AIR-GROUND RADIO
COLLINS 242F-9C TRANSMITTER
DESCRIPTION

CONTENTS PAGE

1. GENERAL

1.01 This practice covers the Collins Radio Company 242F-9C radio transmitter used for SAC and MAC air-ground communications. This transmitter is generally used in conjunction with the Motorola CM-620 radio receiver. The transmitter is mounted in equipment cabinet EQ-210. Space is provided in the equipment cabinet for the Motorola CM-620 receiver, station guardian SG-34 (MAC installations only), and for associated remote radio control circuits.

***Caution:** The 292F-9C transmitter uses voltages which can be fatal. Safety precautions outlined in Section 010-110-001 must be followed during installation and maintenance.*

1.02 The Collins 242F-9C transmitter is a single-frequency, crystal-controlled, amplitude-modulated transmitter capable of producing a power output of 50 watts. This transmitter operates within the 225- to 400-MHz range. The power output is continuously maintained at a 50-watt level at any frequency within the operational band. A remote alarm may be actuated under conditions of transmitter malfunction when station guardian SG-34 is used.

2. SYSTEM

2.01 A block diagram of the communications system is shown in Fig. 1.

2.02 The 242F-9C transmitter is an integral part of the Strategic Air Command Primary Alerting System. The Collins 242F-9C transmitter and the Motorola CM-620 receiver, along with associated remote control, console and line terminating equipment, are used as a base station for air-ground communication. Base stations, such as this, are located at widely dispersed airfields.

Remote Control

2.03 Transmitter control and voice transmission may be accomplished over either one of two voice lines. Lamp indicators at the remote controllers position or console indicate voice channel selected, transmitter channel (if more than one transmitter is provided) and transmitter status, (keyed or not keyed).

3 RECORDS

3.01 A record of meter readings, adjustments, parts replacement, tube replacements, repair work and wiring or apparatus modifications should be kept. Common troubles can be localized by comparing stage-by-stage reading with previous readings.

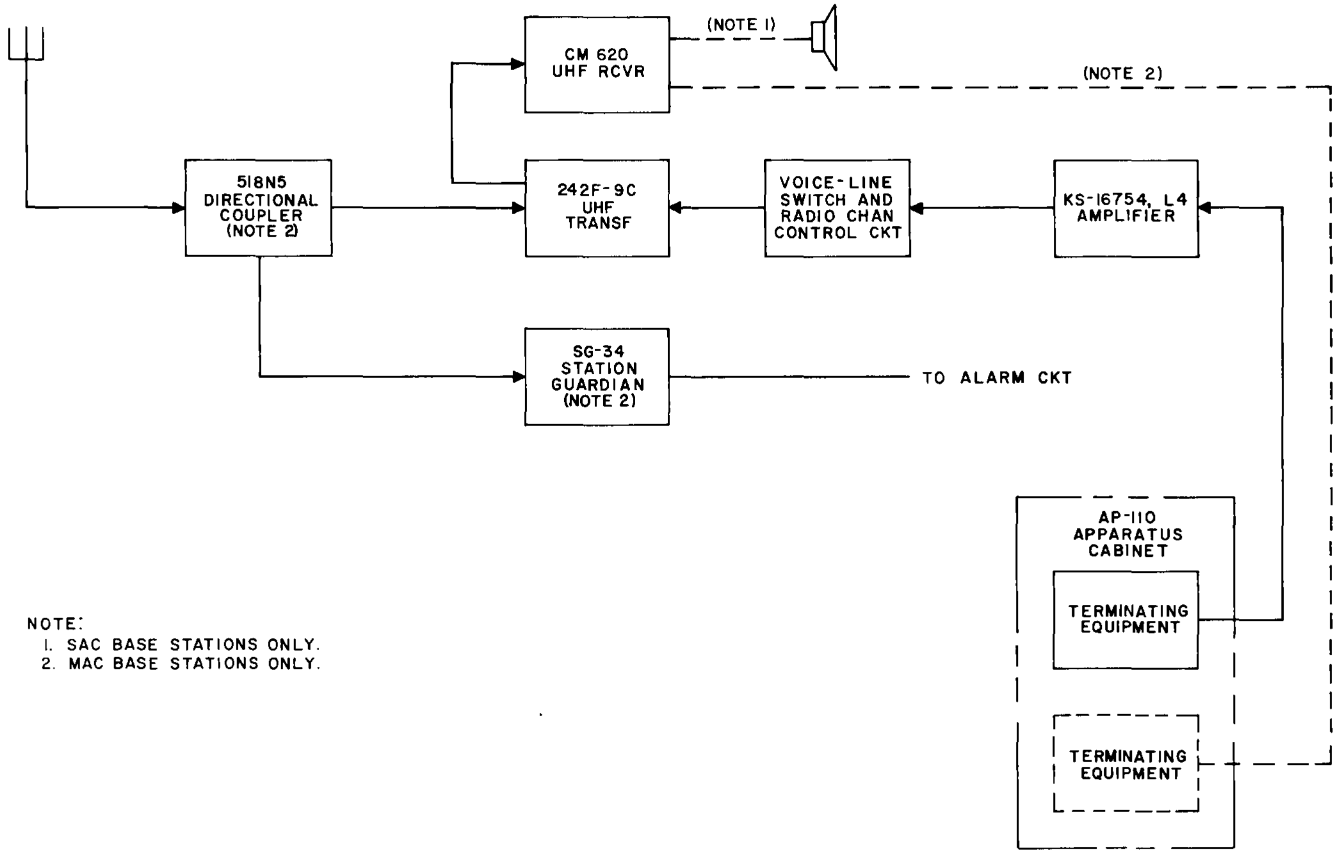

Fig. 1—System Block Diagram

4. POWER REQUIREMENTS

4.01 Primary power requirements for the 242F-9C transmitter are 115 volts, 50 to 60 Hz.

230-Volt Operation:

4.02 The 242F-9C transmitter as shipped from the factory is wired for 115-volt 60-Hz operation. To use a 230-volt ac power source, the following wiring changes should be made:

(a) If necessary, replace the connector on the power cable with a standard 230-volt ac connector.

(b) Remove strapping wires between terminals 7 and 3, and between 5 and 1 on both transformers T401 and T402.

(c) Strap terminal 5 to terminal 3 on both transformers T401 and T402.

(d) The ac input to transformers T401 and T402 should remain connected to terminals 1 and 7 for both 115-volt and 230-volt operation.

(e) Replace front panel fuses with fuses of appropriate values.

5. GENERAL CIRCUIT DESCRIPTION (Refer To Fig. 2)

5.01 The oscillator circuit produces an output ranging between 28 and 50 MHz. This output is multiplied 8 times and then amplified by solid-state amplifiers before being applied to a driver tube stage. The final multiplier output is at the same frequency as the output carrier frequency.

5.02 The transmitter contains three doublers and three RF amplifiers, the third doubler and the three RF amplifiers being contained in separate exciter modules. The RF signal is modulated by the audio signal applied in the RF amplifier stages.

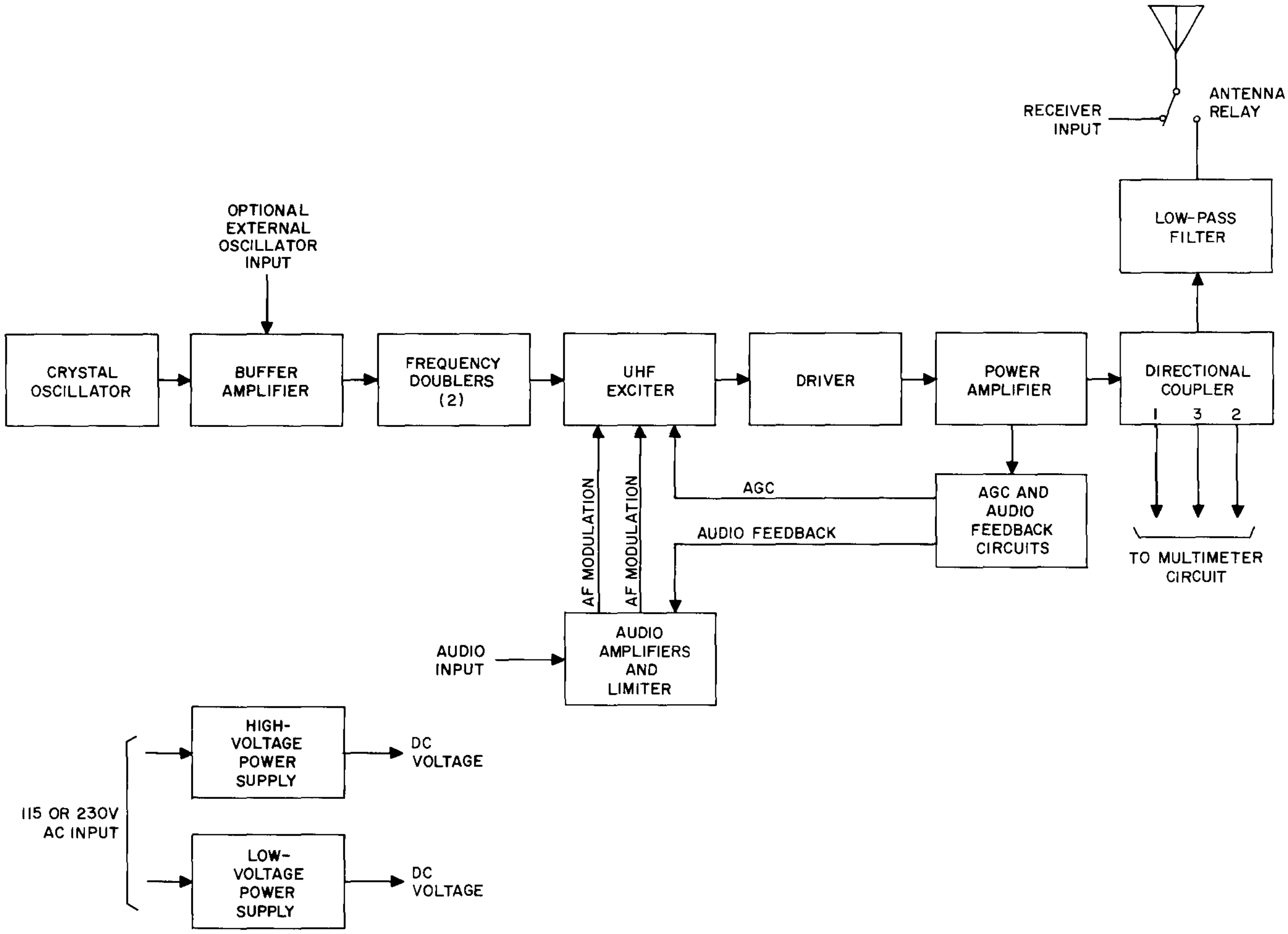

Fig. 2—Transmitter Block Diagram

In addition, an automatic gain control voltage is applied to the RF amplifier stages. The driver stage operates as a class A grounded grid amplifier. This tube supplies the power necessary to develop an adequate voltage swing across the reactively swamped power amplifier tube grid. A coupling network provides the proper impedance match between the driver plate and the power amplifier grid.

5.03 The power amplifier stage operates as a class AB_1 linear amplifier to reduce intermodulation products. This tube is a grounded-cathode amplifier with reactive grid swamping and without neutralization, a combination which provides optimum intermodulation performance. The power amplifier output network is a transmission line cavity using a movable slider to determine its resonant frequency. A set of multiturn gear-driven lead screws move the slider up and down the length of the cavity. Frequency logging is provided by a rotary counter mounted on the gearplate.

5.04 A shaft-driven capacitor mounted near the tube plate provides a variable capacitance to compensate for any impedance mismatch up to 3:1 VSWR over the frequency range.

5.05 The power amplifier output is applied to a directional coupler before connection to a low-pass filter. The directional coupler provides VSWR and power output information to the front panel multimeter. Two filters are available (225 to 300 MHz and 300 to 400 MHz). Each of the filters provides harmonic suppression of 80 dB or more.

5.06 A sample of the power amplifier output is applied to a detector circuit, which produces an automatic gain control voltage for the RF amplifiers in the exciter modules and an audio feedback voltage for the modulator circuit. The modulator contains a manual level control, audio amplifiers, and an audio limiter circuit. Adequate audio is available to fully modulate the RF amplifiers with an input level of -15 dBm. The audio limiter circuit prevents overmodulation and equalizes the inputs from various microphones and operators.

5.07 The power supply circuits provide the required high- and low-voltages. The high-voltage circuit provides a +2000 volt dc power amplifier plate supply, a +850 volt dc driver plate supply and a +300 volt dc driver and power amplifier screen supply. The low-voltage circuit provides power amplifier and driver bias supplies, a +28 volt dc transistor supply, and a +48 volt dc control circuit supply. All of the power supplies use solid-state rectifiers. The bias supplies, the 28-volt dc supply, and the 300-volt dc supply are all regulated. Either 115- or 230-volt, 50-to-60 Hz, single-phase power input may be used. Fuses provide ample overload and short circuit protection. Safety interlock switches are used with the protective covers to provide protection for maintenance personnel.

5.08 A front panel switch controls the primary power input. A key relay controls the voltages to the blower, crystal oscillator, driver, and power amplifier screens.

5.09 Cooling air is required only during the transmitting condition. A thermal cutoff switch is provided to protect the driver and power amplifier tubes in case of blower failure.

6. THEORY OF OPERATION

Crystal Oscillator (Refer to Fig. 3)

6.01 The fundamental signal frequency for the transmitter is generated by an impedance-inverting, transistorized, Pierce crystal oscillator. The oscillator provides an output frequency which ranges between 28.125 to 50.0 MHz. The choice of the output frequency and the use of the formula ***UHF output frequency*** */8* will determine the exact oscillator output frequency.

6.02 The frequency stability of the oscillator is essentially equal to that of the crystal. Frequency stability is achieved by using a crystal oven to maintain a constant crystal temperature. The oscillator functions as follows. Regulated +15 volts dc is applied to the oscillator only when the transmitter is keyed. Figure 3 shows the oscillator as a common-emitter configuration with regenerative feedback applied from the collector to base of Q1. Capacitor C3, crystal Y1, and inductor L2 are series-connected, while L3 and C13 are in parallel. The combination of C3, Y1, and L2 is in parallel with the combination of L3 and C13. A resistive load results at the collector of Q1 when the combination of C3, Y1, and L2 is parallel resonant with the resultant capacitive reactance of L3 and C13. This resistive load is approximately equal to the square of the resultant reactance of L3-C13 divided by the resistance of crystal Y1. The reactance of Y1-L2 at resonance is inductive and is approximately equal to the reactance of L2. Assuming the resistance of Y1 is negligible, then the current in Y1 will lag the collector voltage of Q1 by 90 degrees. The base voltage of Q1 will also lag the current in Y1 by 90 degrees. Therefore, base voltage of Q1 is 180 degrees out of phase with the collector voltage. This 180-degree phase shift is a characteristic of the common-emitter configuration. When Q1 has a resistive load (caused by C3, Y1, and L2 being parallel resonant with the capacitive reactance of L3 and C13), the phasing is again inverted so that the total phase shift around the closed loop is 360 degrees. Regeneration takes place and, because the gain is greater than 1, oscillation will occur.

