

# J. W. Miller Automatic Antenna Tuner



## Auto-Track Model AT 2500

### INSTRUCTION MANUAL

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**GENERAL DESCRIPTION AND SPECIFICATIONS  
of the  
J.W. MILLER AUTOMATIC ANTENNA TUNER MODEL AT 2500**

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The AT 2500 Automatic Antenna Tuner is of advanced design in both the electronics and tuner portion. It has been designed to match any transmitter (2500 W max.) to antenna systems using coaxial lines, long wire, or balanced feed lines (with the addition of an external balun).

**SPECIFICATIONS:**

Frequency Range: 3.0 to 30 MHz.

Power Capability: In excess of 2500 Watts PEP.

Impedance Matching: 10 to 300 ohms to 50 ohms resistive.

Outputs: 3 coaxial antennas, 1 long wire, 1 coaxial bypass.

Power Indication: Illuminated meter with logarithmic scales 0—250 Watts and 0—2500 Watts (push-button select). Continuous carrier RMS, SSB automatic Peak reading.

SWR Indication: Illuminated meter direct reading SWR 1:1 to  $\infty$

Tune-up Time: 15 seconds average.

Minimum Tune-up Power: 1 Watt.

Directional Coupler: Toroidal Bridge type. Separate enclosure.

Cabinet Size: 17" wide x 5¼" high x 14" deep (432 mm x 133 mm x 356 mm).

Style: Standard Tabletop.

Optional Equipment: Handlebar side plates and Rack Mount side plates (extra cost).

Net Weight: 17 lbs.

Power Requirements: 115/230 VAC, 50 to 60 Hz, 10 W operating/5 W standby  
(or) 13.5 VDC, 1 A operating/.5 W standby.

**GENERAL DESCRIPTION:**

The AT 2500 consists of two main assemblies.

The Main Tuner Assembly houses the high power RF components in the RF compartment on the right side and the two printed circuit boards in the compartment on the left side. These PC boards control the motor-driven high voltage capacitors in the RF compartment. The tuner portion has been designed so that it can be operated automatically after the band switch has been set, or manually by operating the tune and load capacitor knobs after the automatic feature is switched off. This manual feature makes it possible to operate the tuner in case of failure of the electronic portion of the unit. Should you have to return the plug-in PC Control Board to the factory for repair, you will still have a manual antenna tuner. However, an external SWR and power meter is needed.

The second assembly consists of a Remote Directional Bridge Coupler which connects to the main tuner assembly via a captive plug-in cable.

The following circuit descriptions deal with the low-level electronic portion of the AT 2500 and consist of seven distinct sections:

- 1) Remote Directional Bridge Coupler.
- 2) SWR Analog Computer.
- 3) Power Logarithmic Amplifier.
- 4) Slope Detection Circuit.
- 5) Logic Control Circuits.
- 6) Tune-Load Motor Drive Circuit.
- 7) Dual Mode Power Supply.

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#### CIRCUIT DESCRIPTIONS:

- 1) Remote Directional Bridge Coupler: The Bridge Coupler has been designed and packaged so that it may be inserted in the antenna feed line right at the output of the RF generator, i.e., transmitter, transceiver or linear amplifier, which is the point in the feed line where low SWR is important. The purpose of the bridge is to generate forward and reflected DC voltages that are proportional to the forward and reflected AC (RF) currents flowing on the antenna feed line. These DC voltages are provided to the AT 2500's input circuits thru a three-wire, captive, shielded cable that terminates in a three-pin male connector. The voltage representing the forward current (BF) inputs on pin 6 of the logic board and the reflected current (BR) inputs on pin 8. Pin 7 is both system and chassis ground and is connected to the Remote Bridge Coupler thru the shield and the white wire of the captive bridge cable. BF and BR are applied to the inputs of both the SWR Analog Computer and the POWER Logarithmic Amplifier.
- 2) SWR Analog Computer: The SWR Analog Computer circuit automatically calculates the SWR as derived from the two input voltages BF and BR. The computer itself is a four-quadrant multiplier (DV-2), which is capable of operating over a wide dynamic range. To achieve a range of 1 Watt to 2500 Watts, an automatic attenuator circuit buffers the front end and consists of a dual photomodulator at DV-1 and an analog control switch at Q3. An internal SWR control is located at R35 on the main board and is factory adjusted. Once set, it need not be readjusted unless DV-1, DV-2, or Q3 are replaced. The calculated SWR is outputted from DV-2 and drives a fast slew rate amplifier at U11, which in turn drives the front panel SWR meter (1 mA F.S.). The SWR meter is calibrated to read 3:1 SWR at center scale and 10:1 SWR at approximately 80% of full scale.
- 3) Power Logarithmic Amplifier: The POWER Logarithmic Amplifier is also driven by BF and BR as derived from the Remote Bridge Coupler. It provides in excess of 60 dB of compression and permits a front panel POWER meter to display power levels of from 1 Watt to 250 Watts on a single range. The 10 Watt point is at approximately 40% of full scale and the 100 Watt point is at approximately 80% of full scale. The heart of this circuit is the amplifier DV-3 which can be best described as a pair of matched, precision transistors, encapsulated in a precisely controlled environmental chamber. An internal heater provides electronic stability over wide extremes of temperature. ALTHOUGH IT IS SOCKET MOUNTED ON THE MAIN BOARD, IT SHOULD NOT BE REMOVED FROM ITS SOCKET. Three potentiometers (R72, R65 and R57) provide ZERO CAL, MID-SCALE CAL and FULL SCALE CAL. These controls are preset at the factory and should not require readjustment. If it is necessary to readjust these controls, ZERO CAL is adjusted at the 1 Watt level, MID-SCALE CAL is adjusted at the 10 Watt level and FULL SCALE CAL is adjusted at a level of 100 Watts. There is some interaction between the controls and two or three passes may be necessary for final calibration. A fourth control 2500 WATT CAL (R68) permits calibration of the 10 Watt to 2500 Watt range. This higher power range is actuated by depressing the front panel switch 250—2500 (S6). This 10 to 1 attenuator circuit is very stable and in some units the factory may have elected to omit R68 and install a fixed resistor in location R69 instead.

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- 4) Slope Detection Circuit: The Slope Detection Circuit consists of a fast slew rate amplifier at U11, which drives the SWR meter as described in Section 2, and provides slope detection information to the Logic Control circuits and to the TUNE-LOAD Motor Drive Circuits. As the high voltage capacitors in the RF compartment are sequentially turned ON and OFF by the electronic logic circuit, the BF and BR supplied to the SWR computer is constantly changing, which produces a varying SWR output to the SWR meter. This output is monitored by the Slope Detection circuit, and as a descending SWR slope starts to change direction (i.e., SWR starts to increase) the particular motor operating at that moment is turned off and the other motor is turned on. As the SWR is reduced by the alternate switching of one motor to the other, the drive level to the motor(s) is reduced, effectively slowing them down for a smooth stop without overshoot. When the SWR reaches a point lower than the desired SWR as set by the front panel TUNE SWR control (R205), a STOP command is issued by the electronic logic section and sent to the TUNE-LOAD Motor Drive circuit, which stops both motors.
- 5) Logic Control Circuits: In addition to the above, the Logic Control Circuits also perform LINEAR ENABLE, ALC CONTROL, ALARM and the AUTO-TRACK functions. A front panel LINEAR ENABLE control permits the operator to enter a level of SWR, above which the companion linear amplifier is automatically switched to Standby, preventing damage to the linear by excessive SWR. This is an automatic and active circuit that permits the linear to automatically come back on line if the SWR is automatically or manually reduced below the preset threshold. The linear may also be switched manually off line by a front panel LINEAR switch (S2). The linear's control line is switched by a set of single pole 6 Amp relay contacts (K1A). The ALC CONTROL circuit utilizes the other half of the relay (K1B) and is interwired thru the front panel LINEAR CONTROL switch. Its purpose is to permit the operator to automatically change the ALC operating conditions of the transmitter when the linear is dropped off line. A separate section of this manual deals with that subject in greater detail. The ALARM circuit consists of a solid state audio alarm generator and a front panel LED visual indicator. This circuit automatically activates the alarms when the SWR has exceeded the preset level of the front LINEAR ENABLE control. With the ALARM switch (S7) depressed, both the visual and audible alarm function. With the switch out, only the LED visual alarm circuit functions. The AUTO-TRACK circuit monitors the ALARM circuit. One second after the alarm has been initiated, the AUTO-TRACK circuit issues a START command to the logic section and the Tune-Load Motor Drive circuits are enabled. This one second delay may be decreased or increased to suit a particular need by changing the value of R95. The standard 1.5 Megohm resistor provides approximately a 1 second delay. Increasing this value by 1 Megohm increases the delay by an additional second, etc. The purpose of the delay (assuming SSB voice operation) is to alert the operator that his SWR has exceeded the permissible threshold he has chosen with the front panel LINEAR ENABLE control, but without permitting the AT 2500 to automatically attempt an immediate retuning. In the SSB mode, the AT 2500 probably would not be able to retune properly since a continuous carrier is not available. In normal operation it would be expected that the operator would switch to a continuous carrier mode (either TUNE, Key-Down CW or RTTY). In one second the AT 2500 would commence a retune sequence. The operator could also initiate an immediate retune by depressing the front panel START switch (S4). The AUTO-TRACK mode can be locked out by releasing the front panel AUTO switch (S8). Since retuning normally requires a continuous carrier, the AUTO-TRACK mode should be considered as an operating convenience for Facsimile, Slow-Scan, RTTY and CW modes of operation. For SSB it is best to disable the Auto-Track feature by leaving S8(AUTO) in the OFF (OUT) position.

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- 6) Tune-Load Motor Drive Circuit: The Tune-Load Motor Drive Circuit consists of 14066 CMOS bilateral switch (4PST) connected thru a pair of operational amplifiers, which in turn drive the motor control transistors Q1 and Q2. The motors are not permitted to operate simultaneously, and the sequencing logic information is provided to the C (control) ports of the 14066 switch by separate Type D flip-flops at U15A and U15B. Each flip-flop also controls a separate LED indicator on the front panel, which lights when its companion motor circuit has been enabled. As mentioned in Section 4, the Slope Detection circuit also provides "level" information to the motor drive circuits, which slows the motors down as the SWR is reduced to a low level. This unique slow down characteristic permits the motors to be stopped without overshooting. The 10K resistors at R100 and R101 also permit the back EMF of the motors themselves to provide a breaking action when motor drive drops to zero. Locations R15 and R18 have been provided on the main board as a method of adding current-limiting to the motors themselves. Should the motors "loosen-up" with age and use, i.e., bearings and gear faces wear smoother and start to operate at speeds higher than intended, low resistance resistors (typically 7.5 ohms) can be used to reduce the motor speed and keep it consistent with reaction times of the Slope Detection and electronic logic circuits.
- 7) Dual Mode Power Supply: The Dual Mode Power Supply is designed to operate from AC mains of 95—125/185—250 Volts, 50 Hz to 400 Hz. In addition, a power converter circuit (U1, U2, U3 and U4) permits operation from DC sources of 12 to 15 Volts. The power converter is a power oscillator producing an AC voltage from the positive DC power source, which is then rectified, filtered and regulated as the negative 8 VDC supply. The nominal DC input voltage should be +13.5 VDC. The AC mains select switch and the AC and DC fuses are located on the main board and their proper positions and values are etched on the top of the board. Do not attempt to change the Mains Switch (S9) or replace the fuses F1 and F2 with the primary power connected. Although most of the high voltage traces are on the bottom side of the board and covered with a solder mask, high voltage is available on the top board in the areas marked DANGER HIGH VOLTAGE and in the area of the mains select switch (S9). Be safe! Disconnect the primary power!

Addendum No. 1: An E-Point (E1) is available on the main board, but the socket and transistor for Q7 are not factory installed. This circuit may be used to provide a ground for an external alarm circuit. This circuit is enabled whenever the ALARM circuit is enabled. The recommended transistor for Q7 is a National Semiconductor's 92PU45 or 2N6724. Since this circuit is an unprotected open-collector, grounded-emitter, care must be taken to current limit any circuit connected to E1. This is a low voltage, low current switching circuit. Voltage must be limited to 50 Volts and current to 30 Milliamperes.

Addendum No. 2: A second E-Point (E2) has been provided on the main board (and not outputted to the rear panel), which is grounded whenever the LINEAR ENABLE circuit drops the linear off line. This E2 point may be used to sound external alerts or to perform other functions, such as switch to alternate antennas, etc.

A second, smaller PC board assembly is mounted behind the front panel. This is the THRESHOLD-DISPLAY ASSEMBLY and contains no logic. It is used as a gathering-up point for the LINEAR ENABLE and TUNE SWR controls, the six LED indicators (CR201 thru CR206), the two meter illumination lamps and the interconnections to the SWR and POWER meters. The meter lamps are series connected 6 volt type 47 bulbs. They are in series with a pair of 15 ohm resistors (R208 and R209), which provide current limiting. The voltage drop across each lamp is approximately 3 volts, which provides adequate illumination and at the same time assures long life. The light intensity may be increased or decreased by increasing or decreasing the value of the resistance of R208 or R209. It is a good idea to keep these resistors of equal value, which will equalize the power drop and the heat generated in each one. Full brilliance of the lamps may be had by adding a jumper wire across both resistors, but the high heat generated at full brilliance may discolor the faces of the meters.

