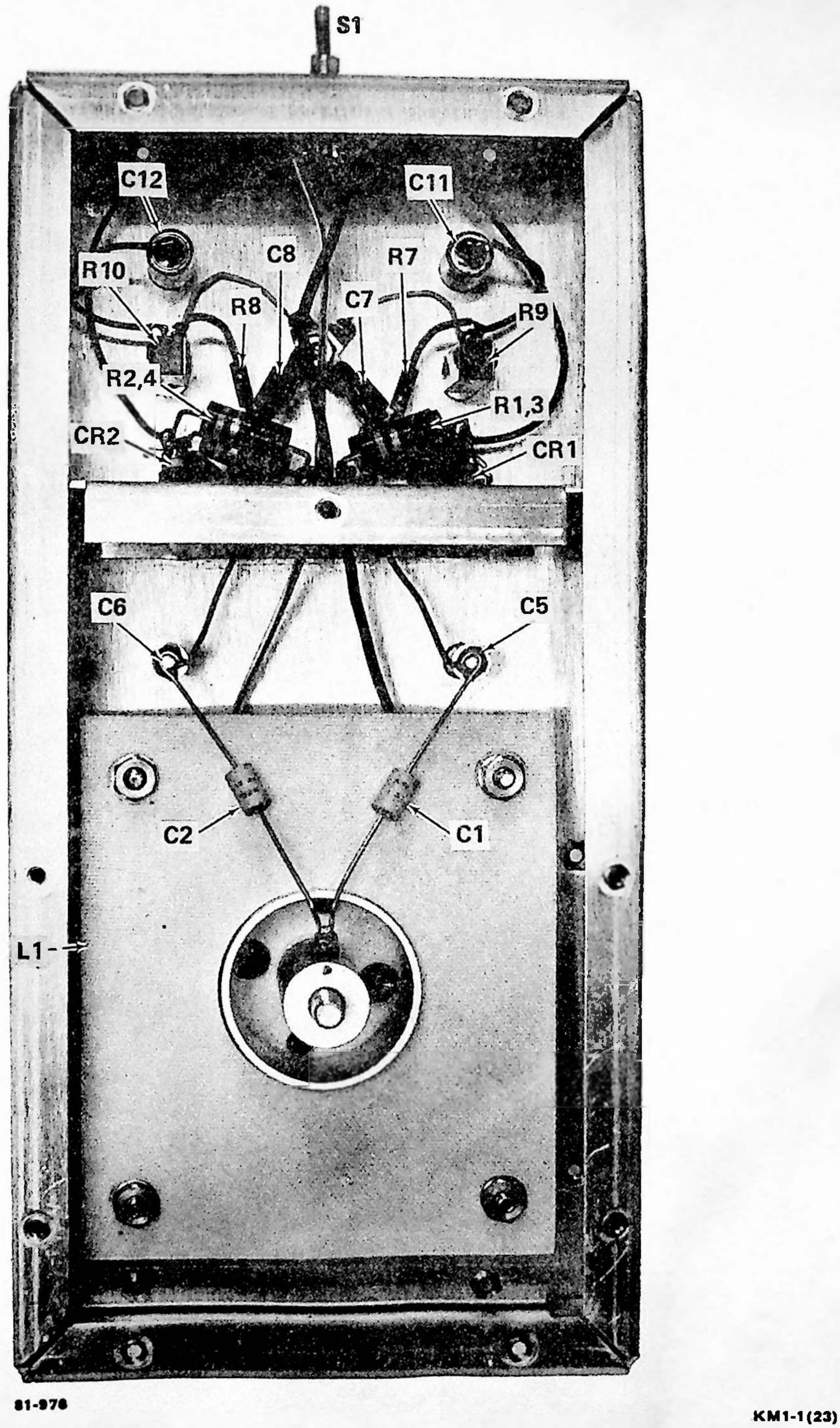

Figure 7-26. RF Power Meter (VSWR) A9A6 (Rear View)

RF Power Meter (VSWR) A9A6

REF DES	DESCRIPTION	VALUE	PART NO.
	VSWR Meter Assy	Assembly	636-9687-001
C1	E Divider	1 pF, 5 kV	913-0973-000
C2	E Divider	1 pF, 5 kV	913-0973-000
C3	E Divider	200 pF, 500V	912-2837-000
C4	E Divider	200 pF, 500V	912-2837-000
C5	Fwd Balance	1-60 pF, 1000V	922-3038-040
C6	Ref Balance	1-60 pF, 1000V	922-3038-040
C7-8	Diode Load Bypass	470 pF, 500V	912-2974-000
C9-10	----------------------NOT USED----------------------		
C11-12	Feedthrough	0.1 mfd,100V	241-0088-000
CR1	RF Detector	1N5711	353-3691-010
CR2	RF Detector	1N5711	353-3691-010
L1	Toroid Pickup	270 mH, 250 mA	636-9686-001
L2	RFC	2.2 mH	240-2548-000
L3	RFC	2.2 mH	240-2548-000
R1-4	Toroid Load	22 Ohms, 2W	745-5582-000
R5-6	Diode Load	10K Ohms, 1/2W	745-1394-000
R7-8	AF Filter	5.6K Ohms, 1/2W	745-1384-000
R9	Fwd Cal	10K Ohms, Pot 10T	377-0659-200
R10	Ref Cal	10K Ohms, Pot 10T	377-0659-200
R11	----------------------NOT USED----------------------		
R12	----------------------NOT USED----------------------		
S1	Norm-Reverse	DPDT Switch	266-5321-200

