INSTRUCTION MANUAL

FM-5B
FM-5BS
5 KILOWATT
FM BROADCAST
TRANSMITTERS

JANUARY, 1997 IM NO. 597-0033-004

BROADCAST ELECTRONICS, INC.

IMPORTANT INFORMATION

EQUIPMENT LOST OR DAMAGED IN TRANSIT.

When delivering the equipment to you, the truck driver or carrier's agent will present a receipt for your signature. Do not sign it until you have: 1) inspected the containers for visible signs of damage and 2) counted the containers and compared with the amount shown on the shipping papers. If a shortage or evidence of damage is noted, insist that notation to that effect be made on the shipping papers before you sign them.

Further, after receiving the equipment, unpack it and inspect thoroughly for concealed damage. If concealed damage is discovered, immediately notify the carrier, confirming the notification in writing, and secure an inspection report. This item should be unpacked and inspected for damage WITHIN 15 DAYS after receipt. Claims for loss or damage will not be honored without proper notification of inspection by the carrier.

RF PRODUCT TECHNICAL ASSISTANCE - REPAIR SERVICE - REPLACEMENT PARTS.

Technical assistance is available from Broadcast Electronics by letter, prepaid telephone, fax, or E-mail. Equipment requiring repair or overhaul should be sent by common carrier, prepaid, insured, and well protected. If proper shipping materials are not available, contact the Customer Service Department for a shipping container. Do not the mail equipment. We can assume no liability for inbound damage, and necessary repairs become the obligation of the shipper. Prior arrangement is necessary. Contact the Customer Service Department for a Return Authorization.

Emergency and warranty replacement parts may be ordered from the following address. Be sure to include the equipment model number, serial number, part description, and part number. Non-emergency replacement parts may be ordered directly from the Broadcast Electronics stock room by fax at the number shown below.

FACILITY CONTACTS -

Broadcast Electronics, Inc. - Quincy Facility
4100 N. 24th St. P.O. BOX 3606
Quincy, Illinois 62305
Telephone: (217) 224-9600
Fax: (217) 224-9607
E-Mail: General - bdcast@bdcast.com
Web Site: www.bdcast.com

RF PRODUCT TECHNICAL ASSISTANCE - REPAIR - EMERGENCY/WARRANTY REPLACEMENT PARTS -

Telephone: (217) 224-9617 (8 AM to 5 PM Central Time)
(217) 224-9600 (During Non-Business Hours)
E-Mail: rfservice@bdcast.com
Fax: (217) 224-9607

NON-EMERGENCY REPLACEMENT PARTS -

Fax: (217) 224-9609

RETURN, REPAIR, AND EXCHANGES.

Do not return any merchandise without our written approval and Return Authorization. We will provide special shipping instructions and a code number that will assure proper handling and prompt issuance of credit. Please furnish complete details as to circumstances and reasons when requesting return of merchandise. All returned merchandise must be sent freight prepaid and properly insured by the customer.

WARRANTY ADJUSTMENT.

Broadcast Electronics, Inc. warranty is included in the Terms and Conditions of Sale. In the event of a warranty claim, replacement or repair parts will be supplied F.O.B. factory. At the discretion of Broadcast Electronics, the customer may be required to return the defective part or equipment to Broadcast Electronics, Inc. F.O.B. Quincy, Illinois. Warranty replacements of defective merchandise will be billed to your account. This billing will be cleared by a credit issued upon return of the defective item.

PROPRIETARY NOTICE.

MODIFICATIONS.

Broadcast Electronics, Inc. reserves the right to modify the design and specifications of the equipment in this manual without notice. Any modifications shall not adversely affect performance of the equipment so modified.

FM-5B/FM-5BS
FM-5 KILOWATT
TRANSMITTER
MANUAL

IM NO. 597-0033-004
JANUARY, 1997

WARNING

OPERATING HAZARDS

READ THIS SHEET AND OBSERVE ALL SAFETY PRECAUTIONS

ALL PERSONS WHO WORK WITH OR ARE EXPOSED TO POWER TUBES, POWER TRANSISTORS, OR EQUIPMENT WHICH UTILIZES SUCH DEVICES MUST TAKE PRECAUTIONS TO PROTECT THEMSELVES AGAINST POSSIBLE SERIOUS BODILY INJURY. EXERCISE EXTREME CARE AROUND SUCH PRODUCTS. UNINFORMED OR CARELESS OPERATION OF THESE DEVICES CAN RESULT IN POOR PERFORMANCE, DAMAGE TO THE DEVICE OR PROPERTY, SERIOUS BODILY INJURY, AND POSSIBLY DEATH.

DANGEROUS HAZARDS EXIST IN THE OPERATION OF POWER TUBES AND POWER TRANSISTORS

The operation of power tubes and power transistors 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. Additional information follows.

B. RF RADIATION - Exposure to RF radiation may cause serious bodily injury possibly resulting in blindness or death. Cardiac pacemakers may be affected. Additional information follows.

C. BERYLLIUM-OXIDE POISONING - Dust or fumes from BeO ceramics used as thermal links with conduction cooled power tubes and power transistors are highly toxic and can cause serious injury or death. Additional information follows.

D. 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. Additional information follows.

HIGH VOLTAGE

Many power tubes operate at voltages high enough to kill through electrocution. Personnel should always break the primary circuits of the power supply and discharge high voltage capacitors when direct access to the tube is required.

RADIO FREQUENCY RADIATION

Exposure of personnel to RF radiation should be minimized, personnel should not be permitted in the vicinity of open energized RF generating circuits, or RF transmission systems (waveguides, cables, connectors, etc.), or energized antennas. It is generally accepted that exposure to "high levels" of radiation can result in severe bodily injury including blindness. Cardiac pacemakers may be affected.

The effect of prolonged exposure to "low level" RF radiation continues to be a subject of investigation and controversy. It is generally agreed that prolonged exposure of personnel to RF radiation should be limited to an absolute minimum. It is also generally agreed that exposure should be reduced in working areas where personnel heat load is above normal. A 10 mW/cm^2 per one tenth hour average level has been adopted by several U.S. Government agencies including the Occupational Safety and Health Administration (OSHA) as the standard protection guide for employee work environments. An even stricter standard is recommended by the American National Standards Institute which recommends a 1.0 mW/cm^2 per one tenth hour average level exposure between 30 Hz and 300 mHz as the standard employee protection guide (ANSI C95.1-1982).

RF energy must be contained properly by shielding and transmission lines. All input and output RF connections, such as cables, flanges and gaskets must be RF leakproof. Never operate a power tube without a properly matched RF energy absorbing load attached. Never look into or expose any part of the body to an antenna or open RF generating tube or circuit or RF transmission system while energized. Monitor the tube and RF system for RF radiation leakage at regular intervals and after servicing.

DANGER--BERYLLIUM OXIDE CERAMICS (BeO) - AVOID BREATHING DUST OR FUMES

BeO ceramic material is used as a thermal link to carry heat from a tube or transistor to the heat sink. Do not perform any operation on any BeO ceramic which might produce dust or fumes, such as grinding, grit blasting, or acid cleaning. Beryllium oxide dust or fumes are highly toxic and breathing them can result in serious personal injury or death. BeO ceramics must be disposed of only in a manner prescribed by the device manufacturer.

HOT SURFACES

The anode portion of power tubes is often air-cooled or conduction-cooled. The air-cooled external surface normally operates at a high temperature (up to 200° to 300°C). Other portions of the tube may also reach high temperatures, especially the cathode insulator and the cathode/heater surfaces. All hot surfaces may remain hot for an extended time after the tube is shut off. To prevent serious burns, take care to prevent and avoid any bodily contact with these surfaces both during and for a reasonable cool-down period after tube operation.

PUBLICATION ADDENDUM
SPECIAL ASSEMBLY REQUIREMENTS
FM–5B/FM–5BS TRANSMITTERS

1–1. INTRODUCTION.

1–2. Due to special shipping requirements, selected components of the Broadcast Electronics FM–5B/FM–5BS transmitters have been disassembled to prevent damage during shipment. This publication addendum provides information required for the re–assembly of the transmitter IN ADDITION TO the information provided in SECTION II, INSTALLATION of FM–5B/FM–5BS instruction manual 597–0033–004. Perform the following assembly instructions prior to executing the procedures described in the instruction manual.

1–3. SPECIAL ASSEMBLY.

1–4. GENERAL.

1–5. Components removed from the transmitter contain identification tags to facilitate re–installation. Items such as interconnecting wires, cables, and miscellaneous small parts are taped or tied for shipment. Remove all tape, string, and packing material used for shipping purposes as each item is installed.

1–6. Terminal blocks and wires contain identification tags with information regarding reconnection. Mounting hardware will be placed in small bags attached to each removed component or inserted in the component mounting holes.

WARNING *ENSURE NO PRIMARY POWER IS CONNECTED TO THE TRANSMITTER BEFORE PROCEEDING.*

WARNING

1–7. INSTALLATION.

1–8. **TRANSMITTER BASE PLATE.** Install components removed from the transmitter base plate by performing the following procedures. Ensure no primary power is applied to the transmitter before any component installation.

1–9. **Plate Transformer Installation.** Refer to Figure 1 and install the plate transformer as follows:

A. Using a small fork–lift, place the plate transformer on the transmitter base plate as indicated.

B. Secure the plate transformer to the transmitter base plate with four 3/8 inch bolts, flat washers, and lock washers.

WARNING ***ENSURE THE GROUND WIRE ON THE PLATE TRANSFORMER BASE IS PROPERLY CONNECTED TO THE CABINET GROUND STRAP.***

WARNING

C. Connect wire 352 from the cabinet ground strap to the plate transformer base as indicated.

D. Connect the appropriate wires to the plate transformer terminals as indicated.

1–10. **Plate Choke Installation.** Refer to Figure 1 and install the plate choke as follows:

A. Place the plate choke on the transmitter base plate as indicated.

B. Secure the plate choke to the transmitter base plate with four 3/8 inch bolts, flat washers, and lock washers.

WARNING ***ENSURE THE GROUND WIRE ON THE PLATE CHOKE BASE IS PROPERLY CONNECTED TO THE CABINET GROUND STRAP.***

WARNING

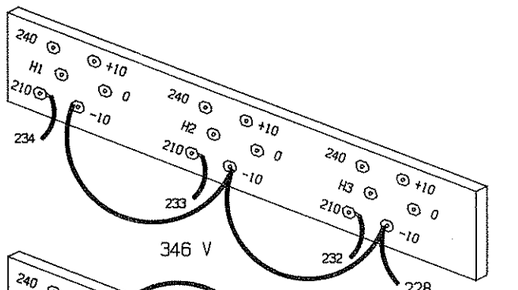
C. Connect wire 353 from the cabinet ground strap to the plate choke base as indicated.

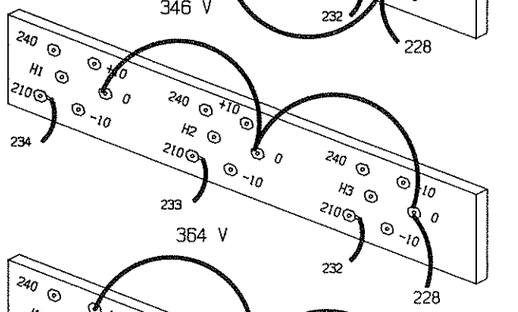
D. Connect the appropriate wires to the plate choke terminals as indicated.

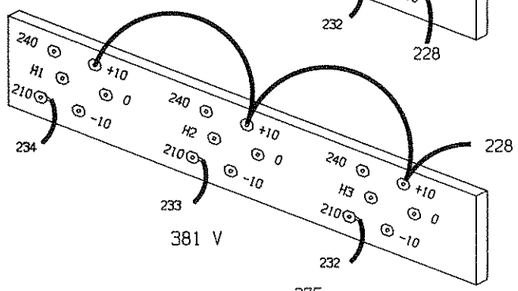
WARNING ***ENSURE NO PRIMARY POWER IS CONNECTED TO THE TRANSMITTER BEFORE PROCEEDING.***

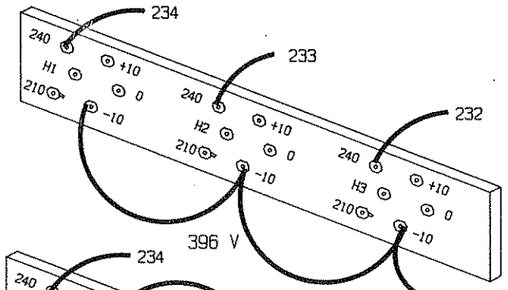
WARNING

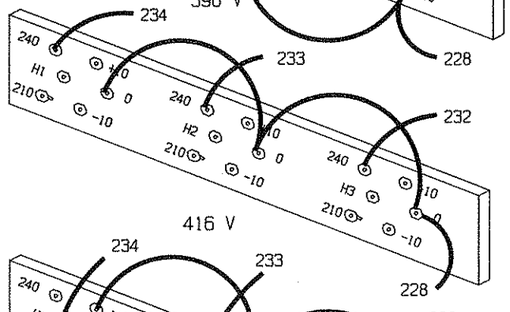
1–11. **MODULAR COMPONENT INSTALLATION.** Refer to Figure 2 and install the exciter, stereo generator, and the IPA unit in the transmitter cabinet as shown. Ensure no primary power is applied before any component installation. The exciter and IPA components are installed by lifting each unit onto the slide–rails. The stereo generator is installed using four No. 12 rack–mount screws. Connect the appropriate wires and cables to the units as indicated.

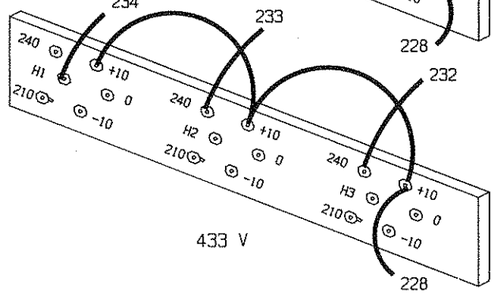












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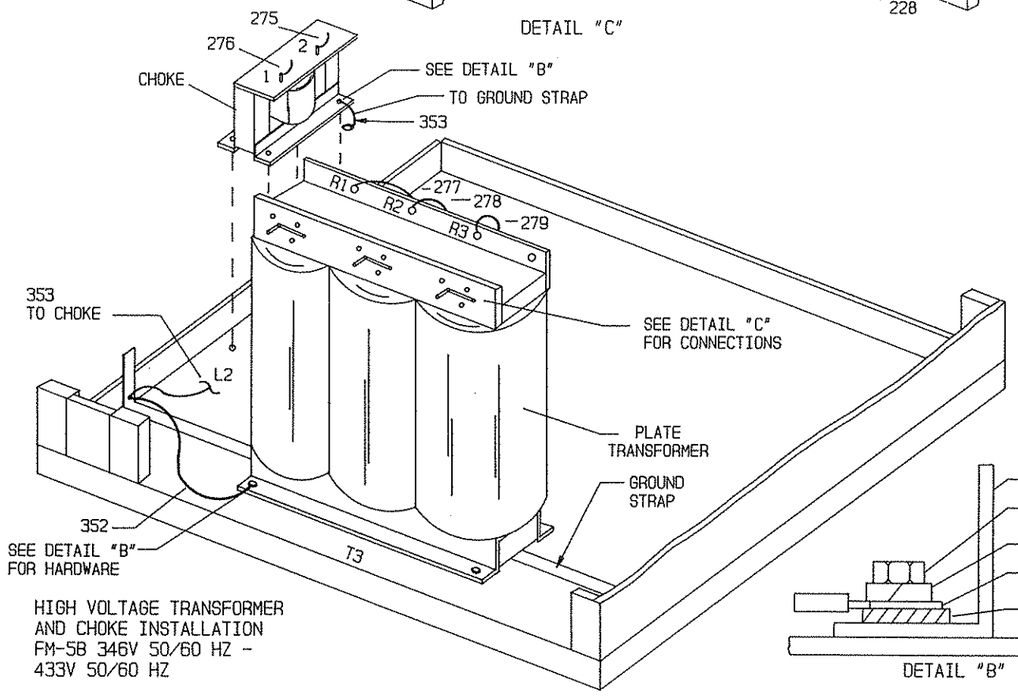
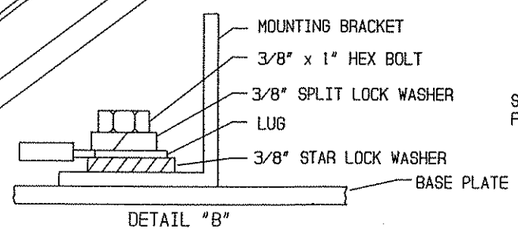


HIGH VOLTAGE TRANSFORMER
AND CHOKE INSTALLATION
FM-5B 346V 50/60 HZ -
433V 50/60 HZ



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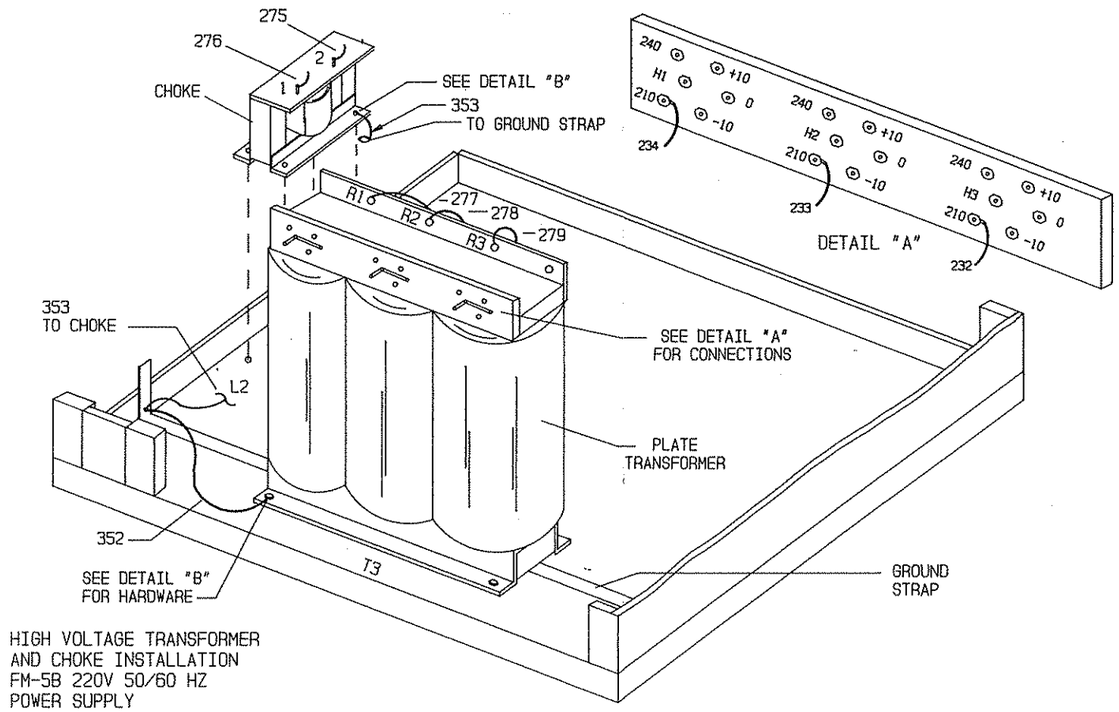
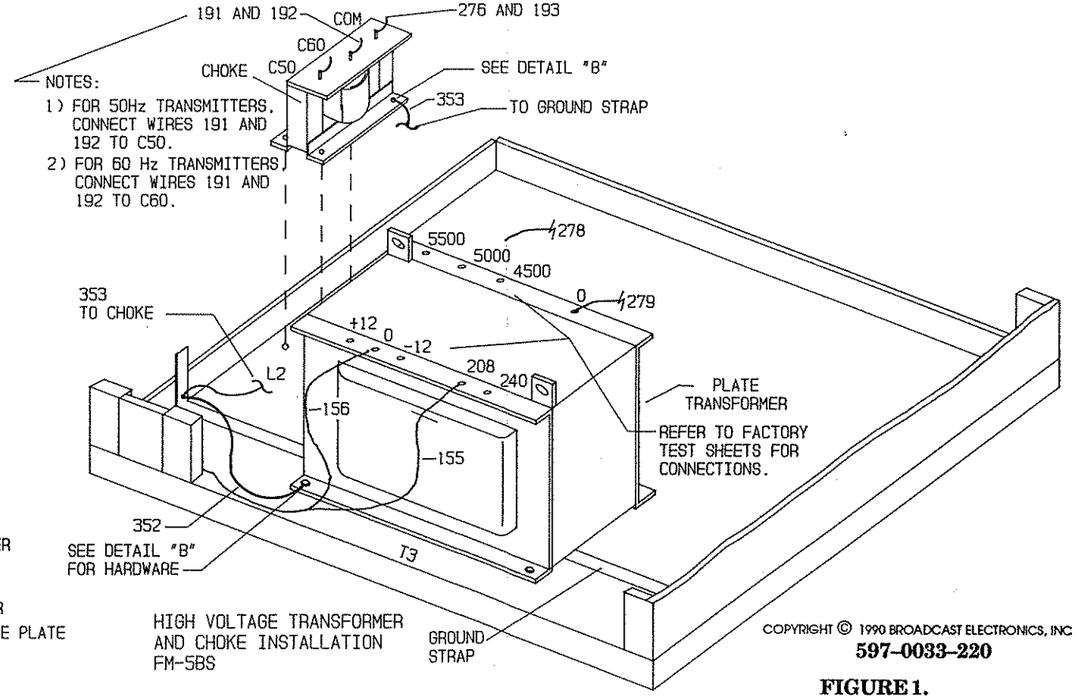


HIGH VOLTAGE TRANSFORMER
AND CHOKE INSTALLATION
FM-5B 220V 50/60 HZ
POWER SUPPLY



HIGH VOLTAGE TRANSFORMER
AND CHOKE INSTALLATION
FM-5BS

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FIGURE 1.
HIGH VOLTAGE TRANSFORMER AND CHOKE INSTALLATION

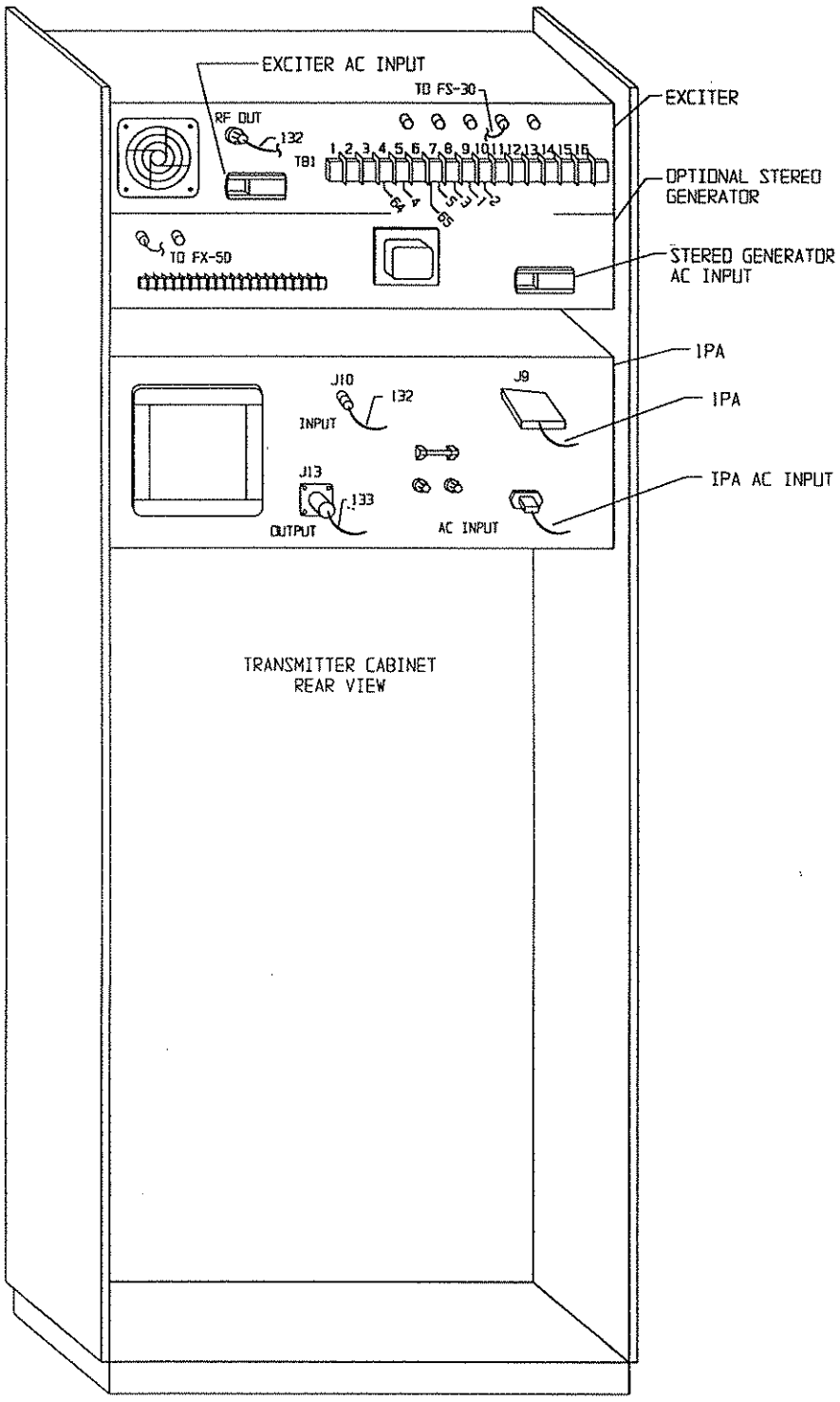

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FIGURE 2. TRANSMITTER CABINET MODULAR COMPONENT INSTALLATION

SCOPE OF MANUAL

This manual consists of two sections providing the following information for the Broadcast Electronics FM–5B/FM–5BS, 5 kW FM Broadcast Transmitter.

A. PART I – Contains information relative to installation, operation, and maintenance applicable to the overall transmitter.

B. PART II – Contains detailed information for the following transmitter modular units.
   1. IPA
   2. AUTOMATIC POWER CONTROL
   3. TRANSMITTER CONTROLLER

PART I – TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

PART II – TABLE OF CONTENTS

SECTION I
GENERAL INFORMATION

1–1. INTRODUCTION.

1–2. Information presented by this section provides a general description of the FM–5B/FM–5BS FM transmitters and lists equipment specifications.

1–3. RELATED PUBLICATIONS.

1–4. The following list of publications provides data for equipment associated with the FM–5B/FM–5BS transmitters.

PUBLICATION NUMBER	EQUIPMENT
597–1050	FX–50 FM Exciter
597–0008–004	FC–30 SCA Generator
597–0009–004	FS–30 Stereophonic Generator
597–0114	MVDS, RC–1, MT–3 FM Transmitter Diagnostic and Remote Control Options
597–1116	VMC–16 Voice Remote Control Unit

1–5. EQUIPMENT DESCRIPTION.

1–6. The Broadcast Electronics FM–5B/FM–5BS are 5 kW FM Transmitters designed for continuous operation in the 87.5 MHz to 108 MHz FM broadcast band. The RF power amplifier, IPA, FM exciter, and the control circuitry are housed in a single cabinet (see Figure 1–1). Each transmitter incorporates a folded half wave cavity PA stage, a solid–state control system, a solid–state IPA, and an exciter with a digital frequency synthesizer. The following text presents ordering information for the transmitter, optional equipment, and recommended spare parts kits.

1–7. TRANSMITTER CONFIGURATIONS.

1–8. The FM–5B/FM–5BS transmitters may be ordered in the following configurations.

MODEL NO.	PART NUMBER	DESCRIPTION
FM–5B	909–5000–204	FM–5B 5 kW FM transmitter complete with FX–50 exciter, three phase 208/240V ac 60 Hz operation.
FM–5B	909–5000–214	Same as 909–5000–204 less the exciter.
FM–5B	909–5000–304	FM–5B 5 kW FM transmitter complete with FX–50 exciter, three phase 208/240V ac 50 Hz operation.
FM–5B	909–5000–314	Same as 909–5000–304 less the exciter.
FM–5B	909–5000–384	FM–5B 5 kW FM transmitter complete with FX–50 exciter, three phase 380V ac 50 Hz operation.
FM–5B	909–5000–334	Same as 909–5000–384 less the exciter.
FM–5BS	909–5000–254	FM–5B 5 kW FM transmitter complete with FX–50 exciter, single phase 208/240V ac 60 Hz operation.

FM-5BS	909-5000-264	Same as 909-5000-254 less the exciter.
FM-5BS	909-5000-354	FM-5B 5 kW FM transmitter complete with FX-50 exciter, single phase 208/240V ac 50 Hz operation.
FM-5BS	909-5000-364	Same as 909-5000-354 less the exciter.

1-9. OPTIONAL EQUIPMENT AND SPARE PARTS KITS.

1-10. The following optional equipment and spare parts kits are available for use in the FM-5B/FM-5BS transmitters:

PART NUMBER	DESCRIPTION
909-0091-034	Microprocessor video diagnostic system, factory installation.
909-0122-034	Microprocessor video diagnostic system remote control, factory installation.
979-0128-034	Microprocessor video diagnostic system remote control, FM-5B, field installation.
979-0128-094	Microprocessor video diagnostic system remote control, FM-5BS, field installation.
909-0127-004	MVDS remote control multiple transmitter interface.
909-0050-204	FS-30 FM stereo generator.
909-0051-204	FC-30 FM SCA generator.
907-0016-034	VMC-16 Voice Remote Control Unit, FM-5B
907-0016-094	VMC-16 Voice Remote Control Unit, FM-5BS
979-0035-004	Recommended spare parts kit for the FM-5B/FM-5BS and the FX-50 exciter. Includes selected meters, switches, relays, etc. Does not include semiconductors.
979-0036-004	Recommended semiconductor kit for the FM-5B/FM-5BS and FX-50 exciter.
979-0037-014	Recommended semiconductor kit for the FM-5B/FM-5BS transmitter only. Does not include exciter spare semiconductors.
979-0035-014	Recommended spare parts kit for the FM-5B/FM-5BS transmitters only. Includes selected meters, switches, relays, etc. Does not include semiconductors.
979-0034-014	Recommended spare HV rectifier kit for the FM-5B/FM-5BS transmitters.

1-11. EQUIPMENT SPECIFICATIONS.

1-12. Refer to Table 1-1 for electrical specifications or Table 1-2 for physical specifications of the FM-5B/FM-5BS FM Transmitters.

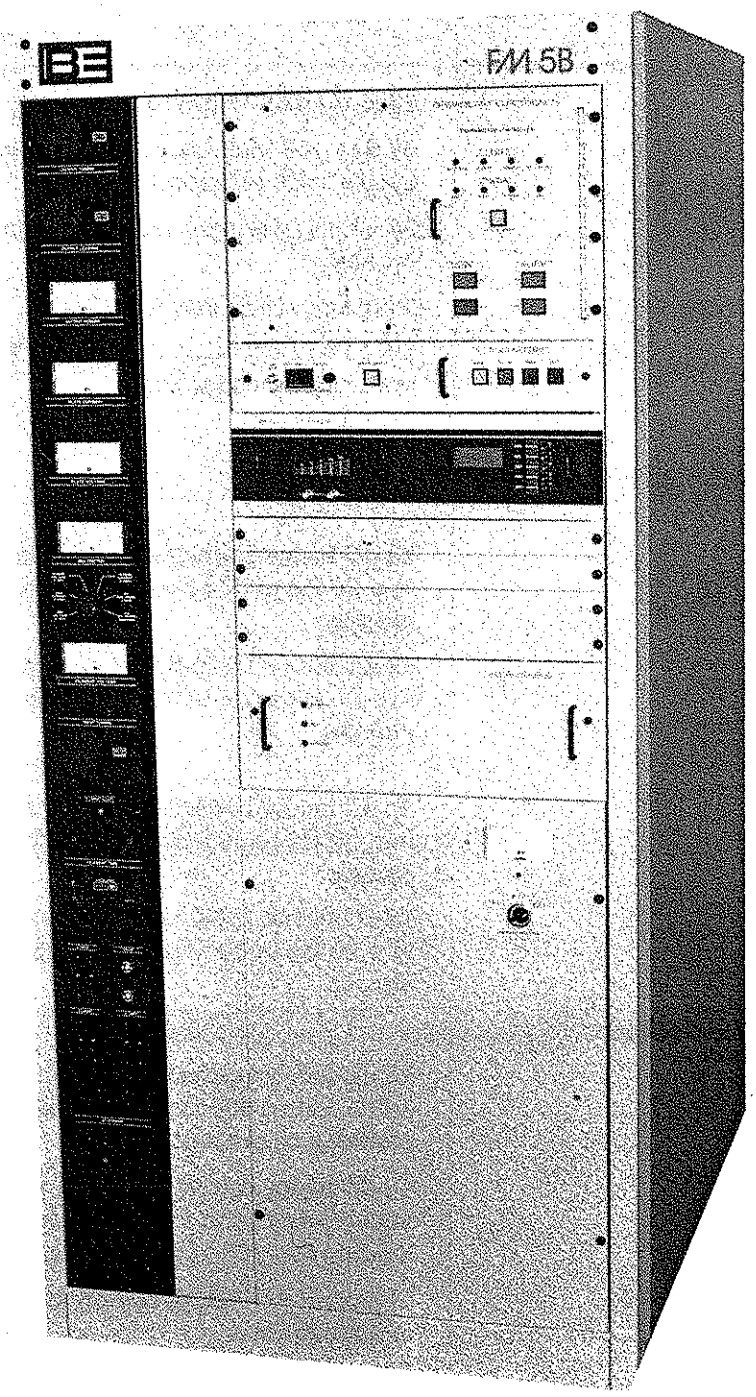

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FIGURE 1–1. FM–5B/FM–5BS TRANSMITTER

TABLE 1–1. ELECTRICAL CHARACTERISTICS
(Sheet 1 of 3)

PARAMETER	SPECIFICATIONS
RF POWER OUTPUT	2500 to 5500 Watts (as ordered).
RF FREQUENCY RANGE	87.5 to 108 MHz (as ordered). Exciter programmable in 10 kHz increments.
RF OUTPUT IMPEDANCE	50 Ohms, Resistive (others available by special request).
RF OUTPUT CONNECTOR	1 5/8 Inch (4.13 cm) EIA flange.
MAXIMUM VSWR	1.8:1 (Will operate into higher VSWR with automatic power reduction).
TUBE COMPLEMENT	4CX3500A (1).
FM SIGNAL–TO–NOISE RATIO:	
FM–5B	
Mono/Composite	85 dB below 100% modulation at 400 Hz measured in a 20 Hz to 30 kHz bandwidth with 75 us deemphasis.
Stereo	82 dB below 100% modulation at 400 Hz measured in a 20 Hz to 30 kHz bandwidth with 75 us deemphasis.
FM–5BS	
Mono/Composite	82 dB below 100% modulation at 400 Hz measured in a 20 Hz to 30 kHz bandwidth with 75 us deemphasis.
Stereo	78 dB below 100% modulation at 400 Hz measured in a 20 Hz to 30 kHz bandwidth with 75 us deemphasis.
AM SIGNAL–TO–NOISE RATIO:	
Asynchronous	55 dB below equivalent reference carrier with 100% AM at 400 Hz, 75 us deemphasis (no FM modulation present).
Synchronous	40 dB below equivalent 5 kW reference carrier with 100% AM at 1 kHz, no deemphasis (FM modulation ±75 kHz at 1 kHz).
RF HARMONIC SUPPRESSION	Meets all FCC/DOC requirements and CCIR recommendations.
POWER SUPPLY RECTIFIERS	Silicon.

TABLE 1–1. ELECTRICAL CHARACTERISTICS
(Sheet 2 of 3)

PARAMETER	SPECIFICATIONS
DISTORTION	
Mono/Composite	
Harmonic	0.02% or less at 400 Hz.
SMPTE Intermodulation Distortion	0.05% or less, 60 Hz/7 kHz, Ratio: 4:1 Monophonic, 1:1 Composite.
CCIF Intermodulation Distortion	0.02% or less, 15 kHz/14 kHz,1:1 Ratio.
Transient Intermodulation Distortion	0.02% or less, Sine Wave/Square Wave.
Stereo	
Harmonic	0.05% or less at 400 Hz.
SMPTE Intermodulation Distortion	0.05% or less, 60 Hz/7 kHz, 4:1 Ratio.
CCIF Intermodulation Distortion	0.05% or less, 15 kHz/14 kHz, 1:1 Ratio.
Transient Intermodulation Distortion	0.05% or less, Sine Wave/Square Wave.
STEREO SEPARATION	50 dB or better, 30 Hz to 15 kHz.
LINEAR CROSSTALK (Main to Sub/Sub to Main Due to Phase Matching)	45 dB minimum below 100% modulation, 30 Hz to 15 kHz.
NON–LINEAR CROSSTALK (Main to Sub/Sub to Main Due to Distortion Products)	70 dB minimum below 100 % modulation.
AC INPUT POWER:	
FM–5B	196 to 252V ac 50/60 Hz or 341V to 435V ac 50 Hz three phase closed–delta or wye (as specified), 28 amperes per phase maximum.
FM–5BS	196 to 252V ac 50/60 Hz single phase (as specified), 55 amperes maximum.
AC POWER CONSUMPTION	
FM–5B	8300 Watts typical at a 5 kW RF power output, 0.92 power factor.
FM–5BS	9600 Watts typical at a 5 kW RF power output, 0.98 power factor.

TABLE 1–1. ELECTRICAL CHARACTERISTICS
(Sheet 3 of 3)

PARAMETER	SPECIFICATIONS
OVERALL EFFICIENCY	
FM–5B	60% Typical (ac line input to RF output).
FM–5BS	52% Typical (ac line input to RF output).

TABLE 1–2. PHYSICAL CHARACTERISTICS

PARAMETER	SPECIFICATIONS
AMBIENT TEMPERATURE RANGE	+14°F to +122°F (–10°C to +50°C).
MAXIMUM ALTITUDE	
60 Hz Models	0 to 10,000 Feet above sea level (0 to 3048 Meters).
50 Hz Models	0 to 7500 Feet above sea level (0 to 2286 Meters).
MAXIMUM HUMIDITY	95%, Non–condensing.
HEAT DISSIPATION	3500 Watts maximum (11,945 BTU/Hr) at 5000 Watts output.
COOLING AIR REQUIREMENT	800 ft^3/min overall (22.6 m^3/min).
SIZE:	
WIDTH	34.5 Inches (87.63 cm).
DEPTH	37.25 Inches (94.61 cm).
HEIGHT	70 Inches (177.8 cm).
WEIGHT:	
UNPACKED	1,000 Pounds (454 kg).
PACKED	1,200 Pounds (544 kg).
CUBAGE	60 Cubic Feet (1.7 m^3).

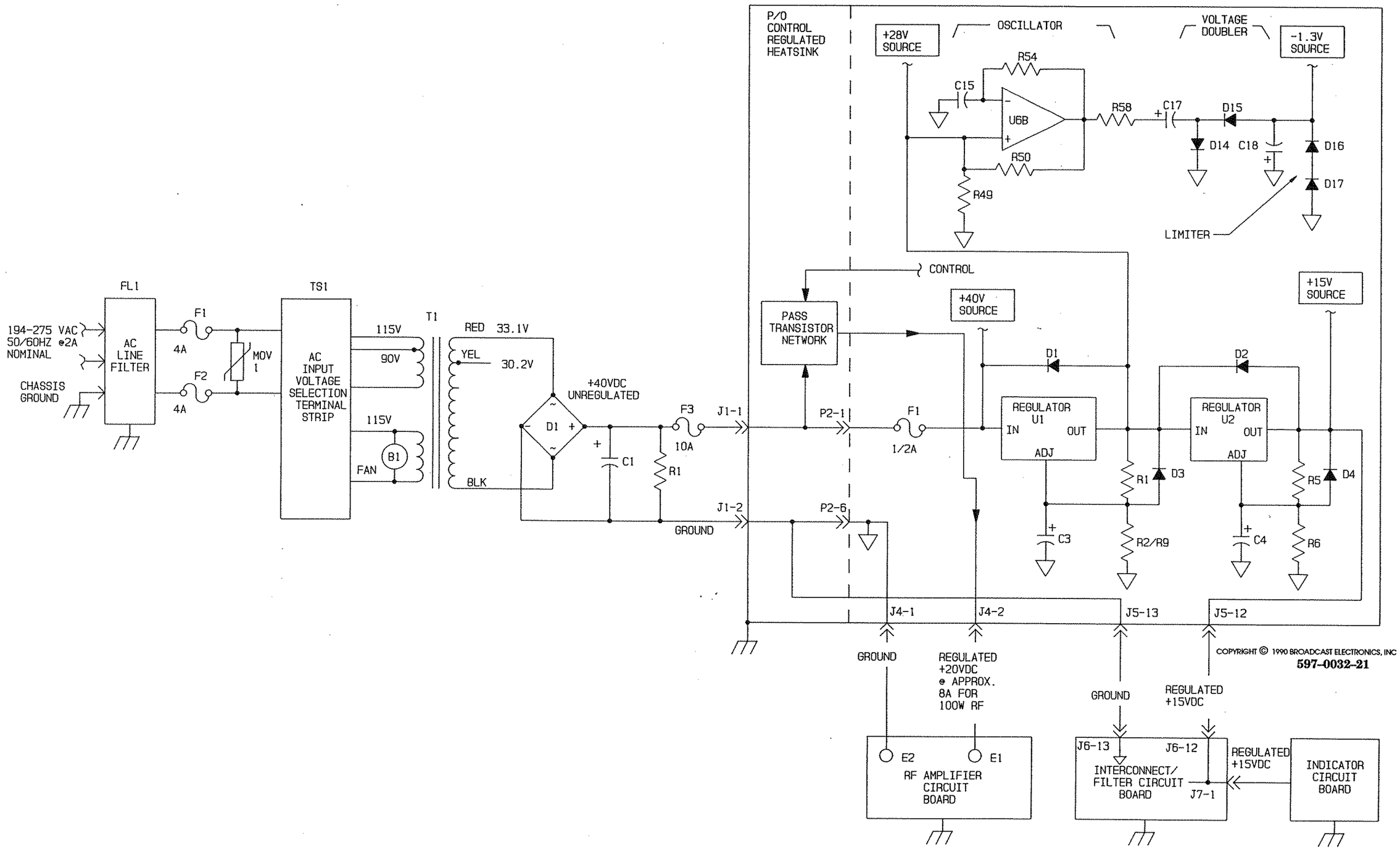

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FIGURE 1–2. PA POWER DISTRIBUTION

SECTION II
INSTALLATION

2–1. INTRODUCTION.

2–2. This section contains information required for installation and preliminary checkout of the Broadcast Electronics FM–5B/FM–5BS FM Transmitters.

2–3. UNPACKING.

2–4. The equipment becomes the property of the customer when the equipment is delivered to the carrier. Carefully unpack the transmitter. Perform a visual inspection to determine that no apparent damage has been incurred during shipment. All shipping materials should be retained until it is determined that the unit has not been damaged. Claims for damaged equipment must be promptly filed with the carrier or the carrier may not accept the claim.

2–5. The contents of the shipment should be as indicated on the packing list. If the contents are incomplete, or if the unit is damaged electrically or mechanically, notify both the carrier and Broadcast Electronics, Inc.

2–6. ENVIRONMENTAL REQUIREMENTS.

2–7. Table 1–2 provides environmental conditions which must be considered prior to transmitter installation.

2–8. COOLING AIR REQUIREMENTS.

2–9. If outside air is to be used to cool the transmitter, the air inlet duct must be sized to allow adequate air flow. The air must be dry and well filtered. If intake louvers are used, operation of the louvers must be electrically interlocked with the transmitter operation.

2–10. If the heated transmitter air is to be ducted from the room, the duct system must not introduce any back–pressure on the equipment. Proper allowances for air flow will ensure that only a limited amount of heat is dissipated into the equipment interior. The duct system must allow for a minimum air flow of 800 cubic feet of air per minute (22.6 m^3/min).

2–11. As a minimum requirement, any duct work must have a cross–sectional area equal to the exhaust area of the cabinet (refer to Figure 2–1). Sharp bends in the duct system will introduce back pressure and are not permissible. A radius bend must be used if a right angle turn is required. An exhaust fan may be used to overcome duct losses or overcome wind pressures if the duct is vented to the outside.

2–12. INSTALLATION.

2–13. Each transmitter is wired, operated, tested and inspected at the factory prior to shipment and is ready for installation when received. Prior to installation, this publication should be studied to obtain an understanding of the operation, circuitry nomenclature, and installation requirements. Installation is accomplished as follows: 1) placement, 2) component installation, 3) remote control connections, 4) wiring, and 5) initial checkout.

2–14. PRIMARY AC POWER.

2–15. **FM–5B.** The FM–5B transmitter is designed for operation from a closed–delta or wye connected three–phase source. Operation from an unsatisfactory power source will void the warranty on this transmitter as any resultant damage is beyond the control of the manufacturer. Before attempting installation of the transmitter, assure that the proper power source is installed. Acceptable power input configurations are shown in Figure 2–2.

2–16. An open–delta, V to V, T to T, T to L, or Scott connected power source will provide unsatisfactory transmitter performance as transients and unstable power can damage components of the FM–5B and provide degraded transmitter specifications. Any of these systems will develop a considerable imbalance between phases in voltage, phase angle, or both voltage and phase angle. These problems can result in premature failure of power supply and RF circuit components.

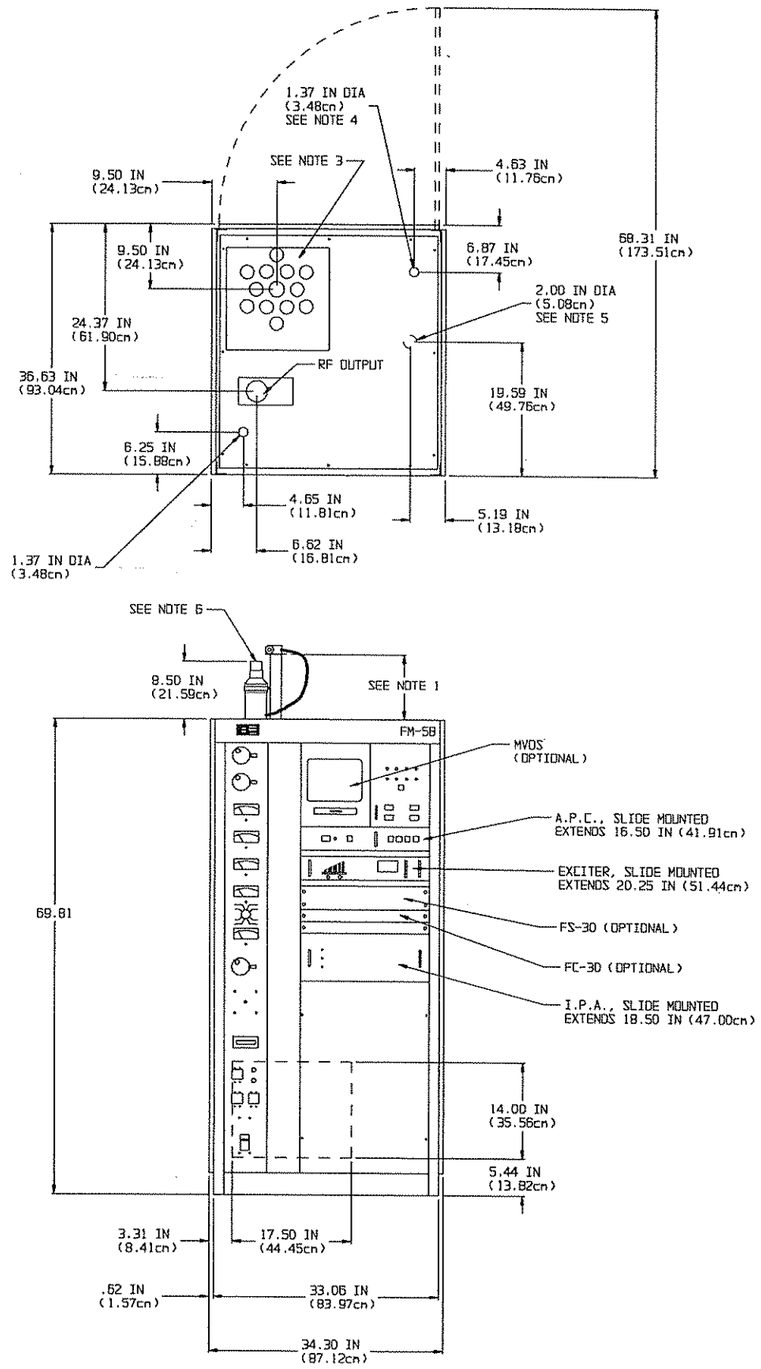
2–17. It is important that the local electric utility be consulted to ensure that the correct service is provided before connection of the FM–5B transmitter to a primary power source. The proper power source can readily be identified by the use of three transformers with one winding each or one transformer with three windings instead of the use of two transformers as required for the unacceptable configurations.

2–18. **FM–5BS.** The FM–5BS transmitter is designed for operation from a 220V ac 50/60 Hz single phase power source. Consult the local electric utility company to ensure that the correct service is provided before connection of the transmitter to the primary power source.

2–19. EQUIPMENT PLACEMENT.

2–20. Access holes in the top and bottom of the cabinet allow either overhead or under–floor ducting of interconnecting wiring (see Figure 2–1). The floor must be capable of supporting the total transmitter weight of approximately 130 pounds per square foot. The floor support should be more than marginal to maintain the proper cabinet alignment and reduce vibration.

2–21. After it has been determined where and how the cabinet will be positioned, set the cabinet in place on a smooth and level location.



NOTES:

1. TUNING LINE HEIGHT (DETERMINED BY TRANSMITTER FREQUENCY:
   MAXIMUM: 11 INCHES (27.94cm), FREQUENCY: 108 MHz.
   MINIMUM: 1 INCH (2.54cm), FREQUENCY: 87.5 MHz.

2. AIR INLET, FILTER REQUIRED (BE P/N 407-0062).
   LOCATION: REAR OF PA/DRIVER CABINET
   DIMENSIONS:
   WIDTH: 17.5 INCHES (44.5cm).
   HEIGHT: 14 INCHES (35.6cm).

3. AIR OUTLET:
   LOCATION: TOP OF PA/DRIVER CABINET
   DESCRIPTION: 15 INCH (38.1cm) SQUARE
   EXHAUST AREA CENTERED AROUND OUTPUT
   TUNING LINE.

4. ACCESS FOR A.C. POWER THROUGH 1 3/8" (3.47cm) DIA. HOLE IN TOP COVER IN REAR. GROUND STRAP ENTRY POINT IN LOWER RIGHT CORNER.

5. ACCESS FOR REMOTE CONTROL AND AUDIO CONNECTIONS THROUGH 2" (5.08cm) DIA. HOLE IN BASEPLATE OR THROUGH EITHER 1 3/8" (3.47cm) DIA. HOLE TOP COVER.

6. RF OUTPUT CONNECTION: 1.625 INCH (4.13cm) EIA 50 OHM COUPLING, 1.625 FEMALE EIA FLANGE, OR 1.625 MALE EIA FLANGE.

7. CUBAGE:
   PA/DRIVER CABINET: 53.0 CUBIC FEET ($1.5m^3$)

8. WEIGHT: 1000 LBS. (455kG).

9. FLOOR: 121 POUNDS PER SQUARE FOOT (MAX.)

10. HEAT DISSIPATION (10 kW OUTPUT): 7 kW (25,000 Btu/H).

11. COOLING AIR REQUIREMENTS: 800 CUBIC FEET PER MINUTE ($22.6m^3$/MIN).

12. AC INPUT:
    THREE PHASE: 196-252 VAC, 3 WIRE, 3 PHASE AT 40 AMPERES PER PHASE MAXIMUM LINE CURRENT, 60 Hz WITH 909-5000-200 (50 Hz WITH 909-5000-300), 909-5000-380 REQUIRES 340-436 PHASE TO PHASE VAC, 50 Hz, 4 WIRE, 3 PHASE AT 40 AMPERES PER PHASE MAXIMUM LINE CURRENT. FUSED DISCONNECT SWITCH RECOMMENDED. FOR PROPER SIZING OF FUSES REFER TO NATIONAL ELECTRICAL CODE OR LOCAL CODES.

    SINGLE PHASE: 196-252 VAC, 60 Hz, SINGLE PHASE AT 55 AMPERES MAXIMUM. FUSED DISCONNECT SWITCH RECOMMENDED. FOR PROPER SIZING OF FUSES REFER TO NATIONAL ELECTRICAL CODE OR LOCAL CODES.

13. POWER CONSUMPTION: 17.2 kW FOR A 10 kW RF POWER OUTPUT, 0.9 POWER FACTOR.

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FIGURE 2-1. FM-5B/FM-5BSTRANSMITTER INSTALLATION
(2-3/2-4)

BROADCAST ELECTRONICS INC

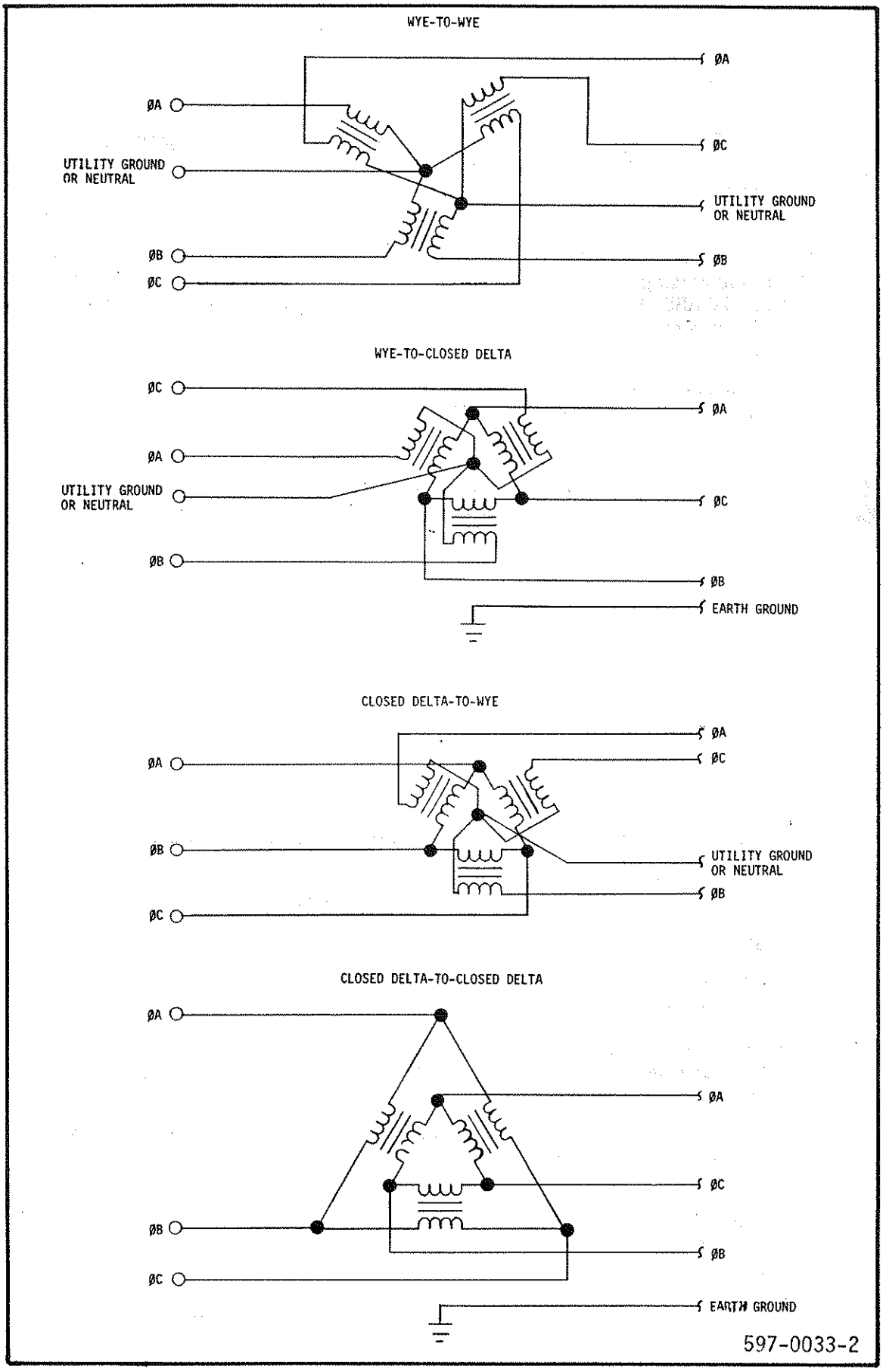


FIGURE 2–2. ACCEPTABLE AC POWER INPUT CONFIGURATIONS

2–22. **COMPONENT INSTALLATION.**

WARNING ***ENSURE PRIMARY POWER IS DISCONNECTED BEFORE PROCEEDING.***

WARNING

2–23. Interconnecting wires and cables are tied in for shipment. Remove all tape, wire ties, string, and packing material used for shipment. Remove the cover from the FAILSAFE SOLENOID ASSEMBLY and cut loose all tie wraps, freeing the plunger. A No. 2 Phillips screwdriver is required. Replace the cover. Also, remove all ties from the shorting stick hanger.

2–24. Cables, connectors, and miscellaneous components to be installed are shipped in separate containers. The following text provides information concerning the installation of these items.

NOTE ***ENSURE ADJUSTMENTS ARE NOT MOVED FROM THEIR FACTORY PRESET POSITIONS DURING INSTALLATION.***

NOTE

2–25. Connect the antenna to the transmitter. A 1 5/8 inch EIA flange is provided with the transmitter to assist installation. The flange can remain off if unflanged connections are desired. A center conductor bullet may be required (BE P/N 427–0009).

2–26. Open the transmitter rear door.

2–27. Remove the lower front access panel. A 5/32 inch hex key is shipped with the transmitter for this purpose.

2–28. Open the cavity access door.

2–29. Disconnect the plate line B+ banana plug along the right side of the plate line.

2–30. Remove all tape and shims from the plate line at the shelf to free the plate line. Raise and rotate the plate line to lock the plate line in the up position.

2–31. Carefully remove all packing material from over the tube socket.

2–32. Carefully install the PA tube with a steady downward pressure. Do not rotate or rock the tube during installation or the tube socket may be damaged.

2–33. After the PA tube is fully seated, rotate and lower the fixed portion of plate line over the PA tube. Slowly lower the fixed portion of plate line down with both hands until the plate line stops contact with the cavity shelf.

2–34. Reconnect the plate RF choke banana plug into the plate line and verify that the choke is straight and perpendicular to the line with all connections secure. The plate line may be rotated as required. The choke turns do not touch when properly aligned.

2–35. Secure the plate line to the tube with the strap clamp provided until the line does not slip from the PA tube when upward pressure is applied. A flat–blade screwdriver with a 1/4 inch tip is required.

2–36. Close and latch the cavity access door.

2–37. On top of the transmitter, loosen the PA tuning line clamp. A flat–blade screwdriver with a 1/4 inch (0.64 cm) tip is required.

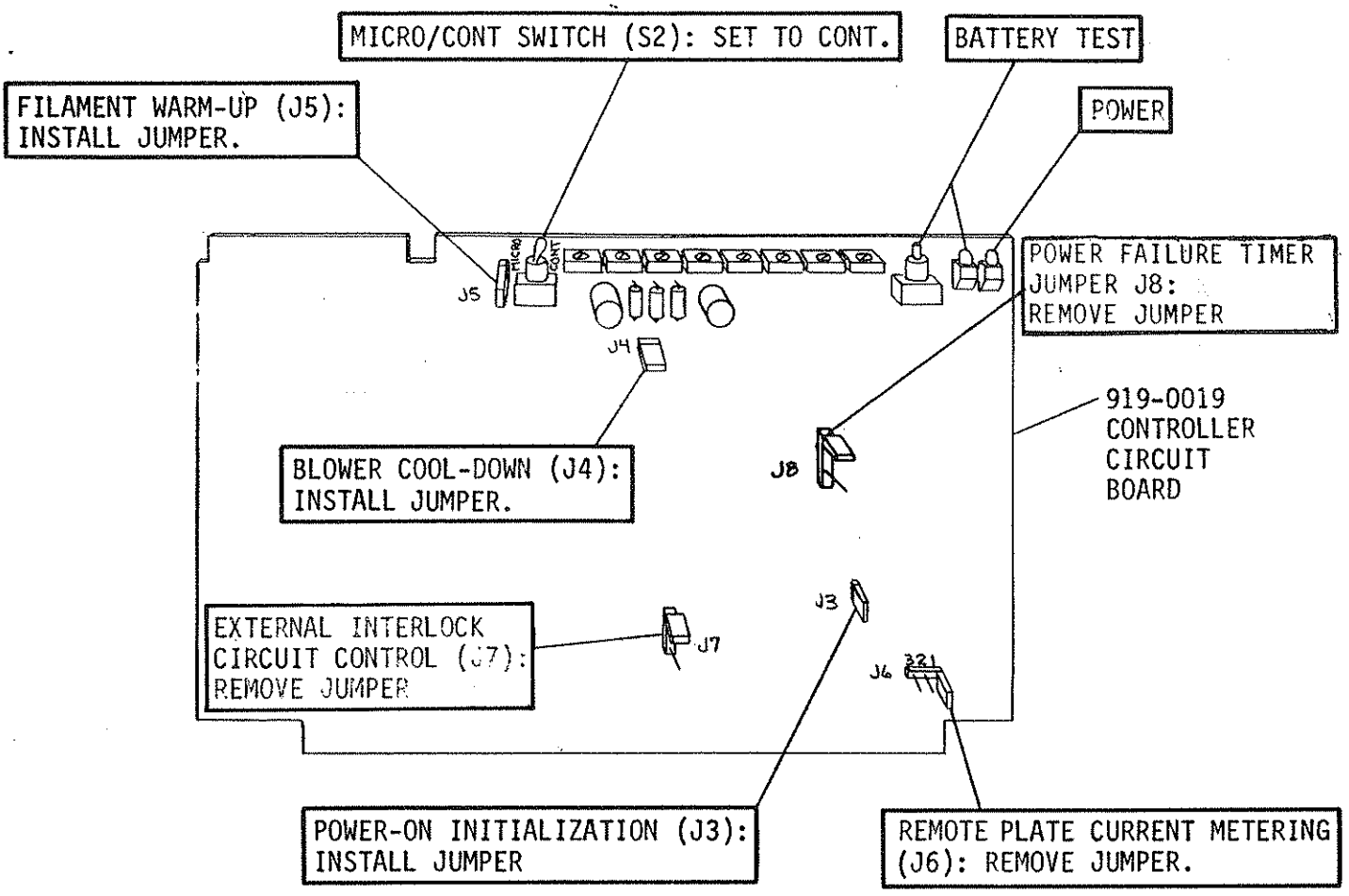
2–38. Raise the PA tuning line until the scribed line is aligned with the top of the cavity clamping flange. Ensure the tuning line is perpendicular to the top of the cabinet and secure the strap clamp.

2–39. Ensure the coarse PA input tuning cyclometer on the rear of the PA input enclosure is set to the value listed on the factory final test data sheets and the control is locked.

2–40. Remove the retainers from each set of slide rails inside the transmitter.

2–41. Due to various shipping methods, the transmitter controller circuit board and the controller extender circuit board may be removed from the controller cabinet. Locate the controller circuit board and install the nine–volt battery (located in the accessory kit) in the transmitter controller battery holder.

2–42. Refer to Figure 2–3 and ensure all controller circuit board jumpers are correctly positioned.



597–0032–39

FIGURE 2–3. CONTROLLER CIRCUIT BOARD JUMPER–PLUG PROGRAMMING

2–43. If the controller circuit board and the extender circuit board are removed for shipment, insert the controller circuit board in the controller cabinet extreme right receptacle with the component side to the left. Insert the extender circuit board in the extreme left receptacle. If the transmitter is equipped with the microprocessor video diagnostic system (MVDS), install the MVDS circuit boards and the video monitor by performing the procedure described in SECTION II, INSTALLATION of manual 597–0114.

2–44. Using a miniature flat–blade screwdriver, mechanically zero all meters.

2–45. EXTENDED LOCAL CONTROL.

2–46. Extended local control of the FM–5B and FM–5BS transmitters is provided up to a maximum of 100 feet (30.48 mm) by the Broadcast Electronics optional master extended local control unit (BE P/N 909–0103). Refer to the extended local control panel instruction manual for installation procedures.

2–47. REMOTE CONTROL.

2–48. The FM–5B/FM–5BS transmitters are designed for complete remote control operation (see Figure 2–4). Transmitter remote control operations may be performed by the Broadcast Electronics MVDS RC–1/MT–3 remote control option or VMC–16 Voice Remote Control Unit. The MVDS RC–1/MT–3 option consists of a software/hardware package which operates in association with a personal computer for control of the transmitter and the associated transmitter facilities. Refer to instruction manual 597–0114 for additional MVDS RC–1/MT–3 information.

2–49. Programmable circuitry on the controller input filter circuit board provides either positive or negative logic remote indications to meet any interfacing requirement. The circuitry is shipped from the factory with negative remote indication logic and +2.5V dc full–scale remote meter indications. If re–programming of the transmitter remote indications is required, proceed as follows:

WARNING ***ENSURE NO PRIMARY POWER IS CONNECTED TO THE TRANSMITTER BEFORE PROCEEDING.***

WARNING

A. Remove the REMOTE INDICATION PROGRAMMING access panel on the controller cabinet rear–panel.

B. Refer to Figure 2–4 and program the input filter circuit board for the desired remote indication logic:

1. Install the inverter integrated circuits in receptacles U1 and U2 for negative remote indication logic.

OR

2. Install two 8–Pin DIP programmable jumpers in receptacle U1 and two jumpers in receptacle U2 for positive remote indication logic.

C. Refer to Figure 2–4 and program the input filter circuit board for the desired meter indications:

1. Install the resistor network in receptacle R35 for +2.5 volt dc remote meter indications.

OR

2. Install one 8–Pin DIP programmable jumper in pins 1–16/2–15/3–14/4–13 of receptacle R35 for +5 volt dc remote meter indications.

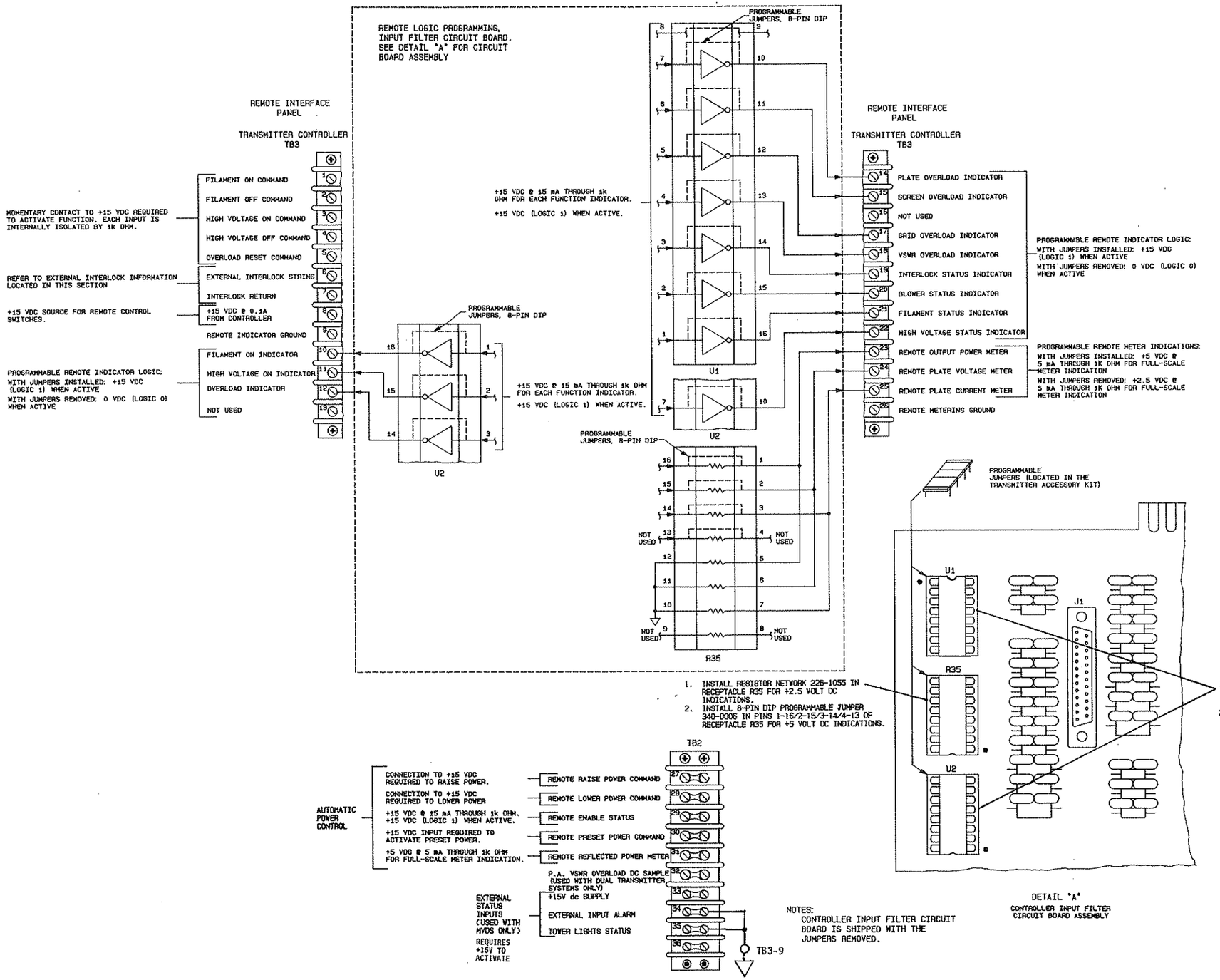


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FIGURE 2–4.
REMOTE LOGIC PROGRAMMING AND WIRING

D. Replace the access panel.

E. Complete the remote control installation by connecting the remote control unit wiring to the transmitter REMOTE INTERFACE PANEL terminal strips (refer to Figure 2–4).

2–50. **WIRING.**

WARNING *ENSURE PRIMARY POWER IS DISCONNECTED BEFORE PROCEEDING.*

WARNING

2–51. **TRANSFORMER TAPS.** Ensure that the transmitter is wired for the input voltage and line frequency to be used. The screen transformer,the plate transformer, the bias transformer, the filament regulator, and the plate supply choke must be checked and changed if required. Refer to Figure 2–5 and the final test data sheets for transformer tap information.

2–52. Check the IPA voltage taps per Figure 2–6 and change the wiring if required. Normally these taps are chosen to limit IPA regulator dissipation over the normal line voltage excursions. The 208–250V selection is typically acceptable.

2–53. The transmitter controller, FM exciter, stereo generator, and SCA generator should be checked as follows:

A. The primary ac line voltage with which the transmitter will be used (220V or 230/240V) must be visible on the ac line voltage selector circuit board located adjacent to the ac input connector on each unit.

B. If an ac line voltage selector must be changed, remove the ac line voltage selector circuit board with a small pair of needle–nose pliers. Reinsert the circuit board so that the correct ac line voltage is visible when the circuit board is reinserted into the receptacle.

2–54. Loosen the exciter front–panel turn–lock fastener and pull the exciter forward, out of the rack until the slide rail stops are encountered.

2–55. Loosen the eight turn–lock fasteners on the top of the exciter and remove the top cover.

2–56. Remove any packing material from the inside of the exciter.

2–57. Ensure the **POS–MUTE–NEG** switch on the power supply/control circuit board is operated to **POS**.

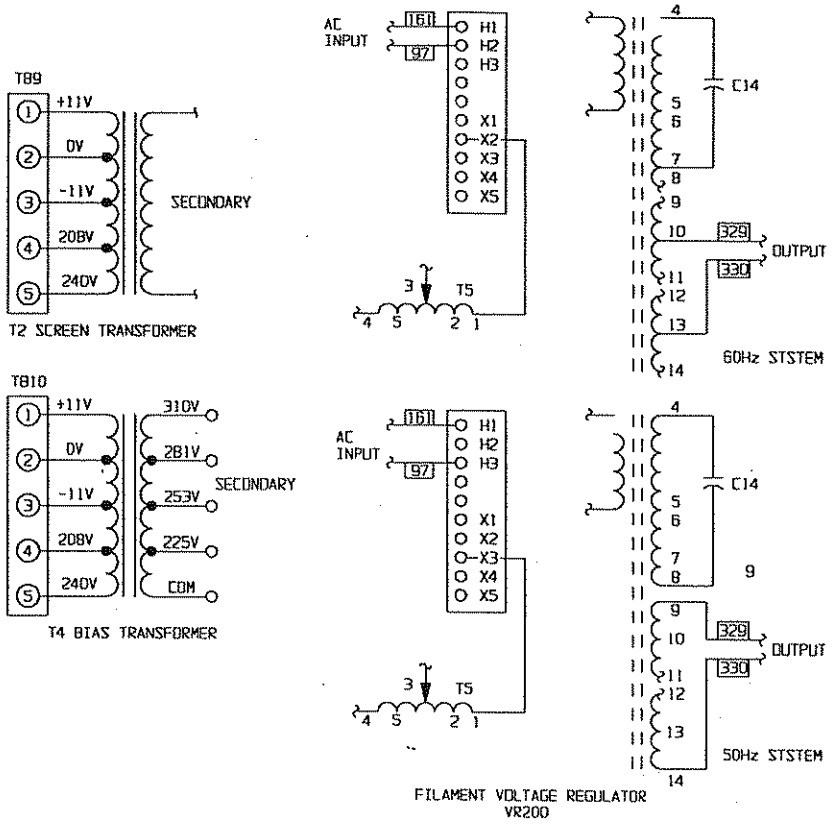
2–58. Ensure the **AUTO–PWR/MAN** switch on the power supply/control assembly is set to **AUTO** and the **NORM–EXT** switch is set to **NORM**.

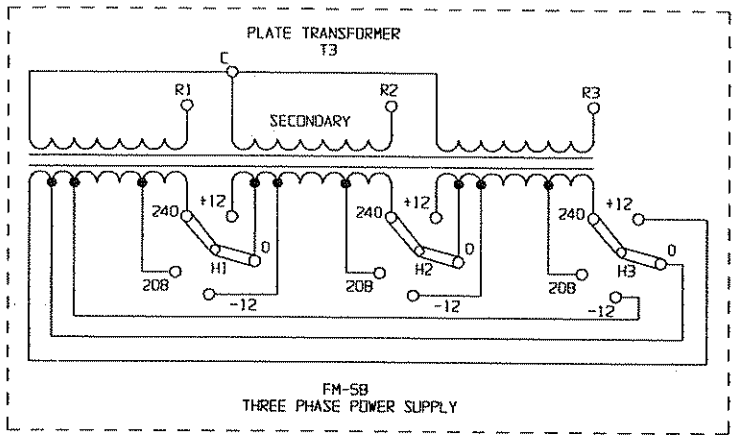
2–59. Refer to the final test data sheets shipped with the exciter and ensure the AFC/PLL assembly **SYNTHESIZER FREQUENCY SELECTION** switches are correctly positioned.

2–60. Remove the two shipping screws securing the modulated oscillator assembly, and allow the unit to float on its mountings.

2–61. Replace the top cover on the exciter and secure the eight turn–lock fasteners on the top of the cover.

2–62. Refer to the stereo generator and SCA generator manuals and complete any applicable checks or programming included in INSTALLATION.





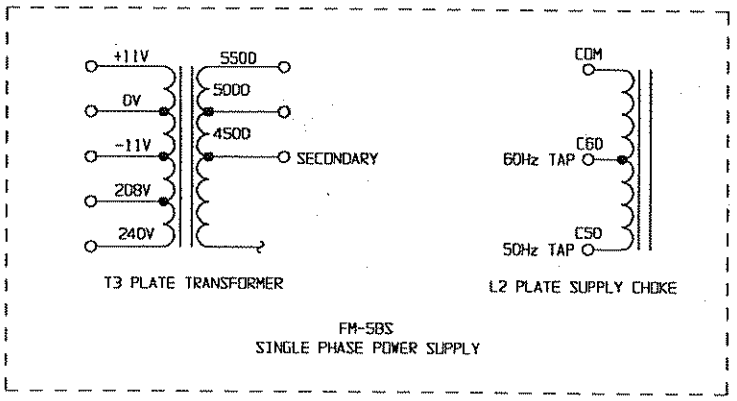


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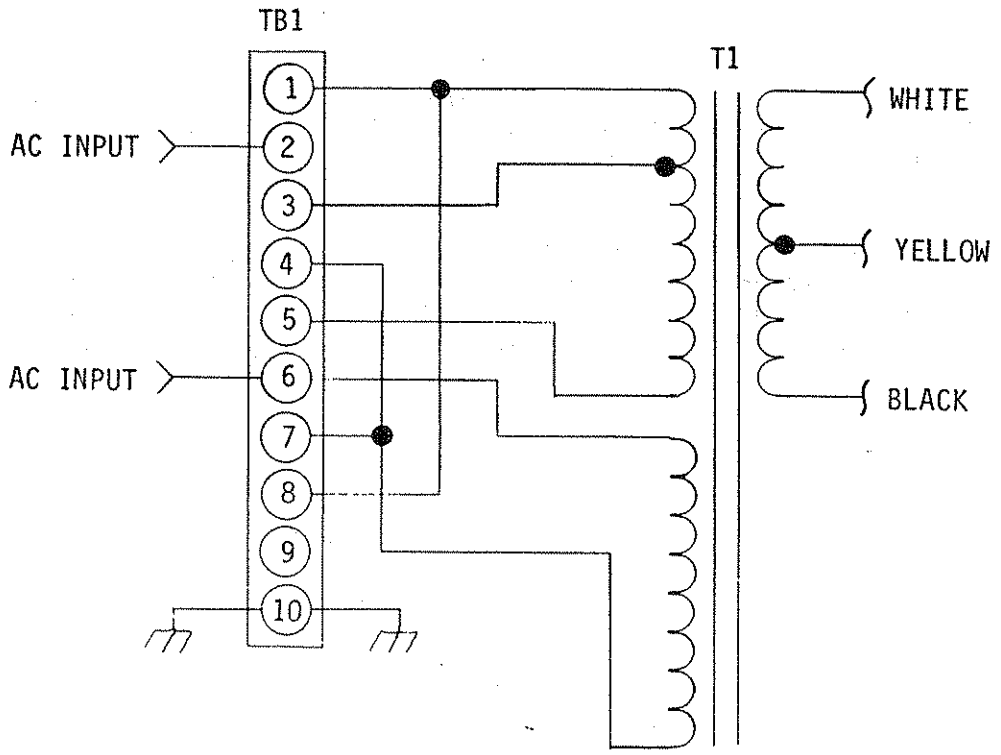
FIGURE 2-5. TRANSFORMER TAPS



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LINE VOLTAGE	JUMPER	SECONDARY WIRING
194-223V	2-3, 4-5, 8-9	BLACK AND WHITE
213-256V	2-3, 4-5, 8-9	BLACK AND YELLOW
208-250V	1-2, 4-5, 8-9	BLACK AND WHITE
229-275V	1-2, 4-5, 8-9	BLACK AND YELLOW

597-0033-10

FIGURE 2–6. IPA VOLTAGE TAPS

WARNING ***ENSURE PRIMARY POWER IS DISCONNECTED BEFORE PROCEEDING.***

WARNING

CAUTION ***THE AC DISTRIBUTION PANEL PROVIDES A 220V AC OPERATING SUPPLY FOR OPTIONAL EQUIPMENT. ENSURE ALL 220V AC AND 110V AC EQUIPMENT IS PROPERLY CONNECTED TO THE PANEL.***

CAUTION

2–63. **OPTIONAL EQUIPMENT WIRING.** An ac distribution panel is provided for the application of ac power to the transmitter modular components. Mount and wire any optional equipment not provided with the transmitter to the distribution panel (refer to Figure 2–7). The ac distribution panel provides a 220V ac operating supply for the optional equipment. Ensure all 220V ac and 110V ac equipment is properly connected to the panel.

2–64. **SIGNAL INPUTS.** Refer to the applicable technical manual for the exciter, stereo generator, and SCA generator and wire the inputs and control connections to each unit. All audio wiring must be routed in the wiring channel away from the power supply components in the base.

2–65. **EXTERNAL INTERLOCKS.** The FM–5B/FM–5BS are equipped with an external interlock circuit such as for a test load or remote control fail–safe connection. The external interlock circuit is independent of the transmitter safety interlock circuit and will disable only the high voltage plate supply when opened. The external interlock circuit however may be programmed to completely deenergize the transmitter. If the external interlock circuit is required to completely deenergize the transmitter, proceed as follows:

A. Remove the **EXTERNAL INTERLOCK PROGRAMMING** access panel on the controller cabinet rear–panel.

B. Refer to input filter circuit board assembly diagram AD919–0056 in PART II, TRANSMITTER CONTROLLER and install jumper J7 in position 2–3.

C. Replace the access panel.

2–66. If an external interlock is desired, refer to Figure 2–8 and remove the jumper between TB3–6 and TB3–7. Install a normally closed interlock switch and interlock indicator as shown. The interlock must be electrically isolated from ground, any ac, or any dc potentials. If unused, ensure the factory installed jumper is connected between the terminals.

WARNING ***ENSURE PRIMARY POWER IS DISCONNECTED BEFORE PROCEEDING.*** *WARNING*

2–67. **AC POWER CONNECTIONS.** The following text presents three phase ac power connections for an FM–5B transmitter and single phase ac power connections for an FM–5BS transmitter. Refer to the following information and connect the FM–5B/FM–5BS transmitters to the appropriate power supply.

WARNING ***ENSURE PRIMARY POWER IS DISCONNECTED BEFORE PROCEEDING.*** *WARNING*

WARNING ***ENSURE AN EARTH GROUND CONDUCTOR IS SECURELY CONNECTED TO THE TRANSMITTER GROUND SYSTEM.*** *WARNING*

2–68. **FM–5B.** A three phase source of 196V to 252V ac 50 Hz or 60 Hz or 341 to 435V ac 50 Hz at 40 Amperes per phase is required for the FM–5B transmitter ac input. Ensure the power source is supplied from an acceptable ac transformer configuration (refer to PRIMARY AC POWER). For operating safety, the power source must be routed to the transmitter through a fused power disconnect (refer to 2–9).

2–69. Refer to Figure 2–9 and connect the 40 Ampere three phase service to TB1 on the transmitter base–plate through a fused service disconnect. Ensure a utility company ground conductor is securely connected to the transmitter ground system. For a three phase 380V WYE service, ensure the neutral wire is connected to ac input terminal TB1–4.