## J.W. MILLER AT 2500 OPERATING INSTRUCTIONS

**CAUTION:** Before connecting the Antenna Tuner to an AC power supply make sure that Switch S9 is in the correct voltage position. Remove the top cover and locate the switch towards the rear of the main PC logic board. See drawing on page 12.

The RF interconnection between Transmitter/Transceiver, Linear Amplifier, the AT 2500 and antenna(s) is standard and the same as with any other tuner.

The Separate Directional Coupler should be connected in line with the Transmission Line at the output of the Transmitter/Transceiver or Linear Amplifier when a linear is used. By connecting the Directional Coupler in this fashion the tuner will tune to the lowest SWR at the output of your RF source and thus protect your final tubes or transistors. Plug the cable with the 3-pin DIN connector coming from the Directional Coupler into the 3-pin DIN receptacle on the back of the AT 2500.

When the AT 2500 is used in a Transmitter/Transceiver and Linear Amplifier setup, the linear control circuit is fed thru the AT 2500 control circuit. To accomplish this, run a shielded lead from the Transmitter/Transceiver to LINEAR CONTROL "IN" (RCA socket) on the back of the AT 2500. Use another shielded lead from the LINEAR CONTROL "OUT" (RCA socket) to the relay control socket of the linear amplifier. **IMPORTANT** -- To reduce RF pickup in the AT 2500 electronic control circuit, it is strongly recommended that a high quality RG58A/U coaxial cable be used for these shielded relay interconnect cables.

When the AT 2500 is to be operated with a Transmitter/Transceiver only, a RCA shorting plug must be inserted into the socket marked LINEAR CONTROL "IN" on the back panel of the AT 2500; otherwise, some of the automatic functions of the AT 2500 will be lost (automatic tracking).

Once the AT 2500 Antenna Tuner has been properly interconnected with the Transmitter/Transceiver and linear combination and the antenna feed lines, the internal logic functions are pretty much automatic.

Until the operator has become familiar with these automatic functions, the two front panel potentiometers, LINEAR ENABLE and TUNE SWR, should be set straight up, i.e., 2:1 SWR.

With these settings, the companion linear amplifier will not be permitted to come on-line if the antenna system is tuned to a SWR greater than 2:1, and the AT 2500 will continue to tune until it has matched the RF equipment to the antenna system with a SWR of 2:1 or less. Use a Dummy Load and help prevent "air pollution."

From left to right, the eight push buttons are:

<u>SWITCH</u>	<u>FUNCTION</u>	<u>SWITCH IN</u>	<u>SWITCH OUT</u>
S1	POWER	ON	OFF
S2	LINEAR	Linear Enable line is active. Linear should be left in the Operate mode. AT 2500 will switch linear between Operate and Standby automatically.	Linear Enable line is open.
S3	REFL FRWD	Power meter reads Forward Power.	Power meter reads Reflected Power.
S4	OPERATE START	This is a spring loaded, momentary switch that starts the Tune cycle.	
S5	OPERATE STOP	This is a spring loaded, momentary switch that stops the Tune cycle.	
S6	250 2500	Power meter reads on 10 Watts to 2500 Watts scale.	Power meter reads on 1 Watt to 250 Watts scale.
S7	ALARM	Visual and audible alarms are enabled.	Visual LED alarm only.
S8	TRACK	Auto-Track mode of operation is ON.	Auto-Track is OFF.

For normal operation with a linear amplifier, S1, S2, S3, S6, S7 and S8 will be ON (IN position). S7 may be left OFF (OUT position) to silence the audio alarm. S8 may be left OFF (OUT position) to disable the Auto-Track mode. If power output is less than 250 Watts, S6 may be left OFF (OUT position) also.

With the linear amplifier set for Operate, it may be put in Standby by releasing the LINEAR Enable switch S2. If the S2 switch is ON (IN position) and the SWR is lower than the setting of the LINEAR ENABLE control, a hard ground is applied to the AT 2500's linear control line and the linear is active. The relay contacts in this circuit are capable of carrying 6 Amps at 115 Volts. This linear control line is automatically opened anytime the SWR exceeds the preset limit; whenever the logic circuits are in the Tune mode, or when the LINEAR switch S2 is on Standby (OFF position).

The AT 2500's always tune with the linear switched to Standby.

When a tune cycle has been completed, the linear enable line is grounded and the linear is switched from Standby to Operate.

Although the antenna tuner cannot be damaged by high power, the automatic control of the linear by the tuner prevents high SWR damage to the linear.

Since the AT 2500 makes its tune decisions from the information generated in the SWR Computer Section, a continuous carrier must be supplied by the RF equipment during the tune cycle. This RF carrier should preferably be 5 to 10 Watts.

Most solid state Transmitters/Transceivers reduce their power output with high SWR, so most tuning will take place with 5 to 50 Watts of power output.

Whenever the SWR exceeds the preset level of LINEAR ENABLE, the linear is dropped off line and the alarm circuit is energized. If S7 is ON (IN position), the solid state audio alert is also sounded. One second later, the Auto-Track circuit (if S8 is also on [IN position]) issues a Start command to the logic. After retuning to an acceptable SWR, provided the SWR is below that set by the operator with the Linear Enable control, the AT 2500 receives a Stop command and the linear enable line is activated. If the Linear S2 switch is ON (IN position), a ground is applied to the linear amplifier and it comes on-line with high power.

If for any reason the tuner cannot retune to an acceptable SWR within approximately 30 seconds, the alarm circuit is re-energized and the tuner switches into a "Step" mode of operation.

In the Step mode, the high voltage Tune and Load capacitors in the RF compartment are alternately stepped in a repetitive sequence that often is capable of finding a very high Q null in the antenna system.

Although the logic is designed to "track" downward changes in SWR, in the absence of a downward improvement in SWR, the logic will command a change of motors. In other words, the tuner is not permitted to just sit there and grind away to no avail.

Although Reflected Power can be read on the POWER meter by releasing S3, reflected power is of little consequence, since the SWR computer is always displaying the actual SWR on the SWR meter.

When operating in SSB, a peak detection circuit automatically displays PEAK output on the POWER meter. On long syllables, the SWR meter will also display the true value of SWR, but out of necessity, the SWR meter circuit is not designed to hold peak values. It must respond to quick changes and variations in the SWR in order that the other electronic circuits can quickly track SWR changes during the Tune cycle.

The mechanical construction of the tuner is such that after an automatic tune cycle, the high voltage Tune and Load capacitors may be touched up manually.

In the commercial world, it is recognized that SWR's of 2:1 (and often 3:1) are acceptable SWR's. In the amateur world, the 1:1 fetish has persisted and the manual tuning capability of the capacitors has been provided to permit the operator to fine tune the SWR if he wishes.

A little time spent comparing the indicated SWR with the forward and reflected power values will provide a better understanding of the real meaning of SWR.

Generally, amateur equipment is not as tolerant as commercial grade to high SWR and manufacturers' recommendations with regards to maximum SWR should be considered.

The six LED indicators offer a quick visual indication of the AT 2500's status:

**LINEAR:** When lit, the SWR is below the Linear Enable threshold and the linear control line is grounded.

**NOTE:** If the transmitter's linear control line is not connected to the tuner's LINEAR CONTROL "IN" connector, a shorting plug should be put in this socket to permit the LED to light up and the tuner to Operate automatically.

**TUNE:** Lights up whenever the motor circuit of the TUNE capacitor is active.

**START:** Lights whenever the AT 2500 is in the Tune cycle.

**STOP:** Lights whenever the AT 2500 is balanced, i.e., locked.

**LOAD:** Lights up whenever the motor circuit of the LOAD capacitor is active.

**ALARM:** Flashes whenever the alarm circuit is activated.

When the AT 2500 is connected to antenna systems with very shallow nulls, the motor slow-down circuit can find the bottom of the null by turning the high voltage capacitors very slowly. This will be evidenced by one of the Tune or Load LED's and the Start LED being lit. Although it may not be immediately apparent, one of the capacitors is still being driven very slowly to the bottom of the null. When the null is reached, the Tune, Load and Start LED's will go off and the Stop LED will be lit.

If it is necessary to rezero the front panel meters, use a non-metallic screwdriver.

It is important to have a good earth ground at the grounding terminal of the AT 2500. To achieve this, it is suggested that 1/2" copper braid rather than regular wire be used. The connection should be as short as possible and lead to a separate ground. The subject of grounding and how to prevent RF ground loops is covered in the ARRL Handbook, the Radio Handbook and in many past issues of various amateur radio publications.

### ADDITIONAL INSTRUCTIONS FOR TUNE MODE OPERATION

There are a number of possible ways that you can operate your AT 2500 in the Tune Mode. However, all methods have to make provision to supply RF power to the tuner within the range of 1 to 25 Watts. Always use a minimum of power.

When only a transmitter or transceiver is to be used, the AT 2500 will operate with as little as 1 Watt of carrier. For CW operation your key can be the ON/OFF source of the RF after you have decided how you are going to reduce the carrier level.

Depending on the transmitter or transceiver you have, there are a number of methods that can be used to control the AT 2500 during the Tune Mode.

1) If your unit has a TUNE position as one of the possible ways to operate your rig, you can physically set this control to TUNE whenever the alarm sounds on the AT 2500. It would be best to leave the AT 2500 TRACK switch in the OFF position and depend on the alarm to alert you to set the transmitter or transceiver to TUNE and then engage the TRACK switch on the AT 2500.

2) Another method to consider is the use of the ALC circuit to control the RF power supplied to the AT 2500. (See ALC Hook Up on page 16)

A set of relay terminals K1B (on schematic) are brought out to terminals 9, 10 and 11 on the Logic PC Board where the edge connector picks up the circuit and carries it to three RCA connectors on the back panel. These terminals are identified as NC (normally closed), W (wiper or moveable contact arm) and NO (normally open).

When the tuner is operating in the TUNE mode the linear amplifier has been taken off line through relay contacts shown as K1A. During this period it is desirable to reduce the power from the transceiver. Most transceivers that are designed for SSB operation have ALC incorporated as a means of limiting peak power from the transceiver when it is operated alone, or of responding to a



bias voltage from the linear amplifier that reduces the drive power. It is possible to reduce the output from the transceiver by placing a fixed bias voltage on the transceiver ALC line during the time that the AT 2500 is in the TUNE mode. The exact value of this bias will have to be determined experimentally for the transceiver you have. If you are lucky this voltage could be supplied by one or two C or D cells since the current drain when operating is very low and the battery life could almost be considered as shelf life.

Most solid state transceivers have a built in SWR indicator and the developed voltage is used as a bias voltage to reduce the output power if the SWR exceeds 2:1. These units are self protecting and do not require any additional bias.

3) Still another method would use an audio tone that can be fed to the microphone circuit. This can be controlled through the K1B set of relay contacts. The level of the tone will determine the RF that would be supplied to the tuner. In some units it is desirable to disengage the microphone during the tune period.

When a linear amplifier is used with the AT 2500, an additional time delay is added due to the switching of the antenna relay in the linear. When the tuner goes into the tune mode K1 is de-energized and this opens the K1A contacts which de-energizes the linear relay. There is a finite amount of time when the linear amplifier relay switches the RF from the input of the tube to the antenna output terminal. During this brief instant the RF circuit is broken and the SWR voltage drops to zero. When this occurs relay chatter is experienced. Hysteresis has been added to the circuit by R74, R79 and C43. This makes switching to the tune mode or back to operate possible without relay chatter except in a case where the RF drive is too low. The relays will then chatter at about 100 to 150 cycles per minute. The cure is to increase your RF output by a few Watts and normal operation will be achieved. Normally relay chatter will only occur if the RF drive is below 1 Watt. A drive level of 5 — 10 Watts appears to be adequate power for reliable tuner operation when a linear amplifier has to be switched in and out of the circuit.

For units such as the Alpha 77D and 77DX with QSK, connect the transceiver and linear to the tuner in the normal manner. The QSK circuit will keep the Alpha in the circuit at all times. Therefore, adjust the drive from the transceiver until the output from the Alpha is around 10 Watts. This may vary from unit to unit but to date we have only found one instance where 20 Watts was required for stable operation.

### TUNING UP YOUR ANTENNA SYSTEM

The Switch S11 selects the appropriate tap on the tank coil. Switch positions A thru R are indicated on the front panel. We list below a good starting switch position for various frequencies. This is for a load of 50 ohms (resistive).