6.03 The oscillator is tuned by first adjusting OSC COARSE, C13, and observing the MULTIMETER in the OSC position for a dip. OSC FINE, L2, is then adjusted until the sharpest dip occurs. When the oscillator is tuned by OSC FINE, L2, the current in Y1 will remain essentially constant, and the voltage which appears across Y1 will be proportional to the crystal impedance. As the frequency approaches series resonance (by adjusting OSC FINE, L2) of Y1, the impedance of Y1 passes through a minimum value. At this time the voltage across Y1 will also be a minimum value. At frequencies above and below the series-resonant frequency of Y1, the crystal impedance increases and reduces the amount of regenerative feedback. This in turn prevents oscillations from occurring at frequencies other than the series-resonant frequency. Therefore, the oscillator can be tuned

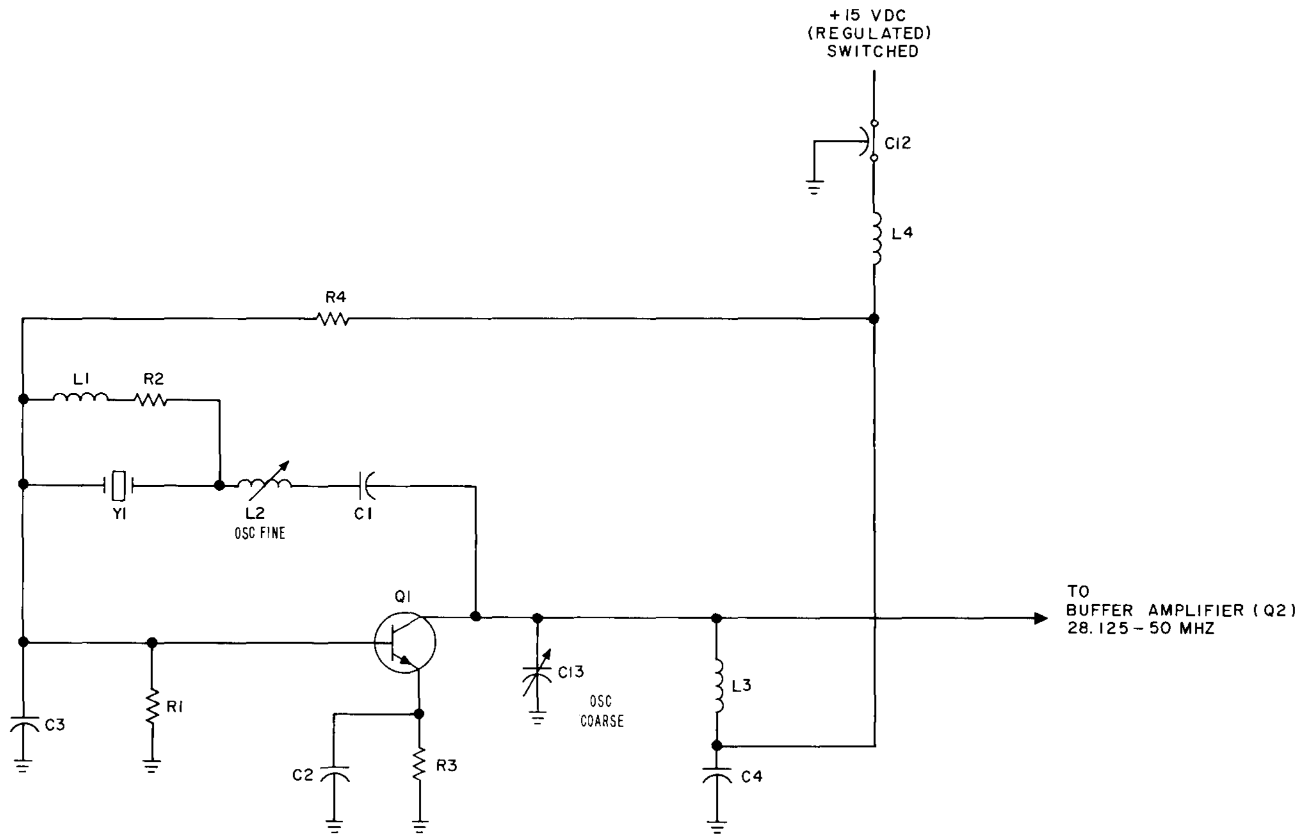

Fig. 3—Crystal Oscillator, Simplified Schematic Diagram

to the series mode of Y1 by observing the MULTIMETER (in OSC position) for the sharpest dip (voltage across Y1) while adjusting OSC FINE, L2.

6.04 To prevent stray capacitance associated with Y1 from interfering with the tuning process, a compensation network consisting of L1 and R2 is placed in parallel with Y1. Resistors R4 and R1 provide a base-biasing voltage divider for Q1. Capacitors C12 and C4 and inductor L4 provide RF filtering for the regulated +15 volts direct current. A meter detector circuit is also connected across crystal Y1. The output of the crystal oscillator is taken from the collector circuit of Q1, and applied to buffer amplifier Q2.

Buffer Amplifier (Refer to Fig. 4)

6.05 The buffer amplifier stage provides isolation between the crystal oscillator and the remaining stages of the RF circuitry. This isolation ensures that the oscillator frequency will not be "pulled" due to the effects of the following doubler and RF stages. The buffer amplifier stage also drives the first doubler by amplifying the RF output from the crystal oscillator. The buffer stage consists of a common-emitter configuration amplifier, associated biasing components, output tank circuit, and RF filtering network. The stage gain is controlled by the base bias on Q2, which is determined by RF DRIVE control R358.

6.06 The output signal from Q2 is developed across the collector tank circuit consisting of L5 and C20. BUFFER capacitor C20 is used in conjunction with the BUFFER position of the MULTIMETER to tune the buffer amplifier output to the appropriate crystal frequency. Inductor L5 is tapped to provide impedance matching between the buffer amplifier and the first doubler.

6.07 The buffer amplifier also has provisions for accepting an input from an external oscillator. An external oscillator can be used by first disabling the internal crystal oscillator. This is accomplished

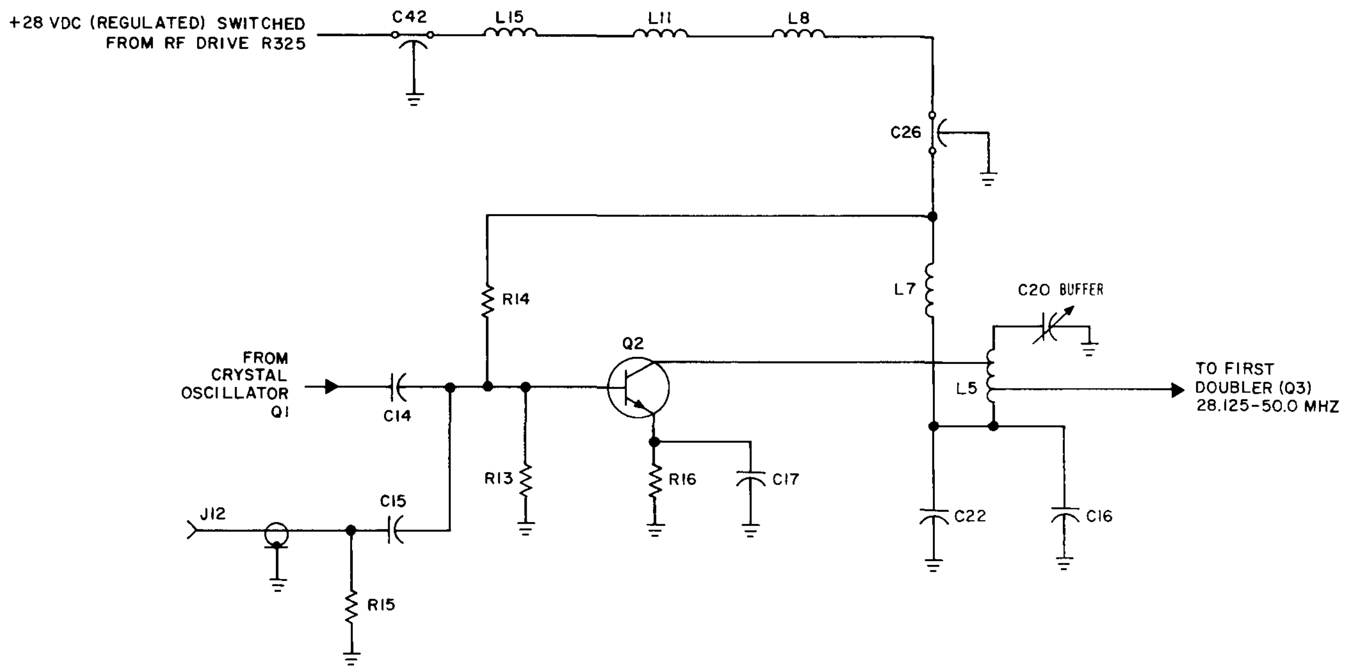

Fig. 4—Buffer Amplifier, Simplified Schematic Diagram

by removing the crystal oven from its socket. The external oscillator is then connected to the buffer amplifier input through the EXTERNAL OSCILLATOR connector J12. In either case, the buffer amplifier functions as described.

First Doubler (Refer To Fig. 5)

6.08 First doubler Q3 is a common-emitter amplifier which drives an output tank circuit tuned to twice the crystal frequency. The output frequency is from 56.25 to 100.0 MHz. The RF DRIVE control R358 also determines the gain of the first doubler stage. The output signal from Q3 is developed across the collector tank circuit consisting of L9 and C31. The value of C31 (DBLR 1) is adjusted so that the output frequency of the tank circuit is twice the crystal oscillator RF output frequency. The DBLR 1 position of the MULTIMETER is used when adjusting C31. Interstage impedance matching between the output of the first doubler and the second doubler input is provided by the tap on L9.

Second Doubler (Refer to Fig. 6)

6.09 Second doubler Q4 amplifies the output of the first doubler and applies this output to a tank circuit which is tuned to four times the crystal oscillator RF output frequency. The output frequency is from 112.5 to 200 MHz. The second doubler stage consists of common-emitter amplifier Q4. The gain of Q4 is determined by the setting of the RF DRIVE control R358. The output signal from Q4 is developed across the collector tank circuit consisting of L13 and C38. The value of C38 (DBLR2) is adjusted so that the output frequency of the tank circuit is four times the crystal oscillator RF output frequency. The DBLR 2 position of the MULTIMETER is used when adjusting C38. Interstage impedance matching between the output of the second doubler and the exciter module input is provided by the tap on L13.

First RF Amplifier/Third Doubler (Refer To Fig. 7)

6.10 First RF amplifier/third doubler Q201 amplifies the 112.5- to 200-MHz output of the second doubler and applies this output to a tank circuit that is tuned to eight times the crystal oscillator RF output frequency. The first RF amplifier/third doubler provides an output in the UHF range of 225 to 400 MHz. The first RF amplifier/third doubler is the first of three stages in the UHF

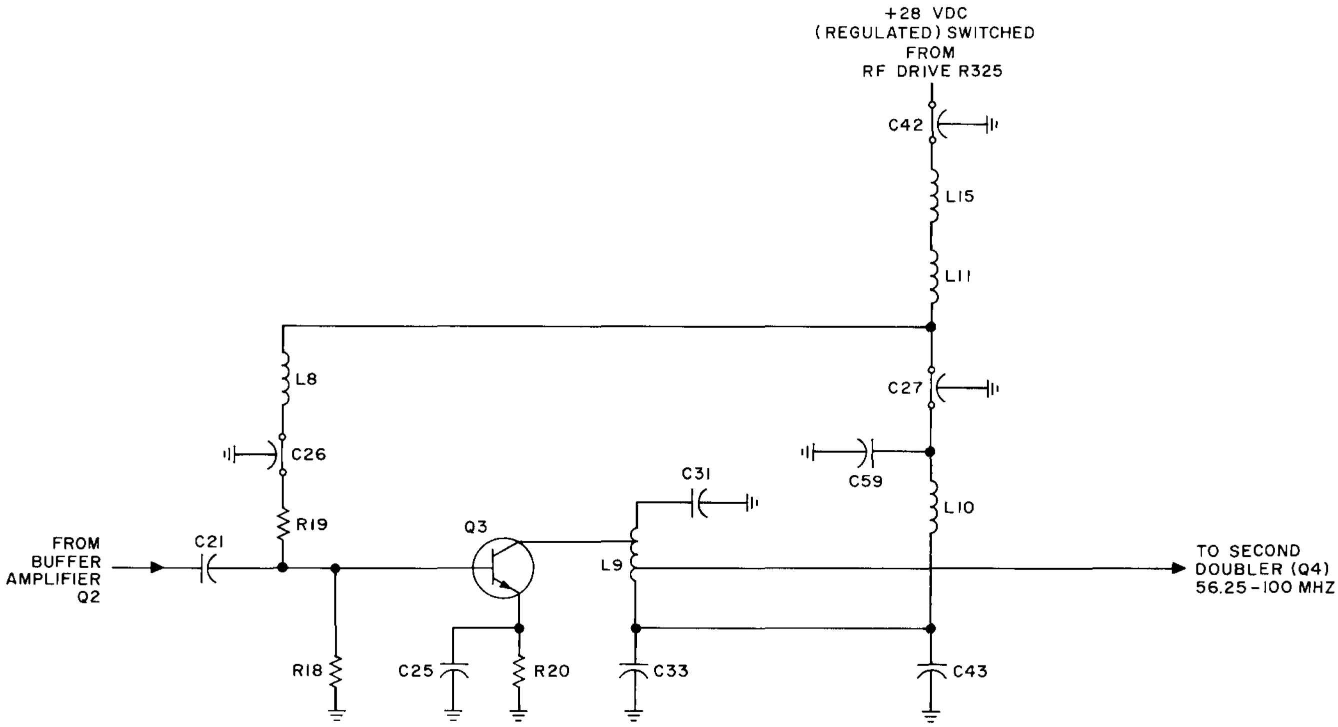

Fig. 5—First Doubler, Simplified Schematic Diagram

exciter module that have their overall gain controlled by AGC voltage. The first RF amplifier/third doubler, Q201, is connected in the common-emitter configuration for a high-power gain factor. The overall stage gain is controlled by dc AGC voltage. The amount of AGC voltage is inversely proportional to the RF power output. AS the AGC voltage decreases (due to an increase in RF power output), the collector-emitter junction voltage of Q201 also decreases. This reduces the gain of Q201. If the AGC voltage increases (due to a decrease in RF power output), the collector-emitter junction voltage of Q201 increases. This results in an increase of gain through Q201. The AGC action ensures that the RF power output remains constant. The output signal from Q201 is developed across the collector tank circuit. The output of Q201 is also sampled by the multimeter circuit. Capacitor C208 (RF AMP 1/DBLR 3) is adjusted so that the tank circuit is tuned to eight times the crystal oscillator frequency. This is accomplished by selecting the RF AMP 1/DBLR 3 position on the MULTIMETER SWITCH and observing the meter for a maximum indication. Interstage impedance matching between the output of the first RF amplifier/third doubler and the second RF amplifier input is provided by the tap on L203.

