Chapter 5

REPAIR INSTRUCTIONS

Note. Failure or unsatisfactory performance of equipment used by Army Ground Forces and Army Service Forces will be reported on WD AGO Form 468, (Unsatisfactory Equipment Report). For particulars see paragraph 115. If Form 468 is not available, see TM 38–250. Failure or unsatisfactory performance of equipment used by Army Air Forces will be reported on Army Air Forces Form 54, Unsatisfactory Report.

Section I. THEORY OF EQUIPMENT

69. Treatment of Theory

The functional theory of Radio Receiver and Transmitter BC–1000–A will be treated in two ways. The first will be a condensed circuit analysis which is keyed to a block diagram and will show signal paths. It can be used for introductory or quick review purposes. The second presents a detailed analysis of each functional circuit used in Radio Receiver and Transmitter BC–1000–A.

70. Condensed Theory of Operation

a. Radio Receiver and Transmitter BC–1000–A consists of a number of interlocking circuits which provide rapid change-over from receive to transmit. The receiver and transmitter frequency is varied by a single tuning control. This makes it possible to change operating frequencies rapidly. The block diagram (fig. 42) shows the signal paths through the transmitter and receiver. The same antenna is used for both transmission and reception.

b. During reception, the incoming signal is passed through the r-f amplifier tube V6, to the grid of the first mixer tube V7 of the double superheterodyne (a superheterodyne which has two intermediate frequency (i-f) channels). The master oscillator tube V4, and doubler tube V3, produce a local oscillator frequency, which is mixed with an incoming signal frequency in the receiver first mixer to produce a 4.3-mc *difference* frequency for the first i-f amplifier system. This same oscillator and doubler also operate during transmission. During transmission, the output of the doubler is fed to the transmitter mixer tube V2 and is

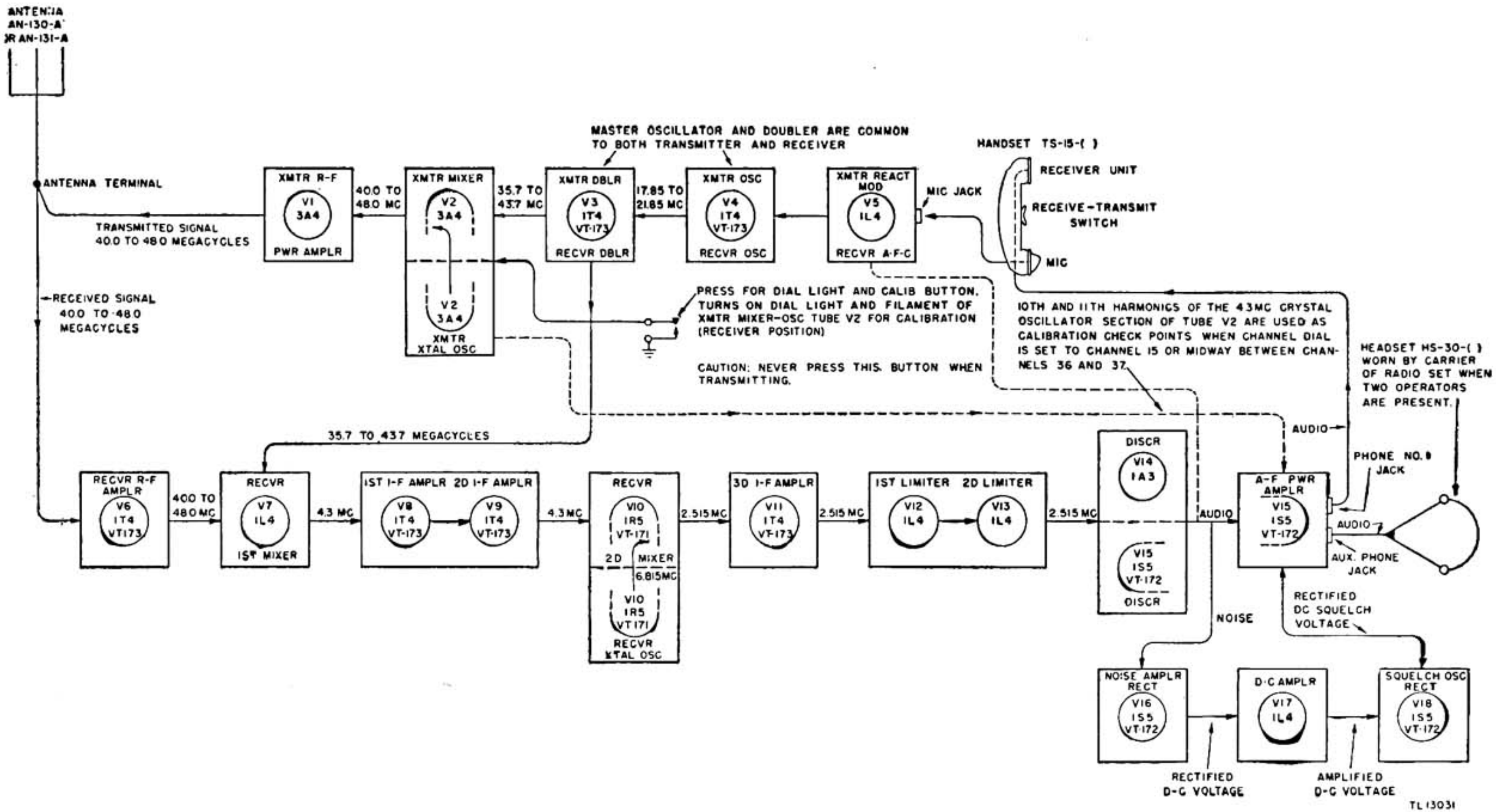

Figure 42. Radio Receiver and Transmitter BC-1000-A—block diagram.

mixed with a 4.3-mc crystal-controlled frequency from the transmitter crystal-oscillator tube V2. The *sum* frequency is developed across the output circuit of tube V2 and drives the r-f power amplifier tube V1, making the receive and transmit frequencies the same.

c. The receiver's first i-f amplifier system, tubes V8 and V9, is followed by a second mixer and i-f amplifier system, tubes V10, V11, V12, and V13. The second local oscillator tube V10 is crystal-controlled on 6.815 mc and its output is mixed with the 4.3-mc first i-f signal to produce a 2.515-mc second i-f frequency. Tubes V12 and V13 of the second i-f system are limiter tubes which insure application of a constant amplitude signal to the frequency discriminator circuit, tubes V14 and V15. The audio output of the discriminator is then amplified by the power amplifier section of tube V15, and applied to the headset or handset.

d. Three separate outputs are taken from the discriminator as follows: (1) audio output, (2) noise impulses which are fed into the noise suppression circuit, tubes V16, V17, and V18, and (3) an automatic-frequency-control (a-f-c) voltage which is applied to the grid of the reactance modulator tube V5, to control the frequency of the master oscillator.

e. In the transmit position, the same reactance modulator is excited by an audio signal from the microphone. The reactance tube frequency modulates the output of the master oscillator at an audio rate. The modulated signal then passes through the doubler tube V3 and transmitter mixer tube V2 to the transmitter r-f power amplifier tube V1 as explained in *b* above. A *small portion* of the r-f output is fed back into the receiver. Thus, receiver and transmitter interlock during transmission and reception.

71. Receiver Circuit Features

The frequency-modulated receiver is a double superheterodyne with a high-frequency first i-f amplifier system to improve selectivity and minimize response to *image* signals (unwanted signals having a frequency 8.6 mc below that of the desired frequency). The second i-f amplifier system uses a lower frequency to further improve the selectivity. The receiver covers a frequency range of 40.0 to 48.0 mc which is divided into 41 channels 200 kc apart. Limiter circuits are used to remove traces of amplitude or noise variations on the received signals, and a noise suppression circuit reduces noise pick-up when no signal is operating the limiters. An a-f-c circuit is used to correct slight maladjustments in tuning or frequency drift caused by changes in circuit constants, or by slight changes in the frequency of the received signal. This circuit shifts the frequency of the receiver master oscillator and keeps the frequency of the first i-f amplifier system constant at 4.3 mc. The block diagram of the receiver is shown in figure 43.

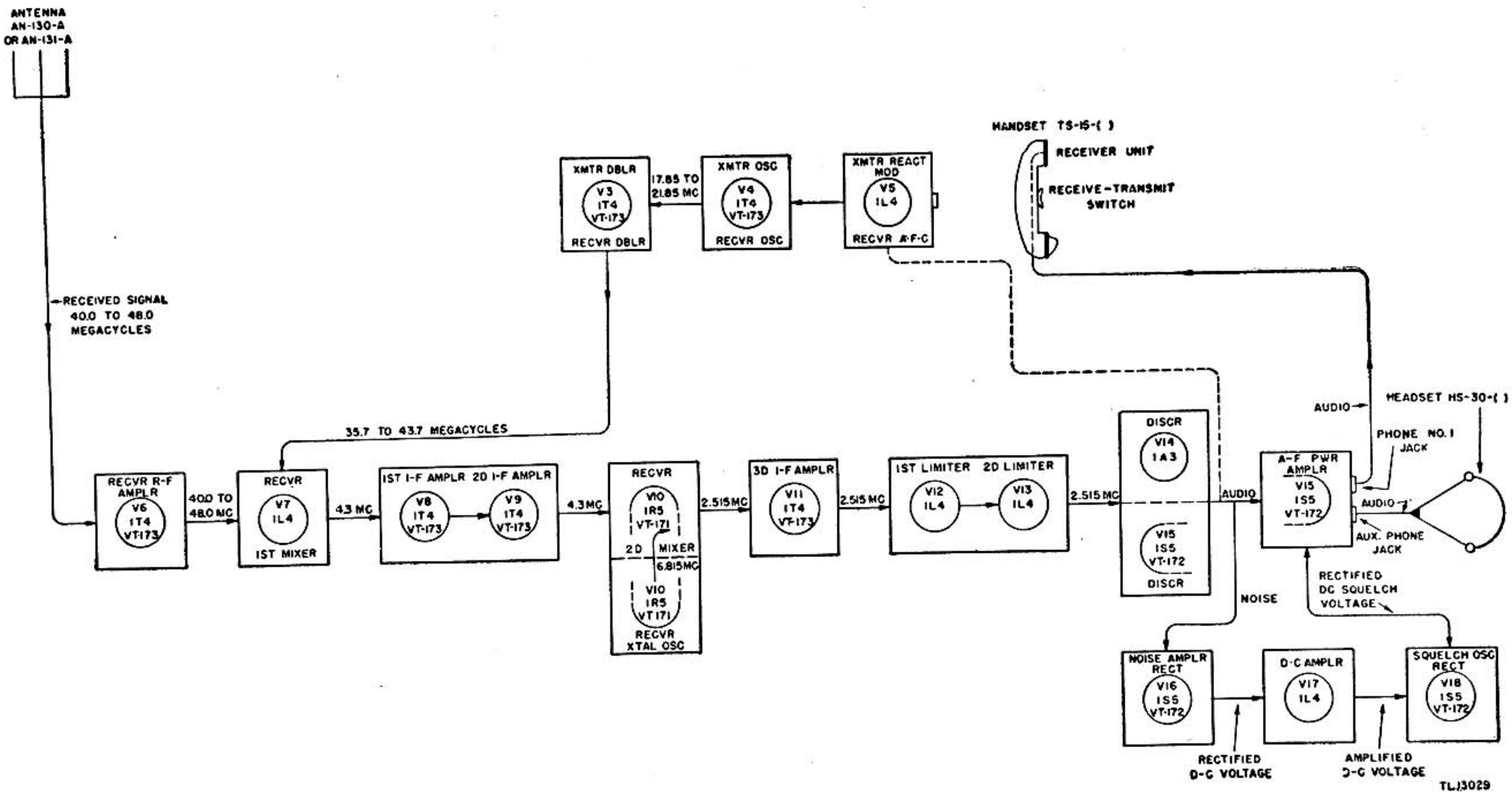

Figure 43. Radio Receiver and Transmitter BC-1000-A, receiver—block diagram.

