

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

BASE TRANSMITTER GE-MASTR PROGRESS LINE

CONTENTS	PAGE	CONTENTS	PAGE
1. GENERAL	2	LOW-VOLTAGE SUPPLY	11
2. PHYSICAL DESCRIPTION	2	—45 VOLT BIAS SUPPLY	11
3. FUNCTIONAL DESCRIPTION	2	REGULATED —20 VOLT SUPPLY	12
GENERAL	2	REGULATED 13.4-VOLT SUPPLY	12
TRANSMITTER-EXCITER	6	REGULATED +10 VOLT SUPPLY	12
POWER AMPLIFIER	6	VOLTAGE SUPPLY RELAY K501	13
POWER SUPPLIES	6	ANTENNA RELAY K502	13
AUDIO CONTROL UNITS	7	MICROPHONE INPUT CIRCUIT	13
METERING CIRCUIT	8	AUDIO LINE MATCHING TRANSFORMER	13
DIPLEXER	8	MAINTENANCE CONSIDERATIONS	13
ANTENNA	8	7. POWER AMPLIFIER POWER SUPPLY	13
DUMMY LOAD	8	GENERAL	13
STATION GUARDIAN	9	POWER CIRCUITS	13
4. TRANSMITTER-EXCITER	9	CONTROL CIRCUITS	14
5. POWER AMPLIFIER	11	INDICATORS	15
6. STATION POWER SUPPLY	11	METERING	15
GENERAL	11	8. AUDIO CONTROL UNITS	15
HIGH-VOLTAGE SUPPLY	11	VOICE FREQUENCY CONTROL UNIT	15

CONTENTS	PAGE
-----------------	-------------

WIDEBAND AUDIO CONTROL UNIT	15
------------------------------------	-----------

1. GENERAL

1.01 This section describes the base station transmitter of an Echo-Fox system. The Echo-Fox system supplies voice information.

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

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 single rack for auxiliary equipment. The modifications to the transmitter involve two modulators: one for narrowband and one for wideband, formerly available through switching. The radio transmitter maintains a constant 30-kHz bandwidth. The station is remotely controlled from a centrally located network control office. This section supercedes Section 406-199-501. Refer to Section 406-116-100 for a description of the overall system operation.

1.03 The cabinet houses a receiver, a transmitter-exciter, and power amplifier (PA), and associated power supplies, and wideband and narrowband control units (Fig. 1 and 2). The transmitter provides a 200-watt FM signal on a single frequency in the UHF spectrum between 406 and 420 MHz. One power supply provides operating voltages for the solid-state circuits in the receiver and the solid-state and vacuum-tube circuits in the exciter. Another power supply provides filament, screen, and plate voltages for the tube in the power amplifier. The audio control units couple the wideband or narrowband signal from the telephone circuit to the transmitter and connect the output of the receiver to the telephone circuit.

1.04 Auxiliary equipment (Fig. 3) consists of an antenna diplexer, a dummy load, a Station Guardian unit, an 806A3 data auxiliary set, and a loopback converter. The diplexer permits simultaneous operation of the receiver and transmitter on one antenna. The dummy load substitutes for the antenna when certain tests are performed. Forward

and reflected power are indicated by the Station Guardian. The data auxiliary set turns on the loopback converter when a signal is received from the network office. The loopback converter converts the transmitted signal to the frequency of the receiver so that the control office or the customer operating location can remotely check the base station operation.

2. PHYSICAL DESCRIPTION

2.01 The transmitter is housed with the other station units in a station cabinet shown in Fig. 1 and 2. Units are mounted on standard 19-inch relay racks. Cooling is provided by a blower for the entire cabinet, a fan for the transmitter-exciter, and a blower for the power amplifier tube. The station 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.

2.02 The auxiliary equipment is mounted in a 7-foot by 23-inch rack (Fig. 3). The Station Guardian indicates transmitter operation. The station jack field consists of a single strip of jacks and lamps, providing normalled connections to the station wideband and narrowband input and output circuits. The jack field has a -48 volt test jack and lamps to indicate modes of station operation.

3. FUNCTIONAL DESCRIPTION**GENERAL**

3.01 The RF signals are received and transmitted through a common diplexer (Fig. 4), feedline, and antenna system. The diplexer permits receiver and transmitter simultaneous 2-way operation without mutual interference.

3.02 The transmitter-exciter is a single-channel, crystal-controlled unit employing phase modulation for voice-frequency operation. A station power amplifier boosts the exciter output to a final output power of approximately 200 watts. The transmitter may be operated without the power amplifier to supply 60 watts RF input to the antenna in the event the power amplifier fails.

3.03 A Station Guardian monitors the forward and reflected power in the feedline to the diplexer and antenna.

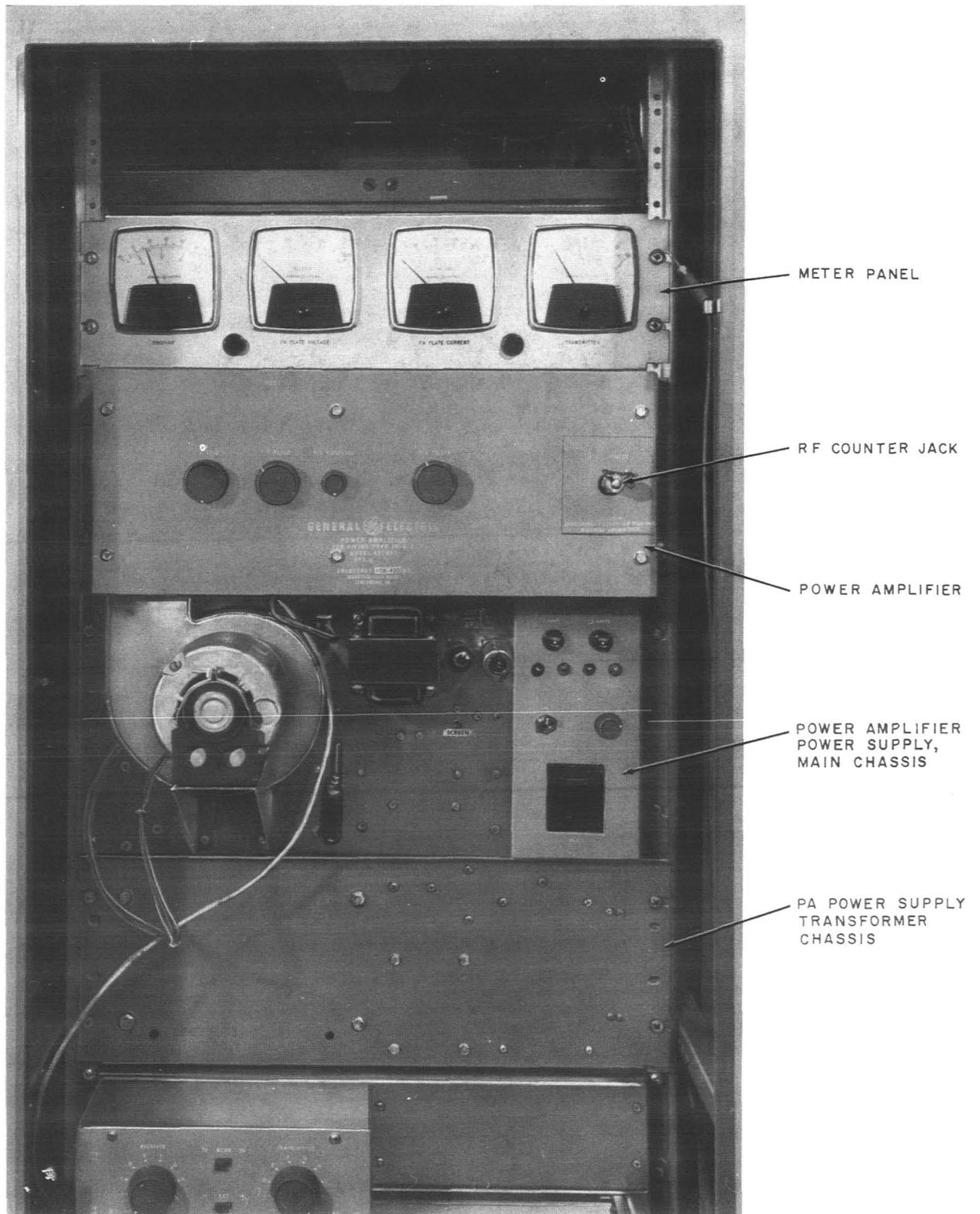


Fig. 1—Station Cabinet—Front View—Top Half

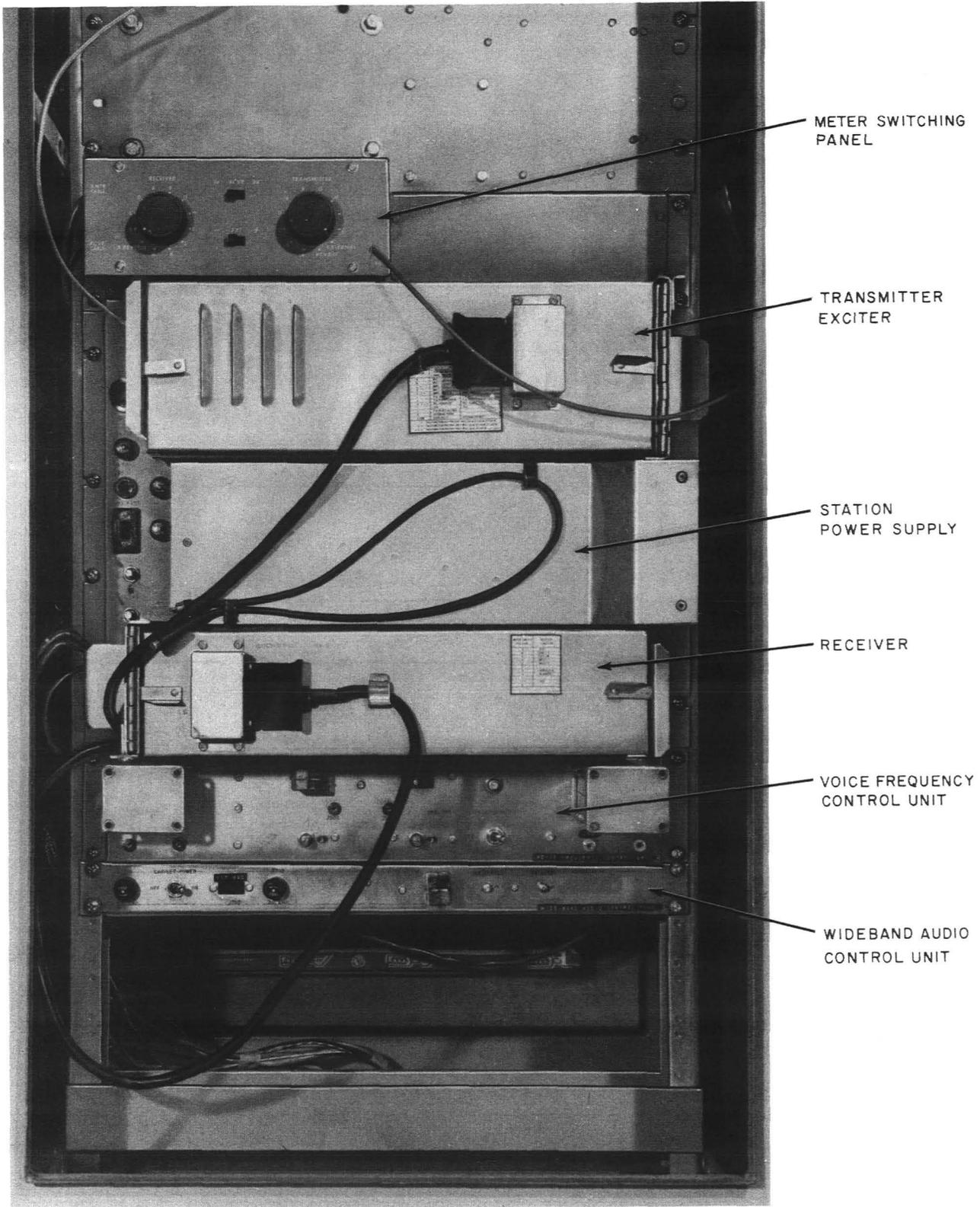


Fig. 2—Station Cabinet—Front View—Lower Half

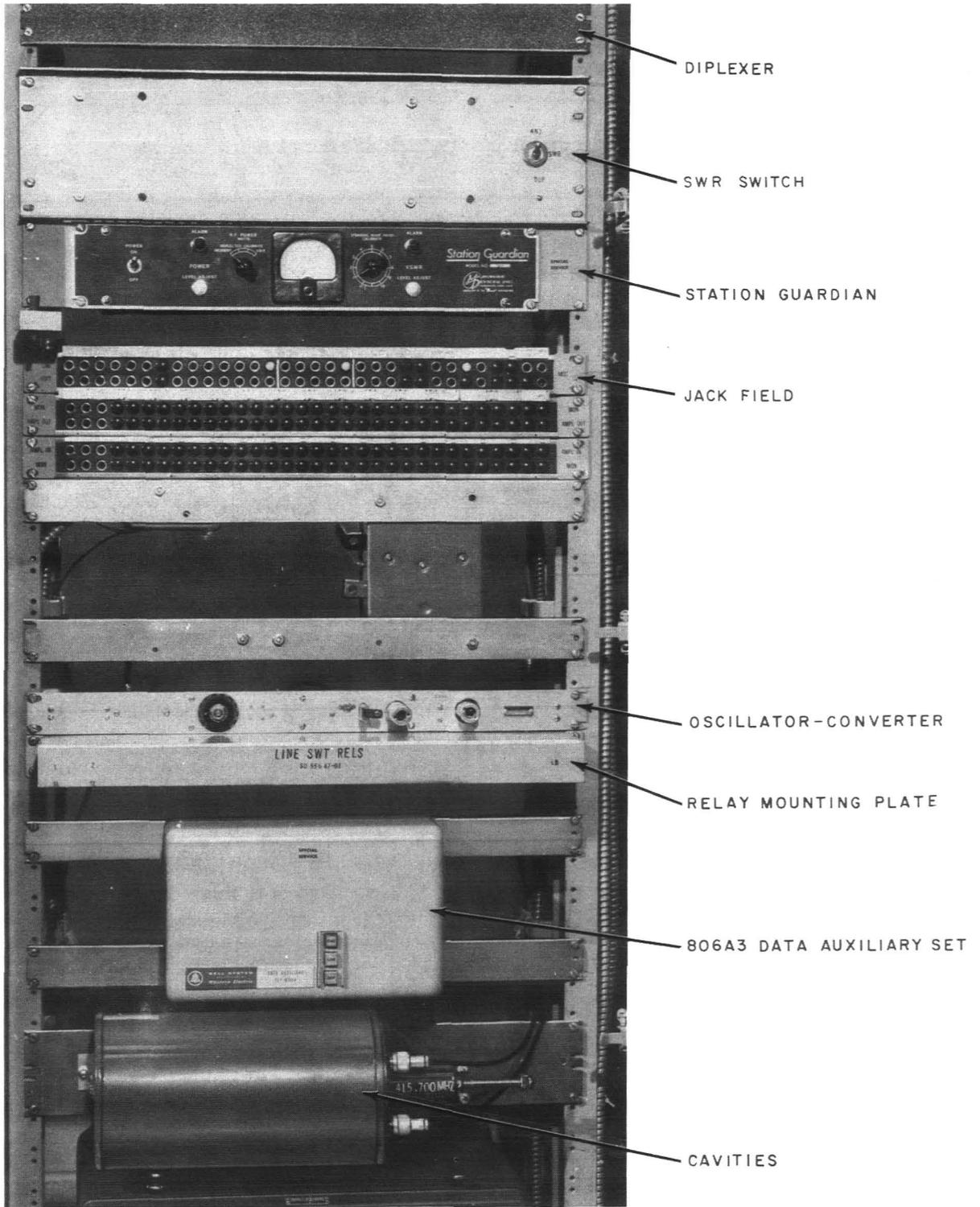


Fig. 3—Auxiliary Bay—Front View

TRANSMITTER-EXCITER

3.04 The transmitter-exciter employs 12 transistors and 3 vacuum tubes. The basic crystal-controlled oscillator frequency ranges from 11.25 to 11.67 MHz. Succeeding stages multiply the oscillator frequency 36 times to produce a final output signal in the region of 406 to 420 MHz.

