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TECHNICAL MANUAL

For

TRANSISTORIZED SSB TRANSMITTER / RECEIVER MODEL TTR-20



THE TECHNICAL MATERIEL CORPORATION
MAMARONECK, N.Y. OTTAWA, CANADA

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FIGURE 1-1. TRANSISTORIZED SSB TRANSMITTER/RECEIVER MODEL TTR-20

SECTION 1

GENERAL DESCRIPTION

1-1. FUNCTIONAL DESCRIPTION.

a. GENERAL. – The Transistorized SSB Transmitter/Receiver, Model TTR-20 (figure 1-1), is a four-channel transmitter/receiver covering the 2 to 32 MHz frequency range and having the capability of simplex or duplex operation. The TTR-20 contains both a fully-transistorized superheterodyne receiver, and a fully transistorized transmitter coupled with a high-power vacuum-tube linear amplifier. Operating potentials for the TTR-20 are provided by a plug-in power supply module (refer to paragraph 1-4). For information regarding the power-supply module, refer to the TPSA-20 manual.

Operating frequencies for the transmit and receive sections of the TTR-20 are obtained from fixed-tuned, crystal-controlled, plug-in modules; TTRR modules for the receiver section, TTRT modules for the transmitter section. Various combinations of these plug-in modules may be used to provide frequency coverage in accordance with operating requirements (refer to paragraph 1-4). Field change to new operating frequencies is easily accomplished (refer to the appropriate TTRR or TTRT manual).

The TTR-20 is designed so that remote selection of upper or lower sideband reception and transmission is possible (see paragraph 1-1b). Remote selection of transmit and receive channels and tuned antenna circuits is also possible.

b. OPTIONS. – The TTR-20 normally provides for transmission of USB signals only; however, it may be modified upon special request at the time of order or upon field modification to provide LSB signals only, or both USB and LSB signals. To cover all possible models, this manual describes the model capable of transmitting both USB and LSB signals. For units with only one sideband the transmitter sideband selector switch must be left in the appropriate position at all times.

In addition, a special transmitter 1750 kHz carrier oscillator that will operate over a temperature range of -30°C to +50°C can be provided upon special request at the time of order or upon field modification. The carrier oscillator provided in the standard TTR-20 operates over a temperature range of 0°C to +50°C.

c. RECEIVER SECTION. – The TTR-20 is capable of receiving amplitude modulation equivalent (AME), continuous wave (CW), facsimile (FAX), frequency shift keying (FSK), modulated continuous wave (MCW), and single sideband (SSB) transmission. It can also

receive one sideband of amplitude modulation (AM) or independent sideband (ISB) transmission.

NOTE

Converter equipment is required to process FAX and FSK signals.

The receiver section uses one of four selectable, fixed-tuned, plug-in modules (TTRR-1, TTRR-2, TTRR-3, or TTRR-4) for its RF section. For information pertaining to any of the TTRR modules, refer to the TTRR manual. Features of the receiver section include:

- (1) High sensitivity for good reception under weak signal conditions.
- (2) A sharp cutoff bandpass filter for optimum selectivity.
- (3) Double conversion and three tuned RF amplifier stages.
- (4) Manual selection of LSB or USB reception.
- (5) An adjustable squelch circuit that mutes the audio output (except for the 600-ohm line output) when no input signal is being received. This circuit also provides an external output (for alarm purposes) to indicate that the receiver is squelched.
- (6) Two separate audio outputs: 500 milliwatts into a 4 ohm load (built-in or external speaker) and 1 milliwatt into a 600-ohm balanced load. The speaker output level can be varied by means of a VOLUME control.

d. TRANSMITTER SECTION. – The TTR-20 can transmit amplitude modulation equivalent (AME), continuous wave (CW), facsimile (FAX), frequency shift keying (FSK), modulated continuous wave (MCW), and single sideband (SSB) signals.

NOTE

Additional equipment is required to provide FAX and FSK output signals.

The transmitter section uses one of five selectable, fixed-tuned plug-in modules (TTRT-1, TTRT-2, TTRT-3, TTRT-4, TTRT-5) for its exciter RF section. The linear amplifier tuning circuits employed in the transmitter section are also contained in plug-in modules (TTRA-1, TTRA-2, TTRA-3, TTRA-4). TTRT and TTRA modules are selected in pairs; TTRT-1 with

TTRA-1, TTRT-2 with TTRA-2, TTRT-3 with TTRA-3, TTRT-4 and TTRT-5 with TTRA-4. Information concerning TTRA modules can be found in this manual; for information pertaining to the TTRT modules, refer to the TTRT manual.

The transmitter section is designed to accept a wide variety of audio inputs including carbon microphone, high-impedance microphone, low-impedance microphone, and 600-ohm balanced line. Provision is also made for operation with a handset (also available from TMC). The transmitter section contains an audio oscillator that can be externally keyed for CW and MCW transmission. Features of the transmitter section include:

- (1) Sharp cutoff bandpass for optimum unwanted sideband rejection.
- (2) Manual selection of either LSB or USB transmission (refer to paragraph 1-1b).
- (3) Built-in power compensation circuit to prevent transmitter overload when mode of operation is changed.
- (4) Automatic compression circuit for higher average power output.
- (5) Selectable voice or push-to-talk operation of transmitter with provision for disabling the receiver section while transmitting (for simplex operation).
- (6) A built-in meter for monitoring the linear amplifier excitation, plate current, and RF output.
- (7) An automatic high-voltage cutout circuit to protect the linear amplifier when overload occurs.

1-2. PHYSICAL DESCRIPTION

a. EXTERNAL. – The TTR-20 is normally provided in a case for mounting in a standard 19-inch rack, but can also be provided in a sturdy metal case for general use. Two handles are located on the front panel for ease of handling. Dust covers protect the unit when it is rack-mounted.

All operator's controls are located on the front and rear panels of the unit. All controls are described in section 3 and illustrated in figures 2-1 and 3-1. A removable control cover is provided to prevent inadvertent changing of front panel control settings. On the rear of the unit three terminal boards (TB1500, TB1501, and TB1502), two BNC connectors (RCVR ANT and ANTENNA jacks), and two twistlock plugs (EXTERNAL OVEN VOLTAGE and AC INPUT) provide for all input and output connections. Coaxial cable assembly W900 is provided for connecting the receiver section input to the transmitting antenna for simplex operation.

b. INTERNAL. – Most of the smaller components in the TTR-20 are located on printed circuit boards that are mounted to the chassis; the larger components are chassis mounted. There are eight printed circuit boards not including those in the TTRR and TTRT modules. The transmitter IF and audio boards are mounted back-to-back on a hinged assembly that permits the boards to swing out so that the components of the audio board are exposed. The receiver IF and audio boards are similarly mounted. All printed circuit boards are located on the bottom side of the TTR-20 chassis. Four TTRA modules are located on the top side of the chassis. The two vacuum tubes for the linear amplifier are located in a compartment between the TTRA modules.

Figures 5-1 through 5-11 show the location of most of the components in the TTR-20.

The vacuum tube and semiconductor complement of the TTR-20 is given in table 1-1.

1-2. EQUIPMENT SUPPLIED

Table 1-2 lists the equipment supplied with the TTR-20.

1-4. TECHNICAL SPECIFICATIONS

a. RECEIVER SECTION.

Frequency range	2 to 32 MHz divided into four bands using the following TTRR modules. Band 1: 2-4 MHz, TTRR-1 Band 2: 4-8 MHz, TTRR-2 Band 3: 8-16 MHz, TTRR-3 Band 4: 16-32 MHz, TTRR-4
Number of channels	4(each having a separate TTRR module)
Tuning system	Each TTRR module is fixed-tuned to a particular frequency within its band. The receiver section is tuned by selecting one of the different TTRR modules (channels).
Frequency control	Crystal-controlled oscillators are used throughout the receiver section.
Types of signals	AME, CW, FAX, FSK, MCW, and SSB (upper and/or lower: see paragraph 1-1b). AM and ISB signals can also be received, but this feature is generally not used.

Noise figure	15 dB or better.		
Sensitivity	1 microvolt input for 15 dB signal-plus-noise to noise ratio.		
Audio bandwidth	3 kHz, ± 2 dB between 300 and 3000 Hz.		
IF frequency	Double conversion from 1.75 MHz to 250 kHz on all bands.	Frequency control	Crystal-controlled oscillators are used throughout the transmitter section.
Image rejection	A minimum of 50 dB from 2 to 28 MHz, a minimum of 40 dB from 28 to 32 MHz.	Types of signals transmitted	AME, CW, FAX, FSK, MCW, and SSB (upper and/or lower: see paragraph 1-1b).
Intermodulation	Intermodulation products are at least 35 dB below a 100 microvolt two tone input at the antenna.	Audio bandwidth	2.75 kHz ± 2 dB between 250 and 3000 Hz.
AGC	With a 100 dB increase in the signal input from 1 microvolt, the output level will not rise more than 6 dB.	IF frequency	1.75 MHz on all bands.
Hum and noise level	At least 40 dB below full output.	Power output	100 watts PEP; 50 watts CW.
Antenna input impedance	50 ohms (nominal) unbalanced.	Signal-to-distortion ratio	35 dB minimum at full PEP output.
Audio output	1. 500 milliwatts into 4 ohms for built in or external speaker. 2. 1 milliwatt into 600-ohm balanced load.	Unwanted sideband rejection	40 dB minimum at full PEP output.
		Spurious signal level	Down a minimum of 50 dB at full PEP output.
		Noise level	Down a minimum of 40 dB at full PEP output.
		Carrier suppression	Automatically preset at -50 dB, -20 dB, or -6 dB from sideband envelope power depending upon operating mode selected as follows: CW and SSB -50 dB -20 dB -20 dB AME and MCW -6 dB

b. TRANSMITTER SECTION.

Frequency range	2 to 32 MHz divided into five bands using the following TTRT and TTRA modules: Band 1: 2-4 MHz, TTRT-1 and TTRA-1 Band 2: 4-8 MHz, TTRT-2 and TTRA-2 Band 3: 8-16 MHz, TTRT-3 and TTRA-3 Band 4: 16-24 MHz, TTRT-4 and TTRA-4 Band 5: 24-32 MHz, TTRT-5 and TTRA-4	Output impedance	50 ohms (nominal) unbalanced into a load with up to 3:1 VSWR.
Tuning system	Each TTRT and TTRA module is fixed-tuned to a particular frequency within		

c. OVERALL.

Primary power input	TPSA-20:104/115/208/230 volts, 50-400 Hz, single phase, ac power.
Dimensions	Length: 16½ inches Width: 19 inches Height: 10½ inches
Weight, uncrated	65 pounds (rack mounted version only).

TABLE 1-1. VACUUM TUBE AND SEMICONDUCTOR COMPLEMENT

REFERENCE DESIGNATION	TYPE	FUNCTION
RECEIVER IF BOARD A10556 CR1401 to CR1404 CR1405 to CR1407 Q1401 Q1402 Q1403 and Q1404 Q1405 Q1406 Q1407 Q1408 Q1409 Q1410 Q1411 Q1412	1N34A 1N68 2N2495 2N2495 2N1370-4 2N2495 2N2495 2N2495 2N2495 2N2495 2N1190 2N697 2N697	Audio detector AGC detector IF amplifier Mixer 1st audio amplifier Buffer amplifier 250 kHz oscillator Lower sideband oscillator Upper sideband oscillator Buffer amplifier 250 kHz amplifier 1st AGC amplifier 2nd AGC amplifier
GRID METERING BOARD A10595 CR1500	1N463	Rectifier
OUTPUT METERING AND ALDC BOARD, A10596 CR1561	1N34A	Rectifier
MAIN CHASSIS CR1501 V1500 V1501	DD122 6GK6 8117	Rectifier, ledex power Intermediate power amplifier Power amplifier
RECEIVER AF BOARD A10541 Q1613 Q1614 and Q1615 Q1616 and Q1617 Q1618 Q1619 and Q1620 Q1621	2N1370-4 2N1370-4 2N1039 2N1370-4 2N1370-4 2N2001	Phase inverter 2nd audio amplifier Audio power amplifier Line amplifier Squelch signal amplifier Relay driver
TRANSMITTER AF BOARD A10540 CR1701 and CR1702	1N34A	Anti-vox detector

TABLE 1-1. VACUUM TUBE AND SEMICONDUCTOR COMPLEMENT (Cont'd)

REFERENCE DESIGNATION	TYPE	FUNCTION
CR1703 and CR1704	1N34A	Vox detector
CR1705	1N34A	Relay suppressor
Q1701	2N1308	Anti-vox amplifier
Q1702	2N1370-4	Audio amplifier
Q1703	2N1370-4	Line amplifier
Q1704	2N1370-4	Emitter follower
Q1705	2N1370-4	Vox amplifier
Q1706	2N1308	DC amplifier
Q1707	2N1370-4	DC amplifier
Q1708	2N2001	Relay driver
TRANSMITTER IF BOARD A10603		
CR1801 to CR1804	1N34A	Balanced modulator
CR1805 to CR1808	1N34A	Balanced modulator
Q1801	2N3904	1st IF amplifier
Q1802	2N3904	2nd IF amplifier
Q1803	2N3904	ALDC amplifier
Q1804	MPF104	Buffer amplifier
Q1805 and Q1806	MPF104	RF switches
Q1807	MPF104	Carrier switch
Q1808	MPF104	Notch switch
PREAMPLIFIER AND CW OSCILLATOR BOARD A10598		
CR1901	1N758A	Voltage regulator
Q1901	MPF104	CW oscillator
Q1902	MPF104	Preamplifier
Q1903	2N3904	Buffer amplifier

TABLE 1-2. EQUIPMENT SUPPLIED

NAME	DESIGNATION	FUNCTION	QUANTITY
Transistorized SSB Transmitter/Receiver	TTR-20	Communications trans- mitter and receiver	1
Fanning Strip		Aid for rear panel wiring	2
RF Connector		Antenna connection	1
Service extension module	AX-436	Aid for adjustment of TTRR and TTRT modules	1

SECTION 2

INSTALLATION

2-1. UNPACKING AND HANDLING

The TTR-20 is shipped from the factory in a wooden crate to ensure maximum protection from damage in transit. The inside of the crate contains additional packing material to protect the unit not only from breakage due to shock, but also from the elements. The equipment supplied with the TTR-20 (table 1-2) is packed in the box as loose items.

As soon as the TTR-20 is unpacked, it should be visually inspected to make sure that it is not damaged. This examination should include the testing of each front panel control. All of the covers on the unit should be removed, and the inside of the unit checked carefully for damaged components and loose items.

With respect to damage to the equipment for which the carrier is liable, TMC (Canada) Limited will assist in describing methods of repair and furnishing of replacement parts.

2-2. POWER REQUIREMENT

a. MAIN POWER. — The TTR-20 is operated with a TPSA-20 power supply module. If the TTR-20 is to be operated from a source other than that for which the power supply is wired, the power supply module must either be modified or replaced. Modification instructions are provided in the TPSA-20 manual.

b. OVEN POWER. — If ovens are used in the TTRT and TTR R modules, the voltage rating of the ovens must be the same as the main power input, or an external oven supply is required. It is most important to make sure the oven supply is correct before energizing the unit.

2-3. EQUIPMENT LOCATION

Before installing the TTR-20, consideration must be given to its location. Two factors are important:

a. ACCESSIBILITY. — The TTR-20 should be located so that there is sufficient clearance for insertion and removal of plug-in modules (TTRR, TTRT, TTRA, and TPSA-20). Also, sufficient space for fuse replacement and accessibility to rear-panel controls is required.

b. VENTILATION. — Although the majority of TTR-20 components are solid-state and do not require ventilation, the vacuum tube linear amplifier requires that air flow not be restricted immediately above or below the unit. If the air flow is restricted, serious damage to the linear amplifier may result.

2-4. ELECTRICAL INSTALLATION

The only considerations for electrical installation are that the proper power-supply module is used and that external equipment is connected in accordance with the following paragraphs. Refer to figure 2-1.

a. ANTENNA. — The TTR-20 requires a 50-ohm unbalanced antenna with a coaxial-cable lead-in for simplex operation. This antenna is connected to the ANTENNA jack on the rear panel. In addition, coaxial-cable assembly W900 should be connected from jack J902 to the RCVR ANT jack J1502.

For duplex operation, two 50-ohm unbalanced antennas with coaxial-cable lead in are required. The transmitting antenna is connected to the ANTENNA jack and the receiving antenna is connected to RCVR ANT jack J1502. Coaxial-cable assembly W900 is not used for duplex operation.

b. AUDIO INPUT (600-OHM LINE). — Terminals 1 and 3 of terminal board TB1500 are used to connect a 600-ohm input line. If the 600-ohm line is balanced, terminal 2 of TB1500 should be grounded.

c. MICROPHONE INPUTS. — Terminals 4, 5, and 6 of HANDSET jack J1515 are provided for carbon microphone, high impedance microphone and low impedance microphone inputs respectively. Connect the microphone between ground (terminal 1 on J1515) and the appropriate terminal.

d. PUSH-TO-TALK. — Connect a push-to-talk switching device between ground and terminal 5 of TB1500.

e. KEYING INPUT. — Terminal 11 of terminal board TB1500 is for connection of a keying signal for CW and MCW transmission.

f. REMOTE SIDEBAND CONTROL.

(1) TRANSMIT. — For models of the TTR-20 capable of transmitting both USB and LSB signals, connect a USB/LSB switching device (any SPST switch) between ground and terminal 6 of TB1500.

(2) RECEIVE. — Connect a USB/LSB switching device (SPST switch) between ground and terminal 10 of TB1501.

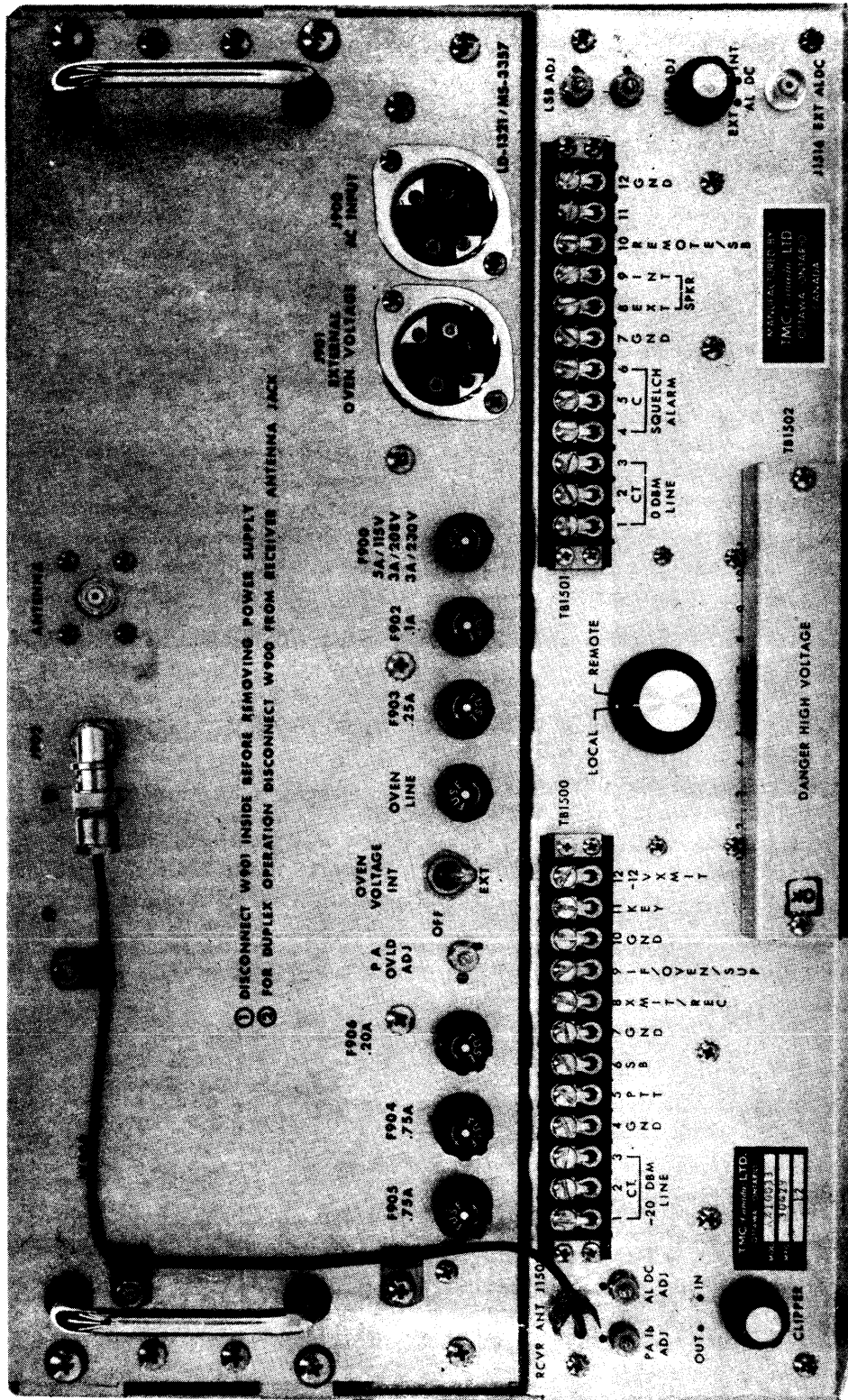


FIGURE 2-1. REAR PANEL, TTR-20

NOTE

Remote sideband control of both the transmit and receive section is possible from one SPST switching device.

g. 600-OHM AUDIO OUTPUT. – Connect a 600-ohm audio load between terminals 1 and 3 of terminal block TB1501. If the load (telephone line, speaker, frequency shift converter, etc.) is balanced, ground should be connected to terminal 2. If the 600-ohm output is not used, it should be terminated with a 600-ohm resistor.

h. 4-OHM AUDIO OUTPUT. – Remove the jumper between terminals 8 and 9 of terminal board TB1501; this disables the internal speaker. Connect a 4-ohm audio load between ground and terminal 8 of TB1501.

i. REMOTE XMTR ON/OFF CONTROL. – Connect a switching device between ground and terminal 8 of TB1500. Ground at terminal 8 energizes the high-voltage control relay in the power supply.

j. SQUELCH ALARM. – Terminals 4, 5, and 6 of TB1501 are provided for attachment of a squelch-indicating device. For an alarm indication when the receiver is squelched, make connections between terminals 4 and 5. For alarm indications when the receiver is not squelched, make connections between terminals 5 and 6.

2-5. PERFORMANCE CHECK

Immediately after the TTR-20 has been installed, it should be checked for proper operation as follows:

a. RECEIVER SECTION. – The receiver section is checked by attempting to receive signals on each of the four channels; LSB and USB reception should also be checked. When signals are received, the operation of the VOLUME and SQUELCH controls should be checked.

b. TRANSMITTER SECTION.

NOTE

For the following tests a 50 ohm, 100 watt dummy load should be connected to the ANTENNA jack.

(1) Select the AME, -20 DB CARRIER, or SSB mode, and check voice mode operation using all possible audio inputs. The EoRF scale of the front-panel meter can be used to indicate that the signal is present at the antenna output. The channel used is not important in this test. Check the XMTR AF GAIN control for proper operation as indicated by a variation in the meter reading.

(2) Repeat step (1) for each of two modes not selected in step (1) using any one of the audio inputs.

(3) For models of the TTR-20 designed to transmit both USB and LSB signals complete step (1) for both sidebands.

(4) Check operation as in step (1) for both the CW and MCW modes using an external key.

(5) Check operation as in step (1) for each of the five channels.

(6) Check the VOX circuit as follows:

(a) Set PTT/VOX switch at VOX.

(b) Turn VOX GAIN control fully counterclockwise.

(c) Turn ANTI-VOX control fully counterclockwise.

(d) Select the AME, -20DB CARRIER, or SSB mode.

(e) Apply the normal audio input; XMTR AF GAIN must be set for normal operation.

(f) Rotate the VOX GAIN control slowly clockwise. A point should be reached where a click will be heard, which is the transmit/receive relay energizing.

NOTE

Be sure to set the VOX GAIN and ANTI-VOX controls according to the applicable operating procedure given in section 3 before using the TTR-20 for transmitting.

SECTION 3

OPERATOR'S SECTION

3-1. CONTROLS AND INDICATORS.

Before attempting to operate the TTR-20, the operator should become familiar with the controls and indicators listed in table 3-1. These are shown in figure 3-1. The type and purpose of each control is described in the table. It is important to stress that these descriptions are not operating instructions. For specific operating instructions, see paragraph 3-2.

NOTE

Operating instructions for the TTRR and TTRT modules are included in this section as part of the overall operating procedure for the TTR-20.

3-2. OPERATING PROCEDURES.

NOTE

Almost all operating controls are protected by a control cover (see figure 1-1). To remove this cover, slide both catches up and lift off the cover. To prevent inadvertent changing of control settings, it is good practice to keep the cover on at all times except when adjusting the controls.

a. RECEIVING.

(1) TYPES OF RECEPTION. – The TTR-20 can receive AME, CW, FSK, MCW, and SSB signals and also one sideband of AM and ISB transmission. All of the above signals are received as if they were SSB transmissions. Procedures for receiving each of the signals are given in the following paragraphs.

(2) VOICE RECEPTION. – The following procedures describe the reception of voice signals that are transmitted as AME or SSB. It is possible also to receive one sideband of AM or ISB transmission using the same method.

(a) Set controls at position given below.

CONTROL	SETTING
RCVR switch	Sideband to be received. If the sideband to be received is not known, set at USB/REMOTE. If the sideband is to be selected remotely, set at USB/REMOTE.

RECEIVER CLARIFIER control	Any control
VOLUME control	Fully counterclockwise.
LOCAL/REMOTE switch	Depending on type of operation desired.
RECEIVER CHANNEL switch	When the LOCAL/REMOTE switch is set to LOCAL, select the channel to be received, unless it is desired that the channel be selected by the TRANSMITTER CHANNEL SWITCH.
SQUELCH control	Fully clockwise.
Power switch	REC or XMIT/REC depending upon type of operation desired.

(b) Turn VOLUME control clockwise until a comfortable signal level is obtained.

NOTE

If no signal is obtained, reduce the volume and set RCVR switch at LSB. Repeat step (b).

(c) Adjust RECEIVER CLARIFIER control for maximum voice clarity.

(d) Adjust SQUELCH control by waiting until no signal is being received, and then turning the control slowly counterclockwise until the noise from the speaker disappears.

(3) CW AND MCW RECEPTION. – CW and MCW signals are received in exactly the same manner as voice signals (paragraph 2). For these signals, however, the RECEIVER CLARIFIER control is used to vary the pitch of the audio tone.

NOTE

In CW operation, the receiver channel frequency must be displaced slightly (300 to 3000 Hz) from the transmitted signal.

(4) FAX RECEPTION. – In receiving facsimile, the setting of the RECEIVER CLARIFIER control is critical. Proceed as follows:

TABLE 3-1. CONTROLS AND INDICATORS

ITEM (Fig. 3-1)	DESIGNATION	FUNCTION
1	VOLUME control (R1515)	Controls the loudspeaker audio output of the receiver.
2	ANTI-VOX control (R1517)	Adjusts the anti-vox input to the transmitter from the receiver. The anti-vox circuit prevents receiver audio output from actuating the VOX circuit.
3	PA METER switch (S1511)	Permits the front panel meter to indicate power amplifier tube grid RF voltage, power amplifier tube plate current, or transmitter output RF voltage.
4	RCVR sideband switch (S1503)	A two-position rotary switch that selects reception of either LSB or USB signals. When the RCVR switch is set at USB/REMOTE, either LSB or USB reception can be selected remotely.
5	SIMPLEX/DUPLEX switch (S1506)	When set at SIMPLFX, the receiver section of the TTR-20 is disabled when the transmitter is keyed; when set at DUPLEX, the receiver can operate even though the transmitter is keyed.
6	SQUELCH control (R1518)	Selects the RF input level required to enable the speaker and anti-vox outputs of the receiver.
7	POWER lamp (DS1500)	Lights when primary power is applied to the low voltage power supply.
8	Mode switch (S1505)	Selects mode of operation of the transmitter. Operation in the CW, SSB (suppressed carrier), -20DB (SSB with reduced carrier), AME, or MCW mode can be selected.
9	PTT/VOX switch (S1501)	Selects either voice-actuated or push-to-talk keying of the transmitter.
10	XMTR sideband switch (S1502)	Selects either upper sideband or lower sideband transmission on models of the TTR-20 that provide both. When set at USB/REMOTE, the sideband to be transmitted may be selected at a remote location.
11	XMTR AF GAIN control (R1514)	Adjusts the gain of the audio amplifier stage of the transmitter.
12	VOX-GAIN control (R1513)	Selects audio level required to key transmitter when PTT/VOX switch is set at VOX.
13	PA OVLD circuit breaker (CB1500)	Controls application of power to the linear-amplifier stages; removes power to these stages when power-amplifier tube plate current is excessive.
14	OFF / REC / XMIT/REC switch (S1500)	When set at OFF, removes power from all TTR-20 circuits except TTRR and TTRT ovens; when set at REC, turns on low voltage power supply, permits remote transmitter ON/OFF control; when set at XMIT/REC, turns on low voltage power supply and, in conjunction with PA OVLD circuit breaker, linear amplifier operating power.

TABLE 3-1. CONTROLS AND INDICATORS (Cont'd)

ITEM	DESIGNATION	FUNCTION
15	Front panel meter (M1500)	Indicates power-amplifier tube grid RF voltage, power amplifier tube plate current, or transmitter output RF voltage as selected by PA METER switch.
16	HANDSET jack (J1515)	Permits connection of microphone.
17	RECEIVER CHANNEL switch (S1517)	Selects frequency of reception provided the LOCAL/REMOTE switch is in the LOCAL position. When set at T, TRANSMITTER CHANNEL switch selects frequency of reception.
18	TRANSMITTER CHANNEL switch (S1518)	Selects frequency of transmission provided the LOCAL/REMOTE switch is in the LOCAL position. Selects frequency of reception when RECEIVER CHANNEL switch is set at T.
19	RECEIVER CLARIFIER control (one on each TTRR module) PA Ib ADJ (R1500) ALDC ADJ (R1545) CLIPPER IN/OUT (S1504) LOCAL/REMOTE (S1518) LSB ADJ (R1543) USB ADJ (R1544) EXT/INT ALDC (S1519)	Permits fine tuning of receiver. Adjusts the bias voltage applied to the grid of the power amplifier. Adjusts the automatic loading and drive circuit dc signal applied to the transmitter IF board. The dc signal is derived from the transmitter antenna output and is used to prevent excessive IF signals from overloading the power amplifiers. Controls the operation of the clipper circuit. With the switch set to the IN position, the clipper circuit limits high modulation peaks permitting higher average output power for voice transmission. Controls channel selection. With the switch in the LOCAL position, transmit and receive channels may be selected using the RECEIVER CHANNEL and TRANSMITTER CHANNEL switches. In the REMOTE position, channel selection is controlled remotely. Adjusts the input to the LSB oscillator, thus controlling the magnitude of the oscillator output. Adjusts the input to the USB oscillator, thus controlling the magnitude of the oscillator output. Selects either an ALDC signal from some external source or the ALDC signal provided in the TTR-20.

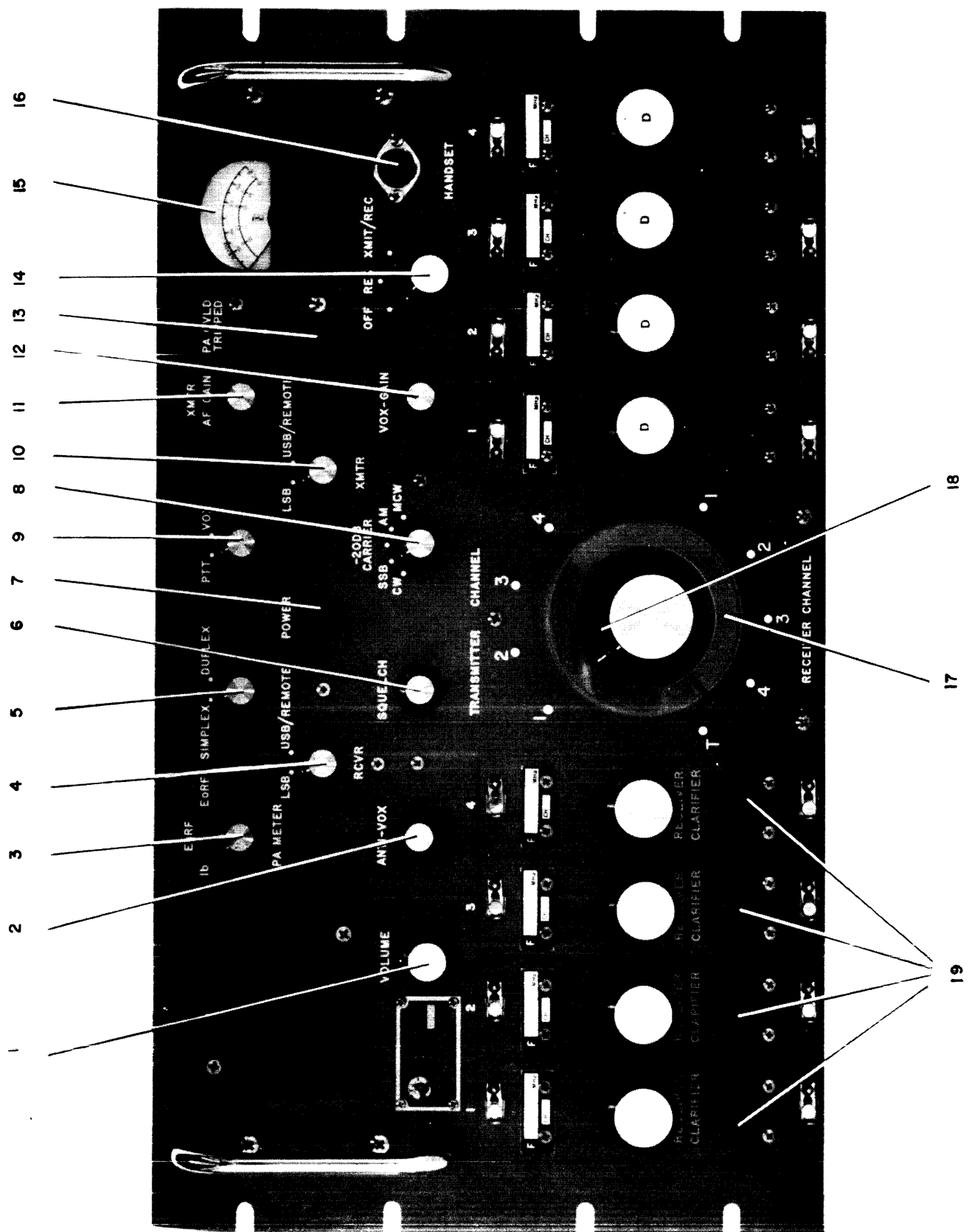


FIGURE 3-1. FRONT PANEL CONTROLS AND INDICATORS, TTR-20

(a) Turn receiver on and set controls at positions given below.

