UHF REPEATER SERVICE MANUAL

LIMITED

WARRANTY

General Aviation Electronics, Inc. (Genave), warrants this product to be free from material defects for a period of 90 days from the date of purchase, provided the warranty registration card properly filled out is returned by the purchaser to Genave within 10 days after purchase. This warranty is limited to the original retail purchaser and is not extended to second owners of the product.

Our obligation under this warranty is limited to replacement of any parts (except periodic maintenance items such as bulbs, fuses, etc.) which, upon our examination, appear to us to be defective in materials or workmanship. The parts will be replaced within 45 days after receipt of the unit, provided the unit is delivered to the Factory (Customer Service Dept., General Aviation Electronics, 4141 Kingman Drive, Indianapolis, Indiana 46226) within 90 days after the date of purchase, shipping prepaid. All shipping costs and labor charges shall be born by the purchaser

The owner may elect to have the unit repaired at an authorized Genave repair facility in which case Genave, within 45 days after receipt of the unit, will replace only those defective parts returned shipping prepaid to the Factory (Customer Service Dept., General Aviation Electronics, 4141 Kingman Drive, Indianapolis, Indiana 46226). Purchaser shall bear any and all other costs including but not limited to labor, transportation and freight.

This warranty does not apply to defects, malfunction, or breakage due to improper installation or to the servicing thereof by other than an authorized Genave dealer nor to units that have been damaged by lightning or other acts of God, excess current, or any units that have had serial number altered or removed. Abuse, misuse, tampering, submersion in water or willful destruction of the unit will also void this warranty.

This warranty gives you specific legal rights. You also have implied warranty rights. In the event of a problem with warranty service or performance, you may be able to go to a small claims court, a State court, or a Federal District court.

Genave offers this warranty in lieu of any and all other guarantees or warranties, either EXPRESSED or IMPLIED, including but not limited to warranties of merchantibility and/or fitness for a particular purpose. Any implied warranties are specifically and expressly limited to the 90-day period specified herein. Damages for breach of any warranties, either expressed or implied are limited to replacement of any defective parts as specified herein and any other incidental or consequential damages are expressly excluded.

General Aviation Electronics, 4141 Kingman Drive, Indianapolis, Indiana 46226—Area 317 - 546-1111

Genave

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Specifications subject to change without notice

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SECTION 1
GENERAL INFORMATION

1-1. INTRODUCTION

Sections 1, 2, and 3 of this Genave Mobile Relay Station Maintenance Manual contain a general description of the unit, and suggestions regarding installation, licensing, and operation.

In addition to the above general information, the maintenance manual contains Theory of Operation, Alignment Procedures, Schematics, and Component Location Drawings in Section 4. Section 5 lists replacement electronic parts and major mechanical components.

1-2. ADVANTAGES OF A REPEATER

A major improvement in UHF-MOBILE coverage is usually noted when a repeater is added to the system, since MOBILE stations normally are severely limited by their low antenna heights and urban environment -- this is especially true where rough terrain exists.

A repeater is a receiver/transmitter combination which receives signals from a MOBILE unit on one frequency, while simultaneously retransmitting these signals to other MOBILE units in the system on a second frequency. Thus, radio coverage through a repeater is generally superior, as the antenna can be located on top of a tall building, such as the Sears Tower in Chicago, or on a tower of the local TV or Broadcast station.

Receivers and transmitters specifically designed for repeater service are preferred, because they contain the extra shielding and filtering needed to minimize mutual interference when receiver and transmitter are operated simultaneously. However, some additional items are needed for a really practical repeater station.

1-3. GENERAL DESCRIPTION

This UHF-FM mobile relay station is to provide reliable, high-quality two-way communications in the various Public Safety, Industrial, and Business Radio Services authorized under F.C.C. Rules Part 90. The unit is capable of receiving and retransmitting frequency modulated radio signals in the frequency range 450 to 512 MHz.

The unit is ready to connect to an antenna and power source. The station can be operated from a 120/240 volt, 50/60 Hz, AC system, with 12-volt emergency standby battery power, if desired.

The complete station is housed in one aluminum cabinet, and consists of the following items:

1) A shielded, filtered UHF receiver

2) A shielded, filtered UHF exciter

3) A shielded, filtered 35W amplifier

4) An optional Duplexer

5) A solid-state, regulated 13.7-volt DC power supply.

6) A control board, containing provisions for a number of subaudible-tone encoders/decoders, a 3-min. timer, a 2-sec. timer, a carrier-operated relay, volume and squelch controls.

7) Internal speaker for monitoring

8) A cooling fan.

The receiver is a crystal-controlled, dual-conversion superheterodyne employing a JFET RF amplifier, a JFET 1st mixer, and an 8-pole monolithic crystal

filter at 10.7 MHz for the selectivity required in a large urban environment. Copper-plated cavities containing 3-pole, aperature-coupled helical resonators tune the input and the output of the RF amplifier. The 10.7 MHz 1st IF provides good image rejection, while the 455 kHz 2nd IF improves receiver stability. A single integrated-circuit chip performs limiting, 2nd mixer, 2nd LO, detection, and squelch functions. An integrated-circuit audio device provides approximately 5-watts of audio when the unit is used as a base radio, or as an aid in equipment servicing.

The exciter module is enclosed in a die-cast alloy housing, with all voltage and control wires filtered. The exciter is completely solid-state, and includes the oscillator, crystal heater, frequency multiplier stages, microphone amplifier, and phase modulator. The crystal frequency multiplies 36 times to reach the output frequency of 450 to 512 MHz. The exciter supplies an RF output of approx. 1-watt over the frequency range to drive the high-power amplifier.

Three NPN grounded-emitter, Class C stages raise the 1-watt input from the exciter to approx. 35-watts. Output from the power amplifier is coupled by a capacitive matching network and co-ax cable to either an optional duplexer or a BNC connector for a 50-ohm antenna.

The repeater cabinet contains provisions for the installation of an optional internal duplexer, which allows both transmitter and receiver to operate simultaneously on a single antenna with at least 75 dB of isolation between the two signals. Multiple BNC connectors on repeater rear panel allow transmitter and receiver to be connected to separate antennas if desired, and also aid in isolating suspected malfunctions in the duplexer.

The internal, solid-state power supply provides an adjustable, regulated 13.75 volt DC output. The supply incorporates a dual-primary, step-down power transformer and DPDT slide switch to select either 120 or 240 VAC operation. The solid-state, full-wave rectifier and the pass transistors are mounted on the rear-panel finned heatsink. If standby battery power for the repeater is desired, a heavy-duty 12-volt battery can be connected to a panel mounted receptacle at rear panel of unit. During normal operation, a relay connects all repeater circuitry to output of power supply, however, if AC power fails, the relay switches repeater circuits to the battery. When AC power is restored, the relay automatically switches repeater back to the internal power supply.

A printed-circuit Control Board contains required control circuitry, such as the carrier-operated relay and the various timers, as well as volume and squelch controls and two LED indicators. Connecting pins provide mountings for a maximum of seven Genave SA-1, or equivalent, subaudible-tone encode/decode boards. A brief description of the control circuitry is given below:

a) COR (carrier-operated relay) circuitry activated by receiver, keys transmitter when an input signal of adequate strength is received.

b) A 2-second timer automatically deactivates transmitter approx. 2-seconds after signals controlling the station cease, as required by FCC Rules 90.243(c)(3). This also prevents repeater transmitter from being keyed ON or Off by rapidly fading signals.

c) The 3-minute timer automatically deactivates repeater transmitter not more than 3-minutes after its activation by a mobile unit, as required by FCC Rule 90.243(c)(4). This timer resets during the short pauses between transmissions, and thus does not interfere with normal communications.

d) FCC Rule 90.243(c)(2) states: Mobile relay stations controlled by signals above 50 MHz ..... are not required to incorporate any coded signal or tone-control devices un-

less the transmitters are consistently activated by undesired signals and thus cause harmful interference to other licensees. If activation by undesired signals does cause harmful interference, the Commission will require the installation of tone-control equipment within 90 days of a notice to the licensee.

Subject to provisions of d) above, the Genave repeater control board may be operated without a subaudible tone encoder/decoder, in which case the transmitter will be activated by any signal on the input frequency. However, the control board can accomodate a maximum of seven individual encoder/decoder boards; thus, as many as seven mobile systems could share the repeater without any system hearing communications of any other system. Of course, it must be understood that only one station can communicate through a repeater at a time, regardless of tone-control equipment.

This Mobile Relay Station has full provisions for use as a base station, in addition to its primary use as a repeater. For use as a base station, or to aid in servicing the unit, the front panel contains volume and squelch controls, an internal speaker, and a 4-pin receptacle which will accept either a standard Genave hand microphone or a desk-style microphone.

If one or more subaudible-tone encoder/decoders are used, an internal jumper on control board determines which tone board will activate the internal speaker during normal operation. An operator at the base-station, if used, can monitor all signals, regardless of their subaudible-tone frequency, by removing the hand microphone from its hang-up metal clip, or by depressing the monitor switch on a desk-style microphone. Note that this ability to over-ride the tone-squelch applies only to front panel, base-station controls, and does not affect the incoming or retransmitted signals.

1-4. SPECIFICATIONS

GENERAL:

Front-Panel Size:	5.25" (13.4 cm) H x 17" (43.2 cm) W Desk Top Mounting
	5.25" (13.4 cm) H x 19" (48.3 cm) W Rack Mounting
Over-all Dimensions:	5.25" (13.4 cm) H x 17" (43.2 cm) W x 14.5" (36.8 cm) D -- Desk Top Mounting
	5.25" (13.4 cm) H x 19" (48.3 cm) W x 14.5" (36.8 cm) D -- Rack Mounting
Power Supply:	115/230 VAC, 50/60 Hz

1-4. SPECIFICATIONS (Cont'd)

Frequency Range:	450 - 512 MHz
Number of Channels:	1 (1 input, Rec. and 1 output, Trans.)
Tone Control:	Up to seven (7) internal plug-in, SA-1 tone boards can be used.
Duplexer:	Optional, may be internally mounted.
Temperature Range:	-30°C to +50°C
Weight:	Approx. 25 Lbs. (11.34 kg)

TRANSMITTER:

Power Output:	35 watts, minimum, to duplexer
Output Impedence:	50-ohms, nominal
Frequency Stability:	±.00025% over temperature range
Frequency Accuracy:	± 250 Hz
Spurious Output Level:	-60 dB
Audio Modulation Deviation:	±5 kHz
Subaudible-Tone Modulation Deviation:	±1.2 kHz, max.

RECEIVER:

Sensitivity:	0.45 uV for 12 dB SINAD
Selectivity:	±7 kHz, min., at -3 dB
Squelch Threshold:	0.35 uV, min.
Modulation Acceptance Bandwidth:	±5 kHz, min.
Adjacent Channel Rejection:	70 dB, min. (EIA)
Intermodulation Response:	70 dB, min. (EIA)
Image Response:	80 dB, min.
Spurious Response:	80 dB, min.

1-4. SPECIFICATIONS (Cont'd)

Audio Output Power:	5 watts min., 3.2-ohm load, less than 15% distortion.
Hum and Noise Level:	45 dB below rated power output.
Frequency Accuracy:	±250 Hz at 25°C.
Frequency Stability:	± .0005% over temperature range.
Circuit Type:	Dual-conversion Superheterodyne.

1-5. EQUIPMENT SUPPLIED

a) Mobile Relay Station, in rugged, all-metal case for Desk-Top mounting. Includes receiver, transmitter, dual-voltage power supply, internal fan, speaker, and crystals for receiver and transmitter.

1-6. EQUIPMENT REQUIRED BUT NOT SUPPLIED

a) Duplexer and one UHF Comm. Antenna

OR

2 UHF Comm. Antennas

b) Co-axial cable for antenna(s)

c) Jumper co-ax cables to connect receiver and transmitter to duplexer, if used.

1-7. OPTIONAL EQUIPMENT/ACCESSORIES

a) Heavy-duty, hand microphone for use in systems with CTCSS (G-15).

b) Desk-style microphone for use in systems with CTCSS (G-11).

c) Subaudible-tone encoder/decoder, one to seven boards usable (SA-1).

d) Internal Duplexer.

e) Mobile Relay Station, equipped with front panel for rack mounting

f) Modification for remote control (Contact Engineering Department).

g) Optional Telephone Interconnect (Must meet Part 68 of FCC Rules, contact Engineering Department).

SECTION II

INSTALLATION MANUAL

2-1. ANTENNA INSTALLATION WARNING

Various Consumer Protection groups request that the potential dangers associated with antenna installation be pointed out, with applicable precautions.

WARNING: Each year a number of persons are electrocuted while installing radio antennas; therefore, use extreme caution when installing antenna/antenna-support for use with this Mobile Relay Station. Observe following precautions:

a. DO NOT attempt to erect antenna while a thunderstorn is gathering.

b. If at all possible, choose an antenna location separated from the nearest high-voltage lines by a distance equal to TWO times the height of the antenna and its support.

c. DO NOT allow antenna, mast, or cable to touch electric signs or overhead electric wires --- even if only 120 or 240-volt wiring.

d. If antenna or mast starts to fall toward overhead wires, get completely away. If the antenna comes to rest against electrical wires, DO NOT attempt to remove it, but call the local electric company.

e. REMEMBER - UNDER THE RIGHT CONDITIONS, ANY CONTACT WITH AN ELECTRICAL CIRCUIT CAN BE LETHAL

2-2. INTRODUCTION

This section provides suggested installation data for repeater service only, or for combined repeater/base station service. For complete technical specifications of the instrument, refer to Section 1-4 (Specifications) in this manual.

2-3. PRE-INSTALLATION CHECK

Visually inspect the unit for any obvious external damage - such as broken knobs, dents, damaged heatsink fins or radio case. Any problem NOT related to shipping must be reported to GENAVE, 4141 Kingman Drive, Indianapolis, In., 46226, Telephone (317) 546-1111, as soon as possible.

If the packing case shows damage, make a notation to that effect on the express receipt or freight bill. Report to the transportation company any damage due to shipping, and file a claim promptly.

2-4. INSTALLATION PLANNING

In choosing a location to install this unit, remember that FCC Rule 90.427 states:

"Each transmitter shall be so installed and protected that it is not accessible to or capable of operation by persons other than those duly authorized by and under the control of the licensee. Provisions of this part authorizing certain unlicensed persons to operate stations, or authorizing unattended operation of stations in certain circumstances, shall not be construed to change or diminish in any respect the responsibility of station licensees to maintain control over the stations licensed to them (including all transmitter units thereof), or for the proper functioning and operation of those stations and transmitter units in accordance with the terms of the licenses of those stations."

"90.429(a) Control point required. Unless permitted to be operated on an unattended basis, each station shall be provided with a control point; (b) A control point is an operating position, which must be under the control and supervision of the licensee;"

The unit was pre-aligned at the factory for RECEIVE and TRANSMIT frequencies specified at time of order. If one or more subaudible-tone frequencies were specified at time of order, the proper tone boards were installed and adjusted to frequencies listed on a tag attached to instrument.

If it is necessary to change RECEIVE and/or TRANSMIT frequencies, alignment procedures contained in Section IV of this manual should be performed by a licensed technician, using proper test equipment. If it should be necessary to readjust subaudible-tone frequency(ies) from factory-set value(s), refer to "Tone-Frequency Adjustment" procedure in Section 4 of this manual, or to the SA-1 Maintenance Manual.

This radio may be installed for operation in either of two modes:

1. As a fully automatic REPEATER station (unattended operation).

2. As a combined REPEATER/BASE STATION (having a control point, at which a person immediately responsible for operation of the transmitter is stationed). A control point may be located at either:

   a) The transmitter location; or,

   b) If so authorized by the station license, at a point remote from the transmitter; however, radio or wire facilities between control point and transmitter must allow operator to turn carrier ON and OFF at will.

Before starting installation of this unit, determine desired mounting method and location; ascertain that 120 or 240 VAC is available; determine location for antenna installation and routing of co-ax cable to rear-panel mounted antenna connector(s).

NOTE: The radio should be placed in its normal resting position; this is, on its four rubber feet. The unit should NOT BE mounted directly above a hot-air register or radiator; nor should books or other objects be placed on the unit in such manner as to restrict air flow thru the cabinet or heatsink.

2-5. REPEATER/BASE STATION INSTALLATION

2-5-1. Automatic Repeater Installation

1. Desk-Top Unit: Place unit on suitable support, convenient to source of AC power. As preventative maintenance and routine checks must be made at times, the equipment should be fairly accessible.

   Rack-Mounting: Install radio in a standard 19" relay rack, using normal 10-32 hardware. The unit should NOT BE installed directly above a high-powered amplifier, or any other high-temperature source.

   NOTE: The repeater site is normally unattended; thus, operator comfort is not a factor. Never-the-less, the area should be weather-proof, and protected from vandalism.

2. Remove #4 self-tapping screws which secure top cover of radio to: Top of front panel, bottom plate on each side, and top of rear heatsink.

3. Locate slide switch on power supply board, which switches unit for operation on either 115 or 230 volts AC. See Figure 2-1.

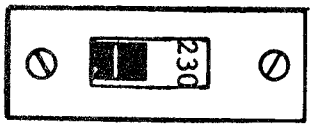


Figure 2-1. 115/230 VAC Switch

4. With a small screwdriver or soldering aid, slide switch to its "115" or "230" volt position, as determined by voltage source to be used.

5. Plug Repeater AC line cord into the applicable AC receptacle.

   NOTE: The AC source should not be a switched line which may be inadvertently turned OFF while Repeater is in use.

6. Install antenna(s) as recommended by manufacturer. The antenna should be fed with low-loss 50-ohm coaxial cable. The loss per 100 feet at 420 MHz is shown in Table 2-1 for several popular types of 50-ohm coax.

   NOTE: If optional DUPLEXER is used, only one antenna and coax cable is needed, otherwise two separate antennas and cables are required.

7. Route coax cable(s) from antenna to rear panel of radio. Clamp or support cable as necessary.

8. If optional accessories are to be installed, such as "telephone interconnect" or "remote control," follow recommendations of Genave Engineering Department and/or supplier of interface equipment. Equipment data, schematics, and Component Location Drawings are located in Section IV of this manual.

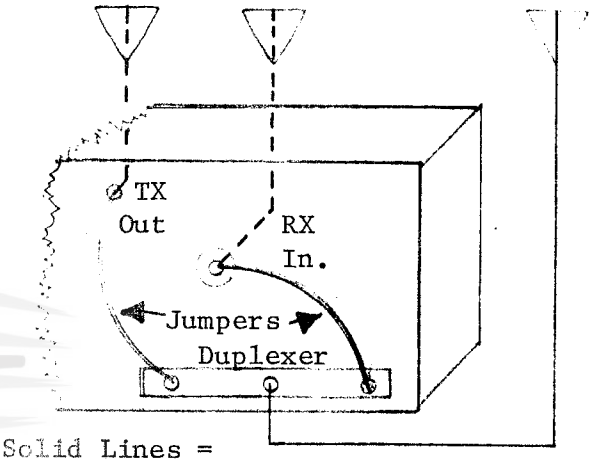
9. After any desired modifications are completed, re-install top cover on instrument. Replace all screws removed in step 2 above to maintain adequate shielding.

10. Install coax connector(s) on antenna cable(s), as given in Section 2-6 of this manual.

    NOTE: BNC connectors for duplexer input and output, receiver input, and transmitter output are located on Repeater rear-panel. If UHF coax plugs (PL-259 or 83-1SP) are installed on antenna cables as given in Section 2-6, an adapter such as UG-255/U may be used to enable the UHF plug to mate with the BNC receptable.

    An alternate plug is the UG-959/U, which is a male BNC connector made for installation directly on large coax, such as RG-8/U. Installation of this connector is also covered in Section 2-6 of this manual.

11. If two antennas are used, connect each antenna to proper connector on repeater rear panel; however, if a single antenna and duplexer are used, connect antenna to duplexer and use two coax jumpers to connect duplexer to receiver input, and to transmitter output. Refer to Figure 2-2 for location of coax connectors on unit rear panel.



Solid Lines = Ant & Duplexer

Dashed Lines = Separate Antennas

Figure 2-2. Repeater Coax Connectors

12. If desired, a hand microphone may be connected to front-panel mic. receptacle for test purposes.

    NOTE: If unit is equipped with sub-audible tone option, the microphone mounting clip should be grounded to repeater chassis in order to enable tone squelch. Removing microphone from clip disables tone squelch for monitoring purposes, without affecting incoming signals.

13. To provide standby battery power for Repeater, connect a heavy-duty 12-volt battery to the 15-pin mounted receptacle at rear panel of unit. During operation on AC power, the battery will receive a "float" charge; then, if AC power fails the battery provides uninterrupted communications.

14. With AC power applied to Repeater, note that green LED power indicator glows. Disable the tone squelch, if used, by removing microphone from its metal hang-up clip.

