FM-20B 20 KILOWATT FM BROADCAST TRANSMITTER

597-0220-004
SEPTEMBER, 1995

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–20B TRANSMITTER

1–1. INTRODUCTION.

1–2. Due to special shipping requirements, selected components of the Broadcast Electronics FM–20B transmitter 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–20B instruction manual 597–0220–004. Perform the following assembly instructions prior to the procedures described in the manual.

1–3. SPECIAL ASSEMBLY.

1–4. **GENERAL.** Components removed from the transmitter contain identification tags to permit reinstallation. 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.

1–5. 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

1–6. **HIGH VOLTAGE POWER SUPPLY CABINET.** Install the power supply cabinet base–plate in the high voltage power supply cabinet by performing the following procedure. Ensure no primary power is connected to the transmitter before attempting any component installation.

1–7. **Power Supply Cabinet Base–Plate.** Refer to Figure 1 and install the power supply cabinet base–plate as follows:

A. Using a small fork–lift, place the base–plate with all components attached in the bottom of the power supply cabinet.

B. Mount the base–plate to the cabinet with three 9/16 inch bolts, nuts, flat washers, and lockwashers. The mounting bolt at the ground strap/base–plate connection must remain off at this time.

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

CAUTION — *ENSURE THE JUMPER WIRE BETWEEN THE TERMINALS ON CAPACITOR C301 IS REMOVED.*
CAUTION

C. Connect ground strap from the plate choke base to the power supply cabinet ground strap with the 9/16 inch base–plate mounting hardware as shown.

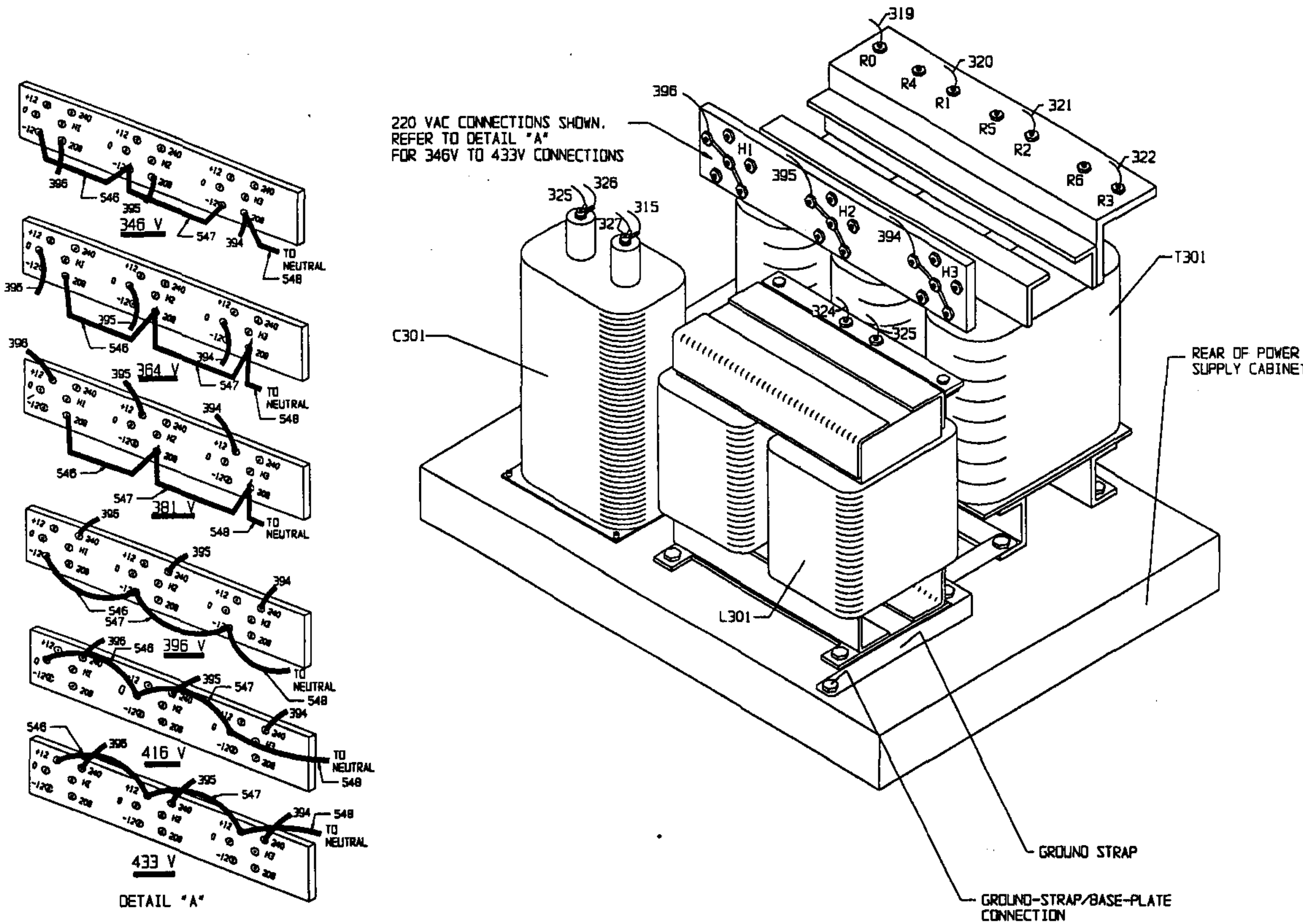

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FIGURE 1. POWER SUPPLY C/ ∴T BASE-PLATE INSTALLATION

D. Remove the jumper wire between the terminals on capacitor C301.

E. Connect the wires to the plate supply transformer, choke, and capacitor as shown.

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

WARNING

1–8. **PA CABINET.** Install components in the PA cabinet as follows.

1–9. **RF Enclosure.** Refer to Figure 2 and install components in the RF enclosure as follows:

A. Insert the chimney assembly in the enclosure as shown.

B. Insert the front section of the cavity shelf into the enclosure as shown. Mount the shelf in place using the brass hardware provided.

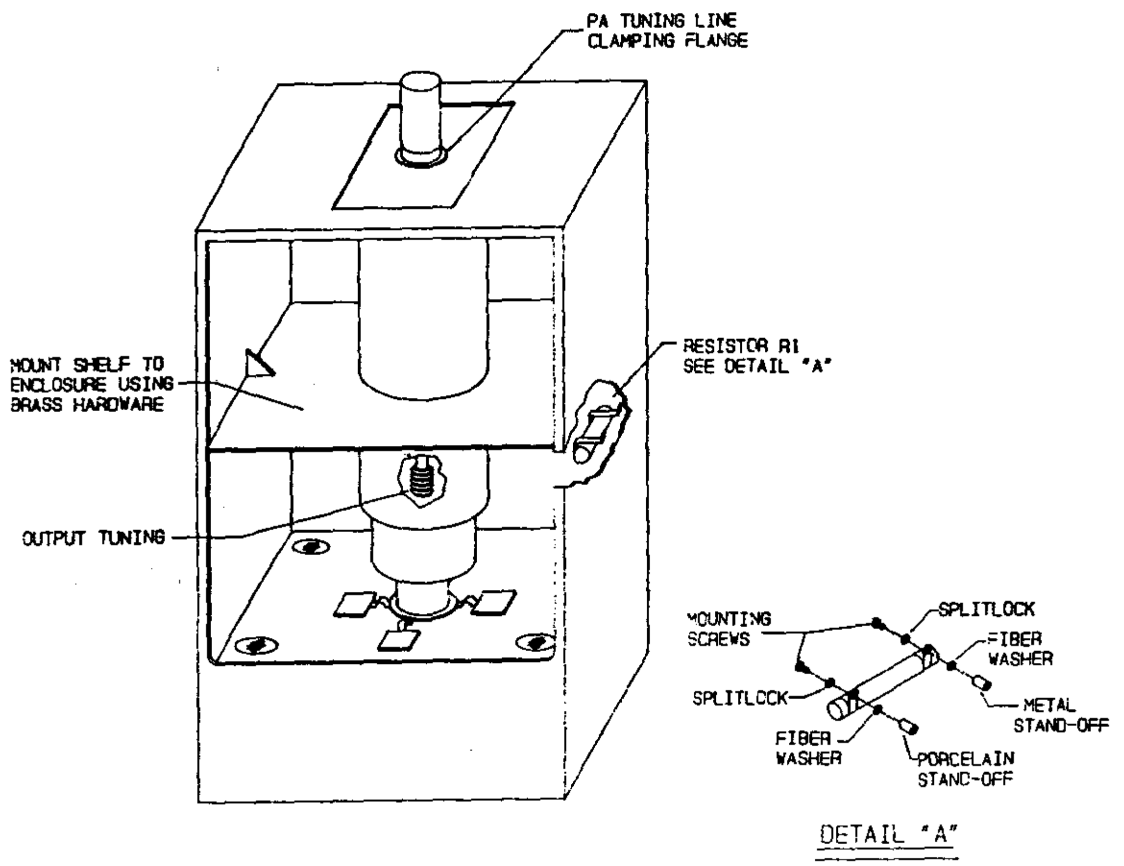

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FIGURE 2. RF ENCLOSURE COMPONENT INSTALLATION

1–10. **Cavity Resistor Installation.** Locate the 100 Ohm, 150 watt suppressor resistor in the accessory kit and install R1 in the PA cavity as follows:

A. Refer to detail A in Figure 2 and install R1 using the hardware supplied in the porcelain and metal stand–offs. Ensure the resistor clamp hardware is positioned in relation to the PA cavity wall as indicated.

1–11. **Blower Assembly.** The transmitter blower assembly has been secured to the cabinet rail for shipment. Ensure all shipping materials are removed from the blower assembly.

1–12. **Tuning Line.** Insert the transmitter tuning line into the PA cabinet RF enclosure. Secure the mounting flange with the hardware provided. Attach the tuning cable to the drive assembly on the top of tuning line.

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

WARNING

1–13. **DRIVER CABINET.** Refer to Figure 3 and install the exciter, stereo generator, and the IPA units in the driver cabinet as shown. The modular components are installed by lifting each unit onto the slide–rails. Connect the cables to the units as shown.

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

WARNING

WARNING *ENSURE THE PA/DRIVER CABINET GROUND STRAPS ARE SECURELY BOLTED TOGETHER.*

WARNING

1–14. **PA/DRIVER CABINET INTERCONNECTIONS.** Refer to Figure 4 and connect the wires between the PA cabinet and the driver cabinet as shown. Ensure the cabinet ground straps are securely bolted together at the location shown.

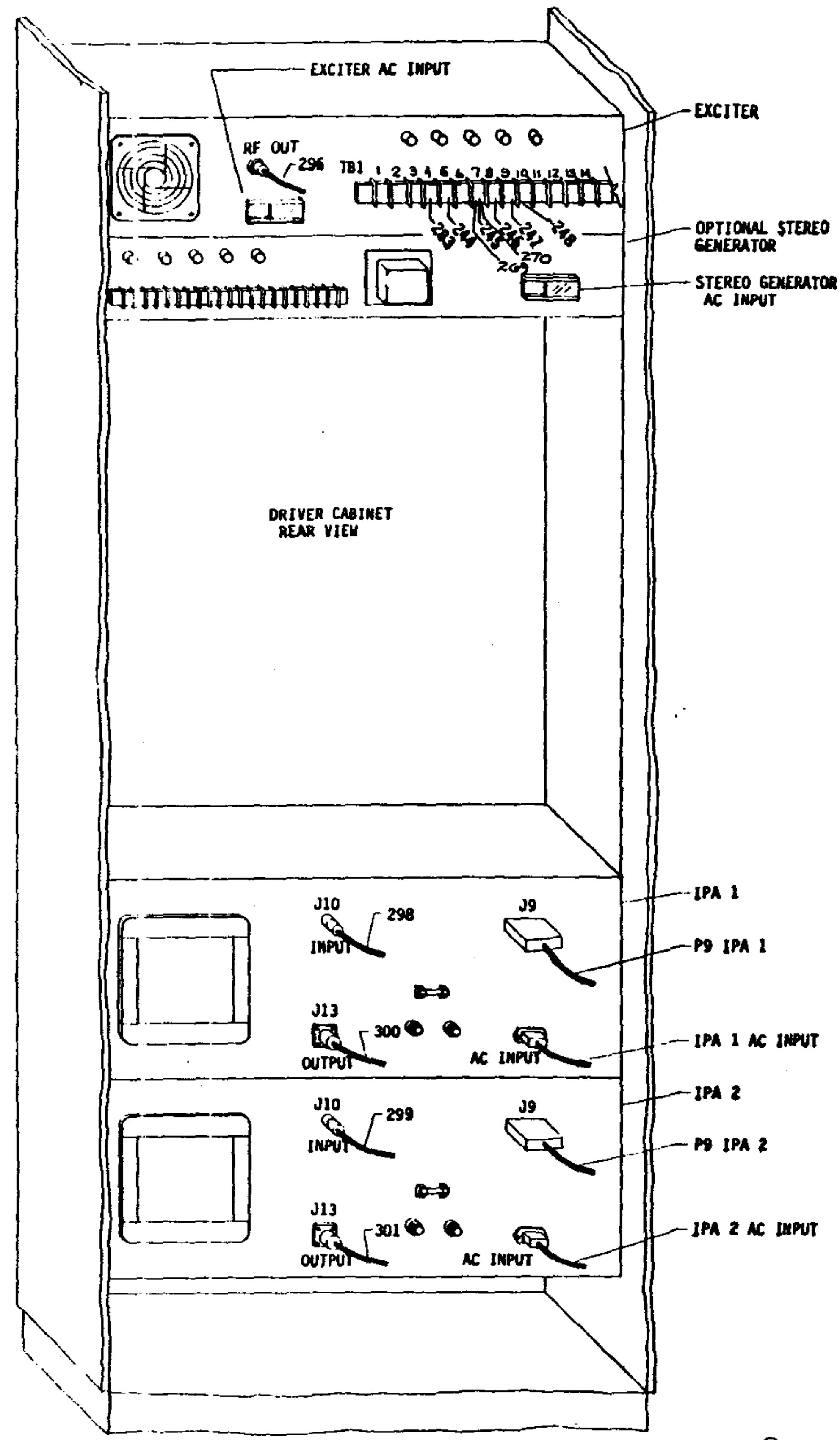

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FIGURE 3. DRIVER CABINET MODULAR COMPONENT INSTALLATION

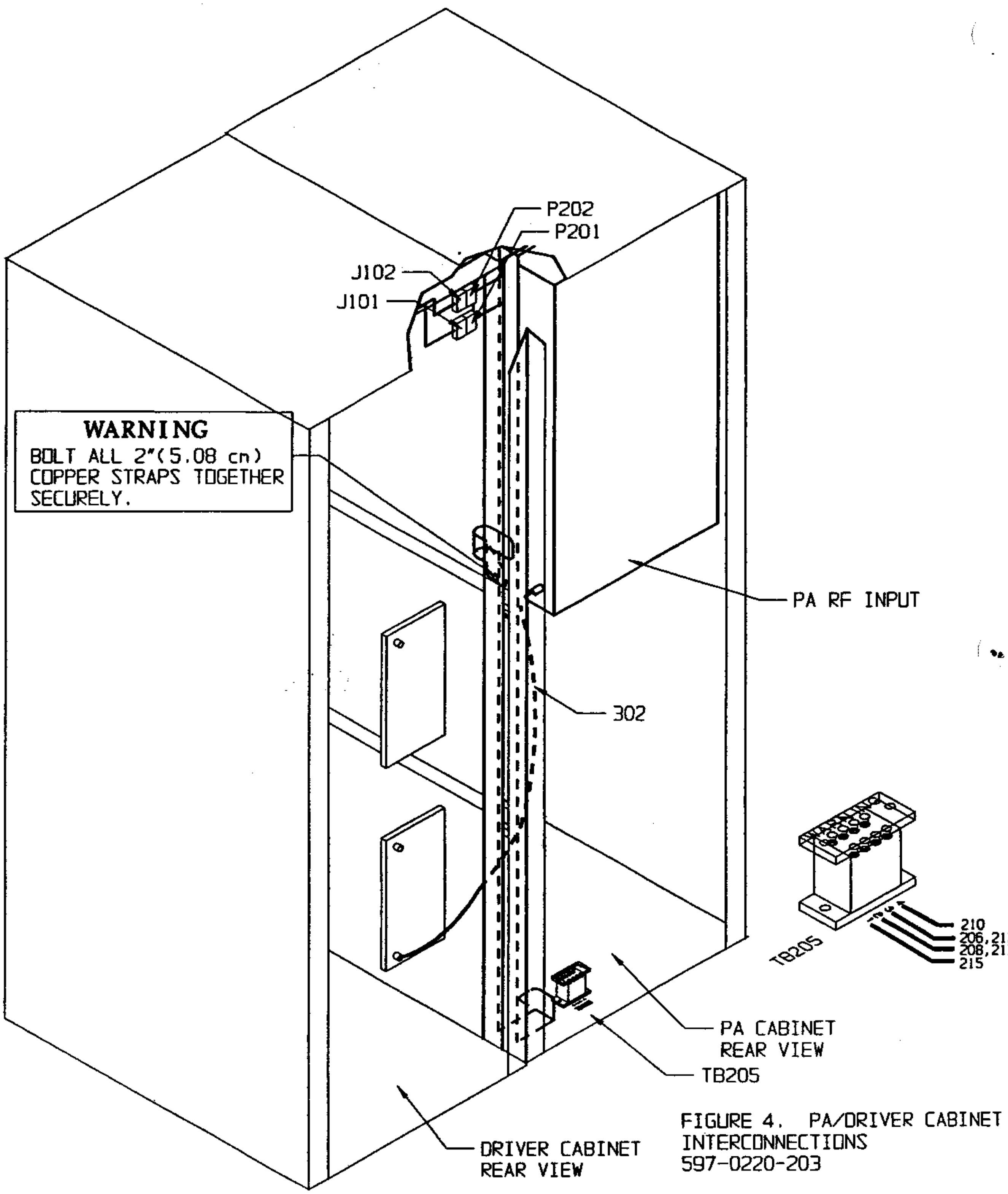

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FIGURE 4. PA/DRIVER CABINET INTERCONNECTIONS

SCOPE OF MANUAL

This manual consists of two sections which provides the following information for the Broadcast Electronics FM–20B FM Broadcast Transmitters.

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 Broadcast Electronics FM–20B FM transmitter and lists equipment specifications.

1–3. RELATED PUBLICATIONS.

1–4. The following list of publications provides data for equipment associated with the FM–20B and 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

1–5. EQUIPMENT DESCRIPTION.

1–6. The Broadcast Electronics FM–20B is a one–tube FM transmitter designed for continuous operation in the 87.5 MHz to 108 MHz broadcast band (refer to Figure 1–1). Specific transmitter features include: a folded half–wave cavity PA stage, a solid–state automatic–power–control unit (APC), a solid–state control system with a microprocessor based video diagnostic option, solid–state intermediate–power–amplifier (IPA) modules, and a solid–state exciter with a digital frequency synthesizer.

1–7. The transmitter RF power amplifier, IPA modules, FM exciter, and control circuitry is housed in a single double–cubicle cabinet. The high voltage power supply is housed in a separate cabinet which may be located remotely from the PA/driver cabinet if desired. The following text provides ordering information for various transmitter configurations, optional equipment, and accessories and recommended spare parts kits.

1–8. TRANSMITTER CONFIGURATIONS.

1–9. The FM–20B may be ordered in the following configurations:

FM–20B TRANSMITTER

P/N	DESCRIPTION
909–0020–204	FM–20B Transmitter complete with FX–50 FM Exciter, 208/240V ac three–phase 60 Hz operation, high voltage power supply adjacent to PA/driver cabinet.
909–0020–214	Same as 909–0020–204 less the exciter.
909–0020–224	FM–20B Transmitter complete with FX–50 FM Exciter, 208/240V ac three–phase 60 Hz operation, remote high voltage power supply.
909–0020–234	Same as 909–0020–224 less the exciter.
909–0020–384	FM–20B Transmitter complete with FX–50 FM Exciter, 208/380V ac three–phase 50 Hz operation, high voltage power supply adjacent to PA/driver cabinet.

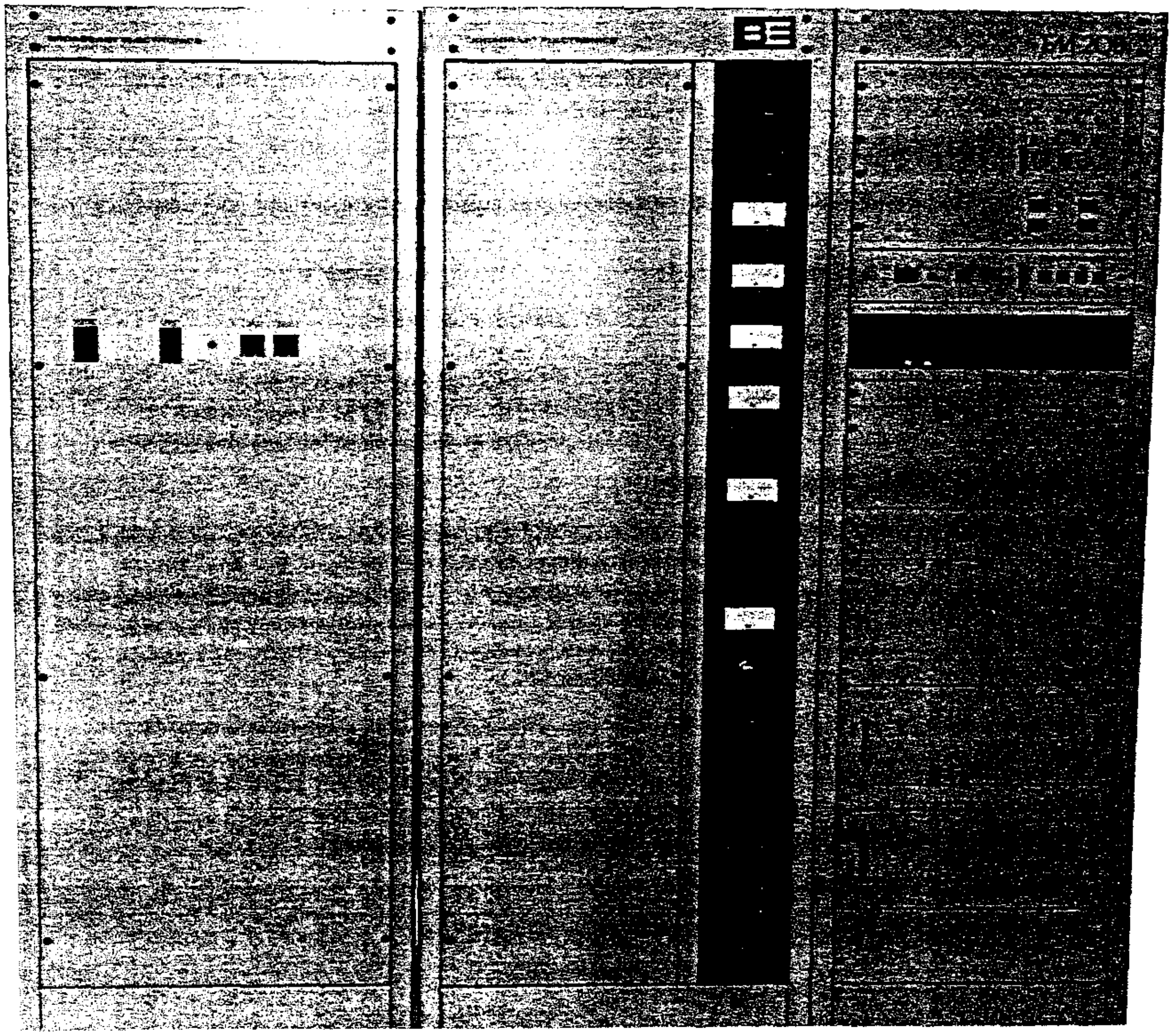

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FIGURE 1-1. FM-20B TRANSMITTER

909–0020–314	Same as 909–0020–384 less the exciter.
909–0020–394	FM–20B Transmitter complete with FX–50 FM Exciter, 208/380V ac three–phase 50 Hz operation, remote high voltage power supply.
909–0020–234	Same as 909–0020–394 less the exciter.

1–10. **OPTIONAL EQUIPMENT.**

1–11. The FM–20B transmitter is available with the following factory–installed options:

P/N	DESCRIPTION
909–0118	1.5 kW filament voltage regulator, 60 Hz operation, factory installed.
909–0118–300	1.5 kW filament voltage regulator, 50 Hz operation, factory installed.
909–0091–074	Microprocessor Video Diagnostic System, FM–20B, factory installed.
909–0122–007	Microprocessor Video Diagnostic System Remote Control, factory installed.
979–0128–074	Microprocessor Video Diagnostic System Remote Control, field installation.
909–0127–004	MVDS Remote Control Multiple Transmitter Interface.

1–12. **ACCESSORIES AND SPARE PARTS KITS.**

1–13. The following accessory products and spare parts kits are available for use with the FM–20B transmitter.

P/N	DESCRIPTION
909–0103	Extended local control unit.
979–0070–004	Recommended spare parts kit for the FM–20B and FX–50 Exciter. Includes selected meters, switches, relays, etc. Does not include semiconductors.
979–0071–004	Recommended semiconductor kit for the FM–20B and FX–50 Exciter.
979–0075–014	Recommended semiconductor kit for the FM–20B transmitter only. Does not include exciter spare semiconductors.
979–0070–014	Recommended spare parts kit for the FM–20B transmitter only. Includes selected meters, switches, relays, etc. Does not include semiconductors.
979–0132–014	Recommended spare HV rectifier kit for the FM–20B transmitter.
907–0016–074	VMC–16 Voice Remote Control Unit, FM–20B

1–14. **EQUIPMENT SPECIFICATIONS.**

1–15. Refer to Table 1–1 for the electrical specifications and Table 1–2 for the physical and environmental specifications of the Broadcast Electronics FM–20B FM Transmitter.

TABLE 1-1. FM-20B ELECTRICAL CHARACTERISTICS
(Sheet 1 of 2)

PARAMETER	SPECIFICATION
RF POWER OUTPUT	7.5 kW to 22 kW Maximum (as specified).
RF FREQUENCY RANGE	87.5 to 108 MHz (as ordered). Exciter programmable in 10 kHz increments.
RF OUTPUT IMPEDANCE	50 Ohms Resistive (others on special request.
RF OUTPUT CONNECTOR	3 1/8 Inch (7.94 cm) EIA Flange.
TUBE COMPLEMENT	8989/4CX12000A (1).
MAXIMUM VSWR	1.8 : 1 (will operate into higher VSWR with automatic power reduction).
AM SIGNAL-TO-NOISE RATIO:	
Asynchronous	55 dB below an equivalent reference carrier with 100% AM modulation @ 400 Hz, 75 microsecond deemphasis (no FM modulation present).
Synchronous	50 dB below an equivalent 20 kW reference carrier with 100% AM modulation @ 1 kHz (FM modulation ±75 kHz @ 1 kHz).
FM SIGNAL-TO-NOISE RATIO:	
Mono/Composite	85 dB below ±75 kHz deviation @ 400 Hz measured in a 20 Hz to 30 kHz bandwidth with 75 microsecond deemphasis.
Stereo	82 dB below 100% modulation @ 400 Hz measured in a 20 Hz to 30 kHz bandwidth with 75 microsecond deemphasis.
RF HARMONIC SUPPRESSION	Meets all FCC/DOC Requirements and CCIR Recommendations.
POWER SUPPLY RECTIFIERS	Silicon.
DISTORTION	
Mono/Composite	
Harmonic	0.02% or less @ 400 Hz.
SMPTE Intermodulation Distortion	0.02% 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 @ 400 Hz.
SMPTE Intermodulation Distortion	0.05% or less, 60 Hz/7 kHz, 4:1 Ratio.

TABLE 1–1. FM-20B ELECTRICAL CHARACTERISTICS (Sheet 2 of 2)

PARAMETER	SPECIFICATION
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 POWER REQUIREMENTS	196V to 252V ac 50/60 Hz or 339V to 437V ac 50 Hz, Three–Phase Closed–Delta or Wye.
AC POWER CONSUMPTION	30 kW typical at a 20 kW RF output level, 0.97 power factor (includes Exciter).
OVERALL EFFICIENCY	67% typical (AC line input to RF output).
PA EFFICIENCY	80% typical.

TABLE 1–2. FM-20B PHYSICAL AND ENVIRONMENTAL CHARACTERISTICS (Sheet 1 of 2)

PARAMETER	SPECIFICATION
PHYSICAL	
DIMENSIONS:	
PA/Driver Cabinet	Width: 50.5 Inches (128.3 cm). Height: 70 Inches (177.8 cm). Depth: 31.5 Inches (80.0 cm).
High Voltage Power Supply Cabinet	Width: 28.5 Inches (72.4 cm). Height: 70 Inches (177.8 cm). Depth: 31.5 Inches (80.0 cm).
WEIGHT:	
PA/Driver Cabinet	1200 Pounds (545 kg).
High Voltage Power Supply Cabinet	1500 Pounds (681 kg).
CUBAGE:	
PA/Driver Cabinet	64 Cubic Feet (1.8 m^3).
High Voltage Power Supply Cabinet	36 Cubic Feet (1.0 m^3).

TABLE 1-2. FM-20B PHYSICAL AND ENVIRONMENTAL CHARACTERISTICS (Sheet 2 of 2)

PARAMETER	SPECIFICATION
LOW-PASS FILTER DIMENSIONS:	
Length	52.12 Inches (132.38 cm).
Diameter	6.13 Inches (15.57 cm).
ENVIRONMENTAL	
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 7,500 Feet above sea level (0 to 2286 Meters).
MAXIMUM HUMIDITY	95%, Non–Condensing.
HEAT DISSIPATION:	
Driver Cabinet	1 kW Maximum (3416 Btu/h).
PA Cabinet	13 kW Maximum (44,450 Btu/h).
Power Supply Cabinet	2 kW Maximum (6838 Btu/h).
COOLING AIR REQUIREMENTS:	
PA Cabinet	810 Cubic Feet Per Minute (23.0 m^3/min).
Driver Cabinet	500 Cubic Feet Per Minute (14.15 m^3/min).

SECTION II
INSTALLATION

2–1. INTRODUCTION.

2–2. This section contains information required for the installation and preliminary checkout of the Broadcast Electronics FM–20B Transmitter.

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 (see Table 2–1). If the contents are incomplete, or if the unit is damaged electrically or mechanically, notify both the carrier and Broadcast Electronics, Inc.

2–6. INSTALLATION REQUIREMENTS.

2–7. ENVIRONMENTAL.

2–8. Table 1–2 provides environmental conditions which must be considered prior to transmitter installation.

2–9. COOLING AIR.

2–10. If outside air is to be used to cool the transmitter, the air inlet duct must be designed 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.

2–11. 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 810 cubic feet of air per minute (23.0 m^3/min) from the PA cabinet and 500 cubic feet of air per minute (14.15 m^3/min) from the driver cabinet. An exhaust fan may be used to boost the flow of heated air from the transmitter but must be capable of exhausting 1310 cubic feet of air per minute (37.15 m^3/min) as a minimum rating.

2–12. As a minimum requirement, any ducting must have a cross–sectional area equal to the exhaust area of the PA cabinet plus the exhaust area of the driver 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.

2–13. PRIMARY POWER.

2–14. The FM–20B transmitter is designed for operation from a closed–delta or wye connected three–phase power source. Operation from an unsatisfactory power source will void the warranty on the 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.

TABLE 2-1. FM-20B PACKING LIST

ITEM	DESCRIPTION	PART NO.	QTY.
1	PA CABINET (ASSEMBLED)	959-0296	1
2	DRIVER CABINET (ASSEMBLED)	959-0297	1
3	HIGH VOLTAGE POWER SUPPLY CABINET (ASSEMBLED)	959-0295	1
4	PA TUBE, 8989/4CX12000A	240-0012	1
5	OUTPUT LINE SECTION (INNER)	463-0034-001	1
6	OUTPUT LINE SECTION (OUTER)	463-0049-001	1
7	TRANSMISSION LINE ELBOW WITH SAMPLING PORT	427-0016	1
8	TRANSMISSION LINE COUPLING FLANGE WITH HARDWARE AND CLAMP	427-0001	1
9	TRANSMISSION LINE COUPLING WITH CLAMP	427-0005	1
10	4 1/2 INCH CLAMP	402-0014	1
11	CABINET DOOR KEY	NPN	6
12	FX-50 ACCESSORY PARTS KIT	957-0003	1
13	TEST DATA SHEETS	NPN	1
14	LOW-PASS FILTER WITH DIRECTIONAL COUPLER	339-0022	1
15	REMOTE POWER SUPPLY INTERLOCK EXTENSION CABLE	P/O 949-0156	1
16	TRANSMITTER ACCESSORY PARTS KIT	969-0005	1

NOTES:

ITEM 15 NOT INCLUDED WHEN POWER SUPPLY CABINET IS TO BE POSITIONED ADJACENT TO THE PA AND DRIVER CABINETS.

ITEM 12 NOT INCLUDED WHEN SHIPPED LESS EXCITER.

2-15. 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 transmitter and provide degraded 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.

2-16. It is important that the local electric utility be consulted to ensure that the correct service is provided before connection of the transmitter to a primary power source. The proper power source can be readily 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.

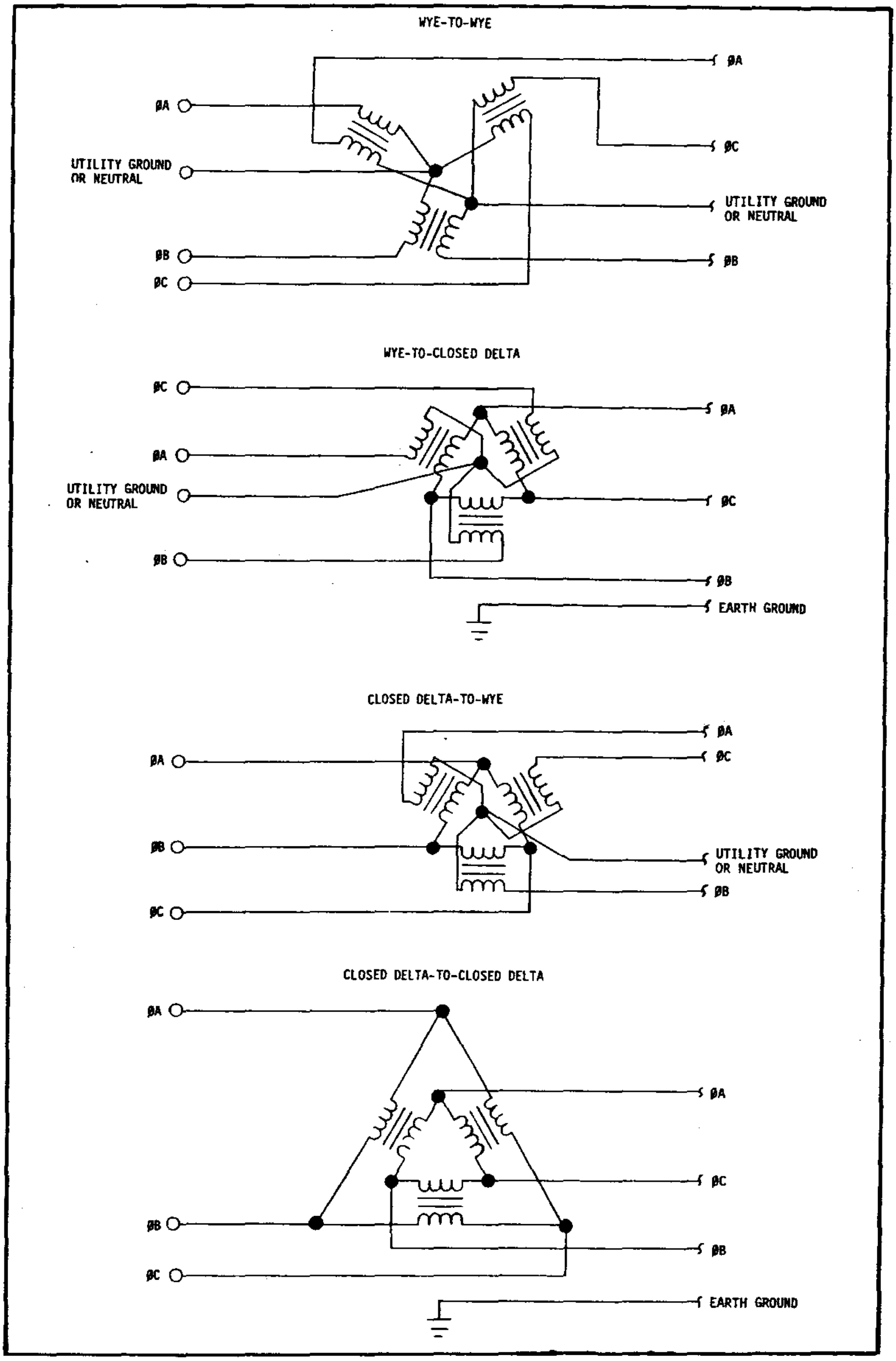

FIGURE 2-2. ACCEPTABLE AC POWER INPUT CONFIGURATIONS

2–17. INSTALLATION.

2–18. 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.

2–19. EQUIPMENT PLACEMENT.

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

2–20. The FM–20B transmitter is designed for two types of installations: 1) adjacent high voltage power supply cabinet installation or 2) remote high voltage power supply cabinet installation. If the cabinets are positioned apart, access holes in the top of the cabinets allow overhead routing of interconnecting wiring (see Figure 2–1).

2–21. Regardless of the type of installation, the floor must be capable of supporting the total transmitter weight. Also, the floor support should be more than marginal to maintain the proper alignment of the cabinets and reduce vibration.

2–22. After determining the position of the cabinets, place the PA and driver cabinets in the desired location as a single unit on a smooth and level surface. Remove the shipping skid bolts (located under the bottom of the skid) and lift the PA/Driver cabinets from the skid.

2–23. Remove the rear access door and the left side panel from the high voltage power supply cabinet. The rear access door may simply be lifted off the hinges. The left side panel is secured by two No. 2 Phillips head screws in the top mounting rail. After the two screws are removed, the side panel may be lifted up and off the rack.

2–24. After the panels are removed from the power supply cabinet, remove the shipping skid (remove four bolts located under the bottom of the skid). After the cabinet is unbolted from the skid, move the supply to the final location with a forklift (see Figure 2–3).

2–25. Once the power supply cabinet is placed, a bolt in each corner of the power supply base plate (see Figure 2–3) should be adjusted to level the base plate. A 9/16 inch open–end wrench is required. If the power supply is positioned adjacent to the PA cabinet, adjust and secure the cabinets as follows:

A. Bolt the power supply cabinet to the PA cabinet through the side rails with the connecting hardware provided. A 7/16 inch open end–box end wrench and a ratchet with a 7/16 inch socket and short extension is required.

B. Check the bolts securing the PA cabinet to the driver cabinet to ensure all three cabinets are securely bolted together.

2–26. COMPONENT INSTALLATION.

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

2–27. To facilitate component installation and wiring, the rear door of the driver cabinet, the rear door and the lower front access panel of the PA cabinet, and the rear door and left side panel of the power supply cabinet should be removed and remain off until installation is complete.

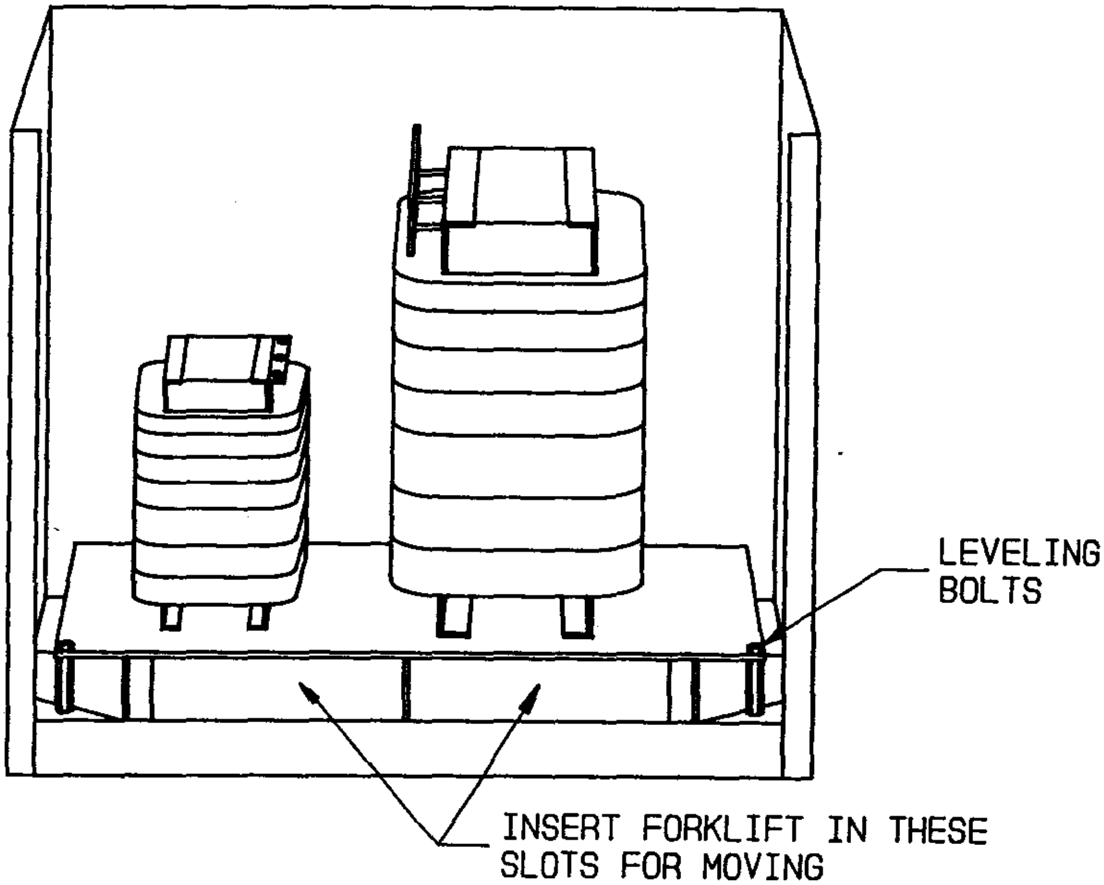

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FIGURE 2–3. POWER SUPPLY CABINET PLACEMENT

2–28. Interconnecting wires and cables are tied in for shipment. Remove all tape, wire ties, string, and packing material used for shipment.

2–29. Cables, connectors, and miscellaneous components to be installed are shipped in separate containers. The following text provides information concerning the installation of these items. Ensure the transmitter adjustments are not moved from the factory preset positions.

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

WARNING

2–30. **HIGH VOLTAGE POWER SUPPLY CABINET.** Unpack components located in the high voltage power supply cabinet as follows.

2–31. Unwrap the grounding stick and place the stick on the interlocked hanger. Ensure the wire tie securing the grounding stick interlocked hanger switch is removed.

2–32. Unwrap the interlock connector (if the cabinets are positioned together) or the interlock cable (if the cabinets are positioned apart).

2–33. Unwrap the PA/driver cabinet ac power cable harness which is coiled inside the high voltage cabinet.

2–34. Connect the high voltage power supply 9300V/4650V half–voltage jack to the 9300V receptacle.

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

2–35. **DRIVER CABINET.** Unpack, check, and install components located in the driver cabinet as follows.

2–36. **Controller Cabinet.** 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.

2–37. Refer to Figure 2–4 and ensure all controller jumpers are correctly positioned on the controller circuit board.

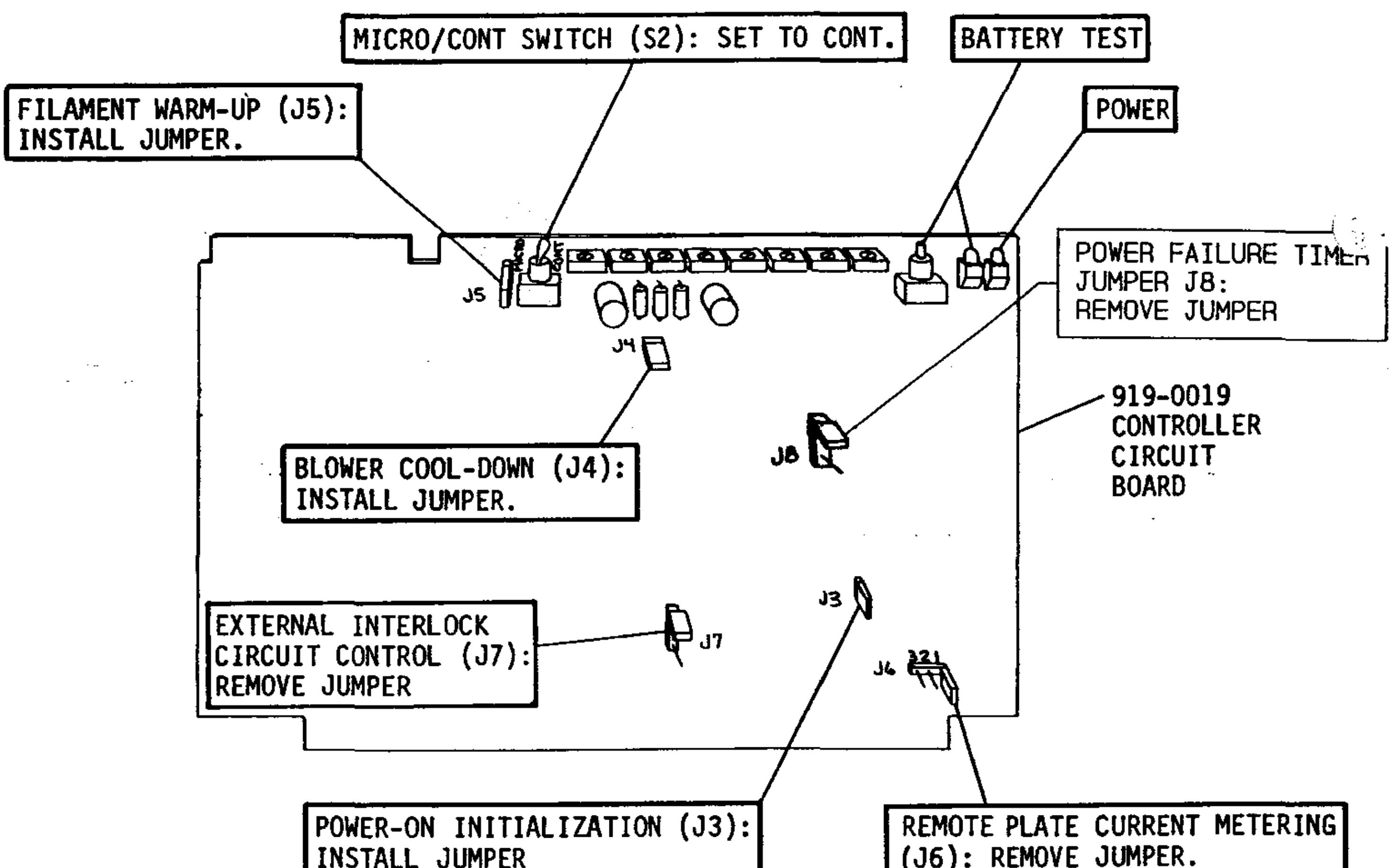

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FIGURE 2–4. CONTROLLER CIRCUIT BOARD JUMPER–PLUG PROGRAMMING

2–38. If the transmitter controller circuit board and the transmitter controller 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.

2–39. If the transmitter is equipped with the microprocessor video diagnostic system (MVDS), install these circuit boards at this time. Refer to manual No. 597–0114, Section II, Installation.

2–40. **Automatic Power Control (APC) Unit.** Remove the slide retainers from the APC unit.

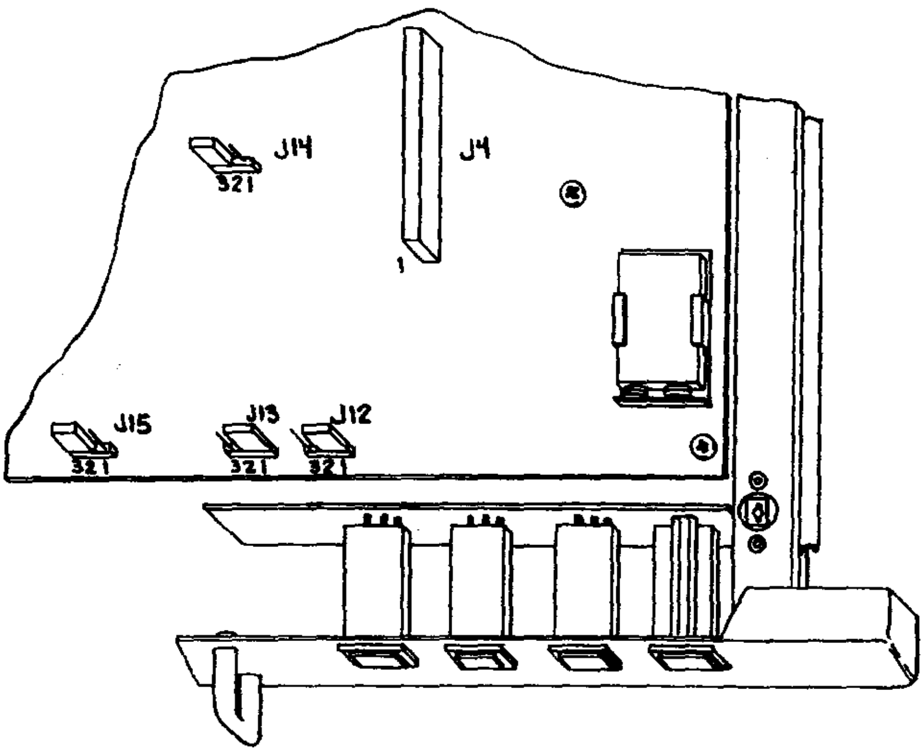
2–41. Extend the APC unit forward and remove the top–panel. A flat–blade screwdriver with a 1/4 inch (0.64 cm) tip is required.

NOTE *DO NOT REMOVE THE APC UNIT BATTERY. THE BATTERY MAINTAINS THE VALUE STORED IN THE APC POWER LEVEL REFERENCE MEMORY AND MUST REMAIN CONNECTED.*

NOTE

2–42. Refer to Figure 2–5 and assure all APC unit jumpers are correctly positioned.

2–43. Replace the top cover on the APC unit and return the unit to the rack.



597–0220–7

FIGURE 2–5. APC MAIN CIRCUIT BOARD JUMPER–PLUG PROGRAMMING

2–44. Two coaxial cables shipped inside the PA/Driver cabinet connect to the APC unit as follows:

	– FROM –	– TO –
CABLE NO.	OUTPUT TRANSMISSION LINE DIRECTIONAL COUPLER	APC UNIT
305	VSWR port	J10 REFL PWR RF SAMPLE
304	FWD port	J9 FWD PWR RF SAMPLE

2–45. **FX–50 Exciter.** Remove the slide retainers from the FX–50 exciter.

2–46. Loosen the exciter front–panel turn–lock fasteners and pull the exciter forward.

2–47. Loosen the eight turn–lock fasteners on the top of the exciter and remove the top cover.

2–48. Remove any packing material from the inside of the exciter.

2–49. Ensure the **POS–MUTE–NEG** switch on the power supply/control circuit board is operated to POS.

2–50. Ensure the **AUTO–PWR–MAN** switch on the power supply/control assembly is operated to AUTO and the **NORM–EXT** switch is operated to NORM.

2–51. Refer to the final test data sheets shipped with the exciter and ensure the AFC/PLL assembly SYNTHESIZER FREQUENCY SELECTION switches are correctly positioned.

2–52. Remove the two shipping screws securing the modulated oscillator assembly, and allow the unit to float on its mountings.

2–53. Replace the top cover on the exciter and secure the eight turn–lock fasteners on the top of the cover.

2–54. **IPA Assemblies.** Remove the slide retainers from the IPA assemblies.

2–55. Check each IPA module circuit board programming as follows:

A. Extend the IPA forward and remove the top–panel.

B. Refer to Figure 2–6 and ensure all circuit board jumpers are correctly positioned.

C. Replace the top–panel.

2–56. **Optional Equipment.** Refer to the stereo generator and SCA generator manuals and complete any applicable checks or programming included in INSTALLATION.

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

WARNING

2–57. **PA CABINET.** Unpack, check, and install components located in PA cabinet as follows.

2–58. **RF Enclosure.** Open the PA cavity access door.

2–59. Disconnect the plate–line B+ banana plug along the left side of the plate–line.

2–60. Remove all tape and packing shims from the plate–line at the cavity shelf to free the plate–line. Align the plate–line pins with the notches in the cavity shelf and raise the plate–line to allow the pins to travel up through the cavity shelf notches. Once the plate–line pins are above the cavity shelf, rotate the plate–line to lock the plate–line in the up position.

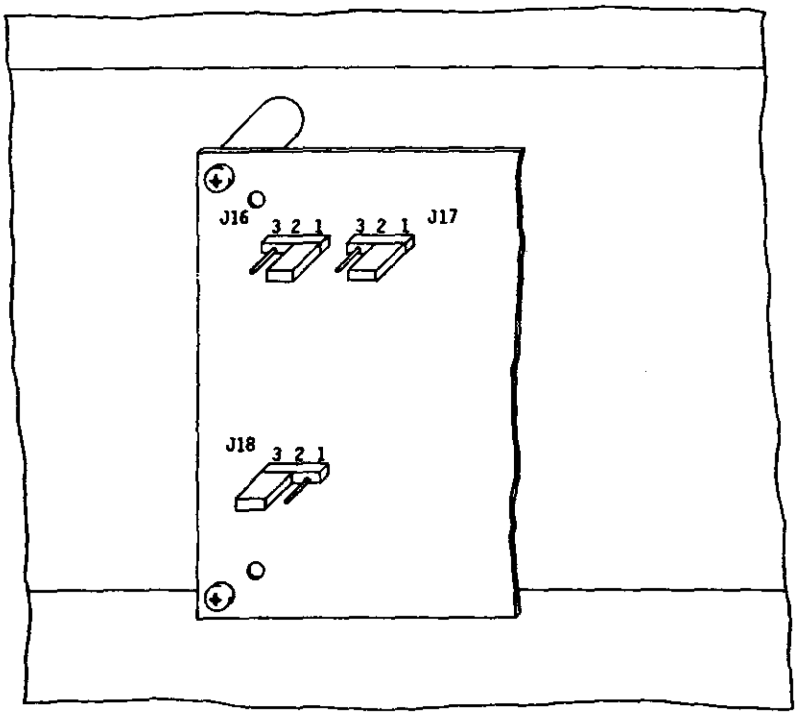


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FIGURE 2–6. IPA JUMPER PROGRAMMING

2–61. Carefully remove all packing material from over the tube socket.

2–62. Carefully install the PA tube with a steady downward pressure. Do not rotate or rock the tube during installation to prevent damage to the tube socket.

2–63. After the PA tube is fully seated, align the plate–line pins with the cavity shelf notches and lower the plate–line. Align the: 1) high–voltage plate line connection and 2) long–tapered plate–line shims with the cavity shelf notches. Once the high–voltage connection and shims are aligned, lower the plate–line over the tube until the plate–line shims engage the shelf notches.

2–64. Reconnect the plate RF choke banana plug to the plate–line. Ensure all connections are secure.

2–65. Secure the plate–line to the tube with the strap clamp. The plate–line must not move from the PA tube when upward pressure is applied. A flat–blade screwdriver with a 1/4 inch (0.64 cm) tip is required.

2–66. Close and secure the PA cavity access door.

2–67. Assure the second harmonic suppresser on the left side panel of the PA cavity is adjusted to the factory preset line scribed on the adjustment rod. If adjustment is required, loosen the lock screws and adjust the suppresser as required. Do not rotate the suppresser during adjustment. A 1/16 inch (1.59 mm) hex wrench is required for adjustment.

NOTE ***ENSURE THE TRANSMITTER COARSE TUNING IS ADJUSTED IN THE THE FOLLOWING STEP.***

NOTE

2–68. Adjust the transmitter coarse tuning as follows:

A. On the top of the PA cabinet, loosen the PA tuning line clamp.

B. Raise the PA tuning line until the factory scribed line is aligned with the top of the cavity clamping flange. Ensure the tuning line is perpendicular to the top surface of the cabinet. Secure the tuning line to the flange with the strap clamp.

CAUTION

CAUTION

CAUTION

CAUTION

TO PREVENT INCREASED HARMONIC OUTPUT LEVELS AND EFFICIENCY DEGRADATION, ASSEMBLE THE TRANSMITTER OUTPUT LINE AS DESCRIBED IN THE FOLLOWING TEXT WITH THE COMPONENTS SUPPLIED BY THE FACTORY. DO NOT INSTALL ADDITIONAL TRANSMISSION LINE SECTIONS BETWEEN THE CAVITY OUTPUT PORT AND THE LOW–PASS FILTER.

2–69. **RF Output Line Assembly.** Refer to Figure 2–7 and the following information to assemble the transmitter RF output transmission line. Assemble the RF output line as described with the components supplied by the factory. Do not install additional transmission line sections between the cavity output port and the low–pass filter. Incorrect assembly may result in increased harmonic output levels and efficiency degradation.

2–70. Locate the RF transmission line inner and outer conductors, elbow assembly, and low–pass filter assembly.

2–71. Access the PA cavity output connection by removing the PA cabinet eight front panel mounting screws.

2–72. Insert the transmission line inner conductor from the top, down onto the bullet connector in the lower transmission line elbow until the inner conductor is fully seated.

2–73. Insert the transmission line outer conductor from the top, down into the transmission line coupler until the outer conductor is fully seated. Secure the coupler strap clamps. A flat–tip screwdriver with a four–inch (10.16 cm) blade and a 1/4 inch (0.64 cm) tip is required.

2–74. Loosen the strap clamp on the transmission line and insert the clamp into the transmission line upper support L–bracket.

2–75. Secure the transmission line strap clamp. A flat–tip screwdriver with a four–inch (10.16 cm) blade and a 1/4 inch (0.64 cm) tip is required.

2–76. On a work surface, assemble the elbow with the monitor jack, the elbow inner conductor, a bullet conductor and insulator, and one unflanged transmission line coupling. Position the monitor receptacle either horizontally or vertically by reversing the elbow as required.

2–77. Ensure all parts of the assembly are fully seated, then secure the assembly together with a strap clamp using a flat–tip screwdriver with a four–inch (10.16 cm) blade and a 1/4 inch (0.64 cm) tip.

2–78. Mount the entire elbow assembly on top of the transmission line. When the assembly is fully seated, position the elbow as desired and secure the elbow strap clamp using a flat–tip screwdriver with a four–inch (10.16 cm) blade and a 1/4 inch (0.64 cm) tip.

2–79. Locate the 3 1/8 flanged coupling and bolt the coupling to the low–pass filter input as shown. The flange is secured with six bolts, six lockwashers, and six nuts.

2–80. Insert a bullet connector and insulator into the 3 1/8 inch (7.94 cm) flange.

2-95. **Cabinet Interconnections For Adjacent Power Supply Cabinet Installation.** For an adjacent power supply cabinet installation, refer to Figure 2-11 and perform the following cabinet interconnections.

A. Connect ac power wires 501 through 516 to TB201 in the PA cabinet.

B. Attach interlock connector P301 to J201.

CAUTION ***TO PREVENT SEVERE DAMAGE TO THE HIGH VOLTAGE POWER SUPPLY, ENSURE WIRES 450 AND 451 ARE PROPERLY INSTALLED IN THE TRANSMITTER.***

CAUTION

C. Attach high voltage wire 450 to the power supply cabinet high voltage point as shown.

D. Connect ground return wire 451 to the bottom terminal of resistor R304 as shown.

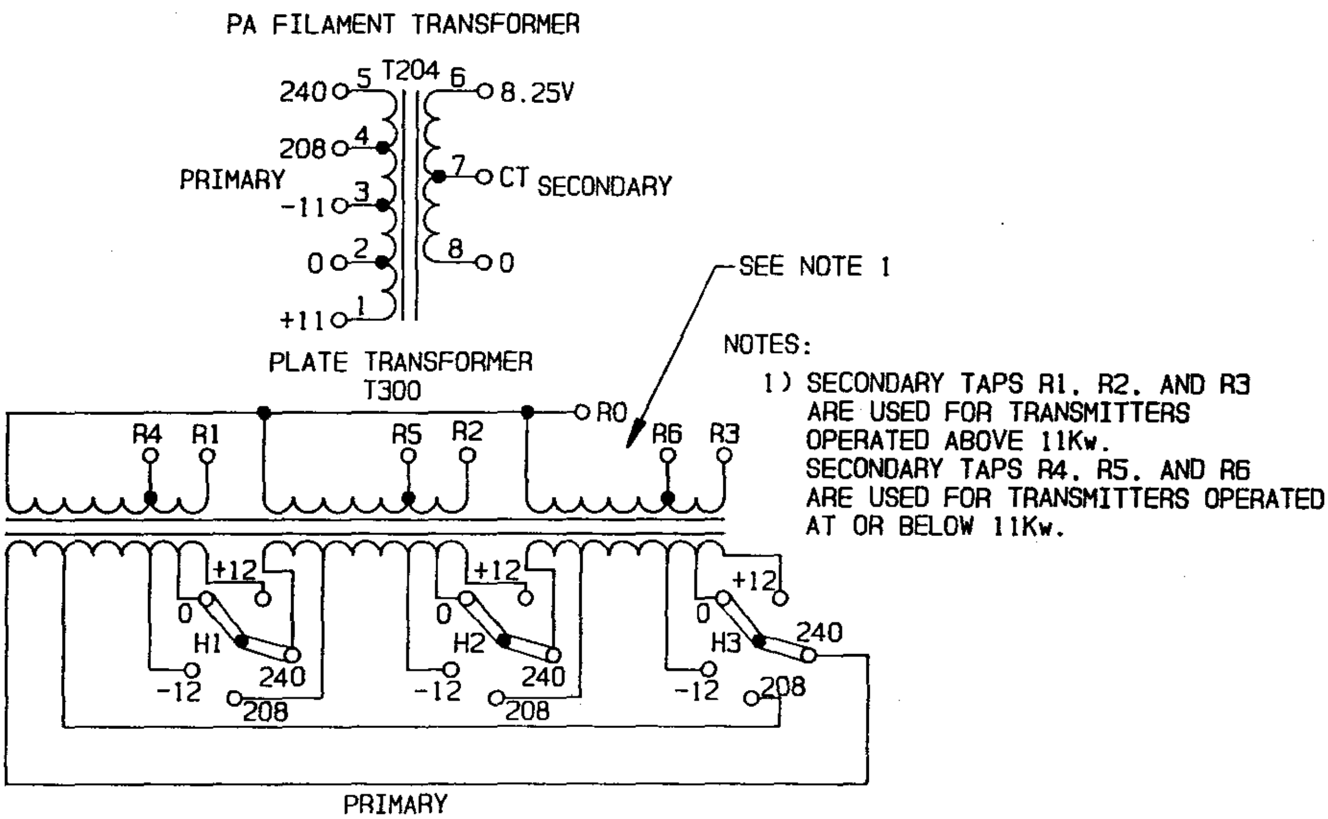

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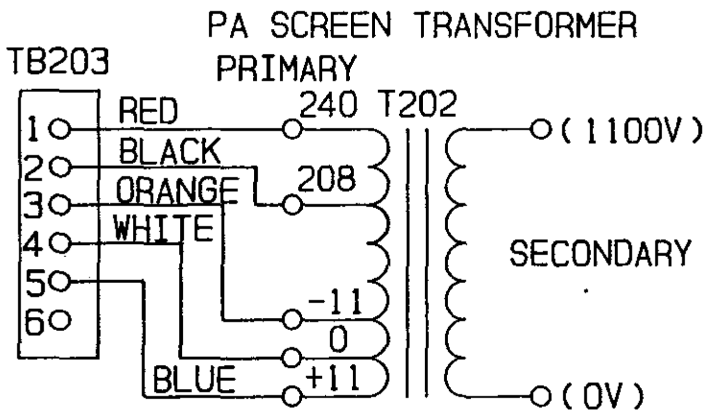
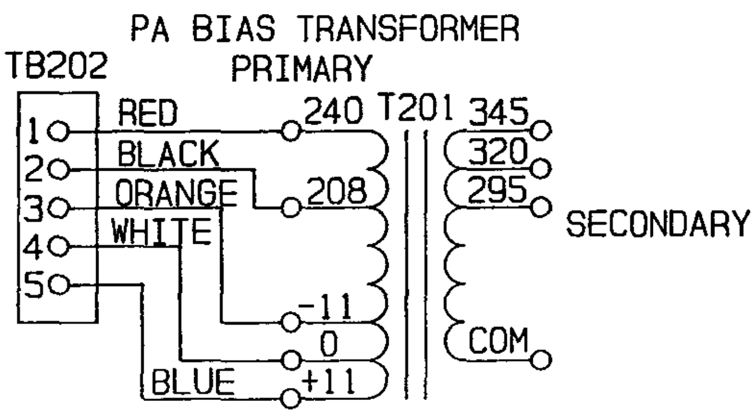
FIGURE 2-9. POWER TRANSFORMER WIRING (Sheet 1 of 2)





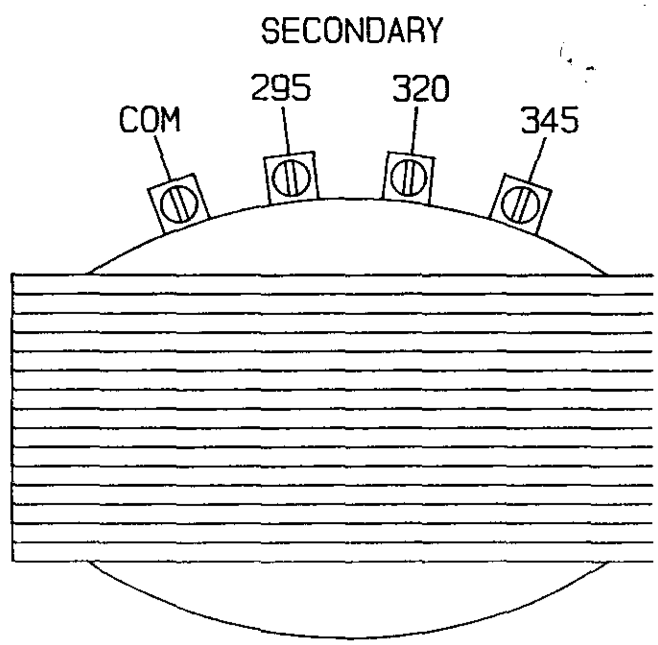


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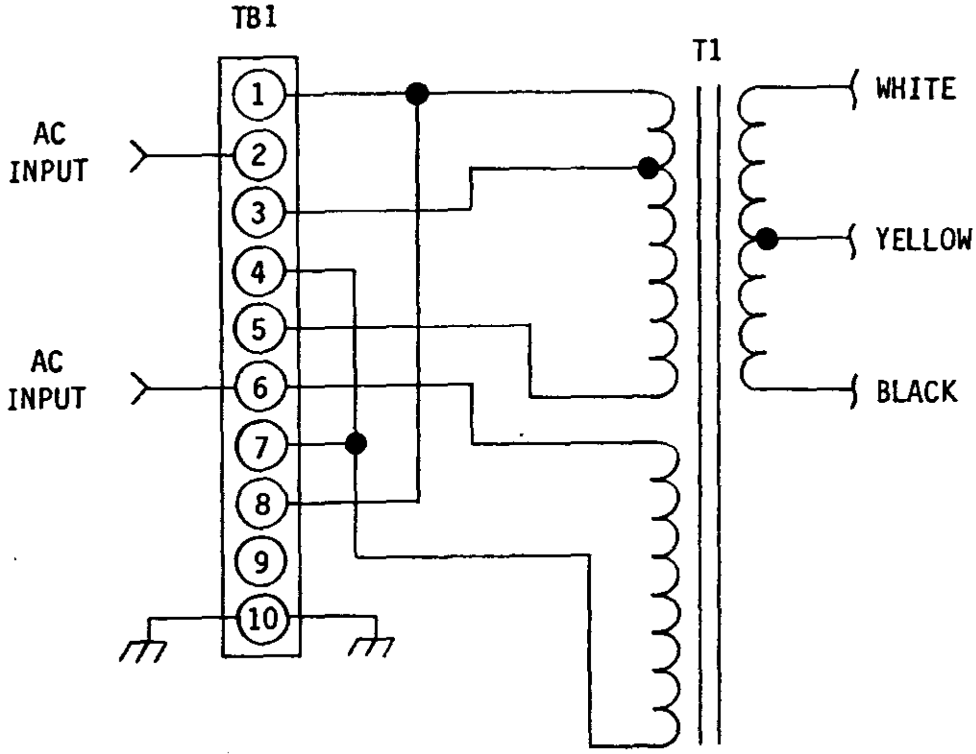
FIGURE 2-9. POWER TRANSFORMER WIRING (Sheet 2 of 2)



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

597–0220–12

FIGURE 2–10. IPA VOLTAGE TAPS

WARNING ***ENSURE ALL GROUND CONNECTIONS ARE PERFORMED IN THE FOLLOWING STEP.***

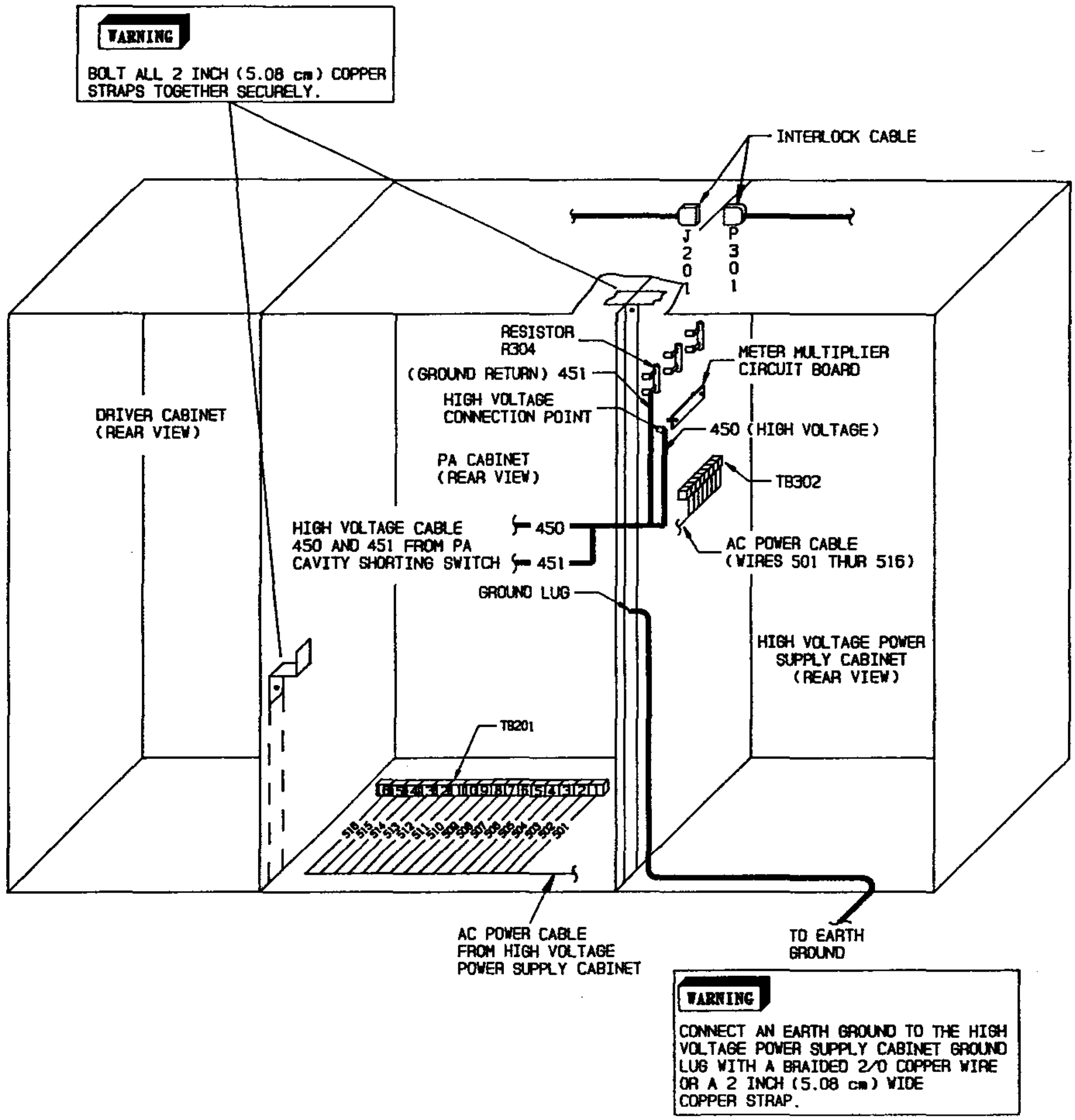
WARNING

E. Attach the ground connections in the cabinets as follows:

1. Connect a 2/0 braided copper wire from earth ground to the power supply cabinet ground terminal.

2. Bolt the copper straps in each adjoining cabinet together securely.

2–96. **Cabinet Interconnections For Remote Power Supply Installation.** For a remote power supply installation, refer to Figure 2–12 and perform the following cabinet interconnections.



597-0220-13

FIGURE 2-11. CABINET INTERCONNECTIONS, ADJACENT POWER SUPPLY CABINET INSTALLATION

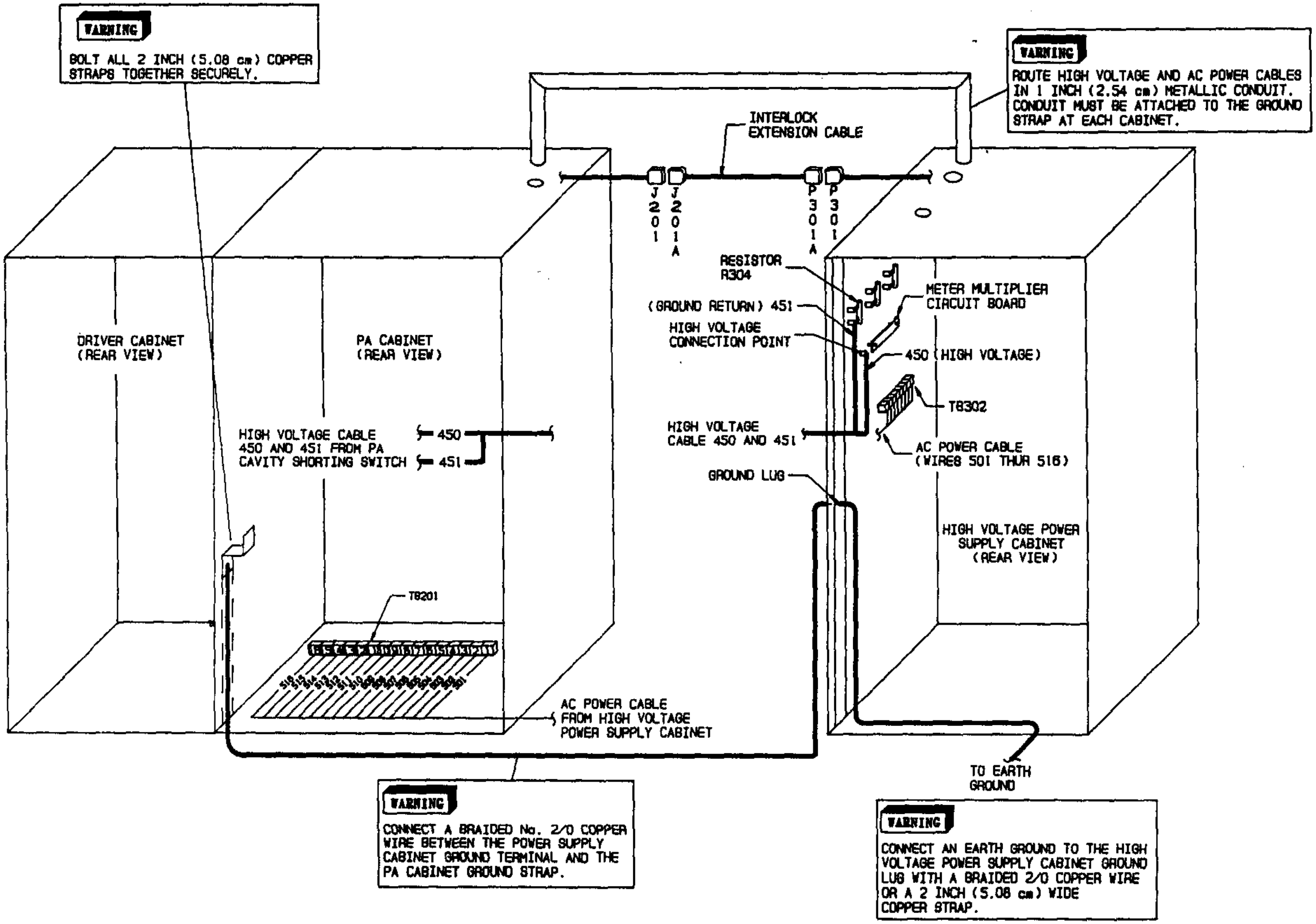


FIGURE 2-12. CABINET INTERCONNECTIONS, REMOTE POWER SUPPLY CABINET INSTALLATION

597-0220-14

WARNING *ROUTE CABINET INTERCONNECTING HIGH VOLTAGE AND AC POWER CABLES IN 1 INCH (2.54 cm) METALLIC CONDUIT TO PREVENT EXPOSURE TO HAZARDOUS VOLTAGES.*
WARNING

A. Using the PA cabinet and power supply cabinet overhead wiring access holes, route the high voltage and ac power cables from the power supply cabinet to the PA cabinet through 1 inch (2.54 cm) metallic conduit. Route all dc control cables in access holes separate from the ac and high voltage cables.

WARNING *CONNECT THE CONDUIT TO THE GROUND STRAP IN EACH CABINET.*
WARNING

B. Connect the conduit to the ground strap in each cabinet.

C. Connect ac power wires 501 through 516 to TB201 in the PA cabinet.

CAUTION *TO PREVENT SEVERE DAMAGE TO THE HIGH VOLTAGE POWER SUPPLY, ENSURE WIRES 450 AND 451 ARE PROPERLY INSTALLED IN THE TRANSMITTER.*
CAUTION

D. Attach high voltage wire 450 to the power supply cabinet high voltage point as shown.

E. Connect ground return wire 451 to the bottom terminal of resistor R304 as shown.

F. Connect the interlock extension cable between J201 and P301.

WARNING *ENSURE ALL GROUND CONNECTIONS ARE PERFORMED IN THE FOLLOWING STEP.*
WARNING

G. Attach the ground connections in the cabinets as follows:

1. Connect a 2/0 braided copper wire from earth ground to the power supply cabinet ground terminal.
2. Connect a 2/0 braided copper wire from the power supply cabinet ground terminal to the PA cabinet ground strap.
3. Bolt the copper strap in the adjoining driver and PA cabinets together securely.

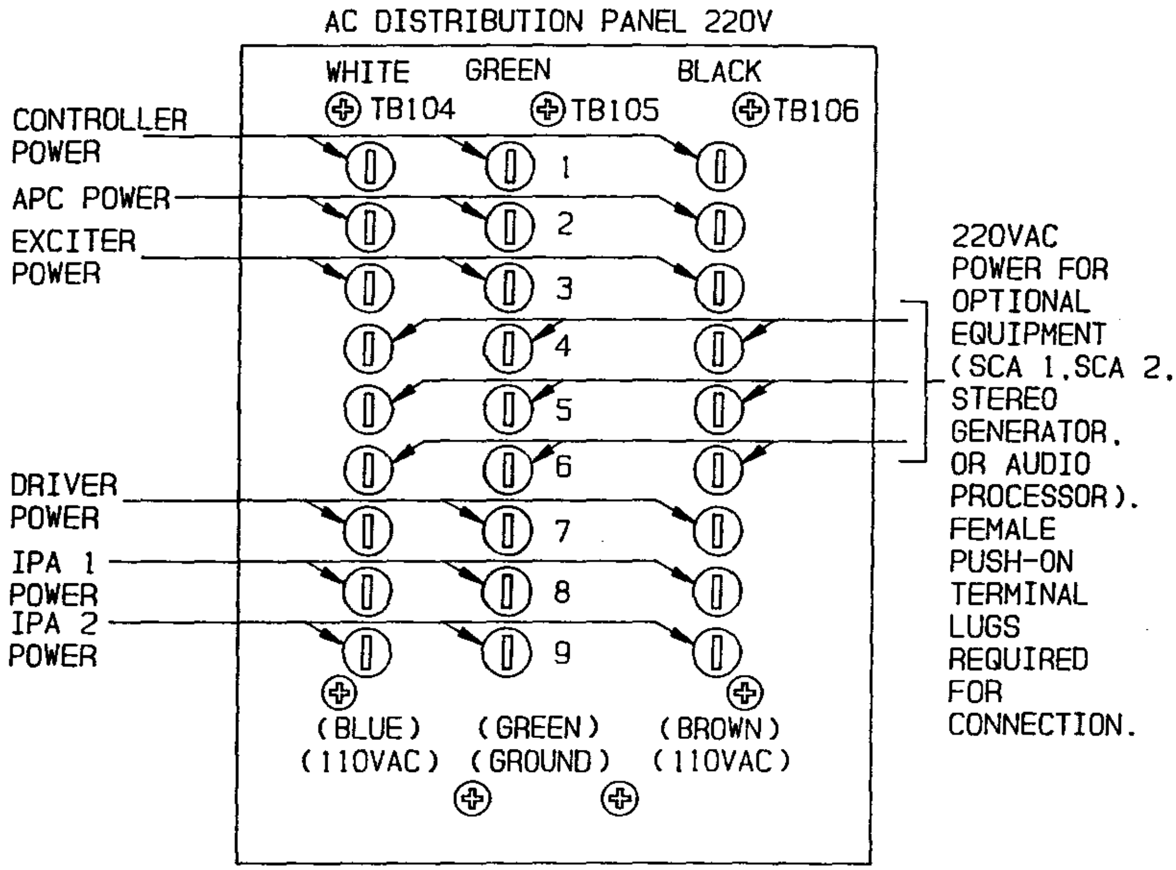
WARNING ***ENSURE PRIMARY POWER IS DISCONNECTED BEFORE PROCEEDING.***

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

2–97. **OPTIONAL EQUIPMENT WIRING.** An ac distribution panel is provided in the driver cabinet for the application of ac power to the driver cabinet modular components. Mount and wire any optional equipment not provided with the transmitter to the distribution panel (refer to Figure 2–13). 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.



597–0220–15

FIGURE 2–13. OPTIONAL EQUIPMENT WIRING

2–98. **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 should be routed in a wiring channel away from the RF circuitry.

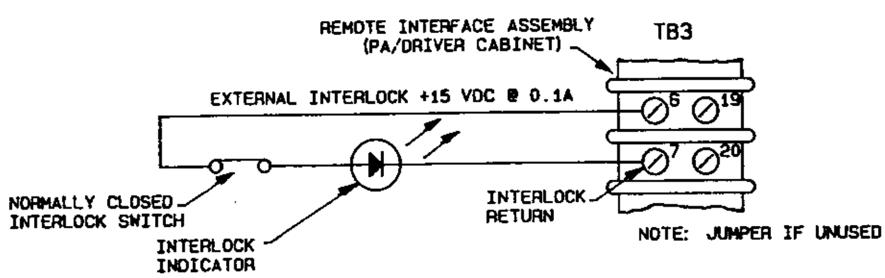
2–99. **EXTERNAL INTERLOCK.** The FM–20B transmitter is equipped with an external interlock circuit such as for a test load or remote control fail–safe connection. The external interlock circuit is independent of the transmitter safety interlock circuit and will disable only the high voltage plate supply 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.

2–100. If an external interlock is desired, refer to Figure 2–14 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.



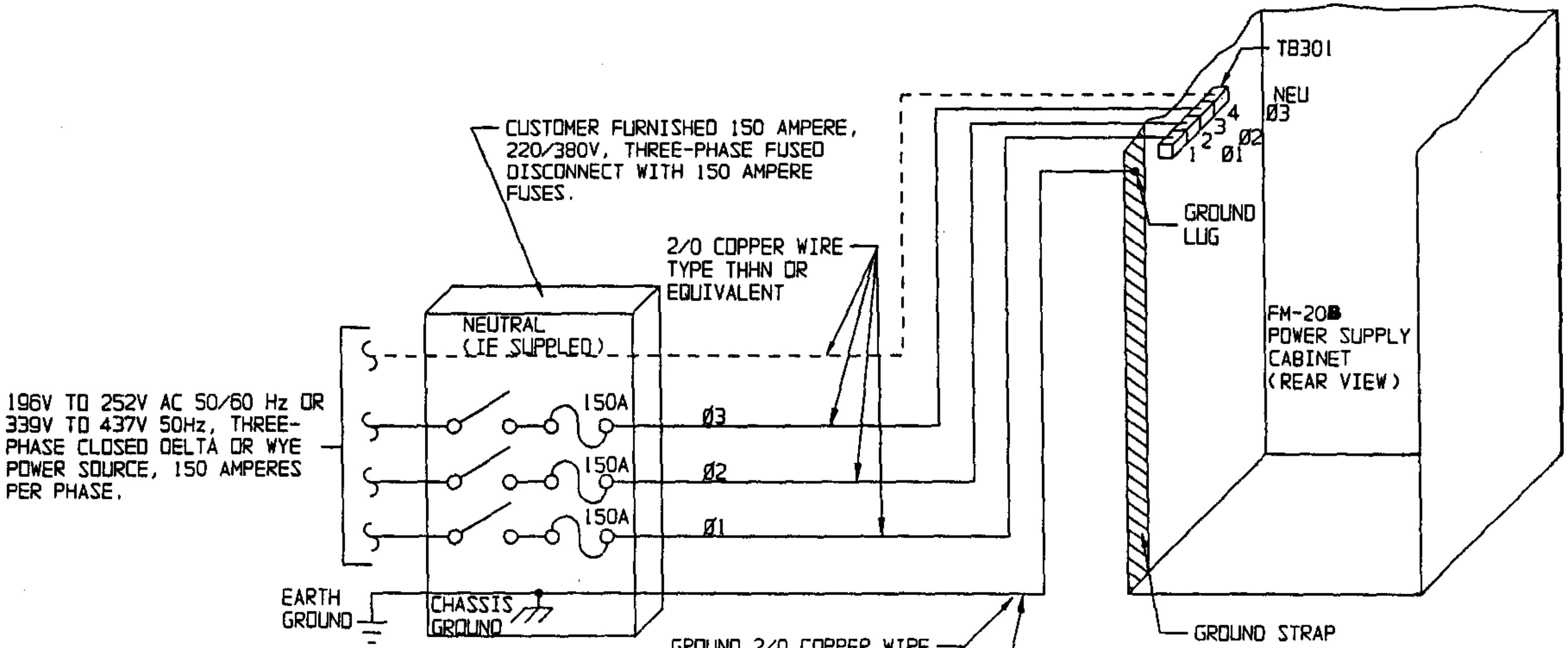
597–0220–16

FIGURE 2–14. EXTERNAL INTERLOCK CIRCUIT

WARNING *ENSURE PRIMARY POWER IS DISCONNECTED BEFORE PROCEEDING.*

WARNING

2–101. **AC POWER CONNECTIONS.** The FM–20B requires a three–phase power source of 196V to 252V ac 50/60 Hz or 339V to 437V ac 50 Hz at 150 amperes per phase. Ensure the required power source is supplied from an acceptable ac transformer configuration (refer to PRIMARY POWER). For operating safety, the power source must be routed to the transmitter through a fused power disconnect (see Figure 2–15).



WARNING

IF THE POWER SUPPLY CABINET IS LOCATED REMOTELY FROM THE PA/DRIVER CABINET, ENSURE A 2/0 COPPER WIRE OR A 2 INCH (5.08 cm) WIDE COPPER STRAP IS CONNECTED FROM THE POWER SUPPLY CABINET GROUND STRAP TO THE PA/DRIVER CABINET GROUND STRAP.

WARNING

ENSURE AN EARTH GROUND IS CONNECTED TO THE POWER SUPPLY CABINET GROUND STRAP WITH BRAIDED 2/0 COPPER WIRE OR A 2 INCH (5.08 cm) WIDE COPPER STRAP.

597-0220-17

FIGURE 2-15. PRIMARY AC WIRING FM-20B

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

	WARNING *WARNING*	***ENSURE AN EARTH GROUND CONDUCTOR IS SECURELY CONNECTED TO THE POWER SUPPLY CABINET GROUND TERMINAL.***

2–102. **Main ac Input.** Refer to Figure 2–15 and connect the three–phase service to the ac distribution panel in the power supply cabinet through a fused service disconnect. Ensure a utility company ground conductor is securely connected to the power supply cabinet ground lug. For a three–phase WYE service, ensure the neutral wire is connected to terminal 4.

2–103. Replace the guard over the primary ac power input terminal strip.

2–104. **INITIAL CHECKOUT.**

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

2–105. Replace all panels and doors on the transmitter.

2–106. Ensure that the transmitter is completely installed by checking the following items.

A. Ensure primary power is correctly wired.

B. Ensure all capacitors on the high voltage rectifier stacks are perpendicular to each respective stack.

C. Ensure all RF connections are secure.

D. Ensure all connections at terminal strips are secure, especially in high current areas.

E. Ensure all ground connections are secure.

F. Ensure the cabinet ground straps are properly connected to earth ground.

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

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

I. Remove any extra hardware and wire lying within the cabinets.

J. Ensure all guards at terminal strips, transformers, etc. are replaced and secure and close all doors.

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

2–107. Operate all six front–panel circuit breakers to OFF and ensure all transmitter controls are preset to the positions indicated on the final test data sheets.

2–108. Ensure an RF load is connected to the transmitter.

2–109. Adjust the **FILAMENT VOLTAGE** control fully counterclockwise (minimum). A small flat–blade screwdriver is required.

2–110. Extend the exciter forward to expose the **RF OUTPUT ADJ.** control access hole in the top–panel. Adjust the control fully counterclockwise (minimum).

2–111. 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.

2–112. **CONTROLLER AND INTERLOCK CHECKOUT.** Check the controller and transmitter interlock circuit operation by performing the following procedures.

2–113. **Controller Checkout.** Close the wall–mounted fused safety disconnect.

2–114. Operate the **CONTROL** circuit breaker to ON. The **HIGH VOLTAGE, SCREEN, FILAMENT,** and **BLOWER** circuit breakers must remain OFF.

2–115. Ensure the **FILAMENT ON** and **HIGH VOLTAGE ON** switch/indicators are extinguished.

2–116. 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.

2–117. **Interlock Checkout.** Complete the following procedure step by step and note the controller **INTERLOCK STATUS** indicator. If problems occur, deenergize all primary power and troubleshoot the series interlock circuit with an Ohmmeter.

2–118. Ensure the **HIGH VOLTAGE, SCREEN, FILAMENT,** and **BLOWER** circuit breakers are operated to OFF.

WARNING ***DEENERGIZE PRIMARY POWER BEFORE PROCEEDING.***

WARNING

2–119. Operate the **CONTROL** circuit breaker to OFF.

2–120. Remove the PA cabinet lower front access panel.