CONTROL	SETTING
RCVR switch	Sideband to be received. If sideband to be received is not known, set at USB/REMOTE. If the sideband is to be selected remotely, set at USB/REMOTE.
RECEIVER CLARIFIER control	Any
VOLUME control	Fully counterclockwise.
LOCAL/REMOTE switch	Depending on type of operation desired.
RECEIVER CHANNEL switch	When the LOCAL/REMOTE switch is set to LOCAL, select the channel to be received, unless it is desired that the channel be selected by the TRANSMITTER CHANNEL SWITCH.
SQUELCH control	Fully clockwise.
Power switch	REC or XMIT/REC depending upon type of operation desired.

(b) Turn VOLUME control clockwise until a comfortable signal level is obtained.

NOTE

If no signal is obtained, reduce the volume and set RCVR switch at LSB. Repeat step (b).

(c) Connect 600-ohm line output of receiver to vertical input of an oscilloscope.

(d) Connect an audio oscillator to horizontal input of oscilloscope.

(e) Set oscillator frequency at 1500 Hz.

(f) Adjust RECEIVER CLARIFIER control to obtain an unsteady, but circular (1:1) Lissajous pattern.

NOTE

A similar pattern, corresponding to the other limit of shift of the picture, will be obtained if the oscillator frequency is set at 2300 Hz.

(5) FSK RECEPTION. – In receiving frequency shift signals, the setting of the RECEIVER CLARIFIER control is critical. The procedure given below

is one method of tuning the receiver for FSK reception. Most FSK converters have built in indicating devices that allow accurate receiver tuning without the necessity for an external scope and oscillator.

(a) Turn receiver on and set controls at position given below.

CONTROL	SETTING
RCVR switch	Sideband to be received. If the sideband to be received is not known, set at USB/REMOTE. If the sideband is to be selected remotely, set at USB/REMOTE.
RECEIVER CLARIFIER control	Any

(b) Connect 600-ohm line output of receiver to vertical input of an oscilloscope.

(c) Connect an audio oscillator to horizontal input of oscilloscope.

(d) Set oscillator frequency at the mark frequency. This frequency is generally 2125 Hz, but another is sometimes specified.

(e) Adjust RECEIVER CLARIFIER control to obtain an intermittent, but circular (1:1) Lissajous pattern. This corresponds to a mark.

NOTE

A similar pattern can be obtained if the oscillator is set at the space frequency (generally 2975 Hz).

b. TRANSMITTING. – Proceed as follows:

(1) Set controls as shown in table 3-2.

NOTE

If audio clipping is desired, the CLIPPER switch on the rear of the TTR-20 should be set at IN. Audio clipping should not be employed for CW, MCW, FSK or FAX transmissions.

(2) Set OFF / REC / XMIT/REC switch at XMIT/REC.

(3) Set PTT/VOX switch at PTT.

NOTE

If the microphone or other audio source does not have a push-to-talk switch, terminal 5 on TB1500 must be grounded. If this terminal has been permanently grounded, do not leave the PTT-VOX switch at its PTT position for more than a few minutes.

(4) Depress push-to-talk switch on microphone, and supply audio signal to the transmitter. For CW or MCW operation, close telegraph key.

(5) Adjust XMTR AF GAIN control until meter indicates 125 mA on peaks.

(6) If VOX operation (voice operated excitation) is desired, set PTT/VOX switch at VOX and adjust VOX-GAIN control until transmitter is turned on when audio is applied.

NOTE

If audio from the loudspeaker actuates the VOX circuit, rotate ANTI-VOX control clockwise until transmitter is unkeyed when no external audio is applied.

(7) If remote transmitter on/off control is desired, set OFF / REC/ XMIT/REC switch at REC.

3.3. CHANGING PLUG-IN MODULES.

a. CHANGING TTRR AND TTRT MODULES

NOTE

When a change in a TTRT module results in a change in the frequency band, the corresponding TTRA module must also be changed (refer to paragraph b).

CAUTION

Be sure to deenergize the unit before changing TTRT modules. Serious damage to the modules can result if the unit is not deenergized.

(1) Deenergize TTR-20.

(2) Loosen snapslides located on top and bottom of module to release module (snapslides on TTRR slide to left; snapslides on TTRT slide to right).

(3) Pull module out of unit. A knob is provided in the center of the module for this purpose.

CAUTION

Before continuing, be sure that the voltage rating on the crystal oven (if used) in the module to be inserted is the same as the voltage rating for the crystal oven in the module just removed.

(4) Insert new module.

(5) Secure snapslides to lock module in place.

b. CHANGING TTRA MODULES. – Generally, when a TTRT module is changed in one of the channels of the transmitter section, the TTRA module for that channel must also be changed unless the new

TABLE 3-2. TRANSMITTER CONTROL SETTINGS

CONTROL	SETTING
LOCAL/REMOTE switch	To select type of operation desired.
TRANSMITTER CHANNEL switch (when LOCAL/REMOTE switch is set to LOCAL)	To correspond with TTRT that includes desired operating frequency.
SIMPLEX/DUPLX switch	To select type of operation desired.
CW/SSB/-20DB CARRIER/AM/MCW switch	To select mode of operation desired.
XMTR switch (when applicable)	At LSB for locally controlled lower sideband operation; at USB/REMOTE for locally controlled upper sideband operation or remote sideband control.
ANTI-VOX control	Maximum counterclockwise.
VOX-GAIN control	Maximum counterclockwise.
XMTR AF GAIN control	Maximum counterclockwise.
PA METER switch	Ib
PA OVLD circuit breaker	Down

TTRT module covers the same frequency band as the TTRT module it replaces.

NOTE

The linear amplifier of the transmitter section must be aligned after changing TTRA modules (refer to paragraph 5-7c).

To change a TTRA module, proceed as follows:

- (1) Deenergize the TTR-20.

WARNING

Dangerously high voltage is present near the TTRA modules whenever the transmitter section is energized. Be sure to deenergize the unit and use a grounding stick before proceeding.

- (2) Lift module out of unit using the two knurled knobs on module for handles.
- (3) Carefully insert new module.
- (4) Align linear amplifier in transmitter section for new TTRA module according to paragraph 5-7c.

SECTION 4

PRINCIPLES OF OPERATION

4-1. GENERAL.

The TTR-20 comprises five major assemblies: main chassis assembly, linear amplifier, receiver module (TTRR), transmitter module (TTRT) and power supply TPSA-20. Circuit analysis for the TTR-20 is outlined in the following paragraphs. Detailed analysis for the TTRR, TTRT and TPSA-20 can be found in the appropriate manual.

4-2. RECEIVER SECTION (Refer to figure 4-1)

a. INPUT CIRCUITS. – The RF input to the receiver section is provided through RCVR ANT jack J1502 and applied to the wiper of S1507. In duplex operation the front panel switch S1517 (RECEIVER CHANNEL switch) positions the control wafer of S1507. A Ledex motor positions the wiper of S1507 to connect the RF input to one of the four TTRR modules. Additional sections of S1507 provide operating voltages and a delayed AGC signal to the TTRR module. In simplex operation, S1517 is set to the "T" position and the TRANSMITTER CHANNEL switch S1516 controls the positioning of the S1507 control wafer.

b. TTRR MODULE. – The TTRR module amplifies the RF signal and converts it to the first IF frequency. The carrier frequency of the IF output is 1.75 MHz.

c. RECEIVER IF BOARD. – The IF signal is supplied to the receiver IF board where it is amplified by Q1401 and applied to mixer Q1402. The mixer is also supplied with the output from either the LSB oscillator (1.5 MHz) or the USB oscillator (2.0 MHz), depending on the position of RCVR switch S1503.

When S1503 is at LSB, relay K1501 is energized and +12 V CONT is applied across LSB ADJ, R1543. The positive voltage supplied by R1543 forward biases Q1407. The USB oscillator is not forward biased and is cut off. When S1503 is at USB/REMOTE, and no remote sideband input is present, K1501 is deenergized and +12 V CONT is applied across USB ADJ, R1544. Q1608 is forward biased and the LSB oscillator is cut off. If ground is supplied as a remote sideband input, K1501 is energized and the LSB oscillator is activated. Thus the desired sideband may be selected remotely.

LSB oscillator Q1407 and USB oscillator Q1408 are modified Colpitts oscillators. The LSB oscillator is tuned to exactly 1.5 MHz by C1429. The USB

oscillator is tuned to exactly 2.0 MHz by C1431. The output of each oscillator is taken from its base. Figure 4-2 shows the input and the two possible outputs of mixer Q1402. If the LSB oscillator output is supplied to the mixer (250 kHz below the carrier frequency of the IF signal), the frequency spectrum of the input signal is not inverted. If the USB oscillator output is supplied to the mixer (250 kHz above the carrier frequency of the IF signal), the frequency spectrum of the input signal is inverted. Because the crystal filter passes only a band of frequencies above 250 kHz, the selection of the desired sideband depends upon which oscillator output is supplied to the mixer.

The output from mixer Q1402, the second IF frequency (250 kHz), is supplied to bandpass filter FL1401. This is a highly selective filter with a bandpass of 2.75 kHz, which rejects frequencies below 250.25 kHz and above 253.0 kHz. Thus, only the sideband whose frequency range is above 250 kHz will be passed by the filter, while all noise and signal frequencies outside of the selected sideband are eliminated. The IF output from the filter is supplied to two stages: detector CR1401 through CR1404 and IF amplifier Q1410 in the AGC circuit.

A 250 kHz signal is provided by BFO Q1406 through buffer amplifier Q1405 to the detector CR1401 to CR1404. The IF input to the detector and the BFO signal beat together in the detector to derive the audio information from the IF signal. The first audio amplifier, Q1403 and Q1404, converts the balanced output from the detector to a single-ended signal and amplifies it. This output is provided to the receiver audio board and to VOLUME control R1515.

The output from filter FL1401 is also supplied to the AGC detector, CR1405 through CR1407, through amplifier Q1410. The AGC detector produces a delayed AGC output signal through amplifiers Q1411 and Q1412. This output is provided to both the receiver audio board and to the TTRR module through S1507.

d. BFO. – BFO Q1406 on the receiver IF board is a modified Colpitts oscillator. Its output is supplied through buffer amplifier Q1405 to potentiometer R1463. R1463 is adjusted so that the BFO signal is self-cancelling at the balanced output of the detector.

The BFO signal controls the switching of the diode network. For positive half-cycles of the BFO signal, CR1401 and CR1404 are forward biased and CR1402 and CR1403 are reverse biased. For negative half-cycles of the BFO signal, CR1401 and CR1404

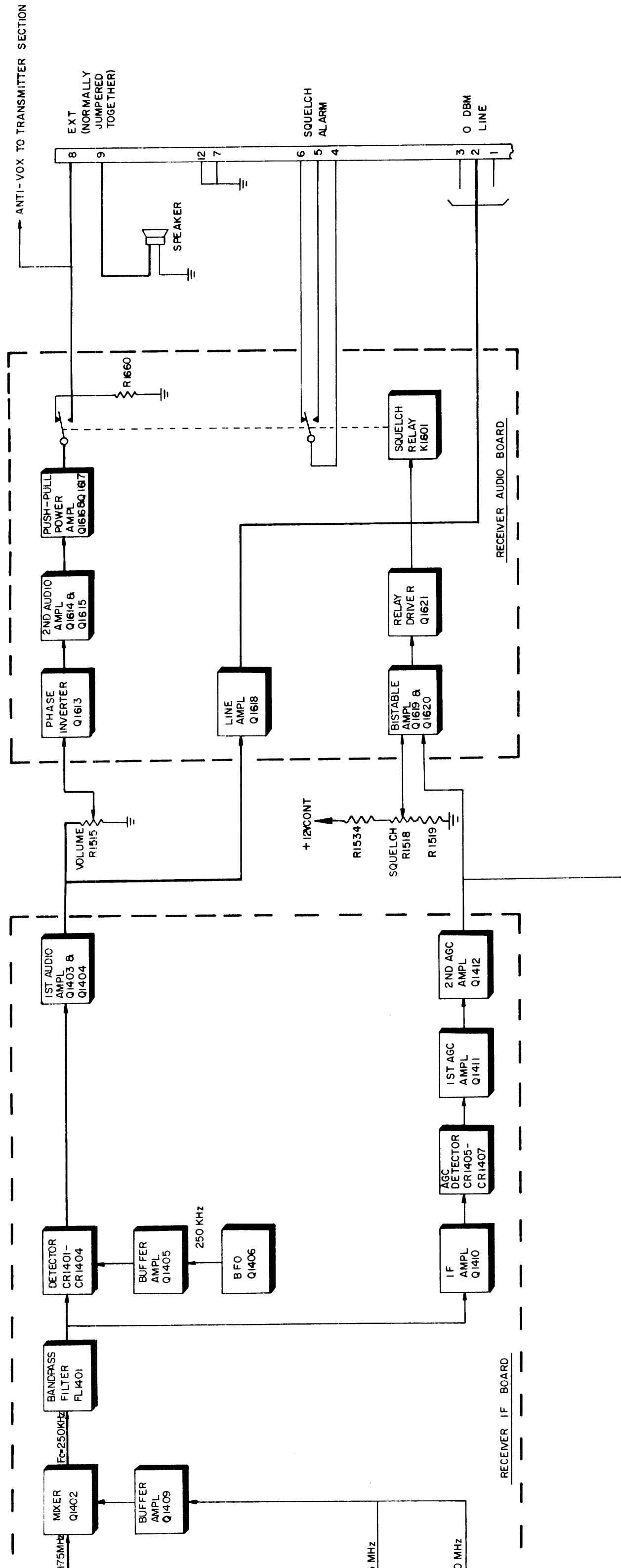


FIGURE 4-1

TTR-20 RECEIVER SECTION, BLOCK DIAGRAM

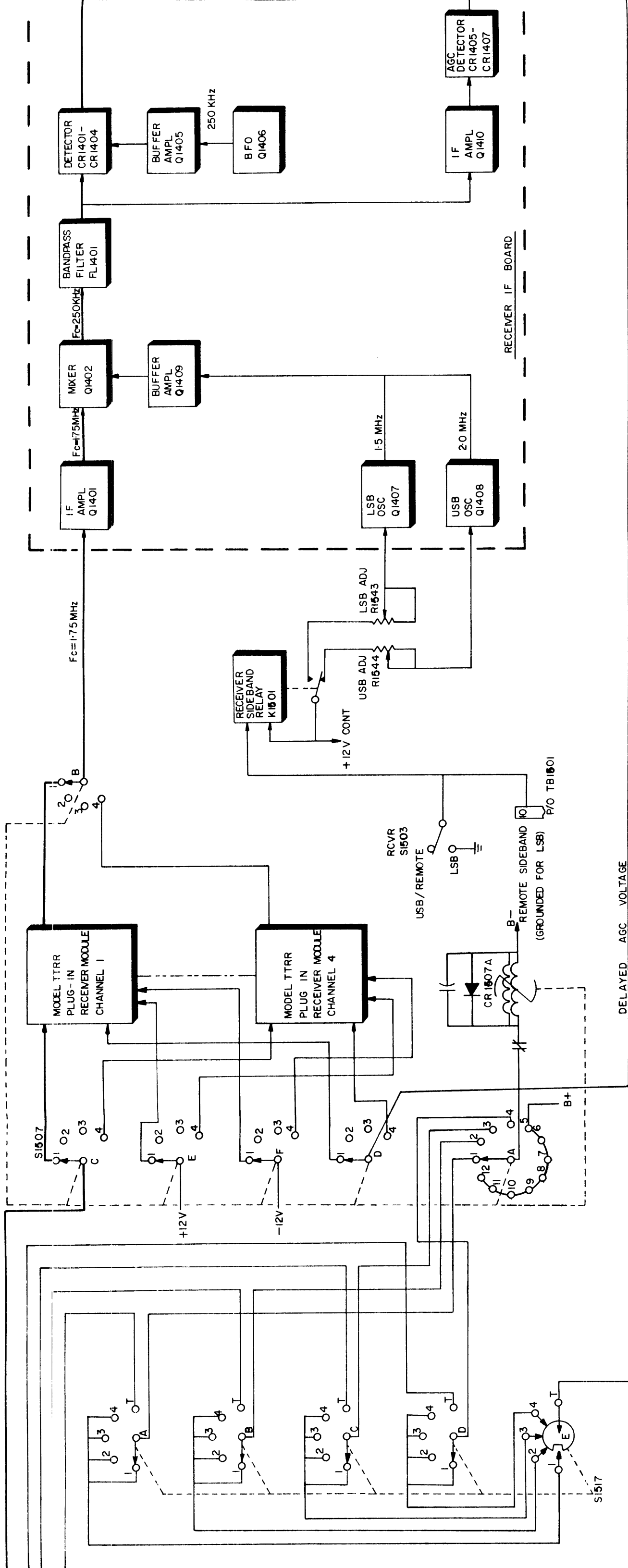
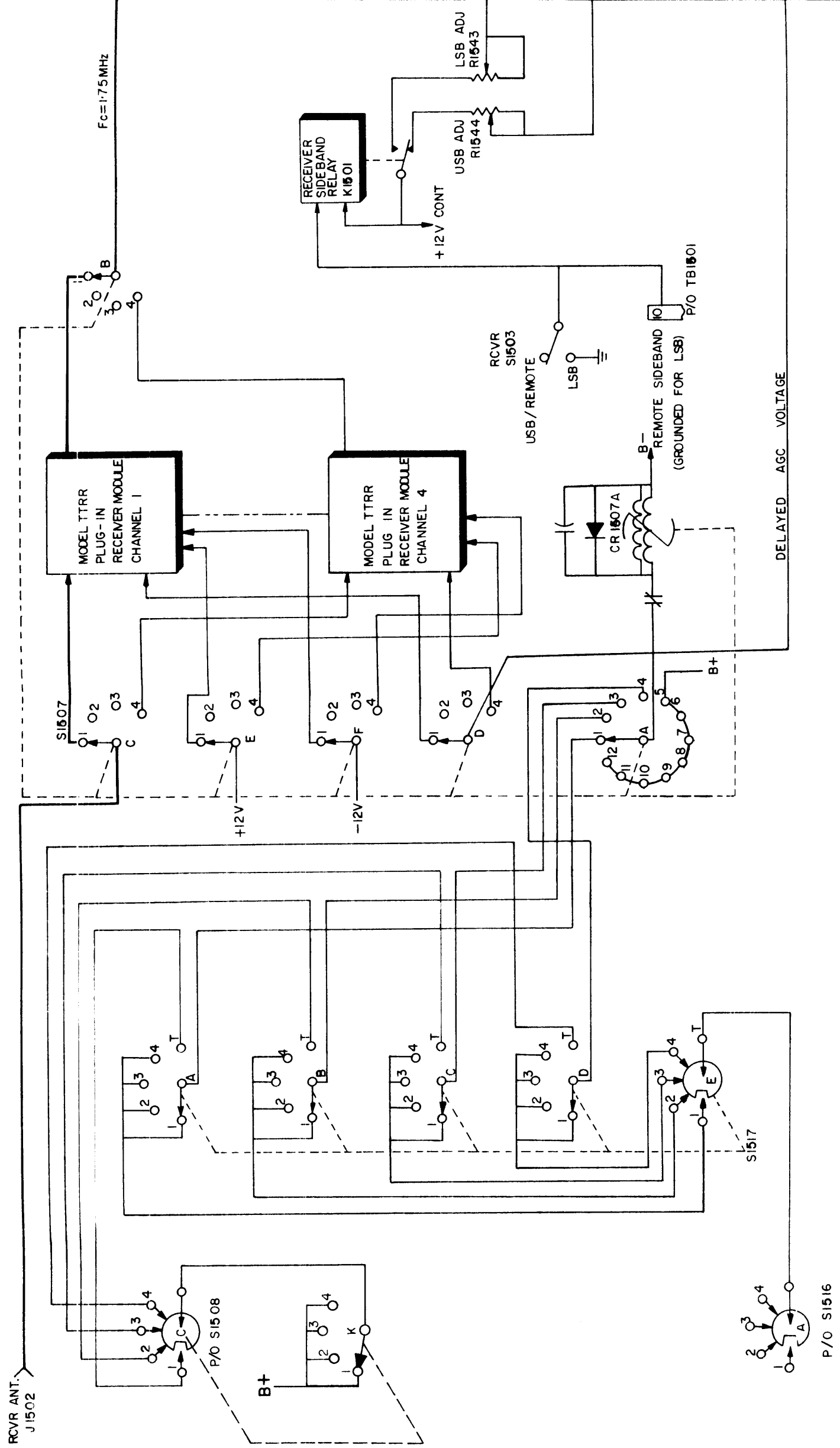


FIGURE 4-1. TTR-20 RECEIVER SECTION, BLOCK DIAGRAM



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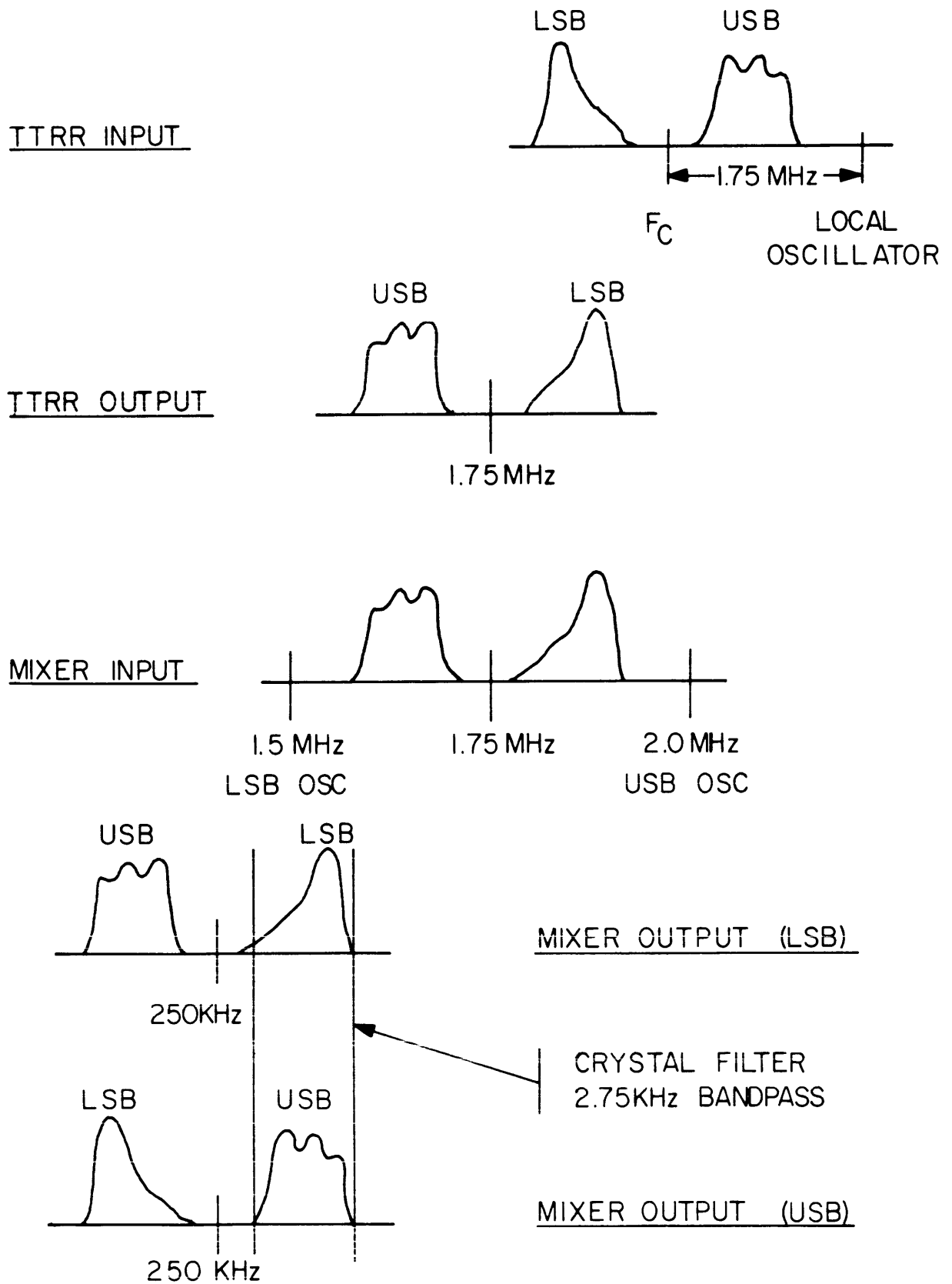


FIGURE 4-2. FREQUENCY INVERSION IN SSB RECEPTION

are reverse biased and CR1402 and CR1403 are forward biased. The balanced IF signal from FL1401 is supplied to the detector through C1410 and C1411. The amplitude of the IF signal is small compared to the BFO signal so that the BFO signal does not lose control of the diode switching.

Figure 4-3 shows idealized waveforms for the detector. For this illustration, the IF signal is a constant frequency in the passband of the filter. Assume that the output shown is taken across R1408 and the IF input is applied at the anode of CR1401 and the cathode of CR1403. When the IF and BFO signals are in phase (between T1 and T2), CR1401 is at maximum conduction and voltage across R1408 is at its maximum positive value. As the IF signal begins to lead the BFO signal (between T2 and T7), CR1401 conducts less and CR1402 begins to conduct more. When the IF and BFO signal are 180° out of phase (between T7 and T8), CR1402 is at its maximum conduction, and voltage across R1408 is at its maximum negative value. As the BFO signal begins to lead the IF signal (between T8 and T14), CR1402 conducts less and CR1401 begins to conduct more. Between T14 and T15, the IF and BFO signals are again in phase.

Since the IF signal at the anode of CR1404 is 180° out of phase with the IF signal at the anode of CR1401, the output across R1409 will always be a mirror image of the output across R1408.

Capacitors C1413 and C1414 remove the IF and any residual BFO components from the detector output.

e. RECEIVER AUDIO BOARD. – The receiver IF board output from the audio amplifier (Q1603 and Q1604) is supplied to line amplifier Q1618 which provides the balanced 600-ohm line output to TB1501, terminals 1, 2 and 3.

The output from VOLUME control R1515 is supplied through phase inverter Q1613 and the 2nd audio amplifier Q1614 and Q1615, to the push-pull power amplifier Q1616 and Q1617. The 2nd audio amplifier is a differential amplifier which converts the single-ended signal to a balanced signal for the push-pull amplifier. The output from the power amplifier is supplied through a contact of squelch relay K1601 (when K1601 is energized) to terminal 8 of TB1501. This is normally jumpered to terminal 9 to connect the audio output to speaker LS1500. The audio output from the receiver audio board is also provided to the transmitter section as an anti-vox signal. The anti-vox signal is used to prevent the speaker output from keying the transmitter.

The squelch relay K1601 is controlled by the delayed AGC signal from the receiver IF board. This signal is supplied to bistable amplifier Q1619 and

Q1620 and then through relay driver Q1621 to relay K1601. When an RF signal is being received, the bistable amplifier is held in its unsquelched state by the AGC voltage and the relay driver is on. When the signal level decreases, the AGC voltage drops. At a point selected by SQUELCH control R1547, the bistable amplifier changes to its squelched state and the relay driver turns off.

When K1601 is energized, the audio output is connected to the speaker terminal and anti-vox circuit. When K1601 is de-energized, the audio output is disconnected from the speaker terminal and anti-vox circuit, and is connected to dummy load R1660. The other set of contacts of relay K1601 can be used to provide squelched and non-squelched indications for external alarm circuitry.

f. POWER SUPPLY. – The operating voltages for the receiver section are +12V dc and -12V dc. The TTR modules operate with +12V dc REC and -12V dc REC. These voltages are always present in duplex operation, but are only present in simplex operation when the transmitter is not keyed. The receiver audio board is supplied with +12V dc CONT and -12V dc CONT which are present continuously whenever the TTR-20 is energized.

4-3. TRANSMITTER SECTION (Refer to figure 4-4)

a. INPUT CIRCUITS. – The input to the transmitter section may be provided from the 600-ohm line, a carbon microphone, a low impedance microphone or a high impedance microphone. Any one of the microphones can be connected into HANDSET jack J1515 on the front panel of the TTR-20. The 600-ohm line input and the carbon microphone input are supplied directly to the transmitter audio board.

The high impedance microphone input and low impedance microphone input are supplied to the transmitter audio board through the audio preamplifier and CW oscillator board.

NOTE

When a high impedance microphone is connected to the board, the low impedance microphone input must be grounded, and vice versa.

b. AUDIO PREAMPLIFIER AND CW OSCILLATOR BOARD. – The high impedance microphone input and low impedance microphone input are supplied to preamplifier Q1902 and buffer amplifier Q1903. The output from the buffer amplifier is supplied to the transmitter audio board.

When the CW or MCW mode is selected by mode switch S1505, +12V dc is supplied to CW oscillator Q1901. The oscillator then supplies an audio tone to

- NOTES:
1. THE IF SIGNAL HAS BEEN ENLARGED FOR CLARITY.
 2. ONLY ONE HALF OF THE OUTPUT IS SHOWN.