Second RF Amplifier (Refer to Fig. 8)

6.11 Capacitor C209 provides interstage coupling and dc isolation between the first RF amplifier/third doubler and the second RF amplifier, Q202. All dc biasing voltage for Q202 is supplied by the 2-stage modulation amplifier in the UHF exciter module. The second RF amplifier is also amplitude modulated by the 2-stage amplifier. The output of this 2-stage amplifier is dc voltage with the audio signal from the modulator superimposed on the dc voltage.

6.12 During periods of no modulation, the base bias level of Q202 is established by the dc output of the 2-stage modulation amplifier. Thermistor RT201 provides base bias stabilization over the operating temperature range of the transmitter. Both the base and collector are modulated in the second RF amplifier. This is done to ensure that a 100-percent modulation capability is obtainable. The modulation signal applied to the base of Q202 provides greater driving power while the modulation signal at the collector provides a higher output voltage. Simultaneously increasing both the base and collector voltages (due to the modulation signal) ensures that Q202 will operate in the linear portion

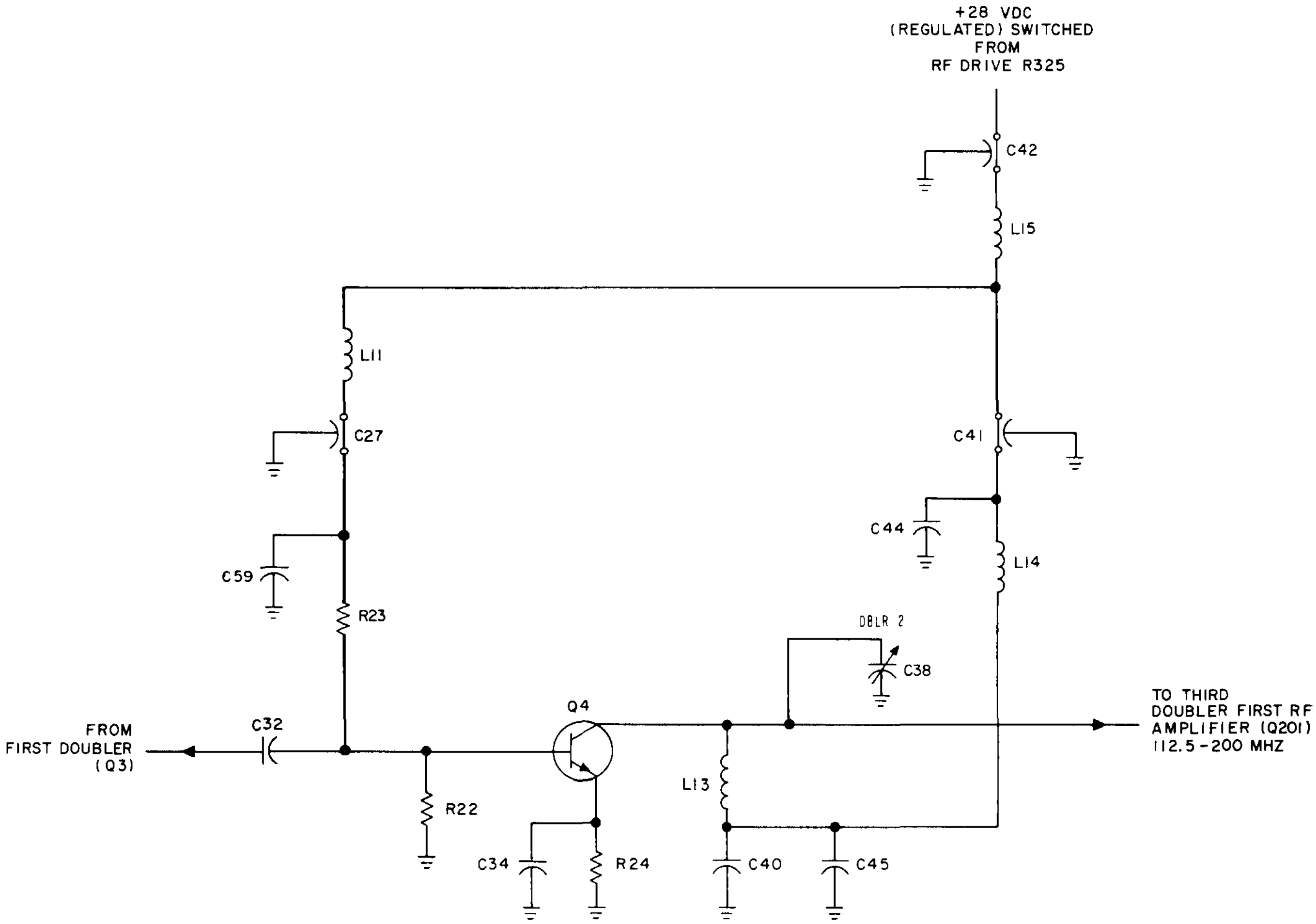

Fig. 6—Second Doubler, Simplified Schematic Diagram

of its characteristic curve. In this way, a high-gain factor and a low percentage of the modulation distortion are provided.

6.13 The output signal from Q202 is developed across the collector tank circuit. The output of Q202 is also sampled by the multimeter circuit. The value of C222 (RF AMP 2) is adjusted so that the tank circuit is tuned to the UHF carrier frequency by selecting the RF AMP 2 position on the MULTIMETER SWITCH and observing the meter for a maximum indication. Interstage impedance matching between the output of the second RF amplifier and the third RF amplifier input is provided by the tap on L205.

Third RF Amplifier (Refer To Fig. 9)

6.14 The modulated RF output from the second RF amplifier is applied through C224 to the third RF amplifier, Q203. The third RF amplifier is connected in the common-emitter configuration for a high-power gain. The third RF amplifier is the second stage in the exciter module to have voltage applied. The dc AGC voltage is used to control the RF gain. The third RF amplifier stage is also modulated by the 2-stage modulation amplifier. All dc biasing, bias stabilization, and amplitude modulating of Q203 are identical to that discussed for the second RF amplifier, Q202. AGC voltage is applied to an RF attenuator circuit. This circuit provides RF gain control by loading the collector

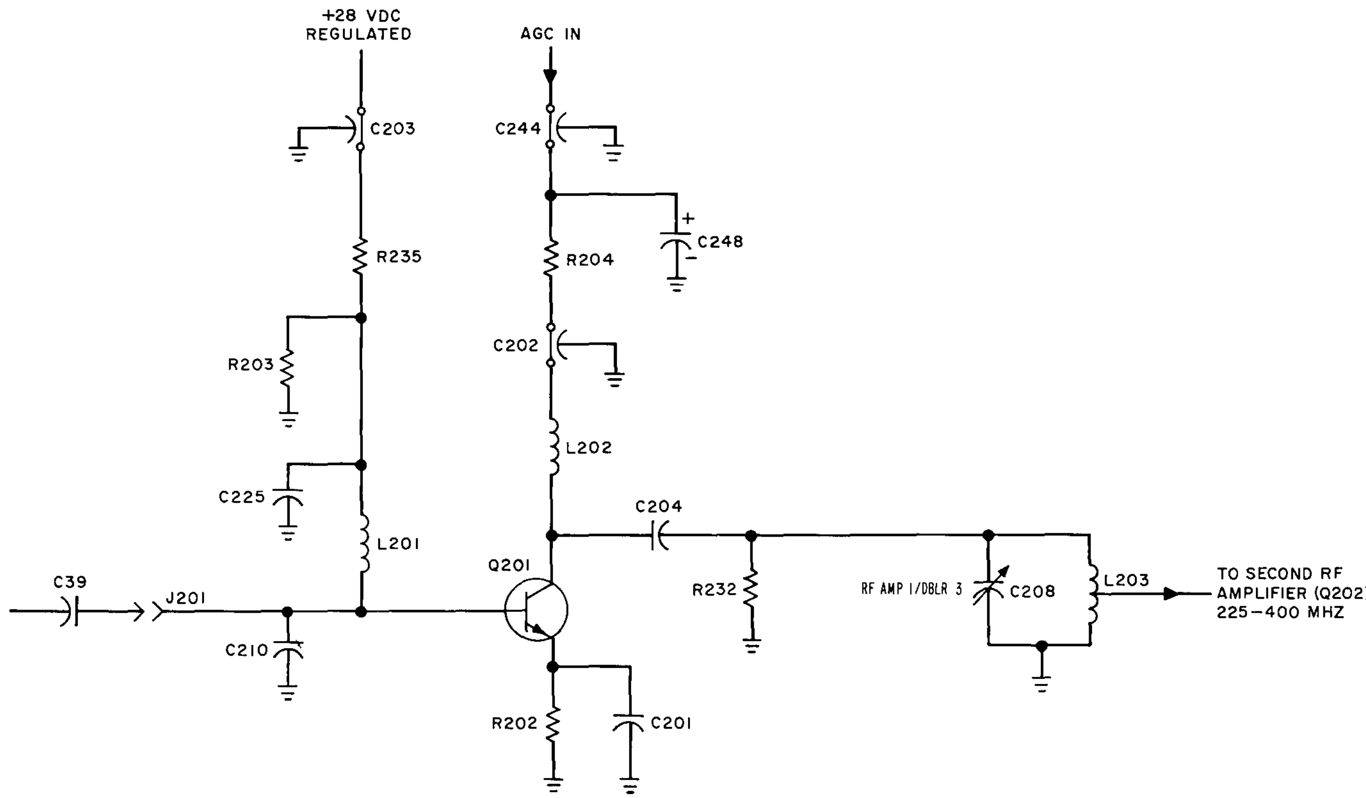

Fig. 7—First RF Amplifier/Third Doubler, Simplified Schematic Diagram

of Q203 as a function of the RF power output. The dc AGC voltage is applied to the cathode of CR205. This dc AGC voltage varies inversely as the RF power output changes. The anode of CR205 has a fixed amount of positive dc voltage applied through voltage dividers R215, R216, and R217. The AGC voltage on the cathode of CR205 controls the biasing and, therefore, the dynamic resistance of CR205.

6.15 The biasing of CR205 by the AGC voltage is continuous and provides the control required to ensure that the RF power output remains constant. The output signal from Q203 is developed across the collector tank circuit. Capacitor C226 provides dc isolation and RF coupling between the collector of Q203 and the tank circuit. The output of Q203 is also sampled by the multimeter circuit. The value of C236 (RF AMP 3) is adjusted to the UHF carrier frequency by selecting the RF AMP 3 position on the MULTIMETER SWITCH and observing the meter for a maximum indication. Interstage impedance matching between the output of the third RF amplifier and the fourth RF amplifier input is provided by the tap on L207.

Fourth RF Amplifier (Refer to Fig. 10)

6.16 The modulated RF output from the third RF amplifier is applied through C237 to the fourth RF amplifier, Q204. The fourth RF amplifier is connected in the common-emitter configuration for a high-power gain. The fourth RF amplifier is the third and last stage in the exciter module to have AGC voltage applied. The RF attenuator circuit for the fourth RF amplifier functions the same as the RF attenuator circuit for the third RF amplifier. The fourth RF amplifier is base modulated by the 2-stage modulation amplifier. Modulating the base emitter circuit of the last RF stage in the UHF exciter module is done to ensure that the modulation envelope will provide the transmitter with a 100-percent modulation capability. Thermistor RT203 provides temperature stabilization for the fourth RF amplifier, Q204.

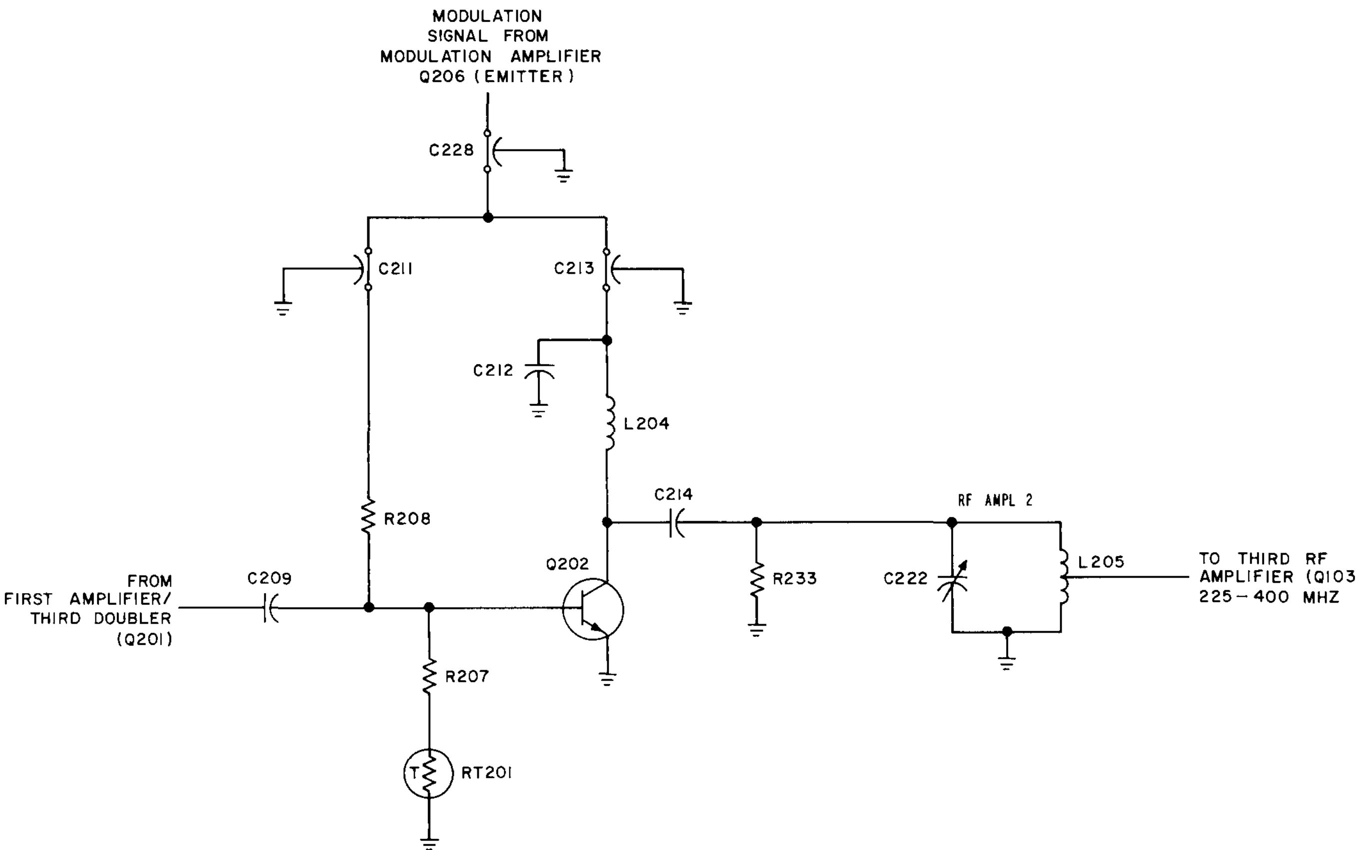

Fig. 8—Second RF Amplifier, Simplified Schematic Diagram

6.17 The output signal from Q204 is developed across the collector tank circuit. The output of Q204 is also sampled by the multimeter circuit. The value of C247 (RF AMP 4) is adjusted to the carrier frequency by selecting the RF AMP 4 position on the MULTIMETER SWITCH and observing the meter for a maximum indication. Interstage impedance matching between the output of the fourth RF amplifier and the driver stage input is provided by the tap on L209.