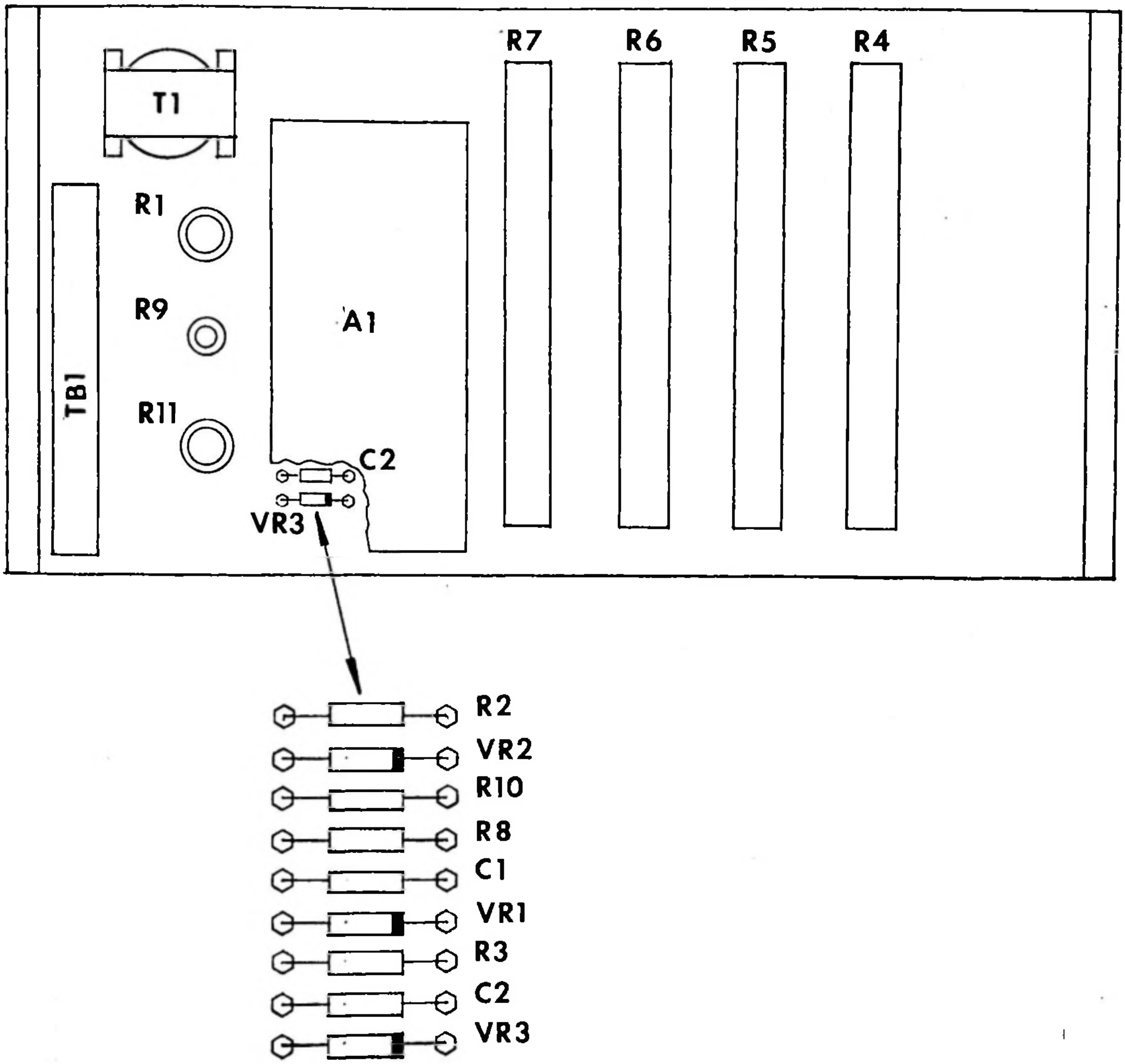

Figure 7-27. High-Voltage Bleeder A10.

WARNING: DISCONNECT PRIMARY POWER BEFORE SERVICING.

High Voltage Bleeder A10

REF DES	DESCRIPTION	VALUE	PART NO.
	HV Bleeder	Assembly	640-9677-001
A1	13-kV Sample Divider	PC Assembly	636-8418-001
C1	Meter Bypass	0.1 mfd, 200V	913-3681-000
C2	Meter Bypass	0.1 mfd,200V	913-3681-000
R1	HVPS Overload	8.2 Ohms, 100W	710-2026-000
R2	Overload Protect	1000 Ohms, 1W RCR	745-3352-000
R3	Remote Ib Protect	1 Kilohm, 1W RCR	745-3352-000
R4	HVPS Bleeder	180K Ohms, 210W	746-6742-000
R5	HVPS Bleeder	180K Ohms, 210W	746-6742-000
R6	HVPS Bleeder	180K Ohms, 210W	746-6742-000
R7	HVPS Bleeder	180K Ohms, 210W	746-6742-000
R8	Plate Curr Mtr	1000 Ohms, 1%,3W	747-0998-050
R9	Ib Mtr	1.0 Ohm, 36W, 1%	710-5076-010
R10	HVPS Overload	47 Ohms, 2W RCR	745-5596-000
R11	Remote IB	4 Ohms, 100W	710-5076-060
T1	Logic PS Xfmr	208/240, 24 V AC	662-0601-010
TB1	Terminal Board	I/O Conn.	367-4160-000
VR1	Ib Mtr Protect	1N3827A 5.6V	353-6316-000
* VR2	Diode	1N4744A	353-6481-330
VR3	Remote Ib	1N3827A 5.6V	353-6316-000