3.05 The exciter (Fig. 5) consists of a wideband modulator board and an exciter board containing solid-state circuits plus a vacuum-tube doubler, intermediate and amplifier stages, and a varactor-tripler circuit.

3.06 When the exciter was operating in the wideband mode, relay K1 (Fig. 5) was energized. Contacts on the relay shorted the narrowband input circuit to ground and applied wideband data information to the wideband modulator board. When the relay was de-energized, wideband information was shorted to ground, and narrowband signals were applied directly to the exciter board. Normal operation is now voice mode only.

3.07 On the exciter board, the modulated signal is amplified and multiplied. The oscillator output is tripled in frequency in the first multiplier and doubled in the second multiplier. The output of the exciter board is doubled in a vacuum-tube third multiplier and tripled in a varactor-tripler, completing the 36-multiplication factor. The signal is now in the 406- to 420-MHz band. It is this signal that is applied to the power amplifier for further amplification before proceeding to the antenna system through the diplexer.

POWER AMPLIFIER

3.08 The power amplifier (Fig. 6) employs a 4CX300A ceramic planar tetrode electron tube. A blower on the power amplifier power supply furnishes forced-air cooling for the tube. A power amplifier power supply provides operating voltages.

3.09 The power amplifier tuning controls most frequently used are located on the front panel of the unit. These are the grid and plate tuning controls, the coupling control, and the filter tuning control. The neutralizing control is mounted in a well in the top cover. High voltage is brought to the plate circuit through a terminal on the rear of the unit. Two cables, one carrying the lower

dc voltage from the power amplifier power supply and the other carrying the RF excitation from the exciter, enter the power amplifier unit through the bottom cover.

POWER SUPPLIES

3.10 Two power supplies are required for operation of the transmitter. The station power supply provides voltages for the transmitter-exciter and receiver, and a control section to coordinate transmitter and receiver functions. A separate power supply furnishes the high and low voltages, controls, and clamping circuits for the power amplifier.

A. Station Power Supply

3.11 The station power supply (Fig. 7) is rack-mounted in the station cabinet with the transmitter-exciter and the receiver affixed to the front side of the unit. A fan on the front panel cools the exciter and regulator transistor.

3.12 When power supply ON-OFF switch S501 is set to ON, 117 Vac is applied to the primary of transformer T501. This voltage is also applied to blower B501 if thermostat S502 is closed or if voltage relay K501 is energized. The voltage relay is energized by the push-to-talk switch on the exciter or by the remote control relay in the voice-frequency (VF) control unit.

3.13 Transformer T501 has four secondary windings associated with four separate power supply circuits. The high-voltage supply and low-voltage supply are connected in series by contacts of voltage relay K501. In the normal Echo-Fox application, the high-voltage supply is disabled by removing fuse F502. This arrangement applies the output voltage (300 Vdc) of the low-voltage supply to the high-voltage output terminal and the low-voltage output terminal of the station power supply.

3.14 In normal operation, when the transmitter-exciter is driving the power amplifier, 300 volts is sufficient to produce the required driving power. In an emergency, when the power amplifier is out of service, the transmitter-exciter output can be increased to 60 watts and applied directly to the diplexer. For this mode of operation, fuse F502 is inserted in the holder. This action turns on the high-voltage supply which adds 365 volts to the output of the low-voltage supply and thus

provides 665 volts for the final stage of the transmitter-exciter.

3.15 The -45 volt bias supply furnishes grid bias for the tube circuits in the exciter and provides an input voltage for the -20 volt regulator. The regulator supplies a constant -20 volts for the transistor circuits in the exciter.

3.16 The $+13.4$ volt supply provides an input voltage for the $+13.4$ volt regulator that drives the $+10$ volt regulator. The $+13.4$ volt output is used for filament voltage in the exciter, for the audio output stage in the receiver, and for the carrier-operated relay circuit in the wideband audio control circuit. The $+10$ volt output is used in the receiver and as an audio gate voltage in the control section of the station power supply. In the latter application, the $+10$ volt output is applied as back bias to a diode in the control section and to normally open contacts of a relay located in the VF control unit. The diode blocks the path of the VF input until the relay is energized, thus forward-biasing the diode. The relay is energized by the control office and is not connected to the PTT switch on the exciter. Therefore, in local base station tests requiring modulation, the VF control unit relay must be energized. This is normally done by applying -48 volts to the TC1 EQPT jack on the station jack field.

3.17 Another pair of contacts on the VF control unit relay energizes voltage relay K501 in the control section of the station power supply. The PTT switch is in parallel with these contacts. Thus, operation of relay K501 is controlled by both the remote control office and the local PTT switch. Operation of relay K501 turns on the power supply blower and applies low-voltage and high-voltage outputs to the exciter.

3.18 In addition to the audio gate circuit and relay K501, the control section of the station power supply also includes an audio line transformer and volume and squelch controls for the receiver.

B. Power Amplifier Power Supply

3.19 The power amplifier power supply (Fig. 8) is composed of a high-voltage supply, a low-voltage supply, and overload and clamping circuits for the power amplifier tube.

3.20 The control switch energizes the low-voltage supply, which provides filament voltage for the PA tube and operating voltage for the overload circuit. The filament voltage is applied to a regulator, which provides a constant 6 volts dc for the tube.

3.21 The overload circuit controls the grid drive relay which must be energized before the high-voltage supply can be turned on. The grid drive relay cannot be energized unless the PA tube is drawing current. This ensures the presence of self-bias prior to the application of plate voltage. The overload circuit also monitors plate current. If the plate current exceeds 375 mA, the grid drive relay is de-energized and plate voltage is removed.

3.22 The plate switch energizes the high-voltage supply through contacts of the plate relay which also controls the blower. The high-voltage supply furnishes a plate voltage of 2000 Vdc and a screen voltage of 300 Vdc. The screen voltage is applied to a clamping circuit which reduces screen voltage if grid current is not present.

C. Power Supply Control Circuits

3.23 A schematic diagram of the power supply control circuits is shown in Fig. 9. All contacts of switches and relays are shown in the normal de-energized position.

AUDIO CONTROL UNITS

A. Voice-Frequency Control Unit

3.24 The voice-frequency control unit (Fig. 10) provides a 600-ohm output circuit for external connections from the station receiver and a 600-ohm input circuit for external connections to the station transmitter. The control unit contains a relay to permit remote control of the station transmitter keying function.

3.25 The incoming audio for transmission is coupled through transformer T501 and potentiometer R501 to the station power supply before it is applied to the exciter. Potentiometer R501 adjusts the audio level to the transmitter audio circuits.

3.26 Transmitter-exciter control relay K502 performs two operations. When 48 Vdc is applied to the coil, one set of relay contacts energizes voltage relay K501 in the station power supply, which turns

on the exciter. Another set of contacts on relay K502 in the VF control unit applies +10 volts to the audio gate in the station power supply, applying the VF modulating signal to the exciter audio input.

B. Wideband Audio Control Unit

3.27 The wideband audio control unit (Fig. 11) coupled data information from associated equipment to the special wideband input circuits in the transmitter and coupled wideband output from the station receiver to the associated data equipment.

3.28 Primary power for the power amplifier power supply and the station power supply passes through the wideband audio control unit. The terms "unreg" and "reg" are used to match the designations of the manufacturer; however, the only difference in this application is the use of fuse F701 in the "reg" circuit.

METERING CIRCUIT

3.29 The meter switching panel (Fig. 12) connects meters to test points in the various stages of the receiver and exciter. The voltage at each test point is indicated on one of the meters in the meter panel near the top of the control cabinet.

3.30 The meter switching panel includes the following: plug P1001 which plugs into the transmitter centralized metering jack J101; plug P1002 which plugs into the receiver centralized metering jack J1002; test probe P1003 which permits measurement of power amplifier grid or screen voltage; switch S1001 which switches exciter voltage test points into the test meter circuit; switch S1002 which switches receiver voltage test points into the test meter circuit; switch S1003 which changes the voltage scale of the receiver meter; and switch S1004 which reverses test probe polarity.

3.31 The station meter panel is located near the top of the station cabinet. This panel contains: meter M901 which indicates test voltages in the exciter circuits; meter M902 which indicates test voltages in the receiver circuits; meter M903 which indicates the power amplifier plate current; and meter M904 which indicates the power amplifier plate voltage.

DIPLEXER

3.32 The diplexer (Fig. 13) permits both the transmitter and the receiver to be used on the same antenna with a minimum of mutual reaction. This unit consists of six cavities: two in the transmitter side and four in the receiver side. One bandpass and one reject cavity are used on the transmitter side. Two bandpass and two reject cavities are used on the receiver side. Aperture coupling throughout eliminates the many cables and connectors normally required for multicavity diplexers. The diplexer is mounted near the top of the auxiliary rack.

ANTENNA

3.33 Two types of omnidirectional antennas are used in the Echo-Fox radio system: a discone type at some stations and a collinear gain type at others. Both types are vertically polarized, have a 50-ohm impedance, and have a maximum voltage standing wave ratio (VSWR) of 1.5:1 over the system frequency range. Both antennas are intended to be gas pressurized.

3.34 The collinear gain antenna consists of phased elements stacked vertically in a fiberglass tube. The gain of the array is 7.8 dB over a reference dipole. The major lobe of the antenna is 6 degrees above the horizontal with a half-power point along the horizontal. This type of antenna presents a short circuit to an ohmmeter test.

3.35 The discone antenna consists of two radiating elements, a disc and a cone. The disc is mounted horizontally with the cone mounted vertically below the disc. The apex of the cone and the center of the disc form the feed point of the antenna. In the version used at the Echo-Fox base station, the disc and cone are not solid; they consist of brass rods arranged to simulate the two geometric forms. The discone antenna does not provide gain; however, it does provide a very wide frequency response. This type of antenna presents an open circuit to an ohmmeter test.

DUMMY LOAD

3.36 A dummy load is provided for making measurements on the transmitter and the transmission line to the antenna connector. This unit has an impedance of 50 ohms, a power dissipation of 600 watts continuous at 40° C, and

a maximum VSWR of 1.05:1 over the system frequency range. It is completely shielded to prevent radiation of RF energy during tests.

STATION GUARDIAN

3.37 The Station Guardian unit (Fig. 14) is used to monitor RF output power, reflected power, and the VSWR of the base station transmitting system. Panel lamp indicators are provided for abnormally low output power and excessive VSWR.

3.38 Directional couplers obtain samples of the incident and reflected portions of the transmitter output power. Two probes in each coupler feed a small amount of RF energy from the transmission line to a pair of built-in matched diodes that rectify the radio frequency and apply the resultant dc voltage to the Station Guardian meter and alarm circuits. One directional coupler is installed between the diplexer and the antenna for making antenna VSWR tests. The coupler monitors transmitter output and load impedance. A second directional coupler is located between the transmitter and the diplexer. A manual switch on the front of the dummy load panel switches the Station Guardian to either directional coupler.

3.39 The rectified incident and reflected power samples are fed to the Station Guardian panel meter through the R.F. POWER switch. The meter is calibrated in WATTS and STANDING WAVE RATIO and is used to measure the incident power, reflected power, and VSWR.

3.40 The dc incident and reflected power samples from the directional coupler are also fed to identical dc amplifiers that control relay-operated lamps. When the incident power level is within the normal range, the green POWER OUTPUT lamp is lighted, and when the incident power drops below a previously established level, this lamp is extinguished. When the reflected power is within the normal range, the red VSWR ALARM lamp is extinguished; and when the VSWR rises above a previously established level, VSWR ALARM lamp is lighted. These indications may also be sent to the station alarm circuit. The controls that set the operating level of the alarm relays are accessible through the front panel.

4. TRANSMITTER-EXCITER

4.01 When the unit is operated in the voice mode, the audio input is applied to the audio amplifiers (Q1 and Q2 on the exciter board, Fig. 15) and the audio amplifiers phase modulate the output of the oscillator.

