RF AMPLIFIER TBM—2500C

# instruction manual





McMartin • mcmartin industries inc. • 4500 south seventy sixth street • omaha, nebraska 68127

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# GENERAL DESCRIPTION

The McMartin TBM-2500C RF Amplifier is designed to amplify an off-the-air signal to a level suitable for driving modulation percentage and frequency deviation monitors located at a site remote from the transmitter.

Of completely solid state design, the TBM-2500C performs this function with minimum degradation of the transmitted signal (including its sidebands) and provides maximum rejection of potentially-interfering signals from other transmitters operating in the immediate portion of the RF spectrum.

To provide this performance, the factors of overall gain, sharp skirt characteristics for the passband and maintenance of phase linearity across the passband are essential. These factors are incorporated in the design of the TBM-2500C.

It is essential that the RF Amplifier contribute no error to the frequency of the "off-air" signal to be amplified. This is accomplished in the TBM-2500C by use of a reference crystal oscillator/multiplier signal. This signal is mixed with the input frequency to produce a "difference" frequency (approximately 10.7 MHz) for which filters are readily designed with the required bandpass and skirt characteristics. This processed signal is then amplified and again mixed with the reference oscillator/multiplier frequency to produce a "sum" signal output on a frequency identical to that which appeared at the input, (the transmitter operating frequency).

In this manner the pre-requisites of gain, selectivity and bandpass linearity are maintained with zero operating frequency error.

The use of cascode-connected FET's in the input RF amplifier stages produces excellent AGC linearity and minimizes cross modulation products generated by overload. The high input impedances afforded by the FET's plus utilization of high-Q input tank circuits provide a degree of selectivity on the operating frequency. The response of the IF filter following the first "difference" mixer, however, insures the selectivity of the overall amplifier. This specially-designed filter exhibits a bandwidth of 290 kiloHertz. This signal is amplified and heavily limited to minimize signal amplitude variations caused by propogation or "flutter" resulting from signal reflections or cancellation of the signal caused by aircraft passing near or through the transmitting/receiving antenna path. AGC voltage derived from the IF signal is used to control the gain of the input RF amplifier stages.

The IF signal frequency and that of the reference oscillator/multiplier chain produce a "sum" frequency in a second mixer to produce an output signal of identical frequency to that appearing at the input. This signal

GENERAL DESCRIPTION, (CONTINUED)

is then amplified to a suitable level to drive external monitoring equipment. These amplifier stages, consisting of driver and output stages are housed in a separate, shielded enclosure. The output stage operates in a Class C mode and output level is controlled by varying the collector supply voltage to this stage, by front panel level control.

Selectable metering of oscillator injection voltage, AGC bus voltage, RF drive and output level is provided.

Although pretuned at the factory, access to coil slugs for the input and output tank circuits (no tuning is required for IF stages) and the oscillator/multiplier circuits, is provided through appropriate openings in the individual shielded compartments.

## CIRCUIT DESCRIPTION

The TBM-2500C circuitry consists of three basic parts. These are a) the RF input/up-down converter section, b) the RF output section; and c) the power supply and protective unit. The circuitry comprising a) and b) are housed in separate, fully-shielded compartments. Section c) is mounted under the chassis.

### RF Input/Up-Down Converter Section (Printed Circuit Board A-1)

The input signal from the antenna coaxial feed line is fed through the BNC input connector to a tap on L-1 which presents a nominal 50-ohm impedance to match the coaxial cable surge impedance. The two tuned input circuits consisting of (C1, L1) and (C2, L2) are mutually coupled to provide some bandpass effect at the input signal frequency. Q1 and Q2 are JFET devices operating in a cascode configuration as a signal-frequency RF amplifier. This arrangement provides high input and output impedances to permit minimum loading of the high-Q input and output tank circuits.

AGC voltage, derived from the first 10.7 MHz I.F. amplifier, is applied to the gate of Q1 and results in relatively linear gain control of the RF amplifier.

The RF amplifier output tank (L3, C9) is tapped to match the base impedance of the first mixer stage (Q3).

Oscillator injection voltage for this mixer is derived from a crystal-oscillator stage, Q-4. Models TBM-2500C and TBM-2500C-L use a diode multiplier circuit to derive the oscillator injection frequency. The diode multiplier is fed to a low-impedance tap on L5. This minimizes loading of the doubler tuned circuit and maintains high-Q characteristics of the multiplier tank to produce a clean output signal with a minimum of spurious responses. The oscillator tank (L4, C47) operates on the crystal frequency and(C51, L5) on the second or fourth harmonic frequency.