WARNING ***DO NOT TOUCH ANYTHING WITHIN THE TRANSMITTER WITH POWER ENERGIZED.***

WARNING

2–121. Operate the **CONTROL** circuit breaker to ON. The controller **INTERLOCK STATUS** indicator will be extinguished.

WARNING ***DEENERGIZE PRIMARY POWER BEFORE PROCEEDING.***

WARNING

2–122. Operate the **CONTROL** circuit breaker to OFF.

2–123. Replace the PA cabinet lower front access panel.

2–124. Operate the **CONTROL** circuit breaker to ON. The controller **INTERLOCK STATUS** indicator will illuminate.

2–125. Open the PA cabinet meter panel. The controller **INTERLOCK STATUS** indicator will extinguish.

2–126. Close the PA cabinet meter panel. The controller **INTERLOCK STATUS** indicator will illuminate.

2–127. Open the PA cabinet rear door. The controller **INTERLOCK STATUS** indicator will extinguish.

2–128. Close the PA cabinet rear door. The controller **INTERLOCK STATUS** indicator will illuminate.

2–129. Open the PA cabinet rear door and perform the following:

WARNING ***PERFORM THE FOLLOWING PROCEDURES AS INDICATED. DO NOT TOUCH ANYTHING WITHIN THE TRANSMITTER WITH POWER ENERGIZED.***
WARNING

A. Depress the PA cabinet rear door interlock switch and remove the grounding stick from the mounting clips. The controller **INTERLOCK STATUS** indicator will extinguish.

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

C. Depress the PA cabinet rear door interlock switch and 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 PA cabinet rear door.

2–130. Open the driver cabinet rear door. The controller **INTERLOCK STATUS** indicator will extinguish.

2–131. Close the driver cabinet rear door. The controller **INTERLOCK STATUS** indicator will illuminate.

2–132. Open the high voltage power supply cabinet rear door. The controller **INTERLOCK STATUS** indicator will extinguish.

2–133. Close the high voltage power supply cabinet rear door. The controller **INTERLOCK STATUS** indicator will illuminate.

2–134. Open the high voltage power supply cabinet rear door and perform the following:

WARNING ***PERFORM THE FOLLOWING PROCEDURES AS INDICATED. DO NOT TOUCH ANYTHING WITHIN THE TRANSMITTER WITH POWER ENERGIZED.***
WARNING

A. Depress the high voltage power supply cabinet 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. Close the high voltage power supply cabinet rear door.

2–135. 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.

2–136. **BLOWER CHECKOUT.** Check blower operation by performing the following procedure.

2–137. Ensure the **CONTROL** circuit breaker is operated to ON and operate the **BLOWER** circuit breaker to ON.

2–138. Depress the **FILAMENT ON** switch/indicator to illuminate the switch/indicator. The **FILAMENT ON** switch/indicator, **BLOWER STATUS**, and **FILAMENT STATUS** indicators will illuminate and the blower will begin operation.

2–139. 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.

2–140. **EXCITER CHECKOUT.** Check exciter operation by performing the following procedure.

2–141. Close the three–phase primary ac fused power disconnect, if opened.

2–142. Ensure the **CONTROL** and **BLOWER** circuit breakers are operated to ON. The **HIGH VOLTAGE**, **SCREEN**, and **FILAMENT** circuit breakers must remain OFF.

2–143. Depress the **HIGH VOLTAGE ON** switch/indicator.

2–144. Apply audio to the exciter. The presence of audio programming will be noted on the exciter digital MODULATION meter and the exciter front–panel **AFC** and **POWER** indicators will illuminate steadily.

2–145. Depress the exciter multimeter **AFC** switch.

A. The exciter 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.

2–146. 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).

2–147. 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).

2–148. 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).

2–149. Depress the **FILAMENT OFF** switch.

2–150. Remove the audio from the exciter.

2–151. **PRELIMINARY OPERATION AND TUNING.** Operate and tune the transmitter by performing the following procedure.

2–152. Check the transmitter controls. Ensure the controls are operated to the positions indicated on the factory final test data sheets.

2–153. Ensure the **CONTROL** and **BLOWER** circuit breakers are operated to ON. The **HIGH VOLTAGE** and **SCREEN** circuit breakers must be operated to OFF.

2–154. 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 doors closed.

B. All panels installed.

C. The grounding sticks are on the hangers.

2–155. 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.

2–156. Ensure the **FILAMENT ON** and **HIGH VOLTAGE ON** switch/indicators are extinguished.

2–157. Ensure the exciter **RF OUTPUT ADJ.** control is fully counterclockwise (minimum).

2–158. Depress the **APC ON** switch/indicator to extinguish the switch/indicator.

2–159. Depress the **APC REMOTE DISABLE** switch/indicator to illuminate the switch/indicator.

2–160. Operate the **APC FORWARD POWER METER** switch to FWD.

CAUTION
CAUTION

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

2–161. Operate the **FILAMENT** circuit breaker to ON.

2–162. 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.

2–163. Adjust the **FILAMENT VOLTAGE** control to obtain a **FILAMENT VOLTAGE** meter indication equal to the value recorded on the final test data sheets accompanying the transmitter.

2–164. Operate the **MULTIMETER** switch to GRID VOLTAGE and note the presence of PA stage grid bias.

2–165. Operate the **SCREEN** and the **HIGH VOLTAGE** circuit breakers to ON.

2–166. Depress the **HIGH VOLTAGE ON** switch/indicator. Both the **HIGH VOLTAGE ON** switch/indicator and the **HIGH VOLTAGE STATUS** indicator will illuminate.

2–167. Note the presence of plate voltage on the PLATE VOLTAGE meter.

2–168. 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.

2–169. Operate the **MULTIMETER** switch to SCREEN VOLTAGE.

2–170. Depress and hold the **APC RAISE** switch to obtain a screen voltage indication of 200 volts.

2–171. Operate the **MULTIMETER** switch to COMBINED FWD POWER.

2–172. Adjust the exciter **RF OUTPUT ADJ** control to obtain approximately 150 watts from the IPA stage.

2–173. Operate the **MULTIMETER** switch to COMBINED RFL POWER.

2–174. Adjust the **INPUT TUNING** control for a minimum reflected power indication.

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

2–175. 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.

2–176. Depress and hold the **APC RAISE** switch/indicator. The switch/indicator will flash. Hold the switch/indicator depressed until the OUTPUT POWER meter indicates 20% power.

2–177. Depress and hold the **APC OUTPUT POWER** meter switch to **VSWR CAL** and adjust the **VSWR CAL** control to obtain an indication of 20% on the OUTPUT POWER meter.

2–178. Release the **OUTPUT POWER** meter switch. The OUTPUT POWER meter must indicate a VSWR of less than 1.4:1. An excessive VSWR indicates improper load conditions.

2–179. Operate the **APC OUTPUT POWER METER** switch to FWD.

2–180. Operate the **MULTIMETER** switch to COMBINED FWD POWER.

2–181. Adjust the exciter **RF OUTPUT ADJ** control to obtain the combined IPA forward power value recorded on the factory test data sheets.

2–182. Operate the **MULTIMETER** switch to COMBINED RFL POWER.

2–183. Adjust the **INPUT TUNING** control for a minimum reflected power indication.

2–184. Adjust the **OUTPUT TUNING** control for a maximum indication on the **OUTPUT POWER** meter.

2–185. 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%.

2–186. Operate the **MULTIMETER** switch to COMBINED RFL POWER.

2–187. Adjust the **INPUT TUNING** control for a minimum reflected power indication. The IPA combined reflected power indication will be in the NORMAL range.

2–188. Adjust the **OUTPUT LOADING** and **OUTPUT TUNING** controls to obtain the meter indications stated on the factory test data sheets.

2–189. Check the **FILAMENT VOLTAGE** meter and adjust the **FILAMENT ADJUST** control as required to obtain the level recorded on the final test data sheets.

CAUTION ***DO NOT EXCESSIVELY UNLOAD THE PA TANK CIRCUIT IN THE FOLLOWING STEP.***

CAUTION

2–190. 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.

2–191. Operate the **MULTIMETER** to COMBINED RFL POWER and adjust the **INPUT TUNING** control for a minimum reflected power indication.

2–192. Depress the **APC RAISE** or **LOWER** switch/indicators as required to obtain a 100% OUTPUT POWER meter indication.

2–193. 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.

2–194. Depress the **APC ON** switch/indicator. The switch/indicator will illuminate and the transmitter will maintain a constant 100% rated RF output.

2–195. Recalibrate the **VSWR CAL** control for a 100% RF output.

2–196. If an external interlock is installed, open the external interlock. The **HIGH VOLTAGE STATUS** indicator will extinguish and PA plate voltage will be removed.

2–197. Close the external interlock. PA plate voltage will be restored, the transmitter will resume operation, and the **HIGH VOLTAGE STATUS** indicator will illuminate.

2–198. 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.

2–199. 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–20B transmitter and provides standard operating procedures.

3–3. CONTROLS AND INDICATORS.

3–4. Refer to Figures 3–1, 3–2, and 3–3 for the location of all controls and indicators associated with normal operation of the FM–20B transmitter. The function of each control or indicator is described in Tables 3–1, 3–2, and 3–3.

3–5. OPERATION.

NOTE	***THE FOLLOWING PROCEDURE IS PRESENTED UNDER THE ASSUMPTION THAT THE TRANSMITTER IS COMPLETELY 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 in Table 3–4.

3–12. Operate the **APC 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.

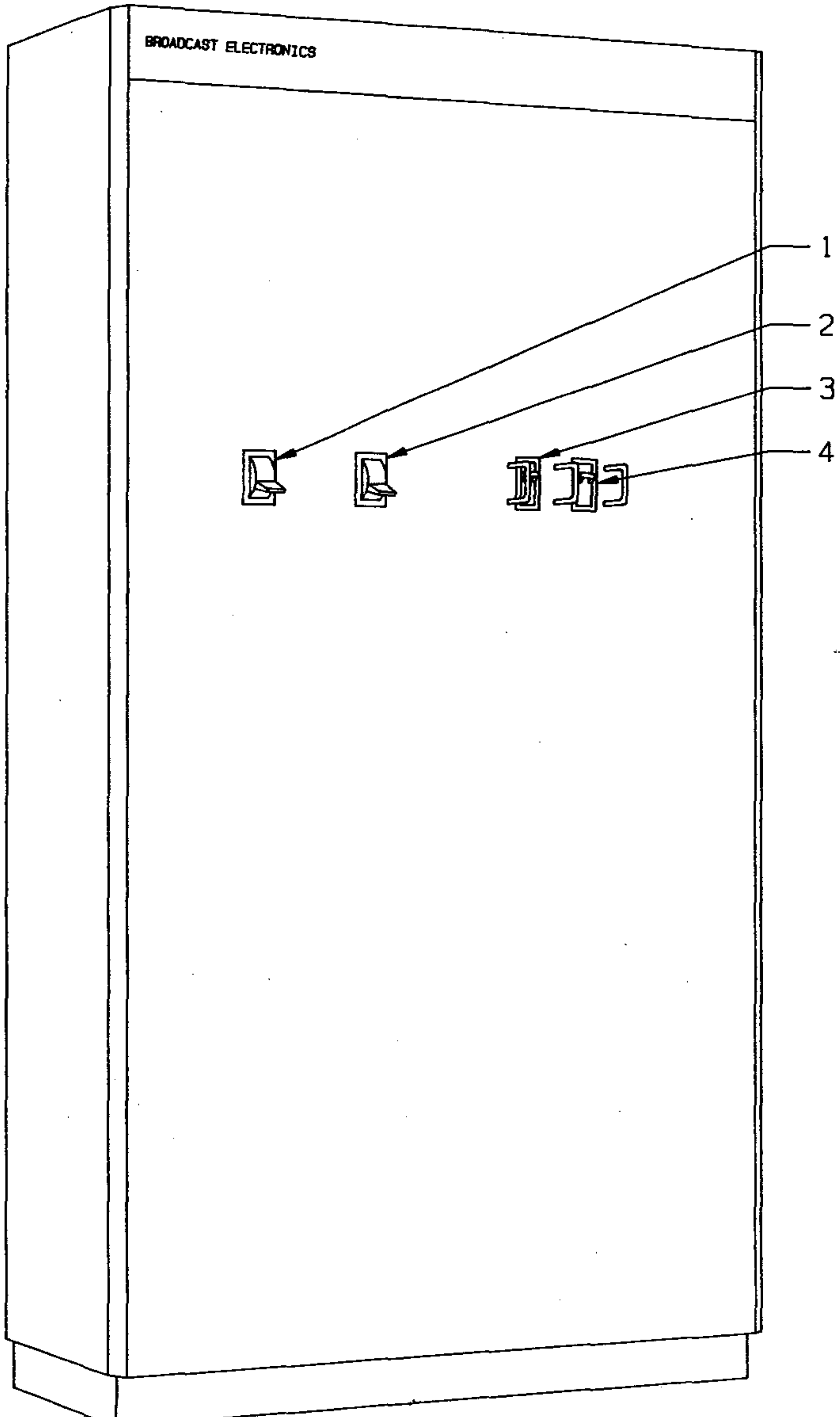
C. Release the **OUTPUT POWER METER** switch to check VSWR.

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

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

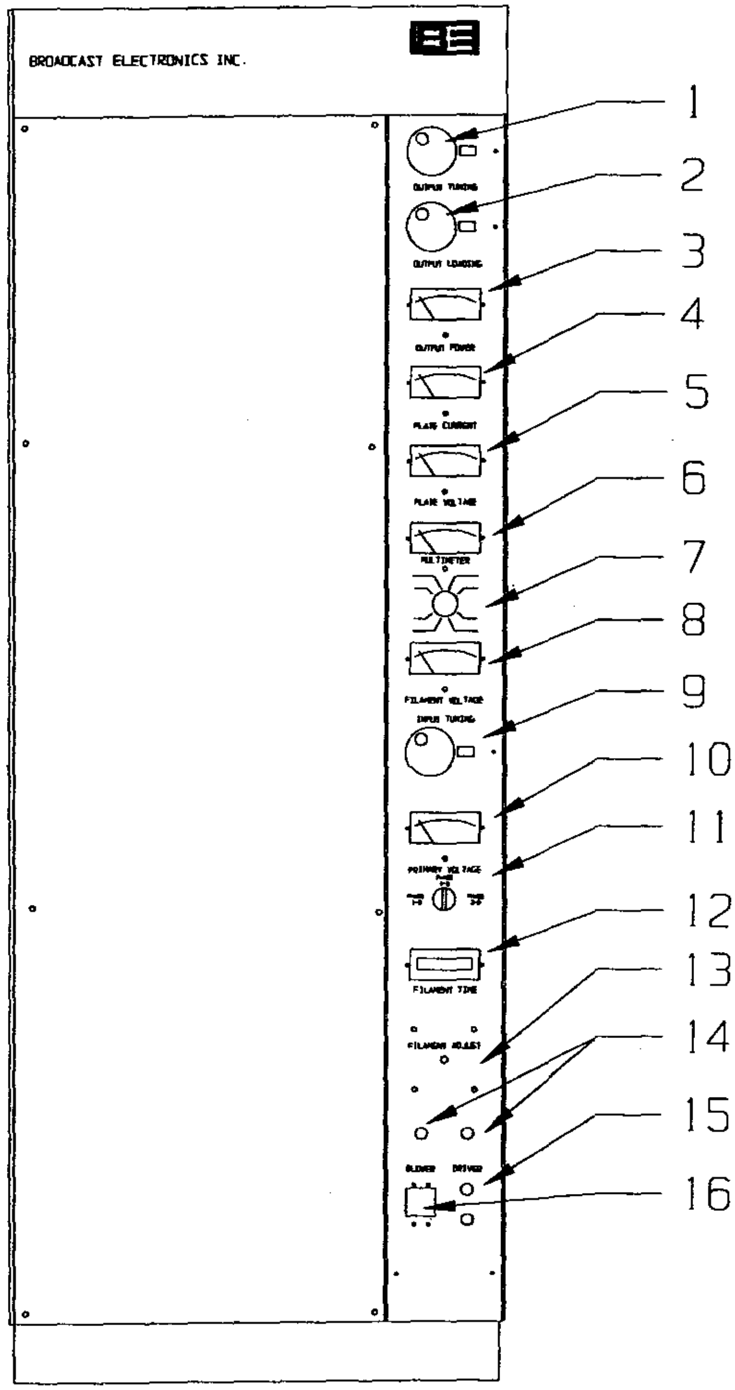
1. Depress the **APC ON** switch/indicator to extinguish the switch/indicator.
2. Depress the **APC RAISE** or **LOWER** switch/indicator to raise or lower the transmitter RF output power as indicated by the OUTPUT POWER meter.

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:



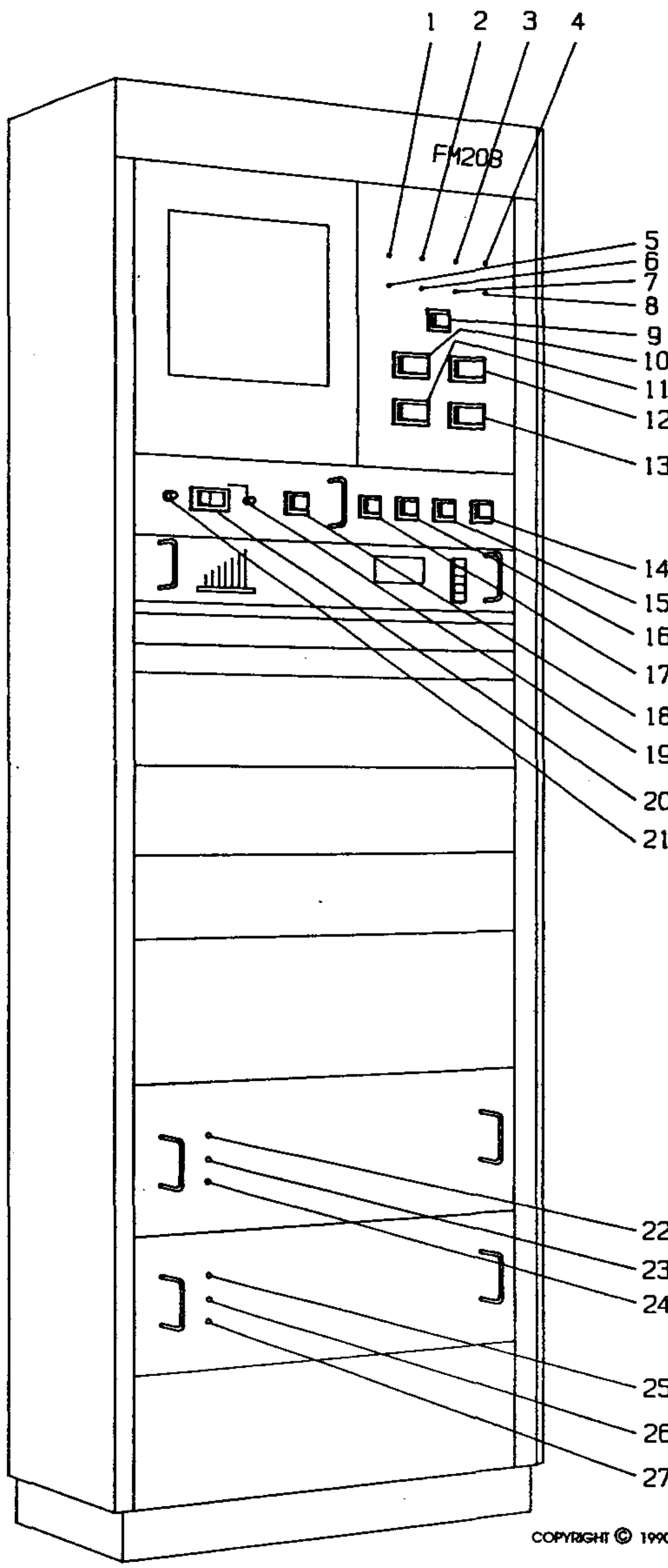
597-0220-19B

FIGURE 3-1. FM-20B POWER SUPPLY CABINET CONTROLS AND INDICATORS



597-0220-21B

FIGURE 3-2. FM-20B PA CABINET CONTROLS AND INDICATORS



597-0220-20B

FIGURE 3-3. FM-20B DRIVER CABINET 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. If the transmitter is disconnected from ac power for longer than one day, remove the controller battery.

3–18. **OPERATING THE TRANSMITTER FOR MAXIMUM TUBE LIFE.**

3–19. The FM–20B is equipped with an Eimac 4CX12000A/8989 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 – 4CX12000A/8989 Tetrodes".
3) The procedures presented in any "Eimac Product Bulletins" shipped with the tube.

TABLE 3–1. FM–20B POWER SUPPLY CABINET CONTROLS AND INDICATORS

INDEX NO.	NOMENCLATURE	FUNCTION
1	**HIGH VOLTAGE** Circuit Breaker	Provides overload protection and primary power control of the PA high voltage plate supply.
2	**CONTROL** Circuit Breaker	Provides overload protection and primary power control for the transmitter controller, APC unit, the PA RF drive components, PA screen supply, PA grid supply, PA filament supply, and the blower supply.
3	**SCREEN** Circuit Breaker	Provides overload protection and primary power control for the PA screen power supply.
4	**FILAMENT** Circuit Breaker	Provides overload protection and primary power control for the PA filament power supply.

TABLE 3-2. FM-20B PA CABINET CONTROLS AND INDICATORS
(Sheet 1 of 2)

INDEX NO.	NOMENCLATURE	FUNCTION
1	**OUTPUT TUNING** Control and Cyclometer	Tunes the PA stage output circuit to resonance.
2	**OUTPUT LOADING** Control and Cyclometer	Adjusts the PA stage output loading.
3	**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.
4	**PLATE CURRENT** Meter	Displays the PA stage plate current.
5	**PLATE VOLTAGE** Meter	Displays the PA stage plate potential.
6	**MULTIMETER**	Displays PA SCREEN VOLTAGE, SCREEN CURRENT, GRID CURRENT, GRID VOLTAGE, IPA 1 FWD POWER, IPA 2 FWD POWER, COMBINED FWD POWER, or COMBINED RFL POWER as selected by the **MULTIMETER** switch.
7	**MULTIMETER** Switch	Selects PA SCREEN VOLTAGE, SCREEN CURRENT, GRID CURRENT, GRID VOLTAGE, IPA 1 FWD POWER, IPA 2 FWD POWER, COMBINED FWD POWER, or COMBINED RFL POWER parameters to be displayed on the MULTIMETER.
8	**FILAMENT VOLTAGE** Meter	Indicates the PA tube filament voltage.
9	**INPUT TUNING** Control and Cyclometer	Tunes the PA stage input circuit to resonance.
10	**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.
11	**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.
12	**FILAMENT TIME** Meter	Indicates hours of filament circuit operation.
13	**FILAMENT ADJUST** Control	Adjusts the PA tube filament voltage.
14	**GRID BIAS** Circuit Breakers	Provides overload protection for the PA grid power supply.

TABLE 3-2. FM-20B PA CABINET CONTROLS AND INDICATORS
(Sheet 2 of 2)

INDEX NO.	NOMENCLATURE	FUNCTION
15	**DRIVER** Circuit Breakers	Provides overload protection and primary power control for the FM exciter, optional SCA and stereo generator units, the IPA units, and the driver cabinet flushing fans.
16	**BLOWER** Circuit Breaker	Provides overload protection and primary power control for the blower.

TABLE 3-3. FM-20B DRIVER CABINET CONTROLS AND INDICATOR
(Sheet 1 of 4)

INDEX NO.	NOMENCLATURE	FUNCTION
1	**INTERLOCK STATUS** Indicator	Indicates all transmitter safety interlocks are closed when illuminated. The external interlock circuit 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.
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.

TABLE 3-3. FM-20B DRIVER CABINET CONTROLS AND INDICATOR
(Sheet 2 of 4)

INDEX NO.	NOMENCLATURE	FUNCTION
10	**FILAMENT ON** Switch/Indicator	SWITCH: Energizes the control contactor when depressed to apply voltage to the exciter, IPA stage, filament, screen, and grid circuitry. INDICATOR: Indicates a filament-on command has been received by the transmitter controller.
11	**FILAMENT OFF** Switch	Deenergizes all transmitter RF circuit power. The blower and flushing fans will operate for approximately 35 seconds after the **FILAMENT OFF** switch has been depressed.
12	**HIGH VOLTAGE ON** Switch/Indicator	SWITCH: Energizes the step-start high voltage contactors when depressed to activate the PA plate supply and enables the RF drive. INDICATOR: Indicates a high voltage-on command has been received by the transmitter controller.
13	**HIGH VOLTAGE OFF** Switch	Deenergizes the plate supply 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. 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.

TABLE 3-3. FM-20B DRIVER CABINET CONTROLS AND INDICATOR
(Sheet 3 of 4)

INDEX NO.	NOMENCLATURE	FUNCTION
16	**AUTOMATIC POWER CONTROL APC ON** Switch/Indicator	SWITCH: Selects APC unit control of transmitter operation. INDICATOR: Indicates the transmitter is under APC unit 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.
21	**AM NOISE TEST** Receptacle	Test receptacle for AM noise measurements.
22	**INTERMEDIATE POWER AMPLIFIER 1 FWD POWER** Indicator	Indicates the IPA 1 stage RF output power exceeds 75 Watts when illuminated.
23	**INTERMEDIATE POWER AMPLIFIER 1 VSWR** Indicator	Indicates excessive IPA 1 stage output circuit VSWR when illuminated (greater than 10 Watts reflected power).
24	**INTERMEDIATE POWER AMPLIFIER 1 OVER TEMP** Indicator	Indicates an IPA 1 stage regulator heat sink over–temperature condition exists when illuminated.

TABLE 3-3. FM-20B DRIVER CABINET CONTROLS AND INDICATOR
(Sheet 4 of 4)

INDEX NO.	NOMENCLATURE	FUNCTION
25	**INTERMEDIATE POWER AMPLIFIER 2 FWD POWER** Indicator	Indicates the IPA 2 stage RF output power exceeds 75 Watts when illuminated.
26	**INTERMEDIATE POWER AMPLIFIER 2 VSWR** Indicator	Indicates excessive IPA 2 stage output circuit VSWR when illuminated (greater than 10 Watts reflected power).
27	**INTERMEDIATE POWER AMPLIFIER 2 OVER TEMP** Indicator	Indicates an IPA 2 stage regulator heat sink over-temperature condition exists when illuminated.

TABLE 3-4. INDICATOR CHECKLIST
(Sheet 1 of 2)

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	OR	OFF
PRESET SWITCH/INDICATOR	ON		OFF
APC ON SWITCH/INDICATOR	ON		OFF
LOWER SWITCH/INDICATOR	ON		OFF
RAISE SWITCH/INDICATOR	ON		OFF
IPA 1 FWD POWER	ON		OFF
IPA 1 VSWR	ON		OFF
IPA 1 OVER TEMP	ON		OFF
IPA 2 FWD POWER	ON		OFF
IPA 2 VSWR	ON		OFF
IPA 2 OVER TEMP	ON		OFF

NOTE

OPERATIONAL STATUS SHOWN BY SHADED INDICATOR

TABLE 3-4. INDICATOR CHECKLIST
(Sheet 2 of 2)

METER	INDICATION		
	POWER	VSWR	
OUTPUT POWER	%	:1	
PLATE CURRENT	A		
PLATE VOLTAGE	kV		
MULTIMETER			
Screen Voltage	V		
Screen Current	mA		
Grid Voltage	V		
Grid Current	mA		
IPA 1 FWD Power	W		
IPA 2 FWD Power	W		
Combined FWD Power	W		
Combined RFL Power	NORMAL/HIGH		
FILAMENT TIME	HOURS		
FILAMENT VOLTAGE	V		
PRIMARY VOLTAGE Phase 1-2 Phase 2-3 Phase 3-1	 V V V		

SECTION IV
THEORY OF OPERATION

4–1. INTRODUCTION.

4–2. This section presents the theory of operation for the Broadcast Electronics FM–20B transmitter.

4–3. The FM–20B transmitter is divided into functional blocks which are discussed by the following text. The functional blocks consist of the FM exciter, the intermediate power amplifier (IPA), the power amplifier, the automatic power control (APC) unit, the transmitter controller, metering circuitry, and the associated power supply circuitry. The power supply and RF circuitry are discussed in further detail at the end of this section. The IPA, APC, and the transmitter controller are described in detail by the modular publications in Part II of this manual. Refer to 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 is equipped with a digital frequency synthesizer which may be programmed to any frequency within FM band in 10 kHz increments. The FX–50 exciter is mounted on 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. Refer to publication 597–1050 for detailed explanation of the FX–50 exciter features.

4–8. INTERMEDIATE POWER AMPLIFIER STAGE.

4–9. The transmitter intermediate power amplifier stage consists of two identical 250 watt amplifier modules. RF drive for the IPA stage is provided by the FX–50 FM exciter. The output of the exciter is routed to a 90° hybrid splitter assembly which generates two identical RF signals for application to the IPA modules. The IPA module outputs are combined to provide approximately 375 watts of power to drive the transmitter PA stage.

4–10. **IPA MODULES.** The IPA modules are broadband devices which feature: 1) solid–state RF amplifier and regulator circuitry and 2) a regulated power supply with over–voltage and over–current protection circuitry. The RF amplifier and regulator are mounted on removable heat sinks built around a fan which provides forced–air cooling. The RF amplifier consists of two bipolar RF power transistors operated in a push–pull Class C configuration. Stripline directional coupler networks in the output circuit provide forward and reflected power samples.

4–11. Each IPA module is self–contained in a slide mounted chassis and equipped with three front–panel status indicators. A green **FWD PWR** indicator illuminates to indicate a sufficient RF output level for normal operation. A yellow **VSWR** indicator illuminates to indicate an excessive reflected power condition. A red **OVER TEMP** indicator indicates that an over–temperature condition exists within the module. Refer to the IPA section in Part II of this manual for a more detailed description.

4–12. **POWER AMPLIFIER.**

4–13. The FM–20B power amplifier operates from a single high–power efficient tetrode to provide 7.5 kW to 22 kW of RF output 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. Removal of the PA tube is simple and quick due to the cavity arrangement. A massive 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 FM–20B PA stage employs a patented folded half–wave coaxial cavity constructed with aluminum sheet metal and copper tubing. The cavity design eliminates the high voltage blocking capacitors and high current sliding contacts of conventional cavities through a unique tuning and output coupling technique. A grounded concentric copper center conductor tunes the cavity by varying the length inserted into the open end of a transmission line inner conductor. The main inner conductor is insulated from ground and carries the anode dc potential. DC power is applied at the RF voltage null point, approximately one–quarter wave from the anode for effective RF decoupling. An untuned output loop is used to couple the RF energy into the transmission line.

4–15. **INPUT CIRCUIT.** The input circuit consists of a patented broadband impedance matching circuit board and a variable inductor tuning network. The impedance matching circuit board utilizes a combination of etched series inductor and shunt capacitor elements to match the 50 Ohm output of the IPA stage to the high grid impedance of the PA tube over the 88 MHz to 108 MHz FM broadcast band. The input tuning network consists of two variable inductor assemblies. Coarse input tuning is accomplished by pre–adjusting a sliding–short variable inductor assembly. Fine input tuning is accomplished by a front–panel control which adjusts a second sliding–short variable inductor assembly.

4–16. **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.

4–17. **OUTPUT TUNING.** Output 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 which is inserted into the main line. Coarse frequency adjustment is accomplished by pre–setting the length of the center conductor into the cavity.

4–18. **NEUTRALIZATION.** Neutralization is accomplished in the PA cavity by an adjustable distributed inductance which develops a counteractive voltage swing between the screen and ground. This 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.

4–19. **SECOND HARMONIC SUPPRESSOR.** A patented second harmonic suppressor is incorporated into the PA cavity design. 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.

4–20. **OUTPUT CIRCUIT.** A low–pass filter is provided with the FM–20B to attenuate all residual second and higher order harmonics. This filter functions over the entire FM broadcast band. Two RF directional couplers are mounted after the filter in the output transmission line connection to provide filtered forward and reflected power RF samples to the automatic power control unit. A third port supplies an RF sample at 40 dB below carrier at 50 Ohms for external test equipment.

4–21. **AUTOMATIC POWER CONTROL.**

4–22. The automatic power control unit (APC) monitors 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.

4–23. **AUTOMATIC RF OUTPUT LEVEL CONTROL.** Part of the APC circuitry rectifies PA forward power and reflected power samples. The samples are routed to the power meter selector switch and to the transmitter controller for further evaluation. The APC also monitors screen current and IPA stage forward power and adjusts the PA screen voltage via a dc servo motor–driven variable autotransformer to maintain a constant transmitter RF output. If excessive PA reflected power, excessive screen current, or low IPA power is 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.

4–24. 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. The indicator illumination intensity and rate indicates the actual servo system drive.

4–25. **VSWR FOLDBACK PROTECTION.** PA forward power is automatically reduced if output reflected power becomes excessive 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.

4–26. **SOFT–START.** A comparator 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.

4–27. **TRANSMITTER CONTROLLER.**

4–28. Transmitter control operations and parameter monitoring 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.

4–29. 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.

4–30. 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.

4–31. **MOMENTARY POWER INTERRUPTION.** In the event of a momentary power interruption, proper operation 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 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 re–applied.

4–32. 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 de–energize the high voltage and filament supplies.

4–33. **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.

4–34. Four green STATUS indicators illuminate to indicate an operational condition as follows: 1) the INTERLOCK LED indicates that the safety interlock loop is closed, 2) the BLOWER LED indicates that the air pressure is correct for the PA stage to operate, 3) the FILAMENT LED indicates primary ac power is applied to the filament transformer, 4) the HIGH VOLTAGE LED indicates the high voltage plate supply is operational.

4–35. **METERING.**

4–36. Seven front panel meters 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.

4–37. Additional transmitter metering features include an eight 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 1 forward power, 6) IPA 2 forward power, 7) IPA combined forward power, and 8) IPA combined 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. 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.

4–38. **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.

4–39. **POWER SUPPLIES.**

4–40. A three–phase ac input of 196 to 252 volts or 339 to 437 volts is required to operate the transmitter internal power supplies. The plate power supply requires a three phase ac input with the remainder of the power supplies requiring conventional 220V single–phase circuits obtained from two phases of the three–phase input. Power to the plate supply is applied in two steps to reduce the inrush current at power–on to limit stress and extend component life in the plate supply.

4–41. The control grid bias and screen power supplies consist of conventional full–wave rectification circuits with choke input filter sections. A hum–null circuit consisting of a transformer and potentiometer assembly injects a small 60 Hz component in series with the ground return of the grid supply to cancel residual ripple from the tetrode amplifier.

4–42. The 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. Advantages of this type of supply is good regulation and a low percentage of ripple output which requires little filtering.

4–43. The filament supply consists of a variable transformer assembly which is used to adjust a high–current low–voltage transformer. A filament voltage regulator option provides a stable input voltage environment for the supply. The device will regulate a wide range of ac input potentials to create a stable 240 ±1% volt output for the filament transformer.

4–44. 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 unit maintain operational information during power outages. The battery in the APC can remain connected at all times. However, the controller battery will discharge if connected during periods of extended power outages. Both batteries are common nine–volt alkaline types.

4–45. DETAILED DESCRIPTION.

4–46. **POWER SUPPLIES.**

4–47. The FM–20B requires a three–phase power source of 196V to 252V ac 50/60 Hz or 339V to 437V ac 50 Hz at 150 amperes per phase maximum (refer to Figure 4–2). The following list presents approximate operating voltage and currents of the transmitter for a 20 kW RF power output.

PARAMETER	APPROXIMATE VALUES
A. PA PLATE	+9200V at 2.7 Amperes
B. PA SCREEN GRID	+700V at 0.13 Amperes
C. PA CONTROL GRID	–310V at 0.050 Amperes
D. PA FILAMENT	7.5V ac at 120 Amperes

4–48. **SEQUENCE OF OPERATION.**

4–49. When the transmitter fused disconnect is closed, three–phase ac power is distributed to the **HIGH VOLTAGE** (CB301) and **CONTROL** (CB302) circuit breakers. Closing the circuit breakers routes ac power to the following circuitry:

CIRCUIT BREAKER	CIRCUITRY
HIGH VOLTAGE	Power amplifier plate and screen supplies.
CONTROL	Transmitter controller, APC unit, and a transmitter ac control circuit (grid supply, filament supply, exciter, IPA modules, and optional stereo and SCA generators).

4–50. AC power is routed to the controller and the APC unit when the **CONTROL** circuit breaker (CB302) is closed. A start sequence is initiated when the **FILAMENT ON** switch/indicator is depressed. Logic from the controller will enable optically–coupled–relay K306. K306 will energize control contactor K303 which applies ac power to **BLOWER** circuit breaker CB202, **FILAMENT** circuit breaker CB202, **DRIVER** circuit breaker CB201, and **SCREEN** circuit breaker CB303. When **BLOWER** circuit breaker CB202 is closed, ac power will be applied to blower B202. The blower will begin operation and the air interlock switch will close. With the air interlock and all transmitter safety interlocks closed, logic from the controller will enable filament optically–coupled–relay K307. With **FILAMENT** circuit breaker CB304 closed, K307 will apply ac power to the PA filament supply and the control grid bias supply. AC power will be applied to the driver cabinet flushing fans, exciter, optional stereo and SCA generators and IPA units when **DRIVER** circuit breaker CB201 is closed.

4–51. Assuming the **HIGH VOLTAGE ON** switch/indicator has been depressed, and the PA filament heating delay of at least ten seconds has expired, logic from the controller will enable optically–coupled–relays K304 and K305. K304 will energize step contactor K302 which limits plate supply current inrush through resistors R301, R302, and R303. K305 will energize start contactor K301 to apply full input potential to the plate supply and screen supplies.

4–52. 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. If the interlock is promptly closed, the blower and flushing fans will resume operation to cool the PA tube. To continue transmitter operation, a new manually initiated start sequence is required.

4–53. 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.

4–54. PA PLATE POWER SUPPLY.

4–55. Three–phase ac power for the PA plate supply is applied to transformer T301. T301 is a three–phase primary, six–phase secondary transformer. The primary winding is connected in a closed delta arrangement and protected by circuit breaker CB301. The secondary winding is connected in a wye configuration. Component stress at power on is eliminated by a step/start circuit which limits supply in–rush current.

4–56. Full–wave rectification is accomplished through high–voltage rectifier diodes D301 through D306. Filtering for the supply is accomplished by a one–section choke–input filter (L301). The choke is inserted in the negative leg of the rectified output to eliminate the dc potential between the choke and ground. Shunt capacitor C301 bypasses residual ac ripple frequencies above 360 Hz to ground. Bleeder resistors R307 through R309 increase regulation and operate in association with the high voltage discharge switch to enhance safety. A series resistance in the anode dc feedline functions to limit peak energy in case of arc–overs in the power amplifier stage. A one–half voltage supply tap is provided for transmitter troubleshooting. Plate voltage metering samples are generated by a plate meter multiplier assembly.

4–57. Component stress at power–on is eliminated by a high voltage step/start circuit which limits the plate supply inrush current. The step/start circuit is interlocked through the control contactor and filament circuit breaker to assure the filament circuit is energized before a high–voltage–on sequence is initiated. A high–voltage–on sequence begins when the controller energizes step contactor K302 via K304. After100 milliseconds, the controller will energize start contactor K301 via K305. Next, the step contactor will deenergize after 160 milliseconds. In this manner, the current limiting resistors will only be subject to heating during a 100 millisecond interval between the step contactor and start contactor closures.

4–58. **PA SCREEN POWER SUPPLY.** The screen power supply is a full–wave bridge–rectified supply with a LC filter consisting inductor L202 and capacitors C202 through C204. Resistors R203 through R205 equalize the voltage across the capacitors. Overload protection for the circuit is provided by circuit breaker CB303. AC power transformation is performed by screen transformer T202. The primary of T202 is connected to a variable autotransformer which is used to adjust the screen supply output. A dc motor connected to the variable autotransformer allows both manual and automatic control of the screen voltage. Bleeder resistor R206 improves regulation and enhances safety. Resistor R207 is incorporated into the circuit to limit the current inrush.

4–59. **PA CONTROL GRID BIAS POWER SUPPLY.** The control grid bias supply is a full–wave bridge–rectified supply with an LC filter consisting of inductor L201 and capacitor C201. The circuit is protected from overloads by circuit breakers CB203 and CB204. Primary power transformation is provided by transformer T201. Bleeder resistor R201 improves regulation and enhances safety by discharging C201. Potentiometer R202 is provided to limit the current inrush.

4–60. **Hum–Null Circuit.** The hum–null circuit consists of a transformer and potentiometer assembly. The circuit is designed to introduce a small 60 Hz voltage into the control grid bias supply to cancel hum in the filament supply. The canceling voltage is obtained from the filament transformer secondary and is out–of–phase with the filament supply 60 Hz ripple component. The amplitude of the 60 Hz signal is adjusted by resistor R208.

4–61. **PA FILAMENT SUPPLY.** The PA filament supply is a low–voltage high–current ac supply obtained from optically–coupled–relay K307. Overload protection for the circuit is provided by circuit breaker CB304. An optional filament voltage regulator is designed to provide a stable ac input voltage environment. Primary power transformation is provided by transformer T204. Variable transformer L204 allows accurate filament voltage adjustment. A FILAMENT TIME meter 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 develops in either leg of the filament supply.

4–62. **BLOWER SUPPLY.** Transmitter blower B202 operates from a conventional 220 volt single–phase supply. The supply is obtained from control contactor K303. Overload protection for the circuit is provided by circuit breaker CB202.

4–63. **DRIVER SUPPLY.** The driver supply provides ac power for the driver cabinet flushing fans, the exciter, the IPA modules, the optional stereo generator, and the optional SCA generators. Overload protection for the circuit is provided by circuit breaker CB201. The supply is obtained from control contactor K303.

4–64. **RF CIRCUITRY.**

4–65. **FM EXCITER.** The modulated FM signal for RF circuit operation is generated by the FX–50 FM exciter (refer to Figure 4–3). Approximately 35 Watts of drive is required from the exciter to operate the FM–20B IPA stage. Refer to publication 597–1050 for a complete description of the FM exciter circuitry.

4–66. **INTERMEDIATE POWER AMPLIFIER STAGE.** The FM–20B IPA stage consists of: 1) an input hybrid splitter, 2) two identical 250 watt INTERMEDIATE POWER AMPLIFIER modules, and 3) an output hybrid combiner. The IPA stage provides an overall gain of approximately 10 to output approximately 375 watts of power to drive the FM–20B PA stage.

4–67. **Input Hybrid Splitter.** The output of the exciter is applied to an input hybrid splitter assembly. The input splitter consists of two stripline inductor networks which divide an input signal into two equal 90 degree out–of–phase outputs. Resistor R1 operates as a reject load for any imbalance in power split or output mismatch. One output is delayed by 90° to allow the IPA's to be driven in–phase.

4–68. **IPA Modules.** The two hybrid splitter outputs drive two identical 250 watt IPA modules. The IPA units are totally self–contained modules consisting of: 1) a power supply circuit, 2) a regulator circuit, and 3) an RF amplifier module. Each amplifier operates in a Class C configuration to provide approximately 200 watts of drive to an output combiner assembly. For a complete description of the IPA modules, refer to Part II of this manual.

4–69. **Output Hybrid Combiner.** The outputs from the IPA modules are routed to a 90° output hybrid combiner assembly. The IPA modules are connected to the combiner with transmission line sections in a manner which results in a 90° phase difference at the input of the combiner. The output combiner assembly consists of two stripline inductor networks which combine the IPA outputs to provide approximately 400 watts of drive to the PA stage.

4–70. **POWER AMPLIFIER.** The FM–20B PA stage contains a single tetrode operated as a class C amplifier in a folded half–wave cavity to provide the rated RF power output. The amplifier operates in a grid driven configuration and exhibits high efficiency and ease of maintenance. The following text describes the operation of components and circuits within the PA stage.

4–71. **PA Input Circuit.** The transmitter IPA stage impedance is matched to the tube grid impedance by an input matching circuit board assembly. The circuit board consists of series inductor and shunt capacitor elements which are etched into the copper–clad laminate. The multiple LC sections match the 50 Ohm IPA impedance to the higher grid circuit impedance of the PA tube. The last LC section on the circuit board is equipped with three taps. Tap B provides standard input matching characteristics. Taps A and C provide alternate input matching characteristics for special operating conditions.

4–72. The input circuit is adjusted to match the 50 Ohm IPA impedance to the higher input impedance of the grid over the 88 MHz to 108 MHz FM broadcast band by input tuning inductor networks L10/C11, L19/C19, and L9/C10. The LC networks are connected in parallel and employ sliding shorts to tune the grid capacitance to resonance. C10, C11, and C19 also function as RF bypass and dc blocking capacitors.

4–73. The L19/C19 network is configured as a frequency dependent coarse tuning component. The L10/C11 network is also configured as a coarse tuning component and is adjusted by a control at the rear of the RF enclosure. Fine tuning is accomplished by the L9/C10 network which is mechanically connected to the front panel input tuning control. Capacitors C4 and C5 are provided for dc blocking operations. Swamping network R2/C16 lowers the Q of the input circuit to increase the bandwidth. This input tuning circuit design provides a wide operating bandwidth and improves the reliability, stability, and maintainability of the transmitter.

4–74. The PA tube screen ring is connected to dual parallel adjustable LC neutralization networks. The LC neutralization networks consist of: 1) inductor L7/A and RF bypass capacitor C7, 2) inductor L8/A and RF bypass capacitor C8, 3) inductor L17/A and RF bypass capacitor C17, and 4) inductor L18/A and RF bypass capacitor C18. The networks are configured as adjustable strap inductors which are inserted into the Kapton RF bypass capacitors (C7, C8, C17, C18). Neutralization is accomplished by adjusting the length of the straps which varies the series screen grid inductance. This introduces an out–of–phase current component causing a voltage swing across the screen to ground which cancels internal ac feedthru components. Spark–gaps E1 and E2 are provided to safely conduct energy if the tube should arc internally.

4–75. RF choke RFC2 and bypass capacitor C15 operate in conjunction to short any screen supply RF voltages to ground. RFC3 and C20 function in a similar manner by shorting any bias supply RF voltages to ground. C12A/B/C are configured as filament bypass capacitors and are incorporated into the tube socket assembly. Inductors L11, L12, L14, and L15 are tube socket mounting components and are frequency dependent.

4–76. **Power Amplifier Cavity.** The PA cavity used in the FM–20B employs a folded coaxial transmission line resonator constructed with aluminum and copper tubing (see Figure 4–4). The design eliminates the high voltage blocking capacitors and high current shorting contacts of conventional cavities. A grounded concentric center conductor tunes the cavity with a variable re–entrant length inserted into the end of a main high voltage inner conductor. The main inner conductor is insulated from ground and carries the anode dc potential. DC power is fed through RF choke RFC1 and high voltage feedthru capacitor C6 at the RF voltage null point which is approximately one–quarter wave from the anode for effective RF decoupling. An untuned loop (L13) operating in the electromagnetic field is used to couple the RF energy into the transmission line. Rather than attenuating the second harmonic after the signal has been generated and amplified, the circuitry within the cavity essentially eliminates formation of the second harmonic component.

4–77. Plate tuning is accomplished by an adjustable bellows on the grounded or center portion of the plate line (L9) 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 which is also the second harmonic peak voltage point. Second harmonic suppression is accomplished by a series LC circuit consisting of L6 and C9 which is inserted at the peak voltage point to essentially eliminate the second harmonic component. Resistor R1 is incorporated into the PA cavity design for RF suppression.

4–78. **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.

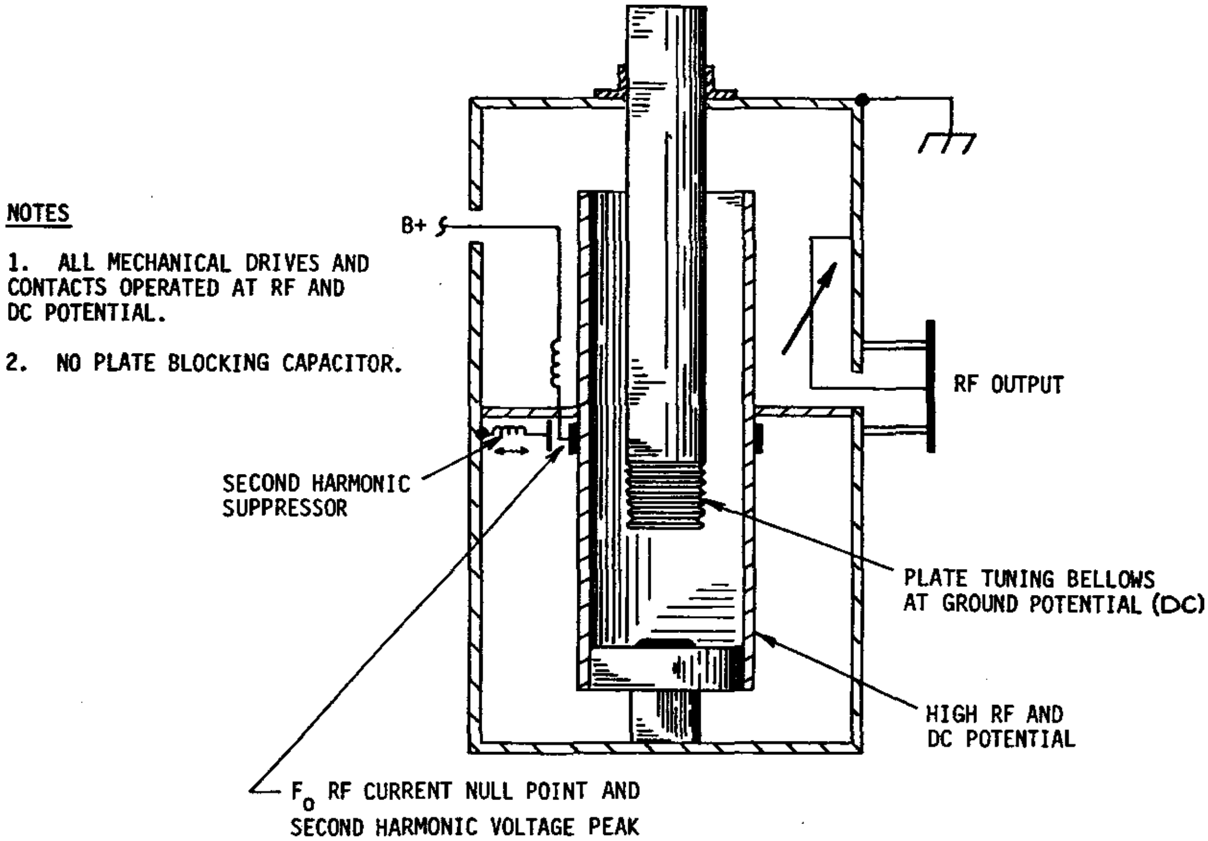


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FIGURE 4–4. PA CAVITY

4–79. 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 provide forward power and VSWR samples for the output power meter, the transmitter controller, and inputs to the automatic power control unit. An additional port in the transmission line provides a connection for a station modulation monitor.

4–80. **PA Metering.** Seven meters 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. Monitoring of ac input potentials is provided by a primary ac voltage meter.

4–81. **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 4–3).

4–82. PA forward and reflected power samples from the transmitter low–pass filter are applied to individual rectifier/amplifier circuits in the APC unit. The outputs from the rectifier/amplifier circuits are routed to the output power meter to provide indications of transmitter operation. The amplified outputs are also applied to automatic forward and reflected power control circuits. Raise/lower power control logic monitors several parameters such as the forward and reflected power control circuits, screen current, and IPA forward power to determine if power control and correction is required. The output of the raise/lower logic is used to control the adjustable screen supply autotransformer when automatic power control is enabled.

4–83. When the automatic power control circuitry is enabled and as RF output 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.

4–84. As an additional function, a plate voltage comparator 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 Broadcast Electronics FM–20B transmitter.

5–3. SAFETY CONSIDERATIONS.

WARNING
WARNING
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.

5–4. The FM–20B transmitter contains high voltages and currents which, if regarded carelessly, could be fatal. The transmitter has many built–in safety features, however good judgment, 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 extremely dangerous to attempt to make measurements or replace components with power energized, therefore such actions must not be performed. 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 shorting switches which discharges the plate supply to ground. Do not bypass the 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.

5–7. Two grounding sticks are provided as safety features. One grounding stick is located in the power supply cabinet and one in the PA cabinet. Each grounding stick consists of a metal hook with an insulated rod. 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 the maintenance.

5–8. The power supply cabinet grounding stick is stored on a hook– switch and the PA cabinet grounding stick is housed in interlocked clips. When the grounding sticks are removed, an associated switch will open the transmitter interlock string and deenergize all transmitter dc potentials until the grounding sticks are replaced.

5–9. FIRST LEVEL MAINTENANCE.

WARNING
WARNING
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.

5–10. First level maintenance consists of procedures applied to the equipment to prevent future failures. The 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 performance levels using the meters and various indicators built into the equipment.

5–11. MISCELLANEOUS.

WARNING
WARNING
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.

5–12. 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, loading drives, cables, the PA tuning line right angle gear mechanism, and the cyclometer drives behind the PA cabinet 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.

5–13. 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.

5–14. AIR FILTERS.

5–15. The FM–20B transmitter is equipped with two air filters. One filter is located in the driver cabinet rear door with the other located in the PA cabinet rear door. Air filter replacement is accomplished from outside the transmitter without interrupting equipment operation. Each filter should be checked once a week with replacement done on an as–required basis. A dirty filter could result in dust leaking into the cabinet from seams, door jambs, etc. Never reverse a dirty filter. Always replace the filter. The transmitter controller and APC unit also contain air filters which should be checked monthly and cleaned as necessary.

5–16. The transmitter uses disposable type air filters 1 inch X 16 inches X 20 inches (2.54 cm X 40.64 cm X 50.8 cm). Additional filters may be ordered for replacement (BE P/N 407–0062) or purchased locally. Always install the filter with the airflow arrow pointing towards the blower and flushing fans.

5–17. 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 COMPO-*
WARNING *NENTS ARE DISCHARGED BEFORE ATTEMPTING MAINTENANCE ON ANY AREA WITHIN THE TRANS-*
WARNING *MITTER.*

5–18. Inspect the transmitter blower and flushing fans for dust accumulation and periodically clean the blower and flushing fans using a brush and vacuum cleaner. The blower and fan motors are cooled by 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 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 also 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. The blower motor and flushing fan are equipped with sealed element–type bearings which do not permit lubrication. Therefore, no regular motor lubrication is required. However, check the blower and flushing fan mounting hardware at regular intervals to ensure proper operation.

5–21. SECOND LEVEL MAINTENANCE.

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

5–22. Second level maintenance consists of procedures required to restore the transmitter to operation after a fault has occurred.

5–23. The maintenance philosophy of the FM–20B transmitter 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 defective assembly or component. If desired, a defective assembly may be returned to the factory for repair or exchange.

5-24. GENERAL

5-25. **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. An Eimac application paper titled "Extending Transmitter Tube Life" is provided in APPENDIX A of this manual. Excess control grid or screen grid dissipation will shorten the life of a tube. Also, excess plate dissipation always produce trouble. Typical FM-20 PA efficiency is plotted in Figure 5-1 and should be referenced to estimate PA efficiency for a particular power level.

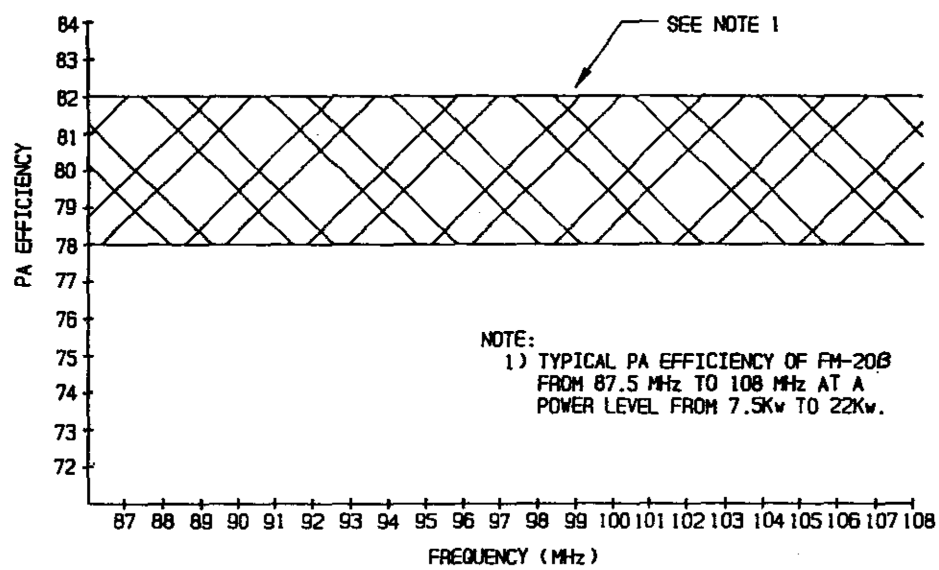

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FIGURE 5-1. FM-20B TYPICAL PA EFFICIENCY

5-26. **PA Tube Warranty.** The transmitter 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, Broadcast Electronics 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 ***BERYLLIUM OXIDE CERAMICS (BeO) - AVOID BREATHING DUST OR FUMES.***

WARNING

WARNING	***THE WHITE CASE MATERIAL USED ON THE IPA RF AMPLIFIER TRANSISTORS IS MADE FROM A 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	
WARNING	
WARNING	
WARNING	

5–27. **IPA STAGE.** The transistors in the intermediate power amplifier assemblies will normally last many times longer than the power amplifier tube unless a major fault occurs such as a regulator malfunction. For further maintenance information, refer to the IPA publication in Part II of this manual.

5–28. **ADJUSTMENTS.**

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	

5–29. Adjustment procedures for controls associated with the IPA modules, APC unit, and the transmitter controller are presented in each applicable publication in Part II of this manual. Adjustment procedures for power supply and PA controls are presented as follows:

A. AM Noise.

B. Control Grid Bias Level Adjustment.

C. Current Meter Calibration.

D. Second Harmonic Suppresser Adjustment.

E. Neutralization.

5–30. **AM NOISE.** Each FM–20B transmitter is 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.

5–31. **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.

5–32. **Asynchronous AM Noise.** Asynchronous AM noise is residual amplitude modulation of the transmitter output due primarily to power supply ripple. The hum null circuit injects a small 60 Hz voltage into the grid bias supply to cancel ac components in the supply and reduce 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.

5–33. **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
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.

5–34. **Procedure.** To adjust the hum null circuit, proceed as follows:

5–35. 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.

5–36. Operate the transmitter at a normal output power level.

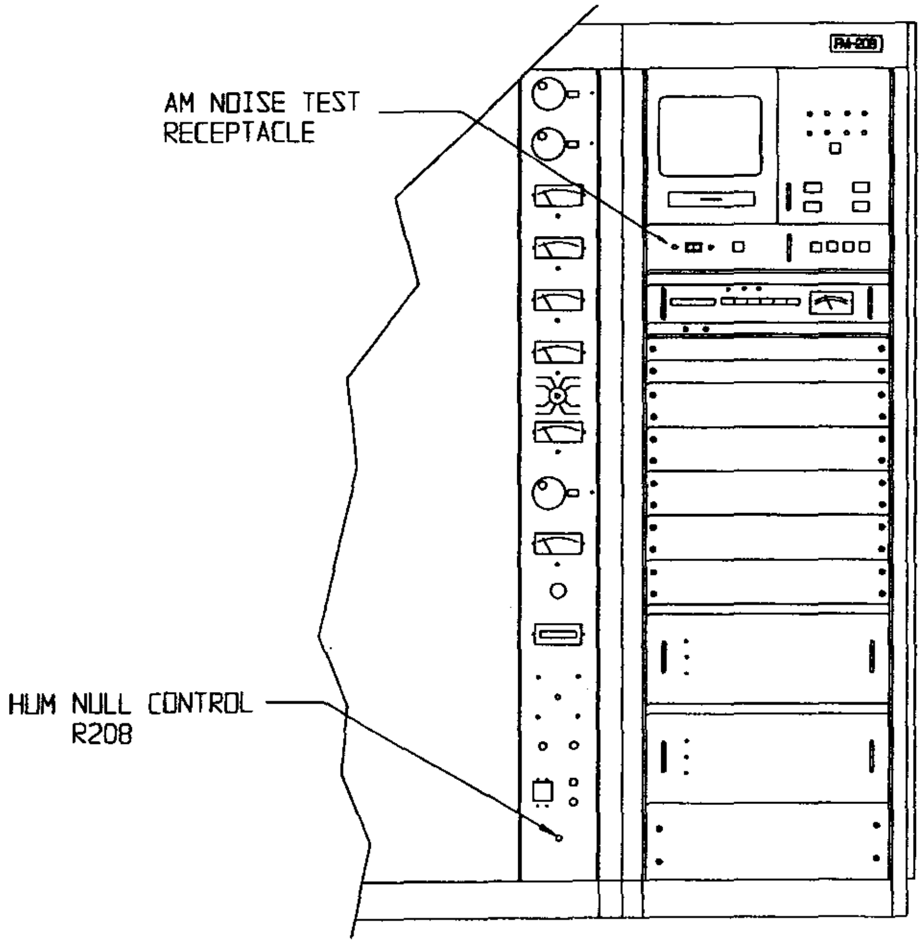
5–37. Refer to Figure 5–2 and adjust hum null control R208 for a minimum asynchronous AM noise indication on the distortion analyzer.

5–38. Disconnect and remove all test equipment.

5–39. **CONTROL GRID BIAS ADJUSTMENT.** A multiple tap transformer in the control grid bias supply allows adjustment of the control grid bias voltage. Adjustment of the taps will not normally be required in the field. If it is certain that adjustment of the grid bias voltage is required, contact the Broadcast Electronics Customer Service Department for maintenance information.

5–40. **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.

5–41. **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.



597–0220–27

FIGURE 5–2. HUM NULL CONTROL LOCATION

5–42. **Required Equipment.** The following equipment is required to complete adjustment of the second harmonic suppressor.

A. 1/16 inch hex wrench.

B. Tektronix Model 492 Spectrum Analyzer or 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 test cable for the spectrum analyzer consisting of the following:

1. 10 feet (3.05 m) of Belden RG58A/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	

5–43. **Procedure.** To adjust the second harmonic suppressor, proceed as follows:

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

5–44. Deenergize all primary power to the transmitter.

5–45. Connect one end of the spectrum analyzer cable (Item D) to the RF sample port on the transmission line elbow near the low–pass filter.

5–46. Connect the attenuator pad (Item C) in series with the cable and attach the attenuator pad to the spectrum analyzer input.

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.

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

5–51. Open the PA 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).

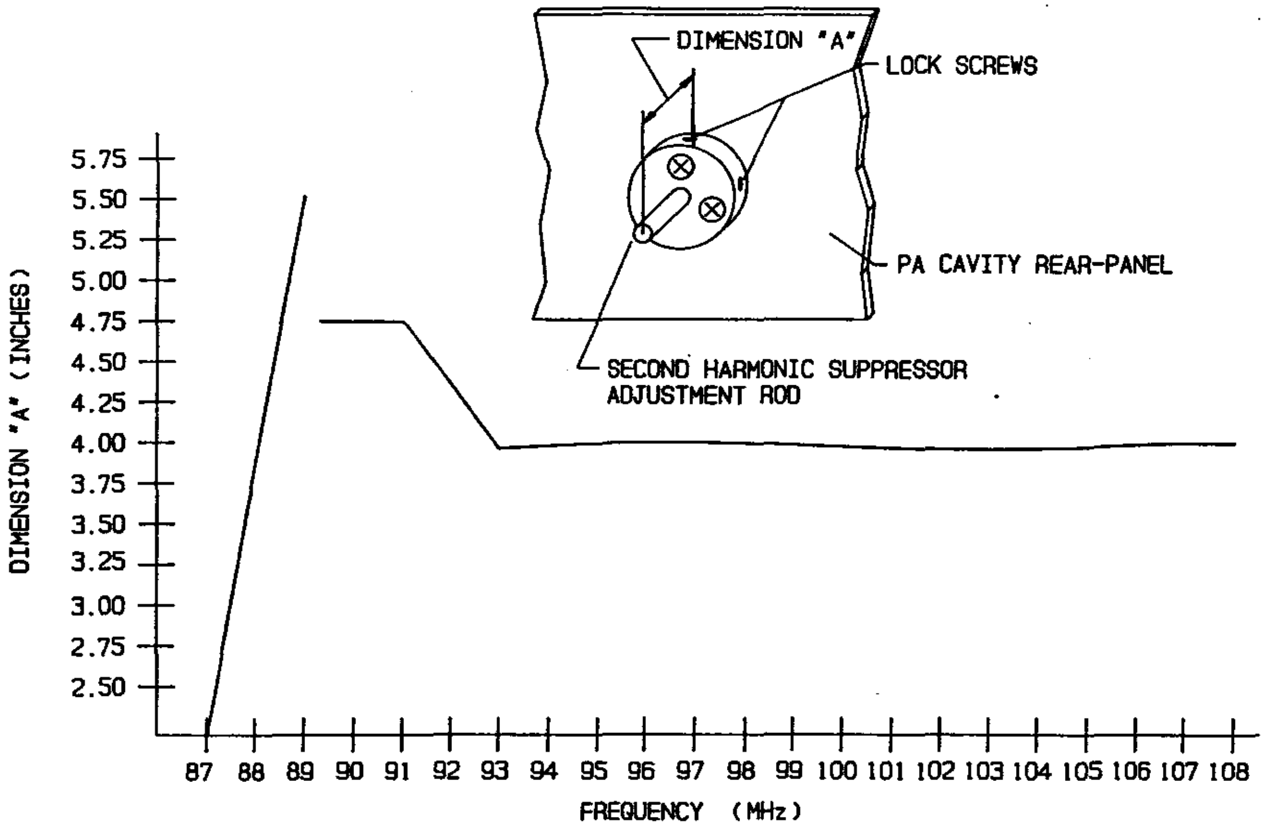


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FIGURE 5-3. SECOND HARMONIC SUPPRESSOR ADJUSTMENT

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). Correct adjustment will be near the original factory position (see Figure 5-3). 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 PA cabinet rear door.

5-55. Operate the transmitter at the normal power output and check for a minimum second harmonic indication displayed on the spectrum analyzer.

5-56. If additional adjustment is required, repeat the procedure. Move the second harmonic suppressor adjustment rod slightly in or out as required to minimize the second harmonic indication.

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

5–58. Open the PA cabinet rear door.

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

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

5–61. Close the PA cabinet rear door. Refer to Figure 5–3 and record the new harmonic suppressor dimension ________________.

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

CAUTION

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 consisting of the following:

1. 36 inches (91.44 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, 1–inch (2.54 cm) blade.

F. Flat–tip screwdriver, 8–inch (20.32 cm) blade and 3/8 inch (0.95 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.

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

5–64. **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 **DISCONNECT ALL TRANSMITTER PRIMARY POWER BEFORE PROCEEDING.**

WARNING

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

5–68. Open the driver cabinet rear 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 attenuator/termination connectors.

5–71. Disconnect the coaxial cable from the PA RF input receptacle which is located on the RF enclosure left side–panel below the PA metering circuit board assembly.

5–72. Connect one cable and one BNC–to–type N adapter between the PA RF input receptacle and the RF termination –20 dB sample output.

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

5–74. Disconnect wire No. 245 from TB1–7 on the exciter rear–panel 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 exciter line cord and remove the fuse from the AC LINE VOLTAGE SELECTOR on the 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 __________V____. 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 driver cabinet to a 110 to 120 volt ac source.

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 on 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 front of the transmitter.

5–82. Open the PA cabinet rear door and observe the grounding stick.

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 four neutralization adjustments (refer to Figure 5–4). Correct neutralization will be found near the original factory position (refer to Figure 5–4).

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

WARNING

5–85. Loosen the four screws (Figure 5–4, detail A) on top of capacitors C7, C8, C17, and C18 slightly—just enough to allow adjustment of the inductors. When the neutralization procedure is properly performed, the height of all inductors will be approximately the same, within 1/16 inch (0.16 cm).

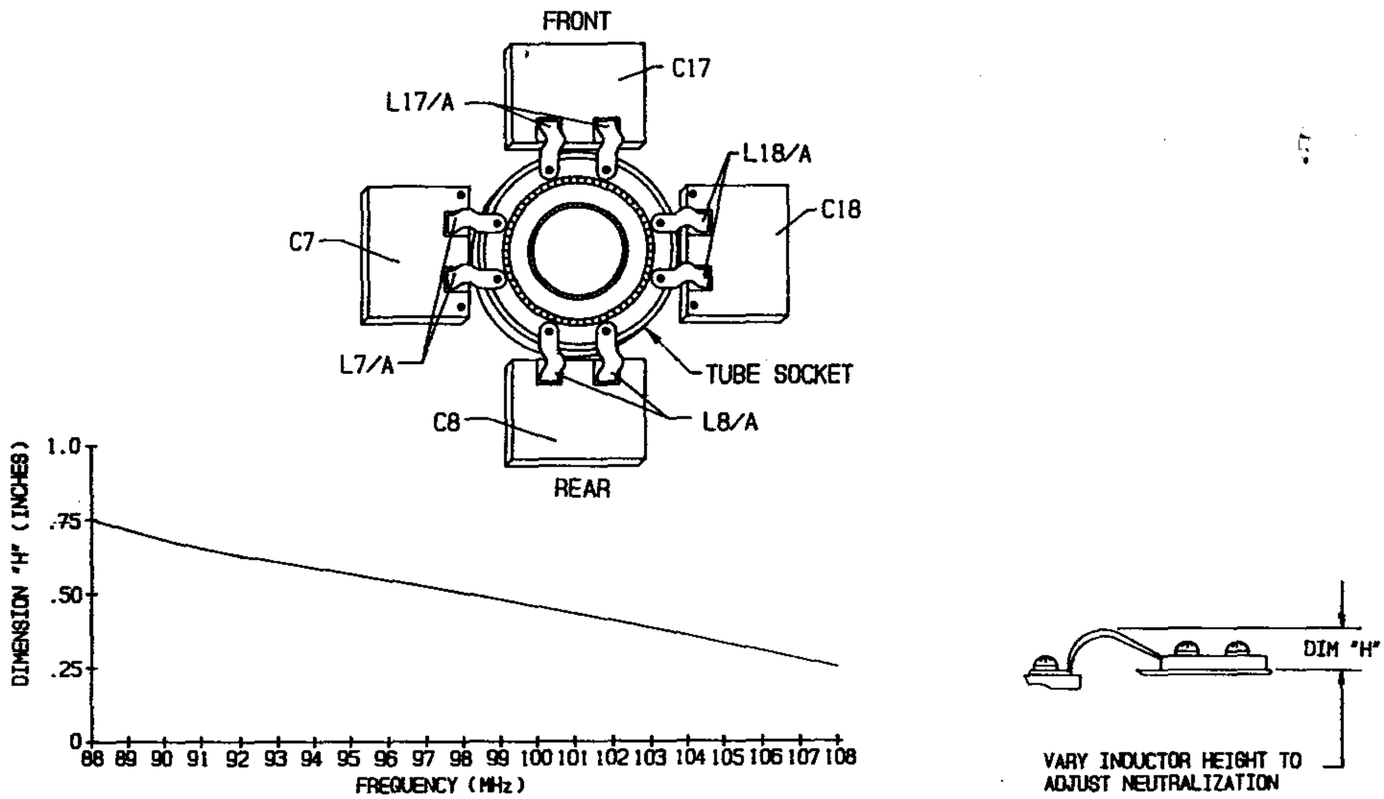

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FIGURE 5–4. COARSE NEUTRALIZATION ADJUSTMENTS

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

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

B. Note the spectrum analyzer indication.

C. Open the cavity access door and adjust one inductor slightly by moving the inductor in or out of the capacitor. Lightly secure the four 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 inductors to minimize the spectrum analyze r indication.

H. Secure the four screws in each capacitor. When the neutralization procedure is properly performed, 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 in the interlocked clips.

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

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

CAUTION

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 recorded voltage 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. 245 to TB1–7.

5–95. Remove the cabling and RF attenuator/termination connected between the exciter **RF OUTPUT** connector and the **PA RF** input receptacle. Remove the adapter from the PA RF input receptacle.

5–96. Reconnect the cable from the splitter to the exciter **RF OUTPUT** receptacle and reconnect the cable from the combiner to the PA input receptacle.

5–97. TRANSMITTER POWER LEVEL CHANGE.

5–98. **GENERAL.** 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.

5–99. **Procedure.** To change the transmitter power output level, 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

5–100. Disconnect all transmitter primary power.

5–101. Open the power amplifier cabinet door and ground all plate supply potentials. Ensure no potentials exist before proceeding.

WARNING *USE THE GROUNDING STICK PROVIDED TO ENSURE NO PA TUBE POTENTIALS ARE PRESENT BY GROUNDING ALL PA TUBE POTENTIALS.*
WARNING

WARNING *ENSURE NO POTENTIALS EXIST BEFORE PROCEEDING.*
WARNING

5–102. Refer to Figure 5–5 and remove the PA cavity lower access panel. Use the grounding stick to ground all PA tube potentials and to ensure no potentials are present within the cavity or PA input circuit. Ensure no potentials exist before proceeding.

5–103. Refer to Figure 5–5 and check the PA matching circuit board programming. Install components as required by the new power level.

5–104. Refer to SECTION II, INSTALLATION and check the plate transformer secondary taps.

5–105. Refer to TRANSMITTER CONTROLLER SECTION II, MAINTENANCE and re–adjust the controller overload controls.

5–106. Refer to SECTION III, OPERATION and reset the APC unit operating reference.

5–107. Energize the transmitter primary ac power and operate the transmitter. Adjust the input tuning control for a minimum IPA combined 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). If input matching problems persist during initial operation, contact the Broadcast Electronics Customer Service Department for adjustment information.

5–108. Refer to APC SECTION III, MAINTENANCE and perform the FWD CAL and RFL CAL adjustment procedures.

5–109. **TRANSMITTER FREQUENCY CHANGE PROCEDURE.**

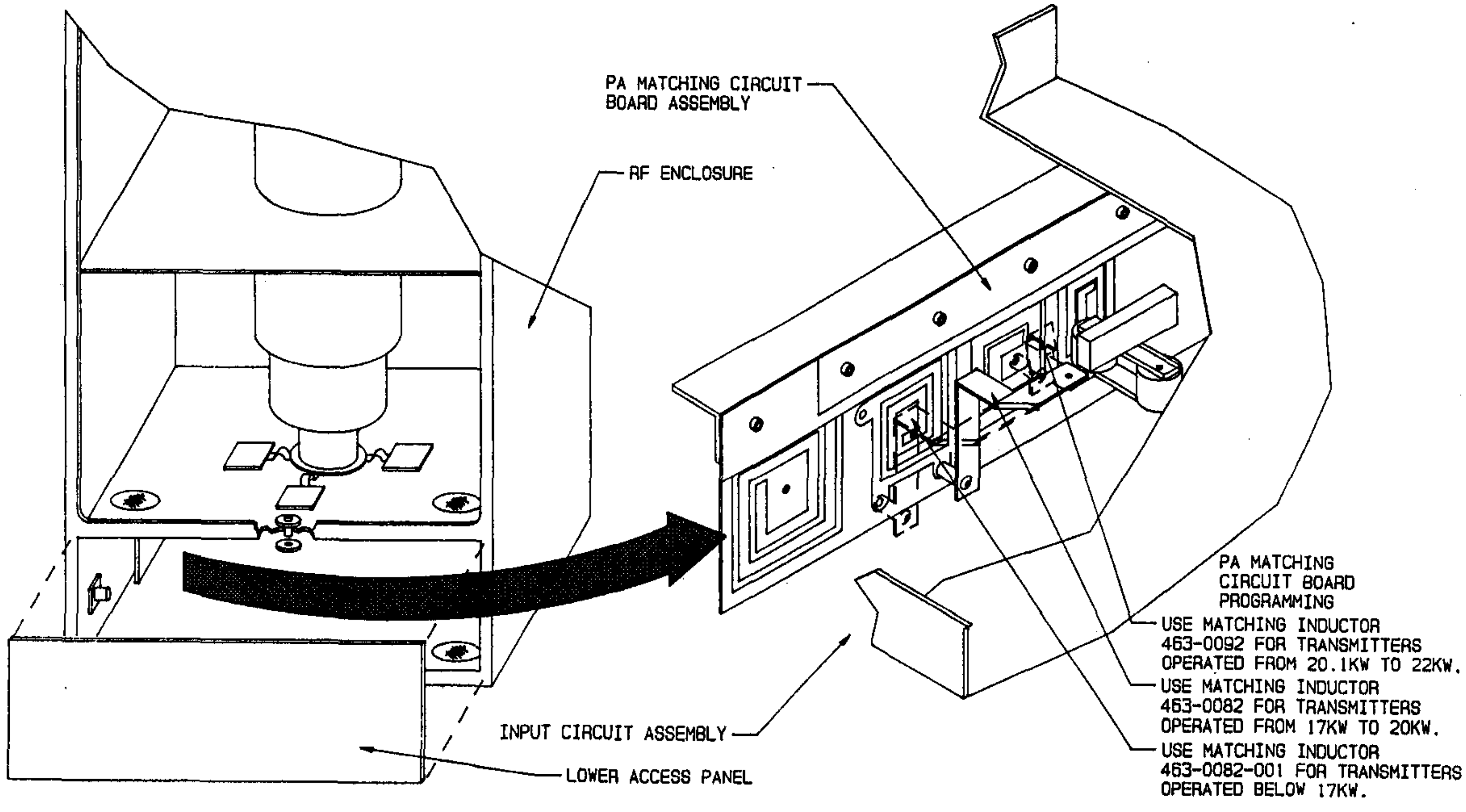

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FIGURE 5-5. COMPONENT PROGRAMMING FOR POWER LEVEL CHANGES

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

5–110. **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.

5–111. **Procedure.** To change the transmitter operating frequency, proceed as follows:

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.***

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

5–112. Disconnect all transmitter primary power. The primary ac power must remain OFF unless specified by an adjustment procedure.

WARNING ***WARNING*** — ***USE THE GROUNDING STICK PROVIDED TO ENSURE NO PA TUBE POTENTIALS ARE PRESENT BY GROUNDING ALL PA TUBE POTENTIALS.***

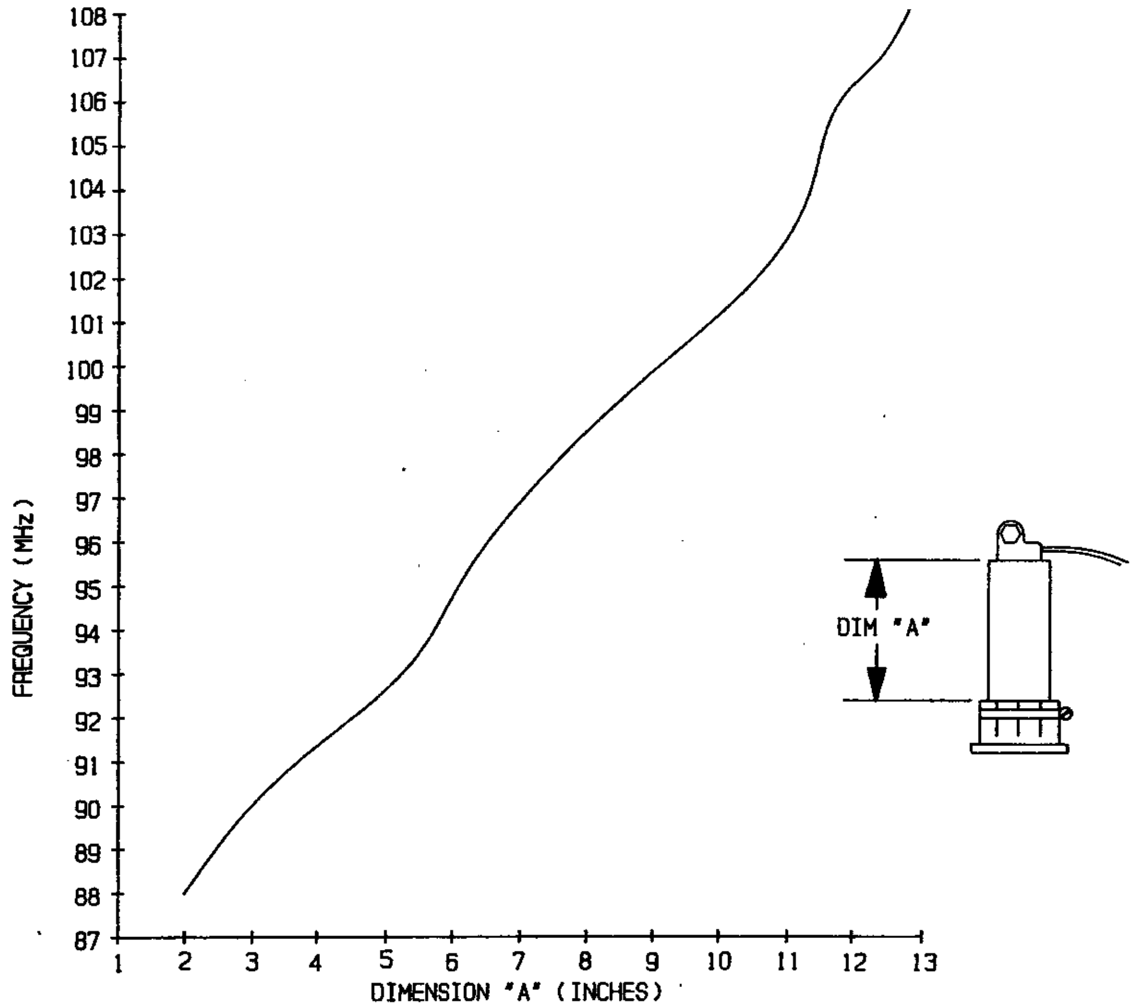
WARNING ***WARNING*** — ***ENSURE NO POTENTIALS EXIST BEFORE PROCEEDING.***

5–113. Open the cavity access door and ground all PA tube potentials to ensure no potentials are present within the cavity or PA input circuit. Ensure no potentials exist before proceeding.

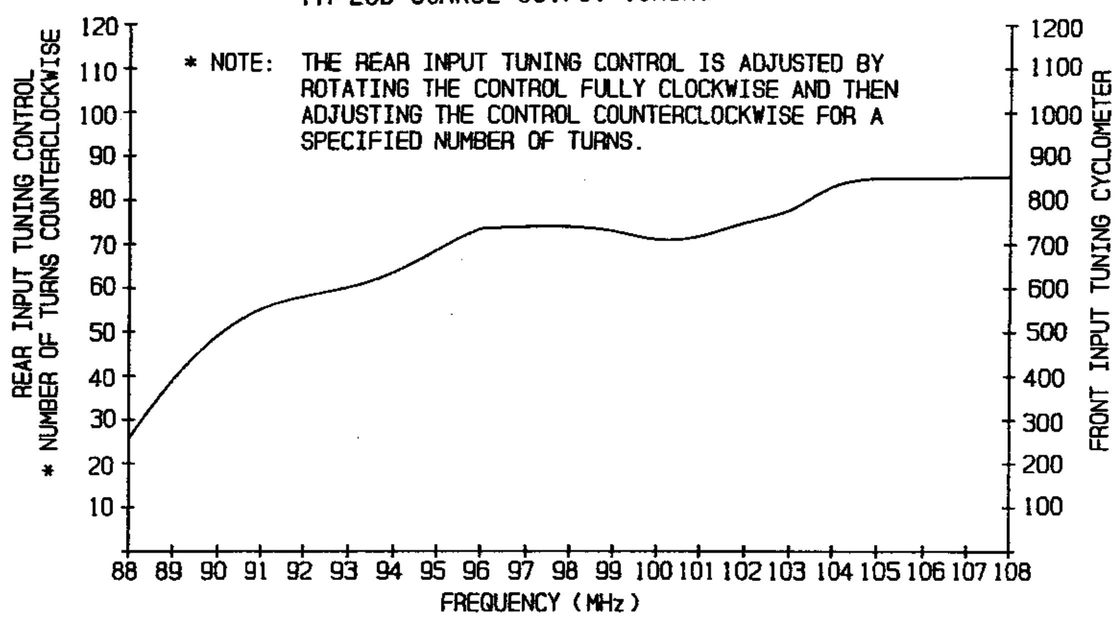
5–114. Refer to Figure 5–6 and check the programming for the: 1) tube socket mounting standoffs, 2) the shorting block, and 3) the plate line shims. Install or move components as required by the new operating frequency.

5–115. Refer to Figure 5–7A and adjust the transmitter coarse output tuning by raising or lowering the PA tuning line on top of the PA cavity. Refer to Figure 5–7B and coarse adjust the transmitter front and rear input tuning controls. The front input tuning control is adjusted by rotating the control for the specified cyclometer indication. The rear tuning control is adjusted by rotating the control fully clockwise and then adjusting the control counterclockwise for a specified number of turns.

5–116. Refer to the following text and Figure 5–10 and check second harmonic suppressor inductor L6. Replace the inductor as required by the new operating frequency.



FM-20B COARSE OUTPUT TUNING



FM-20B COARSE INPUT TUNING

597-0220-105

FIGURE 5-7. FM-20B COARSE TUNING ADJUSTMENTS

FREQUENCY	DESCRIPTION	PART NO.
88 MHz to 89.5 MHz	Inductor, 1 1/2 turn coil	360–0075
89.5 MHz to 91.5 MHz	Inductor, 0.5 inch (1.3 cm) X 8 inch (20.3 cm)	479–0070
91.5 MHz to 108 MHz	Inductor, 0.81 inch (2.0 cm) X 6.56 inch (16.7 cm)	479–0053–001

5–117. 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 rod during adjustment.

5–118. Refer to Figure 5–4 and coarse adjust the transmitter neutralization as follows:

A. Coarse adjust the neutralization inductors. The inductors are adjusted by loosening the screws on top of the capacitors and moving the inductors in or out of the capacitors as required. All inductors must be the same height.

B. Coarse adjust inductors L7/A, L8/A, L17/A, and L18/A. Adjust the inductors in or out as required.

5–119. Refer to FX–50 Exciter publication 597–1050, PART II SECTION 4, AFC/PLL ASSEMBLY and perform the FREQUENCY SELECTION procedure. Operate and test the exciter independently from the transmitter.

5–120. Refer to IPA SECTION II, MAINTENANCE and perform the RF AMPLIFIER TUNING procedure.

5–121. Refer to IPA SECTION II, MAINTENANCE and perform the REFLECTED POWER NULL, FWD CALIBRATION, and RFL CALIBRATION adjustment procedures.

5–122. 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.

5–123. Refer to the adjustment procedures in the preceding text and perform the NEUTRALIZATION procedure.

5–124. Refer to SECTION II, INSTALLATION and complete the PRELIMINARY OPERATION AND TUNING procedure to obtain a 100% power indication from the transmitter.

5–125. Refer to the adjustment procedures in the preceding text and perform the SECOND HARMONIC SUPPRESSOR adjustment procedure.

5–126. Refer to APC SECTION II, MAINTENANCE and perform the FWD CAL and RFL CAL adjustment procedures.

5–127. 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.***

5–128. Most transmitter troubleshooting consists of visual checks. Due to the dangerous voltages and currents in the equipment, it is considered extremely dangerous 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 for the FM–20B transmitter are presented in Table 5–1. Transmitter primary power demand requirements are listed in Table 5–2.

TRANSMITTER TROUBLESHOOTING AREAS

A. Power Supplies
B. Exciter
C. IPA Stage
D. Power Amplifier
E. Automatic Power Control Unit
F. Transmitter Controller
G. Transmitter Load

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

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

5–129. Once the trouble is isolated, refer to the applicable assembly of this manual which presents the theory of operation and troubleshooting for the respective assembly to assist in problem resolution. Figures 5–8 through 5–12 provide drawings to assist component location.

5–130. **COMPONENT REPLACEMENT ON CIRCUIT BOARDS.** Component replacement on printed circuit boards requires extreme care to avoid damage to the board traces.

5–131. On all circuit boards, the adhesive securing the copper trace to the board melts at almost the same temperature at which solder melts. A circuit board trace 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.

TABLE 5-1. TYPICAL METER INDICATIONS, FM-20B

FREQUENCY (MHz)	88.1			98.1			107.9		
POWER OUTPUT (kW)	7.5	15	20	7.5	15	20	7.5	15	20
PLATE VOLTAGE (V)	7150	9300	9150	7150	9300	9200	7150	9350	9220
PLATE CURRENT (A)	1.28	2.00	2.72	1.28	1.96	2.64	1.30	1.98	2.70
SCREEN VOLTAGE (V)	400	450	600	390	480	700	390	445	640
SCREEN CURRENT (mA)	45	100	130	55	115	130	60	120	140
GRID VOLTAGE (V)	–300	–310	–310	–300	–300	–310	–310	–315	–315
GRID CURRENT (mA)	40	50	50	40	50	45	40	48	42
FILAMENT VOLTAGE (V)	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
IPA 1 FORWARD POWER (W)	110	160	220	125	170	195	120	140	200
IPA 2 FORWARD POWER (W)	120	170	210	125	180	205	130	170	205
IPA COMB. FWD POWER (W)	210	310	400	220	330	380	220	300	370
IPA COMB. RFL POWER	NORM	NORM	NORM	NORM	NORM	NORM	NORM	NORM	NORM
PA EFFICIENCY (%)	82	81	80	82	82	82	81	81	80

TABLE 5-2. TYPICAL POWER CONSUMPTION, FM-20B

FREQUENCY (MHz)	88.1			98.1			107.9		
POWER OUTPUT (kW)	7.5	15	20	7.5	15	20	7.5	15	20
AVERAGE AC LINE VOLTAGE (V)	215.5	215	215.5	215.5	215.5	215	215	215.5	215.8
AC LINE CURRENT (A)									
PHASE 1	34.7	62.4	84.7	35.1	61.6	81.3	36.1	63.5	83.5
PHASE 2	37.6	66.1	88.3	38.4	65.6	85.0	39.8	67.0	86.6
PHASE 3	37.2	65.6	87.8	38.0	64.7	84.7	39.1	66.5	86.3
POWER FACTOR	.95	.97	.97	.96	.97	.97	.96	.97	.97
AC POWER CONSUMPTION (kW)	12.7	22.8	30.6	13.0	22.6	29.5	13.4	23.2	30.3

5–132. 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.

5–133. 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.