72. Radio-frequency Amplifier Stage

a. The receiver r-f amplifier Tube JAN–1T4, V6, shown in figure 44, increases the amplitude of the received signal before it is applied to the first mixer tube V7. This stage improves the receiver sensitivity and reduces image response. The r-f amplifier is also a buffer between antenna and receiver, and between transmitter and receiver. The frequency of the mixer tuned circuit, therefore, is not affected by antenna loading or position, and is not upset by transmitter tuning. As a receiver safety precaution, the r-f signal which reaches the receiver when transmitting draws sufficient grid current through resistor R23 to reduce greatly the sensitivity of the r-f amplifier; thus excessive signal is prevented from feeding into the rest of the receiver circuit.

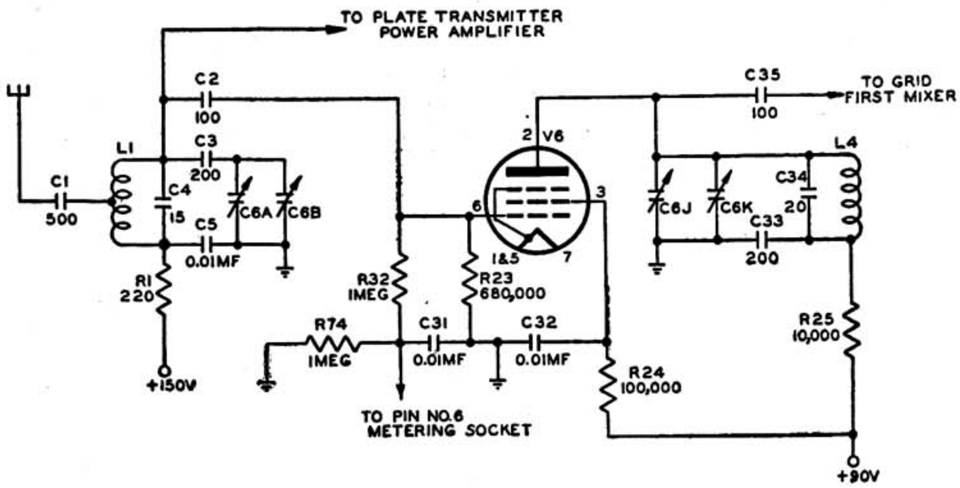

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Figure 44. Radio Receiver and Transmitter BC–1000–A, receiver r-f amplifier.

b. The received signal is applied through capacitor C1 to the resonant circuit consisting of inductor L1, tuning capacitor C6B, alignment trimmer capacitor C6A, shunt temperature compensating capacitor C4, series padder capacitor C3, and bypass capacitor C5. This same tuned circuit is used as the final tank circuit in the transmit position. The signal voltage developed across this tuned circuit is fed to the grid (pin 6) of the r-f amplifier tube V6 through blocking capacitor C2. The output circuit of the r-f amplifier is another resonant circuit consisting of inductor L4, tuning capacitor C6J, trimmer capacitor C6K, temperature compensating capacitor C34, and padder capacitor C33. The voltage developed across this tuned circuit is applied to the grid of the receiver first mixer tube V7 through coupling capacitor C35. As an aid in tuning the transmitter, a voltage divider network consisting of resistors R32 and R74 is connected across grid resistor R23. A voltage proportional to the rectified grid current is measured at pin No. 6 of the metering socket. Capacitor C31 keeps radio frequency out of the metering circuit. Resistor R24 is the screen voltage-dropping resistor, C32 the screen bypass capacitor, and R25 the plate decoupling resistor.

73. First Mixer Stage

First mixer stage Tube JAN–1L4, V7, is triode connected as shown in figure 45. This stage converts the received signal to a 4.3-mc i-f frequency. The signal voltage developed across the single tuned resonant circuit in the preceding stage is applied to the grid of the mixer through

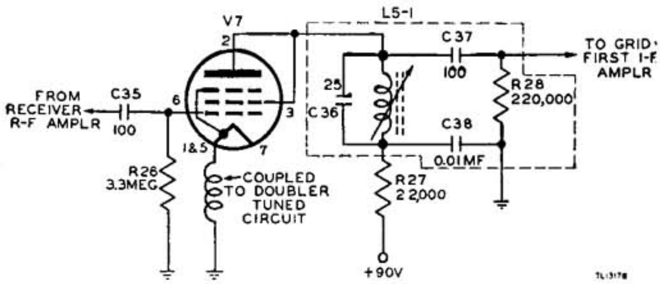

Figure 45. Radio Receiver and Transmitter BC–1000–A, receiver first mixer.

coupling capacitor C35. Local oscillations are applied to the filament by a small pick-up loop coupled to the output of the doubler tube V3. Local oscillations are 4.3 mc below the frequency of the incoming signal. Mixing occurs in tube V7. A 4.3-mc *difference* frequency is brought out by the parallel resonant circuit in the plate circuit of the mixer tube. The resonant circuit of L5–1, which consists of capacitor C36 and an inductor, is tuned to the exact resonant frequency by the variable iron-core tuning adjustment. This stage also contains the following items: coupling and d-c plate blocking capacitor C37, plate bypass capacitor C38, grid resistor R28, and plate decoupling resistor R27.

74. Master Oscillator and Doubler

a. Master-oscillator (receiver and transmitter oscillator) Tube JAN–1T4, V4, and doubler Tube JAN–1T4, V3, shown in figure 46, supply the local oscillator frequency for the receiver first mixer, and the input frequency for the transmitter mixer. The frequency of the master oscillator is controlled by reactance tube V5. In the transmit position, the frequency of the master oscillator is controlled by the audio signal from the microphone; in the receive position, by the a-f-c voltage from the receiver discriminator.

b. The master oscillator V4 is a tuned-plate, untuned-grid oscillator. Class C grid bias (two or three times cut-off) is developed by the flow of rectified grid current through resistor R14. The grid resistor is

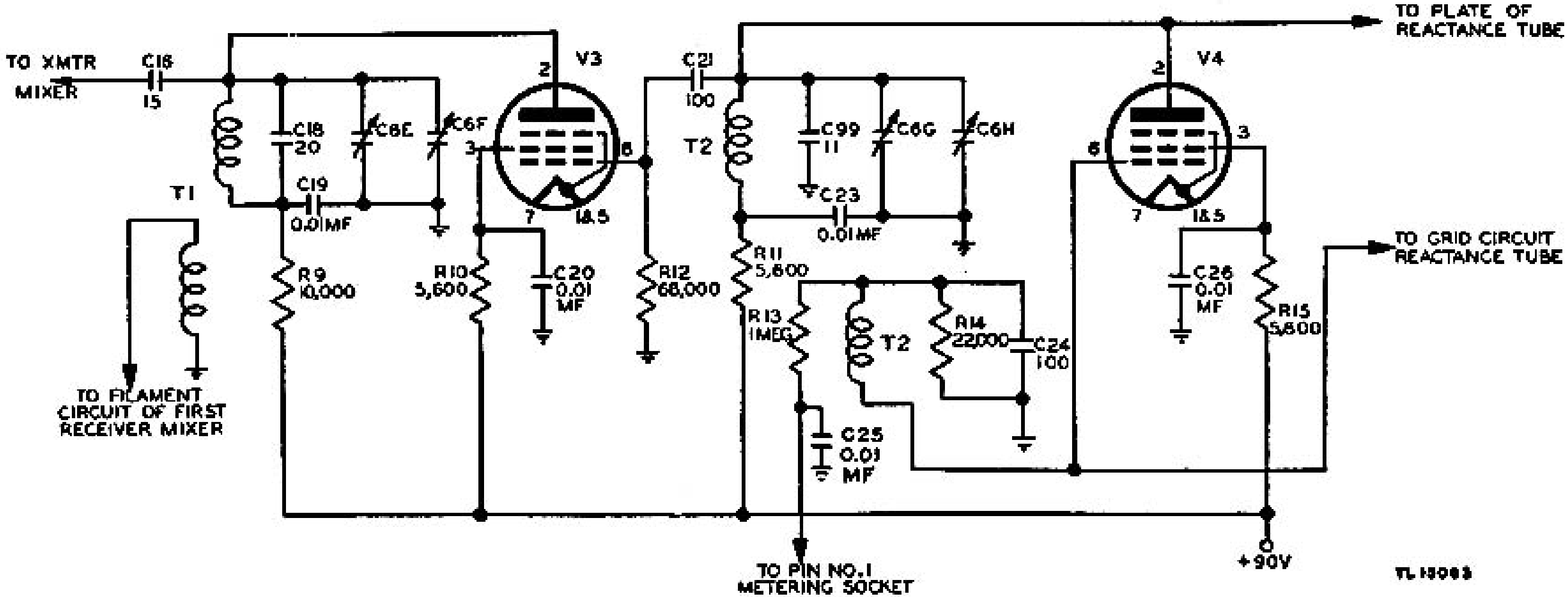

Figure 46. Radio Receiver and Transmitter BC-1000-A, master oscillator and doubler.