The crystal frequency is determined by the formula:

$$C_x = \frac{\text{Input frequency} - 10.7}{2} \qquad \text{(TBM-2500C)}$$

$$C_x = \frac{\text{Input frequency} + 10.7}{2} \qquad \text{(TBM-2500C-L)}$$

Output from the multiplier tank circuit is fed to the first mixer base through coupling capacitor (C52).

In the Model TBM-2500C-H, a diode quadrupler, D9 and an amplifier stage, Q6, are used to derive the oscillator frequency. Output from the amplifier tank (L5, C51) is fed to the first mixer base through coupling capacitor (C52).

The crystal frequency for the TBM-2500C-H is determined by the formula:

$$C_x = \frac{\text{Input frequency} - 10.7}{4}$$

Metering of the oscillator operation is provided through terminal C and an RC network.

The input signal frequency and the oscillator injection frequency appearing at the base of the first mixer, Q3, produce a difference frequency of 10.7 MegaHertz.

This 10.7 MHz is fed to filter, F1. This filter exhibits excellent band-pass characteristics, upon which the selectivity of the TBM-2500C is primarily based. The bandwidth is 290 kHz at the 3 dB points and signal attenuation is 60 dB at 400 kHz either side of the filter center frequency. The filter is essentially phase linear across the pass band. These characteristics account for the excellent rejection of adjacent and alternate channel interference and the fidelity of the desired signal and its sideband components.

Two stages of IF amplification, using CA-3053 integrated circuits are employed. A portion of the 10.7 MHz signal appearing at the output of the first IF stage is fed to a full-wave AGC voltage doubler rectifier (D1-D2), filtered and utilized to control the gain of the first RF amplifier (Q1). Metering of the AGC bus voltage is provided. Gain of the RF amplifier is further adjustable by the RF Gain Set Control, R1.

The gain of the second IF stage may be varied over a 40 dB range by an internal 2500-ohm control, R24, which adjusts the supply voltage fed to pin #7 of the second CA-3053. This control is factory-adjusted to produce full limiting when a 500 microvolt signal is applied to the antenna input connector. The output of the second IF stage is symmetrically limited by diodes D3 and D4.

The second mixer is a bridge balanced modulator comprised of four matched hot-carrier diodes. The reference oscillator injection voltage is derived from a low impedance link winding coupled to the multiplier tank circuit (L5, C51). Note that this is the same injection frequency fed to the first mixer (from which the "difference" IF frequency was generated). The output of the second mixer is the "sum" of the injection frequency and the IF frequency and is equal to the input signal frequency. This latter frequency is, therefore, independent of the injection frequency. L9 and C37 are series-resonated to the injection frequency to remove this signal component from the second mixer output. The parallel-resonant frequency of L10 paralleled by the series combination of C38 and C39 is at the signal frequency. The juncture of C38 and C39 matches the output impedance of the bridge balanced second mixer.

CIRCUIT DESCRIPTION, (CONTINUED)

The signal frequency is amplified by Q5. The capacitance divider network C44 and C45 provides a nominally 50-ohm output termination and in parallel with L11, is tuned to the signal frequency.

A short length of coaxial line interconnects the output of the RF Input/ Up-Down Converter Section to the RF Output Section.

## RF Output Section (Printed Circuit Board A-2)

Q1 and Q2 are conventional, common-emitter RF amplifiers to increase the signal level from the output of the RF Input/Up-Down Converter section to a level adequate to drive the Class C output stage.

The collector circuits of Q1 and Q2 are tuned to the signal frequency. Collector output impedances are matched by taps on L1 and L2 respectively. Input base impedances to each of the devices are matched by the capacitive divider networks appearing across the output tank circuits.

Drive voltage to the output stage is metered. This voltage is developed from current passing through the output transistor Q3, base resistor. Since Q3 operates as a Class C amplifier, metering of the base voltage is the only means of tuning preceding stages under very low input signal conditions. Signal voltage at the base of Q3 must exceed the base-emitter voltage drop in order to turn on Q3.

The collector impedance of Q3 is approximately 150 ohms. The combination of L3, C14 and the output load form an impedance matching, resonant network at the signal frequency. C16 shunting the output termination has an impedance of approximately 300 ohms and serves to limit collector current of the output stage in the event of inadvertent removal of the external load.

