SECTION IV

THEORY OF OPERATION

4-1. OVERALL THEORY.

Refer to figure 4-1 for a block diagram of a typical transmitter. The block diagram is discussed with reference to RF generation and power and control functions.

4-2. RF GENERATION. Transmitter RF originates in the external exciter unit which receives monaural, stereo, and SCA audio inputs and produces an RF, FM carrier in the frequency range of 88 to 108 MHz and at a power output adjustable between approximately 5 and 20 watts. The RF carrier output from the external exciter unit is cabled to a directional coupler in the transmitter cabinet. The transmitter is supplied with either an FM-15QE or an FM-20E exciter. (For further information on the exciter units refer to their manuals).

The transmitter amplifies the exciter RF carrier using two vacuum tube stages (a driver stage and a power amplifier stage). The FM-25KG transmitter provides a nominal RF power output of 25 kW to the antenna transmission line, via a harmonic filter/coupler unit.

4-3. POWER AND CONTROL. The transmitter requires 220-240 Vac, 3-phase, 60 Hz primary power. The power supplies used in the transmitter generate the following outputs:

a. 4.0 and 8.0 kVdc (driver and power amplifier plate voltages).

b. 500 Vdc (driver screen voltage).

c. -165 Vdc (driver bias voltage).

d. +24 Vdc (control circuit power).

e. +5 Vdc (power to integrated circuits).

f. 5.0 Vac (driver filament voltage).
6.3 Vac (power amplifier filament).

When the interlocks (consisting of driver air-flow, PA input air pressure, cabinet door, and access panel safety switches) are closed, the bias, plate, and screen power supplies may be energized. Opening any of the interlocks deenergizes these power supplies.

The overload protection and automatic recycling circuits monitor the driver cathode current, power amplifier cathode current, high voltage power supply current, VSWR and PA compartment exhaust air temperature. If an electrical overload should occur on any of these parameters the automatic recycle circuit shuts down the high voltage power supply for two

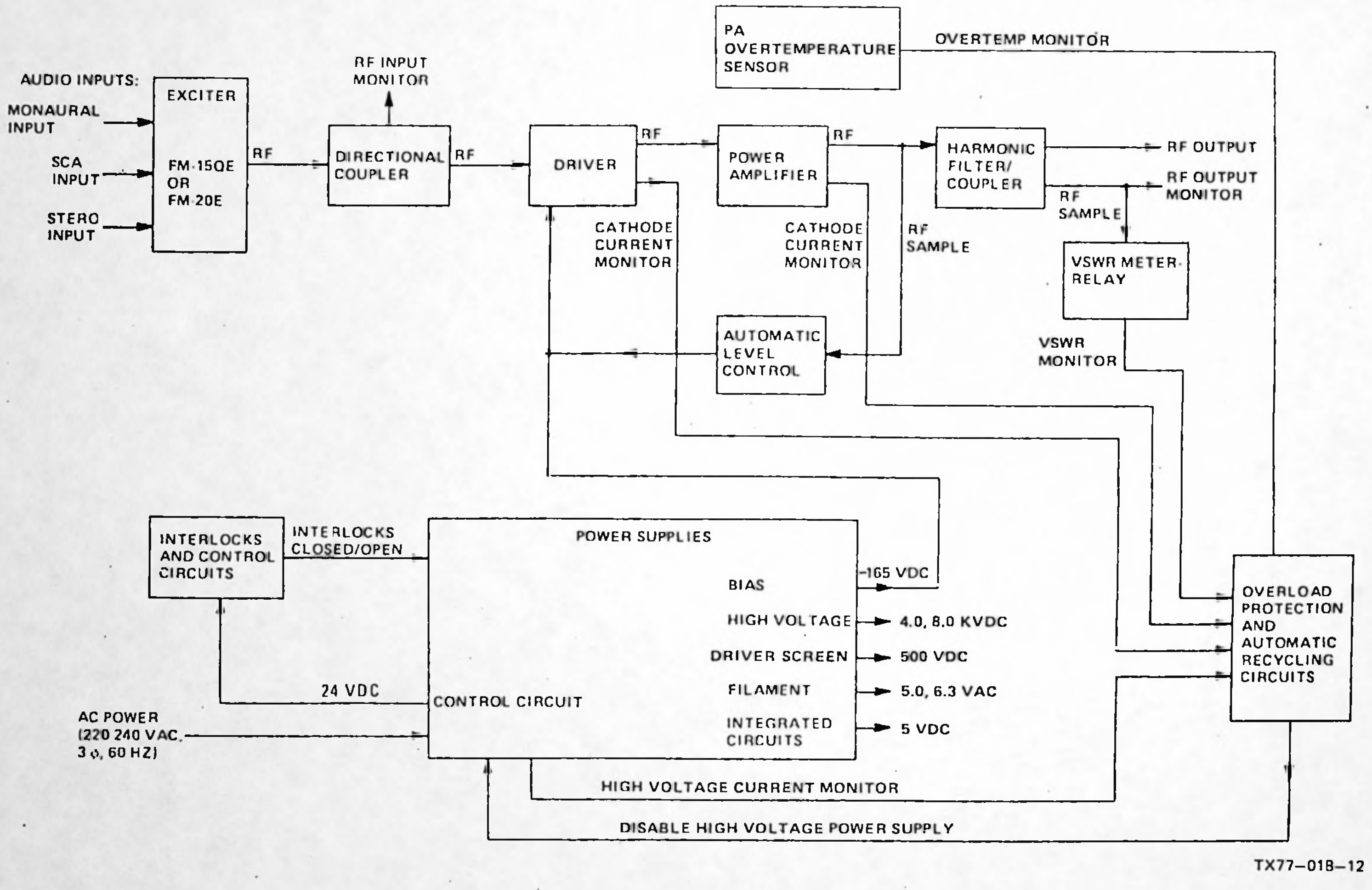


Figure 4-1. Transmitter Block Diagram

seconds. If after the two-second shutdown the overload is still present, the shutdown will be repeated. If three shutdown cycles occur in a 60-second period, the high voltage power supply will remain deenergized and must be manually reset after the cause of the overload is removed. An overtemperature condition in the PA compartment that cuases the exhaust air temperature to exceed 225° F will activate a thermostat connected in parallel with the VSWR input to the fault sense circuit. If the thermostat stays closed for less than 6 seconds the high voltage power supply will shutdown and automatically recycle. If the thermostat stays closed for more than 6 seconds the high voltage power supply will stay deenergized until manually reset and the thermostat opens.

Since the use of digital logic devices in the overload protection circuitry of broadcast transmitters is relatively new technology, a section of the appendix of this manual contains an Introduction to Logic to famaliarize the reader with TTL logic operation.

The automatic level control (ALC) system maintains constant transmitter output power for variations in primary line voltage of up to ±5 percent. The ALC is a feedback system in which the transmitter gain is controlled by varying the bias level to the driver stage.

4-4. DETAILED THEORY.

The following paragraphs refer to drawing 6050393.

4-5. EXCITER. For detailed theory on the exciter units (FM-15QE exciter and FM-20E exciter), refer to their manuals.

4-6. DRIVER. The FM-25KG driver amplifier (V1) employs a 5CX1500A pentode, operated in a RF grounded cathode circuits.

The input of the driver control grid circuit is capacitive coupled to the grid through capacitor C16. Driver grid tuning is accomplished with capacitor C17, and driver input tuning with capacitor C16. The stripline inductance L3 is used for 50-ohm impedance matching.

Bias voltage developed in the bias power supply is shunt fed to the driver control grid through RF chokes RL1, RL2 and resistor R24. The bias voltage is indicated on DRIVER meter M7 when DRIVER GRID switch S4-A is depressed.

A directional coupler (DC1) is installed between the exciter RF output and the driver input coaxial connector (J1). The coupler permits monitoring the reflected and forward RF power for optimum impedance match and transfer of power. The sampled reflected and forward power outputs from the coupler are applied to OUTPUT meter M10 when the OUTPUT EXC REF and EXC FWD switches (S5-A, -B), respectively, are depressed.

The 5.0 Vac filament voltage for the driver tube is furnished by transformer T4. The transformer secondary voltage is monitored by FILAMENT meter M11 when the FILAMENT DR switch (S17-A) is depressed. Capacitors C21 through C24 and C27 through C30 provide low-inductance RF bypassing of the filament wiring at the tube socket. The filament transformer (T4) is used to provide 5.0 Vac with a center tap common for the cathode ground return. This center tap is also connected to the driver screen power supply (A7) negative return.

The center tap of the filaments transformer is connected through the DR CATHODE meter (M6) and an overload sampling resistor (R13) back to the ground side of the high voltage power supply. Capacitor C15 provides an RF bypass for the meter. The voltage sampled by resistor R13 is used as an input to the driver cathode current overload protection circuit (refer to paragraph 4-14).

