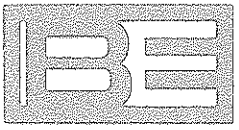
INSTRUCTION MANUAL

FM-1.5A
1.5 KILOWATT
FM BROADCAST
TRANSMITTER

March, 1988 IM No. 597-0031-001

BROADCAST ELECTRONICS, INC.



IMPORTANT INFORMATION

EQUIPMENT LOST OR DAMAGED IN TRANSIT

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

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

TECHNICAL ASSISTANCE AND REPAIR SERVICE

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

FOR TECHNICAL ASSISTANCE
Phone (217) 224-9600 Customer Service

WARRANTY ADJUSTMENT

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

RETURN, REPAIR AND EXCHANGES

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

REPLACEMENT PARTS

Replacement and Warranty Parts may be ordered from the address below. Be sure to include equipment model and serial number and part description and part number.

Broadcast Electronics, Inc.
4100 N. 24th St., P.O. Box 3606
Quincy, Illinois 62305
Tel: (217) 224-9600
Telex: 25-0142
Cable: BROADCAST

PROPRIETARY NOTICE

MODIFICATIONS

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

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.

SCOPE OF MANUAL

This manual comprises two sections providing the following information of the Broadcast Electronics FM-1.5A, 1.5 kW FM Broadcast Transmitter.

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

B. PART II - Contains detailed information for the following transmitter modular units.

1. INTERMEDIATE POWER AMPLIFIER

2. AUTOMATIC POWER CONTROL

3. TRANSMITTER CONTROLLER

PART I - TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

PART II - TABLE OF CONTENTS

SECTION I
GENERAL INFORMATION

1-1. INTRODUCTION.

1-2. Information presented by this section provides a general description of the FM-1.5A 1500 Watt 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-1.5A transmitter.

PUBLICATION NUMBER	EQUIPMENT
597-0002	FX-30 FM Exciter
597-0008	FC-30 SCA Generator
597-0009	FS-30 Stereophonic Generator
597-0036	Microprocessor Video Diagnostic System (MVDS)

1-5. EQUIPMENT DESCRIPTION.

1-6. The Broadcast Electronics FM-1.5A is a 1500 Watt FM Transmitter designed for continuous operation in the 87.5 MHz to 108 MHz FM broadcast band. The RF power amplifier, IPA, FM exciter, and the control circuitry are housed in a single cabinet (see Figure 1-1). The transmitter features a folded half-wave cavity PA stage, a solid-state control system, a solid-state IPA, and an exciter with a digital frequency synthesizer. The following list provides ordering information, optional equipment, and recommended spare parts kits.

PART NUMBER	DESCRIPTION
909-1500-202	FM-1.5A 1500 Watt FM transmitter, complete with final tube including FX-30 FM exciter, for operation on ( ) MHz, 50 Ohm output, transmitter output power to be ( ) Watts, single phase 208/240 VAC, 60 Hz.
909-1500-212	Same as 909-1500-202 less exciter.
909-1500-302	Same as 909-1500-202 with 50 Hz power supply.
909-0091-004	Microprocessor Video Diagnostic System Option, factory installed.
909-0091-020	Microprocessor Video Diagnostic System Option, field installation kit.
979-0030	Recommended semiconductor spare parts kit.

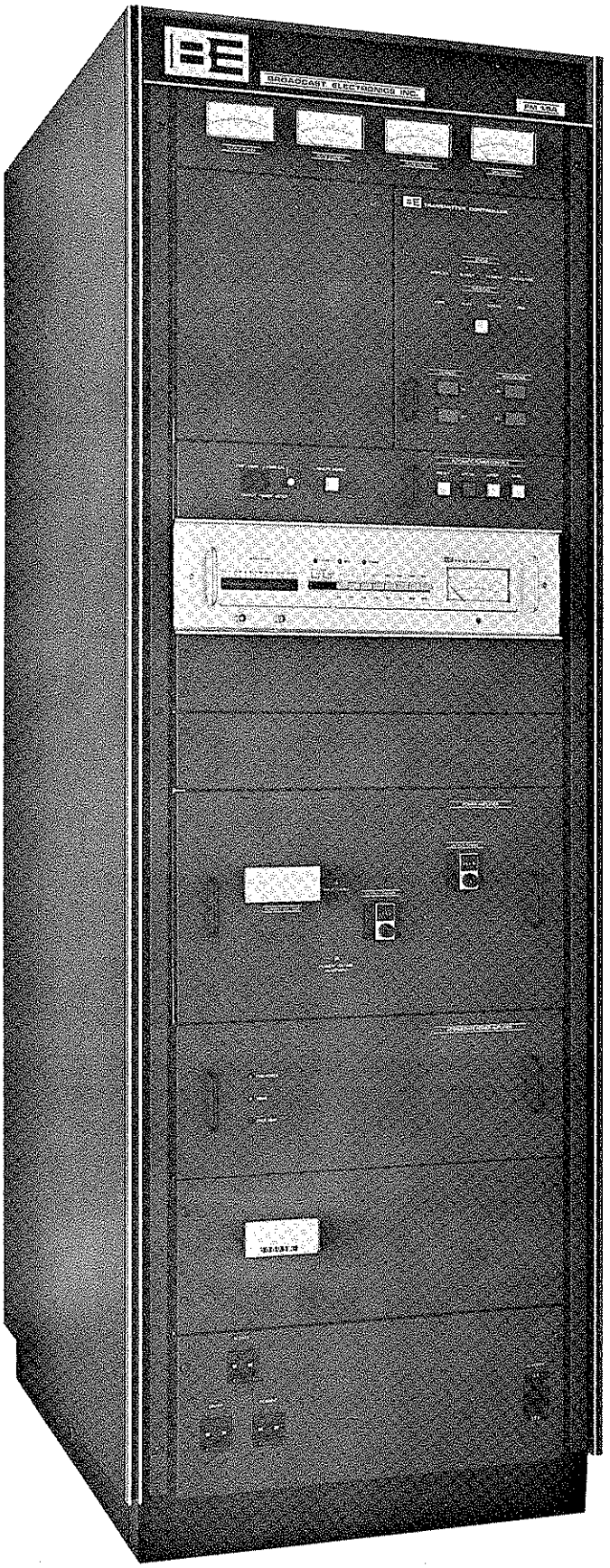


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FIGURE 1-1. FM-1.5A TRANSMITTER

1-7. EQUIPMENT SPECIFICATIONS.

1-8. Refer to Table 1-1 for electrical specifications or Table 1-2 for physical specifications for the FM-1.5A FM Transmitter.

TABLE 1-1. ELECTRICAL CHARACTERISTICS
(Sheet 1 of 2)

PARAMETER	SPECIFICATION
RF POWER OUTPUT	500W to 1.65 kW (as ordered).
AUTOMATIC POWER CONTROL RESOLUTION	±2%.
RF FREQUENCY RANGE	87.5 to 108 MHz (as ordered).
RF OUTPUT IMPEDANCE	50 Ohms Resistive.
RF OUTPUT CONNECTOR	0.875 inch (2.2 cm) EIA Flange (removable flange supplied).
MAXIMUM VSWR	2.0:1 (Will operate into higher VSWR with automatic power reduction).
TUBE COMPLEMENT	3CX1500A7/8877 (1).
FM S/N RATIO	72 dB below ±75 kHz Deviation @ 400 Hz, measured in a 30 Hz to 15 kHz bandwidth with 75 microsecond de-emphasis.
ASYNCHRONOUS AM S/N RATIO	55 dB below reference carrier with 100% AM @ 400 Hz, 75 microsecond deemphasis (no FM present).
SYNCHRONOUS AM S/N RATIO	45 dB below reference carrier with 100% AM @ 400 Hz (FM at ±75 kHz @ 400 Hz).
RF HARMONIC SUPPRESSION	Meets all FCC/DOC requirements and CCIR recommendations.
FREQUENCY STABILITY	±300 Hz, Ø° to 50°C, temperature compensated crystal oscillator.
TYPE OF MODULATION	Direct frequency modulation at carrier frequency.
MODULATION CAPABILITY	Greater than ±200 kHz.

TABLE 1-1. ELECTRICAL CHARACTERISTICS
(Sheet 2 of 2)

PARAMETER	SPECIFICATIONS
PRE-EMPHASIS	FCC 75 uS, CCIR 50 uS (where specified), or 25 uS (Dolby).
MONAURAL AUDIO INPUT IMPEDANCE	600 Ohms balanced, resistive, 50 dB common mode suppression.
AUDIO INPUT LEVEL	+10 dBm nominal for ±75 kHz deviation @ 400 Hz.
MONAURAL AUDIO FREQUENCY RESPONSE	±0.5 dB, 30 Hz to 15 kHz, selectable flat, 25, 50, or 75 microsecond pre-emphasis.
MONAURAL OR COMPOSITE:	
a) HARMONIC DISTORTION	0.08% or less.
b) INTERMODULATION DISTORTION	0.08% or less, 60 Hz/7 kHz, 4:1 ratio
c) TRANSIENT IMD	0.1% or less (square wave/sine wave).
COMPOSITE INPUTS	3, BNC Connectors.
COMPOSITE INPUT IMPEDANCE	10 k Ohm nominal, resistive.
COMPOSITE INPUT LEVEL	3.5V p-p nominal for ±75 kHz deviation.
AC INPUT POWER	196 to 252 VRMS, 50 or 60 Hz (as ordered), single-phase ac, 18 Amperes.
PRIMARY AC POWER CONSUMPTION	3000W Typical @ 0.9 PF for 1.5 kW output.
OVERALL TRANSMITTER EFFICIENCY	50% Typical (AC line input to RF output).

TABLE 1-2. PHYSICAL CHARACTERISTICS

PARAMETER		SPECIFICATION
AMBIENT TEMPERATURE RANGE		+14°F to +122°F (-10°C to +50°C).
MAXIMUM ALTITUDE		Ø to 7500 Feet above sea level (Ø to 2286 Meters).
MAXIMUM HUMIDITY		95% Non-Condensing.
SIZE:		
	WIDTH	23.38 Inches (59.39 cm).
	HEIGHT	69.88 Inches (177.5 cm).
	DEPTH	30.75 Inches (78.11 cm).
WEIGHT:		
	UNPACKED	900 Pounds (408 kg).
	PACKED	
	Domestic	1100 Pounds (499 kg).
	International	1300 Pounds (590 kg).
CUBAGE:	UNPACKED	29.1 Cubic Feet (0.82 m^3).
	PACKED	
	Domestic	31.5 Cubic Feet (0.89 m^3).
	International	36 Cubic Feet (1.02 m^3).
HEAT DISSIPATION (1.5 kW Output)		1825W Maximum (6231 BTU/hr.).
COOLING AIR REQUIREMENTS:		
	TRANSMITTER	500 ft^3/min (14.15 m^3/min).
AIR INLET SIZE (Rear Panel)		13 5/8 inches X 8 1/8 inches (34.6 cm X 20.6 cm).
AIR OUTLET SIZE (Top)		21 3/4 inches X 25 1/2 inches (55.75 cm X 64.77 cm).

SECTION II
INSTALLATION

2-1. INTRODUCTION.

2-2. This section contains information required for installation and preliminary checkout of the Broadcast Electronics FM-1.5A FM 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 lists (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. ENVIRONMENTAL REQUIREMENTS.

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

2-8. COOLING AIR REQUIREMENTS.

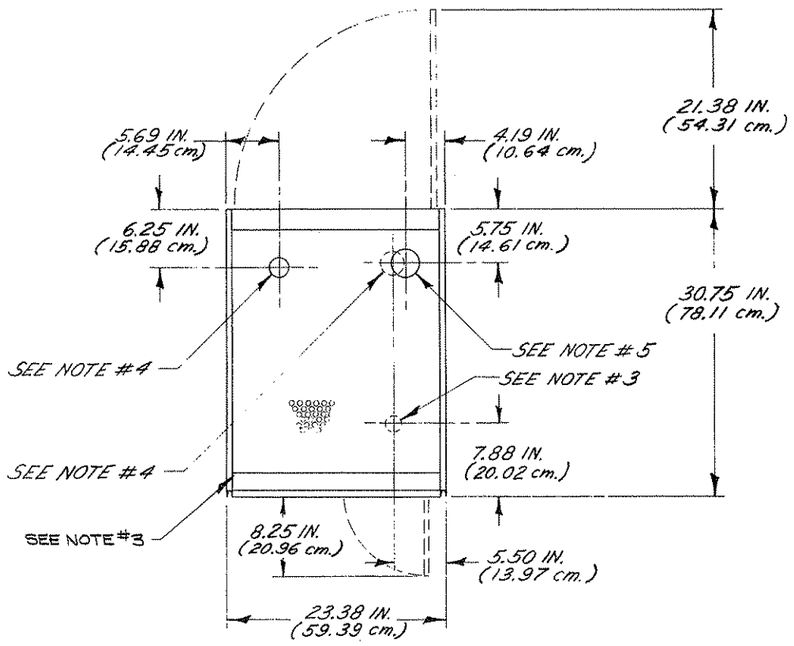
2-9. If outside air is to be used to cool the transmitter, the air inlet duct must be sized to allow adequate air flow. The air must be dry and well filtered. If intake louvers are used, operation of the louvers must be electrically interlocked with the transmitter operation.

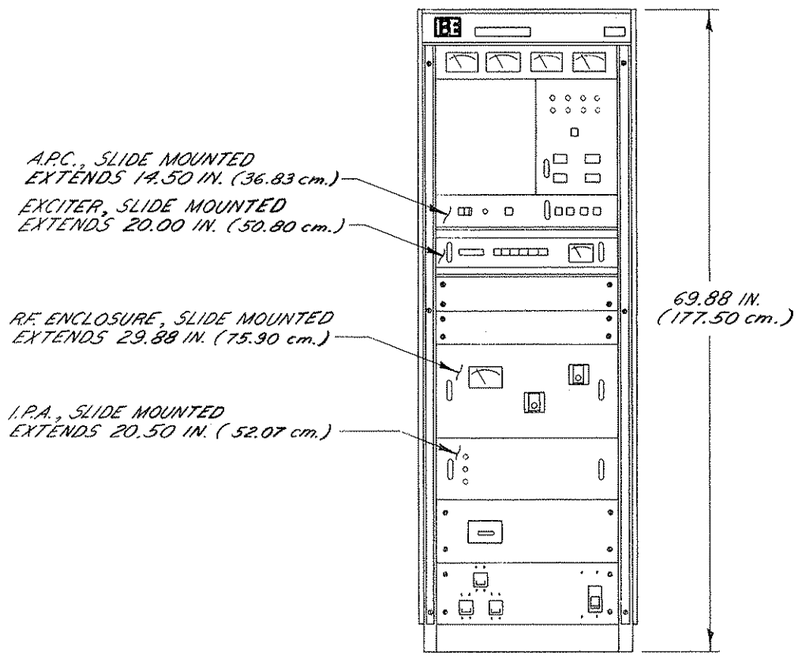
2-10. If the heated transmitter air is to be ducted from the room, the duct system must not introduce any back-pressure on the equipment. Proper allowances for air flow will ensure that only a limited amount of heat is dissipated into the equipment interior. The duct system must allow for a minimum air flow of 500 cubic feet of air per minute (14.15 m^3/min).

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

TABLE 2-1. FM-1.5A PACKING LIST

ITEM	DESCRIPTION	BE PART NO.	QTY.
1	Transmitter, FM-1.5A	909-1500-202	1
2	PA Tube, 3CX1500A7	243-8877	1
3	Manual, FM-1.5A FM Transmitter	597-0031-001	1
4	Manual, FX-30 FM Exciter (Not included when shipped less Exciter)	597-0002-001	1
5	Cabinet Door Keys	NPN	2
6	Exciter Accessory Kit - Less Rails and Coaxial Cables (Not included when shipped less Exciter)	961-0001	1
7	Test Data Sheets, Set	592-0021	1
8	Battery, 9 Volt (Controller)	350-0002	2
9	Extender Circuit Board (Controller)	919-0061	1
10	Hex Key, 5/32 inch (Lower Front Panel Screws)	710-0219	1
11	Coupling, Plate Line to Tube	447-0018	1
12	1 3/4 inches X 0.31 inch wide (4.45 cm X 0.79 cm) Stainless Steel Strap Clamp (for plate line)	402-0034	1
13	4 1/2 inches X 1/2 inch wide (11.43 cm X 1.27 cm) Stainless Steel Strap Clamp (for plate line)	402-0033-001	1
14	Spade Lugs (for Remote Control Terminal Strip)	410-1489	40
15	Programmable Jumpers, 8-Pin DIP	340-0006	5





NOTES:

1. AIR INLET AT REAR OF CABINET, FILTER REQUIRED - P/N 407-0062.
2. AIR OUTLET AT TOP OF CABINET, 21 3/4 IN. X 25 1/2 IN. (55.25 cm X 64.77 cm).
3. ACCESS FOR A.C. POWER THRU BASE PLATE; SEE DRAWING.
   (MAY BE ACCESSED THRU TOP, REAR, OR SIDES BY ADDING ACCESS HOLE.)
   GROUND STRAP ENTRY POINT IN LOWER LEFT CORNER.
4. ACCESS FOR REMOTE CONTROL AND AUDIO CONNECTIONS THROUGH TOP OR BOTTOM OF CABINET.
5. OUTPUT RF CONNECTION IS 7/8" EIA FLANGE, B.E. P/N 427-0033.
   FLANGE IS REMOVABLE IF UNFLANGED 7/8" CONNECTION IS DESIRED.
   NO CENTER CONDUCTOR BULLET IS SUPPLIED: B.E. P/N 427-0034 RECOMMENDED.
6. HEAT DISSIPATION: 1825 WATTS MAXIMUM (6231 BTU/HR.) FOR 1.5KW RF OUTPUT.
7. COOLING AIR REQUIREMENTS: 500 cfm (14.16 M^3/Min).
8. WEIGHT: 900 POUNDS (408 kg).
9. CUBAGE: 31.5 $FT.^3$ (0.89 M^3).
10. A.C. POWER CONSUMPTION: 3325W MAXIMUM AT .9 POWER FACTOR FOR 1.5KW RF OUTPUT.
11. A.C. POWER INPUT: 196-252 VAC SINGLE PHASE AT 18 AMPERES MAXIMUM, 60 Hz WITH 909-1500-201 (50 Hz WITH 909-1500-301) FUSED DISCONNECT SWITCH RECOMMENDED. FOR PROPER SIZING OF FUSES REFER TO NATIONAL ELECTRICAL CODE OR LOCAL CODES.

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

DWN. BY B.C. 8-1-83
CHKD.
ME 8/8/83
EE
PROJ. ENGR. 9-8-83
DFTG. SUPVR. MH
MFG.

NEXT ASSY.
PRODUCT USED ON
FINISH

BROADCAST ELECTRONICS INC.
4100 N. 24TH ST. QUINCY, IL 62305 217/224-9600
TELEX 250142 CABLE BCST ELECT QUI

TITLE
FM 1.5A, INSTALLATION DRAWING

SHEET 1 OF 1
SCALE 1/10
REV E

TYPE R | SIZE C | DWG. NO. 909-1520-202
909-1500-302

2-12. INSTALLATION.

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

2-14. EQUIPMENT PLACEMENT.

2-15. Access holes in the top and bottom of the cabinet allow either overhead or under-floor ducting of interconnecting wiring (see Figure 2-1). The floor must be capable of supporting the total transmitter weight of approximately 130 pounds per square foot. The floor support should be more than marginal to maintain the proper cabinet alignment and reduce vibration.

2-16. After it has been determined where and how the cabinet will be positioned, set the cabinet in place on a smooth and level location.

2-17. COMPONENT INSTALLATION.

WARNING ENSURE PRIMARY POWER IS DISCONNECTED BEFORE PROCEEDING.

2-18. Interconnecting wires and cables are tied in for shipment. Remove all tape, wire ties, string, and packing material used for shipment. Remove the cover from the FAILSAFE SOLENOID ASSEMBLY and cut loose all tie wraps, freeing the plunger. Replace the cover. Also, remove all ties from the shorting stick hanger.

2-19. Cables, connectors, and miscellaneous components to be installed are shipped in separate cartons. The following text provides information concerning the installation of these items.

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

2-20. Install the 1 5/8 inch EIA flange on the low pass filter. Connect the antenna to the 1 5/8 to 7/8 inch reducer. Then attach the reducer to the flange. The flange can be left off if unflanged connections are desired. A center conductor bullet may be required (BE P/N 427-0034).

2-21. Remove the retainers from each set of slide rails inside the transmitter.

2-22. Temporarily, disconnect the RF output line from the rear of the PA drawer and allow the cable to hang free.

2-23. Loosen the POWER AMPLIFIER drawer front-panel turn-lock fasteners and pull the cabinet forward, out of the rack until the slide rail stops are encountered.

2-24. Loosen the (twenty) turn-lock fasteners on the top of the POWER AMPLIFIER drawer and remove the top cover (do not remove the 6-32 screws).

2-25. Remove any packing material from the inside of the cabinet.

2-26. Remove the PA tube, coupling, and two hose clamps from the shipping container.

2-27. Align the polarizing pin of the PA tube with the receptacle on the socket. Carefully install the PA tube with steady pressure.

2-28. After the PA tube is fully seated, slide one hose clamp around the tube and one around the plate line.

2-29. Place the coupling between the lower portion of the tube (hollow side up) and plate line. Slide the hose clamps onto the coupling and tighten until the clamps are snug.

2-30. The plate line outer conductor is normally collapsed for shipping. Loosen the hose clamp on the plate line outer conductor and slide the outer conductor forward until the scribed line is exposed, then secure the plate line at this point.

2-31. Install the nine-volt battery in the transmitter controller battery holder.

2-32. Refer to Figure 2-2 and ensure all programmable jumpers are positioned as indicated.

2-33. Using a miniature flat-blade screwdriver, mechanically zero all meters.

2-34. Replace the top cover on the cabinet.

2-35. Push the POWER AMPLIFIER drawer back into the rack and secure the turn-lock fasteners.

2-36. Reconnect the RF output line to the rear of the PA drawer.

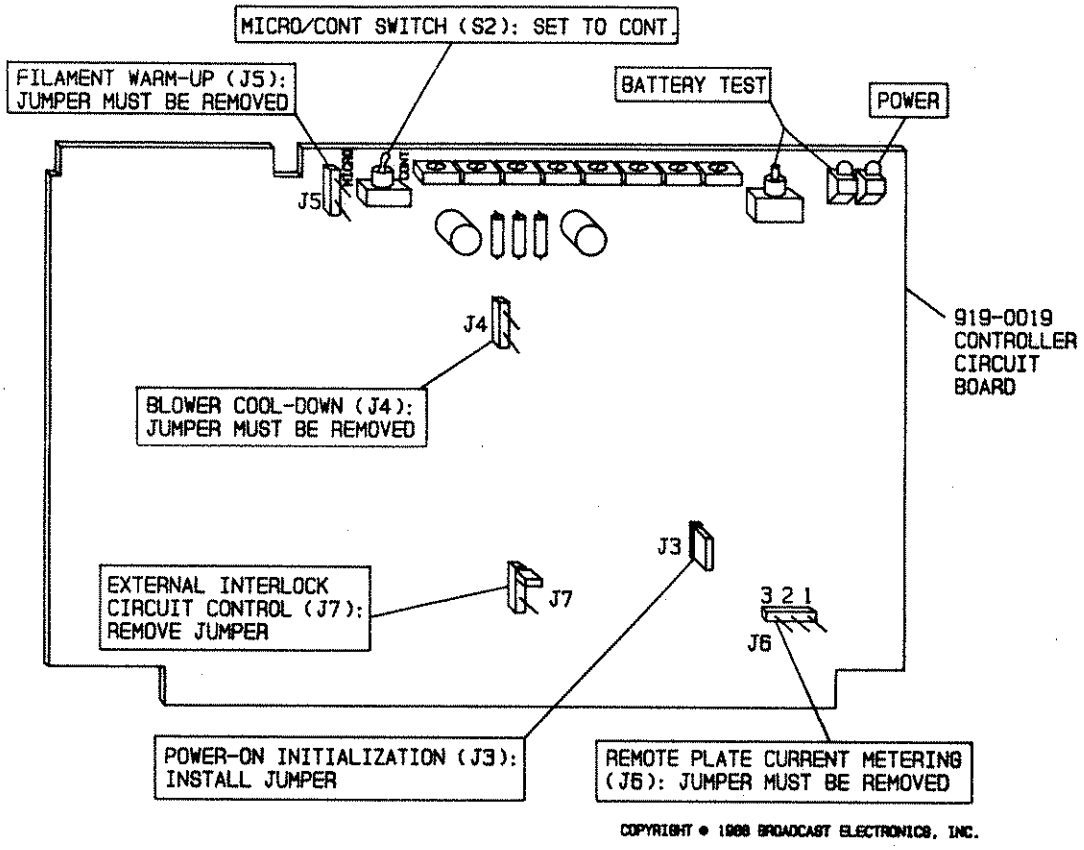


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FIGURE 2-2. CONTROLLER CIRCUIT BOARD JUMPER-PLUG PROGRAMMING

2-37. REMOTE CONTROL.

2-38. Many transmitter functions may be remotely controlled (see Figure 2-3). The transmitter will interface with most modern remote control units such as the sixteen channel Moseley MRC-1600. Programmable circuitry on the controller input filter circuit boards provides either positive or negative logic remote indications to meet any interfacing requirements. 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.

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

B. Refer to Figure 2-3 and program the input filter circuit board for the desired remote indication logic and meter indications:

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

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

3. Install 8-Pin DIP programmable jumpers in receptacles U1, U2, and R35 for positive remote indication logic and +5 volt dc remote meter indications.

C. Replace the access panel.

D. Complete the remote control installation by connecting the remote control unit wiring to the transmitter REMOTE INTERFACE PANEL terminal strips (refer to Figure 2-3).

2-39. WIRING.

WARNING ENSURE PRIMARY POWER IS DISCONNECTED BEFORE PROCEEDING.

2-40. VOLTAGE TAPS. Ensure the transmitter is wired for the input voltage and line frequency to be used. The plate transformer and high voltage plate supply choke must be checked and changed if required (see Figure 2-4). The filament transformer and high voltage plate supply choke have specific input voltage requirements which have been prewired at the factory.

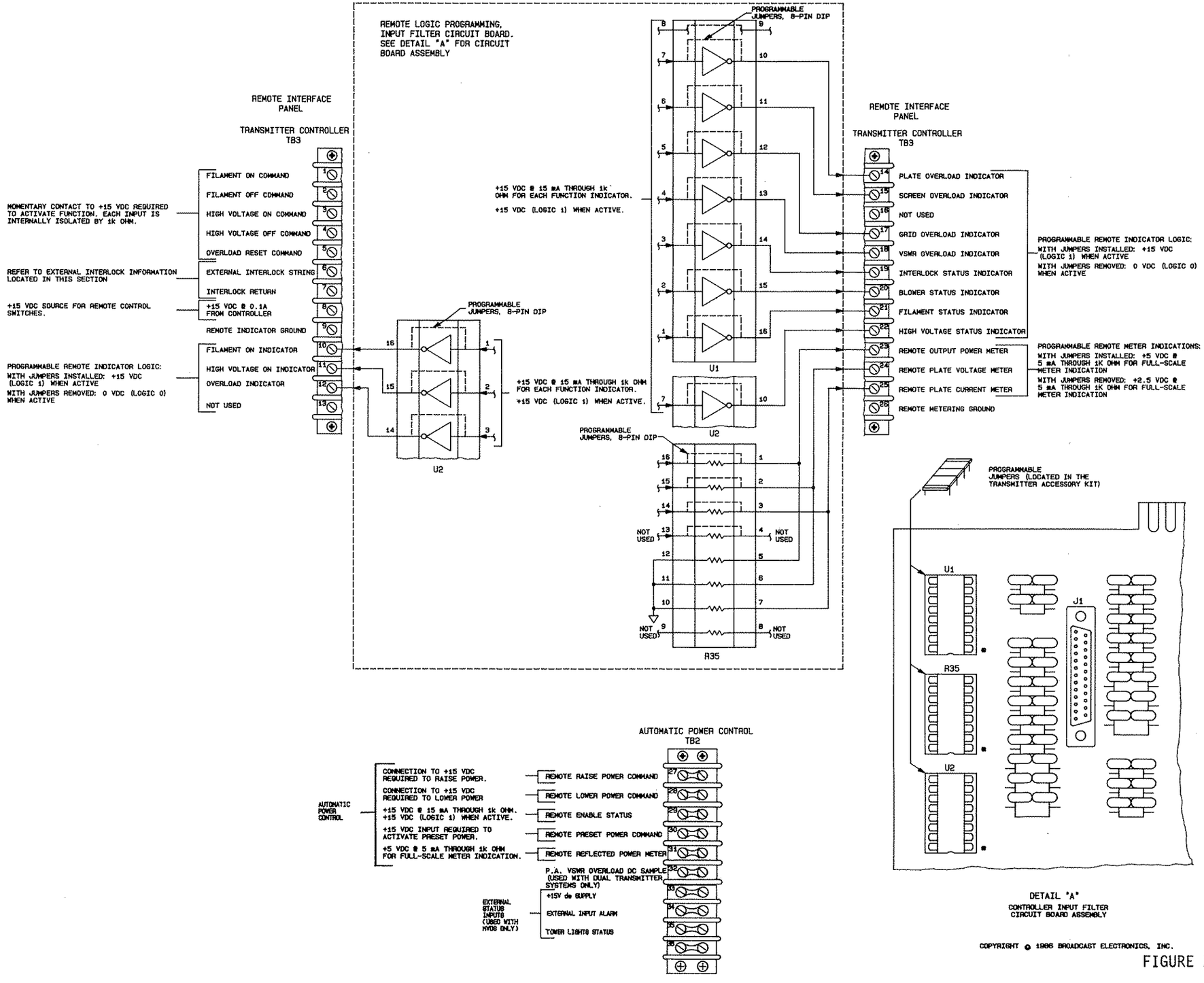
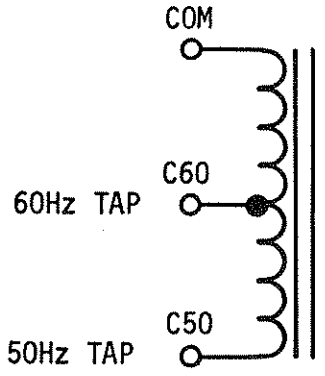
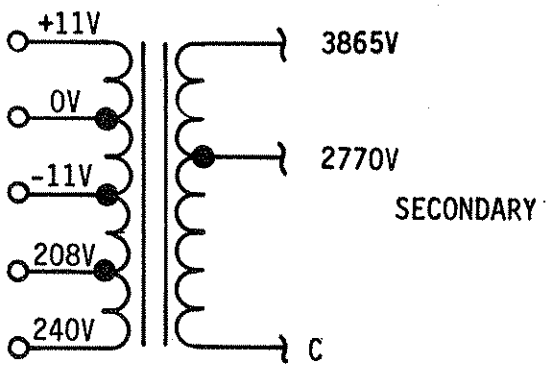


FIGURE 2-3. REMOTE LOGIC PROGRAMMING AND WIRING



L1-HIGH VOLTAGE PLATE SUPPLY CHOKE



T1-PLATE TRANSFORMER

597-0031-8

FIGURE 2-4. TRANSFORMER TAPS

2-41. Check the IPA voltage taps per Figure 2-5 and change the wiring if required. Normally these taps are chosen to limit IPA regulator dissipation over the normal line voltage excursions. The 208-250V selection is typically acceptable.

2-42. The transmitter controller, FM exciter, stereo generator, and SCA generator should be checked as follows:

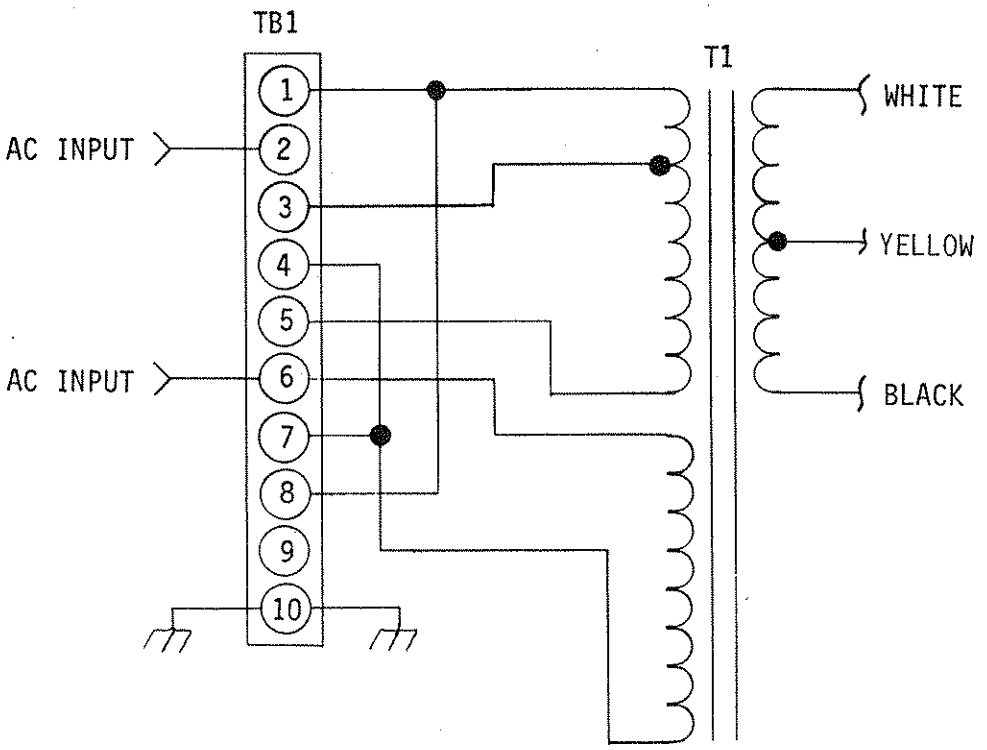
A. The primary ac line voltage with which the transmitter will be used (220V or 230/240V) must be visible on the ac line voltage selector circuit board adjacent to the ac input connector on each unit.

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

2-43. Loosen the exciter front-panel turn-lock fasteners and pull the exciter forward, out of the rack until the slide rail stops are encountered.

2-44. Loosen the eight turn-lock fasteners on the top of the exciter and remove the top cover.

2-45. Remove any packing material from the inside of the exciter.



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

FIGURE 2-5. IPA VOLTAGE TAPS

2-46. Ensure the TEST/NORMAL switch on the metering assembly is set to NORMAL.

2-47. Ensure the AUTO-PWR/MAN switch on the control assembly is set to AUTO and the NORM-EXT switch is set to EXT.

2-48. Refer to the final test data sheets shipped with the exciter and ensure the AFC/PLL assembly SYNTHESIZER FREQUENCY SELECTION jumpers are correctly positioned.

2-49. Remove the two shipping screws securing the modulated oscillator assembly, and allow the unit to float on its mountings.

2-50. Replace the top cover on the exciter and secure the eight turn-lock fasteners on the top of the cover.

2-51. Operate the exciter POWER switch to ON.

2-52. Refer to the stereo generator and SCA generator manuals and complete any applicable checks or programming included in INSTALLATION.

WARNING ENSURE A GROUND CONDUCTOR IS SECURELY CONNECTED TO THE TRANSMITTER GROUND STRAP.

2-53. GROUND. A common ground conductor must connect to the common copper strap inside the cabinet (see Figure 2-6). This ground must be securely connected to the station common earth ground by the most direct route with No. 8 stranded copper wire or a two inch (5.08 cm) wide flat copper strap.

2-54. SIGNAL INPUTS. Refer to the applicable technical manual for the exciter, stereo generator, and SCA generator and wire the inputs and control connections to each unit. All audio wiring must be routed in the wiring channel away from the power supply components in the base.

2-55. EXTERNAL INTERLOCKS. The FM-1.5A 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.

2-56. If an external interlock is desired, refer to Figure 2-7 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.

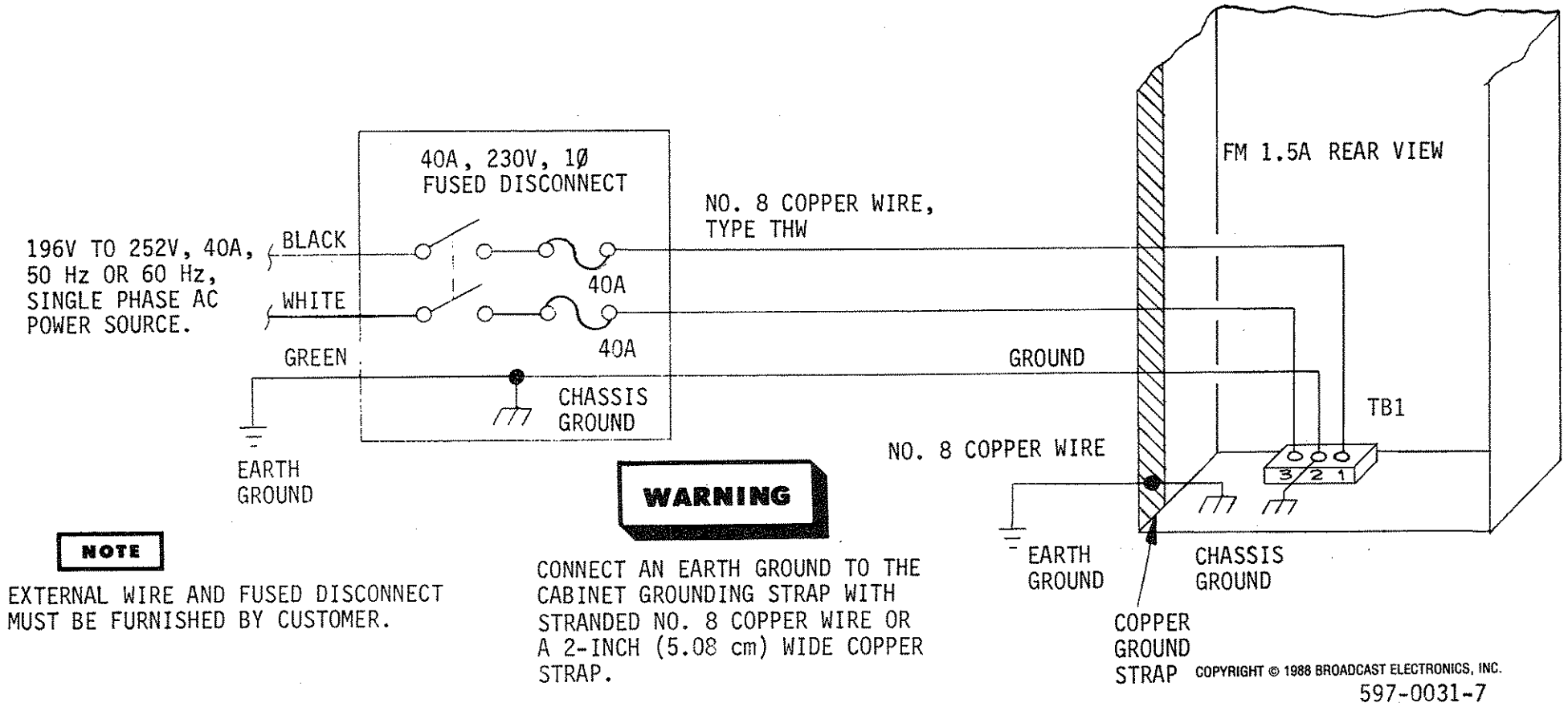

FIGURE 2-6. PRIMARY AC WIRING

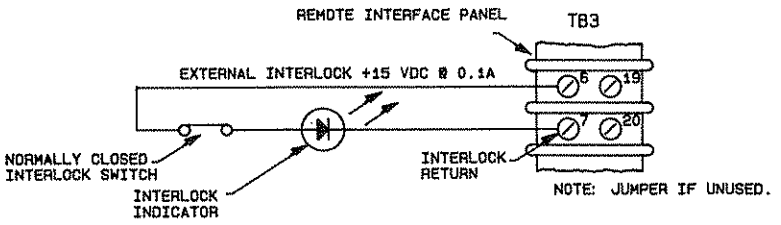

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FIGURE 2-7. EXTERNAL INTERLOCK CIRCUIT

WARNING ENSURE PRIMARY POWER IS DISCONNECTED BEFORE PROCEEDING.

2-57. AC POWER CONNECTIONS. A single-phase source of 196 to 252V ac, 50 Hz or 60 Hz at 40 Amperes is required for the transmitter ac input. It is strongly suggested that the power source be connected to the transmitter through a fused power disconnect for safety reasons (see Figure 2-6).

WARNING ENSURE PRIMARY POWER IS DISCONNECTED BEFORE PROCEEDING.

2-58. Main ac Input. Connect the 40 Ampere service to TB1 on the transmitter base through a fused service disconnect as shown by Figure 2-6. Ensure the ground conductor is securely connected to the transmitter common ground system and the neutral wire is securely connected to TB1-2.

2-59. INITIAL CHECKOUT.

WARNING ENSURE PRIMARY POWER IS DISCONNECTED BEFORE PROCEEDING.

2-60. Ensure that the transmitter is completely installed, the transmitter is connected to a suitable RF load, and the station monitors are connected to the MONITOR port on the RF low-pass filter. The MONITOR port provides a harmonic-filtered RF sample which is approximately 40 dB below the carrier power level.

A. Ensure primary power is correctly wired.

B. Ensure all ground connections are secure.

C. Ensure the PA tube is correctly installed.

D. Ensure the PA RF output line is connected to the low-pass filter input.

E. Ensure all RF connections are secure.

F. Ensure all connections at terminal boards are secure.

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.

2-61. Remove any extra hardware and wire lying within the cabinets and close all doors. Replace the lower front access panel using the black hex-head screws and hex wrench shipped with the transmitter.

2-62. The following procedure will refer to the factory final test data sheets supplied with the transmitter. Some differences in the actual operation may be noted due to differences in primary power or antenna systems. Ensure all controls are preset to the positions indicated on the final test data sheets.

2-63. Operate both counters on the PA cabinet to the number indicated on the factory test data sheets.

2-64. Adjust the FILAMENT ADJUST control fully counterclockwise (minimum).

2-65. Operate all four front-panel circuit breakers to OFF.

2-66. Operate the OUTPUT POWER METER switch to FWD.

2-67. Close the circuit in the wall-mounted fused disconnect.

2-68. Operate the AC POWER and the DRIVER circuit breakers to ON.

2-69. The INTERLOCK STATUS indicator will illuminate. If the INTERLOCK STATUS indicator does not illuminate, disconnect power from the wall-mounted fused disconnect and check the following:

A. All doors closed.

B. All panels installed.

C. The shorting stick in place on its hook switch.

2-70. 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.

2-71. The POWER indicator on the controller circuit board inside the transmitter controller will illuminate.

2-72. The APC ON switch/indicator will be illuminated.

2-73. Depress the APC REMOTE DISABLE switch/indicator to illuminate the switch/indicator.

2-74. Depress the controller circuit board BATTERY TEST switch. The controller circuit board TEST indicator will illuminate.

2-75. Operate the DRIVER and the FILAMENT circuit breakers to ON.

2-76. Depress the FILAMENT ON switch/indicator. The switch/indicator will illuminate and the blower will start operation.

2-77. The BLOWER STATUS and FILAMENT STATUS indicators will illuminate and the exciter AFC and POWER indicators will illuminate.

NOTE: At high altitudes, the BLOWER STATUS indicator may not illuminate. If this occurs, proceed as follows:

WARNING: ENSURE PRIMARY POWER IS DISCONNECTED BEFORE PROCEEDING.

A. Disconnect primary ac power by opening the wall-mounted fused disconnect.

B. Open the transmitter rear door.

C. Using a flat-tip screwdriver, remove the two blower air switch mounting screws. Turn the air switch over so that the adjustment may be accessed, then re-mount the air switch.

D. Using a miniature flat-tip screwdriver, adjust the air switch adjustment slightly counterclockwise.

E. Attempt transmitter operation.

F. If required, disconnect primary power and repeat the adjustment.

2-78. Depress the exciter multimeter + 20 switch.

A. The multimeter must indicate +20 volts ±2 volts.

2-79. Depress the exciter multimeter -20 switch.

A. The multimeter must indicate -20 volts ±2 volts.

2-80. Depress the exciter multimeter +5 switch.

A. The multimeter must indicate +5 volts ±0.5 volts.

2-81. Depress the exciter multimeter AFC switch.

A. The multimeter will indicate a potential within the range of +2.5 volts to +13.5 volts, dependent upon carrier frequency. The correct voltage is noted on the final test data sheets.

2-82. Depress the exciter multimeter FWD switch.

2-83. The FILAMENT VOLTAGE meter indication must be less than 5V. An excessively high FILAMENT VOLTAGE meter indication would indicate improper PA tube installation.

2-84. Adjust the FILAMENT ADJUST control to obtain a FILAMENT VOLTAGE meter indication of 5 volts.

2-85. Depress the APC ON switch/indicator. The switch/indicator will go out, which will indicate the APC is in the manual mode.

2-86. Depress the RAISE switch/indicator for approximately three seconds. The switch/indicator will flash.

2-87. Depress the APC ON switch/indicator to illuminate the switch/indicator. The LOWER switch/indicator will flash until the APC returns to a minimum setting.

2-88. Depress the APC ON switch/indicator. The switch/indicator will go out.

2-89. Depress the HIGH VOLTAGE ON switch/indicator. The switch/indicator will illuminate.

2-90. The exciter multimeter should indicate approximately one Watt.

2-91. Depress the exciter multimeter PAV switch.

A. The multimeter will indicate a potential within the range of +6.5 volts to +7.5 volts (assuming an RF output power of 1 Watt).

2-92. Depress the exciter multimeter PAI switch.

A. The multimeter will indicate approximately 1 ampere (assuming RF output power of 1 Watt).

2-93. Depress the exciter multimeter FWD switch.

CAUTION

CAUTION

IN THE FOLLOWING PROCEDURE, DO NOT APPLY EXCESSIVE DRIVE TO THE PA TUBE AS THIS COULD DAMAGE THE GRID STRUCTURE.

2-94. Depress the APC RAISE switch/indicator until a 25% indication is obtained on the OUTPUT POWER meter. If the IPA VSWR indicator illuminates during the remainder of the initial checkout procedure, this indicates that the IPA load is incorrect. To correct the situation, readjust the INPUT TUNING control for a maximum indication on the OUTPUT POWER meter.

2-95. If a plate or grid current overload occurs during the remainder of the initial checkout procedure, it may be necessary to adjust the OUTPUT LOADING for better efficiency before increasing power to the next level.

2-96. Depress the APC RAISE switch/indicator until a 50% indication is obtained on the output power meter.

2-97. Depress and hold the OUTPUT POWER METER switch to VSWR CAL. Adjust the VSWR CAL control for a 50% indication on the OUTPUT POWER meter.

2-98. Release the OUTPUT POWER METER switch. The OUTPUT POWER meter must indicate a VSWR of less than 1.2. An excessive VSWR indicates improper load connections.

2-99. Operate the OUTPUT POWER METER switch to FWD.

2-100. Depress the APC RAISE switch/indicator until a 100% indication is obtained on the OUTPUT POWER meter. The IPA FWD POWER indicator will illuminate.

2-101. Adjust the OUTPUT TUNING for a maximum indication on the OUTPUT POWER meter, concurrent with a minimum indication on the PLATE CURRENT meter.

2-102. Recheck the FILAMENT VOLTAGE meter and adjust the FILAMENT ADJUST control as required. The meter must indicate 5 volts.

2-103. Peak the INPUT TUNING for a maximum indication on the GRID CURRENT meter.

2-104. All meter indications should agree approximately to the values stated on the factory test data sheets. Some readjustment of the OUTPUT TUNING and OUTPUT LOADING controls may be required to compensate for individual antenna systems. The OUTPUT TUNING control should be touched up for best PA efficiency on the lower current side of resonance.

2-105. Check the cathode voltage using a Simpson 260 or some compatible meter that is uneffected by RF power. Insert the test leads into the CATHODE VOLTAGE (+, -) jacks located on the front panel of the PA cabinet. The meter should indicate +43 volts ±3 volts.

2-106. Depress the APC ON switch/indicator. The switch/indicator will illuminate and the transmitter will maintain a constant 100% rated RF output.

2-107. Recalibrate the VSWR CAL control to 100%.

2-108. If an external interlock is installed, open the external interlock. The HIGH VOLTAGE STATUS indicator will extinguish and the PA plate voltage will be removed.

2-109. Close the external interlock. PA plate voltage will be restored, the transmitter will resume operation, and the HIGH VOLTAGE STATUS indicator will illuminate.

2-110. 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 returned for maximum efficiency at this new level.

2-111. If remote operation is desired, the REMOTE DISABLE switch/indicator must be out. TB7-29 on the remote interface terminal block carries a remote enable 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-1.5A FM transmitter and provides standard operating procedures.

3-3. CONTROLS AND INDICATORS.

3-4. Refer to Figure 3-1 for the location of all controls and indicators associated with normal operation of the FM-1.5A transmitter. The function of each control or indicator is described in Table 3-1.

3-5. OPERATION.

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

3-6. TURN ON.

3-7. Operate all circuit breakers to ON.

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

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

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

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

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

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

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

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

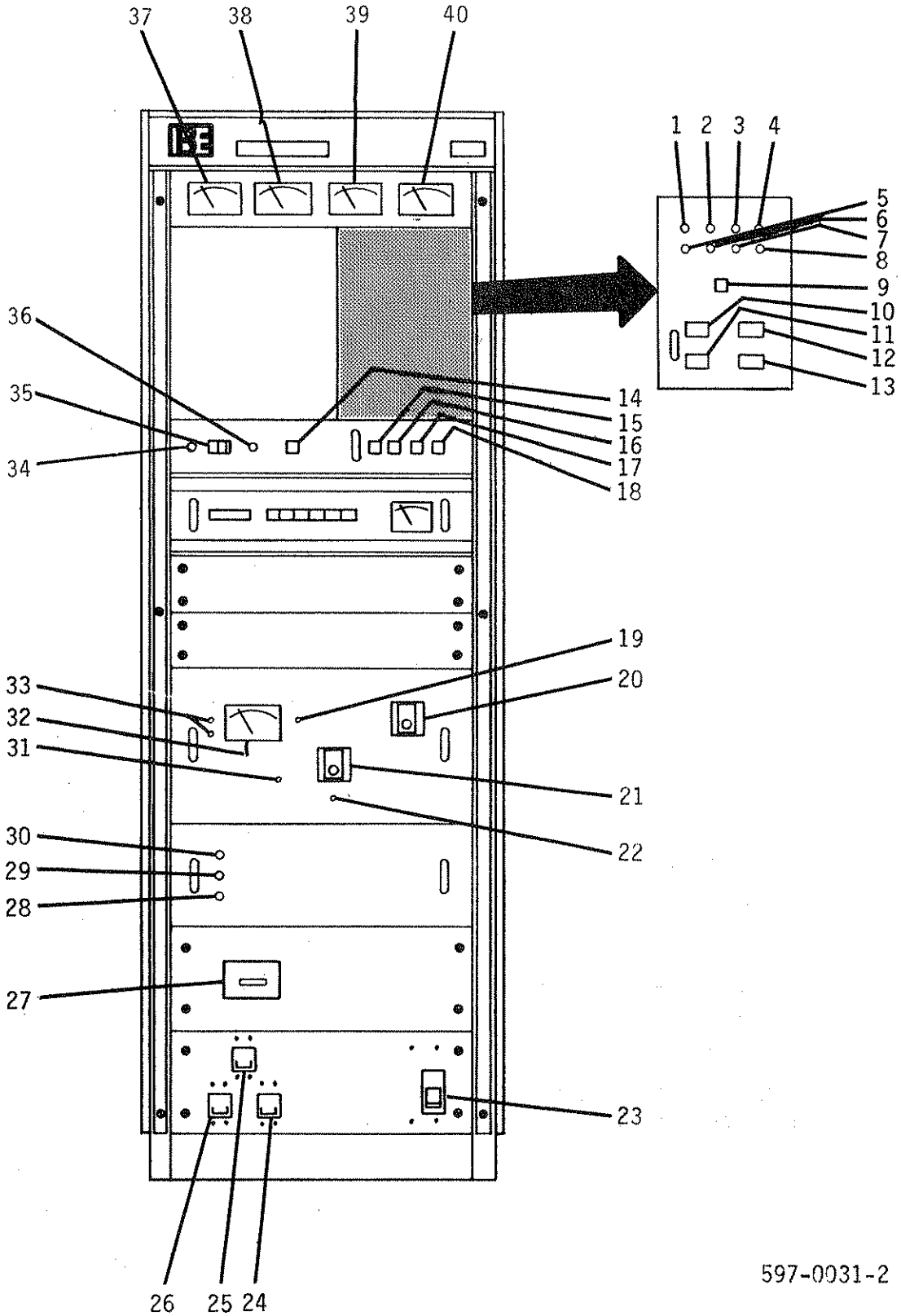

FIGURE 3-1. CONTROLS AND INDICATORS

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:

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 three minutes of blower operation to allow the PA tube to cool, the equipment will deenergize.

3-17. Operate the AC POWER circuit breaker to OFF.

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

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

INDEX NO.	NOMENCLATURE	FUNCTION
1	INTERLOCK STATUS Indicator	Indicates all transmitter safety interlocks are closed when illuminated. The external interlock is not included.
2	BLOWER STATUS Indicator	Indicates proper operation of the blower when illuminated.
3	FILAMENT STATUS Indicator	Indicates primary ac power is applied to the PA filament transformer when illuminated.
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	UNUSED
8	GRID OVERLOAD Indicator	Indicates a PA grid circuit overload has occurred when illuminated.
9	OVERLOAD RESET Switch/Indicator	SWITCH: Clears the overload circuit memory when depressed. INDICATOR: Indicates an overload condition exists when illuminated.
10	FILAMENT ON Switch/Indicator	SWITCH: Energizes the primary contactor when depressed to apply PA filament voltage. Also activates the IPA, exciter, stereo, and SCA generators. INDICATOR: Indicates a filament-on command has been received by the transmitter controller.
11	FILAMENT OFF Switch	Deenergizes all transmitter power. The blower and flushing fans will run for approximately three minutes after the FILAMENT OFF switch has been depressed.

TABLE 3-1. CONTROLS AND INDICATORS
(Sheet 2 of 4)

INDEX NO.	NOMENCLATURE	FUNCTION
12	HIGH VOLTAGE ON Switch/Indicator	SWITCH: Energizes the plate contactor when depressed to activate the plate power supply. INDICATOR: Indicates a high voltage-on command has been received by the transmitter controller.
13	HIGH VOLTAGE OFF Switch	Deenergizes the plate power supply and mutes RF drive when depressed.
14	REMOTE DISABLE Switch/Indicator	SWITCH: Inhibits or enables transmitter remote operation. INDICATOR: Indicates remote operation is inhibited when illuminated.
15	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.
16	AUTOMATIC POWER CONTROL APC ON Switch/Indicator	SWITCH: Selects APC control of transmitter operation. INDICATOR: Indicates the transmitter is under APC control when illuminated.
17	AUTOMATIC POWER CONTROL LOWER Switch/Indicator	SWITCH: In the automatic mode, moves the APC reference downward when depressed. In the manual mode, lowers exciter RF output when depressed. INDICATOR: Indicates the exciter RF output control voltage is being moved in a direction which will lower transmitter RF power output when illuminated. Goes out when minimum level is obtained.

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

INDEX NO.	NOMENCLATURE	FUNCTION
18	AUTOMATIC POWER CONTROL RAISE Switch/Indicator	SWITCH: In the automatic mode, moves the APC reference upward when depressed. In the manual mode, raises exciter RF output when depressed. INDICATOR: Indicates the exciter RF output control voltage is being moved in a direction which will raise transmitter RF power output when illuminated. Goes out when maximum level is obtained.
19	INPUT TUNING Control	Tunes the PA stage input circuit to resonance.
20	OUTPUT TUNING Control and Cyclometer	Tunes the PA stage output circuit to resonance.
21	OUTPUT LOADING Control and Cyclometer	Adjusts the PA stage output loading.
22	Second Harmonic Suppressor Adjustment	Adjusts tuning of the second harmonic suppressor.
23	AC POWER Circuit Breaker	Provides overload protection and primary power control for the transmitter AC input.
24	FILAMENT Circuit Breaker	Provides overload protection and primary power control for the PA tube filament supply.
25	BLOWER Circuit Breaker	Provides overload protection and primary power control for the blower and the flushing fans.
26	DRIVER Circuit Breaker	Provides overload protection and primary power control for the IPA, the FM exciter, the transmitter controller, and the stereo/SCA accessories.
27	Filament HOURS Meter	Indicates hours of filament circuit operation.

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

INDEX NO.	NOMENCLATURE	FUNCTION
28	IPA OVER TEMP Indicator	Indicates an IPA stage regulator heat sink over-temperature condition exists when illuminated.
29	IPA VSWR Indicator	Indicates the PA stage input circuit VSWR is excessive when illuminated (greater than 10 Watts reflected to the IPA).
30	IPA FWD POWER Indicator	Indicates the IPA output power exceeds 25 Watts when illuminated.
31	FILAMENT VOLTAGE ADJUSTMENT	Adjusts the PA tube filament voltage.
32	FILAMENT VOLTAGE Meter	Indicates the PA tube filament voltage.
33	CATHODE VOLTAGE (+, -)	Provides test points to measure the cathode bias voltage with an external meter.
34	AM NOISE TEST Receptacle	Test receptacle for AM noise measurements.
35	OUTPUT POWER METER FWD/VSWR/ VSWR CAL Switch	Selects the parameter to be displayed by the OUTPUT POWER meter.
36	OUTPUT POWER METER VSWR CAL Control	Allows calibration of the OUTPUT POWER meter VSWR display.
37	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.
38	PLATE CURRENT Meter	Displays the PA stage plate current.
39	PLATE VOLTAGE Meter	Displays the PA stage plate potential.
40	GRID CURRENT Meter	Displays the PA tube grid current.

TABLE 3-2. INDICATOR CHECKLIST

INDICATOR	STATUS
INTERLOCK STATUS	ON / OFF
BLOWER STATUS	ON / OFF
FILAMENT STATUS	ON / OFF
HIGH VOLTAGE STATUS	ON / OFF
VSWR OVERLOAD	ON / OFF
PLATE OVERLOAD	ON / OFF
SCREEN OVERLOAD	UNUSED
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 FWD POWER	ON / OFF
VSWR	ON / OFF
OVER TEMP	ON / OFF

NOTE

OPERATIONAL STATUS SHOWN BY SHADED INDICATOR

METER	INDICATION	
	POWER	VSWR
OUTPUT POWER	%	:1
PLATE CURRENT	A	
PLATE VOLTAGE	kV	
GRID CURRENT	mA	
FILAMENT VOLTAGE	V	
FILAMENT TIME	HOURS	

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SECTION IV
THEORY OF OPERATION

4-1. INTRODUCTION.

4-2. This section presents theory of operation for the FM-1.5A FM transmitter in two levels. General theory of operation for the entire transmitter is presented first, followed by detailed discussions for the transmitter power supplies and the RF circuitry. Refer to the overall block diagram (Figure 4-1) as required for the following explanation.

4-3. The IPA, the automatic power control (APC), and the transmitter controller are discussed in detail by the modular assembly publications in Part II of this manual.

4-4. GENERAL DESCRIPTION.

4-5. FM EXCITER.

4-6. The Broadcast Electronics FX-30 is a totally solid-state wideband FM exciter providing a continuously variable RF output from 3 to 30 watts into a 50 Ohm load at any frequency within the 87.5 to 108 MHz FM broadcast band. The exciter may be programmed to any frequency within this band in 10 kHz increments. The FX-30 exciter is mounted in slides to allow easy access to the internal semi-modular exciter circuitry.

4-7. The FX-30 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 597-0002 for detailed explanation of the FM exciter features.

4-8. INTERMEDIATE POWER AMPLIFIER.

4-9. The IPA is a broadband RF amplifier assembly which features: 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 on the RF amplifier provides the regulator circuitry with forward and reflected power samples.

4-10. The 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 illuminates to indicate 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.

4-11. POWER AMPLIFIER.

4-12. The FM-1.5A uses a single 3CX1500A7 triode to provide 1500 Watts of RF power on a single frequency within the FM broadcast band of 87.5 MHz to 108 MHz. The power amplifier operates in a high-gain, grounded-grid class C configuration. The input circuit and a coaxial transformer matches the 50 Ohm output of the IPA down to the lower cathode input impedance. Removal of the PA tube is a simple and quick procedure due to the PA arrangement. A blower cooling system forces air through the tube socket and anode fins. An air pressure sensor monitors the effectiveness of the cooling system and removes power from the tube if air flow is interrupted.

4-13. POWER AMPLIFIER CAVITY. The FM-1.5A PA stage employs a patented folded half-wave cavity constructed with 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 center conductor tunes the cavity by varying the length inserted into the open end of a main high voltage conductor. The main 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.

4-14. OUTPUT COUPLING. Energy is coupled into the transmission line by an adjustable untuned loop which functions in the electromagnetic field along the plate line at the RF voltage null point. One end of the output loop is connected to ground, while the other end connects to the center conductor of the output transmission line through flexible straps.

4-15. OUTPUT TUNING. Plate tuning is accomplished by adjusting a threaded rod which mechanically expands or contracts a beryillium copper bellows on the end of the grounded center conductor inserted into the main line. Coarse frequency adjustment is accomplished by pre-setting the relationship between the center and outer conductors as well as adjusting the length of the main line.

4-16. SECOND HARMONIC SUPPRESSOR. A patented second harmonic suppressor is included in the FM-1.5A. This consists of a capacitive plate 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 impedance and the suppressor forces its standing wave to diminish, reducing 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.

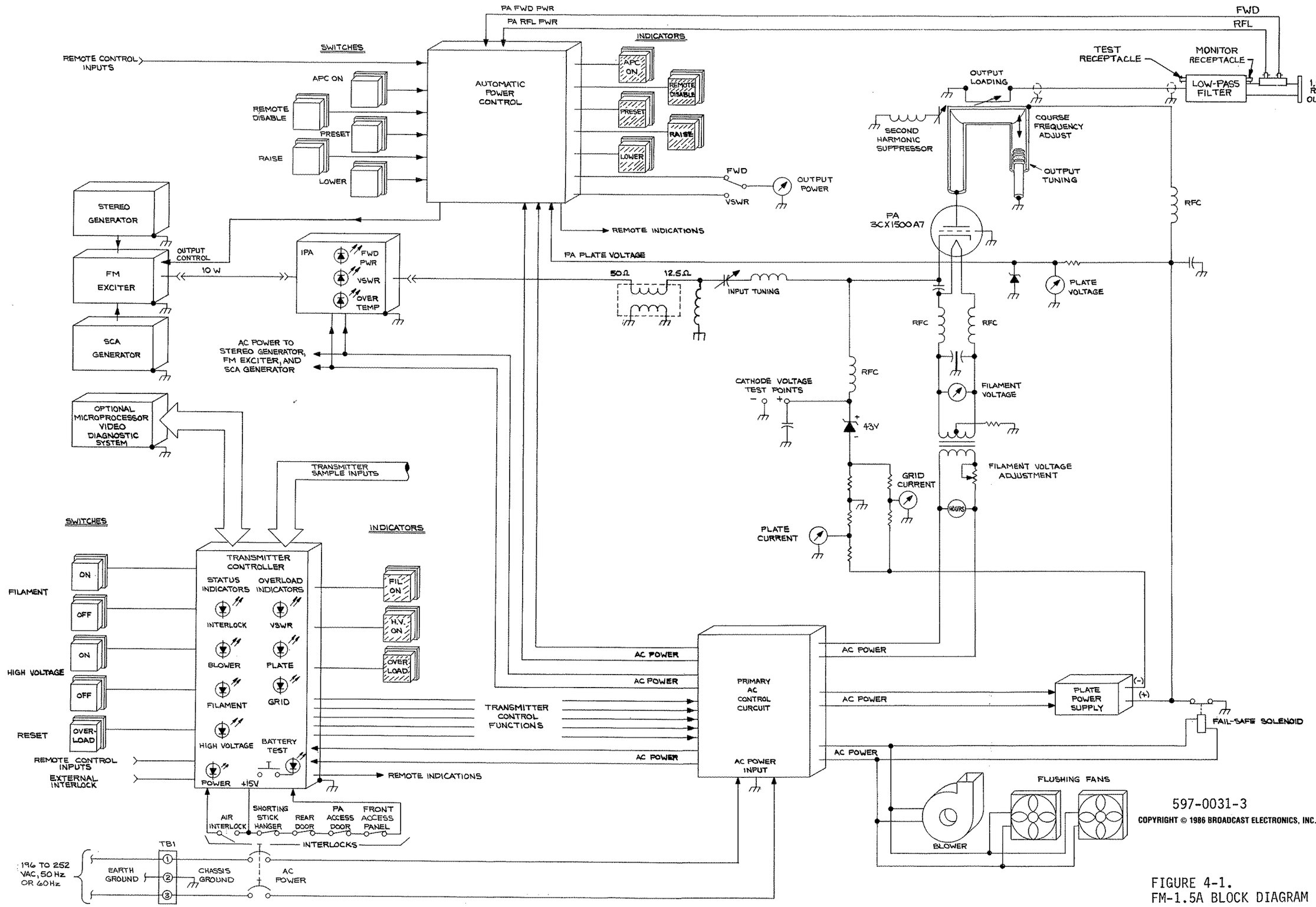

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FIGURE 4-1.
FM-1.5A BLOCK DIAGRAM

4-17. OUTPUT CIRCUIT. A separate low-pass filter is contained within the FM-1.5A cabinet 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. These two supply forward and reflected power RF samples to the automatic power control. Additionally, non-directional ports before (TEST) and after the low-pass filter (MONITOR) supply power samples for external test equipment.

4-18. AUTOMATIC POWER CONTROL.

4-19. The automatic power control unit (APC) measures several transmitter parameters and allows manual or automatic power output control, allows switch selected operation at a preset lower power level, and provides VSWR foldback protection and soft-start features.

4-20. AUTOMATIC RF OUTPUT LEVEL CONTROL. Part of the APC circuitry rectifies PA forward power and reflected power samples and supplies these to the power meter selector switch and to the transmitter controller for further evaluation. The APC uses PA forward power to maintain a constant transmitter RF output. If excessive PA reflected power is measured, the "raise power" command will be inhibited to prevent an overload from occurring. Manual RF power control is assumed by switching the APC off. In the manual mode, the raise and lower switches directly control the exciter RF output. In the automatic mode, the switches control a reference voltage stored as an eight-bit binary word in a digital memory. This digital memory is maintained by a nine-volt battery so that the transmitter can automatically return to the desired power level whenever power is applied. This memory has a very long life, approximately the battery shelf life.

4-21. The APC uses a modulated pulse train scheme to vary the RF output. When large excursions of RF power are required, a more rapid pulse train is employed. Fine adjustments of the RF output power utilize a slower pulse train and therefore slower correction. This feature, combined with an analog deadband in the circuitry, eliminates hunting in this loop.

4-22. VSWR FOLDBACK PROTECTION. PA forward power is automatically reduced if output reflected power becomes excessive enough to overload the transmitter. As the condition which caused the high VSWR returns to normal, RF power will be proportionately raised until full power is again restored.

4-23. SOFT START. A soft start circuit monitors PA plate voltage and reduces the exciter RF output to minimum upon its absence. When the plate supply is energized, as during initial turn on, the circuit will gradually increase the exciter RF output until the stored power setting is achieved. This circuit prevents inadvertent VSWR overloads at turn on, such as during an ice storm.

4-24. TRANSMITTER CONTROLLER.

4-25. Each transmitter timed control function and all overload sensing is performed by a built-in solid-state controller. The controller incorporates extensive use of RFI filtering and optical isolation in conjunction with CMOS logic to assure maximum reliability.

4-26. 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, 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.

4-27. 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 at least eight hours.

4-28. POWER LOSS RECYCLING. In the event of a momentary power interruption, proper action will resume immediately after power returns. If an extended power failure occurs, information maintained by the nine-volt battery will enable the controller to initiate a start cycle to automatically return the transmitter to operation without assistance. If external equipment installed in the interlock string opens during power failure, the automatic restart feature will be defeated and the transmitter will enter the off condition when power is reapplied.

4-29. OVERLOAD RECYCLING. If an overload occurs, the transmitter will deenergize, allow the overload to clear, then automatically return to operation. If four overloads occur within 60 seconds, the transmitter will deenergize. The overload must be manually cleared and the transmitter HIGH VOLTAGE ON switch/indicator depressed before operation will resume. Single overloads of greater than 220 milliseconds duration will immediately deenergize the high voltage and filament supplies.