FREQUENCY (MHz)	SWITCH POSITION
3.550	P
3.750	O
3.950	M
7.050	I
7.225	I
14.050	E
14.275	E
21.050	D
21.300	D
28.050	D
28.600	C
29.500	C

## LOGIC and CONTROL BOARD PARTS LIST

## RESISTORS

REFERENCE	DESCRIPTION	PART NO.
R1	100K ohms ¼ Watt ± 5%	25-116
R2	100K ohms ¼ Watt ± 5%	25-116
R3	2.7 ohms ¼ Watt ± 5%	25-96
R4	2.7 ohms ¼ Watt ± 5%	25-96
R5	2.7 ohms ¼ Watt ± 5%	25-96
R6	2.7 ohms ¼ Watt ± 5%	25-96
R7	2.7 ohms ¼ Watt ± 5%	25-96
R8	2.7 ohms ¼ Watt ± 5%	25-96
R9	2.7 ohms ¼ Watt ± 5%	25-96
R10	2.7 ohms ¼ Watt ± 5%	25-96
R11	470 ohms ¼ Watt ± 5%	25-99
R12	15K ohms ¼ Watt ± 5%	25-110
R13	75K ohms ¼ Watt ± 5%	25-115
R14	2.7K ohms ¼ Watt ± 5%	25-104
R15	Jumper	
R16	75K ohms ¼ Watt ± 5%	25-115
R17	2.7K ohms ¼ Watt ± 5%	25-104
R18	Jumper	
R19	3.6K ohms ¼ Watt ± 5%	25-105
R20	680 ohms ¼ Watt ± 5%	25-100
R21	4.7K ohms ¼ Watt ± 5%	25-106
R22	220K ohms ¼ Watt ± 5%	25-117
R23	220K ohms ¼ Watt ± 5%	25-117
R24	7.5K ohms ¼ Watt ± 5%	25-108
R25	100 ohms ¼ Watt ± 5%	25-98
R26	20K ohms ¼ Watt ± 5%	25-111
R27	2.7K ohms ¼ Watt ± 5%	25-104
R28	20K ohms ¼ Watt ± 5%	25-111
R29	220K ohms ¼ Watt ± 5%	25-117
R30	220K ohms ¼ Watt ± 5%	25-117
R31	680 ohms ¼ Watt ± 5%	25-100
R32	4.7K ohms ¼ Watt ± 5%	25-106
R33	7.5K ohms ¼ Watt ± 5%	25-108
R34	2.7K ohms ¼ Watt ± 5%	25-104
R35	5K ohms Potentiometer	25-38
R36	100K ohms ¼ Watt ± 5%	25-116
R37	1K ohms ¼ Watt ± 5%	25-101
R38	20K ohms ¼ Watt ± 5%	25-111
R39	20K ohms ¼ Watt ± 5%	25-111
R40	100K ohms ¼ Watt ± 5%	25-116
R41	10K ohms ¼ Watt ± 5%	25-109
R42	1 Megohm ¼ W ± 5%	25-120
R43	10K ohms ¼ Watt ± 5%	25-109
R44	470K ohms ¼ Watt ± 5%	25-119
R45	470K ohms ¼ Watt ± 5%	25-119
R46	9.1 Megohms ¼ Watt ± 5%	25-124
R47	100K ohms ¼ Watt ± 5%	25-116
R48	20K ohms ¼ Watt ± 5%	25-111
R49	470 ohms ¼ Watt ± 5%	25-99
R50	20K ohms ¼ Watt ± 5%	25-111
R51	470 ohms ¼ Watt ± 5%	25-99
R52	47K ohms ¼ Watt ± 5%	25-114
R53	330K ohms ¼ Watt ± 5%	25-118
R54	330K ohms ¼ Watt ± 5%	25-118
R55	330K ohms ¼ Watt ± 5%	25-118
R56	2.7K ohms ¼ Watt ± 5%	25-104
R57	1K ohms Potentiometer	25-37
R58	1.5K ohms ¼ Watt ± 5%	25-102
R59	10K ohms ¼ Watt ± 5%	25-109
R60	10K ohms ¼ Watt ± 5%	25-109
R61	47K ohms ¼ Watt ± 5%	25-114
R62	47K ohms ¼ Watt ± 5%	25-114
R63	20K ohms ¼ Watt ± 5%	25-111
R64	680 ohms ¼ Watt ± 5%	25-100

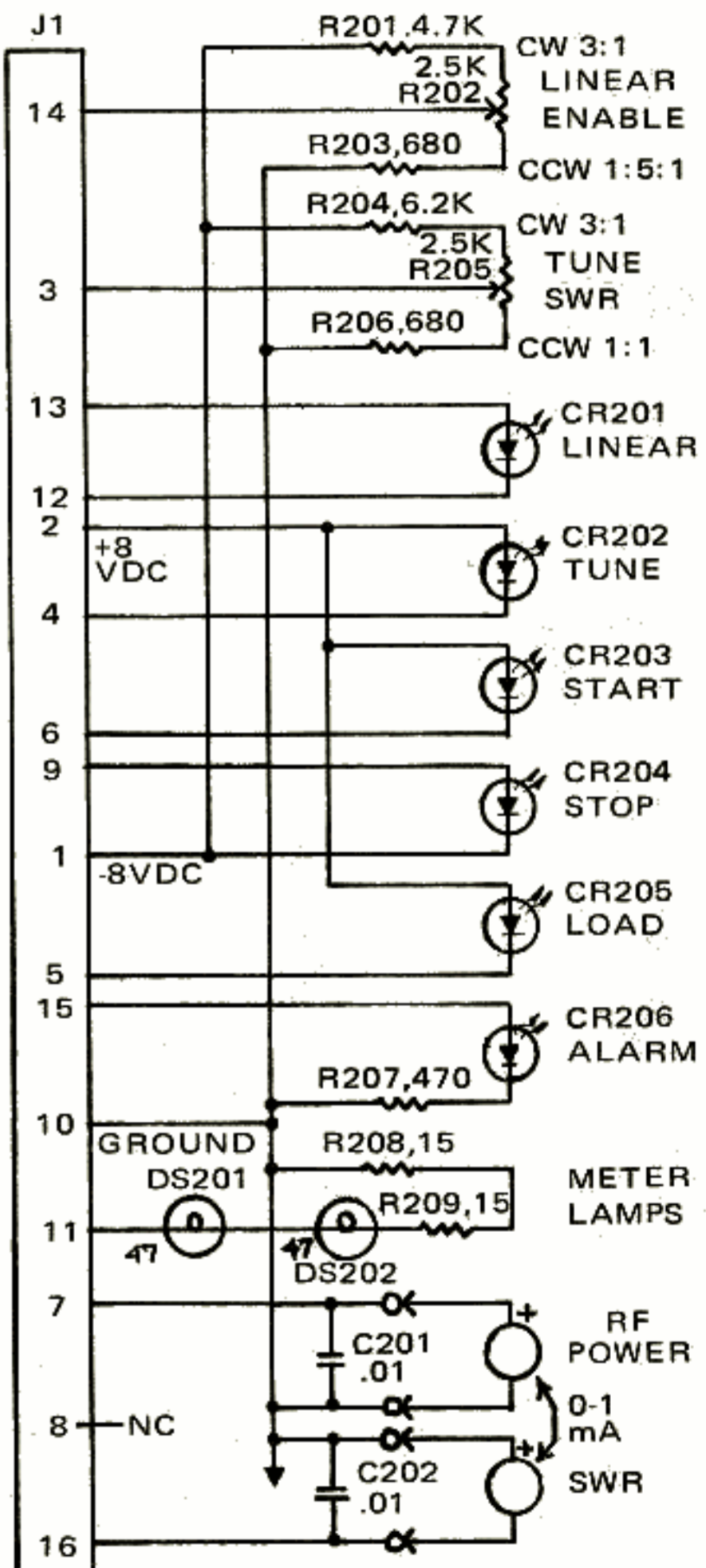
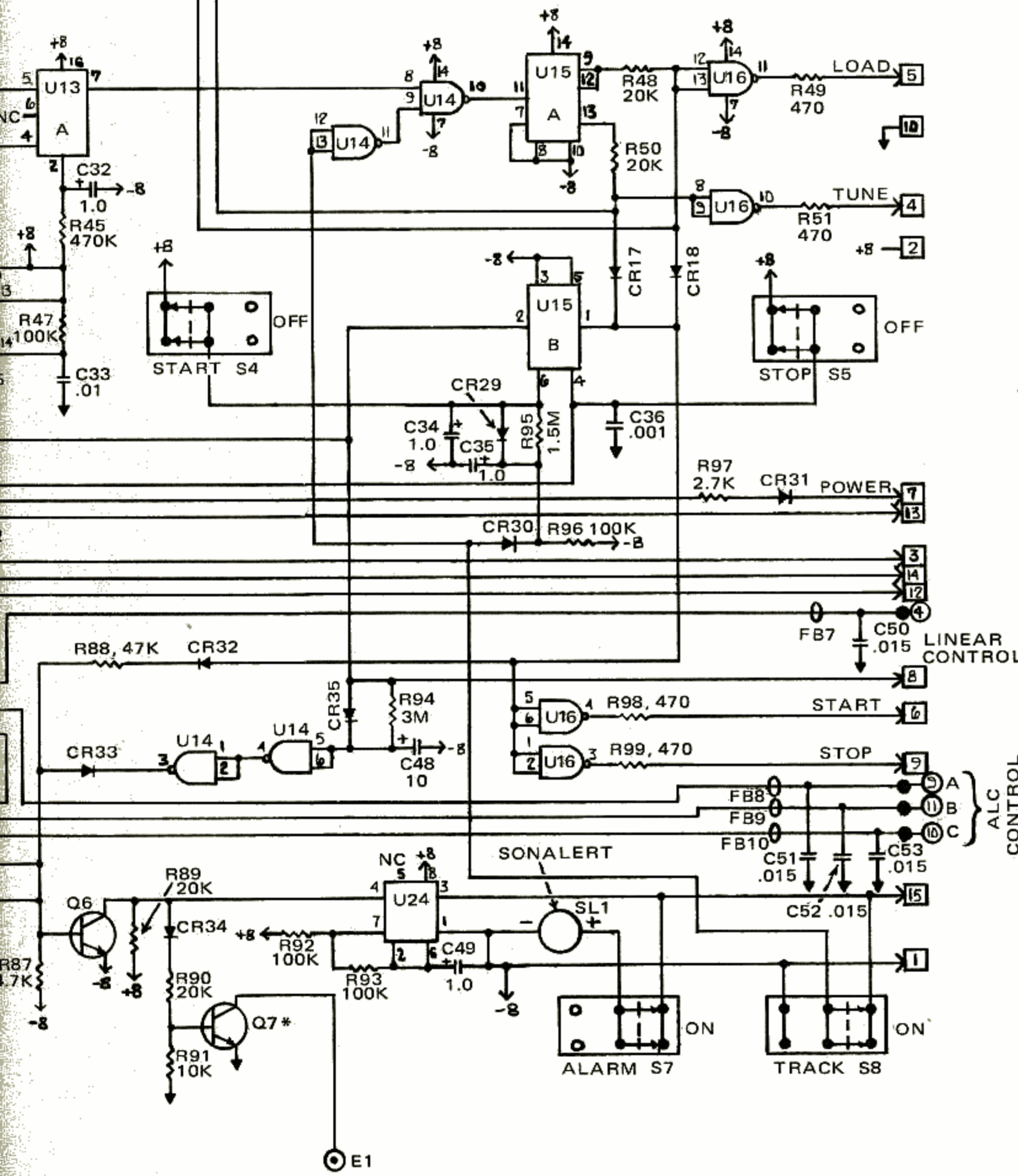
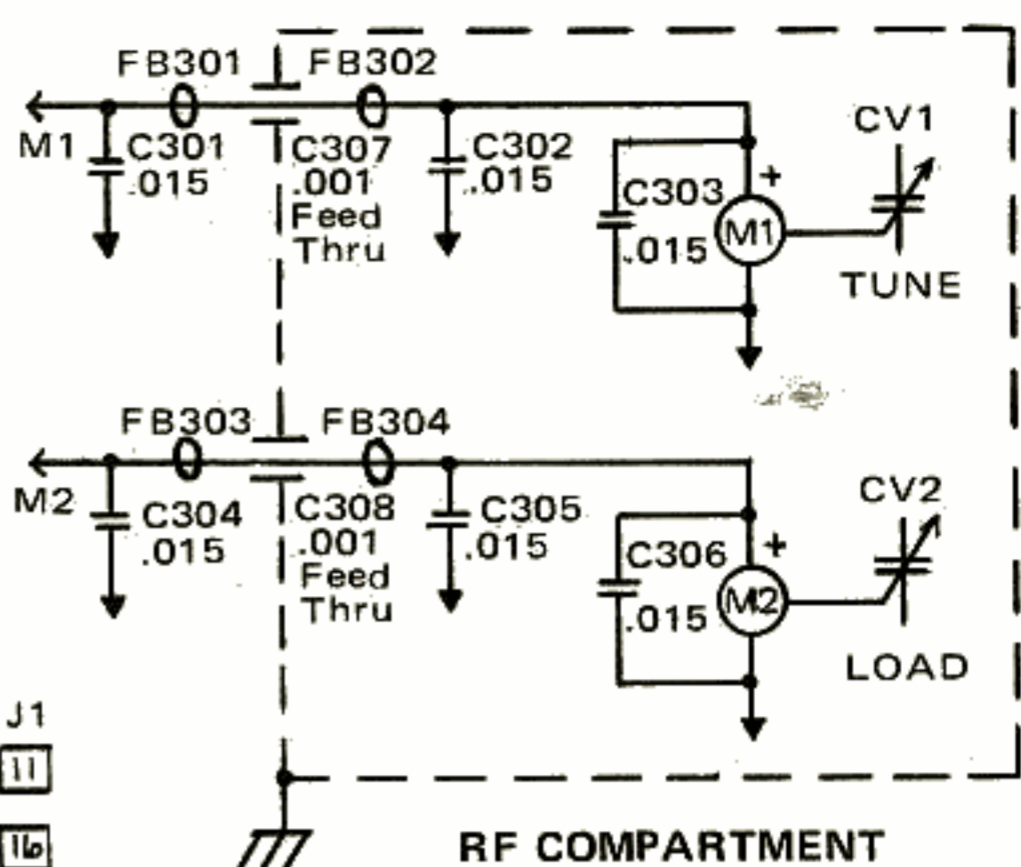
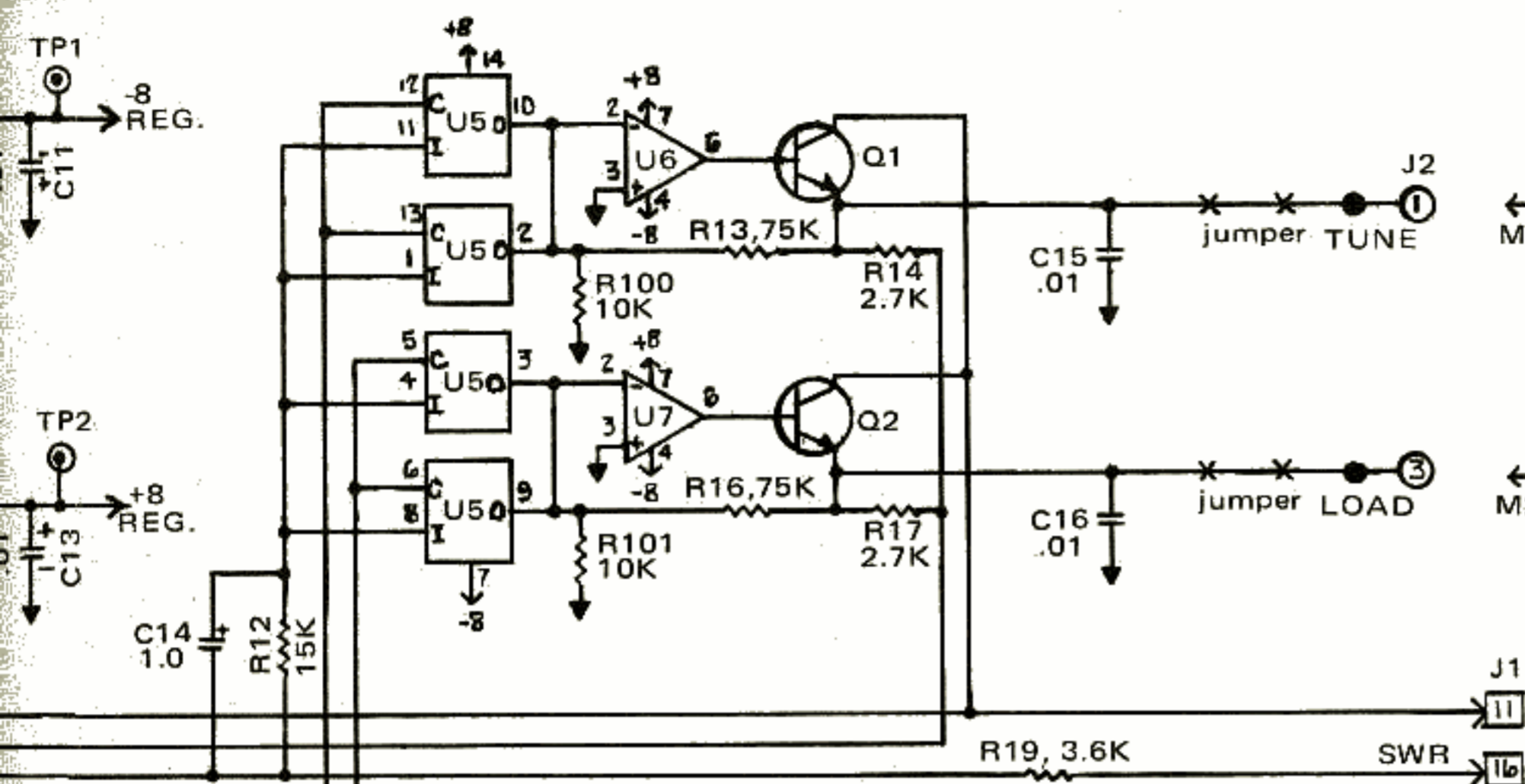
## RESISTORS