15. Turn volume control to approximate mid-range. With NO incoming signal, note that red LED TX indicator is NOT glowing (receiver squelched).

16. Turn squelch control fully counter-clockwise. Background noise should be heard in speaker and red TX indicator should glow, indicating the transmit-keying circuit is activated.

17. Rotate squelch control clockwise until receiver is fully squelched. Within 2-seconds after receiver is squelched, the red TX light should turn OFF -- indicating that transmitter has been disabled.

18. A check should be made with one or two mobile or handheld units in the area to ascertain that signal is being received and retransmitted properly.

2-5-2. Combined Repeater/Base Station Installation

As indicated earlier, FCC Rule 90.429 (a) requires a manned control point for each station, unless the station license specifically authorizes unattended operation.

The operating position (control point) may be located at the transmitter site; or, if authorized by the station license, at a point remote from transmitter.

This section will be confined to those installations where the transmitter i located at the operating position.

1. Desk-Top Unit: Place Repeater on a suitable operating desk within easy reach of the operator. The location should be convenient to a source of AC power, and should provide reasonable access for installation of antenna coax cable. The transmitter and its control point must be under the control and supervision of the licensee.

   Rack-Mounting: Install Repeater/Base Station unit in a standard 19" relay rack, using standard 10-32 hardware. The transmitter/receiver unit should NOT BE mounted directly above a high-powered amplifier, or any other high-temperature source. The rack should be within easy reach of the operator, to enable easy access to microphone, volume and squelch controls.

2. Perform steps 2 through 7 as given in Section 2-5-1 of this manual.

3. The internal Control Board is factory wired with a jumper so that only subaudible-tone board #1 will activate internal speaker, if tone-squelch option used. This jumper can be changed, as explained in Section 4 of this manual, to allow any one of seven tone boards to activate the speaker. Of course, the same thing can be accomplished by simply exchanging the tone boards.

4. Perform steps 8 through 11 in Section 2-5-1 of this Service Manual.

5. Connect either an optional Hand mic. (G-15) or a Desk-Style mic. (G-11) to front-panel mounted microphone receptacle.

NOTE: If unit is equipped with subaudible tone option, the hand mic. mounting clip should be grounded to Repeater chassis in order to enable tone squelch.

6. Complete installation of Repeater/ Base Station by performing steps 13 through 18 in Section 2-5-1 of this manual

2-6. ANTENNA CONNECTOR ASSEMBLY

The antenna should be fed with high-quality coaxial cable. The loss per 100 feet at 420 MHz is shown below for several popular types of coax cable:

TABLE 2-1.

Cable Type	Impedance	dB Loss
RG58/A-AU	53-ohms	10.4 dB
RG58 Foam	50-ohms	7.1 dB
RG8/A-AU	52-ohms	4.8 dB
RG8 Foam	50-ohms	3.9 dB

The procedure for installing a PL-259 (83-1SP) antenna connector is dependent upon type coaxial cable used. The PL-259 is installed directly on 0.405" OD cable such as RG8/A; whereas, the plug requires an adapter when used with the 0.195" OD cable such as RG58/A. The procedures for both cable types are given below, and are shown in Figure 2-3.

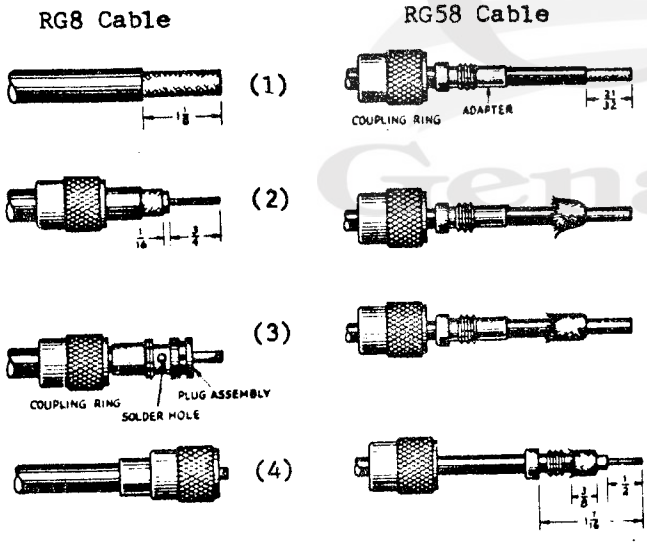


Figure 2-3. Connector Assembly

2-6-1. RG8 Cable Procedure

1. Trim end of cable flush; remove vinyl jacket from 1-1/8" of cable as shown in Figure 2-3(1). DO NOT nick braid.

2. Bare 3/4" of center conductor. Trim braided shield 1/16" and tin. Slide coupling ring on cable. See Figure 2-3(2).

3. Screw plug assembly on cable; solder plug assembly to braid through solder holes; solder center conductor to plug assembly center pin.

4. Screw coupling ring on assembly.

2-6-2. RG58 Cable Procedure

1. Trim end of cable flush; remove vinyl jacket from 21/32" of cable as shown in Figure 2-3(1). DO NOT nick braid. Slide the coupling ring and adapter on cable.

2. Fan braid slightly and fold back over cable. See Figure 2-3(2).

3. Compress braid around cable, Figure 2-3(3), and position adapter to the dimension given in Figure 2-3(4). Press braid over adapter sleeve and trim to dimension shown.

4. Bare 1/2" of center conductor as shown --- do NOT nick conductor. Pre-tin exposed center conductor.

5. Screw plug assembly onto adapter sleeve, and solder the braid to plug assembly through solder holes. Next, solder center conductor to plug assembly center pin.

2-6-3. UG-959/U Connector Installation

1. Slide nut, washer, and spacer on the cable; then trim end of cable flush as shown in Figure 2-4 (1). Remove vinyl jacket from 1/2" of cable as in Figure 2-4 (2).

2. Push braid back and remove 3/16" of dielectric. See Figure 2-4 (3).

3. Smooth braid forward over the center conductor; then slide sleeve over tapered braid until inner shoulder of sleeve fits squarely against end of jacket. Refer to Figure 2-4 (4).

4. With sleeve in place, comb out braid and trim flush with dielectric. Fold braid smoothly over tapered face of sleeve as shown in Figure 2-4 (5).

5. Slightly twist the center-conductor strands; then slip male contact in place and solder per Figure 2-4 (6). DO NOT OVERHEAT DIELECTRIC.

6. Carefully align male-pin assembly with body, and push assembly in body until sleeve, spacer, and washer are seated. Start the nut into body and screw into place, with wrench, until it is moderately tight. (Hold cable and body rigidly and rotate nut).

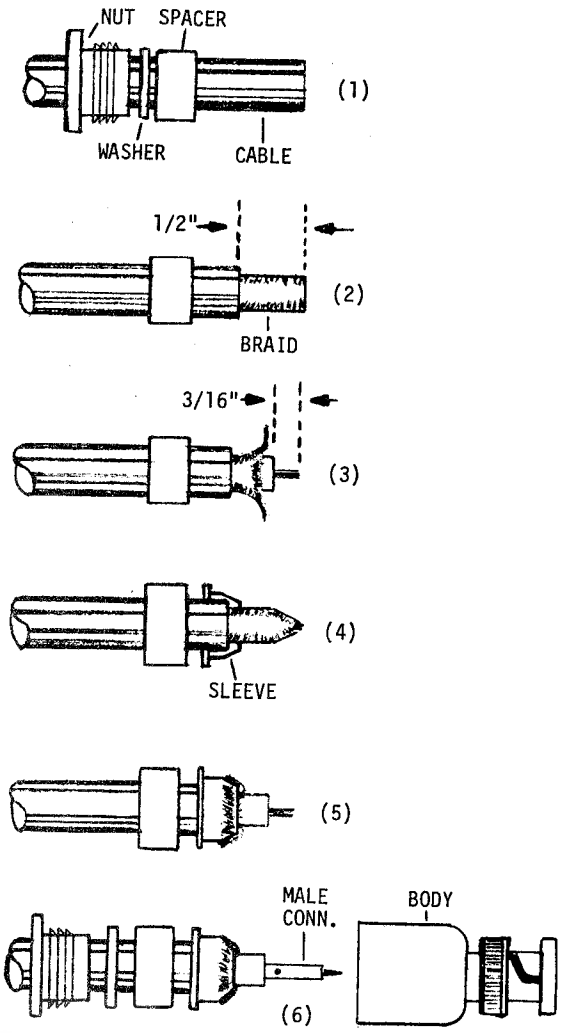
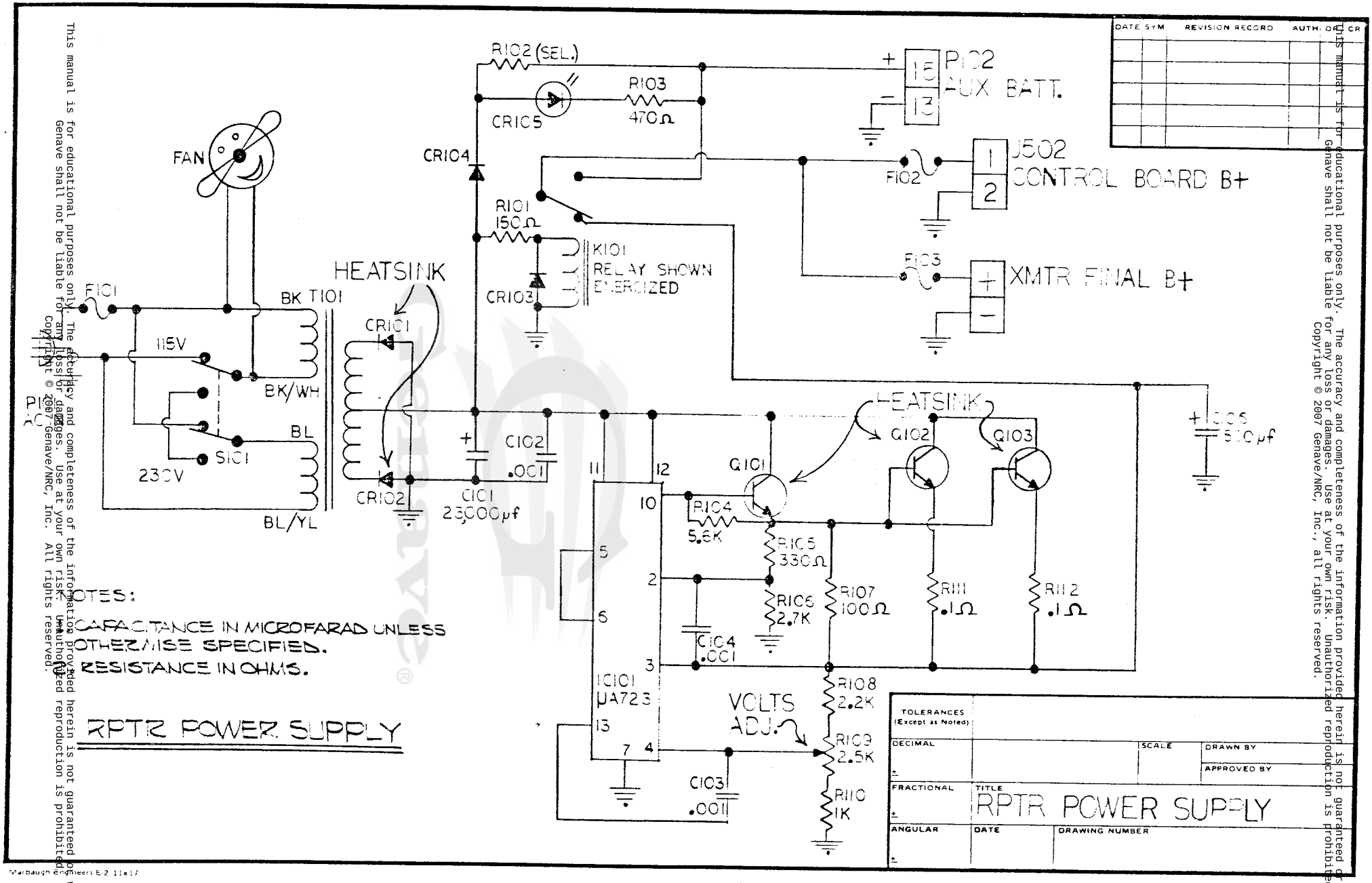


Figure 2-4. UG-959/U Assembly



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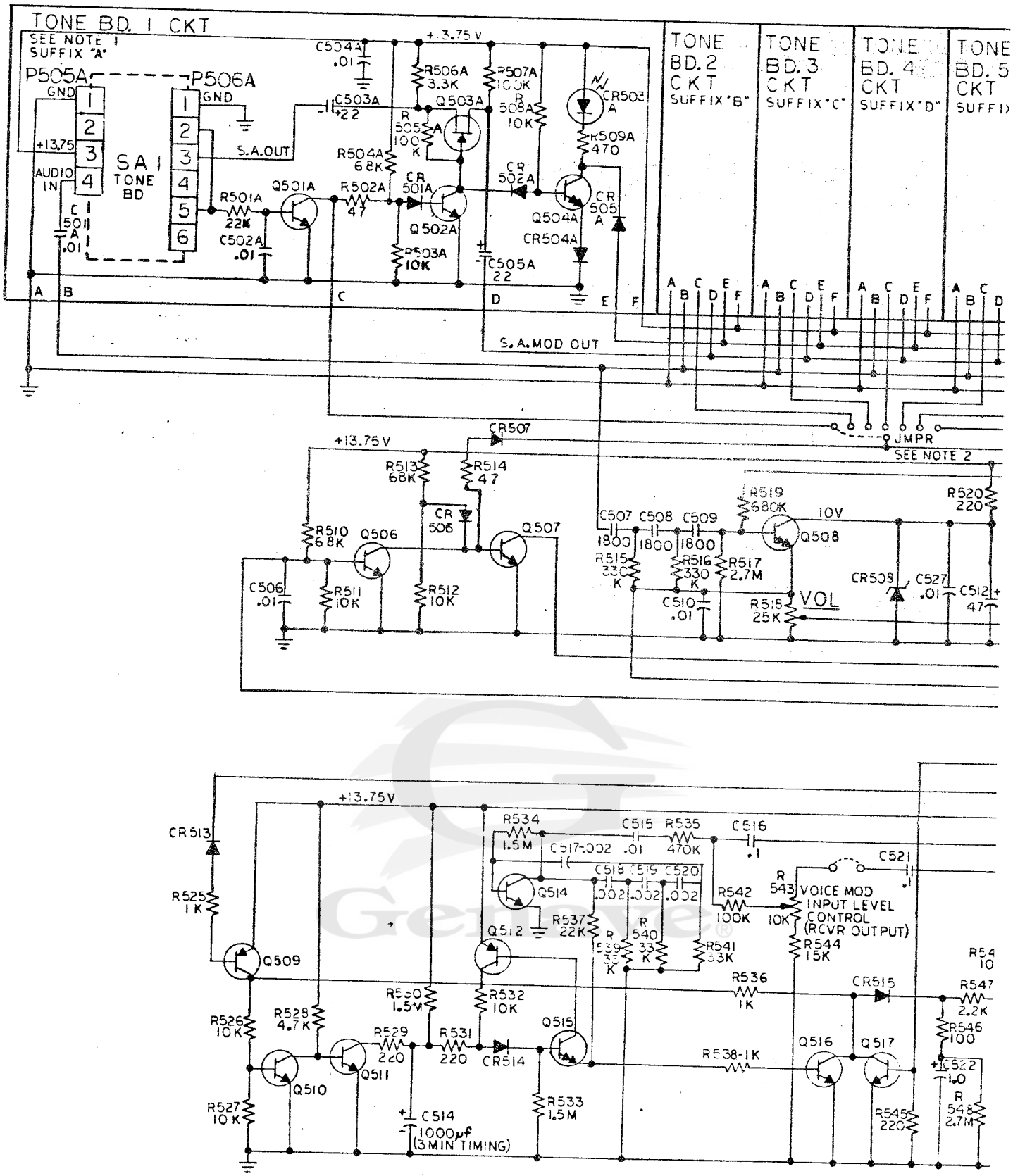

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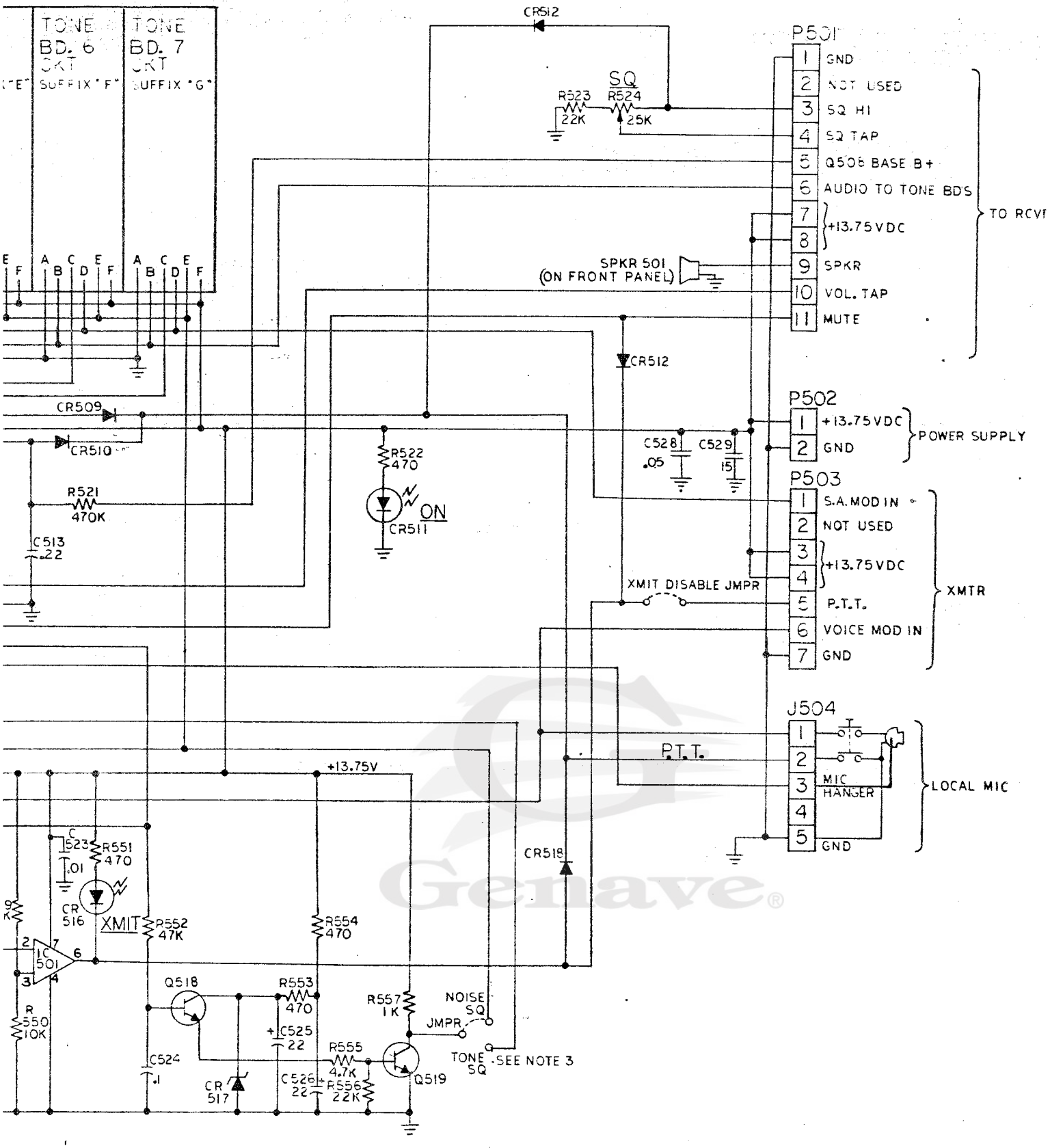