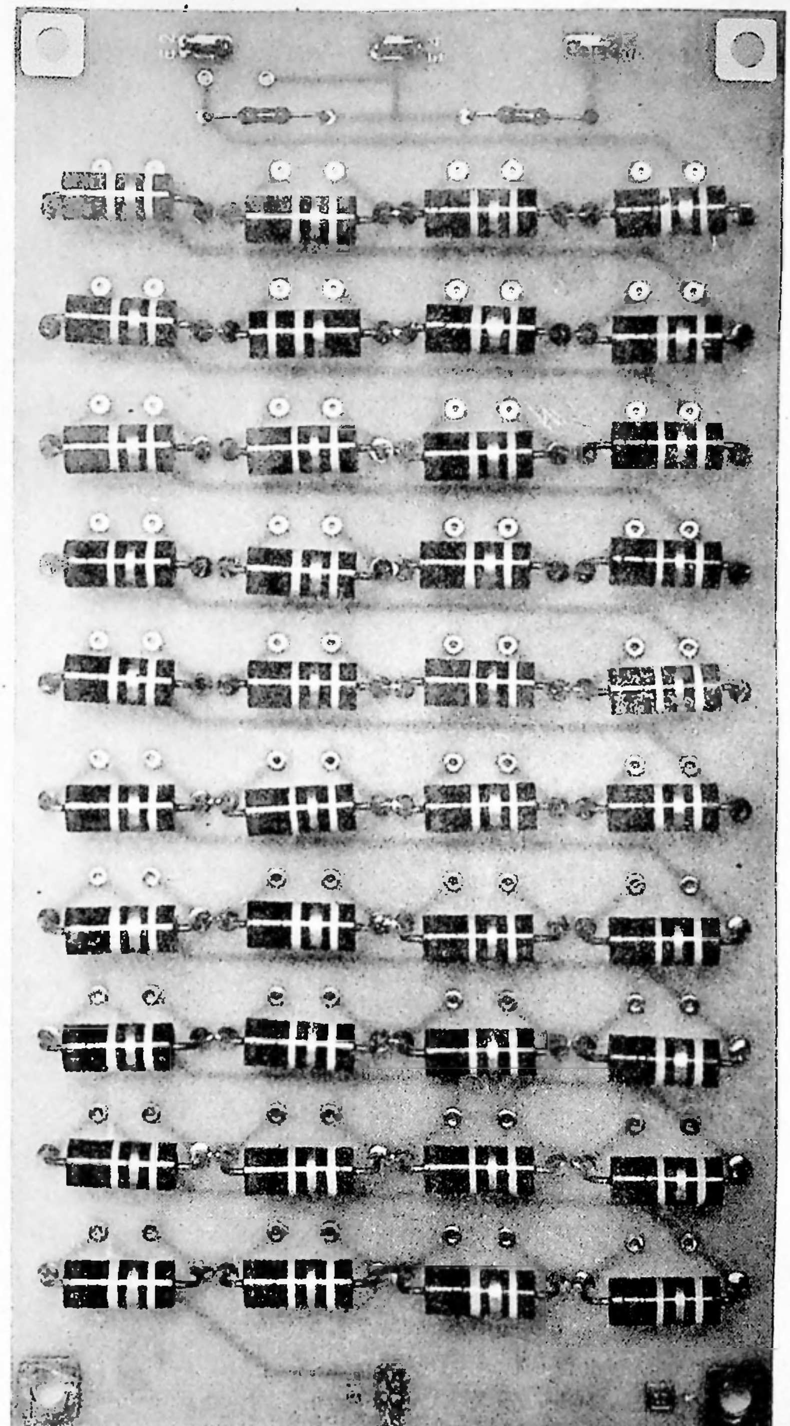

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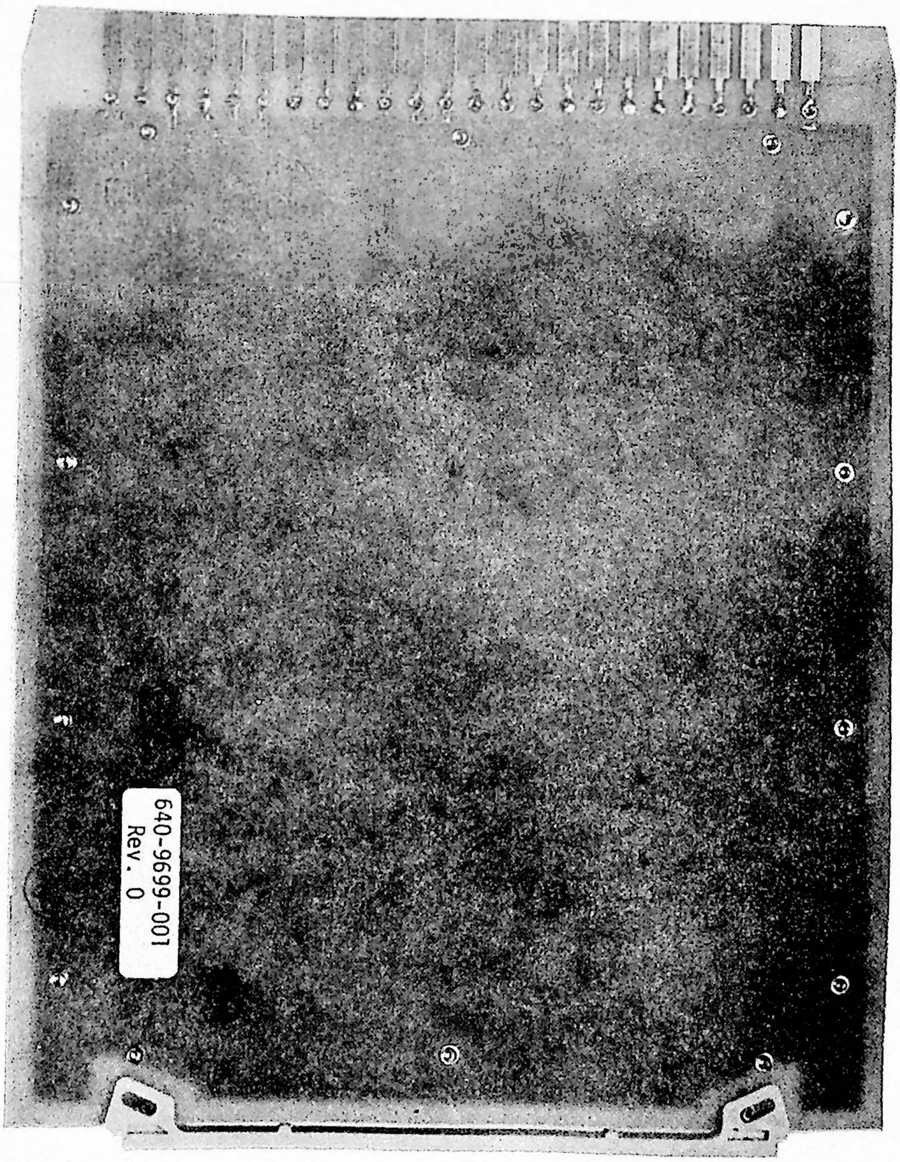
Figure 7-28. 13KV Sample Divider, Component Layout, A10A1

13-kV Sample Divider, A10A1

REF DES	DESCRIPTION	VALUE	PART NO.
	13-kV Sample Divider	PC Assy	636-8418-001
R1-40	Divider	100K Ohms, 10%, 2W	745-5736-000
R41	Divider	560 Ohms, 1/2W	745-0914-590
R42	Divider	560 Ohms, 1/2W	745-0914-590



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KM1-1(11)

Figure 7-29. Signal Access Card All

FREQUENCY KIT FOR THE 315R-1

REF DES	DESCRIPTION	VALUE	PART NO.
		BAND 1, 540 TO 700 KHz	
A9C7A	Node 2 Cap	1200 pF,25 kV	912-4128-050
A9C7B		270pF,30kV 9.1A	912-4128-150
9C8	Node 3 Cap	1500 pF,25 kV	912-4128-060
A9C9	Node 4 Cap	2000 pF, 25 kV	912-4128-070
A9L1	Node 1 Coil	120 mH, 10A	980-0048-000
A9L2	Node 2 Coil	120 mH, 10 A	980-0048-000
A9L3B	Coupling Coil	150 mH, 10 A	980-0041-000
A1Y1	Osc 1 Crystal	See Crystal Table	289-7274-XXX
A1Y2	Osc 2 Crystal	See Crystal Table	289-7274-XXX
		BAND 2, 710 TO 930 KHz	
A9C7	Node 2 Cap	pF, 10 kV	144-0470-100
A9C8	Node 3 Cap	1200 pF, 25 kV	912-4128-050
A9C9	Node 4 Cap	1200 pF, 25 kV	912-4128-050
A9L1	Node 1 Coil	120 mH, 10 A	980-0048-000
A9L2	Node 2 Coil	82 mH, 10 A	980-0047-000
A9L3B	Coupling Coil	150 mH, 10 A	980-0041-000
A1Y1	Osc 1 Crystal	See Crystal Table	289-7274-XXX
A1Y1	Osc 2 Crystal	See Crystal Table	289-7274-XXX
		BAND 3, 940 TO 1230 KHz	
A9C7A	Node 2 Cap	390 pF,30 kV,11A	912-4128-190
A9C7B	Node 2 Cap	390 pF,30 kV,11A	912-4128-190
A9C8	Node 3 Cap	1000 pF,. 30 kV	912-4128-040
A9C9	Node 4 Cap	1000 pF, 30 kV	912-4128-040
A9L1	Node 1 Coil	120 mH, 10 A	980-0048-000
A9L2	Node 2 Coil	82 mH, 10 A	980-0047-000
A1Y1	Osc 1 Crystal	See Crystal Table	289-7274-XXX
A1Y2	Osc 2 Crystal	See Crystal Table	289-7274-XXX
		BAND 4, 1240 TO 1600 KHz	
A9C7A	Node 2 Cap	270 pF,30 kV,9.1A	912-4128-150
A9C7B	Node 2 Cap	270 pF,30 kV, 9.1A	912-4128-150
A9C8A	Node 3 Cap	390 pF,30 kV,11 A	912-4128-190
A9C8B	Node 3 Cap	390 pF,30 kV,11A	912-4128-190
A9C9	Node 4 Cap	750 pF, 30 kV	912-4128-020
A9L1	Node 1 Coil	82 mH, 10 A	980-0047-000
A9L2	Node 2 Coil	82 mH, 10 A	980-0047-000
A1Y1	Osc 1 crystal	See Crystal Table	289-7274-XXX
A1Y2	Osc 2 crystal	See Crystal Table	289-7274-XXX

TABLE 7-3 CRYSTAL FREQUENCIES

OPERATING FREQUENCY (kHz)	CRYSTAL FREQUENCY (kHz)	PART NUMBER
540	2160	289-7274-010
550	2200	289-7274-030
560	2240	289-7274-050
570	2280	289-7274-070
580	2320	289-7274-090
590	2360	289-7274-110
600	2400	289-7274-130
610	2440	289-7274-150
620	2480	289-7274-170
630	2520	289-7274-190
640	2560	289-7274-210
650	2600	289-7274-230
660	2640	289-7274-250
670	2680	289-7274-270
680	2727	289-7274-290
690	2760	289-7274-310
700	2800	289-7274-330
710	2840	289-7274-350
720	2880	289-7274-370
730	2920	289-7274-390
740	2960	289-7274-410
750	3000	289-7274-430
760	3040	289-7274-450
770	3080	289-7274-470
780	3120	289-7274-490
790	3160	289-7274-510
800	3200	289-7274-530
810	3240	289-7274-540
820	3280	289-7274-550
830	3320	289-7274-560
840	3360	289-7274-570
850	3400	289-7274-580
860	3440	289-7274-590
870	3480	289-7274-600
880	3520	289-7274-610
890	3560	289-7274-620
900	3600	289-7274-630

Crystal Table (Cont.)