REFERENCE	DESCRIPTION	PART NO.
R65	1K ohms Potentiometer	25-37
R66	75 ohms ¼ Watt ± 5%	25-115
R67	10K ohms ¼ Watt ± 5%	25-109
R68	25K ohms Potentiometer	25-39
R69	See text - - not supplied	
R70	30K ohms ¼ Watt ± 5%	25-112
R71	20K ohms ¼ Watt ± 5%	25-111
R72	25K ohms Potentiometer	25-39
R73	100K ohms ¼ Watt ± 5%	25-116
R74	47K ohms ¼ Watt ± 5%	25-114
R75	1K ohms ¼ Watt ± 5%	25-101
R76	5.1 Megohms ¼ Watt ± 5%	25-123
R77	1 Megohm ¼ Watt ± 5%	25-120
R78	470K ohms ¼ Watt ± 5%	25-119
R79	3 Megohms ¼ Watt ± 5%	25-122
R80	100K ohms ¼ Watt ± 5%	25-116
R81	15K ohms ¼ Watt ± 5%	25-110
R82	10K ohms ¼ Watt ± 5%	25-109
R83	100K ohms ¼ Watt ± 5%	25-116
R84	2 ohms ¼ Watt ± 5%	25-103
R85	47K ohms ¼ Watt ± 5%	25-114
R86	47K ohms ¼ Watt ± 5%	25-114
R87	4.7K ohms ¼ Watt ± 5%	25-106
R88	47K ohms ¼ Watt ± 5%	25-114
R89	20K ohms ¼ Watt ± 5%	25-111
R90	20K ohms ¼ Watt ± 5%	25-111
R91	10K ohms ¼ Watt ± 5%	25-109
R92	100K ohms ¼ Watt ± 5%	25-116
R93	100K ohms ¼ Watt ± 5%	25-116
R94	3 Megohms ¼ Watt ± 5%	25-122
R95	1.5 Megohm ¼ Watt ± 5%	25-121
R96	100K ohms ¼ Watt ± 5%	25-116
R97	2.7K ohms ¼ Watt ± 5%	25-104
R98	470 ohms ¼ Watt ± 5%	25-99
R99	470 ohms ¼ Watt ± 5%	25-99
R100	10K ohms ¼ Watt ± 5%	25-109
R101	10K ohms ¼ Watt ± 5%	25-109
R102	3 Megohms 1/8 Watt ± 5%	25-135

## MISCELLANEOUS

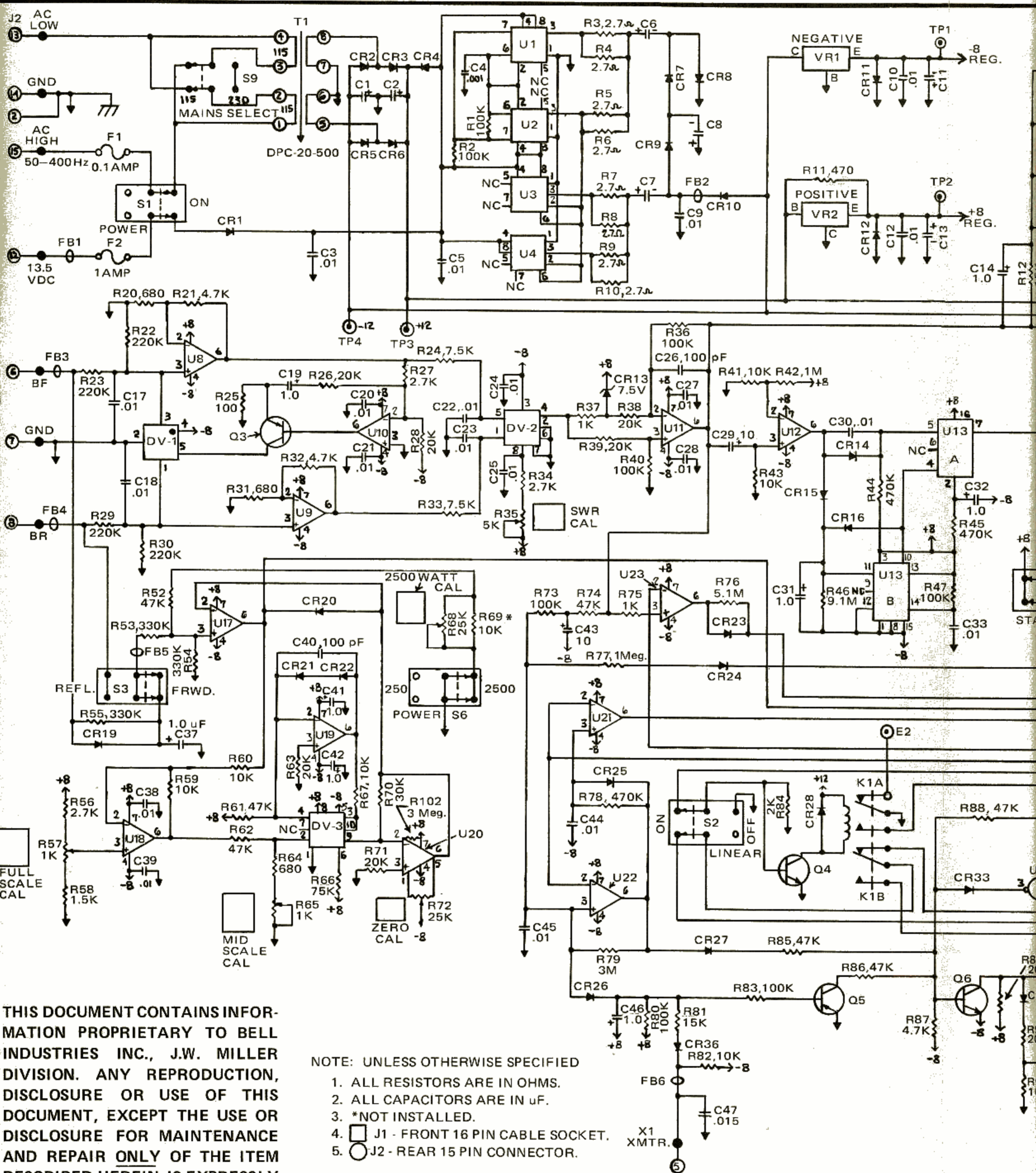
REFERENCE	DESCRIPTION	PART NO.
DV1	Photo Coupler	25-66
DV2	IC	25-67
DV3	Amplifier	25-68
F1	0.1 Amp Fuse	25-41
F2	1 Amp Fuse	25-42
K1	DPDT 12 Volt Relay	25-51
Q1	2N697 Transistor	25-70
Q2	2N697 Transistor	25-70
Q3	2N2907A Transistor	25-69
Q4	2N697 Transistor	25-70
Q5	2N2907A Transistor	25-69
Q6	2N697 Transistor	25-70
Q7	2N6724 Not Supplied See Text	
S1 - S8	8 Section Push Button Switch	25-52
S9	DPDT Slide Switch	25-35
SL1	Sonalert	25-48
T1	Power Transformer	25-40
VR1	-8 Volt Regulator MC7908CT	25-54
VR2	+8 Volt Regulator MC7808CT	25-53

(Continued on Page 14)