4-30. 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, 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.

4-31. The green STATUS indicators illuminate to indicate an operational condition as follows. The INTERLOCK LED indicates that the interlock loop is closed. The BLOWER LED indicates that the air pressure is correct for the PA stage to operate. The FILAMENT LED indicates that the filament contactor has been energized. The HIGH VOLTAGE LED indicates that the high voltage contactor has been energized.

4-32. METERING.

4-33. Six meters on the front of the transmitter indicate transmitter parameters. An iron-vane voltmeter is used to measure filament voltage. Currents are measured in the ground side of each supply to prevent high voltages across the meters. A filament HOURS meter indicates hours of filament circuit operation.

4-34. Additionally, the exciter parameters are displayed by two meters and three status indicators. Refer to publication 597-0002.

4-35. POWER SUPPLIES.

4-36. All power supplies are conventional full-wave rectified circuits which operate from a single-phase ac source of 196 to 252 volts ac. A step-start circuit reduces the inrush current at high voltage-on to limit stress and extend component life in the plate supply.

4-37. The plate supply consists of a full-wave rectifier followed by a resonant filter. Advantages of this approach include good load regulation, reduced 120 Hz ripple, and lower stored energy than conventional single-phase supplies of equivalent filtering. Special non-polarized capacitors with a low power factor are used in this supply, as is a resonating choke with 50 and 60 Hz taps.

4-38. Each modular component of the transmitter contains its own ac operated power supply. In addition, battery back-up supplies in the transmitter controller and automatic power control maintain operational information during power outages. The battery in the APC can be left connected at all times. However, the controller battery will discharge if left connected during periods of extended power outages. Both batteries are common nine-volt alkaline types.

4-39. DETAILED DESCRIPTION.

4-40. POWER SUPPLIES.

4-41. A 196 volt to 252 volt, 50 Hz or 60 Hz, single-phase ac input is required for proper operation of the FM-1.5A transmitter (see Figure 4-2). The following supplies operate from the ac input (typical values are shown for the rated RF power output):

A.	PA PLATE	+3500V at 0.6 Amperes
B.	PA FILAMENT	5V ac at 10.5 Amperes

4-42. SEQUENCE OF OPERATION. Power is applied through the AC POWER circuit breaker (CB1) to contacts of the primary contactor (K1). Power is also applied through the:

1. BLOWER circuit breaker (CB3) to the primary contactor control relay (K4), the blower control relay (K5) and the fail safe solenoid.

2. DRIVER circuit breaker (CB2) to the transmitter controller, the APC, and to one leg of the IPA, FM exciter, stereo generator, and the SCA generator feed.

4-43. When the FILAMENT ON switch/indicator is depressed, K5 will apply power to the blower (B1), the flushing fans (B2 and B3), and energize the fail safe solenoid. After the blower comes up to speed, the air interlock will close. Assuming all the safety interlocks are closed, K4 will energize the primary relay (K1) which will apply power to the second leg of the IPA, FM exciter, stereo generator, and the SCA generator through fuse F1 and through the FILAMENT circuit breaker (CB4) to the step/start circuit and the filament supply.

4-44. Assuming the HIGH VOLTAGE ON switch/indicator has been depressed and the PA filament heating delay of three minutes has expired, K6 will pulse the step relay (K2). After the current inrush to the plate supply has been limited by the step/start resistors (R1 and R2), K7 will energize the start relay (K3) to apply full input to the plate power supply.

4-45. If during a start sequence a safety interlock opens, the entire start sequence will be cancelled and must be re-initiated manually. If a safety interlock opens during operation, the entire power supply section will deenergize. However, if the interlock is promptly closed, the blower and flushing fans will resume operation to cool the PA tube but a new start sequence will have to be manually initiated. Whenever power is removed from the blower and flushing fans, the fail-safe solenoid will short the plate supply to ground.

4-46. If the HIGH VOLTAGE OFF switch/indicator is depressed, the plate power supply will deenergize. If the FILAMENT OFF switch/indicator is depressed, the PA filament supply will deenergize. The blower and flushing fans will continue operation for three minutes to cool the PA tube, then deenergize.

4-47. PA PLATE POWER SUPPLY. The plate power supply is a full-wave bridge-rectified supply with a two-section filter. The first filter section includes a 120 Hz resonant choke. This section provides good load regulation, low 120 Hz ripple, and lower stored energy than conventional filter sections with similarly sized components. The filter location in the negative leg of the rectifier output eliminates the dc potential between the choke and ground. A pi-section filter follows the resonant choke which reduces high frequency components which are passed by the resonant choke. The choke in the pi-section is also connected in the negative leg of the supply to eliminate the dc potential between the choke and ground. A bleeder resistor connected across the supply improves regulation, and in conjunction with fail-safe solenoid K5, enhances safety. A series resistance in the anode dc feed (R5) limits peak energy in case of arc-overs in the power amplifier stage and during high voltage discharge solenoid operation.

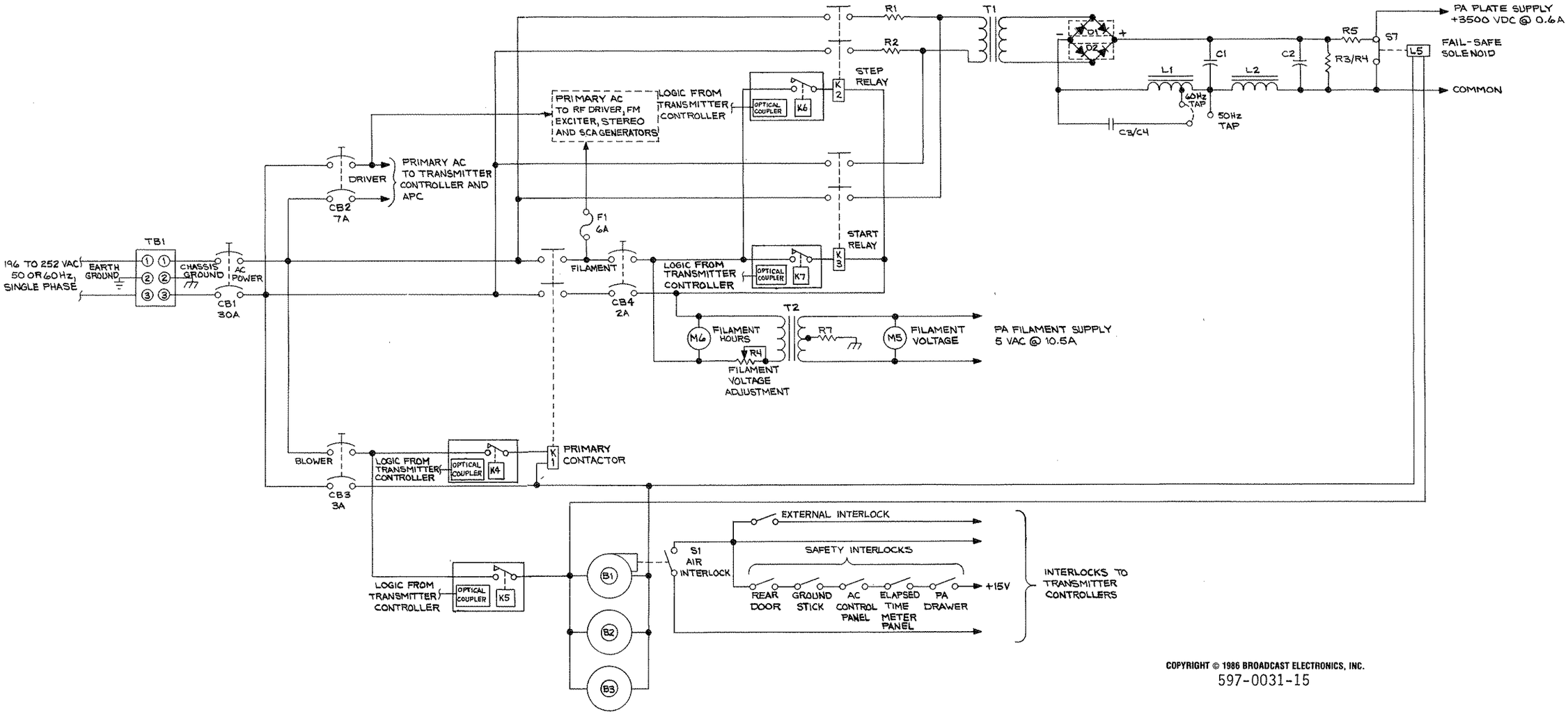

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FIGURE 4-2. POWER SUPPLY SIMPLIFIED SCHEMATIC

4-48. Component stress at power-on is eliminated by a step/start circuit which limits plate supply inrush current. The step/start circuit is interlocked through contacts of the filament circuit breaker and the primary relay to assure that the filament circuit is energized before a high-voltage-on sequence can be initiated. The controller will energize the step relay via K6. After 100 milliseconds, the controller will energize the plate relay via K7. The step/start relay will de-energize after it has been energized for 160 milliseconds. In this manner, the current limiting resistors will only be subject to heating during a 100 millisecond interval between step/start relay and plate relay closures. The limiting resistors are disconnected from the lines after 160 milliseconds, improving reliability.

4-49. PA FILAMENT SUPPLY. The PA filament supply is connected to the primary ac input through circuit breaker CB2 and the primary relay (K1). A FILAMENT VOLTAGE ADJUSTMENT (R4) in the primary of the filament transformer allows filament voltage adjustment. A filament HOURS meter (M2) indicates hours of filament circuit operation. A low resistance in the center-tap of the filament transformer secondary provides overload protection for the filament supply wiring if a short-circuit to ground should develop in either leg of the filament supply. The filament supply voltage is displayed by an iron-vane FILAMENT VOLTAGE meter (M6).

4-50. RF CIRCUITRY.

4-51. FM EXCITER. The FM exciter generates the modulated FM signal. Approximately 10 Watts of drive is required to operate the FM-1.5A RF circuitry (see Figure 4-3). Refer to publication 597-0002 for a complete description of the FM exciter.

4-52. INTERMEDIATE POWER AMPLIFIER. The FM modulated signal from the exciter is applied to the IPA. The IPA is a totally self-contained unit consisting of: 1) a power supply circuit, 2) a regulator circuit, and 3) an RF amplifier module. The amplifier operates in a Class C configuration to provide approximately 25 to 100 watts of drive to the PA stage. For a complete description of the IPA, refer to PART II of this manual.

4-53. POWER AMPLIFIER. The PA stage contains a single 3CX1500A7 triode operated as a class C grounded-grid amplifier into a folded half-wave plate line to output 1.5 kW of RF power.

4-54. PA Input Circuit. The grid impedance-matching circuit used in the FM-1.5A transmitter consists of inductor L8 and a coaxial transformer which matches the 50 Ohm output impedance of the IPA to the 12.5 Ohm impedance of the PA cathode circuit. The input circuit is tuned to resonance by a series LC circuit consisting of C3 and L6.

4-55. L7 functions as an RF choke to isolate the bias supply and metering circuits from RF. The PA bias supply consists of a darlington power transistor and a zener reference which functions as a 43 volt, one Ampere supply. The bias voltage developed biases the PA stage at cutoff for class C operation. With the PA grid maintained at a ground potential, application of the positive voltage on the cathode has the same effect as applying negative bias to the grid.

4-56. PA Cathode Circuit. Capacitors C10 and C11 maintain the RF potential between the cathode and filament at the same level to prevent cathode to filament arcs within the PA tube. The filament transformer (T2) is isolated from the RF circuit by L3 and L4. A low resistance (R7) in the center tap of the PA filament transformer acts as a fuse to prevent damage to the transformer if either filament lead should short to ground.

4-57. Power Amplifier Plate Circuit. The PA used in the FM-1.5A employs a folded half-wave resonator constructed with copper tubing (refer to Figure 4-4). This design eliminates the high voltage blocking capacitors and high current shorting contacts of conventional PA circuits. A grounded concentric center conductor tunes the circuit with a variable re-entrant length inserted into the end of a main high voltage conductor. The main conductor is insulated from ground and carries the anode dc potential. DC power is applied at the fundamental RF voltage null point, approximately one-quarter wave from the anode, for effective RF decoupling.

4-58. Incorporated into the tank design is a patented second harmonic suppressor consisting of a series LC circuit. Rather than attenuating the second harmonic after the signal has been generated and amplified, the design and placement of the suppressor essentially eliminates the formation of this signal.

4-59. Plate tuning is accomplished with an adjustable bellows on the center portion of the plate line which is maintained at chassis ground potential. The PA plate potential is applied to the main conductor at the fundamental frequency RF voltage null point which is also the second harmonic peak voltage point. The second harmonic suppressor is placed at this point to essentially eliminate the second harmonic component in the output signal.

4-60. PA Output Circuit. Output coupling is accomplished with an untuned loop intercepting the magnetic field concentration at the voltage null point along the main plate 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. A multi-stranded copper cable connects one side of the output loop to ground and the other side to the center conductor of the output transmission line. 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.

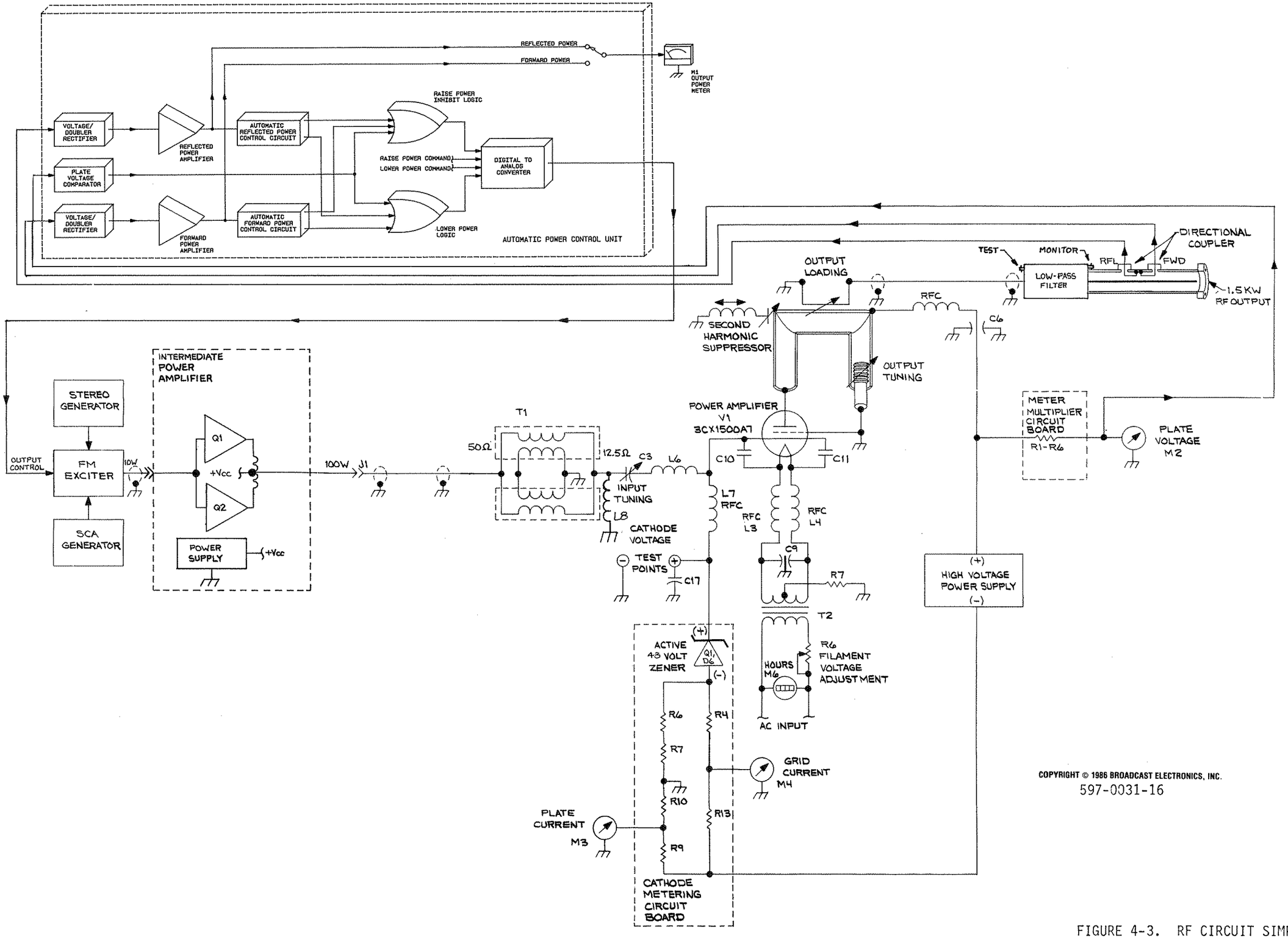

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FIGURE 4-3. RF CIRCUIT SIMPLIFIED SCHEMATIC

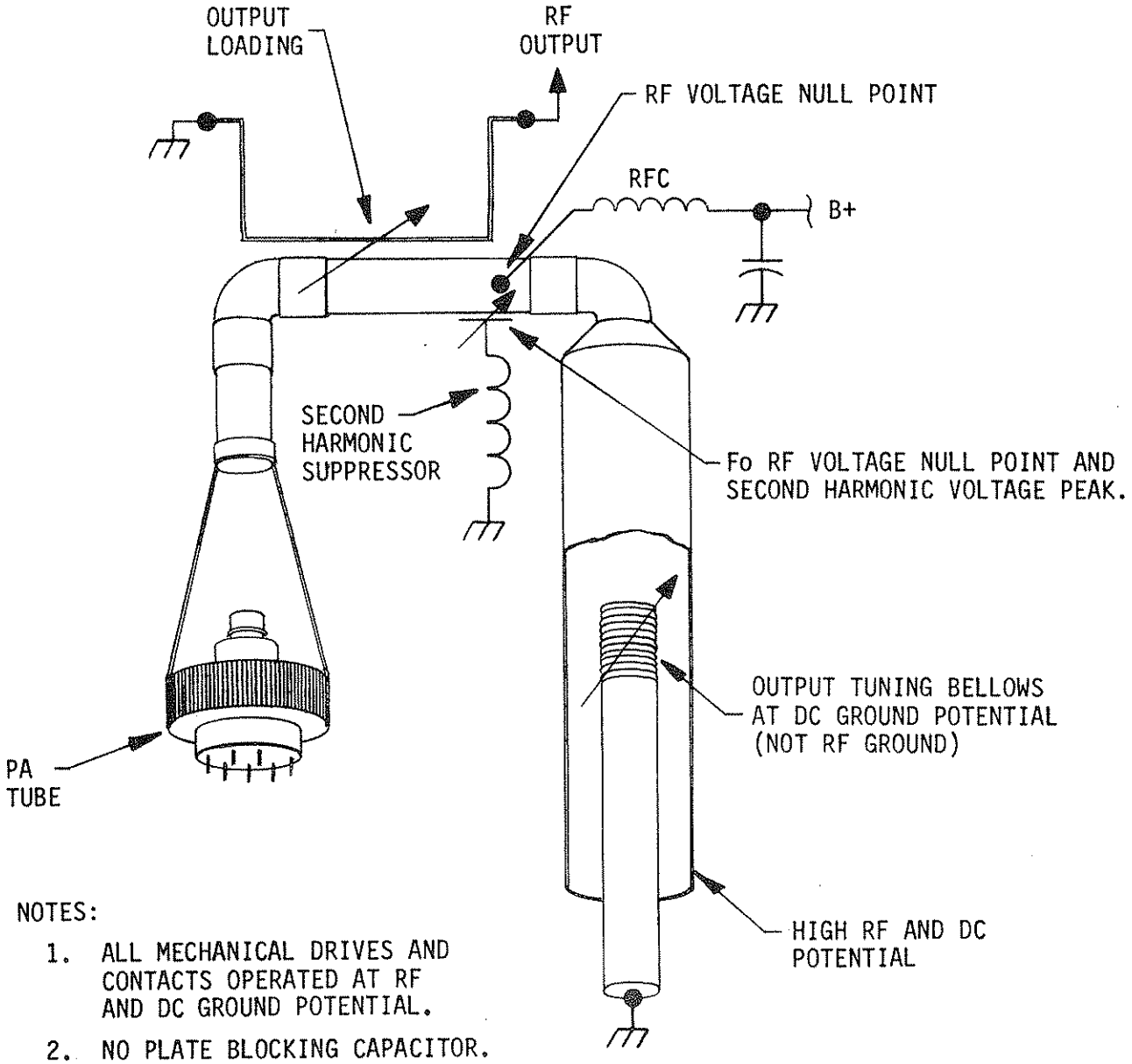

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FIGURE 4-4. PA PLATE CIRCUIT

4-61. A pair of directional couplers located in the output transmission line provide RF output voltages proportional to the PA forward and reflected power. The RF output voltages are rectified and amplified to provide power and VSWR indications on the OUTPUT POWER meter, samples for the transmitter controller, and inputs to the automatic power control unit. Additionally, a -45 dB non-directional port before the low-pass filter (TEST) and a -40 dB non-directional port after the low-pass filter (MONITOR), supply power samples for external test equipment.

4-62. PA METERING. Six meters are used to indicate the transmitter power tube parameters. An iron-vane filament voltmeter is included to accurately measure filament voltage at the RF enclosure filament feed-through terminals. Power output metering is derived from circuitry within the automatic power control unit. An HOURS meter indicates total elapsed time of filament circuit operation.

4-63. Grid current and plate current metering is derived by circuitry on the cathode metering circuit board which subtracts the grid current from the plate current in the cathode circuit. The negative side of the high voltage power supply is connected through R9 and R10 to ground and through R7 and R6 to the cathode bias circuit. The plate current meter measures current through R10. The grid current meter measures current through R9, R10, R7, and R6 in the high voltage power supply return, divided in half by R4 and R13.

4-64. 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).

4-65. PA forward and reflected power samples are voltage doubled and rectified, then amplified and applied to the OUTPUT POWER meter to provide indications of transmitter operation. The amplified power samples are also applied to forward and reflected automatic power control circuits which control the exciter RF output when automatic power control is enabled. As the transmitter RF output power varies, the forward automatic power control circuit will act to maintain the established RF output level. If PA reflected power increases, 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 reestablished when the VSWR condition is corrected.

4-66. As an additional function, a comparator circuit monitors PA plate voltage. This circuit reduces the PA output power to minimum whenever plate voltage is off. Whenever the plate voltage is energized, the circuit will gradually increase the PA output power until the rated transmitter RF output is established unless limited by a high VSWR condition.

SECTION V

MAINTENANCE

5-1. INTRODUCTION.

5-2. This section provides general maintenance information, electrical adjustment procedures, and troubleshooting information for the FM-1.5A Transmitter. Maintenance is divided into two categories depending upon the complexity of the procedure and the test equipment required to complete the maintenance procedure.

5-3. SAFETY CONSIDERATIONS.

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

5-4. The FM-1.5A 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.

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 the PA drawer is opened, the cabinet rear door is opened, the filament time meter panel is removed, or the contactor/breaker panel is removed, interlock switches will deenergize all dc power supplies and release the fail-safe discharge solenoid across the plate supply. Do not bypass interlock switches as a maintenance short-cut.

5-6. AC power to the entire cabinet may be disconnected with the front panel AC POWER ON/OFF circuit breaker.

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

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

5-9. FIRST LEVEL MAINTENANCE.

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 FM-1.5A transmitter consists of good housekeeping, lubrication, and checking performance levels using the meters and various indicators built into the equipment.

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

5-11. On a regular basis, clean the equipment of accumulated dust. Check for overheated components, tighten loose hardware, and lubricate mechanical surfaces as required.

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

5-13. AIR FILTER.

5-14. Air filter replacement is accomplished outside the transmitter without interrupting equipment operation. As only half the filter is exposed to air flow when installed, the filter may be removed and the clean end inserted in the filter housing. A new filter should be ordered at this time. The filter should be checked once each week with replacement done as required. A dirty filter could result in dirt accumulation leaking into the cabinet from seams, door jambs, etc. Never reverse a dirty filter. Always replace the filter. The transmitter controller and APC unit also contain air filters which should be checked monthly and cleaned as necessary.

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

5-16. BLOWER MAINTENANCE.

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

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

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

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

5-20. SECOND LEVEL MAINTENANCE.

WARNING DUE TO THE PROGRAMMING OF THE EQUIPMENT, THE 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.

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

5-22. The maintenance philosophy of the FM-1.5A 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 isolation to a replaceable assembly or component. If desired, a defective assembly may be returned to the factory for repair or exchange.

5-23. GENERAL.

5-24. PA STAGE. Power amplifier tube life is a result of several circuit parameters. Usually, the first indication of the decline of a tube is a slight reduction in power output. This can normally be corrected by a small increase in filament voltage. It may be wise to order a new tube at this time. Further reductions in power output can be compensated in the same manner only a limited number of times. Refer to the Eimac application paper titled "Extending Transmitter Tube Life" included in the "Manufacturers Data" section of this manual. PA efficiency versus RF power is plotted on Figure 5-1 and should be referenced to estimate PA efficiency for a particular power level.

5-25. PA Tube Warranty. The FM-1.5A 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.

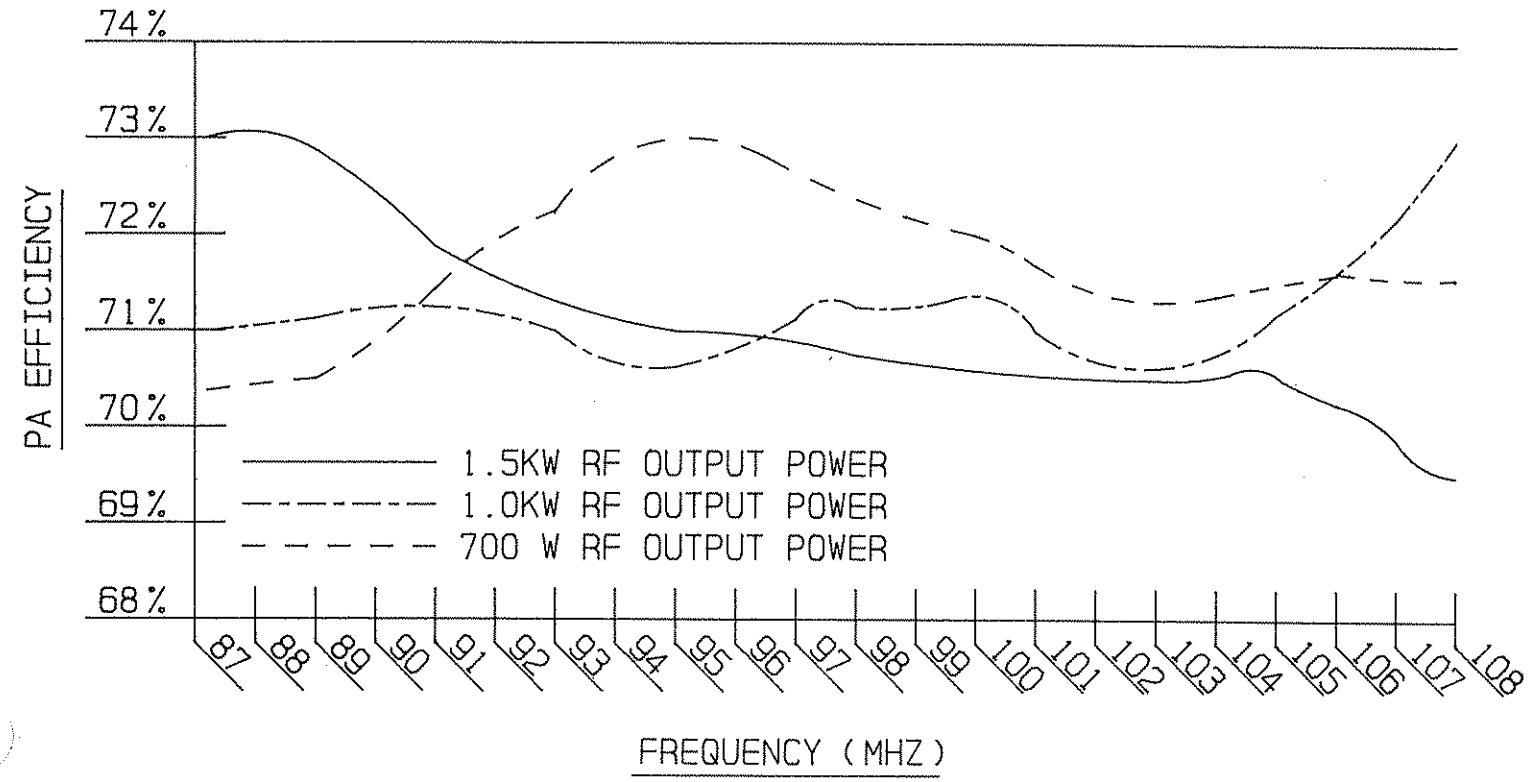

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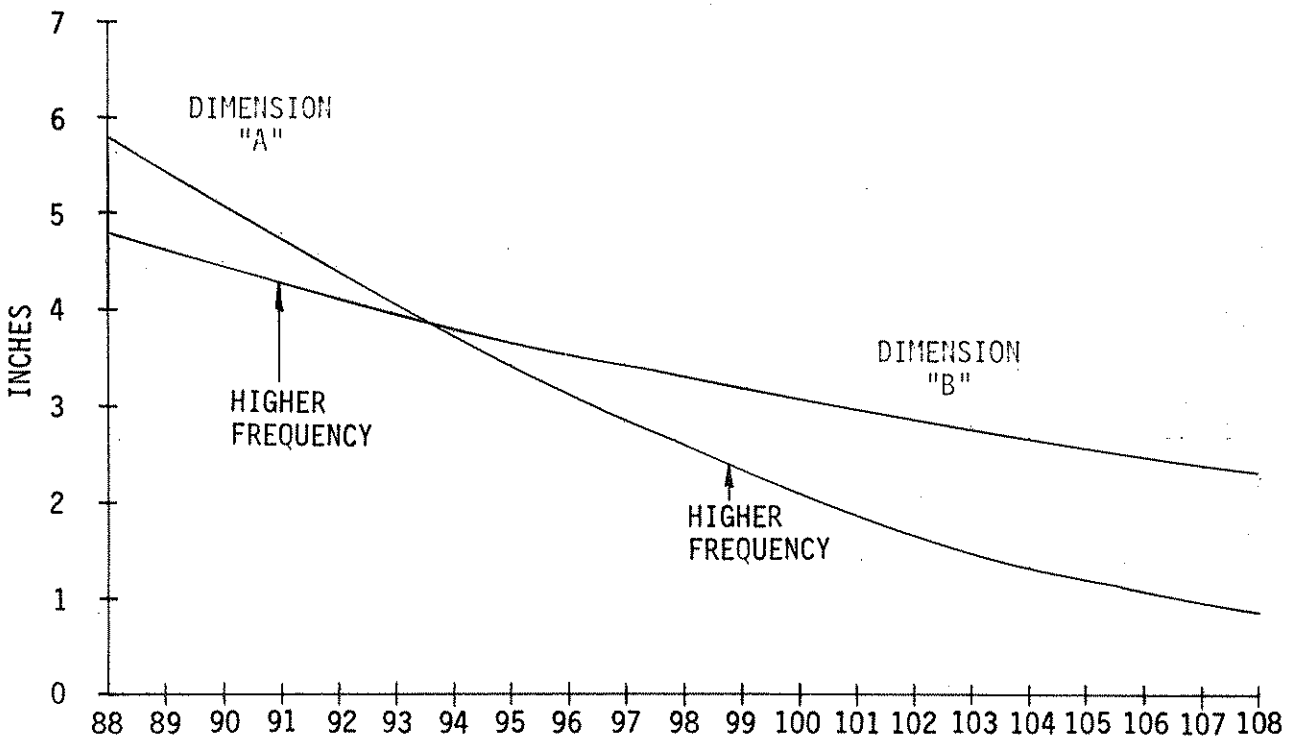
FIGURE 5-1. PA EFFICIENCY CURVE

5-26. PA Frequency Change. PA tuning versus frequency is plotted in Figure 5-2. This curve should be referenced for coarse tuning information if the transmitter output frequency is to be changed. Also, refer to paragraph 5-30 for second harmonic suppressor adjustment.



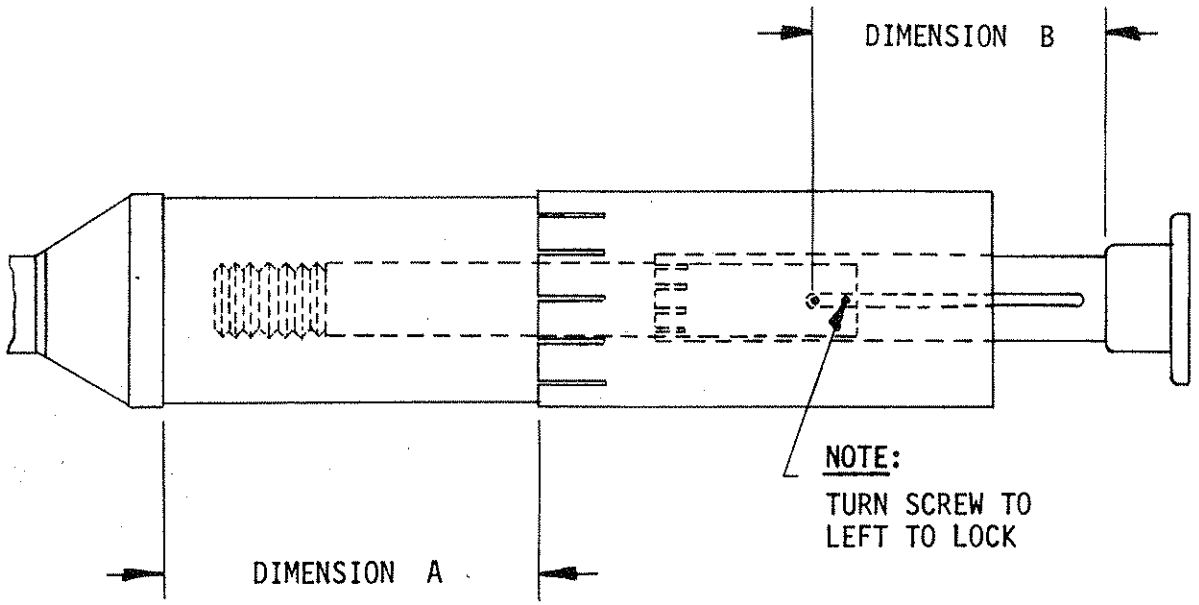


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FIGURE 5-2. PA COARSE OUTPUT TUNING CURVE

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

WARNING THE WHITE CASE MATERIAL OF THE FM-1.5A IPA STAGE RF AMPLIFIER TRANSISTORS IS MADE OF BeO
WARNING CERAMIC MATERIAL. DO NOT PERFORM ANY OPERATION ON ANY BeO CERAMIC WHICH MIGHT PRODUCE DUST OR
WARNING FUMES, SUCH AS GRINDING, GRIT BLASTING, OR ACID CLEANING. BERYLLIUM OXIDE DUST OR FUMES ARE
WARNING HIGHLY TOXIC AND BREATHING THEM CAN RESULT IN SERIOUS PERSONAL INJURY OR DEATH. BeO CERAMICS
WARNING MUST BE DISPOSED OF ONLY IN A MANNER PRESCRIBED BY THE DEVICE MANUFACTURER. USE CARE IN RE-
WARNING PLACING TRANSISTORS OF THIS TYPE.

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

5-28. ADJUSTMENTS.

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

5-29. Adjustment of many controls is considered obvious and may be accomplished with the information provided on the applicable schematic diagram. Adjustment procedures for all controls on all circuit boards are provided by each applicable publication in Part II of this manual.

5-30. 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, 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.

5-31. Required Equipment. The following equipment is required to complete adjustment of the second harminic suppressor.

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

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

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

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

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

D. Miniature Flat-Tip screwdriver.

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

WARNING

5-32. Procedure. To adjust the second harmonic suppressor, proceed as follows.

5-33. Deenergize all primary power to the transmitter.

5-34. Open the cabinet rear door.

5-35. Connect one end of the spectrum analyzer cable (Item C) to the low-pass filter TEST receptacle and run the cable out through the hinge side of the cabinet.

5-36. Close the cabinet rear door.

5-37. Connect the attenuator pad (Item B) in series with the cable and attach the attenuator pad to the spectrum analyzer input.

5-38. Energize the transmitter primary ac input.

CAUTION ASSURE THE TRANSMITTER IS NOT OPERATED ABOVE 750 WATTS IN THE FOLLOWING STEP.

5-39. Operate the transmitter at 750 Watts output or less and assure all PA stage tuning and loading controls are correctly adjusted.

5-40. Apply power to the spectrum analyzer and note the second harmonic indication.

5-41. Remove the snap-in hole plug immediately below the OUTPUT LOADING control to expose the second harmonic suppressor adjustment.

5-42. Adjust the second harmonic suppressor to minimize the spectrum analyzer second-harmonic display.

5-43. Depress the transmitter HIGH VOLTAGE OFF and FILAMENT OFF switch/indicators.

WARNING DISCONNECT ALL TRANSMITTER PRIMARY POWER BEFORE PROCEEDING.

5-44. Disconnect all transmitter primary power.

5-45. Open the cabinet rear door and disconnect the cable from the low-pass filter TEST receptacle.

5-46. Close the cabinet rear door.

5-47. Replace the snap-in hole plug over the second harmonic suppressor adjustment. If the plug has been lost, another plug may be ordered from Broadcast Electronics (P/N 450-0650-1).

5-48. 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

WARNING

5-49. Most troubleshooting consists of visual checks. Because of the voltages and high currents in the equipment, it is considered hazardous to work with power energized. Therefore, the various transmitter indicators (meters, LEDs, fuses, and circuit breakers) should be used to isolate the malfunction to one of the specific areas listed below. Typical meter indications are presented in Table 5-1 and transmitter primary power demand requirements are listed in Table 5-2.

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

CAUTION
CAUTION
CAUTION
CAUTION

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

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.

Table 5-1. TYPICAL METER INDICATIONS (1.5 kW)

METER	SWITCH POSITION/INDICATION
OUTPUT POWER	VSWR LESS THAN 1.2 FWD 100%
PLATE CURRENT	0.57 A
PLATE VOLTAGE	3450 V
GRID CURRENT	35 mA
FILAMENT VOLTAGE	5.0 V

Table 5-2. TYPICAL POWER DEMAND (1.5 kW)

AC Line Frequency	60 Hz
AC Line Voltage	205 V
AC Line Current	15 A
---	---
AC Line Frequency	50 Hz
AC Line Voltage	220 V
AC Line Current	15 A

WARNING: DISCONNECT POWER PRIOR TO SERVICING

5-50. Once the trouble is isolated, refer to the applicable assembly publication in Part II of this manual discussing the theory of operation and providing troubleshooting for the respective assembly to assist in problem resolution. Figures 5-3 through 5-6 provide drawings to assist component location.

5-51. COMPONENT REPLACEMENT ON CIRCUIT BOARDS. Circuit board repair requires that defective components be removed carefully to avoid damage to the board.

5-52. On all circuit boards, the adhesive securing the copper track to the board melts at almost the same temperature at which solder melts. A circuit board track can be destroyed by excessive heat or lateral movement during soldering. Use of a small iron with steady pressure is required for circuit board repairs.

5-53. 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.

5-54. 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.

5-55. Install the new component and apply solder from the bottom side of the board.

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

5-56. After soldering, remove flux with a cotton swab moistened with a suitable solvent. Rubbing alcohol is highly diluted and is not effective.

5-57. The board should be checked to ensure the flux has been removed and not just smeared about. Rosin flux is not normally corrosive, but rosin will absorb enough moisture in time to become conductive and cause problems.

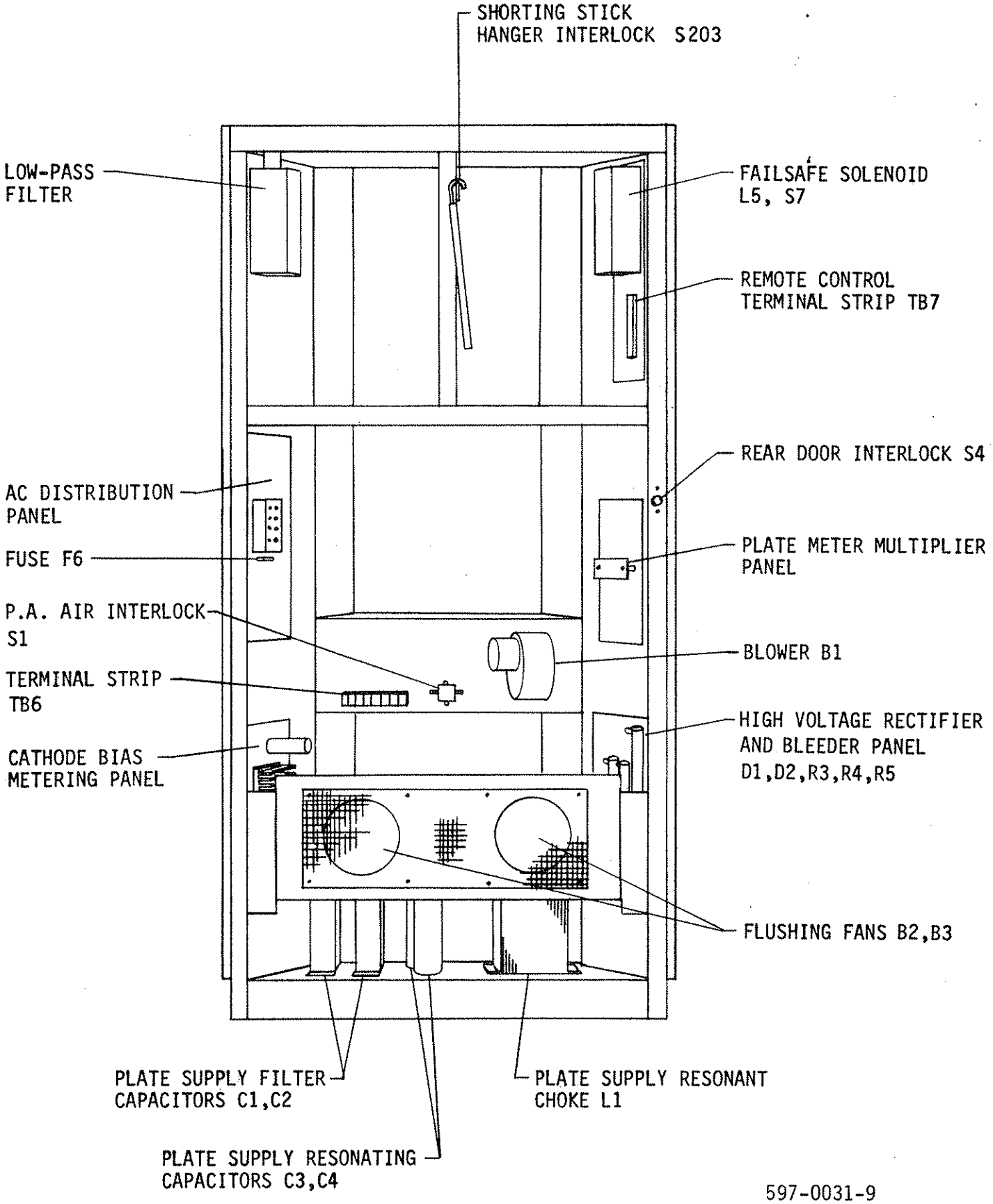


FIGURE 5-3. FM-1.5A CABINET COMPONENT LOCATOR, FRONT

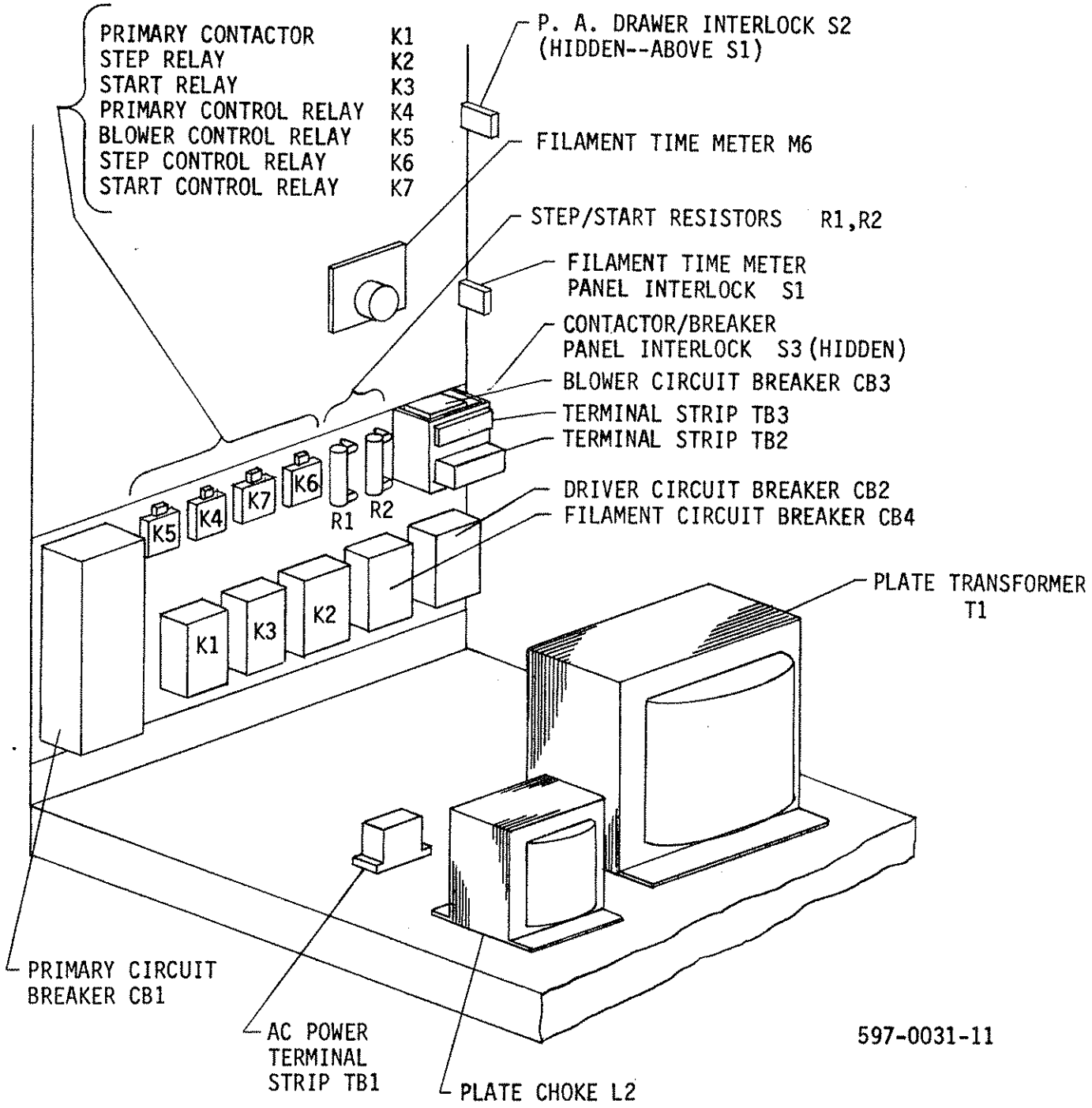


FIGURE 5-4. FM-1.5A CABINET COMPONENT LOCATOR, POWER RIGHT SIDE

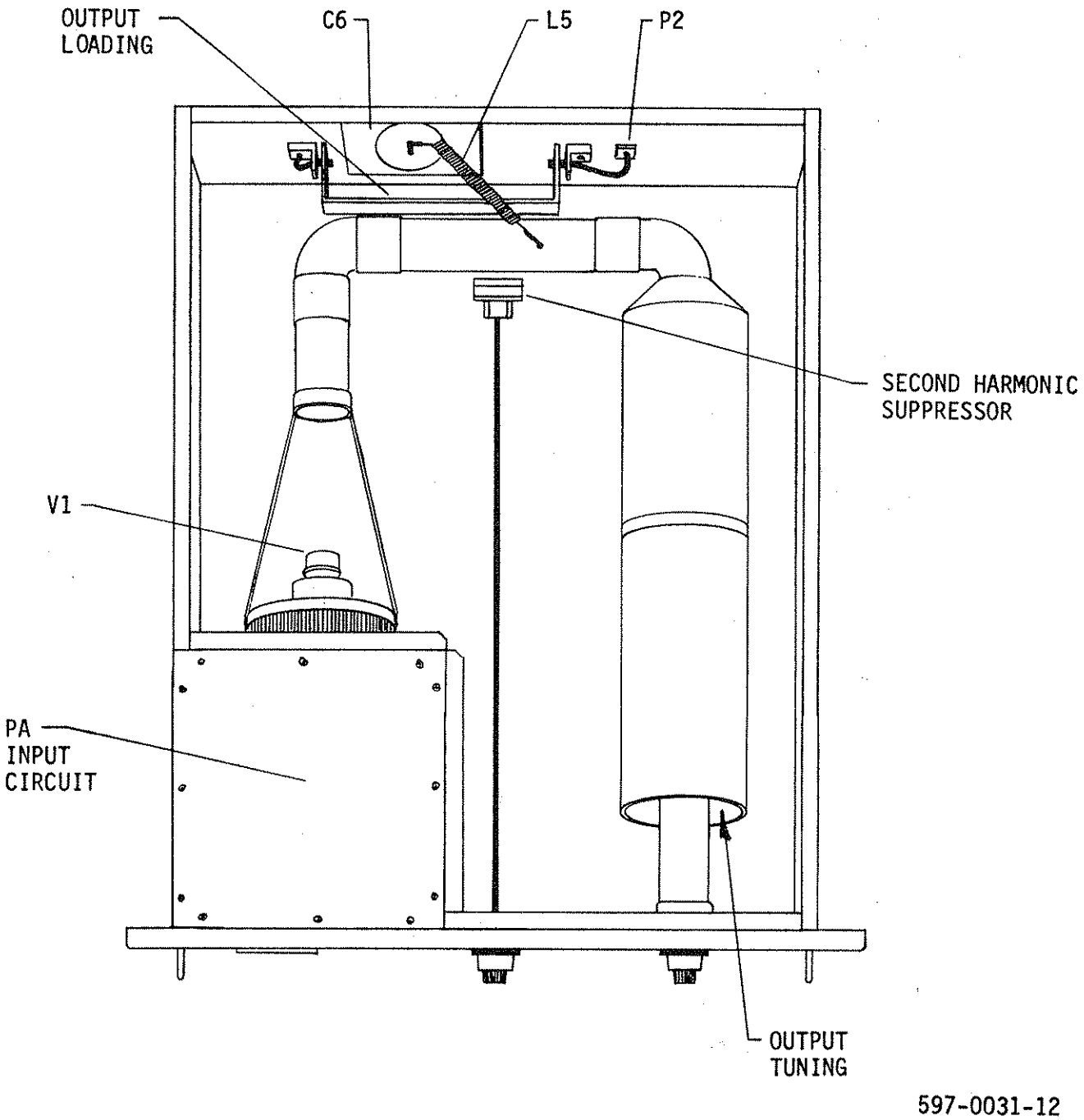


FIGURE 5-5. PA COMPONENT LOCATOR

WARNING: DISCONNECT POWER PRIOR TO SERVICING

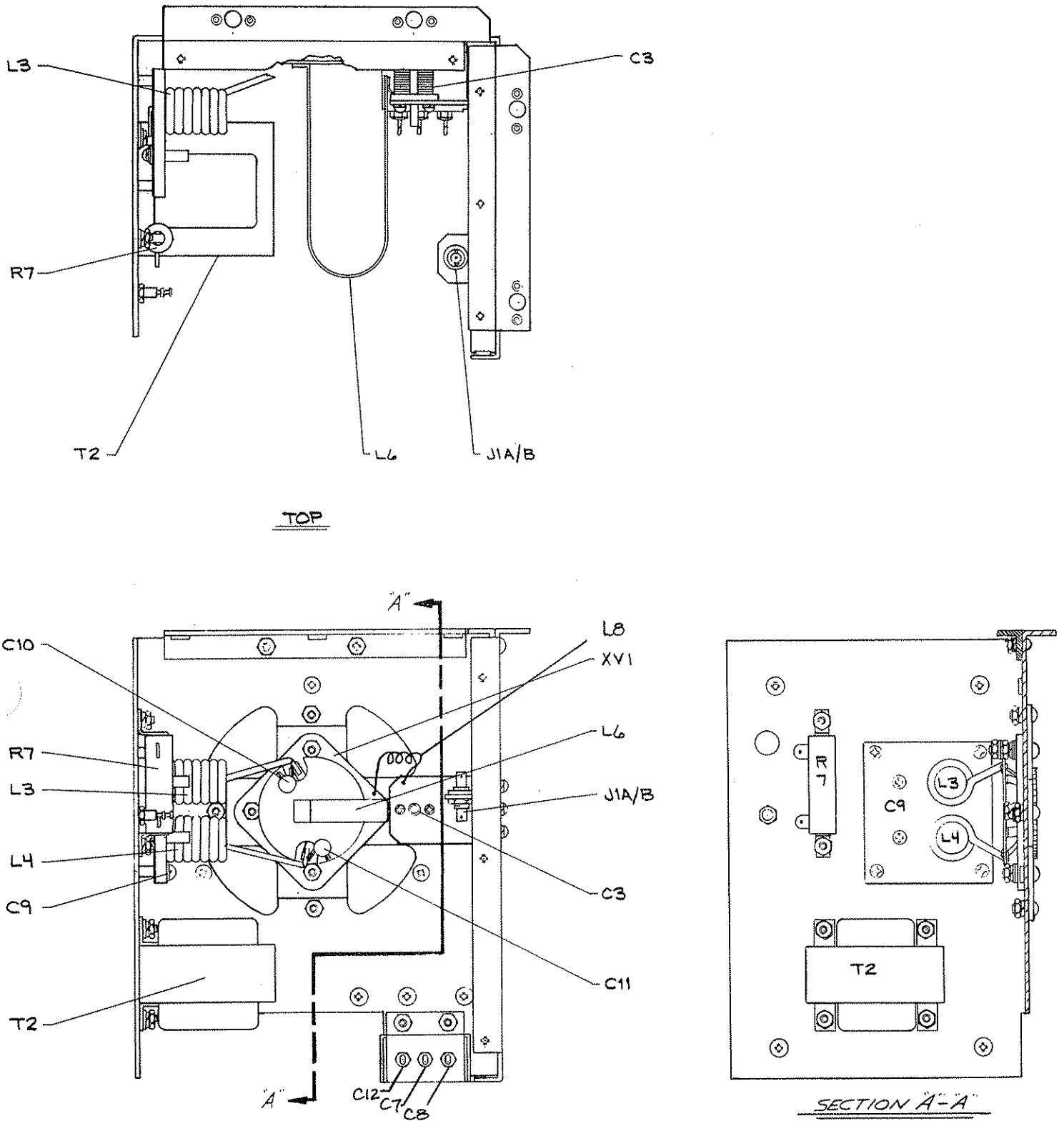


FIGURE 5-6. PA INPUT CIRCUIT COMPONENT LOCATOR

5-15-5-16

WARNING: DISCONNECT POWER PRIOR TO SERVICING

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-1.5A FM Transmitter. Each table entry in this section is indexed by reference designators appearing on the applicable schematic diagram.

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

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

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

TABLE 6-2. FM-1.5A TRANSMITTER - 909-1500-202/-212/-302

REF. DES.	DESCRIPTION	PART NO.	QTY.
M6	Filament Time Meter, 0 - 99,999.9 Hours, Non-Resettable, 60 Hz, 230 Volt, 3.5 inch (8.89 cm)	310-0000	1
----	Alternate Filament Time Meter, Ø - 99,999.9 Hours, Non-Resettable, 50 Hz, 230 Volt, 3.5 inch (8.89 cm)	310-0000-001	1
S1	Filament Time Meter Panel Interlock Switch, SPDT, 15A @ 125 or 250V ac, 0.5A @ 125V dc, 0.25A @ 250V dc	346-3302	1
V1	Tube, Eimac, 8877/3CX1500A7	243-8877	1
----	Assembly, Basic Rack	959-0093	1
----	Assembly, Contactor/Breaker Panel	959-0094	1
----	Assembly, Base Plate	959-0095	1
----	Assembly, Fan and Air Filter Panel	959-0096	1
----	Assembly, High Voltage Rectifier/Bleeder Panel	959-0126	1
----	Assembly, Remote Interface Panel	959-0117	1
----	Assembly, APC	959-0243-001	1
----	Assembly, RF Enclosure	959-0090	1
----	Assembly, Meter Panel	959-0127	1
----	Assembly, Transmitter Controller	959-0046	1
----	FM Exciter	909-0093	1
----	Assembly, Low-Pass Filter	959-0185	1
----	Assembly, IPA	959-0131	1
----	Assembly, Rear Door Panel	959-0138	1
----	Assembly, AC Distribution Panel	959-0128	1
----	Assembly, Meter Multiplier Panel	959-0129	1
----	Assembly, Cathode Bias, Metering Panel	959-0130	1
----	Cable Assembly, Remote Interface	949-0037-001	1
----	Assembly, Wire Harness	949-0052	1
----	Assembly, Resistor Network, RF Driver (listed in RF Driver Section)	959-1000-002	1
----	Assembly, Resistor Network, APC (listed in APC Section)	959-1000-011	1
----	Assembly, Resistor Network, APC (listed in APC Section)	959-1000-012	1
----	Assembly, Resistor Network, APC (listed in APC Section)	959-1000-013	1
----	Assembly, Resistor Network, APC (listed in APC Section)	959-1000-014	1
----	Assembly, 16 Pin Jumper, APC (listed in APC Section)	959-1001-001	1

TABLE 6-3. ASSEMBLY, BASIC RACK - 959-0093

REF. DES.	DESCRIPTION	PART NO.	QTY.
S2,S3,S4	PA, AC Control Panel, and Rear Door Interlock Switches, SPDT, 15A @ 125 or 250V ac, 0.5A @ 125V dc, 0.25A @ 250V dc	346-3302	3
----	Assembly, Ground Stick Hanger	955-0038	1

TABLE 6-4. ASSEMBLY, GROUND STICK HANGER - 955-0038

REF. DES.	DESCRIPTION	PART NO.	QTY.
S203	Grounding Stick Interlock Switch, SPDT, 11A @ 125V or 250V ac, 0.5A @ 125V dc, 0.25A @ 250V dc	346-6100	1

TABLE 6-5. ASSEMBLY, CONTACTOR/BREAKER PANEL - 959-0094

REF. DES.	DESCRIPTION	PART NO.	QTY.
CB1	AC POWER Circuit Breaker, 2-Pole, 240V, 30 Amperes, Modified	341-0022	1
CB2	DRIVER Circuit Breaker, 2-Pole, 250V, 7 Amperes	341-0025	1
CB3	BLOWER Circuit Breaker, 2-Pole, 250V, 3 Amperes	341-0035	1
CB4	FILAMENT Circuit Breaker, 2-Pole, 250V, 2 Amperes	341-0009	1
K1,K2	Relay, Coil: 240V ac, 1200 Ohms resistive Contacts: DPDT, 25 Amperes	270-0037	2
K3	Contactor, Coil: 208 to 240V, 60 Hz or 208 to 220V, 50 Hz Contacts: 3 Sets SPST, 25 Amperes, 600V	341-0033	1
K4 THRU K7	Assembly, Semi-Solid State Relay	919-0096-001	4
R1,R2	Resistor, 5 Ohm ±5%, 25W, W/W	130-5013	2
TB2	Barrier Strip, 6 Terminals, 600V	412-0742	1
TB3	Barrier Strip, 8 Terminals	412-0023	1
----	End Barrier for TB2	412-0730	1
----	Insulator Strip for TB3	407-0128	1

TABLE 6-6. ASSEMBLY, BASE PLATE - 959-0095

REF. DES.	DESCRIPTION	PART NO.	QTY.
C1,C2	Capacitor, Electrolytic Dielectric, 4 uF ±5%, 5 kV dc, non-PCB oil filled mylar/paper	047-0005	2
C3,C4	Capacitor, Polypropylene Film, 0.97 uF ±5%, 2500V RMS @ 120 Hz, Non-Polarized	047-0006	2
L1	Tuned Reactor, 5.06 H ±5%, 21 Ohms dc resistance, tapped at 3.5 H, 1.2 Amperes continuous	361-0003	1
L2	Choke, 3.5 H, 23 Ohms, dc Resistance, 1.2 Amperes continuous	361-0002	1
T1	Transformer, Plate, Special construction for resonant choke input supply Primary: 208/240V ±11V ac, 50/60 Hz, Single Phase Secondary: 3865V @ 0.9 Amperes continuous, 35.3 Ohms dc Resistance Tap at 2770V	376-0042	1
TB1	Terminal Block, 600V @ 100A	412-0041	3
----	End Barrier for TB1	412-0043	1
----	Mounting Channel for TB1	412-0044	3.6 inches
----	End Clamp for TB1	412-0042-001	2

TABLE 6-7. SEMI-SOLID STATE RELAY ASSEMBLY - 919-0096-001

REF. DES.	DESCRIPTION	PART NO.	QTY.
C1	Capacitor, Ceramic Disc, 0.001 uF, 1 kV	002-1034	1
C2	Capacitor, Electrolytic, 100 uF, 35V	020-1083	1
D1	Diode, 1N4005, Silicon, 600V @ 1 Ampere	203-4005	1
D2	Diode, Zener, 1N5359, 24V, 5W	200-5359	1
D3,D4	Diode, 1N4005, Silicon, 600V @ 1 Ampere	203-4005	2
E1 THRU E5	Terminal, Male, 0.25 Tab	410-0064	5
F1	Fuse, PCB Mount, 250V, 1/2 Ampere	330-0052	1
K1	Relay, Coil: 24V dc, 30A, 660 Ohms ±10% dc Resistance Contacts: SPST, 0.5 to 15A @ 12 to 240V dc	270-0054	1
MOV1	Metal Oxide Varistor, VZ50LA15A, 250V ac RMS	140-0008	1
R1	Resistor, 4 k Ohm ±5%, 10W	130-4044	1
R3	Resistor, 820 Ohm ±5%, 1/2W	110-8233	1
U1	Integrated Circuit, 4N33, Optical Isolator, Infared LED-Photo NPN Darlington Transistor Coupled Pair, 1500V Isolation	229-0033	1
XU1	Socket, 6-Pin DIP	417-0600	1
----	Blank Circuit Board	519-0096	1

TABLE 6-8. ASSEMBLY, FAN AND AIR FILTER PANEL - 959-0096

REF. DES.	DESCRIPTION	PART NO.	QTY.
B2,B3	Fan, 6 inch (15.24 cm), 250 ft^3/min, 220V ac, 50/60 Hz, 40 Watt	380-7650	2
TB5	Barrier Strip, 6 Terminals	412-0008	1
----	Insulator Strip for TB5	407-0126	1

TABLE 6-9. ASSEMBLY, HIGH VOLTAGE RECTIFIER/BLEEDER PANEL - 959-0126

REF. DES.	DESCRIPTION	PART NO.	QTY.
D1,D2	Encapsulated high voltage dual diode assembly, 12 kV @ 1.25 Amperes each diode	230-0007	2
R3,R4	Resistor, 100 k Ohm ±5%, 100W, W/W	132-1063	2
R5	Resistor, 22 Ohm ±20%, 150W, Non-Inductive	139-0220	1

TABLE 6-10. ASSEMBLY, REMOTE INTERFACE PANEL - 959-0117

REF. DES.	DESCRIPTION	PART NO.	QTY.
TB7	Barrier Strip, 10 Terminals	412-0010-1	1
----	Barrier Strip, 26 Terminals	412-0045	1
----	Assembly, Fail-Safe Solenoid	959-0083	1

TABLE 6-11. ASSEMBLY, FAIL-SAFE SOLENOID - 959-0083

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

TABLE 6-12. RF ENCLOSURE ASSEMBLY - 959-0090
(Sheet 1 of 2)

REF. DES.	DESCRIPTION	PART NO.	QTY.
B1	Blower, 230V ac, 50/60 Hz, 200 ft^3/min, 3000 R/M	380-0412	1
C3	Capacitor, Air Variable, 5.5 to 100 pF, 850V	090-0002	1
C6	Plate Bypass Capacitor, Kapton, 1800 pF, 20 kV		
	Kapton Dielectric	519-0036	2
	Clear Polycarbonate Plate	417-0330	2
	Teflon Spacer	441-0051	1
C7,C8	Capacitor, Ceramic, 1000 pF ±20%, 500V, Feed-Thru	008-1033	2
C9	Filament Bypass Capacitor, Kapton, 600 pF @ 1 kV each Section	519-0044	1
C10,C11	Capacitor, Ceramic Disc, 0.001 uF, 1 kV	002-1034	2
C12	Capacitor, Ceramic, 1000 pF ±20%, 500V, Feed-Thru	008-1033	1
C17	Capacitor, Ceramic Disc, 0.001 uF, 1 kV	002-1034	1
J1A/B, J1A/B	Receptacle, BNC	417-0017	2
J2	Receptacle, Type N	417-0204	1
L3	Coil, Cathode, 8 1/2 clockwise turns of solid 10 Gauge insulated copper wire, 0.75 inches ID, 1.43 inches long	360-0026	1

TABLE 6-12. RF ENCLOSURE ASSEMBLY - 959-0090
(Sheet 2 of 2)

REF. DES.	DESCRIPTION	PART NO.	QTY.
L4	Coil, Cathode, 8 1/2 counterclockwise turns of solid 10 Gauge insulated copper wire, 0.75 inches ID, 1.43 inches long	360-0027	1
L5	Coil, Plate Choke, 30 1/2 turns of 13 Gauge Nichrome wire, 0.38 inches ID, 3.2 inches long	959-0158	1
L7	Choke, Z144, 1100 mA Maximum, 80 - 200 mHz	360-0144	2
L8	Choke, RF	360-0064	1
M5	Meter, 0 - 10V ac, 100 Ohm coil, Iron Vane type, 3 1/2 inch (FILAMENT VOLTAGE)	310-0024	1
R6	Rheostat, Modified, 175 Ohms, 25W, W/W	190-0002-001	1
R7	Resistor, 5 Ohm, 25W, W/W	130-5013	1
R8	Resistor, 1 k Ohm ±5%, 1/2W	110-1043	1
S1	Switch, Air Interlock, Differential Type, Adjustable from 0.5 to 3.0 inches/water gauge, requires 5/32 inch ID tubing. Contacts: 120V ac @ 20 mA Maximum	340-0017	1
---	Balun Transformer, 50 Ohms to 12.5 Ohms (Part of Cable Assembly 949-0046)	949-0046	1
T2	Filament Transformer Primary: 230V ac ±10%, 50/60 Hz, 1 Ø Secondary: 6.3V CT @ 10A	370-0888-001	1
TB1	Barrier Strip	412-0725	9
TP1	Test Point, Black (CATHODE VOLTAGE -)	417-0092	1
TP2	Test Point, Red (CATHODE VOLTAGE +)	417-0091	1
----	Turn-Lock Fasteners		
	Receptacle	420-0022	20
	Stud	420-0015	20
	Stud Retainer	420-0021	20
----	Grid Contact plate with fingerstock	474-0194	1
----	Cyclometer (for OUTPUT TUNING and OUTPUT LOADING)	290-0002	2
----	Barrier Strip end cap (for TB6)	412-0730	1
----	Connector, Type N plug to Type N Receptacle, Right Angle	417-0105	1
----	Assembly, Output Cable	949-0050	1
----	Assembly, Wire Harness	949-0046	1

TABLE 6-13. OUTPUT LINE CABLE ASSEMBLY - 949-0050

REF. DES.	DESCRIPTION	PART NO.	QTY.
P1,P2	Plug, Type N	427-0028	2

TABLE 6-14. RF ENCLOSURE WIRE HARNESS - 949-0046

REF. DES.	DESCRIPTION	PART NO.	QTY.
P1A,P1B	Plug, BNC	417-0095	2
P1B	Plug, BNC (Input Balun)	417-0205	1

TABLE 6-15. METER PANEL ASSEMBLY - 959-0127

REF. DES.	DESCRIPTION	PART NO.	QTY.
C13 THRU C16	Assembly, Capacitor	959-0144	4
M1	OUTPUT POWER Meter, 3 1/2 inch (8.89 cm), Taut Band Type, FS= 200 uA, 230 Ohm Movement	310-0020-001	1
M2	PLATE VOLTAGE Meter, 3 1/2 inch (8.89 cm), Taut Band Type, FS= 1 mA, 35 Ohm Movement	310-0022	1
M3	PLATE CURRENT Meter, 3 1/2 inch (8.89 cm), Taut Band Type, FS= 1 VDC, 1 k Ohm Movement	310-0023	1
M4	GRID CURRENT Meter, 3 1/2 inch (8.89 cm), Taut Band Type, FS= 100 uA, 640 Ohm Movement	310-0021	1

TABLE 6-16. ASSEMBLY, CAPACITOR - 959-0144

REF. DES.	DESCRIPTION	PART NO.	QTY.
----	Capacitor, Ceramic, 0.001 uF, 1 kV	002-1034	1

TABLE 6-17. ASSEMBLY, REAR DOOR PANEL - 959-0138

REF. DES.	DESCRIPTION	PART NO.	QTY.
----	Filter, Air, 16 inch X 20 inch X 1 inch (40.64 cm X 50.8 cm X 2.54 cm)	407-0062	1
----	Turnlock Fastener		
	Stud	424-0008	2
	Retainer Ring	424-0006	2

TABLE 6-18. ASSEMBLY, AC DISTRIBUTION PANEL - 959-0128

REF. DES.	DESCRIPTION	PART NO.	QTY.
F1	Fuse, 6 Amperes, 250V, Type AGC	330-0602	1
XF1	Holder, Fuse, Type AGC	415-0004	1
----	Barrier Strip, 7 Terminal	412-0022	3

TABLE 6-19. ASSEMBLY, METER MULTIPLIER - 959-0129

REF. DES.	DESCRIPTION	PART NO.	QTY.
----	Meter Multiplier Circuit Board Assembly	919-0200-001	1

TABLE 6-20. METER MULTIPLIER CIRCUIT BOARD ASSEMBLY - 919-0200-001

REF. DES.	DESCRIPTION	PART NO.	QTY.
C1	Capacitor, 390 pF ±5%, 100V	042-3922	1
D1	Diode, Zener, 1N4739A, 9.1V ±5%, 1W	200-0009	1
R1 THRU R5	Resistor, 1 Meg Ohm ±1%, 2W	140-0003	5
R6	Resistor, 4.99 k Ohm ±1%, 1/4W	100-5041	1
----	Blank Circuit Board	519-0200	1

TABLE 6-21. ASSEMBLY, CATHODE BIAS METERING PANEL - 959-0130

REF. DES.	DESCRIPTION	PART NO.	QTY.
C5	Capacitor, Electrolytic, 4200 uF, 75 V	028-4294	1
D6	Diode, Zener, 1N4755A, 43V ±5%, 1W	200-4755	1
Q1	Transistor, MJ11017, Silicon, PNP Darlington, TO-3 Case	219-1017	1
R11,R12	Resistor, 470 Ohm ±5%, 1/2W	110-4733	1
XQ1	Socket, TO-3	417-0298	1
----	Cathode Metering Circuit Board Assembly	919-0043	1

TABLE 6-22. CATHODE METERING CIRCUIT BOARD ASSEMBLY - 919-0043

REF. DES.	DESCRIPTION	PART NO.	QTY.
D1 THRU D3	Diode, Zener, 1N4739A, 9.1V ±5%, 1W	200-0009	3
D4	Diode, Transient Voltage Suppressor, 5 kW, 50V	200-0001	1
D5	Diode, MR502, Silicon, 200V @ 3 Amperes	202-0502	1
J1	Connector, 4-Pin	418-0255	1
J2	Connector, 12-Pin	417-1276	1
R2	Resistor, 12 k Ohm ±5%, 1/2W	110-1253	1
R3	Resistor, 499 Ohm ±1%, 1/4W	103-4993	1
R4	Resistor, 8.87 k Ohm ±1%, 1/4W	103-8874	1
R5	Resistor, 1 k Ohm ±1%, 1/4W	100-1041	1
R6	Resistor, 4 Ohm ±1%, 7.5W, Non-Inductive Wire Wound	130-4001	1
R7	Resistor, 1 Ohm ±1%, 7.5W, Non-Inductive Wire Wound	130-1001	1
R8	Resistor, 1 k Ohm ±1%, 1/4W	100-1041	1
R9	Resistor, 4 Ohm ±1%, 7.5W, Non-Inductive Wire Wound	130-4001	1
R10	Resistor, 1 Ohm ±1%, 7.5W, Non-Inductive Wire Wound	130-1001	1
R12	Resistor, 100 Ohm ±5%, 1/4W	100-1033	1
R13	Resistor, 8.87 k Ohm ±1%, 1/4W	103-8874	1
----	Blank Circuit Board	519-0043	1

TABLE 6-23. CABLE ASSEMBLY, REMOTE INTERFACE - 949-0037-001

REF. DES.	DESCRIPTION	PART NO.	QTY.
J1	Connector, 26-Pin	417-0047	1
P1	Connector, 25-Pin	418-0609	1

TABLE 6-24. ASSEMBLY, WIRE HARNESS - 949-0052

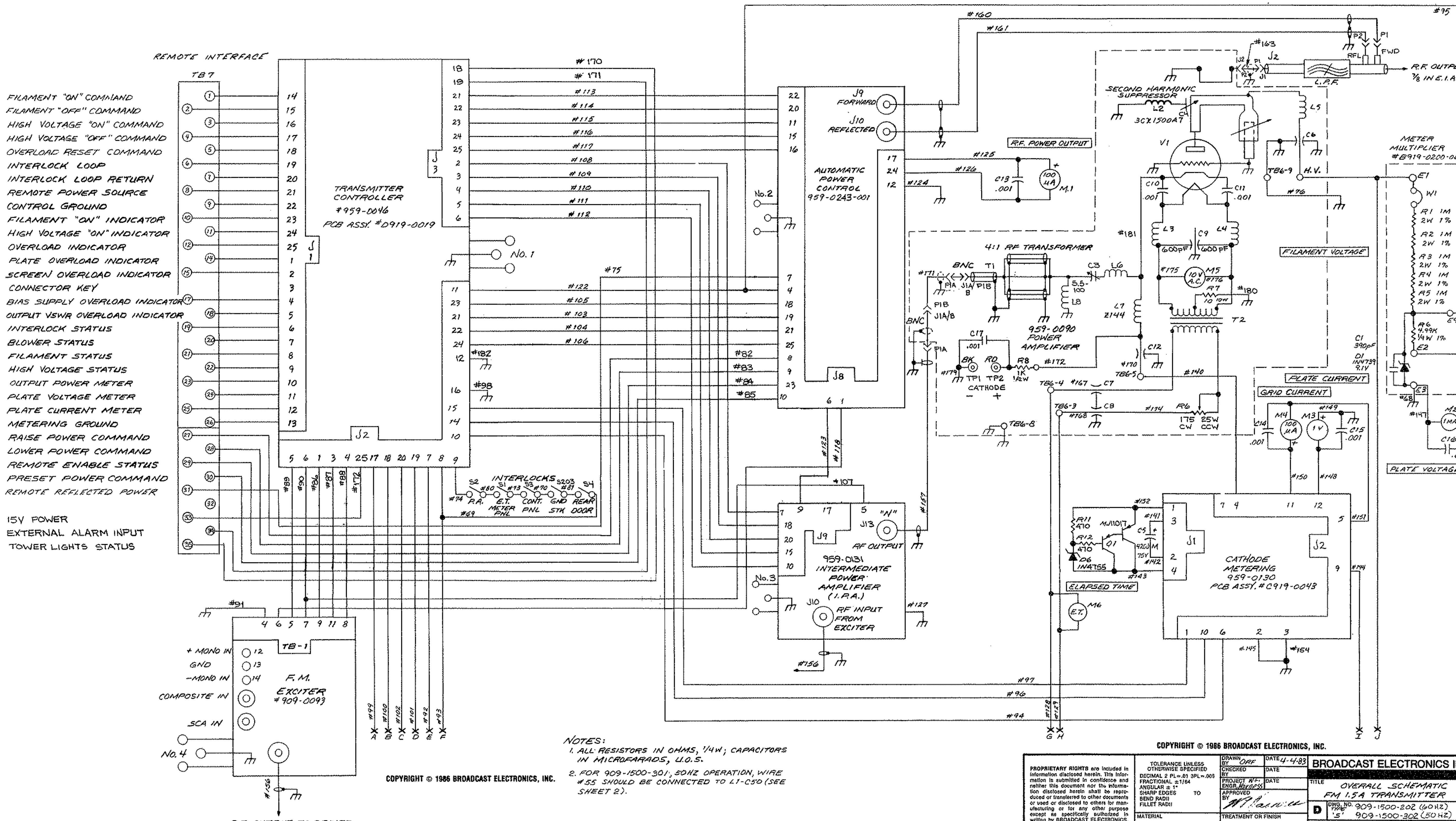
REF. DES.	DESCRIPTION	PART NO.	QTY.
J2,J3,J8, J9	Connector, 25-Pin (CONTROLLER --2, IPA, and APC)	418-3219	4
P1	Plug, 4-Pin	418-0240	1
----	Pins for P1	417-0053	4
P2	Plug, 12-Pin	418-1271	1
----	Pins for P2	417-0053	11
----	Cable Assembly, Contactor/Breaker Panel	949-0058	1
----	Cable Assembly, High Voltage and Filter Assembly	949-0060	1
----	Connector, Type N (IPA to PA)	418-0031	1
----	Connector, BNC (IPA to PA)	417-0095	1
----	Connector, BNC (APC to Low-Pass Filter and Exciter to IPA)	417-0094	6
----	AC Power Cord (Transmitter Controller, Exciter, IPA, APC)	682-0001	4

SECTION VII
DRAWINGS

7-1. INTRODUCTION.