bypassed for r-f variations by capacitor C24. The relative value of bias developed across the grid resistor can be measured at pin No. 1 of the metering socket. The metering lead filter system consists of series resistor R13 and shunt capacitor C25. The tuned plate circuit consists of inductor T2, tuning capacitor C6H, trimmer capacitor C6G, temperature compensating capacitor C99, and plate bypass capacitor C23. At the resonant frequency, a portion of the signal developed across the tuned plate circuit is coupled magnetically to the grid coil, and is of the proper phase and amplitude to sustain oscillations. The oscillations cover a frequency range of 17.85 to 21.85 mc, tunable with capacitor C6H. To start the oscillator, no external or cathode bias is used (zero biasing is necessary to start oscillations; rectified grid current drives grid to Class C point after oscillations start) because the filament of V4 is returned directly to ground. R15 is the screen voltage-dropping resistor, C26 is the screen bypass capacitor, C21 the coupling and d-c plate blocking capacitor to the grid of doubler tube V3, and R11 the plate decoupling resistor.

c. The oscillator output is capacitively coupled to the grid of the doubler V3. The doubler plate circuit which covers a frequency range of 35.7 to 43.7 mc is resonant at the second harmonic of the grid signal, and can be tuned with capacitor C6F. To insure efficient doubler operation, the tube is operated with high screen potential and a high-value grid resistor. The tube is driven beyond the normal Class C biasing point by high grid excitation and produces an output wave form which has a large second harmonic content. Two outputs are taken from the doubler stage; the first, by means of a pick-up coil circuit which injects signal into the filament of the receiver mixer V7; the second, through coupling capacitor C16 to the grid of the transmitter mixer V2. Other parts in the circuit are screen voltage-dropping resistor R10, screen bypass capacitor C20, plate decoupling resistor R9, shunt capacitor C18, plate bypass capacitor C19, plate tuning and coupling coils T1, coupling capacitor C16, trimmer capacitor C6E, and grid resistor R12.

75. First Intermediate-frequency Amplifier System

The first i-f amplifier system consisting of two Tubes JAN–1T4, V8 and V9, as shown in figure 47, amplifies the 4.3-mc output of the first mixer V7 before application to the second mixer of the receiver. The i-f coupling transformer L5–2 between the first and second i-f amplifiers consists of a single tuned circuit formed by capacitor C40 and a tunable iron-core inductor, coupling capacitor C41, plate bypass capacitor C42, and grid resistor R31, all inclosed by a shield. The i-f transformer L5–3 between the second i-f amplifier tube and the second mixer is the same as L5–2, containing tuning capacitor C44, tunable iron-core inductor, coupling capacitor C45, plate bypass capacitor C46, and grid resistor R34. The use of the tunable iron-core inductor insures frequency stability and high gain as it is more rigid mechanically and minimizes the capacitance of the parts to ground. Other parts in the circuits are: plate decoupling resistors R30 and R33, coupling and d-c plate blocking capacitor C37, screen voltage-dropping resistor R29, screen bypass capacitor C39, and grid resistor R28.

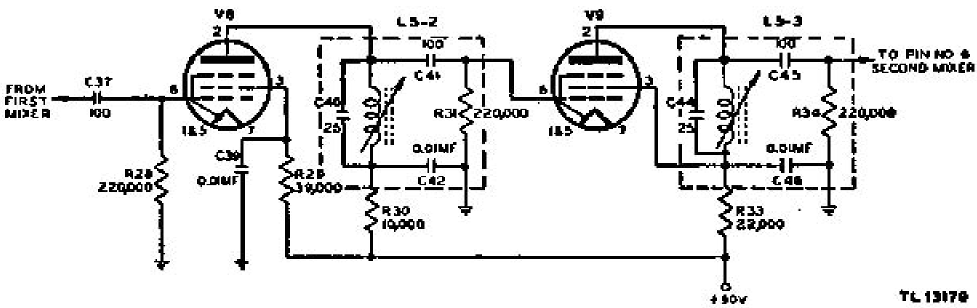

Figure 47. Radio Receiver and Transmitter BC-1000-A, receiver first i-f amplifier system.

76. Second Mixer and Crystal Oscillator

a. The second mixer and crystal-oscillator Tube JAN-1R5, V10, as shown in figure 48, mixes the 4.3-mc first i-f signal with the crystal-controlled frequency to produce a new intermediate-frequency of 2.515 mc. The oscillator section of the converter, on a frequency of 6.815 mc, is a Pierce oscillator with the anode grid of the converter serving as the plate of a triode oscillator. The 4.3-mc signal is applied to the third grid of the converter. The oscillator signal is mixed with the first i-f signal in the electron stream of the tube. The *difference* frequency is brought out in the parallel resonant plate circuit tuned to 2.515 mc. The interstage transformer L6-1 contains tuning capacitor C49, tunable iron

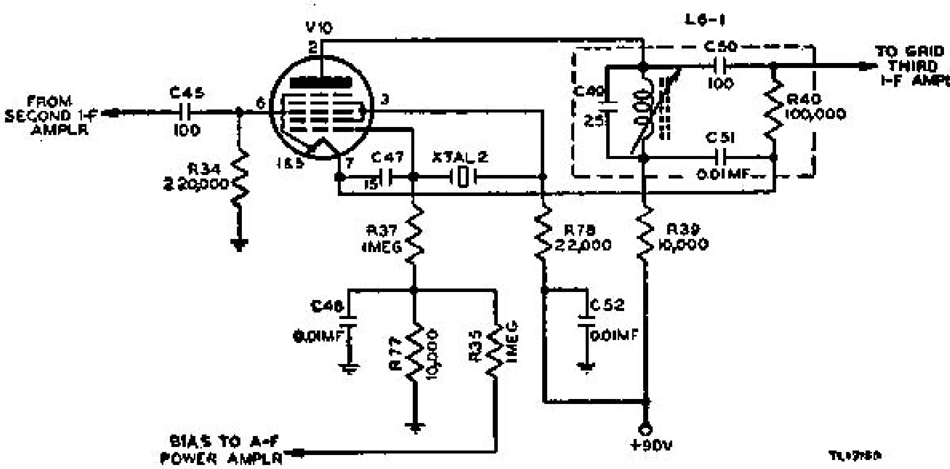

Figure 48. Radio Receiver and Transmitter BC-1000-A, receiver second mixer and crystal oscillator.

inductor, coupling capacitor C50, plate bypass capacitor C51, and grid resistor R40. The circuit also contains decoupling resistor R39, grid resistors R34, R77, and R37, coupling capacitor C45, a-f power amplifier bias filtering circuit capacitor C48 and resistor R35, crystal XTAL 2, and decoupling capacitor C52. Capacitor C47 adds to the interelectrode capacity existing between oscillator grid and filament.

b. A Pierce crystal-controlled oscillator circuit generates the local oscillations. A quartz crystal connected directly between the control grid and anode grid (plate of the triode oscillator section) of the tube serves as a tuned circuit of high Q, replacing the conventional coil and tuning capacitor. The divider of crystal voltage consists of the capacitance between the anode grid and cathode, and the parallel combination of C47 and the interelectrode capacitance between control grid and cathode. The anode potential is applied through decoupling resistor R78. Rectified grid current flows through resistors R37 and R77, and sets the Class C oscillator bias. Voltage developed across resistor R77 is applied through isolating resistors R35, R70, and R71 as bias to the audio-frequency (a-f) power amplifier, V15.

77. Second Intermediate-frequency Amplifier System

a. The second i-f amplifier system as shown in figure 49 consists of the third i-f amplifier Tube JAN–1T4, V11; first limiter Tube JAN–1L4, V12; and second limiter Tube JAN–1L4, V13. The output of the second mixer is increased in amplitude by the third i-f amplifier before application to the limiter stages. The limiter stages confine the i-f signal within fixed voltage limits regardless of the strength of the incoming signal. (This does not apply to a very *weak* signal which may not have sufficient amplitude to swing between these levels.) The signal applied to the frequency discriminator is, therefore, constant in amplitude. The audio output of the receiver is reasonably constant in volume and free of interference from weaker signals on the same frequency.

b. The coupling units between stages consist of single-tuned transformers L6–2 and L6–3, which are similar to the type discussed in paragraph 69 except that they are tuned to the lower frequency of the second i-f amplifier system. L6–2 contains tuning capacitor C53, tunable iron-core inductor, coupling capacitor C54, plate bypass capacitor C55, and grid resistor R42. L6–3 contains tuning capacitor C57, tunable iron-core inductor, coupling capacitor C58, plate bypass capacitor C59, and grid resistor R45. L7 contains tuning capacitor C62, tunable iron-core inductor, coupling capacitor C63, and plate bypass capacitor C64. The first and second limiter tubes have sharp cut-off characteristics and are operated at low plate and screen potentials, so that all signals are confined within the narrowed operating region between cut-off and saturation. The application of a signal of reasonable amplitude to the first limiter and

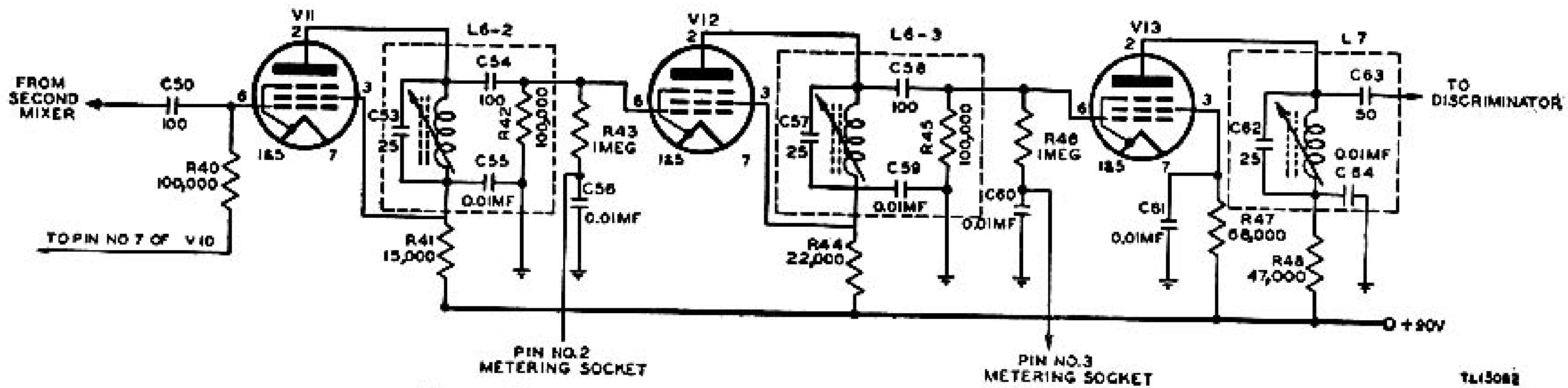

Figure 49. Radio Receiver and Transmitter BC-1000-A, receiver second i-f amplifier system.

the effective limiting of plate current by the flow of rectified grid current through resistors R42 and R45, result in removal of all amplitude variations. The two limiter stages permit the application of a larger limited signal to the discriminator and limiting action on weak signals. Signals not strong enough to operate the first limiter fully will operate the second limiter, thus amplitude noises will be reduced even on weak signals. The output from the tuned circuit of the second limiter V13 is coupled through capacitor C63 to the midpoint of capacitors C5 and C66, a part of the discriminator tuned circuit. To aid in aligning and checking the operation of the limiters, the relative value of the voltage developed across the grid resistors by rectified grid current flow can be measured at the metering socket. The first limiter voltage is applied through the isolating filter circuit which consists of resistor R43 and capacitor C56 to pin No. 2 of the metering socket; the second limiter voltage through the isolating filter circuit which consists of resistor R46 and capacitor 60 to pin No. 3 of the metering socket. The circuit also contains plate decoupling resistors R41 and R44; screen resistor R47; screen bypass capacitor C61; coupling capacitor C50; and grid resistor R40.