The plate voltage for the driver tube is shunt-fed through RF choke L4. Capacitor C36 serves as a plate-voltage blocking and RF coupling capacitor to the coaxial quarter-wave line that serves to match the driver plate impedance to the input impedance of the grounded-grid power amplifier V2. The effective length of the quarter-wave line and its impedance transformation characteristics are controlled by variable capacitor C37 and variable shunt inductor DRIVER TUNING L5.

The screen voltage is derived from a 500 Vdc full-wave screen power supply (A7). The driver screen current is monitored by DR SCREEN meter M8; capacitor C34 provides RF bypass for the meter. The DRIVER SCREEN current meter (M8) is calibrated for 0 to 200 mAdc. Capacitors C33 and C provide an RF ground for the driver screen. See paragraph 4-9 for the power supply description.

4-7. POWER AMPLIFIER. Power amplifier V2 is a 3CX15, 000A7 triode used in a grounded-grid circuit configuration. The RF output from the driver amplifier is coupled to the filament circuit of the power amplifier by means of ceramic coupling capacitors C38 through C41.

The filament is maintained above RF ground by RF chokes L6 and L7. Physically, these chokes are straight silver-plated rods. However, at the frequency of operation, they exhibit sufficient inductive reactance to prevent short-circuiting the driving power to ground. The rods pass through the floor of the lower RF shield compartment by means of feed-through capacitors C42 and C43 wherein the rods themselves serve as one surface of each capacitor. At the bottom end of each rod, heavy gauge wiring is used to connect the rods to the secondary of filament transformer T2.

The 6.3 Vac filament voltage for the power amplifier tube is furnished by transformer T2. The filament voltage is adjustable by the front panel PA FIL ADJUST Variac T6. The Variac is used to control the voltage to the primary of transformer T5, secondary of T5 is in series with the primary of the 24V PA filament transformer T2 and can be connected to back or boost the line voltage. The circuit as shown of 6050393 is shown in the boost mode. If the line voltage is high, the primary of T5 can be reversed so that the circuit will buck the line voltage.

The secondary of the filament transformer is also connected to a coil winding of relay K14. If a malfunction occurs in the filament supply that reduces the filament voltage below the hold-in voltage of the relay, the relay deenergizes. This opens relay contacts 1 and 3 in the plate voltage control circuit to deenergize the high voltage power supply, and opens the relay contacts 6 and 8 to remove the bias voltage to the driver tube.

The secondary center-tap of the filament transformer is connected to ground via parallel resistors R7 through R10, series resistors R11 and R23 and PA CATHODE ammeter M5. Capacitor C13 serves as an RF bypass capacitor for the meter. The voltage drop across resistors R11 and R23 is used as an input to the PA cathode current overload protection circuit (refer to paragraph 4-14).

The plate voltage for the power amplifier is derived from the output of the high voltage power supply and is shunt fed through filter choke L9 and RF choke L8. Capacitors C51 through C56 provide RF bypassing for L8 and L9. Capacitor C44, built into the power amplifier tube socket, serves as a dc blocking and RF coupling capacitor to the output tuned circuit.

The power amplifier output tuned circuit is a pi-network filter. The input capacitance of the pi-network filter consists of variable inductor L10 (PA TUNING) in shunt with the plate-to-filament capacitance of the PA tube. The variable inductor is tunable at some frequency below the operating frequency to provide a variation in the effective negative reactance; this is, in effect, a variable capacitor at the input of the pi-network to tune its overall resonant frequency. The value of the pi-network output loading capacitors C45 through C48 is determined at the factory for the specific operating frequency. The pi-network series inductance L11 (PA LOADING) determines the amount of loading. The output of the pi-network is coupled through the harmonic filter/coupler FL1 to the transmission line.

The PA end of the harmonic filter contains a directional coupler to sample forward and reflected power for display on the front panel OUTPUT meter.

The sampled forward and reflected power outputs from the directional coupler are applied to OUTPUT meter M10, via OUTPUT PA REF and PA FWD switches (S5D, E), respectively, and are calibrated by potentiometers R19 and R20 respectively, to indicate the RF power directly on the OUTPUT meter. The reflected power is also applied to the VSWR meter-relay M9. A contact closure of the meter relay provides a voltage (+24 Vdc) to the VSWR overload protection circuit (refer to paragraph 4-14) when the reflected power exceeds a preset value. When the OUTPUT REM switch (S5-C) is depressed, the forward power level can be monitored at a remote location from terminal TB5-8.

A small wire probe in the PA compartment (connected to BNC coaxial connector J3) samples the power amplifier RF output for application to station monitoring equipment. A similar probe is used to sample the RF output (from coaxial connector J2) that is applied to the automatic level control (ALC) system (refer to paragraph 4-11).

4-8. HIGH VOLTAGE POWER SUPPLY. The high-voltage power supply furnishes plate voltage to the driver and power amplifier tubes (4.0 and 8.0 k Vdc respectively). Voltage for the FM-25KG screen is derived from a separate 500 Vdc screen power supply.

The supply utilizes a three-phase power transformer T1, with 200 to 240 Vac, 60 Hz, three-phase power applied to its input. The secondary is connected to a full-wave bridge rectifier (diodes CR1 through CR6) and then through a filter (choke L1 and capacitor C5) to provide the plate voltage for power amplifier tube V2. Resistors R1 and R2 perform a bleeder function at the output of the supply. They are only connected (by relay K3 contacts) when the plate supply is deenergized. The power amplifier plate voltage is applied to PLATE meter M3 via the voltage divider network of resistor assembly A4 (resistors R1 through R10) when PLATE PA switch S2-B is depressed. Power amplifier plate current is monitored by PA PLATE ammeter M2 which is located in the negative return of the high voltage power supply. The

PA PLATE current voltage drop across resistors R5 and R22 is used as an input to the high voltage overload protection circuit (refer to paragraph 4-14).

The plate voltage for driver tube V1 originates from a half-wave rectifier utilizing diodes CR4, CR5, and CR6. The filtering consists of choke L2 and capacitor C3. Resistor R3 performs a bleeder function. The driver plate voltage is applied to PLATE meter M3 via the voltage divider network of resistor assembly A3 (resistors R1 through R11) when PLATE DR switch S2-A is depressed.

4-9. DRIVER SCREEN POWER SUPPLY. The driver screen power supply (A7) furnishes 500 Vdc to the screen grid of V1 (5CX1500A). AC input power to A7 is applied to the appropriate primary winding taps of power transformer T1 through contacts of relay K11 and fuse F1 when PLATE ON switch S13 is depressed. The secondary winding of T1 is connected to full-wave bridge rectifier CR1. The dc output of CR1 is filtered by C1 and C2; R1 is a current limiting resistor. Resistors R2 and R3 are used to equalize the voltage drop across C1 and C2. Resistor R4 functions as a power supply bleeder. The driver screen voltage is also applied to DRIVER meter M6 when DRIVER SCREEN switch S4-B is depressed.

4-10. BIAS POWER SUPPLY. The bias power supply furnishes -165 Vdc grid bias voltage to driver tube V1.

The ac input power is applied to the proper taps on the primary winding of bias power transformer T3; the secondary is connected to full-wave bridge rectifier CR7.

The filter is made up of resistor R12 and capacitor C3, (P/O A14), in conjunction with potentiometer R15 and capacitor C2 (P/O A14). The coil winding of relay K6 is connected across the output of the power supply. If a malfunction occurs in the bias supply that reduces the bias voltage below the hold-in voltage of the relay, the relay deenergizes and opens contacts 1 and 3 in the plate voltage control circuit, which deenergizes the high voltage power supply. The bias voltage level applied to the grid of driver tube V1 is determined by OUTPUT POWER potentiometer R15, in conjunction with the compensation voltage from the automatic level control unit A8 (refer to paragraph 4-11 for details). The bias voltage is monitored by DRIVER meter M7 when DRIVER GRID switch S4-A is depressed.

4-11. AUTOMATIC LEVEL CONTROL. The automatic level control (ALC) system includes automatic level detector module A10 and automatic level control module A8.

A sample of RF power from the PA tube compartment is fed through connector J2 to automatic level detector A10, where it is detected and filtered. This negative dc voltage, which is proportional to the amplitude of the RF carrier, is applied through ALC ADJUST potentiometer R16 to automatic level control module A8. The ALC ADJUST control adjusts the amount of negative dc voltage applied to transistor Q2, via a filtering network, in the A8 module. The output of transistor Q2 is directly coupled to transistor Q1. Resistor R2 is a voltage dropping resistor for the zener regulator VR1.