4.02 In the voice mode, voice audio is coupled to the exciter board through capacitor C1 and to the base of class A audio amplifier Q1. Capacitor C45 provides the RF decoupling. The amplified audio signal is coupled to the diode limiters CR1 and CR2. These diodes operate in series and are normally in a forward conducting state. An audio signal, with enough amplitude to cause limiting, takes the diodes out of conduction so that one diode conducts only on positive cycles and the other conducts only on negative cycles. The limiter stage is followed by another class A amplifier Q2. The output of Q2 is coupled through MOD ADJUST potentiometer R12 to a combined post-limiter filter and de-emphasis network. The output of the filter and de-emphasis network is applied directly to the phase modulator.

4.03 The phase modulator consists of varactor diode CV1 (voltage variable capacitor) in series with tunable coil L2. This network appears as a series-resonant circuit to the RF output of the oscillator. An audio signal applied to the modulator varies the bias of CV1, resulting in a phase modulated output. The output of the modulator is coupled through blocking capacitor C14 to the base of the second amplifier.

4.04 The second amplifier (Q3) isolates the modulator from the loading effects of the first multiplier and provides amplification. The output is coupled through transformer T6 to the first multiplier.

4.05 Following amplifier Q3 are two inductively coupled class C common-emitter multiplier stages (Q4 and Q5). Multiplier stage employing transistor Q4 is a tripler. A metering position is derived from the junction of resistors R31 and R42 which terminates at MULT-1 on the centralized metering jack J102.

4.06 The second multiplier stage (Q5) operates as a doubler with collector tank T3 tuned to six times the crystal frequency. Resistors R33 and R40 form a metering voltage divider which

terminates at MULT-2 on the centralized metering jack J102. The output of Q5 is inductively coupled through T3 and T4 to the third amplifier Q6. The third amplifier is neutralized by feedback through C35 from the output link on T5. This stage is metered at J102-3 across resistor R37. The output is coupled to the grid tank of multiplier tube V101.

4.07 The output of the transistorized exciter is coupled by a short length of RF cable to the grid tank (Z101) of a beam pentode. This stage, including V101, operates as a doubler with the plate tank tuned to twelve times the crystal frequency.

4.08 Bias voltage (approximately -18 volts) is supplied to the grid of V101 through resistor R108 to protect the tube against excessive current caused by loss of drive voltage. A residual voltage of approximately 0.18 volt appears on the grid of V101 with no drive present. A metering network (R105 and R106) is connected to GRD (J102-16) to provide grid voltage metering. Plate voltage is supplied through choke L105.

4.09 The output of the MULT-3 stage drives the intermediate power amplifier (IPA), a compactron beam power amplifier. Coupling is provided by a pi network consisting of C104, L102, and C108. Approximately 45 volts of bias is supplied to the grid of V102 through resistor R112 and a tap on L102 to protect the tube against loss of drive. A residual voltage of 0.28 volt without any drive to the stage indicates the presence of fixed bias. Grid voltage and the tripler-varactor voltage are metered simultaneously at MULT-4, J102-5. Neutralization is accomplished by C110. The plate tank is tuned by C115 and plate voltage is supplied through L105.

4.10 The RF from the IPA is coupled through C118 to a positive tripler stage. The tripler consists of three tuned stages (C115/L107, C121/L110, and C122/L112) which are coupled together through the common impedance of varactor CV101. The output from the IPA is coupled to the tripler where the first tuned circuit resonates at the fundamental frequency. The second tuned circuit (an idler circuit) is tuned to twice the input signal and mixes with the input signal to produce the desired third harmonic or operating frequency. The third tuned circuit is tuned to the operating frequency.

4.11 Drive from the tripler stage is link-coupled to the grid circuit of V103, the power amplifier of the exciter through L115 and L116. Vacuum tube V103 is a coaxial element, conduction-cooled, beam power tetrode operating as a neutralized class C amplifier. The grid line L127 of V103 is series tuned by C130 with 20 volts of protective bias supplied through L117 and grid bias resistors R103 and R129. Grid current for the exciter power amplifier is metered across resistor R103 at J102-6 (PA GRID) and J102-14 (PA GRID+). Neutralization is provided by a fixed series screen inductance (the fingers on the screen bypass ring) and the screen bypass capacitors C135, C136, C138, and C140.

4.12 The plate tank circuit is made up of C145 (the plate tank tuning flap), L119 (the copper-plated heat sink on the plate of V103), and mechanically constructed capacitor C143. The plate voltage is supplied through choke L122, which is connected to feed-through capacitor C142. The screen voltage is controlled by OUTPUT CONTROL potentiometer R124, which is part of a voltage divider R126, R124, and R125 between J101-4 (+300V) and ground. With the OUTPUT CONTROL fully counterclockwise, the plate dissipation of V103 is reduced below the rated tube limit for tuning purposes. Plate current is metered from J102-1 (PLATE+) to J102-9 (PLATE-) across metering resistors R101 and R102.

4.13 The output of V103 is link-coupled to bandpass filter FL101 consisting of two inductively coupled helical resonators. Capacitors C1 and C3 are the output tuning capacitors. Inductor L6 and capacitor C6 form an additional low-pass filter section. The RF output is fed through J103 to the power amplifier located in another chassis.

4.14 An RF sniffer circuit (CR1, C7, and R1) measures the relative power output at J102-11 (REL PO). When troubleshooting the transmitter, components of the low-pass filter and RF sniffer circuit can be checked by removing the plate on the bottom of the filter casing.

4.15 Adjusting the PA COUPLING control varies the coupling from the plate to the output by controlling the amount of magnetic flux linking the plate line to the filter line. Loop L483 couples energy from the PA FILTER cavity to J481. The signal from J481 is connected to the antenna system through P1 and the reflectometer. The reflectometer

has a limited use in this application since the Station Guardian performs the same function.

5. POWER AMPLIFIER

5.01 The power amplifier develops an RF carrier of 200 watts in the 406- to 420-MHz spectrum. The amplifier employs a 4CX300A ceramic planar tetrode electron tube. A blower on the power amplifier power supply provides forced-air cooling for the tube. The tuning controls most frequently used are located on the front panel of the unit. All power connections, except the high-voltage connection, are made with a 6-pin plug from the front of the unit. High voltage is brought to the plate at the rear of the plate compartment.

5.02 Excitation to the power amplifier at P482 (Fig. 16) is fed to coupling loop L482 and coupled to coil L484 which with C481 forms the grid tank of the amplifier. The grid tank is tuned to the operating frequency by adjusting PA GRID control C481. Capacitors C482, C483, and C484 are RF bypass capacitors. Resistor R481 is a screen RF decoupling resistor. Coil L481 isolates RF from the power cable. A ring-type capacitor is built into the tube socket. This capacitance bypasses the screen grid.

5.03 All voltage connections to the power amplifier, except the B-plus, are made at P481 on the front of the panel. The 2000-volt B-plus lead is connected at terminal PO-2 located in the rear on the plate cavity cover. Capacitors C492 and C493 provide bypassing for the B-plus and L485 is an RF choke. The plate tank is composed of capacitor C488 and the transmission line section formed by the inner and outer boxes of the plate cavity. The plate tank is tuned to the operating frequency by adjusting the PA PLATE control C488. Capacitor C488 is formed by a flat ring around the tube and by the tube plate.

6. STATION POWER SUPPLY

GENERAL

6.01 The station power supply furnishes power for the transmitter-exciter and receiver. The transmitter-exciter and receiver units are mounted on the front side of the station power supply panel. Power supply components are located on the rear of the supply. A fan on the front

panel provides air cooling for the exciter and the heavy duty regulator transistors.

6.02 External power, 117 volts 60 hertz, from TB502-14 and -15 (Fig. 17) enters the power supply through switch S501 and is applied to the primary of transformer T501. Fuse F501 protects the power supply against overloads. The power transformer secondary consists of four separate windings which supply ac for the high and low B-plus supplies and bias and regulated supplies.

HIGH-VOLTAGE SUPPLY

6.03 The ac voltage developed across the high-voltage secondary winding (green-white and green) is rectified by the bridge circuit silicon rectifiers CR1, CR2, CR3, and CR4. The rectified voltage is filtered by the pi filter consisting of choke L501 and capacitors C501, C502, C503, and C504. The high-voltage supply, utilizing the entire secondary winding as described, develops an output of 350 volts. This supply is stacked or placed in series with the low-voltage supply. The result is a nominal 650-volt output.

6.04 Silicon rectifier CR519 is a protective device for the electrolytic filter capacitors. If fuse F502 should blow, reverse voltage across C501, C502, C503, and C504 will be shorted by CR519, preventing damage to the capacitors. Resistors R502 and R520 are bleeder resistors. The high-voltage supply furnishes power to the exciter power amplifier.

LOW-VOLTAGE SUPPLY

6.05 The low-voltage supply is almost the same as the high-voltage supply. The main difference is in the amount of voltage supplied by the secondary winding. Similar components perform similar functions in both supplies. The low-voltage supply furnishes power to the exciter multiplier stages.

- 45 VOLT BIAS SUPPLY

6.06 The alternating current developed across the two blue wires (with center tap to ground) of the T501 secondary is rectified by full-wave silicon rectifiers CR9 and CR10. The rectified voltage is filtered by a pi filter consisting of choke L503 and capacitors C506 and C508. Resistor R506

SECTION 406-116-102

functions as a bleeder. This power supply furnishes bias for the exciter power amplifier.

REGULATED -20 VOLT SUPPLY

6.07 The regulated -20 volt supply receives its voltage from the -45 volt bias supply through the normally open contacts of 6R and 7R on relay K501. When the transmitter is keyed, relay K501 energizes and closes contacts 6R and 7R, feeding the -45 volts into regular circuit A504. Voltage dropping resistor R1 provides the negative bias to turn on transistor Q501. Regulator diode VR1 provides a voltage reference for the regulator.

6.08 When the output voltage of the regulated supply attempts to go more negative, the voltage at the base of Q1 also goes more negative. This causes Q1 to conduct more heavily. When Q1 conducts, there is less base bias on Q501 and less base current. With less base current, the voltage drop across Q501 is larger and the output voltage drops to the point where the circuits are balanced. The supply voltage therefore remains constant. The opposite takes place when the output voltage tends to go less negative.

6.09 Capacitor C512 prevents high-frequency oscillation and also helps to filter the input voltage. Resistor R2 supplies the voltage to operate regulator diode VR1. Resistors R3 and R4 form a voltage divider that can be varied by potentiometer R3 to adjust the base voltage of Q1. By adjusting R3, the output voltage of the supply may be set to exactly -20 volts. The output is measured between jacks J1 and J2 on the regulator board. This power supply furnishes regulated -20 volts for the exciter board.

REGULATED 13.4-VOLT SUPPLY

6.10 The ac voltage developed across the secondary winding of T501, identified by the two brown wires, is rectified by a full-wave rectifier circuit CR515 and CR516. The rectified output is filtered by choke L504 and capacitors C509 and C510. The output of the filter circuit is applied to the emitters of Q502 and Q505 through voltage dropping diode CR517. When the output of Q502 and Q505 begins to rise, the base of Q3 is made more positive. The increase in current flow through R2 and R7 decreases the positive voltage at the base of driver transistor Q504. Driver transistor Q504 then conducts more heavily causing a greater voltage

drop across R508. The bases of Q502 and Q505 become more positive tending to cut off Q502 and Q505. This action keeps the voltage at the output at the regulated level. Resistors R522 and R523 equalize the current through Q502 and Q505.

6.11 When the output of Q502 and Q505 begins to drop, Q3 conducts less, decreasing the forward bias on Q504 and reducing the voltage drop across R508. This causes Q502 and Q505 to conduct more heavily and hold the output voltage constant. Regulator diode VR2 provides a voltage reference for regulator transistor Q3.

6.12 The output voltage is adjusted by potentiometer R6. The output is measured at jacks J1 and J2 on the regulator board A503. The regulated 13.4-volt supply furnishes voltage for heaters, receiver audio, relays, and lamps.

REGULATED +10 VOLT SUPPLY

6.13 The input to the 10-volt regulator board A502 is taken from the 13.4-regulated supply. The output is regulated by transistor Q503. When the output voltage starts to increase, the voltage at the base of Q5 also increases. The emitter of Q5 is held constant by regulator diode VR4 so that the emitter-base voltage increases. This causes Q5 to conduct more heavily which means less base current for Q503. The voltage drop across Q503 becomes larger and the output voltage drops to the regulated level.

6.14 When the input voltage starts to drop, the output voltage also tends to drop and Q5 conducts less. This increases the forward bias on Q503 and reduces the voltage drop across Q503 to keep the output constant.

6.15 Diode CR2 gives reverse polarity protection to the supply. Potentiometer R11 sets the emitter-base voltage of Q5 for the desired 10-volt output. Resistors R8 and R10 limit the maximum current through Q5. Resistor R9 provides bias current for regulator diode VR4 and lamp DS1 supplies bias for Q503. Capacitors C4 and C5 prevent high-frequency oscillation. There are no test jacks on the board. The output may be checked at TB501-7 and -12.

VOLTAGE SUPPLY RELAY K501

6.16 When the transmitter is keyed, relay K501 is energized and the following connections are made:

- (a) High voltage is stacked on the low voltage (3L, 4L, 5L, 6L)
- (b) Low voltage is supplied to the transmitter (1L, 2L)
- (c) The blower is energized (7L, 8L)
- (d) The red transmitter pilot lamp is lighted by 13 volts applied to TB501-15 (8R, 9R).

Continuous power is supplied to the exciter oscillator with contacts 6R and 7R strapped.

ANTENNA RELAY K502

6.17 Antenna relay K502 is not used in Echo-Fox system.

MICROPHONE INPUT CIRCUIT

6.18 Microphone input jack J902 isolates the high-impedance microphone and the control panel. Diode CR518 is back-biased in series with the audio input from the control panel. A 9-volt drop across R517 provides +1 volt with respect to ground at the cathode of CR518 which reverse-biases the diode. The microphone is then loaded only by the transmitter and R518 (both are relatively high impedances).

6.19 The control unit, attached to TB502-12 and -13, supplies (when keyed) +10 volts which is divided by voltage divider R515 and R516 producing 4.5 volts on the anode of the diode. The diode is forward-biased and thus allows audio from the control unit to modulate the transmitter. A network (C513, R515, and R516) equalizes the high-frequency response when the control panel is the audio source.

AUDIO LINE MATCHING TRANSFORMER

6.20 Line matching transformer T502 matches the receiver output to a 600-ohm telephone in remote control installations. The 100-ohm impedance between the RG and BL leads of the secondary is built out to 600 ohms by resistors R509 and R510. One watt delivered to the 3.5-ohm

primary of T503 applies +18 dBm to the telephone line pair.