78. Discriminator

a. The discriminator stage, shown in figure 50, consisting of Tube JAN–1A3, V14, and the diode section of Tube JAN–1S5, V15, converts the frequency variations of the signal into audio variations. A frequency-modulated signal of constant amplitude is presented to the discriminator circuit from the second limiter.
Discriminator action changes the frequency variations to amplitude variations which are proportional to the change in frequency of the incoming signal. (A signal which shifts ±50 kc on each side of the resting frequency produces a greater amplitude audio signal than one shifting only ±20 kc on each side of the resting frequency.) In addition to the audio output, two other outputs are taken from the discriminator; one operates the noise circuit and the other the a-f-c circuit.

b. Capacitive coupling only is used between coupling unit L7, the output circuit of the second limiter tube V13, and coupling unit L8, the tuned circuit of the discriminator. Both are resonant at 2.515 mc, the frequency of the second i-f amplifier system. The signal present across the resonant circuit in coupling unit L7 is fed to the discriminator tuned circuit from the plate side of the inductor through capacitor C63. Capacitor C69, although it introduces some unbalance, is necessary to obtain proper coupling between circuits. A portion of the r-f energy divides between capacitors C66 and C69. The voltage across capacitor C66 excites the tuned circuit in coupling unit L8. This coupling unit is composed of capacitors C65 and C66 and a tunable iron-core inductor.

c. At the second intermediate frequency of 2.515 mc, the phase rela-

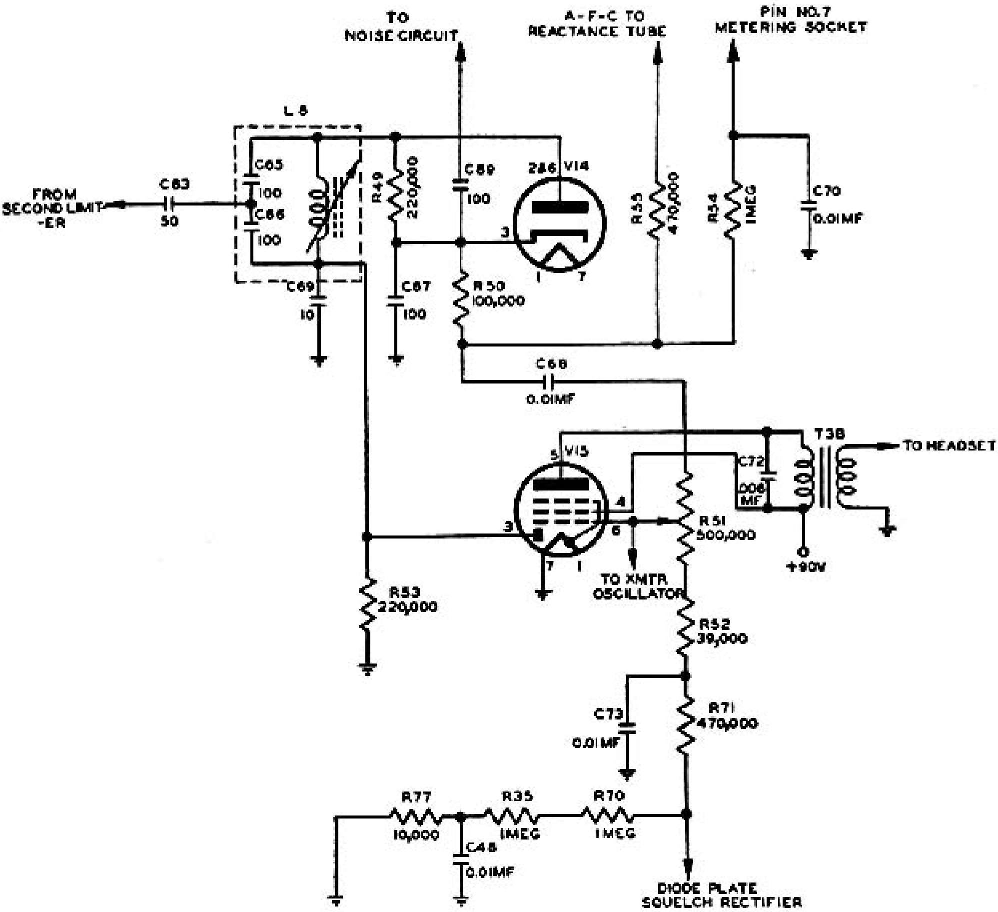

Figure 50. Radio Receiver and Transmitter BC–1000–A, discriminator and a-f power amplifier.

tionship between the voltage developed in coupling unit L7 and the voltage developed across capacitors C65 and C66 will produce essentially equal and opposite d-c voltages across the two diode load resistors R49 and R53. The net d-c voltage is then zero between the cathode of tube V14 and ground.

d. When a frequency higher than the intermediate frequency of 2.515 mc is applied to the circuit, the phase relationship between the voltage developed in coupling unit L7 and the voltages developed across capacitors C65 and C66 shifts. This shift causes unequal voltages to be applied to the two diodes and their load resistors. This results in a positive value of d-c voltage between the cathode of tube V14 and ground. At a frequency lower than 2.515 mc, the opposite condition takes place and a negative voltage is developed between the cathode of tube V14 and ground. The frequency variations in received signals above and below the resting frequency are at an audio rate, and it is the audio voltage developed between the cathode of V14 and ground that is applied as signal voltage to the control grid of the a-f amplifier section of tube V15. Capacitor C67 is an r-f bypass capacitor across the output of the circuit. Other components of the discriminator circuit are filter resistor R50, a-f-c filter resistor R55, metering lead filter resistor R54 and capacitor C70, and noise coupling capacitor C89.

79. Audio-frequency Amplifier

The audio-frequency amplifier stage consists of the pentode section of Tube JAN–1S5, V15 (fig. 50). The audio output of the discriminator is coupled through capacitor C68 to potentiometer R51, the rotor of which connects to the grid (pin No. 6) of the a-f power amplifier. The grid return for the a-f power amplifier is completed through resistors R51, R52, R71, R70, R35, and R77. Resistor R77 is also in the grid return circuit of the receiver crystal-oscillator tube V10, and the voltage developed by the flow of oscillator grid current is applied as bias to the a-f power amplifier. When the squelch circuit is operating, resistors R70, R35, and R77 are the load for the squelch circuit diode. The flow of diode current biases the a-f power amplifier (V15) beyond cut-off when the squelch circuit is operated by noise impulses. The audio output of the a-f power amplifier is transformer coupled by T3B to the headset or handset. Other components of the a-f power amplifier circuit are output transformer shunt capacitor C72 and filter capacitors C73 and C48.

80. Automatic-frequency Control (figs. 50 and 53)

a. An a-f-c circuit holds the center frequency of the frequency-modulated signal constant. To insure linear detection and maximum signal output, the center frequency must be held to exactly 2.515 mc at the discriminator. Frequency control is accomplished by shifting the frequency of the master oscillator V4 with the reactance modulator V5 to compensate for any shift in center frequency caused by a slight change in master-oscillator frequency, change of circuit characteristics, or frequency of the incoming signal. The grid return to ground for the reactance modulator tube V5 is completed through isolating resistors R18, R55, R50, and the diode load resistors R49 and R53. When the center frequency is 2.515 mc, the voltages across the resistors cancel and no extra bias is placed on the reactance tube. However, if the frequency shifts, the voltage across the resistor combination will become negative or positive, depending upon the direction of frequency deviation, and an additional direct current (d-c) bias will be placed on the grid of the reactance tube V5. A filter circuit, consisting of capacitor C30 and isolating resistors R18 and R55, removes the audio components from the a-f-c voltage.

b. The change in reactance tube bias adds to or subtracts from the effective capacitance presented to the master-oscillator tuned circuit. This change in capacitance shifts the frequency of the master oscillator in the direction necessary to maintain at exactly 4.3 mc the center frequency of the signal passing through the first i-f amplifier system. Since the local oscillator for the second i-f amplifier system is crystal-controlled at 6.815 mc, it generates a stable reference frequency for the entire a-f-c circuit and will hold the center frequency of the first i-f amplifier system at 4.3 mc as well as the center frequency of the second i-f amplifier system and discriminator at exactly 2.515 mc. Frequency compensation is effected over a range of 50 kc on each side of the received frequency. Table VIII gives the frequency changes and resulting polarity of the discriminator output voltage for various conditions of frequency shift.

Table VIII. Discriminator polarities

Condition	Received signal frequency (mc)	Master-oscillator frequency (mc)	Doubler frequency (mc)	1st i-f frequency (mc)	2d i-f frequency (mc)	Discriminator polarity
Frequencies in receiver under normal conditions.	40.00	17.85	35.70	4.3	2.515	zero
Received signal higher in frequency.	40.050	17.85	35.70	4.35	2.465	negative
Received signal lower in frequency.	39.950	17.85	35.70	4.25	2.565	positive
Increase in master-oscillator frequency caused by mistuning or drift.	40.00	17.875	35.75	4.25	2.565	positive
Decrease in master-oscillator frequency caused by mistuning or drift.	40.00	17.825	35.65	4.35	2.465	negative

Another output is taken from the discriminator through capacitor C89 and applied to the noise squelch circuit. To prevent operation of the noise circuits by an audio signal, the coupling circuit permits the transfer of the high-frequency noise impulses only.