Transistor Q1 is biased to draw enough current to cause a voltage drop across the OUTPUT POWER control R15. The controlling action is such that an increase in the sampled RF, perhaps due to an increase in line voltage, acts to increase the forward bias on the base of transistor Q2, causing an increase in collector current, and resulting in an increased voltage drop across resistor R3. This increase voltage drop produces a reduction in forward bias on the base of transistor Q1. The reduced bias decreases Q1 collector current flow, permitting the bias voltage on the driver to increase. The increased bias on the driver reduces the RF output of the driver and tends to compensate for the initial rise in the power amplifier RF output.

Conversely, a decrease in the sampled RF results in a decreased bias on the driver, which increases the RF output of the driver and tends to compensate for the initial fall in the power amplifier RF output.

The automatic level control circuit, and thus the driver bias, may be remotely controlled by the operation of mechanically-linked motor B1 and potentiometer R1, via terminals TB5-13 and TB5-14. These terminals are individually connected to ground, by the remote switch, to operate the motor and thus R1 in either direction; 115 Vac is supplied to the motor windings through fuse F6. Potentiometer R1 controls the voltage level available at the ALC ADJ potentiometer R16.

4-12. CONTROL CIRCUIT POWER SUPPLY (A2). The lamps and many of the relays in the transmitter's control circuits require a 24-Volt dc input. This is provided by power supply A2 (see data sheet in Appendix). The power supply, strapped for 220 Vac input line voltage, consists of a full-wave solid-state rectifier (which is transformer coupled to the ac input), and a series regulator. The power supply is over current and over voltage projected and can provide a maximum output of 2.4 amperes at 24 Vdc. Fusing is provided for the ac input via F5 and F6. The +24 Vdc output is not fused. A crowbar circuit is also used in the power supply and is factory adjusted to trip at 30 Vdc.

4-13. <u>INTERLOCKS AND CONTROL CIRCUITS.</u> The transmitter provides an interlocked turn-on sequence to ensure that proper transmitter start-up conditions exist. To energize the transmitter, the LINE circuit breaker (CB1), the BLOWER circuit breaker (CB2), and the FILAMENT circuit breaker (CB3) must first be closed. This action applied ac power to control power supply (A2) which generates the +24 Vdc necessary for operation of the interlock and control circuits. The following sequence can now occur:

NOTE

If the transmitter is connected for remote operation and REMOTE/LOCAL switch S18 is set to LOCAL, START switch S7 and STOP switch S6 have no effect. Applying momentary connection between TB5-1 and TB5-2 provides a remote start voltage which performs the same functions as depressing S7; applying a momentary connection between TB5-1 and TB5-3 provides a remote stop voltage which performs the same function as depressing S6.

Depressing START switch S7 energizes relay K8 (via contacts 2 and 3 of S7 and contacts 5 and 8 of K9, and lights (via contacts 4 and 7 of K8) START indicator DS7. Contacts 6 and 9 of K8 apply ac power to energize cabinet fan B3, driver blower B4, and PA blower relay K4. The contacts of K4 energize PA blowers B1 and B2.

When S7 is depressed, +24 Vdc is applied through closed contacts 5 and 8 of K6 to pin B of control/timer board A11 and then to voltage divider (3R57 and 3R58) to produce 2.6 Vdc. Refer to drawing 4051279. This triggers 180-second timer 3IC21. When 3IC21 is triggered, its $\bar{Q}$ output goes to logic 0. This causes 3IC24 pin 6 to go to logic 1 thereby turning on transistor 3Q5 and energizing relay K12. The normally closed contacts 5 and 8 of K12 are now opened to prevent the application of +24 Vdc to the READY indicator and the high voltage control circuits until after the 180-second preheat period and after cooling contacts 1 and 3 or relay K12 are closed to energize cabinet fan B3, driver blower B4, and PA blower relay K4.

If the action of the blowers is sufficient to close air-interlock switches S14 and S15, relay K9 will be energized and contacts 1 and 3 of K9 will be closed. This applied ac power to energize relay K5. The contacts of K5 are now closed and apply ac power to the primaries of PA filament transformer T2, driver filament transformer T4 and filament adjust. At this time ELAPSED TIME meter M4 is energized.

When the PA filament supply is energized, its output energizes relay K14. Relay contacts 1 and 3 close in the plate control circuit and contacts 6 and 8 close in the driver bias circuit.

If door and access panel interlock switches S8, S9, S10, S11 and S12 are closed, INTERLOCK STATUS indicator DS1 will light and interlock relay K10 will energize. Contacts of K10 close to apply ac power to the primary of bias transformer T3.

When the bias power supply is energized, its output energizes relay K6. Contacts 1 and 3 of K6 now close to light BIAS indicator DS2 and to apply +24 Vdc to contact 5 of relay K12. Also, normally closed contacts 5 and 8 of K6 will now open; these contacts are part of the automatic restart function (refer to paragraph 4-17).

When the 180 second time period has elapsed, the $\bar{Q}$ output of 3IC21 (in control timer A11, schematic diagram 4051279) goes to logic 1. Assuming that no faults are present in the transmitter, both inputs of 3IC24 will be logic 1. This causes pin 6 of 3IC24 to go to logic 0 thereby turning off transistor 3Q5 and deenergizing K12. Contacts 5 and 8 of K12 now close and light READY indicator DS3. Also, the logic 1 from the $\bar{Q}$ output of 3IC21 is coupled via 3C59 to the inputs of 3IC23. This resets fault counter 3IC22 to zero count and turns off any OVERLOAD indicators that may be lit (these devices may turn on in random conditions due to turn-on transients; see paragraph 4-14 for a further description of the overload protection system).

When relay K12 is deenergized, contacts 1 and 3 open. This, however, does not deenergize the blowers as relay K8 contacts 6 and 9 are still closed. Contacts 1 and 3 of K12 are used for after-cooling during transmitter shut-down.

Also, when relay K12 is deenergized, contacts 5 and 8 are closed and apply the plate control voltage to the READY indicator DS3 and to contact 9 of plate on/plate off relay K7.

During a normal turn-on sequence, the output of control/timer board A11 pin K will be ground (logic 0). This causes relay K13 to be energized thus closing contacts 1 and 3 and opening contacts 5 and 8.

The PLATE ON switch S13 may now be depressed. This will energize relay K7 and light the PLATE ON indicator DS13, and will energize relay K11 and close contacts 1 and 3 and 6 and 8. The closure of contacts 1 and 3 energizes the high power relay K2 or the low power relay K1, depending on the position of PLATE VOLTAGE HIGH-LOW switch S3. With the high power relay K2 energized, the high-voltage transformer T1 primary winding is connected to the three-phase ac power in a delta configuration. With the low power relay K1 energized, the transformer primary winding is connected in a wye configuration to provide a reduced voltage at the transformer secondary. Contacts 6 and 8 connect ac power to the driver screen power supply (A7) in the FM-25KG transmitter.

The transmitter is now fully energized.

4-14. OVERLOAD PROTECTION AND AUTOMATIC RECYCLING CIRCUITS. In addition to the circuit breakers, fuses, and surge arrestors which are summarized in table 4-1, the transmitters employ an overload protection and automatic recycling system to monitor the following parameters:

a. Driver cathode current.

b. Power amplifier cathode current.

c. High voltage power supply current.

d. VSWR-reflected RF power output.

e. Power amplifier compartment temperature.

The overload protection and automatic recycling system accomplishes the following:

a. Detects an excess in any of the above parameters.

b. Lights an indicator for the specific fault.

c. Deenergizes the high voltage power supply for two seconds.

d. Reenergizes the high voltage power supply only if the fault has cleared.

e. Counts the number of faults occuring in 60 seconds. If three faults occur, the high voltage power supply will not be reenergized. If less than three faults occur, the fault count will be cleared.

f. Clears the fault count and fault indications after 180 seconds when the START switch is depressed.

Table 4-1. Overload Protection Devices

Item	Ref. Desig.	Rating
LINE circuit breaker	CB1	225A
BLOWER circuit breaker	CB2	20A
FILAMENT circuit breaker	CB3	20A
Fuse (220 Vac, phase 1, meter circuit)	F1	1/2A
Fuse (220 Vac, phase 2, meter circuit)	F2	1/2A
Fuse (220 Vac, phase 3, meter circuit)	F3	1/2A
H. V. control fuse	F4	3A SB
24 Vdc Supply Fuse (ac input to 24 Vdc power supply)	F5	1A SB
24 Vdc Supply Fuse (ac input to 24 Vdc power supply)	F6	3A SB
PA FIL adjust fuse	F7	3A SB
REMOTE CONTROL fuse	F8	1/4A
Fuse (ac input to 500 Vdc driver screen power supply)	A7F1	3A SB
Surge suppressor (high voltage PA plate circuit)	E1	230V
Surge suppressor (PA Cathode circuit)	E2	230V
Surge suppressor (driver high voltage circuit)	E3	230V

The fault level control board A12, lamp driver board A13, and control/timer board A11 comprise the overload protection and automatic recycling circuit. Refer to drawings 4051278, 4051281 and 4051279 respectively for the schematics of these boards. Basically, the fault level control board A12 operates by detecting a threshold voltage level (or overload fault) and then sending the overload fault signals to the lamp driver board A13 and control/timer board A11.

