CHAPTER 2

THEORY

Section I. BLOCK DIAGRAM

7. General

Radio sets AN/PRC–9A and –10A consist of a battery (not supplied with the sets), a long or short antenna, and a receiver-transmitter. The receiver-transmitter includes an fm receiver, an fm transmitter, and a calibration circuit. The block diagram (fig. 4) shows the signal paths for each of these circuits.

8. Receiver Signal Path

(fig. 4)

A frequency-modulated (fm) signal picked up by the antenna in use is applied to first radiofrequency (rf) amplifier stage V4. The signal is further amplified by second rf amplifier V5 and applied to mixer stage V6. The incoming rf signal and the receiver oscillator signal heterodyne (beat together) in mixer stage V6 to produce an intermediate frequency (if.) of 4.3 megacycles (mc). This if. signal is amplified by the four if. amplifier stages (V101). These stages are contained in sealed cans V101 through V104 (fig. 32). The output of the fourth if. is at a constant amplitude and is fed to discriminator circuit T101 which converts if. signals to audio signals. The audio signals are amplified by audio amplifier V7 and are applied to the earphone of the handset.

A squelch circuit, which can be turned on or off, is used with the receiver. This circuit prevents tube and background noises from reaching the handset during intervals when no signal is reaching the receiver.

9. Transmitter Signal Path

(fig. 4)

a. Voice signals from the microphone of the handset (push-to-talk button in) are fed directly modulator stage V2. Here they are amplified and then applied to the transmitter oscillator circuit to vary its output frequency (fm). The transmitter oscillator output is applied through the antenna circuit to one of three antennas that may be used with the radio set.

b. Transmitter oscillator V3 is tuned from the control panel to operate at a frequency of 4.3 mc below that of the receiver oscillator. A portion of the transmitter oscillator output beats with receiver oscillator V8 in mixer stage V6. When the transmitter oscillator is on frequency, the mixer output is exactly 4.3 mc. This beat frequency is fed through the if. stages to the discriminator, which controls the transmitter oscillator frequency. When the mixed if. signal is exactly at 4.3 mc, the transmitter oscillator is locked in at its assigned frequency.

c. When the transmitter oscillator is off frequency, the mixer if. signal is either above or below 4.3 mc. This causes a frequency control voltage to be developed in the discriminator, which changes the bias of modulator tube V2. The plate current of the modulator tube therefore changes and causes the transmitter oscillator frequency to change in a direction opposite to its drift. Because of this automatic frequency control (afc) the transmitter oscillator frequency is constantly controlled at a frequency of 4.3 mc lower than that of the receiver oscillator frequency circuit. Further correction of the transmitter oscillator frequency is provided by a pulse-sweep generator circuit which operates whenever the frequency is beyond the control of the discriminator (about 80 kilocycles (kc) deviation) (as, for example, when the equipment is initially turned on). When the pulse-sweep generator operates, a low-frequency putt-putt sound can be heard in the earphone of the handset. This circuit very slowly varies the

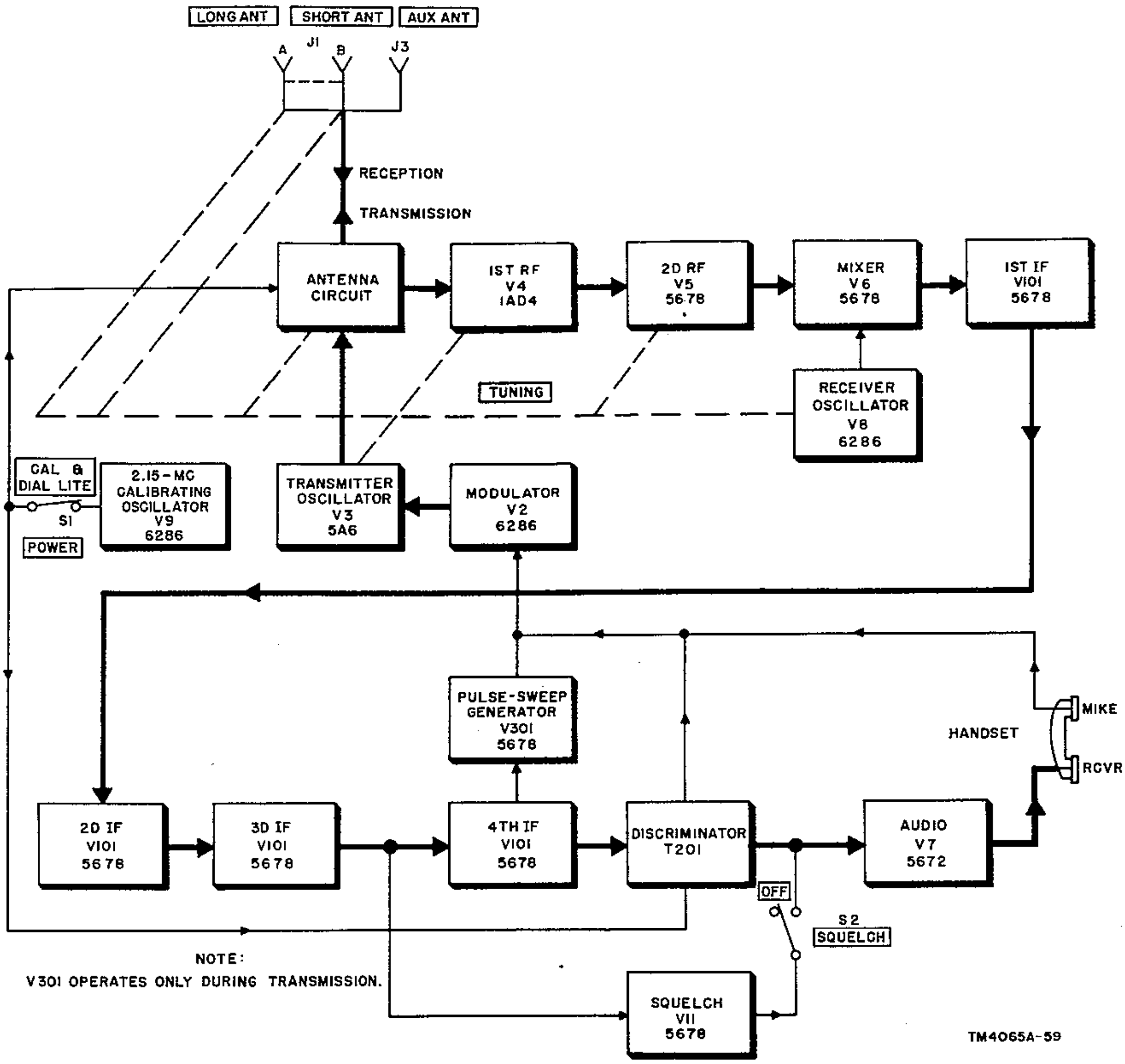


Figure 4. Radio sets AN/PRC-9A and -10A receiver-transmitter, block diagram.

transmitter oscillator frequency up to about 750 kc below and above the center frequency, until the transmitter frequency comes within range of the discriminator. The discriminator then takes over control and the pulse-sweep generator operation ends.

10. Calibration Signal Path

a. The 2.15-mc calibrating oscillator (V9) is a crystal-controlled oscillator used to aline the receiver-transmitter. Harmonics of the 2.15-mc calibrating oscillator are coupled to the rf and mixer circuits when POWER switch S1 is held in the CAL & DIAL LITE position (fig. 3). For example, if the receiver is tuned to a red-marked indication on the dial, such as 51.6 mc (or 35.6 mc on the AN/PRC-9A), the twenty-fourth harmonic of the 2.15-mc calibrating oscillator is picked up in the antenna circuit of the receiver. This 51.6-mc signal, after amplification in the receiver rf stages, beats with the receiver oscillator signal to produce an if. output from the mixer tube. The output is at 4.3 mc, or slightly off this frequency if the receiver is not correctly alined.

This signal is amplified through the four if. stages and applied to discriminator stage T201.

b. The output of 2.15-mc calibrating oscillator V9 is also fed into the discriminator circuit. Here its second harmonic frequency of 4.3 mc mixes with the incoming if. signal received through the if. stages. The beat frequency of these two signals is passed through audio amplifier V7 to the earphone of the handset. If the radio receiver is correctly alined, the incoming if. signal will be at exactly 4.3 mc, and a zero beat results. However, if the radio receiver is not correctly tuned, the receiver oscillator frequency will not be 4.3 mc above the rf frequency to which the TUNING dial is set and the incoming if. signal will be slightly off 4.3 mc. Hence when it beats with the 4.3-mc signal from the calibrating oscillator, an audio beat will result and be heard in the earphone of the handset.

c. If the rf and receiver oscillator tuned circuits are then varied slightly by means of the TUNING control a zero beat is obtained in the handset. The dial of the receiver is now slightly off 51.6 mc because of the TUNING control adjustment. Alinement of the receiver is accomplished by mechanically setting the dial pointer exactly on the 51.6-mc calibration point on the dial. This calibration insures that the receiver oscillator frequency is exactly 4.3 mc above the frequency shown on the dial of the receiver-transmitter and that the dial reading is correct. It also insures the accuracy of the transmitter frequency which is controlled with reference to that of the receiver oscillator.

Section II. RECEIVER STAGES

11. Antenna Circuit
(fig. 5)

a. The antenna circuit is used for both transmitting and receiving. Any one of four antennas can be used. The long whip antenna (AT–271A/PRC) plugs into the LONG ANT connector J1A. Its circuit is tuned by coil L6 and adjusted by variable capacitor C12 (C12 is ganged with main TUNING capacitor C9). The short antenna (AT–272A/PRC) plugs into SHORT ANT connector J1B, and is tuned by coil L7 (L7 is also ganged with C9). An auxiliary antenna (TM11–612, par 11*d*.) plugs into AUX ANT connector J3. A homing antenna may also be plugged into the AUX ANT connector J3. When the long antenna is plugged into the LONG ANT connector J1A, a shorting strap on the plug of the long antenna connects C12 and L6. The signal picked-

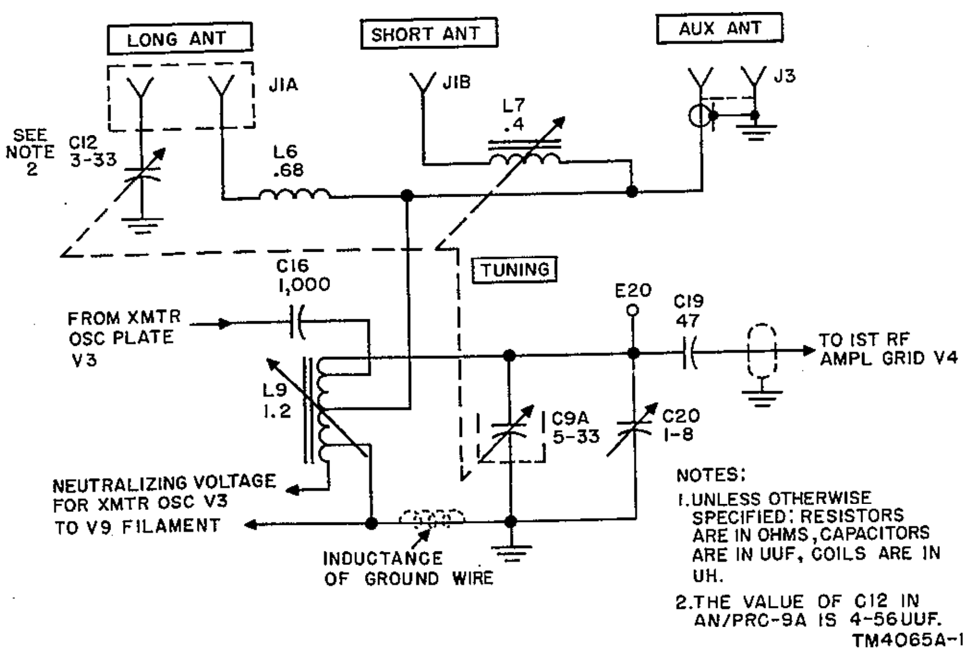


Figure 5. Antenna circuit.