Modulation Amplifier (Refer To Fig. 11)

6.18 The low-level modulation signal from modulator Q305 is applied to 2-stage amplifier Q205 and Q206. The amplified output, taken from Q206, is then applied to the second, third, and fourth RF amplifiers in the exciter module. Transistor Q205 is connected in the common-base configuration to provide impedance matching and voltage gain for the low-level modulation signal. Base biasing for Q205 is provided by regulated +28 volts dc. The +28 volts dc is applied to base bias voltage divider R226 and R227. The output of this voltage divider is such that under quiescent conditions, Q205 is being operated in the linear portion of its characteristic curve. Transistor Q206 provides the output of the 2-stage modulation amplifier. This stage is connected in the common-collector configuration. This configuration provides a high current gain while only having a voltage gain of 1. However, the voltage gain has already been provided by Q205. The additional modulating signal power gain required by the exciter module RF stages is then the product of the voltage gain from Q205 and the current gain from Q206. This power output is taken from the emitter of Q206 and distributed to the second, third, and fourth RF amplifier stages. Under quiesence, the output taken from the emitter of Q206 is approximately +6.5 volts dc. When the modulating signal is applied to Q205, the output from Q206 consists of a dc level with the audio signal superimposed on it.

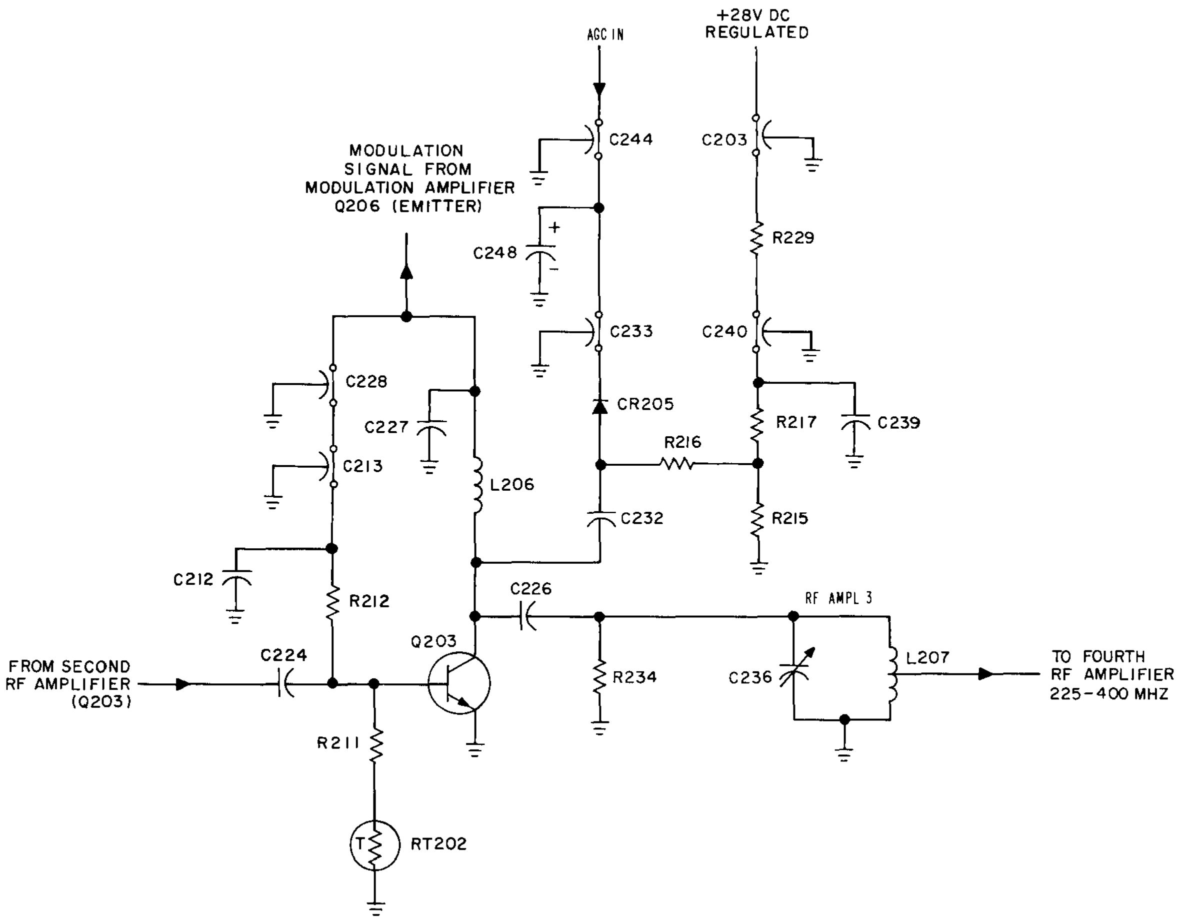

Fig. 9—Third RF Amplifier, Simplified Schematic

Driver Stage (Fig. 12)

6.19 The modulated RF signal from the fourth RF amplifier in the exciter module is applied to the cathode of driver V1. The driver is connected in the grounded grid configuration and operates as a class A linear amplifier. The control grid bias for V1 ranges in value from -7 to -24 volts dc, and is taken from the arm of the DRIVER BIAS potentiometer, R149. The control grid bias is extensively RF filtered. Resistor R38 provides hum cancellation and is placed between the 6.3-volt ac filament voltage and the control grid bias voltage of V1. A small value of the 60-Hz filament voltage is placed on the control grid dc bias voltage which provides cancellation of any hum voltage that may appear on the cathode. The high-voltage power supply provides the operating voltages for the screen grid and plate of V1. Extensive RF filtering is provided for both the screen grid and plate voltages. The regulated +300 volt dc screen voltage is applied to the screen grid only when the transmitter is keyed. Screen protection is automatically provided by the power supply. If the screen current were to increase to a value higher than maximum screen current, this increase in current will result in a decrease of screen voltage output from the power supply. This ensures that rated screen dissipation of driver V1 will not be exceeded. Screen current transients which may occur due to the de-energization of key relay K402 are removed by diode CR411 and resistors R446 and R447.

6.20 The output signal from the plate of V1 is developed across the pi-network plate tank circuit. The output capacitance of driver V1, along with L27 and capacitors C88 through C91, forms the interstage pi-network tank. Inductor L27 (DRIVER) is adjusted until the pi-network tank resonates at the carrier frequency. Resonance is indicated by a maximum power output indication

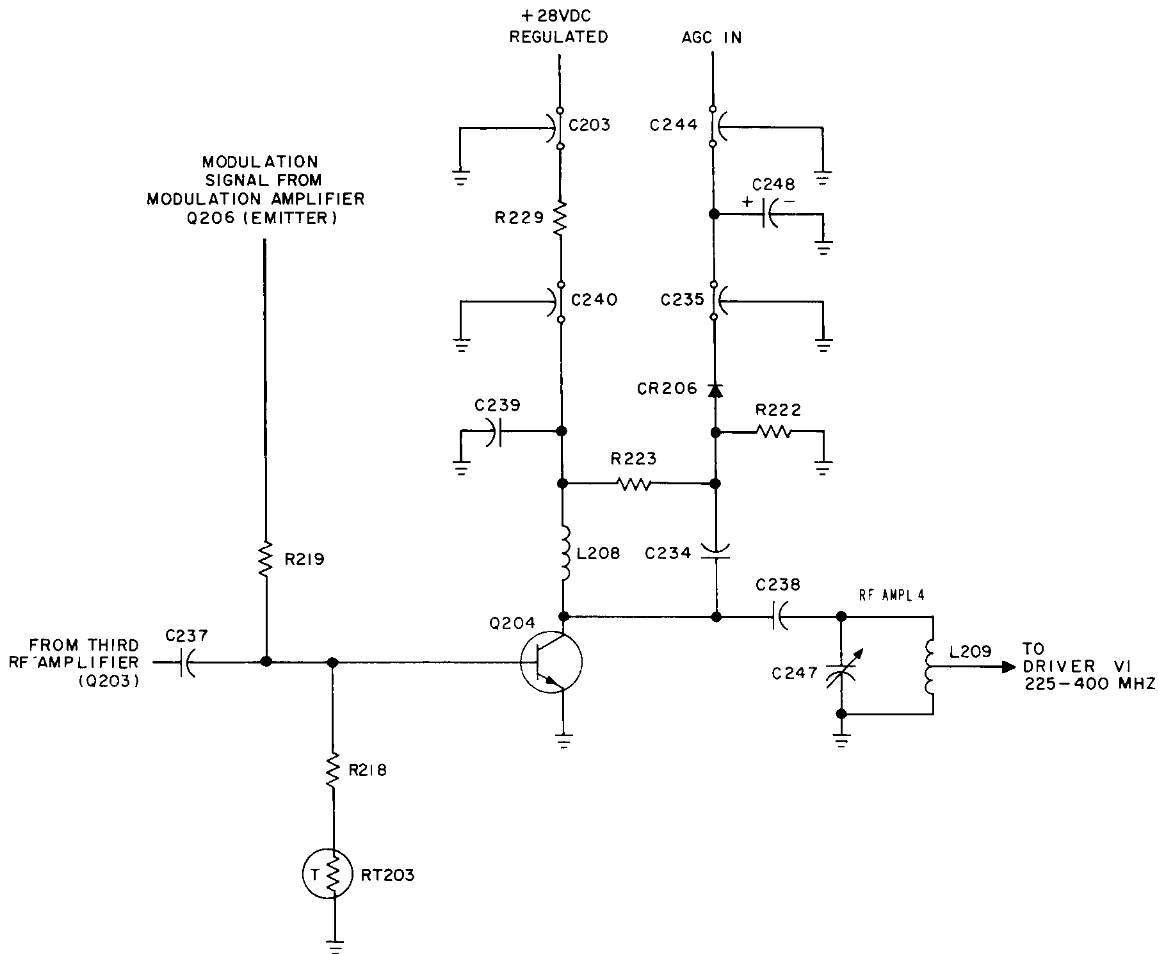

Fig. 10—Fourth RF Amplifier, Simplified Schematic Diagram

on an external wattmeter. Interstage coupling and dc isolation between driver V1 and power amplifier V2 are provided by C58.

Power Amplifier (Refer To Fig. 13)

6.21 The RF signal from the driver plate circuit is applied to the control grid of power amplifier V2. The power amplifier is connected in the grounded cathode configuration and operates as a class AB_1 linear amplifier. A high-voltage gain and a power gain are achieved with this configuration. The control grid bias applied to the grid of V2 is variable and is supplied from the low-voltage power supply. Extensive RF filtering is provided for the 5.87-volt ac filament voltage. The +300 volt dc screen voltage is applied from the high-voltage power supply and is RF filtered by the same components used for the driver tube screen voltage. The output signal from the plate of V2 is developed across the power amplifier cavity.

Power Amplifier Cavity (Refer To Fig. 13, 20, and 21)

6.22 The power amplifier cavity consists of an adjustable foreshortened coaxial quarter-wavelength line. The center conductor of the coaxial line is the adjustable portion. A VHF/UHF band switch positions the center conductor to correspond with the desired mode of frequency operation. The PA TUNE control is used to vary the length of the outer line. With the band switch positioned to UHF, the center conductor of the coaxial line makes contact with plate blocking capacitor C76 at the plate end of the cavity. In this position, the coaxial line consists of only the variable length outer line. Tuning the cavity to

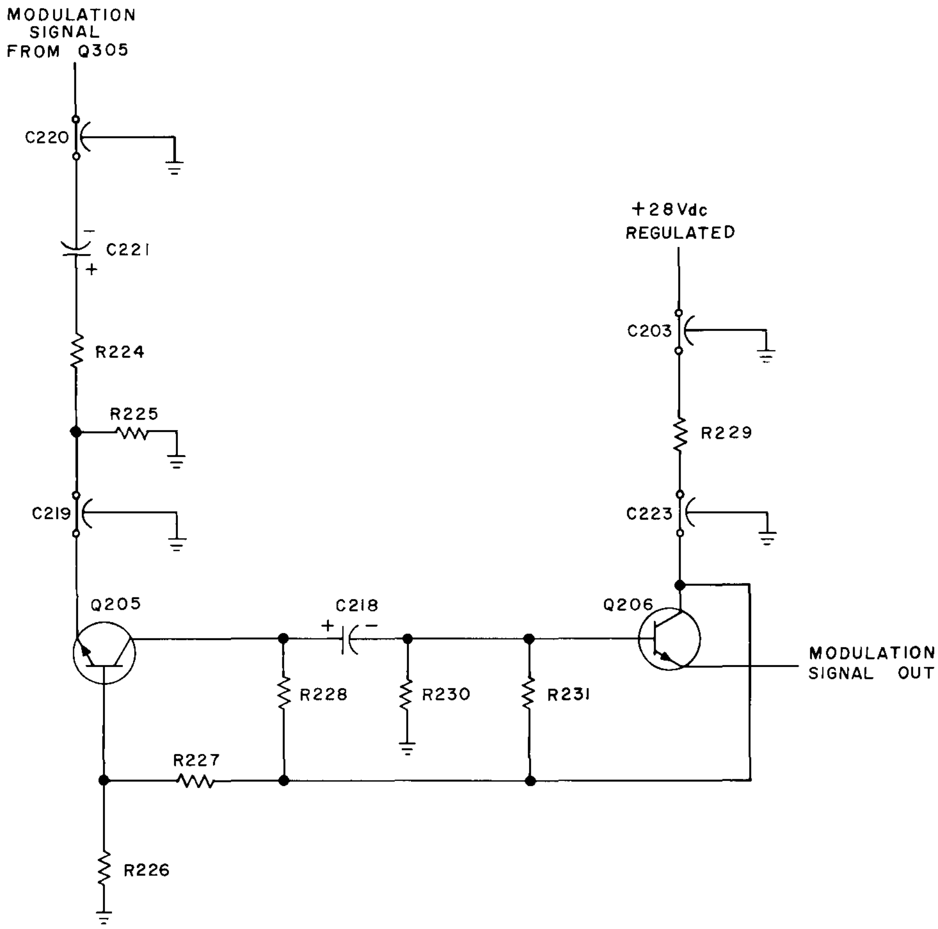

Fig. 11—Modulation Amplifier, Simplified Schematic Diagram

the resonant operating frequency is accomplished by adjusting the PA TUNE control.