MAINTENANCE CONSIDERATIONS

6.21 A 26-inch transmitter test cable is clipped to the outside of the fan ventilating cover on the front side of the power supply so the transmitter can be swung out for servicing.

7. POWER AMPLIFIER POWER SUPPLY**GENERAL**

7.01 The power amplifier power supply furnishes filament, grid, and high voltage to the power amplifier. It consists of a main chassis and a transformer chassis mounted separately in the station cabinet. The overall height of the two panels is 15-3/4 inches. A blower for cooling the power amplifier tube is mounted on the front of the power supply.

7.02 The power supply output is connected to the power amplifier through a jack with the high-voltage connection made through the metering circuit. Jacks are provided on the main chassis front panel to meter the grid current and filament voltage. A ground jack also appears on the front panel. Voltages are not exposed on the front side of the power supply panels. The rear cabinet door is interlocked for protection against exposure to high voltages. The high-voltage indicator lamp is illuminated when the high voltage supply is on. The lamp is extinguished when the cabinet rear door is opened. The high-voltage capacitor is shorted to ground by a shorting bar when the door is open.

POWER CIRCUITS**A. Filament Supply**

7.03 The filament power circuit supplies a regulated 6 volts dc to the filament of the 4CX300A tube in the power amplifier.

7.04 With CONTROL switch S452 (Fig. 18) in the ON position, power is applied to the primary of filament voltage transformer T451. The output across the two brown secondary wires is rectified by a full-wave rectifier circuit CR453 and CR454. The output is filtered by choke input filter L452 and capacitors C452 and C461. The filter

SECTION 406-116-102

output is applied through voltage dropping diode CR455 to the emitters of transistors Q453 and Q451. If the output of Q453 and Q451 attempts to rise, the base of Q1 is made more positive. This decreases the positive voltage at the base of driver transistor Q452. Transistor Q452 then conducts more heavily causing a greater voltage drop across resistor R455. The bases of Q451 and Q453 become more positive, thereby cutting off Q451 and Q453 and keeping the voltage at output terminal J451-2 regulated at 6 volts (± 5 percent).

7.05 If the output of Q453 and Q451 drops, Q1 conducts less, decreasing the forward bias on Q452 and reducing the voltage drop across R455. This causes Q453 and Q451 to conduct more heavily and hold the output voltage within the ± 5 percent regulated level.

7.06 Potentiometer R4 seldom requires any adjustment. Filament measuring jacks J1 and J2 are provided on the A451 board as an aid to servicing the equipment and are accessible from the rear of the supply.

B. Drive Relay Supply

7.07 A second secondary winding on transformer T451 furnishes voltage for the operation of grid drive relay K454. The circuit is rectified by diode CR452, filtered by capacitor C454, and loaded by resistor R452. The output is unregulated at 8 volts.

C. High-Voltage Plate Supply

7.08 The high-voltage plate supply provides 2000 volts for the power amplifier tube plate circuit. The full-wave bridge rectifier circuit consists of 8 silicon diodes in each leg of the bridge (32 diodes). The diodes are shunted with 1-megohm resistors to equalize the voltage and prevent breakdown. The bridge circuit is connected across the secondary of transformer T452. The rectified output is filtered by choke L451 and capacitor C451. Components R457, R469, C458, and C459 form a ringing suppression circuit. The high-voltage output is taken off at terminal 1 of C451 and is connected to the power amplifier unit through the power amplifier plate current meter.

D. Screen Voltage Supply

7.09 The screen voltage supply provides 300 Vdc for the power amplifier tube screen grids. Screen voltage is obtained through a voltage divider in the plate supply circuit of the high-voltage power supply. The voltage divider network, R460, R461, and R462, also serves as a bleeder. The screen voltage is varied by adjusting SCREEN control potentiometer R461 located on the front of the power supply chassis.

CONTROL CIRCUITS

A. Overload and Overload Hold Circuit

7.10 Silicon controlled rectifier SCR1 is driven by excessive current in the secondary of the high-voltage supply. When SCR1 fires, it shunts the drive to trigger transistor Q1. The SCR remains operated until the drive is removed from the power amplifier.

B. Drive Relay K454

7.11 Drive relay K454 is energized only when adequate current exists in the grid circuit. When K454 is energized, it causes the grid current indicator lamp to light. Other contacts on the relay are connected to circuits that are not used in this application. Transistor Q1 operates the grid drive relay when sufficient self-developed grid bias from the power amplifier tube is present. Grid current can be measured at GRID jack J452 located on the front of the power supply chassis.

C. Screen Clamping Circuit

7.12 Clamper tube V451 is connected to the proper amplifier screen to hold the screen grid at a safe level when the self-developed bias on the power amplifier tube is shut off. With no grid drive present, the clamper conducts, lowering its own plate voltage and the power amplifier screen voltage. This action holds the power amplifier plate current at a safe level. With grid drive present, the clamper cuts off and allows the circuit to rise to its normal level.

D. External Interlock

7.13 Safety interlock switch S902 is mounted on the rear of the equipment cabinet and is connected to TB451-4 and -5 on the power supply

chassis. When the rear door is opened, the interlock switch is opened causing K453 to de-energize. Contacts on K453 open the primary of the plate supply.

E. Plate Relay K453

7.14 When the plate relay K453 is energized, external power is applied to plate transformer T452. Plate relay K453 is connected in series with the contacts on the grid drive relay K454 to allow the proper grid current to develop before the 117 Vac is applied to the primary of T452.

F. Time Delay Relay K456

7.15 Thermal time delay relay K456 is actuated by the 6-volt filament circuit. It provides a 45-second delay before closing a set of contacts in the plate supply. The delay allows sufficient time for the tube filaments to warm up before plate voltage is applied.

INDICATORS

7.16 The following indicator lamps appear on the power amplifier power supply.

- (a) PLATE (I451)—Plate indicator lamp (red) on the main chassis front panel is illuminated when the power amplifier plate high voltage is ON.
- (b) TIME DELAY (I452)—Time delay lamp (amber) on the main chassis front panel is illuminated when time delay relay K456 is energized.
- (c) GRID (I453)—Grid lamp (amber) on the main chassis front panel is illuminated when the proper grid bias is present on the power amplifier tube.
- (d) PLATE (I454)—Plate lamp (red) on the rear of the main chassis is illuminated when the power amplifier plate high voltage is ON.

METERING

7.17 There are two meters associated with the power supply. Both are mounted on the cabinet meter panel. Plate voltage meter M904 is connected to TB451-1 and -2 on the power supply chassis. Resistor R467 is the plate voltage dropping

resistor. Plate current meter M903 is connected in series with the power amplifier and TB451-1 on the power supply chassis.

8. AUDIO CONTROL UNITS

VOICE FREQUENCY CONTROL UNIT

8.01 The voice frequency control unit provides an output circuit for external connections from the station receiver, an input circuit for external connections to the transmitter, and a relay to permit remote control of the station transmitter keying function.

8.02 Incoming audio is applied to the voice frequency control unit across TB522-1 and -2 (Fig. 19). The audio signal is coupled through transformer T501 and resistor R501 to TB522-3 and -4. Resistor R501 provides an adjustment for the audio level to the transmitter audio input circuits.

8.03 The output of the station receiver is coupled through the station power supply (6.20) and through the station harness to TB522-8 and -9. This signal is applied through an audio network, which improves the audio response, and through transformer T502 to TB522-10 and 11. The receive audio level is controlled by VOL control R511 which is located in the station power supply.

8.04 The keying function is controlled by relay K502, which responds to a 48-volt dc keying signal across TB522-12 and -13. Contacts 6 and 7 of the relay complete the transmitter keying circuit and contacts 9 and 10 apply a dc signal to the diode gating circuit in the station power supply (at TB501-7) to complete the audio circuit to the transmitter (6.19).

WIDEBAND AUDIO CONTROL UNIT

8.05 The schematic diagram of the wideband audio control unit is shown in Fig. 20. There are no active circuits within the control unit relative to the transmitter. In this application, only the receive signals are affected; transmit signals are strapped directly through the unit. Fused 117-Vac external power is also connected through the wideband control unit, terminating at TB706. Switch S701 on the control unit must be actuated to deliver primary power to the station and power amplifier supplies.