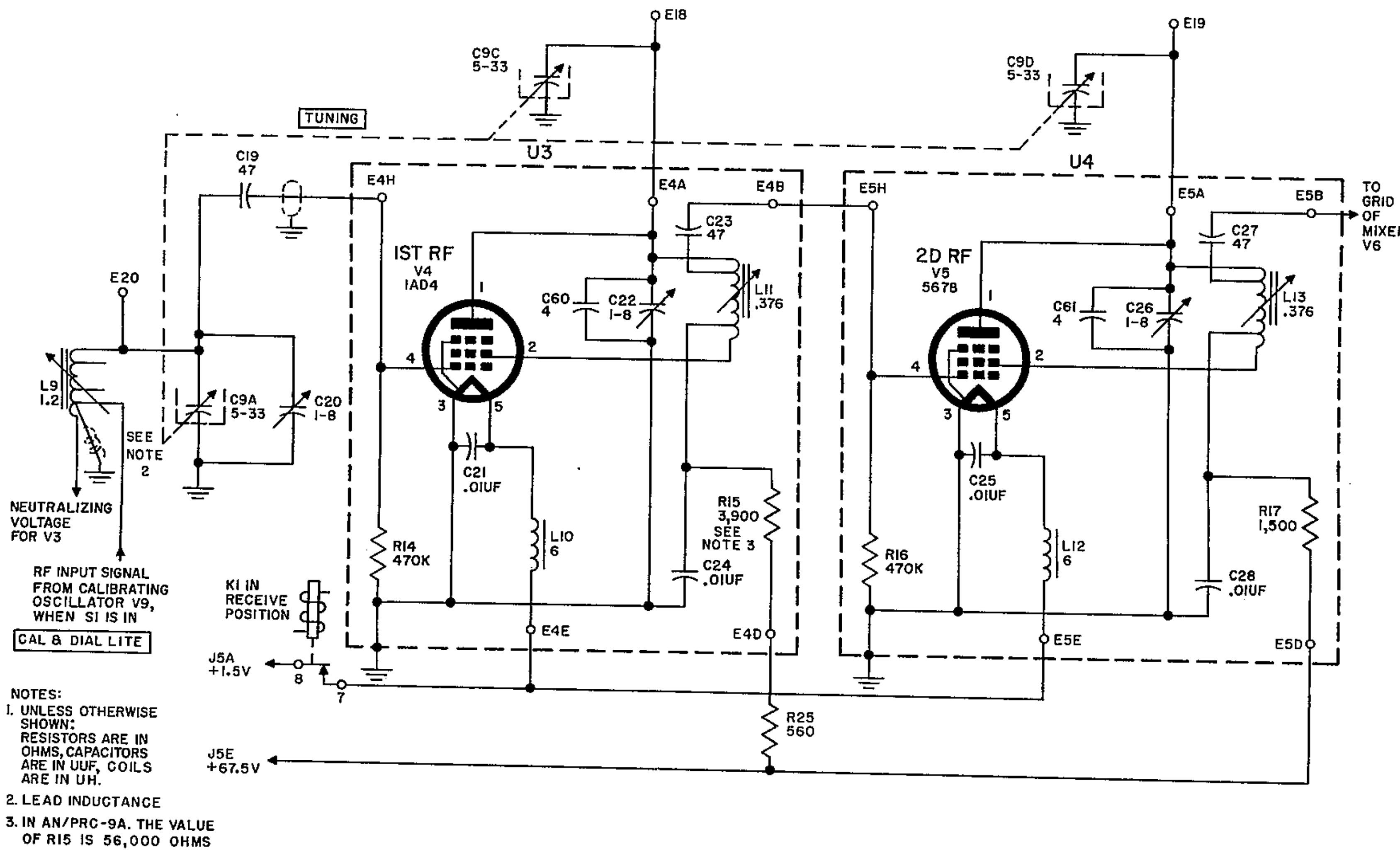


Figure 6. First and second rf amplifiers V4 and V5, schematic diagram.

up in the antenna is resonated in antenna coil L9. This coil, which fuctions as the plate coil of the transmitter oscillator and the grid coil of the first rf amplifier, is tuned by capacitor C9A, a section of the main TUNING capacitor. Capacitor C20 is a trimmer for high frequency (hf) tracking at the high end of the dial, and the adjustable iron core of antenna coil L9 provides low frequency (lf) tracking at the low end of the dial. Capacitor C19 couples the rf signal from the antenna coil to the grid of first rf amplifier V4.

b. The filament of 2.15-mc calibration oscillator V9 is returned to ground through the tap on antenna coil L9. Sufficient rf coupling exists between the coil and the grounding wire at the coil tap to couple the calibration signal and its harmonics inductively into the antenna coil. This signal can then be coupled into first rf stage V4 through C19.

12. First and Second Rf Amplifiers V4 and V5

(fig. 6)

a. First Rf Amplifier. The signal from the antenna circuit is applied through coupling capacitor C19 to the control grid of first rf amplifier V4, a pentode type 1AD4. The signal is amplified by V4 and is then fed through coupling capacitor C23 to the grid of second rf amplifier V5.

(1) Grid resistor R14 provides a dc return to ground. The plate tank circuit consists of C9C, C22, and C60 in parallel with L11. Capacitor C9C is a section of the TUNING capacitor. Coil L11 is adjustable for alinement of the rf amplifier at the low end of the dial. Capacitor C22 is adjustable for alinement at the high end of the dial. Capacitor C60, in parallel with C22, has a negative temperature coefficient. When changes in temperature occur, the value of L11 changes. The value of C60, however, changes in the opposite direction from that of L11 to minimize changes in the resonant frequency of the plate tank circuit. The rf signal is returned to ground through C24 from a tap on L11. The screen grid is connected to the opposite end of L11 from that of the plate to put an rf voltage at the screen that is opposite in polarity to that of the plate. This provides a negative feedback voltage that prevents oscillation of the amplifier.

(2) B+ is applied to the plate and screen through R25 and R15. Resistor R15 and capacitor C24 form a decoupling filter that isolates the B+ supply from rf voltages. Filament voltage is applied through contacts 8 and 7 of receive-transmit relay K1, in series with the rf choke L10 and V4 filament to ground. Capacitor C21 bypasses the filament for rf. Contacts 8 and 7 of K1 are open when the radio set is in the transmit condition, and are closed during reception. Consesequently the first rf stage, as well as second stage V5, operates only when the radio set is in the receive condition.

b. Second Rf Amplifier. The output signal from the plate circuit of V4 is applied through coupling capacitor C23 to the control grid of second rf amplifier V5. This tube, a pentode type 5678, amplifies the signal and feeds it through coupling capacitor C27 to the input circuit of mixer V6. The design of the second rf amplifier is basically the same as that of the first rf amplifier. B+ is applied to the plate and screen through R17. A decoupling filter formed by R17 and C28 isolates the B+ supply from rf voltages. Filament voltage is applied through contacts 8 and 7 of receive-transmit relay K1, in series with rf choke L12 and V5 filament to ground in the same manner that it is applied to first rf amplifier V4. The stage is therefore operative only when the radio set is in the receive condition.

13. Receiver Oscillator V8

(fig. 7)

a. The receiver oscillator supplies a signal 4.3 mc higher than the incoming frequency. During reception, the receiver oscillator signal beats with the incoming rf signal to produce the required if. signal. During transmission, the receiver oscillator signal beats with a portion of the transmitter oscillator signal that is coupled to the mixer, by capacitive coupling through C19 and the first and second if. stages, to produce a frequency control signal.

b. The receiver oscillator is a triode type 6286. The circuit is a series-fed Hartly oscillator in which plate-to-grid feedback occurs across L21. The rf feedback path is from the plate of the tube through C46 to ground and the lower portion of L21 to the cathode. The voltage in the plate (lower) section of L21 induces a voltage in the

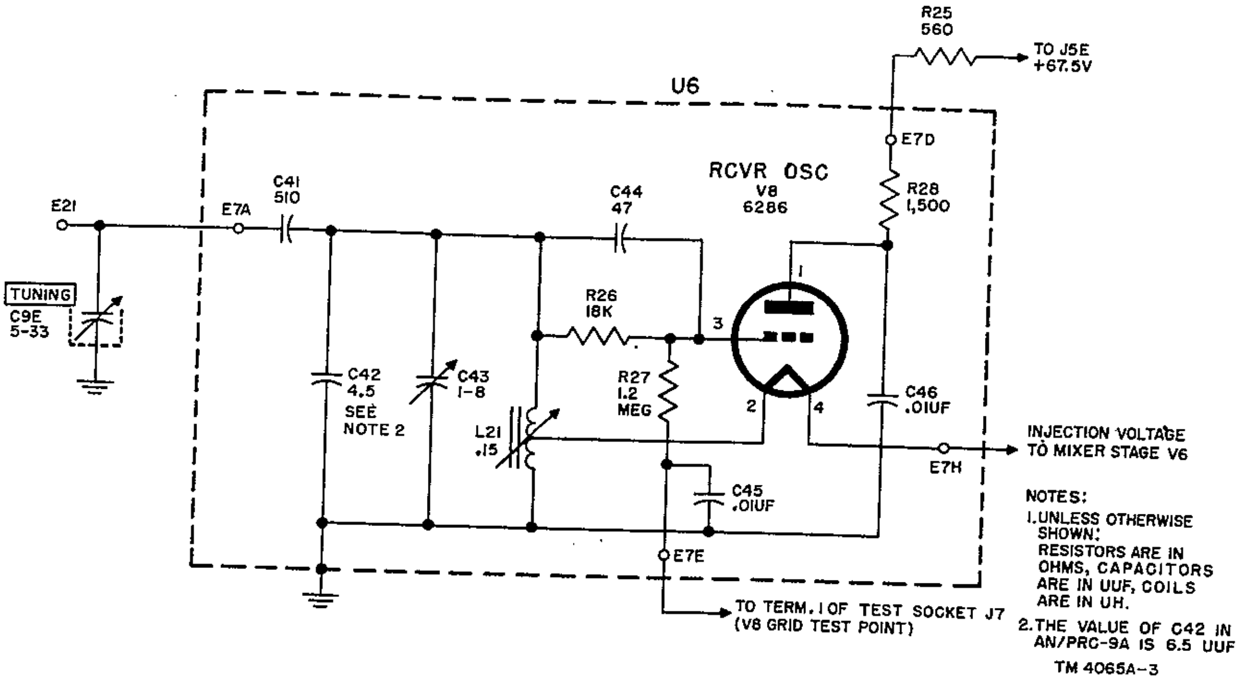


Figure 7. Receiver oscillator V8, schematic diagram.

grid (upper) section of the coil. The grid circuit extends from the grid (pin 3) through the parallel capacitor, resistor combination C44 and R26, and through the upper section of L21 to the cathode. The tuned circuit consists essentially of L21 in parallel with TUNING capacitor C9E. Capacitor C41 is a padder in series with C9E to provide better tracking. Capacitor C43 is a variable trimmer and C42 is for temperature compensation. The core of L21 is adjustable for alinement of the receiver osillator at the low end of the dial; C43 is adjustable for alinement at the high frequency end of the dial.

c. A portion of the receiver oscillator voltage is applied from the filament of V8 to the mixer stage. Filament power is applied to the receiver oscillator from the mixer filament circuit. B+ power is applied to the plate of V8 through R25 and decoupling resistor R28. Resistor R27 and capacitor C45 form a decoupling filter between the grid and a test point at terminal 1 of test socket J7. More current is drawn from the battery during transmit operation of the radio set, than during receive operation. Consequently the plate voltage supply to the receiver oscillator would differ, and would affect the frequency. To offset this change in voltage, resistor R25 is included in the B+ supply circuit.

14. Mixer V6

(fig. 8)

a. A signal is applied to the control grid of the mixer from the output of second rf amplifier V5 at the same time that a signal 4.3 mc higher than the incoming signal is applied to the filament from receiver oscillator V8. These two signals beat in the mixer to produce a frequency of 4.3 mc. The output of the mixer is tuned to this frequency which is called the *intermediate frequency* (if.). All frequencies outside of this if. band are rejected.

b. The output from second rf amplifier V5 is applied to the control grid (pin 4) of mixer V6, a pentode type 5678. Resistor R18 is the grid-leak bias resistor. The signal from the receiver oscillator (4.3 mc higher than the signal from the second rf amplifier) is applied across L16. Coil L16 is returned to ground through C29. A portion of the voltage across L16 is applied to the cathode of V6. The beating (mixing) of the rf signal (injected at the control grid) and the receiver oscillator signal (injected at the filament) produces an intermediate frequency of 4.3 mc in the plate circuit. The plate circuit consists of C30 and the primary of T2. This is a parallel circuit which is tuned to resonance at 4.3 mc. The voltage developed in this circuit is passed through

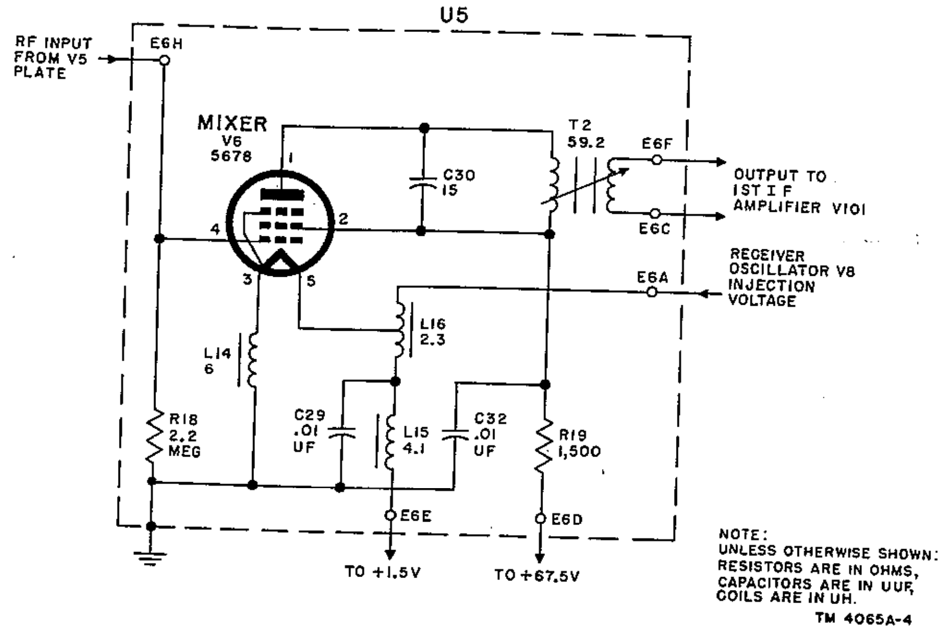


Figure 8. Mixer V6, schematic diagram.

transformer T2 to the grid circuit of first if. amplifier V101.

c. Filament voltage is applied to the filament through L15 and a portion of L16. Filter C29 and L15 decouple the direct current (dc) filament supply from rf voltages. Coil L14 keeps the filament above rf ground. B+ voltage is applied through R19 to the screen (pin 2) and through the primary of T2 to the plate (pin 1) of the tube. Resistor R19 and capacitor C32 form a B+ decoupling filter.