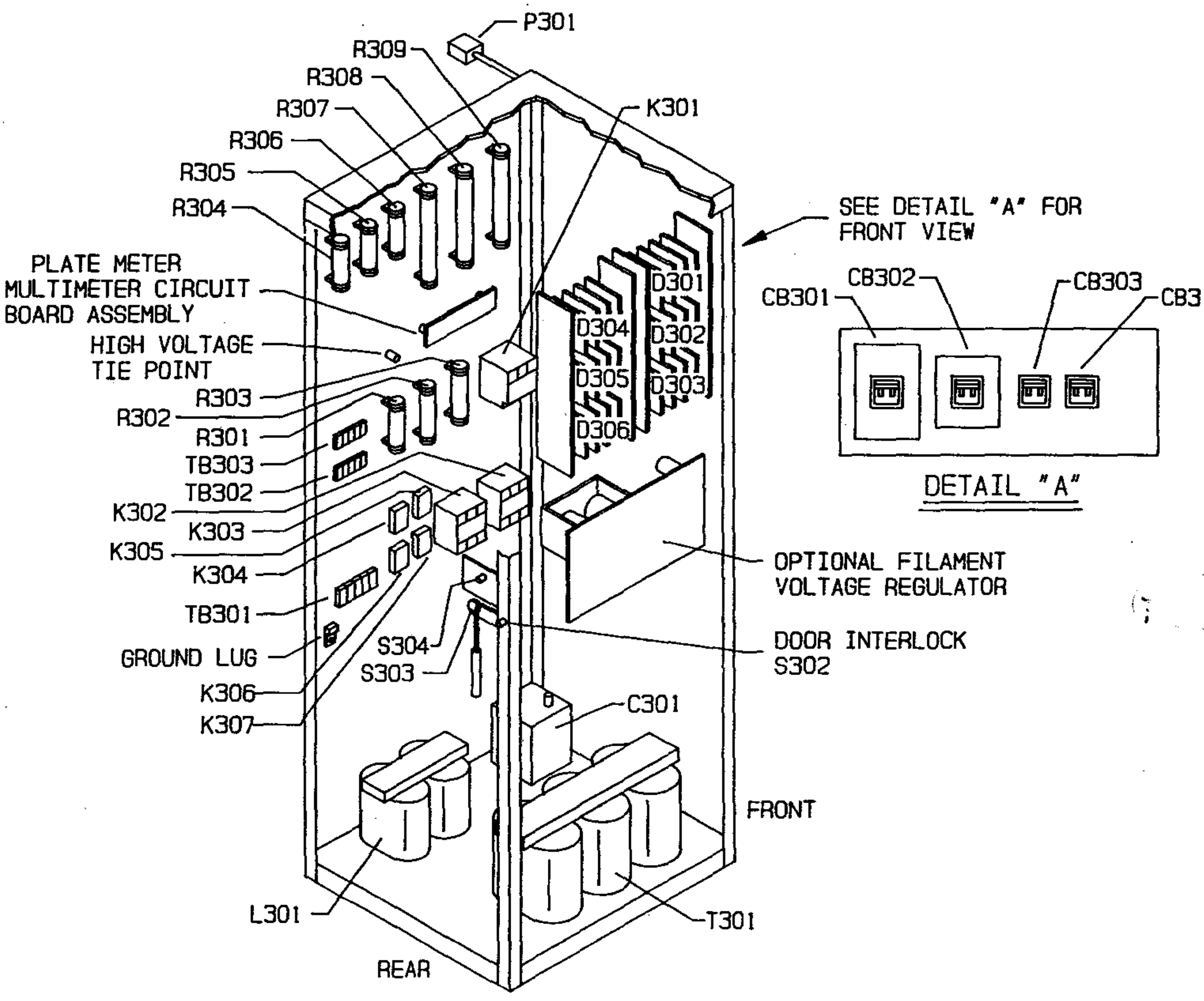
5–134. Install the new component and apply solder from the bottom side of the board.

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.***

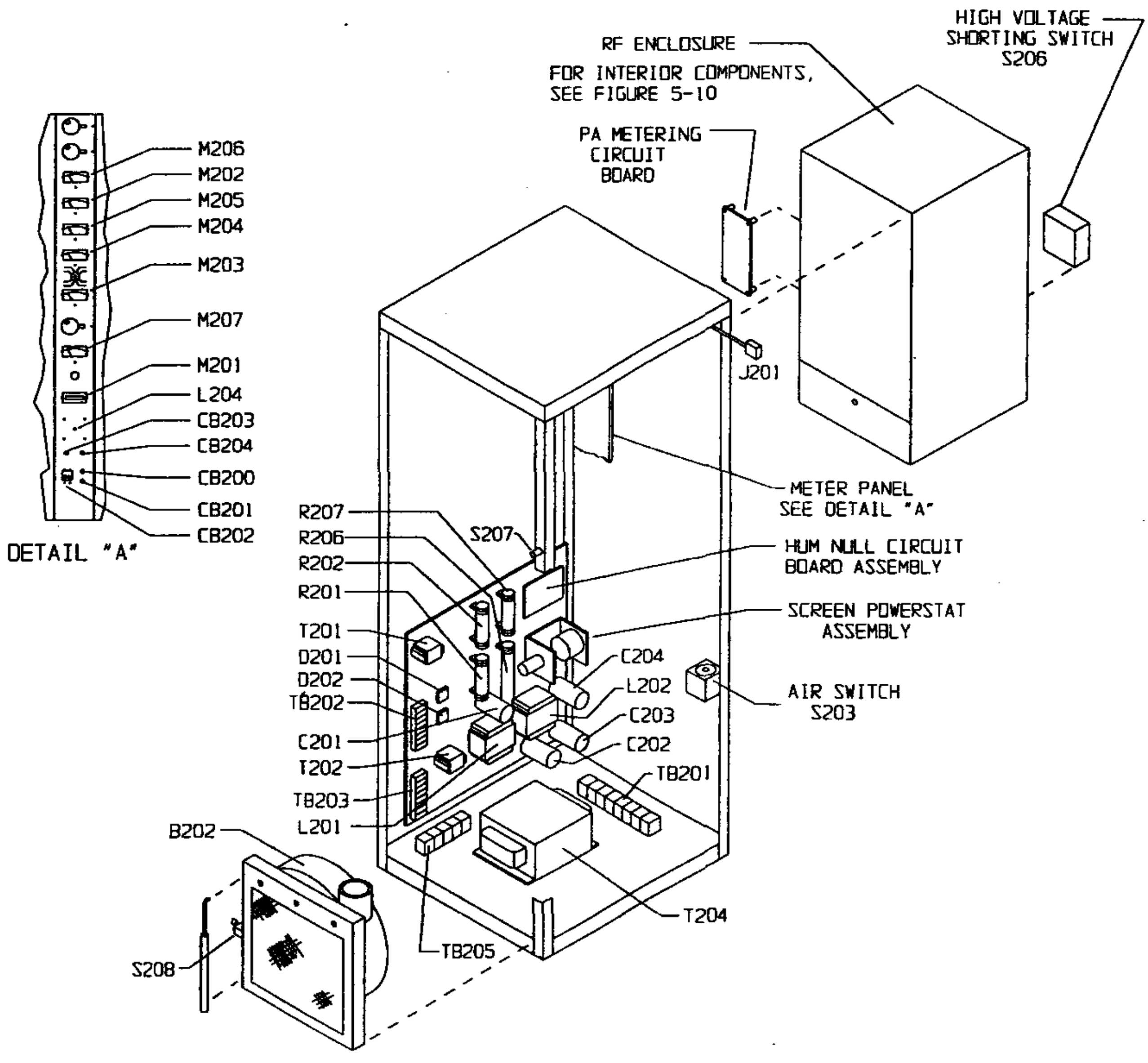
5–135. After soldering, remove flux with a cotton swab moistened with a suitable solvent. Rubbing alcohol is highly diluted and is not effective.

5–136. The board should be checked to ensure the flux has been removed and not just smeared. Rosin flux is not normally corrosive, but rosin will absorb enough moisture in time to become conductive and cause problems.



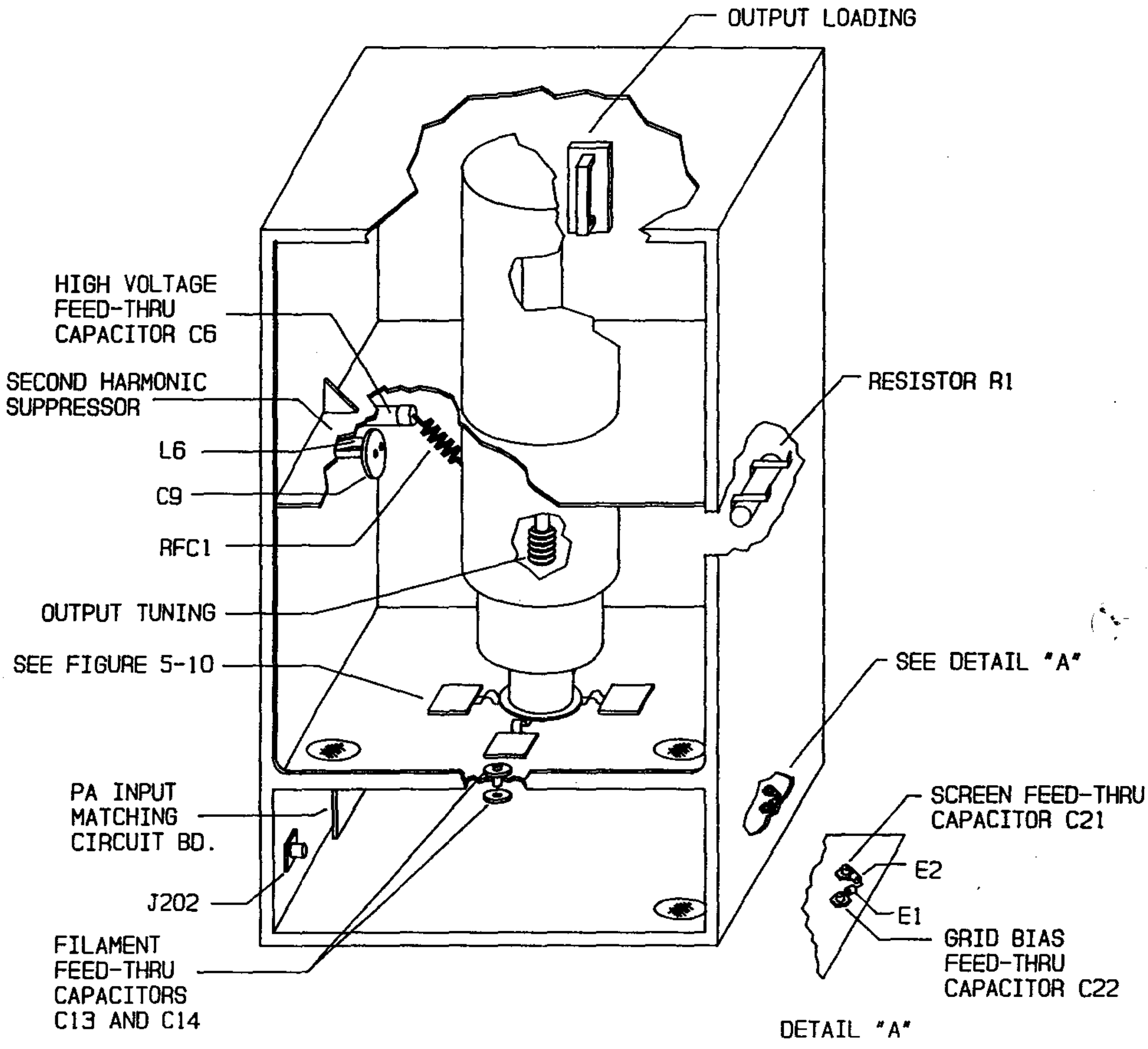
597-0220-30

FIGURE 5-8. FM-20B POWER SUPPLY CABINET COMPONENT LOCATOR



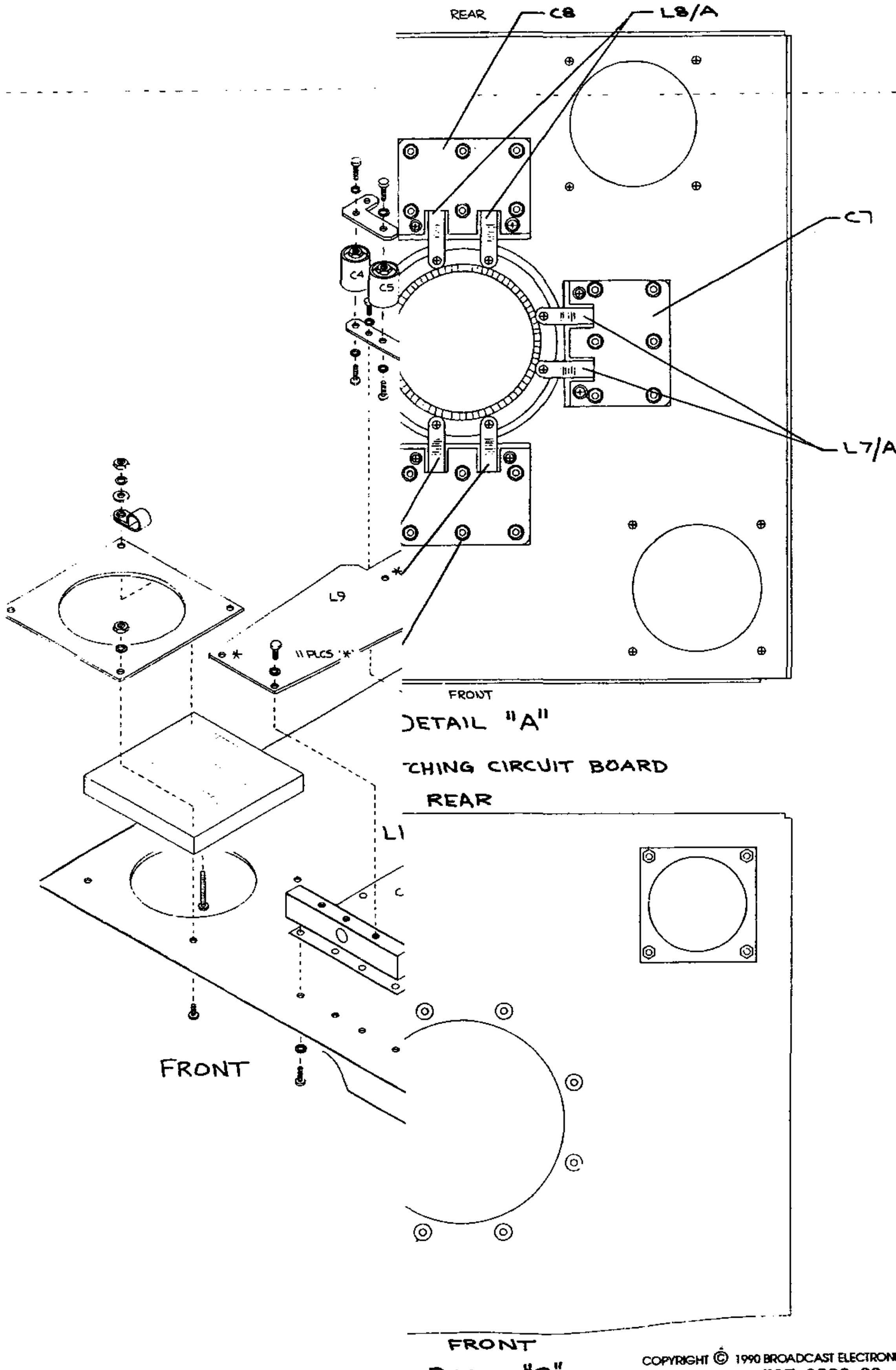
597-0220-31

FIGURE 5-9. FM-20B PA CABINET COMPONENT LOCATOR



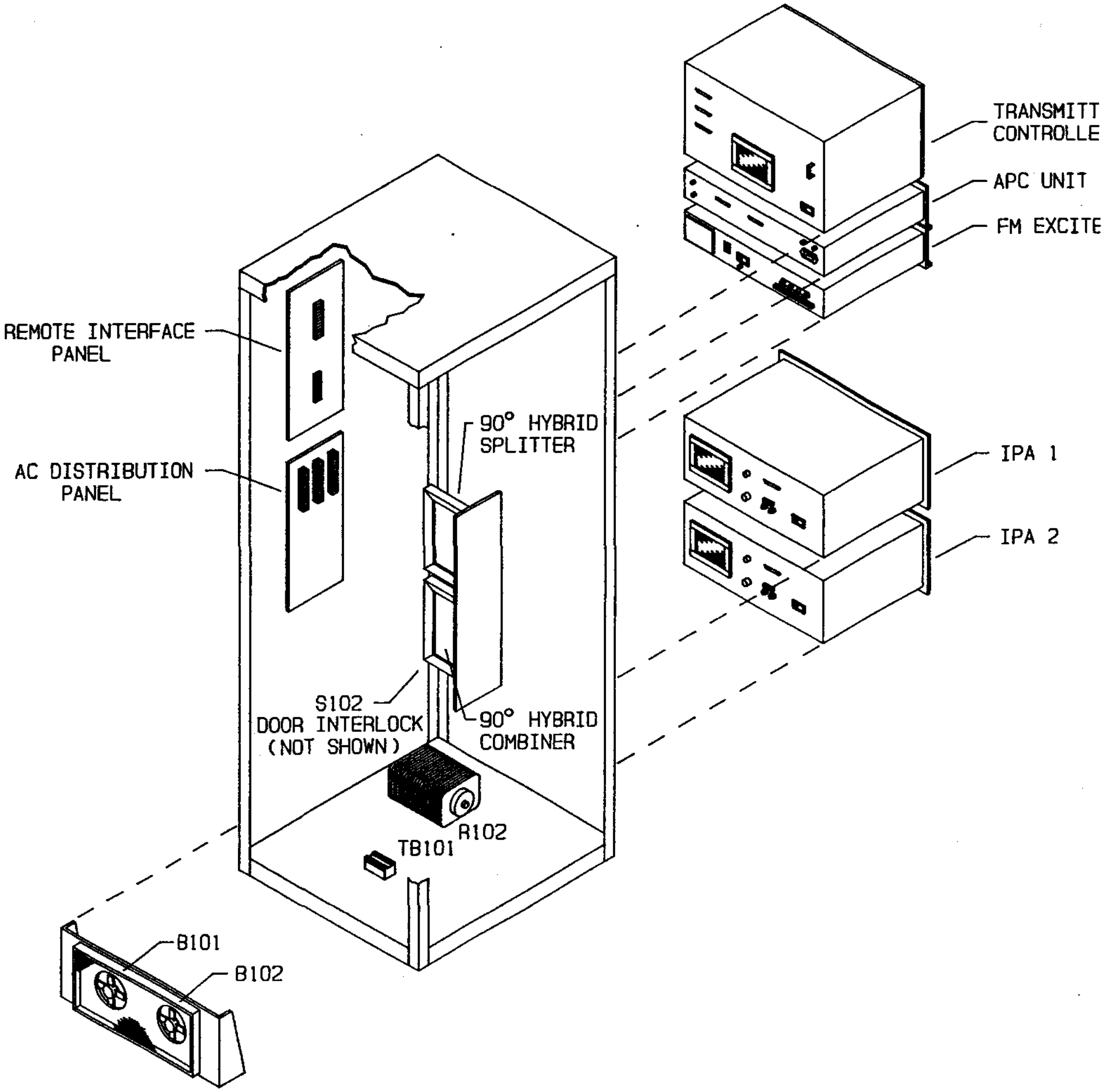
597-0220-32

FIGURE 5-10. RF ENCLOSURE COMPONENT LOCATOR



597-0220-33

FIGURE 5-11. PA INPUT CIRCUIT COMPONENT LOCATOR



597-0220-34

FIGURE 5-12. FM-20B DRIVER CABINET COMPONENT LOCATOR

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-20B transmitter. Each table entry in this section is indexed by reference designators appearing on the applicable schematic diagram.

TABLE 6-1. FM-20B REPLACEABLE PARTS LIST INDEX

TABLE	DESCRIPTION	PART NO.	PAGE
6-2	FM-20B 50/60 Hz FINAL ASSEMBLY	909-0020-224/ -204, -384/ -394	2
6-3	ASSEMBLY, CABLE, REMOTE POWER SUPPLY	949-0156	2
6-4	POWER AMPLIFIER CABINET ASSEMBLY	959-0296	2
6-5	METER ASSEMBLY, PLATE CURRENT	959-0292	4
6-6	METER PROTECTION CIRCUIT BOARD ASSEMBLY	919-0109-002	5
6-7	HUM NULL CIRCUIT BOARD ASSEMBLY	919-0112	5
6-8	PA METERING CIRCUIT BOARD ASSEMBLY	919-0048-002	5
6-9	MULTIMETER CIRCUIT BOARD ASSEMBLY	919-0049	7
6-10	PA CABINET CABLE HARNESS ASSEMBLY	949-0171	7
6-11	RF ENCLOSURE ASSEMBLY	959-0244	7
6-12	TUBE SOCKET ASSEMBLY	959-0245	8
6-13	INPUT MATCHING CIRCUIT BOARD ASSEMBLY	919-0064-002	8
6-14	POWER SUPPLY CABINET ASSEMBLY	959-0295	9
6-15	OPTICALLY-COUPLED-RELAY (OCR) ASSEMBLY	919-0096	10
6-16	GROUND STICK HANGER ASSEMBLY	955-0038	10
6-17	POWER SUPPLY WIRING HARNESS ASSEMBLY	949-0141	10
6-18	METER MULTIPLIER CIRCUIT BOARD ASSEMBLY	919-0079	10
6-19	DRIVER CABINET ASSEMBLY	959-0297	11
6-20	DRIVER CABINET WIRING HARNESS ASSEMBLY	949-0142	11
6-21	COMBINER ASSEMBLY	959-0175	11
6-22	SPLITTER ASSEMBLY	959-0176	12
6-23	FINAL ASSEMBLY PARTS KIT	959-0299	12
6-24	DRIVER REAR DOOR ASSEMBLY	959-0260	12
6-25	OUTPUT DIRECTIONAL COUPLER ASSEMBLY	959-0082-050	12
6-26	ACCESSORY PARTS KIT	969-0005	13
6-27	OPTIONAL FILAMENT VOLTAGE REGULATOR	909-0118	13
6-28	KIT, REMOTE HIGH VOLTAGE POWER SUPPLY	909-0135	13

TABLE 6-2. FM-20B 50/60 Hz FINAL ASSEMBLY - 909-0020-224/-204/-384/394

REF. DES.	DESCRIPTION	PART NO.	QTY.
V1	Tube, Eimac, 4CX12000A/8989	240-0012	1
——	Driver Cabinet Assembly	959-0297	1
——	Power Amplifier Cabinet Assembly	959-0296	1
——	Power Supply Cabinet Assembly	959-0295	1
——	Final Assembly Parts Kit	959-0299	1
——	FX-50 Exciter, 220V ac 50/60 Hz Operation	909-1050-324	1
	FOR REMOTE POWER SUPPLY MODELS 909-0020-224/-394		
——	Assembly, Cable, Remote Power Supply	949-0156	1
	FOR 50 Hz MODELS 909-0020-384/-394		
B202	Blower, Centrifugal, 500 ft/min at 4.2 inches H20 Motor: 110/220V ac, 2850 R/M, 2 hp	380-0010-001	1
L301	Choke, 4.0 H @ 3.75 Amperes	360-0070-001	1
M201	Meter, Elapsed Time, 0-99,999.9 Hour, Non-Resettable, 50 Hz, 230V, 3.5 Inch (8.89 cm) (FILAMENT TIME Meter)	310-0000-003	1
T204	Transformer (Filament) Primary: 208/240V ±11V RMS, 50 Hz, Single Phase Secondary: 7.87V @ 120 Amperes, Continuous	373-0007-001	1
T301	Transformer, Plate Primary: Three-Phase, 196-252V ac Delta Configuration or 339-437V ac Wye Configuration Secondary: Three-Phase, 6923V ac @ 3.1 Amperes, Wye Configuration	370-0096-001	1

TABLE 6-3. ASSEMBLY, CABLE, REMOTE POWER SUPPLY - 949-0156

REF. DES.	DESCRIPTION	PART NO.	QTY.
J201	Receptacle, 15-Pin D-Type	417-1504	1
J301	Connector, 15-Pin D-Type	417-1500	1
——	Assembly, Cable Clamp, 15-Pin	418-3431	1
——	Pins, Socket (for J201)	417-0143	15
——	Pins, Connector (for J301)	417-0142	15

TABLE 6-4. POWER AMPLIFIER CABINET ASSEMBLY - 959-0296 (Sheet 1 of 3)

REF. DES.	DESCRIPTION	PART NO.	QTY.
B201	Motor and Gearhead Assembly, 24V dc @ 235 mA, 9.1 r/min, Torque: 300 oz/in.	381-0001	1
	FOR 60 Hz MODELS		
B202	Blower, Centrifugal, 500 ft/min at 4.2 inches H20 Motor: 110/220V ac, 3450 R/M, 2 hp	380-0010	1

TABLE 6–4. POWER AMPLIFIER CABINET ASSEMBLY – 959–0296
(Sheet 2 of 3)

REF. DES.	DESCRIPTION	PART NO.	QTY.
C201,C202, C203,C204	Capacitor, Electrolytic, 300 uF ±10%, 450WV	025–9086	4
CB201A/B	Circuit Breaker, 2–Pole, 250V, 15 Amperes, Push–On (Driver)	341–0059	2
CB202	Circuit Breaker, 2–Pole, 250V, 30 Amperes (Blower)	341–0047	1
CB203,CB204	Circuit Breaker, 250V, 2.5 Amperes (Grid)	341–0057	2
D201,D202	Bridge Rectifier, H440: Peak Reverse Voltage: 4000V DC Forward Current: 750 mA DC Forward Voltage: 6.0 Volts @ 150 mA	239–0440	2
D203,D204	Diode, 1N4005%, Silicon, 600V @ 1 Ampere	203–4005	2
F203,F204, F205	Fuse, 3AG, 1/2 Ampere, 250V	330–0050	3
L201,L202	Choke, 10 Henrys, 0.4 Amperes, 2500 Volt Insulation, 92 Ohm dc Resistance	377–0002	2
L204	Transformer, Variable, Modified 0–40V, 6 KVA, 21–40, PWS	374–0001–1	1
	FOR 60 Hz MODELS ONLY		
M201	Meter, Elapsed Time, 0–99, 999.9 Hour, Non–Resettable, 60 Hz, 230V, 3.5 Inch (8.89 cm) (FILAMENT TIME Meter)	310–0000–002	1
M202	Meter Assembly (PLATE CURRENT)	959–0292	1
M203	Meter, 3.5 Inch (8.89 cm), Iron Vane Type, FS= 0–10V ac Movement ±3% (FILAMENT VOLTAGE Meter)	310–0024	1
M204	Multimeter, 3.5 Inch (8.89 cm), Taute Band Type, FS= 1 mA dc ±2% 35 Ohm Resistance (MULTIMETER)	310–0057	1
M205	Meter, 3.5 Inch (8.89 cm), Taut Band Type, FS= 1 mA dc ±1%, 35 Ohm Resistance (PLATE VOLTAGE Meter)	310–0051	1
M206	Meter, 3.5 Inch (8.89 cm), Taut Band Type, FS= 200 uA dc ±2%, 230 Ohm Movement (OUTPUT POWER Meter)	310–0058	1
	FOR MODELS 909–0020–204/–224 ONLY		
M207	Meter, 3.5 Inch (8.89 cm), Iron Vane Type, 0V to 300V ac Range, 60 k Ohm Resistance (PRIMARY VOLTAGE)	310–0032	1
	FOR MODELS 909–0020–384/–394 ONLY		
M207	Meter, 3.5 Inch (8.89 cm), Iron Vane Type, 0V to 500V ac Range, 150 k Ohm Resistance (PRIMARY VOLTAGE)	310–0060	1
R201	Resistor, 2 k Ohm ±5%, 100W, W/W	132–2043	1
R202	Resistor, 500 Ohm, Variable, 50W, W/W	130–5033	1
R203,R204, R205	Resistor, 220 k Ohm ±5%, 2W	130–2263	3
R206	Resistor, 10 k Ohm ±5%, 175W, W/W	132–1054	1
R207	Resistor, 250 Ohm, 25W, W/W	130–2503	1
R208	Potentiometer, 50 Ohm ±10%, 25W, W/W	195–0149–001	1
S201,S202	Microswitch, Modified, SPDT, 125V @ 4 Amperes Inductive	346–6100–1	2
S203	Switch, Pressure, 0.15 to 0.5 Inches W.C., 2% Repetitive Accuracy	340–0117	1
S205, S207	Interlock Switch, SPDT, 15A @ 125V ac, 0.5A @ 125V dc, 0.25A @ 250V dc	346–3302	2
S208	Interlock Switch, SPDT, 11A @ 125V or 250V ac, 0.5A @ 125V dc, 0.25A @ 250V dc	346–6100	1

TABLE 6-4. POWER AMPLIFIER CABINET ASSEMBLY - 959-0296
(Sheet 3 of 3)

REF. DES.	DESCRIPTION	PART NO.	QTY.
S209 THRU S212	Assembly, Primary Voltage Meter Switch Select		
	Switch: K346B, Square D	341-0021	1
	Contactor: KA-1, Square D	341-0020	4
	Cam Assembly: Type F, Square D	341-0019	1
T201	Transformer (Grid Bias)	370-0036	1
	Primary: 208/240V ±11V RMS, 50/60 Hz Secondary: 295/320/345V @ 200 mA, Continuous		
T202	Transformer, Power (Screen)	376-0043	1
	Primary: 208/240V ±11V RMS, 50/60 Hz, Single Phase Secondary: 1100V ac @ 385 mA, Continuous		
T203	Powerstat Variable Transformer, Single Phase Input: 240V, 50/60 Hz Output: 280V @ 2.25A, 0.63 kVA, Continuous	370-0007	1
	FOR 60 Hz MODELS ONLY		
T204	Transformer (Filament)	373-0007	1
	Primary: 208/240V ±11V RMS, 60 Hz, Single Phase Secondary: 8.25V @ 130 Amperes, Continuous		
TB201	Barrier Strip, Single Section, 600V	412-0725	16
TB202	Barrier Strip, 5-Terminal	412-0005-1	1
TB203	Barrier Strip, 6-Terminal	412-0008	1
TB204	Barrier Strip, 4-Terminal	412-0011	1
TB205	Barrier Strip, Single Section, 600V	412-0725	4
XF203,XF204, XF205	Fuseholder, Panel Mount	415-2012	3
——	Fuse Clip	415-1009	2
——	Barrier Strip, End Cap (for 412-0725)	412-0730	2
——	Capacitor, Ceramic Disc, 0.001 uF, 1000V	002-1034	5
——	Knob, RB67-3-MD Black	482-0029	1
——	Knob, RB67-5-CT-M Black	482-0027	3
——	RF Enclosure Assembly	959-0244	1
——	Hum Null Circuit Board Assembly	919-0112	1
——	Power Supply Interconnect Jumper Assembly	949-0155	1
——	Transmitter Ground Stick Assembly	955-0032-001	1
——	PA Metering Circuit Board Assembly	919-0048-002	1
——	Multimeter Circuit Board Assembly	919-0049	1
——	PA Cable Assembly	949-0171	1

TABLE 6-5. METER ASSEMBLY, PLATE CURRENT - 959-0292

REF. DES.	DESCRIPTION	PART NO.	QTY.
——	Meter, 3.5 Inch (8.89 cm), Taut Band Type, FS= 1 mA dc ±2%, Scale: 0-4A, 35 Ohm Movement	310-0055	1
——	Meter Protection Circuit Board Assembly	919-0109-002	1

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

REF. DES.	DESCRIPTION	PART NO.	QTY.
C1,C2	Capacitor, Ceramic Disc, 0.001 uF, 1000V	002-1034	2
D1	Diode, Zener, 1N4728, 3.3V ±5%, 1W	201-4728	1
E1,E2	Terminal, Male Disconnect	410-0025	2
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 6-7. HUM NULL CIRCUIT BOARD ASSEMBLY - 919-0112

REF. DES.	DESCRIPTION	PART NO.	QTY.
C1	Capacitor, Electrolytic, 470 uF, 50V	024-4783	1
E1 THRU E6	Terminal, Turret, Double Shoulder	413-1597	6
R1,R2	Resistor, 22 Ohm ±5%, 2W, W/W	130-2223	2
T1	Transformer, Audio Output Primary: 7.5V Secondary: 6.21V @ 0.3A	371-0010	1
TB1	Terminal Strip, 4-Position	411-0815	1
——	Blank Hum Null Circuit Board	519-0112	1

TABLE 6-8. PA METERING CIRCUIT BOARD ASSEMBLY - 919-0048-002 (Sheet 1 of 2)

REF. DES.	DESCRIPTION	PART NO.	QTY.
C1,C2,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 ±5%, 1W	200-0009	7
E13	Terminal, Male Disconnect	410-0025	1
F1,F2	Fuse, AGC, 1 Ampere, Fast-Blow	330-0100	2
F3	Fuseable Link, 0.028 in (0.528 cm) of 28 AWG Silver-plated Copper Wire	630-2806	0.208
J1	Connector, Housing, 10-Pin Dual In-line	418-1003	1
J2	Connector, Housing, 10-Pin	417-0169	1

TABLE 6-8. PA METERING CIRCUIT BOARD ASSEMBLY - 919-0048-002
(Sheet 2 of 2)

REF. DES.	DESCRIPTION	PART NO.	QTY.
J3	Receptacle, 6-Pin	417-0677	1
L1	RF Choke, 2.2 uH ±10%, 0.4 Ohms DC Resistance, 550 mA Maximum	360-2200	1
R1	Resistor, 100 Ohm ±5%, 1/2W	110-1033	1
R2,R3	Resistor, 0.5 Ohm ±1%, 5W, W/W	130-5001	2
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%, 1/4W	110-1033	1
R16	Resistor, 16 Ohm ±1%, 3W	130-1621	1
R17	Resistor, 18 Ohm ±1%, 3W	130-1821	1
R18	Resistor, 1 k Ohm ±1%, 1/4W	100-1041	1
R19	Resistor, 41.2 k Ohm ±1%, 1/4W	103-4125	1
R20	Resistor, 22 k Ohm ±5%, 1/4W	100-2253	1
R21	Resistor, 49.9 k Ohm ±1%, 1/4W	103-4951	1
R22	Resistor, 4.99 k Ohm ±1%, 1/4W	100-5041	1
R23	Resistor, 1 k Ohm ±5%, 1/4W	100-1043	1
R24	Resistor, 16 Ohm ±1%, 3W	130-1621	1
R25	Resistor, 18 Ohm ±1%, 3W	130-1821	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, 18 k Ohm ±5%, 1/4W	100-1853	1
R29	Resistor, 59 k Ohm ±1%, 1/4W	103-5905	1
R30	Resistor, 4.99 k Ohm ±1%, 1/4W	100-5041	1
R31,R32	Resistor, 7.32 k Ohm ±1%, 1/4W	103-7324	2
R33	Resistor, 5.36 k Ohm ±1%, 1/4W	103-5364	1
R34	Resistor, 5.62 k Ohm ±1%, 1/4W	100-5624	1
R35	Resistor, 5.36 k Ohm ±1%, 1/4W	103-5364	1
R36	Resistor, 5.62 k Ohm ±1%, 1/4W	100-5624	1
R37,R38	Resistor, 100 k Ohm ±1%, 1/4W	103-1062	2
R39,R40	Resistor, 4.99 k Ohm ±1%, 1/4W	100-5041	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 6-9. MULTIMETER CIRCUIT BOARD ASSEMBLY - 919-0049

REF. DES.	DESCRIPTION	PART NO.	QTY.
E1,E2	Terminal, Male Disconnect	410-0025	2
J1	Connector, 10-Pin	418-1003	1
S1	Switch, Rotary, 8 Position, 15A @ 1000V ac	340-0110	1
——	Blank PA Multimeter Circuit Board	519-0049	1

TABLE 6-10. PA CABINET CABLE HARNESS ASSEMBLY -949-0171

REF. DES.	DESCRIPTION	PART NO.	QTY.
J201	Receptacle, 15-Pin	417-1504	1
P1	Plug, Housing, 4-Pin (Temperature Sensor Circuit Board)	418-0240	1
P1,P1	Connector, Ribbon Cable, 10-Pin (PA Metering Circuit Board to Multimeter)	417-1003	2
P2	Connector, Housing, 15-Pin (PA Metering Circuit Board)	417-2379	1
P3	Connector, Housing, 6-Pin (PA Metering Circuit Board)	418-0670	1
P201	Connector, 25-Pin D-Type	417-0251	1
P202	Connector, 9-Pin D-Type	417-0900	1
——	Connector, BNC (J1)	417-0095	1
——	Connector, Type N (J202)	417-0076	1
——	Pins, Connector	417-0053	25
——	Pins, Socket	417-0143	10
——	Pins, Connector	417-0142	32
——	Terminal, Disconnect	410-1421	1

TABLE 6-11. RF ENCLOSURE ASSEMBLY 959-0244
(Sheet 1 of 2)

REF. DES.	DESCRIPTION	PART NO.	QTY.
C6	High Voltage Feed-Thru Capacitor Assembly	955-0049-002	1
C9	Capacitor Plate for Second Harmonic Suppressor	474-0319-001	1
C13,C14	Capacitor, Filament Feed-Thru	519-0039	4
E1	Spark Gap, 1000V dc ±20% Breakdown, 5000A Discharge Maximum	140-0015	1
E2	Spark Gap, 2500V dc ±20% Breakdown, 2500A Discharge Maximum	140-0016	1
L6	Inductor, Second Harmonic Suppressor		
	87.5 MHz to 89.5 MHz	360-0075	1
	89.5 MHz to 91.5 MHz	479-0070	1
	91.5 MHz to 108 MHz	479-0053-001	1
R1	Resistor, 100 Ohm ±1%, 150W	139-0006	1
RFC1	Inductor, RF Choke (Plate Circuit)	360-0073	1
S206	Interlock Switch, SPDT, 11A @ 125V or 250V ac, 0.5A @ 125V dc, 0.25A @ 250V dc (PA Cavity Access)	346-6100	1
XF201 THRU XF203	Fuse Holder	415-2012	3
——	Connector, Banana	418-0188	1
——	Jack, Banana	417-0157	1
——	Transmission Line Flange, 3.125 Inches EIA	427-0001	1
——	Transmission Line Elbow, 90°, 3.125 Inches, Modified	427-0002-1	1
——	Transmission Line Coupling Assembly with Inner Connector, 3.125 Inches	427-0005	1
——	Connector, Output Coupling Loop	419-0034	1
——	Transmission Line Outer Conductor, 3.125 Inches	463-0049-001	1
——	Connector, BNC, Modified Flange	417-0203-1	1

TABLE 6–11. RF ENCLOSURE ASSEMBLY 959–0244
(Sheet 2 of 2)

REF. DES.	DESCRIPTION	PART NO.	QTY.
——	Transmission Line Flange, 3.125 Inch EIA, Modified	427–0001–1	1
——	Transmission Line Elbow, with Monitor Port	427–0016–1	
——	Coupling Assembly	427–0005	2
——	Finger Stock, PA Cavity Access Door	469–0368	1
——	Output Loop Assembly	479–0052–007	1
——	Tube Socket Assembly	959–0245	1
——	Tuning Bellows, FM–20B	463–0095	1

TABLE 6–12. TUBE SOCKET ASSEMBLY - 959–0245

REF. DES.	DESCRIPTION	PART NO.	QTY.
C4,C5	Capacitor, Ceramic, 500 pF ±20%, 5 kV	008–5024	2
C7,C8	Capacitor, Screen Bypass, Printed Circuit Board	519–0037	2
C10,C11	Capacitor, Grid Tuning, Printed Circuit Board	519–0208	2
C15	Capacitor, Ceramic, 500 pF ±20%, 5 kV	008–5024	1
C16	Capacitor, Ceramic, 1000 pF ±20%, 5 kV	008–1036	1
C17,C18	Capacitor, Screen Bypass, Printed Circuit Board	519–0037	2
C19	Capacitor, Grid Tuning, Printed Circuit Board	519–0208	1
C20	Capacitor, Ceramic, 500 pF ±20%, 5 kV	008–5024	1
L5A	Inductor, Input Matching		
	20.1 KW to 22 KW	463–0092	1
	17 KW to 20 KW	463–0082	1
	Below 17 KW	463–0082–001	1
L5B	Inductor, Input	474–0313	1
L7/A, L8/A	Inductor, Neutralization	463–0083	4
L9,L10	Inductor, Input Tuning	474–0321	2
L11,L12,	Inductor, Tube Socket Mounting		
L14,L15	88 MHz to 91 MHz	441–0157	2
	91 MHz to 93 MHz	441–0162	2
	93 MHz to 98 MHz	441–0157	3
	98 MHz to 102 MHz	441–0157	3
	102 MHz to 108 MHz	441–0157	4
L17/A, L18/A	Inductor, Neutralization	463–0083	4
L19	Inductor, Input Tuning	474–0370	1
R1	Resistor, 750 Ohm ±10%, 50W	139–7532	1
R3, R4	Resistor, 1.5 Ohm ±5%, 10W	132–0114	2
XV1	Assembly, Tube Socket	417–0360	1
——	Input Matching Circuit Board Assembly	919–0064–002	1

TABLE 6–13. INPUT MATCHING CIRCUIT BOARD ASSEMBLY – 919–0064–002

REF. DES.	DESCRIPTION	PART NO.	QTY.
E1 THRU E5	Terminal, Turret, Double Shoulder	413–0025	5
E8	Terminal, Turret, Single Shoulder	413–0315	1
J2	Connector, BNC	417–0014	1
——	Blank PA Input Matching Circuit Board	519–0064	1
——	Matching Capacitor Circuit Board	519–0064–001	1

TABLE 6-14. POWER SUPPLY CABINET ASSEMBLY - 959-0295

REF. DES.	DESCRIPTION	PART NO.	QTY.
C301	Capacitor, Plastic, 4 uF, 15 kV DC	030-0001	1
CB301	Circuit Breaker, 3-Pole, 600V AC, 150 Amperes (High Voltage)	341-0051	1
CB302	Circuit Breaker, 3-Pole, 480V AC, 30 Amperes (Control)	341-0052	1
CB303	Circuit Breaker, 2-Pole, 3 Amperes (Screen)	341-0055	1
CB304	Circuit Breaker, 2-Pole, 250V AC, 15 Amperes (Filament)	341-0032	1
D301,D302, D303,D304, D305,D306	High Voltage Rectifier Assembly, 28 kV PRV @ 8 Amperes	230-0004	6
K301	Contactor Coil: 120/208/240V 60 Hz or 110/190/220V 50 Hz Contacts: 3-Pole, 550V ac, 120 Amperes	341-0054	1
K302,K303	Contactor Coil: 208/240V ac 60 Hz or 190/220V ac 50 Hz Contacts: 3-Pole, 600V ac, 40 Amperes	341-0053	2
K304,K305, K306,K307	Optically-Coupled-Relay (OCR) Assembly	919-0096	4
	FOR 60 Hz MODELS		
L301	Choke, 3.5 H @ 3.75 Amperes	360-0070	1
R301,R302, R303	Resistor, 2 Ohm ±5%, 50W, W/W	132-1004	3
R304,R305, R306	Resistor, 22 Ohm ±20%, 150W	139-0220	3
R307,R308 R309	Resistor, 100 k Ohm ±5%, 225W, W/W	133-1064	3
S301	Jack, Banana, 1 kV, Capacitance: 7.0 uF (Half-Voltage Supply Receptacle)	417-0109	2
S302	Microswitch, Door Interlock, SPST, 0.5A @ 125V dc	346-3302	1
S303	Switch, Interlock, 600V ac Maximum, Normally Open	340-0051	1
	FOR 60 Hz MODELS ONLY		
T301	Transformer, Plate Primary: Three-Phase, 196-252V or 339-437V ac, Delta Configuration Secondary: Three-Phase, 6923V ac @ 3.1 Amperes, Wye Configuration	370-0096	1
TB301	Barrier Strip, 4-Position	412-0040	1
TB302,TB303	Barrier Strip, Single Section, 600V	412-0725	32
——	Barrier Strip End Cap (for 412-0725)	412-0730	2
——	Assembly, Ground Stick Hanger	955-0038	1
——	Assembly, Ground Stick	955-0032	1
——	Meter Multiplier Circuit Board Assembly	919-0079	1
——	Power Supply Cabinet Wiring Harness Assembly	949-0141	1

TABLE 6-15. OPTICALLY-COUPLED-RELAY (OCR) ASSEMBLY - 919-0096

REF. DES.	DESCRIPTION	PART NO.	QTY.
C1	Capacitor, Ceramic Disc, 0.001 uF, 1 kV	002-1034	1
C2	Capacitor, Electrolytic, 47 uF, 35V	020-4773	1
C3	Capacitor, Ceramic Disc, 0.1 uF, 600V	000-1051	1
C4	Capacitor, Ceramic Disc, 0.001 uF, 1 kV	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	2
D5	Bridge Rectifier, MDA A970A3, 4 Amps, 50-200V	239-0003	1
F1, F2	Fuse, 250V, 3 Ampere, PCB Mount	330-0055	1
K1	Relay, Printed Circuit Board Mount Coil: 24V dc, 660 Ohm ±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, W/W	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
XU1	Socket, 6-Pin DIP	417-0600	1
——	Relay Dust Cover	270-0054-001	1
——	Blank Circuit Board	519-0096	1

TABLE 6-16. GROUND STICK HANGER ASSEMBLY - 955-0038

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

TABLE 6-17. POWER SUPPLY WIRING HARNESS ASSEMBLY - 949-0141

REF. DES.	DESCRIPTION	PART NO.	QTY.
P301	Connector, 15-Pin D-Type	417-1500	1
S301	Plug, Banana, 25 Amperes ac	418-0039	1
——	Pins, Connector	417-0142	11

TABLE 6-18. METER MULTIPLIER CIRCUIT BOARD ASSEMBLY - 919-0079

REF. DES.	DESCRIPTION	PART NO.	QTY.
C1	Capacitor, Mica, 390 pF ±5%, 100V	042-3922	1
D1	Diode, Zener, 1N4739A, 9.1V ±10%, 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 6–19. DRIVER CABINET ASSEMBLY - 959–0297

REF. DES.	DESCRIPTION	PART NO.	QTY.
B101,B102	Fan, 6 inch (15.24 cm), 250 ft^3/min 220V ac, 50/60 Hz, 40 Watt	380–7650	2
R102	Resistor, 50 Ohm, 250W	131–5028	1
S102	Interlock Switch, SPDT, 15A @ 125V ac, 0.5A @ 125V dc, 0.25A @ 250V dc	346–3302	1
TB104,TB105, TB106	Barrier Strip, 9 Terminal	412–0090	3
TB107	26–Pin Terminal Block with Ribbon Cable Connector	412–0045	1
TB108	Barrier Strip, 10 Terminal	412–0010–1	1
——	End Cap for TB101	412–0730	1
——	Driver Cabinet Wiring Harness Assembly	949–0142	1
——	Transmitter Controller Assembly	959–0298–002	1
——	Automatic Power Control (APC) Unit Assembly	959–0262–002	1
——	IPA Assembly	959–0263–001	2
——	Combiner Assembly	959–0175	1
——	Splitter Assembly	959–0176	1
——	Pins, Connector	417–0036	1
——	Connector, 9–Pin	418–0055	1
——	Cable, Reject Load	949–0203	1

TABLE 6–20. DRIVER CABINET WIRING HARNESS ASSEMBLY - 949–0142

REF. DES.	DESCRIPTION	PART NO.	QTY.
J101	Receptacle, 25–Pin D–Type	417–0252	1
J102	Receptacle, 9–Pin D–Type	417–0901	1
P1	Plug, 25–Pin, Ribbon Cable	418–0609	1
P2,P3,P8, P9 Amp 1, P9 Amp 2	Connector, 25–Pin D–Type	417–0251	5
——	AC Line Cord, N.E.M.A. 3–Wire North American Plug	682–0001	5
——	Pins, Socket	417–0143	34
——	Connector, 26–Pin Dual In–line	417–0047	1
——	Connector, BNC for RG–142 Cable	417–0095	9
——	Connector, Type N for RG–142 Cable	418–0031	5
——	Connector, BNC, Crimp Type, RG58U Cable	417–0094	4
——	Connector, 9–Pin	417–0059	1
——	Pins, Connector	417–0053	2

TABLE 6–21. COMBINER ASSEMBLY - 959–0175

REF. DES.	DESCRIPTION	PART NO.	QTY.
——	Receptacle, BNC	417–0203	3
——	Receptacle, Type N	417–0204–001	1
——	Printed Circuit Board, Combiner/Splitter	517–0001	2

TABLE 6-22. SPLITTER ASSEMBLY - 959-0176

REF. DES.	DESCRIPTION	PART NO.	QTY.
——	Receptacle, BNC	417-0203	3
——	Resistor, 50 Ohm, 150W	131-5027	1
——	Printed Circuit Board, Combiner/Splitter	517-0001	2

TABLE 6-23. FINAL ASSEMBLY PARTS KIT - 959-0299

REF. DES.	DESCRIPTION	PART NO.	QTY.
R3	Resistor Network Assembly (IPA)	959-1000-001	2
R82	Resistor Network Assembly (APC)	959-1000-028	1
R86	Resistor Network Assembly (APC)	959-1000-008	1
R89	Resistor Network Assembly (APC)	959-1000-029	1
R96	Resistor Network Assembly (APC)	959-1000-027	1
——	16-Pin DIP Jumper Assembly (APC)	959-1001	1
——	Harmonic Filter, Low-Pass, 88 to 108 MHz, 45 kW	339-0022	1
——	Turnlock Fastener, 1/4 Turn		
	Stud	424-0008	2
	Retainer	424-0006	2
——	Transmission Line Insulator-Connector Assembly	427-0004	1
——	Driver Cabinet Air Filter Door Assembly	959-0260	1
——	Directional Coupler Assembly, 50 dB	959-0082-050	2
——	Accessory Parts Kit	969-0005	1

TABLE 6-24. DRIVER REAR DOOR ASSEMBLY - 959-0260

REF. DES.	DESCRIPTION	PART NO.	QTY.
——	Turnlock Fastener, 1/4 Turn		
	Stud	424-0008	2
	Retainer	424-0006	2

TABLE 6-25. OUTPUT DIRECTIONAL COUPLER ASSEMBLY - 959-0082-050

REF. DES.	DESCRIPTION	PART NO.	QTY.
J1	Receptacle, BNC	417-0016	1
——	Resistor, 150 Ohm ±5%, 2W	130-1533	1
——	Choke, 1.5 uH ±10%, 580 mA Maximum	360-0032	1

TABLE 6-26. ACCESSORY PARTS KIT - 969-0005

REF. DES.	DESCRIPTION	PART NO.	QTY.
——	Battery, 9 Volt, Alkaline	350-0002	2
——	Header, Programmable, 8-Pin DIP	340-0006	5
——	Extender, Controller Circuit Board Assembly	919-0061	1
——	FM-20B, FX-50 Exciter, Binder and Manual	979-0220-004	1

TABLE 6-27. OPTIONAL FILAMENT VOLTAGE REGULATOR – 909-0118

REF. DES.	DESCRIPTION	PART NO.	QTY.
——	Transformer, Filament Voltage Regulator, 60 Hz, 2000 vA Input: 190 to 260V ac Output: 240V ac ±1%	370-0013	1
——	Optional Filament Voltage Regualtor Wire Harness Assembly	949-0146	1

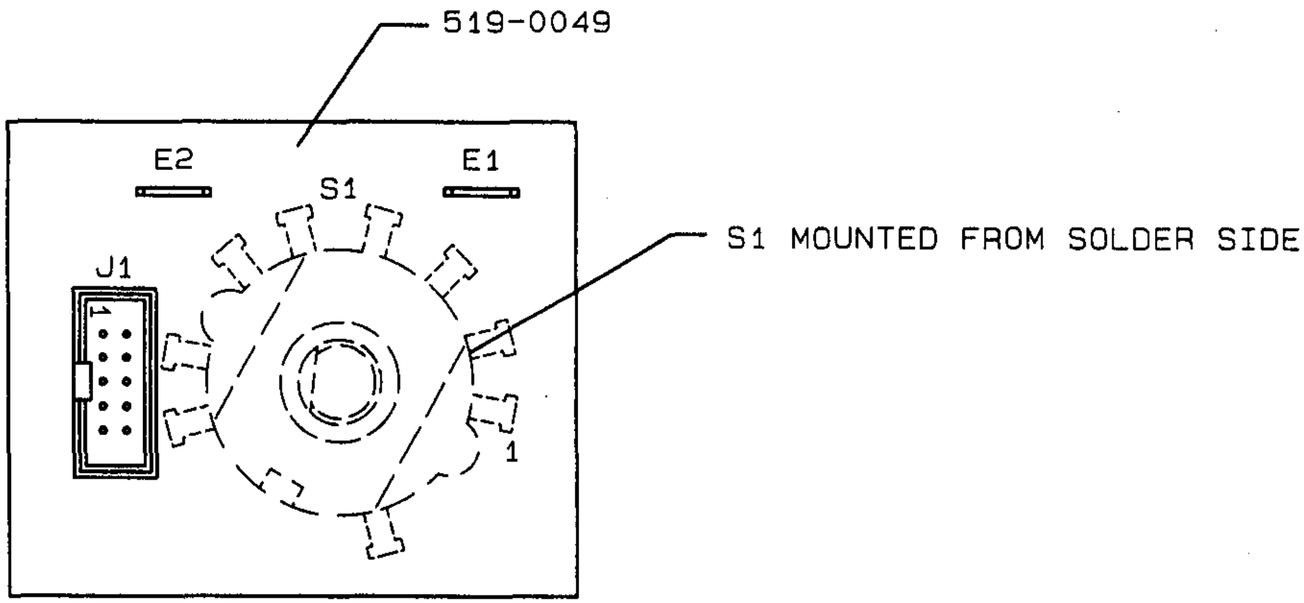
TABLE 6-28. KIT, REMOTE HIGH VOLTAGE POWER SUPPLY – 909-0135

REF. DES.	DESCRIPTION	PART NO.	QTY.
	DELETE FROM ASSEMBLY 959-0296		
——	Assembly, Power Supply Adjacent Interconnect Jumpers	949-0155	1
	ADD TO ASSEMBLY 959-0296		
——	Assembly, Power Supply Remote Interconnect Jumpers	949-0156	1

SECTION VII
DRAWINGS

7–1. INTRODUCTION.

7–2. This section provides schematic diagrams and assembly diagrams as indexed below for the FM–20B transmitter.

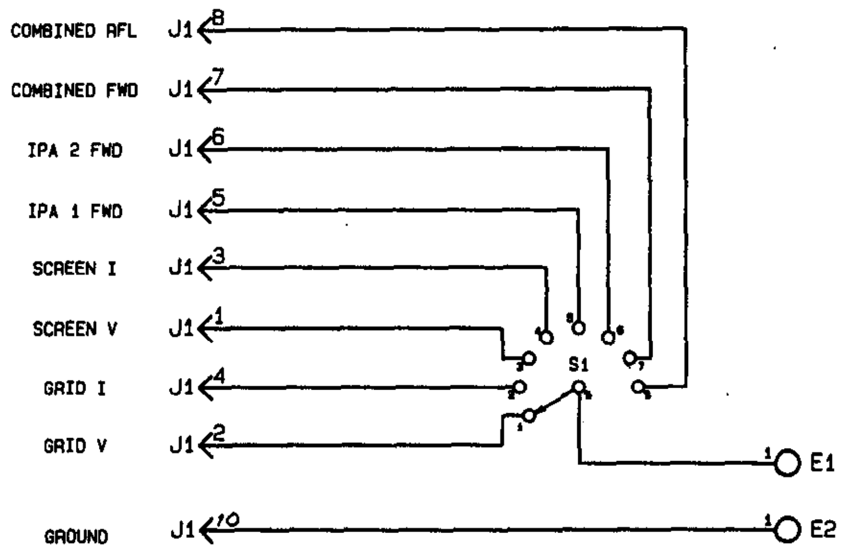


NOTE:

1. SEE SCHEMATIC SB919-0049

TOLERANCE DECIMAL U.O.S.
.X ± .030 .XXX ± .005
.XX ± .015 ANGLES ± 1°

DWN BY MERK 9-8-87	MATERIAL SEE B/M 919-0049	BROADCAST ELECTRONICS INC. 4100 N.24TH ST., P.O.BOX 3606 QUINCY, IL 62305 217/224-9600 TELEX 250142 CABLE BROADCAST	
CHKD MH 11-3-88 B.G. 11-2-88	FINISH	TITLE PCB ASSEMBLY- MULTIMETER BOARD	
ME 11/2/88		TYPE A	SIZE B
PROJ. ENGR. 11-2-88	NEXT ASSY	DWG.NO. 919-0049	REV A
MFG 11/2		MODEL XMTRS SCALE 2/1	SHEET 1 OF 1



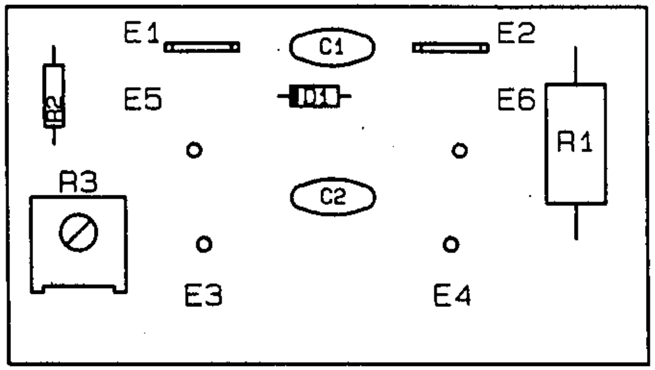
NOTES:

1. LAST COMPONENTS USED: J1, S1, E2

2. SEE PCB ASSEMBLY AB919-0049

TOLERANCE DECIMAL U.O.S.
.X ± .030 .XXX ± .005
.XX ± .015 ANGLES ± 1°

DWN BY MERK	DATE 9-8-87	MATERIAL SEE B/M 919-0049	BROADCAST ELECTRONICS INC. 4100 N. 24TH ST. QUINCY, IL. 62305 217/224-9600 TELEX 250142 CABLE "BROADCAST"
CHKD MH 11-3-88			
ME		FINISH	TITLE PCB SCHEMATIC-MULTIMETER BOARD
PROJ ENGR 11-2-88			TYPE S · SIZE B · DWG.NO. 919-0049 · REV A
MFG 11-2-88		NEXT ASSY	MODEL XMTRS · SCALE NONE · SHEET 1 OF 1



NOTES:

1. LAST COMPONENTS USED: R3, C2, D1, E6.
2. SEE PCB SCHEMATIC: SB919-0109, 919-0109-001, 919-0109-002.

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TOLERANCE DECIMAL U.O.S.
.X ± .030 .XXX ± .005
.XX ± .015 ANGLES ± 1°

DWN BY	KLS 3-11-88
CHKD	MAH 9-27-88
ME	
PROJ. ENGR.	M.SHRESTHA 6-13-88
MFG.	
MATERIAL	SEE B/M NO. 919-0109
FINISH	
NEXT ASSY	

BROADCAST ELECTRONICS INC.
4100 N.24TH ST., P.O.BOX 3606 QUINCY, IL 62305 217/224-9600
TELEX 250142 CABLE BROADCAST

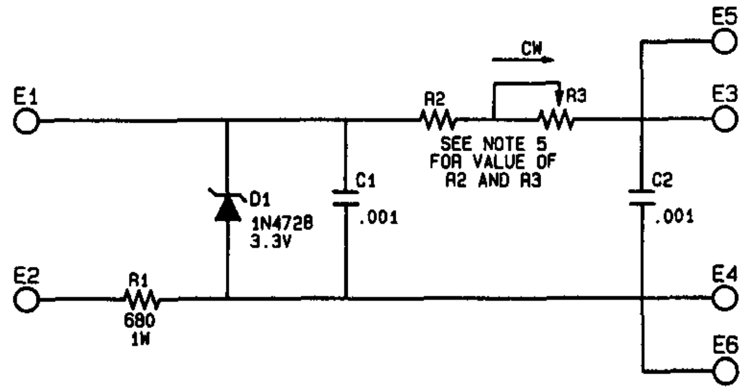
TITLE PCB ASSEMBLY— METER PROTECTION BD.

TYPE	SIZE	DWG.NO.	REV
A	B	919-0109/-001/-002	C

MODEL SEE SB919-0109 | SCALE 2/1 | SHEET 1 OF 1

NOTES:

1. ALL RESISTORS IN OHMS, 1/4W, 5%: ALL CAPACITORS IN MICROFARADS, UNLESS OTHERWISE SPECIFIED.
2. LAST COMPONENTS USED: R3, C2, D1, E6.
3. SEE PCB ASSEMBLY AB919-0109, 919-0109-001, 919-0109-002.
4. 919-0109 USED IN FM-35A, FM-30A, FM-20A.
   919-0109-001 USED IN FM-10A.
   919-0109-002 USED IN FM-3.5B, FM-5B, FM-5BS, FM-10B, FM-20B, FM-30B, FM-35B.
5. R2: 103-2493 USED IN 919-0109.
   100-4713 USED IN 919-0109-001.
   103-1823 USED IN 919-0109-002.
   R3: 177-1034 USED IN 919-0109, 919-0109-001.
   177-2034 USED IN 919-0109-002.

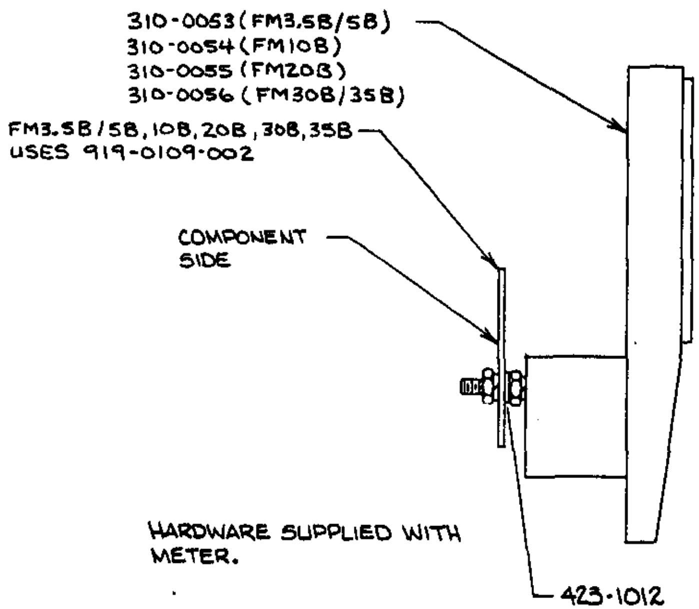


TOLERANCE DECIMAL U.O.S.
.X ± .030 .XXX ± .005
.XX ± .015 ANGLES ± 1°

DWN BY	KLS 3-8-88
CHKD	MAH 9-28-88
ME	
PROJ. ENGR.	M.SHRESTHA 6-13-88
MFG.	
MATERIAL	SEE B/M 919-0109
FINISH	
NEXT ASSY	

BROADCAST ELECTRONICS INC.
4100 N.24TH ST., P.O.BOX 3606 QUINCY, IL 62305 217/224-9600
TELEX 250142 CABLE BROADCAST

TITLE	PCB SCHEMATIC-METER PROTECTION BD.
TYPE	S
SIZE	B
DWG.NO.	919-0109/-001/-002
REV	D
MODEL	SEE NOTE 4
SCALE	NTS
SHEET	1 OF 1



ASSY. NO.	CALIBRATION VOLTAGE	XTMR MODEL
959-0300	1.00 VDC	FM3.5B/5B/5BS
959-0291	0.985 VDC	FM10B
959-0292	0.99 VDC	FM20B
959-0293	1.01 VDC	FM30B/35B

NOTES:

1) ASSEMBLED UNIT TO BE GIVEN TO INCOMING INSPECTION FOR SET-UP AND CALIBRATION AND DELIVERY TO STOCK.

2) INCOMING - SET CALIBRATOR AS PER TABLE 50Ω DIVIDER OFF - ADJUST POTENTIOMETER FOR FULL SCALE READING ON METER, SEAL POTENTIOMETER WITH ANTI-TAMPER LACQUER (B.E. 700-0130)

3) PCB 919-0109-002 USED IN FM3.5B, 5B, FM10B, 20B, 30B, 35B.

TOLERANCE (DECIMAL) U.O.S.
.x ± .030 .xxx ± .005
.xx ± .015 ANGLES ± 1

DWN. BY MSE 6-2-88
CHKD
ME
PROJ. ENGR. [illegible] 4-6-89
MFG. JAS 6-2-88

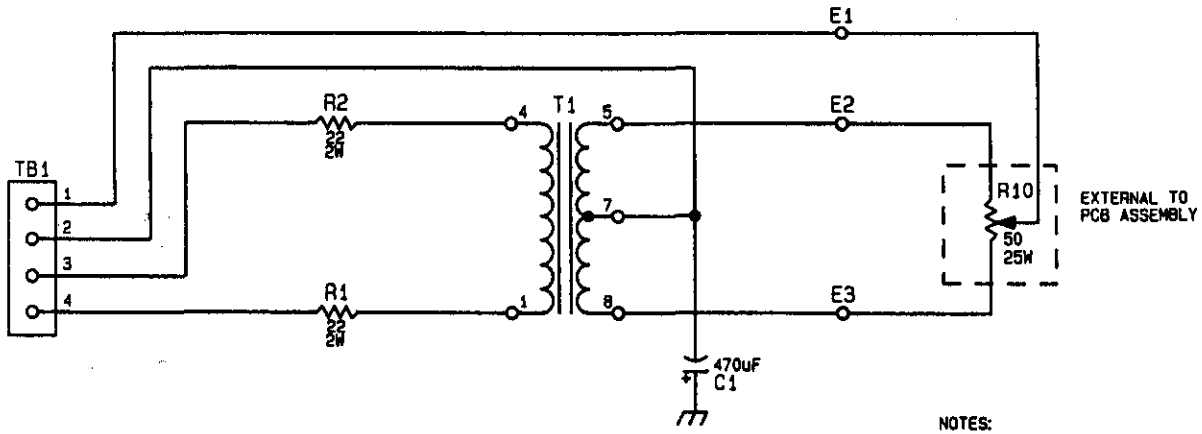
MATERIAL SEE B/M
FINISH
SEE DWG RA592-0000
NEXT ASSY.

BROADCAST ELECTRONICS INC.
4100 N. 24TH ST., P.O. BOX 3606 QUINCY, IL 62305 217/224-9600
TELEX 250142 CABLE BROADCAST

TITLE ASSY, PLATE METER

TYPE A | SIZE B | DWG. NO. 959-0291 (FM10B) 959-0292 (FM20B) 959-0293 (FM30/35B) 959-0300 (FM3.5B, 5B, 5BS) | REV A

MODEL FM3.5B, 5B, 5BS, 10B, FM20B, 30B, 35B | SCALE 1/1 | SHEET 1 OF 1



NOTES:
1. RESISTORS ARE IN OHMS; 1/4, 5%
   UNLESS OTHERWISE SPECIFIED.
2. LAST COMPONENT USED: T1, TB1, E3, C1, & R2.
3. COMPONENTS NOT USED:
4. SEE PCB ASSEMBLY: AB 919-0112

TOLERANCE (DECIMAL) U.O.S.
.X ± .030 .XXX ± .005
.XX ± .015 ANGLES ± 1°

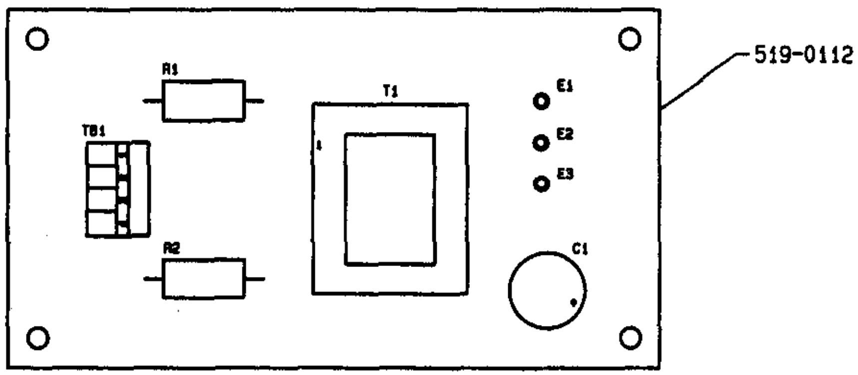
DWN. BY JAH 8-17-89
CHKD MH 3-5-90
ME
PROJ. ENGR [illegible] 3/5/90
MFG.

MATERIAL SEE B/M 919-0112
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 HUM NULL BD

TYPE S SIZE B DWG. NO. 919-0112 REV A
MODEL XMTR'S SCALE NONE SHEET 1 OF 1



TOLERANCE (DECIMAL) U.O.S.
.X ± .030 .XXX ± .005
.XX ± .015 ANGLES ± 1°

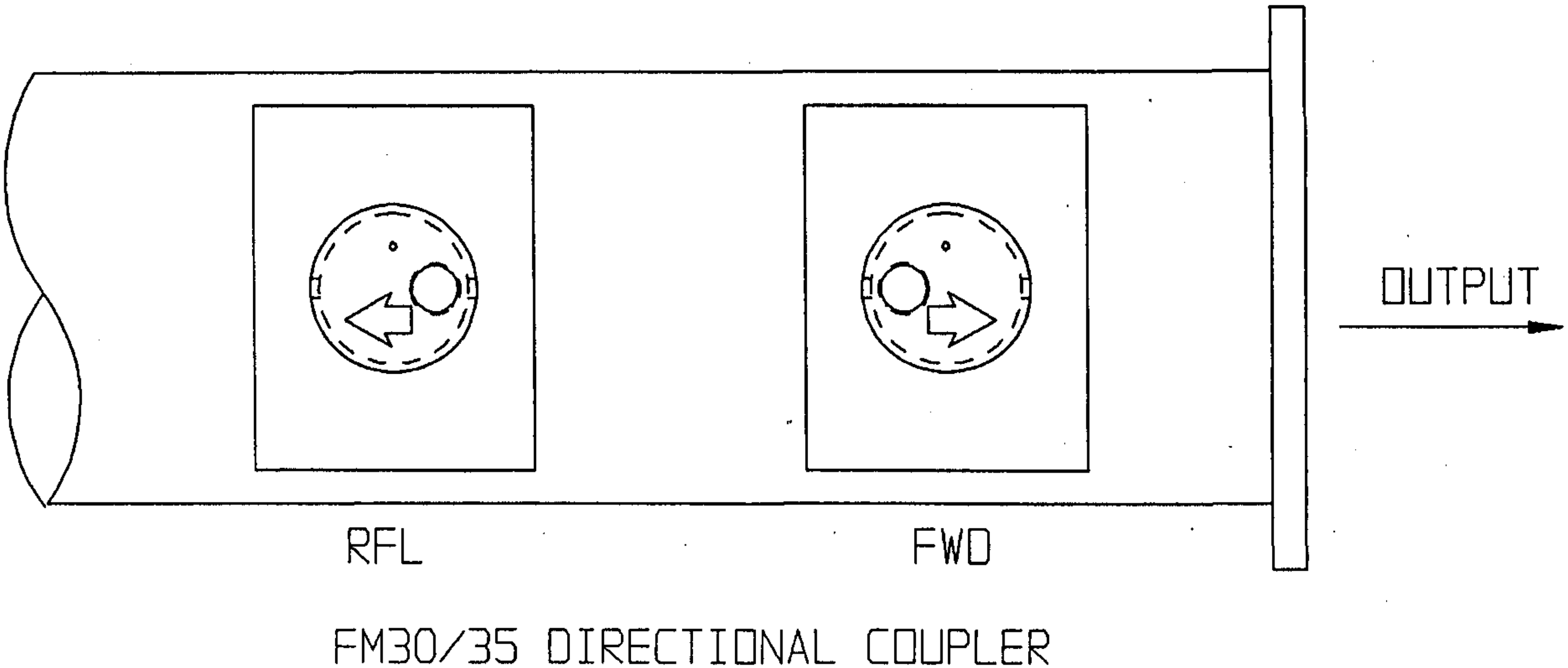
DWN. BY JAH 10-24-89	MATERIAL SEE B/M 919-0112	
CHKD MH 3-5-90		
ME	FINISH	
PROJ. ENGR.	SEE DWG RA592-0000	
MFG.	NEXT ASSY.	

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
HUM NULL

TYPE	SIZE	DWG.No.	REV
A	B	919-0112	A

MODEL	SCALE	SHEET
XMTR'S	1/1	1 OF 1



597–0096–506

FIGURE 7-19. DIRECTIONAL COUPLER ASSEMBLY DIAGRAM

APPENDIX A
MANUFACTURERS DATA

A–1. INTRODUCTION.

A–2. This appendix provides technical data associated with the operation and maintenance of the FM–20B transmitter. The information contained in this appendix is presented in the following order.

A. Service Bulletin, Furnas Contactor, Size 120/150 Amp.

B. Service Bulletin, Furnas Contactor, Size 40 Amp.

C. Operating Instructions and Parts List, Cincinnati Fan Company, LM–6C Volume Blower.

D. Optional Filament Voltage Regulator Operation and Service Manual.

E. Technical Data Sheet, Eimac, 4CX12,000A Tetrode.

F. Application Paper, Eimac, Extending Transmitter Tube Life.

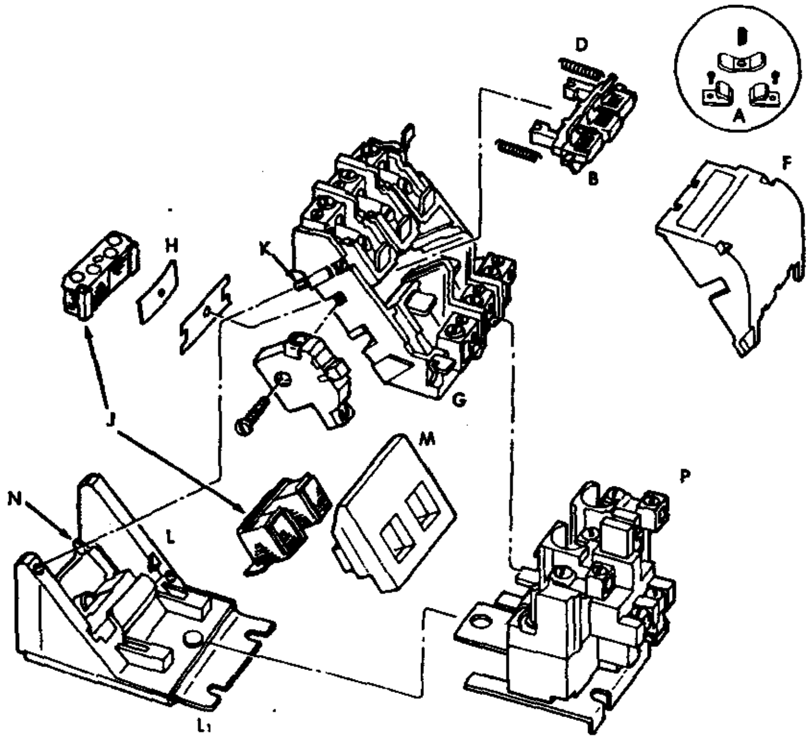
G. Technical Data Sheet, Thompson–CSF SD1460 VHF NPN Power Transistor.

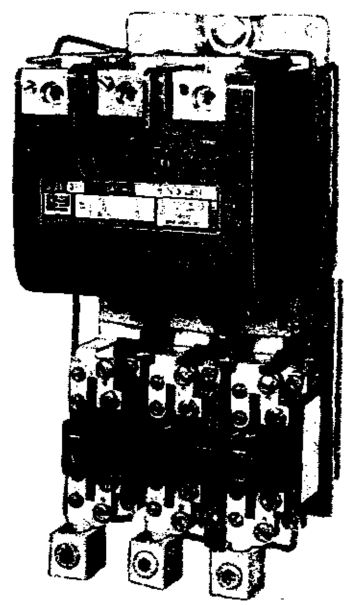
June, 1986
Supersedes Issue of
February 1983

Magnetic Controls
120 & 150 Amp
42HF & 42IF

Class 16 & 42
16HF, 16IF, 42HF & 42IF

FOR PROTECTION OF INTERNAL CONTROL CIRCUIT CONDUCTORS IN ACCORDANCE WITH THE N.E.C., USE FUSE KIT 49D55046002





ITEM	PART NAME		PART NUMBER
A	Contacts & Spring, One Complete Pole	Size 3	75HF14
		Size 3½	75IF14
B	Cross Arm (less contacts)		75P1002
D	Cross Arm Springs		75P1002
F	Contact Board Cover		D55040001
G	Contact Board with Terminals (less contacts)		D73458001
H	Armature Spring Clip		D25842001
J	Magnet and Armature		D27222001
K	Contact Board Screw		D24827001
L	Base		D26080001
L₁	Mounting Panel		D55043001
M	Coil 60 Hz. 110-120/220-240 V. 50 Hz. 110/190-220 V.		75D73251A
	220-240/440-480 V. 190-220/380-440 V.		75D73251C
	550-600 V. 550 V.		75D73251E
N	Coil Spring Clip		D25821001
P	Overload Relays — 3 Pole Standard Bimetal	120 Amp	48HC37AA2
		150 Amp	48IC37AA6
	Amb. Compensated Bimetal	120 Amp	48HC38AA2
		150 Amp	48IC38AA6

NOTE: When ordering replacement parts, give catalog number of control and part name and number.

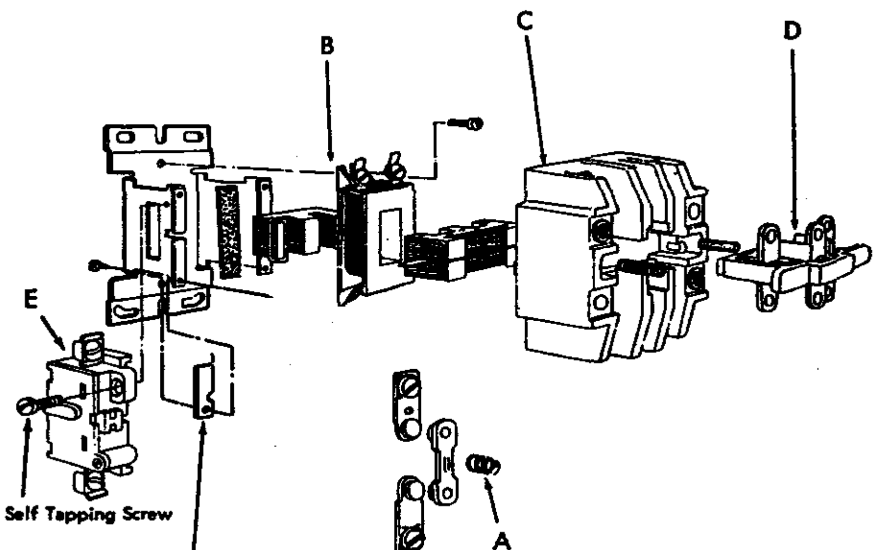
Furnas

Replacement Parts 42-GBE

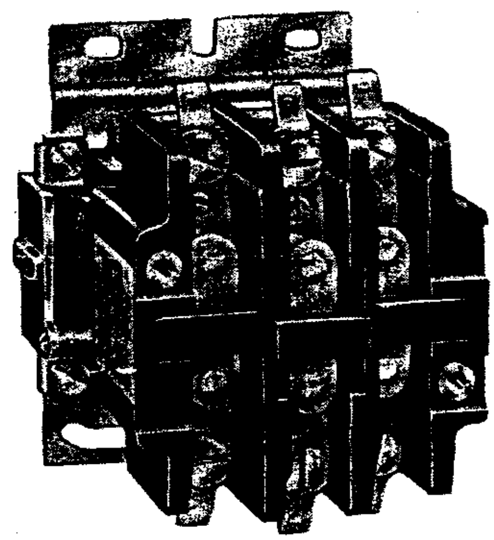
October, 1982
Supersedes issue of
May, 1978

Contactors
30-40 Amp.

Class 42
42BE & 42CE



① CAUTION – Spacers (1 each side) are required when 24 volt coil is used.



ITEM	PART NAME		PART NUMBER	
			42BE	42CE
A	Contacts and Spring One (1) Complete Pole – Specify No. Required.		75BE42	75CE42
B	Coil, *60 Hertz	24 Volts ①	75D54822J	75D54822J
		120 Volts	75D54822F	75D54822F
		240 Volts	75D54822G	75D54822G
		480 Volts	75D54822H	75D54822H
	*Other voltages and frequencies available on request			
C	Contact Board (less hardware)	3 Pole	D73342001	D73342001
		4 Pole	D73142001	D73142001
D	Cross Arm (less hardware)	3 Pole	D55138001	D55138001
		4 Pole	D53753001	D53753001
E	Auxiliary interlock (normally open)		49D22125001	49D22125001
	Auxiliary interlock (normally closed)		49D22125002	49D22125002

① 2 spacers included with 24 Volt 60 Hertz coil.

NOTE: When ordering replacement parts, give catalog number of control and part name and number.

OPERATING & MAINTENANCE INSTRUCTIONS AND PARTS LIST

for
"PB" & "SPB" Pressure Blowers
"LM" Volume Blowers

CONTENTS

⚠ DANGER

ALL FANS AND BLOWERS SHOWN HAVE ROTATING PARTS AND PINCH POINTS. SEVERE PERSONAL INJURY CAN RESULT IF OPERATED WITHOUT GUARDS. STAY AWAY FROM ROTATING EQUIPMENT UNLESS IT IS DISCONNECTED FROM ITS POWER SOURCE AND ALL ROTATING PARTS HAVE STOPPED MOVING.

READ ALL OPERATING INSTRUCTIONS CONTAINED HEREIN BEFORE INSTALLING EQUIPMENT.

⚠ DANGER

NO GUARANTEE OF ANY LEVEL OF SPARK RESISTANCE IS IMPLIED BY SPARK RESISTANT CONSTRUCTION. IT HAS BEEN DEMONSTRATED THAT ALUMINUM IMPELLERS RUBBING ON RUSTY STEEL MAY CAUSE HIGH INTENSITY SPARKS. AIR STREAM MATERIAL AND DEBRIS OR OTHER SYSTEM FACTORS MAY ALSO CAUSE SPARKS.

cincinnati fan and ventilator company, inc.

CATALOG # PMA-289
SUPERSEDES: PMA-177

I GENERAL SAFETY NOTES

1. Rotating parts including shaft and V-belt drives must be properly guarded to prevent personal injury.

2. Electrical wiring must be accomplished by a qualified electrician in accordance with all applicable codes.

3. Care should be taken:
   - Not to run fan above its safe speed (See Performance Tables in Sales Catalog or call CFV sales office).
   - Not to operate in excessive temperatures (See Limitations in Sales Catalog or call CFV sales office).
   - Not to operate in dangerous environments.
   - Read all instructions carefully.

II RECEIVING

Receiving Inspection

When unit is received, inspect immediately for damaged or missing parts. Even though all units are carefully inspected and prepared for shipment at the factory, rough handling enroute may cause concealed damage or cause nuts, set screws, bolts or locking collars to work loose. Be certain all fasteners are tightened securely. Rotate wheel by hand to verify that it rotates freely and that there are no obstructions.

If concealed damage is found, call the freight carrier and ask for their Inspection Department. Fill out a concealed damage inspection report.

III GENERAL INSTALLATION INSTRUCTIONS

Foundations

Fan foundation must be flat, level and rigid. Where foundation is not completely flat, shims must be placed under fan support at each anchor bolt as required. Bolting fan to an uneven foundation distorts alignment and causes vibration.

Structural steel foundations should be heavily cross-braced for load support.

OPERATION

Before Connecting Power

1. Inspect all fasteners and retighten if necessary:
   a. Foundation bolts.
   b. Set screws in fan and wheel and V-belt drive (See Table #1 & #2).
   c. Housing, bearing and motor mounting.

2. Access Doors should be tight and sealed.

3. Bearings should be checked for alignment and lubrication (See Bearing Maintenance).

4. Turn rotating assembly by hand to insure that it does not strike housing. If the wheel strikes the housing, the wheel may have moved on the shaft or the bearings may have shifted in transit. Correction <u>must</u> be made prior to start up.

5. Check motor to insure proper speed and electrical characteristics.

6. Check V-belt drive for alignment and correct belt tension.

7. After wiring, energize motor for 1 second to check for proper rotation.

Table #1

TORQUE VALUES FOR TAPERED BUSHINGS		
	MINIMUM RECOMMENDED TORQUE (INCH-LBS)	
Bushing Size	Steel Parts	Alum. Parts
H	95	60
P	192	80
Q	350	155
R	350	155

Table #2

SET SCREW TORQUE VALUES			
SET SCREW SIZE		MINIMUM REQUIRED TORQUE (INCH-LBS)	
Diameter & No. of Threads/Inch	Hex Size Across Flats (Allen Wrench)	Steel Set Screw Into Steel Threads	Steel Set Screw Into Alum. Threads or Stainless Steel Set Into Stainless Steel Threads
1/4-20	1/8"	65	65
5/16-18	5/32"	165	100
3/8-16	3/16"	228	155
7/16-14	7/32"	348	230
1/2-13	1/4"	504	330
5/8-11	5/16"	1104	700

NOTE: If wheel set screws are loosened and/or wheel is removed from shaft, set screws <u>must</u> be replaced. Set screws cannot be used more than once. Use knurled, cup point set screws with a locking patch.

IV GENERAL MAINTENANCE

CAUTION

Before any maintenance or service is performed, assure that unit is disconnected from power source to prevent accidental starting.

The key to good fan maintenance is a regular and systematic inspection of all fan parts. Severity of the application should determine frequency of inspection. The components requiring service are generally the moving parts which include bearings, fan propeller, belts, sheaves and motor.

Cast Aluminum & Metal Parts

Cast aluminum and steel parts usually do not require maintenance during the life of the unit except painted metal surfaces that may require periodic repainting. In a severe, dirty operation, the wheel should be cleaned with a wire brush to prevent an accumulation of foreign matter that could result in fan unbalance. After cleaning wheel, inspect for possible cracks or excessive wear, which can cause unbalance. DO NOT operate a wheel that is cracked, chipped, has broken blades or excessive wear. NOTE: If wheel set screws are loosened and/or wheel is removed from shaft, set screws must be replaced. Set screws cannot be used more than once. Belts on V-belt drive units require periodic inspection and replacement when worn. For multiple belt drives, belts should be replaced with matched sets.

Motor Maintenance

1. Disconnect power to motor.

2. Removing dust and dirt: Blow out open type motor windings with low pressure air to remove dust or dirt. Air pressure above 50 P.S.I. should not be used as high pressure may damage insulation and blow dirt under loosened tape. Dust accumulation can cause excessive insulation temperatures.

3. Lubrication: Consult the motor manufacturer for recommendations.

4. Motors must be stored under cover in a clean, dry, vibration-free location. Remove sufficient packaging material to allow circulation of air around motor. Maintain the temperature of the windings a few degrees above that of the surrounding air to protect against condensation. This may be accomplished by using space heaters, if supplied, or by any other safe, reliable method of heating. Measure and record monthly the ambient air temperature and winding temperature.

To prevent rusting of bearing parts, the rotor must be rotated at regular intervals (30 days) to assure these parts are will covered with oil or grease.

V V-BELT DRIVES

Care should be taken not to over tighten V-belt drive. Excessive belt tension overloads fan and motor bearings. It is much less expensive to replace belts worn from slippage than to replace bearings damaged from excessive loading.

Fans shipped completely assembled have had V-belt drive aligned at the factory. Alignment should be rechecked before operation as a precaution due to handling during shipment.

1. Be sure sheaves are locked in position.

2. Key should be seated firmly in keyway.

3. Place straight edge or taut cord across faces of driving and driven sheaves to check alignment. The motor and fan shafts must be parallel with V-belts and at right angles to the shafts.

4. Start the fan. Check for proper rotation. Run fan at full speed. A slight bow should appear on slack side of belt. Disconnect power and adjust belt tension by adjusting motor on its sliding base. All belts must have some slack on one side.

A WORD OF CAUTION ABOUT MOTORS

Using your hand to test the running temperature of a motor can be a very painful experience:

Normal body temperature	98.6° F
Threshold of pain caused by heat	120.0° F
Average temperature of hot tap water	140.0° F
Average temperature of hot coffee	180.0° F
Normal operating temperature of a fully loaded electric motor, open type, 70° F ambient temperature	174.0° F

You cannot wash your hands in 140° F water!

You cannot stir a fresh cup of coffee with your finger!

You cannot place your hand on a motor that is operating properly without burning your hand!

5. If belts squeal at start up, they may be too loose.

6. When belts have had time to seat in the sheave grooves, then readjust belt tension.

V-belt drive assembly can be mounted as follows:

1. Clean motor and fan shafts. Be sure they are free from corrosive material. Clean bore of sheaves and coat with heavy oil for ease of shaft entry. Remove oil, grease, rust or burrs from sheaves.

2. Place fan sheave on fan shaft and motor sheave on its shaft. **Do not pound sheaves on** as this may damage bearings. Tighten sheaves in place per Table # 1.

3. Move motor on slide base so belts can be placed in grooves of both sheaves without forcing. Do not roll belts or use a tool to force belts over the grooves.

4. Align fan and motor shafts so they are parallel. The belts should be at right angles to the shafts. A straight edge or taut cord placed across the face of the sheaves will aid in alignment.

5. Tighten belts by adjusting motor base. Correct tension gives the best drive efficiency. Excessive tension causes undue bearing pressure.

6. Start the fan and run it at full speed. Adjust belt tension until only a slight bow appears on the slack side of the belts. If slippage occurs, a squeal will be heard at start-up. Eliminate this squeal by **disconnecting power** and tightening up the belts.

7. Give belts a few days running time to become seated in sheave grooves, then readjust belt tension.

If the shafts become scratched or marked, carefully remove sharp edges and high spots such as burrs with fine emery cloth or honing stone. Avoid getting emery dust in the bearings.

Do not apply any belt dressing unless it is recommended by the drive manufacturer. V-belts are designed for frictional contact between the grooves and sides of the belts. Dressing will reduce this friction.

Belt tension on an adjustable pitch drive is obtained by moving the motor, not by changing the pitch diameter of the adjustable sheave.

VI FAN BEARING MAINTENANCE

Sealed Bearings

Sealed for life bearings are pre-lubricated with the correct amount of manufacturer-approved ball bearing grease, and are designed for application where relubrication is not required.

Arrangement #2 units feature two single-row deep groove bearings in a cast iron bearing bracket. Dirt and grease guard seals are an integral part of the assembly. For high temperature applications the bearings are pre-lubricated with a high temperature grease.

Relubricatable Bearings

Relubricatable Type Bearings must be relubricated periodically to assure long life. The length of interval between greasing is dependent on the running speed and ambient conditions. The following table covers most situations and can be used as a guide.

Generally Recommended
Relubrication Frequency in MONTHS

Operating Speed (RPM)	Bore in Inches			
	1/2 to 1	1-1/8 to 1-1/2	1-5/8 to 1-15/16	2 to 2-1/2
To 500	6	6	6	6
501-1000	6	6	6	5
1001-1500	6	5	5	4
1501-2000	5	5	4	3
2001-2500	5	5	3	2
2501-3000	5	4	2	2
3001-3500	4	3	2	1
3501-4000	3	3	1	–
4001-4500	2	2	1	–
4501-5000	2	1	–	–

For normal operating conditions the grease should be lithium base and conform to the NLGI grade #2 or #3 consistency and be free of any chemical impurities such as free acid or free alkali, dust, rust, metal particles or abrasives.

If bearings are in a hostile environment such as temperatures above 120° F, high moisture areas or contaminated areas, more frequent lubrication is required. Consult bearing manufacturer for recommendations.

For best results, bearings should be relubricated while in operation. **NOTE:** Due caution for personal safety must be observed when servicing rotating equipment. The grease should be pumped in slowly until a slight bead forms around the seals. This bead, in addition to acting as an indicator of adequate relubrication, provides additional protection against the entry of foreign matter.