TOLERANCES (EXCEPT AS NOTED)			
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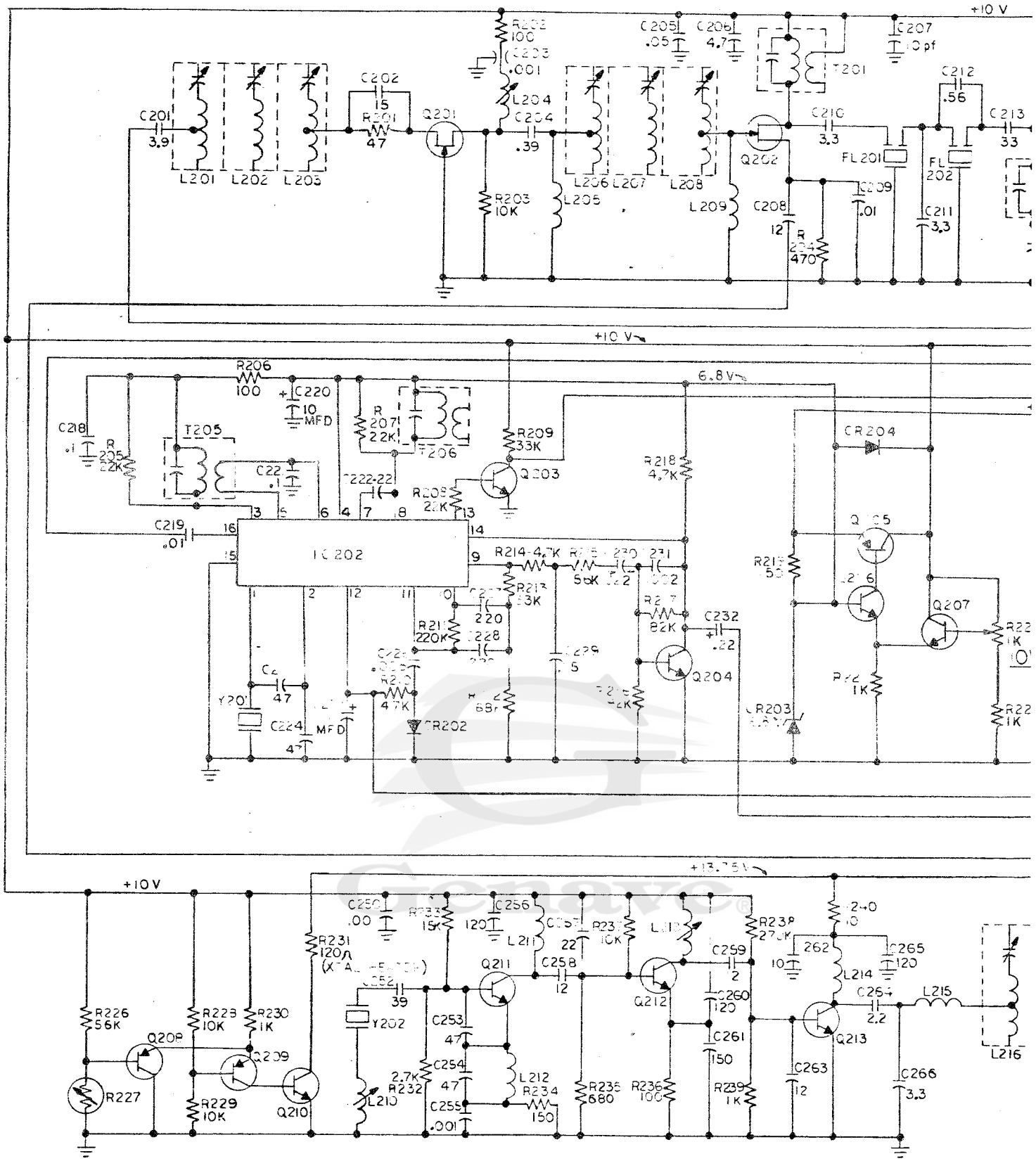
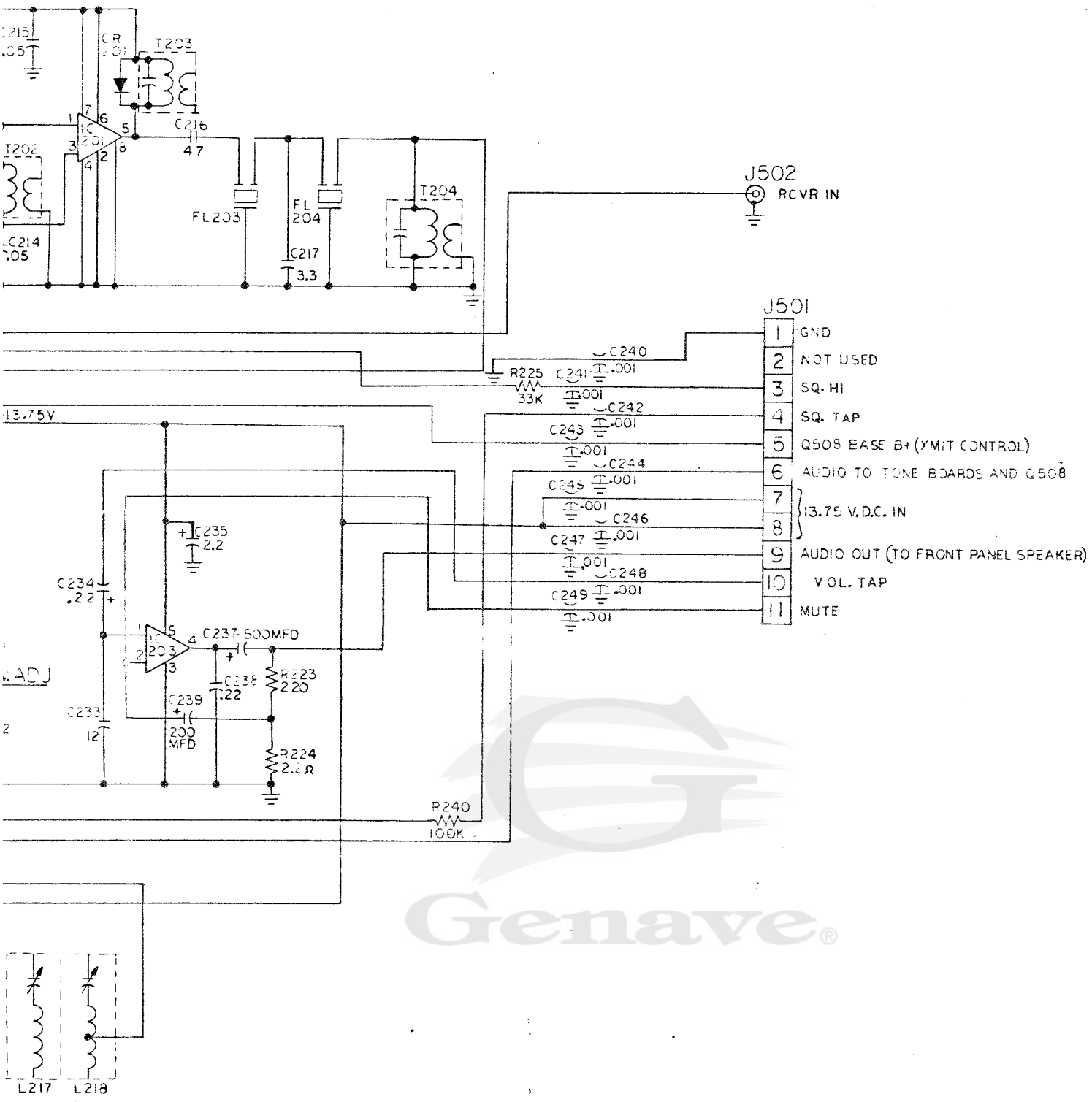
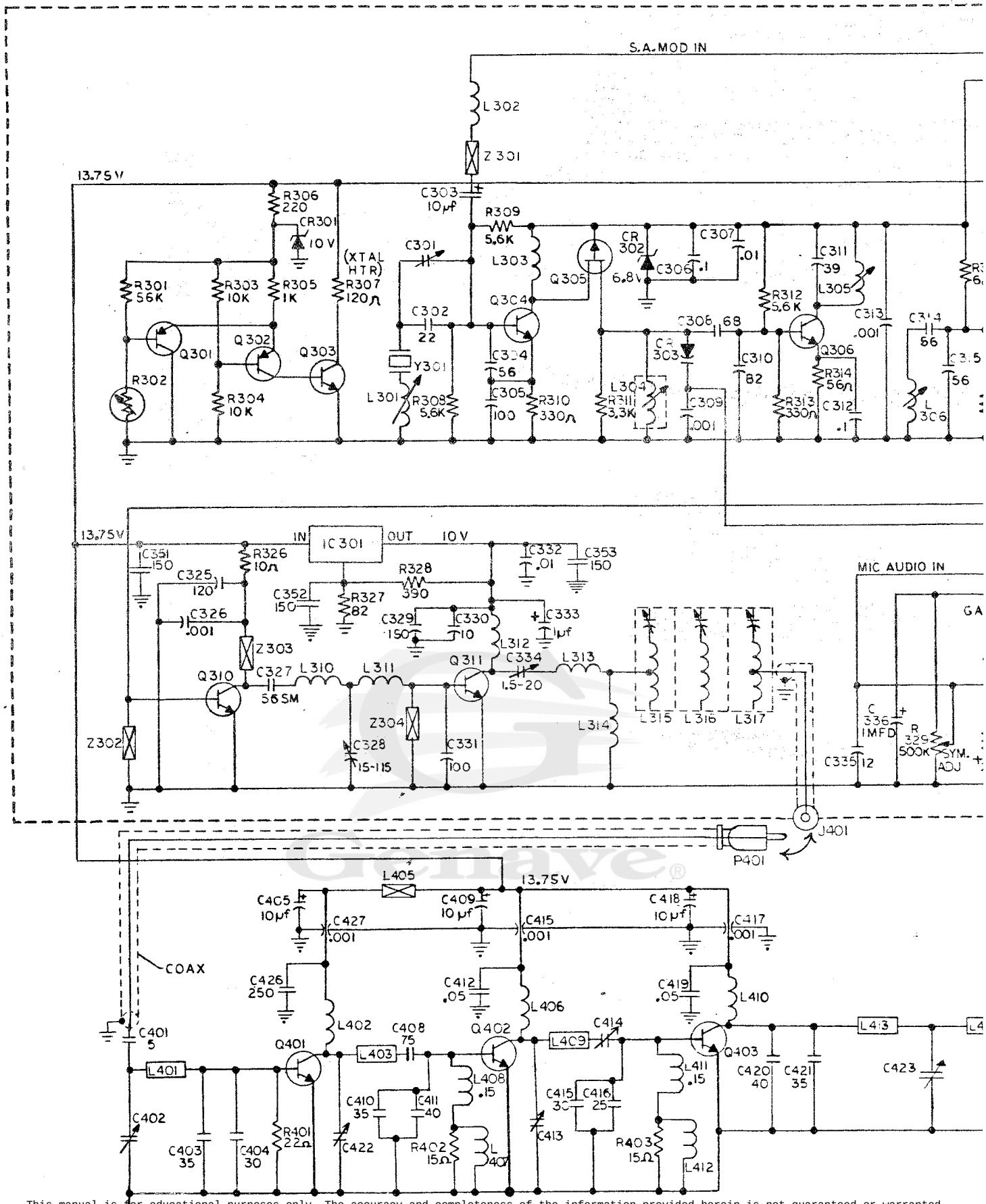
			APPROVED BY
FRACTIONAL	TITLE	RPTR CONTROL CIR.	
ANGULAR	DATE	DRAWING NUMBER	







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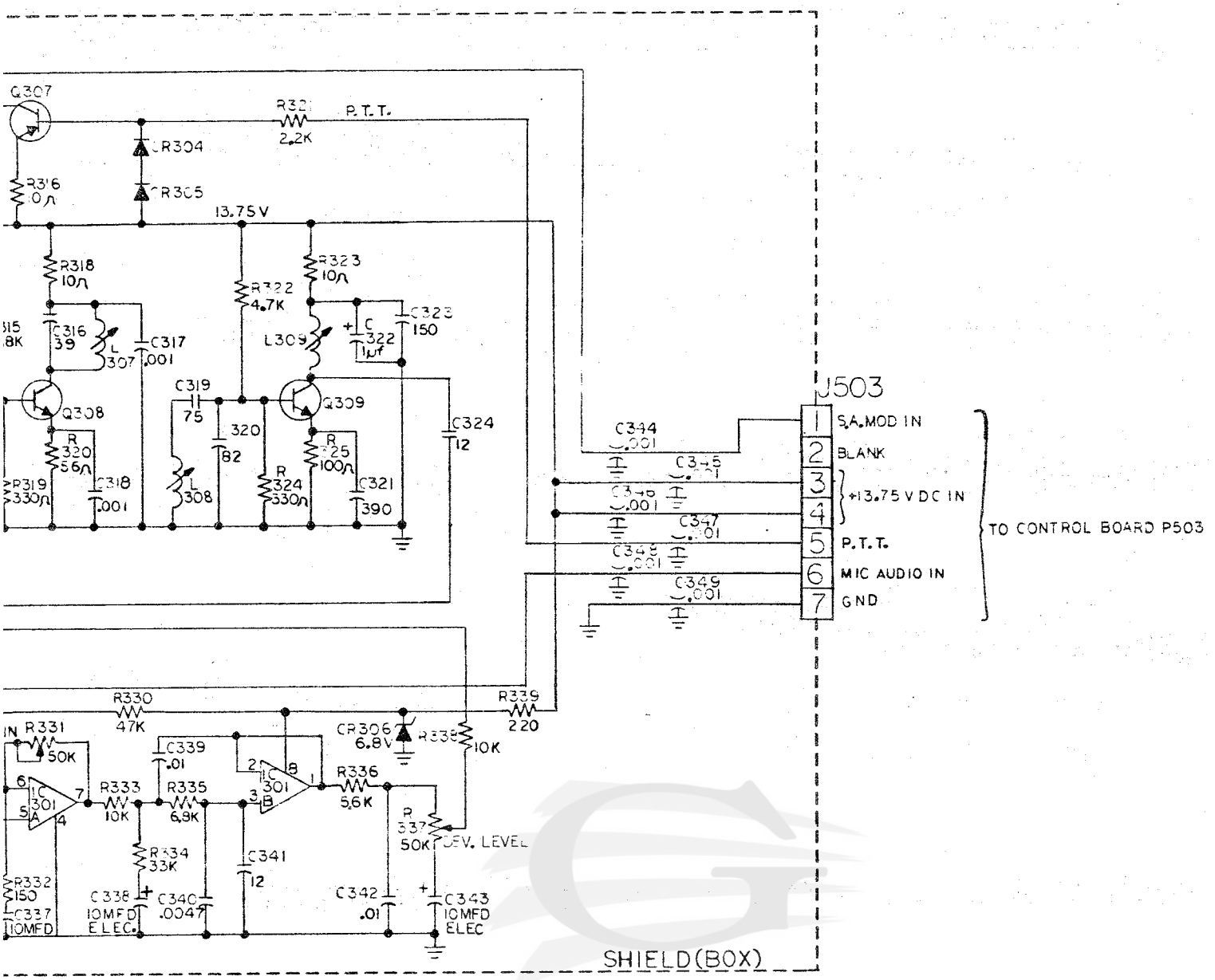

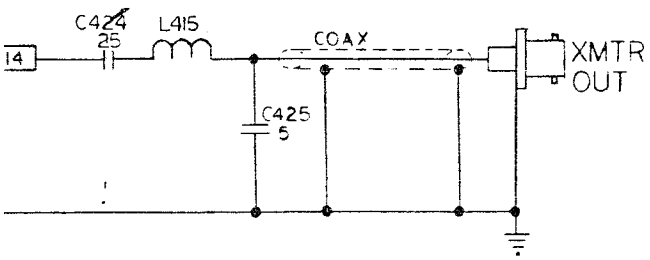

GENAVE REPEATER

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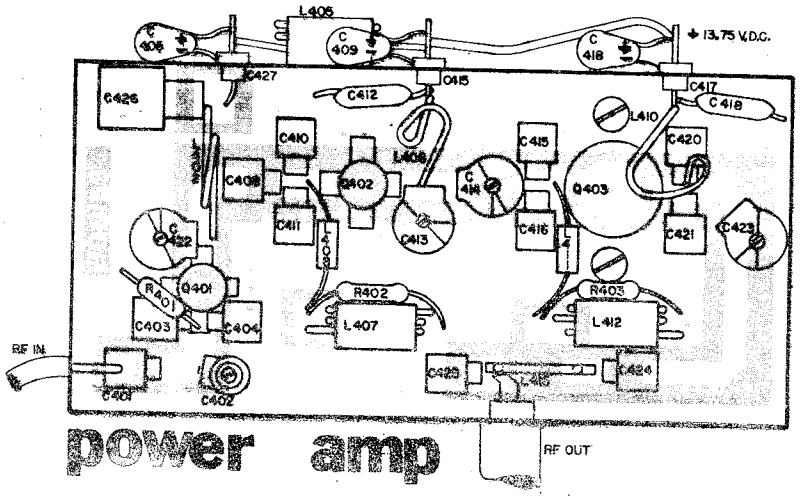
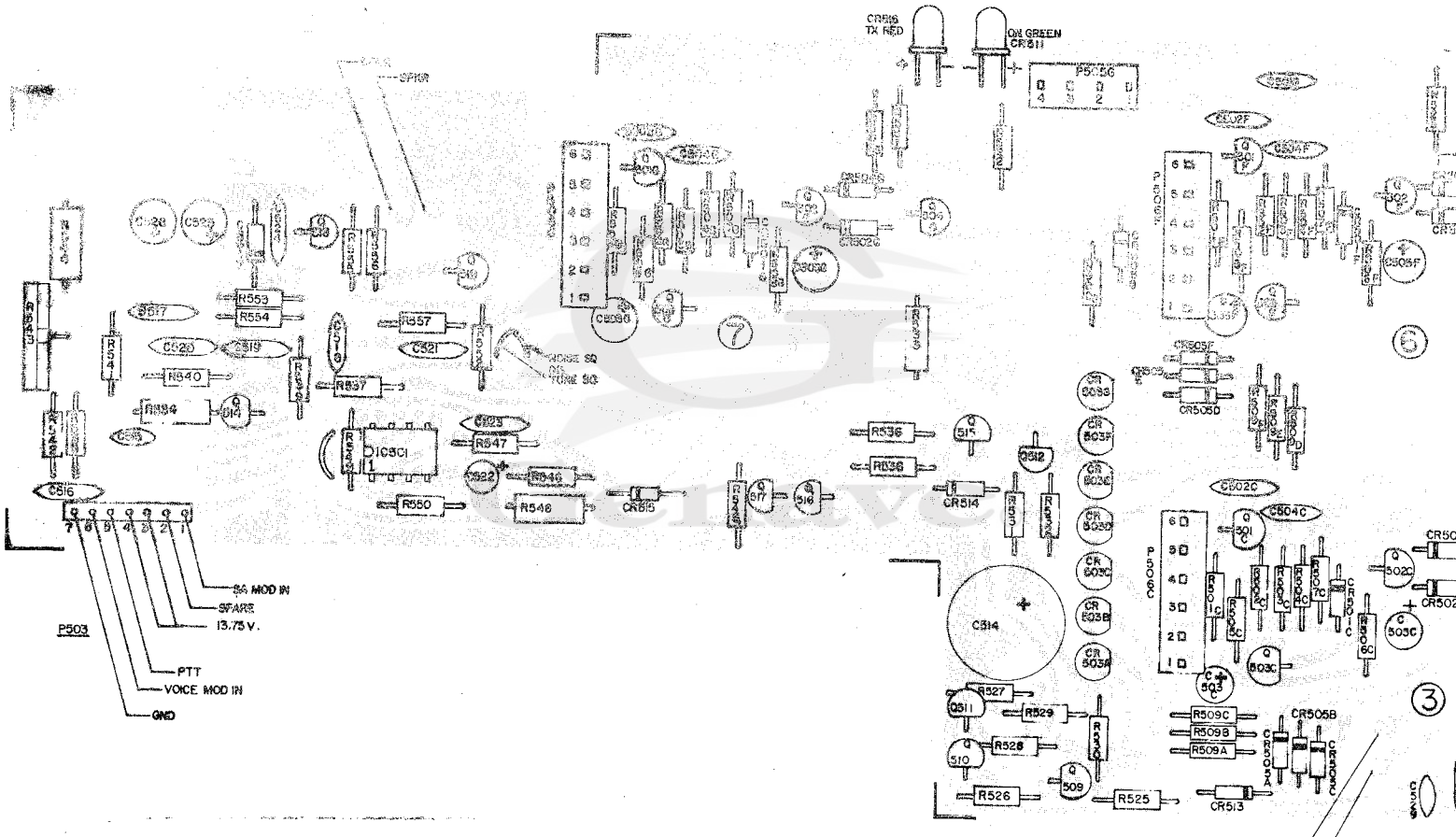
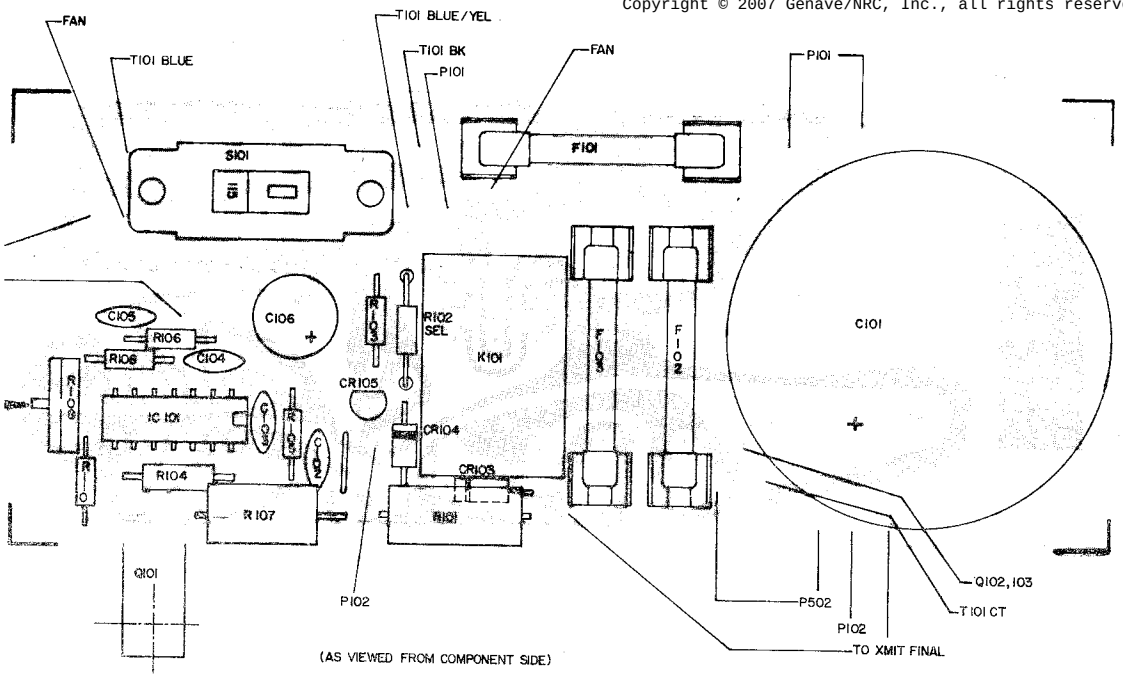
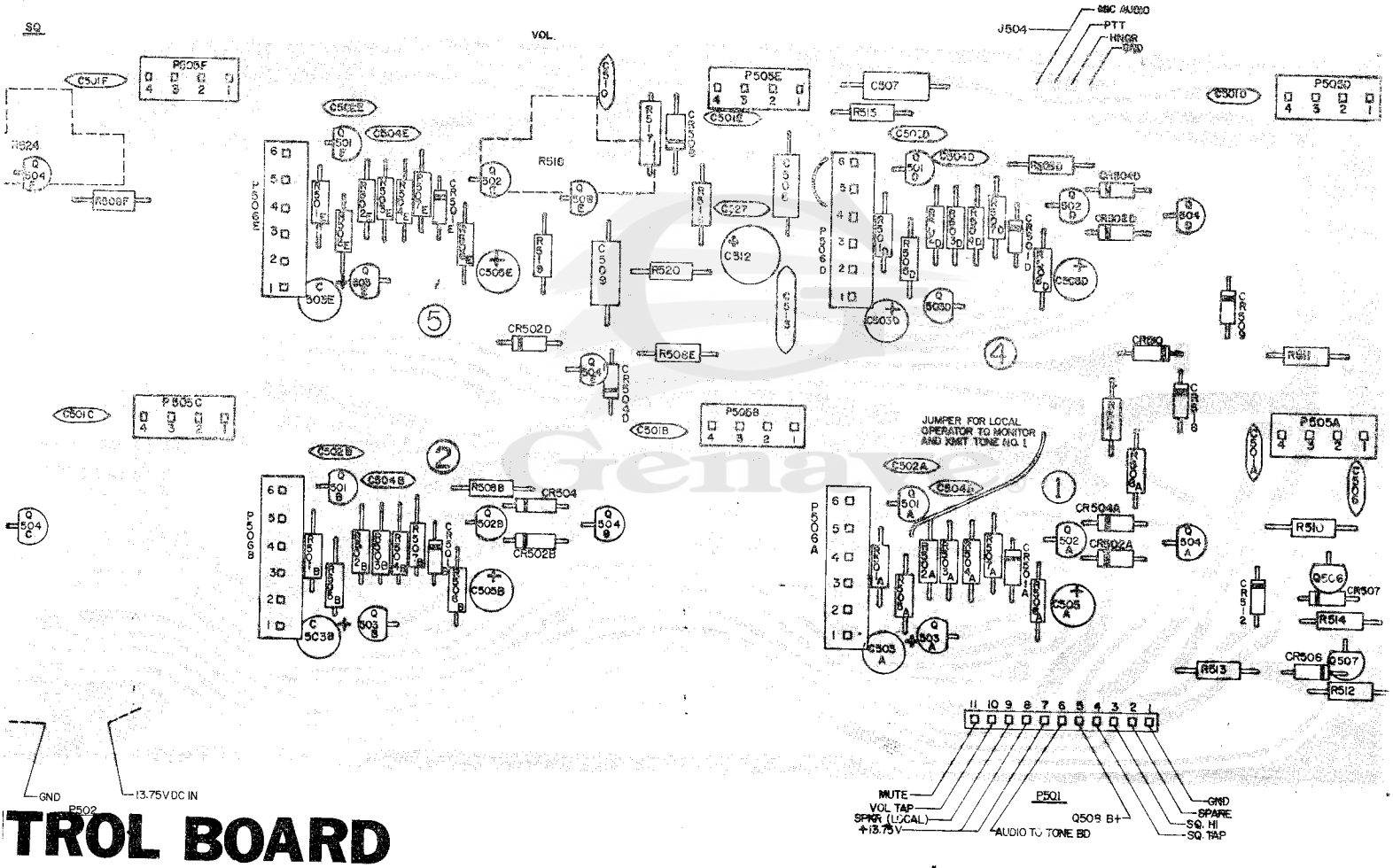