81. Noise Squelch Circuit

a. The noise squelch circuit as shown in figure 51 consists of a noise amplifier-rectifier Tube JAN–1S5, V16; d-c amplifier Tube JAN–1L4, V17; and squelch oscillator-rectifier Tube JAN–1S5, V18. In the reception of a frequency-modulated signal, the action of the receiver limiter prevents amplitude noise impulses from appearing in the discriminator output. However, during the intervals when no signal is received, the

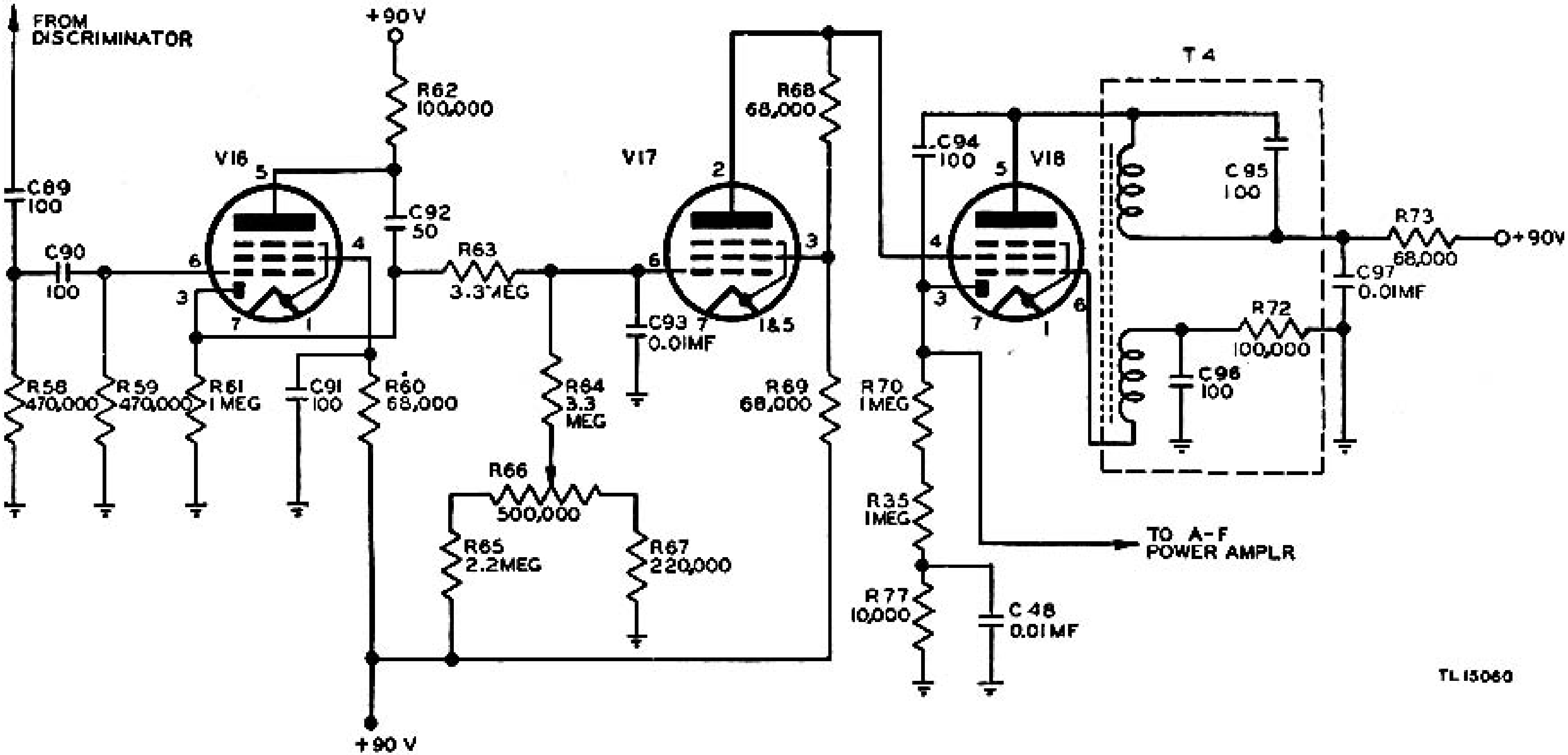

Figure 51. Radio Receiver and Transmitter BC-1000-A, noise squelch circuit.

amplitude noise impulses are detected and appear in the discriminator output. The squelch circuit prevents the application of the noise impulses to the handset by biasing the a-f power amplifier beyond cut-off when no signal is received.

b. The amplitude noise impulses present in the output of the discriminator when no signal is being received are applied to the grid of the noise amplifier rectifier tube V16 through a high-pass filter which consists of capacitors C89 and C90, and resistors R58 and R59. The high-series reactance of the capacitors at low frequencies plus the high-shunt resistance permits application of only the high-frequency noise impulses to the noise circuits. The low-frequency audio signals are not applied. The noise impulses are amplified by the pentode section of the tube, and are applied through capacitor C92 to the diode rectifier section where the impulses are rectified. The rectified impulses are negative in polarity (vary from zero to a negative voltage proportional to their amplitude). In order to maintain the impulses of one polarity, they must be coupled directly to the grid (pin No. 6) of the d-c amplifier tube V17 through filtering resistor R63. If the impulses were coupled through a capacitor, they would again arrange themselves plus and minus about a zero axis.

c. It is necessary to have a signal of one polarity if the basis on the d-c amplifier is to be shifted in only one direction. (With no signal, bias is set at a fixed level and when noise impulses are received the bias must be *increased* in direct proportion to the amplitude of the noise impulses.) The negative impulses are smoothed out by capacitor C93 which has sufficient voltage storing action to cause the sharp negative noise impulses to present a continuous negative potential to the grid; proportional to their amplitude. The d-c amplifier fixed bias level is established by a voltage divider network consisting of resistors R65, R66, and R67 across the power supply circuit. Bias is set by the SQUELCH control potentiometer R66 which applies bias to the grid of the tube through isolating resistor R64. With the fixed bias and no noise impulses on the grid of the d-c amplifier tube V17, the plate current is high and the plate voltage relatively low. When noise impulses reach the amplifier, the bias increases and plate current decreases, increasing the plate voltage.

d. The plate of the *d-c amplifier* tube is directly connected to the screen of the *squelch oscillator-rectifier tube V18,* causing the screen voltage of tube V18 to vary with the plate voltage of tube V17. When the screen voltage is increased to the proper level, the squelch oscillator pentode section of the tube will break into oscillation. The oscillator operates at 400 kc and uses transformer feedback. R-f output from the oscillator is coupled through capacitor C94 to the plate of the diode section of the tube. When diode current flows through resistors R70, R35, and R77, a negative voltage is developed which will bias the a-f power amplifier grid beyond cut-off. The following parts are also contained in the noise circuit: grid resistors R59 and R72, screen resistors R60 and R69, screen bypass capacitor C91, plate load resistors R62 and R68, decoupling resistor R73, plate bypass capacitor C97, diode load resistor R61, tuning capacitors C95 and C96, iron-core inductor, and bypass capacitor C48.

82. Transmitter Circuit Features

The transmitter of Radio Receiver and Transmitter BC–1000–A, as shown in figure 52, consists of the previously described master oscillator (V4) and doubler (V3) (par. 74), transmitter mixer and crystal oscillator, and tuned circuits of the r-f power amplifier. The master oscillator is frequency modulated by the reactance modulator V5. In transmitting, the output of the doubler is *added* to the transmitter

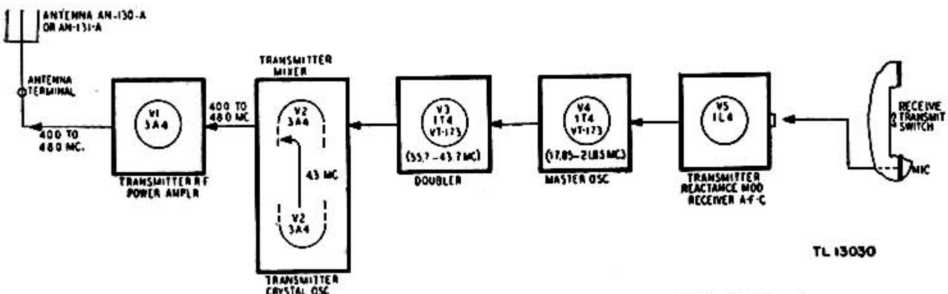

Figure 52. Radio Receiver and Transmitter BC–1000–A, transmitter—block diagram.

crystal oscillator frequency to produce the final transmitter frequency. As a special aid in alignment procedure and operational checks, a switch marked PRESS FOR DIAL LIGHT & CALIB. turns on the transmitter mixer and crystal oscillator V2.

83. Reactance Modulator

a. The reactance modulator Tube JAN–1L4, V5, shown in figure 53, changes the frequency of the master oscillator (V4) in accordance with changes in voltage of the audio signal applied to its control grid. The greater the amplitude of this audio modulating signal, the greater is the frequency deviation on each side of the resting frequency. The higher the audio frequency, the *more often* the frequency deviates on each side of the resting frequency. The audio signal is applied to the grid of the reactance modulator tube V5 by microphone transformer T3A and blocking capacitor C29. The transformer secondary is shunted by resistor R20 to place a more constant load on the microphone circuit and to reduce any audio howl. R17 is an isolating resistor in the control grid circuit.

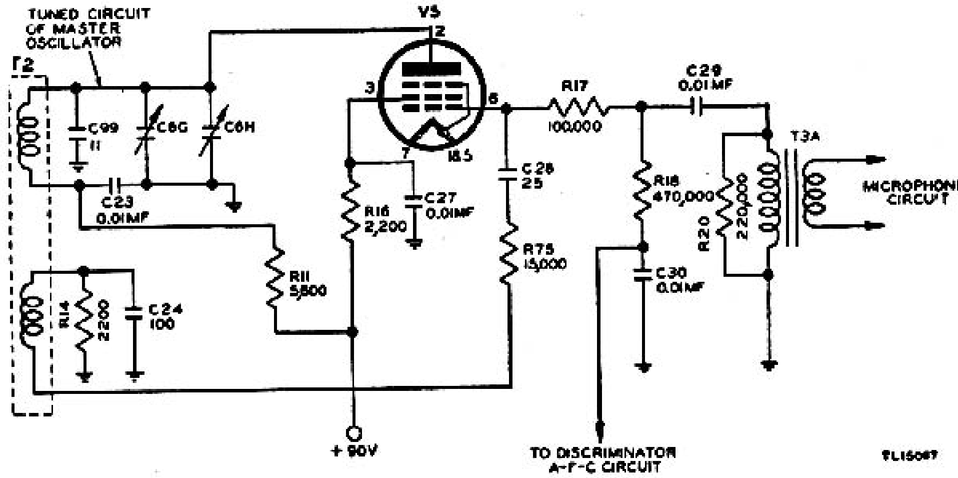

Figure 53. Radio Receiver and Transmitter BC–1000–A, reactance modulator.

b. The reactance modulator tube is an electronic capacitor shunting the tuned circuit of the master oscillator. Any change in value of this effective capacitance changes the frequency of the oscillator. When an audio signal is impressed on the grid of the reactance modulator tube from the microphone circuit, the a-c variations change the effective capacitance at an audio rate. Consequently the oscillator frequency varies at the same rate.

c. To operate this vacuum tube as a capacitive reactance modulator, two conditions must be met: the output must appear as a capacitance, or the plate voltage across the output must lag the plate current by 90° (the voltage across a capacitor lags the current by 90°); and the value of the effective capacitance must vary in accordance with the change in grid potential.