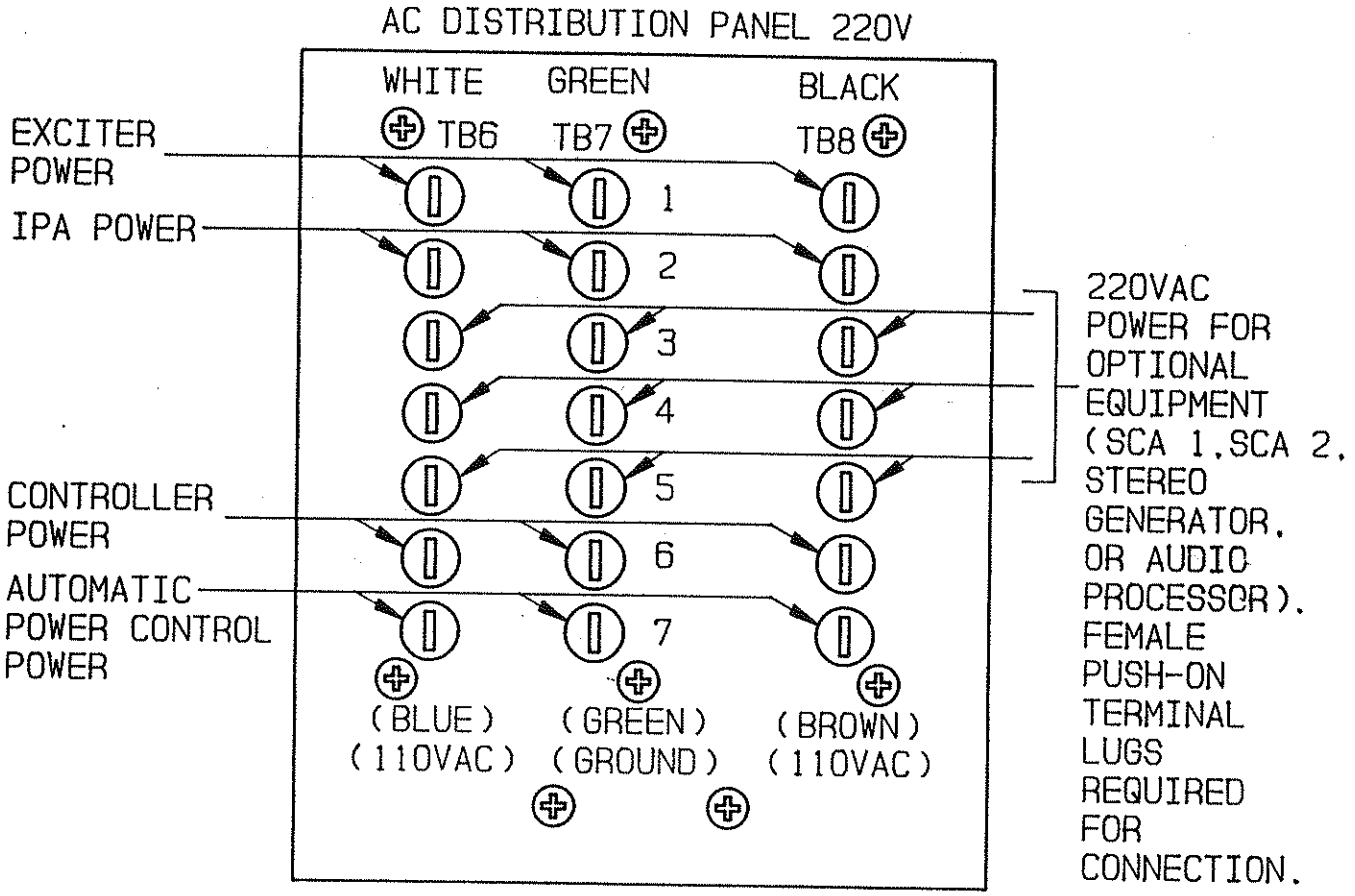

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FIGURE 2-7. OPTIONAL EQUIPMENT WIRING

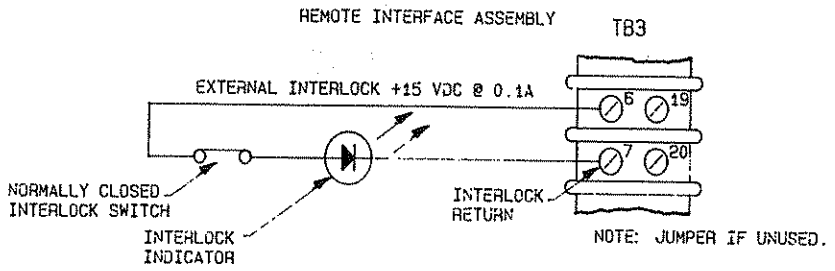

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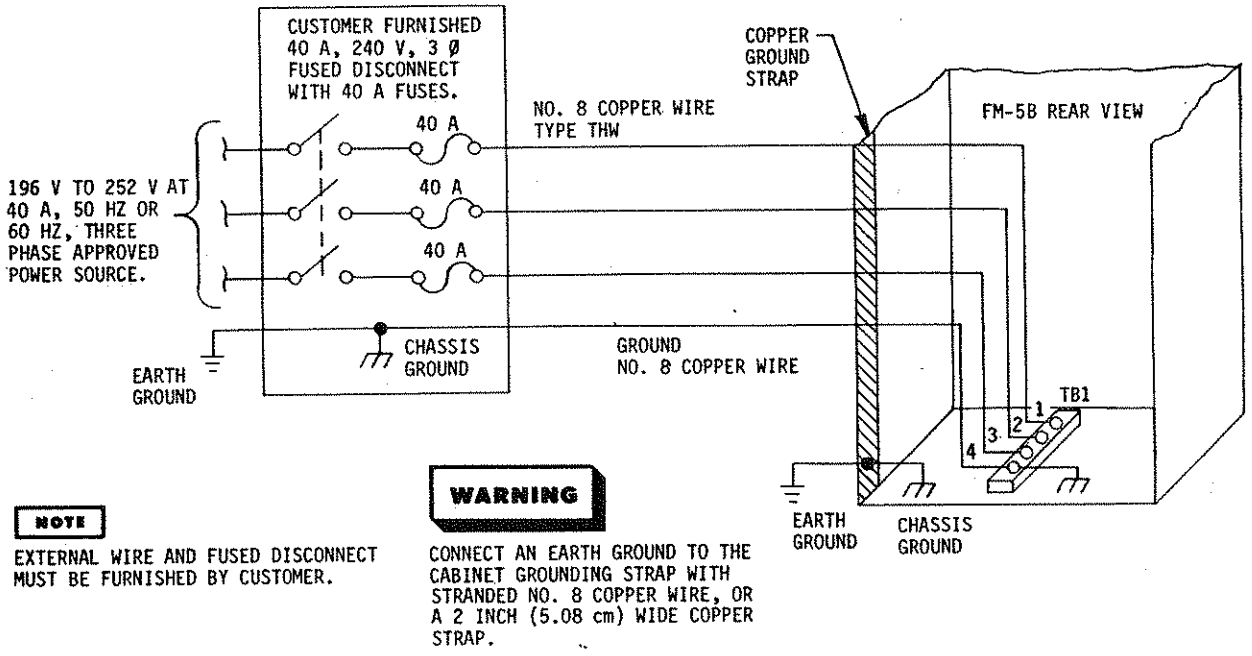
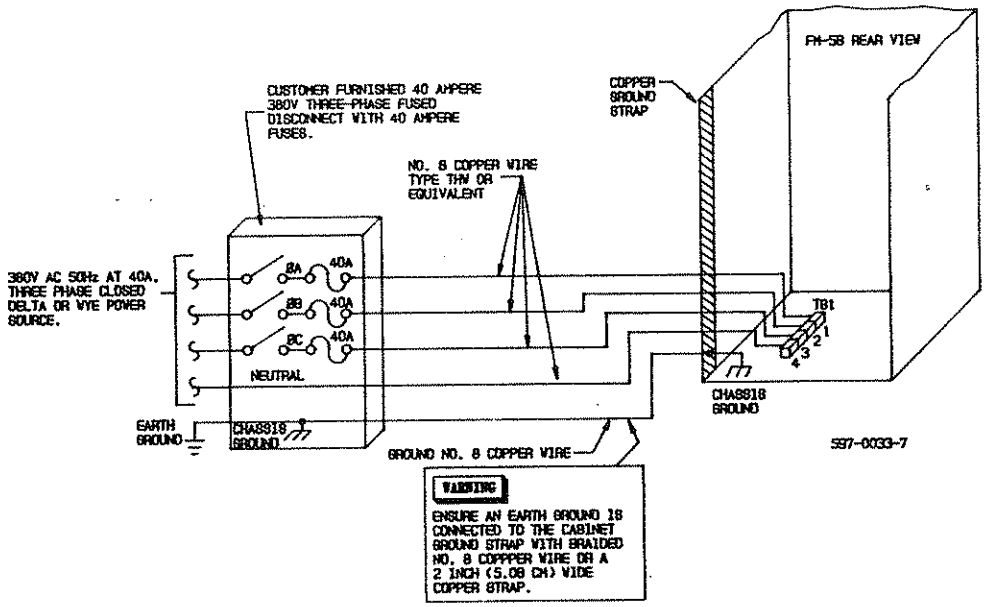
FIGURE 2-8. EXTERNAL INTERLOCK CIRCUIT



FM-5B 208/240V AC INSTALLATION



FM-5B 380V AC INSTALLATION

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FIGURE 2–9. FM–5B PRIMARY AC WIRING

WARNING *ENSURE PRIMARY POWER IS DISCONNECTED BEFORE PROCEEDING.*

WARNING

WARNING *ENSURE AN EARTH GROUND CONDUCTOR IS SECURELY CONNECTED TO THE TRANSMITTER GROUND SYSTEM.*

WARNING

2–70. **FM–5BS.** A single phase source of 196V to 252V ac, 50 or 60 Hz at 70 Amperes is required for the FM–5BS transmitter ac input. For operating safety, the power source must be routed to the transmitter through a fused power disconnect (refer to Figure 2–10).

2–71. Refer to Figure 2–10 and connect the 70 Ampere service to TB1 on the transmitter baseplate through a fused service disconnect. Ensure a utility company ground conductor is securely connected to the transmitter ground system and the neutral wire is securely connected to TB1–2.

2–72. **INITIAL CHECKOUT.**

WARNING *ENSURE PRIMARY POWER IS DISCONNECTED BEFORE PROCEEDING.*

WARNING

2–73. Ensure that the transmitter is completely installed, the transmitter is connected to a suitable RF load, and the station monitors are connected to the MON port in the RF low–pass filter output. The MON port provides a harmonic–filtered RF sample which is approximately 40 dB below the carrier power level. Check the following:

A. Ensure primary power is correctly wired.

B. Ensure all ground connections are secure.

C. Ensure all RF connections are secure.

D. Ensure all connections at terminal boards are secure.

E. Rotate the blower and fans by hand to ensure no obstructions are present.

F. Using an insulator, check relay operation manually to be certain all have free movement.

2–74. Remove any extra hardware and wire lying within the cabinets and close all doors. Replace the lower front access panel using the black hex–head screws and hex wrench shipped with the transmitter.

2–75. Adjust the **FILAMENT ADJUST** control fully counterclockwise (minimum).

2–76. Operate all five front–panel circuit breakers to **OFF**.

2–77. Operate the **OUTPUT POWER METER** switch to **FWD**.

2–78. Close the wall–mounted fused disconnect.

2–79. Extend the exciter forward, out of the rack on the slide rails to expose the **R.F. POWER OUTPUT ADJ.** control access hole in the top cover. Adjust the control fully counterclockwise (minimum output).

2–80. The following procedure will refer to the factory final test data sheets supplied with the transmitter. Some differences in the actual operation may be noted due to differences in primary power or antenna systems. Ensure all controls are preset to the positions indicated on the final test data sheets.

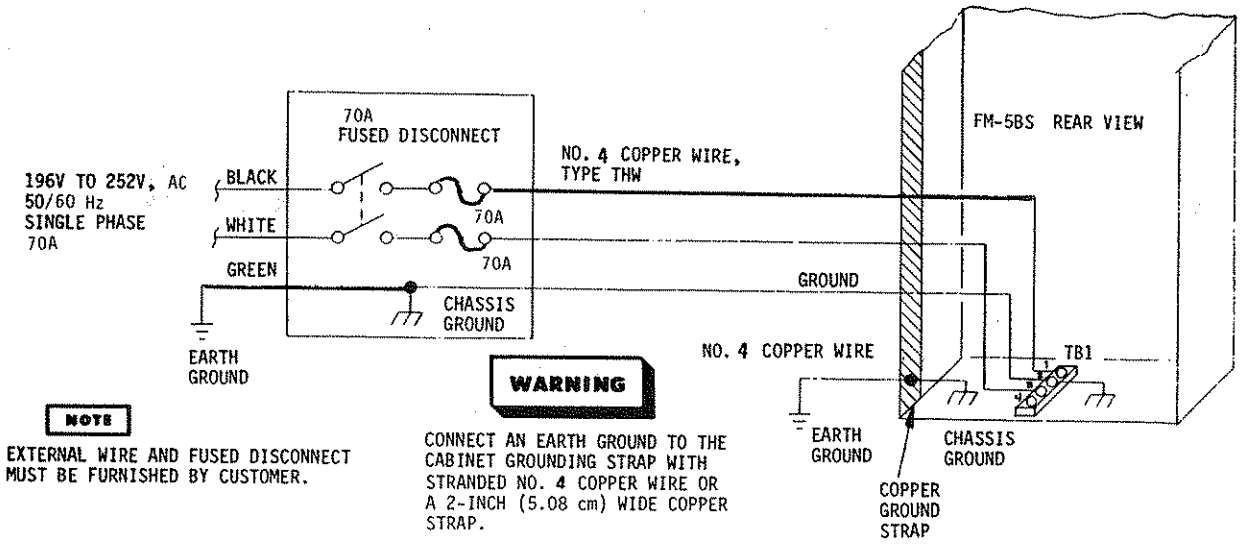

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FIGURE 2–10. FM–5BS PRIMARY AC WIRING

2–81. **CONTROLLER AND INTERLOCK CHECKOUT.** Check the controller and the transmitter interlock circuit by performing the following procedure.

2–82. Operate the **AC POWER** and the **BLOWER** circuit breakers to **ON**. The **FILAMENT** and **SCREEN** circuit breakers must remain **OFF**.

2–83. Open the controller cabinet door and check the following items on the controller circuit board.

A. Ensure the **POWER** indicator is illuminated.

B. Depress the **BATTERY TEST** switch. The **TEST** indicator will illuminate.

WARNING ***PERFORM THE FOLLOWING PROCEDURES AS INDICATED. DO NOT TOUCH ANYTHING WITHIN THE***

WARNING ***TRANSMITTER WITH POWER ENERGIZED.***

2–84. Remove the transmitter lower front access panel. The controller **INTERLOCK STATUS** indicator will extinguish.

2–85. Replace the transmitter lower front access panel. The controller **INTERLOCK STATUS** indicator will illuminate.

2–86. Open the transmitter rear door. The controller **INTERLOCK STATUS** indicator will extinguish.

2–87. Close the transmitter rear door. The controller **INTERLOCK STATUS** indicator will illuminate.

2–88. Open the transmitter rear door and perform the following:

WARNING ***PERFORM THE FOLLOWING PROCEDURES AS INDICATED. DO NOT TOUCH ANYTHING WITHIN THE***

WARNING ***TRANSMITTER WITH POWER ENERGIZED.***

A. Depress the transmitter rear door interlock switch and raise the grounding stick from the hanger. The controller **INTERLOCK STATUS** indicator will extinguish.

B. Replace the grounding stick. The controller **INTERLOCK STATUS** indicator will illuminate.

C. While depressing the transmitter rear door interlock switch, open the PA cavity access door. The controller **INTERLOCK STATUS** indicator will extinguish.

D. Close the PA cavity access door. The controller **INTERLOCK STATUS** indicator will illuminate.

E. Close the transmitter rear door.

2–89. If an external interlock switch and indicator is installed, check the operation as follows:

A. Open the external interlock. The external interlock indicator will extinguish.

B. Close the external interlock. The external interlock indicator will illuminate.

2–90. **BLOWER CHECKOUT.** Check blower operation by performing the following procedure.

2–91. Ensure the **AC POWER** and **BLOWER** circuit breakers are operated to **ON.** The **FILAMENT** and **SCREEN** circuit breakers must remain **OFF.**

2–92. Depress the **FILAMENT ON** switch/indicator to illuminate the switch/indicator. The **FILAMENT ON** switch/indicator, **BLOWER STATUS**, and the **FILAMENT STATUS** indicators will illuminate and the blower will begin operation.

2–93. Ensure the blower, **BLOWER STATUS** indicator, and the **FILAMENT STATUS** indicator are operating properly. At high altitudes, the **BLOWER STATUS** indicator may not illuminate. If this occurs, contact the Broadcast Electronics Customer Service Department.

2–94. **EXCITER CHECKOUT.** Check exciter operation by performing the following procedure.

2–95. Ensure the **AC POWER** and **BLOWER** circuit breakers are operated to **ON.** The **SCREEN** and **FILAMENT** circuit breakers must remain **OFF.**

2–96. Depress the **HIGH VOLTAGE ON** switch/indicator to illuminate the switch/indicator.

2–97. Depress the exciter multimeter **AFC** switch.

A. The multimeter will indicate a potential within the range of +2.0 volts to +9.0 volts, dependent upon carrier frequency. Refer to the final test data sheets for the correct voltage indication.

2–98. Depress the exciter multimeter **PAV** switch.

A. The multimeter will indicate a potential of approximately +4.0 volts (assuming the exciter is configured for a minimum RF power output).

2–99. Depress the exciter multimeter **PAI** switch.

A. The multimeter will indicate approximately 0.5 amperes (assuming the exciter is configured for a minimum RF power output).

2–100. Depress the exciter multimeter **FWD** switch.

A. The exciter will indicate approximately 4 watts (assuming the exciter is configured for a minimum RF power output).

2–101. Depress the **FILAMENT OFF** switch.

2–102. **PRELIMINARY OPERATION AND TUNING.** Operate and tune the transmitter by performing the following procedure.

2–103. Ensure the **AC POWER** and **BLOWER** circuit breakers are operated to **ON**. The **SCREEN** and **FILAMENT** circuit breakers must remain **OFF**.

2–104. Ensure the controller **INTERLOCK STATUS** indicator is illuminated. If the **INTERLOCK STATUS** indicator is extinguished, open the wall–mounted fused disconnect and check the following:

A. All panels are installed.

B. All shorting sticks are on the hangers.

C. All doors are closed.

2–105. If installed, ensure the external interlock indicator is illuminated. If the external interlock indicator is extinguished, open an appropriate power source disconnect if required and check the interlock switch.

2–106. Ensure the **FILAMENT ON** and **HIGH VOLTAGE ON** switch/indicators are extinguished.

2–107. Ensure the exciter **RF OUTPUT POWER ADJ** control is fully counterclockwise (minimum).

2–108. Depress the **APC ON** switch/indicator to extinguish the switch/indicator.

2–109. Depress the **APC REMOTE DISABLE** switch/indicator to illuminate the switch/indicator.

2–110. Operate the **APC FORWARD POWER METER** switch to **FWD**.

CAUTION ***ENSURE AN RF LOAD IS CONNECTED TO THE TRANSMITTER AND THE FILAMENT VOLTAGE CONTROL IS FULLY COUNTERCLOCKWISE.***

CAUTION

2–111. Operate the **FILAMENT** circuit breaker to **ON**.

2–112. Depress the **FILAMENT ON** switch/indicator. Both the **FILAMENT ON** switch/indicator and the **FILAMENT STATUS** indicator will illuminate and the blower will begin operation.

2–113. Adjust the **FILAMENT ADJUST** control to obtain a **FILAMENT VOLTAGE** meter indication of 5.0 volts.

2–114. Operate the **MULTIMETER** switch to **GRID VOLTAGE** and note the presence of PA stage grid bias without drive.

2–115. Depress the **RAISE** switch/indicator for approximately three seconds. The switch/indicator will flash.

2–116. Depress the **APC ON** switch/indicator to illuminate the switch/indicator. The **LOWER** switch/indicator will flash until the APC returns the screen variable auto–transformer to minimum.

2–117. Depress the **APC ON** switch/indicator. The switch/indicator will extinguish.

2–118. Operate the **SCREEN** circuit breaker to **ON**.

2–119. Depress the **HIGH VOLTAGE ON** switch/indicator. Both the **HIGH VOLTAGE ON** switch/indicator and the **HIGH VOLTAGE STATUS** indicator will illuminate.

2–120. Note the presence of plate voltage on the **PLATE VOLTAGE** meter.

2–121. If the transmitter is equipped with MVDS, ensure the MVDS is operated to on. If the MVDS is to remain off, refer to TRANSMITTER OPERATION WITHOUT MVDS in SECTION III of MVDS instruction manual 597–0114.

2–122. If installed, check the external interlock operation as follows:

WARNING ***OBSERVE PROPER SAFETY PRECAUTIONS WHEN PERFORMING THE FOLLOWING PROCEDURE.***

WARNING

A. Open the external interlock. The controller **HIGH VOLTAGE STATUS** indicator and the external interlock indicator will extinguish and the high voltage plate supply will be disabled.

B. Close the external interlock. The plate supply will be restored, the transmitter will resume operation, and the controller **HIGH VOLTAGE STATUS** indicator and the external interlock indicator will illuminate.

2–123. Adjust the exciter **RF POWER OUTPUT ADJ** control to obtain approximately five watts from the exciter.

2–124. Depress the exciter multimeter **PAV** switch.

A. The multimeter will indicate a potential within the range of +5.5 volts to +6.7 volts (assuming an RF output power of 5 watts).

2–125. Depress the exciter multimeter **PAI** switch.

A. The multimeter will indicate approximately 1.1 amperes (assuming RF output power of 5 watts).

2–126. Depress the exciter multimeter **FWD** switch.

2–127. Operate the **MULTIMETER** switch to **IPA RFL POWER** and adjust the **INPUT TUNING** control to obtain a minimum reflected power indication on the **MULTIMETER**.

CAUTION ***CHECK THE TRANSMITTER OUTPUT POWER INDICATION TO ENSURE TRANSMITTER OUTPUT POWER IS PRESENT.***

CAUTION

2–128. Note the presence of output power on the **OUTPUT POWER** meter. If no output power is indicated, perform the following:

1. Ensure the PA coarse tuning line is properly adjusted.
2. Adjust the **OUTPUT TUNING** control for a maximum indication on the **OUTPUT POWER** meter.

2–129. Adjust the exciter output to approximately 7.5 watts.

2–130. The **IPA FWD POWER** indicator will illuminate. If the **IPA VSWR** indicator illuminates during the remainder of the initial checkout procedure, this indicates that the IPA load is incorrect. To correct the situation, operate the **MULTIMETER** switch to **IPA RFL POWER** and re–adjust the **INPUT TUNING** control for a minimum reflected power indication on the **MULTIMETER**.

2–131. The **OUTPUT POWER** and **PLATE CURRENT** meters will indicate a low level of less than 20% full–scale.

2–132. Adjust the **OUTPUT TUNING** and **OUTPUT LOADING** controls for a maximum **OUTPUT POWER** meter indication.

2–133. Depress the **APC RAISE** switch/indicator. The switch/indicator will flash. Hold the switch/indicator depressed until a 400 mA **PLATE CURRENT** meter indication is noted.

2–134. Adjust the **OUTPUT TUNING** and **OUTPUT LOADING** controls for a maximum **OUTPUT POWER** meter indication.

2–135. Operate the **MULTIMETER** switch to **IPA RFL POWER** and adjust the **INPUT TUNING** control to obtain a minimum reflected power indication on the **MULTIMETER**.

2–136. Depress the **APC RAISE** switch/indicator. Hold the switch/indicator depressed until a 50% indication is obtained on the **OUTPUT POWER** meter.

2–137. Depress and hold the **OUTPUT POWER** meter switch to VSWR CAL. Adjust the **VSWR CAL** control for 100% indication on the **OUTPUT POWER** meter.

2–138. Release the **OUTPUT POWER METER** switch. The **OUTPUT POWER** meter must indicate a VSWR of less than 1.8:1. An excessive VSWR indicates improper load connections.

2–139. Operate the **OUTPUT POWER METER** switch to **FWD**.

2–140. Adjust the **OUTPUT TUNING** and **OUTPUT LOADING** controls for maximum indication on the **OUTPUT POWER** meter, concurrent with a minimum indication on the **PLATE CURRENT** meter.

2–141. Adjust the exciter **RF OUTPUT POWER ADJ** control to the value stated on the factory test data sheets.

2–142. Operate the **MULTIMETER** switch to **IPA RFL POWER** and adjust the **INPUT TUNING** control to obtain a minimum reflected power indication on the **MULTIMETER**.

2–143. Depress and hold the **APC RAISE** switch/indicator. Hold the switch/indicator depressed until a 100% power indication is noted on the **OUTPUT POWER** meter. If a plate or screen current overload occurs, it may be necessary to adjust the **OUTPUT LOADING** for better efficiency before increasing power to 100%.

2–144. Operate the **MULTIMETER** switch to **IPA RFL POWER** and adjust the **INPUT TUNING** control to obtain a minimum reflected power indication on the **MULTIMETER**.

2–145. Adjust the **OUTPUT LOADING** and **OUTPUT TUNING** controls to obtain the values stated on the factory test data sheets.

2–146. Check the **FILAMENT VOLTAGE** meter and adjust the **FILAMENT ADJUST** control as required. The meter must indicate 5 volts.

2–147. Adjust the PA stage for the most efficient operation by adjusting the **OUTPUT TUNING** and **OUTPUT LOADING** controls for a maximum indication on the **OUTPUT POWER** meter concurrent with a minimum indication on the **PLATE CURRENT** meter.

2–148. Operate the **MULTIMETER** to **IPA RFL POWER** and adjust the **INPUT TUNING** control for a minimum reflected power indication.

2–149. Depress the **APC RAISE** or **LOWER** switch/indicators as required to obtain a 100% **OUTPUT POWER METER** indication.

2–150. Compare the meter indications to those provided on the final test data sheets. All meter indications should be approximately the same as those stated on the final test data sheets.

2–151. Depress the **APC ON** switch/indicator. The switch/indicator will illuminate and the transmitter will maintain a constant 100% rated RF output.

2–152. Recalibrate the **VSWR CAL** control to 100%.

2–153. Apply programming to the exciter. The presence of programming may be noted on the exciter **MODULATION** meter.

2–154. To adjust the automatic power control unit to maintain a level other than 100%, the **APC ON** switch/indicator must be illuminated. Depress and hold either the **RAISE** or the **LOWER** switch/indicator as desired until the desired percentage of transmitter power output is indicated by the **OUTPUT POWER** meter. The automatic power control circuitry operates in small increments and will take some time to track the reference to the new set point. The automatic power control circuitry will then maintain this new established RF output level. The **VSWR CAL** control must be re–calibrated and the transmitter must be retuned for maximum efficiency at this new level.

2–155. If remote operation is desired, the **REMOTE DISABLE** switch/indicator must be extinguished. TB2–29 on the remote interface terminal block carries a remote enabled signal which can be connected to a relay or logic circuit to control a light or alarm to remind the engineer of the status of the remote disable switch. This feature will hopefully prevent inadvertent remote lockout if the engineer should leave the transmitter site and forget to enable remote operation.

SECTION III
OPERATION

3–1. INTRODUCTION.

3–2. This section identifies all controls and indicators associated with the FM–5B/FM–5BS FM transmitters and provides standard operating procedures.

3–3. CONTROLS AND INDICATORS.

3–4. Refer to Figure 3–1 for the location of all controls and indicators associated with normal operation of the FM–5B/FM–5BS transmitters. The function of each control or indicator is described in Table 3–1.

3–5. OPERATION.

NOTE *THE FOLLOWING PROCEDURE IS PRESENTED UNDER THE ASSUMPTION THAT THE TRANSMITTER IS FULLY INSTALLED AND IS FREE OF ANY DISCREPANCIES.*

NOTE

3–6. TURN ON.

3–7. Operate all circuit breakers to **ON**.

3–8. Depress the **REMOTE DISABLE** switch/indicator to illuminate the switch/indicator.

3–9. Depress the **FILAMENT ON** switch/indicator, then depress the **HIGH VOLTAGE ON** switch/indicator. Each switch/indicator will illuminate as it is depressed.

3–10. If all interlocks are closed, the transmitter will be operational after a short delay to allow PA tube filament warm–up.

3–11. Check and log all meter indications and the status of the various indicators to assure proper equipment operation. A sample log sheet is provided as Table 3–2.

3–12. Operate the **OUTPUT POWER METER** switch to **FWD** to check the forward power output. To check **VSWR**, proceed as follows:

A. Depress and hold the **OUTPUT POWER** meter switch to **VSWR CAL.**

B. Adjust the **VSWR CAL** control to obtain a 100% indication on the **OUTPUT POWER** meter.

C. Release the **OUTPUT POWER METER** switch to check **VSWR.**

3–13. Select the type of RF output power control:

A. If manual power control is desired, proceed as follows:

1. Depress the **APC ON** switch/indicator to extinguish the switch/indicator.

2. Depress the **APC RAISE** or **LOWER** switch/indicator to raise or lower the transmitter RF output power as indicated by the **OUTPUT POWER** meter.

B. If automatic power control is desired, depress the **APC ON** switch/indicator to illuminate the switch/indicator. To adjust the level at which the automatic power control circuitry will maintain, proceed as follows:

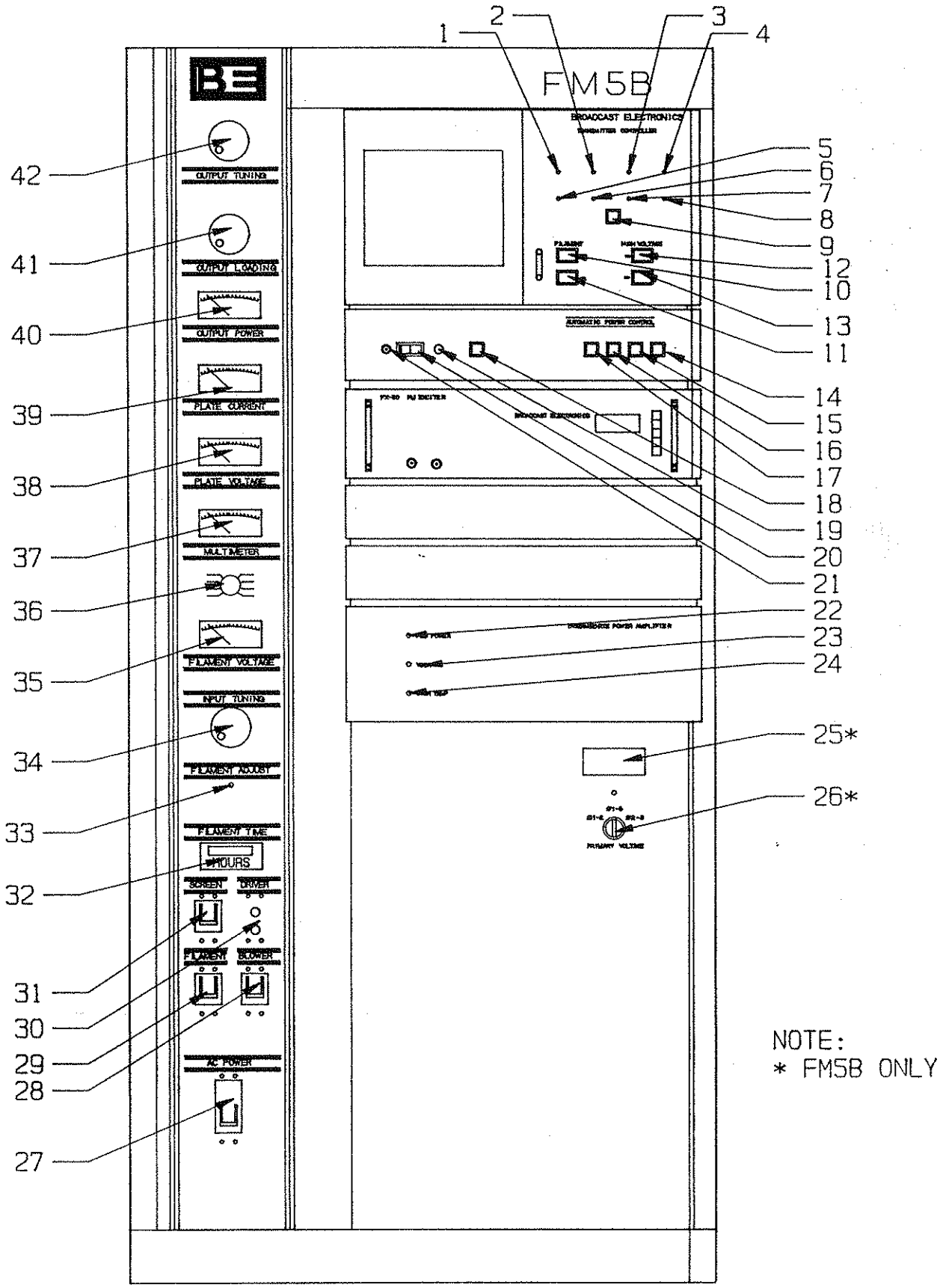

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FIGURE 3-1. CONTROLS AND INDICATORS

1. Depress the **APC ON** switch/indicator to illuminate the switch/indicator.
2. Depress and hold the **APC RAISE** or **LOWER** switch/indicator to establish a new RF power output level as indicated by the **OUTPUT POWER** meter.

3–14. If remote operation is desired, depress the **REMOTE DISABLE** switch/indicator to extinguish the switch/indicator. This will enable both local and remote operation.

3–15. **TURN OFF.**

3–16. Depress the **FILAMENT OFF** switch/indicator. After a period of blower operation to allow the PA tube to cool, the equipment will de–energize.

3–17. Operate the **AC POWER** circuit breaker to **OFF**.

3–18. If the transmitter is disconnected from ac for longer than one hour, remove the controller battery.

3–19. **OPERATING THE TRANSMITTER FOR MAXIMUM TUBE LIFE.**

3–20. The FM–5B/FM–5BS is equipped with an Eimac 4CX3500A tetrode. Maximum tube life is obtained by the implementation of a tube management program. A tube management program consists of operating and monitoring the transmitter to maintain an optimum tube filament voltage. This optimum voltage prevents premature de–carbonization of the tube filament and will result in maximum tube life. To maximize transmitter tube life, implement the procedures and operations presented in the following tube management program.

TUBE MANAGEMENT PROGRAM

1) Refer to APPENDIX A and perform the procedures presented in the Eimac publication titled "Extending Transmitter Tube Life – Eimac Application Bulletin No. 18. – March 1990".

2) Refer to APPENDIX A and the information presented in "Eimac Technical Data Sheet – 4CX3500A Tetrode".

3) The procedures presented in any "Eimac Product Bulletins" shipped with the tube.

TABLE 3–1. CONTROLS AND INDICATORS
(Sheet 1 of 5)

INDEX NO.	NOMENCLATURE	FUNCTION
1	**INTERLOCK STATUS** Indicator	Indicates all transmitter safety interlocks are closed when illuminated. The external interlock is not included.
2	**BLOWER STATUS** Indicator	Indicates proper operation of the blower when illuminated.
3	**FILAMENT STATUS** Indicator	Indicates primary ac power is applied to the PA filament transformer when illuminated.

TABLE 3–1. CONTROLS AND INDICATORS
(Sheet 2 of 5)

INDEX NO.	NOMENCLATURE	FUNCTION
4	**HIGH VOLTAGE STATUS** Indicator	Indicates the plate power supply is operational when illuminated.
5	**VSWR OVERLOAD** Indicator	Indicates a PA stage VSWR overload has occurred when illuminated.
6	**PLATE OVERLOAD** Indicator	Indicates a PA plate circuit overload has occurred when illuminated.
7	**SCREEN OVERLOAD** Indicator	Indicates a PA screen circuit overload has occurred when illuminated.
8	**GRID OVERLOAD** Indicator	Indicates a PA grid power supply overload has occurred when illuminated.
9	**OVERLOAD RESET** Switch/Indicator	SWITCH: Clears the overload circuit memory when depressed. INDICATOR: Indicates an overload condition exists when illuminated.
10	**FILAMENT ON** Switch/Indicator	SWITCH: Energizes the filament contactor when depressed to apply PA filament voltage. INDICATOR: Indicates a filament–on command has been received by the transmitter controller.
11	**FILAMENT OFF** Switch	Deenergizes all transmitter power. The blower and flushing fans will run for approximately 35 seconds after the **FILAMENT OFF** switch has been depressed.
12	**HIGH VOLTAGE ON** Switch/Indicator	SWITCH: Energizes the plate contactor when de–pressed to activate the plate power supply, the screen power supply, and unmutes the exciter. INDICATOR: Indicates a high voltage–on command has been received by the transmitter controller.
13	**HIGH VOLTAGE OFF** Switch	Deenergizes the plate and screen power supplies and mutes RF drive when depressed.
14	**AUTOMATIC POWER CONTROL RAISE** Switch/Indicator	SWITCH: In the automatic mode, moves the APC reference upward when depressed. In the manual mode, operates the screen control motor in a direction which will raise transmitter RF output power when depressed.

TABLE 3–1. CONTROLS AND INDICATORS
(Sheet 3 of 5)

INDEX NO.	NOMENCLATURE	FUNCTION
		INDICATOR: Indicates pulsed screen control motor operation in a direction which will raise transmitter RF power output when illuminated. Extinguishes when a maximum level is obtained.
15	**AUTOMATIC POWER CONTROL LOWER** Switch/Indicator	SWITCH: In the automatic mode, moves the APC reference downward when depressed. In the manual mode, operates the screen control motor in a direction which will reduce transmitter RF output power when depressed.
		INDICATOR: Indicates pulsed screen control motor operation in a direction which will lower transmitter RF power output when illuminated. Extinguishes when a minimum level is obtained.
16	**AUTOMATIC POWER CONTROL APC ON** Switch/Indicator	SWITCH: Selects APC control of transmitter operation.
		INDICATOR: Indicates the transmitter is under APC control when illuminated.
17	**AUTOMATIC POWER CONTROL PRESET** Switch/Indicator	SWITCH: Selects transmitter operation at a preset RF power output level.
		INDICATOR: Indicates transmitter operation at a preset RF power level (such as half power) has been selected when illuminated.
18	**REMOTE DISABLE** Switch/Indicator	SWITCH: Inhibits or enables transmitter remote operation.
		INDICATOR: Indicates remote operation is inhibited when illuminated.
19	**OUTPUT POWER METER VSWR CAL** Control	Allows calibration of the **OUTPUT POWER** meter VSWR display.
20	**OUTPUT POWER METER FWD/VSWR/ VSWR CAL** Switch	Selects the parameter to be displayed by the **OUTPUT POWER** meter.

TABLE 3–1. CONTROLS AND INDICATORS
(Sheet 4 of 5)

INDEX NO.	NOMENCLATURE	FUNCTION
21	**AM NOISE TEST** Receptacle	Test receptacle for AM noise measurements.
22	**INTERMEDIATE POWER AMPLIFIER FWD POWER** Indicator	Indicates the IPA stage RF output power exceeds 75 Watts when illuminated.
23	**INTERMEDIATE POWER AMPLIFIER VSWR** Indicator	Indicates the PA stage input circuit VSWR is excessive when illuminated (greater than 10 Watts reflected to the IPA).
24	**INTERMEDIATE POWER AMPLIFIER OVER TEMP** Indicator	Indicates an IPA stage regulator heat sink over–temperature condition exists when illuminated.
25	**PRIMARY VOLTAGE** Meter	Displays PHASE 1–2, PHASE 2–3, or PHASE 3–1 primary ac input voltage potentials as selected by the **PRIMARY VOLTAGE** switch.
26	**PRIMARY VOLTAGE** Switch	Selects PHASE 1–2, PHASE 2–3, and PHASE 3–1 primary ac input voltage parameters to be displayed on the **PRIMARY VOLTAGE** meter.
27	**AC POWER** Circuit Breaker	Provides overload protection and primary power control for the transmitter AC input.
28	**BLOWER** Circuit Breaker	Provides overload protection and primary power control for the blower, flushing fans, the automatic power control unit, and the transmitter controller.
29	**FILAMENT** Circuit Breaker	Provides overload protection and primary power control for the PA tube filament supply, the control grid bias supply, and the hum null circuitry.
30	**DRIVER** Circuit Breakers	Provides overload protection and primary power control for the FM exciter and intermediate power amplifier.
31	**SCREEN** Circuit Breaker	Provides overload protection and primary power control for the PA screen grid power supply.
32	**FILAMENT TIME** Meter	Indicates hours of filament circuit operation.
33	**FILAMENT ADJUST** Control	Adjusts the PA tube filament voltage.

TABLE 3-1. CONTROLS AND INDICATORS
(Sheet 5 of 5)

INDEX NO.	NOMENCLATURE	FUNCTION
34	**INPUT TUNING** Control and Cyclometer	Tunes the PA stage input circuit to resonance.
35	**FILAMENT VOLTAGE** Meter	Indicates the PA tube filament voltage.
36	**MULTIMETER** Switch	Selects **PA SCREEN VOLTAGE, SCREEN CURRENT, GRID CURRENT, GRID VOLTAGE, IPA FWD POWER** or **IPA RFL POWER** parameters to be displayed on the **MULTIMETER**.
37	**MULTIMETER**	Displays **PA SCREEN VOLTAGE, SCREEN CURRENT,GRID CURRENT, GRID VOLTAGE, IPA FWD POWER,** or **IPA RFL POWER** as selected by the **MULTIMETER** switch.
38	**PLATE VOLTAGE** Meter	Displays the PA stage plate potential.
39	**PLATE CURRENT** Meter	Displays the PA stage plate current.
40	**OUTPUT POWER** Meter	Displays transmitter percentage of RF output power or output VSWR as selected by the **OUTPUT POWER METER FWD/VSWR/VSWR CAL** switch.
41	**OUTPUT LOADING** Control and Cyclometer	Adjusts the PA stage output loading.
42	**OUTPUT TUNING** Control and Cyclometer	Tunes the PA stage output circuit to resonance.

TABLE 3-2. INDICATOR CHECKLIST

INDICATOR	STATUS
INTERLOCK STATUS	ON / OFF
BLOWER STATUS	ON / OFF
FILAMENT STATUS	ON / OFF
HIGH VOLTAGE STATUS	ON / OFF
VSWR OVERLOAD	ON / OFF
PLATE OVERLOAD	ON / OFF
SCREEN OVERLOAD	ON / OFF
GRID OVERLOAD	ON / OFF
OVERLOAD RESET SWITCH/INDICATOR	ON / OFF
FILAMENT ON SWITCH/INDICATOR	ON / OFF
HIGH VOLTAGE ON SWITCH/INDICATOR	ON / OFF
REMOTE DISABLE SWITCH/INDICATOR	ON / OFF
PRESET SWITCH/INDICATOR	ON / OFF
APC ON SWITCH/INDICATOR	ON / OFF
LOWER SWITCH/INDICATOR	ON / OFF
RAISE SWITCH/INDICATOR	ON / OFF
IPA FWD POWER	ON / OFF
VSWR	ON / OFF
OVER TEMP	ON / OFF

OR

NOTE

OPERATIONAL STATUS SHOWN BY SHADED INDICATOR

METER	INDICATION	
OUTPUT POWER	POWER %	VSWR :1
PLATE CURRENT	A	
PLATE VOLTAGE	kV	
MULTIMETER		
Screen Voltage	V	
Screen Current	mA	
Grid Voltage	V	
Grid Current	mA	
IPA FWD Power	W	
IPA RFL Power	NORMAL/HIGH	
FILAMENT VOLTAGE	V	
FILAMENT TIME	HOURS	

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SECTION IV
THEORY OF OPERATION

4–1. INTRODUCTION.

4–2. This section presents general theory of operation for the FM–5B/FM–5BS FM Transmitters.

4–3. The FM–5B/FM–5BS transmitters are divided into functional blocks which are discussed by the following text. Each circuit is discussed in further detail by the modular assembly publications in Part II of this manual. These functional blocks consist of the FM exciter, the intermediate power amplifier (IPA), the power amplifier, the automatic power control (APC), the transmitter controller, and the associated power supplies and control circuits. Each functional block contains an integral power supply except for the power amplifier which obtains dc power from components mounted along the sides and base of the transmitter enclosure. Refer to the block diagram (Figure 4–1) and the overall schematic diagram in Section VII as required for the following explanation.

4–4. ELECTRICAL DESCRIPTION.

4–5. FM EXCITER.

4–6. The Broadcast Electronics FX–50 is a totally solid–state wideband FM exciter providing a continuously variable RF output from 3 to 50 watts. The FX–50 operates into a 50 Ohm load at any frequency within the 87.5 to 108 MHz FM broadcast band. The exciter may be programmed to any frequency within this band in 10 kHz increments. The FX–50 exciter is mounted in slides to allow easy access to the internal semi–modular exciter circuitry.

4–7. The FX–50 will accept multiple wideband composite inputs from a stereo generator or SCA generator as well as a 600 Ohm balanced audio input (see Figure 4–1). Refer to publication 597–1050 for detailed explanation of the FM exciter features.

4–8. INTERMEDIATE POWER AMPLIFIER.

4–9. The intermediate power amplifier consists of a broadband solid–state amplifier assembly and a regulated power supply with over–voltage and over–current protection circuitry. The IPA is contained in a slideout drawer for ease of maintenance. Both the amplifier and the regulator are mounted on easily removable heat sinks built around a fan which provides forced–air cooling.

4–10. The IPA RF stage consists of two bipolar RF power transistors operated push–pull as a class C amplifier. A stripline directional coupler provides forward and reflected power samples. The IPA exhibits a power gain of 10 to output approximately 150 Watts to drive the PA stage.

4–11. A green **FWD PWR** indicator on the front panel illuminates to indicate sufficient RF output level exists for normal PA stage operation. A yellow **VSWR** indicator illuminates to indicate excessive IPA stage reflected power and requires adjustment of the **INPUT TUNING** control to correct a mismatch. A red **OVER TEMP** indicator indicates that an over–temperature condition exists within the IPA. Refer to the IPA section in Part II of this manual for a more detailed description.

4–12. POWER AMPLIFIER.

4–13. The FM–5B/FM5BS uses a single 4CX3500A tetrode to provide 5000 Watts of RF power on a single frequency within the FM broadcast band of 87.5 MHz to 108 MHz. The power amplifier operates in a high–gain, grid– driven class C configuration. A patented input circuit matches the 50 Ohm output of the IPA up to the higher grid input impedance. Use of a large coaxial cavity results in high PA efficiency for comparatively low power consumption. Removal of the PA tube is a simple and quick procedure due to the cavity arrangement. A dual–blower cooling system forces air through the tube socket, anode fins, and out through the main transmission line chimney. A differential air pressure sensor monitors the effectiveness of the cooling system and removes power to the tube if air flow is interrupted.

4–14. **POWER AMPLIFIER CAVITY.** The patented PA cavity used in the FM–5B/FM–5BS employs a folded half–wave coaxial transmission line resonator constructed with aluminum and copper tubing. This cavity design eliminates the high voltage blocking capacitors and high current sliding contacts of conventional cavities by connecting the main transmission line conductor directly to the anode of the power tube. A grounded concentric transmission line center conductor tunes this cavity by varying the length inserted into the open end of a main transmission line inner conductor. The main inner conductor is insulated from ground and carries the anode dc potential. DC power is fed at the RF voltage null point, approximately one–quarter wave from the anode for effective RF decoupling. A large surface area without sliding contacts results in minimal RF loss at this point in the cavity.

4–15. **OUTPUT COUPLING.** Energy is coupled into the transmission line by an adjustable untuned loop which functions in the electromagnetic field within the cavity. One end of the output loop is connected to ground, while the other connects to the center conductor of the output transmission line through flexible straps.

4–16. **PLATE TUNING.** Plate tuning is accomplished by adjusting a threaded rod which mechanically expands or contracts a beryllium copper bellows on the end of the grounded transmission line center conductor inserted into the main line. Coarse frequency adjustment is accomplished by pre–setting the length of the center conductor into the cavity.

4–17. **NEUTRALIZATION.** Neutralization is accomplished in the FM–5B/FM–5BS by distributed inductance added in series between the screen connection and the screen bypass capacitors. The inductance develops a counteractive voltage swing between the screen and ground which cancels out the voltage fed through the internal capacitances of the tube and the stray capacitances of the tube socket. This form of self–neutralization results in very stable operation and requires no adjustment when the power tube is replaced.

4–18. **SECOND HARMONIC SUPPRESSOR.** A patented second harmonic suppressor is included in the PA cavity. This consists of a capacitive disc and a series inductance to ground coupled to the main transmission line at the fundamental frequency RF voltage null point. Here the second harmonic exhibits a high voltage and the suppressor presents a low impedance to ground which reduces the amplitude of the second harmonic. This unique method of harmonic suppression has minimal effect on the fundamental frequency and does not add losses to the PA cavity at the fundamental frequency.

4–19. **OUTPUT CIRCUIT.** A separate low–pass filter is contained within the FM–5B/FM–5BS cabinet to attenuate all residual second and higher order harmonics. This filter functions over the entire FM broadcast band. Three RF directional couplers are mounted after the filter in the output transmission line connection. Two of these supply filtered forward and reflected power RF samples to the automatic power control and the third port supplies a forward power sample at 40 dB below carrier at 50 Ohms for external test equipment.

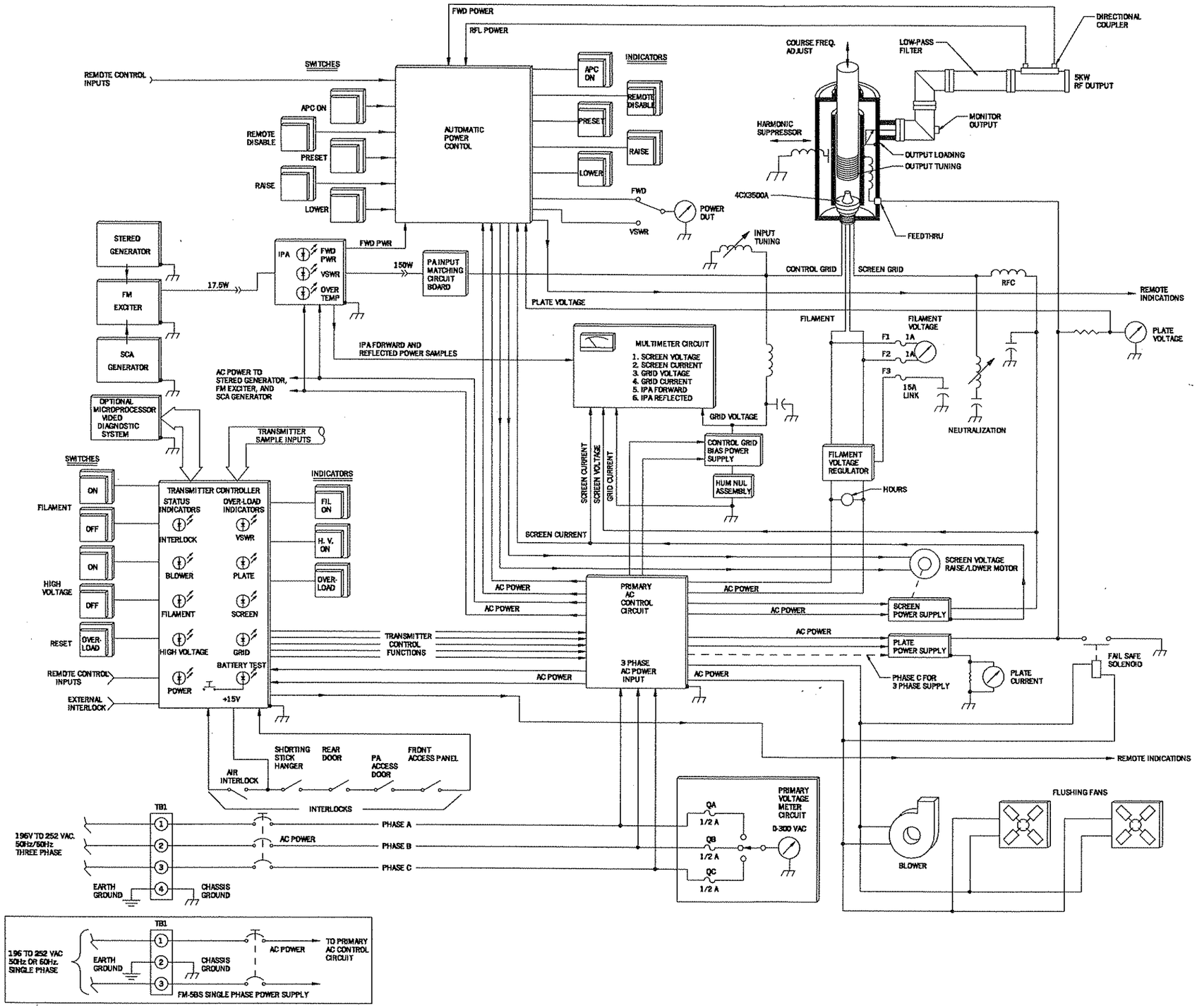

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FIGURE 4-1. FM-5B/FM-5BSBLOCK DIAGRAM

BROADCAST ELECTRONICS INC

4–20. **AUTOMATIC POWER CONTROL.**

4–21. The automatic power control unit (APC) measures several transmitter parameters and allows manual or automatic power output control, allows switch selected operation at a preset lower power level, and provides VSWR foldback protection and soft–start features.

4–22. **AUTOMATIC RF OUTPUT LEVEL CONTROL.** Part of the APC circuitry rectifies PA forward power and reflected power samples and supplies these to the power meter selector switch and to the transmitter controller for further evaluation. The APC also monitors screen current and IPA forward power and adjusts the PA screen voltage via a dc servo motor–driven variable auto transformer to maintain a constant transmitter RF output. If excessive PA reflected power, excessive screen current, or low IPA power are measured, the "raise power" command will be inhibited to prevent an overload from occurring. Manual screen control is assumed by switching the APC off. In the manual mode, the raise and lower switches directly control the dc servo motor to vary the screen voltage supply. In the automatic mode, the switches control a reference voltage stored as an eight–bit binary word in a digital memory. This digital memory is maintained by a nine–volt battery so that the transmitter can automatically return to the desired power level whenever power is applied. This memory has a very long life, approximately the battery shelf life.

4–23. The dc servo motor control circuit uses a pulsed duty–cycle modulation scheme to vary the motor speed. When large excursions of screen voltage are required, a greater duty cycle drives the motor. Fine adjustment of screen voltage utilizes a shorter pulse duty–cycle and therefore slower motor speed. This feature, combined with an analog deadband in the circuitry, eliminates hunting in this servo loop. The front panel **RAISE** and **LOWER** push switches are illuminated by the actual motor drive voltage. Their illumination intensity and rate indicates the actual servo system drive.

4–24. **VSWR FOLDBACK PROTECTION.** PA forward power is automatically reduced if output reflected power becomes excessive enough to overload the transmitter. As the condition which caused the high VSWR returns to normal, RF power will be proportionately raised until full power is again restored.

4–25. **SOFT START.** A soft start circuit monitors PA plate voltage and reduces the screen voltage to zero upon its absence. When the plate supply is energized, as during initial turn on, the circuit will gradually increase the screen voltage until the stored power setting is achieved. This circuit prevents inadvertent VSWR overloads at turn on, such as during icing of an antenna.

4–26. **TRANSMITTER CONTROLLER.**

4–27. Each transmitter timed control function and all overload sensing is performed by a built–in solid–state controller. The controller incorporates extensive use of RFI filtering and optical isolation in conjunction with CMOS logic to assure maximum reliability.

4–28. Adjustable timers on the primary controller circuit board determine filament warm–up time, blower run–down time, overload–recycle time, and AC restart. The plate, screen, grid, and VSWR overload limits can also be adjusted by potentiometers on the controller circuit board. The range of all controls is limited, however so that the safe operating limits of the transmitter cannot be exceeded by incorrect adjustment.

4–29. The **POWER** indicator on the controller circuit board illuminates to indicate power is applied to the circuit. The **BATTERY TEST** indicator indicates the status of the battery backed–up memory supply. When the transmitter is operating on ac power and the **BATTERY TEST** switch is depressed, illumination of the **BATTERY TEST** indicator indicates the battery is capable of maintaining the transmitter control memory for more than eight hours.

4–30. **MOMENTARY POWER INTERRUPTION.** In the event of a momentary power interruption, proper action will resume immediately after power returns. If an extended power failure occurs, information maintained by the nine–volt battery will enable the controller to initiate a start cycle to automatically return the transmitter to operation without assistance. If the transmitter safety interlock string opens during a power failure, the automatic restart feature will be defeated and the transmitter will enter the off condition when power is reapplied.

4–31. **OVERLOADS.** If an overload occurs, the transmitter will deenergize, allow the overload to clear, then automatically return to operation. If four overloads occur within 60 seconds, the transmitter will deenergize. The overload must be manually cleared and the transmitter **HIGH VOLTAGE ON** switch/indicator depressed before operation will resume. Single overloads of greater than 220 milliseconds duration will immediately deenergize the high voltage and filament supplies.

4–32. **INDICATORS.** Eight LEDs and three switch/indicators are provided on the front panel as status and overload indicators. The first overload that occurs will be latched into the controller and will illuminate the appropriate red VSWR, PLATE, SCREEN, or GRID LED and the yellow overload reset switch/indicator. All further overloads are monitored by the controller but will not be displayed by the LEDs.

4–33. The green **STATUS** indicators illuminate to indicate an operational condition as follows. The **INTERLOCK LED** indicates that the interlock loop is closed. The **BLOWER LED** indicates that the air pressure is correct for the PA stage to operate. The **FILAMENT LED** indicates that the filament contactor has been energized. The **HIGH VOLTAGE LED** indicates that the high voltage contactor has been energized.

4–34. **METERING.**

4–35. Seven front panel meters on the FM–5B and six on the FM–5BS are provided to indicate transmitter operating parameters. Output power and output VSWR indications are presented on a precision output power meter. Plate voltage and plate current information are displayed on separate meters for optimum convenience.

4–36. Additional transmitter metering features include a six function multimeter. The multimeter selects and displays information on vital transmitter operating parameters such as: 1) screen current, 2) screen voltage, 3) grid current, 4) grid voltage, 5) IPA forward power, and 6) IPA reflected power. An iron–vane voltmeter is used to measure filament voltage. A **FILAMENT TIME** meter is provided to indicate hours of filament circuit operation. On FM–5B models, primary ac voltage monitoring is provided by a primary ac voltmeter. The meter selects and displays the voltage between all three phases of the ac input. All meter currents are measured on the ground side of each supply to prevent high voltages across the meters.

4–37. **EXCITER METERING.** The exciter operating parameters are displayed by two additional meters and three status indicators. For detailed information on exciter metering, refer to FX–50 exciter manual 597–1050.

4–38. **POWER SUPPLIES.**

4–39. The FM–5B transmitter is designed for operation from a 196 to 252 volt three phase ac input. The plate supply is a conventional three phase power supply circuit. The remaining FM–5B transmitter power supplies are single phase circuits which are obtained from two phases of the three phase input. The FM–5BS transmitter is designed for operation from a 196 to 252 volt single phase ac input. All FM–5BS transmitter power supplies are single phase circuits obtained from the transmitter ac input.

4–40. The grid bias and screen power supplies consist of conventional full–wave rectification and choke input filter sections. A hum–null assembly consisting of a small unfiltered full–wave rectified supply injects a 120 Hz pulsating dc voltage in series with the ground return of the grid bias supply to cancel residual ripple from the screen supply in the tetrode amplifier.

4–41. The FM–5B plate supply is a three–phase primary, six–phase secondary supply. The primary circuit is connected in a closed delta arrangement and the secondary is connected in a wye configuration. The supply consists of a 3–phase full–wave bridge rectifier network with an LC filter section. Advantages of this type of supply is good regulation and low ripple which requires little filtering. The FM–5BS plate supply consists of a single phase full–wave rectifier network with a resonant LC filter stage. Power is applied to each plate supply through a step–start circuit to reduce the inrush current at power–on. This limits stress and extends component life.

4–42. An optional filament voltage regulator provides a stable filament voltage supply for the power amplifier tube. The device will regulate a wide range of ac input potentials into a stable 240 ±1% volt output. The regulator connects in series with the filament transformer at TB12. The input connects to terminals 1 and 4 and the output connects to terminals 5 and 7.

4–43. Each modular component of the transmitter is equipped with a self–contained ac power supply. In addition, battery back–up supplies in the transmitter controller and automatic power control maintain operational information during power outages. The battery in the APC can be left connected at all times. However, the controller battery will discharge if left connected during periods of extended power outages (several days). Both batteries are common nine–volt alkaline types.

4–44. DETAILED DESCRIPTION.

4–45. FM–5B POWER SUPPLY.

4–46. A 196 volt to 252 volt, 50 Hz or 60 Hz, three–phase ac input is required for proper operation of the FM–5B transmitter. The following supplies operate from the ac input (typical values are shown for the rated RF power output):

PARAMETER	APPROXIMATE VALUES
A. PA PLATE	+5300V at 1.3 Amperes
B. PA SCREEN GRID	+525V at 0.060 Amperes
C. PA CONTROL GRID	–260V at 0.045 Amperes
D. PA FILAMENT	5V ac at 90 Amperes
E. HUM NULL	+12.6V at 0.040 Amperes

4–47. **SEQUENCE OF OPERATION.** When the transmitter fused disconnect is closed, power is applied through **AC POWER** circuit breaker CB1 to: 1) the contacts of high voltage step contactor K7, 2) the contacts of high voltage start contactor K4, and 3) the contacts of filament/driver contactor K3 (see Figure 4–2). Power is also applied through **BLOWER** circuit breaker CB2 to the transmitter controller, the automatic power control unit, and to blower control relay K1.

4–48. When the **FILAMENT ON** switch/indicator is depressed, optically–coupled–relay K1 will apply power to blower B1, flushing fans B2 and B3, and energize high voltage shorting solenoid K5. After the blower comes up to speed, the air interlock will close and optically–coupled–relay K2 will energize filament/driver contactor K3 which applies power to: 1) the PA filament supply, 2) the PA control grid supply, 3) the hum–null power supply, 4) the FM exciter, 5) the IPA stage, and 6) the optional stereo and SCA generators.

4–49. Assuming the **HIGH VOLTAGE ON** switch/indicator has been depressed, and the PA filament heating delay of at least ten seconds has expired, optically–coupled–relay K6 will pulse step contactor K7. After the current inrush to the plate supply has been limited by the step/start resistors (R1, R2, and R3), optically–coupled–relay K5 will energize start contactor K4 to apply full input to the plate and screen power supplies.

4–50. If during a start sequence a safety interlock opens, the entire start sequence will be cancelled and must be re–initiated manually. If a safety interlock opens during operation, the entire power supply section will deenergize. However, if the interlock is promptly closed, the blower and flushing fans will resume operation to cool the PA tube but a new start sequence will have to be initiated manually. Whenever power is removed from the blower and flushing fans, the high voltage discharge solenoid will short the plate supply to ground.

4–51. If the **HIGH VOLTAGE OFF** switch/indicator is depressed, the plate and screen power supplies will deenergize. If the **FILAMENT OFF** switch/indicator is depressed, all remaining power supplies will deenergize. The blower and flushing fans will continue operation for 30 seconds or more to cool the PA tube, then deenergize.

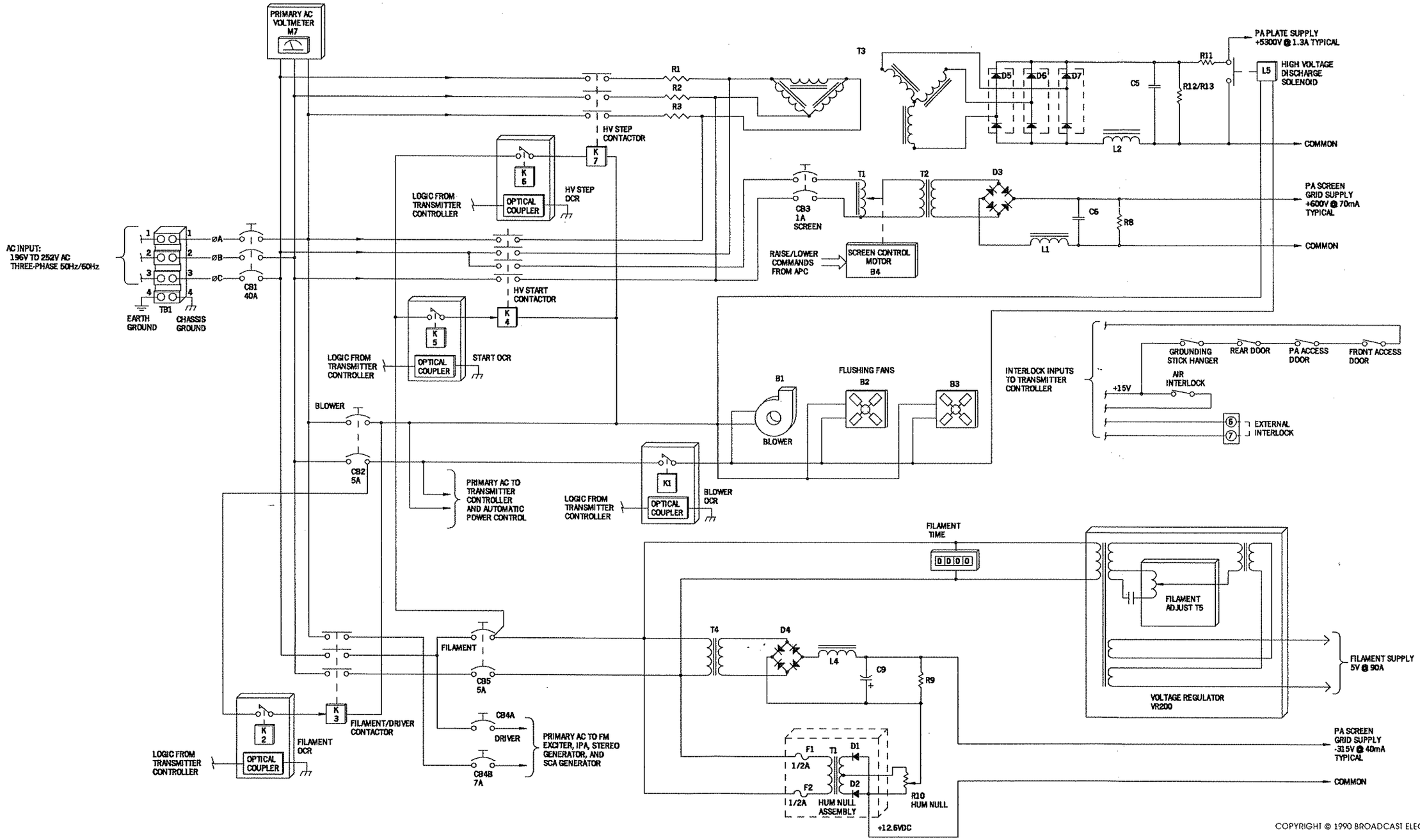
4–52. **PA PLATE POWER SUPPLY.** The plate power supply is a three–phase primary, six–phase secondary supply. The primary circuit is connected in a closed delta arrangement and protected by circuit breaker CB1. Component stress at power on is eliminated by a step/start circuit which limits supply inrush current.

4–53. The secondary of the high voltage transformer is connected in a wye configuration. Due to the physical construction of the transformer, each phase appearing in the secondary will lead and lag a respective phase appearing in the primary by 60 degrees. The secondary phase separation of 60 degrees divided into one primary phase of 360 degrees equals six secondary phases.

4–54. Minimal filtering is required as only 4.2 percent ripple is output from the rectifiers. One requirement of the multiphase supply, however is that the primary ac input must be balanced to within the percentage of ripple voltage which is to be obtained from the supply. Constant primary ac line unbalance can be corrected by the use of primary taps or a tapped three–phase autotransformer.

4–55. Filtering for the supply is accomplished by a one–section choke–input filter. The choke is inserted in the negative leg of the rectified output to eliminate the dc potential between the choke and ground. The negative leg of the supply is referenced to ground through the PA stage current meter shunt. A single shunt capacitor bypasses residual ac ripple at frequencies of 300 to 360 Hz and higher to ground. A bleeder resistor connected across the supply increases regulation and, in conjunction with high voltage discharge solenoid K5, enhances safety. A series resistance in the anode dc feedline limits peak energy in case of arc–overs in the power amplifier stage or high voltage discharge solenoid operations.

4–56. Component stress at power–on is eliminated by a step/start circuit which limits plate supply inrush current. The step/start circuit is interlocked through contacts of the filament circuit breaker and the filament/driver contactor to assure that the filament circuit is energized before a high–voltage–on sequence can be initiated. The controller will energize the step contactor via K6. After 100 milliseconds, the controller will energize the start contactor via K5. The step contactor will deenergize after it has been energized for 160 milliseconds. In this manner, the current limiting resistors will only be subject to heating during a 100 millisecond interval between the step/start relay closures.



597-0033-3

FIGURE 4-2. FM-5B POWER SUPPLY SIMPLIFIED SCHEMATIC

4–57. **PA SCREEN GRID POWER SUPPLY.** The screen power supply is a full–wave bridge–rectified supply with a single L–section filter. The primary of the screen transformer is connected through CB3 to the step/start contactors. The output of the screen supply is adjustable with a variable autotransformer connected in the primary of the screen transformer. A dc motor connected to the variable autotransformer allows both manual and automatic control of the screen voltage. The choke in this supply is connected in the negative leg of the supply to eliminate the dc potential between the choke and ground. A bleeder resistor connected across this supply improves regulation and enhances safety by discharging C6.

4–58. **PA CONTROL GRID POWER SUPPLY.** The control grid bias supply is a full–wave bridge–rectified supply with a single L–section filter. The primary of the supply is connected to the primary ac input through CB5 and filament/driver contactor K3. A bleeder resistor connected across this supply improves regulation and enhances safety by discharging C9, a relatively high capacity electrolytic capacitor.

4–59. **Hum Null Supply.** The ground path for the grid bias supply is routed through the hum–null circuit which introduces a small 120 Hz pulsating dc component into the control grid bias supply to cancel hum in the PA tube from the screen supply. The amount of voltage added to the negative side of the control grid bias supply is adjusted by R10. This voltage is out–of–phase with the 120 Hz ripple component of the screen supply.

4–60. **PA FILAMENT SUPPLY.** The PA filament supply is connected to the primary ac input through circuit breaker CB5 and filament/driver contactor K3. **FILAMENT ADJUST** control R4 in the primary of the filament transformer allows filament voltage adjustment. **FILAMENT TIME** meter M2 indicates hours of filament circuit operation. A fusible link in the center–tap of the filament transformer secondary provides overload protection for the filament supply wiring if a short–circuit to ground should develop in either leg of the filament supply. Individual fuses protect the wiring to the iron–vane **FILAMENT VOLTAGE** meter.

4–61. **FM–5BS POWER SUPPLY.**

4–62. A 196 volt to 252 volt, 50 Hz or 60 Hz, single–phase ac input is required for operation of the FM–5BS transmitter. The following supplies operate from the ac input (typical values are shown for the rated RF power output):

PARAMETER	APPROXIMATE VALUES
A. PA PLATE	+5300V at 1.3 Amperes
B. PA SCREEN GRID	+525V at 0.060 Amperes
C. PA CONTROL GRID	–260V at 0.045 Amperes
D. PA FILAMENT	5V ac at 90 Amperes
E. HUM NULL	+12.6V at 0.040 Amperes

4–63. **SEQUENCE OF OPERATION.** Power is applied through **AC POWER** circuit breaker CB1 to: 1) the contacts of high voltage step contactor K7, 2) the contacts of high voltage start contactor K4, and 3) the contacts of filament/driver contactor K3 (see Figure 4–3). Power is also applied through **BLOWER** circuit breaker CB2 to: 1) the transmitter controller, 2) the automatic power control unit, 3) to blower control relay K1, and 4) to filament control relay K2.

4–64. When the **FILAMENT ON** switch/indicator is depressed, optically–coupled–relay K1 will apply power to blower B1, flushing fans B2 and B3, and energize high voltage shorting solenoid K5. After the blower comes up to speed, the air interlock will close and optically–coupled–relay K2 will energize filament/driver contactor K3 which applies power to: 1) the PA filament supply, 2) the PA control grid supply, 3) the hum–null power supply, 4) the FM exciter, 5) the IPA stage, and 6) the optional stereo and SCA generators.

4–65. Assuming the **HIGH VOLTAGE ON** switch/indicator has been depressed, and the PA filament heating delay of at least ten seconds has expired, optically–coupled–relay K6 will pulse step contactor K7. After the current inrush to the plate supply has been limited by the step/start resistors (R1 and R2), optically–coupled–relay K5 will energize start contactor K4 to apply full input to the plate and screen power supplies.

4–66. If during a start sequence an interlock opens, the entire start sequence will be cancelled and must be re–initiated manually. If an interlock opens during operation, the entire power supply section will deenergize. However, if the interlock is promptly closed, the blower and flushing fans will resume operation to cool the PA tube but a new start sequence will have to be initiated manually. Whenever power is removed from the blower and flushing fans, the high voltage discharge solenoid will short the plate supply to ground.

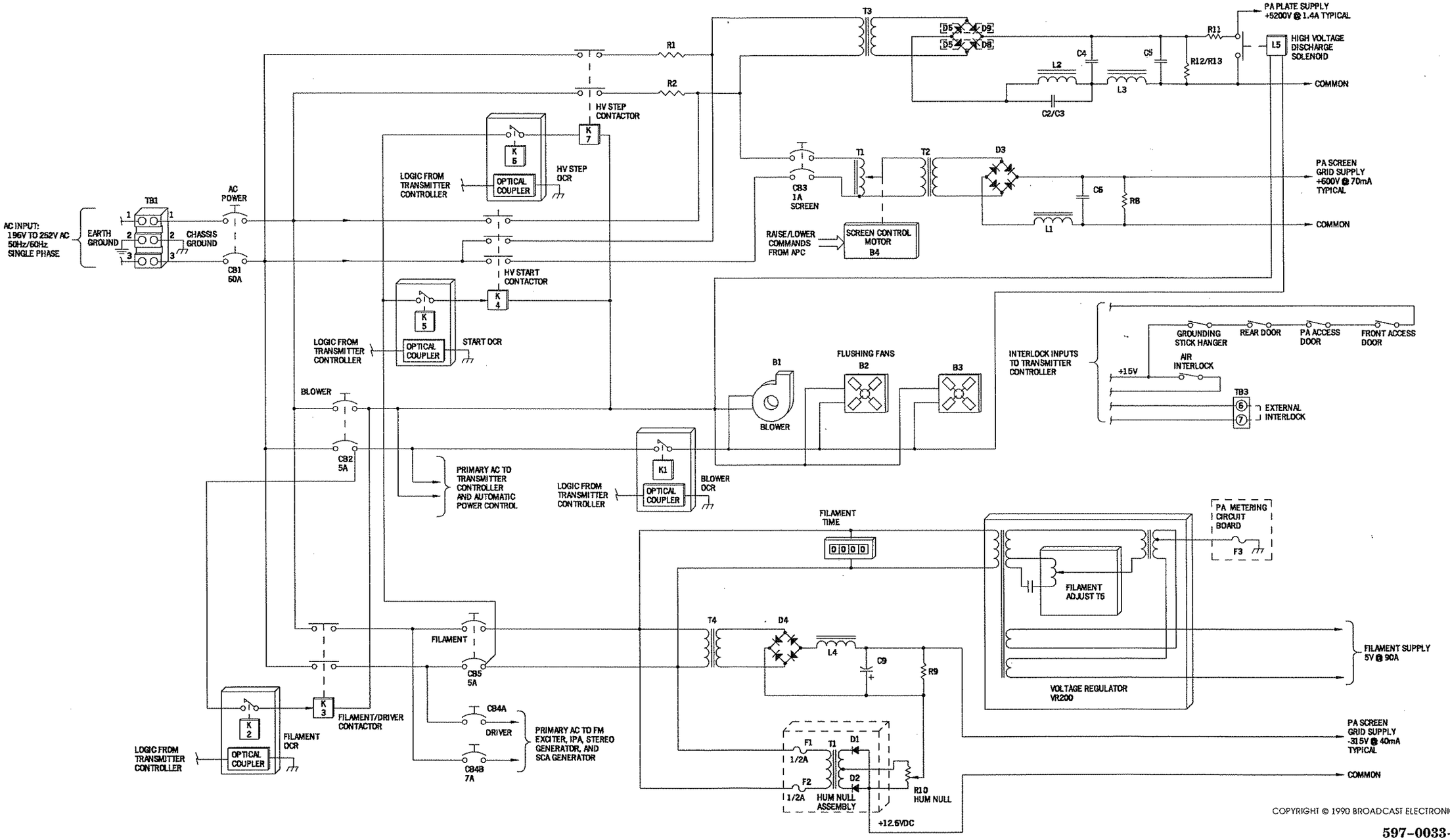
4–67. If the **HIGH VOLTAGE OFF** switch/indicator is depressed, the plate and screen power supplies will deenergize. If the **FILAMENT OFF** switch/indicator is depressed, all remaining power supplies will deenergize. The blower and flushing fans will continue operation for 30 seconds or more to cool the PA tube, then deenergize.

4–68. **PA PLATE POWER SUPPLY.** The plate power supply is a full–wave bridge–rectified supply with a two–section filter. The first filter section includes a 120 Hz resonant choke. This section provides good load regulation, low 120 Hz ripple, and lower stored energy than conventional filter sections with similarly sized components. The filter location in the negative leg of the rectifier output eliminates the dc potential between the choke and ground. A pi–section filter follows the resonant choke which reduces high frequency components which are passed by the resonant choke. The choke in the pi–section is also connected in the negative leg of the supply to eliminate the dc potential between the choke and ground. A bleeder resistor connected across the supply improves regulation, and in conjunction with high voltage discharge solenoid K5, enhances safety. A series resistance in the anode dc feed limits peak energy in case of arc–overs in the power amplifier stage and during high voltage discharge solenoid operation.

4–69. Component stress at power–on is eliminated by a step/start circuit which limits plate supply inrush current. The step/start circuit is interlocked through contacts of the filament circuit breaker and the filament/driver contactor to assure that the filament circuit is energized before a high–voltage–on sequence can be initiated. The controller will energize the step contactor via K6. After 100 milliseconds, the controller will energize the start contactor via K5. The step contactor will deenergize after it has been energized for 160 milliseconds. In this manner, the current limiting resistors will only be subject to heating during a 100 millisecond interval between the step/start relay closures. The limiting resistors are disconnected from the lines after 160 milliseconds, improving reliability.

4–70. **PA SCREEN GRID POWER SUPPLY.** The screen power supply is a full–wave bridge–rectified supply with a single L–section filter. The primary of the screen transformer is connected through CB3 to the step/start contactors. The output of the screen supply is adjustable with a variable autotransformer connected in the primary of the screen transformer. A dc motor connected to the variable autotransformer allows both manual and automatic control of the screen voltage. The choke in this supply is connected in the negative leg of the supply to eliminate the dc potential between the choke and ground. A bleeder resistor connected across this supply improves regulation and enhances safety by discharging C6.

4–71. **PA CONTROL GRID POWER SUPPLY.** The control grid bias supply is a full–wave bridge–rectified supply with a single L–section filter. The primary of the supply is connected to the primary ac input through CB5 and filament/driver contactor K3. A bleeder resistor connected across this supply improves regulation and enhances safety by discharging C9.



597-0033-5BS

FIGURE 4-3. FM-5BS POWER SUPPLY SIMPLIFIED SCHEMATIC

4–72. **Hum Null Supply.** The ground path for the grid bias supply is routed through the hum–null circuit which introduces a small 120 Hz pulsating dc component into the control grid bias supply to cancel hum in the PA tube from the screen supply. The amount of voltage added to the negative side of the control grid bias supply is adjusted by R10. This voltage is out–of–phase with the 120 Hz ripple component of the screen supply.

4–73. **PA FILAMENT SUPPLY.** The PA filament supply is connected to the primary ac input through circuit breaker CB5 and filament/driver contactor K3. **FILAMENT ADJUST** control R4 in the primary of the filament transformer allows filament voltage adjustment. **FILAMENT TIME** meter M2 indicates hours of filament circuit operation. A fusible link in the center–tap of the filament transformer secondary provides overload protection for the filament supply wiring if a short–circuit to ground should develop in either leg of the filament supply. Individual fuses protect the wiring to the iron–vane **FILAMENT VOLTAGE** meter.

4–74. **RF CIRCUITRY.**

4–75. **FM EXCITER.** The FX–50 FM exciter generates the modulated FM signal. Approximately 15 Watts of drive is required to operate the FM–5B/FM–5BS RF circuitry (see Figure 4–4). Refer to publication 597–1050 for a complete description of the FM exciter.

4–76. **INTERMEDIATE POWER AMPLIFIER.** The IPA provides an approximate gain of 10 to output approximately 150 Watts of power to drive the FM–5B/FM–5BS PA stage. The unit is totally self–contained with an internal controller and power supply. The amplifiers are configured as a class C push–pull stage. A complete description of the IPA is provided in Part II of this manual.

4–77. **POWER AMPLIFIER.** The PA stage contains a single 4CX3500A tetrode operated class C in a folded half–wave cavity to output 5 kW of RF power with approximately 150 Watts of RF drive.

4–78. **PA Input Circuit.** The grid impedance–matching circuit used in the FM–5B/FM–5BS transmitter consists of a combination of series inductor and shunt capacitor circuit board elements, implemented with a printed circuit board. The inductors and capacitors are etched into the copper–clad laminate. Multiple LC sections match the 50 Ohm source impedance to the 300 to 400 Ohm input impedance of the grid–driven RF power amplifier.

4–79. This input matching design provides wide bandwidth and improves reliability, stability, and maintainability of the transmitter. A single tuning control in the input circuit is sufficient to tune and match the 50 Ohm IPA impedance to the high input impedance of the grid over the 88 to 108 MHz FM broadcast band with a 4:1 range of RF power levels. The input–matching circuit also eliminates separately mounted components which can be microphonically sensitive to vibrations due to mechanical instability in the cooling air flow.

4–80. The grid circuit is adjusted for proper operation with two paralleled "slider" inductors which connect to ground. These controls employ sliding shorts to tune the grid capacitance to resonance. One inductor is mechanically connected to the front panel input tuning control while the other inductor is connected to a counter in the rear of the FM–5B/FM–5BS. Fine tuning is accomplished by adjusting either one of the inductors (normally the front panel control). A resistive loading component is included in the input circuit to broaden its overall response. The filament bypassing and grid blocking capacitors are specially fabricated in a sandwich–type construction with etched copper–clad Kapton dielectrics for high capacitance with negligible inductance.

4–81. The screen grid ring is connected through eight flexible adjustable straps to four copper–clad Kapton bypass capacitors to ground. Self–neutralization is accomplished by adjusting the length of the straps, thereby varying the series inductance. This introduces an out–of–phase current component causing a voltage swing across the screen to ground which cancels out the voltage fed through internal plate–to–grid capacitances of the tube. A spark gap is included to safely bypass energy if the tube should arc internally.

4–82. **Power Amplifier Cavity.** The PA cavity used in the FM–5B/FM–5BS employs a folded half–wave coaxial transmission line resonator constructed with aluminum and copper tubing. This cavity design eliminates the high voltage blocking capacitors and high current shorting contacts of conventional cavities by connecting the main transmission line conductor directly to the anode of the power tube (see Figure 4–5). A grounded concentric transmission line center conductor tunes this cavity with a variable reentrant length inserted into the end of a main inner conductor. The main inner conductor is insulated from ground and carries the anode dc potential. DC power is fed at the RF voltage null point which is approximately one–quarter wave from the anode for effective RF decoupling. A large surface area without sliding contacts results in minimal loss at this point. Incorporated into the tank design is a second–harmonic suppressor. Rather than attenuating the second harmonic after the signal has been generated and amplified, the circuitry in the FM–5B essentially eliminates formation of this signal by series LC trapping the second harmonic waveform at the point where the wave exhibits a high voltage, approximately one–quarter wave length from the anode.

4–83. Plate tuning is accomplished by an adjustable bellows on the grounded or center portion of the plate line which is maintained at chassis ground potential. The PA plate potential is applied to the main conductor (the fixed portion of the plate line) at the fundamental frequency RF voltage null point. This point is also the point at which the second harmonic will peak in voltage. The basic LC circuit placed at this point will essentially eliminate the second harmonic component in the plate current waveform.

4–84. **PA Output Circuit.** Output coupling is accomplished with an untuned loop intercepting the magnetic field concentration at the voltage null point of the main line. The PA loading control varies the angular position of the plane of the loop with respect to the plate line, changing the amount of magnetic field which it intercepts. Multiple phosphor bronze leaves connect one side of the output loop to ground and the other side to the center conductor of the output transmission line connection. This allows for mechanical movement of the loop by the PA loading control without utilizing any sliding contacts. The grounded loop improves immunity to lightning and static buildup on the antenna connection.

4–85. A pair of directional couplers located in the output transmission line provide RF output voltages proportional to the PA forward and reflected power. The RF output voltages are rectified and amplified to provide power and VSWR indications on the **OUTPUT POWER** meter, samples for the transmitter controller, and inputs to the automatic power control unit. An additional port in the transmission line provides a point to connect a station modulation monitor.

4–86. **PA METERING.** Seven meters on the FM–5B and six on the FM–5BS are used to indicate transmitter operating parameters. The plate current, multimeter, and the filament voltage meters measure samples from a PA metering circuit board which is mounted on the side of the RF enclosure. Additional samples from this circuit board are routed to the controller and APC unit for overload and diagnostic features. The PA metering circuit board also contains fuses which protect the filament meter wiring. Plate voltage metering is obtained from a high voltage meter multiplier circuit board. Power output metering is derived from circuitry within the automatic power control unit. A filament time meter indicates total elapsed time of filament circuit operation. The filament voltage meter is an iron vane type and accurately measures the filament voltage at the cavity feed–thru terminals. On FM–5B models, monitoring of ac input potentials is provided by a primary ac voltage meter.

4–87. **AUTOMATIC POWER CONTROL.** The automatic power control unit (APC) monitors a number of transmitter parameters to function as part of a closed loop which maintains a constant RF output level from the transmitter (see Figure 4–4).

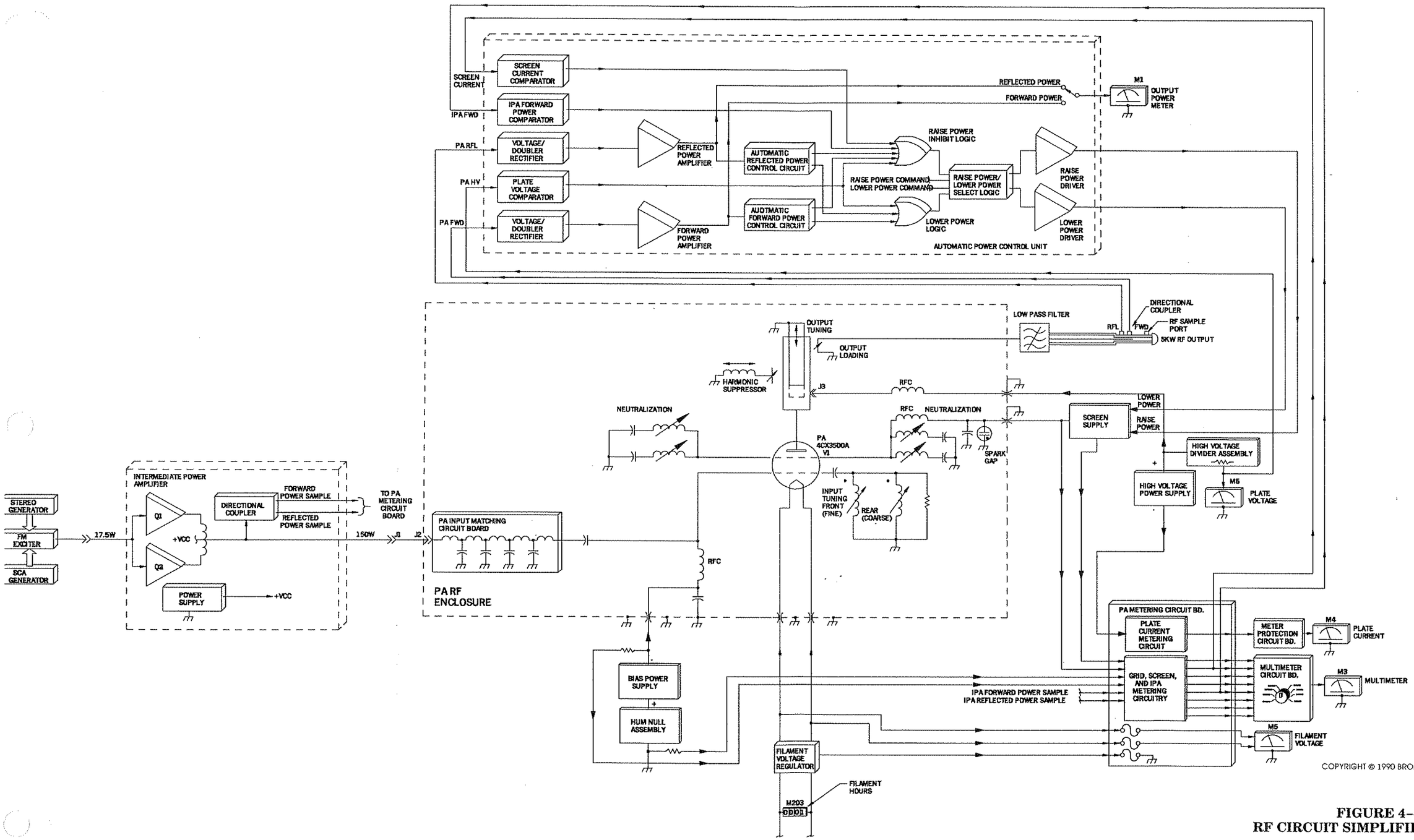


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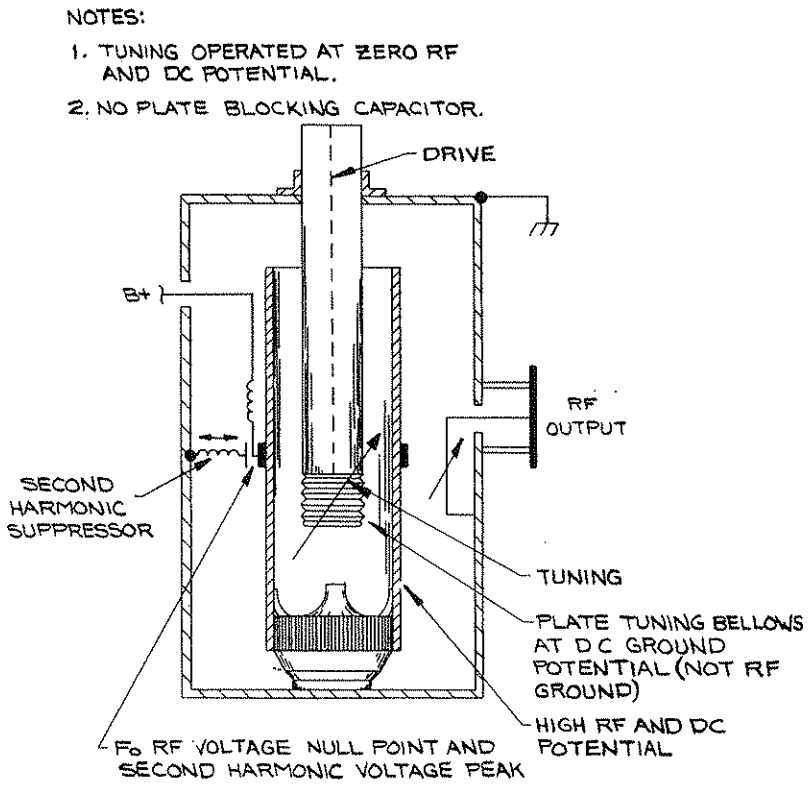
FIGURE 4-4.
RF CIRCUIT SIMPLIFIED SCHEMATIC



597-0032-32

FIGURE 4-5. PA CAVITY

4–88. PA forward and reflected power samples are voltage doubled and rectified, then amplified and applied to the **OUTPUT POWER** meter to provide indications of transmitter operation. The amplified power samples are also applied to the forward and reflected automatic power control circuits which control the adjustable screen supply autotransformer when automatic power control is enabled. As RF power varies, the forward automatic power control circuit will act to maintain the established RF output level. If inadequate IPA drive exists for normal operation or if PA reflected power increases (or screen current is high), any power increase will be inhibited. If the PA reflected power increases to a point which may damage the RF circuitry of the transmitter, the circuit will reduce the RF output to a safe level and the transmitter will continue to operate. Full power will be automatically re–established when the VSWR condition is corrected.