CONTROL BOARD SCHEMATIC

THRESHOLD DISPLAY SCHEMATIC

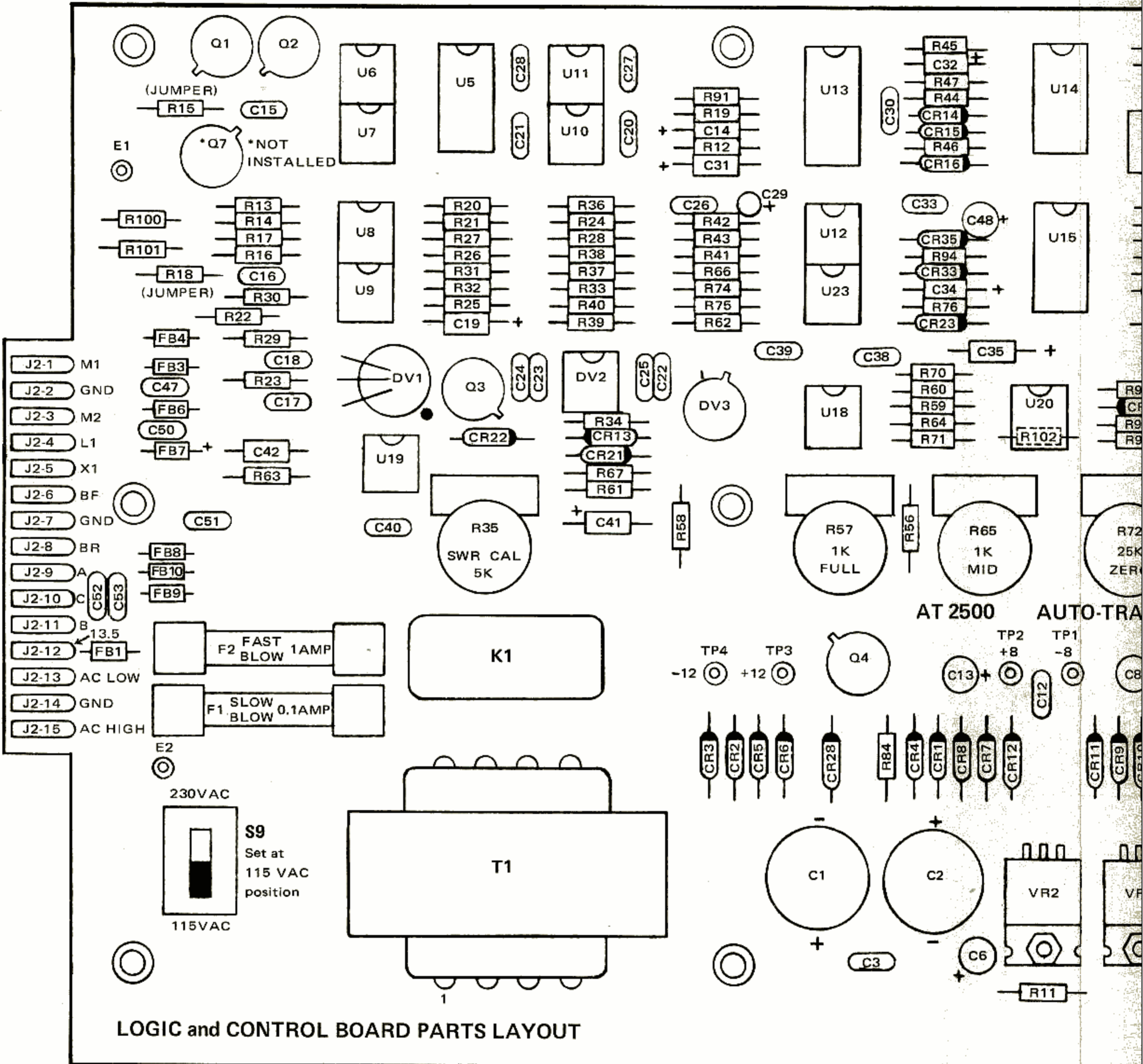


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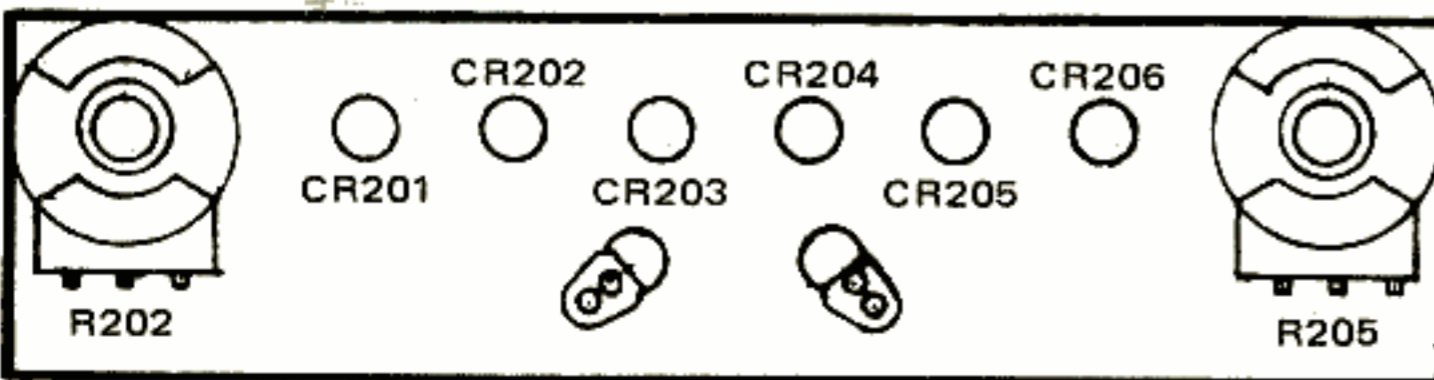
NOTE: UNLESS OTHERWISE SPECIFIED

1. ALL RESISTORS ARE IN OHMS.
2. ALL CAPACITORS ARE IN  $\mu\text{F}$ .
3. \*NOT INSTALLED.
4.  $\square$  J1 - FRONT 16 PIN CABLE SOCKET.
5.  $\circ$  J2 - REAR 15 PIN CONNECTOR.

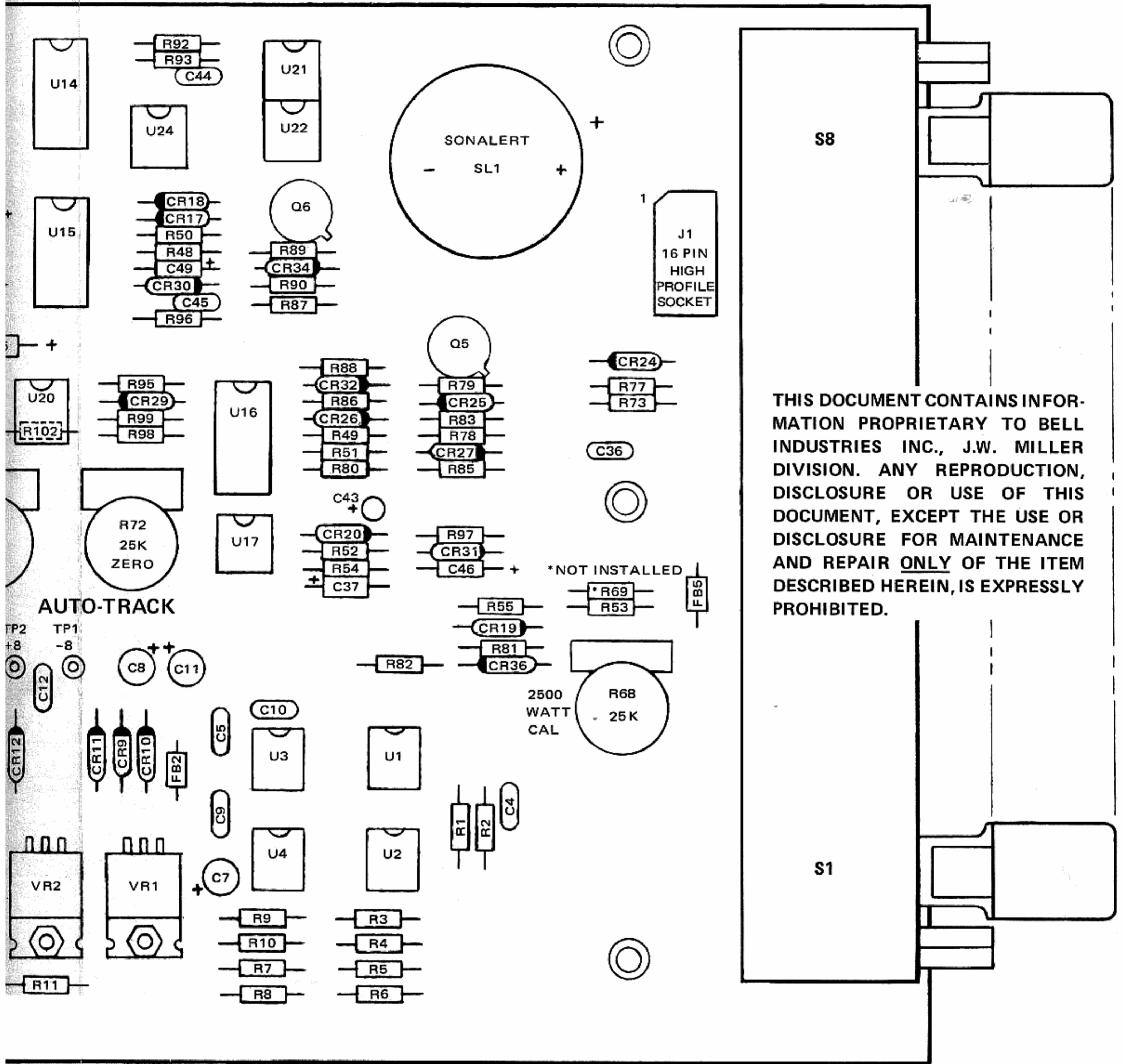
LOGIC and CONTROL BOARD SC



THRESHOLD DISPLAY BOARD LAYOUT – FRONT



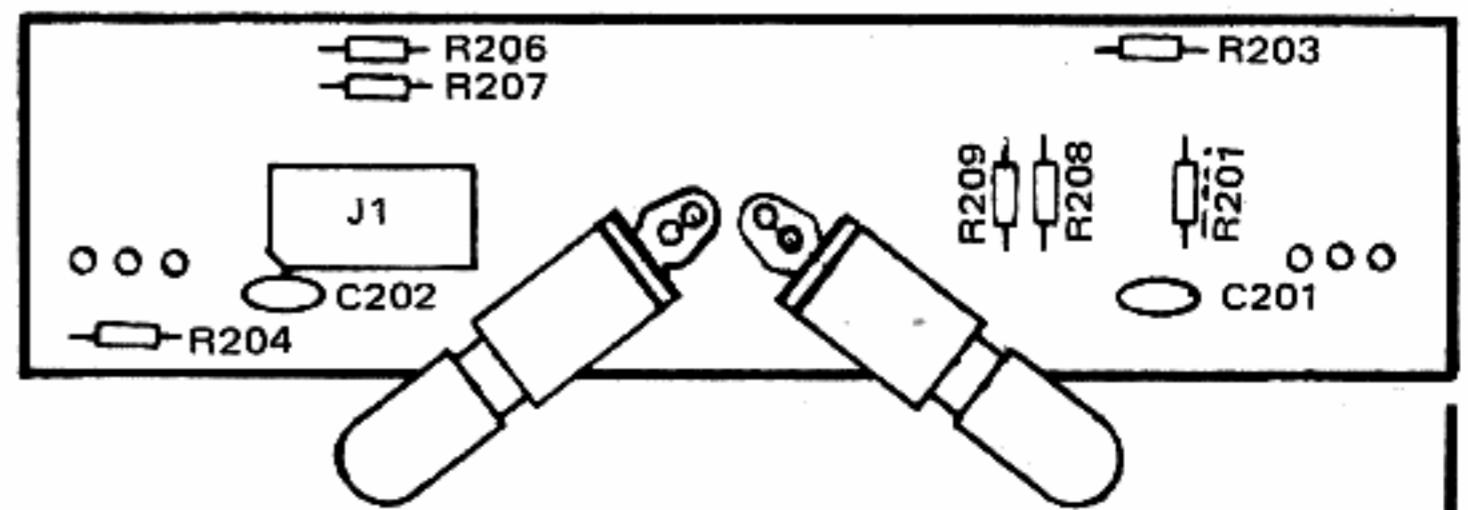
REFERENCE	DESCRIPTION	PART NO.	REFE
C201	.01 uF 50 V Ceramic Disc	25-46	R2
C202	.01 uF 50 V Ceramic Disc	25-46	R2
CR201	LED	25-20	R2
CR202	LED	25-20	R2
CR203	LED	25-20	R2
CR204	LED	25-20	R2
CR205	LED	25-20	R2
CR206	LED	25-20	R2
J1	16 Pin Socket	25-25	
R201	4,700 ohms ¼ W ± 5%	25-106	
R202	2,500 ohms Potentiometer	25-21	



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ID.	REFERENCE	DESCRIPTION	PART NO.
	R203	680 ohms 1/4 W ± 5%	25-100
	R204	6,200 ohms 1/4 W ± 5%	25-107
	R205	2,500 ohms Potentiometer	25-21
	R206	680 ohms 1/4 W ± 5%	25-100
	R207	470 ohms 1/4 W ± 5%	25-99
	R208	15 ohms 1/4 W ± 5%	25-129
	R209	15 ohms 1/4 W ± 5%	25-129
		Pilot Lamp Socket(2 used)	25-23
		No. 47 Pilot Lamp(2 used)	25-24
		PC Board	25-28
		Interconnect Cable	25-26

THRESHOLD DISPLAY BOARD LAYOUT – REAR



## LOGIC and CONTROL BOARD PARTS LIST (Continued from Page 9)

## DIODES and RECTIFIERS

REFERENCE	DESCRIPTION	PART NO.
CR1	1N4007 Silicon Rectifier	25-60
CR2	1N4007 Silicon Rectifier	25-60
CR3	1N4007 Silicon Rectifier	25-60
CR4	1N4007 Silicon Rectifier	25-60
CR5	1N4007 Silicon Rectifier	25-60
CR6	1N4007 Silicon Rectifier	25-60
CR7	1N4007 Silicon Rectifier	25-60
CR8	1N4007 Silicon Rectifier	25-60
CR9	1N4007 Silicon Rectifier	25-60
CR10	1N4007 Silicon Rectifier	25-60
CR11	1N4007 Silicon Rectifier	25-60
CR12	1N4007 Silicon Rectifier	25-60
CR13	1N755A Zener Diode	25-61
CR14	1N914B Silicon Diode	25-62
CR15	1N914B Silicon Diode	25-62
CR16	1N914B Silicon Diode	25-62
CR17	1N914B Silicon Diode	25-62
CR18	1N914B Silicon Diode	25-62
CR19	1N270 Germanium Diode	25-63
CR20	1N914B Silicon Diode	25-62
CR21	1N914B Silicon Diode	25-62
CR22	1N914B Silicon Diode	25-62
CR23	1N914B Silicon Diode	25-62
CR24	1N914B Silicon Diode	25-62
CR25	1N914B Silicon Diode	25-62
CR26	1N914B Silicon Diode	25-62
CR27	1N914B Silicon Diode	25-62
CR28	1N4007 Silicon Rectifier	25-60
CR29	1N914B Silicon Diode	25-62
CR30	1N914B Silicon Diode	25-62
CR31	1N270 Germanium Diode	25-63
CR32	1N914B Silicon Diode	25-62
CR33	1N914B Silicon Diode	25-62
CR34	1N914B Silicon Diode	25-62
CR35	1N914B Silicon Diode	25-62
CR36	1N914B Silicon Diode	25-62