(1) Figure 54 shows how the first condition is met. The r-f voltage developed across the tuned circuit L1-C1 (the tuned plate circuit of the master oscillator) induces a voltage 180° out of phase in grid coil L2 (the grid feedback coil of the master oscillator). A network consisting of resistor R75 and the interelectrode capacitance C_{gf} between the grid

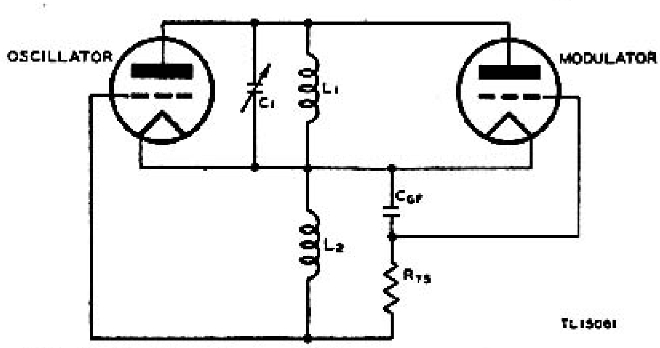

Figure 54. Radio Receiver and Transmitter BC–1000–A, reactance modulator, simplified a-c—schematic.

and the filament of the reactance modulator tube is connected across the inductor L2. Since the resistance of resistor R75 is high in comparison with the reactance of C_{gf} at the oscillator frequency, the current through the series combination is almost in phase with the induced voltage of the coil. But the voltage across the interelectrode capacitance C_{gf} lags the current by 90°. This is the grid voltage applied to the reactance modulator tube, and it lags the voltage across the tuned circuit (or the plate voltage) by a total of 270° (180° plus 90°). This is the same as saying that the reactance modulator tube grid voltage leads the plate voltage by 90°. Since the reactance modulator tube plate current is in phase with the grid voltage, the plate current contributed to the tuned circuit by the reactance modulator tube leads the plate voltage by 90°, forming an effective capacitance.

(2) The second condition, that effective capacitance must be variable in accordance with the change in grid potential of the modulator tube, is met by controlling the amount of plate current contributed by the reactance modulator tube. During modulation the grid of the reactance modulator tube is swung about its operating point by the applied audio signal. These audio signal variations on the grid cause corresponding variations in the plate current, in capacitance across the oscillator tank, and in oscillator frequency. The larger the amplitude of the signal variations impressed on the grid, the greater will be the plate current variations and the farther the master oscillator frequency will swing above and below the resting frequency.

d. The reactance modulator tube serves also as an automatic frequency control device (par. 80). Other parts of the reactance modulator tube circuit are blocking capacitor C28, screen resistor R16, screen bypass capacitor C27, master oscillator tuned circuit consisting of air core inductor, tuning capacitor C6H, trimmer capacitor C6G, temperature compensating capacitor C99, and plate bypass capacitor C23, plate decoupling resistor R11, control grid resistor R17, oscillator grid resistor R14, oscillator grid resistor bypass capacitor C24, audio coupling capacitor C29, microphone transformer T3A, and shunt resistor R20.

84. Transmitter Mixer and Crystal Oscillator

a. The transmitter mixer and crystal-oscillator Tube JAN–3A4, V2, as shown in figure 55, generates a crystal-controlled frequency which is combined with the output of the doubler stage in the mixer section of the tube.

The mixer tuned output circuit is resonant at the *sum* frequency. The crystal oscillator section of the tube is a triode oscillator on 4.3 mc with the screen grid of the pentode used as the plate of the oscillator. The tuned circuit of the oscillator consists of fixed capacitor C13 and tunable iron-core inductor L3. The relative value of the Class C grid

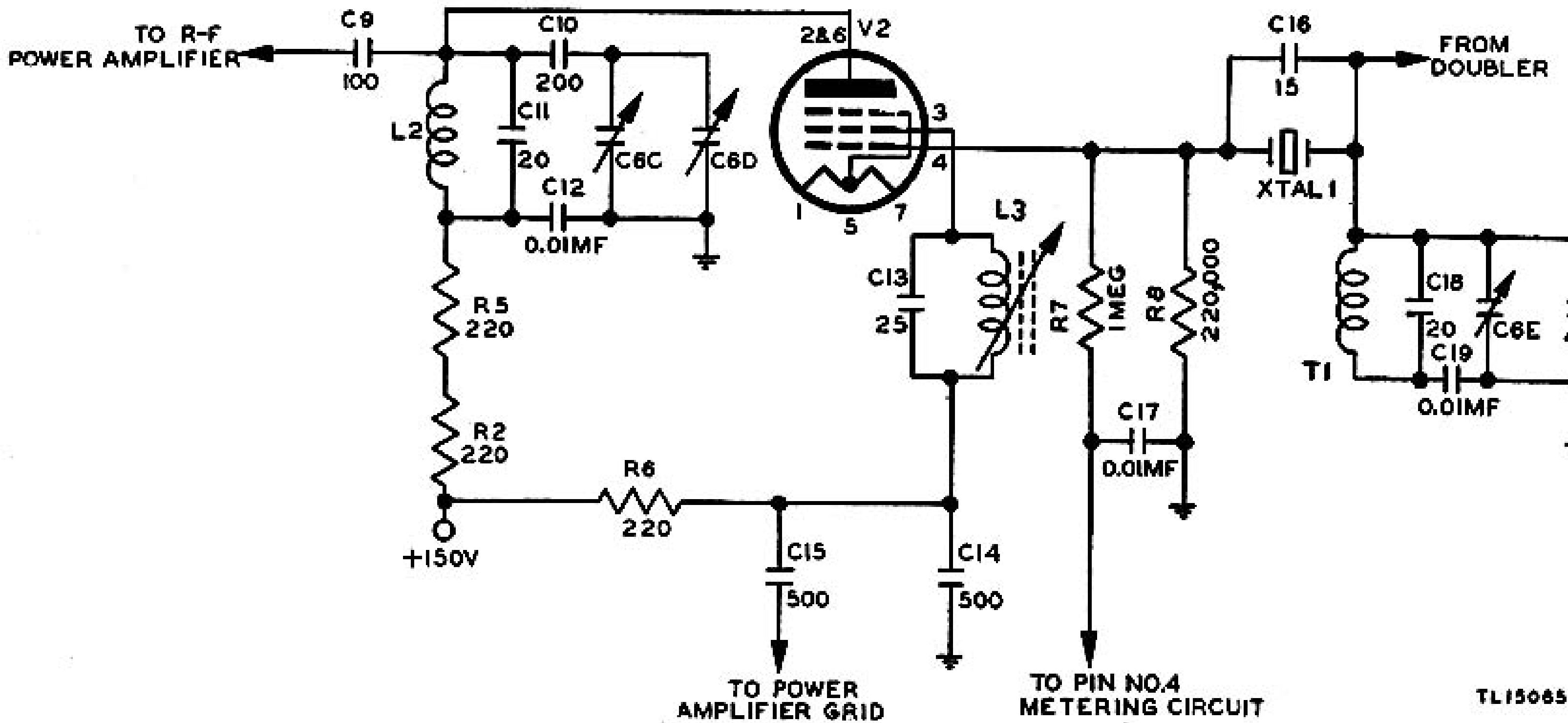

Figure 55. Radio Receiver and Transmitter BC-1000-A, transmitter mixer and crystal oscillator.

bias developed by the flow of rectified grid current through resistor R8 is measured at pin No. 4 of the metering socket. A decoupling network consisting of resistor R7 and capacitor C17 keeps radio frequency out of the metering circuit and prevents the metering circuit from loading the r-f stages of the transmitter. Doubler output is injected into the control grid (pin No. 6) of the mixer tube V2 through capacitor C16. The two signals are mixed in the electron stream and the *sum* frequency is brought out by the tuned mixer circuit consisting of inductor L2, tuning capacitor C6D, trimmer capacitor C6C, temperature compensating capacitors C10 and C11, and bypass capacitor C12. The output of the mixer is coupled to the grid of the power amplifier through capacitor C9. R2, R5 and R6 are decoupling resistors. Capacitor C14 is a B+ bypass capacitor. The double tuned plate circuit consists of an air-core inductor, and associated capacitors C18, C19, C6E, and C6F.

b. A special test switch (PRESS FOR DIAL LIGHT & CALIB.) in the filament circuit of the transmitter mixer and crystal-oscillator tube V2 places the tube in operation. When it is closed a number of receiver alignment and check operations can be made.

(1) The set can be calibrated by pressing the PRESS FOR DIAL LIGHT & CALIB. button. Present in the screen grid circuit of the transmitter mixer and crystal-oscillator tube are the 10th and 11th harmonics of the crystal oscillator (43 mc and 47.3 mc) plus a small value of output voltage in the same frequency range. At the points where the harmonics of crystal XTAL 1 and the output of the transmitter mixer are almost the same frequency, an audible beat note is produced which is coupled to the grid of the a-f power amplifier tube V15 through capacitor C15. The audible beat note obtained at these frequencies is useful in aligning the master oscillator and calibrating the tuning dial.

(2) The discriminator can be aligned. When the test switch is closed, a portion of the 4.3-mc signal leaks into the first i-f amplifier system. This signal is converted in the second mixer to the frequency of the second i-f amplifier system and is applied to the discriminator where it can be used to set the discriminator on the exact intermediate frequency.

(3) An external signal generator can be set exactly to a frequency of 4.3 mc for alignment of the i-f amplifier stages.

(4) All stages except the final transmitter stage can be tuned without radiating any r-f energy.