15. First, Second, Third, and Fourth If. Amplifiers V101

(fig. 9)

a. There are four if. amplifier stages in the receiver. These are all identical and have the same reference symbol, V101. Each stage is a hermetically sealed plug-in can. The reference symbols for these cans are U101, U102, U103, and U104. The four cans plug into sockets X7, X8, X9, and X10 and are identical as to components and com-

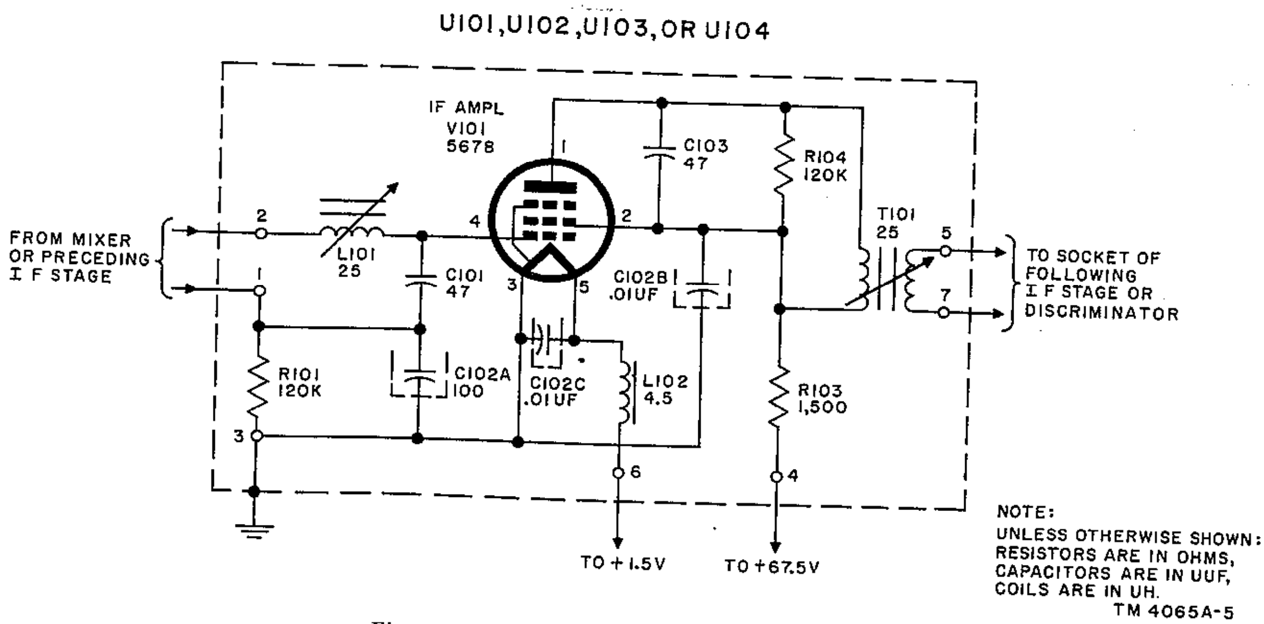


Figure 9. If. amplifier V101, schematic diagram.

ponent reference symbols. Therefore, a description of one of these stages covers all four if. stages.

b. The input signal is applied across terminals 1 and 2 of the can (not the tube) from the secondary of the transformer of the previous stage (either mixer V6 or another if. amplifier V101). The transformer secondary forms a series tuned circuit with L101 and C101. The circuit is resonant at 4.3 mc. The voltage across C101 is applied to the control grid of V101. The if. return to ground from C101 is through C102A. The dc return to ground is through R101. In each succeeding if. stage, the signal level is greater and the grid bias voltage developed across R101 is greater. At the third and fourth if. amplifiers, this bias voltage, together with the relatively low plate voltage, produces limiting action. This clips the positive and negative peaks from signals which exceed a certain amplitude and applies a signal of constant amplitude to the discriminator stage.

c. The plate tuned circuit, consisting of C103 and the primary of T101, is resonant at 4.3 mc. Resistor R104, across this tuned circuit, broadens its response to the desired band width (approximately 100 kc). The output signal is passed through T101 to the next stage. The tuned circuit is alined to 4.3 mc by an adjustment of the powdered shell of transformer T101.

d. The 67.5-volt supply is applied to the plate through decoupling resistor R103 and the primary of T101. Voltage is applied to the screen from the top of R103. Screen rf is bypassed to ground through capacitor C102B. The 1.5-volt supply is applied to the filament through L102. Capacitor C102C and coil L102 form an rf filter to bypass filament rf to ground.

e. Choke coil L17 (fig. 57) prevents any unfiltered rf of the third and fourth if. stages from getting into the dc supply circuit. Bypass capacitor C33 helps prevent regeneration. Resistor R23 is an rf filter in the bias lead from the fourth if. stage to the squelch grid. Resistor R20 is a dropping resistor in the plate circuit of the third if. to limit its gain. Resistor R22 is an additional voltage dropping resistor in the plate circuit of the fourth if. stage for greater limiting action. Resistor R21 shunts the grid resistor of this same stage, to permit its operation as a multivibrator in conjunction with pulse-sweep generator stage V301.

16. Receiver Discriminator T201

(figs. 10 and 11)

a. Discriminator Function. Receiver discriminator T201 converts fm signals into audio signals. When a voltage at the if. center frequency (4.3 mc) is applied to the discriminator, the discriminator output is zero. When the input voltage is below this frequency, the discriminator output is a positive voltage; when the input voltage is above this frequency, the discriminator output is a negative voltage. Since the if. signal applied to the discriminator is fm, its frequency deviates below and above the if. center frequency. On each of these deviations, the discriminator output is alternately positive and negative. The amount of frequency deviation determines the magnitude of the discriminator output voltage (fig. 10). Since these deviations occur at an audiofrequency, the discriminator output voltage varies at an audio rate. The discriminator output is, therefore, an audio signal whose amplitude corresponds to the frequency deviation of the fm signal.

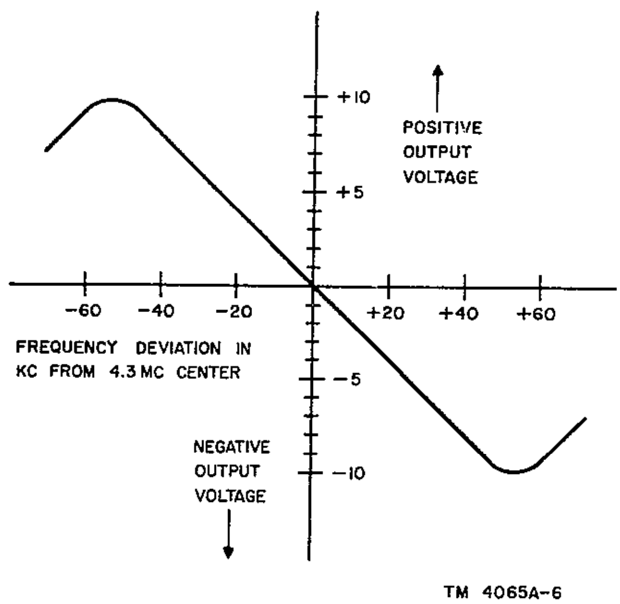


Figure 10. Discriminator frequency response curve.

b. Circuit Arrangement. The input to the discriminator is applied across transformer T202 (fig. 11). The secondary of this transformer in series with capacitor C202 is resonant at the intermediate frequency; thus maximum voltage develops across capacitor C202. The voltage across capacitor C202 is fed through coupling capacitor C203 to the center tap of coil L202. Capacitor

C205 is resonant with coil L202 at the intermediate frequency. Capacitor C204 produces a phase shift which unbalances the network for frequencies above and below the center if. Germanium crystals CR201 and CR202 rectify the if. and develop dc voltages across load resistors R201 and R202, respectively. Capacitor C206 bypasses the if. across these resistors, and C207 returns these frequencies to ground. Resistor R24 and capacitor C38 form a deemphasis network which attenuates the high audiofrequencies.

c. Discriminator Operation. Frequencies above the if. apply a greater voltage across crystal rectifier CR201 than across crystal rectifier CR202. Frequencies below the if. apply a greater voltage across crystal rectifier CR202 than across rectifier CR201. The difference in voltage across the two crystals is proportional to the deviation above or below the if. center frequency. The dc current through resistors R201 and R202 is proportional to the if. voltage applied to their respective crystals. Therefore, a greater dc voltage is developed across resistor R201 than across resistor R202 for frequencies above the if., while a greater dc voltage is developed across resistor R202 for frequencies below the if. The difference between these two voltages is the output voltage of the discriminator.

d. Discriminator Afc Operation. In addition to demodulating received fm signals, the discriminator provides an afc voltage for the transmitter. When the radio set is in transmit operation (relay kl energized), negative bias voltage is applied to the low side of load resistor R202 through the input pin 1. This voltage, approximately of −2.7 volts, is developed at the junction of voltage-dividing resistors R41 and R42. The if. signal voltage coming through the receiver (as a result of the transmitter oscillation being picked-up in the receiver and converted to if. in the mixer) is fed into the discriminator. The deviation of this if. signal from the center frequency of 4.3 mc

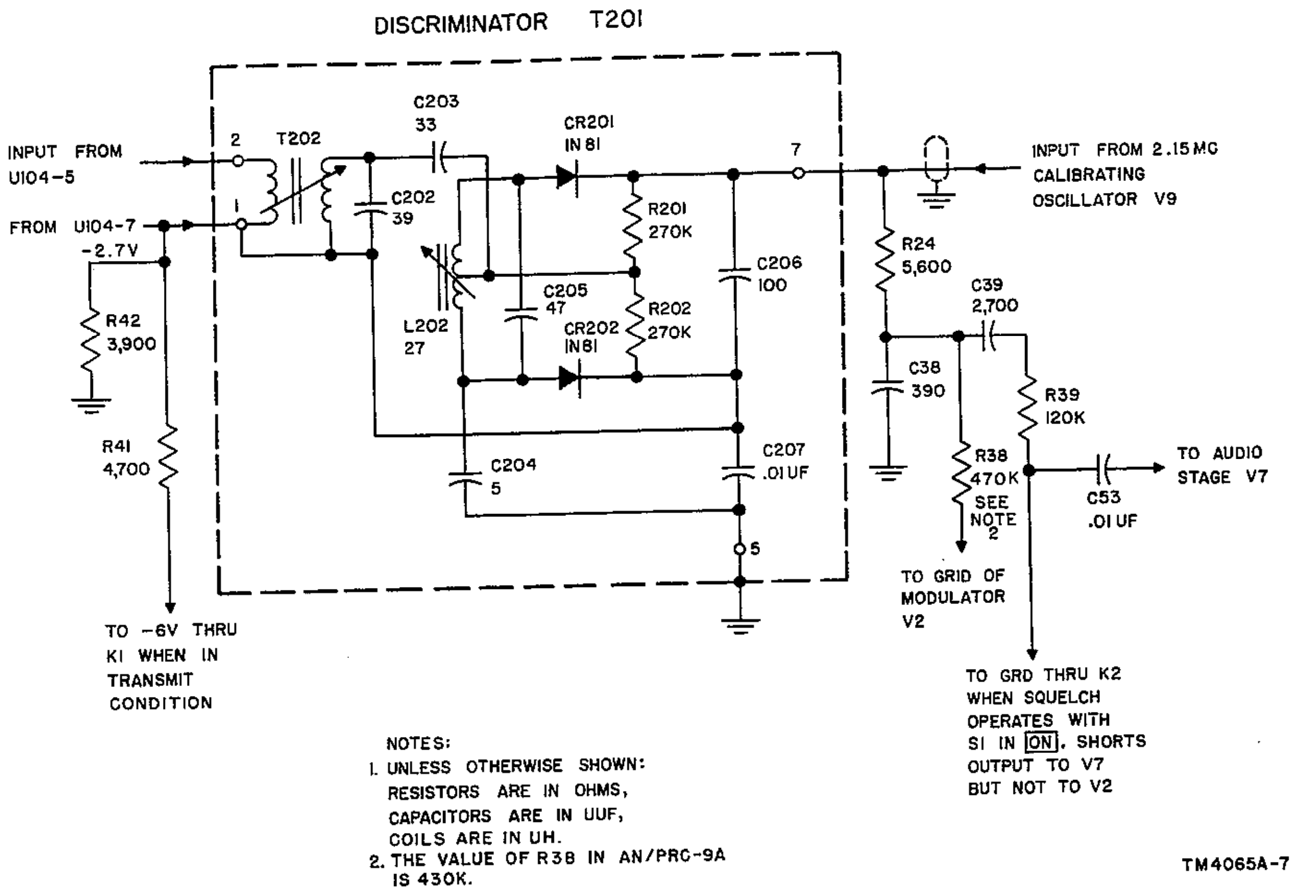


Figure 11. Discriminator T201, schematic diagram.

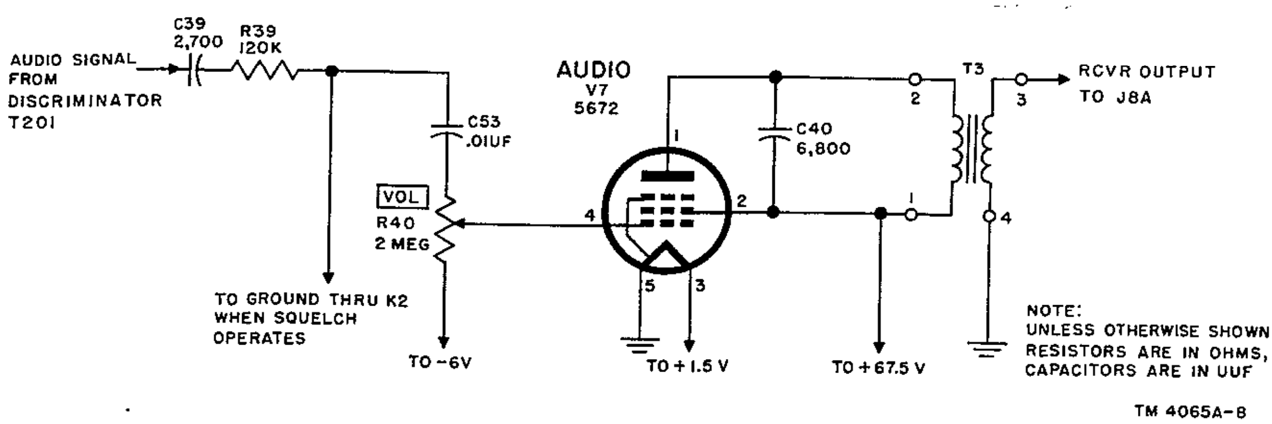


Figure 12. Audio amplifier V7, schematic diagram.

develops a discriminator output dc voltage. This voltage, however, is centered about the −2.7-volt level set by the negative input bias, instead of near ground potential as in receive operation. The correction control voltage is applied through resistor R38 to the grid of modulator tube V2. When the transmitter frequency is beyond the control range of the discriminator afc correction voltage, the fourth if. stage V101 operates in conjunction with pulse-sweep generator stage V301 as a slow cycling multivibrator. The discriminator stage is then practically unaffected by the rectangular wave form appearing at its input terminals. However, the 2.7-volt negative bias connected to its input pin 1, is still applied to the grid of modulator tube V2. The frequency control circuits of the transmitter are described in paragraph 23.