7-2. This section provides assembly drawings, schematic diagrams, and wire lists as indexed below applicable to the overall FM-1.5A Transmitter.

FIGURE	TITLE	NUMBER
7-1	OVERALL SCHEMATIC, FM-1.5A TRANSMITTER	DS909-1500-202/-302
7-2	ASSEMBLY, CATHODE BIAS METERING PANEL	DA959-0130
7-3	SCHEMATIC, PLATE METER MULTIPLIER CIRCUIT BOARD	BS919-0200-001
7-4	ASSEMBLY, METER MULTIPLIER CIRCUIT BOARD	BA919-0200-001
7-5	ASSEMBLY, METER MULTIPLIER PANEL	DA959-0129
7-6	WIRING DIAGRAM, METER PANEL	CW959-0127
7-7	WIRING DIAGRAM, CONTACTOR/BREAKER PANEL	DW959-0094
7-8	WIRING DIAGRAM, HV RECTIFIER/BLEEDER PANEL	CW959-0126
7-9	WIRING DIAGRAM, BASE PLATE	CW959-0095
7-10	WIRING DIAGRAM, A.C. DISTRIBUTION PANEL	CW959-0128
7-11	WIRING DIAGRAM, FAN AND FILTER PANEL	BW959-0096
7-12	WIRING DIAGRAM, REMOTE INTERFACE PANEL	CW959-0117
7-13	SCHEMATIC, CATHODE METERING CIRCUIT BOARD	BS919-0043
7-14	ASSEMBLY, CATHODE METERING CIRCUIT BOARD	CA919-0043
7-15	SCHEMATIC, SEMI-SOLID STATE RELAY	SB919-0096/-001
7-16	ASSEMBLY, SEMI-SOLID STATE RELAY	AC919-0096/-001



NOTES:
1. ALL RESISTORS IN OHMS, 1/4W; CAPACITORS IN MICROFARADS, U.O.S.
2. FOR 909-1500-301, 50HZ OPERATION, WIRE #55 SHOULD BE CONNECTED TO L1-C50 (SEE SHEET 2).

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

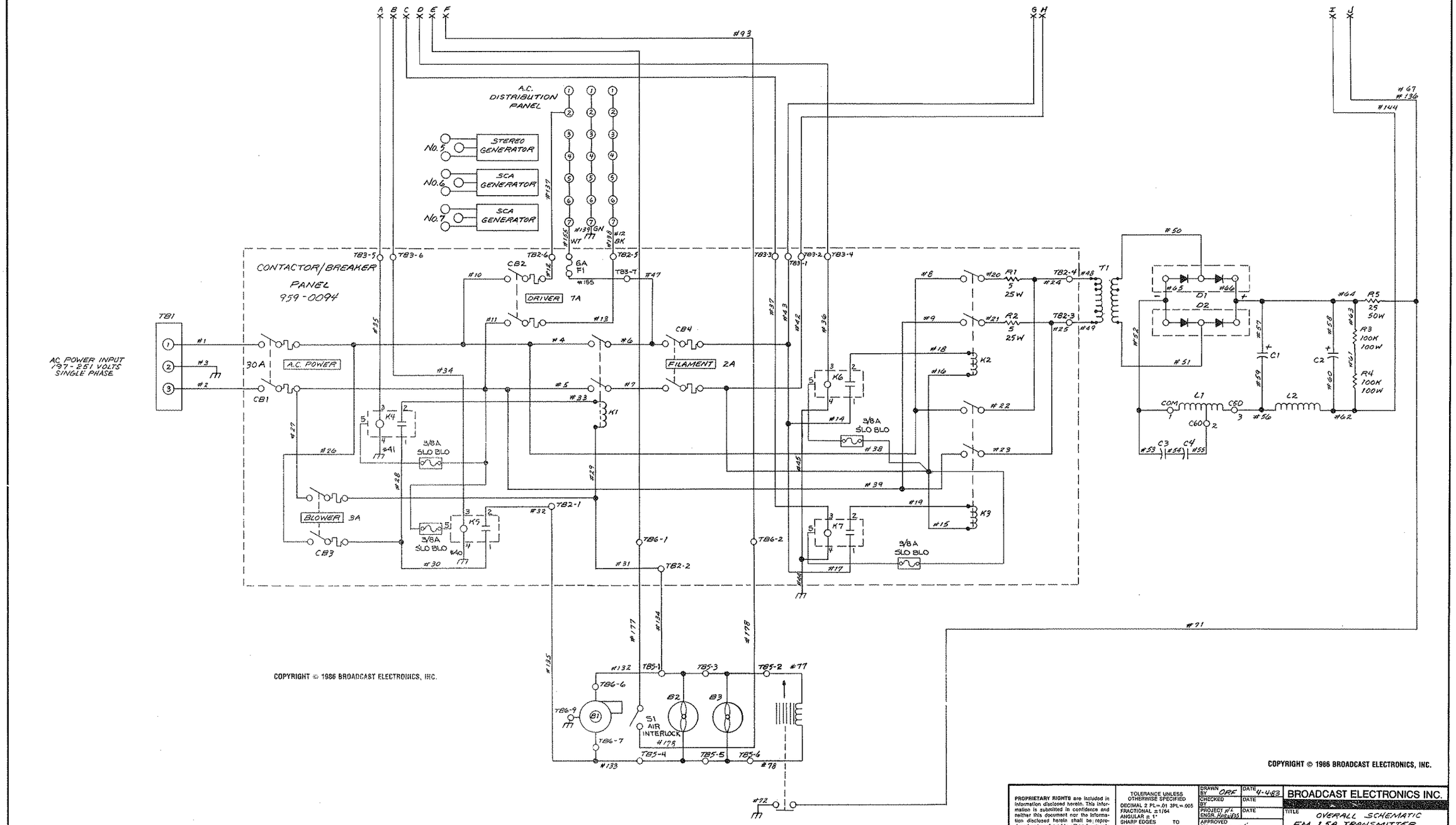
DRAWN BY OFF — DATE 4-4-83
CHECKED BY — DATE
PROJECT ENGR. — DATE
APPROVED BY
TREATMENT OR FINISH

BROADCAST ELECTRONICS INC.

TITLE OVERALL SCHEMATIC FM 1.5A TRANSMITTER

D — DWG. NO. 909-1500-202 (60HZ) / 909-1500-302 (50HZ) — REV. Y

FM-1.5A — SCALE NTS — SHEET 1 OF 2



COPYRIGHT © 1986 BROADCAST ELECTRONICS, INC.

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

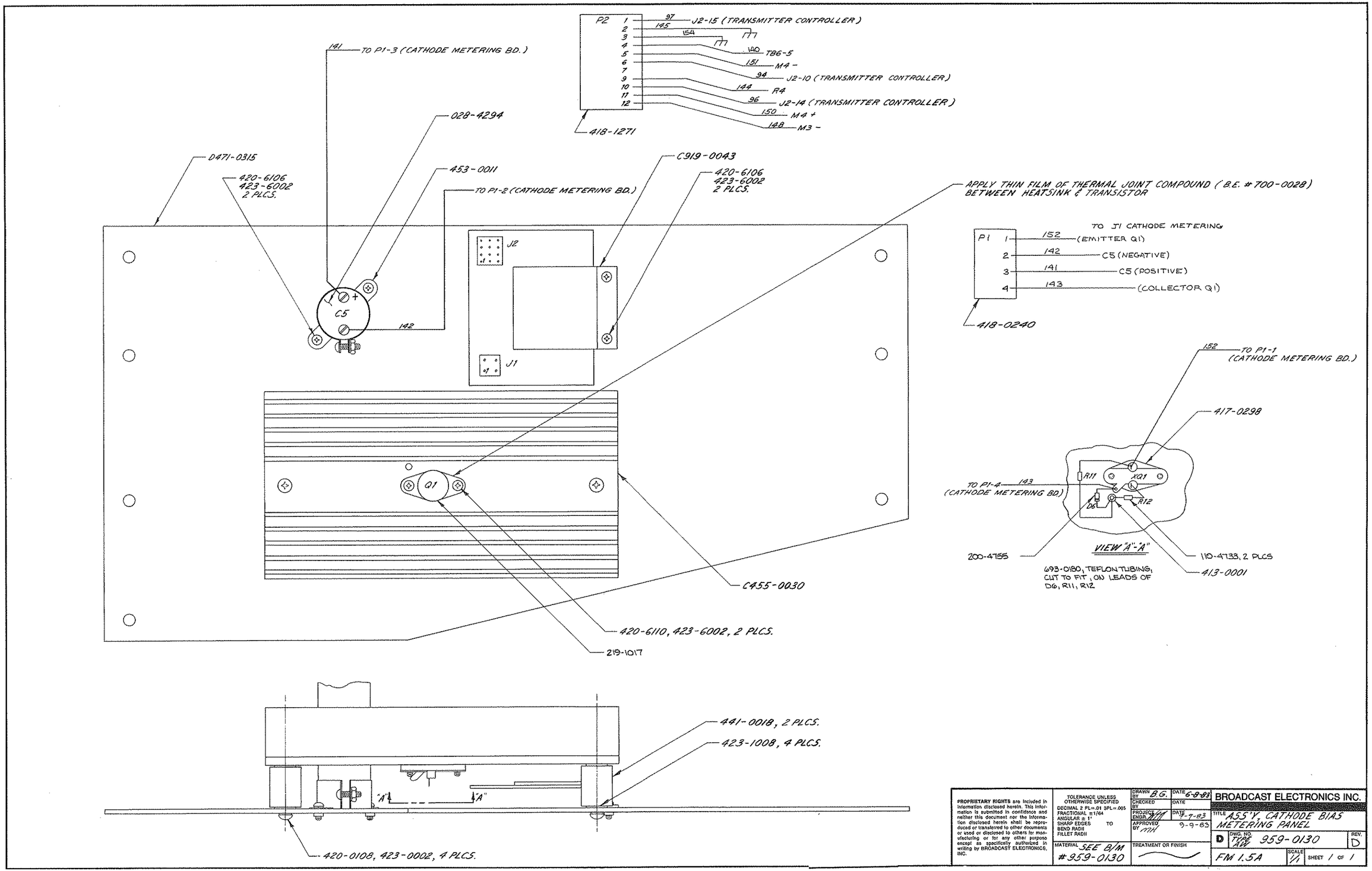
DRAWN BY ORF DATE 4-483
CHECKED BY DATE
PROJECT MGR. HIGHLESS DATE
APPROVED BY

BROADCAST ELECTRONICS INC.

TITLE OVERALL SCHEMATIC FM 1.5A TRANSMITTER

SIZE D | DWG. NO. 909-1500-202 (60 HZ) 909-1500-302 (50 HZ) | REV. W

FM-1.5A | SCALE NTS | SHEET 2 OF 2



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

MATERIAL SEE B/M #959-0130

TREATMENT OR FINISH

DRAWN BY B.G. DATE 6-8-83
CHECKED BY DATE
PROJECT ENGR. DATE 9-7-83
APPROVED BY 9-9-83

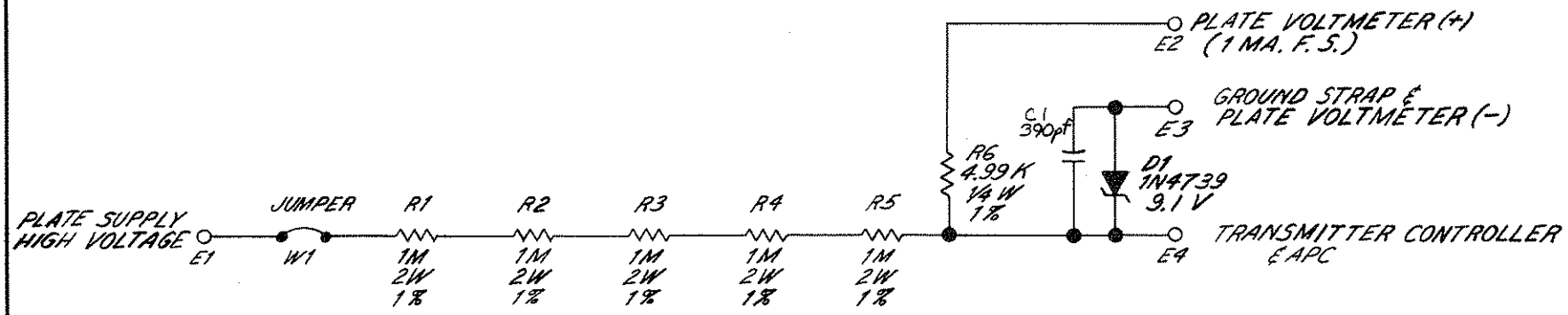
BROADCAST ELECTRONICS INC.

TITLE ASS'Y, CATHODE BIAS METERING PANEL

D DWG. NO. 959-0130 REV. D

FM 1.5A SCALE 1/1 SHEET 1 OF 1

REVISIONS			
REV.	DESCRIPTION	DATE	APPROVED
A	ENGINEERING RELEASE W/O CHANGE	6/1/83	



NOTES:

1. ALL RESISTORS IN OHMS.
2. LAST COMPONENTS USED: C1, E4, R6, D1
3. SEE ASSEMBLY #C919-0200-001
   SEE B/M # 919-0200-001

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

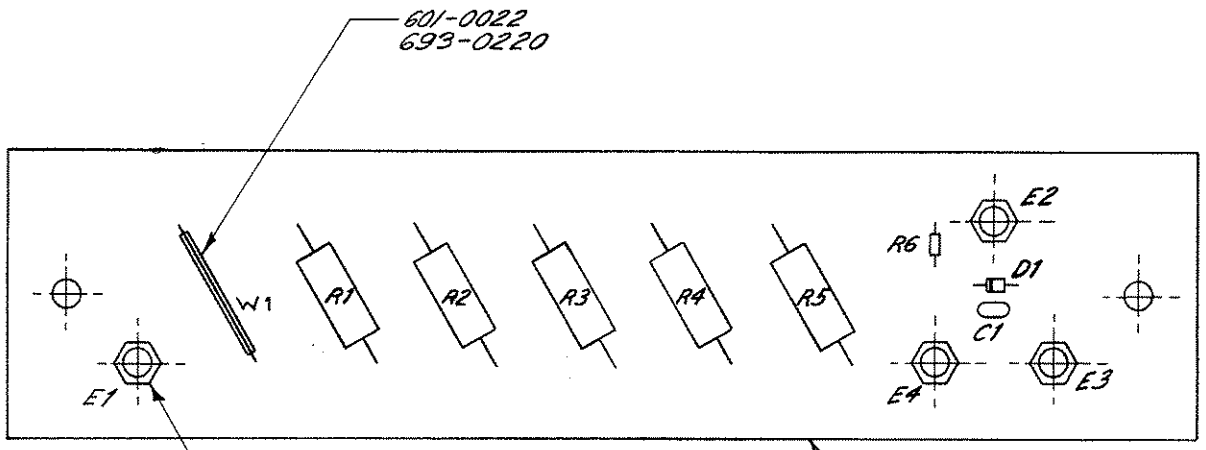
DRAWN BY B.G.	DATE 4-5-83	
CHECKED BY	DATE	
PROJECT ENGR	DATE 6-3-83	
APPROVED BY MH	6-2-83	

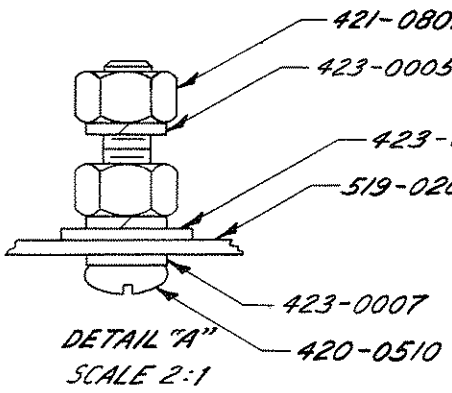
BROADCAST ELECTRONICS INC.

TITLE SCHEMATIC
PLATE METER MULTIPLIER PCB

B	DWG. NO. TYPE S 919-0200-001	REV. A
FM 1.5A	SCALE N/A	SHEET 1 OF 1

REVISIONS			
REV.	DESCRIPTION	DATE	APPROVED
A	ENGINEERING RELEASE W/O CHANGE	6/1/83	





DETAIL "A"
SCALE 2:1

NOTES:
1. SEE SCHEMATIC # B919-0200-001

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

MATERIAL SEE B/M #919-0200-001

DRAWN BY B.G. DATE 4-5-83
CHECKED BY DATE
PROJECT ENGR. DATE 6-3-83
APPROVED BY MH 6-2-83

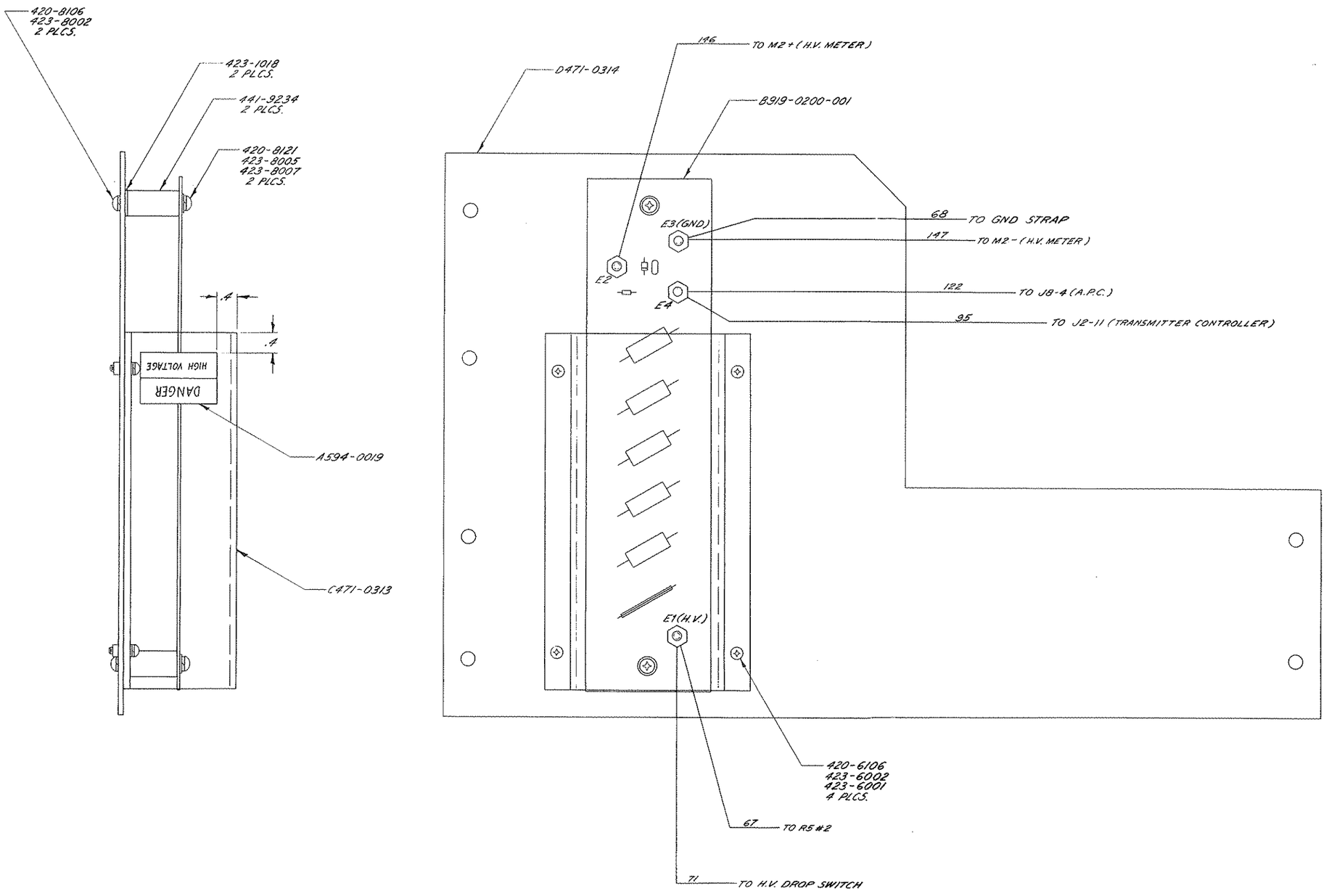
TREATMENT OR FINISH

BROADCAST ELECTRONICS INC.

TITLE PCB ASSEMBLY METER MULTIPLIER

B DWG. NO. TYPE A 919-0200-001 REV. A

FM 1.5A SCALE 1/1 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 SEE B/M #959-0129

TREATMENT OR FINISH

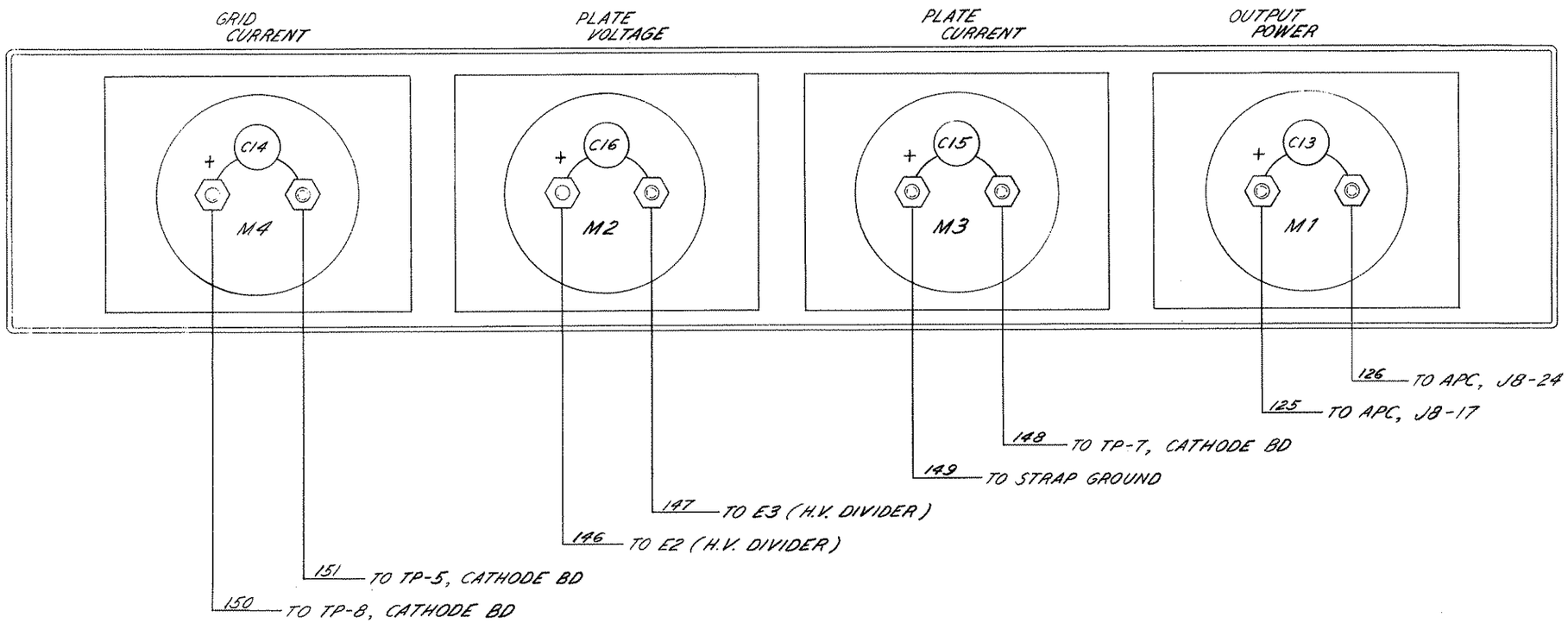
DRAWN BY B.G. DATE 6-16-83
CHECKED BY DATE
PROJECT ENGR. DATE 9-9-83
APPROVED BY DATE 9-9-83

BROADCAST ELECTRONICS INC.

TITLE ASS'Y, METER MULTIPLIER PANEL

D DWG NO. 959-0129 REV. B

FM 1.5A SCALE 1/1 SHEET 1 OF 1



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

DWN. BY E.G.	6-14-83
CHKD.	
ME	
EE	
PROJ. ENGR.	
DFTG. SUPVR. MH	7-7-83
MFG.	

NEXT ASSY.

PRODUCT USED ON FM 1.5A

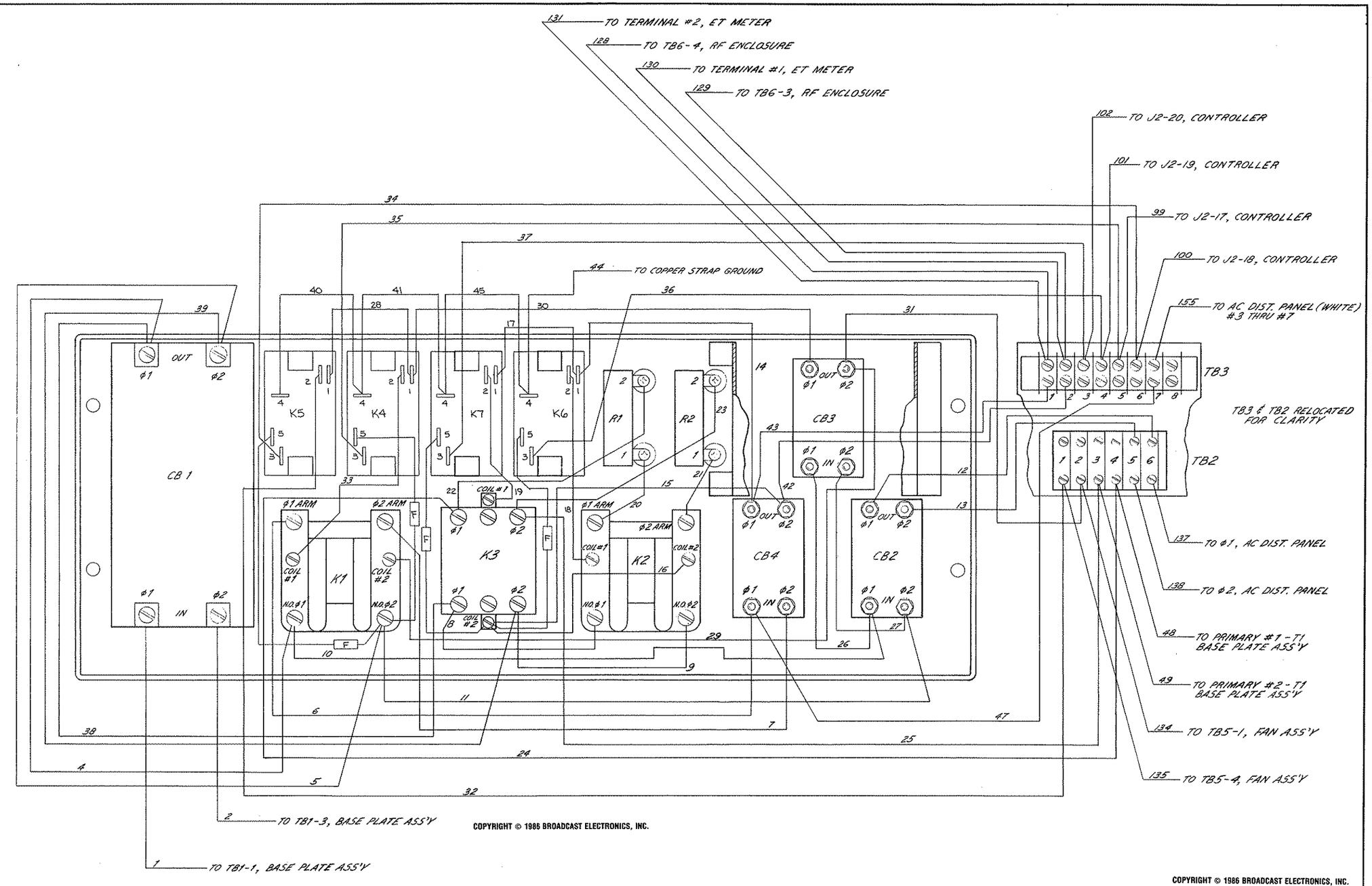
FINISH

BROADCAST ELECTRONICS INC.
4100 N. 24TH ST. QUINCY, IL 62305 217/224-9600
TELEX 250142 CABLE BCST ELECT QUI

TITLE WIRING DIAGRAM METER PANEL

SHEET 1 OF 1 | SCALE 1/1 | REV A

TYPE W | SIZE C | DWG. NO. 959-0127



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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

TREATMENT OR FINISH

DRAWN BY	B.G.	DATE 6-14-83
CHECKED BY		DATE
PROJECT. ENGR.		DATE
APPROVED BY		DATE 6-24-83

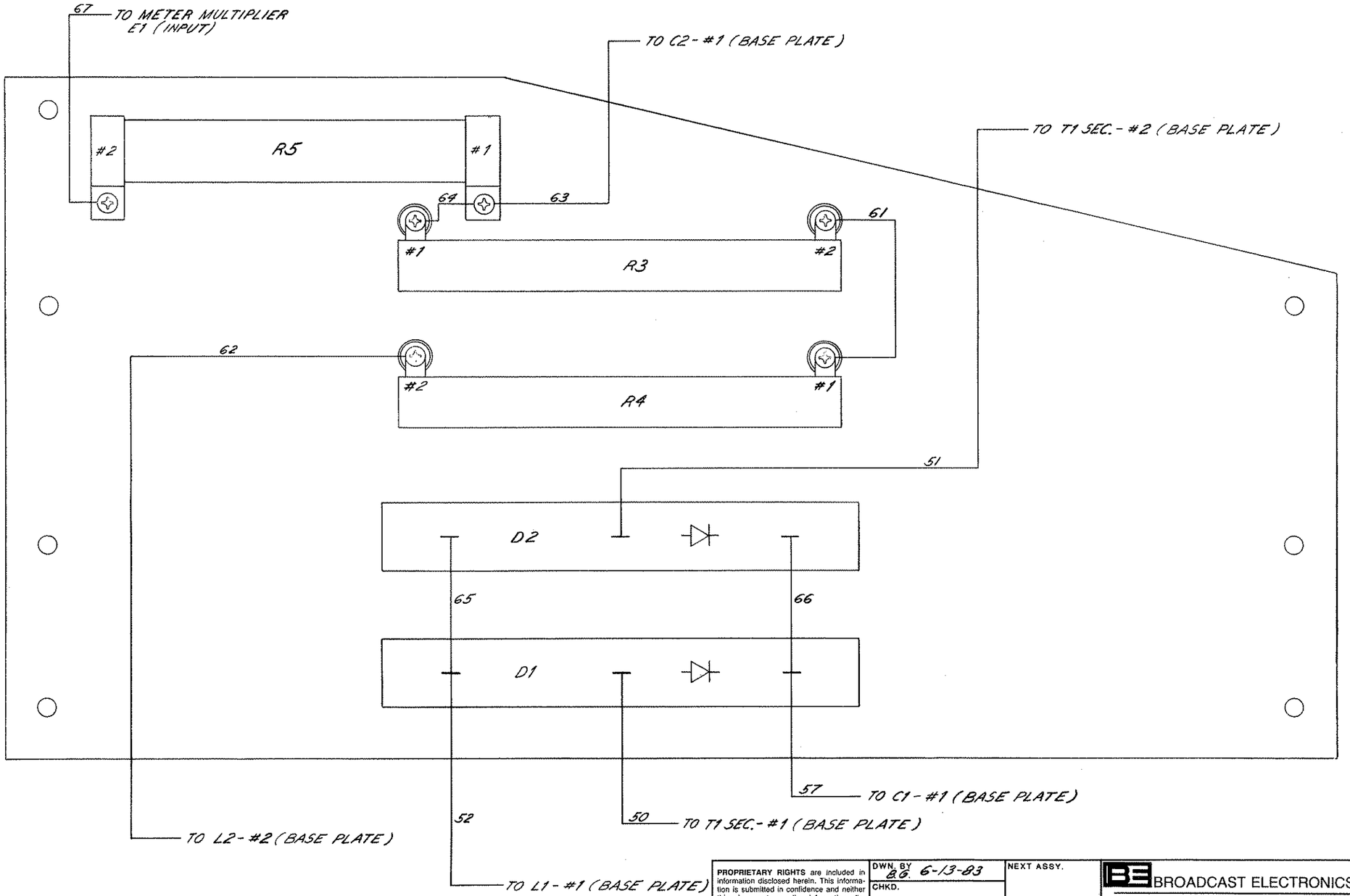
BROADCAST ELECTRONICS INC.

TITLE WIRING DIAGRAM CONTACTOR/BREAKER PANEL

D DWG. NO. TYPE W 959-0094 REV. D

FM 1.5A SCALE 1/1 SHEET 1 OF 1

REVISIONS					
REV	DATE	DESCRIPTION	DFTSMN	ENGR	ECN
A	9-9-83	ENGR. RELEASE W/O CHANGE	B.G.		



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

DWN. BY B.G. 6-13-83
CHKD.
ME
EE
PROJ. ENGR. M. Hamm
DFTG. SUPVR. MH 9-9-83
MFG.

NEXT ASSY.
PRODUCT USED ON
FINISH

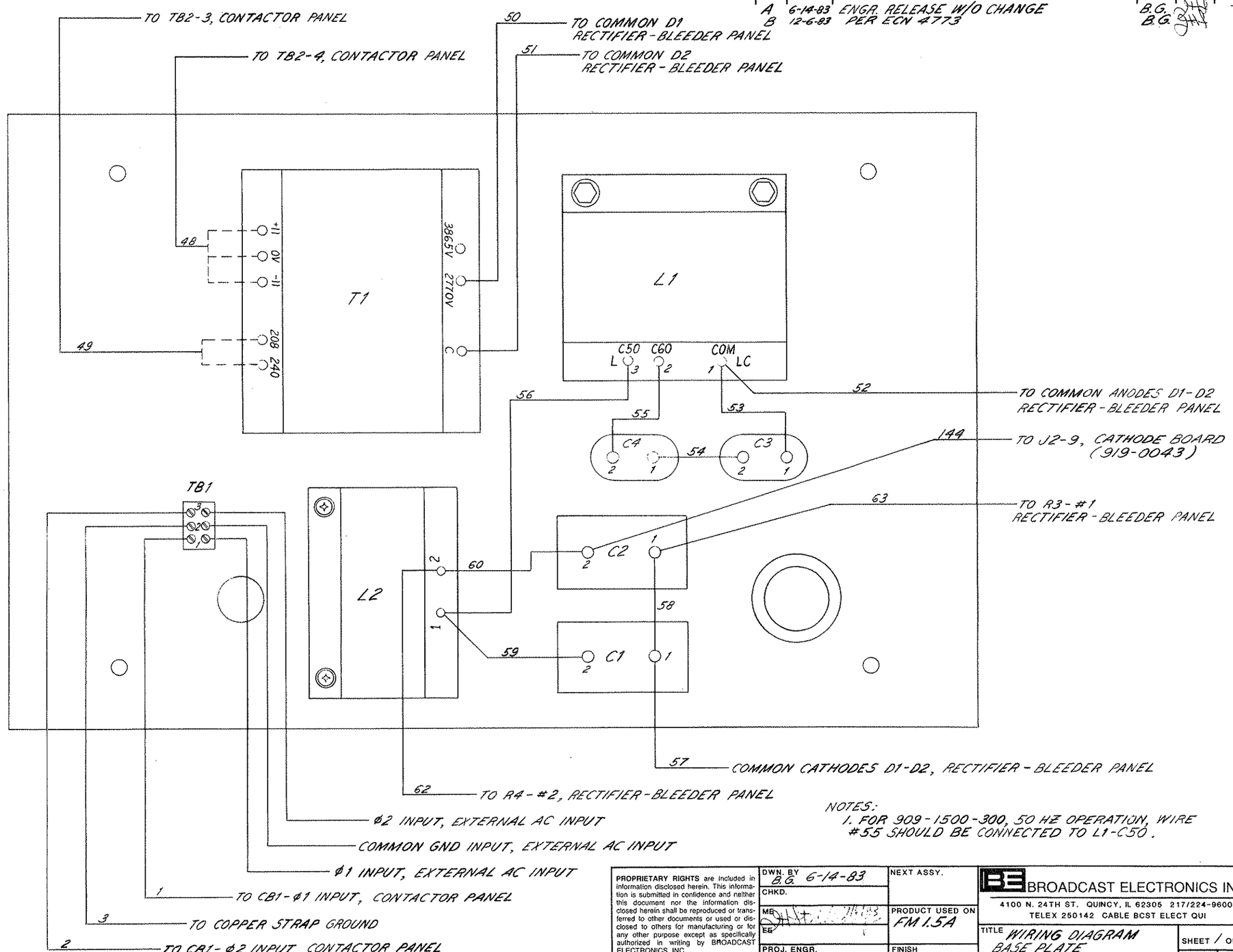
BROADCAST ELECTRONICS INC.
4100 N. 24TH ST. QUINCY, IL 62305 217/224-9600
TELEX 250142 CABLE BCST ELECT QUI

TITLE WIRING DIAGRAM HV RECTIFIER/BLEEDER PANEL

SHEET 1 OF 1
SCALE 1/1
REV A

TYPE W SIZE C DWG. NO. 959-0126

REVISIONS					
REV	DATE	DESCRIPTION	DFTSMN	ENGR	ECN
A	6-14-83	ENGR. RELEASE W/O CHANGE	B.G.		–
B	12-6-83	PER ECN 4773	B.G.		



NOTES:
1. FOR 909-1500-300, 50 HZ OPERATION, WIRE #55 SHOULD BE CONNECTED TO L1-C50.

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

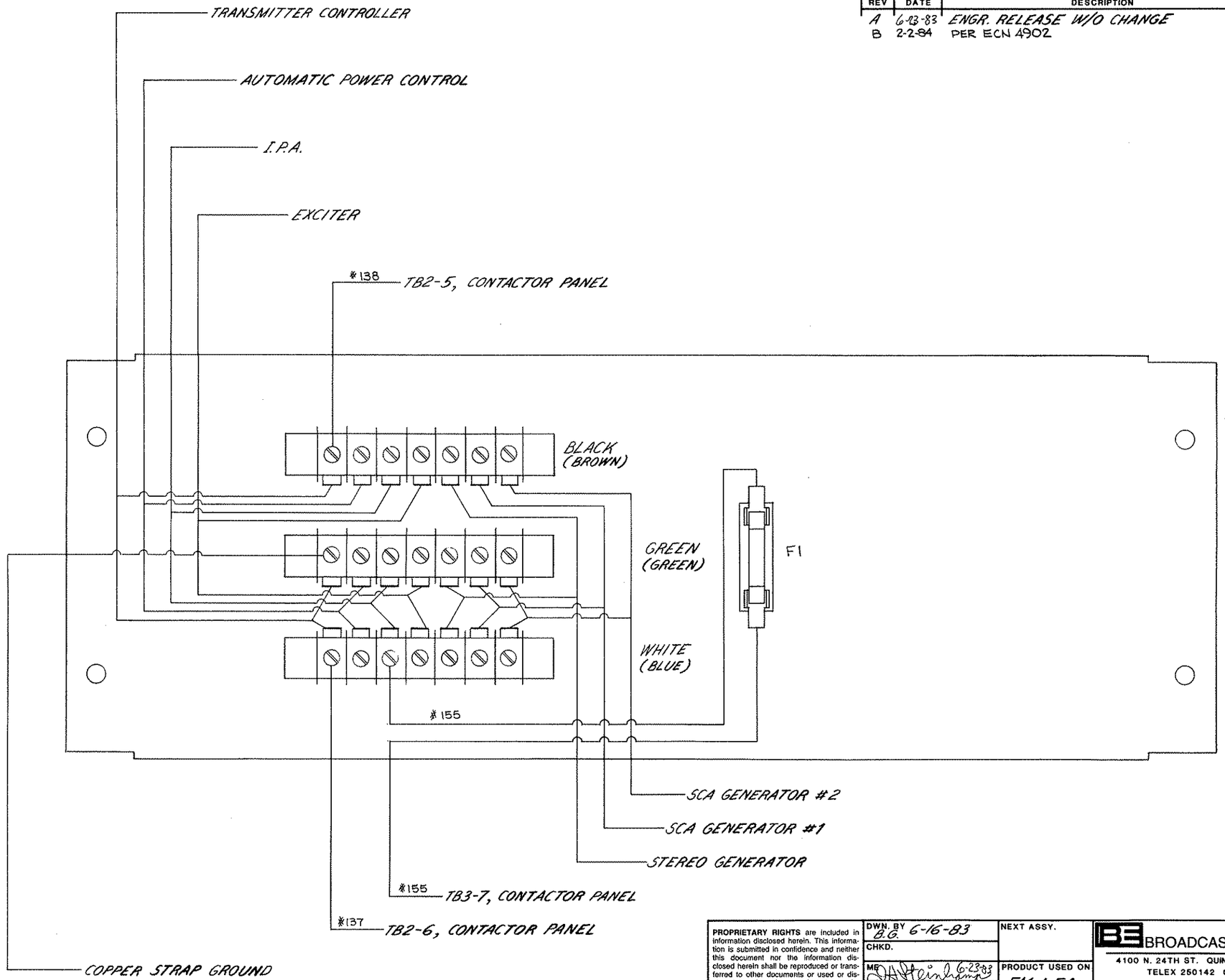
DWN. BY B.G. 6-14-83
CHKD.
ME
EE
PROJ. ENGR.
DFTG. SUPVR. M.H. 7-7-83
MFG.

NEXT ASSY.
PRODUCT USED ON FM 1.5A
FINISH

BROADCAST ELECTRONICS INC.
4100 N. 24TH ST. QUINCY, IL 62305 217/224-9600
TELEX 250142 CABLE BCST ELECT QUI

TITLE WIRING DIAGRAM BASE PLATE
SHEET 1 OF 1
SCALE 1/2
REV B
TYPE W
SIZE C
DWG. NO. 959-0095

REVISIONS					
REV	DATE	DESCRIPTION	DFTSMN	ENGR	ECN
A	6-13-83	ENGR. RELEASE W/O CHANGE	B.G.		—
B	2-2-84	PER ECN 4902	M.E.		



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

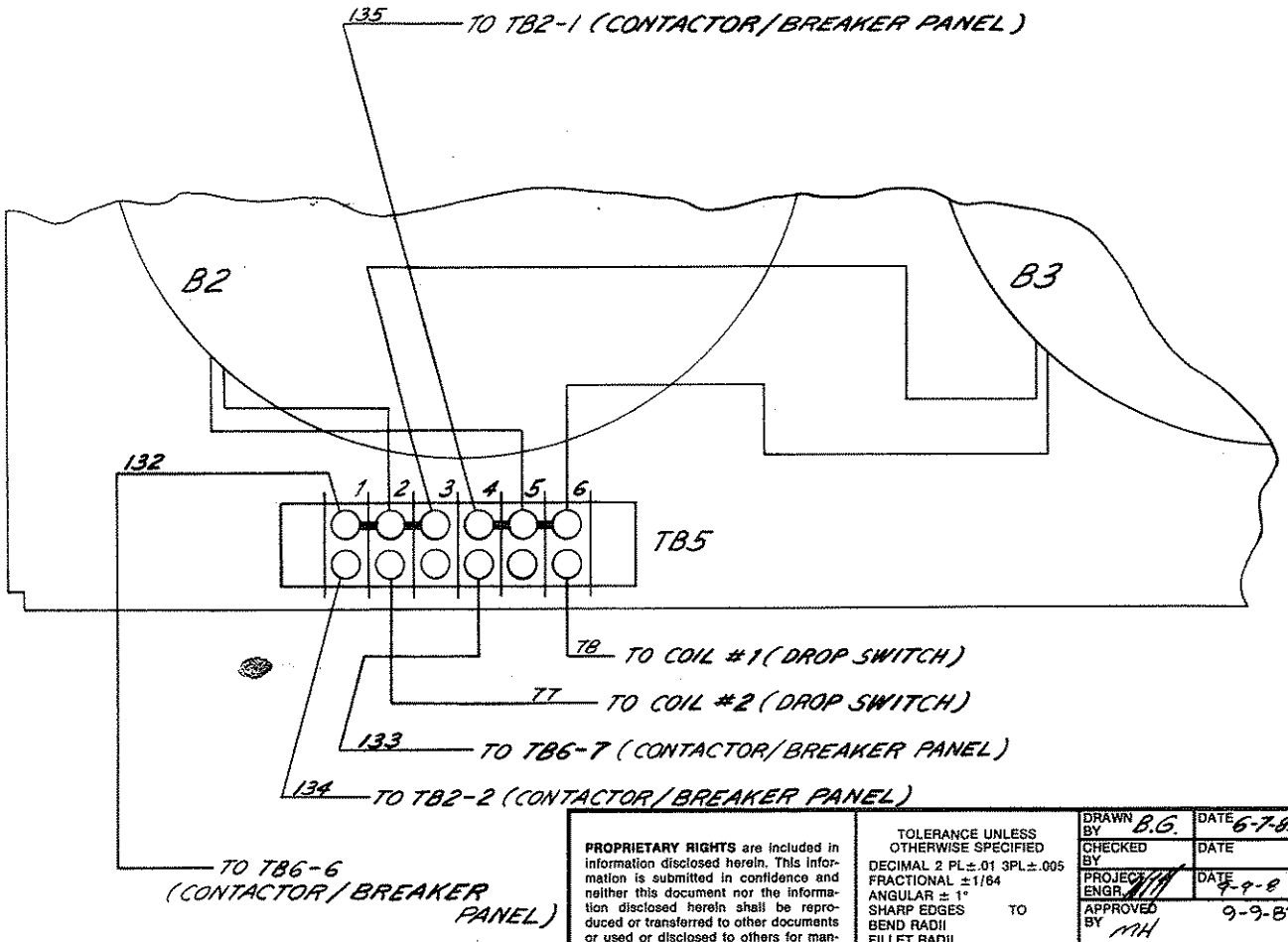
DWN. BY B.G. 6-16-83
CHKD.
ME 6-23-83
EE
PROJ. ENGR.
DFTG. SUPVR. MH 6-24-83
MFG.

NEXT ASSY.
PRODUCT USED ON FM 1.5A
FINISH

BROADCAST ELECTRONICS INC.
4100 N. 24TH ST. QUINCY, IL 62305 217/224-9600
TELEX 250142 CABLE BCST ELECT QUI

TITLE WIRING DIAGRAM A.C. DISTRIBUTION PANEL
SHEET 1 OF 1
SCALE 1/1
REV B
TYPE W SIZE C
DWG. NO. 959-0128

REVISIONS			
REV.	DESCRIPTION	DATE	APPROVED
A	ENGR. RELEASE W/O CHANGE	B.G. 9-9-83	
B	PER ECN 4733	B.G. 12-28-83	



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 B.G.	DATE 6-7-83	
CHECKED BY	DATE	
PROJECT ENGR.	DATE 9-9-83	
APPROVED BY MH	9-9-83	

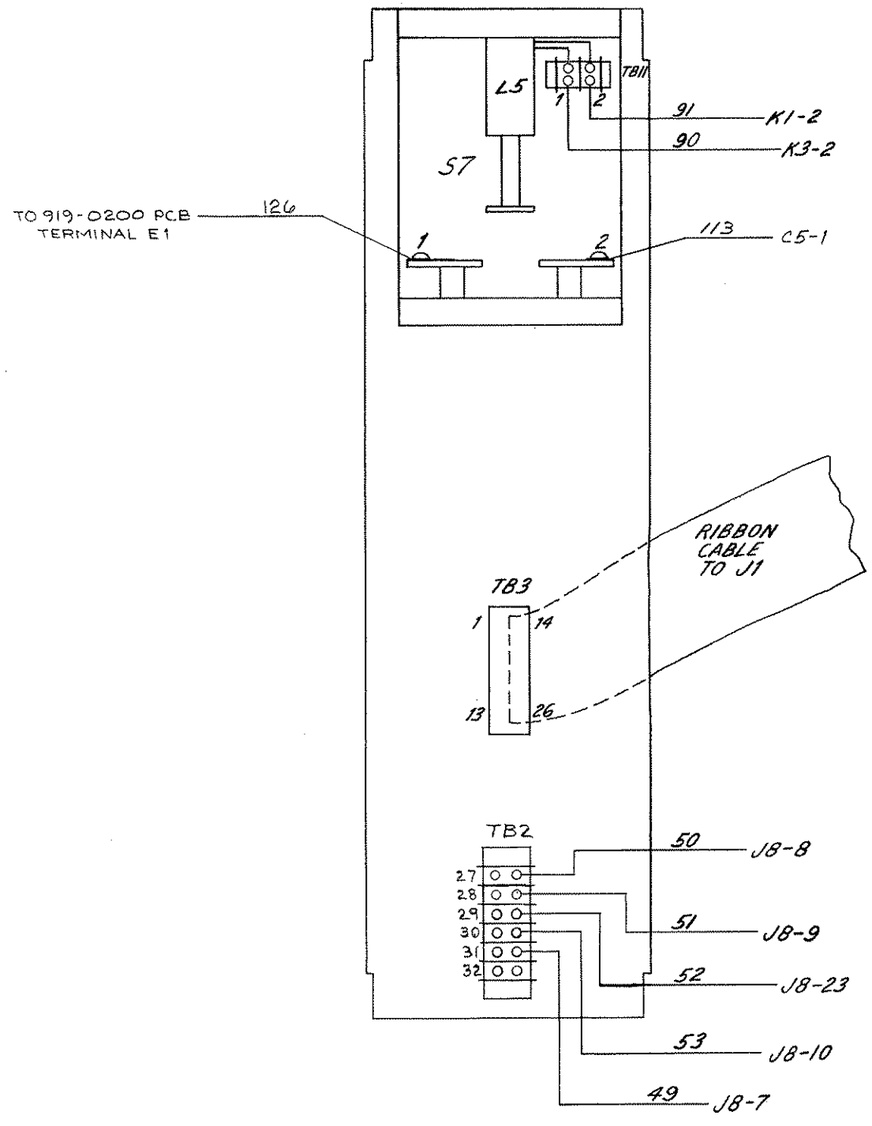
BROADCAST ELECTRONICS INC.

TITLE WIRING DIAGRAM FAN & FILTER PANEL

B | DWG. NO. TYPE W 959-0096 | REV. B

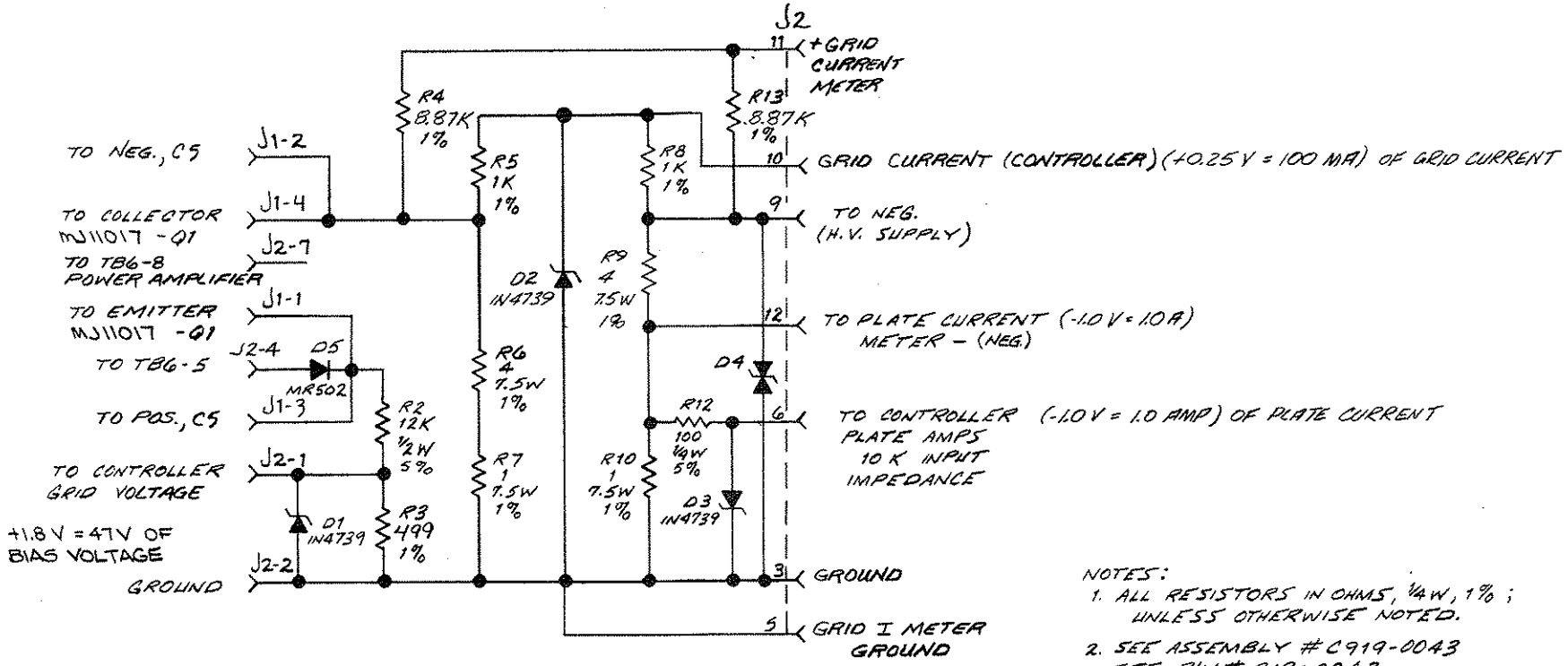
FM 1.5A | SCALE 1/1 | SHEET 1 OF 1

REVISIONS					
REV	DATE	DESCRIPTION	DFTSMN	ENGR	ECN
A	5/19/83	ENGR. RELEASE	SRT	JTML	—



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

DWN. BY B.G. 3-15-83	NEXT ASSY.	BROADCAST ELECTRONICS INC.
CHKD. MH 5-25-83		4100 N. 24TH ST. QUINCY, IL 62305 217/224-9600
ME	PRODUCT USED ON FM 3.5A/5A	TELEX 250142 CABLE BCST ELECT QUI
EE JTML 5-23-83		TITLE: WIRING DIAGRAM REMOTE INTERFACE PANEL
PROJ. ENGR. JTML 5-23-83	FINISH	SHEET 1 OF 1
DFTG. SUPVR.		SCALE NA / REV A
MFG.		TYPE W / SIZE C / DWG. NO. 959-0117



NOTES:

1. ALL RESISTORS IN OHMS, 1/4W, 1%; UNLESS OTHERWISE NOTED.
2. SEE ASSEMBLY # C919-0043
   SEE BIM # 919-0043
3. LAST COMPONENTS USED: D5, R13, J2
4. COMPONENTS NOT USED: R1, R11

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

MATERIAL

TREATMENT OR FINISH

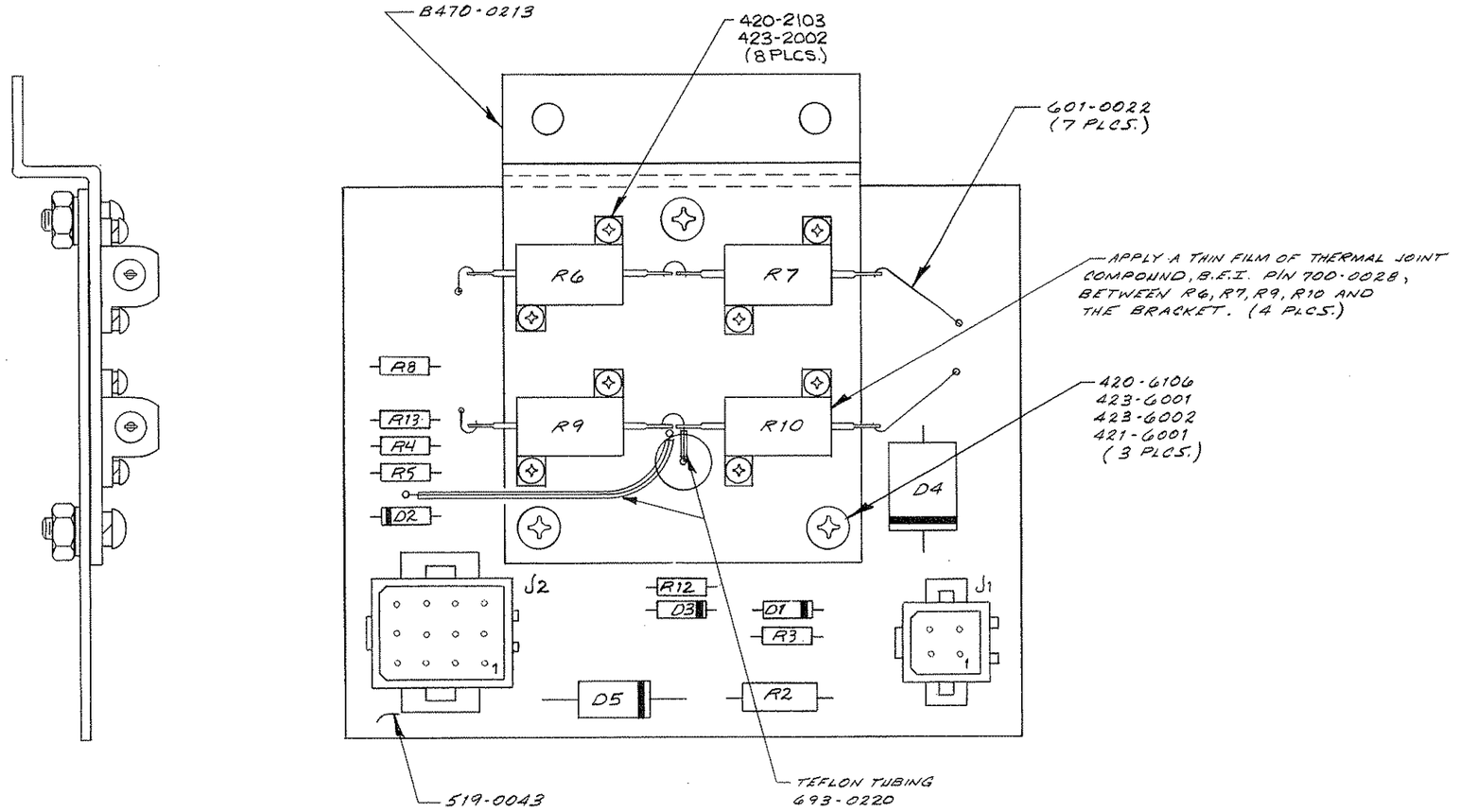
DRAWN BY MERKEL	DATE 3-2-83	
CHECKED BY	DATE	
PROJECT ENGR.	DATE	
APPROVED BY MH	8-1-83	

BROADCAST ELECTRONICS INC.

TITLE SCHEMATIC – CATHODE METERING PCB

B | DWG. NO. TYPE S 919-0043 | REV H

FM 1.5A | SCALE — | SHEET 1 OF 1



SEE SCHEMATIC # B919-0043
SEE B/M # 919-0043

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

DWN. BY MERKEL 3-1-83
CHKD.
ME
EE
PROJ. ENGR. [signature] 5-20-83
DFTG. SUPVR. MH
MFG.

NEXT ASSY.

