

**AIR-GROUND RADIO
PRIVATE SYSTEMS
ECHO-FOX UHF RADIO SYSTEM
DESCRIPTION**

BASE RECEIVER GE-MASTR PROGRESS LINE

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1. GENERAL

1.01 The Echo-Fox UHF air-ground radio system employs a network of base stations located throughout the United States to provide government private-line communication service with aircraft in flight. This section describes the base station receiver which is part of the composite base station unit.

1.02 The base station consists of a modified General Electric MASTR progress line station housed in a single cabinet, an antenna system, and an additional rack for auxiliary equipment. The station is remotely controlled from a centrally located network control office. Refer to Section 406-116-100 for a description of the overall system operation.

Note: The Echo-Fox system is no longer capable of wideband digitally coded transmission or reception, but reference to wideband remains in the descriptive section as a possible aid in trouble clearance.

1.03 The cabinet houses a receiver, a transmitter-exciter and power amplifier, and associated power supplies and audio control units (Fig. 1 and 2). The receiver operates on a single frequency approximately 8 MHz from the transmitter frequency to permit full duplex operation. One power supply provides operating voltages for the transistor circuits in the receiver and for the transistor and vacuum tube circuits in the transmitter-exciter. The audio control units couple the modulating signal from the telephone circuit to the transmitter and connect the output of the receiver to the telephone circuit.