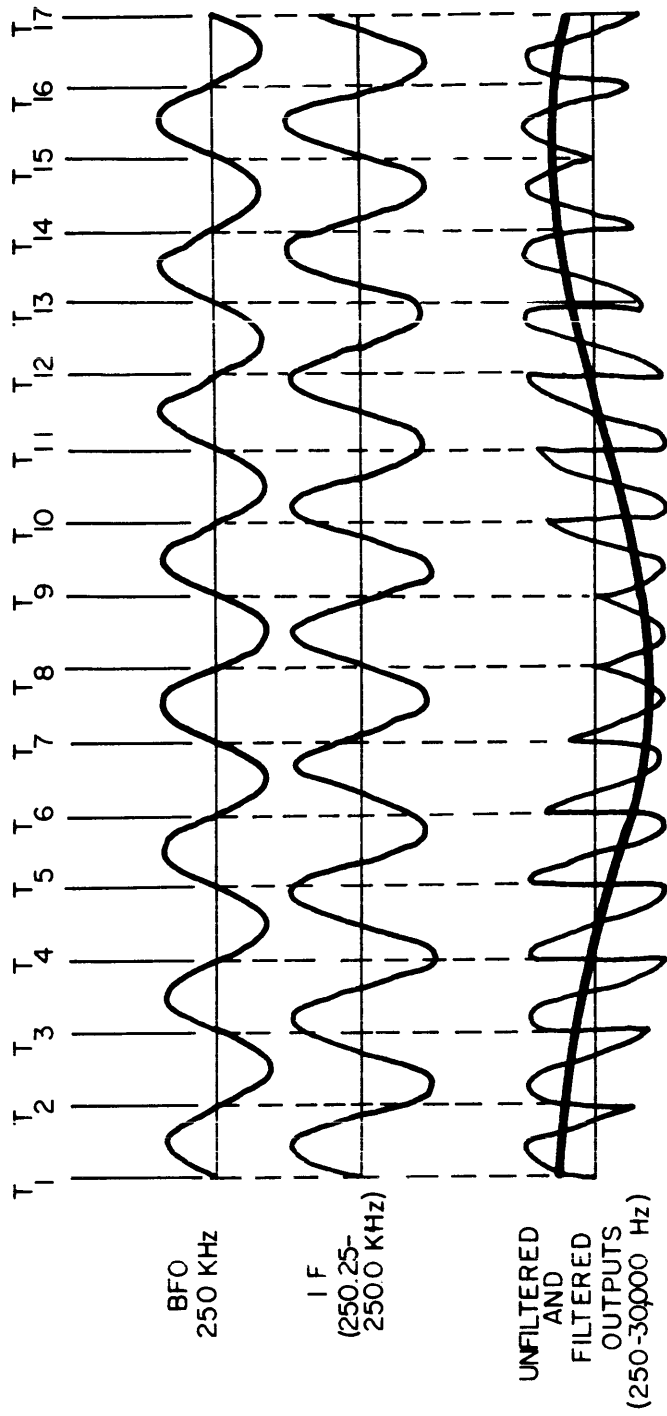


FIGURE 4-3. DEMODULATOR, IDEALIZED FORMS

AUDIO SIGNAL TO XMTR I.F. BOARD

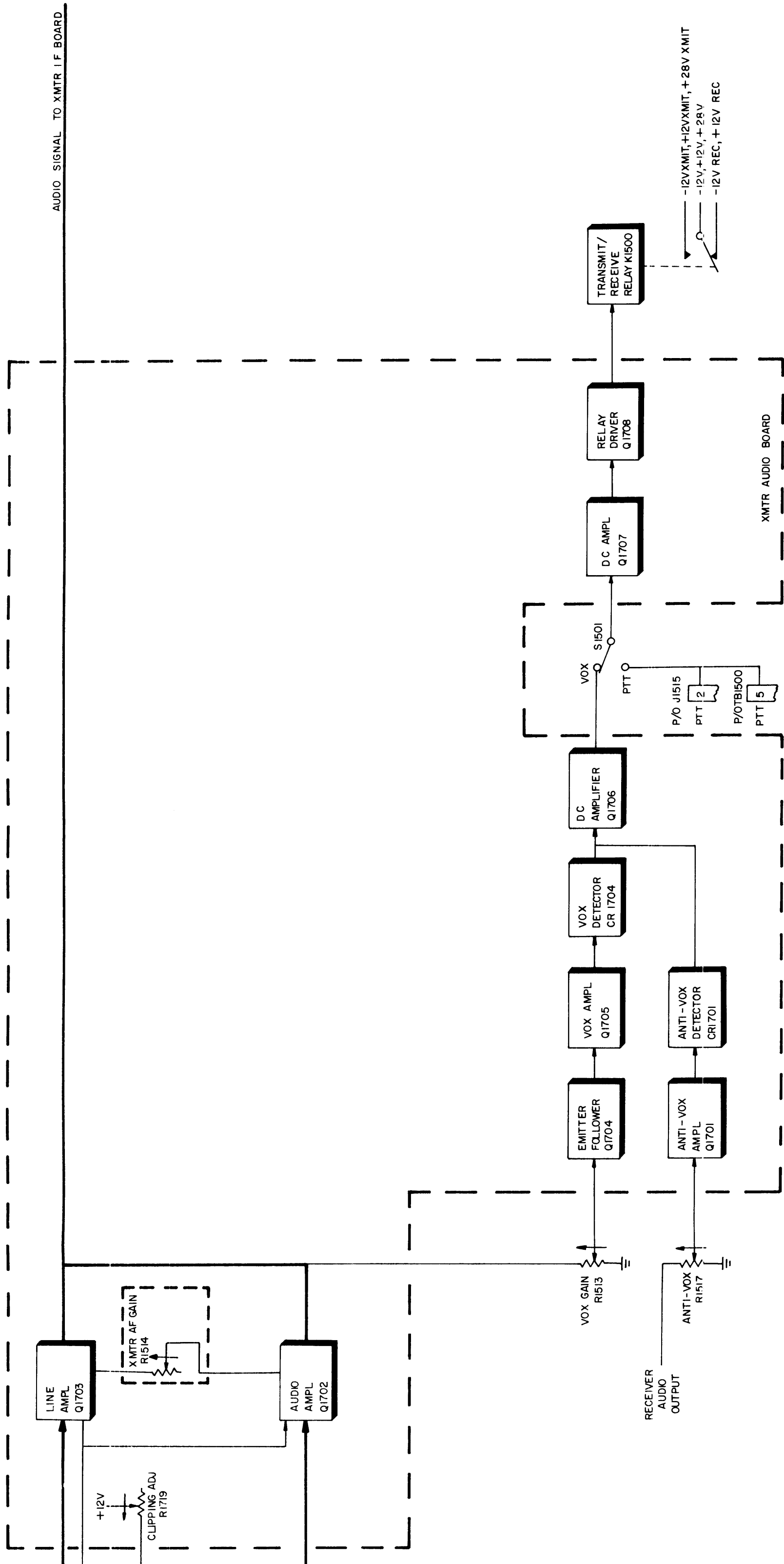


FIGURE 4-4 (Sheet 1 of 2)

FIGURE 4-4. TTR-20 TRANSMITTER SECTION, BLOCK DIAGRAM (Sheet 1 of 2)

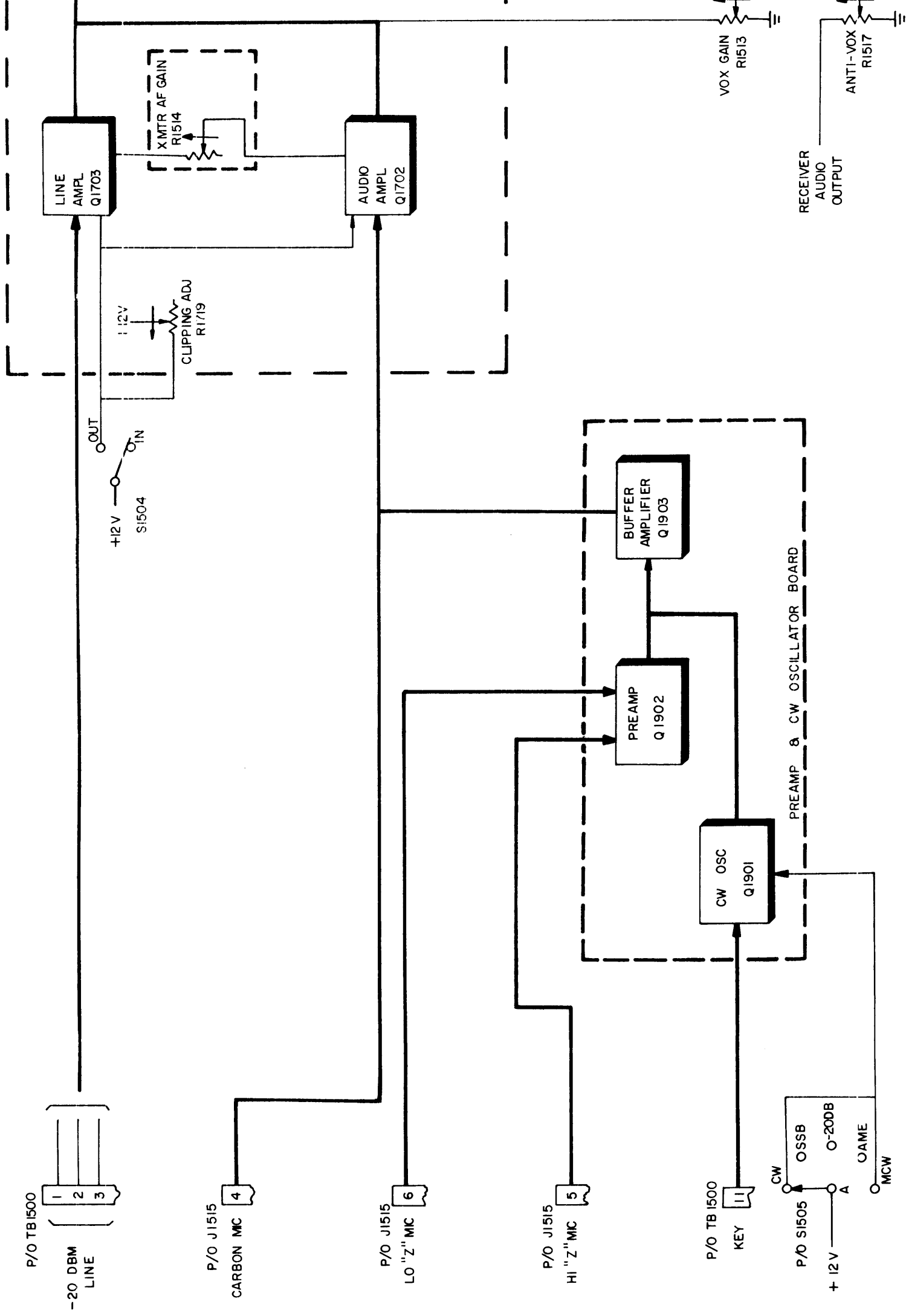


FIGURE 4-4. TTR-2

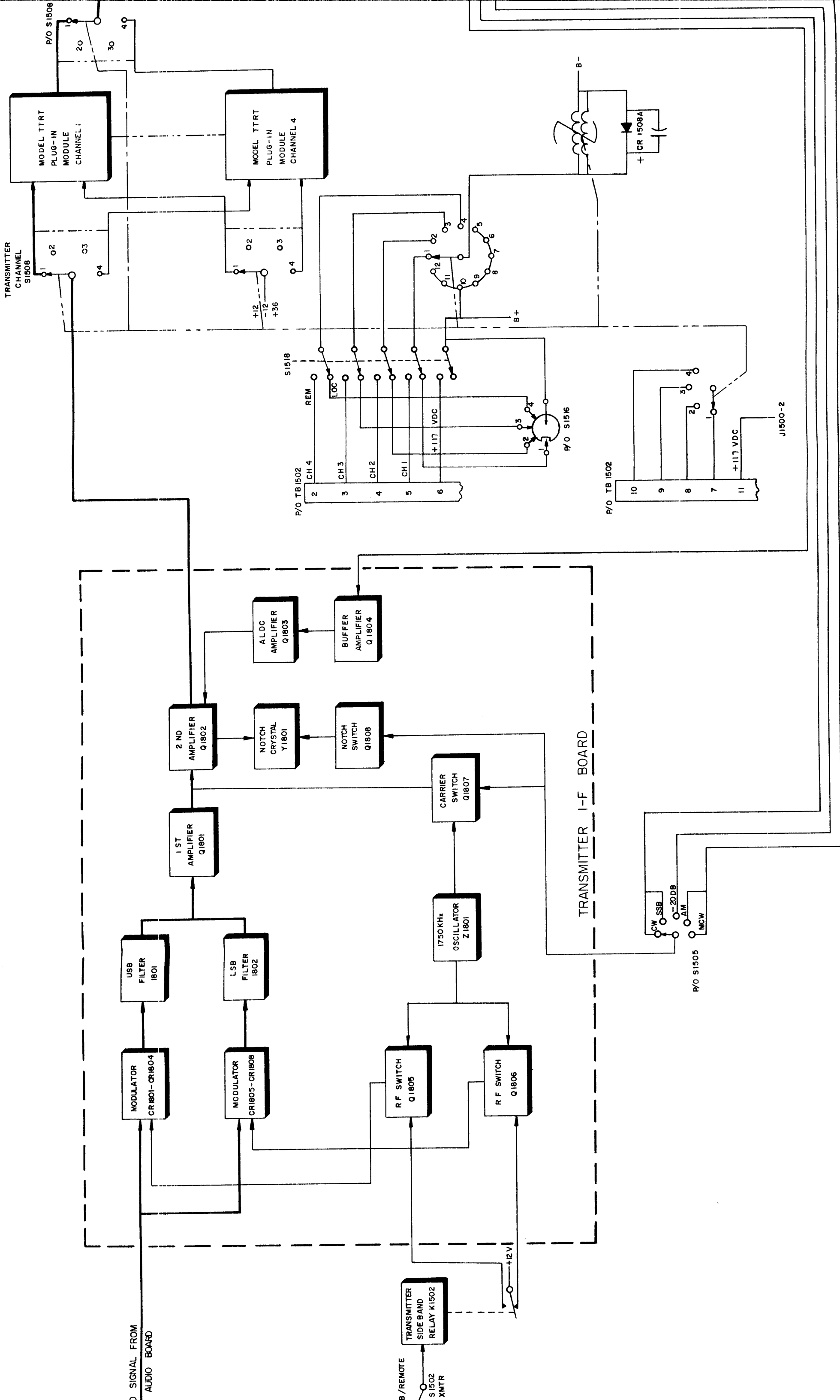
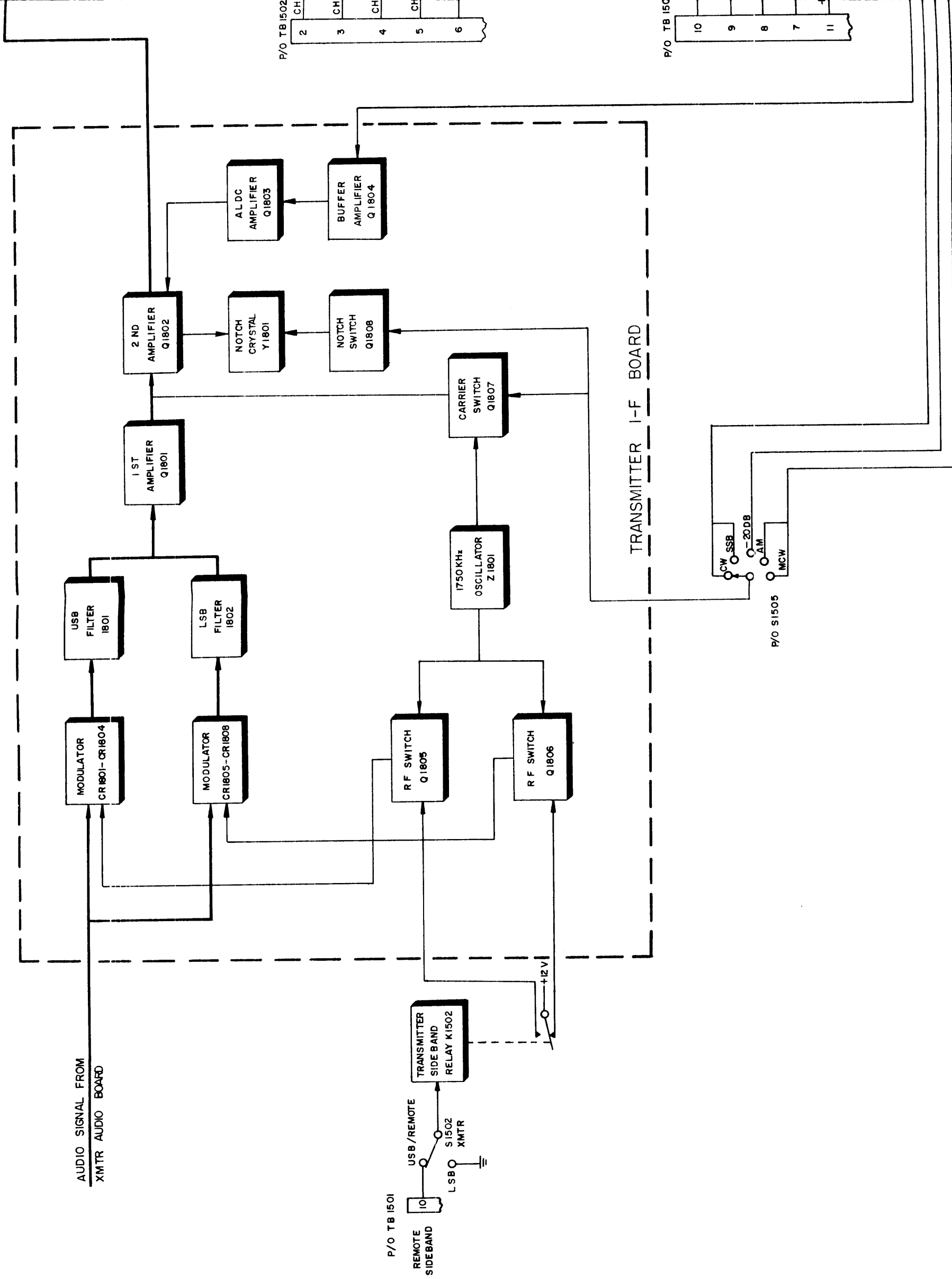


FIGURE 4-4. TTR-20 TRANSMITTER SECTION, BLOCK DIAGRAM (Sheet 2 of 2)



FIGUR

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the buffer amplifier, provided an external keying signal connected to TB1501 (terminal 11) is present.

c. TRANSMITTER AUDIO BOARD – AUDIO STAGES. – The 600-ohm line input is amplified by line amplifier Q1703 and supplied as an audio output to the transmitter IF board and to VOX GAIN control R1513.

The carbon microphone input or audio signal from the preamplifier and CW oscillator board provides the input to audio amplifier Q1702. The audio output from this amplifier is supplied to the transmitter IF board and VOX GAIN control R1513.

The XMTR AF GAIN control R1514 controls the gain of both the line amplifier and audio amplifier. The CLIPPER switch S1504 permits the insertion of a compression circuit, described below, that prevents abnormally high inputs from overmodulating the exciter. By flattening the sharp peaks of the input signal, the compression circuit increases the average sideband power generated.

With S1504 set at OUT, +12V dc CONT is supplied directly to the emitter resistor of both transistors Q1702 and Q1703. The emitter resistors establish an operating point for each transistor that is in the center of the transfer curve for each transistor. Thus, provided the input signal does not overdrive the stage, the amplification of the stage is linear. With S1504 set at IN, +12V dc CONT is supplied through CLIPPING ADJ R1719 to the emitter resistors of both transistors. The additional resistance shifts each operating point down the transfer curve towards the cutoff region. The amount that the operating point is shifted is determined by the clipping adjustment. The operating point is selected so that abnormally high input amplitudes and voice peaks drive the transistors into the nonlinear amplification region. As a result, these signals are compressed. The amount of compression is determined by the setting of the clipping adjustment.

d. TRANSMITTER AUDIO BOARD – VOX AND ANTI-VOX STAGES. – The vox stages permit input-controlled operation of the transmitter by energizing the exciter output stages only when an audio input is present. The anti-vox stages prevent the receiver section output from keying the exciter if the output of the speaker is picked up by a microphone connected to the exciter.

The output of the audio stages is supplied to vox detector CR1704 through VOX GAIN control R1513, emitter follower Q1704, and vox amplifier Q1705. The vox detector produces a positive dc voltage that is proportional to the magnitude of the vox signal. In the CW and MCW modes, the oscillator signal produces the dc voltage. When a microphone is used, however,

the dc voltage can be produced either by the signal intended for transmission, or by the output of the receiver speaker unintentionally picked up by the microphone.

To prevent the output of the speaker from keying the exciter, the output of the receiver section is supplied to the transmitter section as an anti-vox input. This signal is supplied to anti-vox detector CR1701 through ANTI-VOX control R1517, and anti-vox amplifier Q1701; the anti-vox signal can be monitored by phones connected to J1515. The anti-vox detector produces a negative voltage that is proportional to the magnitude of the anti-vox signal.

The outputs of the vox and anti-vox detectors are added algebraically at the input to dc amplifier Q1706. When the vox detector produces an output (positive) with no anti-vox present the output of the dc amplifier is positive. When, however, the vox signal results from pick up from the speaker, and a negative anti-vox voltage is also present, the algebraic sum of the two results in a slightly negative output from the dc amplifier.

When VOX/PTT switch S1501 is set at VOX, the output of the dc amplifier Q1706 is supplied through dc amplifier Q1707 to relay driver Q1708, which controls transmit/receive relay K1500. When the output of the dc amplifier is negative, K1500 is deenergized, +12V dc XMIT, -12V dc XMIT and +28V dc XMIT voltages are disconnected from the exciter IF and RF stages, power amplifier tube V1501 is cut off, and +12V dc REC and -12V dc REC voltages are connected to the receiver RF and IF stages. When the output of the dc amplifier goes positive, K1500 is energized, +12V dc XMIT, -12V dc XMIT, and +28V dc XMIT voltages are connected to the exciter IF and RF stages, V1501 is normally biased, and +12V dc REC and -12V dc REC voltages are disconnected from the receiver RF and IF stages.

NOTE

If SIMPLEX/DUPLEX switch S1506 is set at DUPLEX, the +12V dc REC and -12V dc REC voltages are continuously supplied to the receiver section.

With S1501 in the PTT position, the transmit/receive relay is controlled by the PTT (push-to-talk) input from either TB1502 or J1515. The relay is energized when the PTT input is grounded, and is deenergized when the PTT input is an open circuit.

e. TRANSMITTER IF BOARD – MODULATOR STAGES. The two balanced modulators on the transmitter IF board (CR1801 – CR1804 and CR1805 – CR1808) receive the audio signal from the transmitter audio board. In addition, oscillator Z1801 provides a 1750

kHz signal to one of the modulators, as determined by switches Q1805 and Q1806. (The oscillator also provides a carrier output that can be inserted into 2nd amplifier Q1802.) The output from the modulators is an audio modulated IF signal that contains both upper and lower sidebands. The output from modulator CR1801 – CR1804 is supplied to filter FL1801 which allows only the upper sideband of the signal to pass. The output from modulator CR1805 – CR1808 is supplied to filter FL1802 which allows only the lower sideband of the signal to pass. Filters FL1801 and FL1802 are highly selective filters; the bandpass for FL1801 is 1750.3 to 1753.0 kHz, and the bandpass for FL1802 is 1747.0 to 1749.7 kHz.

NOTE

The sideband generated by the IF board is opposite to the sideband required for transmission as a reversal takes place in the TTRT module (see figure 4-6). Hence, for upper sideband operation, the IF board generates a lower sideband signal, and vice versa.

The standard model of the TTR-20 is provided with filter FL1802 only (for USB operation). Upon special request, filter FL1801 may be provided instead (for LSB operation), or both filters may be included (refer to paragraph 1-1b). To cover all models the following discussion is for the TTR-20 provided with both filters.

Switches Q1805 and Q1806 select the desired sideband by determining which balanced modulator will receive the oscillator signal. These switches are in turn controlled by XMTR switch S1502. When S1502 is in the LSB position, transmitter sideband relay K1502 is energized and +12V dc is supplied to switch Q1805, cutting off the input to modulator CR1805 – CR1808. The input to switch Q1806, however, is open-circuit and the switch allows the oscillator signal to be applied to CR1801 – CR1804. Filter FL1801 passes only the upper sideband of the output from modulator CR1801 – CR1804. This upper sideband signal from the IF board is reversed in the TTRT module, thus providing a lower sideband signal for transmission as required.

When S1502 is in the USB/REMOTE position and no remote sideband input is present, K1502 is de-energized and +12V dc is supplied to switch Q1806, preventing the oscillator signal from being supplied to modulator CR1801 – CR1804. However switch Q1805, being open-circuit, allows the oscillator signal to be applied to modulator CR1805 – CR1808. Filter FL1802 passes only the lower sideband of the output of this modulator, hence a USB signal will be transmitted. If ground is supplied as a remote sideband input when S1502 is in the USB/REMOTE

position, relay K1502 will be energized and a LSB signal will be transmitted.

The balanced modulator selected (say CR1801 – CR1804), receives a balanced audio input and the 1750 kHz input. One side of the audio input is applied to R1801. The other is applied to R1811. The 1750 kHz input is applied to the cathodes of CR1802 and CR1804. Adjustments to R1813 and C1804 provide equal magnitudes of the 1750 kHz signal at the two input points. The output of the modulator is taken across R1813.

The 1750 kHz signal controls the switching of the diodes in the modulator. The amplitude of the audio inputs is sufficiently low so that the 1750 kHz signal does not lose control of the diode switching. On positive half-cycles of the 1750 kHz signal, CR1802 and CR1804 are forward-biased and CR1801 and CR1803 are reverse-biased. On negative half-cycles of the 1750 kHz signal, CR1802 and CR1804 are reverse-biased and CR1801 and CR1803 are forward-biased. Thus, each output of the detector is composed of alternate samplings of the two audio inputs.

Figure 4-5 illustrates diode switching for the modulator. It shows both audio inputs, the 1750 kHz switching signal, and the output. The 1750 kHz signal is not shown as part of the output waveform because it is in phase at both output points and will have no effect in the mixer. For this discussion, input A (solid curve) is at R1801, input B (dashed curve) is at R1811. Between T1 and T2, when the 1750 kHz signal is positive, CR1804 passes input A. Between T2 and T3 when the 1750 kHz signal is negative, CR1803 passes input B. This alternate sampling continues up to T13 when one complete cycle of the audio signal has been covered. The output is an audio modulated IF signal that contains both the upper and lower sidebands. The output is shown in a more familiar form at the right of the illustration.

f. TRANSMITTER IF BOARD – AMPLIFIER STAGES. – The USB or LSB IF signal from filter FL1801 or FL1802 is amplified by Q1801 and Q1802 and the output is supplied to the selected TTRT module.

In the AM, MCW and -20 DB transmitter modes, a carrier signal is inserted at the second amplifier Q1802. The insertion of the carrier is controlled by section B of mode switch S1505.

When S1505 is in the CW or SSB position the carrier control signal is +12 volts. When the +12 volt signal is applied to carrier switch Q1807, the switch cuts off the carrier signal provided by oscillator Z1801 so that no carrier is inserted at amplifier Q1802.

NOTE:

I. THE AUDIO SIGNAL HAS BEEN ENLARGED FOR CLARITY.

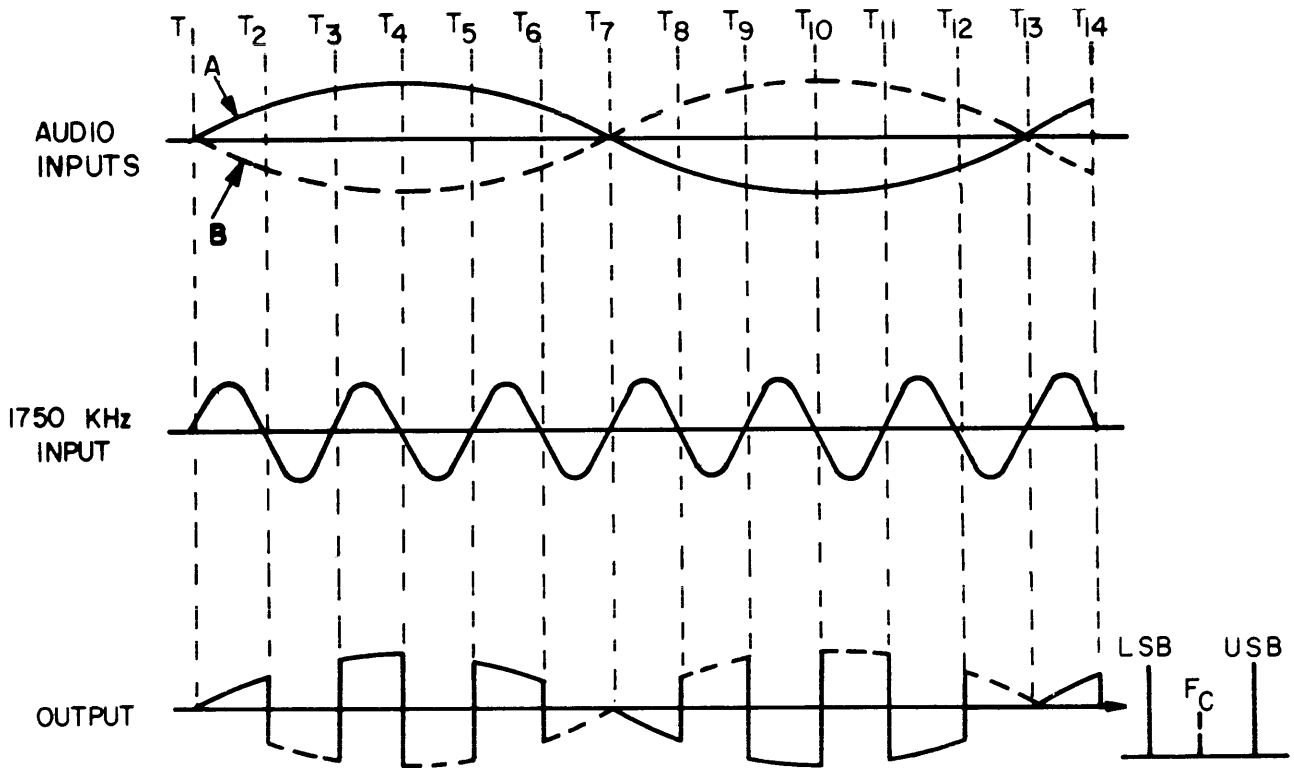


FIGURE 4-5. INTERVAL STUDY OF DIODE SWITCHING, BALANCED MODULATOR

When S1505 is in the AM or MCW position, the carrier control signal is 0 volts. When the 0 volt signal is applied to switch Q1807, the switch allows the carrier signal from Z1801 to be applied to Q1802.

When S1505 is in the -20 dB position, the carrier control signal is set to such a voltage that the carrier inserted at Q1802 is 20 dB down from the IF signal.

Crystal Y1801 is a notch device used to remove any undesirable carrier signal present at the output of amplifier Q1802. So that the carrier will not be removed by Y1801 when it is required at the output, notch switch Q1808 disables the notch device when the carrier control signal is 0 volts, and the carrier is applied to the output. When the carrier control signal is +12 volts, the notch switch is in the "off" condition and does not affect the operation of Y1801. This crystal is factory adjusted and is non-repairable in the field.

g. TRANSMITTER IF BOARD – ALDC CIRCUIT. – The automatic loading and drive circuit (ALDC) input (from the ALDC ADJ control R1545) is supplied to the output of amplifier Q1802 through buffer amplifier Q1804 and ALDC amplifier Q1803. The ALDC signal is provided to reduce the IF output resulting from high level signals, to prevent overloading the linear amplifier. It is a delayed signal, derived from a rectified portion of the output at the transmitter antenna (J1501).

h. TTRT MODULES. – The IF output from the transmitter is supplied to one of five TTRT modules through switch S1508. Front panel switch S1516 (TRANSMITTER CHANNEL switch) positions the control wafer of S1508, provided the REMOTE-LOCAL switch S1518 is in the LOCAL position. When S1518 is in the REMOTE position, S1508 is positioned by signals from a remote unit through TB1502. A Ledex motor positions the various sections of S1508 to the selected channel. The selected TTRT module is energized by -12V dc XMIT, +12V dc XMIT, and +28V dc XMIT through other sections of S1508 and contacts of relay K1500. The TTRT module converts the IF signal to the desired output frequency and amplifies it.

Figure 4-6 shows the input and output of a TTRT module.

i. LINEAR AMPLIFIER. – The linear amplifier consists of two power-amplifier stages, switch selected tuning networks (TTRA modules), and overload protection circuits. The linear amplifier produces an output of 100 watts maximum peak envelope power from an input of 250 milliwatts. (Refer to figure 4-7.)

The RF signal from S1508 is supplied to class AB1 intermediate power amplifier (IPA) V1500. The tuned circuit for the plate is located in the TTRA

module selected by switch S1509. The control wafer of S1509 is ganged to the control wafer of S1508 which is positioned by TRANSMITTER CHANNEL switch S1516. A Ledex motor positions the various sections of S1509 to the selected channel. The output of the selected TTRA module is supplied through S1509 to class AB2 power amplifier (PA) V1501. The control grid bias for V1501 is determined by the condition of the transmit-receive relay. When the transmitter is not keyed, the relay is deenergized, and -105 volts is applied to the grid to keep the tube completely cut off. When the transmitter is keyed, the relay is energized, and a voltage determined by the setting of PA1b ADJ R1500 provides part of the PA bias. In addition, the TTRA contains the pi network for V1501 plate tuning and matching to the transmission line. The output of the selected TTRA module is supplied to XMTR OUTPUT jack J1501.

The power amplifier is protected from overload by a circuit that automatically interrupts the high voltage supply if overload occurs. In addition, a front panel meter can indicate various parameters of the power output stage.

j. TTRA MODULES. – Each TTRA module contains two basic circuits: a plate-tuning circuit for the intermediate power amplifier circuit for the power amplifier, and a load tuning circuit. The tuning of the IPA circuit is variable over the entire frequency range of the module. Coarse tuning and loading of the PA circuits is accomplished by two switches that divide the frequency range of the module into narrow frequency bands; the switches select fixed tuning components. Fine tuning is then accomplished by means of variable capacitors. Thus, to tune and load the power amplifier, the PA TUNE switch and PA LOAD switch must be positioned to select the narrow band that includes the specified operating frequency of the TTRT module for the selected channel, and then the TTRA module must be fine tuned and loaded at the specified frequency.

Each TTRA module is interlocked to prevent operation of the linear amplifier if the module is removed.

k. POWER SUPPLY AND OVERLOAD PROTECTION. – The power supply used in the TTR-20 is a plug-in module that is described in a separate book; however, it is described here to the extent required for understanding the operation of the overload and interlock circuitry.