## IC's

REFERENCE	DESCRIPTION	PART NO.
U1	NE555V Motorola	25-55
U2	NE555V Motorola	25-55
U3	NE555V Motorola	25-55
U4	NE555V Motorola	25-55
U5	14066B RCA, Motorola	25-56
U6	UA741CNE-B Signetics	25-64
U7	UA741CNE-B Signetics	25-64
U8	UA741CNE-B Signetics	25-64
U9	LF351N National	25-65
U10	UA741CNE-B Signetics	25-64
U11	LF351N National	25-65
U12	LF351N National	25-65
U13	MC14528B Motorola	25-57
U14	MC14011B Motorola	25-58
U15	MC14013B Motorola	25-59
U16	MC14011B Motorola	25-58
U17	LM741 Motorola	25-136
U18	UA741CNE-B Signetics	25-64
U19	UA741CNE-B Signetics	25-64
U20	UA741CNE-B Signetics	25-64
U21	LM741 Motorola	25-136
U22	UA741CNE-B Signetics	25-64
U23	LF351N National	25-65
U24	NE555V Motorola	25-55

## CAPACITORS

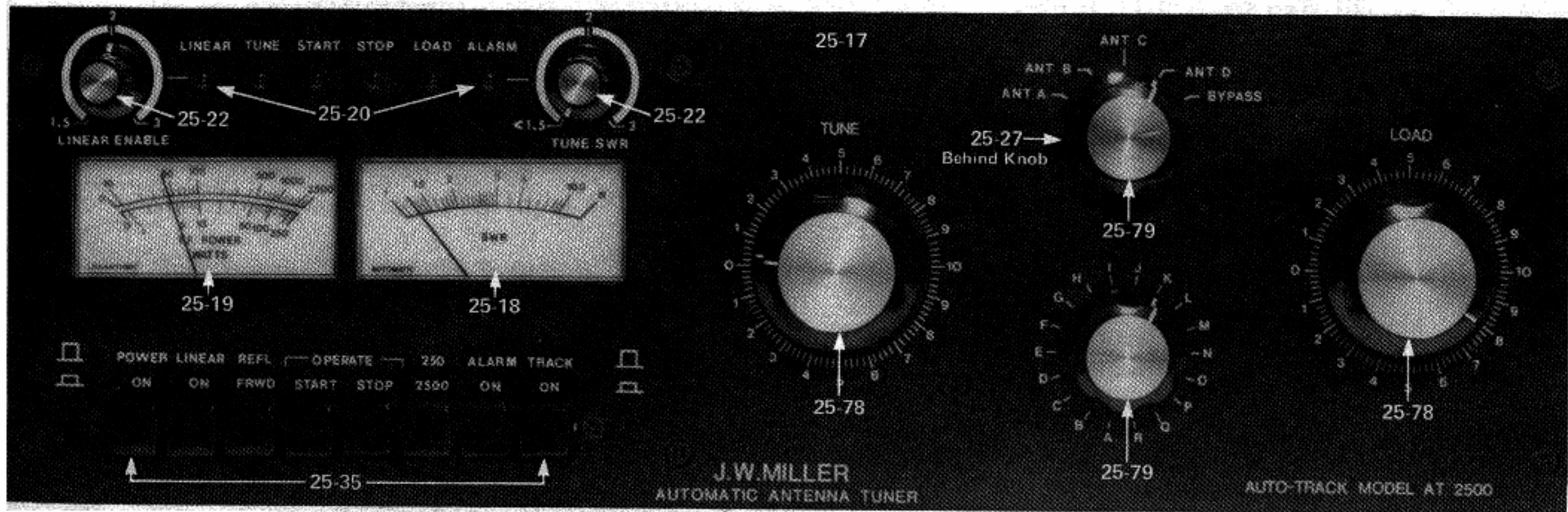
REFERENCE	DESCRIPTION	PART NO.
C1	2200 uF 25 V Electrolytic	25-47
C2	2200 uF 25 V Electrolytic	25-47
C3	.01 uF 50 V Ceramic Disc	25-46
C4	.001 uF 1 kV Ceramic Disc	25-45
C5	.01 uF 50 V Ceramic Disc	25-46
C6	10 uF 35 V Dipped Tantalum	25-43
C7	10 uF 35 V Dipped Tantalum	25-43
C8	10 uF 35 V Dipped Tantalum	25-43
C9	.01 uF 50 V Ceramic Disc	25-46
C10	.01 uF 50 V Ceramic Disc	25-46
C11	10 uF 35 V Dipped Tantalum	25-43
C12	.01 uF 50 V Ceramic Disc	25-46
C13	10 uF 35 V Dipped Tantalum	25-43
C14	1 uF 35 V Tubular Tantalum	25-44
C15	.01 uF 50 V Ceramic Disc	25-46
C16	.01 uF 50 V Ceramic Disc	25-46
C17	.01 uF 50 V Ceramic Disc	25-46
C18	.01 uF 50 V Ceramic Disc	25-46
C19	1 uF 35 V Tubular Tantalum	25-44
C20	.01 uF 50 V Ceramic Disc	25-46
C21	.01 uF 50 V Ceramic Disc	25-46
C22	.01 uF 50 V Ceramic Disc	25-46
C23	.01 uF 50 V Ceramic Disc	25-46
C24	.01 uF 50 V Ceramic Disc	25-46
C25	.01 uF 50 V Ceramic Disc	25-46
C26	100 pF 1 kV Ceramic Disc	25-130
C27	.01 uF 50 V Ceramic Disc	25-46
C28	.01 uF 50 V Ceramic Disc	25-46
C29	10 uF 35 V Dipped Tantalum	25-43
C30	.01 uF 50 V Ceramic Disc	25-46
C31	1 uF 35 V Tubular Tantalum	25-44
C32	1 uF 35 V Tubular Tantalum	25-44
C33	.01 uF 50 V Ceramic Disc	25-46
C34	1 uF 35 V Tubular Tantalum	25-44
C35	1 uF 35 V Tubular Tantalum	25-44
C36	.001 uF 1 kV Ceramic Disc	25-45
C37	1 uF 35 V Tubular Tantalum	25-44
C38	.01 uF 50 V Ceramic Disc	25-46
C39	.01 uF 50 V Ceramic Disc	25-46
C40	100 pF 1 kV Ceramic Disc	25-130
C41	1 uF 35 V Tubular Tantalum	25-44
C42	1 uF 35 V Tubular Tantalum	25-44
C43	10 uF 35 V Dipped Tantalum	25-43
C44	.01 uF 50 V Ceramic Disc	25-46
C45	.01 uF 50 V Ceramic Disc	25-46
C46	1 uF 35 V Tubular Tantalum	25-44
C47	.015 uF 600 V Ceramic Disc	19-15000-20
C48	10 uF 35 V Dipped Tantalum	25-43
C49	1 uF 35 V Tubular Tantalum	25-44
C50	.015 uF 600 V Ceramic Disc	19-15000-20
C51	.015 uF 600 V Ceramic Disc	19-15000-20
C52	.015 uF 600 V Ceramic Disc	19-15000-20
C53	.015 uF 600 V Ceramic Disc	19-15000-20

## MECHANICAL ASSEMBLY PARTS LIST

QUANTITY	DESCRIPTION	PART NO.
1	Chassis Complete with 6 standoffs	25-89
1	Cover	25-1-01
1	Screened Front Panel	25-17
4	Feet (for bottom)	25-81
1 pr	*Side Handles with 4 black screws	25-1-10
1 pr	*Rack Mount Side Panels with 4 black screws	25-1-11

\*These parts are optional at additional cost.

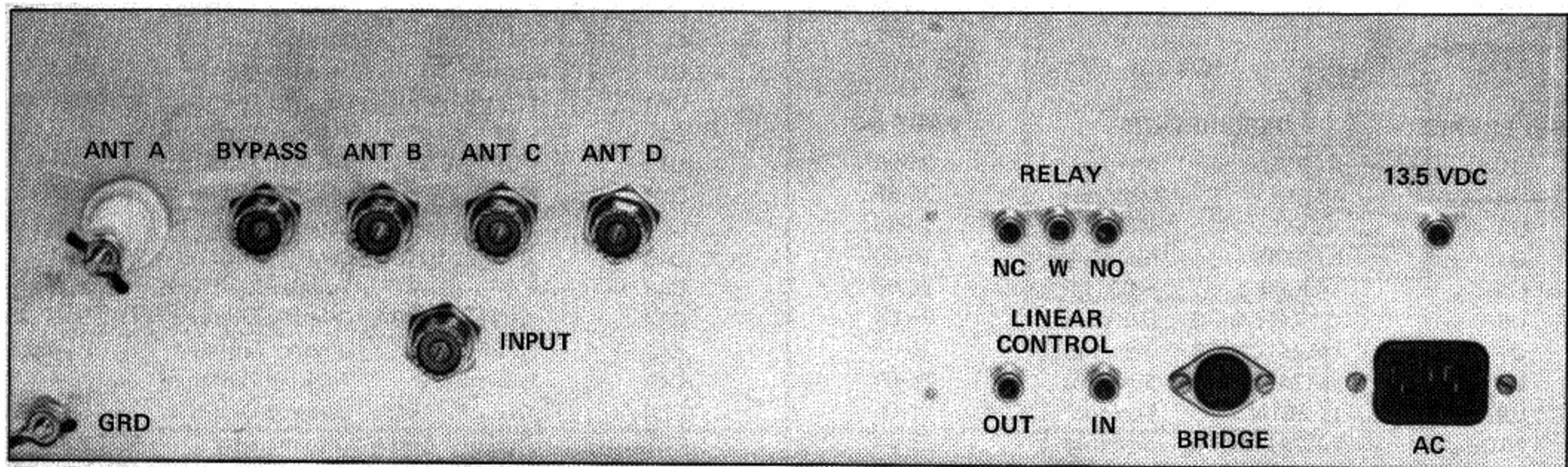
### FRONT PANEL LAYOUT



### PARTS LIST

REFERENCE	DESCRIPTION	PART NO.	REFERENCE	DESCRIPTION	PART NO.
25-17	Screened Front Panel	25-17	25-79	Antenna Selector Knob	25-79
25-19	RF Power Meter	25-19	25-79	Coil Tap Selector Knob	25-79
25-18	SWR Meter	25-18	25-78	Tune Capacitor Knob	25-78
S1 - S8	Function Switch (includes 8 knobs)	25-35	25-78	Load Capacitor Knob	25-78
25-22	Linear Enable Knob	25-22	25-27	Panel Bearing	25-27
25-22	Tune SWR Knob	25-22	25-20	LED Holder (6 used)	25-20