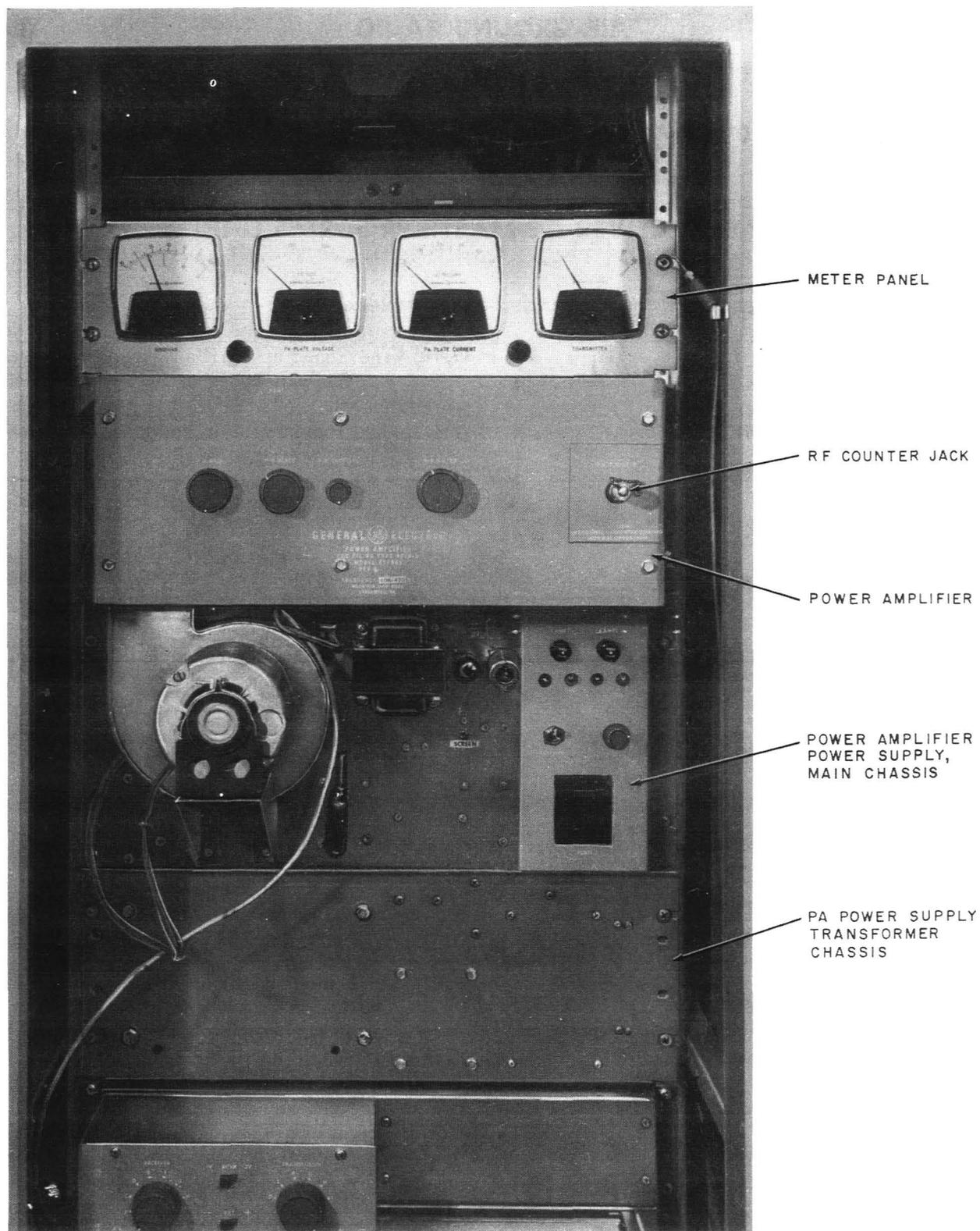


Fig. 1—Station Cabinet—Front View—Top Half

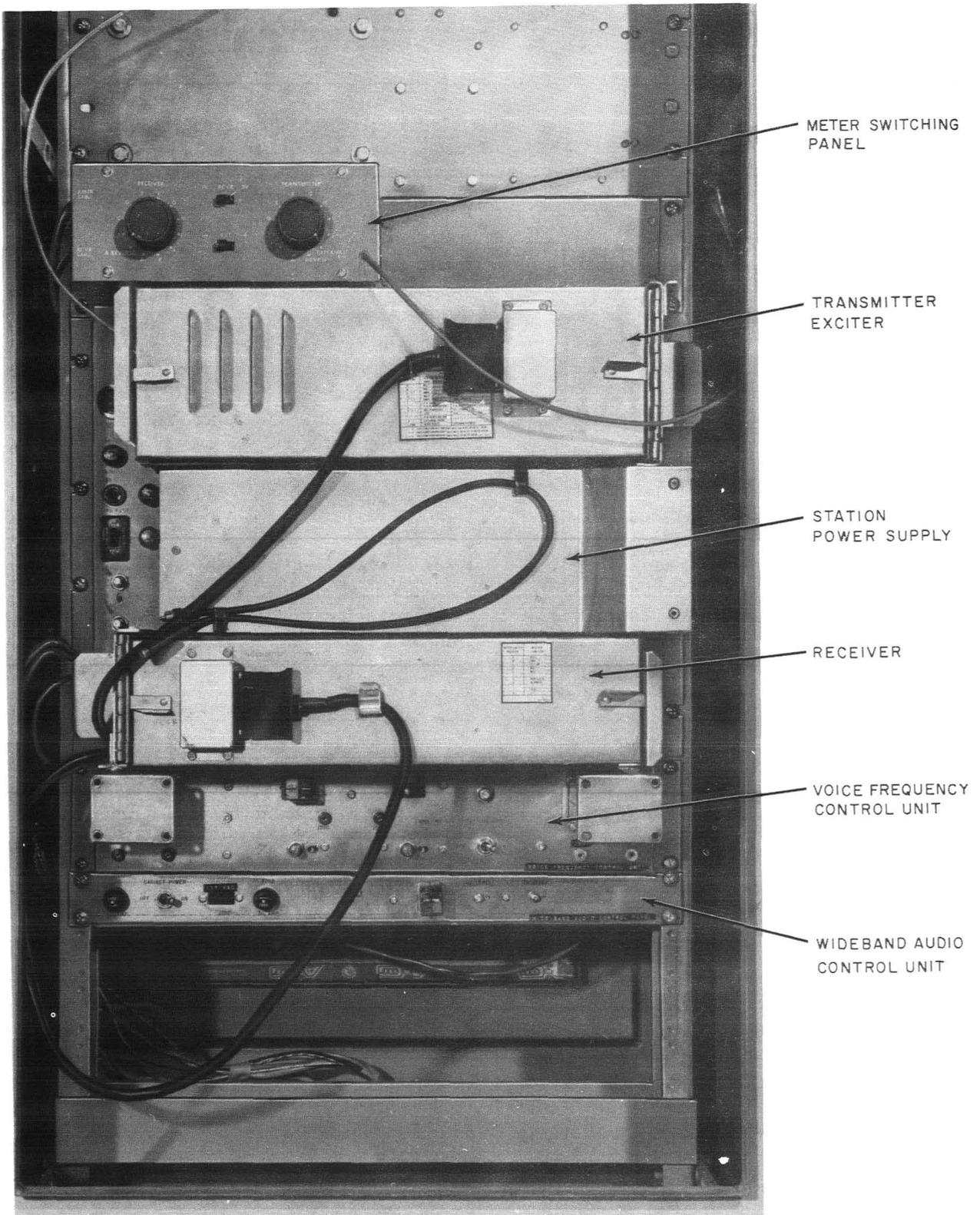


Fig. 2—Station Cabinet—Front View—Lower Half

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1.04 The antenna system is used for transmitting and receiving, either simultaneously or separately. A diplexer in the transmission line to the antenna prevents interaction between the transmitter and the receiver. At some stations, a unity-gain antenna is used; at other stations which were formerly capable of wideband operation, high-gain antennas are used.

1.05 The auxiliary bay is located adjacent to the cabinet which contains the transmitter and receiver. A jack field in the auxiliary panel provides access to audio and control leads in wideband and narrowband modes. Indicator lamps are also located on the jack field.

2. PHYSICAL DESCRIPTION

2.01 The receiver is housed with other station units in a station cabinet shown in Fig. 1 and 2. Units are mounted on standard 19-inch relay racks. The overall cabinet is 69 inches high, 22 inches wide, and 23 inches deep. The rear door of the cabinet is interlocked to protect personnel from operating voltages. Auxiliary equipment is housed in a 7-foot by 23-inch bay adjacent to the station cabinet. Wideband and voice-frequency controls are separate panels mounted in the auxiliary bay.

3. FUNCTIONAL DESCRIPTION

GENERAL

3.01 The RF signals are received and transmitted through a common diplexer, feedline, and antenna system. The diplexer permits receiver and transmitter simultaneous 2-way operation without mutual interference.

3.02 The receiver (Fig. 3) is a dual-conversion superheterodyne unit employing solid-state devices and printed wiring circuits. A centralized metering jack is provided for use with the station meter switching unit and meter panel. This centralized metering circuit monitors the multipliers, limiter, discriminator, audio amplifier, output voice coil, and regulated 10-volt power supply source. The audio power amplifier operates from a regulated 13-volt source; all other receiver stages operate from a regulated 10-volt source.