PRODUCT USED ON FM1.5A XMTR

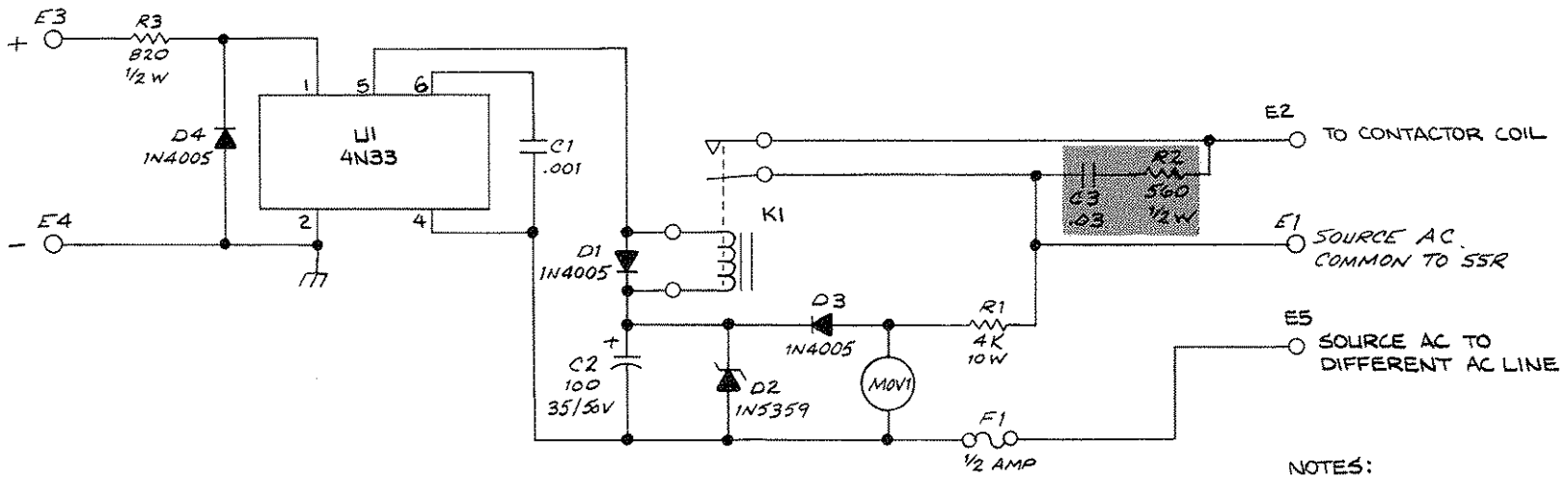
FINISH

BROADCAST ELECTRONICS INC.
4100 N. 24TH ST. QUINCY, IL 62305 217/224-9600
TELEX 250142 CABLE BCST ELECT QUI

TITLE PCB ASSEMBLY - CATHODE METERING BD.

SHEET 1 OF 1
SCALE 4/1
REV H

TYPE A SIZE C DWG. NO. 919-0043



REQUIRES 4000 Ω FOR 3 Ø TRANSMITTERS

NOTES:

1) ALL RESISTORS IN OHMS, 1/4 W; 5 %, ALL CAPACITORS IN MICROFARADS, U.O.S.
2) COMPONENTS LAST USED: R3, C3, D4 S1, U1, F1, MOV1
3) SEE ASSY AC: 919-0096
4) SHADED COMPONENTS NOT USED ON 919-0096-001

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

DWN. BY MSE 1-16-86
CHKD
ME. 7/14/86
PROJ. ENGR. 7-14-86
MFG.

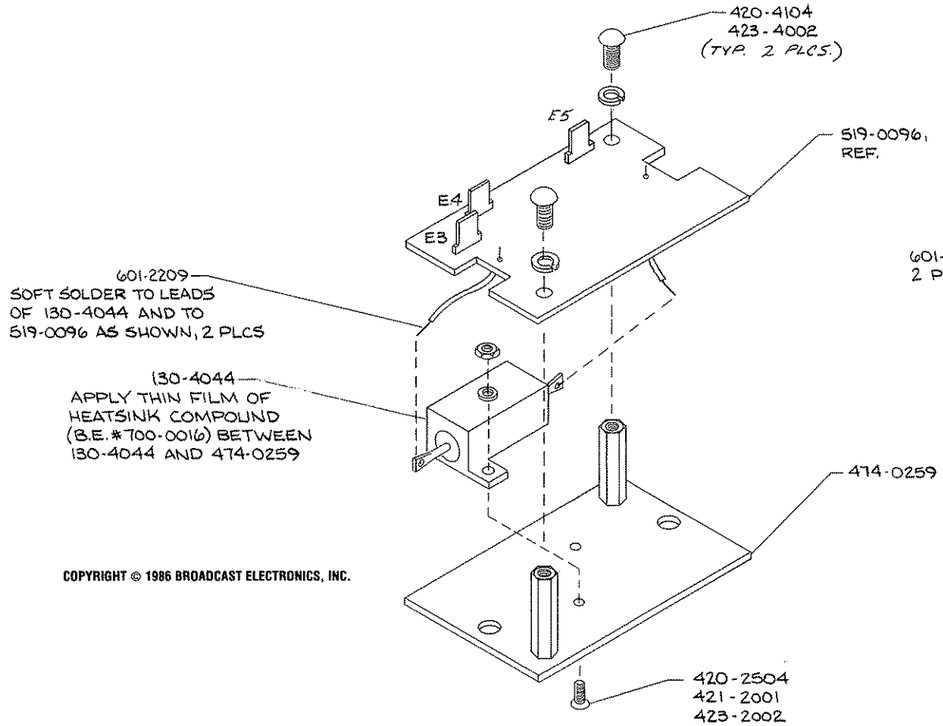
MATERIAL
FINISH
NEXT ASSY.

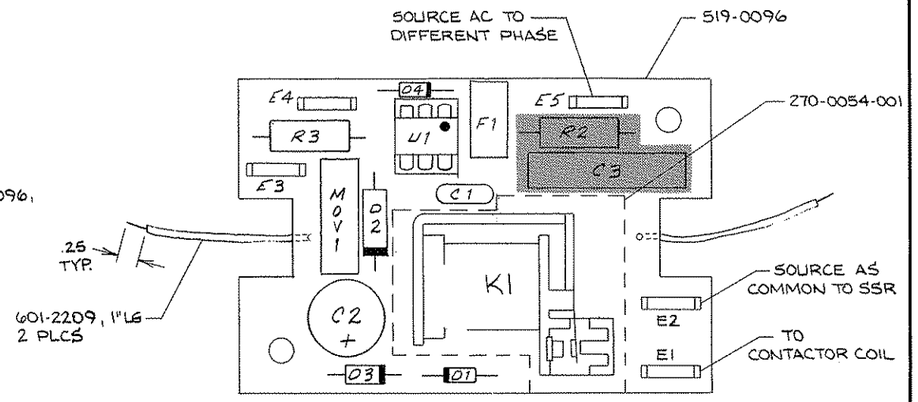
BROADCAST ELECTRONICS INC.
4100 N. 24TH ST., P.O. BOX 3606 QUINCY, IL 62305 217/224-9600
TELEX 250142 CABLE BROADCAST

TITLE SCHEMATIC, S.S.R. SUBSTITUTE CONTACTOR INTERFACE

TYPE	SIZE	DWG. NO.	REV
S	B	919-0096, 919-0096-001	F

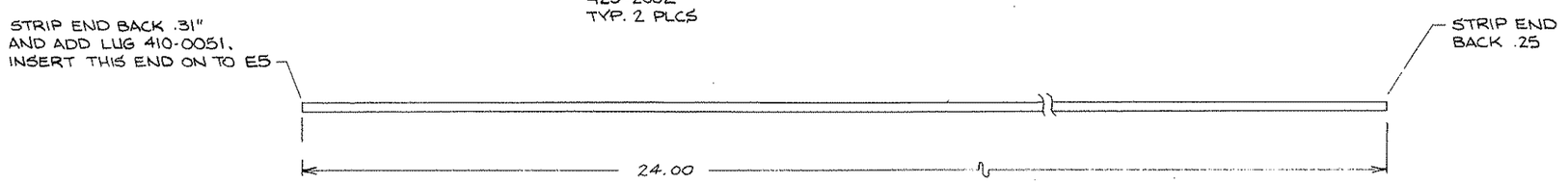
MODEL XTMRS SCALE ~ SHEET 1 OF 1





NOTES:

1) SHADED COMPONENTS NOT USED IN 919-0096-001



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

DWN. BY MSE 7-11-86
CHKD
MFG. 7/14/86
PROJ. ENGR. 7-14-86
MATERIAL SEE B/M 919-0096
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 ASM, SOLID STATE RELAY REPLACEMENT + PCB

TYPE	SIZE	DWG. NO.	REV
A	C	919-0096/919-0096-001	F

MODEL XMTRS | SCALE ~ | SHEET 1 OF 1

APPENDIX A
MANUFACTURERS DATA

A-1. INTRODUCTION.

A-2. This appendix provides the following technical data relative to the operation and maintenance of the FM-1.5A FM transmitter. Information contained in this appendix is provided in the following order.

A. Service Bulletin, Furnas Contactor, Size 25 Ampere.

B. Technical Data Sheet, Eimac 3CX1500A7 Triode.

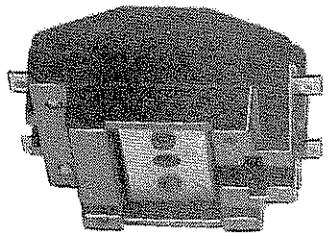
C. Application Note, Eimac, Extending Transmitter Tube Life.

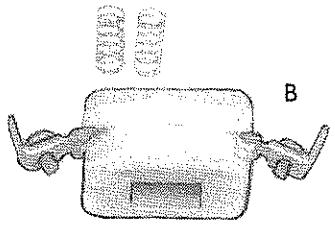
D. Technical Data Sheet, Thompson-CSF SD1460 VHF NPN Power Transistor.

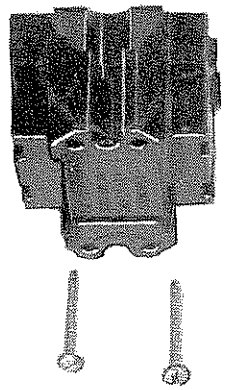
REPLACEMENT PARTS

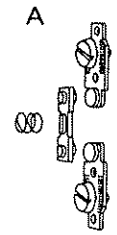
MAGNETIC CONTACTORS

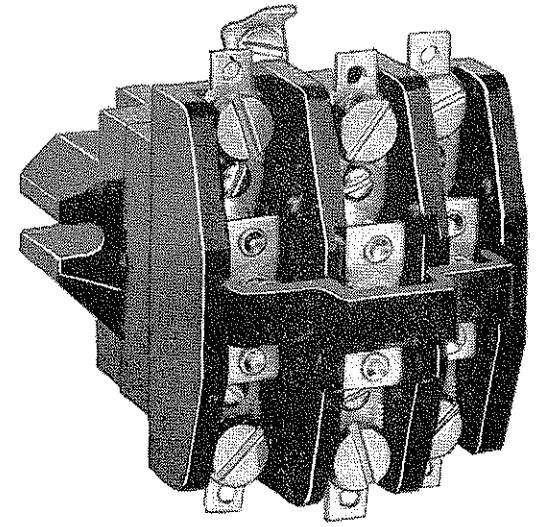
File No.	41-GNB
Cat. No. or Class Series	41NB
Size	25 Amp
Date	APRIL, 1982











Item	Part Name		Part No.
A	Contacts & Spring, One complete pole		75NB41
B	Coil 60 Hz.	24 Volts	75D54760J
		120 Volts	75D54760F
		208-240 Volts	75D54760G
		440-480 Volts	75D54760H
		575-600 Volts	75D54760E

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

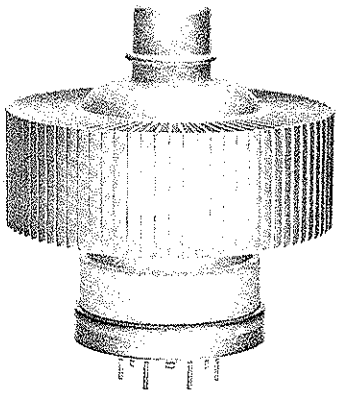
8877
3CX1500A7

TECHNICAL DATA

HIGH-MU
POWER TRIODE

The EIMAC 8877/3CX1500A7 is a rugged ceramic/metal power triode designed for use as a cathode driven Class AB_2 or Class B amplifier, in audio or rf applications including the VHF band, or as a cathode driven plate modulated Class C rf amplifier. As a linear amplifier, high power gain may be obtained without sacrifice of low intermodulation distortion characteristics.

Low grid interception and high amplification factor combine to make the 8877/3CX1500A7 drive power requirements exceptionally low for a tube of this power capacity.



GENERAL CHARACTERISTICS[1]

ELECTRICAL

Cathode: Oxide Coated, Unipotential	
Heater: Voltage	5.0 ± 0.25 V
Current, at 5.0 volts	10.5 A
Transconductance (Average):	
I_b = 1.0 Adc	55,000 μ mhos
Amplification Factor (Average)	200
Direct Interelectrode Capacitance (grounded cathode)[2]	
Cin	38.5 pF
Cout	0.1 pF
Cgp	10 pF
Direct Interelectrode Capacitance (grounded grid)[2]	
Cin	38.5 pF
Cout	10 pF
Cpk	0.1 pF
Ck-htr	9.7 pF
Frequency of Maximum Rating:	
CW	250 MHz

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

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

(Revised 5-15-77) Printed in U.S.A.

MECHANICAL

Maximum Overall Dimensions:	
Length	4.02 in; 102.16 mm
Diameter	3.38 in; 85.85 mm
Net Weight	25.0 oz; 708.8 gm
Operating Position	Any
Maximum Operating Temperature:	
Ceramic/Metal Seals, Anode Core	250°C
Cooling	Forced Air
Base	Special 7-pin
Recommended Air System Socket	
(Grounded Grid)	SK-2210
(Grounded Cathode)	SK-2200
Recommended Air Chimney	
(Teflon)	SK-2216

RANGE VALUES FOR EQUIPMENT DESIGN

	Min.	Max.	
Heater: Current at 5.0 volts	9.5	11.5	A
Cathode Warmup Time	180	---	sec
Interelectrode Capacitance (grounded grid circuit)[1]			
Cin	36.0	41.0	pF
Cout	9.2	11.2	pF
Cpk	---	0.2	pF

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

RADIO FREQUENCY LINEAR AMPLIFIER CATHODE DRIVEN Class AB_2

ABSOLUTE MAXIMUM RATINGS:

DC PLATE VOLTAGE	4000 VOLTS
DC PLATE CURRENT	1.0 AMPERE
PLATE DISSIPATION	1500 WATTS
GRID DISSIPATION	25 WATTS

TYPICAL OPERATION (Frequencies to 30 MHz)
Class AB2 Cathode Driven, Peak Envelope or Modulation Crest Conditions

Plate Voltage	2700	3500	Vdc
Cathode Voltage[1]	+8.2	+8.2	Vdc
Zero-Signal Plate Current[3]	92	182	mAdc
Single-Tone Plate Current	740	1000	mAdc
Two-Tone Plate Current	480	675	mAdc
Single-Tone Grid Current[3]	40	74	mAdc
Two-Tone Grid Current[3]	16	25	mAdc
Peak rf Cathode Voltage[3]	68	81	v
Peak Driving Power[3]	40	64	w
Single-Tone Useful Output Power[3]	1085	2075	W
Resonant Load Impedance	1820	2000	Ω
Intermodulation Distortion Products[2]			
3rd Order	-40	-38	dB
5th Order	-41	-41	dB

1. Positive cathode bias provided by zener diode.
2. The intermodulation distortion products are referenced against one tone of a two equal tone signal.
3. Approximate values.

TYPICAL OPERATION (220 MHz)
Class AB2 Cathode Driven

Plate Voltage	2500 Vdc
Cathode Voltage[1]	+8.2 Vdc
Plate Current	1000 mAdc
Grid Current[2]	10 mAdc
Useful Output Power[2]	1520 W
Driving Power[2]	57 W
Power Gain[2]	14 dB

1. Positive cathode bias provided by zener diode.
2. Approximate value.

RADIO FREQUENCY POWER AMPLIFIER

Class B Telegraphy or FM
(Continous Operating Conditions)

DC PLATE VOLTAGE ..... 4000 VOLTS
DC PLATE CURRENT ..... 1.0 AMPERE
PLATE DISSIPATION..... 1500 WATTS
GRID DISSIPATION ..... 25 WATTS

1. For measured case, idling anode current was set for 10 mAdc.
2. Approximate.
3. Approximate, delivered to the load.
4. For the measured case; may vary from tube to tube.

TYPICAL OPERATION (88-108 MHz)
Measured Values Class B, Cathode Driven

Plate Voltage	2000	2500	3000	4000	Vdc
Cathode Voltage[1,2] ..	+9	+12	+15	+20	Vdc
Plate Current	1.0	1.0	1.0	1.0	Adc
Crid Current[2]	60	58	42	25	mAdc
Driving Power[2]	64	54	65	78	W
Useful Power Output[3]	1330	1670	1960	2600	W
Efficiency[4]	66.5	66.7	65.5	65.2	%
Power Gain[4]	13.2	14.2	14.8	15.3	dB

RADIO FREQUENCY POWER AMPLIFIER

Class C - Cathode Driven, Plate Modulated

ABSOLUTE MAXIMUM RATINGS:

DC PLATE VOLTAGE ..... 3200 VOLTS
DC PLATE CURRENT ..... 0.8 AMPERE
PLATE DISSIPATION.....1000 WATTS
GRID DISSIPATION ..... 25 WATTS

1. Bias may be obtained from a fixed supply of 15.8 volts in series with a 9.5 ohm resistor. The resistor and supply should be bypassed for audio frequencies.
2. Approximate.
3. Approximate, and driver must be modulated approximately 83%.

TYPICAL OPERATION
Carrier Conditions, Frequencies to 30 MHz
Cathode Driven

Plate Voltage ..... 2400 Vdc
Cathode Voltage[1] .....+22 Vdc
Plate Current ..... 600 mAdc
Grid Current[2] ..... 45 mAdc
Plate Load Resistance ..... 2000 Ω
Driving Power[3] ..... 41 W
Plate Output Power ..... 1000 W
Power Gain ..... 14 dB

APPLICATION

MECHANICAL

MOUNTING - The 8877/3CX1500A7 may be mounted in any position.

SOCKET - The grid of the 8877/3CX1500A7 terminates in the cylindrical grid ring about the base of the tube. This may be contacted by multiple clips or flexible finger stock. Connections to the heater and cathode are made via the 7-pin base.

COOLING - The maximum temperature limit for external tube surfaces and the anode core is 250°C. Tube life is prolonged if these area are maintained at lower temperatures. For full 1500 watts anode dissipation 35.0 cfm of air is required at a back pressure of 0.41" H_2O hold tube temperature below 225°C with 50°C ambient temperature at sea level. At frequencies higher than 30 MHz, or at high altitudes, the air quantity must be increased.

Base-to-Anode Air Flow (sea level)		
Anode Dissipation (watts)	Air Flow (CFM)	Pressure Drop In./H_2O
500	7.5	0.10
1000	22.5	0.20
1500	35.0	0.41
Base-to-Anode Air Flow (10,000 ft.)		
Anode Dissipation (watts)	Air Flow (CFM)	Pressure Drop In./H_2O
500	11.0	0.15
1000	32.5	0.29
1500	51.0	0.60

Note: 1). Tube mounted in SK-2200 Socket with SK-2216 Chimney.
2). An allowance of 25 watts has been made for grid dissipation and 50 watts for filament power.

ELECTRICAL

FILAMENT OPERATION - Rated filament voltage for the 8877/3CX1500A7 is 5.0 volts. Filament voltage, as measured at the socket, should be maintained at this value to obtain optimum performance and maximum tube life. In no case should it be allowed to deviate from 5.0 volts by more than plus or minus five per cent (5%).

INPUT CIRCUIT - When the 8877/3CX1500A7 is operated as a cathode driven rf amplifier, the use of a resonant circuit in the cathode is recommended. For best results with a single-ended amplifier it is suggested that the cathode tank circuit operate at a Q or five or more.

ZERO-BIAS OPERATION - Operation at zero-bias is not recommended with plate potentials over 3000 volts, since plate dissipation may be exceeded. Higher plate voltage may be used with the proper protective bias.

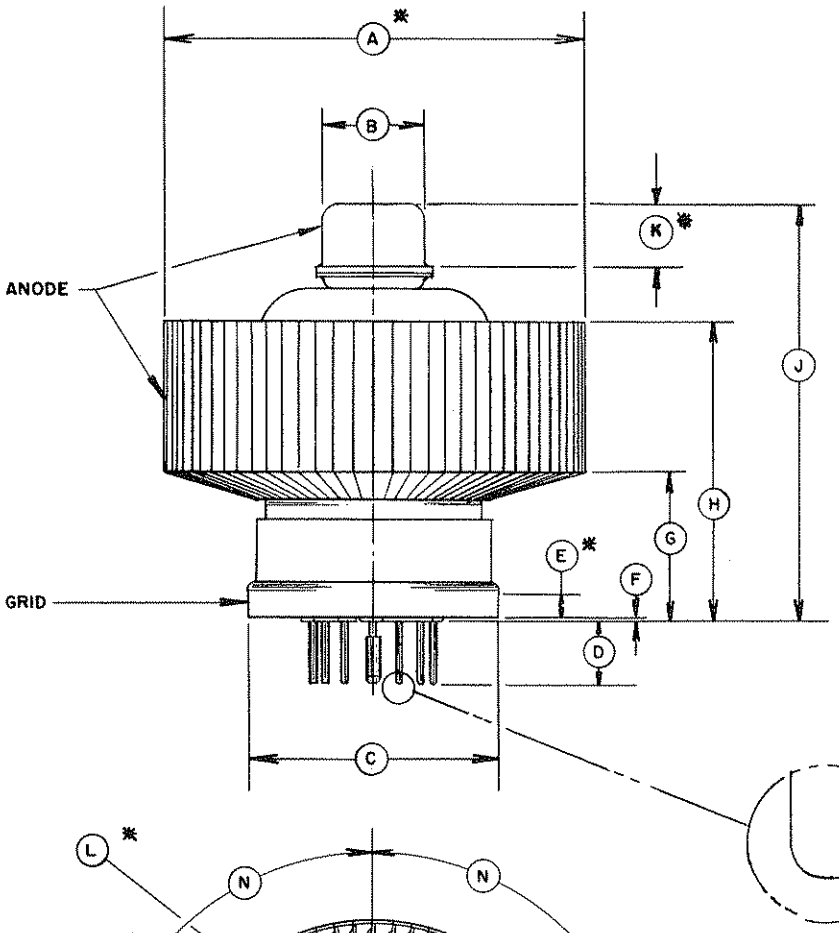
HIGH VOLTAGE - The 3CX1500A7 operates at voltages which can be deadly, and the equipment must be designed properly and operating precautions must be followed. Equipment must be designed so that no one can come in contact with high voltages. All equipment must include safety enclosures for high-voltage circuits and terminals, with interlock switches to open the primary circuits of the power supplies and to discharge high voltage condensers whenever access doors are opened. Interlock switches must not be bypassed or "cheated" to allow operation with access doors open. Always remember that HIGH VOLTAGE CAN KILL.

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

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

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

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

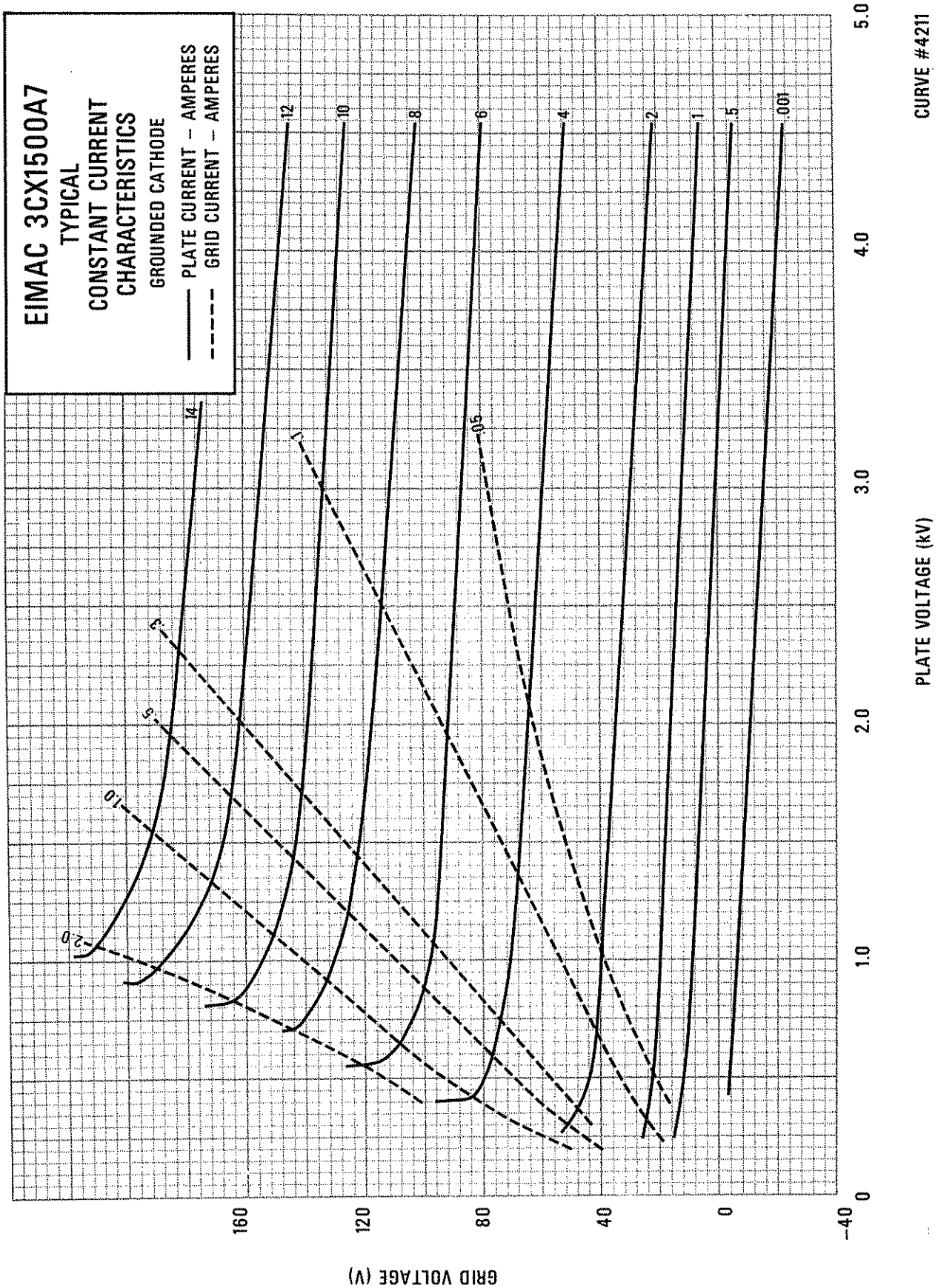


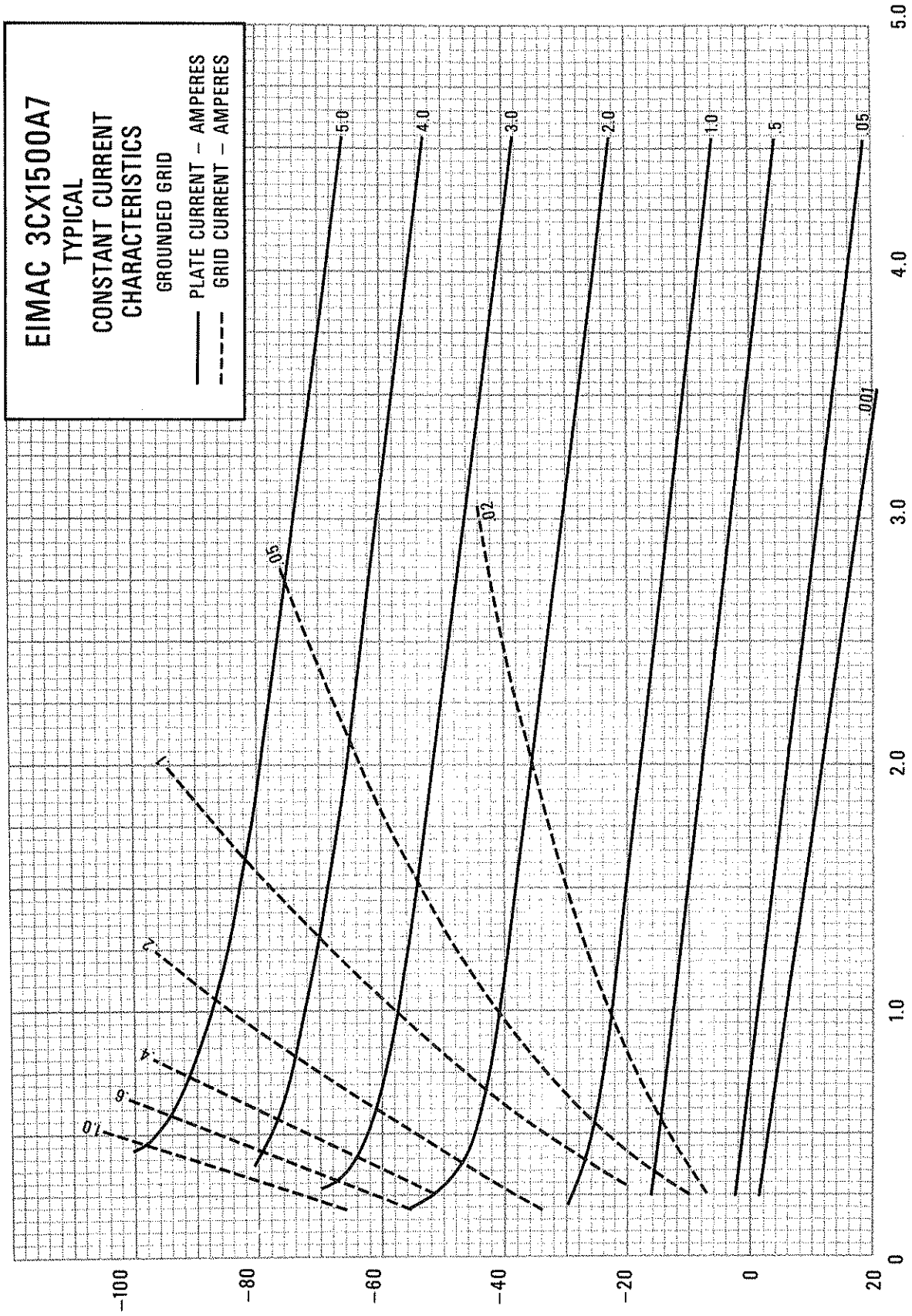
DIMENSIONAL DATA						
DIM.	INCHES			MILLIMETERS		
	MIN.	MAX.	REF	MIN.	MAX.	REF
A	3.350	3.380	— —	85.09	85.85	— —
B	0.810	0.820	— —	20.57	20.83	— —
C	1.995	2.015	— —	50.67	51.18	— —
D	0.438	0.562	— —	11.13	14.27	— —
E	0.235	— —	— —	5.97	— —	— —
F	0.000	0.040	— —	0.00	1.02	— —
G	1.100	1.225	— —	27.94	31.12	— —
H	2.300	2.425	— —	58.42	61.60	— —
J	3.250	3.420	— —	82.55	86.87	— —
K	0.470	0.530	— —	11.94	13.46	— —
L	0.120	0.127	— —	3.05	3.23	— —
M	0.056	0.062	— —	1.42	1.57	— —
N	— —	— —	51°	— —	— —	51°
P	— —	— —	52°	— —	— —	52°
R	— —	— —	1.000	— —	— —	25.40
T	0.020R	— —	— —	0.51R	— —	— —

NOTES:
1. REF DIMENSIONS ARE FOR INFO. ONLY & ARE NOT REQUIRED FOR INSPECTION PURPOSES.
2. * CONTACT SURFACE
3. DIMENSION T APPLIES TO ALL BUT CENTER PIN.

PIN CONNECTIONS

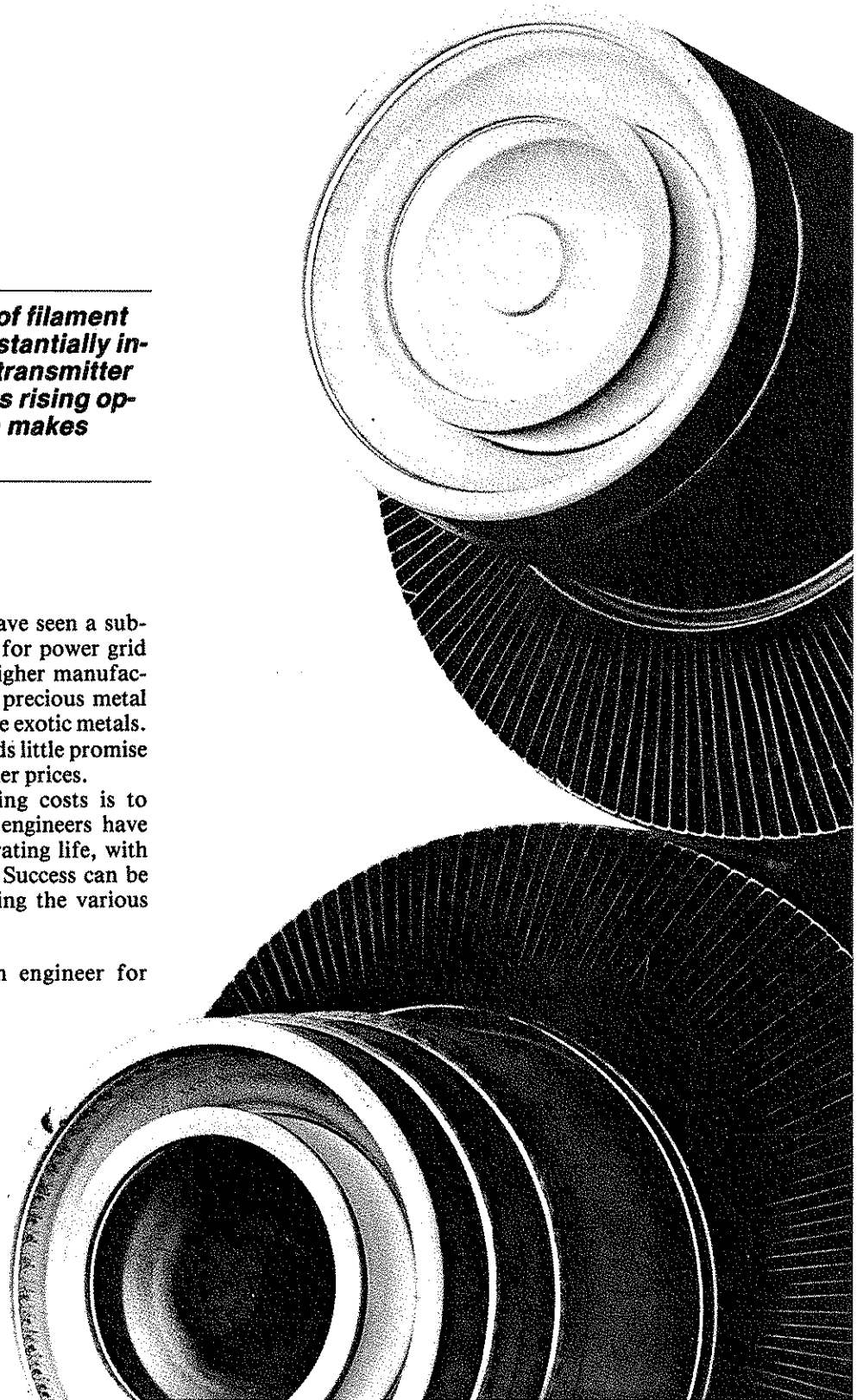
1 - HEATER
5 - HEATER
2 - 3 - 4 - 6 - 7 CATHODE


EIMAC 3CX1500A7
TYPICAL
CONSTANT CURRENT
CHARACTERISTICS
GROUNDED CATHODE
PLATE CURRENT – AMPERES
GRID CURRENT – AMPERES
12
10
8
6
4
2
1
.5
.001
14
7
.5
.05
3
2.0
1.0
GRID VOLTAGE (V)
160
120
80
40
0
-40
0
1.0
2.0
3.0
4.0
5.0
PLATE VOLTAGE (kV)
CURVE #4211


EIMAC 3CX1500A7
TYPICAL
CONSTANT CURRENT
CHARACTERISTICS
GROUNDED GRID
PLATE CURRENT – AMPERES
GRID CURRENT – AMPERES
5.0
4.0
3.0
2.0
1.0
.5
.05
.001
.05
.02
1
2
4
6
10
0
1.0
2.0
3.0
4.0
5.0
PLATE TO GRID VOLTAGE (kV)
CURVE #4250
20
0
−20
−40
−60
−80
−100
CATHODE TO GRID VOLTAGE (V)

EXTENDING TRANSMITTER TUBE LIFE

By Robert Artigo



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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Extending Transmitter Tube Life

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

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

Headroom

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

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

Instrumentation

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

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

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

Transmitter housekeeping

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

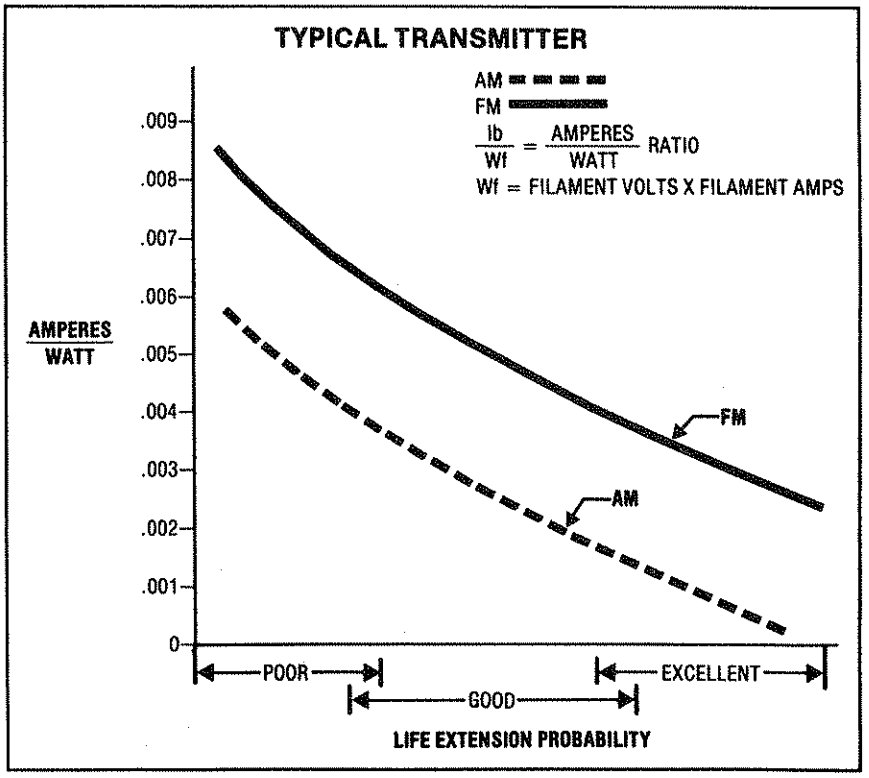


***Fig. 1.** Probability of extended life service can be determined from this graph. Divide the average p.a. plate current in amperes by the product of filament voltage and current. The resulting amperes/watt ratio (Y-axis) is projected horizontally to the appropriate curve. The vertical projection to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

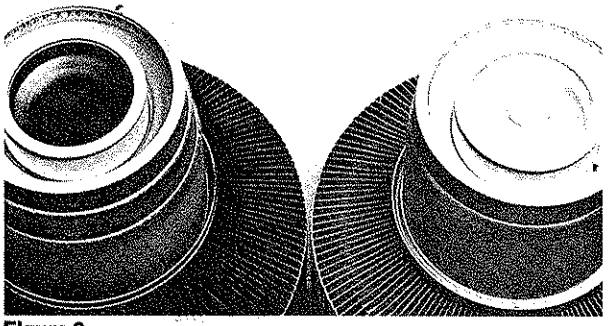


Figure 2

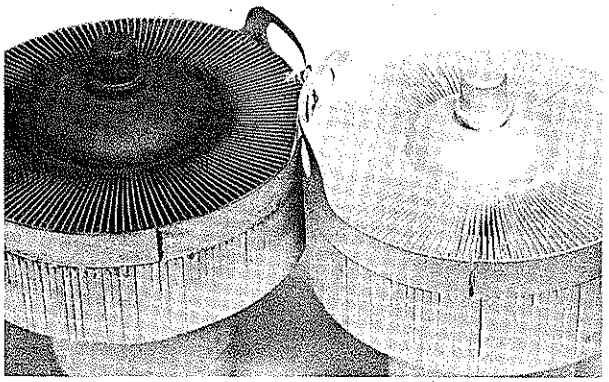


Figure 3

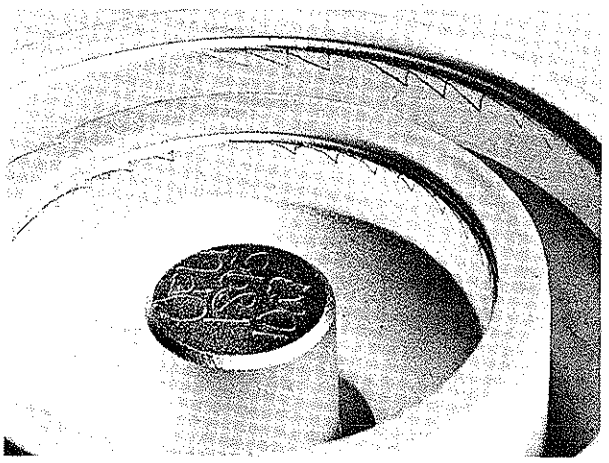


Figure 4

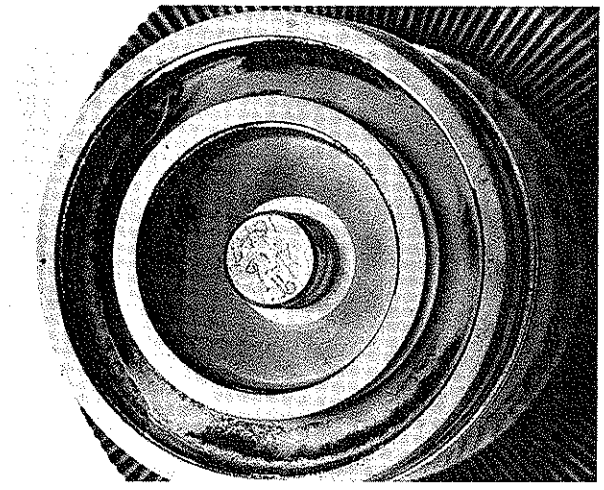


Figure 5

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.

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.

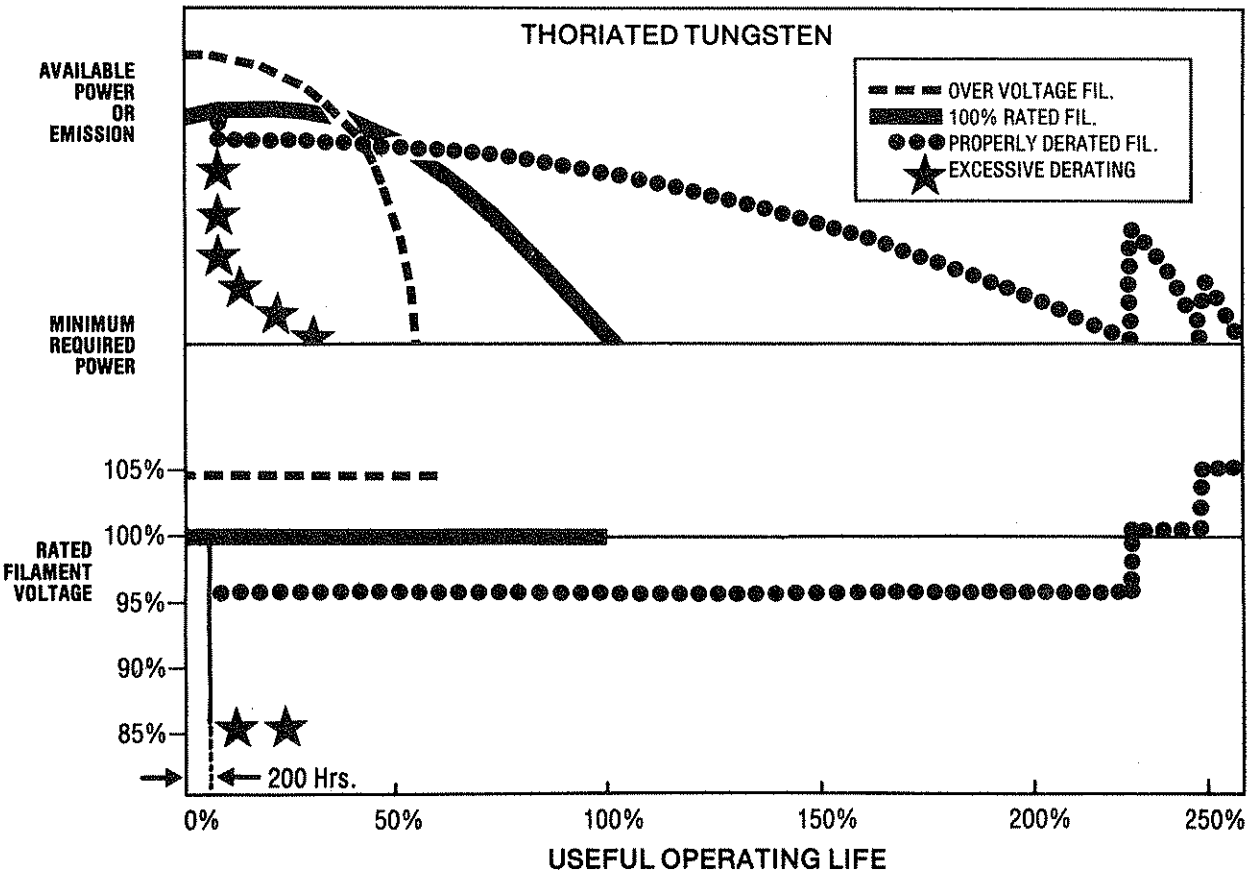
As the tube is used the filament slowly decarburizes. At some point in life, all of the di-tungsten carbide layer is depleted and the reduction of thoria to free thorium stops. The filament is now decarburized and is no longer an effective electron emitter.

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. *If the filament voltage cannot be regulated to within ±3%, the filament should always be operated at the rated nominal voltage.* The danger of operating on the "cold" temperature side is that the emitter may be "poisoned." A cold filament acts as a getter; that is, it attracts contaminants. When a contaminant becomes attached to the surface of the emitter, that area is rendered inactive and loss of emission results. Operation of the filament at slightly below rated nominal voltage, however, can extend tube life if done properly.

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. If this new filament voltage setting is more than 5% below the nominal rated level, filament voltage must be raised to the 95% level. Operation below this point is unpredictable and life expectancy is uncertain. 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. **BM/E**

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

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THOMSON-CSF

DIVISION SEMICONDUCTEURS DISCRETS

SD 1460

VHF NPN POWER TRANSISTOR FOR CLASS C FM OPERATION

FEATURES

- Gold metallizations
- Glass passivated structure
- Hermetical ceramic package

→ high reliability

- Emitter ballast resistors → severe inpedance mismatch
- Auto-aligned structure → high characteristics reproductibility

APPLICATIONS

Telecommunications up to 108 MHz frequency band.

PARTICULARITES

- *Métallisations "Or"*
- *Structure passivée*
- *Boîtier céramique hermétique*

→ *haute fiabilité*

- *Résistances ballast d'émetteur* → *bonne tenue au ROS*
- *Structure auto-alignée* → *bonne reproductibilité des caractéristiques*

APPLICATIONS

Telécommunications dans la bande de fréquences jusqu'à 108 MHz

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

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

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

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

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F - 92403 Courbevoie Cedex FRANCE
Tél. : (1) 788-50-01 Telex : 610560 F

THOMSON-CSF COMPOSANTS

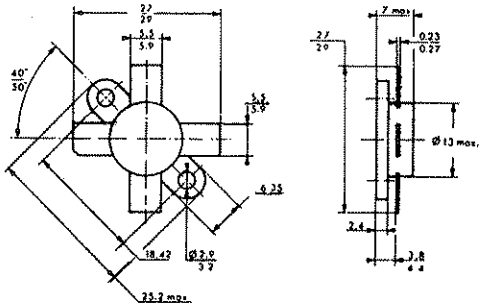
STATIC CHARACTERISTICS at t_{amb} = 25°C
CARACTERISTIQUES STATIQUES à t_{amb} = 25°C

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

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

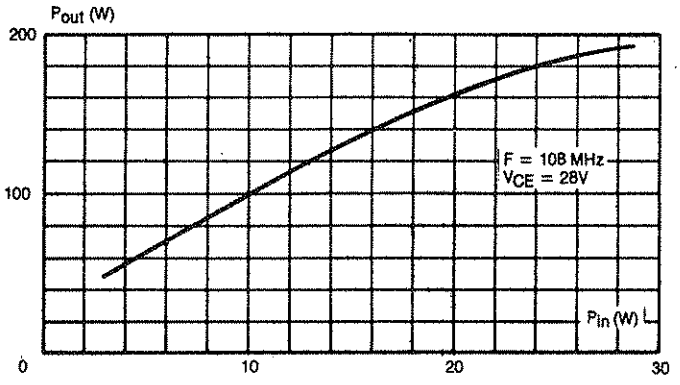
Symbols	Values			Units	Test conditions
	min.	typ.	max.		
P_{OUT}		160		W	f = 108 MHz V_{CB} = 28 V P_{IN} = 20 W
G_P		9		dB	
η_c	70	75		%	

CASE DESCRIPTION
DESCRIPTION DU BOITIER



Dimensions in millimeters

CB-290
(.500 4LFL)



Output power versus input power (typical values)

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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-1.5A IPA. For purposes of definition, the text is divided into functional circuits.

1-3. GENERAL DESCRIPTION.

1-4. The FM-1.5A IPA stage is a totally self-contained solid-state wideband FM amplifier providing a continuously variable output from 25 to 100 Watts. Frequency coverage is 87.5 MHz to 108 MHz. The unit is mounted on slide rails for ease of maintenance.

1-5. The IPA stage consists of an RF amplifier circuit board and a control regulator circuit board mounted side-by-side on easily removed heat sinks. An interconnection filter circuit board, an unregulated dc power supply, and a status indicator circuit board are also mounted within the IPA (see Figure 1-1).

1-6. POWER SUPPLY.

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

1-8. The power supply operates from an input of 194 to 275V ac and will produce the following potentials:

A) +40 Vdc @ 18 Amperes, Filtered

B) +40 Vdc @ 0.5 Amperes, Filtered

C) +28 Vdc @ 0.5 Amperes, Regulated

D) +15 Vdc @ 0.5 Amperes, Regulated

E) -1.3 Vdc @ 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.

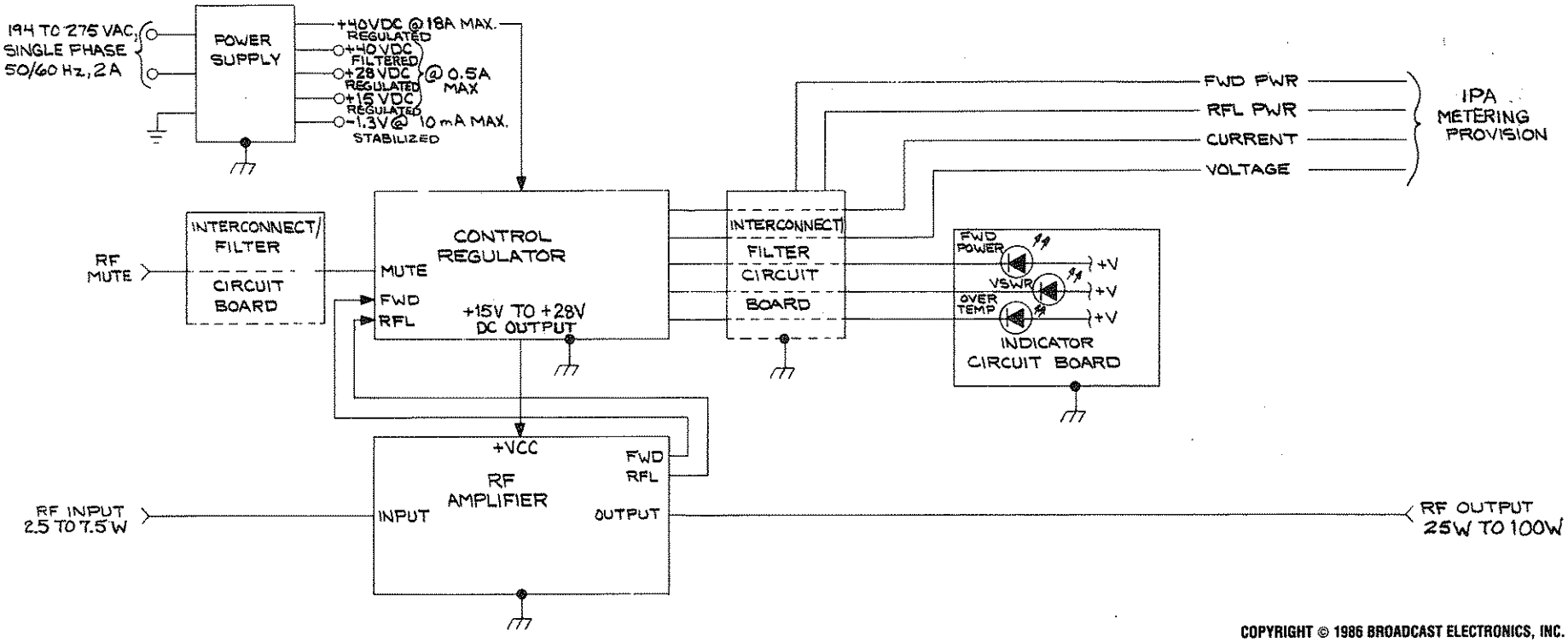

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FIGURE 1-1. IPA BLOCK DIAGRAM

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.

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 IPA RF amplifier consists of two bipolar RF power transistors operated in a push-pull class C configuration. 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. Stripline directional coupler networks provide forward and reflected power samples.

1-17. Normal IPA RF amplifier operation is indicated by illumination of the green FWD POWER indicator (approximately 25 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. If a regulator foldback condition occurs, removal of the dc or RF input to the IPA stage is required to reset the circuitry.

1-18. DETAILED DESCRIPTION.

1-19. POWER SUPPLY.

1-20. PRIMARY CIRCUIT. The IPA power supply operates from an input of 194 to 275 volts ac at approximately 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 multiple tapped 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. 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 D959-0151 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 secondary of T1 produces two ac voltages. Depending on the ac input potential, one secondary voltage is selected and full-wave rectified into a 40V 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 for distribution and regulation into several voltage 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. Additional protection for the regulators is provided by: 1) diodes D3 and D4 which protects the regulators from a reverse polarity potential applied to the output and 2) diodes D1 and D2 which protects the regulators 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 sinusodial 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.

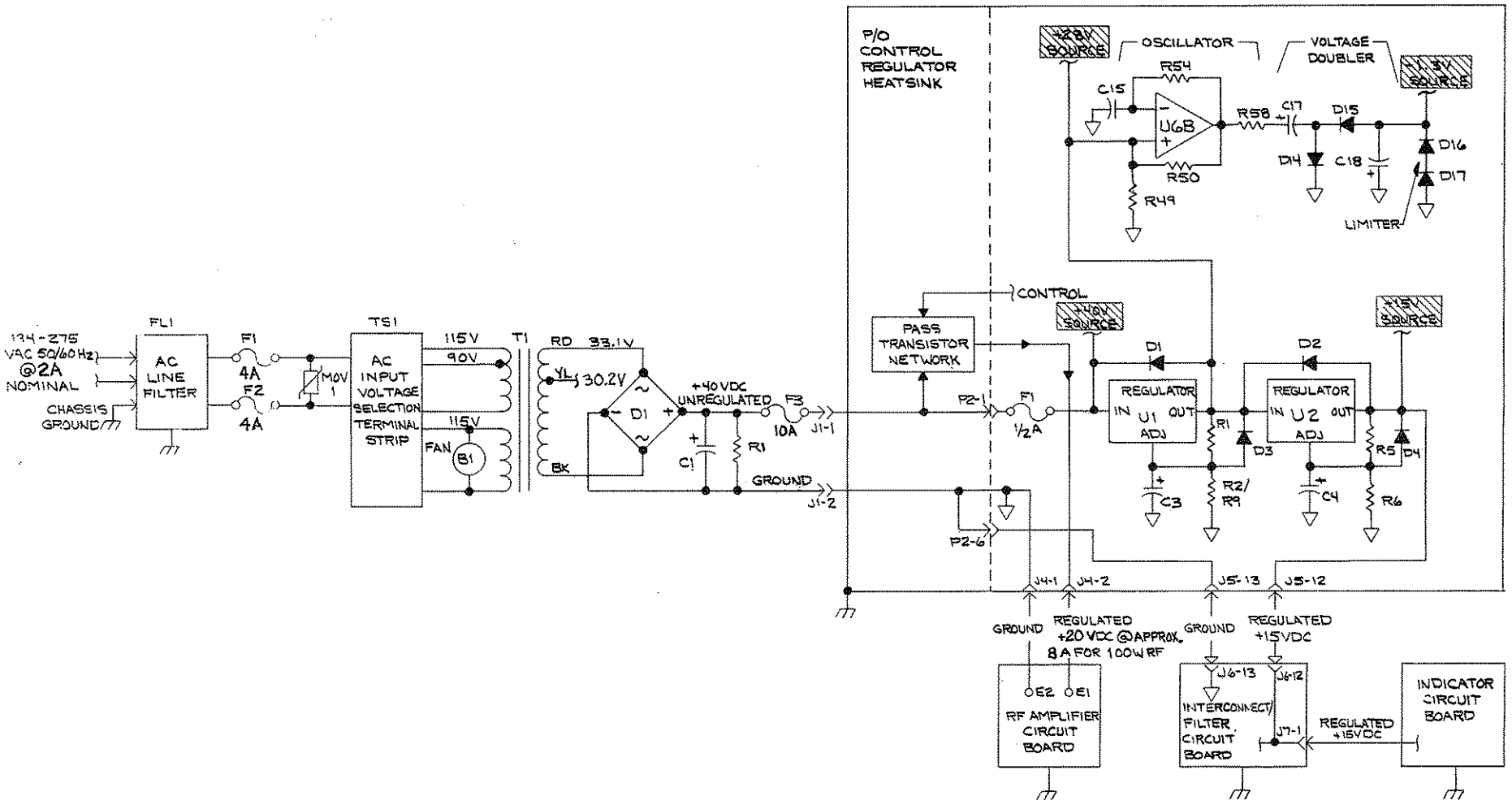

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FIGURE 1-2. IPA POWER DISTRIBUTION

1-26. CONTROL REGULATOR.

1-27. The control regulator consists of a circuit board and a heat-sink 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 reference. Jumper P17 allows the selection of a dc or digital-to-analog converter (DAC) voltage reference. In the FM-1.5A, the jumper is positioned for a dc reference.

1-29. A precision voltage reference for control regulator operation is established by a circuit consisting of R12, R15, R16, and R17. The reference from the circuit and jumper P17 is applied to the non-inverting input of 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.

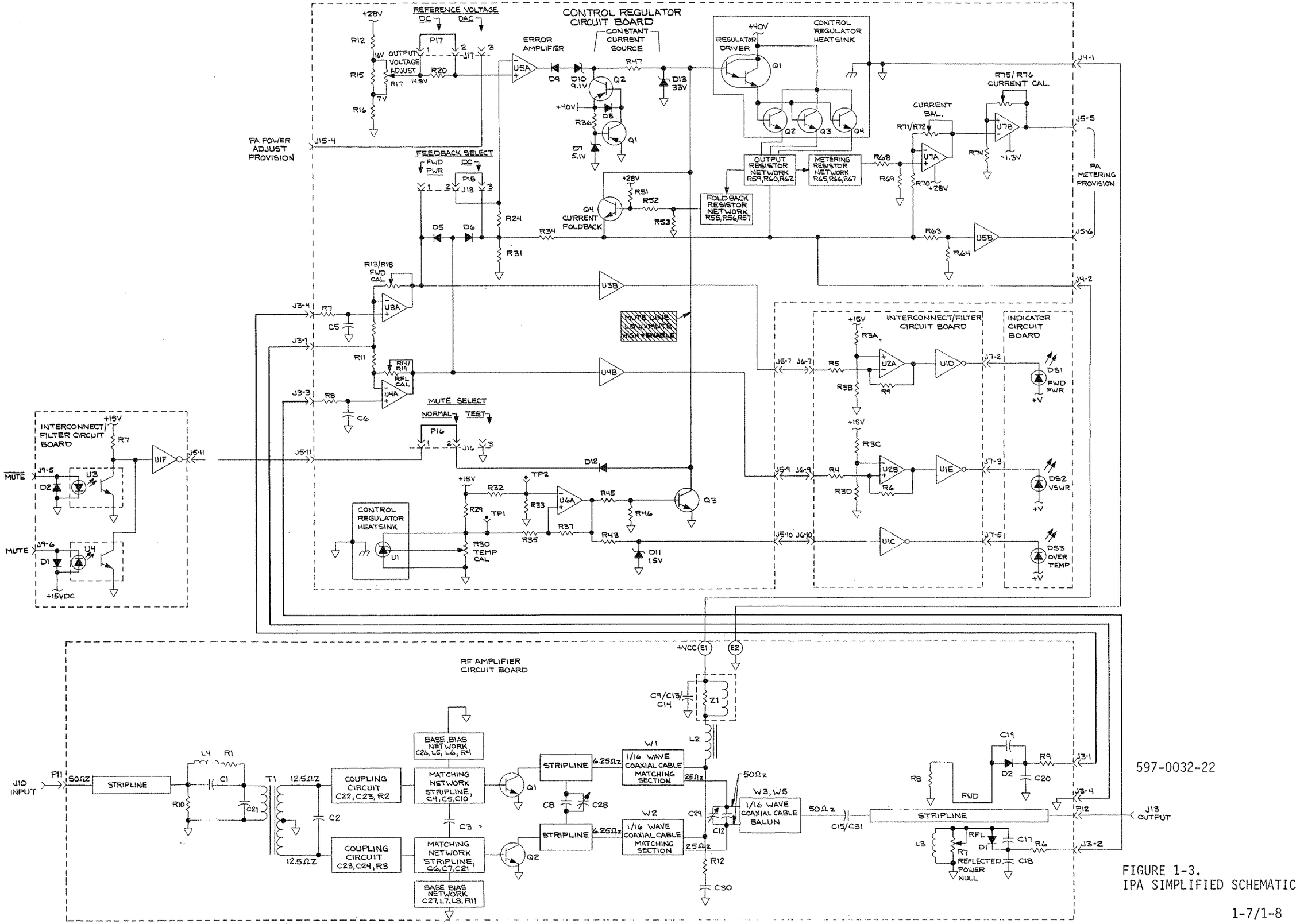

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FIGURE 1-3.
IPA SIMPLIFIED SCHEMATIC

1-34. CURRENT FOLDBACK. The output resistor network and the foldback resistor network work together to provide the current foldback action when the output current reaches approximately 8 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 output voltage across R59, R60, and R62 increases due to current increase, the voltage summed at the junction of R52 and R53 will increase with respect to the emitter of Q4. As Q4 is biased on, current will begin to flow through R51 which saturates Q4. This action grounds the mute line which removes the dc output. DC power must be interrupted to reset the foldback condition or removal of RF drive is required.

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

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

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

1-38. The 15 volt full-scale output of U3A and U4A are routed through 3:1 dividers and voltage follower stages U3B and U4B to amplifiers U2A and U2B on the interconnect filter circuit board. The forward power signal is routed through comparator U1D and the reflected power output is routed through comparator U1E and applied to the front panel VSWR indicator. This indicator illuminates when over 10 Watts of power is reflected back into the IPA from the load. The FWD PWR indicator illuminates when the forward power is 25 Watts or greater.

1-39. REMOTE IPA MUTE. Provisions exist which allow the IPA 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 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-1.5A 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 Ø degrees Celsius. U6A operates as a voltage comparator with +3.61 volts at test point TP2. This corresponds to an 88 degree Celsius comparison threshold.

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

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

1-45. RF AMPLIFIER.

1-46. The RF amplifier is a broadband stripline matched power amplifier with a continuously variable output from 25 watts to 100 watts (refer to Figure 1-3). Tuning of the amplifier over the FM band is not required due to the unique stripline design.

1-47. The dc voltage input and the directional coupler outputs are routed to the amplifier through feed-thru LC circuits to prevent RF interference. All wiring attaches to the amplifier module through plugs to aid in maintenance.

1-48. POWER AMPLIFIER. Approximately 2.5 to 7.5 watts of drive is applied 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. Capacitor C21 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, each source 180° out-of-phase. The output of T1 is capacitive 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 amplifier directional coupler consists of a dual rectifier circuit which provides two dc samples of RF output power. One sample is proportional to the forward RF signal with the other proportional to the reflected RF signal.

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

SECTION II

MAINTENANCE

2-1. INTRODUCTION.

2-2. This section provides maintenance information for the FM-1.5A IPA.

2-3. SAFETY CONSIDERATIONS.

2-4. The FM-1.5A 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 NEVER OPEN THE EQUIPMENT UNLESS ALL TRANSMITTER PRIMARY POWER IS DISCONNECTED.

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-1.5A maintenance philosophy consists of first level maintenance such as cleaning applied to the equipment of forestall future failures and second level maintenance consisting of procedures required to restore the equipment to operation after a fault.

2-7. ADJUSTMENTS.

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

2-8. The following procedures present information required to adjust all controls in the IPA stage. The 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 out of the rack and removing the top cover.

2-9. OUTPUT VOLTAGE ADJUST. Adjustment of the control regulator circuit board output voltage control will only be required if either the RF amplifier or control regulator assemblies are replaced. To adjust V OUT control R17 on the control regulator circuit board, proceed as follows.

2-10. Required Equipment. The following equipment is required to adjust the V OUT control.

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

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

C. Digital voltmeter (Fluke 75 or equivalent).

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

WARNING ASSURE ALL PRIMARY POWER IS DISCONNECTED BEFORE PROCEEDING.

2-12. Disconnect primary power.

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

WARNING MAINTENANCE WITH POWER ENERGIZED IS ALWAYS CONSIDERED HAZARDOUS AND THEREFORE CAUTION

WARNING SHOULD BE OBSERVED. DO NOT TOUCH ANY COMPONENTS WITHIN THE IPA WHEN POWER IS ENERGIZED.

WARNING USE AN INSULATED TOOL FOR ADJUSTMENT.

2-14. Operate the FILAMENT circuit breaker to OFF, operate the AC POWER, DRIVER, and BLOWER circuit breakers to ON, and depress the FILAMENT ON and HIGH VOLTAGE ON switch/indicators.

2-15. Using the insulated adjustment tool, adjust V OUT control R17 to obtain a voltmeter indication of +20.0 volts dc.

WARNING ASSURE ALL PRIMARY POWER IS DISCONNECTED BEFORE PROCEEDING.

2-16. Disconnect primary ac power.

2-17. Remove the test equipment, then operate the FILAMENT circuit breaker to ON.

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

2-19. Required Equipment. The following equipment is required to adjust 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 100 watt element).

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

WARNING DISCONNECT ALL TRANSMITTER PRIMARY POWER BEFORE PROCEEDING.

2-21. Disconnect primary ac power.

2-22. Remove the exciter top-panel.

2-23. Operate the exciter NORM-EXT switch on the control assembly to NORM.

2-24. Replace the exciter top-panel and remove the IPA top-panel.

2-25. Disconnect the cable from the RF amplifier output 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 FILAMENT circuit breaker to OFF. Operate the AC POWER, DRIVER, 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 100 watts.

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

WARNING USE AN INSULATED TOOL FOR ADJUSTMENT.

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 preceeding text.

WARNING DISCONNECT ALL TRANSMITTER PRIMARY POWER BEFORE PROCEEDING.

2-34. Disconnect primary ac power.

2-35. Remove all test equipment, operate the exciter NORM-EXT switch on the control assembly to EXT, and reconnect the cable to the RF amplifier output receptacle. Operate the FILAMENT circuit breaker 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.

NOTE REFLECTED POWER NULL CONTROL R12 ON THE RF AMPLIFIER CIRCUIT BOARD MUST BE ADJUSTED

NOTE BEFORE PERFORMING THE FOLLOWING PROCEDURE (SEE REFLECTED POWER NULL).