4–89. As an additional function, a soft start circuit monitors PA plate voltage. This circuit reduces the PA screen potential to minimum whenever plate voltage is off. Whenever the plate voltage is energized, the circuit will gradually increase the PA screen voltage until the rated transmitter RF output is established unless limited by low IPA drive, a high VSWR condition or high screen current.

SECTION V
MAINTENANCE

5–1. INTRODUCTION.

5–2. This section provides general maintenance information, electrical adjustment procedures, and troubleshooting information for the FM–5B/FM–5BS transmitters.

5–3. SAFETY CONSIDERATIONS.

WARNING *NEVER OPEN THE EQUIPMENT UNLESS ALL TRANSMITTER PRIMARY POWER IS DISCONNECTED. USE*

WARNING *THE GROUNDING STICK PROVIDED TO ENSURE ALL COMPONENTS AND ALL SURROUNDING COMPONENTS ARE DISCHARGED BEFORE ATTEMPTING MAINTENANCE ON ANY AREA WITHIN THE TRANSMITTER.*

5–4. The FM–5B/FM–5BS transmitters contain high voltages and currents which, if regarded carelessly, could be fatal. The transmitter has many built–in safety features, however good judgement, care, and common sense are the best accident preventives. The maintenance information contained in this section should be performed only by trained and experienced maintenance personnel.

5–5. It is very dangerous to attempt to make measurements or replace components with power energized, therefore such actions are not recommended. The design of the equipment provides safety features such that when a door is opened or access panel is removed, interlock switches will deenergize all dc power supplies and release the fail–safe discharge solenoid across the plate supply. Do not short out or bypass interlock switches as a maintenance short cut.

5–6. The PA cavity access door actuates an interlock switch if the door is opened during transmitter operation. All dc supplies will be deenergized and the plate supply will be shorted to ground. AC power to the entire cabinet may be disconnected with the front panel **AC POWER ON/OFF** circuit breaker.

5–7. A grounding stick is provided as a safety feature. The grounding stick consists of a metal hook with an insulated handle. The metal end is connected to chassis ground. Use the grounding stick to touch every part in the area or circuit on which maintenance is to be performed before attempting maintenance.

5–8. The grounding stick rests on a hook switch. When the grounding stick is removed, the associated hook switch will open the transmitter interlock string and deenergize all transmitter dc potentials until the grounding stick is replaced on its respective hook switch.

5–9. FIRST LEVEL MAINTENANCE.

WARNING *WARNING* — ***DUE TO THE PROGRAMMING OF THE EQUIPMENT, THE AFC UNIT WILL ENTER THE REMOTE ENABLED MODE WHENEVER AC POWER IS APPLIED. TO PREVENT INADVERTENT REMOTE START–UP DURING MAINTENANCE PERIODS, DISCONNECT POWER FROM THE TRANSMITTER AND INSTALL JUMPER P14 ON THE APC UNIT MAIN CIRCUIT BOARD IN POSITION 1–2.***

5–10. First level maintenance consists of those precautionary measures applied to the equipment to forestall future failures. These procedures are performed on a regular basis and the results recorded in a maintenance log. Preventive maintenance of the transmitter consists of good housekeeping, lubrication, and checking the performance levels using the meters and various indicators built into the equipment.

WARNING *WARNING* — ***NEVER OPEN THE EQUIPMENT UNLESS ALL TRANSMITTER PRIMARY POWER IS DISCONNECTED. USE THE GROUNDING STICK PROVIDED TO ENSURE ALL COMPONENTS AND ALL SURROUNDING COMPONENTS ARE DISCHARGED BEFORE ATTEMPTING MAINTENANCE ON ANY AREA WITHIN THE TRANSMITTER.***

5–11. On a regular basis, clean the equipment of accumulated dust. Check for overheated components, tighten loose hardware, and lubricate mechanical surfaces as required. A lubricant such as "Lubriplate" should be applied sparingly to the tuning drives, cables, the PA tuning line right angle gear mechanism, and the cyclometer drives behind the front panel. The PA output loading screw drive should be opened (four screws) and lubricated every 36 months, or more often if resistance is noted.

5–12. Periodically, the transmitter controller battery should be checked by depressing the controller battery test switch. If the green battery test indicator fails to illuminate, the battery should be replaced. A good–quality alkaline battery is recommended for replacement. Typically, it is a good practice to replace the transmitter controller and automatic power control unit battery annually, regardless of the battery condition.

5–13. AIR FILTER.

5–14. Air filter replacement is accomplished outside the transmitter without interrupting equipment operation. The filter should be checked once each week with replacement done on an as–needed basis. A dirty filter could result in dirt accumulation leaking into the cabinet from seams, door jambs, etc. Never reverse a dirty filter. Always replace the filter. The transmitter controller and APC also contain air filters which should be checked monthly and cleaned as necessary.

5–15. The transmitter uses one disposable type air filter 1 inch X 16 inches X 20 inches (2.54 cm X 40.64 cm X 50.8 cm) mounted in the rear door of the cabinet. Additional filters may be ordered for replacement (P/N 407–0062) or locally purchased. Always mount the filter with the airflow arrow pointing towards the blower.

5–16. BLOWER MAINTENANCE.

WARNING ***NEVER OPEN THE EQUIPMENT UNLESS ALL TRANSMITTER PRIMARY POWER IS DISCONNECTED. USE***

WARNING ***THE GROUNDING STICK PROVIDED TO ENSURE ALL COMPONENTS AND ALL SURROUNDING COMPONENTS ARE DISCHARGED BEFORE ATTEMPTING MAINTENANCE ON ANY AREA WITHIN THE TRANSMITTER.***

5–17. Inspect the blower and the cabinet flushing fans for dust accumulation and periodically clean the blower and fans using a paint brush and vacuum cleaner. Both the fan and blower bearings are sealed and do not permit lubrication. If a bearing fails, the motor must be replaced. The blower and fan mounting bolts should be checked for tightness.

5–18. The blower and fan motors are cooled by the air passing around each motor. If the ambient air temperature is too high or if the air flow is restricted, then the lubricant will gradually vaporize from the motor bearings and bearing failure will occur. If very dirty air passes over the motors, accumulated dust will impair the motor cooling unless the accumulation is wiped from and blown out of the motor.

5–19. The blower and fan impeller blades should be inspected and cleaned periodically. If the transmitter is operated in a very dusty environment, dust will build up on the concave side of the blower and fan impellers. If this happens, air flow will be reduced and unbalance will result with a possibility of damage to the blower or fans.

5–20. SECOND LEVEL MAINTENANCE.

WARNING ***DUE TO THE PROGRAMMING OF THE EQUIPMENT, THE AFC UNIT WILL ENTER THE REMOTE ENABLED***

WARNING ***MODE WHENEVER AC POWER IS APPLIED. TO PREVENT INADVERTENT REMOTE START–UP DURING MAINTENANCE PERIODS, DISCONNECT POWER FROM THE TRANSMITTER AND INSTALL JUMPER P14 ON THE APC UNIT MAIN CIRCUIT BOARD IN POSITION 1–2.***

5–21. Second level maintenance consists of procedures required to restore the transmitter to satisfactory operation after a fault has occurred.

5–22. The maintenance philosophy for the FM–5B/FM–5BS transmitters consists of problem isolation to a specific area. Subsequent troubleshooting provided by each applicable assembly publication in Part II of this manual will assist problem isolation to a replaceable assembly or component. If desired, a replaceable assembly may be returned to the factory for repair or exchange.

5–23. **GENERAL.**

5–24. **PA STAGE.** Power amplifier tube life is a result of several circuit parameters. Usually, the first indication of the decline of a tube is a slight reduction in power output. This can normally be corrected by a small increase in filament voltage. It may be wise to order a new tube at this time. Further reductions in power output can be compensated in the same manner only a limited number of times. Refer to the Eimac application paper titled "Extending Transmitter Tube Life" included in the "Manufacturers Data" section of this manual. Excess control grid or screen grid dissipation will shorten the life of a tube. Also, excess plate dissipation signals nothing but trouble. PA efficiency versus RF power is plotted on Figure 5–1 and should be referenced to estimate PA efficiency for a particular power level.

5–25. **PA Tube Warranty.** The FM–5B/FM–5BS PA tube is covered by warranty from the Varian/Eimac Company, the tube manufacturer, not Broadcast Electronics, Inc. However, a tube purchased from Broadcast Electronics which is defective must be returned to Broadcast Electronics with a customer–completed warranty claim service report. A warranty claim service report form is shipped with each tube obtained from Broadcast Electronics, Inc. Following this procedure will expedite immediate shipment of a new tube. Contact the Broadcast Electronics, Inc. Customer Service Department for additional details as required. It is recommended that the warranty report be filled out as soon as the new tube is placed in operation while the nominal voltages are known.

WARNING
WARNING

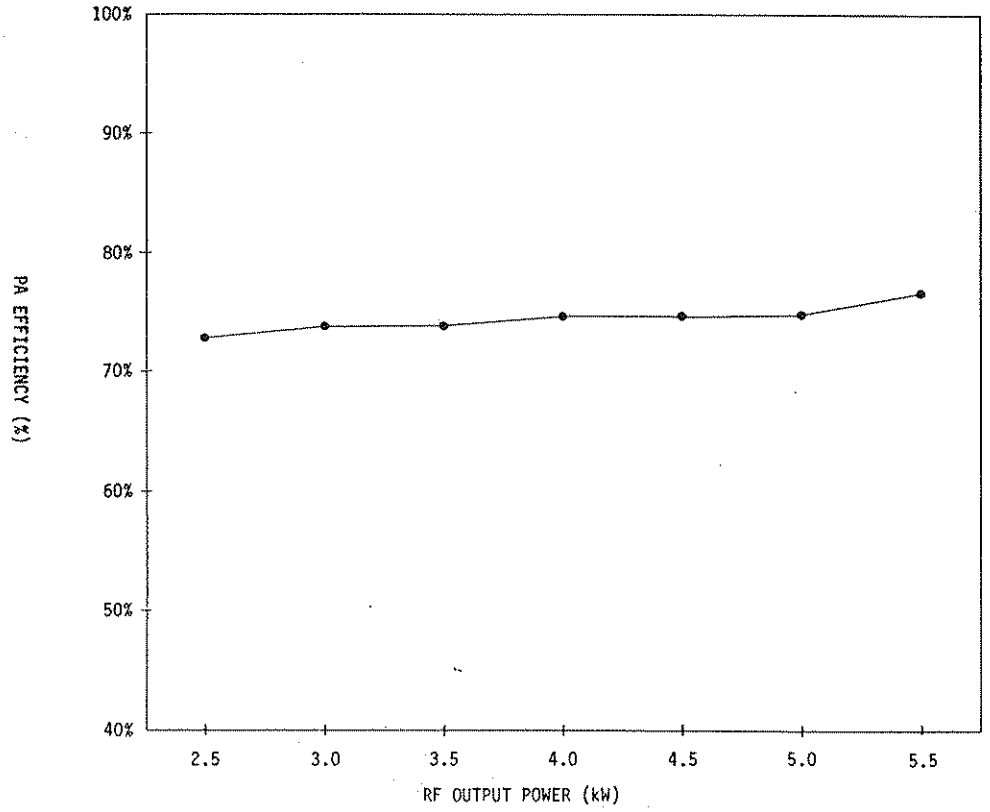
BERYLLIUM OXIDE CERAMICS (BeO) – AVOID BREATHING DUST OR FUMES.

WARNING
WARNING

THE WHITE CASE MATERIAL OF THE FM–5B/FM–5BS IPA STAGE RF AMPLIFIER TRANSISTORS IS MADE OF BeO CERAMIC MATERIAL. DO NOT PERFORM ANY OPERATION ON ANY BeO CERAMIC WHICH MIGHT PRODUCE DUST OR FUMES, SUCH AS GRINDING, GRIT BLASTING, OR ACID CLEANING. BERYLLIUM OXIDE DUST OR FUMES ARE HIGHLY TOXIC AND BREATHING THEM CAN RESULT IN SERIOUS PERSONAL INJURY OR DEATH. BeO CERAMICS MUST BE DISPOSED OF ONLY IN A MANNER PRESCRIBED BY THE DEVICE MANUFACTURER. USE CARE IN REPLACING TRANSISTORS OF THIS TYPE.

WARNING
WARNING

5–26. **IPA STAGE.** The transistors in the intermediate power amplifier will normally last many times longer than the power amplifier tube unless some major fault occurs such as a regulator malfunction. For further information, refer to the IPA assembly publication in Part II of this manual.



597–0033–11

FIGURE 5–1. TYPICAL PA EFFICIENCY CURVE AT 98.1 MHz (Within ±2% from 87.5 to 108 MHz)

5–27. ADJUSTMENTS.

WARNING ***NEVER OPEN THE EQUIPMENT UNLESS ALL TRANSMITTER PRIMARY POWER IS DISCONNECTED. USE***

WARNING ***THE GROUNDING STICK PROVIDED TO ENSURE ALL COMPONENTS AND ALL SURROUNDING COMPONENTS ARE DISCHARGED BEFORE ATTEMPTING ANY MAINTENANCE.***

5–28. Adjustment procedures for controls associated with the IPA, APC unit, and the transmitter controller are presented in each applicable publication in Part II of this manual. Adjustment procedures for the power supply and PA controls are presented as follows:

A. AM Noise.

B. Plate Current Meter Calibration.

C. Second Harmonic Suppressor Adjustment.

D. Neutralization.

5–29. **AM NOISE.** The FM–5B/FM–5BS transmitters are equipped with an **AM NOISE** test receptacle. The test receptacle is located on the APC unit and provides a calibrated AM waveform sample for direct measurement of synchronous and asynchronous AM noise parameters. Refer to the following text for procedures to minimize AM noise parameters in the transmitter.

5–30. **Synchronous AM Noise.** Synchronous AM noise is incidental amplitude modulation of the carrier by the presence of FM modulation. The synchronous AM noise level is related to: 1) the transmitter overall bandwidth and 2) transmitter tuning. An application paper titled "TECHNIQUES FOR MEASURING SYNCHRONOUS AM NOISE IN FM TRANSMITTERS" is available from Broadcast Electronics, Inc. The paper presents detailed information on AM noise measurements and procedures for tuning the transmitter to minimize the synchronous AM noise level. If adjustment of the transmitter is desired, perform the procedures in the application paper and tune the transmitter for a minimum synchronous AM noise level.

5–31. **Asynchronous AM Noise.** Asynchronous AM noise is residual amplitude modulation of the transmitter output due primarily to power supply ripple. The transmitter hum null circuit injects a small 60 Hz voltage into the bias power supply to cancel ac components in the supply and reduce asynchronous AM noise. Adjustment of the circuit will not normally be required in the field. However, if it is certain that hum null circuit adjustment is required, proceed as follows.

5–32. **Required Equipment.** The following equipment is required to adjust the hum null circuit.

A. Distortion analyzer (Tektronics Model AA501 or equivalent).

B. One locally fabricated test cable consisting of the following:

A. 10 feet (3.05 m) of Belden RG58A/U coaxial cable (BE P/N 622–0050).

B. Two BNC connectors (Pomona UG68/U–BE P/N 417–0205).

WARNING *NEVER OPEN THE EQUIPMENT UNLESS ALL TRANSMITTER PRIMARY POWER IS DISCONNECTED. USE*

WARNING *THE GROUNDING STICK PROVIDED TO ENSURE ALL COMPONENTS AND ALL SURROUNDING COMPONENTS ARE DISCHARGED BEFORE ATTEMPTING ANY MAINTENANCE.*

5–33. **Procedure.** To adjust the hum null circuit, proceed as follows:

5–34. Refer to Figure 5–2 and connect the distortion analyzer to the APC unit **AM NOISE** test receptacle using the coaxial test cable (Item B). Configure the distortion analyzer for dBm level indications.

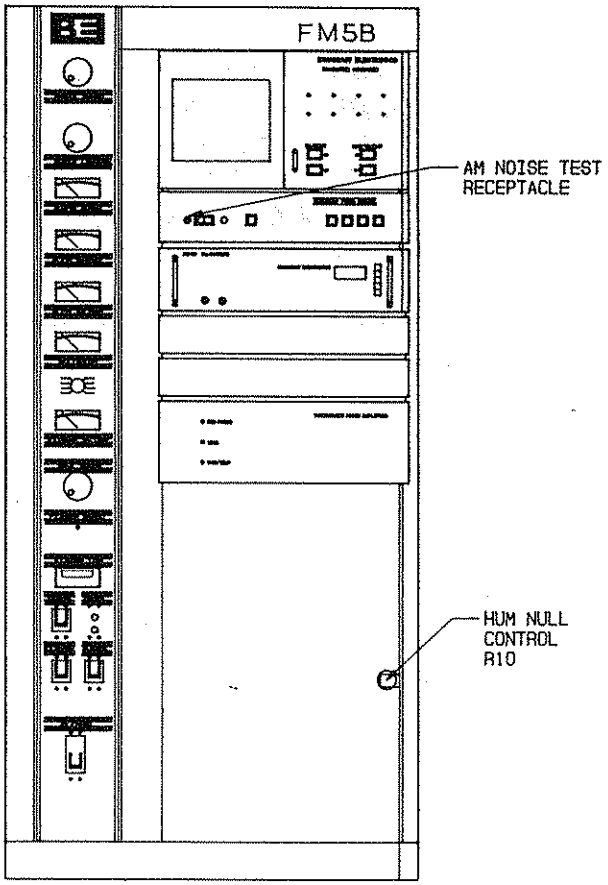
5–35. Operate the transmitter at a normal output power level.

5–36. Refer to Figure 5–2 and adjust hum null control R10 for a minimum asynchronous AM noise indication on the distortion analyzer.

5–37. Disconnect and remove all test equipment.

5–38. **PLATE CURRENT METER CALIBRATION.** The plate current meter assembly is equipped with a calibration control. Due to the special equipment required to adjust the calibration control, the control is not considered field adjustable. If it is certain that adjustment of the plate current meter calibration control is required, contact the Broadcast Electronics Customer Service Department for maintenance information on the plate current meter assembly.

5–39. **SECOND HARMONIC SUPPRESSOR.** Adjustment of the second harmonic suppressor in the field will not normally be required, even if the PA tube is replaced. Adjustment should be attempted only when absolutely necessary. Misadjustment of the suppressor could result in sporadic operation, possibly damaging the PA tube, the cavity, or the low–pass filter. It is suggested the customer contact the Broadcast Electronics Customer Service Department before attempting this adjustment. If it is certain that adjustment of the second harmonic suppressor is required, proceed as follows.



597–0033–128

FIGURE 5–2. HUM NULL CONTROL LOCATION

5–40. **Required Equipment.** The following equipment is required to complete adjustment of the second harmonic suppressor.

A. 1/16 inch (1.6 mm) hex wrench.

B. Tektronix Model 492 Spectrum Analyzer or the equivalent capable of displaying frequencies at twice the transmitter frequency of operation.

C. 50 Ohm 10 dB resistive attenuator pad, BNC jack to BNC plug (Texscan FP–50).

D. A cable for the spectrum analyzer comprising the following:

1. 10 feet (3.05 m) of Belden RG 58A/U coaxial cable (BE P/N 622–0050).

2. Two BNC plugs (Pomona UG88/U—BE P/N 417–0205).

E. Six inch scale.

WARNING ***NEVER OPEN THE EQUIPMENT UNLESS ALL TRANSMITTER PRIMARY POWER IS DISCONNECTED. USE THE GROUNDING STICK PROVIDED TO ENSURE ALL COMPONENTS AND ALL SURROUNDING COMPONENTS ARE DISCHARGED BEFORE ATTEMPTING ANY MAINTENANCE.***

WARNING

5–41. **Procedure.** To adjust the second harmonic suppressor, proceed as follows.

5–42. Deenergize all primary power to the transmitter.

5–43. Open the cabinet rear door.

5–44. Connect one end of the spectrum analyzer cable (Item D) to the RF sample port (J2) on the elbow near the cavity.

5–45. Connect the attenuator pad (Item C) in series with the cable and attach the attenuator pad to the spectrum analyzer input.

5–46. Close the cabinet rear door.

5–47. Energize the transmitter primary ac input.

5–48. Operate the transmitter at the normal power output and ensure all PA stage tuning and loading controls are correctly adjusted.

5–49. Record the level of the second harmonic displayed on the spectrum analyzer _____.

WARNING ***DISCONNECT ALL TRANSMITTER PRIMARY POWER BEFORE PROCEEDING.***

WARNING

5–50. Disconnect all transmitter primary power.

5–51. Open the cabinet rear door.

5–52. Loosen the two hex–head lock–screws securing the second harmonic suppressor adjustment rod very slightly—just enough to allow in and out adjustment (see Figure 5–3).

CAUTION ***THE SECOND HARMONIC SUPPRESSOR IS ADJUSTED BY SLIDING THE ADJUSTMENT ROD IN OR OUT. DO NOT ROTATE THE ROD.***

CAUTION

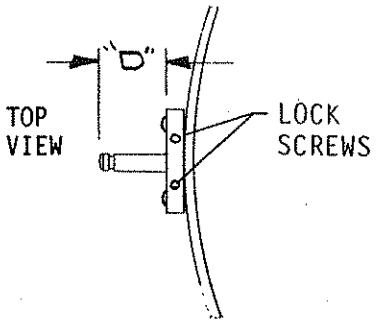
NOTE ***THE ORIGINAL HARMONIC SUPPRESSOR ADJUSTMENT DIMENSION IS RECORDED ON THE FACTORY FINAL TEST DATA SHEETS IF THE DIMENSION MUST BE REFERENCED.***

NOTE

5–53. Move the second harmonic suppressor adjustment rod slightly (approximately 1/16 inch). Record the amount moved and the direction(in or out) _____. Slightly tighten the two screws to secure the rod in place.

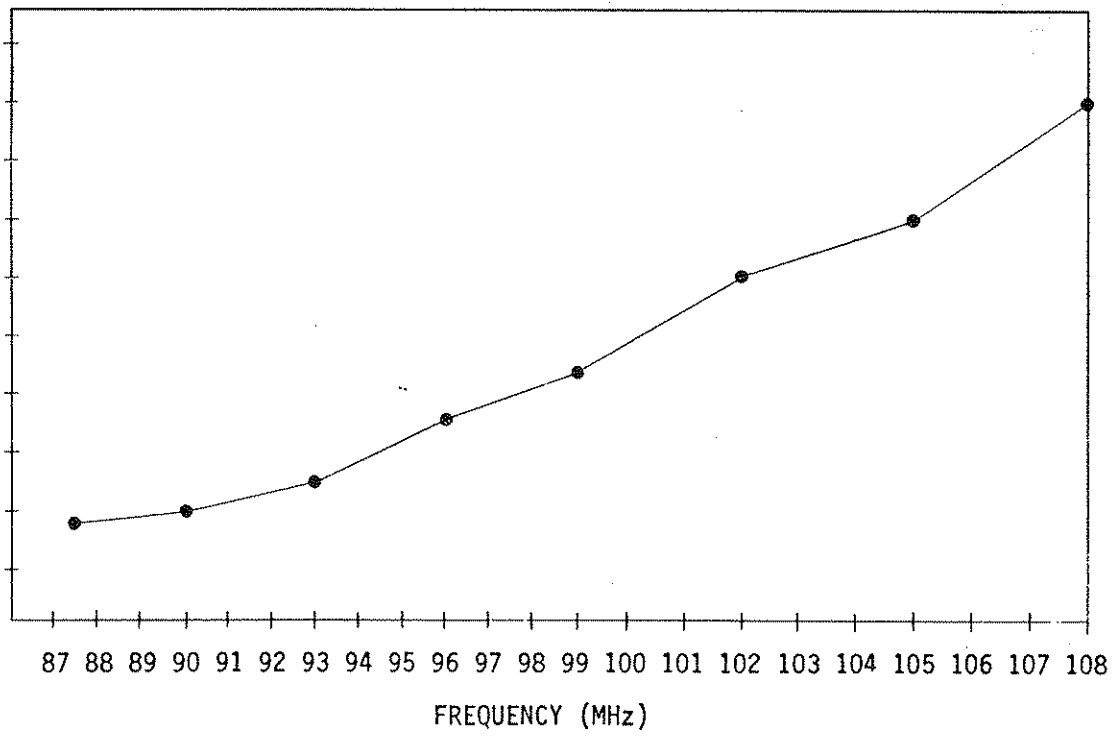
5–54. Close the cabinet rear door.

5–55. Energize the transmitter primary ac input and operate the transmitter at the normal power output.



DIMENSION "D"

CM	INCHES
5.02	2.0
4.76	1.875
4.45	1.75
4.13	1.625
3.81	1.5
3.49	1.375
3.18	1.25
2.86	1.125
2.54	1.0
2.22	0.875



597–0033–33

FIGURE 5–3. SECOND HARMONIC SUPPRESSOR COARSE SETTING

5–56. Repeat paragraphs 5–49 through 5–55, moving the second harmonic suppressor adjustment rod slightly in or out as required to minimize the second harmonic indication.

WARNING ***DISCONNECT ALL TRANSMITTER PRIMARY POWER BEFORE PROCEEDING.***

WARNING

5–57. After the correct setting of the second harmonic suppressor is determined, disconnect all transmitter primary power.

5–58. Open the cabinet rear door.

5–59. Secure both hex–head lock–screws on the second harmonic suppressor bushing (see Figure 5–3).

5–60. Disconnect the spectrum analyzer cable from J2 on the transmission line.

5–61. Close the cabinet rear door. Record the new harmonic suppressor dimension here _____.

5–62. **NEUTRALIZATION.** PA neutralization in the field will not normally be required, even if the PA tube is replaced. If it is certain that adjustment of the neutralization circuitry is required, proceed as follows.

CAUTION

CAUTION

INCORRECT NEUTRALIZATION CAN RESULT IN INSTABILITY WHICH COULD DAMAGE THE PA TUBE, CAVITY, OR LOW-PASS FILTER. CONSULT THE FACTORY BEFORE ATTEMPTING NEUTRALIZATION.

5–63. **Required Equipment.** The following equipment is required to complete PA neutralization.

A. Spectrum analyzer (Tektronix Model 492 or equivalent).

B. 25 Watt, 50 Ohm RF attenuator/termination with –20 dB sample output, type N receptacles (Bird Model 8340–030 or equivalent).

C. Two locally fabricated cables, each comprising the following:

1. 24 inches (61 cm) of Belden RG 58A/U coaxial cable (BE P/N 622–0050).

2. Two BNC plugs (Pomona UG88/U—BE P/N 417–0205).

D. Three adapters, BNC receptacle to type N plug (Pomona UG201A/U—BE P/N 417–3288).

E. No. 2 Phillips screwdriver, 4–inch (10.2 cm) blade.

F. Flat–tip screwdriver, 4–inch (10.2 cm) blade and 1/4 inch (0.64 cm) tip.

G. Exciter line cord, P/O exciter accessory pack—BE P/N 682–0001).

H. Fuse, AGC, 3A slow–blow, 120V (P/O exciter accessory pack—BE P/N 334–0300).

I. Electrical extension cord, 3–wire, 12 feet (3.7 m) long;

J. Six–inch scale, graduated in sixty–fourths of an inch.

5–64. **Procedure.** To adjust PA neutralization, proceed as follows:

5–65. Operate the transmitter at the normal power output and ensure all PA stage tuning and loading controls are correctly adjusted.

5–66. Secure the **INPUT TUNING, OUTPUT LOADING,** and **OUTPUT TUNING** control knobs in position with tape. The controls must not be moved until the entire procedure has been completed.

WARNING

WARNING

ENSURE ALL TRANSMITTER PRIMARY POWER IS DISCONNECTED BEFORE OPENING THE EQUIPMENT.

5–67. Deenergize all primary power to the transmitter.

5–68. Open the cabinet door.

5–69. Disconnect the coaxial cable from the exciter RF OUTPUT connector.

5–70. Connect a BNC–to–type N adapter on each of the RF termination connectors.

5–71. Disconnect the cable from the PA RF INPUT (J1) connector.

5–72. Connect one cable and one BNC–to–type N adapter between the PA RF INPUT (J1) connector and the RF termination –20 dB output.

5–73. Connect one cable between the exciter RF OUTPUT connector and the input to the RF termination.

5–74. Disconnect wire No. 5 from TB1–7 on the rear of the exciter and connect a temporary wire jumper from TB1–6 to TB1–7. Flag the temporary jumper with a piece of tape marked "TEMPORARY".

5–75. Disconnect the line cord plug and remove the fuse from the AC LINE VOLTAGE SELECTOR on the exciter rear panel. Cover the line cord plug with a piece of tape marked "240 VOLTS".

5–76. Remove the AC LINE VOLTAGE SELECTOR circuit board with a small pair of needle–nose pliers and record the circuit board voltage indication _____. Reinsert the circuit board so that "115/120V" is visible when the circuit board is inserted into the receptacle.

5–77. Replace the fuse with a slow–blow type rated at 3 Amperes.

5–78. Connect the accessory exciter line cord to the extension cord. Route the extension cord out through the top or bottom of the cabinet to a source of 110 to 120 Vac.

5–79. Connect the accessory exciter line cord (item G) to the exciter.

WARNING ***PRIMARY TRANSMITTER POWER MUST REMAIN OFF THROUGHOUT THE FOLLOWING PROCEDURE.***

WARNING

5–80. Assure that the exciter is operating independently of the transmitter.

5–81. Connect the spectrum analyzer to the RF sample port (J2) in the transmitter output transmission line. Adjust the analyzer to obtain a reference level display and position the analyzer so that it may be viewed from the rear of the transmitter.

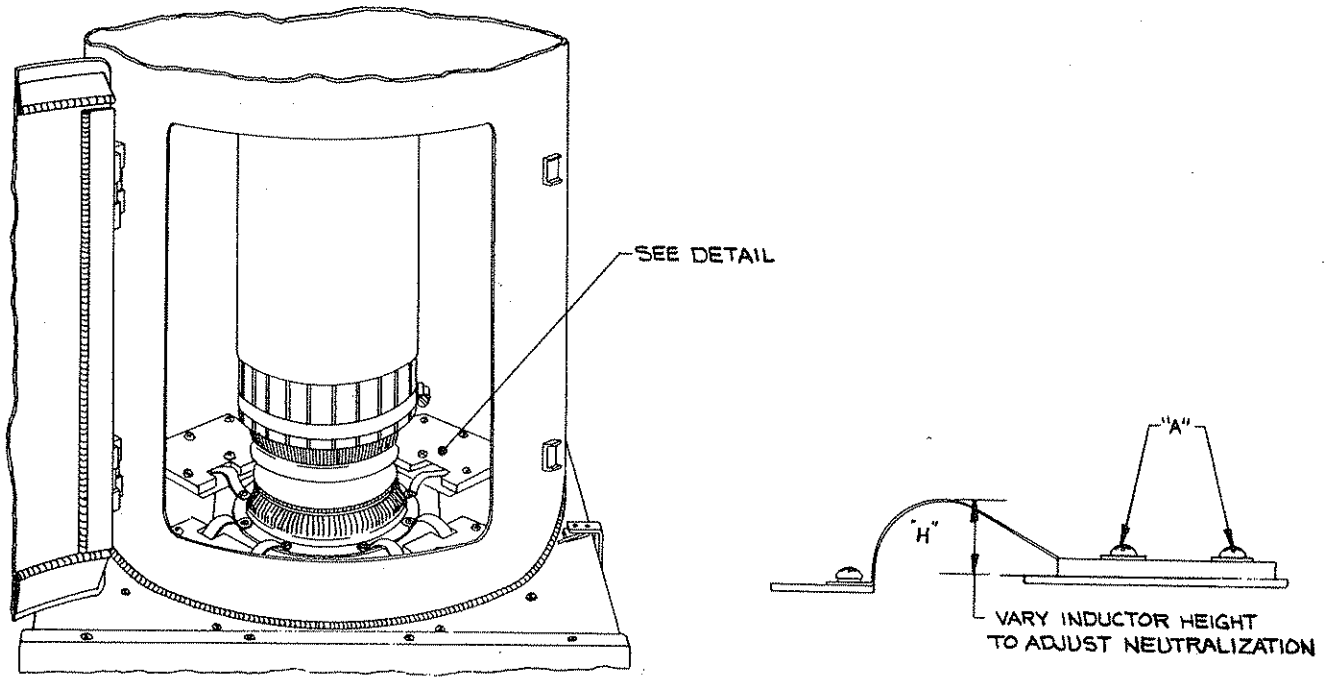
5–82. Note the position of the grounding stick in the rear of the cabinet.

WARNING ***USE THE GROUNDING STICK PROVIDED TO ENSURE NO PA TUBE POTENTIALS ARE PRESENT IN THE FOLLOWING STEP BY GROUNDING THE PA TUBE PLATE AND SCREEN CONNECTIONS BEFORE PROCEEDING.***

WARNING

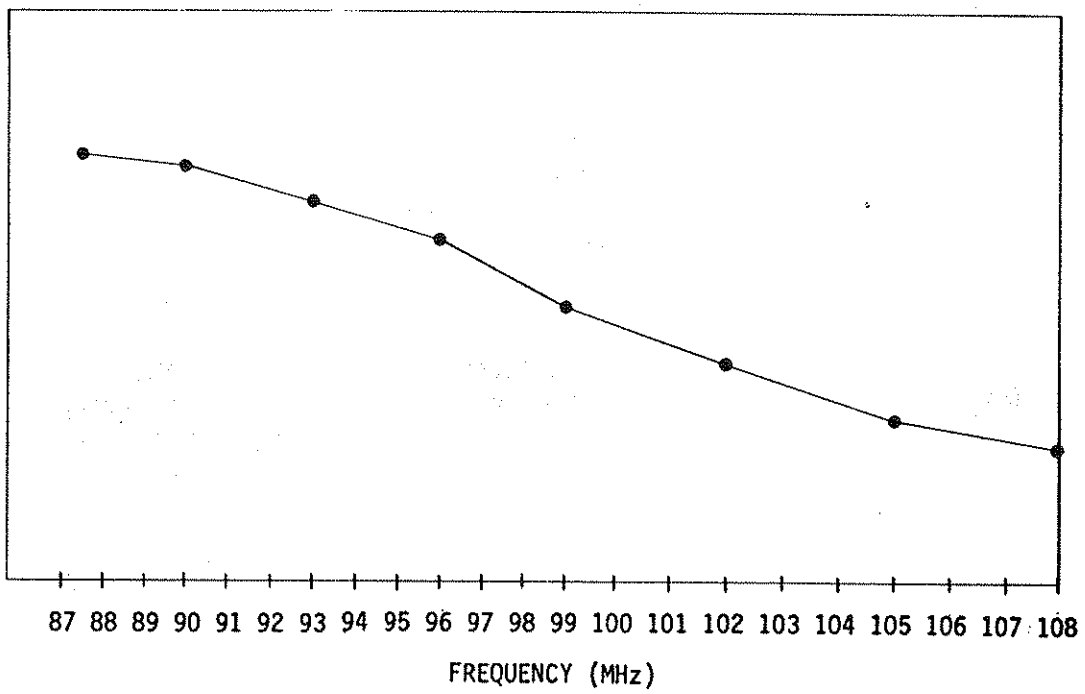
5–83. Open the PA cavity access door and ground the PA tube plate and screen connections to ensure no potentials are present in the cavity before attempting to touch anything within the cavity.

5–84. After it has been determined that no PA tube potentials are present, mark the position of the eight neutralization adjustments, (refer to Figure 5–4). Correct neutralization will be found near the original factory position (refer to Figure 5–4).



DIMENSION "H"

MM	INCHES
25.4	1.0
22.86	0.9
20.32	0.8
17.78	0.7
15.24	0.6
12.7	0.5
10.16	0.4
7.62	0.3
5.08	0.2
2.54	0.1



597-0032-35

FIGURE 5-4. NEUTRALIZATION STRAP COARSE SETTING

WARNING *BE CAREFUL WHEN ADJUSTING THE NEUTRALIZATION STRAPS WITH FINGERS AS THE EDGES OF*
WARNING *THE MATERIAL ARE VERY SHARP.*

5–85. Loosen the six screws (A, Figure 5–4) on top of each capacitor slightly—just enough to allow adjustment of each pair of inductors. When the neutralization procedure is properly completed, the height of all inductors will be approximately the same, within 1/16 inch (0.16 cm).

5–86. Neutralization is adjusted in the following manner:

A. Remove all foreign objects from the cavity then close the cavity access door.

B. Note the spectrum analyzer indication.

C. Open the cavity access door and adjust one pair of inductors very slightly. The inductors must be adjusted in pairs. Lightly secure the six screws on the capacitor plate.

D. Remove all foreign objects from the cavity and close the cavity access door.

E. Note the change in the spectrum analyzer indication.

F. Repeat steps A through E until a minimum spectrum analyzer indication is noted.

G. Repeat steps A through F for the remaining inductor pairs to minimize the spectrum analyzer indication.

H. Secure the six screws in each capacitor. When the neutralization procedure is properly completed, the height of all inductors will be approximately equal.

I. Ensure all four capacitors are secure before closing the cavity access door.

5–87. Close and latch the cavity access door. Replace the grounding stick on the hanger.

5–88. Disconnect the spectrum analyzer from the output transmission line.

CAUTION *DO NOT CONNECT THE EXCITER TO THE LINE CORD WIRED INTO THE TRANSMITTER IN THE FOLLOWING*
CAUTION *STEP.*

WARNING *DISCONNECT ALL EXCITER PRIMARY POWER BEFORE PROCEEDING.*
WARNING

5–89. Remove the electrical extension cord and exciter line cord. Do not connect the exciter to the line cord wired into the transmitter at this time.

5–90. Remove the fuse from the exciter rear panel AC LINE VOLTAGE SELECTOR.

5–91. Remove the AC LINE VOLTAGE SELECTOR circuit board with a small pair of needle–nose pliers. Reinsert the circuit board so that the voltage recorded in the preceding text is visible when the circuit board is inserted into the receptacle.

5–92. Replace the fuse with a slow–blow type rated at 1.5 Amperes.

5–93. Remove the tape from the exciter line cord and connect the plug to the exciter.

5–94. Remove the temporary wire jumper from TB1 on the exciter rear panel and reconnect wire No. 5 to TB1–7.

5–95. Remove the cabling and test load connected between the exciter RF OUTPUT connector and the PA RF INPUT (J1) connector. Remove the adapter from the PA RF INPUT (J1) connector.

5–96. Reconnect the exciter to the IPA input and reconnect the IPA output to the PA input.

5–97. **TRANSMITTER POWER LEVEL CHANGE.**

WARNING ***NEVER OPEN THE EQUIPMENT UNLESS ALL TRANSMITTER PRIMARY POWER IS DISCONNECTED. USE THE GROUNDING STICK PROVIDED TO ENSURE ALL COMPONENTS AND ALL SURROUNDING COMPONENTS ARE DISCHARGED BEFORE ATTEMPTING MAINTENANCE ON ANY AREA WITHIN THE TRANSMITTER.***

WARNING

5–98. Each transmitter is programmed, operated, and tested at a specific power level at the factory prior to shipment. If at a future date the transmitter is to be operated at a power level other than the original factory programmed level, the following transmitter parameters must be checked and adjusted if required to assure proper transmitter operation. If problems occur during initial operation, contact the Broadcast Electronics Customer Service Department for additional service procedures.

A. Refer to TRANSMITTER CONTROLLER SECTION II, MAINTENANCE and re–adjust the controller overload controls.

B. Refer to SECTION III, OPERATION and reset the APC unit operating reference.

C. Energize the transmitter primary ac power and operate the transmitter. Adjust the input tuning control for a minimum IPA reflected power indication on the multimeter (for high reflected power conditions, use the multimeter grid current function and maximum grid current information for indications of correct tuning operations).

D. Refer to APC SECTION III, MAINTENANCE and perform the FWD CAL and RFL CAL adjustment procedures.

5–99. **TRANSMITTER FREQUENCY CHANGE PROCEDURE.**

CAUTION ***CONSULT THE FACTORY BEFORE ATTEMPTING TO CHANGE THE TRANSMITTER OPERATING FREQUENCY.***

CAUTION

5–100. **GENERAL.** The following text presents an overall procedure to change the transmitter operating frequency. The procedure specifies operational adjustment procedures located throughout this publication and FX–50 exciter publication 597–1050. To change the transmitter operating frequency, proceed as follows.

5–101. **Procedure.** To change the transmitter operating frequency, proceed as follows:

WARNING *NEVER OPEN THE EQUIPMENT UNLESS ALL TRANSMITTER PRIMARY POWER IS DISCONNECTED. USE THE GROUNDING STICK PROVIDED TO ENSURE ALL COMPONENTS AND ALL SURROUNDING COMPONENTS ARE DISCHARGED BEFORE ATTEMPTING MAINTENANCE ON ANY AREA WITHIN THE TRANSMITTER.*

WARNING

WARNING *DISCONNECT ALL TRANSMITTER PRIMARY POWER BEFORE PROCEEDING.*

WARNING

5–102. Disconnect all transmitter primary power. The primary ac power must remain OFF unless specified by an adjustment procedure.

5–103. Refer to Figure 5–5A and adjust the transmitter coarse output tuning by raising or lowering the PA tuning line on top of the PA cavity. Refer to Figure 5–5B and coarse adjust the transmitter input tuning cyclometers.

5–104. Refer to Figure 5–3 and coarse adjust the transmitter second harmonic suppressor. The suppressor is adjusted by loosening the two hex–head lock screws and moving the adjustment rod in or out as required. Do not rotate the rod during adjustment.

5–105. Refer to Figure 5–4 and coarse adjust the transmitter neutralization.

5–106. Refer to FX–50 exciter publication 597–1050, PART II SECTION IV, AFC/PLL ASSEMBLY and perform the FREQUENCY SELECTION procedure. Operate and test the exciter independently from the transmitter.

5–107. Refer to IPA SECTION II, MAINTENANCE and perform the RF AMPLIFIER TUNING procedure.

5–108. Refer to IPA SECTION II, MAINTENANCE and perform the REFLECTED POWER NULL, FWD CALIBRATION, and RFL CALIBRATION adjustment procedures.

5–109. Refer to SECTION II, INSTALLATION and perform the PRELIMINARY OPERATION AND TUNING procedure to obtain a 10% power indication from the transmitter. Use a spectrum analyzer to monitor spurious activity during tuning. Also, use an in–line wattmeter connected to the transmitter output transmission line for all power output indications.

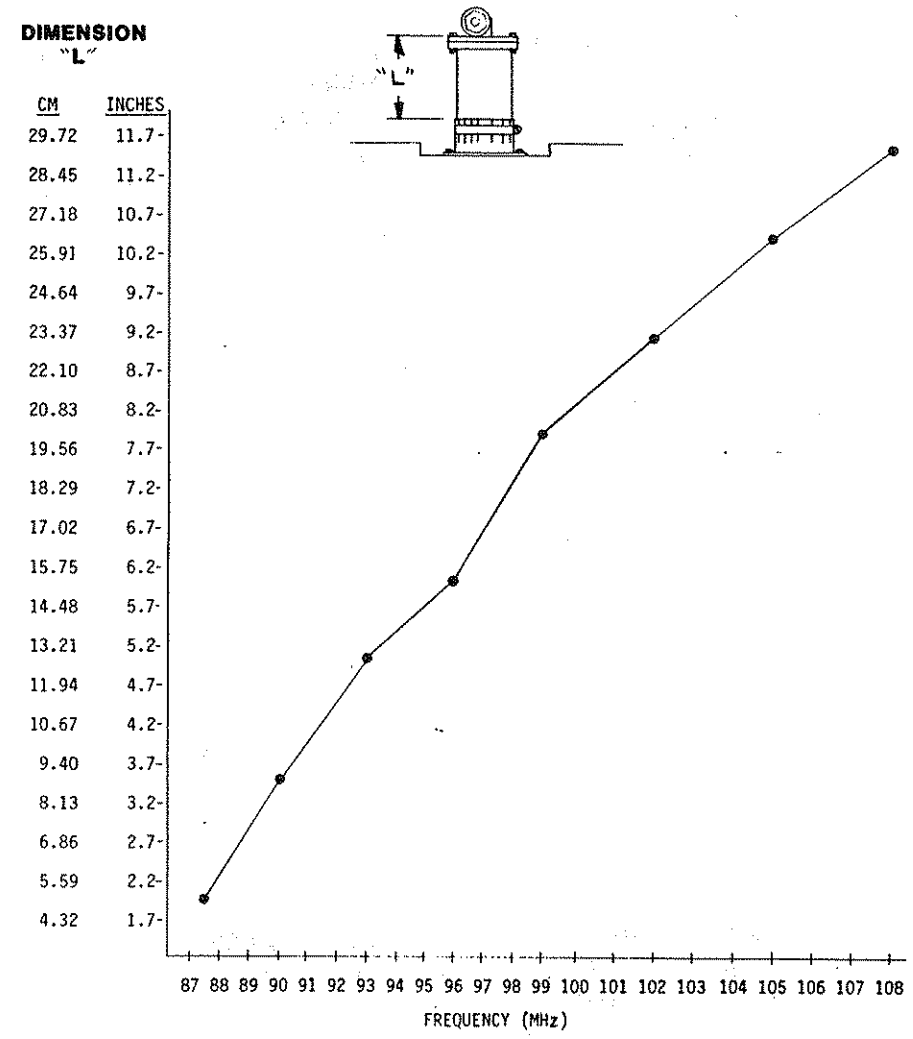
5–110. Refer to the adjustment procedures in the preceding text and perform the NEUTRALIZATION procedure.

5–111. Refer to SECTION II, INSTALLATION and complete the PRELIMINARY OPERATION AND TUNING procedure to obtain a 100% power indication from the transmitter.

5–112. Refer to the adjustment procedures in the preceding text and perform the SECOND HARMONIC SUPPRESSOR adjustment procedure.

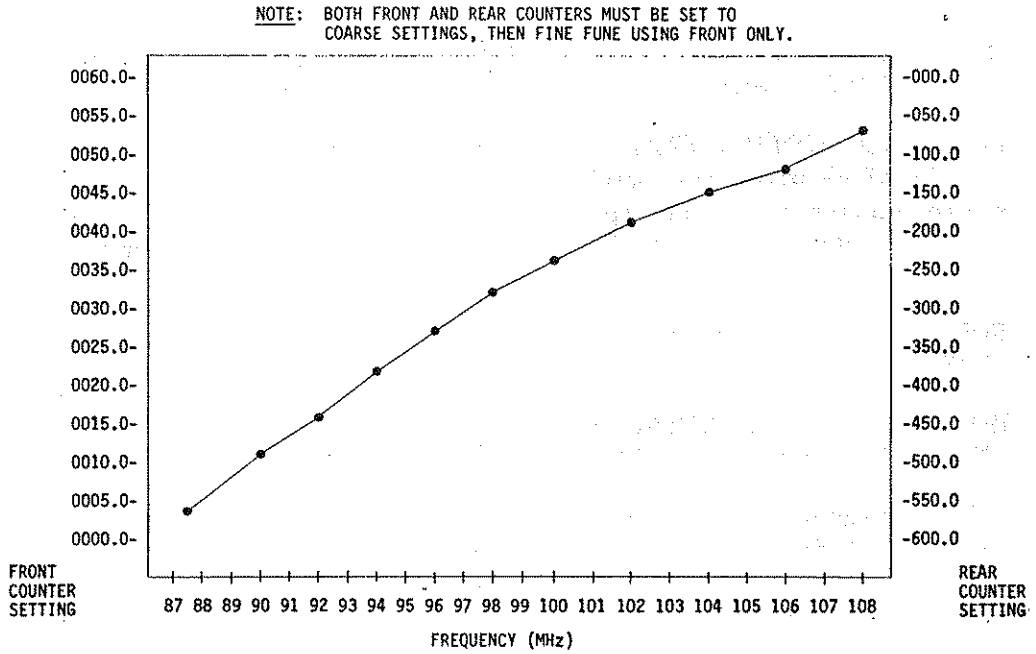
5–113. Refer to APC SECTION II, MAINTENANCE and perform the FWD CAL and RFL CAL adjustment procedures.

A



COARSE OUTPUT TUNING

B



COARSE INPUT TUNING

597-0033-25

FIGURE 5-5. COARSE TUNING ADJUSTMENTS

5–114. TROUBLESHOOTING.

WARNING ***NEVER OPEN THE EQUIPMENT UNLESS ALL TRANSMITTER PRIMARY POWER IS DISCONNECTED. USE***

WARNING ***THE GROUNDING STICK PROVIDED TO ENSURE ALL COMPONENTS AND ALL SURROUNDING COMPONENTS ARE DISCHARGED BEFORE ATTEMPTING MAINTENANCE ON ANY AREA WITHIN THE TRANSMITTER.***

5–115. Most troubleshooting consists of visual checks. Due to the dangerous voltages and high currents in the equipment, it is considered hazardous to work with power energized. Therefore, the various transmitter indicators (meters, LEDs, fuses, and circuit breakers) should be used to isolate the malfunction to one of the specific areas listed below. Typical meter indications are presented in Table 5–1 and transmitter primary power demand requirements are listed in Table 5–2.

TRANSMITTER TROUBLESHOOTING AREAS

A. Power Supplies

B. Exciter

C. IPA

D. Power Amplifier

E. Automatic Power Control

F. Transmitter Controller

G. Transmitter Load

TABLE 5–1. TYPICAL METER INDICATIONS (5 kW RF OUTPUT)
(Sheet 1 of 2)

METER	SWITCH POSITION/INDICATION	
FM–5B		
	VSWR	FWD
OUTPUT POWER	LESS THAN 1.2	100%
PLATE CURRENT	1.3 A	
PLATE VOLTAGE	5300 V	
SCREEN VOLTAGE	525 V	
SCREEN CURRENT	60 mA	
GRID VOLTAGE	–260 V	
GRID CURRENT	45 mA	
FILAMENT VOLTAGE	5.0 V	
EXCITER FORWARD POWER	15 W	
IPA FORWARD POWER	150 W	

TABLE 5–1. TYPICAL METER INDICATIONS (5 kW RF OUTPUT)
(Sheet 2 of 2)

METER	SWITCH POSITION/INDICATION	
FM–5BS		
	VSWR	FWD
OUTPUT POWER	LESS THAN 1.2	100%
PLATE CURRENT	1.3 A	
PLATE VOLTAGE	5300 V	
SCREEN VOLTAGE	525 V	
SCREEN CURRENT	60 mA	
GRID VOLTAGE	–260 V	
GRID CURRENT	45 mA	
FILAMENT VOLTAGE	5.0 V	
EXCITER FORWARD POWER	15 W	
IPA FORWARD POWER	150 W	

TABLE 5–2. TYPICAL POWER DEMAND (5 kW RF OUTPUT)

FM–5B			
AC Line Frequency	60 Hz	50 Hz	50 Hz
AC Line Voltage	210 V	224 V	380 V
AC Line Current	28 A	28 A	16 A
FM–5BS			
AC Line Frequency	60 Hz	50 Hz	50 Hz
AC Line Voltage	210 V	224 V	380 V
AC Line Current	48 A	48 A	28 A

CAUTION

CAUTION

MANY COMPONENTS IN THE TRANSMITTER ARE MOUNTED TO HEAT SINKS UTILIZING A FILM OF HEAT–SINK COMPOUND FOR THERMAL CONDUCTION.

CAUTION

CAUTION

IF ANY SUCH COMPONENT IS REPLACED, ENSURE A THIN FILM OF A ZINC–BASED HEAT–SINK COMPOUND IS USED (BE P/N 700–0028) TO ASSURE GOOD HEAT DISSIPATION.

5–116. Once the trouble is isolated, refer to the applicable assembly publication in Part II of this manual discussing the theory of operation and providing troubleshooting for the respective assembly to assist in problem resolution. Figures 5–6 through 5–10 provide drawings to assist component location.

5–117. **COMPONENT REPLACEMENT ON CIRCUIT BOARDS.** Circuit board repair requires that defective components be removed carefully to avoid damage to the board.

5–118. On all circuit boards, the adhesive securing the copper track to the board melts at almost the same temperature at which solder melts. A circuit board track can be destroyed by excessive heat or lateral movement during soldering. Use of a small iron with steady pressure is required for circuit board repairs.

5–119. To remove a component from a circuit board, cut the leads from the body of the defective component while the device is still soldered to the board.

5–120. Grip each component lead, one at a time, with long nose pliers. Turn the board over and touch a soldering iron to the lead at the solder connection. When the solder begins to melt, push the lead through the back side of the board and cut off the bent–over outer end of the lead. Each lead may now be heated independently and pulled out of each hole. The holes may be cleared of solder by carefully re–heating with a low wattage iron and removing the residual solder with a soldering vacuum tool.

5–121. Install the new component and apply solder from the bottom side of the board.

WARNING

WARNING

MOST SOLVENTS WHICH WILL REMOVE ROSIN FLUX ARE VOLATILE AND TOXIC BY THEIR NATURE AND SHOULD BE USED ONLY IN SMALL AMOUNTS IN A WELL VENTILATED AREA, AWAY FROM FLAME, INCLUDING CIGARETTES AND A HOT SOLDERING IRON.

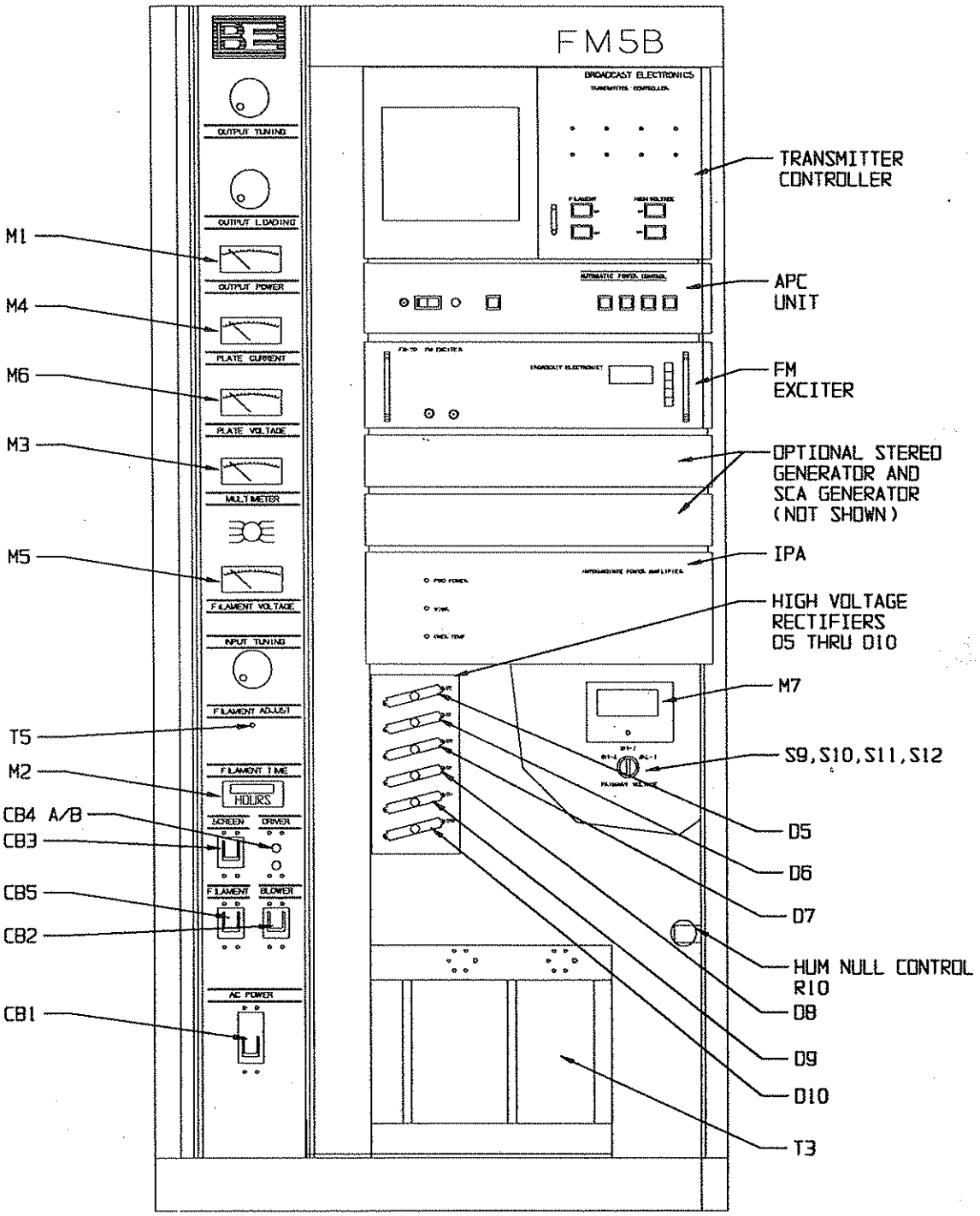
WARNING

WARNING

OBSERVE THE MANUFACTURER'S CAUTIONARY INSTRUCTIONS.

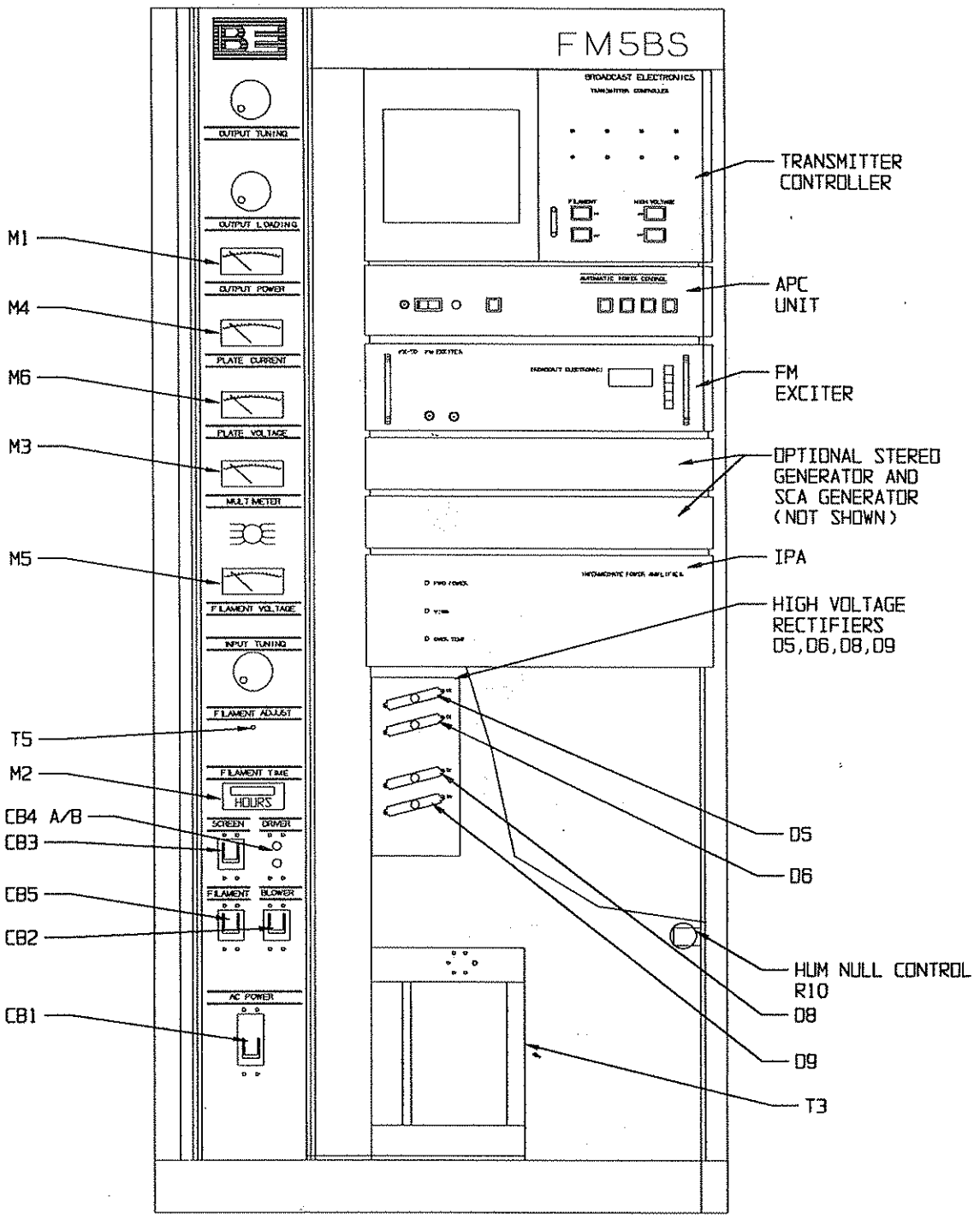
5–122. After soldering, remove flux with a cotton swab moistened with a suitable solvent. Rubbing alcohol is highly diluted and is not effective.

5–123. The board should be checked to ensure the flux has been removed and not just smeared about. Rosin flux is not normally corrosive, but rosin will absorb enough moisture in time to become conductive and cause problems.



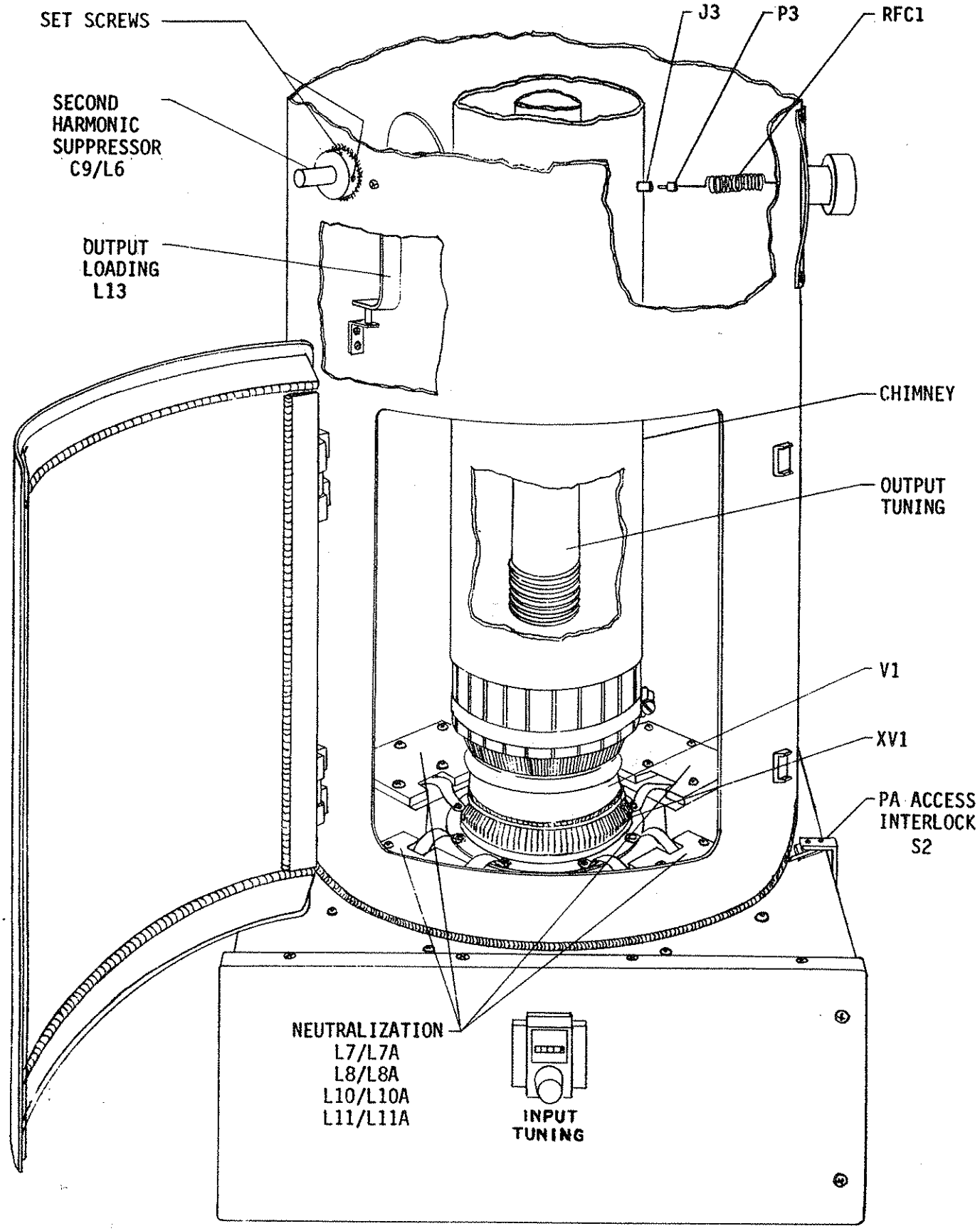
597-0033-12

FIGURE 5-6. FM-5B CABINET COMPONENT LOCATOR, FRONT



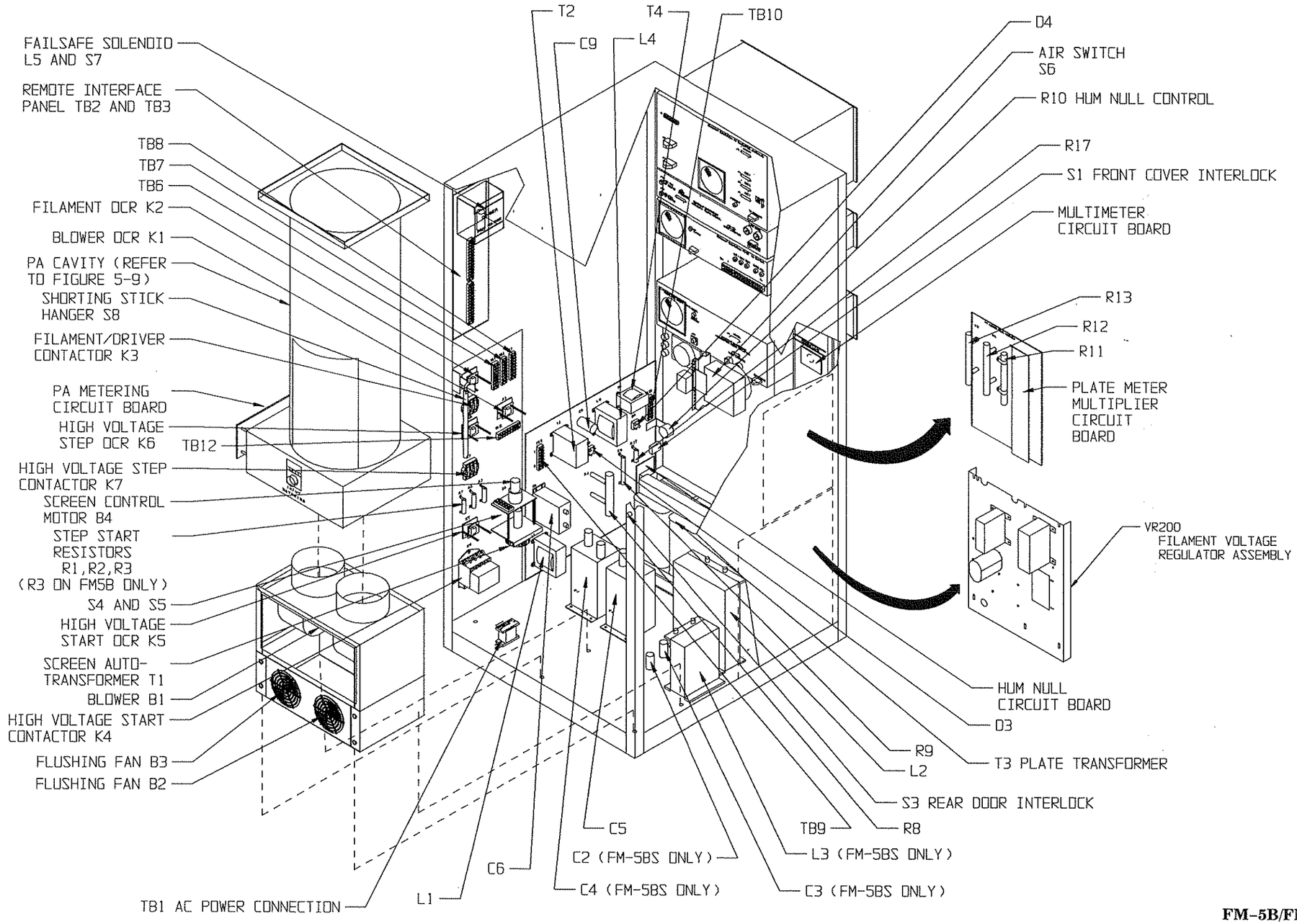
597-0033-14

FIGURE 5-7. FM-5BS CABINET COMPONENT LOCATOR, FRONT



597-0032-36

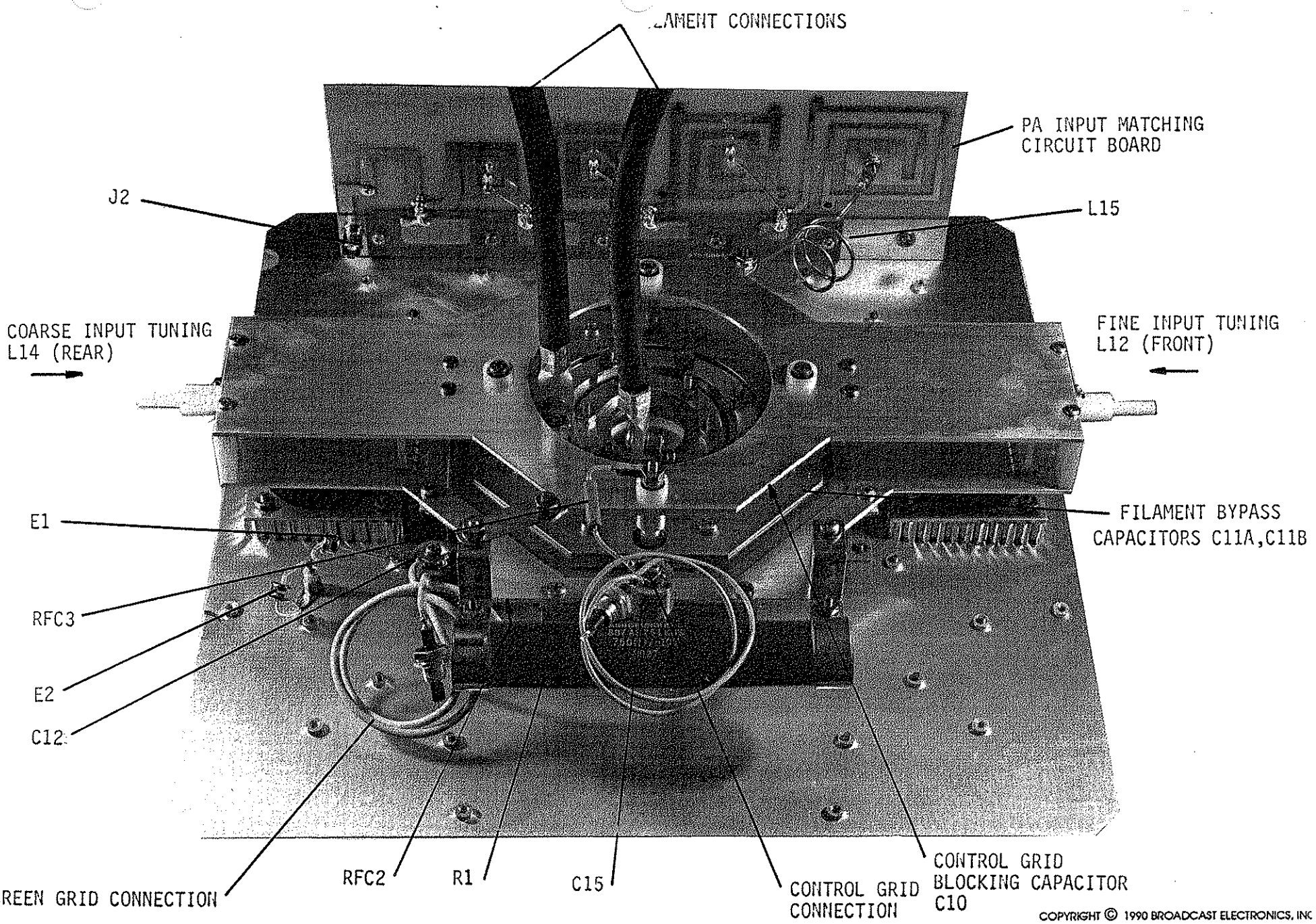
FIGURE 5-8. PA CAVITY COMPONENT LOCATOR



597-0033-13

FIGURE 5-9.
FM-5B/FM-5BS CABINET COMPONENT LOCATOR, REAR

(5-23/5-24)



597-0033-40

FIGURE 5-10. PA TUBE SOCKET

SECTION VI
PARTS LIST

6–1. INTRODUCTION.

6–2. This section provides descriptions and part numbers of electrical components, assemblies, and selected mechanical parts required for maintenance of the Broadcast Electronics FM–5B and FM–5BS FM Transmitters. Each table entry in this section is indexed by reference designators appearing on the applicable schematic diagram.

6–3. Parts located within modular assemblies are listed in Part II of this manual with each applicable assembly publication.

TABLE 6–1. REPLACEABLE PARTS LIST INDEX
(Sheet 1 of 2)

TABLE 6-1. REPLACEABLE PARTS LIST INDEX
(Sheet 2 of 2)

TABLE 6-2. FM-5B TRANSMITTER - 909-5000-204/-304/-384
(Sheet 1 of 2)

REF. DES.	DESCRIPTION	PART NO.	QTY.
C5	Capacitor, Electrolytic, 4 uF, 8 kV, Non-PCB oil/paper	047-0004	1
CB1	Circuit Breaker, 3-Pole, 240 Volt, 40 Amperes (**AC POWER**)	341-0027	1
L2	Choke, 6.8 H, 1.8A Continuous	361-0001	1
	FOR 50 Hz TRANSMITTER MODELS ONLY		
M2	Meter, 0 - 99,999.9 Hour, Non-Resettable, 230 Volt, 3.5 Inch (8.89 cm) (**FILAMENT TIME** Meter)	310-0000-003	1
R3	Resistor Network Assembly (IPA)	959-1000-001	1
R82	Resistor Network Assembly (APC)	959-1000-007	1
R86	Resistor Network Assembly (APC)	959-1000-008	1
R89	Resistor Network Assembly (APC)	959-1000-009	1
R96	Resistor Network Assembly (APC)	959-1000-010	1
S1,S3	Interlock Switch, SPDT, 15A @ 125V ac, 0.5A @ 125V dc, 0.25A @ 250V dc	346-3302	2
S6	Air Switch, 1823-2 Contacts: SPST, 15A @ 120V to 480V ac Operating Range: 0.5 to 5.0 Inch/Water	340-0011	1
T3	Transformer, Plate 3 Φ, 50/60 Hz Primary: 208/240V ±11V ac, Delta Connected; 346V to 433, Wye Connected Secondary: 2300V @ 1.4 Amperes Continuous, Wye Connected	376-0115	1
TB1	Terminal Block, Consisting of:		
	Ground Barrier	412-0043	1
	End Clamp	412-0042-001	2
	Terminal Block Section	412-0041	4
	Mounting Channel, 2.76 Inches (7 cm)	412-0044	1
V1	Tube, 4CX3500A	243-3500	1
VR200	Filament Voltage Regulator Assembly, Output Voltage = 5.5V ac	370-0056	1
----	FX-50 Exciter, 220V ac 50/60 Hz Operation	909-1050-325	1
----	Cable Assembly, Final, FM-5B	949-0163	1
----	RF Enclosure Assembly	959-0272	1
----	Accessory Parts Kit	969-0003	1
----	Directional Coupler Assembly, 45 dB (FWD)	959-0082-045	1
----	Directional Coupler Assembly, 40 dB (RFL)	959-0082-040	1
----	Turnlock Fastener, 1/4 Turn		
	Stud	424-0008	2
	Retainer	424-0006	2
----	Assembly, PA Metering Circuit Board	919-0048-004	1
----	Cable Assembly, Basic	949-0161	1
----	Ground Stick Hanger Assembly	955-0038	1
----	Remote Interface Panel Assembly	959-0117	1
----	Assembly, Ground Stick	959-0145	1
----	Tube Socket and Input Tuning Assembly	959-0151	1
----	Assembly, APC	959-0262-002	1
----	Assembly, IPA	959-0263-001	1
----	Assembly, Screen And Bias Panel	959-0271-001	1
----	Assembly, Bleeder Panel	959-0271-003	1
----	Assembly, Meter Panel	959-0271-005	1
----	Assembly, Fan/Blower	959-0271-006	1
----	Assembly, Rack Preparation	959-0271-007	1
----	Assembly, Rectifier Panel, FM-5B	959-0271-008	1
----	Assembly, Contactor Panel, FM-5B	959-0271-009	1

TABLE 6-2. FM-5B TRANSMITTER - 909-5000-204/-304/-384
(Sheet 2 of 2)

REF. DES.	DESCRIPTION	PART NO.	QTY.
----	Assembly, Three-Phase Voltmeter	959-0271-010	1
----	Assembly, Output Tuning Line	959-0272-001	1
----	Assembly, Transmission Line	959-0272-003	1
----	Assembly, Transmitter Controller	959-0298-002	1
----	16-Pin Jumper Assembly (APC)	959-1001	1

TABLE 6-3. FM-5BS TRANSMITTER - 909-5000-254/-354
(Sheet 1 of 2)

REF. DES.	DESCRIPTION	PART NO.	QTY.
C2,C3	Capacitor, Polypropylene film, 0.97 uF ±5%, 2500 VRMS @ 120 Hz, Non-Polarized	047-0006	2
C4	Capacitor, Electrolytic, 4 uF, 8 kV, Non-PCB oil/paper	047-0004	1
CB1	Circuit Breaker, 2-Pole, 240 Volt, 60 Amperes (AC POWER)	341-0050	1
L2	Tuned Reactor, 5.06/3.5 H ±5%, 21 Ohms dc Resistance, 1.4 Amperes continuous	360-0069	1
L3	Choke, 3.5 H, 20 Ohms dc Resistance, 1.4 Amperes continuous	360-0067	1
	FOR 50 Hz TRANSMITTER MODELS ONLY		
M2	Meter, 0 - 99,999.9 Hour, Non-Resettable, 230 Volt, 3.5 Inch (8.89 cm) (**FILAMENT TIME** Meter)	310-0000-003	1
M6	Meter, 3.5 Inch (8.89 cm), Taut Band Type, FS = 1 mA dc ±1%, 35 Ohm Resistance (**PLATE VOLTAGE** Meter)	310-0051	1
R3	Resistor Network Assembly (IPA)	959-1000	1
R82	Resistor Network Assembly (APC)	959-1000-007	1
R86	Resistor Network Assembly (APC)	959-1000-004	1
R89	Resistor Network Assembly (APC)	959-1000-005	1
R96	Resistor Network Assembly (APC)	959-1000-010	1
S1,S3	Interlock Switch, SPDT, 15A @ 125V ac, 0.5A @ 125V dc, 0.25A @ 250V dc	346-3302	2
S6	Air Switch, 1823-2 Contacts: SPST, 15A @ 120V to 480V ac Operating Range: 0.5 to 5.0 Inch/Water	340-0011	1
T3	Transformer, Plate, Special construction for resonant choke input supply Primary: 208/240V ±12V ac, 50/60 Hz, Single Phase Secondary: 6200V/5900V @ 1.4 Amperes Continuous, 20 Ohms dc Resistance	370-0091	1
TB1	Terminal Block, Consisting of:		
	Ground Barrier	412-0043	1
	End Clamp	412-0042-001	2
	Terminal Block Section	412-0041	3
	Mounting Channel, 2.76 Inches (7 cm)	412-0044	1
V1	Tube, 4CX3500A	243-3500	1
VR200	Filament Voltage Regulator Assembly, Output Voltage = 5.5V ac	370-0056	1
----	Turnlock Fastener, 1/4 Turn		
	Stud	424-0008	2
	Retainer	424-0006	2
----	Assembly, PA Metering Circuit Board	919-0048-004	1
----	Cable Assembly, Basic	949-0161	1
----	Ground Stick Hanger Assembly	955-0038	1
----	Remote Interface Panel Assembly	959-0117	1

TABLE 6-3. FM-5BS TRANSMITTER - 909-5000-254/-354
(Sheet 2 of 2)

REF. DES.	DESCRIPTION	PART NO.	QTY.
----	Assembly, Ground Stick	959-0145	1
----	Assembly, Screen And Bias Panel	959-0271-001	1
----	Assembly, Contactor Panel, FM-5BS	959-0271-002	1
----	Assembly, Bleeder Panel	959-0271-003	1
----	Assembly, Rectifier Panel, FM-5BS	959-0271-004	1
----	Assembly, Meter Panel	959-0271-005	1
----	Assembly, Fan/Blower	959-0271-006	1
----	Assembly, Rack Preparation	959-0271-007	1
----	Assembly, Output Tuning Line	959-0272-001	1
----	Assembly, Transmission Line	959-0272-003	1
----	Assembly, Transmitter Controller	959-0298-002	1
----	16-Pin Jumper Assembly (APC)	959-1001	1
----	FX-50 Exciter, 220V ac 50/60 Hz Operation	909-1050-325	1
----	Tube Socket and Input Tuning Assembly	959-0151	1
----	Assembly, APC	959-0262-002	1
----	Assembly, IPA	959-0263-001	1
----	Meter Multiplier Circuit Board Assembly	919-0079	1
----	Cable Assembly, Final, FM-5BS	949-0162	1
----	RF Enclosure Assembly	959-0272	1
----	Accessory Parts Kit	969-0003	1
----	Directional Coupler Assembly, 45 dB (FWD)	959-0082-045	1
----	Directional Coupler Assembly, 40 dB (RFL)	959-0082-040	1

TABLE 6-4. SCREEN AND BIAS PANEL ASSEMBLY - 959-0271-001

REF. DES.	DESCRIPTION	PART NO.	QTY.
C6	Capacitor, Electrolytic, 10 uF, 2 kV, Non-PCB oil/paper	047-0002	1
C9	Capacitor, Electrolytic, 80 uF, 450V	028-8076	1
D3,D4	Diode Bridge, Silicon, 4 kV, 0.15 Ampere	239-0440	2
L1,L4	Choke, 10 Henrys, 0.4 Amperes, 2500 Volt Insulation, 92 Ohm dc Resistance	377-0002	2
R8	Resistor, 10 k Ohm ±5%, 100W, WW	132-1053	1
R9	Resistor, 5 k Ohm, 50W, W/W	180-0578	1
R10	Potentiometer, 50 Ohm ±10%, 25W W/W (Hum Null Adjust)	195-0149-001	1
R17	Resistor, 50 Ohm ±5%, 25W W/W	130-5023	1
T2	Transformer, Screen Primary: 208/240V ±11V ac, 50/60 Hz, Single Phase Secondary: 1100V @ 0.15 Amperes Continuous, 15 Ohm dc Resistance	370-0009	1
T4	Transformer, Bias Primary: 208/240V ±11V ac, 50/60 Hz, Single Phase Secondary: 1: 225V @ 0.2 Amperes Continuous 2: 253V @ 0.2 Amperes Continuous 3: 281V @ 0.2 Amperes Continuous 4: 310V @ 0.2 Amperes Continuous 1500 Volt Insulation, 70 Ohms dc Resistance	370-0006	1
TB9	Barrier Strip, 6 Terminals	412-0008	1
TB10	Barrier Strip, 5 Terminals	412-0005-1	1
----	Ceramic Insulator Stand-off	441-2618	2
----	Ceramic Stand-off	441-9234	1
----	Hum Null Circuit Board Assembly	919-0063	1

TABLE 6-5. BLEEDER PANEL ASSEMBLY - 959-0271-003

REF. DES.	DESCRIPTION	PART NO.	QTY.
R11	Resistor, 22 Ohm ±20%, 150W	139-0220	1
R12,R13	Resistor, 100 k Ohm ±5%, 100W	132-1063	2
	FOR FM-5B TRANSMITTERS ONLY		
----	Meter Multiplier Circuit Board Assembly	919-0200	1

TABLE 6-6. METER PANEL ASSEMBLY - 959-0271-005

REF. DES.	DESCRIPTION	PART NO.	QTY.
C1, C10 thru C12	Capacitor, Ceramic, 0.001 uF, 1 kV	002-1034	4
CB2	Circuit Breaker, 2-Pole, 250 Volt, 5 Amperes (**BLOWER**)	341-0010	1
CB3	Circuit Breaker, 2-Pole, 250 Volt, 1 Ampere (**SCREEN**)	341-0008	1
CB4A/B	Circuit Breaker, 2-Pole, 250 Volt, 7 Amperes, Push On (**DRIVER**)	341-0060	2
CB5	Circuit Breaker, 2-Pole, 250 Volt, 10 Amperes (**FILAMENT**)	341-0030	1
M1	Meter, 3.5 inch (8.89 cm), Taut Band Type, FS = 200 uA ±2%, 230 Ohm Movement (**OUTPUT POWER** Meter)	310-0058	1
	FOR FM-5B AND FM-5BS 60 HZ TRANSMITTER MODELS ONLY		
M2	Meter, 0 - 99,999.9 Hour, Non-Resettable, 230 Volt, 3.5 Inch (8.89 cm) (**FILAMENT TIME** Meter)	310-0000-002	1
M3	Multimeter, 3.5 inch (8.89 cm), Taut Band Type, FS = 1 mA dc ±2%, 35 Ohm Resistance (**MULTIMETER**)	310-0057	1
M4	Meter Assembly (**PLATE CURRENT**)	959-0300	1
M5	Meter, 3.5 inch (8.89 cm), Iron Vane Type, 0-10V AC -10V AC ±3% Movement (**FILAMENT VOLTAGE**)	310-0024	1
	FOR FM-5B TRANSMITTER MODELS ONLY		
M6	Meter, 3.5 inch (8.89 cm), Taut Band Type, FS = 1 mA ±1%, 35 Ohm Resistance (**PLATE VOLTAGE**)	310-0050	1
----	Multimeter Circuit Board Assembly	919-0049-001	1
T5	Transformer, Variable, Superior Electric Type 21, 120V ac 50/60 Hz Input = 0-120V ac @ 5A Output	370-1790-001	1

TABLE 6-7. FAN/BLOWER ASSEMBLY - 959-0271-006

REF. DES.	DESCRIPTION	PART NO.	QTY.
B1	Blower, Centrifugal, 600 ft^3/min Motor: 230V ac, 2.1 Ampere, 50/60 Hz, 3100 R/M, 1/3 hp	380-0005	1
B2,B3	Fan, 6 inch (15.24 cm), 250 ft^3/min, 220V ac, 50/60 Hz, 40 Watt	380-7650	2
----	Receptacle, Pins	417-0036	4
----	Receptacle, Housing, 6-Pin	418-0006	1
----	Connector, Housing, 9-Pin	418-0055	1

TABLE 6-8. RECTIFIER PANEL ASSEMBLY, FM-5B - 959-0271-008

REF. DES.	DESCRIPTION	PART NO.	QTY.
D5, thru D10	Encapsulated high voltage diode assembly PIV: 18 kV V_F = 21.0V dc @ 1.5 Amperes Configuration MAX	230-0010	6