OPERATING FREQUENCY (KHz)	CRYSTAL FREQUENCY (KHz)	PART NUMBER
910	3640	289-7274-640
920	3680	289-7274-650
930	3720	289-7274-660
940	3760	289-7274-670
950	3800	289-7274-680
960	3840	289-7274-690
970	3880	289-7274-700
980	3920	289-7274-710
990	3960	289-7274-720
1000	4000	289-7274-730
1010	4040	289-7274-740
1020	4080	289-7274-750
1030	4120	289-7274-760
1040	4160	289-7274-770
1050	4200	289-7274-780
1060	4240	289-7274-790
1070	4280	289-7274-800
1080	2160	289-7274-010
1090	2180	289-7274-020
1100	2200	289-7274-030
1110	2220	289-7274-040
1120	2240	289-7274-050
1130	2260	289-7274-060
1140	2280	289-7274-070
1150	2300	289-7274-080
1160	2320	289-7274-090
1170	2340	289-7274-100
1180	2360	289-7274-110
1190	2380	289-7274-120
1200	2400	289-7274-130
1210	2420	289-7274-140
1220	2440	289-7274-150
1230	2460	289-7274-160
1240	2480	289-7274-170
1250	2500	289-7274-180
1260	2520	289-7274-190
1270	2540	289-7274-200
1280	2560	289-7274-210
1290	2580	289-7274-220
1300	2600	289-7274-230

Crystal Table (Cont.)

OPERATING FREQUENCY (KHz)	CRYSTAL FREQUENCY (KHz)	PART NUMBER
1310	2620	289-7274-240
1320	2640	289-7274-250
1330	2660	289-7274-260
1340	2680	289-7274-270
1350	2700	289-7274-280
1360	2720	289-7274-290
1370	2740	289-7274-300
1380	2760	289-7274-310
1390	2780	289-7274-320
1400	2800	289-7274-330
1410	2820	289-7274-340
1420	2840	289-7274-350
1430	2860	289-7274-360
1440	2880	289-7274-370
1450	2900	289-7274-380
1460	2920	289-7274-390
1470	2940	289-7274-400
1480	2960	289-7274-410
1490	2980	289-7274-420
1500	3000	289-7274-430
1510	3020	289-7274-440
1520	3040	289-7274-450
1530	3060	289-7274-460
1540	3080	289-7274-470
1550	3100	289-7274-480
1560	3120	289-7274-490
1570	3140	280-7274-500
1580	3160	289-7274-510
1590	3180	289-7274-520
1600	3200	289-7274-530

TABLE 7-4. SEMICONDUCTOR LIST

DESCRIPTION	PART NO.
SPX3191	270-0547-010
SPX3194	270-0547-030
MC1494L	351-1116-010
LM340T-5	351-1120-010
LM340T-12	351-1120-040
MC7912CT	351-1178-060
MC7906CT	351-1178-040
NE555V	351-1137-020
531	351-1164-010
3403	351-1223-020
8038	351-1231-020
NE5534AN	351-1339-010
710	351-7189-050
7404	351-7630-010
SN7410	351-7635-010
SN7473N	351-7640-010
74121	351-7645-010
7492	351-7771-010
2N2907A	352-0551-010
2N3054	352-0581-010
2N2102	352-0646-010
2N2222A	352-0661-020
2N3772	352-0690-020
2N4036	352-0714-010
MJE243	352-1104-010
MJE253	352-1105-010
2N6575	352-1134-010
Insulator	352-9655-070
1N 5661A	353-0221-660
F89 Rectifier	353-0413-020
Rectifier	353-0417-060
Rectifier	353-0417-130
1N2989B	353-1369-000
1N2822B	353-1915-000
1N914	353-2906-000
1N756A	353-2720-000
1N3017B	353-3122-000
1N3022B	353-3127-000
* 1N4744A	353-6481-330
1N4454	353-3644-010
1N5711	353-3691-010
1N5552	353-3718-060
LED	353-3725-010
1N3826	353-6315-000
1N3827A	353-6316-000
1N3828A	353-6317-000
1N4004	353-6442-040
1N4007	353-6442-070
C6F	353-6468-010
SA7586	353-6599-010
1N5418	353-9009-440
LED	636-6171-001

7-5. SUGGESTED SPARE PARTS LIST

QUANTITY	DESCRIPTION
1	0.1 uF Feedthrough Cap A9C47, C31
1	5600-pf Feedthrough Cap A9C35, C36
1	Blower Motor (B3)
1	Fiber Optic Cable
1	Contactor A8K1
1	Contactor A3K1
1	Contactor A3K2
1	Low Power Relay A2K1
1	Oscillator Select Relay A1K1
1	Power Control Variable Resistor A6R1
1	PWM Card A2
1	Switchmod Card A9A3
1	Driver Card A9A4
1	Switchmod Clamp Diode A9CR1
1	28-Volt Power Supply Transformer A7T1
1	240 pF Capacitor A9C21
1	500 pF Capacitor A9C26, C27, C23
1	100 pF Capacitor A9C14, 15, 16
1	HVPS Overload Resistor A10R1
1	PA Grid Leak Resistor A9R10
1	HVPS Damper A8R1
1	PA Filament Adjust Resistor A6R1
1	HVPS Bleeder A10R4
1	Relay A7A1K2
1	Low Power Relay A7A1K1
1	Blower Relay A7K1-K2
1	Coil Coupling A9L3A
1	Node Percent Coil A9L4-5
1	100% Spare Semiconductors Per Dwg. 636-9706-001
5 Sets	Lamps and Fuses

TUBE DATA SHEETS

3CX3000A7
8162
3CX3000F7
HIGH-MU
AIR COOLED
POWER TRIODES

TECHNICAL DATA

The EIMAC 3CX3000A7 high-mu forced-air cooled power triode provides relatively high power output as an amplifier, oscillator, or modulator at low plate voltages. The tube has a low inductance cylindrical filament-stem structure which readily becomes part of a linear filament tank circuit for VHF operation. The grid provides good shielding between the input and output circuits for grounded-grid applications and conveniently terminates in a ring between the plate and filament terminals.

Operation with zero grid bias in many applications offers circuit simplicity by eliminating the bias supply. Grounded-grid operation is attractive, since a power gain of over 20 times can be obtained.

The 8162/3CX3000F7 tube is identical except for the addition of flexible leads on the base for grid and filament connections which can simplify socketing in low-frequency applications.

3CX3000A7

3CX3000F7

GENERAL CHARACTERISTICS[1]

ELECTRICAL

Filament: Thoriated Tungsten

Voltage	7.5 ± 0.37	V
Current @ 7.5 V	51.5	A
Amplification Factor (average)	160	

Direct Interelectrode Capacitances (grounded filament)[2]

Cin	38.0	pF
Cout	0.6	pF
Cgp	24.0	pF

Direct Interelectrode Capacitances (grounded grid)[2]

Cin	38.0	pF
Cout	24.0	pF
Cpk	0.6	pF

1. Characteristics and operating values are based on 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.

3955 (Effective 7-1-79)

Printed in U.S.A.