6.23 The power amplifier cavity and its associated components also provide a high- to low-impedance match between the power amplifier output and the load. OUTPUT COUPLING capacitor C77 provides output to load coupling. The output is applied through power indicator coupler Z2, a low-pass filter network, and then to the antenna.

Output Circuitry (Refer To Fig. 17, 20, and 21)

6.24 Power indicator coupler Z2 is a 3-element directional coupler inserted between the power amplifier cavity output and the low-pass filter input. Power indicator coupler Z2 provides three sensor functions over the operating frequency range of the transmitter. These functions are forward RF power sensor, reflected RF power sensor, and modulation sensor. Outputs 1 and 3 of Z2 are applied directly to the multimeter circuit. Output 1 provides the multimeter circuit input for the RF POWER position of the MULTIMETER SWITCH, and output 3 provides the input for the VSWR position. Output 2 provides a demodulated audio signal output which is applied to a test point on the modulation panel. The demodulated audio signal is also applied to a modulation percentage calibration circuit only when the MULTIMETER SWITCH is in the % MOD position. The modulation percentage calibration circuit, in turn, provides a dc output to the multimeter circuit. This output is proportional to the amount of audio on the RF carrier at the power amplifier cavity output. In the % MOD position, the meter then indicates the percentage of modulation at the output of the transmitter.

6.25 Harmonic suppression is provided by the low-pass filter connected between power

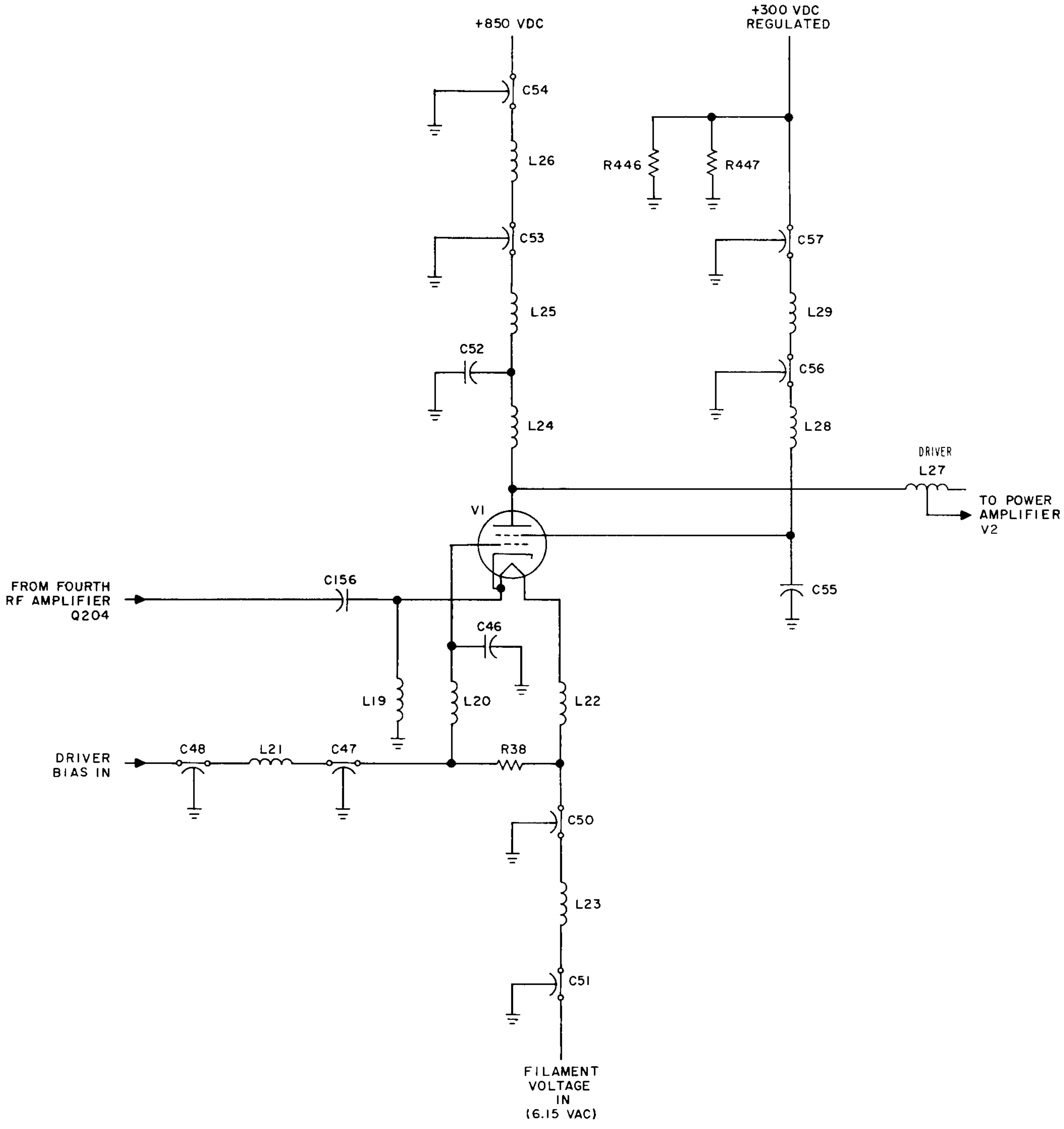

Fig. 12—Driver Stage, Simplified Schematic Diagram

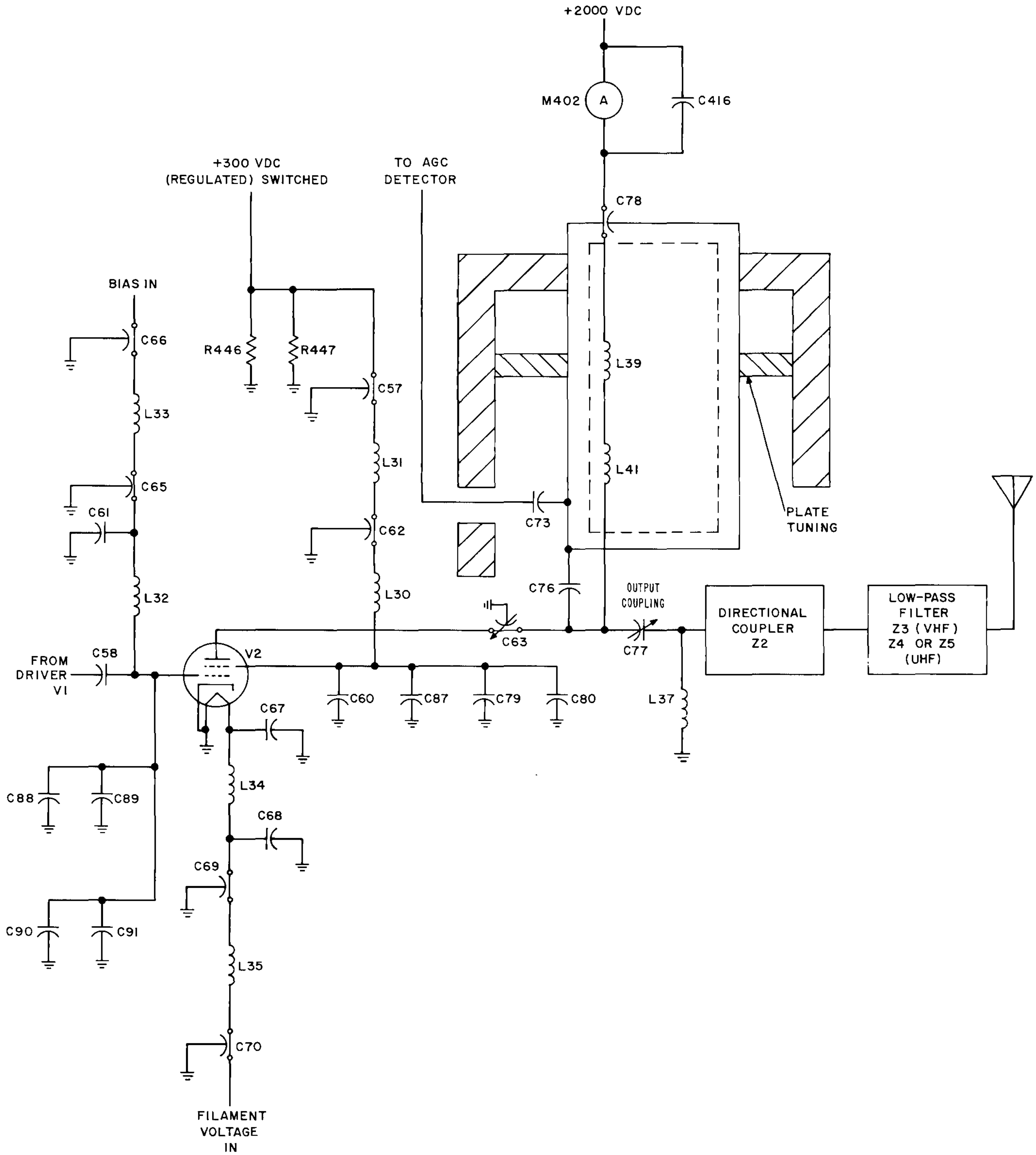

Fig. 13—Power Amplifier and Cavity, Simplified Schematic Diagram

indicator coupler Z2 and the antenna relay. Three filters are available, each of which is designed for a specific frequency range. Two low-pass filters are available. Low-pass filter Z4 covers the range of 225 to 300 MHz, and Z5 covers the range of 300 to 400 MHz. The desired output frequency of the transmitter determines which one of the low-pass filters should be used.

Feedback Circuits

6.26 A sample of the modulated RF output signal is obtained at the power amplifier cavity and is capacitor-coupled to the input of an envelope detector. The envelope detector provides two outputs: one to drive the AGC circuit and one to provide audio feedback to the modulator. These circuits are discussed in the following paragraphs.

AGC Circuit (Refer To Fig. 14)

6.27 The AGC circuit ensures that a constant RF level is provided at the output. A sample of RF signal from the power amplifier cavity is applied to the anode of CR8 in the envelope detector. Resistors R26 and R27 form a voltage divider for the RF signal. Positive AGC bias voltage is applied to the cathode of CR8 from the arm of the AGC BIAS potentiometer, R415. If the RF signal is not being applied to the envelope detector, then the AGC bias voltage will keep CR8 in the reverse biased condition. When an RF signal is applied to the envelope detector, its level must be large enough to overcome the reverse bias voltage at the cathode of CR8. The required level of the RF signal needed to overcome the reverse bias condition of CR8 is determined by the adjustment of the AGC BIAS potentiometer, R415. When CR8 conducts (reverse bias is overcome by the RF level), the resultant output will be rectified RF voltage. This voltage is filtered by C71 and L40. The resultant dc voltage is applied to AGC detector amplifiers Q312 and Q311.

6.28 A 2-stage amplifier is formed by transistor Q312 being connected in the common-emitter configuration, and by Q311 being connected in the common-collector configuration. The output of Q312 is applied directly to the base of Q311. Biasing of Q312 and Q11 is provided by +28 volts dc (regulated) applied through R353 and R354 and the dc signal applied to the base of Q312. The

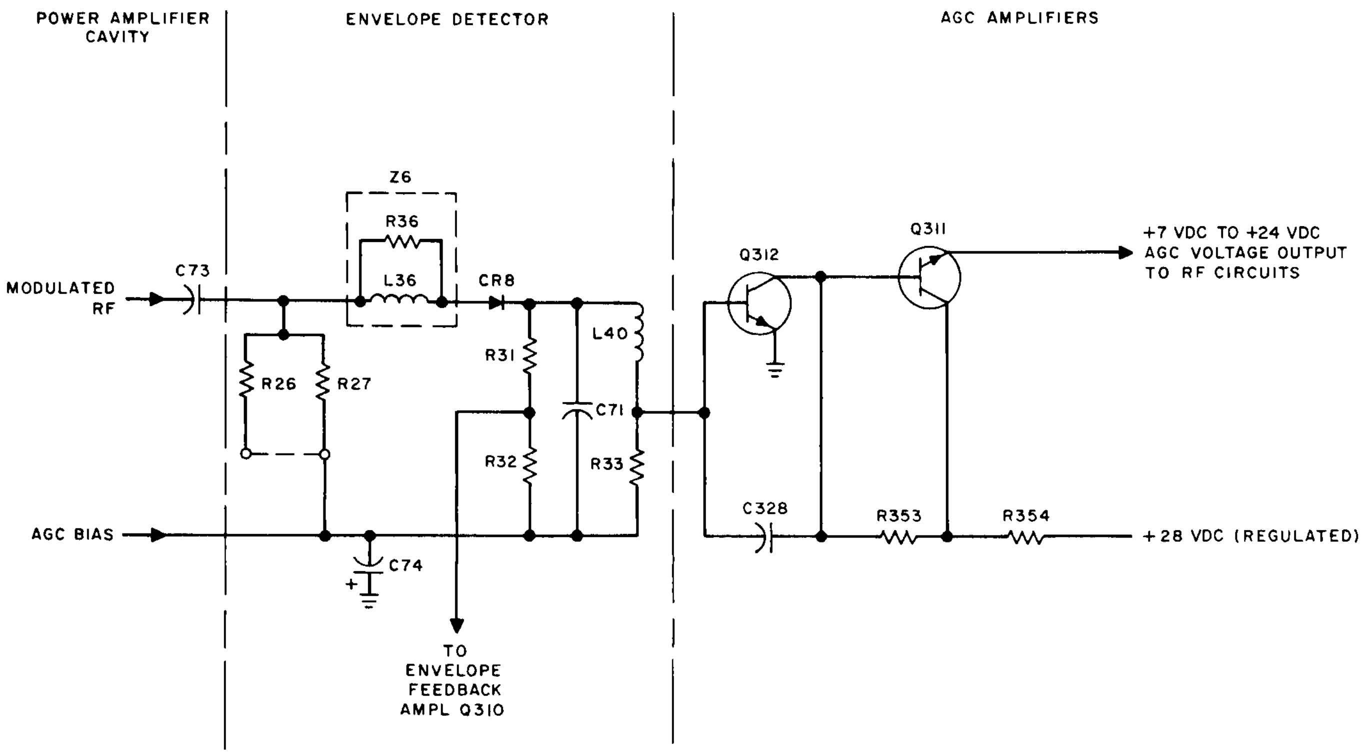

Fig. 14—AGC Circuit, Simplified Schematic Diagram

output of the AGC circuit is taken from the emitter of Q311 and ranges in value from +7 to +28 volts direct current. The output of the AGC circuit is inversely proportional to the RF output.