By the time the slight-grease bead is formed, it will be noted that the temperature rise is in the neighborhood of 30° F. If necessary to relubricate while the bearing is idle, contact bearing manufacturer for the maximum grease capacity for the various sizes of bearings.

VII WARRANTY

Cincinnati Fan & Ventilator Company warrants products of its own manufacture against defects of material and workmanship under normal use and service for a period of eighteen (18) months from date of shipment or twelve (12) months from date of installation, whichever occurs first. This warranty does not cover ordinary wear and tear, abuse, misuse, overloading, negligence, alteration or systems and/or materials not of Seller's manufacture. Expenses incurred by Buyer(s) in repairing or replacing any defective product will not be allowed except where authorized in writing and signed by an officer of the Seller.

The obligation of Seller under this warranty shall be limited to repairing or replacing F.O.B. Seller's plant, or allowing credit at Seller's option. This warranty is expressly in lieu of all other warranties expressed or implied including the warranties of merchantability and fitness for use and of all other obligations and liabilities of the Seller. The Buyer acknowledges that no other representations were made to him or relied upon him with respect to the quality or function of the products herein sold.

On equipment furnished by the Seller, but manufactured by others, such as motors, Seller extends the same warranty as Seller receives from the manufacturer thereof. Repairs for motors should be obtained from nearest authorized motor service station for the make of motor furnished. All motors used are products of well-known manufacturers with nationwide service facilities. Check the yellow pages of your telephone directory for the location of the nearest service shop.

Cincinnati Fan & Ventilator Company assumes no responsibility for material returned to our plant without our prior written permission.

VIII ORDERING REPLACEMENT PARTS

Replacement or spare parts may be ordered through your local Cincinnati Fan representative. (Refer to drawings that begin on Page 6.) The following information should accompany parts orders:

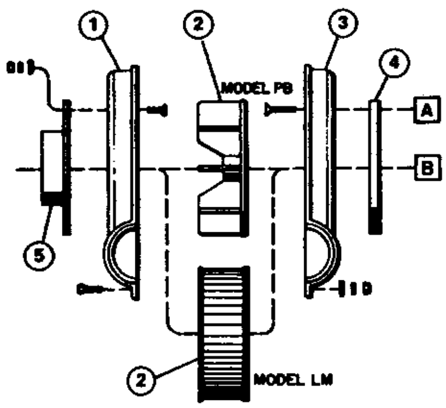
1. Motor horsepower, frame size, motor speed, voltage, phase, cycle and enclosure. Motor manufacturer's model number from motor nameplate.
2. Fan Speed (if V-belt driven).
3. Fan arrangement number.
4. Fan serial AND model numbers from the FAN nameplate and a complete description of the part.

An adequate stock of repair parts is maintained where possible. If your fan is vital to production or to plant operation, it may be advisable to have all spare parts on hand to minimize the possibility of downtime.

IX FAN TROUBLE SHOOTING

In the event that trouble is experienced in the field, the following are the most common fan difficulties. These points should be checked in order to prevent needless delay and expense.

1. **CAPACITY OR PRESSURE BELOW RATING**
   a. Incorrect direction of wheel rotation.
   b. Speed too slow.
   c. Dampers or variable inlet vanes not properly adjusted.
   d. Poor fan inlet or outlet conditions (elbows, restrictions).
   e. Air leaks in system.
   f. Damaged wheel.
   g. Total resistance of system higher than anticipated.
   h. Wheel mounted backwards on shaft.
   i. Fan not properly selected for a high temperature and/or high altitude application.
2. **VIBRATION AND NOISE**
   a. Misalignment of bearings, coupling, wheel or V-belt drive.
   b. Unstable foundation.
   c. Foreign material in fan causing unbalance.
   d. Worn bearings.
   e. Damaged wheel or motor.
   f. Broken or loose bolts and set screws.
   g. Bent shaft.
   h. Worn coupling.
   i. Fan wheel or drive unbalanced.
   j. 120 cycle magnetic hum due to electrical input. Check for high or unbalanced voltage.
   k. Fan delivering more than rated capacity.
   l. Loose dampers.
   m. Speed too high or fan rotating in wrong direction.
   n. Vibration transmitted to fan from some other source.
3. **OVERHEATED BEARINGS**
   a. Check bearing lubrication.
   b. Poor alignment.
   c. Damaged wheel or drive.
   d. Bent shaft.
   e. Abnormal end thrust.
   f. Dirt in bearings.
   g. Excessive belt tension.
4. **OVERLOAD ON MOTOR**
   a. Speed too high.
   b. Blower over capacity due to existing system resistance being lower than original rating.
   c. Specific gravity or density of gas above design value.
   d. Packing too tight or defective (on fans with stuffing box).
   e. Wrong direction of wheel rotation.
   f. Shaft bent.
   g. Poor alignment.
   h. Wheel wedging or binding on inlet bell.
   i. Bearings improperly lubricated.
   j. Motor improperly wired.
   k. Defective motor. Motor must be tested by motor manufacturer's authorized repair shop.



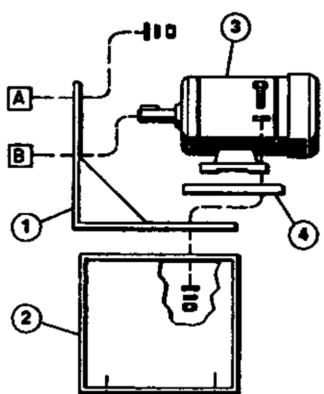
HOUSING WHEEL COMPONENTS

All arrangements

* 1. Housing, inlet side.
* 2. Wheel (PB or LM type).
* 3. Housing, drive side.
4. Drive side plate (if required).
5. Inlet side plate (if required).

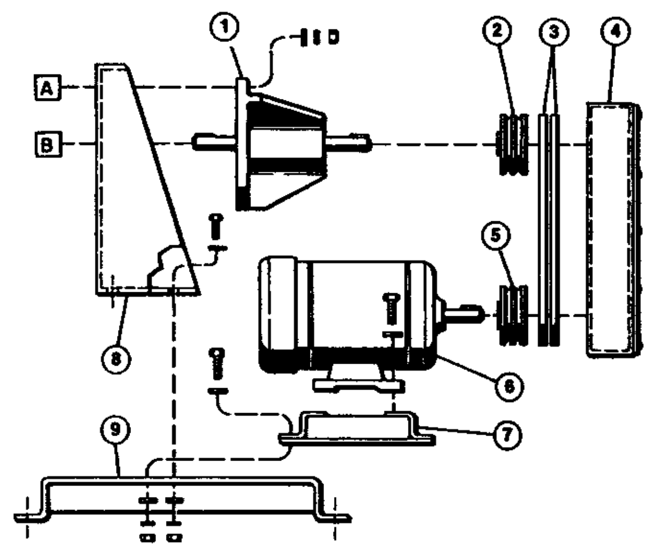
* NOTE: Rotation determined by viewing blower from drive side, not looking into inlet.

BASE ARRANGEMENT COMPONENTS



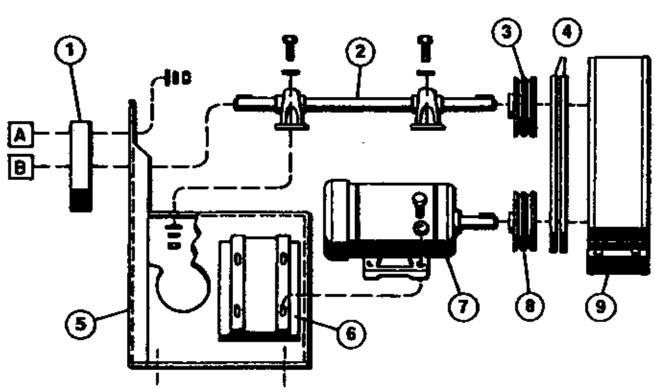
Arrangement 4

1. Angle bracket (if required).
2. Bottom base.
3. Motor.
4. Riser pad (if required).



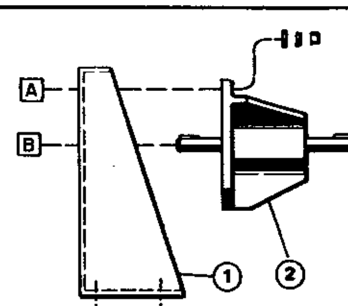
Arrangement 9-2

1. Shaft/bearing assembly.
2. Fan sheave
3. Belt(s).
4. Belt guard.
5. Motor sheave.
6. Motor.
7. Motor slide base.
8. Upright base.
9. Sub base.



Arrangement 9-1

1. Spacer ring.
2. Shaft/bearing assembly.
3. Fan sheave.
4. Belt(s).
5. Bearing base.
6. Motor slide base.
7. Motor.
8. Motor sheave.
9. Belt guard.

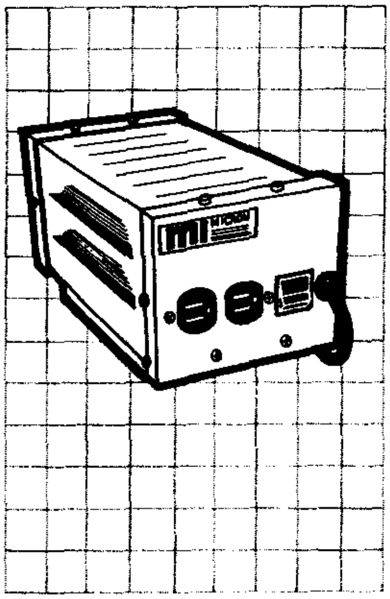


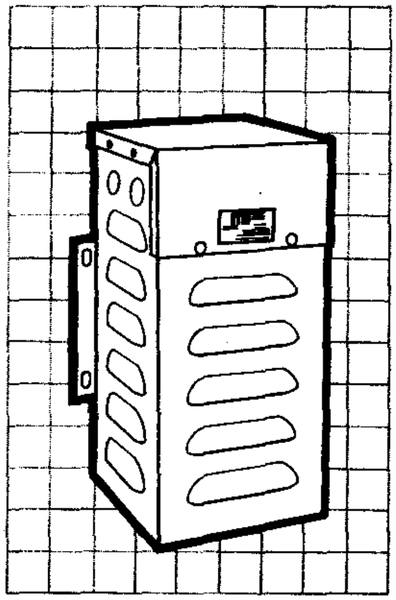
Arrangement 2

1. Upright base.
2. Shaft/bearing assembly.

Micron *Power Conditioners*

Installation, operation and service





MICRON
INDUSTRIES
CORPORATION

1830 N. 32nd Ave.
Stone Park, IL 60165
Telephone: (312) 345-0788 Telex: 27-0248

MICRON INDUSTRIES CORPORATION

INSTALLATION, OPERATING AND SERVICE INSTRUCTIONS FOR POWER CONDITIONERS UL LISTED, CONTROL NUMBER 39L6

DESCRIPTION

Micron Power Conditioners perform four essential functions: 1) attenuate electrical noise contained in the input voltage source, 2) suppress transients, 3) maintain the output voltage to the load constant although the input voltage may fluctuate over a range of +10% to -20% of nominal, and 4) protect against overloads. This is defined as complete power line conditioning as it includes each of the four functions essential to protection of electronic equipment.

Micron Power Conditioners are of ferro-resonant magnetic design which provides excellent electrical isolation between line and load. They are designed to provide noise attenuation of 120 dB for common mode and 60 dB for transverse mode.

The power conditioner is for indoor use only and are intended for wall or floor mounting. A qualified electrician is required for installation.

MOUNTING

Power conditioners can be installed on either wall or floor where the unit weight and size will permit. The units are cooled by natural draft air circulation. Poorly ventilated spaces should be avoided and minimum spacing between two or more power conditioners should be four inches.

If the power conditioner is wall mounted, the wiring compartment should be mounted up. When mounting the power conditioner to a wall, the following minimum size steel bolts must be used in all mounting holes provided.

VA Size of Unit	Minimum Steel Bolt Size
750 and 1000	1/4 Inch Diameter Bolts
2000	5/16 Inch Diameter Bolts

Micron Power Conditioners are fully enclosed. Personnel are safe from accidental burns since the core is not exposed; personnel guards are not required.

FUSING

Micron Power Conditioners are designed with built-in current limitation which may allow the unit to operate under a direct short circuit load without damage. Fusing of the load is not necessary, however, the source side of the power conditioner may be fused. The fuse rating should be 1 1/2 times the rated operating current, except when connected to a rectified load. Then the fuse should be rated at five times nameplate current because of the high inrush current.

CONNECTIONS

Units should be hard wired to a branch circuit in accordance with local and national electrical codes. Power conditioners having output voltages rated 120/240 can operate at full nameplate rating of 120 volts, or 240 volts, or 120/240 volts, three-wire connection. For these power conditioners a load equal to the name plate VA rating of the power conditioner may be connected across 5 and 6 (or 6 and 7 for 120 volts), but the maximum load which can be connected across 5 and 6 and 6 and 7 must not each exceed 1/2 the VA rating of the power conditioner. The sum of all three-wire connected loads at the 120/240 volt rating must not exceed the nameplate VA rating.

PARALLEL WIRING

Micron Power Conditioners may be connected in parallel to increase load capacity to a level equal to the sum of the VA ratings of individual power conditioners. The individual units must be of the same type, VA capacity, voltage rating, and frequency.

THREE-PHRASE OPERATION

Three single-phase power conditioners may be banked and used for three-phase applications. The primaries of the power conditioners must be delta connected to the three-phase source. The secondaries must be WYE connected to the load. Three-phase loads should not be connected phase-to-phase: A to B, B to C, C to A.

Single-phase loads can be connected to the three-phase source. The loads can be balanced (equal load VA to each phase) or totally unbalanced. The load of each phase can not exceed one-third of the total VA of the power conditioners. The loads must be connected phase-to-neutral: A to N, B to N or C to N.

It is highly suggested that the neutral of the power conditioners secondaries and the neutral of the load be connected to a reliable ground. Figure 1 is a typical three-phase wiring diagram.

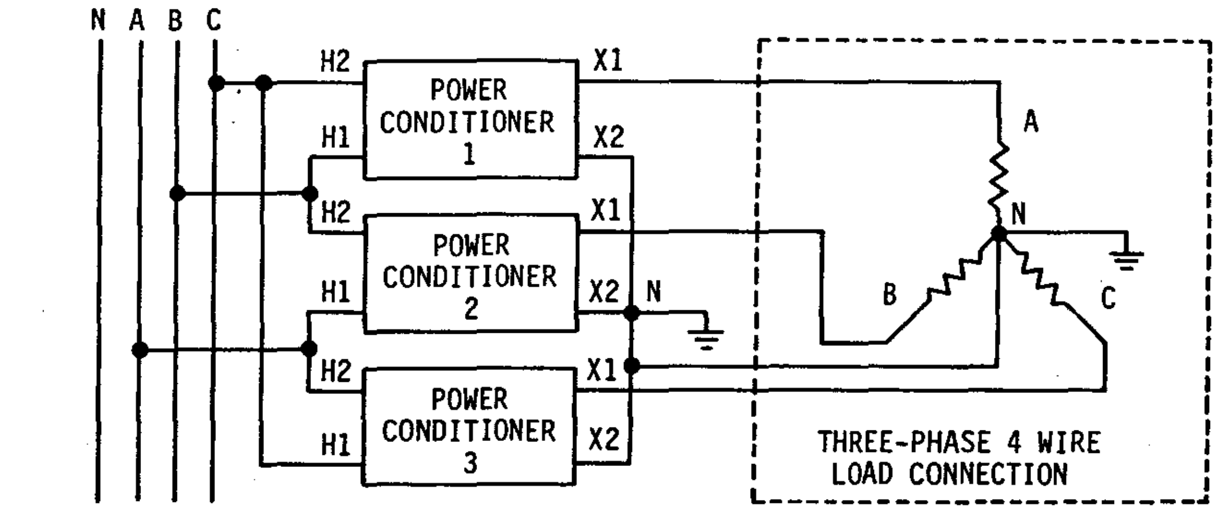


FIGURE 1. THREE-PHASE WIRING DIAGRAM

DERATING FOR WIDER INPUT VOLTAGE RANGE

Where conditions necessitate a greater low voltage input range than the rated range, a power conditioner can be oversized to achieve a lower input voltage range, while maintaining the rated output voltage. Table 1 sets forth the oversizing factor which will achieve a given lower input voltage, express as a percent below the nominal voltage rating of the unit.

TABLE 3. OVERSIZING FACTOR FOR LOWER INPUT VOLTAGE RANGE

INPUT VOLTAGE RANGE BELOW NOMINAL	OVERSIZE FACTOR
-20%	1.00
-30%	1.02
-40%	1.40
-50%	2.00
-60%	3.10

Formula: (1) Input Voltage Range Below Nominal = (Lowest Input ÷ Nominal Voltage) X -100

(2) Round answer of (1) to next largest percent shown in Table 1 and refer to corresponding Oversize Factor

(3) Required Nameplate VA = Oversize Factor X VA of load to be served.

SPECIFICATIONS AND DIMENSIONAL DATA

Power conditioner specifications and dimensional data are shown in Table 2. These specifications should be read in conjunction with dimension drawings (Figure 2), standard wiring connections (Table 3), and the wiring diagram (Figure 3).

TABLE 2. POWER CONDITIONERS, SINGLE PHASE, 60 Hz

VA	INPUT	OUTPUT	DIMENSIONS (Inches) A	B	C	D	E	F	MOUNTING SLOTS	APPROX. SHIP Wt.(Lbs)
750	95-130/ 190-260	120/240	16.25	8.75	5.63	8.13	6.00	9.00	0.38 X 0.75	32
1000	95-130/ 190-260	120/240	16.25	8.75	5.63	8.13	6.00	9.00	0.38 X 0.75	40
2000	95-130/ 190-260	120/240	20.13	10.75	5.13	11.25	6.31	12.25	0.44 X 0.88	60

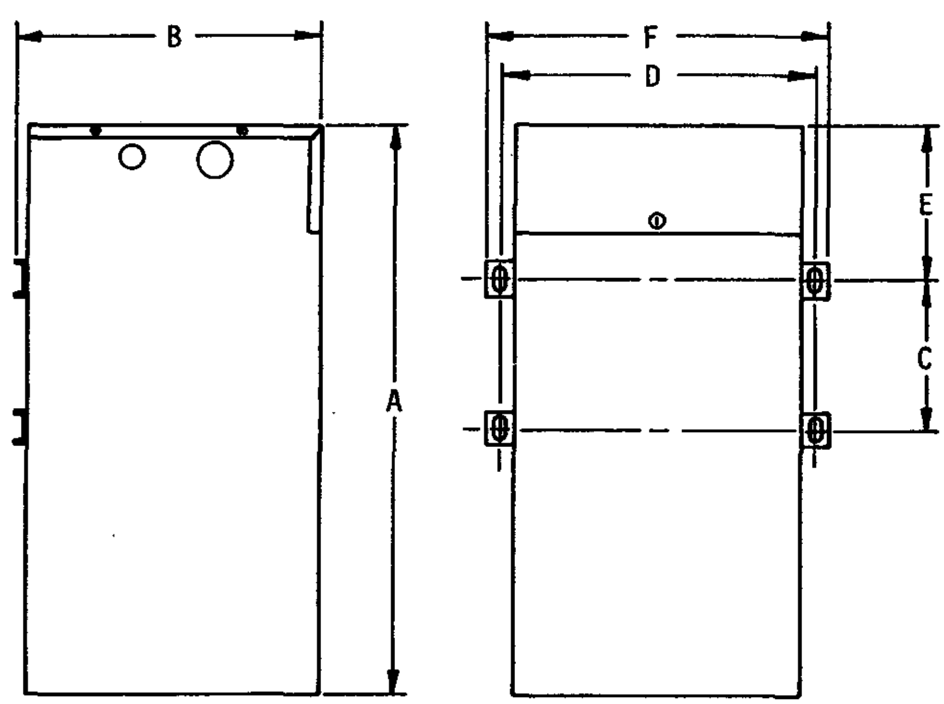


FIGURE 2. POWER CONDITIONER DIMENSIONAL DRAWINGS

TABLE 3. POWER CONDITIONERS STANDARD WIRING CONNECTIONS

INPUT CONNECTIONS			OUTPUT CONNECTIONS		
VOLTAGE (VAC)	POWER LINE CONNECTIONS	INTERNAL CONNECTIONS	VOLTAGE (VAC)	LOAD CONNECTIONS	CAPACITY
95-130	1 & 4	1 to 2 & 3 to 4	120	5&6 or 6&7	Rated VA
			240	5 & 7	Rated VA
190-260	1 & 4	2 to 3	120 120	5 & 8 5 & 6	1/2 Rated VA each
			120 240	5 & 6 5 & 7	1/2 Rated VA each

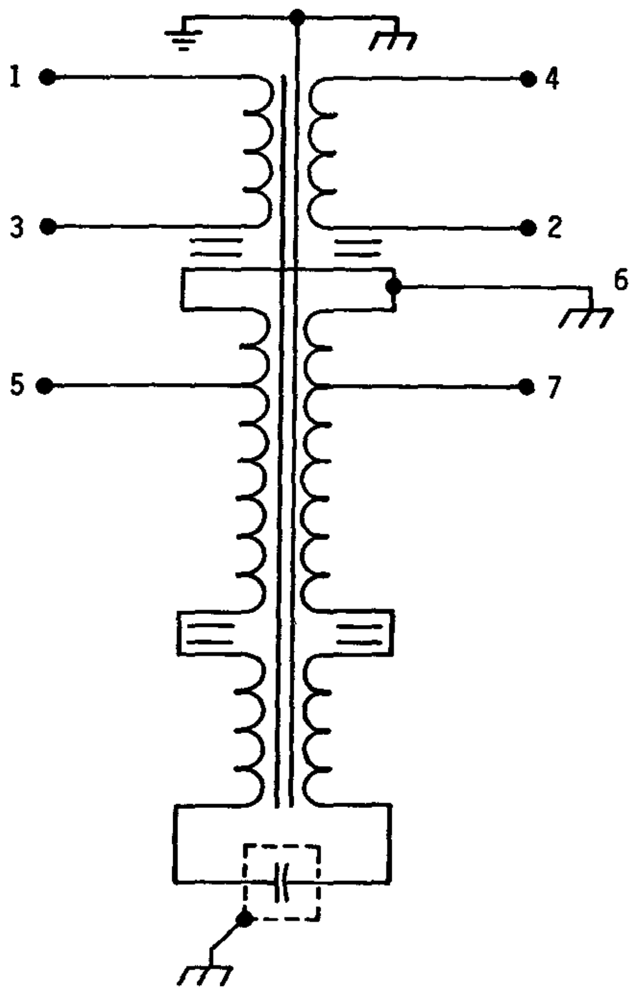


FIGURE 3. WIRING DIAGRAM

AUDIBLE NOISE

Micron Power Conditioners are designed and manufactured to minimize the level of noise. In normal operating environments the noise should not be noticeable. If desired, sound absorption materials may be externally used, provided ventilation to the unit is not impeded. It is suggested whenever possible large units for computer room applications be installed outside the room near the distribution panel.

OPERATING TEMPERATURES

Micron Power Conditioners are designed to operate in ambient temperatures found in typical plant, laboratory, retail, office, and home environments. In operation the temperature of the unit will rise whether or not the power conditioner is delivering to a load. The temperature rise can vary between 45°C to 100°C, depending upon type and rating of the power conditioner. The maximum temperature rise will always be within safe operating conditions for the temperature class of the insulation system used.

MOTOR LOADS

Because of the built-in current-limiting capability of the power conditioner, the nameplate load rating of the power conditioner must be nearly equal to the maximum power drawn during locked-rotor condition of the motor.

EFFECT OF FREQUENCY

Changes in frequency of the input voltage will change the level of output voltage to the load. Each 1.0% change in the frequency of the input voltage will result in approximately 1.8% change in output voltage in the same direction as the frequency change.

CURRENT LIMITATION

Each Micron Power Conditioner is rated to accommodate loads to a given value. If the load is increased beyond the rating of the power conditioner, a point is reached when the output voltage will collapse to near zero. For the power conditioner to regain its normal output voltage, the overload or short-circuit must be removed from the power conditioner. Under short-circuit conditions, the load is current-limited to approximately 150% of the rated full-load value at nominal input voltage. The power conditioner may remain in excessive load or short-circuit conditions without damage to the load or power conditioner. Fusing is not required.

RESPONSE TIME

Micron Power Conditioners provide near instantaneous response to line and load changes. Transient changes in supply voltage will normally return to its original level within 1 1/2 cycles. Fluctuation of the output voltage will remain within a few percent of its original level.

INPUT CHARACTERISTICS

The power conditioner transformer is energized whether it is serving or not serving a load. Input power factor will always be leading, and will average 90% to 100% at full load, around 75% at half load, and 25% at no load.

MAINTENANCE AND TROUBLESHOOTING

MAINTENANCE

Micron Power Conditioners have no moving parts, thus no regular maintenance is required.

REPLACEMENT CAPACITORS

Capacitors used in all power conditioners are of the highest commercial grade available. However, a limited number of capacitors may fail. During the warranty period, new capacitors will be provided without charge.

Replacement capacitors can be ordered through a Micron distributor or sales representative. When ordering replacement capacitors, provide the model number of the power conditioner and the capacitor part number.

TROUBLESHOOTING

Micron Power Conditioners are designed and manufactured to provide years of service. However, if poor performance is suspected, the following procedures may be used to check the power conditioner.

WARNING

WARNING

BECAUSE OF POSSIBLE EXPOSURE TO HIGH VOLTAGES INSIDE THE POWER CONDITIONER, TROUBLESHOOTING PROCEDURES MUST BE CARRIED OUT ONLY BY A QUALIFIED ELECTRICIAN.

1. NO OUTPUT VOLTAGE.
   - A. Assure the input(s) and output(s) ar properly connected.
   - B. Check power supply and input switch.
   - C. If fused, check fuse and fuse rating. (If the fuse rating is correct and it opens repeatedly, a capacitor or magnetic component may be shorted or grounded.)

2. NOMINAL OUTPUT VOLTAGE TOO LOW.
   - A. The load may have a lagging power factor.
   - B. Unit may be slightly over loaded.

3. NOMINAL OUTPUT VOLTAGE TOO HIGH.

   A. The load may have a leading power factor.
   B. If the load is substantially less than full rating of the unit, the voltage will be slightly high.

4. DOES NOT REGULATE TO SPECIFICATIONS.

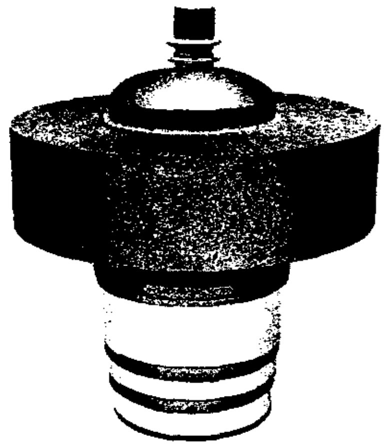
   A. The unit may be slightly over loaded.
   B. With varying loads, a certain degree of load regulation may be mixed with the line voltage regulating action.
   C. Actual input voltage range may be outside the rated input range of the unit. This appears as more prevalent on the low side.

5. OUTPUT VOLTAGE EXTREMELY LOW (20 TO 60 VOLTS).

   A. One or more capacitors in the power conditioner may be defective.
   B. Unknown overloads of significant size occurring intermittently, such as, solenoid inrush currents and motor starting currents.

Warranty

MICRON *Power Conditioners* are warranted against defects in workmanship or material for a period of two years from date of sale.



TECHNICAL DATA

8989/4CX12,000A
VHF POWER TETRODE

The EIMAC 8989/4CX12,000A is a ceramic/metal power tetrode intended for use in audio or radio frequency applications. It features a type of internal mechanical structure which results in high rf operating efficiency. Low rf losses in this structure permit operation at full ratings up to 250 MHz.

The 8989/4CX12,000A has a gain of over 18 dB in FM broadcast service, and is also recommended for rf linear amplifier service, and for VHF television linear amplifier service. The anode is rated for 12 kilowatts of dissipation with forced-air cooling and incorporates a highly efficient cooler of new design.

GENERAL CHARACTERISTICS[1]

ELECTRICAL

Filament: Thoriated Tungsten
- Voltage .... 6.5 V nominal[2]
- Current @ 6.5 volts .... 105 A nominal

Amplification Factor (average) Grid to Screen 6.7

Direct Interelectrode Capacitance (grounded cathode)[3]
- Cin .... 160 pF
- Cout .... 18.5 pF
- Cgp .... 1.0 pF

Direct Interelectrode Capacitance (grid & screen grounded)[3]
- Cin .... 70 pF
- Cout .... 18.6 pF
- Cpk .... 0.1 pF

Maximum Frequency for Full Ratings (CW) .... 250 MHz

1. Characteristics and operating values are based on performance tests. These figures may change without notice as the result of additional data or product refinement. Varian should be consulted before using this information for final equipment design.
2. See ELECTRICAL, FILAMENT OPERATION on page 3.
3. Capacitance values are for a cold tube as measured in a special shielded fixture in accordance with Electronic Industries Association Standard RS-191.

MECHANICAL

Maximum Overall Dimensions:
- Length (height) .... 9.84 in; 25.0 cm
- Diameter .... 7.76 in; 19.7 cm

Net Weight (approximate) .... 14 lbs; 6.4 kg

Operating Position .... Vertical Only

Cooling .... Forced Air

Maximum Operating Temperature, Ceramic/Metal Seals & Anode Core .... 250°C

Base .... Special Concentric

Recommended Air System Socket (for dc, LF, HF applications) .... EIMAC SK-300A

Recommended Air System Socket (for VHF applications) .... EIMAC SK-360

Recommended Air Chimney .... EIMAC SK-336

Available Screen Bypass Capacitor Kit for SK-360 (8000 pF @ DCWV = 5000) .... EIMAC SK-355

Available Anode Connector Clip .... EIMAC ACC-3

(Effective February 1991) 2199 Printed in U.S.A.

varian
power grid & x-ray tube products
301 Industrial Way / San Carlos, CA 94070 / U.S.A. / (415) 592-1221

8989/4CX12,000A

RADIO FREQUENCY POWER AMPLIFIER OR OSCILLATOR
Class C Telegraphy or FM - Key Down Conditions

ABSOLUTE MAXIMUM RATINGS:

DC PLATE VOLTAGE	10.0	KILOVOLTS
DC SCREEN VOLTAGE	2.0	KILOVOLTS
DC GRID VOLTAGE	-500	VOLTS
DC PLATE CURRENT	3.5	AMPERES
PLATE DISSIPATION	12.0	KILOWATTS
SCREEN DISSIPATION	300	WATTS
GRID DISSIPATION	150	WATTS

*Approximate Value #Calculated Data

Typical Operation (Frequencies to 30 MHz)#

Plate Voltage	9.0	kVdc
Screen Voltage	750	Vdc
Grid Voltage	-250	Vdc
Plate Current	2.83	Adc
Screen Current*	135	mAdc
Grid Current*	63	mAdc
Peak rf Grid Voltage*	335	v
Driving Power*	23	W
Plate Dissipation*	5470	W
Plate Output Power*	20	kW
Load Impedance	1590	Ohms

RADIO FREQUENCY POWER AMPLIFIER
Commercial FM Service

ABSOLUTE MAXIMUM RATINGS:

DC PLATE VOLTAGE	10.0	KILOVOLTS
DC SCREEN VOLTAGE	2.0	KILOVOLTS
DC GRID VOLTAGE	-500	VOLTS
DC PLATE CURRENT	3.5	AMPERES
PLATE DISSIPATION	12.0	KILOWATTS
SCREEN DISSIPATION	300	WATTS
GRID DISSIPATION	150	WATTS

*Approximate #Delivered to the Load

Measured Operation, Commercial FM Service
Operation in EIMAC CV-2210 Cavity at 108.1 MHz

Plate Voltage	8.0	8.0	10.0	kVdc
Screen Voltage	750	800	800	Vdc
Grid Voltage	-300	-400	-300	Vdc
Plate Current	1.6	2.58	2.81	Adc
Screen Current*	115	120	130	mAdc
Grid Current*	51	38	32	mAdc
Driving Power*	165	250	275	W
Useful Power Output#	11.0	15.8	22.5	kW
Efficiency	84	77	80.2	%
Gain	18.4	18.0	19.1	dB

TYPICAL OPERATION values are obtained by measurement or by calculation from published characteristic curves. To obtain the specified plate current at the specified bias, screen, and plate voltages, adjustment of rf grid voltage is assumed. If this procedure is followed, there will be little variation in output power when the tube is replaced, even though there may be some variation in grid and screen currents. The grid and screen currents which occur when the desired plate current is obtained are incidental and vary from tube to tube. These current variations cause no performance degradation providing the circuit maintains the correct voltage in the presence of the current variations.

APPLICATION

MECHANICAL

MOUNTING - The 4CX12,000A must be operated with its axis vertical. The base of the tube may be up or down at the convenience of the designer.

SOCKET & CHIMNEY - The EIMAC air-system sockets SK-300A and SK-360, and air chimney SK-336 are designed especially for use with the 4CX12,000A. The SK-300A may be used for dc, LF or HF applications, while for VHF service the SK-360 should be used. The SK-355 screen bypass capacitor kit is available for use with the SK-360. The recommended air flow through either socket, in a base-to-anode direction, provides effective cooling of the base, with air then guided through the anode cooling fins by the air chimney.

COOLING - The maximum temperature rating for the external surfaces of the tube is 250°C, and sufficient forced-air cooling must be used in all applications to keep the temperature of the anode (at the base of the cooling fins) and the temperature of the ceramic/metal seals comfortably below this rated maximum.

It is considered good engineering practice to design for a maximum anode core temperature of 225°C and temperature-sensitive paints are available for checking base and seal temperatures before any design is finalized. Application Bulletin #20 titled TEMPERATURE MEASUREMENTS WITH EIMAC POWER TUBES is available on request.

It is also good practice to allow for variables such as dirty air filters, rf seal heating, and the fact that the anode cooling fins may not be clean if the tube has been in service for some length of time. Special attention is required in cooling the center of the stem (base), by means of special directors or some other provision. An air interlock system should be incorporated in the design to automatically remove all voltages from the tube in case of even partial failure of the tube cooling air.

Minimum air flow requirements for a maximum anode temperature of 250°C for various altitudes and dissipation levels are listed. The pressure drop values shown are approximate and are for the tube mounted in a SK-300A socket with an SK-336 air chimney, with air passing through the socket in a base-to-anode direction and then on to the anode cooler.

Pressure drop in a typical installation will be higher because of system loss.

Inlet Air Temperature = 25°C

Sea Level

Plate Diss. Watts	Flow Rate CFM	Press. Drop In. Water
7500	120	0.27
10000	170	0.55
12500	260	1.12

5000 Feet

Plate Diss. Watts	Flow Rate CFM	Press. Drop In. Water
7500	140	0.40
10000	210	0.56
12500	310	1.14

10,000 Feet

Plate Diss. Watts	Flow Rate CFM	Press. Drop In. Water
7500	170	0.40
10000	250	0.70
12500	380	1.29

Inlet Air Temperature = 35°C

Sea Level

Plate Diss. Watts	Flow Rate CFM	Press. Drop In. Water
7500	130	0.30
10000	190	0.69
12500	300	1.28

5000 Feet

Plate Diss. Watts	Flow Rate CFM	Press. Drop In. Water
7500	160	0.45
10000	240	0.70
12500	360	1.43

10,000 Feet

Plate Diss. Watts	Flow Rate CFM	Press. Drop In. Water
7500	190	0.45
10000	290	0.85
12500	430	1.59

Inlet Air Temperature = 50°C

Sea Level

Plate Diss. Watts	Flow Rate CFM	Press. Drop In. Water
7500	160	0.41
10000	240	0.84
12500	360	1.58

5000 Feet

Plate Diss. Watts	Flow Rate CFM	Press. Drop In. Water
7500	190	0.45
10000	290	0.85
12500	440	1.74

10,000 Feet

Plate Diss. Watts	Flow Rate CFM	Press. Drop In. Water
7500	230	0.56
10000	350	1.00
12500	530	2.05

When long life and consistent performance are factors cooling in excess of minimum requirements is normally beneficial.

Air flow must be applied before or simultaneously with the application of power, including the tube filament, and should normally be maintained for a short period of time after all power is removed to allow for tube cooldown.

ELECTRICAL

FILAMENT OPERATION - During turn-on the filament inrush current should be limited to 300 amperes. At rated (nominal) filament voltage the peak emission capability of the tube is many times that needed for communication service. A reduction in filament voltage will lower the filament temperature, which will substantially increase tube life expectancy. The correct value of filament voltage should be determined for the particular application. It is recommended the tube be operated at full nominal voltage for an initial stabilization period of 100 to 200 hours before any action is taken to operate at reduced voltage. The voltage should gradually be reduced until there is a slight degradation in performance (such as power output or distortion). The filament voltage should then be increased two or three tenths of a volt above the value where performance degradation was noted for operation. The operating point should be rechecked after 24 hours. Filament voltage should be closely regulated when voltage is to be reduced below nominal in this manner, to avoid any adverse influence by normal line voltage variations.

Filament voltage should be measured at the tube base or socket, using an accurate rms-responding meter. Periodically throughout the life of the tube the procedure outlined above for reduction of voltage should be repeated, with voltage reset as required, to assure best tube life. EIMAC Application Bulletin #18 titled EXTENDING TRANSMITTER TUBE LIFE is available on request.

ABSOLUTE MAXIMUM RATINGS - Values shown for each type of service are based on the "absolute system" and are not to be exceeded under any service conditions. These ratings are limiting values outside which the serviceability of the tube may be impaired. In order not to exceed absolute ratings the equipment designer has the responsibility of determining an average design value for each rating below the absolute value of that rating by a safety factor so that the absolute values will never be exceeded under any usual conditions of supply-voltage variation, load variation, or manufacturing variation in the equipment itself. It does not necessarily follow that combinations of absolute maximum ratings can be attained simultaneously.

ELECTRODE DISSIPATION RATINGS - The maximum dissipation ratings for the 4CX12,000A must be respected to avoid damage to the tube. An exception is the plate dissipation which may be permitted to rise above the rated maximum during brief periods (10 seconds maximum) such as may occur during tuning.

GRID OPERATION - The maximum control grid dissipation is 150 watts, determined approximately by the product of the dc grid current and the peak positive grid voltage. A protective spark-gap device should be connected between the control grid and the cathode to guard against excessive voltage.

SCREEN OPERATION - The maximum screen grid dissipation is 300 watts. With no ac applied to the screen grid, dissipation is simply the product of dc screen voltage and the dc screen current. With screen modulation, dissipation is dependent on rms screen voltage and rms screen current. Plate voltage, plate loading, or bias voltage must never be removed while filament and screen voltages are present, since screen dissipation ratings will be exceeded. Energy limiting circuitry (which will activate if there is a fault condition) and spark gap over-voltage protection are recommended as good engineering practice.

The tube may exhibit reversed (negative) screen current under some operating conditions. The screen supply voltage must be maintained constant for any values of negative and positive screen current which may be encountered. Dangerously high plate current may flow if the screen power supply exhibits a rising voltage characteristic with negative screen current. Stabilization may be accomplished with a bleeder resistor connected from screen to cathode, to assure that net screen supply current is always positive. This is absolutely essential if a series electronic regulator is employed.

FAULT PROTECTION - In addition to the normal plate over-current interlock, screen current interlock, and air-flow interlock, the tube must be protected from damage caused by an internal plate arc which may occur at high plate voltage. A protective resistance should always be connected in series with each tube anode, to help absorb power supply stored energy if an internal arc should occur. If power supply stored energy is high an electronic crowbar, which will discharge power supply capacitors in a few microseconds after the start of an arc, is recommended. The test for each electrode supply is to short each electrode to ground, one at a time, through a vacuum relay switch and a 6-inch section of #30 AWG copper wire. The wire will remain intact if the test is met.

EIMAC's Application Bulletin #17 titled FAULT PROTECTION contains considerable detail, and is available on request.

HIGH VOLTAGE - Normal operating voltages used with this tube are deadly, and the equipment must be designed properly and operating precautions must be followed. Design all equipment so that no one can come in contact with high voltages. All equipment must include safety enclosures for high-voltage circuits and terminals, with interlock switches to open primary circuits of the power supply and to discharge high-voltage capacitors whenever access doors are opened. Interlock switches must not be bypassed or "cheated" to allow operation with access doors open. Always remember that HIGH VOLTAGE CAN KILL.

RADIO-FREQUENCY RADIATION - Avoid exposure to strong rf fields even at relatively low frequency. Absorption of rf energy by human tissue is dependent on frequency. Under 300 MHz most of the energy will pass completely through the human body with little attenuation or heating affect. Public health agencies are concerned with the hazard even at these frequencies. OSHA (Occupational Safety and Health Administration) recommends that prolonged exposure to rf radiation should be limited to 10 milliwatts per square centimeter.

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

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

SPECIAL APPLICATIONS - When it is desired to operate this tube under conditions widely different from those listed here, write to Varian Power Grid & X-Ray Tube Products, Attn: Applications Engineering, 301 Industrial Way, San Carlos, CA 94070 U.S.A.

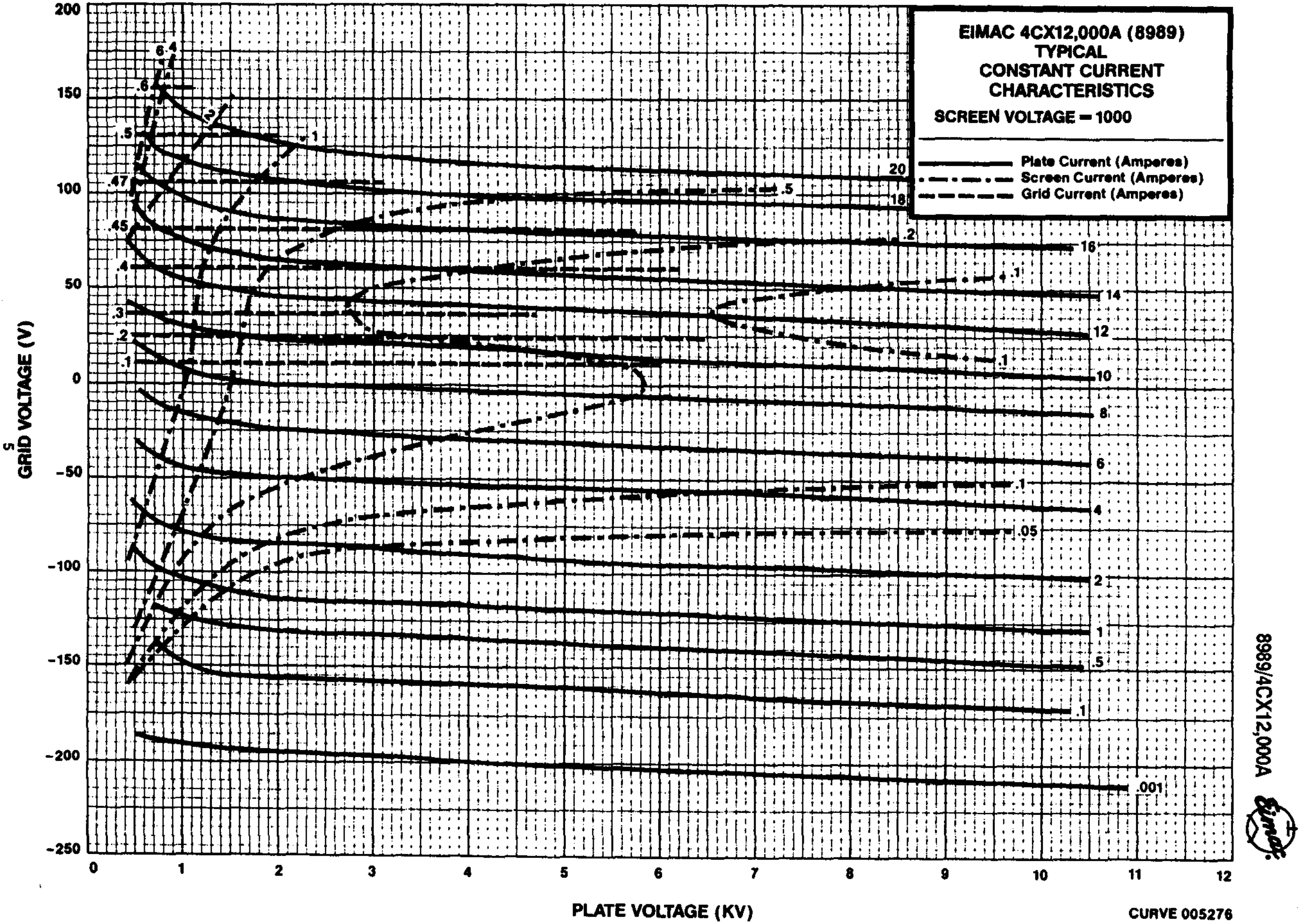
OPERATING HAZARDS

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

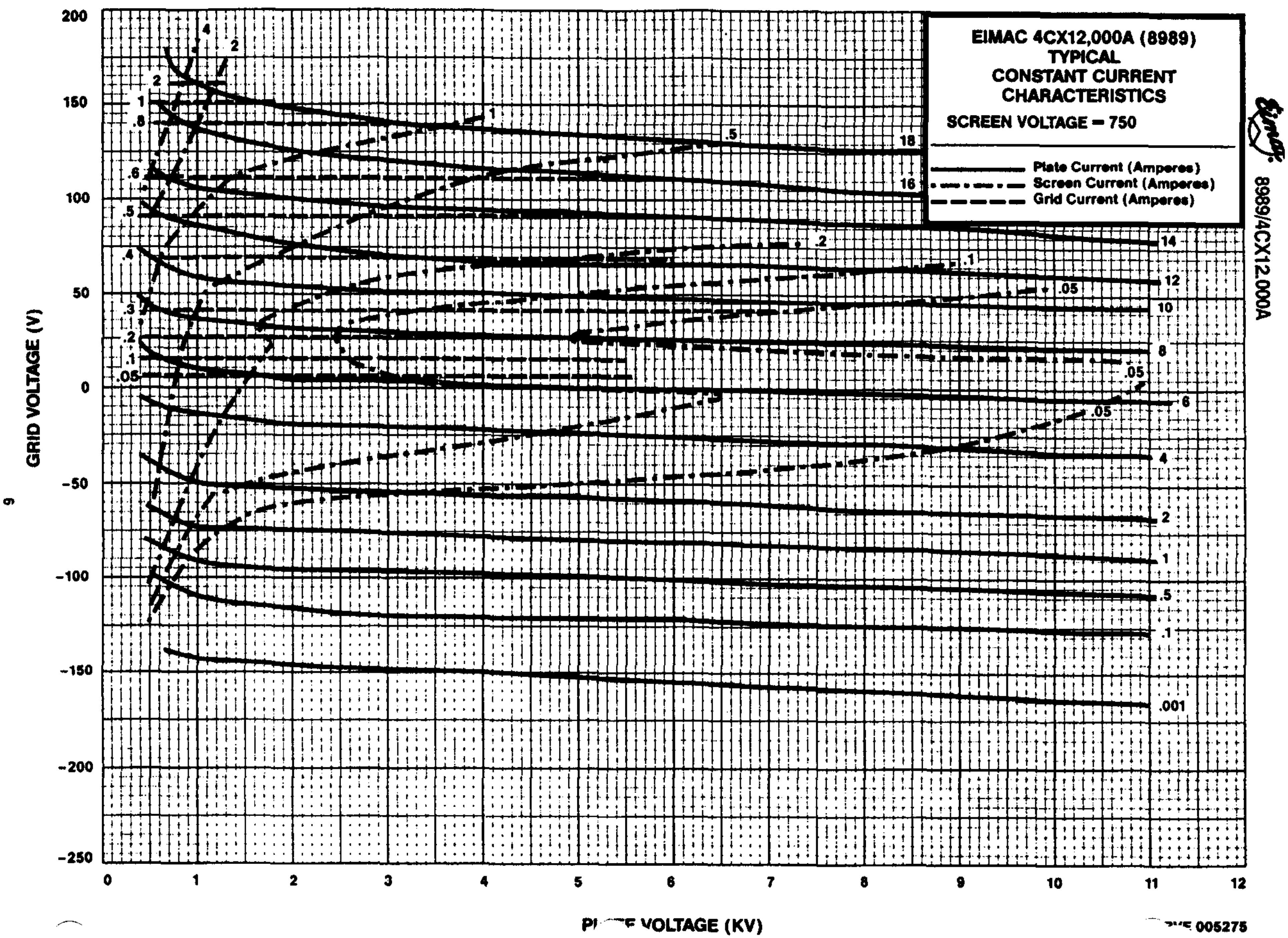
The operation of this tube may involve the following hazards, any one of which, in the absence of safe operating practices and precautions, could result in serious harm to personnel:

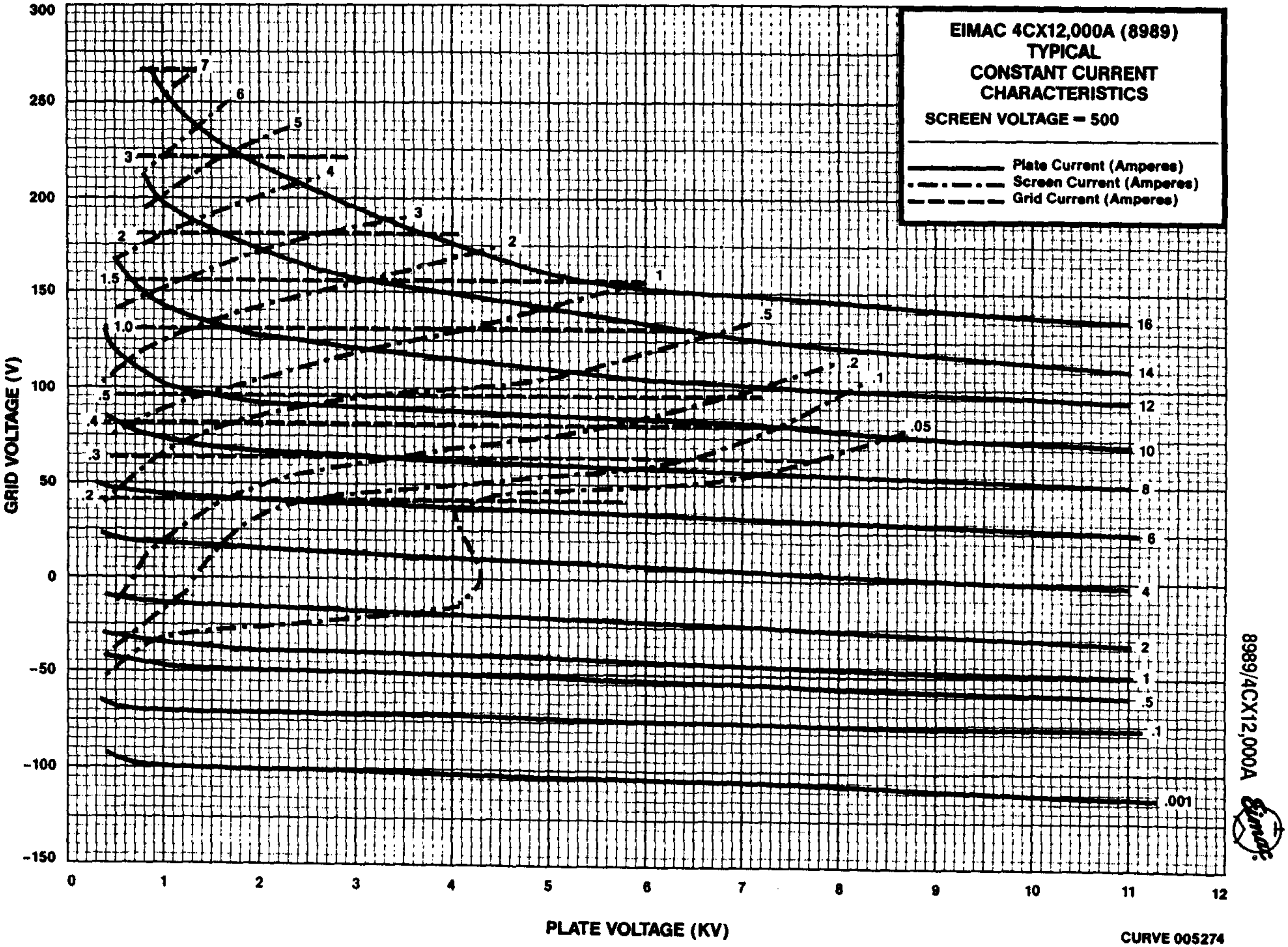
a. HIGH VOLTAGE - Normal operating voltages can be deadly. Remember that HIGH VOLTAGE CAN KILL.
b. LOW-VOLTAGE HIGH-CURRENT CIRCUITS - personal jewelry, such as rings, should not be worn when working with filament contacts or connectors as a short circuit can produce very high current and melting, resulting in severe burns.
c. RF RADIATION - Exposure to strong rf fields should be avoided, even at relatively low frequencies. The dangers of rf radiation are more severe at UHF and microwave frequencies and can cause serious bodily and eye injuries. CARDIAC PACEMAKERS MAY BE AFFECTED.
d. HOT SURFACES - Surfaces of tubes can reach temperatures of several hundred °C and cause serious burns if touched for several minutes after all power is removed.

Please review the detailed operating hazards sheet enclosed with each tube, or request a copy from: Varian Power Grid & X-Ray Tube Products, Power Grid Application Engineering, 301 Industrial Way, San Carlos, CA 94070.



EIMAC 4CX12,000A (8989)
TYPICAL
CONSTANT CURRENT
CHARACTERISTICS
SCREEN VOLTAGE = 1000
Plate Current (Amperes)
Screen Current (Amperes)
Grid Current (Amperes)
GRID VOLTAGE (V)
PLATE VOLTAGE (KV)
CURVE 005276
8989/4CX12,000A

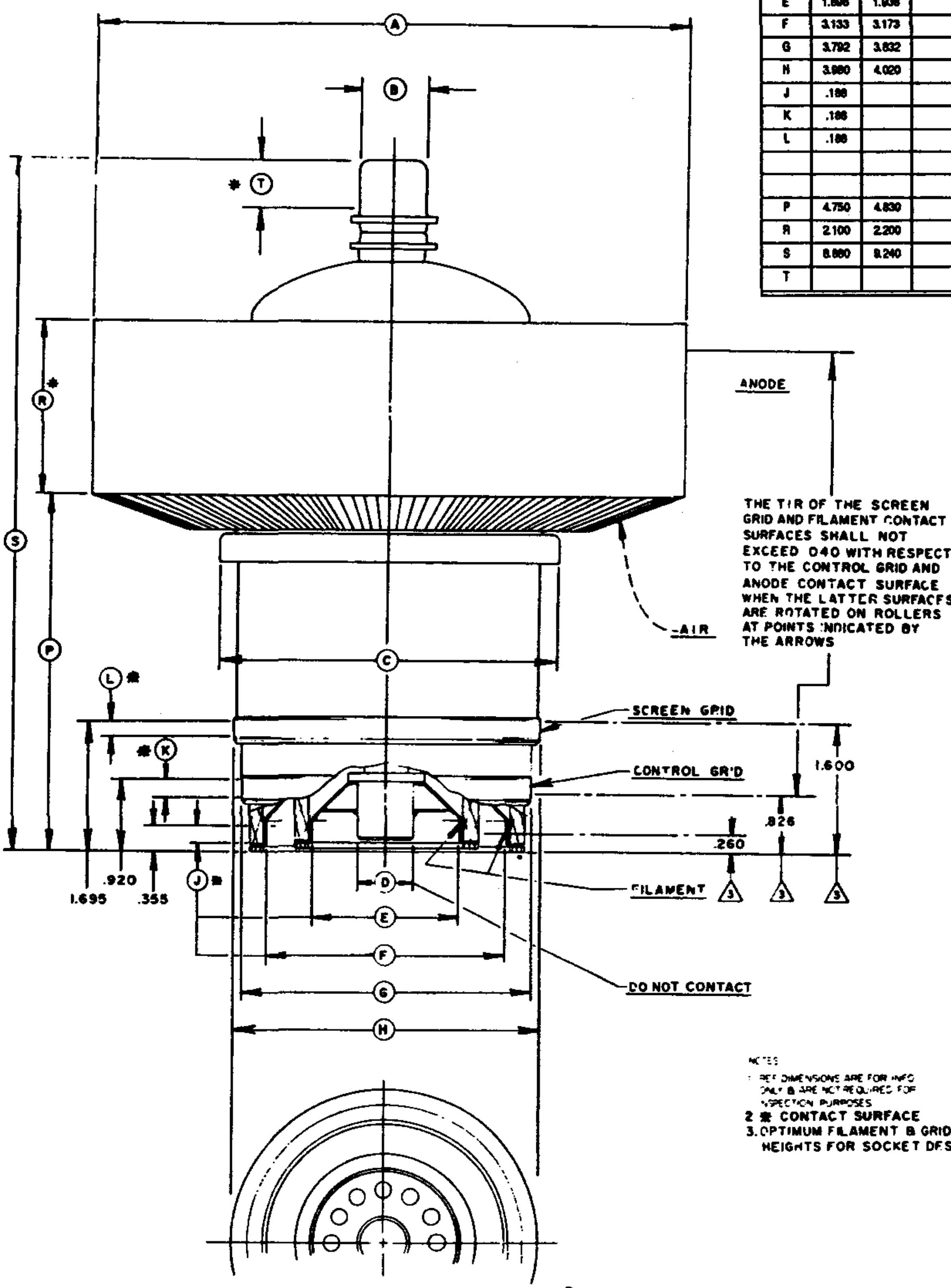

EIMAC 4CX12,000A (8989)
TYPICAL
CONSTANT CURRENT
CHARACTERISTICS
SCREEN VOLTAGE = 750
Plate Current (Amperes)
Screen Current (Amperes)
Grid Current (Amperes)
GRID VOLTAGE (V)
PLATE VOLTAGE (KV)
8989/4CX12,000A
005275



CURVE 005274

8989/4CX12,000A

DIMENSIONAL DATA						
DIM.	INCHES			MILLIMETERS		
	MIN.	MAX.	REF.	MIN.	MAX.	REF.
A	7.700	7.760		195.58	197.10	
B	.855	.895		21.72	22.73	
C	4.300	4.362		109.22	110.79	
D	.600	.760		15.24	19.30	
E	1.896	1.936		48.16	49.17	
F	3.133	3.173		79.58	80.59	
G	3.792	3.832		96.32	97.33	
H	3.980	4.020		101.09	102.11	
J	.188			4.78		
K	.188			4.78		
L	.188			4.78		
P	4.750	4.830		120.65	122.68	
R	2.100	2.200		53.34	55.88	
S	8.880	9.240		225.55	234.69	
T				12.70		



NOTES
1. REF DIMENSIONS ARE FOR INFO ONLY & ARE NOT REQUIRED FOR INSPECTION PURPOSES
2. ✱ CONTACT SURFACE
3. OPTIMUM FILAMENT & GRID CONNECTOR HEIGHTS FOR SOCKET DESIGN PURPOSES

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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EIMAC Application Bulletin AB-18
Revised March, 1990

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.

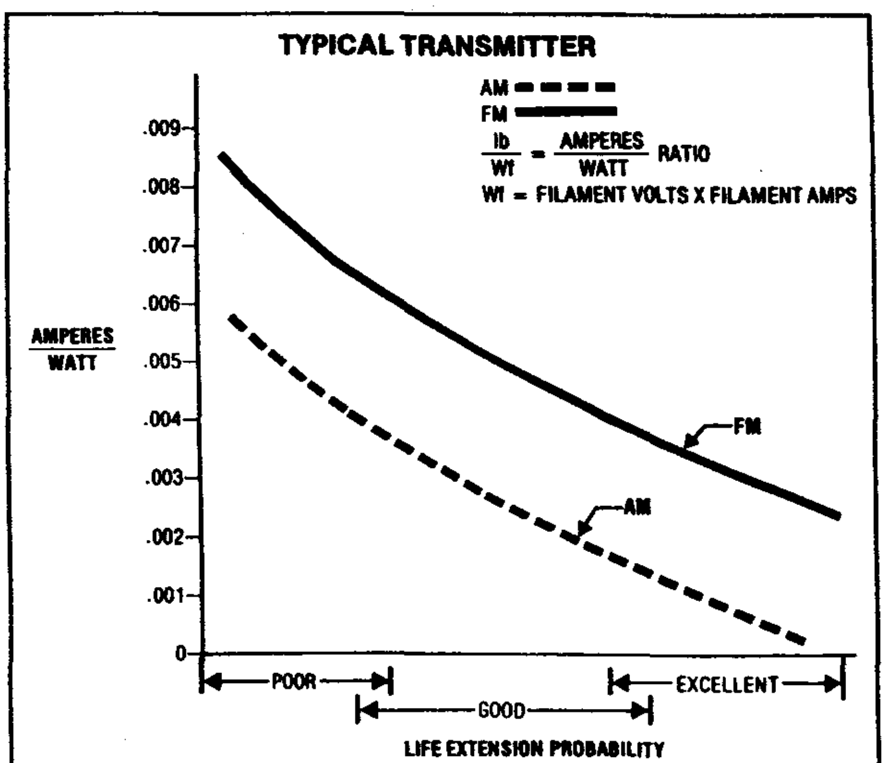
In addition, the following controls are necessary if an effective filament voltage management program is to be undertaken: power output metering for an FM transmitter or a distortion level meter for AM equipment; *accurate* filament voltage metering (an iron-vane instrument is preferred over the more 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

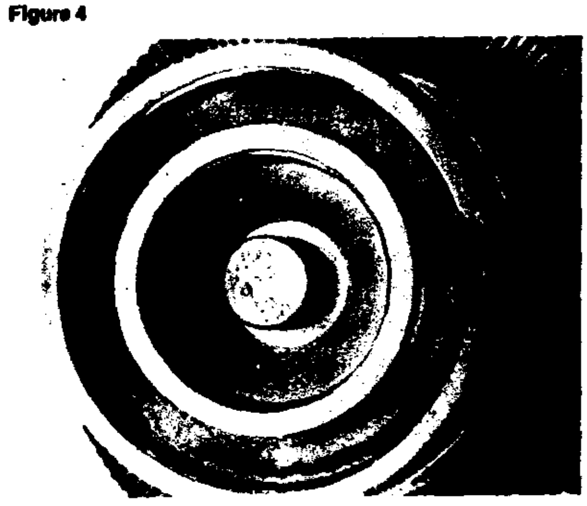


Figure 5

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 additional 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.

Extending Transmitter Tube Life

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.

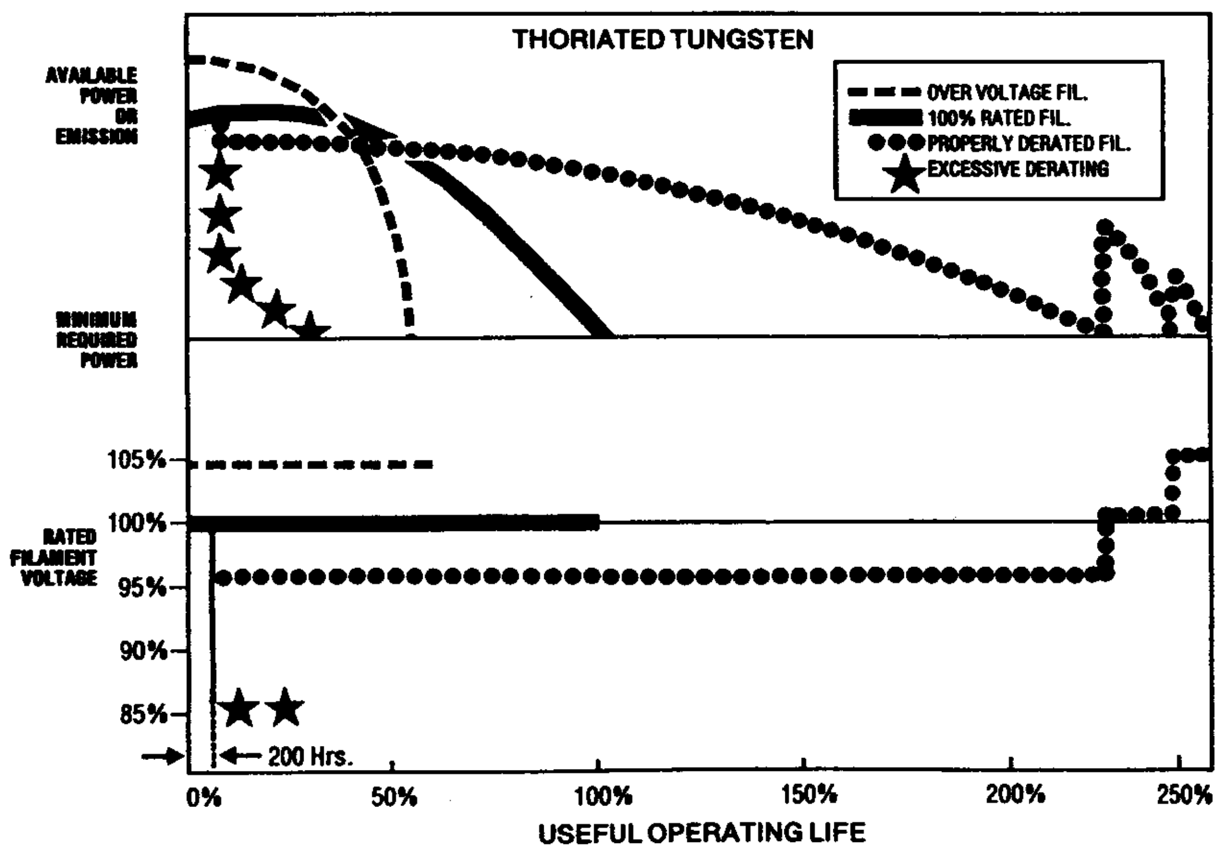
As the tube is used the filament slowly decarburizes. At some point in life, all of the di-tungsten carbide layer is depleted and the reduction of thoria to free thorium stops. The filament is now decarburized and is no longer an effective electron emitter.

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 manufacturer.

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.

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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*
- *Boitier céramique hermétique* → *haute fiabilité*
- *Résistances ballast d'émetteur* → *bonne tenue au ROS*
- *Structure auto-alignée* → *bonne reproductibilité des caractéristiques*

APPLICATIONS

Télécommunications dans la bande de fréquences jusqu'à 108MHz

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

Case / *Boitier* : 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-boitier)*	@ P_D = 100W , T = 25°C	$R_{th(j-c)}$	0,75	°C/W

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THOMSON-CSF
COMPOSANTS

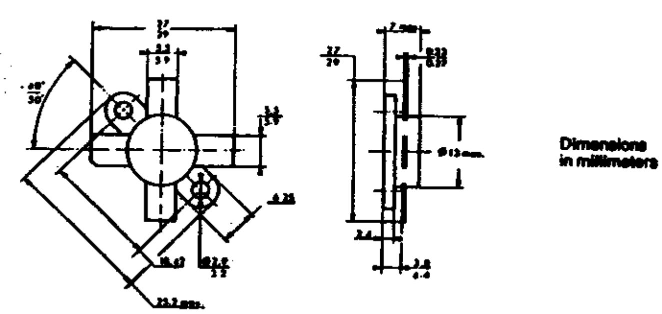
STATIC CHARACTERISTICS at t_{amb} = 25°C
CARACTERISTIQUES STATIQUES à t_{amb} = 25°C

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

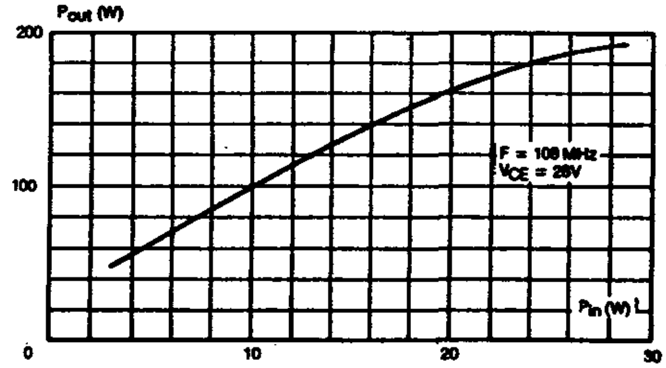
DYNAMIC CHARACTERISTICS at t_{amb} = 25°C
CARACTERISTIQUES DYNAMIQUES à t_{amb} = 25°C

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



CB-290
(.500 4LFL)



Output power versus input power (typical values)

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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–20B IPA modules. For purposes of definition, the text is divided into functional circuits.

1–3. GENERAL DESCRIPTION.

1–4. The FM–20B IPA modules are totally self–contained solid–state wideband FM amplifiers providing a continuously variable output from 75 to 250 watts. The units are mounted on slide rails for ease of maintenance.

1–5. Each 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 module 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 from 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.

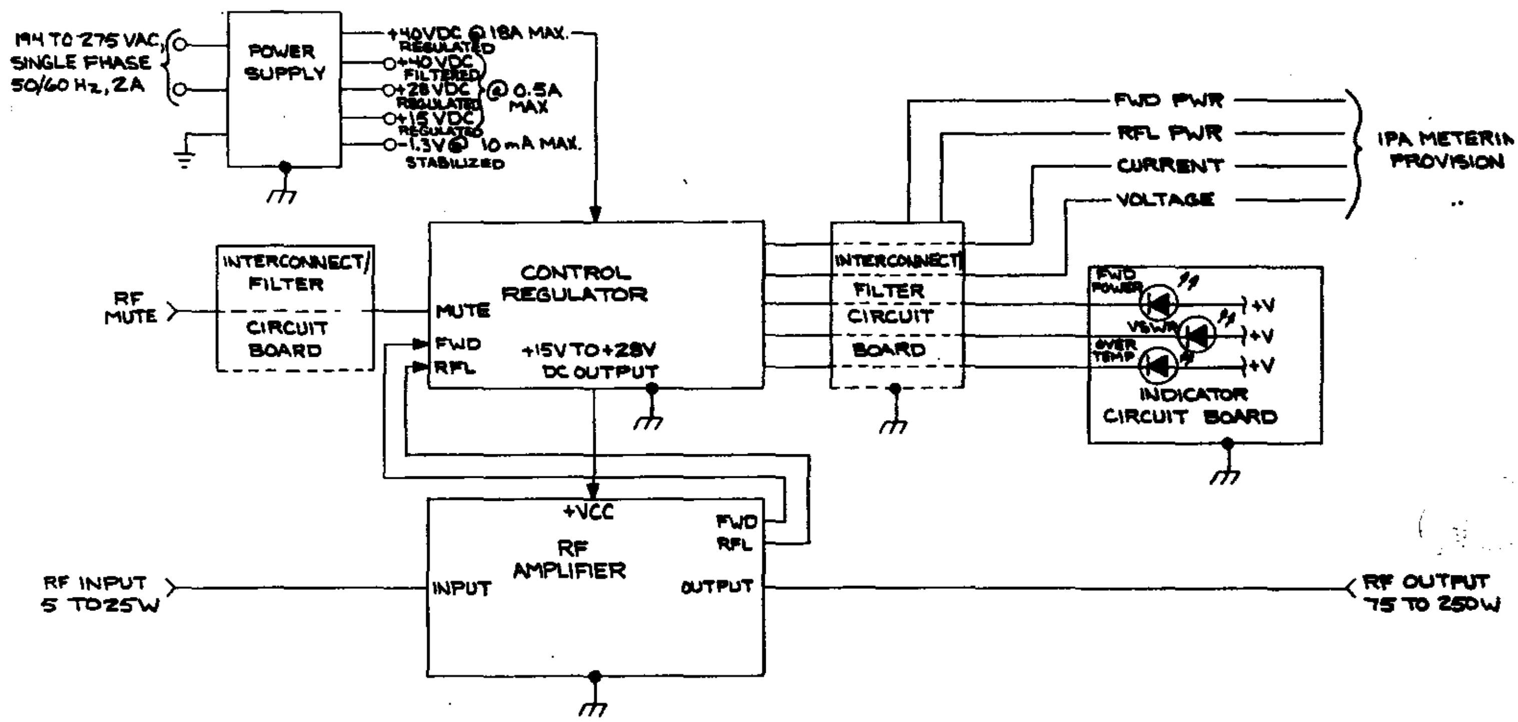

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FIGURE 1-1. IPA BLOCK DIAGRAM

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 amplifier operation is indicated by illumination of the green front–panel **FWD POWER** indicator (approximately 75 Watts of forward power). A high reflected power condition 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 module 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 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 ad– just 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.

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 fold–back 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 8 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 disconnected in the FM–20B, as RF muting is controlled in the FM exciter.

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 pre–determined 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 RF amplifier assembly through plugs to aid in maintenance.

1–48. **POWER AMPLIFIER.** Approximately 35 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–20B IPA modules.

2–3. **SAFETY CONSIDERATIONS.**

2–4. The FM–20B transmitter contains 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 ***WARNING*** — ***NEVER OPEN THE EQUIPMENT UNLESS ALL TRANSMITTER PRIMARY POWER IS DISCONNECTED.***

WARNING ***WARNING*** ***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.***

2–6. The FM–20B maintenance philosophy consists of preventative maintenance such as cleaning applied to the equipment to prevent future failures and second level maintenance consisting of procedures required to restore the equipment to operation after a fault.

2–7. **ADJUSTMENTS.**

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

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 output voltage adjust 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).

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

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

2–12. Disconnect primary power.

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

2–14. Operate the **HIGH VOLTAGE, SCREEN,** and **FILAMENT** circuit breakers to OFF. Operate the **CONTROL** and **BLOWER** circuit breakers to ON.

2–15. Energize the transmitter primary ac power 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

2–16. Using the insulated adjustment tool, adjust V OUT control R17 to obtain a voltmeter indication of +28.0 volts dc.

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

2–17. Disconnect primary ac power.

2–18. Remove the test equipment and operate the **HIGH VOLTAGE, SCREEN,** and **FILAMENT** circuit breakers to ON.

2–19. **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.

2–20. **Required Equipment.** The following equipment is required to adjust the **FWD** calibration control.

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

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

C. Digital voltmeter (Fluke model 75 or equivalent).

D. 300 watt, non–inductive, 50 Ohm test load and connecting cable.

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

2–21. **Procedure.** To adjust the control, proceed as follows:

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

WARNING

2–22. Disconnect primary power.

2–23. Disconnect and label the coaxial cable from the exciter **RF OUTPUT** receptacle.

2–24. Disconnect and label the cables from the **IPA INPUT** receptacle and the RF amplifier output receptacle.

2–25. Connect a test cable from the exciter **RF OUTPUT** receptacle to the **IPA INPUT** receptacle.

2–26. Connect the non–inductive test load to the RF amplifier output receptacle through the in–line wattmeter. Adjust the wattmeter to measure forward power.

2–27. Connect the voltmeter between J9–17 on the IPA interconnect filter circuit board and chassis ground.

2–28. Operate the **HIGH VOLTAGE, SCREEN,** and **FILAMENT** circuit breakers to OFF. Operate the **CONTROL** and **BLOWER** circuit breakers to ON.

2–29. Energize the transmitter primary ac power and depress the **FILAMENT ON** and **HIGH VOLTAGE ON** switch/indicators.

2–30. Depress the exciter **FWD** switch and record the RF output power ____________.

2–31. Using the exciter **RF 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 ANY COMPONENTS WITHIN THE IPA WHEN POWER IS ENERGIZED.***

WARNING

WARNING ***USE AN INSULATED TOOL FOR ADJUSTMENT.***

WARNING

2–32. Using the insulated adjustment tool, adjust **FWD** calibration control R18 on the control regulator circuit board to obtain a voltmeter indication of +5 volts dc.

2–33. Readjust the exciter RF output power to the level recorded in the preceding text.

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

2–34. Disconnect primary ac power.

2–35. Remove all test equipment and reconnect the cables to the exciter **RF OUTPUT, IPA INPUT**, and **IPA RF** amplifier output receptacles. Operate the **HIGH VOLTAGE, SCREEN**, and **FILAMENT** circuit breakers to ON.

2–36. **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.

2–37. **Required Equipment.** The following equipment is required to adjust the **RFL** calibration control.

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

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

C. Digital voltmeter (Fluke model 75 or equivalent).

D. Two 150 watt, non–inductive, 50 Ohm test loads and connecting cables.

E. BNC Tee (Pomona 3285).

F. Calibrated in–line wattmeter and connecting cable (Bird 43 or equivalent with 100 watt element).

2–38. **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 PERFORMING THE FOLLOWING PROCEDURE (SEE REFLECTED POWER NULL).***
NOTE	

2–39. Disconnect primary power.

2–40. Disconnect and label the coaxial cable from the exciter **RF OUTPUT** receptacle.

2–41. Disconnect and label the cable from the IPA INPUT and receptacle.

2–42. Connect a test cable from the exciter **RF OUTPUT** receptacle to the **IPA INPUT** receptacle.

2–43. Disconnect the cable from the IPA RF amplifier output receptacle and connect the BNC tee to the receptacle.

2–44. 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.

2–45. Connect the voltmeter between J9–20 on the IPA interconnect filter circuit board and chassis ground.

2–46. Operate the **HIGH VOLTAGE, SCREEN,** and **FILAMENT** circuit breakers to OFF. Operate the **CONTROL** and **BLOWER** circuit breakers to ON.

2–47. Energize the transmitter primary ac power and depress the **FILAMENT ON** and **HIGH VOLTAGE ON** switch/indicators.

2–48. Depress the exciter **FWD** switch and record the RF output power ____________ .

2–49. 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

2–50. 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.

2–51. Readjust the exciter RF output power to the level recorded in the preceding text.

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

WARNING

2–52. Disconnect primary ac power.

2–53. Remove all test equipment and reconnect the cables to the exciter **RF OUTPUT, IPA INPUT,** and the **IPA RF** amplifier output receptacle. Operate the **HIGH VOLTAGE, SCREEN,** and **FILAMENT** circuit breakers to ON.

2–54. **TEMP CALIBRATION.** This adjustment is required only if temperature sensor U1 is replaced. To adjust **TEMP** calibrate control R30 on the control regulator circuit board, proceed as follows.

2–55. **Required Equipment.** The following equipment is required to adjust **TEMP** calibrate 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.

2–56. **Procedure.** To adjust the control, proceed as follows:

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

WARNING

2–57. Disconnect primary power.

2–58. Attach the temperature probe to the control regulator heatsink assembly near U1.

2–59. Connect the probe to the voltmeter. Record the temperature indication, add +273, and divide by 100 $\left(\frac{°C + 273}{100} = \text{VOLTAGE}\right)$.

2–60. Connect the voltmeter between TP1 and chassis ground on the control regulator circuit board.

2–61. Operate the **HIGH VOLTAGE, SCREEN,** and **FILAMENT** circuit breakers to OFF. Operate the **CONTROL** and **BLOWER** circuit breakers to ON.

2–62. Energize the transmitter primary ac power 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

2–63. Using the insulated adjustment tool, adjust **TEMP** calibrate control R30 to obtain an indication equal to the value calculated in the preceding text.

EXAMPLE: $\frac{25°C + 273}{100} = \frac{298}{100} = 2.98$ volts

2–64. Disconnect primary ac power.

2–65. Remove the test equipment and operate the **HIGH VOLTAGE, SCREEN,** and **FILAMENT** circuit breakers to ON.

2–66. **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.

2–67. **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).

2–68. **Procedure.** To adjust the control, proceed as follows:

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

WARNING

2–69. Disconnect primary ac power.

2–70. Connect the voltmeter between pin 7 of U7 and chassis ground.

2–71. Operate the **HIGH VOLTAGE, SCREEN,** and **FILAMENT** circuit breakers to OFF. Operate the **CONTROL** and **BLOWER** circuit breakers to ON.

2–72. Energize the transmitter primary ac power 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

2–73. 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

2–74. Disconnect primary ac power.

2–75. Remove the test equipment and operate the **HIGH VOLTAGE, SCREEN,** and **FILAMENT** circuit breakers to ON.

2–76. **CURRENT CAL** control R76 must now be adjusted. Refer to the following text.

2–77. **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

2–78. **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).

2–79. **Procedure.** To adjust the control, proceed as follows:

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

WARNING

2–80. Disconnect primary ac power.

2–81. Unplug P4–1 and P4–2 from J4–1 and J4–2.

2–82. Temporarily connect the 5 Ohm, 160 Watt resistor from J4–1 to J4–2.

2–83. Connect the voltmeter between pin 7 of U7 and chassis ground on the control regulator circuit board.

2–84. Operate the HIGH VOLTAGE, SCREEN, and FILAMENT circuit breakers to OFF. Operate the CONTROL and BLOWER circuit breakers to ON.

2–85. Energize the transmitter primary ac power 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

2–86. 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

2–87. Disconnect primary ac power.

2–88. Remove the test equipment and reconnect P4–1 and P4–2 to J4–1 and J4–2, and operate the HIGH VOLTAGE, SCREEN, and FILAMENT circuit breakers to ON.

2–89. **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.

2–90. **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).

2–91. **Procedure.** To adjust the control, proceed as follows:

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

WARNING

2–92. Disconnect primary ac power.

2–93. Disconnect and label the coaxial cable from the exciter **RF OUTPUT** receptacle.

2–94. Disconnect and label the cables from the **IPA INPUT** and **OUTPUT** receptacles.

2–95. Connect a coaxial test cable from the exciter **RF OUTPUT** receptacle to the **IPA INPUT** receptacle.

2–96. Connect the non–inductive test load to the **IPA OUTPUT** connector through the in–line wattmeter. Adjust the wattmeter to indicate forward power.

2–97. Carefully prop the RF amplifier module in the cooling air path with reflected power null control R7 accessible through the hole provided in the module cover.

2–98. Connect the voltmeter between pin 7 of U4B on the control regulator circuit board and chassis ground.

2–99. Operate the **HIGH VOLTAGE, SCREEN,** and **FILAMENT** circuit breakers to OFF. Operate the **CONTROL** and **BLOWER** circuit breakers to ON.

2–100. Energize the transmitter primary ac power and depress the **FILAMENT ON** and **HIGH VOLTAGE ON** switch/indicators.

2–101. Depress the exciter front–panel **FWD** switch and record the exciter RF power output ____________ .

2–102. 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: DISCONNECT POWER PRIOR TO SERVICING

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

2–103. Using the insulated adjustment tool, adjust reflected power null control R7 to obtain a minimum voltmeter indication.

2–104. Readjust the exciter RF power output to the level recorded in the preceding text.

WARNING *DISCONNECT ALL TRANSMITTER PRIMARY POWER BEFORE PROCEEDING.*

WARNING

2–105. Disconnect primary ac power.

2–106. Remove the test equipment and reconnect the cables to the exciter **RF OUTPUT, IPA INPUT,** and **IPA OUTPUT** receptacles. Operate the **HIGH VOLTAGE, SCREEN,** and **FILAMENT** circuit breakers to ON.

NOTE *THE FOLLOWING PROCEDURE IS PART OF THE TRANSMITTER FREQUENCY CHANGE PROCEDURE. DO NOT PERFORM THE PROCEDURE UNLESS THE TRANSMITTER OPERATING FREQUENCY IS CHANGED.*

NOTE

2–107. **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.

2–108. **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.

2–109. **Procedure.** To tune the IPA RF amplifier, proceed as follows:

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

WARNING

2–110. Disconnect all transmitter primary power before proceeding.

2–111. Disconnect and label the coaxial cable from the exciter **RF OUTPUT** receptacle.

2–112. Disconnect and label the cables from the **IPA INPUT** and **OUTPUT** receptacles.

2–113. Connect a coaxial test cable from the exciter **RF OUTPUT** receptacle to the **IPA INPUT** receptacle.

2–114. Connect the test load to the **IPA OUTPUT** receptacle through the in–line wattmeter. Adjust the wattmeter to indicate forward power.

2–115. Connect the spectrum analyzer to the in–line wattmeter RF sample output.

2–116. 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.

2–117. Operate the **SCREEN, FILAMENT,** and **HIGH VOLTAGE** circuit breakers to OFF. Operate the **CONTROL** and **BLOWER** circuit breakers to ON.

2–118. Energize the transmitter primary ac power and depress the **FILAMENT ON** and **HIGH VOLTAGE ON** switch/indicators.

2–119. 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 **DRIVER** circuit breaker to OFF.

WARNING ***THE RF AMPLIFIER OPERATES AT HIGH TEMPERATURES. DO NOT TOUCH ANY COMPONENTS ON THE RF AMPLIFIER.***

WARNING

C. Adjust capacitor C28.

D. Operate the **DRIVER** 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.

2–120. 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

2–121. Disconnect all transmitter primary power before proceeding.

2–122. Disconnect all test equipment, replace the RF amplifier cover and reconnect the cables to the exciter **RF OUTPUT, IPA INPUT,** and **IPA OUTPUT** receptacles. Operate the **HIGH VOLTAGE, SCREEN,** and **FILAMENT** circuit breakers to ON.

2–123. 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 MAINTENANCE ON ANY AREA WITHIN THE TRANSMITTER.***
WARNING

2–124. 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.

2–125. If difficulties are encountered and the IPA is suspected as faulty, the first step in troubleshooting should determine whether the exciter, IPA 1, IPA 2, or the load is at fault. A high VSWR condition or an over–heating condition within one of the IPA modules will cause the control regulator to limit RF output to prevent damage to the IPA module. 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.

2–126. 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 circuit 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

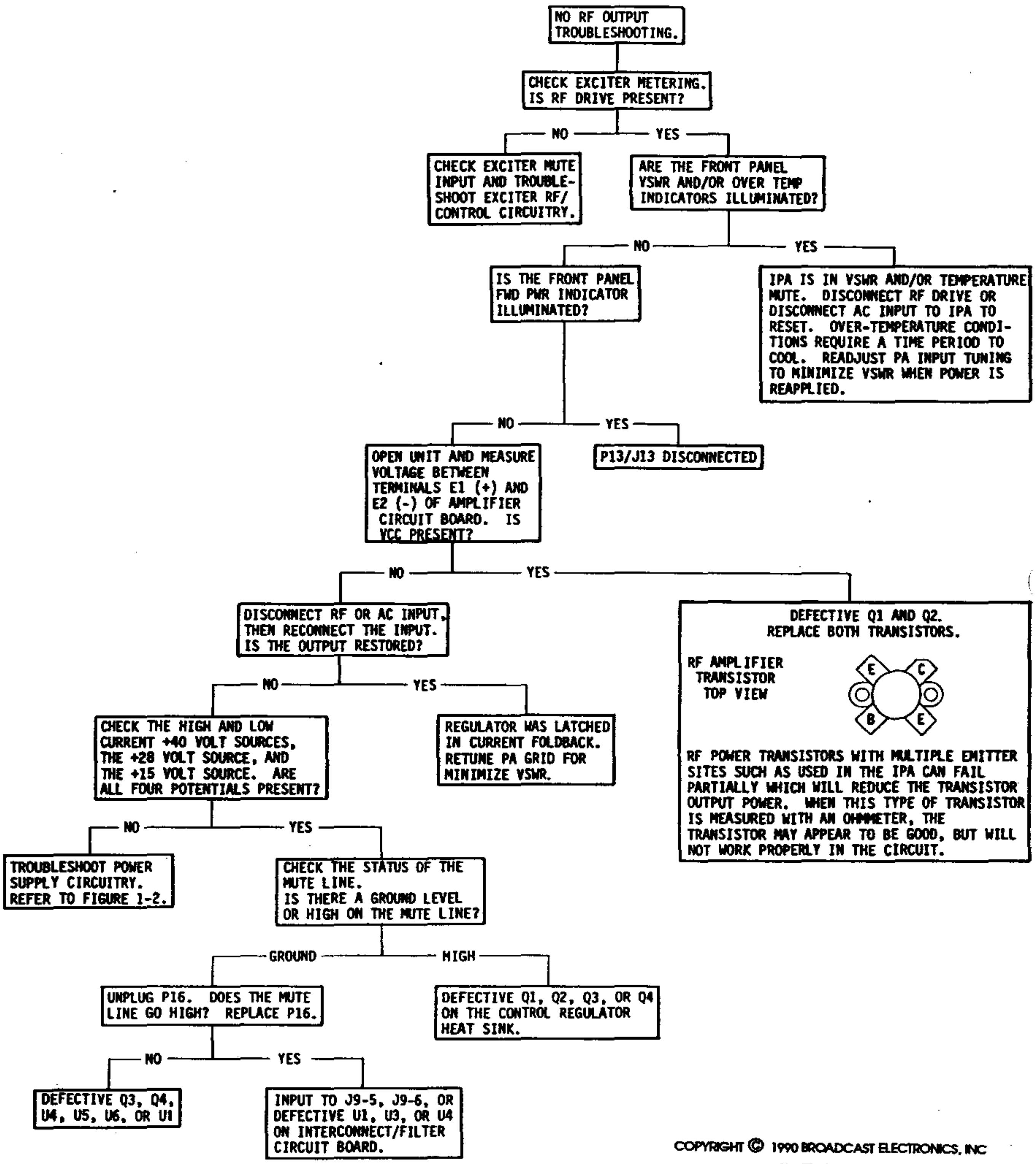
WARNING

WARNING

2–127. Characteristically, the type of RF transistors used in the IPA modules 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 amplifier assembly diagrams in SECTION III 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.

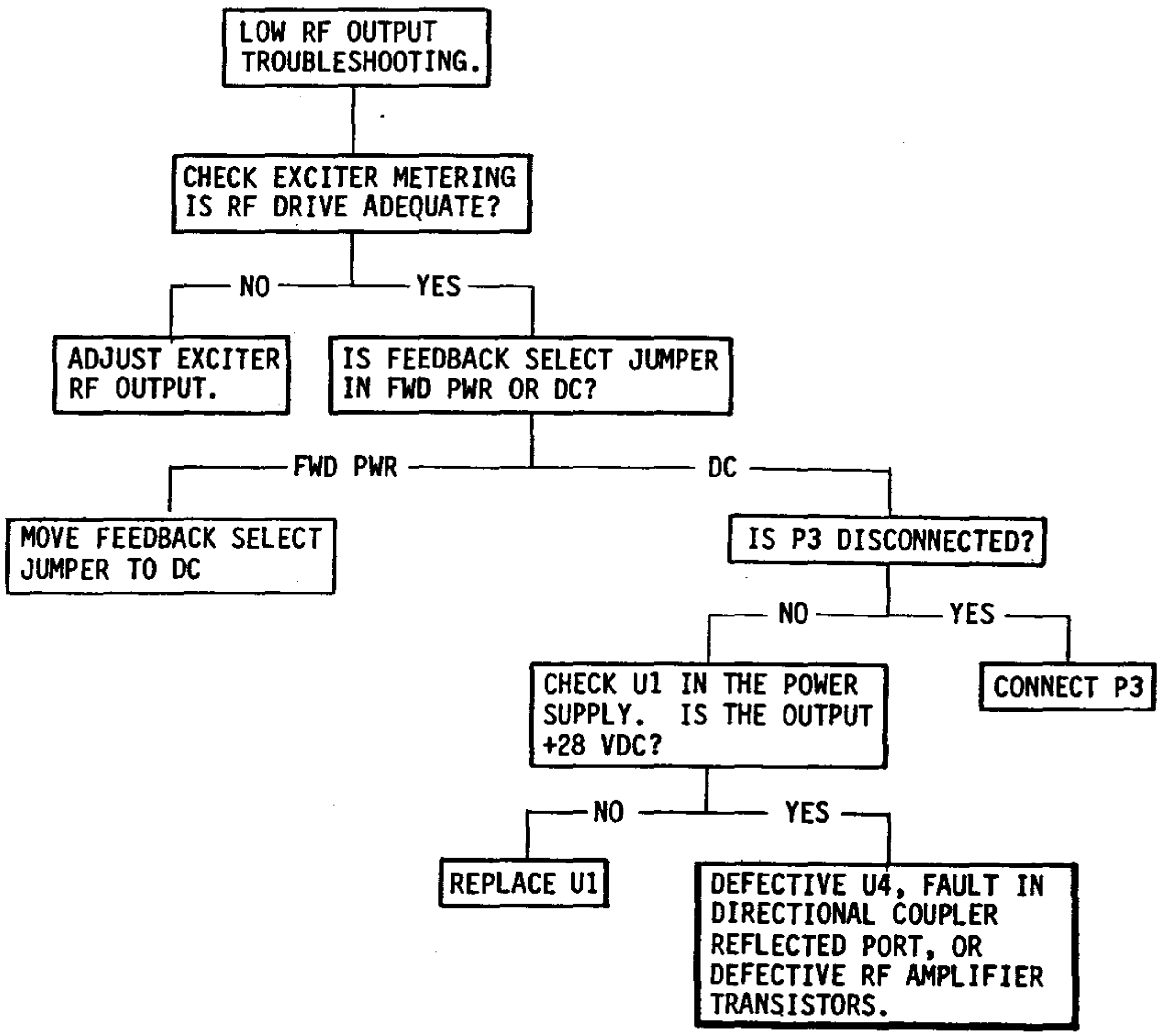
2–128. Once the trouble is isolated and power is totally deenergized, it is suggested that the exact problem be located with resistance checks using the schematic diagrams and theory of operation presented throughout the text. Figures 2–1 and 2–2 provide IPA troubleshooting information and should be referenced as required.