The output level is metered. A portion of the RF voltage appearing at the output connector is rectified by diodes D1 and D2, filtered and fed to the metering circuit.

Output level is controlled by adjustment of the front panel "output level" control which sets Q3 collector voltage.

## Power Supply & Protective Unit (Printed Circuit Board A-3)

The power supply transformer utilizes a dual-winding primary winding to permit either 115 or 220 VAC 50/60 Hz operation. A center-tapped secondary feeds a conventional full wave rectifier circuit.

Q1 is a capacitance-multiplier, Zener-diode reference regulator. Its d-c output is connected to the collector of Q2. The base of Q2 is held at 24 volts by a Zener diode, Z2 (and is also connected to the collector of Q3). Under normal operating loads, Q3 is turned off and its collector connection to the base of Q2 has no effect. The voltage drop across the

6.8 ohm resistor (R3) and the 3.3 ohm resistor (R4) shunted by the 25 ohm control (R5) in series biases the emitter of Q3 to hold Q3 in its "off" condition under normal load conditions. If an abnormal load condition occurs, the voltage to the emitter of Q3 increases turning the device "on". Its collector current thus pulls the base of Q3 to ground which turns Q2 "off" and the power supply voltage instantaneously drops to zero.

The value of maximum load current for operation of the protective circuit is adjusted by the setting of the 25-ohm control (R5).

## INSTALLATION AND OPERATION

After removal from its shipping carton, the TBM-2500C should be carefully inspected for any damage caused in transit due to rough handling. If damage is found, immediately notify the shipping agency and advise McMartin Industries of such action.

The TBM-2500C should be mounted where there is adequate ventilation, well-removed from other equipment which produces heat. The temperature should not exceed 110°F.

Since the TBM-2500C incorporates high-gain RF circuitry, it is essential that the installation be planned to avoid running input and output coaxial cables in proximity to each other. It is recommended that the TBM-2500C be mounted directly above the monitoring equipment it is to drive and that the coaxial cable connecting the output of the TBM-2500C to the monitor input be kept as short as possible. The antenna coaxial transmission line should preferably enter the top of the rack, be dressed into the corner of the rack and run down directly to the TBM-2500C input connector, with a minimum of slack. Coiling of excess lengths of the antenna transmission line within the rack should be avoided.

Failure to exercise good engineering practice in the installation may result in instability of operation of the TBM-2500C. Reasonable cautions in the installation will be rewarded by reliable, stable operation.

Connect the AC cord to a 117 VAC source.

1. Check the mechanical zero setting of the meter before turning the unit on.

2. Turn the "output level" control to its furthest counterclockwise position.

3. Place the meter select switch in the "OSC" position.

4. Apply power by operating the alternate-action power pushbutton switch. The power light indicator will come on. Wait a few minutes to allow the unit to stabilize.

5. The meter should read approximately 25 indicating that the reference crystal oscillator is operating.

6. Switch the meter selector switch to the "AGC" position. A reading in the range between 5 and 50 indicates that the voltage on the AGC bus is correct. (For installations where the received signal is relatively weak, this reading should be monitored while the antenna array is oriented for a maximum value.) If the reading exceeds 50, the RF Gain Set Control (R2) located adjacent to the RF input connector of the RF Input/Up-Down Converter compartment should be adjusted to limit the AGC to a maximum reading of 50.

7. Switch the meter selector switch to the "DRIVE" position. A reading in the range of 20 to 40 indicates voltage appearing on the base of the output transistor.

8. Set meter selector switch to OUTPUT position. Adjust OUTPUT LEVER CONTROL for a reading of approximately 25. (This is the optimum operating level for driving McMartin monitors.)

9. Adjust RF level control on the monitor(s) for a 100% reading.

It is suggested that the meter readings on the TBM-2500C obtained after initial installation be logged for future reference. This information can be helpful in locating problem sources in the event of subsequent deterioration in performance.

# MAINTENANCE

All tuned circuits of the TBM-2500C have been preset at the factory for optimum operation on your specified frequency and should not require field adjustment.

The only possible exception to this relates to the antenna (L1, C1) and RF (L2, C2) input tank circuits. The resonant frequency of these tuned circuits will be adversely affected by a high standing wave ratio produced on the antenna transmission line because of poor line-to-antenna impedance matching. Although best performance will be afforded by correcting such mismatch at the antenna feedpoint, it may be compensated for to some extent by retuning the input tank circuits. Access to L1 and L2 is through separate holes at the extreme left-hand end of the larger shielded enclosure. These holes are labeled RF and ANT.