3.03 The receiver consists of eight basic sections as outlined in the block diagram (Fig. 3).

All sections are housed in a single compact enclosure and are accessible for maintenance.

3.04 The first RF amplifier (A410) consists of two tuned helical resonators and an RF amplifier stage. The RF input signal is fed through the helical resonators to the transistor amplifier. The output of the amplifier is line-coupled to the first of the five helical resonators of the second RF amplifier (A412). The output of the second RF amplifier is loop-coupled to the first mixer stage.

3.05 The first oscillator-multiplier (A415) employs a crystal oscillator operating at a frequency of approximately 16 to 19 MHz. The oscillator is coupled to the first multiplier stage, which is tuned to four times the crystal frequency. The output of the first multiplier is fed through three tuned circuits to the input of the second multiplier, a varactor diode. The two helical resonator circuits that follow the varactor diode are tuned to six times the first multiplier output frequency. These two combined multipliers supply an output that is 24 times the crystal frequency. The output signal from the second multiplier is coupled to the first mixer stage.

3.06 The RF energy from the second RF amplifier is applied to the first mixer (A414) with the injection voltage from the second multiplier. The resonant output circuit of the first mixer is tuned to 12.4 MHz and provides proper impedance matching to the crystal filter.

3.07 The 2-stage crystal filter (A421) following the first mixer provides the major selectivity for the receiver. The output circuit of the filter is an impedance matching transformer which couples the filter to the second mixer.

3.08 The second oscillator is set to a frequency of 11.945 MHz. Both the second oscillator signal and the 12.4-MHz signal from the crystal filter are fed to the second mixer. The 455-kHz output of the second mixer is coupled through three tuned circuits to the first IF amplifier. The second oscillator, second mixer, and first IF amplifier are all part of A422.