17. Audio Amplifier V7

(fig. 12)

The audio signal from the discriminator is fed through capacitor C39, resistor R39, capacitor C53 to resistor R40, the VOL control, which regulates the loudness of the sound in the handset receiver. From the arm of the VOL control, the audio signal goes to the grid, pin 4, of audio amplifier V7. Grid bias for this tube is provided by a connection from resistor R40 to the −6-volt bias supply. The audio output of the stage is coupled to the handset receiver through an impedance matching transformer T3, and a connection through AUDIO jack J8A on the control panel. Capacitor C40 assists in flattening the audio response curve by attenuating the higher frequencies more than the lower frequencies. Capacitor C39 is inserted in the input circuit between coupling capacitor C53 and the discriminator output, so that the squelch circuit may ground the audio input to V7 without affecting the discriminator afc voltage when in transmit operation. Resistor R39 is included in the circuit so that in retransmission operation, when the squelch circuit is inoperative, audio fidelity of the circuit is improved.

18. Squelch Circuit V11

(fig. 13)

a. Squelch circuit V11, when in use, grounds the discriminator output fed to audio stage V7. This prevents random noise from being heard in the handset receiver when no signals are being received. The squelch circuit may be turned ON or OFF manually by means of the SQUELCH control on the control panel.

b. Switch S2, ganged to the SQUELCH control, controls the squelch circuit by opening or closing the filament circuit of tube V11. This switch is open when the SQUELCH control is in the extreme counterclockwise (OFF) position and closed when the SQUELCH control is turned to the ON position. SQUELCH control R35 sets the operating point by adjusting the bias voltage for the control grid, pin 4, of the tube. This bias voltage can be either negative or positive, since the voltage-dividing network consisting of SQUELCH control R35 and resistor R36 is connected between the B+67.5 and −6-volt power supplies. Resistor R37 is an isolating resistor, which permits the fourth if. stage to bias the squelch tube when signals are being received.

c. The plate current of the tube operates relay K2. When the tube conducts, the relay is energized and shorts the output voltage from the discriminator to ground through contacts 3 and 4 of the relay. When a signal is received, the tube is biased to cutoff, thereby releasing the relay and permitting the signal to be heard in the handset

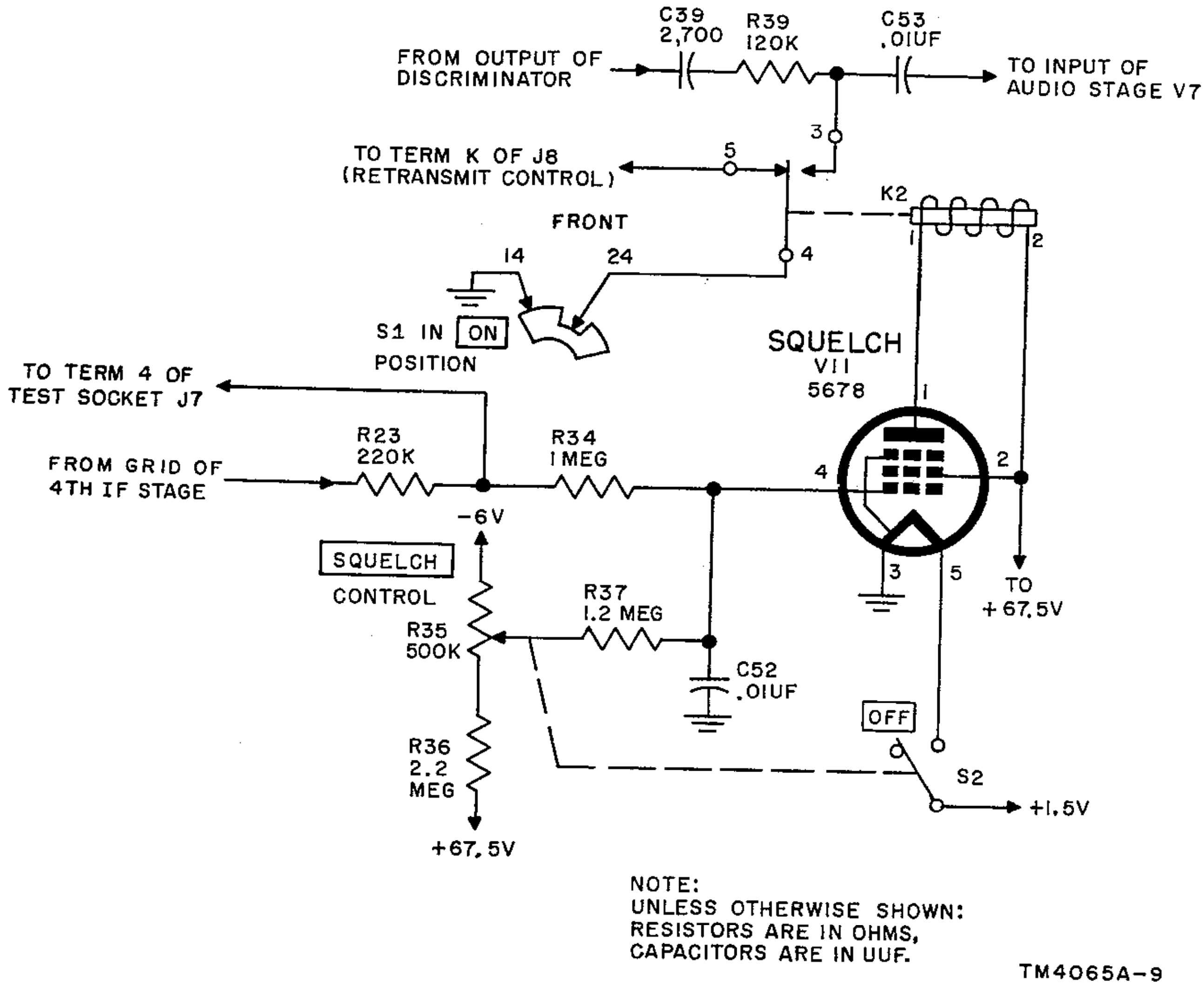


Figure 13. Squelch circuit V11.

receiver. Closed contacts 4 and 5 of relay K2 (in the released condition) complete a 6-volt circuit that is used in relay operation (fig. 26). Resistor R23 is an rf filtering resistor, and R34 is an impedance matching resistor. Capacitor C52 is an audio filter, preventing noise and spurious voltages from developing on V11. The connection to test socket jack J7–4 is for troubleshooting and alinement purposes.

19. The 2.15-mc Calibrating Oscillator V9

(fig. 14)

a. The 2.15-mc calibrating oscillator, tube V9, is a modified Pierce crystal oscillator. It receives its plate voltage through resistor R32 which isolates the plate rf signal from the B+ supply. Capacitor C48 couples the excitation feedback to the crystal, maintaining oscillation. The series arrangement of capacitors C47 and C49 provides the proper loading across the crystal for optimum crystal frequency. Capacitor C50 is the output coupling capacitor. The 2.15-mc crystal Y1, controls the oscillator frequency. Resistor R31 is the grid leak. Iron-core inductor L22 prevents rf voltages from entering or leaving by the positive filament lead. A direct connection couples the calibrating oscillator output from the filament of tube V9 through the ground tap on antenna coil L9 to the first rf amplifier stage. Rf harmonics of the oscillator are amplified in the rf stages and converted to 4.3-mc by the receiver oscillator and mixer stages. These harmonic frequencies provide beat notes at every calibrating point (designated by a red marker) on the tuning dial.

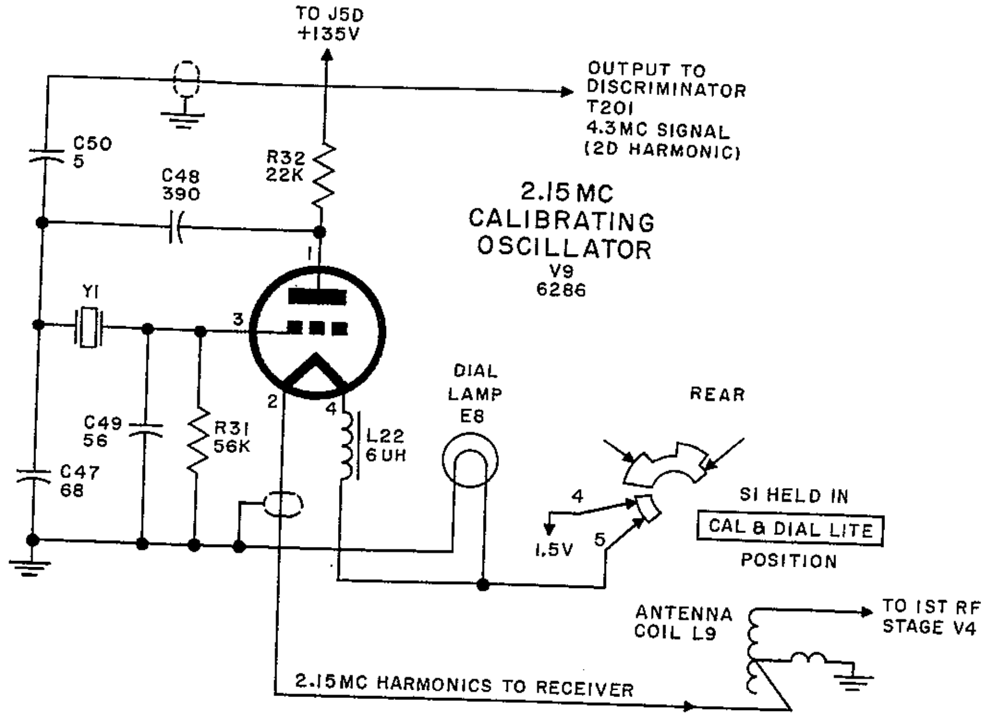


Figure 14. The 2.15-mc calibrating oscillator (V9), schematic diagram.

b. The dial lamp illuminates the dial for tuning and pointer adjustment during calibration. For this reason, it is turned on only when POWER switch S1 is in the CAL & DIAL LITE position. Dial lamp E8 is held in its socket by the LITE CAP on the front panel. The lamp power is obtained from the filament circuit of calibrating oscillator V9.

20. Pulse-Sweep Generator V301

(fig. 15)

a. Function. Pulse-sweep generator stage V301 operates with the fourth if. amplifier stage V101 as a multivibrator to locate the transmitter center frequency and place it within control of the afc circuit. This normally takes 1 or 2 seconds. The pulse-sweep generator stage then becomes inoperative and the fourth if. stage functions as a grid-limiting amplifier. The pulse-sweep generator circuit operates only in the transmit condition of the radio set, because in receive operation the filament voltage to V301 is disconnected by relay K1.

b. Circuit Operation. When the radio set is initially turned on for transmission, the following occurs.

(1) Filament voltage is connected to V301, and the tube begins to conduct. The drop in voltage occurring at the plate of V301 is coupled through R301 and C301 back to the grid circuit of V101 (in U104), and keeps this stage cut off. However, as the negative charge leaks off C301 through R101 and R21 (fig. 19), the first stage (V101 in U104) of the multivibrator circuit begins to conduct. The drop in voltage occurring in the plate circuit of this stage is coupled back through C302 to the grid of V301, and cuts off V301 to complete the multivibrator cycle. The cycle repeats when the negative charge leaks off C302 (through R303, R302, R21, and R101) and V301 again begins to conduct. The repetition frequency is very slow, approximately 5 cycles per second. Usually, after a second or two, the transmitter oscillator is sufficiently stabilized and operating at its correct center frequency. An afc signal will then be coming through the if. stages and, when this signal gets to develop approximately 8 volts of nega-

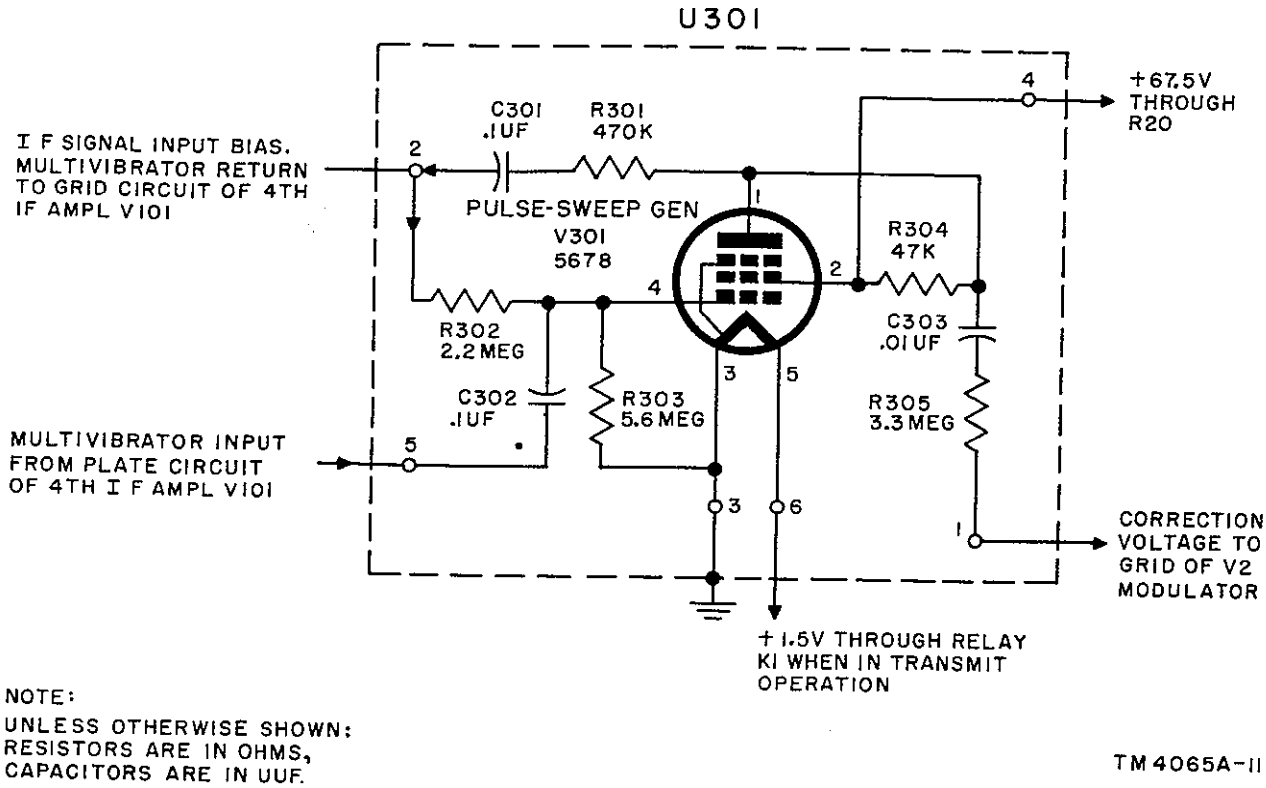


Figure 15. Pulse-sweep generator V301, schematic diagram.

tive bias in the grid circuit of V101 in U104, pulse-sweep generator V301 is cut off. Multivibrator action can resume only when the afc signal at the third if. output falls off, so that the cut off bias is removed from V301.