2-39. Disconnect primary ac power.

2-40. Remove the exciter top-panel.

2-41. Operate the exciter NORM-EXT switch on the control assembly to NORM.

2-42. Replace the exciter top-panel and remove the IPA top-panel.

2-43. Disconnect the cable from the 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 FILAMENT circuit breaker to OFF. Operate the AC POWER, DRIVER, 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 50 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 USE AN INSULATED TOOL FOR ADJUSTMENT.

2-50. Using the insulated adjustment tool, adjust RFL calibration control R19 on the control regulator circuit board to obtain a voltmeter indication of +3.6 volts dc.

2-51. Readjust the exciter RF output power to the level recorded in the preceeding text.

WARNING DISCONNECT ALL TRANSMITTER PRIMARY POWER BEFORE PROCEEDING.

2-52. Disconnect primary ac power.

2-53. Remove all test equipment, operate the exciter NORM-EXT switch on the control assembly to EXT, and reconnect the cable to the RF amplifier output receptacle. Operate the FILAMENT circuit breaker to ON.

2-54. TEMP CAL (R30). To adjust the temp cal control (R30) on the control regulator circuit board, proceed as follows. This adjustment is required only if the temperature sensor (U1) is replaced.

2-55. Required Equipment. The following equipment is required to adjust the temp cal 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 Celsius indicating probe.

2-56. Procedure. To adjust the control, proceed as follows:

WARNING ASSURE ALL PRIMARY POWER IS DISCONNECTED BEFORE PROCEEDING.

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.

WARNING MAINTENANCE WITH POWER ENERGIZED IS ALWAYS CONSIDERED HAZARDOUS AND THEREFORE CAUTION SHOULD

WARNING BE OBSERVED. DO NOT TOUCH ANY COMPONENTS WITHIN THE IPA WHEN POWER IS ENERGIZED.

WARNING USE AN INSULATED TOOL FOR ADJUSTMENT.

2-61. Operate the FILAMENT circuit breaker to OFF, operate the AC POWER, DRIVER, and BLOWER circuit breakers to ON, and depress the FILAMENT ON switch/indicator.

2-62. Using the insulated adjustment tool, adjust R30 to obtain an indication equal to the result obtained in the preceding text.

EXAMPLE: $\frac{25°C + 273}{100} = \frac{298}{100} = 2.98$ volts

WARNING ASSURE ALL PRIMARY POWER IS DISCONNECTED BEFORE PROCEEDING.

2-63. Disconnect primary ac power.

2-64. Remove the test equipment, then operate the FILAMENT circuit breaker to ON.

2-65. CURRENT BAL (R72). To adjust the current bal control (R72) on the control regulator circuit board, proceed as follows. This adjustment is required only if the transmitter diagnostic options indicate a zero offset when there is no RF output from the IPA.

2-66. Required Equipment. The following equipment is required to adjust the 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).

2-67. Procedure. To adjust the control, proceed as follows:

WARNING ASSURE ALL PRIMARY POWER IS DISCONNECTED BEFORE PROCEEDING.

2-68. Disconnect primary power.

2-69. Connect the voltmeter between pin 7 of U7 and chassis ground.

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

WARNING USE AN INSULATED TOOL FOR ADJUSTMENT.

2-70. Operate the FILAMENT circuit breaker to OFF, operate the AC POWER, DRIVER, and BLOWER circuit breakers to ON, and depress the FILAMENT ON and HIGH VOLTAGE ON switch/indicators.

2-71. Using the insulated adjustment tool, adjust R72 to obtain a voltmeter indication of Ø.ØØ volts dc.

WARNING ASSURE ALL PRIMARY POWER IS DISCONNECTED BEFORE PROCEEDING.

2-72. Disconnect primary ac power.

2-73. Remove the test equipment, then operate the FILAMENT circuit breaker to ON.

2-74. The current cal control (R76) must now be adjusted. Refer to the following text.

2-75. CURRENT CAL (R76). To adjust the current cal control (R76) on the control regulator circuit board, proceed as follows. This adjustment is required: 1) if the transmitter diagnostic options indicate improper IPA current, or 2) if either the RF amplifier or control regulator circuit board is replaced.

NOTE CURRENT BAL CONTROL R72 ON THE CONTROL REGULATOR CIRCUIT BOARD MUST BE ADJUSTED BEFORE
NOTE CURRENT CAL CONTROL R76 (REFER TO THE PRECEDING ADJUSTMENT PROCEDURE).

2-76. Required Equipment. The following equipment is required to adjust the 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).

2-77. Procedure. To adjust the control, proceed as follows:

WARNING ASSURE ALL PRIMARY POWER IS DISCONNECTED BEFORE PROCEEDING.

2-78. Disconnect primary power.

2-79. Unplug P4-1 and P4-2 from J4-1 and J4-2.

2-80. Temporarily connect the 5 Ohm, 160 Watt resistor from J4-1 to J4-2.

2-81. Connect the voltmeter between pin 7 of U7 and chassis ground.

WARNING MAINTENANCE WITH POWER ENERGIZED IS ALWAYS CONSIDERED HAZARDOUS AND THEREFORE CAUTION SHOULD

WARNING BE OBSERVED. DO NOT TOUCH COMPONENTS WITHIN THE IPA WHEN POWER IS ENERGIZED.

WARNING USE AN INSULATED TOOL FOR ADJUSTMENT.

2-82. Operate the FILAMENT circuit breaker to OFF, operate the AC POWER, DRIVER, and BLOWER circuit breakers to ON, and depress the FILAMENT ON and HIGH VOLTAGE ON switch/indicators.

2-83. Using the insulated adjustment tool, adjust R76 to obtain a voltmeter indication of +1.87 volts dc.

WARNING ASSURE ALL PRIMARY POWER IS DISCONNECTED BEFORE PROCEEDING.

2-84. Disconnect primary ac power.

2-85. Remove the test equipment and reconnect P4-1 and P4-2 to J4-1 and J4-2. Then operate the FILAMENT circuit breaker to ON.

2-86. REFLECTED POWER NULL. This control is factory calibrated and sealed during final test. Adjustment of the reflected power null control in the field is not normally required unless: 1) replacement components are installed in the IPA directional coupler circuitry, 2) the RF amplifier circuit board is replaced, or 3) the transmitter operating frequency is changed. If it is certain that adjustment is required, proceed as follows.

2-87. Required Equipment. The following equipment is required to adjust the reflected power null 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).

2-88. Procedure. To adjust the control, proceed as follows:

2-89. Refer to the OUTPUT VOLTAGE ADJUST procedure in the preceeding text and adjust the output voltage control for +28V dc.

WARNING DISCONNECT ALL TRANSMITTER PRIMARY POWER BEFORE PROCEEDING.

2-90. Disconnect primary ac power.

2-91. Remove the exciter top-panel.

2-92. Operate the exciter NORM-EXT switch on the control assembly to NORM.

2-93. Replace the exciter top-panel and remove the IPA top-panel.

2-94. Disconnect the cable from the RF amplifier output receptacle.

2-95. Connect the non-inductive test load to the RF amplifier output receptacle through the In-line Wattmeter. Adjust the wattmeter to measure forward power.

2-96. Connect the voltmeter between J9-20 on the IPA interconnect filter circuit board and chassis ground.

2-97. Carefully place the RF amplifier module in the cooling air path. The reflected power null control is accessible from the rear of the amplifier module.

2-98. Operate the FILAMENT circuit breaker to OFF. Operate the AC POWER, DRIVER, and BLOWER circuit breakers to ON.

2-99. Energize the transmitter primary ac power and depress the FILAMENT ON and HIGH VOLTAGE ON switch/indicators.

2-100. Depress the exciter FWD switch and record the RF output power _____.

2-101. 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
WARNING BE OBSERVED. DO NOT TOUCH ANY COMPONENTS WITHIN THE IPA WHEN POWER IS ENERGIZED.

WARNING USE AN INSULATED TOOL FOR ADJUSTMENT.

2-102. Using the insulated adjustment tool, adjust reflected power null control R12 on the RF amplifier module to obtain a minimum voltmeter indication.

2-103. Readjust the exciter RF output power to the level recorded in the preceeding text.

WARNING DISCONNECT ALL TRANSMITTER PRIMARY POWER BEFORE PROCEEDING.

2-104. Disconnect primary ac power.

2-105. Remove all test equipment, operate the exciter NORM-EXT switch on the control assembly to EXT, and reconnect the cable to the RF amplifier output receptacle. Refer to the adjustment procedures in the preceeding text and perform the OUTPUT VOLTAGE ADJUST procedure.

2-106. TROUBLESHOOTING.

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

2-107. 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.

2-108. If problems are encountered and the IPA stage is suspected as faulty, the first step is to determine whether the exciter, the IPA, or the load (PA input circuit) is at fault. A high VSWR or over-heating condition within the IPA will cause the control regulator to limit RF output to prevent damage to the 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.

2-109. As a first check, the RF input level to the IPA stage should be checked and adjusted as required. Next the IPA load (INPUT TUNING control) should be adjusted to the correct point. If neither the input level or the output circuit is at fault, subsequent troubleshooting should determine which circuit is at fault.

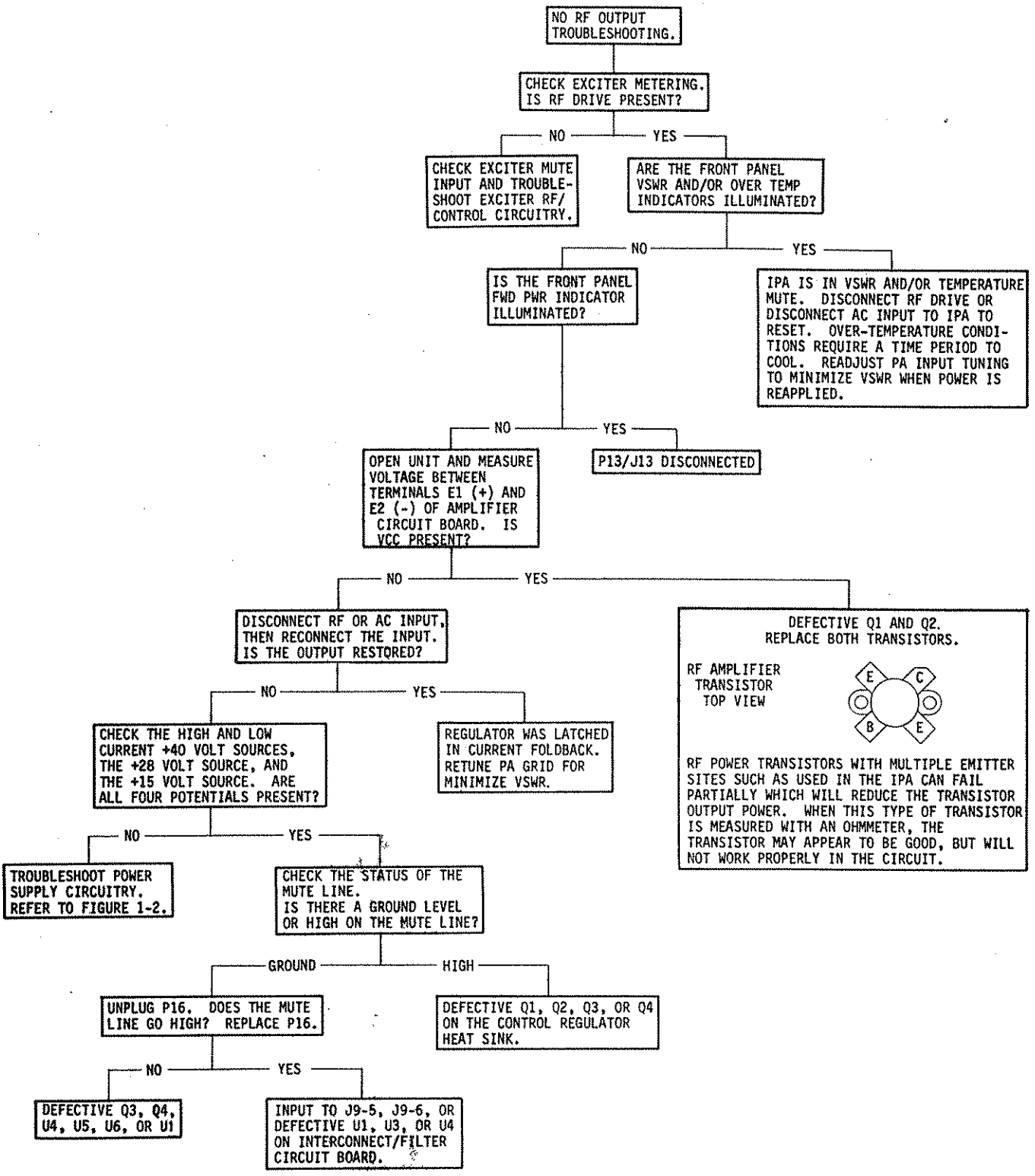
WARNING BERYLLIUM OXIDE CERAMICS (BeO) - AVOID BREATHING DUST OR FUMES.

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

2-110. If the RF power transistors on the amplifier circuit board is determined to be defective, the transistors must be replaced with the same identical type and manufacture as the original device. The IPA RF amplifier assembly diagram in SECTION III contains information relative to replacement of the RF power transistors.

2-111. Once the trouble is isolated and power is totally deenergized, it is suggested that the exact problem be located with resistance checks using the schematic diagrams and theory of operation presented throughout the text. Figures 2-1 and 2-2 provide IPA troubleshooting information and should be referenced as required.

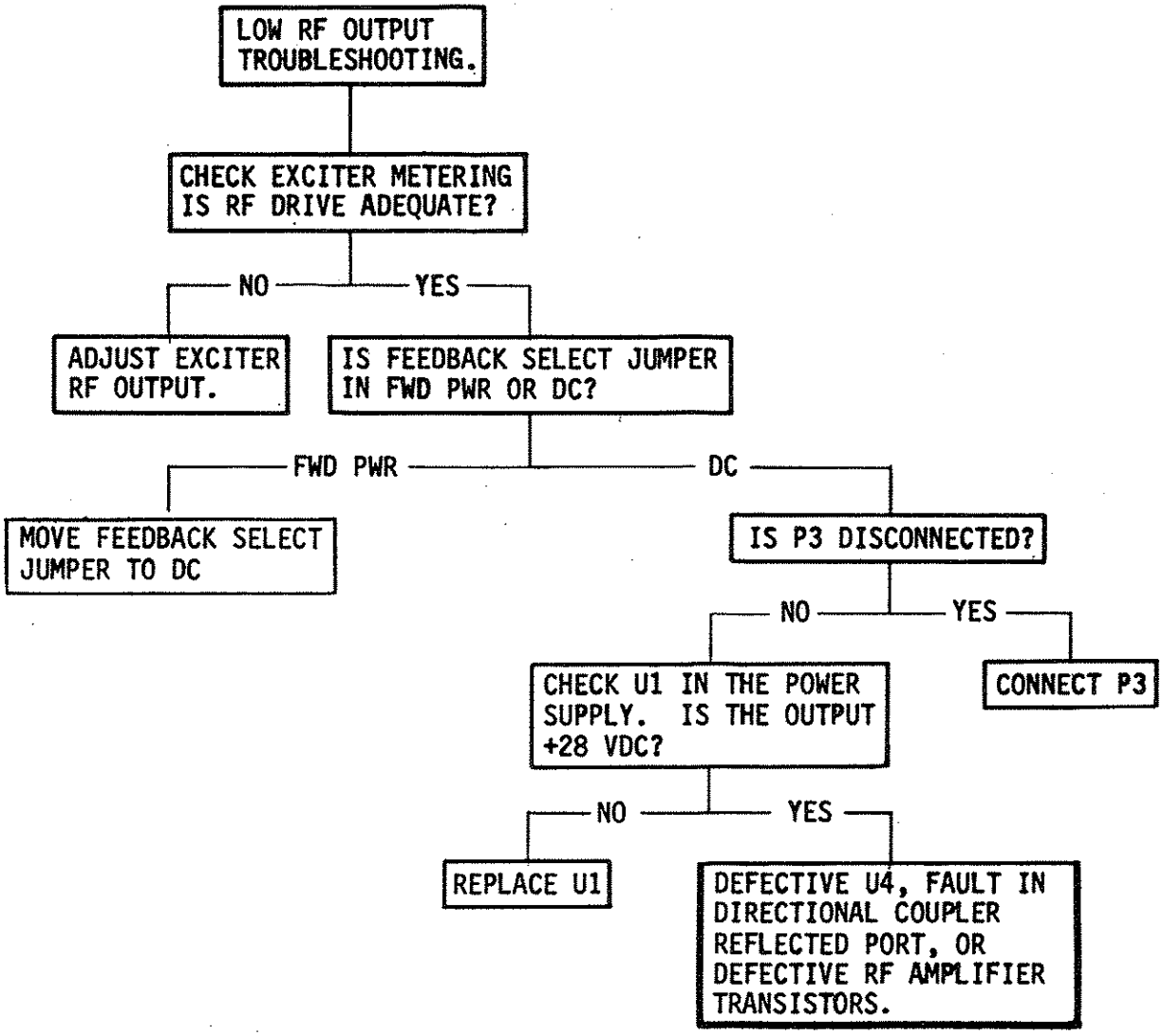
2-112. If a circuit is diagnosed as faulty, the circuit fault may be isolated and repaired locally or the entire device may be returned to Broadcast Electronics, Inc. for exchange, alignment, or replacement. The modular approach used in the construction of the IPA allows a spare control regulator or RF amplifier modules to be substituted in the system with minimal down time.



597-0032-23

FIGURE 2-1. NO RF OUTPUT TROUBLESHOOTING

WARNING: DISCONNECT POWER PRIOR TO SERVICING



597-0032-25

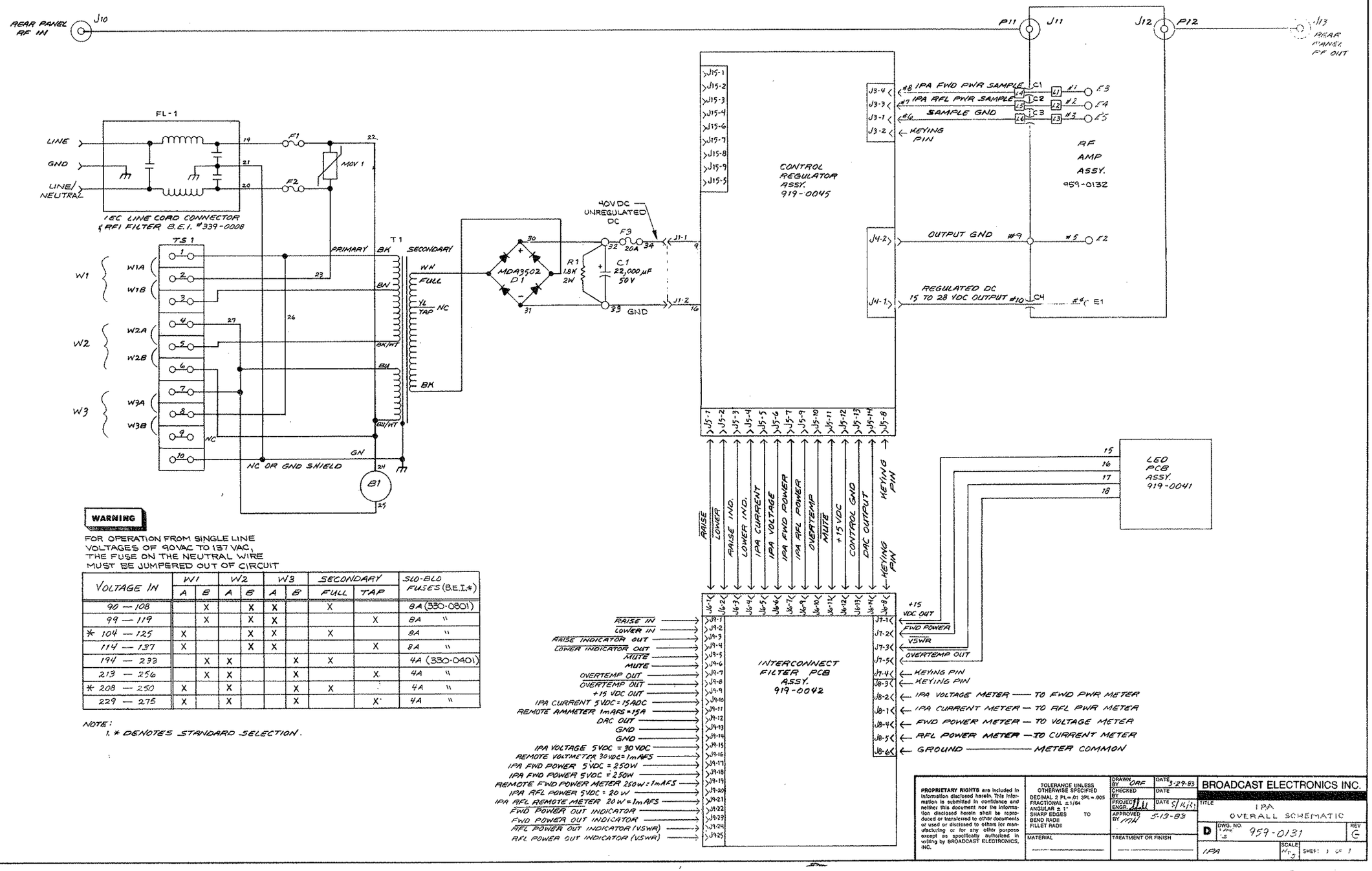
FIGURE 2-2. LOW RF OUTPUT TROUBLESHOOTING

SECTION III
DRAWINGS

3-1. INTRODUCTION.

3-2. This section provides assembly drawings and schematic diagrams as listed below for the FM-1.5A IPA.

FIGURE	TITLE	NUMBER
3-1	SCHEMATIC, IPA OVERALL	SD959-0131
3-2	ASSEMBLY, IPA OVERALL	597-0032-16
3-3	SCHEMATIC, INTERCONNECT/FILTER CIRCUIT BOARD	SD919-0042
3-4	ASSEMBLY, INTERCONNECT/FILTER CIRCUIT BOARD	AC919-0042
3-5	SCHEMATIC, CONTROL REGULATOR OVERALL	SD919-0045
3-6	ASSEMBLY, CONTROL REGULATOR CIRCUIT BOARD	AD919-0045
3-7	COMPONENT LOCATOR, CONTROL REGULATOR CIRCUIT BOARD	597-0032-20
3-8	SCHEMATIC, RF AMPLIFIER OVERALL	SD919-0065
3-9	ASSEMBLY, RF AMPLIFIER CIRCUIT BOARD	AD959-0132
3-10	ASSEMBLY, RESISTOR NETWORK	AA959-1000-001



WARNING

FOR OPERATION FROM SINGLE LINE VOLTAGES OF 90VAC TO 137 VAC, THE FUSE ON THE NEUTRAL WIRE MUST BE JUMPERED OUT OF CIRCUIT

VOLTAGE IN	W1		W2		W3		SECONDARY		SLO-BLO FUSES (B.E.I.#)
	A	B	A	B	A	B	FULL	TAP	
90 — 108		X		X	X		X		8A (330-0801)
99 — 119		X		X	X			X	8A "
* 104 — 125	X			X	X		X		8A "
114 — 137	X			X	X			X	8A "
194 — 233		X	X			X	X		4A (330-0401)
213 — 256		X	X			X		X	4A "
* 208 — 250	X		X			X	X		4A "
229 — 275	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 DRF DATE 3-29-83
CHECKED DATE
BY DATE
PROJECT ENGR. DATE 5/14/83
APPROVED BY DATE 5-13-83

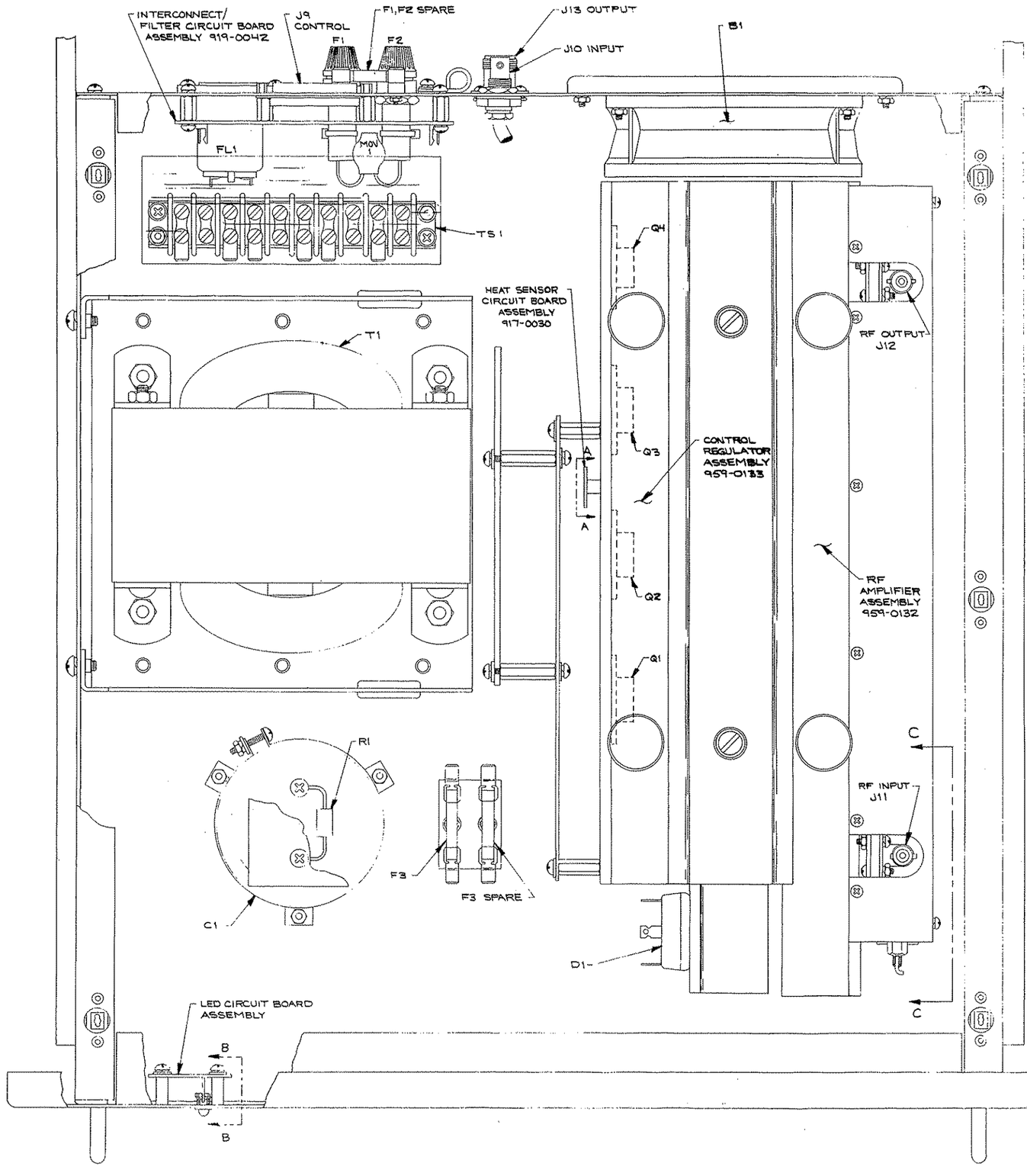
TREATMENT OR FINISH

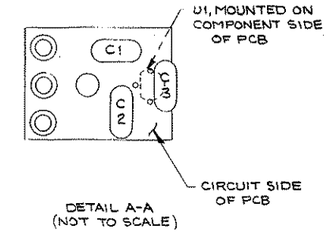
BROADCAST ELECTRONICS INC.

TITLE
IPA
OVERALL SCHEMATIC

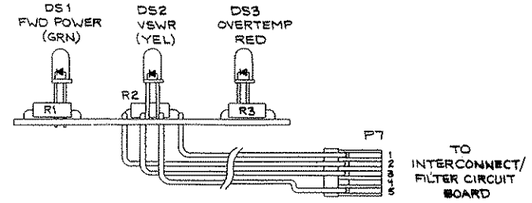
D DWG. NO. 959-0131 REV G

IPA SCALE NONE SHEET 1 OF 1

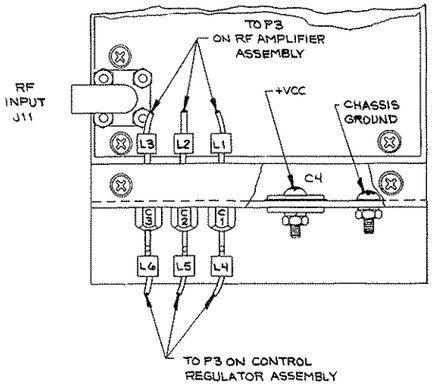




DETAIL A-A
(NOT TO SCALE)



DETAIL B-B
(NOT TO SCALE)



DETAIL C-C
(NOT TO SCALE)

597-0032-16

FIGURE 3-2. INTERMEDIATE POWER AMPLIFIER ASSEMBLY

NOTES:
1. ALL RESISTORS IN OHMS, ¼W, 5% UNLESS OTHERWISE SPECIFIED.
2. ALL CAPACITORS ARE 390 pF, UNLESS OTHERWISE SPECIFIED.
3. ALL COILS ARE 4.7 uH OR 2.2 uH.
4. ⚠ R3A-R3D DENOTES RESISTOR NETWORK, B.E.I. P/N 959-1000-002. FOR FM1.5A, REFERENCE DWG. A959-1000-002.
   FOR FM3.5A/5A, REFERENCE B.E.I. P/N 959-1000. DWG. A959-1000.
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 MATRIX.
6. J8 IS NOT PART OF PRINTED CIRCUIT BOARD ASSEMBLY.

REFERENCE DESIGNATORS	
LAST USED	NOT USED
C46	U16
D2	
J9	
L9	
R31	
U4	

REFERENCE DESIGNATORS	U1	U2	U3, U4
B.E. PART NO.	226-2004	221-0368	229-0033
VENDOR PART NO.	ULN2004	LM 358	4N 33
VOLTAGE PIN NO.	8	8	—
GROUND PIN NO.	8	4	—

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

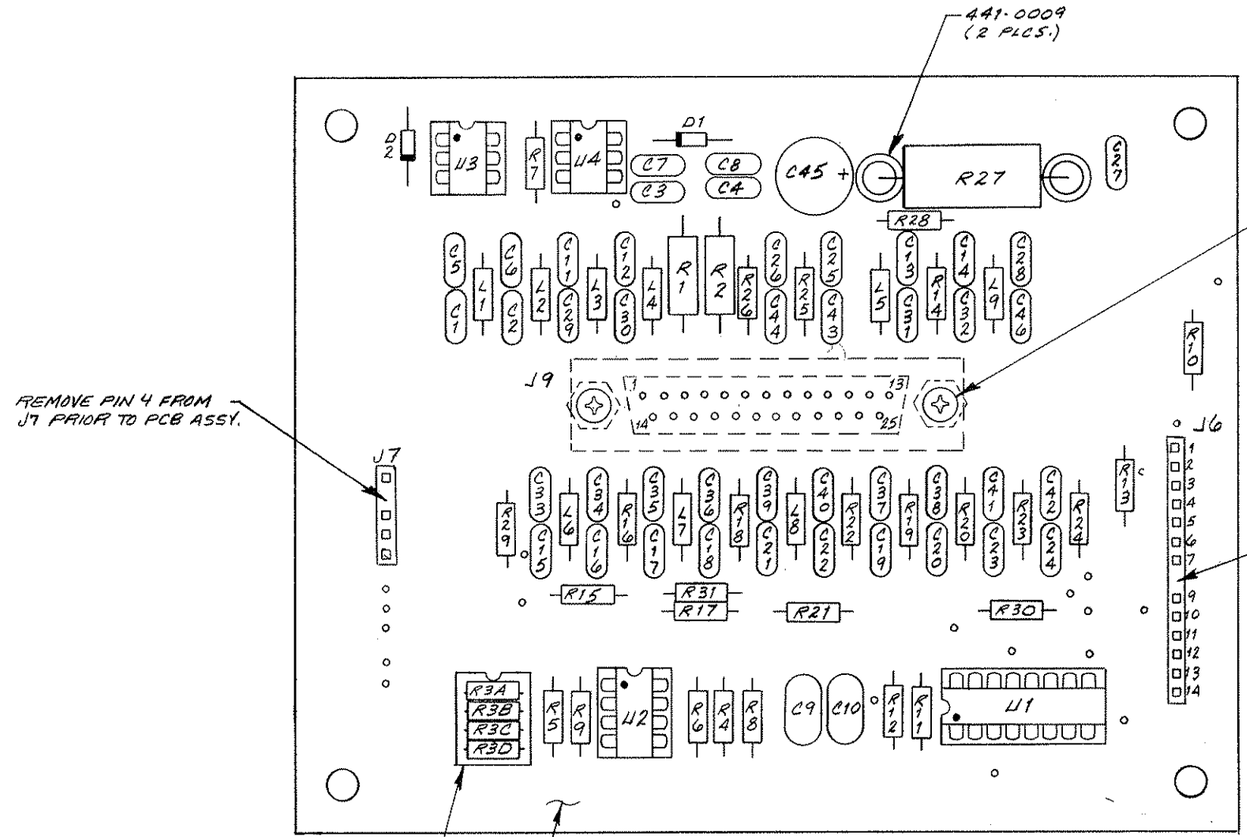
DRAWN BY MCKREZ DATE 2-21-83
CHECKED BY DATE
PROJECT ENGR. DATE 5/16/83
APPROVED BY MH 5-13-83

BROADCAST ELECTRONICS INC.

TITLE SCHEMATIC - IPA INTERCONNECT/FILTER PCB

D DWG. NO. 919-0042 REV. D

IPA SCALE NA SHEET 1 OF 1



NOTE:

1. L1 - L9 MAY BE EITHER 2.2μH OR 4.7μH UNDER P/N 360-0022.
2. J6 & J7 ARE MADE FROM 417-0200.

SEE SCHEMATIC #D919-0042
SEE B/M # 919-0042

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

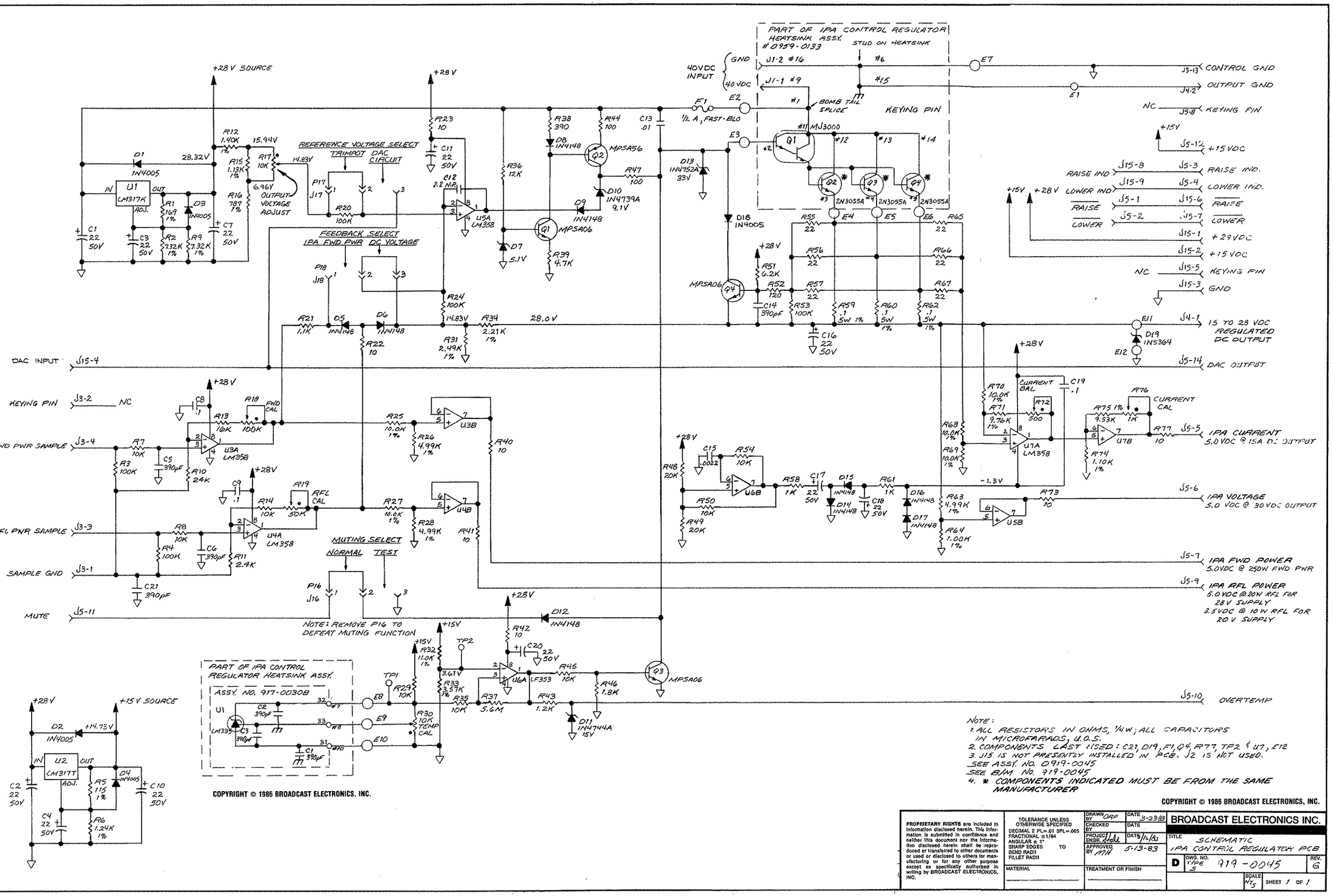
DWN. BY MERKEL 2-26-83	NEXT ASSY.
CHKD.	
ME	PRODUCT USED ON IPA
EE	
PROJ. ENGR. S.J. 5/16/83	FINISH
DFTG. SUPVR. MH 5-13-83	
MFG.	

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 D

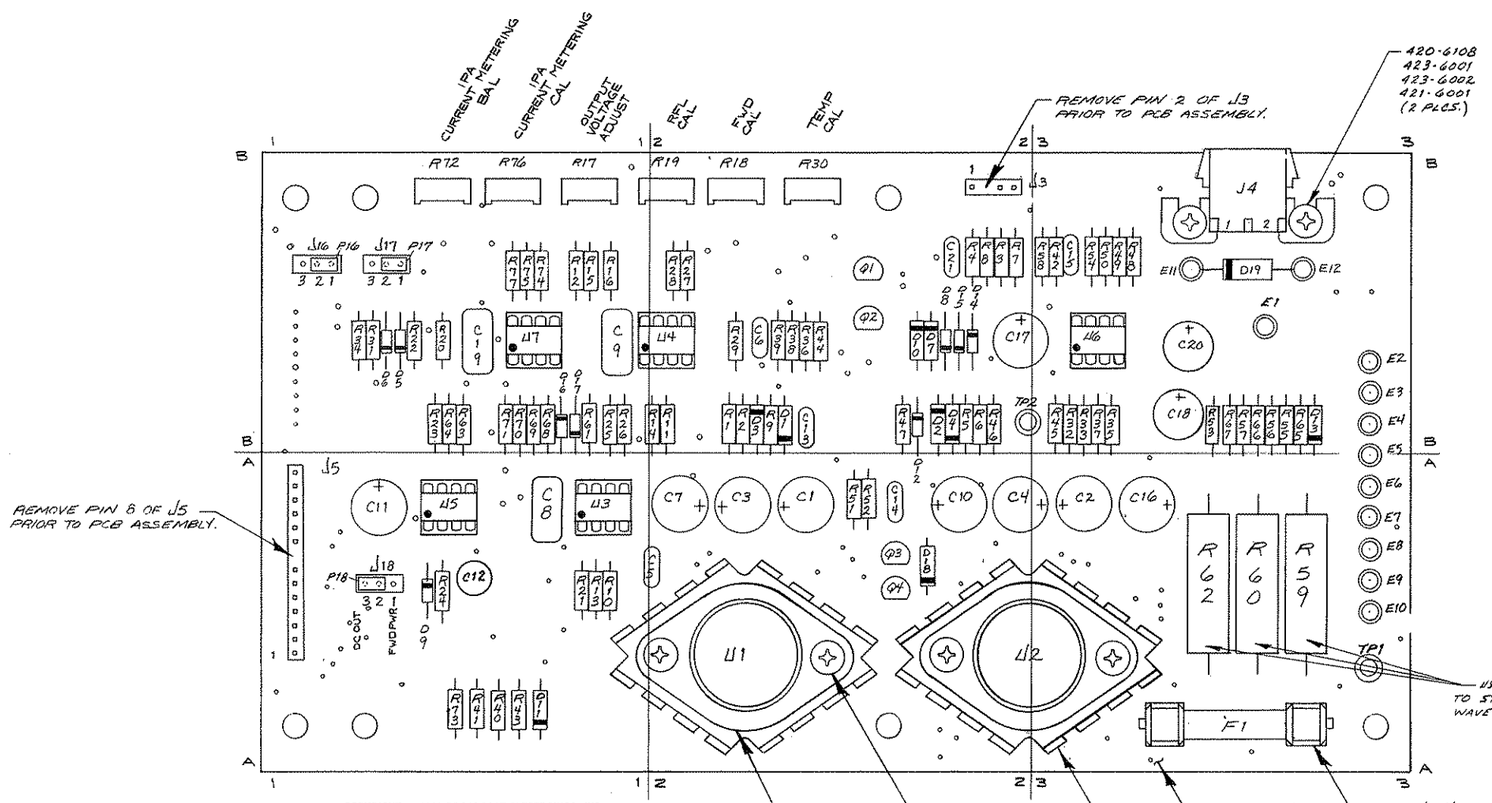
TYPE A | SIZE C | DWG. NO. 919-0042



NOTE:
1. ALL RESISTORS IN OHMS, 1/4 W; ALL CAPACITORS IN MICROFARADS, U.O.S.
2. COMPONENTS LAST USED: C21, D19, F1, Q4, R77, TP2 & U7, E12
3. J15 IS NOT PRESENTLY INSTALLED IN PCB. J2 IS NOT USED.
SEE ASSY. NO. D919-0045
SEE B/M NO. 919-0045
4. * COMPONENTS INDICATED MUST BE FROM THE SAME MANUFACTURER

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 ORF	DATE 3-23-83	BROADCAST ELECTRONICS INC.
CHECKED BY	DATE	
PROJECT ENGR. [illegible]	DATE 5/4/83	TITLE SCHEMATIC IPA CONTROL REGULATOR PCB
APPROVED BY [illegible]	5-13-83	D DWG. NO. TYPE S 919-0045 REV. G
		SCALE NTS SHEET 1 OF 1



SEE SCHEMATIC # 0919-0045
SEE B/M # 919-0045

NOTE:
1. J3 & J5 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

TREATMENT OR FINISH

DRAWN BY DRF DATE 3-7-83
CHECKED BY DATE
PROJECT ENGR. DATE 5/16/83
APPROVED BY MH 5-13-83

BROADCAST ELECTRONICS INC.

TITLE PCB ASSEMBLY IPA CONTROL REGULATOR P.V.

D | DWG. NO. TYPE A 919-0045 | REV. F

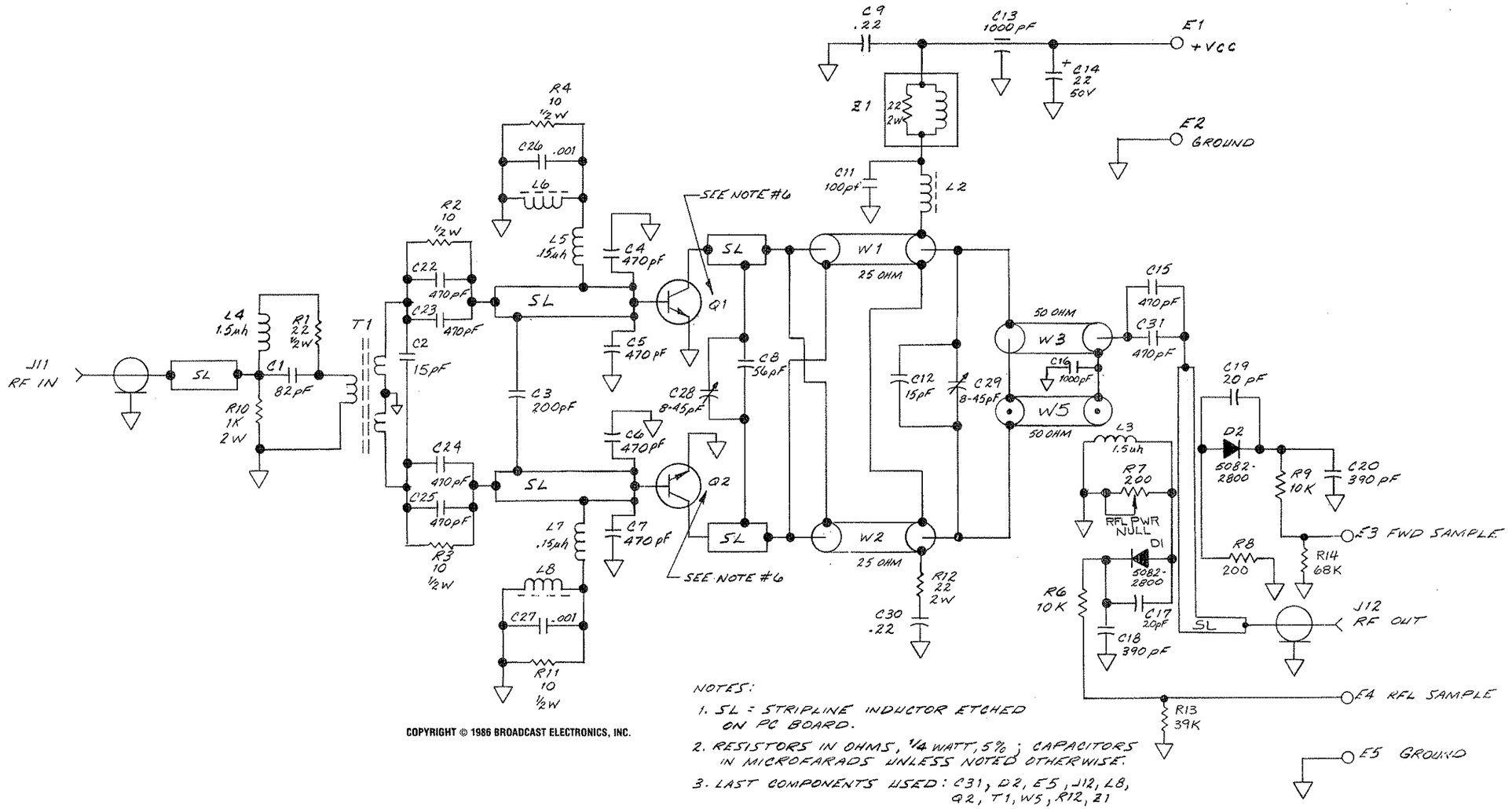
FM 1.5, 3.5 FLAW DATA

SCALE 2/1 SHEET 1 OF 1

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		

597-0032-20

FIGURE 3-7. CONTROL REGULATOR CIRCUIT BOARD COMPONENT LOCATOR



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. # 0959-0132, 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°

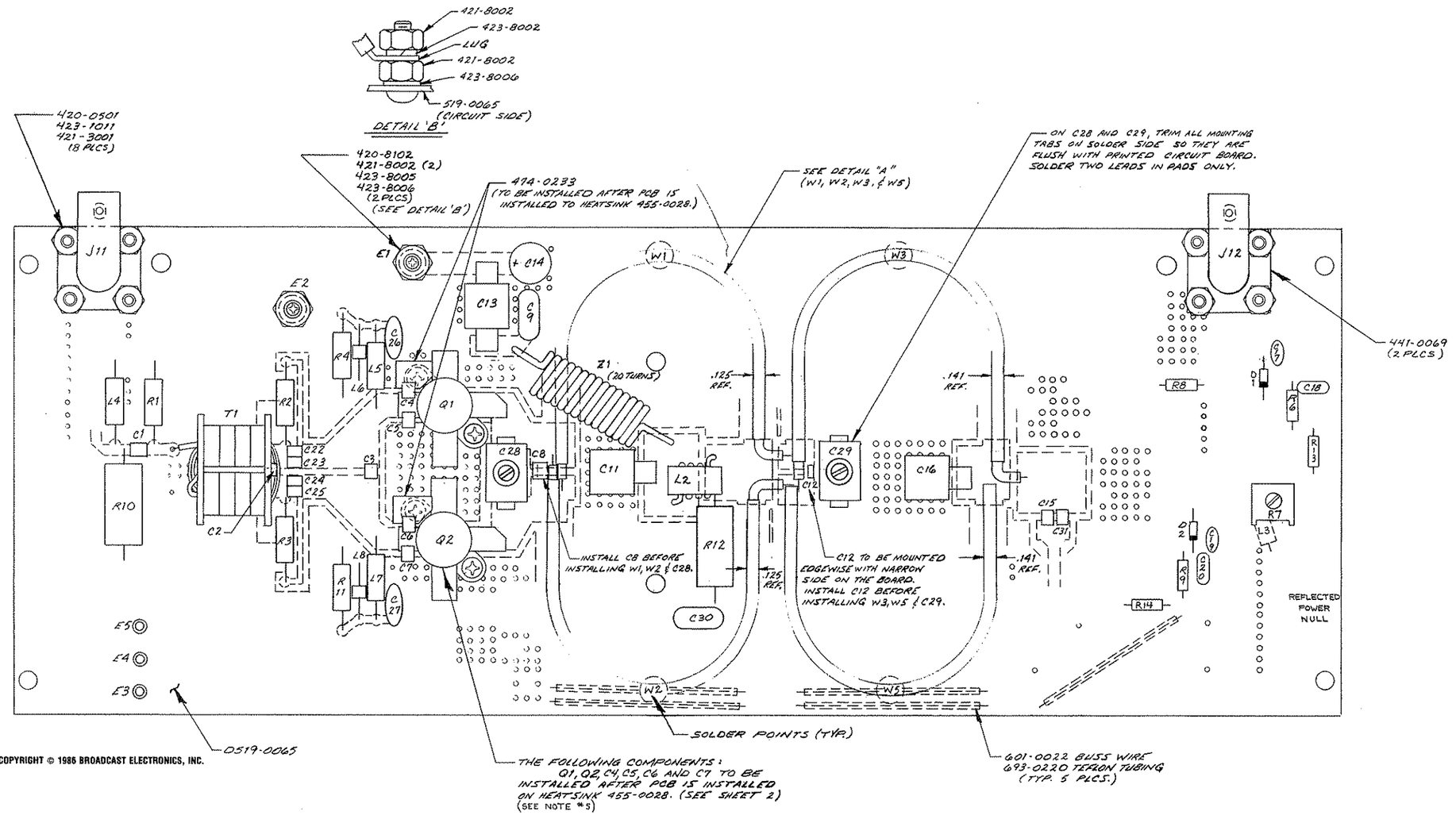
DWN. BY	MERKEL 3-10-83
CHKD.	
ME	
EE	
PROJ. ENGR.	S.S. 5/16/83
DFTG. SUPVR.	MH 5-19-83
MFG.	
NEXT ASSY.	
PRODUCT USED ON	IPA
FINISH	

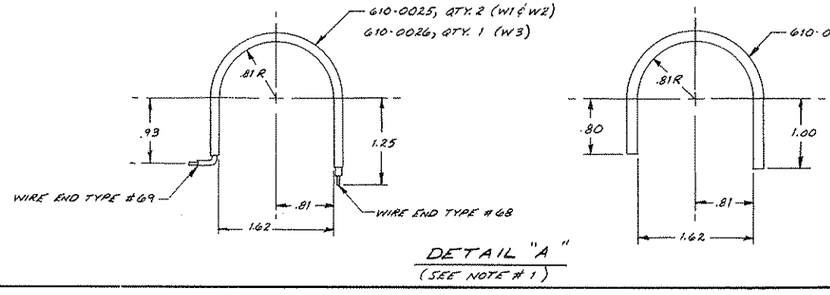
BROADCAST ELECTRONICS INC.
4100 N. 24TH ST. QUINCY, IL 62305 217/224-9600
TELEX 250142 CABLE BCST ELECT QUI

TITLE PCB SCHEMATIC - IPA RF AMP PCB

SHEET 1 OF 1
SCALE NONE
REV G

TYPE S SIZE C DWG. NO. 919-0065





DETAIL "A"
(SEE NOTE # 1)

NOTES:
1. USE FIXTURE TO FORM W1, W2, W3, & W5.
2. REFERENCE SCHEMATIC # D959-0131
3. REFERENCE B/M 919-0065.
4. REFERENCE RF AMP PCB SCHEMATIC # C919-0065.
5. TRANSISTORS Q1 & Q2 ARE MATCHED PAIRS.

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

MATERIAL

DRAWN BY DAVE DATE 9-12-83
CHECKED BY DATE
PROJECT ENGR. DATE 9-16-83
APPROVED BY

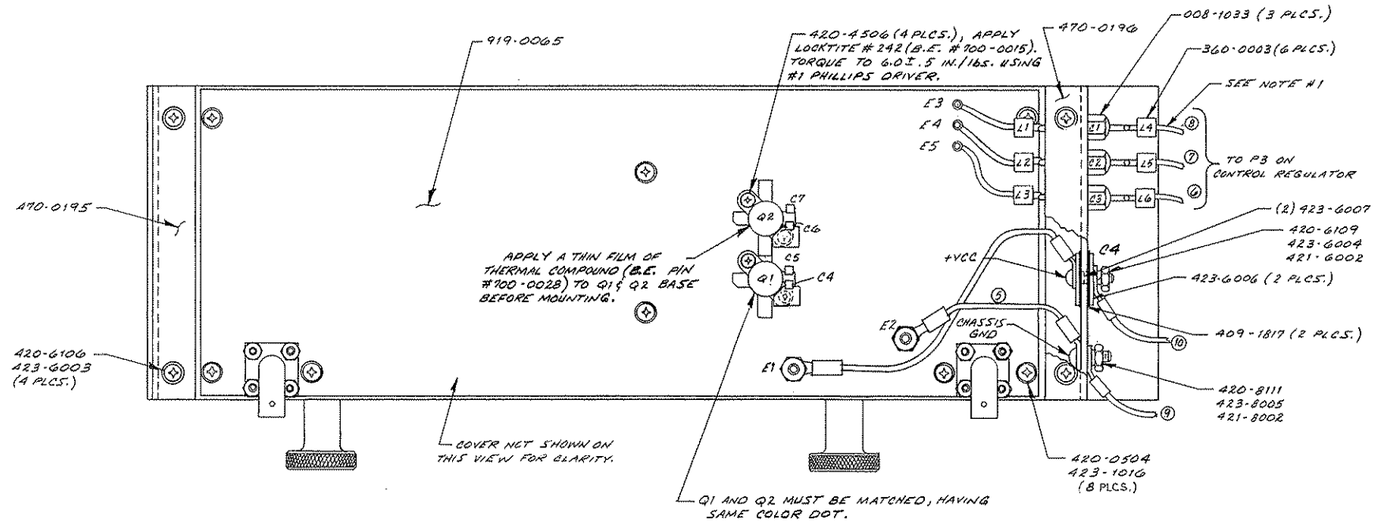
TREATMENT OR FINISH

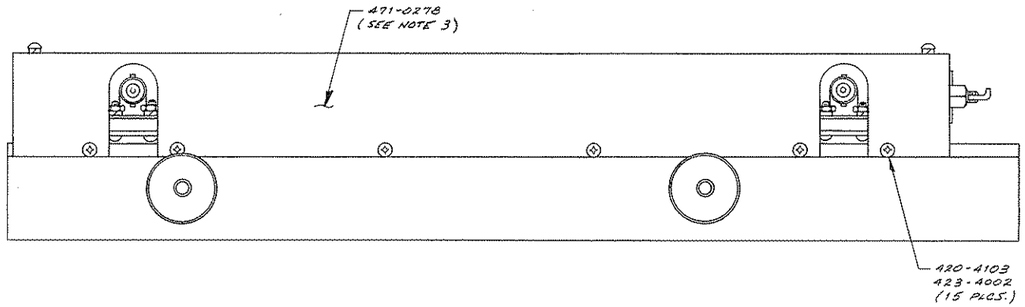
BROADCAST ELECTRONICS INC.

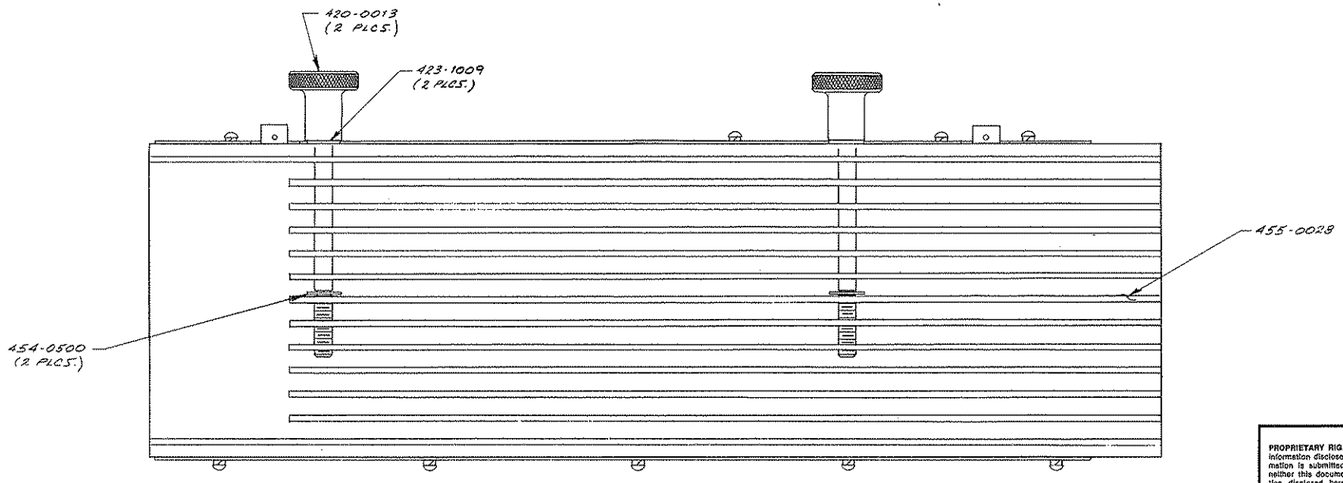
TITLE IPA RF AMP ASSEMBLY

D DWG. NO. TYPE A 959-0132 REV. L

IPA SCALE 2/1 SHEET 1 OF 2







NOTES:
1. SEE DWG. 0949-0040 FOR WIRING ASSEMBLIES.
2. SEE B.I.M. 959-0132
3. ASSEMBLE TOP COVER 471-0278 AFTER TEST.
4. Ⓝ - DENOTES WIRE NUMBERS.

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

DRAWN BY MERKEL DATE 4-28-83
CHECKED BY DATE
PROJECT ENGR. DATE 5/12/83
APPROVED BY 5-13-83

BROADCAST ELECTRONICS INC.

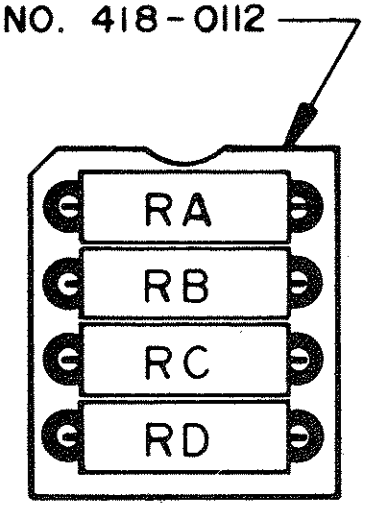
TITLE IPA RF ANT ASSEMBLY

D DWG. NO. TYPE A 954-0132 REV. L

IPA SCALE 1/1 SHEET 2 OF 2

REVISIONS			
REV.	DESCRIPTION	DATE	APPROVED
A	ENGINEERING RELEASE PER ECN 4775 MERK	12-19-83	
B	PER ECN 5113 MSE	5-14-84	

B.E. PART NO. 418-0112



USED ON:
IPA 919-0042 PCB ON FM5A
A5 R3.

B.E.I. PART NO. (VALUE IN OHMS)	RA	RB	RC	RD
100-1053 (10K)	X			
100-2243 (2.2K)		X		
100-1053 (10K)			X	
100-2743 (2.7K)				X

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

MATERIAL

TREATMENT OR FINISH

DRAWN BY MERKEL | DATE 2-22-83
CHECKED BY | DATE
PROJECT ENGR. | DATE
APPROVED BY

BROADCAST ELECTRONICS INC.

TITLE
ASSEMBLY
RESISTOR NETWORK

A | DWG. NO. 959-1000-001 | REV. B

IPA - FM5A | SCALE 4/1 | SHEET 1 OF 1

SECTION IV

PARTS LISTS

4-1. INTRODUCTION.

4-2. This section provides descriptions and part numbers of electrical components, assemblies, and selected mechanical parts required for maintenance of the Broadcast Electronics FM-1.5A IPA. Each table entry in this section is indexed by reference designators appearing on the applicable schematic diagram.

TABLE 4-1. IPA PARTS LIST INDEX

TABLE 4-2. IPA OVERALL - 959-0131

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, 22,000 uF, 50V	027-2200	1
D1	Bridge Rectifier, MDA3502, Silicon, 200V, 35 Amperes	230-3502	1
DS1	Indicator, LED, Green, 521-9175, 3V @ 40 mA Maximum (FWD Power)	323-9224	1
DS2	Indicator, LED, Yellow, 521-9176, 3V @ 40 mA Maximum (VSWR)	323-9225	1
DS3	Indicator, LED, Red, 521-9212, 1.7V @ 50 mA Maximum (OVER TEMP)	323-9217	1
	110V AC Input Operation		
F1,F2, SPARE	Fuse, 250V, 8 Amperes, Slow-Blow	330-0801	3
	220V AC Input Operation		
F1,F2,SPARE	Fuse, MDA, 250V, Slow-Blow, Ceramic Element, 4 Amperes	330-0401	3
F3,SPARE	Fuse, 3AB. 250V. 20 Amperes	330-2000	2
FL1	Power Input Connector/RFI Filter, 3 Amperes, 250V ac, 50/60 Hz	339-0008	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	415-1001	2
----	Fastener, 1/4 Turn-Lock		
	Stud, Long	420-0019	6
	Stud, Short	420-0027	2
	Retainer	420-0021	8
	Receptacle	420-0022	8
----	Blank Circuit Board, Front Panel LED	519-0041	1
----	Assembly, Transformer and Bracket	959-0195	1
----	Interconnect/Filter Circuit Board Assembly	919-0042	1
----	IPA Wiring Assembly	949-0029	1
----	Control Regulator Assembly	959-0133	1
----	IPA RF Amplifier Assembly	959-0132	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
(Sheet 1 of 2)

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

TABLE 4-4. INTERCONNECT/FILTER CIRCUIT BOARD - 919-0042
(Sheet 2 of 2)

REF. DES.	DESCRIPTION	PART NO.	QTY.
C45	Capacitor, Electrolytic, 22 uF, 50V	024-2274	1
C46	Capacitor, Mica, 390 pF ±5%, 100V	042-3922	1
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
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
R3	Resistor Network Assembly	959-1000-002	1
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
U1	Integrated Circuit, ULN2003A, 7-Channel Driver, CMOS/TTL Compatable, 16-Pin DIP	229-2003	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	Rectptacle, 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, multiple taps for 93 volt to 264 volt ac Input Secondary: 33.1V @ 15 Amperes	376-0040	1

TABLE 4-6. RF AMPLIFIER ASSEMBLY - 959-0132

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	Contact, Female	417-0100	2
----	Housing	417-0099	1
----	Pins, Receptacle (for P3)	417-8766	3

TABLE 4-8. RF AMPLIFIER CIRCUIT BOARD - 919-0065

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, 56 pF ±5%, 500V	009-5613	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
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	103-2003	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

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	218-3055	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 2)

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
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, Zener, 1N5363, 30V, 5W	200-5363	1
D19	Diode, 1N4005, Silicon, 600V @ 1 Ampere	203-4005	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
R1	Resistor, 169 Ohms ±1%, 1/4W	103-1693	1
R2	Resistor, 7.32 k Ohm ±1%, 1/4W	103-7324	1
R3,R4	Resistor, 100 k Ohm ±5%, 1/4W	100-1063	2
R5	Resistor, 115 Ohm ±1%, 1/4W	100-1131	1
R6	Resistor, 1.24 k Ohm ±1%, 1/4W	103-1244	1
R7,R8	Resistor, 10 k Ohm ±5%, 1/4W	100-1053	2
R9	Resistor, 7.32 k Ohm ±1%, 1/4W	103-7324	1
R10	Resistor, 24 k Ohm ±5%, 1/4W	100-2453	1
R11	Resistor, 2.4 k Ohm ±5%, 1/4W	100-2443	1
R12	Resistor, 1.40 k Ohm ±1%, 1/4W	103-1404	1

TABLE 4-11. CONTROL REGULATOR CIRCUIT BOARD - 919-0045
(Sheet 2 of 2)

REF. DES.	DESCRIPTION	PART NO.	QTY.
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, 11.0 k Ohm ±1%, 1/4W	103-1105	1
R33	Resistor, 3.57 k Ohm ±1%, 1/4W	103-3574	1
R34	Resistor, 2.21 k Ohm ±1%, 1/4W	103-2241	1
R35	Resistor, 10 k Ohm ±5%, 1/4W	100-1053	1
R36	Resistor, 12 k Ohm ±5%, 1/4W	100-1253	1
R37	Resistor, 5.6 Meg Ohm ±5%, 1/4W	100-5673	1
R38	Resistor, 390 Ohm ±5%, 1/4W	100-3933	1
R39	Resistor, 4.7 k Ohm ±5%, 1/4W	100-4743	1
R40 THRU R42	Resistor, 10 Ohm ±5%, 1/4W	100-1023	3
R43	Resistor, 1.2 k Ohm ±5%, 1/4W	100-1243	1
R44	Resistor, 100 Ohm ±5%, 1/4W	100-1033	1
R45	Resistor, 10 k Ohm ±5%, 1/4W	100-1053	1
R46	Resistor, 1.8 k Ohm ±5%, 1/4W	100-1843	1
R47	Resistor, 100 Ohm ±5%, 1/4W	100-1033	1
R48,R49	Resistor, 20 k Ohm ±5%, 1/4W	100-2053	2
R50	Resistor, 10 k Ohm ±5%, 1/4W	100-1053	1
R51	Resistor, 6.2 k Ohm ±5%, 1/4W	100-6243	1
R52	Resistor, 120 Ohm ±5%, 1/4W	100-1233	1
R53	Resistor, 100 k Ohm ±5%, 1/4W	100-1063	1
R54	Resistor, 10 k Ohm ±5%, 1/4W	100-1053	1
R55 THRU R57	Resistor, 22 Ohm ±5%, 1/4W	100-2223	3
R58	Resistor, 1 k Ohm ±5%, 1/4W	100-1043	1
R59,R60	Resistor, 0.1 Ohm ±1%, 5W, W/W	130-1000	2
R61	Resistor, 1 k Ohm ±5%, 1/4W	100-1043	1
R62	Resistor, 0.1 Ohm ±1%, 5W, W/W	130-1000	1
R63	Resistor, 4.99 k Ohm ±1%, 1/4W	100-5041	1
R64	Resistor, 1.00 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
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

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 ASSEMBLY NETWORK - 959-1000-001

REF. DES.	DESCRIPTION	PART NO.	QTY.
R3A	Resistor, 10 k Ohm ±5%, 1/4W	100-1053	1
R3B	Resistor, 2.2 k Ohm, ±5%, 1/4W	100-2243	1
R3C	Resistor, 10 k Ohm ±5%, 1/4W	100-1053	1
R3D	Resistor, 2.7 k Ohm ±5%, 1/4W	100-2743	1
----	Plug, 8-Pin DIP	418-0112	1

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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-1.5A transmitter 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 to 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 reapplied, full RF output will not suddenly be established, but will slowly increase from minimum (soft start). The unit also contains a front-panel receptacle for AM noise measurements.

1-7. OPERATION. Manual power control can be selected by switching the APC off. In the manual mode, the RAISE and LOWER switch/indicators directly control the dc potential which varies the exciter RF output. The RAISE and LOWER switch/indicators indicate whether transmitter RF output power is being raised or lowered.