TABLE 6-9. CONTACTOR PANEL ASSEMBLY, FM-5B - 959-0271-009

REF. DES.	DESCRIPTION	PART NO.	QTY.
K1,K2	Assembly, Optically-Coupled-Relay (OCR)	919-0096	2
K3	Contactor, Coil: 208-240V, 60 Hz or 208-220V, 50 Hz Contacts: 3 Sets SPST, 25 Amperes, 600V	341-0033	1
K4	Contactor, Coil: 110/230V, 50/60 Hz Contacts: 3 Sets SPST, 60 Amperes, 600V	341-0049	1
K5,K6	Assembly, Optically-Coupled-Relay (OCR)	919-0096	2
K7	Contactor, Coil: 208-240V, 60 Hz or 208-220V, 50 Hz Contacts: 3 Sets SPST, 25 Amperes, 600V	341-0033	1
R1,R2,R3	Resistor, 5 Ohm ±5%, 25W, W/W	130-5013	3
TB6 THRU TB8	Barrier Strip, 9 Terminal	412-0090	3
TB12	Barrier Strip, 4 Terminal	412-0011	1
----	Interlock Switch For K4, Normally Open, Contactor Mounted	341-0058	1
----	Assembly, Screen Powerstat	959-0121	1

TABLE 6-10. THREE-PHASE VOLTMETER ASSEMBLY - 959-0271-010

REF. DES.	DESCRIPTION	PART NO.	QTY.
F1 THRU F3	Fuse, AGC, 1/2 Ampere	330-0050	3
	FOR 208/240V TRANSMITTERS		
M7	Meter, 3.5 Inch (8.89 cm), Iron Vane Type, 0-300V Range 60 k Ohm Resistance (**PRIMARY VOLTAGE**)	310-0032	1
	FOR 380V TRANSMITTERS		
M7	Meter, 3.5 Inch (8.89 cm), Iron Vane Type, 0-500V Range 45 k Ohm Resistance (**PRIMARY VOLTAGE**)	310-0060	1
S10 THRU S12	Assembly, Meter Select Switch		
	Switch: KS46B, Square D	341-0021	1
	Contactor: KA-1, Square D	341-0020	1
	Cam Assembly: Type F, Square D	341-0019	1
XF1 THRU XF3	Fuseholder, Panel Mount	415-2012	3

TABLE 6-11. OUTPUT TUNING LINE ASSEMBLY - 959-0272-001

REF. DES.	DESCRIPTION	PART NO.	QTY.
L10	Output Tuning Bellows	463-0043	1
-----	Unflanged Coupling	447-0025	1

TABLE 6-12. TRANSMISSION LINE ASSEMBLY- 959-0272-003

REF. DES.	DESCRIPTION	PART NO.	QTY.
J2	Connector, BNC, Modified	417-0203-1	1
-----	Harmonic Low-Pass filter, 15 kW, 88 MHz to 108 MHz	339-0021	1
-----	Elbow, 1 5/8 inch Copper, 90 Degree, EIA Unflanged	427-0006	1
-----	Transmission Line Elbow, Modified with Sampling Port	427-0006-002	1
-----	Coupling Assembly, 1 5/8 Inch	427-0007	5
-----	Transmission Lines: Outer, 25.595 Inches (65.0 cm) Inner, 24.72 Inches (62.79 cm)	427-0008-018	1
-----	Transmission Lines: Outer, 8.125 Inches (20.64 cm) Inner, 7.25 Inches (18.41 cm)	427-0008-019	1

TABLE 6-13. FM-5BS CONTACTOR PANEL ASSEMLBY - 959-0271-002

REF. DES.	DESCRIPTION	PART NO.	QTY.
K1,K2	Assembly, Optically-Coupled-Relay (OCR)	919-0096	2
K3	Contactor, Coil: 208-240V, 60 Hz or 208-220V, 50 Hz Contacts: 3 Sets SPST, 25 Amperes, 600V	341-0033	1
K4	Contactor, Coil: 110/230V, 50/60 Hz Contacts: 3 Sets SPST, 60 Amperes, 600V	341-0049	1
K5,K6	Assembly, Optically-Coupled-Relay (OCR)	919-0096	2
K7	Contactor, Coil: 208-240V, 60 Hz or 208-220V, 50 Hz Contacts: 3 Sets SPST, 25 Amperes, 600V	341-0033	1
R1,R2	Resistor, 5 Ohm ±5%, 25W, W/W	130-5013	2
TB12	Barrier Strip, 4 Terminal	412-0011	1
TB6 THRU TB8	Barrier Strip, 9 Terminal	412-0090	3
-----	Assembly, Screen Powerstat	959-0121	1

TABLE 6-14. RECTIFIER PANEL ASSEMBLY, FM-5BS - 959-0271-004

REF. DES.	DESCRIPTION	PART NO.	QTY.
D5, D6, D8, D9	Encapsulated high voltage diode assembly PIV: 18 kV V_F = 21.0V dc @ 1.5 Amperes Configuration MAX	230-0010	4

TABLE 6-15. PLATE CURRENT METER ASSEMBLY - 959-0300

REF. DES.	DESCRIPTION	PART NO.	QTY.
M4	Meter, 3.5 inch (8.89 cm), Taut Band Type, FS = 1 mA ±2%, 0 - 1.5 A Range, 35 Ohm Resistance (**PLATE CURRENT**)	310-0053	1
----	Meter Protection Circuit Board Assembly	919-0109-002	1

TABLE 6-16. METER PROTECTION CIRCUIT BOARD ASSEMBLY - 919-0109-002

REF. DES.	DESCRIPTION	PART NO.	QTY.
C1,C2	Capacitor, Ceramic, 0.001 uF, 1 kV	002-1034	2
D1	Diode, Zener, 1N4728, 3.3V ±5%, 1W	201-4728	1
R1	Resistor, 680 Ohm ±5%, 1W	120-6833	1
R2	Resistor, 182 Ohm ±1%, 1/4W	103-1823	1
R3	Potentiometer, 200 Ohm ±10%, 1/2W	177-2034	1
----	Blank Meter Protection Circuit Board	519-0109	1

TABLE 6-17. MULTIMETER CIRCUIT BOARD ASSEMBLY - 919-0049-001

REF. DES.	DESCRIPTION	PART NO.	QTY.
J1	Connector, Ribbon Cable, 10-Pin, PCB Mount	418-1003	1
S1	Switch, Rotary, Panel Mount, 6 Position, Contacts: single pole, 28V dc @ 0.5A	340-0119	1
----	Blank Multimeter Circuit Board Assembly	519-0049-001	1

TABLE 6-18. ASSEMBLY, HUM NULL - 919-0063

REF. DES.	DESCRIPTION	PART NO.	QTY.
C1	Capacitor, Electrolytic, 470 uF, 50V	024-4783	1
D1,D2	Diode, 1N4005, Silicon, 600V, 1 Ampere	203-4005	1
F1,F2	Fuse, AGC3, 250V, 1/2 Ampere	330-0050	2
T1	Transformer, Circuit Board Mount Primary: Dual 115V @ 50/60 Hz, Single Phase Secondary: Dual 6.3V, 1 Ampere	370-0512	1
TB1	Barrier Strip, 4 Terminal	411-0815	1
----	Blank Circuit Board	519-0063	1

TABLE 6-19. ASSEMBLY, METER MULTIPLIER CIRCUIT BOARD, FM-5B - 919-0200

REF. DES.	DESCRIPTION	PART NO.	QTY.
C1	Capacitor, Mica, 390 pF ±5%, 100V	042-3922	1
D1	Diode, Zener, 1N4739A, 9.1V ±5%, 1W	200-0009	1
R1 THRU R6	Resistor, 1 Meg Ohm ±1%, 2W	140-0003	1
R7	Resistor, 4.99 k Ohm ±1%, 1/4W	100-5041	1
----	Blank Circuit Board	519-0200	1

TABLE 6-20. ASSEMBLY, METER MULTIPLIER CIRCUIT BOARD, FM-5BS - 919-0079

REF. DES.	DESCRIPTION	PART NO.	QTY.
C1	Capacitor, Mica, 390 pF ±5%, 100V	042-3922	1
D1	Diode, Zener, 1N4739A, 9.1V ±5%, 1W	200-0009	1
R1 THRU R10	Resistor, 1 Meg Ohm ±1%, 2W	140-0003	10
R11	Resistor, 4.99 k Ohm ±1%, 1/4W	100-5041	1
----	Blank Circuit Board	519-0079	1

TABLE 6-21. CABLE ASSEMBLY, BASIC - 949-0161

REF. DES.	DESCRIPTION	PART NO.	QTY.
J1	Connector, Ribbon Cable, 26-Pin	417-0047	1
J1	Connector, Housing 6-Pin (PA Metering Circuit Board)	418-0670	1
J1,J2	Receptacle, Housing, 6-Pin	418-0006	2
P1	Connector, D-Type, 25-Pin	418-0609	1
P1, P1	Connector, Ribbon Cable, 10-Pin (PA Metering Circuit Board)	417-1003	2
P1,P2	Connector, Housing 6-Pin (on Blower and Fans)	418-0670	2
P2	Connector, Housing, 15-Pin (PA Metering Circuit Board)	417-2379	1
P2,P3,P8,P9	Connector, Housing, Male, 25-Pin	418-3219	4
----	Connector, Jack, Type N (IPA: P13, RF Enclosure: P1)	418-0031	2
----	Connector, Housing, 4-Pin	418-0240	1
----	Connector, Plug, BNC APC: P9, P10 Directional Coupler: RFL, FWD Exciter: RF OUTPUT IPA: RF INPUT	417-0094	6
----	Connector, Plug, Type-N (RF Enclosure, PA Input)	417-0076	1
----	Connector, Plug, BNC (RF Enclosure, PA Input)	417-0095	1
----	Pins, Connector	417-0053	30
----	Receptacle, Pins	417-0036	18
----	Terminal, Disconnect	410-1421	1

TABLE 6-22. ASSEMBLY, GROUND STICK HANGER - 955-0038

REF. DES.	DESCRIPTION	PART NO.	QTY.
S8	Interlock Switch, SPDT, 11A @ 125V or 250V ac, 0.5A @ 125V dc, 0.25A @ 250V dc	346-6100	1

TABLE 6-23. ASSEMBLY, POWERSTAT - 959-0121

REF. DES.	DESCRIPTION	PART NO.	QTY.
B4	Motor and Gearhead Assembly, 12V dc @ 235 mA, 9.1 r/min, Torque: 300 oz/in.	381-0001	1
D1,D2	Diode, 1N4005, Silicon, 600V, 1 Ampere	203-4005	2
S4,S5	Microswitch, Modified, SPDT, 125V @ 4 Amperes Inductive	346-6100-1	2
T1	Autotransformer, Variable, 240V, 50/60 Hz, 0.7 Ampere Output	374-0003	1
TB5	Barrier Strip, 4 Terminal	412-0011	1

TABLE 6-24. ASSEMBLY, REMOTE INTERFACE PANEL - 959-0117

REF. DES.	DESCRIPTION	PART NO.	QTY.
TB2	Barrier Strip, 10-Terminal	412-0010-1	1
TB3	Barrier Strip, 26-Terminal With Ribbon Cable Connector	412-0045	1
----	Assembly, Fail-Safe Solenoid	959-0083	1

TABLE 6-25. ASSEMBLY, FAIL-SAFE SOLENOID - 959-0083

REF. DES.	DESCRIPTION	PART NO.	QTY.
L5	Solenoid, 230V ac, 50/60 Hz, DC Resistance: 360 Ohms 10%	281-0004	1
S7	Mechanical Switch Assembly, consisting of the following:		
	Brass Side Terminals	470-0181	2
	Brass Center Disc	423-1000	1
TB11	Barrier Strip, 2 Terminals	412-0002	1
----	Teflon Toggle Link	425-0024	1
----	Ceramic Insulator Stand-off	441-2618	2

TABLE 6-26. OPTICALLY-COUPLED-RELAY (OCR) ASSEMBLY - 919-0096
(Sheet 1 of 2)

REF. DES.	DESCRIPTION	PART NO.	QTY.
C1	Capacitor, Ceramic Disc, 0.001 uF, 1kV	002-1034	1
C2	Capacitor, Electrolytic, 47 uF, 35V	020-4773	1
C3	Capacitor, Ceramic Disc, 0.03 uF, 300V	000-1051	1
C4	Capacitor, Ceramic Disc, 0.001 uF, 1kV	002-1034	1
D1	Diode, 1N4005, Silicon, 600V @ 1 Ampere	203-4005	1
D2	Diode, Zener, 1N5359, 24V ±10%, 5W	200-5359	1
D4	Diode, 1N4005, Silicon, 600V @ 1 Ampere	203-4005	1
D5	Bridge Rectifier, MDA970A3, 4 Amps, 50-200V	239-0003	1
E1 THRU E5	Terminal, Male, 0.25 Tab	410-0064	5
F1, F2	Fuse, PCB Mount, 250V, 3 Ampere	330-0055	2
K1	Relay, Printed Circuit Board Mount Coil: 24V dc, 660 Ohms ±10% Contacts: SPST-NO, 0.5 to 15A @ 12 to 240V ac Resistance	270-0054	1
MOV1	Metal Oxide Varistor, V272A60, 27V ac RMS, 120 Joules	140-0023	1
R1	Resistor, 2 k Ohm ±3%, 10W	130-2032	1
R2	Resistor, 560 Ohm ±5%, 1/2W	110-5633	1
R3	Resistor, 820 Ohm ±5%, 1/2W	110-8233	1
R4	Resistor, 51.1 Ohm ±1%, 1/4W	103-5112	1
R5	Resistor, 2 k Ohm ±3%, 10W	130-2032	1
U1	Integrated Circuit, 4N33, Optical Isolator, NPN Photo Transistor/Infared Emitting Diode Type, 1500V Isolation, Response: 30 kHz Maximum, Current: 50 mA Maximum, 6-Pin DIP	229-0033	1

TABLE 6-26. OPTICALLY-COUPLED-RELAY (OCR) ASSEMBLY - 919-0096
(Sheet 2 of 2)

REF. DES.	DESCRIPTION	PART NO.	QTY.
XU1	Socket, 6-Pin DIP	417-0600	1
----	Blank Circuit Board	519-0096	1

TABLE 6-27. RF ENCLOSURE ASSEMBLY - 959-0272

REF. DES.	DESCRIPTION	PART NO.	QTY.
C9	Capacitor, Plate, Second Harmonic Suppessor	474-0187	1
C13,C14	Capacitor, 700 pF, 1.5 kV, Filament Feedthru:		
	Kapton Dielectric	519-0039	4
	Teflon Spacer	441-0054	2
L6	Inductor, Second Harmonic Suppessor	463-0047	1
S2	Microswitch, SPDT, Roller Activated (PA Interlock)	346-3300	1
----	Connector Assembly, Transmission Line, Modified	427-0009-1	1
----	High Voltage Feed-Thru Capacitor Assembly	959-0184	1
----	Assembly, PA chminey	959-0272-002	1
----	Fingerstock, PA Cavity Access	469-0368	1

TABLE 6-28. PA CHIMNEY ASSEMBLY - 959-0272-002

REF. DES.	DESCRIPTION	PART NO.	QTY.
L9	Chimney, PA	479-0067	1
J3	Receptacle, Binding Post, Banana	417-0074	1

TABLE 6-29. PA METERING CIRCUIT BOARD ASSEMBLY - 919-0048-004
(Sheet 1 of 2)

REF. DES.	DESCRIPTION	PART NO.	QTY.
C1 THRU C3	Capacitor, Mica, 390 pF ±5%, 100V	042-3922	3
C4,C5	Capacitor, Monolythic Ceramic, 0.1 uF ±20%, 50V	003-1054	2
C6,C7	Capacitor, Mica, 390 pF ±5%, 100V	042-3922	2
C8,C9	Capacitor, Monolythic Ceramic, 0.1 uF ±20%, 50V	003-1054	2
C10	Capacitor, Mica, 390 pF ±5%, 100V	042-3922	1
C11,C12,C13	Capacitor, Monolythic Ceramic, 0.1 uF ±20%, 50V	003-1054	3
C14	Capacitor, Mica, 390 pF ±5%, 100V	042-3922	1
C15,C16	Capacitor, Monolythic Ceramic, 0.1 uF ±20%, 50V	003-1054	2
C17	Capacitor, Mica, 390 pF ±5%, 100V	042-3922	1
C18	Capacitor, Monolythic Ceramic, 0.1 uF ±20%, 50V	003-1054	1
C19	Capacitor, Mica, 390 pF ±5%, 100V	042-3922	1
C20	Capacitor, Monolythic Ceramic, 0.1 uF ±20%, 50V	003-1054	1
C21	Capacitor, Electrolytic, 470 uF, 50V	024-4783	1
D1 THRU D7	Diode, Zener, 1N4739A, 9.1V ±10%, 1W	200-0009	7
F1,F2	Fuse, AGC, 1 Ampere, Fast Blow	330-0100	2
F3	Fuseable Link, 28 AWG	630-2806	0.208
J1	Connector, 10-Pin	418-1003	1
J2	Connector, 15-Pin	417-0169	1
J3	Connector, 6-Pin	417-0677	1
L1	RF Choke, 2.2 uH ±10%, 0.4 Ohms DC Resistance, 550 mA Maximum	360-2200	1

TABLE 6-29. PA METERING CIRCUIT BOARD ASSEMBLY - 919-0048-004
(Sheet 2 of 2)

REF. DES.	DESCRIPTION	PART NO.	QTY.
R1	Resistor, 100 Ohm ±5%, 1/2W	110-1033	1
R2	Resistor, 2 Ohm ±1%, 5W, W/W	130-2011	1
R3	Resistor, 1 Ohm ±1%, 5W, W/W	132-1111	1
R4,R5	Resistor, 0.5 Meg Ohm ±1%, 2W	140-0005	2
R6	Resistor, 4.99 k Ohm ±1%, 1/4W	100-5041	1
R7	Resistor, 5.1 k Ohm ±5%, 1/4W	100-5143	1
R8	Resistor, 4.99 k Ohm ±1%, 1/4W	100-5041	1
R9	Resistor, 0.5 Meg Ohm ±1%, 2W	140-0005	1
R10	Resistor, 5.62 k Ohm ±1%, 1/4W	103-5624	1
R11	Resistor, 49.9 k Ohm ±1%, 1/4W	103-4951	1
R12	Resistor, 27 k Ohm ±5%, 1/4W	100-2753	1
R13	Resistor, 49.9 k Ohm ±1%, 1/4W	103-4951	1
R14	Resistor, 10 k Ohm ±1%, 1/4W	100-1051	1
R15	Resistor, 100 Ohm ±5%, 1/2W	110-1033	1
R16	Resistor, 22 Ohm ±1%, 3W	130-2221	1
R18	Resistor, 1 k Ohm ±1%, 1/4W	100-1041	1
R19	Resistor, 48.7 k Ohm ±1%, 1/4W	103-4875	1
R20	Resistor, 24 k Ohm ±5%, 1/4W	100-2453	1
R21	Resistor, 49.9 k Ohm ±1%, 1/4W	103-4951	1
R22	Resistor, 5.49 k Ohm ±1%, 1/4W	103-5494	1
R23	Resistor, 1 k Ohm ±5%, 1/4W	100-1043	1
R24	Resistor, 10 Ohm ±1%, 1W	120-1021	1
R26	Resistor, 1 k Ohm ±1%, 1/4W	100-1041	1
R27	Resistor, 24.3 k Ohm ±1%, 1/4W	103-2435	1
R28	Resistor, 16 k Ohm ±5%, 1/4W	100-1653	1
R29	Resistor, 49.9 k Ohm ±1%, 1/4W	103-4951	1
R30	Resistor, 4.99 k Ohm ±1%, 1/4W	100-5041	1
R31	Resistor, 7.32 k Ohm ±1%, 1/4W	103-7324	1
R37,R38	Resistor, 100 k Ohm ±1%, 1/4W	103-1062	2
R41	Resistor, 1 k Ohm ±5%, 1/4W	100-1043	1
U1,U2	Integrated Circuit, LM358N, Dual Operational Amplifier, 8-Pin DIP	221-0358	2
XF1,XF2	Fuse Clip	415-2068	4
XU1,XU2	Socket, 8-Pin DIP	417-0804	2
----	Blank PA Metering Circuit Board	519-0048-001	1

TABLE 6-30. ASSEMBLY, TUBE SOCKET AND INPUT TUNING - 959-0151
(Sheet 1 of 2)

REF. DES.	DESCRIPTION	PART NO.	QTY.
C1	Choke, RF Plate 80-200 MC	360-0144	1
C7,C8	Capacitor, Kapton, 1000 pF, 2 kV, Screen Bypass	519-0037	2
C10	Capacitor, Kapton, 2000 pF, 1.5 kV, Grid Blocking	519-0038	1
C12,C15	Capacitor, Ceramic, 500 pF ±20%, 5 kV	008-5024	2
C16,C17	Capacitor, Kapton, 1000 pF, 2 kV, Screen Bypass	519-0037	2
E1,E2	Spark Gap, 630V ±15% DC Surge Voltage Protection	140-0004	2
FL1, FL2	Filter, RFI 2500V 25A Feedthru	339-0012	2
L7,L7A, L8,L8A, L10,L10A, L11,L11A	Strap, Neutralization	463-0040	8

TABLE 6-30. ASSEMBLY, TUBE SOCKET AND INPUT TUNING - 959-0151
(Sheet 2 of 2)

REF. DES.	DESCRIPTION	PART NO.	QTY.
L12,L14	Input Tuning Fingerstock	469-0004	2
L15	Inductor, Input Matching	360-0100	1
R1	Resistor, Power, 750 Ohm ±10%, 50W	139-7532	1
RF	Choke, RF Plate 80-200 MC	360-0144	1
XU1	Tube Socket, 4CX3500A	417-0350	1
-----	Assembly, Input Matching Circuit Board	919-0064	1
-----	Ceramic Stand-off .	441-9234	1

TABLE 6-31. ASSEMBLY, GRID RESISTOR - 959-0163

REF. DES.	DESCRIPTION	PART NO.	QTY.
R1	Resistor, 750 Ohm ±10%, 50W, Non-Inductive	139-7532	1

TABLE 6-32. ASSEMBLY, INPUT MATCHING CIRCUIT BOARD - 919-0064

REF. DES.	DESCRIPTION	PART NO.	QTY.
J2	Receptacle, BNC	417-0014	1
-----	Inductance Circuit Board	519-0064	1
-----	Capacitance Circuit Board	519-0064-001	1

TABLE 6-33. ASSEMBLY, SPARK GAP - 959-0161

REF. DES.	DESCRIPTION	PART NO.	QTY.
E1,E2	Spark Gap, 630V ±15% Break-Down	140-0004	2
-----	Insulating stand-off	413-2013	1

TABLE 6-34. ASSEMBLY, SCREEN CHOKE - 959-0166

REF. DES.	DESCRIPTION	PART NO.	QTY.
RFC2	Choke, 80 - 200 mHz, 1100 mA Maximum	360-0144	1

TABLE 6-35. ASSEMBLY, GRID CHOKE - 959-0152

REF. DES.	DESCRIPTION	PART NO.	QTY.
RFC3	Choke, 80 - 200 mHz, 1100 mA Maximum	360-0144	1

TABLE 6-36. CABLE ASSEMBLY, SCREEN GRID AND CONTROL GRID FEEDTHRU - 949-0106

REF. DES.	DESCRIPTION	PART NO.	QTY.
FL1,FL2	Feedthru - Grid and Screen, 1200 pF, 2500V, 25 Ampere Maximum	339-0012	1

TABLE 6-37. ACCESSORY PARTS KIT- 969-0003

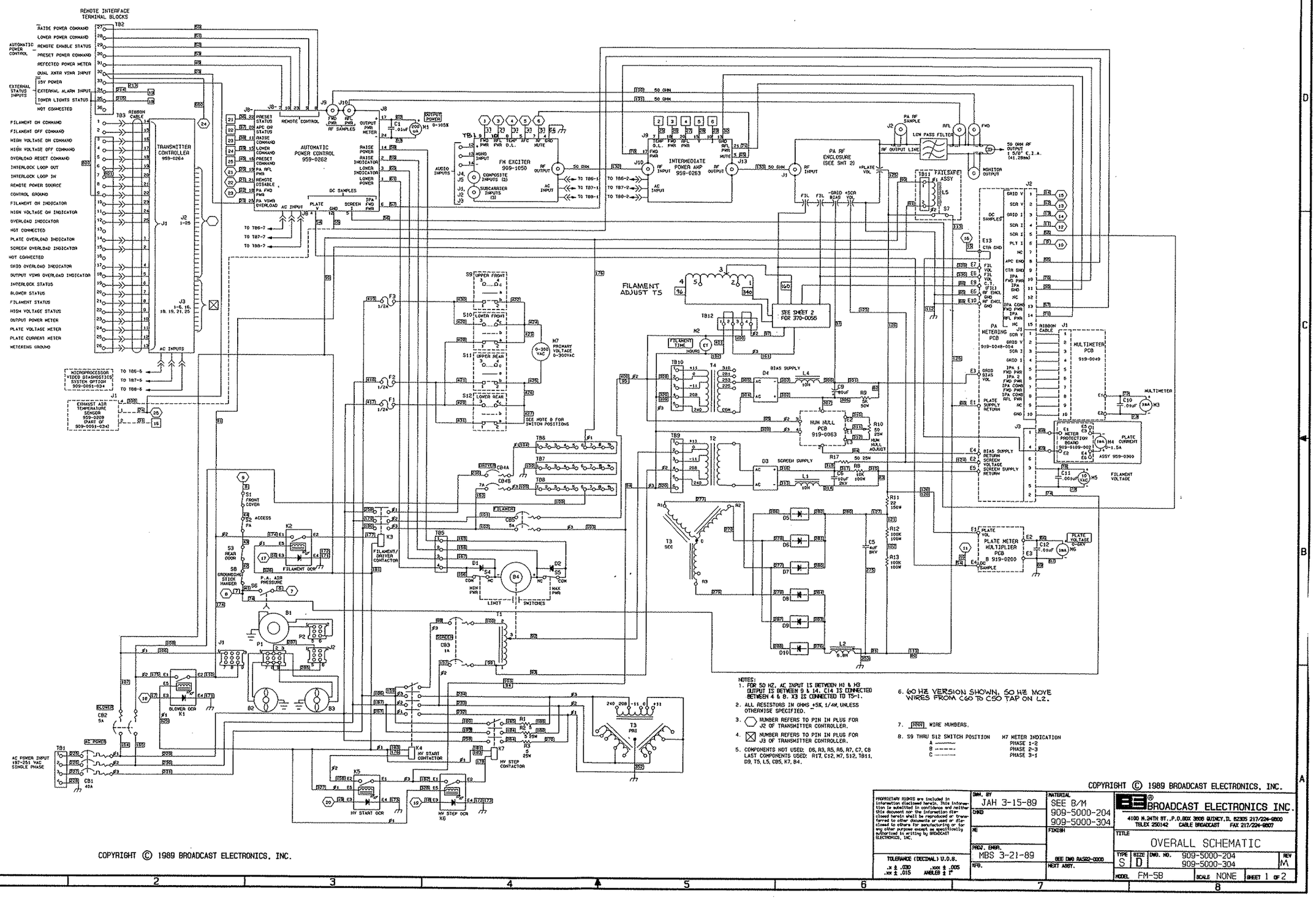
REF. DES.	DESCRIPTION	PART NO.	QTY.
----	Programmable Header, 8-Pin DIP	340-0006	5
----	Battery, 9V Alkaline	350-0002	1
----	Extender Circuit Board Assembly, Controller	919-0061	1
----	Binder and Manuals, FM-5B/FM-5BS and FX-50	979-5000-004	1
----	Hex Key, 5/32 Inch	710-0219	1
----	Elbow, 90°, 1 5/8 inch EIA Unflanged	427-0006	1
----	Coupling, Sleeve Assembly, 1 5/8 inch	427-0007	1
----	Connector, Anchor Insulator, Bullet, 1 5/8 inch, Unflanged	427-0009	1

SECTION VII
DRAWINGS

7-1. INTRODUCTION.

7-2. This section provides assembly drawings and schematic diagrams as indexed below for the FM-5B and FM-5BS Transmitters.

FIGURE	TITLE	NUMBER
7-1	OVERALL SCHEMATIC, FM-5B TRANSMITTER, 208/240V	SD909-5000-204/-304
7-2	OVERALL SCHEMATIC, FM-5B TRANSMITTER, 380V	SD909-5000-384
7-3	OVERALL SCHEMATIC, FM-5BS TRANSMITTER	SD909-5000-254/-354
7-4	ASSEMBLY DIAGRAM, PLATE CURRENT METER	AB959-0300
7-5	SCHEMATIC DIAGRAM, METER PROTECTION CIRCUIT BOARD	SB919-0109-002
7-6	ASSEMBLY DIAGRAM, METER PROTECTION CIRCUIT BOARD	AB919-0109-002
7-7	SCHEMATIC DIAGRAM, MULTIMETER CIRCUIT BOARD	SB919-0049-001
7-8	ASSEMBLY DIAGRAM, MULTIMETER CIRCUIT BOARD	AB919-0049-001
7-9	SCHEMATIC, HUM NULL CIRCUIT BOARD	SB919-0063
7-10	ASSEMBLY, HUM NULL CIRCUIT BOARD	AB919-0063
7-11	SCHEMATIC, PLATE METER MULTIPLIER CIRCUIT BOARD, FM-5B	SB919-0200
7-12	ASSEMBLY, PLATE METER MULTIPLIER CIRCUIT BOARD, FM-5B	AB919-0200
7-13	SCHEMATIC, PLATE METER MULTIPLIER CIRCUIT BOARD, FM-5BS	SB919-0079
7-14	ASSEMBLY, PLATE METER MULTIPLIER CIRCUIT BOARD, FM-5BS	AB919-0079
7-15	SCHEMATIC, PA METERING CIRCUIT BOARD	SC919-0048-004
7-16	ASSEMBLY, PA METERING CIRCUIT BOARD	AD919-0048-004
7-17	SCHEMATIC DIAGRAM, OPTICALLY-COUPLED-RELAY	SB919-0096/-001
7-18	ASSEMBLY DIAGRAM, OPTICALLY-COUPLED-RELAY	AB919-0096/-001
7-19	ASSEMBLY DIAGRAM, LOW-PASS FILTER	597-0032-506


REMOTE INTERFACE TERMINAL BLOCKS
TB2
RAISE POWER COMMAND
LOWER POWER COMMAND
AUTOMATIC POWER CONTROL
REMOTE ENABLE STATUS
PRESET POWER COMMAND
REFECTED POWER METER
QUAL XMTR VSWR INPUT
15V POWER
EXTERNAL STATUS INPUTS
EXTERNAL ALARM INPUT
TOWER LIGHTS STATUS
NOT CONNECTED
TB3
RIBBON CABLE
FILAMENT ON COMMAND
FILAMENT OFF COMMAND
HIGH VOLTAGE ON COMMAND
HIGH VOLTAGE OFF COMMAND
OVERLOAD RESET COMMAND
INTERLOCK LOOP OUT
INTERLOCK LOOP IN
REMOTE POWER SOURCE
CONTROL GROUND
FILAMENT ON INDICATOR
HIGH VOLTAGE ON INDICATOR
OVERLOAD INDICATOR
NOT CONNECTED
PLATE OVERLOAD INDICATOR
SCREEN OVERLOAD INDICATOR
NOT CONNECTED
GRID OVERLOAD INDICATOR
OUTPUT VSWR OVERLOAD INDICATOR
INTERLOCK STATUS
BLOWER STATUS
FILAMENT STATUS
HIGH VOLTAGE STATUS
OUTPUT POWER METER
PLATE VOLTAGE METER
PLATE CURRENT METER
METERING GROUND
TRANSMITTER CONTROLLER 959-0264
J1
J2 1-25
J3 1-5, 16, 18, 19, 21, 25
AC INPUTS
TO TB6-5
TO TB7-5
TO TB8-5
MICROPROCESSOR VIDEO DIAGNOSTICS SYSTEM OPTION 909-0091-024
EXHAUST AIR TEMPERATURE SENSOR 959-0209 (PART OF 909-0091-024)
AUTOMATIC POWER CONTROL 959-0262
J8
J9
J10
REMOTE CONTROL
FWD PWR, RFL PWR SAMPLES
OUTPUT PWR METER
M1 0-105%
PRESET STATUS
APC ON STATUS
LOWER COMMAND
RAISE COMMAND
PRESET COMMAND
PA RFL PWR
PA FWD PWR
REMOTE DISABLE
PA VSWR OVERLOAD
RAISE POWER
RAISE INDICATOR
LOWER INDICATOR
LOWER POWER
DC SAMPLES
AC INPUT
PLATE
SCREEN
IPA FWD PWR
TO TB6-7
TO TB7-7
TO TB8-7
FM EXCITER 909-1050
TB2
AUDIO INPUTS
MONO INPUT
J4, J5 COMPOSITE INPUTS (2)
J1, J2, J3 SUBCARRIER INPUTS (3)
RF OUTPUT
AC INPUT
50 OHM
TO TB6-1
TO TB7-1
TO TB8-1
INTERMEDIATE POWER AMP 959-0263
RF INPUT
RF OUTPUT
TO TB6-2
TO TB7-2
TO TB8-2
PA RF ENCLOSURE (SEE SHT 2)
PA RF SAMPLE
LOW PASS FILTER
RF OUTPUT LINE
50 OHM RF OUTPUT 1 5/8" E.I.A. (41.28MM)
MONITOR OUTPUT
+PLATE VOL
-GRID +SCR BIAS VOL
FIL
TB11 FAILSAFE PCB ASSY
L5
S7
DC SAMPLES
PA METERING PCB 919-0048-004
RIBBON CABLE
MULTIMETER PCB 919-0049
MULTIMETER
PLATE CURRENT M3
ASSY 959-0300
FILAMENT VOLTAGE
METER PROTECTION BOARD 919-0109-002
PLATE METER MULTIPLIER PCB 919-0200
PLATE VOLTAGE M6
SAMPLE
FILAMENT ADJUST T5
SEE SHEET 2 FOR 370-0056
TB12
K2
FILAMENT TIME HOURS
CT
TB10
T4
BIAS SUPPLY
D4
L4
C9
R9
HUN NULL PCB 919-0063
R10
HUN NULL ADJUST
TB9
T2
SCREEN SUPPLY
D3
L1
C6
R8
R17
R11
R12
R13
C5
D5
D6
D7
D8
D9
D10
L2
T3 SEC
R1
R2
R3
SS UPPER FRONT
S10 LOWER FRONT
S11 UPPER REAR
S12 LOWER REAR
SEE NOTE 8 FOR SWITCH POSITIONS
M7 PRIMARY VOLTAGE 0-300VAC
F1 1/2A
F2 1/2A
F3 1/2A
TB6
TB7
TB8
CR4A
CR4B
FILAMENT CR5 5A
TB5
D1
D2
B4
LIMIT SWITCHES
T1
SCREEN CB3 1A
B1
P1
P2
J2
J3
B2
B3
S1 FRONT COVER
ACCESS PA
S3 REAR DOOR
S8 GROUNDING STICK HANGER
S6 P.A. AIR PRESSURE
K2
FILAMENT OCR
K3 FILAMENT/ DRYER CONTACTOR
BLOWER
CB2 5A
BLOWER OCR
K1
AC POWER
TB1
AC POWER INPUT 197-251 VAC SINGLE PHASE
CB1 40A
K4 HV START CONTACTOR
K7 HV STEP CONTACTOR
K5
K6
HV START OCR
HV STEP OCR
T3 PRI
240 209 -11 0 +11
NOTES:
1. FOR 50 HZ, AC INPUT IS BETWEEN H1 & H3 OUTPUT IS BETWEEN 9 & 14. C14 IS CONNECTED BETWEEN 4 & 8. X3 IS CONNECTED TO TS-1.
2. ALL RESISTORS IN OHMS +5%, 1/4W, UNLESS OTHERWISE SPECIFIED.
3. ⬡ NUMBER REFERS TO PIN IN PLUG FOR J2 OF TRANSMITTER CONTROLLER.
4. ⊠ NUMBER REFERS TO PIN IN PLUG FOR J3 OF TRANSMITTER CONTROLLER.
5. COMPONENTS NOT USED: D6, R3, R5, R6, R7, C7, C8 LAST COMPONENTS USED: R17, C12, H7, S12, TB11, D9, T5, L5, CB5, K7, B4.
6. 60 HZ VERSION SHOWN, 50 HZ. MOVE WIRES FROM C60 TO C50 TAP ON L2.
7. [NNN] WIRE NUMBERS.
8. S9 THRU S12 SWITCH POSITION / H7 METER INDICATION
A ——— PHASE 1-2
B – – – PHASE 2-3
C ····· PHASE 3-1
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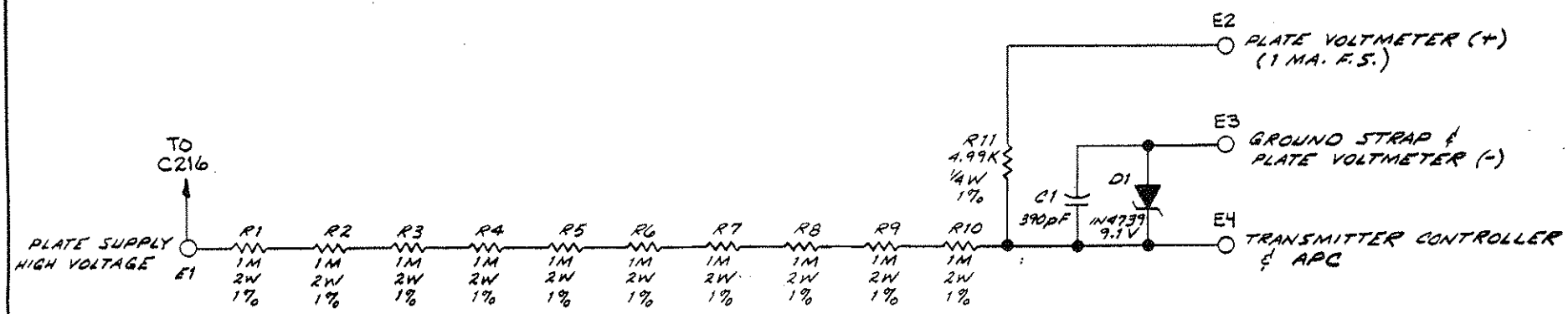
TOLERANCE (DECIMAL) U.O.S. .x ± .030 .xx ± .015 .xxx ± .005 ANGLES ± 1°
DWN. BY JAH 3-15-89
CHKD
ENG
PROJ. ENGR. MBS 3-21-89
REQ.
MATERIAL SEE B/M 909-5000-204 909-5000-304
FINISH
SEE DWG RA582-0006
NEXT ASSY.
BROADCAST ELECTRONICS INC.
4100 N.24TH ST., P.O.BOX 3606 QUINCY, IL 62305 217/224-9600
TELEX 250142 CABLE BROADCAST FAX 217/224-9607
TITLE OVERALL SCHEMATIC
TYPE S SIZE D DWG. NO. 909-5000-204 909-5000-304 REV M
MODEL FM-5B SCALE NONE SHEET 1 OF 2



NOTES:
1. ALL RESISTORS IN OHMS.
2. LAST COMPONENTS USED: C1, D1, E4, R11
3. SEE ASSEMBLY # B 919-0079
   SEE B/M # 919-0079

TOLERANCE UNLESS OTHERWISE SPECIFIED
DECIMAL 2 PL ± .01 3PL ± .005
FRACTIONAL ± 1/64
ANGULAR ± 1°
SHARP EDGES TO
BEND RADII
FILLET RADII

MATERIAL

DRAWN BY MERKEL DATE 1-23-84
CHECKED BY MH DATE 1-23-84
PROJECT ENGR DATE
APPROVED BY

TREATMENT OR FINISH

BROADCAST ELECTRONICS INC.

TITLE PCB SCHEMATIC - METER MULTIPLIER

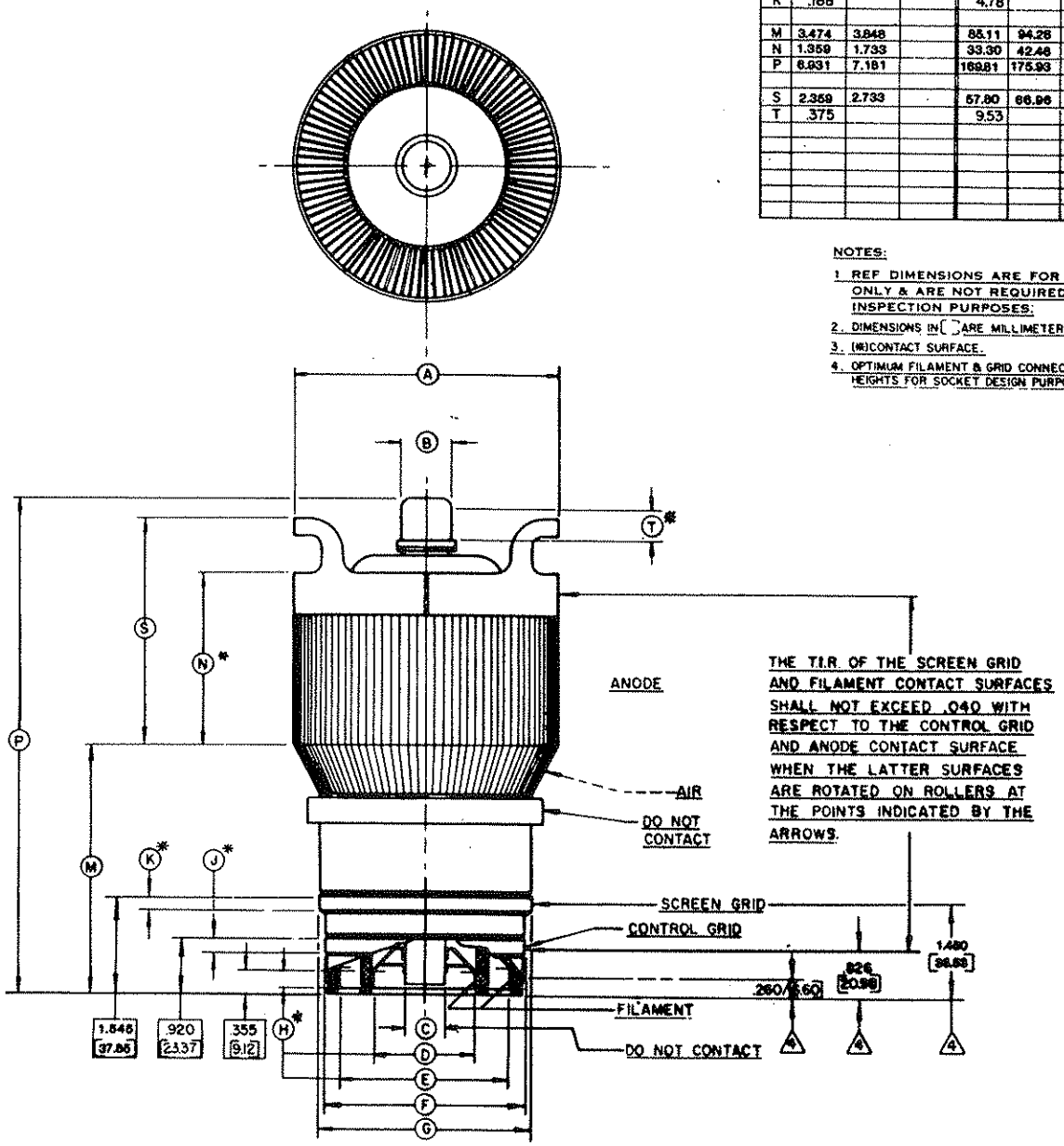
B | DWG. NO. TYPE 5 919-0079 | REV. A

XMTRS | SCALE NONE | SHEET 1 OF 1

DIMENSIONAL DATA						
	INCHES			MILLIMETERS		
DIM	MIN	MAX	REF	MIN	MAX	REF
A	4.812	4.938		122.22	125.43	
B	.855	.895		21.72	22.73	
C	.600	.760		15.24	19.30	
D	1.896	1.936		48.16	49.17	
E	3.133	3.173		79.58	80.59	
F	3.792	3.832		96.32	97.33	
G	3.980	4.020		101.09	102.11	
H	.188			4.78		
J	.188			4.78		
K	.188			4.78		
M	3.474	3.848		88.11	94.26	
N	1.359	1.733		33.30	42.46	
P	6.931	7.181		169.81	175.93	
S	2.359	2.733		57.80	66.96	
T	.375			9.53		

NOTES:

1. REF DIMENSIONS ARE FOR INFO ONLY & ARE NOT REQUIRED FOR INSPECTION PURPOSES.
2. DIMENSIONS IN [ ] ARE MILLIMETERS.
3. (M) CONTACT SURFACE.
4. OPTIMUM FILAMENT & GRID CONNECTOR HEIGHTS FOR SOCKET DESIGN PURPOSES.



Eimac division of varian
San Carlos California

CODE IDENT No.	06980
PART No	4CX3500A
OUTLINE	ELECTRON TUBE
No	4CX3500A - 60

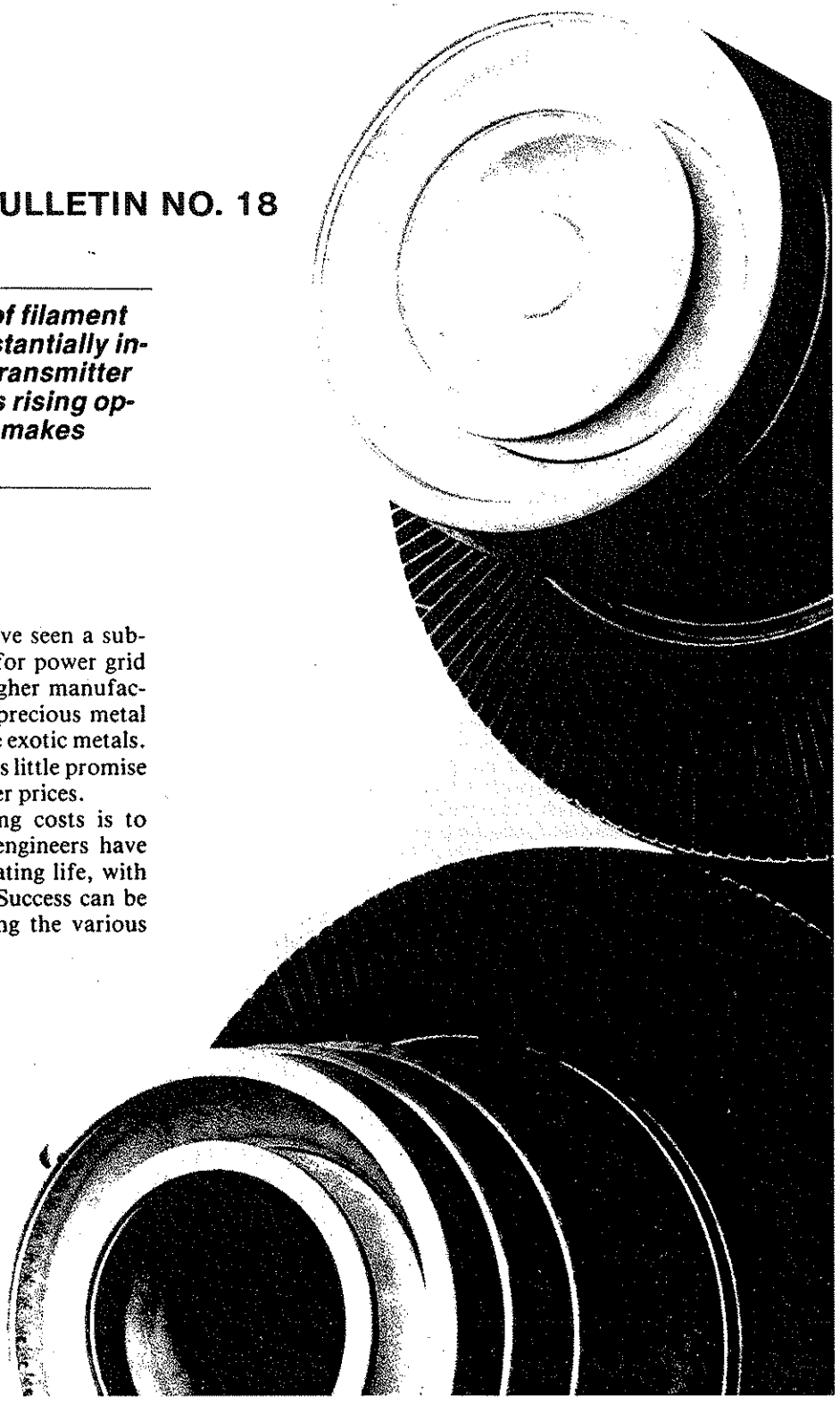
EXTENDING TRANSMITTER TUBE LIFE

EIMAC APPLICATION BULLETIN NO. 18

A carefully followed program of filament voltage management can substantially increase the life expectancy of transmitter power grid tubes. With today's rising operating costs, such a program makes good financial sense.

IN RECENT YEARS station managers have seen a substantial increase in replacement costs for power grid tubes. The blame can be placed on higher manufacturing costs due to inflation, volatile precious metal prices, and an uncertain supply of some exotic metals. The current outlook for the future holds little promise for a reversal in this trend toward higher prices.

One way to offset higher operating costs is to prolong tube life. For years station engineers have used various tricks to get longer operating life, with greater and lesser degrees of success. Success can be maximized, however, by understanding the various



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San Carlos, CA 94070

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Salt Lake City, UT 84104

EIMAC Application Bulletin AB-18
Revised March, 1990

Extending Transmitter Tube Life

factors that affect tube life and implementing a program of filament voltage management.

A number of factors can aid maximum tube life in your transmitter. For example, are the maximum ratings given on the tube manufacturer's data sheet being exceeded? Data sheets are available upon request from most companies. Most tube manufacturers have an application engineering department to assist in evaluating tube performance for a given application. Make use of these services!

Headroom

Is the final power tube of the transmitter capable of delivering power in excess of the desired operating level? Or is the demand for performance so great that minimum output power levels can only be met at rated nominal filament voltage?

Figure 1 can be used as a basic guide to determine if a given transmitter and tube combination has a good probability of giving extended life service. Extended life service is defined as useful operating life beyond that normally achieved by operating at rated nominal filament voltage. The amperes/watt ratio is obtained by dividing average plate current by the product of filament voltage and filament current. If the amperes/watt ratio falls in the "good" to "excellent" range, excess emission is sufficient to permit filament voltage derating. At a lower filament voltage, the filament temperature is lowered, thus extending life. A typical FM transmitter on the market today may have an amperes/watt filament ratio of 0.002 to 0.003. This equipment would be considered an excellent choice to achieve extended tube life. On the other hand, if the amperes/watt ratio falls in the "poor" range, it is unlikely that filament derating is possible due to limited emission. Note that this guideline should be used for thoriated tungsten emitters only, and does not apply to oxide cathode-type tubes.

Instrumentation

Are all tube elements metered in the transmitter? Elements should be metered for both voltage and current, and meters should be redlined to define operation within safe limits. More modern transmitters may incorporate a microprocessor-controlled circuit to monitor all pertinent parameters.

In addition, the following controls are necessary if an effective filament voltage management program is to be undertaken: power output metering for an FM transmitter or a distortion level meter for AM equipment; *accurate* filament voltage metering (an iron-vane instrument is preferred over the more common average responding RMS calibrated type; the filament voltage measurement must be made at the tube socket terminals); filament voltage control, capable of being adjusted to 0.1 V secondary voltage change; and a filament current meter—desirable but optional.

A means must be provided to hold filament voltage constant. If the filament voltage is permitted to vary in accordance with primary line voltage fluctuation, the effect on tube life can be devastating. An acceptable solution is the use of a ferroresonant transformer or line regulator. This accessory is offered by some transmitter manufacturers as an option and should be seriously considered if a tube life extension program is planned.

Transmitter housekeeping

Once the transmitter has been place in operation, tube life is in the hands of the chief engineer. The first action to prolong tube life falls into the category of routine maintenance. Most transmitter manufac-

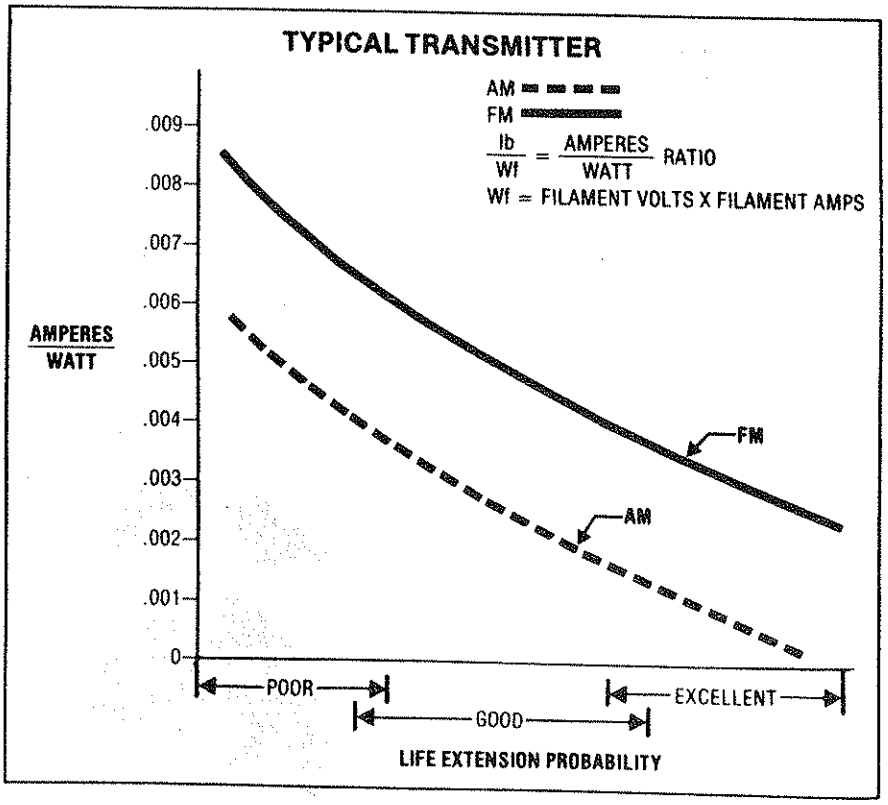


***Fig. 1.** Probability of extended life service can be determined from this graph. Divide the average p.a. plate current in amperes by the product of filament voltage and current. The resulting amperes/watt ratio (Y-axis) is projected horizontally to the appropriate curve. The vertical projection to the X-axis indicate the life extension probability.*

Extending Transmitter Tube Life

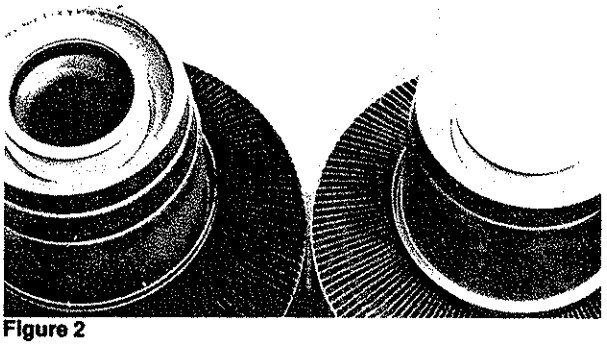


Figure 2

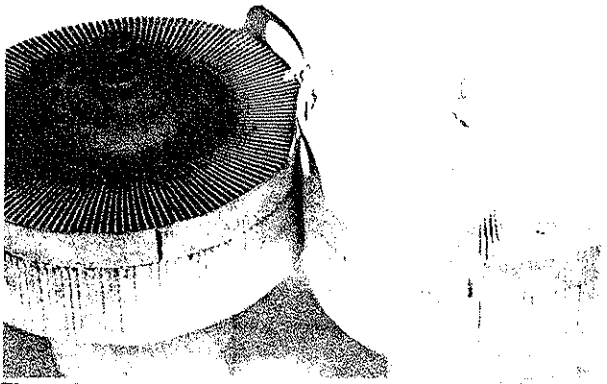


Figure 3

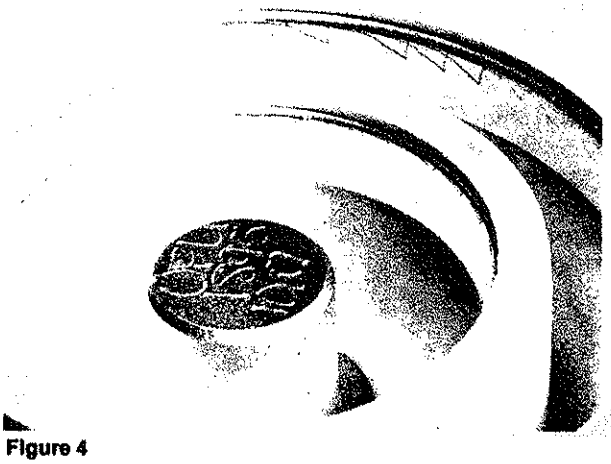


Figure 4

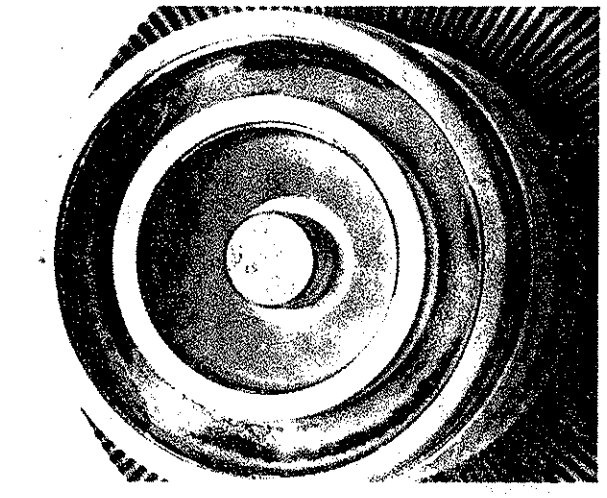


Figure 5

turers have a routine maintenance schedule established in the equipment manual. This procedure must be followed carefully if operating costs are to be held to a minimum. During routine maintenance it is very important to look for tube and socket discoloration, either of which can indicate overheating.

Look for discoloration around the top of the cooler near the anode core and at the bottom of the tube stem where the filament contacts are made. Review Figures 2 and 3 for examples of a tube operating with inadequate cooling. It is possible for discoloration to appear in the areas mentioned if the transmitter has to operate in a dirty environment. If this is the case, the tube should be removed and cleaned with a mild detergent. After cleaning, the tube should be rinsed thoroughly to remove any detergent residue and blown dry with compressed air. If the discoloration remains, this is an indication that the tube has operated at too high a temperature. Check inlet and outlet air ducting and filters for possible air restriction. It may also be necessary to verify that the air blower is large enough to do the job in the present environment and that it is operating at rated capacity.

With the tube removed, the socket should be blown or wiped clean and carefully inspected. Any discoloration in the socket finger stock caused by overheating could contribute to early tube failure. A finger stock that loses its temper through prolonged operation at high temperature will no longer make contact to the tube elements (Figure 4). A well-maintained socket will score the tube contacts when the tube is inserted. If all fingers are not making contact, more currect flows through fewer contacting fingers, causing addi tional overheating and possible burnout (Figure 5).

Filament voltage management

The useful operating life of a thoriated tungsten emitter can vary widely with filament voltage. Figure 6 describes the relative life expectancy with various filament voltage levels. Obviously, a well-managed filament voltage program will result in longer life expectancy. Improper management, on the other hand. can be very costly.

For a better understanding of this sensitive aging mechanism, the filament itself must be understood. Most filaments in high-power, gridded tubes are a mixture of tungsten and thoria with a chemical com-

Fig. 2. Improper cooling means short tube life (left). Discoloration of metal around inner filament stem and anode fins indicates poor cooling or improper operation of tube. Properly cooled and operated tube (right) shows no discoloration after many hours of use. In both cases, good socketing is indicated by scoring on circular connector rings.

Fig. 3. Dirty and discolored cooler of amplifier tube at left indicates combination of discoloration due to heating and lack of cleaning. Tube has operated too hot and dust has collected in anode louvres.

Fig. 4. Minute scoring in base contact rings indicates that socket finger stock has made good, low-resistance contact to tube elements. Well-maintained socket will score the tube contacts when tube is inserted. If all fingers do not make contact, more current will flow through fewer contact fingers, causing additional overheating and burning. as shown in Fig. 5.

Fig. 5. High resistance socket contacts has caused severe burning of contact area in the base. Overheated base caused early demise of tube.

position of W + THO_2. A filament made of this wire is not a suitable electron emitter for extended life applications until it is processed. Once the filament is formed into the desired shape and mounted, it is heated to approximately 2100°C in the presence of a hydrocarbon. The resulting thermochemical reaction forms di-tungsten carbide on the filament's surface. Life is proportional to the degree of carburization. If the filament is overcarburized, however, it will be brittle and easily broken during handling and transporting. Therefore, only approximately 25% of the cross-sectional area of the wire is converted to di-tungsten carbide. Di-tungsten carbide has a higher resistance than tungsten; thus, the reaction can be carefully monitored by observing the reduction in filament current as the carburizing process proceeds.

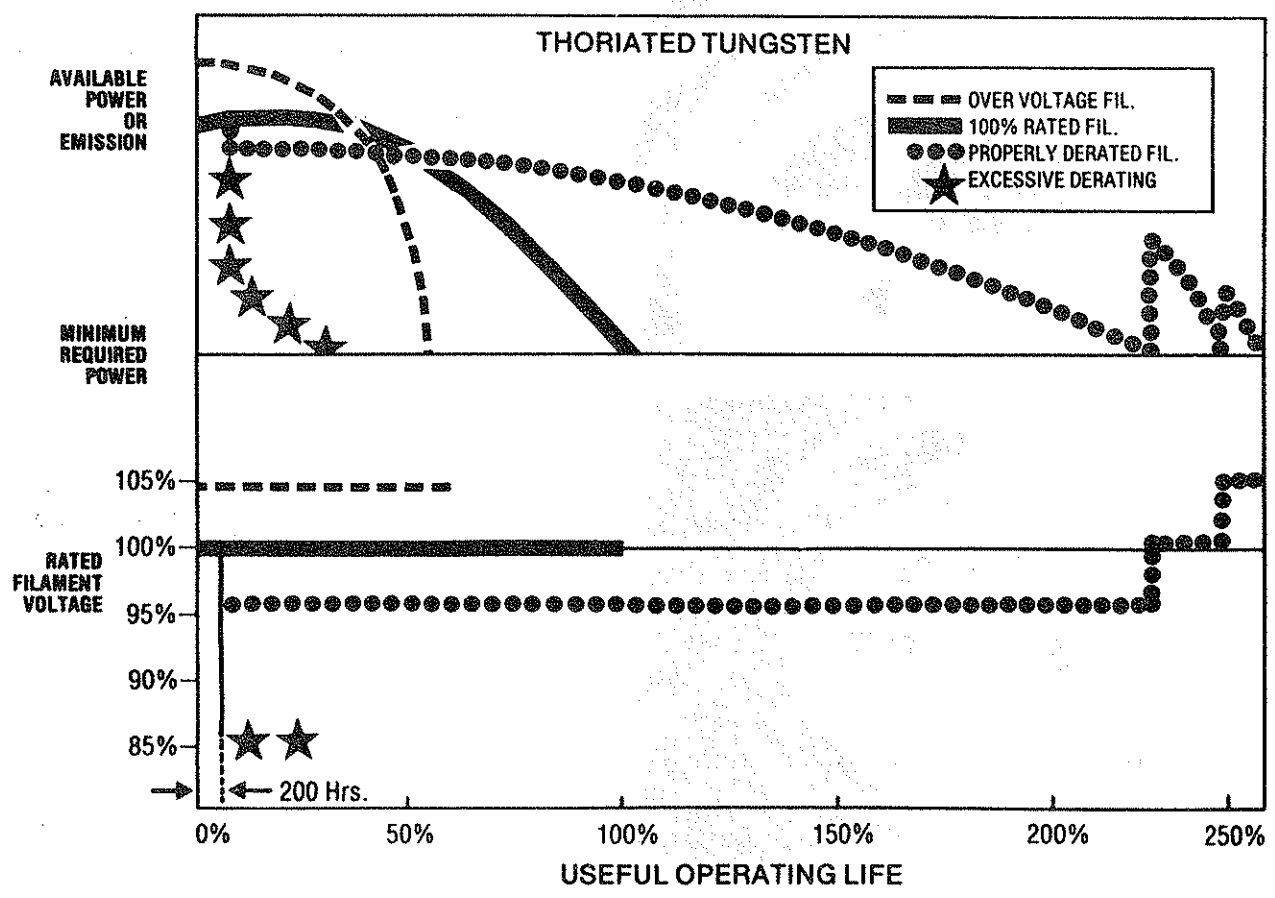
As the tube is used the filament slowly decarburizes. At some point in life, all of the di-tungsten carbide layer is depleted and the reduction of thoria to free thorium stops. The filament is now decarburized and is no longer an effective electron emitter.

The key to extending the life of a thoriated tungsten filament emitter is to control operating temperature. Emitter temperature is a function of the total RMS power applied to the filament. Thus, filament voltage control is temperature control. Temperature varies directly with voltage. As the emitter temperature rises the de-carburizing process is accelerated and tube life shortened. Figure 6 shows that useful tube life can vary significantly with only a 5% change in filament voltage.

FILAMENT VOLTAGE MANAGEMENT (Figure 6)

Filament voltage management allows extended tube life when accompanied by a continuing housekeeping program. When filament voltage is too high (dashes), power tube looses emission rapidly and normal operating life is not achieved. When filament is operated at rated voltage (black curve) normal tube life is achieved in a majority of cases. With a filament voltage management program (bullets), extended tube life may be achieved. When the minimum required output power level is finally reached (right-hand portion of curve), the filament voltage may be raised to rated value, or above, to achieve additional useful operating life. If filament is run "cool" (stars), extremely short life will result. Note that filament voltage management program does not take effect until about 200 hours of operating time have passed.

If voltage management program is not undertaken, tube should be run at rated filament voltage.



Extending Transmitter Tube Life

Of great importance to long tube life is the temperature of the elements and the ceramic-to-metal seals. Element temperature can be held within proper limits by observing the maximum dissipation ratings listed in the data sheet. Seal temperature should be limited to 200°C at the lower anode seal under worst-case conditions. As element temperature rises beyond 200°C, the release of contaminants locked in the materials used in tube manufacturing increases rapidly. These contaminants cause a rapid depletion of the di-tungsten carbide layer of the filament.

When a new power tube is installed in a transmitter, it must be operated at rated nominal filament voltage for the first 200 hours. This procedure is very important for two reasons. First, operation at normal temperature allows the getter to be more effective during the early period of tube life when contaminants are more prevalent. This break-in period conditions the tube for operation at lower filament voltage to obtain longer filament life. Secondly, during the first 200 hours of operation filament emission increases. It is necessary for the life extension program to start at the peak emission point.

A chart recorder or other device should be used to monitor variations in primary line voltage for several days of transmitter operation. The history of line voltage variations during on-air time must be reviewed prior to derating filament voltage. Plan to establish the derated voltage during the time period of historically low line voltage, as this is the worst-case condition. If line variation is greater that ± 3%, filament voltage must be regulated.

Record output power (FM) or distortion level (AM) with the tube operating at rated nominal filament voltage. Next, reduce filament voltage in increments of 0.1 V and record power or distortion levels at each increment. Allow one minute between each increment for the filament emission to stabilize.

When a noticeable change occurs in output power or the distortion level changes, the derating procedure must stop. Obviously, operation at this point is unwise since there is no margin for a drop in line voltage. It is safer to raise the voltage 0.2 V above the critical voltage at which changes are observed to occur. Finally, recheck power output or distortion to see if they are acceptable at the chosen filament voltage level. Recheck again after 24 hours to determine if emission is stable and that the desired performance is maintained. If performance is not repeatable, the derating procedure must be repeated.

Continuing the program

The filament voltage should be held at the properly derated level as long as minimum power or maximum distortion requirements are met. Filament voltage can be raised to reestablish minimum requirements as necessary. This procedure will yield results similar to those shown in the illustration, to achieve as much as 10% to 15% additional life extension. When it becomes necessary to increase filament voltage, it is a good time to order a new tube. Filament voltage can be increased as long as the increase results in maintaining minimum level requirements.

When an increase fails to result in meeting a level requirement, filament emission must be considered inadequate and the tube should be replaced. Don't discard it or sell it for scrap! Put it on the shelf and save it. It will serve as a good emergency spare and may come in very handy some day. Also, in AM transmitters, a low-emission RF amplifier tube can be shifted to modulator use where the peak filament emission requirement is not as severe.

Start planning for longer tube life now! Review the following steps you can take:

- Investigate the manufacturer's ratings on the power tubes in your present equipment, or the transmitter you plan to buy.
- Check that your transmitter has sufficient headroom. Is there a margin of safety in tube operation?
- Look for important instrumentation in the next transmitter you buy. Are all tube elements monitored for voltage and current in the transmitter?
- Whether your transmitter is new or old, start a filament life extension program.

Remember that each time you replace a power tube, the recommended derating procedure must be rerun. Voltage levels required with one tube do not apply to a replacement tube.

When purchasing a tube, insist on a new tube that carries the full, original manufacturer's warranty. Only tubes manufactured by the company of origin have to perform to published data. This is the important reason that transmitter manufacturers buy new, warranted tubes from the original manu facturer.

Thanks to William Barkley, William Orr, William Sain, and Bob Tornoe, all of Varian EIMAC, for their help and suggestions in preparing this paper.

Bibliography

1. Ayer, R.B., "Use of Thoriated-Tungsten Filaments in High Power Transmitting Tubes," *Proceedings of the I.R.E.*, page 591, May, 1952.
2. Kohl, Walter H., *Materials and Techniques for Electron Tubes*, Reinhold Publishing Corp., N.Y., 1960.
3. Horsting, C.W., "Carbide Structures in Carburized Thoriated-Tungsten Filaments," *Journal of Applied Physics*, Volume 18, Jan., 1947.
4. Langmuir, I., "The Electron Emission from Thoriated Tungsten Filaments," *Physical Review*, 1923, Page 357.
5. Walker, H.S., "High Power Transmitting Valves With Thoriated Filaments for Use in Broadcasting," The Institution of Electrical Engineers, Paper No. 3200E, March, 1960.

THOMSON-CSF
DIVISION SEMICONDUCTEURS DISCRETS

SD 1460

VHF NPN POWER TRANSISTOR FOR CLASS C FM OPERATION

FEATURES

- Gold metallizations
- Glass passivated structure
- Hermetical ceramic package
  → high reliability
- Emitter ballast resistors → severe inpedance mismatch
- Auto-aligned structure → high characteristics reproductibility

APPLICATIONS

Telecommunications up to 108 MHz frequency band.

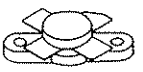
PARTICULARITES

- *Métallisations "Or"*
- *Structure passivée*
- *Boîtier céramique hermétique*
  → *haute fiabilité*
- *Résistances ballast d'émetteur* → *bonne tenue au ROS*
- *Structure auto-alignée* → *bonne reproductibilité des caractéristiques*

APPLICATIONS

Telecommunications dans la bande de fréquences jusqu'à 108MHz

f	=	108	MHz
P_{OUT}	=	160	W
Gp	=	9	dB
ηc	=	75	%
V_{CC}	=	28	V



Case / *Boîtier* : CB-290 (.500 4L FL)

ABSOLUTE RATINGS (LIMITING VALUES) / *VALEURS LIMITES ABSOLUES D'UTILISATION*	Symbols	Values	Units
Emitter-base (d.c.) voltage / *Tension continue émetteur-base* @ I_E = 20 mA	V_{EBO}	4	V
Collector-base (d.c.) voltage / *Tension continue collecteur-base* @ I_C = 100 mA	V_{CBO}	65	V
Collector-emitter (d.c.) voltage / *Tension continue collecteur-émetteur* @ I_C = 100 mA , R_{BE} = 10 Ω	V_{CES}	60	V
Collector (d.c.) current / *Courant continu de collecteur*	I_C	16	A
Storage and junction temperature range / *Températures extrêmes de stockage et de jonction*	T_{stg} T_j	− 65 → + 200	°C °C

Thermal resistance (junction-case) / *Résistance thermique (jonction-boîtier)* @ P_D = 100W , T_c = 25°C	$R_{th(j-c)}$	0,75	°C/W

50, rue Jean-Pierre Timbaud - B.P. 5
F - 92403 Courbevoie Cedex FRANCE
Tél. : (1) 788-50-01 Telex : 610560 F

THOMSON-CSF COMPOSANTS

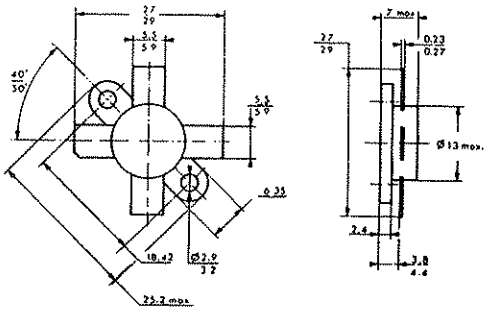
STATIC CHARACTERISTICS at t_{amb} = 25°C
CARACTERISTIQUES STATIQUES à t_{amb} = 25°C

Symbols	Values			Units	Test conditions
	min.	typ.	max.		
$V_{(BR)EBO}$	4			V	I_E = 20 mA
$V_{(BR)CBO}$	65			V	I_C = 100 mA
$V_{(BR)CES}$	60			V	I_C = 100 mA
I_{CBO}				mA	V_{CB} = V
H_{FE}	20		150		I_C = 1 A V_{CE} = 5 V
C_{22b}			150	pF	V_{CB} = 28 V f = 1 MHz

DYNAMIC CHARACTERISTICS at t_{amb} = 25°C
CARACTERISTIQUES DYNAMIQUES à t_{amb} = 25°C

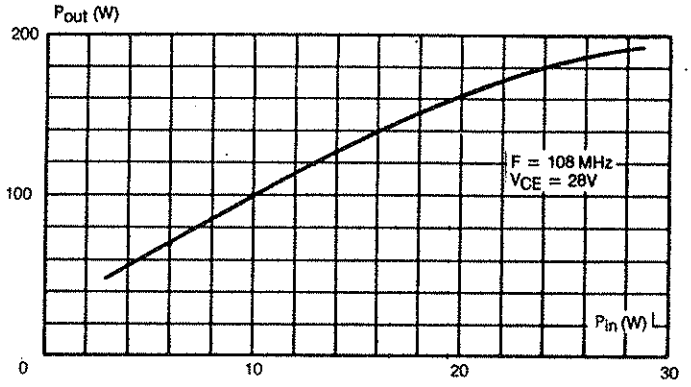
Symbols	Values			Units	Test conditions
	min.	typ.	max.		
P_{OUT}		160		W	f = 108 MHz V_{CB} = 28 V P_{IN} = 20 W
G_P		9		dB	
η_c	70	75		%	

CASE DESCRIPTION
DESCRIPTION DU BOITIER



Dimensions in millimeters

CB-290
(.500 4LFL)



Output power versus input power (typical values)

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

SECTION I
IPA THEORY OF OPERATION

1–1. INTRODUCTION.

1–2. The following text provides detailed theory of operation with supporting diagrams for the FM–5B/FM–5BS IPA. For purposes of definition, the text is divided into functional circuits.

1–3. GENERAL DESCRIPTION.

1–4. The FM–5B/FM–5BS IPA stage is a totally self–contained solid–state wideband FM amplifier providing a continuously variable output from 75 to 250 Watts. The unit is mounted on slide rails for ease of maintenance.

1–5. The IPA consists of: 1) a power supply, 2) a voltage regulator circuit, and 3) an RF amplifier module (refer to Figure 1–1). Three front–panel indicators provide status information on module forward power, reflected power, and temperature conditions. The following text presents a detailed description of the IPA circuitry.

1–6. POWER SUPPLY.

1–7. The IPA power supply consists of a conventional full–wave bridge–rectified supply, a capacitor filter and bleeder, and a series regulator. The transformer primary has multiple taps which must be preset to minimize over–voltage and consequent over–dissipation of the regulator devices. This allows optimum efficiency to be obtained through the supply.

1–8. The power supply operates from an input of 194 to 275V ac at 2 Amperes and produces the following potentials:

A. +40V dc @ 18 Amperes, Filtered.

B. +40V dc @ 0.5 Amperes, Filtered.

C. +28V dc @ 0.5 Amperes, Regulated.

D. +15V dc @ 0.5 Amperes, Regulated.

E. –1.3V dc @ 10 mA, Stabilized.

1–9. INTERCONNECT/FILTER CIRCUIT BOARD.

1–10. The interconnection filter circuit board provides internal connections between circuit boards, provides RFI filtering for the IPA status outputs, and provides interfacing for selected control inputs.

1–11. CONTROL CIRCUIT BOARD.

1–12. The control circuit board regulates the operation of the RF amplifier within preset limits dependent upon several parameters such as reflected power and forward power or dc voltage, control regulator heatsink temperature, dc current, and an external mute input. The control circuit board also contains amplifiers for the forward and the reflected directional couplers, the over–temperature circuit, and the IPA metering circuitry.

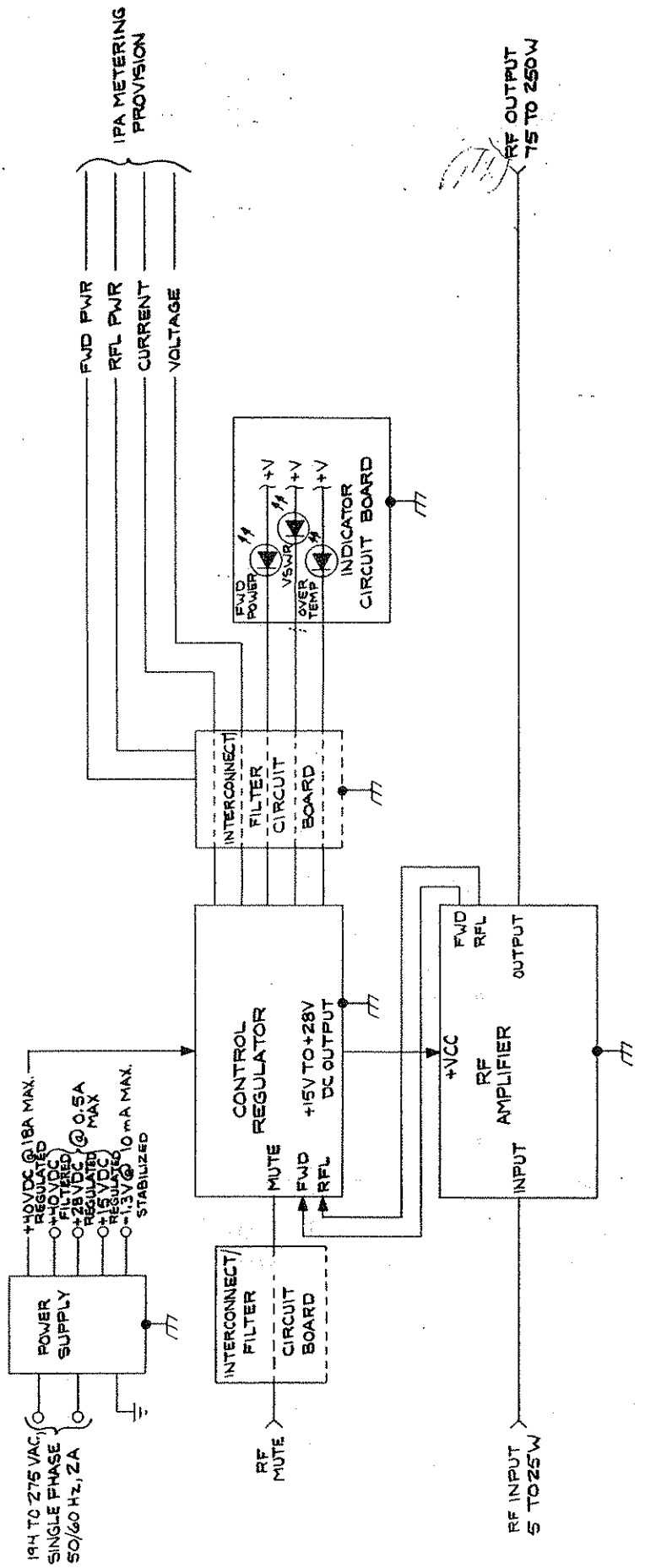


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FIGURE 1-1. IPA BLOCK DIAGRAM

1–13. The regulator and control circuitry is contained on a printed circuit board with the output pass transistors mounted on an attached heatsink. Multiple paralleled devices are used to enhance reliability. The regulator is capable of supplying 28 volts at 18 Amperes of direct current. Voltage foldback will occur when excessive current is drawn or a high reflected power sample is evident. This protects the RF power transistors against output mismatch–induced damage. The drive signal or ac power must be momentarily removed to restore normal voltage from the regulator after foldback has occurred. A yellow front–panel mounted **VSWR** indicator indicates excessive reflected power into the output of the IPA with possible voltage foldback occurring when illuminated.

1–14. **TEMPERATURE SENSOR.** A temperature sensor is bonded to the regulator heatsink. This protects the output pass transistors from over–dissipation in the event of a fault by latching off the regulator driver circuit upon excessive temperature. A red front–panel mounted **OVER TEMP** indicator indicates this condition when illuminated. Removal of power is required to reset the operation of the regulator after an over–temperature condition has occurred.

1–15. **RF AMPLIFIER.**

1–16. The RF circuitry consists of two bipolar RF power transistors conservatively operated as a push–pull class C amplifier. Wide–band transmission–line matching sections transform impedances on the printed circuit board while providing for balanced push–pull operation of the transistors. Stripline networks along with chip capacitors match the base and collector elements of both transistors to the transmission line sections. A stripline directional coupler provides forward and reflected power samples. The IPA exhibits a minimum power gain of 10.

1–17. Normal IPA stage operation is indicated by illumination of the green front–panel **FWD POWER** indicator (approximately 75 Watts of forward power). A high reflection is indicated by illumination of the yellow front–panel **VSWR** indicator (approximately 10 Watts of reflected power) with possible foldback of the control regulator. Removal of the dc or RF input to the IPA stage is required to reset a foldback condition.

1–18. DETAILED DESCRIPTION.

1–19. **POWER SUPPLY.**

1–20. **PRIMARY CIRCUIT.** The IPA power supply operates from an input of 194 to 275 volts ac at a maximum of 2 Amperes (see Figure 1–2). AC power is input through RFI filter FL1 which provides 55 dB of attenuation to frequencies of 10 MHz and above. A special power transformer with a tapped dual primary allows operation from both 50 and 60 Hz as well as a wide range of ac input voltages without component changes. Compensation for different input voltages is accomplished by wiring changes to terminal strip TS1 and a power transformer secondary tap. If the supply is ever operated from a single–line input such as 120 volts ac, the fuse in the common side of the ac input must be jumpered out of the circuit for safety reasons. Refer to schematic diagram D959–0263 for input potentials and required wiring changes.

1–21. The cooling fan is connected across one primary of transformer T1 and runs continuously whenever ac power is applied. Fuses F1 and F2 provide overload protection for the primary circuit and metal–oxide varistor MOV1 provides suppression of voltage surges in excess of 250 volts.

1–22. **SECONDARY CIRCUIT.** The tapped secondary of T1 produces an ac voltage which is full–wave rectified into a +40 volt dc supply. C1 provides filtering, R1 acts as a bleeder, and fuse F3 provides overload protection for the secondary circuit. The +40 volt dc output is routed to the control regulator assembly where it is distributed and regulated into several different potentials.

1–23. **Regulators.** The 40 volt dc potential is fed directly to the pass transistor network mounted on the control regulator heat sink and to the regulators on the control regulator circuit board through fuse F1. The pass transistor network outputs a regulated potential to the RF amplifier to maintain a constant RF output in response to control parameters measured by the control regulator circuit board.

1–24. The 40 volt input to U1 is regulated into a +28 volt source. The +28 volt source is re–regulated by U2 into a +15 volt source. Regulators U1 and U2 are both three–terminal adjustable positive regulators containing internal thermal–overload protection and short–circuit current limiting features. Further protection for the regulators is provided by diodes D3 and D4, each which protects its respective regulator from a reverse polarity potential applied to the output and diodes D1 and D2, each which protects its respective regulator from a short circuit applied to the input.

1–25. **Negative 1.3 Volt Supply.** A negative 1.3 volt potential required for the metering circuit is developed from the output of U6B which is configured as an oscillator. The output of U6B is rectified by a voltage doubler consisting of C17, D14, and D15. The output of this supply is stabilized by diodes D16 and D17, each which provides a constant 0.65 volt drop to maintain the output at a constant –1.3 volts.

1–26. CONTROL REGULATOR.

1–27. The control regulator consists of a circuit board and a heatsink assembly which forms part of a closed loop with the RF amplifier. Jumper–plug programming allows feedback selection of either dc voltage and VSWR or forward RF power and VSWR for feedback (see Figure 1–3).

1–28. The regulator output voltage is established by a precision voltage drop, a series string of resistors, and the output voltage adjust control (R17). For a regulator output voltage of 28 volts, R17 must be adjusted to 14.8 volts on the wiper.

1–29. Plug P17 allows selection of a dc voltage as a regulator reference or an optional digital–to–analog converter reference. Resistor R20 provides an input to error amplifier U5A if P17 is inadvertently removed. The potential from P17 is applied to the non–inverting input to error amplifier U5A. Error amplifier U5A compares this input to the regulator output which is applied through a voltage divider to the inverting input. If the regulator output decreases, the output of U5A will increase. If the regulator output increases, the output of U5A will decrease. This control voltage is routed through steering diode D9 and level–shift diode D10 to a constant–current source.

1–30. Q1 and Q2 form a constant–current source which produces a stable current independent of the 40 volt regulator supply. The constant current generator assures that the current through R47 remains constant and independent of the foldback, mute, or over temperature circuits connected in parallel to the mute line. Diode D13 prevents an excessive voltage applied to the mute line from exceeding a limit which might damage Q1.

1–31. Regulator drive is applied to the base of Q1 which in turn drives regulator pass transistors Q2, Q3, and Q4. The dc supply for the regulator drive and the pass transistors is routed directly from the power supply high–current 40 volt source. A current balancing network for the pass transistors is provided by the output resistor network. The output of the output resistor network is applied to the RF amplifier load.

1–32. Either forward and reflected power feedback or dc voltage and reflected power feedback may be selected with jumper P18. When P18 is set to dc, a dc sample of the output voltage will be applied to the inverting input of U5A through R31 and R34. Resistor R24 provides an input to error amplifier U5A if P17 is inadvertently removed. A reflected power control signal will be added through diode D6 when the reflection is great enough to exceed the 0.7 volt drop across D6, approximately 15 volts at R22.