The power-supply module contains a low-voltage supply and a high-voltage supply. The low voltage outputs (+12V dc, -12V dc, +28V dc) are provided whenever power switch S1500 is set at either REC or XMIT/REC. The low voltage outputs are used in

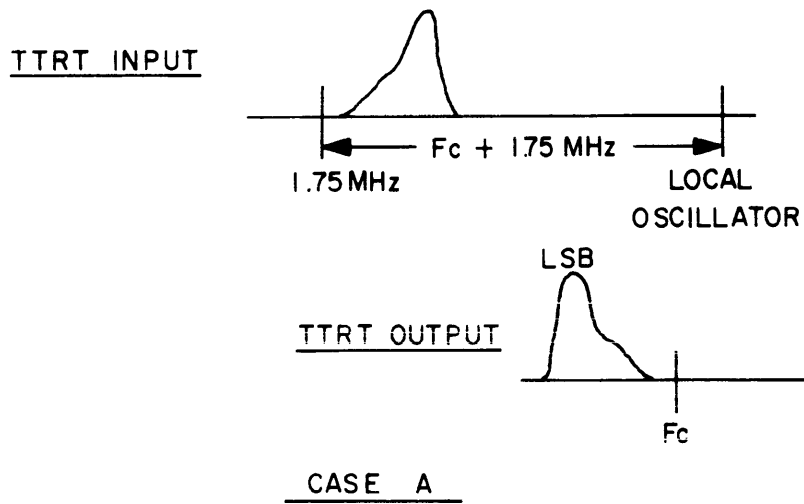
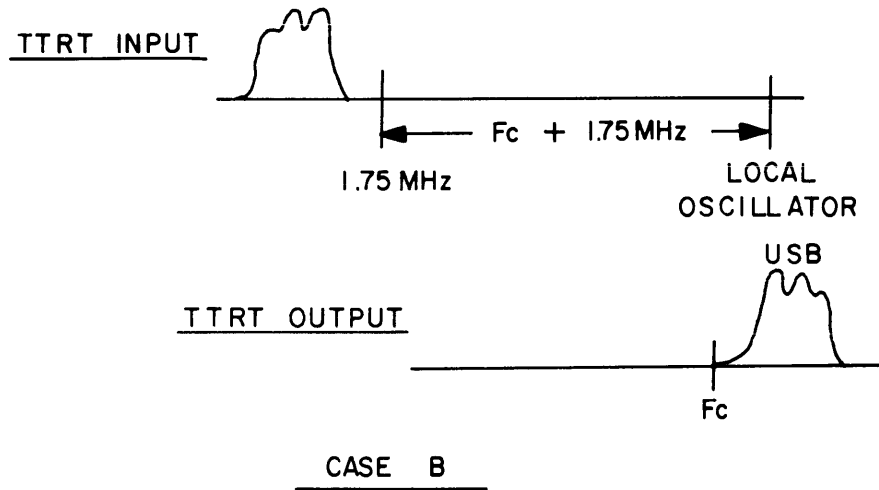


FIGURE 4-6. FREQUENCY INVERSION IN SSB TRANSMISSION

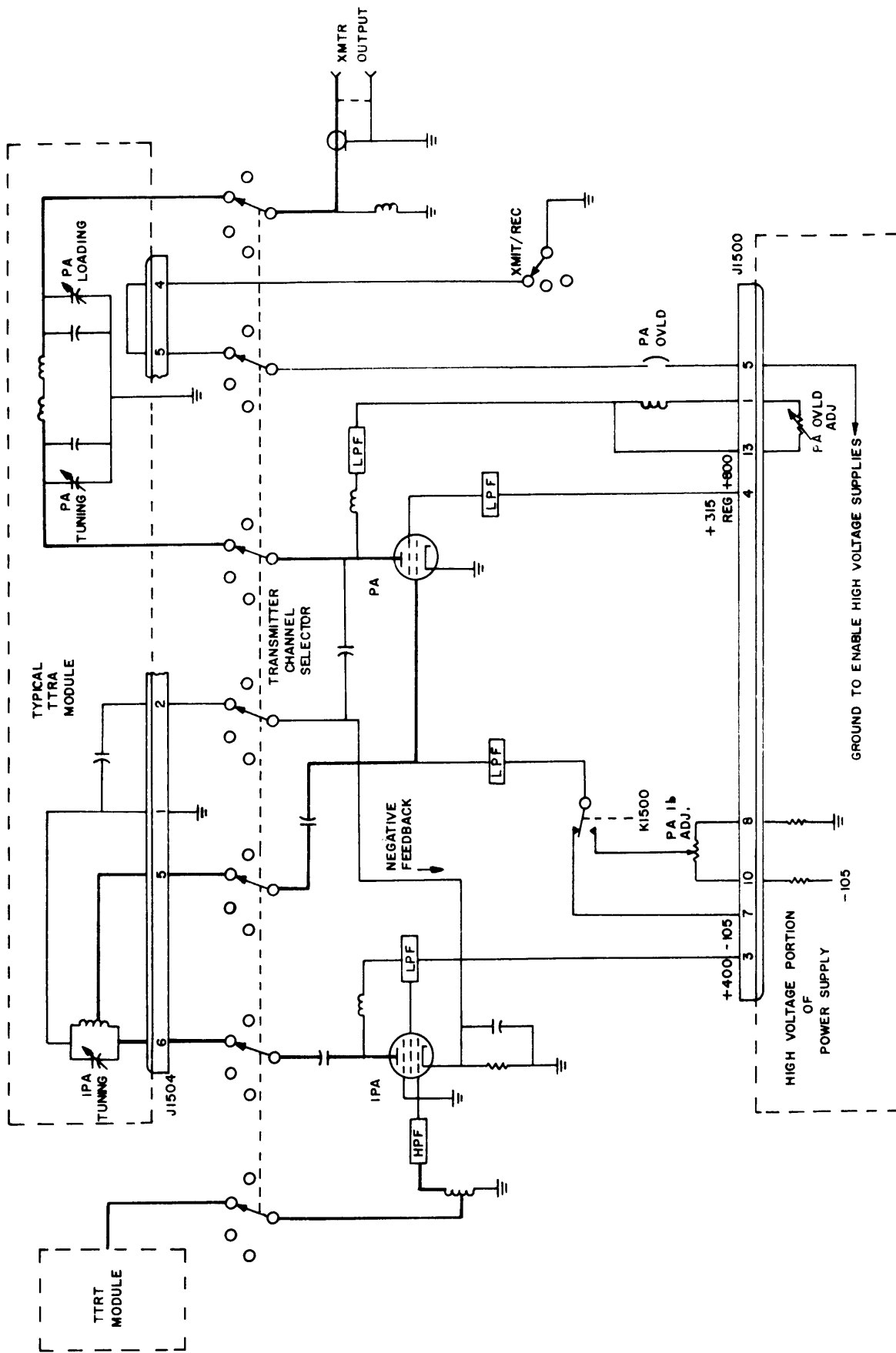


FIGURE 4-7. LINEAR AMPLIFIER, SIMPLIFIED SCHEMATIC

both the receiver section and in the exciter of the transmitter section.

The high-voltage power supply is energized only when power switch S1500 is set at XMIT/REC; other conditions described further on must also be met. The high voltage outputs are +800, +400, +315 and -105 volts; these are the supply and bias voltages for the linear amplifier.

The ac supply for the high voltage supply is connected through normally open contacts of a high voltage relay. This relay is energized by +12V dc whenever the ground return is completed through the power switch, PA OVLD circuit breaker CB1500, and the interlock in the selected TTRA module, and is interrupted whenever the breaker is tripped or the TTRA module for the selected channel is not in place; the circuit breaker trips whenever excessive plate current is drawn by V1501.

The power-supply module also contains an antenna relay (part of K1500) that provides switching of the receiver input and transmitter output for operation with one antenna (simplex operation). The antenna relay is energized through normally open contacts of the high voltage relay and transmit/receive relay connected in series. Thus, the antenna relay is deenergized except when the transmitter is keyed and the high voltage relay is energized. When the TTR-20 is wired for simplex operation and the antenna relay is deenergized, RCVR ANT jack J1502 is connected to the ANTENNA jack; the output of

the transmitter through XMTR OUTPUT jack J1501 is grounded. When the antenna relay is energized, XMTR OUTPUT jack J1501 is connected to the ANTENNA jack and the input to the receiver section through RCVR ANT jack J1502 is grounded.

In duplex operation, the interconnection between the RCVR ANT jack is removed so that the receiver input does not pass through the antenna relay. The transmitter connections are not changed so that the transmitter output to the ANTENNA jack is still switched by the antenna relay.

1. PA METER, METERING BOARDS AND METER CALIBRATION BOARD. – PA METER switch S1511 selects one of three power amplifier parameters for indication on the front panel meter M1500. With the switch in the Ib position, the plate current of the power amplifier is indicated on the meter. The meter is calibrated using R1509 on the meter calibration board. With S1511 in the EgRF position, a portion of the RF signal input to the power amplifier is rectified by CR1500 on the grid metering board and indicated on the meter. The meter is calibrated using R1507 on the meter calibration board. With S1511 in the EoRF position, a portion of the RF signal output at the antenna is rectified by CR1561 on the output metering and ALDC board and indicated on the meter. The meter is calibrated using R1511 on the meter calibration board. The meter calibration board also includes controls (R1513 and R1514) for setting the carrier control signal to the transmitter IF board for the various transmitter modes.

SECTION 5

MAINTENANCE

5-1. GENERAL

Troubleshooting and repair procedures described in this section are limited to the main chassis assembly and to the linear amplifier (TTRA). For troubleshooting and repair instructions for the receiver converter, transmitter converter and power supply, refer to the TTRR, TTRT and TPSA-20 manuals respectively.

Troubleshooting and alignment procedures are described for models of the TTR-20 which transmit both upper sideband and lower sideband signals. Refer to figures 5-2 through 5-10 for aid in locating components.

5-2. TEST EQUIPMENT REQUIRED

Test equipment required for procedures described in this section is listed in Table 5-1.

5-3 PREVENTIVE MAINTENANCE

Preventive maintenance procedures for the TTR-20 consist of routine visual inspection and cleaning. Cleaning is necessary because dust may accumulate on certain components and not only reduce the efficiency of the TTR-20, but also increase component

wear. Either a vacuum cleaner or compressed air hose should be used to clean the unit.

Visually checking the unit when it is opened for cleaning can prevent downtime due to component failure. Often a deteriorating component will look bad before it actually affects the operation of the unit. Some indications of trouble are: discolored components, dirty or pitted switch or relay contacts, warped printed circuit boards, and damaged wiring. Any components found in poor condition should be replaced. In addition, all hardware should be checked for tightness.

5-4. RECEIVER SECTION TROUBLESHOOTING

a. QUICK TESTS USING FRONT PANEL CONTROLS

(1) CHANNEL TEST – Try to receive signals on all frequencies selected by RECEIVER CHANNEL switch. If reception is possible on some but not all channels, the TTRR module for the channel on which reception is not possible is defective. If reception is not possible on any channel, additional tests are required to isolate the trouble.

(2) SIDEBAND TEST – Try to receive signals with RCVR switch set alternately at LSB and

TABLE 5-1 TEST EQUIPMENT REQUIRED

ITEM	FUNCTION
600 ohm ½ watt resistor.	Used in receiver section troubleshooting and alignment.
RF signal generator, Hewlett Packard Model 606A, or equivalent.	
50-ohm, 100 watt dummy load.	Used in transmitter section troubleshooting and alignment.
AF signal generator, Hewlett Packard Model 200CD, or equivalent.	Used in transmitter section and receiver section troubleshooting and alignment.
Vacuum tube voltmeter, Hewlett Packard Model 410B, or equivalent.	
Oscilloscope, Tektronix Type 545, or equivalent.	
Frequency counter, Hewlett Packard Model 524C, or equivalent.	
Volt-ohm-milliammeter, Simpson Model 260, or equivalent.	

USB/REMOTE. If reception is possible in LSB only, the USB oscillator is probably defective. If reception is possible in USB only, the LSB oscillator is probably defective. If reception is not possible in either position of the RCVR switch, additional tests are required to isolate the trouble.

b. SYSTEMATIC TROUBLESHOOTING

(1) Disconnect antenna from J1501 and all external wiring from TB1501.

(2) Connect a 600 ohm, 1 watt resistor across terminals 1 and 3 of TB1501. Set OFF / REC / XMIT/REC switch at REC.

(3) Set RCVR switch at LSB. Measure RF signal at emitter of Q1402 on receiver IF board; level should be between 0.5 and 1.0 V rms. If this signal is not obtained, check circuitry of LSB oscillator Q1407 and buffer Q1409.

(4) Set RCVR switch at USB/REMOTE. Measure RF signal at emitter of Q1402; level should be between 0.5 and 1.0 V rms. If this signal is not obtained, check circuitry of USB oscillator Q1408.

(5) Measure RF signal at arm of potentiometer R1463 on receiver IF board; level should be between 1.0 and 1.5 V rms. If this signal is not obtained, check circuitry of BFO Q1406 and buffer Q1405.

(6) Remove channel 1 TTRR module; set RECEIVER CHANNEL switch at 1.

(7) Connect signal generator to terminal 1 of receiver IF board; adjust signal generator to deliver 1 mV at 1749 kHz.

(8) Remove crystal Y1401. Measure RF signal at output of filter FL1401; level should be approximately 0.28V. If this signal is not obtained, check circuitry of IF amplifier Q1401 and Q1402.

(9) Replace crystal Y1401; reduce signal generator output to 30 uV. Measure AF signal at terminal 13 of receiver IF board, level should be at least 10 mV. If this signal is not obtained, check product detector, AF amplifier Q1403/Q1404 and associated circuitry.

(10) Adjust signal generator until level at terminal 11 is exactly 10 mV.

(11) Measure AF signal at terminals 1 and 3 of terminal board TB1501 (across 600 ohm resistor) level should be approximately 0.78 V rms. If this signal is not obtained, check circuitry of line amplifier Q1618.

(12) Measure signal at ungrounded end of resistor R1660 on receiver AF board (SQUELCH control R1518 must be adjusted so that squelch relay K1601 is deenergized) adjust VOLUME control R1515 until level is approximately 1.3 V rms. If this signal is

not obtained, check circuitry of audio amplifiers Q1613, Q1614/Q1615, and Q1616/Q1617.

(13) Connect signal generator to antenna jack J1502, adjust generator to deliver 1 uV at a frequency 1 kHz above channel 1 frequency. Replace channel 1 TTRR module.

(14) Measure AF signal at terminals 1 and 3 on terminal board TB1501; level should be 0.78 V rms. Disconnect signal generator; noise level should be 0.13 V or lower. If this sensitivity check is not satisfactory, the TTRR module is defective; refer to the appropriate TTRR technical manual.

5-5. TRANSMITTER SECTION TROUBLESHOOTING

a. QUICK TESTS USING FRONT PANEL CONTROLS

(1) CHANNEL TEST – Try to operate transmitter on all frequencies selected by TRANSMITTER CHANNEL switch. If the transmitter section operates properly on some but not all channels, the TTRR module for the inoperative channel is probably defective.

(2) SIDEBAND TEST – Try to transmit with the XMTR switch alternately set at LSB and USB/REMOTE. If transmission is possible on upper sideband only, the LSB oscillator is defective, and vice versa.

(3) VOX/PTT TEST – Set PTT/VOX switch at PTT. Close push-to-talk switch on microphone. Transmitter should key as evidenced by increase of PA plate current (observe front panel meter with PA METER switch set at Ib). If the transmitter does not key, the transmit-receive relay driver is defective. Set PTT/VOX switch at VOX; rotate VOX GAIN control fully clockwise. Speak into microphone; transmitter should key as the XMTR AF GAIN control is rotated clockwise. If the transmitter does not key, the VOX amplifier or detector is probably defective.

(4) CW/SSB TEST – Alternately try to operate the transmitter in the CW and SSB modes. If transmitter operates in CW mode only, the microphone preamplifier is probably defective. If transmitter operates in SSB mode only, the CW oscillator is probably defective.

b. SYSTEMATIC TROUBLESHOOTING

(1) Disconnect antenna from ANTENNA jack. Disconnect all external wiring from TB1500 and TB1501.

(2) Connect RF dissipator to ANTENNA jack.

(3) Connect signal generator to terminals 1 and 3 of terminal board TB1500; adjust generator to deliver 78 mV at 1 kHz.

(4) Measure AF signal across terminals 1 and 2 on transmitter AF board; level should be approximately 10 mV (adjust XMTR AF GAIN control as necessary). If this signal is not obtained, check audio amplifier Q1702/Q1703.

(5) Connect signal generator between ground and terminal 3 on the preamplifier and CW oscillator board; adjust generator to deliver 8 mV at 1 kHz. Signal across terminals 1 and 2 on transmitter AF board should be as noted in step (4). If this signal is not obtained, check audio preamplifier Q1902.

(6) Set CW/SSB/-20DB CARRIER/AM/MCW mode switch at CW. Connect terminal 11 on TB1500 to ground. Signal across terminals 1 and 2 on transmitter AF board should be as noted in step (4). If this signal is not obtained, check CW oscillator Q1901.

(7) Connect pin 5 on TB1500 to ground. Measure the RF output of Z1801 at the junction of R1829 and R1830. The level should be 0.9 V rms or better.

(8) Connect oscilloscope to pin 13 on transmitter IF board. With the mode switch set at SSB and no audio input, check for the presence of 1.75 MHz carrier; there should be no carrier visible on the scope. Set mode switch at -20DB carrier; there should be approximately 20 mV peak-to-peak carrier. Set mode switch at AME and then MCW; there should be approximately 200 mV peak-to-peak carrier. If any of the above voltages are not obtained, check Q1801 and associated circuitry.

(9) Set mode switch at CW. Measure RF signal at pin 2 (grid) of V1500; level should be between 2.1 and 2.8 V rms. If this signal is not obtained, the TTRT module is defective; refer to TTRT manual.

NOTE

When performing steps (10) and (11), do not key transmitter for more than 1 minute at a time. Leaving the transmitter keyed for long periods of time will damage the power amplifier tube.

(10) Set PA OVLD circuit breaker down. Measure RF signal at pin 2 or pin 6 (grid) of V1501; level should be between 15 and 18 V rms. If this signal is not obtained, check intermediate power amplifier V1500.

(11) Measure RF signal at J1501. Level should be 50 V rms. If this signal is not obtained, check power amplifier V1501.

5-6. RECEIVER SECTION ALIGNMENT

a. For change of receiver channel frequency, the IF and AF stage alignment procedure described in step

b need not be performed. For change of receiver channel frequency, perform TTRR alignment as outlined in the TTRR manual.

b. RECEIVER IF AND AF STAGES

(1) Disconnect all external wiring from TB1501. Connect 600 ohm resistor between terminals 1 and 3 on TB1501. Remove channel 1 TTRR module. Set RECEIVER CHANNEL switch at 1.

(2) Connect VTVM to secondary (terminal 3) of T1402; set VTVM at lowest scale.

(3) Adjust R1463 to obtain minimum voltage indication.

(4) Connect RF signal generator to terminal 1 on receiver IF board. Adjust generator to deliver 1 mV at 1749 kHz.

(5) Adjust R1544, C1404, C1402, C1455 and C1456 to obtain maximum signal at secondary of T1402; reduce signal generator output to obtain lowest usable indication on VTVM while performing this step.

(6) Set RCVR switch at LSB, tune signal generator to 1751 kHz; adjust R1543 to obtain maximum signal at secondary of T1402.

(7) Readjust C1404 and C1402, R1544 or R1543 until signal levels at secondary of T1402 are equal with upper sideband and lower sideband inputs applied (RCVR switch must be alternately set at USB and LSB respectively.)

(8) Connect counter across 600 ohm resistor on TB1501. Make sure that the signal generator output frequency is $1749 \text{ kHz} \pm 2 \text{ Hz}$. Set RCVR switch at USB/REMOTF. Adjust C1431 until counter indicates 1000 Hz.

(9) Tune signal generator to $1751 \text{ kHz} \pm 2 \text{ Hz}$. Set RCVR switch at LSB. Adjust C1429 until counter indicates 1000 Hz.

(10) Replace channel 1 TTRR module. Connect signal generator to J1502. Adjust signal generator to deliver 1 uV at a frequency 1 kHz below channel 1 frequency.

(11) Connect VTVM across 600 ohm resistor on TB1501. Adjust R1412 to obtain 0.78 V rms across 600 ohm resistor.

5-7. TRANSMITTER SECTION ALIGNMENT

a. For transmitter channel frequency change, perform TTRT module alignment as outlined in the TTRT technical manual and steps (1) through (3), steps (10) through (18) and step (25) of paragraph 5-7c (linear amplifier alignment). Exciter alignment, paragraph 5-7b, and the remainder of the linear amplifier alignment need be performed for corrective maintenance only.

b. EXCITER ALIGNMENT

- (1) Disconnect all external wiring from TB1500 and TB1501.
- (2) Connect terminal 11 on TB1500 to ground.
- (3) Connect terminal 5 on TB1500 to ground.
- (4) Connect the AF signal generator to terminals 1 and 3 on TB1500; adjust signal generator to deliver 78 mV at 1 kHz.
- (5) Set OFF / REC / XMIT/REC switch at XMIT/REC.
- (6) Rotate XMTR AF GAIN control fully clockwise. Connect oscilloscope to terminals 1 and 2 on transmitter AF board; adjust R1718 to obtain 10 mV rms between terminals 1 and 2.
- (7) Set mode switch at CW. Adjust R1903 (on preamplifier and CW oscillator board) to obtain 10 mV rms between terminals 1 and 2 on receiver audio board.
- (8) Set the XMTR switch at USB/REMOTE; rotate XMTR AF GAIN control fully clockwise.
- (9) Adjust C1810 for maximum output.
- (10) Rotate XMTR AF GAIN control fully counterclockwise; set mode switch at SSB; connect an oscilloscope to pin 13 on transmitter IF board.
- (11) With oscilloscope on its most sensitive range, adjust C1811 for a minimum signal.
- (12) Disconnect AF signal generator; set mode switch at CW.
- (13) Adjust R1814 and C1806 for maximum output with minimum distortion (see figure 5-1).

NOTE

Distortion or jitter along the edge of the waveform is caused by carrier through the improperly balanced bridge. Proper balance is obtained when R1814 is set approximately mid-range.

- (14) Set XMTR switch at LSB and repeat step (13), adjusting R1813 and C1804; repeat steps (13) and (14) until waveform is stable for both LSB and USB.
- (15) Readjust C1810 for equal amplitude in USB and LSB.
- (16) If necessary, align TTRT modules as outlined in the TTRT manual.

c. LINEAR AMPLIFIER ALIGNMENT

NOTE

Make sure that the exciter section of the transmitter has been properly aligned

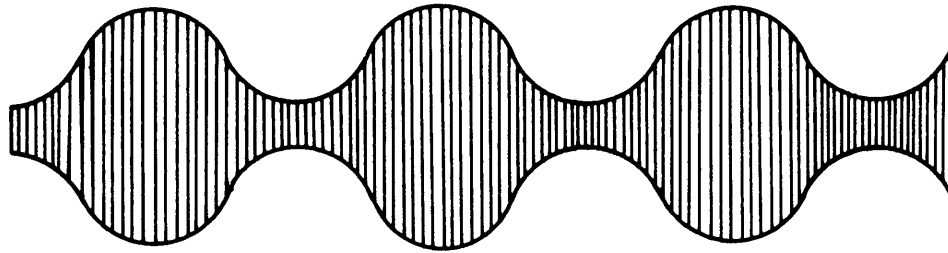
before attempting alignment of the linear amplifier section.

- (1) Connect a dummy load to ANTENNA jack at rear of unit.
- (2) Disconnect all external wiring from TB1500 and TB1501.
- (3) Connect a jumper wire from terminal 5 on TB1500 to ground.
- (4) Set OFF / REC / XMIT/REC switch at OFF.
- (5) Unsolder lead from C1527 at feed through to overload switch.
- (6) Connect VOM between disconnected lead and feed through (positive connection at feed through). Set VOM to scale having maximum reading greater than 50 mA.
- (7) Set OFF / REC / XMIT / REC switch at XMIT / REC. Rotate XMTR AF GAIN control fully counterclockwise. Unground terminal 5 of TB1500. Set PA OVLD circuit breaker down (on). Set PA METER switch at Ib. After 5 minutes ground terminal 5 of TB1500. Adjust R1500 (PA Ib ADJ) until VOM indicates 50 mA. Adjust R1509 on meter calibration board until front panel meter indicates 50 mA.
- (8) Set PA OVLD circuit breaker up (off) and disconnect ac power plug.
- (9) Resolder lead from C1527 to feed through to overload switch.
- (10) Remove TTRT module of channel on which alignment is being performed; connect TTRT module to module extender and insert extender into TTRT receptacle.
- (11) Connect ac power plug. Set PA OVLD circuit breaker down (on); Set OFF / REC / XMIT/REC switch at XMIT/REC.

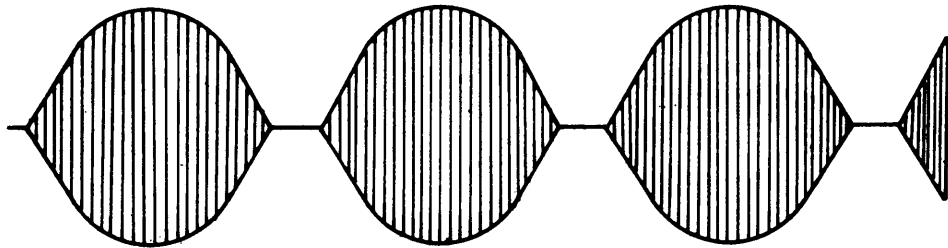
NOTE

When performing steps (12) through (19) below, refer to figure 5-12 for location of TTRA controls.

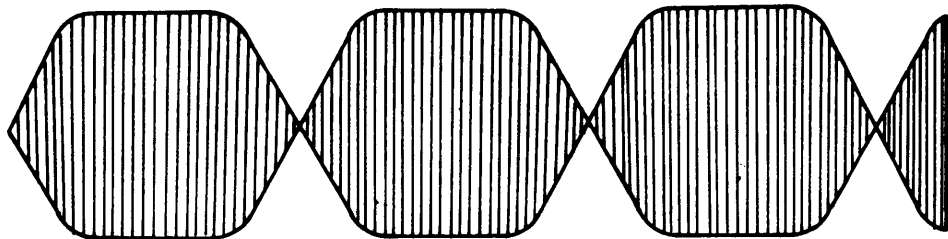
- (12) Set PA TUNING switch on TTRA module as indicated in table 5-2 for appropriate channel frequency. Set PA LOADING switch at 1. Rotate PA LOADING control fully counterclockwise.
- (13) Ensure that terminal 5 of TB1500 is grounded. Rotate XMTR AF GAIN control clockwise, and adjust IPA TUNING control on TTRA to obtain peak indication on front panel meter; keep meter indication as low as possible by adjusting XMTR AF GAIN control.



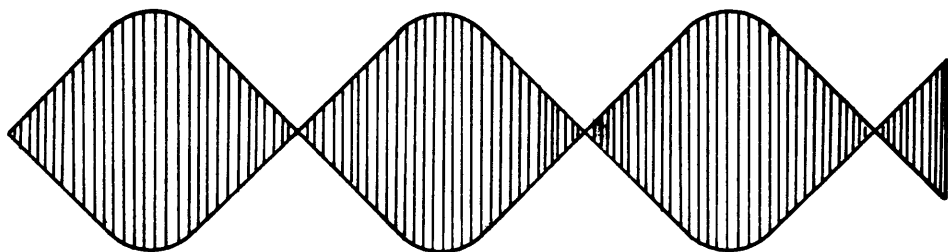
(a) INCORRECT SIDEBAND/CARRIER POWER RATIO



(b) EXCESSIVE DISTORTION (NEGATIVE CLIPPING)



(c) EXCESSIVE DISTORTION (POSITIVE CLIPPING)



(d) CORRECT MODULATION ENVELOPE

FIGURE 5-1. MODULATION ENVELOPES

TABLE 5-2. PA TUNE SWITCH SETTING

FREQUENCY (IN MHZ)	PA TUNE SWITCH SETTING	LINEAR AMPLIFIER MODULE
2-2.2	1	TTRA-1
2.2-2.5	2	
2.5-3.1	3	
3.1-4.0	4	
4.0-5.0	1	TTRA-2
5.0-6.3	2	
6.3-8.0	3 & 4	
8.0-10.0	1	TTRA-3
10.0-12.6	2	
12.6-16.0	3 & 4	
16.0-20.0	1	TTRA-4
20.0-24.0	2	
24.0-28.0	3	
28.0-32.0	4	

(14) Adjust XMTR AF GAIN control to obtain indication of approximately 75 mA on front panel meter. Adjust PA TUNING control to obtain dip on meter.

(15) Rotate PA LOADING switch clockwise until a sharp increase of PA plate current is indicated on front panel meter. Readjust PA TUNING control to obtain dip on front panel meter.

(16) Adjust PA TUNING control, PA LOADING control, and XMTR AF GAIN control until VTVM indicates 50 V rms at J1501, and front panel meter indicates approximately 125 mA.

(17) Adjust gain control on TTRT module until conditions described in step (15) are met with XMTR AF GAIN control at its fully clockwise position.

(18) Set PA OVLD circuit breaker up (off). Connect oscilloscope probe to J1501. Set mode switch at MCW.

(19) Set PA OVLD circuit breaker down; after 5 minutes, ground terminal 5 of TB1500. Oscilloscope pattern should conform with figure 5-1 d. If necessary adjust PA TUNING and PA LOADING controls on TTRA modules to minimize distortion. Adjust gain control on TTRT to keep RF voltage at J1501 at approximately 70 V rms; front panel meter should indicate approximately 175 mA.

NOTE

Slight readjustment of the PA LOADING controls may be necessary after the dummy load is disconnected and the TTR-20 is connected to its antenna.

(20) Connect VTVM to J1501 (parallel with dummy load). Set PA METER switch at EoRF. Adjust XMTR AF GAIN control until VTVM indicates 60 V rms.

(21) Adjust R1511 on meter calibration board until panel meter indicates 60 on red scale.

(22) Set PA OVLD circuit breaker up; unground terminal 5 of TB1500. Connect VTVM to grid (pin 2 or 6) of V1501. Set PA METER switch at EgRF and VTVM on 30 volt scale.

(23) Set PA OVLD circuit breaker down; unground terminal 5 of TB1500. Adjust XMTR AF GAIN control until VTVM indicates 20 V. Adjust R1507 on meter calibration board until front panel meter indicates 20 on green scale.

(24) Set PA OVLD circuit breaker up; unground terminal 5 of TB1501. Disconnect VTVM from equipment.

(25) Set PA OVLD circuit breaker down; ground terminal 5 of TB1501. Set PA METER switch at Ib.

Adjust gain control on TTRT until front panel meter indicates 180 mA; adjust PA OVLD ADJ control on power supply module until PA OVLD circuit breaker trips. Reduce gain of TTRT module, reset PA OVLD circuit breaker, and check that the circuit breaker does not trip with approximately 175 mA plate current.

(26) Set OFF / REC / XMIT/REC switch at OFF. Disconnect all test equipment from the TTR-20 and jumper wires from the terminal boards. Remove module

extender and re-insert TTRT module for normal operation; restore external wiring as required.

5-8. TRANSISTOR AND TUBE VOLTAGE MEASUREMENTS

Transistor and tube voltage measurements are listed in table 5-3. All readings are in volts dc. All voltage measurements are measured to chassis ground using 20 K ohms-per-volt meter.

FIGURE 5-3 TRANSISTOR AND TUBE VOLTAGES

A. TRANSISTORS				
SYMBOL	EMITTER	BASE	COLLECTOR	REMARKS
Q1701	-5.5	-5.6	-4.2	
Q1702	+20	-.06	-9.0	
Q1703	+16	0	-9.5	
Q1704	-1.6 to +1.6	-.15 to +.15	-12.5	
Q1705		-1.6 to +1.6		
Q1706	+.70 to -1.8	-2.0	+12.5	
Q1707	0	0	-12.5	Terminal 5, TB1500 grounded
	0	-.22	0	Terminal 5, TB1500 ungrounded.
Q1708	0	-.30	0	Terminal 5, TB1500 grounded, K1500 energized
	0	+.5	+12.5	K1500 de-energized
Q1801	+1		+10	S1505 at SSB for Q1801 to Q1808
Q1802	+22		+10	
Q1803	0	+35	+10	
Q1804	(SOURCE)	(GATE)	+35 (DRAIN)	
Q1805	+12 "	0 "	+1.8 "	} With LSB filter on XMTR IF BD. Reverse readings for USB filter
Q1806	-.2 "	0 "	-.2 "	
Q1807	+12 "	0 "	0 "	
Q1808	+12 "	0 "	0 "	
Q1401	+27	+.02	-11.5	
Q1402	-.32	0	-11.0	
Q1403	+14	0	-11.7	
Q1404	+17	0	-5.9	
Q1405	+12	+12	-7.7	
Q1406	+29	+12	-5.7	
Q1407	+.01	0	-5.4	K1501 de-energized
	0	0	-12.5	K1501 energized
Q1408	+.01	0	-5.4	K1501 energized
	0	0	-12.5	K1501 de-energized

A. TRANSISTORS (Cont'd)				
SYMBOL	EMITTER	BASE	COLLECTOR	REMARKS
Q1409	+05	0	-11.5	
Q1410	+12	0	-11.3	
Q1411	+3.0	+3.1	+12.5	No signal.
	+5.6	+5.9	+12.5	1mV signal at base of Q1401
Q1412	+2.6	+2.6	+12.5	No signal
	+5.5	+5.6	+12.5	1mV signal at base of Q1401
Q1613	+25	+12	-7.1	
Q1614	+20	+06	-12.3	
Q1615	+14	0	-12.3	
Q1617	+12.5	+12.5	-12.4	
Q1618	+17	+02	-10.0	
Q1619	+1.8	+1.65	-6.3	SQUELCH max. clockwise
	+5.1	+7.1	-12.6	SQUELCH max. counter clockwise
Q1620	-1.8	+2.8	-8.0	SQUELCH max. clockwise, no signal
	+5.1	+2.8	+3.2	SQUELCH max. counter clockwise, no signal
	+1.8	+5.0	-8.6	SQUELCH max. clockwise, 1mV signal at base of Q1401
Q1621	-7.8	-8.0	-8.2	SQUELCH max. clockwise, no signal, K1601 energized.
	0	+3.2	-12.6	SQUELCH max. counter clockwise, no signal, K1601 de-energized
	-8.4	-8.6	-8.5	SQUELCH max. clockwise, 1mV at base of Q1401, K1601 energized.