Place the meter selector switch in the AGC position. Slowly adjust L1 and L2 for maximum readings. There may be interaction between the two adjustments which should be made alternately until a maximum meter reading is obtained.

CAUTION: Any coil slug adjustment for resonance of the ANT, RF or MIXER tuned circuits should be made only with the meter selector switch in the AGC position, since the signals metered in the DRIVE or OUTPUT positions are heavily limited under normal operating conditions and little or no change in meter reading values will occur during adjustment of coil slugs preceding the limiter stages.

## TROUBLESHOOTING

In event of complete, sudden failure of the TBM-2500C, the most probable source is in the power supply/protective circuits.

1. Check supply voltages at the output terminals of A3. These should be within a few per cent of the values shown on the schematic diagrams (+13, +20, +24V respectively).

2. If any one of these voltages are low and the others nominally correct, the basic power supply is operating satisfactorily and the fault lies in circuits receiving voltage from the "low" voltage source.

   Routine voltage/resistance measurements within the affected circuitry permit location of the defective component.

3. If all voltages are low or zero, the fault undoubtedly lies in the power supply/protective circuit. Checking d-c voltages sequentially from the juncture of the diode rectifiers (D1 and D2 on board A3) to the emitter of Q2 will help to isolate the defective component. Check base voltage of Q2 to make certain that Q3 has not turned "on". If other than 24 volts appear at that point, remove each load individually from the voltage output terminals. A sudden return of voltage, occurring with the removal of load from any one of the terminals, indicates a short-circuit which "tripped" the protective circuit.

4. If all d-c supply voltages appear to be normal, place the meter selector switch in the "OSC" position and verify that a normal reading is obtained. A zero, or low, reading indicates a fault in the oscillator/multiplier circuit. Check voltages on Q4. If these appear to be nominally correct, insert a tuning tool into the slug in L4 (osc). Turn the slug a few turns counterclockwise or clockwise either side of the original setting. Observe the meter. The oscillator will start abruptly and to insure reliable starting, the slug should be adjusted on the low-frequency side (clockwise) of resonance for a meter reading of the 90% of the maximum obtained. Apply and remove power several times to verify crystal starting. Adjust L5 (MULT) coil slug for a sharp dip in meter reading. This is an indication of resonance at the harmonic frequency of the crystal oscillator.

5. If it is established that injection voltage is present as observed in the OSC position, set the meter selector switch to the AGC position. Feed a 500,000 microvolt signal from an RF signal

generator to the input connector of the TBM-2500C. If normal AGC readings result, check the antenna installation for open or shorted connections. Experience has proved that the majority of complaints relative to RF amplifier operation are ultimately traceable to failures in the antenna installation, particularly in geographical areas subject to icing and wind.

6. If the AGC bus voltage appears to be normal, the fault lies in the circuitry between the second IF stage and the output stage and should be located by sequentially checking voltage and resistances stage-by-stage and observing Drive and Output meter readings.

7. Note R24, the 2500-ohm control for adjusting voltage to pin 7 of the second IF stage, a CA-3053. This control is set at the factory to produce full output with a 500-microvolt input signal. (This is the guaranteed specification.) The overall gain of the TBM-2500C may be increased, by increasing the pin 7 voltage. Full limiting action and full output at input signals down to 100 microvolts are possible; however, the stability of the TBM-2500C is dependent directly on the electrical integrity of each installation, which is beyond McMartin's control.

   CAUTION: For other than initial installations requiring this increased overall gain, the setting of this IF gain control should not be altered; particularly to compensate for gain deterioriation which has resulted from other causes.

8. CAUTION: If the shielded compartment covers are removed during troubleshooting procedures, they must be securely reinstalled for subsequent testing of repairs or component replacement. The TBM-2500C is a high-gain device and operation with the covers removed is sure to produce unstable results, which in some circumstances can produce damage to the output transistor stage.