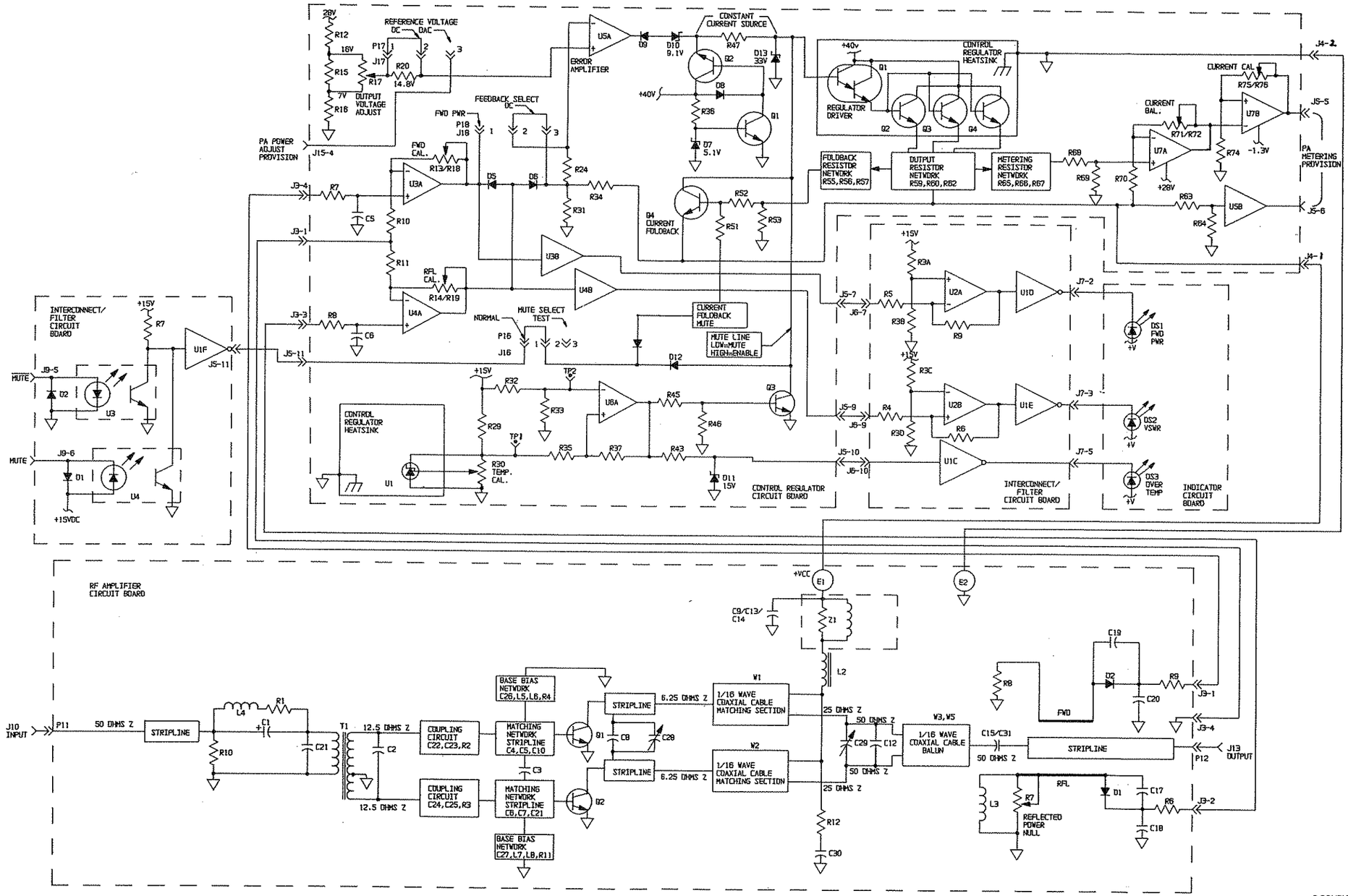

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FIGURE 1-3. IPA SIMPLIFIED SCHEMATIC

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1–33. When P18 is set to **FWD PWR**, a dc potential representative of the IPA forward power level will be applied to the inverting input of U5A. Reflected power control will be added through Diode D5 when the reflection is great enough to exceed the 0.7 volt drop across D5.

1–34. **CURRENT FOLDBACK.** The output resistor network and the foldback resistor network work together to provide the current foldback action when the output current reaches 18 Amperes. If the regulator output is at the correct level, R51 will be essentially out of the circuit as there will be practically no current flow through the resistor. As the voltage across R59, R60, and R62 increases due to current increase, the voltage summed at the junction of R52 and R53 will increase with respect to the emitter of Q4. As Q4 is biased on, current will begin to flow through R51 which saturates Q4. This action grounds the mute line which removes the dc output. DC power must be interrupted to reset the foldback condition or removal of RF drive is required.

1–35. **METERING.** Current through the pass transistor output resistor network is used to generate the voltage used to meter output current. The transistor emitter connections are summed into the non–inverting input of U7A and the output side of the emitter resistor is connected to the inverting input of differential amplifier U7A. The current bal control (R72) adjusts the offset on U7A so that with zero current, the output is zero. The output of U7A is applied to U7B which acts as a meter driver. R76 allows adjustment of the stage calibration. The –1.3 volt supply is connected to the –Vcc connection of U7B so that a meter connected to U7B will properly register zero with no input. This below–ground reference is required with zero volt operation of the operational amplifier.

1–36. **Forward Amplifier.** The rectified output of the forward port of the directional coupler is applied to the forward meter amplifier of the control regulator circuit board. Non–inverting amplifier U3A has a high input impedance and high gain. The exact gain of the amplifier is adjusted by potentiometer R18. RF is filtered from the signal before entering the forward power meter amplifier by R7 and C5.

1–37. **Reflected Amplifier.** The reflected meter amplifier (U4A) works in a manner similar to the forward amplifier section except that the voltage gain of this amplifier is higher than the forward amplifier which compensates for the differences in the coupling factor of the directional coupler sampling lines. RF is filtered from the signal before entering the reflected amplifier by R8 and C6. U4A is calibrated by potentiometer R19.

1–38. The 15 volt full–scale output of U3A and U4A are routed through 3:1 dividers and voltage follower stages U3B and U4B to amplifiers U2A and U2B on the interconnect filter circuit board. The forward power signal is routed through comparator U1D and the reflected power output is routed through comparator U1E and applied to the front panel **VSWR** indicator. This indicator illuminates when over 10 Watts of power is reflected back into the IPA from the load. The FWD PWR indicator illuminates when the forward power is 75 Watts or greater.

1–39. **REMOTE IPA MUTE.** Provisions exist which allow the IPA stage RF output to be externally muted using either a positive voltage or ground connection for control.

1–40. The mute input is applied to J9–5 if a positive voltage is used for muting or J9–6 if a ground is used for muting. When an input is applied, the optical coupler (U3 or U4) will pull the input to inverter U1F LOW which inhibits the drive applied to regulator driver Q1 and mutes the IPA RF output. The mute select jumper (P16) must be in the normal position to allow external muting. Diode D12 steers the input to prevent external devices from loading the mute line. The mute input is controlled by the transmitter controller.

1–41. **TEMPERATURE SENSOR.** An electronic temperature sensing circuit consisting of U1 and U6A senses the control regulator heatsink temperature. If an over–temperature condition occurs, dc output will automatically be removed to prevent damage to the RF output transistors. Under normal conditions, the **OVER TEMP** indicator (DS3) on the front panel will remain off. As a visual indication that an over–temperature condition exists, the **OVER TEMP** indicator will illuminate.

1–42. Temperature sensor U1 is mounted on and is thermally coupled to the control regulator heatsink. U1 functions much as if it were a zener diode with a calibrated positive temperature coefficient. The sensor is calibrated by the **TEMP CAL** control (R30) so that the voltage between test point TP1 at the non–inverting input to U6A and ground is set to +2.98 volts when the heatsink temperature is +25 degrees Celsius and +2.73 volts at 0 degrees Celsius. U6A operates as a voltage comparator with +3.61 volts at test point TP2. This corresponds to an 88 degree Celsius comparison threshold.

1–43. At normal heatsink temperatures, the voltage output of U6A will hold Q3 biased off. As the voltage from U1 increases with heat rise at the rate of 10 millivolts per degree Celsius, U6A will trigger at the point preset by R30 and bias Q3 into conduction. Q3 will inhibit the drive applied to the regulator driver (Q1) and inhibit RF output.

1–44. In this manner, the IPA is allowed to operate until a predetermined temperature is reached, then the RF output will be inhibited. An over–temperature condition is signaled by illumination of the **OVER TEMP** indicator (DS3) through inverter U1C. Zener diode D11 limits the input to U1C to a safe operating level if U6A should internally short. The IPA will return to operation as the temperature cools down.

1–45. **RF AMPLIFIER.**

1–46. The RF amplifier is a broadband stripline matched amplifier covering the FM broadcast band with a nominal output power of 150 Watts (see Figure 1–3). By adjusting the RF drive input, the RF power is variable over a range of 75 to 250 Watts.

1–47. The dc power input and the directional coupler outputs are connected to the circuit board through the chassis with feed–through capacitors to prevent RF interference. All wiring connects to the IPA assembly through plugs to aid in maintenance.

1–48. **POWER AMPLIFIER.** Approximately five to 25 Watts of drive is input to the 50 Ohm primary of transformer T1 through a section of stripline. R10 acts as a swamping resistor to improve the input match and capacitor C1 tunes out the series reactance in the primary circuit of transformer T1. C1 also resonates the primary of T1 to improve the input match and the series combination of L4 and R1 effectively lowers the Q on the input circuit to allow a broadband match.

1–49. Transformer T1 provides a 4:1 step–down in impedance from 50 Ohms to two 12.5 Ohm sources which are 180° out–of–phase. The output of T1 is capacitively coupled by a low–Q circuit to a matching network which further reduces the 12.5 Ohm impedance to approximately 1.5 Ohms to match the base impedance of Q1 and Q2. Base bias networks stabilize gain while C2 and C3 function as lumped matching elements in the impedance transformation. Capacitors C4/C5 and C6/C7 cancel out the inductive base reactance of Q1 and Q2.

1–50. Q1 and Q2 are NPN RF power transistors operated as a class C push–pull stage. The collector of each transistor feeds a stripline section which acts as a broadband impedance step–up transformer to convert the 0.5 Ohm collector impedance of each transistor to 6.25 Ohms. Capacitors C8 and C28 assist in the impedance transformation. Parallel connected inputs and series connected outputs of 25 Ohm coaxial cable raise the 6.25–6.25 Ohm push–pull outputs up to the 25–25 Ohm level. The series combination of R12 and C30 assure stable amplifier operation.

1–51. A coaxial cable balance–to–unbalance (balun) transformer converts the two 25 Ohm impedances to a single 50 Ohm unbalanced RF output. Capacitors C12 and C29 provide balanced transistor operation and paralleled capacitors C15/C31 block dc in the RF output line.

1–52. **DIRECTIONAL COUPLER.** The directional coupler provides two dc signals, each signal obtained by rectifying a portion of the RF output signal, coupled from a transmission line section etched into the circuit board. Due to the polarity of the two samples, one signal will be proportional to the forward traveling RF wave and the other signal will be proportional to the reflected traveling RF wave.

1–53. **Forward Directional Coupler Port.** The forward port of the directional coupler is broadbanded across the FM broadcast band. The voltage sample obtained is rectified by diode D2 and filtered by a PI– section filter. C19 improves the match due to the presence of D2. This output is routed to the control regulator for use in the control and metering circuits.

1–54. **Reflected Directional Coupler Port.** The reflected port of the directional coupler is broadbanded across the FM broadcast band. The voltage sample obtained is rectified by diode D1 and filtered by a PI–section filter. C17 improves the match due to the presence of D1. Inductor L3 in parallel with variable resistor R7 improves the linearity of the coupler across the band. R7 is adjusted to maximum directivity at the frequency of operation. This output is routed to the control regulator for use in the control and metering circuits.

SECTION II
IPA MAINTENANCE

2–1. INTRODUCTION.

2–2. This section provides maintenance information for the FM–5B/ FM–5BS IPA.

2–3. SAFETY CONSIDERATIONS.

2–4. The FM–5B/FM–5BS transmitters contain high voltages and currents which, if regarded carelessly, could be fatal. The transmitter has many built–in safety features, however good judgement, care, and common sense are the best accident preventives. The maintenance information contained in this section should be performed only by trained and experienced maintenance personnel.

2–5. MAINTENANCE.

WARNING *NEVER OPEN THE EQUIPMENT UNLESS ALL TRANSMITTER PRIMARY POWER IS DISCONNECTED.*

WARNING

WARNING *DUE TO THE PROGRAMMING OF THE EQUIPMENT, THE APC UNIT WILL ENTER THE REMOTE ENABLED MODE WHENEVER AC POWER IS APPLIED. TO PREVENT INADVERTENT REMOTE START–UP DURING MAINTENANCE PERIODS, DISCONNECT POWER FROM THE TRANSMITTER AND INSTALL JUMPER P14 ON THE APC UNIT MAIN CIRCUIT BOARD IN POSITION 1–2.*

WARNING

2–6. The transmitter maintenance philosophy consists of preventative maintenance such as cleaning applied to the equipment to forestall future failures and second level maintenance consisting of procedures required to restore the equipment to operation after a fault.

2–7. ADJUSTMENTS.

WARNING *NEVER OPEN THE EQUIPMENT UNLESS ALL TRANSMITTER PRIMARY POWER IS DISCONNECTED.*

WARNING

2–8. The following procedures present information required to adjust all controls in the IPA stage. These adjustments are factory preset and therefore will require readjustment only if components on the individual circuit boards have been replaced. Adjustments for the control regulator are presented first, followed by an adjustment procedure for the RF amplifier circuit board. The adjustments may be accessed by extending the IPA chassis forward on its slide rails out of the rack and removing the top cover.

2–9. **OUTPUT VOLTAGE ADJUST.** To adjust output voltage control R17 on the control regulator circuit board, proceed as follows.

2–10. **Required Equipment.** The following equipment is required to adjust the output voltage adjust control.

A. Flat blade screwdriver, 1/4 inch tip.

B. Insulated adjustment tool, flat tip (BE P/N 407–0083).

C. Digital voltmeter (Fluke 75 or equivalent).

2–11. **Procedure.** To adjust the control, proceed as follows:

WARNING *ASSURE ALL PRIMARY POWER IS DISCONNECTED BEFORE PROCEEDING.*

WARNING

2–12. Disconnect primary power.

2–13. Connect the voltmeter between J4 pin 1 and chassis ground.

2–14. Operate the **SCREEN** and **FILAMENT** circuit breakers to **OFF**, operate the **AC POWER** and **BLOWER** circuit breakers to **ON**, and depress the **FILAMENT ON** and **HIGH VOLTAGE ON** switch/indicators.

WARNING *MAINTENANCE WITH POWER ENERGIZED IS ALWAYS CONSIDERED HAZARDOUS AND THEREFORE CAUTION SHOULD BE OBSERVED. DO NOT TOUCH ANY COMPONENTS WITHIN THE IPA WHEN POWER IS ENERGIZED.*

WARNING

WARNING *USE AN INSULATED TOOL FOR ADJUSTMENT.*

WARNING

2–15. Using the insulated adjustment tool, adjust R17 to obtain a voltmeter indication of +28.0 volts dc.

WARNING *ASSURE ALL PRIMARY POWER IS DISCONNECTED BEFORE PROCEEDING.*

WARNING

2–16. Disconnect primary ac power.

2–17. Remove the test equipment, then operate the **SCREEN** and **FILAMENT** circuit breakers to **ON**.

2–18. **FWD CALIBRATION.** This adjustment is required if: 1) the transmitter diagnostic options indicate improperly, 2) the **FWD POWER** indicator threshold is incorrect by more than 10 Watts, or 3) if either the RF amplifier or control regulator assemblies are replaced. To adjust **FWD** calibration control R18 on the control regulator circuit board, proceed as follows.

2–19. **Required Equipment.** The following equipment is required to adjust **FWD** calibration control R18.

A. Flat blade screwdriver, 1/4 inch tip.

B. Insulated adjustment tool, flat tip (BE P/N 407–0083).

C. Digital voltmeter (Fluke 75 or equivalent).

D. Test load and connecting cable (50 Ohm non–inductive, 300 Watt minimum).

E. Calibrated in–line wattmeter and connecting cable (Bird 43 or equivalent with 250 Watt element).

2–20. **Procedure.** To adjust the control, proceed as follows:

WARNING *ASSURE ALL PRIMARY POWER IS DISCONNECTED BEFORE PROCEEDING.*

WARNING

2–21. Disconnect primary power.

2–22. Remove the IPA top–panel and disconnect the cable from the RF amplifier output receptacle.

2–23. Connect the non–inductive test load to the RF amplifier output receptacle through the In–line Wattmeter. Adjust the wattmeter to measure forward power.

2–24. Connect the voltmeter between J9–17 on the IPA interconnect filter circuit board and chassis ground.

2–25. Operate the **SCREEN** and **FILAMENT** circuit breakers to **OFF**, operate the **AC POWER** and **BLOWER** circuit breakers to **ON**, and depress the **FILAMENT ON** and **HIGH VOLTAGE ON** switch/indicators.

2–26. Depress the exciter **FWD** switch and record the exciter RF output power _____.

2–27. Using the exciter **R.F. POWER OUTPUT ADJ** control, obtain a Wattmeter indication of 250 Watts.

WARNING *MAINTENANCE WITH POWER ENERGIZED IS ALWAYS CONSIDERED HAZARDOUS AND THEREFORE CAUTION SHOULD BE OBSERVED. DO NOT TOUCH COMPONENTS WITHIN THE IPA WHEN POWER IS ENERGIZED.*

WARNING

WARNING *USE AN INSULATED TOOL FOR ADJUSTMENT.*

WARNING

2–28. Using the insulated adjustment tool, adjust **FWD** calibration control R18 to obtain a voltmeter indication of +5 volts dc.

2–29. Re–adjust the exciter RF output power to the level recorded in the preceding text.

WARNING *DISCONNECT ALL TRANSMITTER PRIMARY POWER BEFORE PROCEEDING.*

WARNING

2–30. Disconnect primary ac power.

2–31. Remove the test equipment and reconnect the cable to the RF amplifier output receptacle. Operate the **FILAMENT** and **SCREEN** circuit breakers to **ON**.

2–32. **RFL CALIBRATION.** This adjustment is required if: 1) the **VSWR** indicator threshold is incorrect, 2) the VSWR foldback limits are incorrect, or 3) if either the RF amplifier or the control regulator assemblies are replaced. To adjust **RFL** calibration control R19 on the control regulator circuit board, proceed as follows.

2–33. **Required Equipment.** The following equipment is required to adjust the **RFL** calibration control R19.

A. Flat blade screwdriver, 1/4 inch tip.

B. Insulated adjustment tool, flat tip (BE P/N 407–0083).

C. Calibrated in–line wattmeter and connecting cable. (Bird 43 with 100 Watt element or equivalent.)

D. Digital voltmeter (Fluke 75 or equivalent).

E. BNC Tee (Pomona 3285).

F. Two 150 Watt, Non–Inductive, 50 Ohm test loads and connecting cables.

2–34. **Procedure.** To adjust the control, proceed as follows:

WARNING — *DISCONNECT ALL TRANSMITTER PRIMARY POWER BEFORE PROCEEDING.*

WARNING

NOTE — *REFLECTED POWER NULL CONTROL R7 ON THE RF AMPLIFIER CIRCUIT BOARD MUST BE ADJUSTED BEFORE R19 IS ADJUSTED (SEE REFLECTED POWER NULL).*

NOTE

2–35. Disconnect primary power.

2–36. Remove the IPA top–panel.

2–37. Disconnect the cable from the RF amplifier output receptacle and connect the BNC tee to the receptacle.

2–38. Attach one test load to the BNC tee. Attach the second test load to the BNC tee through the in–line wattmeter. Adjust the wattmeter to measure forward power.

2–39. Connect the voltmeter between J9–20 on the IPA interconnect filter circuit board and chassis ground.

2–40. Operate the **SCREEN** and **FILAMENT** circuit breakers to **OFF**, operate the **AC POWER** and **BLOWER** circuit breakers to **ON**, and depress the **FILAMENT ON** and **HIGH VOLTAGE ON** switch/indicators.

2–41. Depress the exciter **FWD** switch and record the RF output power_____.

2–42. Using the exciter **RF POWER OUTPUT ADJ** control, obtain a wattmeter indication of 75 watts.

WARNING *MAINTENANCE WITH POWER ENERGIZED IS ALWAYS CONSIDERED HAZARDOUS AND THEREFORE CAUTION SHOULD BE OBSERVED. DO NOT TOUCH ANY COMPONENTS WITHIN THE IPA WHEN POWER IS ENERGIZED.*

WARNING

WARNING *USE AN INSULATED TOOL FOR ADJUSTMENT.*

WARNING

2–43. Using the insulated adjustment tool, adjust **RFL** calibration control R19 on the control regulator circuit board to obtain a voltmeter indication of +4.3 volts dc.

2–44. Re–adjust the exciter RF output power to the level recorded in the preceding text.

WARNING *DISCONNECT ALL TRANSMITTER PRIMARY POWER BEFORE PROCEEDING.*

WARNING

2–45. Disconnect primary ac power.

2–46. Remove all test equipment and reconnect the cable to the RF amplifier output receptacle. Operate the **SCREEN** and **FILAMENT** circuit breakers to **ON**.

2–47. **TEMP CALIBRATION.** This adjustment is required only if the temperature sensor (U1) is replaced. To adjust **TEMP** calibration control R30 on the control regulator circuit board, proceed as follows.

2–48. **Required Equipment.** The following equipment is required to adjust **TEMP** calibration control R30.

A. Flat blade screwdriver, 1/4 inch tip.

B. Insulated adjustment tool, flat tip (BE P/N 407–0083).

C. Digital voltmeter (Fluke 75 or equivalent).

D. Fluke 80T–150 temperature probe or equivalent Celcius indicating probe.

2–49. **Procedure.** To adjust the control, proceed as follows:

WARNING *DISCONNECT ALL TRANSMITTER PRIMARY POWER BEFORE PROCEEDING.*

WARNING

2–50. Disconnect primary power.

2–51. Attach the temperature probe to the control regulator heatsink assembly near U1.

2–52. Connect the probe to the voltmeter. Record the temperature indication, add +273, and divide by 100 ($\frac{°C + 273}{100}$ = VOLTAGE).

2–53. Connect the voltmeter between TP1 and chassis ground on the control regulator circuit board.

2–54. Operate the **SCREEN** and **FILAMENT** circuit breakers to **OFF**, operate the **AC POWER** and **BLOWER** circuit breakers to **ON**, and depress the **FILAMENT ON** and **HIGH VOLTAGE ON** switch/indicators.

WARNING *MAINTENANCE WITH POWER ENERGIZED IS ALWAYS CONSIDERED HAZARDOUS AND THEREFORE CAUTION SHOULD BE OBSERVED. DO NOT TOUCH ANY COMPONENTS WITHIN THE IPA WHEN POWER IS ENERGIZED.*

WARNING

WARNING *USE AN INSULATED TOOL FOR ADJUSTMENT.*

WARNING

2–55. Using the insulated adjustment tool, adjust **TEMP** calibration control R30 to obtain an indication equal to the result calculated in the preceding text.

EXAMPLE: $\frac{25°C + 273}{100} = \frac{298}{100} = 2.98$ volts

WARNING *DISCONNECT ALL TRANSMITTER PRIMARY POWER BEFORE PROCEEDING.*

WARNING

2–56. Disconnect primary ac power.

2–57. Remove the test equipment, then operate the **SCREEN** and **FILAMENT** circuit breakers to **ON**.

2–58. **CURRENT BALANCE.** This adjustment is required only if the transmitter diagnostic options indicate a residual value when there is no RF output from the IPA. To adjust **CURRENT BAL** control R72 on the control regulator circuit board, proceed as follows.

2–59. **Required Equipment.** The following equipment is required to adjust **CURRENT BAL** control R72.

A. Flat blade screwdriver, 1/4 inch tip.

B. Insulated adjustment tool, flat tip (BE P/N 407–0083).

C. Digital voltmeter (Fluke 75 or equivalent).

2–60. **Procedure.** To adjust the control, proceed as follows:

WARNING *DISCONNECT ALL TRANSMITTER PRIMARY POWER BEFORE PROCEEDING.*

WARNING

2–61. Disconnect primary power.

2–62. Connect the voltmeter between pin 7 of U7 and chassis ground.

2–63. Operate the **SCREEN** and **FILAMENT** circuit breakers to **OFF**, operate the **AC POWER** and **BLOWER** circuit breakers to **ON**, and depress the **FILAMENT ON** and **HIGH VOLTAGE ON** switch/indicators.

WARNING ***MAINTENANCE WITH POWER ENERGIZED IS ALWAYS CONSIDERED HAZARDOUS AND THEREFORE CAUTION SHOULD BE OBSERVED. DO NOT TOUCH COMPONENTS WITHIN THE IPA WHEN POWER IS ENERGIZED.***

WARNING

WARNING ***USE AN INSULATED TOOL FOR ADJUSTMENT.***

WARNING

2–64. Using the insulated adjustment tool, adjust **CURRENT BAL** control R72 to obtain a voltmeter indication of 0.00 volts dc.

WARNING ***DISCONNECT ALL TRANSMITTER PRIMARY POWER BEFORE PROCEEDING.***

WARNING

2–65. Disconnect primary ac power.

2–66. Remove the test equipment and operate the **SCREEN** and **FILAMENT** circuit breakers to **ON**.

2–67. The **CURRENT CAL** control (R76) must now be adjusted. Refer to the following text.

2–68. **CURRENT CALIBRATION.** This adjustment is required only if the transmitter diagnostic options indicate improper IPA current or if either the RF amplifier or control regulator circuit board is replaced. To adjust **CURRENT CAL** control R76 on the control regulator circuit board, proceed as follows.

NOTE ***CURRENT BAL CONTROL R72 ON THE CONTROL REGULATOR CIRCUIT BOARD MUST BE ADJUSTED BEFORE CURRENT CAL CONTROL R76 (REFER TO THE PRECEDING PROCEDURE).***

NOTE

2–69. **Required Equipment.** The following equipment is required to adjust **CURRENT CAL** control R76.

A. Flat blade screwdriver, 1/4 inch tip.

B. Insulated adjustment tool, flat tip (BE P/N 407–0083).

C. Digital voltmeter (Fluke 75 or equivalent).

D. Resistor, 5 Ohm ±5%, 160 Watt, Wire Wound (BE P/N 130–0005).

2–70. **Procedure.** To adjust the control, proceed as follows:

WARNING ***DISCONNECT ALL TRANSMITTER PRIMARY POWER BEFORE PROCEEDING.***

WARNING

2–71. Disconnect primary power.

2–72. Unplug P4–1 and P4–2 from J4–1 and J4–2.

2–73. Temporarily connect the 5 Ohm, 160 Watt resistor from J4–1 to J4–2.

2–74. Connect the voltmeter between pin 7 of U7 and chassis ground.

2–75. Operate the **SCREEN** and **FILAMENT** circuit breakers to **OFF**, operate the **AC POWER** and **BLOWER** circuit breakers to **ON**, and depress the **FILAMENT ON** and **HIGH VOLTAGE ON** switch/indicators.

WARNING ***MAINTENANCE WITH POWER ENERGIZED IS ALWAYS CONSIDERED HAZARDOUS AND THEREFORE CAUTION SHOULD BE OBSERVED. DO NOT TOUCH COMPONENTS WITHIN THE IPA WHEN POWER IS ENERGIZED.***

WARNING

WARNING ***USE AN INSULATED TOOL FOR ADJUSTMENT.***

WARNING

2–76. Using the insulated adjustment tool, adjust **CURRENT CAL** control R76 to obtain a voltmeter indication of +1.87 volts dc.

WARNING ***DISCONNECT ALL TRANSMITTER PRIMARY POWER BEFORE PROCEEDING.***

WARNING

2–77. Disconnect primary ac power.

2–78. Remove the test equipment and reconnect P4–1 and P4–2 to J4–1 and J4–2, and operate the **SCREEN** and **FILAMENT** circuit breakers to **ON**.

2–79. **REFLECTED POWER NULL.** This control is factory calibrated and sealed during final test. Adjustment in the field is not normally required unless repairs have been made to the IPA directional coupler circuitry, the RF amplifier circuit board has been replaced, or the transmitter operating frequency has been changed. If it is certain adjustment is necessary, proceed as follows.

2–80. **Required Equipment.** The following equipment is required to adjust **REFLECTED POWER NULL** control R7.

A. Flat blade screwdriver, 1/4 inch tip.

B. Insulated adjustment tool, flat tip (BE P/N 407–0083).

C. Digital voltmeter (Fluke 75 or equivalent).

D. Test load and connecting cable (50 Ohm non–inductive,300 Watt minimum).

E. Calibrated in–line wattmeter and connecting cable (Bird 43 with 250 Watt element or equivalent).

2–81. **Procedure.** To adjust the control, proceed as follows:

WARNING *DISCONNECT ALL TRANSMITTER PRIMARY POWER BEFORE PROCEEDING.*

WARNING

2–82. Disconnect primary power.

2–83. Disconnect the transmitter PA input cable and connect the test load to the **IPA OUTPUT** connector through the wattmeter. Adjust the wattmeter to indicate forward power.

2–84. Carefully prop the RF amplifier module in the cooling air path with R7 accessible through the hole provided in the module cover.

2–85. Connect the voltmeter between pin 7 of U4B on the control regulator circuit board and chassis ground.

2–86. Operate the **SCREEN** and **FILAMENT** circuit breakers to **OFF**, operate the **AC POWER** and **BLOWER** circuit breakers to **ON**, and depress the **FILAMENT ON** and **HIGH VOLTAGE ON** switch/indicators.

2–87. Depress the exciter front–panel **FWD** switch and record the exciter RF power output _____.

2–88. Adjust the exciter **R.F. POWER OUTPUT ADJ.** control as required to obtain approximately 200 to 250 Watts of forward power from the IPA.

WARNING *MAINTENANCE WITH POWER ENERGIZED IS ALWAYS CONSIDERED HAZARDOUS AND THEREFORE CAUTION SHOULD BE OBSERVED. DO NOT TOUCH COMPONENTS WITHIN THE IPA WHEN POWER IS ENERGIZED. EVEN THOUGH LOW VOLTAGES ARE USED THROUGHOUT THE IPA, IT IS POSSIBLE TO RECEIVE PAINFUL RF BURNS FROM THE RF AMPLIFIER.*

WARNING

WARNING *USE AN INSULATED TOOL FOR ADJUSTMENT.*

WARNING

2–89. Using the insulated adjustment tool, adjust **REFLECTED POWER NULL** control R7 to obtain a minimum voltmeter indication.

2–90. Re–adjust the exciter RF power output to the level recorded in the preceding text.

WARNING *DISCONNECT ALL TRANSMITTER PRIMARY POWER BEFORE PROCEEDING.*

WARNING

2–91. Disconnect primary ac power.

2–92. Remove the test equipment, reconnect the transmitter load, and operate the **SCREEN** and **FILAMENT** circuit breakers to **ON**.

2–93. **RF AMPLIFIER TUNING.** The following procedure is part of the TRANSMITTER FREQUENCY CHANGE PROCEDURE presented in PART I SECTION V. The following adjustment is required only if the transmitter operating frequency is changed. To tune the IPA RF amplifier, proceed as follows.

2–94. **Required Equipment.** The following equipment is required to tune the IPA RF amplifier.

A. Flat blade screwdriver, 1/4 inch tip.

B. No. 1 Phillips Screwdriver, 4 inch (10.16 cm) blade.

C. Insulated adjustment tool, flat tip (BE P/N 407–0083).

D. Test load and connecting cable (50 Ohm non–inductive 300 watt minimum).

E. Calibrated in–line wattmeter and connecting cable (Bird Model 43 with 250 element or equivalent).

F. Spectrum Analyzer (Tektronix Model 492 Spectrum Analyzer or equivalent, capable of displaying frequencies at twice the transmitter frequency of operation).

2–95. **Procedure.** To tune the IPA RF amplifier, proceed as follows:

WARNING ***DISCONNECT ALL TRANSMITTER PRIMARY POWER BEFORE PROCEEDING.***

WARNING

2–96. Disconnect all transmitter primary power before proceeding.

2–97. Disconnect the cable from the **IPA OUTPUT** receptacle and connect the test load to the **OUTPUT** receptacle through the in–line wattmeter. Adjust the wattmeter to indicate forward power.

2–98. Connect the spectrum analyzer to the in–line wattmeter RF sample output.

2–99. Remove the cover from the IPA RF amplifier and carefully place the amplifier in the cooling air path with capacitors C28 and C29 accessible from the top of the chassis.

2–100. Operate the **SCREEN** and **FILAMENT** circuit breakers to **OFF**. Operate the **AC POWER** and **BLOWER** circuit breakers to **ON**.

2–101. Energize the transmitter primary ac power and depress the **FILAMENT ON** and **HIGH VOLTAGE ON** switch/indicators.

2–102. Tune the IPA RF amplifier as follows:

A. Observe the wattmeter and spectrum analyzer indications.

WARNING ***IT IS POSSIBLE TO RECEIVE SERIOUS RF BURNS FROM THE AMPLIFIER. DO NOT ADJUST THE AMPLIFIER MODULE WITH THE COVER REMOVED AND POWER ENERGIZED.***

WARNING

WARNING ***DEENERGIZE PRIMARY POWER BEFORE PROCEEDING.***

WARNING

B. Operate the **AC POWER** circuit breaker to **OFF**.

WARNING *THE RF AMPLIFIER OPERATES AT HIGH TEMPERATURES. DO NOT TOUCH ANY COMPONENTS ON THE*

WARNING *RF AMPLIFIER.*

C. Adjust capacitor C28.

D. Operate the **AC POWER** circuit breaker to ON.

E. Repeat steps A through D and adjust tuning control C28 for a maximum power output level and a minimum harmonic level.

F. Repeat steps A through D and adjust tuning control C29 for a maximum power output level and a minimum harmonic level.

2–103. Once peak performance is obtained from the RF amplifier, ensure the IPA power output level is approximately equal to the value recorded in the factory final test data sheets. If required, adjust the exciter **RF POWER OUTPUT ADJ** control to obtain a satisfactory IPA output power indication.

WARNING *DISCONNECT ALL TRANSMITTER PRIMARY POWER BEFORE PROCEEDING.*

WARNING

2–104. Disconnect all transmitter primary power before proceeding.

2–105. Disconnect all test equipment, replace the RF amplifier cover, reconnect the cable from the IPA OUTPUT to the PA INPUT, and operate the **SCREEN** and **FILAMENT** circuit breakers to **ON**.

2–106. **TROUBLESHOOTING.**

WARNING *NEVER OPEN THE EQUIPMENT UNLESS ALL TRANSMITTER PRIMARY POWER IS DISCONNECTED. USE*

WARNING *THE GROUNDING STICK PROVIDED TO ENSURE ALL COMPONENTS AND ALL SURROUNDING COMPONENTS ARE DISCHARGED BEFORE ATTEMPTING MAINTENANCE ON ANY AREA WITHIN THE TRANSMITTER.*

2–107. Most troubleshooting consists of visual checks. Because of the voltages and high currents in the transmitter, it is considered hazardous to work with power energized. Therefore, the various transmitter indicators (meters, LEDs, fuses, and circuit breakers) should be used to isolate the malfunction to one specific area.

2–108. If difficulties are encountered and the IPA is suspected as faulty, the first step in troubleshooting should determine whether the exciter, the RF amplifier, the control regulator, the power supply, or the load is at fault. A high VSWR condition or an over–heating condition will cause the control regulator to limit RF output to prevent damage to the IPA stage. The observable symptom would be loss of RF power. However, as the control regulator and the RF amplifier are both components of a closed loop, either circuit could cause this symptom. Complete loss of RF output would indicate power supply problems.

2–109. As a first check, the RF input level to the IPA stage should be checked and adjusted as required. Next the IPA load (**INPUT TUNING** control) should be adjusted to the correct point. If neither the input level or the output circuit is at fault, subsequent troubleshooting should determine which circuit is at fault.

WARNING ***BERYLLIUM OXIDE CERAMICS (BeO) – AVOID BREATHING DUST OR FUMES.***

WARNING

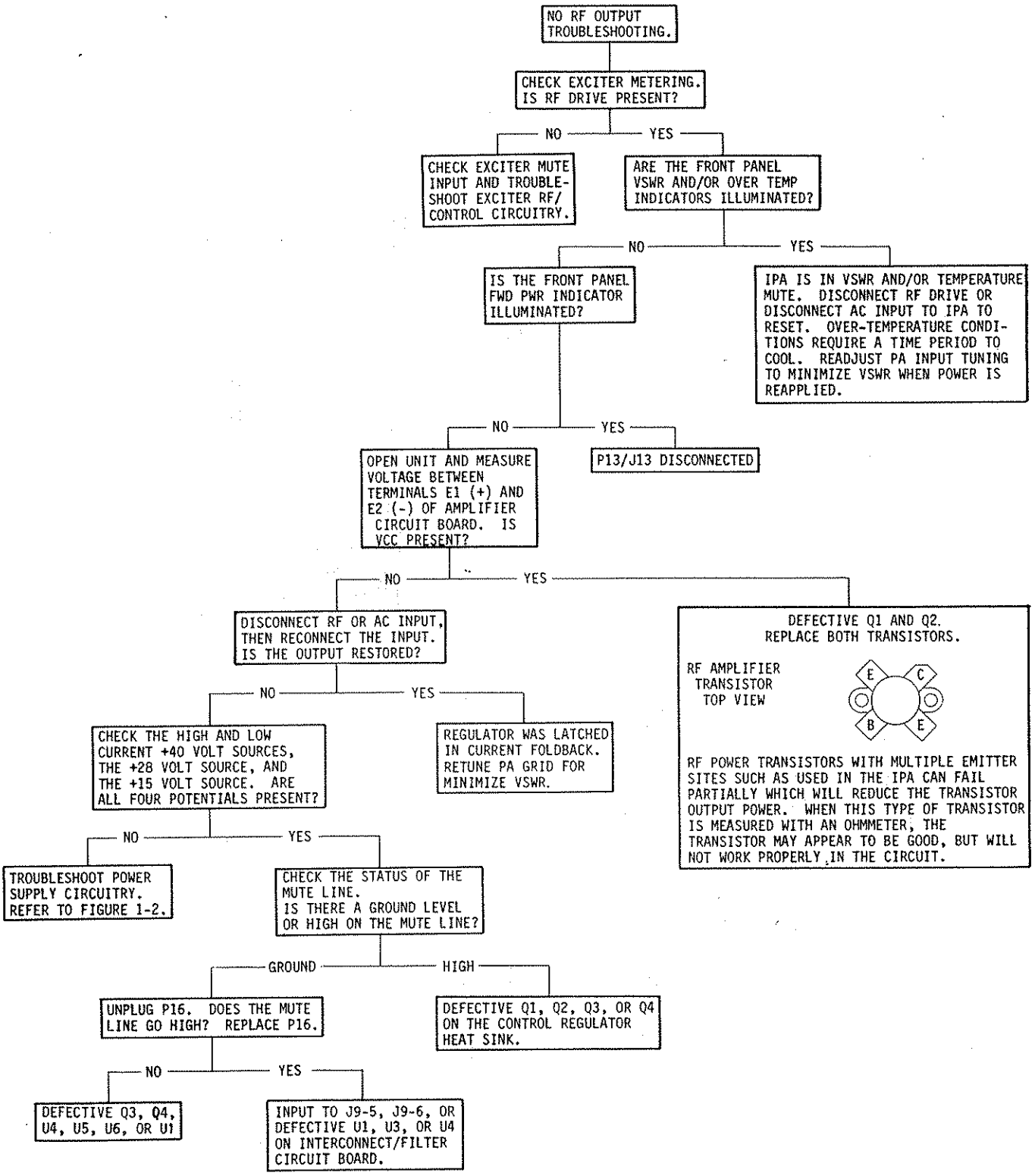
WARNING ***THE WHITE CASE MATERIAL OF THE IPA RF AMPLIFIER TRANSISTORS IS MADE OF BeO CERAMIC MATERIAL. DO NOT PERFORM ANY OPERATION ON ANY BeO CERAMIC WHICH MIGHT PRODUCE DUST OR FUMES, SUCH AS GRINDING, GRIT BLASTING, OR ACID CLEANING. BERYLLIUM OXIDE DUST OR FUMES ARE HIGHLY TOXIC AND BREATHING THEM CAN RESULT IN SERIOUS PERSONAL INJURY OR DEATH. BeO CERAMICS MUST BE DISPOSED OF ONLY IN A MANNER PRESCRIBED BY THE DEVICE MANUFACTURER. USE CARE IN REPLACING TRANSISTORS OF THIS TYPE.***

WARNING

2–110. Characteristically, the type of RF transistors used in the IPA stage can fail partially, but still operate to some extent. If the RF power amplifier transistors are suspected as having inadequate gain, they must be replaced with new devices of the same identical type and manufacture as the original device. The IPA RF assembly diagrams in SECTION IV contain information relative to replacement of the RF transistors. The transistors should be replaced in pairs to maintain matched gain for optimum push–pull operation. Due to the difficulty of replacing Q1 and Q2 in the field, it is recommended to return the RF amplifier module to Broadcast Electronics, Inc. for repair as chip capacitors C4 through C7 may have to be removed with Q1 and Q2.

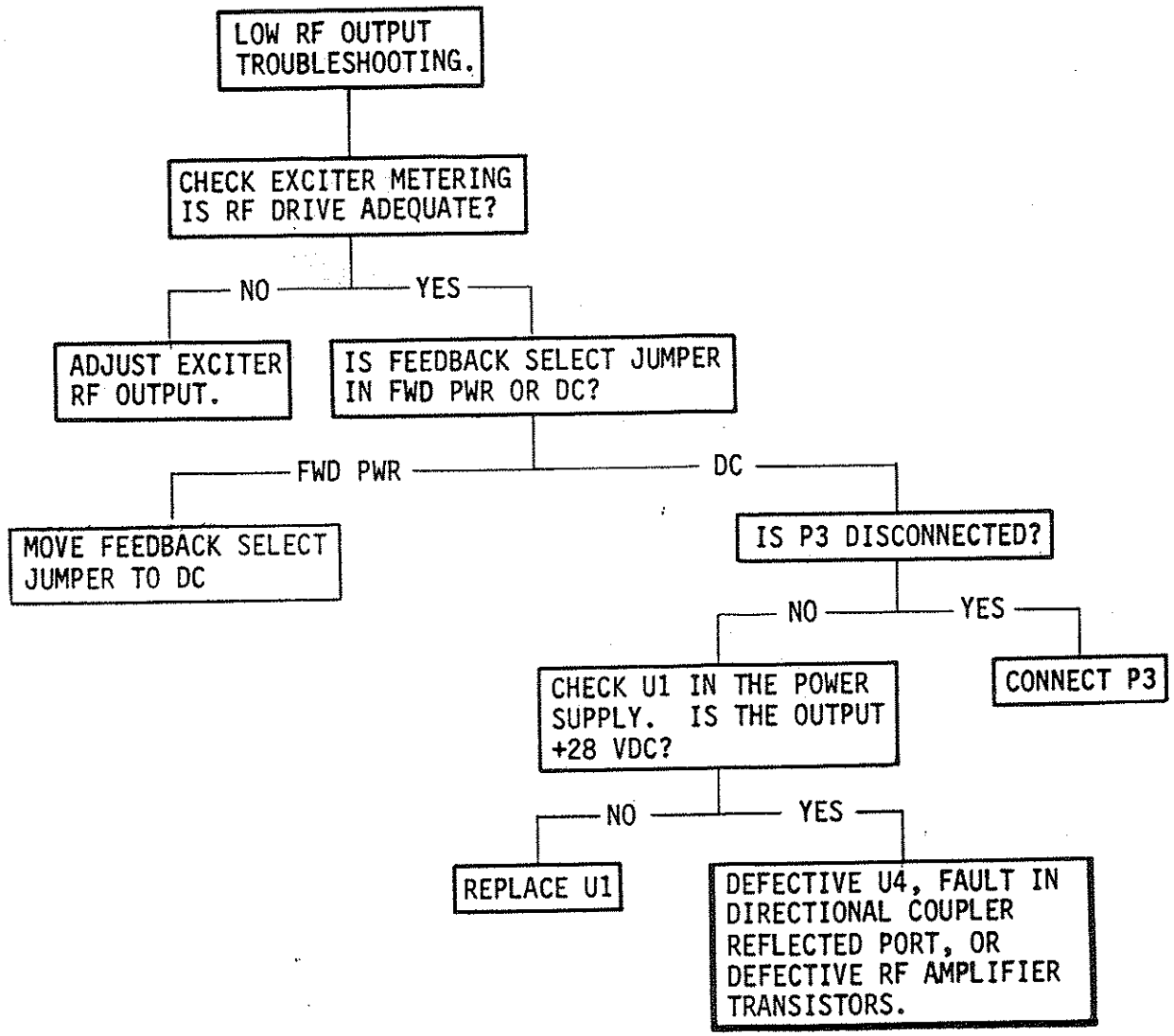
2–111. Once the trouble is isolated and power is totally deenergized, it is suggested that the exact problem be located with resistance checks using the schematic diagrams and theory of operation presented throughout the text. Figures 2–1 and 2–2 should be referenced as troubleshooting aids.

2–112. If a circuit is diagnosed as faulty, the circuit fault may be isolated and repaired locally or the entire device may be returned to Broadcast Electronics, Inc. for exchange, alignment, or replacement. The modular approach used in the construction of the IPA allows spare control regulator or RF amplifier modules to be substituted in the system with minimal down time.



597-0032-23

FIGURE 2-1. NO RF OUTPUT TROUBLESHOOTING



597–0032–25

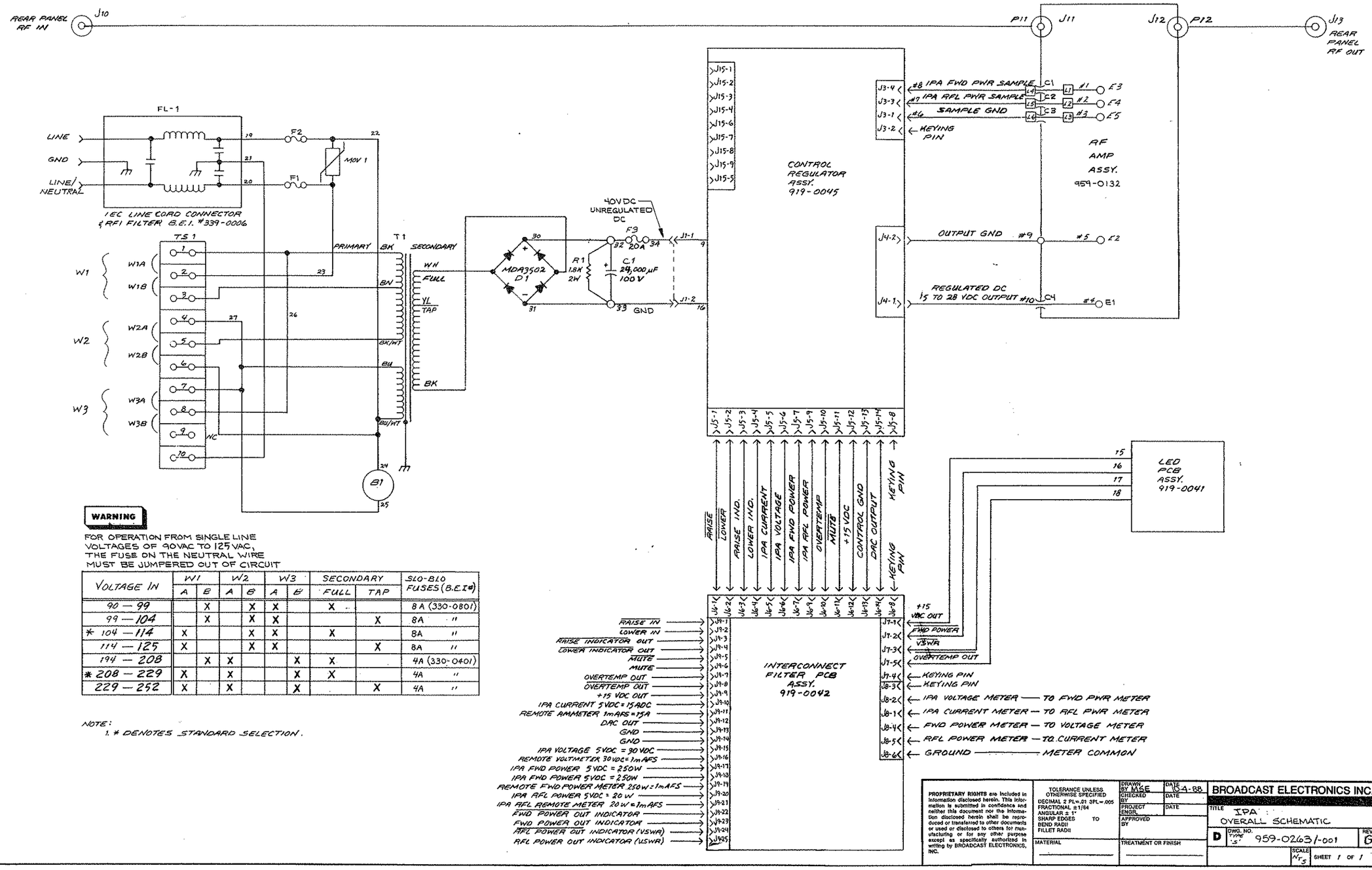
FIGURE 2–2. LOW RF OUTPUT TROUBLESHOOTING

SECTION III
IPA DRAWINGS

3–1. INTRODUCTION.

3–2. This section provides assembly drawings and schematic diagrams as listed below for the FM–5B/FM–5BS IPA.

FIGURE	TITLE	NUMBER
3–1	SCHEMATIC, IPA OVERALL	SD959–0263–001
3–2	ASSEMBLY, IPA OVERALL	597–0032–16
3–3	SCHEMATIC, INTERCONNECT/FILTER CIRCUIT BOARD	SD919–0042
3–4	ASSEMBLY, INTERCONNECT/FILTER CIRCUIT BOARD	AC919–0042
3–5	SCHEMATIC, CONTROL REGULATOR OVERALL	SD919–0045
3–6	ASSEMBLY, CONTROL REGULATOR CIRCUIT BOARD	AD919–0045
3–7	COMPONENT LOCATOR, CONTROL REGULATOR CIRCUIT BOARD	597–0032–20
3–8	SCHEMATIC, RF AMPLIFIER OVERALL	SC919–0065
3–9	ASSEMBLY, RF AMPLIFIER OVERALL	AD959–0132–001
3–10	ASSEMBLY, RESISTOR NETWORK	AA959–1000–001
3–11	ASSEMBLY, RESISTOR NETWORK	AA959–1000



WARNING

FOR OPERATION FROM SINGLE LINE VOLTAGES OF 90VAC TO 125VAC, THE FUSE ON THE NEUTRAL WIRE MUST BE JUMPERED OUT OF CIRCUIT

VOLTAGE IN	W1		W2		W3		SECONDARY		SLO-BLO FUSES (B.E.I#)
	A	B	A	B	A	B	FULL	TAP	
90 — 99		X		X	X		X		8A (330-0801)
99 — 104		X		X	X			X	8A "
* 104 — 114	X			X	X		X		8A "
114 — 125	X			X	X			X	8A "
194 — 208		X	X			X	X		4A (330-0401)
* 208 — 229	X		X			X	X		4A "
229 — 252	X		X			X		X	4A "

NOTE:
1. * DENOTES STANDARD SELECTION.

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TOLERANCE UNLESS OTHERWISE SPECIFIED
DECIMAL 2 PL=.01 3PL=.005
FRACTIONAL ±1/64
ANGULAR ± 1°
SHARP EDGES TO BEND RADII
FILLET RADII

MATERIAL

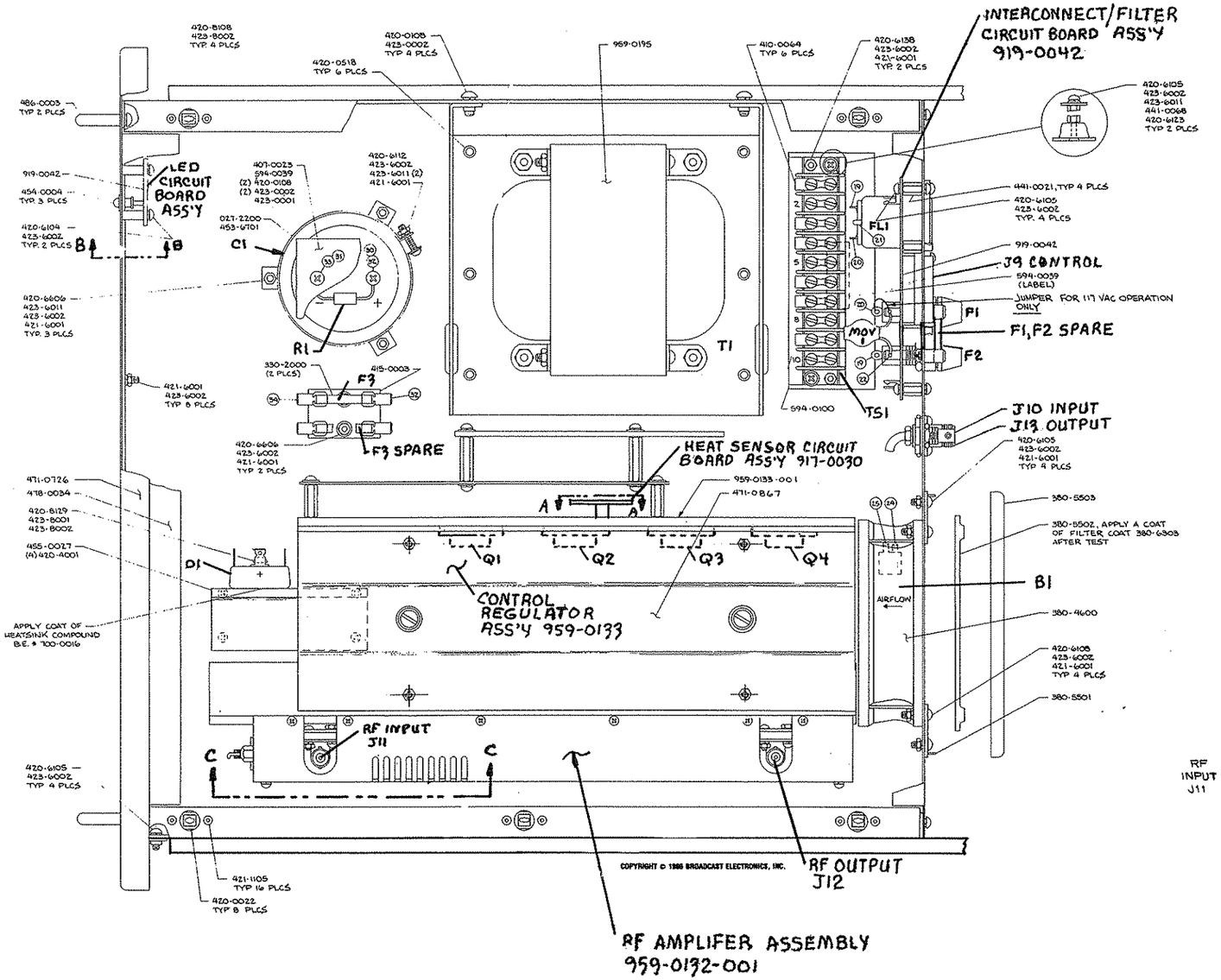
DRAWN BY MSE — DATE 6-4-88
CHECKED BY — DATE
PROJECT ENGR. — DATE
APPROVED BY
TREATMENT OR FINISH

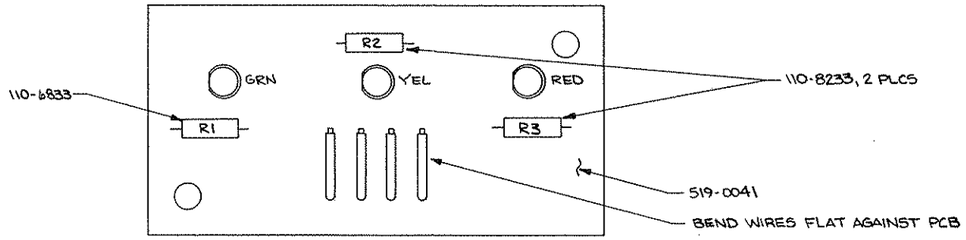
BROADCAST ELECTRONICS INC.

TITLE IPA OVERALL SCHEMATIC

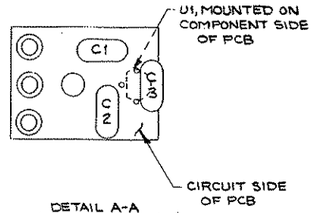
D — DWG. NO. TYPE "S" 959-0263/-001 — REV. G

SCALE NTS — SHEET 1 OF 1





DETAIL E-E



DETAIL A-A
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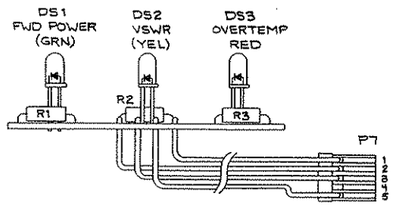
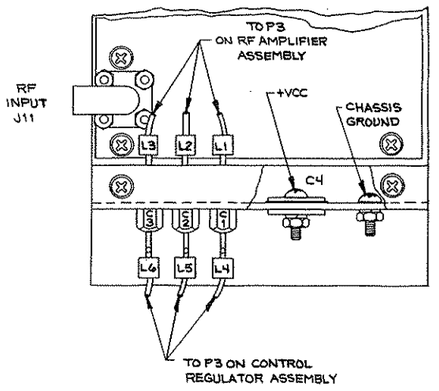
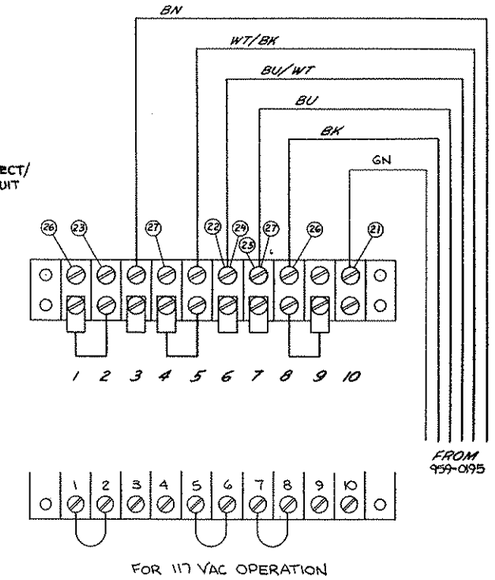


DETAIL B-B
(NOT TO SCALE)



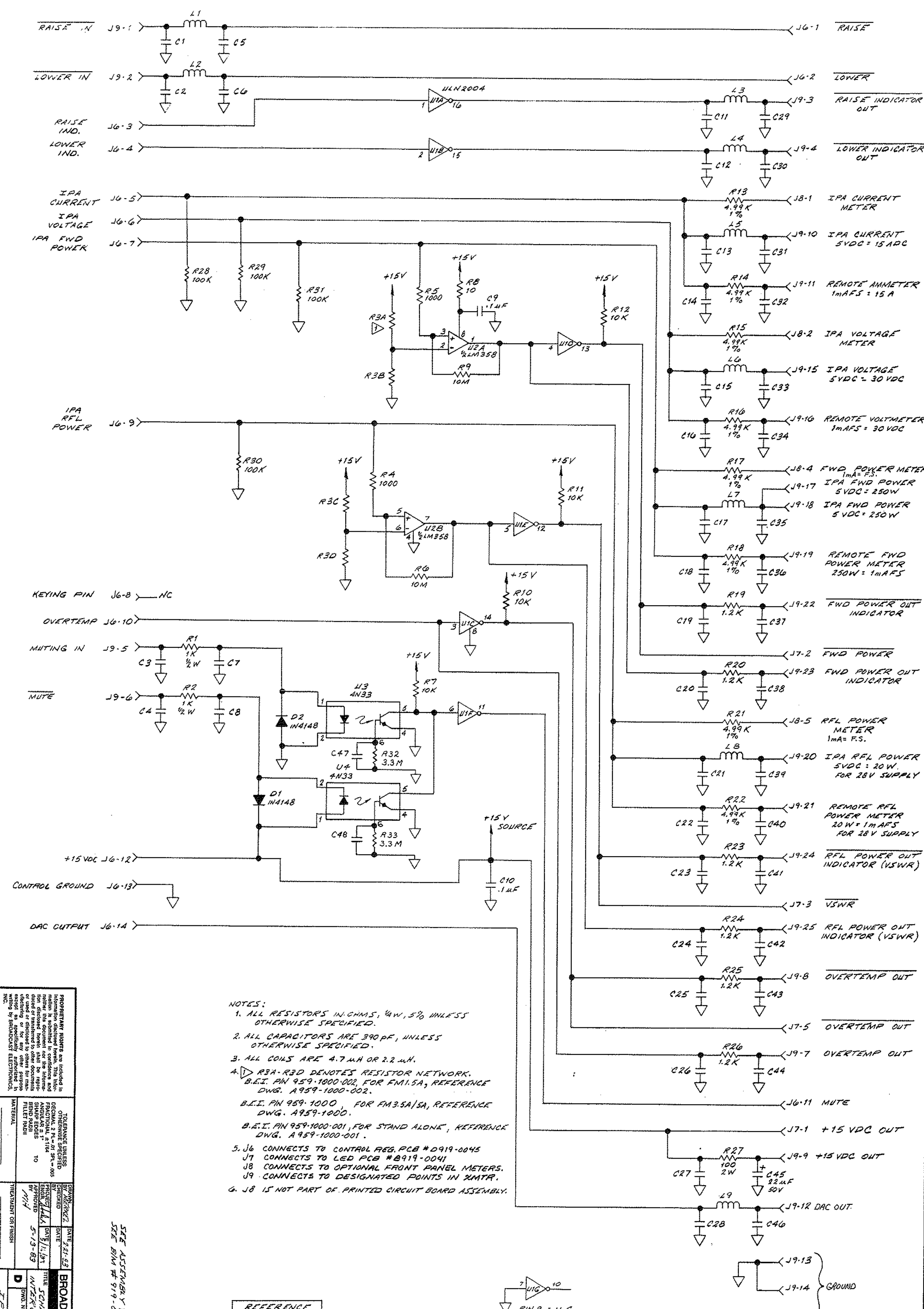
DETAIL C-C
(NOT TO SCALE)



DETAIL D-D

597-0032-16

FIGURE 3-2.
INTERMEDIATE POWER AMPLIFIER ASSEMBLY



NOTES:

1. ALL RESISTORS IN OHMS, 1/4W, 5% UNLESS OTHERWISE SPECIFIED.
2. ALL CAPACITORS ARE 390 pF, UNLESS OTHERWISE SPECIFIED.
3. ALL COILS ARE 4.7 uH OR 2.2 uH.
4. R3A-R3D DENOTES RESISTOR NETWORK.
   B.E.I. P/N 959-1000-002, FOR FM1.5A, REFERENCE DWG. A959-1000-002.
   B.E.I. P/N 959-1000, FOR FM3.5A/5A, REFERENCE DWG. A959-1000.
   B.E.I. P/N 959-1000-001, FOR STAND ALONE, REFERENCE DWG. A959-1000-001.
5. J6 CONNECTS TO CONTROL REG. PCB #D919-0045
   J7 CONNECTS TO LED PCB #B919-0041
   J8 CONNECTS TO OPTIONAL FRONT PANEL METERS.
   J9 CONNECTS TO DESIGNATED POINTS IN XMTR.
6. J8 IS NOT PART OF PRINTED CIRCUIT BOARD ASSEMBLY.

SEE ASSEMBLY # C919-0042
SEE BIM # 919-0042

REFERENCE DESIGNATORS	
LAST USED	NOT USED
C48	U1G
D2	
J9	
L9	
R33	
U4	

REFERENCE DESIGNATORS	U1	U2	U3, U4
B.E. PART NO.	226-2004	221-0358	229-0033
VENDOR PART NO.	ULN2004	LM358	4N33
VOLTAGE PIN NC	——	8	——
GROUND PIN NO.	8	4	——

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TOLERANCE UNLESS OTHERWISE SPECIFIED
DECIMAL 2 PL=.01 3PL=.005
FRACTIONAL ± 1/64
ANGULAR ± 1°
SHARP EDGES TO
BEND RADII
FILLET RADII

MATERIAL

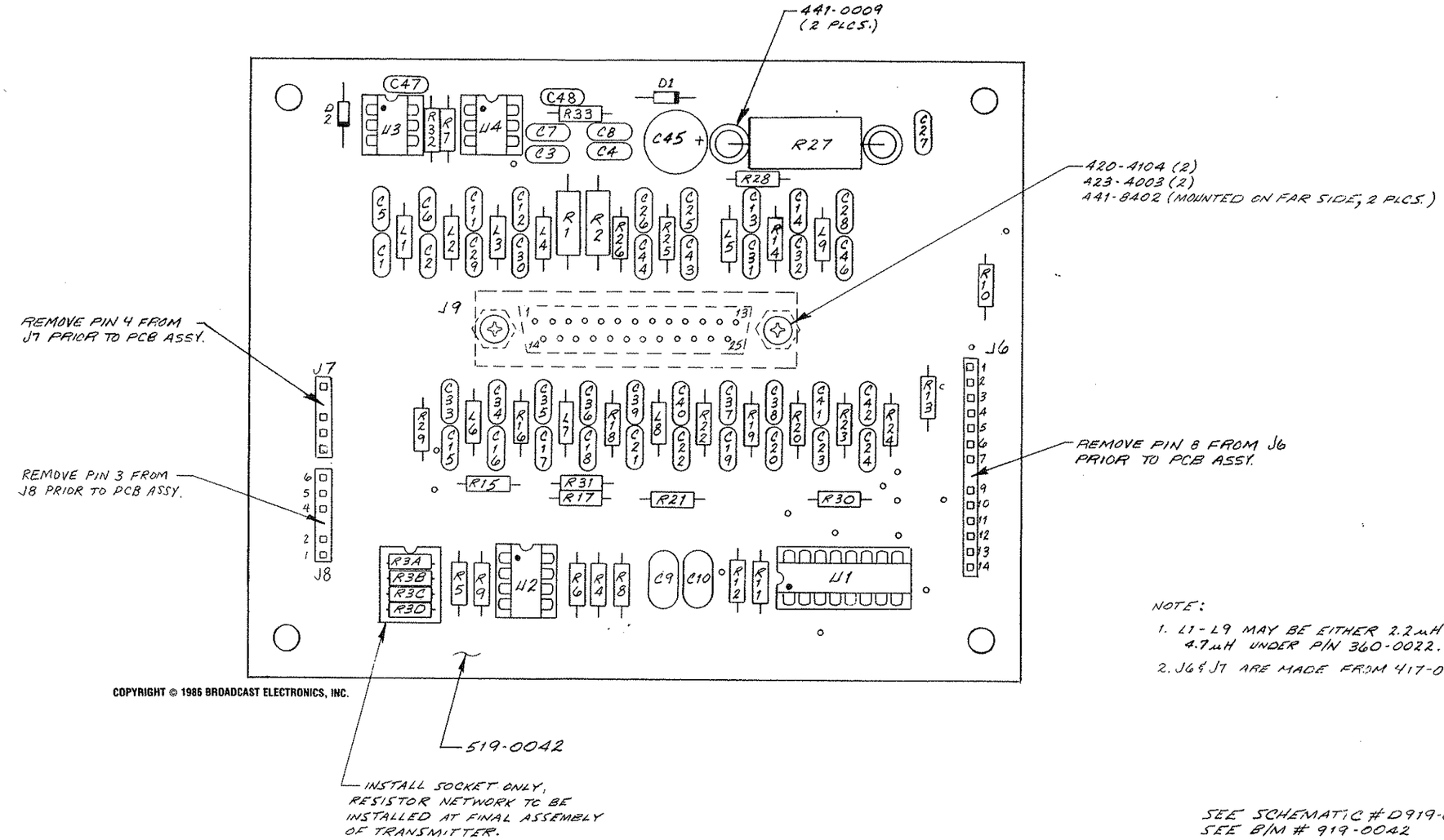
DRAWN BY MERKEL DATE 2-21-83
CHECKED BY DATE
PROJECT ENGR. DATE 5/11/83
APPROVED BY MH 5-13-83
TREATMENT OR FINISH

BROADCAST ELECTRONICS INC.

TITLE SCHEMATIC - IPA INTERCONNECT/FILTER PCB

D DWG. NO. 919-0042 REV. F

IPA SCALE NA SHEET 1 OF 1



NOTE:

1. L1 - L9 MAY BE EITHER 2.2μH OR 4.7μH UNDER P/N 360-0022.
2. J6 & J7 ARE MADE FROM 417-0200.

SEE SCHEMATIC #D919-0042
SEE B/M # 919-0042

TOLERANCE (DECIMAL) U.O.S.
.X ± .030 .XXX ± .005
.XX ± .015 ANGLES ± 1°

DWN. BY MERKEL 2-26-83
CHKD.
ME
EE
PROJ. ENGR. S.S. 9/16/83
DFTG. SUPVR. MH 5-13-83
MFG.

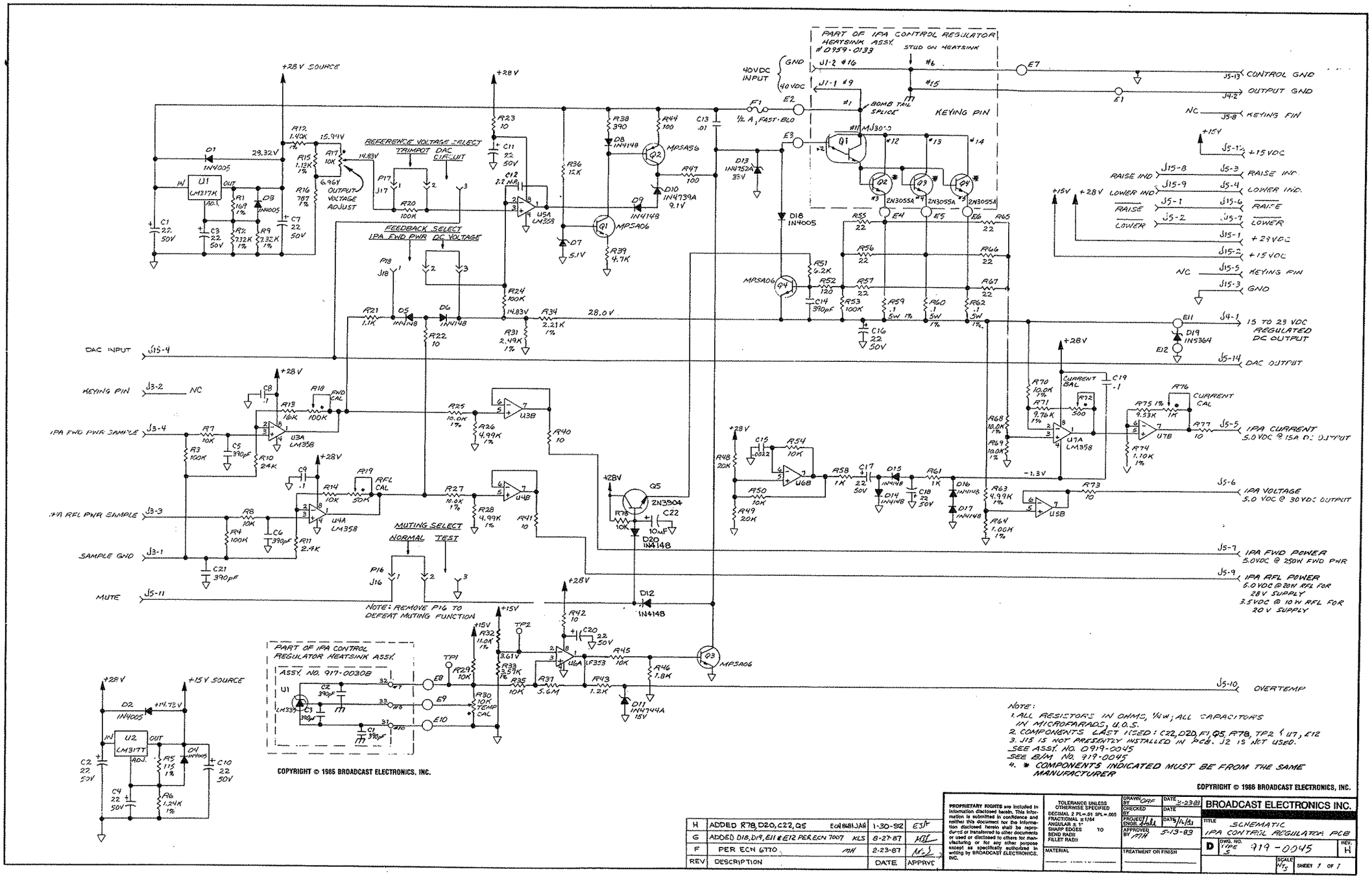
NEXT ASSY.
PRODUCT USED ON IPA
FINISH

BROADCAST ELECTRONICS INC.
4100 N. 24TH ST. QUINCY, IL 62305 217/224-9600
TELEX 250142 CABLE BCST ELECT QUI

TITLE PCB ASSEMBLY - IPA INTERCONNECT/ FILTER BOARD

SHEET 1 OF 1
SCALE 2/1
REV F

TYPE A SIZE C DWG. NO. 919-0042



REV	DESCRIPTION	DATE	APPVD
H	ADDED R78, D20, C22, Q5 ECN 8481 JAH	1-30-92	ESP
G	ADDED D18, D19, E11 & E12 PER ECN 7007 KLS	8-27-87	MSF
F	PER ECN 6770 MN	2-23-87	MSF

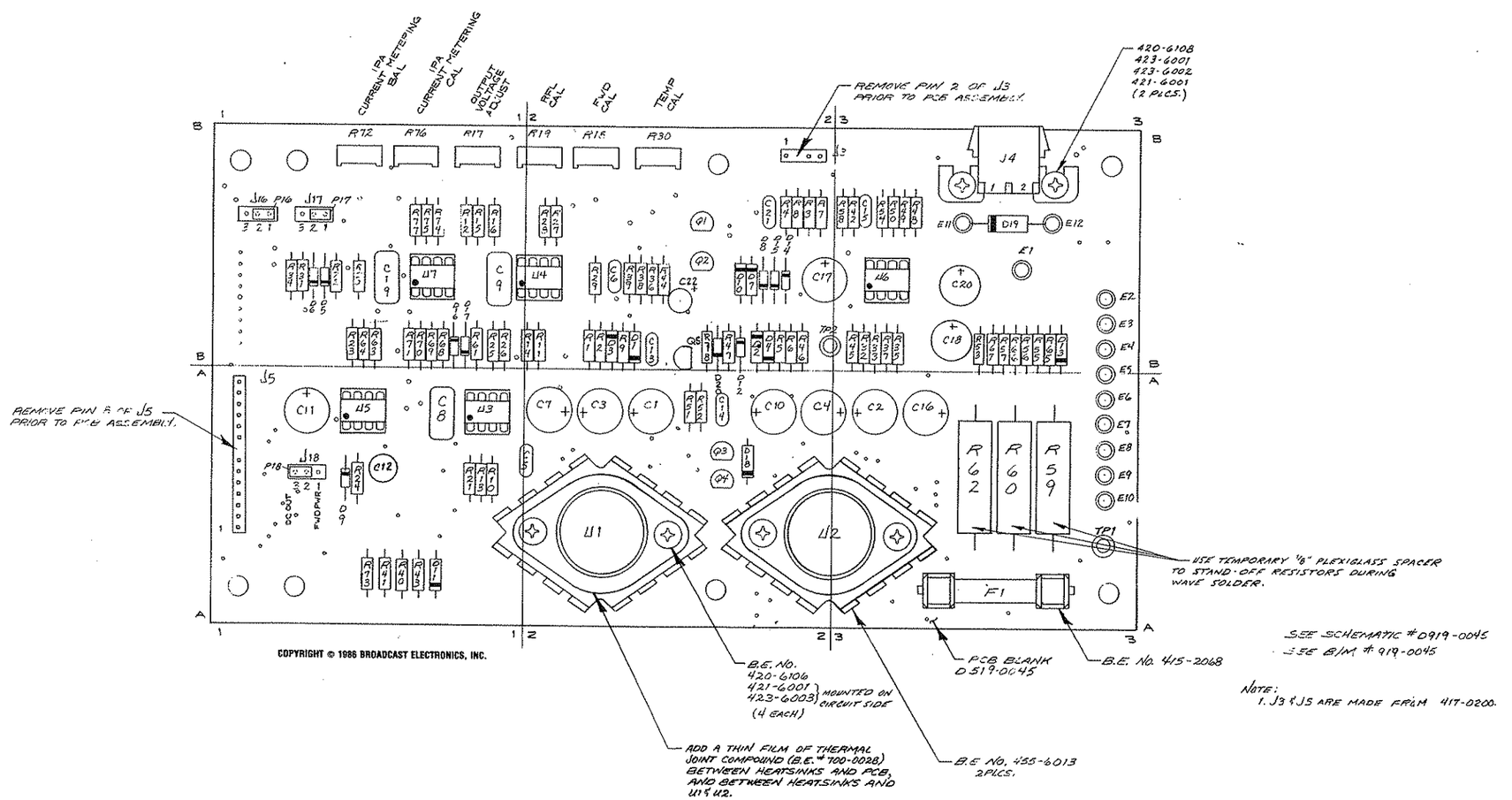
TOLERANCE UNLESS OTHERWISE SPECIFIED
DECIMAL 2 PL=.01 3PL=.005
FRACTIONAL ±1/64
ANGULAR ± 1°
SHARP EDGES TO BEND RADII
FILLET RADII
MATERIAL
TREATMENT ON FINISH

DRAWN BY CAF DATE 2-23-88
CHECKED BY DATE
PROJECT ENGR. JAH DATE 5/14/88
APPROVED BY MH 5-13-88

BROADCAST ELECTRONICS INC.

TITLE SCHEMATIC
IPA CONTROL REGULATOR PCB

D DWG. NO. TYPE 919-0045 REV. H
SCALE W/S SHEET 1 OF 1



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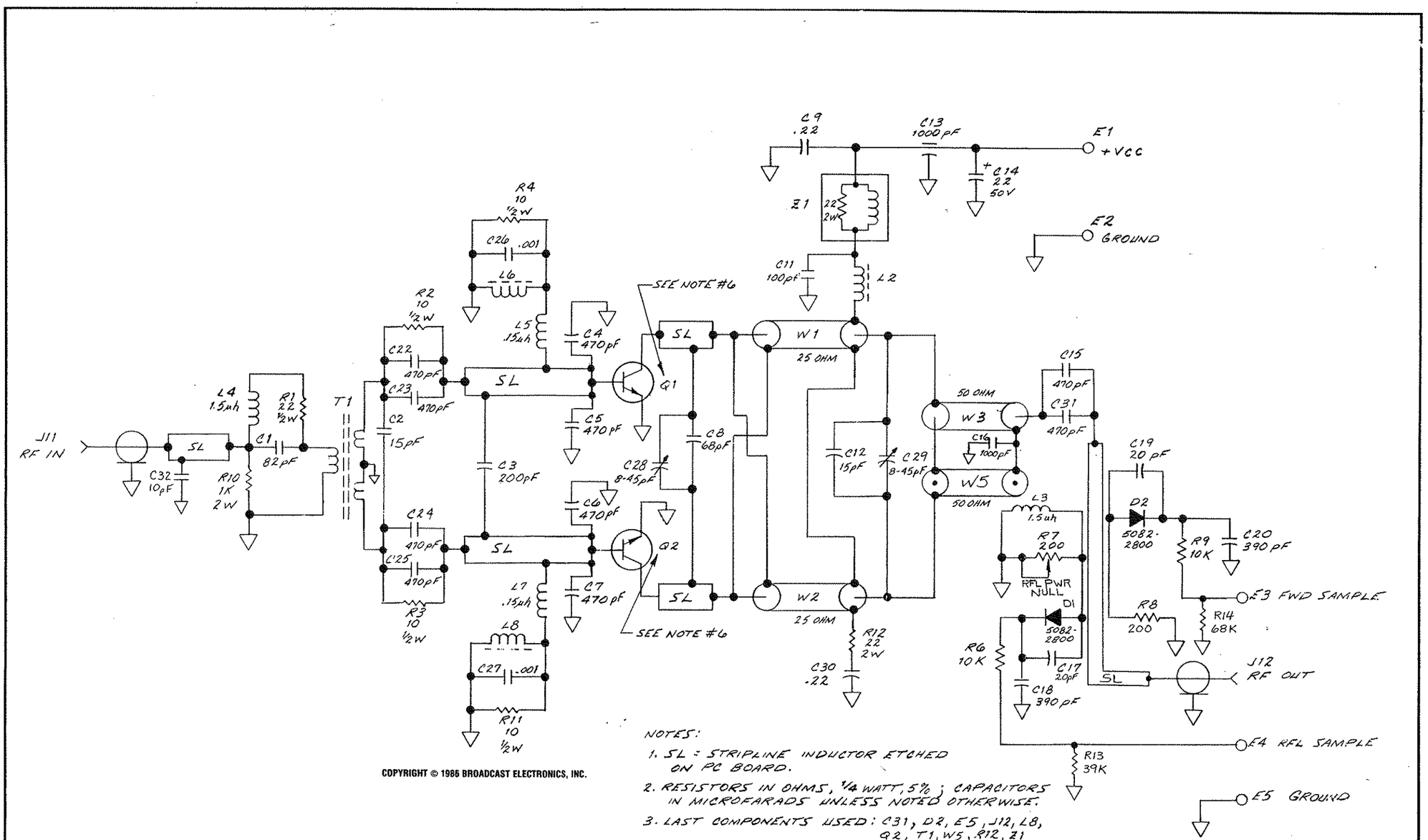
		CHECKED BY DATE	
		PROJECT ENGR. DATE 5/6/83	TITLE PCB ASSEMBLY IPA CONTROL REGULATOR PCB
		APPROVED BY MH 5-13-83	DWG. NO. TYPE A 919-0045 REV. G
MATERIAL	TREATMENT OR FINISH	FINISH	SCALE 2/1 SHEET 1 OF 1

REF	ZONE	REF	ZONE	REF	ZONE	REF	ZONE	REF	ZONE
C1	A2	Q4	A2	R49	B3				
C2	A3	Q5	B2	R50	B3				
C3	A2	R1	B2	R51	A2				
C4	A2	R2	B2	R52	A2				
C5	A2	R3	B2	R53	B3				
C6	B2	R4	B2	R54	B3				
C7	A2	R5	B2	R55	B3				
C8	A1	R6	B2	R56	B3				
C9	B1	R7	B2	R57	B3				
C10	A2	R8	B2	R58	B3				
C11	A1	R9	B2	R59	A3				
C12	A1	R10	A1	R60	A3				
C13	B2	R11	B2	R61	B1				
C14	A2	R12	B1	R62	A3				
C15	B3	R13	A1	R63	B1				
C16	A3	R14	B2	R64	B1				
C17	B2	R15	B1	R65	B3				
C18	B3	R16	B1	R66	B3				
C19	B1	R17	B1	R67	B3				
C20	B3	R18	B2	R68	B1				
C21	B2	R19	B2	R69	B1				
C22	B2	R20	B1	R70	B1				
D1	B2	R21	A1	R71	B1				
D2	B2	R22	B1	R72	B1				
D3	B2	R23	B1	R73	A1				
D4	B2	R24	A1	R74	B1				
D5	B1	R25	B1	R75	B1				
D6	B1	R26	B1	R76	B1				
D7	B2	R27	B2	R77	B1				
D8	B2	R28	B2	R78	B2				
D9	A1	R29	B2	TP1	A3				
D10	B2	R30	B2	TP2	B2–B3				
D11	A1	R31	B1	U1	A2				
D12	B2	R32	B3	U2	A2–A3				
D13	B3	R33	B3	U3	A1				
D14	B2	R34	B1	U4	B2				
D15	B2	R35	B3	U5	A1				
D16	B1	R36	B2	U6	B3				
D17	B1	R37	B3	U7	B1				
D18	A2	R38	B2						
D19	B3	R39	B2						
D20	B2	R40	A1						
F1	A3	R41	A1						
J3	B2	R42	B3						
J4	B3	R43	A1						
J5	A1	R44	B2						
J16	B1	R45	B3						
J17	B1	R46	B2						
J18	A1	R47	B2						
P16	B1	R48	B3						
P17	B1								
P18	A1								
Q1	B2								
Q2	B2								
Q3	A2								

597–0032–20

FIGURE 3–7. CONTROL REGULATOR CIRCUIT BOARD COMPONENT LOCATOR



NOTES:

1. SL = STRIPLINE INDUCTOR ETCHED ON PC BOARD.
2. RESISTORS IN OHMS, ¼ WATT, 5% ; CAPACITORS IN MICROFARADS UNLESS NOTED OTHERWISE.
3. LAST COMPONENTS USED: C31, D2, E5, J12, L8, Q2, T1, W5, R12, Z1
4. SEE PCB ASSY. # D959-0132, SHEET 1 OF 2.
5. COMPONENTS NOT USED: R5, C10, J1-J10
6. Q1 AND Q2 MATCHED PAIR OF B.E. PART NO. 210-1460-001. MUST HAVE SAME COLOR DOT.

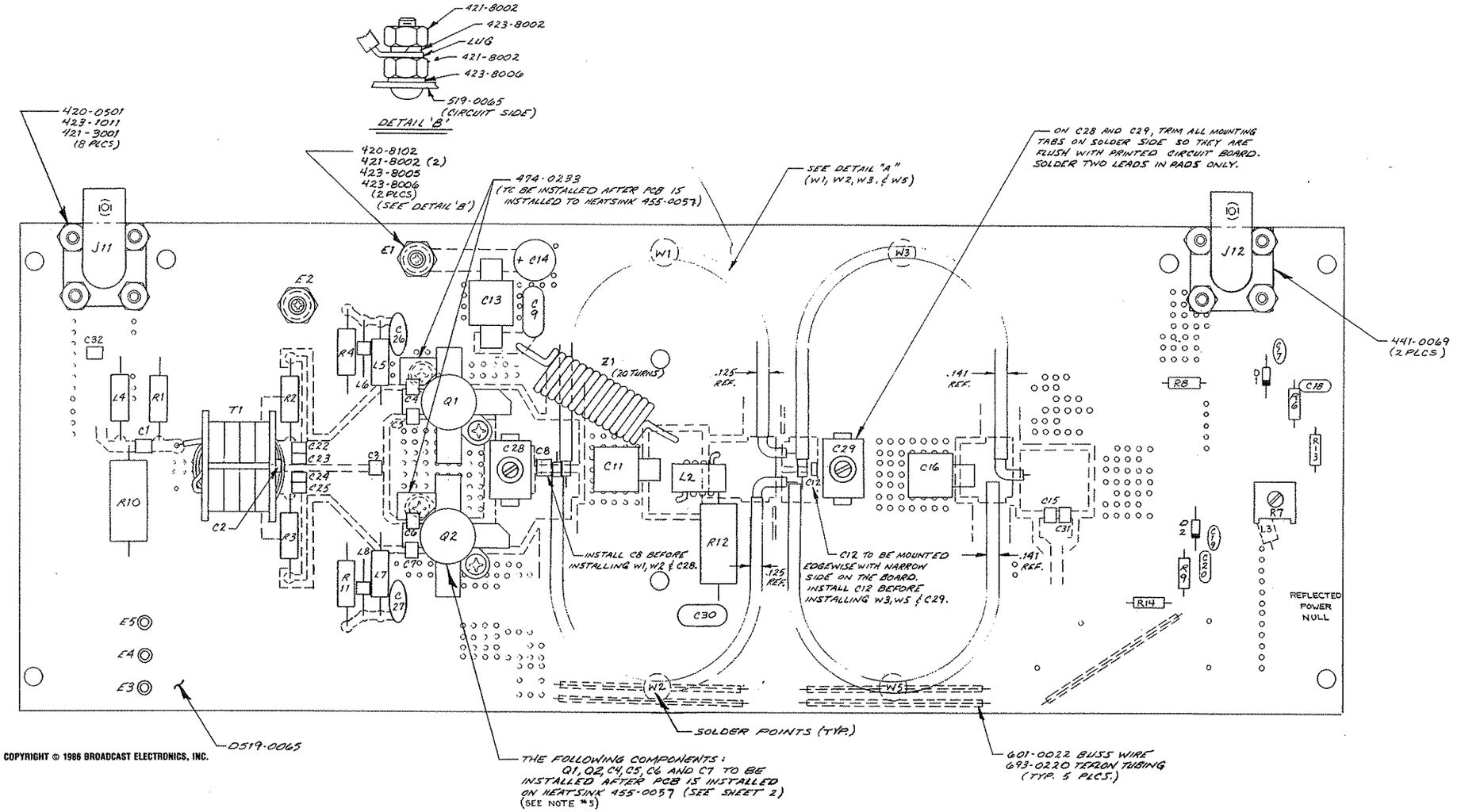
TOLERANCE (DECIMAL) U.O.S.
.X ± .030 .XXX ± .005
.XX ± .015 ANGLES ± 1°

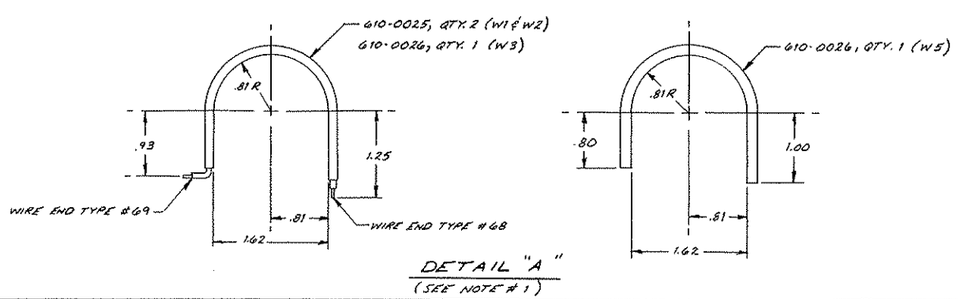
DWN. BY MERKEL 3-10-83
CHKD.
ME
EE
PROJ. ENGR. S.S. 5/16/83
DFTG. SUPVR. MH 5-13-83
MFG.