A voltage representative of power amplifier cathode current is developed across resistor R11 and R23 in the cathode circuit. This voltage via pin M of fault level control board A12, is applied to relay 3K11 and PA CATH OL (fault threshold level) potentiometer 3R117. When the voltage at A12 pin M exceeds approximately four volts, relay 3K11 energizes and opens its normally closed contacts. This causes the voltage at A12 pin L to go from ground to +5 Vdc (through pull-up resistor 3R124). The +5 Vdc is applied via pin N of lamp driver board A13, to the clock input of flip-flop 3IC10-A and sets the Q output to a logic 1 level (+5 Vdc) which turns on lamp driver transistor 3Q9, thus lighting PA CATH OVERLOAD indicator DS5.

A voltage representative of high voltage power supply current is developed across resistor R5 in the high voltage power supply metering circuit. This voltage is applied to A12 pin P and energizes relay 3K13 when the relay's pull-in threshold (set by HV OL potentiometer 3R118) is exceeded. HV OVERLOAD indicator DS6 is lighted in the same manner as described for the PA CATH OVERLOAD indicator.

A voltage representative of driver cathode current is developed across resistor R13 in the driver cathode circuit. The reference for this voltage is the high voltage power supply input voltage. The driver overload voltage is applied to A12 pin H and energizes relay 3K12 when the relay's pull-in threshold (set by DRIVER CATH OL potentiometer 3R116) is exceeded. DR CATH OVERLOAD indicator DS4 is lighted in the same manner as described for the PA CATH OVERLOAD indicator.

An excessive VSWR sensed at the RF output of harmonic filter/coupler FL1 closes the contacts in VSWR meter-relay M9. Contact closure applied 24 Vdc to A12 pin S. The voltage is scaled by voltage divider 3R119 and 3R120 and is applied to pins 1 and 2 of 3IC1, causing the voltage at 31C1 pin to go to a logic 1. This causes VSWR OVERLOAD indicator DS7 to be lighted in the same manner as described for the PA CATH OVERLOAD indicator.

A blockage in the exhaust air ducts or a badly mistuned transmitter can cause severe overheating in the PA compartment and eventually damage to the PA components. PA blower B1 and cabinet fan B3, although operational, will be unable to lower the temperature. Once an overtemperature condition exists in the PA compartment and the exhaust air temperature exceeds 225° F, thermostatic switch S20 will close, applying +24 Vdc to pin S of fault level card A12. If the thermostat stays closed for 6 seconds or more the transmitter will shutdown completely. The VSWR/OVER TEMP panel lamp will light in the same manner as described for the VSWR overload indicator.

Fault signals of +5 Vdc, occurring in any of the parameters monitored are combined in a four-input diode OR circuit on fault level control board A12, which is composed of 3CR15 through 3CR18 and 3R125; thus whenever a fault occurs, the output of the fault level control board (A12-B) goes high (logic 1). This voltage is applied via pin D of control/timer board A11 to one input (pin 4) of nand gate 3IC23; the remaining input (pin 5) is held high by voltage divider 3R49 and 3R50. Both inputs are now high which causes the output to go low, triggering 2-second timer 3IC19. The Q output of 3IC19 goes to logic 1 and the $\bar{Q}$ output goes to logic 0. The $\bar{Q}$ output is fed to one input (pin 5) of nand gate 3IC24. The other 3IC24 input (pin 4) is from the 180-second timer. During a no-fault condition both inputs (pins 4 and 5) of 3IC24 are high (logic 1). When pin 5 of 3IC24 goes low, pin 6 goes high. This turns on transistor 3Q5 which energizes relay K12. This opens K12 contacts 5 and 8, removing +24 Vdc from relays K11 and thus K2 (K1) and thereby removing the input voltage from plate transformer T1. At the end of 2 seconds, the 3IC19 Q output goes low and the Q output goes high. When $\bar{Q}$ output goes high, both inputs 4 and 5 of 3IC24 are high, relay K12 is denergized, and the input plate transformer T1 is restored.

When the fault occurred, the $\bar{Q}$ output (pin 6) of 3IC19 went high; this drove the output of voltage divider 3R49 and 3R50 higher until capacitor 3C88 discharged. Since the voltage divider output was already high there was no change of logic state. When the Q output goes low, 3C88 charges and it drives the voltage divider output low; this is a change in logic state. When the 2-second shut-down occurs, most faults or overloads will disappear and the fault signal will go low. The input to the 2-second timer will therefore go high and remain so. The logic 0 pulse fed back from the $\bar{Q}$ output will normally have no effect. If the fault condition stays, the pulse fed back to pin 5 of 3IC23 will ensure that the input to the 2-second timer goes high then low again thus triggering off the 2-second timer until a count of 3 is reached at 3IC22.

When a fault occurs, the sixty-second timer (3IC20) is triggered; capacitor 3C60 feeds a low level (logic 0) pulse to an input which is already low thus affecting no logic state change. When the first fault occurred, the $\bar{Q}$ logic 0 level from 3IC14 also incremented counted 3IC22 to a count of 1. Pin 8 of 3IC22 went low and pin 9 went high. When a second fault occurs, the 2-second timer (3IC19) is triggered again (the sixty-second timer has already started so it is unaffected) and the counter 3IC22 increments to a count of 2. Pin 9 of 3IC22 goes low and pin 8 goes high.

When a third fault occurs, the 2-second timer is triggered again and pins 8 and 9 of counter 3IC22 go high. This causes the output of 3IC24 (pin 3) to go low. Thus for a count of 0, 1, or 2, 3IC24 pin 3 is high and the 2-second timer is enabled. When the count reaches 3, pin 3 of 3IC24 goes low thus inhibiting the 2-second timer and turning off transistor 3Q4 which deenergizes relay K13. Contacts 5 and 8 of K13 now close, lighting the FAULT RESET switch-indicator S19; contacts 8 and 6 of K13 open now deenergizes relay K11 and prevents relay K2 (K1) from being energized and thus removing power to plate transformer T1.

When less than three faults have occurred in 60 seconds, the level at pin 13 of 3IC24 will be a logic 1. When the 60-second timer times out, the $\bar{Q}$ output of 3IC20 will also be a logic 1. This causes the output at pin 8 of 3IC24 to be logic 1 and reset counter 3IC22 to 0 count. If three faults have occurred, pin 13 of 3IC24 will be logic 0 and the resetting of counter 3IC22 will be inhibited.

This counter must now be reset for the transmitter to operate. An automatic signal from the 180 second timer (3IC21) coupled through 3C59 to 3IC24 pins 1 and 2 will reset the counter or the counter can be manually reset by S19. Depressing the lighted FAULT RESET switch-indicator S19 applies a logic 1 to 3IC23 pins 1 and 2. Pin 3 of 3IC23 now goes log thus driving pin 8 of 3IC24 high and resetting fault counter 3IC22. Also, when pin 3 of 3IC23 goes low, pin 8 goes high. This logic 1, which is applied via pin L of lamp driver board A13, turns on transistor 3Q13 thus, grounding the clear inputs of the flip-flops on A13 and thereby turning off any lighted OVERLOAD indicators (DS4 through DS7). If the source of the fault has been removed, the transmitter will resume normal operation; if the fault is still present, the fault sensing sequence will be repeated.

4-15. OVERLOAD TEST. In order to check the operability of the overload circuits, an overload TEST switch (3S18) has been provided on fault level control board A12. During normal operation, the TEST switch applies a ground through the contacts of the overload relays to the inputs of the diode OR gate (3CR15 through 3CR18) on board A12 and to the clock inputs of the lamp driver flip-flops (3IC10 and 3IC11) on lamp driver board A13. This allows normal functioning of the overload circuits.

When 3S18 is depressed, +5 Vdc is supplied to the diode OR gate and to the clock inputs of the lamp driver flip-flops. This stimulated an overload in the same manner as if all overload relays were energized, and thus illuminates the DR CATH, PA CATH. HV, and VSWR OVERLOAD indicators.

4-16. TRANSMITTER TURN-OFF. Depressing STOP switch S6 applies +24 Vdc to pin B of control/timer A11 and triggers the 180-second timer thereby opening the plate control voltage and removing ac inputs to the high voltage plate transformer T1. Depressing S6 also applies +24 Vdc control voltage to K8 pin 8 and unlatches K8 which causes relays K9, K5, and K4 to be deenergized. Ac power is now removed from all transmitter functions except the LINE meter, control power supply A2, driver blower B3, PA blowers B1 and B2, and cabinet fan B3. The blowers and fan continue to run until the 180-second timer times out and relay K12 is deenergized.