B. ELECTRON TUBES					
SYMBOL	PLATE(S)	SCREEN	CONTROL GRID	CATHODE	FILAMENT
V1500	+300 pin 7	+300 pin 8	0 pin 2	+9 pin 1	6.3 Vac pin 5
V1501	+800 both caps	+320 pin 3	-50 to -30 pins 2 & 6 when keyed 105 when not keyed	0	6.3 Vac pin 5

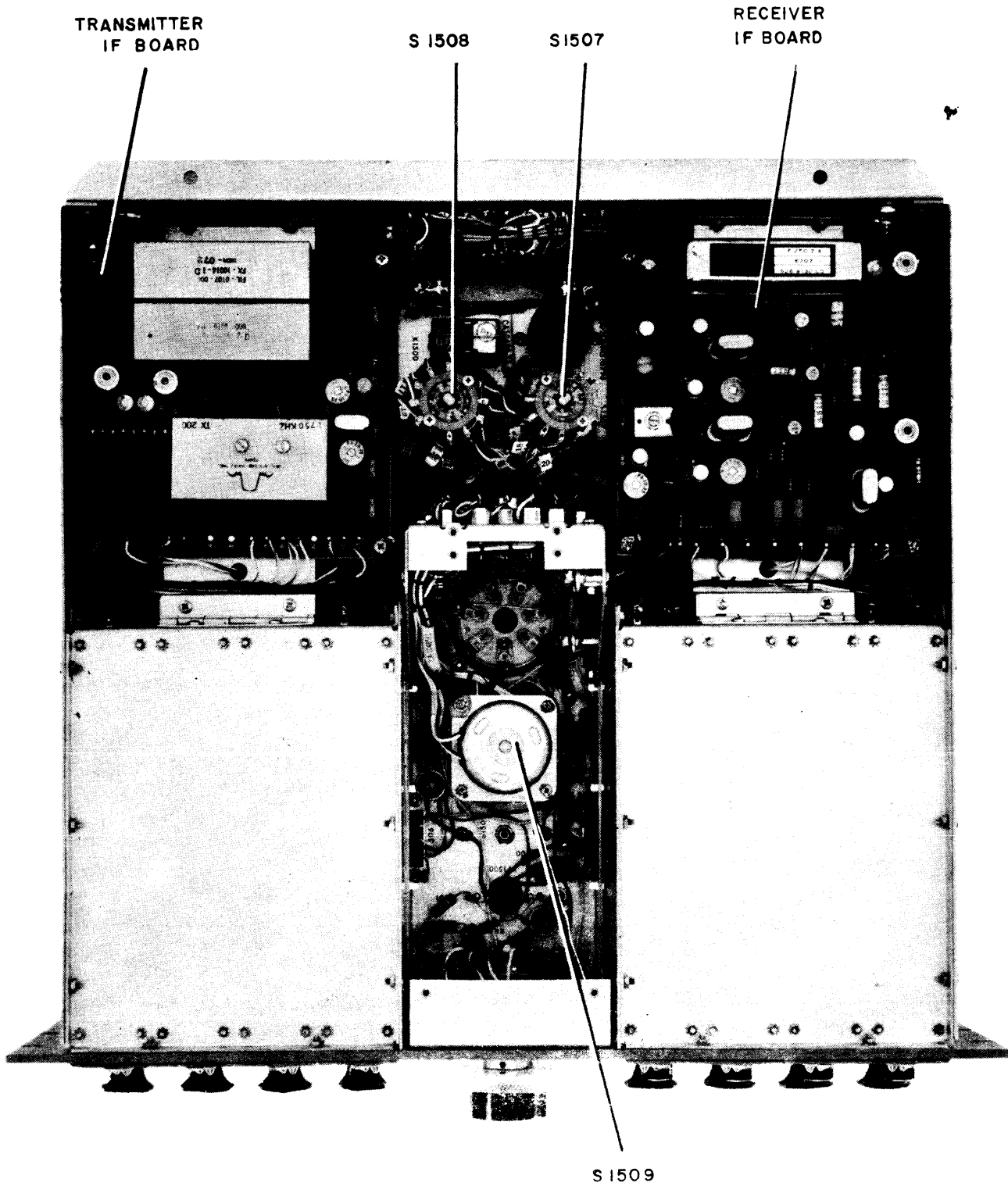
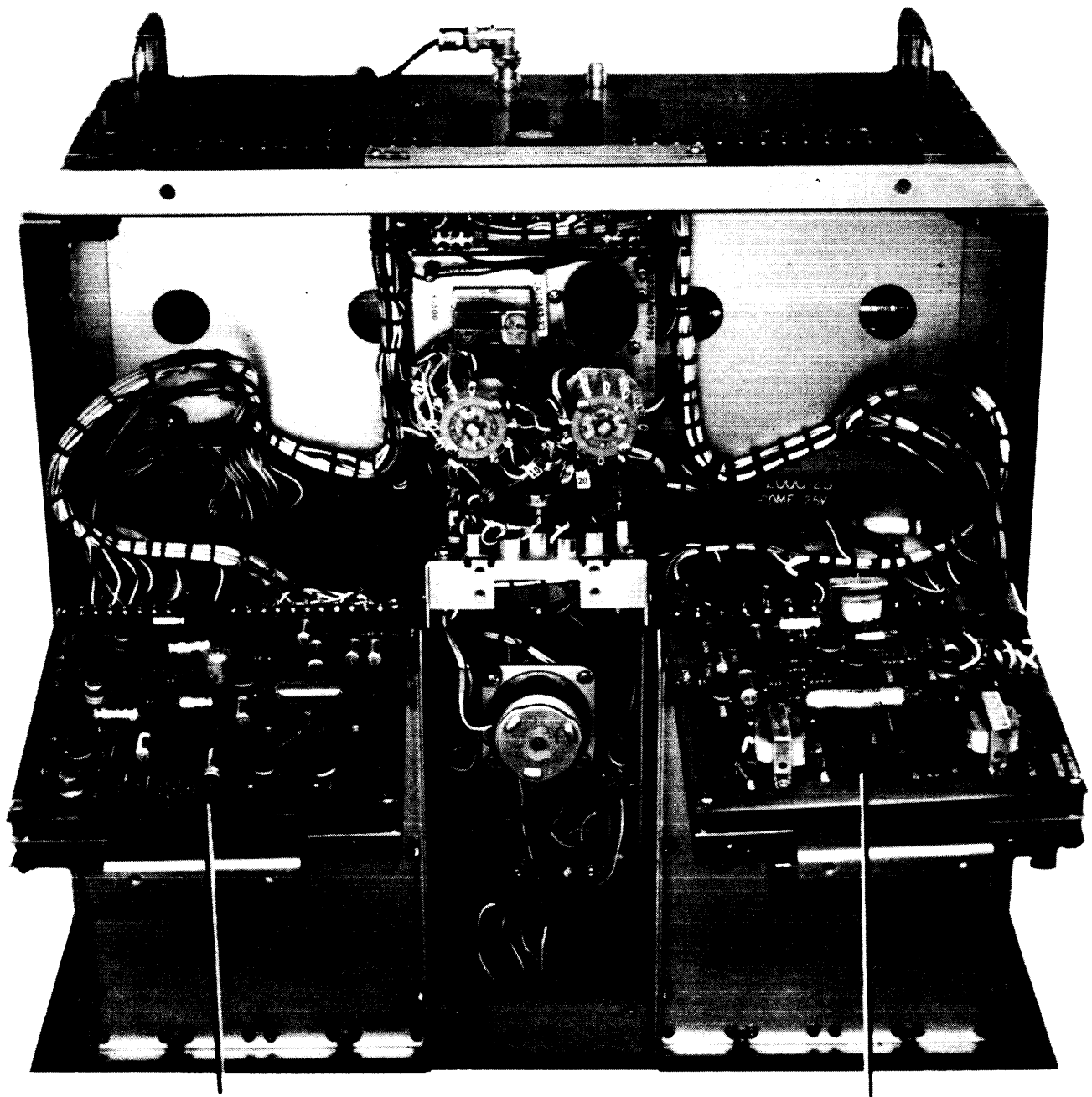


FIGURE 5-2. TTR-20, BOTTOM VIEW

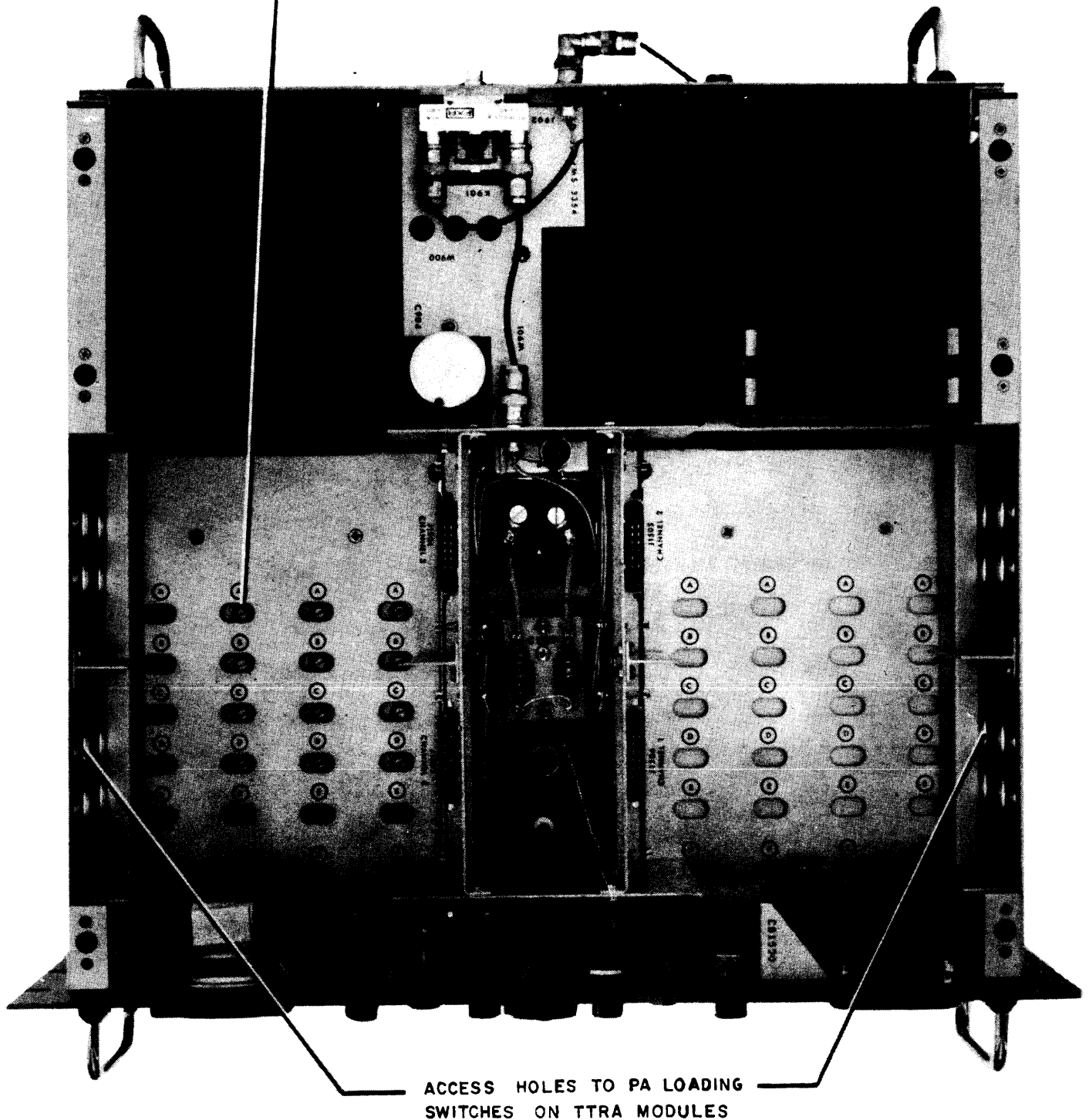


TRANSMITTER AUDIO BOARD

RECEIVER AUDIO BOARD

FIGURE 5-3. TTR-20, BOTTOM VIEW WITH UNDERSIDE OF HINGED BOARD ASSEMBLIES EXPOSED

ACCESS HOLE FOR TTRR
MODULE ADJUSTMENT
(1 OF 20)



ACCESS HOLES TO PA LOADING
SWITCHES ON TTRA MODULES

FIGURE 5-4. TTR-20, TOP VIEW WITH TTRA MODULES REMOVED

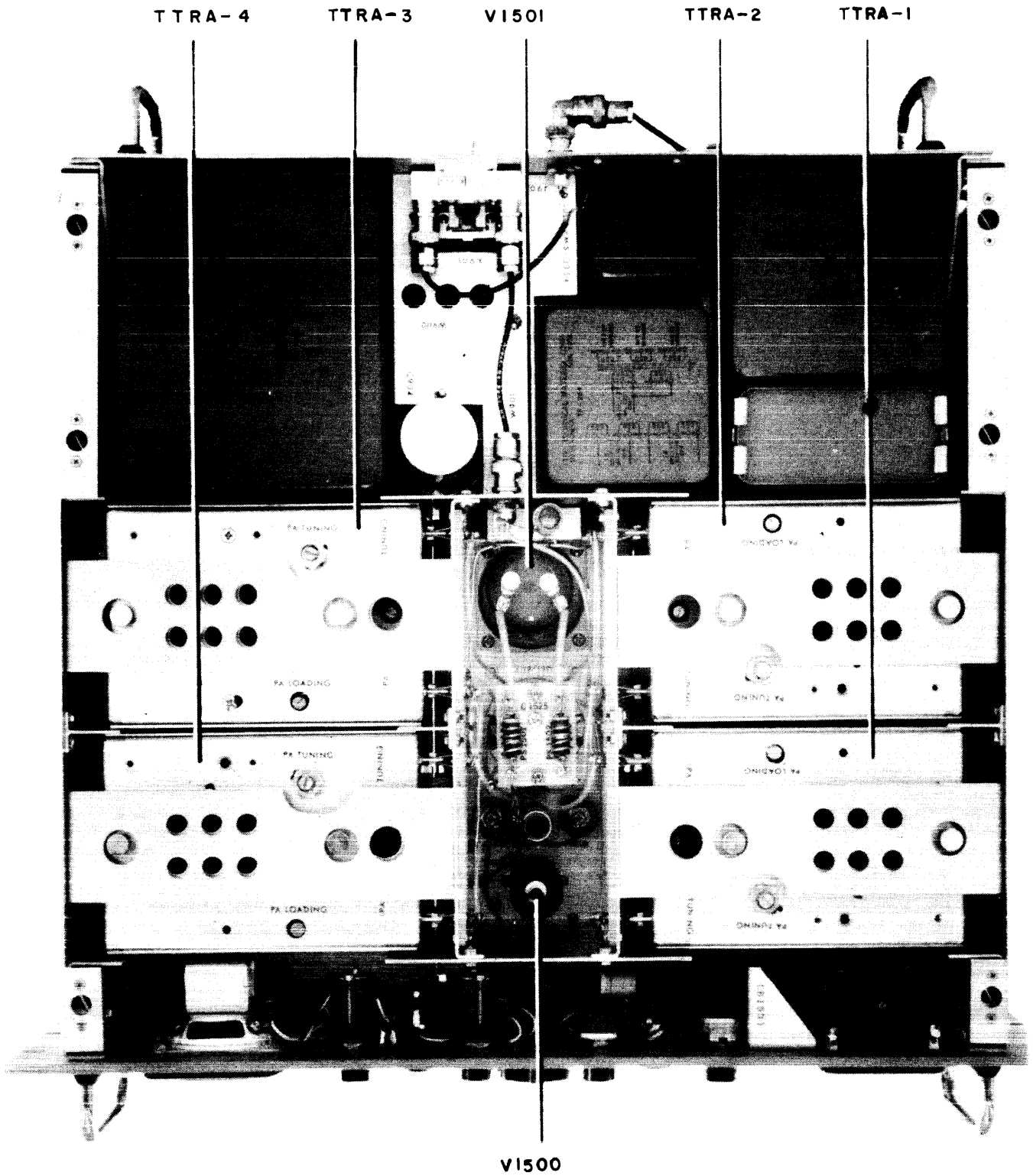


FIGURE 5-5. TTR-20, TOP VIEW



FIGURE 5-6 RECEIVER IF BOARD, TOP VIEW

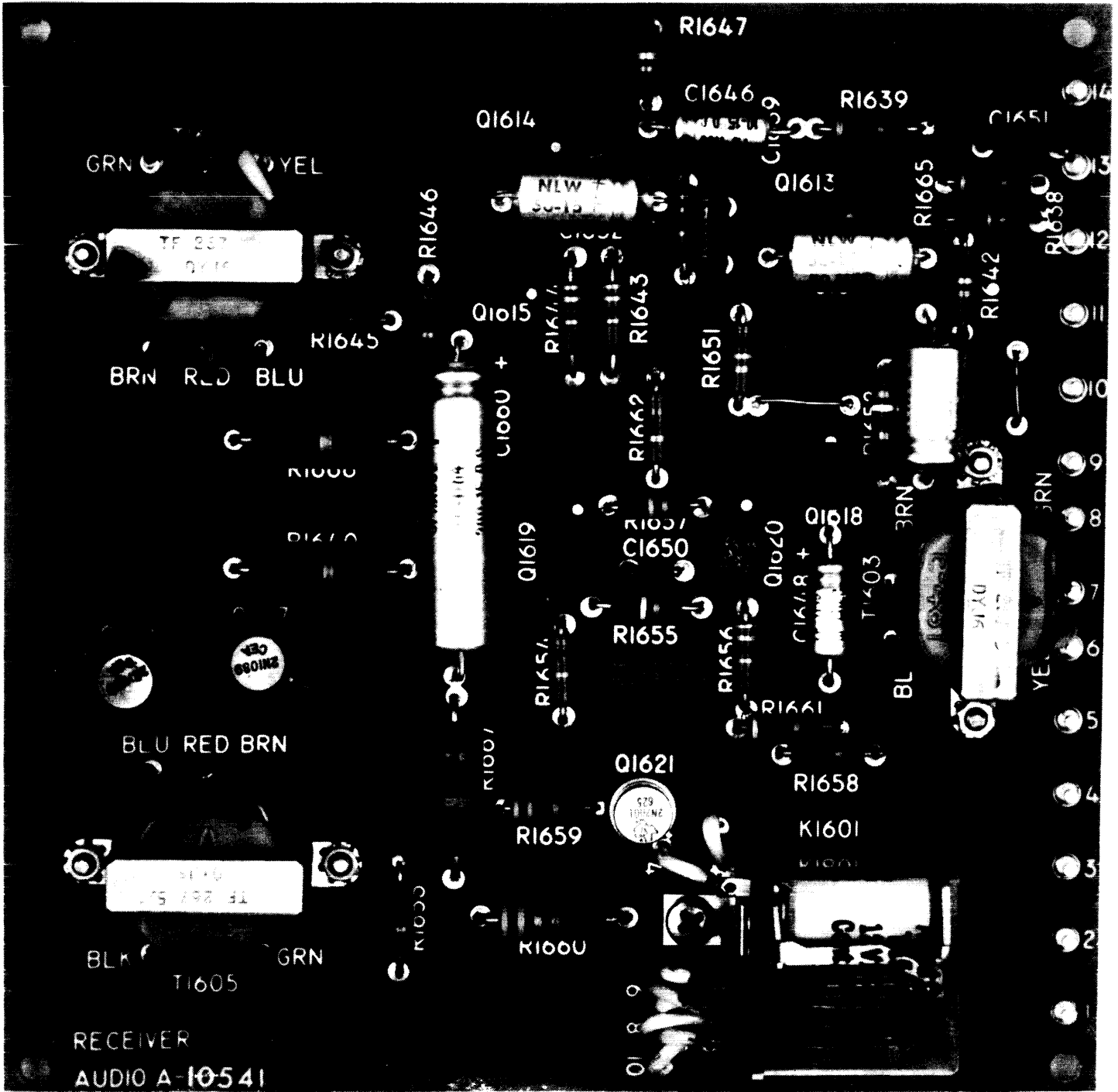


FIGURE 5-7. RECEIVER AUDIO BOARD, TOP VIEW

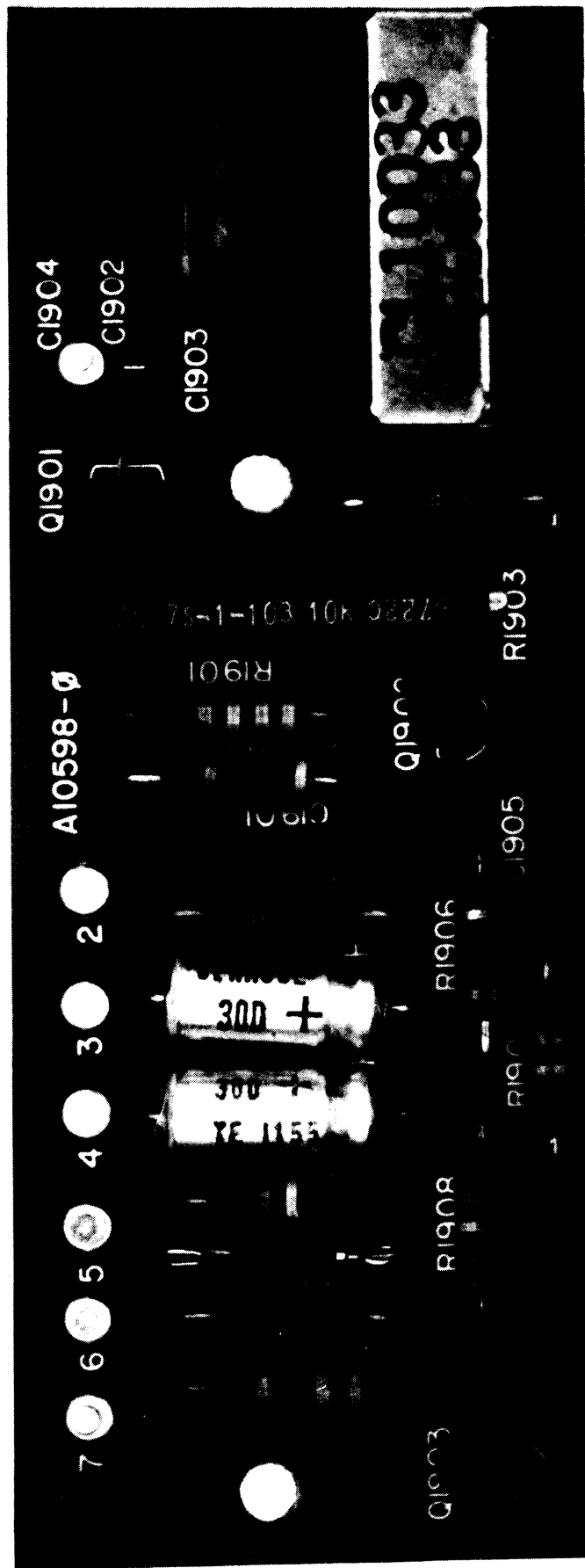


FIGURE 5-10 PREAMPLIFIER AND CW OSCILLATOR BOARD, TOP VIEW



FIGURE 5-11 METER CALIBRATION BOARD, TOP VIEW

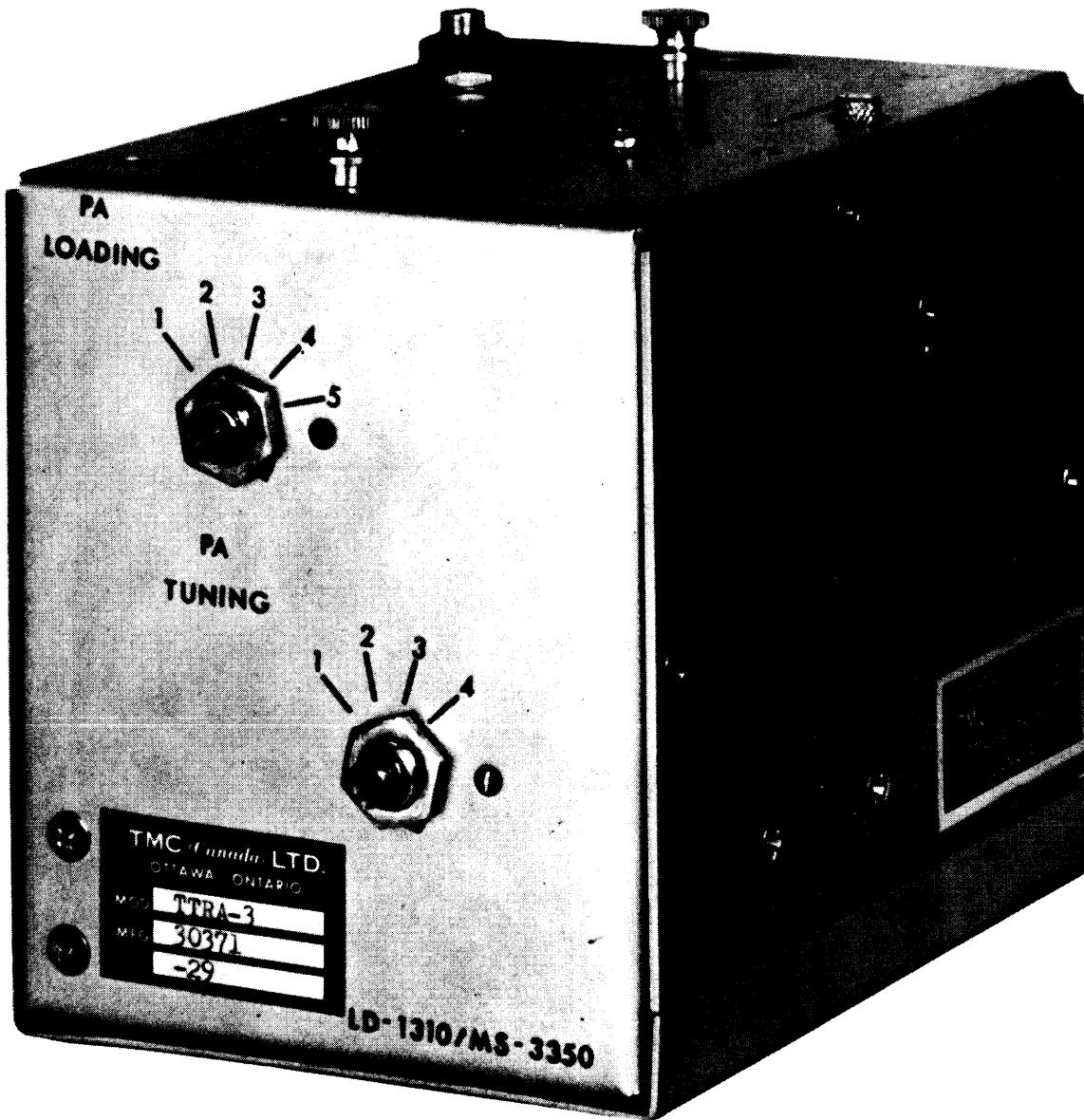


FIGURE 5-12. TTRA MODULE

SECTION 6

PARTS LIST

6-1. INTRODUCTION.

Reference designations have been assigned to identify all electrical parts of the equipment. These designations are used for marking the equipment (adjacent to the parts they identify) and are included on drawings, diagrams and the parts list. The letters of a reference designation indicate the kind of part (generic group), such as resistor, capacitor,

transistor, etc. The number differentiates between parts of the same generic group. Sockets associated with a particular plug-in device, such as transistor or fuse, are identified by a reference designation which includes the reference designation of the plug-in device. For example, the socket for crystal Y101 is designated XY101. To expedite delivery, when ordering replacement parts, specify the TMC part number and the model number of the equipment.

**FINAL TUNE MODULE, 2-4 MHz
TTRA-1
SYMBOL SERIES 1100**

REF SYMBOL	DESCRIPTION	TMC PART NUMBER
C1101	CAPACITOR, VARIABLE, MICA: 210-1000 pf, 175 WVDC	CV113-4
C1102	CAPACITOR, FIXED, MICA: 1500 pf, $\pm 10\%$, 500 WVDC	CM20B152K
C1103	CAPACITOR, VARIABLE, AIR: 12.9-342 pf, 1000 vac peak	CB168-1
C1104	CAPACITOR, FIXED, CERAMIC: 10pf $\pm 10\%$, 5000 WVDC	CC109-5
C1105	CAPACITOR, FIXED, MICA: 560 pf, $\pm 10\%$, 2500 WVDC	CM45B561K
C1106	CAPACITOR, FIXED, MICA: 390 pf, $\pm 10\%$, 2500 WVDC	CM45B391K
C1107	CAPACITOR, FIXED, MICA: 330 pf, $\pm 10\%$, 2500 WVDC	CM45B331K
C1108	CAPACITOR, FIXED, MICA: 220 pf, $\pm 2\%$, 2500 WVDC	CM45B221G
C1109	CAPACITOR, VARIABLE, MICA: 390-1400 pf, 175 WVDC	CV113-8
C1110	CAPACITOR, FIXED, MICA: 1000 pf, $\pm 10\%$, 2500 WVDC	CM45B102K
C1111	Same as C1110	
C1112	Same as C1110	
C1113	Same as C1110	
C1114	Same as C1108	
J1101	CONNECTOR, RECEPTACLE, ELECTRICAL	JJ286-6
S1101	SWITCH, ROTARY	SW330
S1102	SWITCH, ROTARY	SW331
T1101	TRANSFORMER, R.F.	TZ117
T1102	TRANSFORMER, R.F.	TZ120

**FINAL TUNE MODULE, 4-8 MHz
TTRA-2
SYMBOL SERIES 1200**

REF SYMBOL	DESCRIPTION	TMC PART NUMBER
C1201	CAPACITOR, VARIABLE, MICA: 80-480 pf, 175 WVDC	CV113-2
C1202	CAPACITOR, VARIABLE, AIR: 12.9-342 pf, 1000 vac peak	CB168-1
C1203	CAPACITOR, FIXED, MICA: 160 pf, ±10%, 2500 WVDC	CM45B161K
C1204	CAPACITOR, FIXED, MICA: 100 pf, ±10%, 2500 WVDC	CM45B101K
C1205	CAPACITOR, VARIABLE, MICA: 240-1100 pf, 175 WVDC	CV113-7
C1206	CAPACITOR, FIXED, MICA: 560 pf, ±10%, 2500 WVDC	CM45B561K
C1207	Same as C1206	
C1208	Same as C1206	
C1209	Same as C1206	
J1201	CONNECTOR, RECEPTACLE, ELECTRICAL	JJ286-6
S1201	SWITCH, ROTARY	SW330
S1202	SWITCH, ROTARY	SW331
T1201	TRANSFORMER, R.F.	TZ118
T1202	TRANSFORMER, R.F.	TZ121

**FINAL TUNE MODULE, 8-16 MHz
TTRA-3
SYMBOL SERIES 1300**

REF SYMBOL	DESCRIPTION	TMC PART NUMBER
C1301	CAPACITOR, VARIABLE, MICA: 9-180 pf, 175 WVDC	CV113-5
C1302	CAPACITOR, VARIABLE, AIR: 10-210 pf, 1000 vac peak	CB169-1
C1303	CAPACITOR, FIXED, MICA: 56 pf, $\pm 10\%$, 2500 WVDC	CM45B560K
C1304	CAPACITOR, VARIABLE, AIR: 110-580 pf, 175 WVDC	CV113-6
C1305	CAPACITOR, FIXED, MICA: 390 pf, $\pm 10\%$, 2500 WVDC	CM45B391K
C1306	Same as C1305	
C1307	Same as C1305	
C1308	CAPACITOR, FIXED, MICA: 160 pf, $\pm 10\%$, 500 WVDC	CM15B161K
C1309	CAPACITOR, FIXED, CERAMIC: 5 pf, $\pm 10\%$, 5000 WVDC	CC109-3
J1301	CONNECTOR, RECEPTACLE, ELECTRICAL	JJ286-6
S1301	SWITCH, ROTARY	SW330
S1302	SWITCH, ROTARY	SW331
T1301	TRANSFORMER, R.F.	TZ116
T1302	TRANSFORMER, R.F.	TZ122

**FINAL TUNE MODULE, 16-24, 24-32 MHz
TTRA-4
SYMBOL SERIES 1400**

REF SYMBOL	DESCRIPTION	TMC PART NUMBER
C1401	CAPACITOR, VARIABLE, MICA; 25-280 pf, 175 WVDC	CV113-1
C1402	CAPACITOR, VARIABLE, AIR: 10-210 pf, 1000 vac peak	CB169-1
C1403	CAPACITOR, VARIABLE, MICA: 110-580 pf, 175 WVDC	CV113-6
C1404	CAPACITOR, FIXED, MICA: 220 pf, $\pm 10\%$, 2500 WVDC	CM45B221K
C1405	Same as C1404	
C1406	CAPACITOR, FIXED, MICA: 160 pf, $\pm 10\%$, 2500 WVDC	CM45B161K
J1401	CONNECTOR, RECEPTACLE, ELECTRICAL	JJ286-6
S1401	SWITCH, ROTARY	SW330
S1402	SWITCH, ROTARY	SW331
T1401	TRANSFORMER, R.F.	TZ119
T1402	TRANSFORMER, R.F.	TZ123