Envelope Feedback Amplifier (Refer To Fig. 15)

6.29 The envelope feedback circuit ensures that the modulation distortion is held to a minimum. The modulated RF carrier is applied to the envelope detector. The envelope detector output to the envelope feedback circuit is an ac voltage that consists of the detected audio from the modulated RF carrier. The output from CR8 is applied to a voltage divider consisting of R31 and R32. The input to envelope feedback amplifier Q310 is taken from the junction of the two resistors. At this junction point the signal consists of the positive half of the modulated RF carrier. The RF is removed by a filter consisting of C318 and R337. The resulting signal applied to the base of Q310 is the audio modulation signal.

6.30 Transistor Q310 is a conventional common-emitter amplifier. The input signal is applied to the base of Q310 through AUDIO FEEDBACK potentiometer R338. Potentiometer R338 adjusts the amount of ac drive applied to Q310. The output of Q310 is applied to the emitter of modulation driver Q304. Transistor Q304 is also connected in the common-emitter configuration. The signal applied to the emitter of Q304 (from the collector of Q310) is in phase with the signal at the base of Q304. Because the signals at the base and emitter of Q304 are in phase, a reduction of forward bias occurs. The overall gain of Q304 is then decreased. This results in the modulation signal applied to the RF amplifier stages being correspondingly reduced, minimizing any distortion introduced in the RF stages.

Modulator (Refer To Fig. 20)

6.31 Audio signals are applied to the primary winding of input transformer T301. The primary winding consists of two windings and provides impedance matching between the external audio source and the secondary winding. When the primary windings are series connected, the transformer input impedance is 600 ohms. When the windings are parallel connected, the input impedance is 150 ohms. Audio signals are developed across the secondary of T301 and applied to audio amplifier Q301. AUDIO GAIN control R303 provides adjustments of the audio level applied to the modulator.

6.32 The first two stages of the modulator consist of amplifiers Q301 and Q302. These amplifiers are connected in the common-emitter configuration.

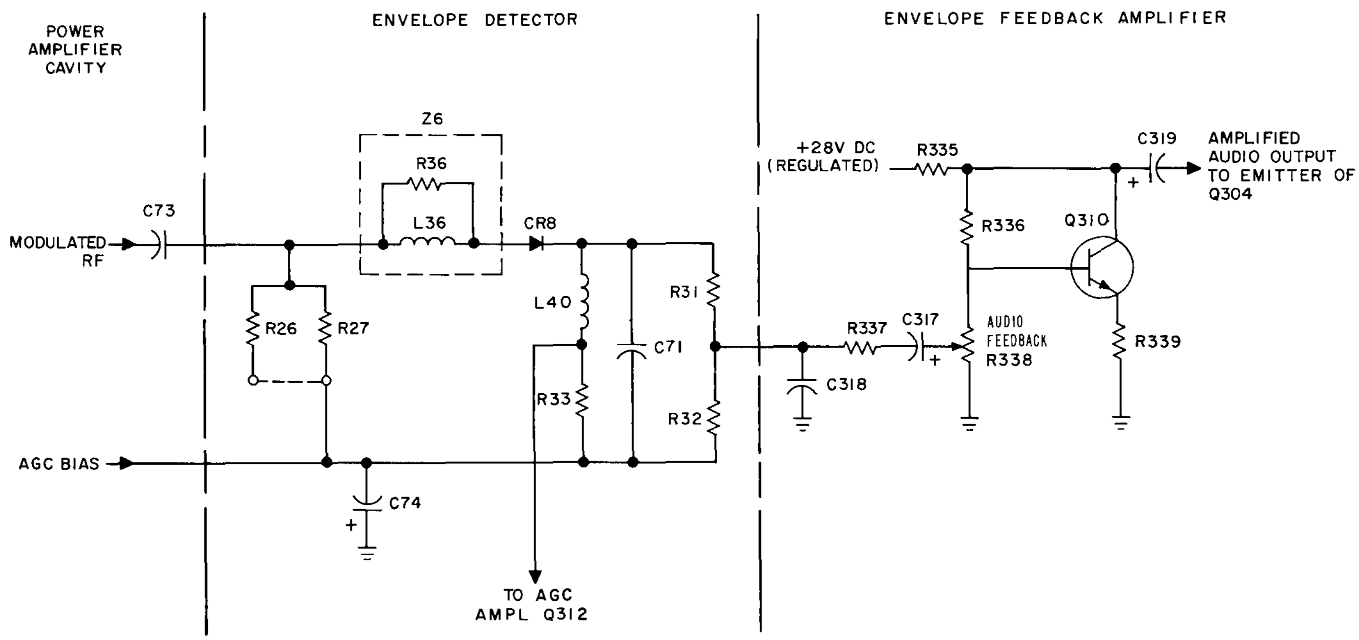

Fig. 15—Envelope Feedback Amplifier, Simplified Schematic Diagram

Audio amplifier Q301 has limiting applied to the base and collector circuits. The limiter is controlled by a 3-stage audio limiter amplifier. A portion of the audio signal from the collector of audio amplifier Q302 is applied to the base of limiter amplifier Q309. The amplified output from Q309 is applied to the base of Q308 through AUDIO LIMITER control R344. AUDIO LIMITER control R344 adjusts the level of the audio signal applied to the limiter. The audio signal is further amplified by Q308, and applied to emitter follower Q307. Transistor Q307 provides impedance matching between audio limiter amplifier Q308 and the input of the limiter. The audio signal at the collector of Q302 is also applied to the remaining stages of the modulator. However, the limiter and its effect on audio amplifier Q301 will be discussed first.

6.33 A closed loop is formed from audio amplifiers Q301 and Q302, through audio limiter amplifiers Q309, Q308, and Q307, through the limiter, and back to Q301. The signal from Q307 is used to control the limiter. This signal is applied to a full-wave rectifier and voltage doubler consisting of CR305, CR306, CR307, CR308, C326, and C327. Rectification of the positive half of the audio signal is provided by CR306 and CR308, and the resulting pulsating dc voltage at the cathode of CR306 is filtered by C326. The negative half of the audio signal is rectified and filtered in the same manner by CR305, CR307, and C327. This dc voltage is used to bias the control diodes of the limiter. CR301, CR302, CR303, and CR304 are two pairs of series-connected control diodes. Due to the polarity of the dc voltage across points A and C, diodes CR301, CR302, CR303, and CR304 are forward biased. The amount of forward bias applied to these diodes is proportional to the audio signal at the emitter of Q307. The dc bias voltage changes in value according to the audio signal level. The amount of dc forward bias determines the impedance of the diodes. This impedance is used to provide the limiting action. When the forward bias is high (due to a large audio signal level), the impedance of the diodes is low. Conversely, a low value of forward bias (due to a small audio signal level) increases the impedance of the diodes. Diodes CR303 and CR304, in conjunction with R312, form a voltage divider for the audio signal at the collector of Q301.

6.34 Limiting occurs when the audio signal increases past a predetermined value (set by AUDIO GAIN and AUDIO LIMITER controls). Assume that the audio signal has increased beyond this point. The dc voltage across points A and C would be large, hence the forward bias applied to CR303 and CR304 would be large. The impedance on CR303 and CR304 would be low, so the audio at point D would be attenuated. This results in less audio being applied to the second audio amplifier, Q302. The output of transistor Q302 would then start to decrease. This decrease would also be applied through audio limiter amplifier Q309, Q308, and Q307, and to the limiter. The dc forward bias applied to CR303 and CR304 would decrease, and the audio at point D would see an increasing impedance to ac ground. This process would continue until such time as the audio signal level at the collector of Q301 reaches the point below the threshold of the limiter. Point E and diodes CR301 and CR302 provide the same function for the base of Q301 as diodes CR303 and CR304 do for the collector circuit. In the base circuit, resistor R304 and the impedance of diodes CR301 and CR302 form the voltage divider. By limiting both the input and output of the first audio amplifier Q301, overmodulation and audio distortion is held to a minimum.

6.35 The limited audio signal is taken from the collector of Q302 and applied to a low-pass filter network. The low-pass filter greatly attenuates audio frequencies above 3000 Hz. The transmitter is supplied with the low-pass filter connected in the modulator circuit. However, wide-band modulation capabilities in the frequency range of 100 to 20,000 Hz are provided by disconnecting the low-pass filter and using the filter bypass jumper. The audio signal is then applied through emitter follower Q303. Transistor Q303 provides impedance matching of the amplified audio signal to the modulator driver, Q304. Modulator driver Q304 is connected in the common-emitter configuration. The output from Q304 is taken at the collector and is applied as two separate modulation levels to modulators Q305 and Q306. Transistor Q305 provides a low-level modulation output while Q306 provides a high-level output.

Metering Circuits (Refer to Fig. 16)

6.36 The transmitter provides a built-in multimeter circuit that permits continuous monitoring of RF levels and dc voltages. The multimeter circuit is included to aid operating and maintenance personnel. All dc bias voltages required may be adjusted to their proper levels by using the multimeter and the potentiometers associated with each bias voltage. The output of each RF stage may be tuned by using the multimeter and the variable capacitors associated with each RF stage. The multimeter also provides an indication of percent of modulation, VSWR, and RF power output. A power amplifier meter, M402, is also provided. This meter is inserted in the +2000 volt dc line going to the power amplifier cavity. The power amplifier meter indicates the plate current of power amplifier tube V2.

Multimeter Circuit (Refer To Fig. 16)

6.37 The multimeter circuit consists of MULTIMETER M401, MULTIMETER SWITCH S409, rectifiers, resistors, voltage dividers, and RF filter components. The multimeter circuit enables operating and maintenance personnel to monitor and adjust numerous transmitter functions. These functions include the tuning of the transistorized RF stages; adjusting the driver, power amplifier, and AGC bias levels; adjusting the percent of modulation; and adjusting the power output level.

Multimeter Switch Positions and Functions

6.38 The following paragraphs describe the purpose of each MULTIMETER SWITCH position. The adjustment controls associated with each switch position are also mentioned. The switch positions are discussed in order beginning with the MULTIMETER SWITCH in the OFF position.

(a) OFF—The positive and negative terminals of M401 are grounded.

(b) BIAS PS X1—The bias output of the low-voltage power supply is applied to the negative terminal of M401 through R417. The resultant indication should be 66 and is read directly from the meter. This check ensures that the proper bias voltage is being applied to the various voltage dividers for the power amplifier bias, driver bias, and AGC bias.

(c) 28 VPS X1/2—The output of the regulated +28 volt dc power supply is applied to the positive terminal of M401 through resistor R431. The resultant meter indication must be divided by 2.

(d) 300 VPS X5—The regulated +300 volt dc portion of the high-voltage power supply output is applied to the positive terminal of M401 by voltage divider R429 and R430. The resultant meter indication must be multiplied by 5.

(e) 850 VPS X10—The +850 volt dc portion of the high-voltage power supply output is applied to the positive terminal of M401 by voltage divider R424 and R425. The resultant meter indication must be multiplied by 10.

(f) 2000 VPS X40—The +2000 volt dc portion of the high-voltage power supply output is applied to the positive terminal of M401 through resistor R432 and by voltage divider R433, R444, R445, and R423. The resultant meter indication must be multiplied by 40.

(g) OSC—In this position, the output of a Darlington dc amplifier circuit in a crystal oscillator stage is applied to the positive terminal of M401. By using the tuning elements in the crystal oscillator circuit and M401, the crystal oscillator may be tuned precisely to resonance. When the crystal oscillator is not tuned to resonance, a voltage drop will appear across the crystal. This voltage is applied to a detector circuit consisting of oscillator meter detectors CR1 and CR2 and detector balance resistor R5. The detected signal is filtered and applied to the dc amplifier circuit. The output of amplifiers Q5 and Q6 is developed across emitter resistors R11 and R12. The junction of these two resistors provides the output signal that is applied to the positive terminal of M401. The tuning elements are adjusted until the meter indication is minimum (dip).

(h) BUFFER—A sample of the collector output signal from Q2 is detected by rectifier CR3 before being applied through R433 to the positive terminal of M401. Capacitor C18 provides RF coupling, and resistor R17 is the detector load. The buffer stage is tuned to the appropriate crystal frequency by adjusting BUFFER tuning capacitor C20 and observing M401 for a maximum indication.

(i) DBLR 1—A sample of the collector output signal from Q3 is detected by rectifier CR4 before being applied through R434 to the positive terminal of M401. Capacitor C28 provides RF coupling, and resistor R21 is the detector load. The first doubler stage is tuned to twice the

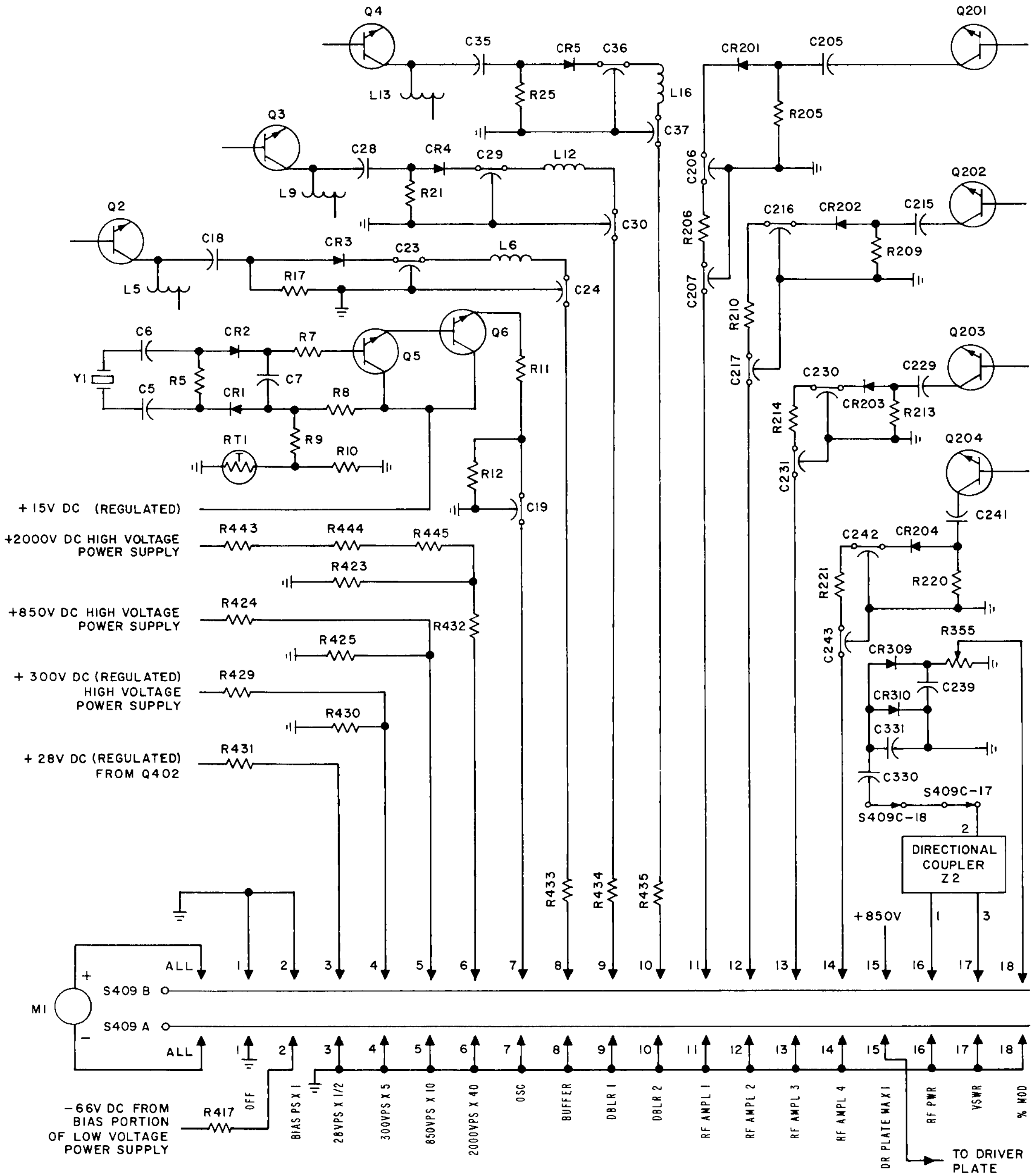

Fig. 16—Multimeter Circuits, Simplified Schematic Diagram

crystal frequency by adjusting DBLR 1 tuning capacitor C31 and observing M401 for a maximum indication.