85. Radio-frequency Power Amplifier

The r-f power amplifier Tube JAN–3A4, V1, as shown in figure 56, is a Class C r-f amplifier which increases the output of the transmitter mixer before it is applied to the antenna. The tuned circuit of the r-f power amplifier is common to both receiver and transmitter. A portion of the r-f output energy is coupled to the receiver input through capacitor C2.

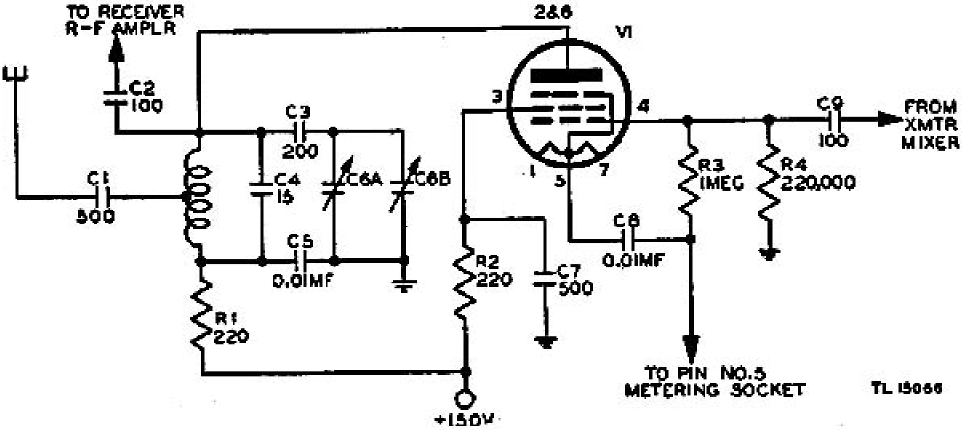

Figure 56. Radio Receiver and Transmitter BC–1000–A, r-f power amplifier.

The small value of signal that gets through the receiver is used to provide sidetone during transmission. The discriminator is held inoperative during transmission by the strong 4.3-mc signal which leaks into the first i-f amplifier circuits from the 4.3-mc crystal oscillator. A relative indication of the r-f power amplifier grid bias developed across R4 is measured at pin No. 5 of the metering socket. Other parts of the r-f power amplifier are decoupling resistor R1, plate bypass capacitor C5, screen grid resistor R2, screen grid bypass capacitor C7, coupling capacitor C9, meter filter circuit resistor R3 and capacitor C8, antenna coupling capacitor C1, and the tuned plate circuit consisting of an air core inductor and associated capacitors C3, C4, C5, C6A, and C6B.

86. Antenna Circuit and Operation

The following antennas can be used with Radio Receiver and Transmitter BC–1000–A: Antenna AN–130–A, Antenna AN–131–A, or Antenna Equipment RC–291–( ).

a. Antenna AN–130–A. This antenna which is 33 inches long and has two sections held together by a stainless steel cable, is provided with

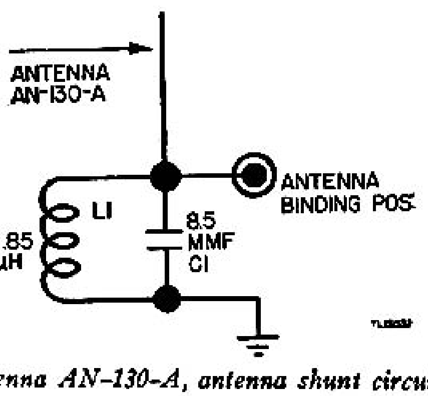

Figure 57. Antenna AN–130–A, antenna shunt circuit within base.

a flexible gooseneck so that it can be kept in a vertical position. A bakelite shell houses an antenna coil and capacitor. This coil L1 and capacitor C1 (fig. 57) are arranged in a parallel or shunt circuit between the antenna and ground, and present a reactance opposite to that presented by Antenna AN–130–A to tube VI of the radio receiver and transmitter. This action permits tracking of the final amplifier stage of the radio set without further adjustment when Antenna AN–130–A is used. Coil L1 has an inductance of 0.85 uh and capacitor C1 has a capacitance of 8.5 mmf. The two sections of Antenna AN–130–A are at no time resonant at the operating frequency.

b. ANTENNA AN–131–A. This antenna is 10 feet, 8 inches long and acts as a vertical radiator resonant at the mean frequency (44 mc) used by the radio receiver and transmitter. It is coupled to the plate tank circuit of the final amplifier by capacitor C1 (fig. 58) which has a value of 500 mmf and offers little reactance at the frequencies used. The function of capacitor C1 is to keep the d-c plate voltage present on L1 from appearing on the antenna proper.

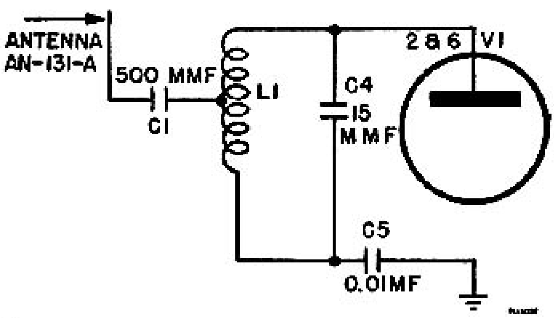

Figure 58. Antenna AN-131-A, coupling circuit.

c. ANTENNA EQUIPMENT RC–291–( ). This antenna, not supplied as part of Radio Set SCR–300–A, consists of a ground plane antenna resonant at the mean frequency (44 mc) used by the radio set. The four radials supplied with the antenna are connected to the outer sheaf of Cord CG–102/TRC–7 and act as a ground plane to concentrate radiation at the horizon, thus providing greater range. The characteristic impedance of Cord CG–102/TRC–7 matches the average impedance of the quarter-wave vertical rod at the frequencies used. The cord itself neither radiates nor absorbs radio signals from the air. This action of the cord permits the antenna to be elevated while the set remains on the ground. The range obtainable with Antenna Equipment RC–291–( ) increases with the elevation of the antenna above ground. This range can be calculated approximately by the formula $R=1.42\sqrt{h}$ where R is the range in miles and h is the height in feet of the quarter-wave antenna above the ground. Screening objects such as mountains

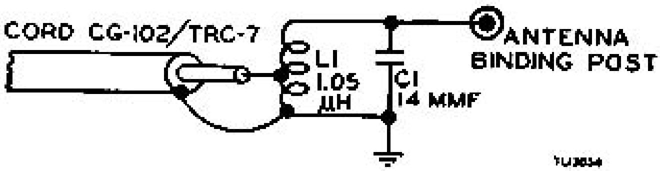

Figure 59. Antenna Equipment RC–291–( ), coupling circuit.

or trees higher than the elevated antenna will cut this range. Cord CG–102/TRC–7 is directly coupled to inductor L1 (fig. 59) at a point where the 50-ohm impedance of the cord matches the impedance of the section of the coil across which the cord is bridged. Coil L1 and capacitor C1 act as an autotransformer. An impedance of approximately 2,400 ohms appears at the antenna binding post, and decreases to zero (approximately) at the grounded end of the coil. L1 and C1 resonate at 40 mc and serve as a tracking network. L1 has an inductance of 1.05 uh; C1 has a capacitance of 15 mmf. L1 and C1 are housed in Terminal Box TM–217 which screws into the antenna terminal on the set.

87. Receive-transmit Control Circuit

The control circuit permits change-over from receive to transmit and from transmit to receive with a double-pole, single-throw switch. The receiver is turned on by closing the two series switches which complete the filament circuits. One switch, SW2, is mounted on the VOLUME control and the other, SW1, is closed when a plug PL–55 is inserted in the PHONE No. 1 jack. When the set is turned on and the receive-transmit switch is in the receive position, the filament circuits of the r-f power amplifier tube (V1) and of the transmitter mixer tube (V2) are not completed to ground. The transmitter is inoperative. When the receive-transmit switch is depressed, the transmitter filament circuit is completed. When the handset is used a 750-ohm resistor is shunted across the receiver unit to reduce side-tone when the receive-transmit switch is depressed. Microphone current is obtained from a 4.5-volt point on the battery which is shunted by a series network consisting of resistor R21, the primary of the microphone transformer T3A, and the microphone.

88. Metering Circuit

Metering socket SO1, mounted on the side of the chassis of Radio Receiver and Transmitter BC–1000–A, is used for alignment and test purposes. An electronic voltmeter must be used in making measurements to prevent loading of the high impedance circuits. Measurements are made by attaching the voltmeter between the correct pin and ground. Pin numbers and their corresponding circuits are as follows:

Pin No.	*Voltage*
1	Master-oscillator grid.
2	First limiter grid.
3	Second limiter grid.
4	Transmitter mixer grid.
5	Transmitter r-f power amplifier grid.
6	Receiver r-f amplifier grid.
7	Discriminator output.
8	Ground or chassis.

89. Filament Circuits (fig. 88)

In order that 1.5 volts can be applied to each filament from the 4.5-volt supply, the filaments of the tubes in Radio Receiver and Transmitter BC–1000–A are arranged in a series-parallel connection. Capacitors C71, C74, C75, C76, C77, C78, C79, C80, C81, C82, C83, C84, C85, C86, C87 and C88 provide low-impedance paths to ground for r-f current, where necessary. Choke CH1 through CH9, connected in series with filament circuits, isolate r-f currents from the circuits in which they are not desired. Because of the voltage drops in the filament circuit, each control grid has an effective fixed bias of one-half the voltage drop across the tube filament plus the voltage drop across the filaments of all other tubes between it and ground. Resistor R22 is a shunt resistor across the filament of tube V1. R76 is a shunt resistor across the filament of tube V4, the transmitter and receiver oscillator. Resistor R76 lowers the filament current and emission, and improves the oscillator stability. Resistor R56 is a dial light shunting resistor and resistor R57 is a filament voltage dropping resistor.

90. Battery Circuit

The voltages used by the various circuits of Radio Receiver and Transmitter BC–1000–A are supplied by Battery BA–70 or BA–80. Filament voltage for both receiver and transmitter and microphone current are supplied by a 4.5-volt section. The receiver and a portion of the transmitter circuit use the 90-volt section for plate and screen supply. Plate and screen voltage for the transmitter r-f power amplifier and for the transmitter mixer and crystal oscillator is supplied by a 150-volt source (90-volt section in series with a 60-volt section).