### REAR PANEL TERMINAL LAYOUT

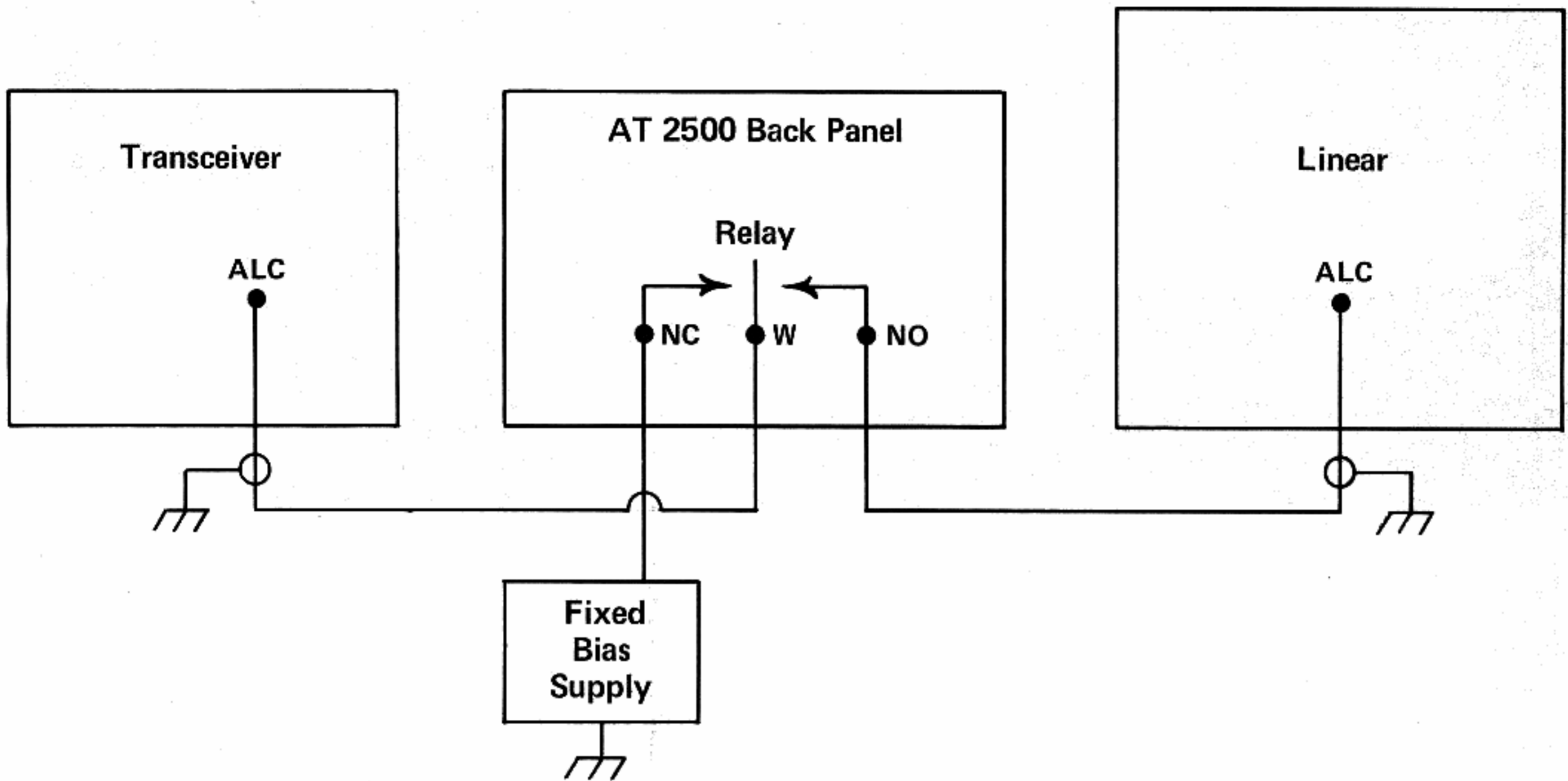


### PARTS LIST

CONNECTOR	REFERENCE	CONNECTOR FOR	CONNECTOR	REFERENCE	CONNECTOR FOR
ANT A	J4	End Fed Antenna	AC	J9	117 Volt AC Line Cord
BYPASS	J5	Coaxial Input	13.5 VDC	J11	13.5 VDC Input
ANT B	J6	Coaxial Input	GRD		Grounding Terminal
ANT C	J7	Coaxial Input	RELAY NC	J15	Normally Closed Position
ANT D	J8	Coaxial Input	RELAY W	J14	Wiper or Contact Arm
LINEAR CONTROL IN	J13	Line from Transceiver	RELAY NO	J12	Normally Open Position
LINEAR CONTROL OUT	J16	Line to Linear	PART NO. 25-85	LABEL	
BRIDGE	J10	Line from Bridge Coupler	PART NO. 25-88		AC Cord (Detachable) Supplied with Tuner

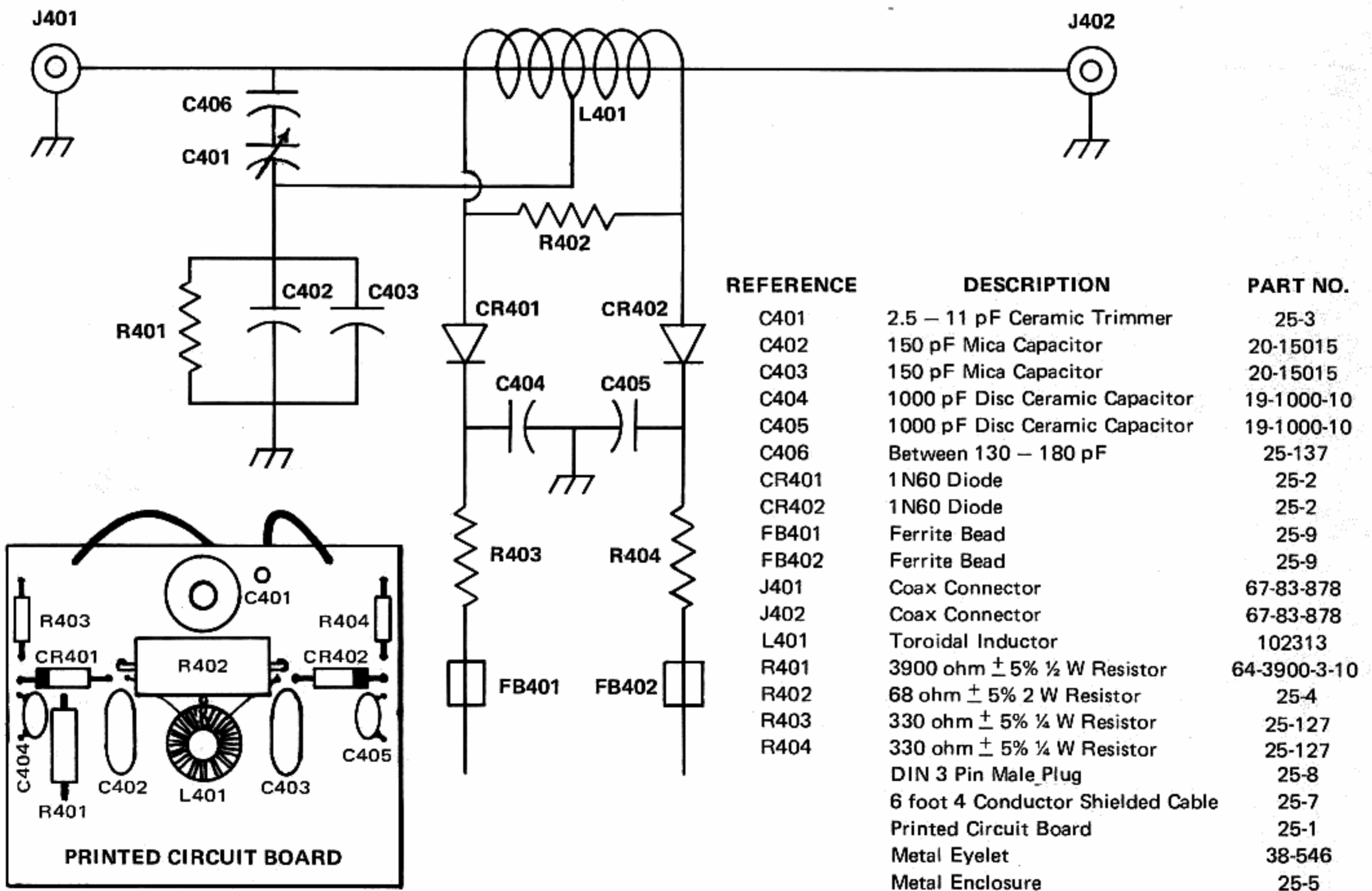


ALC HOOK UP

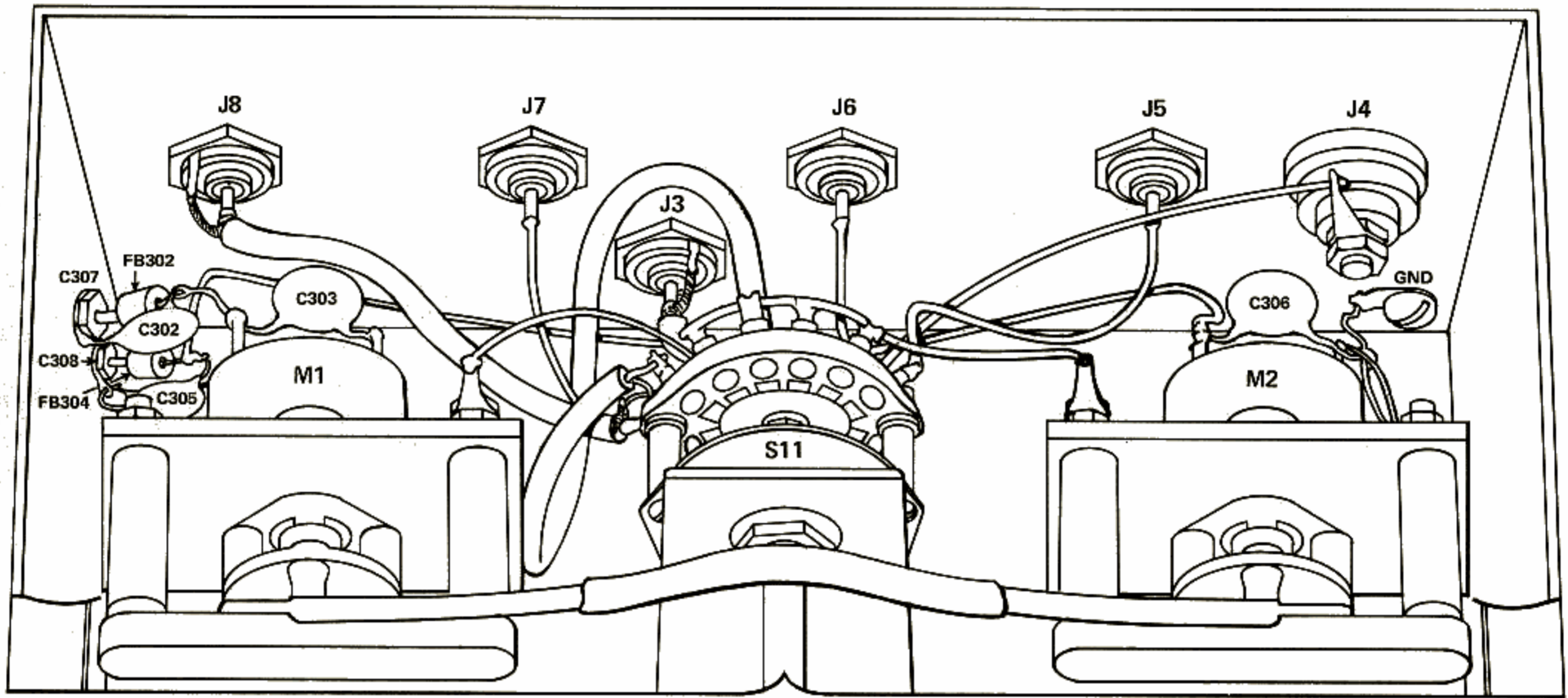


Fixed Bias Hook up to reduce output from Transceiver to safe level during tune phase of AT 2500.