When contacts 1 and 3 of K12 open ac power is removed from B3 and B4 and relay K4 is deenergized which removes ac power from B1 and B2. Control power supply A2 must be deenergized by opening BLOWER circuit breaker CB2. The line input voltage is removed from the LINE meter M1 when LINE circuit breaker CB1 is opened.

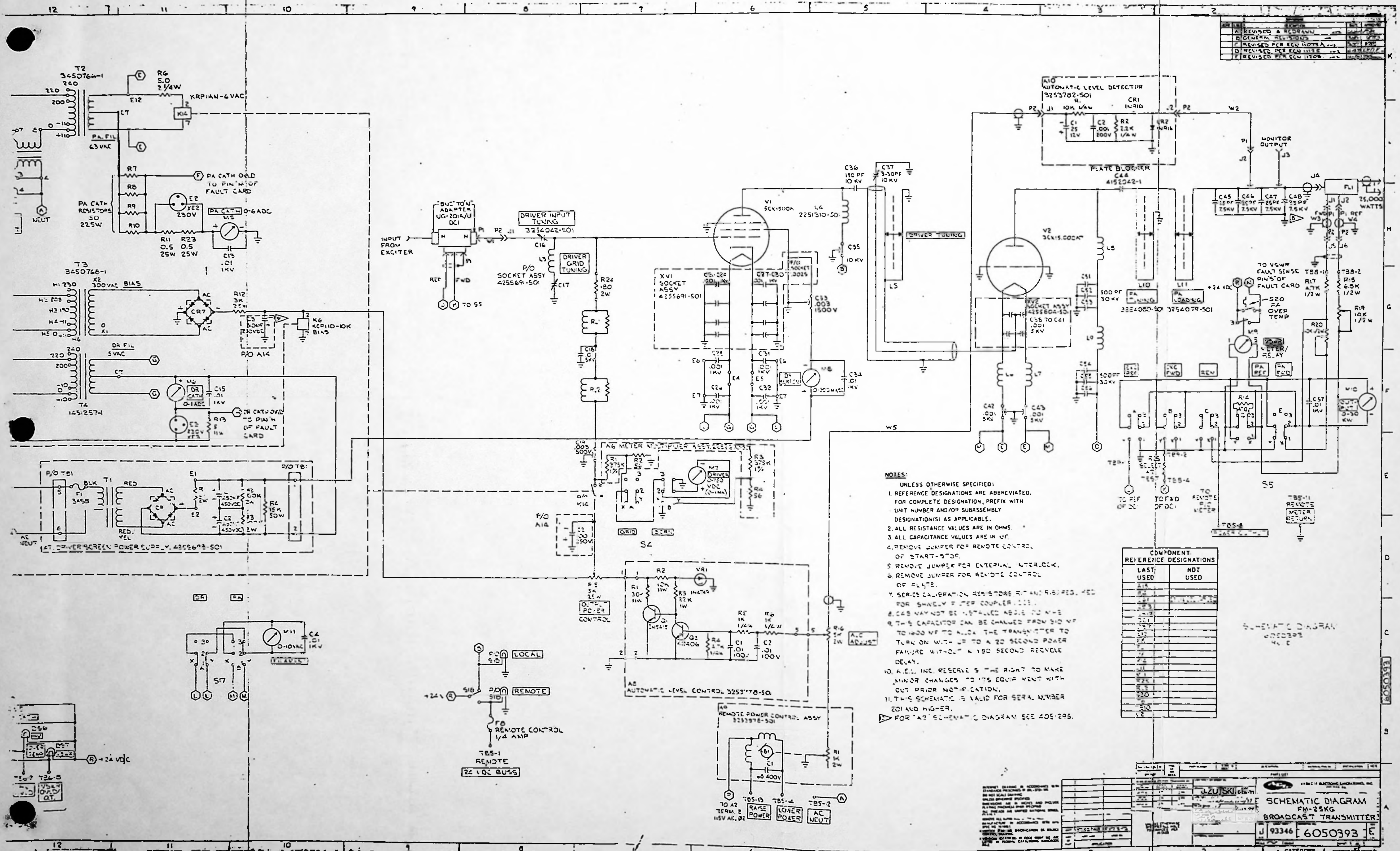
4-17. AUTOMATIC RESTART. In the event of a primary power source failure and subsequent power restoration, the automatic restart feature reenergizes the transmitter after providing filament preheat time.

When a normal turn-on sequence is accomplished, contacts 2 and 3 of START switch S7 apply the +24 Vdc control voltage to one side of relay K8. This causes the relay to latch and close the normally open contacts. If primary power is lost and subsequently restored, the latched contacts of K8 provide a circuit around the START switch and a normal turn-on sequence is initiated.

If the primary power is lost and subsequently restored within 5 seconds, the transmitter is re-energized to full operation immediately. However, should the power be lost and restored after 5 seconds, the transmitter is reenergized to full operation after a 180-second delay. This delay allows minimum filament warmup time for the driver and power amplifier tubes before the application of the high plate and screen voltages.

When the primary power is lost, relay K6 (which is across the output of the driver bias supply) will remain energized for 5 seconds (by the charge on the 310 uF capacitor C3 which is part of A14), holding contacts 1 and 3, in the plate control circuit, closed. If the power is restored within the time interval, the transmitter will immediately reenergize to full operation. If the power is lost for more than 5 seconds, relay K6 will deenergize (capacitor C3 discharged); contacts 1 and 3, in the plate control circuit, will open and deenergize the high voltage powe supply. When power is subsequently restored after the 5-second period, approximately +5 Vdc is applied through relay K6 contacts 5 and 8 to trigger the 180-second timer (3IC21 on control/ timer board A11). This action energizes relay K12 whose contacts 5 and 8 open the plate control circuit to deenergize the high voltage power supply until the 180-second interval has elapsed. At the end of this period, relay K12 is deenergized, the high voltage is applied to the tubes, to operate the transmitter.

For installations with back-up generating equipment, the 5 second limit for immediately re-energizing the transmitter to full operation can be extended to 20 seconds. For information concerning the 20 second option, contact AEL as described in paragraph 6-1.



NOTES:

UNLESS OTHERWISE SPECIFIED:

1. REFERENCE DESIGNATIONS ARE ABBREVIATED. FOR COMPLETE DESIGNATION, PREFIX WITH UNIT NUMBER AND/OR SUBASSEMBLY DESIGNATION(S) AS APPLICABLE.
2. ALL RESISTANCE VALUES ARE IN OHMS.
3. ALL CAPACITANCE VALUES ARE IN UF.
4. REMOVE JUMPER FOR REMOTE CONTROL OF START-STOP.
5. REMOVE JUMPER FOR EXTERNAL INTERLOCK.
6. REMOVE JUMPER FOR REMOTE CONTROL OF PLATE.
7. SERIES CALIBRATION RESISTORS R17 AND R15 REQUIRED FOR SHIVELY FILTER COUPLER.
8. C48 MAY NOT BE INSTALLED ABOVE 100 MHz.
9. THIS CAPACITOR CAN BE CHANGED FROM 510 MF TO 1600 MF TO ALLOW THE TRANSMITTER TO TURN ON WITH UP TO A 20 SECOND POWER FAILURE WITHOUT A 150 SECOND RECYCLE DELAY.
10. A.E.L. INC. RESERVES THE RIGHT TO MAKE MINOR CHANGES TO ITS EQUIPMENT WITHOUT PRIOR NOTIFICATION.
11. THIS SCHEMATIC IS VALID FOR SERIAL NUMBER 201 AND HIGHER.

FOR A2 SCHEMATIC DIAGRAM SEE 4051295.