2–129. 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–20B Transmitter IPA module.

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	597–0220–20
3–8	SCHEMATIC, RF AMPLIFIER OVERALL	SC919–0065
3–9	ASSEMBLY, RF AMPLIFIER CIRCUIT BOARD	AD959–0132–001
3–10	ASSEMBLY, IPA RESISTOR NETWORK	AA959–1000–001

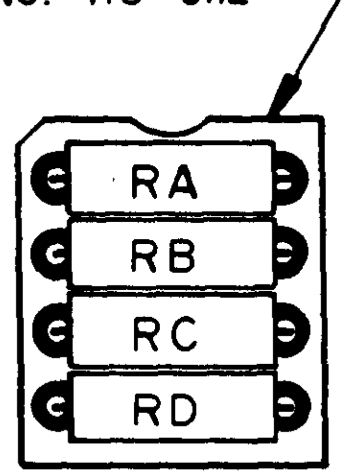
A

REF	ZONE	REF	ZONE	REF	ZONE	REF	ZONE
C1	A2	D16	B1	R19	B2	R55	B3
C2	A3	D17	B1	R20	B1	R56	B3
C3	A2	D18	A2	R21	A1	R57	B3
C4	A2	D19	B3	R22	B1	R58	B3
C5	A2	F1	A3	R23	B1	R59	A3
C6	B2	J3	B2	R24	A1	R60	A3
C7	A2	J4	B3	R25	B1	R61	B1
C8	A1	J5	A1	R26	B1	R62	A3
C9	B1	J16	B1	R27	B2	R63	B1
C10	A2	J17	B1	R28	B2	R64	B1
C11	A1	J18	A1	R29	B2	R65	B3
C12	A1	P16	B1	R30	B2	R66	B3
C13	B2	P17	B1	R31	B1	R67	B3
C14	A2	P18	A1	R32	B3	R68	B1
C15	B3	Q1	B2	R33	B3	R69	B1
C16	A3	Q2	B2	R34	B1	R70	B1
C17	B2	Q3	A2	R35	B3	R71	B1
C18	B3	Q4	A2	R36	B2	R72	B1
C19	B1	R1	B2	R37	B3	R73	A1
C20	B3	R2	B2	R38	B2	R74	B1
C21	B2	R3	B2	R39	B2	R75	B1
D1	B2	R4	B2	R40	A1	R76	B1
D2	B2	R5	B2	R41	A1	R77	B1
D3	B2	R6	B2	R42	B3	TP1	A3
D4	B2	R7	B2	R43	A1	TP2	B2-B3
D5	B1	R8	B2	R44	B2	U1	A2
D6	B1	R9	B2	R45	B3	U2	A2-A3
D7	B2	R10	A1	R46	B2	U3	A1
D8	B2	R11	B2	R47	B2	U4	B2
D9	A1	R12	B1	R48	B3	U5	A1
D10	B2	R13	A1	R49	B3	U6	B3
D11	A1	R14	B2	R50	B3	U7	B1
D12	B2	R15	B1	R51	A2		
D13	B3	R16	B1	R52	A2		
D14	B2	R17	B1	R53	B3		
D15	B2	R18	B2	R54	B3		

597-0220-20

FIGURE 3-7. CONTROL REGULATOR CIRCUIT BOARD COMPONENT LOCATOR

B.E. PART NO. 418-0112



USED ON:
IPA 919-0042 PCB ON FM5A
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

DRAWN BY MERKEL | DATE 2-22-83
CHECKED BY | DATE
PROJECT ENGR. | DATE
APPROVED BY

TREATMENT OR FINISH

BROADCAST ELECTRONICS INC.

TITLE ASSEMBLY RESISTOR NETWORK

A | DWG. NO. 959-1000-001 | REV. B

IPA - FM5A | SCALE 4/1 | SHEET 1 OF 1

SECTION IV
IPA 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-20B IPA module. 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.
B1	Fan, 115V, 50/60 Hz, 18W, 120 ft^3/min, 3100 r/min, 4.5 inch (11.43 cm)	380-4600	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
——	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
——	Transformer and Bracket Assembly	959-0195	1
——	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
——	Transformer, Power, Single Phase 50/60 Hz	376-0040	1
——	Filter, Fan, Pamotor 5502	380-5502	1
——	Blank Circuit Board, IPA Front Panel	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,C47,C48	Capacitor, Mica, 390 pF ±5%, 100V	042-3922	3
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. TRANSFORMER AND BRACKET ASSEMBLY - 959-0195

REF. DES.	DESCRIPTION	PART NO.	QTY.
T1	Transformer, Power, Single Phase, 50/60 Hz Primary: Dual 115 volt windings, one winding tapped at 90V Secondary: 33.1V @ 15 Amperes Continuous, Tapped at 30.2V	376-0040	1

TABLE 4–6. RF AMPLIFIER ASSEMBLY – 959–0132–001

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
L1 THRU L6	Ferrite Bead	360–0003	6
——	RF Amplifier Wiring Assembly	949–0040	1
——	RF Amplifier Circuit Board	919–0065	1

TABLE 4–7. 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 4–8. 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
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

TABLE 4-8. RF AMPLIFIER CIRCUIT BOARD ASSEMBLY - 919-0065
(Sheet 2 of 2)

REF. DES.	DESCRIPTION	PART NO.	QTY.
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
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 4-9. 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 4-10. 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 4-11. 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

TABLE 4-11. CONTROL REGULATOR CIRCUIT BOARD - 919-0045 (Sheet 2 of 3)

REF. DES.	DESCRIPTION	PART NO.	QTY.
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
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

TABLE 4-11. CONTROL REGULATOR CIRCUIT BOARD - 919-0045
(Sheet 3 of 3)

REF. DES.	DESCRIPTION	PART NO.	QTY.
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
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%, 1/4W	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, IPA Control Regulator	519-0045	1

TABLE 4-12. 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 4-13. RESISTOR NETWORK ASSEMBLY, IPA - 959-1000-001
(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, IPA – 959-1000-001
(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 4-14. LED CIRCUIT BOARD ASSEMBLY – 919-0041

REF. DES.	DESCRIPTION	PART NO.	QTY.
DS1	Indicator, LED, Green, 521-9175, 3V @ 40 mA Maximum (FWD Power)	323-9224	1
DS2	Indicator, LED, Yellow, 521-9176, 3V @ 30 mA Maximum (VSWR)	323-9225	1
DS3	Indicator, LED, Red, 521-9212, 2V @ 50 mA Maximum (OVER TEMP)	323-9217	1
R1	Resistor, 680 Ohm ±5%, 1/2W	110-6833	1
R2,R3	Resistor, 820 Ohm ±5%, 1/2W	110-8233	2
——	Blank Circuit Board, Front Panel LED	519-0041	1

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SECTION I
APC THEORY OF OPERATION

1–1. **INTRODUCTION.**

1–2. The following text provides theory of operation with supporting diagrams for the FM–20B 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 reduction 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 reapplied. 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.

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 the screen power transformer is controlled by a variable autotransformer which is driven by dc gearmotor B201. 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 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 supply 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 dead–band. 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 dead–band.

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–20B Automatic Power Control Unit (APC).

2–3. SAFETY CONSIDERATIONS.

2–4. The FM–20B transmitter contains 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 *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 *WARNING*

2–6. The FM–20B 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 *WARNING* ***NEVER OPEN THE EQUIPMENT UNLESS ALL TRANSMITTER PRIMARY POWER IS DISCONNECTED.***

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 (R42, R44, and R87) are presented first, followed by an adjustment procedure for R17 on 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 the OUTPUT METER CALIBRATE procedure 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, 3 1/8 inch line input, 25 kW minimum).

E. Calibrated in–line wattmeter with 3 1/8 inch sampling section and cables (Bird 4805 Thruline with 25 kW element or equivalent).

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

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

WARNING

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 ***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

2–16. Using the insulated adjustment tool, adjust FWD CAL control R42 on the main circuit board for a voltmeter indication of +5.00V dc.

NOTE ***THE TRANSMITTER OUTPUT POWER METER SHOULD INDICATE 100%. IF NOT, REFER TO THE OUTPUT METER CALIBRATE PROCEDURE BEFORE PROCEEDING.***

NOTE

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

WARNING

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

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. Operate the **MULTIMETER** switch to COMBINED FWD POWER.

2–24. Record the IPA combined forward power indication ____________.

2–25. 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

$$E = \frac{\sqrt{P \times 50\ \text{Ohms}}}{316.2}$$

EXAMPLE

Transmitter rated RF output power = 20 kW.
10% of transmitter RF output power = 2000 Watts (P).

$$E = \frac{\sqrt{2000 \times 50}}{316.2} \qquad E = \frac{\sqrt{100000}}{316.2}$$

$$E = \frac{316.2}{316.2} \qquad E = 1.00\ \text{VRMS}$$

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

2–26. Disconnect primary power.

2–27. Connect the voltmeter between U18B, pin 7 and chassis ground.

2–28. Disconnect cables 304 and 305 from the directional coupler FWD and RFL ports and route cable 304 out the top of the transmitter.

2–29. Assemble the RF millivoltmeter probe, 50 Ohm termination, and the BNC plug–to–plug adapter.

2–30. Connect the RF millivoltmeter to the directional coupler FWD port.

2–31. Adjust the exciter **RF OUTPUT ADJ.** control fully counterclockwise.

2–32. Apply power and operate the transmitter in the local manual mode (REMOTE DISABLE illuminated, APC ON extinguished).

2–33. Operate the **MULTIMETER** switch to SCREEN VOLTAGE.

2–34. Depress and hold the **APC RAISE** switch to obtain a screen voltage indication of 200 volts.

2–35. Adjust the exciter **RF OUTPUT ADJ** control to obtain a millivoltmeter indication equal to the voltage (E) calculated in the preceding text.

	WARNING ***WARNING***	***ENSURE THE TRANSMITTER HIGH VOLTAGE IS OFF BEFORE PROCEEDING.***

2–36. Depress the **HIGH VOLTAGE OFF** switch.

2–37. Disconnect the millivoltmeter from the directional coupler FWD port. Connect cable 305 to the directional coupler FWD port.

2–38. Depress the **HIGH VOLTAGE ON** switch.

2–39. Apply power and operate the transmitter in the local manual mode (REMOTE DISABLE illuminated, APC ON out).

	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.***

2–40. Using the insulated adjustment tool, adjust **RFL CAL** control R44 on the main circuit board for a voltmeter indication of +5.00V dc.

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

WARNING

2–41. Disconnect primary power.

2–42. Reconnect cable 304 from APC FWD PWR RF SAMPLE input J9 to the FWD directional coupler port, and reconnect cable 305 from APC RFL PWR RF SAMPLE input J10 to the RFL directional coupler port.

2–43. Apply power to the transmitter.

2–44. Operate the **APC ON** switch/indicator to extinguish the switch/indicator and operate the **HIGH VOLTAGE ON** switch/indicator to illuminate the switch/indicator.

2–45. Operate the **MULTIMETER** switch to COMBINED FWD POWER.

2–46. Adjust the exciter **RF OUTPUT ADJ** control to obtain the IPA combined forward power value recorded in the preceding text.

2–47. Operate the **APC ON** switch/indicator to illuminate the switch/indicator.

2–48. **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.

2–49. **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).

2–50. **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

2–51. Apply power and operate the transmitter in the local automatic mode (REMOTE DISABLE and APC ON illuminated).

2–52. Operate the **OUTPUT POWER METER** switch to FWD.

2–53. Depress the **PRESET POWER** switch/indicator.

2–54. 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.

2–55. **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.

2–56. If required, check and adjust **FWD CAL** control R42 before calibrating R17 (refer to paragraph 2–9).

2–57. **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, 3 1/8 inch line input, 25 kW minimum).

E. Calibrated in–line wattmeter with 3 1/8 inch sampling section and cables (Bird 4805 Thruline with 25 kW element or equivalent).

2–58. **Procedure.** To adjust the control, proceed as follows:

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

2–59. Disconnect primary power.

2–60. Connect the voltmeter between U18A, pin 1 and chassis ground.

2–61. Connect the test load and wattmeter to the transmitter output.

2–62. Apply power and operate the transmitter in the local manual mode (REMOTE DISABLE illuminate, APC ON extinguished) 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

2–63. Using the insulated adjustment tool, adjust **FWD CAL** control R42 on the main circuit board for a voltmeter indication of +5.00V dc.

2–64. Operate the **OUTPUT POWER METER** switch to FWD.

2–65. 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 ***DISCONNECT ALL TRANSMITTER PRIMARY POWER BEFORE PROCEEDING.***

WARNING

2–66. Disconnect primary power.

2–67. Remove the test equipment and reconnect the transmitter output to the antenna load.

2–68. **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:

2–69. **Required Equipment.** The following equipment is required to reset the APC reference voltage.

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

2–70. **Procedure.** To reset the APC reference voltage, proceed as follows:

2–71. 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).

2–72. Slide the APC unit out of the transmitter cabinet and remove the top–cover.

2–73. 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%.

2–74. Replace the APC unit battery, replace the APC unit top–panel, and re–connect the APC unit line cord.

2–75. 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.

2–76. 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 MAINTENANCE ON ANY AREA WITHIN THE TRANSMITTER.***

WARNING

2–77. Most troubleshooting consists of visual checks. Because of the high voltages and 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.

2–78. 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.

2–79. 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–20B Transmitter Automatic Power Control Unit.

A

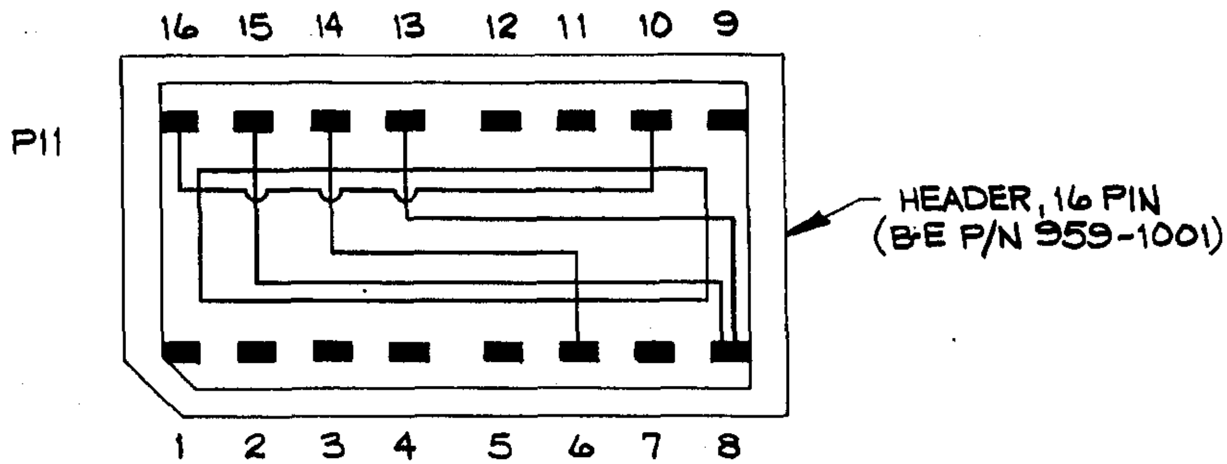
REF	ZONE	REF	ZONE	REF	ZONE	REF	ZONE	REF	ZONE	REF	ZONE
BT1	C4	C39	B1	Q8	B1	R39	B1	R78	A4	U1	B2-B3
C1	B3	D1	A4	R1	B3	R40	A2	R79	A4	U2	A4
C2	B2	D2	C3	R2	B3	R41	A1	R80	A1	U3	B2-B3
C3	A4	D3	C3	R3	B3	R42	A1-A2	R81	A1	U4	C2
C4	C3	D4	A3	R4	B3	R43	A2	R82	B1	U5	C3
C5	C3	D5	A3	R5	B3	R44	A1	R83	B1	U6	C3
C6	C3	D6	C4	R6	B3	R45	A1	R84	A4	U7	A2-A3
C7	C2	D7	C4	R7	B3	R46	B2	R85	--	U8	C3
C8	A3	D8	C4	R8	B3	R47	C1	R86	C1	U9	C2-C3
C9	C2	D9	C4	R9	A4	R48	--	R87	A1	U10	A3
C10	A3	D10	C4	R10	A4	R49	A1	R88	--	U11	B2
C11	A3	D11	C4	R11	B3	R50	--	R89	B1	U12	A2-A3
C12	C1	D12	B4	R12	B3	R51	B2	R90	B1	U13	C2
C13	A2	D13	B4	R13	B3	R52	C1	R91	C1	U14	A3
C14	A1	D14	B4	R14	B3	R53	A1	R92	C2	U15	C3
C15	A3	D15	B4	R15	B3	R54	A1	R93	C2	U16	C1
C16	--	D16	C3	R16	B3	R55	B1	R94	B1	U17	C2-C3
C17	A1	D17	B1	R17	C3	R56	B2	R95	--	U18	A1
C18	C1	D18	B2	R18	C3	R57	A4	R96	A1	U19	B2
C19	B2	D19	B3	R19	C3	R58	C4	R97	--	U20	A2
C20	A1	DS1	B2	R20	C3	R59	C4	R98	--	U21	C1
C21	B1	DS2	B2	R21	C3	R60	C4	R99	B1	U22	A4
C22	C1	DS3	B2	R22	B2	R61	B4	R100	B1	U23	C4
C23	A4	DS4	B2	R23	C3	R62	C3	R101	B1	U24	B4
C24	C4	DS5	B2	R24	C3	R63	C4	R102	C1	U25	B4
C25	B4	J4	A3-B3	R25	C4	R64	B4	R103	B1	U26	A4
C26	B4	J5	A2	R26	C3	R65	C4	R104	B2	U27	A1-A2
C27	A4	J11	C1-C2	R27	A3	R66	B4	R105	B2	U28	A4
C28	A1	J12	C3	R28	A2	R67	C4	R106	B2	U29	B1
C29	B1	J13	C3	R29	A3	R68	B4	R107	B2	U30	C1-C2
C30	A4	J14	B2-B3	R30	C3	R69	C4	R108	B1	U31	B1
C31	C2	J15	C2	R31	A2	R70	--	R109	C4	U32	C1
C32	B1	Q1	A3	R32	B3	R71	--	R110	B3	U33	B2
C33	C1	Q2	A3	R33	C4	R72	B4	R111	C1	U34	B3
C34	C1-C2	Q3	A3	R34	C3	R73	B4	R112	C1		
C35	C1	Q4	A3	R35	A3	R74	B4	R113	B1		
C36	C2	Q5	C3	R36	--	R75	B4	R114	B2		
C37	C1	Q6	B1	R37	--	R76	A4	R115	B3		
C38	B1	Q7	B1	R38	B2	R77	A4	TP1	C1		

BROADCAST ELECTRONICS INC

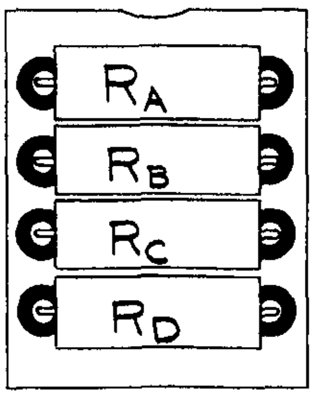
FIGURE 3-5. APC MAIN CIRCUIT BOARD COMPONENT LOCATOR

597-0032-38

A



B



HEADER, 8 PIN

RESISTOR NETWORK ASSEMBLY	RESISTOR NETWORK No.	OHMS RESISTANCE			
		R_A	R_B	R_C	R_D
959-1000-028	R82	390K	5.1K	1K	300
959-1000-008	R86	4.7K	470	4.7K	10K
959-1000-029	R89	249K	2.4K	3.9K	22K
959-1000-027	R96	UNUSED	270	100	3K

597-0220-80

FIGURE 3-10. AUTOMATIC POWER CONTROL PROGRAM NETWORKS

SECTION IV
APC 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–20B Automatic Power Control Unit. Each table entry in this section is indexed by reference designators appearing on the applicable schematic diagram.

TABLE 4-1. AUTOMATIC POWER CONTROL UNIT PARTS LIST INDEX

TABLE 4–2. AUTOMATIC POWER CONTROL ASSEMBLY – 959–0262–002

REF. DES.	DESCRIPTION	PART NO.	QTY.
BT1	Battery, 9 Volt, Alkaline	350–0002	1
DS1 THRU DS5	Lamp, No. 73, 14V, 0.08A, T–1 3/4 Bulb, Wedge Base	320–0007	5
F1,F2, SPARE	Fuse, 250V, 1/2 Ampere, AGC	330–0050	3
FL1	RFI Line Filter, 250V ac, 3 Ampere Maximum, 50/60 Hz	339–0008	1
J9,J10,J12	Receptacle, BNC, Insulated	417–0016	3
MOV 1	Metal Oxide Varistor, V250LA15A, 250V ac RMS, 15 Joules	140–0008	1
R16	Potentiometer, 10 k Ohm ±10%, 1W (VSWR CAL)	192–1053C	1
S1 THRU S5	Push Switch, Momentary, Illuminated, SPDT, 3A @ 125V ac Maximum, Gold Contacts (REMOTE DISABLE, PRESET, APC ON, LOWER and RAISE)	340–0015–001	5
S6	Rocker Switch, DPDT, 5A @ 120V ac or 28V dc Resistive Load or 2A @ 250V ac, Resistive Load (FWD/VSWR/VSWR CAL)	340–0021	1
XF1,XF2	Fuse Holder, AGC	415–2012	2
——	Turn–Lock Fastener, Stud, Rear	420–0027	1
——	Turn–Lock Fastener, Stud, Front and Sides	420–0019	5
——	Stud Retainer, Split Ring	420–0021	6
——	Receptacle, Turn–Lock Fastener	420–0022	6
T1	Power Transformer, Dual/Primary: 120V, 50/60 Hz Dual/Secondary: 25V @ 1.0 Ampere	376–7675	1
——	Rear Panel Circuit Board Jumper Assembly, Automatic Power Control Unit	959–0236	1
——	Wire Harness Assembly	949–0038	1
——	Main Circuit Board Assembly	919–0206	1
——	Front Panel Circuit Board Assembly	919–0028	1
——	Rear Panel Circuit Board Assembly	919–0207	1
——	Lens, Gray, for **LOWER** and **RAISE** Switch/Indicators	340–0022	2
——	Lens, Yellow, for **PRESET** and **REMOTE DISABLE** Switch/Indicators	340–0014	2
——	Lens, Green, for APC ON Switch/Indicator	340–0019	1
——	Pins, Connector	417–0053	4
——	Connector Housing, 6–Pin	418–0670	1

TABLE 4–3. POWER TRANSFORMER ASSEMBLY – 376–7675–001

REF. DES.	DESCRIPTION	PART NO.	QTY.
P1	Plug, 6–Pin	418–0670	1
——	Pins for P1	417–0053	6
T1	Transformer, Power Dual Primary: 120V, 50/60 Hz Dual Secondary: 25V @ 1.0 Ampere	376–7675	1

TABLE 4-4. WIRE HARNESS ASSEMBLY - 949-0038

REF. DES.	DESCRIPTION	PART NO.	QTY.
P3	Connector Housing, 25-Pin In-Line	417-0325	1
P4A	Connector Housing, 17-Pin In-Line	417-0317	1
P4B	Connector Housing, 10-Pin In-Lin	417-0148	1
P5	Connector Housing, 14-Pin In-Line	417-1401	1
P6	Connector Housing, 17-Pin In-Line	417-0317	1
P7	Connector Housing, 4-Pin In-Line	417-0138	1
——	Pins, Receptacle (For Connectors P3, P4, P5, P6, and P7)	417-0053	2
——	Key, Plug	417-0232	1
——	Pins, Crimp, MTE	417-8729	57
——	Pins, Crimp, MOD-IV	417-8766	22

TABLE 4-5. MAIN CIRCUIT BOARD ASSEMBLY - 919-0206
(Sheet 1 of 4)

REF. DES.	DESCRIPTION	PART NO.	QTY.
C1	Capacitor, Electrolytic, 2.2 uF, 25V	013-2064	1
C2 THRU C10	Capacitor, Mylar, 0.1 uF, 100V	030-1053	9
C11	Capacitor, Electrolytic, 100 uF, 25V	023-1084	1
C12	Capacitor, Mylar, 0.1 uF, 100V	030-1053	1
C13,C14	Capacitor, Mica, 390 pF ±5%, 100V	042-3922	2
C15	Capacitor, Electrolytic, 4.7 uF, 35V	024-4753	1
C17,C18	Capacitor, Poly Film, 0.0022 uF ±10%, 100V	031-2033	2
C19	Capacitor, Mica, 390 pF ±5%, 100V	042-3922	1
C20 THRU C22	Capacitor, Mylar, 0.1 uF, 100V	030-1053	3
C23	Capacitor, Electrolytic, 100 uF, 25V	023-1084	1
C24 THRU C32	Capacitor, Mylar, 0.1 uF, 100V	030-1053	9
C33,C34	Capacitor, Electrolytic, 47 uF, 35V	024-4753	2
C35	Capacitor, Mica, 390 pF ±5%, 100V	042-3922	1
C36	Capacitor, Electrolytic, 4.7 uF, 35V	024-4753	1
C37,C38	Capacitor, Mylar, 0.1 uF, 100V	030-1053	2
C39	Capacitor, Electrolytic, 10 uF, 35V	023-1076	1
D1 THRU D3	Diode, 1N4148, Silicon, 75V, 0.3 Ampere	203-4148	3
D4,D5	Diode, 1N4005, Silicon, 600V, 1 Ampere	203-4005	2
D6 THRU D16	Diode, 1N4148, Silicon, 75V, 0.3 Ampere	203-4148	11
D17	Diode, 1N4733A, Zener, 5.1V, 1W	200-4733	1
D18	Diode, 1N4148, Silicon, 75V, 0.3 Ampere	203-4148	1
D19	Diode, 1N4005, Silicon, 600V, 1 Ampere	203-4005	1
DS1	Indicator, LED, Green, 521-9175, 3V @ 40 mA Maximum	323-9224	1
DS2 THRU DS5	Indicator, LED, Red, 521-9212, 2V @ 50 mA Maximum	323-9217	4
J4	Receptacle, Header, 20-Pin	417-0200	1.3
J5	Receptacle, Header, 20-Pin	417-0200	.70
J11	Socket, 16-Pin DIP	417-1604	1
J12 THRU J15	Receptacle, Header, 3-Pin	417-0003	4
P12 THRU P15	Jumper, Programmable	340-0004	4
Q1	Transistor, MPS-U45, Silicon, NPN, Darlington	210-0045	1
Q2	Transistor, MPS-U95, Silicon, PNP, Darlington	210-0095	1
Q3	Transistor, MPS-U45, Silicon, NPN, Darlington	210-0045	1
Q4	Transistor, MPS-U95, Silicon, PNP, Darlington	210-0095	1
Q5	Transistor, MPS-A14, Silicon, NPN, Darlington, TO-92 Case	211-0014	1

TABLE 4-5. MAIN CIRCUIT BOARD ASSEMBLY – 919–0206
(Sheet 2 of 4)

REF. DES.	DESCRIPTION	PART NO.	QTY.
Q6 THRU Q8	Transistor, 2N3906, Silicon, PNP, TO–92 Case	210–3906	3
R1	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	1
R2	Resistor, 1 Meg Ohm ±5%, 1/4W	100–1073	1
R3 THRU R9	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	7
R10	Resistor, 47 k Ohm ±5%, 1/4W	100–4753	1
R11 THRU R19	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	9
R20,R21	Resistor, 47 k Ohm ±5%, 1/4W	100–4753	2
R22	Resistor, 1.2 k Ohm ±5%, 1/4W	100–1243	1
R23 THRU R25	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	3
R26	Resistor, 100 k Ohm ±5%, 1/4W	100–1063	1
R27 THRU R30	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	4
R31,R32	Resistor, 100 k Ohm ±5%, 1/4W	100–1063	2
R33,R34	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	2
R35	Resistor, 150 k Ohm ±5%, 1/4W	100–1563	1
R38	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	1
R39	Resistor, 1.5 k Ohm ±5%, 1/4W	100–1543	1
R40	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	1
R41	Resistor, 910 Ohm ±5%, 1/4W	100–9133	1
R42	Potentiometer, 50 k Ohm ±10%, 1/2W (FWD CAL)	177–5050	1
R43	Resistor, 22 k Ohm ±5%, 1/4W	100–2253	1
R44	Potentiometer, 100 k Ohm ±10%, 1/2W (RFL CAL)	179–1065	1
R45	Resistor, 910 Ohm ±5%, 1/4W	100–9133	1
R46,R47,R49	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	3
R51	Resistor, 10 Meg Ohm ±5%, 1/4W	100–1083	1
R52	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	1
R53	Resistor, 10 Ohm ±5%, 1/4W	100–1023	1
R54	Resistor, 10 k Ohm ±5%, 1/4W	100–1053	1
R55	Resistor, 10 Ohm ±5%, 1/4W	100–1023	1
R56	Resistor, 10 Meg Ohm ±5%, 1/4W	100–1083	1
R57	Resistor, 1 k Ohm ±5%, 1/4W	100–1043	1
R58	Resistor, 1 Meg Ohm ±5%, 1/4W	100–1073	1
R59	Resistor, 2.2 Meg Ohm ±5%, 1/4W	100–2273	1
R60,R61	Resistor, 100 k Ohm ±5%, 1/4W	100–1063	2
R62	Resistor, 470 k Ohm ±5%, 1/4W	100–4763	1
R63 THRU R68	Resistor, 100 k Ohm ±5%, 1/4W	100–1063	6
R69	Resistor, 1 Meg Ohm ±5%, 1/4W	100–1073	1
R72	Resistor, 1.3 Meg Ohm ±5%, 1/4W	100–1373	1
R73	Resistor, 634 k Ohm ±1%, 1/4W	103–6346	1
R74	Resistor, 324 k Ohm ±1%, 1/4W	103–3246	1
R75	Resistor, 162 k Ohm ±1%, 1/4W	103–1626	1
R76	Resistor, 80.6 k Ohm ±1%, 1/4W	103–8065	1
R77	Resistor, 40.2 k Ohm ±1%, 1/4W	103–4025	1
R78	Resistor, 20 k Ohm ±1%, 1/4W	103–2051	1
R79	Resistor, 10 k Ohm ±1%, 1/4W	100–1051	1

TABLE 4-5. MAIN CIRCUIT BOARD ASSEMBLY - 919-0206
(Sheet 3 of 4)

REF. DES.	DESCRIPTION	PART NO.	QTY.
R80	Resistor, 10 Ohm ±5%, 1/4W	100-1023	1
R81	Resistor, 390 k Ohm ±5%, 1/4W	100-3963	1
R83	Resistor, 5.1 k Ohm ±5%, 1/4W	100-5143	1
R84	Resistor, 10 Ohm ±5%, 1/4W	100-1023	1
R87	Potentiometer, 5 k Ohm ±10%, 1/2W (PRESET CAL)	177-5044	1
R90	Resistor, 10 Ohm ±5%, 1/4W	100-1023	1
R91	Resistor, 10 k Ohm ±1%, 1/4W	100-1051	1
R92	Resistor, 115 Ohm ±1%, 1/4W	100-1131	1
R93	Resistor, 1 k Ohm ±1%, 1/4W	103-1041	1
R94	Resistor, 5.1 k Ohm ±5%, 1/4W	100-5143	1
R99	Resistor, 10 Ohm ±5%, 1/4W	100-1023	1
R100,R101	Resistor, 390 k Ohm ±5%, 1/4W	100-3963	2
R102	Resistor, 10 Ohm ±5%, 1/4W	100-1023	1
R103	Resistor, 5.1 k Ohm ±5%, 1/4W	100-5143	1
R104 THRU R107	Resistor, 1.2 k Ohm ±5%, 1/4W	100-1243	4
R108	Resistor, 5.1 k Ohm ±5%, 1/4W	100-5143	1
R109,R110	Resistor, 10 k Ohm ±5%, 1/4W	100-1053	2
R111	Resistor, 1 k Ohm ±5%, 1/4W	100-1043	1
R112	Resistor, 100 k Ohm ±5%, 1/4W	100-1063	1
R113	Resistor, 10 k Ohm ±5%, 1/4W	100-1053	1
R114	Resistor, 47 k Ohm ±5%, 1/4W	100-4753	1
R115	Resistor, 100 Ohm ±5%, 1/4W	100-1033	1
U1	Integrated Circuit, CD4050BCN, Hex Non-Inverting Buffer, 16-Pin DIP	228-4050	1
U2	Integrated Circuit, 4N33, Infrared LED, Photo Darlington, 6-Pin DIP	229-0033	1
U3,U4	Integrated Circuit, CD4027BE, Dual J-K Flip-Flop, 16-Pin DIP	225-0003	2
U5,U6	Integrated Circuit, 4N33, Infrared LED, Photo Darlington, 6-Pin DIP	229-0033	2
U7	Integrated Circuit, MC14001B, Quad 2-Input NOR Gate, 14-Pin DIP	228-4001	1
U8	Integrated Circuit, MC14002B, Dual 4-Input NOR Gate, 14-Pin DIP	228-4002	1
U9	Integrated Circuit, MC14584, Hex Schmitt Trigger Inverter, CMOS, 14-Pin DIP	228-4584	1
U10	Integrated Circuit, MC14001B, Quad 2-Input NOR Gate, 14-Pin DIP	228-4001	1
U11	Integrated Circuit, MC1416, Seven Darlington Peripheral Drivers, 16-Pin DIP	226-2004	1
U12	Integrated Circuit, MC14011B, Quad 2-Input NAND Gate, 14-Pin DIP	228-4011	1
U13	Integrated Circuit, CD4066BE, Quad Bilateral Switch, 14-Pin DIP	225-0004	1
U14	Integrated Circuit, CD4019AE, Quad AND/OR Select Gate, 16-Pin DIP	228-4019	1
U15	Integrated Circuit, MC1416, Seven Darlington Peripheral Drivers, 16-Pin DIP	226-2004	1
U16	Integrated Circuit, 4047B, Monostable/Astable Multivibrator, CMOS, 14-Pin DIP	220-4047	1
U17	Integrated Circuit, MC14011B, Quad 2-Input NAND Gate, 14-Pin DIP	228-4011	1
U18,U19	Integrated Circuit, LM358N, Low Power, Dual Operational Amplifier, 8-Pin DIP	221-0358	2

TABLE 4-5. MAIN CIRCUIT BOARD ASSEMBLY - 919-0206
(Sheet 4 of 4)

REF. DES.	DESCRIPTION	PART NO.	QTY.
U20	Integrated Circuit, MC14584, Hex Schmitt Trigger Inverter, CMOS, 14-Pin DIP	228-4584	1
U21	Integrated Circuit, 14 Stage Counter, CMOS, 16-Pin DIP	228-4020	1
U22	Integrated Circuit, CD4012, Dual 4-Input NAND Gate, 14-Pin DIP	228-4012	1
U23,U24	Integrated Circuit, MC14516B, Binary Up/Down Counter, CMOS, 16-Pin DIP	228-4516	2
U25,U26	Integrated Circuit, CD4050BC, Hex Non-Inverting Buffer, 16-Pin DIP	228-4050	2
U27 THRU U29	Integrated Circuit, LM358, Low Power Dual Operational Amplifier, 8-Pin DIP	221-0358	3
U30	Integrated Circuit, LM317T, Positive 3-Terminal Adjustable Voltage Regulator, 1.2V-37V, 1.5A Maximum, TO-220 Case	227-0317	1
U31,U32	Integrated Circuit, LM358, Low Power Dual Operational Amplifier, 8-Pin DIP	221-0358	2
U33	Integrated Circuit, MC14002B, Dual 4-Input NOR Gate, 14-Pin DIP	228-4002	1
U34	Integrated Circuit, MC14001B, Quad 2-Input NOR Gate, 14-Pin DIP	228-4001	1
XR82,XR86, XR89,XR96	Socket, 8-Pin DIP	417-0088	4
XU1	Socket, 16-Pin DIP	417-1604	1
XU2	Socket, 6-Pin DIP	417-0600	1
XU3,XU4	Socket, 16-Pin DIP	417-1604	2
XU5,XU6	Socket, 6-Pin DIP	417-0600	2
XU7 THRU XU10	Socket, 14-Pin DIP	417-1404	4
XU11	Socket, 16-Pin DIP	417-1604	1
XU12,XU13	Socket, 14-Pin DIP	417-1404	2
XU14,XU15	Socket, 16-Pin DIP	417-1604	2
XU16,XU17	Socket, 14-Pin DIP	417-1404	2
XU18,XU19	Socket, 8-Pin DIP	417-0804	2
XU20	Socket, 14-Pin DIP	417-1404	1
XU21	Socket, 16-Pin DIP	417-1604	1
XU22	Socket, 14-Pin DIP	417-1404	1
XU23 THRU XU26	Socket, 16-Pin DIP	417-1604	4
XU27 THRU XU29,XU31, XU32	Socket, 8-Pin DIP	417-0804	5
XU33,XU34	Socket, 14-Pin DIP	417-1404	2
——	Holder, Battery	415-0002	1
——	Blank Circuit Board, Automatic Power Control Main	519-0206	1

TABLE 4-6. FRONT PANEL CIRCUIT BOARD ASSEMBLY - 919-0028

REF. DES.	DESCRIPTION	PART NO.	QTY.
D1,D2	Diode, 1N4005, Silicon, 600V, 1 Ampere	203-4005	2
J6	Receptacle, Header, 20-Pin In-Line	417-0200	.8
J7	Receptacle, Header, 20-Pin In-Line	417-0200	.2
R1	Resistor, 23.2 k Ohm ±1%, 1/4W	103-2325	1
R2	Resistor, 4.75 k Ohm ±1%, 1/4W	103-4741	1
R3	Resistor, 5.11 k Ohm ±1%, 1/4W	103-5141	1
R4	Resistor, 9.31 k Ohm ±1%, 1/4W	103-9314	1
R5	Resistor, 3.65 k Ohm ±1%, 1/4W	103-3641	1
R6	Resistor, 39 Ohm ±5%, 1/4W	100-3923	1
R7	Resistor, 1.8 k Ohm ±5%, 1/4W	100-1843	1
R8	Resistor, 39 Ohm ±5%, 1/4W	100-3923	1
R9	Resistor, 1.8 k Ohm ±5%, 1/4W	100-1843	1
R10	Resistor, 39 Ohm ±5%, 1/4W	100-3923	1
R11	Resistor, 1.8 k Ohm ±5%, 1/4W	100-1843	1
R12	Resistor, 39 Ohm ±5%, 1/4W	100-3923	1
R13	Resistor, 1.8 k Ohm ±5%, 1/4W	100-1843	1
R14	Resistor, 39 Ohm ±5%, 1/4W	100-3923	1
R15	Resistor, 1.8 k Ohm ±5%, 1/4W	100-1843	1
R17	Potentiometer, 5 k Ohm ±10%, 1/2W	178-5043	1
——	Blank Circuit Board	519-0028	1

TABLE 4-7. REAR PANEL CIRCUIT BOARD ASSEMBLY - 919-0207 (Sheet 1 of 2)

REF. DES.	DESCRIPTION	PART NO.	QTY.
C1 THRU C5, C7 THRU C13, C15,C17 THRU C21,C23 THRU C33	Capacitor, Mica, 390 pF ±5%, 100V	042-3922	29
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

TABLE 4-7. REAR PANEL CIRCUIT BOARD ASSEMBLY - 919-0207
(Sheet 2 of 2)

REF. DES.	DESCRIPTION	PART NO.	QTY.
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, Automatic Power Control Rear Panel	519-0207	1

TABLE 4-8. ASSEMBLY, AUTOMATIC POWER CONTROL UNIT JUMPER NETWORK - 959-1001

REF. DES.	DESCRIPTION	PART NO.	QTY.
P11	Plug, Header, 16-Pin DIP	418-0030	1

TABLE 4-9. REAR-PANEL CIRCUIT BOARD JUMPER ASSEMBLY, AUTOMATIC POWER CONTROL UNIT - 959-0236

REF. DES.	DESCRIPTION	PART NO.	QTY.
P11	Connector Housing, 14-Pin In-Line	417-1401	1
——	Pins, Receptacle (for Connector P11)	417-8766	8

TABLE 4-10. ASSEMBLY, AUTOMATIC POWER CONTROL UNIT RESISTOR NETWORK - 959-1000-028

REF. DES.	DESCRIPTION	PART NO.	QTY.
R82A	Resistor, 390 k Ohm ±5%, 1/4W	100-3963	1
R82B	Resistor, 5.1 k Ohm ±5%, 1/4W	100-5143	1
R82C	Resistor, 1 k Ohm ±5%, 1/4W	100-1043	1
R82D	Resistor, 300 Ohm ±5%, 1/4W	100-3033	1
——	Plug, Header, 8-Pin DIP	418-0112	1

TABLE 4-11. ASSEMBLY, AUTOMATIC POWER CONTROL UNIT RESISTOR NETWORK - 959-1000-008

REF. DES.	DESCRIPTION	PART NO.	QTY.
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
——	Plug, Header, 8-Pin DIP	418-0112	1

TABLE 4-12. ASSEMBLY, AUTOMATIC POWER CONTROL UNIT RESISTOR NETWORK - 959-1000-029

REF. DES.	DESCRIPTION	PART NO.	QTY.
R89A	Resistor, 249 k Ohm ±1%, 1/4W	103-2496	1
R89B	Resistor, 2.4 k Ohm ±5%, 1/4W	100-2443	1
R89C	Resistor, 3.9 k Ohm ±5%, 1/4W	100-3943	1
R89D	Resistor, 22 k Ohm ±5%, 1/4W	100-2253	1
——	Plug, Header, 8-Pin DIP	418-0112	1

TABLE 4-13. ASSEMBLY, AUTOMATIC POWER CONTROL UNIT RESISTOR NETWORK - 959-1000-027

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 k Ohm ±5%, 1/4W	100-3043	1
——	Plug, Header, 8-Pin DIP	418-0112	1

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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–20B 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–20B 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–20B transmitter. 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 bar–graph format. This system may be factory installed or field retrofitted to an existing 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.

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.

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 shut–down 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.

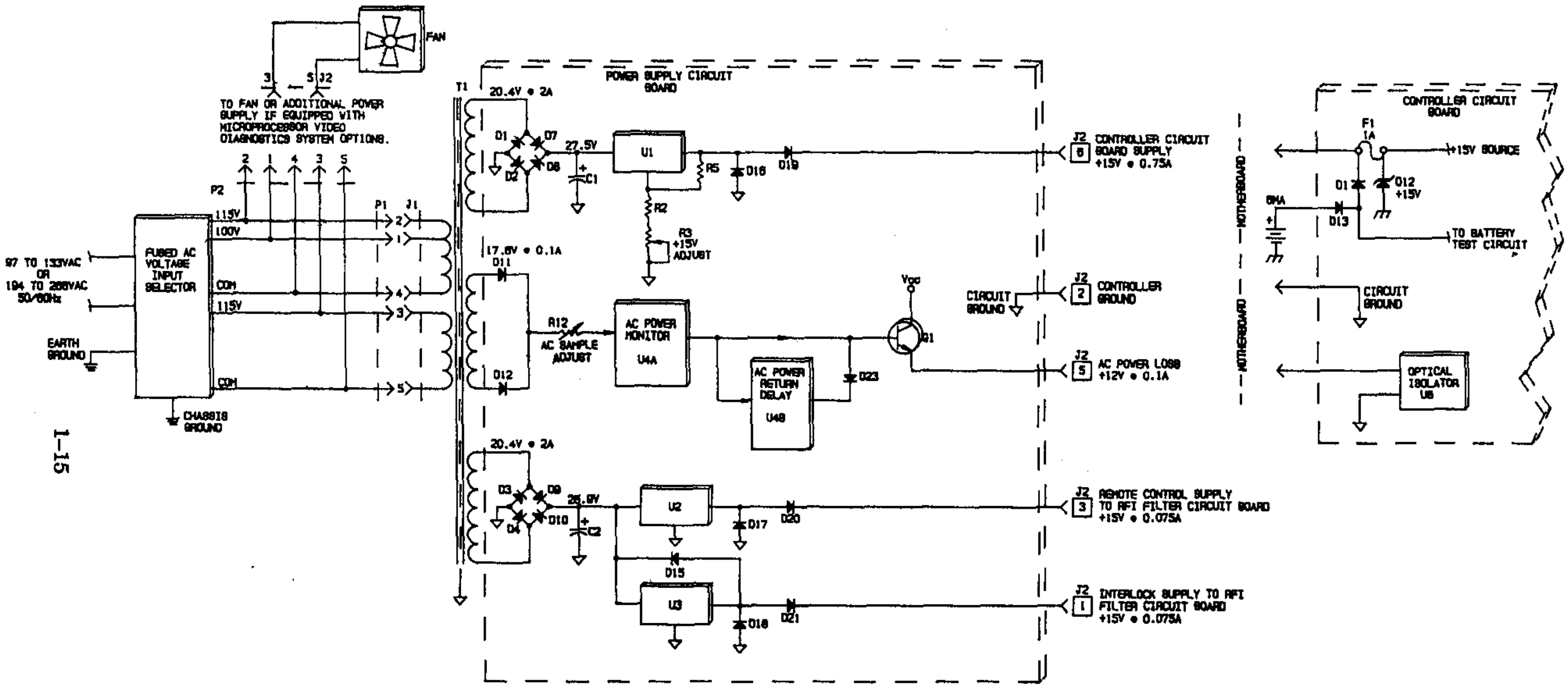

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FIGURE 1-3. CONTROLLER POWER SUPPLY SIMPLIFIED SCHEMATIC

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-20B transmitter controller.

2-3. SAFETY CONSIDERATIONS.

2-4. The FM-20B transmitter contains high voltages and currents which, if regarded carelessly, could be fatal. The transmitter has many built-in safety features, however good judgment, 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

WARNING

WARNING

2-6. The FM-20B 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 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. Record the exciter output power as indicated on the front–panel meter ____________ .

2–17. Operate the **OUTPUT POWER METER** switch to FWD. Assure the OUTPUT POWER meter indicates 100%.

2–18. Operate the **OUTPUT POWER METER** switch to VSWR CAL and adjust the **VSWR CAL** control to obtain an OUTPUT POWER meter indication of 100%.

2–19. Depress the **HIGH VOLTAGE OFF** switch.

2–20. When the **LOWER** switch/indicator stops flashing, depress the **APC ON** and **FILAMENT OFF** switch/indicators.

WARNING ***ENSURE THE TRANSMITTER PA SUPPLIES ARE OFF BEFORE PROCEEDING.***

WARNING

2–21. Ensure the transmitter PA supplies are off and disconnect cable No. 304 and 305 from the **FWD** and **RFL** ports on the output directional coupler. Connect cable No. 305 to the directional coupler **FWD** port.

2–22. Adjust the exciter **RF OUTPUT ADJ** control fully counterclockwise.

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.***

CAUTION

2–23. Depress the **FILAMENT ON** and **HIGH VOLTAGE ON** switch/indicators.

2–24. Verify that the **OUTPUT POWER METER** switch is set to VSWR and the **APC ON** switch/indicator is not illuminated.

2–25. Operate the **MULTIMETER** switch to SCREEN VOLTAGE.

2–26. Depress and hold the **APC RAISE** switch to obtain a screen voltage indication of 200 volts.

2–27. Adjust the exciter **RF OUTPUT ADJ** control until the OUTPUT POWER meter indicates a VSWR of 3 : 1.

2–28. 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.

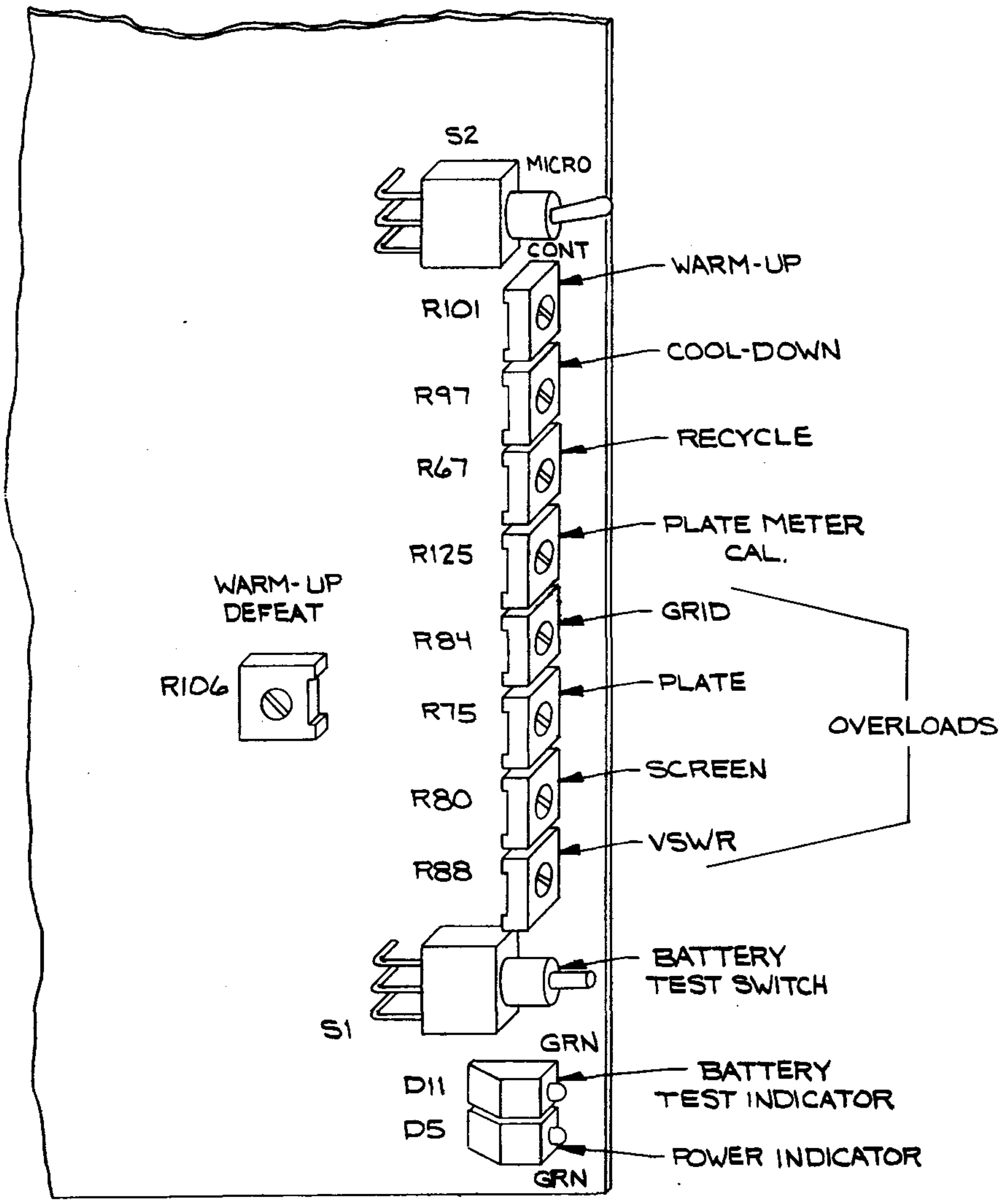

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FIGURE 2-1. CONTROLLER CIRCUIT BOARD CONTROLS

2–29. Depress the **HIGH VOLTAGE OFF** switch and depress the **OVERLOAD RESET** switch/indicator.

2–30. Depress the **APC LOWER** switch/indicator for approximately 4 seconds to lower the transmitter power.

2–31. Depress the **HIGH VOLTAGE ON** switch/indicator to illuminate the switch/indicator.

2–32. 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.

2–33. Depress the **FILAMENT OFF, OVERLOAD RESET,** and **APC ON** switch/indicators.

WARNING ***ENSURE THE TRANSMITTER PA SUPPLIES ARE OFF BEFORE PROCEEDING.***

WARNING

CAUTION ***ENSURE CABLE NO. 305 IS RECONNECTED TO THE RFL PORT AND CABLE NO. 304 IS RECONNECTED TO THE FWD PORT ON THE DIRECTIONAL COUPLER IN THE FOLLOWING STEP OR DAMAGE TO THE TRANSMITTER COULD RESULT.***

CAUTION

2–34. Ensure the transmitter PA supplies are off and reconnect cable No. 305 to the **RFL** port and cable No. 304 to the **FWD** port on the output directional coupler.

2–35. Apply power to the transmitter.

2–36. Operate the **APC ON** switch/indicator to extinguish the switch/indicator and operate the **HIGH VOLTAGE ON** switch/indicator to illuminate the switch/indicator.

2–37. Operate the **OUTPUT POWER METER** switch to FWD.

2–38. Adjust the exciter **RF OUTPUT ADJ** control to obtain the exciter output power recorded in the preceding text.

2–39. Operate the **APC ON** switch/indicator to illuminate the switch/indicator.

2–40. **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.

2–41. **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 ***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.***

CAUTION

2–42. **Procedure.** To adjust the threshold level of the plate overload circuit, proceed as follows:

2–43. 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 ______________.

2–44. Refer to Figure 2–1 and adjust **PLATE** overload control R75 fully clockwise.

2–45. Operate the **APC ON** switch/indicator to extinguish the indicator.

2–46. Operate the **OUTPUT LOADING** control clockwise and the **RAISE** switch/indicator to detune the transmitter until plate current is increased by 0.5 amperes as indicated on the PLATE CURRENT meter.

2–47. Refer to Figure 2–1 and slowly adjust PLATE overload control R75 until the transmitter deenergizes.

2–48. Depress the **HIGH VOLTAGE OFF** switch then depress and hold the **LOWER** switch/indicator for approximately four seconds.

2–49. Depress the **OVERLOAD RESET** and the **HIGH VOLTAGE ON** switch/indicators.

2–50. 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 0.5 amperes above normal. Repeat the procedure if required.

2–51. Depress the **HIGH VOLTAGE OFF** switch and **OVERLOAD RESET** switch/indicator.

2–52. 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.

2–53. **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.

2–54. **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.***

2–55. **Procedure.** To adjust the threshold level of the screen overload circuit, proceed as follows:

2–56. 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 ______________.

2–57. Refer to Figure 2–1 and adjust **SCREEN** overload control R80 fully clockwise.

2–58. Operate the **APC ON** switch/indicator to extinguish the indicator.

2–59. Operate the MULTIMETER to the SCREEN CURRENT position.

2–60. Operate the **OUTPUT LOADING** control counterclockwise and the **RAISE** switch/indicator to detune the transmitter for a screen current of 280 milliamperes as indicated on the MULTIMETER.

2–61. Refer to Figure 2–1 and slowly adjust **SCREEN** overload control R80 until the transmitter deenergizes.

2–62. Depress the **HIGH VOLTAGE OFF** switch then depress and hold the **LOWER** switch/indicator for approximately four seconds.

2–63. Depress the **OVERLOAD RESET** and the **HIGH VOLTAGE ON** switch/indicator.

2–64. 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 280 milliamperes. Repeat the procedure if required.

2–65. Depress the **HIGH VOLTAGE OFF** switch and **OVERLOAD RESET** switch/indicator.

2–66. 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.

2–67. **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.

2–68. **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 R101 on the controller circuit board, proceed as follows.

2–69. **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.

2–70. **Procedure.** To adjust the control, proceed as follows.

2–71. Apply filament power to the transmitter. Simultaneously note the time and depress the **HIGH VOLTAGE ON** switch/indicator.

2–72. Again note the time when the plate contactor energizes.

2–73. Refer to Figure 2–1 and adjust **WARM–UP** control R101 to increase or decrease the time delay. Check the adjustment by repeating the procedure. The control is factory set for 9 seconds.

2–74. **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 the **COOL–DOWN** control on the controller circuit board, proceed as follows.

2–75. **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.

2–76. **Procedure.** To adjust the control, proceed as follows.

2–77. Apply power and operate the transmitter.

2–78. Simultaneously depress the **FILAMENT OFF** switch and note the time.

2–79. Again note the time when the blower halts operation.

2–80. Refer to Figure 2–1 and adjust **COOL–DOWN** control R97 to increase or decrease the blower run–down interval. Check the adjustment by repeating the procedure. The control is factory set for 35 seconds.

2–81. **RECYCLE ADJUSTMENT.** This control adjusts the time the transmitter will remain de-energized 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 the RECYCLE control on the controller circuit board, proceed as follows.

2–82. **Required Equipment.** The following equipment is required to adjust RECYCLE control R67.

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

2–83. **Procedure.** To adjust the control, proceed as follows.

2–84. Apply power and operate the transmitter.

2–85. Refer to Figure 2–1 and adjust RECYCLE control 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.

2–86. **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 the WARM–UP defeat control on the controller circuit board, proceed as follows.

2–87. **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.

2–88. **Procedure.** To adjust the control, proceed as follows.

2–89. Mount the controller circuit board on the extender board.

2–90. Apply power and operate the transmitter.

2–91. Refer to Figure 2–1 and adjust WARM–UP DEFEAT control 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 re–applied immediately or a recycle is initiated.

2–92. Disconnect power and replace the controller circuit board in the transmitter.

2–93. **PLATE I METER CAL ADJUSTMENT.** This control adjusts the remote plate current meter output level for approximately 5 or 2.5 volts dc depending on the remote logic programming at normal plate current. To adjust the PLATE I meter cal. control on the controller circuit board, proceed as follows.

2–94. **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).

2–95. **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 and open the cabinet rear door. Connect the voltmeter between TB3, terminal 25 and terminal 26 (meter ground).

2–97. Route the voltmeter leads out the hinge side of the cabinet door and close and lock the door.

2–98. Apply power and operate the transmitter at the normal power output.

2–99. Refer to Figure 2–1 and adjust R125 until the voltmeter indicates +5 or +2.5 volts dc depending on the remote logic programming.

WARNING *DISCONNECT ALL TRANSMITTER PRIMARY POWER BEFORE PROCEEDING.*

WARNING

2–100. Assure all transmitter power is off and disconnect the voltmeter and leads.

2–101. **POWER SUPPLY CIRCUIT BOARD.**

2–102. **+15 VOLT ADJUST.** To adjust the +15 volt adjust control on the power supply circuit board, proceed as follows.

2–103. **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).

2–104. **Procedure.** To adjust the control, proceed as follows:

WARNING *DISCONNECT ALL TRANSMITTER PRIMARY POWER BEFORE PROCEEDING.*

WARNING

2–105. Assure all transmitter power is off.

2–106. Open the transmitter rear door and disconnect all plugs and cables from the rear of the transmitter controller chassis.

2–107. Remove the eight screws securing the transmitter controller in the rack.

2–108. Remove the transmitter controller from the rack and set the chassis on a work surface.

2–109. Remove the screws which secure the top on the transmitter controller and remove the top cover.

2–110. Remove the four screws securing the power supply in the chassis.

2–111. Disconnect the plug from the power supply circuit board.

2–112. Lift the power supply out of the chassis and set it on top of the card cage.

2–113. Connect the voltmeter between J2 pin 6 and chassis ground.

2–114. 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.

2–115. Replace the fuse with a 1 Ampere fuse.

WARNING ***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.***

2–116. Apply power to the controller and adjust R2 to obtain a voltmeter indication of 15.3 volts dc.

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

2–117. Assure primary power is disconnected before proceeding.

2–118. Disconnect the voltmeter.

2–119. 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.

2–120. Replace the fuse with the original 1/2 Ampere slow–blow fuse.

2–121. Secure the power supply in the controller chassis and reconnect the circuit board plug.

2–122. Replace the top cover on the controller.

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

2–123. Replace the controller in the transmitter. Connect the rear panel plugs.

2–124. **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.

2–125. **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.

2-126. **Procedure.** To adjust the control, proceed as follows:

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

WARNING

2-127. Assure all transmitter power is off.

2-128. Open the transmitter rear door and disconnect all plugs and cables from the rear of the transmitter controller chassis.

2-129. Remove the eight screws securing the transmitter controller in the rack.

2-130. Remove the transmitter controller from the rack and set the chassis on a work surface.

2-131. Remove the screws which secure the top on the transmitter controller and remove the top cover.

2-132. Remove the four screws securing the power supply in the chassis.

2-133. Disconnect the plug from the power supply circuit board.

2-134. Lift the power supply out of the chassis and set it on top of the card cage.

2-135. Connect the voltmeter between J2 pin 5 and chassis ground.

2-136. 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.

2-137. Replace the fuse with a 1 Ampere fuse.

2-138. Connect the controller to the variac using the power interlock line cord.

2-139. Apply power to the variac and adjust the unit as follows:

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

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 PROCEEDING.*

WARNING

2–140. Assure primary power is disconnected before proceeding.

2–141. Disconnect the voltmeter.

2–142. 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.

2–143. Replace the fuse with the original 1/2 Ampere slow–blow fuse.

2–144. Secure the power supply in the controller chassis and reconnect the circuit board plug.

2–145. Replace the top cover on the controller.

WARNING *DISCONNECT ALL TRANSMITTER PRIMARY POWER BEFORE PROCEEDING.*

WARNING

2–146. Replace the controller in the transmitter. Connect the rear panel plugs.

2–147. **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

2–148. Most troubleshooting consists of visual checks. Because of the high voltages and 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.

2–149. 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.

2–150. 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 HEATSINKS 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	

2-151. 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.

2-152. 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–20B transmitter controller.

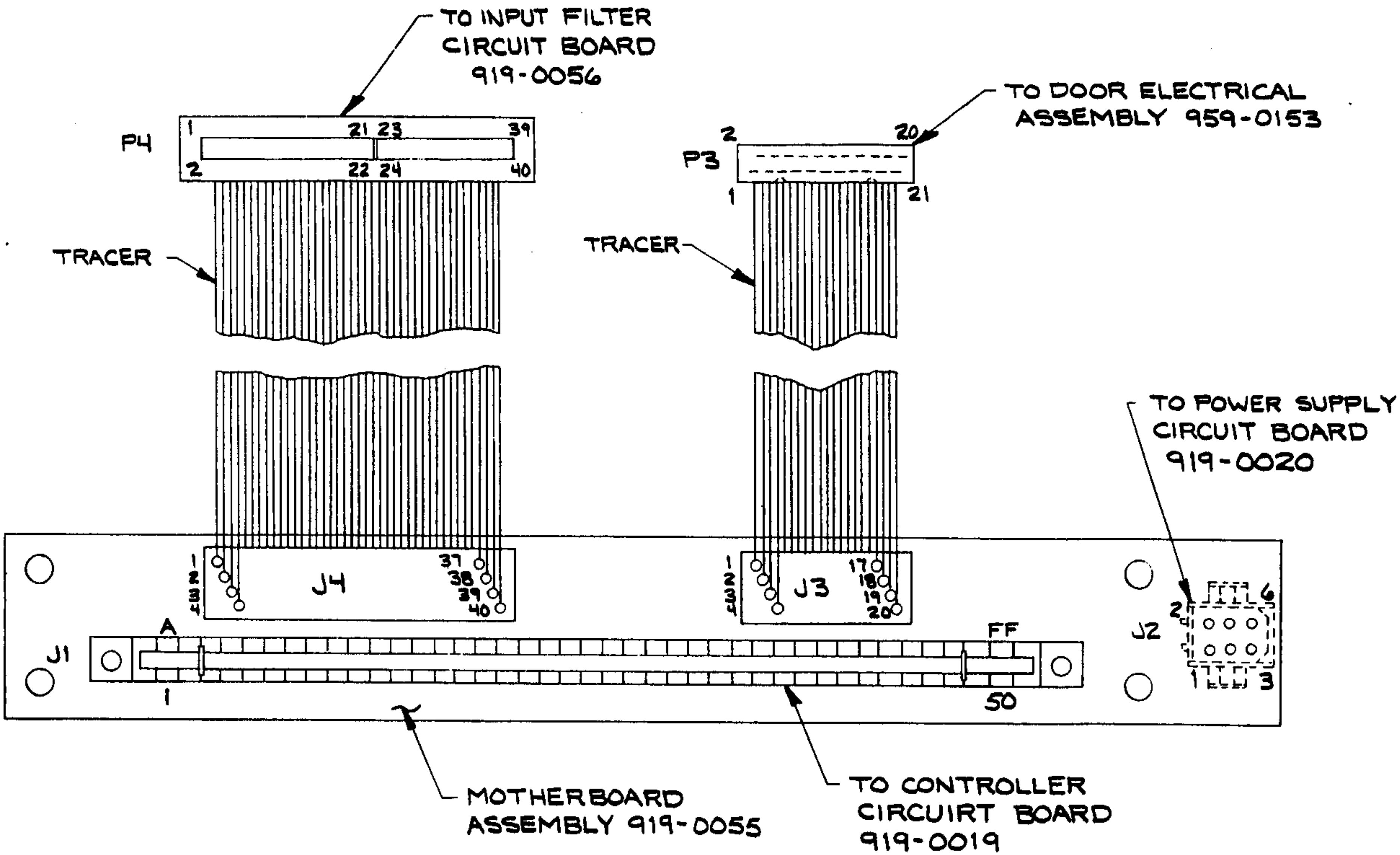

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FIGURE 3–4. MOTHERBOARD ASSEMBLY

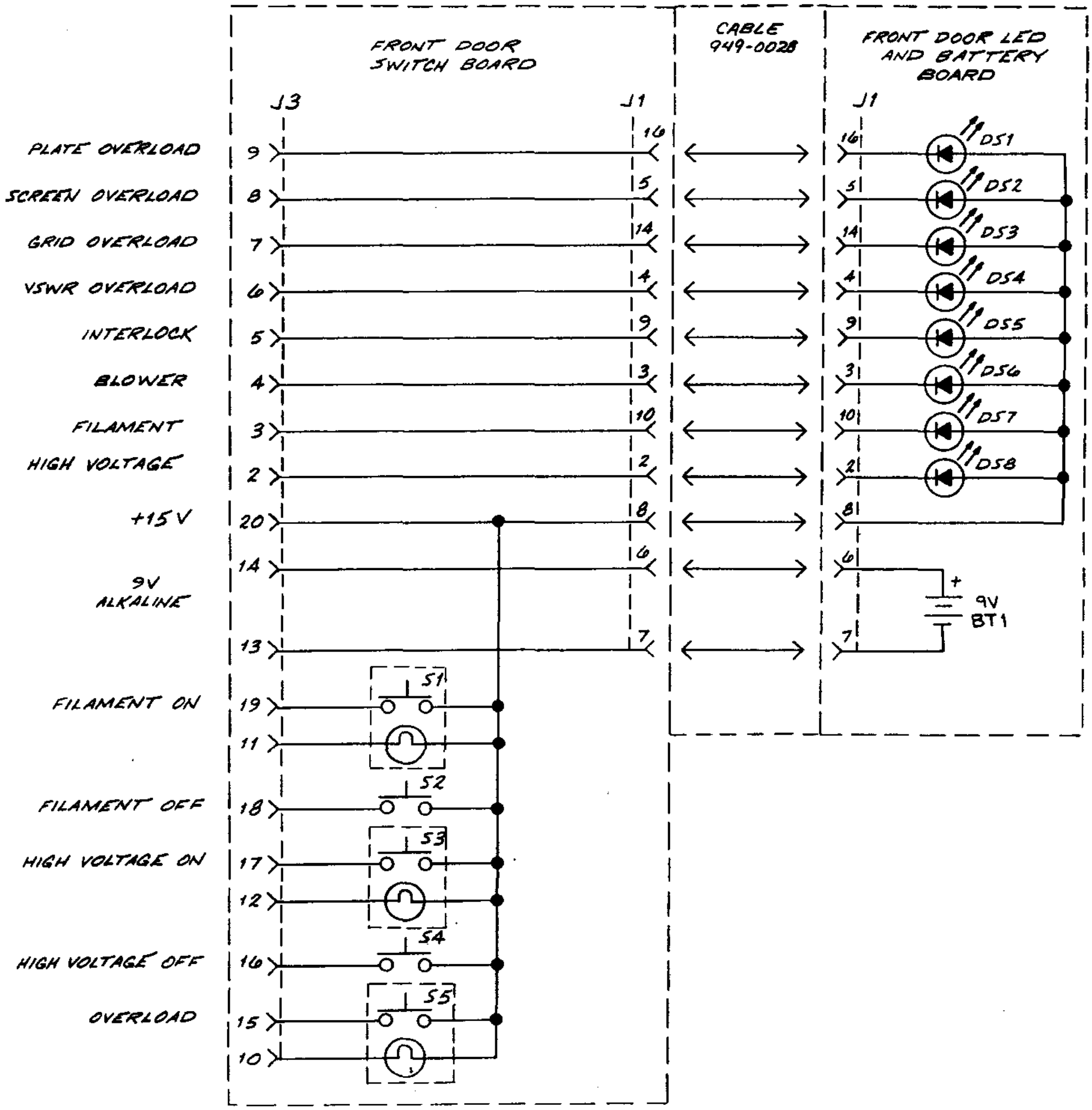

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FIGURE 3-7. SCHEMATIC, DOOR ELECTRICAL ASSEMBLY

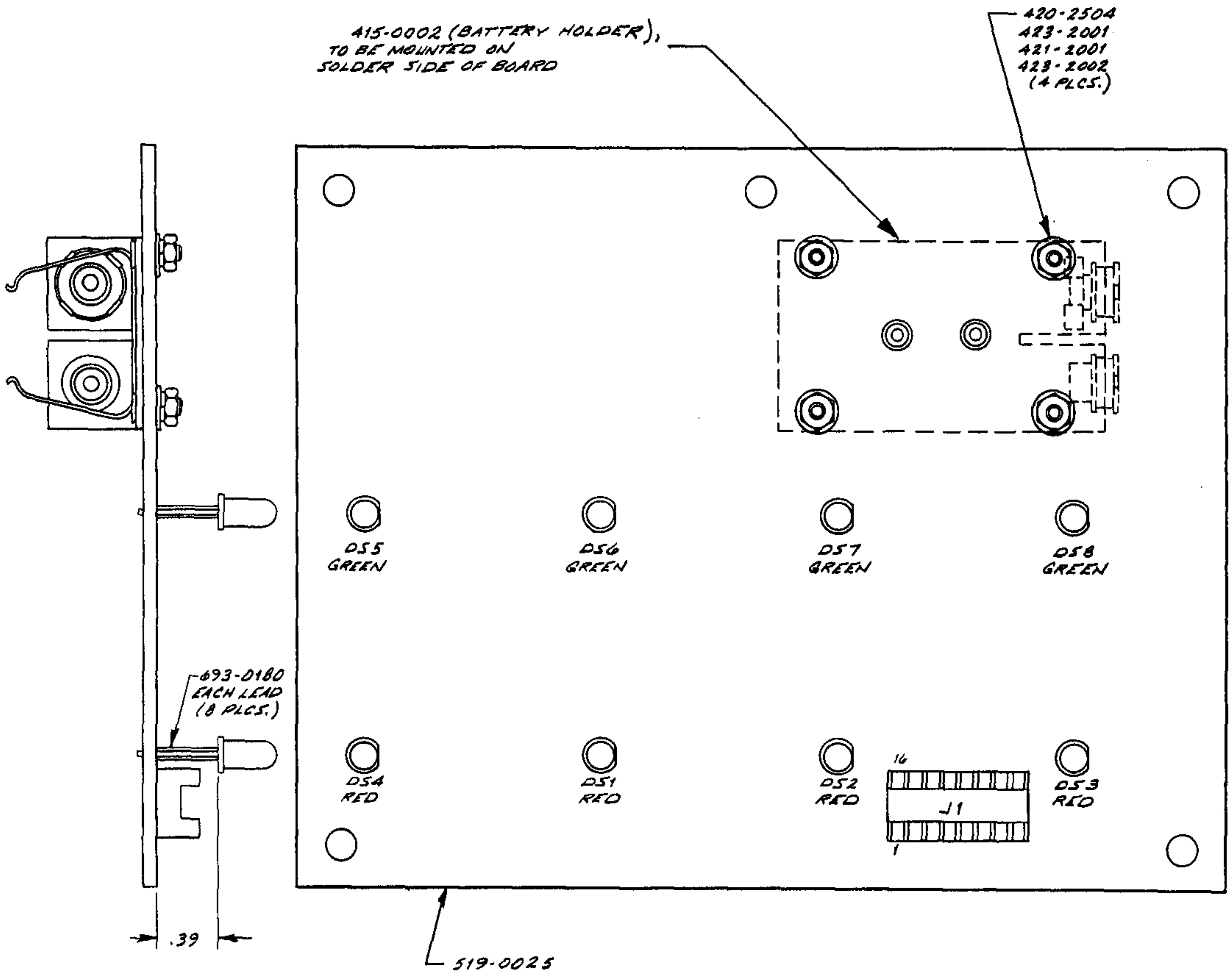

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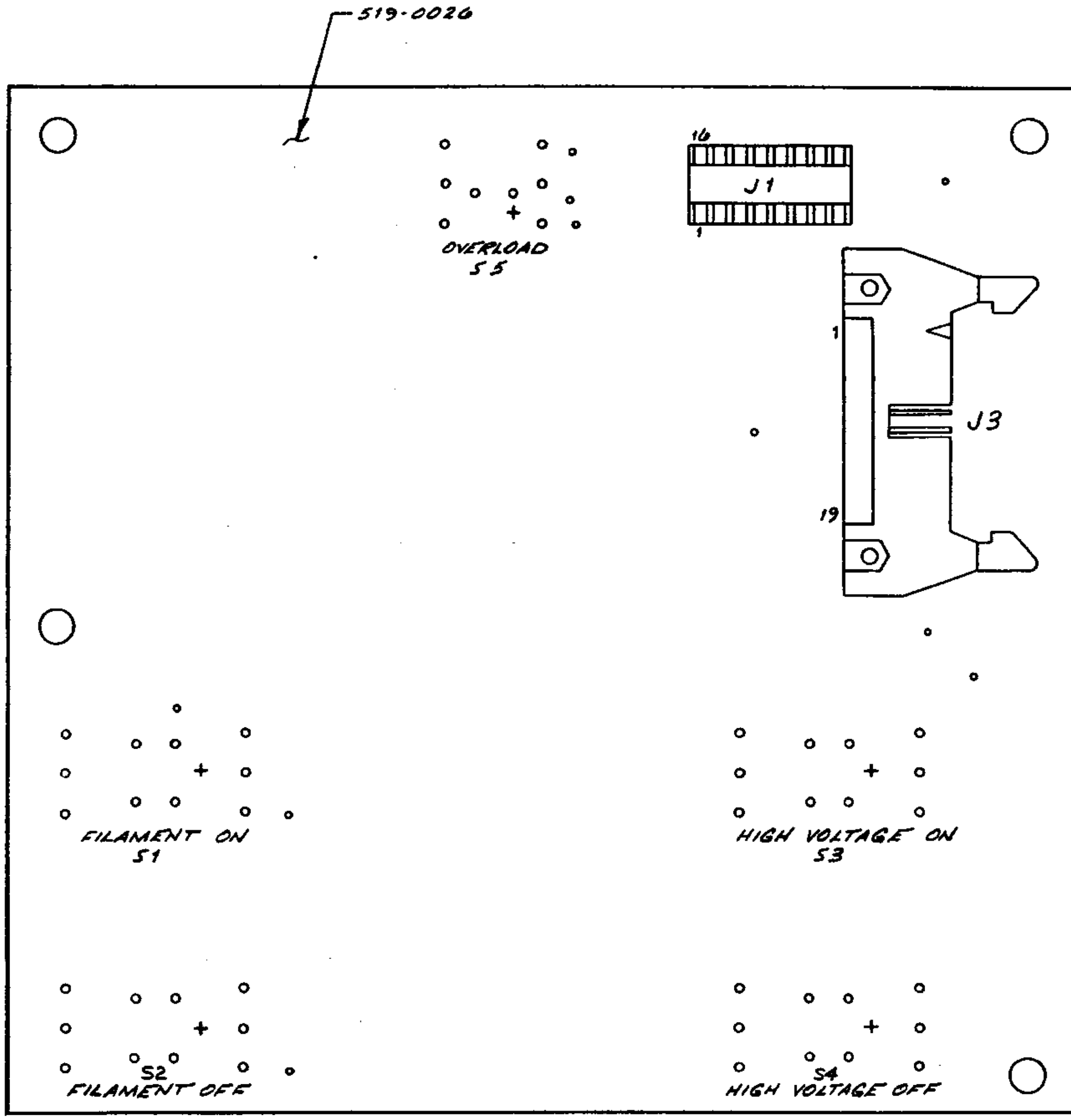
FIGURE 3-8. ASSEMBLY, DOOR ELECTRICAL ASSEMBLY (Sheet 1 of 2)



NOTES:
1. WHEN INSTALLING SWITCHES, (+) TERMINAL MUST MATCH (+) INDICATOR ON PC BOARD.
2. SWITCHES ARE ADDED DURING FINAL DOOR ASSEMBLY.

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FIGURE 3–8. ASSEMBLY, DOOR ELECTRICAL ASSEMBLY (Sheet 2 of 2)

A

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		

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–20B FM 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	DESCRIPTION	PART NO.	PAGE
4–2	TRANSMITTER CONTROLLER	959–0298–002	4–2
4–3	BASIC CONTROLLER AND MVDS ASSEMBLY	959–0298	4–2
4–4	MOTHERBOARD ASSEMBLY	959–0294	4–3
4–5	MOTHERBOARD CIRCUIT BOARD	919–0055	4–3
4–6	INPUT FILTER CIRCUIT BOARD	919–0056	4–3
4–7	CONTROLLER CIRCUIT BOARD	919–0019	4–3
4–8	POWER SUPPLY ASSEMBLY	959–0089	4–8
4–9	POWER TRANSFORMER AND WIRE HARNESS	959–0157	4–8
4–10	POWER SUPPLY CIRCUIT BOARD	919–0111	4–9
4–11	TRANSMITTER CONTROLLER CABLE ASSEMBLY	949–0191–002	4–10
4–12	EXTENDER CIRCUIT BOARD	919–0061	4–10

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 (Sheet 1 of 2)

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 (**OVERLOAD** Indicators)	323–9217	4
DS5 THRU DS8	Indicator, LED, Green, 521–9176, 3V @ 40 mA Maximum (**STATUS** Indicators)	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	3
——	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	949–0191–002	1

TABLE 4-3. BASIC CONTROLLER AND MVDS ASSEMBLY - 959-0298
(Sheet 2 of 2)

REF. DES.	DESCRIPTION	PART NO.	QTY.
——	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-Pin	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

TABLE 4-7. CONTROLLER CIRCUIT BOARD - 919-0019
(Sheet 2 of 6)

REF. DES.	DESCRIPTION	PART NO.	QTY.
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
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 Film, 0.1 uF, 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

TABLE 4-7. CONTROLLER CIRCUIT BOARD - 919-0019
(Sheet 3 of 6)

REF. DES.	DESCRIPTION	PART NO.	QTY.
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
R7,R8	Resistor, 10 k Ohm ±5%, 1/4W	100-1053	2
R9	Resistor, 1 k Ohm ±5%, 1/4W	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%, 1/4W	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%, 1/4W	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

TABLE 4–7. CONTROLLER CIRCUIT BOARD – 919–0019
(Sheet 4 of 6)

REF. DES.	DESCRIPTION	PART NO.	QTY.
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
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

TABLE 4–7. CONTROLLER CIRCUIT BOARD – 919–0019 (Sheet 5 of 6)

REF. DES.	DESCRIPTION	PART NO.	QTY.
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
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 Meg 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, 14–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

TABLE 4-7. CONTROLLER CIRCUIT BOARD - 919-0019
(Sheet 6 of 6)

REF. DES.	DESCRIPTION	PART NO.	QTY.
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
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 ASSEMBLY - 959-0089

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
——	Power Transformer and Wire Harness	959-0157	1
——	Power Supply Circuit Board	919-0111	1

TABLE 4-9. POWER TRANSFORMER AND WIRE HARNESS - 959-0157
(Sheet 1 of 2)

REF. DES.	DESCRIPTION	PART NO.	QTY.
J1	Receptacle, 6-Pin	418-0006	1
P3	Plug, 12-Pin	418-1271	1
T1	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

TABLE 4–9. POWER TRANSFORMER AND WIRE HARNESS - 959–0157
(Sheet 2 of 2)

REF. DES.	DESCRIPTION	PART NO.	QTY.
——	Pins for J1	417–0036	5
——	Pins for P3	417–0053	10

TABLE 4–10. POWER SUPPLY CIRCUIT BOARD - 919–0111

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
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 4–11. TRANSMITTER CONTROLLER CABLE ASSEMBLY – 949–0191–002

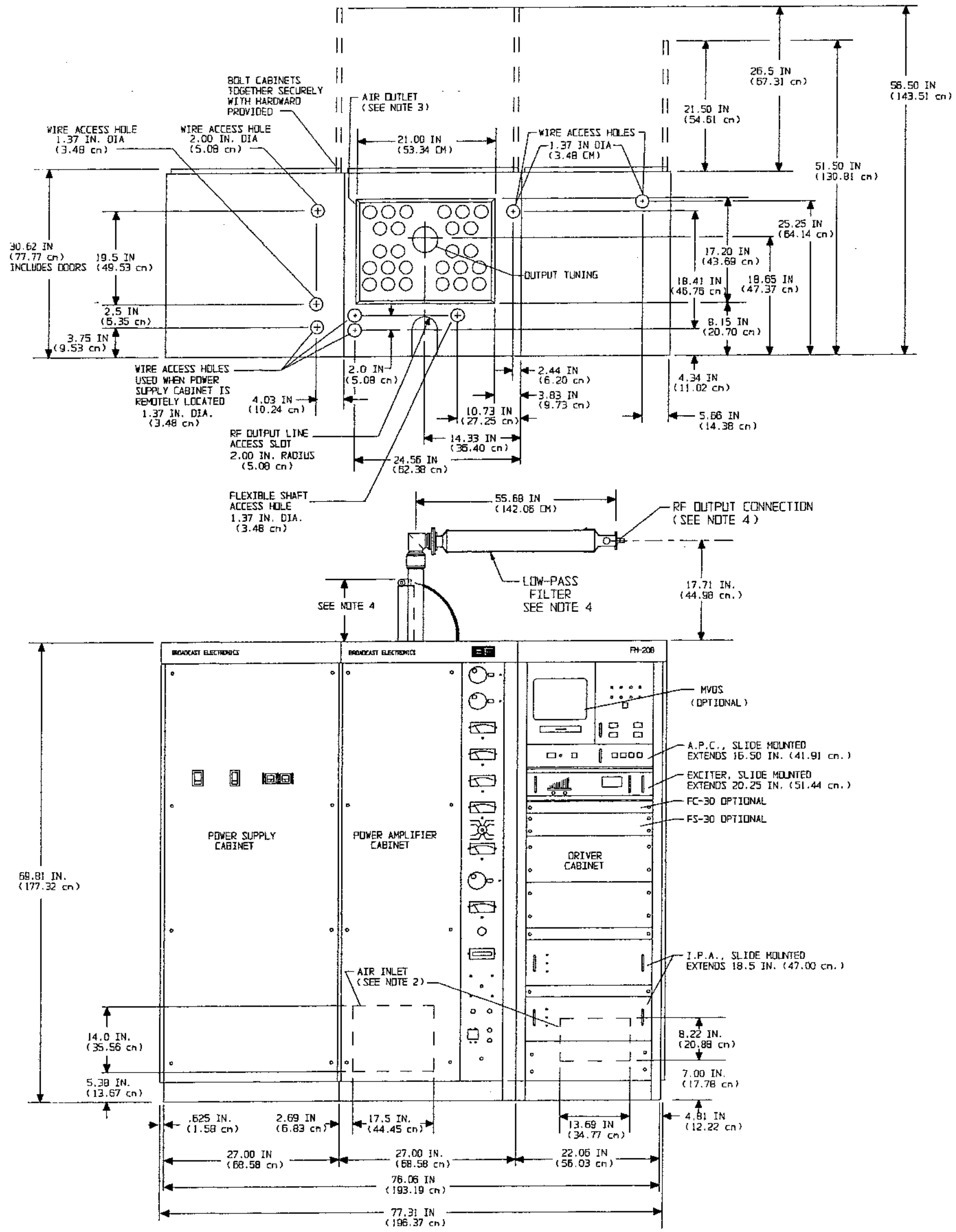
REF. DES.	DESCRIPTION	PART NO.	QTY.
J5	Socket, MR, 24–Pin, Male	417–2403	1
P4	Connector Housing, 6–Pin, Female	418–0670	1
——	Pin Connector	417–0036	5
——	Pins Connector	417–0053	5
——	Keying Plug, 350591–1 AMP	418–0026	1
——	3 Circuit Commoning Bar, AMP, MR	418–0054	2

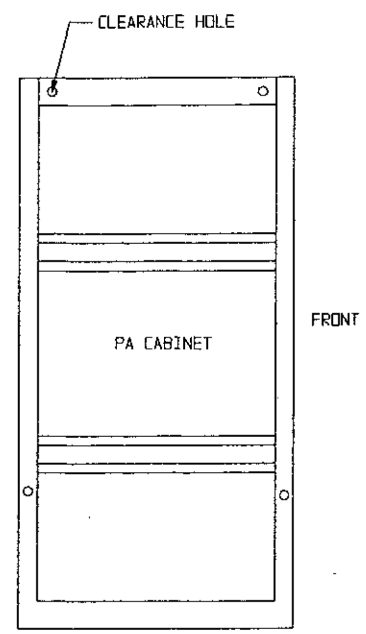
TABLE 4–12. EXTENDER CIRCUIT BOARD – 919–0061

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

FM-20B
20 KILOWATT FM BROADCAST TRANSMITTER

IM NO. 597-0220-004
SEPTEMBER, 1995





DETAIL "A"
CABINET BOLTING INSTRUCTIONS

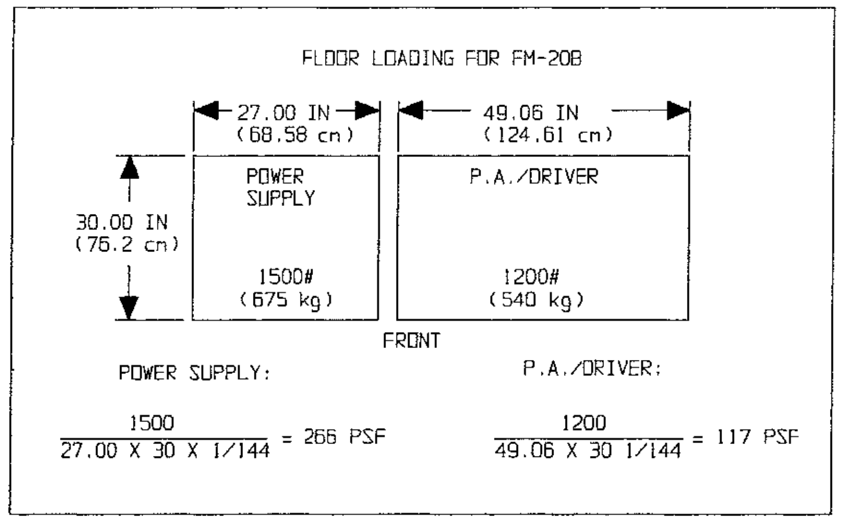
1. REMOVE THE POWER SUPPLY CABINET FRONT PANEL.
2. REFER TO DETAIL "A" FOR THE LOCATION OF FOUR HOLES. POSITION THE PA CABINET UNTIL IDENTICAL HOLES IN THE POWER SUPPLY CABINET ARE ALIGNED.
3. USING THE 1/4-20 HARDWARE PROVIDED SECURE THE CABINETS TOGETHER. THE BOLTS SHOULD BE INSTALLED FROM THE POWER SUPPLY CABINET INTO THE PA CABINET.
4. REPLACE THE FRONT-PANEL ON THE POWER SUPPLY CABINET.