(2) The multivibrator output has a rectangular voltage wave form at the plate of V301. This rectangular wave is differentiated by C303 and R305. The high value of R305 and the other components in the circuit through which the voltage is returned to ground limits the differentiating action. The resultant output wave form applied to the grid of modulator V2 is therefore a voltage of slowly varying amplitude (fig. 19). In effect, this signal can be considered as a sawtooth voltage which continuously varies the modulator bias to sweep the transmitter oscillator over a wide frequency range.

c. Circuit Arrangement. Resistor R303 (fig. 15) is the grid-leak resistor. Resistor R302 couples the negative bias developed in the grid circuit of fourth if. amplifier V101 to cut off V301 and stop multivibrator action. Capacitor C302 provides the feedback path from the plate circuit of V101 (in U104) to the grid of V301, and capacitor C301 and resistor R301 provide the feedback path from the plate of V301 to the grid circuit of V101 (in U104). Resistor R301 is included to increase the time constant of the network which controls the length of time V101 (in U104) is held to cutoff. This is roughly about one-third the interval that V301 is held to cutoff by the time constant of C302, R303, and R302. Plate voltage is applied to V301 through decoupling resistor R20 and load resistor R304. Capacitor C303 and resistor R305 form a differentiating network which shapes the rectangular multivibrator wave form to the desired output. Filament voltage to V301 is applied through contacts 8 and 9 of relay K1 when the radio set is in transmit operation. Resistor R22 (fig. 19) is inserted in the plate supply circuit of V101 (in U104) and resistor R21 is shunted across grid-leak resistor R101 to permit the multivibrator operation of fourth if. stage U104 with pulse-sweep generator stage V301.

Section III. TRANSMITTER STAGES

21. Modulator Stage V2

(fig. 16)

a. The modulator has two functions. It frequency-modulates transmitter oscillator V3, and it also controls the center frequency of the transmitter oscillator. Both of these functions are accomplished by the variation in inductance of transformer L4, whose primary is in the plate circuit of modulator tube V2. Transformer L4 has a ferrite core, common to both its primary and secondary windings. The characteristic of this core is such that changes in magnetic (and current) flux through it cause the inductance of both windings to change in value. An increase in flux and current produces a decrease in the value of the inductance, and a decrease in flux produces an increase in the value of the inductance. Since the primary of transformer L4 is in a bridge circuit with the plate of the modulator tube, changes in plate current will produce changes in magnetic flux through transformer L4 with resulting changes in inductance in both primary and secondary windings. The curve showing the variation in inductance of transformer L4 due to changing magnetic flux is shown in figure 17.

b. Transformer L4 is connected in a bridge circuit consisting of resistors R3, R4, R5, and the plate resistance of modulator tube V2. The primary winding of L4 is across this bridge network (fig. 16), which normally is in an unbalanced state. Consequently, some current will always be flowing through L4. However, an increase of current in V2 plate conduction causes a decrease in current through L4. When V2 tube conduction decreases, the current through L4 increases to cause a greater unbalance in the bridge network. Thus, the value of inductance in the secondary of L4 increases when the control voltage applied to the modulator grid is positive, and decreases when the control voltage is negative. Normally, with no correction voltage or modulation applied to V2, the bias on its grid is −2.7 volts in transmit operation.

c. Voice signal coming from the handset enter the radio receiver-transmitter through AUDIO jack J8C. From here, they are applied across series-connected load resistors R43 and R33, and through resistor R30 and blocking capacitor C51

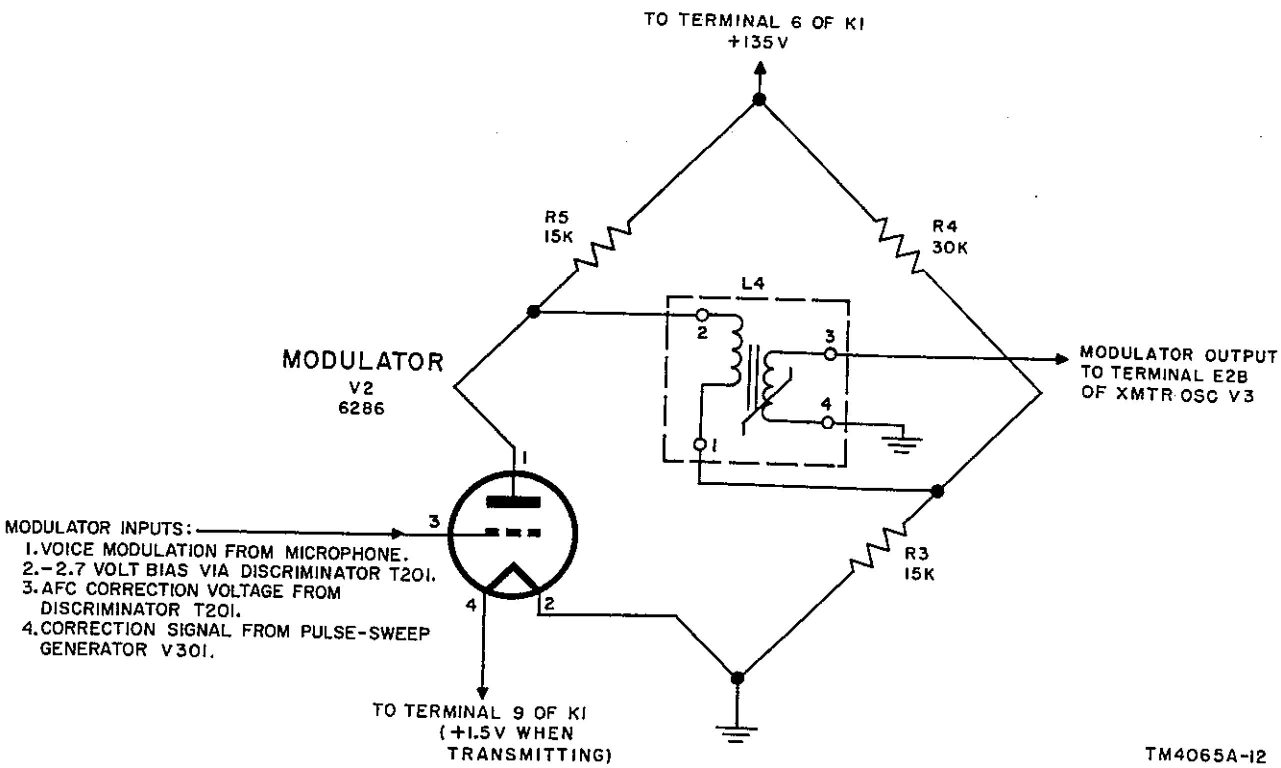
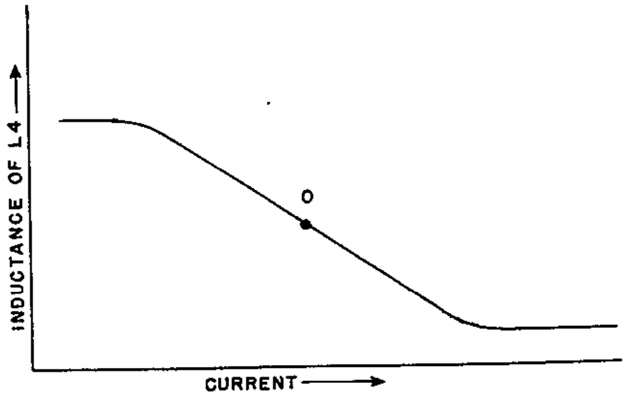


Figure 16. Modulator stage V2, schematic diagram.



NOTE:
POINT O IS OPERATING POINT WITH NO INPUT SIGNAL TO MODULATOR. TM 4065-9

Figure 17. Variation of inductance with current in L4.

to the grid of modulator tube V2. This causes the plate current of V2 to change at an audio-frequency rate, which, in turn, causes the flux and the inductance of the windings in transformer L4 (fig. 16) to change. Since the secondary winding of coil L4 is in the tuned grid circuit of transmitter oscillator V3, changes in the value of the inductance of L4 produce changes in the transmitter frequency at an audio rate. The transmitter oscillator is, therefore, frequency-modulated by the audio signals.

d. Modulator tube V2 obtains its bias voltage through discriminator T202 (fig. 19) from the junction of voltage-dividing resistors R41 and R42, across the negative 6-volt supply to ground. This bias voltage, filtered by capacitor C38, is indirectly fed to the grid of V2. The voltage at the plate of V2 (fig. 16) is obtained through R5 from the 135-volt supply through contacts 5 and 6 of receive-transmit relay K1 (closed only during transmission). The filament voltage is obtained from the 1.5-volt supply through contacts 8 and 9 of relay K1 (closed only during transmission). The modulator therefore operates only during transmitting periods.

22. Transmitter Oscillator V3

(fig. 18)

a. The transmitter oscillator is an electron-coupled, neutralized Hartley oscillator. The oscillator section of V3 consists of the filament, the control grid, and the screen grid, its tuned circuit being located in the grid circuit (U2 can) of the tube. The plate circuit of the tube has no connection to the oscillator except through the electron coupling in the tube. Variations in frequency or loading in the plate circuit will, therefore, have little effect on the oscillator. This makes for a very stable oscillator.

b. The oscillator tuned circuit consists of coil L3 and capacitor C9B. Capacitor C11 is a trimmer, used for alinement of the transmitter at the hf end of the dial. Coil L3 is slug-tuned to permit alinement of the transmitter at the lf end of the dial. The secondary winding of coil L4 (not shown) is in parallel with part of coil L3 in the tuned circuit of the transmitter. Therefore, changes in the inductance of coil L4 will produce changes in the transmitter frequency.

c. Capacitor C10 couples the tuned grid circuit through filter E3 to the grid of the tube. Filter E3 is a resistor-inductor combination which prevents undesirable parasitic oscillations. Resistor R13 and capacitor C15 form a decoupling filter to prevent rf from being applied to terminal 2 of test socket J7 and to prevent test equipment from *loading* the circuit during test. Resistor R11 is the grid leak. Capacitor C14 and coil L5 form an rf filter for the −6-volt filament supply. Capacitor C13 keeps both sides of the filament at the same rf potential. Coil L8 and capacitor C18 keep radio frequency out of the B+ supply.

d. Capacitor C16 couples the output from the plate of tube V3 to its tank circuit, which consists of antenna coil L9 and TUNING capacitor C9A. Capacitor C20 is a trimmer, used for alinement of the transmitter at the hf end of the dial; coil L9 is slug-tuned to permit alinement of the transmitter at the lf end of the dial. Capacitor C17 provides partial neutralization by feeding back some of the voltage of the plate tank circuit to the grid circuit. This prevents undesirable oscillations.

e. A tap on coil L9 connects to LONG ANT jack J1A, SHORT ANT jack J1B, and AUX ANT jack J3. For semipermanent installations, an auxiliary antenna is connected to jack J3. This antenna is not tunable. Where semipermanent installations are not possible, a short antenna is used which connects to jack J1B. When greater range is desired, a long antenna is used which connects to jack J1A. Coil L7, in series with jack J1B, is adjustable. Its slug is attached by a wire