NEXT ASSY.
PRODUCT USED ON IPA
FINISH

BROADCAST ELECTRONICS INC.
4100 N. 24TH ST. QUINCY, IL 62305 217/224-9600
TELEX 250142 CABLE BCST ELECT QUI

TITLE PCB SCHEMATIC - IPA RF AMP PCB
SHEET 1 OF 1
SCALE NONE
REV H
TYPE 5 SIZE C
DWG. NO. 919-0065





DETAIL "A"
(SEE NOTE #1)

NOTES:
1. USE FIXTURE TO FORM W1, W2, W3, & W5.
2. REFERENCE SCHEMATIC # D959-0131.
3. REFERENCE B/M 919-0065.
4. REFERENCE RF AMP PCB SCHEMATIC # C919-0065.
5. TRANSISTORS Q1 & Q2 ARE MATCHED PAIRS.

TOLERANCE UNLESS OTHERWISE SPECIFIED
DECIMAL 2 PL=.01 3PL=.005
FRACTIONAL ±1/64
ANGULAR ± 1°
SHARP EDGES TO BEND RADII
FILLET RADII
MATERIAL
TREATMENT OR FINISH

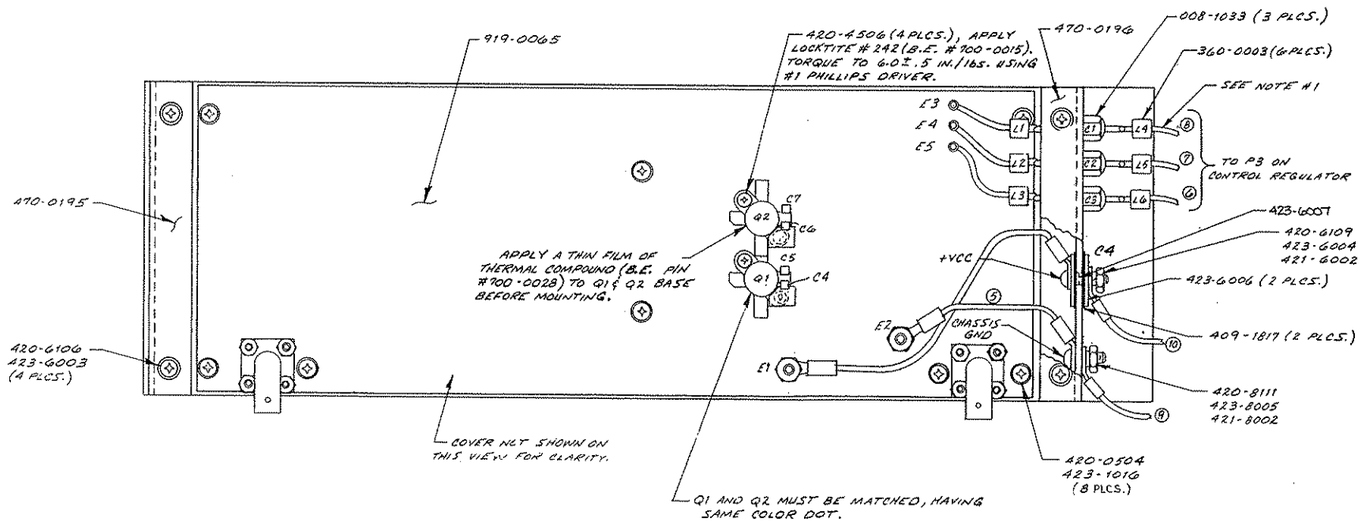
DRAWN BY WLF DATE 3-11-91
CHECKED BY DATE
PROJECT ENGR. DATE
APPROVED BY MH.

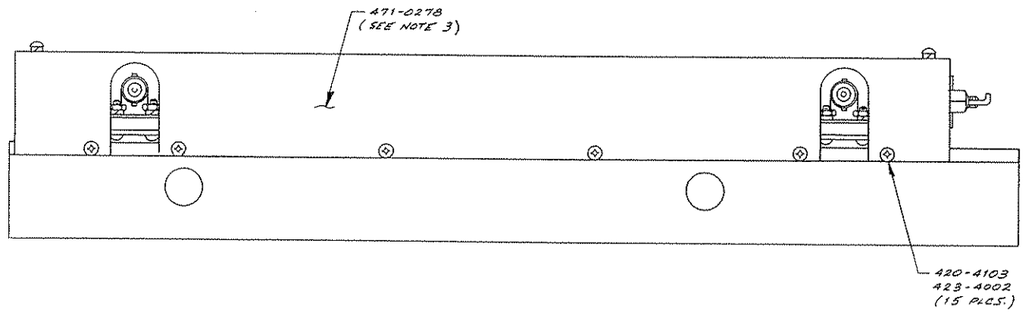
BROADCAST ELECTRONICS INC.

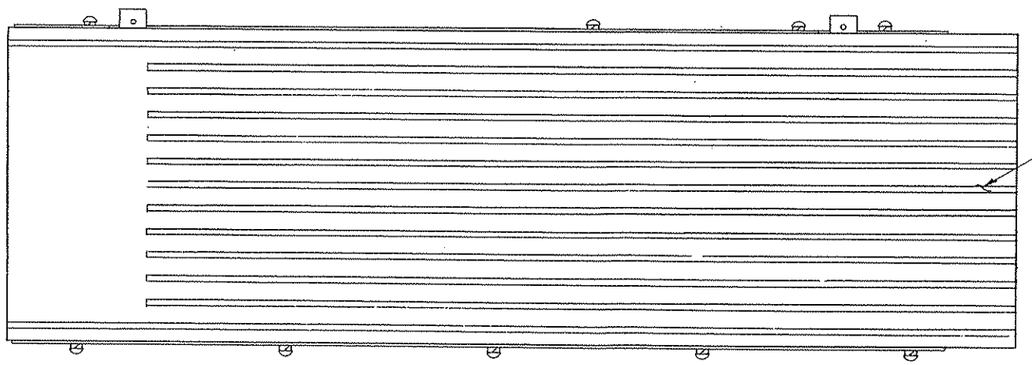
TITLE: IPA RF AMP ASSEMBLY

D | DWG. NO. TYPE A 959-0132-001 | REV. A

IPA | SCALE 2/1 | SHEET 1 OF 2







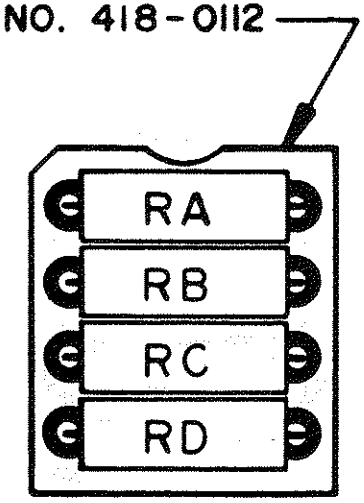
NOTES:
1. SEE DWG. 0949-0040 FOR WIRING ASSEMBLIES.
2. SEE B/M. 959-0132
3. ASSEMBLE TOP COVER 471-0278 AFTER TEST.
4. (N) - DENOTES WIRE NUMBERS.

TOLERANCE UNLESS OTHERWISE SPECIFIED
DECIMAL 2 PL = .01 3PL = .005
FRACTIONAL ± 1/64
ANGULAR ± 1°
SHARP EDGES TO
BEND RADII
FILLET RADII
MATERIAL
TREATMENT OR FINISH

DRAWN BY WLF DATE 2-11-91
CHECKED BY DATE
PROJECT ENGR. DATE
APPROVED BY MH

BROADCAST ELECTRONICS INC.
TITLE IPA RF AMP ASSEMBLY
D DWG. NO. 959-0132-001 REV. A
IPA SCALE 1/1 SHEET 2 OF 2

B.E. PART NO. 418-0112



USED ON:
IPA 919-0042 PCB ON FM5A
A5 R3.

B.E.I. PART NO. (VALUE IN OHMS)	RA	RB	RC	RD
100-1053 (10K)	X			
100-2243 (2.2K)		X		
100-1053 (10K)			X	
100-2743 (2.7K)				X

TOLERANCE UNLESS OTHERWISE SPECIFIED
DECIMAL 2 PL ± .01 3PL ± 005
FRACTIONAL ± 1/64
ANGULAR ± 1
SHARP EDGES TO
BEND RADII
FILLET RADII

MATERIAL

TREATMENT OR FINISH

DRAWN BY MERKEL	DATE 2-22-83
CHECKED BY	DATE
PROJECT ENGR	DATE
APPROVED BY	

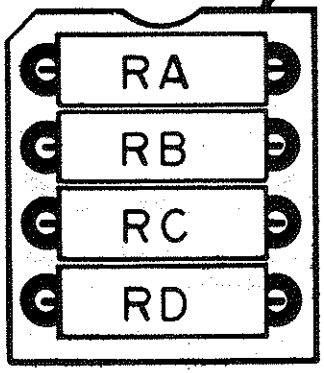
BROADCAST ELECTRONICS INC.

TITLE ASSEMBLY
RESISTOR NETWORK

A | DWG. NO. 959-1000-001 | REV. B

IPA - FM5A | SCALE 4/1 | SHEET 1 OF 1

B.E. PART NO. 418-0112



USED ON:
IPA 919-0042 PCB ON FM3.5A
AS R3.

B.E.I. PART NO. (VALUE IN OHMS)	RA	RB	RC	RD
100-1053 (10K)	X			
100-2243 (2.2K)		X		
100-1053 (10K)			X	
100-2743 (2.7K)				X

TOLERANCE UNLESS OTHERWISE SPECIFIED
DECIMAL 2 PL ±.01 3PL ± 005
FRACTIONAL ±1/64
ANGULAR ± 1°
SHARP EDGES TO
BEND RADII
FILLET RADII

MATERIAL

TREATMENT OR FINISH

DRAWN BY MERKEL | DATE 2-22-83
CHECKED BY | DATE
PROJECT ENGR. | DATE
APPROVED BY

BROADCAST ELECTRONICS INC.

TITLE ASSEMBLY
RESISTOR NETWORK

A | DWG. NO. 959-1000 | REV. B

IPA-FM3.5A | SCALE 4/1 | SHEET 1 OF 1

SECTION IV
IPA PARTS LISTS

4–1. INTRODUCTION.

4–2. This section provides descriptions and part numbers of electrical components, assemblies, and selected mechanical parts required for maintenance of the Broadcast Electronics FM–5B/FM–5BS IPA. Each table entry in this section is indexed by reference designators appearing on the applicable schematic diagram.

TABLE 4–1. IPA PARTS LIST INDEX

TABLE 4–2. OVERALL, IPA – 959–0263–001

REF. DES.	DESCRIPTION	PART NO.	QTY.
	ONE OF THE FOLLOWING FANS		
B1	Fan, 115V, 50/60 Hz, 18W, 120 ft3/min, 3100 r/min, 4.5 inch (11.43 cm)	380–4600	1
B1	Fan, Cooling, Model 7600S, 115V ac, 50/60 Hz, 38/41 W, 7 inch (17.78)	380–7600	1
C1	Capacitor, Electrolytic, 24,000 uF, 100V	024–2490	1
D1	Bridge Rectifier, MDA3502, 200V, 35 Amperes, Silicon	230–3502	1
DS1	Indicator, LED, Green, 521–9175, 3V @ 40 mA Maximum	323–9224	1
DS2	Indicator, LED, Yellow, 521–9176, 3V @ 30 mA Maximum	323–9225	1
DS3	Indicator, LED, Red, 521–9212, 1.7V @ 50 mA Maximum	323–9217	1
	220V AC Input Operation		
F1,F2,SPARE	Fuse, MDA, 250V, Slow–Blow, Ceramic Element, 4 Amperes	330–0401	3
	110V AC Input Operation		
F1,F2,SPARE	Fuse, 250V, Slow–Blow, 8 Amperes	330–0801	3
F3,SPARE	Fuse, 3AG, 250V, 20 Amperes	330–2000	2
FL1	Power Input Connector/RFI Filter, 10 Amperes, 250V ac, 50/60 Hz	339–0006	1
MOV1	Metal Oxide Varistor, V2506A15A, 250V ac RMS, 15 Joules	140–0008	1
R1	Resistor, 680 Ohm ±5%, 1/2W	110–6833	1
R2, R3	Resistor, 820 Ohm ±5%, 1/2W	110–8233	2
TS1	Barrier Strip, 10 Terminal	412–0100	1
XF1,XF2	Fuse Holder, AGC	415–2012	2
XF3	Fuse Holder, Dual, 3AB	415–0003	1
——	Transformer, Power, Single Phase 50/60 Hz	376–0040	1
——	Filter, Fan, Pamotor 5502	380–5502	1
——	Fuse Clips for Spare fuse, AGC	415–1001	2
——	Receptacle, Top Cover Fastener	420–0022	8
——	Turn–Lock Fastener, Long	420–0019	6
——	Turn–Lock Fastener, Short	420–0027	2
——	Retainer, Turn–Lock Fastener	420–0021	8
——	Interconnect/Filter Circuit Board	919–0042	1
——	RF Amplifier Assembly	959–0132–001	1
——	Control Regulator Assembly	959–0133–001	1
——	IPA Wiring Assembly	949–0029	1
——	Blank Circuit Board	519–0401	1

TABLE 4–3. IPA WIRING ASSEMBLY – 949–0029

REF. DES.	DESCRIPTION	PART NO.	QTY.
J10	Receptacle, BNC, Bulkhead UG–909	417–0106	1
J13	Receptacle, Type N	417–0076	1
P1,P2	Plug, BNC, Right Angle	417–0213	2
P1	Plug Assembly:		
	Contact, Male	418–0036	1
	Contact, Female	417–0100	1
	Housing	417–0099	1
P5,P6	Connector, Housing , 14–Pin In–Line	417–1401	2
P7	Connector, Housing, 5–Pin In–Line	417–0165	1
R1	Resistor, 1.8 k Ohm ±5%, 2W	130–1843	1
——	Pins, Receptacle (for Connectors P5, P6, and P7)	417–8766	30

TABLE 4–4. INTERCONNECT/FILTER CIRCUIT BOARD – 919–0042

REF. DES.	DESCRIPTION	PART NO.	QTY.
C1 THRU C8	Capacitor, Mica, 390 pF ±5%, 100V	042–3922	8
C9,C10	Capacitor, Mylar Film, 0.1 uF ±5%, 100V	030–1053	2
C11 THRU C44	Capacitor, Mica, 390 pF ±5%, 100V	042–3922	34
C45	Capacitor, Electrolytic, 22 uF, 50V	024–2274	1
C46	Capacitor, Mica, 390 pF ±5%, 100V	042–3922	1
C47,C48	Capacitor, Mica, 390 pF ±5%, 100V	042–3922	2
D1,D2	Diode, 1N4148, Silicon, 100V, 10 mA	203–4148	2
J6	Receptacle, Header, 20–Pin In–Line	417–0200	70
J7	Receptacle, Header, 20–Pin In–Line	417–0200	30
J8	Receptacle, Male, 20–Pin In–Line	417–0200	1
J9	Receptacle, 25–Pin	417–2500	1
L1 THRU L9	Molded Choke, 4.7 uH ±10%, DC Resistance: 0.55 Ohms, 0.43 Amperes Maximum, Resonant at 130 MHz	360–0022	9
R1,R2	Resistor, 1 k Ohm ±5%, 1/2W	110–1043	2
R4,R5	Resistor, 1 k Ohm ±5%, 1/4W	100–1043	2
R6	Resistor, 10 Meg Ohm ±5%, 1/4W	100–1083	1
R7	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	1
R8	Resistor, 10 Ohm ±5%, 1/4W	100–1023	1
R9	Resistor, 10 Meg Ohm ±5%, 1/4W	100–1083	1
R10 THRU R12	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	3
R13 THRU R18	Resistor, 4.99 k Ohm ±1%, 1/4W	100–5041	6
R19,R20	Resistor, 1.2 k Ohm ±5%, 1/4W	100–1243	2
R21,R22	Resistor, 4.99 k Ohm ±1%, 1/4W	100–5041	2
R23 THRU R26	Resistor, 1.2 k Ohm ±5%, 1/4W	100–1243	4
R27	Resistor, 100 Ohm ±5%, 2W	132–1033	1
R28 THRU R31	Resistor, 100 k Ohm ±5%, 1/4W	100–1063	4
R32,R33	Resistor, 3.3 Meg Ohm ±5%, 1/4W	100–3373	2
U1	Integrated Circuit, ULN2004, 7 NPN Darlington Driver Pack, 16–Pin DIP	226–2004	1
U2	Integrated Circuit, 4N33, Optical Isolator NPN Photo Transistor/Infrared Emitting Diode Type, 1500V Isolation, 6–Pin DIP	229–0033	1
U3,U4	Integrated Circuit, LM358N, Dual Operational Amplifier, 8–Pin DIP	221–0358	2
XR3	Receptacle, 8–Pin DIP	417–0088	1
XU1	Receptacle, 16–Pin DIP	417–1604	1
XU2	Receptacle, 8–Pin DIP	417–0804	1
XU3,XU4	Receptacle, 6–Pin DIP	417–0600	2
——	Blank Circuit Board	519–0042	1

TABLE 4–5. RF AMPLIFIER ASSEMBLY – 959–0132–001
(Sheet 1 of 2)

REF. DES.	DESCRIPTION	PART NO.	QTY.
C1 THRU C3	Capacitor, Ceramic, Feed–Thru, 1000 pF ±20%, 500V	008–1033	3
C4	Capacitor Assembly, Kapton, Feed–Thru, 100 pF		
	Kapton Dielectric	409–1817	2
	Nylon Insulator	423–6007	2

TABLE 4–5. RF AMPLIFIER ASSEMBLY – 959–0132–001
(Sheet 2 of 2)

REF. DES.	DESCRIPTION	PART NO.	QTY.
L1 THRU L6	Ferrite Bead	360–0003	6
——	RF Amplifier Wiring Assembly	949–0040	1
——	RF Amplifier Circuit Board	919–0065	1

TABLE 4–6. RF AMPLIFIER WIRING ASSEMBLY – 949–0040

REF. DES.	DESCRIPTION	PART NO.	QTY.
P3	Connector, Housing, 4–Pin In–Line	417–0138	1
P4	Connector Housing, 2–Pin	417–0099	1
——	Pins, Connector (for P4)	417–0100	2
——	Pins, Receptacle (for P3)	417–8766	3

TABLE 4–7. RF AMPLIFIER CIRCUIT BOARD ASSEMBLY – 919–0065
(Sheet 1 of 2)

REF. DES.	DESCRIPTION	PART NO.	QTY.
C1	Capacitor, Ceramic, Chip, 82 pF ±5%, 500V	009–8013	1
C2	Capacitor, Ceramic, Chip, 15 pF ±5%, 500V	009–1513	1
C3	Capacitor, Ceramic, Chip, 200 pF ±5%, 300V	009–2023	1
C4 THRU C7	Capacitor, Ceramic, Chip, 470 pF ±5%, 200V	009–4723	4
C8	Capacitor, Ceramic, Chip, 68 pF ±5%, 500V	009–6813	1
C9	Capacitor, Mylar, 0.22 uF ±10%, 100V	030–2253	1
C11	Capacitor, Mica, 100 pF ±10%, 350V	046–0001	1
C12	Capacitor, Ceramic, Chip, 15 pF ±5%, 500V	009–1513	1
C13	Capacitor, Mica, Feedthru, 1000 pF ±10%, 350V	046–1030	1
C14	Capacitor, Electrolytic, 22 uF, 50V	024–2274	1
C15	Capacitor, Ceramic, Chip, 470 pF ±5%, 200V	009–4723	1
C16	Capacitor, Mica, 1000 pF ±10%, 350V	046–0002	1
C17	Capacitor, Ceramic, 20 pF ±10%, 1kV	002–2013	1
C18	Capacitor, Mica, 390 pF ±5%, 100V	042–3922	1
C19	Capacitor, Ceramic, 20 pF ±10%, 1kV	002–2013	1
C20	Capacitor, Mica, 390 pF ±5%, 100V	042–3922	1
C22 THRU C25	Capacitor, Ceramic, Chip, 470 pF ±5%, 200V	009–4723	4
C26,C27	Capacitor, Ceramic, 0.001 uF ±10%, 1kV	002–1034	2
C28,C29	Capacitor, Mica, Adjustable Compression, 4 TO 45 pF, 175V	090–0403	2
C30	Capacitor, Mylar, 0.22 uF ±10%, 100V	030–2253	1
C31	Capacitor, Ceramic Chip, 470 pF ±5%, 200V	009–4723	1
C32	Capacitor, Ceramic Chip, 10 pF ±5%, 500V	009–1013	1
D1,D2	Diode, HP5082–2800, High Voltage Schottky Barrier Type, 70V, 15 mA	201–2800	2
J11,J12	Receptacle, Right Angle BNC, UG535/U	417–0049	2
L2	RF Choke: 4 Turns of enameled 16 AWG wire on a 1/2 inch OD ferrite torroid form.	360–0025	1
L3,L4	RF Choke, 1.5 uH ±10%, 580 mA Maximum, DC Resistance = 0.30 Ohms	360–0032	2
L5	RF Choke, 0.15 uH, 1.47A dc Maximum DC Resistance = 0.037 Ohms	360–0151	1

TABLE 4–7. RF AMPLIFIER CIRCUIT BOARD ASSEMBLY – 919–0065
(Sheet 2 of 2)

REF. DES.	DESCRIPTION	PART NO.	QTY.
L6	RF Choke, Consists of BE P/N 360–0041 ferrite bead, OD = 0.13 inch, ID = 0.047 inch, L = 0.11 inch	360–0042	1
L7	RF Choke, 0.15 uH, 1.47A dc Maximum DC Resistance = 0.037 Ohms	360–0151	1
L8	RF Choke, Consists of BE P/N 360–0041 ferrite bead, OD = 0.13 inch, ID = 0.047 inch, L = 0.11 inch	360–0042	1
Q1,Q2	Transistor, Pair, SD1460–4, NPN, Silicon, CB–290 Case	210–1460–001	1
R1	Resistor, 22 Ohm ±5%, 1/2W	110–2223	1
R2 THRU R4	Resistor, 10 Ohm ±5%, 1/2W	110–1023	3
R6	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	1
R7	Potentiometer, 200 Ohm ±10%, 1/2W	177–2034	1
R8	Resistor, 200 Ohm ±1%, 1/4W	100–2003	1
R9	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	1
R10	Resistor, 1 k Ohm ±5%, 2W	130–1043	1
R11	Resistor, 10 Ohm ±5%, 1/2W	110–1023	1
R12	Resistor, 22 Ohm ±5%, 2W	130–2223	1
R13	Resistor, 39 k Ohm ±5%, 1/4W	100–3953	1
R14	Resistor, 68 k Ohm ±5%, 1/4W	100–6853	1
T1	RF Input Transformer, Broadcast Electronics Manufacture Primary: 50 Ohms Impedance Secondary: 25 Ohm Impedance, CT	370–0008	1
W1,W2	Coaxial Cable Sections: 25 Ohm rigid coaxial cable matching section	610–0025	2
W3,W5	Coaxial Cable Sections: 50 Ohm rigid coaxial cable matching section	610–0026	2
Z1	Parasitic Suppressor: 20 Turns of enameled 16 AWG wire close wound on a 22 Ohm ±5%, 2W carbon resistor (BE P/N 130–2223)	360–0024	1
——	Blank Circuit Board	519–0065	1

TABLE 4–8. CONTROL REGULATOR ASSEMBLY – 959–0133–001

REF. DES.	DESCRIPTION	PART NO.	QTY.
Q1	Transistor, MJ3000, Silicon, NPN Darlington, TO–3 Case	219–3000	1
Q2 THRU Q4	Transistor, 2N3055A, Silicon, NPN, TO–3 Case	219–3055	3
XQ1 THRU XQ4	Socket, TO–3 Transistor	417–0298	4
——	Insulator, Mica, TO–3 Transistor	418–0010	4
——	Control Regulator Wiring Assembly	949–0039	1
——	Control Regulator Circuit Board	919–0045	1
——	Temperature Sensor Circuit Board	917–0030	1

TABLE 4–9. CONTROL REGULATOR WIRING ASSEMBLY – 949–0039

REF. DES.	DESCRIPTION	PART NO.	QTY.
J1	Jack Assembly:		
	Contact, Male	418–0036	1
	Contact, Female	417–0100	1
	Housing	417–0098	1

TABLE 4–10. CONTROL REGULATOR CIRCUIT BOARD – 919–0045
(Sheet 1 of 3)

REF. DES.	DESCRIPTION	PART NO.	QTY.
C1 THRU C4	Capacitor, Electrolytic, 22 uF, 50V	024–2274	4
C5,C6	Capacitor, Mica, 390 pF ±5%, 100V	042–3922	2
C7	Capacitor, Electrolytic, 22 uF, 50V	024–2274	1
C8,C9	Capacitor, Mylar Film, 0.1 uF, 100V	030–1053	2
C10,C11	Capacitor, Electrolytic, 22 uF, 50V	024–2274	2
C12	Capacitor, Electrolytic, 2.2 uF, 50V	020–2264	1
C13	Capacitor, Mylar Film, 0.01 uF, 100V	031–1043	1
C14	Capacitor, Mica, 390 pF ±5%, 100V	042–3922	1
C15	Capacitor, Polyester, 0.0022 uF ±10%, 100V	031–2033	1
C16 THRU C18	Capacitor, Electrolytic, 22 uF, 50V	024–2274	3
C19	Capacitor, Mylar Film, 0.1 uF, 100V	030–1053	1
C20	Capacitor, Electrolytic, 22 uF, 50V	024–2274	1
C21	Capacitor, Mica, 390 pF ±5%, 100V	042–3922	1
C22	Capacitor, Electrolytic, 10 uF, 50V	023–1076	1
D1 THRU D4	Diode, 1N4005, Silicon, 600V, 1 Ampere	203–4005	4
D5,D6	Diode, 1N4148, Silicon, 100V, 10 mA	203–4148	1
D7	Diode, Zener, 1N4733A, 5.1V, 1W	200–4733	1
D8,D9	Diode, 1N4148, Silicon, 100V, 10 mA	203–4148	2
D10	Diode, Zener, 1N4739A, 9.1V, 1W	200–0009	1
D11	Diode, Zener, 1N4744A, 15V, 1W	200–0015	1
D12	Diode, 1N4148, Silicon, 100V, 10 mA	203–4148	1
D13	Diode, Zener, 1N4752A, 33V, 1W	200–4752	1
D14 THRU D17	Diode, 1N4148, Silicon, 100V, 10 mA	203–4148	4
D18	Diode, 1N4005, Silicon, 600V @ 1 Ampere	203–4005	1
D19	Diode, Zener, 1N5363, 30V, 5W	200–5363	1
D20	Diode, 1N4148, Silicon, 100V, 10 mA	203–4148	1
F1	Fuse, AGC, 250V, 1/2 Ampere	330–0050	1
J3	Receptacle, Header, 20–Pin In–Line	417–0200	.20
J4	Receptacle, Header, 2–Pin	417–0097	1
J5	Receptacle, Header, 20–Pin In–Line	417–0200	.70
J16 THRU J18	Receptacle, Header, 3–Pin	418–0003	3
P16 THRU P18	Plug, Shorting, 2–Pin	340–0004	3
Q1	Transistor, MPSA06, NPN, TO–92 Case	211–0006	1
Q2	Transistor, MPSA56, PNP, TO–92 Case	210–0056	1
Q3,Q4	Transistor, MPSA06, NPN, TO–92 Case	211–0006	2
Q5	Transistor, 2N3904, NPN, Silicon, TO–92 Case	211–3904	1
R1	Resistor, 169 Ohms ±1%, 1/4W	103–1693	1
R2	Resistor, 7.32 k Ohm ±1%, 1/4W	103–7324	1
R3,R4	Resistor, 100 k Ohm ±5%, 1/4W	100–1063	2
R5	Resistor, 115 Ohm ±1%, 1/4W	100–1131	1
R6	Resistor, 1.24 k Ohm ±1%, 1/4W	103–1244	1
R7,R8	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	2
R9	Resistor, 7.32 k Ohm ±1%, 1/4W	103–7324	1
R10	Resistor, 24 k Ohm ±5%, 1/4W	100–2453	1
R11	Resistor, 2.4 k Ohm ±5%, 1/4W	100–2443	1
R12	Resistor, 1.40 k Ohm ±1%, 1/4W	103–1404	1
R13	Resistor, 16 k Ohm ±5%, 1/4W	100–1653	1

TABLE 4–10. CONTROL REGULATOR CIRCUIT BOARD – 919–0045
(Sheet 2 of 3)

REF. DES.	DESCRIPTION	PART NO.	QTY.
R14	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	1
R15	Resistor, 1.13 k Ohm ±1%, 1/4W	103–1134	1
R16	Resistor, 787 Ohm ±1%, 1/4W	103–7873	1
R17	Potentiometer, 10 k Ohm ±10%, 1/2W	178–1053	1
R18	Potentiometer, 100 k Ohm ±10%, 1/2W	178–1064	1
R19	Potentiometer, 50 k Ohm ±10%, 1/2W	178–5053	1
R20	Resistor, 100 k Ohm ±5%, 1/4W	100–1063	1
R21	Resistor, 1.1 k Ohm ±5%, 1/4W	100–1143	1
R22,R23	Resistor, 10 Ohm ±5%, 1/4W	100–1023	2
R24	Resistor, 100 k Ohm ±5%, 1/4W	100–1063	1
R25	Resistor, 10 k Ohm ±1%, 1/4W	100–1051	1
R26	Resistor, 4.99 k Ohm ±1%, 1/4W	100–5041	1
R27	Resistor, 10 k Ohm ±1%, 1/4W	100–1051	1
R28	Resistor, 4.99 k Ohm ±1%, 1/4W	100–5041	1
R29	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	1
R30	Potentiometer, 10 k Ohm ±10%, 1/2W	178–1053	1
R31	Resistor, 2.49 k Ohm ±1%, 1/4W	103–2494	1
R32	Resistor, 11 k Ohm ±1%, 1/4W	103–1105	1
R33	Resistor, 3.57 k Ohm ±1%, 1/4W	103–3574	1
R34	Resistor, 2.21 k Ohm ±1%, 1/4W	103–2241	1
R35	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	1
R36	Resistor, 12 k Ohm ±5%, 1/4W	100–1253	1
R37	Resistor, 5.6 Meg Ohm ±5%, 1/4W	100–5673	1
R38	Resistor, 390 Ohm ±5%, 1/4W	100–3933	1
R39	Resistor, 4.7 k Ohm ±5%, 1/4W	100–4743	1
R40 THRU R42	Resistor, 10 Ohm ±5%, 1/4W	100–1023	3
R43	Resistor, 1.2 k Ohm ±5%, 1/4W	100–1243	1
R44	Resistor, 100 Ohm ±5%, 1/4W	100–1033	1
R45	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	1
R46	Resistor, 1.8 k Ohm ±5%, 1/4W	100–1843	1
R47	Resistor, 100 Ohm ±5%, 1/4W	100–1033	1
R48,R49	Resistor, 20 k Ohm ±5%, 1/4W	100–2053	2
R50	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	1
R51	Resistor, 6.2 k Ohm ±5%, 1/4W	100–6243	1
R52	Resistor, 120 Ohm ±5%, 1/4W	100–1233	1
R53	Resistor, 100 k Ohm ±5%, 1/4W	100–1063	1
R54	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	1
R55 THRU R57	Resistor, 22 Ohm ±5%, 1/4W	100–2223	3
R58	Resistor, 1 k Ohm ±5%, 1/4W	100–1043	1
R59,R60	Resistor, 0.1 Ohm ±1%, 5W, W/W	130–1000	2
R61	Resistor, 1 k Ohm ±5%, 1/4W	100–1043	1
R62	Resistor, 0.1 Ohm ±1%, 5W, W/W	130–1000	1
R63	Resistor, 4.99 k Ohm ±1%, 1/4W	100–5041	1
R64	Resistor, 1 k Ohm ±1%, 1/4W	103–1041	1

TABLE 4–10. CONTROL REGULATOR CIRCUIT BOARD – 919–0045
(Sheet 3 of 3)

REF. DES.	DESCRIPTION	PART NO.	QTY.
R65 THRU R67	Resistor, 22 Ohm ±5%, 1/4W	100–2223	3
R68 THRU R70	Resistor, 10 k Ohm ±1%, 1/4W	100–1051	3
R71	Resistor, 9.76 k Ohm ±1%, 1/4W	103–9764	1
R72	Potentiometer, 500 Ohm ±10%, 1/2W	178–5000	1
R73	Resistor, 10 Ohm ±5%, 1/4W	100–1023	1
R74	Resistor, 1.10 k Ohm ±1%, 1/4W	103–1104	1
R75	Resistor, 9.53 k Ohm ±1%, 1/4W	103–9534	1
R76	Potentiometer, 1 k Ohm ±10%, 1/2W	178–1043	1
R77	Resistor, 10 Ohm ±5%, 1/4W	100–1023	1
R78	Resistor, 10 k Ohm ±1%, 1/4 W	100–1051	1
U1,U2	Integrated Circuit, LM317K, Three–Terminal Adjustable Positive Voltage Regulator, 1.2 to 37V, 1.5 Ampere Maximum, TO–3 Case	227–0318	1
U3 THRU U5	Integrated Circuit, LM358N, Dual Operational Amplifier, 8–Pin DIP	221–0358	3
U6	Integrated Circuit, LF353N, Dual JFET Input Operational Amplifier, 8–Pin DIP	221–0353	1
U7	Integrated Circuit, LM358N, Dual Operational Amplifier, 8–Pin DIP	221–0358	1
XF1	Fuse Clips, AGC	415–2068	2
XU3 THRU XU7	Socket, 8–Pin DIP	417–0804	5
——	Blank Circuit Board	519–0045	1

TABLE 4–11. TEMPERATURE SENSOR CIRCUIT BOARD – 917–0030

REF. DES.	DESCRIPTION	PART NO.	QTY.
C1 THRU C3	Capacitor, Mica, 390 pF ±5%, 100V	042–3922	3
U1	Integrated Circuit, LM335Z, Precision Temperature Sensor, TO–92 Case	229–0335	1
——	Blank Circuit Board	517–0030	1

TABLE 4–12. RESISTOR NETWORK ASSEMBLY, FM–5B – 959–1000–001

REF. DES.	DESCRIPTION	PART NO.	QTY.
R3A	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	1
R3B	Resistor, 2.2 k Ohm, ±5%, 1/4W	100–2243	1
R3C	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	1
R3D	Resistor, 2.7 k Ohm ±5%, 1/4W	100–2743	1
——	Plug, 8–Pin DIP	418–0112	1

TABLE 4–13. RESISTOR NETWORK ASSEMBLY, FM–5BS – 959–1000
(Sheet 1 of 2)

REF. DES.	DESCRIPTION	PART NO.	QTY.
R3A	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	1

TABLE 4–13. RESISTOR NETWORK ASSEMBLY, FM–5BS – 959–1000
(Sheet 2 of 2)

REF. DES.	DESCRIPTION	PART NO.	QTY.
R3B	Resistor, 2.2 k Ohm, ±5%, 1/4W	100–2243	1
R3C	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	1
R3D	Resistor, 2.7 k Ohm ±5%, 1/4W	100–2743	1
——	Plug, 8–Pin DIP	418–0112	1

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

SECTION I
APC THEORY OF OPERATION

1–1. INTRODUCTION.

1–2. The following text provides theory of operation with supporting diagrams for the FM–5B/ FM–5BS automatic power control unit.

1–3. FUNCTIONAL DESCRIPTION.

1–4. Two levels of discussion are provided. A general discussion of the automatic power control unit operation at block diagram level is followed by a detailed discussion of circuit operation.

1–5. GENERAL DESCRIPTION.

1–6. The automatic power control unit (APC) measures several transmitter parameters and allows both manual and automatic control of RF power output. Additional features include switched operation at a power level which has been predetermined (preset power), automatic power reduction in event of an output VSWR (VSWR foldback), and automatic re–duction of power to minimum at plate–off so that when power is re–applied, full RF output will not suddenly be established, but will slowly increase from minimum (soft start). The unit also contains a front–panel test receptacle for AM noise measurements.

1–7. **OPERATION.** Manual screen control can be selected by switching the APC off. In the manual mode, the **RAISE** and **LOWER** switch/indicators directly control the dc servo motor which varies the screen voltage supply. The **RAISE** and **LOWER** switch/indicators are illuminated by the actual motor drive signal (see Figure 1–1).

1–8. In the automatic mode, the **RAISE** and **LOWER** switch/indicators control a reference voltage stored as an eight–bit word in a digital memory. A nine–volt battery maintains this memory after a power failure so that restoration to operation will proceed automatically after power is re–applied. Battery power consumption of 0.8 microamperes results in a battery life of approximately two years (the shelf life of an alkaline battery).

1–9. The dc servo motor control circuit in the APC uses duty–cycle modulation to vary the motor speed. When large excursions of screen voltage are required, a faster speed is utilized. Small adjustments of screen voltage utilize a shorter pulse duty cycle and consequently slower motor speed. The illumination intensity and flashing rate of the front panel **RAISE** and **LOWER** switch/indicators show in which mode the servo system is operating. The combination of a two–speed loop and analog "deadbands" in the circuitry eliminates over–shoot and hunting of the servo loop.

1–10. Five circuit–board mounted **LED** indicators provide information concerning operation of the APC for maintenance personnel. Each indicator will illuminate to signify its respective function or parameter is active or out–of–tolerance.

1–11. The APC houses the circuitry which rectifies and calibrates the PA directional coupler forward and reflected power signals. These signals serve as APC control inputs and are applied to the **OUTPUT POWER** meter for measurement. These parameters, PA screen current, and IPA forward power allow automatic control of the PA screen voltage as part of a closed loop employing a dc servo–motor driven variable autotransformer. If excessive PA reflected power, excessive screen current, or low IPA power is measured, the "raise power" function will be inhibited to prevent an overload condition. The absence of plate voltage will inhibit the raise function and signal the circuit to adjust the screen voltage to minimum. Excessive transmitter RF output or a high PA reflection will first inhibit the raise function. If the condition exceeds built–in limits, the circuit will initiate a sequence which lowers power proportionately in response to the condition.

1–12. **VSWR Foldback.** In the automatic mode, PA power will be automatically reduced if PA reflected power becomes excessive enough to overload the transmitter. As the condition which caused the high VSWR returns to normal, RF power will be proportionally raised until full output is restored. A similar circuit for PA forward power will reduce power if the output is excessive. The balance of these two circuits stabilizes the transmitter output at a specific level.

1–13. **Soft Start.** In the automatic mode, a circuit monitors plate voltage and reduces the screen voltage to zero upon the absence of plate voltage. When the plate supply is energized, as during power–on, the circuit will gradually increase the screen voltage until the "stored" power level is achieved. This circuit prevents inadvertent cycling of the VSWR overload at turn–on if the load is not optimal, such as during an ice storm.

1–14. **Preset Power.** The preset power function provides a simple means to switch the transmitter output power to a predetermined level other than the rated output power. This feature can be conveniently activated with a generator for emergency operation at a lower power level.

1–15. **Emergency Back–Up Operation.** Emergency adjustment of the screen adjust motor is possible even with the APC main circuit board removed for maintenance. The jumper–plug arrangement and the emergency back–up raise/lower switch on the rear panel circuit board will allow application of a 25 volt potential obtained directly from the power transformer on the chassis for clockwise or counterclockwise rotation of the motor as desired.

1–16. **Power Supply.** The APC power supply consists of two +15 volt regulated sources, a +12 volt regulated source, and a +9.9 volt source established by a zener diode. Each +15 volt supply is fused with a one–ampere fuse. The entire supply is overload protected by two half–ampere fuses in the primary circuit. The transformer secondary of 25 Vac is half–wave rectified to provide a potential to operate the motor if the emergency back–up operation provision is used.

1–17. **DETAILED DESCRIPTION.**

1–18. The APC unit circuitry is implemented on three circuit boards with certain additional components (such as the power transformer) mounted to the chassis.

A. The front panel circuit board contains the switch/indicators and some resistors which calibrate the OUTPUT POWER METER circuitry.

B. The rear panel circuit board primarily contains interface circuitry. It 1) contains the forward and reflected power rectifier circuitry, 2) the PI section low–pass filters which provide RFI filtering for all ac, dc and control inputs, 3) the power supplies which operate the unit, and 4) the emergency bypass circuitry which allows manual screen voltage raise and lower control even with the main circuit board removed.

C. The main circuit board contains all the circuitry required to implement the APC analog and digital control functions.

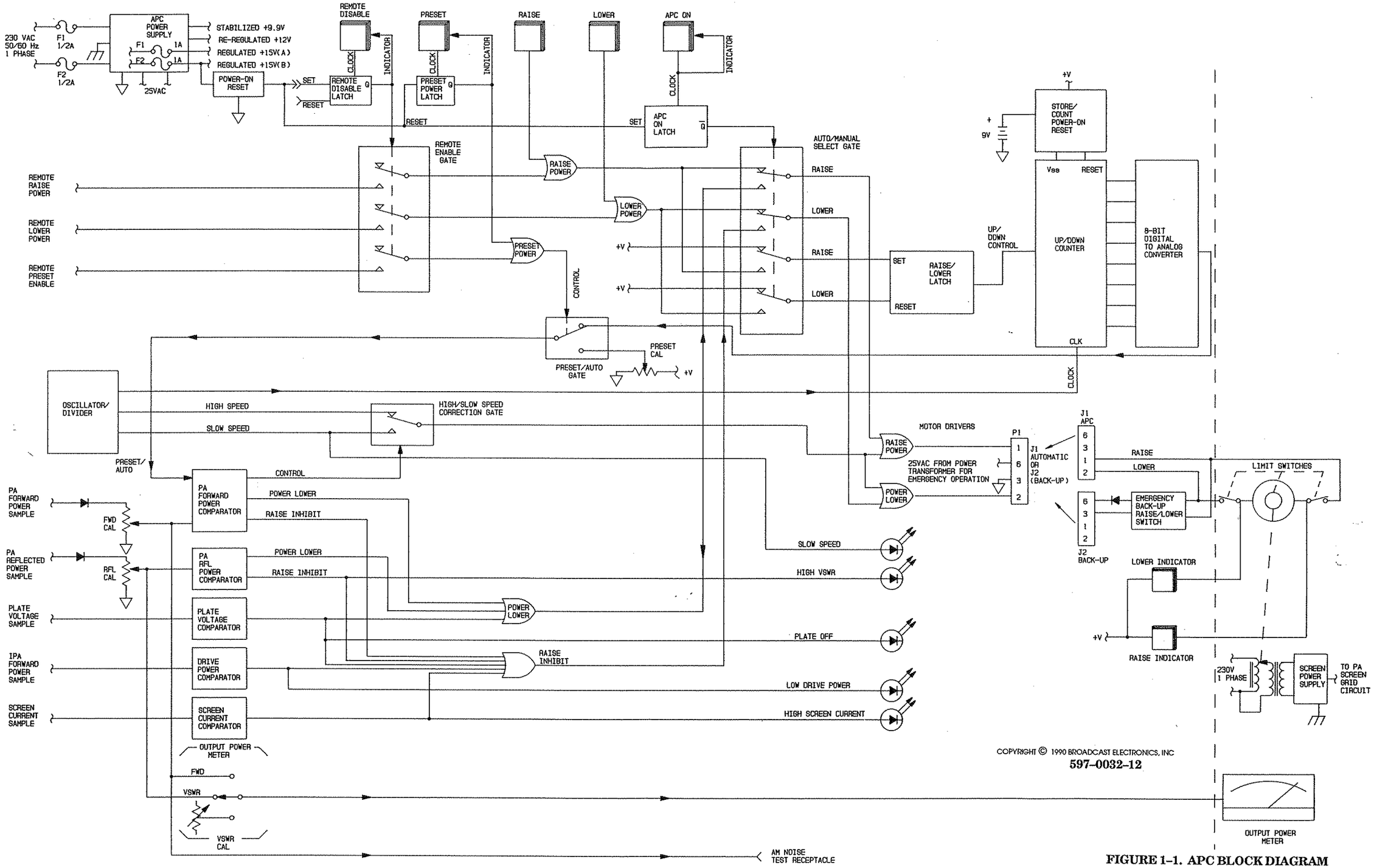


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FIGURE 1–1. APC BLOCK DIAGRAM

1–19. **POWER SUPPLY.** The APC power supply operates from an input of 230 volts ac at a maximum of 1/2 ampere (see Figure 1–2). AC power is input through RFI filter FL1 which provides 55 dB of attenuation to frequencies of 10 MHz and above. A conservatively rated power transformer allows operation from both 50 and 60 Hz. Fuses F1 and F2 provide overload protection for the primary circuit and metal–oxide varistor MOV1 provides suppression of transient voltage surges.

1–20. The secondary of transformer T1 is full–wave bridge rectified by diodes D6, D7, D8, and D9 into a +28 volt source and filtered by C34. This potential is regulated into four separate sources. The transformer plug (P1) may be moved to J2 to provide 25 Vac for emergency back–up screen voltage raise/lower switch operation.

1–21. **Positive Fifteen Volt Source A.** The input potential is regulated into a 15 volt supply by U1. Capacitor C35 prevents regulator oscillation and C46 improves the response of the regulator. The output voltage is established by the value of resistors R24 and R25. The output of this supply operates all APC logic.

1–22. Integrated circuit U1 is a three–terminal adjustable positive regulator containing internal thermal overload protection and short–circuit current limiting features. Overload protection for U1 is provided by fuse F1. Diode D14 protects the regulator from a reverse polarity potential applied to the output and provides transient suppression for all voltages exceeding 16 volts. Diode D12 protects the regulator from possible damage resulting from an input short.

1–23. A second supply connected to the output of U1 consists of regulator U30 which re–regulates the input into a 12 volt source which is applied to the **PRESET CAL** control and the 8–bit digital–to–analog converter on the main circuit board.

1–24. A third supply connected to the output of U1 consists of zener diode D17 and resistor R83. These components establish a 9.9 volt source which is used as a reference for precision current sources for the close–tolerance comparators on the main circuit board.

1–25. In case of power failures, the supply to the APC power level memory circuit will be maintained by a battery. Diode D7 prevents battery discharge through the APC circuitry during periods of battery operation and diode D6 isolates the 9 volt battery from the 15 volt A supply. Battery drain is approximately 0.8 microamperes which allows approximately two years of use (depending on the battery type). The battery is not maintained on charge and must be replaced when discharged.

1–26. **Positive Fifteen Volt Source B.** The power supply input potential is regulated into a 15 volt supply by U2. Capacitor C46 prevents regulator oscillation and C47 improves the response of the regulator. The output voltage is established by the value of resistors R26 and R27. The output of this supply operates all APC indicators and provides power for the APC output stages.

1–27. Integrated circuit U2 is a three–terminal adjustable positive regulator containing internal thermal overload protection and short–circuit current limiting features. Overload protection for U2 is provided by fuse F2. Diode D15 protects the regulator from a reverse polarity potential applied to the output and provides transient suppression for all voltages exceeding 16 volts. Diode D13 protects the regulator from possible damage resulting from input shorts.

1–28. **APC LOGIC CIRCUITRY.**

1–29. **MANUAL OPERATION.** Manual operation refers to operation of the transmitter with the automatic power control circuitry switched off (**APC ON** switch/indicator not illuminated). In this mode, RF power output is not automatically controlled, but responds only to manual raise and lower commands (see Figure 1–3).

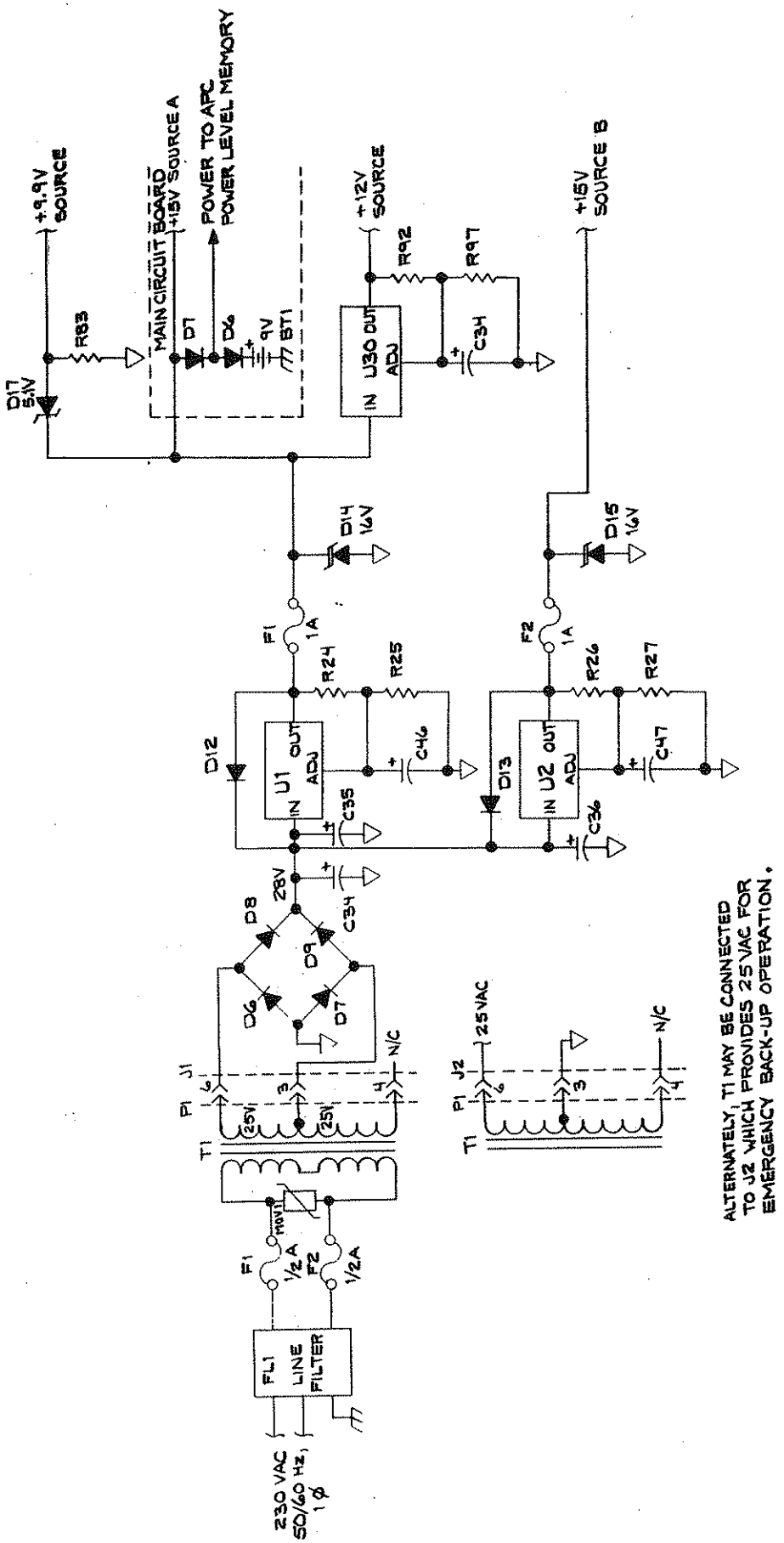

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FIGURE 1-2. APC POWER SUPPLY

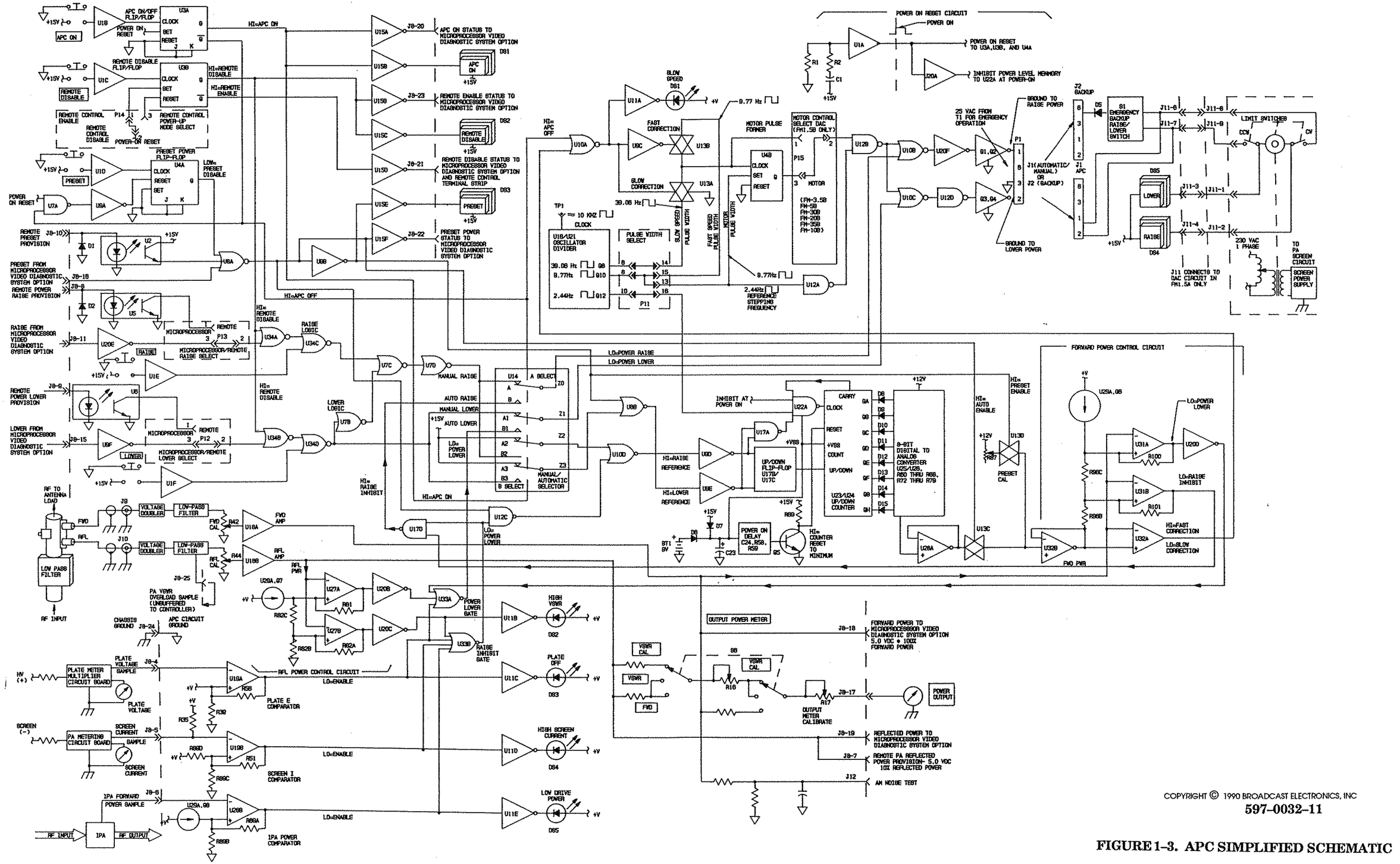

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FIGURE 1–3. APC SIMPLIFIED SCHEMATIC

1–30. When the APC unit is switched off, the Q output of U3A will go HIGH which selects the A inputs to the manual/automatic selector (U14). A HIGH through U7A and U9A will clear any preset power command. Fast speed correction is selected by a HIGH applied to analog switch U13B through U10A and U9C.

1–31. The local and remote raise power commands are applied to NOR gate U34C and the local and remote lower power commands are applied to NOR gate U34D. Each NOR gate will output the logical sum of its inputs. If the Q output of U3B is HIGH (remote disable), the remote inputs will be inhibited as one input of NOR gates U34A and U34B will be held HIGH.

1–32. The logic configuration used prevents simultaneous raise and lower commands. In event both commands are simultaneously initiated, U7B will give the lower power command priority over the raise power command by holding a HIGH on one input of NOR gate U7C.

1–33. The raise or lower power command will be routed through U14 which functions as if it were a four–pole double–throw relay. In this situation, the "A" inputs will be routed to the outputs as follows:

Z0 will output a LOW if power raise was selected.

Z1 will output a LOW if power lower was selected.

Z2 will output a HIGH to U10D to prevent the power reference counter from counting down.

Z3 will output a HIGH to U8B to prevent the power reference counter from counting up.

1–34. A 9.77 Hertz square–wave is applied as a clock to flip–flop U4B through analog switch U13B and is also applied as a set input to U4B. The resultant output forms the signal that actually drives the motor. This drive signal is gated by NAND gate U12B with an inverted 9.77 Hertz square–wave from U12A. The resultant logical sum of the inputs to U12B is a rather short–duration pulse which is applied to the motor through U10B or U10C as a power raise or a power lower signal. This gating of the motor drive pulse through U4B, U12A and U12B forms a precise short–duration motor drive signal and minimizes motor coasting without the requirement for dynamic braking.

1–35. The power raise or power lower drive is then applied through an inverter to a Darlington output stage. When there is no command to raise or lower power, both outputs will be HIGH. When there is a command to raise or lower power, the one output will go LOW. Current through DS5 (the **LOWER** indicator) or DS4 (the **RAISE** indicator) will actually display the motor drive signal.

1–36. The primary of screen power transformer T2 is controlled by variable autotransformer T1 which is driven by dc gearmotor B4. As the motor is a series–wound dc type, the speed at which the motor turns may be controlled by the duty cycle of the applied drive signal. Limit switches S4 and S5 on the motor prevent possible damage to the autotransformer by disconnecting the drive signal at the end of travel for each direction.

1–37. **AUTOMATIC OPERATION.** When power is first applied to the APC, a high–going pulse will be generated by U1A which resets the command logic as follows. The duration of the pulse is determined by the value of C1, R1, and R2.

A. The APC on flip–flop (U3A) will be set to Q = HIGH to signify that the APC is on.

B. The remote disable flip–flop (U3B) will be set to the condition selected by the remote control power–up mode select jumper plug (P14). The following discussion will assume this jumper is set to disable remote control in which case Q = HIGH to signify remote control disable. The **REMOTE DISABLE** indicator will illuminate to signify that the remote control inputs are inhibited and additional outputs inform the optional microprocessor video display system of the remote control states, as well as a separate logic output on the remote control terminal block.

C. The preset power flip–flop (U4A) will be set to Q = LOW via NOR gate U7A and inverter U9A. This action will clear any preset power command at power–on.

D. Inverter U20A will hold a LOW on U22A to disable the power level memory inputs until power is fully energized.

1–38. The HIGH from U3A will inform the optional microprocessor video diagnostic system that the APC is enabled via U15A, illuminate the front–panel **APC ON** switch/indicator via U15B, and select the "B" inputs to the manual/automatic selector (U14).

1–39. The LOW from U4A will hold one input to NOR gate U8A LOW to disable the preset inputs. The HIGH from U8A will inform the optional microprocessor video diagnostic system that the preset power option is disabled via U15F, enable NOR gate U10D via U12C which allows raise memory reference, and enables the automatic level analog switch (U13C). The HIGH from U8A through inverter U9B will hold the front–panel **PRESET** switch/indicator off via U15E, disable the preset power analog switch (U13D), and enable NOR gate U8B which allows lower memory reference.

1–40. Normally, the power level memory battery (BT1) will always be installed and transistor Q5 will constantly be energized. When power is applied to the transmitter, current will be applied to the up/down counter (U23/U24). As the reset line to the up/down counter is normally held LOW by Q5, the count representative of the transmitter RF power output will be retained.

1–41. If, however, the power level memory battery is discharged, current will be applied to the up/down counter with Q5 off which resets the up/down counter to minimum count, representative of minimum transmitter RF power output. After a short delay determined by the value of C24, R58, and R59, Q5 will energize and the reset line will go LOW to terminate the reset.

1–42. During periods of battery operation, diode D7 prevents battery discharge through the power supply and diodes D8 through D15 prevent battery discharge through the digital to analog converter. The battery is not maintained on charge and is isolated from the power sup– ply by diode D6. When the battery is discharged, it must be replaced with a new battery. The only circuitry backed–up by the battery is the up/down counter, composed of U22, U23 and U24.

1–43. Assuming that the up/down counter count has been retained, the up/down counter will begin to output eight–bit digital words as soon as the 2.44 Hertz clock is applied via U22A. The eight–bit digital output of the up/down counter is converted to a dc level by the digital–to–analog converter (U25/U26). This level is buffered by U28A and routed through analog switch U13C (which was selected when the **APC ON** switch was depressed) to voltage follower U32B.

1–44. If the count in the up/down counter was not preserved and was reset at power–on, the count must be manually re–established with the front–panel **RAISE** and **LOWER** switches.

1–45. The raise and lower command input circuit operates in a manner identical to that described by the manual operation discussion, however these inputs do not move the screen control motor directly as in manual operation, but change the count stored in the up/down counter (U23, U24) which establishes the RF output with a dc reference level.

1–46. The raise or lower power commands from the front–panel switches will be routed through U14 which functions as if it were a four–pole, double–throw relay. In this situation, the "B" inputs will be routed to the outputs as follows:

Z2 will output a LOW if power reference raise was manually selected.

Z3 will output a LOW if power reference lower was manually selected.

1–47. Any LOW from the Z2 output of U14 for power reference lower is applied through U10D to inverter U9D and bistable flip–flop U17B/ U17C. The second input of U10D will inhibit power reference raise if preset power has been selected or an abnormal operating condition is signaled by U33B.

1–48. Any LOW from output Z3 of U14 for power reference raise is applied through U8B to inverter U9E and bistable flip–flop U17B/U17C. The second input to U8B will inhibit power reference lower if preset power has been selected.

1–49. When the output of inverter U9D or U9E goes LOW, the resultant output of flip–flop U17B/U17C will enable the up/down counter to count up or count down. A HIGH from the flip–flop will enable the counter to count up. A LOW from the flip–flop will enable the counter to count down. U22A will toggle the clock of the up/down counter (U23/U24) when either a lower or raise reference command is passed by U17A. The carry output of U24, the up/down counter, when LOW, stops the up/down counter from "rolling over" at maximum (1111 1111) or minimum (0000 0000) count.

1–50. **PA Forward Power Control Circuit.** Voltage follower U32B sinks current from constant current source U29A and Q6 to establish three precise voltages across the series string of resistors R96B and R96C. These voltages create dead–bands or windows which determine how the PA forward power control circuit will react when PA forward power increases beyond the level established by the input to U32B.

1–51. A sample of forward power from the PA forward meter amplifier (U18A) is applied to the inverting inputs of U31A, U31B, and U32A. If the PA forward power decreases to the extent that the level applied to the inverting input of U32A falls below the fixed reference on the non–inverting input of U32A, the output of voltage comparator U32A will change states and output a HIGH. This HIGH will force a LOW from U10A which is inverted by U9C to energize analog switch U13B for fast–speed correction. This allows fast correction when the forward power differs greatly from the fixed set–point.

1–52. The motor speed is determined by the duty cycle of the drive signal. In automatic operation, slow–speed and fast–speed correction is used. The lower frequency signal from U13B will drive the motor faster as the duty cycle of the drive signal is greater. The higher frequency signal from U13A will drive the motor slower as the duty cycle is less and the motor "on time" is less.

1–53. As PA forward power increases to the proper level (approximately 90% power), the level applied to the inverting input of U32A will rise above the fixed reference on the non–inverting input of U32A. The output of voltage comparator U32A will change states and output a LOW. This LOW will force a HIGH from U10A which energizes analog switch U13A for slow–speed correction. The HIGH from U10A will also illuminate the **SLOW SPEED LED** on the circuit board via U11A. U9C inverts this HIGH to deenergize analog switch U13B, the fast–speed gate.

1–54. If PA forward power then increases, the level on the inverting input of U31B will rise above the fixed reference on the non–inverting input of U31B. The output of voltage comparator U31B will change states and output a HIGH to U17D which inhibits further raise functions. This is the lower edge of the set–point "window" or deadband. It is usually 1% to 2% below the desired power setting.

1–55. If the PA power should continue to increase to the point which is 1% to 2% above the desired setting, the level on the inverting input of U31A will rise above the fixed level on the non–inverting input of U31A and U31A will output a HIGH. This HIGH is inverted by U20D and applied as a LOW to U33A which lowers power.

1–56. As the PA power is lowered to the normal level, the potential on the inverting inputs of U31A and U31B will fall. First, U31A will return to a LOW output which removes the power lower command from U33A. The power will remain at this point within the set–point deadband. If the power should drop further, then U31B will return to a HIGH output which will output the raise command from U17D. The circuit will now function normally to control power, maintaining operation within the deadband.

1–57. The raise or lower power command will be routed through U14 which functions as if it were a four–pole, double–throw relay. In this situation, the "B" inputs will be routed to the outputs as follows:

Z0 will output a LOW via NAND gate U17D if automatic power raise is required. A LOW input to U17D from U33B will inhibit the raise function.

Z1 will output a LOW via NOR gate U33A if automatic power lower is required.

1–58. The remainder of the control circuitry functions in a manner identical to that described by the manual operation discussion.

1–59. **PA Reflected Power Control Circuit.** A sample of reflected power from the PA reflected meter amplifier (U18B) is applied to the inverting inputs of U27A and U27B.

1–60. Constant current source U29A/Q7 establishes two precise voltages across the series string of resistors R82C and R82B. The voltage across R82C creates a dead–band or "window", which determines how the PA reflected power control circuit will react when PA reflected power increases beyond the level established by the reference on the non–inverting inputs of voltage comparators U27A and U27B.

1–61. The circuit will remain idle when the PA reflected power is below acceptable limits. If the PA reflected power increases and the level applied to the inverting input of U27B rises above the fixed reference on the non–inverting input of U27B (determined by the voltage across R82B), the output of voltage comparator U27B will change states and output a LOW. This LOW is applied as a HIGH to the raise inhibit gate (U33B) through inverter U20C to prevent PA power from increasing and illuminates the **HIGH VSWR LED** on the circuit board via inverter U11B. This prevents the forward power control circuit from raising power if a high VSWR exists, preventing transmitter overload.

1–62. If the PA reflected power continues to rise, the level on the inverting input of U27A will rise above the fixed reference on the non–inverting input and U27A will change states to output a LOW. This LOW is applied as a HIGH to the power lower gate (U33A) through inverter U20B to lower power. Thus, R82C establishes a "deadband", within which no raising or lowering power will occur.

1–63. When PA reflected power falls to a safe level and the level on the inverting input of U27A falls below the fixed reference on the non–inverting input, U27A will output a HIGH. This HIGH is applied as a LOW to U33A via U20B to halt the power reduction. However the raise command will still be inhibited by U27B at the lower edge of the deadband.

1–64. If the PA reflected power continues to fall, the level on the inverting input of U27B will fall below the fixed reference on the non–inverting input and U27B will change states to output a HIGH. The resultant LOW from inverter U20C will enable U33B and allow power raise functions as required by the forward power control circuit. The automatic power control unit will then function normally again with full raise/lower control of the screen voltage.

1–65. **Forward and Reflected Power Circuits.** The directional coupler located at the output end of the low–pass filter provides RF voltages proportional to the PA forward and reflected power. The reflected power sample is rectified by a voltage doubler (D2 and D4 on the rear panel circuit board), calibrated by R44, and amplified by U18B. The forward power sample is rectified by a voltage doubler (D1 and D3), calibrated by R42, and amplified by U18A. A low–pass filter after the rectifiers attenuates carrier envelope modulation caused by power supply ripple and synchronous audio rate amplitude modulation.

1–66. The reflected power signal is applied to the PA reflected power control circuit and the metering circuit. The forward power signal is applied to the PA forward power control circuit and the metering circuit. The metering information is applied to the **OUTPUT POWER METER** switch and displayed by the **OUTPUT POWER** meter. R17 provides a means to calibrate the **OUTPUT POWER** meter without affecting the setup of the automatic system set by R42 and R44. This allows adjustment for routine calibration.

1–67. **Plate Voltage Monitor Circuit.** The soft start circuit monitors actual PA plate voltage. This circuit reduces the PA screen potential to minimum whenever plate voltage is off. Whenever the plate voltage is above the threshold, the circuit will gradually increase the PA screen voltage until the rated transmitter RF output is established unless limited by low IPA drive, excessive screen current, or a high VSWR condition, as gated by U33B.

1–68. A plate voltage sample derived from the plate meter multiplier circuit board is applied to the inverting input of voltage comparator U19A. When the plate voltage sample decreases below the fixed level (approximately 2.5 volts) on the non–inverting input of U19A established by R38 and R39 (such as when the high voltage power supply is off), U19A will output a HIGH. This HIGH will be applied to both the raise inhibit gate (U33B) and the lower power gate (U33A). U33B will inhibit the raise function and U33A will lower power to minimum. The HIGH from U19A will also illuminate the **PLATE OFF LED** on the circuit board via U11C. The power control element will stop lowering at minimum setting, but the lower command will remain present at the output of U33A through U12D.

1–69. When the **HIGH VOLTAGE ON** switch/indicator is depressed, the plate voltage sample from the plate meter multiplier circuit board will rise above the fixed reference on the non–inverting input and U19A will output a LOW. This LOW will remove the raise inhibit from U12C and U17D via U33B to raise power and will remove the power lower signal from U33A to allow the APC circuitry to re–establish transmitter RF power output as previously discussed.

1–70. **Screen Current Monitor Circuit.** A sample of PA screen current obtained from the negative side of the screen supply is applied to the inverting input of voltage comparator U19B. It is biased positive by a voltage divider consisting of R35 on the main circuit board and R4 on the rear panel circuit board. When the screen current increases, the voltage on the inverting input of U19B will fall below the fixed level on the non–inverting input and U19B will output a HIGH. This HIGH is applied to the raise inhibit gate (U33B) to prevent PA power from increasing and illuminates the **HIGH SCREEN CURRENT LED** on the circuit board via inverter U11D.

1–71. When the PA screen current returns to normal and the screen current sample falls below the fixed level on the non–inverting input, U19B will output a LOW. This LOW will remove the raise inhibit from U12C and U17D via U33B and allow PA power to increase.

1–72. **IPA Forward Power Monitor Circuit.** A dc voltage representative of the reflected power from the IPA directional coupler is applied to the inverting input of voltage comparator U28B. When the IPA power decreases below the fixed level on the non–inverting input established by current source Q8 and resistor R89B, U28B will output a HIGH. This HIGH is applied to the raise inhibit gate (U33B) to prevent PA power from increasing. The HIGH from U28B will also illuminate the **LOW DRIVE POWER LED** on the circuit board via inverter U11E.

1–73. When the IPA power returns to normal, the IPA forward power sample will rise above the fixed reference on the non–inverting input and U28B will output a LOW. This LOW will remove the raise inhibit from U12C and U17D via U33B and allow PA power to increase.

1–74. **PRESET POWER.** As an additional function, a preset power level may be selected by the front–panel **PRESET** switch/indicator or activated with a continuous positive voltage connection to one of the APC preset power inputs (the APC must be enabled). This feature is normally used to automatically switch the transmitter to a predetermined power output level such as half–power for periods of auxiliary generator operation. The APC functions as before, only the internal POWER reference is manually adjusted by potentiometer R87.

NOTE ***PRESET POWER IS ONLY USED FOR EMERGENCY OPERATION AT LESS THAN LICENSED POWER OPERATION. NO PROVISION TO REMOTELY ADJUST POWER IS PROVIDED IN THIS MODE.***

NOTE

1–75. The local, remote, and microprocessor video display system generated preset power inputs are applied to NOR gate U8A which outputs the logical sum of its inputs. If preset power is selected by any source, the output of U8A will be a HIGH. This HIGH accomplishes the following:

A. Deenergizes the automatic power control analog switch (U13C).

B. Disables NOR gate U10D via U12C to inhibit raise memory. Thus no change in the original APC power setting can occur if the **RAISE** switch is inadvertently depressed.

C. Informs the optional microprocessor video diagnostic system via U15F that the preset power function is energized.

D. Disables NOR gate U8B via U9B to inhibit lower memory. No change in the original APC power setting can occur if the **LOWER** switch is inadvertently depressed.

E. Energizes the preset analog switch (U13D).

F. Illuminates the front–panel **PRESET** switch/indicator via U15E as a local indication that the preset power function is energized.

1–76. The transmitter power output will now be determined by the setting of the preset cal potentiometer (R87) on the main circuit board. If power is removed from the APC unit, even momentarily, the preset power command will be automatically reset. The preset power mode will remain energized, however, if the remote input is connected to a voltage source.

1–77. **EMERGENCY OPERATION.** During normal operation, P1 on the rear panel circuit board will be connected to J1. If the APC circuitry fails and the main circuit board must be removed for repairs, the transmitter RF output power may be manually controlled by disconnecting P1 from J1 and connecting P1 to J2. The transmitter RF output power may now be controlled with the emergency backup raise/lower switch (S1) on the rear panel circuit board. The potential required for screen control motor operation is obtained from half of the APC power transformer secondary. Half–wave rectification for the dc motor is provided by D5. This mode bypasses all electronics except the fuses, transformer, and auxiliary diodes for a redundant control system.

SECTION II
APC MAINTENANCE

2–1. INTRODUCTION.

2–2. This section provides maintenance information for the FM–5B/ FM–5BS Automatic Power Control Unit (APC).

2–3. SAFETY CONSIDERATIONS.

2–4. The FM–5B/FM–5BS transmitters contain high voltages and currents which, if regarded carelessly, could be fatal. The transmitter has many built–in safety features, however good judgement, care, and common sense are the best accident preventives. The maintenance information contained in this section should be performed only by trained and experienced maintenance personnel.

2–5. MAINTENANCE.

WARNING *NEVER OPEN THE EQUIPMENT UNLESS ALL TRANSMITTER PRIMARY POWER IS DISCONNECTED.*

WARNING

WARNING *DUE TO THE PROGRAMMING OF THE EQUIPMENT, THE APC UNIT WILL ENTER THE REMOTE ENABLED MODE WHENEVER AC POWER IS APPLIED. TO PREVENT INADVERTENT REMOTE START–UP DURING MAINTENANCE PERIODS, DISCONNECT POWER FROM THE TRANSMITTER AND INSTALL JUMPER P14 ON THE APC UNIT MAIN CIRCUIT BOARD IN POSITION 1–2.*

WARNING

2–6. The transmitter maintenance philosophy consists of preventative maintenance such as cleaning applied to the equipment to forestall future failures and second level maintenance consisting of procedures required to restore the equipment to operation after a fault.

2–7. ADJUSTMENTS.

WARNING *NEVER OPEN THE EQUIPMENT UNLESS ALL TRANSMITTER PRIMARY POWER IS DISCONNECTED.*

WARNING

2–8. The following procedures present information required to adjust all controls in the APC. These adjustments are factory preset and therefore will require readjustment only if components in the specific circuit has been replaced. Adjustments for the main circuit board are presented first, followed by an adjustment procedure for the front–panel circuit board. The adjustments may be accessed by extending the APC chassis forward on its slide rails out of the rack and removing the top cover.

2–9. **FWD CAL.** This adjustment will be required only if repairs have been made to the directional coupler forward port, the low–pass filter has been replaced, or if potentiometer R42 has been replaced. If the transmitter **OUTPUT POWER** meter forward power display only requires calibration, refer to OUTPUT METER CALIBRATE in the following text. To adjust **FWD CAL** control R42 on the main circuit board, proceed as follows.

2–10. **Required Equipment.** The following equipment is required to adjust **FWD CAL** control R42.

A. Flat–blade screwdriver, 1/4 inch tip.

B. Insulated adjustment tool, flat–tip (BE P/N 407–0083).

C. Digital voltmeter (Fluke 75 or equivalent).

D. Test load and connecting line (50 Ohm non–inductive, 1 5/8 inch line input, 5000 Watt minimum).

E. Calibrated in–line wattmeter with 1 5/8 inch sampling section and cables (Bird 4712 Thruline with 5kW element or equivalent).

2–11. **Procedure.** To adjust the control, proceed as follows:

WARNING
WARNING
ASSURE ALL PRIMARY POWER IS DISCONNECTED BEFORE PROCEEDING.

2–12. Disconnect primary power.

2–13. Connect the voltmeter between U18A, pin 1 and chassis ground.

2–14. Connect the test load and wattmeter to the transmitter output.

2–15. Apply power and operate the transmitter in the local manual mode (**REMOTE DISABLE** illuminated, **APC ON** out) at the licensed RF power output as indicated by the in–line wattmeter.

WARNING
WARNING
MAINTENANCE WITH POWER ENERGIZED IS ALWAYS CONSIDERED HAZARDOUS AND THEREFORE CAUTION SHOULD BE OBSERVED. DO NOT TOUCH ANY COMPONENTS WITHIN THE APC WHEN POWER IS ENERGIZED.

WARNING
WARNING
USE AN INSULATED TOOL FOR ADJUSTMENT.

2–16. Using the insulated adjustment tool, adjust **FWD CAL** control R42 on the main circuit board for a voltmeter indication of +5.00V dc.

NOTE
NOTE
THE TRANSMITTER OUTPUT POWER METER SHOULD INDICATE 100%. IF NOT, REFER TO THE OUTPUT METER CALIBRATE PROCEDURE BEFORE PROCEEDING.

WARNING
WARNING
ASSURE ALL PRIMARY POWER IS DISCONNECTED BEFORE PROCEEDING.

2–17. Disconnect primary power.

2–18. Remove the test equipment and reconnect the transmitter output to the antenna load.

2–19. **RFL CAL.** This adjustment will be required only if repairs have been made to the directional coupler reflected port, the low–pass filter has been replaced, or potentiometer R44 has been replaced. To adjust **RFL CAL** control R44 on the main circuit board, proceed as follows.

2–20. **Required Equipment.** The following equipment is required to adjust **RFL CAL** control R44.

A. Flat–blade screwdriver, 1/4 inch tip.

B. Insulated adjustment tool, flat–tip (BE P/N 407–0083).

C. RF millivoltmeter, 50 Ohm input (Boonton Model 92B with Model 91–12F RF probe and Model 91–8B 50 Ohm adapter or Fluke Model 85 RF probe or equivalent).

D. BNC plug–to–plug adapter, UG–491B/U (BE P/N 417–0116).

E. Digital voltmeter (Fluke 75 or equivalent).

2–21. **Procedure.** To adjust the control, proceed as follows:

NOTE

NOTE

CORRECT ADJUSTMENT OF R44 REQUIRES THAT THE OUTPUT OF U18B BE ADJUSTED TO +5.00V DC WITH A 10% TRANSMITTER RF OUTPUT REFLECTION. IN THE FOLLOWING PROCEDURE, THE FORWARD PORT OF THE DIRECTIONAL COUPLER IS CLOSELY CALIBRATED AND USED AS A SIGNAL SOURCE TO CALIBRATE R44.

2–22. Operate the transmitter at 100% power output and verify the **VSWR CAL** control is set at 100%.

2–23. Determine the RMS voltage (E) required to calibrate R44 as follows:

Transmitter 100% RF output power=_____Watts.
10% of transmitter rated RF output power=_____Watts =P.

FORMULA

$$E = \frac{\sqrt{P \times 50\ \text{Ohms}}}{100}$$

EXAMPLE Transmitter rated RF output power = 4200 Watts.
10% of transmitter RF output power = 420 Watts (P).

$$E = \frac{\sqrt{420 \times 50}}{100} \qquad E = \frac{\sqrt{21000}}{100}$$

$$E = \frac{144.91}{100} \qquad E = 1.45\ \text{VRMS}$$

WARNING ***ASSURE ALL PRIMARY POWER IS DISCONNECTED BEFORE PROCEEDING.***

WARNING

2–24. Disconnect primary power.

2–25. Connect the voltmeter between U18B, pin 7 and chassis ground.

2–26. Disconnect cables 130 and 131 from the APC and route cable 130 out the top of the transmitter.

2–27. Assemble the RF millivoltmeter probe, 50 Ohm termination, and the BNC plug–to–plug adapter.

2–28. Connect the RF millivoltmeter to cable 130.

2–29. Apply power and operate the transmitter in the local manual mode (**REMOTE DISABLE** illuminated, **APC ON** out).

2–30. Manually adjust the transmitter RF output power to obtain a millivoltmeter indication of the voltage (E) calculated in paragraph 2–23.

WARNING ***ASSURE ALL PRIMARY POWER IS DISCONNECTED BEFORE PROCEEDING.***

WARNING

2–31. Disconnect primary power.

2–32. Disconnect the millivoltmeter from cable 130. Route the cable back inside the transmitter and connect cable 130 to APC RFL PWR RF SAMPLE input J10.

2–33. Apply power and operate the transmitter in the local manual mode (**REMOTE DISABLE** illuminated, **APC ON** out).

WARNING ***MAINTENANCE WITH POWER ENERGIZED IS ALWAYS CONSIDERED HAZARDOUS AND THEREFORE CAUTION SHOULD BE OBSERVED. DO NOT TOUCH ANY COMPONENTS WITHIN THE APC WHEN POWER IS ENERGIZED.***

WARNING

WARNING ***USE AN INSULATED TOOL FOR ADJUSTMENT.***

WARNING

2–34. Using the insulated adjustment tool, adjust **RFL CAL** control R44 on the main circuit board for a voltmeter indication of +5.00V dc.

WARNING ***ASSURE ALL PRIMARY POWER IS DISCONNECTED BEFORE PROCEEDING.***

WARNING

2–35. Disconnect primary power.

2–36. Remove the test equipment, reconnect cable 130 from APC FWD PWR RF SAMPLE input J9 to the FWD directional coupler port, and reconnect cable 131 from APC RFL PWR RF SAMPLE input J10 to the RFL directional coupler port.

2–37. **PRESET CAL.** This adjustment determines the power level which the transmitter will output when the preset power circuit is energized. The **RAISE** or **LOWER** controls have no effect on this adjustment. To adjust **PRESET CAL** control R87 on the main circuit board, proceed as follows.

2–38. **Required Equipment.** The following equipment is required to adjust **PRESET CAL** control R87.

A. Flat–blade screwdriver, 1/4 inch tip.

B. Insulated adjustment tool, flat–tip (BE P/N 407–0083).

2–39. **Procedure.** To adjust the control, proceed as follows:

WARNING *MAINTENANCE WITH POWER ENERGIZED IS ALWAYS CONSIDERED HAZARDOUS AND THEREFORE CAUTION SHOULD BE OBSERVED. DO NOT TOUCH ANY COMPONENTS WITHIN THE APC WHEN POWER IS ENERGIZED.*

WARNING

WARNING *USE AN INSULATED TOOL FOR ADJUSTMENT.*

WARNING

2–40. Apply power and operate the transmitter in the local automatic mode (**REMOTE DISABLE** and **APC ON** illuminated).

2–41. Operate the **OUTPUT POWER METER** switch to **FWD**.

2–42. Depress the **PRESET POWER** switch/indicator.

2–43. Using the insulated adjustment tool, adjust **PRESET CAL** control R87 until the desired percentage of RF power output is indicated by the **OUTPUT POWER** meter.

2–44. **OUTPUT METER CALIBRATE.** This adjustment will be required only if the **OUTPUT POWER** meter or potentiometer R17 is replaced. To adjust **OUTPUT METER CALIBRATE** control R17 on the front panel circuit board, proceed as follows.

2–45. If required, check and adjust **FWD CAL** control R42 before calibrating R17 (refer to paragraph 2–9).

2–46. **Required Equipment.** The following equipment is required to adjust **OUTPUT METER CALIBRATE** control R17.

A. Flat–blade screwdriver, 1/4 inch tip.

B. Insulated adjustment tool, flat–tip (BE P/N 407–0083).

C. Digital voltmeter (Fluke 75 or equivalent).

D. Test load and connecting line (50 Ohm non–inductive, 1 5/8 inch line input, 5000 Watt minimum).

E. Calibrated in–line wattmeter with 1 5/8 inch sampling section and cables (Bird 4712 Thruline with 5kW element or equivalent).

2–47. **Procedure.** To adjust the control, proceed as follows:

WARNING *ASSURE ALL PRIMARY POWER IS DISCONNECTED BEFORE PROCEEDING.*

WARNING

2–48. Disconnect primary power.

2–49. Connect the voltmeter between U18A, pin 1 and chassis ground.

2–50. Connect the test load and wattmeter to the transmitter output.

2–51. Apply power and operate the transmitter in the local manual mode (**REMOTE DISABLE** illuminate, **APC ON** out) at the desired 100% RF power output as indicated by the in–line wattmeter.

WARNING *MAINTENANCE WITH POWER ENERGIZED IS ALWAYS CONSIDERED HAZARDOUS AND THEREFORE CAUTION SHOULD BE OBSERVED. DO NOT TOUCH ANY COMPONENTS WITHIN THE APC WHEN POWER IS ENERGIZED.*

WARNING

WARNING *USE AN INSULATED TOOL FOR ADJUSTMENT.*

WARNING

2–52. Using the insulated adjustment tool, adjust **FWD CAL** control R42 on the main circuit board for a voltmeter indication of +5.00V dc.

2–53. Operate the **OUTPUT POWER METER** switch to **FWD**.

2–54. Using the insulated adjustment tool, adjust **OUTPUT METER CALIBRATE** control R17 to obtain a 100% **OUTPUT POWER** meter indication. The **VSWR CAL** control may also be adjusted to 100% at this time.

WARNING *ASSURE ALL PRIMARY POWER IS DISCONNECTED BEFORE PROCEEDING.*

WARNING

2–55. Disconnect primary power.

2–56. Remove the test equipment and reconnect the transmitter output to the antenna load.

2–57. **APC REFERENCE VOLTAGE RESET.** The transmitter output power is controlled by the APC unit reference voltage. If the reference voltage is accidentally raised in excess of the APC circuit limits, the APC unit will increase power: 1) above the desired operating power level or 2) until an overload condition occurs. To reset the APC reference voltage, proceed as follows:

2–58. **Required Equipment.** The following equipment is required to reset the APC reference voltage.