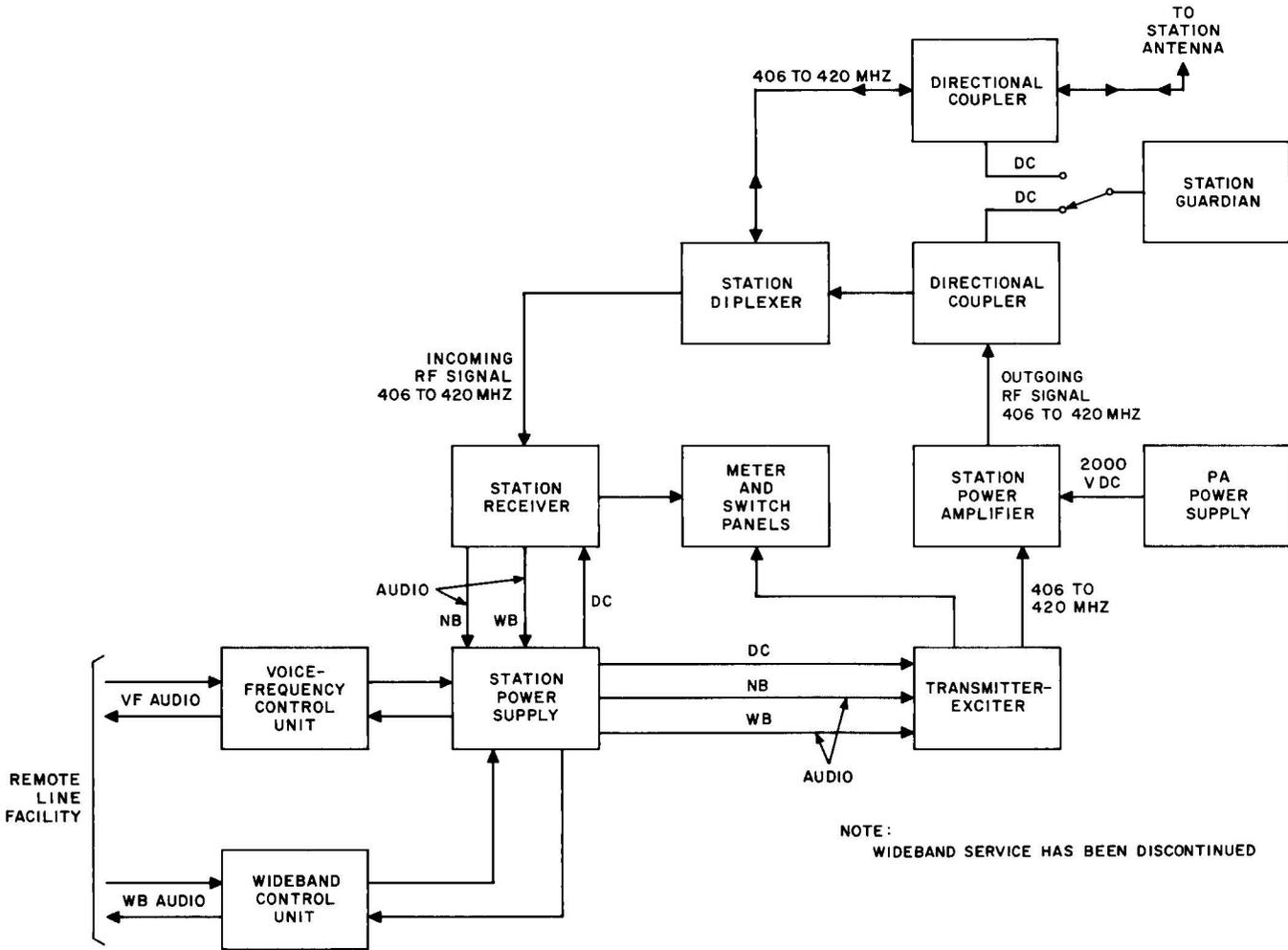


Fig. 4—Base Station—Block Diagram

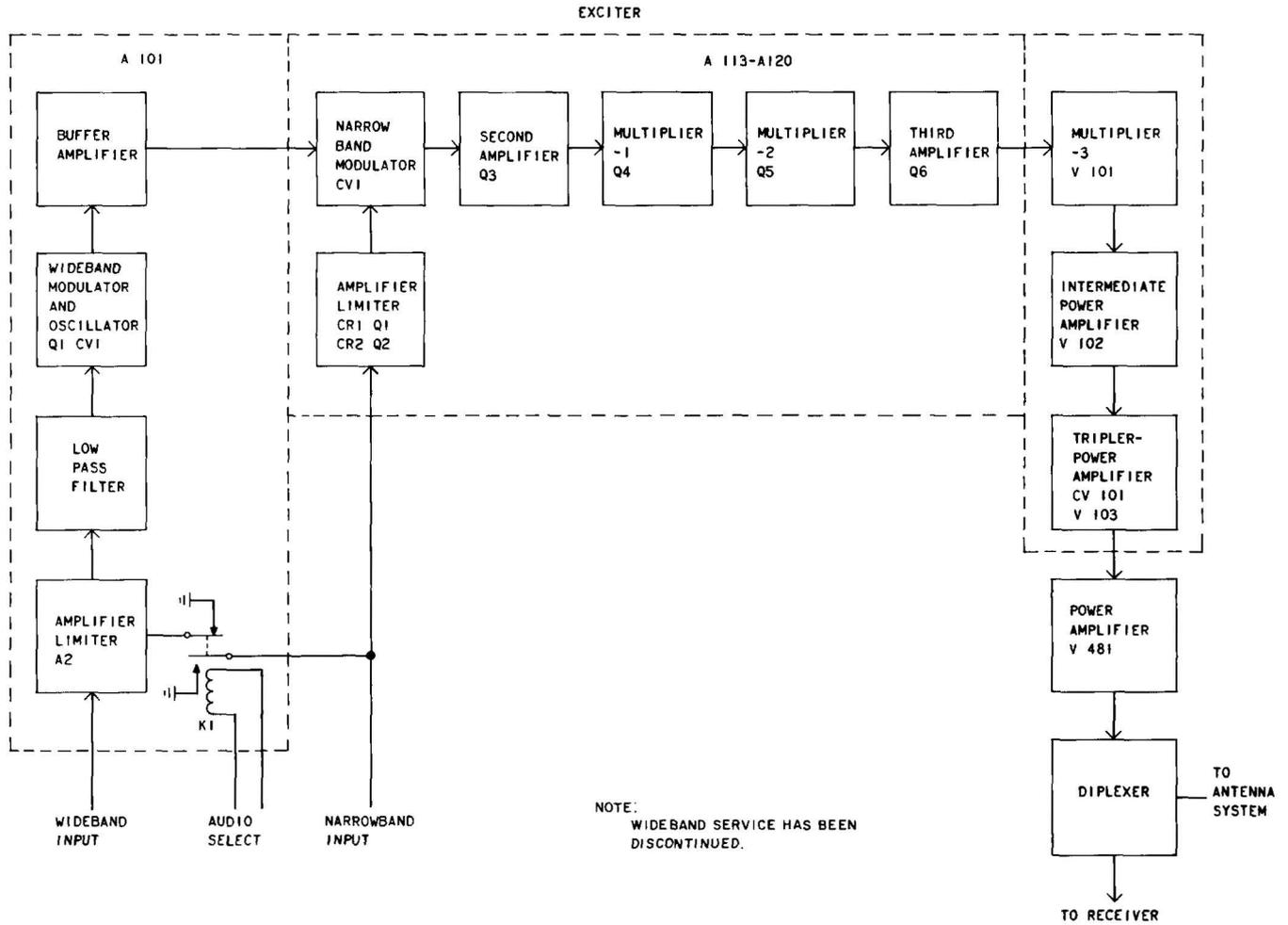


Fig. 5—Transmitter—Block Diagram

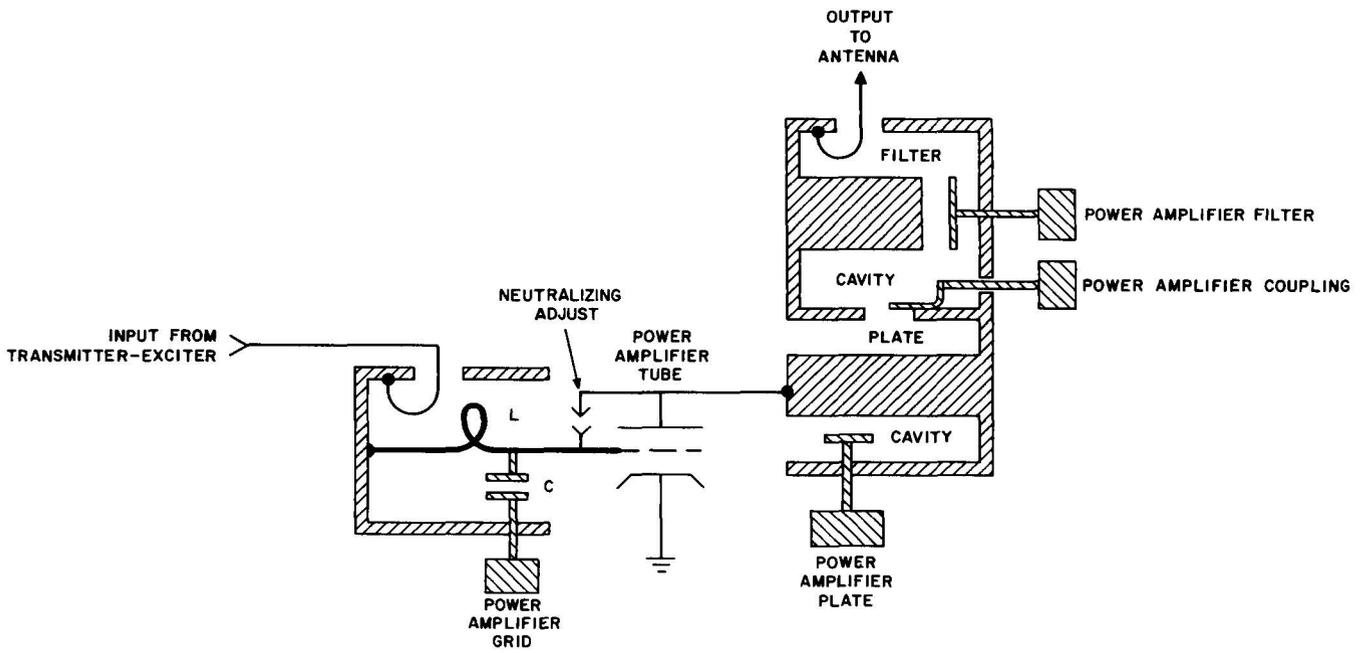


Fig. 6—Power Amplifier—Electromechanical Diagram

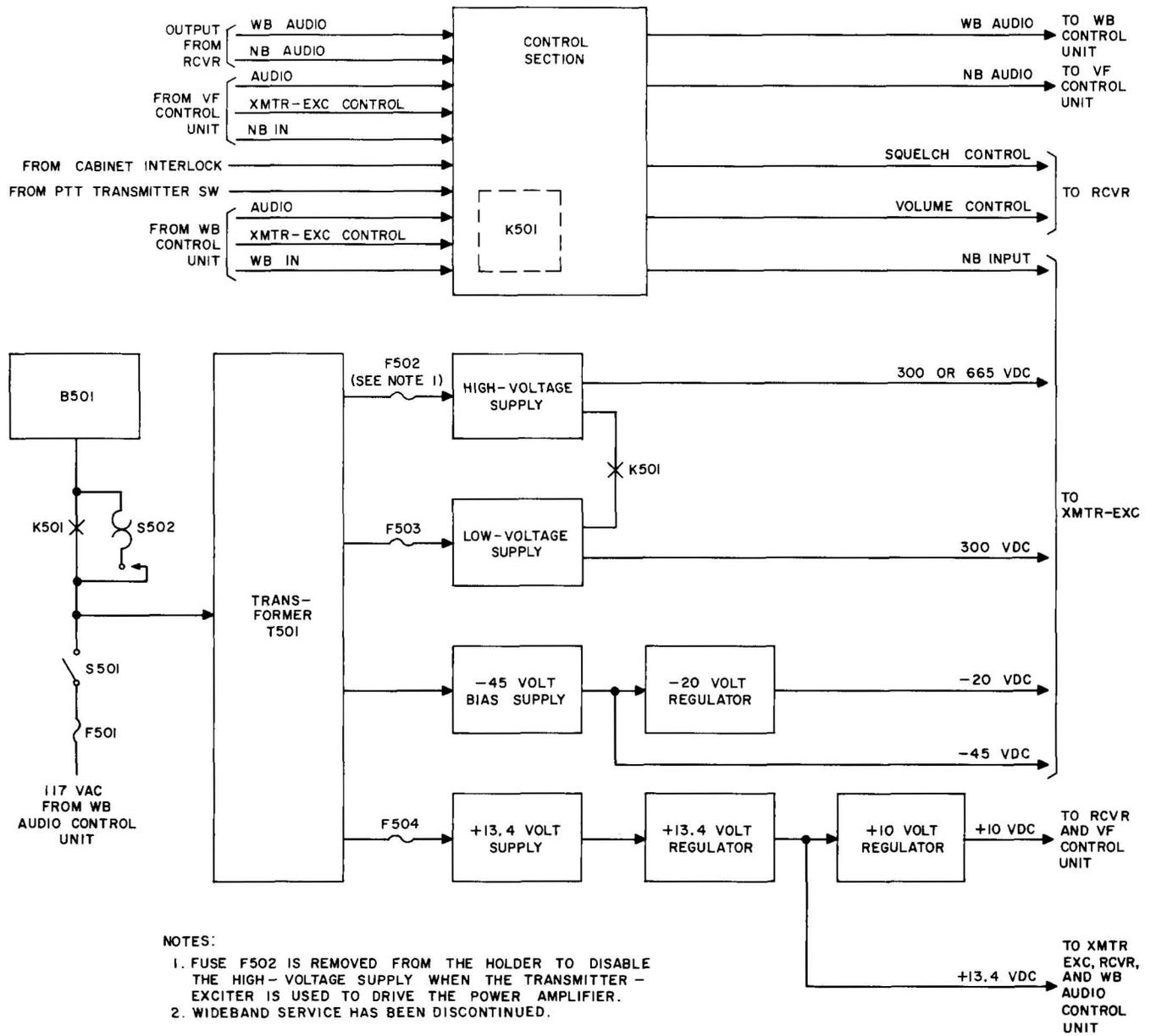


Fig. 7—Station Power Supply—Block Diagram

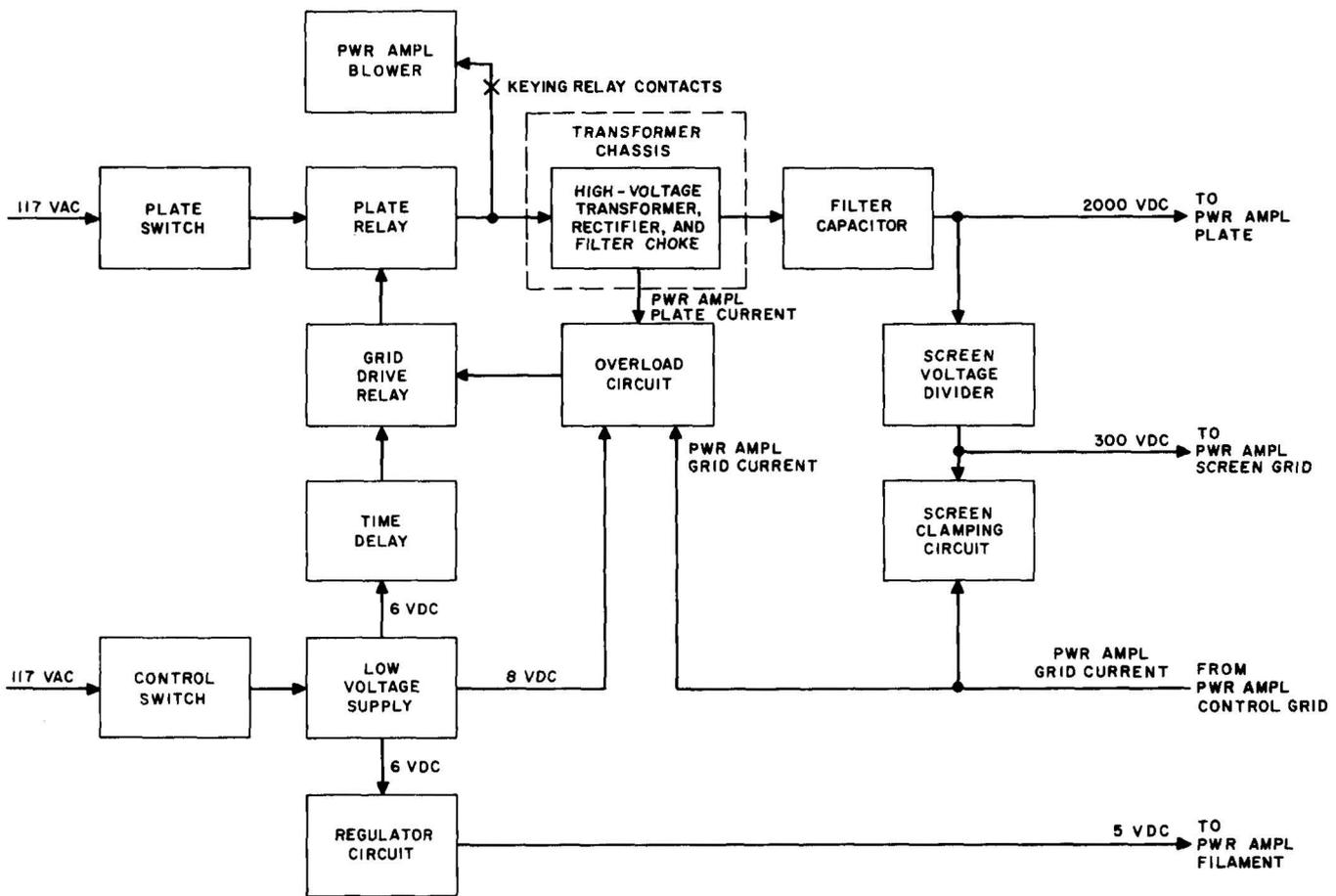


Fig. 8—Power Amplifier Power Supply—Block Diagram