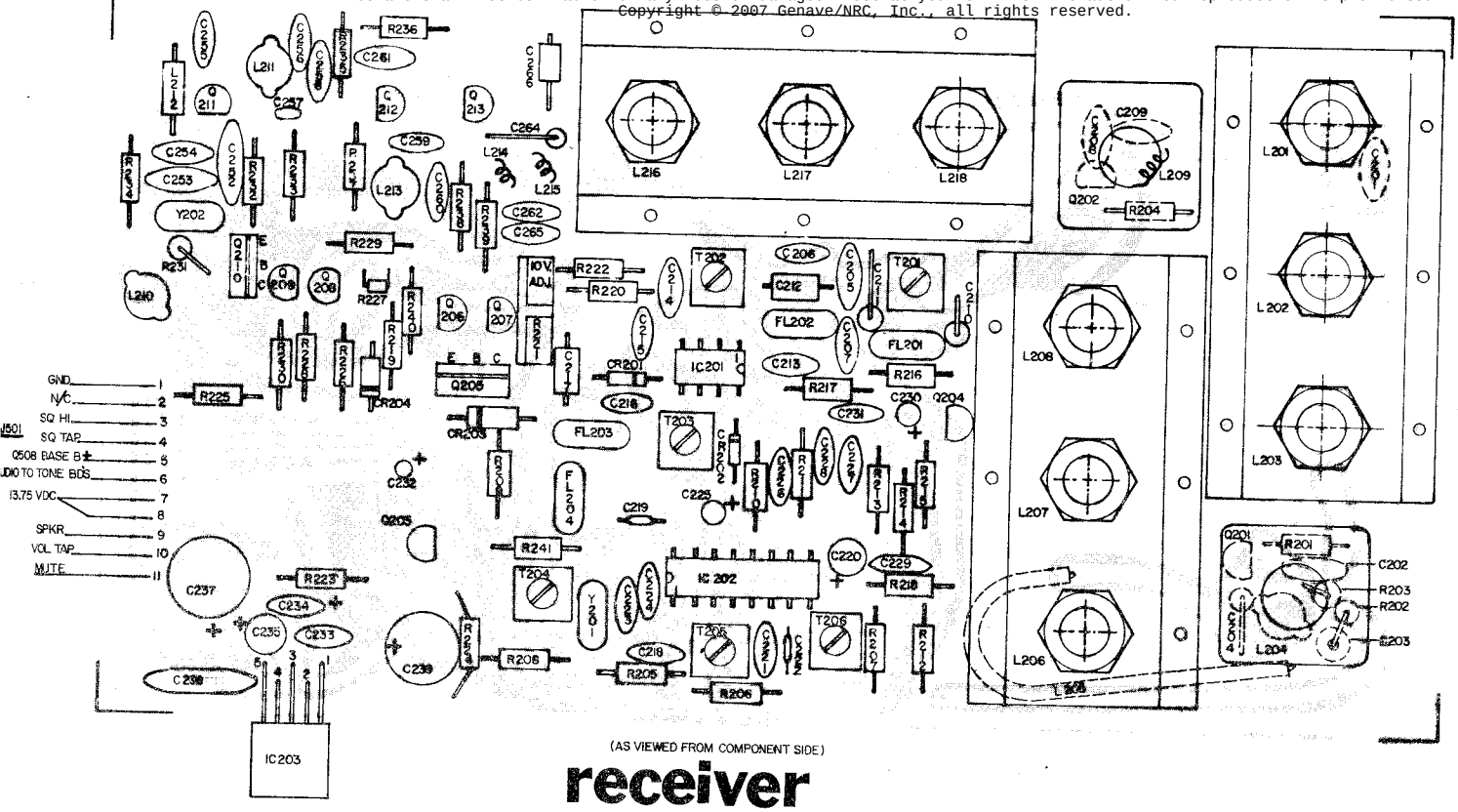
GENAVE REPEATER



power supply

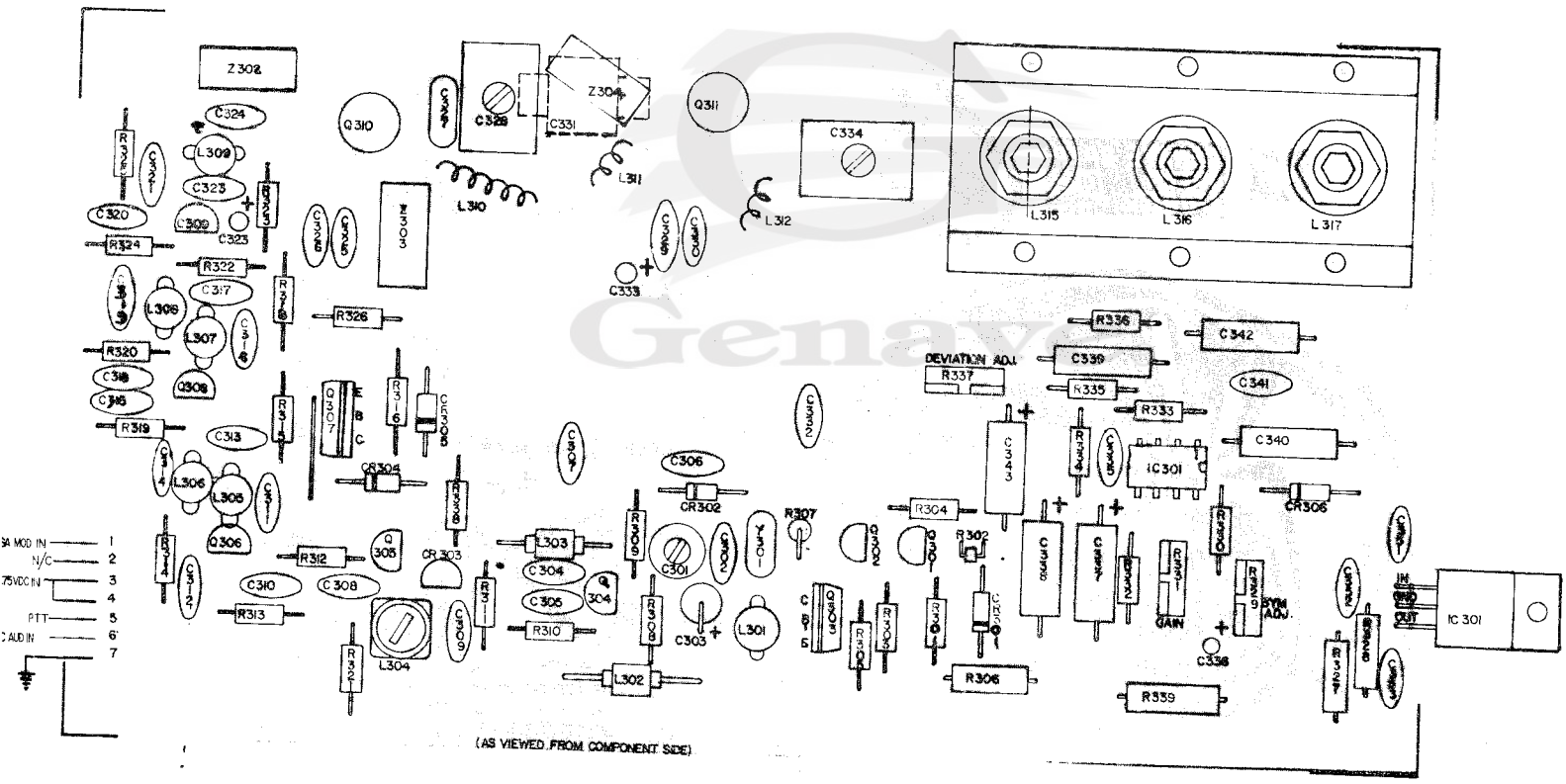


TROL BOARD



(AS VIEWED FROM COMPONENT SIDE)

receiver



(AS VIEWED FROM COMPONENT SIDE)

transmitter

GENAVE REPEATER

xctr

SECTION IV
MAINTENANCE MANUAL

4-1. INTRODUCTION

This UHF Mobile Relay Station receives 16F3 emissions on one frequency and retransmits the information on a second frequency in the 450 to 512 MHz band. The unit provides a minimum power output of 35 watts into a 50-ohm load.

Basically, the receiver is a dual conversion superheterodyne, utilizing the ninth harmonic of the crystal for the 1st L.O. injection. Two 4-pole crystal filters in the 10.7 MHz 1st IF provide good selectivity, while the 455 kHz 2nd IF provides gain with stability. The receiver is housed in a die-cast, alloy box which provides excellent shielding.

The transmitter consists of two modules: The exciter and the power amplifier. The exciter is housed in a die-cast, alloy box which contains the oscillator, frequency multipliers, microphone amplifier, phase modulator, and the crystal heater.

The high-power, amplifier stages are housed in a shielded box which is secured to the rear-panel heatsink. Output of the amplifier is a minimum of 35-watts for continuous duty. The amplifier output is designed to work into a 50-ohm load, either directly or thru a duplexer.

In conjunction with the following circuit description, refer to the block diagram of Figure 4-1, and to Repeater schematics in this Section of the UHF Repeater Service Manual.

4-2. THEORY OF OPERATION - RECEIVER

4-2-1. Input Filter and RF Amplifier

C201 couples incoming signal to a tap on L201 in helical input filter. A tap on L203 then applies signal to source of RF amplifier Q201, an N-channel JFET used as a grounded-gate amplifier. C204 routes amplified signal from drain of Q201 to a tap on L206 in another three-pole helical filter, consisting of L-206, L207, and L208.

4-2-2. 1st Local Oscillator/Multipliers

Q211 and associated circuitry form a crystal-controlled, modified Colpitts, 1st local-oscillator circuit. A crystal between 48.81 and 55.7 MHz determines the receiver's operating frequency. L-210, in series with crystal, adjusts crystal to exact frequency. L211 tunes collector circuit of Q211 to 3 times the crystal frequency; then, C258 couples this signal to base of the buffer, Q212.

L213 tunes collector circuit of buffer Q212 to the 146 to 167 MHz range; then, C259 applies buffer output to base of tripler Q213.

Another helical resonator, composed of L216, L217, and L218, tunes collector circuit of Q213 to the 439 to 501 MHz range. C264, C266, and L215 match collector impedance of Q213 to the input impedance of helical resonator. C208 and the tap on L218 couple the injection signal, which is 10.7 MHz BELOW the desired "receive" frequency, to 1st mixer Q202.

4-2-3. 1st Mixer and 1st IF Amplifier

A tap on L208 in helical output filter routes amplified RF signal to gate of 1st mixer Q202, while C208 applies L.O. injection signal to source of mixer Q-202. T201 couples the 10.7 MHz difference signal, produced in mixer Q202, to a four-pole monolithic crystal filter consisting of FL201 and FL202. T202 tunes output of the crystal filter, and applies IF signal to input of 1st IF amplifier IC201.

T203 couples the amplified 10.7 MHz IF signal to another four-pole monolithic

crystal filter consisting of FL203 and FL204. T204 tunes output of this crystal filter, and connects signal to input of 2nd mixer/limiter IC202.

4-2-4. 2nd LO, Mixer, Limiter, Detector and Squelch

IC202 is a multi-function integrated circuit which includes the 2nd local oscillator, 2nd mixer, limiting 2nd IF amplifier, quadrature discriminator, active filter, and squelch-mute switch in a single chip.

Y201, C223 and C224, together with IC-202 pins 1, 2 and 4, form an internally biased Colpitts-type oscillator. The collector, base, and emitter connections are at pins 4, 1 and 2 respectively. Low-side injection is used; therefore, the crystal frequency is 455 kHz BELOW the 10.7 MHz IF, or 10.245 MHz.

The mixer-oscillator section of IC202 down-converts the 10.7 MHz IF to 455 kHz. T205 tunes mixer output to 455 kHz and also functions as an external bandpass filter. From T205, the signal is routed to input of a five-stage limiter at pins 5 and 6 of IC202. The output of the limiter at pin 7 drives a multiplier, both internally directly, and externally through the quadrature coil T206, to detect the FM signal.

IC202 internally filters and buffers the recovered audio, and then routes it out on pin 9. Pin 9 applies the audio to a de-emphasis network consisting of R214 and C229. An "audio-shaping" circuit, comprised of Q204 and associated components, shapes audio response after de-emphasis.

IC202 pin 9 also supplies detected audio to input (pin 10) of a bandpass active filter, consisting of an internal op-amp and external components R211, R-213, C227 and C228. Noise output from this filter appears on IC202 pin 11. The noise level is maximum with no input signal, and decreases rapidly as amplitude of input signal increases. C226 couples this noise to AM detector CR202; then, R210 applies the resultant NEGATIVE voltage to the squelch-trigger circuit (IC202 pin 12). When IC202 pin 12 is pulled down below approximately 0.7 V by rectified noise voltage across CR202, the audio-muting switch, IC202 pin 14, is internally shorted to ground which squelches receiver by grounding audio input to Control Board.

Front-panel squelch control R517 applies a selected POSITIVE bias to the squelch-trigger circuit, IC202 pin 12, so that audio-muting switch, IC202 pin 14, OPENS; thus, removing ground from audio input to Control Board.

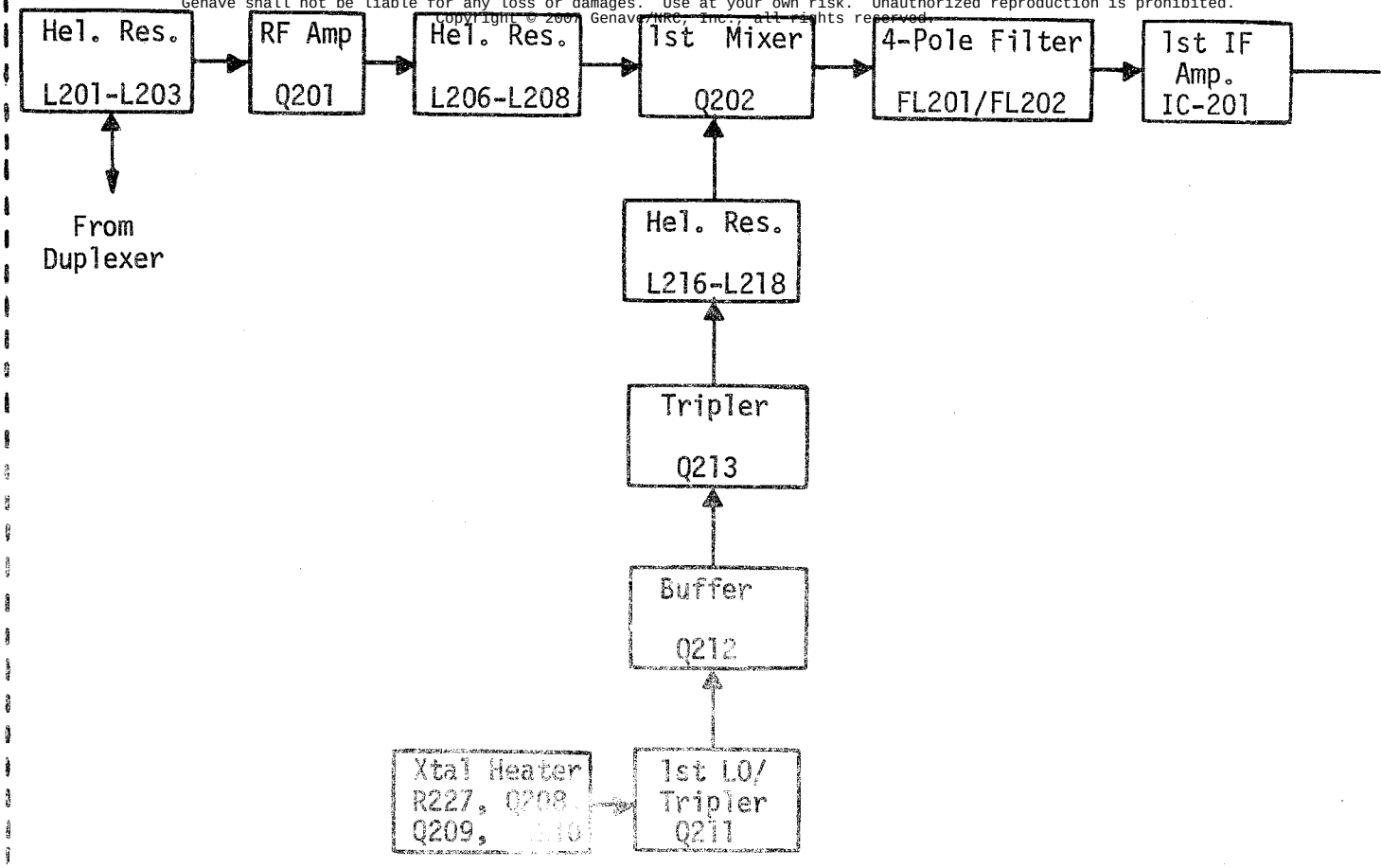
With an incoming signal ABOVE the selected squelch level, a reduced noise voltage is applied to CR202. The detected noise voltage is still applied to IC202 pin 12, but does NOT have sufficient amplitude to hold pin 12 BELOW 0.7 V; therefore, pin 14 opens and removes ground from audio input to Tone Boards and audio buffer Q508, located on Control Board.