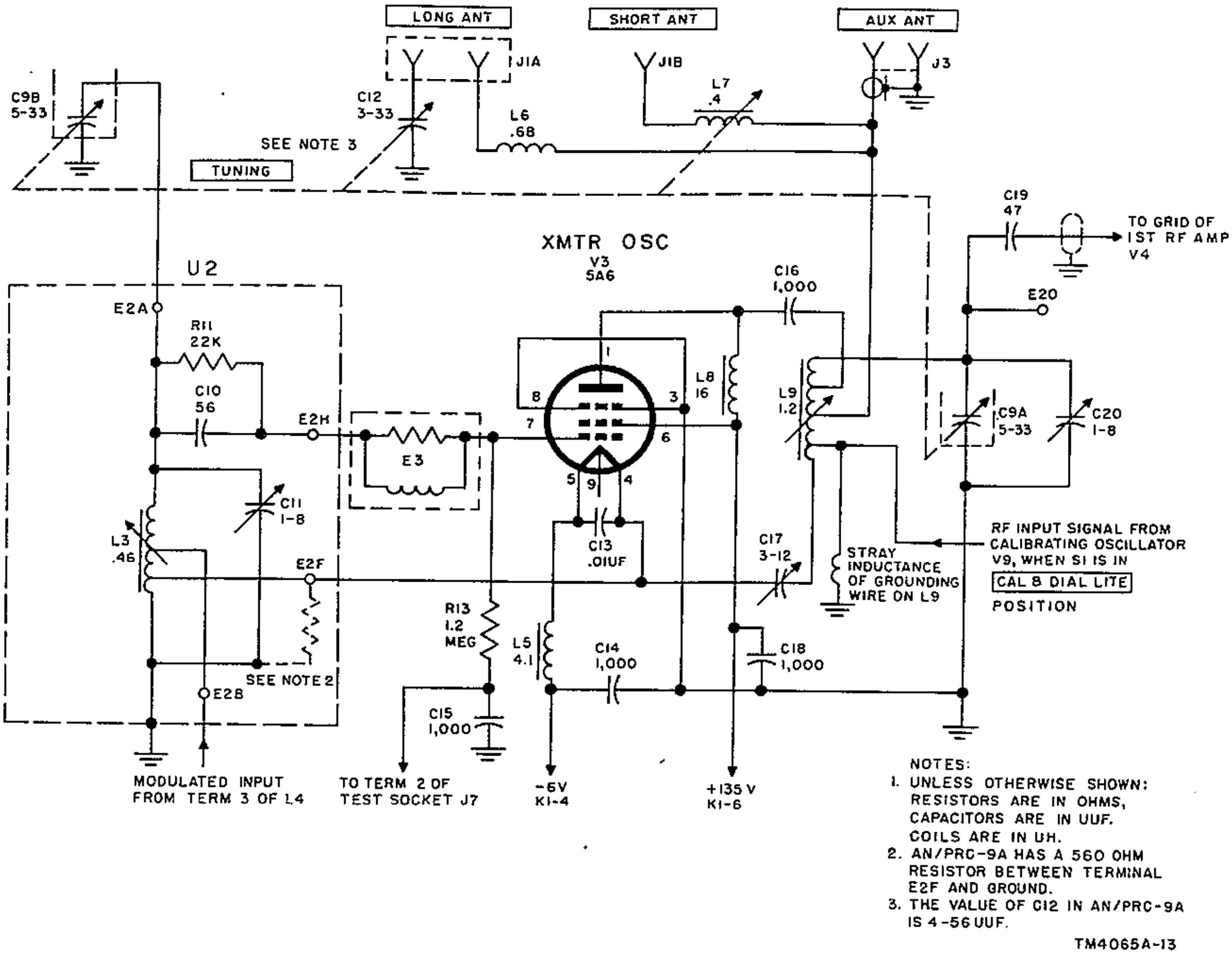


Figure 18. Transmitter oscillator V3, schematic diagram.

to the ear of a gear on the tuning drive assembly (fig. 42). Consequently, when the TUNING control is operated, the slug is moved inside the coil to vary the inductance in the antenna circuit, thereby tuning the short antenna. The tuned circuit for the long antenna includes fixed inductor L6 and capacitor C12. The rotor shaft of capacitor C12 is mechanically linked to the tuning shaft, and the long antenna is thereby tuned when the tuning control is operated. Plugging the long antenna into jack J1A, electrically connects C12 to coil L6 by a shorting strap in the plug of the long antenna. The voltage across coil L9 is coupled through capacitor C19 to the grid of first rf amplifier V4.

23. Transmitter Frequency Control

(fig. 19)

a. General. The transmitter oscillator output signal is affected by two circuits so that its center frequency is constantly 4.3 megacycles (mc) below that of the receiver oscillator. These two circuits are the afc circuit and the pulse-sweep generator circuit.

(1) Pulse-sweep generator V301 circuit operates only when the transmitter oscillator is relatively far off center frequency, from about 80 kc to approximately 750 kc. Normally, this is the case only when the equipment is initially started, or has been in *receive* operation for an extended time. The pulse-sweep generator circuit consists of fourth if. stage U104 and pulse-sweep generator stage V301. These two stages operate together as a multivibrator, generating a rectangular voltage wave shape of very slow frequency (about 5 to 10 cycles per second). This output is partially differentiated, so that it resembles a sawtooth sweep

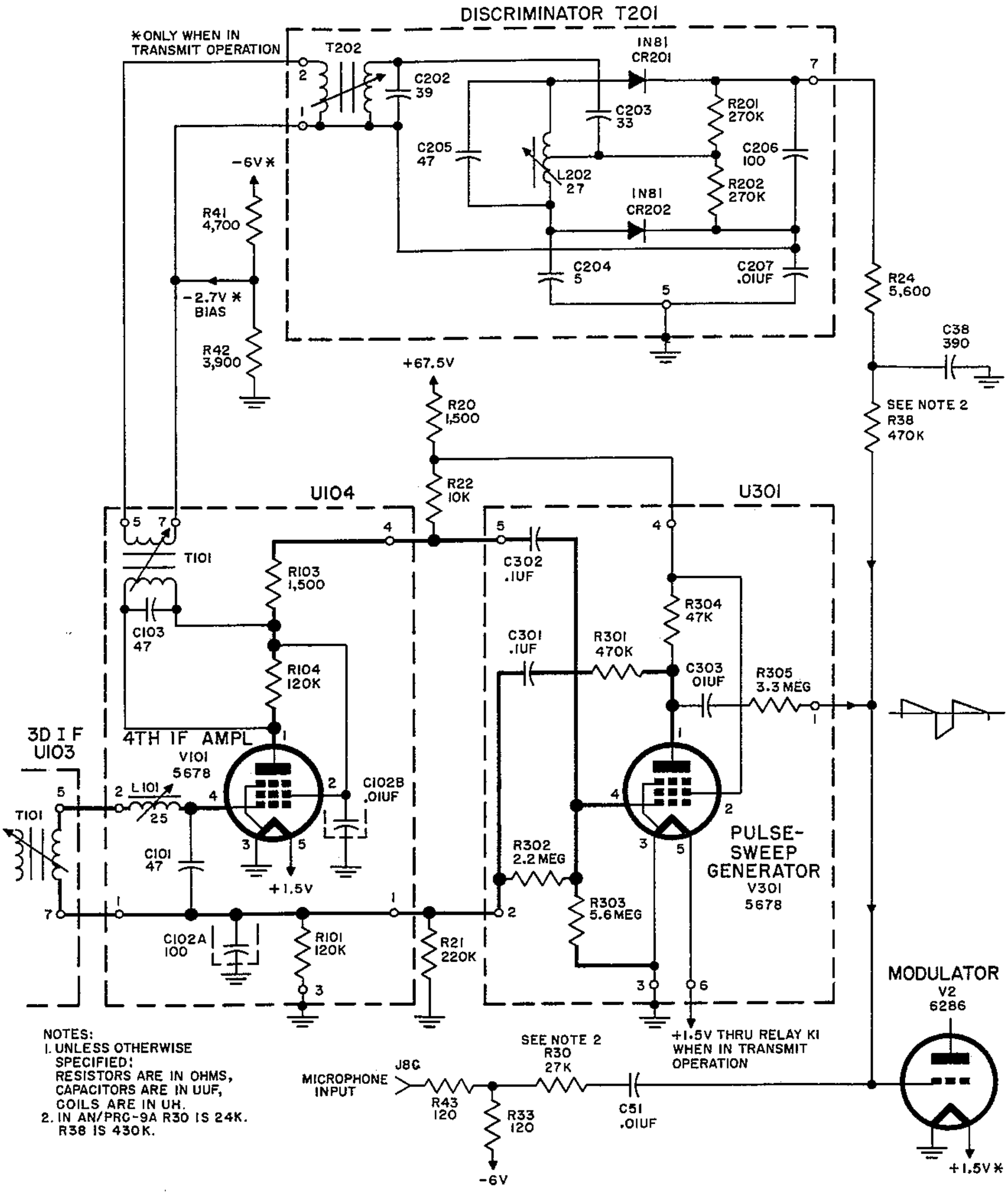


Figure 19. Transmitter frequency control diagram.

voltage. This varying voltage is applied to the grid of modulator tube V2 which, in turn, varies the frequency of the transmitter oscillator. When the transmitter frequency is on (or near) the center frequency, the if. output signal of third if. amplifier stage U103 develops sufficient negative bias to cut off the multivibrator operation. This usually occurs in 1 or 2 seconds. The pulse-sweep generator circuit sweeps the transmitter over a wide frequency range until the proper frequency is located, whereupon the afc circuit takes over frequency control.

(2) The afc circuit uses receiver discriminator stage T201 to provide an afc voltage which compensates for transmitter frequency deviations up to approximately 80 kc of center frequency. The afc circuit is described in *b* below; the pulse-sweep generator circuit is more fully described in paragraph 20.

b. The Afc Signal. When Radio Set AN/PRC–9A or AN/PRC–10A is in *transmit* operation, the transmitter oscillator signal is picked up in the mixer stage. Here it heterodynes with the receiver oscillator signal to produce an if. output at the mixer plate. This is the afc signal. If the transmitter oscillator center frequency is correct, the center frequency of the afc signal is 4.3 mc. If the center frequency of the transmitter oscillator is too high, the center frequency of the afc signal is below 4.3 mc; if the center frequency of the transmitter is too low, then the center of the afc signal is above 4.3 mc. In any case, this afc signal is amplified through the four if. stages and applied to discriminator stage T201.

c. Afc Operation. The discriminator afc operation is described in paragraph 16*d*. Except for a negative direct current a (dc) bias of −2.7 volts being applied at the discriminator input when in *transmit* operation, the action of the discriminator is identically the same as in *receive* operation. In *transmit*, the output of the discriminator provides the afc correction voltage.

(1) The afc correction voltage is a dc signal which controls the bias on modulator tube V2, so that the modulator in turn may regulate the frequency of transmitter oscillator V3.

(2) The deviation of the afc signal from the center frequency of 4.3 mc develops a discriminator output dc voltage. This voltage is centered about the −2.7-volt level set at the junction of resistors R41 and R42. The discriminator output voltage is applied through resistor R38 to the grid of modulator tube V2. It causes the modulator to shift the frequency of the transmitter to compensate (correct) for deviations of the transmitter oscillator from the center frequency.

(3) When the transmitter frequency is beyond the control range of the discriminator afc correction voltage, such as upon initially starting the transmitter, there is little or no signal at the third if. stage output. The pulse-sweep generator circuit then operates and the afc circuit has practically no effect. However, the negative dc bias connected to the input, pin 1 of T201, is still effective on the grid of modulator tube V2.

Section IV. CONTROL CIRCUITS

24. Voltage Distribution

(fig. 20—See foldin in back of Manual)

Operating voltages of 67.5 and 135 volts dc are received through terminals E and D of plug P1. The voltages are fed to the plates and screens of the tubes as follows:

a. Receiver Power-Supply Circuits. All of the receiver stages except 2.15-mc calibrating oscillator V9 are fed plate and screen voltages from the 67.5-volt supply. The circuits are thus interrelated, and a defect in one stage may affect the operation of many other stages. The receiver oscillator, mixer, if., and audio stages all have their filament circuits operating in both the *receive* and *transmit* conditions. Only the two rf stages have their filament circuits disconnected when relay K1 is in the *transmit* condition. The routing of the 67.5-volt potential to the various stages is shown in detail in figure 20, and is summarized as follows:

(1) The first rf and receiver oscillator stages connect to the 67.5-volt supply bus

through resistor R25. This resistor is included so that oscillator stage V8 receives the same voltage in both the *transmit* and *receive* conditions of the radio set. In the *transmit* condition, more current is drawn from the power source which lowers the 67.5-volt supply and, thereby, affects the receiver oscillator frequency. During the receive condition, the increase in current is adding offset by resistor R25 and by adding the first rf stage in parallel with the receiver oscillator stage.

(2) The third and fourth if. stages have dropping resistor R20 in their circuit. Resistor R22, through which the fourth if. stage is fed plate and screen voltage, permits the stage to be operated as part of a multivibrator with pulse-sweep generator stage V301. This stage may operate only when the radio set is in the *transmit* condition.

(3) The plate of squelch tube V11 obtains its voltage through the solenoid of relay K2. The SQUELCH control (S2 and R35) regulates the operation of the stage by opening and closing the filament circuit and by varying the grid bias on V11 (par. 18).

(4) The receiver oscillator, first rf, second rf, and mixer cans all have the B+ potential applied through terminal D of the individual box plug-in connector. The four if. cans and the pulse-sweep generator can have the B+ potential applied through pin 4 of the base connector in each can.

(5) The 2.15-mc calibrating oscillator, V9, receives its operating potential through R32 from the 135-volt supply. The stage is operative, however, only when the POWER switch is in the CAL & DIAL LITE position.

b. Transmitter Power-Supply Circuits.

(1) B+ power for transmitting is received through closed contacts 5 and 6 of receive-transmit relay K1 (when energized) and terminals D of connectors J5, J6, and P1, from the 135-volt dc source.

(2) Modulator stage V2 connects to B+ potential through R5 in one branch of a bridge network (par. 21). The screen grid of transmitter oscillator V3 connects directly to the 135-volt supply; its plate is connected to the same supply bus through inductance coil L8.

(3) Positive operating potentials obtained through a voltage-dividing network (formed by R8, R7, R23, and R21) are applied to the grid circuits of cans U104 and U301 for operation of the pulse-sweep generator circuit.

(4) Positive potential applied to the grid of squelch tube V11, through R34 from the junction of R7 and R23, causes plate conduction in V11 when the radio set is being used in relay operation. In handset operation, the junction of R8 and R7 is returned to ground through terminal J8D; the push-to-talk button is held in so that the circuit through R34 has no effect on V11. When V11 conducts, plate current through K2 energizes the relay to ground the sidetone of the retransmitted signal in the radio set.

25. Control Circuits

(fig. 21—See foldin in back of Manual)

Distribution of operating voltages from the power source (either Battery BA–279/U or Amplifier-Power Supply AM–598/U) to the radio receiver-transmitter is controlled by POWER switch S1 and the push-to-talk button on the handset. Control Group AN/GRA–6 may also be used to control power distribution in the set. The functions of these controls are explained in *a* through *f* below.

a. POWER Switch S1 (fig. 21). The POWER switch is a rotary wafer-type four-position selector switch. When this switch is in the OFF position, there is no ground return for the A, B1, B2, and C voltages supplied (contacts 24 and 11 of S1 are not connected to ground), and no power is applied to the radio set.

b. POWER Switch at ON (fig. 21). All four voltage supplies are returned to ground through contacts 14 and 2 of S1. The filament circuits of all the receiver tubes except squelch tube V11 are completed. Squelch tube V11 is supplied filament voltage when the SQUELCH control knob is turned away from its extreme counterclockwise position, thereby closing switch S2. Plate and screen voltages are supplied to all receiver tubes. Plate voltage is supplied to the squelch tube through the winding of squelch relay K2. The set is in the receive condition when the push-to-talk switch is open.