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 APC uses a modulated pulse train scheme to vary the RF output. When large excursions of RF power are required, a more rapid pulse train is employed. Fine adjustments of RF output utilize a slower pulse train and therefore slower correction. This feature, combined with an analog deadband in the circuitry, eliminates hunting in this loop.

1-10. Three 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 allow automatic control of the exciter RF output as part of a closed loop. If excessive PA reflected 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 exciter RF output 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 exciter RF output to minimum upon the absence of plate voltage. When the plate supply is energized, as during power-on, the circuit will gradually increase the exciter output 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. 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.

1-16. DETAILED DESCRIPTION.

1-17. 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.

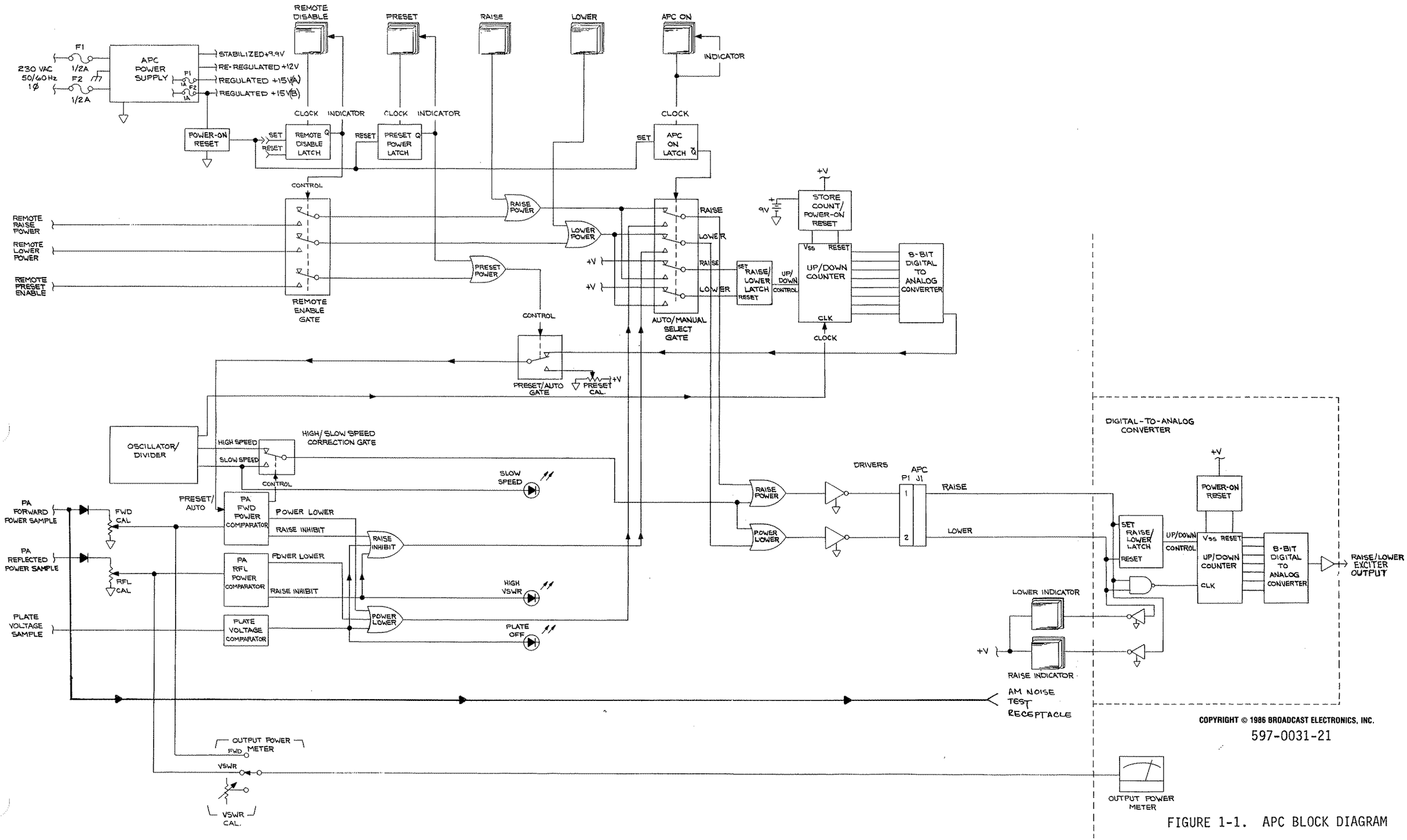

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FIGURE 1-1. APC BLOCK DIAGRAM

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 and 3) the power supplies which operate the unit.

C. The main circuit board contains all the circuitry required to implement the APC analog and digital control functions.

D. The digital-to-analog converter circuit board contains circuitry which converts the APC digital output into an analog voltage as required to adjust the exciter output level.

1-18. 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.

1-19. 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 seperate sources.

1-20. 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 source operates all APC logic.

1-21. 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.

1-22. 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.

1-23. 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.

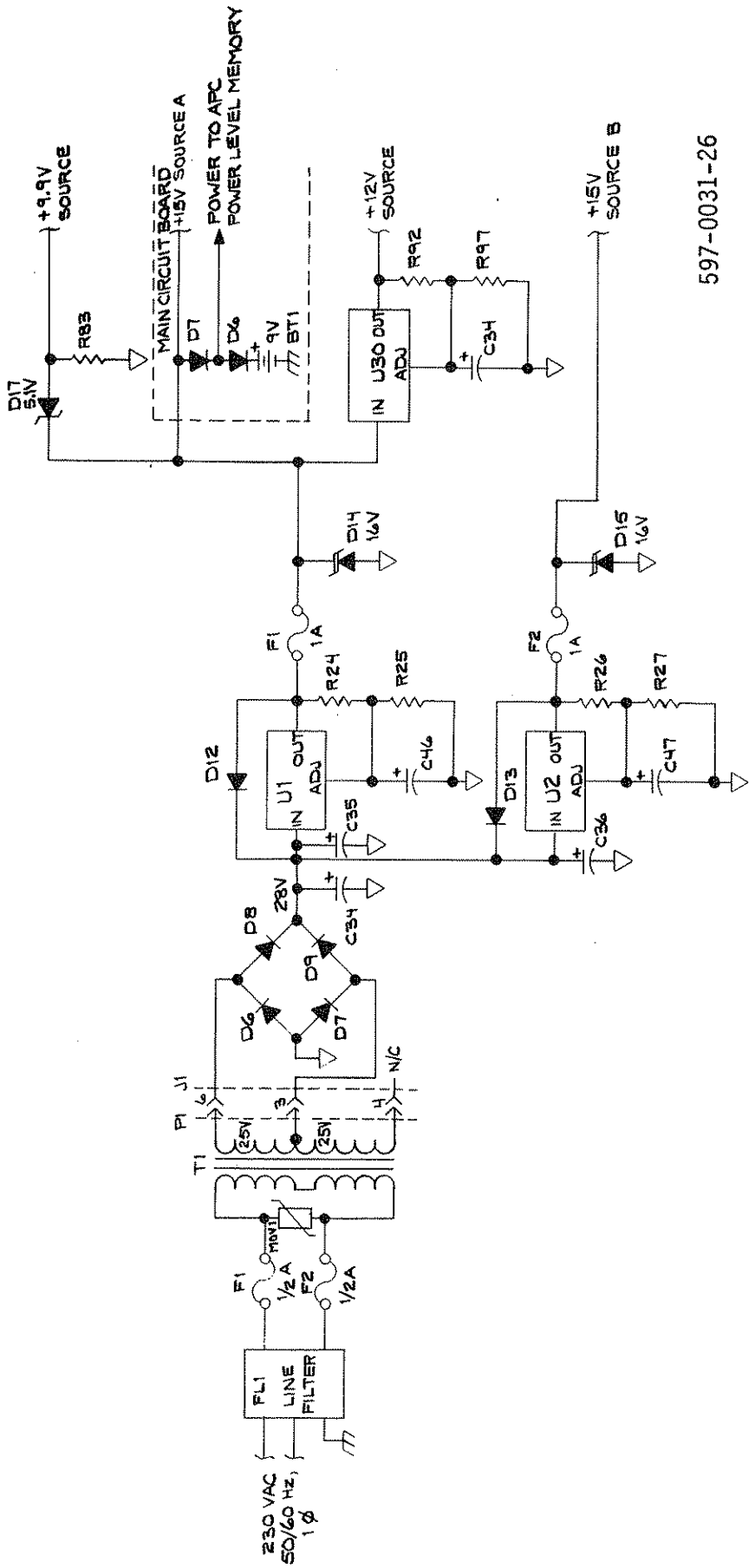

FIGURE 1-2. APC POWER SUPPLY

1-24. 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.

1-25. 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.

1-26. 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.

1-27. APC LOGIC CIRCUITRY.

1-28. 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).

1-29. When the APC unit is switched off, the $\overline{Q}$ 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.

1-30. 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.

1-31. 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.

1-32. 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.

1-33. A 78.13 Hz square wave is applied through analog switch U13B to one input of U12B. A 39.06 Hz square wave is applied to the second input to U12B from inverter U12A. The resultant logical sum of the inputs to U12B gates the power raise or power lower signal through U10B or U10C.

1-34. The power raise or power lower drive is then applied through an inverter to a Darlington 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.

1-35. When the output of a Darlington stage goes LOW, the resultant output of up/down flip-flop U1B/U1C will enable the up/down counter (U3/U4) 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. Clock for the up/down counter is derived from the input signal via U1A and U1D. When the carry output of the up/down counter goes LOW, it will halt the clock and prevent the up/down counter from "rolling over" at maximum (1111 1111) or minimum (ØØØØ ØØØØ) count.

1-36. During normal operation, transistor Q1 will be constantly energized. When power is applied to the transmitter, current will be applied to the up/down counter with Q1 off. This action will reset the up/down counter to minimum count, representative of minimum transmitter RF power output. After a short delay determined by the value of C2, R4, and R5, Q1 will energize and the reset line will go LOW to terminate the reset.

1-37. The up/down counter will begin to output eight-bit digital words as soon as input raise or lower command is applied. The eight-bit digital output of the up/down counter is converted to a dc level by the digital-to-analog converter consisting of U5, U6, and R8 through R23. This level is buffered by U7A and U7B and output as control voltage for the exciter.

1-38. The RAISE and LOWER indicators are driven by the raise and lower input commands. These commands are clocked through NOR gates U2A and U2B by inverted carry signal through NOR gate U26. Q2 and Q3 function as output stages which apply a ground to one side of the appropriate indicator to illuminate the indicator.

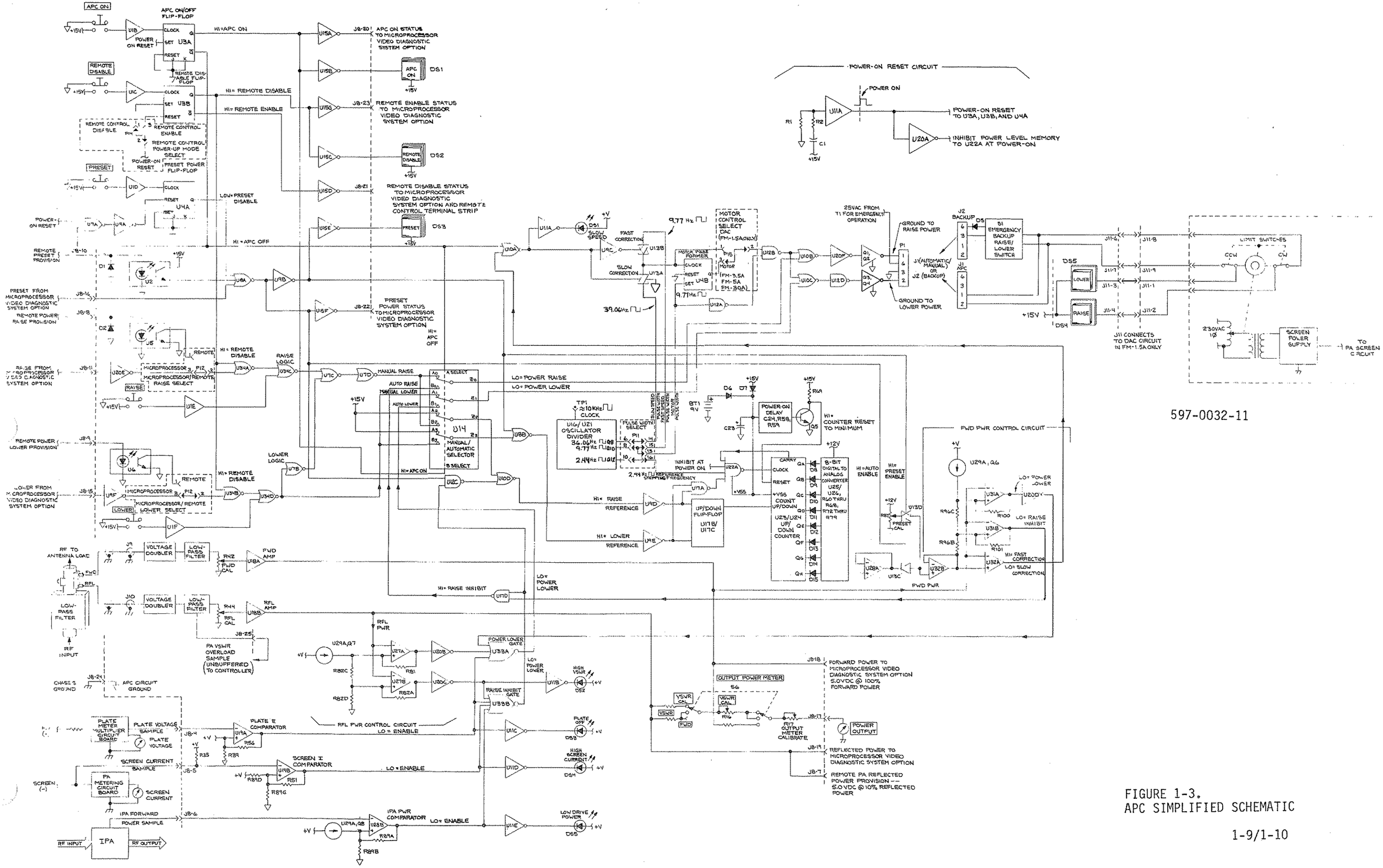

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FIGURE 1-3.
APC SIMPLIFIED SCHEMATIC

1-9/1-10

1-39. AUTOMATIC OPERATION. When power is first applied to the APC, a high-going pulse will be generated by U11 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.

1-40. 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).

1-41. 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.

1-42. 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.

1-43. 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.

1-44. 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.

1-45. 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 (U26/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.

1-46. 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.

1-47. 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 vary the APC output directly as in manual operation, but change the count stored in the up/down counter (U23, U24) which establishes the RF output level with a dc reference voltage.

1-48. 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.

1-49. 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.

1-50. 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.

1-51. 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. When the carry output of the up/down counter goes LOW, it will halt the clock and prevent the up/down counter from "rolling over" at maximum (1111 1111) or minimum (ØØØØ ØØØØ) count.

1-52. 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.

1-53. 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 where the forward power differs greatly from the fixed set-point.

1-54. In automatic operation, slow-speed and fast-speed correction is used. The lower frequency signal from U13A will provide slower correction as the clock rate is slower. The higher frequency signal from U13B will provide faster correction as the clock rate is faster.

1-55. As PA forward power increases to the proper level (approximately 90%), 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.

1-56. 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.

1-57. 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.

1-58. 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.

1-59. 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.

1-60. The remainder of the control circuitry functions in a manner identical to that described by the manual operation discussion.

1-61. 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.

1-62. Constant current source U29A/Q7 establishes two precise voltages across the series string of resistors R82C and R82B. The voltage across R82C creates a deadband 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.

1-63. 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, preventing transmitter overload if a high VSWR exists.

1-64. 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.

1-65. 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.

1-66. 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.

1-67. 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 U18B. A low-pass filter after the rectifiers attenuates carrier envelope modulation caused by the power supply ripple and synchronous audio-rate amplitude modulation.

1-68. 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 set-up of the automatic system set by R42 and R44. This allows adjustment for routine calibration.

1-69. Plate Voltage Monitor Circuit. The soft start circuit monitors actual PA plate voltage. This circuit reduces the exciter output to minimum whenever plate voltage is off. Whenever the plate voltage is above the trip point, the circuit will gradually increase the exciter output until the rated transmitter RF output is established unless limited by a high VSWR condition, as gated by U33B.

1-70. 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.

1-71. 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.

1-72. 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

NOTE PROVISION TO REMOTELY ADJUST POWER IS PROVIDED IN THIS MODE.

1-73. 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 U10C 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.

1-74. 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.

SECTION II

APC MAINTENANCE

2-1. INTRODUCTION.

2-2. This section provides maintenance information for the FM-1.5A Automatic Power Control Unit (APC).

2-3. SAFETY CONSIDERATIONS.

2-4. The FM-1.5A 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 NEVER OPEN THE EQUIPMENT UNLESS ALL TRANSMITTER PRIMARY POWER IS DISCONNECTED.

WARNING DUE TO THE PROGRAMMING OF THE EQUIPMENT, THE APC UNIT WILL ENTER THE REMOTE ENABLED MODE

WARNING WHENEVER AC POWER IS APPLIED. TO PREVENT INADVERTENT REMOTE START-UP DURING MAINTENANCE

WARNING 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-1.5A 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.

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 (R42). To adjust the FWD CAL control (R42) on the main circuit board, proceed as follows. 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 paragraph 2-44.

2-10. Required Equipment. The following equipment is required to adjust the 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 3 1/2 digit model.

D. Test load and connecting line (50 Ohm non-inductive, 7/8 inch line input, 1500 Watt minimum).

E. Calibrated in-line wattmeter with 7/8 inch sampling section and cables (Bird 460 or equivalent).

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

WARNING ASSURE ALL PRIMARY POWER IS DISCONNECTED BEFORE PROCEEDING.

2-12. Disconnect primary power.

2-13. Connect the voltmeter between U18A, pin 1 and chassis ground.

2-14. Connect the test load and wattmeter to the transmitter output.

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 USE AN INSULATED TOOL FOR ADJUSTMENT.

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.

2-16. Using the insulated adjustment tool, adjust 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, ADJUST R17 PER PARAGRAPH 2-44 BEFORE PROCEEDING.

WARNING ASSURE ALL PRIMARY POWER IS DISCONNECTED BEFORE PROCEEDING.

2-17. Disconnect primary power.

2-18. Remove the test equipment and reconnect the transmitter output to the antenna load.

2-19. RFL CAL (R44). To adjust the RFL CAL control (R44) on the main circuit board, proceed as follows. 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.

2-20. Required Equipment. The following equipment is required to adjust the 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 equivalent).

D. BNC plug-to-plug adapter, UG-491B/U (BE P/N 417-0116).

E. Digital voltmeter, Fluke 75 or equivalent 3 1/2 digit model.

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

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% powr output and verify the VSWR CAL control is set at 100%.

2-23. Determine the RMS voltage (E) required to calibrate R44 as follows:

Transmitter 100% RF output power=_____Watts.
10% of transmitter rated RF output power=_____Watts =P.

FORMULA $E = \frac{\sqrt{P \times 50 \text{ Ohms}}}{100}$

EXAMPLE Transmitter rated RF output power = 1500 Watts.
10% of transmitter RF output power = 150 Watts (P).

$E = \frac{\sqrt{150 \times 50}}{100}$ $E = \frac{\sqrt{7500}}{100}$

$E = \frac{86.60}{100}$ E = 0.87V RMS

WARNING ASSURE ALL PRIMARY POWER IS DISCONNECTED BEFORE PROCEEDING.

2-24. Disconnect primary power.

2-25. Connect the voltmeter between U18B, pin 7 and chassis ground.

2-26. Disconnect cables 160 and 161 from the APC and route cable 160 out the top of the transmitter.

2-27. Assemble the RF millivoltmeter probe, 50 Ohm termination, and the BNC plug-to-plug adapter.

2-28. Connect the RF millivoltmeter to cable 160.

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

USE AN INSULATED TOOL FOR ADJUSTMENT.

2-29. Apply power and operate the transmitter in the local manual mode (REMOTE DISABLE illuminated, APC ON out).

2-30. Manually adjust the transmitter RF output power to obtain a millivoltmeter indication of the voltage (E) calculated in paragraph 2-23.

WARNING

ASSURE ALL PRIMARY POWER IS DISCONNECTED BEFORE PROCEEDING.

2-31. Disconnect primary power.

2-32. Disconnect the millivoltmeter from cable 160. Route the cable back inside the transmitter and connect cable 160 to the APC RFL PWR RF SAMPLE input (J10).

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

USE AN INSULATED TOOL FOR ADJUSTMENT.

2-33. Apply power and operate the transmitter in the local manual mode (REMOTE DISABLE illuminated, APC ON out).

2-34. Using the insulated adjustment tool, adjust R44 on the main circuit board for a voltmeter indication of +5.00V dc.

WARNING

ASSURE ALL PRIMARY POWER IS DISCONNECTED BEFORE PROCEEDING.

2-35. Disconnect primary power.

2-36. Remove the test equipment, reconnect cable 160 from the APC FWD PWR RF SAMPLE input (J9) to the FWD directional coupler port, and reconnect cable 161 from the APC RFL PWR RF SAMPLE input (J10) to the RFL directional coupler port.

2-37. PRESET CAL (R87). To adjust the PRESET CAL control (R87) on the main circuit board, proceed as follows. 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.

2-38. Required Equipment. The following equipment is required to adjust the PRESET CAL control (R87).

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

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

2-39. Procedure. To adjust the control, proceed as follows:

WARNING MAINTENANCE WITH POWER ENERGIZED IS ALWAYS CONSIDERED HAZARDOUS AND THEREFORE CAUTION

WARNING SHOULD BE OBSERVED. DO NOT TOUCH ANY COMPONENTS WITHIN THE APC WHEN POWER IS ENERGIZED.

WARNING USE AN INSULATED TOOL FOR ADJUSTMENT.

2-40. Apply power and operate the transmitter in the local automatic mode (REMOTE DISABLE and APC ON illuminated).

2-41. Operate the OUTPUT POWER METER switch to FWD.

2-42. Depress the PRESET POWER switch/indicator.

2-43. Using the insulated adjustment tool, adjust R87 until the desired percentage of RF power output is indicated by the OUTPUT POWER meter.

2-44. OUTPUT METER CALIBRATE (R17). To adjust the output meter calibrate control (R17) on the front panel circuit board, proceed as follows. This adjustment will be required only if the OUTPUT POWER meter or potentiometer R17 is replaced.

2-45. The FWD CAL control (R42) must be checked and adjusted if required before R17 is adjusted (refer to paragraph 2-9).

2-46. Required Equipment. The following equipment is required to adjust the 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 3 1/2 digit model.

D. Test load and connecting line (50 Ohm non-inductive, 7/8 inch line input, 1500 Watt minimum).

E. Calibrated in-line wattmeter with 7/8 inch sampling section and cables (Bird 460 or equivalent).

2-47. Procedure. To adjust the control, proceed as follows:

WARNING ASSURE ALL PRIMARY POWER IS DISCONNECTED BEFORE PROCEEDING.

2-48. Disconnect primary power.

2-49. Connect the voltmeter between U18A, pin 1 and chassis ground.

2-50. Connect the test load and wattmeter to the transmitter output.

WARNING MAINTENANCE WITH POWER ENERGIZED IS ALWAYS CONSIDERED HAZARDOUS AND THEREFORE CAUTION SHOULD

WARNING BE OBSERVED. DO NOT TOUCH ANY COMPONENTS WITHIN THE APC WHEN POWER IS ENERGIZED.

WARNING USE AN INSULATED TOOL FOR ADJUSTMENT.

2-51. Apply power and operate the transmitter in the local manual mode (REMOTE DISABLE illuminate, APC ON out) at the desired 100% RF power output as indicated by the in-line wattmeter.

2-52. Using the insulated adjustment tool, adjust the FWD CAL control (R42) on the main circuit board for a voltmeter indication of +5.00V dc.

2-53. Operate the OUTPUT POWER METER switch to FWD.

2-54. Using the insulated adjustment tool, adjust R17 to obtain a 100% OUTPUT POWER meter indication. The VSWR CAL control must also be adjusted to 100%.

WARNING ASSURE ALL PRIMARY POWER IS DISCONNECTED BEFORE PROCEEDING.

2-55. Disconnect primary power.

2-56. Remove the test equipment and reconnect the transmitter output to the antenna load.

2-57. 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

WARNING ARE DISCHARGED BEFORE ATTEMPTING MAINTENANCE ON ANY AREA WITHIN THE TRANSMITTER.

2-58. 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.

2-59. 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.

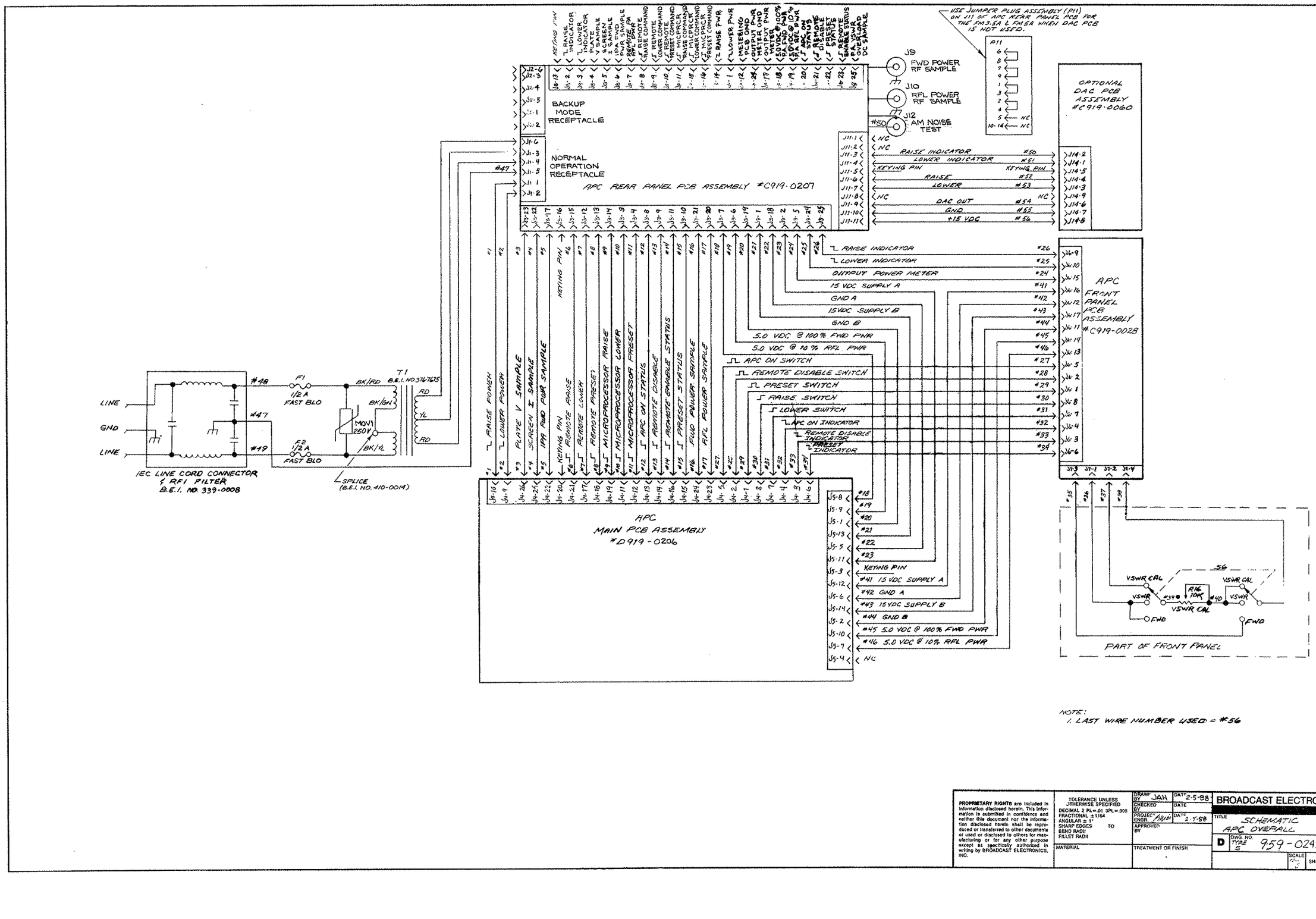
2-60. If a circuit is diagnosed as faulty, the circuit fault may be isolated and repaired locally or the entire device may be returned to Broadcast Electronics, Inc. for exchange, alignment, or replacement.

SECTION III
DRAWINGS

3-1. INTRODUCTION.

3-2. This section provides assembly drawings and schematic diagrams, as listed below for the FM-1.5A Transmitter Automatic Power Control Unit.

FIGURE	TITLE	NUMBER
3-1	SCHEMATIC, APC OVERALL	SD959-0243
3-2	ASSEMBLY, APC OVERALL	597-0031-23
3-3	SCHEMATIC, MAIN CIRCUIT BOARD	SD919-0206
3-4	ASSEMBLY, MAIN CIRCUIT BOARD	AD919-0206
3-5	APC MAIN CIRCUIT BOARD COMPONENT LOCATOR	597-0032-38
3-6	SCHEMATIC, FRONT PANEL CIRCUIT BOARD	SC919-0028
3-7	ASSEMBLY, FRONT PANEL CIRCUIT BOARD	AC919-0028
3-8	SCHEMATIC, REAR PANEL CIRCUIT BOARD	SD919-0207
3-9	ASSEMBLY, REAR PANEL CIRCUIT BOARD	AD919-0207
3-10	SCHEMATIC, DIGITAL-TO-ANALOG CONVERTER CIRCUIT BOARD	SD919-0060-001
3-11	ASSEMBLY, DIGITAL-TO-ANALOG CONVERTER CIRCUIT BOARD	AC919-0060-001
3-12	APC PROGRAM NETWORKS	597-0031-22



NOTE:
1. LAST WIRE NUMBER USED = #56

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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
TREATMENT OR FINISH

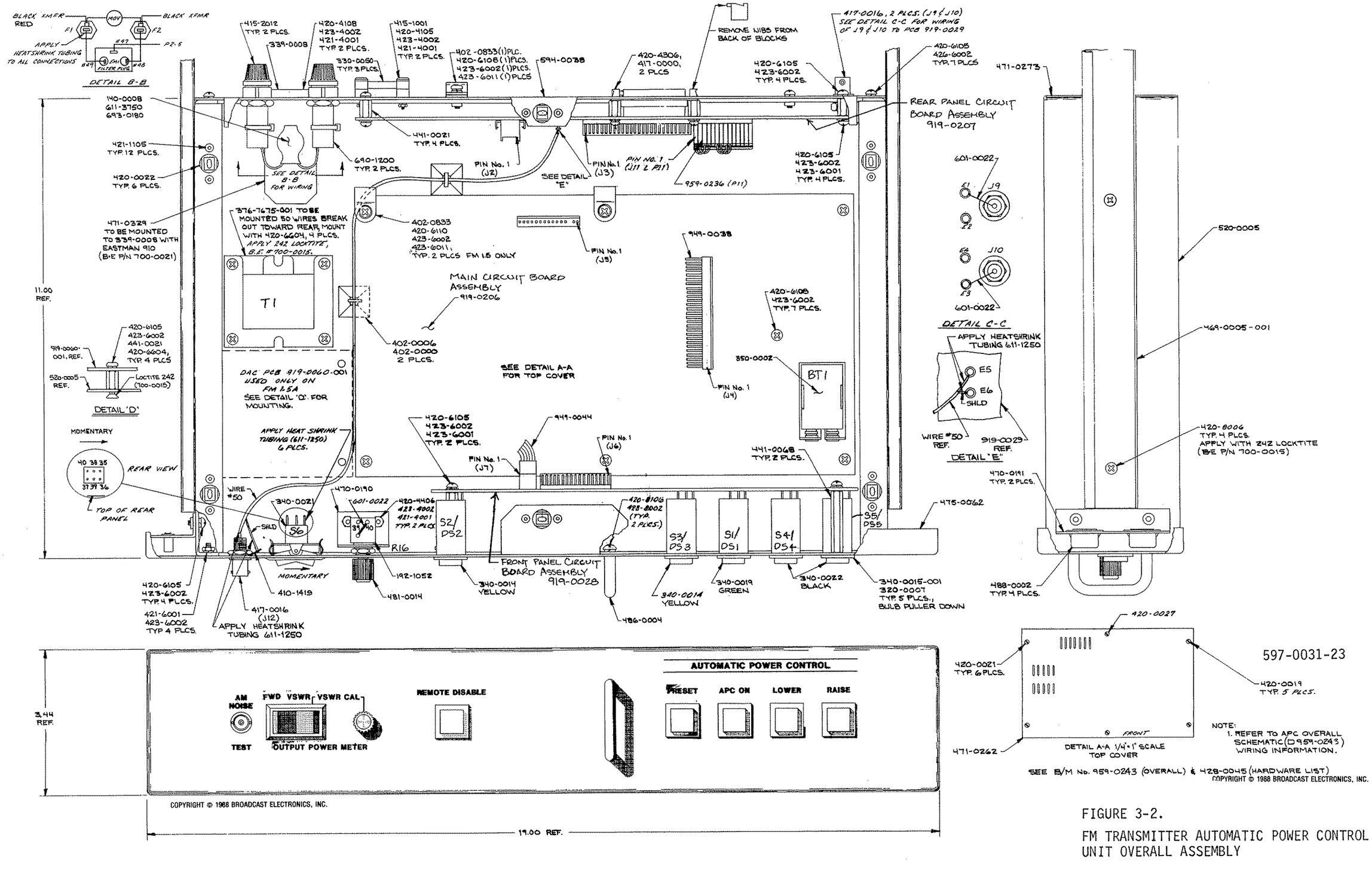
DRAWN BY JAH DATE 2-5-88
CHECKED BY DATE
PROJECT ENGR. JAH DATE 2-7-88
APPROVED BY

BROADCAST ELECTRONICS INC.

TITLE SCHEMATIC APC OVERALL

D DWG NO. TYPE S 959-0243 REV. A

SCALE NONE SHEET 1 OF 1



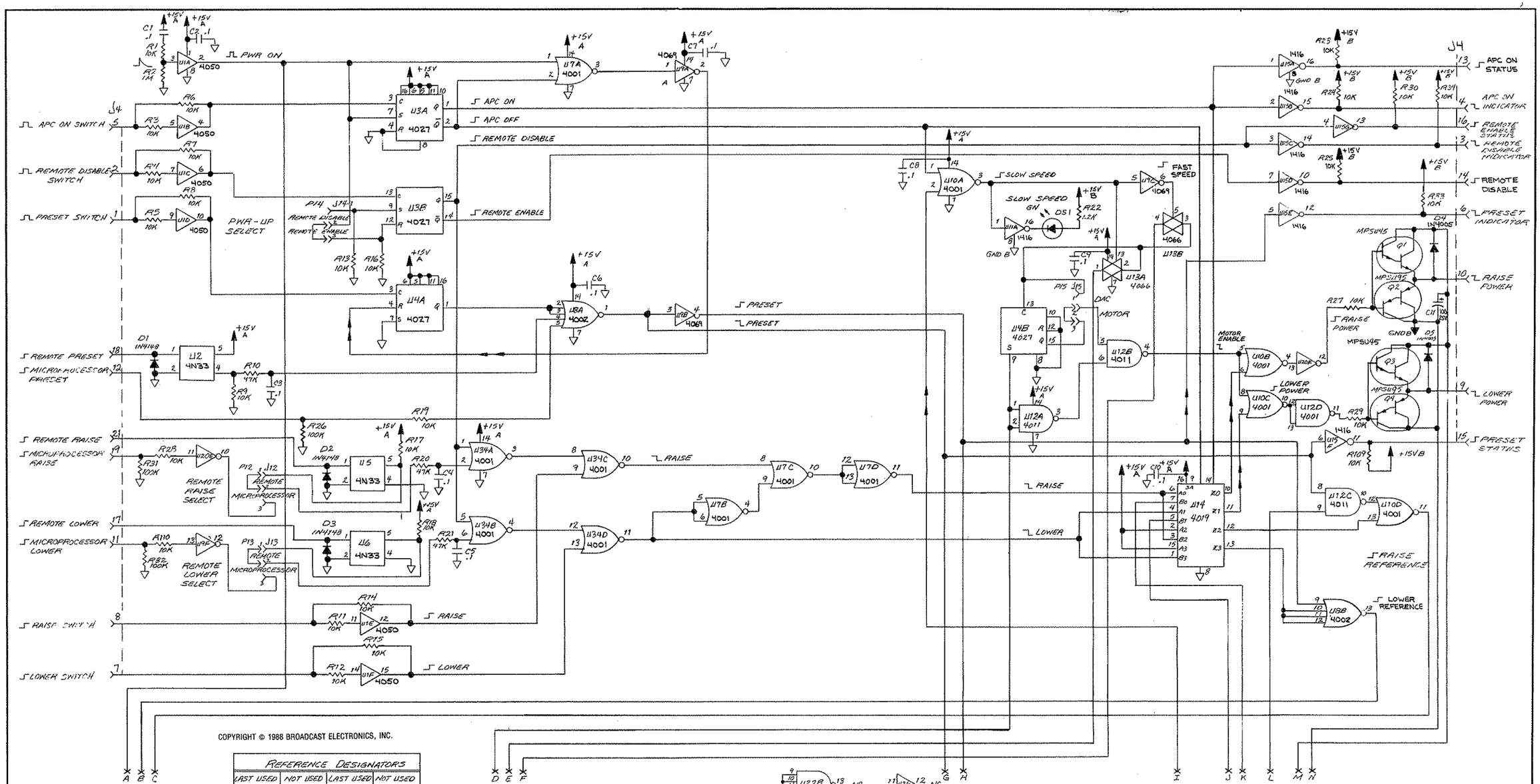
597-0031-23

NOTE:
1. REFER TO APC OVERALL SCHEMATIC (D959-0243) WIRING INFORMATION.

SEE B/M No. 959-0243 (OVERALL) & 428-0045 (HARDWARE LIST)

FIGURE 3-2.

FM TRANSMITTER AUTOMATIC POWER CONTROL UNIT OVERALL ASSEMBLY



REFERENCE DESIGNATORS			
LAST USED	NOT USED	LAST USED	NOT USED
C29	U29-B	DS5	U26-E,F
D17	U11-F,G	TP1	R36, R37
J15		BT1	R42, R50
Q8			R70, R71
R113	U22-B		R85, R88
U34	U25-E,F		R95, R97
			R99

NOTE:
1. RESISTORS IN OHMS, ¼ W 5%; CAPACITORS IN MICROFARADS, U.O.S.
2. SEE PCB ASSY. #D919-0206
   SEE B/M #919-0206

REFERENCE DESIGNATORS	U1, U25 & U26	U2, U5, & U6	U3 & U14	U7, U10 & U34	U8 & U33	U9 & U20	U11 & U15	U12 & U17	U13	U16	U18, U19, U27-U29, U31 & U32	U21	U22	U23 & U24	U30
B.E. PART NO.	228-4050	229-0033	225-0003	228-4001	228-4002	228-4069	226-2004	228-4011	225-0004	228-4019	220-4047	221-0358	228-4020	228-4012	228-4516	227-0317
VENDOR PART NO.	4050	4N33	4027	4001	4002	4069	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	———

TOLERANCE UNLESS OTHERWISE SPECIFIED
DECIMAL ± PL=.01 3PL=.005
FRACTIONAL ±1/64
ANGULAR ± 1°
SHARP EDGES TO BEND RADII
FILLET RADII
MATERIAL
TREATMENT OR FINISH

DRAWN BY MH DATE 1-19-88
CHECKED BY DATE
PROJECT ENGR. BMM DATE 1-21-88
APPROVED BY

BROADCAST ELECTRONICS INC.

TITLE SCHEMATIC
APC MAIN PCB

D DWG. NO. TYPE S 919-0206 REV. A

APC SCALE N.T.S. SHEET 1 OF 2

TP-1 CLOCK
A52 10M
U16 4047
C18 .0022
R47 10K
U21 4020
U11
MOTOR PULSE FREQUENCY
SLOW SPEED PULSE WIDTH
FAST SPEED PULSE WIDTH
REFERENCE STEPPING FREQUENCY
BT-1 9V
D7 IN4148
D6 IN4148
R58 1M
R59 2.2M
C24 .1
MPSA14 Q5
R62 470K
D16 IN4148
R57 1K
C23 100 25V
R69 1M
U24 4516
U25 4050
U26 4050
R60 R61 R63 R64 R65 R66 R67 R68 120K
D8 D9 D10 D11 D12 D13 D14 D15 IN4148
R72 1.91M
R73 634K 1%
R74 324K 1%
R75 162K 1%
R76 80.6K 1%
R77 40.2K 1%
R78 20.0K 1%
R79 10.0K 1%
C25 C26 C27 .1
U22A 4012
U17A U17B U17C U17D 4011
U19A U19B U19C U19D 4069
RAISE REFERENCE
LOWER REFERENCE
POWER ON
C20 .1
R53 10
R54 10K
U20A
J4
FWD POWER SAMPLE 24
RFL POWER SAMPLE 23
PLATE V SAMPLE 26
SCREEN I SAMPLE 25
IPA FWD PWR SAMPLE 22
KEYING PIN 20
NC
C13 390pF
C16 .0022
R40 10K
MULTI-TURN R42 50K
FWD CAL
R43 22K
R46 10K
FWD GAIN
U18A LM358
5.0 VDC @ 100% FWD PWR
C14 390pF
C17 .0022
R41 910
MULTI-TURN R44 100K
RFL CAL
R45 910
RFL GAIN
R55 10
C21 .1
U18B LM358
5.0 VDC @ 10% RFL PWR
R38 10K
C19 390pF
R39 2K
U19A LM358
R56 10M
PLATE OFF
R35 150K
R59D
SCREEN CURRENT CAL
R46 10K
U19B LM358
R51 10M
HIGH SCREEN CURRENT
C15 4.7 35V
R89C
SCREEN CURRENT CAL
COPYRIGHT © 1988 BROADCAST ELECTRONICS, INC.
+15V A
+12V
+0.7 TO +11.3VDC
R84 10
C30 .1
U29A LM358
PRESET RANGE LIMIT
U13C 4066
R86A
PRESET CAL
R87 5K
R86B
U13D 4066
R86C
REFERENCE RANGE LIMIT
R91 10.0K 1%
C31 .1
C33 4.7 35V
U30 LM317 ADJ
C34 4.7 35V
R92 1%
R98 1.00K 1%
+12V SOURCE
C36 4.7 35V
C39 10µF
R113 10K
D17 IN4733 5.1V
R83 5.1K
C29 .1
R90 10
C32 .1
R94 5.1K
R103 5.1K
R108 5.1K
Q6 2N3906
Q7 2N3906
Q8 2N3906
C38 .1
R99 10
LM358 U31 U32
R100 390K
R101 390K
R96C APC DEAD BAND
R96B SLOW SPEED DEAD BAND
R97 1K
R96D REFERENCE RANGE LIMIT
R102 10
C37 .1
C35 330pF
RAISE ENABLE
SLOW SPEED ENABLE
R112 100K
U30A 4069
J5
15 VDC SUPPLY A
15 VDC SUPPLY A
15 VDC SUPPLY B
15 VDC SUPPLY B
GND A
GND A
GND B
GND B
KEYING PIN
NC
NC
5.0 VDC @ 100% FWD PWR
5.0 VDC @ 100% FWD PWR
5.0 VDC @ 10% RFL PWR
5.0 VDC @ 10% RFL PWR
R80 10
C28 .1
U27A U27B LM358
R81 390K
R82A R82B R82C
VSWR FOLDBACK
VSWR LIPPER DEAD BAND
VSWR CAL
VSWR LOWER DEAD BAND
U28A U28B LM358
R89A R89B
DRIVE POWER CAL
DRIVE POWER DEADBAND
U33A U33B 4002
U11A U11B U11C U11D 1416
LOWER
HIGH VSWR
RAISE ENABLE
RAISE
DS2 RD HIGH VSWR
DS3 RD PLATE OFF
DS4 RD HIGH SCREEN CURRENT
DS5 RD LOW DRIVE POWER
R104 1.2K
R105 1.2K
R106 1.2K
R107 1.2K
LOW DRIVE POWER
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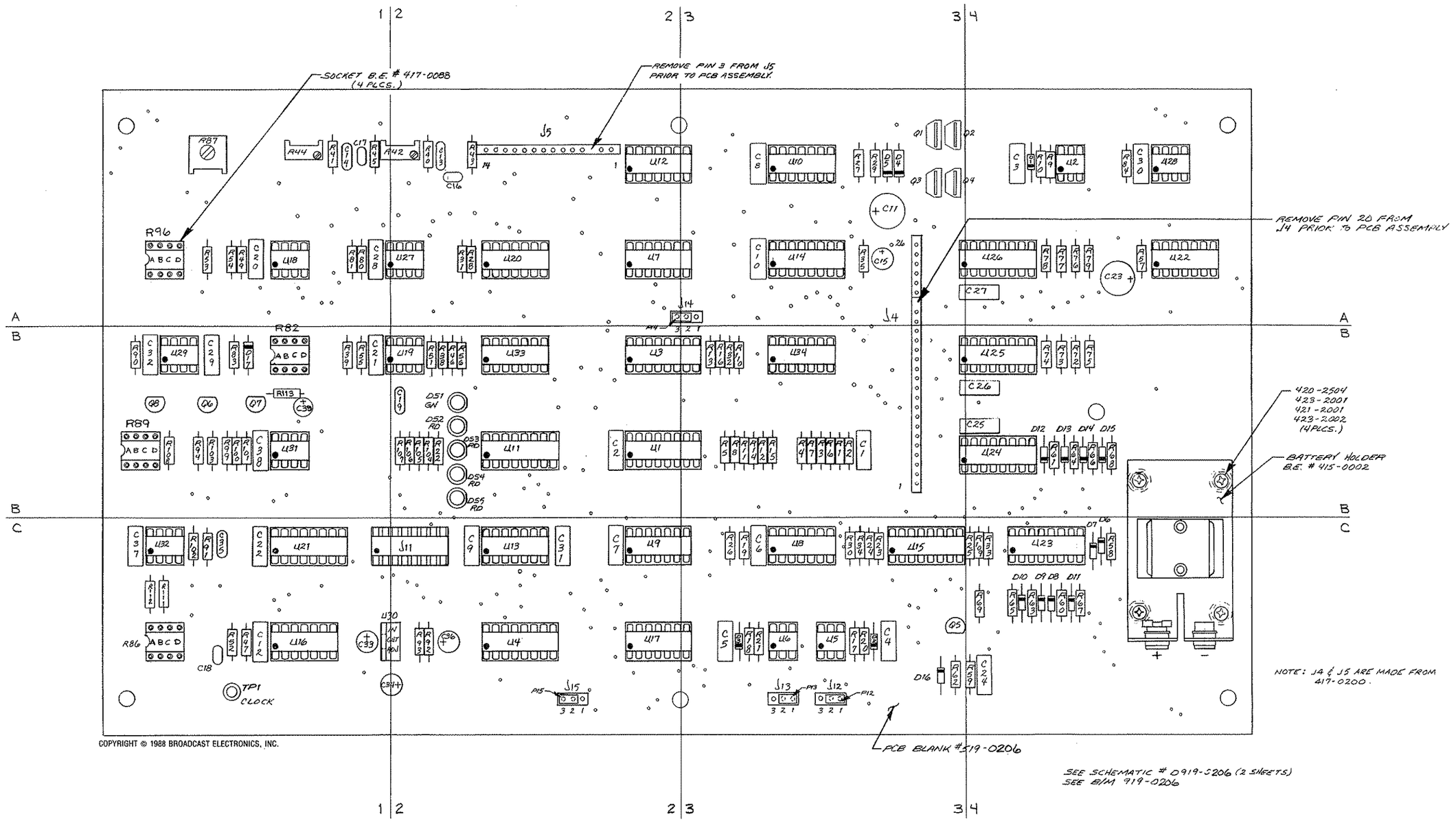
TOLERANCE UNLESS OTHERWISE SPECIFIED
DECIMAL 2 PL=.01 3PL=.005
FRACTIONAL ±1/64
ANGULAR ± 1°
SHARP EDGES TO BEND RADII
FILLET RADII
MATERIAL
TREATMENT OR FINISH

DRAWN BY JAH DATE 1-19-88
CHECKED BY DATE
PROJECT ENGR. DATE 1-26-88
APPROVED BY

BROADCAST ELECTRONICS INC.
TITLE SCHEMATIC APC. MAIN. PCB
D DWG. NO. 919-0206 REV. A
SIZE APC SCALE NTS SHEET 2 OF 2



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

MATERIAL

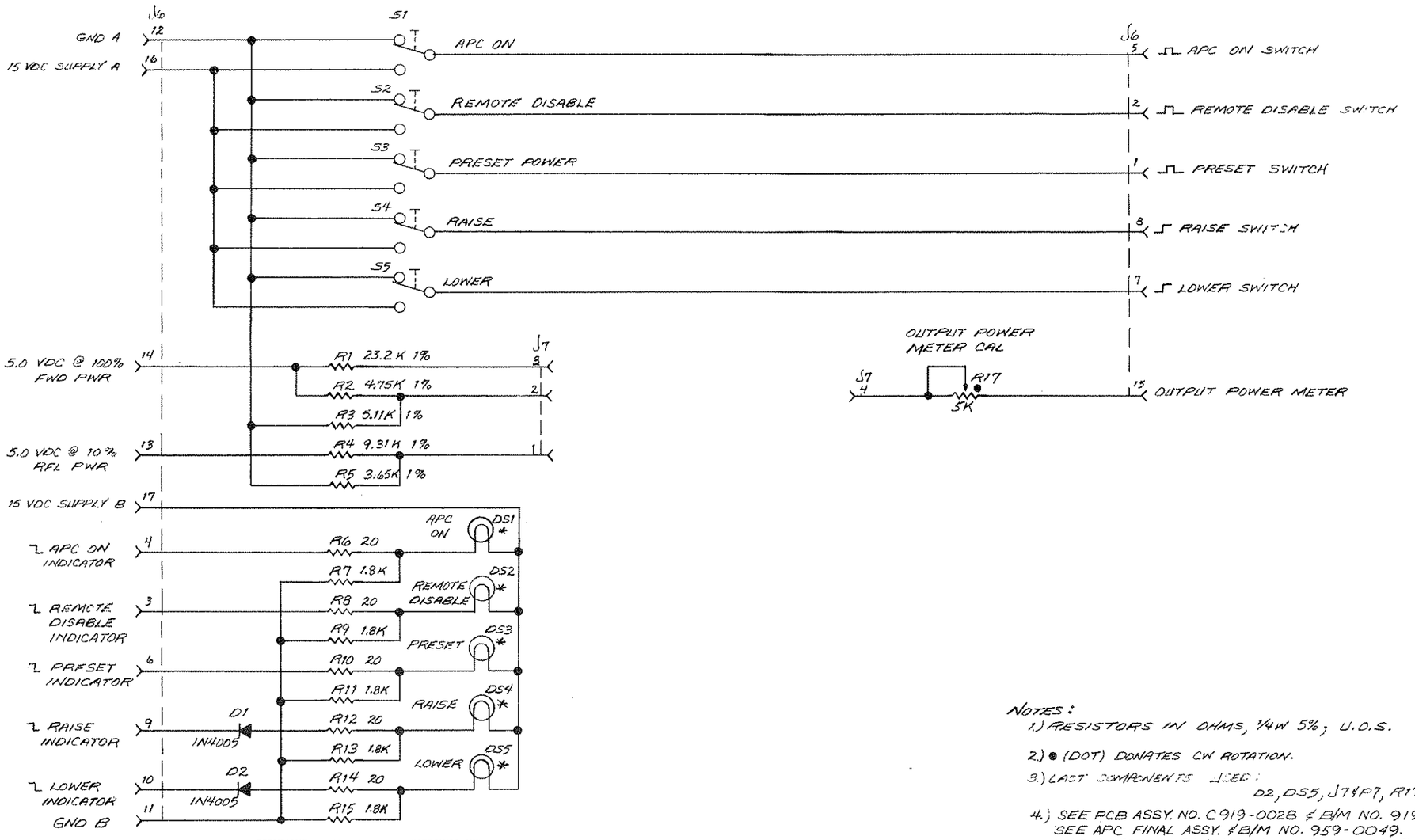
TREATMENT OR FINISH

DRAWN BY JAH	DATE 1-19-88	BROADCAST ELECTRONICS INC.
CHECKED BY	DATE	
PROJECT ENGR Bmm	DATE 1-26-88	TITLE PCB ASSEMBLY APC MAIN P.B.
APPROVED BY		D DWG. NO. TYPE A 919-0206 REV. A
		APC SCALE 2/1 SHEET 1 OF 1

REF	ZONE	REF	ZONE	REF	ZONE	REF	ZONE	REF	ZONE	REF	ZONE
BT1	C4	C39	B1	R2	B3	R41	A1	R80	A1	U5	C3
C1	B3	D1	A4	R3	B3	R42	A1-A2	R81	A1	U6	C3
C2	B2	D2	C3	R4	B3	R43	A2	R82	B1	U7	A2-A3
C3	A4	D3	C3	R5	B3	R44	A1	R83	B1	U8	C3
C4	C3	D4	A3	R6	B3	R45	A1	R84	A4	U9	C2-C3
C5	C3	D5	A3	R7	B3	R46	B2	R85	--	U10	A3
C6	C3	D6	C4	R8	B3	R47	C1	R86	C1	U11	B2
C7	C2	D7	C4	R9	A4	R48	--	R87	A1	U12	A2-A3
C8	A3	D8	C4	R10	A4	R49	A1	R88	--	U13	C2
C9	C2	D9	C4	R11	B3	R50	--	R89	B1	U14	A3
C10	A3	D10	C4	R12	B3	R51	B2	R90	B1	U15	C3
C11	A3	D11	C4	R13	B3	R52	C1	R91	C1	U16	C1
C12	C1	D12	B4	R14	B3	R53	A1	R92	C2	U17	C2-C3
C13	A2	D13	B4	R15	B3	R54	A1	R93	C2	U18	A1
C14	A1	D14	B4	R16	B3	R55	B1	R94	B1	U19	B2
C15	A3	D15	B4	R17	C3	R56	B2	R95	--	U20	A2
C16	A2	D16	C3	R18	C3	R57	A4	R96	A1	U21	C1
C17	A1	D17	B1	R19	C3	R58	C4	R97	--	U22	A4
C18	C1	DS1	B2	R20	C3	R59	C4	R98	--	U23	C4
C19	B2	DS2	B2	R21	C3	R60	C4	R99	B1	U24	B4
C20	A1	DS3	B2	R22	B2	R61	B4	R100	B1	U25	B4
C21	B1	DS4	B2	R23	C3	R62	C3	R101	B1	U26	A4
C22	C1	DS5	B2	R24	C3	R63	C4	R102	C1	U27	A1-A2
C23	A4	J4	A3-B3	R25	C4	R64	B4	R103	B1	U28	A4
C24	C4	J5	A2	R26	C3	R65	C4	R104	B2	U29	B1
C25	B4	J11	C1-C2	R27	A3	R66	B4	R105	B2	U30	C1-C2
C26	B4	J12	C3	R28	A2	R67	C4	R106	B2	U31	B1
C27	A4	J13	C3	R29	A3	R68	B4	R107	B2	U32	C1
C28	A1	J14	B2-B3	R30	C3	R69	C4	R108	B1	U33	B2
C29	B1	J15	C2	R31	A2	R70	--	R109	C4	U34	B3
C30	A4	Q1	A3	R32	B3	R71	--	R110	B3		
C31	C2	Q2	A3	R33	C4	R72	B4	R111	C1		
C32	B1	Q3	A3	R34	C3	R73	B4	R112	C1		
C33	C1	Q4	A3	R35	A3	R74	B4	R113	B1		
C34	C1-C2	Q5	C3	R36	--	R75	B4	TP1	C1		
C35	C1	Q6	B1	R37	--	R76	A4	U1	B2-B3		
C36	C2	Q7	B1	R38	B2	R77	A4	U2	A4		
C37	C1	Q8	B1	R39	B1	R78	A4	U3	B2-B3		
C38	B1	R1	B3	R40	A2	R79	A4	U4	C2		

597-0032-38

FIGURE 3-5. APC MAIN CIRCUIT BOARD COMPONENT LOCATOR



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 #80-311364 IND. STD. #73 14 V, 15,000 HR.
DS1 IS LOCATED WITHIN S1, DS2 IS LOCATED WITHIN S2 AND SO ON.

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 DRF	DATE 12-14-82	
CHECKED BY	DATE	
PROJECT ENGR. JMM	DATE 5/5/83	
APPROVED BY MH	5-6-83	

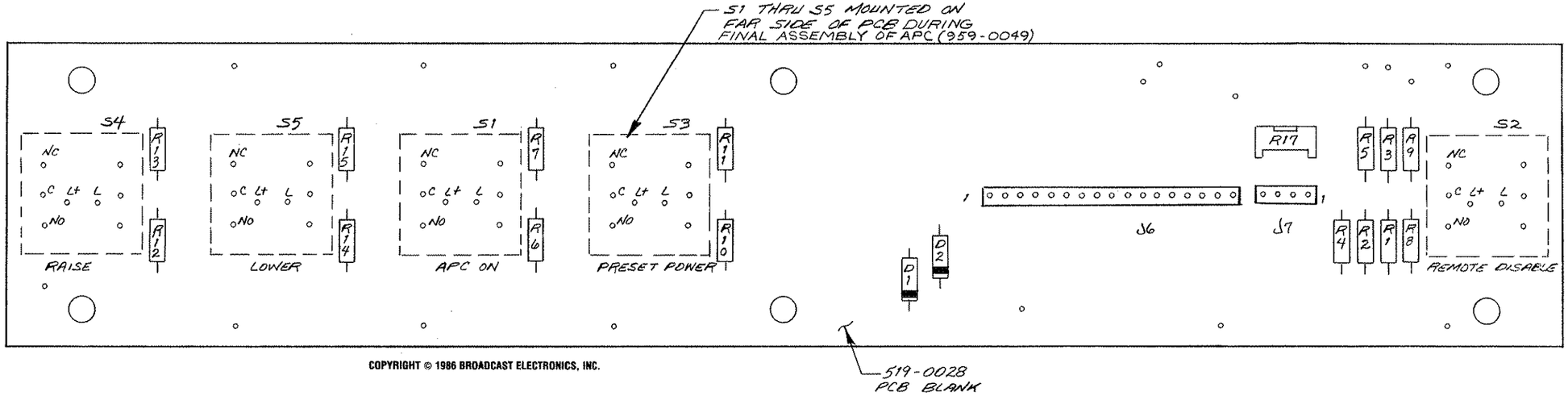
TREATMENT OR FINISH

BROADCAST ELECTRONICS INC.

TITLE SCHEMATIC
APC FRONT PANEL PCB ASSEMBLY

C DWG. NO. TYPE: S 919-0028 REV. B

APC (959-0049) SCALE NTS SHEET 1 OF 1



NOTE: J6 & J7 ARE MADE FROM 417-0200.

SEE SCHEMATIC C919-0028
SEE BIM 919-0028

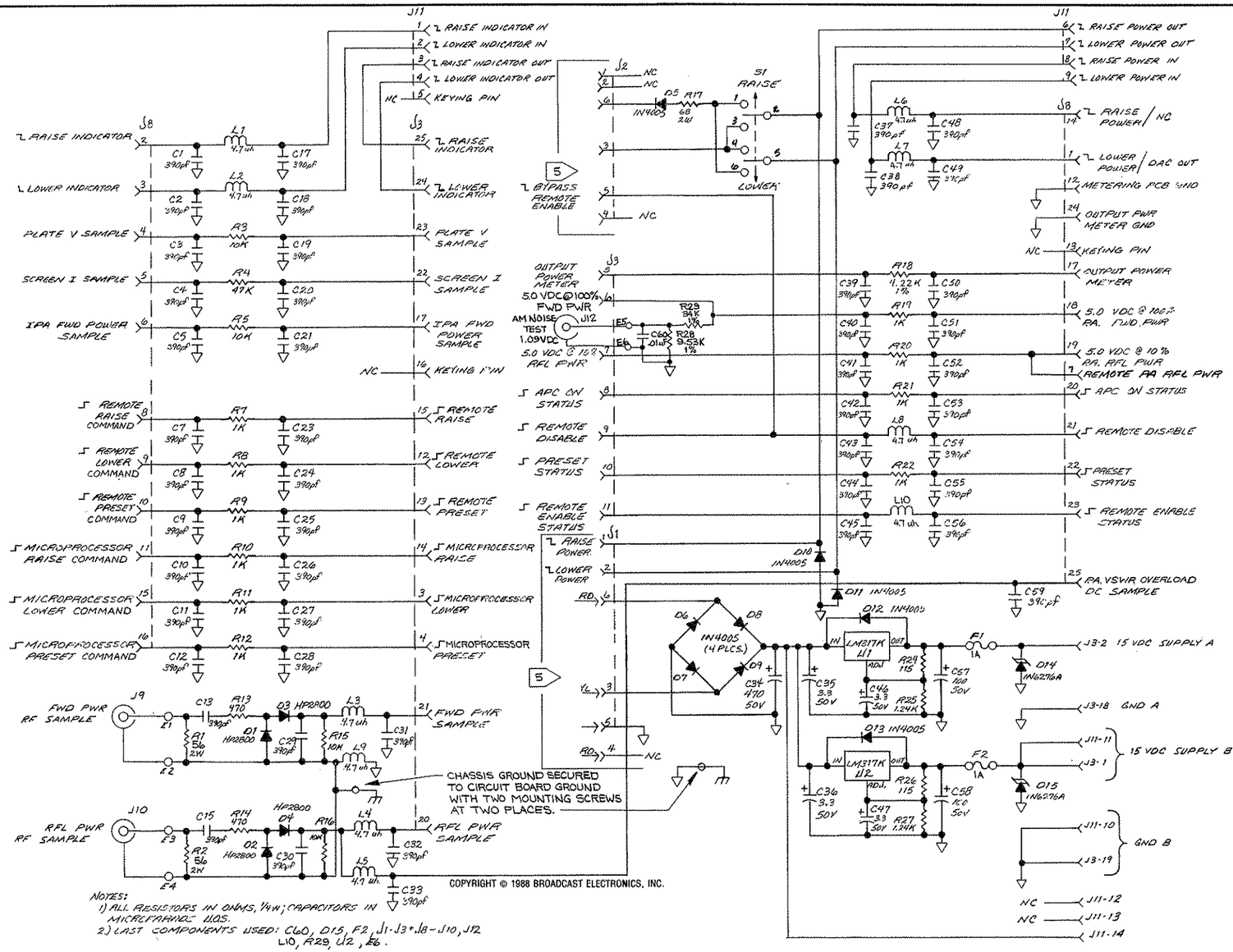
TOLERANCE (DECIMAL) U.O.S.
.X ± .030 .XXX ± .005
.XX ± .015 ANGLES ± 1°

DWN. BY	M.S. OFF
CHKD.	
ME	
EE	David 5/5/83
PROJ. ENGR.	David 5/5/83
DFTG. SUPVR.	MH 5-6-83
MFG.	

NEXT ASSY. 959-0049
PRODUCT USED ON APC
FINISH

BROADCAST ELECTRONICS INC.
4100 N. 24TH ST. QUINCY, IL 62305 217/224-9600
TELEX 250142 CABLE BCST ELECT QUI

TITLE PCB ASSEMBLY APC FRONT PANEL
SHEET 1 OF 1
SCALE 2/1
REV B
TYPE A SIZE C DWG. NO. 919-0028



NOTES:

1) ALL RESISTORS IN OHMS, 1/4W; CAPACITORS IN MICROFARADS UNLESS.
2) LAST COMPONENTS USED: C60, D15, F2, J1-J3+J8-J10, J12 L10, R29, U2, E6.
3) COMPONENTS NOT USED: C4, 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 ± PL=.01 3PL=.005
FRACTIONAL ±1/64
ANGULAR ± 1°
SHARP EDGES TO
BEND RADII
FILLET RADII

MATERIAL

TREATMENT OR FINISH

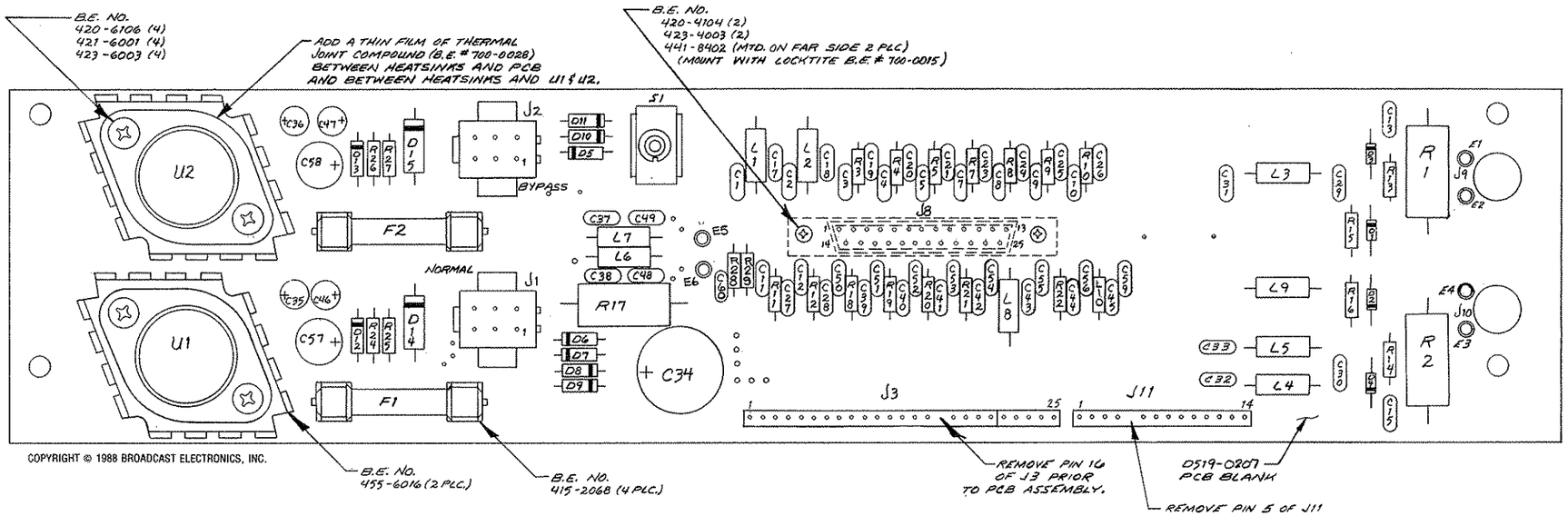
DRAWN BY JAH DATE 1-19-88
CHECKED BY DATE
PROJECT ENGR. DATE 1-26-88
APPROVED BY

BROADCAST ELECTRONICS INC.

TITLE SCHEMATIC APC REAR PANEL PCB

D DWG. NO. 919-0207 REV. A

APL SCALE — SHEET 1 OF 1



SEE SCHEMATIC #D919-0207
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.