**RECEIVER IF BOARD A10556
SYMBOL SERIES 1400**

REF SYMBOL	DESCRIPTION	TMC PART NUMBER
C1401	CAPACITOR, FIXED, CERAMIC: .1 uf, +80%-20%, 300 WVDC	CC100-28
C1402	CAPACITOR, VARIABLE, MICA: 25-280 pf, 175 WVDC	CV114-1
C1403	CAPACITOR, FIXED, MICA: 1800 pf, ±2%, 500 WVDC	CM100-13
C1404	CAPACITOR, VARIABLE, CERAMIC: 10-75 pf, 350 WVDC	CV109-8
C1405	CAPACITOR, FIXED, CERAMIC: .2 uf, +80%-20%, 25 WVDC	CC100-33
C1406	Same as C1401	
C1407	CAPACITOR, FIXED, CERAMIC: .025 uf, +80-20%, 500 WVDC	CC100-25
C1408	CAPACITOR, FIXED, MICA: 68 pf, ±2%, 500 WVDC	CM15C680G03
C1409	CAPACITOR, FIXED, MICA: 510 pf, ±5%, 500 WVDC	CM15F511J03
C1410	CAPACITOR, FIXED, MICA: 180 pf, ±2%, 500 WVDC	CM111D181G5S
C1411	Same as C1410	
C1412	Same as C1407	
C1413	Same as C1407	
C1414	CAPACITOR, FIXED, ELECTROLYTIC: 25 uf, 15 WVDC	CE105-25-15
C1415	CAPACITOR, FIXED, ELECTROLYTIC: 50 uf, 15 WVDC	CE105-50-15
C1416	CAPACITOR, FIXED, ELECTROLYTIC: 4 uf, 15 WVDC	CE105-4-15
C1417	CAPACITOR, FIXED, CERAMIC: .01 uf, GMV, 500 WVDC	CC100-16
C1418	Same as C1405	
C1419	Same as C1405	
C1420	CAPACITOR, FIXED, CERAMIC: 5000 pf, GMV, 500 WVDC	CC100-15
C1421	CAPACITOR, FIXED, MICA: 270 pf, ±5%, 500 WVDC	CM15F271J03
C1422	Same as C1417	
C1423	CAPACITOR, FIXED, MICA: 47 pf, ±5%, 500 WVDC	CM15C470J03
C1424	Same as C1401	
C1425	Same as C1401	
C1426	Same as C1401	
C1427	Same as C1421	
C1428	Same as C1405	
C1429	CAPACITOR, VARIABLE, CERAMIC: 8-50 pf, 350 WVDC	CV109-6
C1430	CAPACITOR, FIXED, MICA: 24 pf, ±5%, 500 WVDC	CM15C240J03
C1431	Same as C1429	
C1432	Same as C1430	
C1433	Same as C1421	

**RECEIVER IF BOARD A10556
SYMBOL SERIES 1400**

REF SYMBOL	DESCRIPTION	TMC PART NUMBER
C1434	Same as C1405	
C1435	Same as C1401	
C1436	Same as C1401	
C1437	Same as C1417	
C1438	Same as C1405	
C1439	Not used	
C1440	CAPACITOR, FIXED, ELECTROLYTIC: 6 uf, 15 WVDC	CE105-6-15
C1441	Same as C1414	
C1442	Same as C1417	
C1443	Same as C1401	
C1444	Same as C1401	
C1445	CAPACITOR, FIXED, MICA: 1000 pf, $\pm 2\%$, 500 WVDC	CM20F102G03
C1453	Same as C1401	
C1454	Same as C1405	
C1455	CAPACITOR, VARIABLE, CERAMIC: 9-35 pf, 100 WVDC	CV112-2
C1456	Same as C1455	
C1457	Same as C1401	
C1458	CAPACITOR, FIXED, MICA: 10pf, $\pm 10\%$, 500 WVDC	CM15C100J03YY
C1461	CAPACITOR, FIXED, MICA: 680 pf, $\pm 5\%$, 500 WVDC	CM111E681J5S
CR1401	DIODE	IN34A
CR1402	Same as CR1401	
CR1403	Same as CR1401	
CR1404	Same as CR1401	
CR1405	DIODE	IN68
CR1406	Same as CR1405	
CR1407	Same as CR1405	
FL1401	FILTER, BANDPASS: 250 kHz	FX195-1
L1401	COIL R.F. FIXED: 47000 uh	CL275-473
L1402	COIL R.F. FIXED: 220 uh, $\pm 10\%$	CL140-6
L1404	Same as L1402	
L1405	Same as L1402	
L1407	COIL RF FIXED: 1000 uh	CL275-102
L1408	Same as L1402	

**RECEIVER IF BOARD A10556
SYMBOL SERIES 1400**

REF SYMBOL	DESCRIPTION	TMC PART NUMBER
L1410	COIL R.F. FIXED: 150 uh	CL275-151
Q1401	TRANSISTOR	2N2495
Q1402	Same as Q1401	
Q1403	TRANSISTOR	2N1370-4
Q1404	Same as Q1403	
Q1405	Same as Q1401	
Q1406	Same as Q1401	
Q1407	Same as Q1401	
Q1408	Same as Q1401	
Q1409	Same as Q1401	
Q1410	TRANSISTOR	2N1190
Q1411	TRANSISTOR	2N697
Q1412	Same as Q1411	
R1401	RESISTOR, FIXED, COMP: 1000 ohms, ±5%, ½ watt	RC20GF102J
R1402	RESISTOR, FIXED, COMP: 100 ohms, ±5%, ½ watt	RC20GF101J
R1403	RESISTOR, FIXED, COMP: 10K ohms, ±5%, ½ watt	RC20GF103J
R1404	Same as R1401	
R1405	Same as R1403	
R1408	Same as R1401	
R1409	Same as R1401	
R1410	RESISTOR, FIXED, COMP: 470 ohms, ±5%, ½ watt	RC20GF471J
R1411	Same as R1403	
R1412	RESISTOR, VARIABLE, COMP: 500 ohms, ±10%, 2 watt	RV111U501A
R1413	Same as R1403	
R1414	RESISTOR, FIXED, COMP: 4700 ohms, ±5%, ½ watt	RC20GF472J
R1415	Same as R1414	
R1416	RESISTOR, FIXED, COMP: 22 ohms, ±5%, ½ watt	RC20GF220J
R1417	Same as R1403	
R1418	RESISTOR, FIXED, COMP: 3300 ohms, ±5%, ½ watt	RC20GF332J
R1419	Same as R1401	
R1420	Same as R1401	
R1421	Same as R1414	
R1422	Same as R1401	

**RECEIVER IF BOARD A10556
SYMBOL SERIES 1400**

REF SYMBOL	DESCRIPTION	TMC PART NUMBER
R1423	Same as R1401	
R1424	Same as R1414	
R1425	Same as R1403	
R1426	Same as R1401	
R1427	Same as R1414	
R1428	Same as R1403	
R1429	RESISTOR, FIXED, COMP: 560 ohms, ±5%, ½ watt	RC20GF561J
R1430	RESISTOR, FIXED, COMP: 6.8 k ohms, ±5%, ½ watt	RC20GF682J
R1431	Same as R1401	
R1432	Same as R1403	
R1433	Same as R1403	
R1434	RESISTOR, FIXED, COMP: 2.7 k ohms, ±5%, ½ watt	RC20GF272J
R1435	Same as R1401	
R1436	RFSISTOR, FIXED, COMP: 220 ohms, ±5%, ½ watt	RC20GF221J
R1437	RESISTOR, FIXED, COMP: 100 k ohms, ±5%, ½ watt	RC20GF104J
R1463	Same as R1412	
R1468	Same as R1401	
T1401	TRANSFORMER, IF	TZ126
T1402	TRANSFORMER, PULSE	TF228K15
Y1401	CRYSTAL, QUARTZ	CR46A/ U250.000 kHz
Y1402	CRYSTAL, QUARTZ	CR18/ U2.000000 MHz
Y1403	CRYSTAL, QUARTZ	CR18/ U1.500000 MHz

**TTR-20 MAIN CHASSIS
SYMBOL SERIES 1500**

REF SYMBOL	DESCRIPTION	TMC PART NUMBER
C1500	CAPACITOR, FIXED, ELECTROLYTIC: 2000 uf, 25 WVDC	CE116-5VN
C1501	CAPACITOR, FIXED, CERAMIC: 2000 pf, ±20%, 500 WVDC	CK70AW202M
C1502	CAPACITOR, FIXED, MICA: 510 pf, ±20%, 500 WVDC	CM15F511J03
C1503	CAPACITOR, FIXED, MICA: 1000 pf, ±2%, 500 WVDC	CM20F102G03
C1504	CAPACITOR, FIXED, MICA: 1000 pf, ±5%, 500 WVDC	CM113QE102J
C1505	CAPACITOR, FIXED, MICA: 2000 pf, ±2%, 500 WVDC	CM100-14
C1506	Same as C1504	
C1507	CAPACITOR, FIXED, MICA: 3000 pf, ±2%, 500 WVDC	CM30F302G03
C1508	Same as C1501	
C1509	Same as C1501	
C1510	CAPACITOR, FIXED, MICA: 8100 pf, ±5%, 500 WVDC	CM113QE812J
C1511	Same as C1503	
C1512	Same as C1504	
C1513	Same as C1510	
C1514	CAPACITOR, FIXED, CERAMIC-HV: 5 pf, ±10%, 5000 WVDC	CC109-3
C1516	Same as C1510	
C1520	Same as C1501	
C1521	Same as C1503	
C1522	Same as C1504	
C1523	Same as C1504	
C1524	Same as C1504	
C1525	CAPACITOR, FIXED, PLASTIC: .001 uf, ±5%, 3000 WVDC	CX109-1
C1526	CAPACITOR, FIXED, CERAMIC-HV: 1000 pf, ±20%, 5000 WVDC	CC109-38
C1527	Same as C1526	
C1530	Same as C1501	
C1531	Same as C1501	
C1532	CAPACITOR, FIXED, CERAMIC: 0.1 uf, +80%-20%, 100 WVDC	CC100-28
C1533	Same as C1532	
C1541	CAPACITOR, FIXED, MICA: 39 pf, ±5%, 500 WVDC	CM15C390J03
C1545	CAPACITOR, FIXED, CERAMIC: 0.1 uf, +80-20%, 500 WVDC	CC100-32
C1546	Same as C1501	
C1547	Same as C1501	
C1548	Same as C1501	

**TTR-20 MAIN CHASSIS
SYMBOL SERIES 1500**

REF SYMBOL	DESCRIPTION	TMC PART NUMBER
C1549	Same as C1501	
C1550	Same as C1501	
C1551	Same as C1501	
C1556	CAPACITOR, FLAT, FOIL: 0.22 uf, 250 VDC	CC10011-10
C1557	Same as C1501	
C1558	Same as C1501	
C1559	Same as C1532	
C1565	CAPACITOR, FIXED, CERAMIC: 3 pf, ±0.5 pf, 500 WVDC	CC21SJ030D
CB1500	CIRCUIT BREAKER, SPST.	SW262
CR1501	RECTIFIER, SILICON, BRIDGE	DD10004
CR1507A	SUPPRESSOR, ARC, DIODE	DD114-2
CR1507B	Same as CR1507A	
CR1508A	Same as CR1507A	
CR1508B	Same as CR1507A	
CR1509A	Same as CR1507A	
CR1509B	Same as CR1507A	
DS1500	LAMP, GLOW	BI112-1
J1500	CONNECTOR, RECEPTACLE, ML	JJ296-1
J1501	CONNECTOR, RECEPTACLE, BNC	UG625/U
J1502	Same as J1501	
J1503	CONNECTOR, RECEPTACLE, FML	JJ285-6
J1504	Same as J1503	
J1505	Same as J1503	
J1506	Same as J1503	
J1507	CONNECTOR, RECEPTACLE, FML	JJ287-20
J1508	Same as J1507	
J1509	Same as J1507	
J1510	Same as J1507	
J1511	Same as J1507	
J1512	Same as J1507	
J1513	Same as J1507	
J1514	Same as J1507	
J1515	CONNECTOR, RECEPTACLE, FML	JJ212

**TTR-20 MAIN CHASSIS
SYMBOL SERIES 1500**

REF SYMBOL	DESCRIPTION	TMC PART NUMBER
J1516	Same as J1501	
K1500	RELAY, 6PDT	RL156-6
K1501	RELAY, MINIATURE	RL143-3
K1502	Same as K1501	
L1500	COIL, RF, FIXED: 2.55 uh \pm 0.1 uh	CL318
L1501	COIL, RF, FIXED: 120 uh, \pm 10%	CL240-120
L1502	Same as L1501	
L1503	Same as L1501	
L1504	Same as L1501	
L1505	Same as L1500	
L1506	Same as L1501	
L1511	Same as L1501	
L1512	Same as L1501	
L1513	Same as L1501	
L1514	COIL, RF, FIXED: 360 uh	CL10034
L1518	Same as L1501	
L1519	COIL, RF, FIXED; 180 uh, \pm 10 uh	CL317
LS1500	LOUDSPEAKER, PM, 2 inch	LS106
M1500	METER	MR172
PS1500	SUPPRESSOR, PARASITIC	AX163
PS1501	SUPPRESSOR, PARASITIC	AX391
PS1502	Same as PS1501	
R1500	RESISTOR, VARIABLE, COMP: 50 k ohms, \pm 20%, $\frac{1}{2}$ watt	RV106UX8B503B
R1501	RESISTOR, FIXED, COMP: 390 ohms, \pm 5%, 1 watt	RC32GF391J
R1502	RESISTOR, FIXED, COMP: 10 k ohms, \pm 5%, $\frac{1}{2}$ watt	RC20GF103J
R1503	RESISTOR, FIXED, COMP: 47 ohms, \pm 5%, $\frac{1}{2}$ watt	RC20GF470J
R1504	RESISTOR, FIXED, COMP: 180 ohms, \pm 5%, 2 watts	RC42GF181J
R1505	RESISTOR, FIXED, COMP: 4.7 k ohms, \pm 5%, 1 watt	RC32GF472J
R1513	RESISTOR, VARIABLE, COMP: 10 k ohms, \pm 20%, 2 watts	RV4NAYSA103BYY
R1514	RESISTOR, VARIABLE, COMP: 5 k ohms, \pm 20%, 2 watts	RV4NAYSA502BYY
R1515	RESISTOR, VARIABLE, COMP: 5 k ohms, \pm 20%, 2 watts	RV4NAYSC502BYY
R1517	RESISTOR, VARIABLE, COMP: 500 ohms, \pm 20%, 2 watts	RV4NAYSA501BYY
R1518	Same as R1514	

**TTR-20 MAIN CHASSIS
SYMBOL SERIES 1500**

REF SYMBOL	DESCRIPTION	TMC PART NUMBER
R1519	RESISTOR, FIXED, COMP: 1000 ohms, ±5%, ½ watt	RC20GF102J
R1525	RESISTOR, FIXED, COMP: 3.9 k ohms, ±5%, ½ watt	RC20GF392J
R1526	Same as R1502	
R1534	RESISTOR, FIXED, COMP: 4.7 k ohms, ±5%, ½ watt	RC20GF472J
R1543	Same as R1500	
R1544	Same as R1500	
R1545	Same as R1500	
R1546	RESISTOR, FIXED, COMP: 10 ohms, ±5%, 1 watt	RC32GF100J
S1500	SWITCH, ROTARY, TAP	SW336-4
S1501	SWITCH, ROTARY, TAP	SW336-1
S1502	Same as S1501	
S1503	Same as S1501	
S1504	Same as S1501	
S1505	SWITCH, ROTARY, TAP	SW10039
S1506	SWITCH, ROTARY, TAP	SW336-2
S1507	SWITCH, ROTARY, RCVR, ASSY.	AS10003
S1508	SWITCH, ROTARY, XMIT, ASSY.	AS10004
S1509	SWITCH, ROTARY, ASSY.	AS10001
S1511	SWITCH, ROTARY, TAP	SW336-3
S1516	SWITCH, WAFER, ASSY.	AS10002
S1517	Same as S1516	
S1518	SWITCH, ROTARY, WAFER	SW10036
S1519	Same as S1501	
T1500	TRANSFORMER, RF	TF10034
TB1500	TERMINAL STRIP, BARRIER	TM100-12
TB1501	Same as TB1500	
TB1502	TERMINAL STRIP, BARRIER	TM100-11
V1500	TUBE, ELECTRON	6GK6
V1501	TUBE, ELECTRON	8117
XCR1501	SOCKET, ELECTRON TUBE	TS101P01
XDS1500	LAMPHOLDER	TS164
XK1500	SOCKET, RELAY	TS171-2
XV1500	SOCKET, ELECTRON TUBE	TS103P01
XV1501	SOCKET, ELECTRON TUBE	TS168-1

**METER CALIBRATION BOARD A10597
SYMBOL SERIES 1500**

REF SYMBOL	DESCRIPTION	TMC PART NUMBER
R1507	RESISTOR, VARIABLE, COMP: 50 k ohms, $\pm 20\%$, $\frac{1}{4}$ watt	RV10006-2P
R1508	RESISTOR, FIXED, COMP: 27 k ohms, $\pm 5\%$, $\frac{1}{2}$ watt	RC20GF273J
R1509	Same as R1507	
R1510	RESISTOR, FIXED, COMP: 47 k ohms, $\pm 5\%$, $\frac{1}{2}$ watt	RC20GF473J
R1511	RESISTOR, VARIABLE, COMP: 1000 k ohms	RV10006-7P
R1512	Same as R1510	
R1513	Same as R1507	
R1514	Same as R1507	

**GRID METERING BOARD A10595
SYMBOL SERIES 1500**

REF SYMBOL	DESCRIPTION	TMC PART NUMBER
C1515	CAPACITOR, FIXED, CERAMIC: 3 pf, ± 5 pf, 500 WVDC	CC21CJ030D
C1517	CAPACITOR, FIXED, MICA: 15 pf, 500 WVDC	CM15D150G03YY
C1518	CAPACITOR, FIXED, MICA: 1000 pf	CM20F102G03
C1519	Same as C1518	
CR1500	DIODE, SILICON	IN463
L1507	COIL, RF, FIXED: 1.1 uh	CL139
L1508	COIL, RF, FIXED: 750 uh	CL100-5
L1509	COIL, RF, FIXED: 120 uh	CL240-120
L1510	Same as L1509	

**OUTPUT METERING AND ALDC BOARD A10596
SYMBOL SERIES 1500**

REF SYMBOL	DESCRIPTION	TMC PART NUMBER
C1561	CAPACITOR, FIXED, MICA: 33 pf, $\pm 5\%$, 500 WVDC	CM15C330J03
C1562	CAPACITOR, FIXED, MICA: 1000 pf, $\pm 5\%$, 100 WVDC	CM111C102J1S
C1563	Same as C1562	
CR1561	DIODE	IN34A
L1561	COIL, RF, FIXED: 1000 uh	CL275-102
L1562	Same as L1561	

**RECEIVER AF BOARD A10541
SYMBOL SERIES 1600**

REF SYMBOL	DESCRIPTION	TMC PART NUMBER
C1639	CAPACITOR, FIXED, CERAMIC: .01 uf, GMV, 500 WVDC	CC100-16
C1646	CAPACITOR, FIXED, ELECT: 10 uf, 15 WVDC	CE105-10-15
C1647	CAPACITOR, FIXED, ELECT: 50 uf, 15 WVDC	CE105-50-15
C1648	Same as C1646	
C1649	Same as C1647	
C1650	CAPACITOR, FIXED, CERAMIC: .001 uf, GMV, 500 WVDC	CC100-29
C1651	CAPACITOR, FIXED, CERAMIC: .1 uf, +80%-20%, 100 WVDC	CC100-28
C1652	Same as C1647	
C1660	CAPACITOR, FIXED, ELECT: 200 uf, 15 WVDC	CE105-200-15
K1601	RELAY 4 PDT	RL156-2
Q1613	TRANSISTOR	2N1370-4
Q1614	Same as Q1613	
Q1615	Same as Q1613	
Q1616	TRANSISTOR	2N1039
Q1617	Same as Q1616	
Q1618	TRANSISTOR	2N1370-7
Q1619	Same as Q1613	
Q1620	Same as Q1613	
Q1621	TRANSISTOR	2N2001
R1638	RESISTOR, FIXED, COMP: 10 k ohms, ±5%, ½ watt	RC20GF103J
R1639	RESISTOR, FIXED, COMP: 4.7 k ohms, ±5%, ½ watt	RC20GF472J
R1640	RESISTOR, FIXED, COMP: 22 ohms, ±5%, 2 watts	RC42GF220J
R1641	RESISTOR, FIXED, COMP: 3.3 k ohms, ±5%, ½ watt	RC20GF332J
R1642	Same as R1638	
R1643	Same as R1641	
R1644	Same as R1641	
R1645	RESISTOR, FIXED, COMP: 680 ohms, ±5%, ½ watt	RC20GF681J
R1646	RESISTOR, FIXED, COMP: 10 ohms, ±5%, ½ watt	RC20GF100J
R1647	RESISTOR, FIXED, COMP: 100 k ohms, ±5%, ½ watt	RC20GF104J
R1651	Same as R1638	
R1652	RESISTOR, FIXED, COMP: 3.9 k ohms, ±5%, ½ watt	RC20GF392J
R1653	RESISTOR, FIXED, COMP: 2.2 k ohms, ±5%, ½ watt	RC20GF222J
R1654	RESISTOR, FIXED, COMP: 1000 ohms, ±5%, ½ watt	RC20GF102J

**RECEIVER AF BOARD A10541
SYMBOL SERIES 1600**

REF SYMBOL	DESCRIPTION	TMC PART NUMBER
R1655	Same as R1647	
R1656	Same as R1641	
R1657	RESISTOR, FIXED, COMP: 22 k ohms, ±5%, ½ watt	RC20GF223J
R1658	Same as R1653	
R1659	RESISTOR, FIXED, COMP: 33 ohms, ±5%, ½ watt	RC20GF330J
R1660	RESISTOR, FIXED, COMP: 3.3 ohms, ±5%, 1 watt	RC32GF3R3J
R1661	RESISTOR, FIXED, COMP: 470 ohms, ±5%, ½ watt	RC20GF471J
R1662	RESISTOR, FIXED, COMP: 1.8 k ohms, ±5%, ½ watt	RC20GF182J
R1665	Same as R1639	
R1666	Same as R1640	
R1667	RESISTOR, FIXED, COMP: 27 ohms, ±5%, 2 watts	RC42GF270J
T1603	TRANSFORMER, AF	TF267-3
T1604	TRANSFORMER, AF	TF267-2
T1605	TRANSFORMER, AF	TF267-5

TRANSMITTER AF BOARD A10540
SYMBOL SERIES 1700

REF SYMBOL	DESCRIPTION	TMC PART NUMBER
C1701	CAPACITOR, FIXED, ELECT: 6 uf, 15 WVDC	CE105-6-15
C1702	CAPACITOR, FIXED, CERAMIC: .2 uf, +80%-20%, 25 WVDC	CC100-33
C1703	CAPACITOR, FIXED, ELECT: 50 uf, 15 WVDC	CE105-50-15
C1704	Same as C1701	
C1705	CAPACITOR, FIXED, ELECT: 10 uf, 15 WVDC	CE105-10-15
C1706	Same as C1703	
C1707	Same as C1705	
C1708	CAPACITOR, FIXED, ELECT: 4 uf, 15 WVDC	CE105-4-15
C1709	Same as C1701	
C1710	Same as C1703	
C1711	Same as C1702	
C1712	CAPACITOR, FIXED, ELECT: 20 uf, 15 WVDC	CE105-20-15
C1729	Same as C1705	
C1761	Same as C1702	
C1764	Same as C1702	
CR1701	DIODE	IN34A
CR1702	Same as CR1701	
CR1703	Same as CR1701	
CR1704	Same as CR1701	
CR1705	Same as CR1701	
Q1701	TRANSISTOR	2N1308
Q1702	TRANSISTOR	2N1370-4
Q1703	Same as Q1702	
Q1704	Same as Q1702	
Q1705	Same as Q1702	
Q1706	Same as Q1701	
Q1707	Same as Q1702	
Q1708	TRANSISTOR	2N2001
R1701	RESISTOR, FIXED, COMP: 22 k ohms, ±5%, ½ watt	RC20GF223J
R1702	RESISTOR, FIXED, COMP: 10 k ohms, ±5%, ½ watt	RC20GF103J
R1703	Not used	
R1704	RESISTOR, FIXED, COMP: 4.7 k ohms, ±5%, ½ watt	RC20GF472J
R1705	RESISTOR, FIXED, COMP: 2.2 k ohms, ±5%, ½ watt	RC20GF222J

**TRANSMITTER AF BOARD A10540
SYMBOL SERIES 1700**

REF SYMBOL	DESCRIPTION	TMC PART NUMBER
R1706	Same as R1702	
R1707	Same as R1705	
R1708	RESISTOR, FIXED, COMP: 68 k ohms, ±5%, ½ watt	RC20GF683J
R1709	Same as R1702	
R1710	RESISTOR, FIXED, COMP: 3.3 k ohms, ±5%, ½ watt	RC20GF332J
R1711	Same as R1710	
R1712	RESISTOR, FIXED, COMP: 220 ohms, ±5%, ½ watt	RC20GF221J
R1713	Same as R1702	
R1714	Same as R1702	
R1715	RESISTOR, FIXED, COMP: 8.2 k ohms, ±5%, ½ watt	RC20GF822J
R1716	RESISTOR, FIXED, COMP: 3.9 k ohms, ±5%, ½ watt	RC20GF392J
R1717	RESISTOR, FIXED, COMP: 1000 ohms, ±5%, ½ watt	RC20GF102J
R1718	RESISTOR, VARIABLE, COMP: 500 ohms, ±10%, .25 watt	RV111U501A
R1719	RESISTOR, VARIABLE, COMP: 250 k ohms, ±10%, .25 watt	RV111U254A
R1720	RESISTOR, FIXED, COMP: 1.5 MEG. ohm, ±5%, ½ watt	RC20GF155J
R1721	Not used	
R1722	Same as R1702	
R1723	RESISTOR, FIXED, COMP: 5.6 k ohms, ±5%, ½ watt	RC20GF562J
R1724	Same as R1704	
R1725	Same as R1702	
R1726	Same as R1717	
R1727	Same as R1723	
R1728	RESISTOR, FIXED, COMP: 100 k ohms, ±5%, ½ watt	RC20GF104J
R1729	RESISTOR, FIXED, COMP: 150 k ohms, ±5%, ½ watt	RC20GF154J
R1730	Same as R1704	
R1731	Same as R1705	
R1732	Same as R1715	
R1733	Same as R1729	
R1734	RESISTOR, FIXED, COMP: 33 ohms, ±5%, 1 watt	RC32GF330J
R1735	Same as R1729	
R1774	RESISTOR, FIXED, COMP: 100 ohms, ±5%, ½ watt	RC20GF101J
T1701	TRANSFORMER, A.F.	TF267-4
T1702	TRANSFORMER, A.F.	TF246-17Z

**TRANSMITTER IF BOARD A10603
SYMBOL SERIES 1800**

REF SYMBOL	DESCRIPTION	TMC PART NUMBER
C1801	CAPACITOR, FIXED, CERAMIC: .01 uf, 500 WVDC	CC100-16
C1802	Same as C1801	
C1803	CAPACITOR, FIXED, MICA: 22 pf, ±5%, 500 WVDC	CM111C220J1S
C1804	CAPACITOR, VARIABLE, CERAMIC: 9-35 pf, 100 WVDC	CV112-2
C1805	Same as C1803	
C1806	Same as C1804	
C1807	CAPACITOR, FIXED, MICA: 1000 pf, ±5%, 500 WVDC	CM111C102J1S
C1808	Same as C1807	
C1809	CAPACITOR, FIXED, MICA: 47 pf, ±5%, 500 WVDC	CM111C470J1S
C1810	CAPACITOR, VARIABLE, CERAMIC: 10-75 pf, 350 WVDC	CV109-8
C1811	Same as C1810	
C1812	CAPACITOR, FIXED, CERAMIC: .2 uf, +80%-20%, 25 WVDC	CC100-33
C1813	Same as C1807	
C1814	Same as C1801	
C1815	Same as C1807	
C1816	Same as C1807	
C1817	Same as C1812	
C1818	Same as C1807	
C1819	CAPACITOR, FIXED, MICA: 100 pf, ±5%, 500 WVDC	CM111C101J1S
C1820	Same as C1801	
CR1801	DIODE	IN34A
CR1802	Same as CR1801	
CR1803	Same as CR1801	
CR1804	Same as CR1801	
CR1805	Same as CR1801	
CR1806	Same as CR1801	
CR1807	Same as CR1801	
CR1808	Same as CR1801	
FL1801	FILTER, USB	FX10014-1
FL1802	FILTER, LSB	FX10014-2
L1801	COIL, RF, FIXED: 1000 uh	CL275-102
L1802	Same as L1801	
L1803	Same as L1801	

**TRANSMITTER IF BOARD A10603
SYMBOL SERIES 1800**

REF SYMBOL	DESCRIPTION	TMC PART NUMBER
L1804	Same as L1801	
L1805	Same as L1801	
Q1801	TRANSISTOR	2N3904
Q1802	Same as Q1801	
Q1803	Same as Q1801	
Q1804	TRANSISTOR	MPF104
Q1805	Same as Q1804	
Q1806	Same as Q1804	
Q1807	Same as Q1804	
Q1808	Same as Q1804	
R1801	RESISTOR, FIXED, COMP: 1000 ohms, $\pm 5\%$, $\frac{1}{2}$ watt	RC20GF102J
R1802	Same as R1801	
R1803	Same as R1801	
R1804	Same as R1801	
R1805	Same as R1801	
R1806	Same as R1801	
R1807	Same as R1801	
R1808	Same as R1801	
R1809	Same as R1801	
R1810	Same as R1801	
R1811	Same as R1801	
R1812	Same as R1801	
R1813	RESISTOR, VARIABLE, COMP: 1000 ohms, $+10\%$	RV111U102A
R1814	Same as R1813	
R1815	RESISTOR, FIXED, COMP: 330 ohms, $\pm 5\%$, $\frac{1}{2}$ watt	RC20GF331J
R1816	Same as R1815	
R1817	Same as R1815	
R1818	Same as R1815	
R1819	RESISTOR, FIXED, COMP: 3300 ohms, $\pm 5\%$, $\frac{1}{2}$ watt	RC20GF332J
R1820	Same as R1819	
R1821	RESISTOR, FIXED, COMP: 470 k ohms, $\pm 5\%$, $\frac{1}{2}$ watt	RC20GF474J
R1822	RESISTOR, FIXED, COMP: 47 ohms, $\pm 5\%$, $\frac{1}{2}$ watt	RC20GF470J
R1823	RESISTOR, FIXED, COMP: 100 k ohms, $\pm 5\%$, $\frac{1}{2}$ watt	RC20GF104J

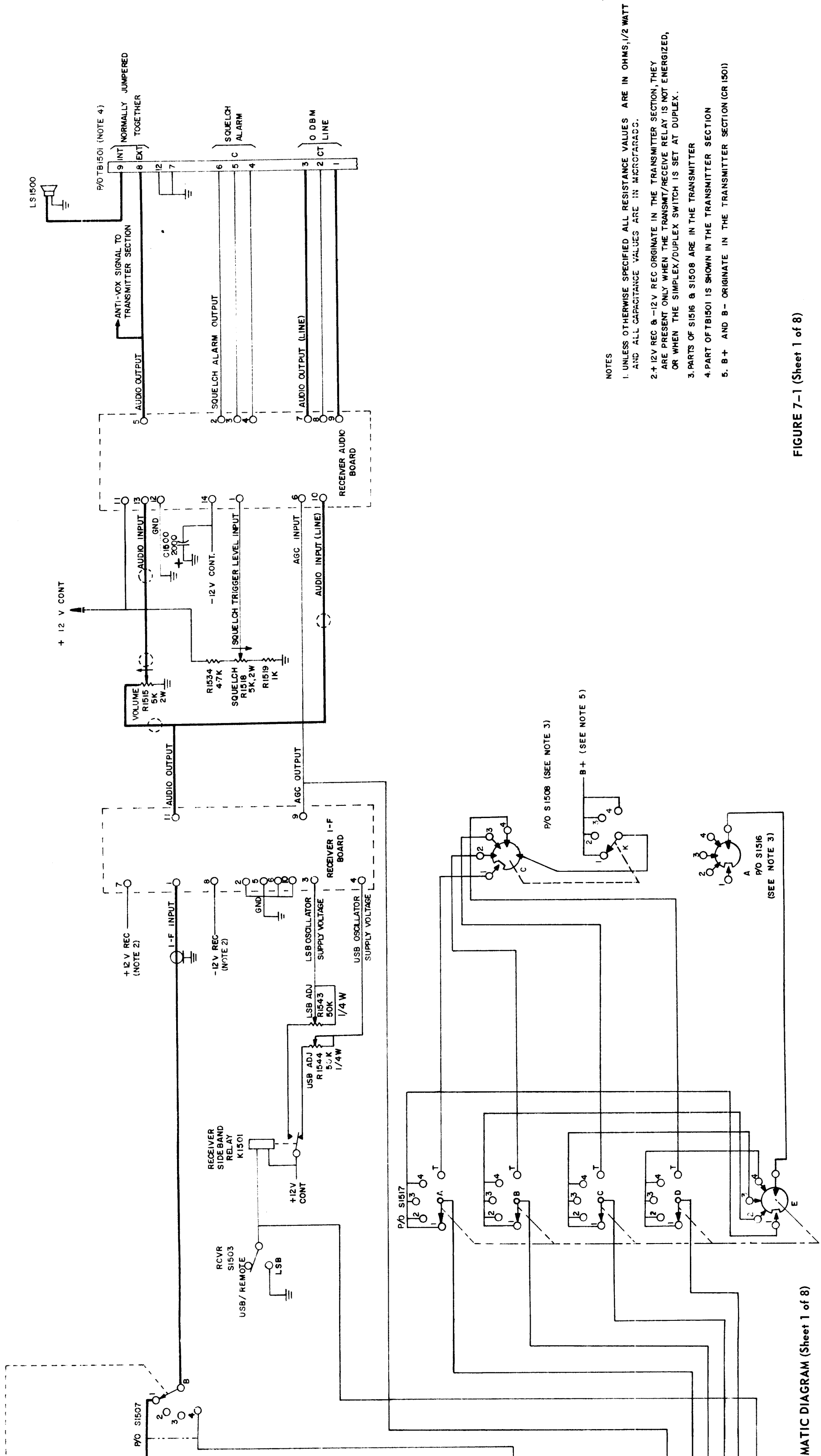
**TRANSMITTER IF BOARD A10603
SYMBOL SERIES 1800**