# PARTS LIST

## TBM-2500C

The majority of the components used in the TBM-2500C are of standard values and tolerances generally available from local electronic parts jobbers. The following parts list includes those items of unusually critical values and tolerances, or components and assemblies manufactured by McMartin Industries.

| Symbol | McMartin Stock No. | Description |
|---|---|---|
| **RF Amplifier and Converter Section (A-1)** | | |
| L-1 | 930080 | Ant Coil (Brown) |
| L-2 | 930081 | RF Coil (White) |
| L-3 | 930080 | RF Coil (Brown) |
| L-4 | 930083 | OSC Coil (Red) |
| L-5 | 930079 | Doubler (Blue) |
| L-6 | 930083 | IF Coil (Red) |
| L-7 | 930083 | IF Coil (Red) |
| L-8 | 930083 | IF Coil (Red) |
| L-9 | 930081 | Trap (White) |
| L-10 | 930079 | RF Coil (Blue) |
| L-11 | 930079 | RF Coil (Blue) |
| F-1 | 920019 | 10.7 MHz Filter |
| D-6 | 220024 | Diode Quad Matched Set |
| M-1 | 700040 | 50 UA meter |
| Q-1 | 201062 | 2N5246, IDSS - 4 - 5 MA |
| Q-2 | 201062 | 2N5246, IDSS - 4 - 5 MA |
| **RF Power Amplifier (A-2)** | | |
| L-1 | 930079 | RF Coil (Blue) |
| L-2 | 930079 | RF Coil (Blue) |
| L-3 | 930168 | RF Coil |
| **AC Power Supply and Protective Circuit (A-3)** | | |
| T-1 | 900038 | Power Transformer, 115-230V 50/60 Hz |
| SW-1 | 484024 | Push on-off Switch |

## WARRANTY

McMartin Broadcast products are warranted to be free from defects and workmanship for a period of one year after shipping date when subjected to normal usage or service. A shorter warranty period (generally 90 days) applies to semi-conductor devices and tubes. All warranties are void, a) if equipment has been altered or repaired by others without McMartin's specific prior authorization, or b) if equipment is operated under environmental conditions or circumstances other than those specifically described in McMartin literature or instruction manuals.

## ERRATA

Change #1: Page 4, Paragraph 5, Change "... RF Gain Set Control, R1"

to read

"... RF Gain Set Control, R2"

| ZONE | SYM | DESCRIPTION | DATE | APP'D |
|---|---|---|---|---|
| | A | ECN-2183 | 11-12-71 | |
| | B | ECN 2354 | 6-27-72 | |