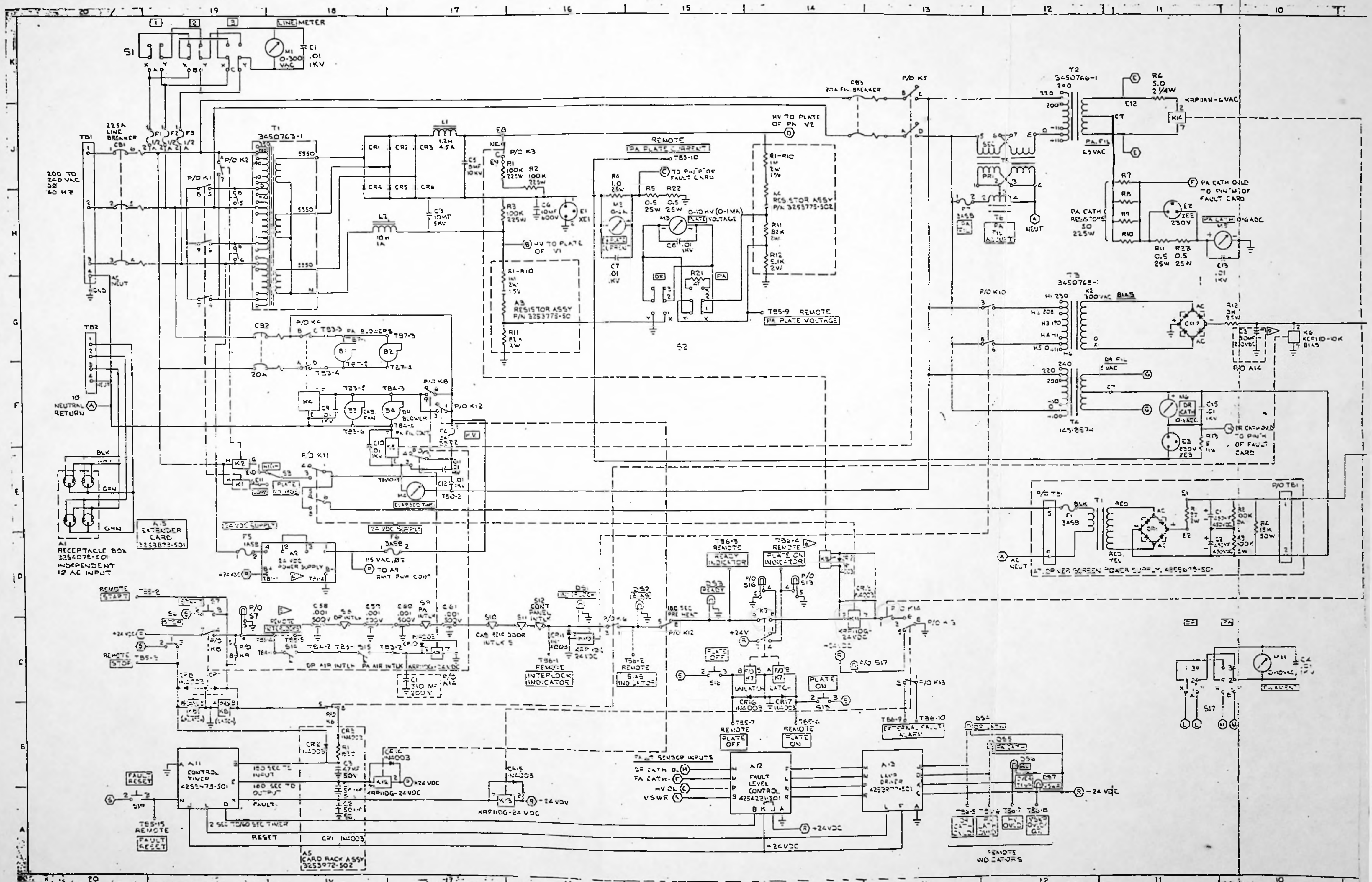
COMPONENT REFERENCE DESIGNATIONS

LAST USED	NOT USED
[illegible]	[illegible]

SCHEMATIC DIAGRAM
FM-25KG
BROADCAST TRANSMITTER

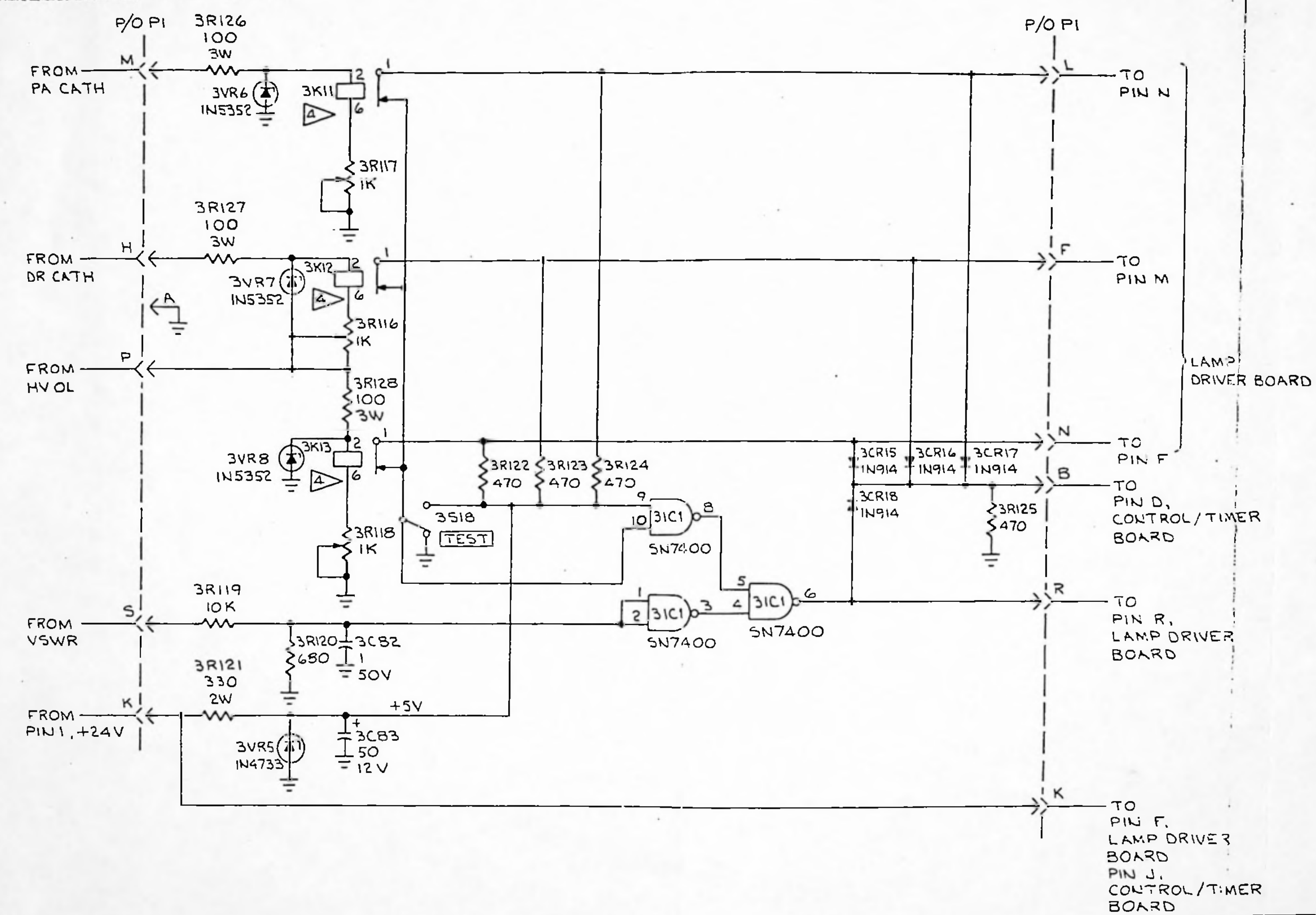
J 93346 6050393 E

CATEGORY 1



LINE METER
225A LINE BREAKER CB1
200 TO 240 VAC 3Ø 60 HZ
T1 3450763-1
HV TO PLATE OF PA V2
REMOTE PA PLATE CURRENT
RES STOR ASSY P/N 3253775-502
HV TO PLATE OF V1
A3 RESISTOR ASSY P/N 3253775-501
REMOTE PA PLATE VOLTAGE
T2 3450766-1
PA CATH OVLD TO PIN "M" OF FAULT CARD
PA CATH RESISTORS 50 225W
T3 3450768-1
BIAS
T4 145-257-1
NEUTRAL RETURN
A1 RECEPTACLE BOX 3254075-501 INDEPENDENT 1Ø AC INPUT
A15 EXTENDER CARD 3253873-501
24 VDC POWER SUPPLY
115 VAC, Ø2 TO A9 RMT PWR CONT
REMOTE START
REMOTE STOP
REMOTE READY INDICATOR
REMOTE PLATE ON INDICATOR
REMOTE INTERLOCK INDICATOR
A11 CONTROL TIMER 4253475-501
A5 CARD RACK ASSY 3253972-502
A12 FAULT LEVEL CONTROL 4254221-501
FAULT SENSOR INPUTS
REMOTE INDICATORS
REMOTE FAULT RESET

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	DELETED "3A1" FROM TITLE.		



NOTES:

UNLESS OTHERWISE SPECIFIED:

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2. ALL RESISTANCE VALUES ARE IN OHMS.
3. ALL CAPACITANCE VALUES ARE IN UF.
4. RELAYS 3K11, 3K12 & 3K13 - PINS 1&14, 7&8 ARE INTERNALLY CONNECTED

INTERPRET DRAWING IN ACCORDANCE WITH STANDARDS PRESCRIBED BY MIL-STD-100.
DO NOT SCALE DRAWING.
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES AND INCLUDE PLATING THICKNESS WHEN SPECIFIED.
ALL THREADS ARE UNIFIED NATIONAL SERIES, CLASS 2.
REMOVE ALL BURRS AND SHARP EDGES.
MANUFACTURE IN ACCORDANCE WITH MFG. SPEC.
*VENDOR ITEM—SEE SPECIFICATION OR SOURCE CONTROL DRAWING.
†VENDORS IDENTIFIED BY CODE IDENT. NO. ARE LISTED IN FEDERAL CATALOGING HANDBOOK H4-2.