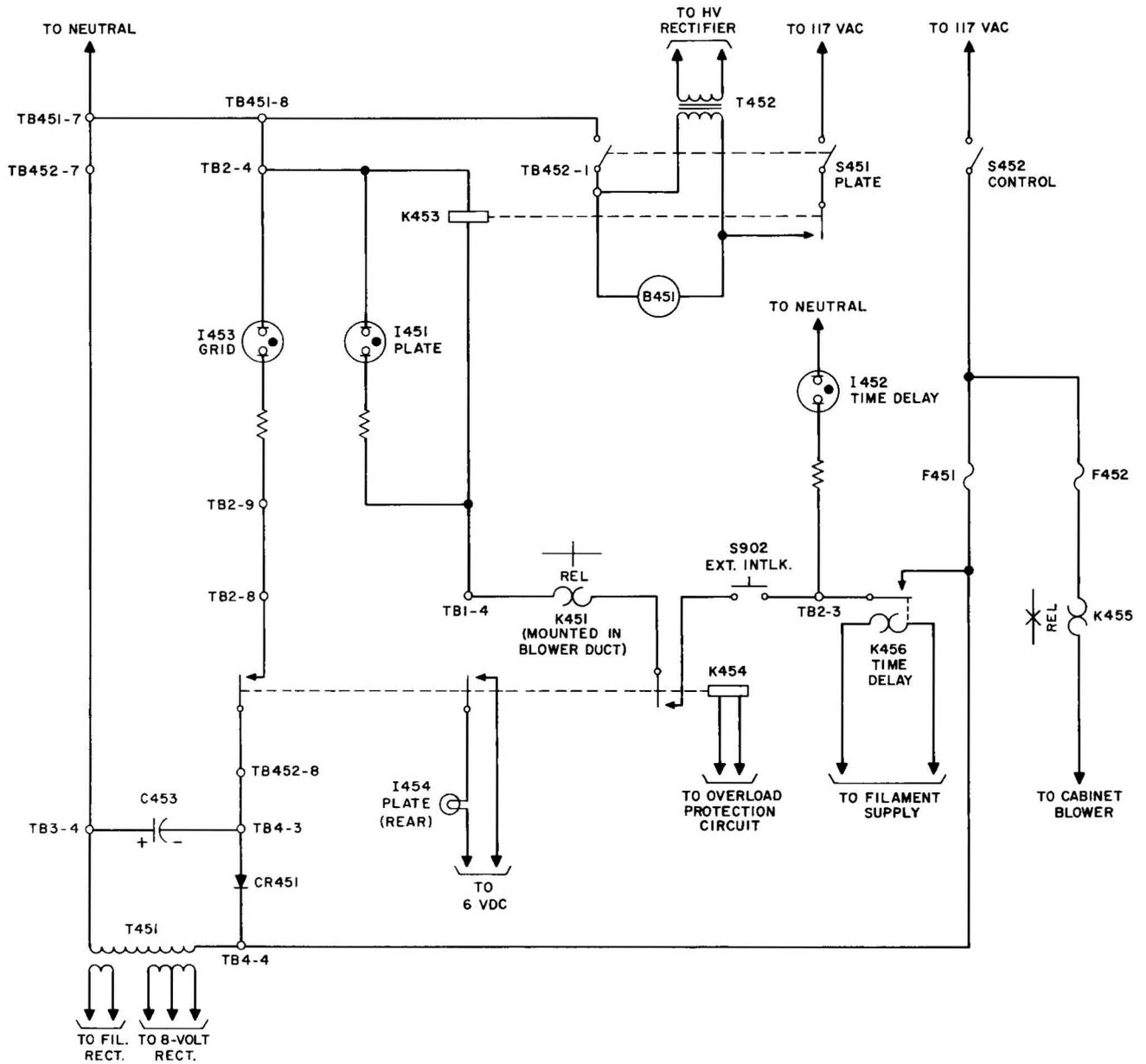


Fig. 9—Power Amplifier Power Supply—Control Circuits

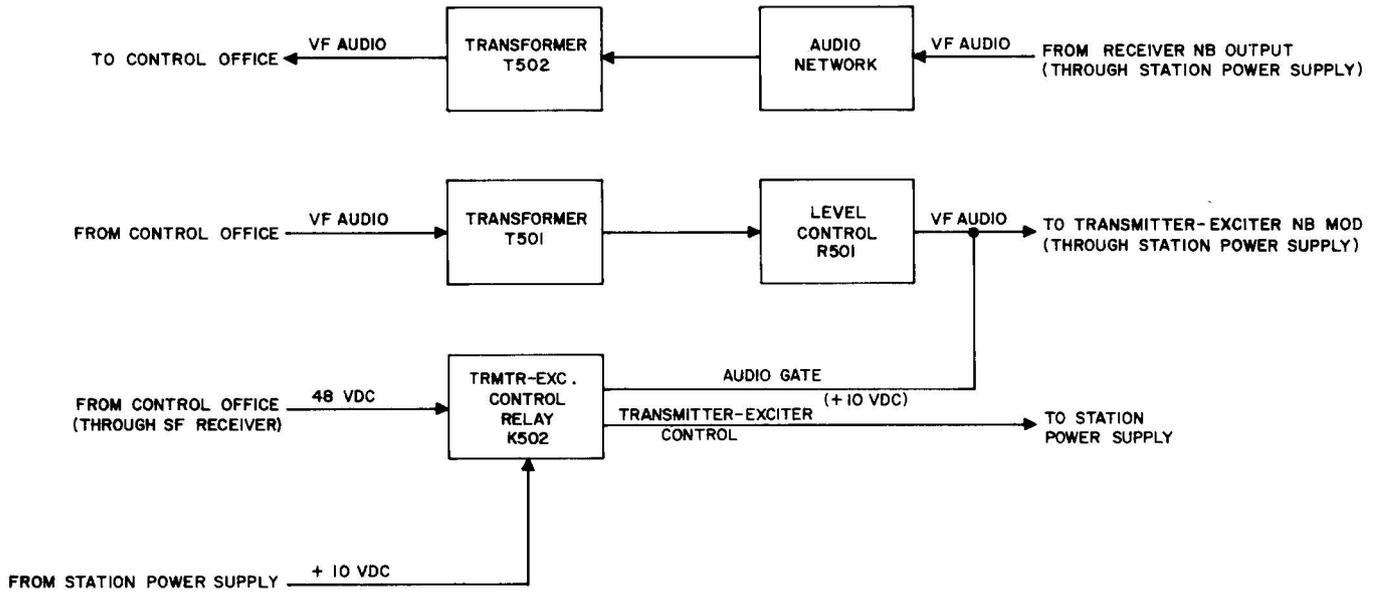


Fig. 10—Voice Frequency Control Unit

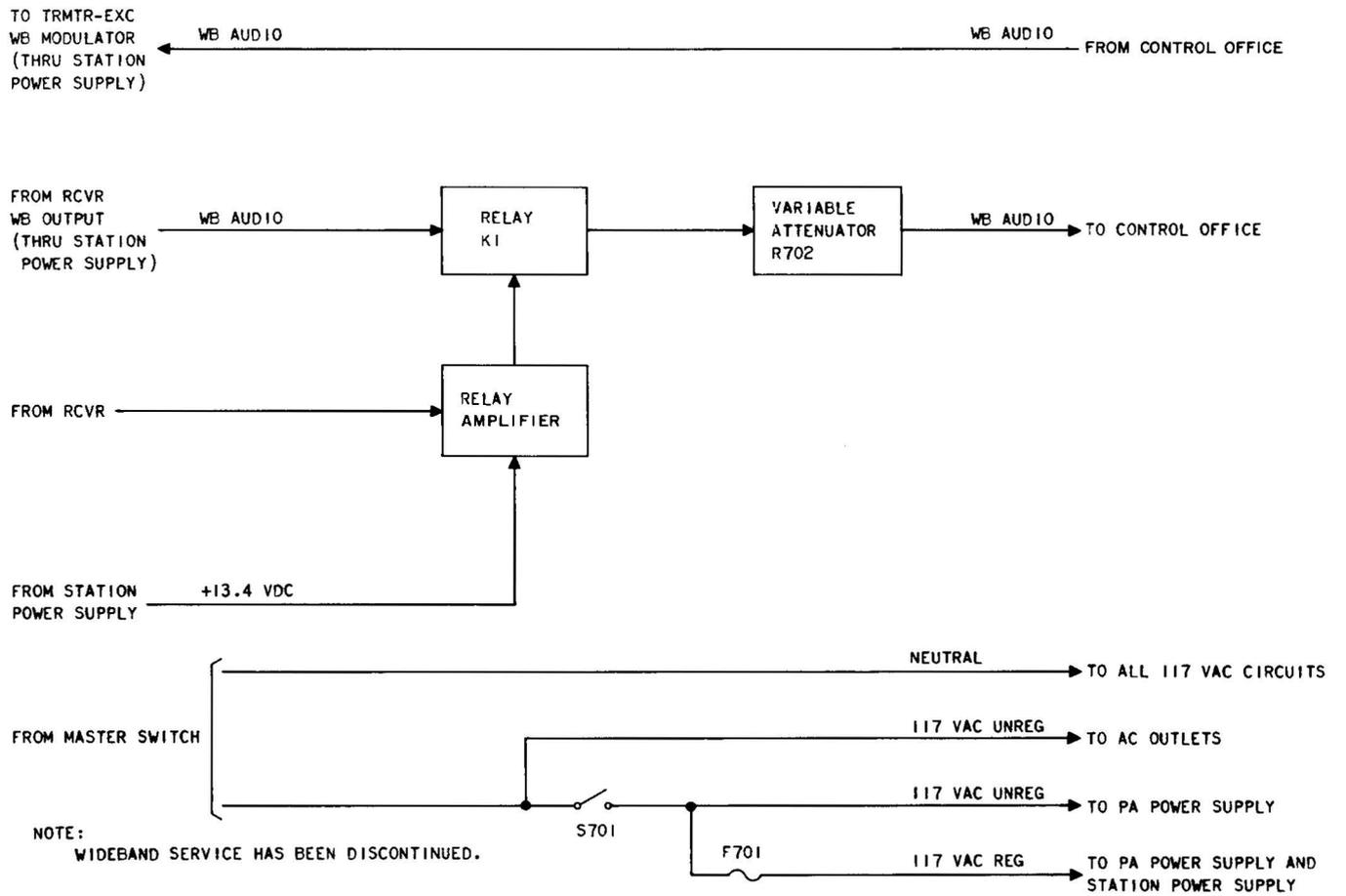
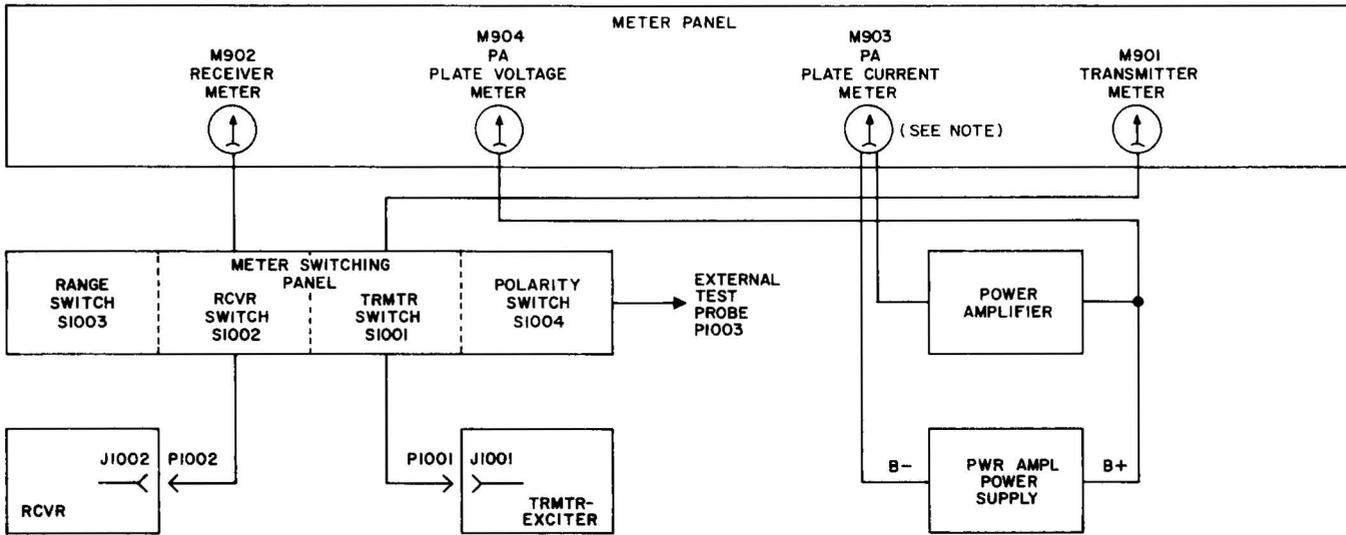


Fig. 11—Wideband Audio Control Unit



NOTE:
PA PLATE CURRENT METER READS 25mA HIGH DUE TO MODIFICATION PLACING THE METER IN THE LOW SIDE OF THE POWER SUPPLY.