Note. B+ voltages are also supplied to the plate circuits of pulse-sweep generator tube V301 and 2.15-mc calibrating oscillator V9. However, these tubes do not operate when their filament circuits are open.

c. POWER Switch at ON, and Push-To-Talk Switch Held In (fig. 21). Pressing in the push-to-talk switch of the handset completes the microphone circuit in the handset, and also the 6-volt circuit to the coil of relay K1. (The handset plugs directly into AUDIO connector J8 on the receiver-transmitter control panel, except when in relay or remote operation.) When relay K1 energizes, contacts 3 and 4 close, contacts 7 and 8 open, and contacts 8 and 9 and 5 and 6 close. Contacts 3 and 4 complete the 6-volt filament circuit of transmitter oscillator tube V3, and apply dc voltage across the handset microphone. The opening of contacts 7 and 8 breaks the filament circuits of first and second rf amplifiers V4 and V5. The closure of contacts 8 and 9 completes the 1.5-volt filament circuits to pulse-sweep generator and modulator tubes V301 and V2. The closure of contacts 5 and 6 connects the 135-volt supply to the plate circuits of transmitter oscillator and modulator tubes V3 and V2. Transmitter oscillator V3 and modulator V2 are now operating; pulse-sweep generator V301 is able to operate if the transmitter is far off frequency, or if other circuits are not operating properly. The receiver tubes, with the exception of the rf amplifiers, are also all operating. (They provide the audio sidetone and afc signal which control the transmitter frequency.) The radio set is now in the *transmit* condition. When the push-to-talk switch is released, the radio set is returned to the *receive* condition.

d. POWER Switch at ON, in Relay Operation (figs. 21 and 26). In relay operation, both unattended radio sets at the relay station have their POWER and SQUELCH controls turned on. Both radio sets are in the *receive* condition, with squelch relays K2 energized. When the radio set at either end of the communications link begins to transmit, its signal is received by the radio set at the relay station tuned to that particular carrier frequency. This received signal caused squelch relay K2 in the receiving radio set to release, and completes a 6-volt circuit through J8K to relay K1 of the companion radio set at the relay station. Relay K1 operates and the companion (or second) radio set then goes into retransmit operation. In retransmit operation, positive dc voltage is applied to the grid circuit of V11 so that the tube is constantly conducting to keep squelch relay K2 energized. The contacts of relay K2, which are then closed, ground the audio sidetone of the signal retransmitted (relayed) by the radio set. Except for this difference, operation of the radio set is essentially the same in the *retransmit* condition as in the *transmit* condition. The radio set remains in the *retransmit* condition as long as a carrier signal is being received by its companion radio set in the *receive* condition. The radio set in the *retransmit* condition will not be affected by any station transmitting on its frequency, because the two rf stages in its receiver section are inoperative. When the receiving radio set at the relay station no longer receives a carrier signal, squelch relay K2 energizes. This action breaks the 6-volt circuit across relay K1 of its companion radio set in the *retransmit* condition. Relay K1 then releases to remove the positive voltage applied to the grid circuit of V11, and places the radio set in the *receive* condition.

e. POWER Switch at CAL & DIAL LITE (fig. 21). The set is in the *receive* condition when the POWER switch is held in the CAL & DIAL LITE position. In addition, the filaments of 2.15-mc calibrating oscillator V9 and dial lamp E8 are heated through contacts 4 and 5 of S1. The set is then ready for calibration. The spring-return action of the POWER switch in the CAL & DIAL LITE position prevents the switch from being left in this position. Unless held back, the switch will return to the ON position.

f. POWER Switch at REMOTE (fig. 21).

(1) In the REMOTE position of the POWER switch, all four voltage supplies are connected to AUDIO jack J8J instead of to ground. Power can now be applied to the set only when jack J8J is connected to ground. This connection is made through a relay circuit in remote Control Group AN/GRA–6, which connects terminal J to grounded terminal B. Remote Control Group AN/GRA–6 includes Local Control C–434/GRC and Remote Control C–433/GRC as two of its basic components (fig. 22).

(2) The SET 1 cable of Local Control C–434/GRC is plugged into AUDIO jack

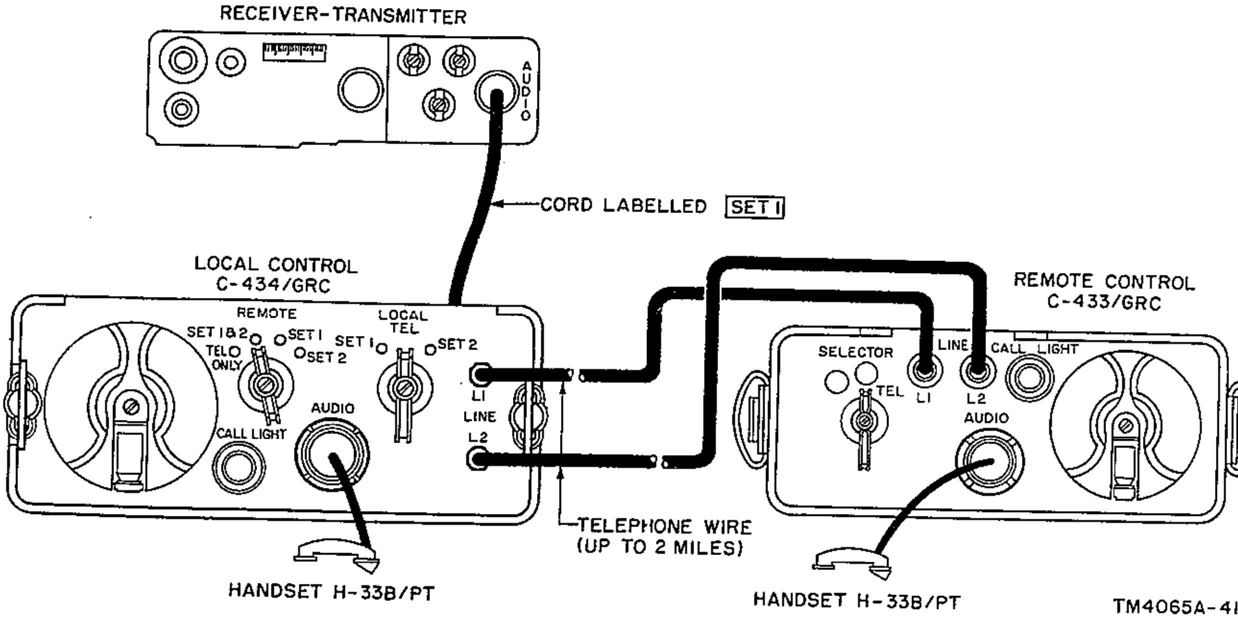


Figure 22. Connections to Control Group AN/GRA-6.

J8 of the radio receiver-transmitter. Remote Control C–433/GRC is connected to the local control unit by a two-wire telephone line whose maximum length may be 2 miles (fig. 22). On the local control unit, the LOCAL switch is set at TEL and the REMOTE switch is set at SET 1. On the remote control unit, the SELECTOR switch is set to the left write-in position and the push-to-talk button on the handset is pressed and then released. With the above settings on the local control unit, jack J8J in the radio set is grounded through a relay circuit in the local control unit and power is applied to the receiver section of the radio set.

(3) When the push-to-talk button is pushed in, on the handset that is plugged into the remote control unit, relays are actuated in the local control unit. This action completes the circuits from jack J8F to jack J8H, and from jack J8C to jack J8E through the handset microphone. These circuits energize receiver-transmit relay K1 in the radio set and complete the microphone input circuit. The radio set is then in the *transmit* condition. Releasing the push-to-talk button returns the set to the *receive* condition. Turning the SELECTOR switch on the remote control unit away from the left write-in position, breaks the connection from jack J8J to ground and turns off all power in Radio Set AN/PRC–9A or AN/PRC–10A.

26. Handset Operation

(figs. 23 and 24)

The operation of the handset during the *receive* and *transmit* conditions is described in *a* and *b* below.

a. Listening. The POWER switch S1 is in the ON position. The SQUELCH control is also on (away from its extreme counterclockwise OFF position) and adjusted. The −B, −A, and +C

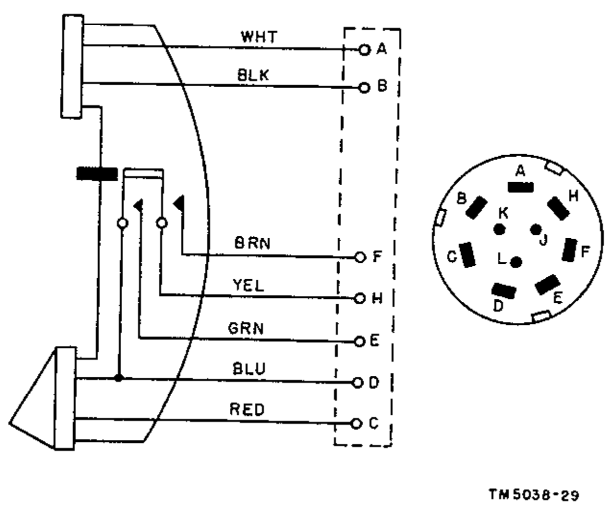


Figure 23. Handset H–33B/PT, schematic diagram.

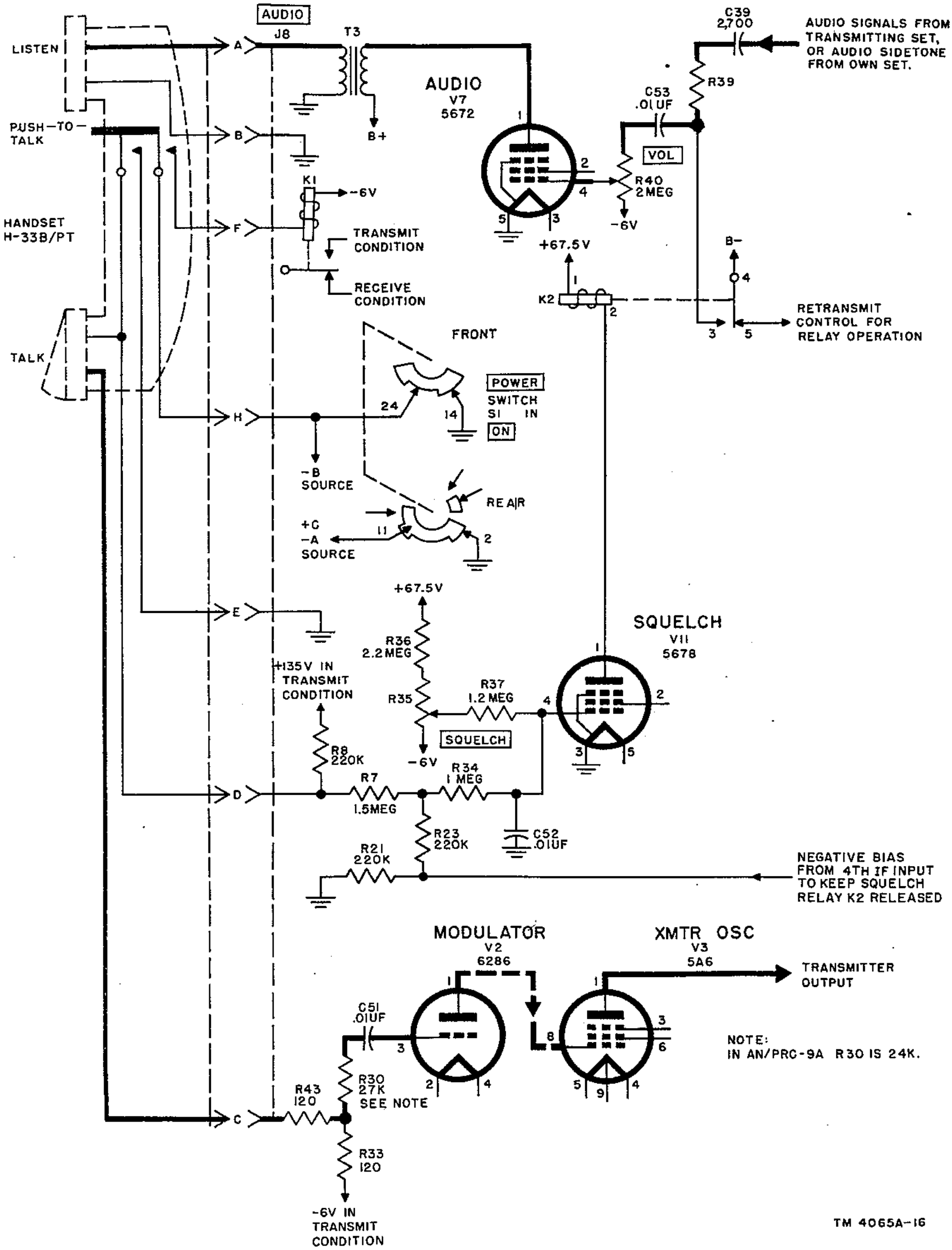


Figure 24. Handset operation.

sides of the power source are all returned to ground through POWER switch S1, thereby applying power to the receiver-transmitter. Relay K1 is in its released condition, so that the receiver-transmitter is in the *receive* condition. Operating voltages are applied to all the tubes in the receiver section, but not in the transmitter section. Signals received from the transmitting radio set at the other end of the radio communication link are converted, amplified, and applied through the discriminator stage to the grid of audio amplifier stage V7. The output of the audio stage feeds into the earphone of Handset H-33B/PT. When no signal is being received, squelch tube V11 conducts to energize K2, and contacts 4 and 3 close to ground the audio input to V7. Noise voltages and weak signals are thus squelched. When a signal is being received, negative bias developed across R23 in the fourth if. amplifier stage cuts off conduction in squelch tube V11 and releases relay K2 so that the received signal may be heard in the handset.

b. Talking. The POWER switch and SQUELCH control are in the same positions as for listening. However, the handset push-to-talk button is pushed in, and held in until through talking.