N/A	4254221	12408
ASSY OR PART	NEXT ASSY	USED ON
	APPLICATION	

UNLESS OTHERWISE SPECIFIED ALL HOLE TOLERANCES PER 1610123

PARTS LIST

DRAWN J. ZUTSKI 9-26-77

AMERICAN ELECTRONIC LABORATORIES, INC. COLMAR, PA.

SCHEMATIC DIAGRAM
FAULT LEVEL CONTROL BOARD
FM TRANSMITTERS

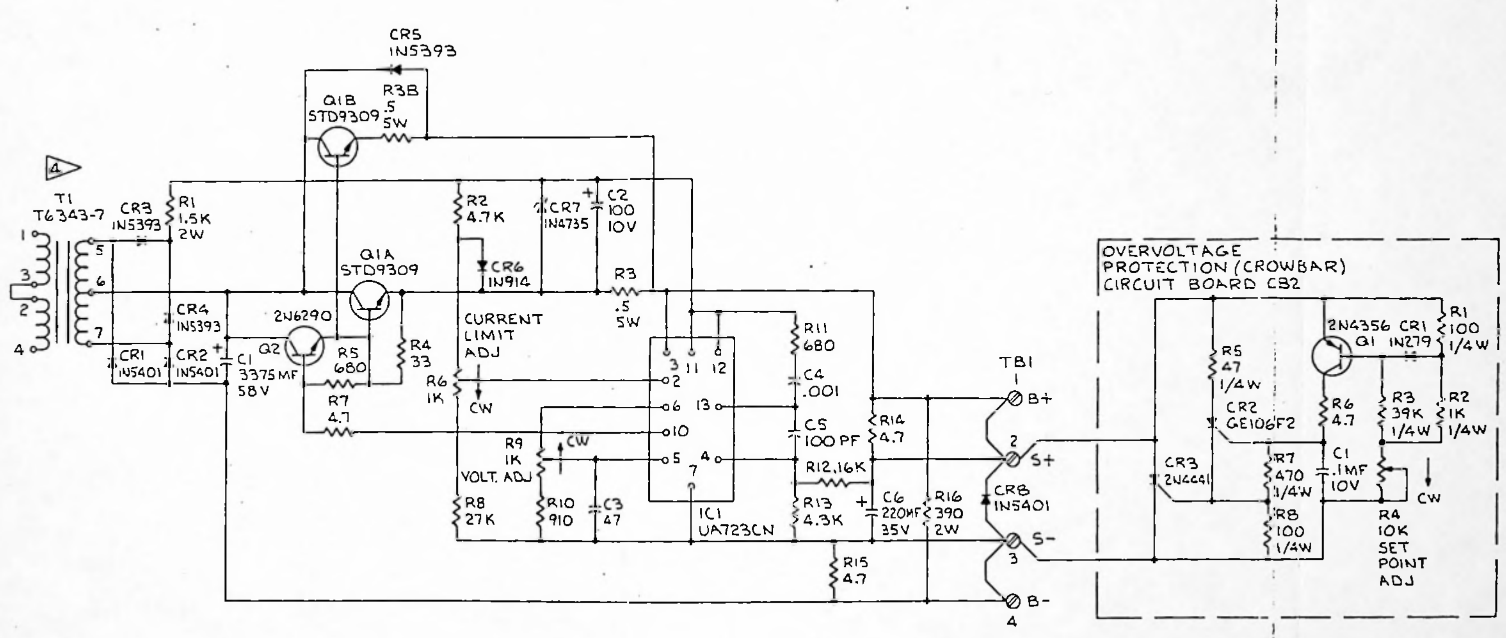
SIZE	CODE IDENT	DRAWING NO.	REV
D	93346	4051278	A

SHEET 1 OF 1

CATEGORY

4051278

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED



NOTES:

UNLESS OTHERWISE SPECIFIED:

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3. ALL CAPACITANCE VALUES ARE IN UF.

4

INPUT VOLTAGE	TERM 1 AND 4
115 V	JUMPER 1 TO 2 3 TO 4
230 V	JUMPER 2 TO 3

INTERPRET DRAWING IN ACCORDANCE WITH STANDARDS PRESCRIBED BY MIL-STD-100.
DO NOT SCALE DRAWING.
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DIMENSIONS ARE IN INCHES AND INCLUDE PLATING THICKNESS WHEN SPECIFIED.
ALL THREADS ARE UNIFIED NATIONAL SERIES, CLASS 2.
REMOVE ALL BURRS AND SHARP EDGES.
MANUFACTURE IN ACCORDANCE WITH MFG. SPEC.
* VENDOR ITEM-SEE SPECIFICATION OR SOURCE CONTROL DRAWING.
† VENDORS IDENTIFIED BY CODE IDENT. NO. ARE LISTED IN FEDERAL CATALOGING HANDBOOK H4-2.

ASSY OR PART	NEXT ASSY	USED ON
		FM1S
		FM2S
APPLICATION		

UNLESS OTHERWISE SPECIFIED ALL HOLE TOLERANCES PER 1610123

QTY REQD				ITEM OR REF DESIG	PART NUMBER	CODE IDENT †	DESCRIPTION	MATERIAL/FINISH	SPECIFICATION	NOTE
504	503	502	501							

PARTS LIST

CONTRACT OR ORDER NO

		DATE
DRAWN	J.ZUTSKI	1-19-78
CHECKED		1-23-78
		1-23-78
		1-23-78
APPROVAL (PROJECT)		
APPROVAL (CUSTOMER)		

AMERICAN ELECTRONIC LABORATORIES, INC.
COLMAR, PA.

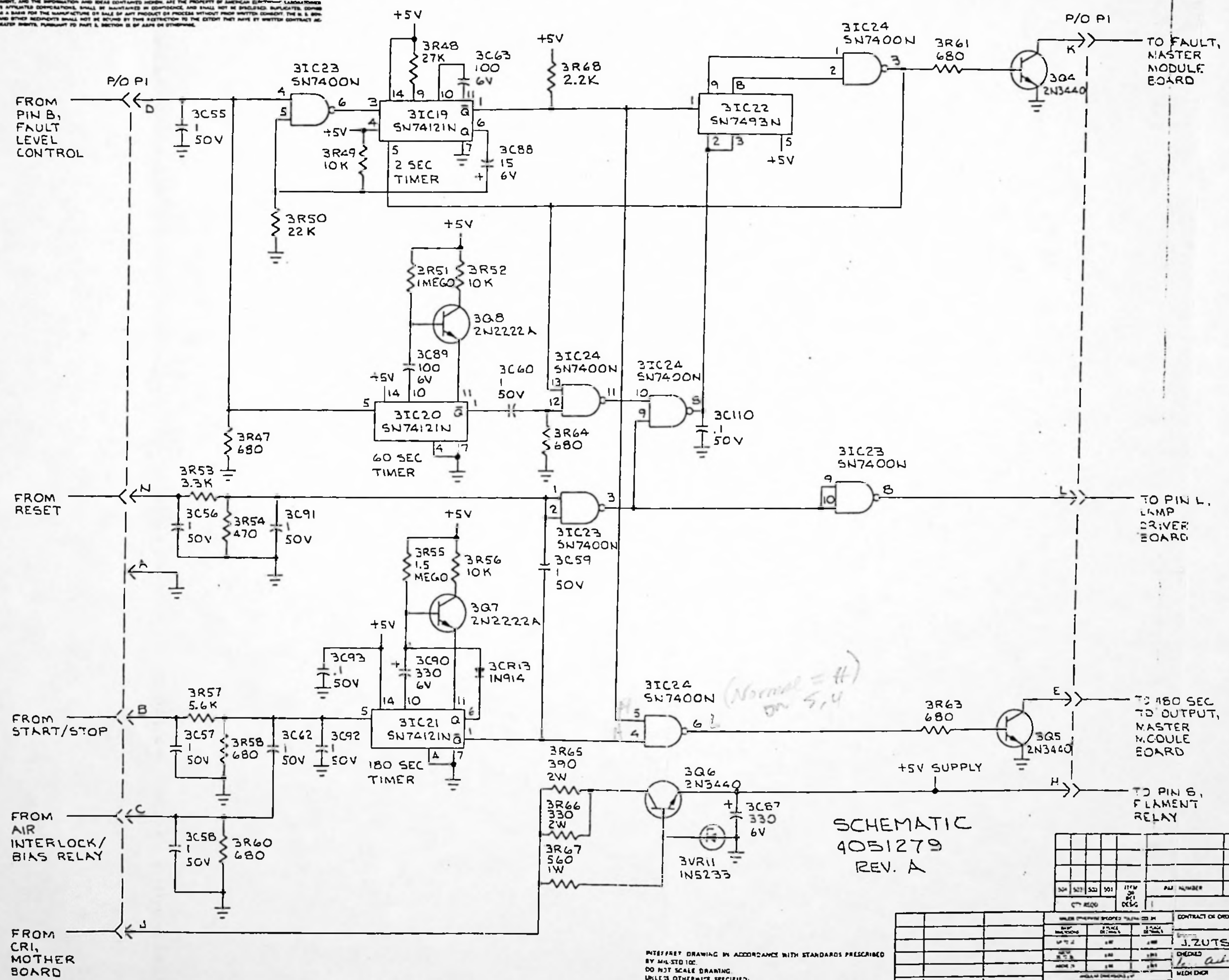
SCHEMATIC DIAGRAM
24 VDC POWER SUPPLY
A2 ASSY

DWG SIZE	CODE IDENT	DRAWING NO.	REV
D	93346	4051295	

SCALE ~ | WEIGHT | SHEET 1 OF 1

CATEGORY

4051295



SCHEMATIC
4051279
REV. A

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	REVISED PER ECN 11157	11-9-77	
	–	RECORD CHANGE.		