Fig. 12—Meter Circuit

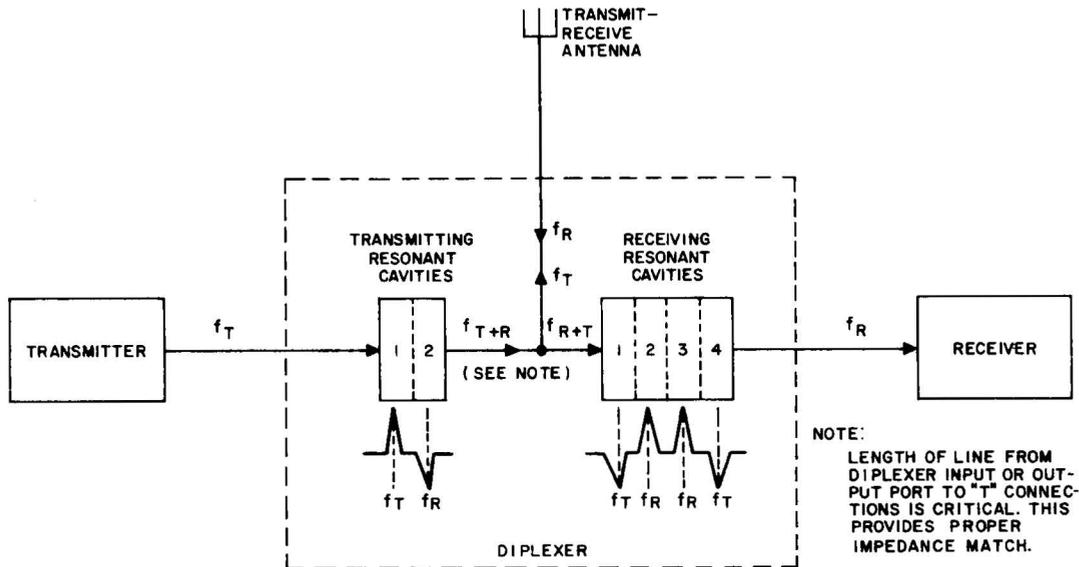


Fig. 13—Diplexer—Block Diagram

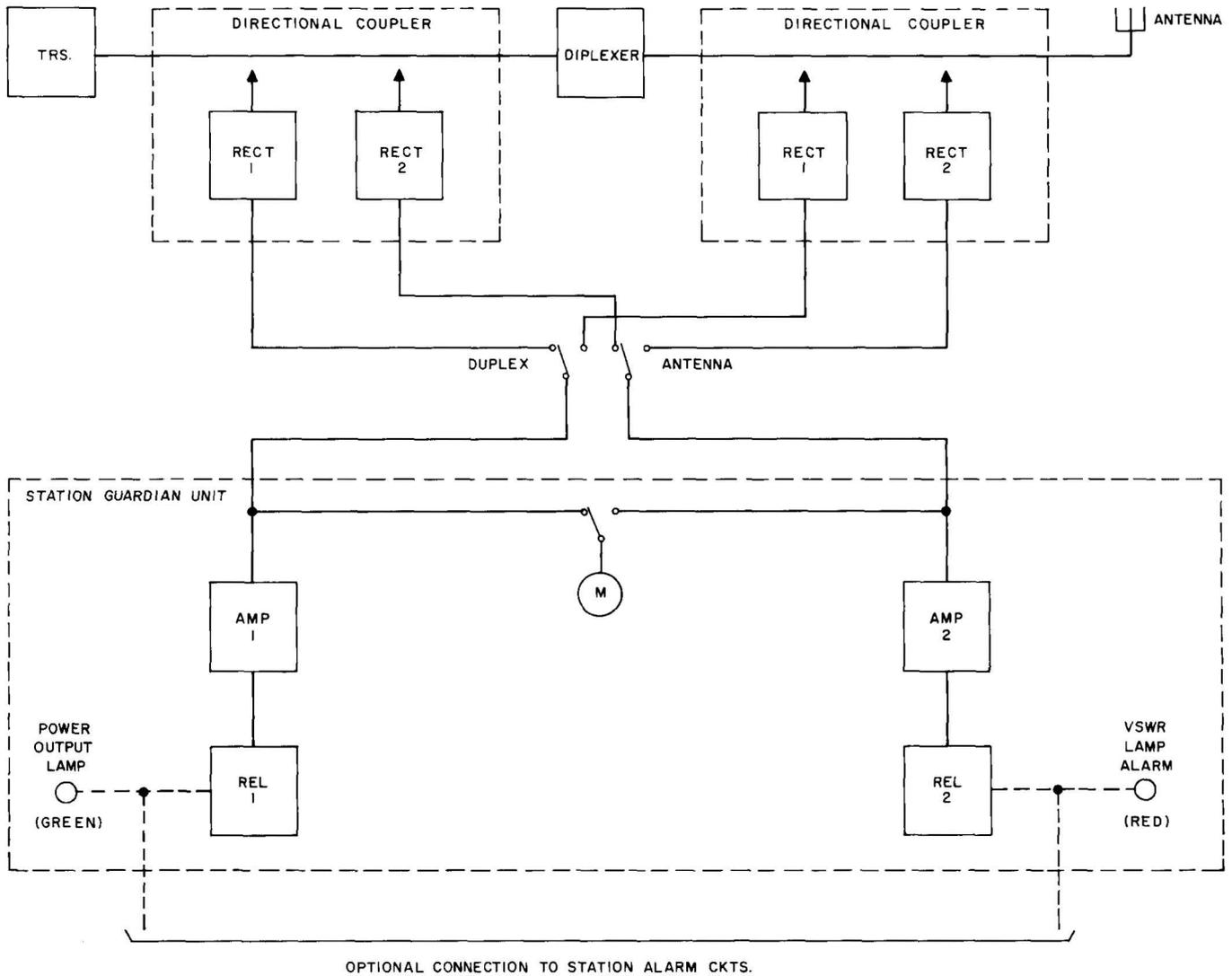
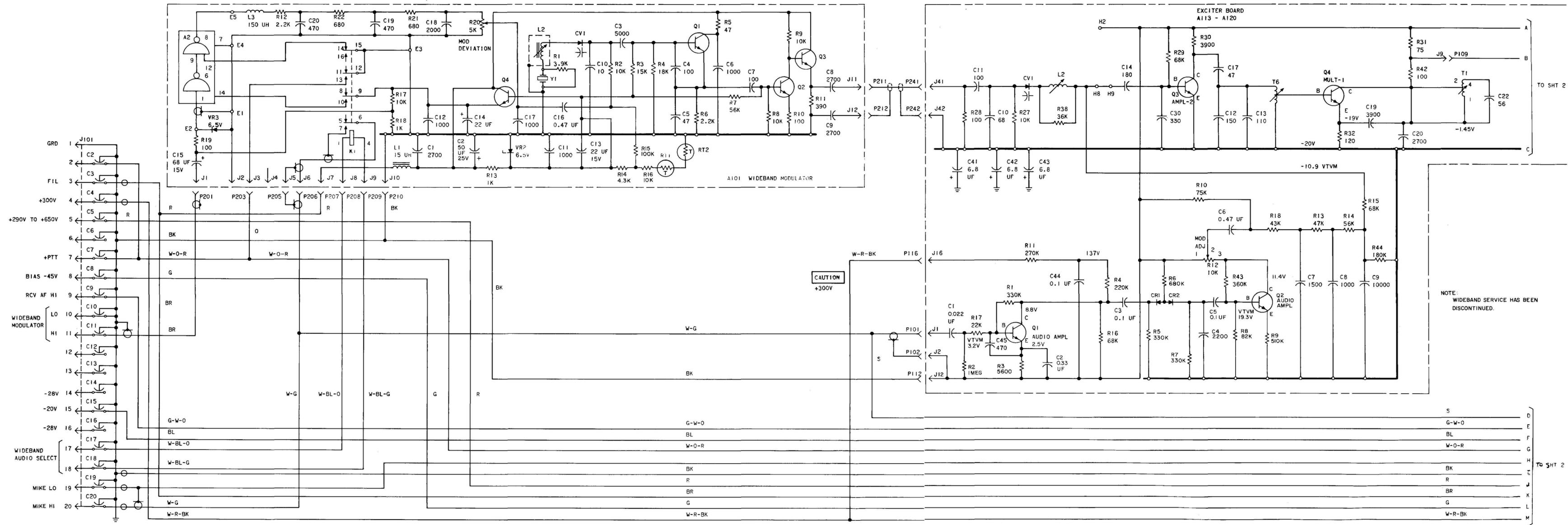


Fig. 14—Station Guardian—Block Diagram



NOTE: WIDEBAND SERVICE HAS BEEN DISCONTINUED.

Fig. 15—Transmitter-Exciter—Schematic Diagram (Sheet 1 of 2)

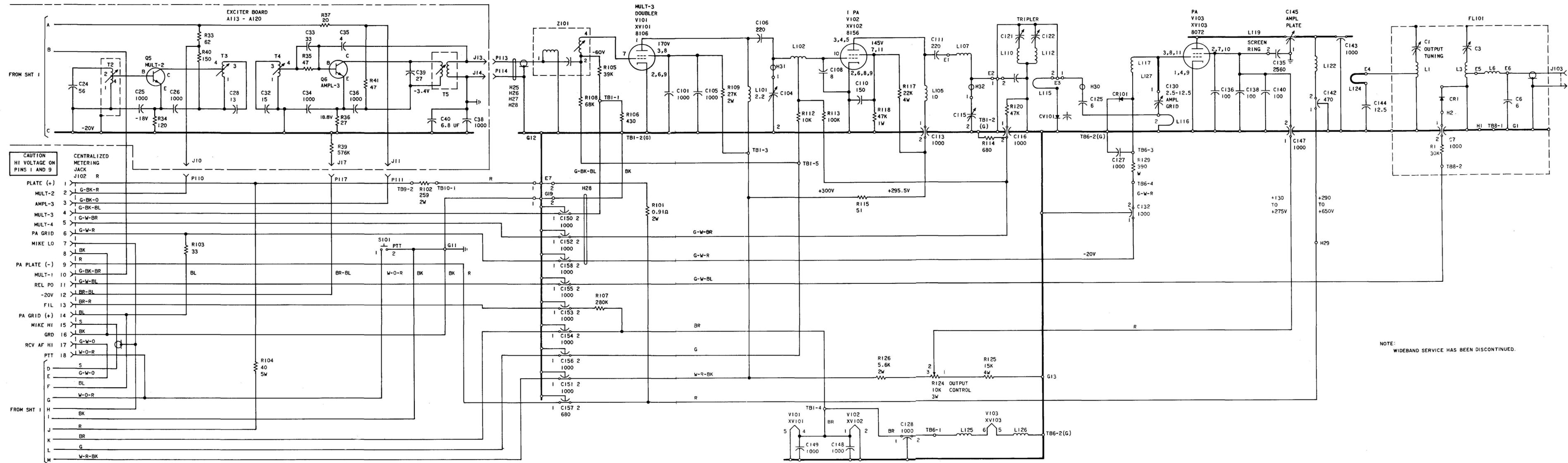


Fig. 15—Transmitter-Exciter—Schematic Diagram (Sheet 2 of 2)