REF SYMBOL	DESCRIPTION	TMC PART NUMBER
R1824	RESISTOR, FIXED, COMP: 15 k ohms, $\pm 5\%$, $\frac{1}{2}$ watt	RC20GF153J
R1825	RESISTOR, FIXED, COMP: 10 k ohms, $\pm 5\%$, $\frac{1}{2}$ watt	RC20GF103J
R1826	Same as R1822	
R1827	RESISTOR, FIXED, COMP: 6.8 k ohms, $\pm 5\%$, $\frac{1}{2}$ watt	RC20GF682J
R1828	RESISTOR, FIXED, COMP: 10 ohms, $\pm 5\%$, $\frac{1}{2}$ watt	RC20GF100J
R1829	Same as R1801	
R1830	Same as R1819	
R1831	Same as R1824	
R1832	Same as R1815	
T1801	TRANSFORMER, RF	TZ10001
Y1801	QUARTZ, CRYSTAL: 1750 kHz	CR10008- 1.750000 MHz
Z1801	OSCILLATOR, OVEN, PROPORTIONAL	NF10002

**AUDIO PREAMP/CW OSC BOARD A10598
SYMBOL SERIES 1900**

REF SYMBOL	DESCRIPTION	TMC PART NUMBER
C1901	CAPACITOR, FIXED, CERAMIC: 0.02 uf, ±80%–40%, 150 WVDC	CC100-35
C1902	CAPACITOR, FLAT, FOIL: 0.022 uf, 250 VDC	CC10011-3
C1903	CAPACITOR, FLAT, FOIL: 0.33 uf, 250 VDC	CC10011-10
C1904	Same as C1902	
C1905	Same as C1901	
C1906	CAPACITOR, FIXED, ELECT: 10 uf, 15 WVDC	CE105-10-15
C1907	Same as C1906	
C1908	CAPACITOR, FIXED, CERAMIC: 0.2 uf, +80%–20%, 25 WVDC	CC100-33
C1909	CAPACITOR, FLAT, FOIL: 0.01 uf, 250 VDC	CC10011-1
CR1901	DIODE, ZENER	IN758A
CR1902	DIODE	IN34A
L1901	INDUCTOR: 1.2 H	CL10033
Q1901	TRANSISTOR	MPF104
Q1902	Same as Q1901	
Q1903	TRANSISTOR	2N3904
R1901	RESISTOR, FIXED, COMP: 33 k ohms, ±5%, ½ watt	RC20GF333J
R1902	RESISTOR, FIXED, COMP: 4.7 k ohms, ±5%, ½ watt	RC20GF472J
R1903	RESISTOR, VARIABLE, COMP: 10 k ohms	RV10005-7
R1904	RESISTOR, FIXED, COMP: 22 k ohms, ±5%, ½ watt	RC20GF223J
R1905	RESISTOR, FIXED, COMP: 100 k ohms, ±5%, ½ watt	RC20GF104J
R1906	RESISTOR, FIXED, COMP: 8.2 k ohms, ±5%, ½ watt	RC20GF822J
R1907	RESISTOR, FIXED, COMP: 2.2 k ohms, ±5%, ½ watt	RC20GF222J
R1908	RESISTOR, FIXED, COMP: 330 k ohms, ±5%, ½ watt	RC20GF334J
R1909	RESISTOR, FIXED, COMP: 3.3 k ohms, ±5%, ½ watt	RC20GF332J
R1910	RESISTOR, FIXED, COMP: 270 ohms, ±5%, ½ watt	RC20GF271J
R1911	RESISTOR, FIXED, COMP: 15 k ohms, ±5%, ½ watt	RC20GF153J
R1912	RESISTOR, FIXED, COMP: 6.8 k ohms, ±5%, ½ watt	RC20GF682J

SECTION 7
SCHEMATIC DIAGRAMS



NOTES

1. UNLESS OTHERWISE SPECIFIED ALL RESISTANCE VALUES ARE IN OHMS, 1/2 WATT AND ALL CAPACITANCE VALUES ARE IN MICROFARADS.
2. +12V REC & -12V REC ORIGINATE IN THE TRANSMITTER SECTION, THEY ARE PRESENT ONLY WHEN THE TRANSMIT/RECEIVE RELAY IS NOT ENERGIZED, OR WHEN THE SIMPLEX/DUPLEX SWITCH IS SET AT DUPLEX.
3. PARTS OF S1516 & S1508 ARE IN THE TRANSMITTER
4. PART OF B1501 IS SHOWN IN THE TRANSMITTER SECTION
5. B+ AND B- ORIGINATE IN THE TRANSMITTER SECTION (CR 1501)

FIGURE 7-1 (Sheet 1 of 8)

MATIC DIAGRAM (Sheet 1 of 8)

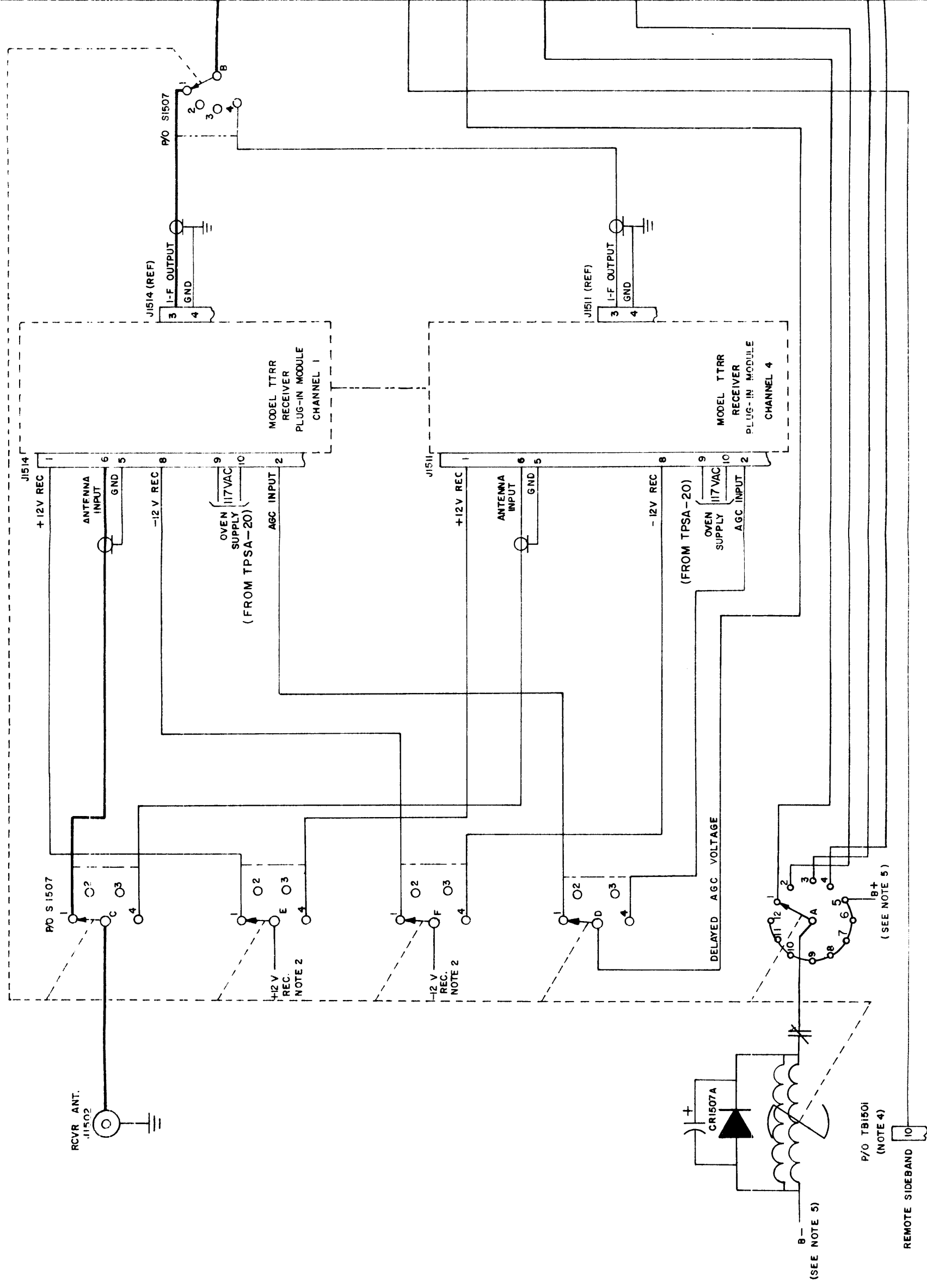
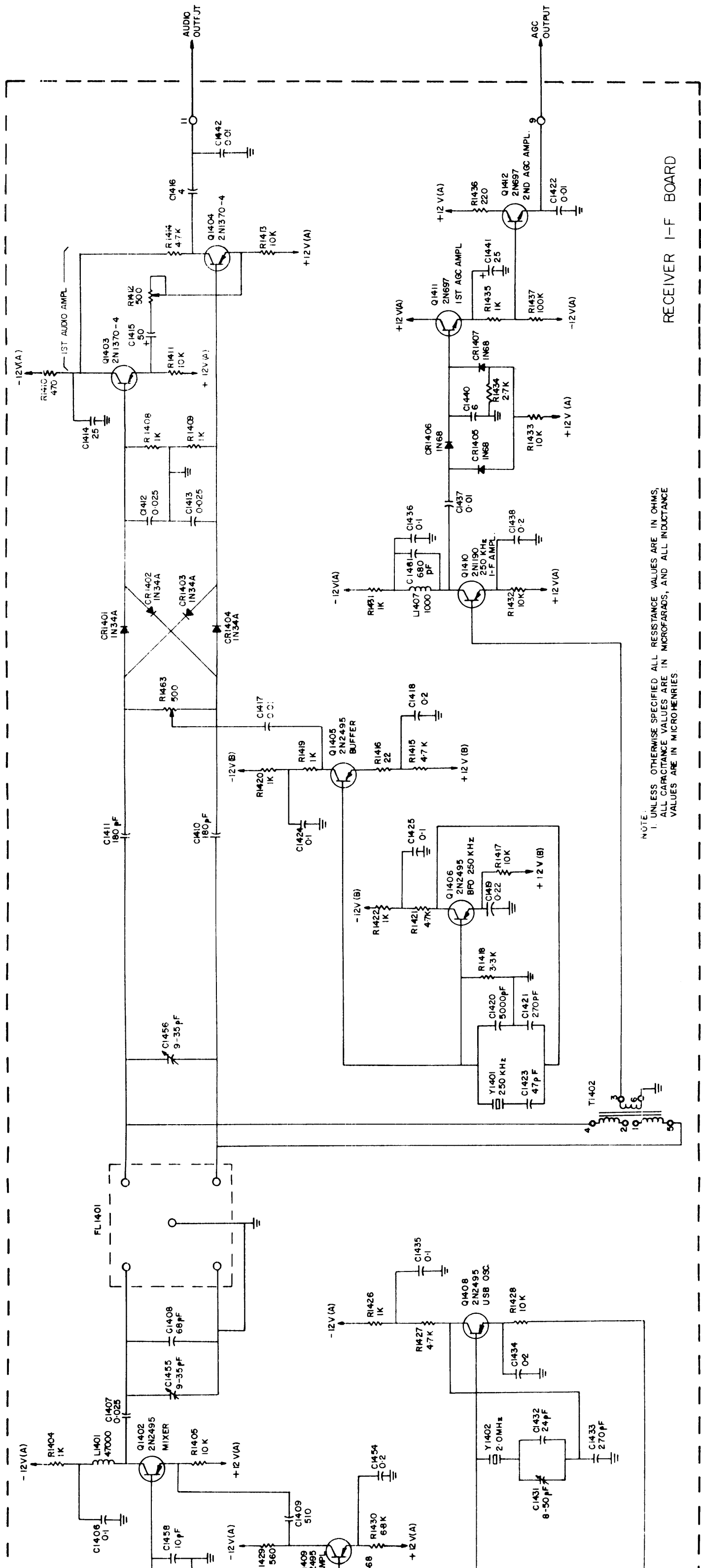


FIGURE 7-1. TTR-20 SCHEMATIC DIAGRAM (Sh et



NOTE:
 1. UNLESS OTHERWISE SPECIFIED ALL RESISTANCE VALUES ARE IN OHMS,
 ALL CAPACITANCE VALUES ARE IN MICROFARADS, AND ALL INDUCTANCE
 VALUES ARE IN MICROHENRIES

FIGURE 7-1. TTR-20 SCHEMATIC DIAGRAM (Sheet 2 of 8)

FIGURE 7-1 (Sheet 2 of 8)

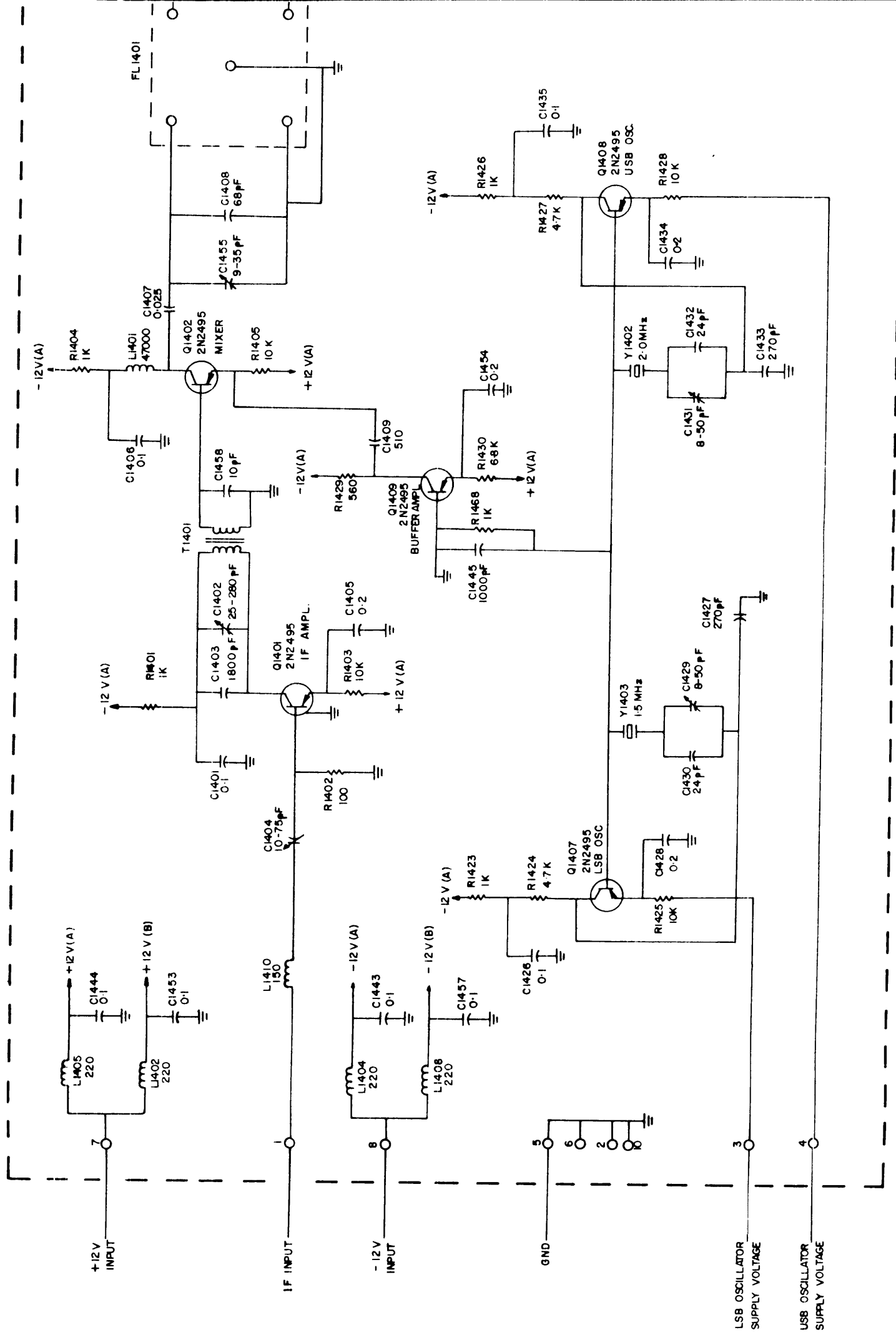


FIGURE 7-1. TT

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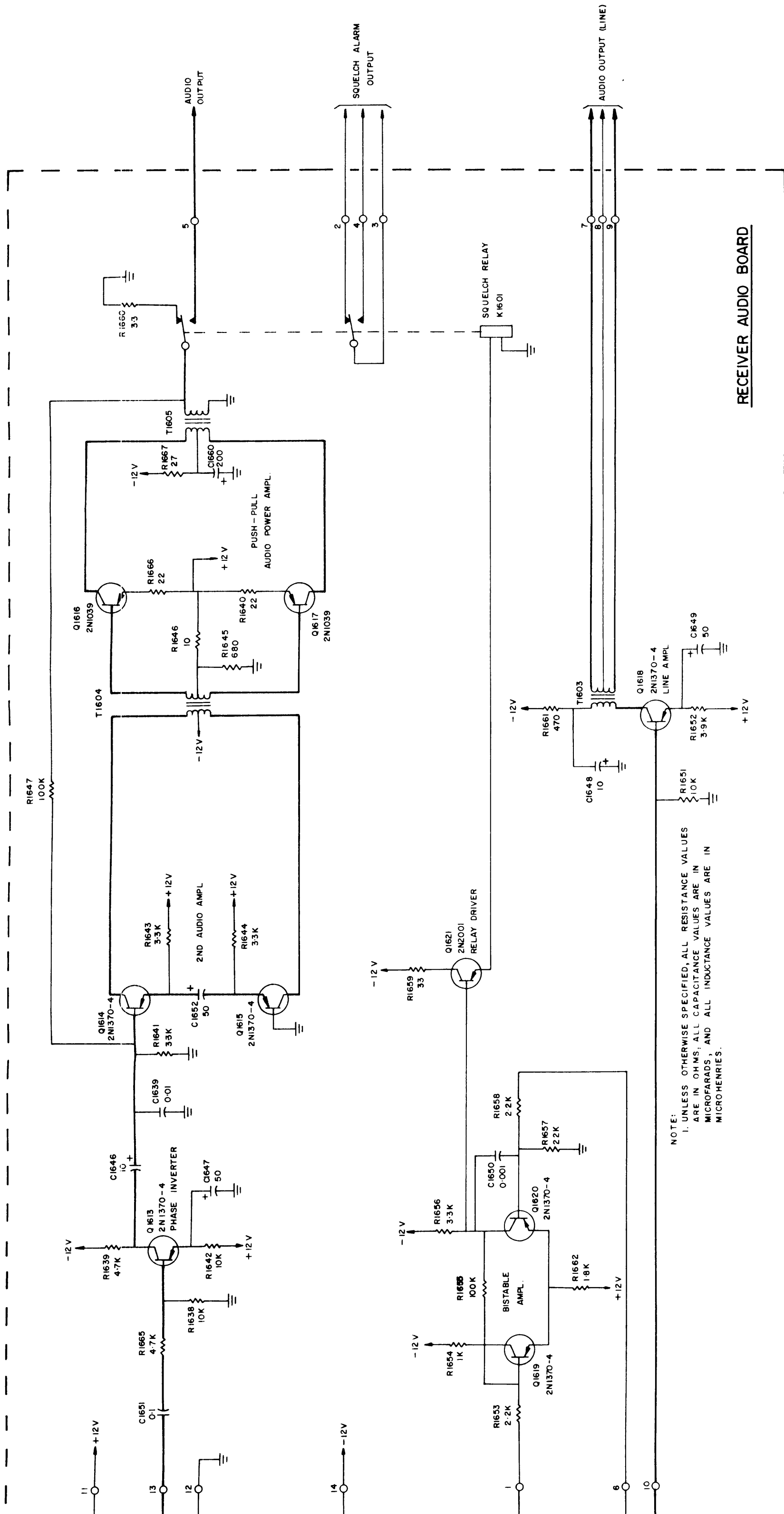
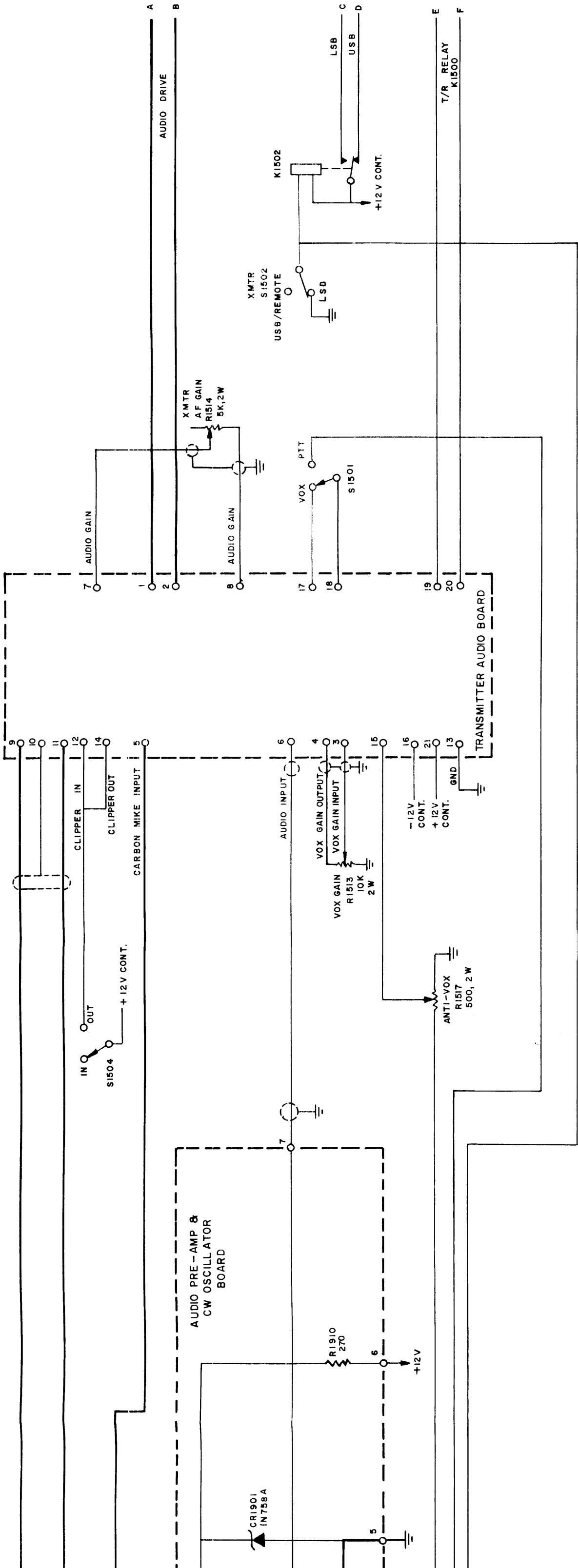


FIGURE 7-1. TTR-20 SCHEMATIC DIAGRAM (Sheet 3 of 8)

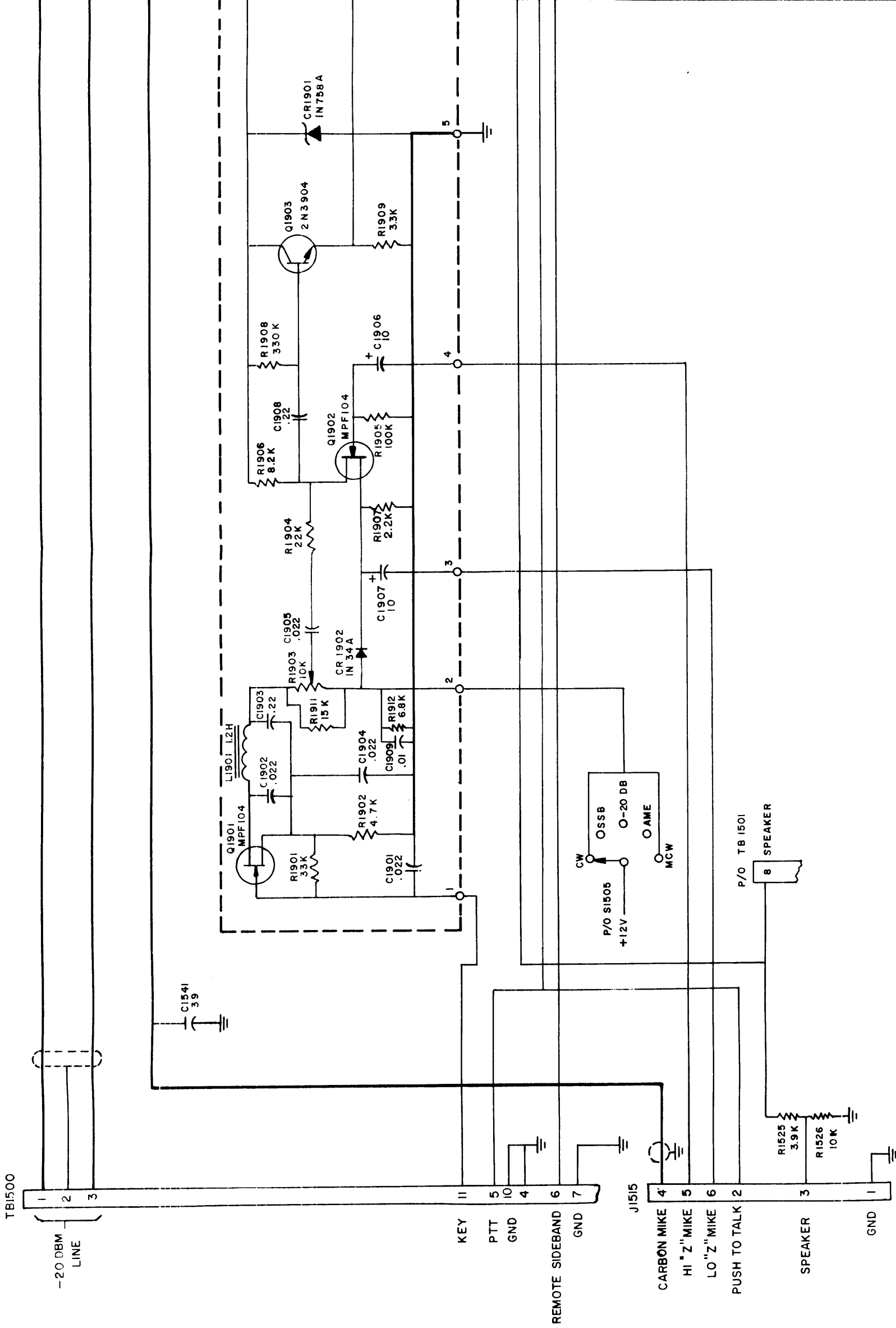
FIGURE 7-1. TTR-20 SCHEMATIC DIAGRAM (Sheet 3 of 8)



NOTE
 UNLESS OTHERWISE SPECIFIED, ALL RESISTANCE VALUES ARE IN OHMS, 1/2 WATT
 ALL CAPACITANCE VALUES ARE IN MICRO FARADS, AND ALL INDUCTANCE VALUES
 ARE IN MICROHENRIES.

FIGURE 7-1 (Sheet 4 of 8)

FIGURE 7-1. TTR-20 SCHEMATIC DIAGRAM (Sheet 4 of 8)



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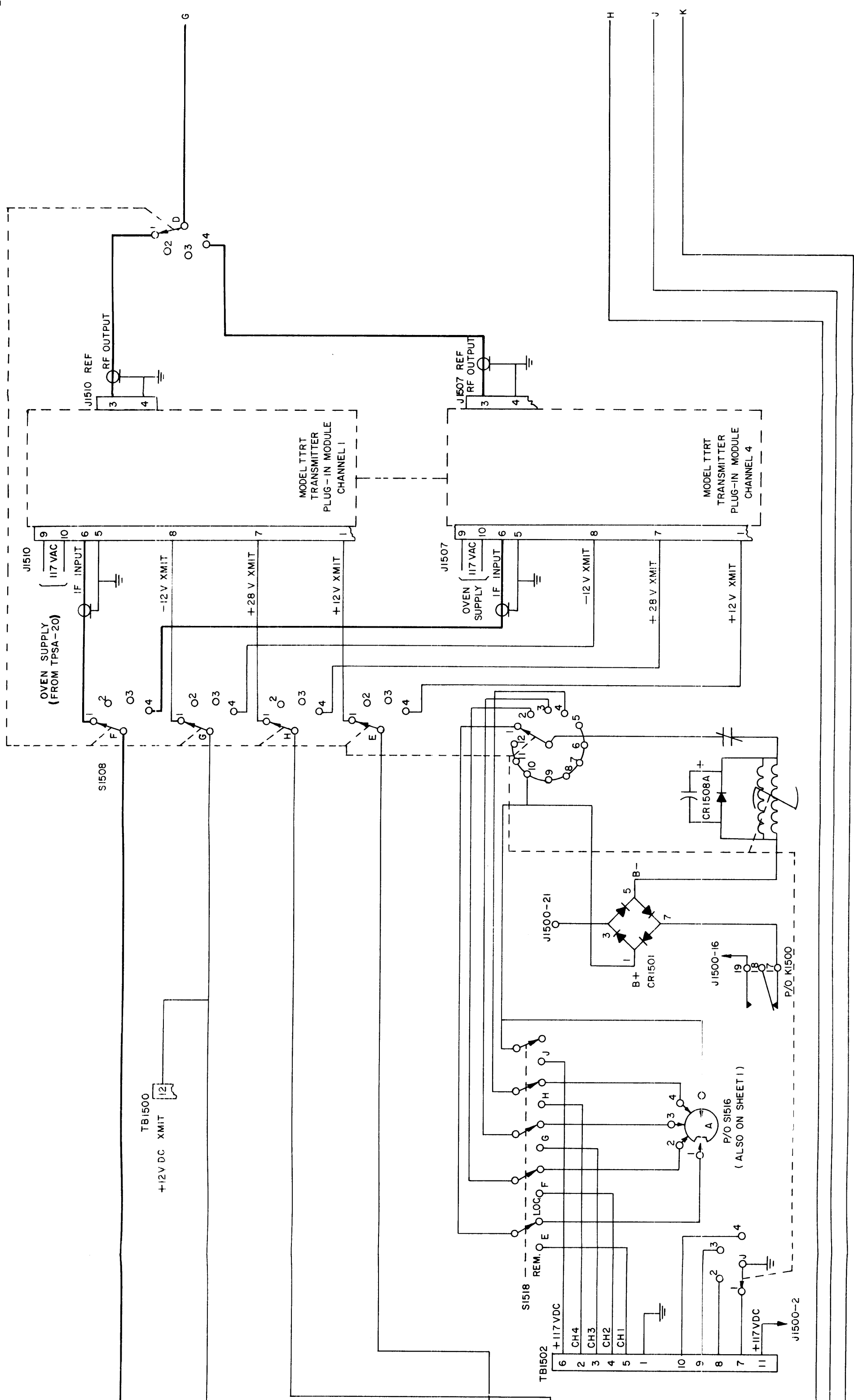
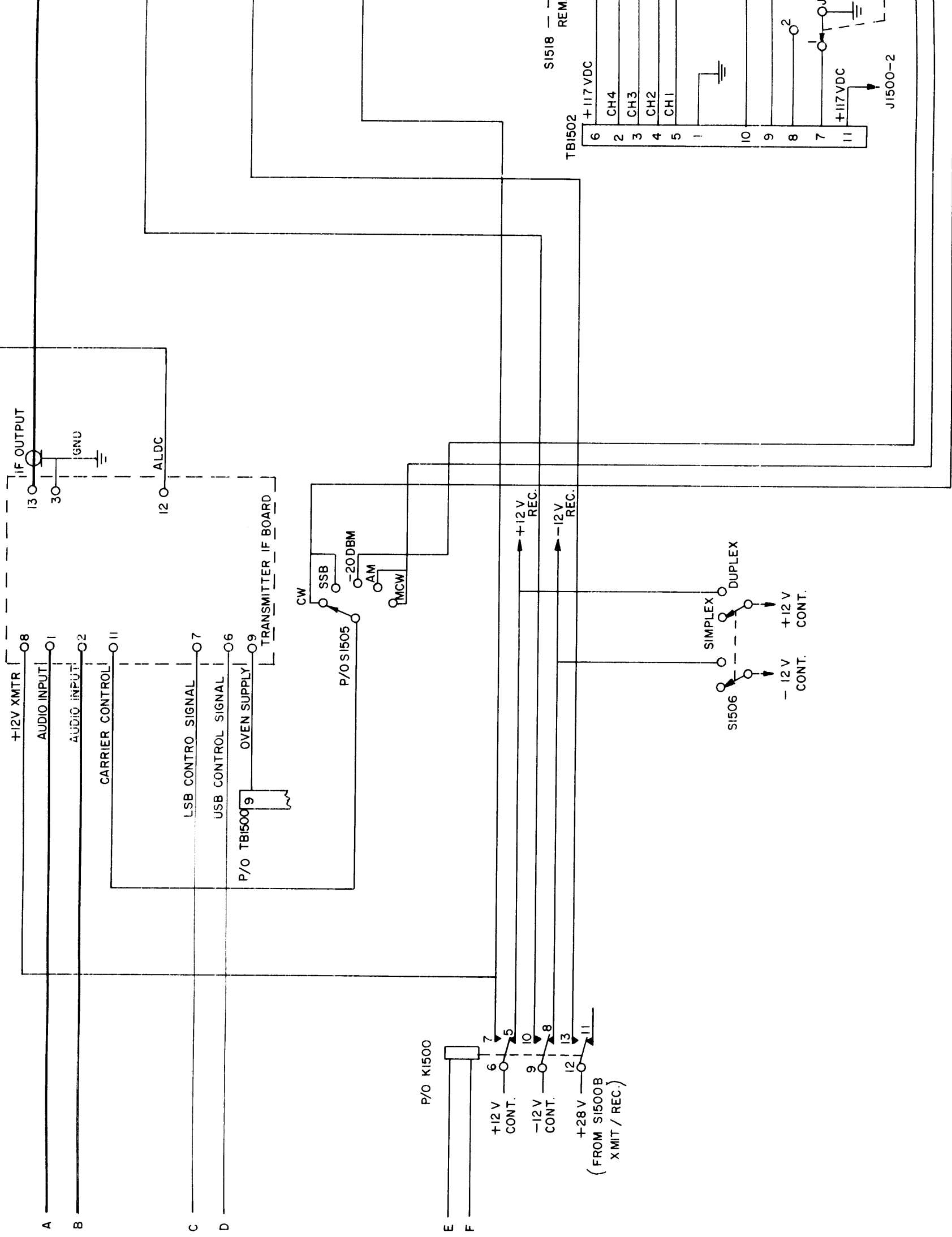