3.09 The A423 circuit board contains the second and third IF amplifiers; the first, second, and third limiter stages; the discriminator; and the receiver audio circuits.

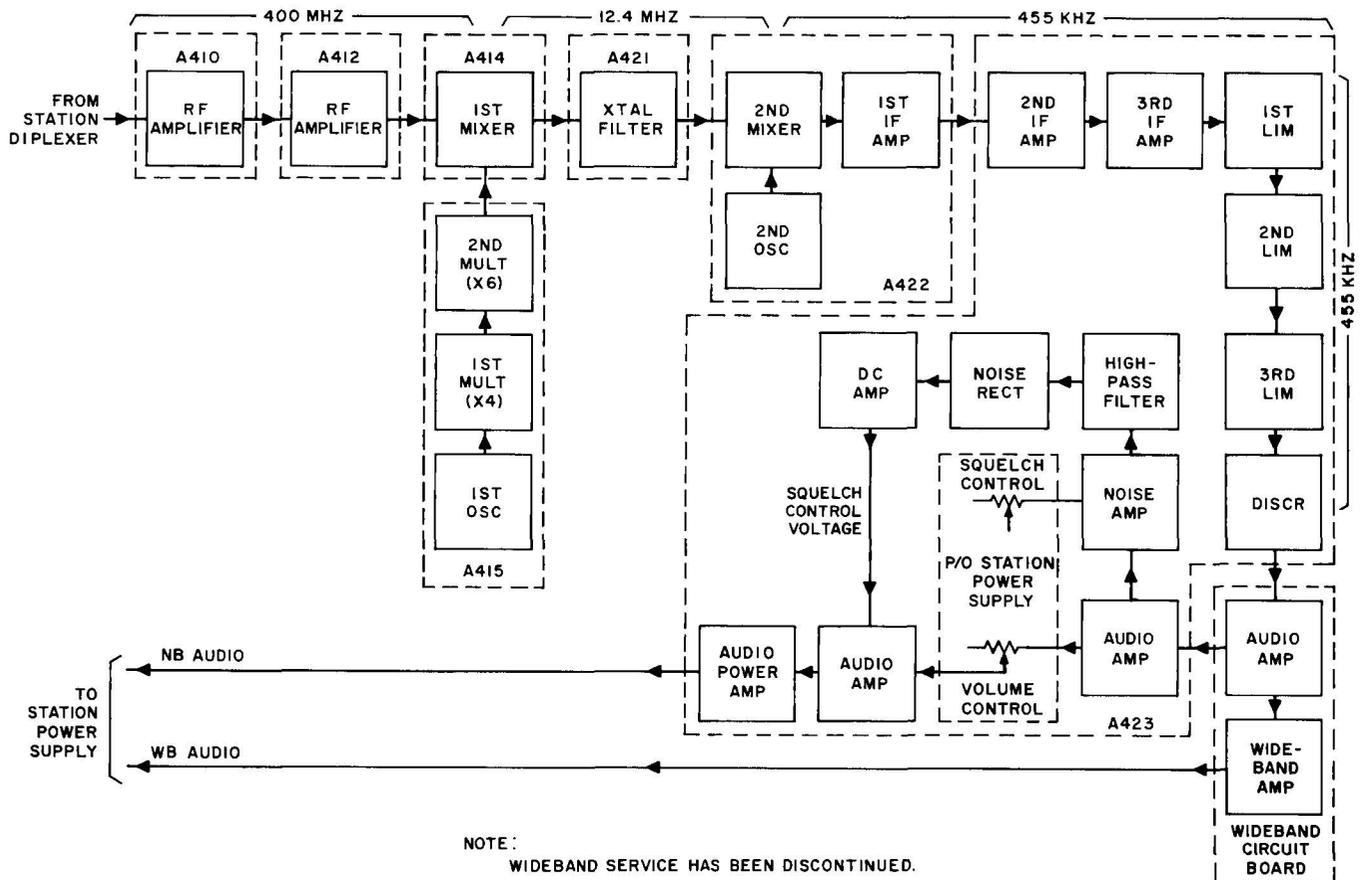


Fig. 3—Receiver—Block Diagram

3.10 The second and third IF amplifiers and the three limiter stages provide amplification and limiting of amplitude variations of the IF signal. The output of the third limiter is coupled to the discriminator. The signal containing intelligence and noise from the discriminator is routed to the audio amplifier on the wideband circuit board. From the wideband circuit board, the audio is fed in two directions: (a) to the audio amplifier on the A423 board, and (b) to the wideband processing circuits. The portion of the signal continuing through the wideband circuits is amplified, shaped, and routed through the station power supply to the wideband audio control unit.