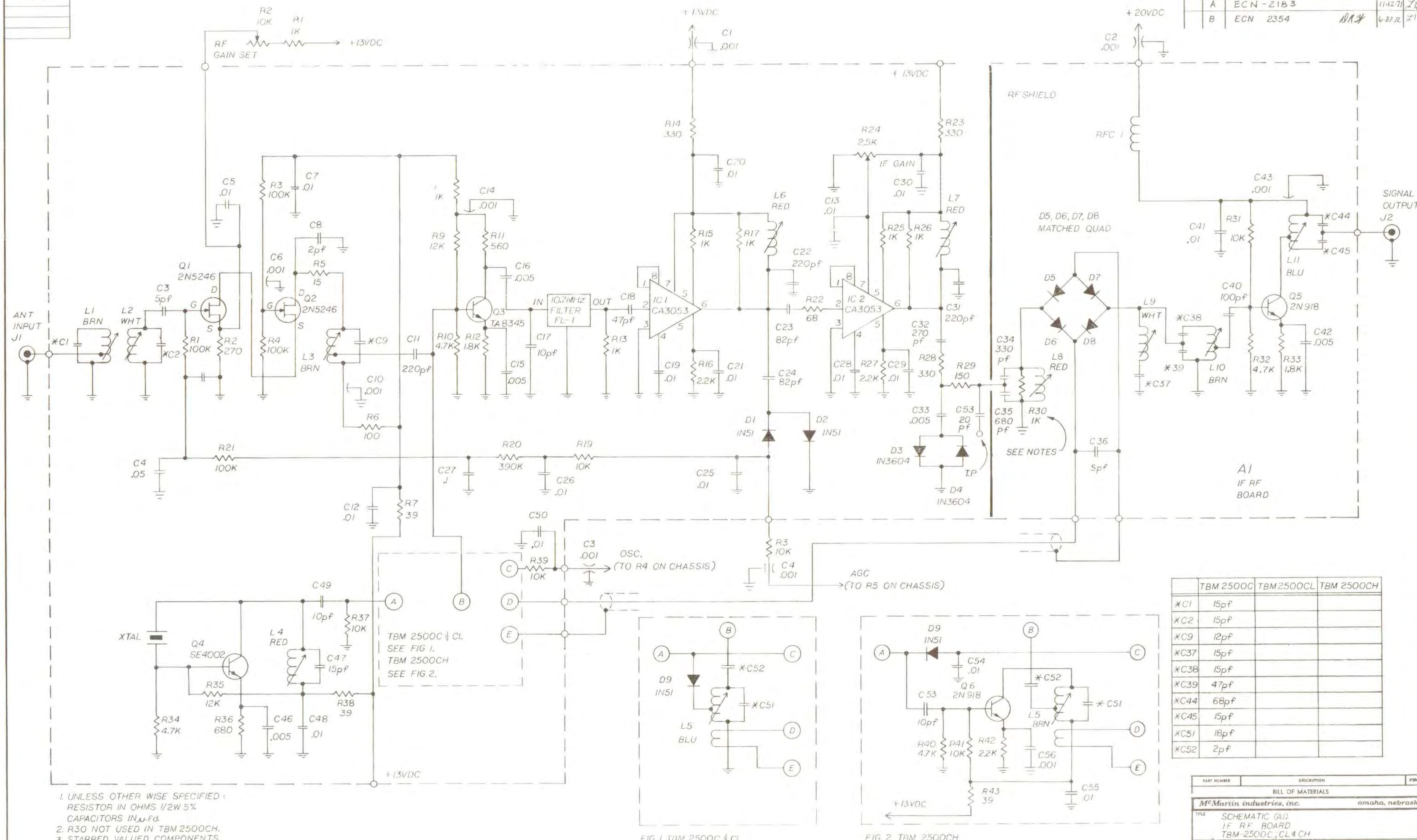



FIG. 1 TBM 2500C & CL

FIG. 2 TBM 2500CH

| | TBM 2500C | TBM 2500CL | TBM 2500CH |
|---|---|---|---|
| *C1 | 15pf | | |
| *C2 | 15pf | | |
| *C9 | 12pf | | |
| *C37 | 15pf | | |
| *C38 | 15pf | | |
| *C39 | 47pf | | |
| *C44 | 68pf | | |
| *C45 | 15pf | | |
| *C51 | 18pf | | |
| *C52 | 2pf | | |

NOTES:

1. UNLESS OTHER WISE SPECIFIED: RESISTOR IN OHMS 1/2W 5% CAPACITORS IN μfd.
2. R30 NOT USED IN TBM 2500CH.
3. STARRED VALUED COMPONENTS SELECTED IN PRODUCTIONS.