Frequency of Maximum Rating:	3CX3000A7	110 MHz
	3CX3000F7	75 MHz

MECHANICAL

Maximum Overall Dimensions:

Length (3CX3000A7)	9.000 In; 227.60 mm
(3CX3000F7, incl. fil. leads)	18.437 In; 468.30 mm
Diameter (both types)	4.156 In; 105.56 mm
Operating Position	Vertical, base up or down
Net Weight: (3CX3000A7) (Approx.)	6.2 Lb; 2.8 kg
(3CX3000F7) (Approx.)	7.0 Lb; 3.2 kg
Cooling	Forced Air
Base (3CX3000A7)	Special Coaxial
(3CX3000F7)	Special with Flying Leads

Maximum Operating Temperature:

Anode Core and Ceramic/Metal Seals	250°C
3CX3000F7 Filament Lead/Tube Base Junctions	150°C

RADIO FREQUENCY LINEAR AMPLIFIER
CATHODE DRIVEN
Class AB_2

ABSOLUTE MAXIMUM RATINGS:

DC PLATE VOLTAGE	5000 VOLTS
DC PLATE CURRENT	2.5 AMPERES
PLATE DISSIPATION	4000 WATTS
GRID DISSIPATION	225 WATTS

1. Approximate value.

TYPICAL OPERATION (Frequencies to 30 MHz)
Class AB_2, Peak Envelope or Modulation Crest Conditions

Plate Voltage	4000	4800	4800	Vdc
Zero-Signal Plate Current[1]	0.25	0.35	0.35	Adc
Single-Tone Plate Current	2.00	1.68	2.00	Adc
Single-Tone Grid Current[1]	0.61	0.46	0.60	Adc
Peak Driving Power	420	293	410	w
Plate Dissipation	2285	2275	2775	W
Single-Tone Plate Output Power	6030	6000	7266	W
Resonant Load Impedance	1210	1720	1425	Ω
Driving Impedance	47.5	50.0	46.3	Ω

RADIO FREQUENCY LINEAR AMPLIFIER
GRID DRIVEN
Class AB_2

ABSOLUTE MAXIMUM RATINGS:

DC PLATE VOLTAGE	5000 VOLTS
DC PLATE CURRENT	2.5 AMPERES
PLATE DISSIPATION	4000 WATTS
GRID DISSIPATION	225 WATTS

1. Approximate value.

TYPICAL OPERATION (Frequencies to 30 MHz)
Class AB_2, Grid Driven, Carrier Conditions

Plate Voltage	4000	Vdc
Zero-Signal Plate Current[1]	0.25	Adc
DC Plate Current	0.74	Adc
DC Grid Current[1]	0.13	Adc
Peak rf Grid Voltage[1]	85.0	v
Peak Driving Power[1]	11.5	w
Plate Dissipation	1830	W
Single-Tone Plate Output Power	1130	W
Resonant Load Impedance	1750	Ω
Peak rf Plate Voltage	2000	v

RADIO FREQUENCY POWER AMPLIFIER
Class C Telegraphy or FM, Cathode Driven
(Key-down Conditions)

ABSOLUTE MAXIMUM RATINGS:

DC PLATE VOLTAGE	5000 VOLTS
DC PLATE CURRENT	2.5 AMPERES
PLATE DISSIPATION	4000 WATTS
GRID DISSIPATION	225 WATTS

1. Approximate value.
2. Output circuit and filter loss of 10% assumed.

TYPICAL OPERATION (Frequencies to 110 MHz for 3CX3000A7, to 30 MHz for 3CX3000F7)

Plate Voltage	3500	4800	Vdc
Grid Voltage	-50	-60	Vdc
Plate Current	1.30	1.54	Adc
Grid Current[1]	0.42	0.48	Adc
Peak rf Cathode Voltage[1]	220	267	v
Calculated Driving Power[1]	310	435	W
Plate Dissipation	985	1480	W
Useful Output Power[2]	3300	5500	W

HIGH-LEVEL MODULATED RADIO-FREQUENCY AMPLIFIER PULSE-WIDTH MODULATION -
Grid Driven

ABSOLUTE MAXIMUM RATINGS:

	RF Amplifier	Switching Modulator	
DC PLATE VOLTAGE ...	5.5	15.0	KILOVOLTS
DC PLATE CURRENT ...	2.5	2.5	AMPERES
DC GRID VOLTAGE	-500	-500	VOLTS
PLATE DISSIPATION ..	4000	4000	WATTS
GRID DISSIPATION	225	225	WATTS

TYPICAL OPERATION
(Carrier Conditions)[1]

	RF Amplifier	Switching Modulator	
Plate Voltage	5.0	13.7	kVdc
Plate Current	1.25	0.53	Adc
Grid Voltage	-240	-125	Vdc
Grid Current[2]	0.8	0.6	Adc
Useful Power Output[2]	5.5	6.25	kW

1. These conditions assume rectangular drive waveform and a third harmonic, high-efficiency "Tyler" circuit.
2. Approximate value.

AUDIO FREQUENCY POWER AMPLIFIER OR MODULATOR
Class AB 2, Grid Driven (Sinusoidal Wave)

ABSOLUTE MAXIMUM RATINGS: (Per Tube)

DC PLATE VOLTAGE	5000	VOLTS
DC PLATE CURRENT	2.5	AMPERES
PLATE DISSIPATION	4000	WATTS
GRID DISSIPATION	225	WATTS

1. Approximate value.
2. Per tube.

TYPICAL OPERATION (Two Tubes)

Plate Voltage	4000	Vdc
Zero-Signal Plate Current[1]	0.50	Adc
Max. Signal Plate Current	3.58	Adc
Max. Signal Grid Current[1]	0.58	Adc
Peak af Grid Voltage[2]	190	v
Peak Driving Power[3]	115	w
Max. Signal Plate Dissipation	1850	W
Plate Output Power	10,500	W
Load Resistance (plate to plate)	2720	Ω

3. Nominal drive power is one-half peak power.

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.	
Filament: Current @ 7.5 volts	48.0	54.0	A
Interelectrode Capacitances[1] (grounded filament connection)			
Cin	30.0	45.0	pF
Cout	---	1.0	pF
Cgp	20.0	28.0	pF
Interelectrode Capacitances[1] (grounded grid connection)			
Cin	30.0	45.0	pF
Cout	20.0	28.0	pF
Cpk	---	1.0	pF
Zero Bias Plate Current (E b = 5000 volts)	0.36	0.52	A
Cut-off Bias (E b = 5000 volts, I b = 1.0 mAdc)	---	-45.0	V

1. Capacitance values are for a cold tube as measured in a shielded fixture.

APPLICATION

MECHANICAL

MOUNTING - The 3CX3000A7 and 3CX3000F7 must be mounted vertically, base down or up at the convenience of the circuit designer. The filament connections to the 3CX3000A7 should be made through spring collets. These are available from EIMAC with the following part numbers:

149575 Inner line collet
149576 Outer line collet

Reasonable care should be taken that these collets do not impart undue strain to the terminals or the base of the tube.

COOLING - The maximum temperature rating for the anode core and the ceramic/metal seal areas of either tube is 250°C, and sufficient forced-air cooling must be provided to assure operation at safe tube temperatures. Tube life is usually prolonged if cooling in excess of absolute minimum requirements is provided for cooler tube temperatures.

The filament leads of the 3CX3000F7 are attached to the tube with soft solder, and care must therefore be taken to supply sufficient cooling to this area of the tube to maintain temperatures below 150°C to avoid melting or loosening of these leads.

Minimum air flow requirements to maintain anode core and ceramic/metal seal areas below 225°C at sea level with an inlet-air temperature of 40°C are tabulated for air-flow in the base-to-anode and anode-to-base directions. At higher ambient temperatures, frequencies above 30 MHz, or at higher altitudes, a greater quantity of air will be required.

With air flowing in a base-to-anode direction, and with the specified air also flowing past the base section of the tube, no additional base cooling of either type is normally required. With air flowing in an anode-to-base direction, both types require additional cooling air directed into the filament stem structure, between the inner and outer filament terminals, in the amount of 5 cfm minimum, directed by an appropriate air nozzle or pipe.