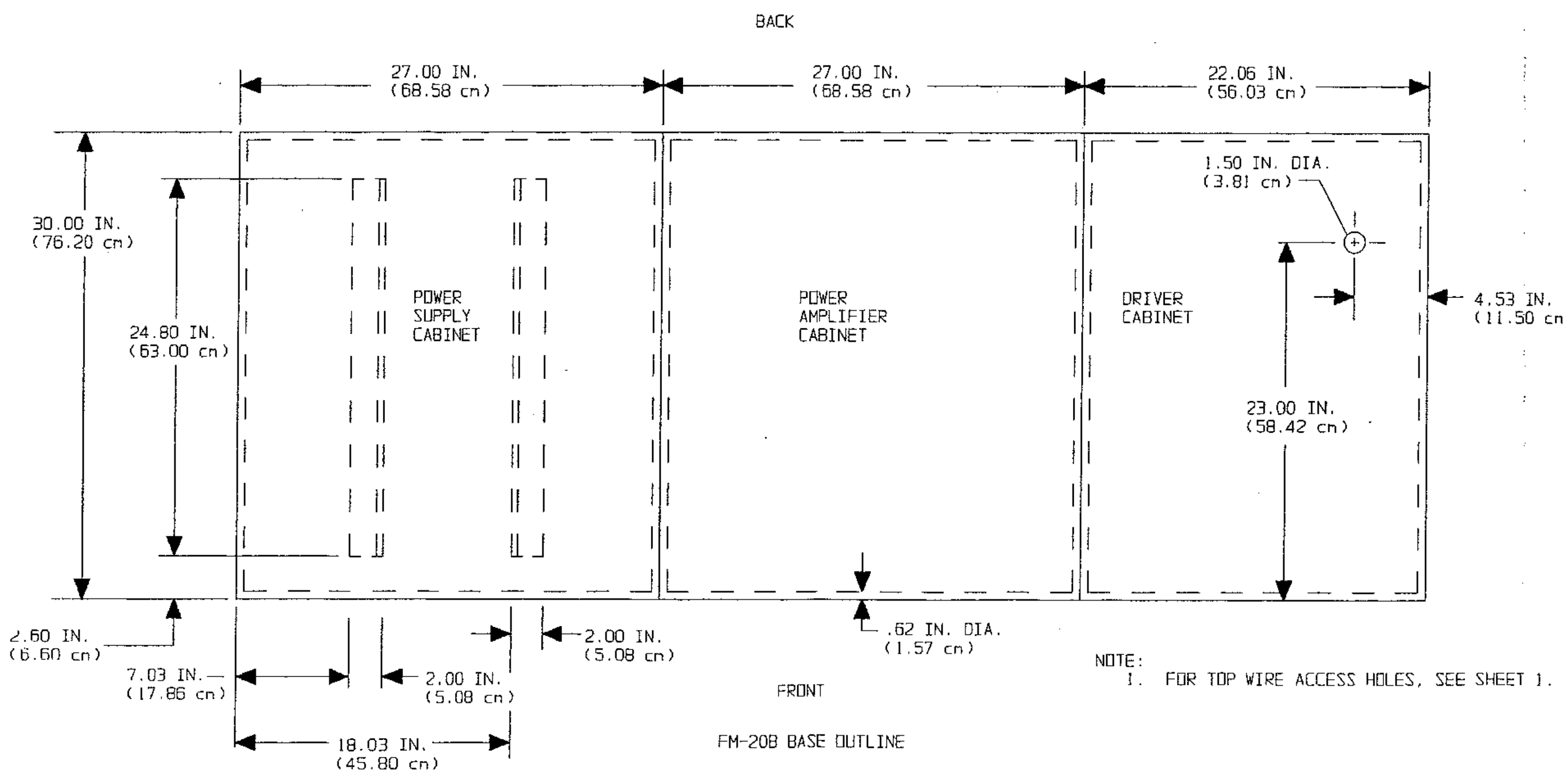
NOTES:

1. POWER SUPPLY CABINET MAY BE LOCATED REMOTELY FROM THE PA/DRIVER CABINET IF DESIRED. 30 FEET (9.14 m) STANDARD.
2. AIR INLET:
   1. LOCATION: PA CABINET REAR-PANEL
      DIMENSIONS:
      WIDTH: 17.5 INCHES (44.45 cm)
      HEIGHT: 14.0 INCHES (35.56 cm)
      FILTER: 16 INCHES X 20 INCHES X 1 INCH NOMINAL. BEI P/N 407-0062.
   2. LOCATION: DRIVER CABINET REAR-PANEL
      DIMENSIONS:
      WIDTH: 13.69 INCHES (34.77 cm)
      HEIGHT: 8.22 INCHES (20.88 cm)
      FILTER: 16 INCHES X 20 INCHES X 1 INCH NOMINAL. BEI P/N 407-0062.
3. AIR OUTLET:
   DESCRIPTION: 17 INCHES (43.18 cm) X 20.75 INCHES (52.71 cm) EXHAUST AREA AROUND OUTPUT TUNING LINE.
4. RF OUTPUT ASSEMBLY:
   CONNECTION: 3.125 INCH EIA 50 OHM MALE FIELD FLANGE.
   LOW-PASS FILTER (BEI P/N 339-0022):
   DIMENSIONS:
   LENGTH: 52.12 INCHES (132.38cm)
   DIAMETER: 6.13 INCHES (15.57 cm)
   MOUNTING: MECHANICAL SUPPORT REQUIRED EXTERNAL TO TRANSMITTER.
   WEIGHT: 65 POUNDS (29.48 kg)
   TUNING LINE HEIGHT (DETERMINED BY TRANSMITTER FREQUENCY):
   MAXIMUM: 17.0 INCHES (43.18 cm) @ 108 MHz
   MINIMUM: 5.0 INCHES (12.7 cm) @ 88 MHz
5. CUBAGE:
   PA/DRIVER CABINET: 64 CUBIC FEET ($1.8m^3$)
   POWER SUPPLY CABINET: 36 CUBIC FEET ($1.0m^3$)
6. WEIGHT:
   PA/DRIVER CABINET: 1200 POUNDS (545 kg)
   POWER SUPPLY CABINET: 1500 POUNDS (681 kg)
7. COOLING AIR REQUIREMENTS:
   PA CABINET: 810 CUBIC FEET PER MINUTE ($23 m^3/min$)
   DRIVER CABINET: 500 CUBIC FEET PER MINUTE ($14.2 m^3/min$)
   POWER SUPPLY CABINET: NATURAL CONVECTION
8. AC INPUT REQUIRMENTS:
   196V TO 252V ac 50/60 Hz OR 339V TO 437 ac 50 Hz, THREE-PHASE CLOSED-DELTA OR WYE, 200 AMPERES PER PHASE MAXIMUM. FUSED DISCONNECT RECOMMENDED.
9. HEAT DISSIPATION:
   20 kW OUTPUT: 16 kW (54,725 BTU/H)
10. POWER CONSUMPTION:
    30.0 kW FOR A 20 kW OUTPUT, 0.97 POWER FACTOR

597-0220-4B

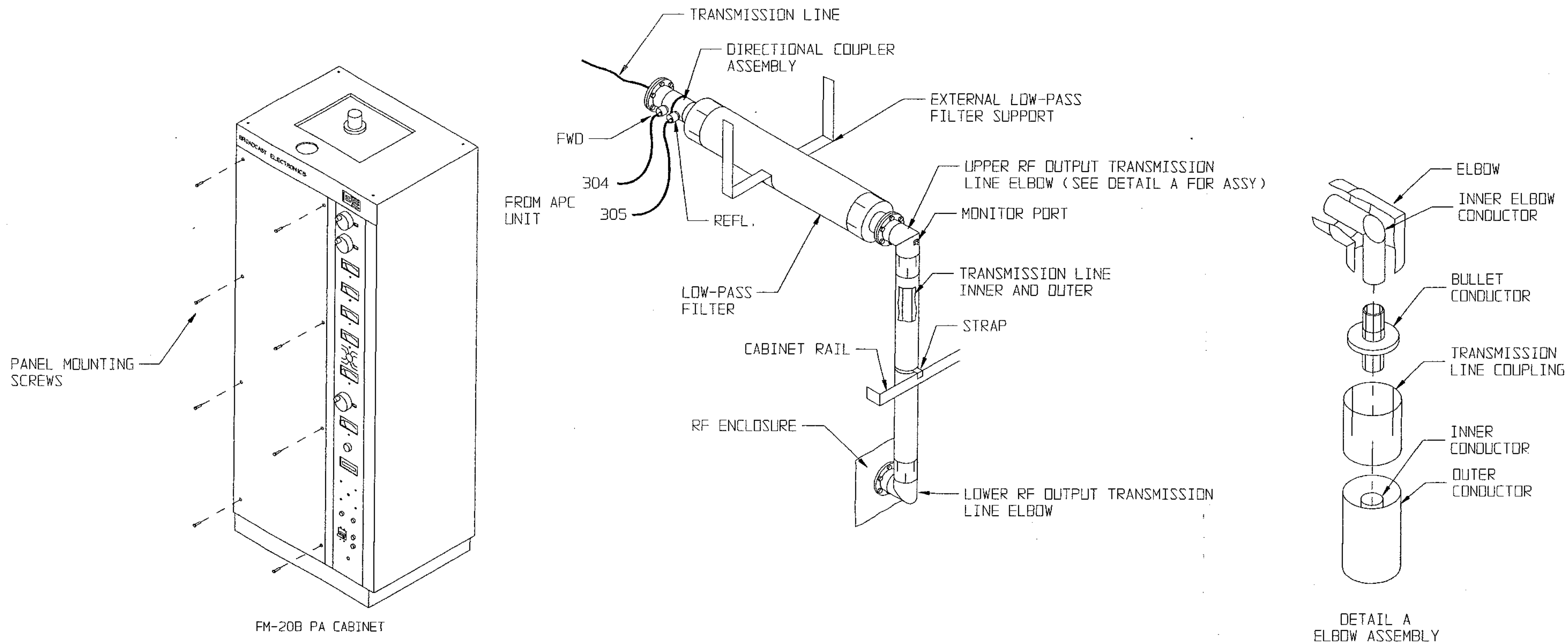
FIGURE 2-1. FM-20B TRANSMITTER INSTALLATION (Sheet 1 of 2)





597-0220-4B

FIGURE 2-1. FM-20B TRANSMITTER INSTALLATION (Sheet 2 of 2)



597-0220-9B

FIGURE 2-7. FM-20B RF OUTPUT TRANSMIS-SION LINE ASSEMBLY

BROADCAST ELECTRONICS INC

CAUTION ***THE TRANSMITTER WILL NOT SUPPORT THE WEIGHT OF THE LOW–PASS FILTER ASSEMBLY. MECHANICAL SUPPORT EXTERNAL TO THE TRANSMITTER IS REQUIRED.***

CAUTION

2–81. Using mechanical support external to the transmitter, insert the low–pass filter assembly directly into the transmission line elbow as shown. Secure the coupling to the elbow with the strap clamp.

2–82. Connect the APC and monitor coaxial cables to the assembly as follows:

A. Connect APC unit forward power cable 304 to the ⇒ (FWD) port on the directional coupler.

B. Connect APC unit VSWR cable 305 to the ⇐ (RFL) port on the directional coupler.

C. Connect the station monitor cable to the monitor port on the output line assembly.

2–83. After assembling the RF output transmission line, secure the meter panel. Bolt the antenna transmission line to the low–pass filter. The flange is secured with six bolts, six lockwashers, and six nuts.

2–84. **PA Cabinet Grounding Stick.** Unpack the PA cabinet grounding stick located in the rear of the cabinet and insert the stick in the interlocked clips provided on the blower assembly.

2–85. **EXTENDED LOCAL CONTROL.**

2–86. Extended local control of the FM–20B transmitter 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.

2–87. **REMOTE CONTROL.**

2–88. The FM–20B transmitter is designed for complete remote control operation (refer to Figure 2–8). Transmitter remote control operations may be performed by the Broadcast Electronics MVDS RC–1/MT–3 remote control option. 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 information.

2–89. The transmitter will also interface with most modern remote control units such as the Broadcast Electronics VMC–16 voice remote control system. 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 2–8 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 2–8 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.

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 2–8).

2–90. **WIRING.**

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

WARNING

2–91. **TRANSFORMER TAPS.** Ensure the transmitter is wired for the input voltage and line frequency to be used. The PA screen transformer, the PA plate transformer, the PA bias transformer, and the PA filament transformer must be checked and changed if required (see Figure 2–9). Refer to the final test data sheets for transformer information.

2–92. Check the IPA voltage taps per Figure 2–10 and change the wiring if required. Normally the taps are chosen to limit IPA regulator dissipation over the normal line voltage excursions. The 208–250V selection is typically acceptable.

2–93. **INPUT VOLTAGE CHECK.** The transmitter controller, FM exciter, the optional stereo generator, and the optional 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.

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

WARNING

2–94. **CABINET INTERCONNECTIONS.** Refer to the following cabinet interconnection procedures for the type of transmitter installation used.

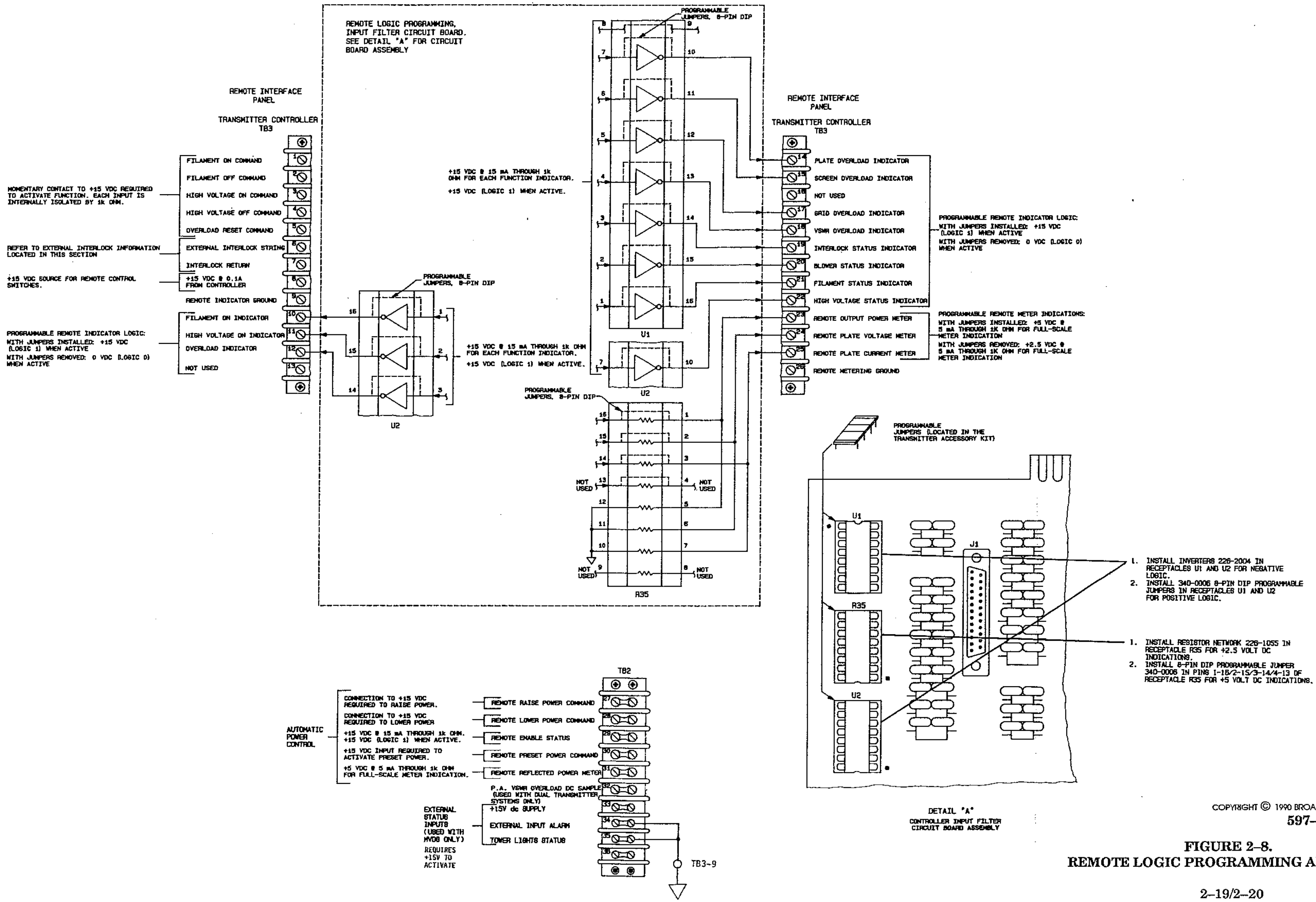


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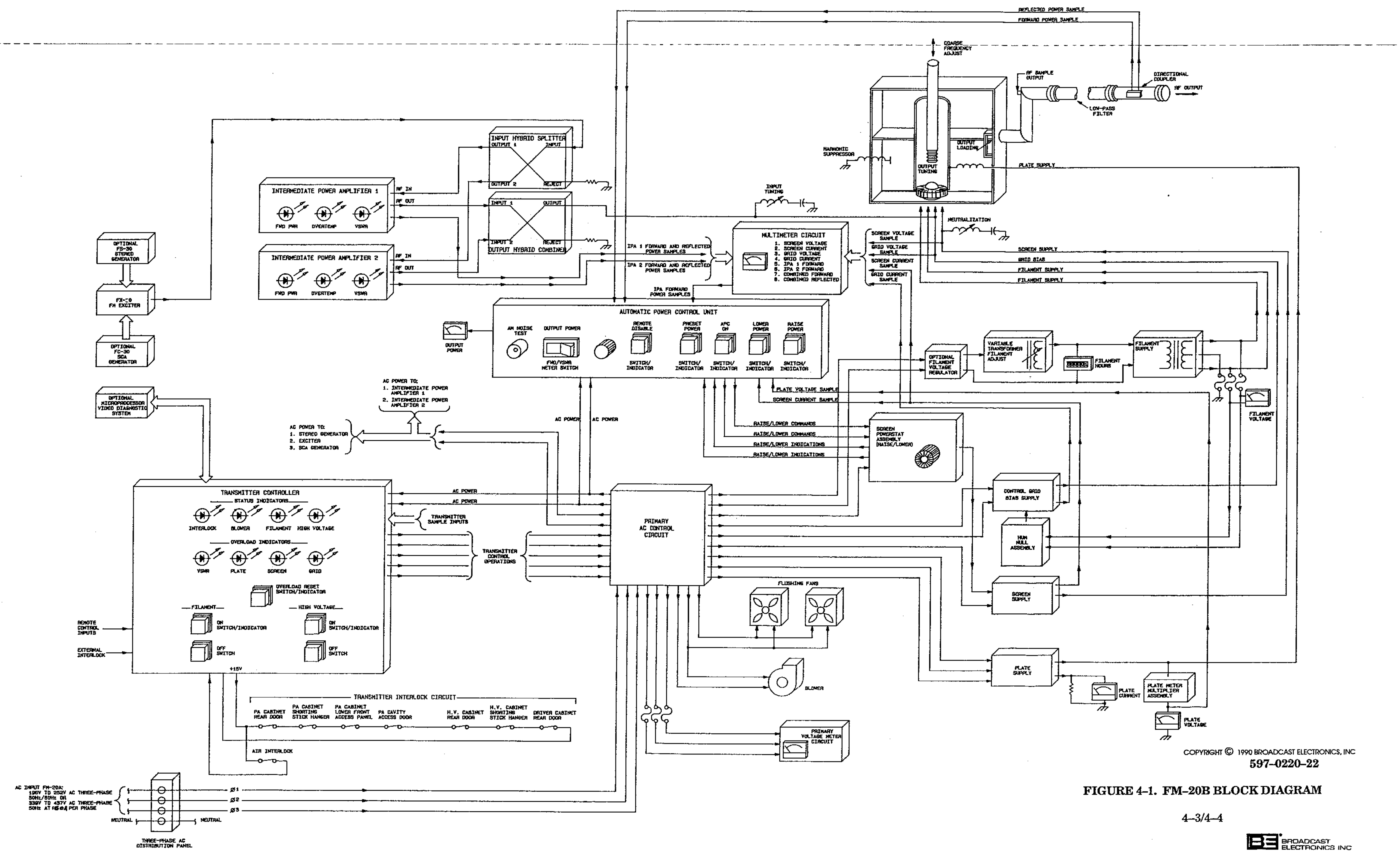
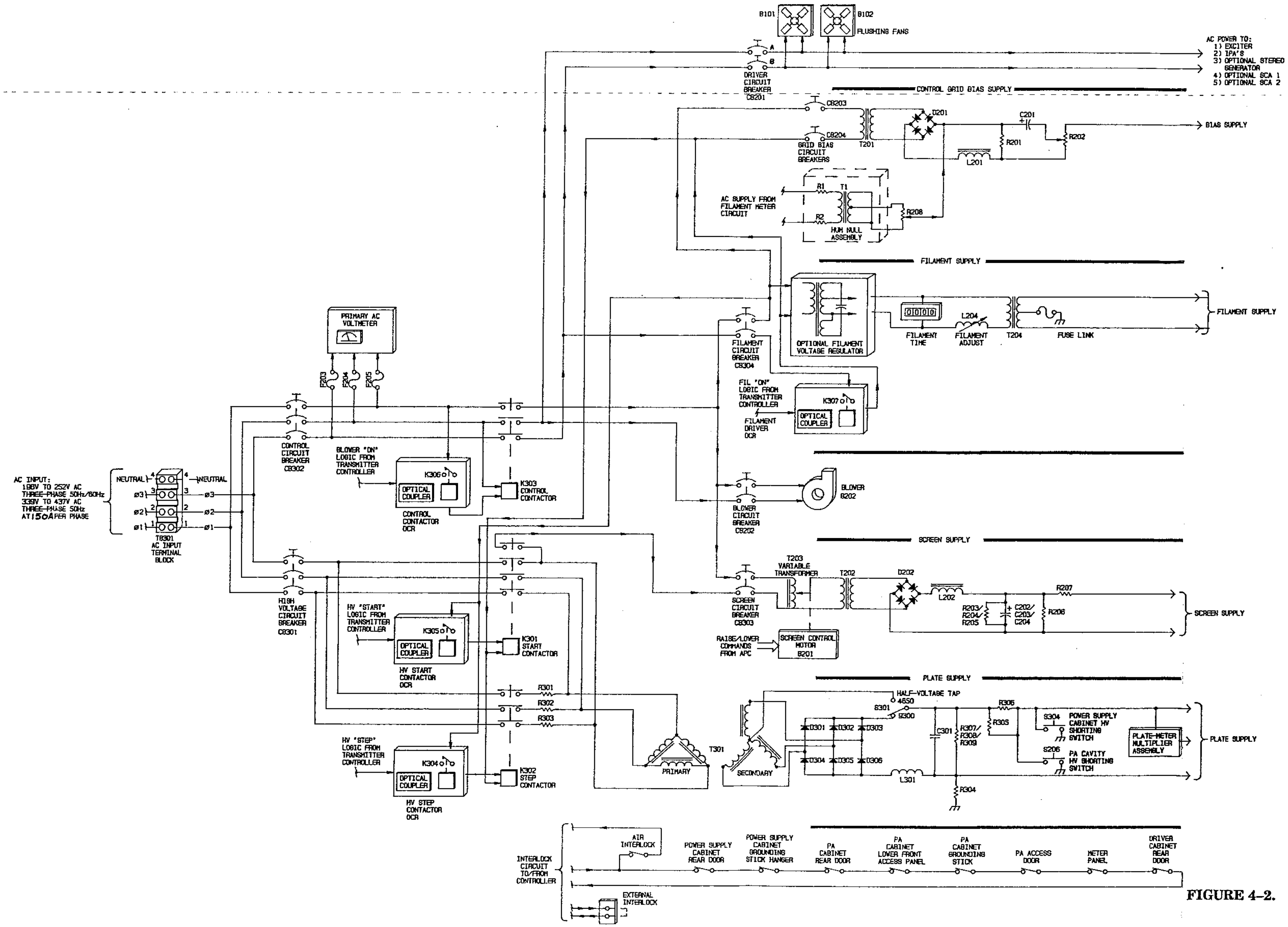
FIGURE 2-8.
REMOTE LOGIC PROGRAMMING AND WIRING

BE BROADCAST ELECTRONICS INC



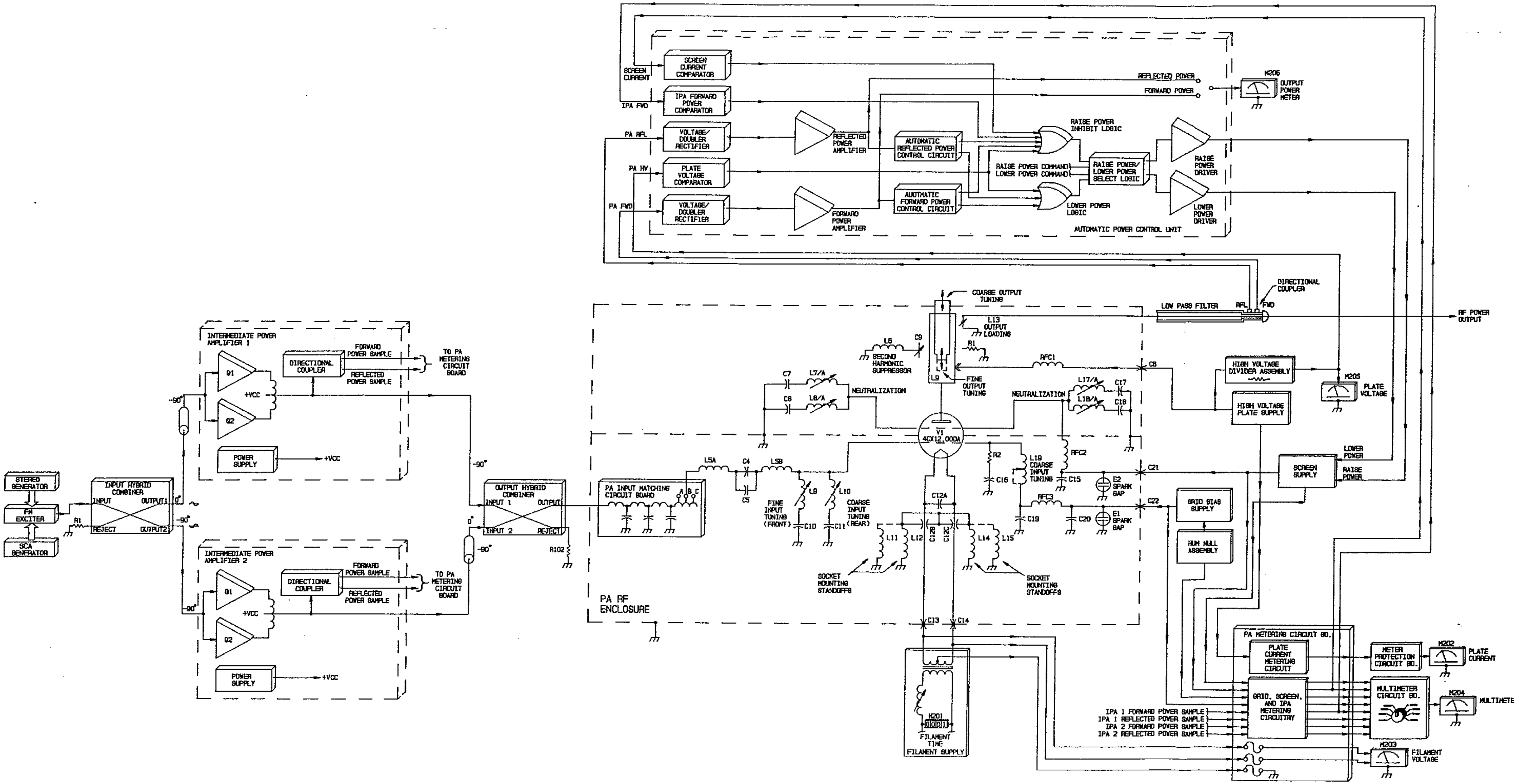
597-0220-22

FIGURE 4-1. FM-20B BLOCK DIAGRAM



597–0220–23

FIGURE 4–2. FM–20B POWER SUPPLY SIMPLIFIED SCHEMATIC



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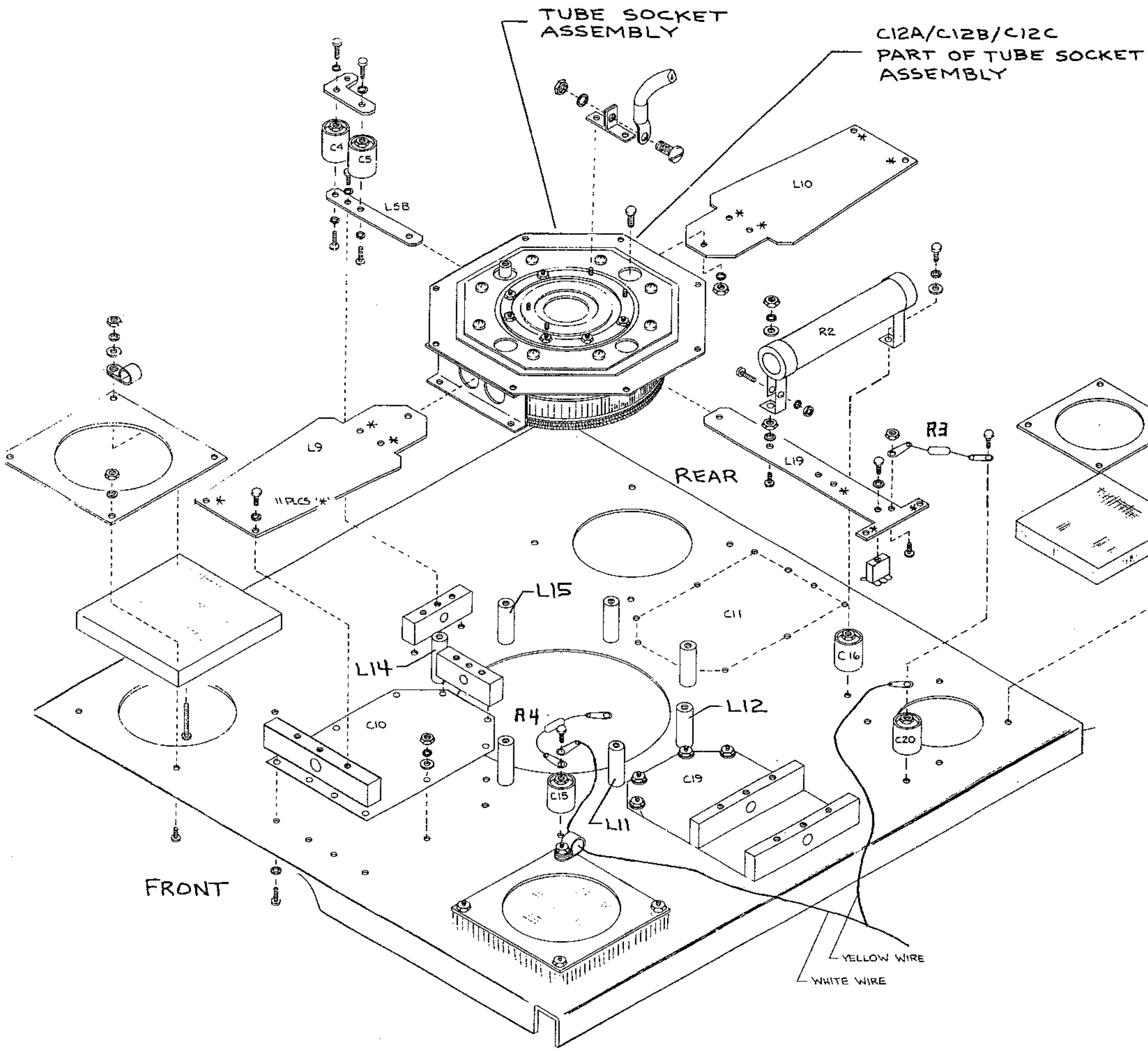
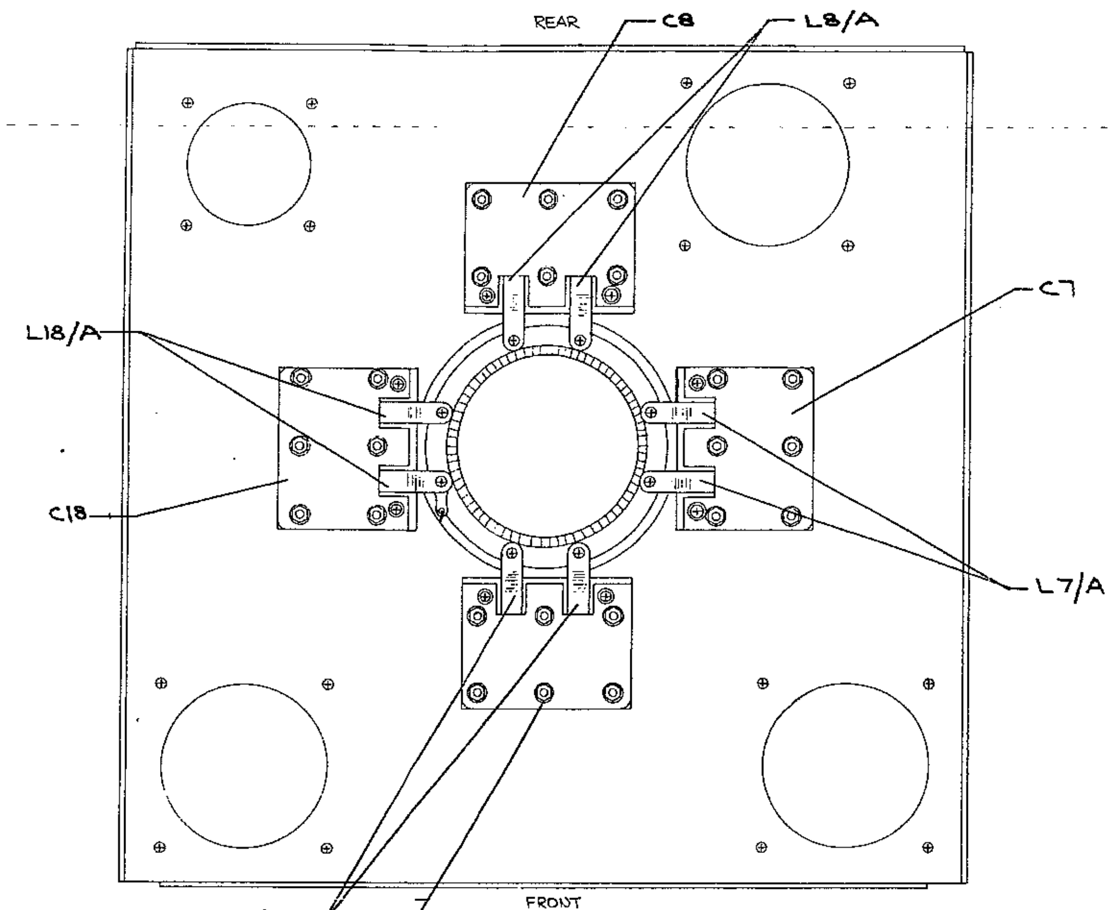
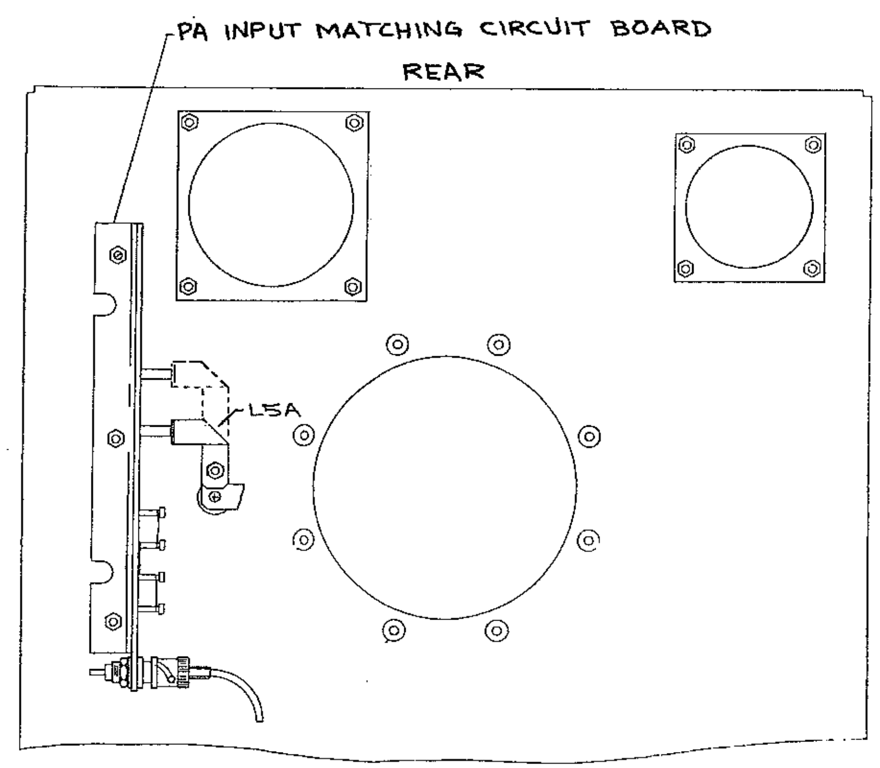
597–0220–24

FIGURE 4–3.
FM–20B RF CIRCUIT SIMPLIFIED SCHEMATIC





DETAIL "A"



DETAIL "B"

597-0220-33

FIGURE 5-11. PA INPUT CIRCUIT COMPONENT LOCATOR

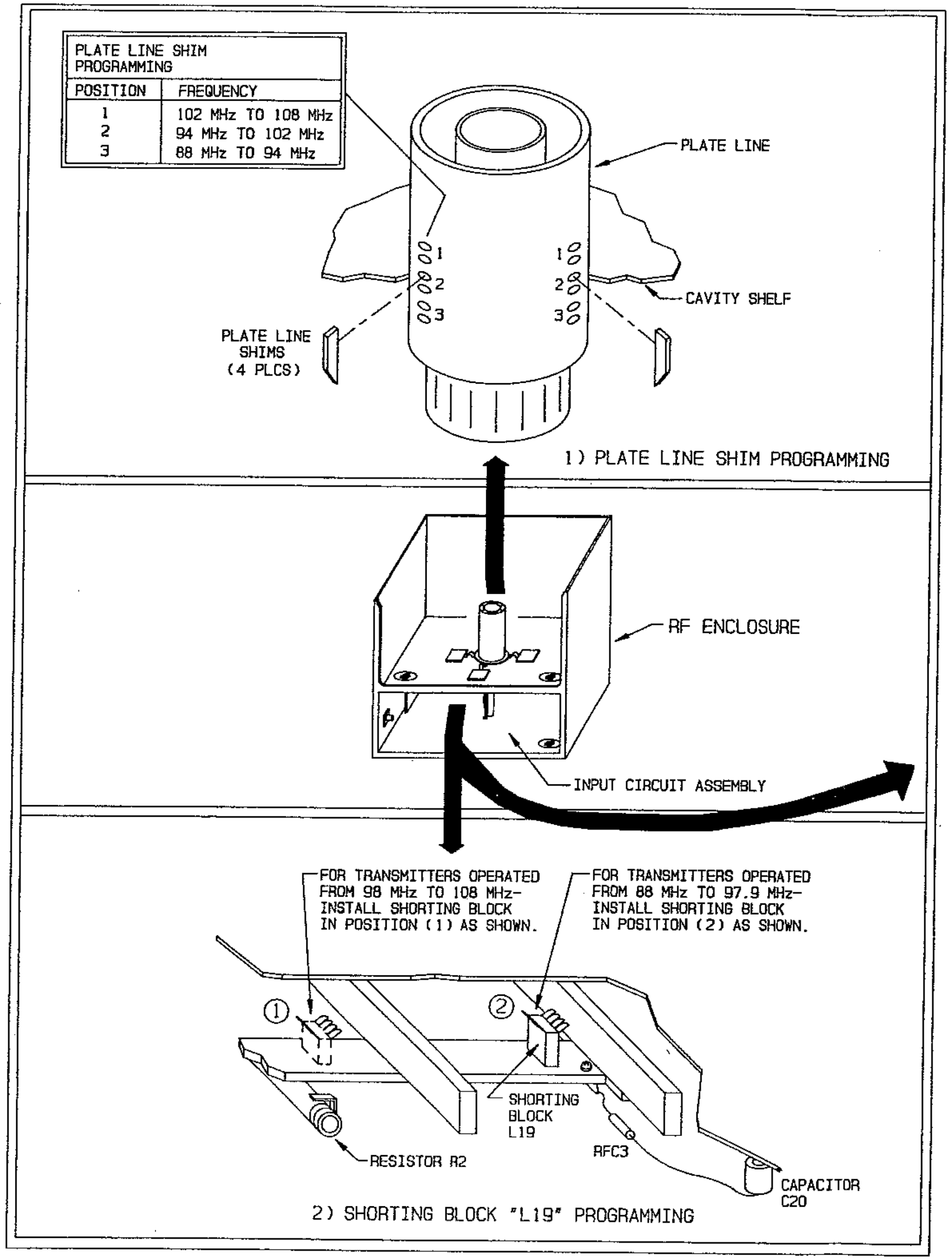
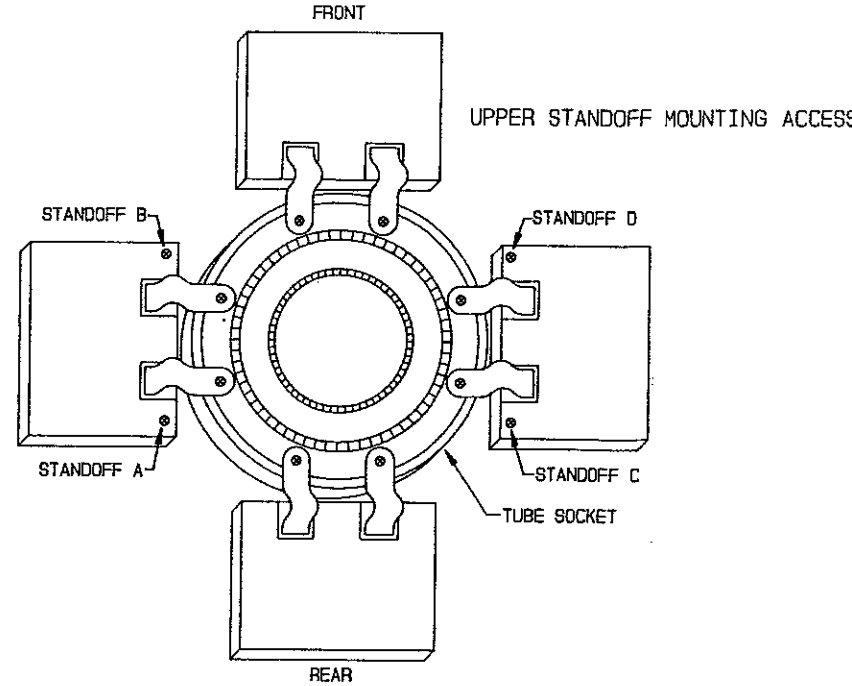


PLATE LINE SHIM PROGRAMMING	
POSITION	FREQUENCY
1	102 MHz TO 108 MHz
2	94 MHz TO 102 MHz
3	88 MHz TO 94 MHz



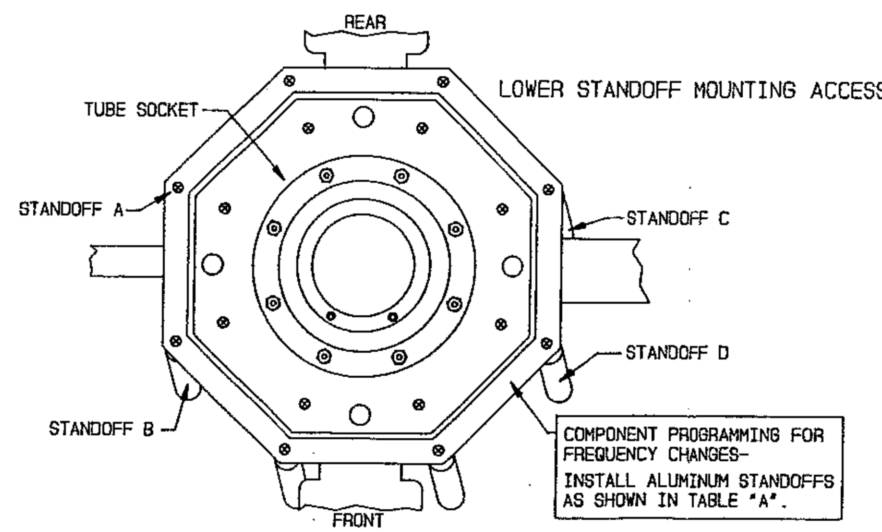


TABLE "A"

CONFIGURATION	FREQUENCY	ALUMINUM STANDOFF	BE STANDOFF-PART NUMBER	STANDOFF DIAMETER
1	88MHz-91MHz	B,C	441-0157	.375 O.D.
2	91MHz-93MHz	B,C	441-0162	.500 O.D.
3	93MHz-98MHz	A,B,C	441-0157	.375 O.D.
4	98MHz-102MHz	A,B,C	441-0157	.375 O.D.
5	102MHz-108MHz	A,B,C,D	441-0157	.375 O.D.

NOTE: ALL OTHER MOUNTING STANDOFFS ARE DELRIN.

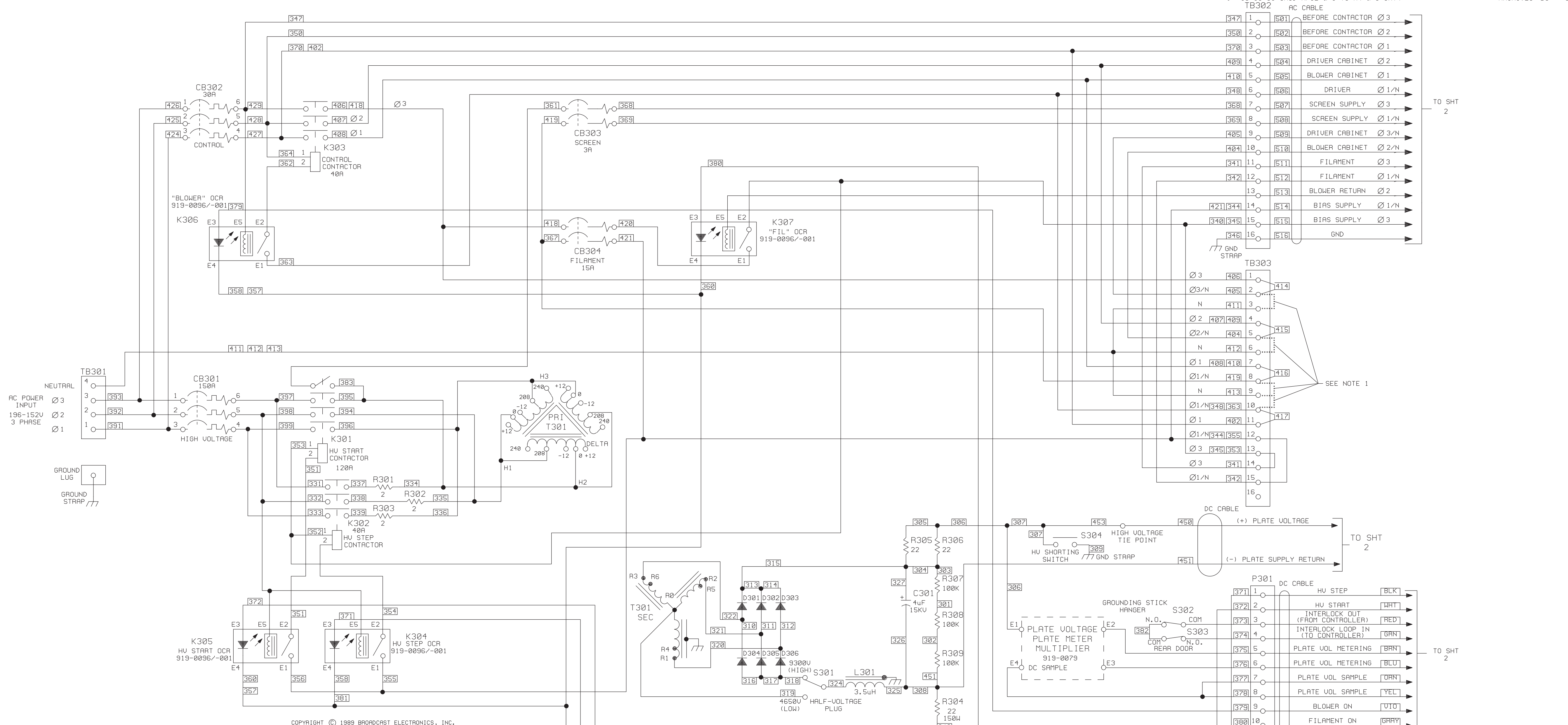
3) TUBE SOCKET MOUNTING STANDOFF PROGRAMMING

597-0220-126

FIGURE 5-6. COMPONENT PROGRAMMING FOR FREQUENCY CHANGES

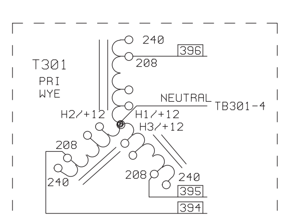
REV	DATE	DESCRIPTION	DFTSMN	ENGR	ECN
K	3-3-94	SEE SHEET 2	MH	BG	9097A
L	9-29-94	SEE SHEET 3	MH	BG	9259
M	1-18-96	REMOVED OPTIONAL FILAMENT VOLTAGE REGULATOR.	AEB		9649

REV	DATE	DESCRIPTION	DFTSMN	ENGR	ECN
A	3-18-89	ENGINEERING RELEASE	JAH	MBS	----
B	8-1-89	ADDED AC POWER STRIP INFORMATION TO SHT 2	JAH	MBS	7878
C	10-9-89	UPDATED DOCUMENTATION	ELP	MBS	7988
D	1-24-90	ADDED WIRE COLORS TO DC CABLE SHT 1 & 2 ADDED WIRE No. 800 & 801 SHT 3.	RLC	DBN	8169 8181
E	3-7-90	DELETED F201 & F202 ADDED CB203 & CB204 SHT 2	RLC	MBS	8225
F	5-14-90	CHGD TB107 TO TB3 & TB108 TO TB2 SHT 3	JAH	MBS	8291
G	3-7-91	DELETED TB102 SHT 3	KLS	MBS	8473
H	6-19-91	CHGD CIRCUIT BREAKER CONFIG SHT2 DEL TB101 SHT3			
J	10-08-93	CHGD RFC2 & 3 TO R4 & 3 SHT4	ARCHIVES	BG	9037



NOTES:

1. FOR 50 HZ INSTALLION, CONNECT WIRE 672 TO REGULATOR TERMINAL H3. WIRE 658 TO REGULATOR TERMINAL X3. CONNECT WIRE 687 TO REGULATOR TRANSFORMER TERMINAL 9. MOVE THE CONNECTION FROM THE CAPACITOR FROM REGULATOR TRANSFORMER TERMINAL 7 TO TERMINAL 8.
2. JUMPERS SHOWN IN 208/240 PRIMARY DELTA CONFIGURATION ON TB303-1 THRU 11 FOR PRIMARY 380 WYE CONFIGURATION MOVE TO POSITIONS INDICATED BY DOTTED LINES.
3. FOR PRIMARY 380 WYE CONFIGURATION STRAP TAPS OF T301 AS FOLLOWS:
   H1 +12 TO H2 +12 WIRE No. 546
   H2 +12 TO H3 +12 WIRE No. 547
   H3 +12 TO TB301-4 WIRE No. 548
4. USING SECONDARY TAPS R4,R5,& R6 OF TB301 HIGH = 7100V, LOW = 3500V.



PRIMARY 380 WYE CONFIGURATION (SEE NOTE 2)

TOLERANCE (DECIMAL) U.O.S.
.x ± .030 .xxx ± .005
.xx ± .015 ANGLES ± 1°

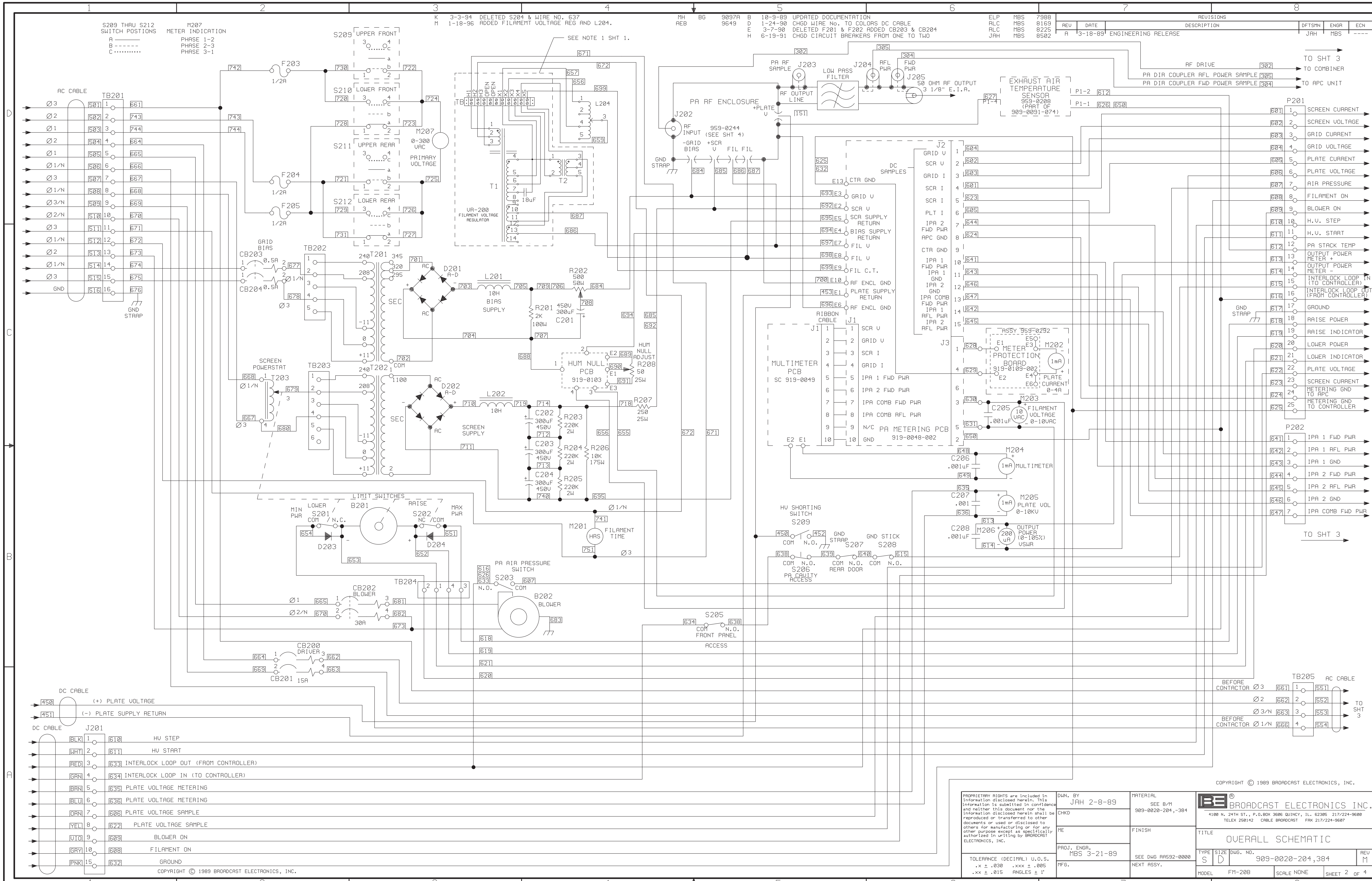
DWN. BY JAH 2-4-89	MATERIAL SEE B/M 909-0020-204,-384	
CHKD		
ME	FINISH	
PROJ. ENGR. MBS 3-21-89	SEE DWG RA592-0000	
MFG.	NEXT ASSY.	

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. 909-0020-204,-384 | REV M

MODEL FM-20B | SCALE NONE | SHEET 1 OF 4


K 3-3-94 DELETED S204 & WIRE NO. 637
M 1-18-96 ADDED FILAMENT VOLTAGE REG AND L204.
MH BG 9097A B 10-9-89 UPDATED DOCUMENTATION
REB 9649 D 1-24-90 CHGD WIRE No. TO COLORS DC CABLE
E 3-7-90 DELETED F201 & F202 ADDED CB203 & CB204
H 6-19-91 CHGD CIRCUIT BREAKERS FROM ONE TO TWO
ELP MBS 7988
ALC MBS 8169
ALC MBS 8225
JAH MBS 8502
REVISIONS
REV DATE DESCRIPTION DFTSMN ENGR ECN
A 3-18-89 ENGINEERING RELEASE JAH MBS
S209 THRU S212 SWITCH POSTIONS
M207 METER INDICATION
PHASE 1-2
PHASE 2-3
PHASE 3-1
TO SHT 3
TO COMBINER
TO APC UNIT
RF DRIVE
PA DIR COUPLER RFL POWER SAMPLE
PA DIR COUPLER FWD POWER SAMPLE
EXHAUST AIR TEMPERATURE SENSOR 959-0208 (PART OF 909-0091-074)
PA RF ENCLOSURE
LOW PASS FILTER
50 OHM RF OUTPUT 3 1/8" E.I.A.
MULTIMETER PCB SC 919-0049
PA METERING PCB 919-0048-002
HUM NULL PCB 919-0103
METER PROTECTION BOARD 919-0109-002
VR-200 FILAMENT VOLTAGE REGULATOR
AC CABLE
DC CABLE
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TOLERANCE (DECIMAL) U.O.S. .x ± .030 .xxx ± .005 .xx ± .015 ANGLES ± 1°
DWN. BY JAH 2-8-89
CHKD
ME
PROJ. ENGR. MBS 3-21-89
MFG.
MATERIAL SEE B/M 909-0020-204,-384
FINISH
SEE DWG AA592-0000
NEXT ASSY.
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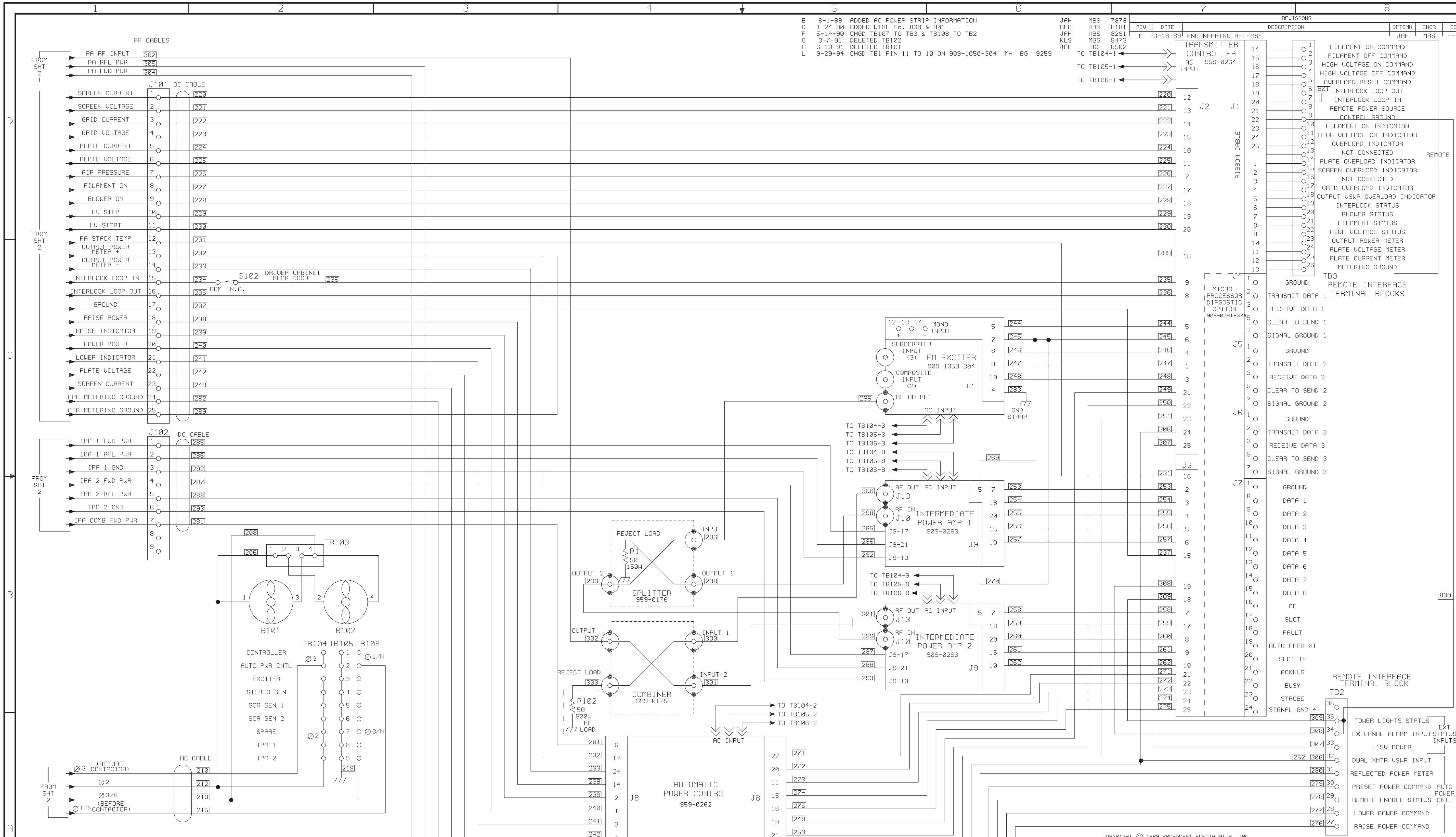
4100 N. 24TH ST., P.O.BOX 3606 QUINCY, IL. 62305 217/224-9600
TELEX 250142 CABLE BROADCAST FAX 217/224-9607
TITLE
OVERALL SCHEMATIC
TYPE S SIZE D DWG. NO. 909-0020-204,384 REV M
MODEL FM-20B SCALE NONE SHEET 2 OF 4



REV	DATE	DESCRIPTION	DFTSMN	ENGR	ECN
A	3-18-89	ENGINEERING RELEASE	JAH	MBS	----
B	8-1-89	ADDED AC POWER STRIP INFORMATION	JAH	MBS	7878
D	1-24-90	ADDED WIRE No. 800 & 801	RLC	DBN	8181
F	5-14-90	CHGD TB107 TO TB3 & TB108 TO TB2	JAH	MBS	8291
G	3-7-91	DELETED TB102	KLS	MBS	8473
H	6-19-91	DELETED TB101	JAH	BG	8502
L	9-29-94	CHGD TB1 PIN 11 TO 10 ON 909-1050-304	MH	BG	9259

TOLERANCE (DECIMAL) U.O.S. .x ± .030 .xxx ± .005 .xx ± .015 ANGLES ± 1°

DWN. BY JAH 2-10-89
CHKD
ME
PROJ. ENGR. MBS 3-21-89
MFG.

MATERIAL SEE B/M 909-0020-204,-384
FINISH
SEE DWG AA592-0000
NEXT ASSY.

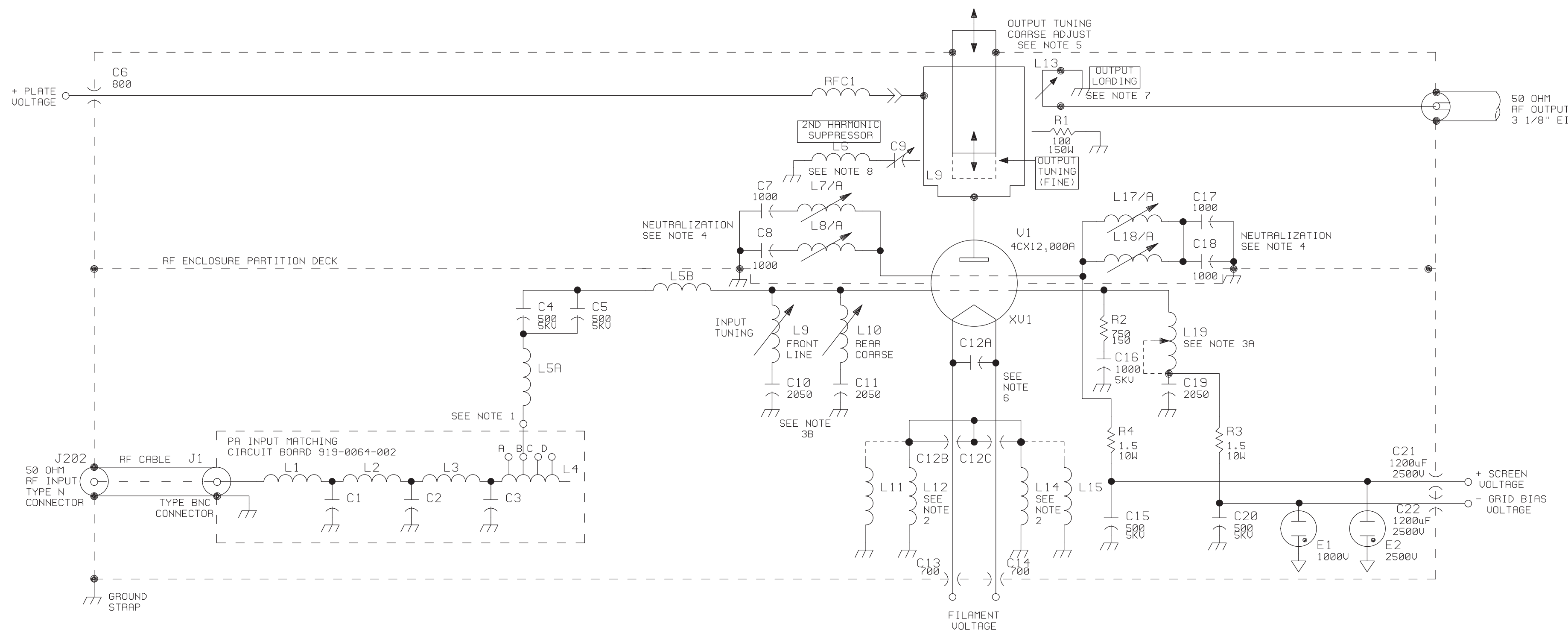
BROADCAST ELECTRONICS INC.
4100 N. 24TH ST., P.O.BOX 3606 QUINCY, IL. 62305 217/224-9600
TELEX 250142 CABLE BROADCAST FAX 217/224-9607

TITLE OVERALL SCHEMATIC

TYPE S | SIZE D | DWG. NO. 909-0020-204,-384 | REV M

MODEL FM-20B | SCALE NONE | SHEET 3 OF 4

REVISIONS					
REV	DATE	DESCRIPTION	DFTSMN	ENGR	ECN
A	3-18-89	ENGINEERING RELEASE	JAH	MBS	----
H	6-24-91	CHGD RF ENCLOSURE CONFIGURATION	JAH	MBS	8502
J	10-08-93	CHGD RFC2 & 3 TO R4 & 3 (NOW 132-0114)	ARCHIVES	BG	9037
M	1-18-96	SEE SHEETS 1 & 2.	AEB		----



NOTES:

CONSULT INSTRUCTION MANUAL FOR THE FOLLOWING:

1. SCHEMATIC SHOWS PA INPUT MATCHING STRAP (L5A) CONNECTED TO STANDARD TAP (POSITION B) OF INDUCTOR (L4) ON THE PA INPUT MATCHING PCB.
2. TUBE SOCKET MOUNTING STANDOFF (L11-L15) FREQUENCY DEPENDENT PART.
3. A) INPUT TUNING PLATE "SIDE" (L19) FREQUENCY DEPENDENT ADJUSTMENT.
   B) INPUT TUNING PLATES "FRONT & REAR" (L9,L10). FREQUENCY DEPENDENT ADJUSTMENT.
4. NEUTRALIZATION STRAPS (L7,L8,L17,L18) FREQUENCY DEPENDENT ADJUSTMENT.
5. OUTPUT TUNING HALF-WAVE FOLDED TRANSMISSION LINE (L9), COARSE AND FINE ADJUSTMENT, FREQUENCY DEPENDENT.
6. CAPACITORS C12A,B, & C ARE PART OF TUBE SOCKET XV1.
7. OUTPUT LOADING LOOP (L13) FREQUENCY AND OUTPUT POWER DEPENDENT ADJUSTMENT.
8. SECOND HARMONIC SUPPRESSOR (L6&C9) FREQUENCY DEPENDENT PARTS AND ADJUSTMENT.
9. ALL CAPACITORS IN pF: ALL RESISTORS IN OHMS, UNLESS OTHERWISE SPECIFIED.

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TOLERANCE (DECIMAL) U.O.S.
.x ± .030 .xxx ± .005
.xx ± .015 ANGLES ± 1°

DWN. BY JAH 2-13-89	MATERIAL SEE B/M 909-0020-204,-384	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
CHKD		
ME	FINISH	TITLE OVERALL SCHEMATIC
PROJ. ENGR. MBS 3-21-89	SEE DWG RA592-0000	TYPE S / SIZE D / DWG. NO. 909-0020-204,-384 / REV M
MFG.	NEXT ASSY.	MODEL FM-20B / SCALE NONE / SHEET 4 OF 4

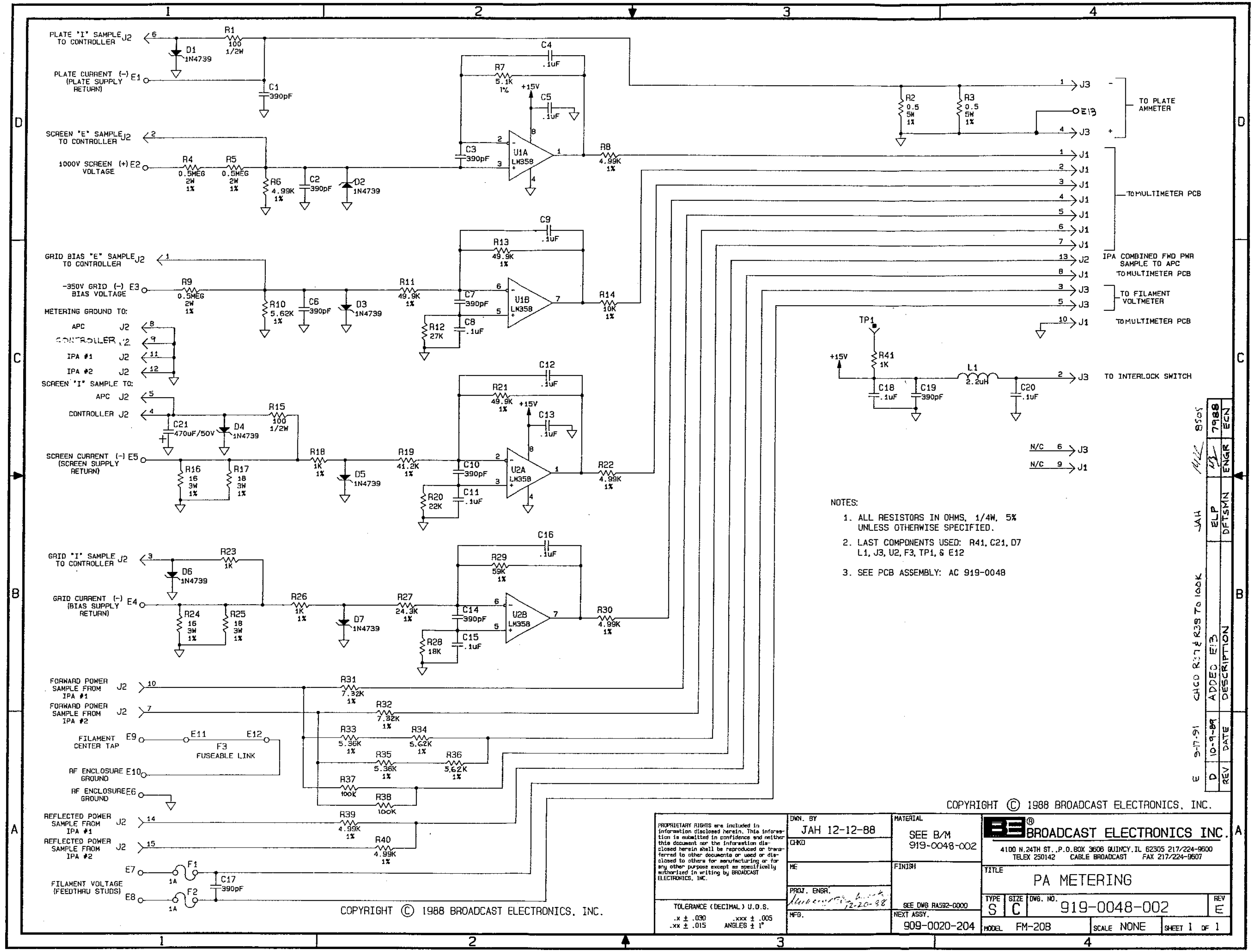
PLATE "I" SAMPLE TO CONTROLLER J2
PLATE CURRENT (-) (PLATE SUPPLY RETURN) E1
SCREEN "E" SAMPLE TO CONTROLLER J2
1000V SCREEN (+) VOLTAGE E2
GRID BIAS "E" SAMPLE TO CONTROLLER J2
-350V GRID (-) BIAS VOLTAGE E3
METERING GROUND TO:
APC J2
CONTROLLER J2
IPA #1 J2
IPA #2 J2
SCREEN "I" SAMPLE TO:
APC J2
CONTROLLER J2
SCREEN CURRENT (-) (SCREEN SUPPLY RETURN) E5
GRID "I" SAMPLE TO CONTROLLER J2
GRID CURRENT (-) (BIAS SUPPLY RETURN) E4
FORWARD POWER SAMPLE FROM IPA #1 J2
FORWARD POWER SAMPLE FROM IPA #2 J2
FILAMENT CENTER TAP E9
E11 E12
F3 FUSEABLE LINK
RF ENCLOSURE GROUND E10
RF ENCLOSURE GROUND E6
REFLECTED POWER SAMPLE FROM IPA #1 J2
REFLECTED POWER SAMPLE FROM IPA #2 J2
FILAMENT VOLTAGE (FEEDTHRU STUDS) E7 E8
TO PLATE AMMETER
TO MULTIMETER PCB
IPA COMBINED FWD PWR SAMPLE TO APC
TO MULTIMETER PCB
TO FILAMENT VOLTMETER
TO MULTIMETER PCB
TO INTERLOCK SWITCH
N/C 6 J3
N/C 9 J1
NOTES:
1. ALL RESISTORS IN OHMS, 1/4W, 5% UNLESS OTHERWISE SPECIFIED.
2. LAST COMPONENTS USED: R41, C21, D7 L1, J3, U2, F3, TP1, & E12
3. SEE PCB ASSEMBLY: AC 919-0048
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TOLERANCE (DECIMAL) U.O.S. .x ± .030 .xx ± .015 .xxx ± .005 ANGLES ± 1°
DWN. BY JAH 12-12-88
CHKD
ME
PROJ. ENGR.
MFG.
MATERIAL SEE B/M 919-0048-002
FINISH
SEE DWG RA592-0000
NEXT ASSY. 909-0020-204
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 PA METERING
TYPE S SIZE C DWG. NO. 919-0048-002 REV E
MODEL FM-20B SCALE NONE SHEET 1 OF 1
REV DATE DESCRIPTION DFTSMN ENGR ECN
D 10-9-89 ADDED E13 JAH
E 9-17-91 7988
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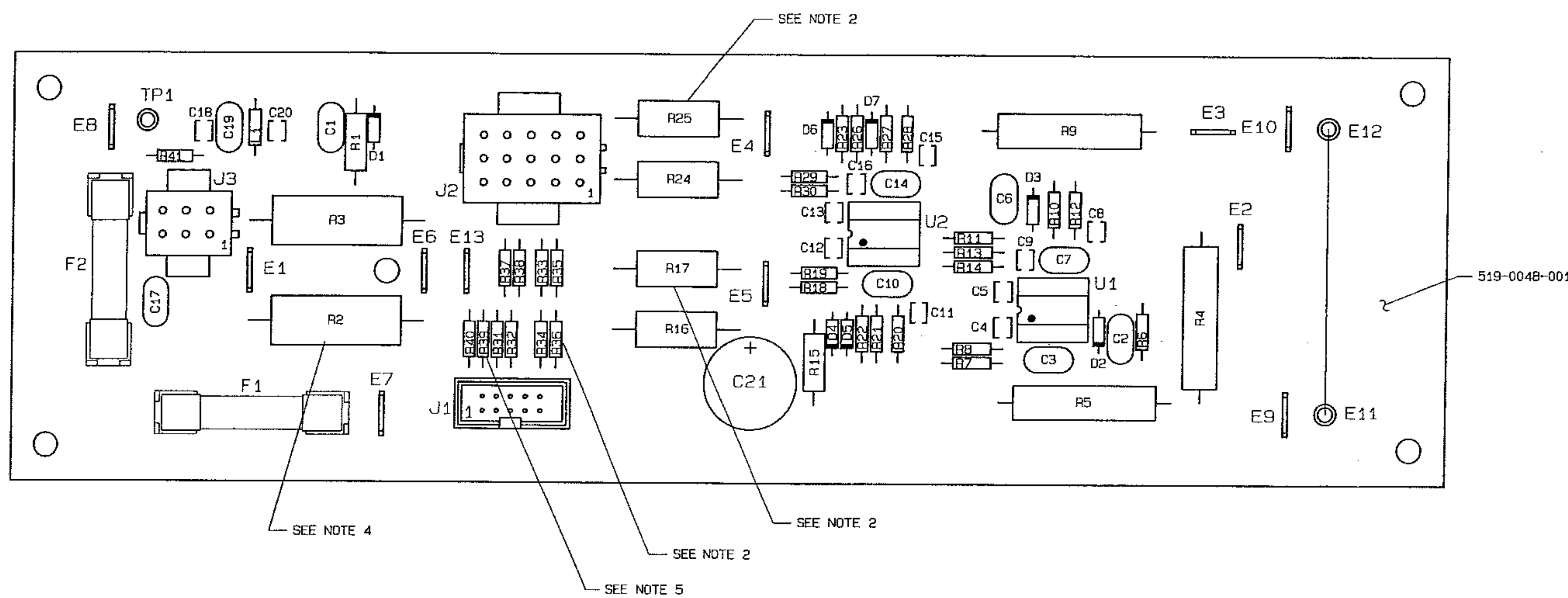
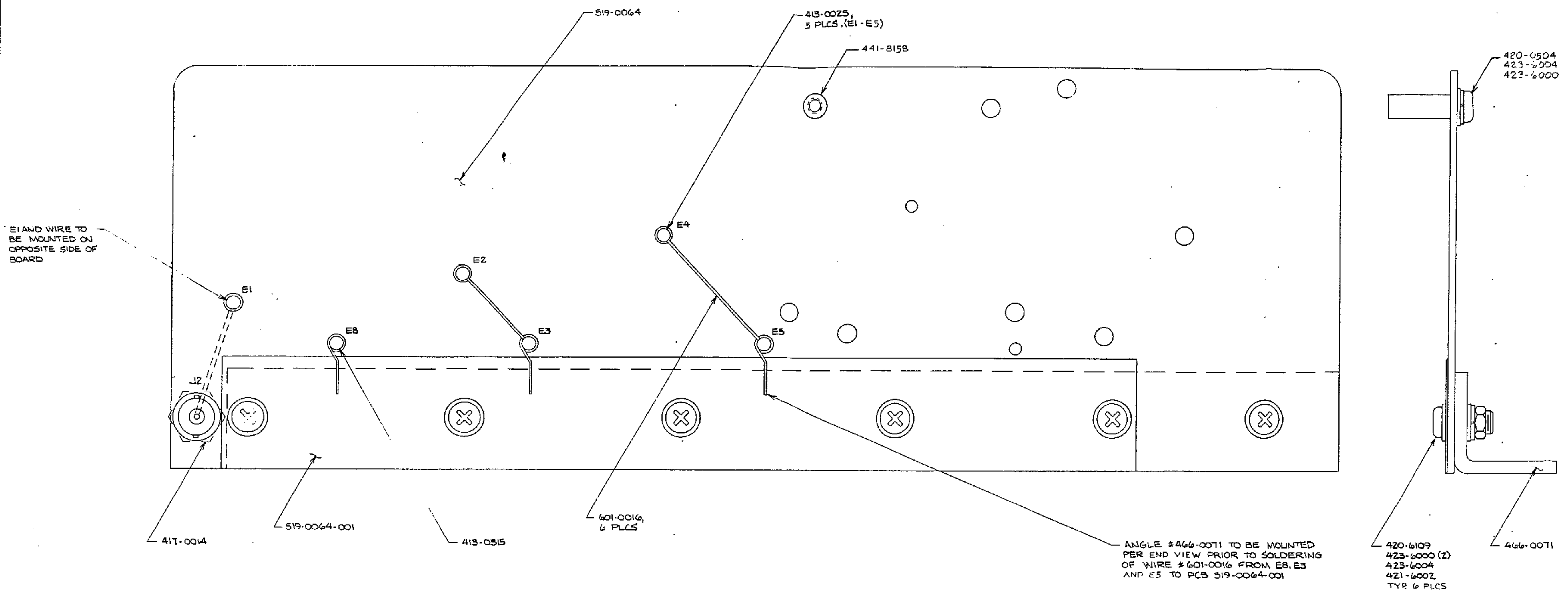


NOTES:

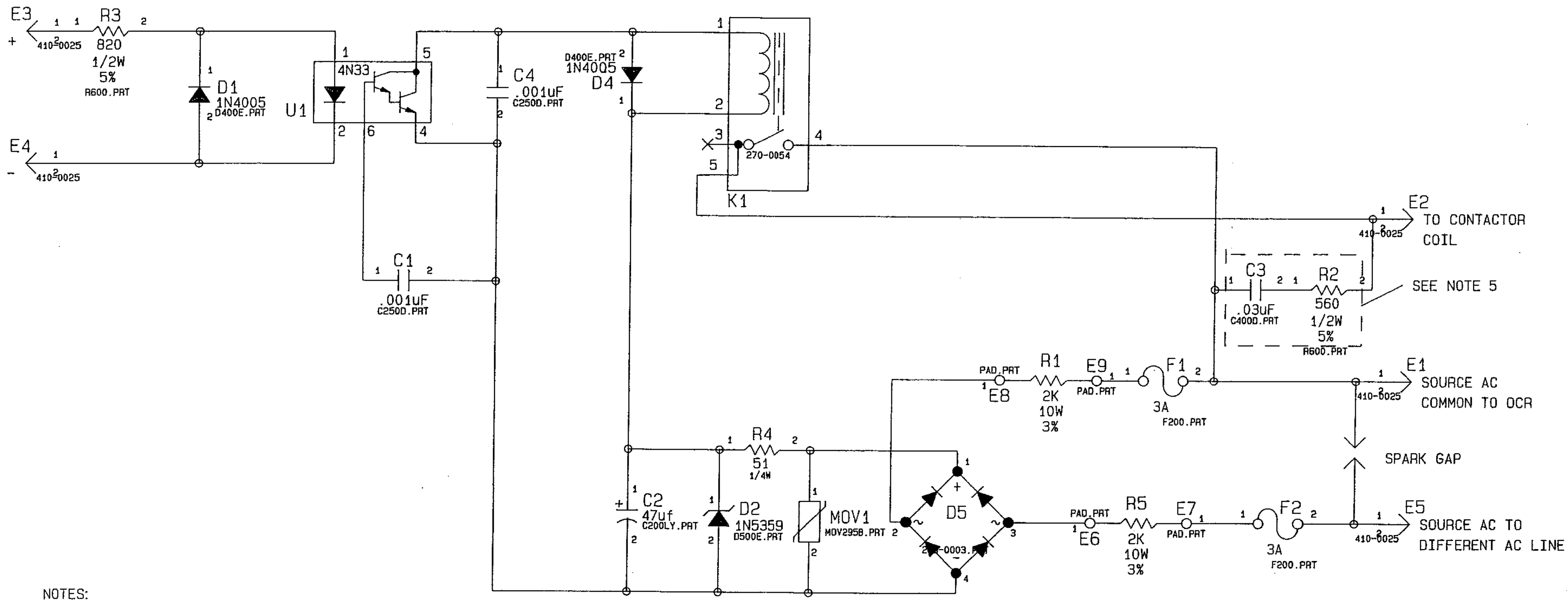
1. LAST COMPONENT USED: R41, C20, D7, L1, J3, U2, F3, TP1, E13
2. R17, R25, R32-R36, R39, R40 NOT USED ON MODELS: FM-3.5B, FM-5B, FM-5BS, FM-10B
3. SEE B/M AND SCHEMATIC 919-0048-001 FOR FM-30B, FM-35B
   SEE B/M AND SCHEMATIC 919-0048-002 FOR FM-20B
   SEE B/M AND SCHEMATIC 919-0048-003 FOR FM-10B
   SEE B/M AND SCHEMATIC 919-0048-004 FOR FM-3.5B, FM-5B, FM-5BS
4. R2, R3 BODY SIZE IS LARGER THAN SHOWN ON MODELS: FM30B, FM-35B.
5. ADD W1 601-0022 WIRE IN PLACE OF R39 ON:
   PCB 919-0048-003 FM-10B
   PCB 919-0048-004 FM-3.5B, FM-5B

TOLERANCE DECIMAL U.O.S.
.X ± .030 .XXX ± .005
.XX ± .015 ANGLES ± 1°

DWN BY: KLS 9-17-87	MATERIAL: SEE NOTE 3	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
CHKD: MH 1-5-89		
ME: JH STEINKAMP 1-5-89	FINISH	TITLE: PCB ASSEMBLY- PA METERING BD.
PROJ. ENGR: MUKANDA SHRESTHA 1-5-89		TYPE: A / SIZE: D / DWG.NO. 919-0048-001, -002, -003, -004 / REV: G
MFG.: PR BROSE 1-5-89	NEXT ASSY	MODEL: SEE NOTE 3 / SCALE: 2/1 / SHEET 1 OF 1



TOLERANCE (DECIMAL) U.O.S. .x ± .030 .xxx ± .005 .xx ± .015 ANGLES ± 1°	DWN. BY 8-2-88 M. HAYDEN	MATERIAL SEE B/M 919-0064-002	BROADCAST ELECTRONICS INC. 4100 N. 24TH ST., P.O. BOX 3606 QUINCY, IL 62305 217/224-9600 TELEX 250142 CABLE BROADCAST
	CHKD	FINISH	TITLE ASSY, P.A. INPUT MATCHING PCB
	ME	~~SEE DWG RA602-0000~~	TYPE A SIZE D DWG. NO. 919-0064-002 REV
	PROJ. ENGR 4-6-87	NEXT ASSY.	MODEL FM-CCA SCALE 2/1 SHEET 1 OF 1
	MFG.		



NOTES:

1. ALL RESISTORS IN OHMS; 1/4W, 1% UNLESS OTHERWISE SPECIFIED.
2. LAST COMPONENT USED: R5, F2, MOV1, C4, D4, U1, K1, E9
3. COMPONENTS NOT USED: D3
4. SEE ASSEMBLY: AB 919-0096
5. THESE COMPONENTS NOT USED ON 919-0096-001 C3, R2

TOLERANCE (DECIMAL) U.O.S.
.x ± .030 .xxx ± .005
.xx ± .015 ANGLES ± 1°

DWN. BY JAH 11-26-91	MATERIAL SEE B/M 919-0096 919-0096-001
CHKD BG 11-92	
ME	FINISH
PROJ. ENGR. BG 11-92	SEE DWG RA592-0000
MFG.	NEXT ASSY.

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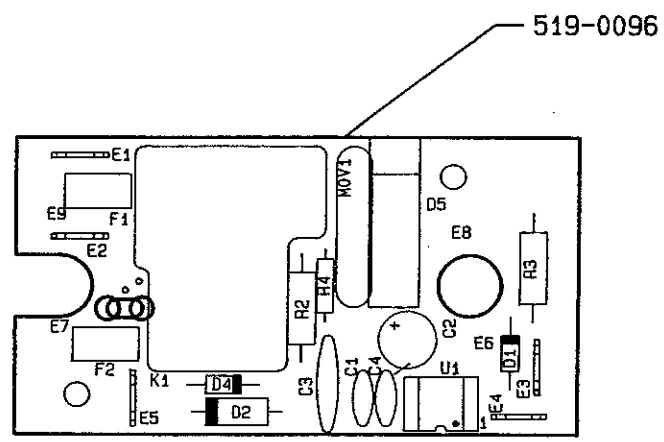
TELEX 250142 CABLE BROADCAST FAX 217/224-9607

TITLE OPTICALLY COUPLED RELAY

TYPE	SIZE	DWG. NO.	REV
S	B	919-0096, -001	J

MODEL FM XMTR'S | SCALE NONE | SHEET 1 OF 1



NOTE: R2 AND C3 FOR 919-0096-001 NOT INSTALLED.

TOLERANCE (DECIMAL) U.O.S.
.X ± .030 .XXX ± .005
.XX ± .015 ANGLES ± 1°

DWN. BY	JAH 12-13-91
DESIGNER (S)	
PROJ. LEADER	J.TUCKER 7-14-86
MFG.	J.STEINKAMP 7-14-86
MATERIAL	SEE B/M 919-0096 919-0096-001
FINISH	SEE DWG RA592-0000
NEXT ASSY.	

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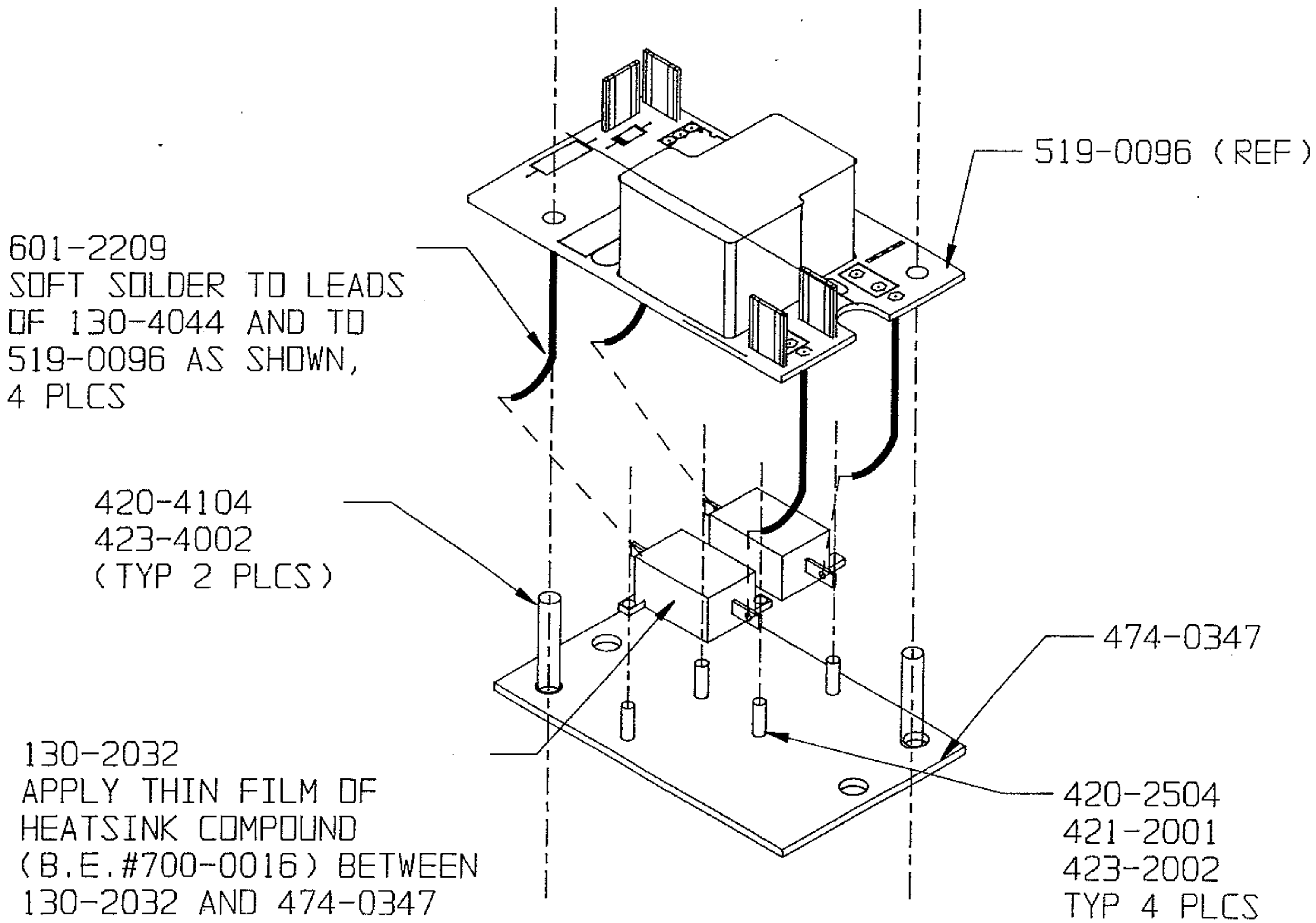
TELEX 250142 CABLE BROADCAST FAX 217/224-9607

TITLE PCB ASSEMBLY
OPTICALLY COUPLED RELAY BD.