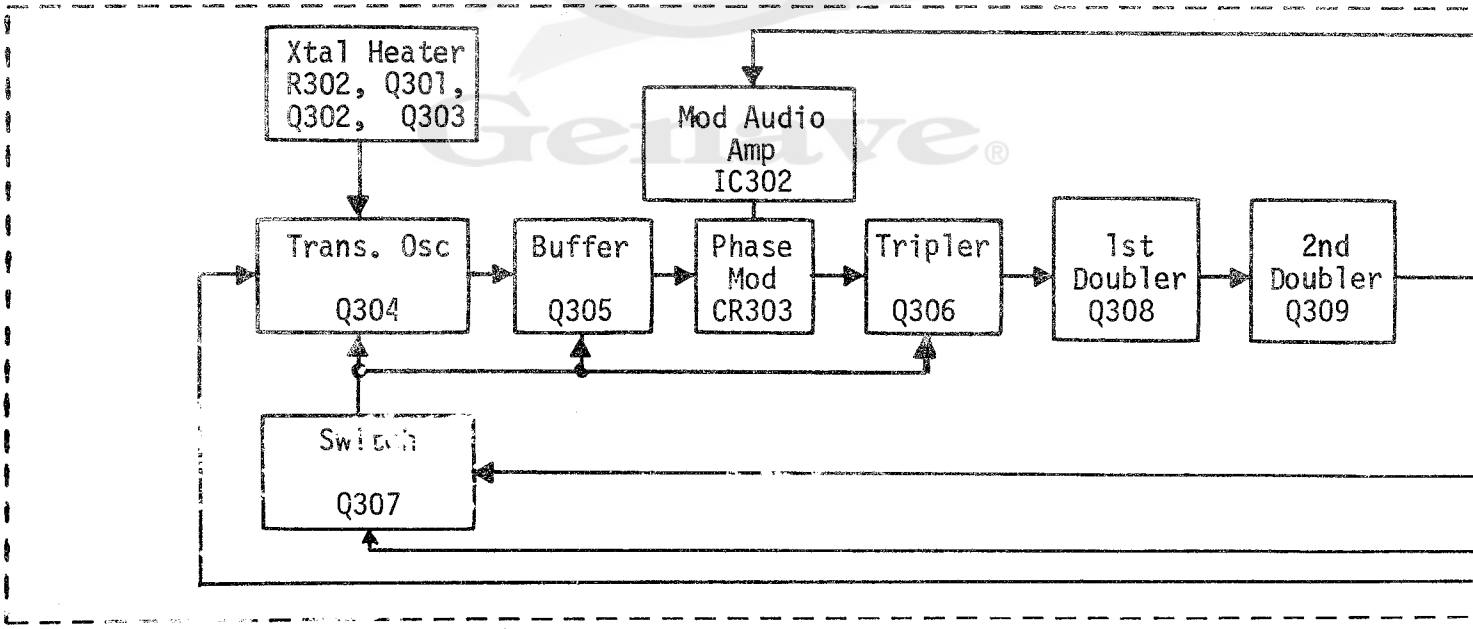
R208 connects base of squelch inverter, Q203, to IC202 pin 13. With NO input signal, pin 13 goes "high;" therefore, Q203 saturates and its collector pulls down almost to ground. This removes the operating bias from audio buffer Q508 on Control Board and Q508 turns OFF. With an incoming signal, pin 13 goes "low," and Q203 turns OFF; thus, its collector pulls up toward the supply voltage. This applies operating bias to audio buffer Q508, and it turns ON.

4-2-5. Audio Output Amplifier

The output audio amplifier consists of IC203 and associated circuitry. The amplifier drives the internal speaker, SP501, for monitoring or maintenance purposes, or when the unit is used as a base station. C234 couples audio from front-panel volume control R518 to IC-203 pin 1.

R223, R224, and C239 form a feedback loop to improve amplifier linearity. C-237 connects audio output from IC203 pin 4 to internal speaker, SP501. IC203





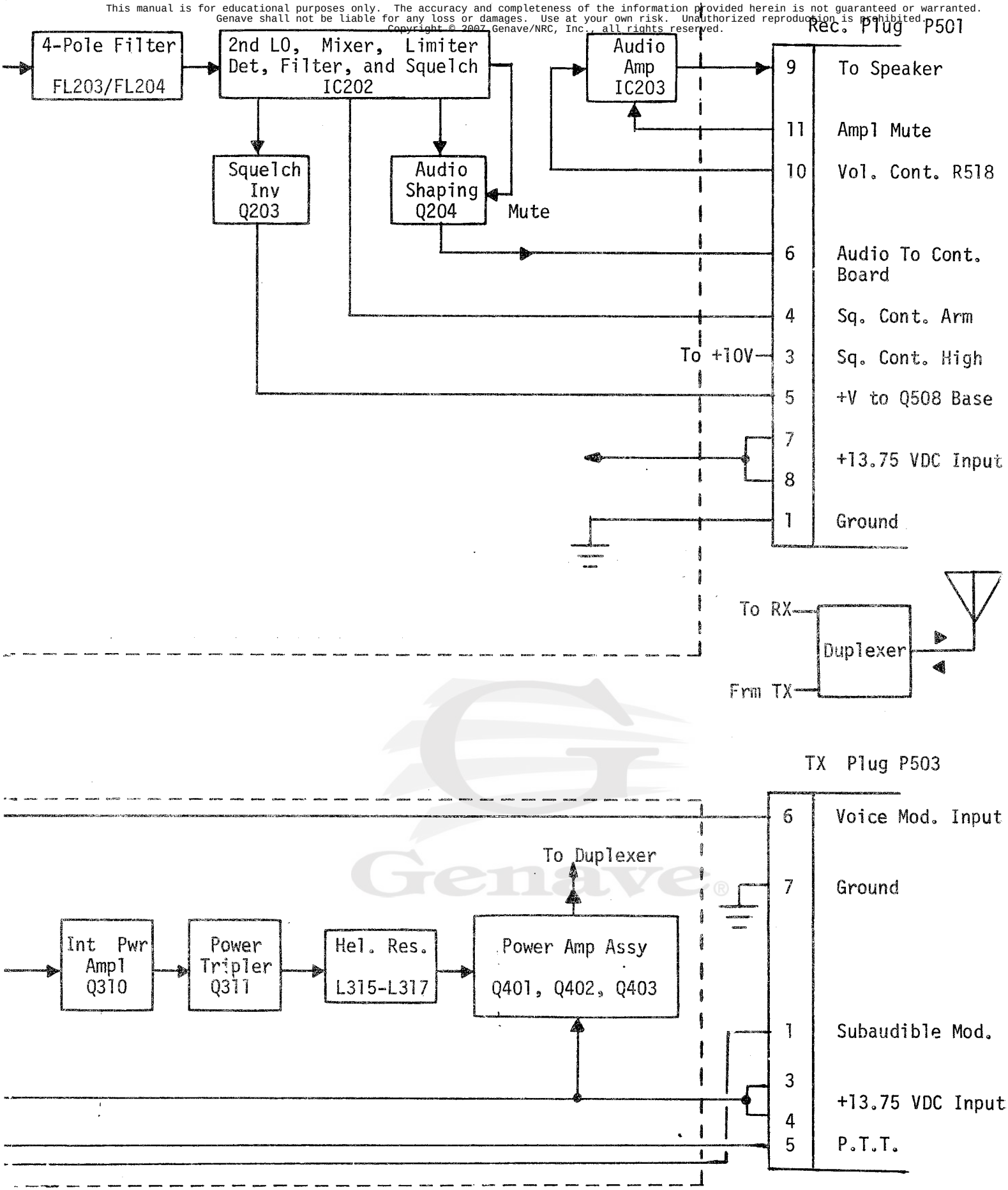


Figure 4-1. Receiver & Transmitter Block Diagrams

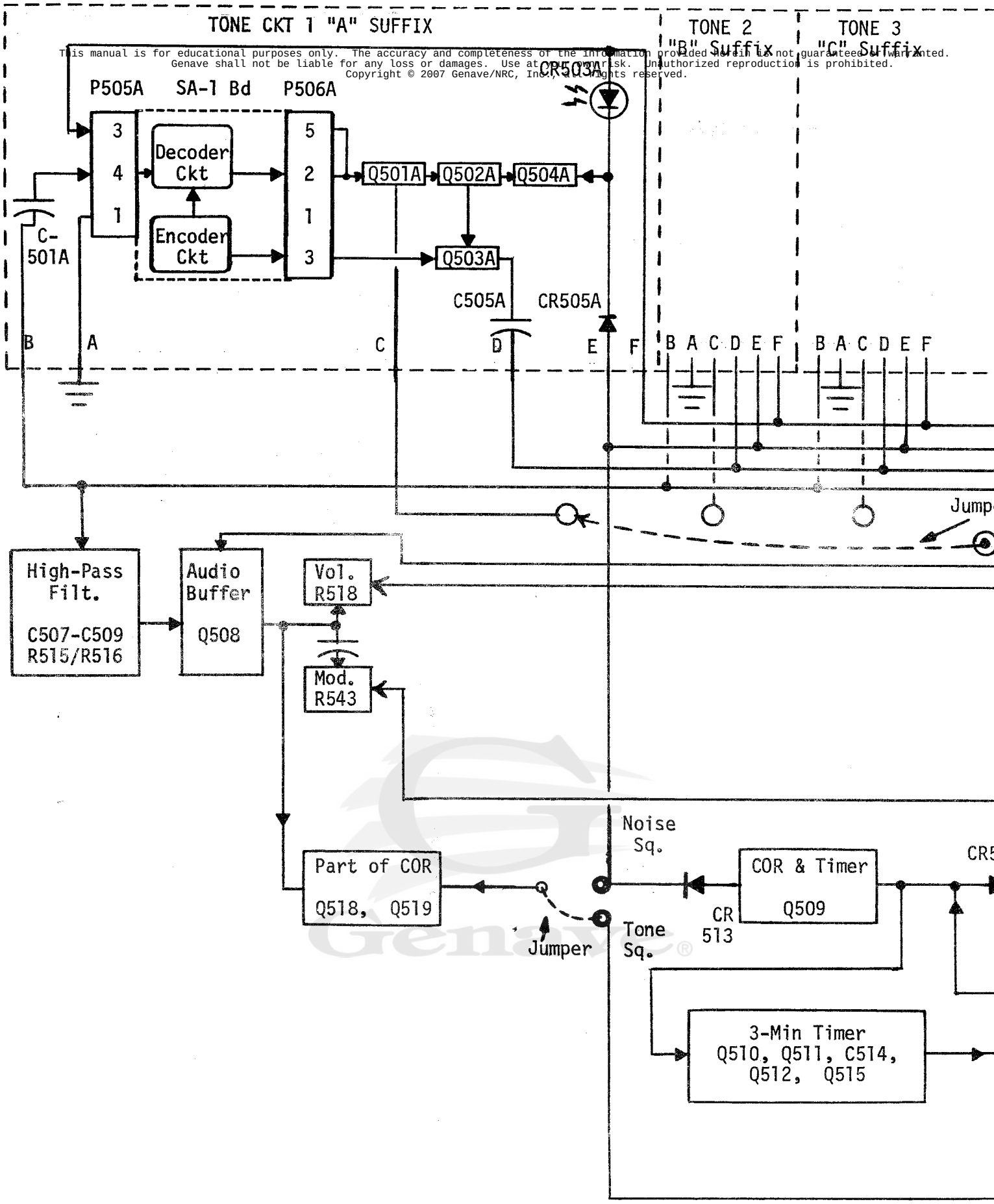
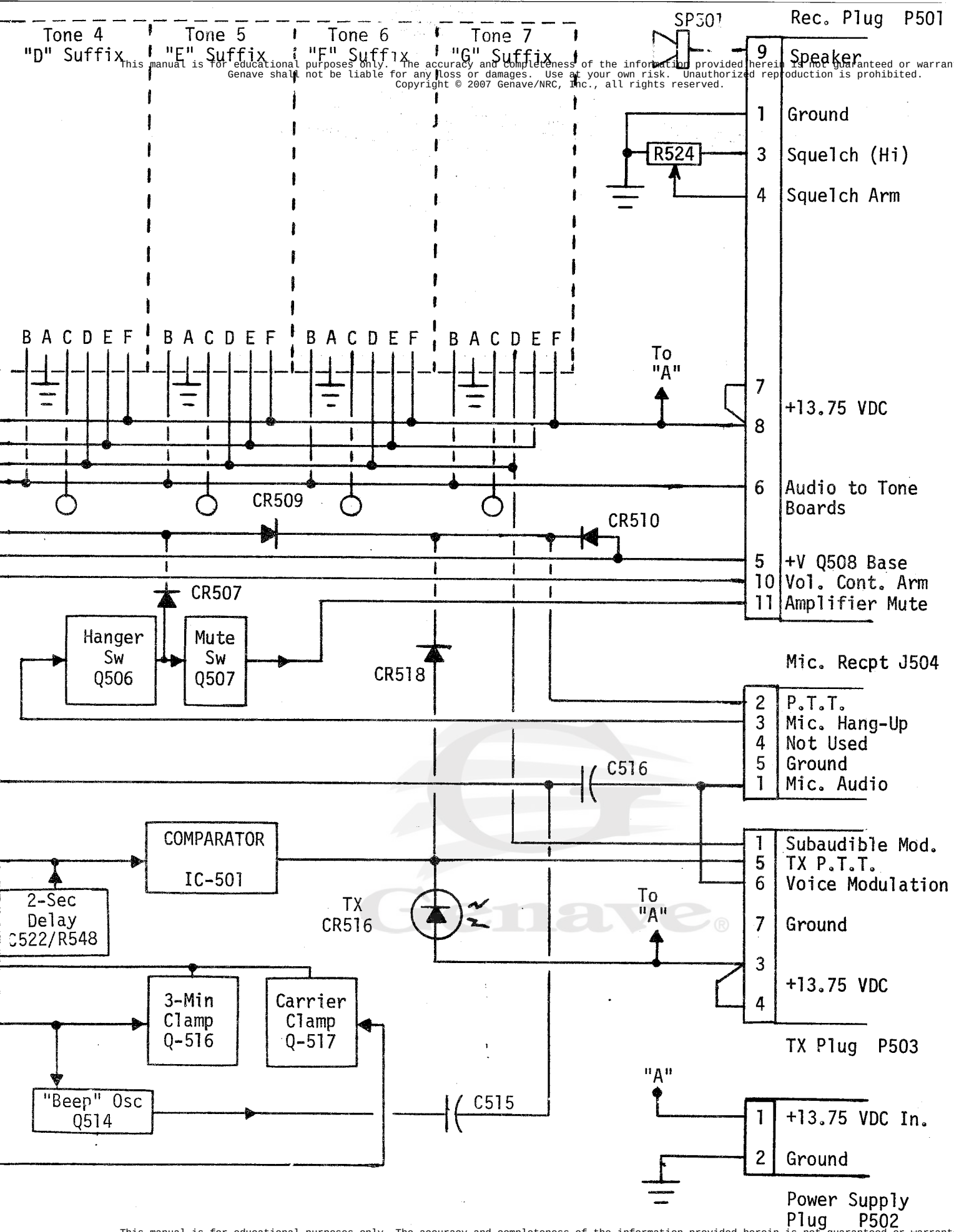


Figure 4-2. Control Board Block Diagram



pin 2 is connected to "local PTT" line on Control Board; thus, internal speaker is muted during time transmissions are made with local microphone.

All audio, control, and DC connections for the receiver module are made via an 11-pin female connector. A BNC connector and coax cable route incoming signals from antenna to receiver helical input filter.

4-2-6. Receiver Power

13.75 VDC is the primary power for the receiver, and supplies the following stages: L.O. tripler, Q213; crystal-heater stage, Q210; audio output, IC-203; and input to 10-volt regulator.

In the 10-volt regulator circuit, Q206 and Q207 form a differential amplifier which controls base bias for the pass-transistor, Q205. CR203 sets reference voltage for the 10-volt regulator. The 10-volt regulator supplies following stages: Crystal heater, Q208 and Q209; L.O./tripler, Q211; buffer, Q212; RF amp, Q201; squelch inverter, Q203; 1st mixer, Q202; and 1st IF, IC201.

CR203, in addition to setting reference voltage above, also supplies 6.8 V for audio-shaping stage, Q204, and for 2nd mixer/IF, IC202.

4-3. THEORY OF OPERATION - TRANSMITTER

4-3-1. Microphone Amplifier/Limiter

IC302, a single integrated-circuit containing dual operational amplifiers, is the basis for the voice-modulation audio amplifier. The schematic shows this IC as IC302A and IC302B. IC302A amplifies audio output of the local ceramic microphone, as well as amplifying the detected audio of an incoming signal which is to be re-transmitted. Symmetry potentiometer R329 loads the 1500 pF capacitance of the ceramic mic. to give mic. audio a 6-dB per octave rising characteristic. IC302A also provides the required limiting by symmetrically clipping amplified audio near supply-voltage level, and near ground level. R339 drops 13.75 VDC supply to approximately 6.8 VDC; then, zener diode CR306 regulates IC302 supply at 6.8 VDC.

Output of limiter IC302A drives IC302B, which functions as an active Chebyshev two-pole, low-pass filter with the cut-off frequency set at 3 kHz. R336 and C-342 add a third pole to the filter response to ensure an 18-dB per octave roll-off above 3 kHz. R337 sets deviation by controlling amount of audio applied to voltage-variable capacitor CR-303. C343 maintains low end of deviation control R337 at AC ground.

4-3-2. Voice Modulator

Varactor CR303 functions as the phase modulator. R338 and C309 shape audio response to the phase modulator to insure proper pre-emphasis in the transmitted audio. DC bias for phase modulator diode CR303 is supplied by IC302B.

4-3-3. Sub-Audible Tone Modulator

An isolating network, comprised of L-302, Z301 and C303, couples a small amount of low-frequency audio to base circuit of transmit oscillator Q304. This audio voltage frequency-modulates the oscillator, and the level of the audio tone determines deviation. The tone frequency(ies) and level(s) are adjusted by circuitry on the subaudible tone encoder/decoder board(s). From 1 to 7 SA-1 or equivalent tone boards may be installed on the Repeater Control Board.

4-3-4. Transmit Oscillator

Q304 and associated circuitry form the transmit oscillator, a modified crystal controlled Colpitts circuit. C301, C302 and L301, in series with crystal Y301, adjust crystal to exact frequency. Typical frequency at output of oscillator is between 12.5 and 14.222 MHz.

4-3-5. Crystal Heater

Transistors Q301, Q302 and Q303, with their associated resistors, control the temperature of transmit crystal at low ambient temperatures. Thermistor R302

senses ambient temperature within exciter compartment; then, if the ambient temperature is below 0°C, the voltage division of R301 and R302 turns Q301 OFF. This raises emitter voltage of Q-302, which then turns ON. Q302 supplies base current to Q303, and it also turns ON. The resultant current flow through R307, in contact with the crystal case, raises temperature of crystal; thus, the crystal maintains frequency tolerance even at low ambient temperatures.