(j) DBLR 2—A sample of the collector output signal from Q4 is detected by rectifier CR5 before being applied through R435 to the positive terminal of M401. Capacitor C35 provides RF coupling, and resistor R25 is the detector load. The second doubler stage is tuned to four times the crystal frequency by adjusting DBLR 2 tuning capacitor C38 and observing M401 for a maximum indication.

(k) RF AMP 1—This stage performs a dual function. In addition to being an RF amplifier, Q201 is also a doubler stage. A sample of the collector output signal from Q201 is detected by rectifier CR201 before being applied to the positive terminal of M401. Feedthrough capacitors C206 and C207 provide RF filtering, and resistor R206 provides attenuation. The first RF amplifier/third doubler stage is tuned to eight times the crystal frequency by adjusting RF AMP 1/DBLR 3 tuning capacitor C208 and observing M401 for a maximum indication.

(l) RF AMP 2—A sample of the collector output signal from Q202 is detected by rectifier CR202 before being applied to the positive terminal of M401. Feedthrough capacitors C216 and C217 provide RF filtering, and resistor R210 provides attenuation. The second RF amplifier is tuned to the operating frequency by adjusting RF AMP 2 tuning capacitor C222 and observing M401 for a maximum indication.

(m) RF AMP 3—A sample of the collector output signal from Q203 is detected by rectifier CR203 before being applied to the positive terminal of M401. Feedthrough capacitors C230 and C231 provide RF filtering, and resistor R214 provides attenuation. The third RF amplifier is tuned to the operating frequency by adjusting RF AMP 3 tuning capacitor C236 and observing M401 for a maximum indication.

(n) RF AMP 4—A sample of the collector output signal from Q204 is detected by rectifier CR204 before being applied to the positive terminal of M401. Feedthrough capacitors C242 and C423 provide RF filtering, and resistor R221 provides attenuation. The fourth RF amplifier is tuned to the operating frequency by adjusting RF AMP 4 tuning capacitor C247 and observing M401 for a maximum indication.

(o) DR PLATE MA X1—A sampling of the driver tube plate current passing through R439 is applied to M401. The indication of the M401 is the driver plate current in milliamperes.

(p) RF PWR—The forward RF power sensor output from directional coupler Z2 is applied directly to the positive terminal of M401. With the MULTIMETER SWITCH in the RF PWR position, M401 functions as a wattmeter. The indication on the top scale of M401 is the RF power output measured in watts.

(q) VSWR—The reflected RF power sensor output from directional coupler Z2 is applied directly to the positive terminal of M401. With the MULTIMETER SWITCH in the VSWR position, M401 functions as a reflected power wattmeter. The indication on M401 indicates the VSWR at the output.

(r) % MOD—The modulation power sensor output from directional coupler Z2 is a demodulated audio signal that is applied to a modulation percentage calibration circuit only when the MULTIMETER SWITCH is in the % MOD position. Percent of modulation is indicated on the top scale of M401 after R355 has been adjusted to calibrate the known percent of modulation to the M401 indication. The known percentage of modulation can be determined by displaying the modulated RF carrier on an oscilloscope.

Power Supplies (Refer To Fig. 19)

6.39 The transmitter contains two power supplies that furnish all of the required ac and dc operating voltages. These power supplies consist of a low- and a high-voltage supply, and provide nine operational dc voltages. In addition, two ac filament voltages and an ac crystal oven heater voltage are provided. All voltages are derived from two separate power supplies. One power supply contains high-voltage transformer T401, and the other supply contains low-voltage transformer T402.

6.40 Transformer T401 contains two secondary windings. The output of each winding is applied to a full-wave rectifier bridge (CR409 or CR410). The output from CR409 is filtered by a pi-section LC filter. The resultant output from this supply is unregulated +2000 volts dc which is applied to the plate of power amplifier V2. The output from CR410 is also filtered and provides unregulated +850 volts dc which is applied to the plate of driver V1. A center tap is provided on the +850 volt dc secondary winding which provides the source for the +300 volt dc supply. The voltage at this tap is applied to an RC filter network consisting of resistors R426, R427, and R428 and capacitors C413 and C414. The output is regulated by diode regulators VR406 and VR407. The +300 volt dc output is then applied through a set of contacts on key relay K402 to the screens of driver V1 and power amplifier V2. All three voltages from the high-voltage power supply are monitored by the multimeter circuit.

6.41 Low-voltage transformer T402 has four secondary windings. Two of these windings provide the ac filament and heater voltages for driver V1, power amplifier V2, and crystal oven heater Z1. Each of the remaining two secondary windings is connected to a full-wave bridge rectifier. The output from CR401 through CR404 provides +48 volts dc for the control of key relay K402 and antenna relay K403. The output from the same bridge rectifier is filtered by capacitor C402 before being applied to a series regulator circuit. The base of the first series regulator, Q401, is clamped at +39 volts dc by diode regulator VR401. The base of the second series regulator, Q402, is clamped at +30 volts dc by diode regulator VR402. The emitters of Q401 and Q402 are held at constant voltage levels due to the diode regulators on their respective bases.

6.42 Therefore, if the output load current should vary, the output voltage would be maintained at a level of 28 volts. The +15 volt dc supply for the crystal oscillator and the multimeter amplifier circuit is derived by placing diode regulator VR405 across the +28 volt dc output. The output from bridge CR405 and through CR408 provides the source voltage for the bias supplies. After preregulation to -75 volts dc by a series regulator circuit, the bias supply voltage is clamped to -66 volts dc by diode regulators VR403 and VR404. At the junction of these diodes the voltage is -33 volts dc. The power amplifier bias voltage range is established by applying -66 volts dc to one end of PA BIAS control R416 and -33 volts dc to the other end. The AGC bias voltage range is established by first applying -33 volts dc through R422 which drops the voltage to -15 volts dc. This reduced voltage is then applied to the end of AGC BIAS control R415, the other end of which is at ground potential (0-volt dc). The driver bias is established by applying -33 volts dc through R418 which then reduces the voltage to -24 volts dc. This reduced voltage is applied to one end of DRIVER BIAS control R419. R421 maintains the other end of R419 at -7 volts dc with respect to ground. Thus the range for R419 will be between -7 and -24 volts dc.

Control Circuits, Local Operation (Refer To Fig. 18)

6.43 The transmitter provides circuitry for either local or remote controlled operation. The local operation control circuitry may be used when the transmitter is installed at an operator's position. Local operation control circuitry is also employed during initial tuning and adjustment, and during troubleshooting procedures.

6.44 Local operation is initiated by positioning local-remote switch S402 to OFF, POWER switch S401 to ON, and PLATE switch S403 to on. Ac power is applied directly to the primary winding of low-voltage transformer T402. A reduced ac power is applied to the primary of high-voltage transformer T401 for a period of approximately 75 to 100 milliseconds. Inserted in one side of the ac line at the primary of T401 is a step-start circuit consisting of K401, CR412, R453, R436, and C419. This circuit prevents pitting and burning of PLATE switch S403 contacts due to surge current during turn on. The low- and high-voltage power supplies will provide the following outputs:

(a) Low-Voltage Power Supply Outputs

(1) Unswitched regulated +28 volts dc to the modulator circuit and exciter module

(2) Ac filament voltages to the driver and power amplifier tubes

(3) Ac heater voltage to the crystal oven

(4) Unregulated +48 volts dc to one side of the coil on key relay K402 (and antenna relay K403).

(b) High-Voltage Power Supply Outputs

(1) Unregulated +850 volts dc to the driver plate

(2) Unregulated +2000 volts dc to the power amplifier plate.

(c) The following indicators will also light at this time:

(1) POWER indicator DS403

(2) PLATE indicator DS402

(3) CRYSTAL HEATER indicator DS401.

6.45 The transmitter may now be keyed in one of two ways. The first method requires that a low-impedance microphone be connected between TB401-3 and TB401-4, and the local-remote switch S402 be positioned to LOCAL KEY. The second keying method for local operation involves inserting a low-impedance push-to-talk microphone into MIKE jack J301 and positioning local-remote switch S402 to OFF. Regardless of which method is used to key the transmitter, a ground is applied to the other side of the key relay (K402) coil, causing K402 to actuate. When K402 actuates, the following events occur simultaneously.

(a) Switched regulated +300 volts dc is applied to the driver and power amplifier screens through contacts 1 and 2 of K402.

(b) Switched regulated +28 volts dc is applied to the buffer amplifier stage, and to the first and second doubler stages through contacts 3 and 4 of K402.

(c) Switched regulated +15 volts dc is applied to the crystal oscillator. This voltage is derived from the switched regulated +28 volts dc (controlled by contacts 3 and 4 of K402).

(d) Contacts 5 and 6 of K402 close and provide control for an auxiliary circuit if desired.

(e) Interconnected contacts 9, 10, 11, and 12 of K402 close and complete the ac circuit for blower B401, causing B401 to operate.

6.46 Capacitor C401 and resistor R403 provide arc suppression for contacts 9, 10, 11, and 12 when K402 actuates or de-energizes. Thermal switch S407 and resistor R405 form a protection circuit for the driver and power amplifier tubes. In the event that blower V401 or fuse F403 fails, the heat dissipated by R405 will cause thermal switch S407 to open. When this occurs, the +48 volt dc power applied to key relay K402 is removed, causing K402 to de-energize. This removes the +300 volt dc driver and power amplifier screen voltage the, +28 volts dc applied to the buffer and doubler stages, and the +15 volts dc applied to the crystal oscillator. The transmitter is then inoperative and will remain so until cooling air is restored.

Control Circuits Remote Operation (Refer To Fig. 18)

6.47 The remote control circuitry is employed when the transmitter is installed at a site that is remote from the operating position. All theory discussed is also applicable to the remote control circuitry with the exception of the method of keying. Local-remote switch S402 must be positioned to REMOTE. The transmitter may now be remotely keyed in one of two ways. The first method uses the internal +48 volt dc supply for key relay power. The jumpers on TB402 are connected as shown. When the push-to-talk switch is pressed, terminal 8 of key relay K402 becomes grounded, causing K402 to actuate. The second keying method for remote operation involves the use of an external +48 volt dc supply. This method of keying can be used only if the jumpers between TB402-1 and 2, and TB402-3 and 4 are removed. It is then necessary to install a jumper between TB402-1 and 3 to complete the key relay circuit. When power is applied to the external +48 volt dc supply, key relay K402 actuates. The sequence of events that occurs after K402 actuates is the same as previously discussed.

7. ASSOCIATED APPARATUS

7.01 ***Station Guardian SG-34 (Refer to Fig. 17)*** The Microwave Devices Station Guardian, Model SG-34 is used in base station installations for the Military Airlift Circuits (MAC). Its purpose is to provide an alarm signal at a location remote from the transmitter under conditions of transmitter malfunction.

7.02 The station guardian model SG-34 is a rack-mounted unit designed for use with a radio transmitter and antenna system. It is used in monitoring RF incident power output, reflected

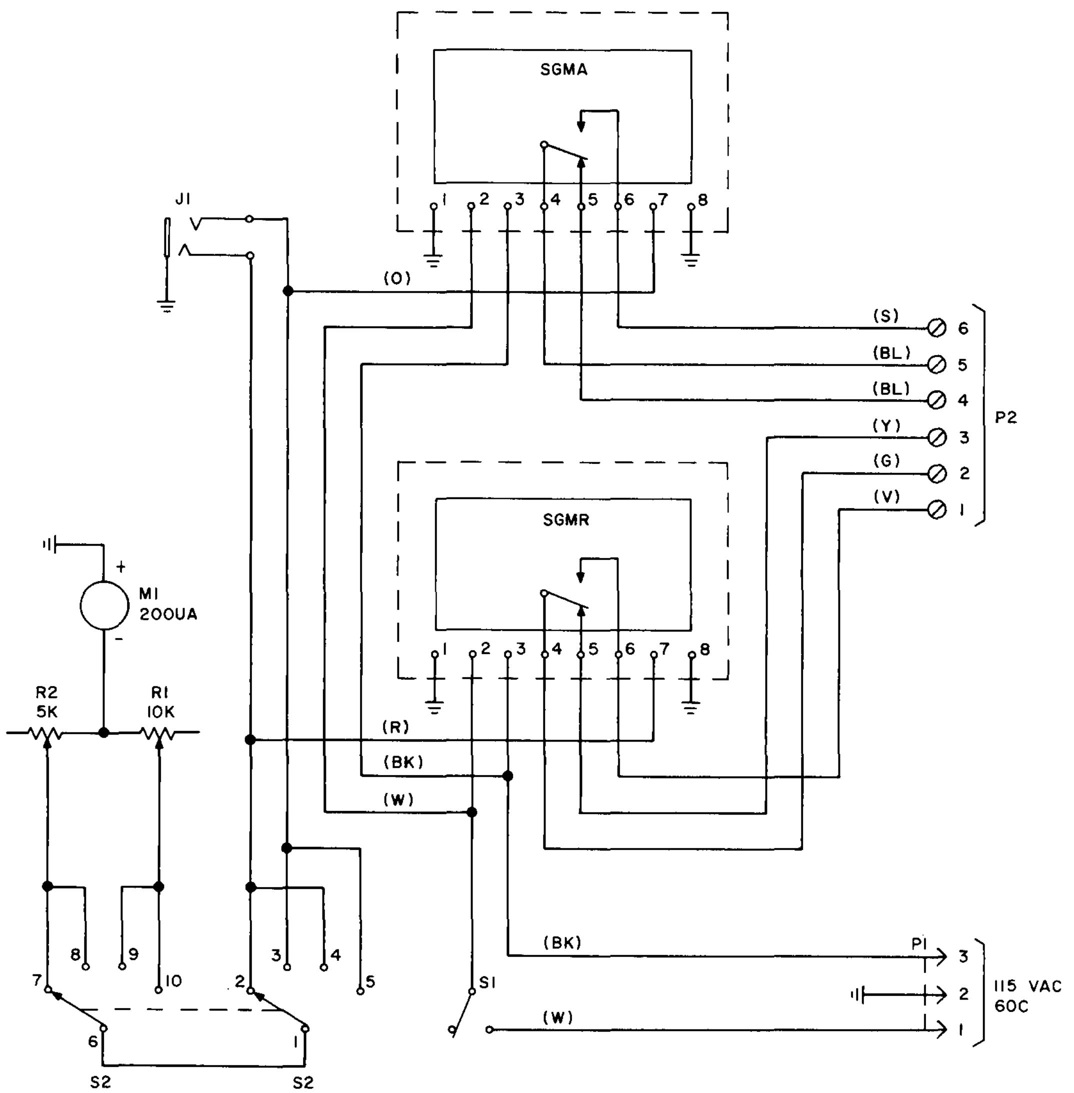

Fig. 17—SG-34 Station Guardian, Schematic Diagram

power, and standing-wave ratio for the purpose of protecting transmitter and antenna from damage caused by abnormal load conditions.