NOTES:

UNLESS OTHERWISE SPECIFIED:

1. REFERENCE DESIGNATIONS ARE ABBREVIATED. FOR COMPLETE DESIGNATION, PREFIX WITH UNIT NUMBER AND/OR SUBASSEMBLY DESIGNATION(S) AS APPLICABLE.
2. ALL RESISTANCE VALUES ARE IN OHMS.
3. ALL CAPACITANCE VALUES ARE IN UF.
4. FOR ASSY SEE 4253578-501

INTERPRET DRAWING IN ACCORDANCE WITH STANDARDS PRESCRIBED BY MIL-STD-100.
DO NOT SCALE DRAWING.
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES AND INCLUDE PLATING THICKNESS WHEN SPECIFIED.
ALL THREADS ARE UNIFIED NATIONAL SERIES, CLASS 2.
REMOVE ALL BURRS AND SHARP EDGES.
MANUFACTURE IN ACCORDANCE WITH MFG. SPEC.
VENDOR ITEM-SEE SPECIFICATION OR SOURCE CONTROL DRAWING.
VENDORS IDENTIFIED BY CODE IDENT. NO. ARE LISTED IN FEDERAL CATALOGING HANDBOOK H4-2.

PARTS LIST

UNLESS OTHERWISE SPECIFIED ALL HOLE TOLERANCES PER 1610123

ASSY PART	NEXT ASSY	USED ON
	4253578	
	APPLICATION	

DRAWN J. ZUTSKI 9-29-77

AMERICAN ELECTRONIC LABORATORIES, INC. COLMAR, PA.

SCHEMATIC DIAGRAM CONTROL/TIMER BOARD

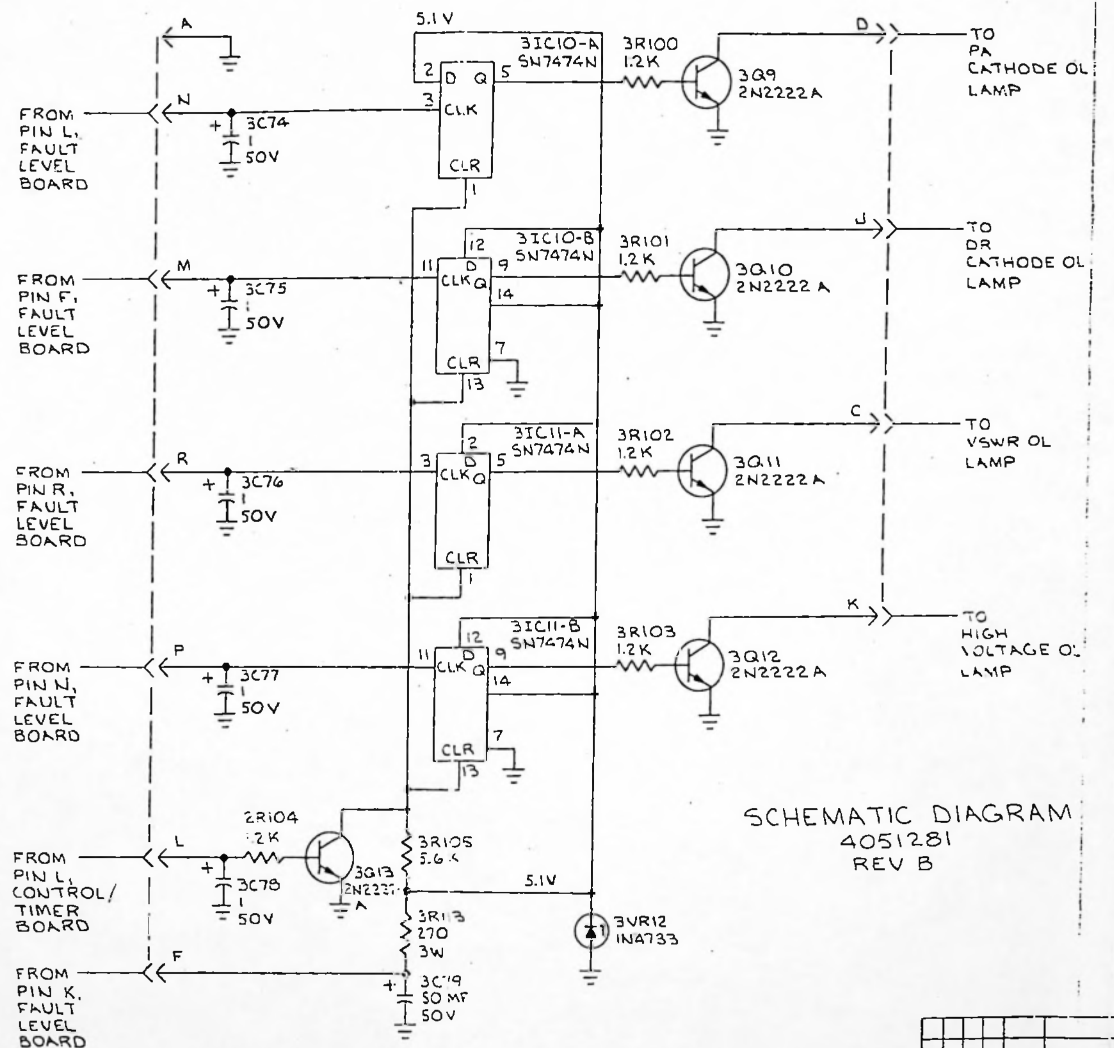
SIZE	CODE IDENT	DRAWING NO.	REV
D	93346	4051279	A

SHEET 1 OF 1

CATEGORY

4051279

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	GENERAL REVISIONS.	11/14/77	PQ
	—	RECORD CHANGE.	4/6/78	
	B	REVISED PER ECN 11236.	2-1-79	



SCHEMATIC DIAGRAM
4051281
REV B

NOTES:

UNLESS OTHERWISE SPECIFIED:

1. REFERENCE DESIGNATIONS ARE ABBREVIATED. FOR COMPLETE DESIGNATION, PREFIX WITH UNIT NUMBER AND/OR SUBASSEMBLY DESIGNATION(S) AS APPLICABLE.
2. ALL RESISTANCE VALUES ARE IN OHMS.
3. ALL CAPACITANCE VALUES ARE IN UF.
4. FOR ASSY. SEE 4253977-501

INTERPRET DRAWING IN ACCORDANCE WITH STANDARDS PRESCRIBED BY MIL STD 100.
DO NOT SCALE DRAWING.
UNLESS OTHERWISE SPECIFIED;
DIMENSIONS ARE IN INCHES AND INCLUDE PLATING THICKNESS WHEN SPECIFIED.
ALL THREADS ARE UNIFIED NATIONAL SERIES, CLASS 2.
REMOVE ALL BURRS AND SHARP EDGES.
MANUFACTURE IN ACCORDANCE WITH MFG. SPEC.
* VENDOR ITEM-SEE SPECIFICATION OR SOURCE CONTROL DRAWING.
† VENDORS IDENTIFIED BY CODE IDENT. NO. ARE LISTED IN FEDERAL CATALOGING HANDBOOK H4-2.

N/A	4253977	12408
ASSY OR PART	NEXT ASSY	USED ON
	APPLICATION	

UNLESS OTHERWISE SPECIFIED ALL HOLE TOLERANCES PER 1610123

PARTS LIST

AMERICAN ELECTRONIC LABORATORIES, INC.
COLMAR, PA.

DRAWN J. ZUTSKI 9-30-77

SCHEMATIC DIAGRAM
LAMP DRIVER BOARD

SIZE	CODE IDENT	DRAWING NO.	REV
D	93346	4051281	B

SHEET 1 OF 1

CATEGORY