4-3-6. Buffer Amplifier

Q305 is a P-channel JFET which buffers the 12.5 to 14.222 MHz RF output from oscillator Q304, and then applies this signal to a tuned circuit consisting of L304, C309 and varactor diode CR303. The changing audio voltage from IC302 varies capacitance of CR303, causing resonant frequency of L304 and CR303 to increase and decrease accordingly; thus a phase change occurs in the oscillator signal. After being multiplied 36 times this signal becomes the frequency modulated exciter output to drive the power amplifier.

4-3-7. First Tripler

C308 capacity couples phase-modulated output of Q305 to base of tripler Q306. The tripler output circuit is an inductively coupled, double-tuned network, consisting of L305, C311, L306, C314, and C315. The tripler output covers the frequency range from 37.5 to 42.67 MHz.

4-3-8. First Doubler

C314 and C315 form a capacitive-tap matching network into base of first doubler Q308. The output circuit covers the frequency range from 75 to 85.34 MHz, and is an inductively coupled, double-tuned network comprised of L307, C316, L308, C319 and C320.

4-3-9. Second Doubler

Another capacitive-tap matching network, C319 and C320, applies RF to base of doubler Q309. R322 and R324 apply a small forward-bias to base of Q309. A variable inductor, L309, tunes output of Q309 to the 150 - 170.67 MHz range.

4-3-10. Intermediate Power Amplifier

C324 capacitively couples RF from doubler Q309 to base of intermediate power amplifier Q310. This stage operates in class "C," with no external bias. The output circuit of Q310 is a two-stage "L" network, which covers the frequency range from 150 to 170.67 MHz.

4-3-11. Power Tripler

RF power from the doubler "L-network" drives base of Q311 - a grounded emitter class-C frequency tripler. This stage also uses no external bias. A matching network, consisting of C334, L313 and L314, transforms collector impedance of Q311 to the input impedance of helical resonator L315, L316, and L317.

4-3-12. Helical Bandpass Filter

The three-pole bandpass filter consists of three aperature-coupled helical resonators, having a 1-dB bandpass of approximately 7 MHz. The filter is comprised of L315, L316, and L317.

4-3-13. Power Amplifier Assembly

A coaxial cable couples RF from L317 in Exciter helical bandpass filter to an input filter, comprised of C402, L401, C403 and C404, in Power Amplifier Assembly. C401 serves as a DC-blocking capacitor. Output of filter drives the base of pre-driver Q401, an NPN transistor in a class-C, grounded emitter configuration.

A matching network, comprised of C407, L403, C408, C410 and C411, couples output of Q401 to base of driver Q402, another grounded emitter, class-C amplifier. L408 in series with the parallel combination of L407 and R402 completes DC base circuit for the driver stage.

Another matching network, C413, L409, C414, C415 and C416, couples output of driver to base of final power ampli-

fier, Q403, an NPN silicon transistor in a grounded emitter, class-C circuit. L411, R412, and R403 form the DC return for base circuit of Q403. The output network, C420, C421, C422, L413, C423, L414, C424, L415, and C425, matches collector impedance of Q403 to the 50-ohm antenna impedance, and also filters any undesired spurious responses from amplifier output. A coaxial cable connects RF output to the rear-panel BNC antenna connector.

4-3-14. Transmitter Power

Pass-transistor Q307 activates transmitter by applying voltage to transmit-oscillator, buffer, and tripler when "push-to-talk" circuitry biases Q307 ON. The "push-to-talk" line activates Q307 through resistor R321 by either of two means: (1) An incoming signal on RECEIVE frequency which activates IC-501; (2) The local-microphone "push-to-talk" button. Voltage for the oscillator, buffer, and tripler is regulated at 6.8 VDC by zener CR302.

The first and second doublers, intermediate power amplifier, crystal heater, as well as the final three stages of the power amplifier, are supplied by a filtered line from +13.75-volt DC input voltage. The power tripler operates from a regulated 10-volt supply, consisting of an 8-volt, solid-state regulator IC301, which is programmed, with R327 and R328, to regulate this supply at 10-volts. R339 and CR306 drop the 13.75-volt input, and supply a regulated 6.8 VDC to the microphone amplifier/limiter, IC302.

4-4. THEORY OF OPERATION: CONTROL BOARD

The Control Board is a versatile unit, accomodating a maximum of 7 separate sub-audible tone boards. A jumper arrangement switches the Repeater for operation by the "noise" squelch only, or by the "tone" plus "noise" squelch. Another jumper connects the local operating position to desired sub-audible tone board, both transmit and receive. The 3-minute timer, 2-second delay, and various other control circuits are located on this PC board.

4-4-1. Repeater Operation (Noise Squelch Only)

With no incoming signal, the receiver is squelched and the transmitter is in "standby." Upon receipt of an incoming signal ABOVE selected squelch threshold the signal is detected, and receiver is unsquelched as given in Section 4-2-4 above. The detected audio is routed to Control Board via pin 6 of receiver connector P501, and operating bias for audio buffer Q508 is applied to pin 5 of this connector.

A high-pass filter, comprised of C507, C508, C509, R515 and R516, removes the audio frequencies below approximately 400-Hz from detected audio. The filter then applies the audio to base of emitter follower Q508. At the same time, P-501 pin 5 biases Q508 ON. Emitter current of Q508 flows through front-panel volume control R518, and the resultant voltage drop across R518 turns Q518 ON. Emitter current of Q518 then causes Q-519 to saturate; thus, its collector pulls down and effectively grounds the "noise squelch" line through a jumper on the PC board.

The "noise squelch" line grounds base of pass-transistor Q509 through CR513 and R525; therefore, Q509 turns ON and applies approximately +13 V to the inverting pin of comparator IC501. The non-inverting pin of IC501 is biased at approximately 6.8 V by R549 and R550. When voltage applied to the inverting pin of IC501 exceeds 6.8 V, comparator output swings from +6 V to 0 (ground). Thus, a ground is applied to cathode of TX indicator LED, CR516, and to transmitter push-to-talk line on pin 5 of transmitter connector P503. Therefore, transmitter is placed "on-the-air," and the TX indicator glows.

The detected audio from the incoming signal passes through audio buffer Q508 to a parallel resistor combination, consisting of volume control R518 and voice modulation control R543. R518 supplies a selected portion of the audio through P501 pin 10 to the receiver output stage and internal speaker SP501

(if a local operator is utilized). R543 applies a portion of the audio through P503 pin 6 to voice amplifier IC302 in exciter module. Thus, the transmitter is frequency-modulated by the received signal.

With transmitter in "standby," Q509 and Q510 are turned OFF, whereas Q511 is turned ON, which places the low resistance of R529 in parallel with the timing capacitor C514; therefore, while Q-511 is conducting, C514 remains discharged.

At the same time that Q509 turns ON to key transmitter, Q509 also starts the 3-minute timing process. Collector current for Q509 flows through R526 and R-527. The resulting voltage drops bias Q510 into saturation. Q510 pulls base of Q511 "low" and Q511 turns OFF; thus, removing the short across C514 which slowly begins to charge through R530.

When the charge across C514 reaches approximately 2-volts (base-emitter voltage drops of Q515 and Q516 in series), Q515 turns ON and applies base current to turn ON Q512. The series combination, Q512 and R532, in parallel with R530, thus increases charge current for C514, as well as increasing base current to Q515, causing it to conduct heavily and turn ON Q516. Now Q516 becomes a short across the line connected to inverting input of comparator IC501. The 2-second drop-out delay circuit, consisting of C522 and R548, will continue to hold inverting input of IC501 "high" until C522 discharges through R-548. The comparator output then pulls up to +6 volts, turning OFF the TX indicator, CR516, and disabling transmitter.

As Q515 turns Q516 ON, Q515 also supplies collector current to the Time-Out Warning Oscillator Q514. Q514 functions as a phase-shift oscillator which has its output connected into the transmitter modulation input circuitry. The tone from the Time-Out Warning Oscillator is transmitted during the 2 second interval between time Q516 turns ON and C522 is discharged.

The above paragraphs illustrate repeater operation in which an incoming signal keeps repeater transmitter activated beyond the 3-minute limit. For the usual short-duration transmissions, operation is as follows:

With transmitter and 3-minute timer activated as explained above, but prior to charge across C514 reaching 2-volts, the incoming signal ceases. Q508 turns OFF immediately; thus, no DC voltage is developed across R518, which causes Q-518 and Q519 to turn OFF. The collector of Q519 pulls "noise squelch" line HIGH and turns OFF pass-transistor Q509. The 2-second drop-out delay circuit holds inverting input of IC501 HIGH until C-522 discharges through R548; then, output of IC501 (P.T.T.) swings from zero to approx. 6 volts, which turns OFF the TX indicator LED, CR516, and unkeys the transmitter.

To enable transmitter to be re-keyed almost immediately, time-out capacitor C514 must be discharged quickly. As the pass-transistor, Q509, turns OFF, it turns OFF Q510 also. Then Q511 turns ON, and shunts R529 across C514; thus, C514 is discharged in milliseconds.

4-4-2. Repeater Operation (Tone Squelch Plus Noise Squelch)

The following circuit description assumes that Control Board is jumpered for "tone squelch," that Board is jumpered so that Local Control utilizes the #1 tone board, and that subaudible modulation of incoming signal is compatible with tone board #1.

An incoming tone-modulated signal, that is above squelch threshold, is detected and receiver unsquelched as explained in Section 4-2-4 above. The detected audio is routed to Control Board via P501 pin 6, while bias to activate audio buffer Q508 is applied to P501 pin 5.

Detected audio, including the subaudible tone, is next applied to the paralleled inputs of all installed SA-1 tone boards; however, only the tone board

whose encoder frequency is within ±0.5 Hz of the incoming tone frequency will develop an output. The input audio is routed via P505A pin 4 to a low-pass filter to eliminate voice frequencies; then, the signal is decoded and checked against the encoder tone frequency. If the subaudible tone is within limits, the SA-1 comparator will pull P506A pins 2 and 5 "high."

This biases Q501A into saturation, making its collector "low." Therefore, Q-502A turns OFF, making its collector "high." The voltage drop across R505A now disappears, thus FET switch Q503A turns ON and connects subaudible tone output from P506A pin 3 to P503 pin 1 to modulate transmitter. The "high" at collector of Q502A also allows Q504A to turn ON, making its collector "low," which effectively grounds cathode of Tone Board #1 LED, CR503A. The seven SA-1 LED indicators are mounted in a row on the Control Board. During servicing or troubleshooting, they tell at a glance which SA-1 is activated, and thus, which subaudible tone is being used at any moment.

With collector of Q504A "low," the base of pass-transistor Q509 is effectively grounded through R525, CR513, and CR-505A; therefore, Q509 turns ON to initiate the transmitter keying sequence and the 3-minute timing cycle. With Q-509 conducting, its collector applies approximately 13 V to the inverting pin (2) of comparator IC501. R549 and R550 bias non-inverting pin (3) of IC501 at approx. 6.8 V. When voltage applied to the inverting pin of IC501 exceeds 6.8 volts, comparator output swings from +6 volts to zero (ground). This grounds cathode of TX indicator LED, CR516, as well as transmitter "push-to-talk" line on pin 5 of P503. Thus, transmitter is placed "on-the-air," and the TX indicator glows.

Q509 also starts the 3-minute timing process. Collector current for Q509 flows through R526 and R527. The resulting voltage drops bias Q510 into saturation. Q510 ther pulls base of Q-511 "low" and Q511 turns OFF; thus, removing the short across C514, which begins to charge slowly through R530.

At the same time that detected audio is applied to SA-1 inputs, the audio is also routed to a high-pass filter, comprised of C507, C508, C509, R515 and R-516, which removes audio frequencies (subaudible tones) BELOW approximately 400-Hz. The filter then applies this audio to base of emitter-follower Q508. At the same time, P501 pin 5 biases Q-508 ON.

Therefore, Q508's emitter current flows through front-panel volume control R-518, and the resultant voltage drop now turns Q518 ON. Emitter current of Q518, in turn, causes Q519 to conduct; thus, its collector pulls down and effectively grounds the "tone squelch" line through a jumper on PC board.

The "tone squelch" line grounds base of Q517 which turns OFF and unclamps the inverting input to IC501. Now, with Q-509 conducting as explained above, and Q517 non-conducting, the transmitter is keyed and the TX indicator glows. As can be seen from the above, when unit utilizes "tone squelch" plus "noise squelch," the subaudible tone activates Q509, while the incoming carrier turns OFF the DC clamp, Q517. Q517 prevents transmitter from being keyed without an incoming carrier.

The detected audio from the incoming signal passes through audio buffer Q508 to a parallel resistor combination, consisting of volume control R518 and voice modulation control R543. R518 supplies a selected portion of the audio through P501 pin 10 to the receiver output stage and internal speaker SP501 (if a local operator is utilized). R543 applies a portion of the audio through P503 pin 6 to voice amplifier IC302 in exciter module. Thus, the transmitter is frequency-modulated by the received signal.

With transmitter and 3-minute timer activated as explained above, but prior to charge across C514 reaching 2-volts, the incoming signal drops out. Q508

turns OFF immediately; thus, no voltage is developed across R518, which causes Q518 and Q519 to turn OFF. The collector of Q519 pulls "tone squelch" line HIGH, and biases clamp transistor Q517 into conduction. Q517 thus grounds output of pass-transistor Q509 through R-536. The 2-second drop-out delay circuit (C522, R548) holds inverting input of IC501 HIGH until C522 is discharged through R548; then, output of IC501 switches from zero to approx. 6 volts, which turns OFF the TX indicator CR516, and unkeys the transmitter.

4-4-3. Repeater Operation - By Local Operator

Assume that unit Control Board is jumpered for tone squelch operation. With no incoming signal, and with metal button on back of microphone inserted into metal hang-up clip, the tone squelch is "enabled" so that an incoming signal will NOT be heard unless it is modulated with a specific subaudible tone.

With microphone on metal hang-up clip, base of Q506 is grounded through pin 3 of mic. receptacle J504; thus, Q506 turns OFF and its collector is "high," which turns ON Q507. The collector of Q507, connected to receiver output IC-203 pin 2 through P501 pin 11, now goes "low." The resulting "low" on pin 2 of IC203 mutes the receiver output stage.

An incoming tone-modulated signal is detected, and receiver unsquelched as explained in Section 4-2-4 above. The detected audio is routed to the Control Board via P501 pin 6, while bias to activate audio buffer Q508 is applied to P501 pin 5.

Detected audio, including subaudible tone, is next applied to the paralleled inputs of all the installed SA-1 Tone Boards; however, only the tone board whose encoder frequency is within ±0.5 Hz of the incoming tone frequency will develop an output, as explained below:

The input audio is routed via P505A pin 4 to a low-pass filter to eliminate the voice frequencies; then, the signal is decoded and checked against the encoder tone frequency. If the subaudible tone is within limits, the SA-1 comparator will pull P506A pins 2 and 5 "high."

This biases Q501A into saturation, making its collector "low." Therefore, Q-502A turns OFF, making its collector "high." The voltage drop across R505A (source to gate voltage for Q503A) now becomes zero; therefore, FET switch Q-503A turns ON and connects subaudible tone output from P506A pin 3 to P503 pin 1 to modulate transmitter. A "high" at collector of Q502A also causes Q504A to turn ON, making its collector "low," which effectively grounds cathode of #1 Tone Board LED, CR503A. The seven SA-1 LED indicators are mounted in a row on the Control Board. During servicing or troubleshooting, they tell at a glance which SA-1 is activated, and thereby, which subaudible tone is being used at any moment.

With collector of Q504A "low," the base of pass-transistor Q509 is effectively grounded through R525, CR513, and CR-505A; therefore, Q509 turns ON to initiate the transmitter keying sequence and the 3-minute timing cycle. With Q-509 conducting, its collector applies approximately 13 V (if Q517 is OFF) to the inverting pin (2) of comparator IC-501. R549 and R550 bias non-inverting pin (3) of IC501 at approx. 6.8 V. When voltage applied to the inverting pin of IC501 exceeds 6.8 volts, the comparator output swings from +6 volts to zero (ground). This grounds cathode of TX indicator LED, CR516, as well as transmitter "push-to-talk" line on pin 5 of P503. Thus, transmitter is placed "on-the-air," as indicated by the TX LED.

Q509 also starts the 3-minute timing process. Collector current for Q509 flows through R526 and R527. The resulting voltage drops bias Q510 into saturation. Q510 then pulls base of Q-511 "low" and Q511 turns OFF; thus, removing the short across C514, which begins to charge slowly through R530.

At the same time that detected audio is applied to SA-1 inputs, the audio is

also routed to a high-pass filter, comprised of C507, C508, C509, R515 and R-516, which eliminates audio frequencies (subaudible tones) BELOW approximately 400 Hz. The filter then applies this audio to base of emitter-follower Q508. At the same time, P501 pin 5 biases Q-508 ON.

Therefore, Q508's emitter current flows through front-panel volume control R-518, and the resultant voltage drop now turns Q518 ON. Emitter current of Q518, in turn, causes Q519 to conduct; thus, its collector pulls down and effectively grounds the "tone squelch" line through a jumper on PC board.

The "tone squelch" line grounds base of Q517 which turns OFF and unclamps the inverting input to IC501. Now, with Q-509 conducting as explained above, and Q517 non-conducting, the transmitter is keyed and the TX indicator glows. As can be seen from the above, when unit utilizes "tone squelch" plus "noise squelch," the subaudible tone activates Q509, while the incoming carrier turns OFF the DC clamp, Q517. Q517 prevents transmitter from being keyed without an incoming carrier.

The detected audio from the incoming signal passes through audio buffer Q508 to a parallel resistor combination, consisting of volume control R518 and voice-modulation control R543. R543 applies a portion of the audio through P-503 pin 6 to voice amplifier IC302 in exciter module. Thus, the transmitter is frequency-modulated by the received signal. At the same time, front-panel volume control R518 supplies a selected portion of the audio through P501 pin 10 to the receiver output stage and internal speaker SP501. R518 allows the local operator to adjust the receiver volume as desired.

Note that Q507 is now turned OFF, and no longer mutes receiver output stage. When subaudible tone causes Q501A to saturate, its collector then grounds base of Q507 through R514, CR507, and the tone-board jumper; thus, Q507 turns OFF. The resulting "high" on Q507's collector un-mutes the receiver output stage, IC203.

Lifting microphone from its metal hang-up clip ungrounds base of Q506 and it turns ON. This causes Q507 to turn OFF, and the "high" on its collector again un-mutes receiver output stage; thus, local operator is able to monitor the repeater system as desired.

Pressing microphone "push-to-talk" button keys transmitter and lights the TX indicator, CR516, by grounding P.T.T. line through CR518 and J504 pin 2. The "push-to-talk" button also mutes receiver audio by grounding squelch circuitry through CR512. During transmission, incoming receiver signals are prevented from being applied to transmitter modulator or receiver output amplifier and speaker, by grounding bias for Q508 through CR510 and the "push-to-talk" button. Subaudible tone to modulate transmitter is "enabled" by grounding base of Q502A through R502A, PC board jumper, CR509, and the "push-to-talk" button; thus, Q502A turns OFF and FET switch Q503A turns ON to apply subaudible tone to transmitter through P503 pin 1.

Microphone audio is applied to voice-modulation circuitry in transmitter via "push-to-talk" switch, J504 pin 1, and P503 pin 6.

Provided the same subaudible tone is used by each mobile station in the system, each mobile will hear both sides of a conversation between a mobile and the local operator at the Repeater -- the mobile's signal will be automatically re-transmitted, and the local operator will be received directly.

4-5. THEORY OF OPERATION - POWER SUPPLY

A standard 3-prong plug applies 120 **or** 240 VAC input to the primaries of T101 through fuse F101 and voltage-selector switch, S101. The 3rd (grounded) input wire connects power-supply ground to the electrical-system ground for safety purposes. S101 connects the dual primaries of T101 in parallel for 120-volt

operation, or in series for operation on 240-volts.

Secondary voltage from step-down transformer, T101, is applied to a solid-state, full-wave rectifier consisting of CR101 and CR102. This rectifier is inverted from the usual arrangement, in that the ends of the secondary winding are grounded through the diodes, and the positive output voltage is taken from the secondary center-tap. Connecting the diode anodes directly to the heatsink results in improved thermal conduction.

A large-value, electrolytic capacitor, C101, forms a capacitive-input filter to smooth the rectifier output and provide a low-impedance for the 120-Hz ripple voltage.