BILL OF MATERIALS

McMartin industries, inc. omaha, nebraska

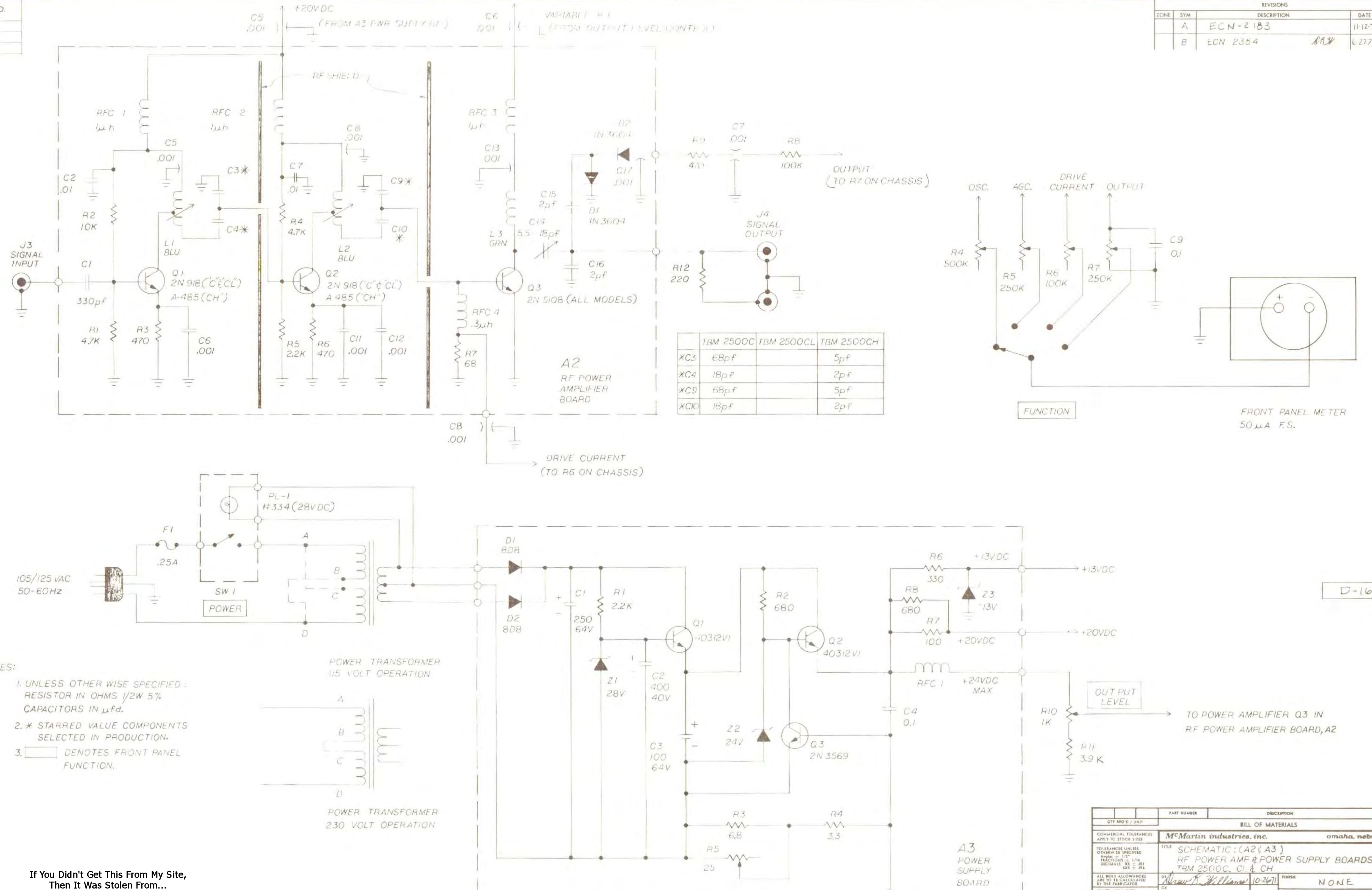
TITLE: SCHEMATIC (A1) IF RF BOARD TBM-2500C, CL & CH

DR: 10-28-71 | FINISH: NONE | MATERIAL: NONE

SIZE D | SHEET 1 OF 1 | DWG D-1643 | SCALE NONE

| REVISIONS | | | | |
|---|---|---|---|---|
| ZONE | SYM | DESCRIPTION | DATE | APP'D |
| | A | ECN-2183 | 11-12-71 | ZH |
| | B | ECN 2354 | 6-27-72 | YH |

PART NO.




| | TBM 2500C | TBM 2500CL | TBM 2500CH |
|---|---|---|---|
| *C3 | 68pf | | 5pf |
| *C4 | 18pf | | 2pf |
| *C9 | 68pf | | 5pf |
| *C10 | 18pf | | 2pf |

NOTES:

1. UNLESS OTHER WISE SPECIFIED: RESISTOR IN OHMS 1/2W 5% CAPACITORS IN μfd.
2. * STARRED VALUE COMPONENTS SELECTED IN PRODUCTION.
3. [ ] DENOTES FRONT PANEL FUNCTION.