3.11 A signal is fed from the audio amplifier on the A423 board to the volume control located in the station power supply. From the volume control, the signal is routed to a second audio amplifier. De-emphasis is provided by a capacitance-inductance network. The amplified

audio signal is routed to the audio power amplifier, and the output from the audio power amplifier is transformer coupled to either a loudspeaker or the telephone line facility.

3.12 Noise from the first audio amplifier on the A423 board is used to operate the squelch circuit. When little or no carrier is present in the receiver, noise is present and is coupled to the base of the noise amplifier. The gain of the noise amplifier is adjusted with the externally located squelch control by varying the bias for the noise amplifier transistor. The output from the noise amplifier is fed through a high-pass filter, which attenuates frequencies below 3 kHz. Noise from the high-pass filter is rectified, and the resultant negative dc output is supplied to the base of the dc amplifier transistor.

3.13 The dc amplifier performs as a squelch switch. A negative output from the noise

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rectifier cuts off the dc amplifier. The carrier-operated relay circuit (2-transistor relay amplifier and relay K1) is used (a) to quiet the receiver wideband output by terminating the line when the receiver RF input signal is below the squelch operating point, and (b) to send an on-hook or off-hook condition as applicable to the SF unit.

3.14 The station power supply provides operating voltages for the transmitter-exciter and the receiver. In addition, the power supply provides a control section to coordinate transmitter and receiver functions.

3.15 The receiver is mounted on the front side of the station power supply panel. A fan is mounted on the front panel to cool the transmitter-exciter and the 13.4-volt regulator transistor.

3.16 A control section is part of the station power supply. An audio line transformer and volume and squelch controls for the receiver are included in the control section. The line transformer matches the output impedance of the receiver to the 600-ohm input impedance of the VF control unit. The volume control is used to set the audio transmission level from the base station to the control office. The squelch control is used to establish the RF signal strength required to unmute the receiver.

3.17 A detailed description of the station power supply is included in the base transmitter description, Section 406-116-102.

4. DETAILED DESCRIPTION

RF AMPLIFIER (A410)

4.01 RF amplifier A410 (Fig. 4) consists of two tuned helical resonators and an RF amplifier stage. The RF signal from the antenna system is coupled through RF cable W444 to a tap on inductor L410. The tap is positioned to provide the proper impedance match to the antenna. RF energy is coupled through the second coil (L411) through an opening in the shield wall, and then to the base of RF preamplifier Q1. Diode CR1 protects Q1 from damage by high signal levels. The output of Q1 is developed across tuned circuit L1 and C3 and is coupled through five helical resonators to RF amplifier Q2.

RF AMPLIFIER (A412)

4.02 RF amplifier A412 consists of five tuned helical resonators and an RF amplifier stage. RF energy is coupled to the base of RF amplifier Q2, through the five coils by openings in the shield walls. The output of Q2 is loop-coupled to the base of the first mixer A414.

FIRST OSCILLATOR AND MULTIPLIER (A415/A420)

4.03 The receiver first oscillator is a transistorized Colpitts oscillator. The oscillator crystal operates in a fundamental mode at a frequency of approximately 16 to 19 MHz. The crystal is cut to provide temperature compensation at the high end of the temperature range and is thermistor compensated at low temperatures. This arrangement provides acceptable frequency stability without crystal ovens or warmers.