Integrated circuit IC101 and associated components form an adjustable DC voltage regulator which is the heart of the power supply. Potentiometer R109 provides a means of adjusting the regulator output, which drives emitter follower Q101. Q101 supplies base current to the paralleled pass-transistors, Q-102 and Q103. Resistors R111 and R112 in the emitter leads of Q102 and Q103, respectively, are necessary to equalize currents through the two pass transistors. C106 provides additional filtering of power supply output. To aid in removing heat from the supply, Q101 is mounted to bottom cover of Repeater, while Q102 and Q103 are mounted on a large heatsink which forms part of unit rear panel.

If desired, an auxiliary 12-volt battery may be connected to Repeater circuitry through P102 for emergency back-up. Relay K101 automatically connects Repeater to the internal power supply through "normally-open" contacts when rectifier is delivering DC voltage; however, if AC input to supply fails, K101 is no longer energized and its "normally closed" contacts switch Repeater circuits to the battery supply. R101 drops DC output of rectifier to approximately twelve-volts for coil of K101, and CR103 suppresses transients developed across coil of K101 when coil voltage is removed.

R102 is a selected value, chosen to provide proper "float" current to maintain auxiliary battery fully charged. Note, however, that this circuit is NOT INTENDED TO CHARGE A FULLY-DISCHARGED BATTERY.

Charge-Indicator LED, CR105, and its current-limiting resistor, R103, indicate when charge current is flowing to battery -- as the battery reaches full charge, the current decreases until the voltage drop across R102 is not sufficient to make the LED glow. CR105 is on the power supply PC board, and thus can not be seen with the top cover on unit.

If AC power fails, blocking diode CR104 isolates coil of K101 from the battery; otherwise, battery would energize K101, and would thus keep repeater connected to the inoperative AC power supply.

Three protective fuses are located on power supply board. F101 is in the 120- or 240-VAC input to power supply; F102 is in the 13.75 VDC input to Control Board, and thus supplies voltage to the receiver, exciter, and tone boards. F-103 is in the 13.75-volt lead to the transmitter power amplifier.

4-6. DISASSEMBLY INSTRUCTIONS

The repeater's outside protective cover may be removed for service by removing the screws along the sides and the screws through the front trim panel. DO NOT remove the screws at the bottom edge of the front trim panel.

4-7. REPEATER TRANSMITTER ALIGNMENT

4-7-1. Introduction

The repeaters transmitting circuitry is enclosed in two separate boxes. The exciter is housed in a metal, covered enclosure mounted to the bottom of the main chassis and the transmitters final amplifier stages are located in a shielded enclosure mounted directly to the rear panel heatsink.

The exciter stages are normally aligned first as follows.

4-7-2. General Preparation

1- Remove outside trim cover from repeater and the lid covering the exciter enclosure.

2- Unplug P401 from the rear side of the exciter enclosure. This plug connects a coax cable from the exciters RF output to the transmitter final amplifier.

   Connect a 50 ohm, 2 watt power meter or 50 ohm relative power measuring device to the exciters output jack, J401.

3- Disable the receivers activation of the transmitter by removing J501 from P501 (The connecting cable from the receiver enclosure to the control board).

   The transmitter stages can now be controlled with the "local operators" microphone plugged into the repeaters front panel mic. jack.

4- The repeater is equipped with a 3 second carrier drop-out delay. During transmitter alignment it is generally desirable to disable this function. This can be done by soldering a short jumper wire from the anode of CR515, located on the control board, to ground.

   NOTE: Be certain to remove this jumper when alignment is completed.

5- Install the appropriate crystal into the exciters crystal socket and preset the following oscillator components to the approximate center of their range: C301, and L301.

   Preset mic. amplifier/limiter controls R329 (symmetry) and R331 (mic gain) to their approximate midrange positions. Preset the mic deviation pot, R337, to its MINIMUM position by rotating the top of the pot towards the front of the repeater.

6- If the repeater is equipped with a SA-1 tone board, (under the "local operators" control and usually in position #1), remove it from its plugs.

7- NOTE: The repeater is normally shipped ready for use on 110 VAC. If the unit is to be used on 220 VAC, the repeater will need the appropriate plug installed on its Line cord and switch S101, located on the power supply board, will have to be set to the 220 VAC position.

   ALSO- The repeater has no "on/off" switch and must be unplugged from the A.C. outlet to be turned completely off!

8- With step #7 in mind, plug the A.C. line cord into the proper voltage receptacle.

4-7-3. Exciter Alignment

1- NOTE: Key the microphone only when tuning to reduce heating of the exciter stages.

2- Connect VTVM DC probe to emitter of Q306, key microphone, and adjust L304 for maximum reading.

3- Move DC probe to emitter of Q308, key microphone, and adjust L305 and L306 for a maximum VTVM reading.

4- Move DC probe to emitter of Q309, key microphone, and adjust L307 and L308 for a maximum VTVM reading.

5- CAUTION: When adjusting C334 for maximum output it is possible to tune to the SECOND HARMONIC if trimmer C334 is compressed completely. This condition will cause excessive current to flow through Q311. Also when adjusting helical resonator L315, L316, and L317- The center adjustment (L316) should be made first; then the order of adjustment for L315 and L317 is not critical.

6- Remove the VTVM probe and with the 50 ohm power meter or relative output meter connected to the exciter output jack (J401), adjust C328, C334, L315, L316, and L317 for a maximum output reading.

7- Adjust frequency counter to read the repeaters R.F. output frequency. A pick-up loop adjacent to L314 will give adequate output.

8- Key microphone and adjust C301 to bring frequency to within 1 KHz of assigned frequency; then adjust L301 to "fine-tune" to correct frequency.

9- Repeat steps 1 through 6 using the power measuring device, connected to J401 for a maximum output at J401.

10- Repeat steps 7 and 8.

11- Proceed to Modulation Adjustment.

4-7-4. Modulation Adjustments (Voice and Sub. Aud.)

1- Connect oscilloscope to junction of IC302 pin 7 and R 333; then check for symmetrical clipping by whistling into microphone while keying the mic button. Adjust R 329 for equal clipping at top and bottom of display.

2- If the repeater is equipped with an SA-1 tone board(s), install it/them at this time. This includes the tone board which may have been removed during step #6 under "General Preparation".

3- Couple a deviation meter to L314 with a "Loop" pick-up.

4- NOTE: Each SA-1 tone board installed in the repeater will need to have its subaudible modulation level adjusted. The repeater is normal shipped from the factory with the tone board position #1 under control of the local operators microphone. A tone board in position #1 will decode and encode the same as other installed tone boards and in addition will "turn on" the front panel speaker when an RF signal with the #1 tone boards subaudible frequency is received. Also the #1 tone board will encode its particular S.A. frequency when the "front panel" microphone button is pressed.

Therefore, a tone board in position #1 can have its subaudible deviation level set by keying the local microphone and adjusting R113 (Located on the SA-1 board) for a deviation of ± 1 KHz as indicated on the deviation meter.

5- To adjust the subaudible modulation levels of tone boards installed in positions 2 through 7, proceed as follows:

A- Temporarily remove the tone board for position #1.

B- Tone boards 2 through 7 have identical circuitry and switching, therefore, instructions given here will apply to any of these tone board positions. Note that these boards must be adjusted one at a time. Do not attempt adjustment with more than one tone board encoding at any given time.

C- Install a temporary jumper from SA-1 board J101, pin 3 to J 102, pin 5 (Note, J101 and J102 are jack numbers assigned to the SA-1 board and will be found on the SA-1 schematic. These jack numbers correspond to P505 A-G and P506 A-G respectively which are plug numbers assigned to the repeaters control board schematic.

D- With the jumper installed (from step C above) key the local microphone and adjust R113 (SA modulation deviation level on the SA-1 board) for ± 1 KHz deviation.

E- Repeat Step "D" on each tone board in positions 2 through 7, moving the jumper wire in each position.

F- Reinstall the tone board in position #1 if so equipped.

G- With the local microphone keyed, and "one" of the SA-1 boards encoding, whistle into the local microphone and adjust R 337 (Deviation level adjustment, located in exciter enclosure), for a total deviation (tone and voice) of ± 5 KHz.

H- Proceed to Modulation Gain Adjustment.

4-7-5. Modulation Adjustment (Voice Only)

1- Connect oscilloscope to junction of IC302, pin 7 and R333; then, check for symmetrical clipping by whistling into microphone while keying the mic button. Adjust R329 for equal clipping at top and bottom of display.

2- With the local microphone keyed, whistle into the microphone and adjust R337 (Deviation level adjustment located in exciter enclosure), for ±5 KHz deviation.

3- Proceed to Modulation Gain Adjustment.

4-7-6. Modulation Gain Adjustments

1- These adjustments are normally made after other alignments are finished and just prior to returning the repeater to service.

2- R331, "Modulation gain adjustment" (located in the exciter enclosure) and R543, "Received audio level" located between the speaker and the edge of the control board) control the gain of the "local microphone audio" and the "received audio" to be transmitted.

R331 sets the gain of both local mic audio and received audio. R543 sets the level of the "received" audio only. Normal adjustment of R 331 is maximum gain (with the top of its pot rotated away from the I. C. located next to it).

R543 also normally sets at max. with the top of its pot rotated towards the rear of the repeater.

3--Replace the lid on the exciter enclosure. Remove the power measuring device from J 401 and reconnect the

coax leading to the final transmitter amplifier.

4- If the transmitter final amplifier is to be aligned, leave the jumper on CR 515's anode to ground in place and also leave the receiver plug J501 disconnected. Otherwise remove the jumper and reconnect the plug.

4-7-7. Transmitter Final Amplifier Adjustment

1- Connect a 50 Ohm, 100 W inline power meter and dummy load to the transmitter output connector (located on the rear heatsink and directly below the transmitter).

NOTE: Final amplifier transistors may become very hot during alignment If necessary, allow the devices to cool occasionally during the alignment procedure.

2- Key the microphone and adjust C402 C413, C414, C422, and C423 for maximum output power. Key the microphone only when tuning to avoid transistor heating.

3- Repeat step # 2 until no further increase in output power is seen.

4- Remove jumper on CR515's anode to ground. Reconnect J501 (Receiver box to control board).

4-8. REPEATER RECEIVER ALIGNMENT

4-8-1. Introduction

The Receiver RF, discriminator, squelch and audio amplifier circuits are contained in a metal, RF-tight enclosure which is attached to bottom of Repeater main chassis.

Squelch and volume controls are mounted on the Control Board and extend through trim panel.

Prepare receiver for alignment as given in the following steps:

4-8-2. General Preparation

1) Remove outside (top) cover from the Repeater cabinet, and remove the lid covering receiver enclosure.

2) Disable transmitter by unplugging J-503 from P503 (the cable connecting exciter enclosure to Control Board).

3) Remove "Local Operator" microphone plug from front panel mic. jack.

4) Install appropriate crystal in receiver crystal socket.

NOTE: The repeater is normally set for use on 110VAC. If the unit is to be used on 220VAC, the repeater will need the appropriate plug installed on its line cord. Switch S-101, located on the power supply PC board, MUST BE set to its 220 VAC position.

The repeater has no ON/OFF switch; therefore, it must be unplugged from the AC source to be completely turned OFF.

5) With above NOTE in mind, plug the AC line cord into appropriate receptacle.

4-8-3. Order of Alignment

These paragraphs provide proper alignment instructions for the receiver; be sure to perform steps listed below in the order given. When connecting or removing test leads, REMOVE B+ FROM RECEIVER BY UNPLUGGING J501 FROM P501.

4-8-4. 10-Volt Supply Adjustment

1) Connect a DVM to junction of R221, Q205, and Q207.

2) If DVM does NOT rear +10 V ±250 mV, adjust potentiometer R221 until DVM reads +10 V.

4-8-5. 10.7 MHz & 455 kHz IF Alignment

NOTE: The receiver enclosure may be unbolted from the main chassis and laid on its side to gain access to bottom of the PC board for test equipment connections.

1) Connect output of an FM signal generator through a 39 pF capacitor to source of 1st Mixer Q202.

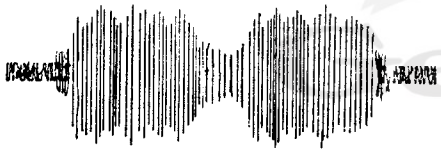
   Connect vertical input of oscilloscope to pin 3 of 2nd Mixer, IC202, through a X10 probe. Connect AC VTVM across speaker leads.

2) Set generator frequency to exactly 10.7 MHz, and modulate generator with a low-frequency audio signal (below 100-Hz).

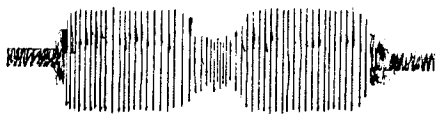
   Set generator deviation for approximately ±9 kHz -- the total swing MUST BE somewhat greater than the IF bandwidth.

3) During alignment of the 10.7 MHz and 455 kHz IFs, keep generator output level low enough to prevent saturating the 2nd Mixer, as indicated by scope connected to IC202.

4) Set scope Internal Sweep and Vertical Sensitivity to present a usable scope pattern similar to that shown in Figure 4-3.



Improperly Tuned



Correctly Tuned for Min. Ripple

Figure 4-3. IF Tuning Response

5) Adjust cores in transformers T201, T202, T203, and T204 for MAXIMUM amplitude and MINIMUM ripple in the scope pattern, as shown in Figure 4-3.

6) Change FM generator modulation to a 1-kHz signal with ±5 kHz deviation. Set generator output level for MAX. quieting. Move scope X10 probe to junction of R214, R215, and C229.

7) Adjust core in quadrature transformer T206 for MAXIMUM amplitude of the 1-kHz signal on the scope. If scope does not indicate a pure sine wave, make a SLIGHT readjustment of T201, T202, T203, or T204, as needed.

8) Remove 10.7 MHz signal from source of Mixer Q202. With NO signal input to receiver, adjust core in 455-kHz transformer, T205, for MAXIMUM noise as shown on AC VTVM.

4-8-6. 1st Local Oscillator Alignment

1) Set VTVM function to "DC -", and connect meter lead to base of tripler Q213.

2) Adjust L211 and L213 for most negative reading on VTVM.

3) Move VTVM lead to source of Mixer, Q202, and set the VTVM function for "DC +". The VTVM may indicate .45 to .50 VDC.

4) Tune helical resonators L217, L218, and L216, in that order, for MAXIMUM positive indication on VTVM (an increase of .1 to .15 volts).

5) Carefully tighten locking nuts on helical resonators; BE SURE ADJUSTMENTS DO NOT CHANGE.

NOTE: The receiver crystal will be netted to exact operating frequency in a later step, using L210.

4-8-7. Input Filter and RF Alignment

1) Connect output of an FM signal generator to the receiver antenna connector. Set generator to desired frequency, and modulate generator with a 1-kHz tone at ±5 kHz deviation.

2) Connect a Sinadder, or equivalent, across the speaker. If Sinad measuring equipment is not available, substitute an AC VTVM. Back slug in L204 out FLUSH with end of form.

3) Increase generator output until the 1-kHz tone is heard in speaker.

NOTE: During the following steps, reduce generator output as necessary to prevent overdriving the receiver.

4) Adjust helical resonators L207, L206 and L208, in that order, for best Sinad (or MAX. quieting).

5) Tune resonators L202, L201 and L203, in that order, for best Sinad.

6) Repeat steps 4) and 5), until no further improvement is noted.

7) Tune slug in L204 for best Sinad, or best quieting. If L204 does not tune through peak, a small change in the length of wire from feedthru C203 to coil L204 will help.

8) Touch up L203 and L206 for the best Sinad (or quieting).

9) Tighten locking nuts on cavities --- Be careful NOT TO change adjustment of resonators.

10) Turn FM-generator deviation up until Sinad just starts to drop (keep generator RF level low enough to prevent overdriving receiver). Now tune crystal-netting inductance L-210 for best Sinad.

NOTE: Due to tolerance accumulation in FL201, 202, 203, 204 and Y201, the actual local oscillator frequency and the calculated frequency may not be identical for the center frequency of channel.

11) Turn generator deviation down to ±5 kHz, and check sensitivity of receiver. The generator attenuator should indicate NOT MORE than 0.45 uV for 12 dB Sinad.

4-8-8. Squelch Operation

1) Set FM signal generator to desired "receive" frequency, and modulate generator with a 1-kHz tone at ±5 kHz deviation. Set RF attenuator for MINIMUM RF output.

2) Turn squelch control fully CW -- set receiver audio control (front panel) for MAXIMUM volume. Receiver should be silent.

3) Set volume control at midrange, and adjust squelch control fully CCW; then, turn squelch control CW until receiver background noise just disappears.

4) Increase setting of signal generator RF attenuator until the squelch just fully opens. The attenuator should show 0.35 uV or less.

4-8-9. Audio-Output Power

1) Set FM signal generator on desired "receive" frequency, and modulate generator with a 1-kHz tone at ±5 kHz deviation. Set RF attenuator in the vicinity of 5 uV.

2) Turn volume control fully CW. The AC VTVM should indicate NOT LESS than 4 volts (5 watts).

3) Repeat steps 1) and 2) using audio frequencies of 500-Hz and 3-kHz.

4) Remove test leads, and re-install receiver enclosure on repeater main chassis.

5) Replace cover on receiver enclosure, and re-connect J503 to P503 (plug from exciter box to Control Board). Replace outside trim cover on the repeater unit.

6) Re-connect "local Operators" microphone to front panel mic. jack.

5-1. INTRODUCTION-REPEATER POWER SUPPLY

The power supply circuit board contains the adjustment control for setting power supply voltage and is located directly in front of the power transformer and to the rear of the control board.

Switch S101 is located on this circuit board and is normally set at 110 V.A.C. when shipped from the factory. If the repeater is to be used on 220 V.A.C., S101 will have to be set to the 220 V.A.C. position and the repeaters A.C. line cord plug must be changed.

Also, the repeater has no " on/off "-switch and must be unplugged to turn the repeater completely off.

5-2. PRELIMINARY

See Figure 2 for location and description of fuses on the power supply board.

> CAUTION: 110 V.A.C. exists at several places on the power supply board. Use extreme caution when connecting test equipment or making adjustments!
>
> NOTE: For slight readjustment of the +13.75 V.D.C. supply it is not necessary to disconnect B+ from the repeater. However, if components have been changed on the power supply board, the power supply should be isolated from repeater circuitry during 13.75 V.D.C. adjustment. This step protects repeater circuitry from excessive D.C. voltages during adjustment.

To isolate power supply from repeater: Unplug J 502 from P 502 (the 2 pin plug connecting the power supply board to the control board.) Also, remove fuse F103 from power supply board (F 103 supplies B+ to the transmitter final amp).

5-3. +13.75 V.D.C. ADJUSTMENT

1- Connect an accurate D.C. voltmeter from the end of F 103 nearest the front panel and ground.

2- Adjust R109, (located on the power supply board), for +13.75 V.D.C. $\pm$ .25V.

3- Remove meter leads, replace F103 and reconnect J 502 if removed earlier.

5-4. BACK UP BATTERY CHARGING

If desired, an emergency back up battery may be connected to P102 (15 pin plug on rear panel) with pin 13 being ground and pin 15 positive.

Relay K 101 (on the power supply board) will automatically switch the repeater to the battery if A.C. service is interrupted and will also automatically switch back to the A.C. supply when A.C. service is restored.

R102, (on power supply board) controls the charge rate of the emergency battery.

Select the value of R 102 by using the following formula.

$R=\frac{(27V-E)}{I}$ E=Back up battery voltage
I=Float charge battery current

Example: A 12.6 V battery with a float charge rate of .100 amps $R=\frac{27-12.6}{.1}$

R= approximately 150 Ohms.

R power rating--P=EXI, P-12.6 x .1 = 1.26 watts. So the proper resistor would be 150 Ohm, 2 watt.

CAUTION: The repeaters power supply is designed to maintain a "float charge" only. This float charge should be kept below .5 amps or damage may result.

"LED" CR 105 (on the power supply board) should light when an emergency battery is connected and is being charged. CR 105 will be "off" when the repeater is being operated by the emergency battery or when an emergency battery is not connected to the repeater.

SECTION VI

SET-UP INSTRUCTIONS

This section covers the actual set up of the repeater. These steps assume that the repeater has been crystalled and properly tuned and that all external components, such as the antenna system, are properly installed and tuned.

6-1. NOISE SQUELCH OPERATION

In "Noise Squelch" operation the transmitter is activated anytime the receiver squelch is opened or the local operator's microphone is keyed.

The front panel speaker will be silenced anytime the local operator's microphone is "hung up". The local mic should be removed from its hanger, (or the monitor bar pushed on the desk mic), if it is desired to monitor repeater traffic.

NOTE: Keying the local operators mic will "squelch" the repeater's receivers and give the local operators control of the transmitter.

Set-up the repeater using the following steps:

1- See Figure 3 and check that the jumper wire located on the control board is in its proper position for noise squelch operation.

2- Adjust the front panel volume control to approximate midrange.