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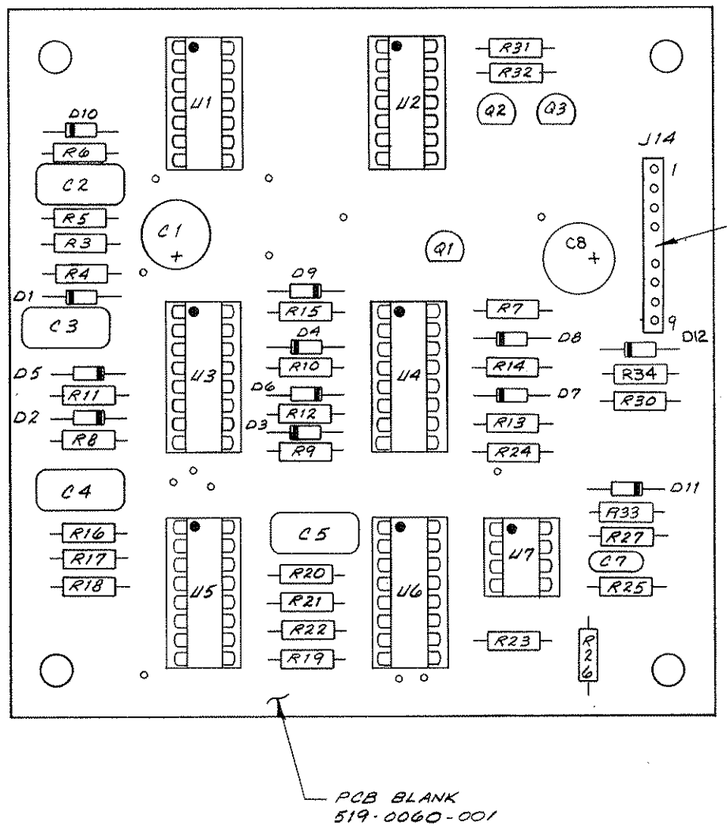


SEE B/M # 919-0060-001

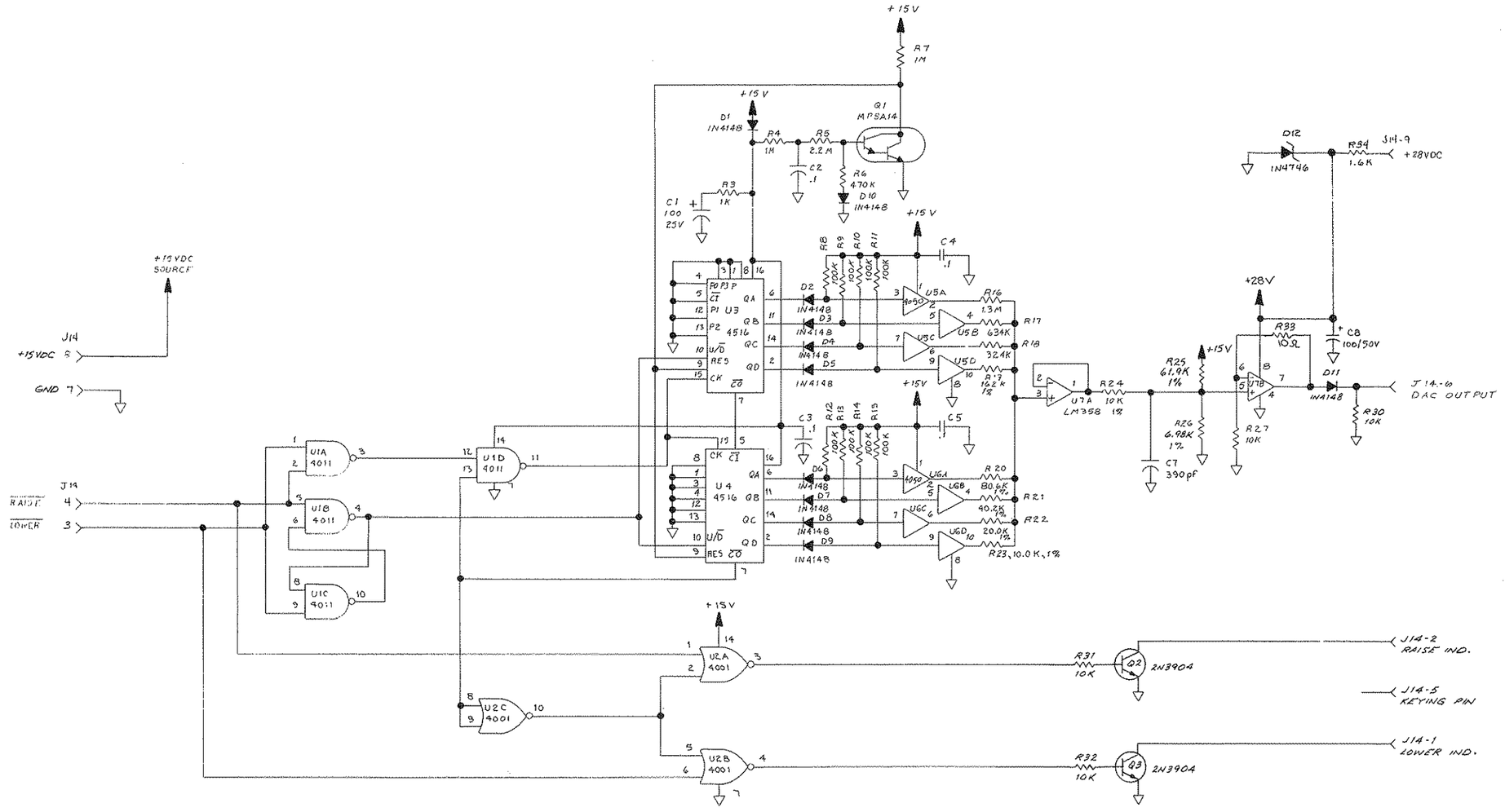
TOLERANCE (DECIMAL) U.O.S.
.X ± .030 .XXX ± .005
.XX ± .015 ANGLES ± 1°

DWN. BY MSE 3-21-86
CHKD.
ME
EE
PROJ. ENGR.
DFTG. SUPVR.
MFG.

NEXT ASSY.
PRODUCT USED ON FM1.5A
FINISH

BROADCAST ELECTRONICS INC.
4100 N. 24TH ST. QUINCY, IL 62305 217/224-9600
TELEX 250142 CABLE BCST ELECT QUI

TITLE PCB ASSEMBLY — APC DAC
SHEET 1 OF 1
SCALE 2/1
REV C
TYPE A SIZE C DWG. NO. 919-0060-001



NOTES:

1. ALL CAPACITORS IN MICR. FIRADS; ALL RESISTORS IN OHMS, 1/4W, 5% UNLESS OTHERWISE SPECIFIED.
2. LAST COMPONENTS USED: C8, D11, Q3, R34, U7.
3. COMPONENTS NOT USED: R1, R2, R28

SEE ASSEMBLY #C919-0060-001
SEE B/M # 919-0060-001

REFERENCE DESIGNATORS	U1	U2	U3, U4	U5, U6	U7
B.E. PART NO.	228-4011	228-4001	228-4516	228-4050	221-0358
VENDOR PART NO.	4011	4001	4516	4050	LM358
VOLTAGE PIN NO.	14	14	16	1	8
GROUND PIN NO.	7	7	8	8	4

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

MATERIAL

TREATMENT OR FINISH

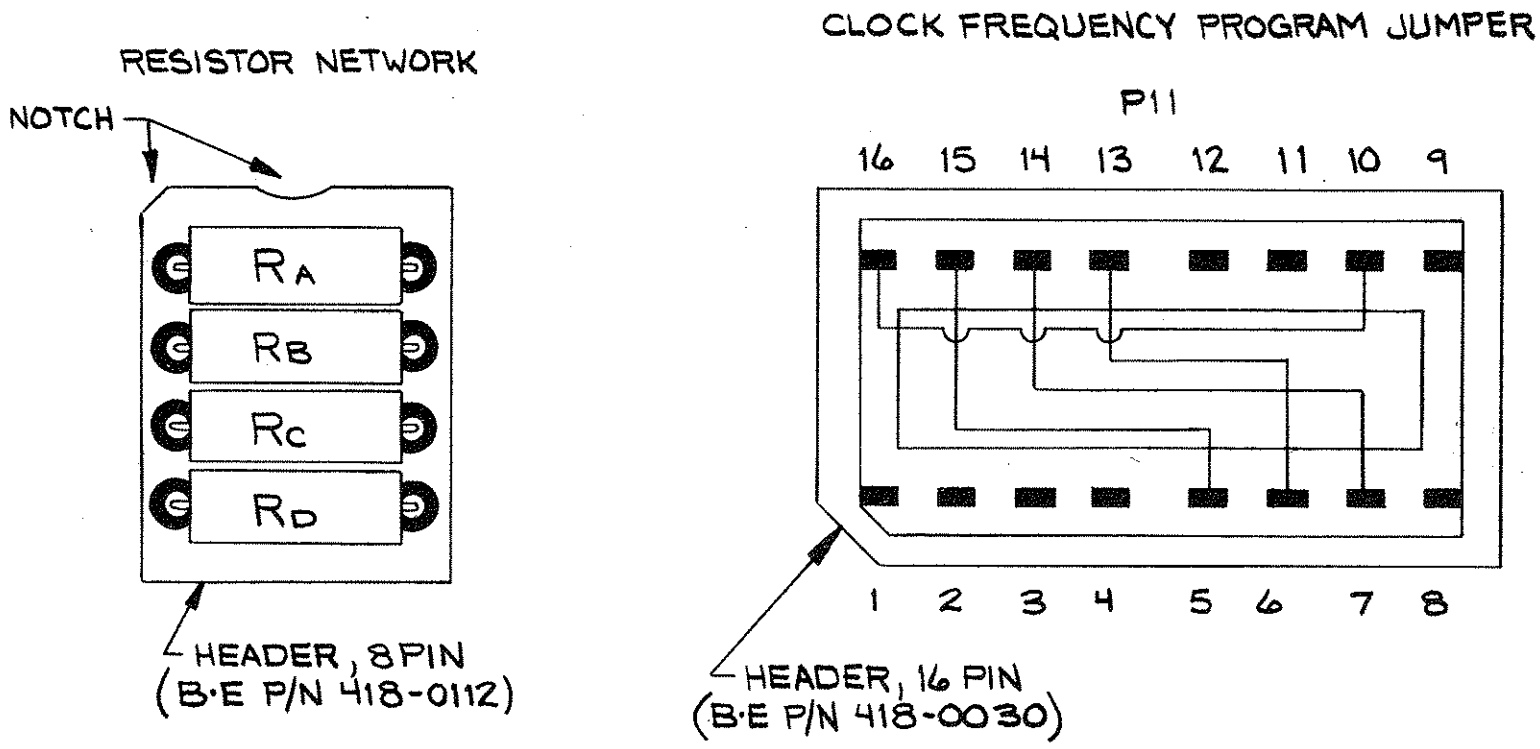
DRAWN BY MSE DATE 3-21-86
CHECKED BY DATE
PROJECT ENGR DATE
APPROVED BY DATE

BROADCAST ELECTRONICS INC.

TITLE SCHEMATIC PCB - APC DAC

SIZE D | DWG. NO. TYPE 5 919-0060-001 | REV. C

FM1.5A | SCALE N/A | SHEET 1 OF 1



RESISTOR NETWORK No.	OHMS RESISTANCE			
	R_A	R_B	R_C	R_D
R82	390K	5.1K	1K	180
R86	4.7K	470	4.7K	10K
R89	10M	100	1.5K	15K
R96	UNUSED	560	220	1.91K

597-0031-22

FIGURE 3-12. APC PROGRAM NETWORKS

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-1.5A Transmitter 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 UNIT ASSEMBLY - 959-0243-001

REF. DES.	DESCRIPTION	PART NO.	QTY.
----	Automatic Power Control Unit	959-0243	1
----	Digital-To-Analog Converter Circuit Board Assembly	919-0060-001	1
----	Digital-To-Analog Converter Circuit Board Cable	949-0051	1

TABLE 4-3. AUTOMATIC POWER CONTROL UNIT - 959-0243

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)	192-1052	1
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
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
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
----	Power Transformer Assembly	376-7675-001	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
----	Meter Switch Wire Harness Assembly	949-0044	1
----	Chassis Slides	469-0413-002	1
----	Magnet for Latch	488-0002	2
----	Clips for Spare Line Fuse	415-1001	2
----	Knob, Black, 1/4 inch ID (0.635 cm) for VSWR CAL Control	481-0014	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

TABLE 4-4. 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 4-5. WIRE HARNESS ASSEMBLY - 949-0038

REF. DES.	DESCRIPTION	PART NO.	QTY.
P3	Connector, Housing, 25-Pin In-line	417-0163	1
P4	Connector, Housing, 26-Pin In-line	417-0164	1
P5	Connector, Housing, 14-Pin In-line	417-1401	1
P6	Connector, Housing, 17-Pin In-line	417-0162	1
P7	Connector, Housing, 4-Pin In-line	417-0138	1
----	Pins, Receptacle (for Connectors P3, P4, P5, P6, and P7)	417-0053	83

TABLE 4-6. MAIN CIRCUIT BOARD ASSEMBLY - 919-0206
(Sheet 1 of 3)

REF. DES.	DESCRIPTION	PART NO.	QTY.
C1 THRU C10	Capacitor, Mylar, 0.1 uF, 100V	030-1053	10
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
C16 THRU C18	Capacitor, Poly Film, 0.0022 uF ±10%, 100V	031-2033	3
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
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 In-line	417-0200	1.3
J5	Receptacle, Header, 20-Pin In-line	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
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, 2 k Ohm ±5%, 1/4W	100-2043	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)	177-1065	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

TABLE 4-6. MAIN CIRCUIT BOARD ASSEMBLY - 919-0206
(Sheet 2 of 3)

REF. DES.	DESCRIPTION	PART NO.	QTY.
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
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
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, CD4069CN, Inverter, CMOS, 14-Pin DIP	228-4069	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

TABLE 4-6. MAIN CIRCUIT BOARD ASSEMBLY - 919-0206
(Sheet 3 of 3)

REF. DES.	DESCRIPTION	PART NO.	QTY.
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
U20	Integrated Circuit, CD4069CN, Inverter, CMOS, 14-Pin DIP	228-4069	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	519-0027	1

TABLE 4-7. FRONT PANEL CIRCUIT BOARD ASSEMBLY - 919-0028
(Sheet 1 of 2)

REF. DES.	DESCRIPTION	PART NO.	QTY.
D1,D2	Diode, 1N4005, Silicon, 600V, 1 Ampere	203-4005	2
J6	Connector, Header, 20-Pin In-line	417-0200	.8
J7	Connector, 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, 20 Ohm ±5%, 1/4W	100-2023	1
R7	Resistor, 1.8 k Ohm ±5%, 1/4W	100-1843	1

TABLE 4-7. FRONT PANEL CIRCUIT BOARD ASSEMBLY - 919-0028
(Sheet 2 of 2)

REF. DES.	DESCRIPTION	PART NO.	QTY.
R8	Resistor, 20 Ohm ±5%, 1/4W	100-2023	1
R9	Resistor, 1.8 k Ohm ±5%, 1/4W	100-1843	1
R10	Resistor, 20 Ohm ±5%, 1/4W	100-2023	1
R11	Resistor, 1.8 k Ohm ±5%, 1/4W	100-1843	1
R12	Resistor, 20 Ohm ±5%, 1/4W	100-2023	1
R13	Resistor, 1.8 k Ohm ±5%, 1/4W	100-1843	1
R14	Resistor, 20 Ohm ±5%, 1/4W	100-2023	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 4-8. 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	Capacitor, Mica, 390 pF ±5%, 100V	042-3922	1
C60	Capacitor, Mylar, 0.01 uF ±10%, 100V	031-1043	1
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
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	.7
L1 THRU L10	Choke, 4.7 uH ±10%, 430 mA	360-0022	10
P11	Plug, Header, 14-Pin	417-6002-0014	1
R1,R2	Resistor, 56 Ohm ±5%, 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, 9.53 k Ohm ±1%, 1/4W	103-9534	1
R29	Resistor, 34.0 k Ohm ±1%, 1/4W	103-3405	1
S1	Switch, Toggle, DPDT 5 Amperes, resistive load @ 120V ac/28V dc 2 Amperes, resistive load @ 250V ac	340-0012	1

TABLE 4-8. REAR PANEL CIRCUIT BOARD ASSEMBLY - 919-0207
(Sheet 2 of 2)

REF. DES.	DESCRIPTION	PART NO.	QTY.
U1,U2	Integrated Circuit, LM317K, Positive 3-Terminal Adjustable Voltage Regulator, 1.2V to 37V, 1.5A Maximum, TO-3 Case	227-0318	2
----	Cover for P11	417-6001-0014	1
----	Fuse Clips	415-2068	4
----	Blank Circuit Board	519-0029	1

TABLE 4-9. ASSEMBLY, AUTOMATIC POWER CONTROL JUMPER NETWORK - 959-1001-001

REF. DES.	DESCRIPTION	PART NO.	QTY.
P11	Plug, Header, 16-Pin DIP	418-0030	1

TABLE 4-10. ASSEMBLY, AUTOMATIC POWER CONTROL RESISTOR NETWORK - 959-1000-014

REF. DES.	DESCRIPTION	PART NO.	QTY.
PR82	Plug, Header, 8-Pin DIP	418-0112	1
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, 180 Ohm ±5%, 1/4W	100-1833	1

TABLE 4-11. ASSEMBLY, AUTOMATIC POWER CONTROL RESISTOR NETWORK - 959-1000-013

REF. DES.	DESCRIPTION	PART NO.	QTY.
PR86	Plug, Header, 8-Pin DIP	418-0112	1
R86A	Resistor, 4.7 k Ohm ±5%, 1/4W	100-4743	1
R86B	Resistor, 470 Ohm ±5%, 1/4W	100-4733	1
R86C	Resistor, 4.7 k Ohm ±5%, 1/4W	100-4743	1
R86D	Resistor, 10 k Ohm ±5%, 1/4W	100-1053	1

TABLE 4-12. ASSEMBLY, AUTOMATIC POWER CONTROL RESISTOR NETWORK - 959-1000-012

REF. DES.	DESCRIPTION	PART NO.	QTY.
PR89	Plug, Header, 8-Pin DIP	418-0112	1
R89A	Resistor, 10 Meg Ohm ±5%, 1/4W	100-1083	1
R89B	Resistor, 100 Ohm ±5%, 1/4W	100-1033	1
R89C	Resistor, 1.5 k Ohm ±5%, 1/4W	100-1543	1
R89D	Resistor, 15 k Ohm ±5%, 1/4W	100-1553	1

TABLE 4-13. ASSEMBLY, AUTOMATIC POWER CONTROL RESISTOR NETWORK - 959-1000-011

REF. DES.	DESCRIPTION	PART NO.	QTY.
PR96	Plug, Header, 8-Pin DIP	418-0112	1
R96B	Resistor, 560 Ohm ±5%, 1/4W	100-5633	1
R96C	Resistor, 220 Ohm ±5%, 1/4W	100-2233	1
R96D	Resistor, 1.91 k Ohm ±1%, 1/4W	103-1914	1

TABLE 4-14. APC DIGITAL-TO-ANALOG CONVERTER CIRCUIT BOARD ASSEMBLY - 919-0060-001

REF. DES.	DESCRIPTION	PART NO.	QTY.
C1	Capacitor, Electrolytic, 100 uF, 25V	023-1084	1
C2 THRU C5	Capacitor, Mylar, 0.1 uF ±5%, 100V	030-1053	4
C7	Capacitor, Mica, 390 pF ±5%, 100V	042-3922	1
C8	Capacitor, Electrolytic, 100 uF, 50V	020-1083	1
D1 THRU D11	Diode, 1N4148, Silicon, 100V, 10 mA	203-4148	11
D12	Diode, Zener, 1N4746, 18V ±10%, 1W	200-4746	1
J14	Header, 20-Pin In-line	417-0200	.5
Q1	Transistor, MPSA14, Silicon, Darlington NPN, TO-92 Case	211-0014	1
Q2,Q3	Transistor, 2N3904, Silicon, NPN, TO-92 Case	211-3904	2
R3	Resistor, 1 k Ohm ±5%, 1/4W	100-1043	1
R4	Resistor, 1 Meg Ohm ±5%, 1/4W	100-1073	1
R5	Resistor, 2.2 Meg Ohm ±5%, 1/4W	100-2273	1
R6	Resistor, 470 k Ohm ±5%, 1/4W	100-4763	1
R7	Resistor, 1 Meg Ohm ±5%, 1/4W	100-1073	1
R8 THRU R15	Resistor, 100 k Ohm ±5%, 1/4W	100-1063	8
R16	Resistor, 1.3 Meg Ohm ±5%, 1/4W	100-1373	1
R17	Resistor, 634 k Ohm ±1%, 1/4W	103-6346	1
R18	Resistor, 324 k Ohm ±1%, 1/4W	103-3246	1
R19	Resistor, 162 k Ohm ±1%, 1/4W	103-1626	1
R20	Resistor, 80.6 Ohm ±1%, 1/4W	103-8065	1
R21	Resistor, 40.2 Ohm ±1%, 1/4W	103-4025	1
R22	Resistor, 20.0 k Ohm ±1%, 1/4W	103-2051	1
R23	Resistor, 10.0 k Ohm ±1%, 1/4W	100-1051	1
R24	Resistor, 10 k Ohm ±5%, 1/4W	100-1053	1
R25	Resistor, 2.1 k Ohm ±1%, 1/4W	103-1215	1
R26	Resistor, 5.36 k Ohm ±1%, 1/4W	103-5364	1
R27	Resistor, 10 k Ohm ±5%, 1/4W	100-1053	1
R30 THRU R32	Resistor, 10 k Ohm ±5%, 1/4W	100-1053	3
R33	Resistor, 10 Ohm ±5%, 1/4W	100-1023	1
R34	Resistor, 1.6 k Ohm ±5%, 1/4W	100-1643	1
U1	Integrated Circuit, MC14011BCP, CMOS, Quad 2-Input NAND Gate, 14-Pin DIP	228-4011	1
U2	Integrated Circuit, MC14001BCP, CMOS, Quad 2-Input NOR Gate, 14-Pin DIP	228-4001	1
U3,U4	Integrated Circuit, MC14516BCP, CMOS, Binary Up/Down Counter, 16-Pin DIP	228-4516	2
U5,U6	Integrated Circuit, CD4050BCN, CMOS, Hex Non-Inverting Buffer, 16-Pin DIP	228-4050	2
U7	Integrated Circuit, LM358N, Dual Operational Amplifier, 8-Pin DIP	221-0358	1
XU1,XU2	Socket, 14-Pin DIP	417-1404	2
XU3 THRU XU6	Socket, 16-Pin DIP	417-1604	4
XU7	Socket, 8-Pin DIP	417-0804	1
----	Blank Circuit Board	519-0060	1

TABLE 4-15. DIGITAL-TO-ANALOG CONVERTER CIRCUIT BOARD CABLE - 949-0051

REF. DES.	DESCRIPTION	PART NO.	QTY.
P11	Connector, Housing, 14-Pin	417-1401	1
P14	Connector, 9-Pin In-line	417-0161	1
----	Pins, Connector (for P11)	417-8766	14

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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-1.5A 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-1.5A transmitter 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-1.5A 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 FM-1.5A 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.

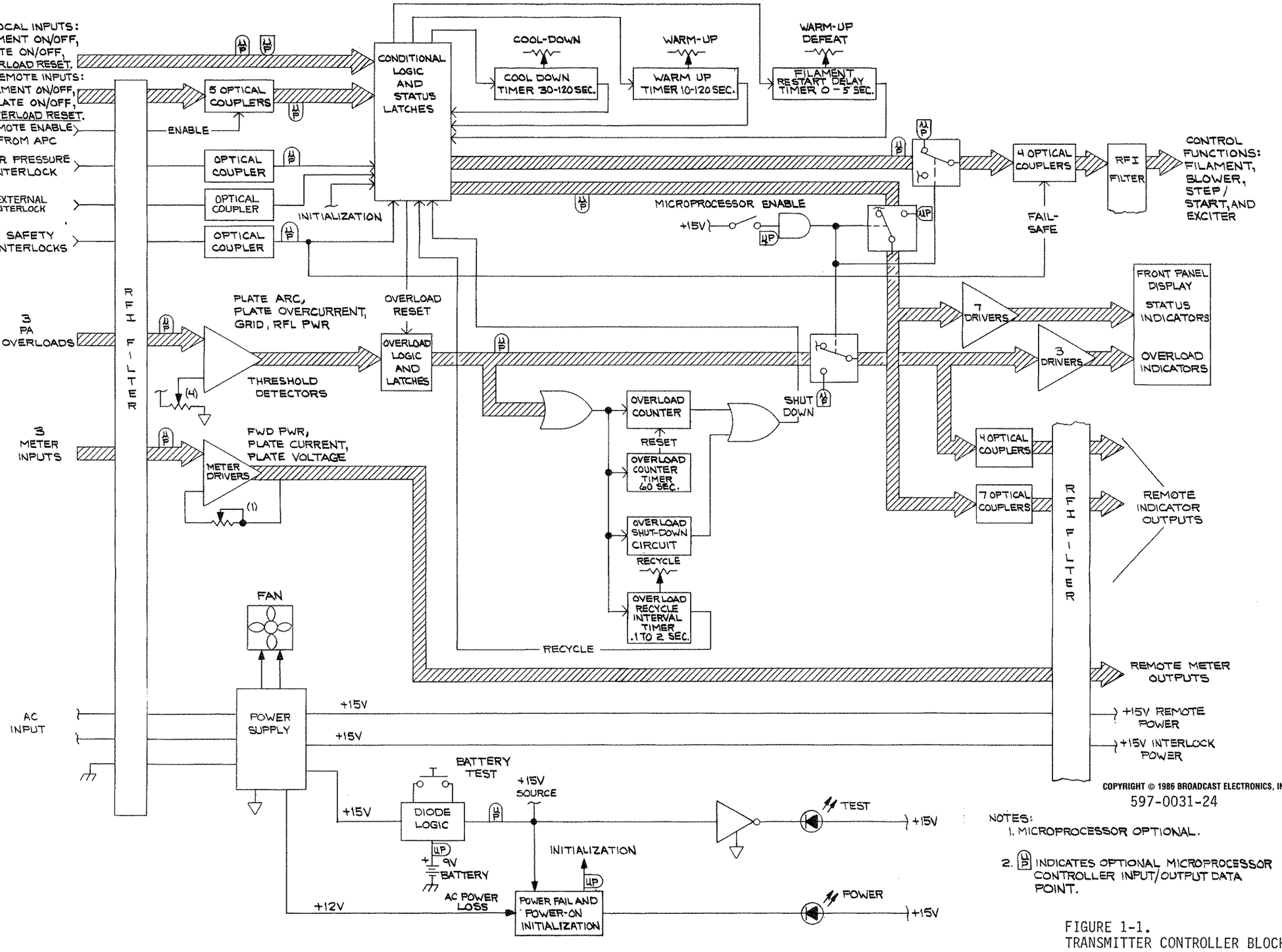
1-11. Commands such as "filament on" and "high voltage on" are initiated by a momentary HIGH applied to conditional logic circuitry on the controller circuit board. A "one-button start" may be selected by depressing the HIGH VOLTAGE ON switch/indicator only. As each switch is depressed, the associated 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.



597-0031-24

NOTES:
1. MICROPROCESSOR OPTIONAL.
2. (UP) INDICATES OPTIONAL MICROPROCESSOR CONTROLLER INPUT/OUTPUT DATA POINT.

FIGURE 1-1.
TRANSMITTER CONTROLLER BLOCK DIAGRAM

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, control grid 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 determine 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.

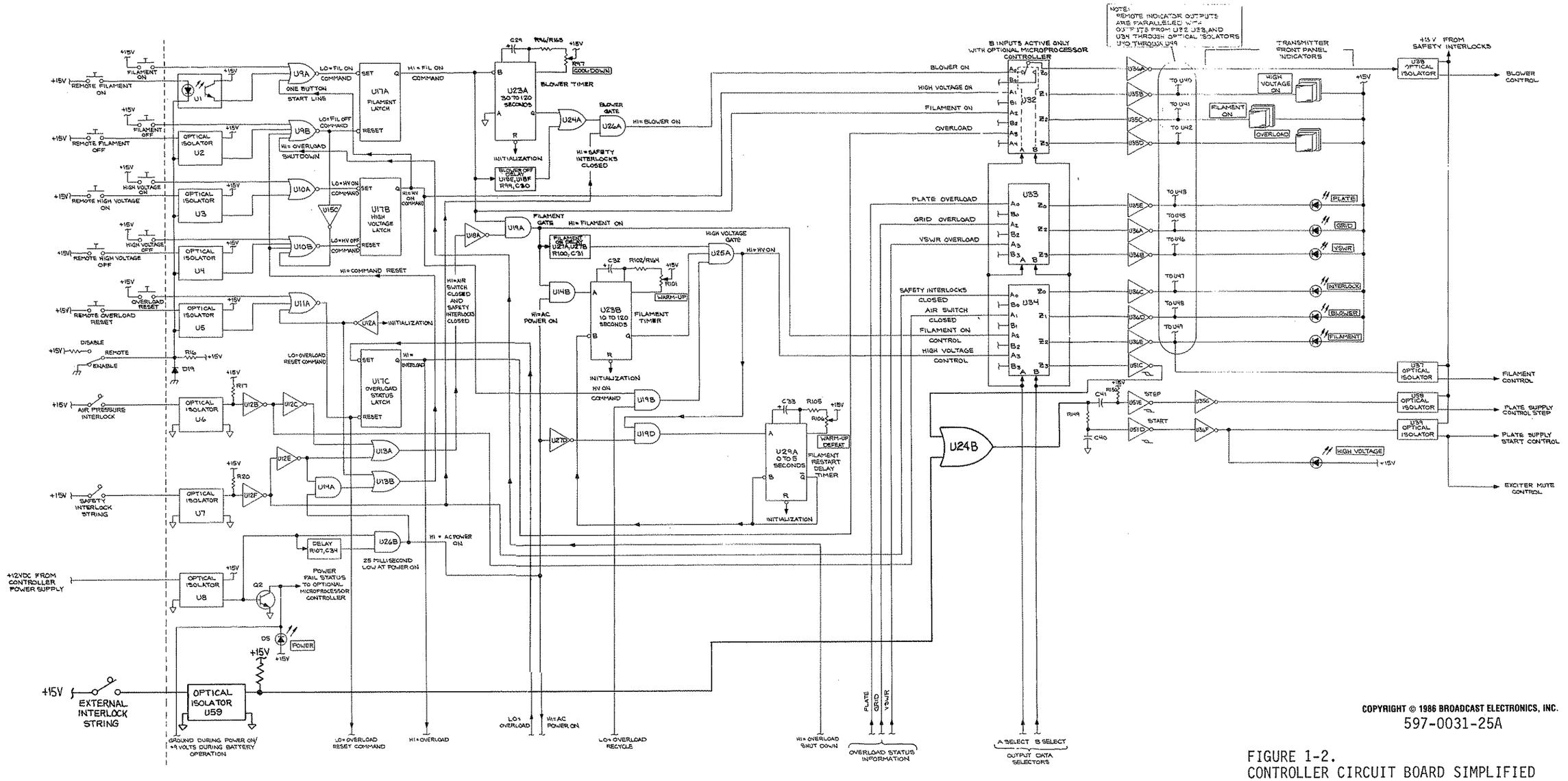


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FIGURE 1-2.
CONTROLLER CIRCUIT BOARD SIMPLIFIED SCHEMATIC

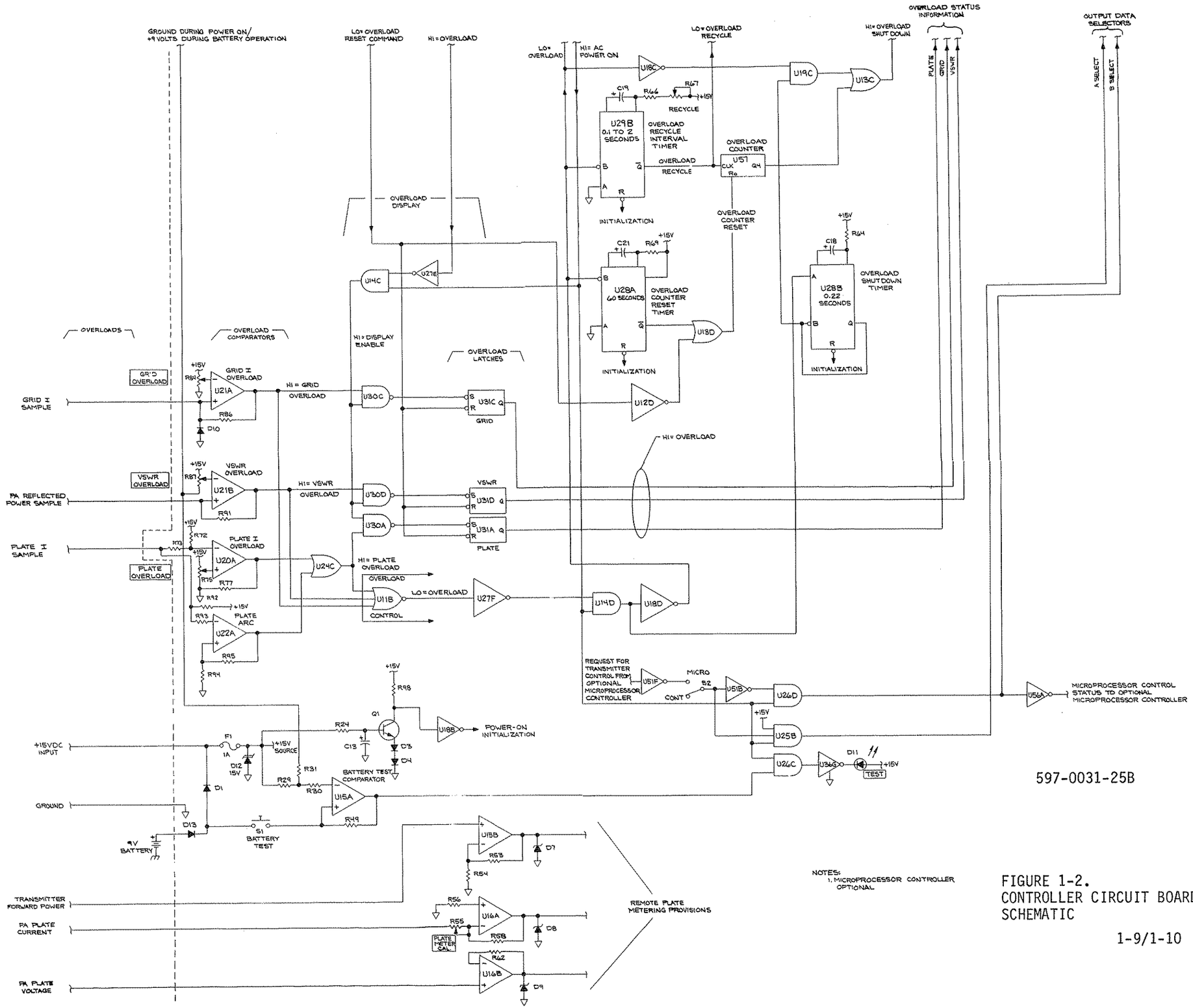

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FIGURE 1-2.
CONTROLLER CIRCUIT BOARD SIMPLIFIED SCHEMATIC

1-9/1-10

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, 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 VSWR overload control R97, and battery test comparator U15A. During periods of battery operation, this same line routes a positive potential to the VSWR overload reference control. This eliminates false overloads on ac power failure due to a slowly decaying VSWR sample.

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. Three parameters are monitored for overload conditions by the controller circuit board: control grid 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 form voltage dividers with the series input resistors (R93 and R73) 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 current overload will trip on excessive drive.

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 four 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, U31C, and U31D) through U30A, 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, GRID, or VSWR) indicator will go out.

B. The overload display latches (U31A, U31C, and U31D) will be reset.

C. The inhibit from U14C will be removed from the overload display gates.

D. The overload counter will be cleared via inverter U12D and OR gate U13D.

1-54. Overload Control Circuits. The overload control circuit inputs are obtained from the overload comparators. This circuit is not inhibited by a single overload as is the overload display circuit. The logical output of each comparator is ORed in U11B, routed through inverter U27F, and ANDed with the ac power status in U14D. An output from U14D is applied as a HIGH to overload shutdown timer U28B. This timer measures the duration of the high overload signal. If it is greater than 220 milliseconds, it applies a signal through U19C and U13C to deenergize filament latch U17A via U9B. This same HIGH is routed through inverter U18D and applied as a LOW to enable the overload counter reset timer (U28A), enable the overload recycle interval timer (U29B), and set the overload status latch (U17C).

1-55. The overload recycle interval timer (U29B) determines the length of time the transmitter remains off-the-air after an overload to allow the condition that prompted the overload to dissipate. Timer U29B can be adjusted from 0.1 to 2 seconds using R67. The overload counter (U57) counts the overload recycle attempts and the overload counter reset timer (U28A) resets the overload counter 60 seconds after the first overload occurred.

1-56. Each overload will initiate a recycle by deenergizing high voltage via AND gates U19B and U25A to attempt to clear the overload. The overload counter (U57) will count each recycle attempt. If four overloads occur within the 60 second interval of U28A, OR gate U13C will output a HIGH. This HIGH is applied to OR gate U9B which resets the filament latch (U17A) and deenergize the transmitter.

1-57. If an overload cycles the transmitter off-the-air and removing high voltage does not clear the overload after 220 milliseconds, the overload shutdown timer (U28B) will output a HIGH. This HIGH is ANDed in U19C with a HIGH from inverter U18C and signals overload shutdown through OR gate U13C.

1-58. Turn Off. The high voltage off sequence is initiated by a positive potential which resets the high voltage latch (U17B) through NOR gate U10B. When U17B is reset, the following actions will occur:

A. The HIGH VOLTAGE ON switch/indicator will go out.

B. A LOW via U19B and U25A will deenergize the plate power supply and the HIGH VOLTAGE status indicator will go out.

1-59. The filament off sequence is initiated by a positive potential which resets the filament latch (U17A) through NOR gate U9B. When U17A is reset, the following actions will occur:

A. The plate latch (U17B) will be reset by U10B via U9B.

B. The FILAMENT ON switch/indicator will go out.

C. A LOW via U19A will deenergize the filament supply and the FILAMENT status indicator will go out.

D. The blower timer (U23A) will begin time-down operation. The blower-off delay circuit composed of U18E, U18F, C30, and R99 will hold a momentary HIGH through U24A on blower gate U26A to prevent the time delay encountered in starting timer U23A from pulsing the blower off, then on, then back off after the blower run-down delay.

E. When the blower ceases operation, the BLOWER status indicator will go out.

1-60. Remote Control. The transmitter can be controlled by momentary positive-polarity dc inputs to the controller circuit board. Positive-logic enabled remote inputs are used for safety. Each remote input is routed through an optical isolator for isolation. Additional resistance to noise interference is provided by an RC circuit in each remote input. Diodes across each optical isolator input and diode D19 prevent possible damage to the remote circuitry caused by inadvertent connection to negative polarity control inputs. A +15 volt output is provided for remote operation, however the optical isolators can operate on any positive dc voltage from +5 volts to +24 volts.

1-61. The remote circuitry is enabled by a ground through the REMOTE ENABLE/DISABLE switch which enables the optically-isolated inputs. The input of this switch is connected to a pull-up resistor (R16) as a safety consideration to prevent remote operation in case the switch input were to become disconnected.

1-62. Remote PA Metering. The remote meter amplifiers for transmitter forward power, PA plate current, and PA plate voltage are mounted on the controller circuit board.

1-63. U15B is a non-inverting voltage amplifier with a gain of approximately one 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, R55 is included for level adjustment. Positive five volts output can be obtained by varying R55. The output is clamped with a 15 volt zener diode for circuit protection.

1-65. U16B functions as a non-inverting 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 (5 kV).

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 four dc sources which supply all operating voltages for the exciter circuitry. When power is applied to the controller, the cooling fan will run continuously.

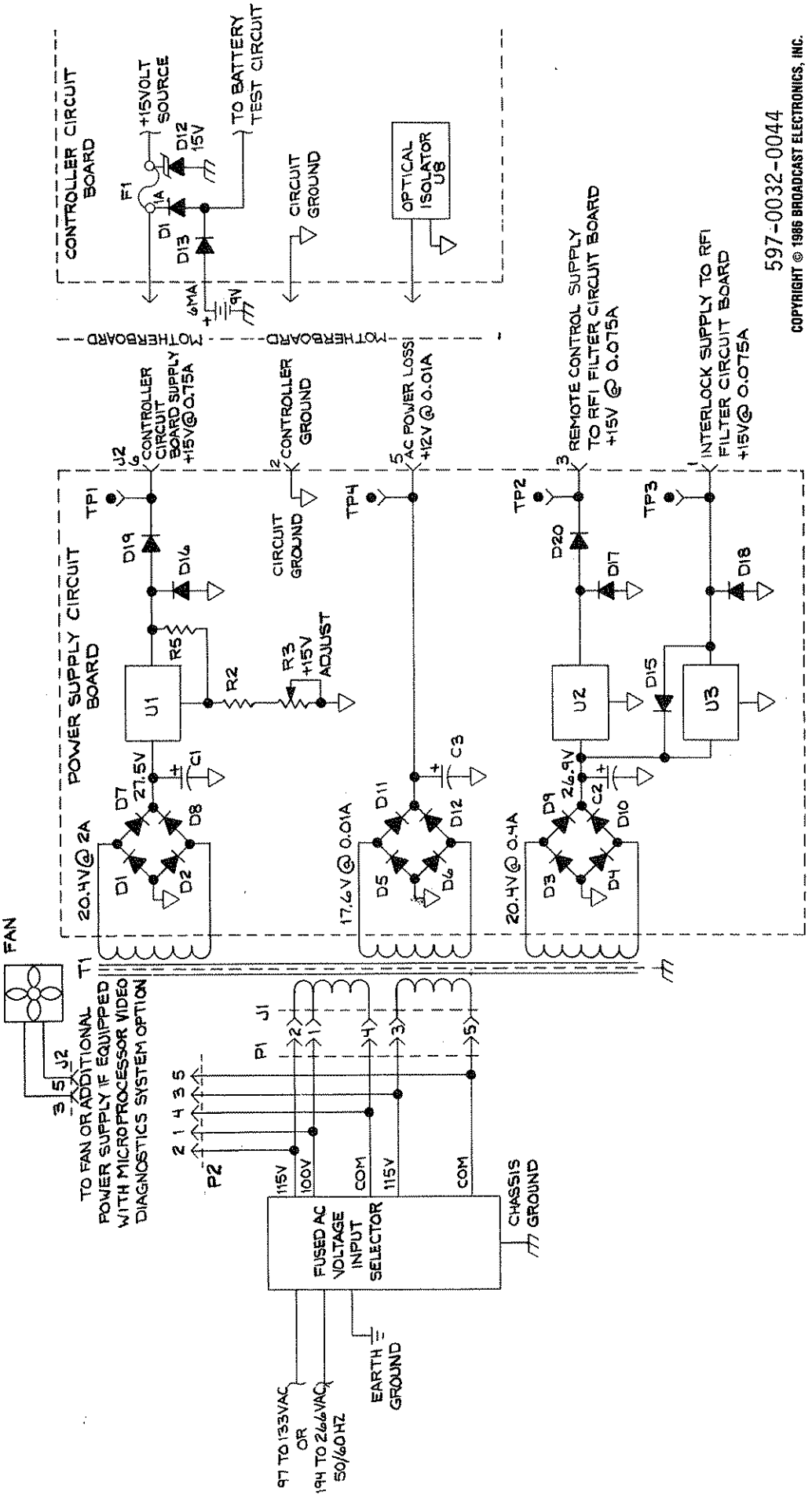


FIGURE 1-3. CONTROLLER POWER SUPPLY SIMPLIFIED SCHEMATIC

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. Test point TP1 provides a convenient point to check operation of the supply.

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.

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 full-wave bridge-rectified into a +12 volt supply by diodes D5, D6, D11, and D12 and filtered by capacitor C3. This potential is routed to optical isolator U8 on the controller circuit board for loss of ac power information. Test point TP4 provides a convenient point to check operation of the supply.

1-71. 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 C1. 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. Test point TP2 provides a convenient point to check operation of the supply.

1-72. 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.

1-73. Positive Fifteen Volt Interlock Supply. The input to regulator U3 is paralleled from the same +27 volt supply as regulator U2. Test point TP3 provides a convenient point to check operation of the supply.

1-74. 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-1.5A FM transmitter controller.

2-3. SAFETY CONSIDERATIONS.

2-4. The FM-1.5A 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 NEVER OPEN THE EQUIPMENT UNLESS ALL TRANSMITTER PRIMARY POWER IS DISCONNECTED.

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-1.5A maintenance philosophy consists of preventative maintenance such as cleaning applied to the equipment of forestall future failures and second level maintenance consisting of procedures required to restore the equipment to operation after a fault.

2-7. ADJUSTMENTS.

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

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. VSWR OVERLOAD THRESHOLD ADJUST (R88). To adjust the VSWR overload control on the controller circuit board, proceed as follows.

2-11. Required Equipment. The following equipment is required to adjust the VSWR overload control (R88).

A. Insulated adjustment tool, flat-tip (BE P/N 407-0083).

2-12. Procedure. To adjust the control, proceed as follows.

2-13. Refer to Figure 2-1 and adjust the VSWR overload threshold adjust control (R88) fully clockwise.

2-14. Operate the transmitter at the normal power output with the APC on.

2-15. Operate the OUTPUT POWER METER switch to FWD. Assure the OUTPUT POWER meter indicates 100%.

2-16. Operate the OUTPUT POWER METER switch to VSWR CAL and adjust the VSWR CAL control to obtain an OUTPUT POWER meter indication of 100%.

2-17. Depress the HIGH VOLTAGE OFF switch/indicator.

2-18. When the LOWER switch/indicator stops flashing, depress the APC ON and FILAMENT OFF switch indicators.

2-19. From the top of the transmitter, disconnect cable No. 161 from the output directional coupler RFL port and connect the cable to the MON port.

CAUTION ADJUSTMENT OF THE OVERLOAD CONTROLS DETERMINES AT WHAT POINT THE CONTROLLER WILL INITIATE

CAUTION ACTION. IF A CONTROL IS INCORRECTLY ADJUSTED, THE CONTROLLER MAY NOT SENSE A FAULT AND DAMAGE

CAUTION TO THE TRANSMITTER MAY RESULT.

2-20. Depress the FILAMENT ON and HIGH VOLTAGE ON switch/indicators.

2-21. Verify that the OUTPUT POWER METER switch is set to VSWR and the APC ON switch/indicator is not illuminated.

WARNING: DISCONNECT POWER PRIOR TO SERVICING

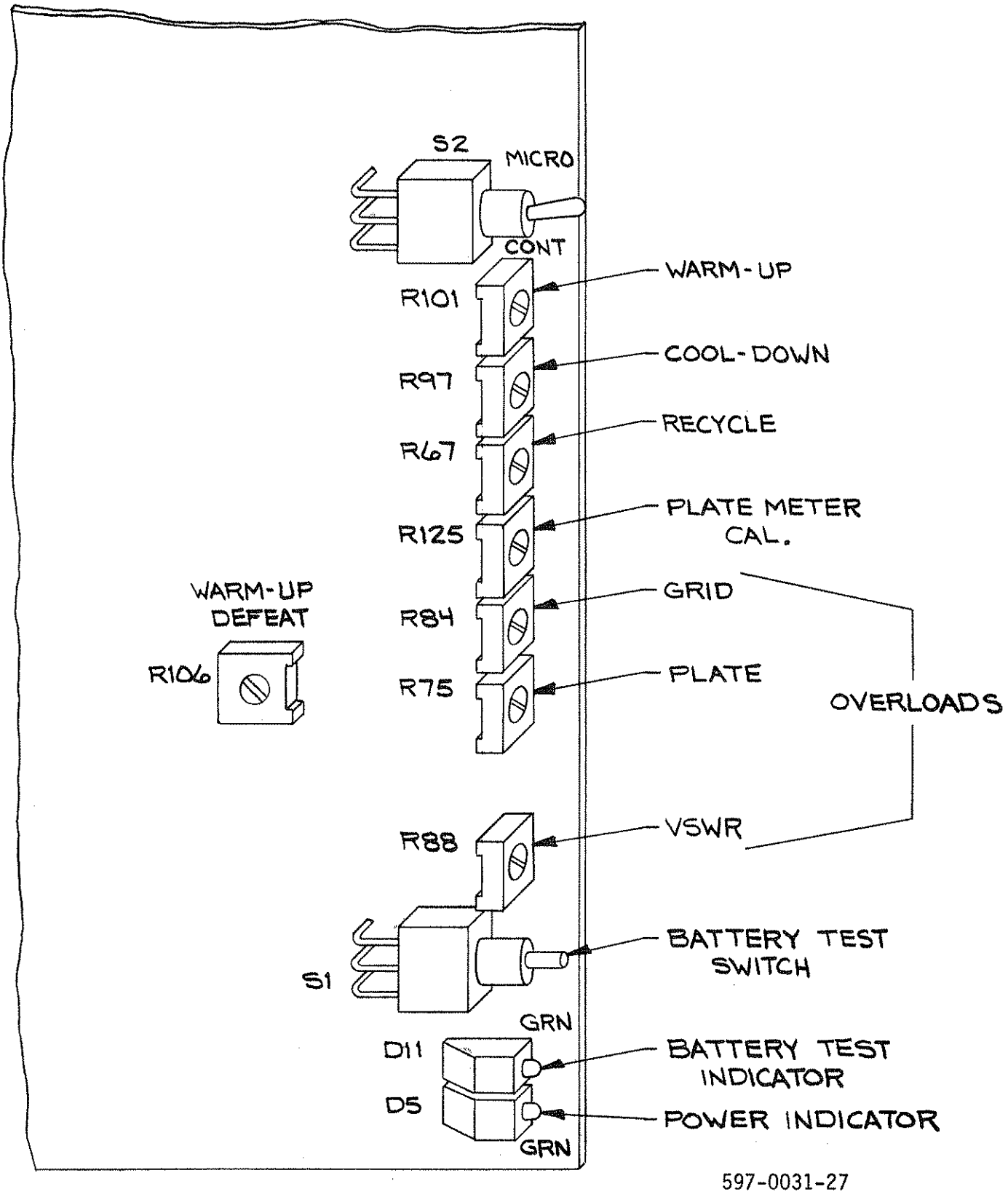


FIGURE 2-1. CONTROLLER CIRCUIT BOARD CONTROLS

WARNING: DISCONNECT POWER PRIOR TO SERVICING

2-22. Raise power manually by depressing the RAISE switch/indicator until the OUTPUT POWER meter indicates a VSWR of 3 : 1.

2-23. Refer to Figure 2-1 and adjust R88 until the VSWR indicator and the overload reset switch/indicator illuminate and the transmitter cycles off.

2-24. Depress the LOWER switch/indicator to lower the transmitter power, then depress the overload reset switch/indicator.

2-25. 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.

2-26. Depress the HIGH VOLTAGE OFF, FILAMENT OFF, and APC ON switch/indicators.

CAUTION

CAUTION

ENSURE CABLE NO. 161 IS RECONNECTED TO THE OUTPUT DIRECTIONAL COUPLER RFL PORT IN THE FOLLOWING STEP OR DAMAGE TO THE TRANSMITTER COULD RESULT.

2-27. Reconnect cable No. 161 to the RFL port in the output directional coupler.

2-28. GRID (R84) OVERLOAD ADJUSTMENT. To adjust the GRID overload control on the controller circuit board, proceed as follows.

2-29. Required Equipment. The following equipment is required to adjust the GRID (R84) overload control.

A. Insulated adjustment tool, flat-tip (BE P/N 407-0083).

2-30. Procedure. To adjust the control, proceed as follows. If more than one overload control is to be adjusted, the controls must be adjusted in a specific sequence: VSWR, PLATE, and GRID. The VSWR control is adjusted in paragraph 2-10 and the PLATE control is adjusted in paragraph 2-40.

CAUTION

CAUTION

CAUTION

ADJUSTMENT OF THE OVERLOAD CONTROLS DETERMINES AT WHAT POINT THE CONTROLLER WILL INITIATE ACTION. IF A CONTROL IS INCORRECTLY ADJUSTED, THE CONTROLLER MAY NOT SENSE A FAULT AND DAMAGE TO THE TRANSMITTER MAY RESULT.

2-31. Refer to Figure 2-1 and adjust R84 fully clockwise.

2-32. Apply power and operate the transmitter within specifications at the rated RF output into a proper 50 Ohm load.

2-33. Assure the APC ON switch/indicator is not illuminated.

2-34. Depress the exciter FWD switch and record the exciter RF output _____.

2-35. Record the OUTPUT LOADING cyclometer indication _____.

2-36. Decouple the output loading by adjusting the OUTPUT LOADING control in the direction which causes the PLATE current meter indication to fall.

CAUTION DO NOT EXCEED 1.5 kW RF OUTPUT IN THE FOLLOWING PARAGRAPH.

2-37. Using the exciter R.F. POWER OUTPUT ADJ control, increase drive until the GRID meter indicates 200 milliamperes.

2-38. Refer to Figure 2-1 and adjust R84 counterclockwise until the transmitter deenergizes.

2-39. Readjust the exciter RF output power to the level recorded in paragraph 2-34 and readjust the OUTPUT LOADING control to the cyclometer indication recorded in paragraph 2-35.

2-40. PLATE (R75) OVERLOAD ADJUSTMENT. To adjust the PLATE overload control on the controller circuit board, proceed as follows.

2-41. Required Equipment. The following equipment is required to adjust the PLATE (R75) overload control.

A. Insulated adjustment tool, flat-tip (BE P/N 407-0083).

2-42. Procedure. To adjust the control, proceed as follows. If more than one overload control is to be adjusted, the controls must be adjusted in a specific sequence: VSWR, PLATE, and GRID. The VSWR control is adjusted in paragraph 2-10 and the GRID control is adjusted in paragraph 2-28.

CAUTION ADJUSTMENT OF THE OVERLOAD CONTROLS DETERMINES AT WHAT POINT THE CONTROLLER WILL INITIATE

CAUTION ACTION. IF A CONTROL IS INCORRECTLY ADJUSTED, THE CONTROLLER MAY NOT SENSE A FAULT AND DAMAGE

CAUTION TO THE TRANSMITTER MAY RESULT.

2-43. Refer to Figure 2-1 and adjust R75 fully clockwise.

CAUTION ASSURE THE INPUT TUNING CONTROL IS CORRECTLY ADJUSTED IN THE FOLLOWING STEP.

2-44. Apply power and operate the transmitter within specifications at the rated RF output into a proper 50 Ohm load. Assure the INPUT TUNING control is correctly adjusted.

2-45. Assure the APC ON switch/indicator is not illuminated.

2-46. Depress the exciter FWD switch and record the exciter RF output _____.

2-47. Using the exciter R.F. POWER OUTPUT ADJ control, increase drive until the PLATE meter indicates 950 milliamperes.

2-48. Refer to Figure 2-1 and adjust R75 counterclockwise unitl the transmitter deenergizes.

2-49. Readjust the exciter RF output power to the level recorded in paragraph 2-46.

2-50. WARM-UP ADJUSTMENT (R101). To adjust the WARM-UP control on the controller circuit board, proceed as follows. This control adjusts the filament heating delay, prior to high voltage on. A minimum interval of three minutes is preset so that incorrect adjustment cannot damage the PA tube.

2-51. Required Equipment. The following equipment is required to adjust the WARM-UP control (R101).

A. Insulated adjustment tool, flat-tip (BE P/N 407-0083).

B. Wristwatch with seconds hand or stopwatch function.

2-52. Procedure. To adjust the control, proceed as follows.

2-53. Apply filament power to the transmitter. Simultaneously note the time and depress the HIGH VOLTAGE ON switch/indicator.

2-54. Again note the time when the plate contactor energizes.

2-55. Refer to Figure 2-1 and adjust R101 to increase or decrease the time delay. Check the adjustment by repeating paragraphs 2-53 and 2-54. The control is factory set for three minutes.

2-56. COOL-DOWN ADJUSTMENT (R97). To adjust the COOL-DOWN control on the controller circuit board, proceed as follows. This control adjusts the blower run-down interval after high voltage is switched off. A minimum interval of three minutes is preset so that incorrect adjustment cannot damage the PA tube.

2-57. Required Equipment. The following equipment is required to adjust the COOL-DOWN control (R97).

A. Insulated adjustment tool, flat-tip (BE P/N 407-0083).

B. Wristwatch with seconds hand or stopwatch function.

2-58. Procedure. To adjust the control, proceed as follows.

2-59. Apply power and operate the transmitter.

2-60. Simultaneously depress the FILAMENT OFF switch and note the time.

2-61. Again note the time when the blower halts operation.

2-62. Refer to Figure 2-1 and adjust R97 to increase or decrease the blower run-down interval. Check the adjustment by repeating paragraphs 2-60 and 2-61. The control is factory set for three minutes.

2-63. RECYCLE ADJUSTMENT (R67). To adjust the RECYCLE control on the controller circuit board, proceed as follows. This control adjusts the time the transmitter will remain deenergized to allow an overload to dissipate after an overload occurs. The control allows adjustment from 100 milliseconds to 2.5 seconds. A minimum delay is built into the circuitry to prevent transmitter damage.

2-64. Required Equipment. The following equipment is required to adjust the RECYCLE control (R67).

A. Insulated adjustment tool, flat-tip (BE P/N 407-0083).

2-65. Procedure. To adjust the control, proceed as follows.

2-66. Apply power and operate the transmitter.

2-67. Refer to Figure 2-1 and adjust R67 for the desired delay. The control is factory preset for 2.5 seconds. The adjustment may be checked by simulating a screen or plate overload with the OUTPUT LOADING control.

2-68. WARM-UP DEFEAT ADJUSTMENT (R106). To adjust the WARM-UP defeat control on the controller circuit board, proceed as follows. 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.

2-69. Required Equipment. The following equipment is required to adjust the 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.

2-70. Procedure. To adjust the control, proceed as follows.

2-71. Mount the controller circuit board on the extender board.

2-72. Apply power and operate the transmitter.

2-73. Refer to Figure 2-1 and adjust R106 for the desired interval. The control is factory preset for two seconds. The adjustment may be checked by interrupting the transmitter ac feed for known time intervals, and observing if the high voltage is reapplied immediately or a recycle is initiated.

2-74. Replace the controller circuit board in the transmitter.

2-75. PLATE I METER CAL. ADJUSTMENT (R125). To adjust the PLATE I meter cal. control on the controller circuit board, proceed as follows. This control adjusts the remote plate current meter output level for approximately 5 volts dc at normal plate current.

2-76. Required Equipment. The following equipment is required to adjust the PLATE I meter cal. control (R125).

A. Insulated adjustment tool, flat-tip (BE P/N 407-0083).

B. Digital voltmeter, Fluke 75 or equivalent 3 1/2 digit model.

2-77. Procedure. To adjust the control, proceed as follows.

WARNING DISCONNECT ALL TRANSMITTER PRIMARY POWER BEFORE PROCEEDING.

2-78. Assure all transmitter power is off and open the cabinet rear door. Connect the voltmeter between TB7, terminal 25 and terminal 26 (meter ground).

2-79. Route the voltmeter leads out the hinge side of the cabinet door and close and lock the door.

2-80. Apply power and operate the transmitter at the normal power output.

2-81. Refer to Figure 2-1 and adjust R125 until the voltmeter indicates +5 volts dc.

WARNING DISCONNECT ALL TRANSMITTER PRIMARY POWER BEFORE PROCEEDING.

2-82. Assure all transmitter power is off and disconnect the voltmeter and leads.

2-83. POWER SUPPLY CIRCUIT BOARD.

2-84. +15 VOLT ADJUST (R2). To adjust the +15 volt adjust control on the power supply circuit board, proceed as follows.

2-85. Required Equipment. The following equipment is required to adjust the +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 3 1/2 digit model.

2-86. Procedure. To adjust the control, proceed as follows:

WARNING DISCONNECT ALL TRANSMITTER PRIMARY POWER BEFORE PROCEEDING.

2-87. Assure all transmitter power is off.

2-88. Open the transmitter rear door and disconnect all plugs and cables from the rear of the transmitter controller chassis.

2-89. Remove the eight screws securing the transmitter controller in the rack.

2-90. Remove the transmitter controller from the rack and set the chassis on a work surface.

2-91. Remove the screws which secure the top on the transmitter controller and remove the top cover.

2-92. Remove the four screws securing the power supply in the chassis.

2-93. Disconnect the plug from the power supply circuit board.

2-94. Lift the power supply out of the chassis and set it on top of the card cage.

2-95. Connect the voltmeter between test point TP1 and chassis ground.

2-96. 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.

2-97. Replace the fuse with a 1 Ampere fuse.

2-98. Apply power to the controller and adjust R2 to obtain a voltmeter indication of 15.6 volts dc.

WARNING DISCONNECT PRIMARY POWER BEFORE PROCEEDING.

2-99. Assure primary power is disconnected before proceeding.

2-100. Disconnect the voltmeter.

2-101. 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.

2-102. Replace the fuse with the original 1/2 Ampere slow-blow fuse.

2-103. Secure the power supply in the controller chassis and reconnect the circuit board plug.

2-104. Replace the top cover on the controller.

WARNING DISCONNECT ALL TRANSMITTER PRIMARY POWER BEFORE PROCEEDING.

2-105. Replace the controller in the transmitter. Connect the rear panel plugs.

2-106. TROUBLESHOOTING.

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 ANY MAINTENANCE ON ANY AREA WITHIN THE TRANSMITTER.

2-107. Most troubleshooting consists of visual checks. Because of the voltages and high currents in the equipment, it is considered hazardous to work with power energized. Therefore, the various transmitter indicators (meters, LEDs, and fuses) should be used to isolate the malfunction to one specific area.

2-108. Troubleshooting within the controller card cage 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.

2-109. 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
CAUTION

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

CAUTION
CAUTION

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

2-110. 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.

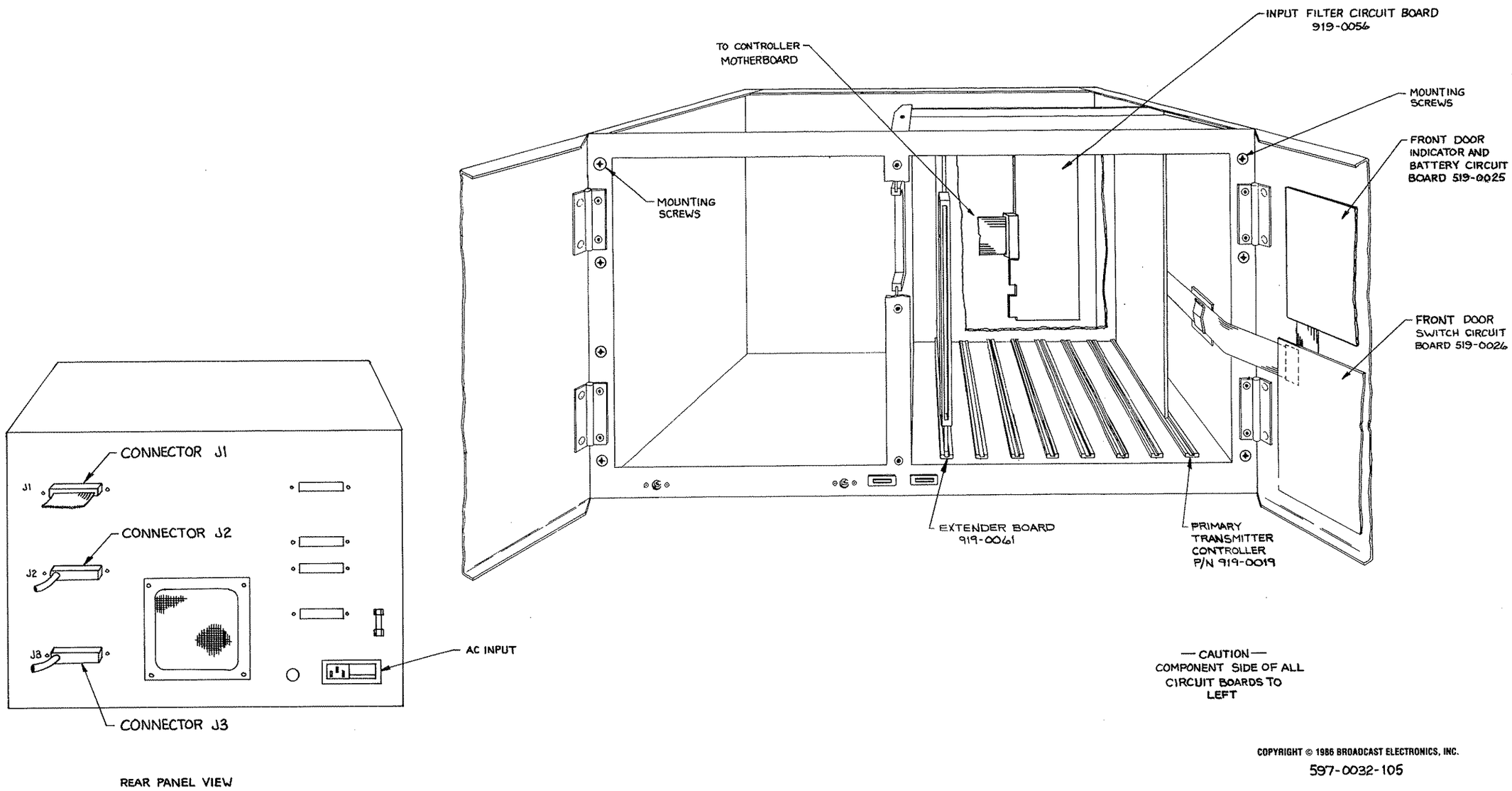
2-111. A built-in microprocessor video diagnostic system is optionally available which enables the transmitter controller to display fault conditions and diagnosis to the sub-system level in plain English on a CRT screen. The system may be field-installed in an existing transmitter.

SECTION III
DRAWINGS

3-1. INTRODUCTION.

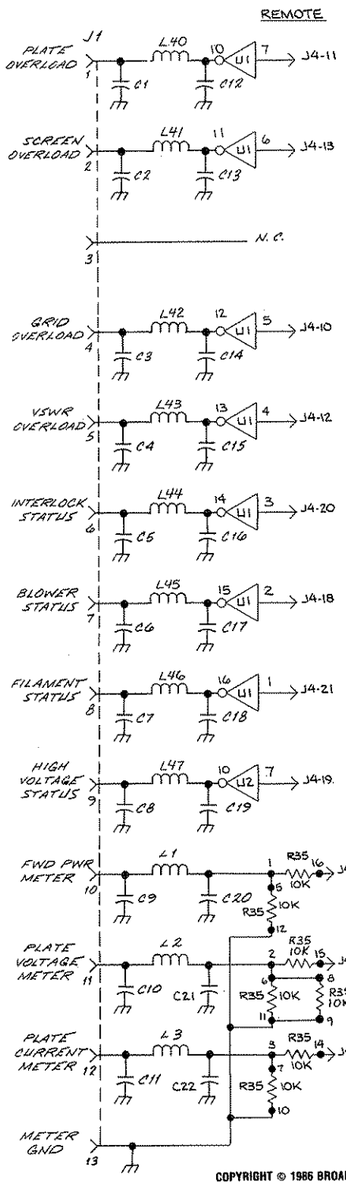
3-2. This section provides assembly drawings, schematic diagrams, and wiring diagrams as indexed below for the FM-1.5A transmitter controller.