4.04 When the receiver is used on a single frequency as for Echo-Fox systems, a jumper from J2 to R5 connects the regulated 10 volts to the crystal circuit, which forward biases diode CR1. Forward biasing the diode reduces its impedance. The crystal frequency signal is applied to the base of oscillator transistor Q1. Feedback for the oscillator is developed across capacitor C47. The oscillator output is fed through C45 to the base of first multiplier Q2. The output of the first multiplier is fed through three tuned circuits (T7/T8, T410/T412, and T411/T413) to the second multiplier assembly. The first multiplier circuits are tuned to four times the crystal frequency. This stage is metered at centralized metering jack J442-4 through metering network CR6, R17, and R18.

SECOND MULTIPLIER

4.05 The first multiplier output is applied to the anode of multiplier diode CR410. Two helical resonator circuits follow CR410 and are tuned to six times the first multiplier frequency for a total multiplication of 24 times the crystal frequency. The second multiplier output is fed through capacitor C434 to the emitter of the first mixer.

FIRST MIXER (A414)

4.06 The RF signal from the RF amplifier is applied to the base of the first mixer transistor and the injection voltage from the second

multiplier is applied to the emitter. The mixer collector tank (L3 and C9) is tuned to 12.4 MHz and provides impedance matching to the crystal filter.

CRYSTAL FILTER (A421)

4.07 The highly selective 2-stage crystal filter (A421) following the first mixer provides the major selectivity for the receiver. The output of the filter is fed through impedance matching transformer A422-T2 to the base of the second mixer.

SECOND OSCILLATOR (A422)

4.08 The second oscillator Q4 operates in a Colpitts oscillator circuit with feedback supplied through capacitor C20. The oscillator frequency is 11.945 MHz with the low-side injection voltage fed to the base of the second mixer.

SECOND MIXER (A422)

4.09 The IF signal from the crystal filter is fed to the base of the second mixer with the output from the second oscillator. The 455-kHz second mixer output is fed to three tuned low IF circuits (L5, L2, and L6). The three tuned circuits are required for shaping the IF waveform. These tuned circuits also provide some additional selectivity.

FIRST IF AMPLIFIER (A422)

4.10 The IF signal from the second mixer is coupled through C14 to the base of the first IF amplifier transistor Q3. The output of Q3 is resistance-coupled to the base of the second IF amplifier.

SECOND IF AMPLIFIERS AND LIMITERS (A423)

4.11 Following the first IF amplifier (A422-Q3) are two additional resistance-coupled IF amplifiers, A424-Q1 and -Q2. The second IF amplifier stage is metered at J442-2 through metering network C8, CR1, and R12. The third IF amplifier is metered at J442-4 through C13, CR2, and R18. Following the IF amplifiers are three resistance-coupled limiter stages, A423-Q3, -Q4, and -Q5.

DISCRIMINATOR (A423)

4.12 The receiver employs a Foster-Seeley discriminator. The output of the third limiter is connected to a tap on the tuned primary of discriminator transformer T1. Diodes CR5 and CR6 rectify the 455-kHz IF signals to recover the audio. The discriminator is metered at J442-10 through metering network R27 and C22.

AUDIO AMPLIFIERS (A423)

4.13 The output of the discriminator is coupled to emitter follower transistor Q1 in the wideband audio board. The output of Q1 is coupled through R63 to the normal audio circuits (Q6) and is applied through R5 to the wideband audio circuits.

4.14 When audio is present in the incoming signal, the audio is taken from the emitter of audio amplifier Q6 and connected to the volume control through connector J9. The arm of the volume control connects to J8 which feeds the audio signal to the base of the second audio amplifier Q9. De-emphasis is provided by C34, C37, C53, and L4. Potentiometer R47 is used to adjust the collector current. The collector current is adjusted for 650 mA. This value is indicated as 0.65 volt at metering jack J442-1. The adjustment is made with the volume control set fully counterclockwise. After potentiometer R47 has been set, thermistor RT1 keeps the output current constant over wide variations in temperature.

4.15 The final portion of the audio amplifier section is composed of a Darlington circuit consisting of compound-connected transistors Q10 and Q410. This circuit provides a high input impedance with low distortion at maximum output.

SQUELCH

4.16 Noise from audio amplifier transistor Q6 is used to operate the squelch circuit. When little or no carrier is present in the receiver, noise is coupled to the base of noise amplifier Q7. The gain of the noise amplifier is determined by the squelch control which varies the bias on the base of Q7. The output from the noise amplifier is fed through a high-pass filter (C64 and L1) which attenuates frequencies below 3 kHz. Thermistor RT2 keeps the critical squelch constant over wide variations in temperature. Noise from the high-pass filter is rectified by CR3 and CR4. The negative

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dc output of the noise rectifiers is fed to the base of dc amplifier Q8.