A. Flat–blade screwdriver, 1/4 inch tip.

2–59. **Procedure.** To reset the APC reference voltage, proceed as follows:

2–60. The following procedure can be performed when the transmitter is energized or de–energized. If the transmitter is energized, operate the transmitter in the manual mode (APC ON switch/indicator extinguished).

2–61. Slide the APC unit out of the transmitter cabinet and remove the top–cover.

2–62. Reset the APC unit voltage reference as follows:

A. Disconnect the APC unit ac line cord.

The output power meter will be disabled.

B. Remove the APC unit battery.

C. Wait approximately 15 minutes to allow the supply to discharge and replace the battery.

The APC reference will default to a power level of approximately 50%.

2–63. Replace the APC unit battery, replace the APC unit top–panel, and re–connect the APC unit line cord.

2–64. Ensure power is applied to the transmitter and adjust the APC unit voltage reference to maintain the desired output power level as follows:

A. Ensure the APC ON switch/indicator is illuminated.

B. Depress and hold the APC RAISE or LOWER switch/indicator to establish a new RF power output level as indicated by the OUTPUT POWER meter.

2–65. **TROUBLESHOOTING.**

WARNING *NEVER OPEN THE EQUIPMENT UNLESS ALL TRANSMITTER PRIMARY POWER IS DISCONNECTED. USE*

WARNING *THE GROUNDING STICK PROVIDED TO ENSURE ALL COMPONENTS AND ALL SURROUNDING COMPONENTS ARE DISCHARGED BEFORE ATTEMPTING MAINTENANCE ON ANY AREA WITHIN THE TRANSMITTER.*

2–66. Most troubleshooting consists of visual checks. Because of the voltages and high currents in the transmitter, it is considered hazardous to work with power energized. Therefore, the various transmitter indicators (meters, LEDs, fuses, and circuit breakers) should be used to isolate the malfunction to one specific area.

2–67. Once the trouble is isolated and power is totally deenergized, it is suggested that the exact problem be located with resistance checks using the schematic diagrams and theory of operation presented throughout the test.

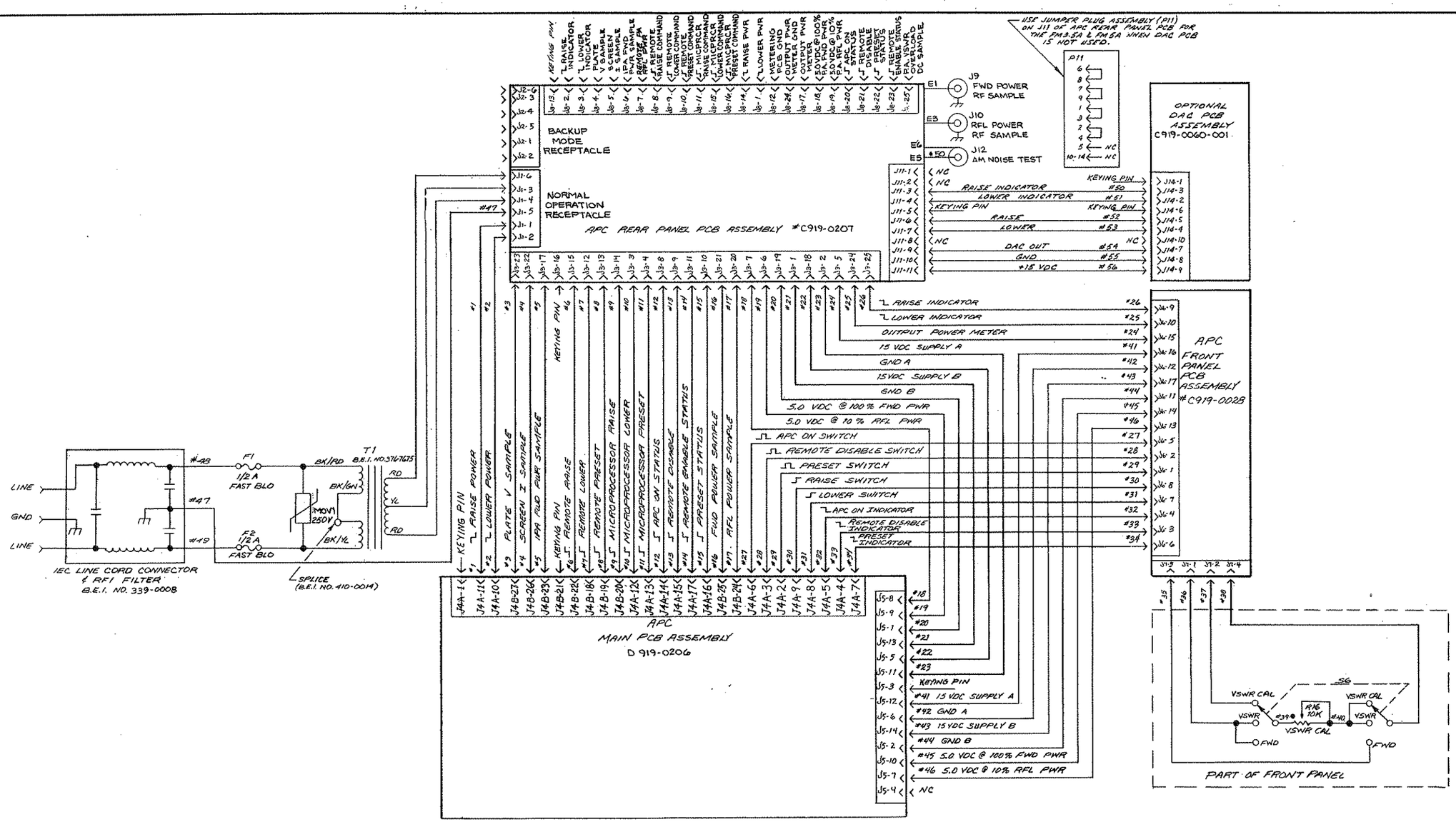
2–68. If a circuit is diagnosed as faulty, the circuit fault may be isolated and repaired locally or the entire device may be returned to Broadcast Electronics, Inc. for exchange, alignment, or replacement.

SECTION III
APC DRAWINGS

3-1. INTRODUCTION.

3-2. This section provides assembly drawings and schematic diagrams as listed below for the FM-5B/FM-5BS Automatic Power Control Unit.

FIGURE	TITLE	NUMBER
3-1	SCHEMATIC, APC OVERALL	SD959-0262-002
3-2	ASSEMBLY, APC OVERALL	597-0032-23
3-3	SCHEMATIC, MAIN CIRCUIT BOARD	SD919-0206
3-4	ASSEMBLY, MAIN CIRCUIT BOARD	AD919-0206
3-5	APC MAIN CIRCUIT BOARD COMPONENT LOCATOR	597-0032-38
3-6	SCHEMATIC, FRONT PANEL CIRCUIT BOARD	SC919-0028
3-7	ASSEMBLY, FRONT PANEL CIRCUIT BOARD	AC919-0028
3-8	SCHEMATIC, REAR PANEL CIRCUIT BOARD	SD919-0207
3-9	ASSEMBLY, REAR PANEL CIRCUIT BOARD	AD919-0207
3-10	APC PROGRAM NETWORKS	597-0033-14



NOTE:
1. LAST WIRE NUMBER USED = #56

TOLERANCE UNLESS OTHERWISE SPECIFIED
DECIMAL 2 PL = .01 3PL = .005
FRACTIONAL ±1/64
ANGULAR ± 1°
SHARP EDGES TO BEND RADII
FILLET RADII
MATERIAL
TREATMENT OR FINISH

DRAWN BY MSE DATE 10-5-98
CHECKED BY DATE
PROJECT ENGR. DATE
APPROVED BY

BROADCAST ELECTRONICS INC.

TITLE SCHEMATIC APC OVERALL

D DWG. NO. TYP/S 959-0262/-002 REV. D

SCALE NTS SHEET 1 OF 1

TABLE 4–6. REAR PANEL CIRCUIT BOARD ASSEMBLY – 919–0207
(Sheet 2 of 2)

REF. DES.	DESCRIPTION	PART NO.	QTY.
C34	Capacitor, Electrolytic, 470 uF, 50V	024–4783	1
C35,C36	Capacitor, Electrolytic, 3.3 uF, 50V	020–3363	2
C37 THRU C45	Capacitor, Mica, 390 pF ±5%, 100V	042–3922	9
C46,C47	Capacitor, Electrolytic, 3.3 uF, 50V	020–3363	2
C48 THRU C56	Capacitor, Mica, 390 pF ±5%, 100V	042–3922	9
C57,C58	Capacitor, Electrolytic, 100 uF, 50V	020–1083	2
C59,C60	Capacitor, Mica, 390 pF ±5%, 100V	042–3922	2
D1 THRU D4	Diode, HP5082–2800, Silicon, High Voltage Schottky Barrier Type, 70V, 15 mA	201–2800	4
D5 THRU D13	Diode, 1N4005, Silicon, 600V, 1 Ampere	203–4005	9
D14,D15	Diode, 1N6276A, Silicon, Transient Voltage Suppressor, 16V ±0.05% Breakdown	206–6276	2
D16,D17	Diode, Zener, 1N4739A, 9.1V ±5%, 1W	200–0009	2
F1,F2	Fuse, 3 AG, 1 Ampere	330–0100	2
J1,J2	Receptacle, 6–Pin	417–0677	2
J3	Receptacle, 20–Pin In–Line	417–0200	1.3
J8	Receptacle, 25–Pin	417–2500	1
J11	Receptacle, 20–Pin In–Line (Jumper in place of DAC circuit board used in FM–1.5A only)	417–0200	.70
L1 THRU L10	Choke, 4.7 uH ±10%, 430 mA, DC Resistance: 0.55 Ohms, 0.43 Amperes Maximum, Resonant at 115 MHz	360–0022	10
P11	Plug, Header, 14–Pin	417–6002–014	1
R1,R2	Resistor, 56 Ohm ±10%, 2W	130–5621	2
R3	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	1
R4	Resistor, 47 k Ohm ±5%, 1/4W	100–4753	1
R5	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	1
R7 THRU R12	Resistor, 1 k Ohm ±5%, 1/4W	100–1043	6
R13,R14	Resistor, 470 Ohm ±5%, 1/4W	100–4733	2
R15,R16	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	2
R17	Resistor, 68 Ohm ±5%, 2W	132–6832	1
R18	Resistor, 4.22 k Ohm ±1%, 1/4W	103–4224	1
R19 THRU R22	Resistor, 1 k Ohm ±5%, 1/4W	100–1043	4
R24	Resistor, 115 Ohm ±1%, 1/4W	100–1131	1
R25	Resistor, 1.24 k Ohm ±1%, 1/4W	103–1244	1
R26	Resistor, 115 Ohm ±1%, 1/4W	100–1131	1
R27	Resistor, 1.24 k Ohm ±1%, 1/4W	103–1244	1
R28	Resistor, 150 Ohm ±1%, 1/4W	100–1531	1
R29	Resistor, 536 Ohm ±1%, 1/4W	103–5363	1
S1	Switch, Toggle, DPDT 5 Amperes, resistive load @ 120V ac/28V dc 2 Amperes, resistive load @ 250V ac	340–0012	1
U1,U2	Integrated Circuit, LM317K, Positive 3–Terminal Adjustable Voltage Regulator, 1.2V to 37V, 1.5A Maximum, TO–3 Case	227–0318	2
——	Fuse Clips	415–2068	4
——	Blank Circuit Board	519–0029	1

TABLE 4–12. ASSEMBLY, AUTOMATIC POWER CONTROL RESISTOR NETWORK, FM–5B/FM–5BS – 959–1000–010 (Sheet 2 of 2)

REF. DES.	DESCRIPTION	PART NO.	QTY.
R96B	Resistor, 270 Ohm ±5%, 1/4W	100–2733	1
R96C	Resistor, 100 Ohm ±5%, 1/4W	100–1033	1
R96D	Resistor, 3.9 k Ohm ±5%, 1/4W	100–3943	1

TABLE 4–13. ASSEMBLY, AUTOMATIC POWER CONTROL RESISTOR NETWORK, FM–5BS – 959–1000–004

REF. DES.	DESCRIPTION	PART NO.	QTY.
PR86	Plug, Header, 8–Pin DIP	418–0112	1
R86A	Resistor, 4.7 k Ohm ±5%, 1/4W	100–4743	1
R86B	Resistor, 470 Ohm ±5%, 1/4W	100–4733	1
R86C	Resistor, 4.7 k Ohm ±5%, 1/4W	100–4743	1
R86D	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	1

TABLE 4–14. ASSEMBLY, AUTOMATIC POWER CONTROL RESISTOR NETWORK, FM–5BS – 959–1000–005

REF. DES.	DESCRIPTION	PART NO.	QTY.
PR89	Plug, Header, 8–Pin DIP	418–0112	1
R89A	Resistor, 10 Meg Ohm ±5%, 1/4W	100–1083	1
R89B	Resistor, 2.7 k Ohm ±5%, 1/4W	100–2743	1
R89C	Resistor, 2.4 k Ohm ±5%, 1/4W	100–2443	1
R89D	Resistor, 22 k Ohm ±5%, 1/4W	100–2253	1

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

SECTION I
TRANSMITTER CONTROLLER THEORY OF OPERATION

1–1. INTRODUCTION.

1–2. The following text provides theory of operation with supporting diagrams for the FM–5B/ FM–5BS transmitter controller.

1–3. FUNCTIONAL DESCRIPTION.

1–4. Two levels of discussion are provided. A general discussion of the transmitter controller operation at block diagram level is followed by a detailed discussion of circuit operation.

1–5. GENERAL DESCRIPTION.

1–6. All status displays and most control functions in the FM–5B/ FM–5BS transmitters are implemented through use of a digital controller that monitors transmitter operation (see Figure 1–1). Using information collected throughout the transmitter, the controller will determine what control actions are required and complete these actions (such as timed intervals, overloads, or interlocks) without delay. The transmitter control logic will interface with most modern remote control devices and ATS units.

1–7. Information concerning overloads is presented by four front–panel indicators and stored for analysis after the problem has occurred to aid in problem resolution. Seven additional front–panel status indicators provide information relative to transmitter operation. Two internal LEDs indicate the transmitter power supply status and the controller overload and power–up memory battery status.

1–8. An optional diagnostic monitoring system utilizing a CRT display is available with the FM–5B/FM–5BS transmitters. This microprocessor–based system continuously monitors and controls all major parameters of the transmitter and functions independently of the standard digital control circuit. Video displays of the transmitter operating conditions may be displayed in either an analog tabular chart format or a digital bargraph format. This system may be factory installed or field retrofitted to an existing FM–5B/FM–5BS transmitter.

1–9. OPERATION.

1–10. The controller is constructed with solid–state digital circuitry on five circuit boards. The circuit boards are mounted within an enclosed chassis with a removable top for ease of maintenance. The RFI filter circuit board processes all inputs and outputs to minimize susceptibility to RF interference, the motherboard provides bus interconnections for the controller circuit board, and the controller circuit board provides logic functions. All the front–panel LED indicators are mounted on the front–panel indicator circuit board and all the front–panel switches are mounted on the front–panel switch circuit board. All operational potentials for the controller are provided by its own power supply. A fan ensures cool and reliable operation of the controller power supply.

1–11. Commands such as "filament on" and "high voltage on" are initiated by a momentary HIGH applied to conditional logic circuitry on the controller circuit board. A "one–button start" may be selected by depressing the **HIGH VOLTAGE ON** switch/indicator only. As each switch is depressed, the associated switch/indicator will illuminate to indicate that the selected command has been received and stored.

1–12. Assuming the **FILAMENT ON** and/or **HIGH VOLTAGE ON** switch/indicators have been depressed and all safety interlocks are closed, the blower will start. The safety–interlocks closed condition is signified by illumination of the front–panel **INTERLOCK** indicator.

1–13. When the air pressure switch closes, the **BLOWER** indicator will illuminate and the conditional logic will start the filament warm–up timer, apply filament voltage to the PA tube, and illuminate the **FILAMENT** indicator.

1–14. After the filament warm–up delay expires, if no overloads exist, all interlocks remain closed, and the air switch remains closed, a "high–voltage on" signal will be output to the high voltage step–start circuitry and remove the mute command from the FM exciter. The associated **HIGH VOLTAGE** indicator will illuminate to indicate that a "high voltage on command" has been output from the controller.

1–15. If the **HIGH VOLTAGE OFF** switch/indicator is depressed, a momentary HIGH applied to the conditional logic circuitry will deenergize the high voltage supply. When the **FILAMENT OFF** switch is depressed, a momentary HIGH applied to the conditional logic circuitry will deenergize the filament supply and initiate a filament cool–down interval. When the filament cool–down timer delay expires, the blower will deenergize. The **FILAMENT OFF** switch/indicator can be used to simultaneously deenergize both the plate and filament supplies if desired.

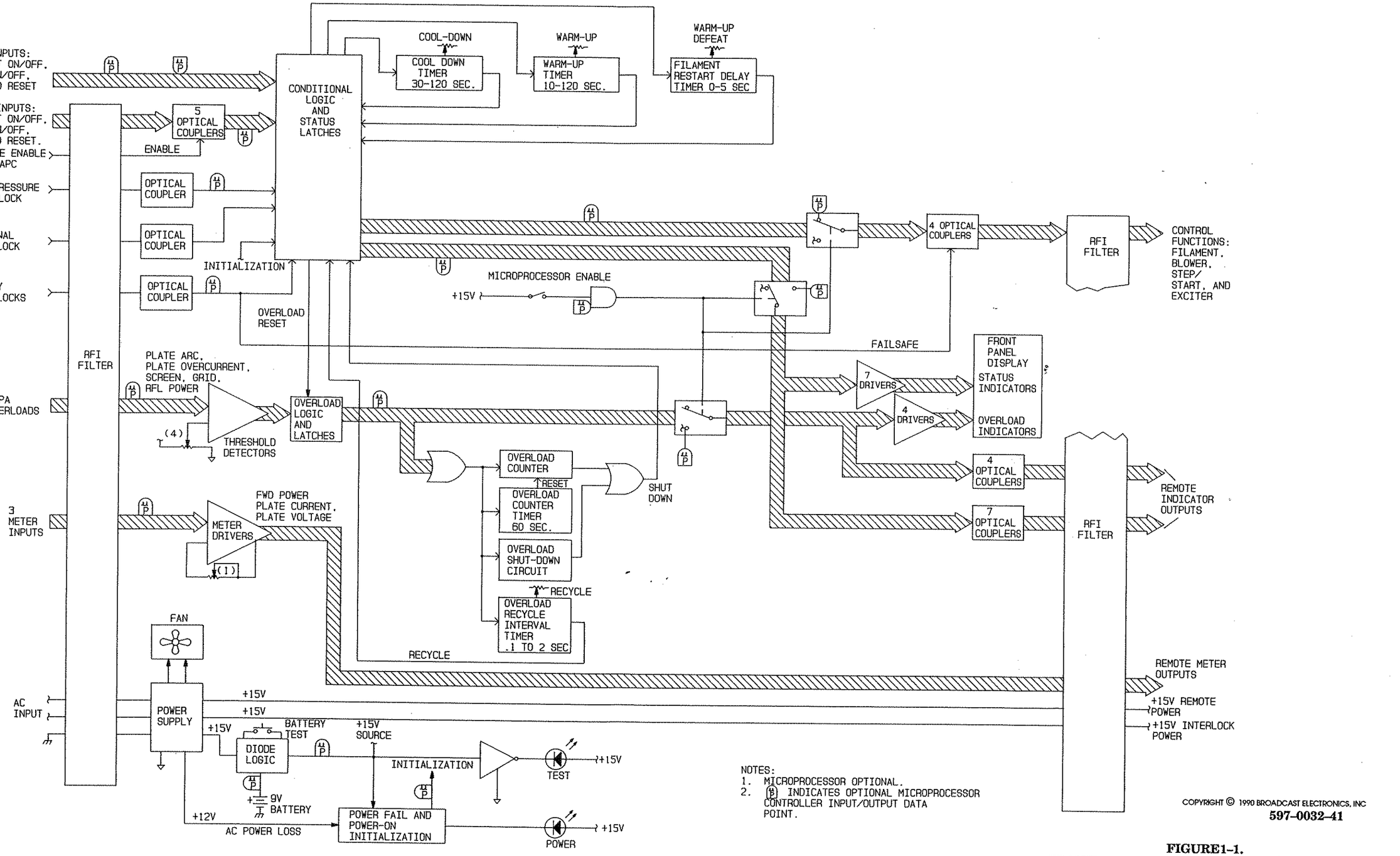
1–16. **REMOTE CONTROL.** Transmitter remote control is enabled whenever the automatic power control unit (APC) **REMOTE DISABLE** switch/indicator is not illuminated. Local control of the transmitter is possible at all times. The remote control inputs are routed through the controller RFI filter and coupled to the conditional logic circuitry in parallel with the local inputs through optical isolators. These optical isolators are enabled by a ground from the **APC REMOTE DISABLE** switch/indicator. Remote metering and status outputs are active at all times. A "one–button start" feature is incorporated as a remote control provision by using the high voltage on feature for one–button start and the filament off feature for one–button stop. All timing will be handled by the controller logic.

1–17. **INTERLOCKS.** If a safety interlock opens, the transmitter will deenergize immediately. The transmitter must be manually restored to operation after the open interlock is closed. The controller front– panel **INTERLOCK** indicator will go out to indicate an open interlock. If the opened safety interlock is closed before the filament cool–down timer interval expires, the blower will re–energize for the remaining duration of the cool–down cycle and then deenergize. If the air pressure interlock opens, the power supplies will deenergize immediately. When the interlock closes, the transmitter will return to operation automatically.

1–18. If the external interlock is opened, only the high voltage plate supply will be deenergized. The controller **HIGH VOLTAGE STATUS** indicator and the external interlock indicator (if installed) will extinguish to indicate an open interlock. When the external interlock is closed, the transmitter will return to operation automatically.

1–19. **OVERLOADS.** Plate current, screen current, control grid bias supply current, and PA reflected power are monitored for overload conditions. If an overload occurs, this information will be applied to the overload logic circuitry.

1–20. Any overload will illuminate the **OVERLOAD** indicator and initiate two timed intervals. A timer/counter pair monitors the number of times an overload occurs during a 60 second interval and the second timer delays restoration of the transmitter to operation to allow the condition that prompted the overload to dissipate.



NOTES:
1. MICROPROCESSOR OPTIONAL.
2. (µP) INDICATES OPTIONAL MICROPROCESSOR CONTROLLER INPUT/OUTPUT DATA POINT.

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FIGURE1-1.
TRANSMITTER CONTROLLER BLOCK DIAGRAM

1–21. When the timed interval delaying restoration of the transmitter to operation has expired, the transmitter will recycle back into operation. If no further overloads occur during the 60 second interval following the first overload, the 60 second timer will clear the overload counter. If four overload recycles occur during the 60 second counter/timer interval, the transmitter will deenergize and must be manually reset. This can be done by depressing the **OVERLOAD** switch/indicator, the **FILAMENT ON** switch/indicator, and the **HIGH VOLTAGE ON** switch/indicator. The overload can also be cleared by remote control if remote control is enabled by the **APC REMOTE DISABLE** switch/indicator.

1–22. If an overload persists in duration for longer than 0.22 seconds, the overload shut–down circuit will consider the overload a short circuit and immediately deenergize the transmitter. The transmitter must then be manually restored to operation after the fault is repaired.

1–23. **DETAILED DESCRIPTION.**

1–24. **RFI FILTER CIRCUIT BOARD.** All controller inputs and outputs are routed through connectors J1, J2, and J3 mounted to the RFI filter circuit board. The circuitry consists of single PI–section low–pass RC and LC filters effective to 108 MHz and connected in series with each input and output to prevent RF leakage into the controller. The filter circuit board also contains the following programmable circuitry: 1) inverter arrays U1 and U2 which determines the remote status indication logic, 2) resistor network R35 which functions as a voltage divider to reduce the remote meter indications to +2.5V dc, and 3) jumper J7 which selects either independent or safety external interlock operation.

1–25. **MOTHERBOARD.** The motherboard provides a single 100–pin edge connector (J1) to mount the controller circuit board. Logic inputs and outputs to the motherboard are routed via ribbon cables and connected to J3 and J4. Power is connected to J2.

1–26. **CONTROLLER CIRCUIT BOARD.** Input latches U17A, U17B, and U17C are used to store the momentary contact closures representative of command inputs (see Figure 1–2). When the **FILAMENT ON** switch/indicator is depressed, a momentary LOW from NOR gate U9A will force the Q output of U17A HIGH. When the **HIGH VOLTAGE ON** switch/indicator is depressed, a momentary LOW from NOR gate U10A will force the Q output of U17B HIGH. A "one–button start" feature is provided by a connection from the Q output of U17B to U9A.

1–27. **Blower On.** The HIGH from the Q output of U17A is applied to the blower off delay circuit, analog switch U32, blower timer U23A and filament gate U19A. The blower off delay circuit has no function at transmitter turn–on. The input to analog switch U32 illuminates the **FILAMENT ON** switch/indicator to signify that the filament on command has been received and stored. A HIGH from the Q output of blower timer U23A will be applied to blower AND gate U26A through OR gate U24A. Assuming the safety interlocks remain closed, the remaining input to U26A will be HIGH and a HIGH will be output through analog switch U32 and optical isolator U38 to energize the blower control circuitry.

1–28. The output potential for optical isolator U38 is routed through the safety interlocks. If the safety interlock string opens, the blower control voltage will be disconnected and the safety interlock control logic will completely deenergize the transmitter.

1–29. **Filament On.** As the blower continues to operate, the air switch will close. The air switch closed signal is applied to optical isolator U6 which forces a HIGH from U12B and a LOW from U12C. The LOW from U12C is applied to inverter U18A which will output a HIGH to filament AND gate U19A. As the remaining input to U19A was set HIGH by the Q output of U17A, a HIGH will be output through analog switch U34 and optical isolator U37 to activate the filament circuit. The **FILAMENT** status indicator will illuminate to signify that the filament circuit is energized.

1–30. The output potential for optical isolator U37 is routed through the safety interlocks. If the safety interlock string opens, the filament control voltage will be disconnected and the safety interlock control logic will completely deenergize the transmitter.

1–31. **High Voltage On.** Assuming the **HIGH VOLTAGE ON** switch/indicator has been depressed, a HIGH from the Q output of U17B through analog switch U32 will illuminate the **HIGH VOLTAGE ON** switch/indicator to signify the high voltage on command has been received and stored. The previously set HIGH from U19A (the filament gate) will also be applied to the filament on delay and gate U14B.

1–32. If the ac power status input to U14B is HIGH, AND gate U14B will output a HIGH to start filament timer U23B. The output of U23B will start HIGH, go LOW for the duration of the filament heating delay, then return HIGH. The filament on delay circuit will hold a momentary LOW on high voltage gate U25A to prevent the time delay encountered in starting timer U23B from pulsing the high voltage circuit on, then off, then back on after the filament heating delay.

1–33. When the filament heating delay has expired and a HIGH from U19B signals that no overloads exist, U25A will output a HIGH to U34. U34, operating in conjunction with inverter U51C will output a LOW to step–start OR gate U24B. If a LOW from the external interlock circuit is present (indicating the interlock is closed), U24B will output a LOW to energize the step–start circuit.

1–34. The step driver will energize the plate supply step relay to apply primary voltage to the plate supply transformer through three limiting resistors. After a 100 millisecond delay determined by R149, C40, and U51D, the start driver will energize the start contactor and apply the full primary potential to the plate supply transformer. The step circuit will deenergize after being energized for 160 milliseconds, determined by R150, C41, and U51E. In this manner, the plate supply inrush is limited and the current limiting resistors are subject to heating only during a 100 millisecond interval before start contactor closure. For added reliability, the limiting resistors are disconnected after 160 milliseconds.

1–35. The exciter enable line and the HIGH voltage status indicator are wired in parallel from U39 with the start driver. Simultaneous with generation of the start signal, the exciter will be enabled and the **HIGH VOLTAGE** status indicator will illuminate to indicate that the plate supply control signal has been output. The high voltage supply is prevented from step–starting under full load in this manner.

1–36. The output potential for optical isolator U39 is routed through the safety interlocks. If the safety interlock string opens, the plate supply start control voltage will be disconnected and the safety interlock control logic will completely deenergize the transmitter.

1–37. **Power–On Initialization.** When power is initially first applied to the transmitter controller circuit board, the +15 volt input to inverter U18B through R98 will produce a LOW output from U18B which clears all timers and resets all latches to the off condition. Capacitor C13 will gradually charge from the +15 volt dc input through resistor R24. When the charge on C13 equals the 2 volt threshold established by D3, D4, and Q1, transistor Q1 will conduct and force a HIGH from inverter U18B which will terminate the power–on initialization. Q1 will remain conducting as long as power is continuously applied to the +15 volt input.

1–38. Initialization is also applied to inverter U12A. U12A outputs a HIGH which resets the overload status latch (U17) via U11A, resets the overload latches (U31A, U31B, U31C, and U31D), and resets the overload counter (U57) through inverter U12D. The HIGH from U12A is also applied through OR gate U13B to U9B and U10B to reset the filament latch and the high voltage latch.

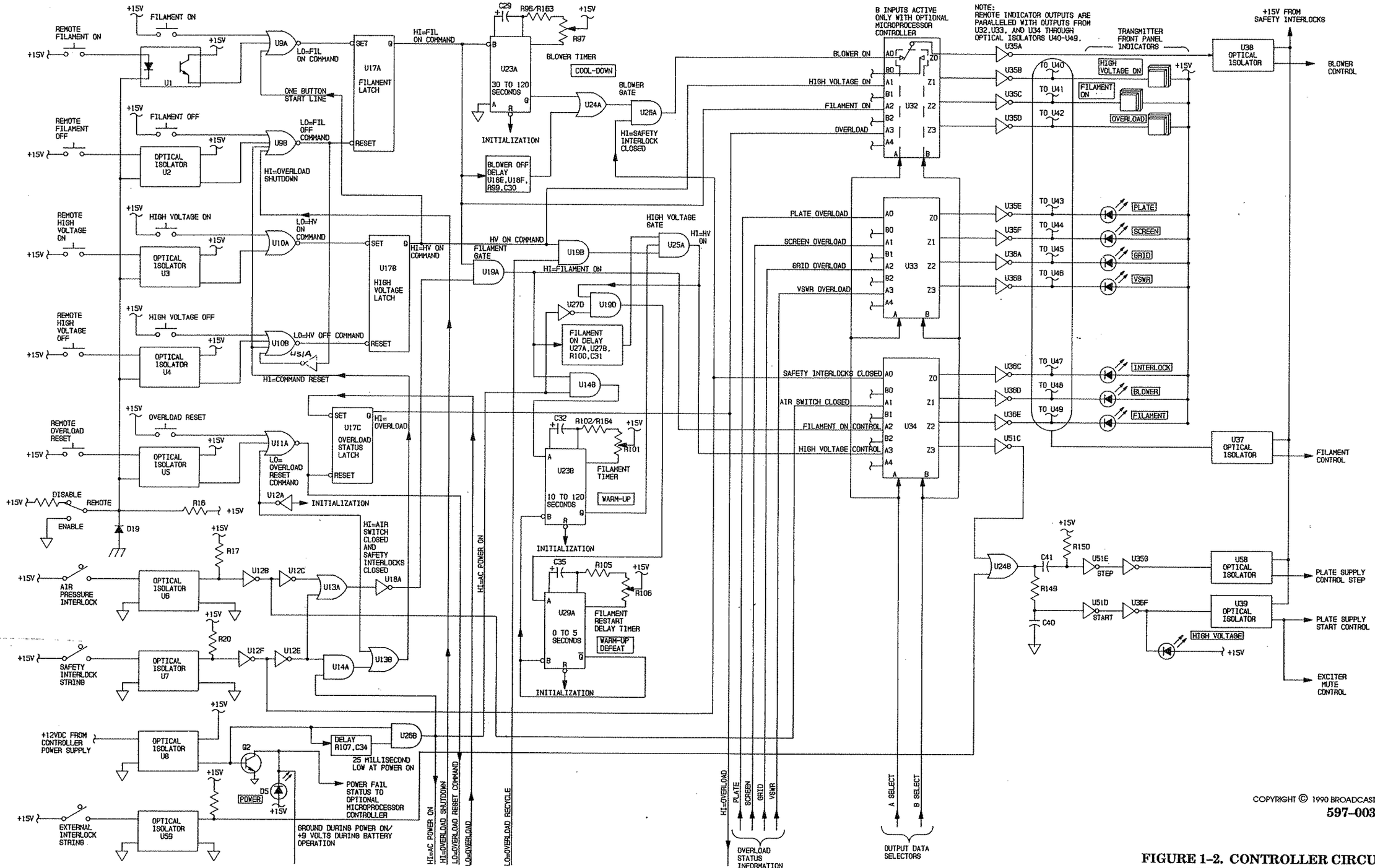

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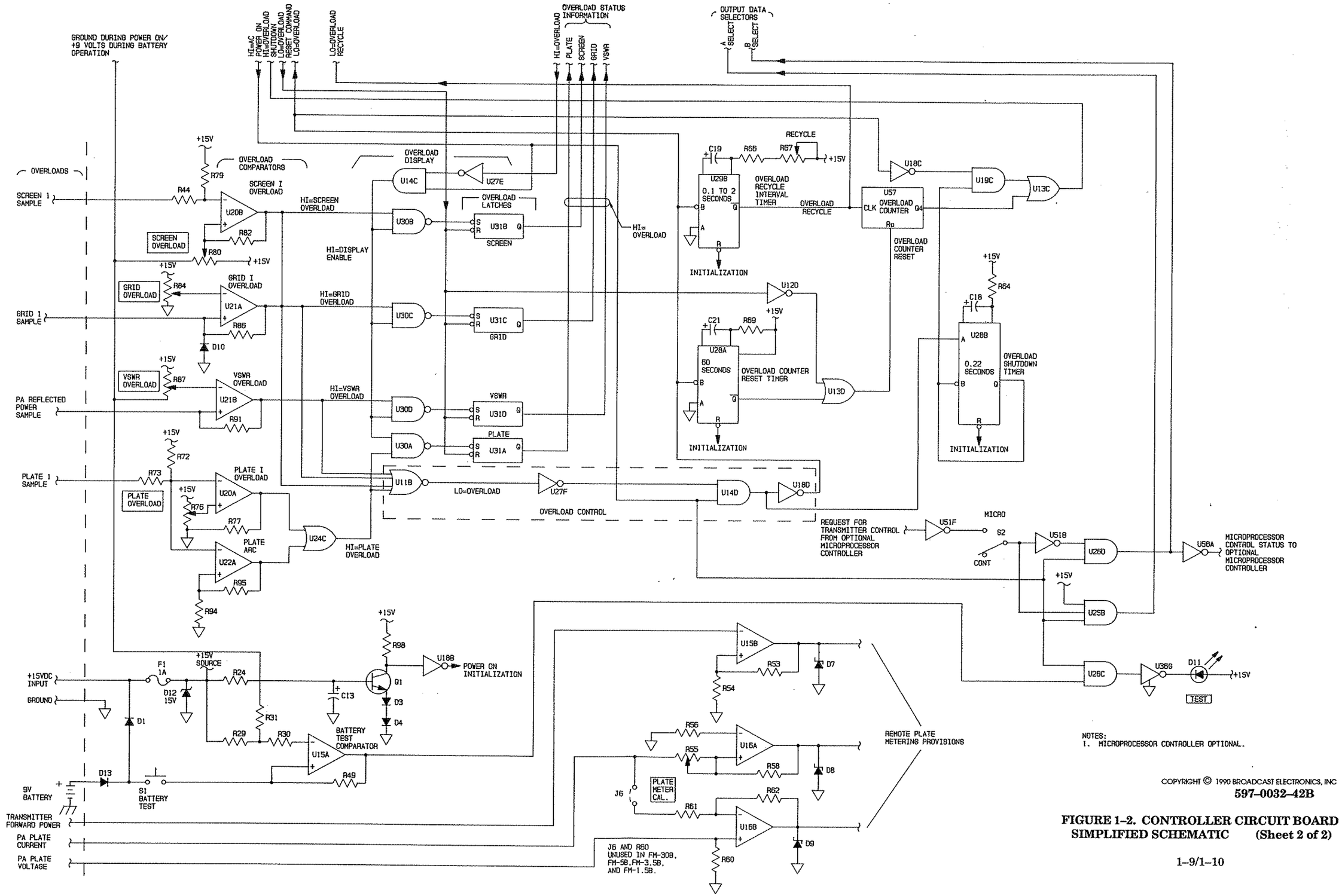
FIGURE 1–2. CONTROLLER CIRCUIT BOARD SIMPLIFIED SCHEMATIC (Sheet 1 of 2)



NOTES:
1. MICROPROCESSOR CONTROLLER OPTIONAL.

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FIGURE 1-2. CONTROLLER CIRCUIT BOARD SIMPLIFIED SCHEMATIC (Sheet 2 of 2)

1–39. **Ac Power Monitor.** A +12 volt dc input from the controller power supply is monitored for instantaneous loss of ac power information. This input to optical isolator U8 will drive transistor Q2 into conduction which illuminates the **POWER** indicator. U8 also forces a HIGH from U26B which signifies ac power is applied to the transmitter. A 25 millisecond delay connected to the second input of U26B will delay the HIGH from U26B to allow all logic adequate time to reset before signaling ac power has returned to normal.

1–40. The ac power status information from U26B is ANDed in U14A with the safety interlock status. If the safety interlocks are opened while ac power is energized, a HIGH from U14A will be applied through OR gate U13B to U9B and U10B to reset the filament latch and the high voltage latch.

1–41. When the output of U26B is LOW (ac power lost), several actions occur:

A. The filament restart delay timer (U29A) is set via U19D as soon as ac power is lost. If ac power is removed long enough for the filament restart delay timer interval to expire, U29A will reset the filament timer. When power returns, a new filament heating delay will be initiated before the plate supply is energized. If the ac power outage is momentary and U29A is not allowed to time out, high voltage will energize immediately upon restoration of ac power.

B. The overload comparators and latches will be inhibited by U30 as any inputs during power off will be false.

C. Additional circuitry inhibits the battery **TEST** indicator to conserve battery current, selects the A inputs to the analog switches for solid–state controller operation only, and advises the optional microprocessor controller of battery operation status.

1–42. The collector of Q2 routes power failure information to the optional microprocessor controller and provides a ground reference when ac power is on for **SCREEN** overload control R80, **VSWR** overload control R97, and battery test comparator U15A. During periods of battery operation, this same line routes a positive potential to the **SCREEN** overload and **VSWR** overload reference controls. This eliminates false overloads on ac power failure due to slowly decaying screen current and VSWR samples.

1–43. **Safety Interlocks.** The safety interlock circuitry consists of a series string of normally closed switches mounted in areas which contain electrical or mechanical hazards. Each switch is mechanically activated by a door or panel to deenergize the entire transmitter when opened. Logic states from the safety interlock circuitry are used in conditional logic for blower and filament turn on as described in the following text.

1–44. All outputs from the controller are routed through optical isolators. The output potential for the optical isolators is obtained from the series–wired safety interlock string. If an interlock opens, all output drivers from the controller circuit board will be disconnected. In addition, the safety interlock control logic input will be removed and the transmitter will completely deenergize.

1–45. The safety interlock closed information is input to optical isolator U7 and applied to inverter U12F as a LOW. When HIGH, the output of U12F will illuminate the **INTERLOCK** status indicator through analog switch U34 to signify the interlocks are closed and enable blower gate U26A.

1–46. The HIGH from U12F is also applied as a LOW to OR gate U13A and AND gate U14A through inverter U12E. OR gate U13A enables the filament gate (U19A) to allow filament turn–on. When both inputs to U13A are LOW, U13A will output a LOW to inverter U18A which applies a HIGH to the filament AND gate. This will occur whenever both the air pressure and the safety interlock switches are closed. AND gate U14A will produce the logical sum of a LOW from the safety interlock circuit and a HIGH from the ac power monitor circuit. If the safety interlocks are opened while ac power is applied to the transmitter, a HIGH through U13B will reset the filament latch via U9B and the high voltage latch via U10B to deenergize the transmitter. This will prevent the transmitter from re–energizing the filament or high voltage circuit upon closing the open interlock condition. Only the blower run–down timer (U23A) is allowed to continue operation.

1–47. **External Interlock.** The external interlock circuit is independent of the transmitter safety interlock circuit. External interlock closed information is applied to optical isolator U59 as a HIGH. The output of U59 will pull one input of step–start control OR gate U24B LOW, allowing a control pulse from U51C to enable the step–start circuitry. If the interlock is opened during transmitter operation, a HIGH is applied to U24B which disables the high voltage step–start circuit and deenergizes the plate supply.

1–48. **Overload Input Circuit.** Four parameters are monitored for overload conditions by the controller circuit board: screen current, control grid bias supply current, PA VSWR, and plate current. Each sample is input to a threshold comparator which converts the analog input to a digital state. Depending upon the polarity of the sample, the input is applied to the inverting or non–inverting input of the comparator. Resistors R92 and R72 on the plate sample and R79 on the screen sample form voltage dividers with the series input resistors (R93, R73, and R74) to convert the negative samples to positive voltages for the comparators. An adjustable threshold is established on the remaining input to each comparator. When the sample crosses the preset threshold, the output will switch from a LOW to a HIGH to signal an overload condition. The grid bias supply current overload trips on excessive supply current such as a short circuit in the tube socket.

1–49. Two comparators are used to monitor the plate current sample. The slower overload comparator (U20A) monitors for gradual increases such as mistuning which can draw up to two times normal plate current. The plate arc comparator (U22A) is a faster operating circuit that monitors for high–level short–duration arcs which will not trigger U20A. The two plate overload comparators are ORed in U24C. A HIGH from U24C signals a plate overload.

1–50. All five comparators normally output a LOW and switch to a HIGH to signal an overload condition. This logic is used as inputs for the overload display as well as the overload control circuitry.

1–51. **Overload Diagnostics.** For diagnostic display purposes, the output of each comparator is ANDed with a comparator enable signal and latched into a bistable flip–flop. Immediately after an overload is latched, the display enable signal will go LOW and inhibit further inputs. Until cleared with the overload **RESET** switch, no further overload information will be accepted for diagnostic display purposes. Any overload will be output from the latches as a HIGH through analog switch U33 for display as a diagnostic indication.

1–52. The overload latch (U17C) is set by a LOW from inverter U18D. A HIGH from the Q output of U17C will illuminate the **OVERLOAD** switch/indicator to signify that an overload has occurred. The HIGH from U17C is also inverted by U27E and ANDed in U14C with the ac power status to disable the overload latches (U31A, U31B, U31C, and U31D) through U30A, U30B, U30C, and U30D, inhibiting further overload inputs to the latches.The overload latch that was set by the overload input will illuminate its respective front–panel indicator via U33.

1–53. The overload display reset sequence is initiated by a positive potential which resets overload status latch U17C through NOR gate U11A. When U17C is reset, several actions occur:

A. The **OVERLOAD** reset switch/indicator and the overload diagnostic indicator (**PLATE, SCREEN, GRID,** or **VSWR**) indicator will go out.

B. The overload display latches (U31A, U31B, U31C, and U31D) will be reset.

C. The inhibit from U14C will be removed from the overload display gates.

D. The overload counter will be cleared via inverter U12D and OR gate U13D.

1–54. **Overload Control Circuits.** The overload control circuit inputs are obtained from the overload comparators. This circuit is not inhibited by a single overload as is the overload display circuit. The logical output of each comparator is ORed in U11B, routed through inverter U27F, and ANDed with the ac power status in U14D. An output from U14D is applied as a HIGH to overload shutdown timer U28B. This timer measures the duration of the high overload signal. If it is greater than 220 milliseconds, it applies a signal through U19C and U13C to deenergize filament latch U17A via U9B. This same HIGH is routed through inverter U18D and applied as a LOW to enable the overload counter reset timer (U28A), enable the overload recycle interval timer (U29B), and set the overload status latch (U17C).

1–55. The overload recycle interval timer (U29B) determines the length of time the transmitter remains off–the–air after an overload to allow the condition that prompted the overload to dissipate. Timer U29B can be adjusted from 0.1 to 2 seconds using R67. The overload counter (U57) counts the overload recycle attempts and the overload counter reset timer (U28A) resets the overload counter 60 seconds after the first overload occurred.

1–56. Each overload will initiate a recycle by deenergizing high voltage via AND gates U19B and U25A to attempt to clear the overload. The overload counter (U57) will count each recycle attempt. If four overloads occur within the 60 second interval of U28A, OR gate U13C will output a HIGH. This HIGH is applied to OR gate U9B which resets the filament latch (U17A) and deenergize the transmitter.

1–57. If an overload cycles the transmitter off–the–air and removing high voltage does not clear the overload after 220 milliseconds, the overload shutdown timer (U28B) will output a HIGH. This HIGH is ANDed in U19C with a HIGH from inverter U18C and signals overload shutdown through OR gate U13C.

1–58. **Turn Off.** The high voltage off sequence is initiated by a positive potential which resets the high voltage latch (U17B) through NOR gate U10B. When U17B is reset, the following actions will occur:

A. The **HIGH VOLTAGE ON** switch/indicator will go out.

B. A LOW via U19B and U25A will deenergize the plate power supply and the **HIGH VOLTAGE** status indicator will go out.

1–59. The filament off sequence is initiated by a positive potential which resets the filament latch (U17A) through NOR gate U9B. When U17A is reset, the following actions will occur:

A. The plate latch (U17B) will be reset by U10B via U9B.

B. The **FILAMENT ON** switch/indicator will go out.

C. A LOW via U19A will deenergize the filament supply and the **FILAMENT** status indicator will go out.

D. The blower timer (U23A) will begin time–down operation. The blower–off delay circuit composed of U18E, U18F, C30, and R99 will hold a momentary HIGH through U24A on blower gate U26A to prevent the time delay encountered in starting timer U23A from pulsing the blower off, then on, then back off after the blower run–down delay.

E. When the blower ceases operation, the **BLOWER** status indicator will go out.

1–60. **Remote Control.** The transmitter can be controlled by momentary positive–polarity dc inputs to the controller circuit board. Positive–logic enabled remote inputs are used for safety. Each remote input is routed through an optical isolator for isolation. Additional resistance to noise interference is provided by an RC circuit in each remote input. Diodes across each optical isolator input and diode D19 prevent possible damage to the remote circuitry caused by inadvertent connection to negative polarity control inputs. A +15 volt output is provided for remote operation, however the optical isolators can operate on any positive dc voltage from +5 volts to +24 volts.

1–61. The remote circuitry is enabled by a ground through the **REMOTE ENABLE/DISABLE** switch which enables the optically–isolated inputs. The input of this switch is connected to a pull–up resistor (R16) as a safety consideration to prevent remote operation in case the switch input were to become disconnected.

1–62. **Remote PA Metering.** The remote meter amplifiers for transmitter forward power, PA plate current, and PA plate voltage are mounted on the controller circuit board.

1–63. U15B is a non–inverting voltage amplifier with a gain of approximately one and used for transmitter forward power. The input is obtained from the forward power buffer in the automatic power control unit. The output is clamped with a 15 volt zener diode for circuit protection. Positive five volts output corresponds to 100% power.

1–64. U16A is an inverting voltage amplifier with a gain of approximately 12. The input is obtained from one end of a resistor in the negative side of the plate power supply. As the plate current varies with power, R152 is included for level adjustment. Positive five volts output can be obtained by varying R152. The output is clamped with a 15 volt zener diode for circuit protection.

1–65. U16B functions as a non–inverting amplifier with a gain of one. The input is obtained from the low–potential end of the plate meter multiplier circuit board. Positive five volts corresponds to full–scale plate voltage.

1–66. **POWER SUPPLY CIRCUIT BOARD.** AC power is input to the controller through a voltage range selector which additionally provides overload protection and RFI isolation for the ac input (see Figure 1–3). A special power transformer with a tapped dual primary allows operation from both 50 and 60 Hz and a wide range of ac voltages without component changes. The primary and secondary windings are electrostatically shielded from each other. The secondary windings of the transformer produce three ac potentials which are full–wave rectified and regulated into three dc sources which supply all operating voltages for the controller circuitry. When power is applied to the controller, the cooling fan will run continuously.

1–67. **Positive Fifteen Volt Controller Supply.** A 20.4 volt secondary of transformer T1 is full–wave bridge–rectified into a +27.5 volt supply by diodes D1, D2, D7, and D8 and filtered by capacitor C1. This rectified voltage is routed to U1 which regulates the input potential to a +15 volt source for the controller logic circuitry. The output potential is adjusted by R3. Diode D19 prevents capacitor and battery discharge through the regulator biasing circuit during power failures.

1–68. Integrated circuit U1 is a three–terminal adjustable positive regulator containing internal thermal overload protection and short–circuit current limiting features. Further protection for U1 is provided by diode D16 which protects the regulator from a reverse polarity potential applied to the output.

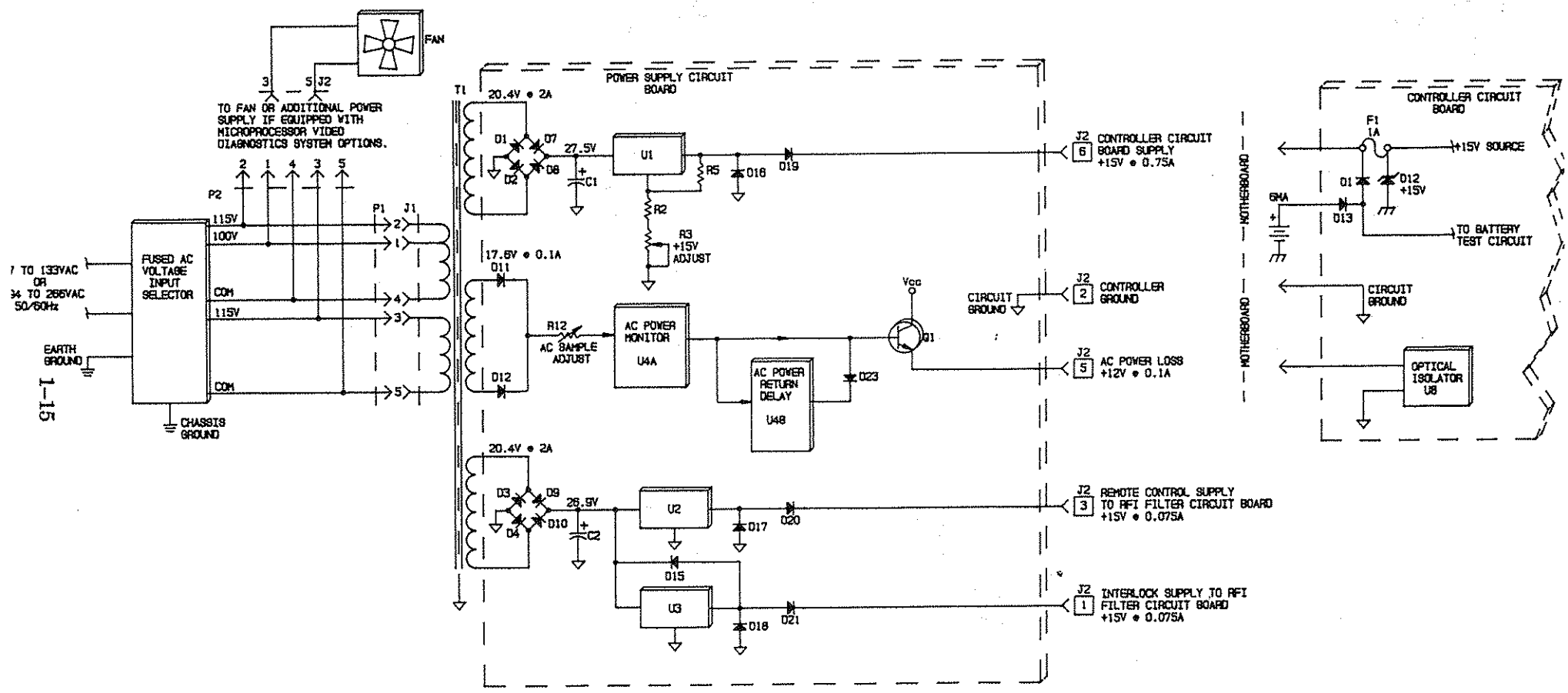

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FIGURE 1-3. CONTROLLER POWER SUPPLY SIMPLIFIED SCHEMATIC

1–69. The 15 volt potential is routed to the controller circuit board to provide operating potentials for the logic circuitry. Fuse F1 provides overload protection and diode D12 limits transients on the supply to 15.2 volts. Diodes D1 and D13 are steering diodes which isolate the 9 volt battery from the 15 volt supply and allow the battery to be tested while the circuit operates from the 15 volt input. In case of power failures, the 15 volt supply will be maintained at 9 volts by current flow through D1 and D13 to allow transmitter restoration to proceed automatically. Battery drain is approximately six milliamperes which allows three days of memory. The battery is not maintained on charge and must be replaced when discharged.

1–70. **Positive Twelve Volt AC Loss–of–Power Supply.** A 17.6 volt secondary (open–circuit voltage) of transformer T1 is half–wave rectified into a dc supply by diodes D11 and D12. The dc potential is routed through ac sample adjust potentiometer R12 to ac power monitor U4A. U4A is a retriggerable one–shot which biases transistor Q1 on during normal ac power operating conditions.

1–71. When a power failure condition occurs, the output of U4A will go LOW to bias Q1 off and route a LOW ac power loss command to an optical coupler on the transmitter controller circuit board. When ac power is re–applied to the unit, the output of U4A will go HIGH and trigger ac power return delay one–shot U4B. After a 500 millisecond delay to allow the power supplies to completely energize, the output of U4B will go HIGH to bias Q1 on and route a HIGH ac power loss command to the controller circuit board.

1–72. **Positive Fifteen Volt Remote Control Supply.** A 20.4 volt secondary of transformer T1 is full–wave bridge–rectified into a +27 volt supply by diodes D3, D4, D9, and D10 and filtered by capacitor C2. This rectified voltage is routed to U2 which regulates the input potential to a +15 volt source for the remote control circuitry. Diode D20 prevents capacitor discharge through the regulator during power failures.

1–73. Integrated circuit U2 is a three–terminal fixed positive regulator containing internal thermal overload protection and short–circuit current limiting features. Further protection for U2 is provided by diode D17 which protects the regulator from a reverse polarity potential applied to the output.

1–74. **Positive Fifteen Volt Interlock Supply.** The input to regulator U3 is paralleled from the same +27 volt supply as regulator U2. Integrated circuit U3 is a three–terminal fixed positive regulator containing internal thermal overload protection and short–circuit current limiting features. Further protection for U3 is provided by diode D18 which protects the regulator from a reverse polarity potential applied to the output and diode D15 which protects the regulator from a short circuit on the regulator input.

SECTION II
TRANSMITTER CONTROLLER MAINTENANCE

2–1. INTRODUCTION.

2–2. This section provides maintenance information for the FM–5B/ FM–5BS transmitter controller.

2–3. SAFETY CONSIDERATIONS.

2–4. The FM–5B/FM–5BS transmitters contain high voltages and currents which, if regarded carelessly, could be fatal. The transmitter has many built–in safety features, however good judgement, care, and common sense are the best accident preventives. The maintenance information contained in this section should be performed only by trained and experienced maintenance personnel.

2–5. MAINTENANCE.

WARNING *NEVER OPEN THE EQUIPMENT UNLESS ALL TRANSMITTER PRIMARY POWER IS DISCONNECTED.*

WARNING

WARNING *DUE TO THE PROGRAMMING OF THE EQUIPMENT, THE APC UNIT WILL ENTER THE REMOTE ENABLED MODE WHENEVER AC POWER IS APPLIED. TO PREVENT INADVERTENT REMOTE START–UP DURING MAINTENANCE PERIODS, DISCONNECT POWER FROM THE TRANSMITTER AND INSTALL JUMPER P14 ON THE APC UNIT MAIN CIRCUIT BOARD IN POSITION 1–2.*

WARNING

2–6. The FM–5B/FM–5BS maintenance philosophy consists of preventative maintenance such as cleaning applied to the equipment of forestall future failures and second level maintenance consisting of procedures required to restore the equipment to operation after a fault.

2–7. ADJUSTMENTS.

WARNING *NEVER OPEN THE EQUIPMENT UNLESS ALL TRANSMITTER PRIMARY POWER IS DISCONNECTED.*

WARNING

2–8. The following text provides procedures to adjust all controls associated with the transmitter controller. Adjustment procedures for each control are presented in the following order.

A. Controller circuit board control adjustment.

B. Power supply circuit board control adjustment.

2–9. CONTROLLER CIRCUIT BOARD CONTROL ADJUSTMENT.

2–10. The following text presents the controller overload adjustment procedures. If more than one control is adjusted, the adjustment sequence is VSWR, PLATE, SCREEN, and GRID.

2–11. **VSWR OVERLOAD THRESHOLD ADJUST.** To adjust the **VSWR** overload control on the controller circuit board, proceed as follows.

2–12. **Required Equipment.** The following equipment is required to adjust **VSWR OVERLOAD** control R88.

A. Insulated adjustment tool, flat–tip (BE P/N 407–0083).

2–13. **Procedure.** To adjust the control, proceed as follows.

2–14. Operate the transmitter at the normal power output with the APC on.

2–15. Refer to Figure 2–1 and adjust **VSWR OVERLOAD THRESHOLD ADJUST** control R88 fully clockwise.

2–16. Operate the **OUTPUT POWER METER** switch to **FWD**. Assure the **OUTPUT POWER** meter indicates 100%.

2–17. Operate the **OUTPUT POWER METER** switch to **VSWR CAL** and adjust the **VSWR CAL** control to obtain an **OUTPUT POWER** meter indication of 100%.

2–18. Depress the **HIGH VOLTAGE OFF** switch.

2–19. When the **LOWER** switch/indicator stops flashing, depress the **APC ON** and **FILAMENT OFF** switch/indicators.

2–20. From the top of the transmitter, disconnect cable No. 130 and No. 131 from the FWD and RFL ports on the directional coupler. Connect cable No. 131 to the directional coupler FWD port.

CAUTION

CAUTION

ADJUSTMENT OF THE OVERLOAD CONTROLS DETERMINES AT WHAT POINT THE CONTROLLER WILL INITIATE ACTION. IF A CONTROL IS INCORRECTLY ADJUSTED, THE CONTROLLER MAY NOT SENSE A FAULT AND DAMAGE TO THE TRANSMITTER MAY RESULT.

2–21. Depress the **FILAMENT ON** and **HIGH VOLTAGE ON** switch/indicators.

2–22. Verify that the **OUTPUT POWER METER** switch is set to **VSWR** and the **APC ON** switch/indicator is not illuminated.

2–23. Raise power manually by depressing the **RAISE** switch/indicator until the **OUTPUT POWER** meter indicates a VSWR of 3 : 1.

2–24. Refer to Figure 2–1 and slowly adjust R88 until the **VSWR** indicator and the **OVERLOAD RESET** switch/indicator illuminate and the transmitter cycles off.

2–25. Depress the **HIGH VOLTAGE OFF** switch and **OVERLOAD RESET** switch/indicator.

2–26. Depress the **APC LOWER** switch/indicator for approximately 4 seconds to lower the transmitter power.

2–27. Depress the **HIGH VOLTAGE ON** switch/indicator to illuminate the switch/indicator.

2–28. Depress the **RAISE** switch/indicator to raise power. The transmitter will cycle off at a VSWR indication of 3 : 1. If not, repeat the adjustment.

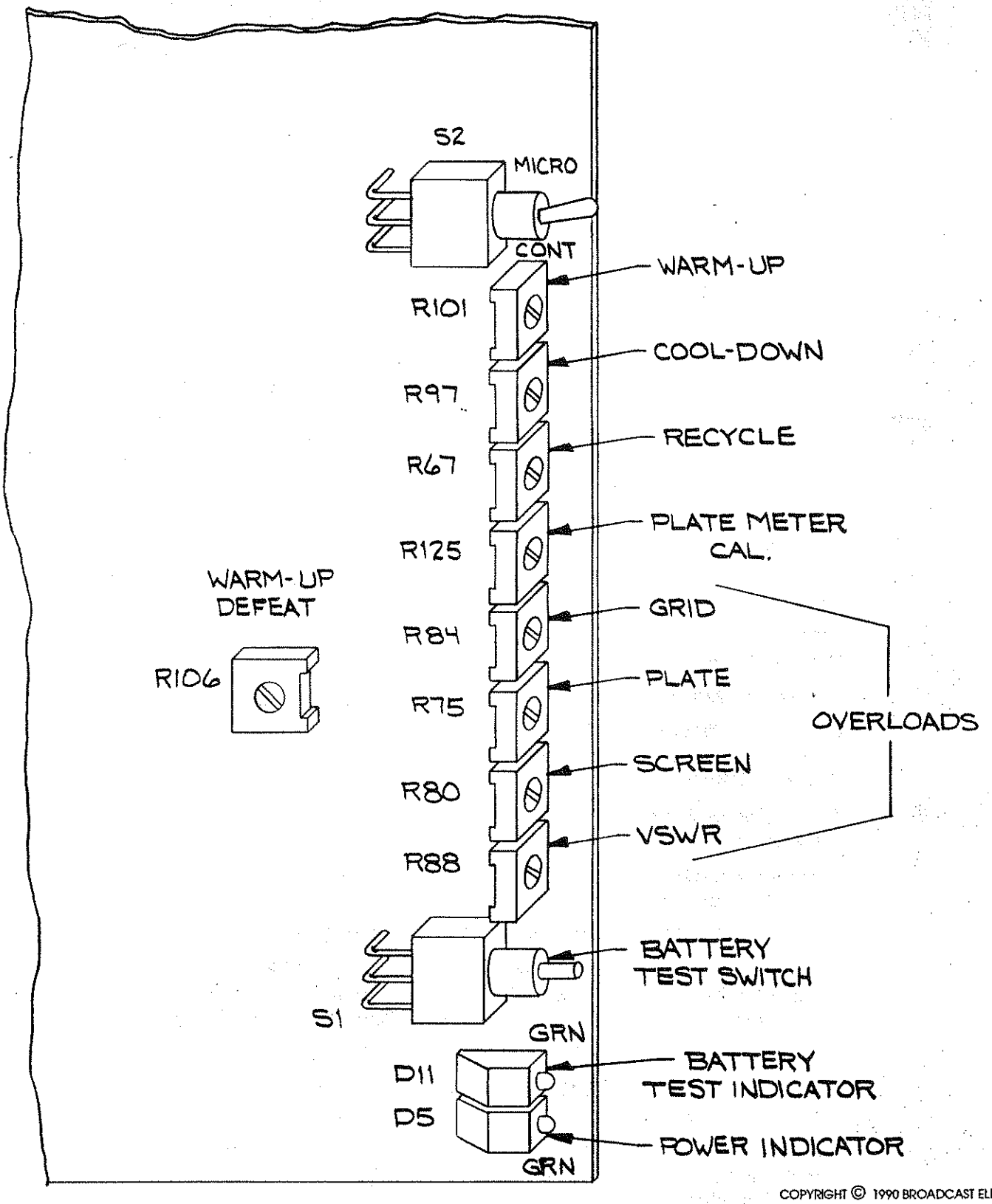


FIGURE 2–1. CONTROLLER CIRCUIT BOARD CONTROLS **597–0032–43**

2–29. Depress the **FILAMENT OFF, OVERLOAD RESET,** and **APC ON** switch/indicators.

CAUTION

CAUTION

ENSURE CABLE NO. 130 IS RECONNECTED TO THE FWD PORT AND CABLE NO. 131 IS RECONNECTED TO THE RFL PORT ON THE DIRECTIONAL COUPLER IN THE FOLLOWING STEP OR DAMAGE TO THE TRANSMITTER COULD RESULT.

2–30. Reconnect cable No. 131 to the RFL port and cable No. 130 to the **FWD** port on the output directional coupler.

2–31. **PLATE OVERLOAD ADJUSTMENT.** Potentiometer R75 on the controller circuit board adjusts the threshold level of the plate overload circuit. The plate overload circuit is adjusted as follows.

2–32. **Required Equipment.** The following equipment is required to adjust the plate overload control.

A. Insulated adjustment tool, flat–tip (BE P/N 407–0083).

CAUTION

CAUTION

THE OVERLOAD THRESHOLD LEVEL ADJUSTMENTS DETERMINE WHEN THE TRANSMITTER INITIATES ACTION. IF A CONTROL IS INCORRECTLY ADJUSTED THE CONTROLLER MAY NOT SENSE THE FAULT AND DAMAGE TO THE TRANSMITTER MAY RESULT.

2–33. **Procedure.** To adjust the threshold level of the plate overload circuit, proceed as follows:

2–34. Apply power and operate the transmitter within specifications at the rated RF output into a proper 50 Ohm load. Record the **OUTPUT LOADING** control cyclometer indication _____.

2–35. Refer to Figure 2–1 and adjust **PLATE** overload control R75 fully clockwise.

2–36. Operate the **APC ON** switch/indicator to extinguish the indicator.

2–37. Operate the **OUTPUT LOADING** control clockwise and the **RAISE** switch/indicator to detune the transmitter until plate current is increased by 0.2 amperes as indicated on the **PLATE CURRENT** meter.

2–38. Refer to Figure 2–1 and slowly adjust **PLATE** overload control R75 until the transmitter deenergizes.

2–39. Depress the **HIGH VOLTAGE OFF** switch, then depress and hold the **LOWER** switch/indicator for approximately four seconds.

2–40. Depress the **OVERLOAD RESET** and the **HIGH VOLTAGE ON** switch/indicators.

2–41. Observe the **PLATE CURRENT** meter and operate the **RAISE** switch/indicator until the transmitter deenergizes. Correct adjustment is obtained when the transmitter deenergizes and plate current is 0.2 amperes above normal. Repeat the procedure if required.

2–42. Depress the **HIGH VOLTAGE OFF** switch and **OVERLOAD RESET** switch/indicator.

2–43. Restore the **OUTPUT LOADING** control to the cyclometer indication recorded in the preceding text and operate the **APC ON** switch/indicator to illuminate the indicator.

2–44. **SCREEN OVERLOAD ADJUSTMENT.** Potentiometer R80 on the controller circuit board adjusts the threshold level of the screen overload circuit. The screen overload circuit is adjusted as follows.

2–45. **Required Equipment.** The following equipment is required to adjust the screen overload control.

A. Insulated adjustment tool, flat–tip (BE P/N 407–0083).

CAUTION

CAUTION

THE OVERLOAD THRESHOLD LEVEL ADJUSTMENTS DETERMINE WHEN THE TRANSMITTER INITIATES ACTION. IF A CONTROL IS INCORRECTLY ADJUSTED THE CONTROLLER MAY NOT SENSE THE FAULT AND DAMAGE TO THE TRANSMITTER MAY RESULT.

2–46. **Procedure.** To adjust the threshold level of the screen overload circuit, proceed as follows:

2–47. Apply power and operate the transmitter within specifications at the rated RF output into a proper 50 Ohm load. Record the **OUTPUT LOADING** control cyclometer indication_____ .

2–48. Refer to Figure 2–1 and adjust **SCREEN** overload control R80 fully clockwise.

2–49. Operate the **APC ON** switch/indicator to extinguish the indicator.

2–50. Operate the **MULTIMETER** to the **SCREEN CURRENT** position.

2–51. Operate the **OUTPUT LOADING** control counterclockwise and the **RAISE** switch/indicator to detune the transmitter for a screen current of 145 milliamperes as indicated on the **MULTIMETER.**

2–52. Refer to Figure 2–1 and slowly adjust **SCREEN** overload control R80 until the transmitter deenergizes.

2–53. Depress the **HIGH VOLTAGE OFF** switch, then depress and hold the **LOWER** switch/indicator for approximately four seconds.

2–54. Depress the **OVERLOAD RESET** and the **HIGH VOLTAGE ON** switch/indicators.

2–55. Observe the **MULTIMETER** and operate the **RAISE** switch/indicator until the transmitter deenergizes. Correct adjustment is obtained when the transmitter deenergizes and the **MULTIMETER** indicates 145 milliamperes. Repeat the procedure is required.

2–56. Depress the **HIGH VOLTAGE OFF** switch and **OVERLOAD RESET** switch/indicator.

2–57. Restore the **OUTPUT LOADING** control to the cyclometer indication recorded in the preceding text and operate the **APC ON** switch/indicator to illuminate the indicator.

2–58. **GRID OVERLOAD ADJUSTMENT.** Potentiometer R84 on the controller circuit board adjusts the threshold level of the grid overload circuit. To adjust the grid overload circuit, refer to Figure 2–1 and adjust R84 to the mid–range position.

2–59. **WARM–UP ADJUSTMENT.** This control adjusts the filament heating delay, prior to high voltage on. The control allows adjustment from 9 seconds to 2 minutes. A minimum interval is preset so that incorrect adjustment cannot damage the PA tube. To adjust **WARM–UP** control on the controller circuit board, proceed as follows.

2–60. **Required Equipment.** The following equipment is required to adjust **WARM–UP** control R101.

A. Insulated adjustment tool, flat–tip (BE P/N 407–0083).

B. Wristwatch with seconds hand or stopwatch function.

2–61. **Procedure.** To adjust the control, proceed as follows.

2–62. Apply filament power to the transmitter. Simultaneously note the time and depress the **HIGH VOLTAGE ON** switch/indicator.

2–63. Again note the time when the plate contactor energizes.

2–64. Refer to Figure 2–1 and adjust R101 to increase or decrease the time delay. Check the adjustment by repeating paragraphs 2–62 and 2–63. The control is factory set for 9 seconds.

2–65. **COOL–DOWN ADJUSTMENT.** This control adjusts the blower run–down interval after high voltage is switched off. The control allows adjustment from 30 seconds to 2.5 minutes. A minimum interval is preset so that incorrect adjustment cannot damage the PA tube. To adjust **COOL–DOWN** control on the controller circuit board, proceed as follows.

2–66. **Required Equipment.** The following equipment is required to adjust **COOL–DOWN** control R97.

A. Insulated adjustment tool, flat–tip (BE P/N 407–0083).

B. Wristwatch with seconds hand or stopwatch function.

2–67. **Procedure.** To adjust the control, proceed as follows.

2–68. Apply power and operate the transmitter.

2–69. Simultaneously depress the **FILAMENT OFF** switch and note the time.

2–70. Again note the time when the blower halts operation.

2–71. Refer to Figure 2–1 and adjust R97 to increase or decrease the blower run–down interval. Check the adjustment by repeating paragraphs 2–69 and 2–70. The control is factory set for 35 seconds.

2–72. **RECYCLE ADJUSTMENT.** This control adjusts the time the transmitter will remain deenergized to allow an overload to dissipate after an overload occurs. The control allows adjustment from 100 milliseconds to 2.5 seconds. A minimum delay is built into the circuitry to prevent transmitter damage. To adjust **RECYCLE** control on the controller circuit board, proceed as follows.

2–73. **Required Equipment.** The following equipment is required to adjust **RECYCLE** control R67.

A. Insulated adjustment tool, flat–tip (BE P/N 407–0083).

2–74. **Procedure.** To adjust the control, proceed as follows.

2–75. Apply power and operate the transmitter.

2–76. Refer to Figure 2–1 and adjust R67 for the desired delay. The control is factory preset for 2.5 seconds. The adjustment may be checked by simulating a screen or plate overload with the **OUTPUT LOADING** control.

2–77. **WARM–UP DEFEAT ADJUSTMENT.** This control adjusts the length of the interval the transmitter will tolerate after a power interruption before initiating a new filament warm–up cycle. The control allows adjustment from 25 milliseconds to 5 seconds. A minimum delay is built into the circuitry so that momentary power fluctuations will not initiate a new filament warm–up cycle. To adjust **WARM–UP** defeat control on the controller circuit board, proceed as follows.

2–78. **Required Equipment.** The following equipment is required to adjust **WARM–UP** defeat control R106.

A. Insulated adjustment tool, flat–tip (BE P/N 407–0083).

B. Controller Extender Board (BE P/N 919–0061).

C. Wristwatch with seconds hand or stopwatch function.

2–79. **Procedure.** To adjust the control, proceed as follows.

2–80. Mount the controller circuit board on the extender board.

2–81. Apply power and operate the transmitter.

2–82. Refer to Figure 2–1 and adjust R106 for the desired interval. The control is factory preset for two seconds. The adjustment may be checked by interrupting the transmitter ac feed for known time intervals, and observing if the high voltage is reapplied immediately or a recycle is initiated.

2–83. Replace the controller circuit board in the transmitter.

2–84. **PLATE I METER CAL ADJUSTMENT.** This control adjusts the remote plate current meter output level for approximately 5 volts or 2.5V dc (depending on the remote logic programming) at normal plate current. To adjust **PLATE I** meter cal control on the controller circuit board, proceed as follows.

2–85. **Required Equipment.** The following equipment is required to adjust **PLATE I** meter cal control R125.

A. Insulated adjustment tool, flat–tip (BE P/N 407–0083).

B. Digital voltmeter (Fluke 75 or equivalent).

2–86. **Procedure.** To adjust the control, proceed as follows.

WARNING *DISCONNECT ALL TRANSMITTER PRIMARY POWER BEFORE PROCEEDING.* *WARNING*

2–87. Assure all transmitter power is off and open the cabinet rear door. Connect the voltmeter between REMOTE INTERFACE PANEL TB3–25 and TB3–26 (meter ground).

2–88. Route the voltmeter leads out the hinge side of the cabinet door and close and lock the door.

2–89. Apply power and operate the transmitter at the normal power output.

2–90. Refer to Figure 2–1 and adjust R125 until the voltmeter indicates +5 volts or 2.5 volts dc (depending on the remote logic programming).

WARNING *DISCONNECT ALL TRANSMITTER PRIMARY POWER BEFORE PROCEEDING.* *WARNING*

2–91. Assure all transmitter power is off and disconnect the voltmeter and leads.

2–92. **POWER SUPPLY CIRCUIT BOARD.**

2–93. **+15 VOLT ADJUST.** To adjust the +15 volt adjust control on the power supply circuit board, proceed as follows.

2–94. **Required Equipment.** The following equipment is required to adjust **+15 VOLT ADJUST** control R2.

A. Flat–blade screwdriver, 1/4 inch tip.

B. No. 2 Phillips screwdriver, 11 inch blade.

C. Insulated adjustment tool, flat–tip (BE P/N 407–0083).

D. Small pair of needle–nose pliers.

E. Power interlock line cord (BE P/N 682–0001), shipped with exciter accessory pack.

F. Fuse, 1 Ampere, Type AGC, quick acting.

G. Digital voltmeter (Fluke 75 or equivalent).

2–95. **Procedure.** To adjust the control, proceed as follows:

WARNING ***DISCONNECT ALL TRANSMITTER PRIMARY POWER BEFORE PROCEEDING.***

WARNING

2–96. Assure all transmitter power is off.

2–97. Open the transmitter rear door and disconnect all plugs and cables from the rear of the transmitter controller chassis.

2–98. Remove the eight screws securing the transmitter controller in the rack.

2–99. Remove the transmitter controller from the rack and set the chassis on a work surface.

2–100. Remove the screws which secure the top on the transmitter controller and remove the top cover.

2–101. Remove the four screws securing the power supply in the chassis.

2–102. Disconnect the plug from the power supply circuit board.

2–103. Lift the power supply out of the chassis and set it on top of the card cage.

2–104. Connect the voltmeter between J2 pin 6 and chassis ground.

2–105. Remove the ac line voltage selector circuit board with a small pair of needle–nose pliers, reinsert the circuit board so that 115/120V is visible when the circuit board is reinserted into the receptacle.

2–106. Replace the fuse with a 1 Ampere fuse.

WARNING ***MAINTENANCE WITH POWER ENERGIZED IS ALWAYS CONSIDERED HAZARDOUS AND THEREFORE CAUTION SHOULD BE OBSERVED. DO NOT TOUCH ANY COMPONENTS WITHIN THE POWER SUPPLY MODULE WHEN POWER IS ENERGIZED.***

WARNING

2–107. Apply power to the controller and adjust R2 to obtain a voltmeter indication of 15.3 volts dc.

WARNING *DISCONNECT PRIMARY POWER BEFORE PROCEEDING.*

WARNING

2–108. Assure primary power is disconnected before proceeding.

2–109. Disconnect the voltmeter.

2–110. Remove the ac line voltage selector circuit board with a small pair of needle–nose pliers. Reinsert the circuit board so that 220V is visible when the circuit board is reinserted into the receptacle.

2–111. Replace the fuse with the original 1/2 Ampere slow–blow fuse.

2–112. Secure the power supply in the controller chassis and reconnect the circuit board plug.

2–113. Replace the top cover on the controller.

WARNING *DISCONNECT ALL TRANSMITTER PRIMARY POWER BEFORE PROCEEDING.*

WARNING

2–114. Replace the controller in the transmitter. Connect the rear panel plugs.

2–115. **AC POWER LOSS ADJUST.** This adjustment is required only if the AC power loss circuitry is repaired. To adjust the AC power loss control on the power supply circuit board, proceed as follows.

2–116. **Required Equipment.** The following equipment is required to adjust AC power loss control R12.

A. Flat–blade screwdriver, 1/4 inch tip.

B. No. 2 Phillips screwdriver, 11 inch blade.

C. Insulated adjustment tool, flat–tip (BE P/N 407–0083).

D. Small pair of needle–nose pliers.

E. Power interlock line cord (BE P/N 682–0001), shipped with exciter accessory pack.

F. Fuse, 1 Ampere, Type AGC, quick acting.

G. Digital voltmeter (Fluke 75 or equivalent).

H. Variac.

2–117. **Procedure.** To adjust the control, proceed as follows:

WARNING *DISCONNECT ALL TRANSMITTER PRIMARY POWER BEFORE PROCEEDING.*

WARNING

2–118. Assure all transmitter power is off.

2–119. Open the transmitter rear door and disconnect all plugs and cables from the rear of the transmitter controller chassis.

2–120. Remove the eight screws securing the transmitter controller in the rack.

2–121. Remove the transmitter controller from the rack and set the chassis on a work surface.

2–122. Remove the screws which secure the top on the transmitter controller and remove the top cover.

2–123. Remove the four screws securing the power supply in the chassis.

2–124. Disconnect the plug from the power supply circuit board.

2–125. Lift the power supply out of the chassis and set it on top of the card cage.

2–126. Connect the voltmeter between J2 pin 5 and chassis ground.

2–127. Remove the ac line voltage selector circuit board with a small pair of needle–nose pliers, reinsert the circuit board so that 115/120V is visible when the circuit board is reinserted into the receptacle.

2–128. Replace the fuse with a 1 Ampere fuse.

2–129. Connect the controller to the variac using the power interlock line cord.

2–130. Apply power to the variac and adjust the unit as follows:

WARNING ***MAINTENANCE WITH POWER ENERGIZED IS ALWAYS CONSIDERED HAZARDOUS AND THEREFORE CAU-***

WARNING ***TION SHOULD BE OBSERVED. DO NOT TOUCH ANY COMPONENTS WITHIN THE POWER SUPPLY MODULE WHEN POWER IS ENERGIZED.***

A. Adjust the variac for an output of approximately 90 volts.

B. Refer to the power supply circuit board assembly diagram in SECTION III and adjust ac sample control R12 until the voltmeter just indicates 0 volts dc.

C. Adjust the variac for an output of approximately 97 volts. The voltmeter will indicate approximately 14 volts. If a 14 volt indication is not observed, repeat the preceding adjustment procedure and adjust the ac sample control slightly.

WARNING ***DISCONNECT ALL PRIMARY POWER BEFORE PRO-CEEDING.***

WARNING

2–131. Assure primary power is disconnected before proceeding.

2–132. Disconnect the voltmeter.

2–133. Remove the ac line voltage selector circuit board with a small pair of needle–nose pliers. Reinsert the circuit board so that 220V is visible when the circuit board is reinserted into the receptacle.

2–134. Replace the fuse with the original 1/2 Ampere slow–blow fuse.

2–135. Secure the power supply in the controller chassis and reconnect the circuit board plug.

2–136. Replace the top cover on the controller.

WARNING ***DISCONNECT ALL TRANSMITTER PRIMARY POWER BEFORE PROCEEDING.***

WARNING

2–137. Replace the controller in the transmitter. Connect the rear panel plugs.

2–138. **TROUBLESHOOTING.**

WARNING ***NEVER OPEN THE EQUIPMENT UNLESS ALL TRANSMITTER PRIMARY POWER IS DISCONNECTED. USE THE GROUNDING STICK PROVIDED TO ENSURE ALL COMPONENTS AND ALL SURROUNDING COMPONENTS ARE DISCHARGED BEFORE ATTEMPTING ANY MAINTENANCE ON ANY AREA WITHIN THE TRANSMITTER.***

WARNING

2–139. Most troubleshooting consists of visual checks. Because of the voltages and high currents in the equipment, it is considered hazardous to work with power energized. Therefore, the various transmitter indicators (meters, LEDs, and fuses) should be used to isolate the malfunction to one specific area.

2–140. Troubleshooting within the controller circuit board enclosure is not considered hazardous due to the low potentials and currents involved. An extender circuit board (BE P/N 919–0061) is provided to assist troubleshooting. When the extender circuit board is not used, it must be inserted in the far left side position in the controller card cage to allow the front door to close.

2–141. Once the trouble is isolated and power is totally deenergized, it is suggested that the exact problem be located with resistance checks using the schematic diagrams and theory of operation presented throughout the text.

CAUTION ***MANY COMPONENTS IN THE TRANSMITTER ARE MOUNTED TO HEAT–SINKS UTILIZING A THIN FILM OF HEATSINK COMPOUND FOR THERMAL CONDUCTION.***

CAUTION

CAUTION ***IF ANY SUCH COMPONENT IS REPLACED, ENSURE A THIN FILM OF A ZINC–BASED HEAT–SINK COMPOUND IS USED (BE P/N 700–0028) TO ASSURE GOOD HEAT DISSIPATION.***

CAUTION

2–142. If a circuit is diagnosed as faulty, the circuit fault may be isolated and repaired locally or the entire device may be returned to Broadcast Electronics, Inc. for exchange, alignment, or replacement.

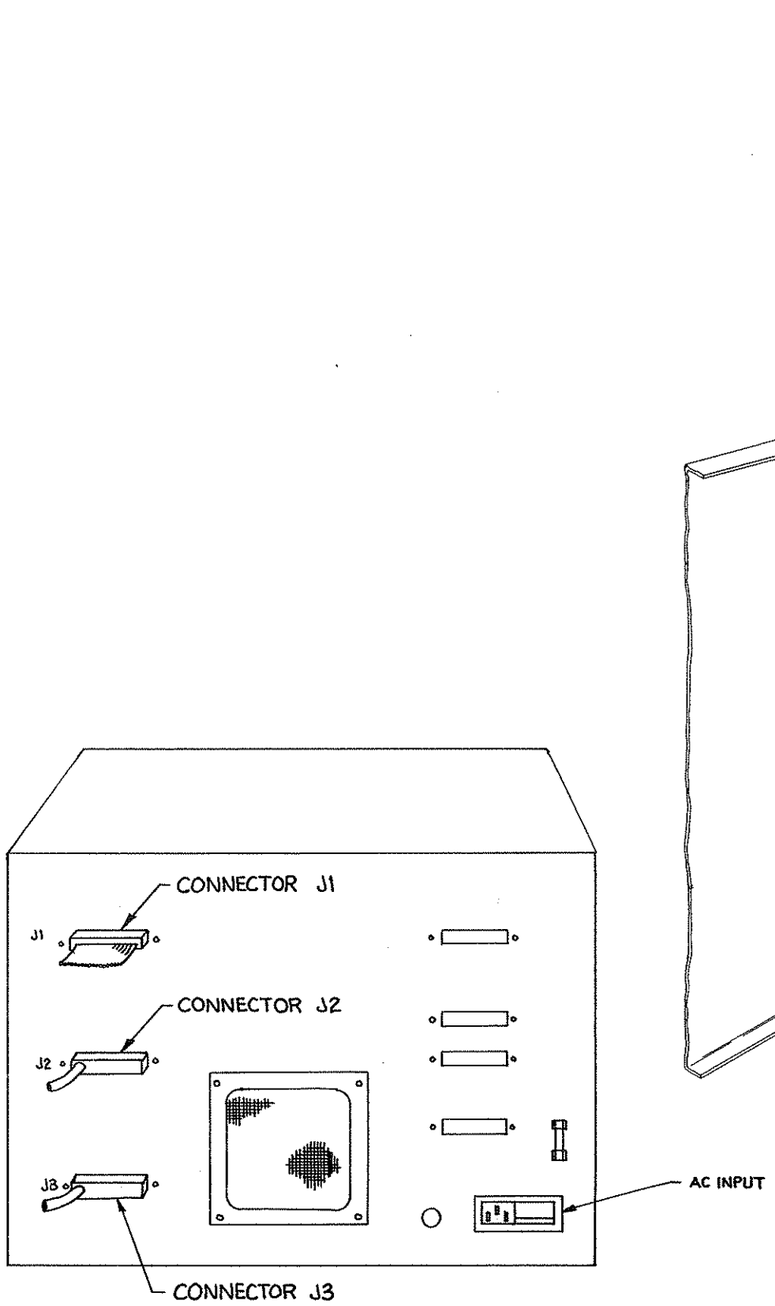
2–143. A built–in microprocessor video diagnostic system is optionally available which enables the transmitter controller to display fault conditions and diagnosis to the sub–system level in plain English on a CRT screen. The system may be field–installed in an existing transmitter.

SECTION III
DRAWINGS

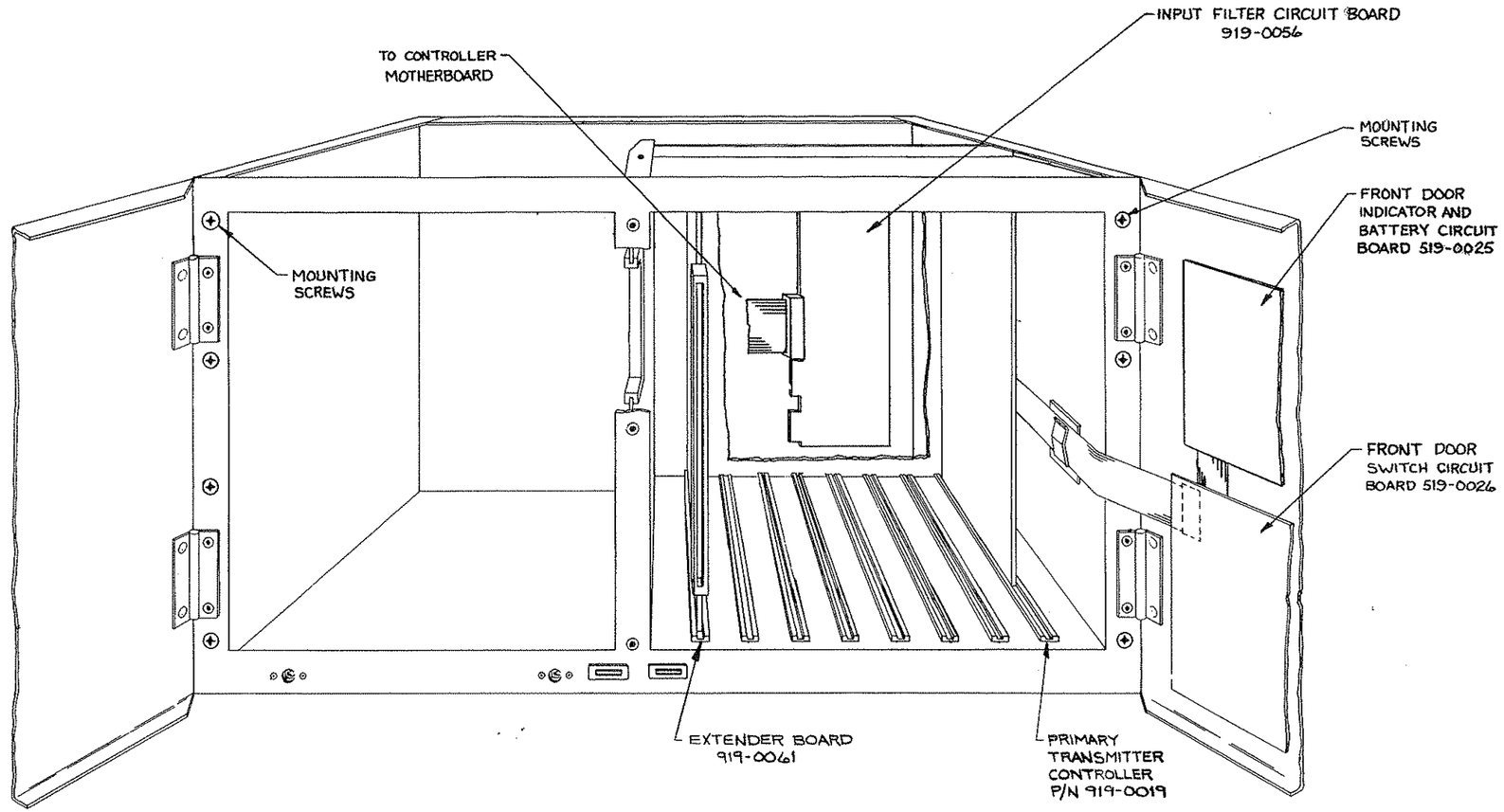
3-1. INTRODUCTION.