TYPE	SIZE	DWG No.	REV
A	B	919-0096, 919-0096-001	L

MODEL TRANSMITTERS SCALE 1=1 SHEET 1 OF 2



DWN. BY	MSE 7-11-86
DESIGNER(S)	
PROJ. LEADER	J.STEINKAMP 7-14-86
MFG.	
MATERIAL	SEE B/M 919-0096
FINISH	SEE DWG RA592-0000
NEXT ASSY.	
TOLERANCE (DECIMAL) U.O.S.	.x ± .030 .xx ± .015 .xxx ± .005 ANGLES ± 1°

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	ASSY, PCB OPTICALLY COUPLED RELAY (OCR)
TYPE	A
SIZE	B
DWG. NO.	919-0096 919-0096-001
REV	J
MODEL	XMTRS
SCALE	
SHEET	2 OF 2

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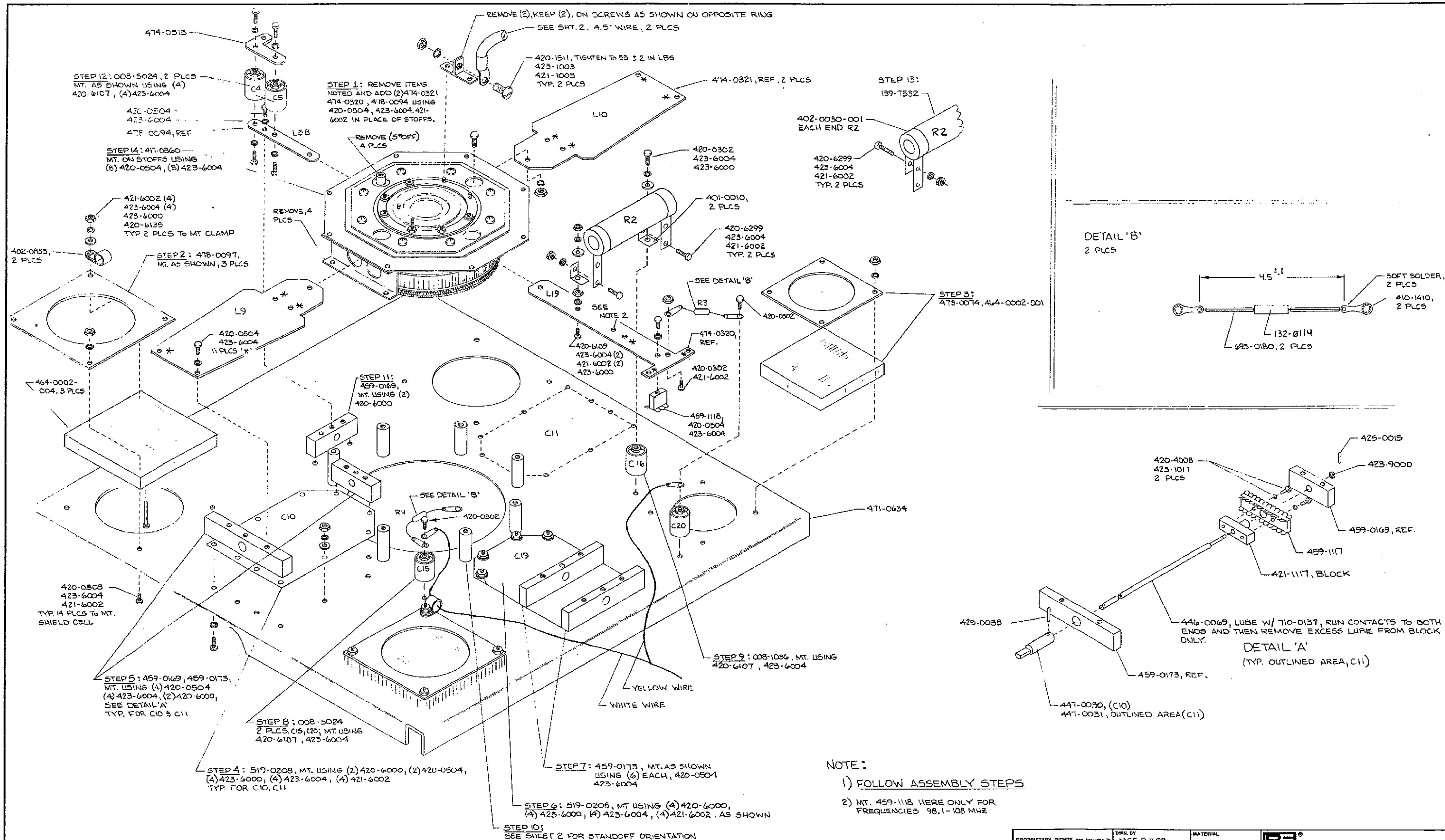


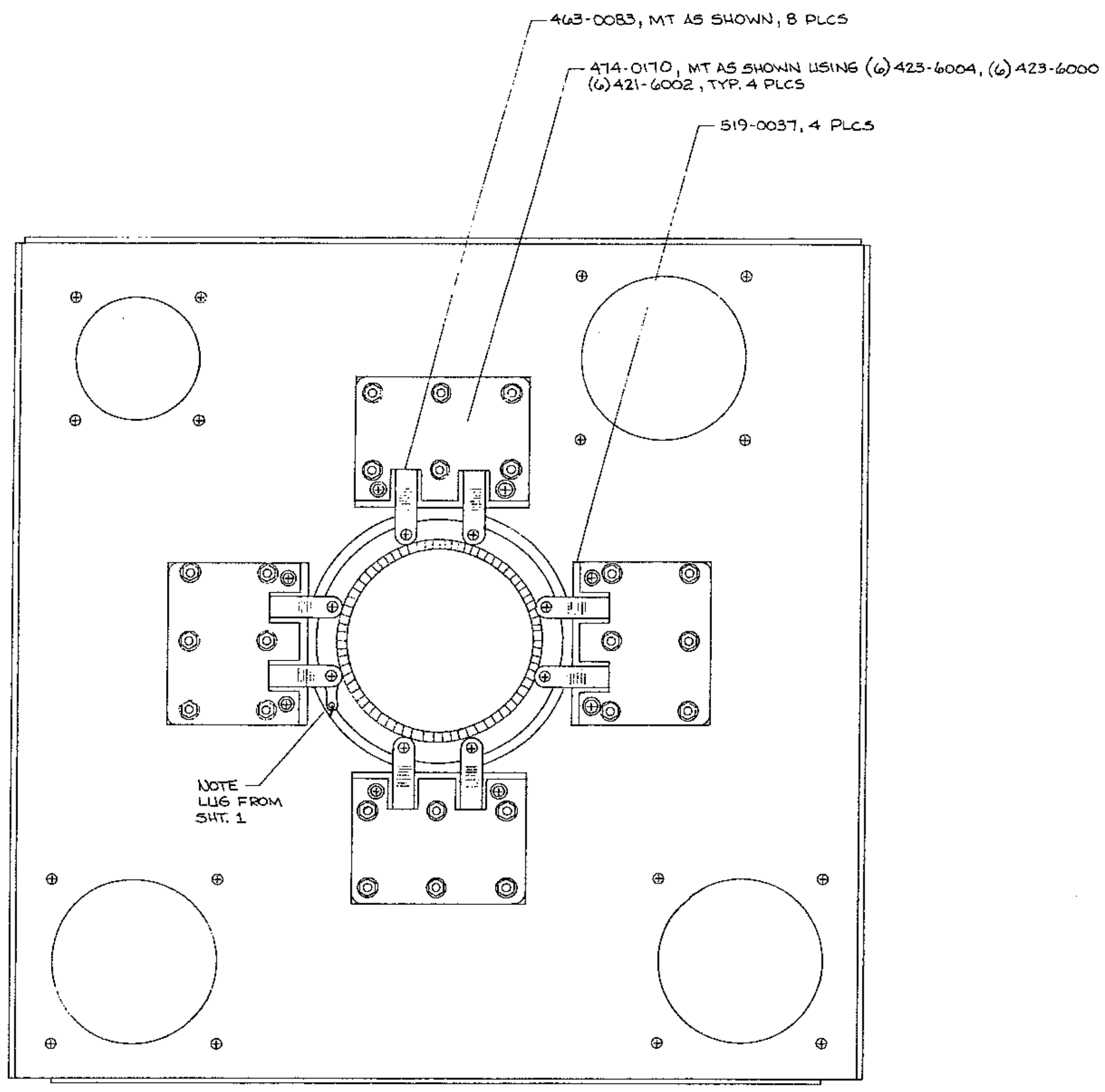
NOTE:

1) FOLLOW ASSEMBLY STEPS

2) MT. 459-1118 HERE ONLY FOR FREQUENCIES 98.1-108 MHZ

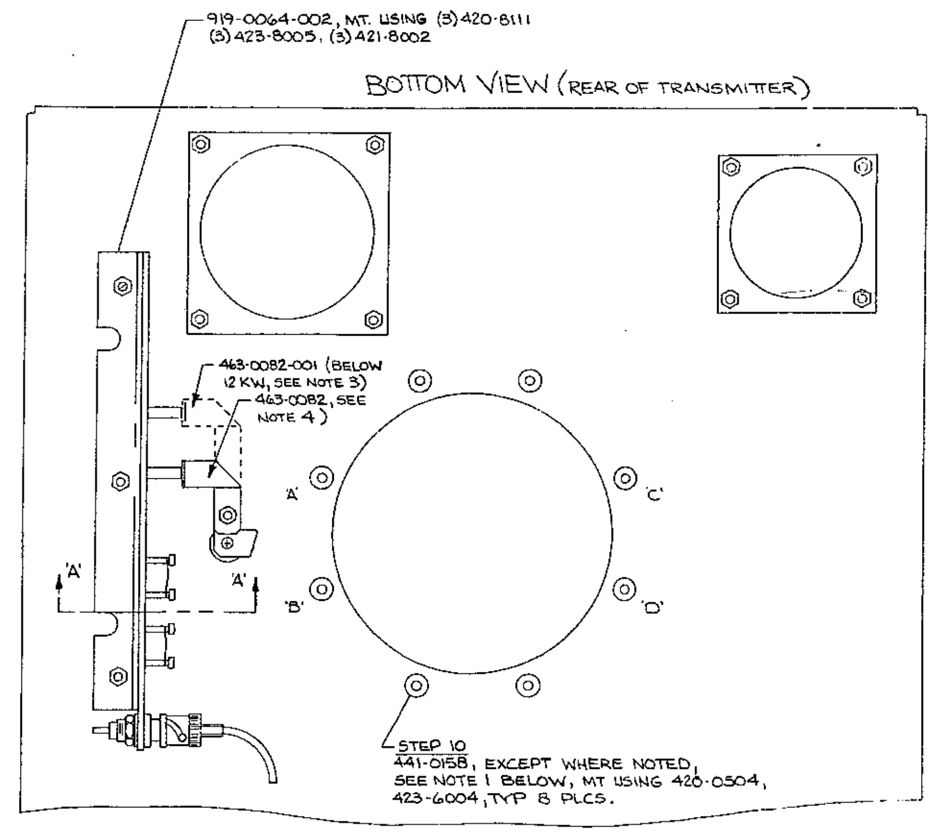
TOLERANCE (DECIMAL) U.O.S. .x ± .030 .xxx ± .005 .xx ± .015 ANGLES ± 1°	DWN. BY MSE 9-7-88	MATERIAL SEE B/M 959-0245	BROADCAST ELECTRONICS INC. 4100 N. 24TH ST., P.O.BOX 3606 QUINCY, IL 62305 217/224-9600 TELEX 250142 CABLE BROADCAST
	CHKD	FINISH	TITLE — ASSY — TUBE SOCKET
	ME	SEE DWG RA592-0000	TYPE A · SIZE D · DWG. NO. 959-0245 · REV 4
	PROJ. ENGR.	NEXT ASSY.	MODEL FM20A/B · SCALE ∼ · SHEET 1 OF 2
	MFG.		

MOUNT THESE LAST

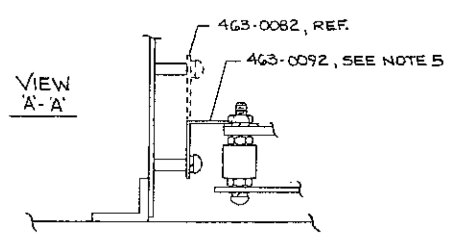


TOP VIEW (FRONT OF TRANSMITTER)

BOTTOM VIEW (REAR OF TRANSMITTER)



VIEW 'A'-'A'



FREQUENCY	STANDOFF	PART No.	STANDOFF
87.5-91 MHZ	B + C	441-0157	.375 O.D. AL.
91.1-93 MHZ	B + C	441-0162	.50 O.D. AL.
93.1-98 MHZ	A, B + C	441-0157	.375 O.D. AL.
98.1-102 MHZ	A, B + C	441-0157	.375 O.D. AL.
102.1-108 MHZ	A, B, C + D	441-0157	.375 O.D. AL.

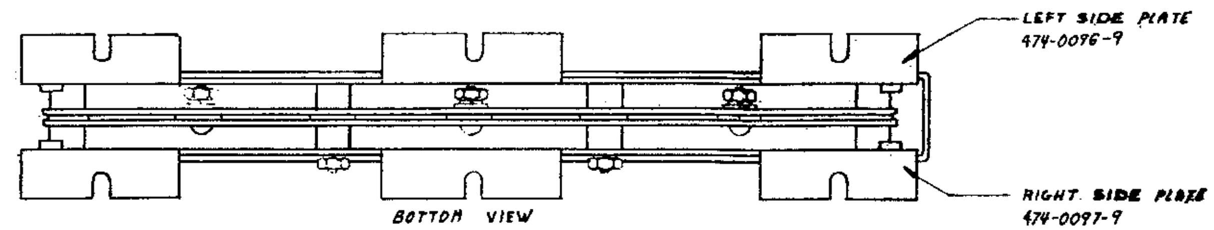
WIRE PART No.	LENGTH	STRIP	LUG PART No.	WIRE No.
610-0206	4.5"	.60/.60	410-0004/410-1015	
"	"	" "	" / "	
"	16.0	.60/.50	410-0004/410-1015	686
"	"	.60/.60	410-0004/410-0004	687
601-1604	14.0	.25/.25	/410-1410	
610-0200	14.0	.25/.25	/410-1410	

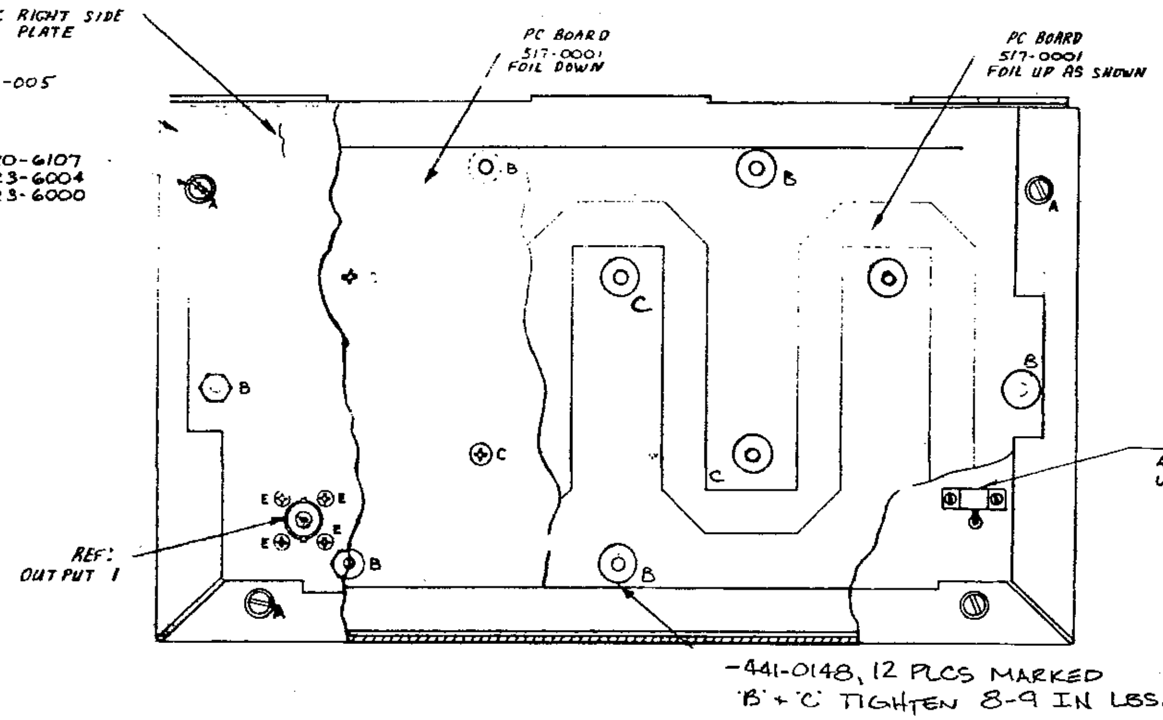
NOTES:

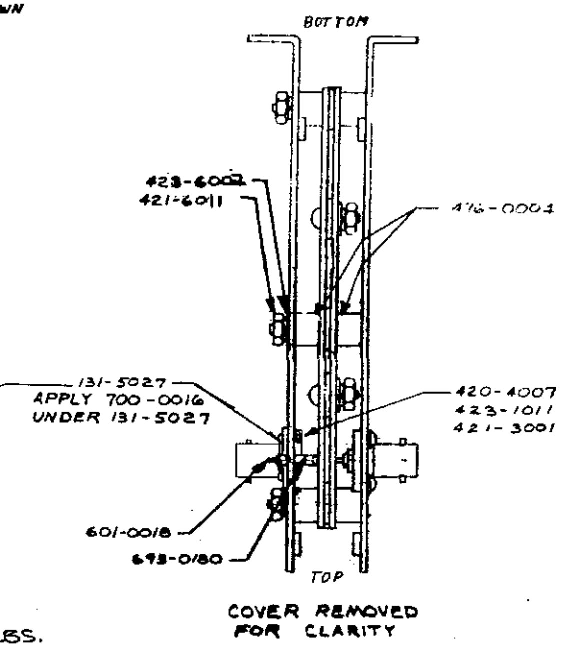
1) ASSEMBLE FREQ. DEPENDENT STOFFS FOR THE CUSTOMER FREQUENCY SPECIFIED IN THE SALES ORDER PER THE CHART ABOVE. IF FREQUENCY IS NOT SPECIFIED ASSEMBLE FOR DEFAULT FREQUENCY RANGE OF 98-102.
2) BAG REMAINING STANDOFFS AND SEND TO TEST WITH XMTR.
3) USE ONLY WHEN NEEDED FOR BETTER INPUT MATCH, TO BE DETERMINED AT FINAL TEST.
4) STANDARD, THIS PART TO BE INSTALLED DURING TRANSMITTER ASSEMBLY.
5) ABOVE 20 KW, USE ONLY WHEN NEEDED FOR BETTER INPUT MATCH, TO BE DETERMINED BY FINAL TEST.

TOLERANCE (DECIMAL) U.O.S.
.x ± .030 .xxx ± .005
.xx ± .015 ANGLES ± 1°

DWN. BY MSE 9-7-88	MATERIAL SEE B/M 959-0245	BROADCAST ELECTRONICS INC. 4100 N. 24TH ST., P.O. BOX 3606 QUINCY, IL 62305 217/224-9600 TELEX 250142 CABLE BROADCAST	
CHKD			
ME [illegible]	FINISH	TITLE — ASSY — TUBE SOCKET	
PROJ. ENGR. [illegible]	SEE DWG RA592-0000	TYPE A SIZE D DWG. NO. 959-0245	REV G
MFG. [illegible]	NEXT ASSY.	MODEL FM 20A SCALE ~	SHEET 2 OF 2

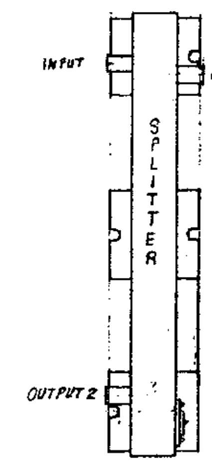






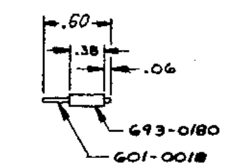
SEQUENCE & ASSY. PROCEDURE

1. Ref: Drawing AD 959-0176 and BM 959-0176
2. Temporarily assemble the BNC connectors 417-0203 on the left side plate 474-0096-9 with hardware shown on drawing.
3. Place a P.C. Board 517-0001 on the left side plate and allign the two connector holes with the connector center pins. Temporarily assemble with screws 420-6119 and spacers 476-0004, flat washers 423-6000 and Hex nuts 421-6002, tighten hardware to ensure that the PCB is firmly in position and parallel with the side plate. Note: The foil faces to the inside or middle of the unit.
4. Solder the BNC connectors center pins to the foil holes on the PCB.
5. Remove the hardware and scpacers assembled in steps 2 and 3 and lay parts aside for later assembly.
6. Temporarily assemble the BNC connectors 417-0203 on the right side plate 474-0097-9 with hardware shown on the drawing.
7. Place a PCB #517-0001 on the right side plate and align the foil holes in the PCB to the BNC connector center pin. Temporarily assemble with screws 420-6119, spacers 476-0004, flat washers 423-6000 and Hex nuts 421-6002, tighten the hardware to insure that the PCB is firmly in position and parallel with the side plate. Note: The foil faces to the inside or middle of the unit.
8. Insert wire 601-0018 with sleeving 693-0180 into the matching hole in the PCB.
9. Solder the BNC center pin and wire the foil holes in the PCB.
10. Remove the hardware and spacers assembled in steps 6 and 7 and lay aside.
11. Assemble the two PC Boards and the top and lower separator plates (foil to inside) with screws 420-0504, flat washers, 423-6000, split lockwashers 423-6004 and Hex nuts 421-6002 in five locations nearest the center of the assembly. Note: All screws to be inserted from the side which has two BNC connectors.
12. Assemble the load resistor 131-5027 to the right side plate with hardware shown on the drawing. Apply heat sink compound 700-0016 between the resistor and sideplate.
13. Assemble both side plates on the assembly completed in step 11 using hardware and spacers shown on the drawing.
14. Solder the wire to the tab on the load resistor.
15. Install the cover as shown on the drawing.
16. Send to QC and test.

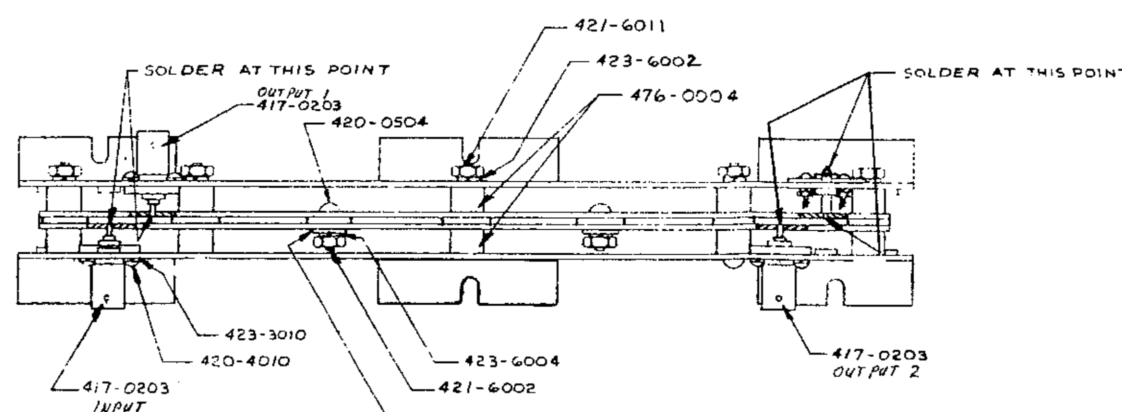


HOLE	HARDWARE USED	QTY
A	420-6107 423-6004 423-6000	8 8 8
B	476-0004 423-6011 421-6002	14 7 7
C	420-0504 423-6000 423-6004 421-6002	5 5 5 5
E	420-4010 423-3010	12 12
F	420-4007 423-1011 421-3001	2 2 2

NOTE:
ALL HARDWARE IS BRASS EXCEPT SPACERS

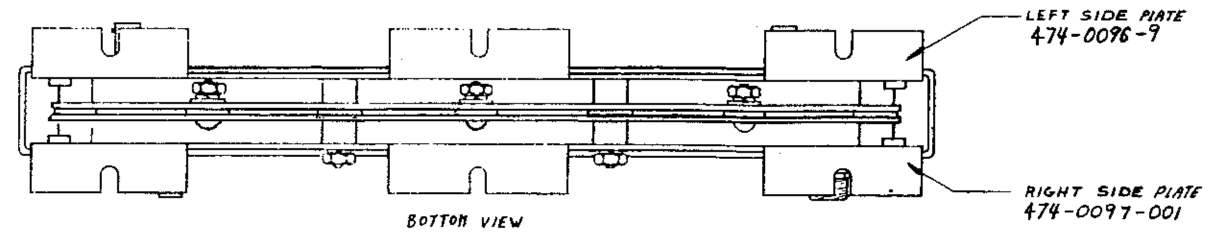


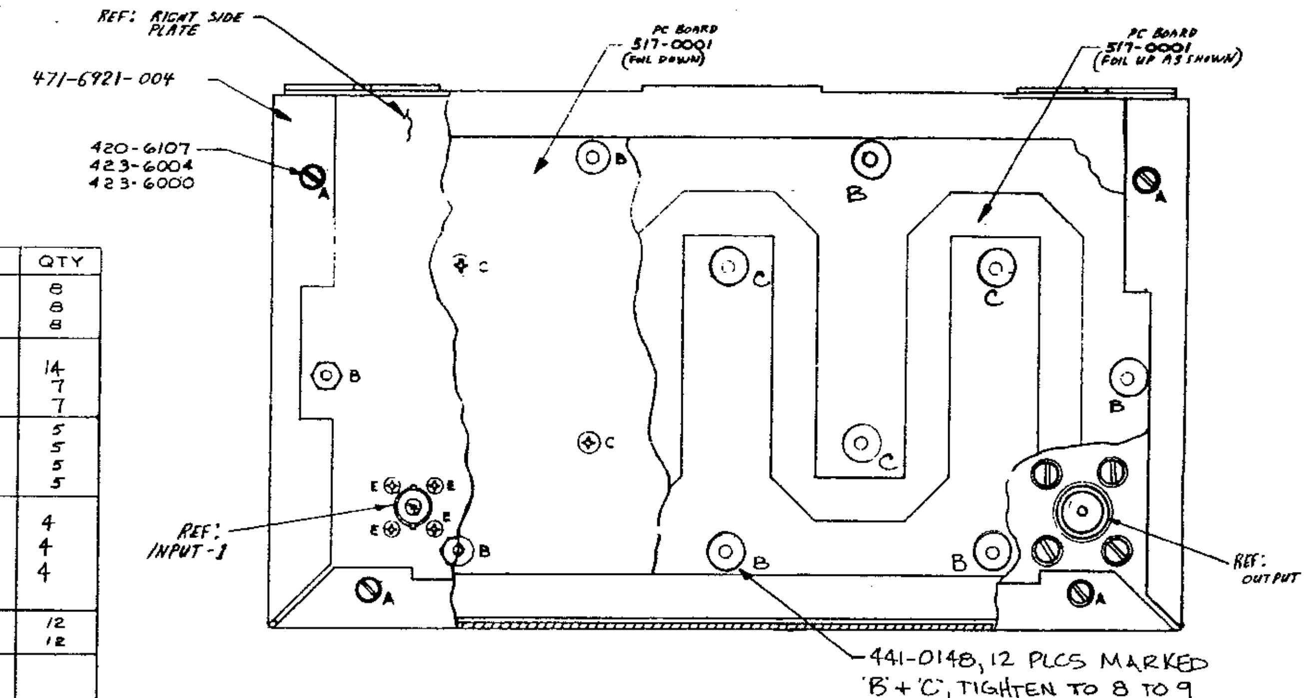
DETAIL OF LENGTHS FOR CUTTING

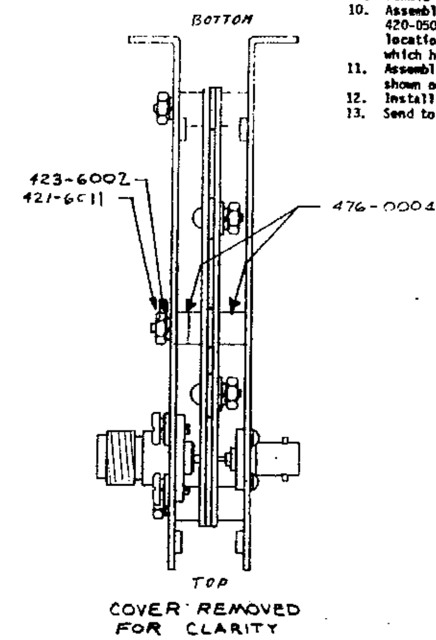


COVER REMOVED FOR CLARITY
VIEW FROM TOP

TOLERANCE UNLESS OTHERWISE SPECIFIED DECIMAL 2 PL = .01 3PL .005 FRACTIONAL ± 1/64 ANGULAR ± 1° SHARP EDGES TO BEND RADII FILLET RADII	DRAWN BY RHP CHECKED BY PROJECT ENGR JWS	DATE DATE DATE	BROADCAST ELECTRONICS INC. A FILMWAYS COMPANY
MATERIAL NOTED	APPROVED BY JS		TITLE ASSEMBLY SPLITTER
	TREATMENT OR FINISH		D DWG NO 959-0176 REV C
			FM 30-MA FM 300 B SCALE 1/1 SHEET 1 of 1

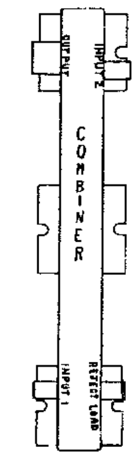






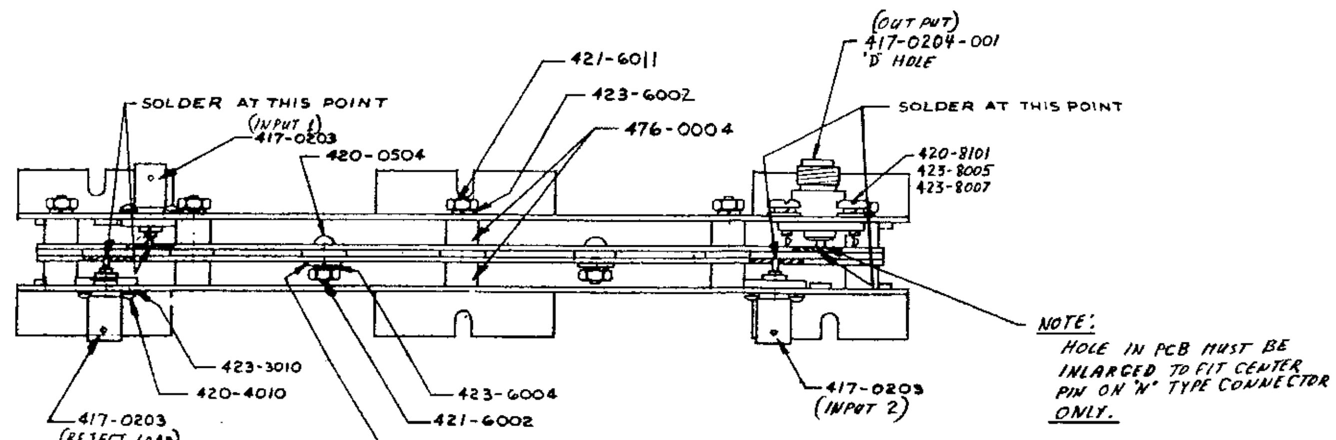
SEQUENCE & ASSY. PROCEDURE

1. Ref: Drawing AD 959-0175 and BM 959-0175
2. Temporarily assemble the BNC connector 417-0203 and "N" connector 417-0204-001 to the right side plate 474-0097-001.
3. Place a P.C. Board 517-0001 on the right side plate and allign the two connector holes with the connector center pins. Enlarge the hole for the "N" connector center pin to just fit. Temorarily assemble with screws 420-6119 and spacers 476-0004, flat washers 423-6000 and Hex nuts 421-6002, tighten hardware to ensure that the PCB is firmly in position and parallel with the side plate. Note: The foil faces to the inside or middle of the unit.
4. Solder the BNC & "N" connector center pins to the foil holes on the PCB.
5. Remove the hardware and spacers assembled in steps 3 and 4 and lay parts aside for later assembly.
6. Temporarily assemble the BNC connectors 417-0203 on the left side plate 474-0096-9 with hardware shown on the drawing.
7. Place a PCB #517-0001 on the left side plate and align the foil holes in the PCB to the BNC connector center pins. Temporarily assemble with screws 420-6119, spacers 476-0004, flat washers 423-6000 and Hex nuts 421-6002, tighten the hardware to insure that the PCB is firmly in position and parallel with the side plate. Note: The foil faces to the inside or middle of the unit.
8. Solder the BNC center pins to the foil holes in the PCB.
9. Remove the hardware and spacers assembled in steps 6 and 7 and lay aside.
10. Assemble the two PC Boards and the top and lower separator plates (foil to inside) with screws 420-0504, flat washers, 423-6000, split cockwashers 423-6004 and Hex nuts 421-6002 in five locations nearest the center of the assembly. Note: All screws to be inserted from the side which has two BNC connectors.
11. Assemble both side plates on the assembly completed in step 10 using hardware and spacers shown on the drawing.
12. Install the cover as shown on the drawing.
13. Send to QC and test.



HOLE	HARDWARE USED	QTY
A	420-6107 423-6004 423-6000	8 8 8
B	476-0004 423-6002 421-6011	14 7 7
C	420-0504 423-6000 423-6004 421-6002	5 5 5 5
D	420-8101 420-8005 423-8007	4 4 4
E	420-4010 423-3010	12 12
F		

NOTE: ALL HARDWARE IS BRASS EXCEPT SPACERS.



COVER REMOVED
FOR CLARITY
VIEW FROM TOP

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

MATERIAL: NOTED

DRAWN BY: RHB DATE: 10 APR. '84
CHECKED BY: DATE:
PROJECT ENGR.: JWS DATE:
APPROVED BY: JS
TREATMENT OR FINISH:

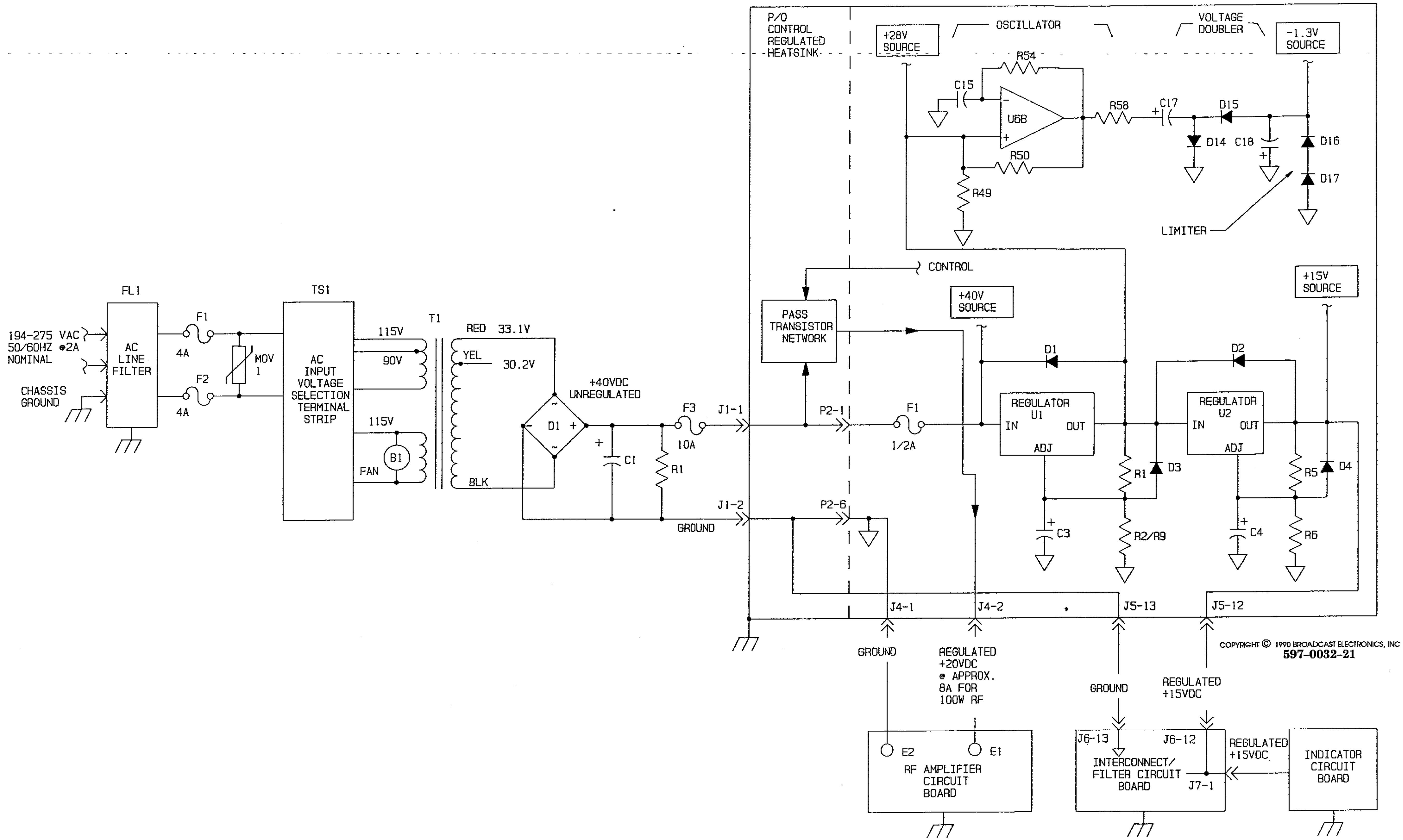
BROADCAST ELECTRONICS INC.
—A FILMWAYS COMPANY—

TITLE: ASSEMBLY, COMBINER

D DWG NO. 959-0175 REV. C

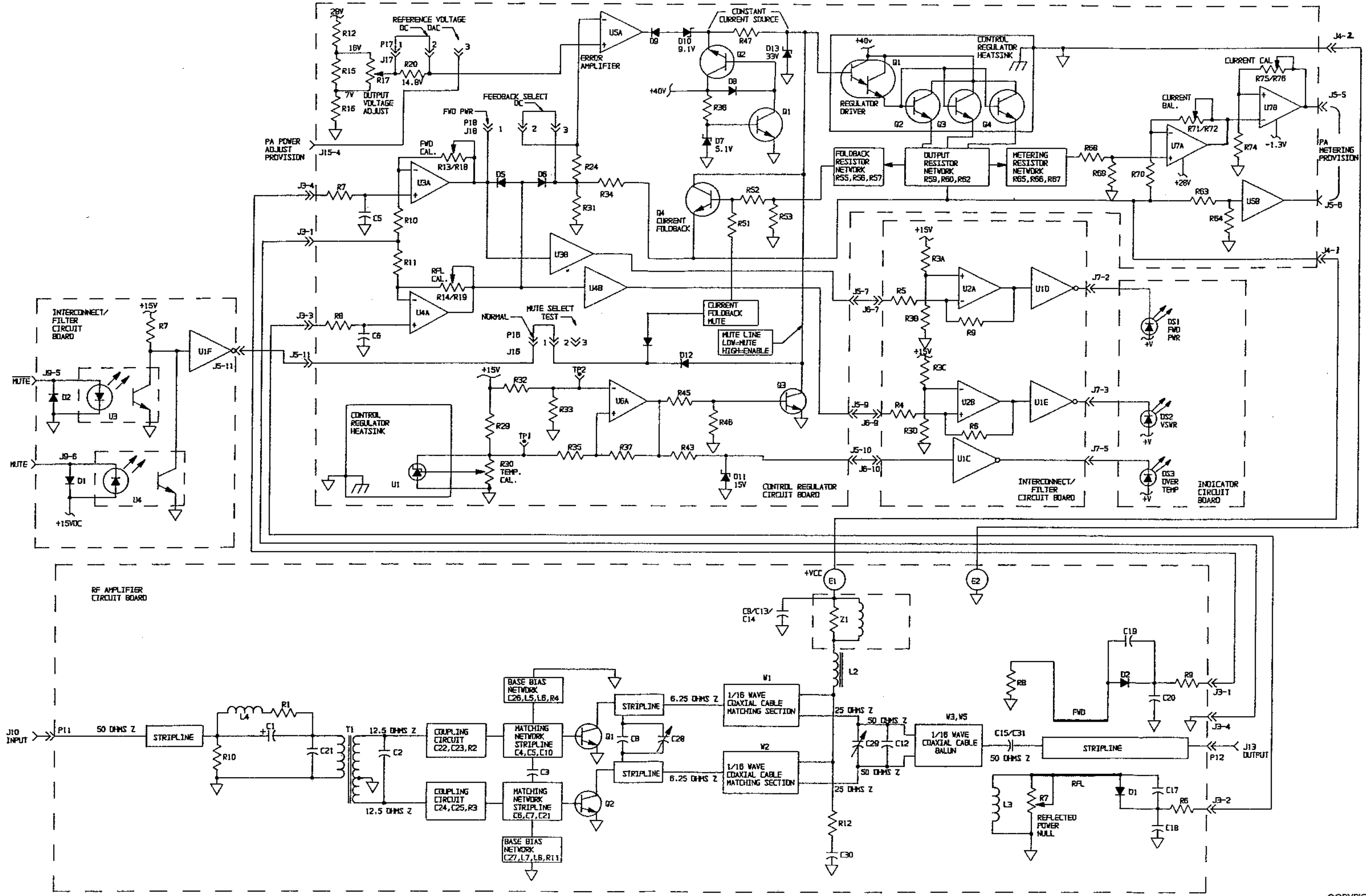
FM 300 MA
FM 300 A

SCALE 1/1 SHEET 1 OF 1



597-0032-21

FIGURE 1-2. IPA POWER DISTRIBUTION



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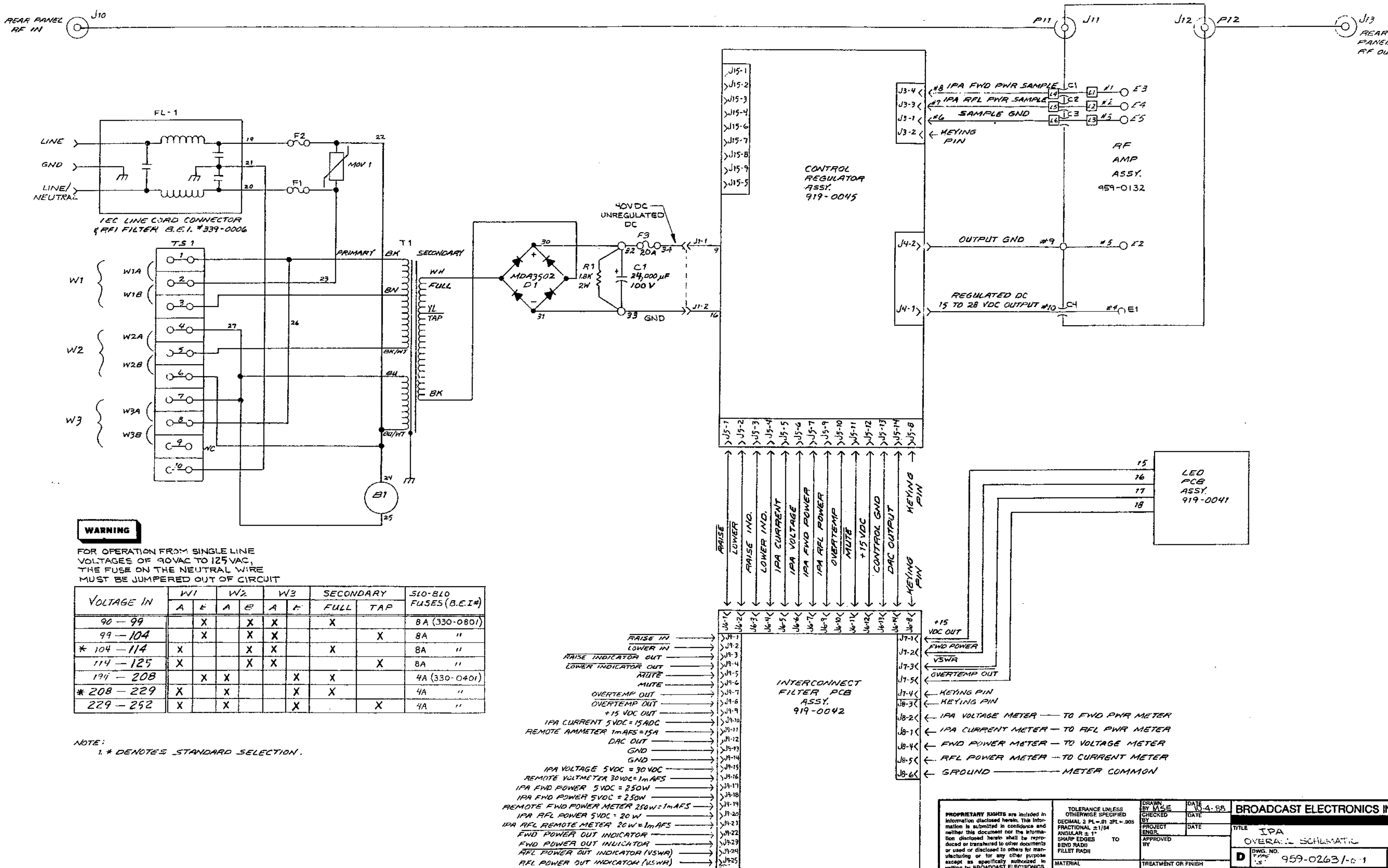
597–0032–22

FIGURE 1–3. IPA SIMPLIFIED SCHEMATIC

BROADCAST ELECTRONICS INC



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		510-810 FUSES (B.E.I#)
	A	E	A	E	A	E	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.

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	10-4-88
CHECKED BY	
PROJECT ENGR.	
APPROVED BY	
TREATMENT OR FINISH	
	BROADCAST ELECTRONICS INC.
TITLE	IPA OVERALL SCHEMATIC
SIZE	D
DWG. NO.	959-0263/-0-1
REV.	G
SCALE	N/S
SHEET	1 OF 1

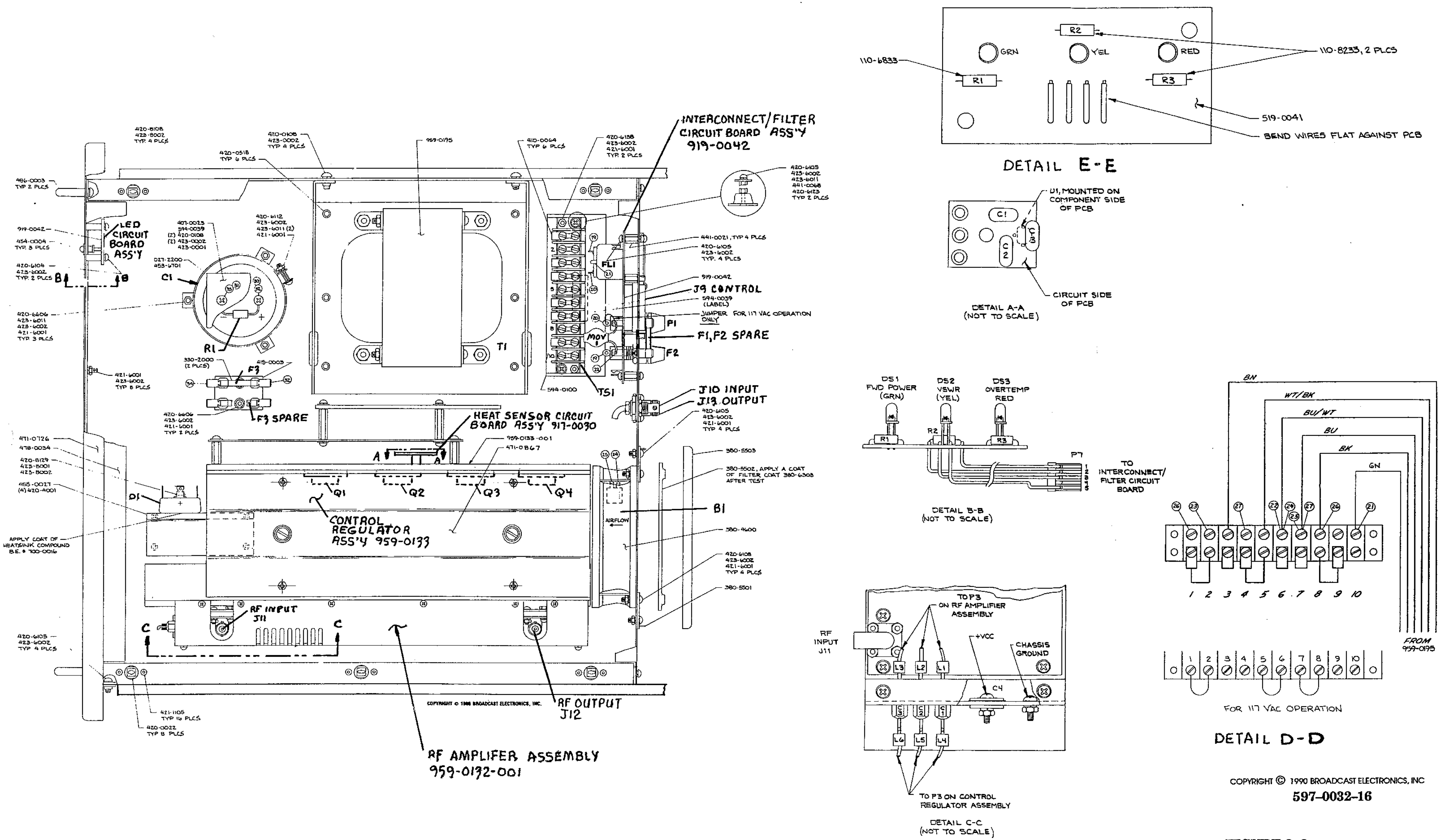
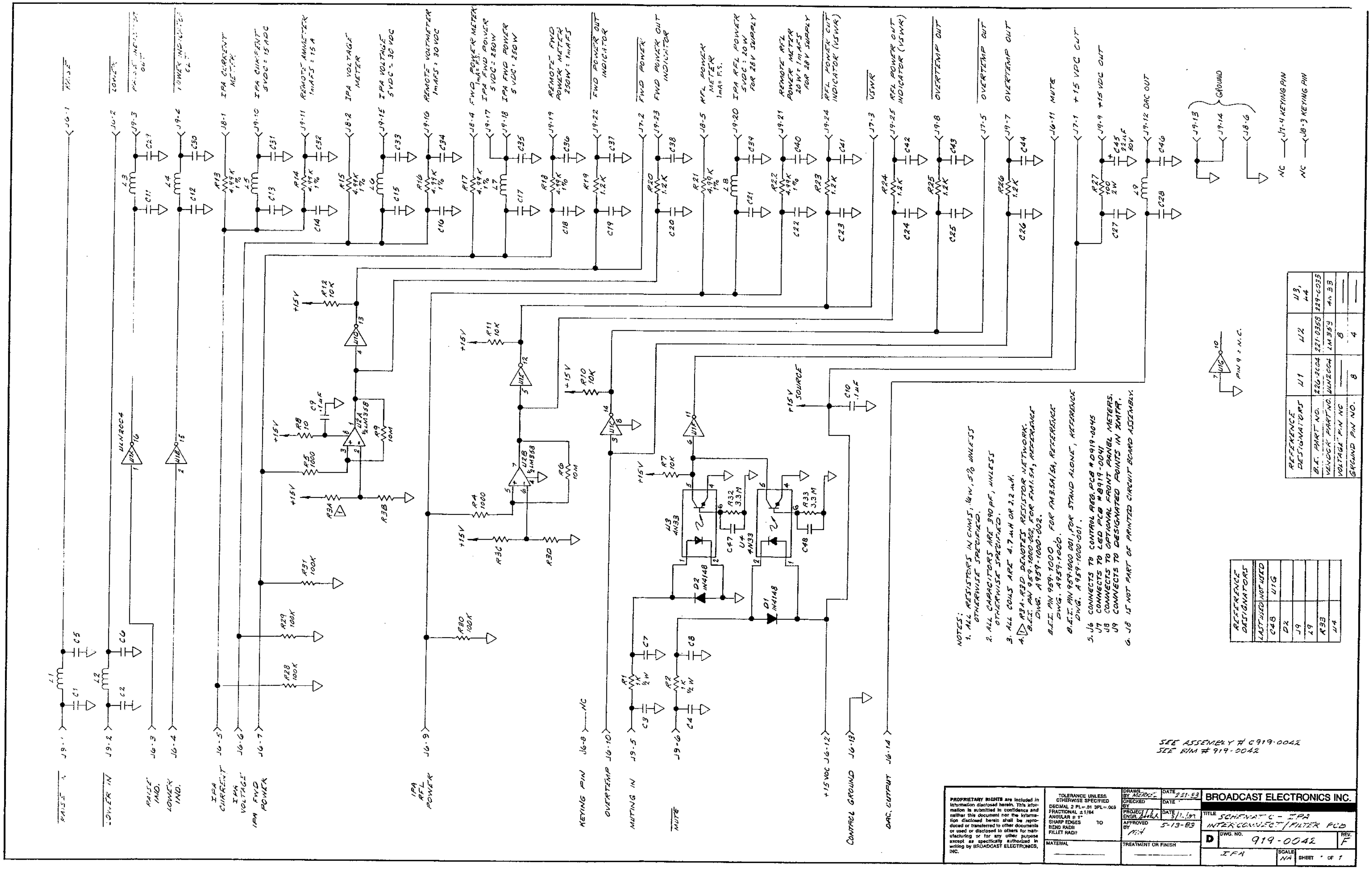


FIGURE 3-2. INTERMEDIATE POWER AMPLIFIER ASSEMBLY


NOTES:
1. ALL RESISTORS IN OHMS, 1/4W, 5% UNLESS OTHERWISE SPECIFIED.
2. ALL CAPACITORS ARE 390pF, UNLESS OTHERWISE SPECIFIED.
3. ALL COILS ARE 4.7uH OR 2.2uH.
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 #0919-0045
J7 CONNECTS TO LED PCB #8919-0041
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 B/M # 919-0042
BROADCAST ELECTRONICS INC.
TITLE SCHEMATIC - IPA INTERCONNECT/FILTER PCB
DWG. NO. 919-0042
REV. F
IPA
SCALE NA
SHEET 1 OF 1
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
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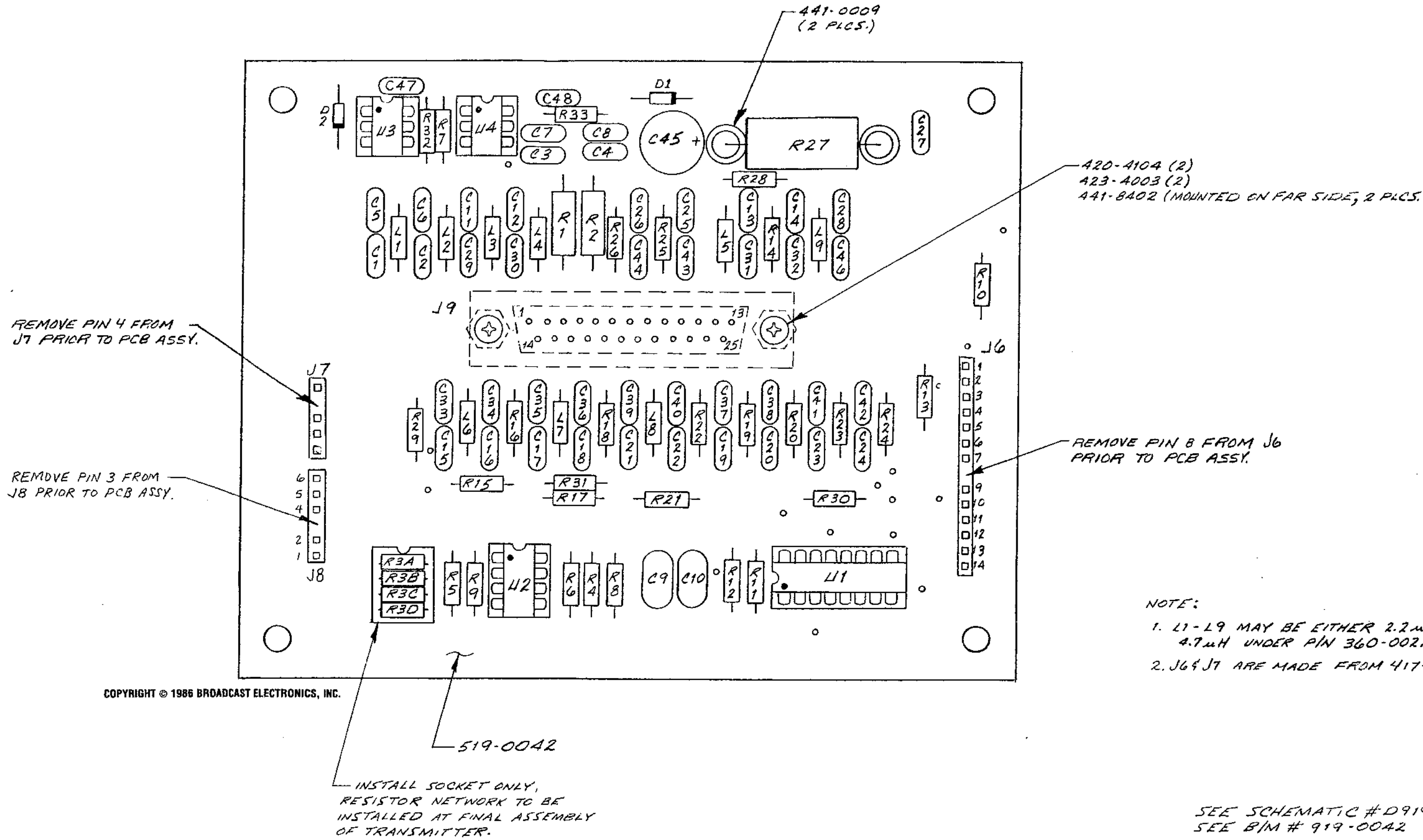


NOTE:

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°

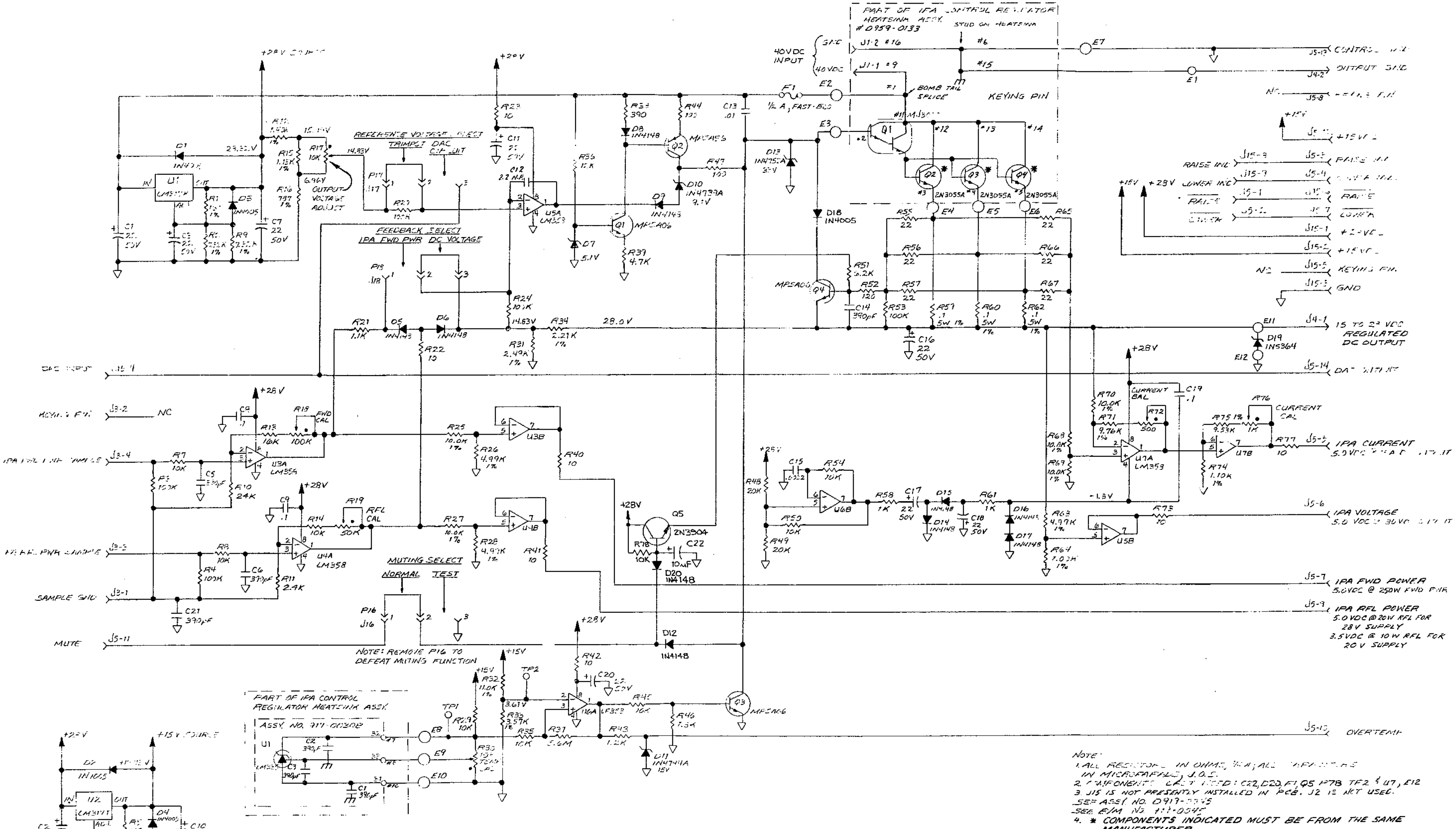
DWN. BY	MERKEL 2-26-83
CHKD.	
ME	
EE	
PROJ. ENGR.	S.S. 5/16/83
DFTG. SUPVR.	MH 5-13-83
MFG.	
NEXT ASSY.	
PRODUCT USED ON	IPA
FINISH	

BROADCAST ELECTRONICS INC.
4100 N. 24TH ST. QUINCY, IL 62305 217/224-9600
TELEX 250142 CABLE BCST ELECT QUI

TITLE PCB ASSEMBLY - IPA INTERCONNECT/FILTER BOARD

SHEET 1 OF 1 | SCALE 2/1 | REV F

TYPE A | SIZE C | DWG. NO. 919-0042



NOTE:
1. ALL RESISTORS IN OHMS, 1/4W; ALL CAPACITORS IN MICROFARADS, U.O.S.
2. COMPONENTS ADDED: C22, D20, F1, Q5, R78, TP2 & U7, E12
3. J15 IS NOT PRESENTLY INSTALLED IN PCB. J2 IS NOT USED. SEE ASSY NO. 0917-0045 SEE E/M NO. 917-0045
4. ✱ COMPONENTS INDICATED MUST BE FROM THE SAME MANUFACTURER

REV	DESCRIPTION		DATE	APPRVD
H	ADDED R78, D20, C22, Q5	ECN 8481 JAR	1-30-92	
G	ADDED D18, D19, E11 & E12 PER ECN 7007	KLS	8-27-87	
F	PER ECN 6770	MH	2-23-87	

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

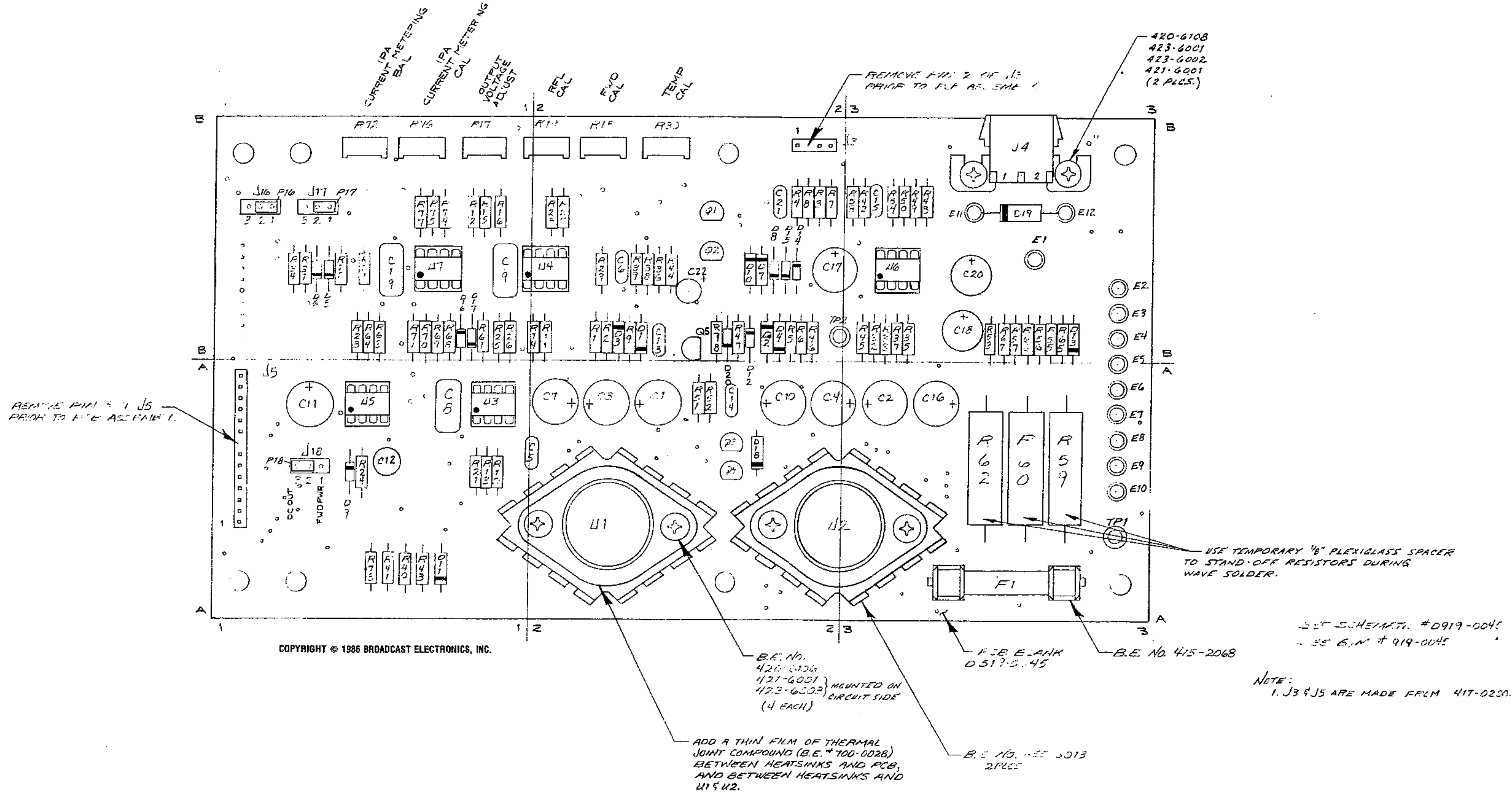
DRAWN BY | DATE
CHECKED BY | DATE
PROJECT ENGR | DATE
APPROVED BY MH | 5-13-83

BROADCAST ELECTRONICS INC.

TITLE SCHEMATIC IPA CONTROL REGULATOR PCB

D | DWG. NO. 919-0045 | REV. H

SCALE | SHEET 1 OF 1



NOTE:
1. J3 & J5 ARE MADE FROM 417-0250.

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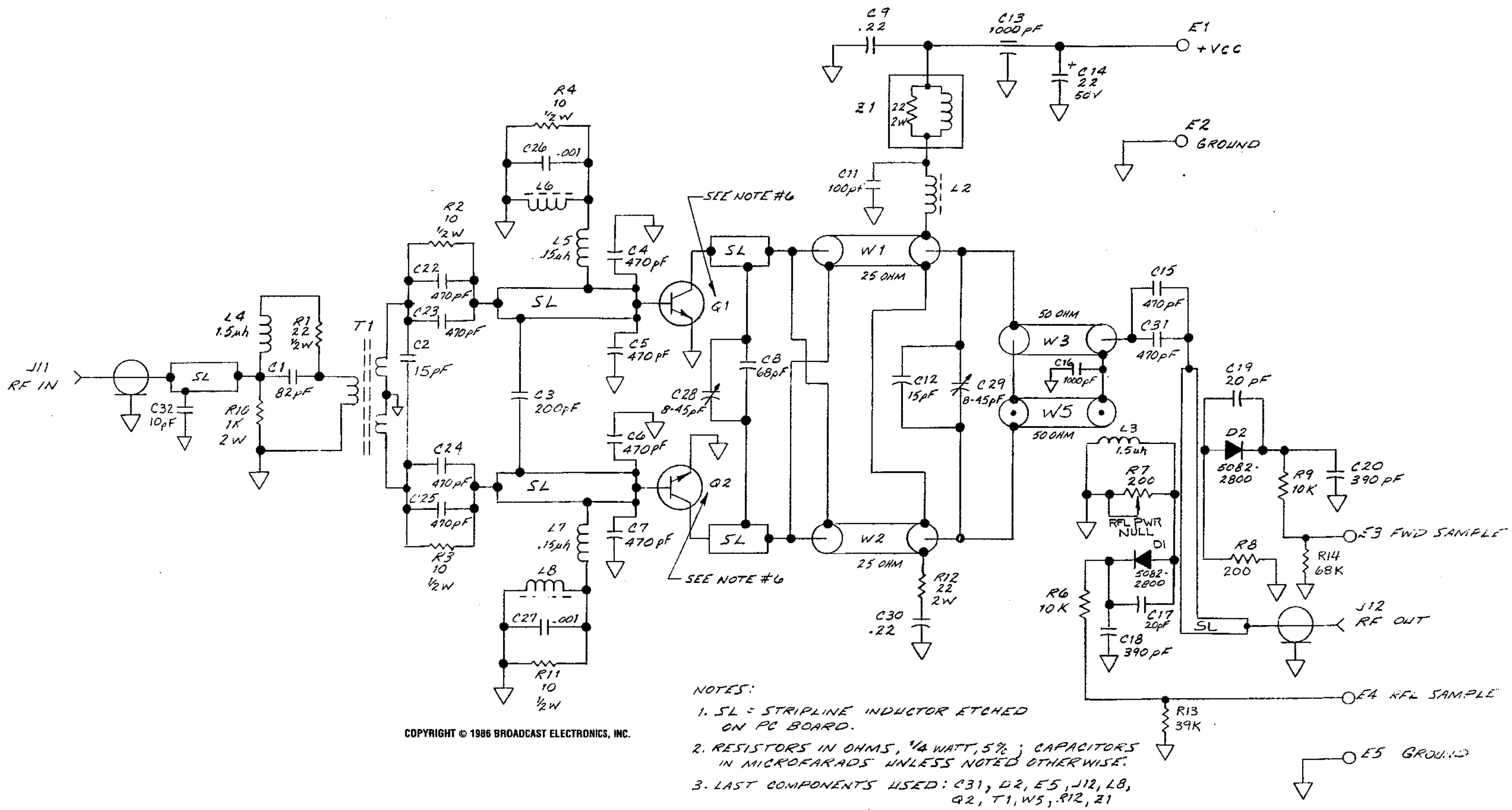
	MATERIAL	TREATMENT OR FINISH	D — DWG. NO. TYPE A 917-0045 — REV. G SCALE 2/1 — SHEET 1 OF 1



NOTES:

1. SL = STRIPLINE INDUCTOR ETCHED ON PC BOARD.
2. RESISTORS IN OHMS, 1/4 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.

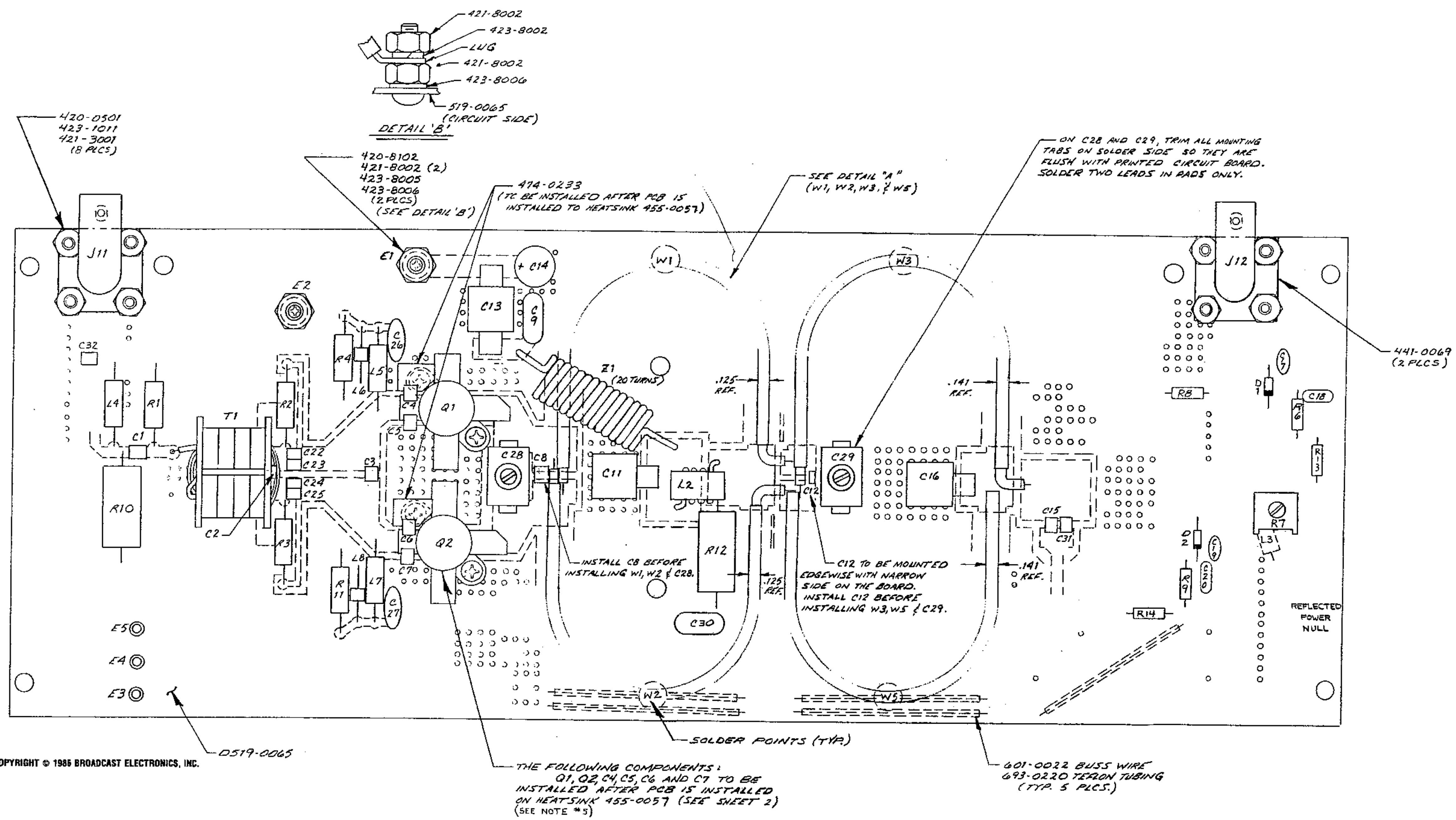
TOLERANCE (DECIMAL) U.O.S.
.X ± .030 .XXX ± .005
.XX ± .015 ANGLES ± 1°

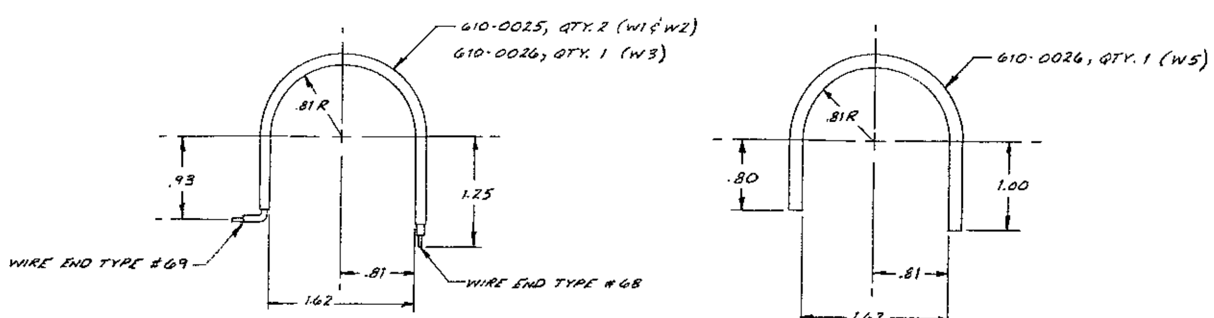
DWN. BY	MERKEL 3-10-83
CHKD.	
ME	
EE	
PROJ. ENGR.	S S 5/16/83
DFTG. SUPVR.	MH 5-13-83
MFG.	

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 —
REV H
TYPE 5 | SIZE C | DWG. NO. 919-0065



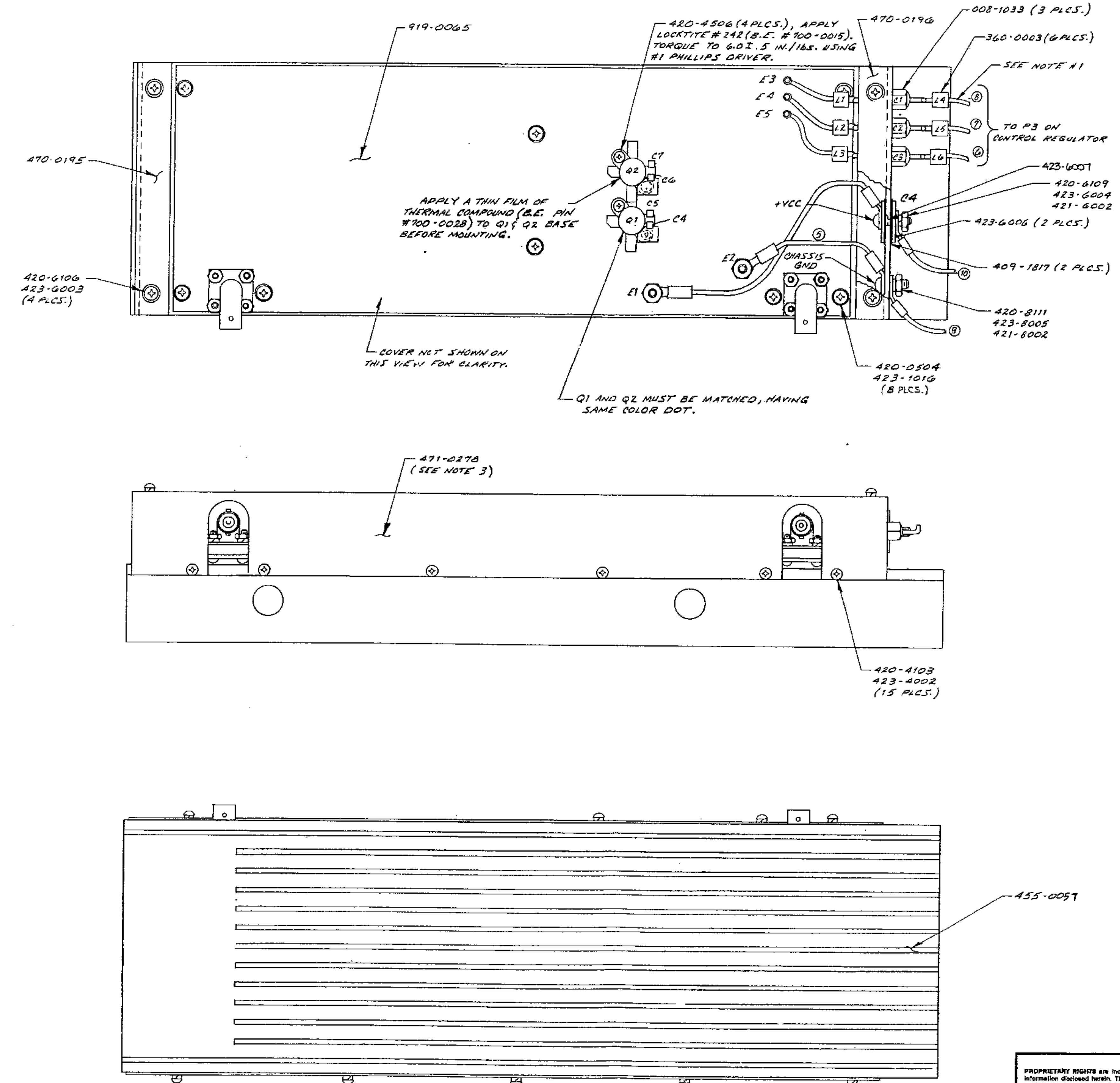


DETAIL "A"
(SEE NOTE #1)

NOTES:

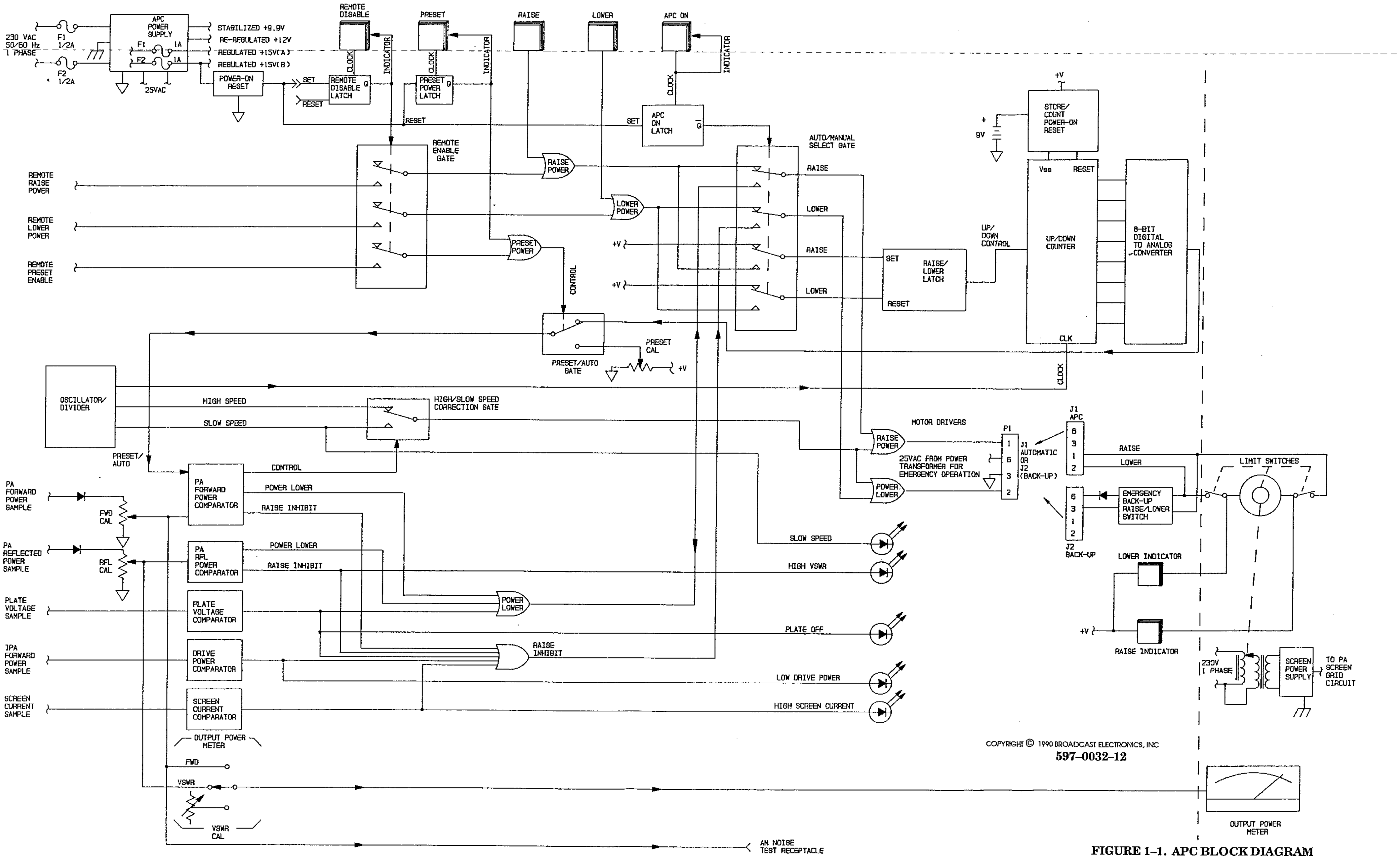
1. USE FIXTURE TO FORM W1, W2, W3, & W5.
2. REFERENCE SCHEMATIC #D959-0131.
3. REFERENCE B/M 919-0065.
4. REFERENCE RF AMP PCB SCHEMATIC #C919-0065.
5. TRANSISTORS Q1 & Q2 ARE MATCHED PAIRS.

TOLERANCE UNLESS OTHERWISE SPECIFIED DECIMAL 2 PL=.01 3PL=.005 FRACTIONAL ±1/64 ANGULAR ± 1° SHARP EDGES TO BEND RADII FILLET RADII	DRAWN BY GLF DATE 3-11-91 CHECKED BY DATE PROJECT ENGR. DATE APPROVED BY MH	BROADCAST ELECTRONICS INC.	
MATERIAL	TREATMENT OR FINISH	TITLE IPA RF AMP ASSEMBLY	
		D TYPE A DWG. NO. 959-0132-001	REV. A
		IPA SCALE 2/1 SHEET 1 OF 2	



NOTES:
1. SEE DWG. C949-0040 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	DRAWN BY WLF	DATE 3-11-91	BROADCAST ELECTRONICS INC.
	CHECKED BY	DATE	TITLE IPA RF AMP ASSEMBLY
	PROJECT ENGR.	DATE	
	APPROVED BY MH		DWG. NO. D TYPE A 959-0132-001 REV. A
MATERIAL	TREATMENT OR FINISH		IPA SCALE 1/1 SHEET 2 OF 2



597-0032-12

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.

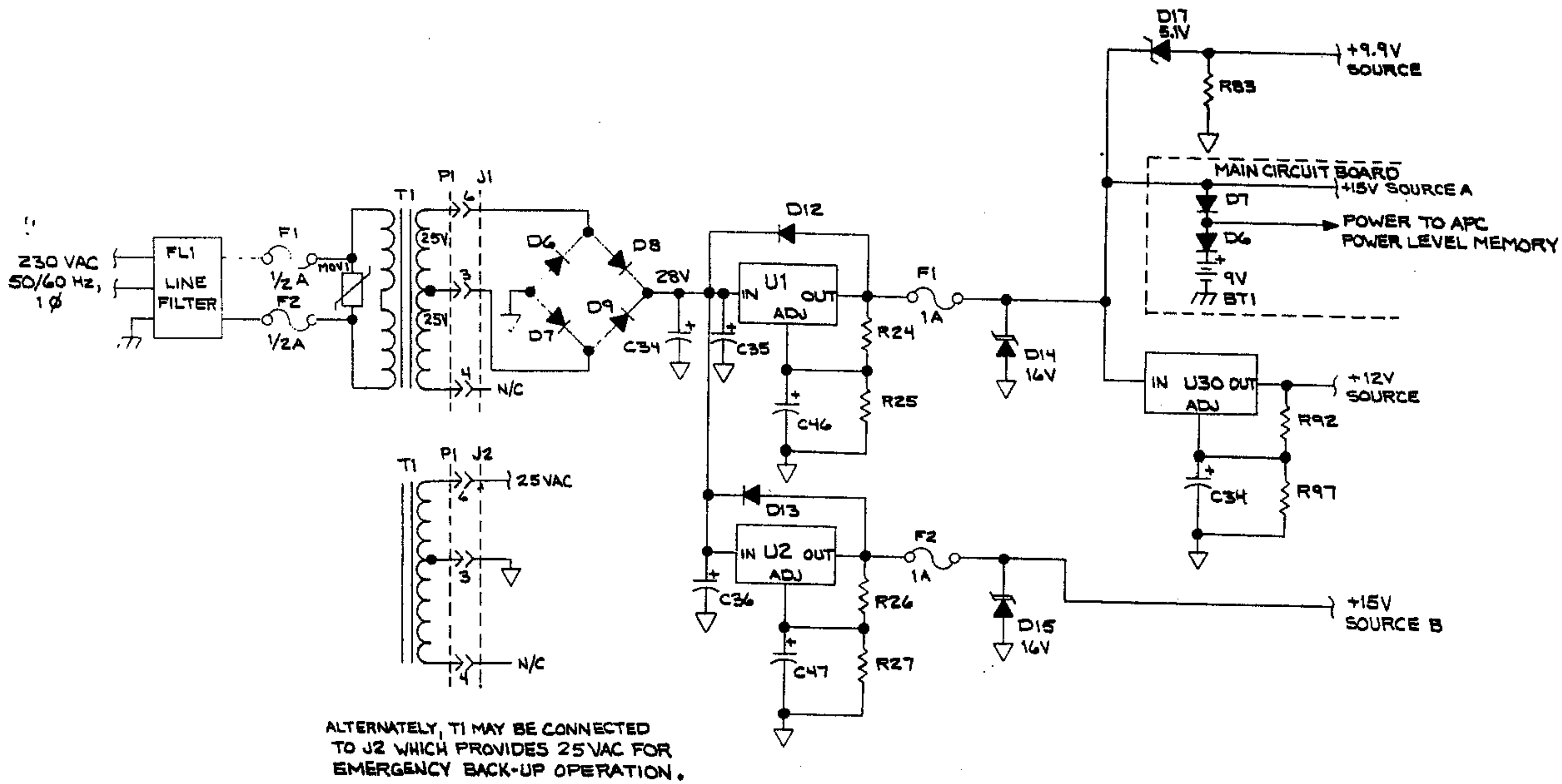
1–25. In case of power failures, the supply to the APC power level memory circuit will be maintained by a battery. Diode D7 prevents battery discharge through the APC circuitry during periods of battery operation and diode D6 isolates the 9 volt battery from the 15 volt A supply. Battery drain is approximately 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.