4.17 DC amplifier Q8 acts as a squelch switch.

A negative output from the noise rectifiers cuts off the dc amplifier. When turned off, the collector potential is at the +10 volt supply level. This positive voltage is fed to the base of Q9, a PNP transistor, cutting it off. As audio stages Q9, Q10, and Q401 are dc coupled, all of them are cutoff. The positive voltage from the collector circuit of the dc amplifier is used as feedback through resistor R33 to the base of noise amplifier Q7, causing it to conduct more heavily. The feedback helps to cut off Q8 sharply, resulting in

sharp, quick-acting switching. The carrier/voice operated relay K1 also drops out.

4.18 When the receiver is quieted by a signal, noise voltage from the noise rectifiers is reduced and the dc amplifier conducts. When conducting, the collector potential of Q8 is negative, and negative feedback to the base of noise amplifier Q7 causes it to conduct less. The negative voltage is applied to the base of transistor Q9 causing it to conduct. Audio is now applied to the output. When the receiver is squelched, the final audio stages are cutoff and the current drain is less than 50 mA.

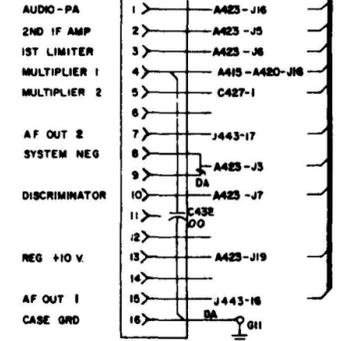
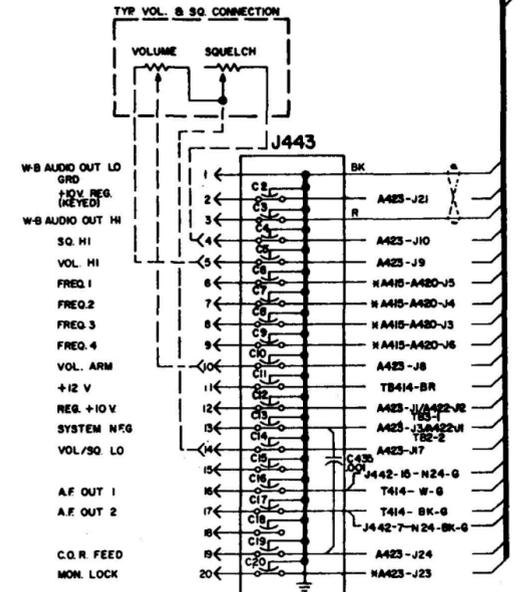
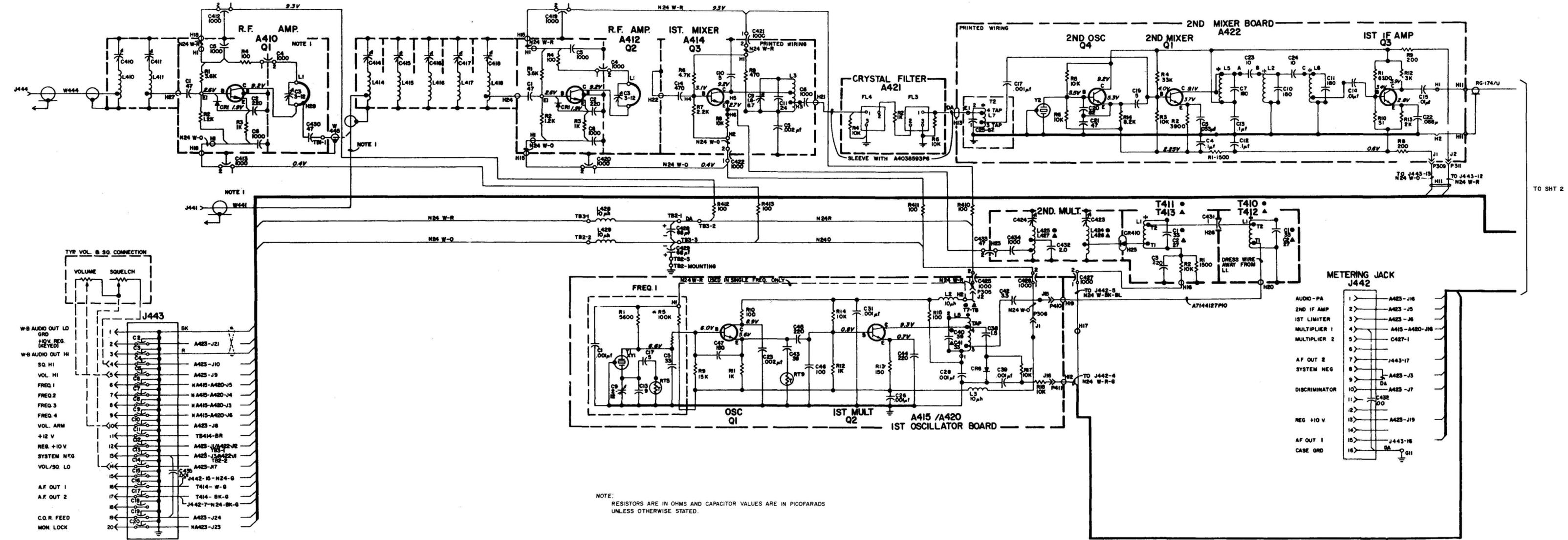