3-2. This section provides assembly drawings, schematic diagrams, and wiring diagrams as indexed below for the FM-5B/FM-5BS transmitter controller.

FIGURE	TITLE	NUMBER
3-1	ASSEMBLY, CONTROLLER CABINET	597-0032-105
3-2	SCHEMATIC, INPUT FILTER CIRCUIT BOARD	SD919-0056
3-3	ASSEMBLY, INPUT FILTER CIRCUIT BOARD	AD919-0056
3-4	ASSEMBLY, MOTHERBOARD	597-0032-18
3-5	SCHEMATIC, OVERALL TRANSMITTER CONTROLLER POWER SUPPLY	SD959-0298-002
3-6	ASSEMBLY, POWER SUPPLY CIRCUIT BOARD	AB919-0111
3-7	SCHEMATIC, DOOR ELECTRICAL ASSEMBLY	597-0032-500
3-8	ASSEMBLY, DOOR ELECTRICAL ASSEMBLY	597-0032-501
3-9	SCHEMATIC, CONTROLLER CIRCUIT BOARD	SD919-0019
3-10	ASSEMBLY, CONTROLLER CIRCUIT BOARD	AD919-0019
3-11	COMPONENT LOCATOR, CONTROLLER CIRCUIT BOARD	597-0032-19

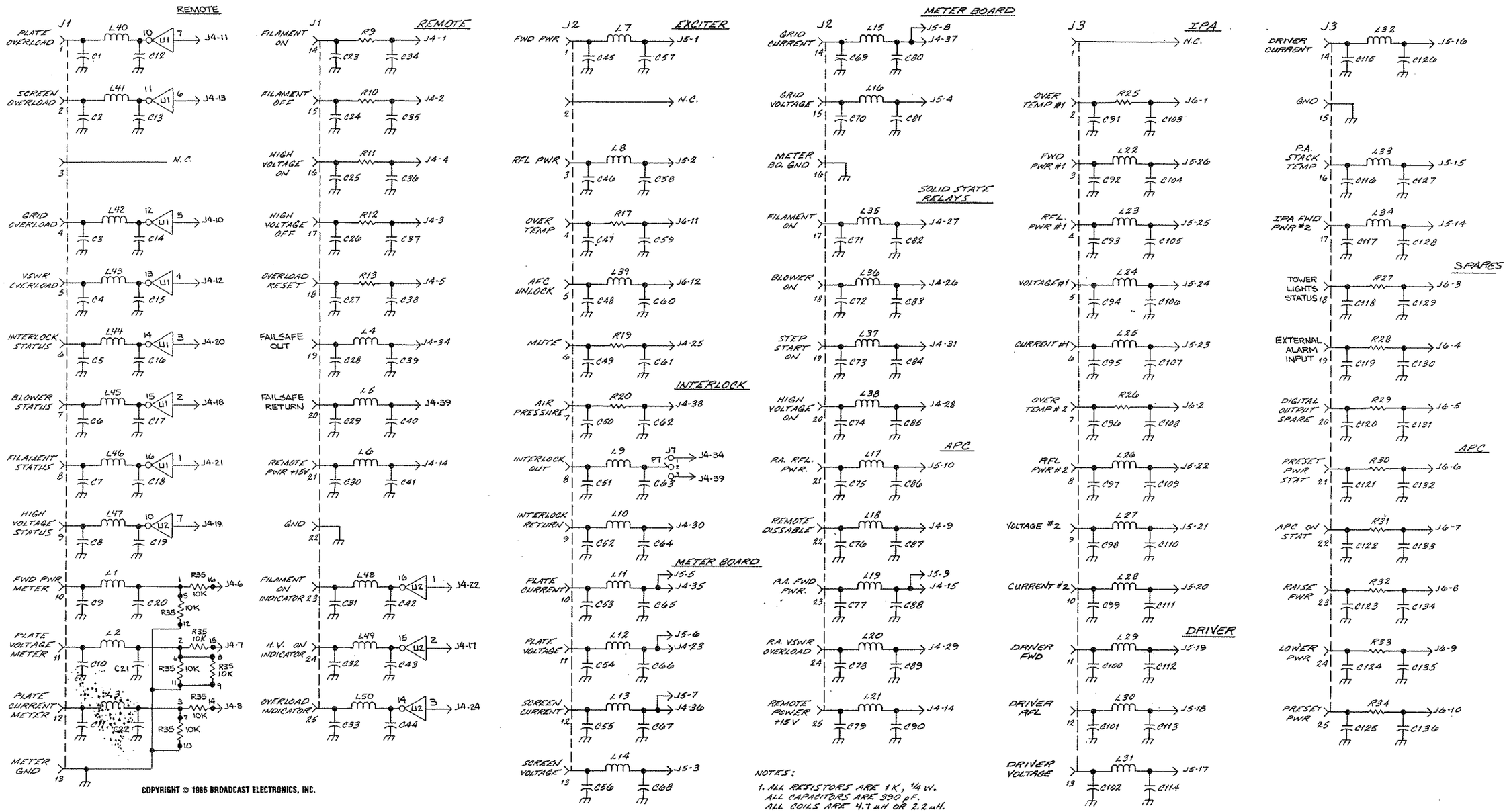


REAR PANEL VIEW



— CAUTION —
COMPONENT SIDE OF ALL CIRCUIT BOARDS TO LEFT

FIGURE 3-1.
ASSEMBLY, CONTROLLER CABINET



NOTES:

1. ALL RESISTORS ARE 1K, 1/4 W.
   ALL CAPACITORS ARE 390 pF.
   ALL COILS ARE 4.7 uH OR 2.2 mH.
2. LAST COMPONENTS USED: C136, L39, R35, U2, J7
3. COMPONENTS NOT USED: R18
   SEE ASSEMBLY # D919-0056
   SEE BIM # 919-0056
4. ON J7, CONNECT 1 TO 2 FOR INDEPENDENT FAILSAFE INTERLOCK STRING OR CONNECT 2 TO 3 FOR SERIAL FAILSAFE INTERLOCK. INDEPENDENT FAILSAFE INTERLOCK REQUIRES REVISION C OR LATER PRIMARY TRANSMITTER CONTROLLER BOARD.

TOLERANCE UNLESS OTHERWISE SPECIFIED
DECIMAL 2 PL=.01 3PL=.005
FRACTIONAL ±1/64
ANGULAR ± 1°
SHARP EDGES TO BEND RADII
FILLET RADII
MATERIAL
TREATMENT OR FINISH

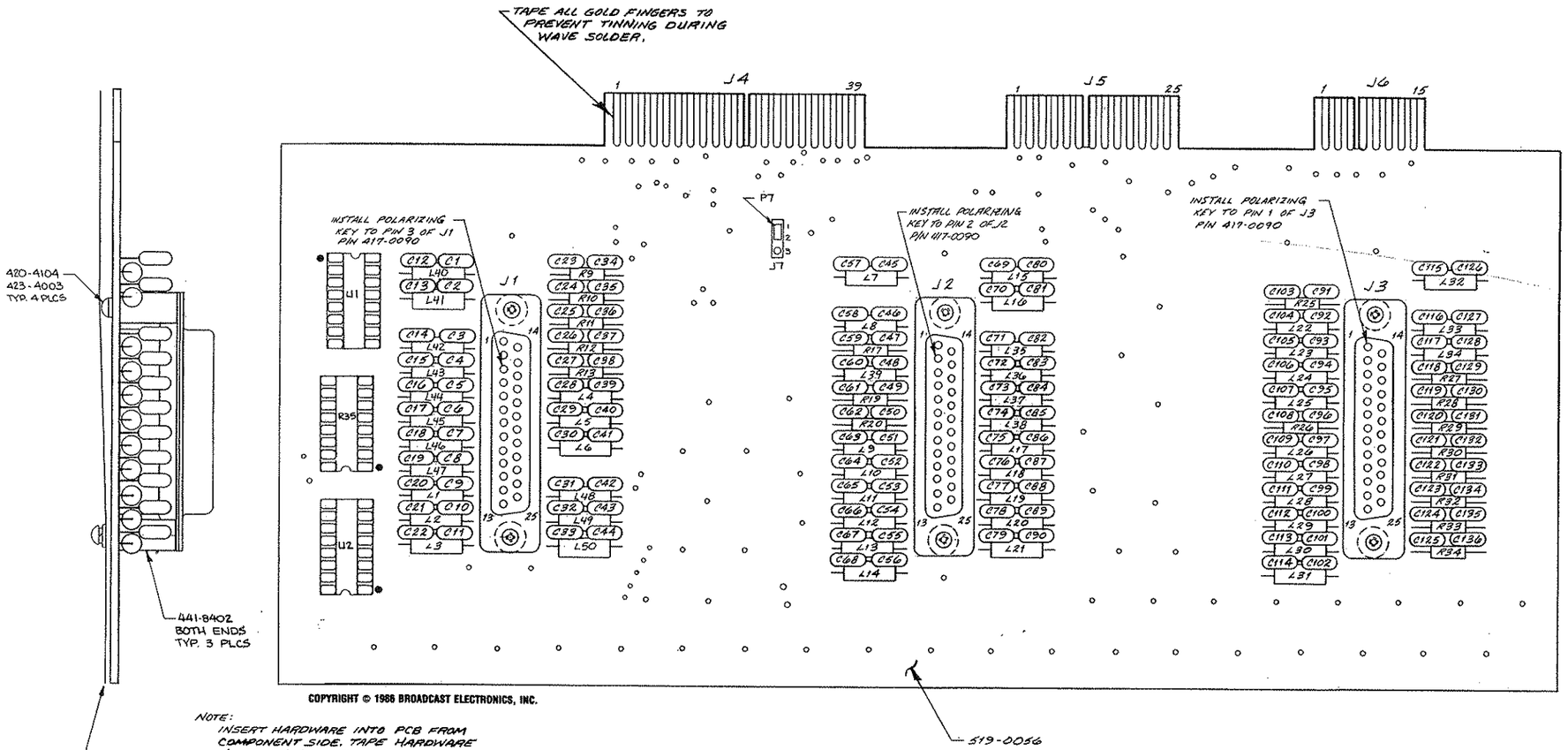
DRAWN BY M.ERVEZ DATE 7-21-83
CHECKED BY
PROJECT ENGR. DATE 7-27-83
APPROVED BY MH DATE 5-13-83

BROADCAST ELECTRONICS INC.

TITLE SCHEMATIC - TRANSMITTER CONTROLLER INPUT FILTER BD.

D DWG. NO. TYPE 3 919-0056 REV. G

TRANSMITTER CONTROLLER SCALE 2/1 SHEET 1 OF 1



NOTE:
INSERT HARDWARE INTO PCB FROM COMPONENT SIDE. TAPE HARDWARE HOLES ON CIRCUIT SIDE OF PCB TO PREVENT FILLING DURING WAVE SOLDER. AFTER WAVE SOLDER, REMOVE HARDWARE FROM COMPONENT SIDE AND INSERT INTO CIRCUIT SIDE OF PCB.

SEE SCHEMATIC # D919-0056
SEE B/M # 919-0056

NOTE:
1. L1-L39 MAY BE EITHER 2.2 uH OR 4.7 uH UNDER P/N 360-0022.
2. FOR MOSLEY REMOTE CONTROL SYSTEMS, REPLACE U1, U2 & R35 WITH JUMPERS P/N 360-0006. INSTALL JUMPER AT PIN 1 POSITION OF R35.

TOLERANCE UNLESS OTHERWISE SPECIFIED
DECIMAL 2 PL=.01 3PL=.005
FRACTIONAL ±1/64
ANGULAR ± 1°
SHARP EDGES TO BEND RADII
FILLET RADII
MATERIAL

TREATMENT OR FINISH

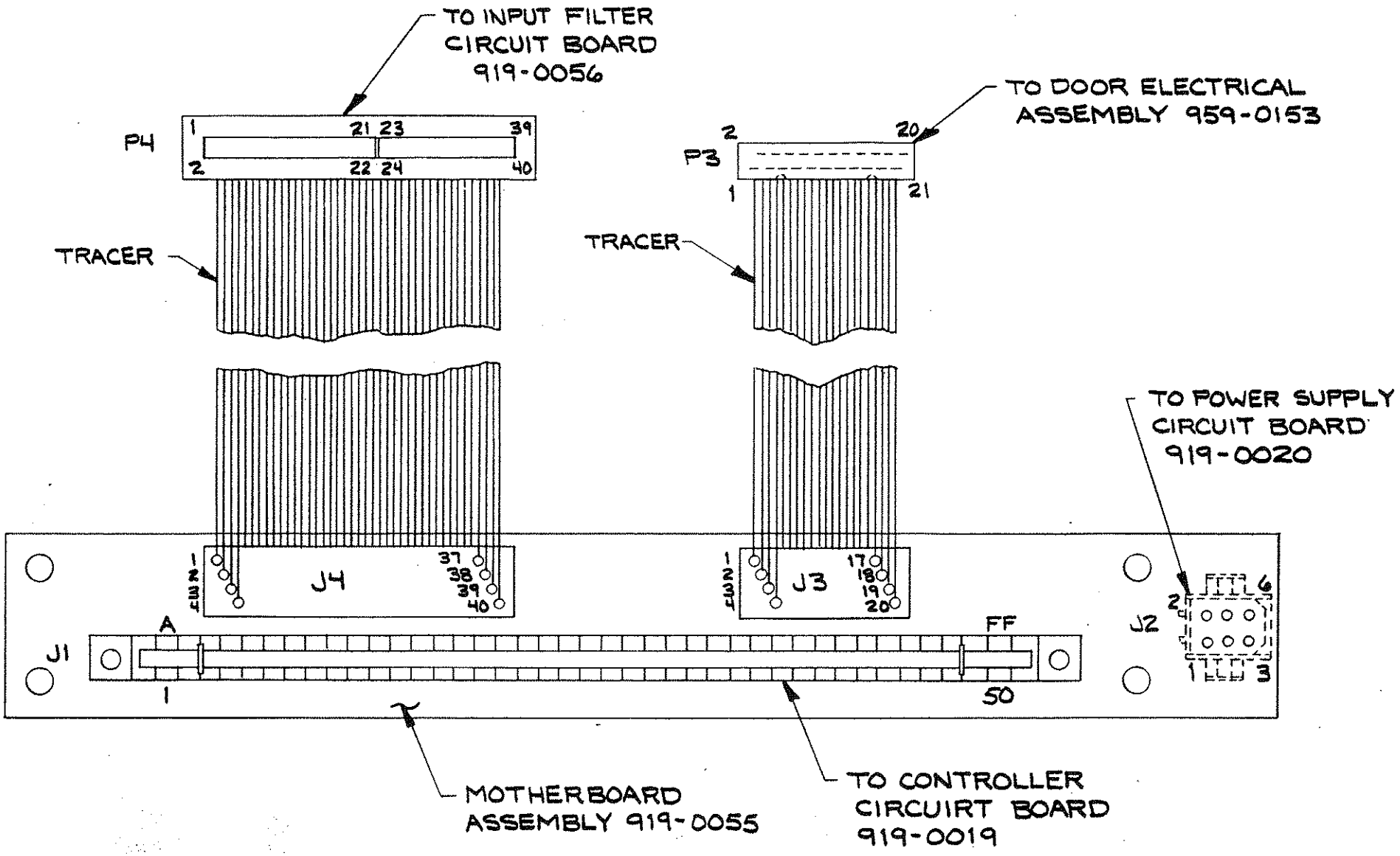
DRAWN BY MCKELL DATE 1-20-83
CHECKED BY
PROJECT ENGR DATE 5-13-83
APPROVED BY MH

BROADCAST ELECTRONICS INC.

TITLE PCB ASSEMBLY-TRANSMITTER CONTROLLER INPUT FILTER BD.

D DWG. NO. TYPE A 919-0056 REV. F

TRANSMITTER CONTROLLER SCALE 2/1 SHEET 1 OF 1



597-0032-18

FIGURE 3-4. MOTHERBOARD ASSEMBLY

RFI FILTER
360-6504

PRIMARY VOLTAGE SELECTION CIRCUIT BOARD

100V 115/120V 230V 230/240V

97 TO 133 OR 194 TO 266 VAC — NEUTRAL
VAC SINGLE — EARTH GROUND
SINGLE PHASE 50/60 Hz — LINE

P5 J5

418-0026 FILE SHORTING BAR JUMPERS MTG ON J5

KEY 418-0026

STANDARD CONTROLLER TRANSFORMER PRIMARY

T1 P3 P4 J4

BLU/WHT — VL 100MA — BLU
OR 400MA OR
BLK/WHT — YL 2A — BN — BLK

FAN

MOV1

P6 J6

ASSY AC919-0111

LM350K — U1 — 7815CT — U2 — LM78L15 — U3

MR502 D19 — 1N4004 D20 — 1N4004 D21

D1 D2 D7 D8 MR502 — D3 D4 D9 D10 1N4004 — D5 D6 D11 D12 1N4004

D16 MR502 — D17 D18 1N4004 — D15 1N4004 — D22 1N4742 12V

C1 15000/50V — C2 2500/50V — C4 C5 C6 C7 .1 — C8 C9 C10 10/50V — C11 C12 1/50V — C13 .1

R1 470/2W — R2 1.27K 1% — R3 200 — R5 120 — R11 1K — R12 10K — R13 15K — R14 470K — R15 47K

4538 U4 A — POWER PRESENT 0/5

4538 U4 B — POWER RETURN DELAY

D24 1N6276A 16V

Q1 2N3904

1N4005 D23

CONTROLLER REGULATOR 15V @ 750MA
POWER FAIL 12V @ 10MA
REMOTE REGULATOR 15V @ 75MA
CONTROLLER GROUND
INTERLOCK REGULATOR 15V @ 75MA

P2 KEY 418-0026 P2 J2 — STD CNTRLR MOTHER BD

919-0110

NOTES:
1) ALL RESISTORS IN OHMS, 1/4W 5% CAPACITORS IN MICROFARADS, UNLESS OTHERWISE SPECIFIED.
2) ▷ HEATSINK REQUIRED.
3) LAST COMPONENTS USED:
C13 R15 D24 Q1
U4 J3 T1
4) #13, 14, 15, AND 16 ARE LOCATED ON ASSY. AC959-0157.

TOLERANCE (DECIMAL) U.O.S.
.x ± .030 .xxx ± .005
.xx ± .015 ANGLES ± 1°

DWN. BY ARCH. 9/8/93
DESIGNER(S)
PROJ. LEADER
MFG.

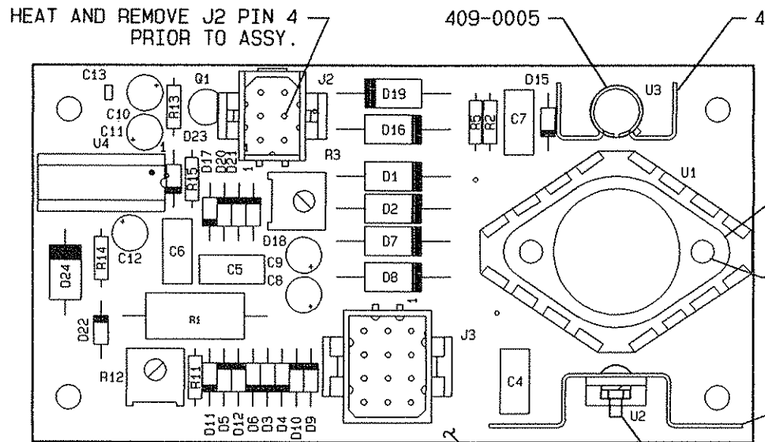
MATERIAL
FINISH
SEE DWG RA592-0000
NEXT ASSY.

BROADCAST ELECTRONICS INC.
4100 N. 24TH ST., P.O.BOX 3606 QUINCY, IL. 62305 217/224-9600
TELEX 250142 CABLE BROADCAST FAX 217/224-9607

TITLE: OVERALL SCHEMATIC
POWER SUPPLY FOR XMTR CONTLR

TYPE S | SIZE D | DWG. NO. 959-0298-002 | REV C

MODEL - | SCALE NONE | SHEET 1 OF 1



HEAT AND REMOVE J2 PIN 4 PRIOR TO ASSY.

409-0005

455-0024

ADD A THIN FILM OF THERMAL JOINT COMPOUND BE700-0028 BETWEEN HEATSINK 455-6016 AND U1.

420-6106
421-6001
423-6003
2 PLCS.
TIGHTEN TO
10 ±1 IN.-LBS.

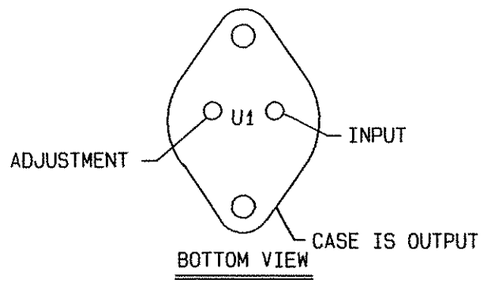
455-0221

519-0111

420-4105
421-4007
423-4002

NOTES:

1. LAST COMPONENT USED: R15, C13, D24, Q1, U4, & J3.
2. SEE SCHEMATIC SD 959-0089 / SB 959-0298-002.



BOTTOM VIEW

TOLERANCE (DECIMAL) U.O.S.
.X ± .030 .XXX ± .005
.XX ± .015 ANGLES + 1°

DWN. BY	JAH 9-4-91
CHKD	MH 5-9-89
ME	JHS 5-8-89
PROJ. ENGR.	JLT 5-8-89
MFG.	PRB 5-8-89

MATERIAL: SEE B/M 919-0111

FINISH:

SEE DWG RA592-0000

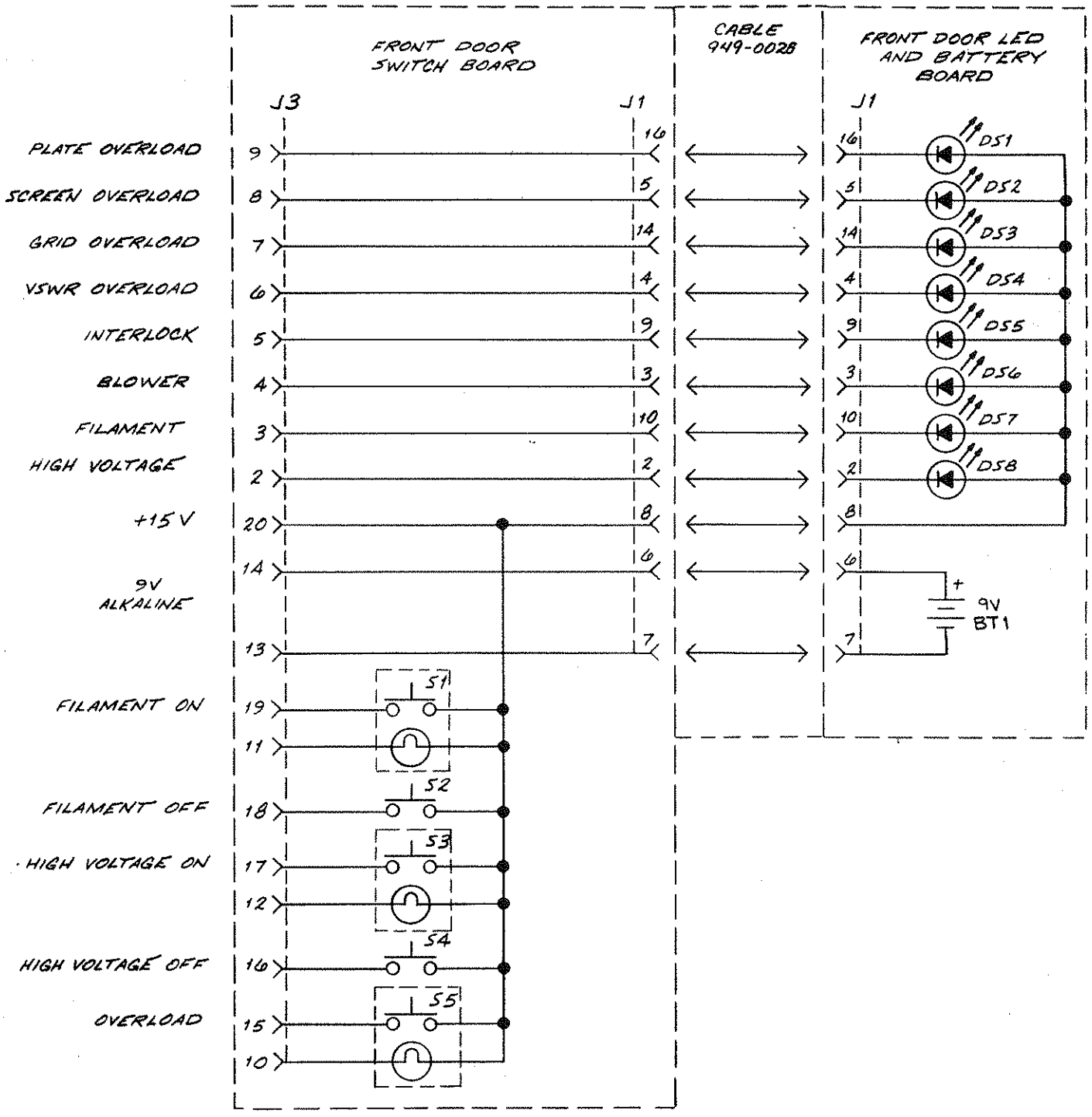
NEXT ASSY.

BROADCAST ELECTRONICS INC.
4100 N.24TH ST. P.O.BOX 3606 QUINCY, IL. 62305 PH. 217/224-9600
TELEX 250142 CABLE BROADCAST FAX 217/224-9607

TITLE: PCB ASSEMBLY
CONTROLLER POWER SUPPLY BD

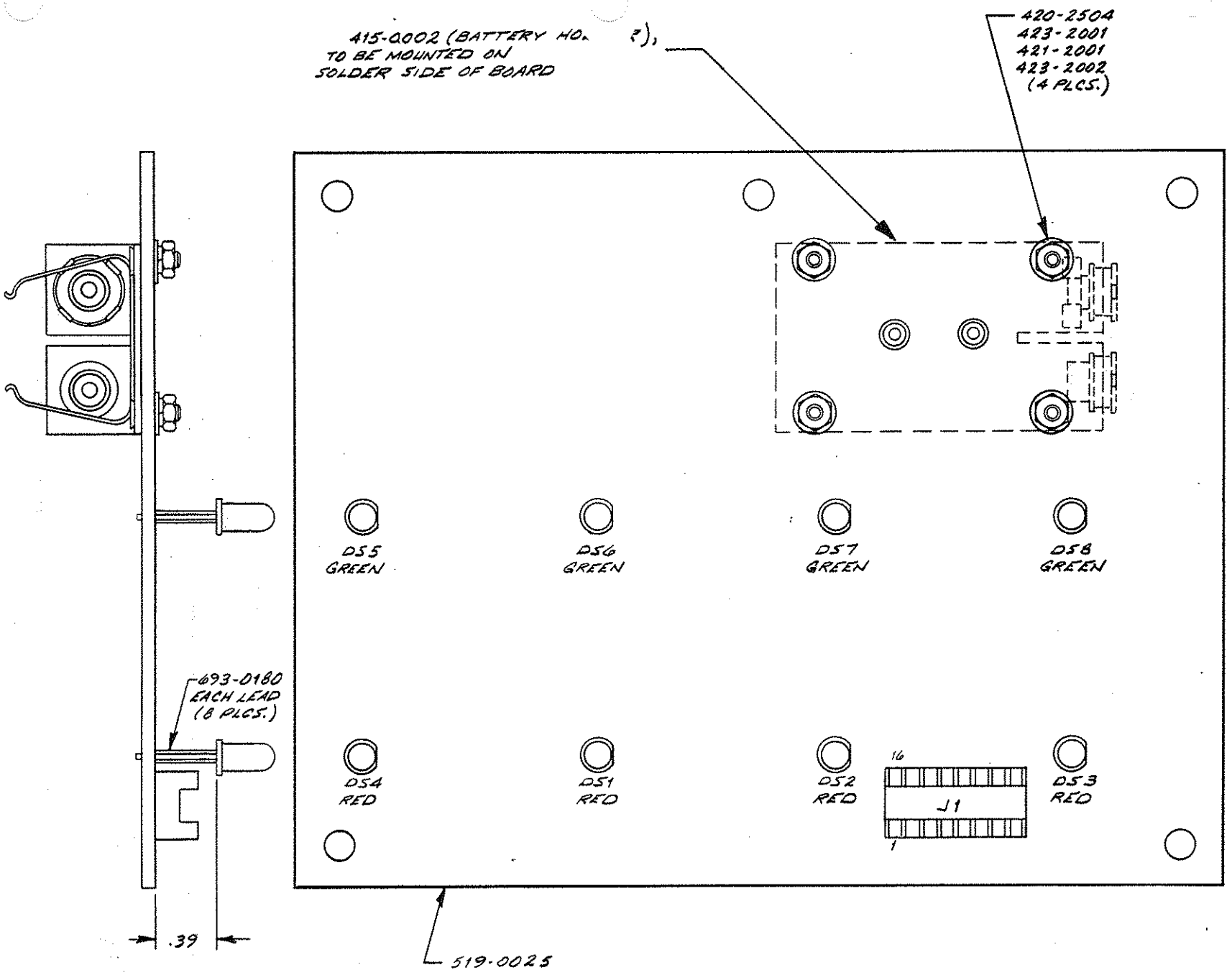
TYPE	SIZE	DWG No.	REV
A	B	919-0111	E

MODEL XMTRS | SCALE 1=1 | SHEET 1 OF 1



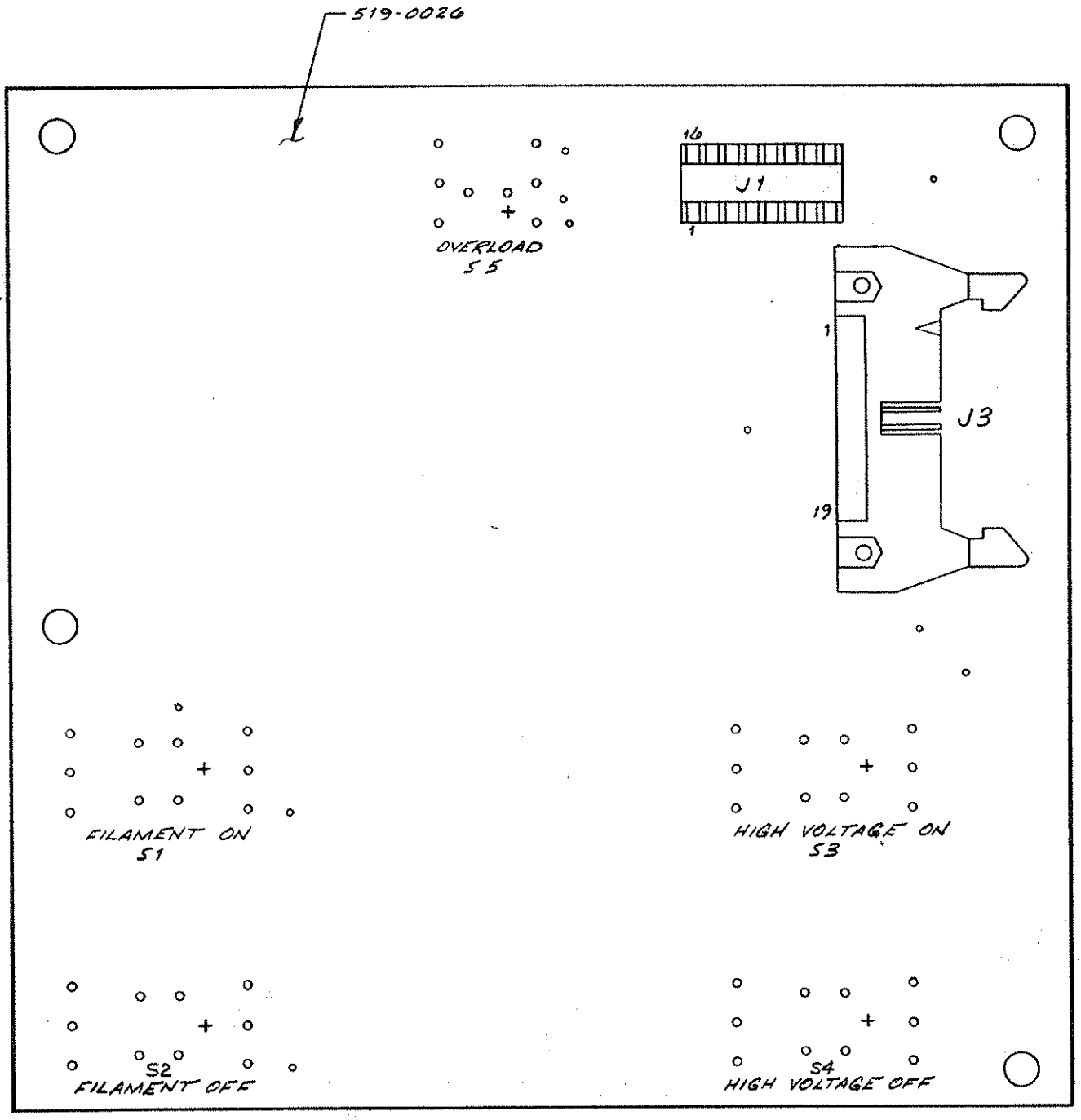
597-0032-500

FIGURE 3–7. SCHEMATIC, DOOR ELECTRICAL ASSEMBLY



597-0032-501A

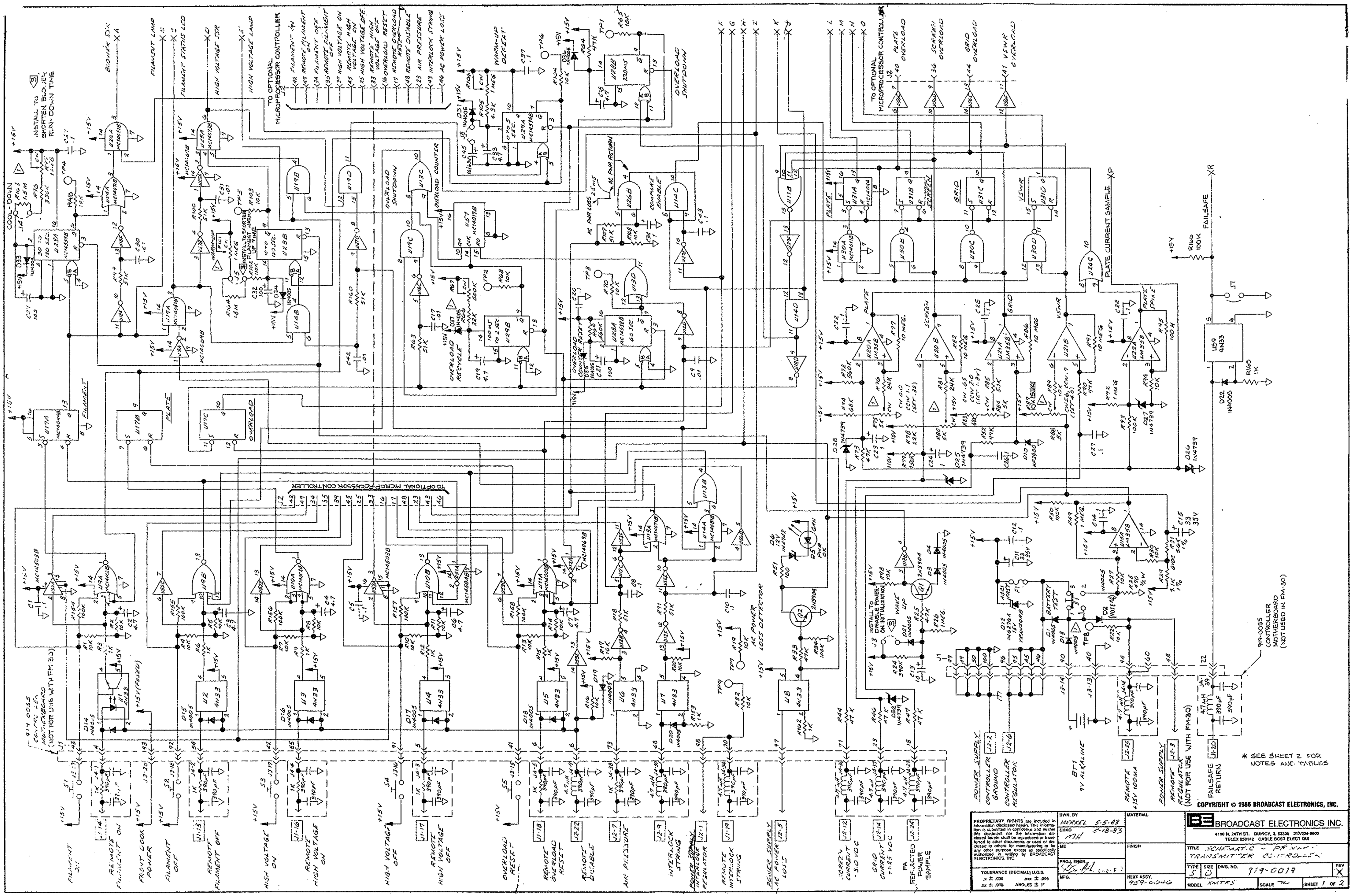
FIGURE 3–8. ASSEMBLY, DOOR ELECTRICAL ASSEMBLY (Sheet 1 of 2)



NOTES:
1. WHEN INSTALLING SWITCHES, (+) TERMINAL MUST MATCH (+) INDICATOR ON PC BOARD.
2. SWITCHES ARE ADDED DURING FINAL DOOR ASSEMBLY.

597-0032-501B

FIGURE 3–8. ASSEMBLY, DOOR ELECTRICAL ASSEMBLY (Sheet 2 of 2)



TO OPTIONAL MICROPROCESSOR CONTROLLER
FAILSAFE
PLATE CURRENT SAMPLE
* SEE SHEET 2 FOR NOTES AND TABLES
919-0055 CONTROLLER MOTHERBOARD (NOT USED IN FM-30)
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BROADCAST ELECTRONICS INC.
4100 N. 24TH ST. QUINCY, IL 62305 217/224-9600
TELEX 250142 CABLE BCST ELECT QUI
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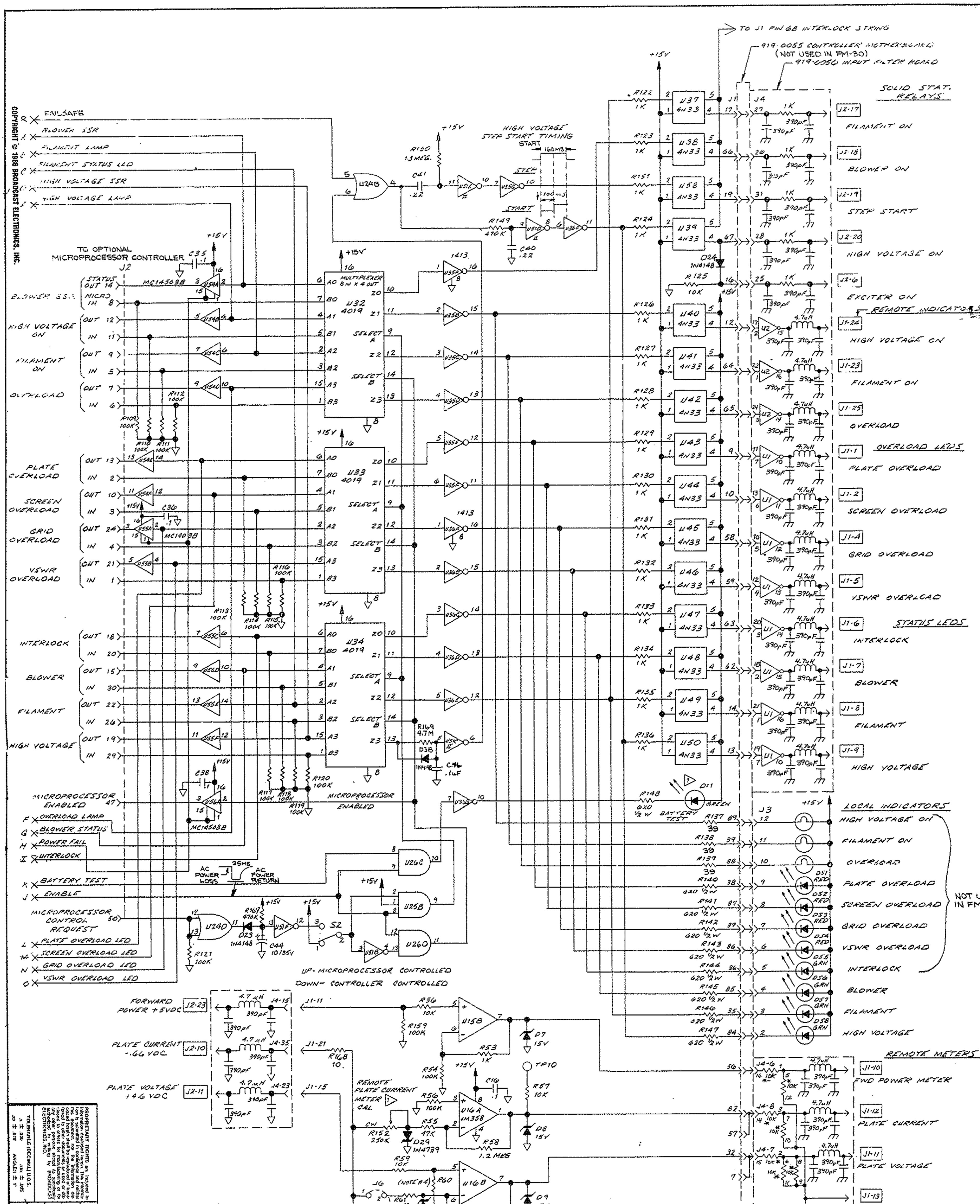
TOLERANCE (DECIMAL) U.O.S.
DWN. BY MERKEL 5-5-83
CHKD 5-18-83
NEXT ASSY. 959-0046
DWG. NO. 919-0019
SHEET 1 of 2



NOTES:

1.) ALL RESISTORS IN OHMS, 1/4 W, 5%; ALL CAPACITORS IN MICROFARADS, UNLESS OTHERWISE NOTED.

2.) [1▷] - DESIGNATES COMPONENTS WHICH ARE CARD EDGE MOUNTED.

3.) J3 TO BE REMOVED FOR NORMAL OPERATION IN ALL XMTRS USING BATTERY BACK UP.
J4 & J5 REMOVED FOR FM 1.5A ONLY.
J6 USED IN POSITION 1 TO 2 FOR FM30, REMOVED FOR OTHER XMTRS.

4.) R60, 10K 1/4W 5%; AND Q2; INSTALLED FM-30 ONLY.

5.) MICROPROCESSOR CONTROLLER OPTION NOT AVAILABLE IN FM-30 TRANSMITTER.
SEE ASSEMBLY # 919-0019
SEE B/M # 919-0019 OR 919-0019-001(FM30)

6.) SHADED AREA FM30 ONLY

REFERENCE DESIGNATORS			
LAST USED	NOT USED	LAST USED	NOT USED
C45		R168	R23
D32	R161	52	R37-R43
F1	R35	TP10	R45
J8		U59	
Q2	R21		

REFERENCE DESIGNATORS	U1-U8 U37-U50, U58	U9-U11	U12, U18, U27	U13, U24	U14, U19, U26	U15, U16, U20-U22	U17, U31	U23, U28, U29	U25	U30	U32-U34	U35, U36	U51	U52-U56	U57
B.E. PART NO.	229-0033		228-4023	225-0005	225-4008	221-0358			228-4075	228-4011	228-4019	229-2003	228-4584		220-4017
VENDOR PART NO.	4N33	MC14002B	MC14023	MC14081B	MC14081B	LM358AN	MC14044B	MC14538B	MC14073B	MC14011B	14019B	MC1413	MC14584B	MC14503B	MC14017B
VOLTAGE PIN NO.	WA	14	14	14	14	8	16	16	14	14	16	NA	14	16	16
GROUND PIN NO.	WA	7	7	7	7	4	8	1,3,15	7	7	8	8	7	8	8

TOLERANCE (DECIMAL) U.O.S. .x ± .030 .xx ± .010 .xxx ± .005 ANGLES ± 1°

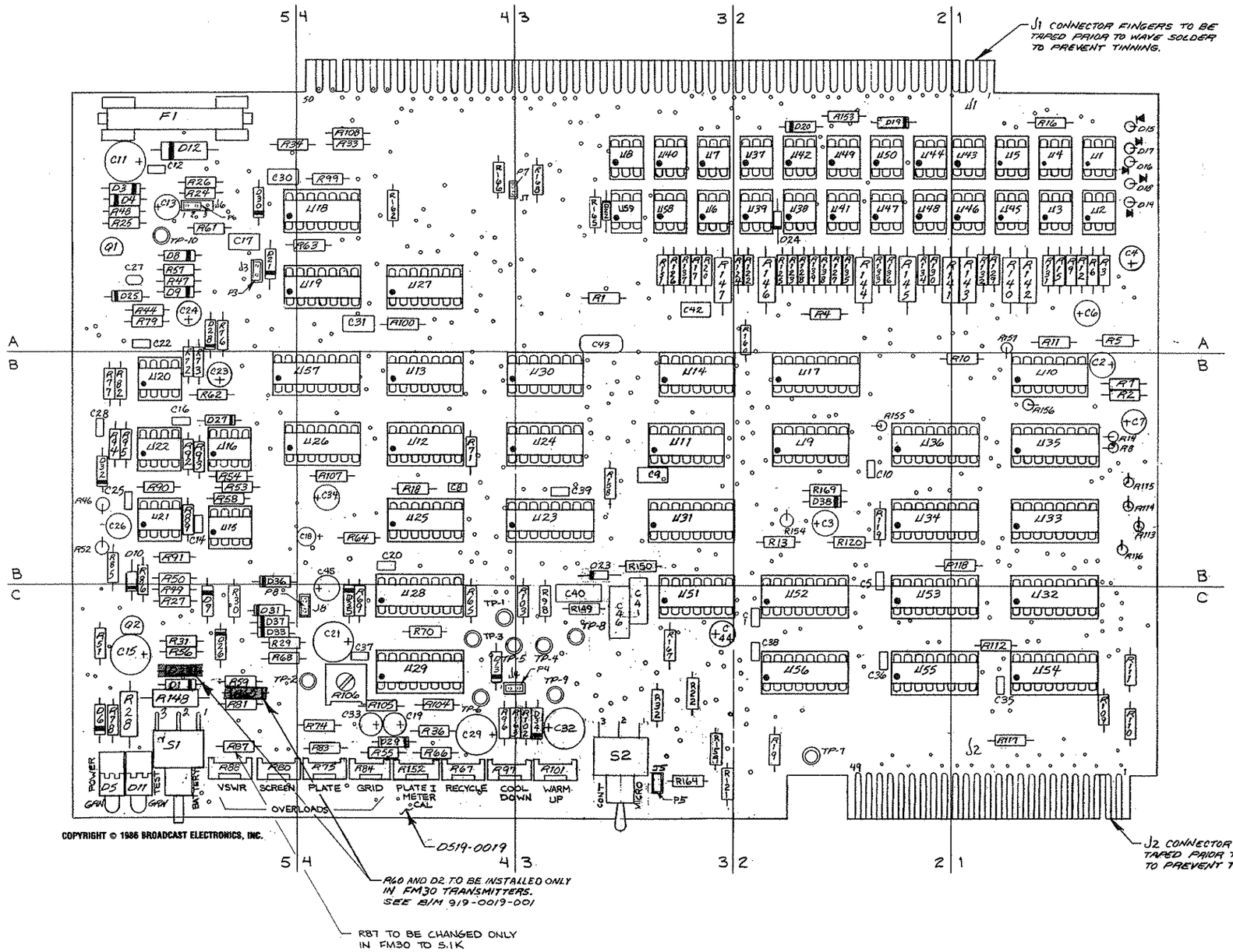
DWN. BY MERKEL 5-5-83
CHKD MH 5-18-83
ME
PROJ. ENGR.
MFG.
MATERIAL
FINISH
NEXT ASSY. 959-0046

BROADCAST ELECTRONICS INC.
4100 N. 24TH ST. QUINCY, IL 62305 217/224-9600
TELEX 250142 CABLE BCST ELECT QUI

TITLE SCHEMATIC - PRIMARY TRANSMITTER CONTROLLER

TYPE 5 SIZE D DWG. NO. 919-0019 REV X

MODEL XMTRS SCALE — SHEET 2 OF 2



TOLERANCE UNLESS OTHERWISE SPECIFIED
DECIMAL 2 PL=.01 3PL=.005
FRACTIONAL ±1/64
ANGULAR ± 1°
SHARP EDGES TO BEND RADII
FILLET RADII

MATERIAL

TREATMENT OR FINISH

DRAWN BY DAF DATE 1-28-83
CHECKED BY DATE
PROJECT ENGR. N/A DATE 3-24-83
APPROVED BY MH 5-16-83

BROADCAST ELECTRONICS INC.

TITLE ASSEMBLY PRIMARY TRANSMITTER CONTROLLER

D DWG. NO. 919-0019 REV.
A 919-0019-001 X

SCALE 2/1 SHEET 1 OF 1

REF	ZONE	REF	ZONE	REF	ZONE	REF	ZONE	REF	ZONE	REF	ZONE	REF	ZONE	REF	ZONE
C1	C2	C44	C3	J4	C3	R32	C3	R75	C4	R118	B1	R161	---	U23	B3
C2	B1	C45	B4-C4	J5	C3	R33	A4	R76	A5	R119	B2	R162	A3	U24	B3
C3	B2	C46	C3	J6	A5	R34	A4	R77	B5	R120	B2	R163	C3	U25	B4
C4	A1	D1	C5	J7	A3-A4	R35	---	R78	C5	R121	B3	R164	C3	U26	B4
C5	B2	D2	--	J8	C4	R36	C4	R79	A5	R122	A2	R165	A3	U27	A4
C6	A1	D3	A5	P3	A5	R37	---	R80	C5-C4	R123	A2	R166	A4	U28	C4
C7	B1	D4	A5	P4	C3	R38	---	R81	C5	R124	A2	R167	C3	U29	C4
C8	B4	D5	C5	P5	C3	R39	---	R82	B5	R125	A2	R168	A3	U30	B3
C9	B3	D6	C5	P6	A5	R40	---	R83	C4	R126	A3	R169	B2	U31	B3-B2
C10	B2	D7	C5	P8	C4	R41	---	R84	C4	R127	A2	S1	C5	U32	C1
C11	A5	D8	A5	Q1	A5	R42	---	R85	B5	R128	A2	S2	C3	U33	B1
C12	A5	D9	A5	Q2	C5	R43	---	R86	B5	R129	A1	TP1	C3	U34	B2-B1
C13	A5	D10	B5	R1	A3	R44	A5	R87	C5	R130	A2-A1	TP2	C4	U35	B1
C14	B5	D11	C5	R2	B1	R45	---	R88	C5	R131	A1	TP3	C4	U36	B2-B1
C15	C5	D12	A5	R3	A1	R46	B5	R89	B5	R132	A1	TP4	C3	U37	A2
C16	B5	D13	C4-C3	R4	A2	R47	A5	R90	B5	R133	A2	TP5	C3	U38	A2
C17	A5	D14	A1	R5	A1	R48	A5	R91	B5	R134	A2	TP6	C4	U39	A2
C18	B4	D15	A1	R6	A1	R49	B5-C5	R92	B5	R135	A2	TP7	C2	U40	A3
C19	C4	D16	A1	R7	B1	R50	B5	R93	B5	R136	A2	TP8	C3	U41	A2
C20	B4	D17	A1	R8	B1	R51	C5	R94	B5	R137	A3	TP9	C3	U42	A2
C21	C4	D18	A1	R9	A1	R52	B5	R95	B5	R138	A2	TP10	A5	U43	A1
C22	A5	D19	A2	R10	B1	R53	B5	R96	C3	R139	A2	U1	A1	U44	A2-A1
C23	B5	D20	A2	R11	A1	R54	B5	R97	C4-C5	R140	A1	U2	A1	U45	A1
C24	A5	D21	A5	R12	A1	R55	C4	R98	C3	R141	A1	U3	A1	U46	A1
C25	B5	D22	A3	R13	B2	R56	C5	R99	A4	R142	A1	U4	A1	U47	A2
C26	B5	D23	B3	R14	B1	R57	A5	R100	A4	R143	A1	U5	A1	U48	A2-A1
C27	A5	D24	A2	R15	A1	R58	B5	R101	C3	R144	A2	U6	A1	U49	A2
C28	B5	D25	A5	R16	A1	R59	C5	R102	C3	R145	A2	U7	A3-A2	U50	A2
C29	C4	D26	C5	R17	A3	R60	C5	R103	C3	R146	A2	U8	A3	U51	C3-C2
C30	A5-A4	D27	B5	R18	B4	R61	A5	R104	C4	R147	A2	U9	B2	U52	C2
C31	A4	D28	A5	R19	C2	R62	B5	R105	C4	R148	C5	U10	B1	U53	C2-C1
C32	C3	D29	C4	R20	A3	R63	A4	R106	C4	R149	C3	U11	B3	U54	C1
C33	C4	D30	A5	R21	---	R64	B4	R107	B4	R150	B3	U12	B4	U55	C2-C1
C34	B4	D31	C5	R22	C3	R65	B4	R108	A4	R151	A3	U13	B4	U56	C2
C35	C1	D32	B5	R23	---	R66	C4	R109	C1	R152	C4	U14	B3-B2	U57	B4
C36	C2	D33	C5	R24	A5	R67	C4	R110	C1	R153	A2	U15	B5	U58	A3
C37	C4	D34	C3	R25	A5	R68	C5-C4	R111	C1	R154	B2	U16	B5	U59	A3
C38	C2	D35	C4	R26	A5	R69	C4	R112	C1	R155	B2	U17	B2		
C39	B3	D36	B5-C5	R27	C5	R70	C4	R113	B1	R156	B1	U18	A4		
C40	B3-C3	D37	C5	R28	C5	R71	B4	R114	B1	R157	A1	U19	A4		
C41	B3-C3	D38	B2	R29	C5-C4	R72	B5	R115	B1	R158	B3	U20	B5		
C42	A3	F1	A5	R30	C5	R73	B5	R116	B1	R159	C2	U21	B5		
C43	A3	J3	A5	R31	C5	R74	C4	R117	C1	R160	A2	U22	B5		

A

597-0032-19

FIGURE 3-11. CONTROLLER CIRCUIT BOARD COMPONENT LOCATOR

SECTION IV
PARTS LIST

4–1. INTRODUCTION.

4–2. This section provides descriptions and part numbers of electrical components, assemblies, and selected mechanical parts required for maintenance of the Broadcast Electronics FM–5B/FM–5BS Transmitter Controller. Each table entry in this section is indexed by reference designators appearing on the applicable schematic diagram.

TABLE 4–1. TRANSMITTER CONTROLLER PARTS LIST INDEX

TABLE 4–2. TRANSMITTER CONTROLLER – 959–0298–002

REF. DES.	DESCRIPTION	PART NO.	QTY.
	220V AC Input Operation		
F1, SPARE	Fuse, AGC, 250V, 1/2 Ampere, Slow–Blow	334–0050	2
	110V AC Input Operation		
F1, SPARE	Fuse, AGC, 250V, Slow–Blow, 1 Ampere	334–0100	2
——	Motherboard Assembly	959–0294	1
——	Input Filter Circuit Board	919–0056	1
——	Controller Circuit Board	919–0019	1
——	Transmitter Controller Cable Assembly	949–0191–002	1
——	Basic Controller and MVDS Assembly	959–0298	1

TABLE 4–3. BASIC CONTROLLER AND MVDS ASSEMBLY – 959–0298

REF. DES.	DESCRIPTION	PART NO.	QTY.
C1	Capacitor, Electrolytic, 15,000 uF, 50V	024–1590	1
C2	Capacitor, Electrolytic, 2500 uF, 50V	024–2590	1
DS1 THRU DS4	Indicator, LED, Red, 521–9212, 2V @ 50 mA Maximum	323–9217	4
DS5 THRU DS8	Indicator, LED, Green, 521–9175, 3V @ 40 mA Maximum	323–9224	4
FL1	Fused Power Connector/Voltage Selector/EMI Filter, 120/240V	360–6504	1
J1, J1	Receptacle, 16–Pin DIP	417–1604	2
J3	Receptacle, 20–Pin	417–0201	1
S1 THRU S4	Switch, Push, SPST, Illuminated, 3 Ampere @ 125V **(FILAMENT ON, FILAMENT OFF, HIGH VOLTAGE ON, HIGH VOLTAGE OFF)**	340–0018	4
S5	Switch, Push, SPST, 3 Ampere @ 125V (**OVERLOAD** Reset)	340–0015–001	1
XBT1	Battery Holder, 9 Volt Rectangular	415–0002	1
——	Metal Oxide Varistor, V250LA15A, 250V ac RMS, 15 Joules	140–0008	1
——	Lamp, Incandescent, No. 73, 14V @ 0.08 Ampere, T 1 3/4 Base (for **OVERLOAD RESET, HIGH VOLTAGE ON,** and **FILAMENT ON** Switch/Indicators)	320–0007	1
——	Switch Cap, Yellow	340–0014	1
——	Lens, Green (for S1 and S3)	340–0016	2
——	Lens, Red (for S2 and S4)	346–1018	2
——	Power Transformer, Single Phase, 50/60 Hz Primary: Dual 115 Volt Windings, One Winding tapped at 90V Secondary: 17.6V RMS @ 0.1 Ampere Open Circuit 20.4V RMS @ 0.4 Ampere Open Circuit 20.4V RMS @ 2 Amperes Open Circuit	370–0005	1
——	Blower, 29 Ft / Min (0.82 m / Min) @ 2700 r/Min Motor: 115V, 50/60 Hz	380–0018	1
——	Filter, Fan, Pamotor 5502	380–5502	1
——	Pin Connector	417–0036	5
——	Pins Connector	417–0053	10
——	Receptacle, 6–Pin	418–0006	1
——	Plug, Connector Housing, 12–Pin	418–1271	1
——	Bezel for DS1 thru DS8	454–0004	8
——	Controller Power Supply, B Series Circuit Board Assembly	919–0111	1
——	Basic Controller Cable Assembly	949–0191	1
——	Blank LED Circuit Board	519–0025	1
——	Blank Switch Circuit Board	519–0026	1

TABLE 4–4. MOTHERBOARD ASSEMBLY – 959–0294

REF. DES.	DESCRIPTION	PART NO.	QTY.
P3	Plug, 20–Pin	417–0207	1
P4	Plug, 40–Pin	417–0038	1
——	Motherboard Circuit Board	919–0055	1

TABLE 4–5. MOTHERBOARD CIRCUIT BOARD – 919–0055

REF. DES.	DESCRIPTION	PART NO.	QTY.
J1	Receptacle, 100–Pi	418–5001	1
J2	Receptacle, 6–Pin	417–0677	1
J3	Receptacle, 20–Pin	418–0027	1
J4	Receptacle, 40–Pin	418–0028	1
——	Blank Circuit Board	519–0055	1

TABLE 4–6. INPUT FILTER CIRCUIT BOARD – 919–0056

REF. DES.	DESCRIPTION	PART NO.	QTY.
C1 THRU C136	Capacitor, Mica, 390 pF ±5%, 100V	042–3922	136
J1 THRU J3	Receptacle, 25–Pin	417–2500	3
J7	Receptacle, Header, 3–Pin In–Line	417–0003	1
L1 THRU L50	Coil, Molded, 4.7 uH ±10%, 430 mA Maximum, DC Resistance: 0.55 Ohms, Resonant at 130 MHz	360–0022	50
P7	Jumper, Programmable	340–0004	1
R9 THRU, R13,R17,R19, R20, R25 THRU R34	Resistor, 1 k Ohm ±5%, 1/4W	100–1043	18
R35	Resistor Network, 8–10 k Ohm ±1%, 1/4W Resistors, 16–Pin DIP	226–1055	1
U1, U2	Integrated Circuit, MC1416P, 7 NPN Darlington Drivers, 16–Pin DIP	226–2004	2
XU1, XU2, XR35	Socket, 16–Pin DIP	417–1604	3

TABLE 4–7. CONTROLLER CIRCUIT BOARD – 919–0019
(Sheet 1 of 6)

REF. DES.	DESCRIPTION	PART NO.	QTY.
C1	Capacitor, Ceramic, 0.1 uF ±20%, 50V	003–1054	1
C2 THRU C4	Capacitor, Electrolytic, 4.7 uF, 35V	024–4764	3
C5	Capacitor, Ceramic, 0.1 uF ±20%, 50V	003–1054	1
C6,C7	Capacitor, Electrolytic, 4.7 uF, 35V	024–4764	2
C8	Capacitor, Ceramic, 0.1 uF ±20%, 50V	003–1054	1
C9	Capacitor, Mylar Film, 0.01 uF, 100V	030–1043	1
C10	Capacitor, Ceramic, 0.1 uF ±20%, 50V	003–1054	1
C11	Capacitor, Electrolytic, 33 uF, 35V	024–3374	1
C12	Capacitor, Ceramic, 0.1 uF ±20%, 50V	003–1054	1
C13	Capacitor, Electrolytic, 10 uF, 35V	023–1076	1
C14	Capacitor, Ceramic, 0.1 uF ±20%, 50V	003–1054	1

TABLE 4–7. CONTROLLER CIRCUIT BOARD – 919–0019
(Sheet 2 of 6)

REF. DES.	DESCRIPTION	PART NO.	QTY.
C15	Capacitor, Electrolytic, 33 uF, 35V	024–3374	1
C16	Capacitor, Ceramic, 0.1 uF ±20%, 50V	003–1054	1
C17	Capacitor, Mylar Film, 0.01 uF, 100V	030–1043	1
C18,C19	Capacitor, Electrolytic, 4.7 uF, 35V, Tantalum	064–4763	2
C20	Capacitor, Ceramic, 0.1 uF ±20%, 50V	003–1054	1
C21	Capacitor, Electrolytic, 100 uF ±10%, 25V, Low–Leakage	023–1085	1
C22	Capacitor, Ceramic, 0.1 uF ±20%, 50V	003–1054	1
C23,C24	Capacitor, Electrolytic, 1 uF, 50V	024–1064	2
C25	Capacitor, Ceramic, 0.1 uF ±20%, 50V	024–1054	1
C26	Capacitor, Electrolytic, 1 uF, 50V	020–1064	1
C27	Capacitor, Ceramic, 0.1 uF ±20%, 50V	003–1054	1
C28	Capacitor, Ceramic, 0.1 uF ±20%, 50V	003–1054	1
C29	Capacitor, Electrolytic, 100 uF ±10%, 25V, Low–Leakage	023–1085	1
C30,C31	Capacitor, Mylar Film, 0.01 uF, 100V	030–1043	2
C32	Capacitor, Electrolytic, 100 uF ±10%, 25V, Low–Leakage	023–1085	1
C33	Capacitor, Electrolytic, 4.7 uF, 35V, Tantalum	064–4763	1
C34	Capacitor, Electrolytic, 1 uF, 50V	024–1064	1
C35 THRU C39	Capacitor, Ceramic, 0.1 uF ±20%, 50V	003–1054	5
C40,C41	Capacitor, Mylar Film, 0.22 uF, 100V	030–2253	2
C42	Capacitor, Mylar Film, 0.01 uF, 100V	030–1043	1
C43	Capacitor, Mylar Film, 0.1 uF, 100V	030–1053	1
C44	Capacitor, Electrolytic, 10 uF, 35V	023–1076	1
C45	Capacitor, Electrolytic, 10 uF ±20%, 63V	020–1075	1
C46	Capacitor, Mylar, 0.1 uF ±10%, 100V	030–1053	1
D1,D3,D4	Diode, 1N4005, Silicon, 600V, 1 Ampere	203–4005	3
D5	POWER Indicator, LED, Green, 550–2206, 2.3V @ 50 mA Maximum	323–2206	1
D6	Diode, Zener, 1N4742A, 12V ±5%, 1W	200–4742	1
D7 THRU D9	Diode, Zener, 1N4744A, 15V ±5%, 1W	200–0015	3
D10	Diode, HP5082–2800, High Voltage Schottky Barrier, 70V @ 15 mA Maximum	201–2800	1
D11	TEST Indicator, LED, Green, 550–2206, 2.3V @ 50 mA Maximum	323–2206	1
D12	Diode, 1N6276A, Transient Voltage Suppressor, 15.2V, 67 Ampere Peak Current	206–6276	1
D13 THRU D22	Diode, 1N4005, Silicon, 600V, 1 Ampere	203–4005	10
D23, D24	Diode, 1N4148, Silicon, 75V @ 0.3 Amperes	203–4148	2
D25 THRU D30	Diode, Zener, 1N4739A, 9.1V ±5%, 1W	200–0009	6
D31	Diode, 1N4005, Silicon, 600V, 1 Ampere	203–4005	1
D32	Diode, Zener, 1N4739A, 9.1V ±5%, 1W	200–0009	1
D33 THRU D37	Diode, 1N4005, Silicon, 600V, 1 Ampere	203–4005	5
D38	Diode, 1N4148, Silicon, 75V @ 0.3 Amperes	203–4148	1
F1	Fuse, AGC, 250V, 1 Ampere	330–0100	1
J3 THRU J5	Receptacle, Header, 2–Pin	417–4004	3
J6	Receptacle, Header, 3–Pin	417–0003	1
J7,J8	Receptacle, Header, 2–Pin	417–4004	2
P3 THRU P8	Plug, 2–Pin	340–0004	6
Q1,Q2	Transistor, 2N3904, Silicon, NPN, TO–92 Case	211–3904	2
R1,R2	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	2
R3	Resistor, 1 k Ohm ±5%, 1/4W	100–1043	1
R4,R5	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	2
R6	Resistor, 1 k Ohm ±5%, 1/4W	100–1043	1

TABLE 4–7. CONTROLLER CIRCUIT BOARD – 919–0019
(Sheet 3 of 6)

REF. DES.	DESCRIPTION	PART NO.	QTY.
R7,R8	Resistor, 10 k Ohm ±5%, 1/4	100–1053	2
R9	Resistor, 1 k Ohm ±5%, 1/4	100–1043	1
R10,R11	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	2
R12	Resistor, 1 k Ohm ±5%, 1/4W	100–1043	1
R13,R14	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	2
R15	Resistor, 1 k Ohm ±5%, 1/4W	100–1043	1
R16,R17	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	2
R18	Resistor, 51 k Ohm ±5%, 1/4W	100–5153	1
R19,R20,R22	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	3
R24	Resistor, 390 k Ohm ±5%, 1/4W	100–3963	1
R25	Resistor, 4.7 k Ohm ±5%, 1/4W	100–4743	1
R26	Resistor, 1 Meg Ohm ±5%, 1/4W	100–1073	1
R27	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	1
R28	Resistor, 470 Ohm ±5%, 1/2W	110–4733	1
R29	Resistor, 9.1 k Ohm ±5%, 1/4W	100–9143	1
R30	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	1
R31	Resistor, 5.6 Ohm ±5%, 1/4W	100–5643	1
R32	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	1
R33	Resistor, 47 k Ohm ±5%, 1/4W	100–4753	1
R34	Resistor, 100 k Ohm ±5%, 1/4W	100–1063	1
R36	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	1
R44,R46,R47	Resistor, 47 k Ohm ±5%, 1/4	100–4753	3
R48	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	1
R49	Resistor, 1 Meg Ohm ±5%, 1/4W	100–1073	1
R50	Resistor, 100 k Ohm ±5%, 1/4W	100–1063	1
R51	Resistor, 100 Ohm ±5%, 1/4W	100–1033	1
R52	Resistor, 47 k Ohm ±5%, 1/4W	100–4753	1
R53	Resistor, 1 k Ohm ±5%, 1/4W	100–1043	1
R54	Resistor, 100 k Ohm ±5%, 1/4	100–1063	1
R55	Resistor, 47 k Ohm ±5%, 1/4W	100–4753	1
R56	Resistor, 100 k Ohm ±5%, 1/4W	100–1063	1
R57	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	1
R58	Resistor, 1.2 Meg Ohm ±5%, 1/4W	100–1273	1
R59, R60	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	2
R61, R62	Resistor, 1 Meg Ohm ±5%, 1/4W	100–1073	2
R63	Resistor, 51 k Ohm ±5%, 1/4W	100–5153	1
R64	Resistor, 47 k Ohm ±5%, 1/4W	100–4753	1
R65	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	1
R66	Resistor, 22 k Ohm ±5%, 1/4W	100–2253	1
R67	Potentiometer, 500 k Ohm ±10%, 1/2W	178–5064	1
R68	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	1
R69	Resistor, 560 k Ohm ±5%, 1/4W	100–5663	1
R70	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	1
R71	Resistor, 51 k Ohm ±5%, 1/4W	100–5153	1
R72	Resistor, 560 k Ohm ±5%, 1/4W	100–5663	1
R73	Resistor, 47 k Ohm ±5%, 1/4W	100–4753	1
R74	Resistor, 68 k Ohm ±5%, 1/4W	100–6853	1
R75	Potentiometer, 5 k Ohm ±10%, 1/2W	178–5044	1
R76	Resistor, 24 k Ohm ±5%, 1/4W	100–2453	1
R77	Resistor, 10 Meg Ohm ±5%, 1/4W	100–1083	1

TABLE 4–7. CONTROLLER CIRCUIT BOARD – 919–0019
(Sheet 4 of 6)

REF. DES.	DESCRIPTION	PART NO.	QTY.
R78	Resistor, 22 k Ohm ±5%, 1/4W	100–2253	1
R79	Resistor, 150 k Ohm ±5%, 1/4W	100–1563	1
R80	Potentiometer, 5 k Ohm ±10%, 1/2W	178–5044	1
R81	Resistor, 24 k Ohm ±5%, 1/4W	100–2453	1
R82	Resistor, 10 Meg Ohm ±5%, 1/4W	100–1083	1
R83	Resistor, 68 k Ohm ±5%, 1/4W	100–6853	1
R84	Potentiometer, 5 k Ohm ±10%, 1/2W	178–5044	1
R85	Resistor, 5.1 k Ohm ±5%, 1/4W	100–5143	1
R86	Resistor, 10 Meg Ohm ±5%, 1/4W	100–1083	1
R87	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	1
R88	Potentiometer, 5 k Ohm ±10%, 1/2W	178–5044	1
R89	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	1
R90	Resistor, 47 k Ohm ±5% 1/4W	100–4753	1
R91	Resistor, 10 Meg Ohm ±5%, 1/4W	100–1083	1
R92	Resistor, 1 Meg Ohm ±5%, 1/4W	100–1073	1
R93	Resistor, 100 k Ohm ±5%, 1/4W	100–1063	1
R94	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	1
R95	Resistor, 100 k Ohm ±5%, 1/4W	100–1063	1
R96	Resistor, 330 k Ohm ±5%, 1/4W	100–3363	1
R97	Potentiometer, 1 Meg Ohm ±10%, 1/2W	178–1074	1
R98	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	1
R99,R100	Resistor, 51 k Ohm, ±5%, 1/4W	100–5153	2
R101	Potentiometer, 1 Meg Ohm ±10%, 1/2W	178–1074	1
R102	Resistor, 110 k Ohm ±5%, 1/4W	100–1163	1
R103,R104	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	2
R105	Resistor, 4.3 k Ohm ±5%, 1/4W	100–4343	1
R106	Potentiometer, 1 Meg Ohm ±10%, 1/2W	177–1074	1
R107	Resistor, 51 k Ohm ±5%, 1/4W	100–5153	1
R108	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	1
R109 THRU R121	Resistor, 100 k Ohm ±5%, 1/4W	100–1063	13
R122 THRU R124	Resistor, 1 k Ohm ±5%, 1/4W	100–1043	3
R125	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	1
R126	Resistor, 1 k Ohm ±5%, 1/4W	100–1043	1
R127 THRU R136	Resistor, 1 k Ohm ±5%, 1/4W	100–1043	10
R137 THRU R139	Resistor, 39 Ohm ±5%, 1/4W	100–3923	3
R140 THRU R148	Resistor, 620 Ohm ±5%, 1/2W	110–6233	8
R149	Resistor, 470 k Ohm ±5%, 1/4W	100–4763	1
R150	Resistor, 1.3 Meg Ohm ±5%, 1/4W	100–1373	1
R151	Resistor, 1 k Ohm ±5%, 1/4W	100–1043	1
R152	Potentiometer, 250 k Ohm ±10%, 1/2W	180–0001	1
R153	Resistor, 1 k Ohm ±5%, 1/4W	100–1043	1
R154 THRU R159	Resistor, 100 k Ohm ±5%, 1/4W	100–1063	6
R160	Resistor, 51 k Ohm ±5%, 1/4W	100–5153	1
R162	Resistor, 1 k Ohm ±5%, 1/4W	100–1043	1
R163	Resistor, 1.5 Meg Ohm ±5%, 1/4W	100–1573	1
R164	Resistor, 1.8 Meg Ohm ±5%, 1/4W	100–1873	1

TABLE 4–7. CONTROLLER CIRCUIT BOARD – 919–0019
(Sheet 5 of 6)

REF. DES.	DESCRIPTION	PART NO.	QTY.
R165	Resistor, 1 k Ohm ±5%, 1/4W	100–1043	1
R166	Resistor, 100 k Ohm ±5%, 1/4W	100–1063	1
R167	Resistor, 470 k Ohm ±5%, 1/4W	100–4763	1
R168	Resistor, 10 Ohm ±5%, 1/4W	100–1023	1
R169	Resistor, 4.7 k Ohm ±5%, 1/4W	100–4773	1
S1	Switch, Push, SPST, Normally Open, 1 Ampere @ 120V ac	343–6330	1
S2	Switch, Toggle, SPST, 5 Ampere @ 120V ac or 28V dc	348–0123	1
U1 THRU U8	Integrated Circuit, 4N33, Optical Isolator, NPN Photo Transistor/Infared Emitting Diode Type, 1500V Isolation, 6–Pin DIP	229–0033	8
U9 THRU U11	Integrated Circuit, MC14002B, Dual 4–Input NOR Gate, CMOS, 4–Pin DIP	228–4002	3
U12	Integrated Circuit, MC14069UB, Hex Inverter, CMOS, 14–Pin DIP	228–4069	1
U13	Integrated Circuit, CD4071B, OR Gate, CMOS, 14–Pin DIP	225–0005	1
U14	Integrated Circuit, CD4081B, AND Gate, CMOS, 14–Pin DIP	225–0008	1
U15,U16	Integrated Circuit, LM358N, Dual Operational Amplifier, 8–Pin DIP	221–0358	2
U17	Integrated Circuit, MC14044BP, Quad NAND R–S Latch, CMOS, 16–Pin DIP	228–4044	1
U18	Integrated Circuit, MC14069UB, Hex Inverter, CMOS, 14–Pin DIP	228–4069	1
U19	Integrated Circuit, CD4081B, AND Gate, CMOS, 14–Pin DIP	225–0008	1
U20 THRU U22	Integrated Circuit, LM358N, Dual Operational Amplifier, 8–Pin DIP	221–0358	3
U23	Integrated Circuit, MC14538B, Dual Resettable/Retriggerable Monostable Multivibrator, CMOS, 16–Pin DIP	228–4538	1
U24	Integrated Circuit, CD4071B, OR Gate, CMOS, 14–Pin DIP	225–0005	1
U25	Integrated Circuit, MC14073B, Tripple 3–Input AND Gate, CMOS, 14–Pin DIP	228–4073	1
U26	Integrated Circuit, CD4081B, AND Gate, CMOS, 14–Pin DIP	225–0008	1
U27	Integrated Circuit, MC14069UB, Hex Inverter, CMOS, 14–Pin DIP	228–4069	1
U28,U29	Integrated Circuit, MC14538B, Dual Resettable/Retriggerable Monostable Multivibrator, CMOS, 16–Pin DIP	228–4538	1
U30	Integrated Circuit, MC14011B, Quad 2–Input NAND Gate, CMOS, 14–Pin DIP	228–4011	1
U31	Integrated Circuit, MC14044BP, Quad NAND R–S Latch, CMOS, 16–Pin DIP	228–4044	1
U32 THRU U34	Integrated Circuit, CD4019BE, Quad AND/OR Select Gate, CMOS, 16–Pin DIP	228–4019	3
U35,U36	Integrated Circuit, ULN2003A, 7 Section NPN Darlington Driver, CMOS, 16–Pin DIP	229–2003	2
U37 THRU U50	Integrated Circuit, 4N33, Optical Isolator, NPN Photo Transistor/Infared Emitting Diode Type, 1500V Isolation, 6–Pin DIP	229–0033	14
U51	Integrated Circuit, MC14584, Hex Schmitt Trigger, CMOS, 14–Pin DIP	228–4584	1
U52 THRU U56	Integrated Circuit, MC14503B, Hex Non–Inverting 3–State Buffer, CMOS, 16–Pin DIP	228–4503	5
U57	Integrated Circuit, CD4017B, 10–Output Counter/Divider, CMOS, 16–Pin DIP	220–4017	1
U58, U59	Integrated Circuit, 4N33, Optical Isolator, NPN Photo Transistor/Infared Emitting Diode Type, 1500V Isolation, 6–Pin DIP	229–0033	2
XF1	Fuse Clip, AGC	415–2068	2
XU1 THRU XU8	Socket, 6–Pin DIP	417–0600	8

TABLE 4–7. CONTROLLER CIRCUIT BOARD – 919–0019
(Sheet 6 of 6)

REF. DES.	DESCRIPTION	PART NO.	QTY.
XU9 THRU XU14	Socket, 14–Pin DIP	417–1404	6
XU15,XU16	Socket, 8–Pin DIP	417–0804	2
XU17	Socket, 16–Pin DIP	417–1604	1
XU18,XU19	Socket, 14–Pin DIP	417–1404	2
XU20 THRU XU22	Socket, 8–Pin DIP	417–0804	3
XU23	Socket, 16–Pin DIP	417–1604	1
XU24 THRU XU27	Socket, 14–Pin DIP	417–1404	4
XU28,XU29	Socket, 16–Pin DIP	417–1604	2
XU30	Socket, 14–Pin DIP	417–1404	1
XU31 THRU XU36	Socket, 16–Pin DIP	417–1604	6
XU37 THRU XU50	Socket, 6–Pin DIP	417–0600	14
XU51	Socket, 14–Pin DIP	417–1404	1
XU52 THRU XU57	Socket, 16–Pin DIP	417–1604	6
XU58, XU59	Socket, 6–Pin DIP	417–0600	2
——	Blank Circuit Board	519–0019	1

TABLE 4–8. POWER SUPPLY CIRCUIT BOARD – 919–0111
(Sheet 1 of 2)

REF. DES.	DESCRIPTION	PART NO.	QTY.
C4 THRU C7	Capacitor, Mylar Film, 0.1 uF ±10%, 100V	030–1053	4
C8,C9,C10	Capacitor, Electrolytic, 10 uF, 35V	023–1076	3
C11,C12	Capacitor, Electrolytic, 1 uF, 50V	024–1064	2
C13	Capacitor, Monolythic Ceramic, 0.1 uF ±20%, 50V	003–1054	1
D1,D2	Diode, MR502, Silicon, 200V, 3 Amperes	202–0502	2
D3 THRU D6	Diode, 1N4004, Silicon, 400V, 1 Ampere	203–4004	4
D7,D8	Diode, MR502, Silicon, 200V, 3 Amperes	202–0502	2
D9 THRU D12,D15	Diode, 1N4004, Silicon, 400V, 1 Ampere	203–4004	5
D16	Diode, MR502, Silicon, 200V, 3 Amperes	202–0502	1
D17,D18	Diode, 1N4004, Silicon, 400V, 1 Ampere	203–4004	2
D19	Diode, MR502, Silicon, 200V, 3 Amperes	202–0502	1
D20,D21	Diode, 1N4004, Silicon, 400V, 1 Ampere	203–4004	2
D22	Diode, Zener, 1N4742A, 12V ±5%, 1W	200–4742	1
D23	Diode, 1N4005, Silicon, 600V @ 1 Ampere	203–4005	1
D24	Diode, 1N6276A, Silicon, Transient Voltage Suppressor, 16V ±0.05% Breakdown	206–6276	1
J2	Receptacle, 6–Pin	417–0677	1
J3	Receptacle, 12–Pin	417–1276	1
Q1	Transistor, 2N3904, NPN, Silicon, TO–92 Case	211–3904	1
R1	Resistor, 470 Ohm ±5%, 2W	130–4733	1
R2	Resistor, 1.27 k Ohm ±1%, 1/4W	103–1274	1
R3	Potentiometer, 200 Ohm ±10%, 1/2W	177–2034	1
R5	Resistor, 120 Ohm ±5%, 1/4W	100–1233	1
R11	Resistor, 1 k Ohm ±5%, 1/4W	100–1043	1
R12	Potentiometer, 10 k Ohm ±10%, 1/2W	177–1054	1
R13	Resistor, 15 k Ohm ±5%, 1/4W	100–1553	1

TABLE 4–8. POWER SUPPLY CIRCUIT BOARD – 919–0111
(Sheet 2 of 2)

REF. DES.	DESCRIPTION	PART NO.	QTY.
R14	Resistor, 470 k Ohm ±5%, 1/4W	100–4763	1
R15	Resistor, 47 k Ohm ±5%, 1/4W	100–4753	1
U1	Integrated Circuit, LM350K, Three–Terminal Adjustable Positive Voltage Regulator, 1.2V to 33V, 3 Ampere Maximum, TO–3 Case	227–0350	1
U2	Integrated Circuit, MC7815CT, Voltage Regulator, 15V @ 1A, TO–220 Case	227–7815–C	1
U3	Integrated Circuit, LM78L15ACH, Three–Terminal Fixed 15 Volt Regulator, 0.1 Ampere, 15V, TO–39 Case	227–7800	1
U4	Integrated Circuit, MC14538B, Dual Retriggerable, Resettable Monostable Multivibrator, CMOS, 16–Pin DIP	228–4538	1
——	Socket, 16–Pin DIP	417–1604	1
——	Blank Circuit Board	519–0111	1

TABLE 4–9. TRANSMITTER CONTROLLER CABLE ASSEMBLY – 949–0191–002

REF. DES.	DESCRIPTION	PART NO.	QTY.
J5	Socket, MR, 24–Pin, Male	417–2403	1
P4	Connector Housing, 6–Pin, Female	418–0670	1
——	Pin Connector	417–0036	5
——	Pins Connector	417–0053	5
——	Keying Plug, 350591–1 AMP	418–0026	1
——	3 Circuit Commoning Bar, AMP, MR	418–0054	2

TABLE 4–10. CABLE ASSEMBLY, BASIC CONTROLLER – 949–0191

REF. DES.	DESCRIPTION	PART NO.	QTY.
P1	Plug, 16–Pin DIP, Dual In–Line	417–1602	1
P5	Housing, 24–Pin, MR, Female	417–2402	1
——	Connector, Housing, 6–Pin	418–0670	1
——	Pins Connector	417–0053	15

TABLE 4–11. EXTENDER CIRCUIT BOARD – 919–0061

REF. DES.	DESCRIPTION	PART NO.	QTY.
J1	Receptacle, 100–Pin	418–5001	1
S1	Push Switch, SPST, Normally Open, 1 Ampere @ 120V ac	343–6330	1
——	Switch Cap, for J1	343–6331	1
——	Blank Circuit Board	519–0061	1

PRODUCT WARRANTY

LIMITED TWO YEAR

While this warranty gives Purchaser specific legal rights, which terminate two (2) years (one year on cartridge and blower motors) from the date of shipment, Purchaser may also have other rights which vary state to state.

Broadcast Electronics, Inc. ("Seller") hereby warrants cartridge machines, consoles, and other new Equipment manufactured by Seller against any defects in material or workmanship at the time of delivery thereof, that develop under normal use within a period of two (2) years (one year for cartridge and blower motors) from the date of shipment, as such term is defined herein. Other manufacturer's and suppliers' Equipment and services, if any, including electronic tubes, solid state devices, transmission line, antennas, towers, related equipment and installation and erection services, shall carry only such manufacturer's or suppliers' standard warranty. This warranty extends to the original user and any subsequent purchaser during the warranty period. Seller's sole responsibility with respect to any equipment or parts not conforming to this warranty is to replace such equipment or parts upon the return thereof F.O.B. Seller's factory or authorized repair depot within the period aforesaid.

In the event of replacement pursuant to the foregoing warranty, only the unexpired portion of the warranty from the time of the original purchase will remain in effect for any such replacement. However, the warranty period will be extended for the length of time that Purchaser is without the services of the Equipment due to its being serviced pursuant to this warranty. The terms of the foregoing warranty shall be null and void if the Equipment has been altered or repaired without specific written authorization of Seller, or if Equipment is operated under environmental conditions or circumstances other than those specifically described in Seller's product literature or instruction manual which accompany the Equipment. Seller shall not be liable for any expense of any nature whatsoever incurred by the original user without prior written consent of Seller.

Seller shall not be liable to Purchaser for any and all incidental or consequential damages for breach of either expressed or implied warranties. However, some states do not allow the exclusion or limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to Purchaser. All express and implied warranties shall terminate at the conclusion of the period set forth herein. Any card which is enclosed with the equipment will be used by Seller for survey purposes only.

If the Equipment is described as used, it is sold as is and where is. If the contract covers equipment not owned by Seller at this date, it is sold subject to Seller's acquisition of possession and title.

EXCEPT AS SET FORTH HEREIN, AND EXCEPT AS TO TITLE, THERE ARE NO WARRANTIES, OR ANY AFFIRMATIONS OF FACT OR PROMISES BY SELLER, WITH REFERENCE TO THE EQUIPMENT, OR TO MERCHANTABILITY, FITNESS FOR A PARTICULAR APPLICATION, SIGNAL COVERAGE, INFRINGEMENT, OR OTHERWISE, WHICH EXTEND BEYOND THE DESCRIPTION OF THE EQUIPMENT ON THE FACE HEREOF.

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