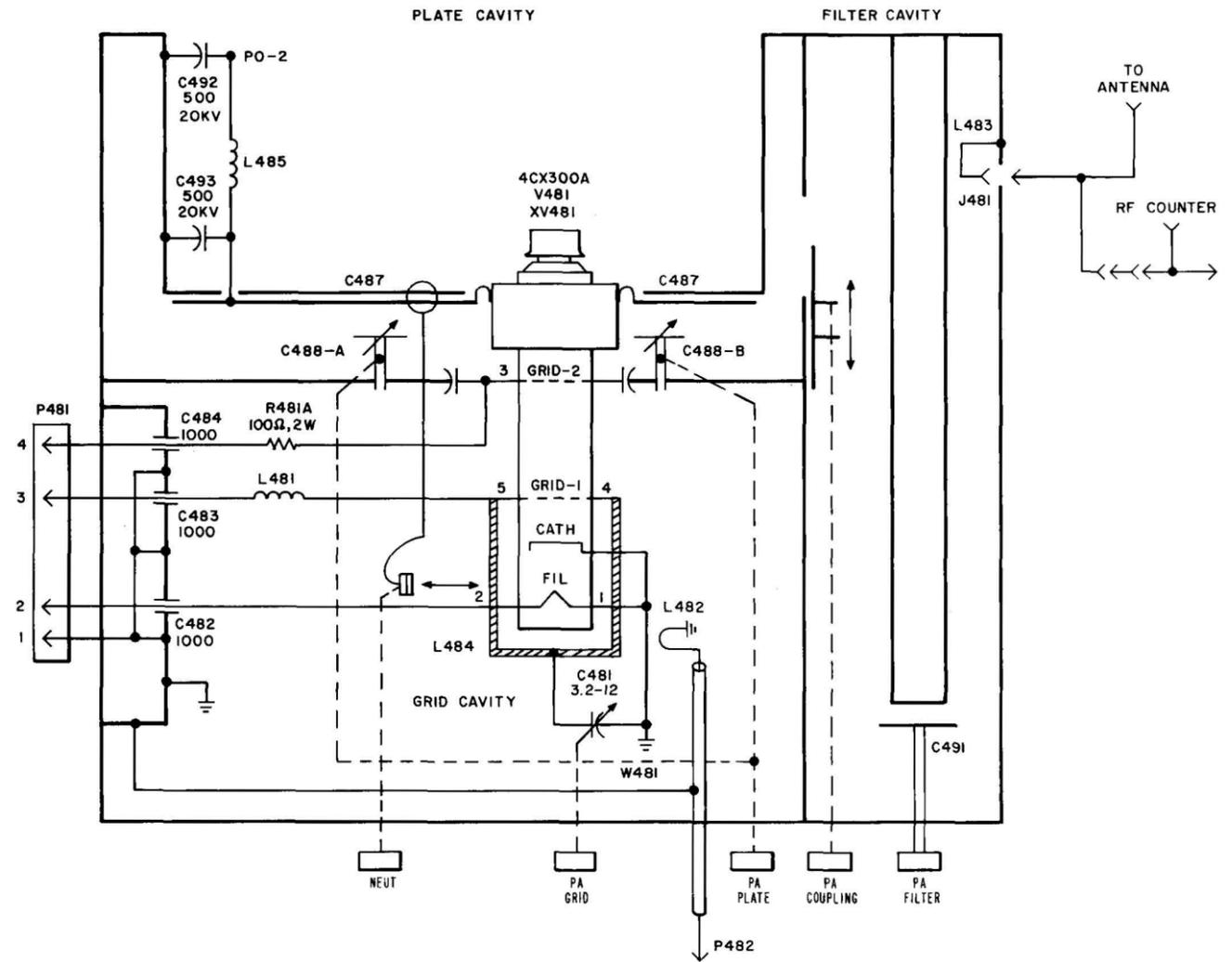


Fig. 16—Power Amplifier—Schematic Diagram

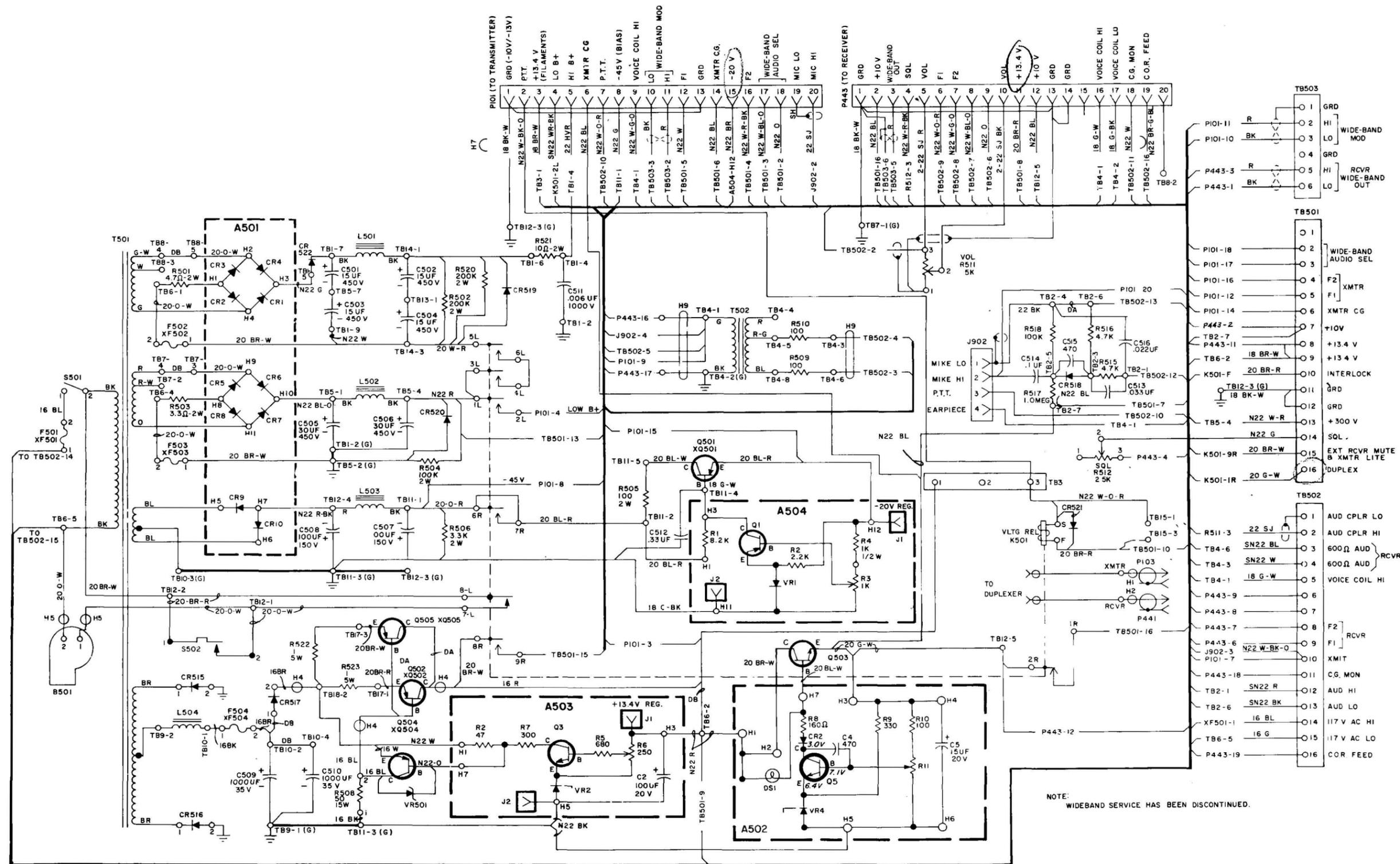
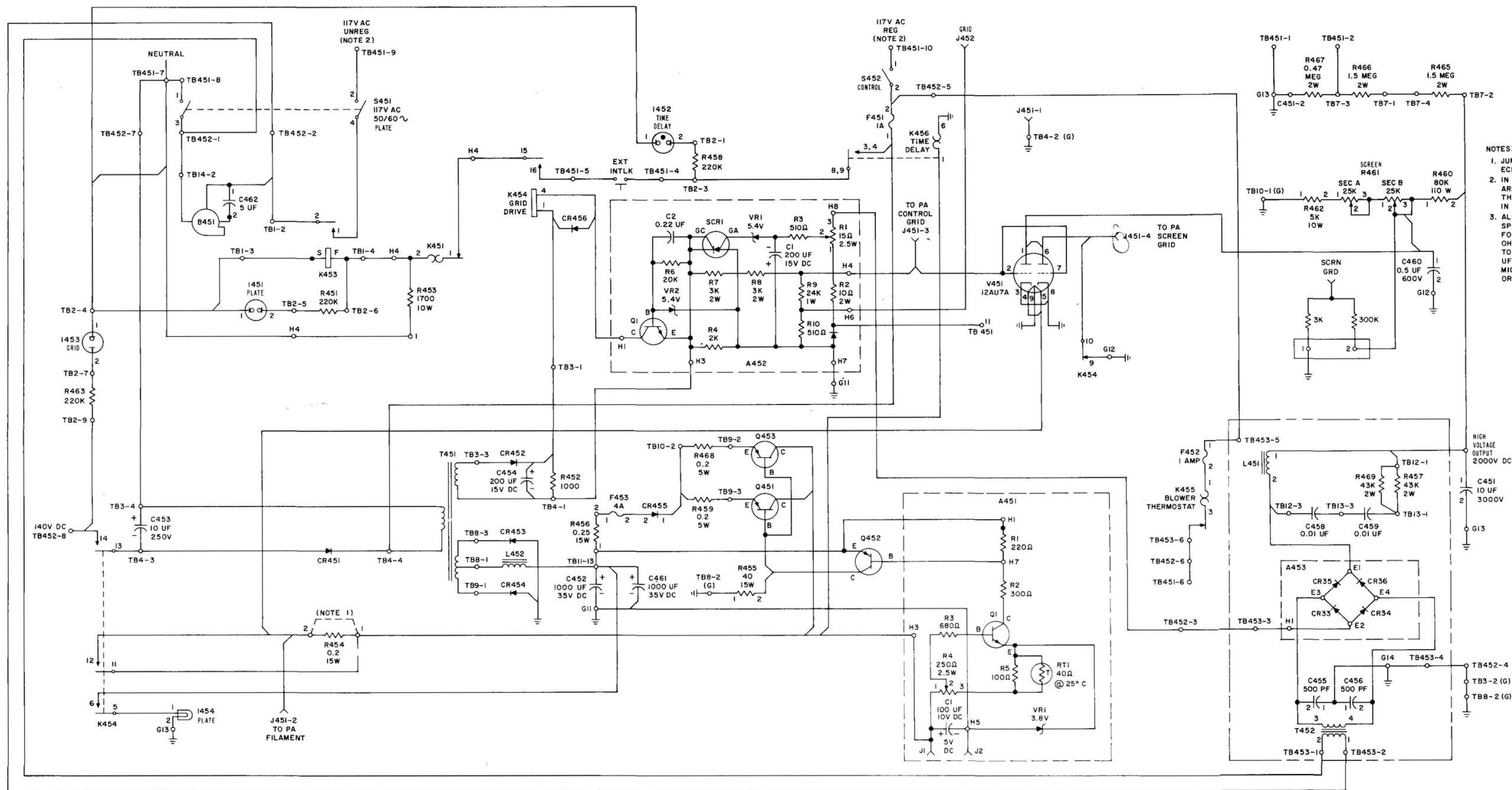


Fig. 17—Station Power Supply—Schematic Diagram



- NOTES:
1. JUMPER IS PRESENT IN PA MODEL USED AT ECHO-FOX BASE STATIONS.
 2. IN THIS INSTALLATION, REG AND UNREG VOLTAGES ARE OBTAINED FROM THE SAME SOURCE; HOWEVER, THE REG CIRCUIT IS PROTECTED BY A 20-AMP FUSE IN THE WIDEBAND AUDIO CONTROL UNIT.
 3. ALL RESISTORS ARE 1/2 WATT UNLESS OTHERWISE SPECIFIED AND RESISTOR VALUES IN OHMS UNLESS FOLLOWED BY K=1000 OHMS OR MEG=1,000,000 OHMS. CAPACITOR VALUES IN PICOFARADS (EQUAL TO MICROMICROFARADS) UNLESS FOLLOWED BY UF= MICROFARADS. INDUCTANCE VALUES IN MICROHENRYS UNLESS FOLLOWED BY MH=MILLIHENRYS OR H=HENRYS.

Fig. 18—Power Amplifier Power Supply—Schematic Diagram

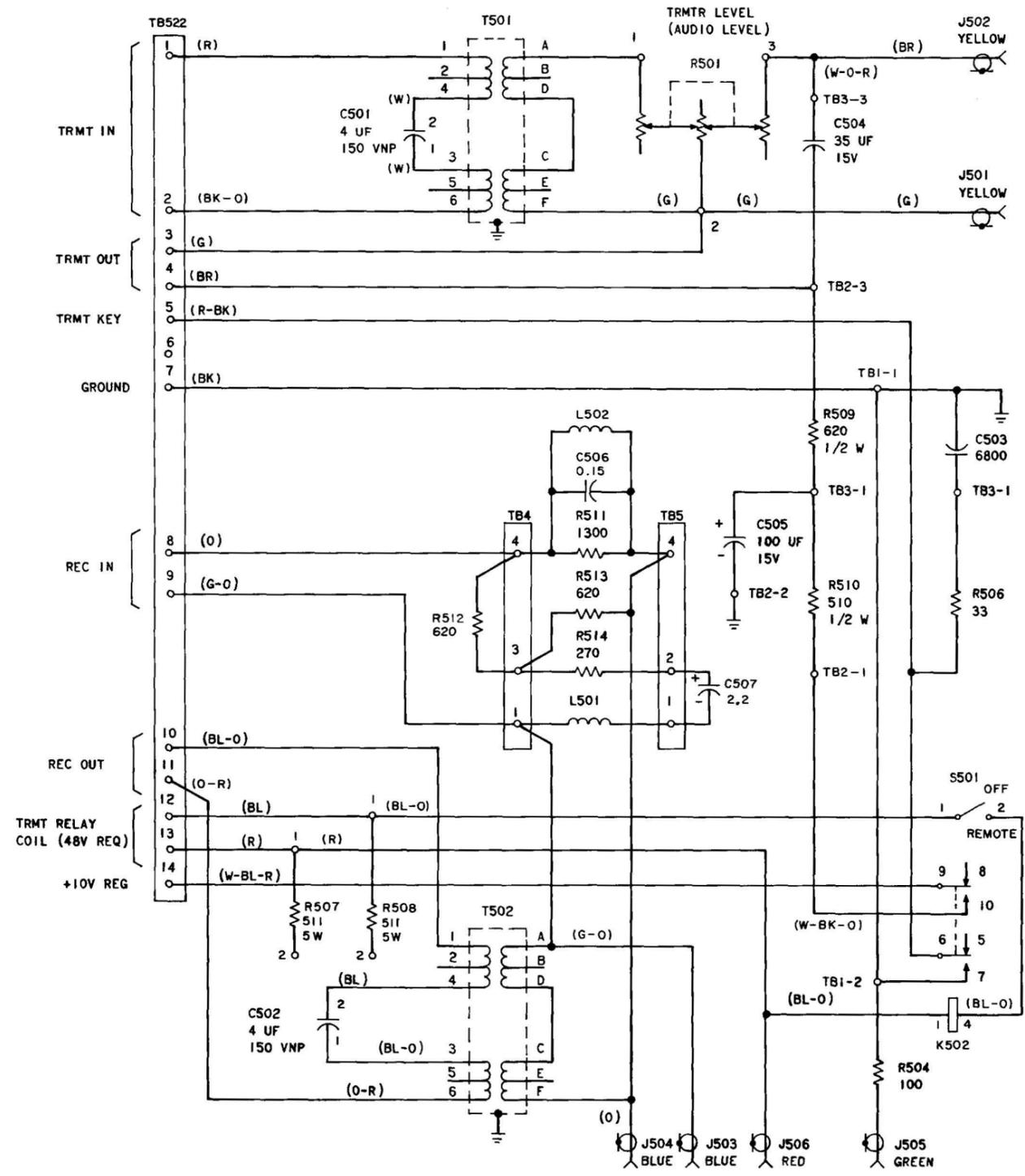


Fig. 19—Voice Frequency Control Unit—Schematic Diagram

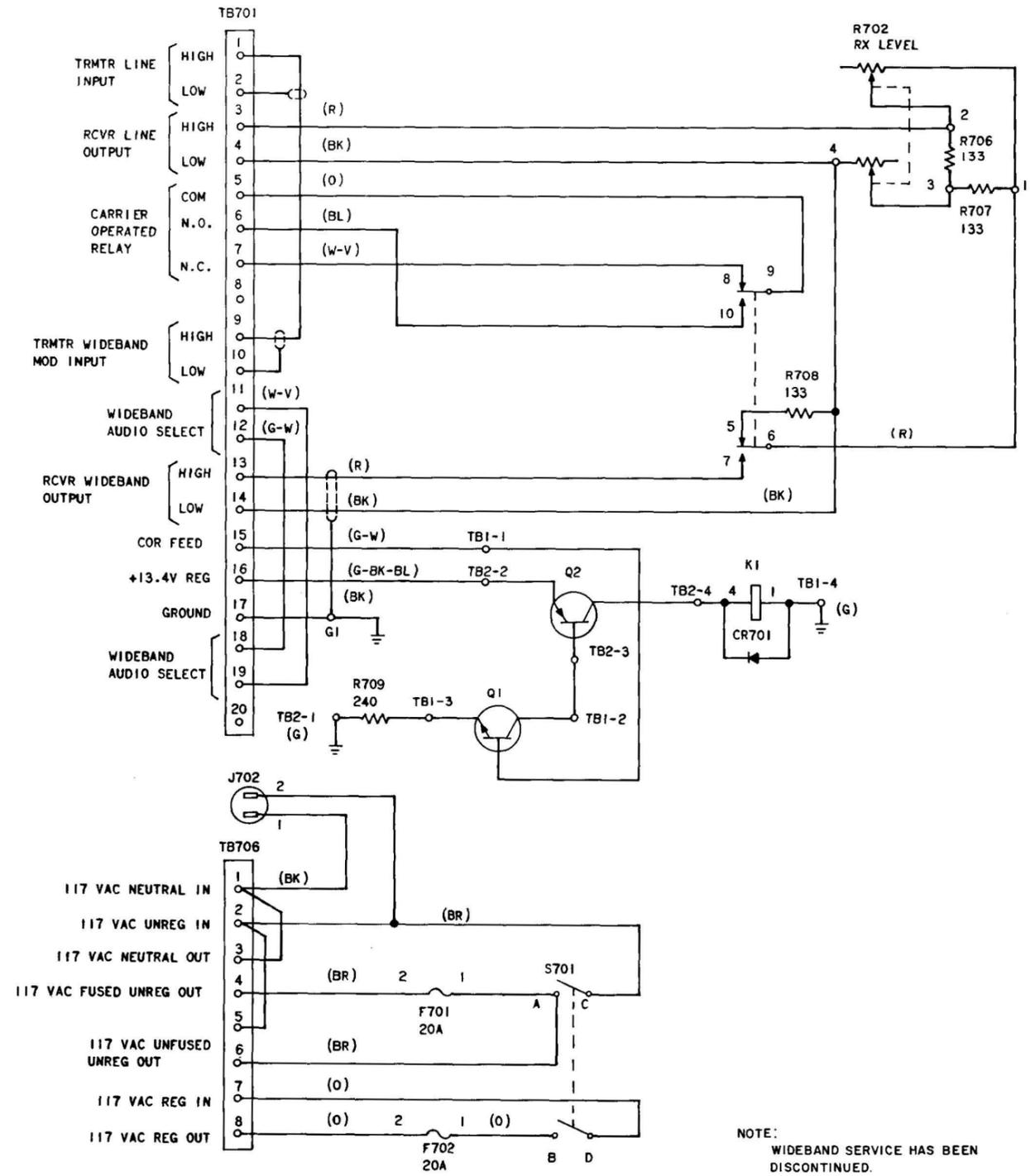


Fig. 20—Wideband Audio Control Unit—Schematic Diagram

NOTE:
WIDEBAND SERVICE HAS BEEN
DISCONTINUED.