91. Modifications during Manufacture

a. Change of Capacitors C5, C12, and C72. To decrease the possibility of voltage break-down, capacitor C5, which is the plate bypass capacitor for the r-f amplifier tube V1, and capacitor C12, which is the plate bypass capacitor for transmitter mixer tube V2, have both been changed from a 400-volt rating to 500 volts. Capacitor C72, a 0.006

mmf, 400-volt, molded paper capacitor, has been replaced by a 0.006 mmf, 500-volt, molded mica capacitor. C72 is shunted across the primary of output transformer T3B. These changes are effective on all sets on Order No. 10185–Phila–44–01 after Serial No. 5800, and all of Order No. 23916–Phila–44–01.

b. CHANGES TO INCREASE GAIN OF THIRD INTERMEDIATE-FREQUENCY STAGE (fig. 88). The following changes are incorporated in Radio Set SCR–300–A beginning with Serial No. 6500 on Order No. 8558–Phila–44–01 and effective on Order No. 10185–Phila–44–01 after Serial No. 5800 and all Serial Nos. between 4625 and 4935, inclusive. This change has been made to permit the use of most tubes that are within JAN specifications without tube selection.

(1) R41, the plate and screen-grid voltage-dropping resistor for the third i-f amplifier tube V11, has been changed from 22,000 ohms, 1/3 watt, to 15,000 ohms, 1/3 watt. This change results in a higher plate and screen-grid voltage applied to tube V11, which increases the amplification of this stage.

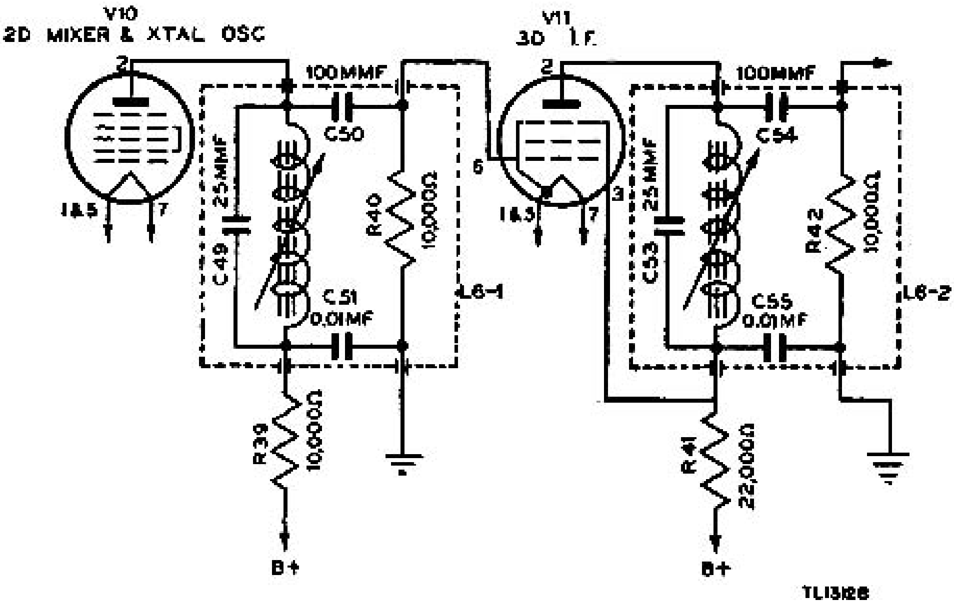

Figure 60. Third i-f amplifier, before circuit change.

(2) The grid-return resistor R40 of the third i-f amplifier tube V11 is connected to the positive filament leg, terminal No. 7, of the second mixer and oscillator tube V10. In this manner the grid bias of the third i-f amplifier tube V11 is reduced from a minimum of 1½ volts, which increases the amplification of the stage. Figure 60 shows the circuit of the third i-f amplifier before the change was made. The above changes also apply to Order No. 29316–Phila–44–01.

c. REVISION OF FIFTH FILAMENT STRING. The arrangement of the fifth filament string has been changed to improve the operation of the set. Figure 61① shows the arrangement of the filaments before the change while figure 61② shows the filament string after the change. The string has been revised to put the filament of doubler tube V3 at the ground end of the string. This filament revision is effective on all sets on Order No. 15025–Phila–43 from Serial Nos. 4775 through 8824 and from 9111 through 14707. It is also effective on all sets on the entire Order No. 32870–Phila–43, Order No. 23916–Phila–44–01, and Order No. 10185–Phila–44–01.

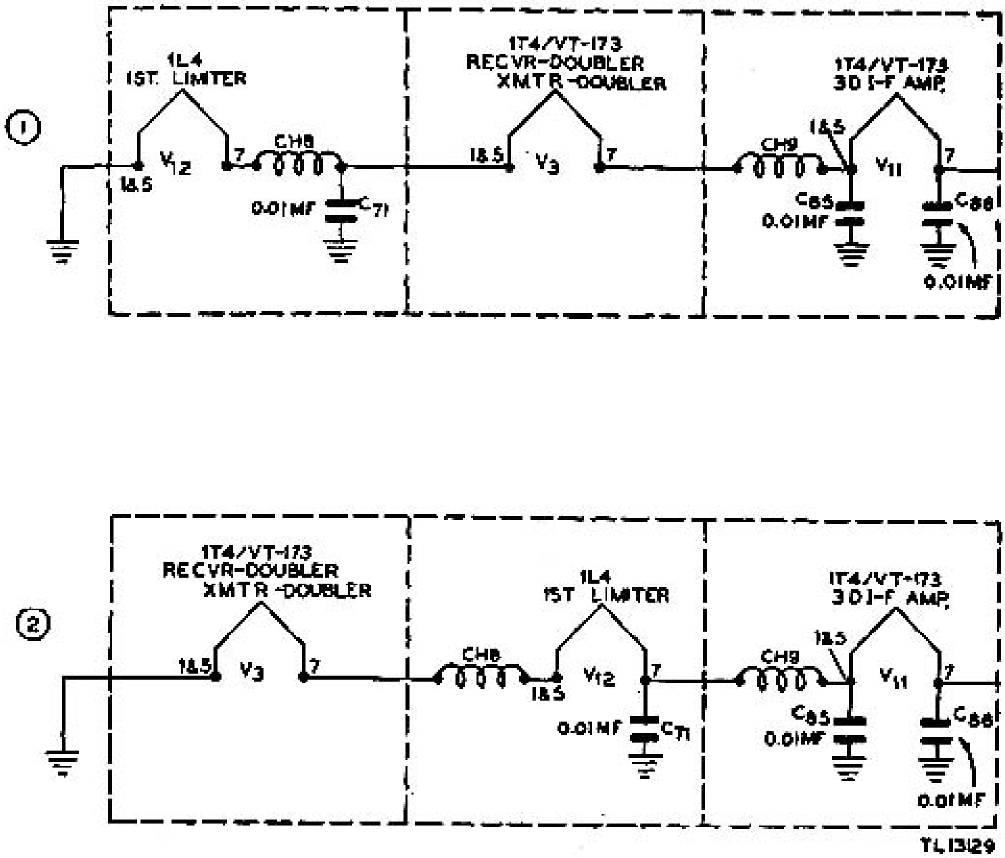

Figure 61. Radio Receiver and Transmitter BC–1000–A, wiring change in filament circuit of tubes, V3, V11, and V12.

d. CAPACITOR C98. Capacitor C98 is connected from the anode grid, pin No. 3, of the second mixer and crystal-oscillator tube V10 to ground (fig. 62) in all sets on Order No. 15025–Phila–43 from Serial No. 2601 through 8824, approximately. It is omitted from all other sets which have Serial Nos. below 2601 and above 8824, as well as all sets on Order Nos. 32870–Phila–43, 10185–Phila–44–01, and 23916–Phila–44–01.

e. CAPACITORS C99 AND C22. Capacitor C22 (8.5 mmf) is used only on radio sets bearing Serial No. 1 through 4401 on Order No. 15025–Phila–43. In all other sets, C22 has been replaced by C99 which has a capacity of 11 mmf. This change is effective on all sets on Order No. 15025–Phila–43 from Serial No. 4402 and above, as well as on the entire Order No. 10185–Phila–44–01. C22 (or C99) is connected between the top end of the primary of transformer T2 and ground. The above changes also apply to Order No. 29316–Phila–44–01.

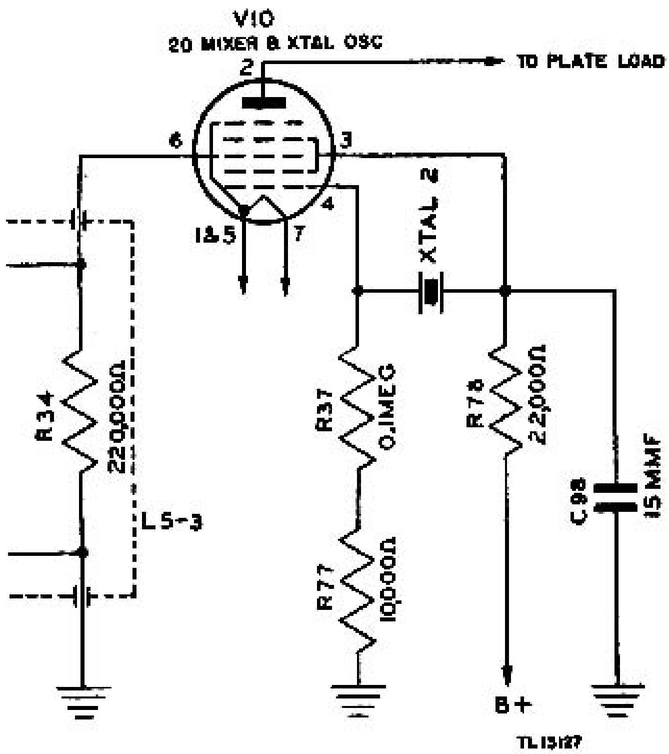

Figure 62. Radio Receiver and Transmitter BC–1000–A, second mixer and crystal-oscillator circuit change.

f. Resistors R77 and R36. Resistor R36, 22,000-ohm grid resistor of oscillator tube V10, is used in all sets on Order No. 15025–Phila–43 bearing Serial Nos. from 1 through 8823. In all sets above Serial No. 8823 and in all those on Order Nos. 32870–Phila–43, 10185–Phila–44–01, and 23916–Phila–44–01, resistor R36 has been replaced by Resistor R77 (10,000 ohms).

g. Resistors R78 and R38. Resistor R38 is a 39,000-ohm screen-grid voltage-dropping resistor for tube V10 used only in sets bearing Serial Nos. 1 through 8823 on Order No. 15025–Phila–43. Resistor R78, 22,000 ohms, replaces resistor R38 in all sets on Order No. 15025–Phila–43, above Serial No. 8823, as well as in all sets on Order Nos. 32870–Phila–43, 10185–Phila–44–01, and 29316–Phila–44–01.