Fig. 4—Echo-Fox Receiver—Schematic Diagram (Sheet 1 of 2)

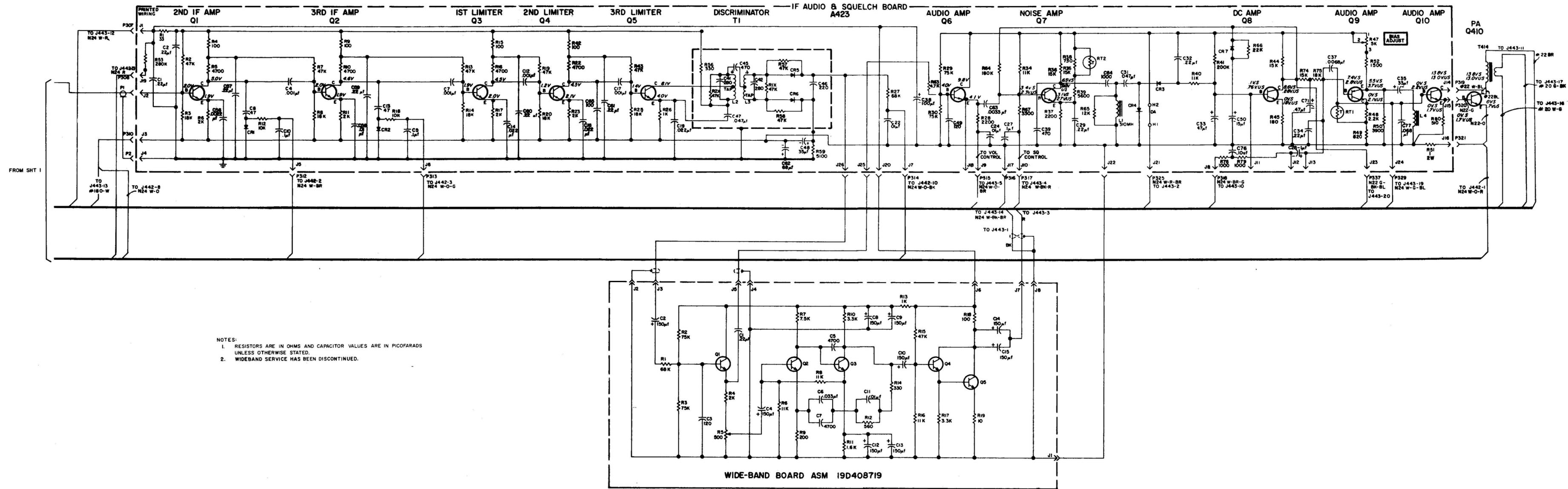


Fig. 4—Echo-Fox Receiver—Schematic Diagram (Sheet 2 of 2)