DIRECTIONAL BRIDGE COUPLER SCHEMATIC and PARTS LIST

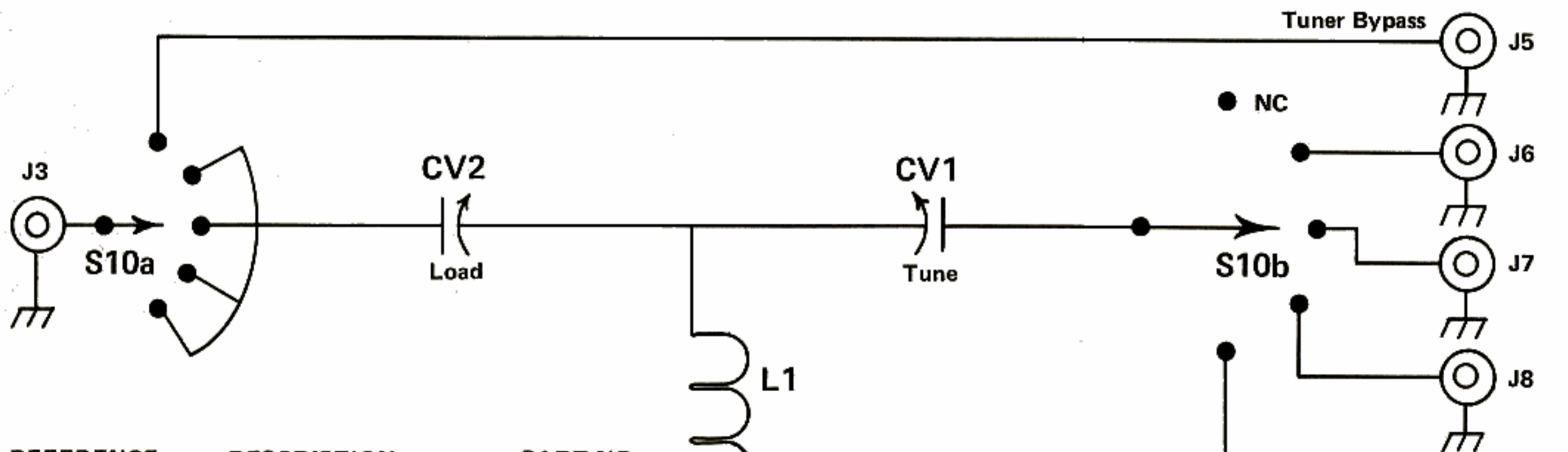


RF TUNER - INSIDE BACK PANEL SECTION LAYOUT and PARTS LIST



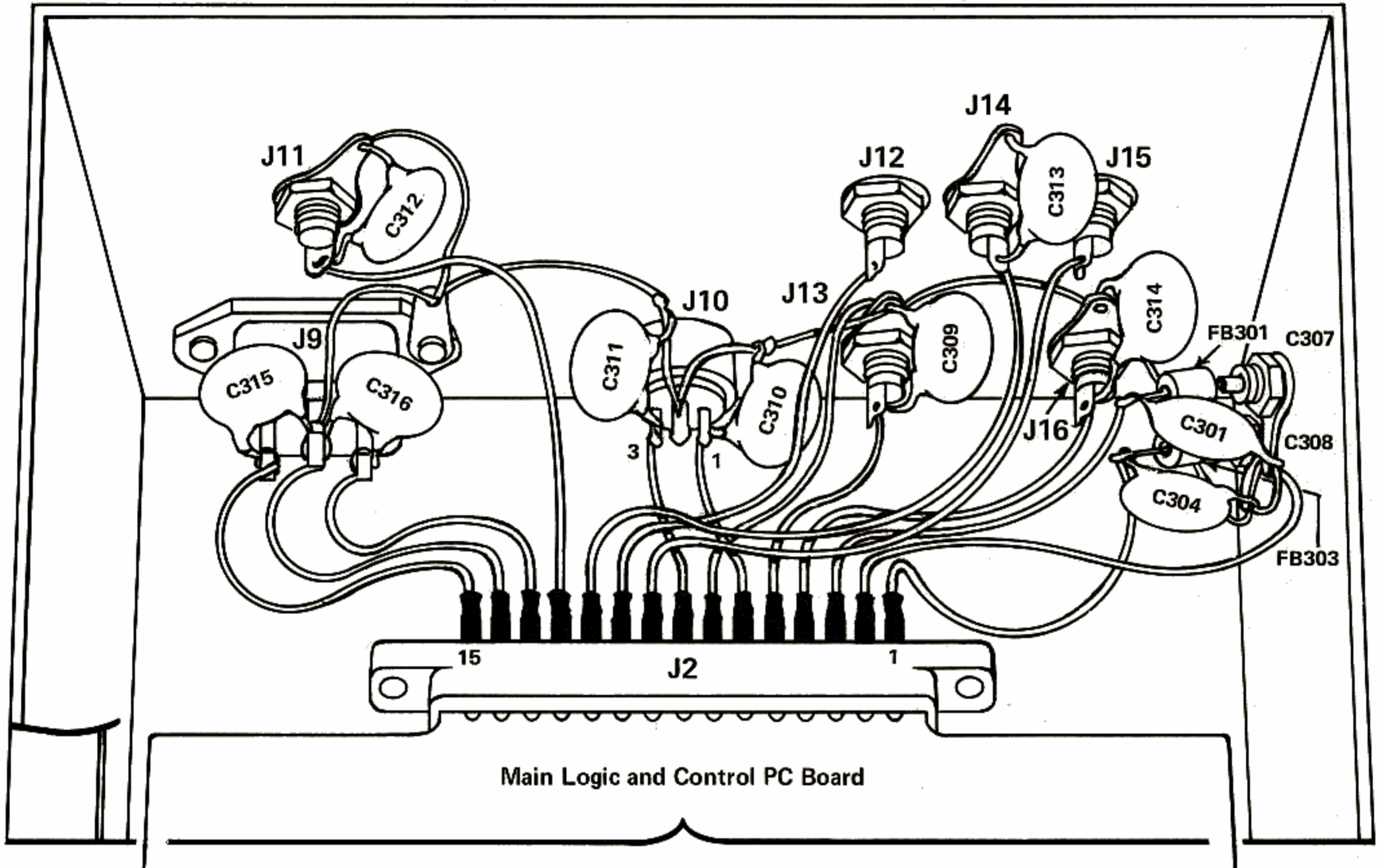
REFERENCE	DESCRIPTION	PART NO.	REFERENCE	DESCRIPTION	PART NO.
C302	.015 uF 600 V Capacitor	19-15000-20	J3	Coax Connector	67-83-879
C303	.015 uF 600 V Capacitor	19-15000-20	J4	Ceramic Feed thru Insulator	25-74
C305	.015 uF 600 V Capacitor	19-15000-20	J5	Coax Connector	67-83-879
C306	.015 uF 600 V Capacitor	19-15000-20	J6	Coax Connector	67-83-879
C307	.001 uF 600 V Feed thru Capacitor	25-80	J7	Coax Connector	67-83-879
C308	.001 uF 600 V Feed thru Capacitor	25-80	J8	Coax Connector	67-83-879
FB302	Ferrite Bead	25-9	M1	12 V DC Motor	25-12
FB304	Ferrite Bead	25-9	M2	12 V DC Motor	25-12
			S11	Antenna Sector Switch	25-71

RF TUNER - FRONT SECTION SCHEMATIC and PARTS LIST



REFERENCE	DESCRIPTION	PART NO.
CV1	Tune Capacitor Assembly	25-2-00L
CV2	Load Capacitor Assembly	25-2-00R
J3	Coax Connector	67-83-878
J4	Ceramic Feed thru Insulator	25-74
J5	Coax Connector	67-83-878
J6	Coax Connector	67-83-878
J7	Coax Connector	67-83-878
J8	Coax Connector	67-83-878
L1	Tapped Inductor	05943
S10a } S10b }	Antenna Switch	25-71
S11	Inductor Tap Selector Switch	25-16

INSIDE BACK PANEL LOGIC SECTION LAYOUT



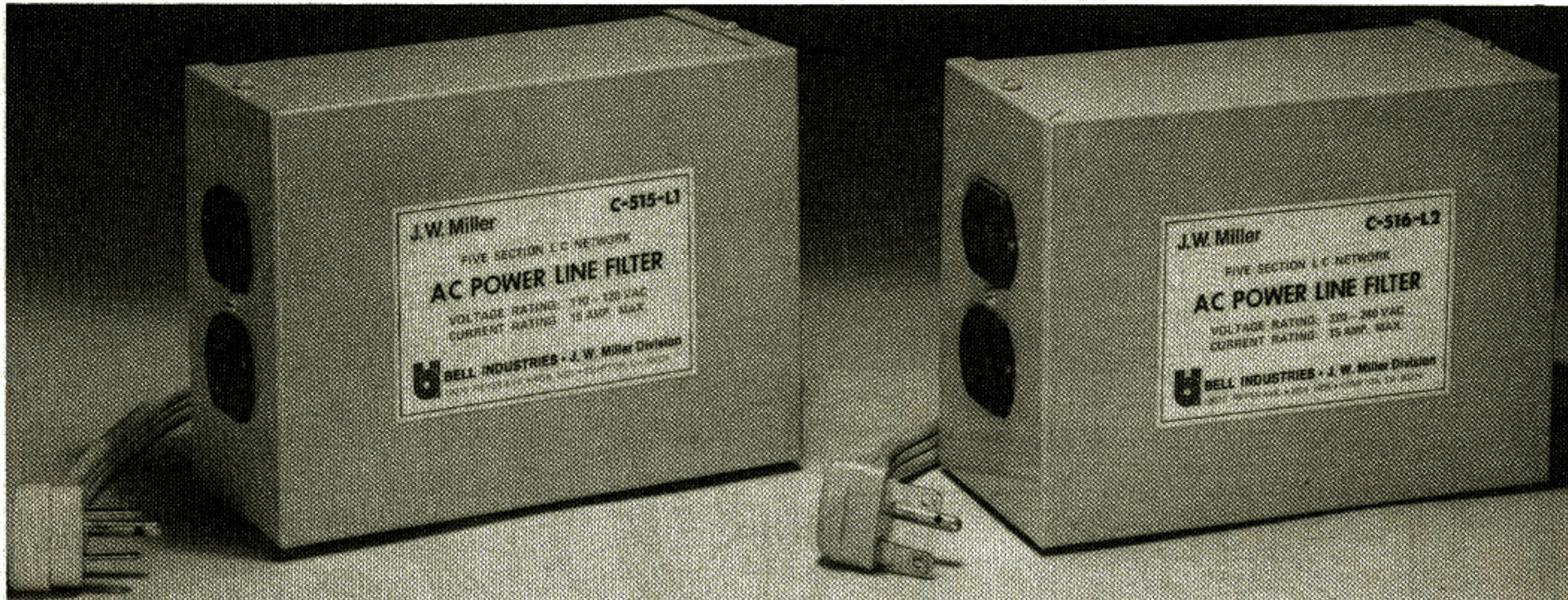
PARTS LIST

REFERENCE	DESCRIPTION	PART NO.	REFERENCE	DESCRIPTION	PART NO.
C301	.015 uF 600 V Disc Capacitor	19-15000-20	FB301	Ferrite Bead	25-9
C304	.015 uF 600 V Disc Capacitor	19-15000-20	FB303	Ferrite Bead	25-9
C307	.001 uF 600 V Feed thru Capacitor	25-80	J2	15 Terminal PCB Edge Connector	25-83
C308	.001 uF 600 V Feed thru Capacitor	25-80	J9	3 Terminal Male AC Connector	25-76
C309	.015 uF 600 V Disc Capacitor	19-15000-20	J10	3 Terminal Female DIN Connector	25-77
C310	.015 uF 600 V Disc Capacitor	19-15000-20	J11	RCA Phono Socket	25-75
C311	.015 uF 600 V Disc Capacitor	19-15000-20	J12	RCA Phono Socket	25-75
C312	.015 uF 600 V Disc Capacitor	19-15000-20	J13	RCA Phono Socket	25-75
C313	.015 uF 600 V Disc Capacitor	19-15000-20	J14	RCA Phono Socket	25-75
C314	.015 uF 600 V Disc Capacitor	19-15000-20	J15	RCA Phono Socket	25-75
C315	.01 uF 1400 V Disc Capacitor	25-133	J16	RCA Phono Socket	25-75
C316	.01 uF 1400 V Disc Capacitor	25-133			

WIRING FOR PCB EDGE CONNECTOR J2

EDGE CONN.	WIRE COLOR	CONNECT TO	EDGE CONN.	WIRE COLOR	CONNECT TO
Pin 1	Brown & White	Bottom Feed thru C308	Pin 9	Orange	Relay NC J15
2	Black	Ground Lug for C307	10	Brown	Relay NO J12
3	Black & Yellow	Top Feed thru C307	11	Violet	Relay W J14
4	Black & White	Linear Control OUT J16	12	Red	13.5 Volts DC J11
5	Blue	Linear Control IN J13	13	White	AC Low J9
6	Red & White	DIN Socket J10 Pin 1	14	Green	AC Ground J9
7	Black	Ground Lug for J13	15	White	AC Hot J9
8	Gray	DIN Socket J10 Pin 3			

## AC FILTERS For Your AT 2500 and Other Equipment



### FIVE SECTION LC NETWORK

# HEAVY DUTY AC POWER LINE FILTERS

15 AMPS MAX.

PLUG IN INSTALLATION

**C-515-L1** ATTENUATION: 50 dB OR BETTER FROM 500 kHz TO 300 MHz. **C-516-L2**  
 110 – 120 VAC PHYSICAL SIZE: 7" x 5" x 3" (178 mm x 127 mm x 76 mm) 220 – 240 VAC

*Heavy Surges of Electrical Interference Coming over Power Lines can Damage Sensitive Electrical Equipment.*

The new C-515-L1 and C-516-L2 filters will eliminate this possibility and at the same time effectively prevent the device from putting interference into the lines. They are especially useful with Small Computers, Copying Machines and Amateur Transmitters. Virtually any electrical or electronic device that feeds back into, or picks up interference from, the power lines will be adequately filtered. Simply plug the filter into the AC outlet and the equipment into the filter.

The pleasant Beige color and attractive styling are compatible with office and home furnishings.

### LIMITED WARRANTY

BELL INDUSTRIES, J.W. MILLER DIVISION, warrants to the original retail purchaser of the J.W. MILLER AT 2500 that, for a period of ninety (90) days from date of purchase by the original retail purchaser, said equipment shall be free of defects caused by faulty materials or workmanship. Any defect covered by this warranty will be repaired or replaced at Bell's option, without charge. Said repairs will be made at the J.W. Miller Division plant, located at 19070 Reyes Avenue, Compton, California. In order to obtain performance of Bell's obligation under this warranty, the original retail purchaser must follow the procedure described in paragraph number 5, below. Performance by Bell under this warranty will occur within thirty (30) days after receipt of the equipment at the J.W. Miller Division plant. This warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

This limited warranty and any and all implied warranties are subject to the following conditions:

1. All implied warranties, including but not limited to the implied warranty of merchantability or fitness for a particular purpose in fact or in law, shall terminate ninety (90) days from the date of purchase of the above designated equipment by the original retail purchaser. Some states do not allow limitations on how long an implied warranty lasts, so the above limitation may not apply to you.

2. The foregoing limited warranty is given in place and instead of any and all other express guarantees or warranties.

3. The foregoing limited warranty does not cover consequential damages caused by any defect. 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.

4. Neither this limited warranty nor any implied warranty shall apply to: (a) any equipment which has been sold or transferred by the original retail purchaser; (b) equipment which has been subjected to misuse or improper installation care; or which has been operated in any way contrary to the provisions of the AT 2500 Instruction Manual; (c) equipment which has been modified by the original retail purchaser in any manner other than as specifically described in the AT 2500 Instruction Manual, or otherwise authorized by the J.W. Miller Division of Bell Industries; or (d) equipment which has been subjected to damage, whether accidental or intentional.

5. In order to obtain performance of Bell's obligation under this limited warranty, the original retail purchaser must send the possibly defective equipment to BELL INDUSTRIES, J.W. MILLER DIVISION, 19070 Reyes Avenue, Compton, California, 90221, in its original container or equivalent, fully insured and shipping or postage charges prepaid, along with the original or legible copy of sales slip or other proof of purchase to determine eligibility for warranty work, a detailed description of the problem, and the original retail purchaser's name and address.