(1) The push-to-talk switch closes two sets of contacts. One set of contacts completes a 6-volt dc circuit to energize receive-transmit relay K1. The second set of contacts completes a dc circuit through the handset microphone, and grounds a positive potential in the grid circuit of V11 to keep squelch relay K2 released. These actions immediately place the receiver-transmitter in the *transmit* condition. Voice frequencies spoken into the handset microphone are fed to the grid of modulator stage V2, which frequency-modulates transmitter oscillator V3.

(2) When relay K1 energizes, it disables rf amplifiers V4 and V5 in the receiver section and connects operating voltages to the tubes in the transmitter section. A very small amount of rf energy from transmitter oscillator V3 is picked-up in the receiver section, converted, amplified through the if. stages, and passed through the discriminator. The output audio signal is applied to audio stage V7. Audio sidetone is thus heard in the earphone of the handset, while talking into the mouthpiece.

Note. If the radio set were being used in relay operation, terminal D would not be grounded through the push-to-talk switch. Positive potential in the grid circuit of V11 would then cause V11 to conduct, energize K2, and ground the input to audio state V7.

27. Relay Operation

(fig. 25, fig. 26—See foldin in back of Manual)

a. In relay operation, the POWER switch of both radio sets must be turned to ON, and the SQUELCH control adjusted for squelch operation. When no signals are being sent in either direction (and the transmitter carriers are off), squelch relays K2 in both sets are energized and pulled in. They release only when negative bias developed from the received signal in the fourth if. amplifier cuts off plate conduction in squelch V11. Consequently, when neither of the two terminal (or end) stations is transmitting, both radio sets at the relay station are in the *receive* condition.

b. When radio set No. 1 starts transmitting, its carrier signal is received only by radio set No. 2 which is tuned to its frequency. The signal received by radio set No. 2 develops a negative bias voltage in the fourth if. amplifier stage.

(1) The negative voltage developed in the grid circuit of the fourth if. amplifier is applied to the grid of squelch tube V11 and cuts off its conduction to deenergize squelch relay K2. Upon being deenergized, relay K2 breaks contacts 3 and 4 (through which the audio signal in radio set No. 2 is grounded), and makes contacts 5 and 4 to complete a dc circuit that energizes relay K1 of radio set No. 3. When relay K1 energizes radio set No. 3 is in the *transmit* condition. The audio output of radio set No. 2 is fed through pin J8A, the relay cable, and pin J8C of radio set No. 3 to the modulator input circuit of radio set No. 3. This set retransmits the signal on its carrier frequency to radio set No. 4. The carrier frequencies of the two radio sets at the relay station differ by at least 3 mc.

(2) When relay K1 of radio set No. 3 is energized, a positive bias from the junction of R7 and R23 is applied to the grid circuit of squelch V11. This keeps tube

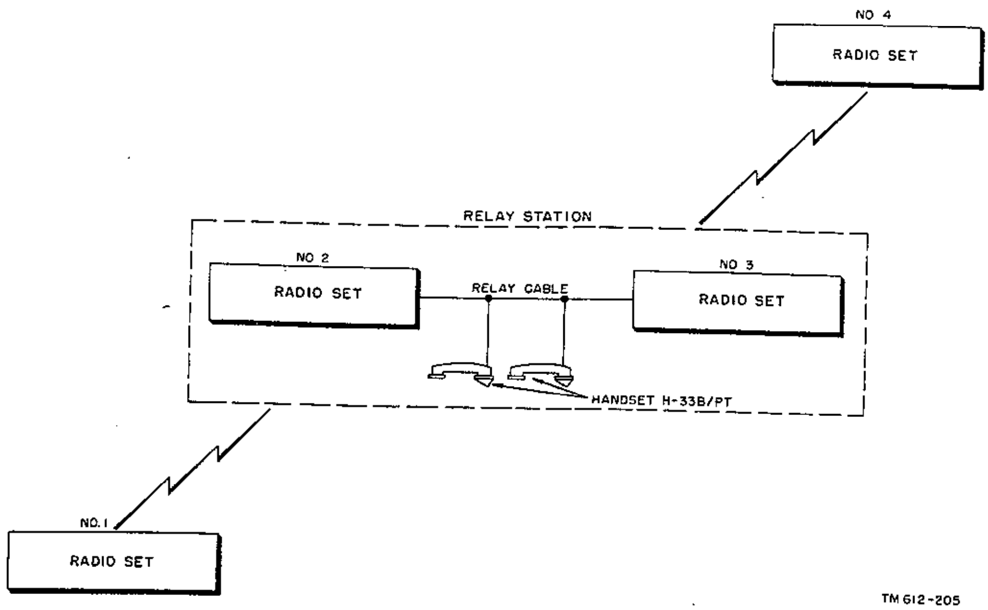


Figure 25. Radio Sets arranged for relay operation.

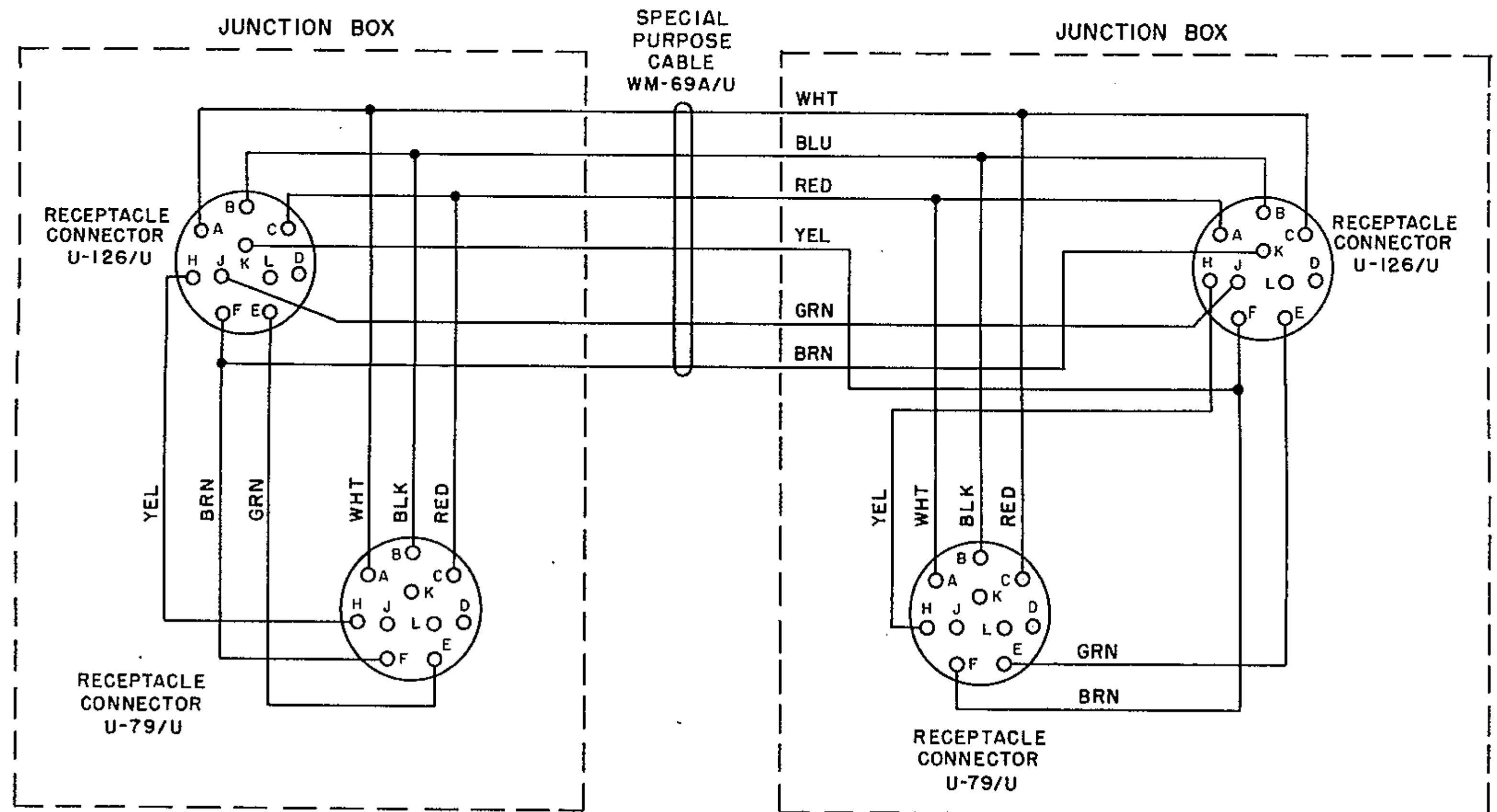
V11 conducting and relay K2 in its plate circuit energized. No signal or other voltage can then develop a negative bias to cut off conduction of V11. Contacts 3 and 4 of relay K2 ground the sidetone of the retransmitted signal developed in the circuit of radio set No. 3. However, when a handset plugged into the connector of Cable Assembly CX–1961/U has its push-to-talk button pushed in, the junction point of R8 and R7 is grounded. This removes the positive bias on V11 which stops tube conduction and deenergizes relay K2. Contacts 4 and 5 close and permit sidetone to be heard in the handset.

(3) Radio set No. 3 is shown in the *retransmit* condition with modulator V2 and transmitter oscillator V3 operative. However, when radio set No. 1 stops transmitting, the negative bias on squelch tube V11 of radio set No. 2 is removed. Tube V11 resumes conduction and squelch relay K2 energizes. This breaks the energizing circuit for receive-transmit relay K1 in radio set No. 3. Both sets at the relay station are now again in the *receive* condition.

c. When radio set No. 4 starts transmitting, its carrier signal is received only by radio set No. 3 which is tuned to its frequency.

(1) The signal received by radio set No. 3 develops a negative bias voltage in the if. stage. The negative voltage developed in the grid circuit of the fourth if. amplifier stage is applied to the grid of squelch tube V11 and cuts off its conduction to release relay K2. When released, relay K2 breaks contacts 3 and 4 through which the received audio signal in radio set No. 3 is grounded, and makes contacts 5 and 4 to complete a dc circuit that energizes relay K1 of radio set No. 2. When relay K1 is energized it puts radio set No. 2 in the *retransmit* condition. The audio output of radio set No. 3 is fed through pin J8A, the relay cable, and pin J8C of radio set No. 2 to the modulator input circuit of radio set No. 2 which, in turn, retransmits the signal on its carrier frequency to radio set No. 1.

(2) When relay K1 of radio set No. 2 is energized, a positive bias is applied to the grid circuit of squelch V11 in radio set No. 2. This keeps V11 conducting and squelch relay K2 in its plate circuit energized. No signal voltage can then develop a negative bias to cut off conduction of V11. The sidetone of the retransmitted signal developed in the circuit of radio set No. 2 is grounded through contacts 3 and 4 of relay K2, unless a



NOTE:
THE BROWN (F TO K) AND YELLOW (K TO F) WIRES ARE SIZE NO. 18.

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Figure 27. Electrical special purpose cable assembly CX-1961/U.

handset is plugged into cable assembly CX-1961/U and its push-to-talk button is held in. Although figure 26 shows only radio set No. 2 in the *receive* condition and radio set No. 3 in the *retransmit* condition, their conditions are identically reversed when radio set No. 4 transmits to radio set No. 1. If radio set No. 1 starts to transmit at the same time that radio set No. 4 begins to transmit, only one squelch relay K2 (in radio set No. 2 or No. 3) at the relay station will release. This is the relay in which the plate current of V11 is first cut off. It is highly improbable that the tubes in both radio sets will ever cut off simultaneously.

d. The two handsets which plug into Cable Assembly CX-1961/U are so connected that the handset located near radio set No. 2 may receive and transmit over radio set No. 2; the handset located near radio set No. 3 may receive and transmit over radio set No. 3. The handset earphone is connected across terminals A and B of the handset connector (fig. 26). The handset microphone is connected across terminals C and E through two normally open contacts of the push-to-talk switch. The other two contacts of the push-to-talk switch short terminal F to H when the switch is pushed in. Terminals A and B of the handset located near radio set No. 2 are connected through the relay cable to terminals A and B of AUDIO jack J8 on radio set No. 2. Since the audio output of radio set No. 2 appears across these terminals, it is fed into the handset near set No. 2. Similarly, the audio output of radio set No. 3 is fed to the handset located near this set. The retransmission cable (fig. 27) is approximately 15 feet long, and the two radio sets can be arranged so that one operator can handle both handsets, if necessary.

e. When the push-to-talk button on the handset located near radio set No. 2 is pushed in, the handset microphone circuit is completed to the modulator input circuit of radio set No. 2 by the closure of contacts C and E. The receive-transmit relay (K1) circuit of this set is also completed by the closure of the contacts across F and H. This puts radio set No. 2 in the *transmit* condition, and the operator at this handset may transmit over radio set No. 2. Similarly, when an operator presses the push-to-talk button on the handset located near radio set No. 3, he may transmit over that set. The handsets which are plugged into the relay cable have dominating control over the direction of transmission when they are used to transmit.

f. The lead on the relay cable which interconnects terminals J of the two radio sets, enables the relay station to be operated remotely by means of Control Group AN/GRA-6 (par. 27*f*). For this remote relay type of operation, the POWER switch on each set must be set at REMOTE. Power to the radio sets at the relay station may then be turned on or off from Control Group AN/GRA-6. Reception and transmission is possible in one direction through one of the relay sets by an operator at the control unit. When an operator is stationed with the Local Control C-434/GRC unit, he may, by turning its REMOTE switch between SET 1 and SET 2, enable an operator stationed with the Remote Control C-433/GRC unit to receive and transmit through the relay station in either direction.