Plug the repeater into an A.C. outlet and adjust the front panel squelch control to just silence the front panel speaker with no incoming signal being received. Make squelch control adjustment quickly as the repeater's transmitter will be activated whenever the squelch is opened by either a received R.F. signal or the squelch control is rotated "off".

3- The front panel volume control adjusts the front panel speaker audio level only and has no effect on transmitter deviation level.

Adjust the volume control for desired level in the front panel speaker.

4- NOTE: Final adjustment of the front panel squelch control is very important to insure the receiver's squelch will open to valid signals only and will not open to short noise spikes, etc.

This is done by setting the squelch control to the point where the receiver "just squelches" and then turning the squelch control just beyond that point.

Rotating the squelch farther toward "tight squelch" than necessary may prevent distant mobiles from opening the repeater's squelch circuit.

6-2. TONE SQUELCH OPERATION

In tone squelch operation the repeater's transmitter will be keyed only when an R.F. signal containing appropriate subaudible tone is decoded by one of up to 7 installed SA-1 tone boards or when the "local operators" microphone is keyed.

The repeater control board contains plugs for up to 7 SA-1 tone boards. Each tone board installed will decode and encode its own particular subaudible frequency.

Tone board position #1 is normally set-up at the factory to be under control of the "local operators" microphone as well as access by mobile units.

In "Tone Squelch" operation and with the local, front panel microphone "hung up", the front panel speaker will be silent to all incoming calls and will "turn on" only when receiving calls with tone board #1's subaudible frequency.

Lifting the front panel mic from its hook (or pushing the monitor bar on the desk mic) will allow the local operator to monitor "any" incoming repeater call.

NOTE: Keying the local operator's microphone will "squelch" the repeater's receiver and give the local operator control of the repeater.

Keying the local mic also will encode the repeater's transmitter with the #1 tone boards subaudible frequency.

For tone squelch operation, set up the repeater as follows:

1- Tone board levels and operational tests should be made at this time if not done already,(See alignment section of manual).

2- See figure 3 and check that the jumper wire located on the control board is in its proper position for "tone squelch operation."

3- Plug the repeater into an A.C. outlet and lift the local microphone from its hanger.

4- Adjust the front panel volume control to its approximate midrange position and the squelch control to just silence the receiver.

As in "noise squelch" operation, the front panel volume control sets the level of the front panel speaker only and has no effect on transmitter deviation level. However, in "tone squelch" operation, the front panel squelch control operation differs slightly.

In "tone squelch" operation, rotating the repeater's squelch pot "off" will not activate the repeater's transmitter.

For an incoming R.F. signal to activate the transmitter, it must first "open" the repeater's squelch circuit and then must also contain an appropriate subaudible tone to be decoded by one of the repeater's installed tone boards.

Therefore, the squelch control should be adjusted to silence the front panel speaker, keeping in mind that rotating the squelch control to "tight" squelch may prevent distant mobiles from opening the repeater's squelch circuit.

6-3. OPERATION OF 3 MINUTE TIMER

The repeater is equipped with a 3 minute timeout circuit and a 2 second carrier dropout delay.

The repeater will automatically stop transmitting if it receives a solid carrier for 3 minutes without pause. There will be a short tone burst approximately 2 seconds before this shutdown occurs to signal the 3 minute time has elapsed.

The repeater will automatically reset itself after the received carrier has been removed for a few seconds.

The 2 second carrier dropout delay keeps the repeater keyed during short signal dropouts or between short breaks of incoming mobile transmissions.

SECTION VII
PARTS LIST

This section of the Maintenance Manual lists replacement parts, as well as major mechanical components, for use in the UHF Repeater.

The first column in the list contains components reference numbers as shown on schematics or wiring diagrams.

In general, 100 series through 500 series numbers are located in the repeaters as follows: 100 series numbers pertain to power supply components; 200 series to receiver circuits; 300 series to exciter circuits; 400 series to transmitter final amplifier circuits; and 500 series to control board components.

Reference Number	Part Number	Description
Capacitors C100		
1,	1540022	Electrolytic, 23, 000MFD, 4(
2,3,4,5	1520071	Disc.,.001 MFD,+ 10%
6	1540049	Electrolytic, 500 MFD
Capacitors C200		
1,	1520003	Disc. 3.9pf, NPO
2	1520009	Disc. 15pf, NPO
3,40,41,42,43,44,45, 45,46,47,48,49	1520086	Feedthru, .001 MFD
4,	1510006	Gimmick, .39pf, NPO
5,14,15,29,	1520054	Disc. .05 MFD, M25
6,16	1520004	Disc., 4.7pf, NPO
7,62	1520007	Disc., 10pf, NPO
8,33,58,59,63	1520008	Disc., 12 pf, NPO
9,19	1520051	Disc., .01 MFD, Y5U
10,11,17,66	1510017	Gimmick, 3.3pf, NPO
12	1510008	Gimmick, .56pf, NPO
13	1520013	Disc., 33 pt, NPO
18,21	1520055	Disc., .1 MFD, +80% −20%
20	1540014	Electrolytic, 10 MFD,Y5U
22,57	1520190	Disc., 22 pf, NPO
23,24,53,54,	1520060	Disc., 47pf, N220
25	1550002	Tant, 1 MFD, 35V
26	1500079	Disc., .005 MFD, Z5U
27,28	1520033	Disc.,220 pf, Z5F
30,32	1550001	Tant,.22MFD, 35V
31	1520077	Disc., .002MFD, Z5P
34	1520053	Disc.,.02 MFD M25
35	1550015	Tant. 2.2 MFD+20%
37	1540049	Electrolytic 500 MFD, 12V
38	1520057	Disc., .22 MFD, +80% -20%
39	1540212	Electrolytic, 200MFD, 12V
50,55	1520071	Disc., .001 MFD, JF
52	1520014	Disc., 39 pf, NPO
56,60,65	1520025	Disc., 120pf,N1500
61	1520028	Disc., 150pf, Y5E
64	1510015	Gimmick, 2.2pf, NPO

Capacitors C300		
1	1570008	Variable,7-35pf
2	1520190	Disc.,22 pf, NPO
3,37,38,43	1540014	Electrolytic, 10MFD
4,14,15	1520018	Disc.,56pf, N220
5	1520022	Disc.,100pf, N220
6,12	1520055	Disc.,.1MFD,+80%,-20%
7,32	1520051	Disc.,.01MFD,Y5U
8	1520019	Disc.,68pf,NPO
9,13,17,18,26	1520071	Disc., .001 MFD, JF
10,20,	1520176	Disc., 82 pf, N330
11, 16	1520014	Disc., 39 pf, NPO
19	1520204	Disc., 75pf, N750
21	1520039	Disc., 390pf, Y5E
22,33,36	1550002	Tant, 1MFD,35V
23,29,51,52,53	1520028	Disc., 150pf, Y5E
24,35,41	1520008	Disc., 12pf, NPO
25	1520025	Disc, 120pf, N1500
27	1530013	S.Mica, 56pf
28	1560406	Variable 15-115pf, PC406
30	1520007	Disc., 10pf, NPO
31	1530033	Unelco T-101, 100pf
34	1570010	Variable, 1.5-20pf, PC402
39,42	1500018	Mylar, .01 MFD
40	1500013	Mylar, .0047MFD, 600UE
44,45,46,47,48,49,	1520086	Feed thru, .001MFD

Capacitors C400		
1,22,25	1570123	Chip,5pf
2	1570009	Variable,2-18pf
3,10,21	1570125	Chip, 35pf
4,28	1570124	Chip, 30pf
5,9,18	1550007	Tant,10MFD,±20%, 35V
8	1570127	Chip, 75pf
11,20	1570126	Chip, 40pf
12,19	1520054	Disc., .05 MFD
13,14,23	1570130	Variable, Air, Johnson#187-0109-175
15,17,27	1520086	Feed thru, .001MFD
16,24	1570128	Chip, 25pf
26	1520238	Chip, 250pf

Capacitors C500		
1(A-G),2(A-G)4(A-G),6,10 15,23,27	1520051	Disc., .01MFD,Y5U
3(A-G),5(A-G),25,26	1540217	Disc., .01MFD,Y5U
7,8,9	1500006	Mylor, .0018MFD, 100V
12	1541009	Electrolytic, 47MFD
13	1520057	Disc., .22 MFD
14	1540038	Electrolytic, 1000 MFD
16,21,24	1520055	Disc., .1MFD, +80%, -20%
17,18,19,20	1520077	Disc., .002MFD

Reference Number	Part Number	Description
Capacitors C500 continued		
22	1550002	Tant, 1.0MFD 35V
28	1520054	Disc. .05 MFD
29	1520009	Disc, 15 pf, NPO
Diodes CR100		
1,2,	4810048	MR1122R, Anode to stud
3,4	4810013	IN4001
5	3900050	LED Green
Diodes C200		
1,2	4810017	IN4148
3	4810007	Zener, 6.8V
4	4810013	IN4001
Diodes CR300		
1	4810008	Zener, 10V
2,6	4810007	Zener, 6.8V
3	4812109	Varicap, MV2109
4,5	4810017	IN4148
Diodes CR500		
1(A-G),2(A-G),4(A-G),5(A-G),6	4810017	IN4148
7,9,10,12,13,14,15,18		
3(A-G),16	3900030	LED Red
8	4810008	Zener, 10V
11	3900050	LED Green "on" front pan
17	4810049	Zener, 5.1V
Filters FL200		
1/2 , 3/4	2303504	crystal, 4 pole monolith marched 10.7 MHz
Integrated Circuits IC100		
1	3133063	NA723 regulator
Integrated Circuits IC200		
1	3130366	SC74126P, IFAMP
2	3130038	MC3357,2nd mixer, quad. detector
3	3130367	LM383, Audio AMP
4	3130021	MC7808CT, 8 volt regulat
Integrated Circuits IC300		
1	3130021	Regulator, MC7808CT,8V
2	3130012	MC1458, Dual op-amp
Integrated Circuits IC501	3130013	MC1741CPI, Single op=amp

Reference Number	Part Number	Description
Inductors L200		
4	1800411	Coil, 2½ turn, P.Smith
5		Coil, R.F., 2" of #24 tinned bu
9	1800005	Coil,RF,2½ Turn, #24 DCP
10	1800308	Coil, RF, 8½ turn,P Smith
11	1800321	Coil, RF 3½ turn, P Smith
12	1800338	Coil, RF, .47 µhy
13	1800322	Coil, RF 4½ Turn, P Smith
14,15	1800234	Coil, RF, 1½ turn, tinned
Inductors L300		
1,5,6	1800312	Coil, 1½ turn, P Smith
2	1800354	Coil,1 µhy
3	1800360	Coil, 220 µhy
4	5600072	Coil, modulator
7,8	1800304	Coil, P Smith 4½ turn
9	1800321	Coil, P Smith
10	1800237	Coil
11	1800201	Coil
12	1800233	Coil
Inductors L400		
1,3,9,13,14		Etched in board
2	1802651	Coil .310" I.D. 1 turn
5,7,12	1800339	Coil, ferrox cube
6	1802652	Coil, .325 I.D. 1 turn
8	1800368	Coil, .15 µhy
10	1802653	Coil, .375" I.D. 1 turn
11	1800368	Coil, .15 µhy
15	1802654	Coil, #18 wire
Transistors Q100		
1	4800013	Trans., MJE520
2,3	4800001	Trans., 2N3055
Transistors Q200		
1,2	4805484	Trans,2N5484,JFET,N Channel
3	4800028	Trans., Red dot MPS6514
4,6,7	4805089	Trans, 2N5089,NPN, Sil.
5	4800023	Trans.,MPS u52,NPN, SIL.
8,9	4800043	Trans., 2N5227, PNP, Sil.
10	4800018	Trans. MPS u01
11	4800026	Trans.,MPS3693, White dot, Sil. NPN
12	4800024	Trans., MPS 3563, Blue dot, sil, NPN
13	4800027	Trans., MPS 6511, NPN, Sil

Reference Number	Part Number	Description
Transistors Q300		
1,2	4800043	Trans., 2N5227, PNP, Sil.
3	4800018	Trans., MPSu01, NPN, Sil.
4	4800033	Trans., 2N5172, NPN, Sil.
5	4805461	Trans.,2N5461, JFET, P Cahnne
6,8	4800026	Trans., white dot, MPS3693 NPN, Sil.
7	4800023	Trans., MPSu52, PNP, Sil.
9	4800024	Trans. Blue dot, MPS3563,NPN
10	4800069	Trans., MRF 237, NPN
11	4800063	Trans. MRF 227, NPN
Transistors Q400		
1	4806101	Trans., CTC CD5944, Cx181
2	4806102	Trans., CTC CD 3025, CM900
3	4806103	Trans., CTC CM50-12A CV538
Transistors Q500		
1(A-G),2(A-G),6,7,10,11, 14,16,17,18,19	4800028	Trans., Red dot, MPS6514, NPN
3(A-G)	4805458	Trans. 2N5458, JFET, N channe
4(A-G),8,15	4800051	Trans.,A13, Darlington, NPN
9	4806535	Trans.,MPS 6535, PNP
12	4800043	Trans., 2N5227, PNP, Sil
Resistors R100		
1	4740035	Res.,150Ω, 2W±10%
2	(see text)	Select for charge rate
3	4710013	Res., 470Ω,±10%, ¼W
4	4710026	Res., 5.6K, ±10%, ¼W
5	4710012	Res., 330Ω,±10%, ¼W
6	4710022	Res. 2.7K, ±10%, ¼W
7	4740034	Res., 100Ω,±10%, 2W
8	4710021	Res., 2.2K ±10% ¼W
9	4760017	Res. 2.5K, variable minipot
10	4710017	Res., 1K, ±10%, ¼W
11,12	4740024	Res., .1Ω, 7W
Resistors R200		
1	4710005	Res., 47Ω, ±10%, ¼W
2,6,36	4710008	Res., 100 Ω, ±10%, ¼W
3,28,29,37	4710029	Res, 10K, ±10%, ¼W
4	4710013	Res., 470 Ω, ±10%, ¼W
5,7,8	4710032	Res., 22K,±10%,¼W
9,13,25	4710033	Res., 33K,±10%, ¼W
10	4710035	Res., 47K, ±10%, ¼W
11	4710041	Res., 220K,±10%, ¼W
12	4710068	Res., 68K, ±10%, ¼W
14,18	4710025	Res., 4.7K,±10%, ¼W
15,26	4710036	Res.,56K, ±10%, ¼W
16,17	4710037	Res., 82K, ±10%, ¼W
19,34	4710009	Res., 150Ω, ±10%, ¼W
20,22,30,39	4710017	Res., 1K, ±10%, ¼W

Reference Number	Part Number	Description
Resistors R200 continued		
21,35	4760015	Res., 1K, variable, 20% minipot
23	4710011	Res.,220 Ω,±10%, ¼W
24,40	4700001	Res. 2.2 Ω,±10%, ¼W
27	4760034	Res., 10K, Thermistor JA41J1
31	4700014	Res. 120 Ω,±10%,½W
32	4710022	Res., 2.7K, ±10%, ¼W
33	4710030	Res., 15K, ±10%, ¼W
38	4710043	Res., 270K, ±10%, ¼W
41	4710038	Res., 100K ±10%, ¼W
Resistors R300		
1	4710036	Res., 56K, ±10%, ¼W
2	4760034	Res., 10K, Thermistor, JA41J1
3,4,33,38	4710029	Res. 10K, ±10%, ¼W
5	4710017	Res. 1K, ±10%, ¼W
6,39	4700017	Res, 220 Ω, ±10%, ½W
7	4700014	Res. 120 Ω,±10%, ½W
8,9,12,36	4710026	Res., 5.6K, ±10%, ¼W
10,13,19,24,27,	4710012	Res., 330Ω, ±10%, ¼W
11	4710023	Res., 3.3K, ±10%, ¼W
14,20	4710006	Res., 56Ω,±10%, ¼W
15,35	4710027	Res., 6.8K, ±10%, ¼W
16,18,23,26	4710001	Res., 10 Ω,±10%, ¼W
21	4710021	Res., 2.2K, ±10%, ¼W
22	4710025	Res., 4.7K, ±10%, ¼W
25	4710008	Res., 100 Ω,±10%, ¼W
28	4700020	Res., 390 Ω,±10%, ½W
29	4760039	Res., 500K, Variable, 20% minipot
30	4710035	Res., 47K, ±10% ½W
31,37	4760021	Res. 50K, variable, 20% minipot
32	4710009	Res. 150 Ω±10%, ¼W
Resistors R400		
1	4700006	Res. 22 Ω, ±10%, ½W
2,3	4700005	Res., 15 Ω, ±10%, ½W
Resistors R500		
1,23,37,56	4710032	Res.,22K, ±10%, ¼W
2(A-G)	4710005	Res. 47Ω ,±10%, ¼W
3(A-G),8(A-G),11,12,26,27 32,49,50	4710029	Res., 10K, ±10%, ¼W
4(A-G),10,13,	4710068	Res., 68K, ±10%, ¼W
5(A-G), 7(A-G),42	4710038	Res., 100K, ±10%, ¼W
6(A-G)	4710023	Res., 3.3K, ±10%, ¼W
9(A-G),22,51,53,54,	4710013	Res., 470 Ω, ±10%, ¼W
14	4710005	Res. 47 Ω, ±10%, ¼W
15,16	4710080	Res., 330K, ±10%, ¼W
17	4700075	Res., 2.7M, ±10%, ½W

Reference Number	Part Number	Description
Resistors R500 continued		
18	4760054	Res. 25K, variable (volume)
19	4710070	Res., 680K, ±10%, ¼W
20,29,31,45	4710011	Res. 220 Ω, ± 10%, ¼W
21,35	4710039	Res., 470K, ±10%, ¼W
24	4760053	Res., 25 K, variable (squelc
25,36,38,57	4710017	Res., 1K, ±10%, ¼W
28,55	4710025	Res. 4.7K, ±10%, ¼W
30,33,34,	4710071	Res. 1.5M, ±10%, ¼W
39,40,41	4710033	Res. 33K, ±10%, ¼W
43	4760019	Res. 10K, variable, 20% minipot
44	4710030	Res., 15K, ±10%, ¼W
46	4710008	Res., 100 Ω, ±10%, ¼W
47	4710021	Res. 2.2K, ±10%, ¼W
48	4700075	Res. 2.7M, ±10%, ½W
52	4710035	Res. 47K, ±10%, ¼W
Transformers T101	5600104	Transformer, Power, 12 AMP
Transformers T200		
1,2,3,4	5600044	Transformer, I.F., 10.7 MHz, green
5,6	5600043	Transformer, I.F. 455 KHz, black
Crystals Y200		
1	2300342	2nd L.O. 10.245 MHz
2	2300341	Receive (specify freq.)
Crystals Y301	2300340	Xmit (Specify freq)
MISCELLANEOUS		
S101	5100138	Switch, 115 & 230V (on power supply board)
K101	4500008	Relay, 4PDT (on power supply board)
F101	5140008	Fuse, A.C. in
F102	5140002	Fuse, 2AMP, 3AG (control brd)
F013	5140022	Fuse, 15AMP, 3AG, (xmtr final
P505 (A-G)	2100070	Plug, 4 pin (SA-1 tone mntg.)
P506(A-G)	2100069	Plug, 6 pin (SA-1 tone mntg.)
	2830043	spacers (for part #s 2100070 and 2100069)
P501	2100282	Plug, 10 pin
P503	2100280	Plug, 6 pin
P502	2100246	Plug, 2 pin
	2100248	Pins(male) for part# 2100246
SP501	2509991	Speaker
	6070075	Clamp, speaker mounting
	2510606	Panel, front trim, short, desk
	2510624	Panel front trim, long, rack mount

MISCELLANEOUS continued

	2510645	Fan, with blade
	2510631	Bracket, fan mounting
	2510625	Cover (main cabinet)
	2413700	Handles (front panel)
	2400021	Knob, vol. and squelch
P102	2100255	Conn. 15 pin, male (rear panel)
	2100253	Pins, for conn.# 2100255
J504	2100077	Conn. microphone, panel mt
	2510643	Heatsink, final amp
	2510642	Heatsink, power supply regulator
	2500201	Nylon cover cap (for Q102 & Q103)
	5300007	Xstr insulator mica for Q102 & Q103
	6010030	A.C. Line cord
	6070071	Grommet, Heyco for A.C. Line cord
J501	2100286	Plug, 10 pin (11 counting guard)
J503	2100281	Plug, 6 pin (7 counting guard)
	2100241	Pins, for plug #s 100286 & 2100281
J102	2100252	Conn. 15 pin female (r panel)
	2100254	Term. female (for conn. # 2100252)
	7083001	Cavity, signal
	7083002	Cavity, L.O.
	7083003	Cavity, Xmit
	2100062	Socket, crystal pins