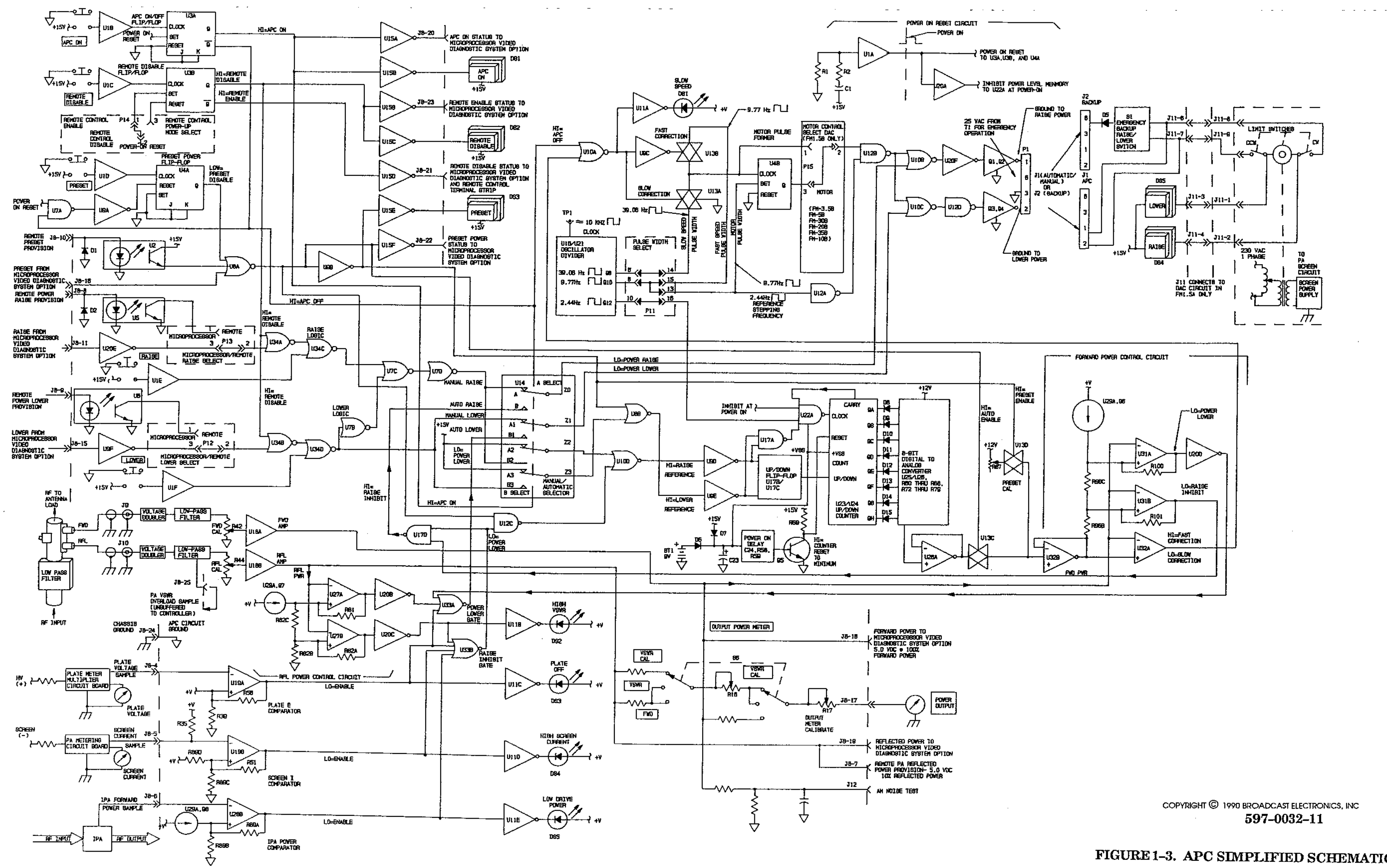
1–28. **APC LOGIC CIRCUITRY.**

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).



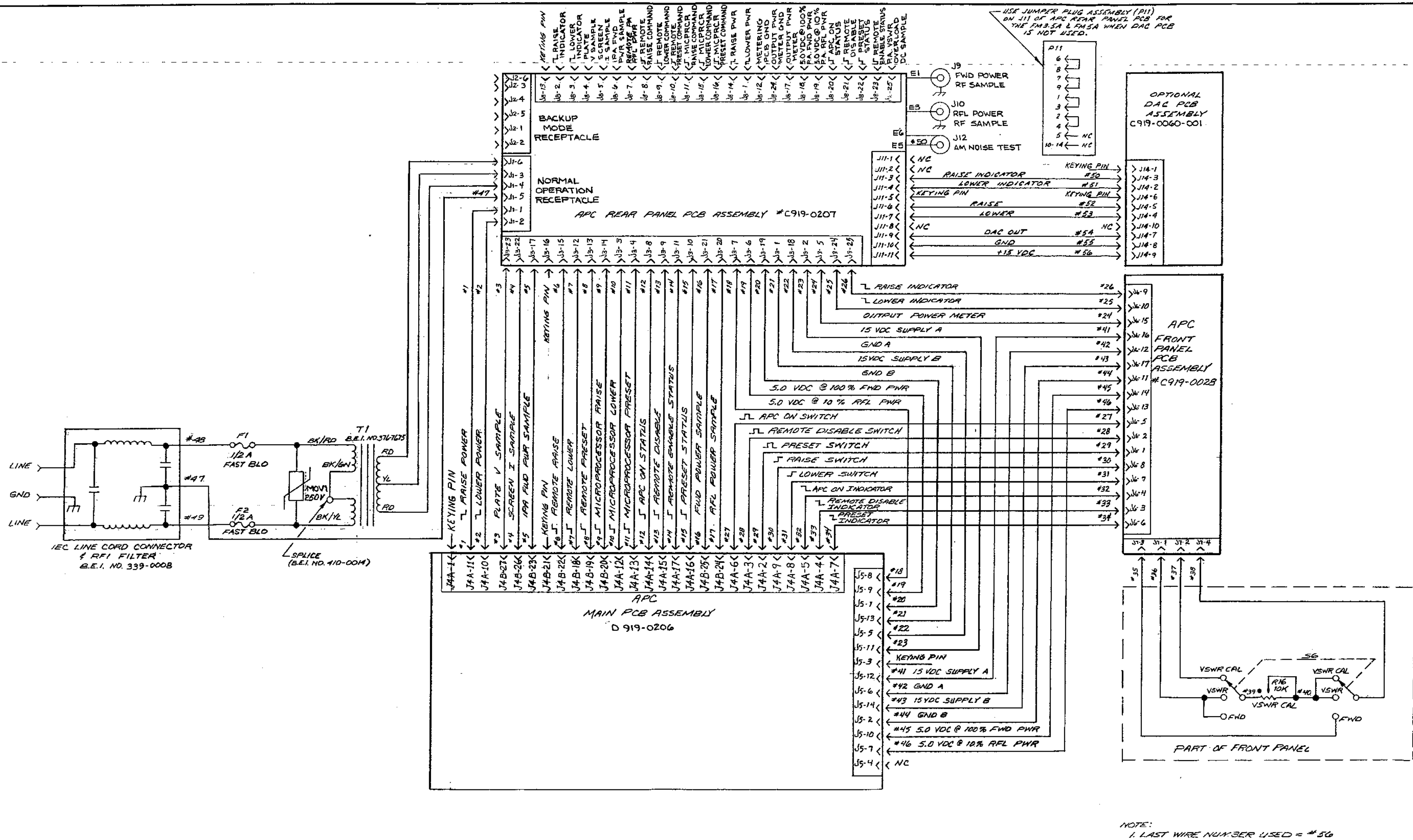
597-0032-37

FIGURE 1-2. APC POWER SUPPLY



597-0032-11

FIGURE 1-3. APC SIMPLIFIED SCHEMATIC



TOLERANCE UNLESS OTHERWISE SPECIFIED DECIMAL 2 PL=.01 3PL=.005 FRACTIONAL ±1/64 ANGULAR ± 1° SHARP EDGES TO BEND RADII FILLET RADII	DRAWN BY MSE DATE 10-5-88 CHECKED BY DATE PROJECT ENGR. DATE APPROVED BY	BROADCAST ELECTRONICS INC.
MATERIAL	TREATMENT OR FINISH	TITLE SCHEMATIC APC OVERALL D DWG. NO. TYPE S 959-0262/-002 REV. D SCALE NTS SHEET 1 OF 1

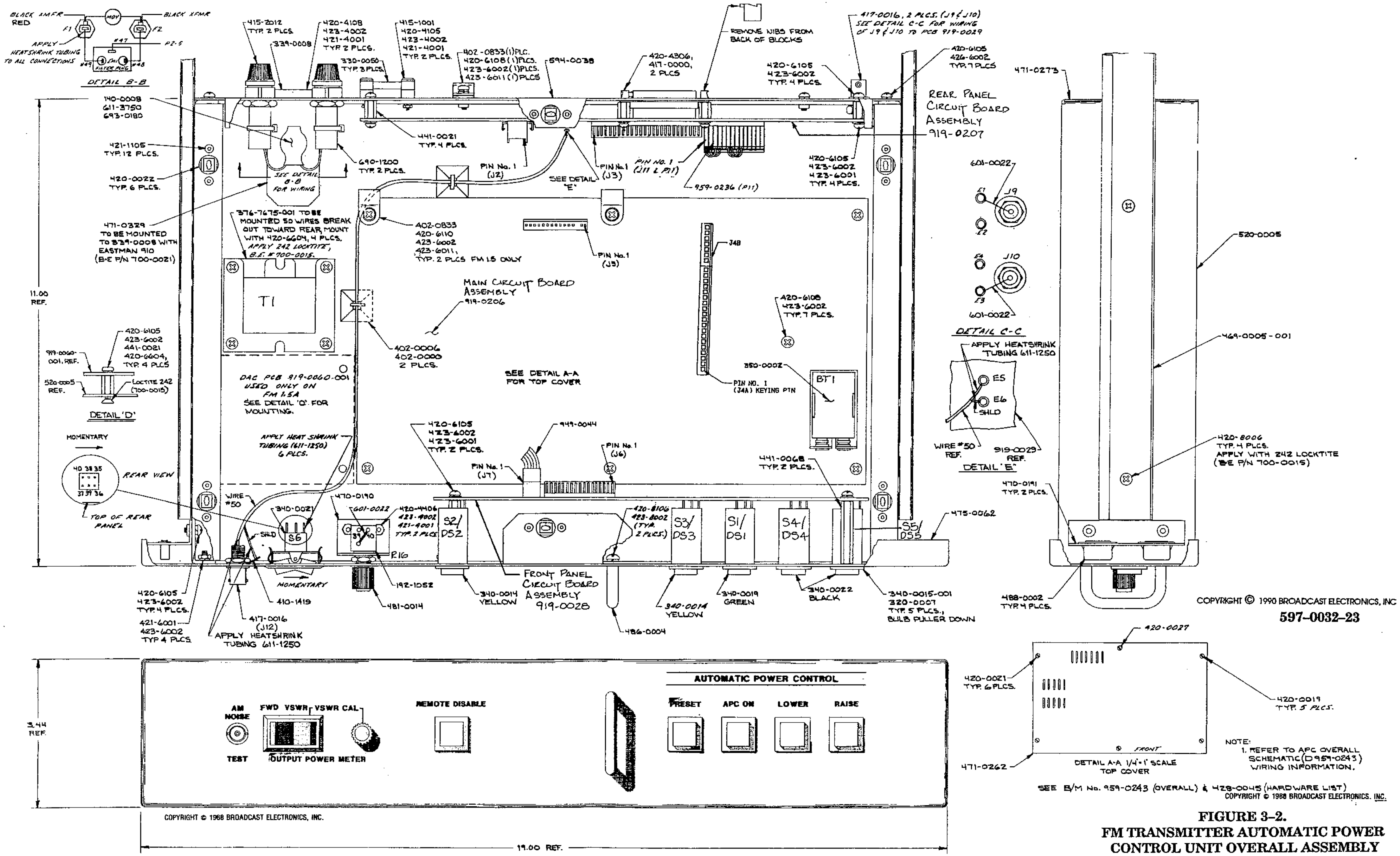
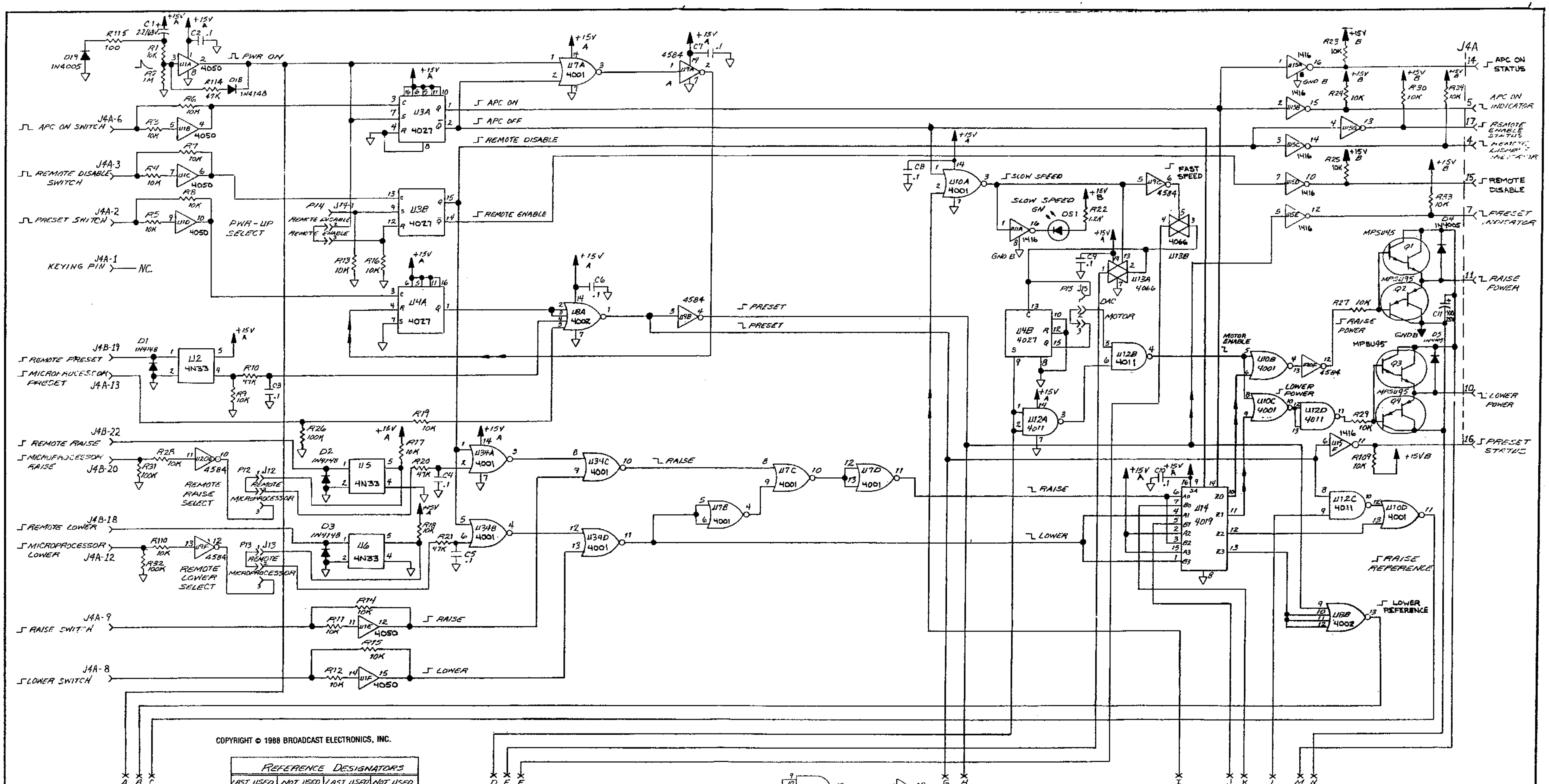


FIGURE 3-2.
FM TRANSMITTER AUTOMATIC POWER CONTROL UNIT OVERALL ASSEMBLY



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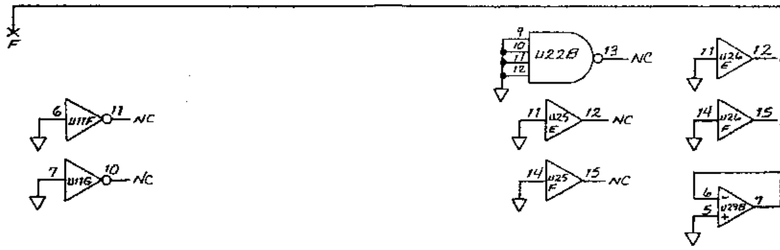
REFERENCE DESIGNATORS			
LAST USED	NOT USED	LAST USED	NOT USED
C40	U29-E	DS5	U26-E,F
D19	U11-F,G	TP1	R36, R37
J15		BT1	R48, R50
Q8			R70, R71
R115	U22-B		R85, R88
U34	U25-E,F		R95, R97
			R98



NOTE:
1. RESISTORS IN OHMS, 1/4 W 5%; CAPACITORS IN MICROFARADS, U.O.S.
2. SEE PCB ASSY. #0919-0206
SEE B/M #919-0206

REFERENCE DESIGNATORS	U1, U25 & U26	U2, U5, & U6	U3 & U4	U7, U10 & U34	U8 & U33	U9 & U20	U11 & U15	U12 & U17	U13	U14	U16	U18, U19, U27 - U29, U31 & U32	U21	U22	U23 & U24	U30
B.E. PART NO.	228-4050	229-0035	225-0003	228-4001	228-4002	228-4584	226-2004	228-4011	225-0004	228-4019	220-4047	221-0358	228-4020	228-4012	228-4516	227-0317
VENDOR PART NO.	4050	4N35	4027	4001	4002	4584	MC1416	4011	4066	4019	4047	LM358	4020	4012	4516	LM317T
VOLTAGE PIN NO.	1	——	16	14	14	14	——	14	14	16	14	8	16	14	16	——
GROUND PIN NO.	8	——	8	7	7	7	8	7	7	8	7	4	8	7	8	——

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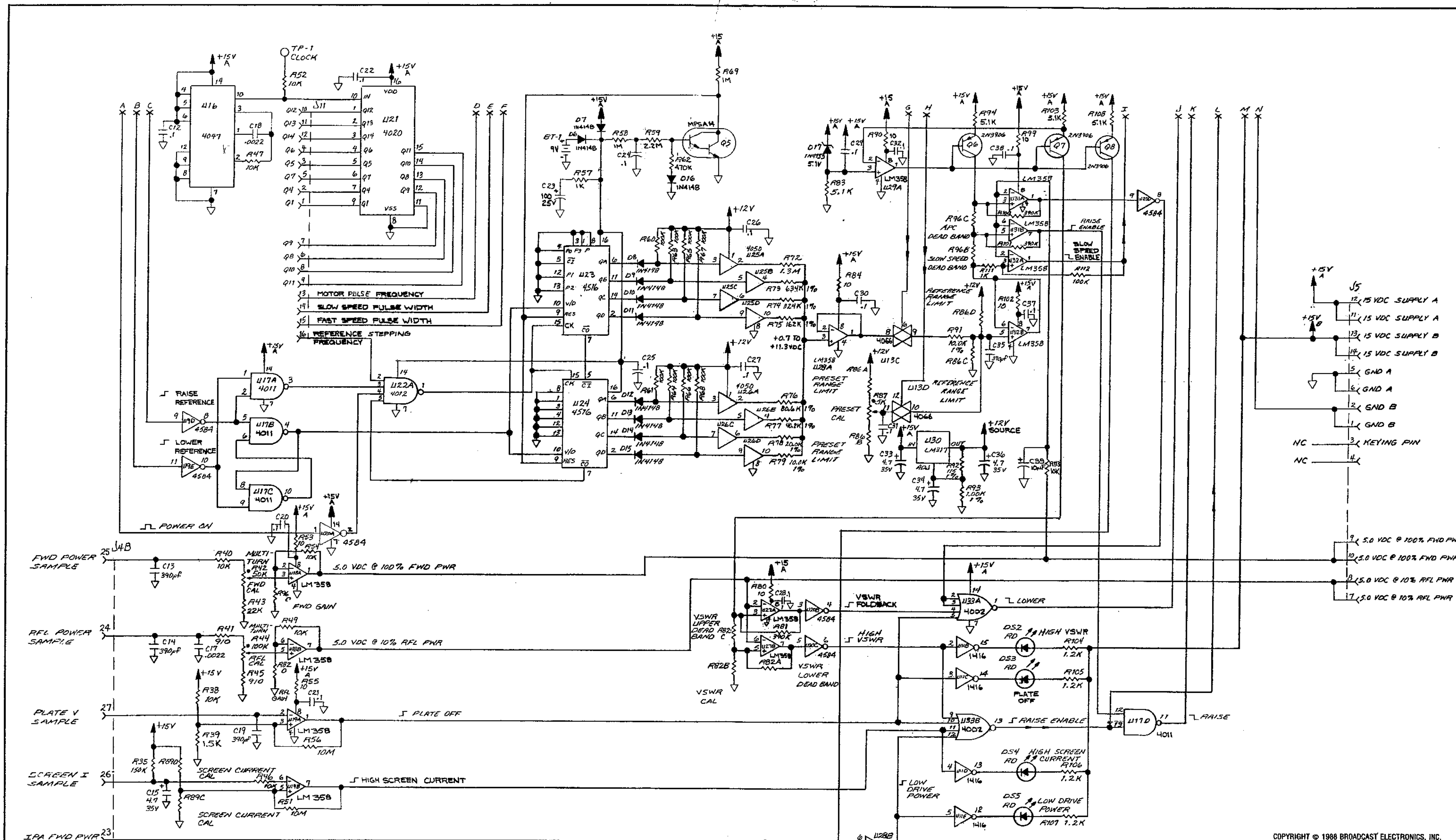
DRAWN BY JAH DATE 1-1988	BROADCAST ELECTRONICS INC.
CHECKED BY DATE	TITLE SCHEMATIC APC MAIN PCB
PROJECT ENGR. DATE 1-26-88	D DWG. NO. TYPE S 919-0206 REV. G
APPROVED BY	APC SCALE NTS SHEET 1 OF 2
TREATMENT OR FINISH	



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

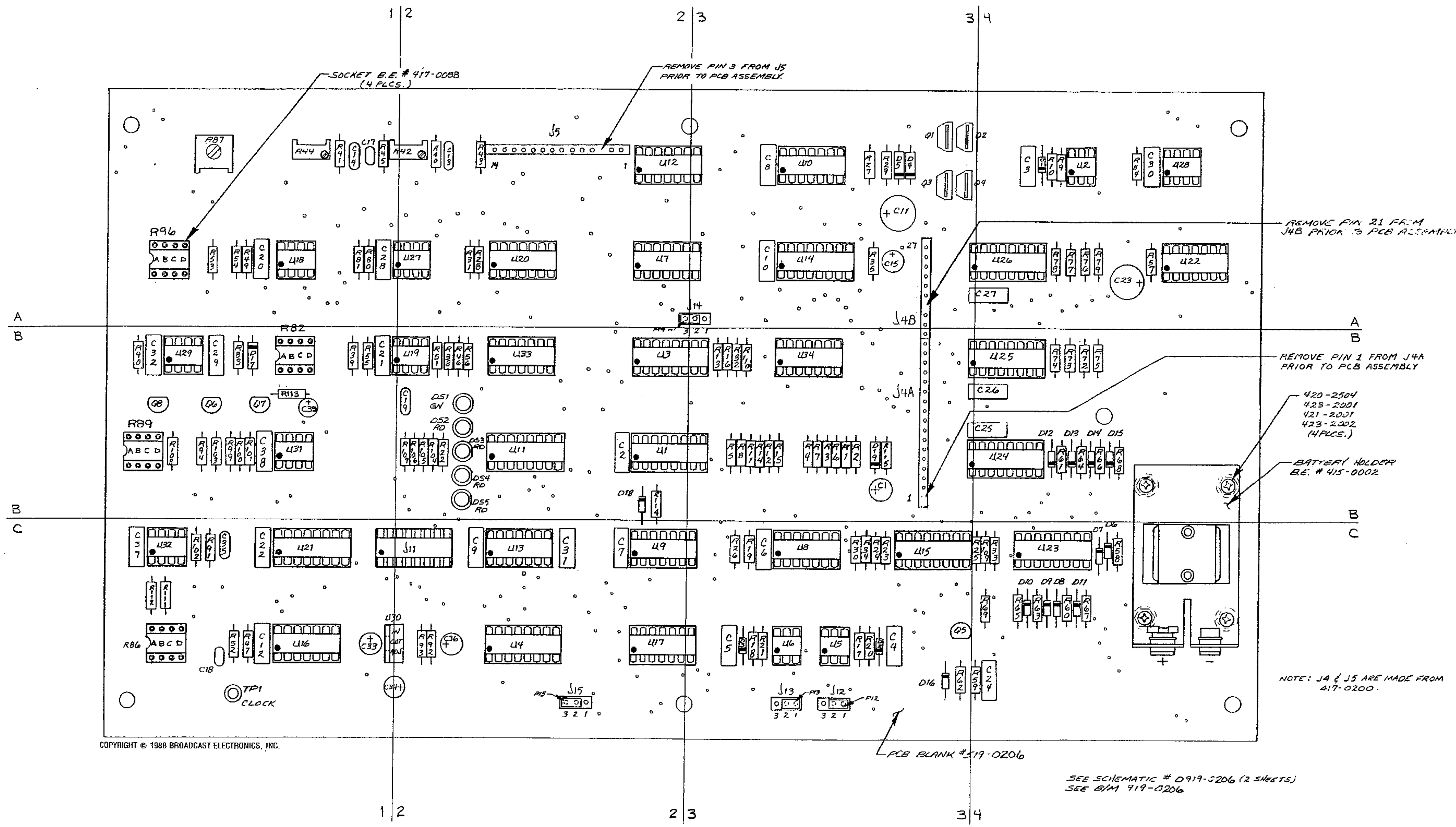
DRAWN BY JAH DATE 1-19-88
CHECKED BY
PROJECT ENGR.
APPROVED BY
TREATMENT OR FINISH

BROADCAST ELECTRONICS INC.

TITLE SCHEMATIC APC MAIN PCB

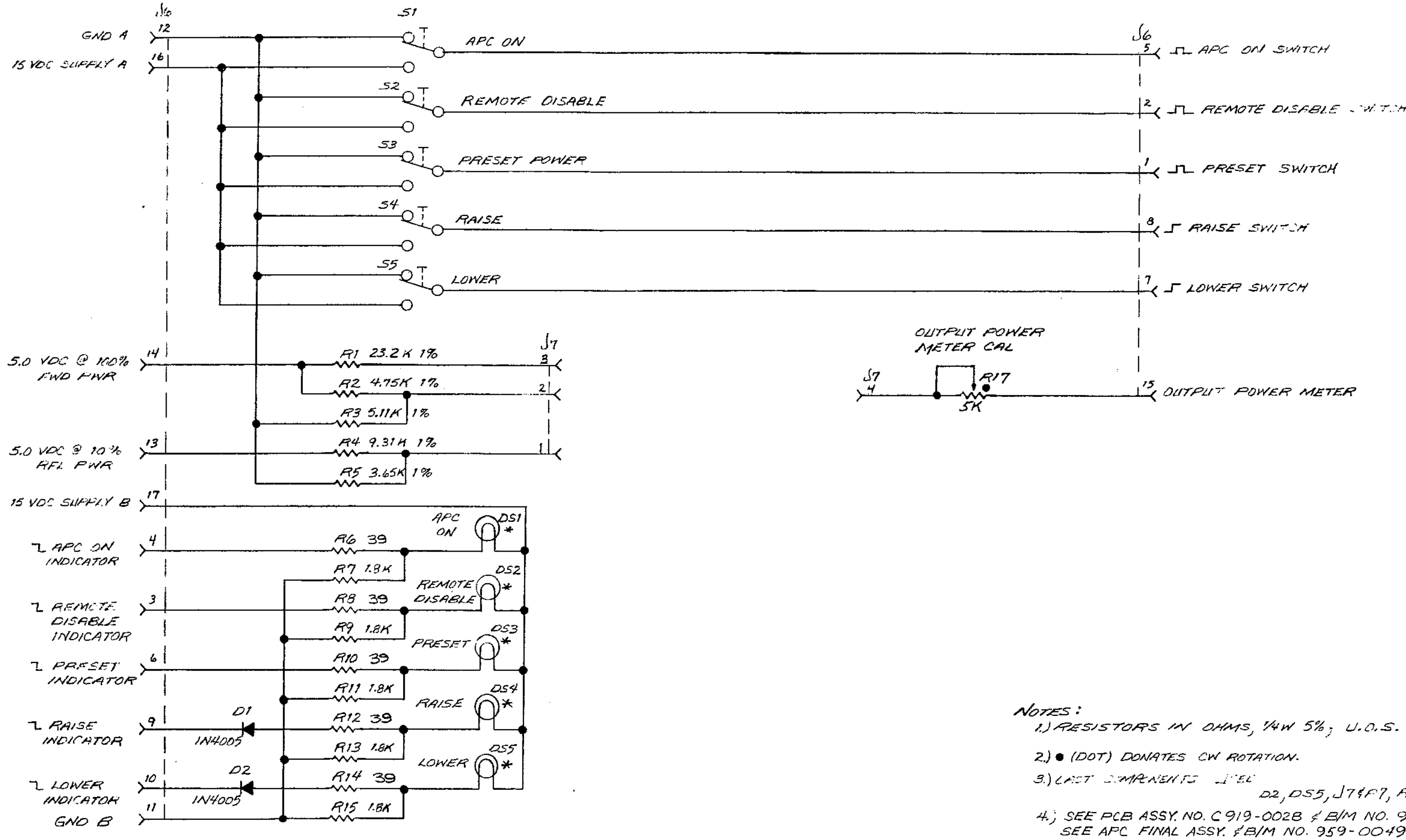
D DWG. NO. 919-0206 REV. G

APC SCALE NTS SHEET 2 OF 2



SEE SCHEMATIC # D919-0206 (2 SHEETS)
SEE B/M 919-0206

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	JAH — DATE 1-19-88
CHECKED BY	DATE
PROJECT ENGR.	BAM — DATE 1-26-89
APPROVED BY	
TREATMENT OR FINISH	
BROADCAST ELECTRONICS INC.	
TITLE	PCB ASSEMBLY APC MAIN P.B.
D	DWG. NO. TYPE A 919-0206 — REV. F
APC	SCALE 2/1 — SHEET 1 OF 1



NOTES:

1.) RESISTORS IN OHMS, 1/4W 5%; U.O.S.

2.) ● (DOT) DONATES CW ROTATION.

3.) LAST COMPONENTS USED
D2, DS5, J7 & P7, R17, S6

4.) SEE PCB ASSY. NO. C919-0028 & B/M NO. 919-0028.
SEE APC FINAL ASSY. & B/M NO. 959-0049.
SEE OVERALL SCHEMATIC NO. D959-0049.

* 5.) DS1 THRU DS5 ARE LICON #50-311364 IND. STD. #73
14 V, 15,000 HR.
DS1 IS LOCATED WITHIN S1, DS2 IS LOCATED
WITHIN S2 AND SO ON.

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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

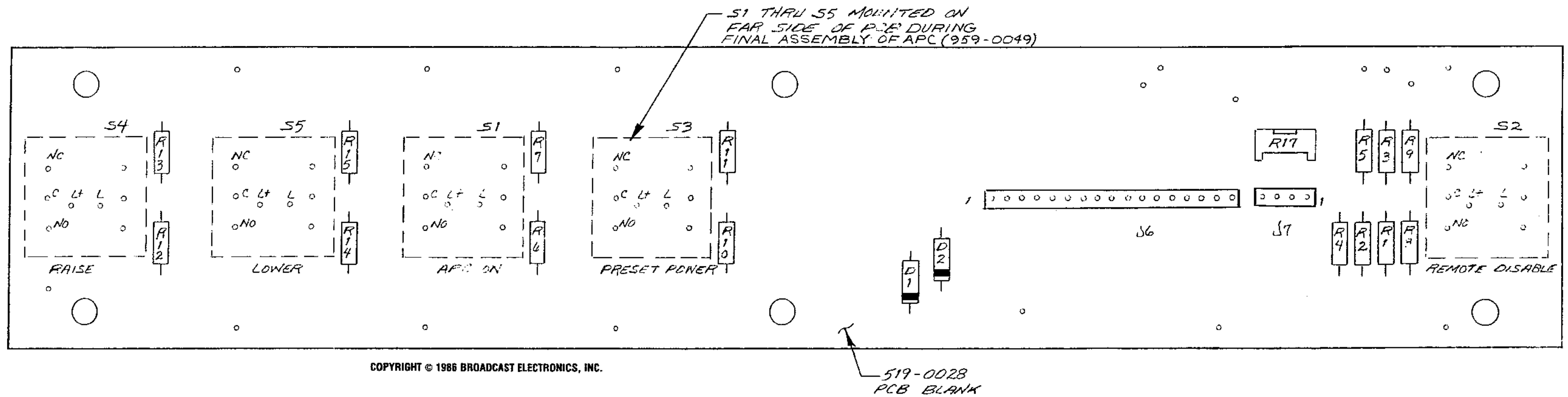
MATERIAL

DRAWN BY ORF	DATE 12-14-82		
CHECKED BY	DATE		
PROJECT ENGR. JMD	DATE 5/5/83		
APPROVED BY MH	5-6-83		
TREATMENT OR FINISH			

BROADCAST ELECTRONICS INC.

TITLE SCHEMATIC
APC FRONT PANEL PCB ASSEMBLY

C	DWG. NO. TYPE: 5 919-0028	REV. C
APC (959-0049)	SCALE NTS	SHEET 1 OF 1

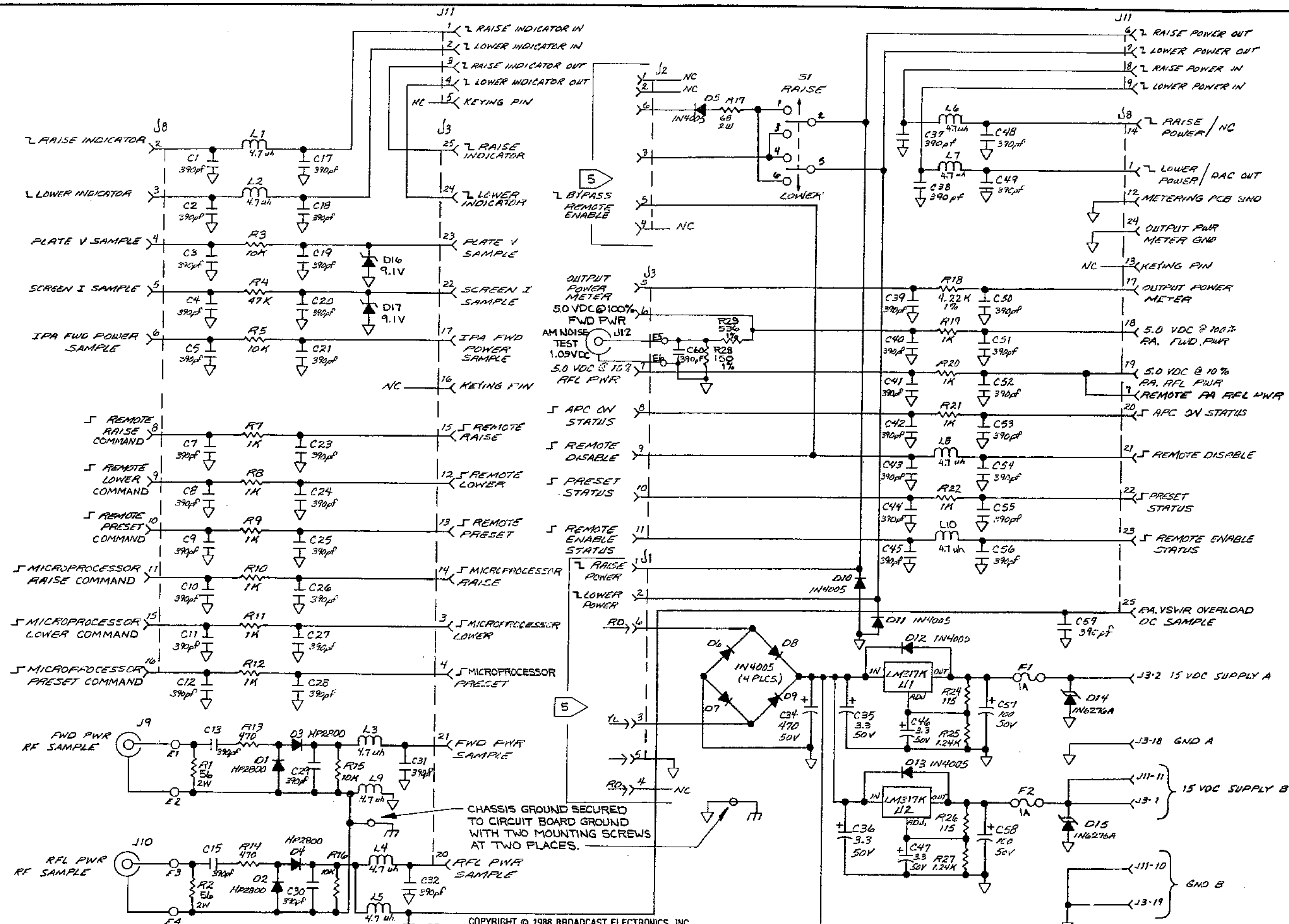


NOTE: J6 & J7 ARE MADE FROM 417-0200.

SEE SCHEMATIC C919-0028
SEE B/M 919-0028

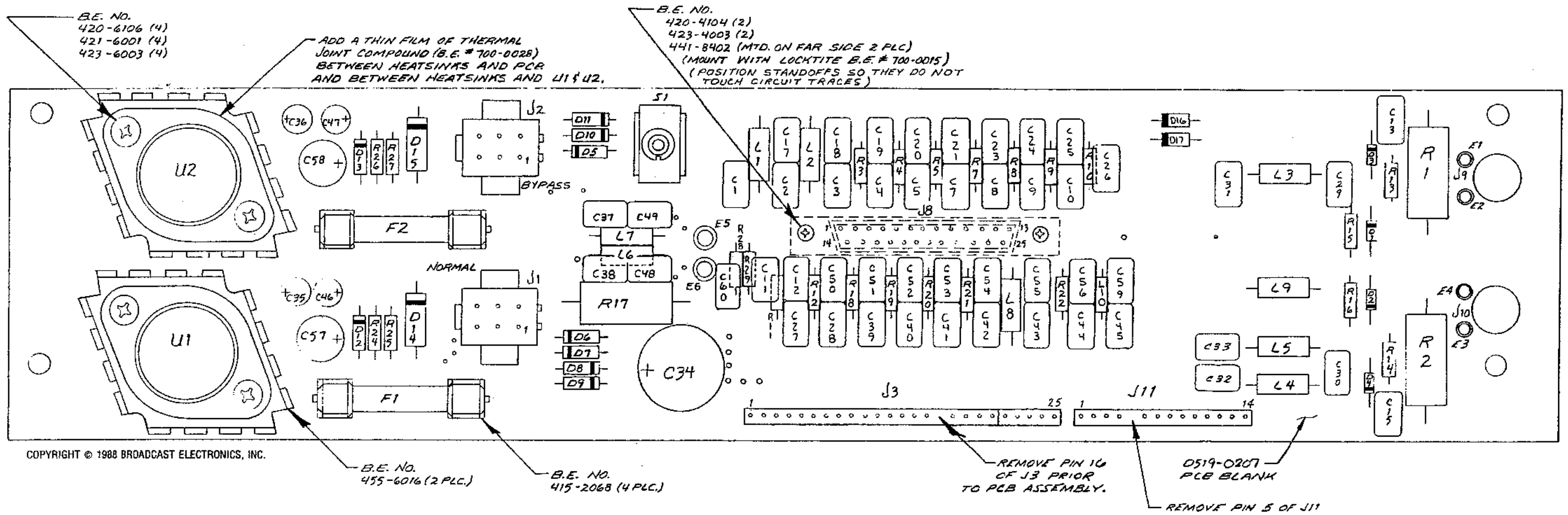
TOLERANCE (DECIMAL) U.O.S.
.X ± .030 .XXX ± .005
.XX ± .015 ANGLES ± 1°

DWN. BY M.S. OFF	NEXT ASSY. 959-0049	BROADCAST ELECTRONICS INC. 4100 N. 24TH ST. QUINCY, IL 62305 217/224-9600 TELEX 250142 CABLE BCST ELECT QUI	
CHKD.			
ME	PRODUCT USED ON APC	TITLE PCB ASSEMBLY APC FRONT PANEL	SHEET 1 OF 1
EE			
PROJ. ENGR.	FINISH		SCALE 2/1 REV C
DFTG. SUPVR. MH 5-6-83			
MFG.		TYPE A SIZE C DWG. NO. 919-0028	



NOTES:
1) ALL RESISTORS IN OHMS, 1/4W; CAPACITORS IN MICROFARADS.
2) LAST COMPONENTS USED: C60, D17, F2, J1-J3+J8-J10, J12, L10, R29, U2, E6.
3) COMPONENTS NOT USED: C6, R6, C22, R23, C14, C16,
4) SEE B/M 919-0207
5.) FOR NORMAL APC OPERATION, PLUG P1 MUST BE CONNECTED TO RECEPTACLE J1. PLUG P1 IS CONNECTED TO P2 ONLY TO ALLOW MANUAL EMERGENCY BACKUP OPERATION.
6.) L1-L10 MAY BE EITHER 2.2 OR 4.7 uH AS P/N 360-0022

TOLERANCE UNLESS OTHERWISE SPECIFIED	DECIMAL 2 PL=.01 3PL=.005; FRACTIONAL ±1/64; ANGULAR ±1°; SHARP EDGES; BEND RADII; FILLET RADII
DRAWN BY	JAH
DATE	1-19-88
PROJECT ENGR.	
DATE	1-26-88
MATERIAL	
TREATMENT OR FINISH	
	BROADCAST ELECTRONICS INC.
TITLE	SCHEMATIC APC REAR PANEL PCB
DWG. NO.	D 919-0207
REV.	B
SHEET	1 OF 1



SEE SCHEMATIC # 0919-0207
SEE B/M # 919-0207

NOTE:
1. L1 - L10 MAYBE EITHER 2.2 OR 4.7 µH AS P/N 360-0022
2. J3 & J11 ARE MADE FROM 417-0200.

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

MATERIAL

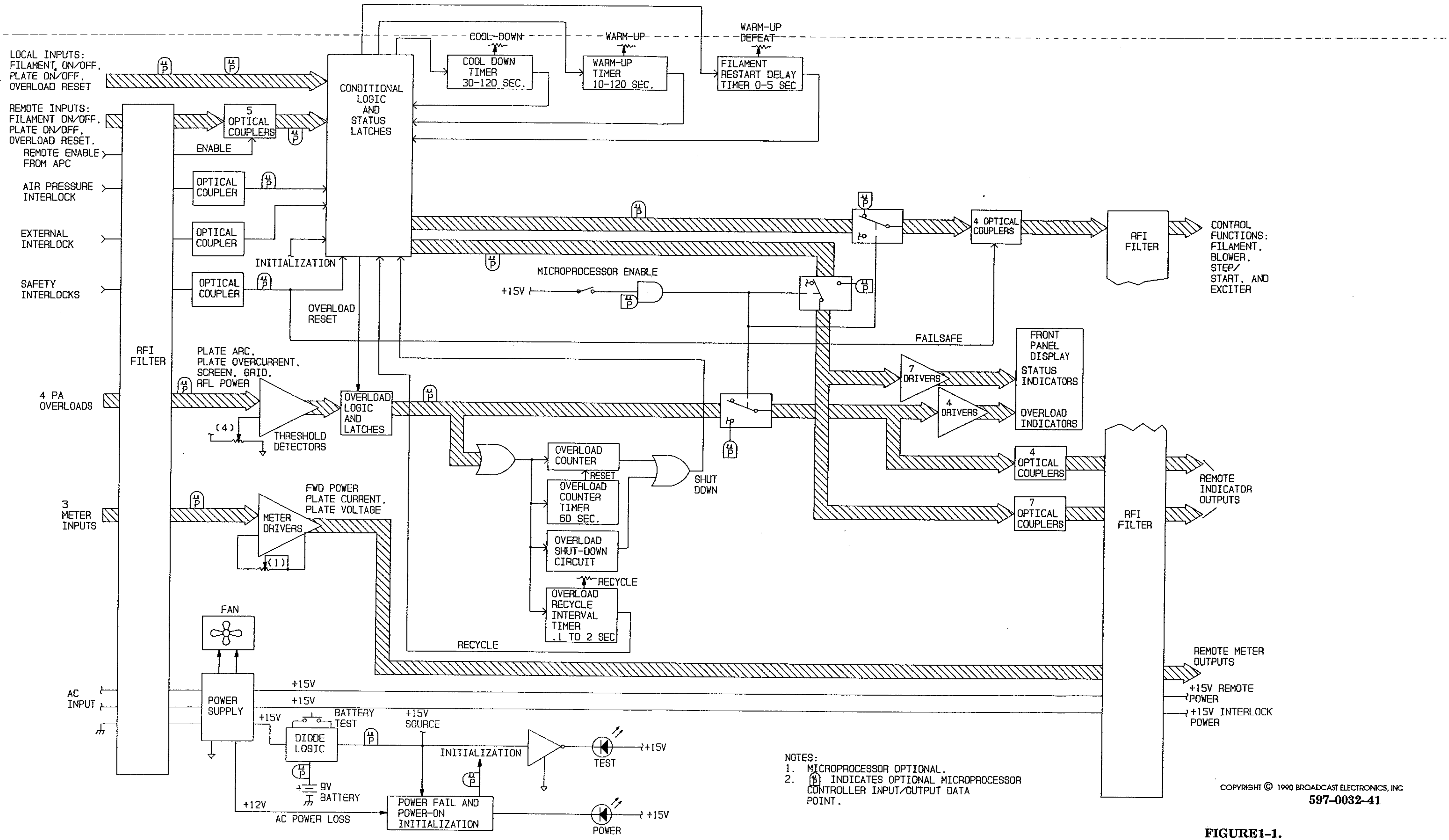
DRAWN BY JAH — DATE 1-19-89
CHECKED BY — DATE
PROJECT ENGR. — DATE 1-26-89
APPROVED BY
TREATMENT OR FINISH

BROADCAST ELECTRONICS INC.

TITLE PCB ASSEMBLY APC REAR PANEL

D — DWG. NO. A 919-0207 — REV. D

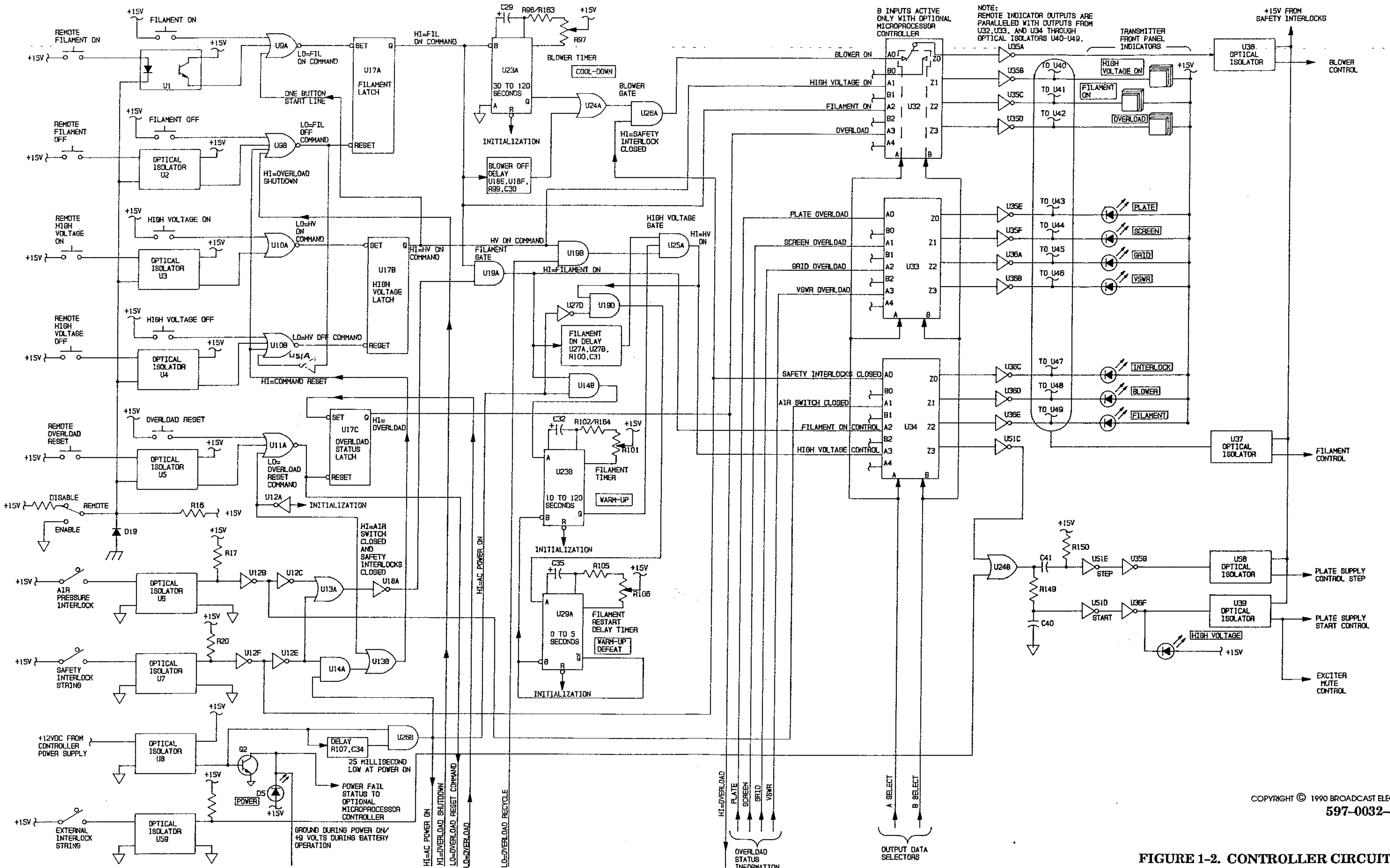
APC — SCALE 2/1 — SHEET 1 OF 1



NOTES:
1. MICROPROCESSOR OPTIONAL.
2. μP INDICATES OPTIONAL MICROPROCESSOR CONTROLLER INPUT/OUTPUT DATA POINT.

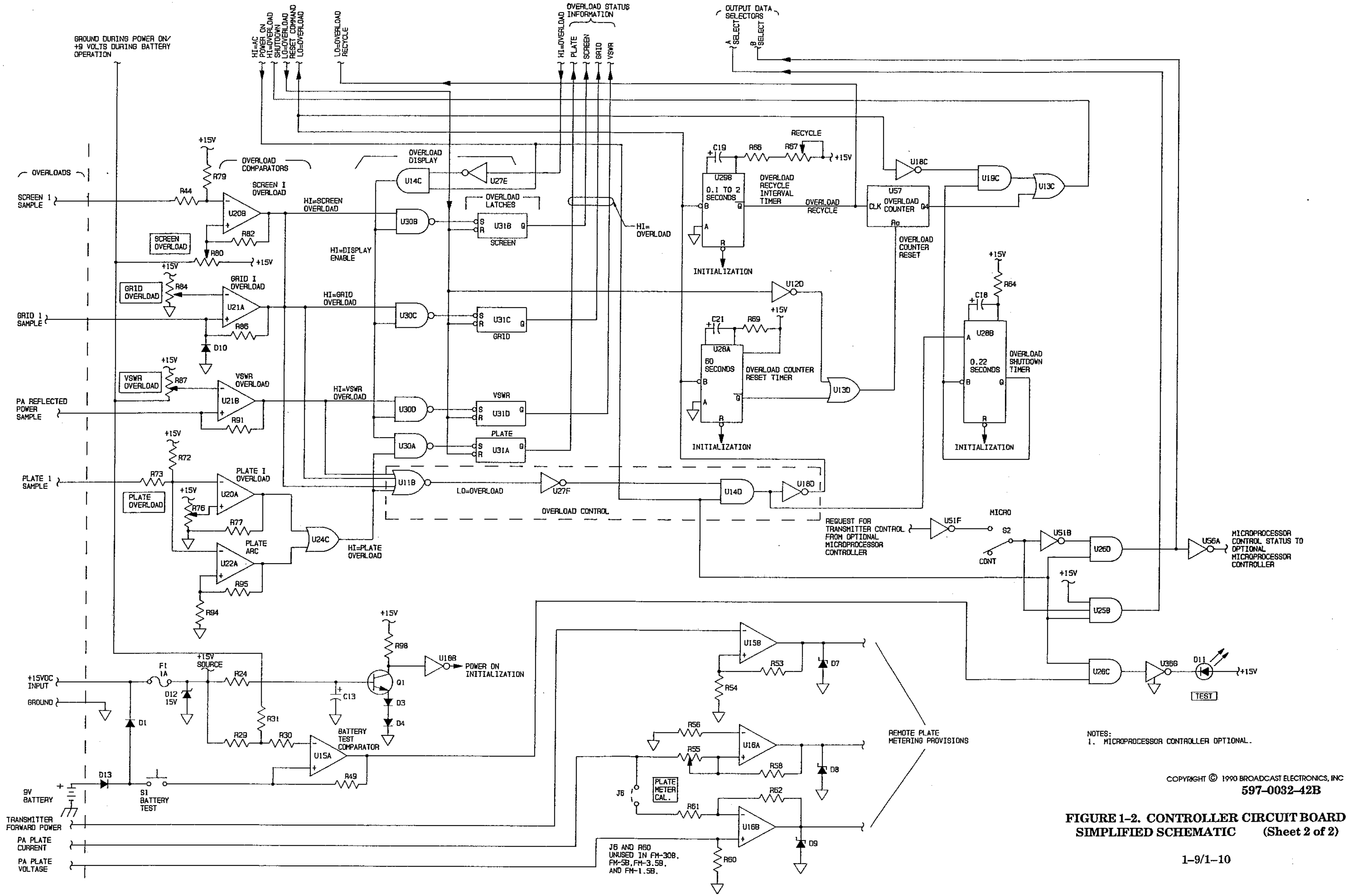
597-0032-41

FIGURE 1-1. TRANSMITTER CONTROLLER BLOCK DIAGRAM



597–0032–42A

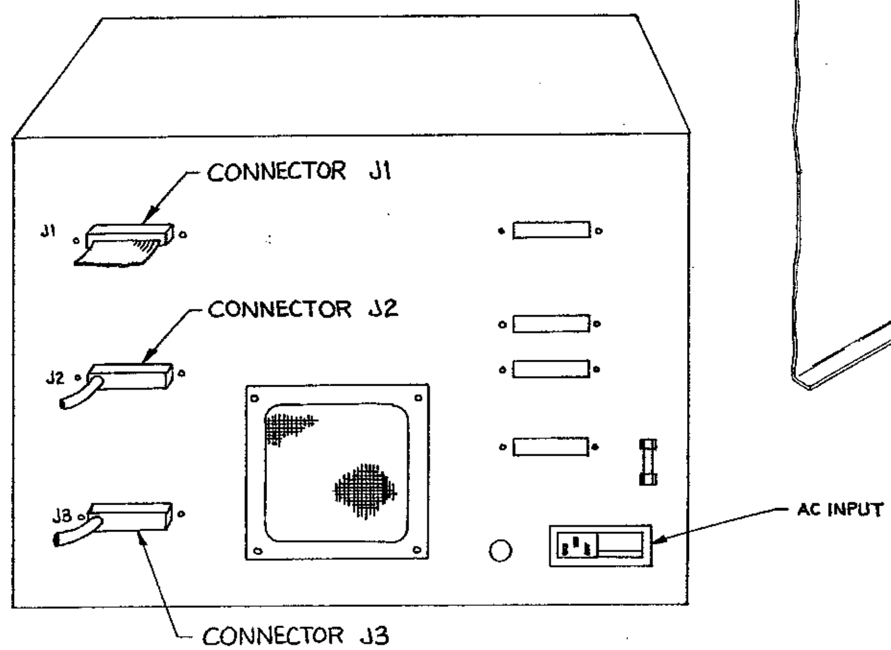
FIGURE 1-2. CONTROLLER CIRCUIT BOARD SIMPLIFIED SCHEMATIC (Sheet 1 of 2)



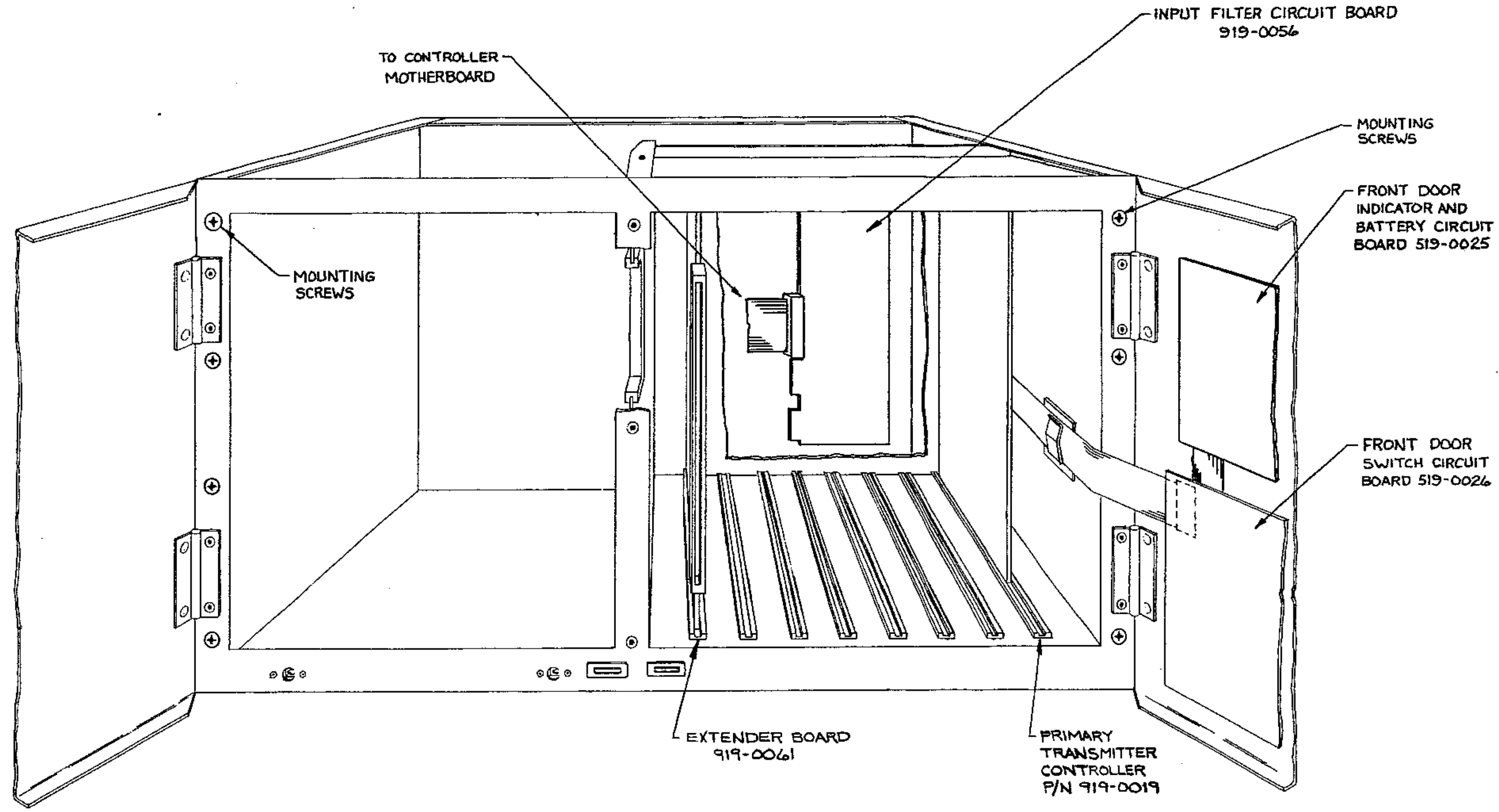
NOTES:
1. MICROPROCESSOR CONTROLLER OPTIONAL.

597-0032-42B

FIGURE 1-2. CONTROLLER CIRCUIT BOARD SIMPLIFIED SCHEMATIC (Sheet 2 of 2)



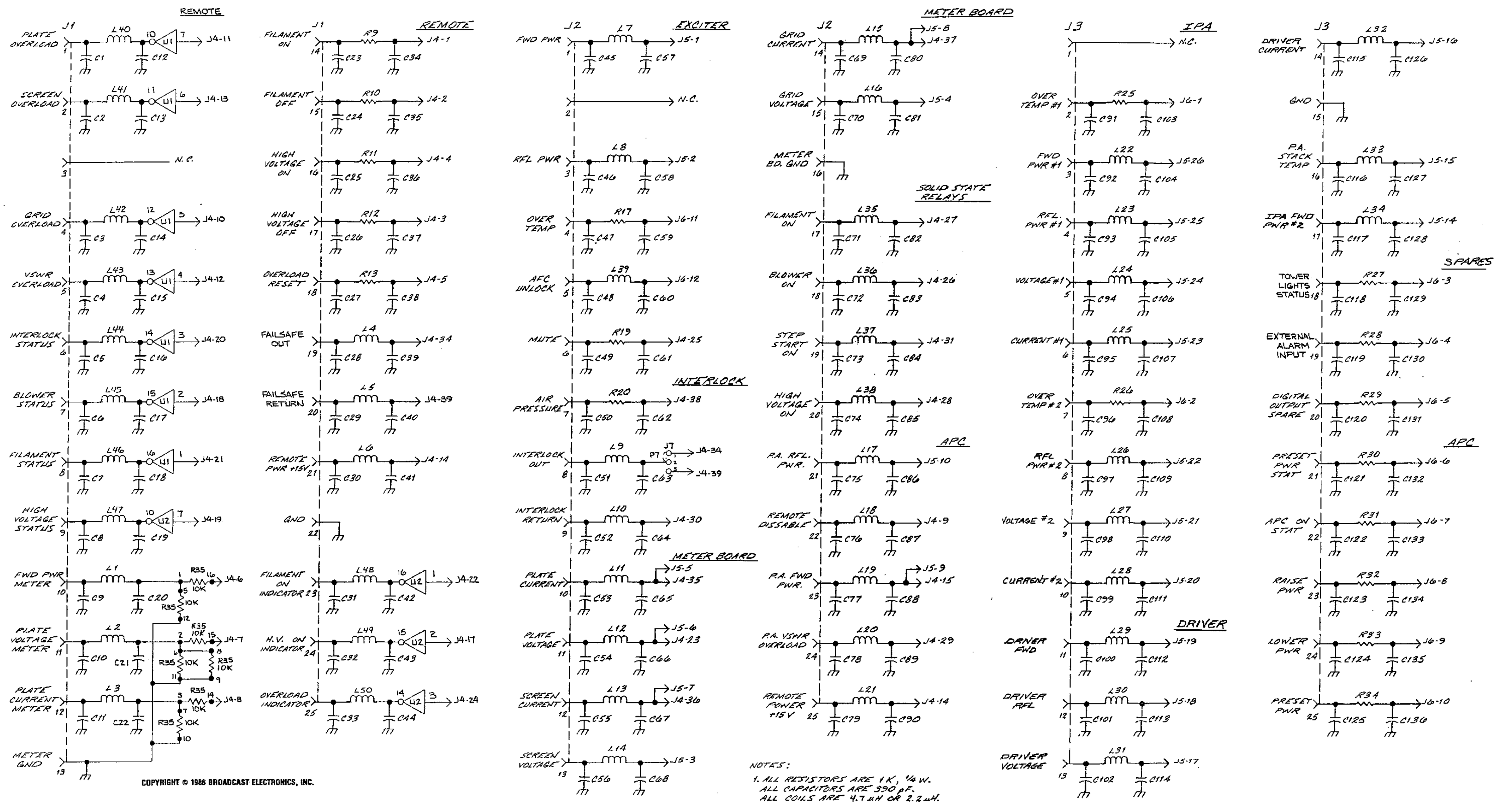
REAR PANEL VIEW



— CAUTION —
COMPONENT SIDE OF ALL CIRCUIT BOARDS TO LEFT

597-0032-105

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 µH OR 2.2 µH.
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

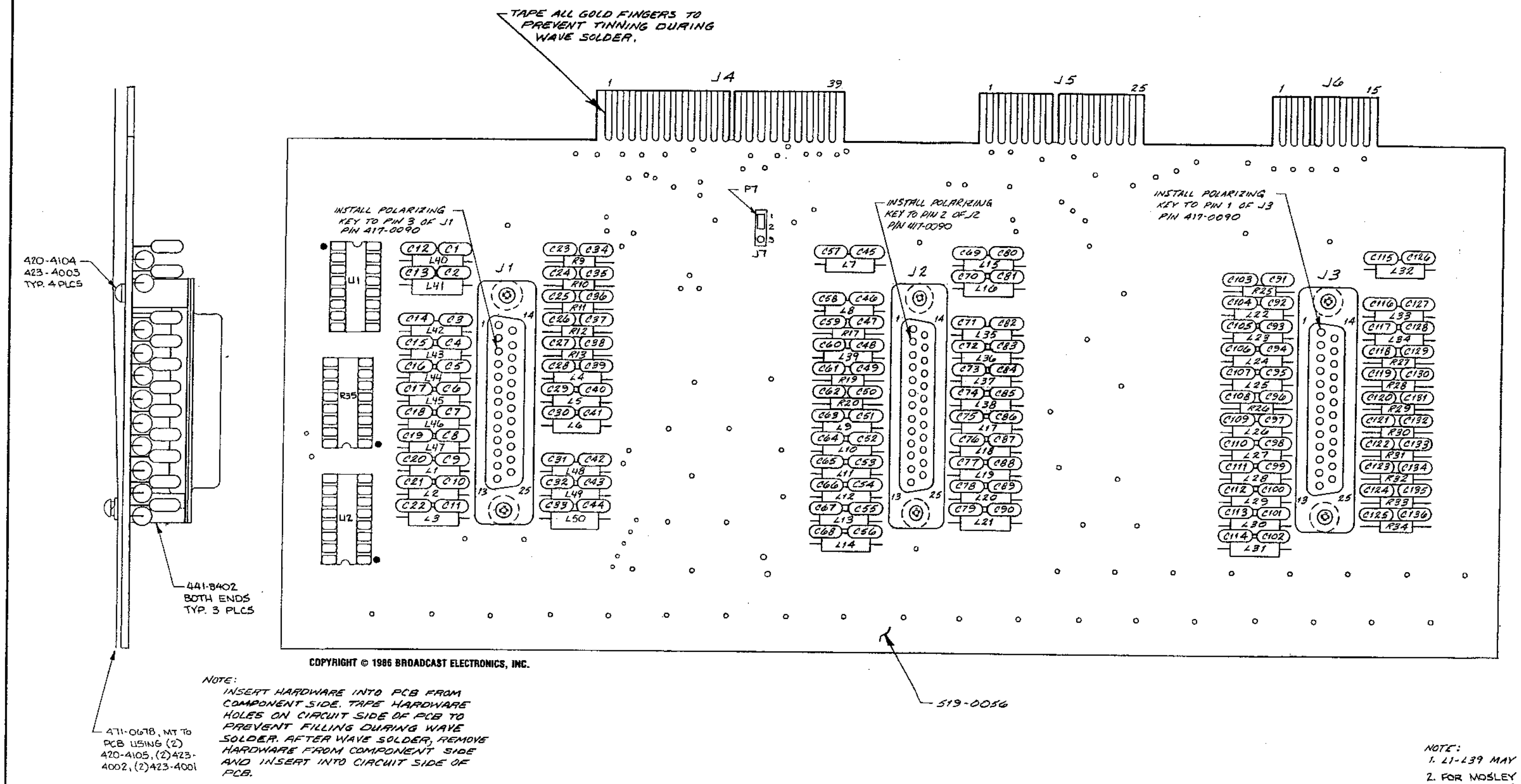
DRAWN BY MERKER DATE 1-21-83
CHECKED BY
PROJECT ENGR. DATE 5-13-83
APPROVED BY MH 5-13-83

BROADCAST ELECTRONICS INC.

TITLE SCHEMATIC - TRANSMITTER CONTROLLER INPUT FILTER BD.

D TYPE S DWG. NO. 919-0056 REV. G

TRANSMITTER CONTROLLER SCALE 2/1 SHEET 1 OF 1

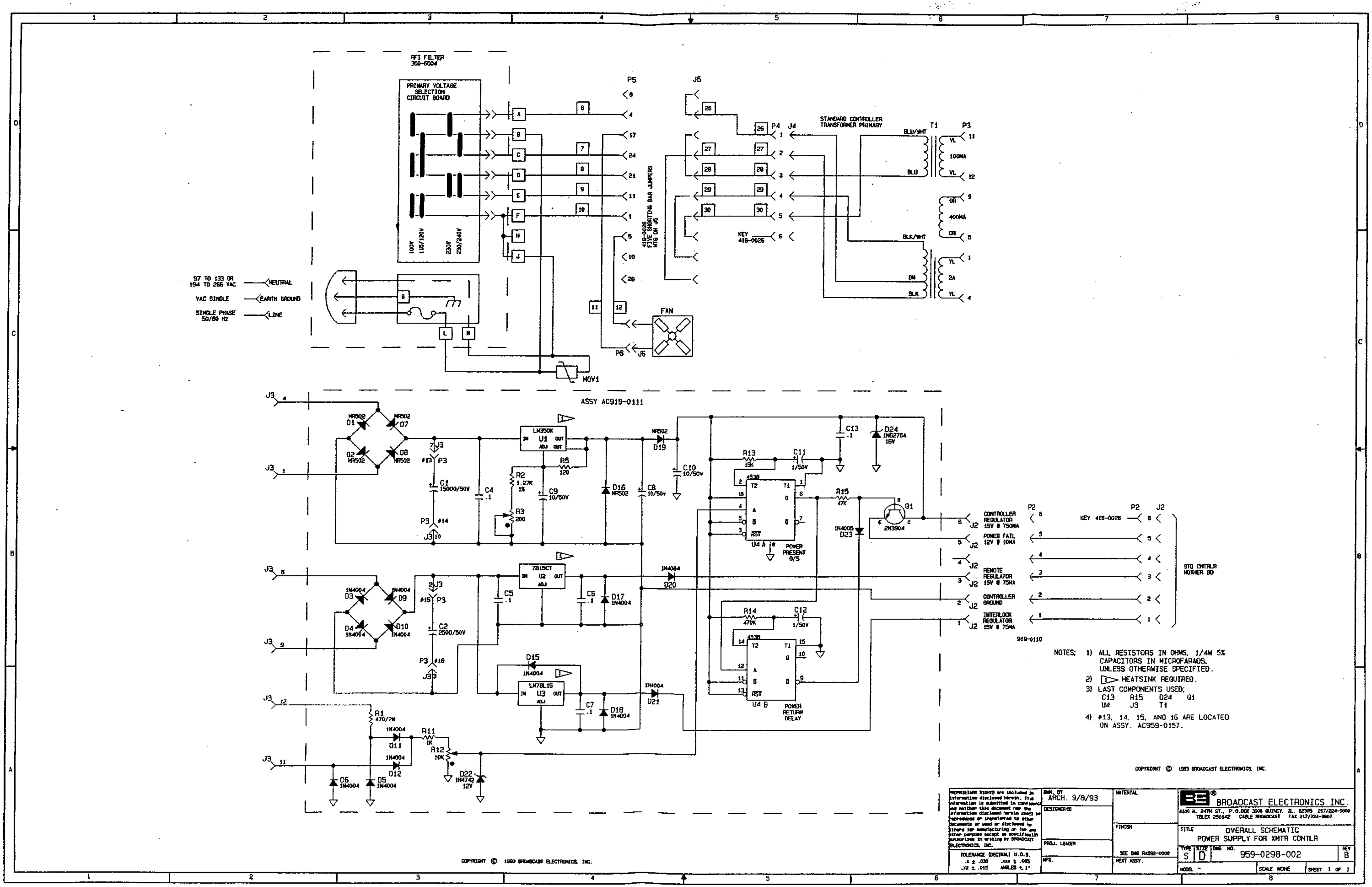


NOTE:
INSERT HARDWARE INTO PCB FROM COMPONENT SIDE. TAPE HARDWARE HOLES ON CIRCUIT SIDE OF PCB TO PREVENT FILLING DURING WAVE SOLDER. AFTER WAVE SOLDER, REMOVE HARDWARE FROM COMPONENT SIDE AND INSERT INTO CIRCUIT SIDE OF PCB.

SEE SCHEMATIC # D919-0056
SEE B/M # 919-0056

NOTE:
1. L1-L39 MAY BE EITHER 2.2 µH OR 4.7 µH 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	DRAWN BY MERKEL	DATE 1-20-83	BROADCAST ELECTRONICS INC.
	CHECKED BY	DATE	TITLE PCB ASSEMBLY - TRANSMITTER CONTROLLER INPUT FILTER BD.
	PROJECT ENGR	DATE 5-13-83	
	APPROVED BY MH	5-13-83	D DWG. NO. TYPE A 919-0056 REV. F
MATERIAL	TREATMENT OR FINISH		TRANSMITTER CONTROLLER SCALE 2/1 SHEET 1 OF 1


RFI FILTER
360-6504
PRIMARY VOLTAGE SELECTION CIRCUIT BOARD
100V
115/120V
230V
230/240V
97 TO 133 OR 194 TO 266 VAC
VAC SINGLE
SINGLE PHASE 50/60 Hz
NEUTRAL
EARTH GROUND
LINE
P5
J5
418-0406 FIVE SHORTING BAR JUMPERS MTG ON J5
KEY 418-0026
P4
J4
STANDARD CONTROLLER TRANSFORMER PRIMARY
T1
P3
BLU/WHT
BLU
BLK/WHT
BN
BLK
YL
100MA
OR
400MA
2A
FAN
P6
J6
MOV1
ASSY AC919-0111
MR502
D1
D7
D2
D8
LM350K
U1
R5 120
R2 1.27K 1%
R3 200
C1 15000/50V
C4 .1
C9 10/50V
D16 MR502
C8 10/50V
MR502
D19
C10 10/50V
C13 .1
D24 1N6276A 15V
R13 15K
C11 1/50V
4538
U4 A
POWER PRESENT O/S
R15 47K
Q1 2N3904
1N4005 D23
7815CT
U2
1N4004
D3
D9
D4
D10
C2 2500/50V
C5 .1
C6 .1
D17 1N4004
D20
R14 470K
C12 1/50V
U4 B
POWER RETURN DELAY
D15
LM78L15
U3
C7 .1
D18 1N4004
D21
R1 470/2W
D11
R11 1K
R12 10K
D22 1N4742 12V
D6 1N4004
D5 1N4004
D12
CONTROLLER REGULATOR 15V @ 750MA
POWER FAIL 12V @ 10MA
REMOTE REGULATOR 15V @ 75MA
CONTROLLER GROUND
INTERLOCK REGULATOR 15V @ 75MA
P2
J2
KEY 418-0026
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.
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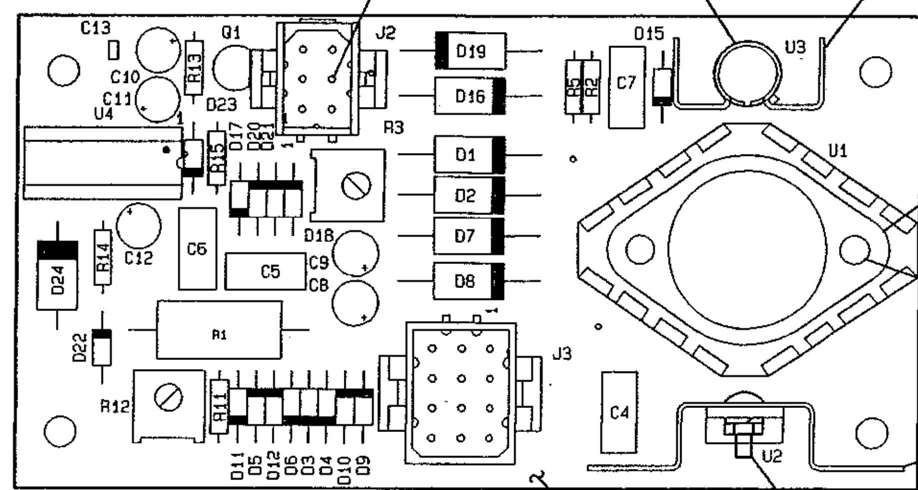
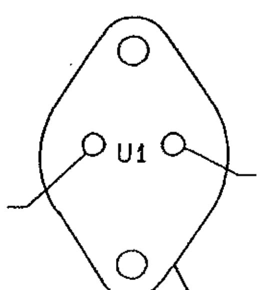
DRN. BY ARCH. 9/8/93
BROADCAST ELECTRONICS INC.
TITLE OVERALL SCHEMATIC POWER SUPPLY FOR XMTR CONTLR
SIZE D
959-0298-002
REV B
SCALE NONE
SHEET 1 OF 1



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°

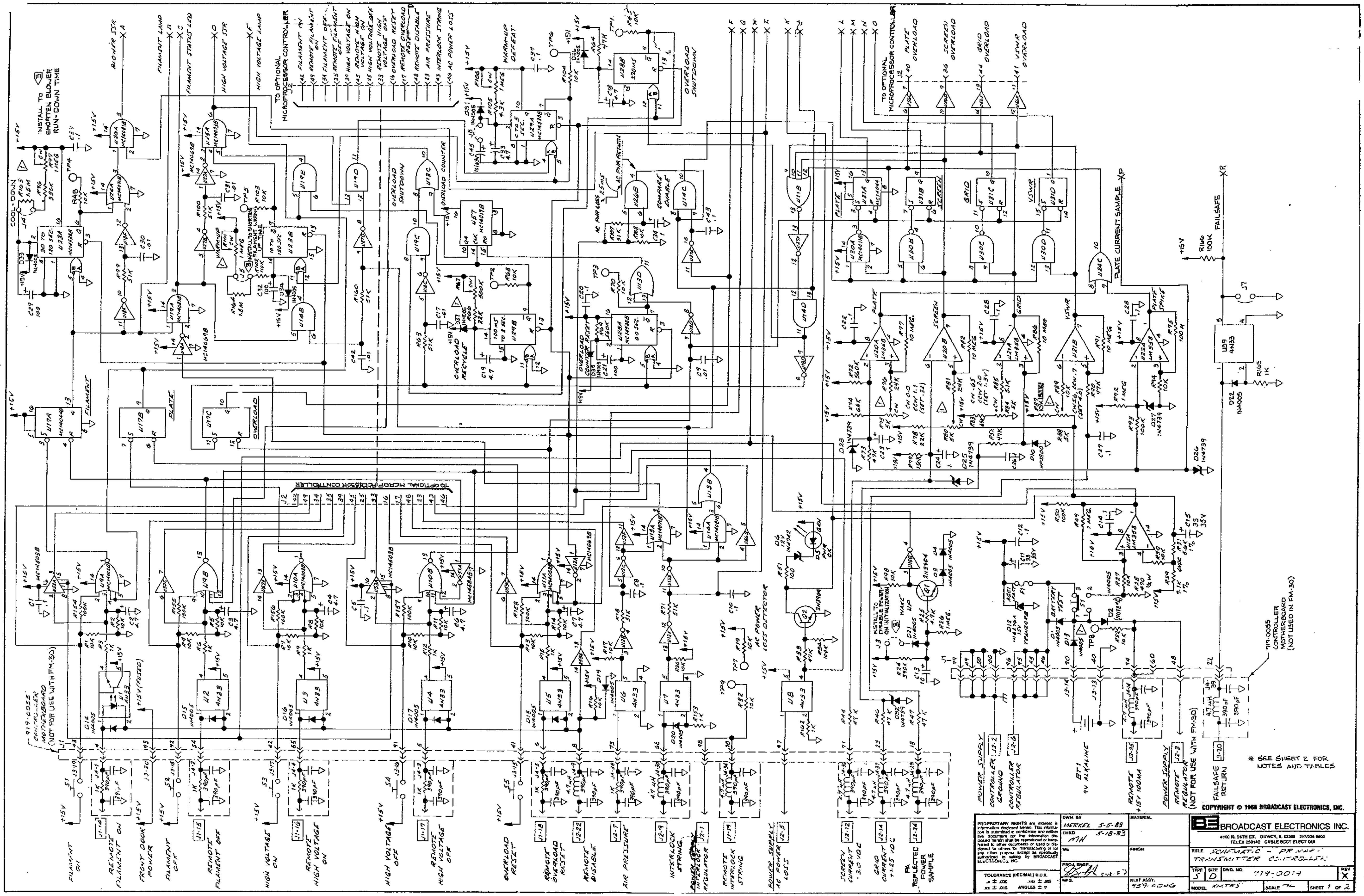
DWN. BY	JAH 9-4-91
CHKD	MH 5-9-89
ME	JHS 5-8-89
PROJ. ENGR.	JLT 5-8-89
MFG.	PRB 5-8-89
MATERIAL	SEE B/M 919-0111
FINISH	SEE DWG RA592-0000
NEXT ASSY.	

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


* SEE SHEET 2 FOR NOTES AND TABLES
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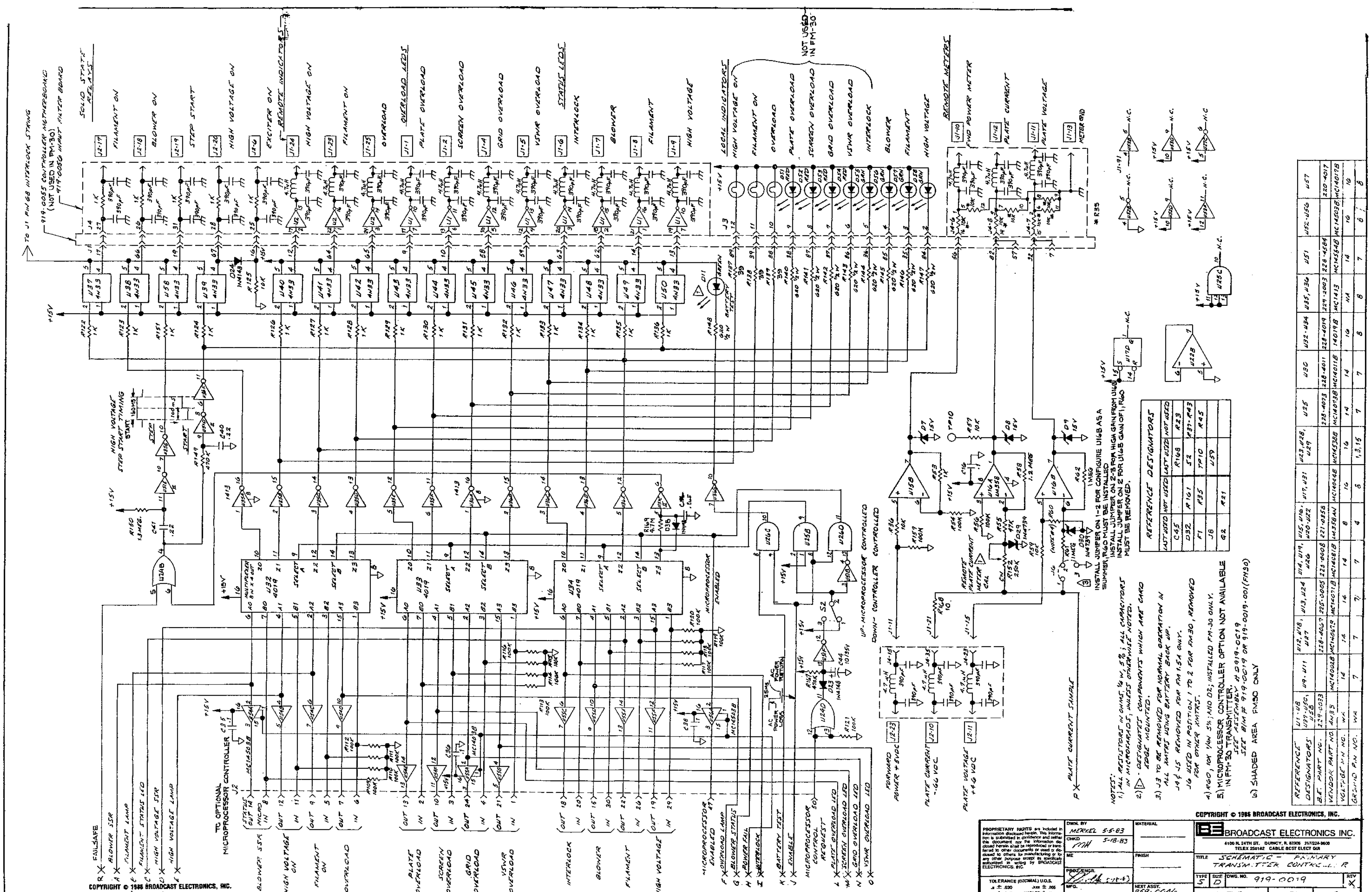
TOLERANCE (DECIMAL) U.O.S.
.x ± .030 .xxx ± .005
.xx ± .015 ANGLES ± 1°
DWN. BY MERKEL 5-5-83
CHKD MH 5-18-83
ME
PROJ. ENGR.
MFG.
MATERIAL
FINISH
NEXT ASSY. 959-0046
BROADCAST ELECTRONICS INC.
4100 N. 24TH ST. QUINCY, IL 62305 217/224-9600
TELEX 250142 CABLE BCST ELECT QUI
TITLE SCHEMATIC - PRIMARY TRANSMITTER CONTROLLER
TYPE S
SIZE D
DWG. NO. 914-0019
REV X
MODEL XMTRS
SCALE
SHEET 1 OF 2
TO OPTIONAL MICROPROCESSOR CONTROLLER
FILAMENT ON
REMOTE FILAMENT ON
FRONT DOOR POWER
FILAMENT OFF
REMOTE FILAMENT OFF
HIGH VOLTAGE ON
REMOTE HIGH VOLTAGE ON
HIGH VOLTAGE OFF
REMOTE HIGH VOLTAGE OFF
OVERLOAD RESET
REMOTE OVERLOAD RESET
REMOTE DISABLE
AIR PRESSURE
INTERLOCK STRING
REMOTE INTERLOCK STRING
POWER SUPPLY AC POWER LOSS
SCREEN CURRENT -3.0 VDC
GRID CURRENT +1.25 VDC
PA REFLECTED POWER SAMPLE
POWER SUPPLY CONTROLLER GROUND
CONTROLLER REGULATOR
BT1 9V ALKALINE
REMOTE +15V 100MA
POWER SUPPLY REMOTE REGULATOR (NOT FOR USE WITH FM-30)
FAILSAFE RETURN
BLOWER SSR
FILAMENT LAMP
FILAMENT STATUS LED
HIGH VOLTAGE SSR
HIGH VOLTAGE LAMP
PLATE OVERLOAD
SCREEN OVERLOAD
GRID OVERLOAD
VSWR OVERLOAD
OVERLOAD SHUTDOWN
OVERLOAD COUNTER
OVERLOAD RECYCLE
WARMUP DEFEAT
AC PWR LOSS
AC PWR RETURN
COMPARE ENABLE
PLATE CURRENT SAMPLE
FAILSAFE
AC POWER LOSS DETECTOR
INSTALL TO SHORTEN BLOWER RUN-DOWN TIME
COOL-DOWN
914-0055 CONTROLLER MOTHERBOARD (NOT FOR USE WITH FM-30)
914-0055 CONTROLLER MOTHERBOARD (NOT USED IN FM-30)



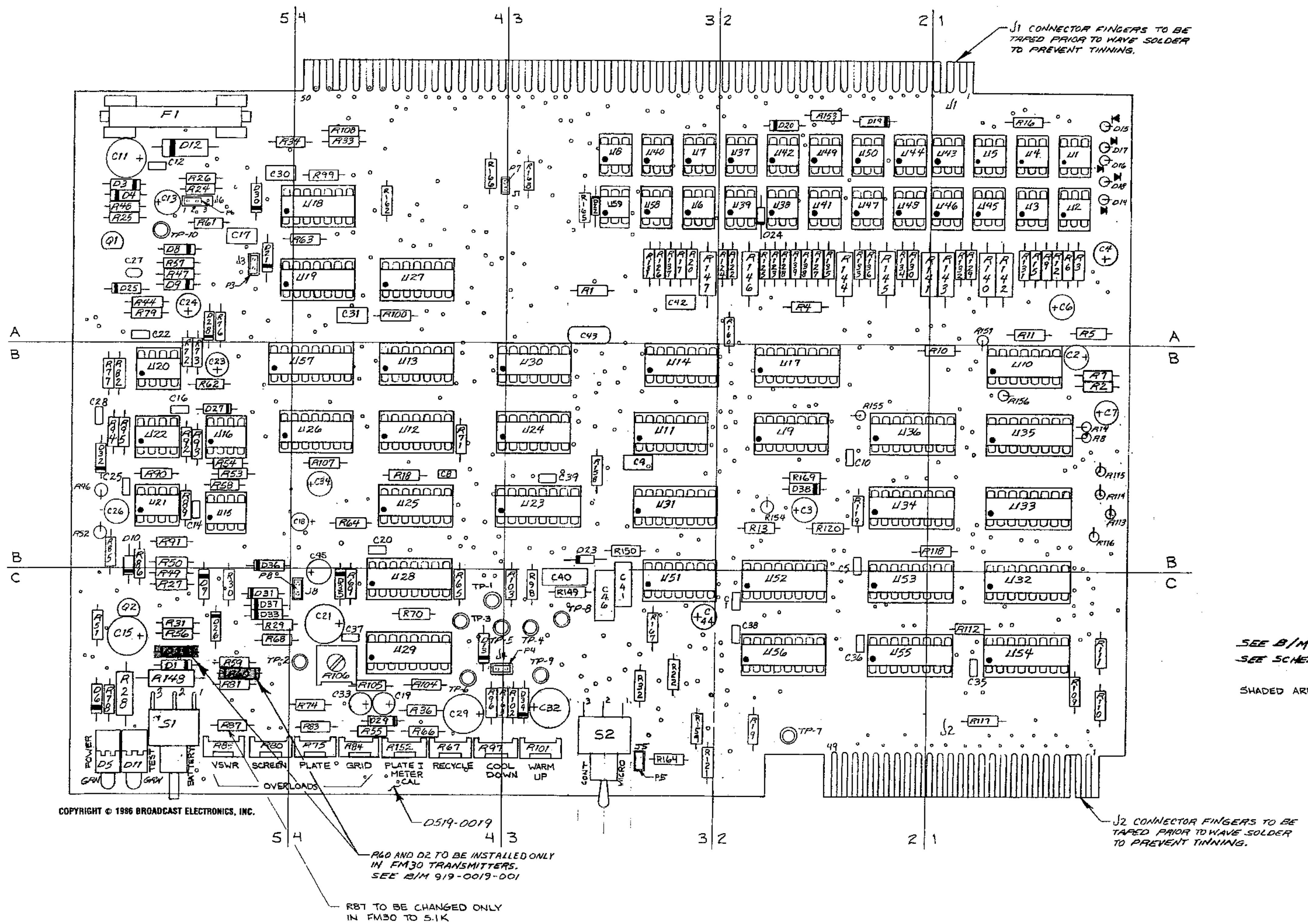
TOLERANCE (DECIMAL) U.O.S.
.x ± .030 .xxx ± .005
.xx ± .015 ANGLES ± 1°

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



SEE B/M #919-0019 OR 919-0019-001(FM30)
SEE SCHEMATIC #D919-0019

SHADED AREA LOCATED IN FM30 ONLY

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 OAF	DATE 1-28-83	BROADCAST ELECTRONICS INC.
CHECKED BY	DATE	TITLE ASSEMBLY PRIMARY TRANSMITTER CONTROLLER
PROJECT ENGR.	DATE 5-16-83	D DWG. NO. A 919-0019 919-0019-001 REV. X
APPROVED BY MH 5-16-83		XMTRS SCALE 2/1 SHEET 1 OF 1
TREATMENT OR FINISH		