| QTY REQ'D / UNIT | PART NUMBER | DESCRIPTION | ITEM |
|---|---|---|---|
| | | BILL OF MATERIALS | |

McMartin industries, inc. omaha, nebraska

COMMERCIAL TOLERANCES APPLY TO STOCK SIZES

TOLERANCES UNLESS OTHERWISE SPECIFIED Angles ± 1/2° FRACTIONS ± 1/16 DECIMALS XX ± .031 XXX ± .016

ALL BEND ALLOWANCES ARE TO BE CALCULATED BY THE FABRICATOR

LIMITS APPLY OVER NON-PAINTED SURFACES

BREAK SHARP EDGES AND DEBURR

TITLE SCHEMATIC: (A2 & A3) RF POWER AMP & POWER SUPPLY BOARDS TBM 2500C, CL & CH

DR Drew R. Williams 10-26-71

CK

APP'D

FINISH NONE

MATERIAL NONE

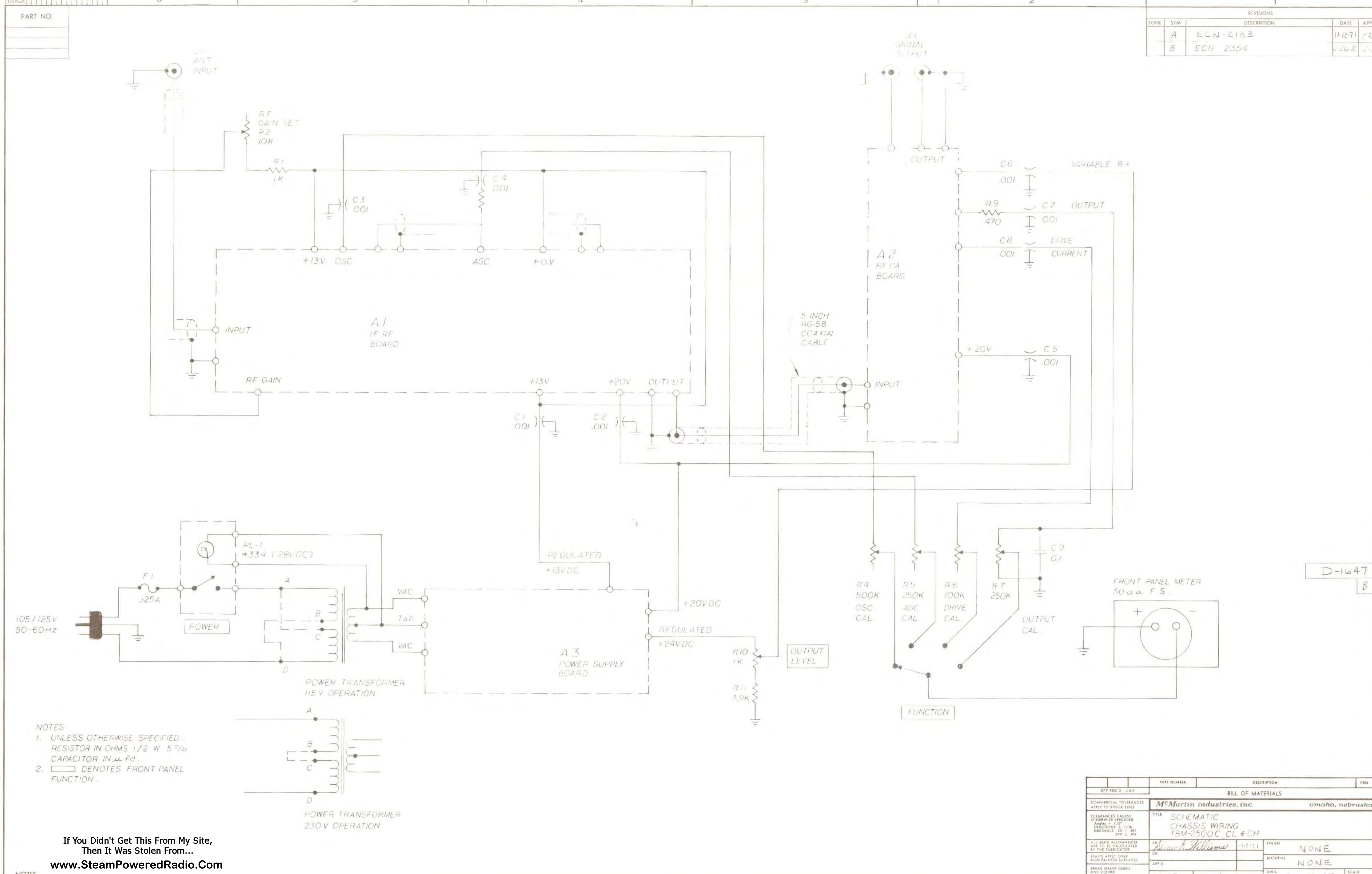
SIZE D SHEET 1 OF 1

DWG D-1644

SCALE NONE



NOTES:




| ZONE | SYM | DESCRIPTION | DATE | APP'D |
|---|---|---|---|---|
| | A | ECN-2183 | 11-12-71 | |
| | B | ECN 2354 | | |

D-1647 B

NOTES:
1. UNLESS OTHERWISE SPECIFIED: RESISTOR IN OHMS 1/2 W 5% CAPACITOR IN $\mu$fd.
2. ▭ DENOTES FRONT PANEL FUNCTION.



BILL OF MATERIALS

McMartin industries, inc. omaha, nebraska

TITLE: SCHEMATIC CHASSIS WIRING TBM-2500C, CL & CH

FINISH: NONE
MATERIAL: NONE
SIZE: D SHEET 1 OF 1 DWG D-1647 SCALE NONE