It is suggested that temperatures, especially in the base area of the tube, be monitored in any new installation to insure proper cooling. Temperatures may be measured with any of the available temperature-sensing paint or crayon materials.

Base-to-Anode Air Flow				
	Sea Level		5,000 Feet	
Anode Dissipation watts	Air Flow CFM	Pressure Drop Inches water	Air Flow CFM	Pressure Drop Inches water
2500	36	0.60	43	0.72
4000	67	1.20	80	1.45
Anode-to-Base Air Flow				
2500	42	0.70	50	0.84
4000	84	1.70	101	2.00

ELECTRICAL

FILAMENT OPERATION - The filament voltage, as measured at the filament terminals, should be 7.5 volts, with maximum allowable variation due to line fluctuations of from 7.12 to 7.87 volts.

INTERLOCKS - An interlock device should be provided to insure that cooling air flow is established before application of electrical power, including the heater. The circuit should be so arranged that rf drive cannot be applied in the absence of normal plate voltage.

INPUT CIRCUIT - When operated as a grounded-grid rf amplifier, the use of a matching network in the cathode circuit is recommended. For best results with a single-ended amplifier, and depending on the application, it is suggested the network have a "Q" of at least 5, and higher if possible.

RADIO FREQUENCY RADIATION - Avoid exposure to strong rf fields even at relatively low frequency. Absorption of rf energy by human tissue is dependent on frequency. Under 30 MHz, most of the energy will pass completely through the human body with little attenuation or heating effect. Public health agencies are concerned with the hazard, however, even at these frequencies, and it is worth noting that some commercial dielectric heating units actually operate at frequencies as low as the 13 and 27 MHz bands.

Many EIMAC power tubes, such as these, are specifically designed to generate or amplify radio frequency power. There may be a relatively strong rf field in the general proximity of the power tube and its associated circuitry--the more power involved, the stronger the rf field. Proper enclosure design and efficient coupling of rf energy to the load will minimize the rf field in the vicinity of the power amplifier unit itself.

FAULT PROTECTION - In addition to normal cooling airflow interlock and plate over-current interlock it is good practice to protect the tube from internal damage which could result from occasional plate arcing at high plate voltage.

In all cases some protective resistance

should be used in series with the tube anode to absorb power supply stored energy in case a plate arc should occur. EIMAC Application Bulletin #17, titled "FAULT PROTECTION" is available on request.

HIGH VOLTAGE - Normal operating voltages used with these tubes are deadly, and the equipment must be designed properly and operating precautions must be followed. Design all equipment 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 primary circuits of the power supply and to discharge high-voltage capacitors 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.

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.

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

DIMENSIONAL DATA						
DIM.	INCHES			MILLIMETERS		
	MIN	MAX	REF	MIN	MAX	REF
A	4094	4156	- -	10399	105 56	- -
B	0781	0844	- -	19 83	21 44	- -
C	2990	3010	- -	7595	76 45	- -
D	0615	0635	- -	15 62	16 13	- -
E	1490	1510	- -	37 85	3835	- -
F	- -	3625	- -	- -	92 08	- -
G	0813	0937	- -	2065	2380	- -
H	1375	1625	- -	34 92	41 28	- -
J	0391	0422	- -	9 93	1072	- -
K	3875	4250	- -	98 43	10795	- -
L	2937	3063	- -	74 60	7780	- -
N	1187	1687	- -	30 15	4285	- -
P	8000	9000	- -	203 20	228 60	- -
Q	0687	0813	- -	17.45	2065	- -

NOTES

1 REF DIMENSIONS ARE FOR INFO ONLY & ARE NOT REQUIRED FOR INSPECTION PURPOSES.

OPERATING HAZARDS

PROPER USE AND SAFE OPERATING PRACTICES WITH RESPECT TO POWER TUBES ARE THE RESPONSIBILITY OF EQUIPMENT MANUFACTURERS AND USERS OF SUCH TUBES. ALL PERSONS WHO WORK WITH OR ARE EXPOSED TO POWER TUBES OR EQUIPMENT WHICH UTILIZES SUCH TUBES MUST TAKE PRECAUTIONS TO PROTECT THEMSELVES AGAINST POSSIBLE SERIOUS BODILY INJURY. DO NOT BE CARELESS AROUND SUCH PRODUCTS.

The operation of power tubes involves one or more of the following hazards, any one of which, in the absence of safe operating practices and precautions, could result in serious harm to personnel:

a. *HIGH VOLTAGE* - Normal operating voltages can be deadly.

b. *RF RADIATION* - Exposure to strong rf fields should be avoided, even at relatively low frequencies. The dangers of rf radiation are more severe at UHF and microwave frequencies and can cause serious bodily and eye injuries. CARDIAC PACEMAKERS MAY BE AFFECTED.

c. *X-RAY RADIATION* - High voltage tubes can produce dangerous and possibly fatal x-rays.

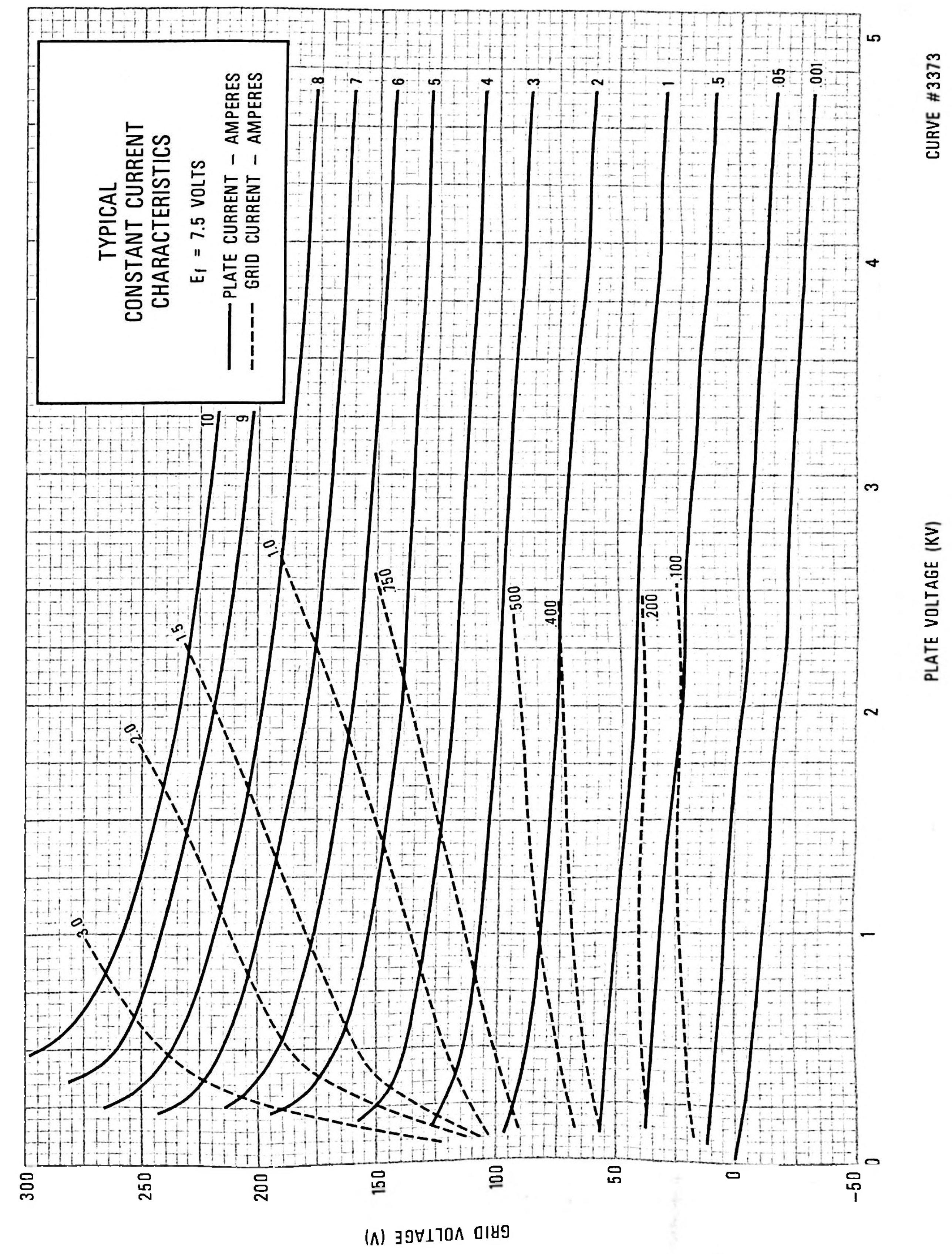
d. *BERYLLIUM OXIDE POISONING* - Dust or fumes from BeO ceramics used as thermal links with some conduction-cooled power tubes are highly toxic and can cause serious injury or death.