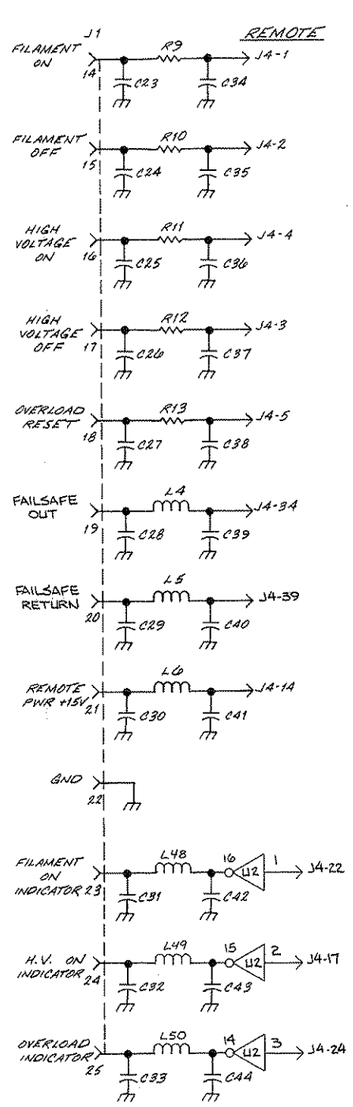
FIGURE	TITLE	NUMBER
3-1	ASSEMBLY, CONTROLLER CABINET	597-0032-105
3-2	SCHEMATIC, INPUT FILTER CIRCUIT BOARD	DS919-0056
3-3	ASSEMBLY, INPUT FILTER CIRCUIT BOARD	DA919-0056
3-4	ASSEMBLY, MOTHERBOARD	597-0032-18
3-5	SCHEMATIC, POWER SUPPLY	CS959-0045
3-6	ASSEMBLY, POWER SUPPLY CIRCUIT BOARD	BA919-0020
3-7	SCHEMATIC, DOOR ELECTRICAL ASSEMBLY	CS959-0153
3-8	ASSEMBLY, DOOR ELECTRICAL ASSEMBLY	CA959-0153
3-9	SCHEMATIC, CONTROLLER CIRCUIT BOARD	DS919-0019
3-10	ASSEMBLY, CONTROLLER CIRCUIT BOARD	DA919-0019
3-11	COMPONENT LOCATOR, CONTROLLER CIRCUIT BOARD	597-0032-19

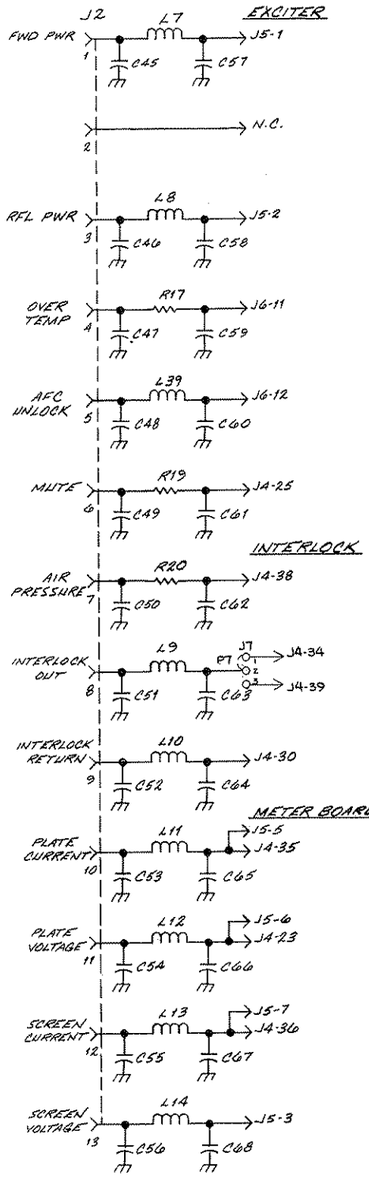


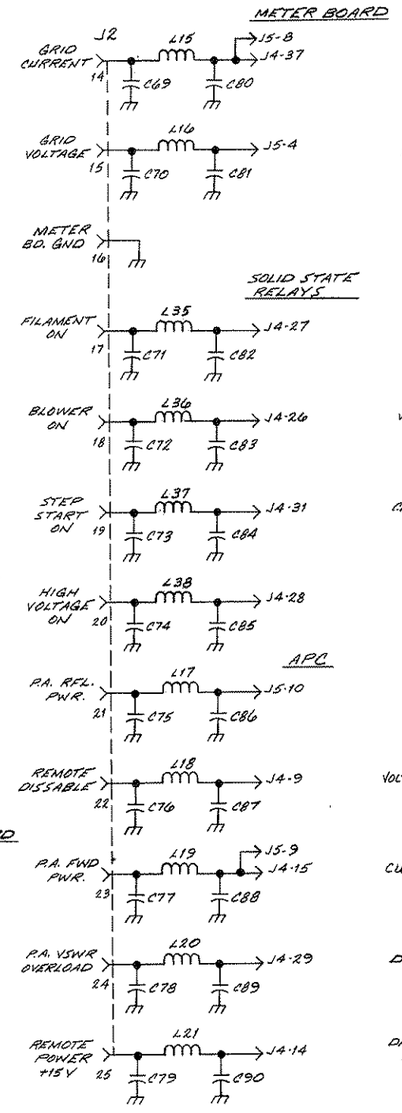
597-0032-105

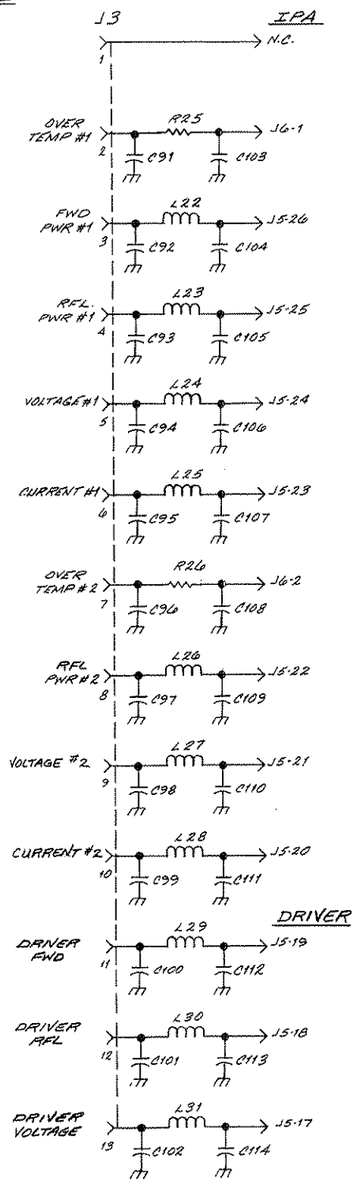
FIGURE 3-1. ASSEMBLY, CONTROLLER CABINET

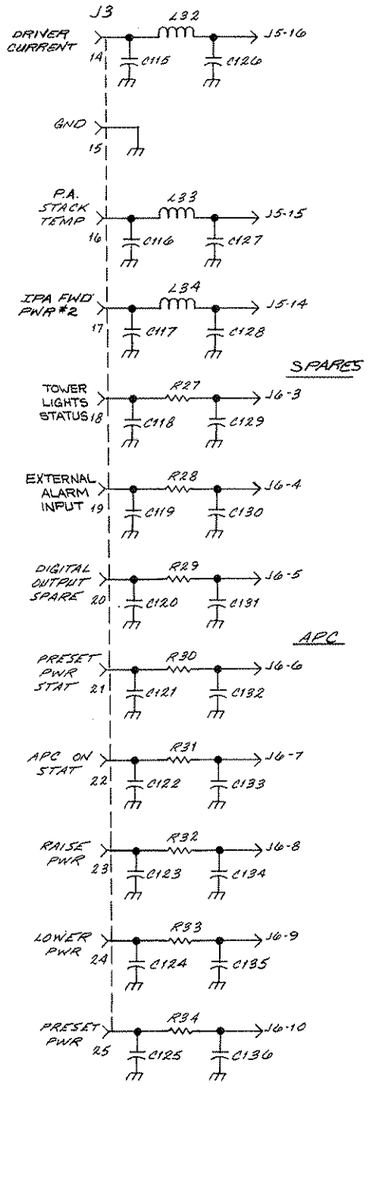












NOTES:

1. ALL RESISTORS ARE 1K, 1/4 W.
   ALL CAPACITORS ARE 390 pF.
   ALL COILS ARE 4.7 uH OR 2.2 uH.
2. LAST COMPONENTS USED: C136, L 39, R35, U2, J7
3. COMPONENTS NOT USED: R18
   SEE ASSEMBLY # D 919-0056
   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

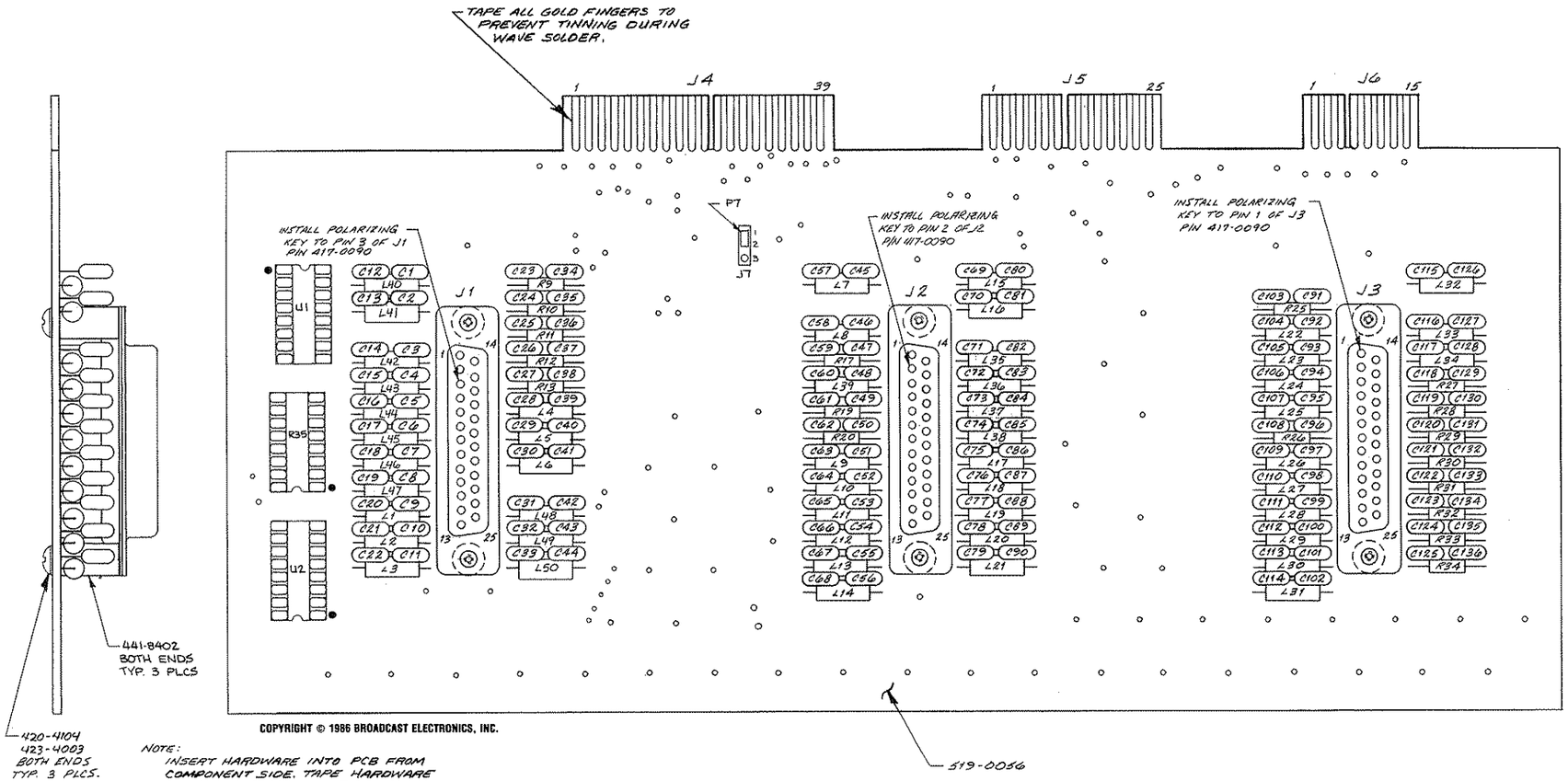
DRAWN BY MERKEL DATE 1-21-83
CHECKED BY DATE
PROJECT ENGR DATE 3-13-83
APPROVED BY MH DATE 3-13-83

BROADCAST ELECTRONICS INC.

TITLE SCHEMATIC - TRANSMITTER CONTROLLER INPUT FILTER BD.

D | DWG. NO. TYPE 5 919-0056 | REV. G

TRANSMITTER CONTROLLER | SCALE 2/1 | SHEET 1 OF 1



NOTE:
INSERT HARDWARE INTO PCB FROM COMPONENT SIDE. TAPE HARDWARE HOLES ON CIRCUIT SIDE OF PCB TO PREVENT FILLING DURING WAVE SOLDER. AFTER WAVE SOLDER, REMOVE HARDWARE FROM COMPONENT SIDE AND INSERT INTO CIRCUIT SIDE OF PCB.

SEE SCHEMATIC # D919-0056
SEE B/M # 919-0056

NOTE:
1. L1-L39 MAY BE EITHER 2.2 uH OR 4.7 uH UNDER P/N 360-0022.
2. FOR MOSLEY REMOTE CONTROL SYSTEMS, REPLACE U1, U2 & R35 WITH JUMPERS P/N 360-0006. INSTALL JUMPER AT PIN 1 POSITION OF R35.

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

DRAWN BY MEYKEL DATE 7-20-83
CHECKED BY DATE
PROJECT ENGR DATE 5-13-83
APPROVED BY MH
TREATMENT OR FINISH

BROADCAST ELECTRONICS INC.

TITLE PCB ASSEMBLY - TRANSMITTER CONTROLLER INPUT FILTER BD.

D | DWG. NO. TYPE A 919-0056 | REV. E

TRANSMITTER CONTROLLER | SCALE 4/1 | SHEET 1 OF 1

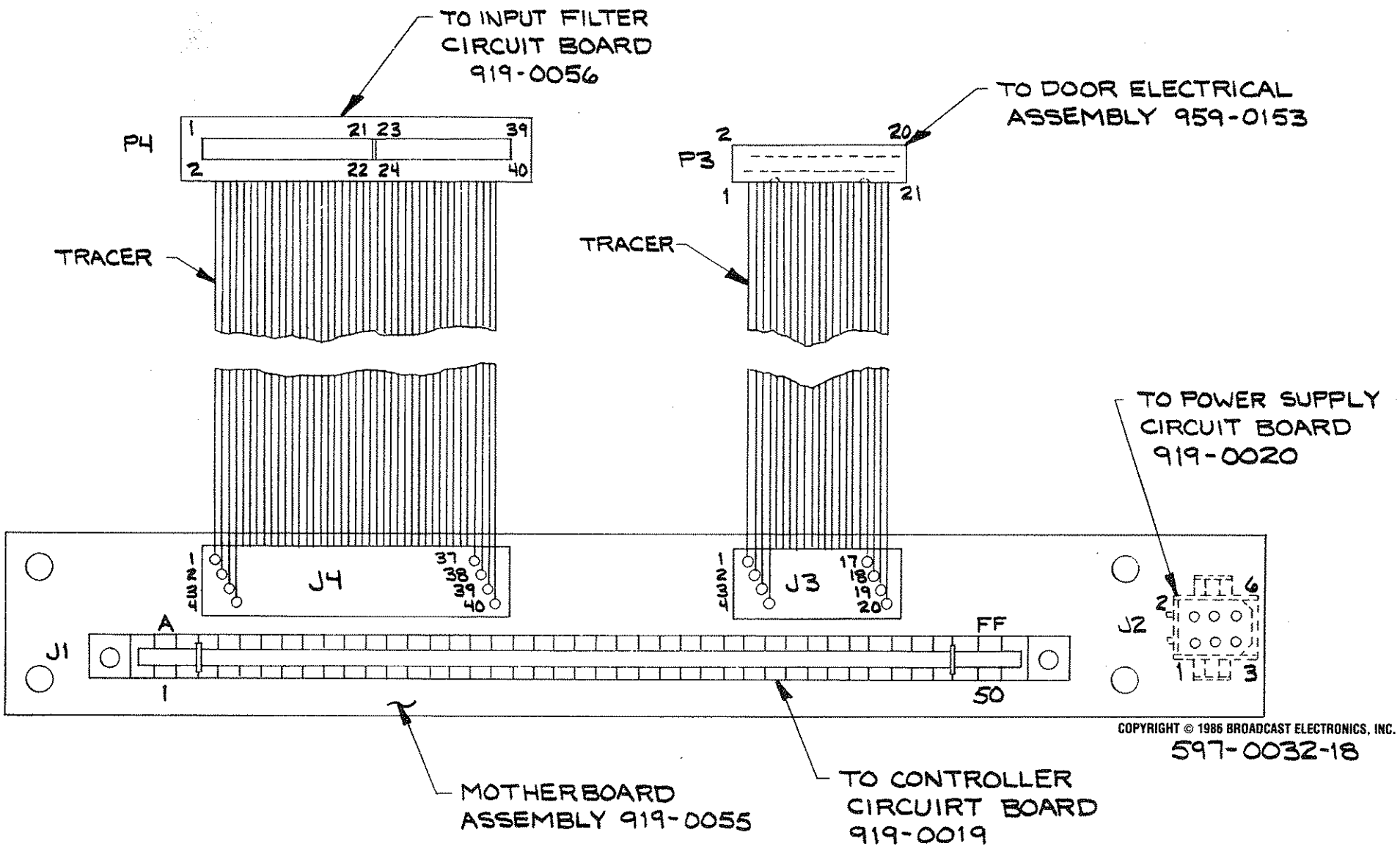


FIGURE 3-4. MOTHERBOARD ASSEMBLY

ASSY. # B949-0026

TO FAN-ASSY. No. 959-0136 OR TO No. 949-0030 (J2) IF EQUIPPED WITH MICRO-PROCESSOR VIDEO DIAGNOSTIC SYSTEM OPTIONS 979-0091 OR 909-0091

ASSY. # B919-0020

ASSY # C959-0157

RFI FILTER 360-6504

PRIMARY VOLTAGE SELECTOR CIRCUIT BOARD

100 V 115/120 V

230 V 230/240 V

97 TO 133 VAC OR 194 TO 266 VAC SINGLE SINGLE PHASE 50/60 HZ

NEUTRAL

EARTH GROUND

LINE

J2-1 ASSY B959-0136

No.11 FAN B1

No.12

P2 P1 J1 T1 P3 J3

115 VAC BK

100 VAC BN

BK/WT

BU

115 VAC

BU/WT

YL 2A YL

OR 400 MA OR

VL 100 MA YL

GN

RFI FILTER

F1

MOV1

D1 D2 D7 D8 MR502

U1 LM350K IN OUT ADJ

C1 15000 50V

C4 .1

R2 1.27K 1%

R3 200

C9 10 35V

R5 120

D16 MR502

D19 MR502

C8 10 35V

R7 1K ½W

TP1

J2-6 CONTROLLER REGULATOR 15V @750 M.A.

J2-2 CONTROLLER GROUND

D3 D4 D9 D10 IN4004

U2 LM78L15ACH IN OUT GND

C2 2500 50V

C5 .1

C6 .1

D17 IN4004

D20 IN4004

R8 1K ½W

TP2

J2-3 REMOTE REGULATOR 15V @75 M.A.

D15 IN4004

U3 LM78L15ACH IN OUT GND

C7 .1

D18 IN4004

R9 1K ½W

TP3

J2-1 INTERLOCK REGULATOR 15V @75 M.A.

R10 1K ½W

TP4

J2-5 AC POWER LOSS 12V @10 M.A.

R1 470 2W

D5 D6 D11 D12 IN4004

C3 10 35V

N/C KEYING PIN J2-4

OUTPUT

INPUT

GND CASE

LM78L15ACH BOTTOM VIEW

U2 & U3

ADJUSTMENT

INPUT

CASE IS OUTPUT

LM350 BOTTOM VIEW

U1

1. ALL RESISTORS IN OHMS, ¼ W; CAPACITORS IN MICROFARADS, U.O.S.
2. 1 — HEATSINK REQUIRED
3. LAST COMPONENTS USED: C9, D21, R10, T1, U3, J3, E10, & TP4
4. 2 POLARIZING PLUG # 418-0026
5. * WIRE #'s 13, 14, 15 & 16 ARE INCLUDED ON ASSY. # C959-0157

SEE B/M's 919-0020, 959-0157, 949-0026 & 959-0045

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 MERK	DATE 9-24-82	
CHECKED BY	DATE	
PROJECT ENGR.	DATE 5-16-83	
APPROVED BY MH	5-16-83	

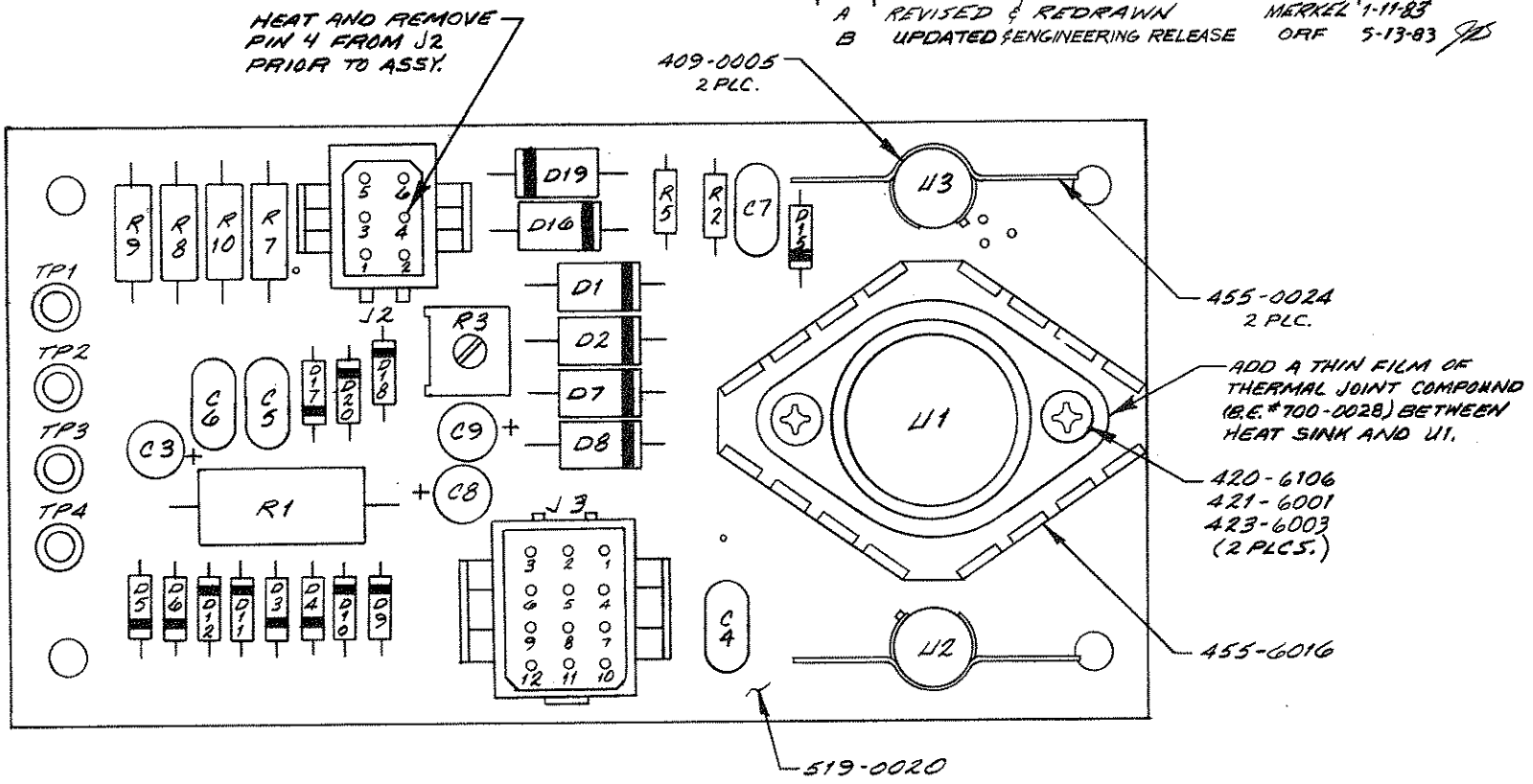
BROADCAST ELECTRONICS INC.

TITLE SCHEMATIC — TRANSMITTER CONTROLLER POWER SUPPLY

C DWG. NO. 959-0045 REV. C

SCALE NTS SHEET 1 OF 1

REVISIONS			
REV.	DESCRIPTION	DATE	APPROVED
A	REVISED & REDRAWN	MERKEL 1-11-83	
B	UPDATED TO ENGINEERING RELEASE	ORF 5-13-83	



SEE SCHEMATIC #C959-0045
SEE B/M # 919-0020

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

MATERIAL

TREATMENT OR FINISH

DRAWN BY MERKEL	DATE 1-11-83	
CHECKED BY	DATE	
PROJECT ENGR	DATE 5-16-83	
APPROVED BY MH	5-16-83	

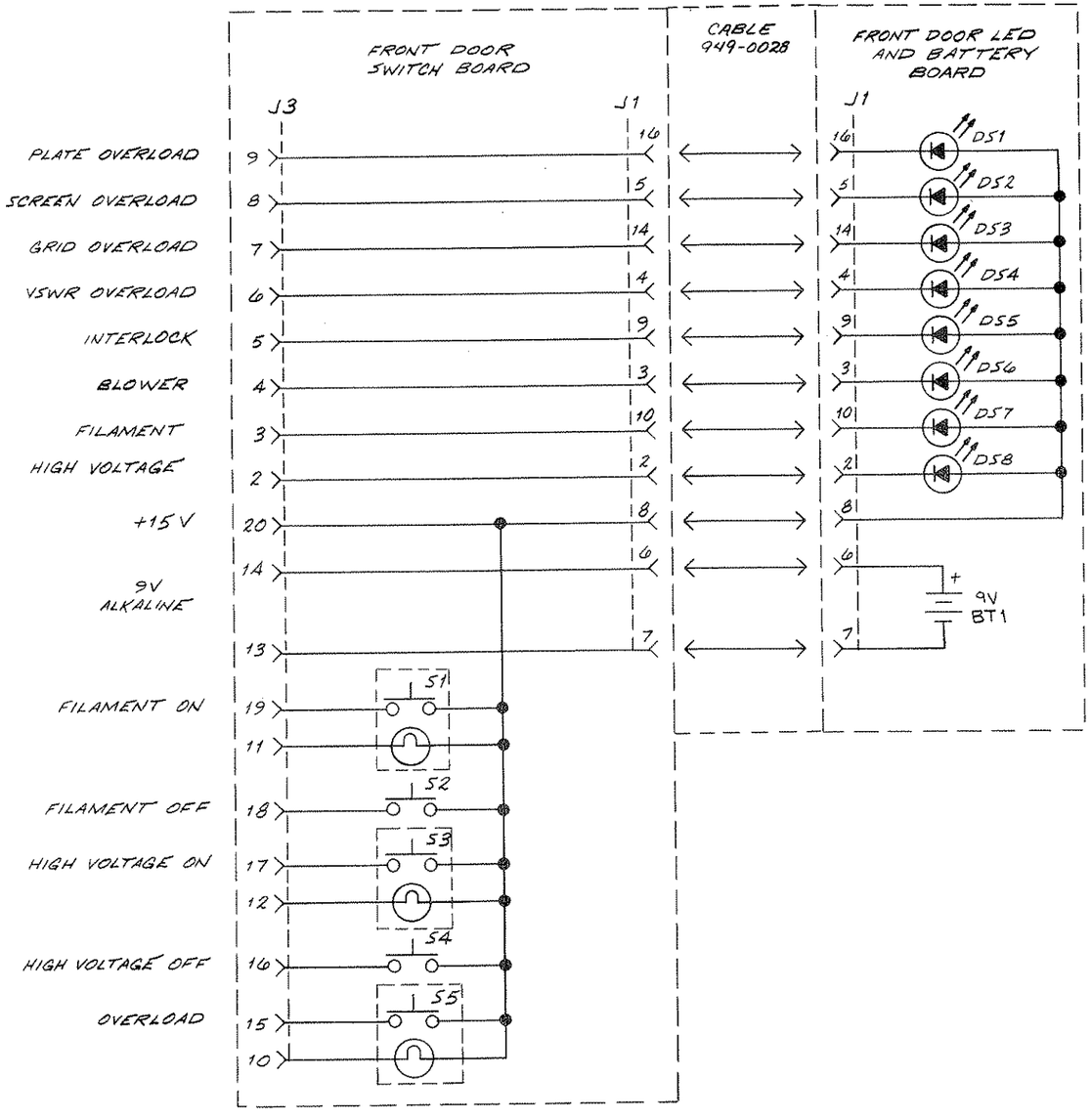
BROADCAST ELECTRONICS INC.

TITLE PCB ASSEMBLY TRANSMITTER CONTROLLER POWER SUPPLY

B | DWG. NO. 919-0020 | REV. B

XMTRS | SCALE 2/1 | SHEET 1 OF 1

REVISIONS					
REV	DATE	DESCRIPTION	DFTSMN	ENGR	ECN
A	5-13-83	ENGINEERING RELEASE W/O CHANGE	MH	[signature]	—
B	7-3-84	ADDED VOLTAGE TO BATTERY	JAH	[signature]	5205



NOTES:
1. LAST COMPONENTS USED: DS8, J3, S5
2. SEE ASSEMBLY # C&D 959-0153
   # A949-0028

SEE B/M # 959-0153
949-0028

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

DWN. BY	MERKEL 1-28-83
CHKD.	
ME	
EE	[signature]
PROJ. ENGR.	[signature] 5-13-83
DFTG. SUPVR.	5-13-83 MH
MFG.	

NEXT ASSY. 959-0046

PRODUCT USED ON TRANSMITTER CONTROLLER

FINISH —

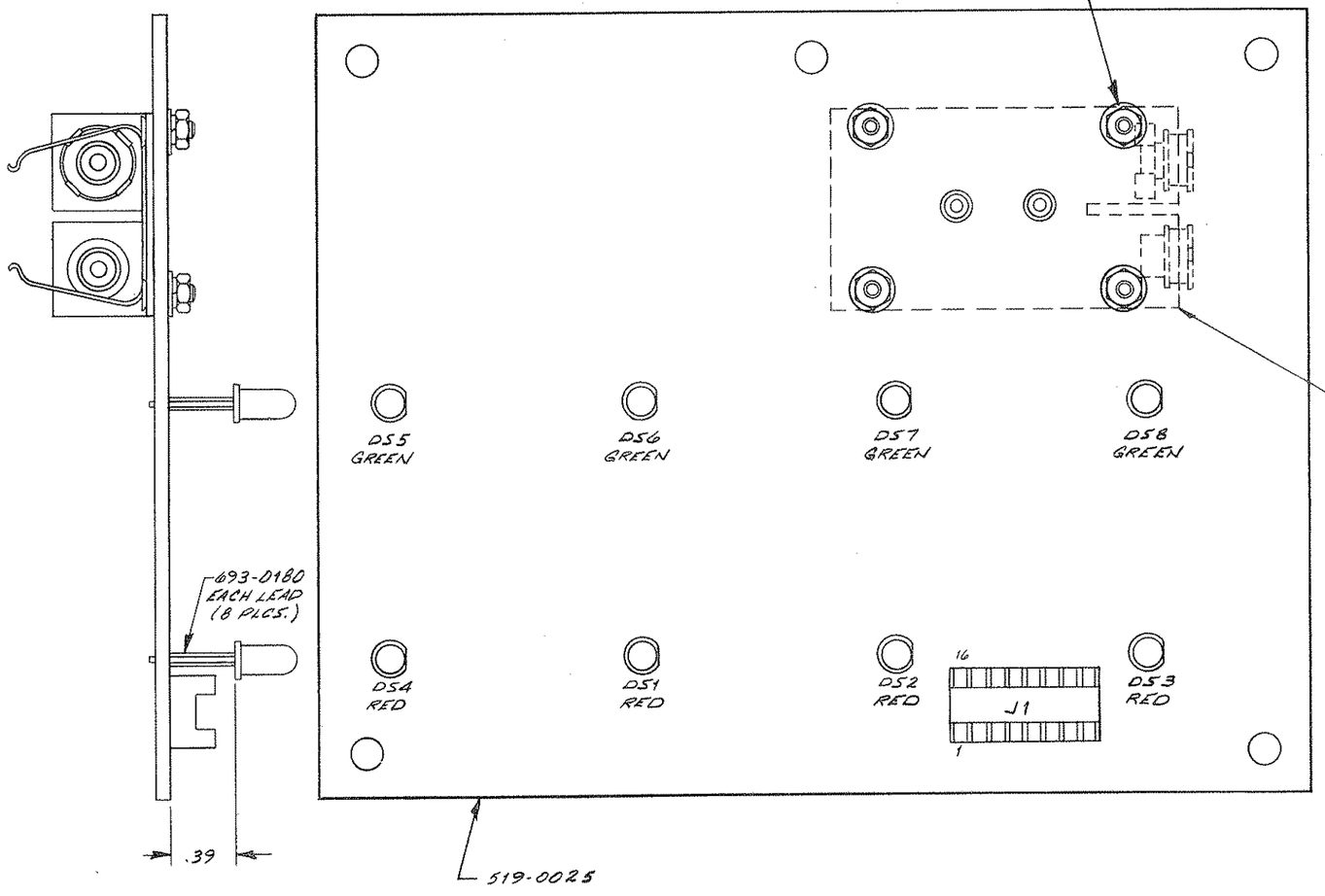
BROADCAST ELECTRONICS INC.
4100 N. 24TH ST. QUINCY, IL 62305 217/224-9600
TELEX 250142 CABLE BCST ELECT QUI

TITLE SCHEMATIC — FRONT DOOR SWITCH BD AND LED & BATTERY BD.

SHEET 1 OF 1 | SCALE — | REV B

TYPE S | SIZE C | DWG. NO. 959-0153

REVISIONS			
REV.	DESCRIPTION	DATE	APPROVED
A	ENGINEERING RELEASE W/O CHANGE	5-13-83	



REF ASSY. # D959-0153
SEE SCHEMATIC # C959-0153
SEE B/M # 959-0153

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

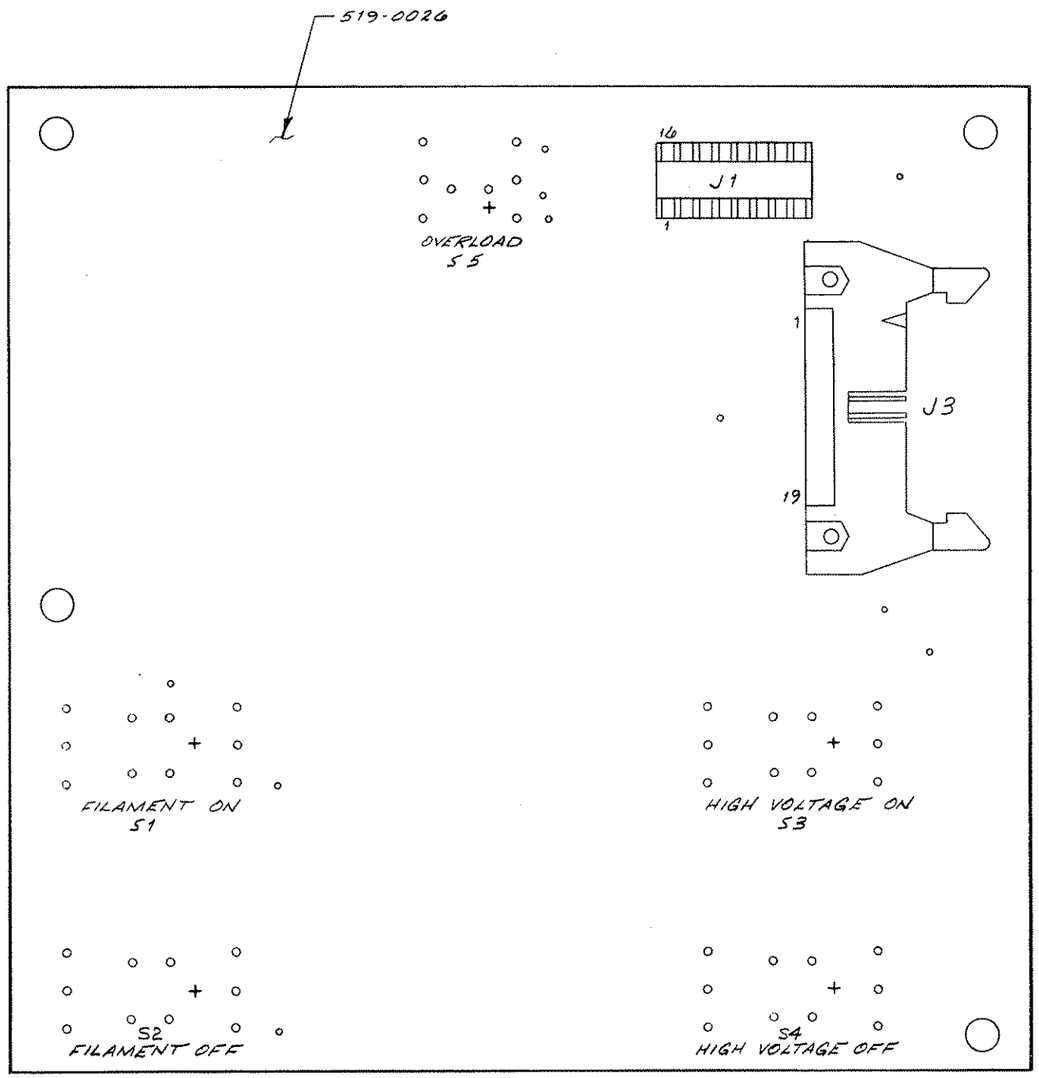
DRAWN BY	MERK	DATE 12-11-82
CHECKED BY		DATE
PROJECT ENGR		DATE 5-13-83
APPROVED BY	MH	5-13-83

BROADCAST ELECTRONICS INC.

TITLE PCB ASSEMBLY - CONTROLLER FRONT DOOR LED AND BATTERY

C | DWG. NO. TYPE A 959-0153 | REV. A

TRANSMITTERS | SCALE 2/1 | SHEET 1 OF 2



NOTES:
1. WHEN INSTALLING SWITCHES, (+) TERMINAL MUST MATCH (+) INDICATOR ON PC BOARD.
2. SWITCHES ARE ADDED DURING FINAL DOOR ASSEMBLY.

REF ASSY # D959-0153
SEE SCHEMATIC # C959-0153
SEE B/M # 959-0153

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

MATERIAL

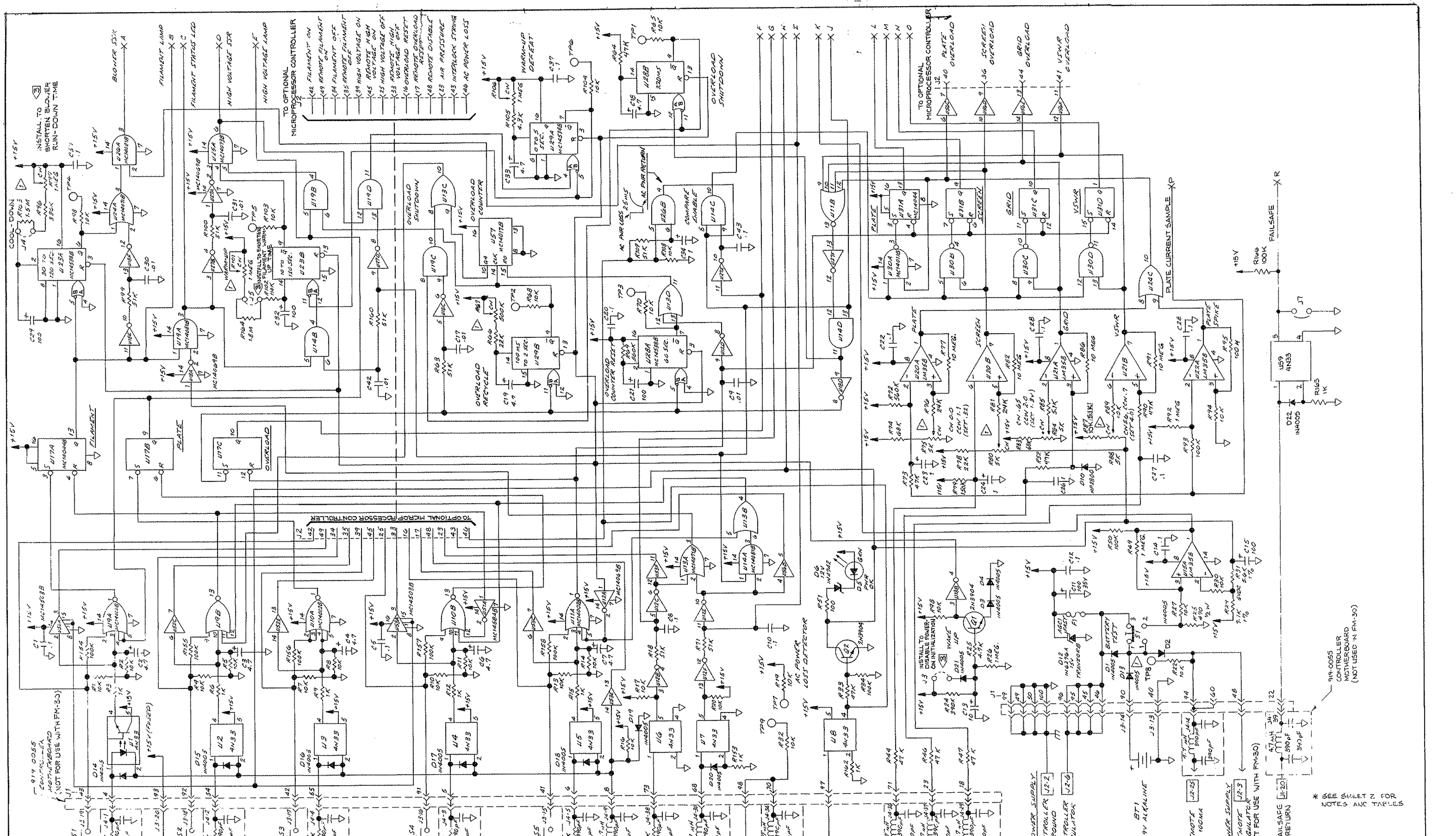
DRAWN BY MERK	DATE 12-11-82	
CHECKED BY	DATE	
PROJECT ENGR	DATE 573-83	
APPROVED BY MH	5-13-83	

TREATMENT OR FINISH

BROADCAST ELECTRONICS INC.

TITLE PCB ASSEMBLY-CONTROLLER FRONT DOOR SWITCH BOARD

C	DWG. NO. TYPE A 959-0153	REV. A
TRANSMITTERS	SCALE 2/1	SHEET 2 OF 2

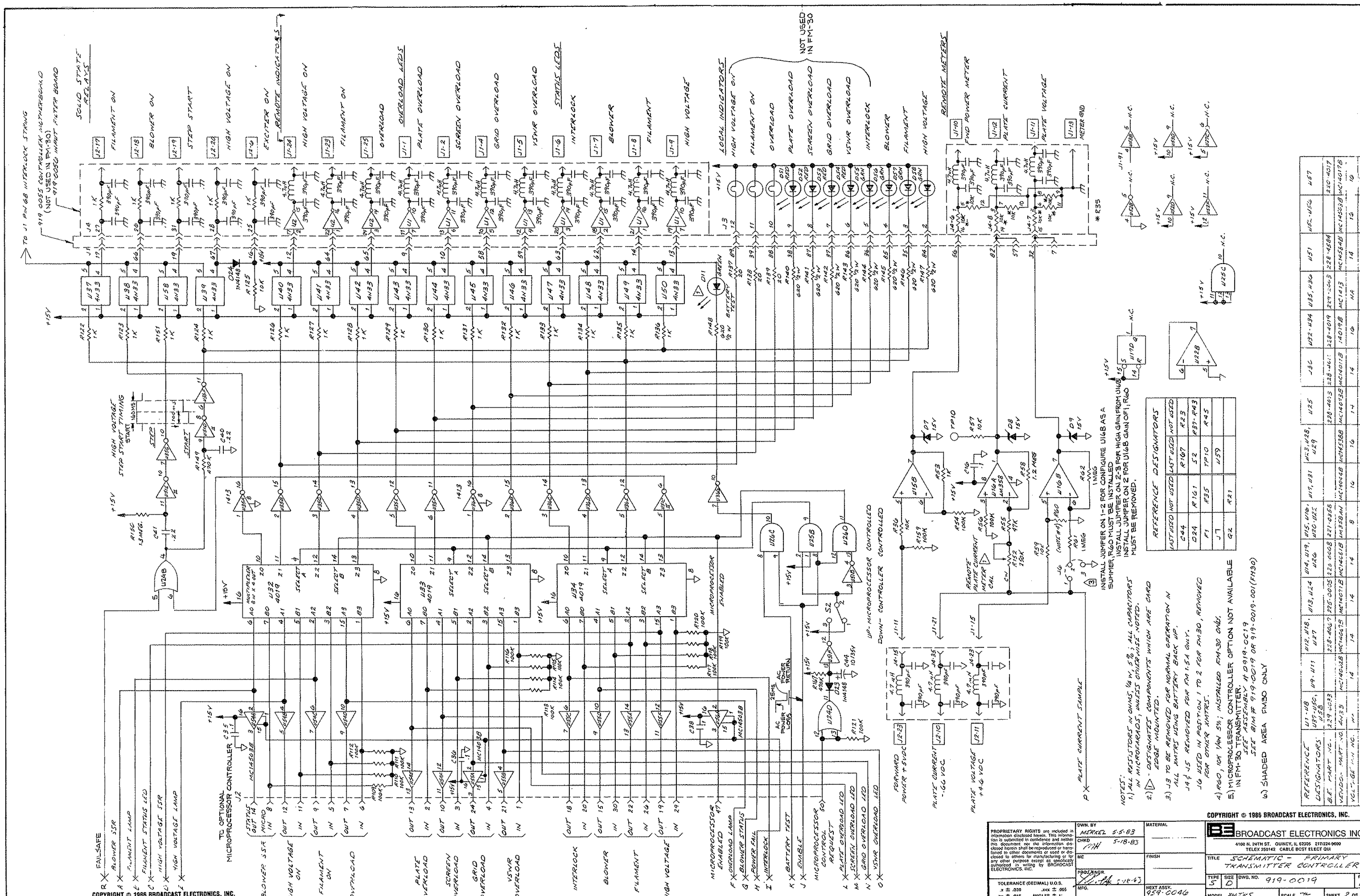


* SEE SHEET 2 FOR NOTES AND TABLES

DWN. BY MERKEL 5-5-83	MATERIAL		
CHKD MH 5-18-83			
ME	FINISH	TITLE SCHEMATIC - PRIMARY TRANSMITTER CONTROLLER	
PROJ. ENGR.		TYPE 5 / SIZE D / DWG. NO. 919-0019	M
MFG.	NEXT ASSY. 959-0046	MODEL XMTRS / SCALE ~	SHEET 1 OF 2

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

BROADCAST ELECTRONICS INC.
4100 N. 24TH ST. QUINCY, IL 62305 217/224-9600
TELEX 250142 CABLE BCST ELECT QUI


SOLID STATE RELAYS
REMOTE INDICATORS
OVERLOAD LEDS
STATUS LEDS
LOCAL INDICATORS
NOT USED IN FM-30
REMOTE METERS
FILAMENT ON
BLOWER ON
STEP START
HIGH VOLTAGE ON
EXCITER ON
OVERLOAD
PLATE OVERLOAD
SCREEN OVERLOAD
GRID OVERLOAD
VSWR OVERLOAD
INTERLOCK
BLOWER
FILAMENT
HIGH VOLTAGE
FWD POWER METER
PLATE CURRENT
PLATE VOLTAGE
METER GND
HIGH VOLTAGE STEP START TIMING
TO OPTIONAL MICROPROCESSOR CONTROLLER
UP-MICROPROCESSOR CONTROLLED
DOWN-CONTROLLER CONTROLLED
REMOTE PLATE CURRENT METER CAL
INSTALL JUMPER ON 1-2 FOR CONFIGURE U16B AS A SUMMER, R60 MUST BE INSTALLED. INSTALL JUMPER ON 2-3 FOR HIGH GAIN FROM U16B. INSTALL JUMPER ON 2 FOR U16B GAIN OF 1, R60 MUST BE REMOVED.
FORWARD POWER +5VDC
PLATE CURRENT -.66 VDC
PLATE VOLTAGE +4.6 VDC
PLATE CURRENT SAMPLE
FAILSAFE
BLOWER SSR
FILAMENT LAMP
FILAMENT STATUS LED
HIGH VOLTAGE SSR
HIGH VOLTAGE LAMP
MICROPROCESSOR ENABLED
OVERLOAD LAMP
BLOWER STATUS
POWER FAIL
INTERLOCK
BATTERY TEST
ENABLE
MICROPROCESSOR CONTROL REQUEST
PLATE OVERLOAD LED
SCREEN OVERLOAD LED
GRID OVERLOAD LED
VSWR OVERLOAD LED
NOTES:
1.) ALL RESISTORS IN OHMS, 1/4 W, 5%; ALL CAPACITORS IN MICROFARADS, UNLESS OTHERWISE NOTED.
2.) DESIGNATES COMPONENTS WHICH ARE CARD EDGE MOUNTED.
3.) J3 TO BE REMOVED FOR NORMAL OPERATION IN ALL XMTRS USING BATTERY BACK UP. J4 & J5 REMOVED FOR FM 1.5A ONLY. J6 USED IN POSITION 1 TO 2 FOR FM30, REMOVED FOR OTHER XMTRS.
4.) R60, 10K 1/4W 5%; INSTALLED FM-30 ONLY.
5.) MICROPROCESSOR CONTROLLER OPTION NOT AVAILABLE IN FM-30 TRANSMITTER. SEE ASSEMBLY # 919-0019 OR 919-0019-001 (FM30)
6.) SHADED AREA FM30 ONLY
REFERENCE DESIGNATORS
LAST USED
NOT USED
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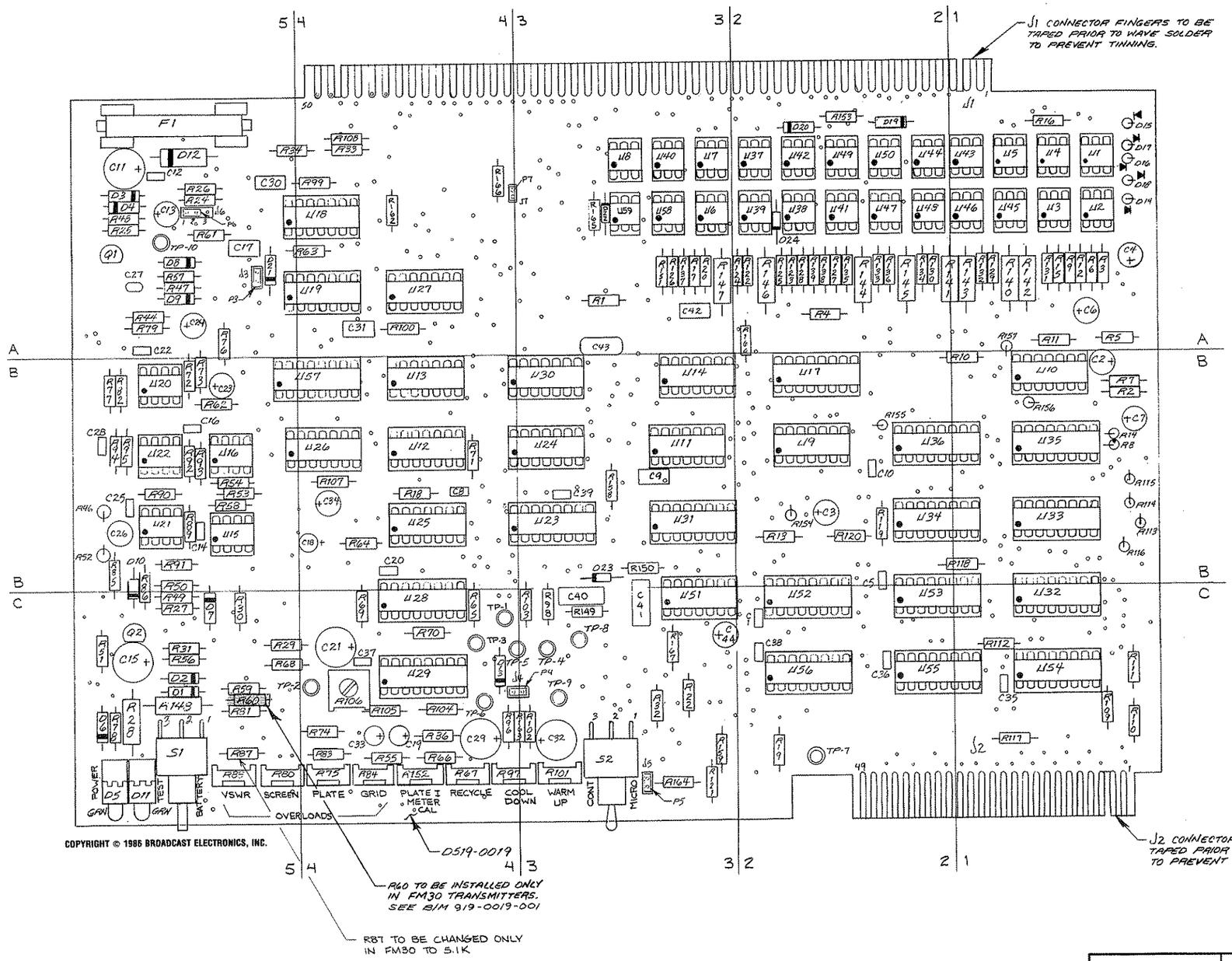
TOLERANCE (DECIMAL) U.O.S.
DWN. BY MERKEL 5-5-83
CHKD 5-18-83
NEXT ASSY. 959-0046
BROADCAST ELECTRONICS INC.
4100 N. 24TH ST. QUINCY, IL 62305 217/224-9600 TELEX 250142 CABLE BCST ELECT QUI
TITLE SCHEMATIC - PRIMARY TRANSMITTER CONTROLLER
TYPE 5 SIZE D DWG. NO. 919-0019 REV M
MODEL XMTRS
SHEET 2 OF 2



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

MATERIAL

TREATMENT OR FINISH

DRAWN BY CAF DATE 7-28-83
CHECKED BY DATE
PROJECT ENGR. DATE 7-16-83
APPROVED BY 5-16-83

BROADCAST ELECTRONICS INC.

TITLE ASSEMBLY PRIMARY TRANSMITTER CONTROLLER

D DWG. NO. 919-0019 REV. K
A 919-0019-001

XMTRS SCALE 2/1 SHEET 1 OF 1

REF	ZONE	REF	ZONE	REF	ZONE	REF	ZONE	REF	ZONE	REF	ZONE	REF	ZONE	REF	ZONE
C1	C2	C44	C3	R7	B1	R50	B5	R93	B5	R136	A2	TP10	A5	U43	A1
C2	B1	D1	C5	R8	B1	R51	C5	R94	B5	R137	A3	U1	A1	U44	A2-A1
C3	B2	D2	C5	R9	A1	R52	B5	R95	B5	R138	A2	U2	A1	U45	A1
C4	A1	D3	A5	R10	B1	R53	B5	R96	C3	R139	A2	U3	A1	U46	A1
C5	B2	D4	A5	R11	A1	R54	B5	R97	C4-C5	R140	A1	U4	A1	U47	A2
C6	A1	D5	C5	R12	A1	R55	C4	R98	C3	R141	A1	U5	A1	U48	A2-A1
C7	B1	D6	C5	R13	B2	R56	C5	R99	A4	R142	A1	U6	A1	U49	A2
C8	B4	D7	C5	R14	B1	R57	A5	R100	A4	R143	A1	U7	A3-A2	U50	A2
C9	B3	D8	A5	R15	A1	R58	B5	R101	C3	R144	A2	U8	A3	U51	C3-C2
C10	B2	D9	A5	R16	A1	R59	C5	R102	C3	R145	A2	U9	B2	U52	C2
C11	A5	D10	B5	R17	A3	R60	C5	R103	C3	R146	A2	U10	B1	U53	C2-C1
C12	A5	D11	C5	R18	B4	R61	A5	R104	C4	R147	A2	U11	B3	U54	C1
C13	A5	D12	A5	R19	C2	R62	B5	R105	C4	R148	C5	U12	B4	U55	C2-C1
C14	B5	D13	C4-C3	R20	A3	R63	A4	R106	C4	R149	C3	U13	B4	U56	C2
C15	C5	D14	A1	R21	---	R64	B4	R107	B4	R150	B3	U14	B3-B2	U57	B4
C16	B5	D15	A1	R22	C3	R65	B4	R108	A4	R151	A3	U15	B5	U58	A3
C17	A5	D16	A1	R23	---	R66	C4	R109	C1	R152	C4	U16	B5	U59	A3
C18	B4	D17	A1	R24	A5	R67	C4	R110	C1	R153	A2	U17	B2		
C19	C4	D18	A1	R25	A5	R68	C5-C4	R111	C1	R154	B2	U18	A4		
C20	B4	D19	A2	R26	A5	R69	C4	R112	C1	R155	B2	U19	A4		
C21	C4	D20	A2	R27	C5	R70	C4	R113	B1	R156	B1	U20	B5		
C22	A5	D21	A5	R28	C5	R71	B4	R114	B1	R157	A1	U21	B5		
C23	B5	D22	A3	R29	C5-C4	R72	B5	R115	B1	R158	B3	U22	B5		
C24	A5	D23	B3	R30	C5	R73	B5	R116	B1	R159	C2	U23	B3		
C25	B5	D24	A2	R31	C5	R74	C4	R117	C1	R160	A2	U24	B3		
C26	B5	F1	A5	R32	C3	R75	C4	R118	B1	R161	---	U25	B4		
C27	A5	J3	A5	R33	A4	R76	A5	R119	B2	R162	A3	U26	B4		
C28	B5	J4	C3	R34	A4	R77	B5	R120	B2	R163	C3	U27	A4		
C29	C4	J5	C3	R35	---	R78	C5	R121	B3	R164	C3	U28	C4		
C30	A5-A4	J6	A5	R36	C4	R79	A5	R122	A2	R165	A3	U29	C4		
C31	A4	J7	A3-A4	R37	---	R80	C5-C4	R123	A2	R166	A4	U30	B3		
C32	C3	P3	A5	R38	---	R81	C5	R124	A2	R167	C3	U31	B3-B2		
C33	C4	P4	C3	R39	---	R82	B5	R125	A2	S1	C5	U32	C1		
C34	B4	P5	C3	R40	---	R83	C4	R126	A3	S2	C3	U33	B1		
C35	C1	P6	A5	R41	---	R84	C4	R127	A2	TP1	C3	U34	B2-B1		
C36	C2	Q1	A5	R42	---	R85	B5	R128	A2	TP2	C4	U35	B1		
C37	C4	Q2	C5	R43	---	R86	B5	R129	A1	TP3	C4	U36	B2-B1		
C38	C2	R1	A3	R44	A5	R87	C5	R130	A2-A1	TP4	C3	U37	A2		
C39	B3	R2	B1	R45	---	R88	C5	R131	A1	TP5	C3	U38	A2		
C40	B3-C3	R3	A1	R46	B5	R89	B5	R132	A1	TP6	C4	U39	A2		
C41	B3-C3	R4	A2	R47	A5	R90	B5	R133	A2	TP7	C2	U40	A3		
C42	A3	R5	A1	R48	A5	R91	B5	R134	A2	TP8	C3	U41	A2		
C43	A3	R6	A1	R49	B5-C5	R92	B5	R135	A2	TP9	C3	U42	A2		

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-1.5A 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 4-2. TRANSMITTER CONTROLLER - 959-0046

REF. DES.	DESCRIPTION	PART NO.	QTY.
B1	Fan Assembly; consisting of: 1. Fan, 115V, 50/60 Hz, 70 ft^3/min, 4.71 in X 4.71 in X 1.5 in 2. 6-Pin Receptacle (J2) and Wiring	380-6300	1
BT1	Battery, 9 Volt, Alkaline	350-0002	1
	110V AC Input Operation		
F1, SPARE	Fuse, AGC, 250V, 1 Ampere, Slow-Blow	334-0100	2
	220V AC Input Operation		
F1, SPARE	Fuse, AGC, 250V, 1/2 Ampere, Slow-Blow	334-0050	2
----	Receptacle, Turn-Lock, for optional video monitor	420-0022	2
----	Door Electrical Assembly	959-0153	1
----	Extender Circuit Board Assembly	919-0061	1
----	Controller Circuit Board	919-0019	1
----	Power Supply Assembly	959-0045	1
----	Motherboard Assembly	959-0155	1
----	Input Filter Circuit Board	919-0056	1
----	EMI/AC Power Cable Assembly	949-0026	1

TABLE 4-3. MOTHERBOARD ASSEMBLY - 959-0155

REF. DES.	DESCRIPTION	PART NO.	QTY.
P2,P2	Plug, 6-Pin	418-0670	2
P3	Plug, 20-Pin	417-0207	1
P4	Plug, 40-Pin	417-0038	1
----	Pins for P2,P2	417-0053	10
----	Motherboard Circuit Board	919-0055	1

TABLE 4-4. 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 4-5. DOOR ELECTRICAL ASSEMBLY - 959-0153
(Sheet 1 of 2)

REF. DES.	DESCRIPTION	PART NO.	QTY.
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
DS9 THRU DS12	Lamp, Incandescent, No. 73, 14V @ 0.08 Ampere, T 1 3/4 Base	320-0007	4
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

TABLE 4-5. DOOR ELECTRICAL ASSEMBLY - 959-0153
(Sheet 2 of 2)

REF. DES.	DESCRIPTION	PART NO.	QTY.
----	Bezel for DS1 thru DS8	454-0004	8
----	Lens, Red (for S2 and S4)	346-1018	2
----	Lens, Green (for S1 and S3)	340-0016	2
----	Lens, Yellow (for S5)	340-0014	1
----	Front Door Switchboard to LED Board Cable	949-0028	1
----	Blank LED Circuit Board	519-0025	1
----	Blank Switch Circuit Board	519-0026	1

TABLE 4-6. FRONT DOOR SWITCHBOARD TO LED BOARD CABLE - 949-0028

REF. DES.	DESCRIPTION	PART NO.	QTY.
P1,P1	Plug, 16-Pin DIP	417-1602	2

TABLE 4-7. 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 4-8. CONTROLLER CIRCUIT BOARD - 919-0019
(Sheet 1 of 5)

REF. DES.	DESCRIPTION	PART NO.	QTY.
C1	Capacitor, Ceramic, 0.1 uF ±20%, 50V	003-1054	1
C2 THRU C4	Capacitor, Electrolytic, 4.7 uF, 35V	024-4764	3
C5	Capacitor, Ceramic, 0.1 uF ±20%, 50V	003-1054	1
C6,C7	Capacitor, Electrolytic, 4.7 uF, 35V	024-4764	2
C8	Capacitor, Ceramic, 0.1 uF ±20%, 50V	003-1054	1
C9	Capacitor, Mylar Film, 0.01 uF, 100V	030-1043	1
C10	Capacitor, Ceramic, 0.1 uF ±20%, 50V	003-1054	1
C11	Capacitor, Electrolytic, 100 uF, 25V	023-1084	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, 100 uF, 25V	023-1084	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

TABLE 4-8. CONTROLLER CIRCUIT BOARD - 919-0019
(Sheet 2 of 5)

REF. DES.	DESCRIPTION	PART NO.	QTY.
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
D1 THRU D4	Diode, 1N4005, Silicon, 600V, 1 Ampere	203-4005	4
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 Type, 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, 1N4008, Silicon, 75V @ 0.3 Amperes	203-4148	2
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	Receptacle, Header, 2-Pin	417-4004	1
P3 THRU P7	Plug, 2-Pin	340-0004	5
Q1	Transistor, 2N3904, Silicon, NPN, TO-92 Case	211-3904	1
Q2	Transistor, MPSA14, Silicon, NPN, Darlington, TO-92 Case	211-0014	1
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	100-4743	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

TABLE 4-8. CONTROLLER CIRCUIT BOARD - 919-0019
(Sheet 3 of 5)

REF. DES.	DESCRIPTION	PART NO.	QTY.
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	Resistor, 10 k Ohm ±5%, 1/4W	100-1053	1
R61,R62	Resistor, 1 Meg Ohm ±5%, 1/4W	100-1073	2
R63	Resistor, 51 k Ohm ±5%, 1/4W	100-5153	1
R64	Resistor, 47 k Ohm ±5%, 1/4W	100-4753	1
R65	Resistor, 10 k Ohm ±5%, 1/4W	100-1053	1
R66	Resistor, 22 k Ohm ±5%, 1/4W	100-2253	1
R67	Potentiometer, 500 k Ohm ±10%, 1/2W	178-5064	1
R68	Resistor, 10 k Ohm ±5%, 1/4W	100-1053	1
R69	Resistor, 560 k Ohm ±5%, 1/4W	100-5663	1
R70	Resistor, 10 k Ohm ±5%, 1/4W	100-1053	1
R71	Resistor, 51 k Ohm ±5%, 1/4W	100-5153	1
R72	Resistor, 560 k Ohm ±5%, 1/4W	100-5663	1
R73	Resistor, 47 k Ohm ±5%, 1/4W	100-4753	1
R74	Resistor, 68 k Ohm ±5%, 1/4W	100-6853	1
R75	Potentiometer, 5 k Ohm ±10%, 1/2W	178-5044	1
R76	Resistor, 24 k Ohm ±5%, 1/4W	100-2453	1
R77	Resistor, 10 Meg Ohm ±5%, 1/4W	100-1083	1
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, 20 Ohm ±5%, 1/4W	100-2023	3
R140 THRU R148	Resistor, 620 Ohm ±5%, 1/2W	110-6233	8
R149	Resistor, 470 k Ohm ±5%, 1/4W	100-4763	1
R150	Resistor, 1.3 Meg Ohm ±5%, 1/4W	100-1373	1
R151	Resistor, 1 k Ohm ±5%, 1/4W	100-1043	1

TABLE 4-8. CONTROLLER CIRCUIT BOARD - 919-0019
(Sheet 4 of 5)

REF. DES.	DESCRIPTION	PART NO.	QTY.
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
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
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

TABLE 4-8. CONTROLLER CIRCUIT BOARD - 919-0019
(Sheet 5 of 5)

REF. DES.	DESCRIPTION	PART NO.	QTY.
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 4-9. 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

TABLE 4-10. POWER SUPPLY ASSEMBLY - 959-0045

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	919-0020	1

TABLE 4-11. POWER TRANSFORMER AND WIRE HARNESS - 959-0157

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 @ 0.1 Ampere 20.4V @ 0.4 Ampere 20.4V @ 2 Amperes	370-0005	1
----	Pins for J1	417-0036	5
----	Pins for P3	417-0053	10

TABLE 4-12. POWER SUPPLY CIRCUIT BOARD - 919-0020

REF. DES.	DESCRIPTION	PART NO.	QTY.
C3	Capacitor, Electrolytic, 10 uF, 35V	023-1076	1
C4 THRU C7	Capacitor, Mylar Film, 0.1 uF ±10%, 100V	030-1053	4
C8,C9	Capacitor, Electrolytic, 10 uF, 35V	023-1076	2
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	Diode, 1N4004, Silicon, 400V, 1 Ampere	203-4004	1
J2	Receptacle, 6-Pin	417-0677	1
J3	Receptacle, 12-Pin	417-1276	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
R7 THRU R10	Resistor, 1 k Ohm ±5%, 1/2W	110-1043	4
U1	Integrated Circuit, LM350K, Three-Terminal Adjustable Positive Voltage Regulator, 1.2V to 33V, 3 Amperes Maximum, TO-3 Case	227-0350	1
U2,U3	Integrated Circuit, LM78L15ACH, Three-Terminal Fixed 15 Volt Regulator, 0.1 Ampere, 15V, TO-39 Case	227-7800	2
----	Blank Circuit Board	519-0020	1

TABLE 4-13. EMI/AC POWER CABLE ASSEMBLY - 949-0026

REF. DES.	DESCRIPTION	PART NO.	QTY.
FL1	Fused Power Connector/120/240V Voltage Selector/EMI Filter	360-6504	1
MOV1	Metal-Oxide Varistor, V250LA15A, 250V RMS, 15 Joules	140-0008	1
P1,P2	Plug, 6-Pin	418-0670	2
----	Pins for P1 and P2	417-0053	10

PRODUCT WARRANTY

LIMITED ONE YEAR

While this warranty gives you specific legal rights, which terminate one (1) year (6 months on turntable motors) from the date of shipment, you may also have other rights which vary from state to state.

Broadcast Electronics, Inc. ("BE"), 4100 North 24th Street, P. O. Box 3606, Quincy, Illinois 62305, hereby warrants cartridge machines, consoles, transmitters and other new Equipment manufactured by BE against any defects in material or workmanship at the time of delivery thereof, that develop under normal use within a period of one (1) year (6 months for turntable motors) from the date of shipment. Other manufacturers' Equipment, if any, shall carry only such manufacturers' standard warranty. This warranty extends to the original user and any subsequent purchaser during the warranty period. BE's sole responsibility with respect to any Equipment or parts not conforming to this warranty is to replace such equipment or parts upon the return thereof F.O.B. BE's factory or authorized repair depot within the period aforesaid.

In the event of replacement pursuant to the foregoing warranty, only the unexpired portion of the warranty from the time of the original purchase will remain in effect for any such replacement. However, the warranty period will be extended for the length of time that the original user is without the services of the Equipment due to its being serviced pursuant to this warranty. The terms of the foregoing warranty shall be null and void if the Equipment has been altered or repaired without specific written authorization of BE, or if Equipment is operated under environmental conditions or circumstances other than those specifically described in BE's product literature or instruction manual which accompany the Equipment purchased. BE shall not be liable for any expense of any nature whatsoever incurred by the original user without prior written consent of BE.

BE shall not be liable to the original user for any and all incidental or consequential damages for breach of either expressed or implied warranties. However, some states do not allow the exclusion or limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you. All express and implied warranties shall terminate at the conclusion of the period set forth herein.

Except as set forth herein, and except as to title, there are no warranties, or any affirmations of fact or promises by BE, with reference to the Equipment, or to merchantability, fitness for a particular application, signal coverage, infringement, or otherwise, which extend beyond the description of the Equipment in BE's product literature or instruction manual which accompany the Equipment. Any card which is enclosed with the Equipment will be used by BE for survey purposes only.

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