FIGURE 7-1. TTR-20 SCHEMATIC DIAGRAM (Sheet 5 of 8)

FIGURE 7-1 (Sheet 5 of 8)



FIGURE

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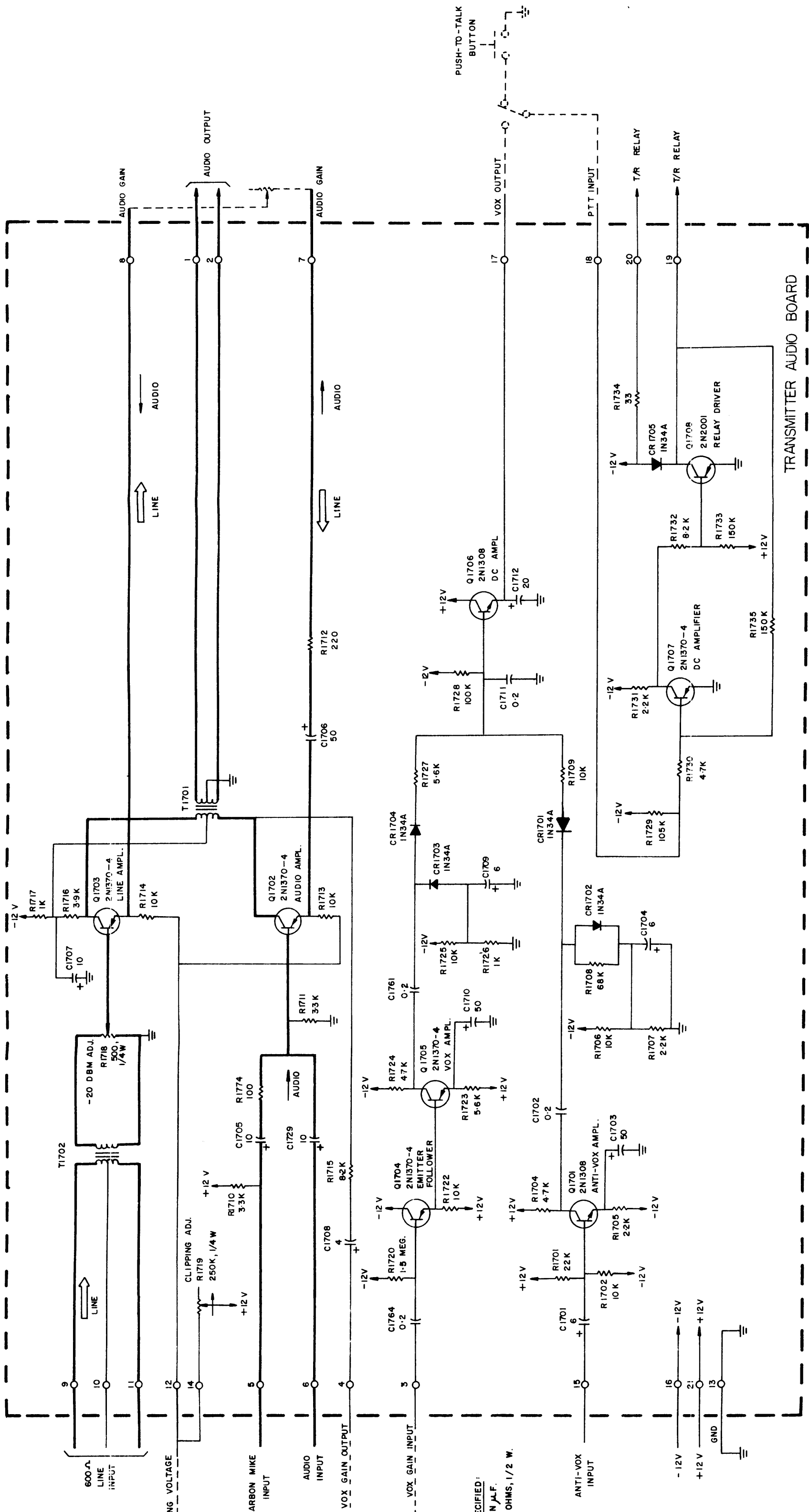
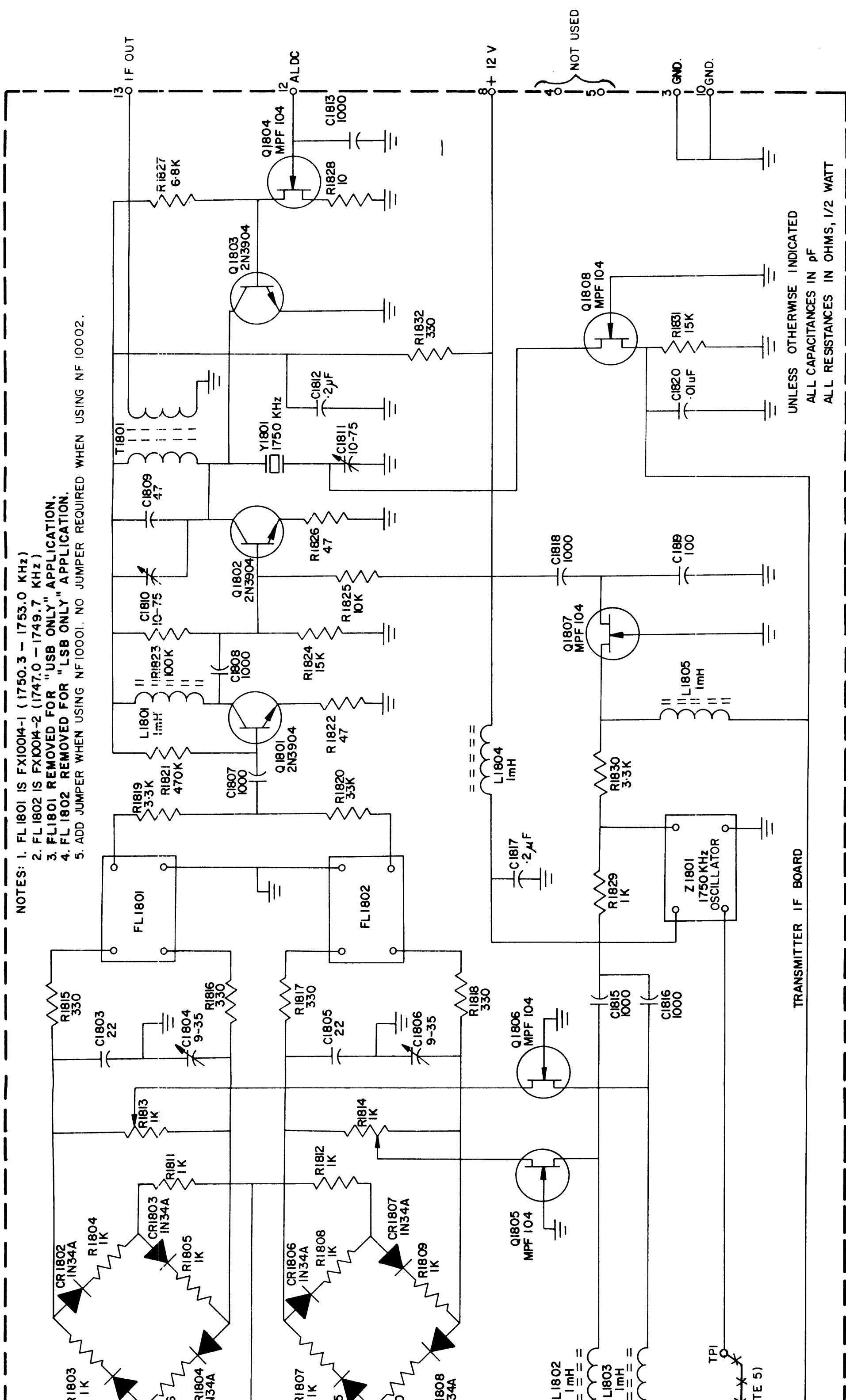


FIGURE 7-1. TTR-20 SCHEMATIC DIAGRAM (Sheet 7 of 8)

FIGURE 7-1 (Sheet 7 of 8)



- NOTES:
1. FL1801 IS FX1004-1 (1750.3 - 1753.0 KHz)
 2. FL1802 IS FX1004-2 (1747.0 - 1749.7 KHz)
 3. FL1801 REMOVED FOR "USB ONLY" APPLICATION.
 4. FL1802 REMOVED FOR "LSB ONLY" APPLICATION.
 5. ADD JUMPER WHEN USING NF10001. NO JUMPER REQUIRED WHEN USING NF10002.

UNLESS OTHERWISE INDICATED
 ALL CAPACITANCES IN pF
 ALL RESISTANCES IN OHMS, 1/2 WATT

FIGURE 7-1. TTR-20 SCHEMATIC DIAGRAM (Sheet 8 of 8)

FIGURE 7-1 (Sheet 8 of 8)

- NOTES: 1. FL 1801 IS FX1004-1 (1750.3 - 1753.0 KHz)
 2. FL 1802 IS FX1004-2 (1747.0 - 1749.7 KHz)
 3. FL1801 REMOVED FOR "USB ONLY" APPLICATION
 4. FL 1802 REMOVED FOR "LSB ONLY" APPLICATION
 5. ADD JUMPER WHEN USING NF10001. NO JUMPER RE

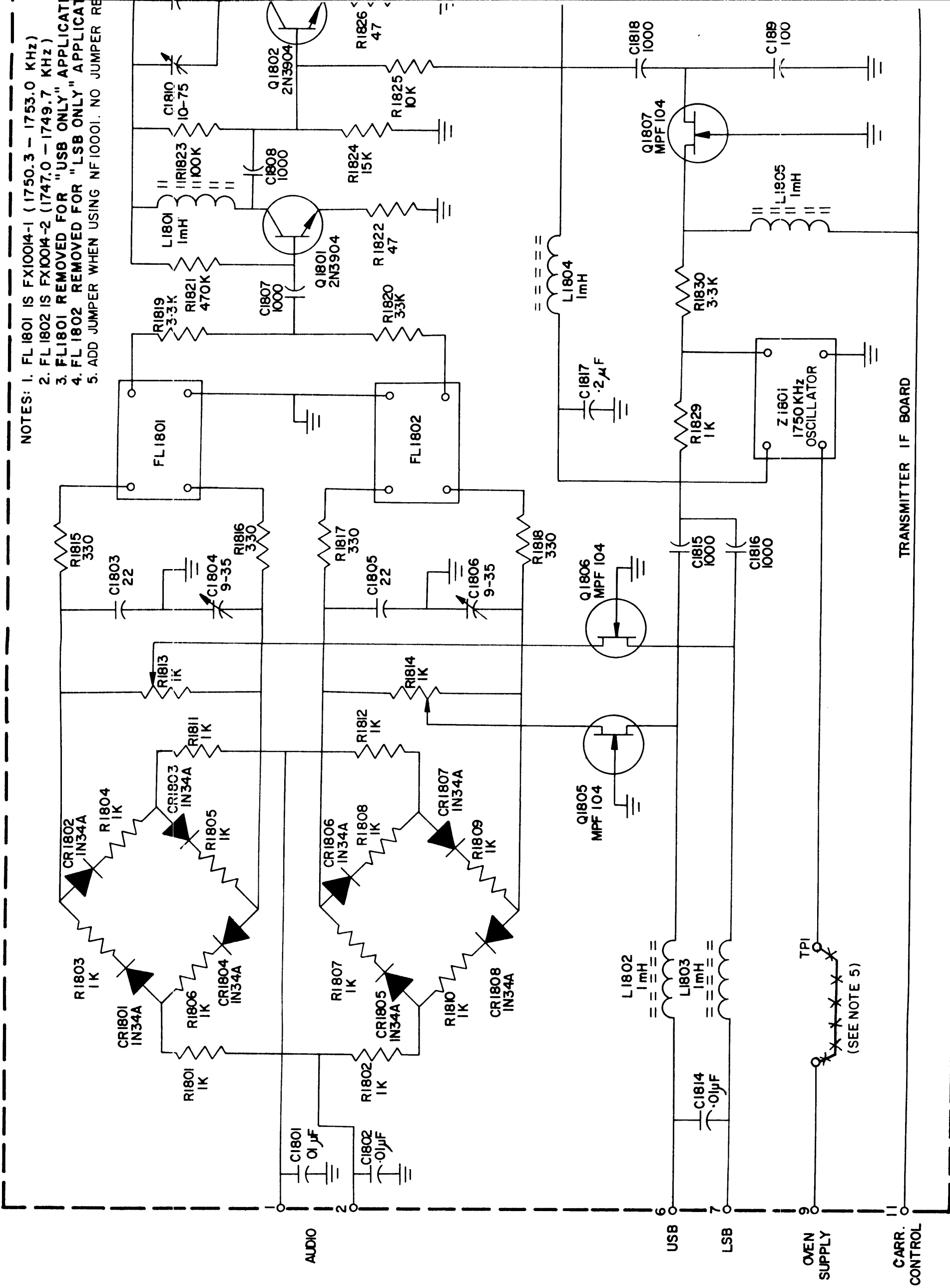
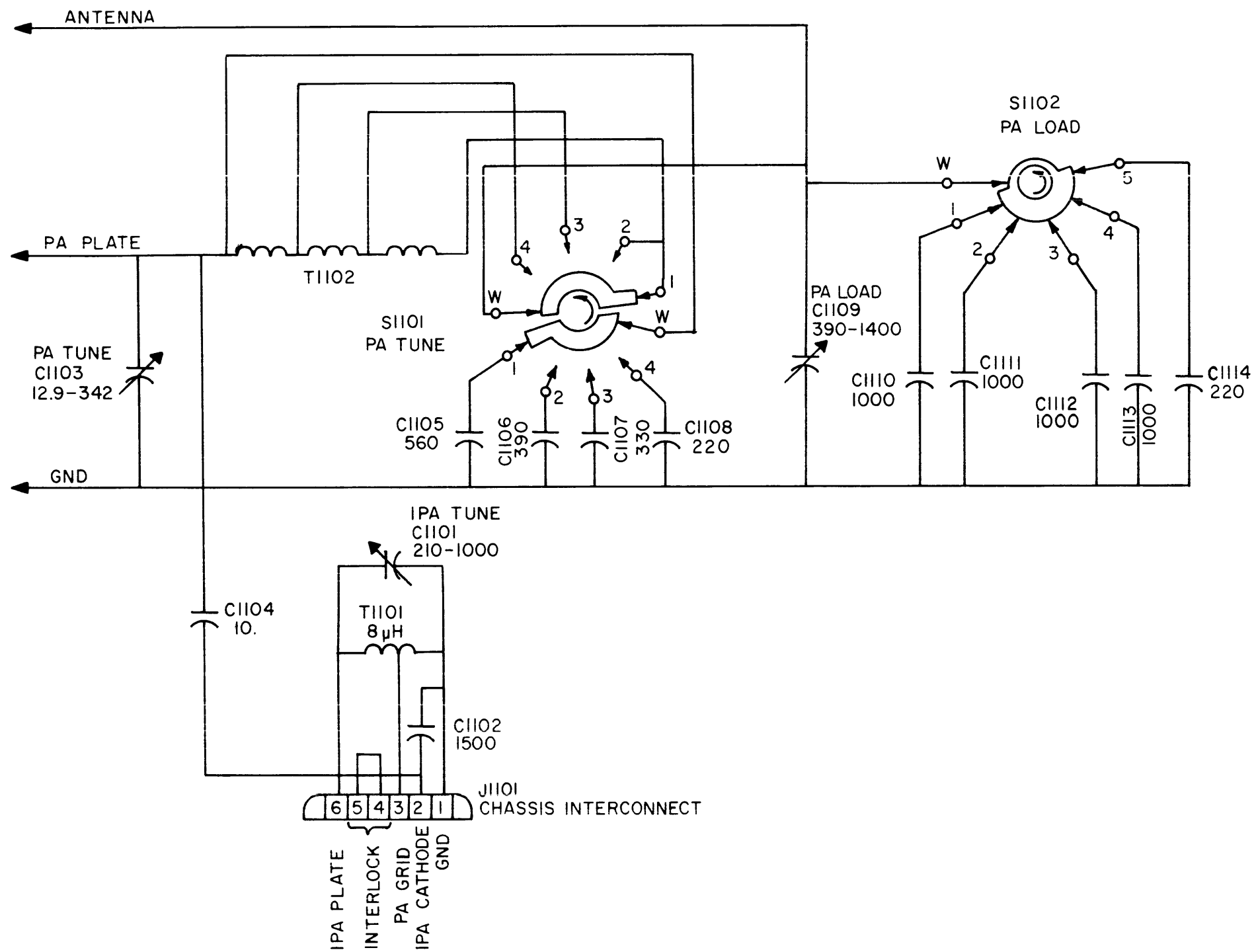


FIGURE 7-1. TTR-20 SCHEMATIC DIAGRAM (Sh + 8 of 8)

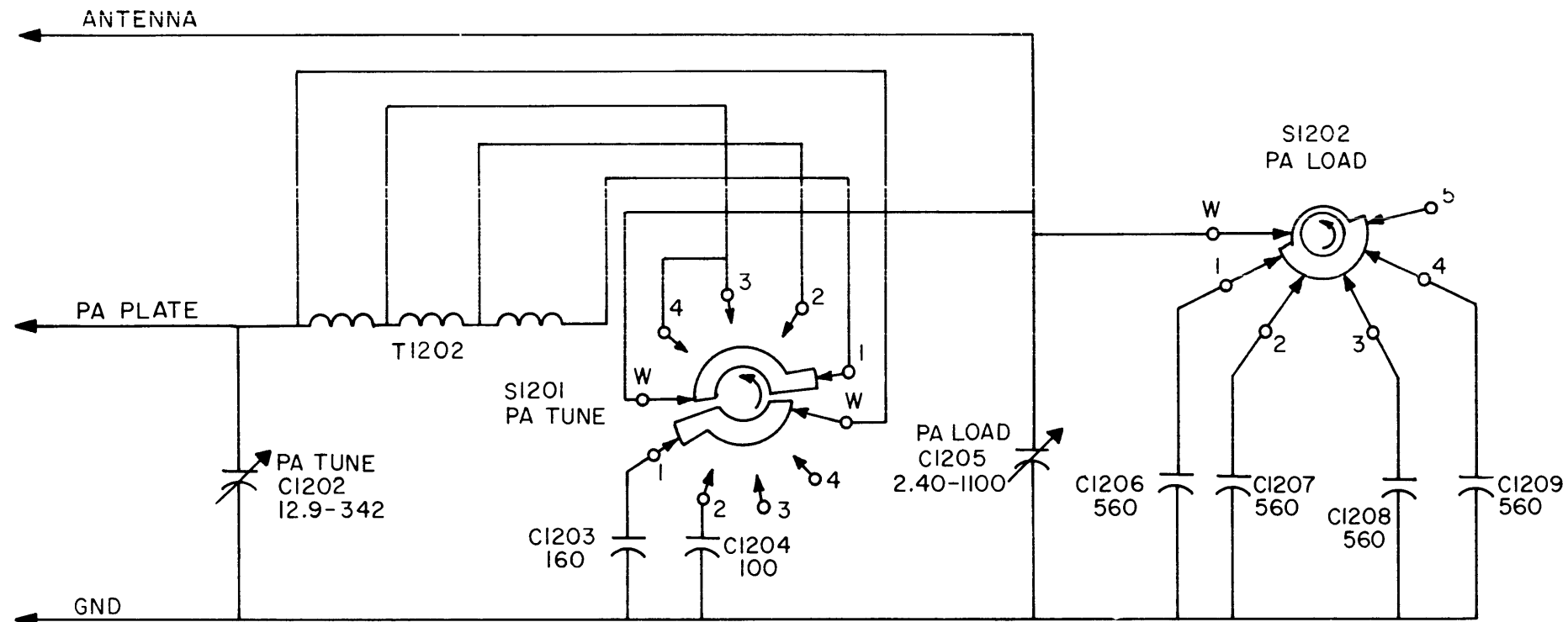


PA TUNE	
SWITCH POS.	FREQ. IN MHZ
1	2-2.2
2	2.2-2.5
3	2.5-3.1
4	3.1-4

NOTE:
ALL CAPACITORS IN pF

FIGURE 7-2. SCHEMATIC DIAGRAM: TTRA-1

FIGURE 7-2



NOTE:
ALL CAPACITORS IN pF

PA TUNE	
SWITCH POS.	FREQ. IN MHz
1	4-5
2	5-6.3
3 & 4	6.3-8

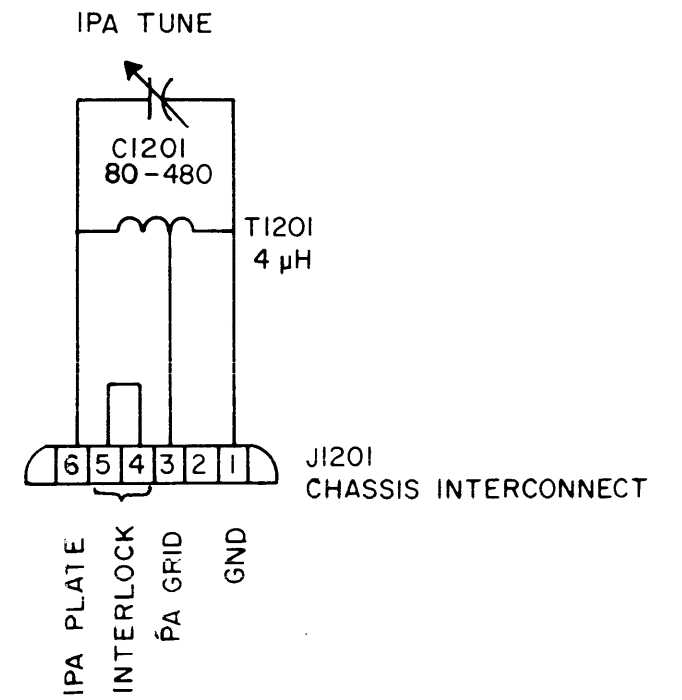
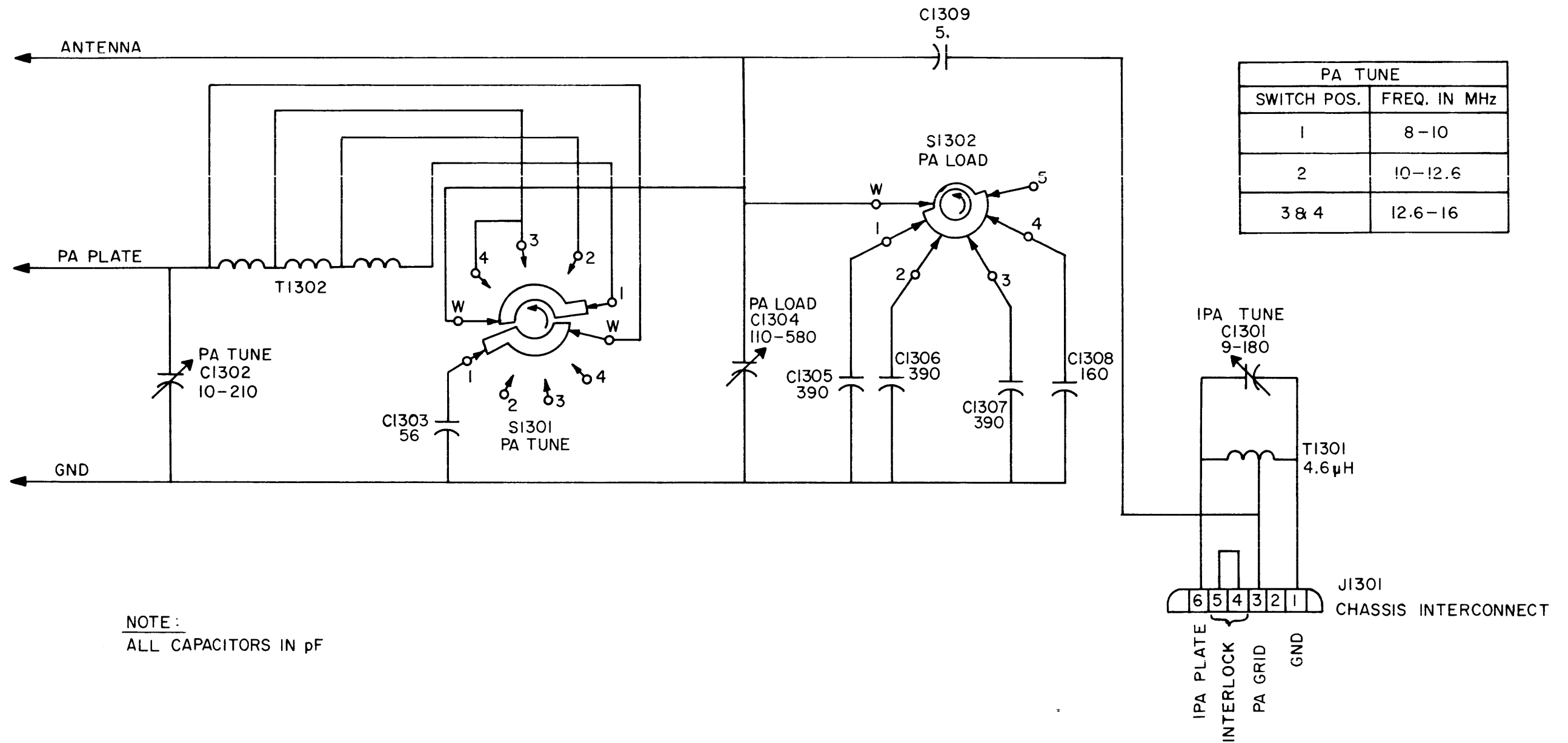


FIGURE 7-3. SCHEMATIC DIAGRAM: TTRA-2

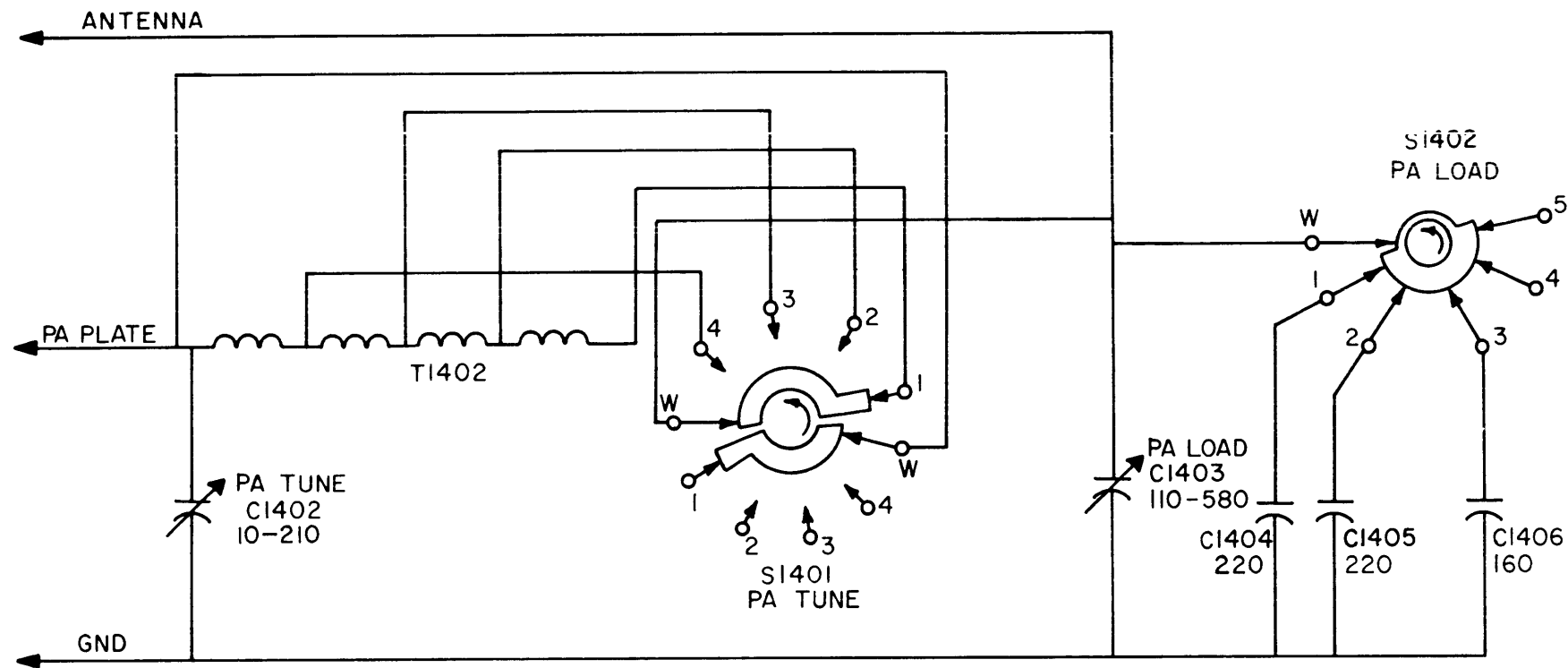
FIGURE 7-3



NOTE:
ALL CAPACITORS IN pF

FIGURE 7-4. SCHEMATIC DIAGRAM: TTRA-3

FIGURE 7-4



NOTE:
ALL CAPACITORS IN pF

PA TUNE	
SWITCH POS.	FREQ. IN MHz
1	16-20
2	20-24
3	24-28
4	28-32

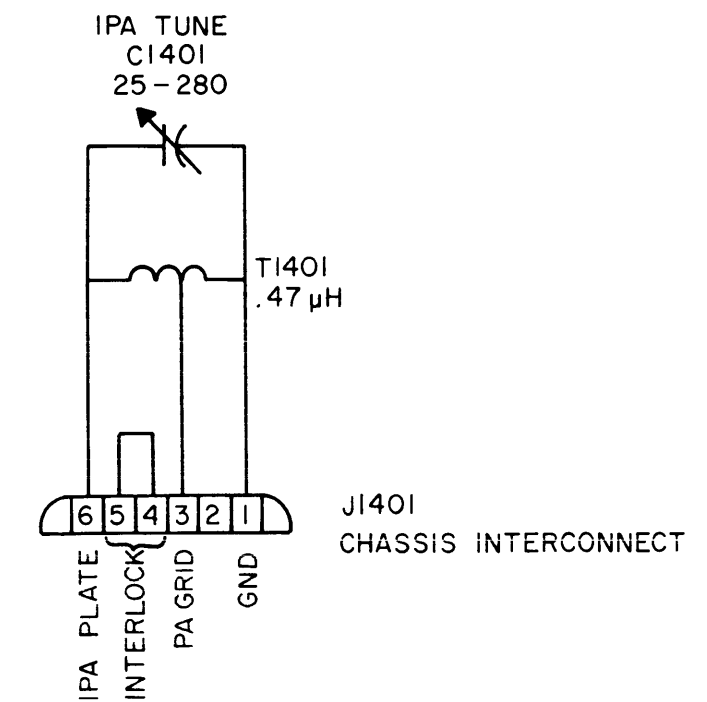


FIGURE 7-5. SCHEMATIC DIAGRAM: TTRA-4

FIGURE 7-5