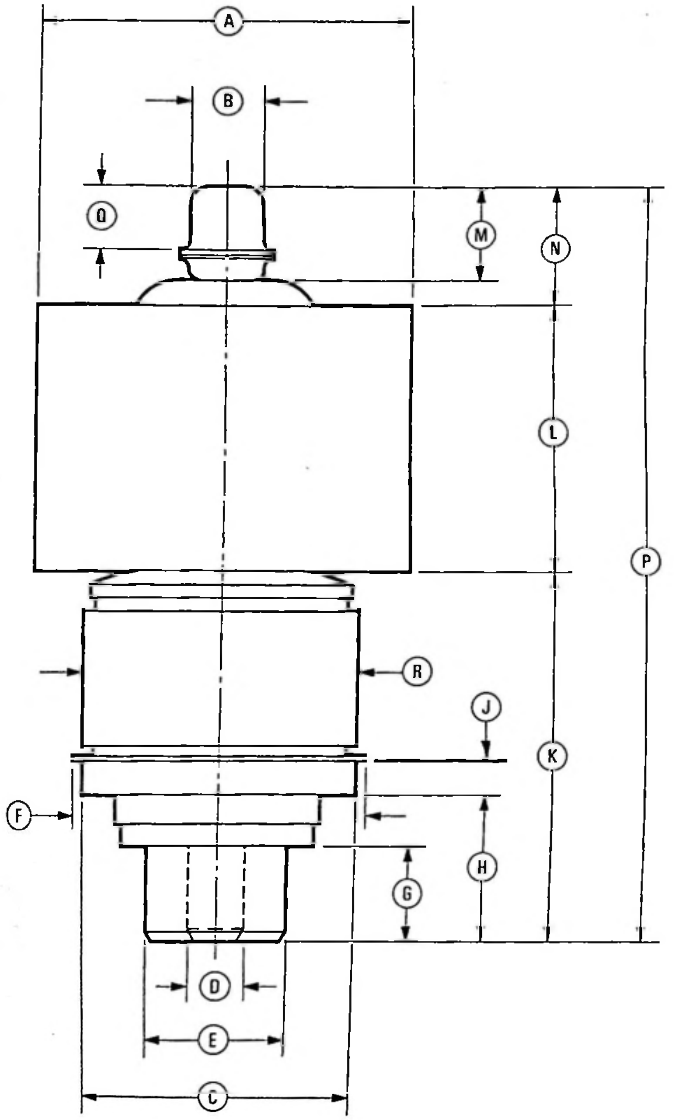
e. *GLASS EXPLOSION* - Many electron tubes have glass envelopes. Breaking the glass can cause an implosion, which will result in an explosive scattering of glass particles. Handle glass tubes carefully.

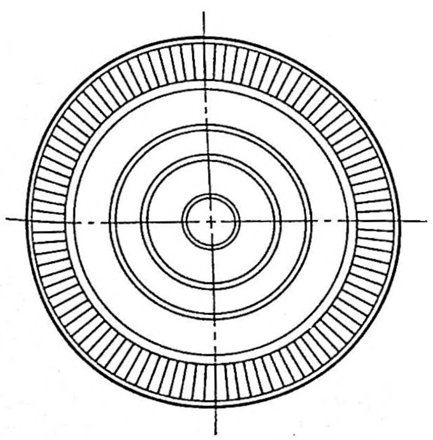
f. *HOT WATER* - Water used to cool tubes may reach scalding temperatures. Touching or rupture of the cooling system can cause serious burns.

g. *HOT SURFACES* - Surfaces of air-cooled radiators and other parts of tubes can reach temperatures of several hundred degrees centigrade and cause serious burns if touched.

Please review the detailed operating hazards sheet enclosed with each tube or request a copy from the address shown below: Power Grid Tube Division, EIMAC Division of Varian, 301 Industrial Way, San Carlos, California 94070.


TYPICAL
CONSTANT CURRENT
CHARACTERISTICS
E_f = 7.5 VOLTS
PLATE CURRENT – AMPERES
GRID CURRENT – AMPERES
PLATE VOLTAGE (KV)
GRID VOLTAGE (V)
CURVE #3373





DIMENSIONAL DATA						
DIM.	INCHES			MILLIMETERS		
	MIN.	MAX.	REF.	MIN.	MAX.	REF.
A	4.094	4.156	- -	103.99	105.56	- -
B	0.781	0.844	- -	19.83	21.44	- -
C	2.990	3.010	- -	75.95	76.45	- -
D	0.615	0.635	- -	15.62	16.13	- -
E	1.490	1.510	- -	37.85	38.35	- -
F	- -	3.625	- -	- -	92.08	- -
G	0.813	0.937	- -	20.65	23.80	- -
H	1.375	1.625	- -	34.92	41.28	- -
J	0.391	0.422	- -	9.93	10.72	- -
K	3.875	4.250	- -	98.43	107.95	- -
L	2.937	3.063	- -	74.60	77.80	- -
N	1.187	1.687	- -	30.15	42.85	- -
P	8.000	9.000	- -	203.20	228.60	- -
Q	0.687	0.813	- -	17.45	20.65	- -

NOTES:
1. REF. DIMENSIONS ARE FOR INFO. ONLY & ARE NOT REQUIRED FOR INSPECTION PURPOSES.