7.03 The unit consists basically of two solid-state modules. Input to these modules is obtained from a standard MicroMatch directional coupler or equivalent pick-up device which provides 0- to 1-volt dc samples of incident and reflected power from the transmitter-to-antenna transmission line. The incident power sample is applied to one module and the reflected power sample to the other. The output of each module operates a relay which controls a warning light on the front panel of the unit. The incident power alarm is an amber lamp which remains "on" unless the power output falls below a preset level. The Voltage Standing Wave Ratio (VSWR) alarm is a red lamp which lights if the relected power rises above a preset level. A direct reading meter having "WATTS" and "STANDING WAVE RATIO" scales is located on the front panel of the unit along with the necessary controls. Adjustment screws used in setting the warning light operating levels are accessible through the front panel.

7.04 Spare contacts are provided on the relays for use according to individual requirements. These may be used to actuate a nearby or distant audible alarm system as well as to reduce or cut off power to the transmitter whenever load conditions or RF power output change enough to threaten damage. Connections to the spare contact are brought out to a terminal strip located on the rear panel of the unit. No internal change is necessary in the unit when used with external alarms or transmitter protective devices.

7.05 Power to operate the unit is 115 volt 50/60 cycle ac. The internal power supply permits stable operation with line fluctuations of 105 to 125 VAC. Power consumption is approximately 5 watts.

7.06 The SG-34 is designed to monitor RF power from 40 watts to 40 kilowatts. The precise range covered is determined by the MicroMatch coupler or instrument to which the SG-34 is connected. A 0 to 200 microampere meter is used to give a direct reading of incident power, reflected power, or VSWR as desired. Power readings are accurate within ±5% full scale, depending on the coupler used. The controls can be set to cause the relays to operate with a change of incident or reflected power of 5% or less. Two relay circuits are provided, one associated with the VSWR alarm, and the other associated with the RF forward power alarm. Each relay is provided with a spare single pole, double-throw type contact rated at 1 ampere at 125 volts for use as desired to actuate external alarms and protective devices.

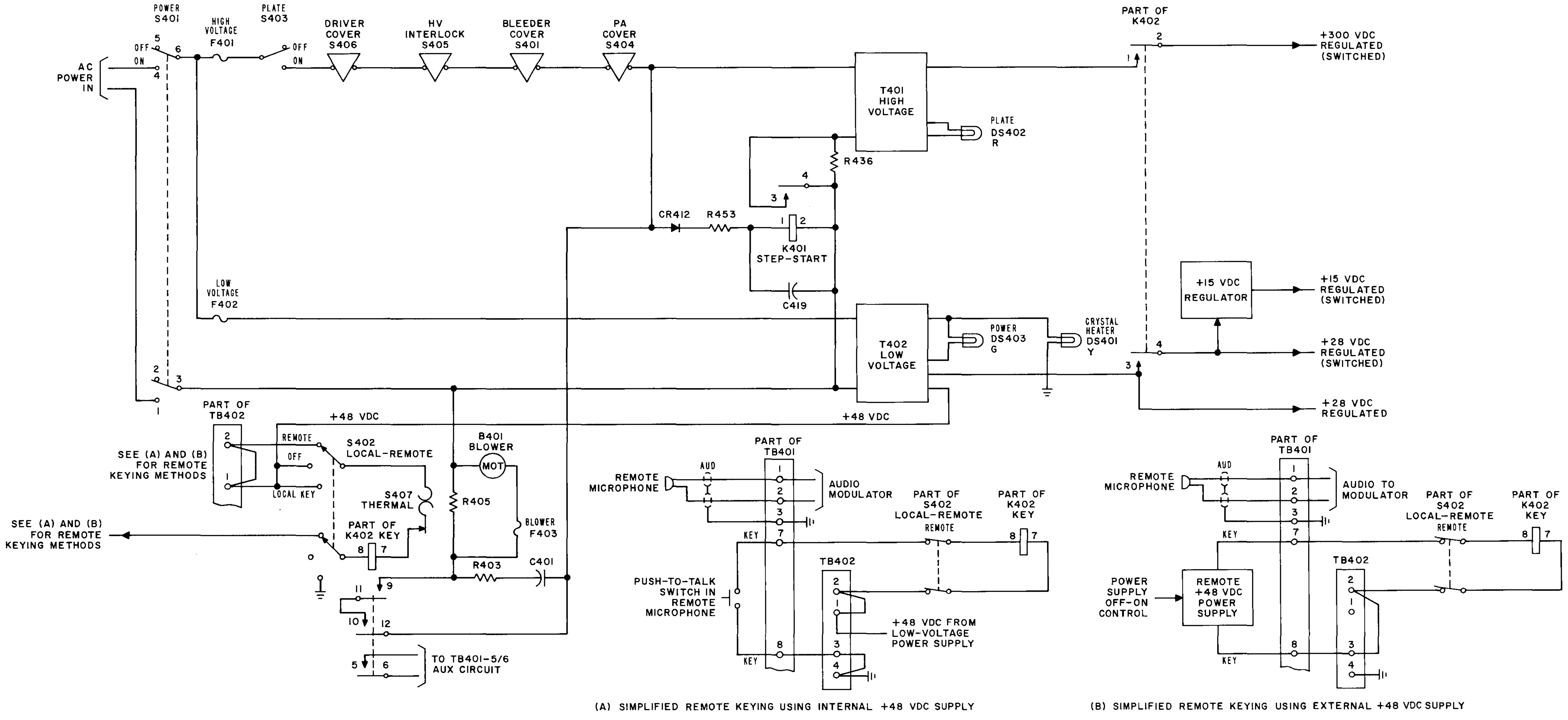

Fig. 18—Control Circuits, Simplified Schematic Diagram

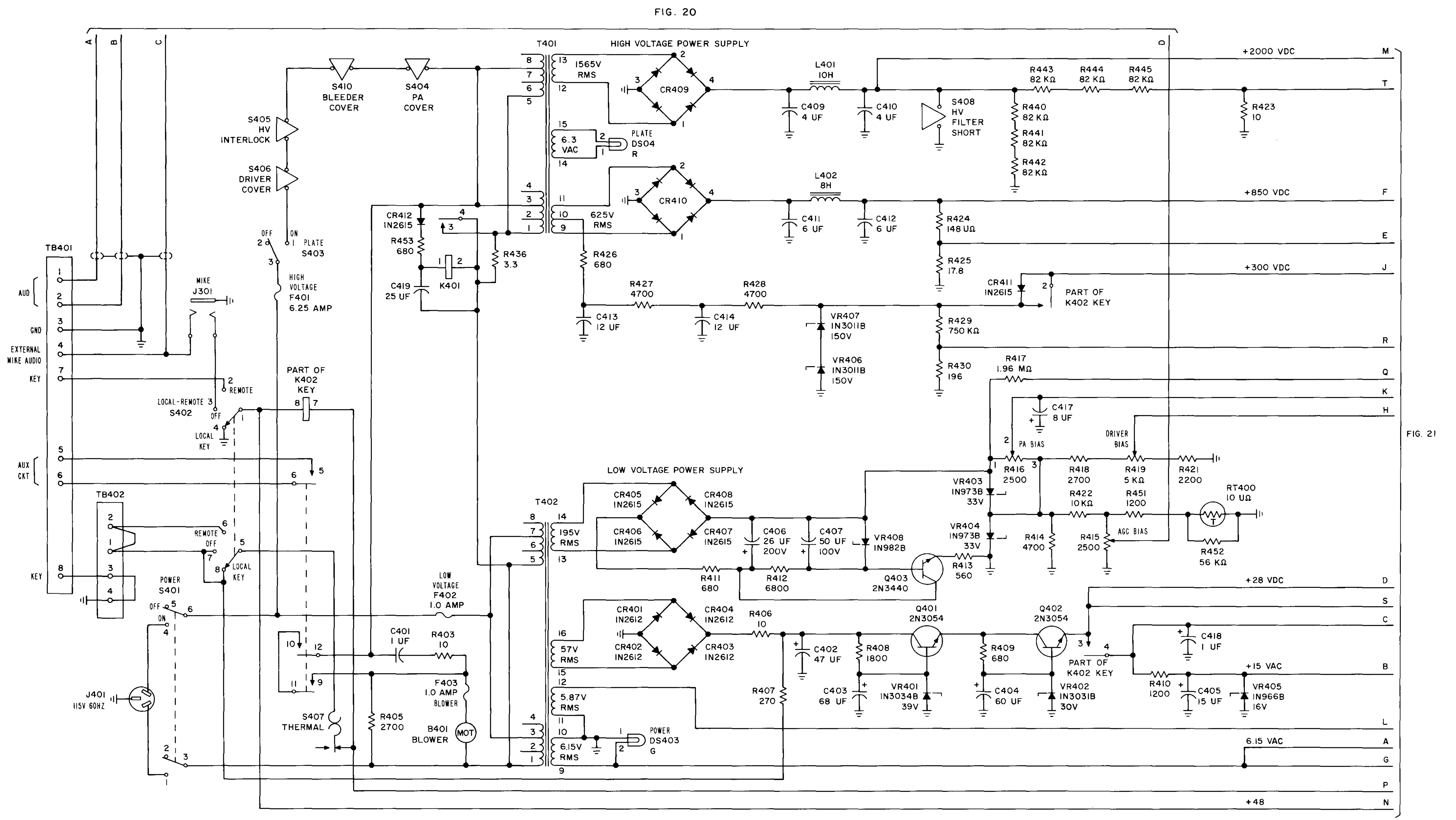

Fig. 19—Transmitter Power Supply, Schematic Diagram

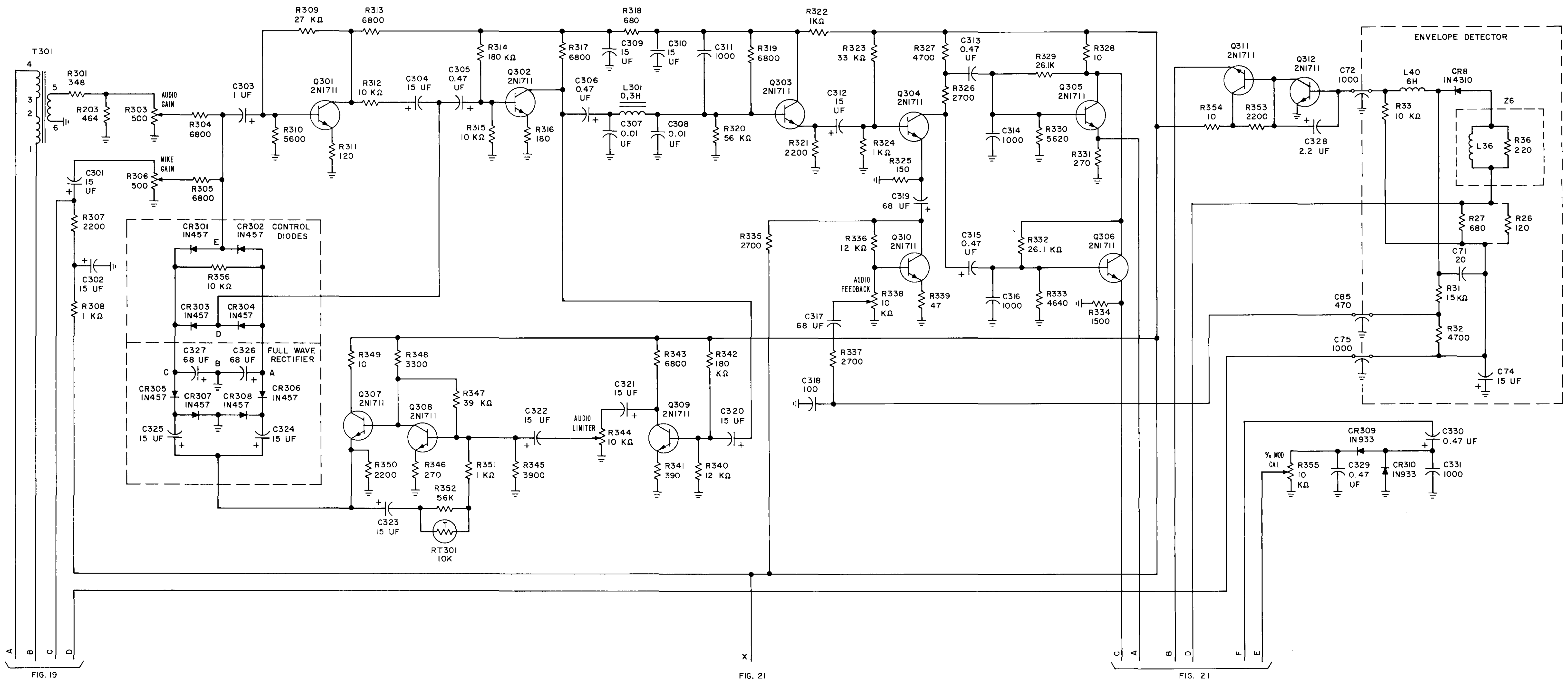

Fig. 20—Transmitter Audio and Modulator, Schematic Diagram

Fig. 21—RF Transmitter, Schematic Diagram