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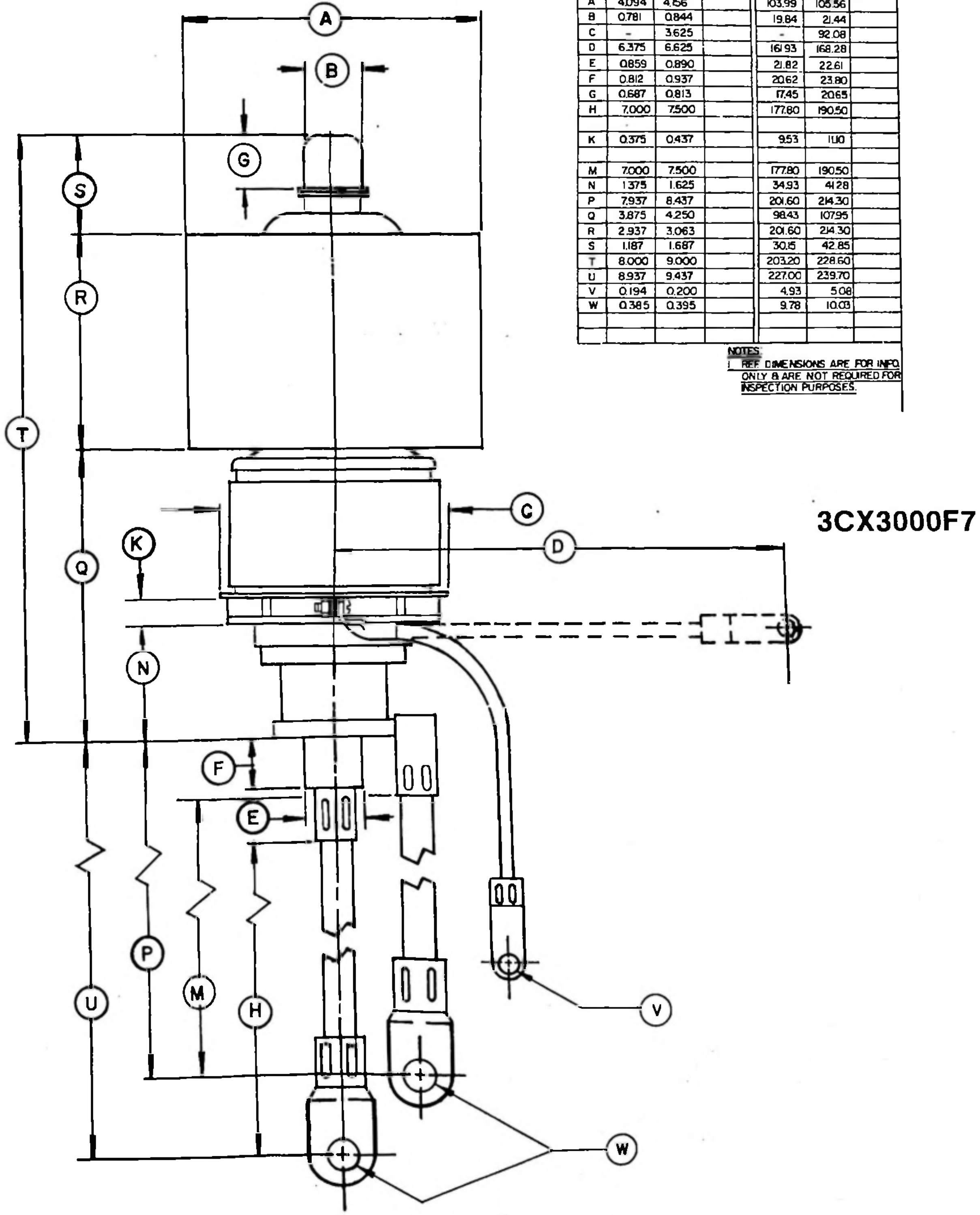

DIMENSIONAL DATA						
DIM.	INCHES			MILLIMETERS		
	MIN.	MAX.	REF.	MIN.	MAX.	REF
A	4.094	4.156		103.99	105.56	
B	0.781	0.844		19.84	21.44	
C	-	3.625		-	92.08	
D	6.375	6.625		161.93	168.28	
E	0.859	0.890		21.82	22.61	
F	0.812	0.937		20.62	23.80	
G	0.687	0.813		17.45	20.65	
H	7.000	7.500		177.80	190.50	
K	0.375	0.437		9.53	11.10	
M	7.000	7.500		177.80	190.50	
N	1.375	1.625		34.93	41.28	
P	7.937	8.437		201.60	214.30	
Q	3.875	4.250		98.43	107.95	
R	2.937	3.063		201.60	214.30	
S	1.187	1.687		30.15	42.85	
T	8.000	9.000		203.20	228.60	
U	8.937	9.437		227.00	239.70	
V	0.194	0.200		4.93	5.08	
W	0.385	0.395		9.78	10.03	

NOTES:
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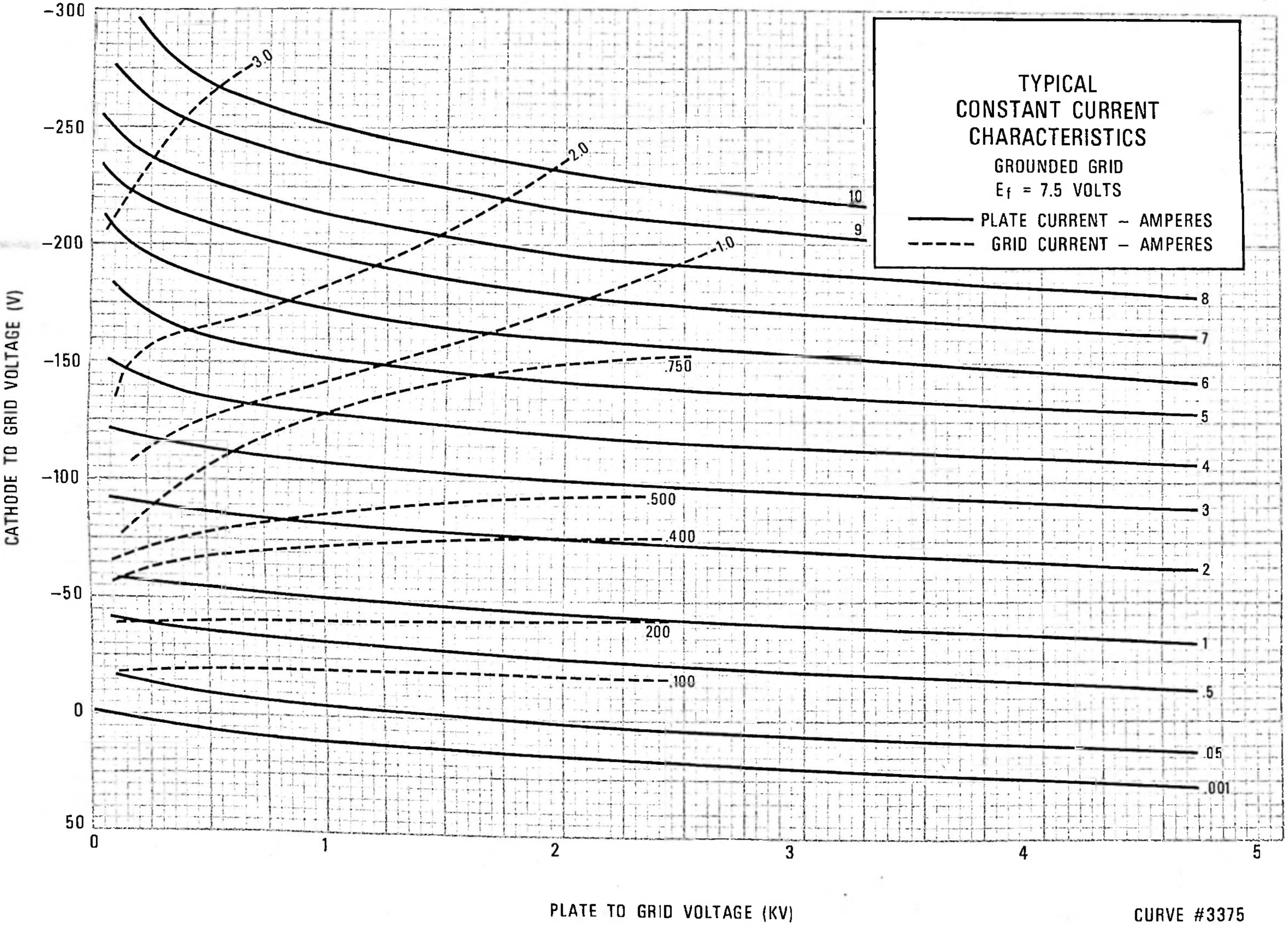
3CX3000A7/F7



CURVE #3375